HORIZONTAL DIRECTIONAL DRILL ANALYSIS
JOANNA ROAD CROSSING
PADEP SECTION 105 PERMIT NO.S:
PA-BR-00181.0000-RD, PA-BR-0181.0000-RD-16 & PA-BR-0183.0000
(SPLP HDD# S3-0250)

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(SPLP HDD# S3-0250)

This reanalysis of the horizontal directional drill (HDD) installation of a 16-inch and 20-inch diameter pipeline crossing under Joanna Road and the wetlands and streams to the east, has been completed in accordance with Stipulated Order issued under Environmental Hearing Board Docket No. 2017-009-L. This HDD is number 24 on the list of HDDs included on Exhibit 2 of the Stipulated Order.

This HDD was in the pilot hole phase for installation of the 20-inch pipeline when drilling operations were stopped in response to the temporary injunction issued by the Pennsylvania Department of Environmental Protection Environmental Hearing Board on July 25, 2017.

PIPE INFORMATION

20-Inch: 0.456 wall thickness; X-65
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: 20-INCH

- Horizontal length: 2,120 feet (ft)
- Entry angle: 12 degrees
- Maximum depth of cover: 79 ft
- Pipe design radius: 2,000 ft

HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

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

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

Low, et. al. (2002) reported that the 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).

Karst geology is not present at this HDD location. At this HDD location the use of geophysics assessments was considered but not conducted because the results from these types of assessments have limited useable data after 20 to 50 ft below the ground surface (bgs).

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

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HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

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 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 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.

Attachment 1 provides an extensive discussion on the geology, 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 as discussed further in Attachment 1, is that based on the hydro-structural characteristics of the underlying geology the Joanna Road HDD is susceptible to the inadvertent return (IR) of drilling fluids during HDD operations; however the use of drilling best management practice should mitigate IR potential, and there were no IRs experienced in this HDD in which the pilot has advanced 805 feet.

The IR statement above from the geology report does not account for depth of profile, the use drilling pressure monitoring tools, and the monitoring of return mud weight and mud cleaning (fluid recycling) to minimize downhole pressure requirements to maintain return flows to the entry point of the HDD during the pilot hole phase. Once a HDD pilot hole is completed, then an open hole exists from entry to exit which significantly decreases the IR potential since there is a means of pressure relief on both ends of the profile so long as good drilling practices are followed.

Commonly, an HDD will have an IR to the land surface during the entry or at exit of the pilot hole due to the weakness of the ground at shallow depths. Typically these occur within the approved and controlled workspace for the entry and exit points.

As stated in the introduction, this 20-inch HDD was 805 ft into the pilot hole phase having a total profile length of 2,145 ft. No inadvertent returns (IR) occurred to this point of the HDD. Prior to engaging this HDD, the drill entry located on the west end, adjacent to Joanna Road, was adjusted in the field to increase the angle of entry in order to accelerate the run down to horizontal depth as a measure to prevent IRs.

As can be verified by comparing the geotechnical core data presented in the geology report in Attachment 1 to the HDD profiles, the 16-inch and 20-inch pilot holes on the HDD entry (west) side enters sandstone

at 10 ft bgs and conglomeratic sandstone at 30 ft bgs. As shown on the core data inside the attached hydrogeology report, these sandstone and conglomeratic sandstone layers had high recovery but poor quality values indicative of good structural integrity but low strength. On the west side of the HDD, the first natural resource, a stream, is passed at 26 ft bgs, or 14 ft within bedrock. The horizontal run of the profile varies from 74-100 ft bgs while passing below the stream and wetlands resources and is 64-90 ft of depth in bedrock. On the exit (east) side, the overlying wetlands are passed by with a minimum of 30 ft of depth in bedrock. The HDD exit radius leaves bedrock at 12 ft bgs, 100 ft (2 joints of drill stem) before exiting the ground.

The 20-inch pilot hole drilling is unlikely to have an IR continuing forward until near the exit point, as evidenced by successfully progressing 805 ft into the profile with no IR. Because the exit point is only 42 ft in elevation above the entry point, only minimal drilling pressure is needed to maintain returns flows of cuttings and fluids back to the entry pit, which decreases the potential for fracturing the bedrock and overburden.

As set forth in the conclusions, monitoring of the annulus pressures during the drilling of the pilot hole, while maintaining a cleared annulus and return flows to the entry point, and recycling of the returned fluids and cuttings to keep total mud weights down are good drilling practices that minimize downhole pressures on the overlying geology and 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 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 ft buffer.

Water well records and a review of aerial photography indicate the presence of three (3) water wells within the 450 ft buffer around the HDD profile location. These occur outward from the west HDD entry point. These water wells are not directly within the area of influence of the HDD profile, and due to the nature of the geology at and surrounding this HDD 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 of any direction of this HDD location. SPLP will also inform 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, and authorization issued by the U.S. Army Corps of Engineers.

Open-Cut and Conventional Bore Analysis

These HDDs are approximately 2,160 foot 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 auguring 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 paralleling 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. To meet this cover requirement and have 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 having a top 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 hole under the road and the braces are too tight in spacing 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 subsurfaces that contain soils and rock formations of varying composition and density may cause deflection of the bore pipe. The horizontal length of the wetlands and streams east of Joanna Road to be crossed 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 reroute 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 reroute would require field assessments for the presence of regulated and protected resources

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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 by open cut construction procedures. The alternatives analysis submitted to PADEP conceptually analyzed the feasibility of any alternative to trenched resource crossings (e.g., reroute, 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.

CONCLUSION

As discussed above, no IRs occurred during the drilling of the pilot hole for the 20-inch pipeline, and the pilot hole is already beyond the area of the profile most susceptible to the occurrence of an IR.

Upon the restart of these HDDs, SPLP will employ the following HDD best management practices:

- 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;

- During the reaming phase, the use of Loss Control Materials can be implemented if indications of a potential IR are 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 down to structurally better rock, to prevent vertical or lateral movement of drilling fluids at shallow depths.

Other than the implementation of the above described drilling practices and procedures, no changes to the HDD plans for the pipelines at this location are recommended or planned.

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(SPLP HDD# S3-0250)

ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT

RETTEW

We answer to you.

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Engineers
Environmental Consultants
Surveyors
Landscape Architects
Safety Consultants

October 2, 2017

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

RE: Sunoco Pipeline, L.P. Pipeline Project - Mariner East II
Wetland J-48 Joanna Road Horizontal Directional Drill Location (S3-0250)
Hydrogeological Re-Evaluation Report
Caernarvon Township, Berks County, Pennsylvania
RETTEW Project No. 096302011

Dear Mr. Gordon:

RETTEW Associates, Inc. is pleased to provide the enclosed Hydrogeological Re-Evaluation Report for the Wetland J-48 Joanna Horizontal Directional Drill (HDD) Location (S3-0250). This HDD Re-Evaluation Report was performed as required by the Stipulated Order dated August 8, 2017. Please note that the HDD Re-Evaluation Report for S3-0250 was prepared by Skelly and Loy, Inc. (Skelly & Loy) under subcontract to RETTEW. Mr. Douglas Hess, Director of Groundwater and Site Characterization Services, was the Professional Geologist (P.G.) at Skelly and Loy that supervised the work for this report.

If you have any questions regarding the Hydrogeological Re-Evaluation Report for HDD S3-0250, please do not hesitate to call Mr. Hess at 717-232-1799.

Sincerely,

Matthew T. Bruckner, P.G.
Geosciences Group Manager

Enclosure

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October 2, 2017

Mr. Matthew Gordon
Sunoco Pipeline, L.P.
535 Fritztown Road
Sinking Spring, Pennsylvania 19608

Re: Sunoco PA Pipeline Project Mariner East II, Wetland J48 - Joanna Road Horizontal Directional Drill (HDD) Location (S3-0250)
Hydrogeological Reevaluation Report
Caernarvon Township, Berks County, Pennsylvania
Rettew Project No. 096302011

EXECUTIVE SUMMARY

1. The 20-inch S3-0250 Wetland J48 - Joanna Road Horizontal Directional Drill (HDD) location is included in the Stipulated Order of August 8, 2017, requiring reevaluation, including a geologic report.

2. HDD Wetland J48 - Joanna Road 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 fractures 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 is characterized by abundant, well-developed, and regularly spaced joints that are open and steeply dipping.

4. Water-bearing zones 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 proposed HDD bore path is relatively shallow compared with the land surface of Wetland J48 and streambeds of unnamed tributaries (Streams S-A57, S-A58, S-A59, S-A61, and S-J51).

6. To date, HDD operations at the Wetland J48 - Joanna Road site have involved drilling of the 20-inch pipeline. Available drilling observations indicated that no inadvertent returns (IRs) have occurred during HDD operations for the 20-inch pipeline.

7. Based on the hydro-structural characteristics of the underlying geology and proposed bore path through shallow unconsolidated soil materials and within shallow bedrock, the Wetland J48 - Joanna Road 20-inch and proposed 16-inch HDDs are susceptible to the inadvertent return of drilling fluids during HDD operations. The HDD profile and best management practices during drilling operations will be used to reduce the risk of an IR.

1. INTRODUCTION

The purpose of this report is to describe the hydrogeologic setting of the Wetland J48 - Joanna Road (S3-0250) HDD location on the Sunoco Pipeline, L.P. (SPLP) Pennsylvania Pipeline Project-Mariner East II (PPP-ME2) Project. The Wetland J48 - Joanna Road HDD is located in Caernarvon Township, Berks County, Pennsylvania. The site is located approximately 0.25 mile southwest of the intersection of Joanna Road and Elverson Road and approximately 0.50 mile east of State Route 10. The HDD was designed to be drilled under Joanna Road, Wetland Area J48, and stream channels of several unnamed tributaries discharging to the East Branch Conestoga River (refer to **Figure 1**). This hydrogeologic report is part of the response to the Stipulated Order dated August 8, 2017, related to the potential for the inadvertent return of drilling fluids during proposed drilling operations.

HDD S3-0250 is located within the Gettysburg-Newark Lowland Section of the Piedmont Physiographic Province (Pennsylvania Department of Conservation and Natural Resources [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 above mean sea level (AMSL) to 622 feet AMSL (GoogleEarth, 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 surrounding the HDD consists of rural properties and land uses (e.g., farming, agriculture).

The HDD entry point is at a surface elevation of 581 feet AMSL and forms a slightly concave HDD profile that slopes gently upward toward the east to an elevation of 622 feet AMSL at the HDD exit point. The HDD will cross under several streams at the following depths: Stream S-A57, 26 feet below ground surface (bgs); Stream S-A59, 38 feet bgs; Stream S-A58, 47 feet bgs; Stream S-A61, 54 feet bgs; and Stream S-J51, 66 feet bgs. The HDD is located between

Stations 14256+25 and 14278+00 on the pipeline, for an overall horizontal length of 2,149 feet. The location of HDD S3-0250 is shown on **Figure 1**.

2. GEOLOGY AND SOILS

Twenty-four available published and online references were reviewed to evaluate the hydrogeology and soils present in the vicinity of HDD Wetland J48 - Joanna Road (S3-0250). Detailed descriptions of the soils and bedrock geology underlying S3-0250 are included in the following section.

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**.

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 Wetland J48 - Joanna Road 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, the first 400 to 500 feet of HDD S3-0250 were completed in the Stockton Formation and the remainder of the HDD will be 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-northwest-ward dipping homocline (Newport, 1971).

According to Geyer and Wilshusen (1982), the Stockton formation underlying the HDD S3-0250 site 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 slow due to the presence of quartz pebble conglomerate and in areas where 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 large, rounded boulders. Joints are well-developed, abundant, and open providing a very low secondary porosity. The overlying soil is thin. Dikes typically form narrow ridges, and larger intrusions form hills of moderate relief. Excavation and/or drilling are slow due to the density and hardness of the rock.

3. 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). 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 the HDD Wetland J48 - Joanna Road site or surrounding area. As a result, no water table mapping was available for

review or inclusion with this HDD reevaluation 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 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 Pennsylvania Department of Conservation and Natural Resources (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 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 northwestern 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.

4. 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 parallel 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 in a northwest (NW)-southeast (SE) trend. 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.

5. 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.

The geotechnical investigation was performed in two 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.

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.**

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**.

Please note that Skelly and Loy/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/RETTEW relied on these reports and incorporated their data into the general geologic and hydrogeologic framework of the analysis of the 20-inch S3-0250 Wetland J48 - Joanna Road HDD for this report.

6. 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 cut slopes

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 last 1,700 to 1,750 feet of the HDD bore path are underlain by bedrock characterized as Diabase; this mapping is consistent with the 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 HDD entry point. With the exception of the unnamed tributaries and previously mapped J48 wetland area, no additional environmental receptors of concern were noted within the defined 450-foot HDD buffer area.

7. CONCEPTUAL HYDROGEOLOGIC MODEL

Groundwater occurring in the watershed occupied by HDD Wetland J48 - Joanna Road 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 August 2017 indicated 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.

This 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 reevaluation.

The groundwater flow direction in the overburden soils is presumed to mimic surface topography which slopes gently to the northwest toward the wetland area 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. Wetland J48 is sustained by local shallow groundwater flow discharges. Wetland J48 is situated in two areas: 1) immediately surrounding the eastern half of the HDD trace and 2) approximately 400 feet south of the western half of the HDD trace. 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. CONCLUSIONS

Based on published geologic and hydrogeologic information, the S3-0250 Wetland J48 - Joanna Road 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 the beds. Geotechnical rock core observations have confirmed that the local bedrock is fractured and comprised of steeply dipping joint and bedding planes. All of the water supply wells identified in the vicinity of the HDD 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 wetland and unnamed tributaries to the East Branch Conestoga River. The HDD profile extends entirely within both the shallow unconsolidated regolith materials and weathered to highly weathered bedrock. Based on the hydro-structural characteristics of the underlying geology described in this report and the proposed HDD profile, the S3-0250 Wetland J48 - Joanna Road HDD is susceptible to the inadvertent return of drilling fluids during HDD operations. The proposed engineering controls and/or drilling best management practices will be used to reduce the risk of an IR.

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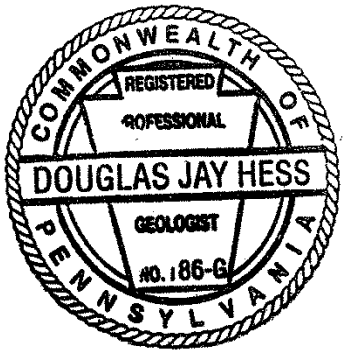
10.0 CERTIFICATION

The studies and evaluations presented in this report (other than Section 5) 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.



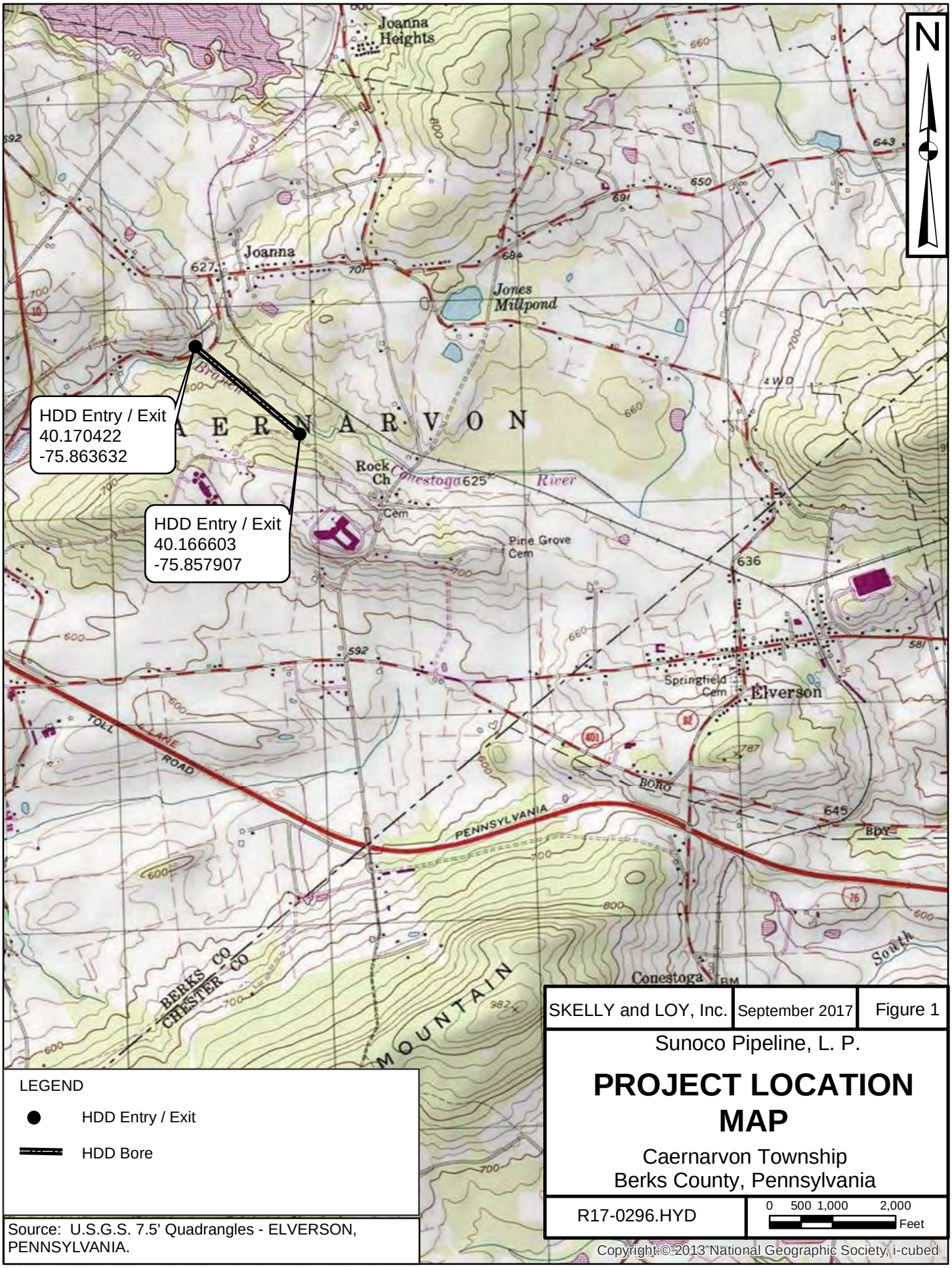
Douglas J. Hess, P.G.
License No. PG-000186-G

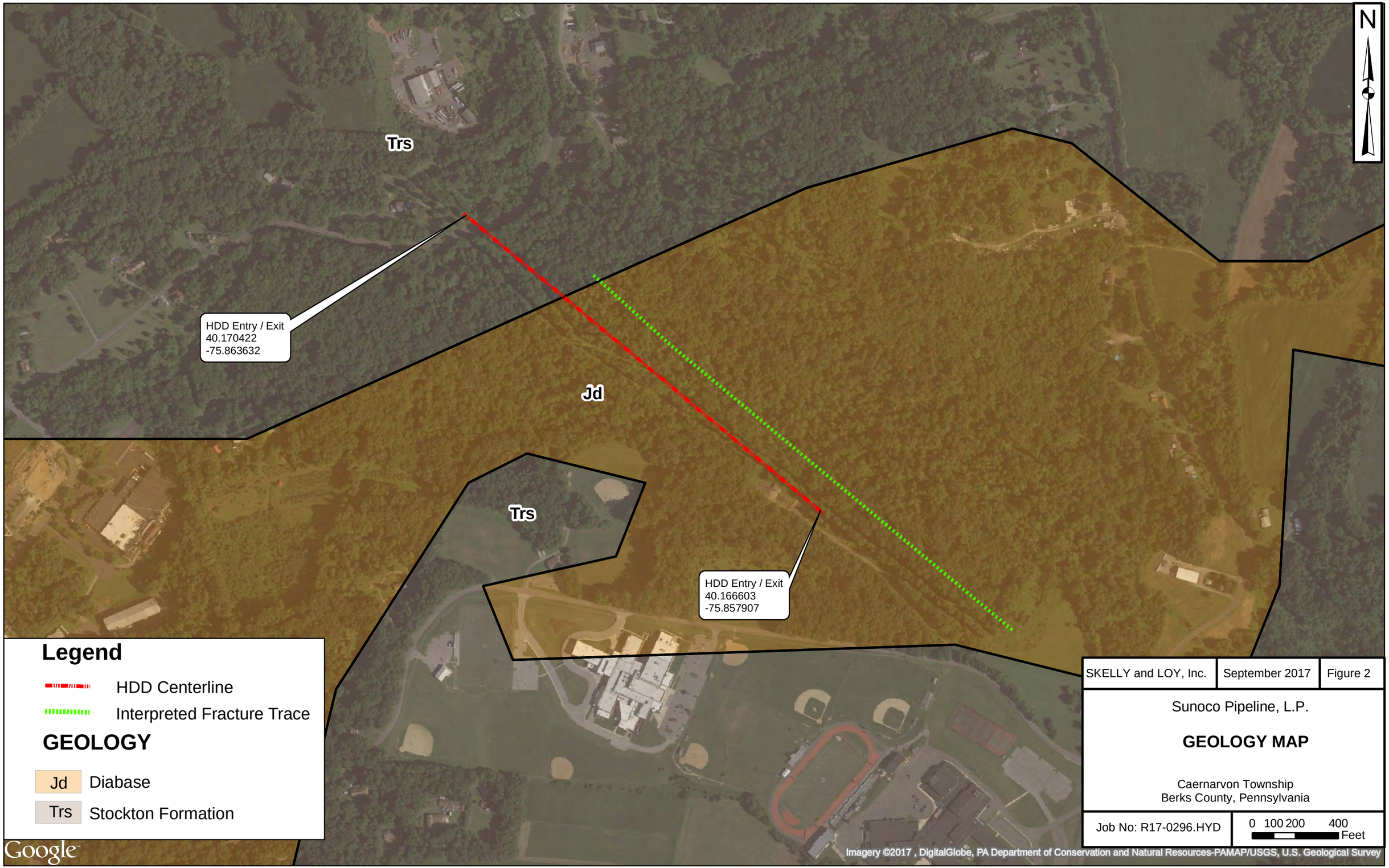
Sincerely yours,

SKELLY and LOY, Inc.

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

Enclosure
cc: R17-0296.HYD
File: HYDROGEOLOGIC_REPORT-Joanna Road_DJH - FINAL MASTER.docx





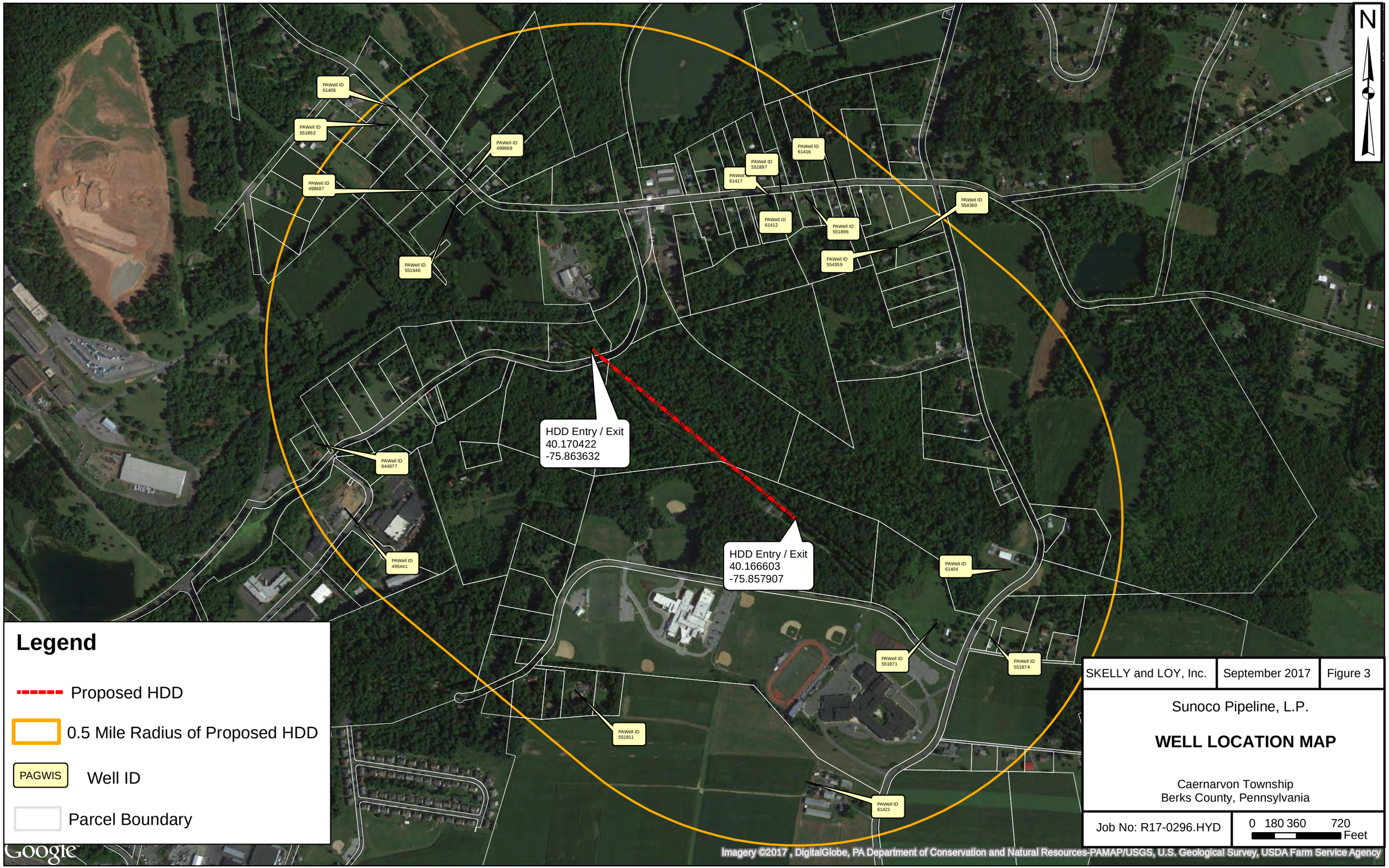
SKELLY and LOY, Inc.	September 2017	Figure 2

Sunoco Pipeline, L.P.

GEOLOGY MAP

Caernarvon Township
Berks County, Pennsylvania

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



SKELLY and LOY, Inc.	September 2017	Figure 3

Sunoco Pipeline, L.P.

WELL LOCATION MAP

Caernarvon Township
Berks County, Pennsylvania

Job No: R17-0296.HYD	0 180 360 720 Feet

PAWellID	County	Municipali	QuadName	WellAddres	WellZipCod	DateDrille	TypeOfActi	LatitudeDD	LongitudeD	Driller	OriginalOw	WellUse	WaterUse	WellDepth_	TopOfCasin	BottomOfCa	CasingDiam	DepthToBed	BedrockNot	WellYield_	StaticWate	WaterLevel	LengthOfTe	YieldMeasu	SaltwaterZ	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.	kerry	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0				http://www.iframeapps.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.iframeapps.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.iframeapps.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.iframeapps.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	-75.86486	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.iframeapps.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.iframeapps.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	-75.86126	SENSENIG & 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.iframeapps.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.iframeapps.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.iframeapps.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.iframeapps.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.iframeapps.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.iframeapps.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.iframeapps.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.iframeapps.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	SENSENIG & 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	SENSENIG & 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.iframeapps.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		

ATTACHMENT 1

United States Department of Agriculture

NRCS

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

September 19, 2017

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

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

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

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

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

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

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

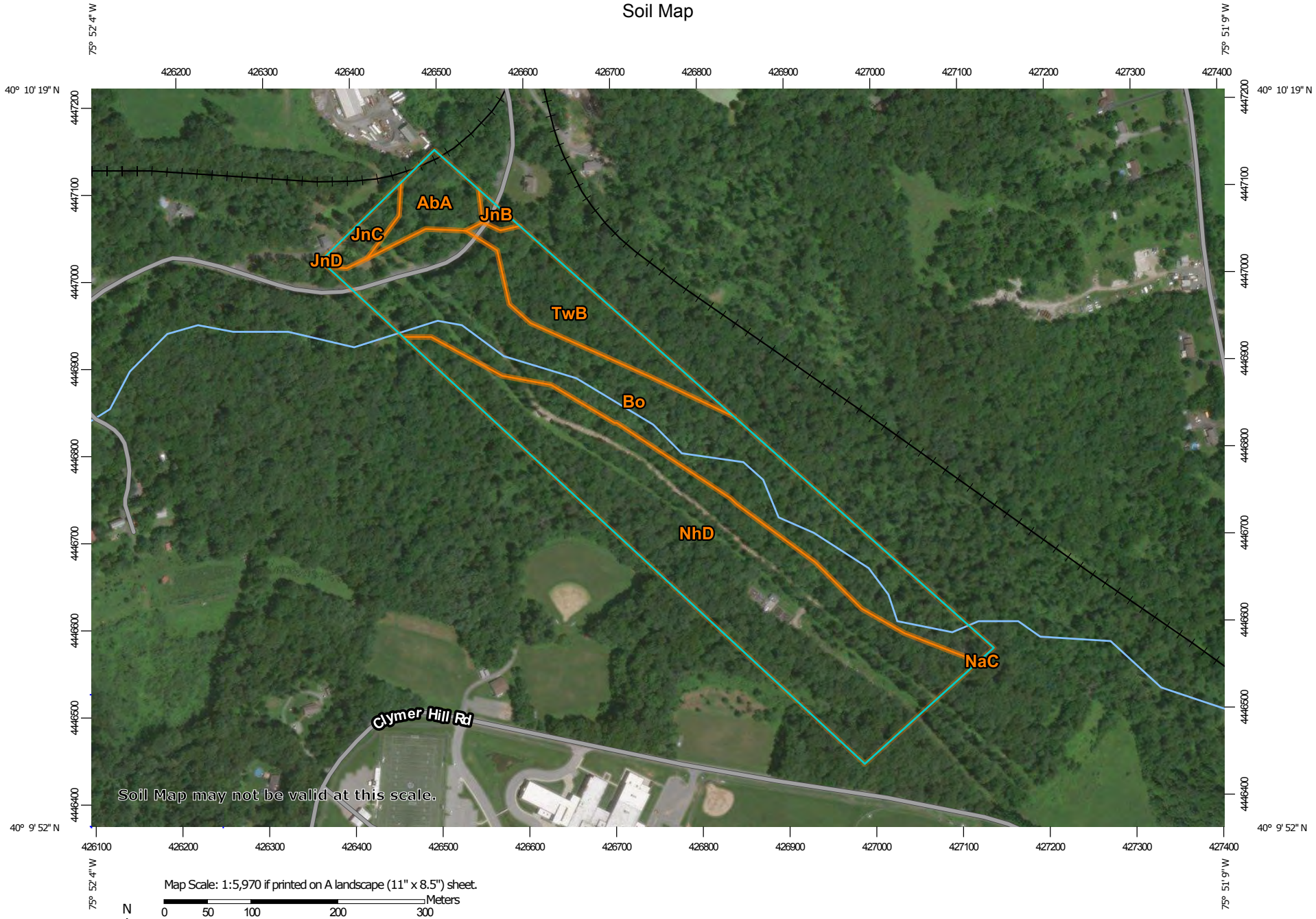
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

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

Soil Map

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

Custom Soil Resource Report
Soil Map



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

N

Meters: 0 50 100 200 300

Feet: 0 250 500 1000 1500

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.

Map Unit Legend

Berks County, Pennsylvania (PA011)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
AbA	Abbottstown silt loam, 0 to 3 percent slopes	1.8	4.4%
Bo	Bowmansville-Knauers silt loams	15.4	38.0%
JnB	Joanna loam, 3 to 8 percent slopes	0.2	0.6%
JnC	Joanna loam, 8 to 15 percent slopes	0.8	2.0%
JnD	Joanna loam, 15 to 25 percent slopes	0.0	0.0%
NaC	Neshaminy silt loam, 8 to 15 percent slopes	0.0	0.0%
NhD	Neshaminy gravelly silt loam, 8 to 25 percent slopes, extremely bouldery	18.4	45.5%
TwB	Towhee silt loam, 0 to 8 percent slopes, very stony	3.8	9.4%
Totals for Area of Interest		**40.5**	**100.0%**

Map Unit Descriptions

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

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

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the

scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

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

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

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

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

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

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

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

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

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

Berks County, Pennsylvania

AbA—Abbottstown silt loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2tt88
Elevation: 130 to 660 feet
Mean annual precipitation: 40 to 48 inches
Mean annual air temperature: 50 to 57 degrees F
Frost-free period: 150 to 178 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

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

Description of Abbottstown

Setting

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

Typical profile

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

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 18 to 22 inches to fragipan; 46 to 50 inches to lithic bedrock
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.7 inches)

Interpretive groups

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

Minor Components

Penn

Percent of map unit: 5 percent

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

Croton

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

Bo—Bowmansville-Knauers silt loams

Map Unit Setting

National map unit symbol: l70l
Elevation: 150 to 900 feet
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 150 to 210 days
Farmland classification: Not prime farmland

Map Unit Composition

Bowmansville and similar soils: 40 percent
Knauers and similar soils: 40 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bowmansville

Setting

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

Typical profile

Ap - 0 to 7 inches: silt loam
Bg - 7 to 26 inches: silty clay loam
Cg - 26 to 43 inches: fine sandy loam
2Cg - 43 to 65 inches: stratified gravel to sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 72 to 99 inches to lithic bedrock

Natural drainage class: Somewhat poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 0 to 18 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.2 inches)

Interpretive groups

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

Description of Knauers

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Parent material: Recent alluvium derived from sandstone and shale

Typical profile

A - 0 to 8 inches: silt loam
Bg1 - 8 to 17 inches: silt loam
Bg2 - 17 to 24 inches: gravelly sandy loam
2Cg - 24 to 60 inches: stratified sand to gravelly sandy loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 72 to 99 inches to lithic bedrock
Natural drainage class: Poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: Occasional
Frequency of ponding: Frequent
Available water storage in profile: Low (about 5.5 inches)

Interpretive groups

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

Minor Components

Rowland

Percent of map unit: 20 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Head slope, base slope
Down-slope shape: Linear, concave

Across-slope shape: Linear, concave
Hydric soil rating: No

JnB—Joanna loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l722
Elevation: 200 to 1,000 feet
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 150 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

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

Description of Joanna

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Residuum weathered from conglomerate and/or residuum weathered from sandstone

Typical profile

Ap - 0 to 8 inches: loam
Bt - 8 to 39 inches: clay loam
C - 39 to 85 inches: sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 72 to 100 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B

Hydric soil rating: No

Minor Components

Readington

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Footslope, backslope
Landform position (three-dimensional): Base slope, head slope, side slope
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear
Hydric soil rating: No

Croton

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

JnC—Joanna loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: l723
Elevation: 200 to 1,000 feet
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

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

Description of Joanna

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Residuum weathered from conglomerate and/or residuum weathered from sandstone

Typical profile

Ap - 0 to 8 inches: loam
Bt - 8 to 39 inches: clay loam

C - 39 to 85 inches: sandy loam

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 72 to 100 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.7 inches)

Interpretive groups

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

Minor Components

Readington

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Footslope, backslope
Landform position (three-dimensional): Base slope, head slope, side slope
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear
Hydric soil rating: No

Croton

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

JnD—Joanna loam, 15 to 25 percent slopes

Map Unit Setting

National map unit symbol: l724
Elevation: 200 to 1,000 feet
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Joanna

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Residuum weathered from sandstone and/or residuum weathered from conglomerate

Typical profile

Ap - 0 to 8 inches: loam
Bt - 8 to 39 inches: clay loam
C - 39 to 85 inches: sandy loam

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: 72 to 100 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Readington

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Footslope, backslope
Landform position (three-dimensional): Base slope, head slope, side slope
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear
Hydric soil rating: No

Croton

Percent of map unit: 5 percent
Landform: Depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear

Across-slope shape: Linear, concave
Hydric soil rating: Yes

NaC—Neshaminy silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: l72y
Elevation: 300 to 1,600 feet
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 150 to 210 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Neshaminy and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Neshaminy

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Residuum weathered from diabase

Typical profile

Ap - 0 to 9 inches: silt loam
Bt - 9 to 39 inches: channery clay loam
C - 39 to 65 inches: channery sandy clay loam
R - 65 to 80 inches: bedrock

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 48 to 80 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.7 inches)

Interpretive groups

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

Minor Components

Towhee

Percent of map unit: 5 percent
Landform: Depressions
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Side slope, head slope
Down-slope shape: Concave, linear
Across-slope shape: Concave
Hydric soil rating: Yes

NhD—Neshaminy gravelly silt loam, 8 to 25 percent slopes, extremely bouldery

Map Unit Setting

National map unit symbol: l731
Elevation: 300 to 1,600 feet
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 150 to 210 days
Farmland classification: Not prime farmland

Map Unit Composition

Neshaminy, extremely bouldery, and similar soils: 97 percent
Minor components: 3 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Neshaminy, Extremely Bouldery

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Parent material: Residuum weathered from diabase

Typical profile

A - 0 to 11 inches: gravelly silt loam
Bt - 11 to 39 inches: channery clay loam
C - 39 to 65 inches: channery clay loam
R - 65 to 80 inches: bedrock

Properties and qualities

Slope: 8 to 25 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: 48 to 80 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium

Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Towhee, extremely stony

Percent of map unit: 3 percent
Landform: Depressions, mountain valleys
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Side slope, head slope
Down-slope shape: Concave, linear
Across-slope shape: Concave
Hydric soil rating: Yes

TwB—Towhee silt loam, 0 to 8 percent slopes, very stony

Map Unit Setting

National map unit symbol: l73n
Elevation: 300 to 1,100 feet
Mean annual precipitation: 34 to 48 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 130 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Towhee, very stony, and similar soils: 90 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Towhee, Very Stony

Setting

Landform: Depressions
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Side slope, head slope
Down-slope shape: Concave, linear
Across-slope shape: Concave
Parent material: Colluvium derived from diabase and/or residuum weathered from diabase

Typical profile

A - 0 to 8 inches: silt loam
Btg - 8 to 28 inches: silty clay loam
Btx - 28 to 63 inches: silt loam
C - 63 to 76 inches: coarse sandy loam

Properties and qualities

Slope: 0 to 8 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: 20 to 30 inches to fragipan; 48 to 96 inches to lithic bedrock
Natural drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C/D
Hydric soil rating: Yes

Minor Components

Mount lucas

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

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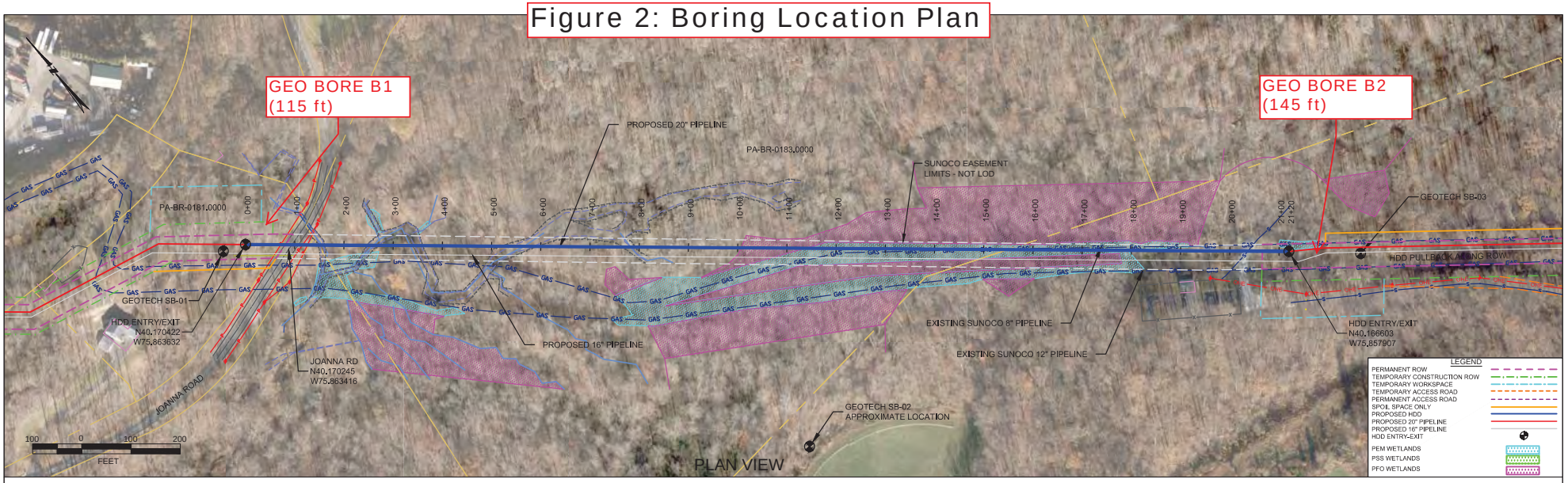
ATTACHMENT 2

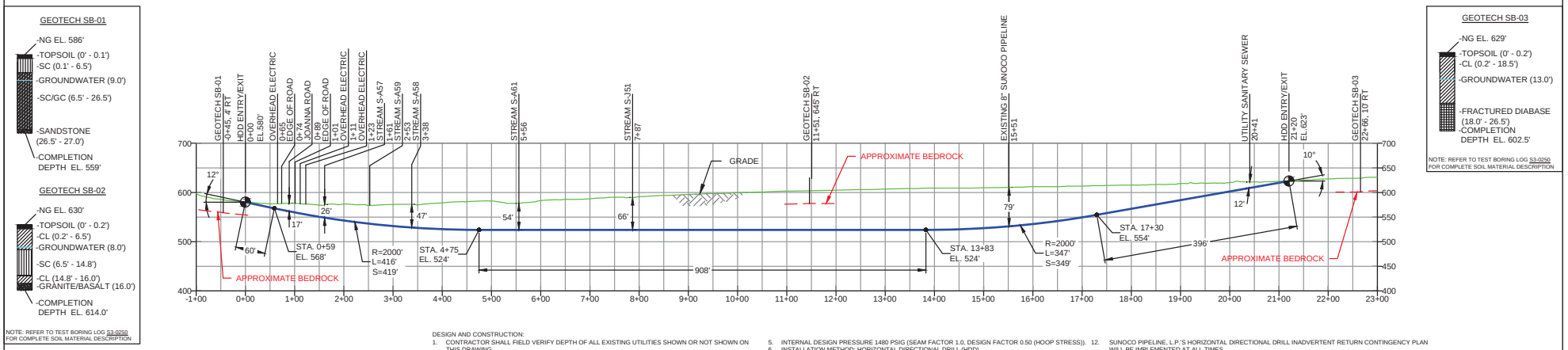
Figure 2: Boring Location Plan



PLAN VIEW

BERKS COUNTY, PENNSYLVANIA - CAERNARVON TOWNSHIP
S3-0250

PROFILE VIEW



GEOTECH SB-01

-NG EL. 586'
-TOPSOIL (0' - 0.1')
-SC (0.1' - 6.5')
-GROUNDWATER (9.0')
-SC/GC (6.5' - 26.5')
-SANDSTONE (26.5' - 27.0')
-COMPLETION DEPTH EL. 559'

GEOTECH SB-02

-NG EL. 630'
-TOPSOIL (0' - 0.2')
-CL (0.2' - 6.5')
-GROUNDWATER (8.0')
-SC (6.5' - 14.8')
-CL (14.8' - 16.0')
-GRANITE/BASALT (16.0')
-COMPLETION DEPTH EL. 614.0'

NOTE: REFER TO TEST BORING LOG S3-0250 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH SB-03

-NG EL. 629'
-TOPSOIL (0' - 0.2')
-CL (0.2' - 18.5')
-GROUNDWATER (13.0')
-FRACTURED DIABASE (18.0' - 26.5')
-COMPLETION DEPTH EL. 602.5'

NOTE: REFER TO TEST BORING LOG S3-0250 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):2120'
   HDD PIPE LENGTH (S=):2132'
   20" x 0.456" W.T., X-65, APISL, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
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 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. NUMBER: PA-BR-0181.0000-RD

BORING B-01

DATE STARTED:	8/31/17	**DRILL COMPANY:**	Eichelbergers
DATE COMPLETED:	9/1/17	**DRILLER:** T. Growden	**LOGGED BY:** R. Peddishree
COMPLETION DEPTH	115.0 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:

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 ✚ (0, 25, 50) / STRENGTH, tsf Qu ▲ / Qp ✳ (0, 2.0, 4.0)	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%
	5					**RESIDUUM**-Dense, Brown, Clayey GRAVEL with Sand, wet	GC				
				S-3	15			11-10-26-50/3" N=36			Fines=24.3%
	10					**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.
	15									>>▲ Qu=22.0 tsf	170.4 pcf
				R-1	63			RQD=11 Rec=75%			2 min. 4 min. 3 min. 3 min.
	20					**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					4 min. 3 min. 4 min. 4 min.
				R-2	49			RQD=0 Rec=82%			4 min. 4 min. 4 min. 4 min. 4 min. 4 min. 3 min.
	25										
	30					*Continued Next Page*					

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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

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

DATE STARTED: 8/31/17	**DRILL COMPANY:** Eichelbergers	**BORING B-01**		
DATE COMPLETED: 9/1/17	**DRILLER:** T. Growden **LOGGED BY** R. Peddishree	Water	While Drilling	8 feet
COMPLETION DEPTH 115.0 ft	**DRILL RIG:** Dledrich D-50		Pre-Core	9.5 feet
BENCHMARK: N/A	**DRILLING METHOD:** Casing/Rock Coring		Post-Core	10.4 feet
ELEVATION: N/A	**SAMPLING METHOD:** 2-in SS1.874-in Core			
LATITUDE: n/a°	**HAMMER TYPE:** Automatic	**BORING LOCATION:**		
LONGITUDE: n/a°	**EFFICIENCY** N/A	See Boring Location Plan		
STATION: N/A **OFFSET:** N/A	**REVIEWED BY:** F. Hoffman			
REMARKS:				

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL 0 25 50; STRENGTH, tsf ▲ Qu ✳ Qp 0 2.0 4.0	Additional Remarks
	30			R-3	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.
	40			R-4	103			RQD=4 Rec=86%			3 min. 3 min. 3 min. 3 min. 3 min.
	45										3 min. 3 min. 4 min. 3 min. 3 min.
	50			R-5	77			RQD=0 Rec=64%			3 min. 3 min. 3 min. 3 min. 3 min.
	55										3 min. 3 min. 2 min.
						SHALE-Dark gray, Very fine grained, Highly Weathered, very broken to broken, moderately hard					3 min. 3 min.
	60										

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

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

DATE STARTED:	8/31/17	**DRILL COMPANY:**	Eichelbergers
DATE COMPLETED:	9/1/17	**DRILLER:** T. Growden	**LOGGED BY:** R. Peddishree
COMPLETION DEPTH	115.0 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-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 (0 25 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 2.0 4.0)	Additional Remarks
	60			R-6	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.
											3 min.
											3 min.
	65										3 min.
						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.
											3 min.
											3 min.
						SHALE-Dark gray-brown, Very fine grained, Weathered to Slightly Weathered, very broken to massive, moderately hard					>> Q_u = 422.9 tsf 162.2 pcf
	70			R-7	120			RQD=0 Rec=100%			3 min.
											3 min.
											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.
											3 min.
											3 min.
	75										3 min.
											3 min.
											3 min.
											3 min.
											3 min.
											>> Q_u = 622.9 tsf 150.1 pcf
	80			R-8	119			RQD=27 Rec=99%			3 min.
											3 min.
											3 min.
						Broken/Weathered layer @ 81.7 feet (~ 5-1/2 inches thick)					3 min.
											3 min.
											3 min.
	85										3 min.
						SANDSTONE-Dark gray-brown, Fine grained, Highly Weathered, very broken to slightly broken, very hard, trace calcite stringers					3 min.
											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.
											>> Q_u = 418.3 tsf 149.6 pcf
	90										

Continued Next Page

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

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

BORING B-01

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:** R. Peddishree
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

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 (0, 25, 50) STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	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)					3 min.
	100			R-10	87	**SILTSTONE**-Gray-brown to dark gray-brown, Very fine grained, Highly Weathered, very broken to broken, moderately hard		RQD=22 Rec=73%			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. >> Q_u = 250.5 tsf 161.5 pcf
	110			R-11	120			RQD=45 Rec=100%			3 min.
	115					**SILTSTONE**-Gray-brown to dark gray-brown, Very fine grained, Weathered, broken to massive, moderately hard **SILTSTONE**-Dark gray-brown, Very fine grained, Highly Weathered, very broken to broken, moderately hard Test boring terminated @ 115 feet					3 min.

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

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


04911457
Pennsylvania
Morgan Twp. Bucks Co. PA
BB-1 JOANNA RD
Box 1 of 6
Run #
DEPTH
Rec.
RQD
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"
20.0'
25.0'


0491457
Morgan Twp. Beaver Co. PA
JOANNA RD.
Run 2 of 6
Run # | Depth | Rec.= " | RQD= "
R-4 | 35.0'-45.0' | 107"/120" | 5"
R-5 | 45.0'-55.0' | 77"/120" | 0"
35.0'
45.0'


DS17145
Precision Pipeline
Morgan Twp. Banks Co. PA
GB-1
Box 3 of 6
Run #
Depth
Rec.= "
RQD = "
R-5 cont.
R-5
55.0'-65.0'
116"/120"
0"
R-6
65.0-75.0'
120"
0"
55.0'
65.0'


Run #
Depth
Rec.
RQD
Precision Pipeline
GB-1
Box 4 of 6
R-7 cont.
65.0'-75.0'
120"/120"
0"
R-8
75.0'-85.0
119"/120"
32"/120"
R-7 cont.
75.0'


DRILLING
Precision Pipeline
Morgan Twp. Beaver Co. PA
Log
Run 5 & 6
Run #
Depth
Rec.= "
RQD= "
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"
R-8 Cont
85.0'
95.0


Rock Cut
Precision Pipeline
Morgan Twp. Beaver Co. PA
GB-1
Run #
Depth
Rec. = "
RQD = "
R-10 cont.
95.0'-105.0'
87"/120"
26"/120"
R-11
105.0'-115.0'
120"/120"
54"/120"
R-10 Cont.

BORING B-02

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:

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 (0 25 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 2.0 4.0)	Additional Remarks
	0			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		
						Possible FILL-Diabase Boulder, Light gray to dark gray, Fine to medium grained, very hard					
				R-1	16	**Possible FILL**-No recovery within this stratum		RQD=24 Rec=32%		>>	
	5			S-2	0			4-4-11-12 N=15			
				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
	10										
						DIABASE-Light gray to dark gray, Fine to medium grained, Slightly Weathered, slightly broken to massive, very hard				>> ▲	Q_u = 1837.1 tsf 189.8 pcf
	15			R-2	56			RQD=86 Rec=94%			2 min. 2 min. 2 min. 3 min. 3 min.
										>> ▲	Q_u = 1141.5 tsf 188.5 pcf
	20			R-3	78			RQD=93 Rec=93%			2 min. 2 min. 2 min. 2 min. 2 min. 2 min. 2 min. 2 min. 2 min. 2 min. 2 min.
	25										
	30										

Continued Next Page

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

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

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 (0 25 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 2.0 4.0)	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		RQD=73 Rec=93%			2 min.
						DIABASE-Light gray to black, Fine to coarse grained, Slightly Weathered, very broken to massive, very hard to extremely hard					2 min.
											1 min.
											1 min.
											1 min.
	35										1 min.
										>>▲ Q_u = 1615.4 tsf	189.4 pcf
											2 min.
											2 min.
											2 min.
				R-5	90			RQD=91 Rec=94%			2 min.
	40										2 min.
											2 min.
											2 min.
											2 min.
											2 min.
											3 min.
	45										3 min.
				R-6	72			RQD=82 Rec=100%			3 min.
						Broken/Weathered layer @ 47.2 feet (~ 12-1/2 inches thick)					3 min.
											3 min.
											3 min.
										>>▲ Q_u = 374.1 tsf	187.8 pcf
	50										3 min.
											4 min.
				R-7	72			RQD=67 Rec=100%			4 min.
											4 min.
											4 min.
											4 min.
	55					Weathered layer @ 55 feet (~ 8 inches thick) Diagonal calcite-filled fracture @ 55.5 feet.					3 min.
											3 min.
											3 min.
											3 min.
											3 min.
	60					*Continued Next Page*					

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

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

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 (0 25 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 2.0 4.0)	Additional Remarks
	60			R-8	120	**DIABASE**-Light gray to black, Fine to coarse grained, Slightly Weathered, very broken to massive, very hard to extremely hard		RQD=88 Rec=100%			3 min. >> Q_u = 2821.0 tsf 189.1 pcf 3 min. 3 min. 3 min.
	65										3 min. 4 min. 4 min. 4 min. 4 min.
	70			R-9	118			RQD=66 Rec=98%			4 min. 4 min. 4 min. 4 min. 4 min. 4 min.
	75										4 min. >> Q_u = 2245.0 tsf 188.6 pcf 4 min. 4 min. 4 min.
	80			R-10	114			RQD=96 Rec=95%			4 min. 4 min. 4 min. 4 min. 4 min. 4 min.
	85										4 min. 4 min. 4 min. 4 min. >> Q_u = 2137.1 tsf 189.1 pcf
	90										

Continued Next Page

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

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

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 (0 25 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 2.0 4.0)	Additional Remarks
	90			R-11	120	**DIABASE**-Light gray to black, Fine to coarse grained, Slightly Weathered, very broken to massive, very hard to extremely hard		RQD=95 Rec=100%			4 min. 4 min. 4 min. 4 min. 4 min.
	95					Weathered layer @ 94.6 feet (~ 5 inches thick)					4 min. 4 min. 4 min. 4 min. 4 min.
						Weathered layer @ 97.5 feet (~ 8-1/2 inches thick)					>> Q_u = 1369.5 tsf 190.5 pcf
	100			R-12	120			RQD=93 Rec=100%			4 min. 4 min. 4 min. 3 min. 3 min.
	105										3 min. 4 min. 4 min. 4 min. >> Q_u = 559.3 tsf 190.0 pcf
	110			R-13	118			RQD=96 Rec=98%			4 min. 4 min. 4 min. 4 min. 4 min.
	115										4 min. 3 min. 3 min. 3 min. 3 min.
	120					*Continued Next Page*					>> Q_u = 242.1 tsf

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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 (0, 25, 50) STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	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%			192.1 pcf 3 min. 3 min. 3 min. 3 min. 3 min.
	125			R-15	60			RQD=78 Rec=100%			4 min. 4 min. 4 min. 4 min. 4 min.
	130					Weathered layer @ 131.9 feet (~ 3-1/2 inches thick)					4 min. 4 min. 4 min. 4 min. >> Q_u = 1157.2 tsf 191.6 pcf
	135			R-16	120			RQD=63 Rec=100%			4 min. 4 min. 4 min. 4 min. 4 min.
	140					Broken/very broken layer @ 138 feet (~ 22-1/2 inches thick)					4 min. 4 min. 4 min. 4 min. 4 min.
	145			R-17	60	Test boring terminated @ 145 feet		RQD=86 Rec=100%			4 min. 4 min. 4 min. 4 min.

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LOCATION: Joanna Road (PPP5)
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The stratification lines represent approximate boundaries. The transition may be gradual.


0491-1457
Joanna Rd, PPPS
B-2
Box 1 of _
8/28/17
Run | Depth | Rec. | RQD
R-1 | 1.8-6.0 (boulder) | 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, PPPS
B-2
Box 2 of _
8/28/17
Run | Depth | Rec. | RQD
R-4(cont) | 25.0-35.0 | 9.6 | 9.6
1.3 | 7.3
R-5 | 35.0-43.0 | 7.5 | 7.3
TOP
350
43.0


0491-1457
Joanna Rd, PPPS
B-2
Box 3 of _
8/29/17
Run | Depth | Rec. | RQD
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 | 10(
TOP
43.0
49.0
55.0


04491-1457
Joanna Rd, PPPS.
B-2
Box 4 of _
8/29/17
Run
Depth
Rec.
RQD
R-8 (cont'd)
55.0-65.0
10.0
100%
R-9
65.0-75.0
9.8
79.0"
TOP
65.0


0491-1457
Joanna Rd, PPPS
B-2
Box 4 of –
8/29/17
0491-1457
Joanna Rd, PPPS
B-2
Box 5 of –
8/29/17
Run
Depth
Rec.
R-9 (cont)
65.0-75.0
9.8
R-10
75.0-85.0
R-11
85.0-93.9
TOP
75.0
85.0


Run
Depth
Rec.
RQD
85.0-95.0
10.0
11"
95.0-105.0
10.0
11"
TOP
95.0


0491-1157
Joanna RA, PPPS
B-2
Box 7 of —
4/29/19
Run | Depth | Rec | RQD
R-12(cont) | 95.0-105.0 | 10.0 | 111"
R-13 | 105.0-115.0 | 9.5 | 115"
R-14 | 115.0-125.0 | 10.0 | 9.6"
105.0
115.0


PSI DH11459 7-7-17
Box B-2
Spread PPP5
OHW-1457
Joanna RA, PPP5
B-2
Box 1 of 1
1129 ft
Run | Depth | Rec | RQD
R-14 | 115.0 - 125.0 | 10.0 | 7.7'
R-15 | 125.0 - 130.0 | 5.0 | 3.9'
R-16 | 130.0 - 140.0 | 10.0 | 6.3'
125.0
130.0


Spread PPP5 Creek + T307 Box
0491-1457
Joanna Rd., PPP5
B-2
Box 9 of 9
6/29/17
Run | Depth | Rec. | RQD
R-16 1300-1400 | 10.0 | 6.3
R-17 140.0-145.0 | 5.0 | 4.3
EOB
140.0

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GENERAL NOTES

SAMPLE IDENTIFICATION

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

DRILLING AND SAMPLING SYMBOLS

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

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

SOIL PROPERTY SYMBOLS

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

RELATIVE DENSITY OF COARSE-GRAINED SOILS

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

ANGULARITY OF COARSE-GRAINED PARTICLES

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

GRAIN-SIZE TERMINOLOGY

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

PARTICLE SHAPE

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

RELATIVE PROPORTIONS OF FINES

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

GENERAL NOTES

(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

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

MOISTURE CONDITION DESCRIPTION

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

RELATIVE PROPORTIONS OF SAND AND GRAVEL

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

STRUCTURE DESCRIPTION

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

SCALE OF RELATIVE ROCK HARDNESS

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

ROCK BEDDING THICKNESSES

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

ROCK VOIDS

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

GRAIN-SIZED TERMINOLOGY

(Typically Sedimentary Rock)

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

ROCK QUALITY DESCRIPTION

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

Degree of Brokeness

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

DEGREE OF WEATHERING

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

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

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

SOIL CLASSIFICATION CHART

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

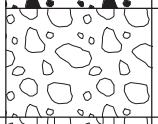
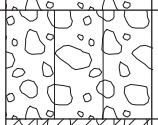
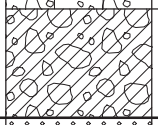
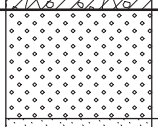
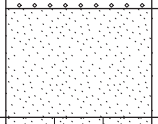
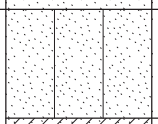
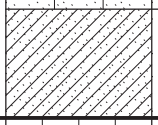
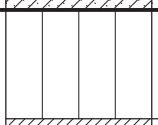
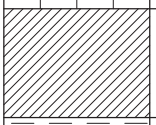
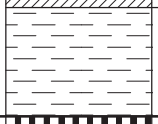
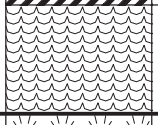
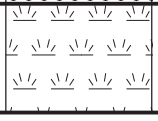
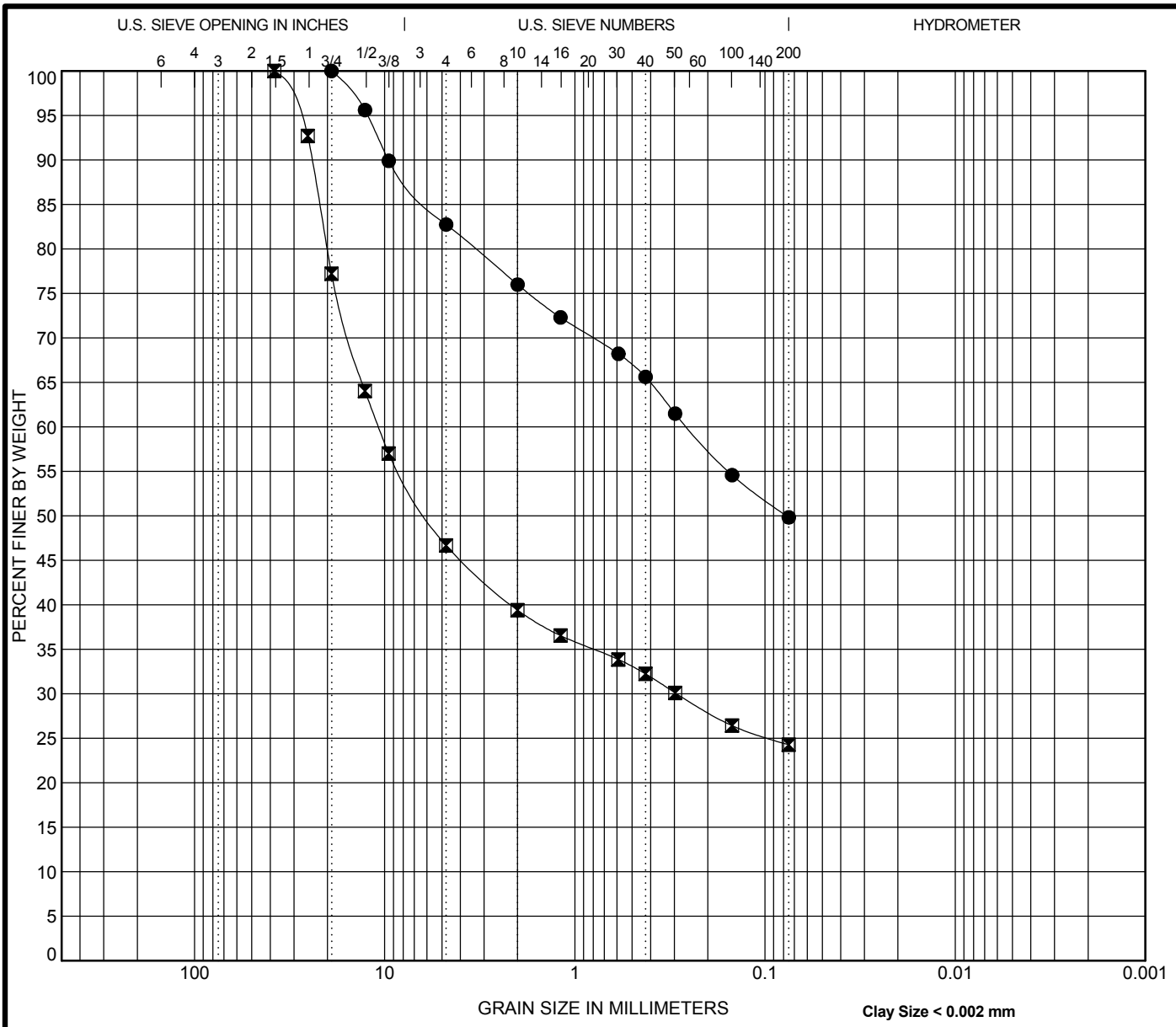
MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND 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.



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	B-01	4.0	Clayey SAND with Gravel (SC)					
⊠	B-01	9.0	Clayey GRAVEL with Sand (GC)					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-01	4.0	19.05	0.256			17.3	32.9	49.8	
⊠	B-01	9.0	38.1	10.767	0.291		53.3	22.4	24.3	

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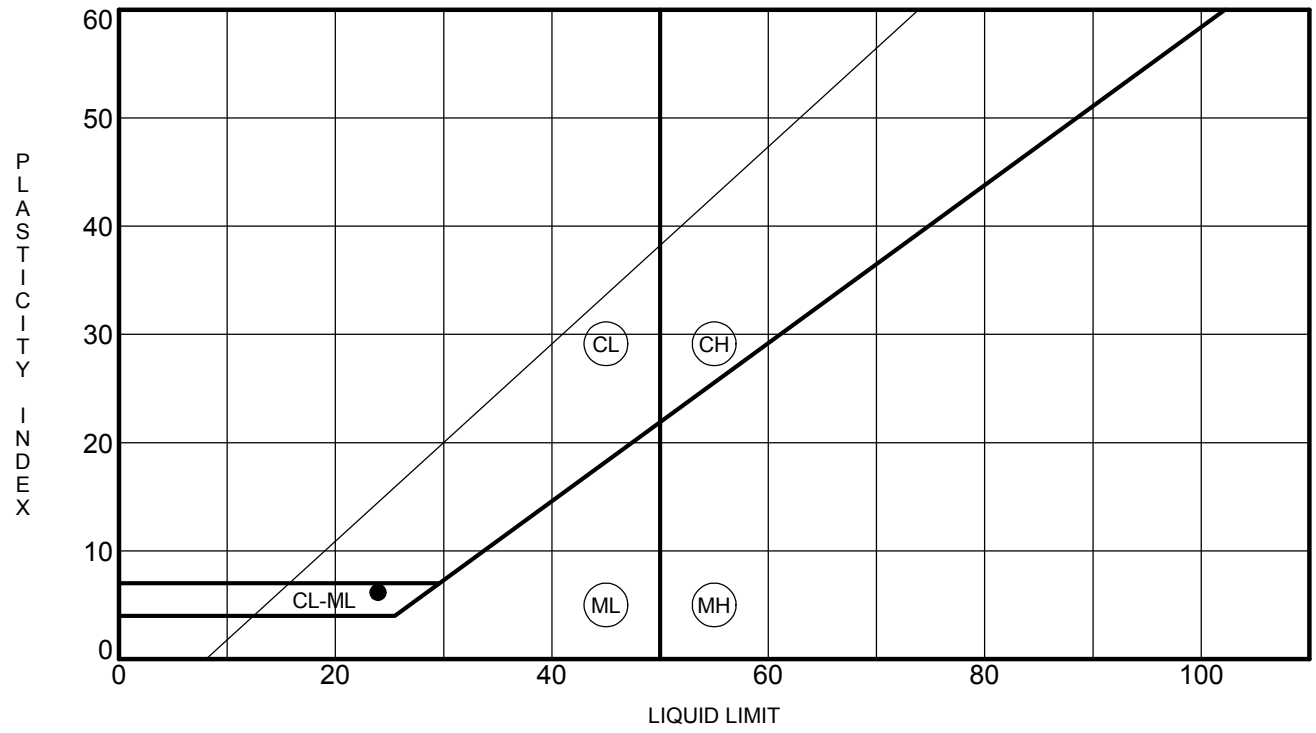
GRAIN SIZE DISTRIBUTION

Project: Energy Transfer HDD (DPS)
PSI Job No.: 04911457
Location: Joanna Road (PPP5)
Berks Co., PA



	Boring	Depth (ft)	LL	PL	PI	Fines	Classification (*Visual)
●	**B-02**	**9.0**	**24**	**18**	**6**		**Sandy Silty CLAY with Gravel (CL-ML)**

Professional Service Industries, Inc.
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ATTERBERG LIMIT RESULTS

PSI Job No.: 04911457
Project: Energy Transfer HDD (DPS)
Location: Joanna Road (PPP5)
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-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						

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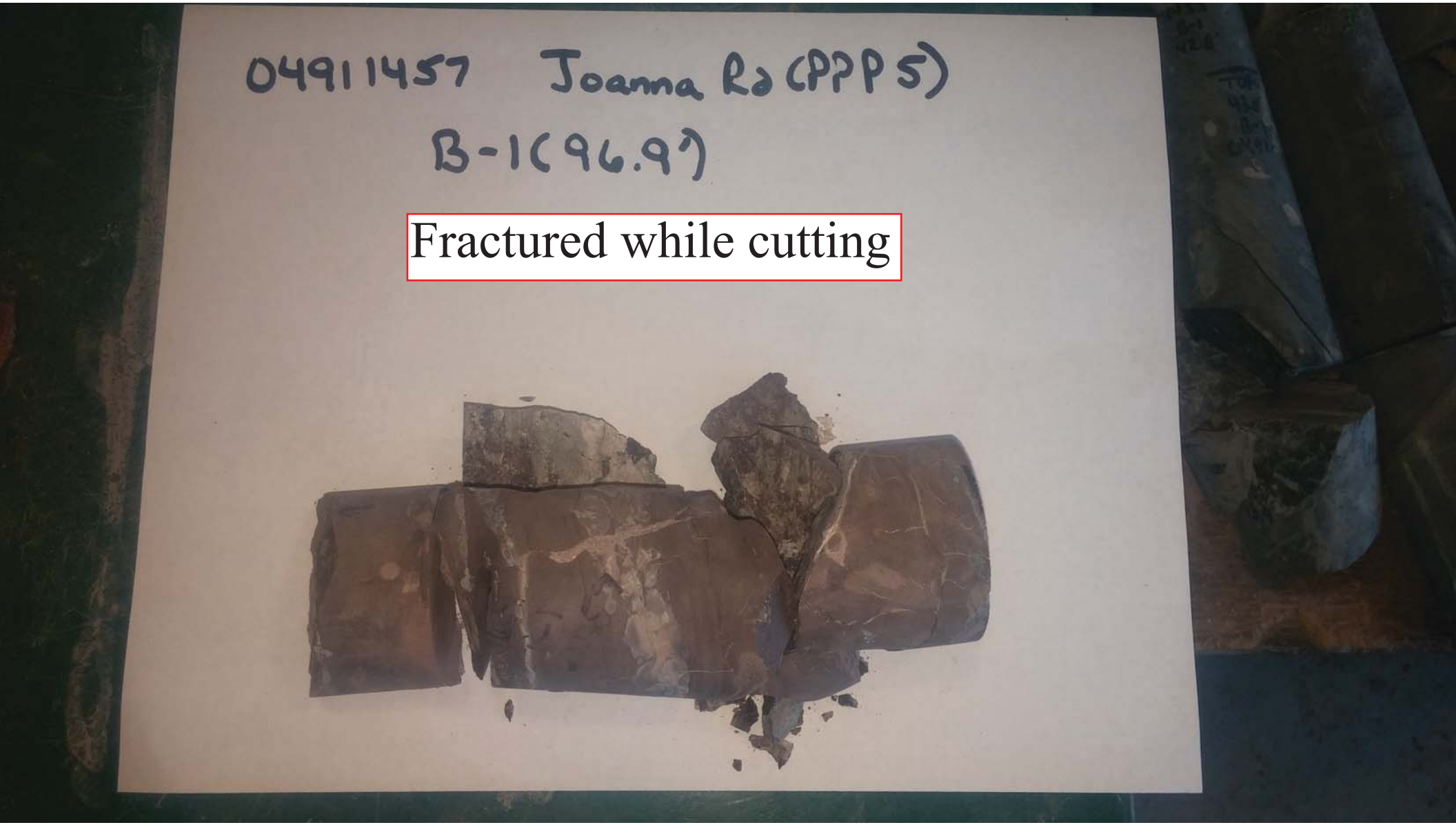
Summary of Laboratory Results

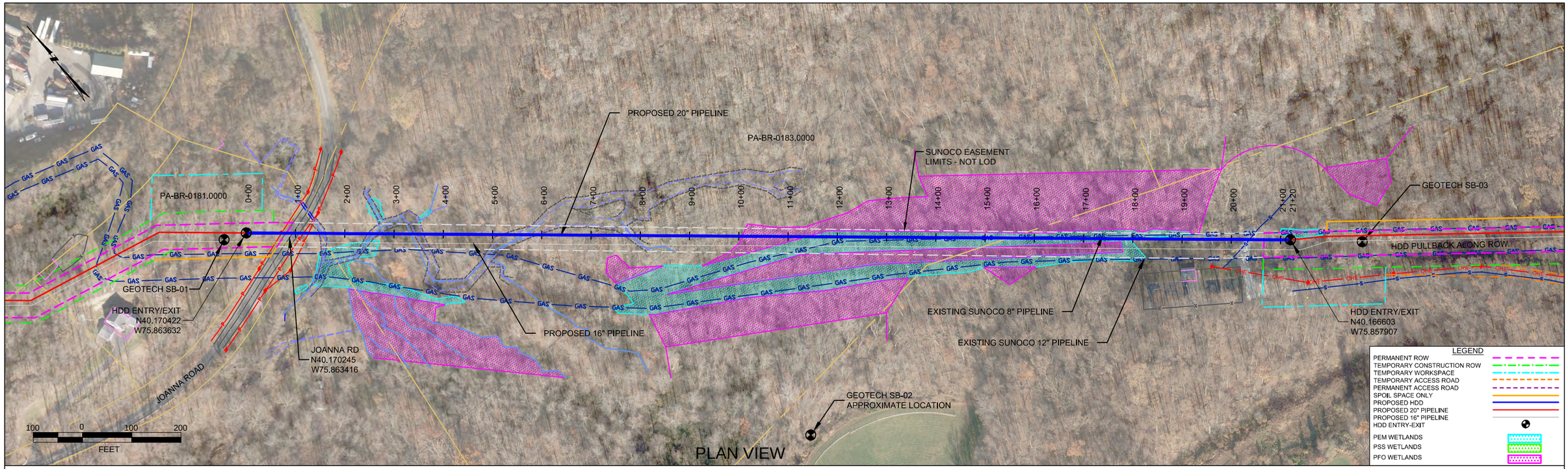
PSI Job No.: 04911457
Project: Energy Transfer HDD (DPS)
Location: Joanna Road (PPP5)
Berks Co., PA
PA-BR-0181.0000-RD/PO#20170822


04911457 Joanna Rd (PPP 5)
B-1(96.97)
Fractured while cutting

JOANNA ROAD CROSSING
PADEP SECTION 105 PERMIT NO.S:
PA-BR-00181.0000-RD, PA-BR-0181.0000-RD-16 & PA-BR-0183.0000
(SPLP HDD# S3-0250)

ATTACHMENT 2

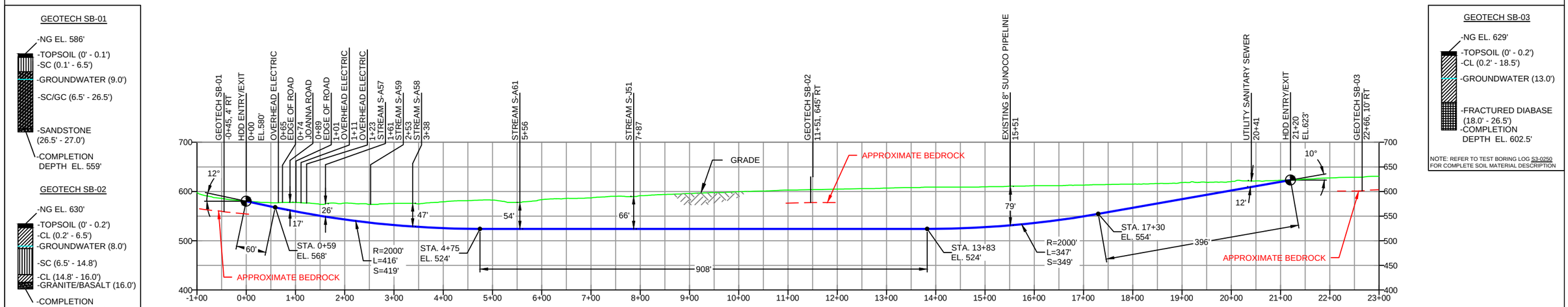
HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES



PLAN VIEW

PROFILE VIEW

BERKS COUNTY, PENNSYLVANIA - CAERNARVON TOWNSHIP
S3-0250



GEOTECH SB-01

-NG EL. 586'
-TOPSOIL (0' - 0.1')
-SC (0.1' - 6.5')
-GROUNDWATER (9.0')
-SC/GC (6.5' - 26.5')
-SANDSTONE (26.5' - 27.0')
-COMPLETION DEPTH EL. 559'

GEOTECH SB-02

-NG EL. 630'
-TOPSOIL (0' - 0.2')
-CL (0.2' - 6.5')
-GROUNDWATER (8.0')
-SC (6.5' - 14.8')
-CL (14.8' - 16.0')
-GRANITE/BASALT (16.0')
-COMPLETION DEPTH EL. 614.0'

NOTE: REFER TO TEST BORING LOG S3-0250 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH SB-03

-NG EL. 629'
-TOPSOIL (0' - 0.2')
-CL (0.2' - 18.5')
-GROUNDWATER (13.0')
-FRACTURED DIABASE (18.0' - 26.5')
-COMPLETION DEPTH EL. 602.5'

NOTE: REFER TO TEST BORING LOG S3-0250 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):2120'
   HDD PIPE LENGTH (S=):2132'
   20" x 0.456" W.T., X-65, APISL, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

Figure 1. 20-Inch HDD Plan and Profile

NOTES

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

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 Logistics Partners L.P.

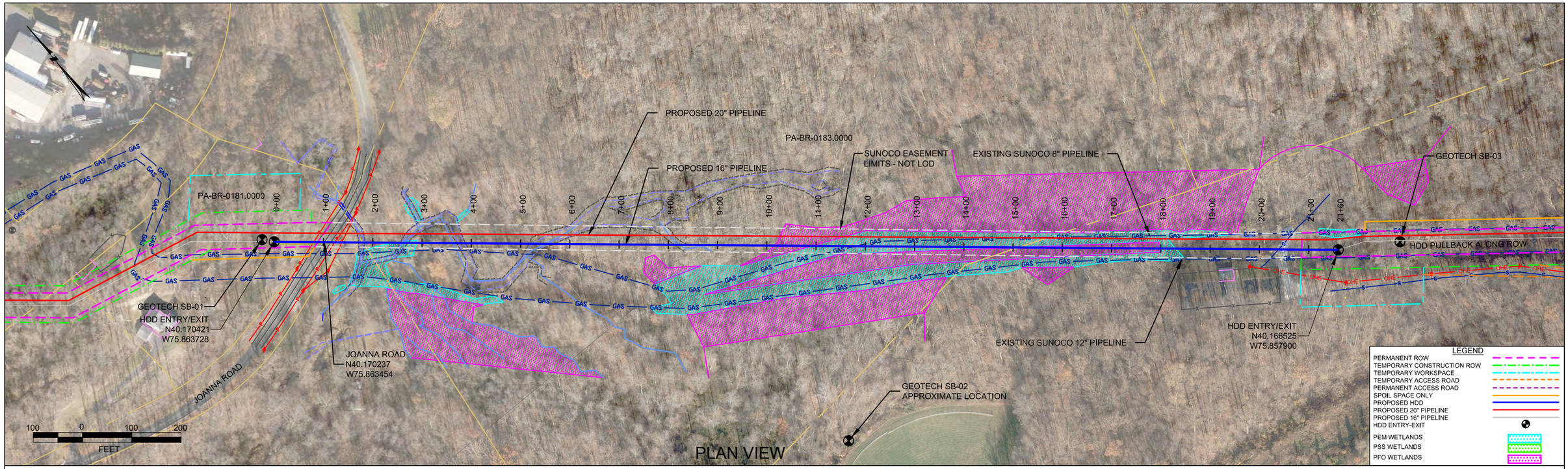
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
JOANNA ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

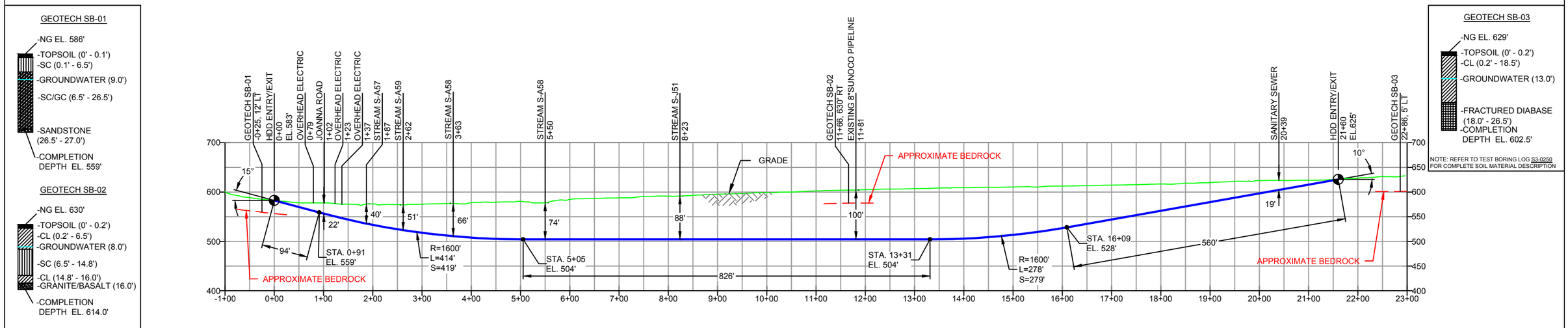
DWG. NUMBER: PA-BR-0181.0000-RD



PLAN VIEW

PROFILE VIEW

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



DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):2160'
   HDD PIPE LENGTH (S=):2178'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

Figure 2. 16-Inch HDD Plan and Profile

NOTES

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REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
5	DESIGN CHANGE (LOWER & MOVED DRILL DESIGN)	DLM	02/21/17	RMB	02/21/17	AMC	02/21/17
4	REVISED PROFILE WITH 2017 LIDAR	MRS	02/15/17	RMB	02/15/17	AAW	02/15/17
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

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