

**HORIZONTAL DIRECTIONAL DRILL ANALYSIS
JOANNA ROAD CROSSING
PADEP SECTION 105 PERMIT NO: E06-701
PA-BR-0181.0000-RD-16
(SPLP HDD No. S3-0250-16)**

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This reanalysis of the horizontal directional drill (HDD) installation of a 16-inch diameter pipeline crossing under Joanna Road, streams A57, A58 and J51 and wetlands A37 & J48, is in accordance with Condition No. 3 of the Stipulated Order issued under Environmental Hearing Board Docket No. 2017-009-L. Condition No. 3 stipulates, for HDDs initiated after the temporary injunction issued by the Pennsylvania Department of Environmental Protection (PADEP) Environmental Hearing Board on July 25, 2017, a reanalysis must be performed on HDDs for which an inadvertent return (IR) occurs during the installation of one pipe (20-inch or 16-inch diameter) where a second pipe will thereafter be installed in the same right-of-way (ROW).

The 16-inch pipe HDD is referenced to herein as HDD S3-0250-16.

There were two IR events during the installation of the 20-inch pipe which were remediated. The HDD installation of the 20-inch pipeline at this location is complete.

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY

16-Inch: 0.438 wall thickness; X-70

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

HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH 2017 VERSION

- Horizontal length: 2,160 feet (ft)
- Entry angle: 10-15 degrees
- Maximum depth of cover: 100 ft
- Pipe design radius: 1,600 ft

ROOT CAUSE ANALYSIS FOR THE 20-INCH PIPE INSTALLATION IRs

There were two (2) IRs during installation of the 20-inch pipe. The IRs occurred from a combination of frequent tripping in and out of the east exit hole with the reaming tool which mechanically disturbed and loosened the unconsolidated diabase boulder-soil matrix above the borehole; the shallow exit angle and depth of the borehole, and the rainfall saturated unconsolidated soils within the overlying boulder-soil matrix migrated downward into the underlying HDD borehole annulus. This resulted in subsidence into and blockage of the annulus which induced the IRs to the overlying land surface.

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

The Joanna Road HDD location is situated in the northern portion of the Gettysburg-Newark Lowland Section of the Piedmont Physiographic Province. In eastern Pennsylvania, this portion of the Gettysburg-Newark Lowland Physiographic Province is underlain by sedimentary rocks of the Newark Group. These sedimentary rocks were deposited in a fault-bounded rift basin, commonly referred to as the Newark Basin, during late Triassic through early Jurassic time (Root and Maclachlan, 1999). According to Poth (1977) and Berg and Dodge (1981), the area in the vicinity of HDD is underlain by both elastic rocks (i.e., conglomerate, siltstone/sandstone, and shale) that are mapped as the Stockton Formation of Triassic age (Trs) and crystalline igneous (intrusive) diabase rocks of Jurassic age (Jd).

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Karst geology is not present at this HDD location. At this HDD location the use of geophysical assessments was not considered since SPLP possesses a complete geologic profile from the horizontal drilling and installation of the 20-inch pipeline.

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

HYDROGEOLOGY, GROUNDWATER, AND WELL PRODUCTION ZONES

Bedrock geology ultimately influences the storage, transmission, occurrence and use of groundwater. Geologic factors such as rock type, intergranular porosity, rock strata inclination, faults, joints, bedding planes, and solution channels affect groundwater movement and availability. According to Wood (1980) and Low (2002), groundwater within the elastic rocks of Berks County occurs under both unconfined (i.e., water table) and confined conditions. In general, groundwater generally occurs under unconfined conditions within the upper portion of the aquifer and under confined or semiconfined conditions in the deeper portions of the aquifer.

Locally, shallow groundwater discharges to the gaining portions of nearby streams and deeper regional groundwater flow is toward points of regional groundwater discharge such as the Schuylkill River. Groundwater divides may be different for each zone of groundwater flow and therefore may not coincide with surface water divides. Based on the geotechnical report and boring logs, the depth to water is quite shallow proximate to the HDD path with depths ranging from 8 to 13.5 ft below ground surface (bgs).

Based on the Pennsylvania Groundwater Information System (PaGWIS) database, the depth to bedrock ranges from 12 to 50 ft bgs, and well construction consists of 36 to 63 ft of steel casing with the open-rock portions of the wells extending from 36 ft to 250 ft bgs. Reported water well yields range from 1 to 20 gallons per minute (gpm).

SPLP's ROW agents have identified and monitored two private water wells within 450 feet of the proposed HDD alignment. These occur outward toward the west HDD entry point.

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

INADVERTENT RETURNS DISCUSSION

The HDD profile extends entirely within both the shallow unconsolidated regolith materials and weathered to highly weathered bedrock. The opinion by the reviewing geologists and HDD design specialists, as discussed further in Attachment 1, is that based on the hydro-structural characteristics of the underlying geology and the IR events during the 20-inch pipe installation, the Joanna Road HDD, as originally designed, is susceptible to an IR of drilling fluids during HDD operations and a redesign is warranted.

The proposed redesign will extend the HDD approximately 390 feet east to an area where additional geotech drilling identified competent bedrock very close to the land surface. The new eastern entry/exit area will allow the HDD tools to quickly enter bedrock and avoid the problem of the large diabase boulders within a soil matrix that were encountered during the 20-inch HDD. The new design also places the HDD profile deeper to allow for more cover under the aquatic resources, and the angles of entry and exit have been increased to allow this HDD to more rapidly enter into and exit out of competent rock..

As set forth in the conclusions section below, redesign of the 16-inch profile to be deeper and longer; increased entry/exit angles; monitoring of the annulus pressures during the drilling of the pilot hole, while

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maintaining a cleared annulus and return flows to the entry point; and recycling of the returned fluids and cuttings to maintain reduced total mud weights are good drilling practices that will minimize the potential for an IR occurrence.

ADJACENT FEATURES ANALYSIS

The crossing of Joanna Road is located in Berks County, approximately 0.4 miles south-southeast of the community of Joanna, and 1.8 miles northeast of Morgantown, Pennsylvania.

The pipeline route follows parallel to two (2) existing Sunoco Pipeline, L.P. (SPLP) pipelines. This HDD is located primarily within unmanaged deciduous woodlands and will cross under Joanna Road, five (5) streams, and one (1) emergent and forested wetland complex. None of the streams or wetlands are classified as high quality or exceptional value resources.

In addition to the resources listed above, the HDD is located immediately adjacent to a presumed agricultural building associated with a public school located south of the HDD. Two (2) residences and a commercial building are also located within the 450-foot buffer.

SPLP's ROW agents have identified two private water wells within 450 ft of the proposed HDD alignment. These occur outward toward the west HDD entry point. These water wells are not directly within the area of influence of the HDD profile, and due to the documented nature of the geology surrounding the HDD profile and groundwater movement patterns, an affect to these wells is highly unlikely.

To further avoid and mitigate any adverse effects from the HDD to private water wells, and in accordance with the requirements of the Stipulated Order, SPLP will transmit a copy of this HDD analysis to all landowners having a property line within 450 ft in any direction of this HDD location. SPLP previously informed these landowners that SPLP will conduct pre-, during, and post-construction sampling of their private water wells to ensure that mitigating actions are taken, if necessary.

ALTERNATIVES ANALYSIS

The proposed HDD is an alternative plan of installation to a conventional open trench construction plan. Using the HDD method avoids new unavoidable direct impacts to Joanna Road, streams, wetlands, and associated forested or adjacent woodland and riparian habitats. Alteration of the current permitted route and plans for installation would require modifications of the state Chapter 102 and Chapter 105 permits, create large "greenfield" impacts, and require new authorization from the U.S. Army Corps of Engineers.

Open-Cut and Conventional Bore Analysis

S3-0250-16 is approximately 2,700 ft. in horizontal length and includes the crossing of Joanna Road, five stream channel crossings, approximately 100 ft of emergent wetland, and 850 ft of forested wetlands.

The County will not allow an open-cut crossing of Joanna Road. This crossing could be converted to a conventional auger bore, using the existing permitted workspace; however, this would require excavating a "bore pit" to hold the augering machine, and a "receiving pit" to hold the prepared pipeline segment to pull under the roadway. Both pits would need to be approximately 100 ft in length. One of these pits would have to be excavated through the stream that is perpendicular to Joanna Road on the east side and would capture or impact the adjacent and parallel stream in the south edge of the permanent easement. The standard cover requirement for passing under a County road is 5 ft below the pavement surface. Meeting this cover requirement with sufficient room to either operate the auger or install the pipeline segment for pulling under the road, would require excavating a trench 9 ft in depth with a top

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width of 27 ft for the safety of workers, since neither activity can be completed using trench boxes. Trench box bracing will not allow for auger movement to complete a boring under the road and the braces would be too tightly spaced to insert a pipeline segment into a trench box supported excavation.

For conventional open cut excavation construction east of Joanna Road, SPLP specifications require a minimum of 48-inches of cover over the installed pipelines. To meet these cover requirements, construction through the stream and wetlands would require a minimum authorized open-cut work space 75 ft in width to accommodate the 16- and 20-inch pipelines, allowing for each pipeline to be installed with sufficient separation for integrity management. The assessed area of impact by this open-cut plan would directly affect approximately 0.10 acres of stream bottoms, 0.52 acres of emergent wetland, and 1.32 acres of forested wetland.

A conventional auger bore is a practical means of pipeline installation where the topography is conducive, groundwater is manageable, and the length is short, but these criteria vary by substrate conditions at each location. Auger bores do not work well in rock, since the auger steering capability is nearly non-existent, and portions of the subsurface containing soils and rock formations of varying composition and density may cause deflection of the bore pipe. The horizontal length of the wetlands and streams to be crossed east of Joanna Road are beyond the technical limits of an auger bore to complete regardless of substrate conditions.

In sum, a combination of open-cut and conventional bores would not work as an alternative to the Joanna Road HDD.

Re-Route Analysis

No practicable re-route option lies to the north or south of the proposed route that would not transect the same roadway and waterways transected by the proposed route. Any re-route considered would be a "greenfield" or entirely new utility corridor requiring landowner consent or the use of condemnation and would create a new encumbrance on every private property crossed. As stated above, the existing alignment parallels existing pipelines.

There are no other routes that can be considered that will eliminate or minimize the potential affects to natural resources. Any re-route would require field assessments for the presence of regulated and protected resources. During the PADEP Chapter 105 permit process for the Mariner II East Project, SPLP created and submitted for review a project wide alternatives analysis. The baseline route provided for the pipeline construction to cross every wetland and stream on the project utilized open-cut construction procedures. The alternatives analysis submitted to PADEP conceptually analyzed the feasibility of any alternative to trenched resource crossings (e.g., re-route, bore, HDD). The decision-making processes for switching from an open-cut to HDD is discussed thoroughly in the previously submitted alternatives analysis and was an important part of the permit application package of HDD plans as currently permitted. The re-route analysis conducted for the Joanna Road HDD confirms the conclusions reached in the previously submitted alternatives analysis.

HORIZONTAL DIRECTIONAL DRILL REDESIGN

After review of the original HDD designs; available geologic/geotechnical data; field reports related to IR events that occurred during installation of the 20-inch pipe, and the hydro-structural characteristics of the underlying geology, 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.

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Revised Horizontal Directional Drill Design Summary: 16-inch

- Horizontal length: 2,700 ft
- Entry/Exit angle: 11-16 degrees
- Maximum Depth of cover: 140 ft
- Pipe design radius: 2,400 ft

CONCLUSION

The proposed redesign will extend the HDD approximately 390 ft east to an area where an additional geotechnical survey identified competent bedrock closer to the ground surface. The new eastern entry/exit area will allow the HDD tools to quickly enter bedrock and avoid large diabase boulders that were encountered during the 20-inch HDD. The entry/exit angle on the west side was increased. The new design places the HDD deeper to allow for more cover under the aquatic resources. Upon the start of S3-0250-16, SPLP will employ the following HDD best management practices (BMPs):


- 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, and allows the operator to manage the development of pressures that can induce an IR;
- SPLP inspectors will ensure that an appropriate diameter pilot tool, relative to the diameter of the drilling pipe, is used to ensure adequate "annulus spacing" around the drilling pipe exits to allow good return flows during the pilot drilling;
- SPLP will mandate short-tripping of the reaming tools 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;
- If necessary, SPLP will proactively grout the areas of previous IR locations and areas determined susceptible to IR events;
- During the reaming phase, the use of Loss Control Materials or grouting can be implemented if indications of a potential IR, such as a Loss of Circulation, is noted or an IR is observed, and
- If necessary, the pilot hole and reaming phases at the point of entry for the HDD may utilize casing, hammered into the substrate to the depth of more structurally competent bedrock, to prevent vertical or lateral movement of drilling fluids at shallow depths.

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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-evaluation 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


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2/12/2019
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Pertaining to the practice of geology


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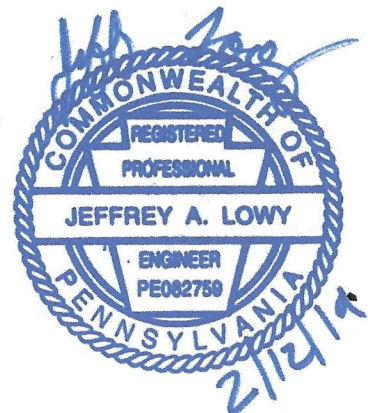
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Pertaining to the pipeline stress and HDD geometry


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**ATTACHMENT 1
GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT**



February 7, 2019

Mr. Matthew Gordon
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535 Fritztown Road
Sinking Spring, Pennsylvania 19608

Re: Sunoco PA Pipeline Project Mariner
East II, Wetland J48 - Joanna Road
HDD
S3-0250, PA-BR-0181.0000-RD-16
Hydrogeological Re-Evaluation Re-
port for 16-inch Pipeline
Caernarvon Township, Berks Coun-
ty, Pennsylvania
RETTEW Project No. 096302011

EXECUTIVE SUMMARY

1. This hydrogeologic re-evaluation is being prepared as a result of multiple inadvertent returns (IRs) that occurred during 30-inch reaming operations for the Wetland J48 - Joanna Road Horizontal Directional Drill (HDD) S3-0250 near the HDD exit point.
2. The Wetland J48 - Joanna Road HDD is underlain by sedimentary rocks of the Stockton Formation (Trs) and crystalline intrusive (igneous) rocks composed of diabase (Jd).
3. Geologic mapping, published reports, and field observations indicate a high degree of bedrock fracturing occur in the Stockton formation that are characterized by poorly formed, very closely spaced, generally open, and moderately well-developed joints with steeply dipping beds. Geologic mapping, published reports, and field observations indicate that the diabase unit is characterized by abundant, well-developed, and regularly spaced joints that are open and steeply dipping.
4. Water-bearing zones in the underlying geology generally occur in secondary openings along bedding planes, joints, faults, and fractures. Water-bearing zones in the Stockton Formation are reported to be distributed within the first 8 to 454 feet of the subsurface, with the greatest density of water-bearing zones occurring within the upper 100 feet of the subsurface. Water-bearing zones in the diabase generally occur in the weathered zone at the top of the bedrock; however, half of these occur within the uppermost 75 feet of the subsurface, with the greatest density of water-bearing zones occurring within the upper 350 feet of the subsurface. As a result, the storage and transmission of groundwater in the diabase is primarily dependent on the degree and extent of fracturing and joint development.
5. The 20-inch HDD pipeline installation was completed on November 18, 2018. The HDD profile for the proposed 16-inch HDD has been redesigned to increase its depth below buried utilities (sanitary sewer and existing SPLP pipeline), the land surface of Wetland

J48, Wetland W-BA8 and streambeds of unnamed tributaries (Streams S-A57, S-A58, S-A59, and S-J51).

6. Based on the hydro-structural characteristics of the underlying geology, and the IRs that occurred during installation of the 20-inch pipeline, the proposed Wetland J48 - Joanna Road 16-inch HDD is susceptible to the inadvertent return of drilling fluids during HDD operations. The redesigned 16-inch HDD profile and 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 Joanna Road S3-0250 HDD location on the Sunoco Pipeline, L.P. (SPLP) Pennsylvania Pipeline Project-Mariner II East (PPP-ME2) Project. The Joanna Road HDD is located in Caernarvon Township, Berks County, Pennsylvania. The HDD is located approximately 0.25-mile southwest of the intersection of Joanna Road and Elverson Road and approximately 0.5-mile east of State Route 10. The HDD was designed to be drilled under Joanna Road, Wetland Area J48, Wetland W-BA8, and stream channels of several unnamed tributaries discharging to the East Branch Conestoga River as shown on **Figure 1**.

The 16-inch HDD profile was redesigned on January 17, 2019, to extend the profile to the east and increase the depth of the HDD bore path crossing beneath the streams and wetlands. The redesigned west HDD entry/exit is at a surface elevation of approximately 583 feet above mean sea level (AMSL) and the redesigned east HDD entry/exit is at a surface elevation of approximately 649 feet AMSL. The HDD profile was extended to the east resulting in a total bore length of 2,700 feet and a path/pipe length of 2,726 feet. The extended HDD profile allows for deepening of the profile under the wetlands, streams, existing 8-inch SPLP pipeline and the Twin Valley School District Wastewater Treatment Plant (TVSD WWTP) sanitary sewer line (with the proposed 16-inch pipe being between 5 to 110 feet deeper than the 20-inch pipe). The existing 20-inch and proposed 16-inch S2-0210 HDD locations are shown on **Figure 1**, and the redesigned 16-inch HDD profile is included as **Appendix A**.

The proposed 16-inch HDD S3-0250 is located within the Gettysburg-Newark Lowland Section of the Piedmont Physiographic Province (Pennsylvania Department of Conservation and Natural Resources [PA DCNR], 2000). The dominant topography in areas underlain by the Stockton Formation is typified by undulating valleys of low relief with shallow valleys and isolated hills. In areas underlain by diabase, the topography is comprised of undulating hills of medium relief with moderately steep and stable natural slopes. Where the diabase was formed as dikes, the topography is expressed as narrow ridges; whereas areas of larger intrusions or flows form hills of moderate relief. Local relief is low to moderate and ranges in the vicinity of the site from approximately 581 feet AMSL to 622 feet AMSL (Google Earth, 2017). The site is drained by a large wetland area (J48) fed by shallow unnamed tributary streams which flow from east to west through the western half of the proposed west-east HDD path. The unnamed tributaries flow to the northwest across the western half of the HDD site where they discharge into

the East Branch Conestoga River. The area immediately surrounding the proposed 16-inch HDD is wooded. The Twin Valley Middle School and Twin Valley High School are located approximately 1,000 feet south of the site. The general area also consists of rural properties and land uses (e.g., farming, agriculture, and some commercial properties).

The proposed 16-inch HDD western entry/exit point is at a surface elevation of 583 feet AMSL and forms a slightly concave HDD profile that slopes gently upward toward the east to an elevation of 649 feet AMSL at the eastern HDD entry/exit point. The proposed 16-inch HDD will cross under several streams at the following depths: Stream S-A57, 42 feet below ground surface (bgs); Stream S-A59, 56 feet bgs; Stream S-A58, 76 feet bgs; and Stream S-J51, 117 feet bgs. The proposed HDD is located between Stations 14296+00 and 14278+00 on the pipeline, for an overall approximate horizontal length of 2,700 feet and a pipe length of 2,726 feet. The location of HDD S3-0250 is shown on **Figure 1**.

2.0 GEOLOGY AND SOILS

Twenty-four available published and online references were reviewed to evaluate the hydrogeology and soils present in the vicinity of HDD S3-0250. Detailed descriptions of the soils and bedrock geology underlying S3-0250 are included in the following section.

Low, et al. (2002) reported that the S3-0250 HDD site is situated in the northern portion of the Gettysburg-Newark Lowland Section of the Piedmont Physiographic Province. In eastern Pennsylvania, this portion of the Gettysburg-Newark Lowland Physiographic Province is underlain by sedimentary rocks of the Newark Group. These sedimentary rocks were deposited in a fault-bounded rift basin, commonly referred to as the Newark Basin, during late Triassic through early Jurassic time (Root and MacLachlan, 1999). According to Poth (1977) and Berg and Dodge (1981), the area in the vicinity of HDD S3-0250 is underlain by both clastic rocks (i.e., conglomerate, siltstone/sandstone, and shale) that are mapped as the Stockton Formation of Triassic age (Trs) and crystalline igneous (intrusive) diabase rocks of Jurassic age (Jd). Rocks comprising the Newark Basin often exhibit a reddish color and consist principally of conglomerate, arkose, sandstone, siltstone, argillite, and shale. Locally, the sedimentary sequence is interbedded with basaltic lava flows and is intruded by diabase dikes and sills. Based on available mapping, and field observations during completion of the 20-inch pipeline, the first (western entry point) 600 feet of the proposed 16-inch HDD will be completed in the Stockton Formation with the remainder of the HDD bore path (eastern exit point) completed in diabase. This geologic contact is identified on the geologic mapping included as **Figure 2**.

The Stockton Formation in Berks County is comprised primarily of light gray to buff, coarse-grained, arkosic sandstone but also includes red to purplish-red conglomerates, sandstone, shale, and siltstone. The shales and siltstones are typically thin to medium-bedded, whereas the sandstones are very fine- to coarse-grained and thin to thick-bedded. The conglomerates are thick-bedded with clasts/interbeds of quartz, quartzite, sandstone, siltstone, limestone, and shale. The diabase is comprised of a dense, very fine- to coarsely-crystalline, non-granular lithology forming narrow dikes and sheets that weather to form large, massive,

spheroidal boulders (Geyer and Wilshusen, 1982; Low, et. al., 2002). The rocks of the Newark Basin generally dip an average of 20° to the north-northwest. The geologic structure of the Gettysburg-Newark Lowland Physiographic Province consists principally of a north-northwestward dipping homocline (Newport, 1971).

According to Geyer and Wilshusen (1982), the Stockton Formation underlying HDD S3-0250 has moderately developed, moderately abundant, very closely spaced, naturally occurring fractures known as joints. These joints are typically open and vertical. Primary porosity occurs in the weathered portion of the formation. The joint and bedding plane openings collectively provide a secondary porosity in unweathered rock. The formation is only slightly resistant to weathering and is highly weathered to a moderate depth. The topography is characterized by undulating valleys of low relief. Natural slopes are generally stable, and cut slope stability is fair to poor due to rapid weathering when exposed to moisture. The overlying soil mantle is generally thin. The shales comprising the formation are highly weathered to a moderate depth, whereas areas underlain by sandstones and conglomerates exhibit much less weathering. The formation is moderately easy to excavate. The rock reportedly provides good foundation stability. Drilling rates are typically classified as slow due to the presence of quartz pebble conglomerate and in areas where the rock is adjacent to diabase intrusions.

The igneous diabase that occurs in the Gettysburg-Newark Lowland is dark gray to black, medium- to coarse-grained, with high silica content. The diabase is highly resistant to weathering and commonly weathers to form large, rounded boulders. Joints are well-developed, abundant, and open providing a very low secondary porosity. The overlying soil is thin. Diabase dikes typically form narrow ridges, and larger intrusions form hills of moderate relief. Excavation and/or drilling are classified as slow due to the density and hardness of the rock.

According to the United States Department of Agriculture Soil Survey of Berks County, Pennsylvania, soils within 450 feet of the drill path for HDD S3-0250 consist of Abbottstown silt loam (AbA), Bowmansville-Knauers silt loam (Bo), Joanna loam, 3 to 8% slopes (JnB), Joanna loam, 8 to 15% slopes (JnC), Joanna loam, 15 to 25% slopes (JnD), Neshaminy silt loam (NaC), Neshaminy gravelly silt loam, extremely bouldery (NhD), and Towhee silt loam, very stony (TwB). A site map showing the spatial distribution of the various soils along with the soil profile descriptions is included as **Attachment 1**.

3.0 HYDROGEOLOGY

Bedrock geology ultimately influences the storage, transmission, and use of groundwater. Geologic factors such as rock type, intergranular porosity, rock strata inclination, faults, joints, bedding planes, and solution channels affect groundwater movement and availability. According to Wood (1980) and Low (2002), groundwater within the clastic rocks of Berks County occurs under both unconfined (i.e., water table) and confined conditions. In general, groundwater generally occurs under unconfined conditions within the upper portion of the aquifer and under confined or semiconfined conditions in the deeper portions of the aquifer. The

groundwater flow system was conceptualized by Wood (1980) as 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 multi-aquifer system (LMAS, Wood 1980). Groundwater flow paths within the clastic rocks have both local and regional components. Locally, shallow groundwater discharges to the gaining portions of nearby streams and deeper regional groundwater flow is toward points of regional groundwater discharge such as the Schuylkill River. Groundwater divides may be different for each zone of groundwater flow and therefore may not coincide with surface water divides. Based on our review of available reference sources, no regional water table mapping is available for HDD S3-0250 or the surrounding area. As a result, no water table mapping was available for review or inclusion with this HDD re-evaluation report. Based on the geotechnical report and boring logs included as **Attachment 2**, the depth to water is quite shallow proximate to the HDD path with depths ranging from 8 to 13.5 feet bgs.

The direction of groundwater flow within the clastic rocks of Berks County is largely controlled by the hydraulic gradient and spatial variability of hydraulic conductivity. The groundwater flow system in the clastic rocks is highly anisotropic with the predominant flow direction parallel to the strike of the rock beds (Poth, 1977). The movement of groundwater in the fractured bedrock is generally greatest in highly permeable fractures and the orientation of bedding planes and fractures strongly influence the direction of groundwater flow within the aquifer (Sloto and Schreffler, 1994). Wells drilled to the same depth along strike generally penetrate the same water-bearing zones, whereas wells drilled to the same depth several hundred feet down dip of each other rarely intersect the same water bearing beds. The potential for well interference related to pumping is generally greatest for wells aligned parallel to strike, rather than in wells drilled in the direction of dip (i.e., perpendicular to strike). Wells spaced less than 2,000 feet apart along strike often experience interference effects (Newport, 1971). The cones of depression induced by pumping wells are usually elliptical in nature rather than circular, with the long axis orientated parallel to the strike of the rock bedding (Sloto and Schreffler, 1994). The presence of diabase often acts as a barrier to flow (Becher and Root, 1981; and Wood, 1980). No groundwater modeling was performed for the area surrounding HDD S3-0250.

The dense, uniform, crystalline, non-granular matrix of the diabase lacks bedding planes or consistent foliation and therefore possesses very low primary porosity and hydraulic conductivity. Although abundant, joint openings within the diabase provide very low secondary porosity (low permeability) and, combined with the corresponding low hydraulic conductivity, there is minimal pore space. As a result, the storage and transmission of groundwater in the diabase are primarily dependent on the degree and extent of fracturing. Water levels in the diabase show a strong seasonal influence. A thin mantle of stiff clay that is relatively impervious to moisture generally overlies diabase bedrock. This results in poor drainage in low-lying areas underlain by diabase (Low, et. al, 2002).

According to Low, et al (2002), the depths of water-bearing zones in the Stockton Formation range from 8 to 454 feet below land surface. Fifty percent (50%) of the 388 water-

bearing zones were penetrated at a depth of less than 97 feet with 90% of the water-bearing zones occurring at a depth of less than 265 feet. The greatest density of water-bearing zones (1.14 per 50 feet of well depth) is from 51 to 100 feet below land surface. The density of water-bearing zones encountered at depths greater than 351 feet are based on the presence of 4 or fewer water-bearing zones per 50-foot interval. The overall density of water-bearing zones in the Stockton Formation is 0.66 per 50-feet of well depth.

Well records from the PA DCNR Pennsylvania Groundwater Information System (PaGWIS) database were reviewed to identify domestic water supply wells located within a 0.5-mile radius of the proposed HDD right-of-way (ROW) boundary (PaGWIS, 2017). The search identified 19 wells within the 0.5-mile radius of the HDD. These wells consist of 17 private supply wells and 2 closed-loop geothermal wells used for heating and cooling purposes. A map showing the well locations relative to the proposed HDD location is included as **Figure 3**. Based on the PaGWIS database (**Figure 3**), it appears that the majority of the identified wells were completed as 6-inch-diameter open-rock wells at depths ranging from 70 to 250 feet bgs. Based solely on the PaGWIS database, the depth to bedrock ranges from 12 to 50 feet, and well construction consists of 36 to 63 feet of steel casing with the open-rock portions of the wells extending from 36 feet to 250 feet bgs. Reported well yields range from 1 to 20 gallons per minute (gpm). Three static water level measurements were recorded and range from 20 to 64 feet bgs. Based on the geologic mapping available for the area, it appears that the majority of the wells identified above were completed in the Stockton Formation proximate to the north-western end of the HDD bore path. Four of the 19 wells are located southeast of the proposed HDD exit point and along North Twin Valley Road, exclusively within diabase.

In January 2019, other Sunoco subcontractors researched private water supplies located within a 450-foot radius of the Joanna Road HDD. Two water wells were identified approximately 337 and 405 feet from the northwest HDD entry/exit. Additional information was available for one of these wells, and it is reported to have a total depth of 240 feet and a water level of 40 feet. A figure depicting the inventoried supply well locations and 450-foot radius relative to the HDD bore path is included in **Attachment 3**.

4.0 FRACTURE TRACE ANALYSIS

Fracture traces are defined as concentrated areas of high-angle bedrock fracturing forming linear features that can be identified using topographic mapping and aerial photography. The web-based Pennsylvania Imagery Navigator was used to access, download, and view aerial imagery of the HDD area. Six series of aerial photographs were reviewed that included photography dated March 12, 1938; August 8, 2004; June 11, 2008; July 4, 2010; June 1, 2013; and August 15, 2015 (Pennsylvania Spatial Data Access [PASDA], 2017). Two fracture traces were interpreted proximate to the HDD. One of these traces was oriented on a northwest-southeast trend roughly parallel to the HDD trace and East Branch Conestoga River. The second fracture trace was interpreted to be trending southwest-northeast roughly parallel to North Twin Valley Road and approximately 0.33 mile southeast of the HDD exit point. These features are likely related to the primary geologic structure of the site discussed above. The feature par-

allel to the HDD is identified on the Geology Map included as **Figure 2**. These fracture trace locations, or their associated degree of topographic expression, were not verified in the field; however, general surface drainage patterns near the HDD are characterized by the linear stream reach of the East Branch Conestoga River trending northwest (NW)-southeast (SE). Several surface streams flow generally NW-SE and southwest (SW)-northeast (NE) which also appear to reflect this local geologic structure. No other fracture trace features were apparent on the photographs reviewed and no fracture traces were identified in the published literature sources referenced.

5.0 GEOTECHNICAL EVALUATION

Five geotechnical borings were completed from March 9, 2015, through September 1, 2017, during the preliminary investigation of HDD S3-0250 and prior to initiating HDD operations. The five borings are located within the HDD limit of disturbance (LOD) and within the vicinity of Wetland J48. The borings were completed to investigate soil, residual soil, and shallow weathered bedrock conditions using hollow-stem auger drilling methods. An NQ core barrel/bit was used for rock coring. Three additional borings were completed in December 2018 and early January 2019.

The geotechnical investigation was performed in three phases. Three shallow borings, SB-01 through SB-03, were completed from March 9, 2015, through May 19, 2015, and two additional bedrock borings, Geo Bore B1 and Geo Bore B2, were completed in August/September 2017. Borings B-101, B-102, and B-103 were completed between December 26, 2018, and January 8, 2019.

2015 Borings

SB-01 was located approximately 50 feet west of the northwesternmost HDD entry/exit point, and SB-02 was located south of Wetland J48 approximately 0.25 mile south of the northwestern HDD S3-0250 entry/exit point. SB-03 was located approximately 150 feet southeast of the southeasternmost HDD S3-0250 entry/exit point. A map depicting soil boring locations is provided in **Attachment 2**. The generalized subsurface profile observed in SB-01 through SB-03 is described as follows.

- **SB-01:** 8.0 feet of SAND and SILTY CLAY with trace fine to coarse GRAVEL overlying 18.5 feet of FINE to MEDIUM SAND and SILTY CLAY with FINE to COARSE GRAVEL overlying partially weathered gray sandstone bedrock encountered at 26.5 feet. The total depth of the soil boring was 27.0 feet. Groundwater was encountered at 9.0 feet bgs.
- **SB-02:** 8.0 feet of SILTY CLAY and FINE SAND overlying 5.0 feet of CLAYEY SAND, overlying 3.0 feet of SILTY CLAY and FINE to MEDIUM SAND. The total depth of the soil boring was 16.0 feet where refusal was encountered at what appeared to be GRANITE or BASALT. Groundwater was encountered at 8.0 feet bgs.

- **SB-03:** 18.5 feet of SILTY CLAY and FINE SAND. Depth to bedrock was 18.5 feet where auger refusal was encountered. The underlying bedrock was described as fractured DIABASE with OLIVINE deposits. Total depth of the boring was 26.5 feet. Groundwater was encountered at 13.5 feet bgs.

The boring logs indicate that the soil/bedrock interface ranges from greater than 16 feet (SB-02) to 26.5 feet (SB-01 and SB-03) bgs. According to the Unified Soil Classification System (USCS), the soils consist of clayey sands (SC) above a clayey sand (SC)/clayey gravel (GC) mixture in SB-01. The soils in SB-02 consist of silty clay and fine sand (CL) above clayey fine and medium sand (SC) overlying silty clay and fine to medium sand (CL). SB-03 soils consist of silty clay and fine sand (CL) overlying partially weathered Diabase bedrock.

Below the auger refusal depth to the total depth of the additional core runs, bedrock was encountered and was described as follows.

- **SB-03:** From 18 to 21.5 feet, moderately fractured to slightly fractured Diabase and from 21.5 to 26.5 feet, intensely fractured Diabase with some Olivine deposits to unfractured Diabase with Olivine deposits at total depth of the boring. Total core recovery (TCR) ranged from good to excellent (80% to 100%) and rock quality designations (RQD) were fair (55% to 74%).

A geotechnical report for S3-0250 Wetland J48 was prepared for soil borings SB-01 through SB-03 and is provided in **Attachment 2**.

2017 Borings

Two additional borings were completed during August/September 2017 (Geo Bore B1) and August 28 through August 30, 2017 (Geo Bore B2), as part the second phase of the geotechnical investigation. Geo Bore B1 was drilled immediately adjacent to the HDD S3-0250 northwestern entry/exit point, and Geo Bore B2 was drilled immediately adjacent to the southeastern entry/exit point for HDD S3-0250. A map depicting soil boring locations is included with **Attachment 2**.

- **Geo Bore B1:** Geo Bore B1 was completed to a total depth of 115 feet with the top of bedrock encountered at approximately 13 feet bgs. The bedrock consisted of gray, partially to highly weathered SANDSTONE from 13 feet to 35 feet, with intermittent beds of CONGLOMERATE at approximately 15.5 feet to 16.5 feet and 28 feet to 29.5 feet. Reddish-brown to grayish-purple highly weathered SANDSTONE was encountered from approximately 35 feet to 66 feet bgs, followed by a bed of CONGLOMERATE from approximately 66 feet to 69 feet. SILTSTONE and MUDSTONE were encountered from approximately 65 feet to 85 feet, and reddish-brown weathered SILTSTONE was encountered from 85 to 115 feet. Groundwater was encountered at 10.4 feet bgs.

- **Geo Bore B2:** Geo Bore B2 was completed to a total depth of 145.0 feet bgs with the top of bedrock encountered at 13.0 feet. The bedrock consists of very fine to fine-grained, thin to thick-bedded, slightly weathered DIABASE to the total depth of the rock core (145.0 feet). Vertical fractures and clay seams were encountered at 32.4 feet to 34.4 feet, and a vertical fracture was encountered at 55.0 feet to 55.9 feet. Groundwater was encountered at 14.6 feet bgs.

The summary descriptions of Geo Bore B1 and Geo Bore B2 were derived from boring logs (provided for Geo Bore B2 only) and photographs of the core boxes (provided for Geo Bore B1 only) which are also included in **Attachment 2**.

2018-2019 Borings

Three additional borings were completed in December 2018 and January 2019 (Boring B-101, Boring B-102, and Boring B-103) as part of the third phase of geotechnical investigation. Borings B-101, B-102, and B-103 are located approximately 210, 490, and 600 feet, respectively, southeast of the eastern 20-inch HDD entry/exit point. A map depicting soil boring locations is included with **Attachment 2**.

Unconsolidated

- **Boring B-101:** Soil samples were not collected from the upper 5 feet of the boring, diabase boulders and soil, stiff to very stiff CLAY (CL) with sand and gravel, and diabase boulders and soil. Bedrock was encountered at 12.5 feet bgs.
- **Boring B-102:** Soil and residual soil samples were not collected at this location.
- **Boring B-103:** Soil and residual soil samples were not collected at this location.

Bedrock

- **Boring B-101** was completed to a total depth of 179.5 feet bgs with the top of bedrock encountered at 12.5 feet. From 12.5 to 29.5 feet bgs, hard to very hard, broken to massive, weathered to slightly weathered DIABASE was observed. A broken zone was encountered from 21.5 to 27 feet bgs and a mineral filled, 60⁰ fracture was encountered between 24.2 to 24.5 feet bgs. TCR ranged from 96 to 100%, while RQDs ranged from poor (37%) to good (83%). From 29.5 to 179.5 feet bgs, very hard, massive, fresh DIABASE was observed. A green chlorite filled 60⁰ fracture was encountered at 45.5 feet bgs, vertical fractures were encountered between 53 and 54 feet bgs. Chlorite filled fractures were encountered between 72.5 and 73.5 (70⁰ fractures), 134.5 and 146.3, and 162 and 163.5 (vertical fractures) feet bgs. A granite vein was encountered between 165.5 to 167.78 feet bgs. TCR was 100% and RQDs were excellent (100%). Groundwater was observed at ground surface at the completion of coring operations.
- **Boring B-102** was completed to a total depth of 130 feet bgs with the top of bedrock encountered at 3.5 feet. From 3.5 to 11.5 feet bgs, very hard, slightly bro-

ken, moderately to slightly weathered DIABASE was observed. TCR was 83%, while RQDs ranged from poor (30%) to fair (58%). From 11.5 to 130 feet bgs, very hard, massive, fresh DIABASE was observed. A mineral deposit was observed at 45 bgs. TCR was 100% and RQDs were excellent (100%). Groundwater was initially observed at 4 feet bgs and was observed at 6.8 feet bgs at the completion of coring operations.

- **Boring B-013** was completed to a total depth of 190 feet bgs with the top of bedrock encountered at 3.5 feet bgs. From 3.5 to 11 feet bgs, hard to very hard, slightly broken, slightly weathered to fresh DIABASE was observed. TCR ranged from 90 to 100%, while RQDs were good (80-88%). From 11 to 21 feet bgs, hard to very hard, massive, slightly weathered to fresh DIABASE was encountered. An 80⁰ fracture was encountered from 18 to 20 feet bgs. TCR was 100% and RQDs were excellent (100%). From 21 to 190 feet bgs, very hard, massive, fresh DIABASE was observed. Several 45⁰ fractures were encountered between 101 and 106 feet bgs. Long, near-vertical fractures were encountered between 106 and 111 feet bgs, and several horizontal fractures were encountered between 112.5 and 113 feet bgs. TCR was 100% and RQDs were excellent (100%). Groundwater was observed at ground surface at the completion of coring operations.

Please note that Skelly and Loy or RETTEW did not oversee or direct the geotechnical drilling programs associated with the S3-0250 HDD including but not limited to the selection of boring locations, determination of location, determination of surface elevation, 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, L.P. contractors. Skelly and Loy and RETTEW relied on these reports and incorporated their data into the general geologic and hydrogeologic framework included in this report.

6.0 FIELD OBSERVATIONS

Based on a site reconnaissance performed by a RETTEW geologist on September 19, 2017, there are bedrock exposures in the vicinity of the HDD entry point that occur in cutslopes consisting of fine-grained, light gray to tan sandstone of the Stockton Formation. Structural geologic measurements indicate that the bedding strike of the Stockton Formation is generally N30°E with a near vertical dip. Large diabase outcrops were also observed along the southeastern section of the alignment; however, these exposures consisted of massive boulders with indistinct bedding typical of the diabase unit. According to available geologic mapping, the southeastern 1,700 to 1,750 feet of the HDD bore path are underlain by bedrock characterized as diabase; this mapping is consistent with the referenced field observations. Based on local topography and bedrock dip reported in the published literature (Newport 1971; and Wood, 1980), bedrock strike is generally to the north-northeast (20° to 70°) which is also consistent with the field observations and geologic measurements of the Stockton Formation near the southeast HDD entry point. With the exception of the unnamed tributaries and previously

mapped J48 and W-BA8 wetland areas, no additional environmental receptors of concern were noted within the defined 450-foot HDD buffer area.

Multiple IRs occurred during the installation of the 20-inch pipe using HDD methods. The first IR occurred on April 13, 2018. Specific details regarding any of the IRs of drilling fluids that occurred can be found in the HDD Daily Reports submitted to SPLP.

The initial drilling events, performed by Ellingson Trenchless (Ellingson), started on July 16, 2017, when the 20-inch pilot hole was spudded in. After advancing the pilot bit to a trajectory length of 805 feet from the northwest entry point, Ellingson terminated the advancement of the pilot boring on July 21, 2017. SPLP stopped the advancement of the boring at the request of the Pennsylvania Governor.

Following is a summary and discussion of drilling activity and other events which occurred during the HDD installation upon re-starting operations on March 16, 2018.

- **March 16 and 17, 2018 – Pilot Drilling Resumes with Full Returns**
United Piping, Inc. (UPI) began to trip-in pilot bit to continue pilot hole advancement from west entry/exit of HDD profile. Extent of existing pilot hole is reached at 781 feet from the west entry point on March 17. No IRs were observed, and full returns were maintained at the west entry/exit returns pit.
- **March 18 – April 17, 2018 – Pilot Drilling Continued with Full Returns**
UPI advanced the pilot bit from a trajectory length of 781 feet to 2,000 feet from the west entry/exit point. No IRs were observed, and full returns were maintained the entire time.
- **April 18, 2018 – Pilot Completion with Full Returns**
The pilot hole was completed at a trajectory length of 2,132-feet from the west entry/exit point. No IRs were observed, and full returns were maintained at the west entry/exit returns pit.
- **April 20, 2018 – Borehole Ream with Full Returns 000**
UPI began the 32-inch push ream from the northwest entry and advanced the reamer 94 feet from the west entry/exit point. No IRs were observed, and full returns were maintained at the west entry/exit returns pit.
- **April 21 – May 4, 2018 – Borehole Ream with Full Returns**
UPI advanced the 32-inch reamer from a trajectory length of 94 to 724.5 feet from the west entry/exit point. No IRs were observed, and full returns were maintained the entire time.
- **May 5, 2018 – Borehole Ream with Full Returns**
UPI ceased advancement of the 32-inch reamer at an approximate trajectory length of 735-feet from the west entry/exit point. UPI began to trip the reamer out of the boring to inspect the reamer for wear since advancement rates had slowed down. No IRs were observed, and full returns were maintained at the west entry/exit returns pit.
- **May 7, 2018 – Borehole Ream with Full Returns**

Thirty-two-inch reamer was tripped out of the boring and inspected. UPI determined that the reamer was too worn for continued use and it needed to be replaced. No IRs are observed, and full returns were maintained at the west entry/exit returns pit.

- **May 8, 2018 – Borehole Ream with Full Returns**
UPI installed a 24-inch reamer onto the drill string and began to trip it back into the borehole. No IRs were observed, and full returns were maintained at the west entry/exit returns pit.
- **May 9, 2018 – Borehole Ream with Full Returns**
UPI finished tripping the 24-inch reamer into the borehole and began the 24-inch push ream at a trajectory length of 735 feet from the west entry point. No IRs were observed, and full returns were maintained at the west entry/exit returns pit.
- **May 10 – May 17, 2018 – Borehole Ream with Full Returns**
UPI advanced the 24-inch reamer from a trajectory length of 735 to approximately 1,570 feet from the west entry/exit point. No IRs were observed, and full returns were maintained the entire time.
- **May 18 – May 20, 2018 – Borehole Ream with Full Returns**
UPI ceased advancement of the 24-inch reamer at an approximate trajectory length of 1,570 feet from the west entry point and began to trip out the 24-inch reamer for an inspection of the cutting heads. Reamer bit was severely worn, and two roller-cones were missing and presumed to be downhole. UPI chose to initiate a 24-inch pull-ream (pulling the reamer from the east entry/exit point to the west entry/exit point). No IRs were observed, and full returns were maintained at the west entry/exit returns pit.
- **May 21 – May 24, 2018 – Borehole Ream with Full Returns**
UPI set up to initiate the 24-inch pull ream from the east entry/exit. No drilling fluids were circulated while UPI was setting up and no IRs were observed.
- **May 25, 2018 – Borehole Ream with Full Returns**
UPI began the 24-inch pull ream from the east entry/exit point toward the west entry/exit point and advanced the reamer a total of 128 feet. No IRs were observed, and full returns were maintained. Drilling fluid returns alternate between east and west entry/exit pits depending on the ability to clear cuttings through the borehole to the west entry/exit; no losses of circulation are observed or reported.
- **May 26 – June 1, 2018 – Borehole Ream with Full Returns**
UPI advanced the 24-inch reamer from a trajectory length of 128 to approximately 439 feet from the east entry/exit point. The total reamed footage was 2,009 feet. No IRs were observed, and full returns were maintained at the east and west entry/exit pits; no losses of circulation were observed or reported.
- **June 2, 2018 – Borehole Ream with Full Returns**
UPI ceased 24-inch pull ream operations at a trajectory length of 439 feet from the west entry/exit point. The 24-inch reamer is tripped out of the borehole and found to be worn and two roller-cones were missing and presumed to be down-

hole. No IRs were observed, and full returns were maintained at the east and west entry/exit pits; no losses of circulation are observed or reported.

- **June 3 – 25, 2018 – Roller-Cone Retrieval Attempts with Full Returns**
UPI began attempts to retrieve (i.e., “fish”) the lost downhole roller-cones to permit the continued advancement of the 24-inch pull ream without damaging additional tooling. Magnetic retrievers and basket-catchers were utilized in the attempts to retrieve the lost roller-cones; however, all attempts at recovering the cones were unsuccessful. No IRs were observed, and full returns were maintained at the east and west entry/exit pits.
- **June 26, 2018 – Roller-Cone Retrieval with Suspected IR**
UPI continued retrieval efforts for lost downhole roller-cones. At approximately 1825 hours on June 26, 2018, during routine inspection of the HDD path, turbidity and sediment deposits were identified within stream S-A58, East Branch Conestoga River, approximately 300 feet east-northeast of the HDD path near the southeast exit. UPI immediately ceased circulation of drilling fluids. The source of turbidity/sediment was determined to be a discharge outfall pipe associated with the nearby TVSD WWTP. Drilling fluids from the exit pit were pumped down, and tooling was removed from the borehole without drilling fluids be circulated. When the retrieval tool returned to the surface, one of the two lost cones had been recovered. No additional discharge was observed from the outfall.
- **June 27, 2018 – Roller Cone Retrieval Attempt with Confirmed IR**
HDD/retrieval operations resumed on June 27. As tooling entered the exit pit and drilling fluids were circulated, a turbid discharge was observed at the TVSD WWTP outfall and HDD operations were terminated. A containment structure made of sandbags and visqueen sheeting was immediately constructed around the outfall. Vacuum trucks, pumps, and hand tools were used to collect the drilling fluid released on June 26 and 27, 2018. A total of 12.5 gallons of drilling fluid were estimated to have been released within the East Branch Conestoga River since the turbidity/sediment in the stream was first discovered on June 26.
- **June 28, 2018 – No HDD Operations**
No HDD operations were completed on June 28, 2018, waiting for approval to rotate drill rods to create a flow path from the eastern entry/exit point to the western entry/exit point and to “dry” fish for the remaining cone.
- **June 29, 2018 – Roller-Cone Retrieval Attempts with No Drilling Fluid Circulation**
UPI was granted permission to rotate drilling rods and “dry” fish if no drilling fluids were circulated. UPI resumed cone retrieval attempts, the retrieval attempt was unsuccessful, and no additional attempts were completed.
- **July 3, 2018 – Drill Rig Removed from Eastern Entry/Exit Point**
UPI removed the Vermeer D140x100 drill rig from the eastern entry/exit point.
- **July 6 and 9, 2018 – Outfall Pipe Inspection**
FRANC Environmental Inc. performed video inspections of the TVSD WWTP effluent pipe on July 6 and 9, 2018. On July 6, 2018, a camera was advanced from the TVSD WWTP in a northeast direction toward the HDD path and the out-

fall location. The camera was advanced to approximately 148 feet, and no defects in the effluent pipe were observed. On July 9, 2018, the TVSD WWTP outfall pipe was excavated approximately 10 feet northeast of the limit of disturbance and a hole was cut in the pipe to insert the camera. The camera was advanced southwest toward the HDD path. Approximately 60 feet from the camera entry point in the immediate vicinity of the HDD path, a section of the metal outfall pipe was found to have been previously replaced/repared with polyvinyl chloride (PVC) pipe. The camera was unable to be advanced beyond this point. Evidence of a loose connection between the metal and PVC portions of the pipe was observed. The loose connection appeared to be allowing drilling fluid to enter the effluent pipe and flow towards the outfall. The end points of the two video inspections were estimated to be within 10 to 20 feet of each other.

- **August 1, 2018 – HDD Operations Resumed with Full Returns**
UPI pumped 30 cubic yards of grout into the eastern entry/exit point in accordance with Pennsylvania Department of Environmental Protection (PA DEP)-approved restart report dated July 5, 2018, and revised July 17, 2018. No IRs were observed, full returns were maintained as the drill rods were tripped out of the boring after grouting operations, and the TVSD WWTP outfall remained clear at the East Branch Conestoga River.
- **August 2, 2018 – Subsidence Feature Identified**
A subsidence feature, approximately 11 feet by 7 feet wide and approximately 10 feet deep, was identified along the HDD profile approximately 60 feet from the eastern entry/exit point. The feature was located between the two ME1 pipelines, approximately 10 feet from the 8-inch pipeline and 25 feet from the 12-inch pipeline. Operations were temporarily stopped to allow for further evaluation.
- **August 4, 2018 – Subsidence Feature Grouted and Borehole Grout Removal**
UPI pumped 9 cubic yards of grout into the subsidence feature. A 24-inch reamer was used to clear the previously grouted (August 1) eastern entry/exit portion of the HDD profile. Swabbing of the eastern end of the HDD profile was performed using the 24-inch reamer. No IRs were observed, and full returns were maintained.
- **August 5 – 6, 2018 – Borehole Ream with Full Returns**
UPI advanced the 24-inch reamer from the eastern entry/exit point westward to ensure that the borehole was clear of cuttings and grout prior to resuming cone retrieval efforts are resumed. No IRs were observed, and full returns were maintained.
- **August 7, 2018 – Roller Cone Retrieval Attempts with Full Returns**
While attempting to recover the missing roller-cone on the eastern entry/exit portion of the HDD profile, the retrieval basket became lodged in the borehole and broke free from the drill string under the August 2 subsidence feature, approximately 60 feet from the eastern entry/exit point. No IRs were observed, and full returns were maintained.
- **August 8 – 10, 2018 – Borehole Swabbing with Full Returns**

UPI mobilized to west entry/exit point to swab the western portion of the HDD boring with the 24-inch reamer prior to initiating roller cone retrieval efforts. No IRs were observed, and full returns were maintained.

- **August 11, 2018 – Roller-Cone Retrieval with Full Returns**
UPI completed swabbing efforts along the western portion of the HDD boring and initiated roller-cone retrieval efforts for the two-missing roller-cones from that direction. Efforts to recover the three remaining missing roller-cones have been unsuccessful to date. No IRs were observed, and full returns were maintained.
- **August 12 – 16, 2018 – Roller-Cone Retrieval Attempts with Full Returns**
UPI continued attempts to retrieve the two lost cones in the western portion of the borehole; however, all attempts at recovering the cones were unsuccessful. No IRs were observed, and full returns were maintained.
- **August 17, 2018 – Roller Cone and Basket Retrieval Attempts with Full Returns**
While attempting to recover the missing roller-cones on the western portion of the HDD boring, a portion of the retrieval basket became sheared off and was lost in the borehole. UPI installed a “J-hook” to the drill string and tripped it into the boring to retrieve the lost portion of the basket. No IRs were observed, and full returns were maintained.
- **August 18 – 23, 2018 – Fishing Basket Retrieval Attempts with Full Returns**
UPI continued attempts to retrieve the section of the fishing basket which had sheared off in the western portion of the boring. No IRs were observed, and full returns were maintained.
- **August 24, 2018 – Start Intercept Boring and Retrieval Attempts Continued with Full Returns**
UPI continued to fish for the missing cones and fishing baskets in the borehole. In addition, an intercept pilot was authorized and spudded in for the purposes of bypassing the sections of the existing boring containing roller cones and fishing basket debris. No IRs were observed, and full returns were maintained at the east and west entry/exit pits.
- **August 25 – September 9, 2018 – Intercept Boring and Roller Cone and Basket Retrieval Efforts Continued with Full Returns**
UPI continued to advance the pilot bit from a trajectory length of 0 to 1,085 feet from the new eastern entry/exit point. Efforts to recover the lost cones and fishing baskets continued; however, none of the recovery efforts was successful. No IRs were observed, and full returns were maintained.
- **September 10, 2018 – Intercept Boring Continued with Full Returns**
UPI continued the pilot intercept boring and reached a trajectory length of 1,212 feet. The fishing effort for the lost cones and fishing baskets was abandoned. A 24-inch reamer will be used to push the lost cones and fishing baskets into the abandoned eastern section of the boring. No IRs were observed, and full returns were maintained.

- **September 11, 2018 – Intercept Boring Continued with Full Returns**
UPI suspended advancement of the pilot intercept boring while the 24-inch reamer was pushed into the boring from the western entry/exit point and the lost debris was pushed into the section of the original boring that was going to be abandoned. No IRs were observed, and full returns were maintained.
- **September 12, 2019 – Intercept Pilot Completion and Full Returns**
Once the 24-inch reamer and drill rods were removed from the western entry/exit point, UPI resumed pilot bit advancement. The pilot bit intercepted the existing 32-inch borehole at a trajectory length of 1,327 feet from the eastern intercept entry/exit point. No IRs were observed, and full returns were maintained.
- **September 14, 2018 – Borehole Ream and Full Returns**
UPI began 30-inch push ream from eastern intercept entry/exit point. No IRs were observed, and full returns were maintained at the eastern returns pit.
- **September 15 – 17, 2018 – Borehole Ream with Full Returns**
A mixture of stormwater and drilling fluid overflowed the western entry/exit pit. Reaming was suspended, and remedial actions were initiated. Notification of the event submitted to the PA DEP and PA DEP completed a site inspection. Following completion of remedial activities, the 30-inch ream pass was resumed and continued without any incidents through September 17, 2018. No IRs were observed, and full returns were maintained.
- **September 18, 2018 – Borehole Ream and IR**
The 30-inch ream pass continued from east to west to a trajectory length of 310 with full returns. At 0515 hours, an IR was observed emanating from a subsidence feature which was located approximately 90 feet west of the eastern intercept returns pit. Drilling fluid from the subsidence feature flowed off the limits of disturbance (LOD) in a southwesterly direction and into Wetland BA10. The drilling fluid flowed through the wetland and into the TVHS WWTP ROW and into the surrounding woodland. The drilling fluid did not impact the East Branch Conestoga River. The subsidence feature was approximately 15 feet long by 8 feet wide and 6 feet deep. Reaming was immediately suspended, and containment of the IR, consisting of sandbags and filter socks, was constructed. It is estimated that approximately 30,000 gallons of drilling fluid were released through the subsidence feature, based on 5 to 10 minutes of pumping at 600 gpm, the draining of the returns pit, and the drainage of a portion of the borehole.
- **September 21, 2018 – PA DEP Restart Approval Received**
The Restart Plan was approved by PA DEP, and UPI indicated that reaming activities would not resume until the subsidence feature was remediated.
- **September 22, 2018 – Subsidence Feature Remediation**
The subsidence feature that was identified on September 18, 2018, and the cause of the IR was excavated and 27 cubic yards of flowable fill (grout) were placed within the feature and allowed to cure for 24 hours. This feature was referred to as “Subsidence Area #2”.

- **September 23, 2018 – Resumed Borehole Ream**
UPI began to advance the 30-inch reamer into the boring from the eastern intercept entry/exit point. Advancement of the reamer was temporarily stopped after advancing approximately 80 feet into the borehole when a new cavity opened west of Subsidence Area #2 and drilling fluid began to enter this cavity.
- **September 24, 2018 – Borehole Ream with Full Returns**
The 30-inch pull ream (east to west) resumed with no IRs observed and full returns maintained.
- **September 25 – October 19, 2018 – Borehole Ream with Full Returns**
UPI continued to advance the 30-inch reamer from a trajectory length of 342 feet to 1,512 feet from the eastern intercept entry/exit point. No IRs were observed, and full returns were maintained.
- **October 20, 2018 – 30-inch Borehole Ream Completed with Full Returns**
UPI completed the 30-inch ream when the reamer entered the previously 32-inch reamed section of the borehole. As the 30-inch reamer is being tripped back out to the eastern intercept entry/exit point, it became stuck at an approximately trajectory length of 1,528 feet from the east intercept entry/exit point. No IRs were observed, and full returns were maintained.
- **October 21 – 22, 2018 – Removal of 30-inch Reamer**
UPI continued attempts to free the 30-inch reamer from the borehole. UPI was able to free the reamer on October 22 and continued to trip the reamer out to the eastern intercept entry/exit point. No IRs were observed, and full returns were maintained.
- **October 23, 2018 – Pipe Pull Test**
The 30-inch reamer was tripped out of the boring. No cones were lost from the reamer. UPI began a pipe pull test by pulling a test section of 20-inch product pipe through the boring to determine if additional reaming/swabbing of the borehole was needed. The test section of pipe was pulled through the borehole without getting stuck, and preparations were made to perform the 20-inch product pipe pull.
- **October 26, 2018 – 20-inch Product Pipe Pull**
The 20-inch product pipe pull was initiated and, at a trajectory length of approximately 600 feet from the eastern intercept entry/exit point, the pipe became stuck. No IRs were observed, and full returns were maintained.
- **October 28, 2018 – 20-inch Product Pipe Pull**
The 20-inch product pipe was freed and removed from the borehole. The 24-inch reamer that was in front of the product pipe was missing all 5 roller-cones and the product pipe was badly gouged. UPI began another 30-inch pull from the western entry/exit point to the eastern intercept entry/exit point.
- **October 29 – 30, 2018 – Borehole Ream**
UPI continued to pull the 30-inch reamer through the borehole from the west to the east. At an approximate trajectory length of 1,700 feet, UPI began to trip the 30-inch reamer back to the western entry/exit point. Once the 30-inch reamer

was removed from the borehole, UPI began to pull a 28-inch reamer from the western entry/exit point to the eastern intercept entry/exit point.

- **October 31 – November 1, 2018 – UPI Demobilization**
UPI demobilized from the location and left the 28-inch reamer and drill rods remaining in the boring.
- **November 4 – 6, 2018 – Michels Directional Crossing Mobilization**
Michels Directional Crossing (Michels) began to mobilize to the location to recover the lost cones and fishing basket from the boring and complete the borehole reaming and 20-inch product pipe pull. Michels began to remove UPI's drill rods and 28-inch reamer from the borehole by tripping the equipment out of the western entry/exit point.
- **November 7, 2018 – Borehole Survey and Roller Cone Retrieval Attempts**
Michels conducted a survey of the boring looking for the 12 lost cones with a metal detector and to check the integrity of the boring. Michels completed the survey and began to trip retrieval tools into the boring from the western entry/exit point to the east to recover the twelve lost cones.
- **November 8 – 9, 2018 – Roller Cone Retrieval Attempts with Full Returns**
Michels recovered 11 of the 12 lost cones after the first retrieval attempt. A second attempt was undertaken but was not successful. Michels advanced a milling tool from the western entry/exit point to the eastern intercept entry/exit point to remove any ledges or obstructions that were present in the borehole. No IRs were observed, and full returns were maintained while drilling fluids when circulated.
- **November 10 – 16, 2018 – Installation of Surface Casing**
Michels installed 36-inch and 30-inch sections of surface casing into the boring from the eastern intercept entry/exit point through the "boulder collapse zone" and into competent bedrock. The 36-inch casing was installed to a trajectory length of 137 feet from the eastern intercept entry/exit point. Michels utilized a "Durango" tool to break up the boulders that were in the borehole and set the 30-inch casing at a trajectory length of 138 feet. No IRs were observed, and full returns were maintained while drilling fluids were circulated.
- **November 17, 2018 – Borehole Reaming with Full Returns**
Michels completed two ream passes with a 28-inch reamer. No IRs were observed, and full returns were maintained.
- **November 18, 2018 – 20-inch Product Pipe Pull**
Michels completed the 20-inch product pipe pull.

7.0 CONCEPTUAL HYDROGEOLOGIC MODEL

Groundwater occurring in the watershed occupied by HDD S3-0250 originates as precipitation or snowmelt. The precipitation infiltrates through the overburden soils. As previously described, shallow groundwater generally occurs under unconfined conditions within the upper portion of the bedrock LMAS. Due to the lack of site-specific data, it was not determined if the groundwater table occurs within the soils or bedrock. It is assumed that the groundwater table

proximate to the HDD path is relatively shallow and may exist in some areas of the overburden soils that contribute flow to these local shallow groundwater discharge zones given that several unnamed tributaries flow above (across) the HDD profile where they discharge to the East Branch Conestoga River. The thickness of the regolith and saturated regolith varies according to the underlying geohydrologic unit and topographic setting (Low, et. al, 2002).

Logs of the five geotechnical borings drilled from March 2015 through January 2019 indicate that the soil thickness near HDD S3-0250 ranges from approximately 13 to 26.5 feet and consists predominantly of sand, silty sand, clayey sand, silty clay, fine to medium sand, and inorganic clay. Recorded descriptions for the bedrock cores included mudstone, siltstone, sandstone, quartz pebble conglomerate, and diabase (also described as basalt or granite). Data tabulated for supply wells found in the PaGWIS database (**Figure 3**) within a 0.5-mile radius of the HDD trace recorded measured water levels in the bedrock aquifer ranging from 20 to 64 feet bgs. Depth to water measurements obtained from three shallow geotechnical soil borings (SB-01, SB-02, and SB-03) completed within the soil regolith ranged from 8 to 13.5 feet bgs.

The Stockton Formation is highly anisotropic with the predominant flow direction parallel to bedrock strike. As mentioned above, the local occurrence of an intrusive diabase sill or dike was identified proximate to this HDD. The transport of groundwater in the fractured bedrock is generally greatest within highly permeable fractures. The orientation of the bedding planes and fractures primarily influence the direction of groundwater flow (Sloto and Schreffler, 1994). Wells drilled to the same depths along bedrock strike generally penetrate the same water-bearing zones, whereas wells drilled to the same depth several hundred feet down dip of each other rarely intersect the same water-bearing zones. Parker and others (1964, p. 84) considered most of the water in the Stockton Formation to be semi-confined or confined by shale and poorly permeable sandstone and conglomerate units acting as confining layers. Some site-specific evaluation of the bedrock has been completed in areas proximate to the geotechnical borings completed along this HDD profile. No detailed characterization or groundwater flow modeling of the bedrock aquifer was performed as part of this hydrogeologic re-evaluation.

The groundwater flow direction in the overburden soils is presumed to mimic surface topography which slopes gently to the northwest toward the wetland areas and each of the unnamed tributaries to the East Branch Conestoga River. This shallow groundwater flow direction is supported by the above-referenced depth to water measurements recorded during the geotechnical investigation of the unconsolidated regolith. Wetlands J48 and W-BA8 are sustained by local shallow groundwater flow discharges. Wetland J48 is situated in two areas: 1) immediately surrounding the eastern half of the proposed 16-inch HDD trace and 2) approximately 400 feet south of the western half of the proposed HDD trace. The proposed HDD crosses under Wetland W-BA8 approximately 250 to 300 feet east of the western HDD exit point. The unnamed tributaries flow to the northwest beginning near the center of the HDD trace and eventually discharging to the East Branch Conestoga River. The geotechnical report and boring logs included as **Attachment 2** show that the depth to water is quite shallow proximate to the HDD path with depths ranging from 8 to 13.5 feet bgs. Based on this information,

the uppermost groundwater table is presumed to occur within the unconsolidated regolith under unconfined conditions.

8.0 CONCLUSIONS

Based on published geologic and hydrogeologic information, the S3-0250 HDD location is underlain by clastic sedimentary rocks (conglomerate, siltstone/sandstone, and shale) of the Stockton Formation and dense, very fine to coarsely crystalline intrusive diabase. Groundwater movement within these rocks is primarily through a network of interconnected secondary openings (e.g., fractures, joints, and faults) that were developed by external forces following deposition of these geologic units. Geotechnical rock core observations have confirmed that the local bedrock underlying the site is fractured and comprised of steeply dipping joint and bedding planes. All of the water supply wells identified in the vicinity of HDD S3-0250 are constructed in the deeper bedrock portion of the LMAS indicating that none of the domestic wells relies on the shallow (uppermost) LMAS that provides a source of sustaining groundwater discharge to the wetlands and unnamed tributaries discharging to the East Branch Conestoga River. The HDD profile extends entirely within both the shallow unconsolidated regolith materials and weathered to highly weathered bedrock.

The originally proposed 16-inch HDD profile was relatively shallow at the entry and exit points and passed through both the shallow unconsolidated overburden and weathered to highly weathered bedrock. Based on the hydro-structural characteristics of the underlying geology described in this report and the previous occurrence of IRs during installation of the 20-inch pipe, the Joanna Road HDD site is susceptible to an IR of drilling fluids during HDD operations. As a result, the HDD profile has been redesigned to allow for deeper crossings beneath the wetlands, streams, existing SPLP pipeline and sanitary sewer line (with the proposed 16-inch pipe being between 5 to 110 feet deeper than the 20-inch pipe). The inclination of the entry and exit angles has been increased to allow the pipe to be installed through protective soils, residual soils, and bedrock, and in closer proximity to the entry and exit points than the original, shorter and shallower profile. From a geologic perspective, the longer and deeper profile, in conjunction with the proposed engineering controls and/or drilling best management practices, will be used to reduce the risk of an IR and/or a loss of drilling fluid. Drilling procedures should account for the variability in bedrock strength and fracturing. Drilling BMPs are described in the Horizontal Directional Drill Analysis component of the overall re-evaluation package.

9.0 REFERENCES

- Becher, A. E., and S. I. Root, 1981, Groundwater and Geology of the Cumberland Valley, Cumberland County, Pennsylvania: Pennsylvania Geological Survey, 4th series, Water Resource Report 50, 95 pages.
- Berg, T. M., W. E. Edmunds, A. R. Geyer, and others, Compilers, 1980, Geologic Map of Pennsylvania: Pennsylvania Geologic Survey, Fourth Series, Map 1, 2nd Edition, 3 sheets, Scale 1:250,000.

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Confidential and Privileged , Subject to Attorney and Client Review

- Berg, T. M., and C. M., Dodge, 1981, Atlas of Preliminary Geologic Quadrangle Maps of Pennsylvania, Pennsylvania Topographic and Geologic Survey, Map 61, 636 pages.
- Faill, R. T., 1973, Tectonic Development of the Triassic Newark-Gettysburg Basin in Pennsylvania, Geological Society of America Bulletin, Volume 84, pages 725-740.
- Geyer, A. R., and W. H. Bolles, 1979, Scenic Geologic Features of Pennsylvania, Pennsylvania Topographic and Geologic Survey, Environmental Geology Report 7, 508 pages.
- Geyer, A. R., and P. J. Wilshusen, 1982, Engineering Characteristics of the Rocks of Pennsylvania, Pennsylvania Topographic and Geologic Survey, Environmental Geology Report 1, Second Edition, 300 pages.
- Glaeser, J. D., 1963, Lithostratigraphic nomenclature of the Triassic Newark-Gettysburg Basin, Proceedings of the Pennsylvania Academy of Sciences, Volume 37, pages 179-188.
- Google Earth Pro, 2017, Version 7.1.8.3036, August 29, 2017.
- Hall, G. M., 1934, Groundwater on Southeastern Pennsylvania, Pennsylvania Topographic and Geologic Survey, Water Resources Report, No. 2, 255 pages.
- Johnston, H. E., 1966, Hydrology of the New Oxford Formation in Lancaster County, Pennsylvania: Pennsylvania Geological Survey, 4th Series, Water Resource Report 23, 80 pages.
- Longwill, S. M., and C. R. Wood, 1965, Ground-Water Resources of the Brunswick Formation in Montgomery and Berks Counties, Pennsylvania, Pennsylvania Topographic and Geologic Survey, Water Resources Report, W22, 59 pages.
- Low, Dennis J., Daniel J. Hippe, and Dawna Yannacci, 2002, Geohydrology of Southeastern Pennsylvania, U.S. Geological Survey, Water-Resources Investigations Report 00-4166, 347 pages.
- Newport, T. G., 1971, Ground-water Resources of Montgomery County, Pennsylvania, Pennsylvania Topographic and Geologic Survey, Water Resources Report, W29, 83 pages.
- Parker, G. G., A. G. Hely, W. B. Keighton, Olmstead, F.H., and others, 1964, Water Resources of the Delaware River Basin: U.S. Geological Survey Professional Paper 381, 200 pp.
- Pennsylvania Bureau of Topographic and Geologic Survey, Department of Conservation and Natural Resources, 2001, Bedrock Geology of PA, Edition: 1.0, Digital Map. Retrieved from internet 9-30-2004; [HTTP://www.dcnr.state.pa.us/topogeo/map1/bedmap.aspxDL](http://www.dcnr.state.pa.us/topogeo/map1/bedmap.aspxDL) Data: Page oexp.zip [[HTTP://www.dcnr.state.pa.us/topogeo/map1/bedmap.aspx](http://www.dcnr.state.pa.us/topogeo/map1/bedmap.aspx)].

Mr. Matthew Gordon
Sunoco Pipeline, L.P.
RETTEW Project No. 096302011
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February 7, 2019
Confidential and Privileged , Subject to Attorney and Client Review

Pennsylvania Department of Conservation and Natural Resources, Pennsylvania Groundwater Information System (PaGWIS) database, website address: <http://www.dcnr.pa.gov/Conservation/Water/Groundwater/PAGroundwaterInformationSystem/Pages/default.aspx>, accessed February 6, 2019.

Pennsylvania Department of Conservation and Natural Resources, 2000, Map 13 Physiographic Provinces of Pennsylvania, Fourth Edition.

Pennsylvania Spatial Data Access, 2017, The Pennsylvania Geospatial Data Clearinghouse, website address <https://imagery.PASDA.psu.edu/ArcGIS/Rest/Services/PASDA>, accessed February 5, 2019 (aerial photographic imagery database).

Poth, C. W., 1977, Summary Ground-Water Resources of Lancaster County, Pennsylvania: Pennsylvania Geological Survey, 4th Series, Water Resource Report 43, 80 pages.

Root, S. I., and D. B. MacLachlan, 1999, Gettysburg-Newark Lowland, in C. H. Shultz (editor), Geology of Pennsylvania: Pennsylvania Topographic and Geologic Survey and Pittsburgh Geological Society, Special Publication 1, pages 298-305.

Sloto, R. A., and C. L. Schreffler, 1994, Hydrogeology and Groundwater Quality of Northern Bucks County, Pennsylvania, United States Geological Survey, Water-Resources Investigations Report 94-4109, 85 pages.

United States Department of Agriculture, 2017, Natural Resources Conservation Service, Published Soil Surveys for Pennsylvania, Berks County, Pennsylvania: website address <https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=PA>, accessed September 19, 2017.

Vecchioli, J., L. D. Carswell, and H. F. Kasabach, 1969, Occurrence and Movement of Ground Water in the Brunswick Shale at a Site Near Trenton, New Jersey, United States Geological Survey, Professional Paper 650-B, 154-157 pages.

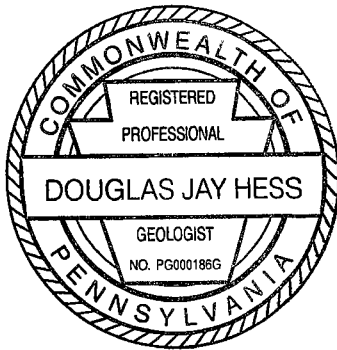
Wood, C. R., 1980, Groundwater Resources of the Gettysburg and Hammer Creek Formations, Southeastern, Pennsylvania, Pennsylvania Geologic Survey, 4th Series, Water Resources Report 49, 87 pages.

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10.0 CERTIFICATION

The studies and evaluations presented in this report (other than Section 5.0) were completed under the direction of a licensed professional geologist (P.G.), and are covered under the P.G. seal that follows.

By affixing my seal to this document, I am certifying that the information 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, P.G.
License No. PG-000186-G

Sincerely yours,

SKELLY and LOY, Inc.

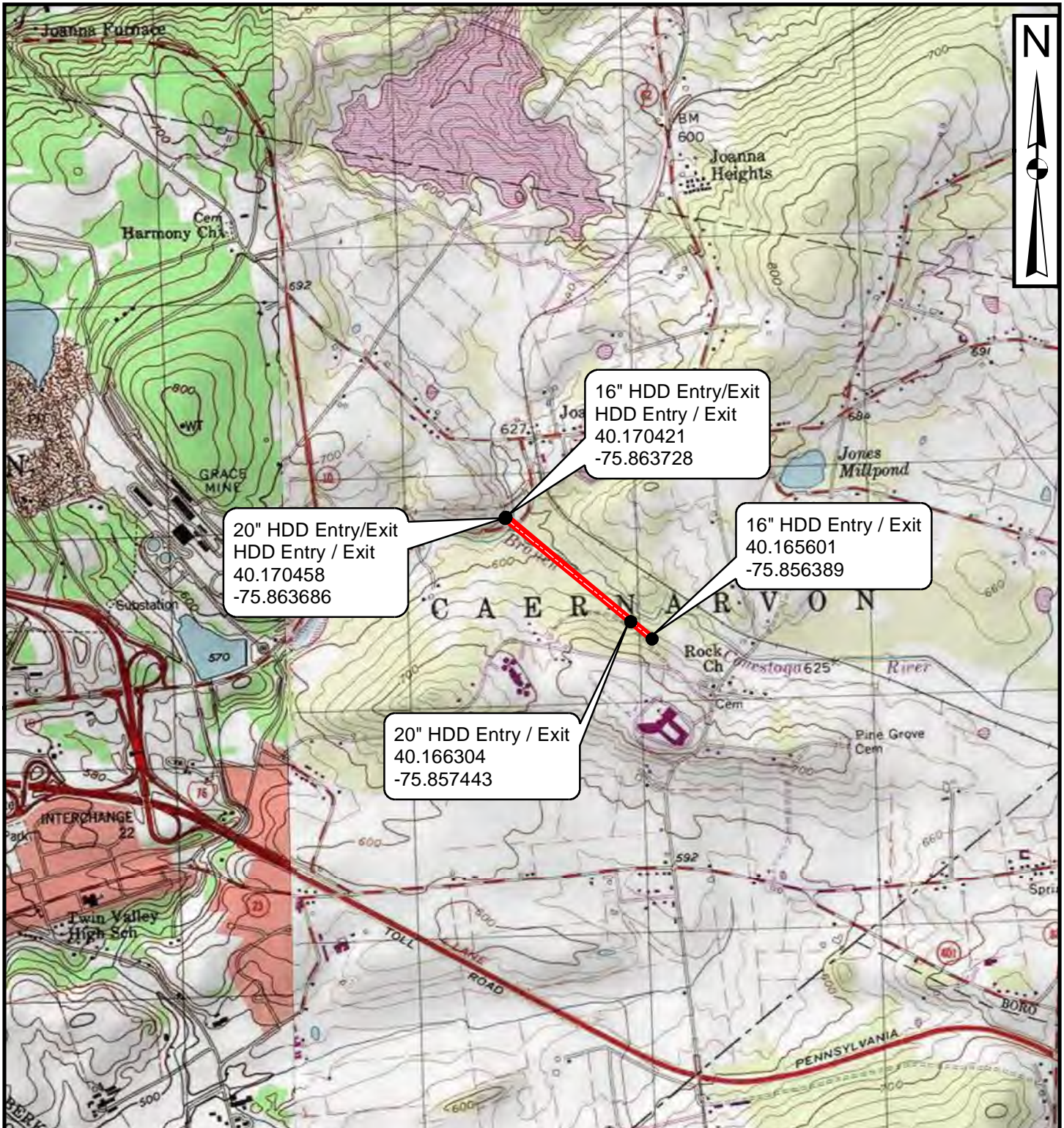
A handwritten signature in blue ink, appearing to read "Douglas J. Hess", is written over the typed name.

Douglas J. Hess, P.G.
Director of Groundwater
and Site Characterization
Geo-Environmental Services

Enclosure

cc: R17-0296.HYD
File: 16 inch re eval_Rpt Joanna Road - DJH edits_.docx

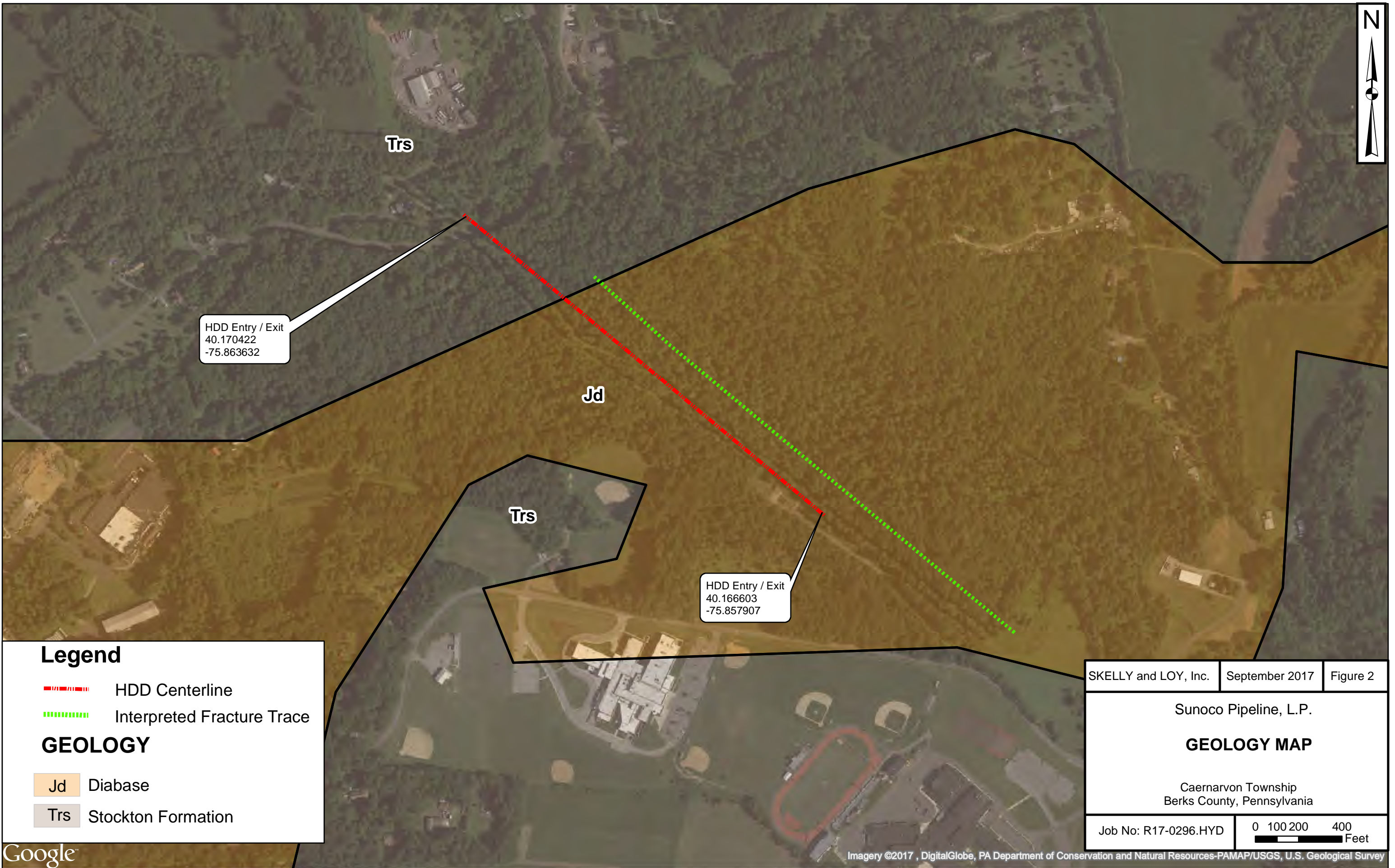
FIGURES





LEGEND	
●	HDD Entry / Exit
—	HDD Bore

Source: U.S.G.S. 7.5' Quadrangles - ELEVERSON, PENNSYLVANIA.



SKELLY and LOY, Inc.	February 2019	Figure 1
Sunoco Pipeline, L. P. Joanna Road		
PROJECT LOCATION MAP		
Caernarvon Township Berks County, Pennsylvania		
R17-0296.HYD	0 500 1,000 2,000 Feet	



Legend

-  HDD Centerline
-  Interpreted Fracture Trace

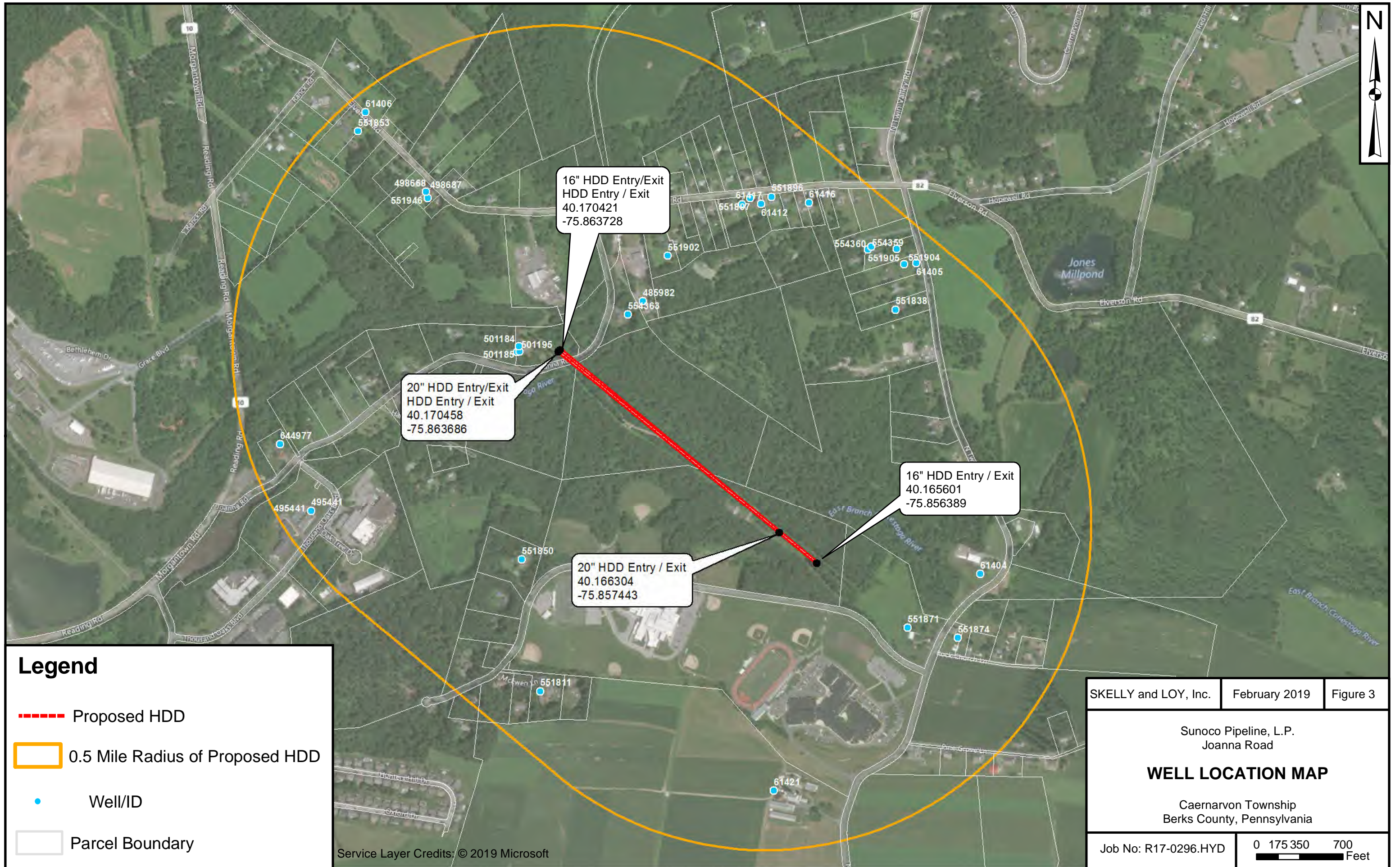
GEOLOGY

-  Jd Diabase
-  Trs Stockton Formation

SKELLY and LOY, Inc. | September 2017 | Figure 2

Sunoco Pipeline, L.P.
GEOLOGY MAP
Caernarvon Township
Berks County, Pennsylvania

Job No: R17-0296.HYD | 0 100 200 400 Feet



ATTACHMENT 1



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 **Berks County, Pennsylvania**

HDD S3-0250



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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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

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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

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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: 1:5,970 if printed on A landscape (11" x 8.5") sheet.

0 50 100 200 300 Meters

0 250 500 1000 1500 Feet

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 1:24,000.

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: Berks County, Pennsylvania
 Survey Area Data: Version 13, Sep 19, 2016

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

Date(s) aerial images were photographed: Jul 18, 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.

ATTACHMENT 2

Figure 1: Site Vicinity Map

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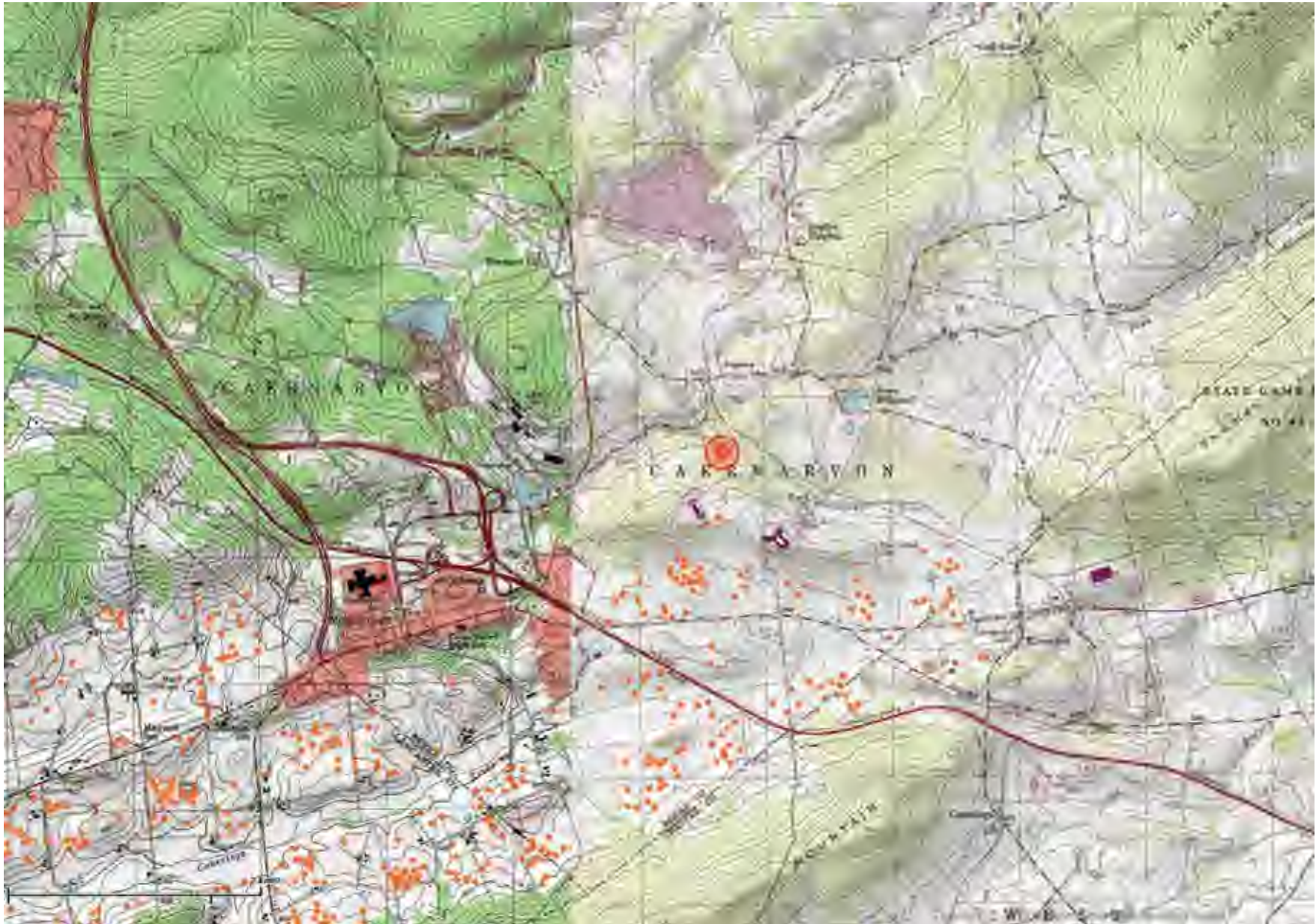
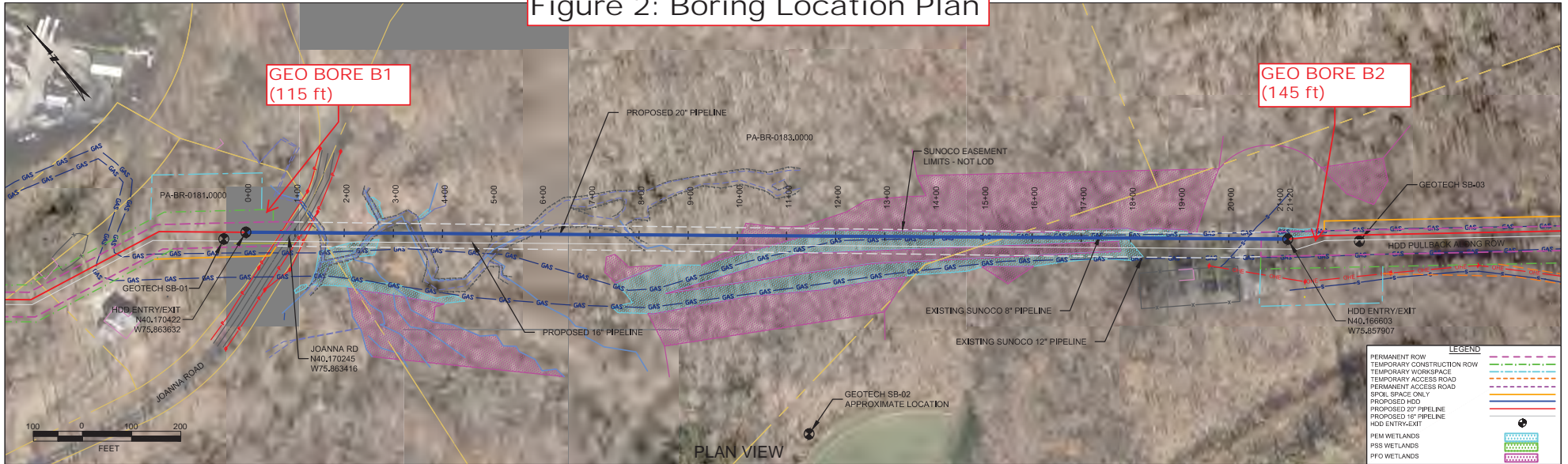
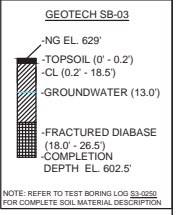
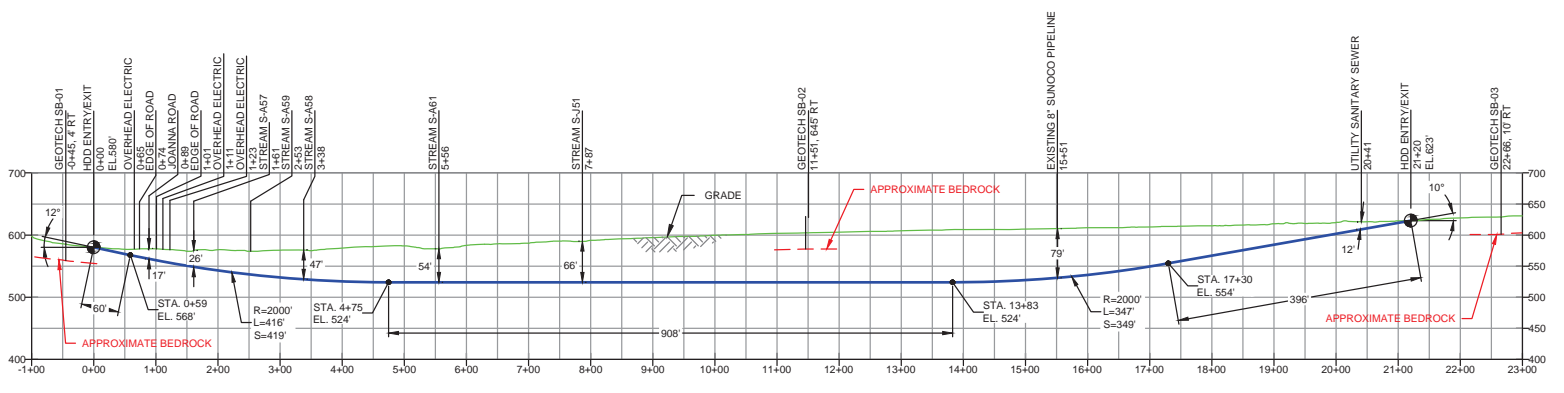
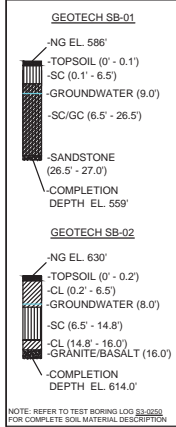


Figure 2: Boring Location Plan



PROFILE VIEW



- DESIGN AND CONSTRUCTION:
- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
 - 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.
 - DESIGNED IN ACCORDANCE WITH CFR 49.195 & ASME B31.4
 - CROSSING PIPE SPECIFICATION:
HDD HORZ LENGTH (L)=2132'
HDD PIPE LENGTH (S)=2132'
20" x 0.456" W.T. X45 AP5L PSL2 ERW, BFW COATING, 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R99)
 - INTERNAL DESIGN PRESSURE: 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS))
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD)
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 - CARRIER PIPE NOT ENCASED.
 - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
 - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
 - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

- NOTES
- ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
 - STATIONING IS BASED ON HORIZONTAL DISTANCES.
 - ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, L.P. 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, L.P. FOR ANY DAMAGES RESULTING FROM ERRORS OR OMISSIONS THEREIN.
 - CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.
 - SUNOCO EMERGENCY HOTLINE NUMBER IS 811-800-786-7440.

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
5	DESIGN CHANGE (OFFSET DRILL 10')	MRS	02/23/17	RMB	02/23/17	AMC	02/23/17
4	REVISED PROFILE WITH 2017 LIDAR	MRS	02/23/17	RMB	02/23/17	AMC	02/23/17
3	UPDATED SUNOCO EASEMENT LIMITS - NOT LOD	MRS	10/24/16	RMB	10/24/16	AAW	10/24/16
2	REVISED PER ENGINEERING COMMENTS	MRS	08/19/16	RMB	08/19/16	AAW	08/19/16
1	REVISED PER COMMENTS FROM REI REVIEW	MRS	02/26/16	RMB	02/26/16	AAW	02/26/16
0	ISSUED FOR CONSTRUCTION	MRS	01/21/16	RMB	01/21/16	AAW	01/21/16

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
JOANNA ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'
DWG. NUMBER: PA-BR-0181.0000-RD

Figure 3: Site Geology Map

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DATE STARTED: 8/31/17
 DATE COMPLETED: 9/1/17
 COMPLETION DEPTH: 115.0 ft
 BENCHMARK: N/A
 ELEVATION: N/A
 LATITUDE: n/a°
 LONGITUDE: n/a°
 STATION: N/A OFFSET: N/A
 REMARKS:

DRILL COMPANY: Eichelbergers
 DRILLER: T. Growden LOGGED BYR. Peddishree
 DRILL RIG: Dledrich D-50
 DRILLING METHOD: Casing/Rock Coring
 SAMPLING METHOD: 2-in SS1.874-in Core
 HAMMER TYPE: Automatic
 EFFICIENCY: N/A
 REVIEWED BY: F. Hoffman

BORING B-01		
Water	▽ While Drilling	8 feet
	▼ Pre-Core	9.5 feet
	▽ Post-Core	10.4 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	STRENGTH, tsf ▲ Qu * Qp	Additional Remarks	
0				S-1	2	FILL -Limited recovery consisted of gravel-sized sandstone fragments; the SPT N-value indicates a loose relative density		6-6-4-4 N=10	3	⊙			
				S-2	5	Possible FILL -Loose, Brown, Clayey SAND, moist	SC	9-4-4-5 N=8	23	⊙	×	Fines=49.8%	
				S-3		RESIDUUM -Dense, Brown, Clayey GRAVEL with Sand, wet	GC	11-10-26-50/3*15			×	⊙	Fines=24.3%
						Highly Weathered SANDSTONE -No sample recovery within this stratum							
				S-4	0	Conglomeratic SANDSTONE -Light gray-brown to dark gray, Fine to coarse grained, Weathered to Highly Weathered, very broken to massive, very hard		50/0"				⊙	3 min.
				R-1	63			RQD=11 Rec=75%				⊙	170.4 pcf 2 min.
				R-2	49	SANDSTONE -Light gray-brown to dark gray-brown, Fine grained, Highly Weathered, very broken to slightly broken, very hard to extremely hard, multiple soil seams and layers		RQD=0 Rec=82%					4 min. 3 min. 3 min. 4 min. 3 min. 4 min. 4 min. 4 min. 4 min. 3 min.
Continued Next Page													

 <p>Professional Service Industries, Inc. 1707 S. Cameron Street, Suite B Harrisburg, PA 17104 Telephone: (717) 230-8622</p>	PROJECT NO.:	04911457
	PROJECT:	Energy Transfer HDD (DPS)
	LOCATION:	Joanna Road (PPP5)
		Berks Co., PA
		PA-BR-0181.0000-RD/PO#20170822

DATE STARTED: 8/31/17
 DATE COMPLETED: 9/1/17
 COMPLETION DEPTH: 115.0 ft
 BENCHMARK: N/A
 ELEVATION: N/A
 LATITUDE: n/a°
 LONGITUDE: n/a°
 STATION: N/A OFFSET: N/A
 REMARKS:

DRILL COMPANY: Eichelbergers
 DRILLER: T. Growden LOGGED BY: Peddishree
 DRILL RIG: Dledrich D-50
 DRILLING METHOD: Casing/Rock Coring
 SAMPLING METHOD: 2-in SS1.874-in Core
 HAMMER TYPE: Automatic
 EFFICIENCY: N/A
 REVIEWED BY: F. Hoffman

BORING B-01		
Water	▽	While Drilling 8 feet
	▼	Pre-Core 9.5 feet
	▽	Post-Core 10.4 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, %	STRENGTH, tsf	Additional Remarks	
30			R-3	70	70	Conglomeratic SANDSTONE -Light gray to dark gray-brown, Fine to very coarse grained, Weathered to Highly Weathered, very broken to slightly broken, very hard to extremely hard		RQD=3 Rec=58%			3 min. 3 min. 4 min. 3 min. 3 min.	
35						SANDSTONE -Light gray to dark gray-brown, Fine to medium grained, Highly Weathered, very broken to slightly broken, moderately hard to very hard, trace calcite stringers, multiple soil seams and layers					3 min. 3 min. 3 min. 3 min. 3 min. 3 min. 3 min. 3 min.	
40				R-4	103				RQD=4 Rec=86%			3 min. 3 min. 3 min. 3 min. 3 min. 3 min. 3 min. 3 min.
45												3 min. 4 min. 3 min. 3 min. 3 min. 3 min.
50				R-5	77				RQD=0 Rec=64%			3 min. 3 min. 3 min. 3 min. 3 min. 3 min. 3 min.
55												3 min. 3 min. 3 min. 3 min.
60							SHALE -Dark gray, Very fine grained, Highly Weathered, very broken to broken, moderately hard					2 min. 3 min. 3 min.

Continued Next Page



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

PROJECT NO.: 04911457
 PROJECT: Energy Transfer HDD (DPS)
 LOCATION: Joanna Road (PPP5)
 Berks Co., PA
 PA-BR-0181.0000-RD/PO#20170822

DATE STARTED: 8/31/17
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 COMPLETION DEPTH: 115.0 ft
 BENCHMARK: N/A
 ELEVATION: N/A
 LATITUDE: n/a°
 LONGITUDE: n/a°
 STATION: N/A OFFSET: N/A
 REMARKS:

DRILL COMPANY: Eichelbergers
 DRILLER: T. Growden LOGGED BY: Peddishree
 DRILL RIG: Dledrich D-50
 DRILLING METHOD: Casing/Rock Coring
 SAMPLING METHOD: 2-in SS1.874-in Core
 HAMMER TYPE: Automatic
 EFFICIENCY: N/A
 REVIEWED BY: F. Hoffman

BORING B-01			
Water	▽	While Drilling	8 feet
	▽	Pre-Core	9.5 feet
	▽	Post-Core	10.4 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, %	STRENGTH, tsf	Additional Remarks
60			R-6	116	116	Conglomeratic SANDSTONE -Light gray to light gray-brown, Fine to very coarse grained, Highly Weathered, very broken to slightly broken, hard to very hard		RQD=0 Rec=97%			3 min.
						SANDSTONE -Light gray to dark gray, Fine to medium grained, Highly Weathered, very broken to slightly broken, hard to very hard				3 min.	
65			R-7	120	120	CONGLOMERATE -Light gray to light gray-brown, Fine to very coarse grained, Highly Weathered, very broken to massive, very hard to extremely hard					3 min.
						SHALE -Dark gray-brown, Very fine grained, Weathered to Slightly Weathered, very broken to massive, moderately hard		RQD=0 Rec=100%		3 min.	
						SANDSTONE -Dark gray to gray-brown, Fine to medium grained, Weathered to Slightly Weathered, very broken to massive, moderately hard to very hard, numerous calcite-filled fractures				3 min.	
70			R-8	119	119	Broken/Weathered layer @ 81.7 feet (~ 5-1/2 inches thick)		RQD=27 Rec=99%			3 min.
						SANDSTONE -Dark gray-brown, Fine grained, Highly Weathered, very broken to slightly broken, very hard, trace calcite stringers				3 min.	
						SANDSTONE -Dark brown to dark gray-brown, Fine grained, Slightly Weathered, broken to massive, moderately hard, trace calcite stringers				3 min.	
										3 min.	
										3 min.	
										3 min.	
										3 min.	
										3 min.	
										3 min.	
										3 min.	
75										>> Q _u = 422.9 tsf 462.1 pcf	
80										>> Q _u = 622.9 tsf 150.1 pcf	
85										>> Q _u = 118.3 tsf 149.6 pcf	
90											

Continued Next Page



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

PROJECT NO.: 04911457
 PROJECT: Energy Transfer HDD (DPS)
 LOCATION: Joanna Road (PPP5)
 Berks Co., PA
 PA-BR-0181.0000-RD/PO#20170822

DATE STARTED: 8/31/17
 DATE COMPLETED: 9/1/17
 COMPLETION DEPTH: 115.0 ft
 BENCHMARK: N/A
 ELEVATION: N/A
 LATITUDE: n/a°
 LONGITUDE: n/a°
 STATION: N/A OFFSET: N/A

DRILL COMPANY: Eichelbergers
 DRILLER: T. Growden LOGGED BY: Peddishree
 DRILL RIG: Dledrich D-50
 DRILLING METHOD: Casing/Rock Coring
 SAMPLING METHOD: 2-in SS1.874-in Core
 HAMMER TYPE: Automatic
 EFFICIENCY: N/A
 REVIEWED BY: F. Hoffman

BORING B-01		
Water	▽ While Drilling	8 feet
	▼ Pre-Core	9.5 feet
	▽ Post-Core	10.4 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, %	STRENGTH, tsf	Additional Remarks
90				R-9	117	SANDSTONE -Dark brown to dark gray-brown, Fine grained, Slightly Weathered, broken to massive, moderately hard, trace calcite stringers Broken seam @ 90.9 feet (~ 1-1/4 inches thick) Weathered/Highly Weathered layer @ 92.3 feet (~ 7-3/4 inches thick) Highly Weathered/Completely Weathered seam @ 94.4 feet (~ 2-3/4 inches thick)		RQD=28 Rec=98%			3 min.
95						SILTSTONE -Dark gray-brown, Very fine grained, Slightly Weathered, very broken to massive, moderately hard to hard, trace calcite stringers Broken/Weathered layer @ 96.5 feet (~ 3-3/4 inches thick) Highly Weathered/Completely Weathered layer @ 97.8 feet (~ 5 inches thick)		RQD=22 Rec=73%			3 min.
100				R-10	87	SILTSTONE -Gray-brown to dark gray-brown, Very fine grained, Highly Weathered, very broken to broken, moderately hard					3 min.
105						SILTSTONE -Gray-brown to dark gray-brown, Very fine grained, Slightly Weathered, very broken to massive, moderately hard Weathered seam @ 108 feet (~ 1 inch thick)					3 min.
110				R-11	120	SILTSTONE -Gray-brown to dark gray-brown, Very fine grained, Weathered, broken to massive, moderately hard		RQD=45 Rec=100%			3 min.
115						SILTSTONE -Dark gray-brown, Very fine grained, Highly Weathered, very broken to broken, moderately hard Test boring terminated @ 115 feet					3 min.

STANDARD PENETRATION TEST DATA
 N in blows/ft @

Moisture: %
 X Moisture PL
 LL

STRENGTH, tsf
 ▲ Qu * Qp



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 LOCATION: Joanna Road (PPP5)
 Berks Co., PA
 PA-BR-0181.0000-RD/PO#20170822

ORDER 04911457
Canaan Pottery
Morgan Twp. Berks Co. PA
88-1 JOANNA RD
Box 1056

Run #	DEPTH	Rec.	RGD
R-1	13.0'-20.0'	63"/84"	9"
R-2	20.0'-25.0'	49"/60"	0"
R-3	25.0'-35.0'	70"/120"	4"

R-1

10.0'

25.0'



04911457
Crescent Pipeline
Morgan Twp. Bucks Co. PA
Box JOANNA RD
Box 206

Run #	Depth	Rec. #	Rec. #	
R-4	35.0'-45.0'	107 / 120	5"	
R-5	45.0'-55.0'	77 / 120	5"	

35.0'

45.0'



1571145
 Precision Pipeline
 Morgan Twp. Bucks Co. PA
 68'
 Box 3066

Run #	Depth	Rec. = "	ROD = "
45	45.0-55.0	116"/120"	0"
45	55.0-65.0	116"/120"	0"
47	65.0-75.0	120"	0"



55'

D3-111
Transect Pipeline
6-1
Box 4-26

Run	DEPTH	Pec	R30
R-T cont	65.0'-75.0'	120"/120"	0"
R-S	75.0'-85.0'	119"/120"	32"/120"



R-T cont

D37145
 Precision Pipeline
 Program S.P. Burns Co. PA
 650
 Box 525

Run #	Depth	Rec. = "	R60 = "
R-8 Cont.	75.0'-85.0'	119" / 120"	32" / 120"
R-9	85.0'-95.0'	117" / 120"	34" / 120"
R-10	95.0'-105.0'	87" / 120"	26" / 120"



85.0'

95.0'

R-8 Cont.

OSTIME
Precision Pipeline
Purveyor T. L. Burns Co. PA
65-1
Run 64

Run #	Depth	Rad = "	Rad = "
R-10 cont.	75.0'-105.0'	87"/120"	26"/120"
R-11	105.0'-115.0'	120"/120"	54"/120"



R-10 cont.

DATE STARTED: 8/28/17 **DRILL COMPANY:** Eichelbergers
DATE COMPLETED: 8/30/17 **DRILLER:** T. Growden **LOGGED BY:** C. Lehman
COMPLETION DEPTH: 145.0 ft **DRILL RIG:** Diedrich D-50
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-02

Water	▽	While Drilling	8 feet
	▼	Post-Core	14.6 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 ⊕ STRENGTH, tsf ▲ Qu * Qp	Additional Remarks
0		[Cross-hatched pattern]	S-1	1		FILL -Dark gray-brown, SILT with Sand, trace organics and woody matter, moist	ML	1-3-6-50/4" N=9	31	⊙ ⊗	
		[Dotted pattern]	R-1	16		Possible FILL -Diabase Boulder, Light gray to dark gray, Fine to medium grained, very hard		RQD=24 Rec=32%			>> ⊙
		[Diagonal lines]	S-2	0		Possible FILL -No recovery within this stratum		4-4-11-12 N=15			
		[Diagonal lines]	S-3	24		RESIDUUM -Stiff, Brown, Sandy Silty CLAY with Gravel, moist/wet	CL	9-5-6-7 N=11	18	⊙ ⊗ ⊕	LL = 24 PL = 18
		[Dotted pattern]	R-2	56		DIABASE -Light gray to dark gray, Fine to medium grained, Slightly Weathered, slightly broken to massive, very hard		RQD=86 Rec=94%			>> ▲ 1837.1 tsf 189.8 pcf 2 min.
		[Dotted pattern]	R-3	78				RQD=93 Rec=93%			>> ▲ 1141.5 tsf 188.5 pcf 2 min.
		[Dotted pattern]									2 min. 2 min. 2 min. 2 min. 2 min. 2 min. 2 min. 2 min.

Continued Next Page

 <p>Intertek PSI Total Quality. Assured.</p>	<p>Professional Service Industries, Inc. 1707 S. Cameron Street, Suite B Harrisburg, PA 17104 Telephone: (717) 230-8622</p>	<p>PROJECT NO.: 04911457 PROJECT: Energy Transfer HDD (DPS) LOCATION: Joanna Road (PPP5) Berk's Co., PA PA-BR-0181.0000-RD/PO#20170822</p>
--	---	---

DATE STARTED: 8/28/17
DATE COMPLETED: 8/30/17
COMPLETION DEPTH: 145.0 ft
BENCHMARK: N/A
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LATITUDE: n/a°
LONGITUDE: n/a°
STATION: N/A **OFFSET:** N/A
REMARKS:

DRILL COMPANY: Eichelbergers
DRILLER: T. Growden **LOGGED BY:** C. Lehman
DRILL RIG: Diedrich D-50
DRILLING METHOD: Casing/Rock Coring
SAMPLING METHOD: 2-in SS1.874-in Core
HAMMER TYPE: Automatic
EFFICIENCY: N/A
REVIEWED BY: F. Hoffman

BORING B-02

Water	▽ While Drilling	8 feet
	▼ Post-Core	14.6 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 ©	Additional Remarks
30				R-4	112	DIABASE -Gray to light brown, Fine to medium grained, Weathered, very broken to massive, very hard to extremely hard DIABASE -Light gray to black, Fine to coarse grained, Slightly Weathered, very broken to massive, very hard to extremely hard		RQD=73 Rec=93%	X Moisture □ PL + LL	STRENGTH, tsf ▲ Qu * Qp	2 min. 2 min. 1 min. 1 min. 1 min. 1 min.
35				R-5	90			RQD=91 Rec=94%			1 min. 1615.4 tsf >>▲ Q _u = 289.4 pcf 2 min.
40				R-6	72			RQD=82 Rec=100%			2 min. 2 min. 2 min. 2 min. 3 min.
45						Broken/Weathered layer @ 47.2 feet (~ 12-1/2 inches thick)					3 min. 3 min. 3 min. 3 min.
50				R-7	72			RQD=67 Rec=100%			3 min. 374.1 tsf >>▲ Q _u = 387.8 pcf 4 min.
55						Weathered layer @ 55 feet (~ 8 inches thick) Diagonal calcite-filled fracture @ 55.5 feet.					4 min. 4 min. 4 min. 4 min. 3 min. 3 min. 3 min. 3 min.
60											3 min.

Continued Next Page



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BORING B-02

Water	▽ While Drilling	8 feet
	▼ Post-Core	14.6 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, %	STRENGTH, tsf	Additional Remarks			
120			R-14		120	DIABASE -Light gray to black, Fine to coarse grained, Slightly Weathered, very broken to massive, very hard to extremely hard Highly Weathered layer @ 121.1 feet (~ 5-3/4 inches thick) Weathered layer @ 123.5 feet (~ 6-1/2 inches thick)	RQD=73 Rec=100%	0	N in blows/ft © X Moisture PL LL	392.1 pcf 3 min. 3 min. 3 min. 3 min. 3 min.				
125			R-15	60	Weathered layer @ 131.9 feet (~ 3-1/2 inches thick)						RQD=78 Rec=100%	0	Qu Qp * *	4 min. 4 min. 4 min. 4 min.
130			R-16	120	Broken/very broken layer @ 138 feet (~ 22-1/2 inches thick)						RQD=63 Rec=100%	0		4 min. 4 min. 4 min. 4 min.
135			R-17	60	Test boring terminated @ 145 feet						RQD=86 Rec=100%	0		4 min. 4 min. 4 min. 4 min.
140										4 min. 4 min. 4 min. 4 min.				
145										4 min. 4 min. 4 min. 4 min.				

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

PROJECT NO.: 04911457
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Joanna Road (PPP5)
 Berks Co., PA
 PA-BR-0181.0000-RD/PO#20170822

DAW-1957
Surrey Rd, PP45
B-2
Box 2 of -
shells

Run	Depth	Rc	R2D
R-1	1.8-2.0 (Number)	1.4	1.0
R-2	13.0-18.0	4.7	4.3
R-3	18.0-25.0	6.5	6.5
R-4	25.0-35.0	6.6	4.6

TOP

1.8

6.0
13.0

18.0

25.0



0491-1457
Joanna Rd, PPS
B-2
Box 2 of -
42387

Recon	Depth	Pr.	RPD
R-4(cont)	25.0-35.0	6.6	9.8
		7.3	7.2
R-5	35.0-47.0	2.5	7.3

TOP



35.0

47.0



0491-1457
 Jomon Rd PPS
 B-2
 Box 3 of -
 9/29/17

Run	Depth	R _g	R ₀₁
R-6	43.0-49.0	6.0	4.9
R-7	49.0-55.0	6.0	4.0
R-8	55.0-65.0	10.0	12.0



0401-1457
Sommers Rd, PPS.
B-2
Box 4 of 4
8/2/17

Row	Depth	Re.	ROD
8-10	55.0-65.0	10.0	10.0"
11-12	65.0-75.0	9.5	9.5"

TOP



0491-1157
 Tanna RA PPS
 B-2
 Box 1 of 1
 W29117

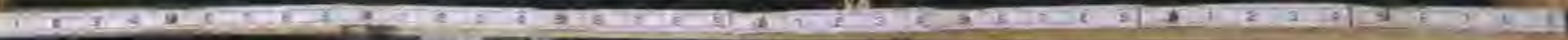
0491-1157
 Tanna RA PPS
 B-2
 Box 1 of 1
 W29117

Run	Depth	W	RSD
R-10	65.0-75.0	9.7	79"
R-11	75.0-85.0	9.7	79"
R-12	85.0-95.0	9.7	79"

TDP

054

054

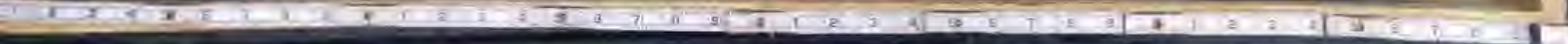


1457
Rd, PPS
2
lot 6 of
42972

Year	Depth	Rd	RAD
1974	85.0-95.0	15.0	1117
1974	95.0-105.0	10.0	1117

TOP

15.0



0101-1157
Lumber 81, 1000
B-2
B-3
B-4

Run	Depth	in	sqd
80004	100-105 to	10.0	111"
80005	105-110 to	5.0	113.4"
80006	110-115 to	5.0	115"



TO ORDER: 10000
D: 100
WALL THK: 0.800

E-81
18.0
135.0
135.0

10000
10000
10000

R	Depth	R	Depth
R-11	115.0-135.0	10.0	135.0
R-12	125.0-150.0	50.0	135.0
R-16	135.0-140.0	10.0	135.0



135.0

135.0

0170-1157
 Johnson Rd, 11005
 E-2
 Box 9 of 9
 1/24/17

Core	Depth	Gr	RBG
2-17	140.0-145.0	10.0	6.3
	140.0-145.0	5.0	4.3
	BOB		









140.0

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.		SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted.
HSA: Hollow Stem Auger - typically 3 1/4" or 4 1/4" I.D. openings, except where noted.		ST: Shelby Tube - 3" O.D., except where noted.
M.R.: Mud Rotary - Uses a rotary head with Bentonite or Polymer Slurry		RC: Rock Core
R.C.: Diamond Bit Core Sampler		TC: Texas Cone
H.A.: Hand Auger		BS: Bulk Sample
P.A.: Power Auger - Handheld motorized auger		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.
- N₆₀: 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 ANGULARITY OF COARSE-GRAINED PARTICLES

<u>Relative Density</u>	<u>N - Blows/foot</u>	<u>Description</u>	<u>Criteria</u>
Very Loose	0 - 4	Angular:	Particles have sharp edges and relatively plane sides with unpolished surfaces
Loose	4 - 10	Subangular:	Particles are similar to angular description, but have rounded edges
Medium Dense	10 - 30	Subrounded:	Particles have nearly plane sides, but have well-rounded corners and edges
Dense	30 - 50	Rounded:	Particles have smoothly curved sides and no edges
Very Dense	50 - 80		
Extremely Dense	80+		

GRAIN-SIZE TERMINOLOGY

<u>Component</u>	<u>Size Range</u>
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

<u>Description</u>	<u>Criteria</u>
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

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

GENERAL NOTES

(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

<u>Q_u - TSF</u>	<u>N - Blows/foot</u>	<u>Consistency</u>
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

<u>Description</u>	<u>Criteria</u>
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

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

STRUCTURE DESCRIPTION

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

<u>Q_u - TSF</u>	<u>Consistency</u>
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

<u>Description</u>	<u>Criteria</u>
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

<u>Voids</u>	<u>Void Diameter</u>
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)

<u>Component</u>	<u>Size Range</u>
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

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

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.

Degree of Brokenness

<u>Characteristic</u>	<u>Description</u>
Less than 1 inch	Very Broken
1 inch to 3 inches	Broken
3 inches to 6 inches	Slightly Broken
Greater than 6 inches	Massive

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.
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SOIL CLASSIFICATION CHART

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS		
			GRAPH	LETTER			
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES		
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES		
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES		
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES		
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES		
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES		
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES		
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES		
		FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	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 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		

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.

Laboratory Summary Sheet

Sheet 1 of 1

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-01	1							3			
B-01	4					49.8%		23			
B-01	9					24.3%		15			
B-01	15.1				322.01						
B-01	68.7				422.94						
B-01	79.2				622.95						
B-01	89.2				18.29						
B-01	106.9				250.47						
B-02	1							31			
B-02	9	24	18	6				18			
B-02	13.2				1837.12						
B-02	18.7				1141.49						
B-02	35.3				1615.35						
B-02	49.5				374.09						
B-02	60.6				2820.96						
B-02	76				2245.01						
B-02	88.9				2137.14						
B-02	99				1369.51						
B-02	109				559.29						
B-02	119.9				242.14						
B-02	133.5				1157.23						



 <p>Professional Service Industries 1707 S. Cameron Street, Suite B Harrisburg, PA 17104 Telephone: (717) 230-8622 Fax: (717) 230-8626</p>	<p style="text-align: center;">Summary of Laboratory Results</p> <p>PSI Job No.: 04911457 Project: Energy Transfer HDD (DPS) Location: Joanna Road (PPP5) Berks Co., PA PA-BR-0181.0000-RD/PO#20170822</p>
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04911457 Joana Rd (PPPS)

B-1(96.9')

Fractured while cutting



PROJECT NAME: Joanna Rd. PROJECT LOCATION: Berks Co. PROJ./WO NO: 0491-1457
 DRILL COMPANY: Eichelbergers LEAD DRILLER: Tom Growden
 DRILL RIG TYPE & SPT HAMMER TYPE: Diedrich D-50 Automatic
 DRILLING METHOD & H.S.A./CASING DIAMETERS: Spm Casing, 3"
 ROCK CORE BARREL TYPE/SIZE: Long-ear / NQ2
 BORING COORDINATES: 40.166282; 75.857548 BORING GROUND ELEVATION:

DESCRIPTION (Color, Soil Type, Moisture Condition)	Sample Interval (ft)	SAMPLE ID#	REC (in)	RQD (in)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: N/A		S, R, ST, GS					
1 FILL - Light brown and gray brown, SILT, with wood chips, trace sand.	0.0-1.8	S-1	1.0	-	1-3-6-50/3	-	
2 COLLUVIUM - Gray, DIABASE, 3" boulder.	1.8-6.0	R-1	1.4	1.0	-	-	
3							
4							
5							
6	6.0-8.0	S-2	0.0	-	4-4-11-12	-	
7							
8 COLLUVIUM - Stiff, moist, light orange brown, Lean CLAY, with sand, trace sandstone frags.	8.0-10.0	S-3	2.0	-	9-5-6-7	-	
9							
10							
11							
12							
13 Gray, DIABASE, very fine to fine grained, thin to thick bedded,	13.0-18.0	R-2	4.7	4.3	-	-	13.0-14.0: 2m3s
14 slightly weathered, hard to very hard (8-9)							14.0-15.0: 2m1.6s
15 "							15.0-16.0: 2m1.4s
16							16.0-20.0: 3m1.1s

Tetra Tech Drawing Name & No.: PA-CH-0181.0000-RD DPS PO#: 20170731
 Split-Spoon (S); Rock Core (R); Shelby Tube (ST); Grab "bulk" Sample (GS)
 Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT)
 DATE OF DRILLING FOR THIS LOG PAGE: 8/28/17
 DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling
 DRILLING OBSERVER/COMPANY: Clarissa Lehman / PSJ
 The information presented in this field boring log is preliminary in nature and presented for informational purposes only. The final completed boring log report shall be conclusive as to PSI's findings or opinions of the subsurface conditions encountered at this boring location. Therefore, this information is subject to review and change. The boring log descriptions apply only to the specific location(s) noted and may not represent any other locations or elevations. This field boring log may not be reproduced without written permission by Professional Service Industries, Inc.

PROJECT NAME:		PROJECT LOCATION:		PROJ./WO NO: 0491-1457	
DRILL COMPANY:		LEAD DRILLER:		GROUNDWATER LEVELS	
DRILL RIG TYPE & SPT HAMMER TYPE:		DRILLING STAGE	Groundwater Depth*	Date	Time
DRILLING METHOD & H.S.A./CASING DIAMETERS:					
ROCK CORE BARREL TYPE/SIZE					
BORING COORDINATES:		BORING GROUND ELEVATION:			

DESCRIPTION (Color, Soil Type, Moisture Conditon)	Sample Interval (ft)	SAMPLE ID#	REC (ft)	RQD (%)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: 0		S, R, ST, GS					
#17 same diabase							17.0-18.0 3m15s
#18	18.0-25.0	R-3	6.5	6.5	-	-	18.0-19.0 2m5s
#19 "							19.0-20.0 2m1s
#20							20.0-21.0 1m58s
#21 "							21.0-22.0 2m10s
#22							22.0-23.0 2m7s
#23 "							23.0-24.0 2m3s
#24							24.0-25.0 2m6s
#25 same diabase	25.0-35.0	R-4	9.3	7.3	-	-	25.0-26.0 2m13s
#26							26.0-27.0 2m8s
#27 "							27.0-28.0 2m15
#28							28.0-29.0 2m15s
#29 "							29.0-30.0 2m18s
#30							30.0-31.0 1m40s
#31 "							31.0-32.0 56s
#32							32.0-33.0 58s

Tetra Tech Drawing Name & No.:		DPS PO#:	
Split-Spoon (S); Rock Core (R), Shelby Tube (ST); Grab "bulk" Sample (GS)		DATE OF DRILLING FOR THIS LOG PAGE: 8/28/17	
Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT)		DRILLING OBSERVER/COMPANY: Clarissa Lehman/PSI	
DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling			
<p>The information presented in this field boring log is preliminary in nature and presented for informational purposes only. The final/completed boring log report shall be conclusive as to PSI's findings or opinions of the subsurface conditions encountered at this boring location. Therefore, this information is subject to review and change. The boring log descriptions apply only to the specific location(s) noted and may not represent any other locations or elevations. This field boring log may not be reproduced without written permission by Professional Service Industries, Inc.</p>			

RECORD OF SUBSURFACE EXPLORATION			BORING NO: B-2		PPP#: 5		SHEET 3 OF			
PROJECT NAME:			PROJECT LOCATION:			PROJ./WO NO: 0491-1457				
DRILL COMPANY:		LEAD DRILLER:		GROUNDWATER LEVELS						
DRILL RIG TYPE & SPT HAMMER TYPE:				DRILLING STAGE	Groundwater Depth*	Date	Time			
DRILLING METHOD & H.S.A./CASING DIAMETERS:										
ROCK CORE BARREL TYPE/SIZE										
BORING COORDINATES:			BORING GROUND ELEVATION:							
DESCRIPTION (Color, Soil Type, Moisture Condition)				Sample Interval (ft)	SAMPLE ID#	REC (in)	RQD (in)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: 0					S, R, ST, GS					
32.4-34.4; vertical fractures #33 and clay seams.										33.0-34.0 1m2s
#34										34.0-36.0 59s
#35 same diabase				35.0-43.0	R-5	7.5	7.3			35-36 2m3s
#36										36-37 2m18s
#37 "										37-38 2m10s
#38										38-39 2m5s
#39 "										39-40 2m3s
#40										40-41 2m8s
#41 "										41-42 2m9s
#42										42-43 2m3s
#43 same diabase				43.0-49.0	R-6	6.0	4.9			43-44 3m5s
#44										44-45 2m58s
#45 "										45-46 2m51s
#46										46-47 2m59s
#47 "										47-48 3m3s
#48										48-49 3m10s
Tetra Tech Drawing Name & No.:						DPS PO#:				
Split-Spoon (S); Rock Core (R); Shelby Tube (ST); Grab "bulk" Sample (GS)				DATE OF DRILLING FOR THIS LOG PAGE: 8/28/17 - 8/29/17						
Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT)				DRILLING OBSERVER/COMPANY: Clarissa Lehman / PSI						
DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling				The information presented in this field boring log is preliminary in nature and presented for informational purposes only. The final/completed boring log report shall be conclusive as to PSI's findings or opinions of the subsurface conditions encountered at this boring location. Therefore, this information is subject to review and change. The boring log descriptions apply only to the specific location(s) noted and may not represent any other locations or elevations. This field boring log may not be reproduced without written permission by Professional Service Industries, Inc.						

PROJECT NAME:		PROJECT LOCATION:		PROJ./WO NO: 0491-1457	
DRILL COMPANY:		LEAD DRILLER:		GROUNDWATER LEVELS	
DRILL RIG TYPE & SPT HAMMER TYPE:		DRILLING STAGE	Groundwater Depth*	Date	Time
DRILLING METHOD & H.S.A./CASING DIAMETERS:					
ROCK CORE BARREL TYPE/SIZE					
BORING COORDINATES:		BORING GROUND ELEVATION:			

DESCRIPTION (Color, Soil Type, Moisture Conditon)	Sample Interval (ft)	SAMPLE ID#	REC (in)	RQD (in)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: 0		S, R, ST, GS					
49 same diabase	49.0-55.0	R-7	6.0	4.0			49-50 3m18s
50							50-51 3m45s
51 "							51-52 3m50s
52							52-53 3m36s
53 "							53-54 3m32s
54							54-55 3m36s
55 same diabase vertical fracture 55.0-55.9	55.0-65.0	R-8	10.0	10.0			55-56 3m10s
56							56-57 3m12s
57 "							57-58 3m8s
58							58-59 3m9s
59 "							59-60 3m15s
60							60-61 3m18s
61 "							61-62 3m7s
62							62-63 3m21s
63 "							63-64 3m19s
64							64-65 3m18s

Tetra Tech Drawing Name & No.: _____ DPS PO#: _____

Split-Spoon (S); Rock Core (R), Shelby Tube (ST); Grab "bulk" Sample (GS) Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT) DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling	DATE OF DRILLING FOR THIS LOG PAGE: 8/29/17 DRILLING OBSERVER/COMPANY: Clarissa Lehman
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PROJECT NAME:		PROJECT LOCATION:		PROJ./WO NO: 0491-1457	
DRILL COMPANY:		LEAD DRILLER:		GROUNDWATER LEVELS	
DRILL RIG TYPE & SPT HAMMER TYPE:		DRILLING STAGE	Groundwater Depth*	Date	Time
DRILLING METHOD & H.S.A./CASING DIAMETERS:					
ROCK CORE BARREL TYPE/SIZE					
BORING COORDINATES:		BORING GROUND ELEVATION:			

DESCRIPTION (Color, Soil Type, Moisture Conditon)	Sample Interval (ft)	SAMPLE ID#	REC (in)	RQD (in)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: 0		S, R, ST, GS					
①65 same diabase	65.0-75.0	R-9	9.8'	79"			65-66 3m40s
②66							66-67 3m39s
③67 "							67-68 3m36s
④68							68-69 3m48s
⑤69 "							69-70 3m50s
⑥70							70-71 3m51s
⑦71 "							71-72 3m51s
⑧72							72-73 3m48s
⑨73 "							73-74 3m50s
⑩74							74-75 4m10s
⑪75 same diabase	75.0-85.0	R-10	9.5'	115"			75-76 4m55s
⑫76							76-77 4m1s
⑬77 "							77-78 4m3s
⑭78							78-79 4m10s
⑮79 "							79-80 4m7s
⑯80							80-81 4m12s

Tetra Tech Drawing Name & No.:	DPS PO#:
Split-Spoon (S); Rock Core (R), Shelby Tube (ST); Grab "bulk" Sample (GS)	DATE OF DRILLING FOR THIS LOG PAGE: 8/29/17
Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT)	DRILLING OBSERVER/COMPANY: Clarissa Lehman / PST
DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling	

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PROJECT NAME:	PROJECT LOCATION:	PROJ./WO NO: 0491-1457
DRILL COMPANY:	LEAD DRILLER:	GROUNDWATER LEVELS
DRILL RIG TYPE & SPT HAMMER TYPE:	DRILLING STAGE	Groundwater Depth* Date Time
DRILLING METHOD & H.S.A./CASING DIAMETERS:		
ROCK CORE BARREL TYPE/SIZE		
BORING COORDINATES:	BORING GROUND ELEVATION:	

DESCRIPTION (Color, Soil Type, Moisture Conditon)	Sample Interval (ft)	SAMPLE ID#	REC (in)	RQD (in)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: 0		S, R, ST, GS					
81							81-82 4m35
82							82-83 4m125
83							83-84 4m75
84							84-85 4m95
85 same diabase	85.0-95.0	R-11	10.0'	114"			85-86 3m585
86							86-87 3m575
87							87-88 4m105
88							88-89 4m185
89							89-90 4m195
90							90-91 4m235
91							91-92 4m215
92							92-93 4m175
93							93-94 4m205
94							94-95 4m215
95 same diabase	95.0-105.0	R-12	10.0'	111"			95-96 3m575
96							96-97 3m545

Tetra Tech Drawing Name & No.: DPS PO#:

Split-Spoon (S); Rock Core (R); Shelby Tube (ST); Grab "bulk" Sample (GS)
 Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT)
 DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling
 DATE OF DRILLING FOR THIS LOG PAGE: 8/29/17
 DRILLING OBSERVER/COMPANY: Classsa Lehman / PSI

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PROJECT NAME:		PROJECT LOCATION:		PROJ./WO NO: 0491-1457	
DRILL COMPANY:		LEAD DRILLER:		GROUNDWATER LEVELS	
DRILL RIG TYPE & SPT HAMMER TYPE:		DRILLING STAGE	Groundwater Depth*	Date	Time
DRILLING METHOD & H.S.A./CASING DIAMETERS:					
ROCK CORE BARREL TYPE/SIZE					
BORING COORDINATES:			BORING GROUND ELEVATION:		

DESCRIPTION (Color, Soil Type, Moisture Conditon)	Sample Interval (ft)	SAMPLE ID#	REC (in)	RQD (in)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: 0		S, R, ST, GS					
97	"						97-98 3m53s
98							98-99 3m56s
99	"						99-100 4m1s
100							100-101 4m3s
101	"						101-102 3m59s
102							102-103 3m30s
103	"						103-104 3m28s
104							104-105 3m27s
105 same diabase	105.0-115.0	R-13	9.8'	115"			105-106 3m35s
106							106-107 3m41s
107	"						107-108 3m43s
108							108-109 3m39s
109	"						109-110 3m44s
110							110-111 3m48s
111	"						111-112 3m49s
112							112-113 3m37s

Tetra Tech Drawing Name & No.:	DPS PO#: 1
Split-Spoon (S); Rock Core (R), Shelby Tube (ST); Grab "bulk" Sample (GS) Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT) DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling	DATE OF DRILLING FOR THIS LOG PAGE: 8/29/17 DRILLING OBSERVER/COMPANY: Clarissa Lehman / PSI

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RECORD OF SUBSURFACE EXPLORATION			BORING NO: R-2		PPP#: 5		SHEET 8 OF			
PROJECT NAME:			PROJECT LOCATION:			PROJ./WO NO: 0491-1457				
DRILL COMPANY:		LEAD DRILLER:		GROUNDWATER LEVELS						
DRILL RIG TYPE & SPT HAMMER TYPE:				DRILLING STAGE	Groundwater Depth*	Date	Time			
DRILLING METHOD & H.S.A./CASING DIAMETERS:										
ROCK CORE BARREL TYPE/SIZE										
BORING COORDINATES:			BORING GROUND ELEVATION:							
DESCRIPTION (Color, Soil Type, Moisture Conditon)				Sample Interval (ft)	SAMPLE ID#	REC (in)	RQD (in)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: 0					S, R, ST, GS					
Ø113 "										113-114 3m395
Ø114										114-115 3m325
Ø115 same diabase				1150-1250	R-14	10.0'	88"			115-116 3m155
Ø116										116-117 3m215
Ø117 "										117-118 3m225
Ø118										118-119 3m185
Ø119 "										119-120 3m205
Ø120										120-121 3m235
Ø121 "										121-122 3m265
Ø122										122-123 3m255
Ø123 "										123-124 3m215
Ø124										124-125 3m205
Ø125 same diabase				1250-1300	R-15	50	3.9			125-126 3m415
Ø126										126-127 3m485
Ø127 "										127-128 3m605
Ø128										128-129 3m495
Tetra Tech Drawing Name & No.:						DPS PO#:				
Split-Spoon (S); Rock Core (R), Shelby Tube (ST); Grab "bulk" Sample (GS) Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT) DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling				DATE OF DRILLING FOR THIS LOG PAGE:		8/29/17 - 8/30/17				
				DRILLING OBSERVER/COMPANY: Clarissa Lehman / PST						

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RECORD OF SUBSURFACE EXPLORATION			BORING NO: B-2		PPP#: 5		SHEET 9 OF			
PROJECT NAME:		PROJECT LOCATION:				PROJ./WO NO: 0491-1457				
DRILL COMPANY:		LEAD DRILLER:		GROUNDWATER LEVELS						
DRILL RIG TYPE & SPT HAMMER TYPE:				DRILLING STAGE	Groundwater Depth*	Date		Time		
DRILLING METHOD & H.S.A/CASING DIAMETERS:				Upon Completion	1418"	8/30/17		9:45 AM		
ROCK CORE BARREL TYPE/SIZE										
BORING COORDINATES:			BORING GROUND ELEVATION:							
DESCRIPTION (Color, Soil Type, Moisture Conditon)				Sample Interval (ft)	SAMPLE ID#	REC (in)	RQD (in)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: 0					S, R, ST, GS					
①129 "										129-130 3m47s
①130 Same diabase				130.0-140.0	R-16	10.0	6.3			130-131 4m5s
①131 "										131-132 4m8s
①132 "										132-133 4m3s
①133 "										133-134 3m59s
①134 "										134-135 4m2s
①135 "										135-136 4m1s
①136 "										136-137 3m56s
①137 137.3-139.7: Core very dry + extremely broken. Not enough water getting to the bit?										137-138 3m59s
①138 "										138-139 4m8s
①139 "										139-140 4m0s
①140 Same diabase				140.0-145.0	R-17	5.0	4.3			140-141 4m8s
①141 "										141-142 4m12s
①142 "										142-143 4m11s
①143 "										143-144 4m16s
①144 EOB @ 145.0 ft.										144-145 4m21s
Tetra Tech Drawing Name & No.:						DPS PO#:				
Split-Spoon (S); Rock Core (R); Shelby Tube (ST); Grab "bulk" Sample (GS)				DATE OF DRILLING FOR THIS LOG PAGE:		8/30/17				
Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT)				DRILLING OBSERVER/COMPANY: Clarissa Lehman / PST						
DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling				The information presented in this field boring log is preliminary in nature and presented for informational purposes only. The final/completed boring log report shall be conclusive as to PSI's findings or opinions of the subsurface conditions encountered at this boring location. Therefore, this information is subject to review and change. The boring log descriptions apply only to the specific location(s) noted and may not represent any other locations or elevations. This field boring log may not be reproduced without written permission by Professional Service Industries, Inc.						

PROJECT NAME: Joanna Rd. PROJECT LOCATION: Berks Co. PROJ./WO NO: 0491-1457

DRILL COMPANY: Eichelbergers LEAD DRILLER: Tom Growden

DRILL RIG TYPE & SPT HAMMER TYPE: Diedrich D-50 Automatic

DRILLING METHOD & H.S.A./CASING DIAMETERS: Spm Casing, 3"

ROCK CORE BARREL TYPE/SIZE: Long-ear / NQ2

BORING COORDINATES: 40.166282; 75.857548 BORING GROUND ELEVATION:

DESCRIPTION (Color, Soil Type, Moisture Condition)	Sample Interval (ft)	SAMPLE ID#	REC (in)	RQD (in)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: N/A		S, R, ST, GS					
1 FILL - Light brown and gray brown, SILT, with wood chips, trace sand.	0.0-1.8	S-1	1.0	-	1-3-6-50/3	-	
2 COLLUVIUM - Gray, DIABASE, 3" boulder.	1.8-6.0	R-1	1.4	1.0	-	-	
3							
4							
5							
6	6.0-8.0	S-2	0.0	-	4-4-11-12	-	
7							
8 COLLUVIUM - Stiff, moist, light orange brown, Lean CLAY, with sand, trace sandstone frags.	8.0-10.0	S-3	2.0	-	9-5-6-7	-	
9							
10							
11							
12							
13 Gray, DIABASE, very fine to fine grained, thin to thick bedded,	13.0-18.0	R-2	4.7	4.3	-	-	13.0-14.0: 2m3s
14 slightly weathered, hard to very hard (8-9)							14.0-15.0: 2m1.6s
15 "							15.0-16.0: 2m1.4s
16							16.0-17.0: 3m1.1s

Tetra Tech Drawing Name & No.: PA-CH-0181.0000-RD DPS PO#: 20170731

Split-Spoon (S); Rock Core (R); Shelby Tube (ST); Grab "bulk" Sample (GS) DATE OF DRILLING FOR THIS LOG PAGE: 8/28/17

Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT) DRILLING OBSERVER/COMPANY: Clarissa Lehman / PSI

DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling

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PROJECT NAME:		PROJECT LOCATION:		PROJ./WO NO: 0491-1457	
DRILL COMPANY:		LEAD DRILLER:		GROUNDWATER LEVELS	
DRILL RIG TYPE & SPT HAMMER TYPE:		DRILLING STAGE	Groundwater Depth*	Date	Time
DRILLING METHOD & H.S.A./CASING DIAMETERS:					
ROCK CORE BARREL TYPE/SIZE					
BORING COORDINATES:		BORING GROUND ELEVATION:			

DESCRIPTION (Color, Soil Type, Moisture Conditon)	Sample Interval (ft)	SAMPLE ID#	REC (ft)	RQD (ft)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: 0		S, R, ST, GS					
#17 same diabase							17.0-18.0 3m15s
#18	18.0-25.0	R-3	6.5	6.5	-	-	18.0-19.0 2m5s
#19 "							19.0-20.0 2m1s
#20							20.0-21.0 1m58s
#21 "							21.0-22.0 2m10s
#22							22.0-23.0 2m7s
#23 "							23.0-24.0 2m3s
#24							24.0-25.0 2m6s
#25 same diabase	25.0-35.0	R-4	9.3	7.3	-	-	25.0-26.0 2m13s
#26							26.0-27.0 2m8s
#27 "							27.0-28.0 2m15
#28							28.0-29.0 2m15s
#29 "							29.0-30.0 2m18s
#30							30.0-31.0 1m40s
#31 "							31.0-32.0 56s
#32							32.0-33.0 58s

Tetra Tech Drawing Name & No.:		DPS PO#:	
Split-Spoon (S); Rock Core (R), Shelby Tube (ST); Grab "bulk" Sample (GS)		DATE OF DRILLING FOR THIS LOG PAGE: 8/28/17	
Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT)		DRILLING OBSERVER/COMPANY: Clarissa Lehman/PSI	
DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling			
<small>The information presented in this field boring log is preliminary in nature and presented for informational purposes only. The final/completed boring log report shall be conclusive as to PSI's findings or opinions of the subsurface conditions encountered at this boring location. Therefore, this information is subject to review and change. The boring log descriptions apply only to the specific location(s) noted and may not represent any other locations or elevations. This field boring log may not be reproduced without written permission by Professional Service Industries, Inc.</small>			

RECORD OF SUBSURFACE EXPLORATION			BORING NO: B-2			PPP#: 5		SHEET 3 OF	
PROJECT NAME:		PROJECT LOCATION:				PROJ./WO NO: 0491-1457			
DRILL COMPANY:		LEAD DRILLER:		GROUNDWATER LEVELS					
DRILL RIG TYPE & SPT HAMMER TYPE:		DRILLING STAGE		Groundwater Depth*		Date		Time	
DRILLING METHOD & H.S.A./CASING DIAMETERS:									
ROCK CORE BARREL TYPE/SIZE									
BORING COORDINATES:		BORING GROUND ELEVATION:							
DESCRIPTION (Color, Soil Type, Moisture Condition)			Sample Interval (ft)	SAMPLE ID#	REC (in)	RQD (in)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: 0				S, R, ST, GS					
32.4-34.4; vertical fractures #33 and clay seams.									33.0-34.0 1m2s
#34									34.0-36.0 59s
#35 same diabase			35.0-43.0	R-5	7.5	7.3			35-36 2m3s
#36									36-37 2m18s
#37 "									37-38 2m10s
#38									38-39 2m5s
#39 "									39-40 2m3s
#40									40-41 2m8s
#41 "									41-42 2m9s
#42									42-43 2m3s
#43 same diabase			43.0-49.0	R-6	6.0	4.9			43-44 3m5s
#44									44-45 2m58s
#45 "									45-46 2m51s
#46									46-47 2m59s
#47 "									47-48 3m3s
#48									48-49 3m10s
Tetra Tech Drawing Name & No.:					DPS PO#:				
Split-Spoon (S); Rock Core (R); Shelby Tube (ST); Grab "bulk" Sample (GS)			DATE OF DRILLING FOR THIS LOG PAGE: 8/28/17 - 8/29/17						
Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT)			DRILLING OBSERVER/COMPANY: Clarissa Lehman / PSI						
DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling			The information presented in this field boring log is preliminary in nature and presented for informational purposes only. The final/completed boring log report shall be conclusive as to PSI's findings or opinions of the subsurface conditions encountered at this boring location. Therefore, this information is subject to review and change. The boring log descriptions apply only to the specific location(s) noted and may not represent any other locations or elevations. This field boring log may not be reproduced without written permission by Professional Service Industries, Inc.						

PROJECT NAME:	PROJECT LOCATION:	PROJ./WO NO: 0491-1457		
DRILL COMPANY:	LEAD DRILLER:	GROUNDWATER LEVELS		
DRILL RIG TYPE & SPT HAMMER TYPE:	DRILLING STAGE	Groundwater Depth*	Date	Time
DRILLING METHOD & H.S.A./CASING DIAMETERS:				
ROCK CORE BARREL TYPE/SIZE				
BORING COORDINATES:		BORING GROUND ELEVATION:		

DESCRIPTION (Color, Soil Type, Moisture Conditon)	Sample Interval (ft)	SAMPLE ID#	REC (in)	RQD (in)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: 0		S, R, ST, GS					
49 same diabase	49.0-55.0	R-7	6.0	4.0			49-50 3m18s
50							50-51 3m45s
51 "							51-52 3m50s
52							52-53 3m36s
53 "							53-54 3m32s
54							54-55 3m36s
55 same diabase vertical fracture 55.0-55.9	55.0-65.0	R-8	10.0	10.0			55-56 3m10s
56							56-57 3m12s
57 "							57-58 3m8s
58							58-59 3m9s
59 "							59-60 3m15s
60							60-61 3m18s
61 "							61-62 3m7s
62							62-63 3m21s
63 "							63-64 3m19s
64							64-65 3m18s

Tetra Tech Drawing Name & No.: _____ DPS PO#: _____

Split-Spoon (S); Rock Core (R), Shelby Tube (ST); Grab "bulk" Sample (GS) Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT) DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling	DATE OF DRILLING FOR THIS LOG PAGE: 8/29/17 DRILLING OBSERVER/COMPANY: Clarissa Lehman
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PROJECT NAME:		PROJECT LOCATION:		PROJ./WO NO: 0491-1457	
DRILL COMPANY:		LEAD DRILLER:		GROUNDWATER LEVELS	
DRILL RIG TYPE & SPT HAMMER TYPE:		DRILLING STAGE	Groundwater Depth*	Date	Time
DRILLING METHOD & H.S.A./CASING DIAMETERS:					
ROCK CORE BARREL TYPE/SIZE					
BORING COORDINATES:		BORING GROUND ELEVATION:			

DESCRIPTION (Color, Soil Type, Moisture Conditon)	Sample Interval (ft)	SAMPLE ID#	REC (in)	RQD (in)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: 0		S, R, ST, GS					
①65 same diabase	65.0-75.0	R-9	9.8'	79"			65-66 3m40s
②66							66-67 3m39s
③67 "							67-68 3m36s
④68							68-69 3m48s
⑤69 "							69-70 3m50s
⑥70							70-71 3m51s
⑦71 "							71-72 3m51s
⑧72							72-73 3m48s
⑨73 "							73-74 3m50s
⑩74							74-75 4m10s
⑪75 same diabase	75.0-85.0	R-10	9.5'	115"			75-76 4m55s
⑫76							76-77 4m1s
⑬77 "							77-78 4m3s
⑭78							78-79 4m10s
⑮79 "							79-80 4m7s
⑯80							80-81 4m12s

Tetra Tech Drawing Name & No.:	DPS PO#:
Split-Spoon (S); Rock Core (R), Shelby Tube (ST); Grab "bulk" Sample (GS) Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT) DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling	DATE OF DRILLING FOR THIS LOG PAGE: 8/29/17 DRILLING OBSERVER/COMPANY: Clarissa Lehman / PST

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PROJECT NAME:	PROJECT LOCATION:	PROJ./WO NO: 0491-1457
DRILL COMPANY:	LEAD DRILLER:	GROUNDWATER LEVELS
DRILL RIG TYPE & SPT HAMMER TYPE:	DRILLING STAGE	Groundwater Depth* Date Time
DRILLING METHOD & H.S.A./CASING DIAMETERS:		
ROCK CORE BARREL TYPE/SIZE		
BORING COORDINATES:	BORING GROUND ELEVATION:	

DESCRIPTION (Color, Soil Type, Moisture Conditon)	Sample Interval (ft)	SAMPLE ID#	REC (in)	RQD (in)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: 0		S, R, ST, GS					
81							81-82 4m35
82							82-83 4m125
83							83-84 4m75
84							84-85 4m95
85 same diabase	85.0-95.0	R-11	10.0'	114"			85-86 3m585
86							86-87 3m575
87							87-88 4m105
88							88-89 4m185
89							89-90 4m195
90							90-91 4m235
91							91-92 4m215
92							92-93 4m175
93							93-94 4m205
94							94-95 4m215
95 same diabase	95.0-105.0	R-12	10.0'	111"			95-96 3m575
96							96-97 3m545

Tetra Tech Drawing Name & No.: DPS PO#:

Split-Spoon (S); Rock Core (R); Shelby Tube (ST); Grab "bulk" Sample (GS)
 Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT)
 DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling
 DATE OF DRILLING FOR THIS LOG PAGE: 8/29/17
 DRILLING OBSERVER/COMPANY: Classsa Lehman / PSI

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PROJECT NAME:		PROJECT LOCATION:		PROJ./WO NO: 0491-1457	
DRILL COMPANY:		LEAD DRILLER:		GROUNDWATER LEVELS	
DRILL RIG TYPE & SPT HAMMER TYPE:		DRILLING STAGE	Groundwater Depth*	Date	Time
DRILLING METHOD & H.S.A./CASING DIAMETERS:					
ROCK CORE BARREL TYPE/SIZE					
BORING COORDINATES:		BORING GROUND ELEVATION:			

DESCRIPTION (Color, Soil Type, Moisture Conditon)	Sample Interval (ft)	SAMPLE ID#	REC (in)	RQD (in)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: 0		S, R, ST, GS					
97	"						97-98 3m53s
98							98-99 3m56s
99	"						99-100 4m1s
100							100-101 4m3s
101	"						101-102 3m59s
102							102-103 3m30s
103	"						103-104 3m28s
104							104-105 3m27s
105 same diabase	105.0-115.0	R-13	9.8'	115"			105-106 3m35s
106							106-107 3m41s
107	"						107-108 3m43s
108							108-109 3m39s
109	"						109-110 3m44s
110							110-111 3m48s
111	"						111-112 3m49s
112							112-113 3m37s

Tetra Tech Drawing Name & No.:	DPS PO#: 1
Split-Spoon (S); Rock Core (R), Shelby Tube (ST); Grab "bulk" Sample (GS) Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT) DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling	DATE OF DRILLING FOR THIS LOG PAGE: 8/29/17 DRILLING OBSERVER/COMPANY: Clarissa Lehman / PSI

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RECORD OF SUBSURFACE EXPLORATION			BORING NO: R-2		PPP#: 5		SHEET 8 OF			
PROJECT NAME:			PROJECT LOCATION:			PROJ./WO NO: 0491-1457				
DRILL COMPANY:		LEAD DRILLER:		GROUNDWATER LEVELS						
DRILL RIG TYPE & SPT HAMMER TYPE:				DRILLING STAGE	Groundwater Depth*	Date	Time			
DRILLING METHOD & H.S.A./CASING DIAMETERS:										
ROCK CORE BARREL TYPE/SIZE										
BORING COORDINATES:			BORING GROUND ELEVATION:							
DESCRIPTION (Color, Soil Type, Moisture Conditon)				Sample Interval (ft)	SAMPLE ID#	REC (in)	RQD (in)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: 0					S, R, ST, GS					
Ø113 "										113-114 3m395
Ø114										114-115 3m325
Ø115 same diabase				1150-1250	R-14	10.0'	88"			115-116 3m155
Ø116										116-117 3m215
Ø117 "										117-118 3m225
Ø118										118-119 3m185
Ø119 "										119-120 3m205
Ø120										120-121 3m235
Ø121 "										121-122 3m265
Ø122										122-123 3m255
Ø123 "										123-124 3m215
Ø124										124-125 3m205
Ø125 same diabase				1250-1300	R-15	50	3.9			125-126 3m415
Ø126										126-127 3m485
Ø127 "										127-128 3m605
Ø128										128-129 3m495
Tetra Tech Drawing Name & No.:						DPS PO#:				
Split-Spoon (S); Rock Core (R), Shelby Tube (ST); Grab "bulk" Sample (GS)				DATE OF DRILLING FOR THIS LOG PAGE: 8/29/17 - 8/30/17						
Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT)				DRILLING OBSERVER/COMPANY: Clarissa Lehman / PST						
DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling										
<small>The information presented in this field boring log is preliminary in nature and presented for informational purposes only. The final/completed boring log report shall be conclusive as to PSI's findings or opinions of the subsurface conditions encountered at this boring location. Therefore, this information is subject to review and change. The boring log descriptions apply only to the specific location(s) noted and may not represent any other locations or elevations. This field boring log may not be reproduced without written permission by Professional Service Industries, Inc.</small>										

RECORD OF SUBSURFACE EXPLORATION			BORING NO: B-2		PPP#: 5		SHEET 9 OF			
PROJECT NAME:		PROJECT LOCATION:			PROJ./WO NO: 0491-1457					
DRILL COMPANY:		LEAD DRILLER:		GROUNDWATER LEVELS						
DRILL RIG TYPE & SPT HAMMER TYPE:				DRILLING STAGE	Groundwater Depth*	Date	Time			
DRILLING METHOD & H.S.A/CASING DIAMETERS:				Upon Completion	1418"	8/30/17	945 AM			
ROCK CORE BARREL TYPE/SIZE										
BORING COORDINATES:			BORING GROUND ELEVATION:							
DESCRIPTION (Color, Soil Type, Moisture Conditon)				Sample Interval (ft)	SAMPLE ID#	REC (in)	RQD (in)	Blows Per 6 in.	Qp	REMARKS
Surface Materials: 0					S, R, ST, GS					
①129 "										129-130 3m47s
①130 Same diabase				130.0-140.0	R-16	10.0	6.3			130-131 4m5s
①131 "										131-132 4m8s
①132 "										132-133 4m3s
①133 "										133-134 3m59s
①134 "										134-135 4m2s
①135 "										135-136 4m1s
①136 "										136-137 3m56s
①137 137.3-139.7: Core very dry + extremely broken. Not enough water getting to the bit?										137-138 3m59s
①138 "										138-139 4m8s
①139 "										139-140 4m0s
①140 Same diabase				140.0-145.0	R-17	5.0	4.3			140-141 4m8s
①141 "										141-142 4m12s
①142 "										142-143 4m11s
①143 "										143-144 4m16s
①144 EOB @ 145.0 ft.										144-145 4m21s

Tetra Tech Drawing Name & No.:

DPS PO#:

Split-Spoon (S); Rock Core (R); Shelby Tube (ST); Grab "bulk" Sample (GS)

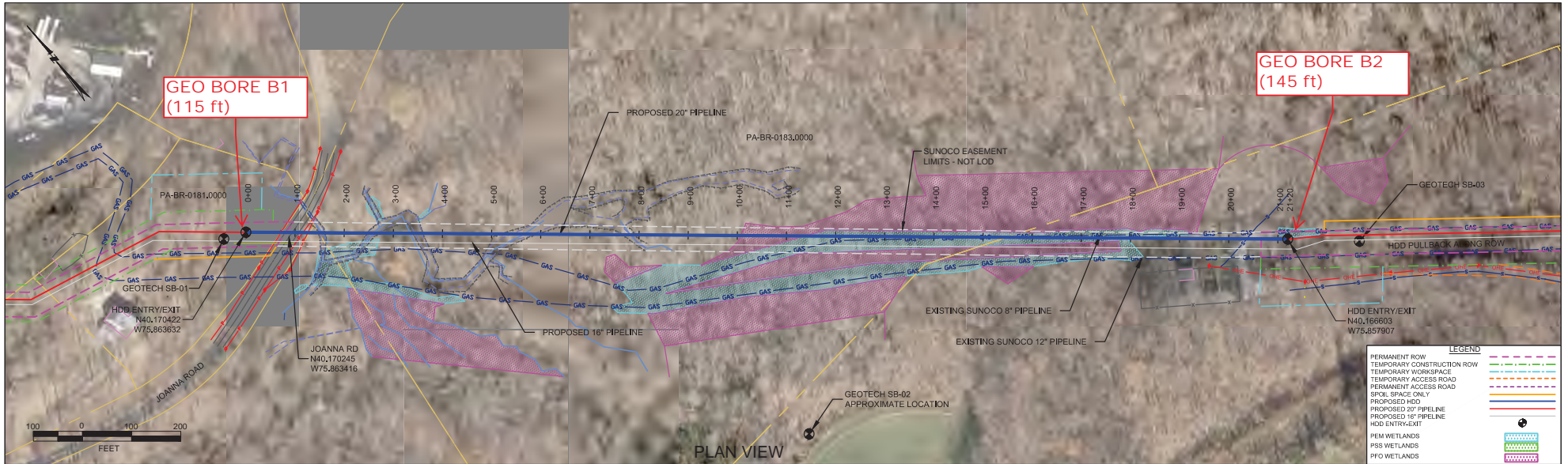
DATE OF DRILLING FOR THIS LOG PAGE: 8/30/17

Pocket Penetrometer (Qp); Weight of Hammer (WH); Weight of Tools (WT)

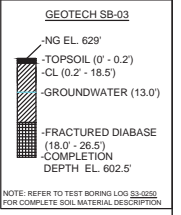
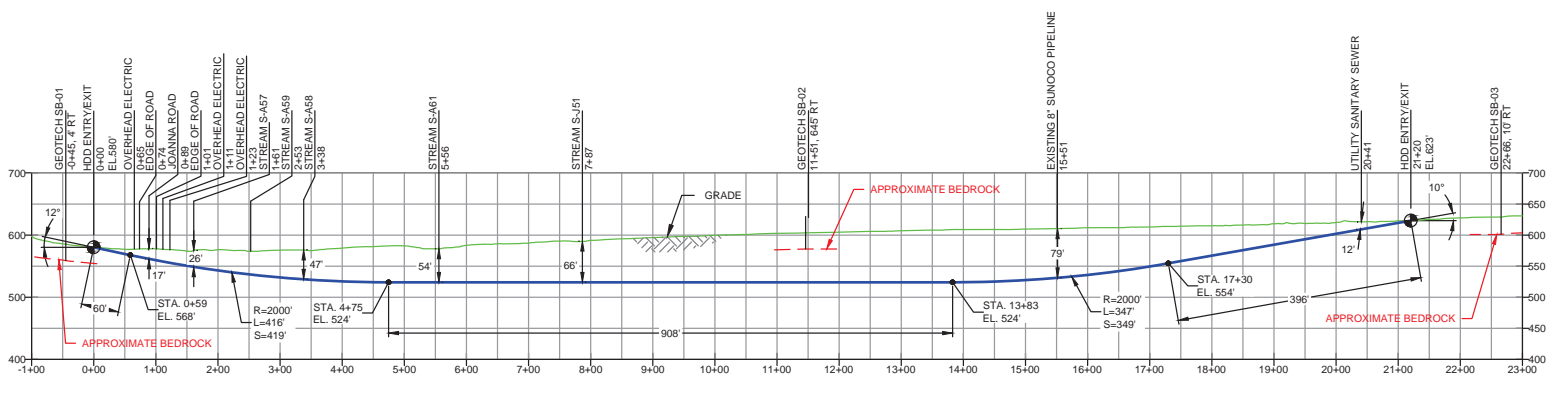
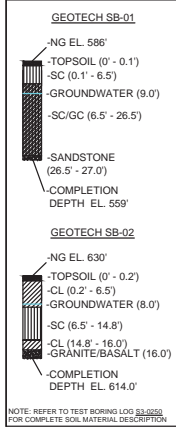
DRILL STAGE: Pre-core, Post-core, Upon Completion, Post Drilling

DRILLING OBSERVER/COMPANY: Clarissa Lehman / PST

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PROFILE VIEW



- DESIGN AND CONSTRUCTION:
- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
 - 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.
 - DESIGNED IN ACCORDANCE WITH CFR 49.195 & ASME B31.4
 - CROSSING PIPE SPECIFICATION:
HDD HORIZ. LENGTH (L)=2132'
HDD PIPE LENGTH (S)=2132'
20" x 0.456" W.T., X-45, APSL, PSL, ERW, BFW
COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R99)
 - INTERNAL DESIGN PRESSURE: 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS))
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD)
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 - CARRIER PIPE NOT ENCASED.
 - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
 - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
 - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

- NOTES
- ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
 - STATIONING IS BASED ON HORIZONTAL DISTANCES.
 - ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, L.P. 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, L.P. FOR ANY DAMAGES RESULTING FROM ERRORS OR OMISSIONS THEREIN.
 - CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.
 - SUNOCO EMERGENCY HOTLINE NUMBER IS 811-800-786-7440.

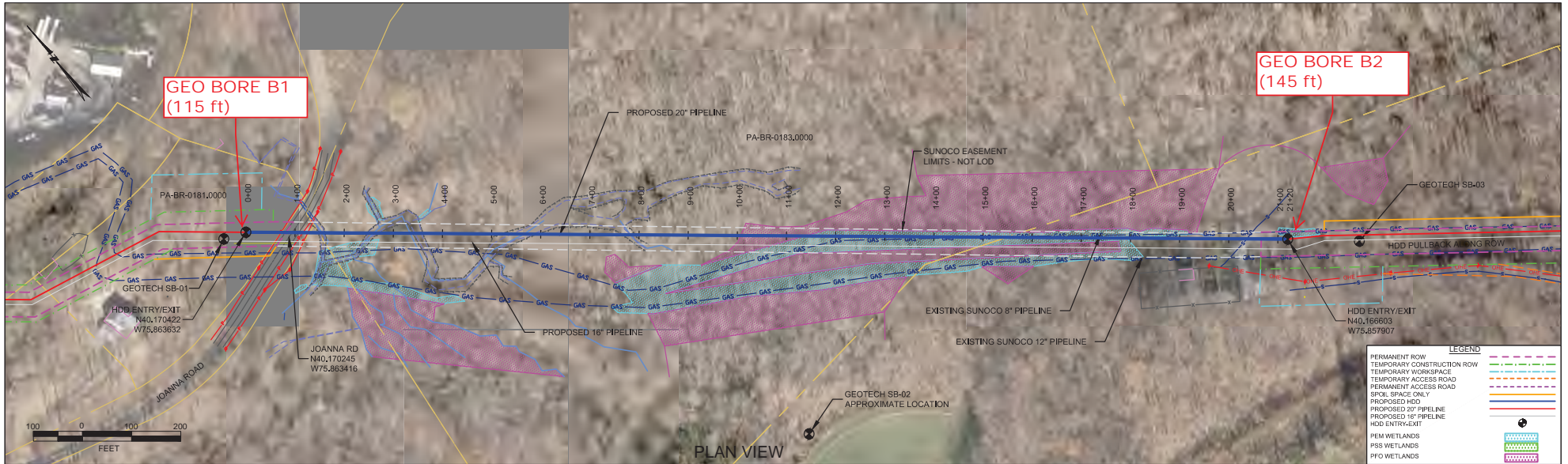
REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
5	DESIGN CHANGE (OFFSET DRILL 10')	MRS	02/23/17	RMB	02/23/17	AMC	02/23/17
4	REVISED PROFILE WITH 2017 LIDAR	MRS	02/23/17	RMB	02/23/17	AMC	02/23/17
3	UPDATED SUNOCO EASEMENT LIMITS - NOT LOD	MRS	10/24/16	RMB	10/24/16	AAW	10/24/16
2	REVISED PER ENGINEERING COMMENTS	MRS	08/19/16	RMB	08/19/16	AAW	08/19/16
1	REVISED PER COMMENTS FROM REI REVIEW	MRS	02/26/16	RMB	02/26/16	AAW	02/26/16
0	ISSUED FOR CONSTRUCTION	MRS	01/21/16	RMB	01/21/16	AAW	01/21/16

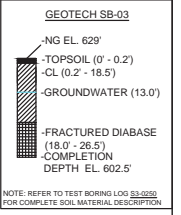
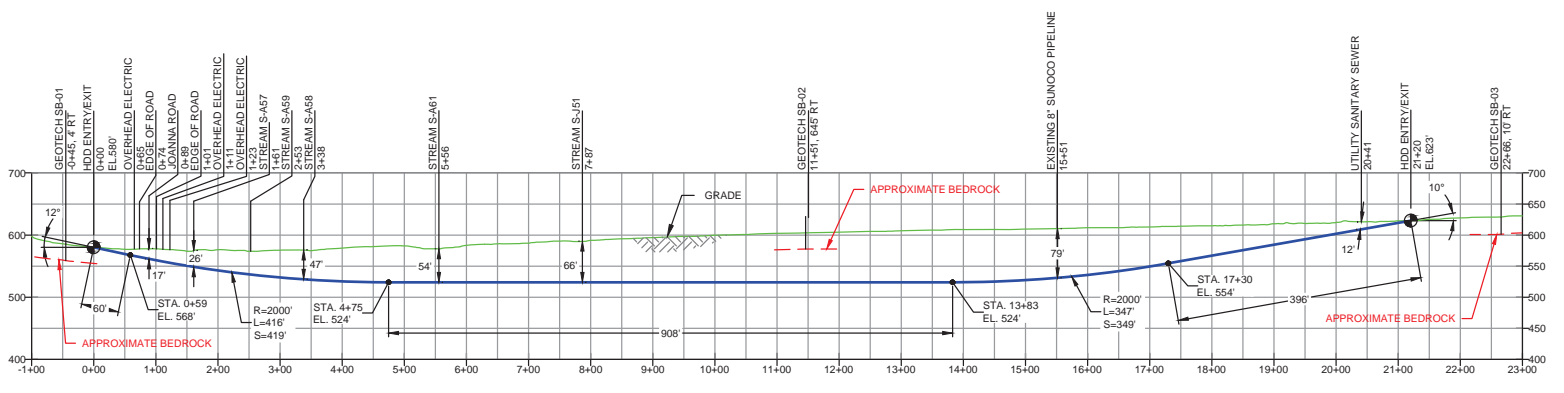
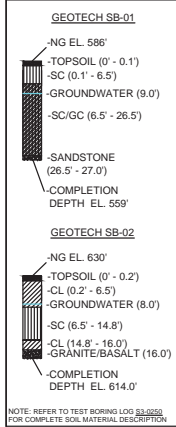
SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
JOANNA ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'
DWG. NUMBER: PA-BR-0181.0000-RD



PROFILE VIEW



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 - DESIGNED IN ACCORDANCE WITH CFR 49.195 & ASME B31.4
 - CROSSING PIPE SPECIFICATION:
HDD HORZ LENGTH (L)=2132'
HDD PIPE LENGTH (S)=2132'
20" O.D. 450' W.T., X-45, APSL, PSL, ERW, BFW
COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R99)
 - INTERNAL DESIGN PRESSURE: 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS))
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD)
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 - CARRIER PIPE NOT ENCASED.
 - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
 - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
 - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

- NOTES
- ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
 - STATIONING IS BASED ON HORIZONTAL DISTANCES.
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 - CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.
 - SUNOCO EMERGENCY HOTLINE NUMBER IS 811-800-786-7440.

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
5	DESIGN CHANGE (OFFSET DRILL 10')	MRS	02/23/17	RMB	02/23/17	AMC	02/23/17
4	REVISED PROFILE WITH 2017 LIDAR	MRS	02/23/17	RMB	02/23/17	AMC	02/23/17
3	UPDATED SUNOCO EASEMENT LIMITS - NOT LOD	MRS	10/24/16	RMB	10/24/16	AAW	10/24/16
2	REVISED PER ENGINEERING COMMENTS	MRS	08/19/16	RMB	08/19/16	AAW	08/19/16
1	REVISED PER COMMENTS FROM REI REVIEW	MRS	02/26/16	RMB	02/26/16	AAW	02/26/16
0	ISSUED FOR CONSTRUCTION	MRS	01/21/16	RMB	01/21/16	AAW	01/21/16

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
JOANNA ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'
DWG. NUMBER: PA-BR-0181.0000-RD















0141-1157
Joanna Rd. PPS
B-3
Box 9 of 9
4/24/17

Run	Depth	R	RQD
R-17	130.0-140.0	10.0	6.3
R-17	140.0-145.0	5.0	4.3
	EOB		

TOP

140.0





LEGEND:

⊙ Geotechnical Soil Boring (SB) Locations



GEOTECHNICAL BORING LOCATIONS
 HDD S3-0250 WETLAND J48 - JOANNA ROAD
 BERKS COUNTY, CAERNARVON 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: CLYMER HILL ROAD, ELVERSON, PA			Page 1 of 1		
HDD No.: S3-0250		Dates(s) Drilled: 03-09-15		Inspector: E. WATT	
Boring No.: SB-02		Drilling Method: SPT - ASTM D1586		Driller: S. HOFFER	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): 8.0		Total Depth (ft): 16.0	
Boring Location Coordinates:			40° 10' 1.241" N		75° 51' 43.350" W

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (ft)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
	From	To	From	To								
			0.0	0.2			TOPSOIL (2")					
1	3.0	5.0	0.2		19	CL	MOTTLED BROWN SILTY CLAY AND FINE SAND.	2	8	7	7	15
				6.5								
2	8.0	10.0	6.5		10	SC	DECOMPOSED ROCK WEATHERED TO A GREENISH GRAY TO BROWN	1	5	14	6	19
				14.8			CLAYEY FINE TO MEDIUM SAND.					
3	13.0	15.0	14.8		24	CL	GRAY AND GREENISH GRAY DECOMPOSED ROCK WEATHERED TO A	1	3	8	10	11
				16.0			SILTY CLAY AND FINE TO MEDIUM SAND. (USCS: CL).					
4	16.0	16.0	16.0	16.0	<1		REFUSAL MATERIAL APPEARS TO BE GRANITE or BASALT	50/0"				>50
							AUGER REFUSAL AT 16'.					
							WET ON SPOON AT 8'.					
							NO WATER LEVEL THROUGH AUGERS.					
							CAVED AT 11', WATER LEVEL ON CAVE AT 8'.					
							STARTED GRINDING AT 15.5'					
							AUGERS WERE TOO HIGH OUT OF GROUND TO BE ABLE TO SET CORE BARREL.					

Notes/Comments:
Pocket Pentrometer Testing
 5': 0.75 TSF

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

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: CLYMER HILL ROAD, ELVERSON, PA			Page 1 of 1		
HDD No.: S3-0250		Dates(s) Drilled: 05-19-15		Inspector: E. WATT	
Boring No.: SB-03		Drilling Method: SPT - ASTM D1586		Driller: S. HOFFER	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): 13.0		Total Depth (ft): 26.5	
Boring Location Coordinates:			40° 9' 58.805" N		75° 51' 27.075" W

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (ft)	Strata (USCS)	Description of Materials	6" Increment Blows *				N	
	From	To	From	To									
			0.0	0.2			TOPSOIL (2")						
1	3.0	5.0	0.2		18	CL	MOTTLED BROWN, ORANGE BROWN, GRAY SILTY CLAY AND FINE SAND.	1	4	6	10	10	
2	8.0	10.0			12		MOTTLED BROWN, ORANGE BROWN, GRAY SILTY CLAY AND FINE SAND.	5	5	5	8	10	
3	13.0	15.0			24		ORANGE BROWN SILTY CLAY AND FINE SAND. (USCS: CL).	1	2	2	2	4	
4	18.0	18.9			10		MOTTLED BROWN, LIGHT BROWN AND WHITE SILTY CLAY AND FINE SAND.	1	50/5"			>50	
				18.5									
			18.5	18.9									
							GRAY TO DARK GRAY PARTIALLY WEATHERED DIABASE.						
							AUGER REFUSAL AT 18.5'. AUGERS WERE TOO SKEWED TO CORE, SO OFF-SET 6' AND AUGERED TO REFUSAL AT 18'. BEGIN CORING.						
							<u>ROCK CORING</u>						
RUN 1	18.0	21.5	18.0	19.2	42	ROCK	MODERATELY FRACTURED DIABASE.	TCR: 100%, SCR: 93%, RQD: 74%					
			19.2	21.5			SLIGHTLY FRACTURED DIABASE.						
RUN 2	21.5	26.5	21.5	22.4	48		INTENSELY FRACTURED DIABASE, SOME OLIVINE DEPOSITS.	TCR: 80%, SCR: 60%, RQD: 55%					
			22.4	25.5			UNFRACTURED DIABASE WITH OLIVINE DEPOSITS						
			25.5	26.5			FRACTURE, RODS DROPPED QUICKLY						
							<u>CORE TESTING RESULTS (RUN 1, DEPTH 21')</u> :						
							COMPRESSIVE STRENGTH: 1,510 PSI						
							UNIT WEIGHT: 187.3 PCF						

Notes/Comments:
Pocket Pentrometer Testing

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 S3-0250 WETLAND J48 - JOANNA ROAD**

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.)		Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318)			USCS Classif. (ASTM D2487)
			From	To			Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	
S3-0250	SB-01	1	3.0	5.0	11.8	43.4	33	21	12	SC
		2	8.0	10.0	13.4	16.1	-	-	-	-
		3	13.0	14.9	12.0	37.6	-	-	-	-
		4	18.0	18.1	5.1	6.7	-	-	-	-
		5	23.0	23.8	18.0	42.9	34	21	13	SC
		6	26.5	27.0	10.5	24.5	-	-	-	-
	SB-02	1	3.0	5.0	21.0	57.1	-	-	-	-
		2	8.0	10.0	30.8	37.9	-	-	-	-
		3	13.0	15.0	41.2	54.4	41	21	20	CL
	SB-03	1	3.0	5.0	22.6	63.1	-	-	-	-
		2	8.0	10.0	20.9	59.2	-	-	-	-
		3	13.0	15.0	66.2	55.8	36	20	16	CL
		4	18.0	18.9	53.5	52.3	-	-	-	-

Rock Core Testing Results				
Boring No.	Core Run	Approximate Depth (ft)	Compressive Strength (psi)	Unit Weight (pcf)
SB-03	1	21.0	1,510	187.3

Notes:

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

**ROCK CORE DESCRIPTION SUMMARY
 SUNOCO PENNSYLVANIA PIPELINE PROJECT
 HDD S3-0250 WETLAND J48 - JOANNA ROAD**

Location	Boring No.	Core Run	Core Depth (ft)		TCR (%)	SCR (%)	RQD (%)	Depth (ft)		Weathering	Classification	Bedding Thickness (ft)	Color	Discontinuity Data
			From	To				From	To					
S3-0250	SB-03	1	18	21.5	100	93	74	18	26.5	Slight	Diabase	Massive	Gray	Fractures ranging from 30° to 70°, Avg. 45°
		2	21.5	26.5	80	60	55							

**REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0250 WETLAND J48 - JOANNA ROAD**

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
S3-0250	Wetland J48 - Joanna Rd.	SB-01	Stockton Formation - Light-gray to buff, coarse-grained, arkosic sandstone; includes reddish-brown to grayish-purple sandstone, siltstone, and mudstone.	Gently-moderately sloping lowlands	Stockton Fm	primarily sandstone with siltstone and mudstone		35-53	
		SB-02 and SB-03	Diabase - occurs primarily as dikes and sheets and forms a complex igneous network that extensively intrudes sedimentary rocks in the Gettysburg and Newark basins.		Diabase	Ophitic texture , an important variety of basalt texture where pyroxene (or occasionally olivine) forms larger crystals and typically contains numerous crystals of plagioclase		13	

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)

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

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 No. 10 to No. 40 sieve (M) (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)

Relative Proportions

<u>Description Term</u>	<u>Percent</u>
Trace	1 - 10
Little	11 - 20
Some	21 - 35
And	36 - 50

COHESIVE SOILS

(Silt, Clay & Combinations)

<u>Consistency</u>	<u>N (blows)*</u>
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

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

ROCK

(Rock Cores)

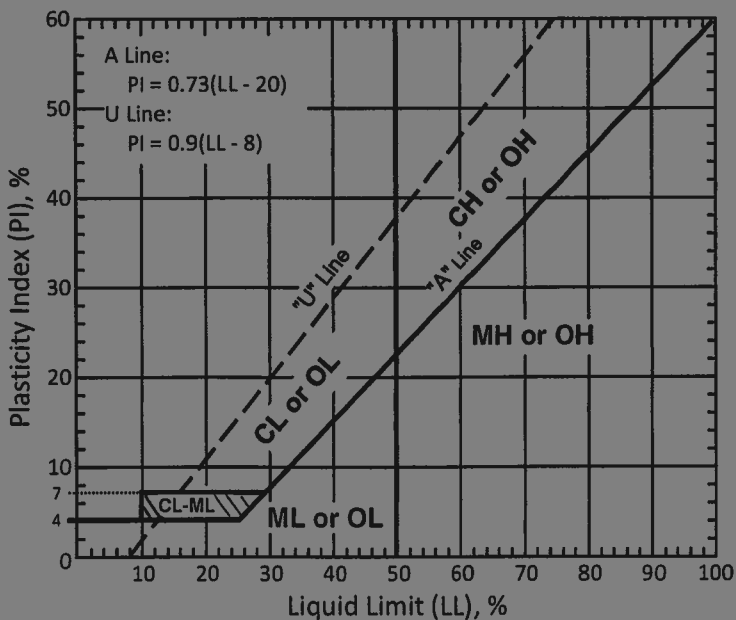
<u>Rock Quality Designation (RQD), %</u>	<u>Rock Quality Description</u>
0-25	Very Poor
25-50	Poor
50-75	Fair
75-90	Good
90-100	Excellent

***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 size	Clean gravel (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4: $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3 Not meeting C_u or C_c requirements for GW		
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines			
		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 Atterberg limits above A line with I_p greater than 7 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			
		Sands (More than half of coarse fraction is smaller than No. 4 Sieve)	Clean sands (Little or no fines)	SW	Well graded sands, gravelly 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 Not meeting C_u or C_c requirements for SW	
				SP	Poorly graded sands, gravelly sands, little or no fines		
	Sands with fines (Appreciable amount of fines)		SM	Silty sands, sand-silt mixtures	Atterberg limits below A Line or I_p less than 4 Atterberg limits above A line with I_p greater than 7 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			
	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⁾						
	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.						
	Major Divisions		Group Symbols	Typical Descriptions			
	Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silt 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				
Silt 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				



(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.

FIGURE 1: SITE VICINITY MAP

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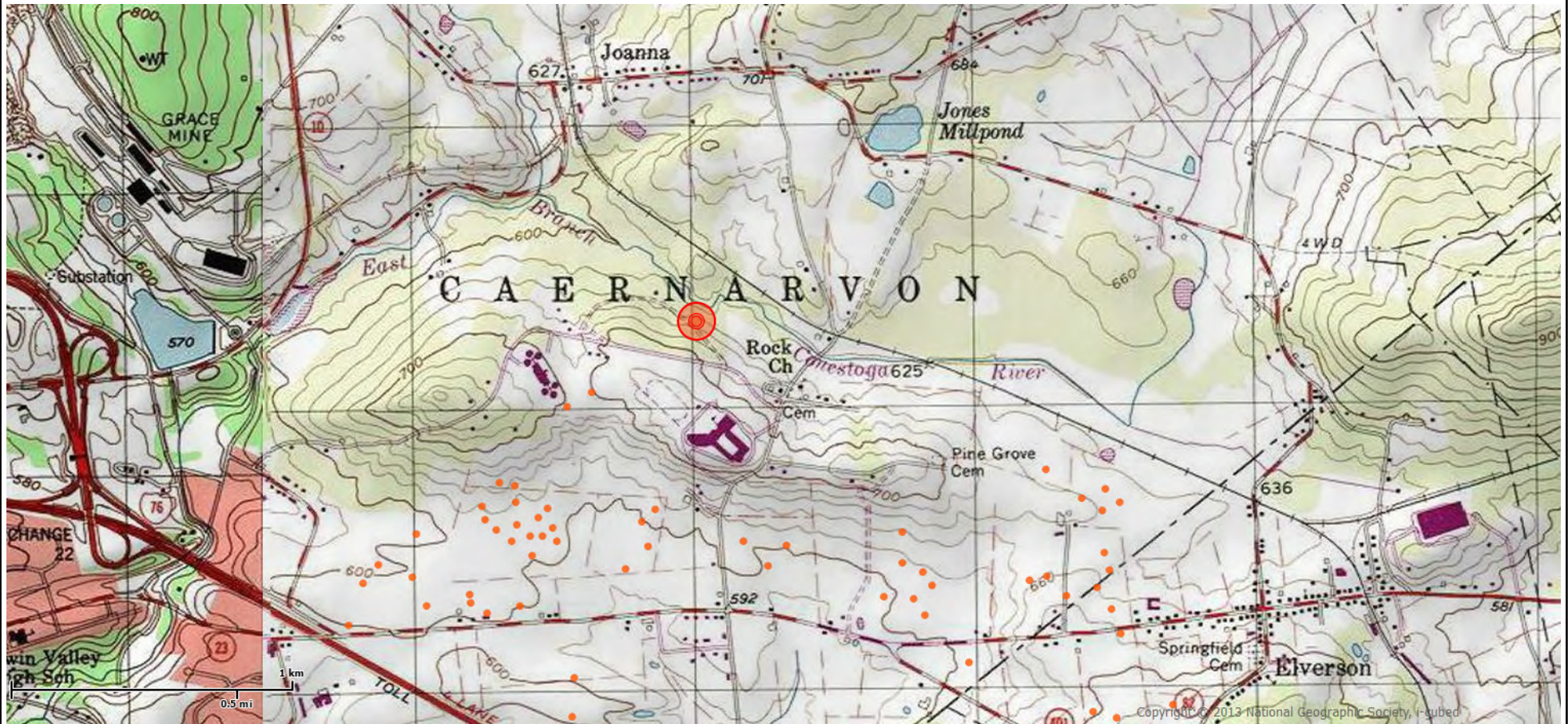
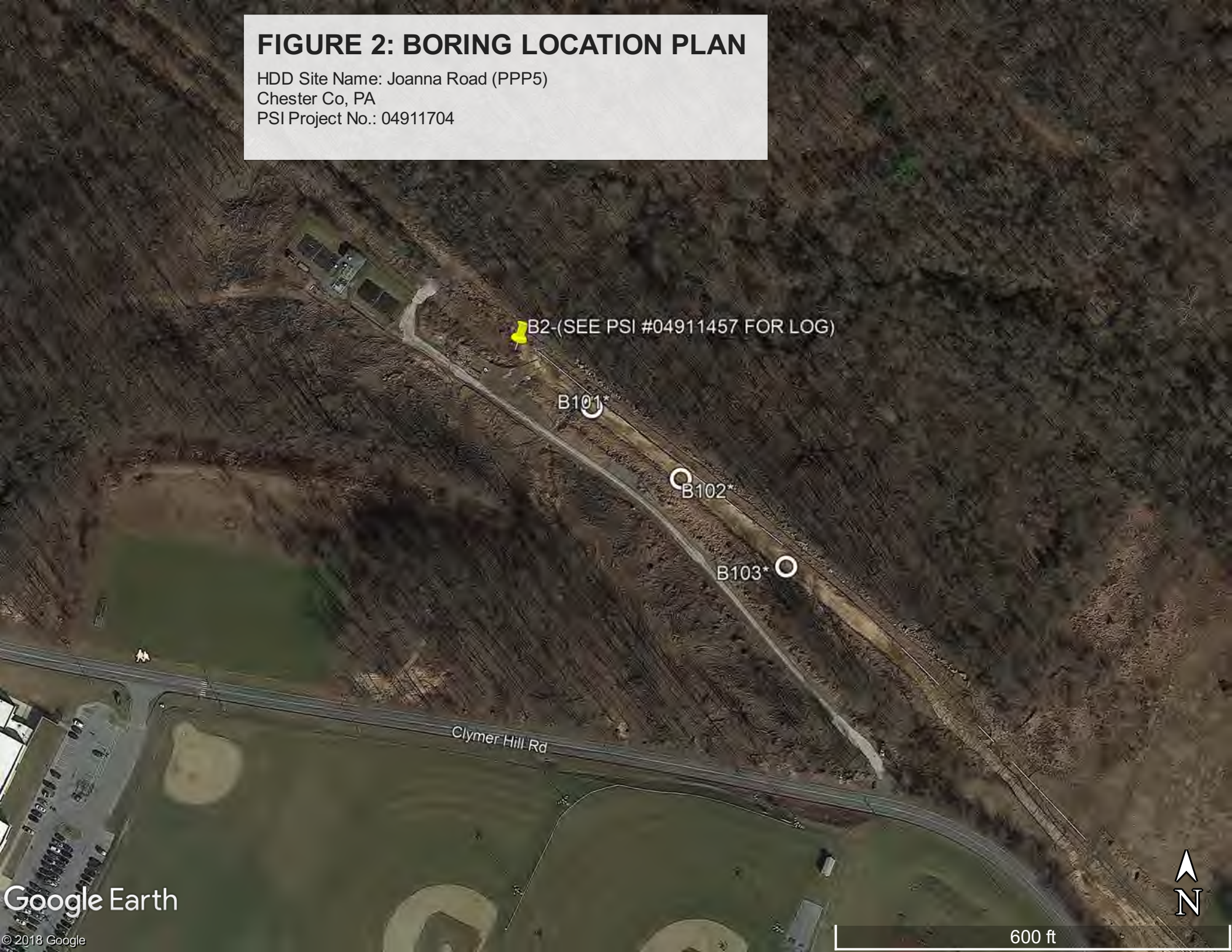


FIGURE 2: BORING LOCATION PLAN

HDD Site Name: Joanna Road (PPP5)

Chester Co, PA

PSI Project No.: 04911704



B2-(SEE PSI #04911457 FOR LOG)

B101*

B102*

B103*

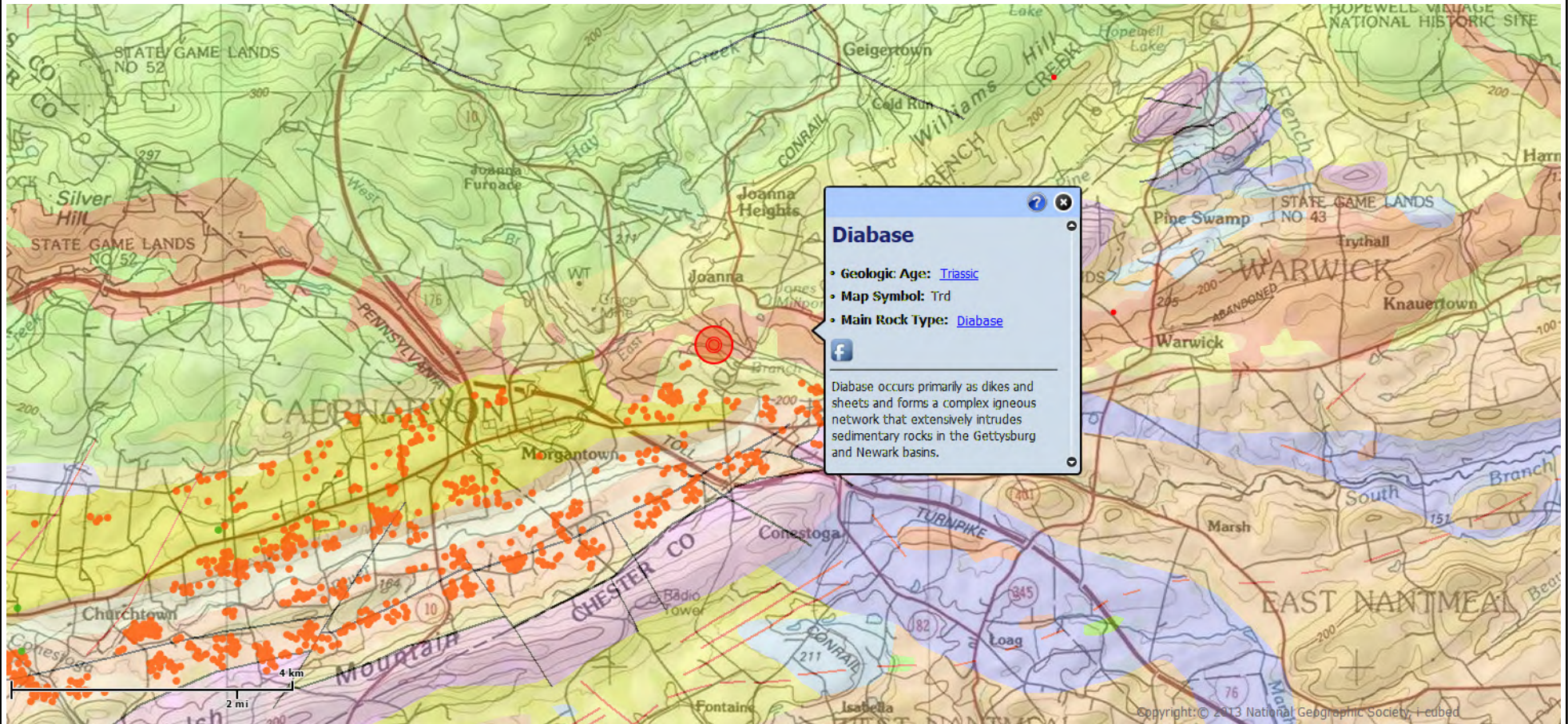
Clymer Hill Rd



FIGURE 3: SITE GEOLOGY MAP

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



DATE STARTED: 12/26/18 **DRILL COMPANY:** Allied Well Drilling, Inc.
DATE COMPLETED: 12/31/18 **DRILLER:** R. Miller **LOGGED BY:** M. Kauffman
COMPLETION DEPTH: 179.5 ft **DRILL RIG:** CME 45 Track
BENCHMARK: N/A **DRILLING METHOD:** Casing/Rock Coring
ELEVATION: 633.0 ft **SAMPLING METHOD:** 2-in SS2-in Core
LATITUDE: 40.166199° **HAMMER TYPE:** Automatic
LONGITUDE: -75.857329° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael
REMARKS: Boring ground elevations provided by DPS; boring coordinates estimated from Google Earth.

BORING B-101

Water	▽ While Coring (79.5 ft)	0.6 ft
	▼ While Coring (154.5 ft)	0 ft
	▽ Completion (179.5 ft)	0 ft

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 @	Additional Remarks
0	0					Unable to hand clear. Cased to 5 feet; soil washed away during casing activities.					
630	5		S-1	0	0	Diabase Boulders and Soil		50/0.0"			
625	10		S-2	18	18	RESIDUUM - Stiff to Very Stiff, red brown, CLAY with Sand and Gravel , moist	CL 4-6-24-50/0.0"	N=30			
620	15		R-1	23	23	BEDROCK - DIABASE , green, gray, very hard, broken to massive, slightly weathered		RQD=83 Rec=96%			4 min. Qu = 1653.7 tsf 190.2 pcf
615	20		R-2	60	60	BEDROCK - DIABASE , green, gray, hard to very hard, broken to massive, weathered to slightly weathered		RQD=73 Rec=100%			3 min. Qu = 1298.3 tsf 189.1 pcf
610	25		R-3	58	58	Broken from 21.5 to 27 feet		RQD=37 Rec=97%			4 min. Qu = 546.2 tsf 190.6 pcf
						Mineral filled, 60 degree fracture from 24.2 to					3 min. 4 min.

Continued Next Page



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

PROJECT NO.: 04911704
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Joanna Road (PPP5)
 N. Twin Valley Rd & Clymer Hill Rd
 Berks Co, PA

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▽	While Coring (79.5 ft)	0.6 ft
▼	While Coring (154.5 ft)	0 ft
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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 @		Additional Remarks
										Moisture	PL	
25						24.5 feet BEDROCK - DIABASE , green, gray, hard to very hard, broken to massive, weathered to slightly weathered NOTE: The near vertical fractures in broken area caused the driller to stop and pull up to facilitate water flow and the relay likely broke the rock more		RQD=60 Rec=100%				3 min. 3 min. 3 min. 3 min.
605				R-4	60							>> Q _u = 1166.8 tsf 190.4 pcf
30						BEDROCK - DIABASE , green, gray, very hard, massive, fresh		RQD=100 Rec=100%				>> Q _u = 1435.5 tsf 190.0 pcf
600				R-5	60							3 min. 3 min. 3 min. 3 min.
35								RQD=100 Rec=100%				2 min. 3 min. 3 min.
595				R-6	60							>> Q _u = 1699.3 tsf 189.7 pcf
40								RQD=100 Rec=100%				3 min. 3 min.
590				R-7	60							>> Q _u = 1146.7 tsf 190.1 pcf
45								RQD=100 Rec=100%				3 min. 3 min.
585				R-8	60	Green chlorite filled 60 degree fracture at 45.5 feet						>> Q _u = 1563.2 tsf 188.9 pcf
50								RQD=100 Rec=100%				3 min. 2 min. 3 min. 3 min.
												>> Q _u = 1349.5 tsf

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BORING B-101

Water	Depth (ft)	Remarks
▽	While Coring (79.5 ft)	0.6 ft
▼	While Coring (154.5 ft)	0 ft
▽	Completion (179.5 ft)	0 ft

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				Additional Remarks
										N in blows/ft @				
50						BEDROCK - DIABASE , green, gray, very hard, massive, fresh								190.9 pcf 3 min.
580				R-9	60	Vertical fracture from 53 to 54 feet		RQD=100 Rec=100%						>>⊙ 3 min.
55														>>⊙ 3 min. Qu = 1139.3 tsf
575				R-10	60			RQD=100 Rec=100%						>>⊙ 3 min. Qu = 844.4 tsf
60														>>▲ 3 min. 189.2 pcf
570				R-11	60			RQD=100 Rec=100%						>>⊙ 3 min. Qu = 1338.9 tsf
65						Mechanically broken by hammer blows on inner barrel								>>▲ 3 min. 190.1 pcf
565				R-12	60			RQD=100 Rec=100%						>>⊙ 3 min. Qu = 832.7 tsf
70														>>▲ 3 min. 187.4 pcf
560				R-13	60	Chlorite filled 70 degree fracture from 72.5 to 73.5 feet		RQD=100 Rec=100%						>>⊙ 3 min. Qu = 935.8 tsf
75														>>⊙ 3 min. 176.8 pcf

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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 @	Additional Remarks	
75						BEDROCK - DIABASE , green, gray, very hard, massive, fresh				X Moisture □ PL + LL 0 25 50		
			R-14	60			RQD=100 Rec=100%			▲ Qu * Qp 0 2.0 4.0	>>> ▲ Qu = 1740.7 tsf 192.3 pcf 3 min. >>> ⊙ 3 min. 3 min. 3 min. >>> ▲ Qu = 629.7 tsf 188.9 pcf 3 min. >>> ⊙ 3 min. 3 min. 3 min. >>> ⊙ 3 min. 3 min. 3 min. >>> ⊙ 3 min. 3 min. 3 min. >>> ▲ Qu = 939.1 tsf 191.5 pcf 3 min. 3 min. 3 min. >>> ▲ Qu = 1037.1 tsf 191.3 pcf 3 min. 3 min. 3 min. >>> ▲ Qu = 1647.8 tsf 191.6 pcf 3 min. 3 min. 3 min. >>> ⊙ 3 min. 3 min. 3 min. >>> ▲ 3 min.	
555												
80												
550												
85												
545												
90												
540												
95												
535												
100												

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See Boring Location Plan

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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		Additional Remarks
										N in blows/ft @	Strength, tsf	
100						BEDROCK - DIABASE , green, gray, very hard, massive, fresh						
530				R-19	60		RQD=100 Rec=100%					Qu = 1347.6 tsf 199.2 pcf 3 min. 3 min. 3 min. 3 min. Qu = 1078.0 tsf 189.8 pcf 3 min. 3 min. 3 min. Qu = 1303.2 tsf 191.4 pcf 3 min. 3 min. 3 min. Qu = 1508.2 tsf 192.4 pcf 3 min. 3 min. 3 min. Qu = 1583.3 tsf 191.5 pcf 3 min. 3 min. 3 min. Qu = 1685.0 tsf 192.5 pcf 3 min. 3 min. 3 min.
105				R-20	60	RQD=100 Rec=100%						
525				R-21	60	RQD=100 Rec=100%						
110				R-22	60	RQD=100 Rec=100%						
520				R-23	60	RQD=100 Rec=100%						
115												
515												
120												
510												
125												

Continued Next Page



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LATITUDE: 40.166199° **HAMMER TYPE:** Automatic
LONGITUDE: -75.857329° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael

BORING B-101

Water	▽ While Coring (79.5 ft)	0.6 ft
	▼ While Coring (154.5 ft)	0 ft
	▽ Completion (179.5 ft)	0 ft

BORING LOCATION:
See Boring Location Plan

REMARKS: Boring ground elevations provided by DPS; boring coordinates estimated from Google Earth.

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		Additional Remarks
										N in blows/ft @	Strength, tsf	
125						BEDROCK - DIABASE , green, gray, very hard, massive, fresh						
505			R-24		60		RQD=100 Rec=100%					>>▲ Qu = 1327.5 tsf 199.4 pcf 3 min. >>⊙ 3 min. 3 min.
130												>>▲ Qu = 1306.2 tsf 193.9 pcf 3 min.
500			R-25		60	Chlorite fractures from 134.5 to 146.3 feet	RQD=100 Rec=100%					>>⊙ 3 min. 3 min.
135												>>▲ Qu = 1768.3 tsf 193.2 pcf 3 min.
495			R-26		60		RQD=100 Rec=100%					>>⊙ 3 min. 3 min.
140												>>▲ Qu = 874.8 tsf 193.9 pcf 3 min.
490			R-27		60	Core has many chlorite filled fractures and fell apart beating it out of inner barrel	RQD=100 Rec=100%					>>⊙ 3 min. 3 min.
145												>>▲ Qu = 1955.3 tsf 192.3 pcf 3 min.
485			R-28		60		RQD=100 Rec=100%					>>⊙ 3 min. 3 min.
150												>>▲ Qu = 1181.6 tsf 3 min.

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

PROJECT NO.: 04911704
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Joanna Road (PPP5)
 N. Twin Valley Rd & Clymer Hill Rd
 Berks Co, PA

DATE STARTED: 12/26/18 **DRILL COMPANY:** Allied Well Drilling, Inc.
DATE COMPLETED: 12/31/18 **DRILLER:** R. Miller **LOGGED BY:** M. Kauffman
COMPLETION DEPTH: 179.5 ft **DRILL RIG:** CME 45 Track
BENCHMARK: N/A **DRILLING METHOD:** Casing/Rock Coring
ELEVATION: 633.0 ft **SAMPLING METHOD:** 2-in SS2-in Core
LATITUDE: 40.166199° **HAMMER TYPE:** Automatic
LONGITUDE: -75.857329° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael
REMARKS: Boring ground elevations provided by DPS; boring coordinates estimated from Google Earth.

BORING B-101

Water	▽	While Coring (79.5 ft)	0.6 ft
	▼	While Coring (154.5 ft)	0 ft
	▽	Completion (179.5 ft)	0 ft

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 @	Additional Remarks
175				R-34	60	BEDROCK - DIABASE , green, gray, very hard, massive, fresh		RQD=100 Rec=100%		X Moisture PL + LL 0 25 50	3 min. >> $Q_u = 1395.5$ tsf 191.8 pcf 3 min. >> \odot 3 min. 3 min. 3 min.
455						Boring terminated at 179.5 feet					



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PROJECT NO.: 04911704
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Joanna Road (PPP5)
 N. Twin Valley Rd & Clymer Hill Rd
 Berks Co, PA

DATE STARTED: 1/4/19 **DRILL COMPANY:** Allied Well Drilling, Inc.
DATE COMPLETED: 1/8/19 **DRILLER:** G. Brugger **LOGGED BY:** M. Kauffman
COMPLETION DEPTH: 130.0 ft **DRILL RIG:** Deidrich D-50 Track
BENCHMARK: N/A **DRILLING METHOD:** Casing/Rock Coring
ELEVATION: 642.0 ft **SAMPLING METHOD:** 2-in SS2-in Core
LATITUDE: 40.165898° **HAMMER TYPE:** Automatic
LONGITUDE: -75.856842° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael
REMARKS: Boring ground elevations provided by DPS; boring coordinates estimated from Google Earth.

BORING B-102

Water	▽	While Coring (36.5 ft)	4 ft
	▼	While Coring (101.5 ft)	6.8 ft
	▽		

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 @	Additional Remarks
										X Moisture □ PL + LL STRENGTH, tsf ▲ Qu * Qp	
0	0					Unable to hand clear. Cased to casing refusal at 3.5 feet; soil washed away during casing activities.					
640	3					▽ BEDROCK - DIABASE , green, gray, very hard, slightly broken, moderately to slightly weathered					4 min.
635	5		R-1		30		RQD=58 Rec=83%				3 min.
630	10		R-2		50		RQD=30 Rec=83%				3 min.
625	15					BEDROCK - DIABASE , green, gray, very hard, massive, fresh					2 min.
620	20		R-3		60		RQD=100 Rec=100%				4 min.
615	25										4 min.
610	30		R-4		60		RQD=100 Rec=100%				4 min.
605	35										4 min.
600	40		R-5		60		RQD=100 Rec=100%				4 min.
595	45										4 min.
590	50										4 min.
585	55										4 min.
580	60										4 min.
575	65										4 min.
570	70										4 min.
565	75										4 min.
560	80										4 min.
555	85										4 min.
550	90										4 min.
545	95										4 min.
540	100										4 min.
535	105										4 min.
530	110										4 min.
525	115										4 min.
520	120										4 min.
515	125										4 min.
510	130										4 min.

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Professional Service Industries, Inc.
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 Harrisburg, PA 17104
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PROJECT NO.: 04911704
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Joanna Road (PPP5)
 N. Twin Valley Rd & Clymer Hill Rd
 Berks Co, PA

DATE STARTED: 1/4/19 **DRILL COMPANY:** Allied Well Drilling, Inc.
DATE COMPLETED: 1/8/19 **DRILLER:** G. Brugger **LOGGED BY:** M. Kauffman
COMPLETION DEPTH: 130.0 ft **DRILL RIG:** Deidrich D-50 Track
BENCHMARK: N/A **DRILLING METHOD:** Casing/Rock Coring
ELEVATION: 642.0 ft **SAMPLING METHOD:** 2-in SS2-in Core
LATITUDE: 40.165898° **HAMMER TYPE:** Automatic
LONGITUDE: -75.856842° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael

BORING B-102

Water	▽	While Coring (36.5 ft)	4 ft
	▼	While Coring (101.5 ft)	6.8 ft
	▽		

BORING LOCATION:
See Boring Location Plan

REMARKS: Boring ground elevations provided by DPS; boring coordinates estimated from Google Earth.

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 @	Additional Remarks
25						BEDROCK - DIABASE , green, gray, very hard, massive, fresh				X Moisture □ PL ▼ + LL	
615				R-6	60			RQD=100 Rec=100%		0 25 50 0 2.0 4.0	3 min. >> ⑨ min. 1596.4 tsf 190.6 pcf 3 min. 3 min. >> ⑧ min.
30											3 min.
610				R-7	60			RQD=100 Rec=100%			>> ⑨ min. 1570.9 tsf 190.6 pcf 3 min. 3 min. >> ⑧ min.
35											3 min.
605				R-8	60			RQD=100 Rec=100%			>> ⑨ min. 1353.9 tsf 189.7 pcf 7 min. 10 min. >> ⑥ min.
40											5 min.
600				R-9	60			RQD=100 Rec=100%			>> ⑨ min. 1176.9 tsf 190.9 pcf 4 min. 4 min. >> ④ min.
45						Mineral deposit 45 degrees at 45 feet					4 min.
595				R-10	60			RQD=100 Rec=100%			>> ⑨ min. 1577.2 tsf 191.0 pcf 3 min. 3 min. >> ⑥ min.
50											

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DATE STARTED: 1/4/19 **DRILL COMPANY:** Allied Well Drilling, Inc.
DATE COMPLETED: 1/8/19 **DRILLER:** G. Brugger **LOGGED BY:** M. Kauffman
COMPLETION DEPTH: 130.0 ft **DRILL RIG:** Deidrich D-50 Track
BENCHMARK: N/A **DRILLING METHOD:** Casing/Rock Coring
ELEVATION: 642.0 ft **SAMPLING METHOD:** 2-in SS2-in Core
LATITUDE: 40.165898° **HAMMER TYPE:** Automatic
LONGITUDE: -75.856842° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael

BORING B-102

Water
 ▽ While Coring (36.5 ft) 4 ft
 ▼ While Coring (101.5 ft) 6.8 ft
 ▽

BORING LOCATION:
 See Boring Location Plan

REMARKS: Boring ground elevations provided by DPS; boring coordinates estimated from Google Earth.

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 @				Additional Remarks	
										Moisture	PL	LL	Strength		
50						BEDROCK - DIABASE , green, gray, very hard, massive, fresh									
590				R-11	60			RQD=100 Rec=100%							3 min. 3 min. -> @ 1241.7 tsf 190.0 pcf 3 min. -> @ 3 min.
555				R-12	60			RQD=100 Rec=100%							4 min. -> @ 1470.1 tsf 189.3 pcf 4 min. 4 min. -> @ 4 min.
585				R-13	60			RQD=100 Rec=100%							4 min. -> @ 1180.9 tsf 191.0 pcf 3 min. 3 min. -> @ 3 min.
60				R-14	60			RQD=100 Rec=100%							3 min. -> @ 1169.7 tsf 192.0 pcf 3 min. 3 min. -> @ 3 min.
575				R-15	60			RQD=100 Rec=100%							3 min. -> @ 1615.3 tsf 190.7 pcf 4 min. 4 min. -> @ 3 min.
70															
570															
75															

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DATE STARTED: 1/4/19 **DRILL COMPANY:** Allied Well Drilling, Inc.
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BENCHMARK: N/A **DRILLING METHOD:** Casing/Rock Coring
ELEVATION: 642.0 ft **SAMPLING METHOD:** 2-in SS2-in Core
LATITUDE: 40.165898° **HAMMER TYPE:** Automatic
LONGITUDE: -75.856842° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael

BORING B-102

Water
 ▽ While Coring (36.5 ft) 4 ft
 ▼ While Coring (101.5 ft) 6.8 ft
 ▽

BORING LOCATION:
 See Boring Location Plan

REMARKS: Boring ground elevations provided by DPS; boring coordinates estimated from Google Earth.

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 @				Additional Remarks	
										Moisture	PL	LL	Strength		
75						BEDROCK - DIABASE , green, gray, very hard, massive, fresh									
565				R-16	60			RQD=100 Rec=100%							3 min. 4 min. >>▲ Qu = 1975.0 tsf 394.8 pcf
80															3 min. 4 min.
560				R-17	60			RQD=100 Rec=100%							>>▲ Qu = 1207.1 tsf 189.0 pcf
85															4 min. 4 min.
555				R-18	60			RQD=100 Rec=100%							>>▲ Qu = 955.0 tsf 190.7 pcf
90															3 min. 3 min.
550				R-19	60			RQD=100 Rec=100%							>>▲ Qu = 954.8 tsf 192.8 pcf
95															3 min. 3 min.
545				R-20	60			RQD=100 Rec=100%							>>▲ Qu = 1550.8 tsf 190.5 pcf
100															3 min. 3 min.

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 Berks Co, PA

DATE STARTED: 1/4/19 **DRILL COMPANY:** Allied Well Drilling, Inc.
DATE COMPLETED: 1/8/19 **DRILLER:** G. Brugger **LOGGED BY:** M. Kauffman
COMPLETION DEPTH: 130.0 ft **DRILL RIG:** Deidrich D-50 Track
BENCHMARK: N/A **DRILLING METHOD:** Casing/Rock Coring
ELEVATION: 642.0 ft **SAMPLING METHOD:** 2-in SS2-in Core
LATITUDE: 40.165898° **HAMMER TYPE:** Automatic
LONGITUDE: -75.856842° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael

BORING B-102

Water
 ▽ While Coring (36.5 ft) 4 ft
 ▽ While Coring (101.5 ft) 6.8 ft

BORING LOCATION:
 See Boring Location Plan

REMARKS: Boring ground elevations provided by DPS; boring coordinates estimated from Google Earth.

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 @	Additional Remarks	
100						BEDROCK - DIABASE , green, gray, very hard, massive, fresh				X Moisture □ PL + LL STRENGTH, tsf ▲ Qu * Qp		
540				R-21	60		RQD=100 Rec=100%			3 min. >>▲ Qu = 1009.9 tsf 390.2 pcf	5 min.	
											4 min.	
											>>@ 4 min.	
105											4 min.	
				R-22	60		RQD=100 Rec=100%				4 min. >>▲ Qu = 989.4 tsf 191.7 pcf	4 min.
535											4 min.	
											>>@ 4 min.	
110											3 min.	
											>>▲ Qu = 1647.1 tsf 192.7 pcf	3 min.
530											3 min.	
				R-23	60		RQD=100 Rec=100%				>>@ 3 min.	
115											3 min.	
											>>▲ Qu = 1528.4 tsf 192.9 pcf	3 min.
525											3 min.	
				R-24	60		RQD=100 Rec=100%				>>@ 2 min.	
120											2 min.	
											>>▲ Qu = 1077.8 tsf 190.7 pcf	3 min.
520											2 min.	
				R-25	60		RQD=100 Rec=100%				>>@ 3 min.	
125												

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PROJECT NO.: 04911704
PROJECT: Energy Transfer HDD (DPS)
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 N. Twin Valley Rd & Clymer Hill Rd
 Berks Co, PA

DATE STARTED: 1/4/19 **DRILL COMPANY:** Allied Well Drilling, Inc.
DATE COMPLETED: 1/8/19 **DRILLER:** G. Brugger **LOGGED BY:** M. Kauffman
COMPLETION DEPTH: 130.0 ft **DRILL RIG:** Deidrich D-50 Track
BENCHMARK: N/A **DRILLING METHOD:** Casing/Rock Coring
ELEVATION: 642.0 ft **SAMPLING METHOD:** 2-in SS2-in Core
LATITUDE: 40.165898° **HAMMER TYPE:** Automatic
LONGITUDE: -75.856842° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael

BORING B-102

Water	▽	While Coring (36.5 ft)	4 ft
	▼	While Coring (101.5 ft)	6.8 ft
	▽		

BORING LOCATION:
See Boring Location Plan

REMARKS: Boring ground elevations provided by DPS; boring coordinates estimated from Google Earth.

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 @	Additional Remarks
										X Moisture □ PL + LL 0 25 50	
										STRENGTH, tsf ▲ Qu * Qp 0 2.0 4.0	
125			R-26	42	42	BEDROCK - DIABASE , green, gray, very hard, massive, fresh					3 min. ① 1349.5 tsf 190.6 pcf
515										RQD=100 Rec=100%	
130						Boring terminated at 130 feet					



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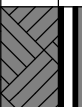
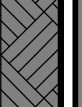
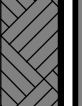
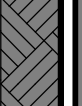
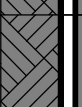
PROJECT NO.: 04911704
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Joanna Road (PPP5)
 N. Twin Valley Rd & Clymer Hill Rd
 Berks Co, PA

DATE STARTED: 12/19/18 **DRILL COMPANY:** Allied Well Drilling, Inc.
DATE COMPLETED: 1/3/19 **DRILLER:** G. Brugger **LOGGED BY:** M. Kauffman
COMPLETION DEPTH: 190.0 ft **DRILL RIG:** Deidrich D-50 Track
BENCHMARK: N/A **DRILLING METHOD:** Casing/Rock Coring
ELEVATION: 643.0 ft **SAMPLING METHOD:** 2-in SS2-in Core
LATITUDE: 40.165534° **HAMMER TYPE:** Automatic
LONGITUDE: -75.856271° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael
REMARKS: Boring ground elevations provided by DPS; boring coordinates estimated from Google Earth.

BORING B-103

Water	▽ While Coring (66 ft)	8.2 ft
	▼	
	▽ Completion (190 ft)	40.9 ft

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 @	Additional Remarks
0						Hand cleared to refusal at 3.5 feet; soils generally consisted of silt and sand.					
640	5		R-1		27	BEDROCK - DIABASE , green, gray, hard to very hard, slightly broken, slightly weathered to fresh		RQD=80 Rec=90%		X Moisture □ PL + LL 0 25 50	>> Q _u = 866.6 tsf >> Q _u = 188.8 pcf >> 5 min. 4 min. 3 min.
635	10		R-2		60			RQD=88 Rec=100%		▲ Qu * Qp 0 2.0 4.0	>> Q _u = 802.5 tsf >> Q _u = 188.5 pcf >> 3 min. 4 min.
630	15		R-3		60	BEDROCK - DIABASE , green, gray, hard to very hard, massive, slightly weathered to fresh		RQD=100 Rec=100%			>> Q _u = 1334.5 tsf >> Q _u = 388.1 pcf >> 3 min. 3 min.
625	20		R-4		60	80 Degree fracture from 18 to 20 feet		RQD=100 Rec=100%			>> Q _u = 1159.4 tsf >> Q _u = 189.8 pcf >> 4 min. 3 min.
620	25		R-5		60	BEDROCK - DIABASE , green, gray, very hard, massive, fresh		RQD=100 Rec=100%			>> Q _u = 1175.7 tsf >> Q _u = 189.5 pcf >> 3 min. 3 min.

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PROJECT NO.: 04911704
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Joanna Road (PPP5)
 N. Twin Valley Rd & Clymer Hill Rd
 Berks Co, PA

DATE STARTED: 12/19/18 **DRILL COMPANY:** Allied Well Drilling, Inc.
DATE COMPLETED: 1/3/19 **DRILLER:** G. Brugger **LOGGED BY:** M. Kauffman
COMPLETION DEPTH: 190.0 ft **DRILL RIG:** Deidrich D-50 Track
BENCHMARK: N/A **DRILLING METHOD:** Casing/Rock Coring
ELEVATION: 643.0 ft **SAMPLING METHOD:** 2-in SS2-in Core
LATITUDE: 40.165534° **HAMMER TYPE:** Automatic
LONGITUDE: -75.856271° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael
REMARKS: Boring ground elevations provided by DPS; boring coordinates estimated from Google Earth.

BORING B-103

Water	▽ While Coring (66 ft)	8.2 ft
	▼	
	▽ Completion (190 ft)	40.9 ft

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 @	Additional Remarks
25						BEDROCK - DIABASE , green, gray, very hard, massive, fresh					
615				R-6	60		RQD=100 Rec=100%			3 min. >>▲ Qu = 987.7 tsf 189.7 pcf 3 min.	
30										3 min. >>⊙ 3 min.	
610				R-7	60		RQD=100 Rec=100%			3 min. >>▲ Qu = 965.3 tsf 189.7 pcf 3 min.	
35										3 min. >>⊙ 3 min.	
605				R-8	60		RQD=100 Rec=100%			4 min. >>▲ Qu = 1319.5 tsf 189.2 pcf 4 min.	
40										4 min. >>⊙ 3 min.	
600				R-9	60		RQD=100 Rec=100%			3 min. >>▲ Qu = 1366.1 tsf 190.6 pcf 3 min.	
45										3 min. >>⊙ 3 min.	
595				R-10	60		RQD=100 Rec=100%			3 min. >>▲ Qu = 860.8 tsf 190.5 pcf 4 min.	
50										4 min. >>⊙ 3 min.	

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

PROJECT NO.: 04911704
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Joanna Road (PPP5)
 N. Twin Valley Rd & Clymer Hill Rd
 Berks Co, PA

DATE STARTED: 12/19/18 **DRILL COMPANY:** Allied Well Drilling, Inc.
DATE COMPLETED: 1/3/19 **DRILLER:** G. Brugger **LOGGED BY:** M. Kauffman
COMPLETION DEPTH: 190.0 ft **DRILL RIG:** Deidrich D-50 Track
BENCHMARK: N/A **DRILLING METHOD:** Casing/Rock Coring
ELEVATION: 643.0 ft **SAMPLING METHOD:** 2-in SS2-in Core
LATITUDE: 40.165534° **HAMMER TYPE:** Automatic
LONGITUDE: -75.856271° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael

BORING B-103

Water	▽ While Coring (66 ft)	8.2 ft
	▼	
	▽ Completion (190 ft)	40.9 ft

BORING LOCATION:
See Boring Location Plan

REMARKS: Boring ground elevations provided by DPS; boring coordinates estimated from Google Earth.

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 @	Additional Remarks	
50						BEDROCK - DIABASE , green, gray, very hard, massive, fresh						
590				R-11	60			RQD=100 Rec=100%			4 min. 4 min. 4 min. $Q_u = 1847.1$ tsf 190.6 pcf 4 min. 3 min.	
555											4 min. 4 min. 4 min. $Q_u = 985.4$ tsf 390.4 pcf 3 min. 3 min.	
585				R-12	60			RQD=100 Rec=100%			4 min. 4 min. 4 min. $Q_u = 1128.7$ tsf 189.7 pcf 13 min.	
60											11 min. 10 min.	
580				R-13	60			RQD=100 Rec=100%			10 min. 10 min. 10 min. $Q_u = 1174.6$ tsf 190.8 pcf 6 min.	
65											5 min. 4 min.	
575				R-14	60			RQD=100 Rec=100%			4 min. 4 min. 4 min. $Q_u = 1522.0$ tsf 311.8 pcf 4 min.	
70											4 min. 3 min.	
570				R-15	60			RQD=100 Rec=100%				
75												

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BORING B-103

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	▽ Completion (190 ft)	40.9 ft

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 @	Additional Remarks
100						BEDROCK - DIABASE , green, gray, very hard, massive, fresh					1124.1 tsf 192.6 pcf 3 min. 3 min. 3 min.
540			R-21		60	Several 45 degree fractures Long near vertical fracture, had to break sample up to get it out of inner barrel		RQD=100 Rec=100%			1540.3 tsf 192.5 pcf 3 min. 3 min. 3 min.
105											
535			R-22		60			RQD=100 Rec=100%			1095.1 tsf 191.0 pcf 3 min. 3 min. 3 min.
110											
530			R-23		60	Several horizontal fractures from 112.5 to 113.0 feet		RQD=100 Rec=100%			966.9 tsf 192.5 pcf 3 min. 4 min. 4 min.
115											
525			R-24		60			RQD=100 Rec=100%			2121.8 tsf 192.8 pcf 4 min. 4 min. 4 min.
120											
520			R-25		60			RQD=100 Rec=100%			4 min. 4 min.
125											4 min.

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BORING B-103

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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 @	Additional Remarks
150						BEDROCK - DIABASE , green, gray, very hard, massive, fresh				0 25 50 X Moisture PL + LL STRENGTH, tsf ▲ Qu * Qp 0 2.0 4.0	
490			R-31	60			RQD=100 Rec=100%				192.3 pcf 3 min. 2 min. 2 min. 3 min. >> ⊕ 3 min.
155											3 min. >> ▲ Qu = 1667.3 tsf 194.8 pcf 3 min.
485			R-32	60			RQD=100 Rec=100%				3 min. 3 min. >> ⊕ 3 min.
160											3 min. 3 min. >> ▲ Qu = 1478.1 tsf 198.4 pcf 3 min.
480		R-33	60		RQD=100 Rec=100%					3 min. >> ⊕ 3 min.	
165										3 min. 3 min. >> ⊕ 3 min.	
475		R-34	60		RQD=100 Rec=100%					3 min. >> ▲ Qu = 819.8 tsf 193.9 pcf 3 min.	
170										3 min. 2 min. 3 min. >> ⊕ 3 min.	
470		R-35	60		RQD=100 Rec=100%					3 min. >> ▲ Qu = 887.9 tsf 195.2 pcf 3 min.	
175										3 min. >> ⊕ 3 min.	

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BORING LOCATION:
See Boring Location Plan

REMARKS: Boring ground elevations provided by DPS; boring coordinates estimated from Google Earth.

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 @	Additional Remarks
175						BEDROCK - DIABASE , green, gray, very hard, massive, fresh				X Moisture □ PL + LL 0 25 50	3 min. 3 min. >> ● 864.3 tsf 194.8 pcf 3 min. >> ⊙ 3 min. 3 min. 3 min. >> ● 1032.9 tsf 195.1 pcf 3 min. >> ⊙ 3 min. 2 min. 2 min. >> ● 881.3 tsf 195.2 pcf >> ⊙ 3 min. 2 min. 2 min.
465			R-36	60			RQD=100 Rec=100%				
180											
460			R-37	60		RQD=100 Rec=100%					
185											
455			R-38	48		RQD=100 Rec=100%					
190						Boring terminated at 190 feet					



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PROJECT NO.: 04911704
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Joanna Road (PPP5)
 N. Twin Valley Rd & Clymer Hill Rd
 Berks Co, PA

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.		SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted.
HSA: Hollow Stem Auger - typically 3 1/4" or 4 1/4" I.D. openings, except where noted.		ST: Shelby Tube - 3" O.D., except where noted.
M.R.: Mud Rotary - Uses a rotary head with Bentonite or Polymer Slurry		RC: Rock Core
R.C.: Diamond Bit Core Sampler		TC: Texas Cone
H.A.: Hand Auger		BS: Bulk Sample
P.A.: Power Auger - Handheld motorized auger		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.
- N₆₀: 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 ANGULARITY OF COARSE-GRAINED PARTICLES

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

<u>Description</u>	<u>Criteria</u>
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

<u>Component</u>	<u>Size Range</u>
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

<u>Description</u>	<u>Criteria</u>
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

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

GENERAL NOTES

(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

<u>Q_u - TSF</u>	<u>N - Blows/foot</u>	<u>Consistency</u>
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

<u>Description</u>	<u>Criteria</u>
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

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

STRUCTURE DESCRIPTION

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

<u>Q_u - TSF</u>	<u>Consistency</u>
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

<u>Description</u>	<u>Criteria</u>
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

<u>Voids</u>	<u>Void Diameter</u>
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)

<u>Component</u>	<u>Size Range</u>
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

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

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.

Degree of Brokenness

<u>Characteristic</u>	<u>Description</u>
Less than 1 inch	Very Broken
1 inch to 3 inches	Broken
3 inches to 6 inches	Slightly Broken
Greater than 6 inches	Massive

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.
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SOIL CLASSIFICATION CHART

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS	
			GRAPH	LETTER		
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES	
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES	
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES	
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES	
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES	
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES	
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES	
	FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	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 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	

Laboratory Summary Sheet

Borehole	Approx. Depth	Liquid Limit	Plastic Limit	Plasticity Index	Qu (tsf)	%<#200 Sieve	Est. Specific Gravity	Water Content (%)	Dry Density (pcf)	Saturation (%)	Void Ratio
B-101	13				1653.69						
B-101	16.5				1298.26						
B-101	20.5				546.24						
B-101	27.4				1166.84						
B-101	30.2				1435.52						
B-101	36.9				1699.29						
B-101	40.6				1146.73						
B-101	44				1563.20						
B-101	49.9				1349.47						
B-101	54.9				1139.25						
B-101	58.9				844.38						
B-101	63.5				1338.95						
B-101	67.5				832.69						
B-101	71.5				935.81						
B-101	75.2				1740.68						
B-101	80				629.72						
B-101	86.5				939.09						
B-101	91				1037.06						
B-101	94.8				1647.85						
B-101	100				1347.60						
B-101	104.8				1077.99						
B-101	109.2				1303.17						
B-101	114				1508.25						
B-101	118				1583.31						
B-101	121.1				1685.03						
B-101	125				1327.49						
B-101	129.8				1306.21						
B-101	133.7				1768.27						
B-101	138.6				874.78						
B-101	145.8				1955.34						
B-101	149.7				1181.58						
B-101	155				943.53						
B-101	160.2				2060.10						
B-101	164.6				714.37						
B-101	170.1				879.69						
B-101	176				1395.54						
B-102	6				1338.01						
B-102	11.7				1327.96						
B-102	16				1140.89						
B-102	21				1714.72						
B-102	26				1596.40						
B-102	31.1				1570.91						



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Summary of Laboratory Results

PSI Job No.: 04911704
 Project: Energy Transfer HDD (DPS)
 Location: Joanna Road (PPP5)
 N. Twin Valley Rd & Clymer Hill Rd
 Berks 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-102	36				1353.91						
B-102	41				1176.90						
B-102	46				1577.23						
B-102	52				1241.67						
B-102	56				1470.13						
B-102	61				1180.87						
B-102	66				1169.65						
B-102	71				1615.34						
B-102	76.6				1974.98						
B-102	81				1207.06						
B-102	86				954.99						
B-102	91				954.75						
B-102	95.5				1550.80						
B-102	100.7				1009.94						
B-102	106				989.36						
B-102	111.1				1647.14						
B-102	116				1528.36						
B-102	121				1077.75						
B-102	126				1349.47						
B-103	4				866.60						
B-103	8.3				802.53						
B-103	11.5				1334.50						
B-103	17.4				1159.36						
B-103	21.4				1175.73						
B-103	26.3				987.73						
B-103	30.6				965.28						
B-103	36.2				1319.54						
B-103	41.5				1366.07						
B-103	46.9				860.75						
B-103	52.1				1847.07						
B-103	56.6				985.39						
B-103	61.3				1128.73						
B-103	66.3				1174.56						
B-103	71.5				1522.04						
B-103	76.3				1063.25						
B-103	81.2				708.06						
B-103	86.1				1132.70						
B-103	92.5				883.20						
B-103	96.5				934.64						
B-103	100.1				1124.05						
B-103	104				1540.28						
B-103	109.2				1095.06						



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

Summary of Laboratory Results

PSI Job No.: 04911704
 Project: Energy Transfer HDD (DPS)
 Location: Joanna Road (PPP5)
 N. Twin Valley Rd & Clymer Hill Rd
 Berks Co, PA

Laboratory Summary Sheet

Sheet 3 of 3

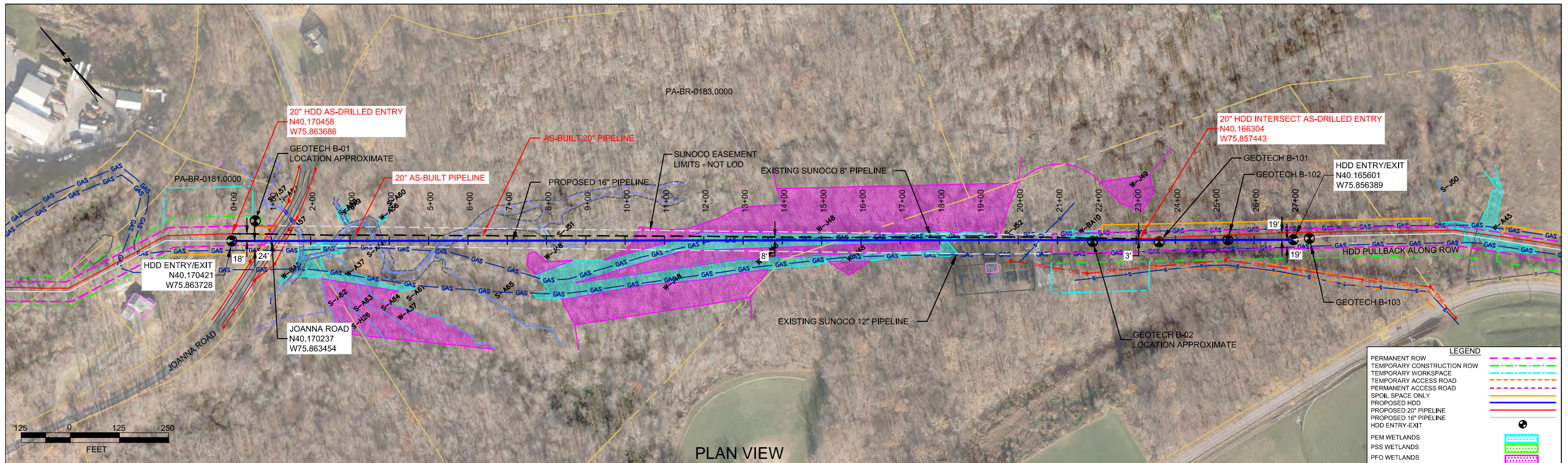
Borehole	Approx. Depth	Liquid Limit	Plastic Limit	Plasticity Index	Qu (tsf)	%<#200 Sieve	Est. Specific Gravity	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
B-103	115				966.91						
B-103	120				2121.83						
B-103	125				1608.56						
B-103	129				986.56						
B-103	134.4				991.93						
B-103	140.1				838.07						
B-103	145				1214.78						
B-103	149.8				1239.80						
B-103	155.3				1667.25						
B-103	161.7				1478.08						
B-103	167				819.83						
B-103	172				887.88						
B-103	177				864.26						
B-103	182				1032.86						
B-103	187				881.33						



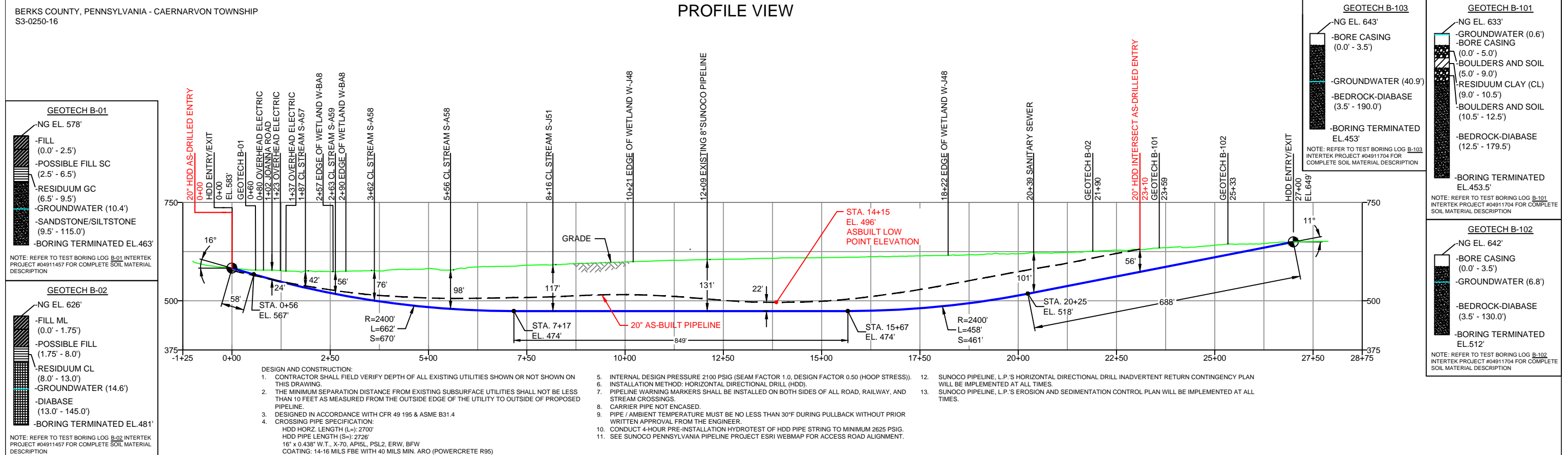
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Summary of Laboratory Results

PSI Job No.: 04911704
 Project: Energy Transfer HDD (DPS)
 Location: Joanna Road (PPP5)
 N. Twin Valley Rd & Clymer Hill Rd
 Berks Co, PA



PLAN VIEW



PROFILE VIEW

BERKS COUNTY, PENNSYLVANIA - CAERNARVON TOWNSHIP
S3-0250-16

GEOTECH B-01
-NG EL. 578'
-FILL (0.0' - 2.5')
-POSSIBLE FILL SC (2.5' - 6.5')
-RESIDUUM GC (6.5' - 9.5')
-GROUNDWATER (10.4')
-SANDSTONE/SILTSTONE (9.5' - 115.0')
-BORING TERMINATED EL.463'

GEOTECH B-02
-NG EL. 626'
-FILL ML (0.0' - 1.75')
-POSSIBLE FILL (1.75' - 8.0')
-RESIDUUM CL (8.0' - 13.0')
-GROUNDWATER (14.6')
-DIABASE (13.0' - 145.0')
-BORING TERMINATED EL.481'

NOTE: REFER TO TEST BORING LOG B-01 INTERTEK PROJECT #04911457 FOR COMPLETE SOIL MATERIAL DESCRIPTION

NOTE: REFER TO TEST BORING LOG B-02 INTERTEK PROJECT #04911457 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-103
-NG EL. 643'
-BORE CASING (0.0' - 3.5')
-GROUNDWATER (40.9')
-BEDROCK-DIABASE (3.5' - 190.0')
-BORING TERMINATED EL.453'

NOTE: REFER TO TEST BORING LOG B-103 INTERTEK PROJECT #04911704 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-101
-NG EL. 633'
-GROUNDWATER (0.6')
-BORE CASING (0.0' - 5.0')
-BOULDERS AND SOIL (5.0' - 9.0')
-RESIDUUM CLAY (CL) (9.0' - 10.5')
-BOULDERS AND SOIL (10.5' - 12.5')
-BEDROCK-DIABASE (12.5' - 179.5')
-BORING TERMINATED EL.453.5'

NOTE: REFER TO TEST BORING LOG B-101 INTERTEK PROJECT #04911704 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-102
-NG EL. 642'
-BORE CASING (0.0' - 3.5')
-GROUNDWATER (6.8')
-BEDROCK-DIABASE (3.5' - 130.0')
-BORING TERMINATED EL.512'

NOTE: REFER TO TEST BORING LOG B-102 INTERTEK PROJECT #04911704 FOR COMPLETE SOIL MATERIAL DESCRIPTION

- DESIGN AND CONSTRUCTION:
- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
 - 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.
 - DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
 - CROSSING PIPE SPECIFICATION:
HDD HORZ. LENGTH (L=): 2700'
HDD PIPE LENGTH (S=): 2720'
16" x 0.438" WT., X-70, API 5L, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWDERCOATE R95)
 - INTERNAL DESIGN PRESSURE 2100 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 - CARRIER PIPE NOT ENCASED.
 - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 2625 PSIG.
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
 - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
 - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

- NOTES**
- ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
 - STATIONING IS BASED ON HORIZONTAL DISTANCES.
 - 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.
 - CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.
 - SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING		REVISIONS	
EP-5.68	TO ES-5.69	NO.	DESCRIPTION
SHEET 40	TO SHEET 41	EP5	DESIGN CHANGE - EXTENDED DRILL & ADDED GEOTECH
		EP4	ADDED 20" AS-BUILT INFORMATION AND ADDITIONAL GEOTECH
		EP3	UPDATED TO MATCH 16" IFC DESIGN AND NOTE 5 AND 10 PER INCREASED 16" MOP
		EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16
		EP1	REVISED PER PADEP COMMENTS
		EP	
DWG NO	DWG NO	NO.	DESCRIPTION

**Sunoco Logistics
Partners L.P.**

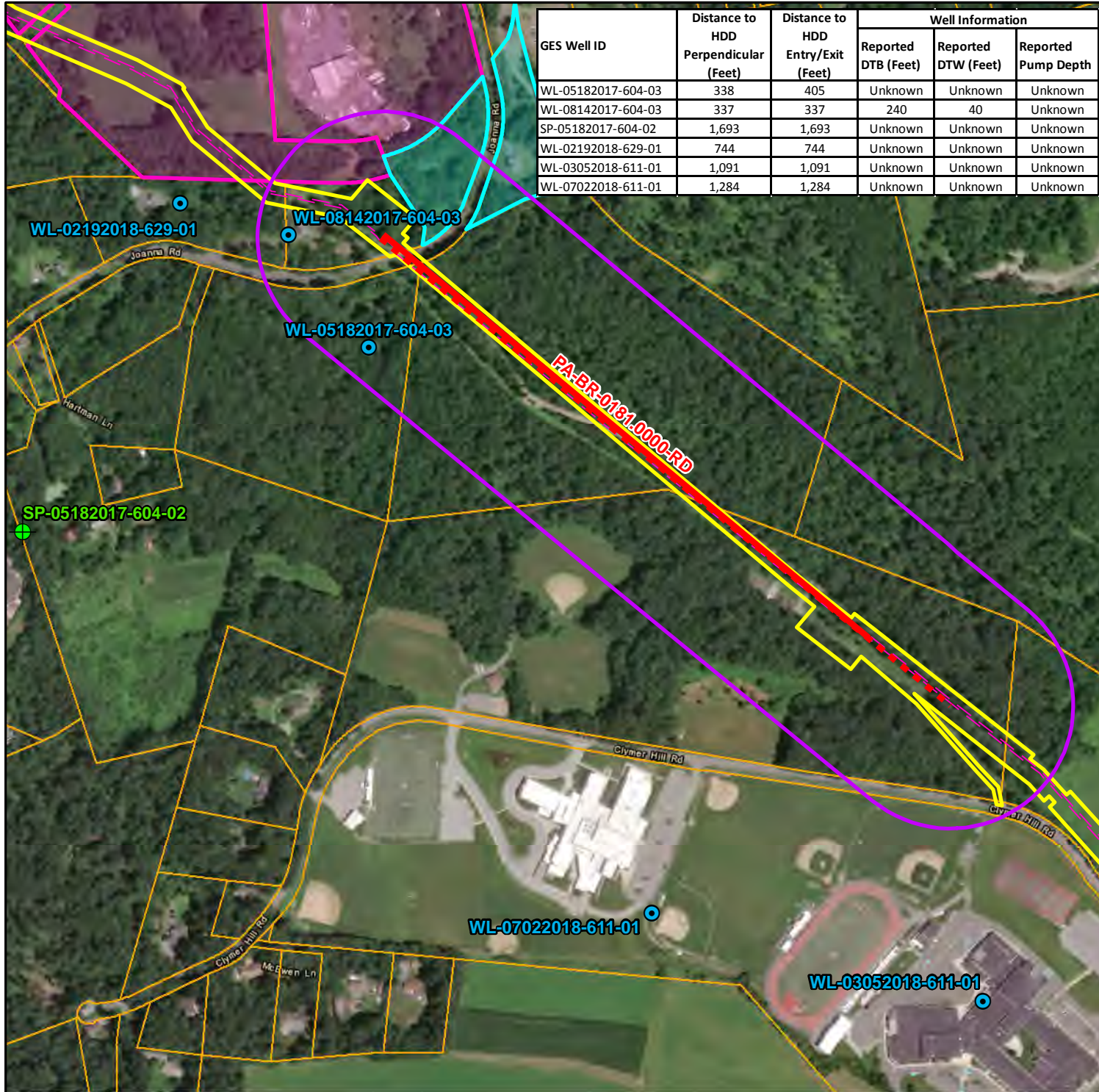
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
JOANNA ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=250' DWG. NO. PA-BR-0181.0000-RD-16

ATTACHMENT 3

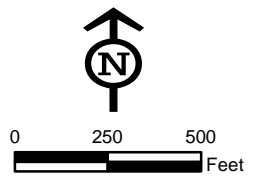


GES Well ID	Distance to HDD Perpendicular (Feet)	Distance to HDD Entry/Exit (Feet)	Well Information		
			Reported DTB (Feet)	Reported DTW (Feet)	Reported Pump Depth
WL-05182017-604-03	338	405	Unknown	Unknown	Unknown
WL-08142017-604-03	337	337	240	40	Unknown
SP-05182017-604-02	1,693	1,693	Unknown	Unknown	Unknown
WL-02192018-629-01	744	744	Unknown	Unknown	Unknown
WL-03052018-611-01	1,091	1,091	Unknown	Unknown	Unknown
WL-07022018-611-01	1,284	1,284	Unknown	Unknown	Unknown

Legend

- LOD
- Parcel
- PPP Centerline
- PPP 1 HDD
- Proposed PPP 2 HDD Redesign
- Public Water Supply/Landowner Confirmed No Well
- Testing Refused
- **Testing locations current as of 02/05/2019**
- GES Testing Location
- GES Spring Testing Location

Location



Well Location Map
HDD# PA-BR-0181.0000-RD
Berks County, PA.

Prepared By:		Date:	2/5/2019
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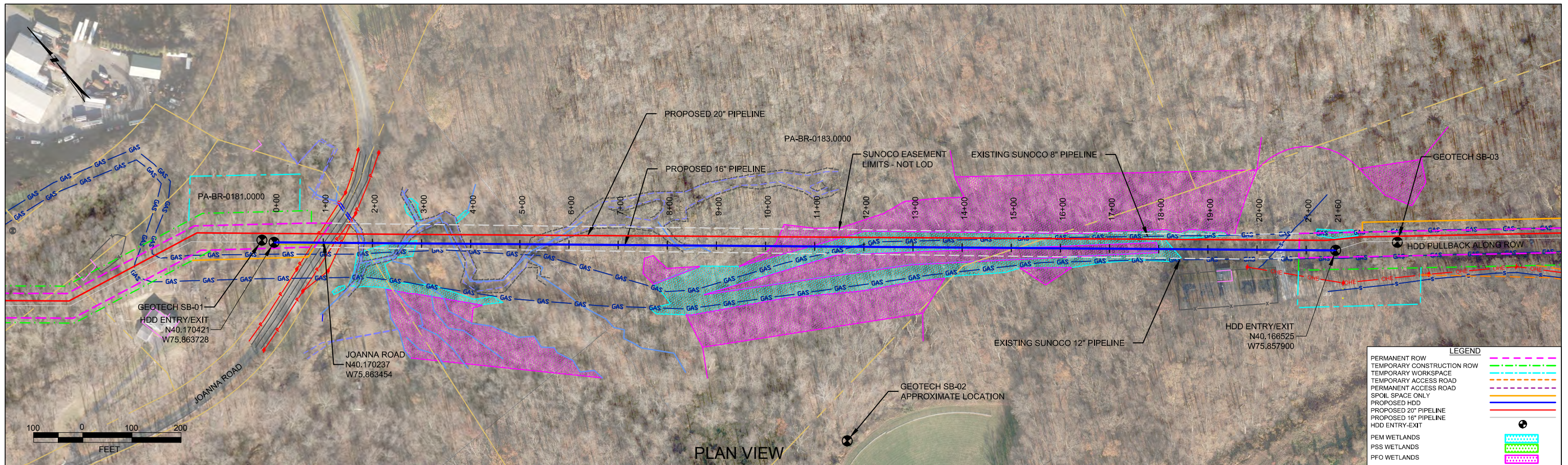
Base Map:
 ESRI World Imagery, 09/24/2015
 Coordinate System: NAD 83 Stateplane, PA South, Feet

C:\GIS\workspace\Tetra\Projects\PA\GIS\WellLocations\WellLocations_PA_BR_0181_0000.mxd LUN

PAWellID	County	Municipali	QuadName	WellAddress	WellZipCod	DateDrille	TypeOfAct	LatitudeDD	LongitudeD	Driller	OriginalOw	WellUse	WaterUse	WellDe pth	TopOf Casin	Bottom OfCa	Casing Diam	Depth ToBed	Bedrock Not	WellY eld	Static Wate	Water Level	Length OfTe	YieldMeasu	Saltwat erZ	FormationN	PaperImage	Remark
61421	BERKS	CAERNARVON TWP.	ELVERSON				NEW WELL	40.16056	-75.85778	C S GARBER & SONS INC	CONESTOGA T&TEL	WITHDRAWAL	INDUSTRIAL	380	0	45	6	18	False	0	130	0	0	UNKNOWN	STOCKTON FORMATION			
551811	BERKS	CAERNARVON TWP.				1991-10-01	NEW WELL	40.16288	-75.86448	PETERSHEIM BROS. INC.	kery	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0			http://www.framesapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM201636	Note: Coordinates are approximate. A second location based on the driller sketch was placed more than 500 feet away from this location.	
551874	BERKS	CAERNARVON TWP.				1989-06-01	NEW WELL	40.16387	-75.85236	PETERSHEIM BROS. INC.	kurtz	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0			http://www.framesapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM201700		
551871	BERKS	CAERNARVON TWP.				1989-05-01	NEW WELL	40.16412	-75.85381	PETERSHEIM BROS. INC.	smith	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0			http://www.framesapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM201697		
61404	BERKS	CAERNARVON TWP.	ELVERSON			1967-01-01	NEW WELL	40.16528	-75.85167	PETERSHEIM BROS. INC.	STOLTZFUS CLARE	WITHDRAWAL	DOMESTIC	155	0	50	6	50	False	20	58	0	0	UNKNOWN	UNKNOWN			
551850	BERKS	CAERNARVON TWP.				1999-06-24	NEW WELL	40.16582	-75.86493	H & M WELL DRILLING INC	wenrich-brookewood homes	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0			http://www.framesapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM201676	Note: Coordinates are approximate. A second location based on the driller sketch was placed more than 500 feet away from this location.	
495441	BERKS	CAERNARVON TWP.		Thousand Oak Blvd	19520	2009-09-15	NEW WELL	40.167	-75.871	B L MYERS BROS. OF PA. INC.	Stoltzfus Enterprises	CLOSED-LOOP GEOTHERMAL	GEOTHERMAL	400	0	59	6	53	False	2	0	0	0				Test geothermal well drilled of Thousand Oak Blvd across from Oak Tree Lane incorporate center located off of Rt. 10 just outside of Morgantown PA	
495441	BERKS	CAERNARVON TWP.		Thousand Oak Blvd	19520	2009-09-15	NEW WELL	40.167	-75.871	B L MYERS BROS. OF PA. INC.	Stoltzfus Enterprises	CLOSED-LOOP GEOTHERMAL	GEOTHERMAL	400	59	400	6	53	False	2	0	0	0				Test geothermal well drilled of Thousand Oak Blvd across from Oak Tree Lane incorporate center located off of Rt. 10 just outside of Morgantown PA	
644977	BERKS	CAERNARVON TWP.	ELVERSON	5 Joanna Road	19543	2016-11-10	NEW WELL	40.16849	-75.87186	PETERSHEIM BROS. INC.	Minjock	WITHDRAWAL	DOMESTIC	460	0	60	6	50	False	2	20	0	30			VOLUMETRIC WATCH & BUCKET		
501195	BERKS	CAERNARVON TWP.		609 Joanna Rd.	19543	2012-08-15	NEW WELL	40.17043	-75.86493	PETERSHEIM BROS. INC.	Apex	WITHDRAWAL	DOMESTIC	240	0	80	6	70	False	12	40	0	30			VOLUMETRIC WATCH & BUCKET		
501185	BERKS	CAERNARVON TWP.		609 Joanna Rd.	19543	2012-08-16	NEW WELL	40.17044	-75.86488	PETERSHEIM BROS. INC.	Apex	GEOTHERMAL	GEOTHERMAL	300	0	60	6	50	False	0	0	0	0					
501184	BERKS	CAERNARVON TWP.		609 Joanna Rd.	19543	2012-08-16	NEW WELL	40.17056	-75.86488	PETERSHEIM BROS. INC.	Apex	GEOTHERMAL	GEOTHERMAL	300	0	60	6	50	False	0	0	0	0					
551838	BERKS	CAERNARVON TWP.				1987-11-01	NEW WELL	40.17119	-75.85396	PETERSHEIM BROS. INC.	chester scholl builder	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0			http://www.framesapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM201663		
554363	BERKS	CAERNARVON TWP.				2008-01-29	NEW WELL	40.17121	-75.86171	PHARES FRY WELL DRILLING & PUMP SERVICE INC	greth homes	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0			http://www.framesapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM203757		
485982	BERKS	CAERNARVON TWP.		1102 Elverson Road	19543	2010-01-21	NEW WELL	40.1715	-75.86128	SENSENG & WEAVER WELL DRILLING	Moyer	WITHDRAWAL	DOMESTIC	200	0	63	6	50	False	20	0	0	0			VOLUMETRIC WATCH & BUCKET		
551904	BERKS	CAERNARVON TWP.				1988-02-01	NEW WELL	40.17219	-75.85368	PETERSHEIM BROS. INC.	scholl	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0			http://www.framesapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM201729	Note: Coordinates are approximate. A second location based on the driller sketch was placed more than 2000 feet away from this location.	
61405	BERKS	CAERNARVON TWP.	ELVERSON			1966-01-01	NEW WELL	40.17222	-75.85333	PETERSHEIM BROS. INC.	LYKENS J BLAIR	WITHDRAWAL	DOMESTIC	112	0	53	6	40	False	18	64	0	0	UNKNOWN	UNKNOWN			
551902	BERKS	CAERNARVON TWP.				1989-10-01	NEW WELL	40.1725	-75.86051	C S GARBER & SONS INC	brennan constr.	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0			http://www.framesapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM201727		
554359	BERKS	CAERNARVON TWP.				2008-10-15	NEW WELL	40.17254	-75.85472	PETERSHEIM BROS. INC.	bradley	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0			http://www.framesapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM203753		
551905	BERKS	CAERNARVON TWP.				1988-02-01	NEW WELL	40.17254	-75.85388	PETERSHEIM BROS. INC.	scholl	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0			http://www.framesapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM201730	Note: Coordinates are approximate. A second location based on the driller sketch was placed more than 1000 feet away from this location.	
554360	BERKS	CAERNARVON TWP.				2008-10-16	NEW WELL	40.17261	-75.85462	PETERSHEIM BROS. INC.	bradley	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0			http://www.framesapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM203754		
61417	BERKS	CAERNARVON TWP.	ELVERSON			1972-01-01	NEW WELL	40.17361	-75.85833	PETERSHEIM BROS. INC.	SCHAFFER CLEM	WITHDRAWAL	DOMESTIC	70	0	56	6	0	False	0	0	0	0			UNKNOWN		
61412	BERKS	CAERNARVON TWP.	ELVERSON			1972-01-01	NEW WELL	40.17361	-75.85778	PETERSHEIM BROS. INC.	SCHAFFER CLEM	WITHDRAWAL	DOMESTIC	85	0	40	6	0	False	6	0	0	0			UNKNOWN		
61416	BERKS	CAERNARVON TWP.	ELVERSON			1970-01-01	NEW WELL	40.17361	-75.85639	KERR BROS	BLAKE SHIRLEY	WITHDRAWAL	DOMESTIC	100	0	38	6	12	False	0	30	0	2	UNKNOWN	BRUNSWICK FORMATION			
551897	BERKS	CAERNARVON TWP.				1987-10-01	NEW WELL	40.17374	-75.8581	PETERSHEIM BROS. INC.	chester scholl builder	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0			http://www.framesapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM201722		
551896	BERKS	CAERNARVON TWP.				1987-10-01	NEW WELL	40.17376	-75.85747	PETERSHEIM BROS. INC.	chester scholl builder	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0			http://www.framesapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM201721	Note: Coordinates are approximate. A second location based on the driller sketch was placed more than 500 feet away from this location.	
551946	BERKS	CAERNARVON TWP.				2006-05-10	NEW WELL	40.1739	-75.86742	PETERSHEIM BROS. INC.	weiss	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0			http://www.framesapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM201772		
498687	BERKS	CAERNARVON TWP.		976 Elverson Road	19543	2012-03-28	NEW WELL	40.17403	-75.86747	SENSENG & WEAVER WELL DRILLING	Weiss	CLOSED-LOOP GEOTHERMAL	GEOTHERMAL	235	0	0	0	39	False	0	0	0	0					
498668	BERKS	CAERNARVON TWP.		976 Elverson Road	19543	2012-03-28	NEW WELL	40.17403	-75.86747	SENSENG & WEAVER WELL DRILLING	Weiss	CLOSED-LOOP GEOTHERMAL	GEOTHERMAL	235	0	0	0	39	False	0	0	0	0					
551853	BERKS	CAERNARVON TWP.				1998-02-23	NEW WELL	40.17541	-75.8694	PETERSHEIM BROS. INC.	smith	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0			http://www.framesapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM201679	Note: Coordinates are approximate. A second location based on the driller sketch was placed more than 4000 feet away from this location.	
61406	BERKS	CAERNARVON TWP.	ELVERSON			1968-01-01	NEW WELL	40.17583	-75.86917	PETERSHEIM BROS. INC.	MOORE PAUL	WITHDRAWAL	DOMESTIC	250	0	36	6	35	False	1	20	0	0	UNKNOWN	UNKNOWN			

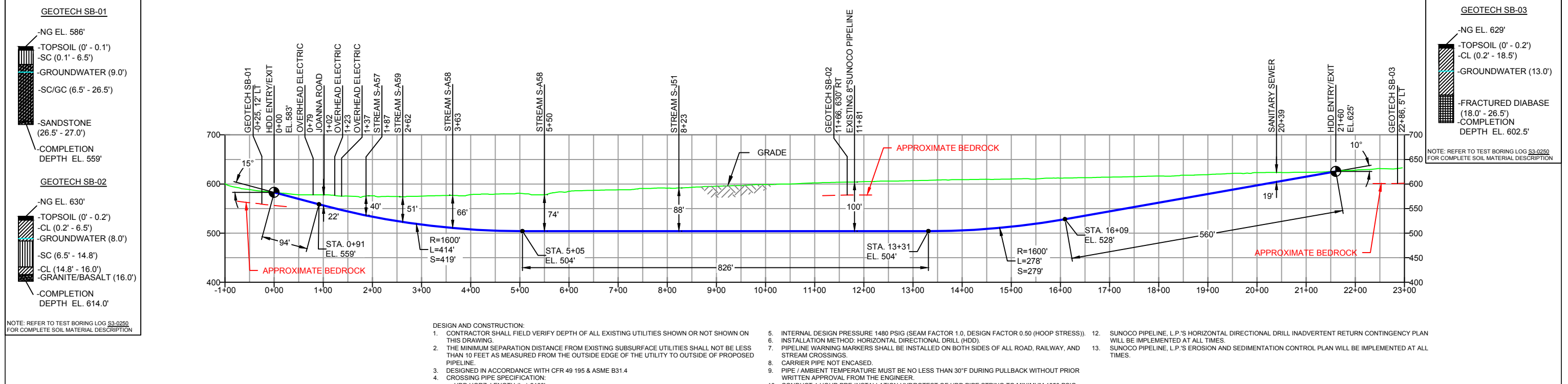
**JOANNA ROAD CROSSING
PADEP SECTION 105 PERMIT NO: E06-701
PA-BR-0181.0000-RD-16
(SPLP HDD No. S3-0250-16)**

**ATTACHMENT 2
HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES**



PLAN VIEW

PROFILE VIEW



DESIGN AND CONSTRUCTION:

- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
- 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.
- DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
- CROSSING PIPE SPECIFICATION:
HDD HORZ. LENGTH (L=): 2160'
HDD PIPE LENGTH (S=): 2178'
16" x 0.438" WT., X-70, API 5L, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
- INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
- INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
- PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
- CARRIER PIPE NOT ENCASED.
- PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
- CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
- SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
- SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
- SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES		REVISIONS	
1. ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83		5. DESIGN CHANGE (LOWER & MOVED DRILL DESIGN)	DLM 02/21/17 RMB 02/21/17 AMC 02/21/17
2. STATIONING IS BASED ON HORIZONTAL DISTANCES		4. REVISED PROFILE WITH 2017 LIDAR	MRS 02/15/17 RMB 02/15/17 AAW 02/15/17
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.		3. UPDATED SUNOCO EASEMENT LIMITS - NOT LOD	MRS 10/24/16 RMB 10/24/16 AAW 10/24/16
4. CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.		2. REVISED PER ENGINEERING COMMENTS	MRS 08/19/16 RMB 08/19/16 AAW 08/19/16
5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.		1. REVISED PER COMMENTS FROM REI REVIEW	MRS 02/26/16 RMB 02/26/16 AAW 02/26/16
		0. ISSUED FOR CONSTRUCTION	MRS 01/21/16 RMB 01/21/16 AAW 01/21/16

Figure 1. 2017 Version of the 16-Inch HDD Plan and Profile

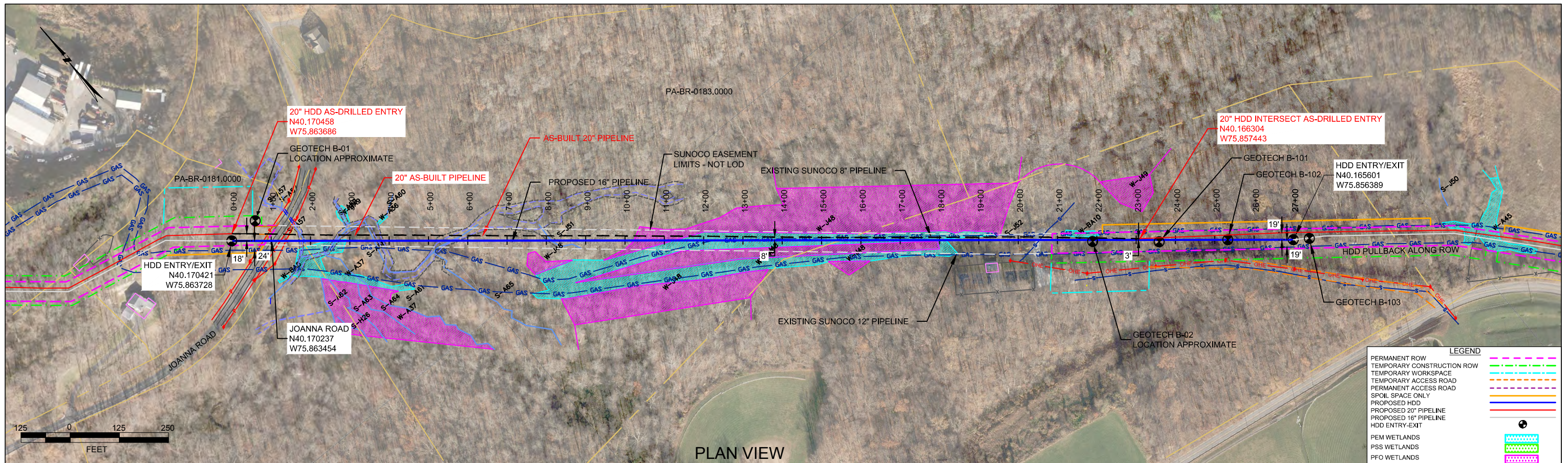
**Sunoco Logistics
Partners L.P.**

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
JOANNA ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' DWG. NO. PA-BR-0181.0000-RD-16



PROFILE VIEW

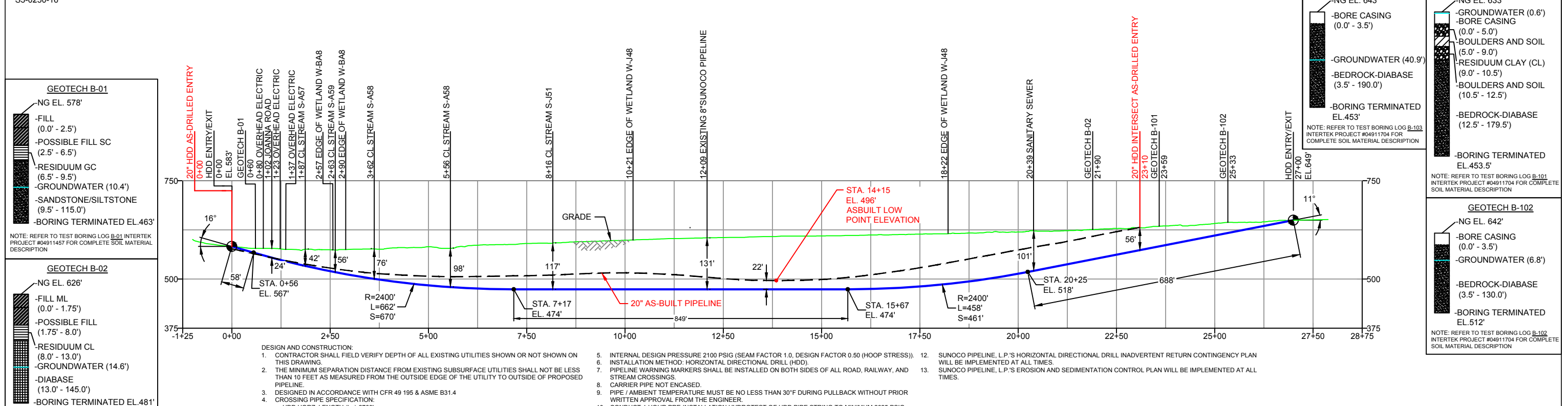


Figure 2. 2019 Design of the 16-Inch HDD Plan and Profile

NOTES	REF. DRAWING	REVISIONS		
1. ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83	EP-5.68 TO ES-5.69	DESIGN CHANGE - EXTENDED DRILL & ADDED GEOTECH	MRS	01/17/19
2. STATIONING IS BASED ON HORIZONTAL DISTANCES	SHEET 40 TO SHEET 41	ADDED 20" AS-BUILT INFORMATION AND ADDITIONAL GEOTECH	MRS	11/28/18
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.		UPDATED TO MATCH 16" IFC DESIGN AND NOTE 5 AND 10 PER INCREASED 16" MOP	MRS	05/10/18
4. CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.		REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	10/21/16
5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.		REVISED PER PADEP COMMENTS	JTW	05/18/16
			MRS	03/15/16
			MRS	01/17/19
			MRS	11/28/18
			MRS	05/10/18
			MRS	10/21/16
			JTW	05/18/16
			MRS	03/15/16
			MRS	01/17/19
			MRS	11/28/18
			MRS	05/10/18
			MRS	10/21/16
			JTW	05/18/16
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