HORIZONTAL DIRECTIONAL DRILL ANALYSIS
MIDDLE CREEK & T307 CROSSING
PADEP SECTION 105 PERMIT NO.: E38-194
PA-LE-0117.0000-WX-16
(SPLP HDD No. S3-0110)

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This reevaluation of the horizontal directional drill (HDD) installation of a 16-inch diameter pipeline that traverses Middle Creek and Township Road 307 (Creek & T307) in Heidelberg Township, Lebanon County, Pennsylvania is in accordance with the Stipulated Order issued under Environmental Hearing Board Docket No. 2017-009-L for HDDs listed on Exhibit 3 of the Stipulated Order. This HDD is number 13 on the list of HDDs included on Exhibit 3 of the Order requiring a reevaluation.

The 20-inch HDD was initiated before the temporary injunction issued by the Pennsylvania Department of Environmental Protection (PADEP) Environmental Hearing Board on July 25, 2017. This HDD had two inadvertent returns (IR) during installation of the 20-inch pipeline, which were fully remediated and the pipeline installation completed.

The 16-inch pipe HDD is referred to herein as HDD S3-0110.

PIPE INFORMATION

16-Inch: 0.438 wall thickness; X-70

Pipe stress allowances are an integral part of the design calculations performed for each HDD.

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 1,481 feet (ft)
- Entry/Exit angle: 12-16 degrees
- Maximum depth of cover: 72 ft
- Maximum depth of cover under wetland H14: 72 ft
- Maximum depth of cover under Middle Creek (stream S-C86): 72 ft
- Maximum depth of cover under wetland H13: 72 ft
- Pipe design radius: 1,400-1600 ft

ROOT CAUSE ANALYSIS FOR THE 20-INCH PIPE INSTALLATION IR

Two IR events occurred during the pilot hole drilling phase of the 20-inch pipeline. Both IRs surfaced within 98 ft of the exit point, where the pilot drilling tool, a mud motor, was at 19 ft below ground or less. IRs at this location and setting on a drilling profile are considered “Punch Out” IRs in the horizontal drilling industry. These IRs resulted from the shallow depth of cover on the HDD exit radius while proceeding through weathered rock or overburden material in the upper 20 ft of the profile.

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

Based upon publications by the Pennsylvania Bureau of Topographic and Geologic Survey (PABTGS), the site lies within the Gettysburg-Newark Lowland Section of the Piedmont Physiographic Province of Pennsylvania, which is regionally underlain by mainly red shale, siltstone, and sandstone with some conglomerate and diabase. The site geology for the redesigned 16-inch HDD profile is mapped west to east as the Triassic age Hammer Creek Conglomerate (Trhc) and the Hammer Creek Formation (Trh). The contact between the two runs along a section of the proposed HDD profile near T307.

The Hammer Creek Conglomerate consists of very coarse quartz conglomerate with abundant pebbles, and cobbles of gray quartzite containing minor interbeds of coarse sandstone. Ease of excavation is difficult and drill rates tend to be slow due to the hardness of the quartz-pebble conglomerate.

The Hammer Creek Formation near the HDD is described as a red, brown, and less abundant light gray to gray very fine to coarse grained conglomerate, thin- to thick-bedded quartz-rich sandstone and thin to medium-bedded red shale and siltstone. From an engineering stand point, the formation is difficult to excavate with slow drilling rates because of quartz-pebble conglomerate and in areas adjacent to diabase intrusions where the rock is harder.

Karst geology is not present at this HDD location. A multi-technique geophysical survey at the site was completed in on January 2019. The purpose of the survey was to detect and delineate subsurface fracture zones that could contribute to potential IRs and/or a loss of returns, and to determine the rock profile and rock rippability for ease-of-excavation along the HDD path. Results from the geophysical techniques are consistent with each other, and with the geology as mapped by the PA Geological Survey; all suggesting that the local bedrock is mildly fractured, with a few potential anomalous zones of concern.

SPLP possesses a complete geologic profile from the 20-inch pipeline HDD, and vertical geotechnical data. No additional information is required to reevaluate the installation of the 16-inch pipeline by HDD.

Attachment 1 provides an extensive discussion on the geology and results of the geotechnical investigation performed at this location.

HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

Groundwater at the site moves through narrow secondary openings such as bedding plans, joints, faults, and folds. The openings are best developed near the surface which allows water to move more freely near the ground surface than within deeper zones due to the compression of overlying materials (Wood, 1980). The groundwater flow also occurs through a series of sedimentary beds with relatively high transmissivity separated by beds exhibiting lower transmissivities. This sequence of beds exhibits different hydraulic properties that collectively act as a series of alternating aquifers and confining or semi-confining units forming a leaky (i.e., hydraulically interconnected) multi-aquifer system (LMAS). The groundwater flow direction within the Hammer Creek Formation and Conglomerate is controlled by hydraulic gradients and variability of hydraulic conductivity.

The yield of water wells is typically influenced by topographic position, with water-bearing zones located on the tops and slopes of high hills and ridges generally having low yields. Conversely, wells located in valleys typically have higher yields. Water wells completed in the Hammer Creek Formation and Conglomerate typically have higher yields when completed in valleys and lower yields when completed on hilltops. Well records within a 0.5-mile radius of the T307 & Creek S-C86 HDD was obtained from the Pennsylvania Groundwater Information System (PaGWIS, 2019), and resulted in information being obtained for one domestic water well with a depth of 220 ft and a yield of 12 gallons per minute. This HDD location is relatively isolated and no other structures that could have a water supply are located within the ½-mile radius.

Attachment 1 provides an extensive discussion on the hydrogeology and results of the geotechnical investigation performed at this location.

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INADVERTENT RETURN (IR) DISCUSSION

During the pilot phase drilling for the 20-inch pipe, one IR occurred at 98 ft before the exit point, and a second IR occurred at 68 ft before the exit point. As discussed above, the root cause of this IR is the weathered bedrock or weak weathered material overlying bedrock (bedrock/overburden interface) which as the pilot tool was drilling through and coming out of the bedrock, allowed for the movement of drilling fluids to the land surface. As stated previously, this is called a "Punch Out" IR in the drilling industry, and these type of events are difficult to prevent, especially when drilling out of the bedrock with shallow overburden between the bedrock and land surface.

"Punch In" and "Punch Out" IRs are difficult to prevent when bedrock is shallow below the land surface, and the pilot hole mud motor has to continue cutting through rock to proceed into or out of bedrock to enter or exit the profile. The profile for the 16-inch pipeline has been redesigned so that it is deeper than previously permitted and the entry and exit angles increased to minimize drilling time while entering or exiting the profile.

ADJACENT FEATURES ANALYSIS

The crossing of Middle Creek & T307 is located in Heidelberg Township, Lebanon County, approximately 9.8 miles (mi) southeast of the community of Lebanon, and approximately 34.1 mi east of Harrisburg, Pennsylvania. The alignment crosses Middle Creek (S-C86) and road T307 approximately 0.3 mi southwest of the intersection of T307 and Chapel Road. The entire HDD alignment is located on State Game Land 46, also designated as the Middle Creek Wildlife Management Area.

The 16-inch HDD route parallels, within the same permanent easement, the recently installed 20-inch pipeline and two other existing SPLP pipelines. The HDD will proceed underneath Middle Creek and adjacent wetlands (H14 and H13) and Federal Emergency Management Agency (FEMA) 100-year floodplain. The wetlands are comprised of emergent, scrub-shrub, and forested components and occur over the majority of the length of the HDD. Middle Creek is a Chapter 93 designated approved trout water and stocked trout stream. The HDD of the area avoids direct surface impacts to Middle Creek and the adjacent wetlands. Additionally, this HDD avoids surficial impacts to the floodway and forested riparian area associated with Middle Creek, the floodway of a tributary Middle Creek (stream S-C85), and it avoids conversion of the forested cover type conversion in wetlands H14 and H13.

SPLP identified all landowners with property located within 450 ft of the HDD alignment. SPLP sent each of these landowners a notice letter via both certified and first class mail that included an offer to sample the landowner's private water supply/well in accordance with the terms of the Order and the Water Supply Assessment, Preparedness, Prevention and Contingency Plan. The letter also requested that each landowner contact the Right-of-Way agent for the local area and provide SPLP with information regarding: (1) whether the landowner has a well; (2) where that well is located, and its depth and size if known; and (3) whether the landowner would like to have the well sampled. In accordance with paragraph 10 of the Order, copies of the certified mail receipts for the letters sent to landowners have been provided to Karyn Yordy, Executive Assistant, Office of Programs at the Department's Central Office.

As a result of these communications, no water wells were identified within 450 ft of the proposed HDD.

ALTERNATIVES ANALYSIS

As part of the PADEP Chapter 105 permit process for the Mariner II East Project, SPLP developed and submitted for review a project-wide Alternatives Analysis. During the development and siting of the

project, SPLP considered a number of different routings, locations, and designs to determine whether there was a practicable alternative to the proposed route. SPLP performed this determination through a sequential review of routes and design techniques, which concluded with an alternative that has the least environmental impacts, taking into consideration cost, existing technology and logistics. The baseline route provided for the pipeline construction was to cross every wetland and stream on the project by open cut construction procedures. The Alternatives Analysis submitted to PADEP conceptually analyzed the potential feasibility of any alternative to baseline route trenched resource crossings (e.g., reroute, conventional bore, HDD). The decision-making processes for selection of the HDD instead of an open cut crossing methodology is discussed thoroughly in the submitted alternatives analysis and was an important part of the overall PADEP approval of HDD plans as currently permitted. As described below, the open cut and re-route analyses have confirmed the conclusions reached in the previously submitted Alternatives Analysis.

Open-cut Analysis

The HDD avoids surface impacts to Middle Creek, its associated floodway and riparian area, the floodway of stream S-C85, two wetlands, and a FEMA 100-year floodplain, all located within a Commonwealth owned wildlife management area. If these areas and resources were to be open trenched, the assessed area of impact would directly affect 1,275 square feet of state water bottoms; 0.284 acre of floodway; and 1.843 acres wetlands, including 0.673 acre of forested wetland.

Use of Conventional Auger Bore

Planning for a conventional bore must account for the extent or width of the feature (road, stream, etc.) being bored under, as well as the length and width of the setup-entry pit for setting the boring equipment within while operating, and the receiving pit through which the product pipeline is pulled back through after the boring machinery exits. Based on experience gained during construction of the Mariner II Pipeline project, conventional auger bores should be limited to approximately 200 linear foot at a time, or less, varying by the underlying substrate.

The linear extent of wetland resources above this HDD is 1,180 ft, although they are bisected by a public road. Additionally, the permanent easement has a minor change in direction approximately 1/3 of the distance across the wetland area. Due to these aspects there is no means to setup and complete a conventional bore without the need to clear and excavate either an entry pit, an exit pit, or both within the wetland area. Furthermore, due to the change of direction by the permanent easement, at minimum two bore would be required, or possible three bores due to the overall footage.

Re-Route Analysis

The pipeline route follows an existing SPLS easement occupied by three previously existing SPLP pipelines, and the newly installed Mariner 20-inch pipeline.

The general orientation of the PPP is from west to east. There are no existing utility corridors to the north that provide a practical alternative route. An existing electrical power corridor occurs approximately 1.0 mile south; however deviating the route of the PPP would require establishing a new greenfield utility corridor to leave and return to the route of the PPP, and with no existing line right to establish a new utility corridor, the use of eminent domain would be possibly required, and the route would proceed through existing woodlands, potentially encounter stream crossings, and possibly encroach on private residences before it could rejoin the current route.

In summary, due to the setting that surrounds the overall route of the Mariner II pipelines in this area, there is no alternative route that provides advantage over the existing route.

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This re-route analysis conducted for the Middle Creek and Township Road 307 HDD confirms the conclusions reached in the previously submitted alternatives analysis.

HORIZONTAL DIRECTIONAL DRILL REDESIGN

After review of the original HDD designs, geotechnical data, field reports related to the IR events that occurred during installation of the 20" pipeline, SPLP HDD specialists have redesigned this HDD. A summary of the redesign factors is provided below. The original and redesigned HDD plan and profile drawings are provided in Attachment 2.

Revised Horizontal Directional Drill Design Summary: 16-inch

- Horizontal length: 1,678 (ft)
- Entry/Exit angle: 12-16 degrees
- Maximum Depth of cover: 79 ft
- Pipe design radius: 2,000 ft

CONCLUSION

As shown on Figure 2, the redesigned HDD extends the profile by 197 ft and increases the entry and exit angles to minimize the risk of drilling fluid loss and IRs.

The redesign of the HDD will not prevent all IRs. IR's are common on entry and exit of the drilling tool and other measures are required to minimize IR potential. In particular, upon the start of this HDD, SPLP will employ the following HDD best management practices:

- The drilling contractor, craft inspector, and monitoring geologists will be provided an orientation on the IR that occurred during drilling of the 20-inch pipeline installation, and the contractor will be required to utilize low drilling fluid pressure during pilot entry down to the bedrock face, and will monitor pilot tool progress on the exit radius to attempt to cut drilling fluid pressures immediately upon exiting out of bedrock into overburden;

- SPLP will mandate annular pressure monitoring during the drilling of the pilot hole, which assists in immediate identification of pressure changes indicative of loss of return flows or over pressurization of the annulus, to help manage development pressures that can induce an IR;

- SPLP inspectors will ensure that an appropriate diameter pilot tool, relative to the diameter of the drilling pipeline, is used to ensure adequate "annulus spacing" around the drilling pipeline exits to allow good return flows during the pilot drilling;

- SPLP will implement short-tripping of the reaming tools, as indicated by monitoring of return flows, to ensure an open annulus is maintained to manage the potential inducement of IRs;

- SPLP will require monitoring of the drilling fluid viscosity, such that fissures and fractures in the subsurface are sealed during the drilling process;

- During all drilling phases, the use of Loss Control Materials (LCMs) will be implemented upon detection of a Loss of Circulation (LOC) or indications of a potential IR are noted or an IR is observed. The use of LCMs, however, is less effective below 70 ft of the ground surface.

Accordingly, the preferred corrective action needed to address the presence of fractures or LOC at greater depths below ground will require grouting of the HDD annulus. Two types of grouting may be utilized for corrective actions to seal fractures. These are: 1) grouting using "neat cement"; and 2) grouting using a sand/cement mix. Neat cement grout is a slurry of Portland cement and water which is highly reactive to bentonite and induces solidification. The sand/cement grout mix is a slurry of mostly sand with a small percentage of Portland cement and activators that after setup results in a material having the competency of a friable sandstone or mortar. Both grouting actions require tripping out the drilling tool, and then tripping in with an open-ended drill stem to apply or inject the grout mixes. Either of these grouting actions may be implemented upon the first detection of an LOC with the selection of the treatment based upon the circumstances of the LOC, being small or large in magnitude.

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FEASIBILITY DETERMINATION

Based on the information reviewed by the Geotechnical Evaluation Leader, Professional Geologists, Professional Engineers, and HDD specialists, the HDD Reevaluation Team's opinion is that the proposed HDD design and implementation of the management measures contained within this re-revaluation report will minimize the risk of IRs and impacts to public and private water supplies during the construction phases of the HDD.

Pertaining to Horizontal Directional Drilling Practices and Procedures; Conventional Construction; Alternatives; and Environmental Effects

Larry J. Gremminger, CWB
Geotechnical Evaluation Leader
Mariner East 2 Pipeline Project

2-24-2019
Date

Pertaining to the practice of geology

Douglas J. Hess, P.G.
License No. PG-000186-G
Skelly and Loy, Inc.
Director of Groundwater
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Geo-Environmental Services

2-25-2019
Date

Pertaining to the pipeline stress and HDD geometry

Jeffrey A. Lowy, P.E.
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Rooney Engineering, Inc.
Civil Engineer

2/25/19
Date

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ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT

RETTEW

We answer to you.

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Engineers
Environmental Consultants
Surveyors
Landscape Architects
Safety Consultants

February 18, 2019

Mr. Matthew Gordon
Sunoco Pipeline, LP
535 Fritztown Road
Sinking Spring, PA 19608

RE: Sunoco Pipeline, LP Pipeline Project - Mariner East II
T307 & Creek S-C86 HDD (S3-0110), PA-LE-0117.0000-WX-16
Hydrogeological Re-Evaluation Report for 16-Inch Pipeline
Heidelberg Township, Lebanon County, Pennsylvania
RETTEW Project No. 096302011

EXECUTIVE SUMMARY

1. The 20-inch and 16-inch T307 & Creek S-C86 horizontal directional drill (HDD) S3-0110 locations are included in the Corrected Stipulated Order Dated August 10, 2017 requiring re-evaluation, including a geologic report. This HDD is listed as No. 13 of the HDDs on Exhibit 3. This re-evaluation was also prepared as a result of inadvertent returns (IRs) that occurred during the completion of the T307 & Creek S-C86 HDD for the 20-inch pipeline.
2. The site is underlain by clastic sedimentary rocks of the Triassic age Hammer Creek Formation (Trh) and Hammer Creek Conglomerate (Trhc).
3. Water-bearing zones in the underlying geology generally occur in secondary openings along bedding planes, joints, faults, and fractures.
4. Reported median yields in non-domestic wells installed in shale, quartz conglomerate and sandstone within the Hammer Creek Formation were 144, 120, and 90 gallons per minute, respectively.
5. The HDD profile for the proposed 16-inch drill has been redesigned to increase the amount of protective cover at the eastern end of the proposed 16-inch HDD alignment.
6. Based on the hydro-structural characteristics of the underlying geology, information obtained from installation of the 20-inch pipe, and the inadvertent returns (IRs) that occurred during the installation of the 20-inch pipe, the T307 & Creek S-C86 HDD is susceptible to an IR of drilling fluids during HDD operations for the planned 16-inch drill. The redesigned 16-inch HDD profile and protective HDD best management practices during drilling operations will be used to reduce the risk of an IR.

1.0 INTRODUCTION

The purpose of this report is to describe the geologic and hydrogeologic setting of the T307 & Creek S-C86 S3-0110 horizontal directional drill (HDD) location on the Sunoco Pipeline, LP (SPLP) Pennsylvania Pipeline Project - Mariner East II (PPP-ME2) Project. The T307 & Creek S-C86 HDD is located within Heidelberg Township, Lebanon County, Pennsylvania as shown on **Figure 1**. The 16-inch HDD will be drilled under Township Road T307, streams (S-C85 and S-C86) and a wetland complex (W-H13). This re-evaluation report is part of the response to the Corrected Stipulated Order dated August 10, 2017, related to the potential for the inadvertent return (IR) of drilling fluids during proposed drilling operations. This

re-evaluation was also prepared in response to the IRs of drilling fluids that occurred on June 23 and 24, 2017, as the T307 & Creek S-C86 HDD was being completed for the 20-inch pipeline.

The original 16-inch HDD was redesigned on November 19, 2018, to increase the length of the HDD; however the HDD profile was not deepened. The redesigned profile will provide additional protective cover beneath the sensitive receptors at the eastern end of the HDD profile where IRs occurred during the installation of the 20-inch pipe. The maximum depth of the proposed 16-inch HDD is approximately 79 feet below ground surface (bgs) (approximately 30 feet deeper than the maximum depth of the as-built 20-inch HDD). The redesigned western HDD entry/exit point is at an elevation of approximately 569 feet above mean sea level (AMSL) and the redesigned eastern entry/exit point is at an elevation of approximately 560 feet AMSL. The HDD profile was extended approximately 150 feet to the east resulting in a new horizontal length and pipe length of 1,678 feet and 1,696 feet, respectively. The inclination of the eastern and western entry/exit angles has remained unchanged but by lengthening the bore profile by approximately 150 feet approximately 25 feet of additional protective soils has been gained at the location of the previous IRs. The as-built 20-inch and proposed 16-inch S3-0110 HDD locations are shown on **Figure 1**, and the redesigned 16-inch profile is included as **Attachment 1.**

2.0 GEOLOGY AND SOILS

Based upon publications by the Pennsylvania Bureau of Topographic and Geologic Survey (PABTGS), the site lies within the Gettysburg-Newark Lowland Section of the Piedmont Physiographic Province of Pennsylvania, which is regionally underlain by mainly red shale, siltstone, and sandstone with some conglomerate and diabase. Local topography is characterized by long narrow ridges and broad to narrow valleys (Sevon, 2000). The regional structure of the Newark Group consists of a north-northwestward dipping homocline, with local folds plunging northward and reversed dips located adjacent to the northern border of the basin. The structure is cut by a few faults that are at high angles to the general bedrock strike. The overall bedding dip direction is northwestward or northward ranging from 15 to 30 degrees and sometimes exceeding 40 degrees (MacLachlan et al., 1975). Outcrop patterns are broadly parallel to the Appalachian fold belt. These rocks generally have good surface drainage (Wood, 1980). Based on the United States Geologic Survey (USGS) 7.5-Minute Womelsdorf, PA Topographic Quadrangle Map shown on **Figure 1**, the site is situated at an approximate elevation of 560 feet AMSL. Surface topography at the site slopes to the east and west along the proposed HDD towards Middle Creek. Middle Creek flows primarily in a southeasterly direction before discharging into Middle Creek Lake.

The site geology for the redesigned 16-inch HDD profile is mapped west to east as the Triassic age Hammer Creek Conglomerate (Trhc) and the Hammer Creek Formation (Trh). The contact between the two runs along a section of the proposed HDD profile near T307. The Hammer Creek Conglomerate consists of very coarse quartz conglomerate with abundant pebbles, and cobbles of gray quartzite containing minor interbeds of coarse sandstone. The unit has a measured thickness of 2,580 feet. Beds are thick to massive and well bedded. Joints in this unit have a blocky pattern, are moderately developed and abundant, and occur regularly. There is a moderate distance between fractures which are open and steeply dipping. The unit is classified as moderately resistant to weathering. Weathering of the Hammer Creek results in large blocks to individual pebbles, cobbles and sand grains. The overlying mantle tends to be thin. From an engineering standpoint, slope stability is good to fair. Landslides may occur where the cut slopes are steep and the rocks dip towards the cut. Ease of excavation is difficult and drill rates tend to be slow due to the hardness of the quartz-pebble conglomerate. Foundation stability is classified as good, but the excavation should be continued to sound material. Surface drainage is good with the unit having low primary porosity

and low secondary porosity from joint- and bedding-plane openings. Permeability is also low in the Hammer Creek Conglomerate (Geyer and Wilshusen, 1982).

The Hammer Creek Formation near the HDD is described a red, brown, and less abundant light gray to gray very fine to coarse grained conglomerate, thin- to thick-bedded quartz-rich sandstone and thin to medium-bedded red shale and siltstone. The sandstones exhibit some crossbedding, lensing, channeling, and ripple marks, while the siltstone and shale exhibit ripple marks and mud cracks (Low et al., 2002).

The Hammer Creek Formation is well bedded with thick to massive beds. Joints are regularly occurring, open and steeply dipping, moderately developed and moderately abundant with a blocky pattern. Overall, the formation is moderately resistant to weathering, generally forming a rough terrain of high relief. The shale is highly weathered to a moderate depth, while the sandstone and conglomerate display less weathering. Weathering results in size from large blocks to sand grains. The overlying mantle tends to be thick. From an engineering stand point, the formation is difficult to excavate with slow drilling rates because of quartz-pebble conglomerate and in areas adjacent to diabase intrusions where the rock is harder. Foundation stability is good when material is excavated to sound rock. Slope stability tends to be good to fair with landslides occurring where the cut slopes are steep and rocks dip towards the cut. Surface drainage for this formation is good. The formation has low primary porosity, but the joints and bedding openings provide moderate secondary porosity and low to moderate permeability (Geyer and Wilshusen, 1982).

According to the United States Department of Agriculture (USDA) Soil Surveys of Lebanon County, Pennsylvania, soils in the vicinity of the T307 & Creek S-C86 HDD consists of six distinct soil units. A USDA map that depicts the mapped area, along with the soil profile descriptions, is included as **Attachment 2**.

3.0 HYDROGEOLOGY

Groundwater at the site moves through narrow secondary openings such as bedding plans, joints, faults, and folds. The openings are best developed near the surface which allows water to move more freely near the ground surface than within deeper zones due to the compression of overlying materials (Wood, 1980). The degree to which openings have developed depends on the composition and texture of the rock, and on the direction and intensity of the forces that have acted upon the rock. The groundwater flow also occurs a series of sedimentary beds with relatively high transmissivity separated by beds exhibiting lower transmissivities. This sequence of beds exhibits different hydraulic properties that collectively act as a series of alternating aquifers and confining or semi-confining units forming a leaky (i.e., hydraulically interconnected) multi-aquifer system (LMAS). The groundwater flow direction within the Hammer Creek Formation and Conglomerate is controlled by hydraulic gradients and variability of hydraulic conductivity. The predominant flow direction is parallel to bedding (Wood, 1980). Since the direction of shallow groundwater flow typically mimics that of the surface topography, it is presumed that the direction of shallow groundwater flow at the T307 & Creek S-C86 HDD is to the east and west, towards Middle Creek. Middle Creek bisects the redesigned HDD profile and flows in a southeasterly direction from the site before discharging into Middle Creek Lake. Middle Creek Lake is approximately 2,700 feet southeast of the T307 & Creek S-C86 HDD.

The yield of water wells is typically influenced by topographic position, with water-bearing zones located on the tops and slopes of high hills and ridges generally having low yields. Conversely, wells located in valleys typically have higher yields. Water wells completed in the Hammer Creek Formation and Conglomerate typically have higher yields when completed in valleys and lower yields when completed

on hilltops. Industrial and public water supply wells show little to no uniform correlation to well yield and topography largely because these wells are completed to greater depths. Most of the yield in these wells is provided by the deeper zones, masking the influence of topography. Reported median yields in non-domestic wells installed in shale, quartz conglomerate and sandstone within the Hammer Creek Formation were 144, 120, and 90 gallons per minute, respectively (Wood, 1980). The direction of shallow groundwater flow typically mimics that of the surface topography. Therefore, it is presumed that the direction of shallow groundwater at the HDD site is towards Middle Creek, which bisects the HDD alignment and ultimately discharges to Middle Creek Lake. Middle Creek Lake is approximately 2,700 feet southeast of the HDD alignment. The groundwater system consists of a series of alternating tabular aquifers dipping 20 to 40 degrees to the northwest. The water-bearing fractures in the tabular aquifers are more or less continuous along bedrock strike (Wood, 1980).

Well records for one individual water supply well reviewed within a 0.5-mile radius of the T307 & Creek S-C86 HDD was obtained from the Pennsylvania Groundwater Information System (PaGWIS, 2019). The well location is shown on **Figures 2** and **3.** The information obtained from this well record is summarized in the following table:

Well No.	Well Use	Casing Depth (feet)	Total Depth (feet)	Water Level (feet)	Yield (gpm)
125367	DOMESTIC	23	220	220	12

As a condition of the Corrected Stipulated Order, in January 2019, other Sunoco subcontractors researched private water supplies located within a 450-foot radius of the T307 & Creek S-C86 HDD. No additional water wells were identified within the 450-foot search radius as shown on the figure in **Attachment 3.**

4.0 FRACTURE TRACE ANALYSIS

Fracture traces are natural linear features that are unaffected by local topographic relief and, as a result, are considered surface manifestations of fractures, joints, faults or bedding planes within the subsurface. Fracture traces may be observed on aerial photographs as linear topography, straight stream segments, vegetation or soil tonal alignments. These features can transmit groundwater through the fractured bedrock aquifer underlying the S3-0110 HDD site. Fracture traces underlying or in close proximity to the T307 & Creek S-C86 HDD were evaluated using historical aerial photographs from the years 1995 through 2018 (Google Earth Pro, 2018), the Womelsdorf, PA USGS 7.5 Minute Quadrangle Map and the Geologic Map of the Womelsdorf Quadrangle Map (Berg and Dodge, 1981 and Geyer et al., 1963). The aerial photographs and maps were reviewed to approximate locations of natural linear features or lineaments expressed on the ground surface.

Figures 2 and **3** show the results of the fracture trace analysis overlain on the geologic map and aerial base map, respectively. Five possible fracture traces were identified in close proximity to the T307 & Creek S-C86 HDD site that are likely related to the primary geologic structure of the area. Three of the fracture traces trend approximately northeast-southwest (NE-SW); generally parallel to geologic strike. The remaining two fracture traces trend northwest-southeast (NW-SE), generally at an angle to the regional strike, and may represent stress-related joint sets. General surface drainage patterns near the site are characterized by linear stream reaches trending NE-SW or NW-SE that reflect the general geologic structure.

5.0 GEOTECHNICAL EVALUATION

Two geotechnical drilling investigations were performed at the site; with the initial investigation being performed in December 2014 during the preliminary investigation of the T307 & Creek S-C86 HDD prior to initiating the 20-inch HDD operations. The second phase of geotechnical drilling was performed in September 2017. The 2014 test borings were advanced by hollow-stem auger drilling methods. These borings are designated as SB-01, SB-02 and SB-03. The 2017 test borings were advanced using hollow stem auger drilling and NQ-sized wireline rock coring methods and are designated B-1 and B-2. Soil, residual soil and weathered bedrock collected during both investigations were sampled using split-spoon sampling methods. Geotechnical boring logs are included in **Attachment 1**.

Boring SB-01 was located approximately 75 feet southwest of the western HDD entry/exit point. Boring SB-02 was located approximately 675 feet east-southeast of the western HDD entry/exit point and near the midpoint of the proposed 16-inch profile. Boring SB-03 was located approximately 150 feet northwest of the eastern HDD entry/exit on the east side of the profile. Boring B-1 was located approximately 50 feet to the north of the western HDD entry/exit point, while B-2 was located approximately 50 feet north of the western HDD entry/exit point. The locations of these borings are depicted on **Figure 2** and **Figure 3.**

In general, the subsurface profile at the site, as observed in the borings, is described as follows:

- Soil and residual soil depths vary from boring to boring; 20.0 feet at SB-01, 70.0 feet at SB-02, 28.8 feet at SB-03, 18.0 feet at B-1 and 30.0 feet in B-2. The residual soils are described as follows:
    - **Boring SB-01**: Topsoil, fine to medium SAND (SM), trace conglomerate, with little silt. Unweathered gravel was observed between 13.0 and 18.0 feet bgs. Auger refusal occurred at 20 feet bgs. Groundwater was not encountered.
    - **Boring SB-02**: Topsoil, mottled fine to medium SAND (SM) with little silt, little fine to coarse gravel, fine to medium SAND (SM) with little to some silt, with little conglomerate matrix, trace fine quartz gravel, with little fine to coarse sandstone gravel, fine to coarse SAND with some fine to coarse GRAVEL (SM/GM), with little to some silt, with little conglomerate gravel. Partially weathered conglomerate and SILTSTONE was encountered between 70.0 to 70.1 feet bgs. Auger refusal occurred at 70.0 feet bgs. Groundwater was encountered at 6.0 feet bgs.
    - **Boring SB-03**: Topsoil, silty CLAY (CL) with some to little fine sand, trace fine gravel, fine to coarse SAND (SM) with little silt and clayey silt, with little fine to coarse gravel, trace gravel. Augers were advanced to a total depth of 30 feet bgs. Groundwater was observed at 4 feet bgs.
    - **Boring B-1**: soft, SILT (ML) with sand, moist, medium dense clayey SAND (SC), trace gravel, moist, dense silty SAND (SM), moist, highly weathered SANDSTONE sampled as very dense silty SAND (SM), trace clay inclusions. Groundwater was encountered at 12.0 feet bgs.
    - **Boring B-2:** very loose silty SAND (SM), moist, very dense silty SAND (SM) with gravel, moist, highly weathered SANDSTONE sampled as very dense silty SAND (SM), moist, with trace gravel (20 to 20.3 feet bgs), highly weathered SANDSTONE sampled as very dense, poorly graded SAND with silt, trace gravel, wet. Groundwater was encountered at 5.2 feet bgs.

- At depths of auger or split-spoon refusal, and to the total depth of the NQ cores, weathered bedrock and bedrock were encountered and are described as follows:
    - **Boring B-1:** B-1 was completed to a total depth of 150.0 feet bgs.
        - From 18 to 36 feet bgs, dark red-brown to dark gray-brown, fine- to coarse-grained, slightly to highly weathered, very broken to massive, moderately hard to hard, SANDSTONE with vugs, multiple soil layers and trace pits was encountered. Rock recoveries ranged from 17% to 77%, while rock quality designations (RQDs) were very poor (0-18).
        - From 36 to 42.5 feet bgs, light gray-brown to dark brown, fine- to very coarse-grained, weathered to slightly weathered, very broken to massive, hard conglomeratic SANDSTONE with trace pits and vugs was encountered. Rock recovery was 100% and the RQD value was good (87).
        - From 42.5 to 47 feet bgs, light gray to dark brown, medium- to very coarse-grained, weathered, slightly broken to massive hard, CONGLOMERATE was encountered. A highly weathered zone with low recovery consistent with gravel-size rock fragments was encountered between 42.5 to 46 feet bgs. Rock recovery was 43% and the RQD value was poor (27).
        - From 47 to 58.5 feet bgs, gray-brown to dark brown, fine- to coarse-grained, weathered to slightly weathered, very broken to massive, moderately hard to hard, SANDSTONE with trace pits and vugs was encountered. A highly weathered zone with low recovery consistent with gravel-size rock fragments was encountered between 49.5 to 51.5 feet bgs. Rock recoveries ranged from 68% to 83% and the RQD values ranged from very poor (17) to fair (63).
        - From 58.5 to 79.5 feet bgs, gray-brown to dark brown, fine- to very coarse-grained, slightly to highly weathered, very broken to massive, hard, conglomeratic SANDSTONE with trace pits and vugs was encountered. A highly weathered seam (approximately 2.75-inches thick) was observed at 79.3 feet bgs. Rock recoveries ranged from 50% to 100% and RQDs ranged from very poor (0) to good (82).
        - From 79.5 to 87 feet bgs, alternating red-brown to dark red-brown, very fine- grained, slightly weathered, massive, moderately hard, SILTSTONE and dark red-brown to dark brown, fine- to medium-grained, slightly weathered, broken to massive, hard to very hard, SANDSTONE layers were encountered. Diagonal fractures were observed between 86.3 to 86.5 feet bgs. Rock recoveries ranged from 95% to 100% while RQDs ranged from fair (72) to good (84).
        - From 87 to 95.5 feet bgs, light gray to red-gray-brown, fine- to very coarse-grained, slightly weathered, broken to massive, hard to very hard conglomeratic SANDSTONE was encountered. A siltstone layer was observed between 87 and 87.7 feet bgs. Rock recoveries were 100% and RQD values ranged from fair (65) to good (80).
        - From 95.5 to 103 feet bgs, light gray-brown to dark red-brown, fine- to very coarse-grained, slightly weathered, broken to massive, moderately hard to very hard SANDSTONE was encountered. A conglomeratic sandstone interval (approximately 11 inches thick) was observed at 101.9 feet bgs. Rock recovery was 100% and the RQD value was good (78).
        - From 103 to 112.5 feet bgs, dark gray-brown to gray brown, fine- to very coarse-grained, weathered to slightly weathered, very broken to massive, hard to very hard

conglomeratic SANDSTONE was encountered. An approximately 3.25-inch thick highly weathered interval was observed at 107.3 feet bgs. Rock recovery was 100% and RQD values ranged from very poor (16) to fair (58).

- From 112.5 to 114 feet bgs, light gray to dark gray-brown, medium- to very coarse-grained, slightly weathered, broken to massive, hard, CONGLOMERATE was encountered.
- From 114 to 119 feet bgs, dark red-brown to dark brown, very fine-grained, weathered to highly weathered, very broken to massive, moderately hard SHALE was encountered. Rock recovery was 100% and the RQD value was fair (55).
- From 119 to 122 feet bgs, brown to dark brown, fine- to medium-grained, weathered to slightly weathered, broken to massive, hard SANDSTONE was encountered. Rock recovery was 100% and the RQD value was very poor (24).
- From 122 to 123.5 feet bgs, light gray to dark brown, fine- to very coarse-grained, slightly weathered, broken to massive, CONGLOMERATE with trace pits and vugs was encountered.
- From 123.5 to 139 feet bgs, light gray-brown to dark brown, medium- to very coarse-grained, slightly weathered, very broken to massive, hard conglomeratic SANDSTONE was encountered. An approximately 7.25-inch thick sandstone layer was observed at 135.8 feet bgs and nearly vertical fractures were observed between 138.2 to 138.7 feet bgs. Rock recovery was 100% and the RQD values ranged from fair (68) to excellent (90).
- From 139 to 144 feet bgs, dark brown to dark red-brown, very fine-grained, weathered, to slightly weathered, very broken to massive, moderately hard, SILTSTONE was encountered. Rock recovery was 85% and the RQD value was poor (45).
- From 144 to 150 feet bgs, light gray to dark brown, fine- to coarse-grained, slightly weathered, broken to massive, hard to very hard SANDSTONE was encountered. Rock recovery was 100% and the RQD values ranged from fair (74) to good (76).

o **Boring B-2:** B-2 was completed to a depth of 135.0 feet bgs.

- From 30 to 60.5 feet bgs, light gray-brown to brown, medium- to coarse-grained, slightly weathered to highly weathered, very broken to massive, moderately hard SANDSTONE was encountered. Highly weathered/completely weathered SANDSTONE was observed between 36.5 to 41.5 and 46.5 to 60.5 feet bgs resulting in either low or no recovery from the rock cores. Rock recoveries ranged from 0% to 93% and the RQD values ranged from very poor (0) to fair (60).
- From 60.5 to 62.5 feet bgs, gray-brown to dark brown, fine- to coarse-grained, weathered, broken to slightly broken, moderately hard conglomeratic SANDSTONE was encountered.
- From 62.5 to 66.5 feet bgs, dark brown to dark gray-brown, medium- to very coarse-grained, weathered to highly weathered, very broken to slightly broken, moderately hard to hard, CONGLOMERATE with trace pits and vugs, and multiple soil layers was encountered. Rock recovery was 58% and the RQD value was very poor (16).
- From 66.5 to 76.5 feet bgs, gray-brown to dark brown, fine-grained, slightly weathered to highly weathered, very broken to massive, moderately hard

SANDSTONE with multiple soil layers. Rock recovery ranged from 28% to 100% and the RQD values ranged from very poor (8) to good (82).

- From 76.5 to 106.5 feet bgs, gray-brown to dark brown, fine- to very coarse-grained, slightly weathered to highly weathered, very broken to massive, moderately hard to hard, conglomeratic SANDSTONE with trace pits and vugs. An approximately 6.5-inch thick highly weathered interval was observed at 91 feet bgs. Rock recoveries ranged from 34% to 100% and the RQD values ranged from very poor (12) to excellent (90).
- From 106.5 to 113 feet bgs, dark brown to gray-brown, fine-grained, slightly weathered, broken to massive, moderately hard to hard SANDSTONE was encountered. A broken seam, approximately 2-inches thick, was observed at 106.5 feet bgs, while an approximately 7.5-inch thick highly weathered interval was observed at 110.9 feet bgs. Rock recovery was 100% and the RQD value was fair (70).
- From 113 to 115 feet bgs, brown to dark brown, fine to very coarse grained, weathered, very broken to massive, moderately hard to hard, conglomeratic SANDSTONE with trace pits and vugs was encountered. Rock recovery was 100% and the RQD value was poor (34).
- From 115 to 116.5 feet bgs, gray-brown to dark gray-brown, fine- to medium- grained, weathered, very broken to slightly broken, moderately hard to hard, SANDSTONE was encountered.
- From 116.5 to 123.5 feet a highly weathered to completely weathered conglomeratic SANDSTONE was encountered. Rock recovery was 16% and the RQD value was very poor (0).
- From 123.5 to 135 feet bgs, gray-brown to dark brown, medium- to coarse grained, weathered to slightly weathered, broken to massive, moderately hard SANDSTONE was encountered. Nearly vertical fractures were observed between 165.5 to 127.1 feet bgs. Rock recoveries ranged from 68% to 100%, while RQD values ranged from poor (42) to excellent (90).

Please note that RETTEW nor Skelly and Loy did not oversee or direct the geotechnical drilling program associated with HDD S30110, including but not limited to, the selection of boring locations and target depths, observations of rock cores during drilling operations, or preparation of boring logs. The geotechnical reports, boring logs, and core photographs that resulted from these programs were generated by other Sunoco Pipeline, LP contractors. RETTEW and Skelly and Loy relied on these reports and incorporated the data into the general geologic and hydrogeologic framework included in this report.

6.0 GEOPHYSICS INVESTIGATION

RETTEW completed a multi-technique geophysical survey at the site on January 16, 2019. The purpose of the survey was to detect and delineate subsurface fracture zones that could contribute to potential inadvertent returns (IRs) and/or a loss of returns, and to determine the rock profile and rock rippability for ease-of-excavation along the HDD path.

Two different geophysical techniques were utilized to detect and delineate subsurface features and provide a bedrock profile. These methods, and their general results are as follows:

- Seismic refraction and Multi-Spectral Analysis of Surface Waves results confirmed the presence of low-velocity zones within the bedrock that could represent fracture zones

- Electrical resistivity imaging identified a conductive surface layer over a discontinuous resistive layer, with the discontinuities possibly suggesting the presence of fracture zones.

Results from the geophysical techniques are consistent with each other, and with the geology as mapped by the PA Geological Survey; all suggesting that the local bedrock is mildly fractured, with a few potential anomalous zones of concern. The top-of-rock is expected to be slightly irregular with a weathered zone above competent rock and potential residual clay- or soil-filled fractures within the bedrock formation.

7.0 FIELD OBSERVATIONS DURING 20-INCH HDD ACTIVITIES

RETTEW staff were on-site during the HDD activities for the 20-inch pipeline. The pilot drilling was initiated by Laney Directional Drilling (Laney) on June 15, 2017. On June 23, 2017, an IR occurred within an upland area and approximately 28 feet below ground surface. Laney immediately ceased drilling operations while containment and recovery efforts were implemented. Laney placed silt fence around the IR location and two recovery sumps were used for the collection and recovery of drilling fluid from within the containment structure. Approximately 1,000 gallons of drilling fluid was recovered by Laney. No Waters of the Commonwealth were impacted by the IR. Laney resumed advancement of the pilot bit on June 24, 2017, when a second IR occurred near the eastern entry/exit point. The occurrence of IRs near an HDD entry or exit point, as the drill bit enters or exits bedrock and traverses through overburden, is not uncommon. Approximately 25 gallons of drilling fluids were released to the ground surface within an upland area. Drilling activities were immediately stopped, and recovery efforts were initiated by constructing a hay bale and silt fence containment structure around the IR and recovering the drilling fluid using a vacuum truck. Following completion of containment and recovery efforts, Laney resumed drilling and the pilot hole was completed on June 24, 2017. No additional IRs were observed during the reaming and swabbing operations and the 20-inch product pipe was successfully pulled through on August 23, 2017.

A field investigation was performed by RETTEW staff on January 28, 2019, to identify rock outcrops for fracture fabric analysis, evaluation and ground-truthing of fracture traces identified during the desktop exercise, and to identify potential sensitive receptors to IRs. No readily accessible bedrock outcrops were observed. No additional sensitive receptors to IRs beyond the previously mapped streams and wetlands were identified during January 2019 site reconnaissance.

8.0 CONCEPTUAL HYDROGEOLOGIC MODEL AND CONCLUSION

Based on published geologic and hydrogeologic information, results of the geotechnical investigations, and field observations during completion of the 20-inch HDD, the T307 & Creek S-C86 HDD location is underlain by clastic sedimentary rocks of the Hammer Creek Formation and Hammer Creek Conglomerate. The hydrogeologic setting is dominated by groundwater flow through secondary openings along geologic features including bedding planes, joints, faults, and fractures. This is supported by the observation of weathering, fractures, and joints in the geotechnical cores. Well records and published hydrogeological reports indicate that the median depth of water-bearing zones in the Hammer Creek Formation ranges from 14 to 85 feet bgs with well yields of approximately 90-150 gallons per minute (Wood, 1980).

The originally designed 16-inch HDD profile was relatively shallow and was designed to be advanced through unconsolidated overburden and fractured bedrock. Based on the hydro-structural characteristics of the underlying geology described in this report and geologic information obtained during the completion of the 20-inch HDD, the T307 & Creek S-C86 HDD is susceptible to and IR of drilling fluids

during HDD operations. As a result, the 16-inch HDD profile was redesigned and lengthened to the east by approximately 150 feet. Lengthening of the proposed HDD profile will provide additional protective cover near the eastern end of the proposed HDD profile where two IRs occurred during the 20-inch HDD operations. From a geologic perspective, the longer profile, in conjunction with the proposed proactive engineering controls and/or drilling best management practice (BMPs), will be used to reduce the risk of an IR and/or a loss of drilling fluids. Drilling BMPs are described in the Horizontal Directional Drill Analysis component of the overall re-evaluation package.

9.0 REFERENCES

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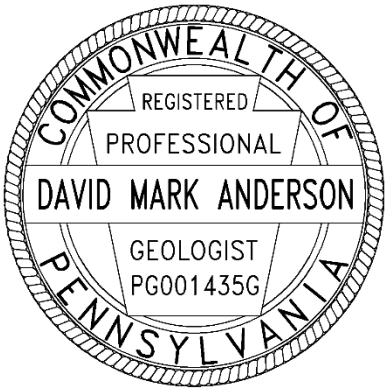
9.0 CERTIFICATION

The studies and evaluations presented in this report (other than Section 5.0) were completed under the direction of a licensed professional geologist (PG) and are covered under the PG seals that follow.

By affixing my seal to this document, I am certifying that, to my knowledge and belief, the information herein is true and correct. I further certify, that I am licensed to practice in the Commonwealth of Pennsylvania and that it is within my professional expertise to verify the correctness of the information herein.

Douglas J. Hess, PG
License No. PG000186G



David M. Anderson, PG
License No. PG001435G

Enclosures

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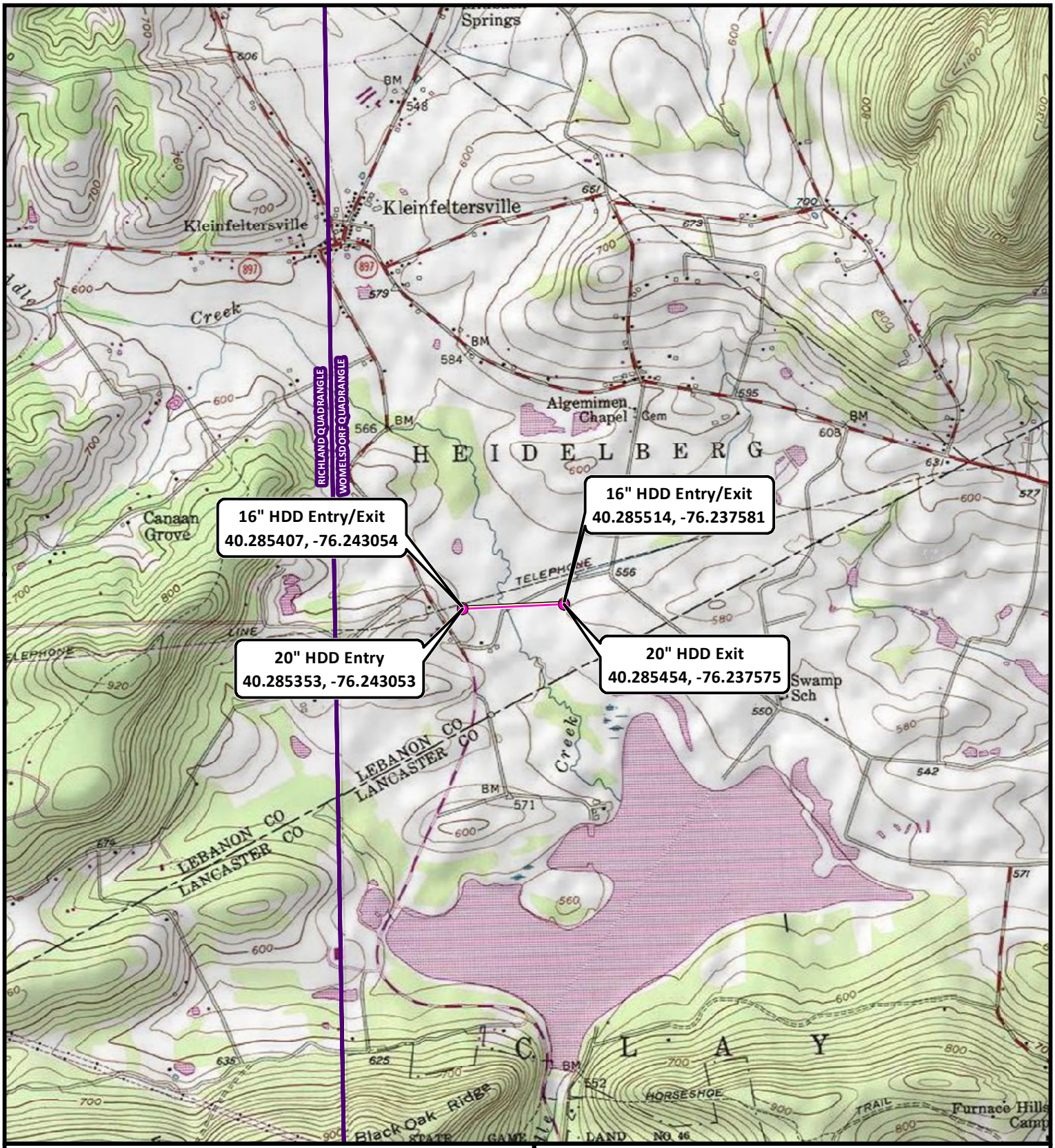
FIGURES



16" HDD Entry/Exit

20" HDD Entry/Exit

16" HDD Profile

20" HDD Profile

Womelsdorf, PA USGS 7.5' Topographic Quadrangle 2/7/2019

Sunoco Pipeline, L.P.

T-307 & Creek S-C86 HDD Location

Figure 1 - Topographic Basemap

Heidelberg Township, Lebanon County, PA

Project No. 096302011

N W E S

0 2,000 Feet

1 inch = 2,000 feet

Sunoco Logistics Partners L.P.

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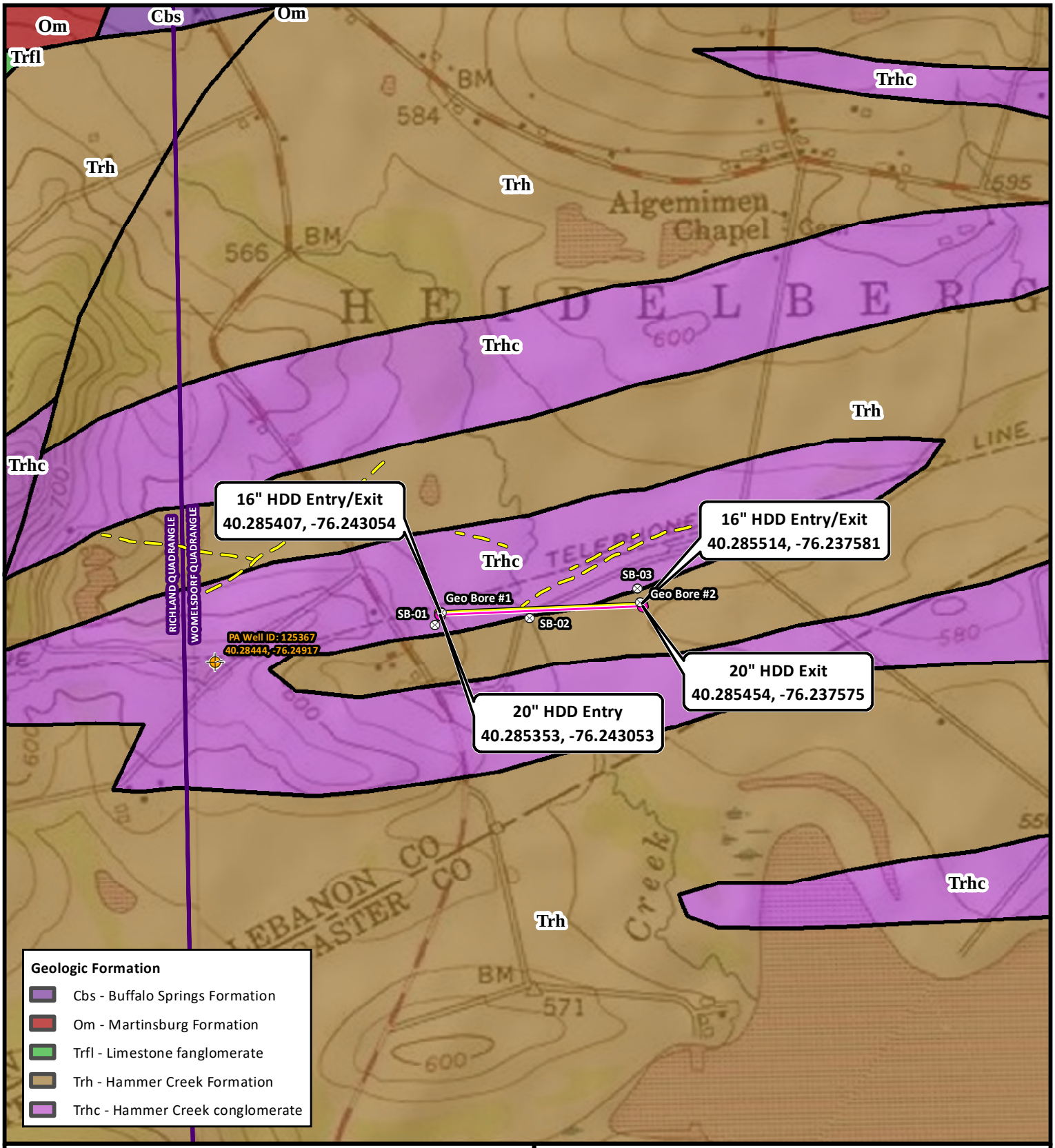

Sunoco Pipeline, L.P.

T-307 & Creek S-C86 HDD Location

Figure 2 - Geologic Map

Heidelberg Township, Lebanon County, PA

Project No. 096302011

0 1,000 Feet

1 inch = 1,000 feet

Service Layer Credits: Copyright:© 2013 National Geographic Society, i-cubed

Sunoco Logistics Partners L.P.

Womelsdorf, PA USGS 7.5' Topographic Quadrangle 2/7/2019

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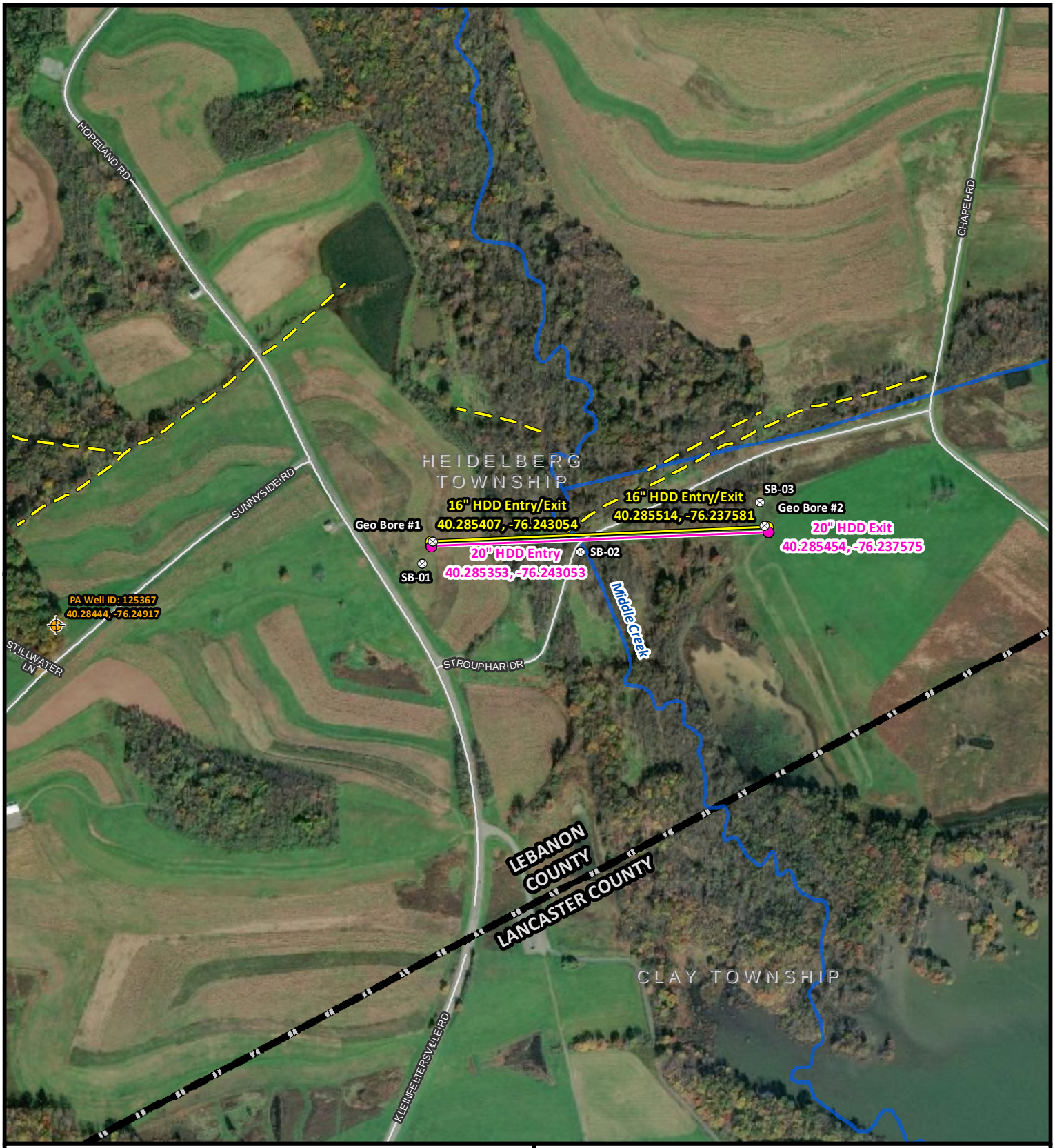

Residential Well
Boring Location
16" HDD Entry/Exit
20" HDD Entry/Exit
16" HDD Profile
20" HDD Profile
Inferred Fracture Trace
Road
NHD Stream
Municipal Boundary
County Boundary

2/7/2019

Sunoco Pipeline, L.P.

T-307 & Creek S-C86 HDD Location

Figure 3 - Aerial Basemap

Heidelberg Township, Lebanon County, PA

Project No. 096302011

N
W E
S

0 600 Feet

1 inch = 600 feet

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Sunoco Logistics Partners L.P.

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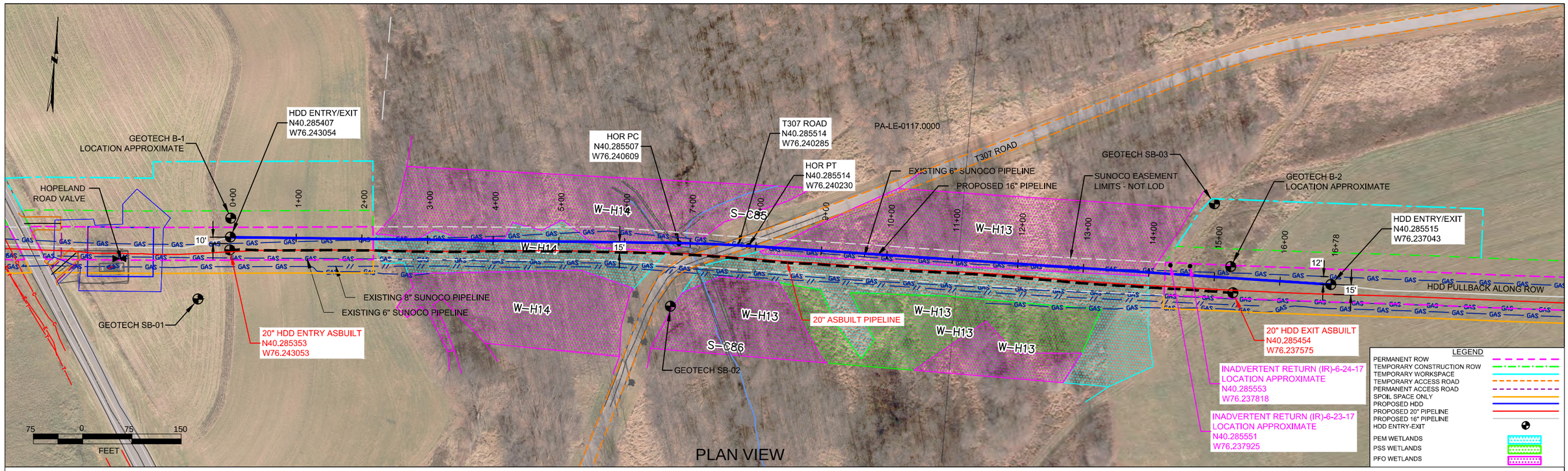
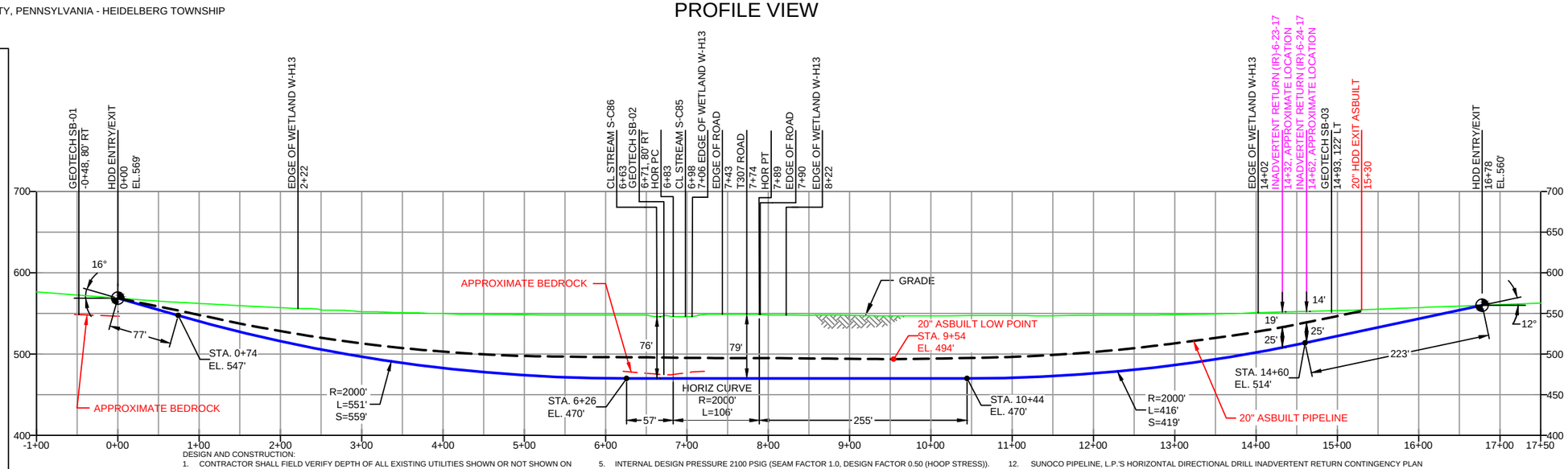
ATTACHMENT 1
HDD PROFILES AND GEOTECHNICAL BORING LOGS



PLAN VIEW

LEBANON/LANCASTER COUNTY, PENNSYLVANIA - HEIDELBERG TOWNSHIP
S3-0110-16

PROFILE VIEW



DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 1678'
   HDD PIPE LENGTH (S=): 1696'
   16" x 0.438" W.T., X-70, APISL, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 2100 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 2625 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

GEOTECH SB-01
- NG EL. 573'
- -TOPSOIL (0.0' -0.7')
- -SM (0.7' - 20.0')
- -SANDSTONE (20.0' - 20.2')
- -COMPLETION DEPTH EL. 553'

GEOTECH SB-02
- NG EL. 548'
- -TOPSOIL (0.0' -0.5')
- -SM (0.5' - 13.7')
- -GROUNDWATER (6.0')
- -SM / GM (13.7' - 70.0')
- -SILT STONE (70.0' - 70.1')
- -COMPLETION DEPTH EL. 478'

GEOTECH SB-03
- NG EL. 552'
- -TOPSOIL (0.0' -0.7')
- -CL (0.7' - 13.5')
- -GROUNDWATER (16.0')
- -SM (13.5' - 30.0')
- -COMPLETION DEPTH EL. 522'

NOTE: REFER TO TEST BORING LOG S3-0110 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-1
- NG EL. 568'
- -RESIDIUM-SILT W/ SAND ML (0.0' - 6.0')
- -RESIDIUM-CLAYEY SAND SC (6.0' - 8.5')
- -GROUNDWATER (12.2')
- -RESIDIUM-SILTY SAND SM (8.5' - 13.5')
- -SANDSTONE/SILTSTONE (13.5' - 150.0')
- -BORING TERMINATED EL.418'

NOTE: REFER TO TEST BORING LOG B-1 INTERTEK PROJECT #04911459 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-2
- NG EL. 554'
- -GROUNDWATER (3.4')
- -RESIDIUM-SILTY SAND SM (0.0' - 8.5')
- -WEATHERED SANDSTONE/ SILTY SAND SM (8.5' - 22.5')
- -WEATHERED SANDSTONE/ SAND W/ SILT SP-SM (22.5' - 27.5')
- -SANDSTONE (27.5' - 135.0')
- -BORING TERMINATED EL.419'

NOTE: REFER TO TEST BORING LOG B-2 INTERTEK PROJECT #04911459 FOR COMPLETE SOIL MATERIAL DESCRIPTION

NOTES

1. ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
2. STATIONING IS BASED ON HORIZONTAL DISTANCES.
3. ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, LP ARE NOT RESPONSIBLE FOR LOCATION OF FOREIGN UTILITIES SHOWN IN PLOT PLAN OR PROFILE. THE INFORMATION SHOWN HEREON IS FURNISHED WITHOUT LIABILITY ON THE PART OF ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, LP, FOR ANY DAMAGES RESULTING FROM ERRORS OR OMISSIONS THEREIN.
4. CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.
5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING

ES-5.66	TO	ES-5.67	EROSION & SEDIMENT PLAN
SHEET 38	TO	SHEET 38	AERIAL SITE PLAN
DWG NO		DWG NO	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP5	ADDED IR INFORMATION	MRS	02/15/19	RMB	02/15/19	AMC	02/15/19
EP4	DESIGN CHANGE - EXTENDED DRILL 150' AND ADDED GEOTECH INFORMATION	MRS	12/07/18	RMB	12/07/18	JAL	12/07/18
EP3	UPDATED TO MATCH 16" IFC DESIGN AND NOTE 5 AND 10 PER INCREASED 16" MOP	MRS	05/10/18	RMB	05/10/18	AMC	05/10/18
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	10/07/16	RMB	10/07/16	AAW	10/07/16
EP1	REVISED PER PADEP COMMENTS	JTW	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
CREEK & T307
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'

DWG. NO: PA-LE-0117.0000-WX-16

LEGEND:

Geotechnical Soil Boring (SB) Locations

TETRA TECH

GEOTECHNICAL BORING LOCATIONS
HDD S3-0110
LEBANON COUNTY, SOUTH HEIDELBERG TOWNSHIP, PA
SUNOCO PENNSYLVANIA PIPELINE PROJECT

TETRA TECH
240 Continental Drive, Suite 200
Newark, Delaware 19713
302.738.7551
fax: 302.454.5988

TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	HOPELAND ROAD, MIDDLECREEK WILDLIFE MANAGEMENT AREA, NEWMANSTOWN, PA		Page 1 of 1
HDD No.:	S3-0110	Dates(s) Drilled: 12-14-14	Inspector: E. WATT
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 20.2
Boring Location Coordinates:		40° 17' 6.502" N	76° 14' 35.550" W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.7			TOPSOIL (8")					
1	3.0	5.0	0.7		24	SM	REDDISH BROWN FINE TO MEDIUM SAND, TRACE CONGLOMERATE,	6	29	42	50	**71**
							WITH A LITTLE SILT.					
2	8.0	9.4			14		REDDISH BROWN FINE TO MEDIUM SAND, TRACE CONGLOMERATE,	6	45	50/5"		**>50**
							WITH SOME SILT.					
3	13.0	13.7			8		REDDISH BROWN FINE TO MEDIUM SAND, TRACE CONGLOMERATE,	8	50/2"			**>50**
							WITH SOME SILT, TRACE UNWEATHERED GRAVEL.					
4	18.0	18.6			6		REDDISH BROWN FINE TO MEDIUM SAND, TRACE CONGLOMERATE,	10	50/1"			**>50**
				20.0			WITH SOME SILT, TRACE UNWEATHERED GRAVEL.					
5	20.0	20.2	20.0	20.2	2		PARTIALLY WEATHERED SANDSTONE GRAVEL.	50/2"				
							AUGER REFUSAL AT 20.0'. OFFSET BORING AND AUGUERED TO					
							REFUSAL AT 19.1'.					
							CAVED AND DRY AT 18'.					

Notes/Comments:
Pocket Pentrometer Testing

DR: DECOMPOSED ROCK

Strata (USCS) Designations are approximated based on visual review, except where indicated in Description of Materials.

* Number of blows of 140 lb. Hammer dropped 30 in. required to drive 2 in. split-spoon sampler in 6 in. increments.
N: Number of blows to drive spoon from 6" to 18" interval.

TETRA TECH
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Newark, Delaware 19713
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TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	MIDDLECREEK WILDLIFE MANAGEMENT AREA, NEWMANSTOWN, PA		Page 1 of 1
HDD No.:	S3-0110	Dates(s) Drilled: 11-21 & 12-15-14	Inspector: E. WATT
Boring No.:	SB-02	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 6.0	Total Depth (ft): 70.1
Boring Location Coordinates:		40° 17' 6.866" N	76° 14' 26.278" W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.5			TOPSOIL (6")					
1	3.0	5.0	0.5		16		MOTTLED (GRAY, GREENISH GRAY, LIGHT BROWN) FINE TO MEDIUM	2	7	11	11	**18**
						SM	SAND WITH A LITTLE SILT, A LITTLE F-C GRAVEL.					
2	8.0	10.0			13		BROWN, YELLOW BROWN AND REDDISH BROWN MEDIUM TO COARSE	1	6	14	22	**20**
				13.7			SAND WITH A LITTLE SILT, LITTLE F-C GRAVEL.					
3	13.0	15.0	13.7		22		MAROON FINE TO MEDIUM SAND WITH A LITTLE SILT, TRACE	6	17	25	28	**42**
							FINE QUARTZ GRAVEL.					
4	18.0	18.8			8		MAROON FINE TO MEDIUM SAND WITH SOME SILT WITH A	24	50/4"			**>50**
							LITTLE CONGLOMERATE MATRIX.					
5	23.0	23.6			6		MAROON FINE TO MEDIUM SAND WITH SOME SILT WITH A	20	50/1"			**>50**
							LITTLE CONGLOMERATE MATRIX.					
6	28.0	28.8			7		MAROON FINE TO MEDIUM SAND WITH SOME SILT WITH A	34	50/4"			**>50**
							LITTLE CONGLOMERATE MATRIX.					
7	33.0	33.7			7		MAROON FINE TO MEDIUM SAND WITH SOME SILT WITH A	27	50/2"			**>50**
						SM	LITTLE CONGLOMERATE MATRIX.					
8	38.0	38.7			7		MAROON FINE TO MEDIUM SAND WITH SOME SILT WITH A	7	50/2"			**>50**
							LITTLE CONGLOMERATE MATRIX.					
9	43.0	43.8			6		MAROON FINE TO MEDIUM SAND WITH SOME SILT WITH A	20	50/3"			**>50**
							LITTLE CONGLOMERATE MATRIX.					
10	48.0	48.7			6		MAROON FINE TO MEDIUM SAND WITH SOME SILT WITH A	33	50/2"			**>50**
							LITTLE CONGLOMERATE MATRIX.					
11	53.0	53.4			5		MAROON FINE TO MEDIUM SAND WITH SOME SILT, WITH A	50/5"				**>50**
							LITTLE FINE TO COARSE SANDSTONE GRAVEL.					
12	58.0	58.3			3		REDDISH BROWN MEDIUM TO COARSE SAND WITH SOME FINE TO	50/4"				
							COARSE GRAVEL, WITH A LITTLE SILT.					
13	63.0	63.4			5	SM/	REDDISH BROWN MEDIUM TO COARSE SAND, SOME FINE TO COARSE	50/5"				
						GM	GRAVEL, SOME SILT.					
14	68.0	68.4			5		LIGHT REDDISH BROWN FINE TO MEDIUM SAND, WITH A LITTLE	50/5"				
				70.0			CONGLOMERATE GRAVEL.					
15	70.0	70.1	70.0				PARTIALLY WEATHERED REDDISH BROWN CONGLOMERATE AND	50/1"				
				70.1			GRAY SILTSTONE.					
							AUGUR REFUSAL AT 70'.					
							WET ON SPOON AT 7'. WATER LEVEL THROUGH AUGERS AT 6'					
							CAVED AT 30'					

Notes/Comments:

Pocket Pentrometer Testing

DR: DECOMPOSED ROCK

DRILL RIG BROKED DOWN AT 55'. REMOBILIZED TO CONTINUE DRILLING ON 12/15/14.

Strata (USCS) Designations are approximated based on visual review, except where indicated in Description of Materials.

* Number of blows of 140 lb. Hammer dropped 30 in. required to drive 2 in. split-spoon sampler in 6 in. increments.
N: Number of blows to drive spoon from 6" to 18" interval.

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TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	MIDDLECREEK WILDLIFE MANAGEMENT AREA, NEWMANSTOWN, PA		Page 1 of 1
HDD No.:	S3-0110	Dates(s) Drilled: 12-14-14	Inspector: E. WATT
Boring No.:	SB-03	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): SEE BELOW	Total Depth (ft): 30.0
Boring Location Coordinates:		40° 17' 8.951" N	76° 14' 15.746" W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.7			TOPSOIL (8")					
1	3.0	5.0	0.7		15	CL	REDDISH BROWN SILTY CLAY WITH SOME FINE SAND, TRACE	1	4	10	12	**14**
							FINE GRAVEL.					
2	8.0	10.0			14		REDDISH BROWN SILTY CLAY WITH A LITTLE FINE SAND, TRACE	3	11	13	16	**24**
				13.5			FINE GRAVEL (USCS: CL).					
3	13.0	13.9	13.5		9	SM	REDDISH BROWN MEDIUM TO COARSE SAND WITH A LITTLE SILT,	8	50/5"			**>50**
							WITH A LITTLE FINE TO COARSE GRAVEL.					
4	18.0	18.8			8		REDDISH BROWN MEDIUM TO COARSE SAND AND CLAYEY SILT,	3	50/4"			**>50**
							WITH A LITTLE FINE TO COARSE GRAVEL. (USCS: SM)					
5	23.0	24.4			16		REDDISH BROWN FINE TO COARSE SAND WITH A LITTLE SILT, TRACE	12	42	50/5"		**>50**
							FINE GRAVEL.					
6	28.0	28.8			7		REDDISH BROWN FINE TO MEDIUM SILTY SAND, TRACE FINE GRAVEL,	7	50/3"			**>50**
				30.0			(WEATHERED ROCK IN TIP).					
							AUGURED TO 30'.					
							MOIST RETURN AT 15' AND 18'.					
							WET ON SPOON AT 16".					
							WATER LEVEL THROUGH AUGERS AT 4'.					
							CAVED AT 26.5'. WATER LEVEL ON CAVE AT 4'.					

Notes/Comments:

Pocket Pentrometer Testing

DR: DECOMPOSED ROCK

Strata (USCS) Designations are approximated based on visual review, except where indicated in Description of Materials.

* Number of blows of 140 lb. Hammer dropped 30 in. required to drive 2 in. split-spoon sampler in 6 in. increments.
N: Number of blows to drive spoon from 6" to 18" interval.

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0110

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.) From	Depth of Sample (ft.) To	Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318) Liquid Limit, %	Atterburg Limits (ASTM D4318) Plastic Limit, %	Atterburg Limits (ASTM D4318) Plasticity Index, %	USCS Classif. (ASTM D2487)
S3-0110	SB-01	1	3.0	5.0	6.9	16.4	-	-	-	-
		2	8.0	9.4	8.6	29.5	-	-	-	-
		3	13.0	13.7	7.9	28.3	-	-	-	-
		4	18.0	18.6	6.1	32.2	32	24	8	SM
		5	20.0	20.2	6.8	31.2	-	-	-	-
	SB-02	2	8.0	10.0	11.8	14.9	-	-	-	-
		4	18.0	18.8	12.4	21.0	-	-	-	-
		6	28.0	28.8	11.4	27.2	-	-	-	-
		8	38.0	38.7	12.8	20.7	-	-	-	-
		11	53.0	53.4	9.7	28.7	-	-	-	-
		13	63.0	63.4	14.4	29.2	-	-	-	-
		14	68.0	68.4	3.4	43.3	-	-	-	-
	SB-03	2	8.0	10.0	13.0	82.4	28	20	8	CL
		3	13.0	13.9	6.7	20.6	-	-	-	-
		4	18.0	18.8	11.0	47.5	33	25	8	SM
		5	23.0	24.4	17.2	12.1	-	-	-	-
		6	28.0	28.8	10.5	36.9	-	-	-	-

Notes:

1) Sample depths based on feet below grade at time of exploration.

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0110

HDD No.	NAME	BORING NO.	REGIONAL GEOLOGY DESCRIPTION	GENERAL TOPOGRAPHIC SETTING	BEDROCK FORMATION	GENERAL ROCK TYPE	APPROX MAX FM THICKNESS (FT)	DEPTH TO ROCK (Ft bgs) based on nearby well drilling logs	NOTES / COMMENTS
S3-0110	Wetland H14 - T307	SB-01	**Hammer Creek Formation** - Gray and pale red, fine- to coarse-grained quartzose sandstone, siltstone, and mudstone	Lowland, wetlands area	Hammer Creek Fm	sandstone with quartz pebble conglomerate	9,360	32-71	
		SB-02	**Hammer Creek Conglomerate** - very coarse quartz conglomerate having abundant pebbles and cobbles of gray quartzite.		Hammer Creek Conglomerate	quartz conglomerate; reddish brown cross-bedded sandstone	2,580		
		SB-03	**Hammer Creek Formation** - Gray and pale red, fine- to coarse-grained quartzose sandstone, siltstone, and mudstone		Hammer Creek Fm	sandstone with quartz pebble conglomerate	9,360		

Note : Source of well log data - http://www.dcnr.state.pa.us/topogeo/groundwater/pagwis/records/index.htm. All other sources as referenced in comments section.

FIELD DESCRIPTION AND LOGGING SYSTEM FOR SOIL EXPLORATION

GRANULAR SOILS

(Sand, Gravel & Combinations)

Density	***N (blows)****
Very Loose	5 or less
Loose	6 to 10
Medium Dense	11 to 30
Dense	31to 50
Very Dense	51 or more

Relative Proportions

Description Term	*Percent*
Trace	1 - 10
Little	11 - 20
Some	21 - 35
And	36 - 50

Particle Size Identification

Boulders	8 in. diameter or more	
Cobbles	3 to 8 in. diameter	
Gravel	Coarse (C)	3 in. to ¾ in. sieve
	Fine (F)	¾ in. to No. 4 sieve
Sand	Coarse (C)	No. 4 to No. 10 sieve (4.75mm-2.00mm)
	Medium (M)	No. 10 to No. 40 sieve (2.00mm – 0.425mm)
	Fine (F)	No. 40 to No. 200 sieve (0.425 – 0.074mm)
Silt/Clay	Less Than a No. 200 sieve (<0.074mm)	

COHESIVE SOILS

(Silt, Clay & Combinations)

Consistency	***N (blows)****
Very Soft	3 or less
Soft	4 to 5
Medium Stiff	6 to 10
Stiff	11 to 15
Very Stiff	16 to 30
Hard	31 or more

Plasticity

Degree of Plasticity	*Plasticity Index*
None to Slight	0 - 4
Slight	5 - 7
Medium	8- 22
High to Very High	> 22

ROCK

(Rock Cores)

Rock Quality Designation (RQD), %	***Rock Quality Description***
0-25	Very Poor
25-50	Poor
50-75	Fair
75-90	Good
90-100	Excellent

N - Standard Penetration Resistance. Driving a 2.0" O.D., 1-3/8" I.D. sampler a distance of 18 inches into undisturbed soil with a 140 pound hammer free falling a distance of 30.0 inches. The number of hammer blows to drive the sampler through each 6 inch interval is recorded; the number of blows required to drive the sampler through the final 12 inch interval is termed the Standard Penetration Resistance (SPR) N-value. For example, blow counts of 6/8/9 (through three 6-inch intervals) results in an SPR N-value of 17 (8+9).

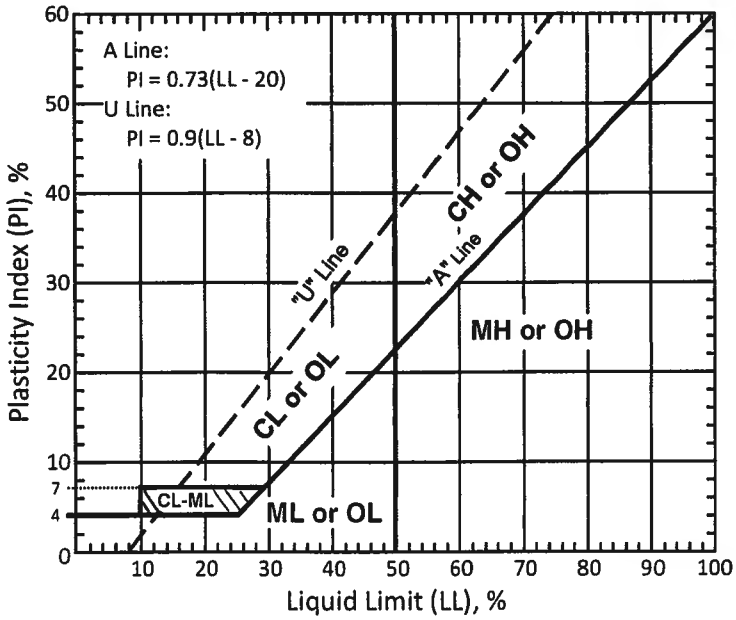
Groundwater observations were made at the times indicated. Groundwater elevations fluctuate throughout a given year, depending on actual field porosity and variations in seasonal and annual precipitation.

UNIFIED SOIL CLASSIFICATION SYSTEM [Casagrande (1948)]

Major Divisions			Group Symbols	Typical Descriptions	Laboratory Classifications		
Coarse Grained Soils (More than half of material is larger than No. 200 sieve)	Gravels More than half of coarse fraction is larger than No. 4 sieve	Clean gravel (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine Percentage of sand and gravel from grain size curve. Depending on Percentage of fines (fraction smaller than No. 200 sieve), coarse-grained soils are classified as follows: Less than 5 percent GW, GP, SW, SP; More than 12 percent GM, GC, SM, SC; 5 to 12 percent Borderline cases requiring dual symbols[1]	$C_u=\frac{D_{60}}{D_{10}}$ greater than 4: $C_c=\frac{(D_{30})2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting C_u or C_c requirements for GW	
		Gravel with fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below A Line or I_p less than 4	Limits plotting in hatched zone with I_p between 4 and 7 are borderline cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits above A line with I_p greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 Sieve)	Clean sands (Little or no fines)	SW	Well graded sands, gravely sands, little or no fines		$C_u=\frac{D_{60}}{D_{10}}$ greater than 6 $C_c=\frac{(D_{30})2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines		Not meeting C_u or C_c requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures		Atterberg limits below A Line or I_p less than 4	Limits Plotting in hatched zone with I_p between 4 and 7 are borderline cases requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits above A line with I_p greater than 7	

Major Divisions		Group Symbols	Typical Descriptions
Fine–grained soils (More than half of material is smaller than No. 200 sieve)	Silts and clays (Liquid limit less than 50)	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays , sandy clays, silty clays, lean clays
		OL	Organic silts and organic silty clays of low plasticity
	Silts and Clays (Liquid limit greater than 50)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity, organic silts
	Highly organic soils	Pt	Peat and other highly organic soils

For soils plotting nearly on A line use dual symbols i.e ., I_p = 29.5, w_L=60 gives CH-MH. When w_L is near 50 use CL-CH or ML-MH. Take near as ± 2 percent.



(1) Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC. well-graded gravel-sand mixture with clay binder.

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AND NATURAL RESOURCES

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Figure 1: Site Vicinity Map

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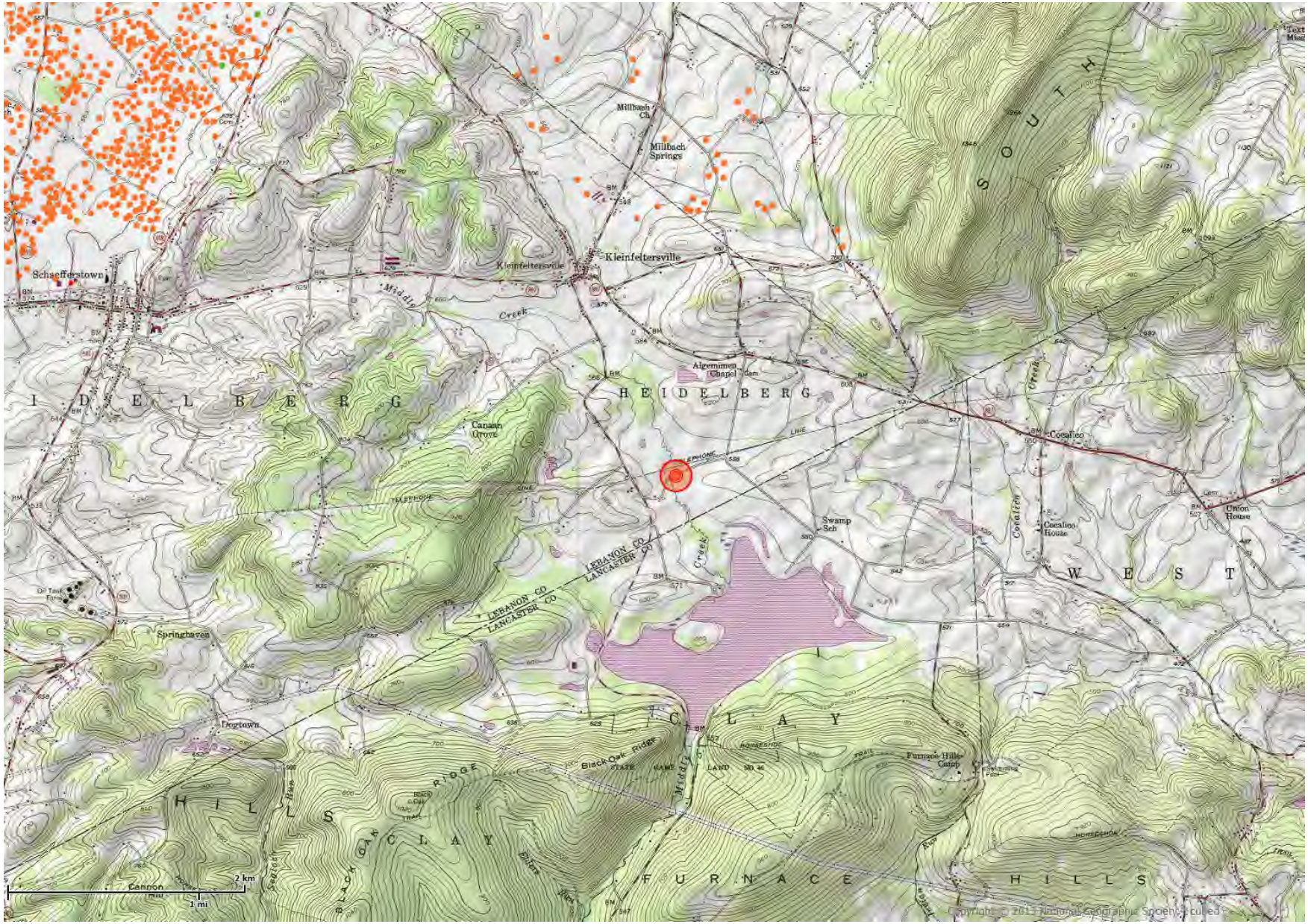


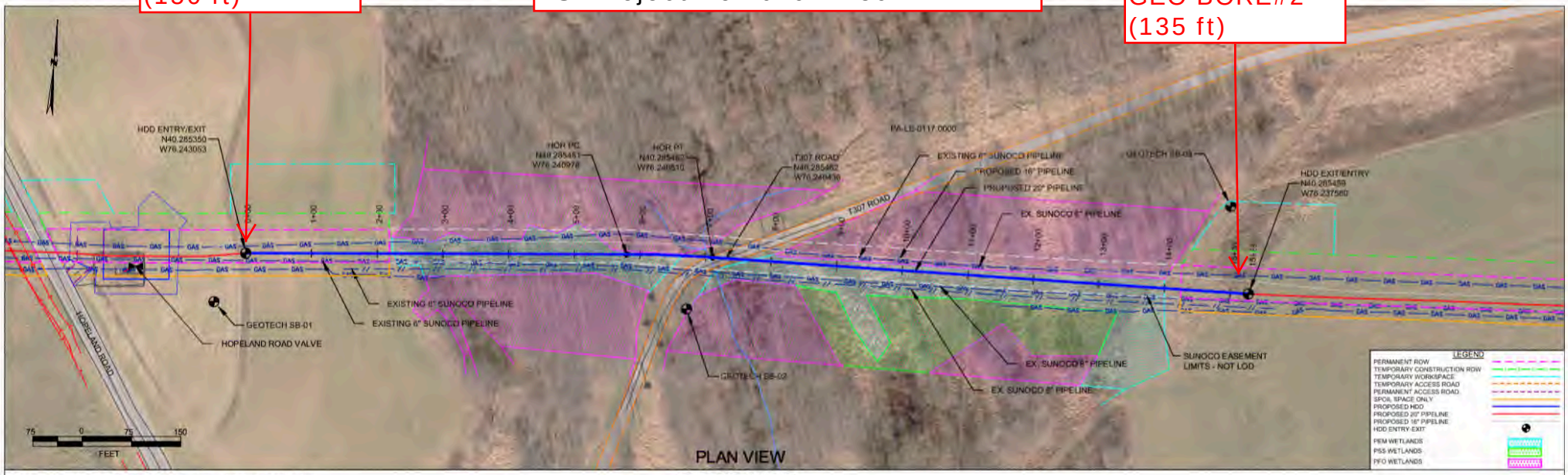
Created using PA DCNR Map Viewer

Map created on Mon Sep 25 2017

FIGURE 2: BORING LOCATION PLAN
Creek&T307-PPP5
PSI Project No.: 04911459

GEO BORE#1 (150 ft)

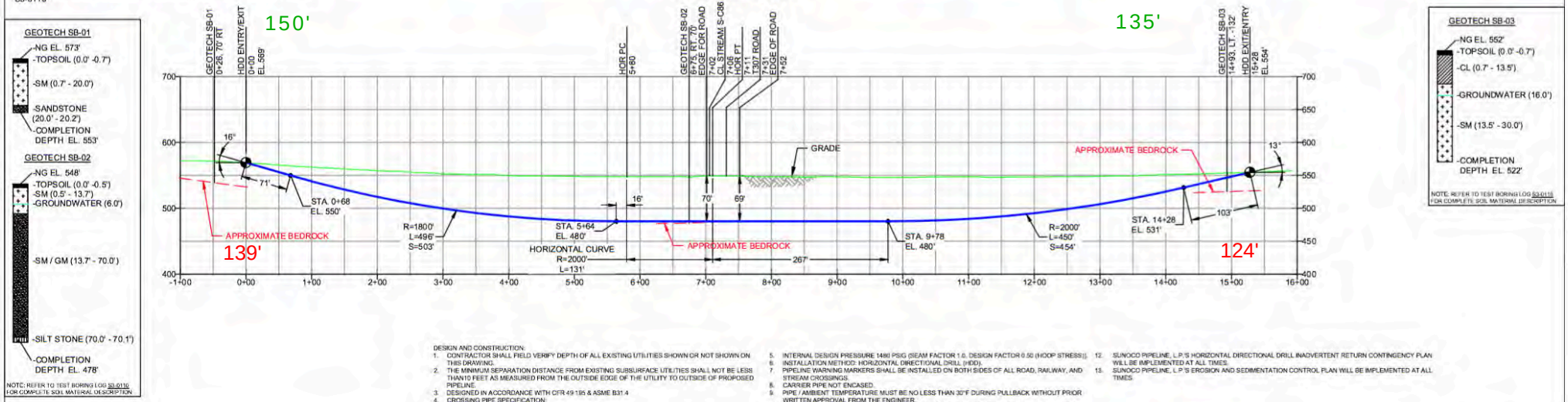
GEO BORE#2 (135 ft)



PLAN VIEW

LEBANON/LANCASTER COUNTY, PENNSYLVANIA - HEIDELBERG TOWNSHIP
S3-0110

PROFILE VIEW



DESIGN AND CONSTRUCTION:
1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49:195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L+): 1528'
   HDD PIPE LENGTH (S+): 1540'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R86)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES
1. ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
2. STATIONING IS BASED ON HORIZONTAL DISTANCES.
3. ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, LP ARE NOT RESPONSIBLE FOR LOCATION OF FOREIGN UTILITIES SHOWN IN PLOT PLAN OR PROFILE. THE INFORMATION SHOWN HEREON IS FURNISHED WITHOUT LIABILITY ON THE PART OF ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, LP, FOR ANY DAMAGES RESULTING FROM ERRORS OR OMISSIONS THEREIN.
4. CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.
5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
6	DESIGN CHANGE - MOVED ENTRY/EXIT POINTS	MRS	03/15/17	RMS	03/15/17	AMC	03/15/17
5	REVISED PROFILE WITH 2017 LIDAR	MRS	02/15/17	RMS	02/15/17	AMC	02/15/17
4	REVISED PER ENGINEERING COMMENTS	MRS	08/19/16	RMS	08/19/16	AAW	08/19/16
3	DESIGN CHANGE	DLM	04/14/16	RMS	04/14/16	AAW	04/14/16
2	MLV NAME UPDATED	DLM	04/07/16	RMS	04/07/16	AAW	04/07/16
1	HDD PIPE LENGTH CORRECTED	DLM	03/29/16	RMS	03/29/16	AAW	03/29/16

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
CREEK & T307
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150' | DWG. NUMBER: PA-LE-0117.0000-WX

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

Visit us at http://www.dcnr.state.pa.us

Figure 3: Site Geology Map

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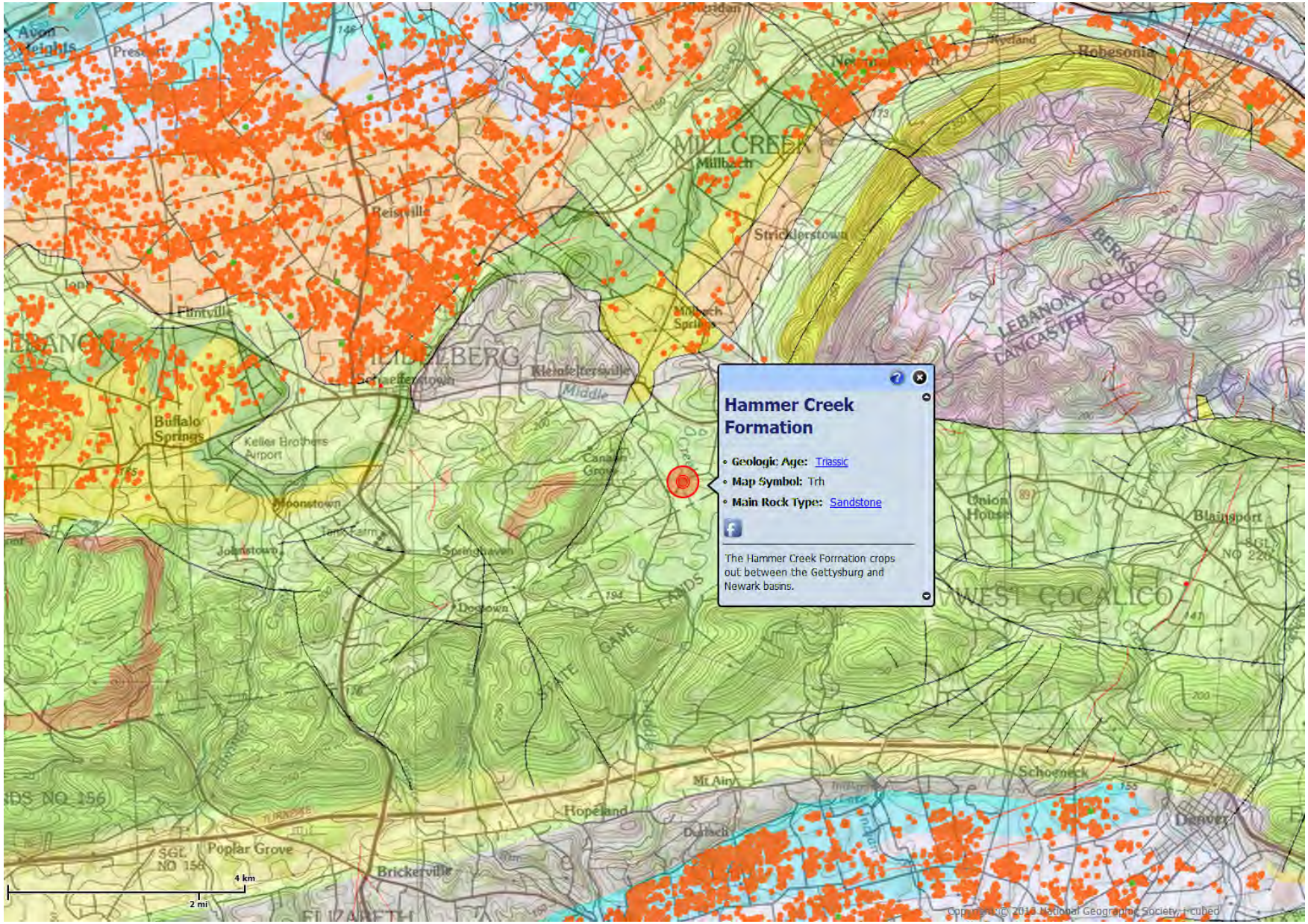

Created using PA DCNR Map Viewer

Map created on Mon Sep 25 2017

BORING B-1

DATE STARTED:	9/8/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	9/13/17	**DRILLER:** D. Novotny	**LOGGED BY:** H. Patel
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water
- Pre-Core 12 feet
- Upon Completion 12.2 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ Moisture × PL ◪ LL ✚ (0, 25, 50) STRENGTH, tsf Qu ▲ Qp ✳ (0, 2.0, 4.0)	Additional Remarks
	0			S-1	18	**RESIDUUM**-Soft, Brown, SILT with Sand, moist	ML	1-1-2-2 N=3	19		LL = 38 PL = 27
	5			S-2	24	**RESIDUUM**-Medium Dense, Dark brown, Clayey SAND, trace Gravel, moist with Gravel	SC	5-9-12-14 N=21	10		Fines=23.8%
	10			S-3	24	**RESIDUUM**-Dense, Dark brown, Silty SAND, moist	SM	10-16-25-41 N=41	10		Fines=16.7%
	15			S-4	7	**Highly Weathered SANDSTONE Sampled as Soil**-Very Dense, Dark brown, Silty SAND, trace clay inclusions, moist	SM	30-50/1"	12	>>	Fines=28.5%
				S-5	0	**SANDSTONE**-Brown, Medium grained, Highly Weathered, very broken to slightly broken, hard		50/0"		>>	
	20			R-1	8			RQD=10 Rec=17%			
						SANDSTONE-Gray-brown to dark gray-brown, Medium to coarse grained, Slightly Weathered, slightly broken to massive, moderately hard, trace pits				>> ▲	Q_u = 301.2 tsf 144.1 pcf
	25			R-2	46	**SANDSTONE**-Dark red-brown to gray-brown, Fine to medium grained, Highly Weathered, very broken to slightly broken, moderately hard, multiple soil layers		RQD=18 Rec=77%			
	30			R-3	19			RQD=0			

Continued Next Page

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1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911459
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Creek&T307 (PPP5)
Lebanon Co., PA
PA-LE-0117.0000-WX/PO#DPS 20170830-3

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED:	9/8/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	9/13/17	**DRILLER:** D. Novotny	**LOGGED BY:** H. Patel
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

BORING B-1

Water
- Pre-Core 12 feet
- Upon Completion 12.2 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	30					**SANDSTONE**-Dark red-brown to gray-brown, Fine to medium grained, Highly Weathered, very broken to slightly broken, moderately hard, multiple soil layers		Rec=32%			
	35			R-4	29			RQD=7 Rec=48%			
						Conglomeratic SANDSTONE-Light gray-brown to dark brown, Fine to very coarse grained, Weathered to Slightly Weathered, very broken to massive, hard, trace pits and vugs					
	40			R-5	60			RQD=87 Rec=100%		>> ▲	Q_u = 121.6 tsf 140.1 pcf
						Highly Weathered CONGLOMERATE-Low recovery consisted of gravel-sized rock fragments					
	45			R-6	26			RQD=27 Rec=43%			
						CONGLOMERATE-Light gray to dark brown, Medium to very coarse grained, Weathered, slightly broken to massive, hard					
						SANDSTONE-Gray-brown to brown, Fine to coarse grained, Weathered to Slightly Weathered, broken to massive, moderately hard to hard				>> ▲	Q_u = 185.2 tsf 155.6 pcf
	50			R-7	41			RQD=17 Rec=68%			
						Highly Weathered SANDSTONE-Low recovery consisted of gravel-sized rock fragments					
						SANDSTONE-Gray-brown to brown, Fine to coarse grained, Weathered to Slightly Weathered, broken to massive, moderately hard to hard					
	55			R-8	50			RQD=63 Rec=83%			
						SANDSTONE-Gray-brown to dark brown, Medium to coarse grained, Weathered, very broken to slightly broken, hard, trace pits and vugs					
	60			R-9	58			RQD=50		>> ▲	

Continued Next Page

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PROJECT NO.: 04911459
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Creek&T307 (PPP5)
Lebanon Co., PA
PA-LE-0117.0000-WX/PO#DPS 20170830-3

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED:	9/8/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	9/13/17	**DRILLER:** D. Novotny	**LOGGED BY:** H. Patel
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

BORING B-1

Water

Pre-Core	12	feet
Upon Completion	12.2	feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / STRENGTH, tsf	Additional Remarks
	60					**Conglomeratic SANDSTONE**-Gray-brown, Fine to very coarse grained, Slightly Weathered, slightly broken to massive, hard, trace pits and vugs		Rec=97%		>>	Q_u = 119.5 tsf 143.4 pcf
						Conglomeratic SANDSTONE-Gray-brown to dark gray-brown, Fine to very coarse grained, Weathered to Highly Weathered, very broken to slightly broken, hard					
				R-10	30			RQD=0 Rec=50%			
	65										
						Conglomeratic SANDSTONE-Gray-brown to dark brown, Medium to very coarse grained, Slightly Weathered, broken to massive, hard, trace pits and vugs					1 min.
										>>	Q_u = 178.6 tsf 143.0 pcf
				R-11	60			RQD=68 Rec=100%			1 min.
	70										1 min.
											1 min.
											1 min.
											1 min.
				R-12	55			RQD=82 Rec=92%			1 min.
	75										1 min.
											1 min.
											1 min.
											1 min.
											1 min.
				R-13	57	Highly Weathered seam @ 79.3 feet (~ 2-3/4 inches thick)		RQD=72 Rec=95%		>>	Q_u = 194.0 tsf 162.8 pcf
	80					**SILTSTONE**-Red-brown, Very fine grained, Slightly Weathered, massive, moderately hard					3 min.
						SANDSTONE-Dark red-brown to dark gray-brown, Fine to medium grained, Slightly Weathered, broken to slightly broken, hard					1 min.
						SILTSTONE-Dark red-brown, Very fine grained, Slightly Weathered, massive, moderately hard					1 min.
				R-14	60			RQD=84 Rec=100%			2 min.
	85					**SANDSTONE**-Light gray-brown to dark brown, Fine to medium grained, Slightly Weathered, slightly broken to massive, moderately hard to very hard Developing diagonal fracture from 86.3 to 86.5 feet. Siltstone layer from 87 to 87.7 feet.					1 min.
											1 min.
											1 min.
											1 min.
				R-15	60			RQD=65		>>	Q_u = 247.7 tsf
	90										

Continued Next Page

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PROJECT NO.: 04911459
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Creek&T307 (PPP5)
Lebanon Co., PA
PA-LE-0117.0000-WX/PO#DPS 20170830-3

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED:	9/8/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	9/13/17	**DRILLER:** D. Novotny	**LOGGED BY:** H. Patel
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

BORING B-1

Water
- Pre-Core 12 feet
- Upon Completion 12.2 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	Additional Remarks
	90			**Conglomeratic SANDSTONE**-Light gray to red-gray-brown, Fine to very coarse grained, Slightly Weathered, broken to massive, hard to very hard		Rec=100%		162.1 pcf 1 min. 1 min. 1 min. 1 min. 1 min.
	95	R-16	60			RQD=80 Rec=100%		1 min. 2 min. 2 min. 1 min. 1 min.
				SANDSTONE-Light gray-brown to dark red-brown, Fine to very coarse grained, Slightly Weathered, broken to massive, moderately hard to very hard				
	100	R-17	60			RQD=78 Rec=100%		>> Q_u = 434.9 tsf 160.6 pcf 1 min. 1 min. 2 min.
				Conglomeratic Sandstone layer @ 101.9 feet (~ 11 inches thick)				
				Conglomeratic SANDSTONE-Dark gray-brown to gray-brown, Fine to very coarse grained, Weathered, very broken to slightly broken, hard				1 min. 1 min. 1 min.
	105	R-18	60			RQD=16 Rec=100%		1 min. 1 min. 1 min.
				Conglomeratic SANDSTONE-Gray-brown to dark gray-brown, Fine to very coarse grained, Weathered to Slightly Weathered, very broken to massive, hard to very hard				
	110	R-19	60	Highly Weathered layer @ 107.3 feet (~ 3-1/4 inches thick)		RQD=58 Rec=100%		2 min. 1 min. >> Q_u = 220.5 tsf 148.8 pcf 1 min. 2 min.
				CONGLOMERATE-Light gray to dark gray-brown, Medium to very coarse grained, Slightly Weathered, broken to massive, hard				2 min. 2 min.
		R-20	60	**SHALE**-Dark red-brown to dark brown, Very fine grained, Weathered to Highly Weathered, very broken to massive, moderately hard		RQD=55 Rec=100%		3 min. 4 min. 4 min.
	115							3 min. 3 min.
	120	R-21	60			RQD=24		

STANDARD PENETRATION TEST DATA
N in blows/ft ◎
Moisture ✕ PL ◪ LL
0 25 50
STRENGTH, tsf
Qu ▲ Qp ✳
0 2.0 4.0

Continued Next Page

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PROJECT NO.: 04911459
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Creek&T307 (PPP5)
Lebanon Co., PA
PA-LE-0117.0000-WX/PO#DPS 20170830-3

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-1

DATE STARTED:	9/8/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	9/13/17	**DRILLER:** D. Novotny	**LOGGED BY:** H. Patel
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water
- Pre-Core 12 feet
- Upon Completion 12.2 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Additional Remarks
	120			**SANDSTONE**-Brown to dark brown, Fine to medium grained, Weathered to Slightly Weathered, broken to to massive, hard		Rec=100%	4 min.
							>> Q_u = 402.7 tsf, 162.8 pcf
				CONGLOMERATE-Light gray to dark brown, Fine to very coarse grained, Slightly Weathered, broken to massive, hard, trace pits and vugs			3 min.
							3 min.
		R-22	60	**Conglomeratic SANDSTONE**-Light gray-brown to dark brown, Medium to very coarse grained, Slightly Weathered, very broken to massive, hard		RQD=68 Rec=100%	3 min.
	125						4 min.
							4 min.
							3 min.
							1 min.
							1 min.
		R-23	60			RQD=90 Rec=100%	1 min.
	130						1 min.
							2 min.
							>> Q_u = 121.8 tsf, 157.7 pcf
							1 min.
		R-24	60			RQD=87 Rec=100%	1 min.
	135						1 min.
				Sandstone layer @ 135.8 feet (~ 7-1/4 inches thick)			2 min.
							2 min.
				Nearly vertical fracture from 138.2 to 138.7 feet.			2 min.
		R-25	51	**SILTSTONE**-Dark brown to dark red-brown, Very fine grained, Weathered to Slightly Weathered, very broken to massive, moderately hard		RQD=45 Rec=85%	1 min.
	140						2 min.
							2 min.
							3 min.
							1 min.
		R-26	60	**SANDSTONE**-Light gray to dark brown, Fine to coarse grained, Slightly Weathered, broken to massive, hard to very hard		RQD=74 Rec=100%	2 min.
	145						2 min.
							2 min.
							2 min.
							1 min.
		R-27	36			RQD=76 Rec=100%	1 min.
				Test boring terminated @ 150 feet			1 min.
	150						

STANDARD PENETRATION TEST DATA
N in blows/ft ◎
Moisture ✕ PL ◪ LL
0 25 50
STRENGTH, tsf
Qu ▲ Qp ✳
0 2.0 4.0

Moisture, %

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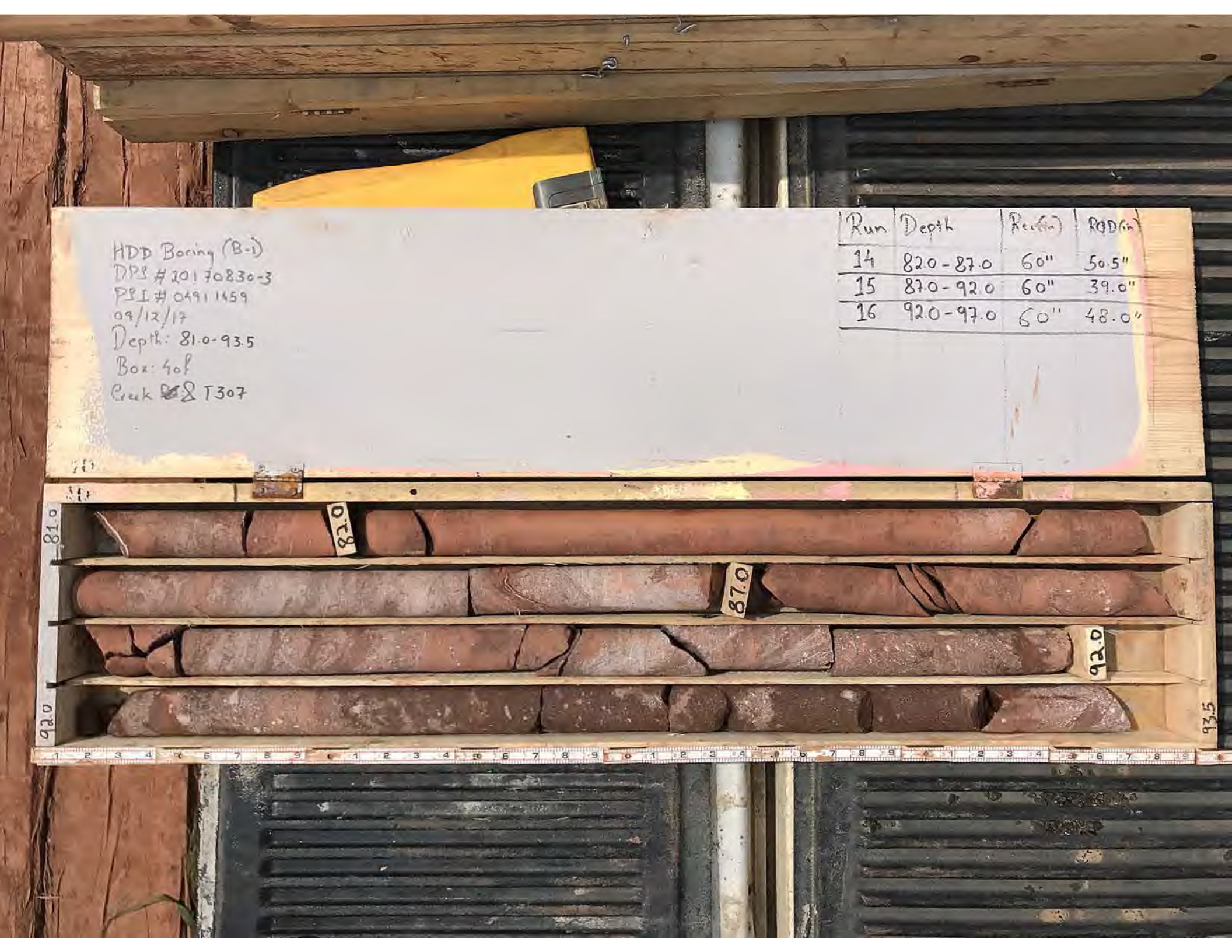
PROJECT NO.: 04911459
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Creek&T307 (PPP5)
Lebanon Co., PA
PA-LE-0117.0000-WX/PO#DPS 20170830-3

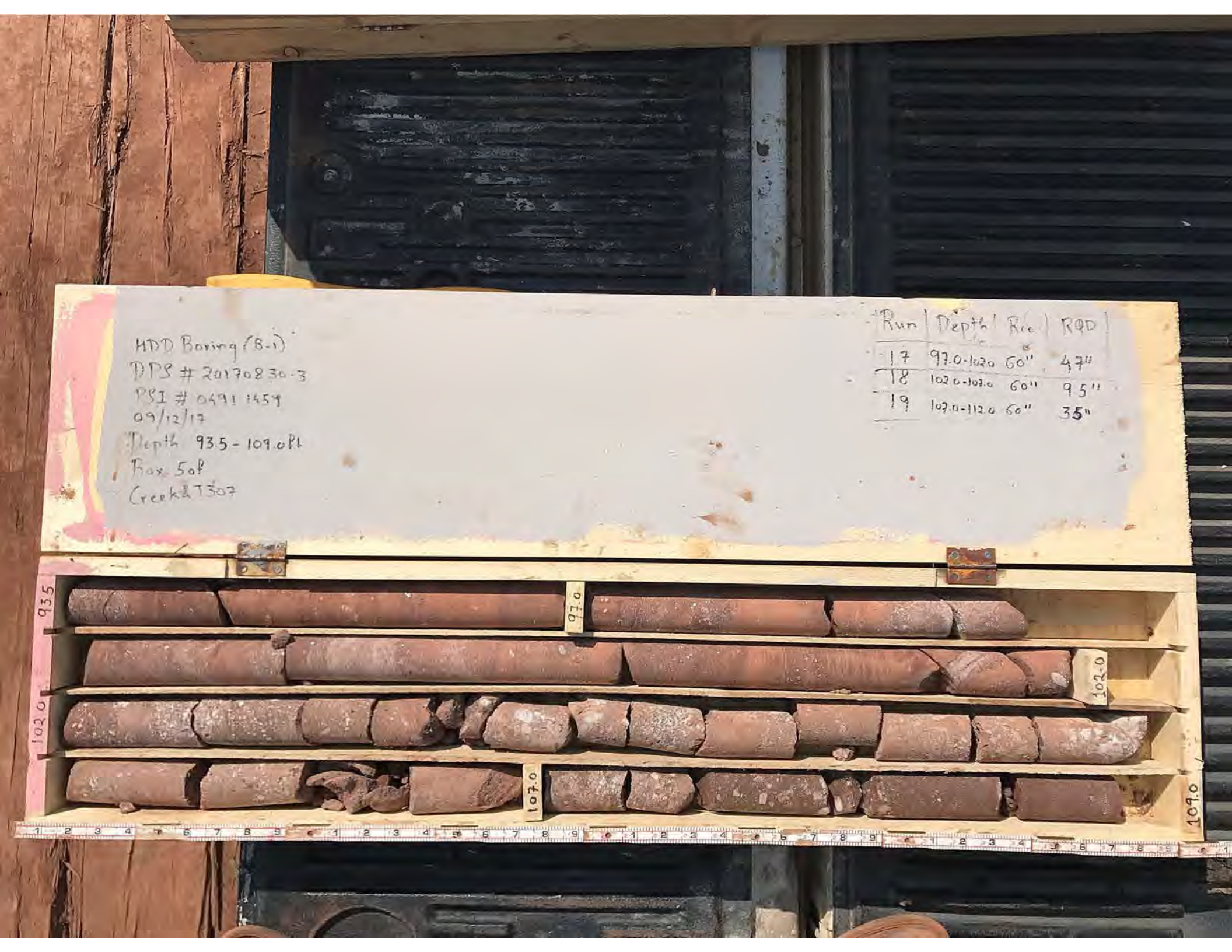
The stratification lines represent approximate boundaries. The transition may be gradual.


HDD Boring (B-1)
DPS# 20170830-3
PSI# 04911459
08/11/17
Depth: 18.0ft - 44.0ft
Box: 1 of
Creek Rd & T307
Run | Depth | rec. | RQD
1 | 18.0-22.0 | 0.65 | 0.40
2 | 22.0-27.0 | 3.8 | 0.85
3 | 27.0-32.0 | 1.6 | 0
4 | 32.0-37.0 | 3.45 | 0.35
5 | 37.0-42.0 | 5.0 | 4.3
Run | depth | rec. | RQD
6 | 42.0-47.0 | 2.2 | 1.3
18.0
22.0
27.0
32.0
37.0
42.0
44.0


HDD Boring (B-1)
DPS# 20170830-3
09/12/17 (PSI #0491 145 9)
Depth: 44.0 ft - 63.5 ft
Crab Rd & T307
Box: 2 of
Run | depth | rec. | RQD
6 cont. | 42.0 - 47.0 | 3.2 | 1.3
7 | 47.0 - 52.0 | 3.4 | 0.8
8 | 52.0 - 57.0 | 4.2 | 3.2
9 | 57.0 - 62.0 | 4.8 | 2.5
10 | 62.0 - 67.0 | 2.5 | 0*
44.0
47.0
52.0
57.0
62.0
63.5


T307
of
HDD Boring (B-1)
DPS # 20170830-3
PSI # 0491 1459
09/12/17
Depth: 63.5ft - 81.0ft.
Box: 3 of
Creek Rd & T307
Run | Depth | Rec (in) | RQD (in)
11 | 67.0-72.0 | 60" | 41"
12 | 72.0-77.0 | 55" | 49"
13 | 77.0-82.0 | 57" | 43"
67.0
72.0
77.0
63.5
81.0


HDD Boring (B-1)
DPS #20170830-3
PSI #0491 1459
09/12/17
Depth: 81.0-93.5
Box: 4of
Creek & T307
Run | Depth | Rec(in) | RQD(in)
14 | 82.0-87.0 | 60" | 50.5"
15 | 87.0-92.0 | 60" | 39.0"
16 | 92.0-97.0 | 60" | 48.0"
81.0
82.0
87.0
92.0
93.5


HDD Boring (B-1)
DPS # 20170830-3
PSI # 0491 1459
09/12/17
Depth 93.5 - 109.0 ft
Box 5 of
Creek & T307
Run | Depth | Rec | RQD
17 | 97.0-102.0 | 60" | 47"
18 | 102.0-107.0 | 60" | 95"
19 | 107.0-112.0 | 60" | 35"
93.5
97.0
102.0
107.0
109.0


HDD Boring (B-1)
DPS # 20170830-3
PSI # 0491 1459
09/12/17
Depth: 109.0ft - 123.0ft
Box: 6 of
Geok & T307
Run | Depth | Rec | RQD
20 | 112.0-117.0 | 60" | 33"
21 | 117.0-122.0 | 60" | 14.5"
22 | 122.0-127.0 | 60" | 41"
109.0
112.0
117.0
122.0
123.0


HDD Boring (B-1)
JPS # 20170830-3
PSI # 0491 1459
09/13/17
Depth: 123.0 - 13 ft
Box: 7 of
Creek & T307
Run | Depth | Rec(in) | RQD(in)
23 | 127.0 - 132.0 | 60" | 54"
24 | 132.0 - 137.0 | 60" | 52"
123.0
127.0
132.0
137.0

DPS# 20170830-3
PSI# 0491 1459
HDD Boring (B-1)
09/13/17
Depth: 137.0ft. 150.0ft
Box: 8 of
Creek & T307

Run	Depth	Rec.	RQD
25	137.0-142.0	51"	27"
26	142.0-147.0	60"	44.5"
27	147.0-150.0	36"	27.5"

BORING B-2

DATE STARTED:	9/1/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	9/8/17	**DRILLER:** D. Novotny	**LOGGED BY:** M. Wildman
COMPLETION DEPTH	135.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water
- Pre-Core 5.2 feet
- Post-Core 3.4 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	0			S-1	20	**RESIDUUM**- Very Loose, Brown, Silty SAND, moist	SM	1-1-3-5 N=4	9		Fines=16.6%
	5			S-2	24	**RESIDUUM**- Very Dense, Brown, Silty SAND with Gravel, moist	SM	14-24-36-36 N=60	7	>>◎	
	10			S-3	17	**Highly Weathered SANDSTONE Sampled as Soil**- Very Dense, Brown, Silty SAND, moist		20-24-50/5"	11	>>◎	Fines=18.3%
	15			S-4	5		SM	50/4"	13	>>◎	
	20			S-5	5	Trace Gravel from 20 to 20.3 feet.		50/4"	16	>>◎	Fines=14.1%
	25			S-6	2	**Highly Weathered SANDSTONE Sampled as Soil**-Very Dense, Brown, Poorly Graded SAND with Silt, trace Gravel, wet	SP-SM	50/2"	16	>>◎	
	30					**Highly Weathered SANDSTONE Sampled as Soil**-No split-spoon sample recovery within this stratum.					

Continued Next Page

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PROJECT NO.: 04911459
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Creek&T307 (PPP5)
Lebanon Co., PA
PA-LE-0117.0000-WX/PO#DPS 20170830-3

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED:	9/1/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	9/8/17	**DRILLER:** D. Novotny	**LOGGED BY:** M. Wildman
COMPLETION DEPTH	135.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

BORING B-2

Water

Pre-Core	5.2 feet
Post-Core	3.4 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture ✕ / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	30			S-7	0	**SANDSTONE**-Light gray-brown to brown, Medium to coarse grained, Weathered, very broken to slightly broken, moderately hard		50/1"		>>◎	
				R-1	29			RQD=0 Rec=71%			1 min. 1 min.
	35			R-2	34	**SANDSTONE**-Light gray-brown to gray-brown, Medium to coarse grained, Weathered to Slightly Weathered, very broken to massive, moderately hard		RQD=60 Rec=93%		>>▲ Q_u = 195.0 tsf, 129.5 pcf	1 min. 1 min. 1 min. 1 min. 1 min.
				R-3	4	**Highly Weathered/Completely Weathered SANDSTONE**-Low recovery from rock coring operations		RQD=0 Rec=6%			1 min. 1 min. 1 min. 2 min.
	40			R-4	54	**SANDSTONE**-Gray-brown to brown, Medium to coarse grained, Weathered to Slightly Weathered, very broken to massive, moderately hard		RQD=46 Rec=90%		>>▲ Q_u = 154.6 tsf, 136.1 pcf	1 min. 1 min. 1 min. 1 min. 1 min.
	45					**SANDSTONE**-Gray-brown, Medium to coarse grained, Highly Weathered, very broken to broken, moderately hard					1 min. 1 min. 1 min. 1 min. 1 min.
				R-5	0	**Highly Weathered/Completely Weathered SANDSTONE** No recovery from rock coring operations from 46.5 to 51.5 feet.		RQD=0 Rec=0%			1 min. 1 min. 1 min. 1 min. 1 min.
	50										1 min. 1 min. 1 min. 1 min. 1 min.
				R-6	6	Low recovery from 51.5 to 60.5 feet generally consisted of silty/clayey sand and gravel.		RQD=0 Rec=10%			1 min. 1 min. 1 min. 1 min. 1 min.
	55			R-7	18			RQD=16 Rec=30%			1 min. 1 min. 1 min. 1 min. 1 min.
	60					*Continued Next Page*					

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PROJECT NO.: 04911459
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Creek&T307 (PPP5)
Lebanon Co., PA
PA-LE-0117.0000-WX/PO#DPS 20170830-3

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED:	9/1/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	9/8/17	**DRILLER:** D. Novotny	**LOGGED BY:** M. Wildman
COMPLETION DEPTH	135.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

BORING B-2

Water
- Pre-Core 5.2 feet
- Post-Core 3.4 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ Moisture PL LL (0 25 50) STRENGTH, tsf Qu Qp (0 2.0 4.0)	Additional Remarks
	60					**Conglomeratic SANDSTONE**-Gray-brown to dark brown, Fine to coarse grained, Weathered, broken to slightly broken, moderately hard					1 min.
						CONGLOMERATE-Dark brown to dark gray-brown, Medium to very coarse grained, Weathered to Highly Weathered, very broken to slightly broken, moderately hard to hard, trace pits and vugs, multiple soil layers					1 min.
				R-8	35			RQD=16 Rec=58%			1 min.
	65										1 min.
											1 min.
											1 min.
											1 min.
						SANDSTONE-Gray-brown, Fine grained, Weathered to Highly Weathered, very broken to slightly broken, moderately hard, multiple soil layers					1 min.
				R-9	17			RQD=8 Rec=28%			1 min.
	70										1 min.
											2 min.
											2 min.
						SANDSTONE-Dark red-brown to dark brown, Fine grained, Slightly Weathered, massive, moderately hard					1 min.
				R-10	60			RQD=82 Rec=100%			>> Qu = 113.7 tsf 1 min. 157.6 pcf
	75										1 min.
											1 min.
											1 min.
						Conglomeratic SANDSTONE-Gray to brown, Fine to very coarse grained, Weathered to Highly Weathered, very broken to massive, moderately hard, trace pits and vugs					1 min.
				R-11	38			RQD=18 Rec=64%			1 min.
	80										1 min.
											1 min.
											1 min.
											1 min.
				R-12	20			RQD=12 Rec=34%			1 min.
	85										1 min.
											2 min.
											>> Q_u = 440.8 tsf 1 min. 150.3 pcf
						Conglomeratic SANDSTONE-Gray-brown to dark brown, Fine to very coarse grained, Weathered to Slightly Weathered, very broken to massive, moderately hard to hard, trace pits and vugs					1 min.
				R-13	60			RQD=62 Rec=100%			1 min.
	90										

Continued Next Page

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PROJECT NO.: 04911459
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Creek&T307 (PPP5)
Lebanon Co., PA
PA-LE-0117.0000-WX/PO#DPS 20170830-3

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED:	9/1/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	9/8/17	**DRILLER:** D. Novotny	**LOGGED BY:** M. Wildman
COMPLETION DEPTH	135.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

BORING B-2

Water
- Pre-Core 5.2 feet
- Post-Core 3.4 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0 25 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 2.0 4.0)	Additional Remarks
	90					**Conglomeratic SANDSTONE**-Gray-brown to dark brown, Fine to very coarse grained, Weathered to Slightly Weathered, very broken to massive, moderately hard to hard, trace pits and vugs Highly Weathered layer @ 91 feet (~ 6-1/2 inches thick)					1 min. 1 min. 1 min.
				R-14	53			RQD=14 Rec=88%		>> Q_u = 148.0 tsf 132.8 pcf	1 min.
	95					**Conglomeratic SANDSTONE**-Gray-brown to brown, Fine to very coarse grained, Slightly Weathered, slightly broken to massive, hard, trace pits					1 min. 1 min.
				R-15	60			RQD=90 Rec=100%		>> Q_u = 233.6 tsf 136.4 pcf	1 min. 1 min. 1 min.
	100					**Conglomeratic SANDSTONE**-Gray-brown to dark brown, Fine to very coarse grained, Weathered to Slighly Weathered, very broken to massive, moderatey hard to hard, trace pits					1 min. 1 min. 1 min. 1 min.
				R-16	58			RQD=50 Rec=96%			1 min. 1 min.
	105					**SANDSTONE**-Dark brown to gray-brown, Fine grained, Slightly Weathered, broken to massive, moderately hard to hard Broken seam @ 106.5 feet (~2 inches thick)					1 min. 1 min.
				R-17	60			RQD=70 Rec=100%		>> Q_u = 154.4 tsf 159.6 pcf	1 min. 1 min. 1 min.
	110					Highly Weathered layer @ 110.9 feet (~7-1/2 inches thick)					1 min. 1 min. 1 min.
				R-18	60	**Conglomeratic SANDSTONE**-Brown to dark brown, Fine to very coarse grained, Weathered, very broken to massive, moderately hard to hard, trace pits and vugs		RQD=34 Rec=100%		>> Q_u = 168.3 tsf 138.6 pcf	1 min. 1 min.
	115					**SANDSTONE**-Gray-brown to dark gray-brown, Fine to medium grained, Weathered, very broken to slighty broken, moderately hard to hard **Highly Weathered/Completely Weathered Conglomeratic SANDSTONE**					1 min. 1 min. 1 min. 1 min.
				R-19	10			RQD=0 Rec=16%			1 min. 1 min.
	120					*Continued Next Page*					

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Lebanon Co., PA
PA-LE-0117.0000-WX/PO#DPS 20170830-3

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-2

DATE STARTED:	9/1/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	9/8/17	**DRILLER:** D. Novotny	**LOGGED BY:** M. Wildman
COMPLETION DEPTH	135.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water
- Pre-Core 5.2 feet
- Post-Core 3.4 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	120					**Highly Weathered/Completely Weathered Conglomeratic SANDSTONE**					1 min.
											1 min.
											1 min.
											1 min.
				R-20	41	**SANDSTONE**-Gray-brown to dark brown, Medium to coarse grained, Weathered to Slighly Weathered, broken to massive, moderately hard		RQD=42 Rec=68%			>> Qu = 296.1 tsf 1 min. 148.3 pcf
	125					Nearly vertical fracture from 126.5 to 127.1 feet.					1 min.
											1 min.
											1 min.
				R-21	60			RQD=90 Rec=100%			1 min.
	130										1 min.
											1 min.
											1 min.
				R-22	42			RQD=86 Rec=100%			1 min.
											1 min.
	135					Test boring terminated @ 135 feet					1 min.

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Lebanon Co., PA
PA-LE-0117.0000-WX/PO#DPS 20170830-3

The stratification lines represent approximate boundaries. The transition may be gradual.

PSI #: 04911459 Date: 8/31/17

Bor: B-2 Depth Ø to 46.5

Spread: PPP5 Creek + T-307

Run	Depth	Rec	RQD
1	30.1-33.5	2.4	0.0
2	33.5-36.5	2.8	1.8
3	36.5-41.5	0.3	0.0
4	41.5-46.5	4.5	2.3

PSI # 04911459 Date ~~8/31/17~~ 9-1-17, 9-5-17

Bor B2 Depth 46.5 to 81.5

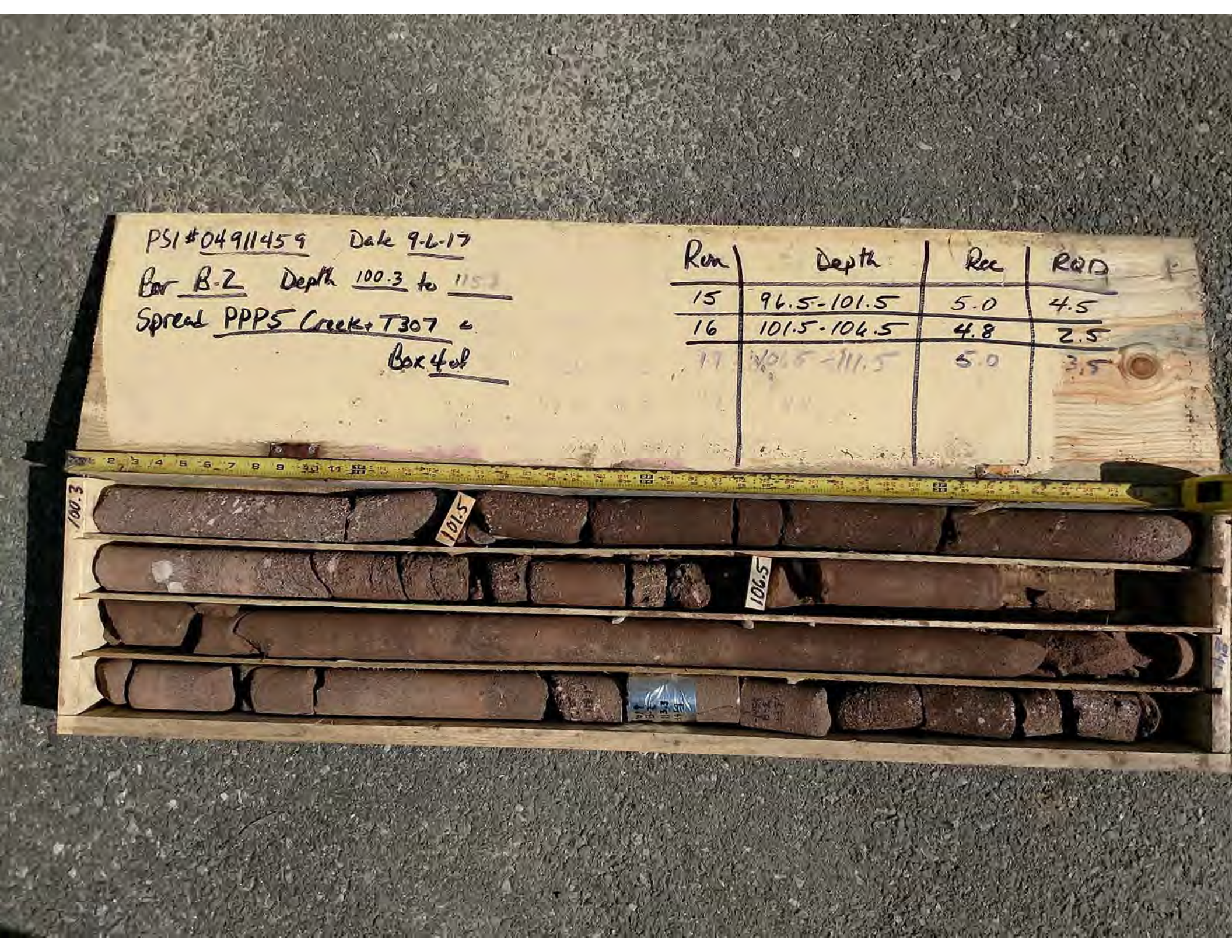
Spread PPPS Creek + T-307

Box 2 of

Run	Depth	Rec	RQD
5	46.5-51.5	0.0	0.0
6	51.5-56.5	0.5	0.0
7	56.5-61.5	1.5	0.8
8	61.5-66.5	2.9	0.8
9	66.5-71.5	1.4	0.4
10	71.5-76.5	5.0	4.1
11	76.5-81.5	3.2	0.9

PSI #04911459 Date 9-5-17
Bor B-2 Depth 81.5 to 100.3
Spread PPP5 Creek T-307
Box 3 of ____

Run	Depth	Rec	RQD
12	81.5 - 86.5	1.7	0.6
13	86.5 91.5	5.0	3.1
14	91.5 - 96.5	4.4	0.7
15	96.5 - 101.5	5.0	4.5


PSI #04911459 Date 9-6-17
Bor B-2 Depth 100.3 to 115.3
Spread PPP5 Creek T307 c
Box 4 of
Run | Depth | Rec | RQD
15 | 96.5-101.5 | 5.0 | 4.5
16 | 101.5-106.5 | 4.8 | 2.5
17 | 106.5-111.5 | 5.0 | 3.5
100.3
101.5
106.5

PSI 04911459 9-7-17
Bor B-2 Depth 115.3 to 135.0
Spread APP.5 Creek T-307 Box 5 of 5

Run	Depth	Rec	RQD
18	111.5 - 116.5	5.0	1.7
19	116.5 - 221.5	0.8	0.0
20	121.5 - 126.5	3.4	2.1
21	126.5 - 131.5	5.0	4.5
22	131.5 - 135.0	3.5	3.0
	E.O.B.		

GENERAL NOTES

SAMPLE IDENTIFICATION

The Unified Soil Classification System (USCS), AASHTO 1988 and ASTM designations D2487 and D-2488 are used to identify the encountered materials unless otherwise noted. Coarse-grained soils are defined as having more than 50% of their dry weight retained on a #200 sieve (0.075mm); they are described as: boulders, cobbles, gravel or sand. Fine-grained soils have less than 50% of their dry weight retained on a #200 sieve; they are defined as silts or clay depending on their Atterberg Limit attributes. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size.

DRILLING AND SAMPLING SYMBOLS

SFA: Solid Flight Auger - typically 4" diameter flights, except where noted.
HSA: Hollow Stem Auger - typically 3¼" or 4¼ I.D. openings, except where noted.
M.R.: Mud Rotary - Uses a rotary head with Bentonite or Polymer Slurry
R.C.: Diamond Bit Core Sampler
H.A.: Hand Auger
P.A.: Power Auger - Handheld motorized auger

SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted.
ST: Shelby Tube - 3" O.D., except where noted.
RC: Rock Core
TC: Texas Cone
BS: Bulk Sample
PM: Pressuremeter
CPT-U: Cone Penetrometer Testing with Pore-Pressure Readings

SOIL PROPERTY SYMBOLS

N: Standard "N" penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2-inch O.D. Split-Spoon.
N_{60}: A "N" penetration value corrected to an equivalent 60% hammer energy transfer efficiency (ETR)
Q_u: Unconfined compressive strength, TSF
Q_p: Pocket penetrometer value, unconfined compressive strength, TSF
w%: Moisture/water content, %
LL: Liquid Limit, %
PL: Plastic Limit, %
PI: Plasticity Index = (LL-PL),%
DD: Dry unit weight, pcf
▼,▽,⧩ Apparent groundwater level at time noted

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Relative Density	N - Blows/foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	50 - 80
Extremely Dense	80+

ANGULARITY OF COARSE-GRAINED PARTICLES

Description	Criteria
Angular:	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular:	Particles are similar to angular description, but have rounded edges
Subrounded:	Particles have nearly plane sides, but have well-rounded corners and edges
Rounded:	Particles have smoothly curved sides and no edges

GRAIN-SIZE TERMINOLOGY

Component	Size Range
Boulders:	Over 300 mm (>12 in.)
Cobbles:	75 mm to 300 mm (3 in. to 12 in.)
Coarse-Grained Gravel:	19 mm to 75 mm (¾ in. to 3 in.)
Fine-Grained Gravel:	4.75 mm to 19 mm (No.4 to ¾ in.)
Coarse-Grained Sand:	2 mm to 4.75 mm (No.10 to No.4)
Medium-Grained Sand:	0.42 mm to 2 mm (No.40 to No.10)
Fine-Grained Sand:	0.075 mm to 0.42 mm (No. 200 to No.40)
Silt:	0.005 mm to 0.075 mm
Clay:	<0.005 mm

PARTICLE SHAPE

Description	Criteria
Flat:	Particles with width/thickness ratio > 3
Elongated:	Particles with length/width ratio > 3
Flat & Elongated:	Particles meet criteria for both flat and elongated

RELATIVE PROPORTIONS OF FINES

Descriptive Term	% Dry Weight
Trace:	< 5%
With:	5% to 12%
Modifier:	>12%

GENERAL NOTES

(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

Q_U - TSF	N - Blows/foot	Consistency
0 - 0.25	0 - 2	Very Soft
0.25 - 0.50	2 - 4	Soft
0.50 - 1.00	4 - 8	Firm (Medium Stiff)
1.00 - 2.00	8 - 15	Stiff
2.00 - 4.00	15 - 30	Very Stiff
4.00 - 8.00	30 - 50	Hard
8.00+	50+	Very Hard

MOISTURE CONDITION DESCRIPTION

Description	Criteria
Dry:	Absence of moisture, dusty, dry to the touch
Moist:	Damp but no visible water
Wet:	Visible free water, usually soil is below water table

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term	% Dry Weight
Trace:	< 15%
With:	15% to 30%
Modifier:	>30%

STRUCTURE DESCRIPTION

Description	Criteria
Stratified:	Alternating layers of varying material or color with layers at least ¼-inch (6 mm) thick
Laminated:	Alternating layers of varying material or color with layers less than ¼-inch (6 mm) thick
Fissured:	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided:	Fracture planes appear polished or glossy, sometimes striated
Blocky:	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed:	Inclusion of small pockets of different soils
Layer:	Inclusion greater than 3 inches thick (75 mm)
Seam:	Inclusion 1/8-inch to 3 inches (3 to 75 mm) thick extending through the sample
Parting:	Inclusion less than 1/8-inch (3 mm) thick

SCALE OF RELATIVE ROCK HARDNESS

Q_U - TSF	Consistency
2.5 - 10	Extremely Soft
10 - 50	Very Soft
50 - 250	Soft
250 - 525	Medium Hard
525 - 1,050	Moderately Hard
1,050 - 2,600	Hard
>2,600	Very Hard

ROCK BEDDING THICKNESSES

Description	Criteria
Very Thick Bedded	Greater than 3-foot (>1.0 m)
Thick Bedded	1-foot to 3-foot (0.3 m to 1.0 m)
Medium Bedded	4-inch to 1-foot (0.1 m to 0.3 m)
Thin Bedded	1¼-inch to 4-inch (30 mm to 100 mm)
Very Thin Bedded	½-inch to 1¼-inch (10 mm to 30 mm)
Thickly Laminated	1/8-inch to ½-inch (3 mm to 10 mm)
Thinly Laminated	1/8-inch or less "paper thin" (<3 mm)

ROCK VOIDS

Voids	Void Diameter
Pit	<6 mm (<0.25 in)
Vug	6 mm to 50 mm (0.25 in to 2 in)
Cavity	50 mm to 600 mm (2 in to 24 in)
Cave	>600 mm (>24 in)

GRAIN-SIZED TERMINOLOGY

(Typically Sedimentary Rock)

Component	Size Range
Very Coarse Grained	>4.76 mm
Coarse Grained	2.0 mm - 4.76 mm
Medium Grained	0.42 mm - 2.0 mm
Fine Grained	0.075 mm - 0.42 mm
Very Fine Grained	<0.075 mm

ROCK QUALITY DESCRIPTION

Rock Mass Description	RQD Value
Excellent	90 -100
Good	75 - 90
Fair	50 - 75
Poor	25 -50
Very Poor	Less than 25

Degree of Brokeness

Characteristic	Description
Less than 1 inch	Very Broken
1 inch to 3 inches	Broken
3 inches to 6 inches	Slightly Broken
Greater than 6 inches	Massive

DEGREE OF WEATHERING

Slightly Weathered: Rock generally fresh, joints stained and discoloration extends into rock up to 25 mm (1 in), open joints may contain clay, core rings under hammer impact.

Weathered: Rock mass is decomposed 50% or less, significant portions of the rock show discoloration and weathering effects, cores cannot be broken by hand or scraped by knife.

Highly Weathered: Rock mass is more than 50% decomposed, complete discoloration of rock fabric, core may be extremely broken and gives clunk sound when struck by hammer, may be shaved with a knife.

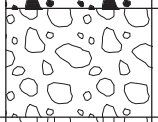
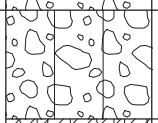
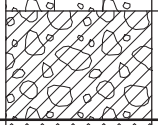
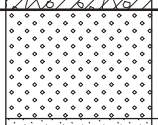
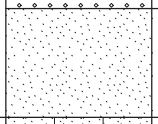
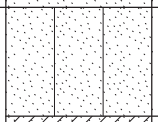
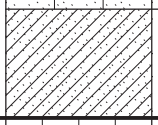
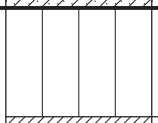
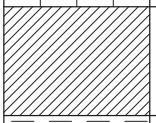
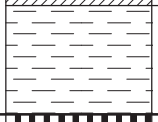
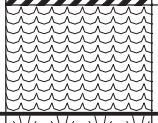
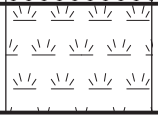
Table 4–3 Hardness and unconfined compressive strength of rock materials

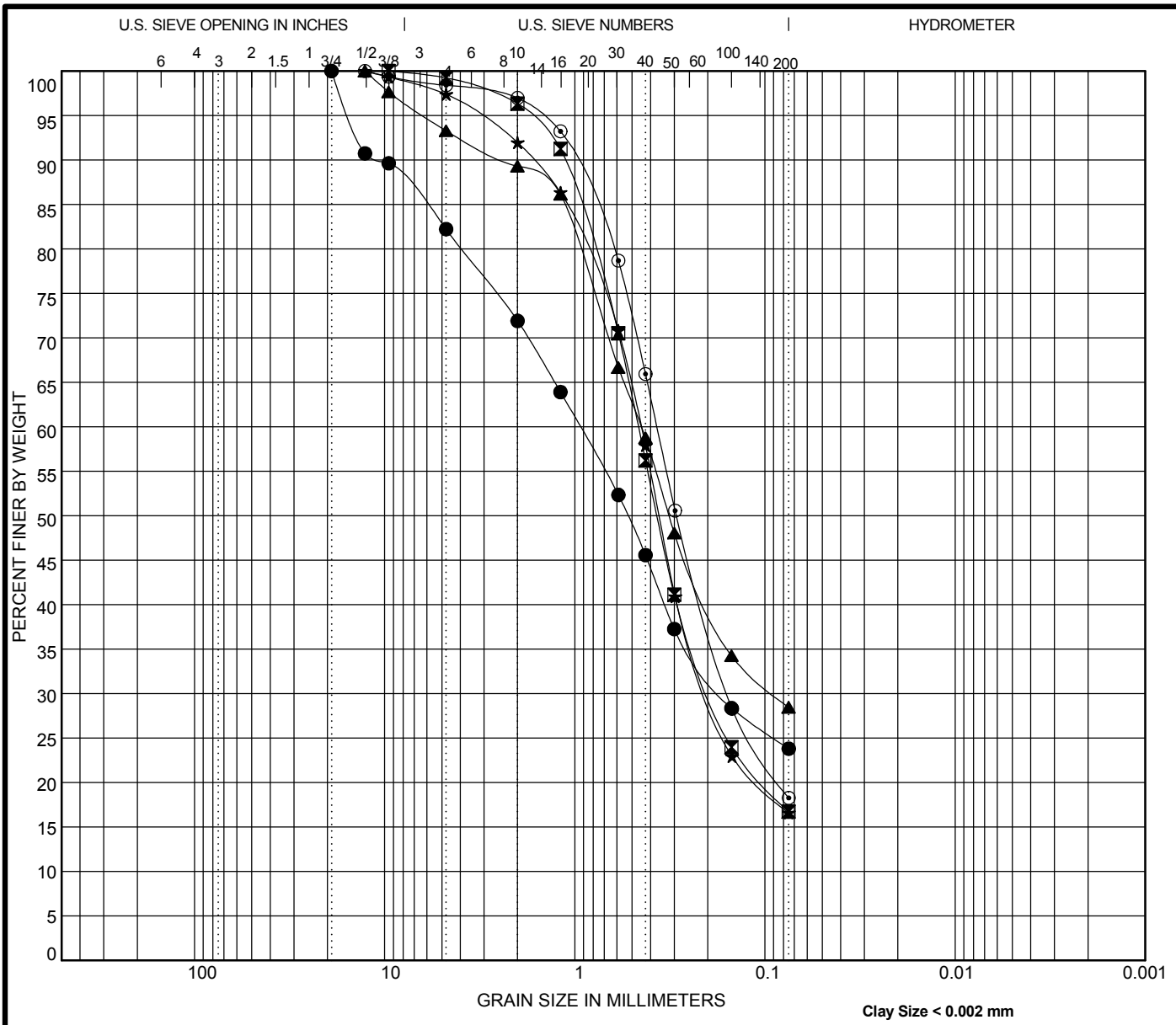
Hardness category	Typical range in unconfined compressive strength (MPa)	Strength value selected (MPa)	Field test on sample	Field test on outcrop
Soil*	< 0.60		Use USCS classifications	
Very soft rock or hard, soil-like material	0.60–1.25		Scratched with fingernail. Slight indentation by light blow of point of geologic pick. Requires power tools for excavation. Peels with pocket knife.	
Soft rock	1.25–5.0		Permits denting by moderate pressure of the fingers. Handheld specimen crumbles under firm blows with point of geologic pick.	Easily deformable with finger pressure.
Moderately soft rock	5.0–12.5		Shallow indentations (1–3 mm) by firm blows with point of geologic pick. Peels with difficulty with pocket knife. Resists denting by the fingers, but can be abraded and pierced to a shallow depth by a pencil point. Crumbles by rubbing with fingers.	Crumbles by rubbing with fingers.
Moderately hard rock	12.5–50		Cannot be scraped or peeled with pocket knife. Intact handheld specimen breaks with single blow of geologic hammer. Can be distinctly scratched with 20d common steel nail. Resists a pencil point, but can be scratched and cut with a knife blade.	Unfractured outcrop crumbles under light hammer blows.
Hard rock	50–100		Handheld specimen requires more than one hammer blow to break it. Can be faintly scratched with 20d common steel nail. Resistant to abrasion or cutting by a knife blade, but can be easily dented or broken by light blows of a hammer.	Outcrop withstands a few firm blows before breaking.
Very hard rock	100–250		Specimen breaks only by repeated, heavy blows with geologic hammer. Cannot be scratched with 20d common steel nail.	Outcrop withstands a few heavy ringing hammer blows but will yield large fragments.
Extremely hard rock	> 250		Specimen can only be chipped, not broken by repeated, heavy blows of geologic hammer.	Outcrop resists heavy ringing hammer blows and yields, with difficulty, only dust and small fragments.

Method used to determine consistency or hardness (check one):
Field assessment: _____ Uniaxial lab test: _____ Other: _____ Rebound hammer (ASTM D5873): _____
* See NEH631.03 for consistency and density of soil materials. For very stiff soil, SPT N values = 15 to 30. For very soft rock or hard, soil-like material, SPT N values exceed 30 blows per foot.

SOIL CLASSIFICATION CHART

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	SAND AND SANDY SOILS	CLEAN SANDS		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SANDS WITH FINES		SM	SILTY SANDS, SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

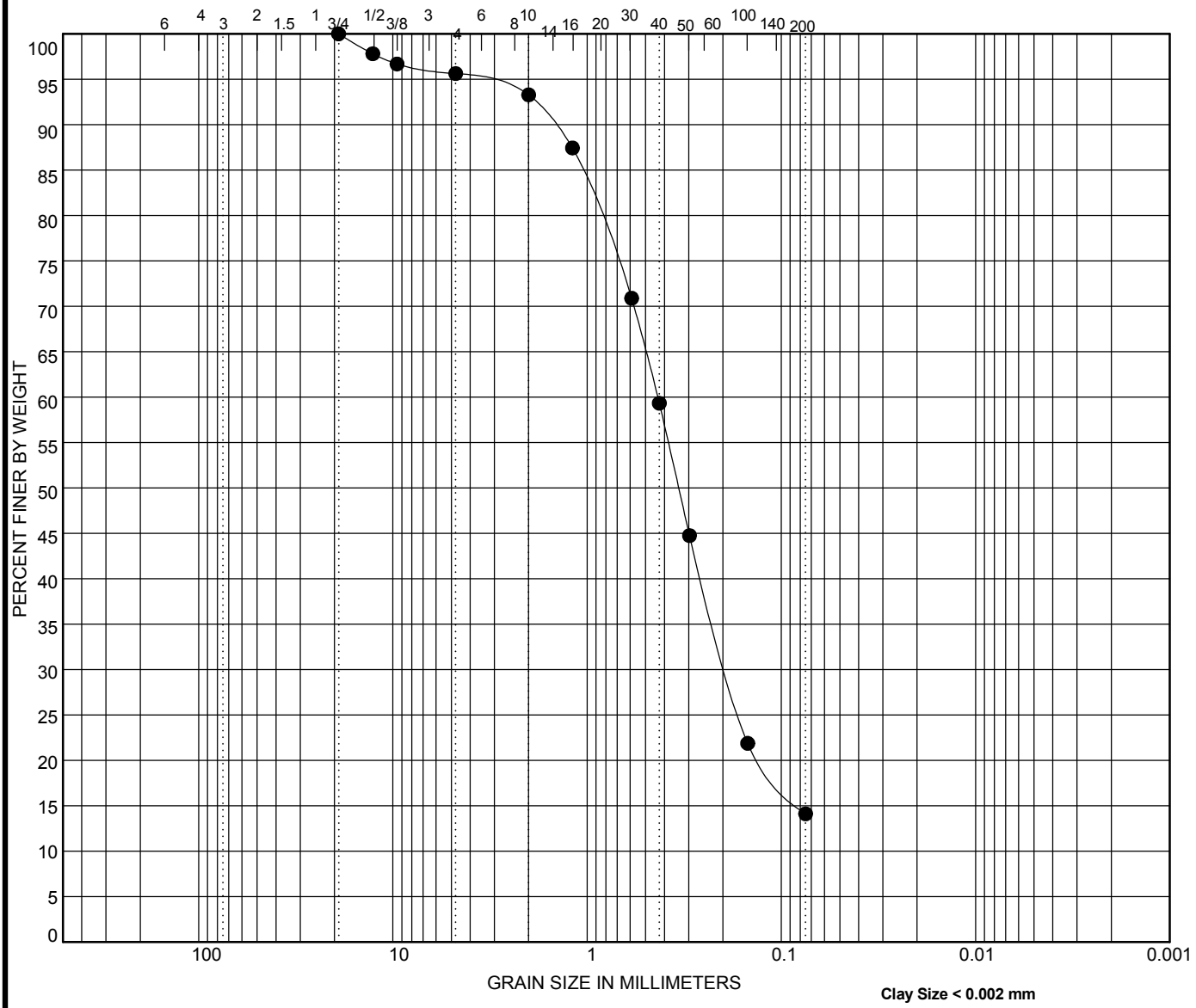
Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	B-1	6.5	Clayey SAND with Gravel (SC)					
⊠	B-1	11.0	Silty SAND (SM)					
▲	B-1	15.5	Silty SAND (SM)					
★	B-2	1.0	Silty SAND (SM)					
⊙	B-2	11.0	Silty SAND (SM)					

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-1	6.5	19.05	0.939	0.17		17.8	58.4	23.8	
⊠	B-1	11.0	9.525	0.464	0.191		0.8	82.5	16.7	
▲	B-1	15.5	12.7	0.448	0.09		6.7	64.8	28.5	
★	B-2	1.0	12.7	0.448	0.195		2.6	80.8	16.6	
⊙	B-2	11.0	12.7	0.37	0.157		1.6	80.1	18.3	

Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622
Fax: (717) 230-8626

GRAIN SIZE DISTRIBUTION

Project: Energy Transfer HDD (DPS)
PSI Job No.: 04911459
Location: Creek&T307 (PPP5)
Lebanon Co., PA



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	B-2	20.0	Silty SAND (SM)					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-2	20.0	19.05	0.433	0.19		4.4	81.5	14.1	

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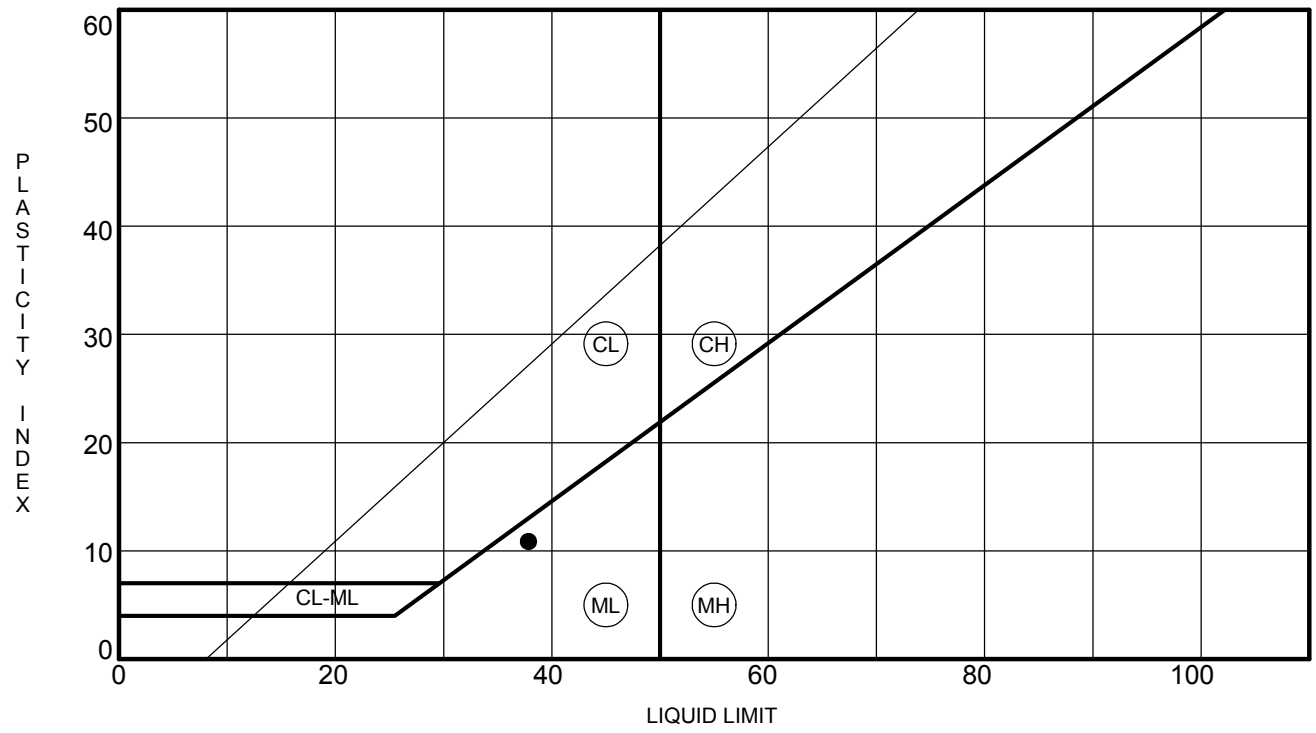

	Boring	Depth (ft)	LL	PL	PI	Fines	Classification (*Visual)
●	**B-1**	**1.0**	**38**	**27**	**11**		**SILT with Sand (ML)**

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ATTERBERG LIMIT RESULTS

PSI Job No.: 04911459
Project: Energy Transfer HDD (DPS)
Location: Creek&T307 (PPP5)
Lebanon Co., PA

Laboratory Summary Sheet

Borehole	Approx. Depth	Liquid Limit	Plastic Limit	Plasticity Index	Qu (tsf)	%<#200 Sieve	Est. Specific Gravity	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
B-1	1	38	27	11				19			
B-1	6.5					23.8%		10			
B-1	11					16.7%		10			
B-1	15.5					28.5%		12			
B-1	22.6				301.18						
B-1	39.1				121.60						
B-1	48.2				185.19						
B-1	60				119.53						
B-1	69.1				178.58						
B-1	80				193.97						
B-1	89.5				247.70						
B-1	99.8				434.94						
B-1	110.3				220.51						
B-1	121.1				402.67						
B-1	132.4				121.83						
B-2	1					16.6%		9			
B-2	6							7			
B-2	11					18.3%		11			
B-2	15							13			
B-2	20					14.1%		16			
B-2	25							16			
B-2	34.4				195.02						
B-2	44.3				154.63						
B-2	74.5				113.66						
B-2	87				440.78						
B-2	93.1				148.02						
B-2	96.5				233.60						
B-2	107.4				154.41						
B-2	113.3				168.30						
B-2	124.5				296.08						

intertek PSI

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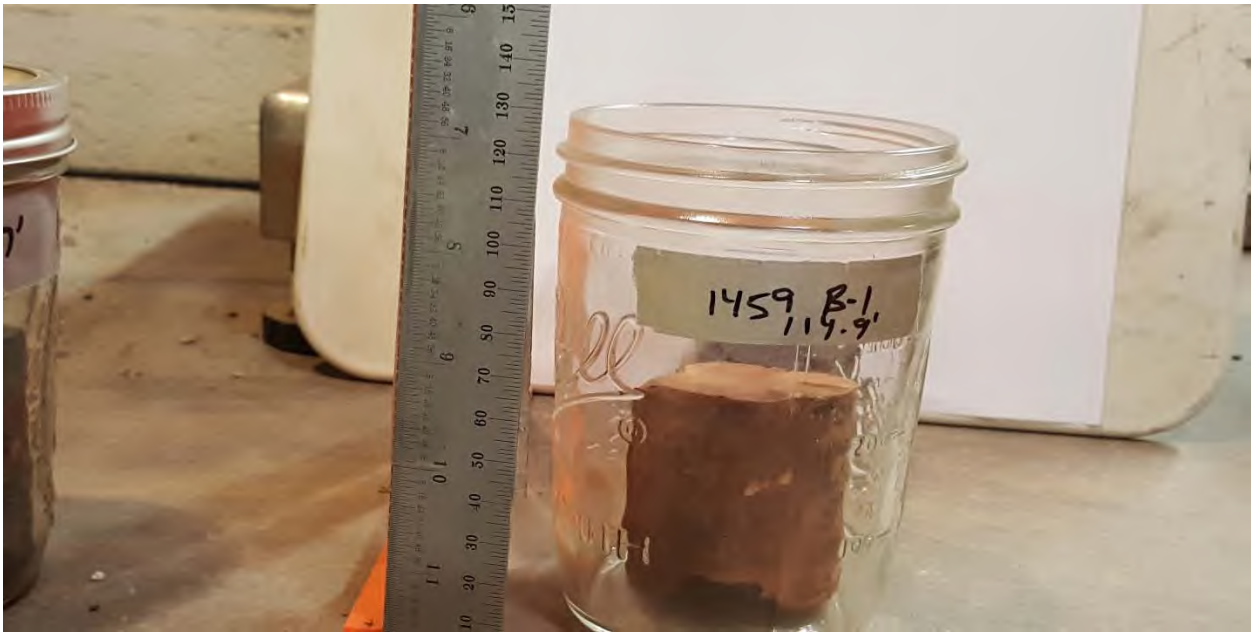
Summary of Laboratory Results

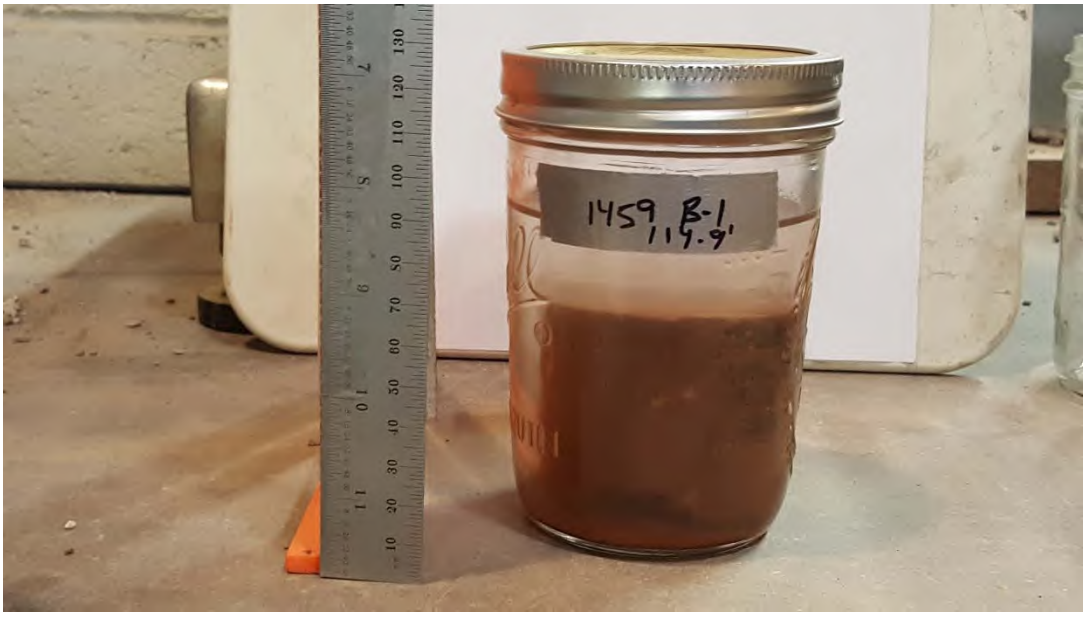
PSI Job No.: 04911459
Project: Energy Transfer HDD (DPS)
Location: Creek&T307 (PPP5)
Lebanon Co., PA
PA-LE-0117.0000-WX/PO#DPS 20170830-3

Slake Test: 04911459 B-1 114.9’

Test Date: September 28, 2017

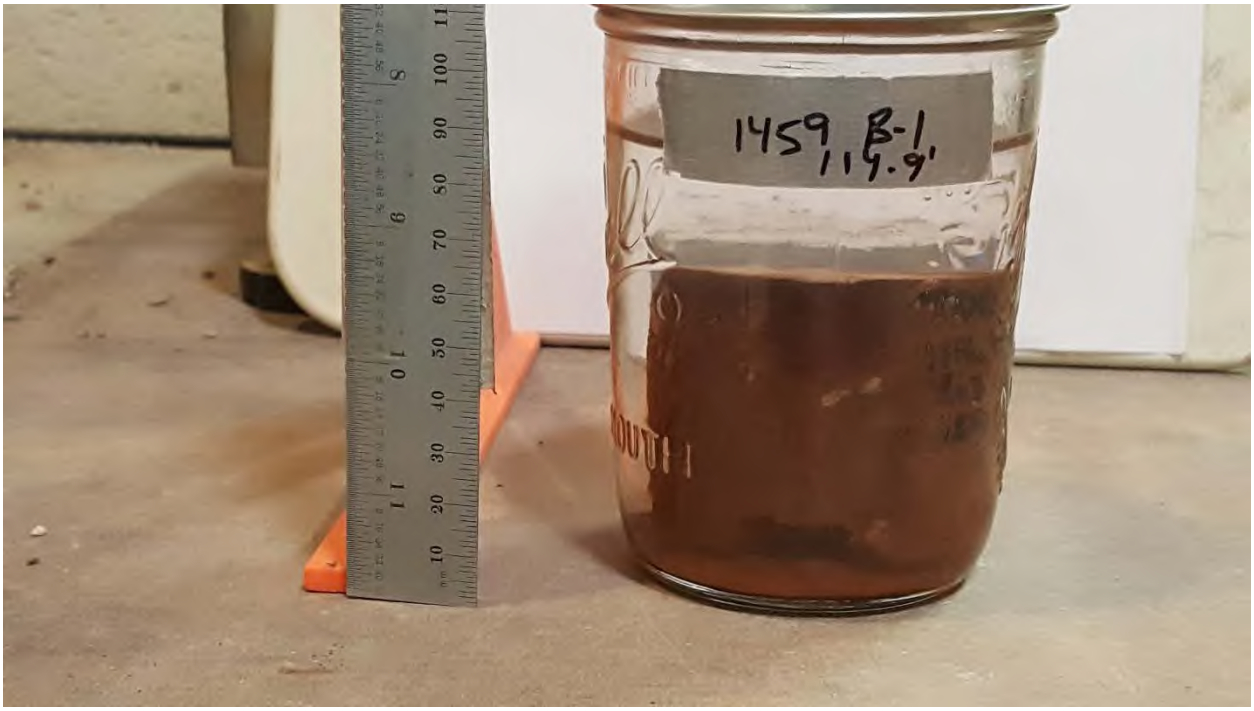


Start

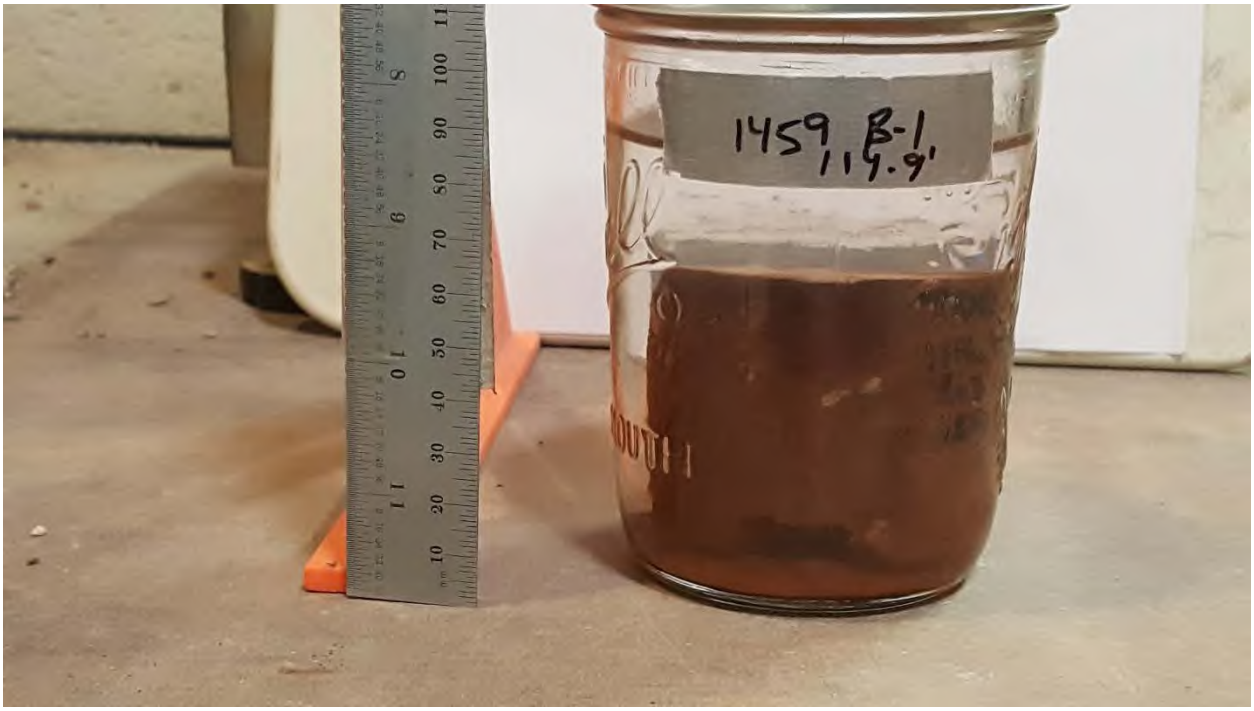


2 Minutes: Slake Index 6

4 Hours: Slake Index 6



8 Hours: Slake Index 6



24 Hours: Slake Index 6

Test Fluid: Distilled Water

Initial Ph: 6

Final Ph: 6

Slake Index Table

Jar Slake Index, Ij	General behavior during test
1	Degrades rapidly into a pile of flakes or mud
2	Breaks readily and/or forms many chips
3	Breaks slowly and/or forms few chips
4	Breaks rapidly and/or develops several fractures
5	Breaks slowly and/or develops few fractures
6	Very little or no change

Jar Slake Index Descriptions

ATTACHMENT 2
SOIL RESOURCES MAP AND PROFILE DESCRIPTIONS

United States Department of Agriculture

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Lebanon County, Pennsylvania

T307 & Creek S-C86

February 13, 2019

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map

Map Scale: 1:3,880 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 50 100 200 300

Feet: 0 150 300 600 900

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Lebanon County, Pennsylvania
Survey Area Data: Version 14, Sep 19, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 29, 2011—Mar 16, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
AbB	Abbottstown silt loam, 3 to 8 percent slopes	5.1	11.6%
Bm	Bowmansville silt loam	15.9	36.4%
BrA	Brinkerton silt loam, 0 to 3 percent slopes	1.1	2.6%
BrB	Brinkerton silt loam, 3 to 8 percent slopes	6.9	15.8%
UnB	Ungers loam, 3 to 8 percent slopes	9.6	22.0%
UnC	Ungers loam, 8 to 15 percent slopes	5.1	11.6%
Totals for Area of Interest		**43.7**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it

was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Lebanon County, Pennsylvania

AbB—Abbottstown silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2v7gd
Elevation: 130 to 660 feet
Mean annual precipitation: 40 to 48 inches
Mean annual air temperature: 52 to 57 degrees F
Frost-free period: 190 to 210 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Abbottstown and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Abbottstown

Setting

Landform: Hillslopes
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Parent material: Acid reddish brown residuum weathered from shale and siltstone

Typical profile

Ap - 0 to 10 inches: silt loam
Bt - 10 to 20 inches: silt loam
Bx - 20 to 39 inches: channery silt loam
BCg - 39 to 48 inches: channery silt loam
R - 48 to 58 inches: bedrock

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 18 to 22 inches to fragipan; 40 to 60 inches to lithic bedrock
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Klinesville

Percent of map unit: 5 percent

Landform: Hills
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Hydric soil rating: No

Croton

Percent of map unit: 5 percent
Landform: Depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: Yes

Penn

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Hydric soil rating: No

Bm—Bowmansville silt loam

Map Unit Setting

National map unit symbol: l57c
Elevation: 200 to 900 feet
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 168 to 210 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Bowmansville and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bowmansville

Setting

Landform: Flood plains
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Head slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Parent material: Recent alluvial deposits weathered from sandstone and siltstone; recent alluvial deposits weathered from sandstone and siltstone

Typical profile

Ap - 0 to 7 inches: silt loam
B - 7 to 35 inches: silty clay loam
C - 35 to 52 inches: fine sandy loam
2C - 52 to 66 inches: stratified gravel to sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 72 to 99 inches to lithic bedrock
Natural drainage class: Somewhat poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 0 to 18 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water storage in profile: High (about 9.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C/D
Hydric soil rating: Yes

Minor Components

Rowland

Percent of map unit: 10 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Head slope, base slope
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Hydric soil rating: No

BrA—Brinkerton silt loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: l57g
Elevation: 300 to 3,000 feet
Mean annual precipitation: 35 to 55 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 120 to 217 days
Farmland classification: Not prime farmland

Map Unit Composition

Brinkerton and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Brinkerton

Setting

Landform: Depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Local fine-silty colluvium derived from sedimentary rock

Typical profile

H1 - 0 to 9 inches: silt loam
H2 - 9 to 18 inches: silty clay loam
H3 - 18 to 46 inches: silty clay loam
H4 - 46 to 65 inches: channery silt loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 15 to 34 inches to fragipan
Natural drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: D
Hydric soil rating: Yes

Minor Components

Atkins

Percent of map unit: 6 percent
Landform: Flood plains
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Laidig

Percent of map unit: 5 percent
Landform: Mountains
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Lower third of mountainflank
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: No

Philo

Percent of map unit: 5 percent
Hydric soil rating: No

Berks

Percent of map unit: 4 percent
Landform: Ridges, valleys
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Hydric soil rating: No

BrB—Brinkerton silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l57h
Elevation: 300 to 3,000 feet
Mean annual precipitation: 30 to 65 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 120 to 217 days
Farmland classification: Not prime farmland

Map Unit Composition

Brinkerton and similar soils: 75 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Brinkerton

Setting

Landform: Depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Local fine-silty colluvium derived from sedimentary rock

Typical profile

H1 - 0 to 9 inches: silt loam
H2 - 9 to 18 inches: silty clay loam
H3 - 18 to 46 inches: silty clay loam
H4 - 46 to 65 inches: channery silt loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 15 to 34 inches to fragipan
Natural drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: None
Frequency of ponding: None

Available water storage in profile: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: D
Hydric soil rating: Yes

Minor Components

Ernest

Percent of map unit: 10 percent
Hydric soil rating: No

Laidig

Percent of map unit: 5 percent
Landform: Mountains
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Lower third of mountainflank
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: No

Berks

Percent of map unit: 5 percent
Landform: Ridges, valleys
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Hydric soil rating: No

Atkins

Percent of map unit: 3 percent
Landform: Flood plains
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Philo

Percent of map unit: 2 percent
Hydric soil rating: No

UnB—Ungers loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l59g
Elevation: 250 to 1,500 feet
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 160 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Ungers and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ungers

Setting

Landform: Mountain slopes
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from sandstone and siltstone

Typical profile

H1 - 0 to 11 inches: loam
H2 - 11 to 40 inches: gravelly sandy clay loam
H3 - 40 to 60 inches: very channery sandy loam
H4 - 60 to 64 inches: bedrock

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 40 to 80 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Penn

Percent of map unit: 7 percent
Hydric soil rating: No

Readington

Percent of map unit: 5 percent
Hydric soil rating: No

Bucks

Percent of map unit: 3 percent
Hydric soil rating: No

UnC—Ungers loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: l59h
Elevation: 250 to 1,500 feet
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 160 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Ungers and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ungers

Setting

Landform: Mountain slopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from sandstone and siltstone

Typical profile

H1 - 0 to 9 inches: loam
H2 - 9 to 40 inches: gravelly sandy clay loam
H3 - 40 to 60 inches: very channery sandy loam
H4 - 60 to 64 inches: bedrock

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 40 to 80 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Penn

Percent of map unit: 7 percent
Hydric soil rating: No

Readington

Percent of map unit: 5 percent
Hydric soil rating: No

Bucks

Percent of map unit: 3 percent
Hydric soil rating: No

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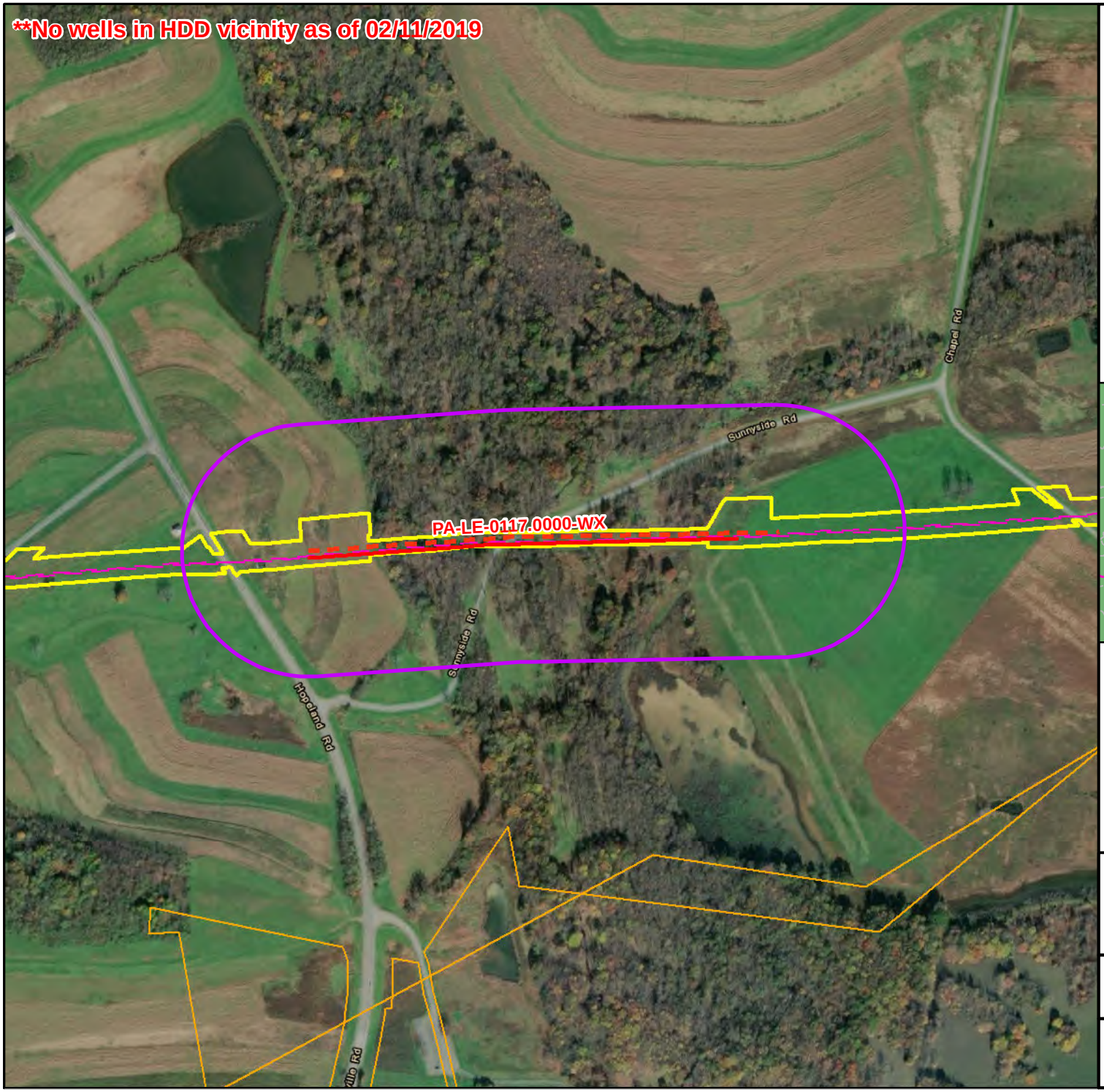
ATTACHMENT 3
450-FOOT WELL SURVEY



Legend

- LOD
- Parcel
- PPP Centerline
- PPP 1 HDD
- Proposed PPP 2 HDD Redesign
- 450 foot buffer of HDD alignment

****Testing locations current as of 02/11/2018**

- GES Testing Location

Location

N

0 250 500
Feet

Well Location Map
HDD# PA-LE-0117.0000-WX
Lebanon County, PA.

Prepared By: TETRA TECH

Date: 2/11/2019

Base Map;
ESRI World Imagery, 09/24/2015

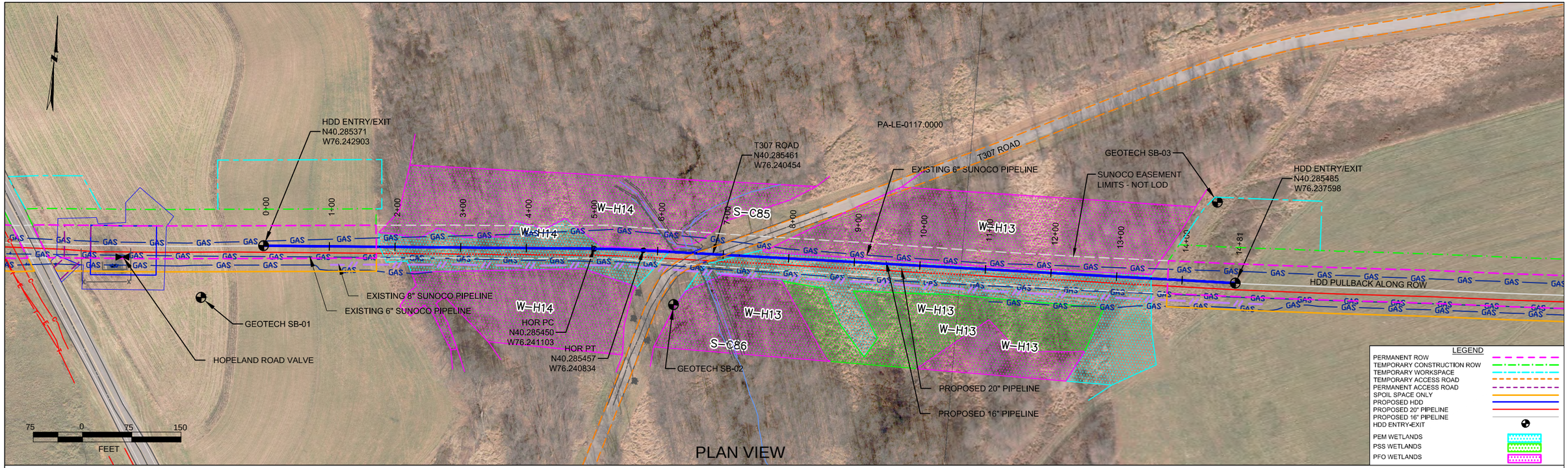
Coordinate System: NAD 83 Stateplane, PA South, Feet

P:\GIS\projects\112\D3938-PPP\MXD\WellLocations\WellLocation_PA_LE_0117_0000_NoWells.mxd LN

HORIZONTAL DIRECTIONAL DRILL ANALYSIS
MIDDLE CREEK & T307 CROSSING
PADEP SECTION 105 PERMIT NO.: E38-194
PA-LE-0117.0000-WX-16
(SPLP HDD No. S3-0110)

ATTACHMENT 2

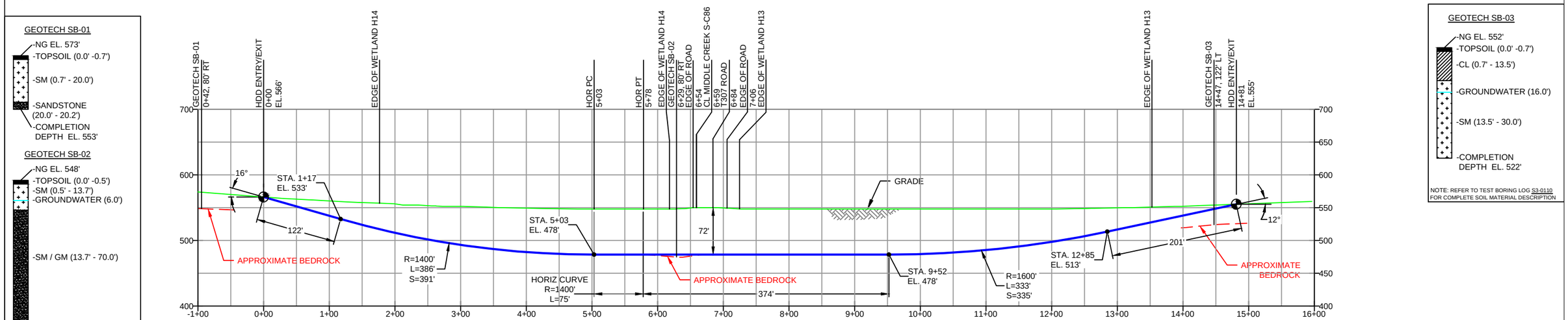
HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES



PLAN VIEW

PROFILE VIEW

LEBANON/LANCASTER COUNTY, PENNSYLVANIA - HEIDELBERG TOWNSHIP
S3-0110-16



NOTE: REFER TO TEST BORING LOG S3-0110 FOR COMPLETE SOIL MATERIAL DESCRIPTION

NOTE: REFER TO TEST BORING LOG S3-0110 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXITING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):1481'
   HDD PIPE LENGTH (S=):1498'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

Figure 1. Permitted 16-Inch HDD Plan and Profile

NOTES

1. ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
2. STATIONING IS BASED ON HORIZONTAL DISTANCES.
3. ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, LP ARE NOT RESPONSIBLE FOR LOCATION OF FOREIGN UTILITIES SHOWN IN PLOT PLAN OR PROFILE. THE INFORMATION SHOWN HEREON IS FURNISHED WITHOUT LIABILITY ON THE PART OF ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, LP, FOR ANY DAMAGES RESULTING FROM ERRORS OR OMISSIONS THEREIN.
4. CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.
5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-5.66	TO	ES-5.67	EROSION & SEDIMENT PLAN
SHEET 38	TO	SHEET 38	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	10/07/16	RMB	10/07/16	AAW	10/07/16
EP1	REVISED PER PADEP COMMENTS	JTW	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
B	ADDED GEOTECH INFO	MRS	09/23/15	RMB	09/23/15	AAW	09/23/15
A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15

Sunoco Logistics Partners L.P.

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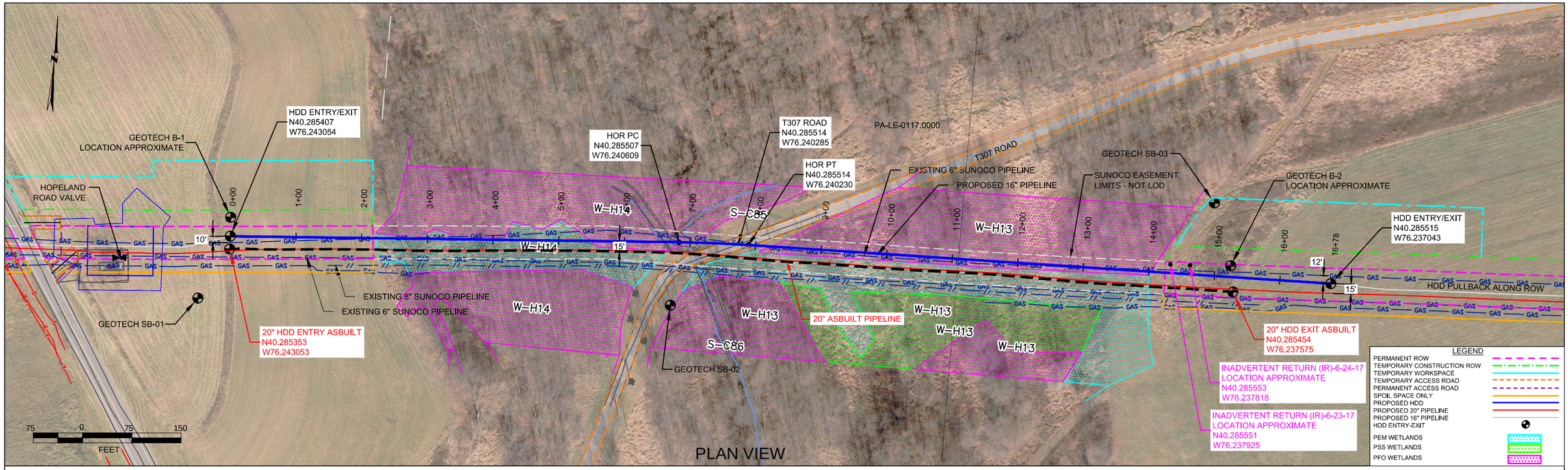
SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
CREEK & T307
PENNSYLVANIA PIPELINE PROJECT

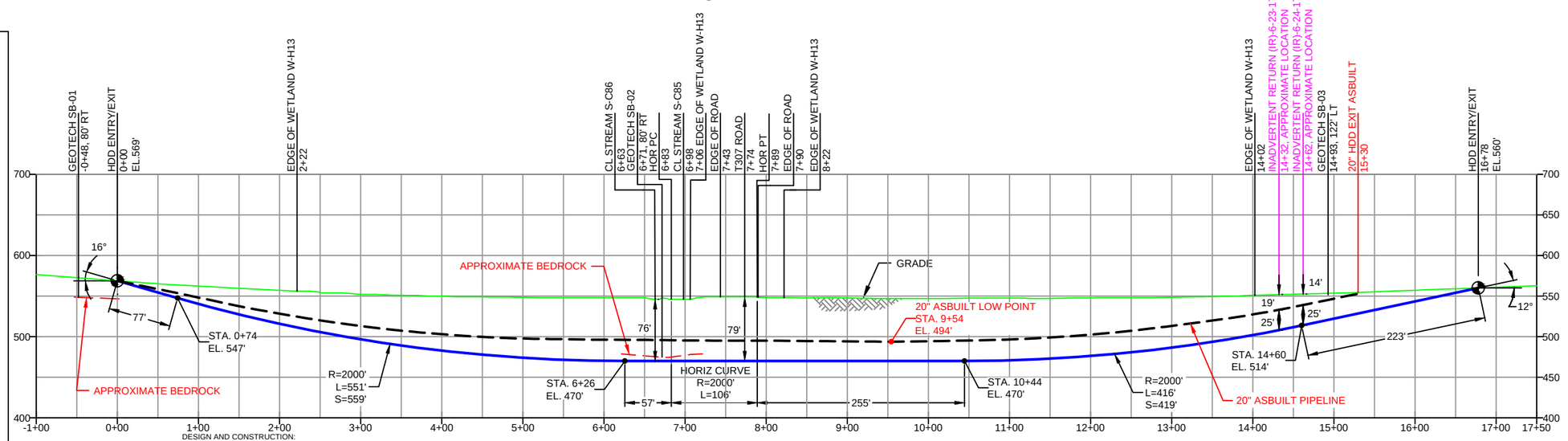
SCALE: 1"=150'

DWG. NO: PA-LE-0117.0000-WX-16



LEBANON/LANCASTER COUNTY, PENNSYLVANIA - HEIDELBERG TOWNSHIP
S3-0110-16

PROFILE VIEW



GEOTECH SB-01
- NG EL. 573'
- -TOPSOIL (0.0' -0.7')
- -SM (0.7' - 20.0')
- -SANDSTONE (20.0' - 20.2')
- -COMPLETION DEPTH EL. 553'

GEOTECH SB-02
- NG EL. 548'
- -TOPSOIL (0.0' -0.5')
- -SM (0.5' - 13.7')
- -GROUNDWATER (6.0')
- -SM / GM (13.7' - 70.0')
- -SILT STONE (70.0' - 70.1')
- -COMPLETION DEPTH EL. 478'

GEOTECH SB-03
- NG EL. 552'
- -TOPSOIL (0.0' -0.7')
- -CL (0.7' - 13.5')
- -GROUNDWATER (16.0')
- -SM (13.5' - 30.0')
- -COMPLETION DEPTH EL. 522'

NOTE: REFER TO TEST BORING LOG S3-0110 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-1
- NG EL. 568'
- -RESIDIUM-SILT W/ SAND ML (0.0' - 6.0')
- -RESIDIUM-CLAYEY SAND SC (6.0' - 8.5')
- -GROUNDWATER (12.2')
- -RESIDIUM-SILTY SAND SM (8.5' - 13.5')
- -SANDSTONE/SILTSTONE (13.5' - 150.0')
- -BORING TERMINATED EL.418'

NOTE: REFER TO TEST BORING LOG B-1 INTERTEK PROJECT #04911459 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-2
- NG EL. 554'
- -GROUNDWATER (3.4')
- -RESIDIUM-SILTY SAND SM (0.0' - 8.5')
- -WEATHERED SANDSTONE/ SILTY SAND SM (8.5' - 22.5')
- -WEATHERED SANDSTONE/ SAND W/ SILT SP-SM (22.5' - 27.5')
- -SANDSTONE (27.5' - 135.0')
- -BORING TERMINATED EL.419'

NOTE: REFER TO TEST BORING LOG B-2 INTERTEK PROJECT #04911459 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:
1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):1678'
   HDD PIPE LENGTH (S=):1696'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 2100 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 2625 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

Figure 2. Redesigned 16-Inch HDD Plan and Profile with 20-Inch IR Data

NOTES

1. ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
2. STATIONING IS BASED ON HORIZONTAL DISTANCES.
3. ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, LP ARE NOT RESPONSIBLE FOR LOCATION OF FOREIGN UTILITIES SHOWN IN PLOT PLAN OR PROFILE. THE INFORMATION SHOWN HEREON IS FURNISHED WITHOUT LIABILITY ON THE PART OF ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, LP, FOR ANY DAMAGES RESULTING FROM ERRORS OR OMISSIONS THEREIN.
4. CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.
5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING

ES-5.66	TO	ES-5.67	EROSION & SEDIMENT PLAN	
SHEET 38	TO	SHEET 38	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP5	ADDED IR INFORMATION	MRS	02/15/19	RMB	02/15/19	AMC	02/15/19
EP4	DESIGN CHANGE - EXTENDED DRILL 150' AND ADDED GEOTECH INFORMATION	MRS	12/07/18	RMB	12/07/18	JAL	12/07/18
EP3	UPDATED TO MATCH 16" IFC DESIGN AND NOTE 5 AND 10 PER INCREASED 16" MOP	MRS	05/10/18	RMB	05/10/18	AMC	05/10/18
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	10/07/16	RMB	10/07/16	AAW	10/07/16
EP1	REVISED PER PADEP COMMENTS	JTW	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16

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