

**HORIZONTAL DIRECTIONAL DRILL ANALYSIS
OLD MILL ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E34-136
PA-JU-0004.0000-WX-16
(SPLP HDD No. S2-0156-16)**

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This reevaluation of the horizontal directional drill (HDD) installation of a 16-inch diameter pipeline that traverses under Old Mill Road/Berry Ridge Road, Tuscarora Creek (Stream K-74) and associated emergent and forested wetlands (WK-59, WK-60) in Juniata County, Lack Township, Pennsylvania has been completed in accordance with Condition No. 3 of the Stipulated Order issued under Environmental Hearing Board Docket No. 2017-009-L. Condition No. 3 stipulates, for HDDs initiated after the temporary injunction issued by the Pennsylvania Department of Environmental Protection (PADEP) Environmental Hearing Board on July 25, 2017, a reanalysis must be performed on HDDs for which an inadvertent return (IR) occurs during the installation of one pipe (20-inch or 16-inch diameter) where a second pipe will thereafter be installed in the same right-of-way (ROW).

During the HDD for installation of the 20-inch diameter pipeline, an inadvertent return (IR) to the land surface occurred as the 30-reamer progressed 180 ft from the west entry point. The IR discharged into the partially backfilled original entry pit excavated by the prior drilling contractor for the HDD attempted prior to the field redesign of the 20-inch HDD profile, and resetting of the HDD entry, exit, and depth of profile. No other IR events occurred during completion of the HDD and installation of the 20-inch pipeline. Due to the single IR event the second HDD requires reevaluation.

PIPE INFORMATION

16-Inch: 0.438 wall thickness; X-70

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

ORIGINAL PERMITTED HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 860 foot (ft)
- Entry/Exit angle: 7-10 degrees
- Maximum Depth of cover: 44 ft
- Depth below Tuscarora Creek: 25 ft
- Pipe design radius: 1,600 ft

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

Based upon publications by the Pennsylvania Bureau of Topographic and Geologic Survey (BTGS, 2001 and Sevon, 2000), the HDD location is in the Appalachian Mountain Section of the Ridge and Valley Physiographic Province of Pennsylvania. The Appalachian Mountain section is underlain by sedimentary rocks consisting of sandstone, siltstone, shale, conglomerate, limestone, and dolomite. The site geology for the revised 16-inch HDD profile is mapped west to east as the Devonian age Hamilton Group (Dh), Onondaga and Old Port Formations, undivided (Doo), and Keyser and Tonoloway Formations, undivided (DSkt).

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

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HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

Groundwater along the HDD occurs in a fractured carbonate and clastic sedimentary bedrock aquifer system within the geology described in Section 2.0. In these rock types of Juniata County, water-bearing zones generally occur in secondary openings developed along bedding planes, joints, faults and fractures. Most of the water-bearing zones penetrated by wells occur in individual fractures or groups of interconnected fractures that can be sufficiently enlarged by dissolution of the bedrock.

The depths of 243 domestic and non-domestic water supply wells in the Hamilton Group range from 10 to 695 feet below ground surface (bgs), with yields ranging from 1 to 380 gallons per minute (gpm). Reported depths of 228 domestic and nondomestic wells in the Onondaga and Old Port Formations ranged from 35 to 500 feet below ground surface (bgs). Well yields ranged from 0 to 1,400 gallons per minute (gpm) and the median well yield was 10 gpm for domestic wells and 66 gpm for nondomestic wells (Taylor, 1982). The depths of 184 domestic and nondomestic wells in the Keyser and Tonoloway Formations ranged from 27 to 504 feet bgs. Well yields ranged from 0 to 315 gpm and the median well yield was 10 gpm for domestic wells and 33 gpm for nondomestic wells (Taylor, 1982). Attachment 1 provides an extensive discussion on the hydrogeology and results of the geotechnical investigation performed at this location.

INADVERTENT RETURN (IR) DISCUSSION

No IR events occurred during the pilot phase of this HDD for installation of the 20-inch pipeline. After completion of the pilot hole, the reaming phase commenced with entry at the west end using a 24-inch diameter tool, then a 30-inch diameter reaming tool proceeding from west to east.

At 180 ft of progress by the 30-inch reamer, drilling fluids and cuttings pushed up and into the partially backfilled entry pit for the original 20-inch HDD attempt by the prior drilling contractor. No loss of fluids or cuttings to outside the permitted limits of disturbance occurred and no fluids or cuttings discharged to a Water of the Commonwealth. For the remainder of the 30-inch reaming phase and installation of the pipeline, a vacuum truck captured any continuing fluid releases into the old pit and relayed the fluids and cuttings to the active HDD entry pit for recycling and reuse.

The root cause of the IR event was from failure to completely backfill and compact the original HDD entry pit. This situation was corrected upon completion of the 20-inch pipeline installation along with backfilling of the of the active HDD entry used to complete the 20-inch pipeline installation. No further corrective actions for the original HDD entry pit are recommended.

During the 20-inch HDD, the production of groundwater through the annulus of the pilot or reamed hole was not an issue and no measures were undertaken during the HDD to control groundwater production. Similar drilling circumstances are expected during the HDD for the 16-inch pipeline.

ADJACENT FEATURES ANALYSIS

The crossing of Old Mill Road/Berry Ridge Road, Tuscarora Creek and associated adjacent wetlands occurs in rural Juniata County, approximately 0.9 miles north-northwest of the community of Waterloo, Pennsylvania. The pipeline route follows parallel to an existing Sunoco pipeline.

This HDD location is within active agricultural lands and unmanaged deciduous woodlands. The pipeline route follows parallel to an existing SPLP pipeline easement. The HDD would cross under one perennial stream, Tuscarora Creek (S-K74), which is not designated as high quality, and two wetlands (wetlands K59 & K60), neither of which are designated as exceptional value. Wetlands K59 and K60 are

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comprised of emergent and forested vegetative cover types. Although wetland K59 is not designated as an exceptional value wetland, it provides a buffer and is riparian to Tuscarora Creek. This HDD avoids surficial impacts to Tuscarora Creek (S-K74) and wetlands K59 & K60, forested wetland cover type conversion, and existing underground gas pipelines.

A water well records search of the Pennsylvania Groundwater Information System (PaGWIS, January 15, 2018) was completed with a search radius of 0.5-miles. No water well records were identified within the 0.5-mile search radius. In 2018, SPLP subcontractors issued consultation letters and offers for temporary replacement of water supplies to each landowner within 450 ft of the HDD profile. No additional water wells were identified within the 450-foot buffer of the alignment; however, one well was identified approximately 1,240 feet from the western entry/exit point of the HDD.

Impacts to public or private water supplies are not a concern during operations of this HDD.

ALTERNATIVES ANALYSIS

As part of the PADEP Chapter 105 permit process for the Mariner II East Project, SPLP developed and submitted for review a project-wide Alternatives Analysis. During the development and siting of the project, SPLP considered a number of different routings, locations, and designs to determine whether there was a practicable alternative to the proposed impact. SPLP performed this determination through a sequential review of routes and design techniques, which concluded with an alternative that has the least environmental impacts, taking into consideration cost, existing technology, and logistics. The baseline route provided for the pipeline construction was to cross every wetland and stream on the project by open cut construction procedures. The Alternatives Analysis submitted to PADEP conceptually analyzed the potential feasibility of any alternative to baseline route trenched resource crossings (e.g., reroute, conventional bore, HDD). The decision-making processes for selection of the HDD instead of an open cut crossing methodology is discussed thoroughly in the submitted alternatives analysis and was an important part of the overall PADEP approval of HDD plans as currently permitted. As described below, the open cut and re-route analyses have confirmed the conclusions reached in the previously submitted Alternatives Analysis.

Open-cut and Conventional Bore Analysis

SPLP specifications require a minimum of 48 inches of cover over the installed pipelines. To meet these cover requirements, during construction through the stream and wetlands would require a minimum authorized open cut work space 75 ft in width to accommodate the 16-inch pipeline. The assessed area of impact by this open cut plan would directly affect approximately 0.02 acres of state water bottoms, 0.05 acres of emergent wetland, and 0.18 acres of forested wetland.

Due to the existing saturated ground conditions, a significant volume of produced groundwater will fill all the excavations during the open cut process. These water volumes can be pumped to a discharge filtration structure; however, the current feasible filtration ability does not exceed 50 microns, therefore, cloudy water (from suspended fine clay and silt particles) would be discharged downstream regardless of all control methods employed for the entire duration of this open cut installation until completion.

The crossing distance of the emergent and forested wetlands, which are the most expansive natural features crossed by the HDDs, is beyond the technical limits of a conventional auger bore.

In summary, a combination of open-cut and conventional bores will not work as an alternative to the Old Mill Road HDD.

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Re-Route Analysis

The pipeline route as currently permitted follows parallel to two existing Sunoco pipelines.

There are no existing utility corridors to the north or south that provide a practical alternative route. Any alternate route considered north or south of the existing utility corridor would require the clearing of a new "greenfield" corridor through existing woodlands and croplands, increase the number of stream crossings, and possibly encroach on additional private residences before it could rejoin the current route.

In sum, the re-route analysis conducted for the Old Mill Road HDD confirms the conclusions reached in the previously submitted alternatives analysis.

HORIZONTAL DIRECTIONAL DRILL REDESIGN

Additional geologic investigations were completed and utilized in field revision of the 20-inch HDD. As a result of the observations and monitoring of the drilling and installation of the 20-inch pipeline the 16-inch HDD was redesigned to approximate the profile of the field revised 20-inch pipeline. A summary of the redesign factors is provided below. The original permitted and post 20-Inch installation 16-inch redesigned HDD plan and profiles are provided in Attachment 2.

Revised Horizontal Directional Drill Design Summary: 16-inch

- Horizontal length: 1,360 ft
- Entry/Exit angle: 16 degrees
- Maximum Depth of cover: 81 ft
- Depth below Tuscarora Creek: 79 ft
- Pipe design radius: 2,000 ft

As shown on Figure 2 the revised HDD profile for the 16-inch pipeline is 500 longer, with a depth of cover increased by 50 ft, and designed for a sharp and quick entry into and exit from the horizontal depth.

CONCLUSION

HDD specialists revised the 16-inch diameter pipeline profile as set forth above to maximize the potential to complete the HDD without an occurrence of an IR.

Upon the start of the 16-inch HDD, SPLP will employ the following HDD best management practices:

- SPLP will provide the drilling crew and company inspectors (UI, EI, PGs) the location(s) data on potential zones of higher risk for fluid loss and IRs, including the area related to previous IRs, and potential zones of fracture concentration identified by the fracture trace analysis so that monitoring can be enhanced when drilling through these locations;
- SPLP will require and enforce the use of annular pressure monitoring during the drilling of the pilot holes, which assists in immediate identification of pressure changes indicative of loss of return flows or over pressurization of the annulus to manage development of pressures that can induce an IR;

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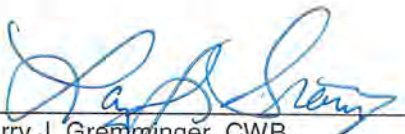
- SPLP inspectors will ensure that an appropriate diameter pilot tool, relative to the diameter of the drilling pipe, is used to ensure adequate “annulus spacing” around the drilling pipe exits to allow good return flows during the pilot drilling;
- SPLP will implement short-tripping of the reaming tools as return flow monitoring indicates to ensure an open annulus is maintained to manage the potential inducement of IRs;
- SPLP will require monitoring of the drilling fluid viscosity, such that fissures and fractures in the subsurface are sealed during the drilling process;
- During all drilling phases, the use of Loss Control Materials (LCMs) will be proactively implemented to control Loss of Circulation of drilling fluids, or if indications of a potential IR are noted, or an IR is observed; and
- If LCMs prove ineffective to mitigate loss of returns or IRs, then proactive grouting of the pilot hole and re-drilling will be implemented to control Losses of Circulation or IRs.

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FEASIBILITY DETERMINATION

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

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


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Geotechnical Evaluation Leader
Mariner East II Pipeline Project

2/4/2019
Date


Pertaining to the practice of geology as set forth in the attached Hydrogeologic Reevaluation Report


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2/4/2019
Date



Pertaining to Pipe Stress and HDD Geometry


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2/11/19
Date



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**ATTACHMENT 1
GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT**

February 4, 2019

Mr. Matthew Gordon
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Engineers

Environmental
Consultants

Surveyors

Landscape
Architects

Safety
Consultants

RE: Sunoco Pipeline, L.P. Pipeline Project - Mariner East II
Old Mill Road HDD (S2-0156), PA-JU-0004.0000-WX-16
Hydrogeologic Re-Evaluation Report for 16-Inch Pipeline
Lack Township, Juniata County, PA
RETTEW Project No. 096302011

EXECUTIVE SUMMARY

1. This hydrogeologic re-evaluation was prepared as a result of an inadvertent return (IR) that occurred when the Old Mill Road horizontal directional drill (HDD) location S2-0156 30-inch ream was being advanced for the 20-inch pipeline. It was later determined, during the subsequent root cause analysis, that the IR resulted from the migration of drilling fluids and cuttings into a partially backfilled, abandoned entry pit.
2. The site is underlain by carbonate and sedimentary rocks of the Devonian age Hamilton Group (Dh), Onondaga and Old Port Formations, undivided (Doo), and Keyser and Tonoloway Formations, undivided (DSkt).
3. Water-bearing zones in the underlying geology generally occur in secondary openings along bedding planes, joints, faults, fractures, and solution openings. The permeability of these features is enhanced by dissolution of the carbonate bedrock formations.
4. Water-bearing zones in the Hamilton Group occur most frequently from 50 to 350 feet below ground surface (bgs) and occur evenly distributed to 300 feet bgs in the Onondaga Formation. Water-bearing zones in the Keyser and Tonoloway Formations are reported to be abundant to a depth of 300 feet bgs.
5. The HDD profile for the proposed 16-inch drill has been redesigned to increase its depth beneath the stream and wetlands.
6. Based on hydro-structural characteristics of the underlying geology, information obtained from installation of the 20-inch pipe, and the IR that occurred during the installation of the 20-inch pipe, the Old Mill HDD is susceptible to an IR of drilling fluids during HDD operations for the planned 16-drill. The redesigned 16-inch HDD profile and proactive HDD best management practices during drilling operations will be used to reduce the risk of an IR.



1.0 INTRODUCTION

The purpose of this report is to describe the geologic and hydrogeologic setting of the Old Mill Road S2-0156 HDD location on the Sunoco Pipeline, L.P. (SPLP) Pennsylvania Pipeline Project - Mariner II East (PPP-ME2) Project. The Old Mill Road HDD is located in Lack Township, Juniata County, Pennsylvania as shown on **Figure 1**. The HDD was designed to be drilled under Old Mill Road/Berry Ridge Road, Tuscarora Creek (Stream K-74) and associated emergent and forested wetlands (WK-59, WK-60). The redesigned 16-inch HDD profile will underlie these same features. This re-evaluation report was prepared as a result of an inadvertent return (IR) that occurred as the Old Mill Road horizontal directional drill (HDD) 30-inch ream was being advanced for the 20-inch pipeline.

The original 16-inch HDD profile was redesigned on January 25, 2019. The inclination of the entry and exit angles has been increased in order to install the 16-inch pipe through protective soils, residual soils, and bedrock in closer proximity to the entry and exit points than the original, shorter and shallower profile. The redesigned western HDD entry/exit is at a surface elevation of approximately 736 feet above mean sea level (AMSL) and the redesigned eastern entry/exit is at an elevation of approximately 692 feet AMSL. The HDD profile was extended 500 feet to the east and west resulting in a new horizontal length of 1,360 feet. The inclination of the eastern and western entry/exit angles has been increased to approximately 16° to install the pipe through the soils and bedrock in closer proximity to the entry and exit points, and to deepen the profile to approximately 79 feet below Tuscarora Creek (this is approximately 25 feet deeper than the 20-inch pipe). The as-built 20-inch and proposed 16-inch, S2-0156 HDD locations are shown on **Figure 1**, and the redesigned 16-inch profile is included as **Attachment 1**.

2.0 GEOLOGY AND SOILS

Based upon publications by the Pennsylvania Bureau of Topographic and Geologic Survey (PABTGS), the site is in the Appalachian Mountain Section of the Ridge and Valley Physiographic Province of Pennsylvania, and is underlain by sedimentary rocks consisting of sandstone, siltstone, shale, conglomerate, limestone, and dolomite. Local topography is characterized by a northeast to southwest trending succession of long narrow ridges and broad to narrow valleys, with some karst terrain. Natural slopes are steep and geologic structure includes open and closed plunging folds with narrow hinges and planar limbs, and a variety of faults. These rocks generally have good surface drainage (Sevon, 2000). Based on the United States Geologic Survey (USGS) 7.5-Minute Blairs Mills Topographic Quadrangle Map shown on **Figure 1**, the site is situated at an approximate elevation range of 740 to 700 feet AMSL. Surface topography at the site slopes to the east along the HDD towards Tuscarora Creek. The major surface water feature proximate to the Old Mill HDD is Tuscarora Creek which flows to the northeast before discharging to the Juniata River.

The site geology for the redesigned 16-inch HDD profile is mapped west to east as the Devonian age Hamilton Group (Dh), Onondaga and Old Port Formations, undivided (Doo), and Keyser and Tonoloway Formations, undivided (DSkt) as shown on **Figure 2** (Berg and Dodge, 1981). The Hamilton Group (Dh) includes the Mahantango Formation (Dmh) and the Marcellus Formation (Dmr). The Mahantango Formation consists of gray, brown and olive interbedded shales, siltstones, and very fine-grained sandstones and claystones containing marine fossils. Oolitic hematite occurs near the top of the Mahantango Formation, while the middle section contains medium to coarse grained sandstone and thin conglomerate layers. The Marcellus Formation consists of very dark to black, fissile, homogeneous carbonaceous shales. The group is well bedded with the shale units having thin to flaggy beds and the sandstone units having thin, flaggy to medium beds. Joints are well developed, closely spaced, mostly

open, and steeply dipping. The joints produce smooth, even faced, sharp edged rectangular blocks in the sandstone units. Permeability is described as moderate with joint and bedding plane openings providing a secondary porosity of low to moderate magnitude. The Hamilton Group is poorly to moderately resistant to weathering, with the shale units being less resistant to weathering. The overlying mantle is thin. Slope stability is good in the sandstone units but only fair in the shale. The ease of excavation is classified as moderately easy in the shale to difficult in the siltstone and sandstone. The drilling rates are reported to range from moderate to fast. Foundation stability is good when material is excavated to sound bedrock. Surface drainage is considered to be good. (Geyer and Wilshusen, 1982).

The undivided Onondaga and Old Port Formations (Doo) are described as interbedded dark-gray limestone, shaly limestone, and calcareous and noncalcareous shale (Onondaga); and an upper unit of calcareous quartz sandstone and a lower unit of chert, cherty limestone and calcareous shale (Old Port). Bedding features in these formations are described as well bedded and flaggy to thick in nature. Most joints are blocky to seamy; moderately abundant, open and vertical. Joints and bedding plane fractures are moderately to closely spaced and provide secondary porosity of moderate magnitude with low to moderate permeability. These rocks are moderately weathered with the deepest weathering occurring in the shales. Weathering results in small- to medium sized blocks. The overlying mantle is thin and surface drainage is good. From an engineering standpoint, excavation (and drilling) is classified as difficult with slope stability being generally good in the limestone member and fair in the shale member. Foundation stability is good, provided the excavation is completed to sound material and identified solution cavities are investigated and mitigated (Geyer and Wilshusen, 1982).

The undivided Keyser and Tonoloway Formations consist of dark-gray highly fossiliferous, crystalline to nodular limestone, with shaly limestone near the top (Keyser), and medium-gray laminated limestone containing interbedded zones of medium to dark gray to light olive-gray shale and siltstone (Tonoloway). Bedding features within these formations are described as well bedded with flaggy to thick beds, but some beds are massive. Moderate to highly abundant joints exhibiting a platy pattern, are present in this formation. The joints are regularly spaced, with moderate to close distance between fractures which are open and steeply dipping. Secondary porosity occurs in solution channels and joint-and bedding-plane openings and is described as having moderate magnitude. Permeability is described as low to moderate. This unit is moderately resistant to weathering. Weathering occurs to a shallow to moderate depth resulting in small- to medium-sized irregular blocks. The overlying mantle is thin in most places, and bedrock pinnacles may exist. Excavation is classified as difficult, with bedrock pinnacles presenting a special problem. Drilling rates are typically fast. Foundation stability is good, but a thorough investigation for solution openings should be completed with material excavated until sound material is encountered (Geyer and Wilshusen, 1982).

According to the United States Department of Agriculture (USDA) Soil Survey of Juniata County, Pennsylvania, soils in the vicinity of the Old Mill Road HDD consist of six separate soil units. A USDA soils map that depicts the mapped area, along with the soil profile descriptions, is included as **Attachment 2**.

3.0 HYDROGEOLOGY

Groundwater at the site occurs in a fractured, solution-prone carbonate and clastic sedimentary bedrock aquifer system within the geologic units described above. Water-bearing zones generally occur in secondary openings developed along bedding planes, joints, faults and fractures. In the carbonate sequences, the water-bearing zones may form in solution-enhanced secondary openings. Most of the

water-bearing zones penetrated by wells occur in individual fractures or groups of interconnected fractures that can be sufficiently enlarged by dissolution of the bedrock (Taylor et al., 1982). A summary of the review of published data on water wells completed in the Hamilton Group, Onondaga and Old Port Formations, undivided and Keyser and Tonoloway Formations, undivided is below.

The depths of 243 domestic and non-domestic water supply wells in the Hamilton Group range from 10 to 695 feet bgs, with yields ranging from 1 to 380 gallons per minute (gpm). The median well depth for domestic wells is 173 feet bgs and 300 feet bgs for non-domestic wells. The median well yield for domestic wells is 12 gpm and 38 gpm for non-domestic wells. Water-bearing zones among 198 wells reviewed are most frequent from 50 to 350 feet bgs and are relatively common to a depth of 350 feet, with the deepest water-bearing zone being reported at 635 feet bgs (Taylor et al., 1982).

Reported depths of 228 domestic and non-domestic wells in the Onondaga Formation ranged from 35 to 500 feet bgs. The median well depth for 144 domestic and 24 non-domestic wells was 141 and 215 feet, respectively. Well yields ranged from 0 to 1,400 gallons gpm and the median well yield was 10 gpm for domestic wells and 66 gpm for non-domestic wells. Water-bearing zones among 88 wells reviewed showed an even distribution to a depth of 300 feet. Approximately 25% of the wells drilled deeper than 300 feet penetrated water bearing zones, with the deepest water-bearing zone being reported at 460 feet bgs (Taylor et al., 1982).

The depths of 184 domestic and non-domestic wells completed in the Keyser and Tonoloway Formations ranged from 27 to 504 feet bgs. The median well depth for domestic wells was 180 feet bgs and the median well depth for non-domestic wells was 225 feet bgs. Well yields ranged from 0 to 315 gpm with the median well yield of 10 gpm for domestic wells and 33 gpm for non-domestic wells. Water-bearing zones are reported to be abundant to a depth of 300 feet bgs. Four of the nine wells (44%) drilled deeper than 300 feet had water-bearing zones occurring below that 300 feet bgs, with the deepest occurring at 470 feet bgs (Taylor et al, 1982).

A water well records search of the Pennsylvania Groundwater Information System (PaGWIS, February 3, 2019) was completed within a 0.5-mile radius of the Old Mill Road HDD. No water wells records were identified within the 0.5-mile search radius.

In January 2019, other Sunoco subcontractors researched private water supplies located within a 450-foot radius of the Old Mill Road HDD. No additional water wells were identified within the 450-foot radius; however, one well was identified approximately 1,240 feet northeast of the western entry/exit point of the HDD as shown on **Attachment 3**. No information pertaining to the well depth, depth to water or well yield was reported.

4.0 FRACTURE TRACE ANALYSIS

Fracture traces underlying, or in close proximity to, the Old Mill Road HDD were evaluated using historical aerial photographs from the years 1993 through 2016 (Google Earth, 2017), the Blairs Mills, PA USGS 7.5 Minute Quadrangle Topographic Map and the Geologic Map of the Blairs Mills Quadrangle (Berg and Dodge, 1981). The aerial photographs and maps were used to approximate locations of natural linear features or lineaments expressed on the ground surface. The linear features may be the surficial representation of deeper fractures, joints, faults or bedding planes within the subsurface which can transmit groundwater through the fractured bedrock aquifer underlying the Old Mill HDD.

Figures 2 and 3 show the results of the fracture trace analysis overlain on the geologic map and aerial base map, respectively. Six fracture traces were identified in close proximity to the proposed Old Mill HDD that are likely related to the primary geologic structure of the area. Due to the nature of the ridges and folded geology near the site, the most prominent fracture trace trends approximately northeast-southwest (NE-SW) and perpendicular to the HDD alignment. Additional fracture traces were identified in an approximately northwest-southeast (NW-SE) orientation crossing the prominent fracture trace and generally parallel to the HDD alignment. Fracture lineaments are presumed to be stress-related joint sets. General surface drainage patterns near the site are characterized by linear stream reaches trending NE-SW that reflect the local geologic structure.

5.0 GEOTECHNICAL EVALUATION

Two geotechnical drilling investigations were performed at the site. The initial investigation was performed in October 2014 during the preliminary investigation of the Old Mill HDD and prior to initiating the 20-inch HDD operations. A second phase of geotechnical drilling was performed in September of 2017. The 2014 test borings were advanced by hollow-stem auger drilling to a maximum depth of 21.3 feet bgs or until auger refusal. NQ-sized wireline rock coring methods were utilized in borings that were continued past auger refusal. Soil, residual soil and weathered bedrock were sampled using split-spoon samplers. These borings are designated as SB-01 and SB-02. The second phase test borings completed in 2017 were advanced using hollow-stem auger drilling and NQ-sized wireline rock coring methods. The 2017 borings were designated as B-01 and B-02. Soil, residual soil and weathered bedrock collected during both investigations were sampled using split-spoon samplers. Geotechnical boring logs are included in **Attachment 1**.

Boring SB-01 was located approximately 425 feet southeast of the HDD western entry/exit point. Boring SB-02 was located approximately 200 feet southwest of the HDD eastern entry/exit point. Boring B-01 was located approximately 375 feet to the north of the HDD western entry/exit point, and Boring B-02 was located approximately 225 feet to the south of the HDD eastern entry/exit point. The locations of these borings are depicted on **Figures 2 and 3**.

The generalized subsurface profile at the site, as observed in the borings, is described as follows:

- Variable and residual soil depths vary boring from boring; 21.3 feet at SB-01, 17.2 feet at SB-02, 15.4 feet at B-01, and 20.6 feet at B-02. The residual soils are described as follows:
 - **Boring SB-01:** Topsoil, decomposed bedrock consisting of SILT and fine SAND (ML/SM), fine to coarse SAND (SM) with some silt, partially weathered SHALE mixed with fine sand and little silt. Auger refusal occurred at 21.0 feet bgs. Groundwater was encountered at 8 feet bgs.
 - **Boring SB-02:** Topsoil, decomposed bedrock consisting of fine to medium SAND with some fine to coarse gravel (SC) with some silty clay, silty CLAY (CL) with a little fine gravel (shale), partially weathered SHALE. Auger refusal occurred at 17.0 feet bgs. Groundwater was encountered at 12.5 feet bgs.
 - **Boring B-01:** Topsoil, very stiff, damp mottled SILT (ML) with sand, clay and shale fragments, medium dense, moist, SANDSTONE and SHALE fragments (GC) with sand and clay, very stiff, moist lean CLAY (CL) with sand, very dense, moist weathered carbonaceous SHALE (GP). Auger refusal occurred at approximately 15.4 feet bgs and groundwater was encountered at 1.55 feet bgs.

- **Boring B-02:** Very dense, dry SHALE fragments (GP-GM) with silt and sand, very dense, moist to wet, SAND (SP) with river gravel, sandstone fragments and silt, medium dense, moist to wet, poorly graded SAND (SP-SC) with river gravel, silt, and clay cobbles, stiff, wet SILT (ML) with sand cobbles, very dense, dry weathered LIMESTONE (GP) with gravel and cobbles. Auger refusal occurred at approximately 20.6 feet bgs and groundwater was encountered at 5.18 feet bgs.
- From the initiation of coring operations to the total depth of the NQ cores, weathered bedrock and bedrock were encountered and are described as follows:
 - **Boring S2-0156 SB-01:** Rock coring was not completed at this location.
 - **Boring S2-0156 SB-02:** Rock coring was not completed at this location.
 - **Boring B-01:** B-01 was completed to a total depth of 120 feet bgs. From 15.4 to 120 feet bgs dark gray, very fine grained, very thin to medium bedded, slightly weathered, medium to moderately hard carbonaceous SHALE with shallow to very steep laminated bedding joints with calcite veining and interbedded siltstone was observed. Quartz vein filling was observed between 90 and 95 feet bgs. The interval between 90 and 95 feet bgs showed evidence of transitioning into fine grained SANDSTONE with carbonaceous shale and siltstone interbeds; however, this was an isolated zone and the carbonaceous SHALE was the dominate rock type at the sampling interval starting at 95 feet bgs. Rock recoveries ranged from 63 to 100%, while rock quality designations (RQDs) ranged from very poor (0%) to excellent (100%). RQDs ranged from very poor to fair (18% to 68%) for the bottom 30 feet (90-120 feet bgs) of the boring. Groundwater was observed at 0.55 feet bgs at the completion of coring operations (1.55 feet bgs before coring).
 - **Boring B-02:** B-02 was completed to a total depth of 120 feet bgs. From 20.6 to 120 feet bgs gray to light blue gray, very fine grained, very thin to thick bedded, weathered to slightly weathered, moderately hard to hard LIMESTONE with shallow to very steeply dipping bedding joints with calcite veins were observed. A moderately to completely weathered zone was encountered from 20.6 to 23 feet bgs. Weathered zones were observed between 35 to 40, 50 to 55, 75 to 80, 105 to 110, and 115 to 120 feet bgs, and solution activity was observed between 40 to 50, 60 to 70, 75 to 80 and 115 to 120 feet bgs. Discrete zones of solution activity were observed between 90.8 to 91.5 and 98.5 to 98.9 feet bgs. A 1-foot tool drop, indicative of a soft weathered or solutioned zone, occurred between 55 and 60 feet bgs, while a 2-foot tool drop occurred between 60 and 65 feet bgs. Rock recoveries ranged from 36 to 100%, while rock quality designations (RQDs) ranged from very poor (0%) to excellent (100%). Groundwater was observed at 2.25 feet bgs at the completion of coring operations (5.18 feet before coring).

Unconfined compressive strength testing was performed on the core samples, and these testing results are summarized in the table below.

Boring	Sample Depth (feet bgs)	Compressive Strength (tons per square foot)
B-01	19.5	119.05
B-01	34.1	105.53
B-01	44	98.97
B-01	53.8	146.22
B-01	63.9	124.49
B-01	83	87.64
B-01	95	655.24
B-01	105	540.70
B-01	116.5	366.37
B-02	20.9	303.77
B-02	24	104.11
B-02	35.5	165.82
B-02	45.3	360.47
B-02	55	341.87
B-02	65.5	351.92
B-02	75	343.70
B-02	85	472.82
B-02	95.5	386.06
B-02	105	409.92
B-02	114	241.13

Please note that RETTEW Associates, Inc. and Skelly and Loy did not oversee or direct the geotechnical drilling program associated with HDD S2-0156 including, but not limited to, the selection of boring locations and target depths, observations of rock cores during drilling operations, or preparation of boring logs. The geotechnical reports, boring logs, and core photographs that resulted from these programs were generated by other Sunoco Pipeline, L.P. contractors. RETTEW and Skelly and Loy relied on these reports and incorporated the data into the general geologic and hydrogeologic framework included in this report.

6.0 GEOPHYSICAL SURVEY

The use of geophysical surveys during the hydrogeologic re-evaluation was considered for study purposes but was ultimately not implemented at this HDD location. The data generated from these surveys will not reduce the risk of a shallow IR near the entry or exit of the HDD as observed during 20-inch operations.

7.0 FIELD OBSERVATIONS DURING 20-INCH HDD ACTIVITIES

RETTEW staff were on-site during 20-inch HDD operations which began on October 20, 2017. On October 25, 2017, the 20-inch HDD profile was redesigned to increase the amount protective cover beneath sensitive receptors, to allow more rapid advancement of the boring through the shallow unconsolidated materials proximate to the HDD entry/exit points. Advancement of the revised 20-inch HDD was started on November 3, 2017. The pilot hole was completed on November 16, 2017 and the first in a series of ream passes (14-, 24- and 30-inch) was started on November 17, 2017. The reaming passes continued until January 3, 2018 when all work on the PPP-ME2 Project was shut down by the Pennsylvania Department of Environmental Protection (PA DEP). Following PA DEP re-start approval, drilling operations resumed on March 3, 2018. On March 6, 2018, an IR occurred while the 30-inch reamer was approximately 180 feet from the western HDD entry/exit point, as shown on **Attachment 1**. The occurrence of IRs in the vicinity of an HDD entry or exit point is not uncommon. A root cause analysis determined that the March 6, 2018 IR occurred due to the migration of drilling fluid and cuttings into the partially backfilled entry pit of the original HDD boring. Drilling operations were suspended until re-start approval was received from the PA DEP. On March 27, 2018, HDD operations were restarted for the the 30-inch ream. These HDD activities were completed on April 3, 2018 and the 20-inch product pipe was successfully pulled through on April 7, 2018.

No other IRs occurred during the completion of 20-inch HDD activities. The abandoned entry pit in which the IR occurred was backfilled and compacted upon completion of the 20-inch pipeline installation; therefore, the corrective action to prevent a reoccurrence of an IR at this location has been completed. No HDD operations have started for the 16-inch.

8.0 CONCEPTUAL HYDROGEOLOGIC MODEL AND CONCLUSION

Based on published geologic and hydrogeologic information, and results geotechnical investigations and field observations during the completion of the 20-inch HDD, the Old Mill Road HDD is underlain by carbonate and clastic sedimentary rocks of the Hamilton Group, Onondaga and Old Port Formations (undivided), and the Keyser and Tonoloway Formations (undivided). The hydrogeologic setting is dominated by groundwater flow that occurs in secondary openings formed along geologic features that include bedrock bedding planes, joints, and fractures. The secondary openings may be enlarged or enhanced to some degree by dissolution of the underlying carbonate bedrock. Water-bearing zones in the Hamilton Group occur most frequently from 50 to 350 feet bgs and occur evenly distributed to 300 feet bgs in the Onondaga Formation. Water-bearing zones in the Keyser and Tonoloway Formations are reported to be abundant to a depth of 300 feet bgs.

The originally designed 16-inch HDD profile was relatively shallow at the eastern and western entry/exit points in comparison to the land surface and surface streambed (Tuscarora Creek, StreamK-74). The original profile also passed through soil overburden and fractured bedrock. Based on the hydro-structural characteristics of the underlying geology described in this report and geologic information obtained and utilized during installation of the 20-inch HDD, the Old Mill HDD is susceptible to an IR of drilling fluids during HDD operations. As a result, the 16-inch HDD profile was redesigned to depth greater than the as-built 20-inch HDD boring to allow for a deeper crossing beneath the stream and wetlands. The revised profile is approximately 79 feet below Tuscarora Creek (this is approximately 25 feet deeper than the 20-inch pipe). The inclination of the entry and exit angles has been increased to allow the pipe to be installed through protective soils, residual soils, and bedrock, and in closer proximity to the entry and exit points than the original, shorter and shallower profile. From a geologic perspective, the longer and deeper

profile, in conjunction with the proposed engineering controls and/or drilling best management practices, will be used to reduce the risk of an IR and/or a loss of drilling fluid. Drilling best management practices are described in the Horizontal Directional Drill Analysis component of the overall re-evaluation package.

9.0 REFERENCES

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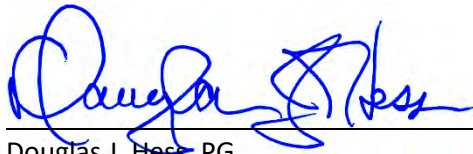
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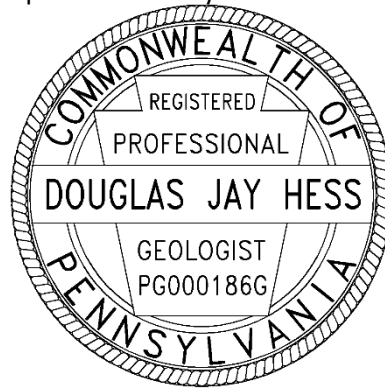
10.0 CERTIFICATION

The studies and evaluations presented in this report (other than Section 5) were completed under the direction of a licensed professional geologist (PG) and are covered under the PG seals that follow.

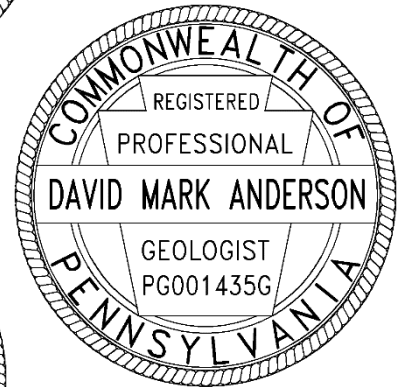
By affixing my seal to this document, I am certifying that, to my knowledge and belief, the information herein is true and correct. I further certify, that I am licensed to practice in the Commonwealth of Pennsylvania and that it is within my professional expertise to verify the correctness of the information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



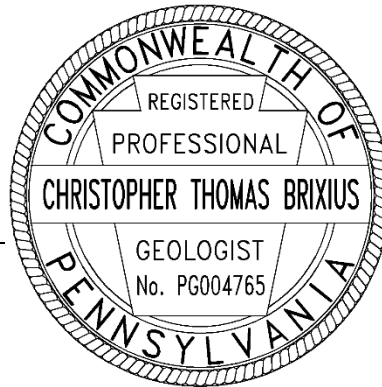
Douglas J. Hess, PG
License No. PG000186G



David M. Anderson, PG
License No. PG001435G



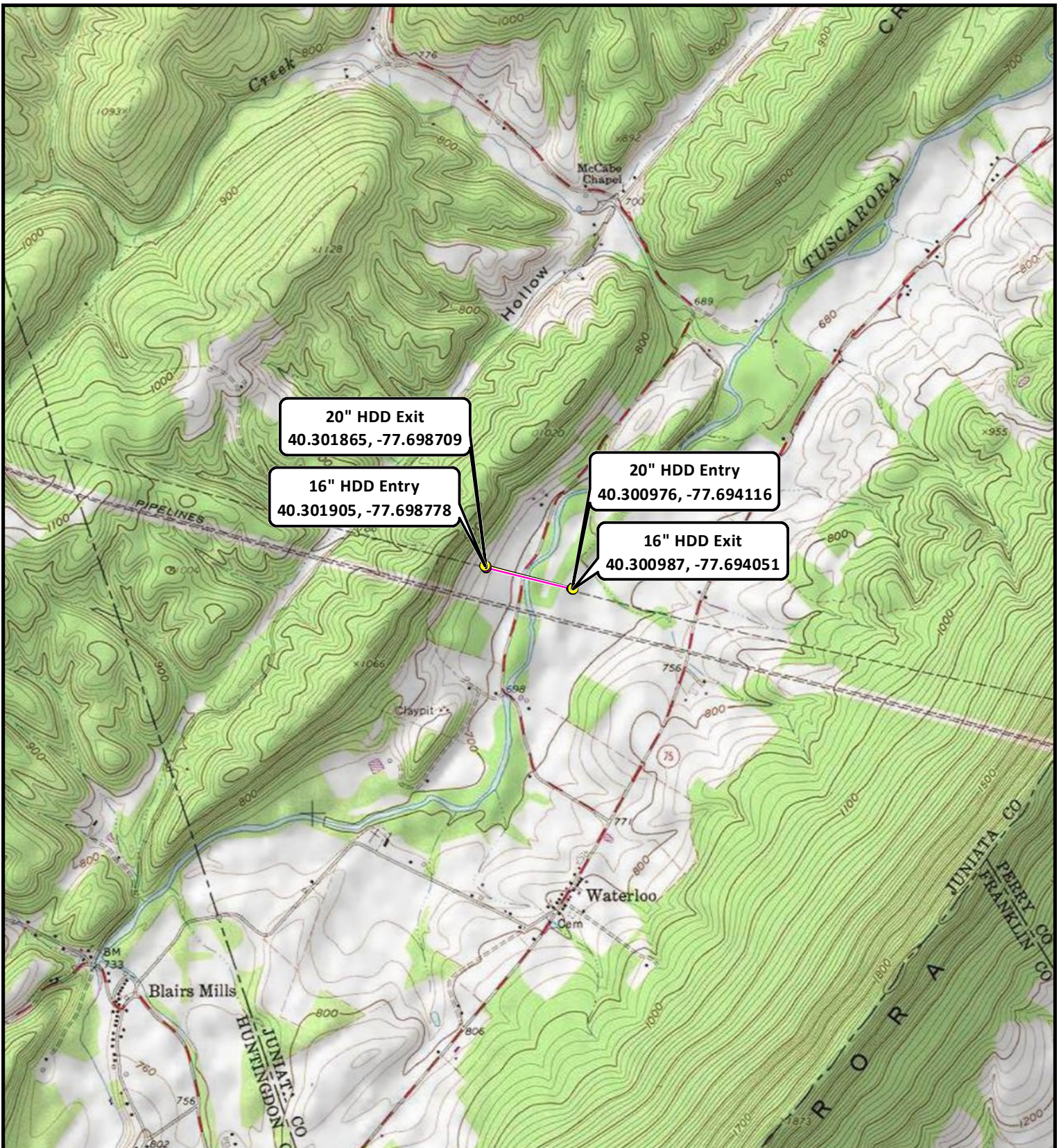
Christopher T. Brixius, PG
License No. PG004765



Enclosures

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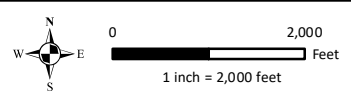
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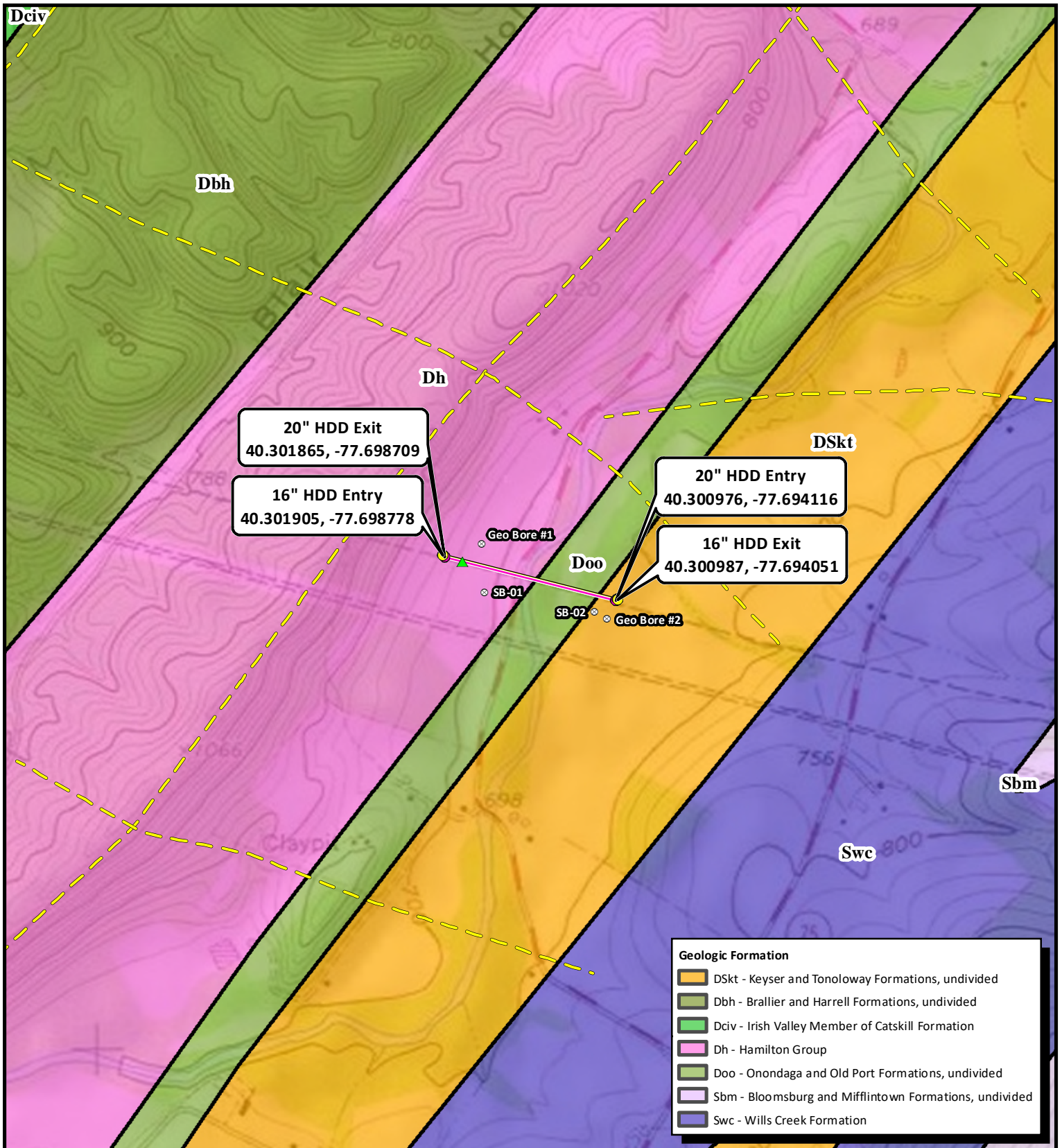


- 16" HDD Entry/Exit
- 20" HDD Entry/Exit
- 16" HDD Profile
- 20" HDD Profile

Sunoco Pipeline, L.P.
Old Mill Road / S.R. 3025 HDD Location

Figure 1 - Topographic Basemap
 Lack Township, Juniata County, PA
 Project No. 096302011







▲ Inadvertent Return	— 16" HDD Profile
⊙ Soil Boring	— 20" HDD Profile
● 16" HDD Entry/Exit	- - - Inferred Fracture Trace
● 20" HDD Entry/Exit	

Blairs Mills, PA USGS 7.5' Topographic Quadrangle 2/4/2019

Sunoco Pipeline, L.P.
Old Mill Road / S.R. 3025 HDD Location
Figure 2 - Geologic Map
 Lack Township, Juniata County, PA
 Project No. 096302011

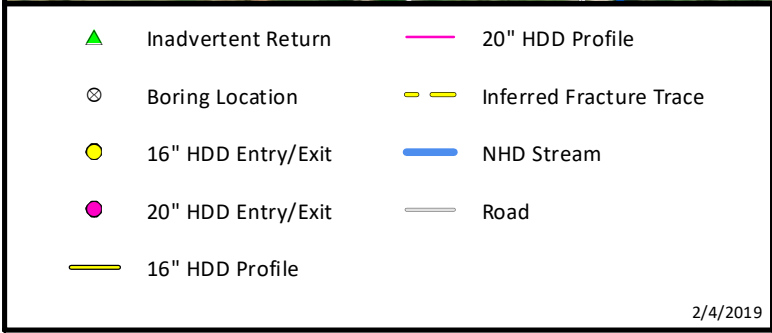
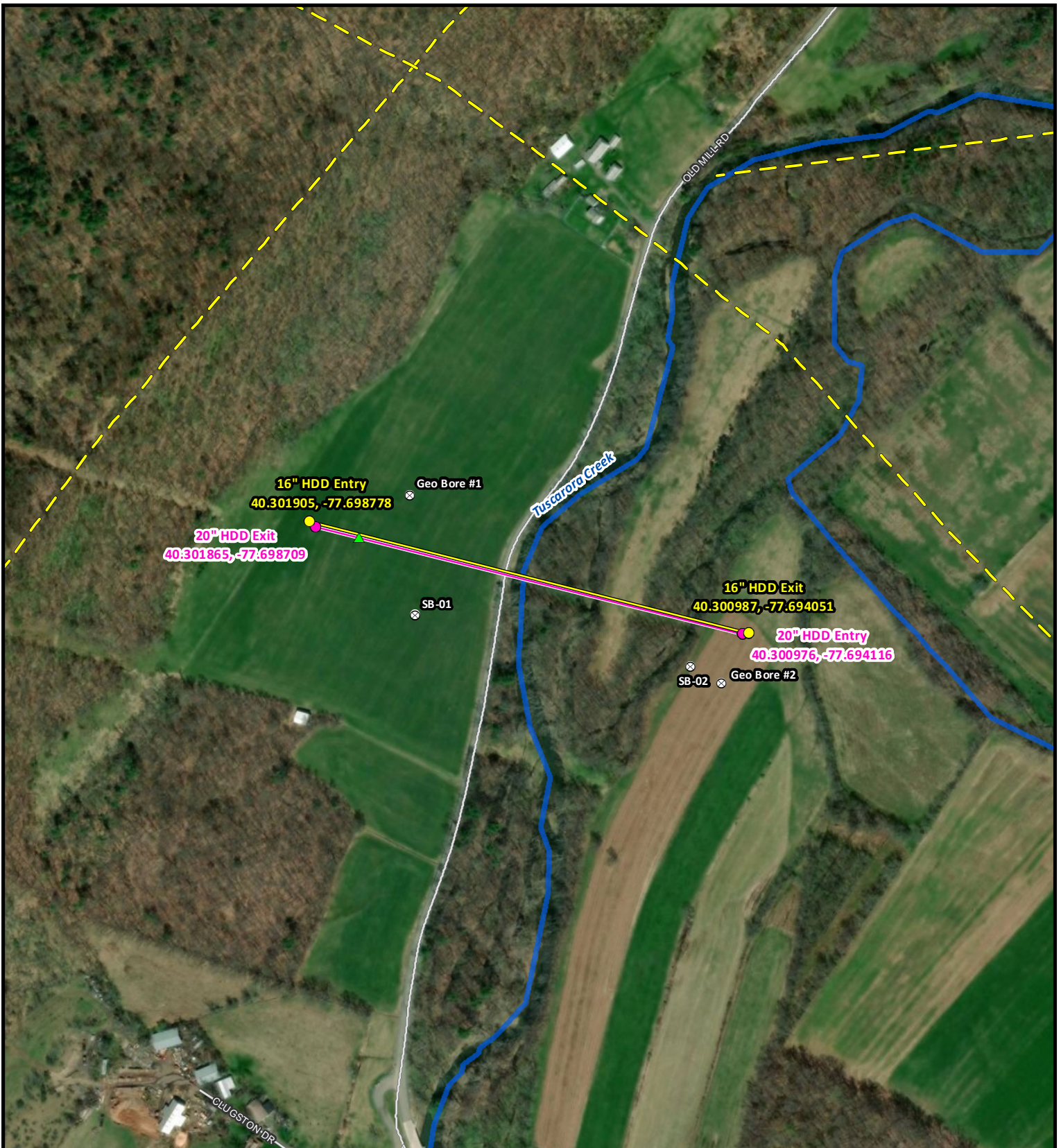


0 1,000
1 inch = 1,000 feet

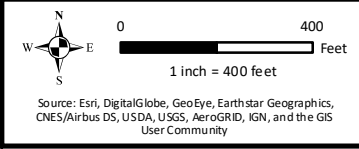


Sunoco Logistics
Partners L.P.

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



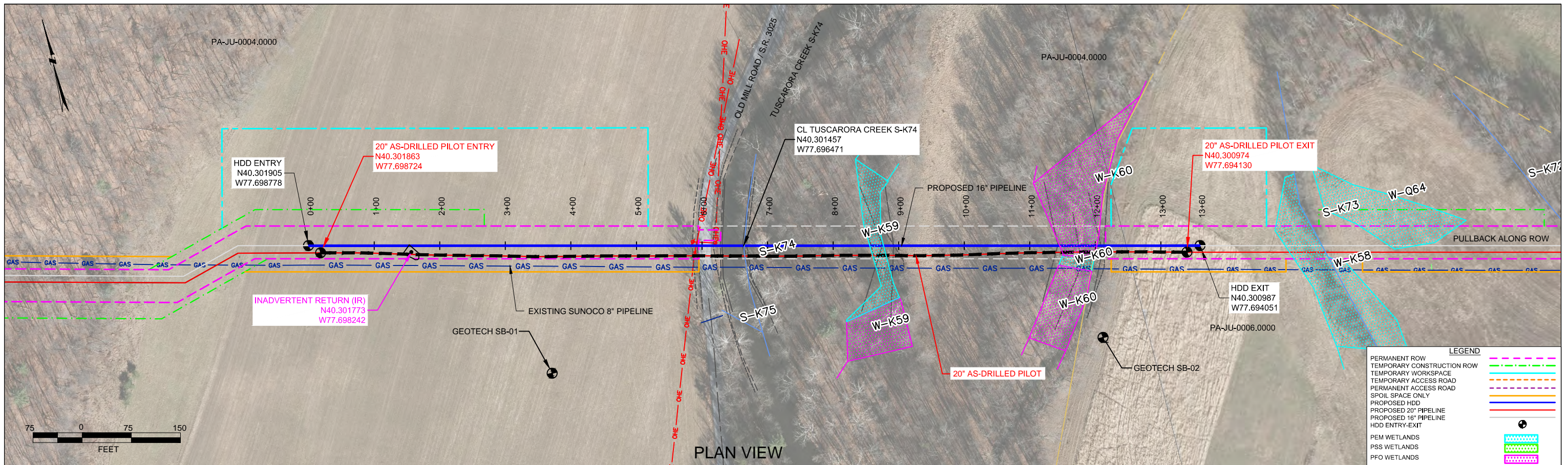
Sunoco Pipeline, L.P.
Old Mill Road / S.R. 3025 HDD Location
Figure 3 - Aerial Basemap
 Lack Township, Juniata County, PA
 Project No. 096302011



2/4/2019

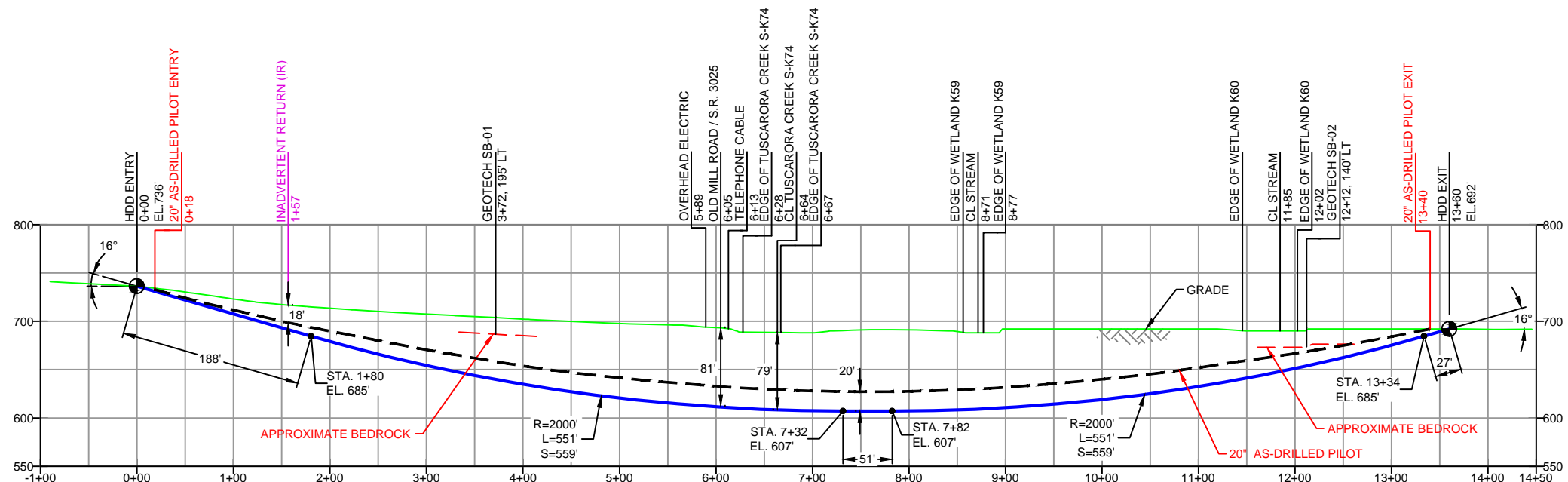
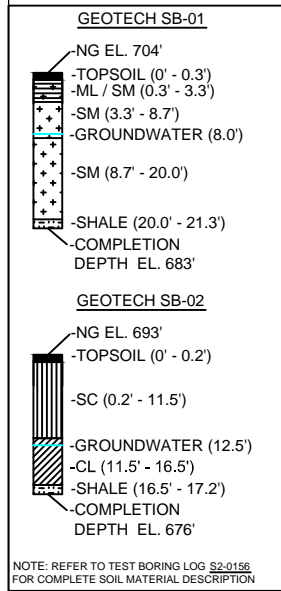


ATTACHMENT 1
HDD PROFILES AND GEOTECHNICAL BORING LOGS



JUNIATA COUNTY PENNSYLVANIA, LACK TOWNSHIP
S2-0156-16

PROFILE VIEW



DESIGN AND CONSTRUCTION:

- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
- THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
- DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
- CROSSING PIPE SPECIFICATION:
HDD HORZ. LENGTH (L=): 1360'
HDD PIPE LENGTH (S=): 1383'
16" x 0.438" W.T., X-70, API5L PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
- INTERNAL DESIGN PRESSURE 2100 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
- INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
- PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
- CARRIER PIPE NOT ENCASED.
- PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
- CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 2625 PSIG.
- SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
- SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
- SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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

REF. DRAWING		REVISIONS	
ES-3.05	TO	ES-3.05	DESCRIPTION
SHEET 3	TO	SHEET 3	AERIAL SITE PLAN
		EP5	UPDATED NOTE 5 AND 10 PER INCREASED 16" MOP
		EP4	MODIFIED ENTRY SIDE ATWS TO MATCH LAND ACQUISITION
		EP3	RELOCATED ENTRY/EXIT AND INCREASED DEPTH OF DRILL PER CLIENT REQUEST
		EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16
		EP1	REVISED PER PADEP COMMENTS
		EP	
DWG NO	DWG NO	NO.	DESCRIPTION

**Sunoco Logistics
Partners L.P.**

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
OLD MILL ROAD / S.R. 3025
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'
DWG. NO: PA-JU-0004.0000-WX-16



LEGEND:

⊙ Geotechnical Soil Boring (SB) Locations



TETRA TECH

GEOTECHNICAL BORING LOCATIONS
 HDD S2-0156
 JUNIATA COUNTY, LACK TOWNSHIP, PA
 SUNOCO PENNSYLVANIA PIPELINE PROJECT



TETRA TECH

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

TEST BORING LOG

Project Name: SUNOCO PENNSYLVANIA PIPELINE PROJECT			Project No.: 103IP3406		
Project Location: CROSS KEYS ROAD, EAST WATERFORD, PA			Page 1 of 1		
HDD No.:	S2-0156	Dates(s) Drilled:	10-14-14	Inspector:	E. WATT
Boring No.:	SB-01	Drilling Method:	SPT - ASTM D1586	Driller:	S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft):	8	Total Depth (ft):	21.3

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (ft)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
	From	To	From	To								
			0.0	0.3			TOPSOIL (3").					
1	3.0	5.0	0.3	3.3	14	ML/SM	MOTTLED (BROWN, ORANGE BROWN, GRAY) SILT AND FINE SAND.	2	10	10	22	20
			3.3			SM	DR WEATHERED TO MOTTLED (LIGHT GRAY, OR. BROWN, REDDISH BROWN) FINE SAND AND SILT. QUARTZ LENSE 8.6 TO 8.7'.					
				8.7								
2	8.0	9.1	8.7		10	SM	DR WEATHERED TO A DARK GRAY FINE SAND WITH SOME SILT AND SOME FINE SHALE GRAVEL.	9	50	50/1"		>50
3	13.0	13.9			10		DR WEATHERED TO A GRAY TO ORANGE BROWN FINE TO COARSE SAND, SOME SILT, WITH A LITTLE FINE SHALE GRAVEL.	2	50/5"			>50
4	18.0	18.9			9		DR WEATHERED TO A DARK GRAY FINE SAND WITH A LITTLE SILT, AND SOME FINE TO COARSE SHALE GRAVEL.	5	50/3"			>50
				20.0								
5	21.0	21.3	20.0		3		PARTIALLY WEATHERED DARK GRAY SHALE, MIXED WITH FINE SAND AND LITTLE SILT.	50/3"				>50
				21.3								
							AUGER REFUSAL AT 21'.					
							CAVED AT 21', WATER LEVEL ON CAVE AT 8'.					

Notes/Comments:
Pocket Pentrometer Testing DR: DECOMPOSED ROCK

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

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

**GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0156**

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.)		Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318)			USCS Classif. (ASTM D2487)
			From	To			Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	
S2-0156	SB-01	1	3.0	5.0	14.9	44.4	-	-	-	-
		2	8.0	9.1	6.7	23.2	-	-	-	-
		3	13.0	13.9	11.8	24.4	-	-	-	-
		4	18.0	18.9	13.3	20.5	-	-	-	-
		5	21.0	21.3	10.7	28.6	-	-	-	-
	SB-02	1	3.0	5.0	5.4	21.6	-	-	-	-
		2	8.0	10.0	10.2	30.5	-	-	-	-
		3	13.0	15.0	72.9	98.5	37	22	15	CL

Notes:

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

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0156

HDD No.	NAME	BORING NO.	REGIONAL GEOLOGY DESCRIPTION	GENERAL TOPOGRAPHIC SETTING	BEDROCK FORMATION	GENERAL ROCK TYPE	APPROX MAX FM THICKNESS (FT)	DEPTH TO ROCK (Ft bgs) based on nearby well drilling logs	NOTES / COMMENTS
S2-0156	Cross Keys	SB-01	Mahantango Fm - gray, dark gray, brown, and olive laminated shale; siltstone; and very fine-grained sandstone or claystone containing marine fossils	Valley	Mahatango (aka Hamilton Group)	Shale-siltstone, laminated, fossiliferous		14-38	
		SB-02	Keyser/Tonoloway Fm -dark-gray, highly fossiliferous, crystalline to nodular limestone with shaly limestone near its top. Wills Creek Fm -variegated gray, grayish-red, yellowish-gray and greenish-gray calcareous shale with interbedded limestone, dolomite, and sandstone zones		Keyser/Tonoloway Fm	See notes			Keyser and Tonoloway Formations, undivided - In descending order: Keyser Formation--medium-gray, crystalline to nodular, fossiliferous limestone; upper part laminated and mud-cracked; not present east of Harrisburg; Tonoloway Formation--medium-gray, laminated, mud-cracked limestone containing some medium-dark- or olive-gray shale interbeds; lower part passes into Wills Creek Formation east and south

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

FIELD DESCRIPTION AND LOGGING SYSTEM FOR SOIL EXPLORATION

GRANULAR SOILS

(Sand, Gravel & Combinations)

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

Particle Size Identification

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

Relative Proportions

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

COHESIVE SOILS

(Silt, Clay & Combinations)

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

Plasticity

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

ROCK

(Rock Cores)

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

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

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

UNIFIED SOIL CLASSIFICATION SYSTEM [Casagrande (1948)]

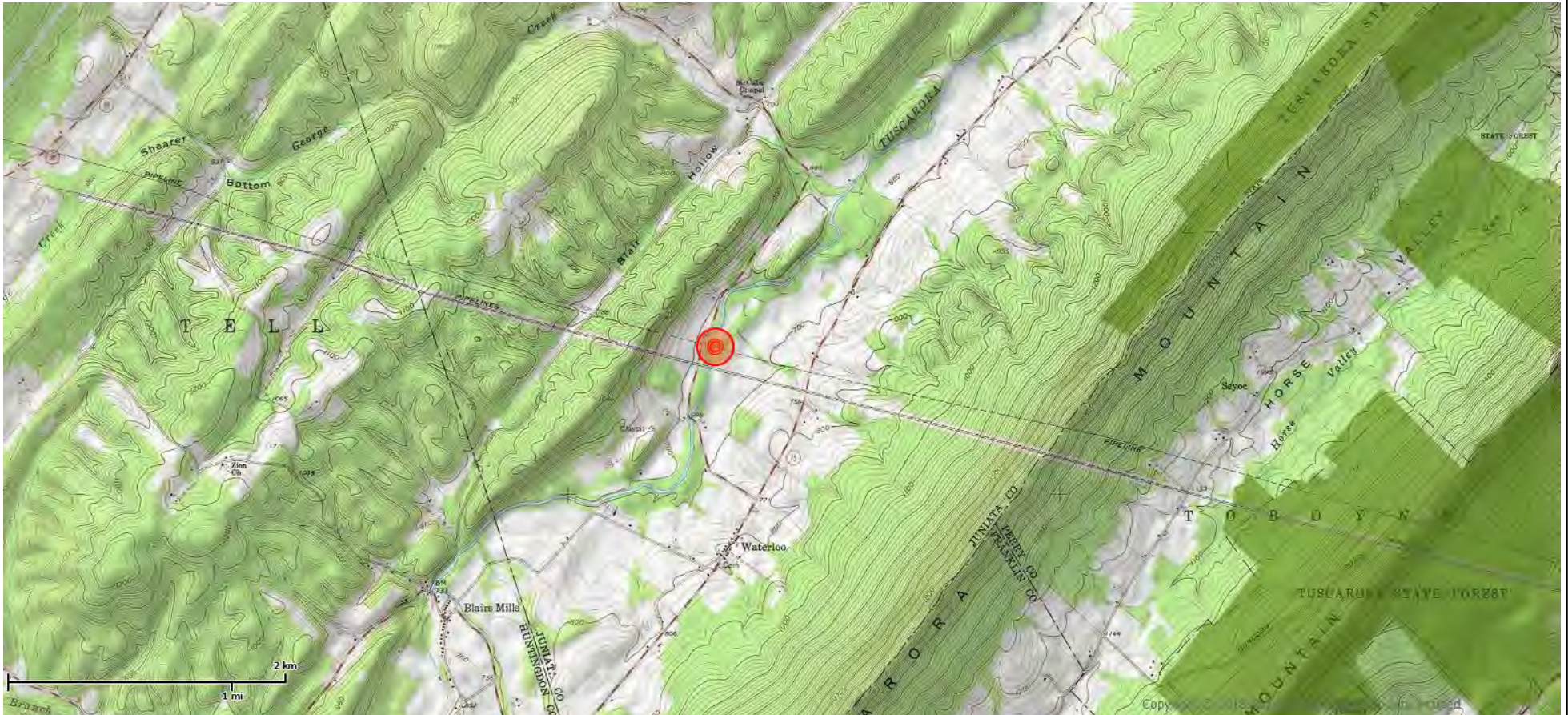
Major Divisions		Group Symbols	Typical Descriptions	Laboratory Classifications				
Coarse Grained Soils (More than half of material is larger than No. 200 sieve)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravel (Little or no fines)	GW Well-graded gravels, gravel-sand mixtures, little or no fines	Determine Percentage of sand and gravel from grain size curve. Depending on Percentage of fines (fraction smaller than No. 200 sieve), coarse-grained soils are classified as follows: Less than 5 percent GW, GP, SW, SP More than 12 percent GM, GC, SM, SC 5 to 12 percent Borderline cases requiring dual symbols ⁽¹⁾	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4: $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3			
		GP Poorly graded gravels, gravel-sand mixtures, little or no fines	Not meeting C_u or C_c requirements for GW					
		Gravel with fines (Appreciable amount of fines)	GM Silty gravels, gravel-sand-silt mixtures		Atterberg limits below A Line or I_p less than 4	Limits plotting in hatched zone with I_p between 4 and 7 are borderline cases requiring use of dual symbols		
			GC Clayey gravels, gravel-sand-clay mixtures		Atterberg limits above A line with I_p greater than 7			
	Sands (More than half of coarse fraction is smaller than No. 4 Sieve)	Clean sands (Little or no fines)	SW Well graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 6: $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3			
			SP Poorly graded sands, gravelly sands, little or no fines		Not meeting C_u or C_c requirements for SW			
		Sands with fines (Appreciable amount of fines)	SM Silty sands, sand-silt mixtures		Atterberg limits below A Line or I_p less than 4	Limits Plotting in hatched zone with I_p between 4 and 7 are borderline cases requiring use of dual symbols		
			SC Clayey sands, sand-clay mixtures		Atterberg limits above A line with I_p greater than 7			
						For soils plotting nearly on A line use dual symbols i.e., $I_p = 29.5$, $w_L = 60$ gives CH-MH. When w_L is near 50 use CL-CH or ML-MH. Take near as ± 2 percent.		
		Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silt and clays (Liquid limit less than 50)		ML Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity			
CL Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays								
OL Organic silts and organic silty clays of low plasticity								
Silt and Clays (Liquid limit greater than 50)	MH Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts							
	CH Inorganic clays of high plasticity, fat clays							
	OH Organic clays of medium to high plasticity, organic silts							
Highly organic soils	Pt Peat and other highly organic soils							

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

Figure 1: Site Vicinity Plan

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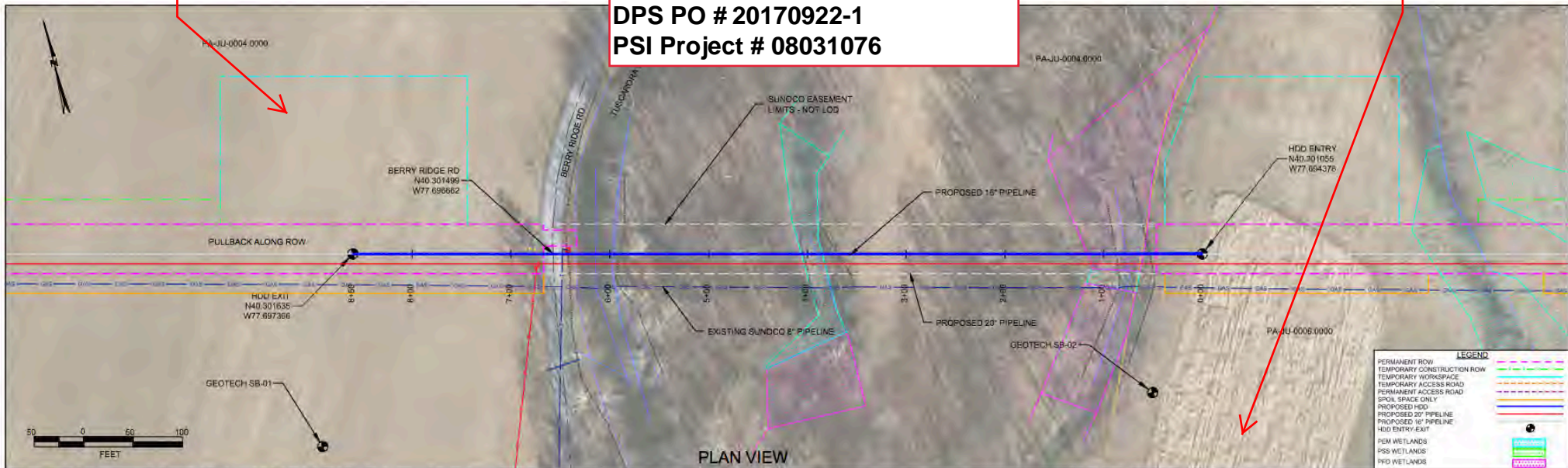
Visit us at <http://www.dcnr.state.pa.us>



**GEO BORE #1
(120 FT)**

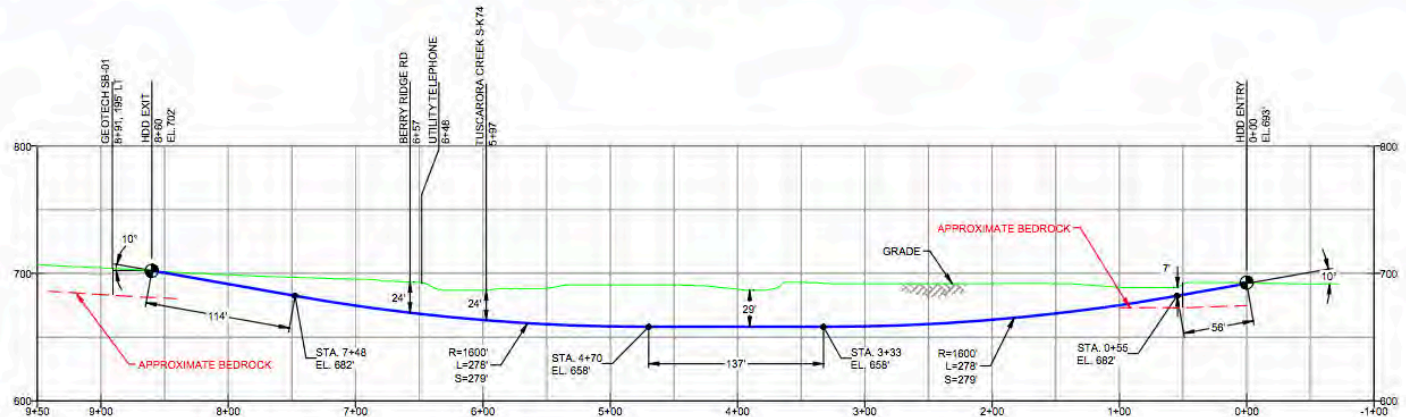
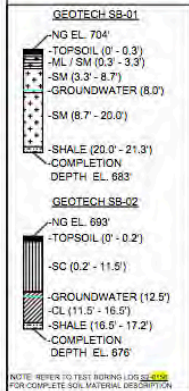
**FIGURE 2: Boring Location Plan
Berry Ridge Road - PPP3
DPS PO # 20170922-1
PSI Project # 08031076**

**GEO BORE #2
(120 FT)**



JUNIATA COUNTY PENNSYLVANIA, LACK TOWNSHIP
S2-0155-16

PROFILE VIEW



- DESIGN AND CONSTRUCTION:**
- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
 - THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 12 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
 - DESIGNED IN ACCORDANCE WITH CTR 49 195 & ASME B31.4
 - CROSSING PIPE SPECIFICATION:
HDD HORZ. LENGTH (L): 880'
HDD PIPE LENGTH (S): 180'
16" x 3.438" W.T., X-70, API 5L, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 3-35 MIL ABD (POWERCRITE OR ENGINEER APPROVED EQUIV.)
 - INTERNAL DESIGN PRESSURE: 1800 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.85)
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD)
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS
 - CARRIER PIPE NOT ENCASED
 - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER
 - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRONG TO MINIMUM 1800 PSIG
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT EBR WEBSITE FOR ACCESS ROAD ALIGNMENT
 - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL (HDD) RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
 - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

- NOTES**
- ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE MADS
 - STATIONING IS BASED ON HORIZONTAL DISTANCES
 - ROONEY ENGINEERING, INC AND SUNOCO PIPELINE, LP ARE NOT RESPONSIBLE FOR LOCATION OF FOREIGN UTILITIES SHOWN IN PLOT PLAN OR PROFILE. THE INFORMATION SHOWN HEREON IS FURNISHED WITHOUT LIABILITY ON THE PART OF ROONEY ENGINEERING, INC AND SUNOCO PIPELINE, LP FOR ANY DAMAGES RESULTING FROM ERRORS OR OMISSIONS THEREIN.
 - CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.
 - SUNOCO EMERGENCY HOTLINE NUMBER IS 1-800-788-7440.

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP.	GATE
3	REVISED PROFILE WITH 2017 LOGAR	MRS	03/22/17	KMB	03/22/17	CAG	03/22/17
2	REVISED PER ENGINEERING COMMENTS	DMJ	05/26/16	RMB	08/26/16	AAV	06/29/16
1	ROAD CROSSING NAME UPDATED	DMJ	02/04/16	RMB	02/04/16	AAV	02/04/16
0	ISSUED FOR CONSTRUCTION	MRS	12/22/16	KMB	12/22/16	AAV	12/22/16

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

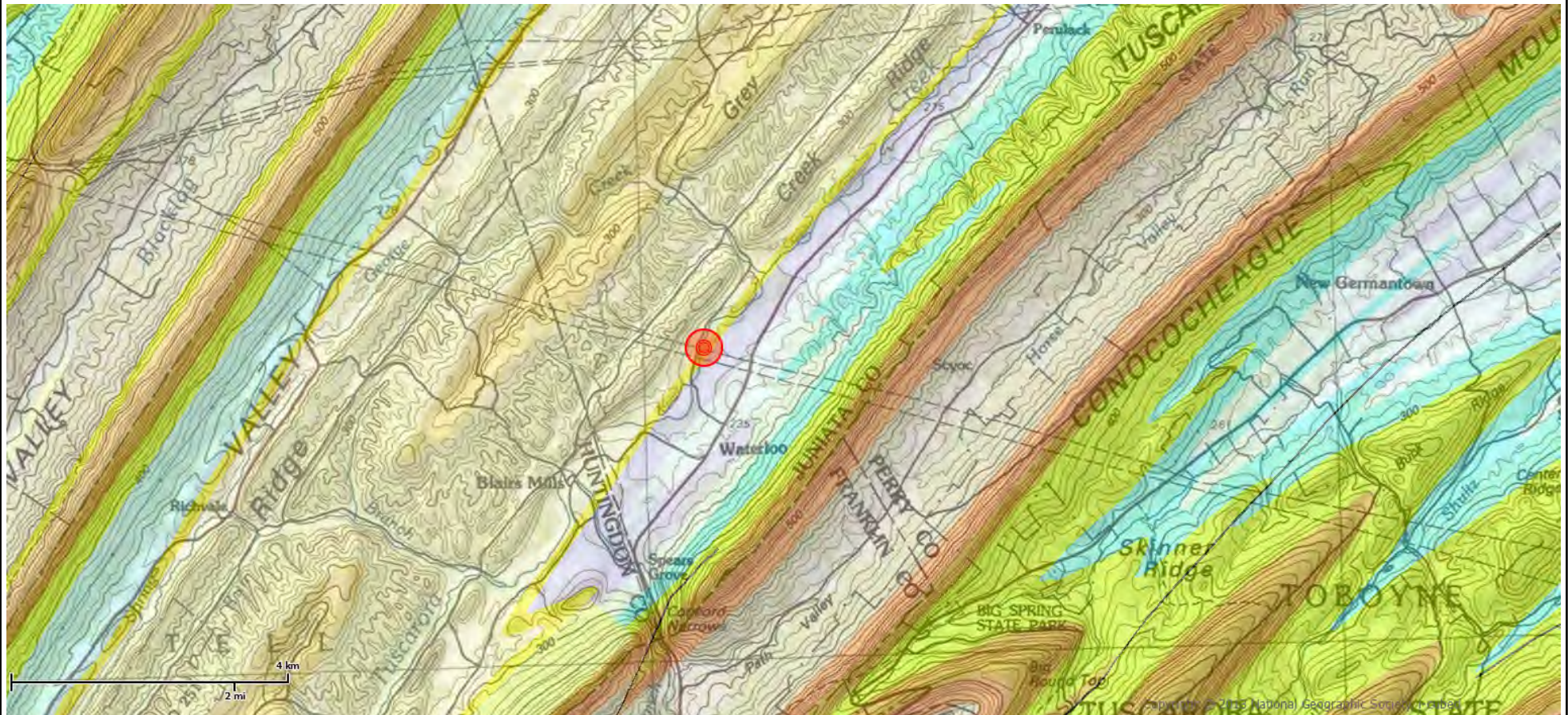
SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
BERRY RIDGE RD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=100' DWG NO: PA-JU-0004.0000-WX-16

Figure 3: Site Geology Plan

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



DATE STARTED: 9/26/17
 DATE COMPLETED: 9/27/17
 COMPLETION DEPTH: 120.0 ft
 BENCHMARK: N/A
 ELEVATION: N/A
 LATITUDE:
 LONGITUDE:
 STATION: N/A OFFSET: N/A
 REMARKS:


DRILL COMPANY: Allied
 DRILLER: R. Miller LOGGED BY: K. Gibney
 DRILL RIG: Diedrich D-50 Track
 DRILLING METHOD: Hollow Stem Auger
 SAMPLING METHOD: SS, 3' Centers
 HAMMER TYPE: Automatic
 EFFICIENCY: N/A
 REVIEWED BY: S. Simonette

Water	▽ Pre-Core	1.55 feet
	▽ Upon Completion	.55 feet
	▽ 16 Hr.	1.30 feet

BORING LOCATION:
 Refer to 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)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft @	Additional Remarks
0						Approximately 6 inches of TOPSOIL					
	12		S-1		12	ALLUVIUM - Very stiff, damp, light brown and light gray, Mottled SILT , with Sand, Clay, and Shale Fragments *Geo Silt Bag being utilized as well as recycled water *No loss of drill water return	ML	4-5-7-13 N=20	22	Moisture: X PL: ◻ LL: +	
	5		S-2		19	ALLUVIUM - Medium dense, moist, light brown and light gray, SANDSTONE AND SHALE FRAGMENTS , with Sand and Clay Increased sandstone and sand content	GC	7-9-11-11 N=22	19	Moisture: X PL: ◻ LL: +	LL = 29 PL = 18 Fines=35.6%
	10		S-3		24	ALLUVIUM - Very stiff, moist, light brown and light gray, Lean CLAY , with Sand	CL	5-9-12-15 N=27	20	Moisture: X PL: ◻ LL: +	LL = 27 PL = 17 Fines=86.8%
	15		S-4		5	Auger refusal encountered at approximately 15.4 feet	GP	50/4"			
			R-1		12	WEATHERED ROCK - Very dense, moist, brown and dark gray, Carbonaceous SHALE , supliutic (sampled as a Poorly Graded Gravel)		RQD=0 Rec=63%			>>⊙
			R-2		32	BEDROCK - Dark gray, Carbonaceous SHALE , very fine grained, very thin to medium bedded, slightly weathered, medium to moderately hard, shallow to very steep, laminated bedding joints, moderate to very steep, closely to widely spaced discontinuities, tight to open joints, with calcite veining, interbedded with Siltstone		RQD=37 Rec=90%			>>⊙ ▲ Qu = 119.1 tsf 169.5 pcf
			R-3		59			RQD=18 Rec=98%			>>⊙ 2 min. 3 min. 3 min. 3 min. 165.7 pcf
			R-4		60	Carbonaceous Shale, calcite veining		RQD=52 Rec=100%			>>⊙ 6 min. 6 min. 4 min. 4 min.

Continued Next Page

	Professional Service Industries, Inc.	PROJECT NO.:	08031076
	850 Poplar Street	PROJECT:	Berry Ridge Rd PPP3 Pipeline Juniata Co.
	Pittsburgh, PA 15220	LOCATION:	Berry Ridge Road
	Telephone: (412) 922-4000		Lack Township
			Juniata Co., PA

DATE STARTED: 9/26/17 **DRILL COMPANY:** Allied
DATE COMPLETED: 9/27/17 **DRILLER:** R. Miller **LOGGED BY:** K. Gibney
COMPLETION DEPTH: 120.0 ft **DRILL RIG:** Diedrich D-50 Track
BENCHMARK: N/A **DRILLING METHOD:** Hollow Stem Auger
ELEVATION: N/A **SAMPLING METHOD:** SS, 3' Centers
LATITUDE: _____ **HAMMER TYPE:** Automatic
LONGITUDE: _____ **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** S. Simonette
REMARKS: _____


BORING B-01

Water
 ▽ Pre-Core 1.55 feet
 ▼ Upon Completion .55 feet
 ▼ 16 Hr. 1.30 feet

BORING LOCATION:
 Refer to 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)	Moisture, %	STANDARD PENETRATION TEST DATA				Additional Remarks
										N in blows/ft @				
										X Moisture PL LL				
											STRENGTH, tsf			
											▲ Qu * Qp			
	35			R-5	60	BEDROCK - Dark gray, Carbonaceous SHALE , very fine grained, very thin to medium bedded, slightly weathered, medium to moderately hard, shallow to very steep, laminated bedding joints, moderate to very steep, closely to widely spaced discontinuities, tight to open joints, with calcite veining, interbedded with Siltstone R-5: More calcite veining		RQD=100 Rec=100%					4 min. 4 min. >>⊙ 3 min. >>▲ Q _u = 105.5 tsf 166.2 pcf 2 min.	
				R-6	60			RQD=58 Rec=100%					4 min. 4 min. >>⊙ 4 min. 3 min.	
	40			R-7	60	Carbonaceous Shale with calcite veining and slightly calcareous		RQD=84 Rec=100%					3 min. 4 min. 3 min. >>⊙ 3 min.	
	45			R-8	60			RQD=100 Rec=100%					>>▲ Q _u = 99.0 tsf 168.3 pcf 3 min.	
	50			R-9	60			RQD=100 Rec=100%					2 min. 2 min. >>⊙ 2 min. 2 min.	
	55			R-10	60			RQD=86 Rec=100%					3 min. 5 min. 3 min. >>⊙ 3 min. 146.2 tsf 169.3 pcf 3 min.	
	60												2 min. 3 min. >>⊙ 2 min. 3 min. 3 min.	

Continued Next Page

 <p> Professional Service Industries, Inc. 850 Poplar Street Pittsburgh, PA 15220 Telephone: (412) 922-4000 </p>	<p> PROJECT NO.: 08031076 PROJECT: Berry Ridge Rd PPP3 Pipeline Juniata Co. LOCATION: Berry Ridge Road Lack Township Juniata Co., PA </p>
--	--


DATE STARTED: 9/26/17 **DRILL COMPANY:** Allied
DATE COMPLETED: 9/27/17 **DRILLER:** R. Miller **LOGGED BY:** K. Gibney
COMPLETION DEPTH: 120.0 ft **DRILL RIG:** Diedrich D-50 Track
BENCHMARK: N/A **DRILLING METHOD:** Hollow Stem Auger
ELEVATION: N/A **SAMPLING METHOD:** SS, 3' Centers
LATITUDE: _____ **HAMMER TYPE:** Automatic
LONGITUDE: _____ **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** S. Simonette
REMARKS:

BORING B-01

Water	▽ Pre-Core	1.55 feet
	▼ Upon Completion	.55 feet
	▽ 16 Hr.	1.30 feet

BORING LOCATION:
Refer to 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)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft @	Additional Remarks
				R-11	60	BEDROCK - Dark gray, Carbonaceous SHALE , very fine grained, very thin to medium bedded, slightly weathered, medium to moderately hard, shallow to very steep, laminated bedding joints, moderate to very steep, closely to widely spaced discontinuities, tight to open joints, with calcite veining, interbedded with Siltstone Quartzite veining R-17: Starting to transition into Sandstone <i>Continued Next Page</i>	RQD=100 Rec=100%			X Moisture □ PL + LL STRENGTH, tsf ▲ Qu * Qp	>> 2 min. >> 2 min. >> 2 min. >> 124.5 tsf >> 169.1 pcf 2 min. 3 min. 3 min. >> 3 min. 3 min. 3 min. 4 min. >> 3 min. 166.7 pcf 2 min. 3 min. 2 min. >> 3 min. 3 min. 3 min. 2 min. 3 min. >> 87.6 tsf >> 169.9 pcf 2 min. 3 min. 2 min. 2 min. 2 min. 2 min. 2 min. 2 min. >> 2 min.
				R-12	60		RQD=100 Rec=100%				
				R-13	60		RQD=48 Rec=100%				
				R-14	60		RQD=80 Rec=100%				
				R-15	60		RQD=94 Rec=100%				
				R-16	60		RQD=48 Rec=100%				
				R-17	60		RQD=18				

	Professional Service Industries, Inc. 850 Poplar Street Pittsburgh, PA 15220 Telephone: (412) 922-4000	PROJECT NO.: 08031076 PROJECT: Berry Ridge Rd PPP3 Pipeline Juniata Co. LOCATION: Berry Ridge Road Lack Township Juniata Co., PA
--	---	---

DATE STARTED: 9/26/17
 DATE COMPLETED: 9/27/17
 COMPLETION DEPTH: 120.0 ft
 BENCHMARK: N/A
 ELEVATION: N/A
 LATITUDE:
 LONGITUDE:
 STATION: N/A OFFSET: N/A
 REMARKS:


DRILL COMPANY: Allied
 DRILLER: R. Miller LOGGED BY: K. Gibney
 DRILL RIG: Diedrich D-50 Track
 DRILLING METHOD: Hollow Stem Auger
 SAMPLING METHOD: SS, 3' Centers
 HAMMER TYPE: Automatic
 EFFICIENCY: N/A
 REVIEWED BY: S. Simonette

BORING B-01

Water	▽ Pre-Core	1.55 feet
	▼ Upon Completion	.55 feet
	▽ 16 Hr.	1.30 feet

BORING LOCATION:
 Refer to 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)	Moisture, %	STRENGTH, tsf	Additional Remarks
95				R-18	60	(fine-grained), with Carbonaceous Shale and Siltstone interbeds BEDROCK - Dark gray, Carbonaceous SHALE , very fine grained, very thin to medium bedded, slightly weathered, medium to moderately hard, shallow to very steep, laminated bedding joints, moderate to very steep, closely to widely spaced discontinuities, tight to open joints, with calcite veining, interbedded with Siltstone Boring terminated at approximately 120 feet Grouted to depth 9/28/17 the following day after completion	Rec=100%			2 min. 2 min. $Q_u = 655.2$ tsf $Q_{u1} = 152.9$ pcf 2 min. 2 min. 2 min. 2 min. 2 min. 3 min. 2 min. 3 min. $Q_u = 640.7$ tsf $Q_{u1} = 157.8$ pcf 2 min. 2 min. 2 min. 3 min. 2 min. 2 min. 2 min. $Q_u = 366.4$ tsf $Q_{u1} = 268.7$ pcf 2 min. 2 min. 2 min.	
				R-19	60		RQD=68 Rec=100%				
				R-20	60		RQD=50 Rec=100%				
				R-21	60		RQD=62 Rec=100%				
				R-22	60		RQD=40 Rec=100%				

	Professional Service Industries, Inc.	PROJECT NO.:	08031076
	850 Poplar Street	PROJECT:	Berry Ridge Rd PPP3 Pipeline Juniata Co.
	Pittsburgh, PA 15220	LOCATION:	Berry Ridge Road
	Telephone: (412) 922-4000		Lack Township
			Juniata Co., PA

FSI-08031076 9/26/17
 B-1 BOX 1 OF 7 Depth 15.4 to 31.1
 PPP#3 PA-JU-0004.0000-WX-16

RUN	DEPTH	REC	RGD
R-1	15.4 - 17.0	1.0	0.0
R-2	17.0 - 20.0	2.7	1.1
R-3	20.0 - 25.0	4.9	0.9
R-4	25.0 - 30.0	5.0	2.6

Run	Depth	Rec	RGD
R-5	30.0 - 35.0	5.0	5.0



20.0 15.4 17.0 25.0 30.0 31.1

PST # 08031076 9/27/17
B-1 BOX 2 of 7 Depth 31.1 to 45.8
PPP#3 PA-JU-0004.0000-WX-16

Run	Depth	Rec	ROD
R-5	30.0 - 35.0	5.0	5.0
R-6	35.0 - 40.0	5.0	2.9
R-7	40.0 - 45.0	5.0	4.2
R-8	45.0 - 50.0	5.0	5.0



WX-16
TO 458

PSI # 08031076 9/27/17
B-1 Box 5 of 7 Depth 45.8 to 60.4
PPP# 3 PA-JU-0004.0000-WX-16

Run	DEPTH	REC	REQ
R-8	45.0 - 50.0	5.0	5.0
R-9	50.0 - 55.0	5.0	5.0
R-10	55.0 - 60.0	5.0	4.3
R-11	60.0 - 65.0	5.0	5.0



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

PSI # 08031076 9/27/17
B-1 BOX 4 OF 7 DEPTH 60.4 TO 75.0
PPP#3 PA-JU-0004.0000-WX-16

Run	DEPTH	REC	POD
R-11	60.0 - 65.0	5.0	5.0
R-12	65.0 - 70.0	5.0	5.0
R-13	70.0 - 75.0	5.0	2.4
R-14	-	-	-



PSI# 08031076 9/27/17

B-1 Box 5 of 7 Depth 75.0 to 89.7

PPP# 3 PA-JU-0004.0000-wx-16

Run	Depth	Rec	Pod
R-14	75.0 - 80.0	5.0	4.0
R-15	80.0 - 85.0	5.0	4.7
R-16	85.0 - 90.0	5.0	2.4
R-17	-		

75.0



80.0

85.0

89.7



PSI# 08031076 9/27/17
 B-1 Box 6 of 7 Depth 87.7 to 104.4
 PPP# 3 PA-JU-0004.0000-WX-16

Run	Depth	Rec	ROD
R-16	85.0 - 90.0	5.0	2.4
R-17	90.0 - 95.0	5.0	0.9
R-18	95.0 - 100.0	5.0	3.4
R-19	100.0 - 105.0	5.0	3.4



104.4

PSI # 08031076 9/27/17
B-1 Box 7 of 7 Depth 104.4 to 120.0
PPP#3 PA-JU-0004 0000-WX-16

Run	Depth	Rec	Rad
R-19	100.0-105.0	5.0	3.4
R-20	105.0-110.0	5.0	2.5
R-21	110.0-115.0	5.0	3.1
R-22	115.0-120.0	5.0	2.0

104.4

105.0

110.0

115.0

120.0



Box 7 of 7
Depth 104.4 to 120.0

DATE STARTED: 9/28/17
 DATE COMPLETED: 9/29/17
 COMPLETION DEPTH: 120.0 ft
 BENCHMARK: N/A
 ELEVATION: N/A
 LATITUDE:
 LONGITUDE:
 STATION: N/A OFFSET: N/A
 REMARKS:

DRILL COMPANY: Allied
 DRILLER: R. Miller LOGGED BY: K. Gibney
 DRILL RIG: Diedrich D-50 Track
 DRILLING METHOD: Hollow Stem Auger
 SAMPLING METHOD: SS, 3' Centers
 HAMMER TYPE: Automatic
 EFFICIENCY: N/A
 REVIEWED BY: S. Simonette

BORING B-02

Water	▽ Pre-Core	5.18 feet
	▼ Upon Completion	2.25 feet
	▽ 72 Hr.	6.44 feet

BORING LOCATION:
 Refer to 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)	Moisture, %	STRENGTH, tsf	Additional Remarks		
0	0			S-1	20	ALLUVIUM - Very dense, dry, gray brown, SHALE FRAGMENTS , with Silt and Sand, (sampled as a Poorly Graded Gravel with Silt)	GP-GM	4-9-23-19 N=42	5	×	⊙		
5	5			S-2	20	ALLUVIUM - Very dense, moist to wet, light brown, SAND , with light brown and purple brown, River Gravel, Sandstone Fragments, and Silt	SP	13-17-29-31 N=60	17	×	>> ⊙ Fines=15.5%		
10	10			R-1	11	ALLUVIUM - Medium dense, moist to wet, light brown and dark gray, Poorly Graded SAND , with River Gravel, Silt, and Clay Cobbles in R-1	SP-SC	15-12-11-8 N=19	14	×	⊙	>> ⊙ Fines=16.6%	
15	15			R-2	8					ALLUVIUM - Stiff, wet, light brown, SILT , with Sand Cobbles in R-2	ML	5-2-5-8 N=13	42
20	20			R-3	7	WEATHERED ROCK - Very dense, dry, gray and gray brown, LIMESTONE , (sampled as a Poorly Graded Gravel) Gravel and Cobbles in R-3 Auger refusal encountered at approximately 20.6 feet	GP	12-50/1"			⊙	>> ⊙	
25	25			R-4	52					BEDROCK - Gray and light blue gray, LIMESTONE , very fine grained, very thin to thick bedded, weathered to slightly weathered, moderately hard to hard, with calcite veins, shallow to very steep dip bedding joints, tight to large joint openings, narrowly to widely spaced discontinuities Moderately to completely weathered from 20.6 to 23 feet	RQD=36 Rec=98%		⊙
30	30			R-5	60	Weathered zone		RQD=48 Rec=100%			⊙	⊙	⊙ = 303.8 tsf 167.2 pcf 4 min. ⊙ = 104.1 tsf 144.5 pcf 4 min.

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Professional Service Industries, Inc.
 850 Poplar Street
 Pittsburgh, PA 15220
 Telephone: (412) 922-4000

PROJECT NO.: 08031076
 PROJECT: Berry Ridge Rd PPP3 Pipeline Juniata Co.
 LOCATION: Berry Ridge Road
 Lack Township
 Juniata Co., PA

DATE STARTED: 9/28/17
 DATE COMPLETED: 9/29/17
 COMPLETION DEPTH: 120.0 ft
 BENCHMARK: N/A
 ELEVATION: N/A
 LATITUDE:
 LONGITUDE:
 STATION: N/A OFFSET: N/A
 REMARKS:

DRILL COMPANY: Allied
 DRILLER: R. Miller LOGGED BY: K. Gibney
 DRILL RIG: Diedrich D-50 Track
 DRILLING METHOD: Hollow Stem Auger
 SAMPLING METHOD: SS, 3' Centers
 HAMMER TYPE: Automatic
 EFFICIENCY: N/A
 REVIEWED BY: S. Simonette

BORING B-02

Water	▽ Pre-Core	5.18 feet
	▼ Upon Completion	2.25 feet
	▽ 72 Hr.	6.44 feet

BORING LOCATION:
 Refer to 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)	Moisture, %	STANDARD PENETRATION TEST DATA			Additional Remarks
										N in blows/ft ⊙			
				R-6	55	BEDROCK - Gray and light blue gray, LIMESTONE , very fine grained, very thin to thick bedded, weathered to slightly weathered, moderately hard to hard, with calcite veins, shallow to very steep dip bedding joints, tight to large joint openings, narrowly to widely spaced discontinuities		RQD=86 Rec=92%				3 min. 3 min. 3 min. 2 min.	
35				R-7	56	Weathered zone		RQD=56 Rec=94%				3 min. 3 min. 3 min. 2 min.	
40				R-8	22	Solution activity within run		RQD=0 Rec=36%				2 min. 2 min. 2 min. 2 min.	
45				R-9	53	Solution activity soil seam		RQD=82 Rec=88%				2 min. 2 min. 2 min. 2 min.	
50				R-10	60	Weathered zone		RQD=92 Rec=100%				3 min. 2 min. 3 min. 2 min.	
55				R-11	47	1 foot tool drop		RQD=70 Rec=78%				3 min. 2 min. 2 min. 2 min.	
60						Solution activity						2 min. 2 min.	
						Tool drop, solution activity from 61 to 63 feet						2 min.	

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 LOCATION: Berry Ridge Road
 Lack Township
 Juniata Co., PA

DATE STARTED: 9/28/17
 DATE COMPLETED: 9/29/17
 COMPLETION DEPTH: 120.0 ft
 BENCHMARK: N/A
 ELEVATION: N/A
 LATITUDE:
 LONGITUDE:
 STATION: N/A OFFSET: N/A
 REMARKS:

DRILL COMPANY: Allied
 DRILLER: R. Miller LOGGED BY: K. Gibney
 DRILL RIG: Diedrich D-50 Track
 DRILLING METHOD: Hollow Stem Auger
 SAMPLING METHOD: SS, 3' Centers
 HAMMER TYPE: Automatic
 EFFICIENCY: N/A
 REVIEWED BY: S. Simonette

BORING B-02

Water
 ▽ Pre-Core 5.18 feet
 ▼ Upon Completion 2.25 feet
 ▽ 72 Hr. 6.44 feet

BORING LOCATION:
 Refer to 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)	Moisture, %	STANDARD PENETRATION TEST DATA		Additional Remarks
										N in blows/ft @	Strength, tsf	
65			R-12	46		BEDROCK - Gray and light blue gray, LIMESTONE , very fine grained, very thin to thick bedded, weathered to slightly weathered, moderately hard to hard, with calcite veins, shallow to very steep dip bedding joints, tight to large joint openings, narrowly to widely spaced discontinuities	RQD=66 Rec=76%				>> 1 min. 2 min. 2 min. 1 min. 351.9 tsf 142.2 pcf	
70			R-13	36		Solution activity Filled seam	RQD=46 Rec=60%				>> 1 min. 1 min. 2 min. 2 min.	
75			R-14	60			RQD=96 Rec=100%				>> 1 min. 2 min. 2 min. 343.7 tsf 144.5 pcf	
80			R-15	60		Weathered area Solution activity	RQD=88 Rec=100%				>> 1 min. 2 min. 2 min. 2 min. 3 min.	
85			R-16	60			RQD=86 Rec=100%				>> 1 min. 2 min. 2 min. 172.8 tsf 152.0 pcf	
90			R-17	60		5 Foot solid core broke when removing	RQD=100 Rec=100%				>> 1 min. 2 min. 2 min. 2 min.	
			R-18	52		Solution activity from 90.8 to 91.5 feet	RQD=68				>> 1 min. 2 min.	

Continued Next Page



Professional Service Industries, Inc.
 850 Poplar Street
 Pittsburgh, PA 15220
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PROJECT NO.: 08031076
 PROJECT: Berry Ridge Rd PPP3 Pipeline Juniata Co.
 LOCATION: Berry Ridge Road
 Lack Township
 Juniata Co., PA

DATE STARTED: 9/28/17	DRILL COMPANY: Allied	BORING B-02
DATE COMPLETED: 9/29/17	DRILLER: R. Miller LOGGED BY: K. Gibney	
COMPLETION DEPTH: 120.0 ft	DRILL RIG: Diedrich D-50 Track	Water
BENCHMARK: N/A	DRILLING METHOD: Hollow Stem Auger	▽ Pre-Core 5.18 feet
ELEVATION: N/A	SAMPLING METHOD: SS, 3' Centers	▼ Upon Completion 2.25 feet
LATITUDE:	HAMMER TYPE: Automatic	▽ 72 Hr. 6.44 feet
LONGITUDE:	EFFICIENCY: N/A	BORING LOCATION:
STATION: N/A OFFSET: N/A	REVIEWED BY: S. Simonette	Refer to Boring Location Plan
REMARKS:		

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	STRENGTH, tsf	Additional Remarks
95				R-19	56	BEDROCK - Gray and light blue gray, LIMESTONE , very fine grained, very thin to thick bedded, weathered to slightly weathered, moderately hard to hard, with calcite veins, shallow to very steep dip bedding joints, tight to large joint openings, narrowly to widely spaced discontinuities	Rec=86%				2 min. 2 min. 2 min. Qu = 386.1 tsf 158.8 pcf
						Solution activity from 98.5 to 98.9 feet	RQD=90 Rec=94%				2 min. 2 min. 2 min. 2 min.
100				R-20	58		RQD=92 Rec=96%				2 min. 2 min. 2 min. 2 min. 2 min.
105				R-21	58	Weathered area	RQD=86 Rec=96%				2 min. 2 min. 2 min. 2 min. 2 min. 2 min.
110				R-22	60		RQD=92 Rec=100%				2 min. 2 min. 2 min. 2 min. Qu = 241.1 tsf 152.7 pcf
115				R-23	44	Weathered area Solution activity	RQD=64 Rec=74%				2 min. 2 min. 2 min. 2 min. 2 min.
120						Boring terminated at approximately 120 feet					2 min.

 Professional Service Industries, Inc. 850 Poplar Street Pittsburgh, PA 15220 Telephone: (412) 922-4000	PROJECT NO.: 08031076
	PROJECT: Berry Ridge Rd PPP3 Pipeline Juniata Co.
	LOCATION: Berry Ridge Road
	Lack Township Juniata Co., PA

Box 1 of 3 9/28/17 PSI# 08031076
 B-2 Depth 7.0 to 33.2 PPP#3
 PA-3U-0004.0000-WX-16

Run	Depth	ReC	Rad
R-5	25.0 - 30.0	5.0	2.4
R-6	30.0 - 35.0	4.6	4.3

Run	Depth	ReC	RSD	
R-1	7.0 - 10.0	0.7	0.4	Conds
R-2	12.0 - 15.0	0.7	0.0	Conds
R-3	17.0 - 20.0	0.6	0.0	Conds
R-4	20.6 - 25.0	4.3	1.6	

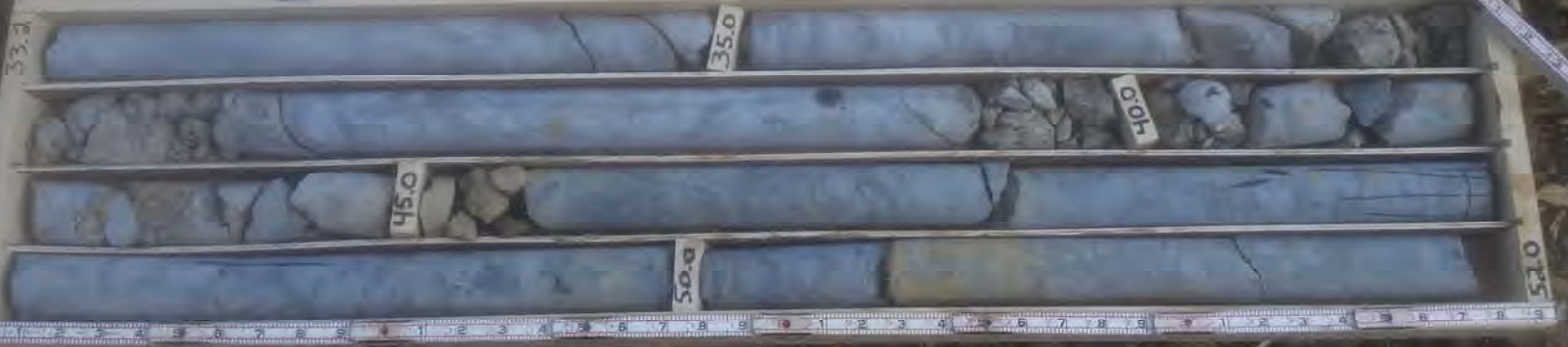


PSI # 08031076 9/28/17
 B-2 Box 1 of 7 Depth 7.0 to 33.2
 PPP#3 PA-JV-0004.0000-WX-16

Box 2 of 7 9/29/17 PSI# 08031076
 B-2 Depth 33.2 to 52.0 PPP#3
 PA-JV-0004.0000-WX-16

Run	DEPTH	Rec	RQD
R-10	50.0 - 55.0	5.0	4.6
R-11			

Run	Depth	Rec	RQD
R-6	30.0 - 35.0	4.6	4.3
R-7	35.0 - 40.0	4.7	2.8
R-8	40.0 - 45.0	1.8	0.0
R-9	45.0 - 50.0	4.4	4.1



PA-JU-0004.0000-WY-16

PA-JU-0004.0000-WY-16
PPP#3

Box 3 of 7 9/29/17 PSI #08031076
B-2 Depth 52.0 to 71.2 PPP#3
PA-JU-0004.0000-WY-16

Run	DEPTH	Rec	RAD
R-14	70.0 - 75.0	4.8	4.8

Run	DEPTH	Rec	RAD
R-10	50.0 - 55.0	5.0	4.6
R-11	55.0 - 60.0	3.9	3.5
R-12	60.0 - 65.0	3.8	3.3
R-13	65.0 - 70.0	3.0	2.3



Box 3 of 7 9/29/17 PSI# 08031076
 B-2 Depth 52.0 to 71.2 PPP#3
 PA-JU-0604.0000-WX-16

PSI# 08031076 9/29/17
 B-2 Box 4 of 7 Depth 71.2 to 86.1
 PPP#3 PA-JU-0604.0000-WX-16

Run	Depth	Ret	RQD
R-14	70.0 - 75.0	5.0	4.8
R-15	75.0 - 80.0	5.0	4.4
R-16	80.0 - 85.0	5.0	4.3
R-17	85.0 - 90.0	5.0	5.0



08031076 9/29/17
B-2 Box 4 of 7 Depth 71.2 to 86.1
PPP #3 PA-JV-0004.0000-WX-16

Box 5 of 7 9/29/17 PST 08031076
B-2 Depth 86.1 to 101.6 PPP 3
PA-JV-0004.0000-WX-16

Run	Depth	Rec	RQD
R-17	85.0 - 90.0	5.0	5.0
R-18	90.0 - 95.0	4.3	3.4
R-19	95.0 - 100.0	4.7	4.5
R-20	100.0 - 105.0	4.8	4.6

86.1

90.0

95.0

100.0

101.6



Box 6 of 7 9/29/17 PSI 08031076
 B-2 Depth 101.6 TO 116.6 PPP 3
 PA-Ju-0004.0000-LX-16

Run	Depth	Rel	Pad
R-20	100.0 - 105.0	4.8	4.6
R-21	105.0 - 110.0	4.8	4.3
R-22	110.0 - 115.0	5.0	4.6
R-23	115.0 - 120.0	3.7	3.2



B-2 Box 7 of 7 9/29/17 PST 08031076
Depth ~~106.6~~ to 120.0 PPP #3
PA - Ju - 0004.0000 - wx - 16

Run	DEPTH	Rec	Rqd
R-23	115.0 - 120.0	3.7	3.2
R-21	-		

116.6

021









GENERAL NOTES


SAMPLE IDENTIFICATION

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

DRILLING AND SAMPLING SYMBOLS

SFA: Solid Flight Auger - typically 4" diameter flights, except where noted.		SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted.
HSA: Hollow Stem Auger - typically 3 1/4" or 4 1/4" I.D. openings, except where noted.		ST: Shelby Tube - 3" O.D., except where noted.
M.R.: Mud Rotary - Uses a rotary head with Bentonite or Polymer Slurry		RC: Rock Core
R.C.: Diamond Bit Core Sampler		TC: Texas Cone
H.A.: Hand Auger		BS: Bulk Sample
P.A.: Power Auger - Handheld motorized auger		PM: Pressuremeter
		CPT-U: Cone Penetrometer Testing with Pore-Pressure Readings

SOIL PROPERTY SYMBOLS

- N: Standard "N" penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2-inch O.D. Split-Spoon.
- N₆₀: A "N" penetration value corrected to an equivalent 60% hammer energy transfer efficiency (ETR)
- Q_u: Unconfined compressive strength, TSF
- Q_p: Pocket penetrometer value, unconfined compressive strength, TSF
- w%: Moisture/water content, %
- LL: Liquid Limit, %
- PL: Plastic Limit, %
- PI: Plasticity Index = (LL-PL),%
- DD: Dry unit weight, pcf
-  Apparent groundwater level at time noted

RELATIVE DENSITY OF COARSE-GRAINED SOILS ANGULARITY OF COARSE-GRAINED PARTICLES

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

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

GRAIN-SIZE TERMINOLOGY

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

PARTICLE SHAPE

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

RELATIVE PROPORTIONS OF FINES

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

GENERAL NOTES

(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

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

MOISTURE CONDITION DESCRIPTION

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

RELATIVE PROPORTIONS OF SAND AND GRAVEL

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

STRUCTURE DESCRIPTION

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

SCALE OF RELATIVE ROCK HARDNESS

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

ROCK BEDDING THICKNESSES

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

ROCK VOIDS

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

GRAIN-SIZED TERMINOLOGY

(Typically Sedimentary Rock)

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

ROCK QUALITY DESCRIPTION

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

DEGREE OF WEATHERING

Slightly Weathered:	Rock generally fresh, joints stained and discoloration extends into rock up to 25 mm (1 in), open joints may contain clay, core rings under hammer impact.
Weathered:	Rock mass is decomposed 50% or less, significant portions of the rock show discoloration and weathering effects, cores cannot be broken by hand or scraped by knife.

Degree of Brokenness

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

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

SOIL CLASSIFICATION CHART

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

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

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

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

Method used to determine consistency or hardness (check one):

Field assessment: _____ Uniaxial lab test: _____ Other: _____ Rebound hammer (ASTM D5873): _____

* See NEH631.03 for consistency and density of soil materials. For very stiff soil, SPT N values = 15 to 30. For very soft rock or hard, soil-like material, SPT N values exceed 30 blows per foot.

Laboratory Summary Sheet

Sheet 1 of 1

Borehole	Approx. Depth	Liquid Limit	Plastic Limit	Plasticity Index	Qu (tsf)	%<#200 Sieve	Est. Specific Gravity	Water Content (%)	Dry Density (pcf)	Saturation (%)	Void Ratio
B-01	1							22			
B-01	6	29	18	11		35.6%		19			
B-01	11	27	17	10		86.8%		20			
B-01	19.5				119.05						
B-01	34.1				105.53						
B-01	44				98.97						
B-01	53.8				146.22						
B-01	63.9				124.49						
B-01	83				87.64						
B-01	95				655.24						
B-01	105				540.70						
B-01	116.5				366.37						
B-02	1							5			
B-02	6					15.5%		17			
B-02	11					16.6%		14			
B-02	16	41	26	15		85.7%		42			
B-02	20.9				303.77						
B-02	24				104.11						
B-02	35.5				165.82						
B-02	45.3				360.47						
B-02	55				341.87						
B-02	65.5				351.92						
B-02	75				343.70						
B-02	85				472.82						
B-02	95.5				386.06						
B-02	105				409.92						
B-02	114				241.13						

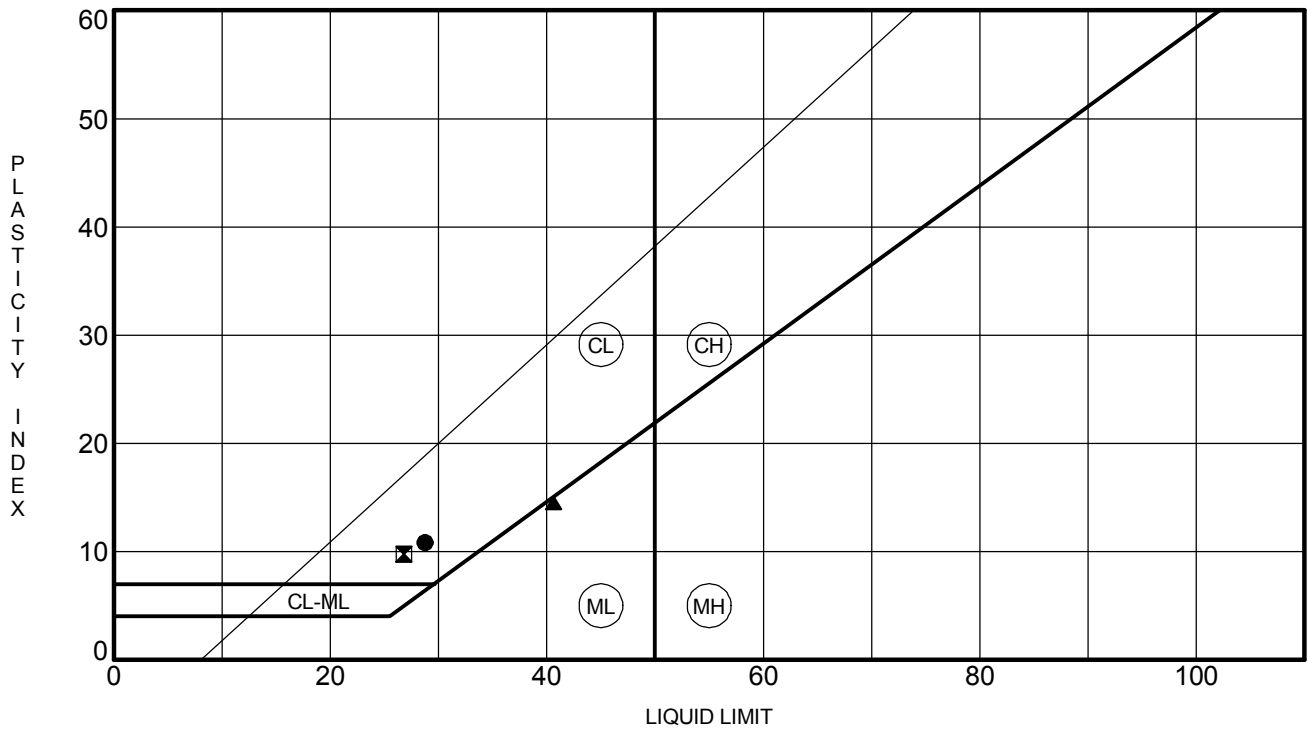




 Professional Service Industries
 850 Poplar Street
 Pittsburgh, PA 15220
 Telephone: (412) 922-4000
 Fax: (412) 922-4014

Summary of Laboratory Results

PSI Job No.: 08031076
 Project: Berry Ridge Rd PPP3 Pipeline Juniata Co.
 Location: Berry Ridge Road
 Lack Township
 Juniata Co., PA

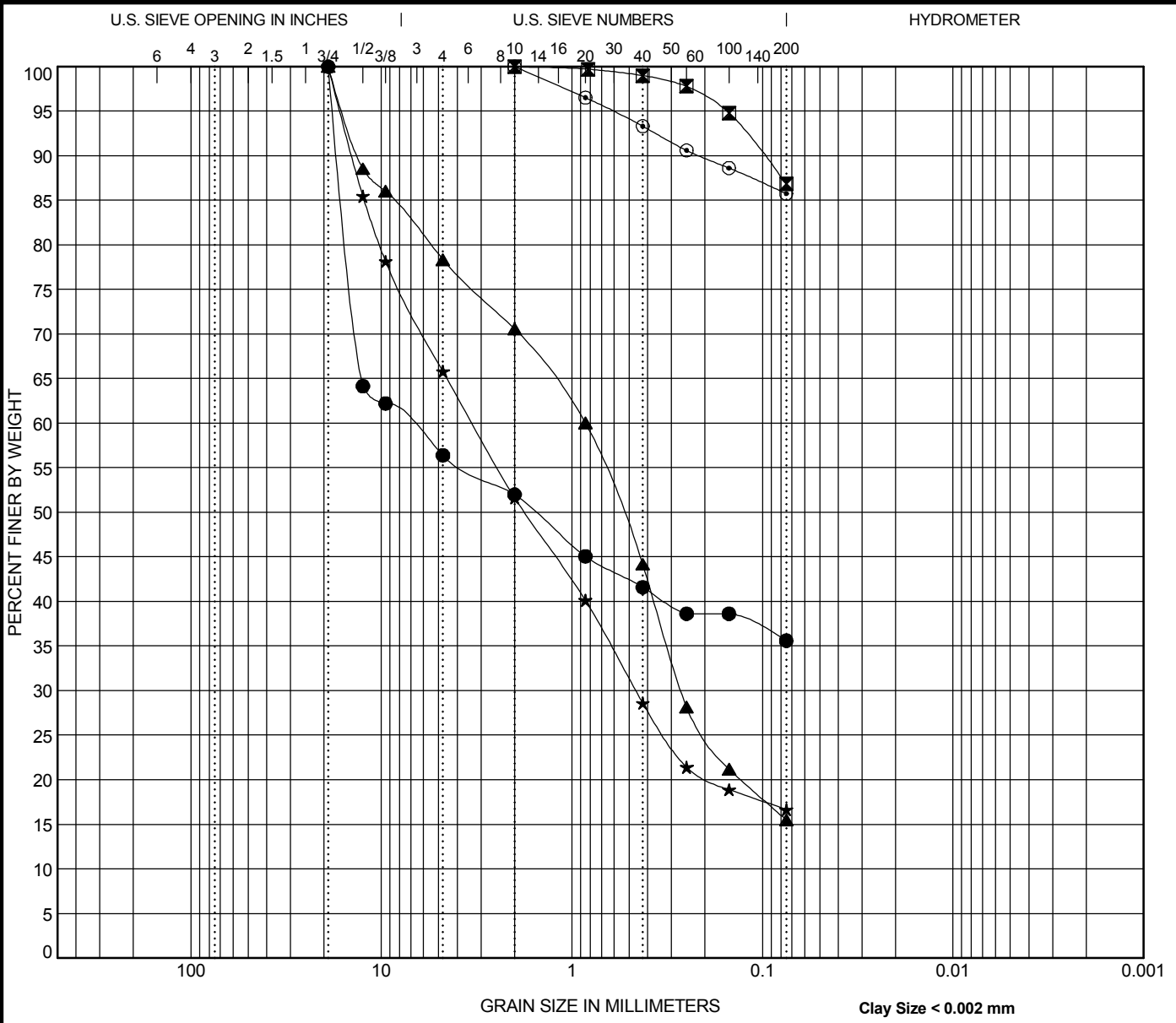


Boring	Depth (ft)	LL	PL	PI	Fines	Classification (*Visual)
● B-01	6.0	29	18	11	35.6	
⊠ B-01	11.0	27	17	10	86.8	
▲ B-02	16.0	41	26	15	85.7	

ATTERBERG LIMIT RESULTS

Professional Service Industries, Inc.
 850 Poplar Street
 Pittsburgh, PA 15220
 Telephone: (412) 922-4000
 Fax: (412) 922-4014

PSI Job No.: 08031076
 Project: Berry Ridge Rd PPP3 Pipeline Juniata Co.
 Location: Berry Ridge Road
 Lack Township



COBBLES	GRAVEL		SAND			SILT OR CLAY	
	coarse	fine	coarse	medium	fine		

Specimen Identification	Classification	LL	PL	PI	Cc	Cu		
● B-01 6.0		29	18	11				
☒ B-01 11.0		27	17	10				
▲ B-02 6.0								
★ B-02 11.0								
◎ B-02 16.0		41	26	15				
Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● B-01 6.0	19	7.305			43.6	20.8	35.6	
☒ B-01 11.0	2				0.0	13.2	86.8	
▲ B-02 6.0	19	0.849	0.266		21.6	62.9	15.5	
★ B-02 11.0	19	3.333	0.463		34.2	49.2	16.6	
◎ B-02 16.0	2				0.0	14.3	85.7	

<p>Professional Service Industries, Inc.</p> <p> 850 Poplar Street Pittsburgh, PA 15220 Telephone: (412) 922-4000 Fax: (412) 922-4014</p>	<h3 style="margin: 0;">GRAIN SIZE DISTRIBUTION</h3> <p>Project: Berry Ridge Rd PPP3 Pipeline Juniata Co. PSI Job No.: 08031076 Location: Berry Ridge Road Lack Township</p>
---	---

Slake Test

08031076 B-1 R-2 18.3'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.01

Final Ph: 6.20

Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-1 R-4 26.3'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.01

Final Ph: 7.13

Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-1 R-5 33.8'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.01

Final Ph: 8.31

Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-1 R-7 44.8'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.01

Final Ph: 8.30

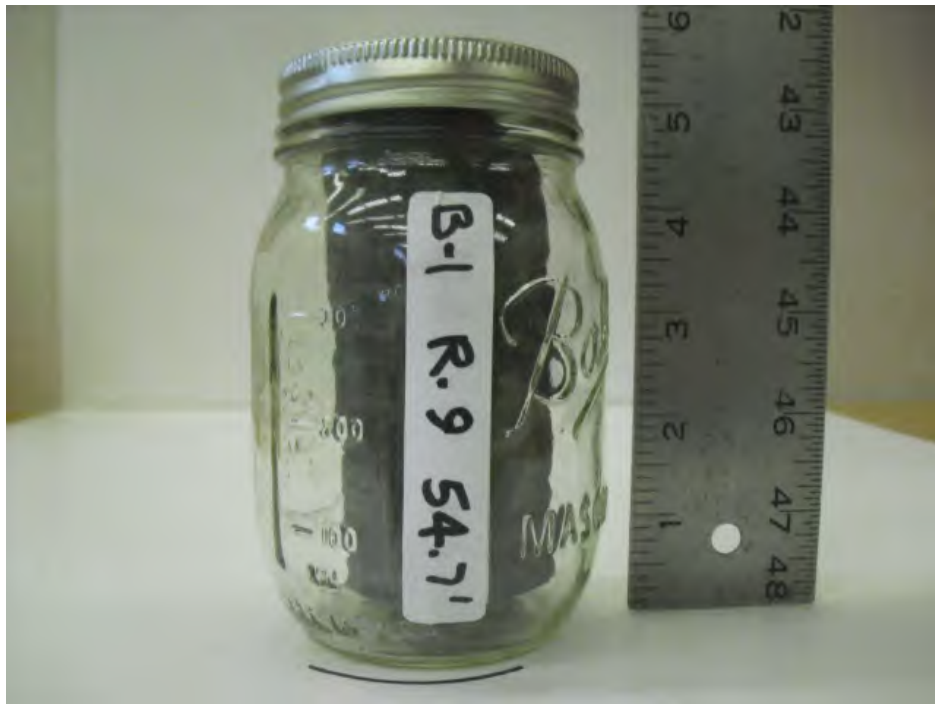
Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-1 R-9 54.7'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.01

Final Ph: 8.44

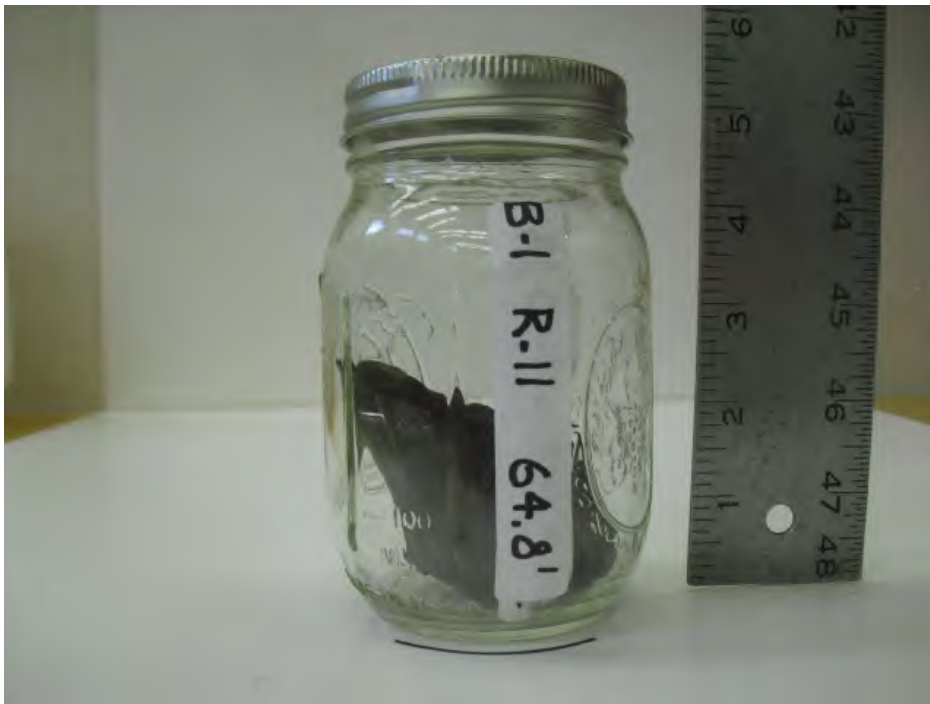
Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-1 R-11 64.8'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.01

Final Ph: 7.63

Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-1 R13 74.0'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.01

Final Ph: 8.12

Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-1 R-15 84.7'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.01

Final Ph: 8.06

Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-1 R-17 94.7'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.01

Final Ph: 6.81

Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-1 R-19 104.4'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.01

Final Ph: 7.34

Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-1 R-21 114.7'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.01

Final Ph: 7.73

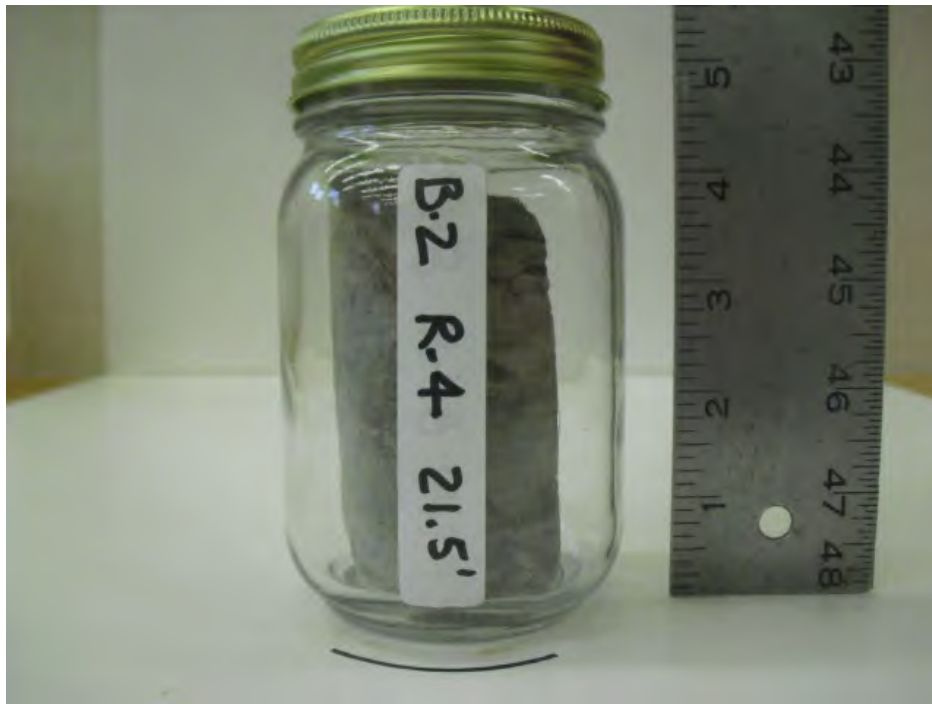
Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-2 R-4 21.5'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.01

Final Ph: 8.39

Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-2 R-5 25.1'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.53

Final Ph: 8.47

Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-2 R-7 35.0'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.53

Final Ph: 8.50

Slake Index Table

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

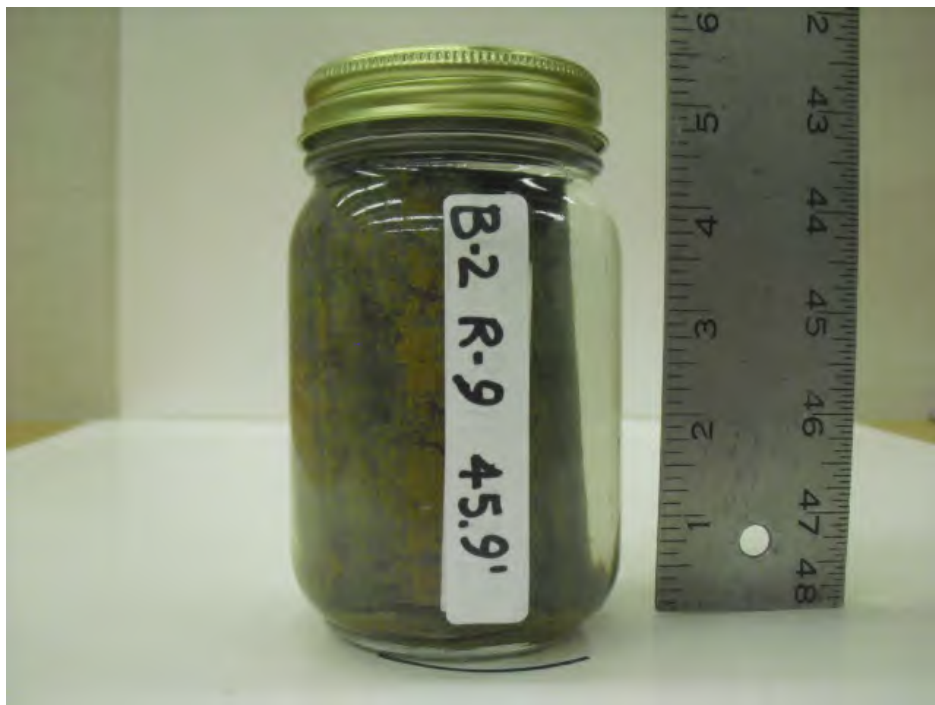
Jar Slake Index Descriptions

Slake Test

08031076 B-2 R-9 45.9'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.53

Final Ph: 8.53

Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-2 R-11 55.7'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.53

Final Ph: 8.55

Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-2 R-13 65.0'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.53

Final Ph: 8.61

Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-2 R-15 75.4'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.53

Final Ph: 8.58

Slake Index Table

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

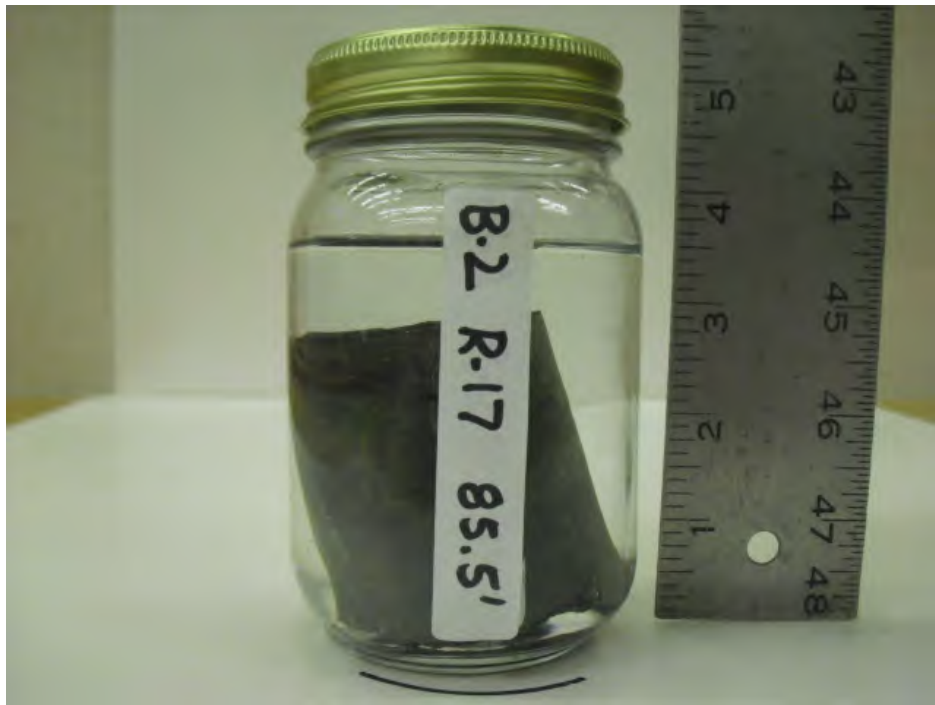
Jar Slake Index Descriptions

Slake Test

08031076 B-2 R-17 85.5'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.53

Final Ph: 8.48

Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-2 R-19 95.3'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.53

Final Ph: 8.68

Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-2 R-21 105.7'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.53

Final Ph: 8.67

Slake Index Table

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

Jar Slake Index Descriptions

Slake Test

08031076 B-2 R-23 115.3'



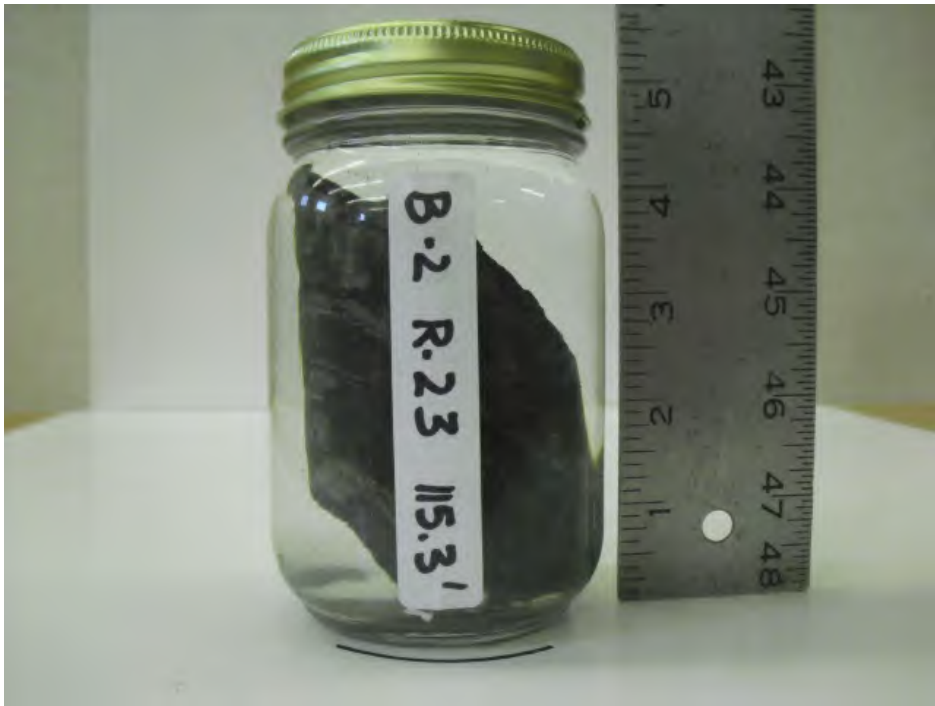
Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 9 & 10, 2017

Test Fluid: Distilled Water

Initial Ph: 5.53

Final Ph: 8.54

Slake Index Table

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

Jar Slake Index Descriptions



**ATTACHMENT 2
SOIL RESOURCES MAP AND PROFILE DESCRIPTIONS**



United States
Department of
Agriculture



Natural
Resources
Conservation
Service

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

Custom Soil Resource Report for Juniata and Mifflin Counties, Pennsylvania

Attachment 2 — Old Mill Road HDD Soil Map



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At—Atkins silt loam.....	13
BID—Berks-Weikert channery silt loams, 15 to 25 percent slopes.....	14
ErB—Ernest silt loam, 2 to 8 percent slopes.....	16
ErC—Ernest silt loam, 8 to 15 percent slopes.....	18
MoB—Monongahela silt loam, 3 to 8 percent slopes.....	19
Ty—Tyler silt loam.....	21
W—Water.....	22
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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

Custom Soil Resource Report

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

Custom Soil Resource Report

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

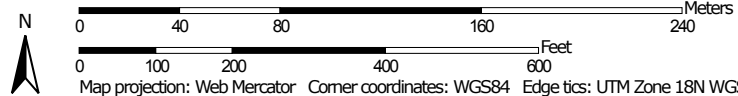
The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report Soil Map







































Soil Map may not be valid at this scale.

Map Scale: 1:3,010 if printed on A landscape (11" x 8.5") sheet.



MAP LEGEND

- Area of Interest (AOI)**
-  Area of Interest (AOI)
- Soils**
-  Soil Map Unit Polygons
-  Soil Map Unit Lines
-  Soil Map Unit Points
- Special Point Features**
-  Blowout
-  Borrow Pit
-  Clay Spot
-  Closed Depression
-  Gravel Pit
-  Gravelly Spot
-  Landfill
-  Lava Flow
-  Marsh or swamp
-  Mine or Quarry
-  Miscellaneous Water
-  Perennial Water
-  Rock Outcrop
-  Saline Spot
-  Sandy Spot
-  Severely Eroded Spot
-  Sinkhole
-  Slide or Slip
-  Sodic Spot
-  Spoil Area
-  Stony Spot
-  Very Stony Spot
-  Wet Spot
-  Other
-  Special Line Features
- Water Features**
-  Streams and Canals
- Transportation**
-  Rails
-  Interstate Highways
-  US Routes
-  Major Roads
-  Local Roads
- Background**
-  Aerial Photography

MAP INFORMATION

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

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

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

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

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

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

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

Soil Survey Area: Juniata and Mifflin Counties, Pennsylvania
 Survey Area Data: Version 15, Sep 19, 2018

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

Date(s) aerial images were photographed: Mar 23, 2010—Mar 10, 2017

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
At	Atkins silt loam	5.3	33.2%
BID	Berks-Weikert channery silt loams, 15 to 25 percent slopes	1.3	7.9%
ErB	Ernest silt loam, 2 to 8 percent slopes	1.1	6.7%
ErC	Ernest silt loam, 8 to 15 percent slopes	1.6	10.3%
MoB	Monongahela silt loam, 3 to 8 percent slopes	0.5	3.0%
Ty	Tyler silt loam	5.6	35.5%
W	Water	0.6	3.5%
Totals for Area of Interest		15.9	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

Custom Soil Resource Report

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.

Juniata and Mifflin Counties, Pennsylvania

At—Atkins silt loam

Map Unit Setting

National map unit symbol: 191b
Elevation: 200 to 3,000 feet
Mean annual precipitation: 32 to 55 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 120 to 214 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Atkins and similar soils: 85 percent
Minor components: 14 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Atkins

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Acid alluvium derived from sedimentary rock

Typical profile

H1 - 0 to 10 inches: silt loam
H2 - 10 to 30 inches: silt loam
H3 - 30 to 60 inches: gravelly silty clay loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 60 to 99 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 high
(0.06 to 2.00 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.9 inches)

Interpretive groups

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

Minor Components

Philo

Percent of map unit: 6 percent
Hydric soil rating: No

Barbour

Percent of map unit: 6 percent
Hydric soil rating: No

Saprists

Percent of map unit: 2 percent
Landform: Depressions
Hydric soil rating: Yes

BID—Berks-Weikert channery silt loams, 15 to 25 percent slopes

Map Unit Setting

National map unit symbol: 2sgbp
Elevation: 410 to 3,570 feet
Mean annual precipitation: 37 to 50 inches
Mean annual air temperature: 47 to 56 degrees F
Frost-free period: 148 to 192 days
Farmland classification: Not prime farmland

Map Unit Composition

Berks and similar soils: 50 percent
Weikert and similar soils: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Berks

Setting

Landform: Ridges
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex, linear
Parent material: Residuum weathered from shale and siltstone and/or fine grained sandstone

Typical profile

A - 0 to 7 inches: channery silt loam
Bw1 - 7 to 14 inches: channery silt loam
Bw2 - 14 to 21 inches: very channery silt loam
C - 21 to 36 inches: extremely channery silt loam
R - 36 to 46 inches: bedrock

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: 20 to 40 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 (0.57 to 5.95 in/hr)

Custom Soil Resource Report

Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 1 percent
Gypsum, maximum in profile: 1 percent
Salinity, maximum in profile: Nonsaline (0.0 to 1.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Other vegetative classification: Dry Uplands (DU2)
Hydric soil rating: No

Description of Weikert

Setting

Landform: Ridges
Landform position (two-dimensional): Shoulder, backslope, summit
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex, linear
Parent material: Gray and brown acid residuum weathered from shale and siltstone and/or fine grained sandstone

Typical profile

A - 0 to 6 inches: channery silt loam
Bw - 6 to 12 inches: very channery silt loam
C - 12 to 15 inches: extremely channery silt loam
R - 15 to 25 inches: bedrock

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Natural drainage class: Somewhat excessively drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.0 mmhos/cm)
Available water storage in profile: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Other vegetative classification: Droughty Shales (SD3)
Hydric soil rating: No

Minor Components

Ernest

Percent of map unit: 5 percent

Custom Soil Resource Report

Landform: Ridges

Landform position (two-dimensional): Summit, shoulder, backslope

Landform position (three-dimensional): Head slope, base slope

Down-slope shape: Convex, concave

Across-slope shape: Convex, linear

Hydric soil rating: No

Blairton

Percent of map unit: 5 percent

Landform: Ridges

Landform position (two-dimensional): Shoulder, backslope, summit

Landform position (three-dimensional): Side slope

Down-slope shape: Concave

Across-slope shape: Concave

Hydric soil rating: No

Bedington

Percent of map unit: 4 percent

Landform: Ridges

Landform position (two-dimensional): Summit, shoulder, backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Convex

Across-slope shape: Convex, linear

Hydric soil rating: No

Typic endoaquults

Percent of map unit: 1 percent

Landform: Ridges

Landform position (two-dimensional): Summit, shoulder, backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Concave

Across-slope shape: Concave, linear

Hydric soil rating: Yes

ErB—Ernest silt loam, 2 to 8 percent slopes

Map Unit Setting

National map unit symbol: 19m5

Elevation: 900 to 1,800 feet

Mean annual precipitation: 36 to 46 inches

Mean annual air temperature: 41 to 62 degrees F

Frost-free period: 130 to 160 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Ernest and similar soils: 85 percent

Minor components: 15 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ernest

Setting

Landform: Hillslopes
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Head slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Acid fine-loamy colluvium derived from shale and siltstone

Typical profile

Ap - 0 to 8 inches: silt loam
Bt - 8 to 24 inches: silty clay loam
Btx - 24 to 50 inches: channery silt loam
C - 50 to 74 inches: channery silt loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 36 inches to fragipan
Natural drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.33 in/hr)
Depth to water table: About 17 to 22 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.6 inches)

Interpretive groups

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

Minor Components

Brinkerton

Percent of map unit: 5 percent
Landform: Draws, hills
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: Yes

Gilpin

Percent of map unit: 5 percent
Landform: Hills
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex, linear
Hydric soil rating: No

Lobdell

Percent of map unit: 5 percent
Landform: Flood plains

Custom Soil Resource Report

Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

ErC—Ernest silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 19m6
Elevation: 300 to 3,000 feet
Mean annual precipitation: 30 to 65 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 120 to 214 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

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

Description of Ernest

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Parent material: Local fine-silty colluvium derived from sedimentary rock

Typical profile

H1 - 0 to 10 inches: silt loam
H2 - 10 to 31 inches: silty clay loam
H3 - 31 to 43 inches: channery silt loam
H4 - 43 to 63 inches: channery silt loam

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 18 to 36 inches to fragipan
Natural drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.60 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e

Custom Soil Resource Report

Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Brinkerton

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

Berks

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

Wharton

Percent of map unit: 3 percent
Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Interfluvium, side slope, head slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: No

Blairton

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

MoB—Monongahela silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 19nd
Elevation: 300 to 1,800 feet
Mean annual precipitation: 30 to 55 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 110 to 187 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

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

Description of Monongahela

Setting

Landform: Stream terraces
Landform position (two-dimensional): Toeslope

Custom Soil Resource Report

Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Old alluvium derived from sedimentary rock

Typical profile

H1 - 0 to 10 inches: silt loam
H2 - 10 to 23 inches: silt loam
H3 - 23 to 48 inches: loam
H4 - 48 to 63 inches: silt loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 18 to 30 inches to fragipan
Natural drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.60 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.1 inches)

Interpretive groups

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

Minor Components

Unadilla

Percent of map unit: 7 percent
Landform: Outwash terraces
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Wheeling

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

Lakin

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

Holly

Percent of map unit: 3 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Ty—Tyler silt loam

Map Unit Setting

National map unit symbol: 19nz

Elevation: 300 to 2,000 feet

Mean annual precipitation: 35 to 55 inches

Mean annual air temperature: 45 to 59 degrees F

Frost-free period: 120 to 180 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Tyler and similar soils: 90 percent

Minor components: 10 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tyler

Setting

Landform: Terraces

Landform position (two-dimensional): Toeslope

Landform position (three-dimensional): Tread

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Old silty alluvium

Typical profile

H1 - 0 to 15 inches: silt loam

H2 - 15 to 21 inches: silt loam

H3 - 21 to 46 inches: silt loam

H4 - 46 to 60 inches: loam

Properties and qualities

Slope: 0 to 3 percent

Depth to restrictive feature: 15 to 24 inches to fragipan

Natural drainage class: Somewhat poorly drained

Runoff class: Very high

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)

Depth to water table: About 6 to 18 inches

Frequency of flooding: None

Frequency of ponding: None

Salinity, maximum in profile: Nonsaline (0.0 to 0.2 mmhos/cm)

Available water storage in profile: Low (about 4.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 3w

Hydrologic Soil Group: D

Hydric soil rating: No

Minor Components

Purdy

Percent of map unit: 5 percent
Landform: Depressions
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Monongahela

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

W—Water

Map Unit Setting

National map unit symbol: 19p1
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 120 to 214 days
Farmland classification: Not prime farmland

Map Unit Composition

Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Water

Setting

Parent material: Rivers streams ponds

Properties and qualities

Runoff class: Negligible
Frequency of ponding: Frequent



**ATTACHMENT 3
450-FOOT WELL SURVEY**

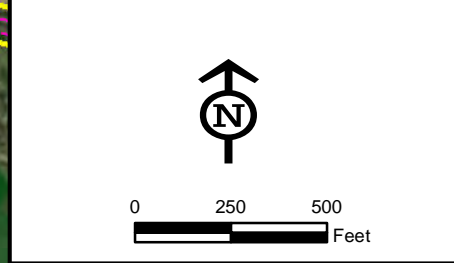
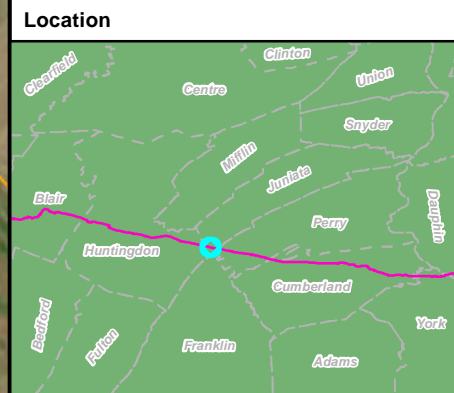
GES Well ID	Distance to HDD Perpendicular (Feet)	Distance to HDD Entry/Exit (Feet)	Well Information		
			Reported DTB (Feet)	Reported DTW (Feet)	Reported Pump Depth
WL-09212017-614-01	1,129	1,238	Unknown	Unknown	Unknown

Legend

- LOD
- Parcel
- HDD
- PPP Centerline
- 450 foot buffer of HDD alignment
- Public Water Supply/Landowner Confirmed No Well

****Testing locations current as of 01/14/2019**

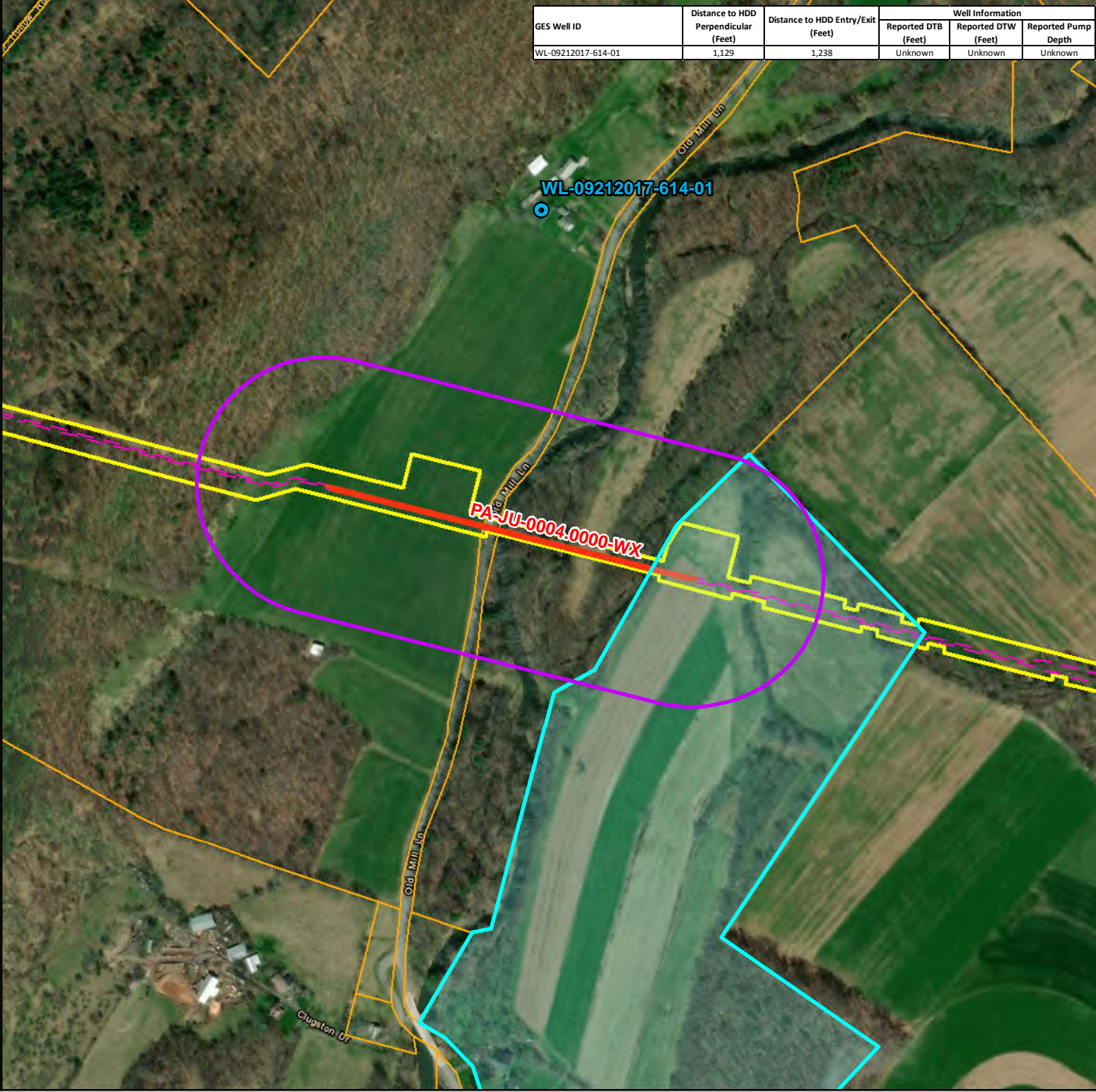
- GES Testing Location



Well Location Map
HDD# PA-JU-0004.0000-WX
Juniata County, PA.

Prepared By:	Date: 1/14/2019
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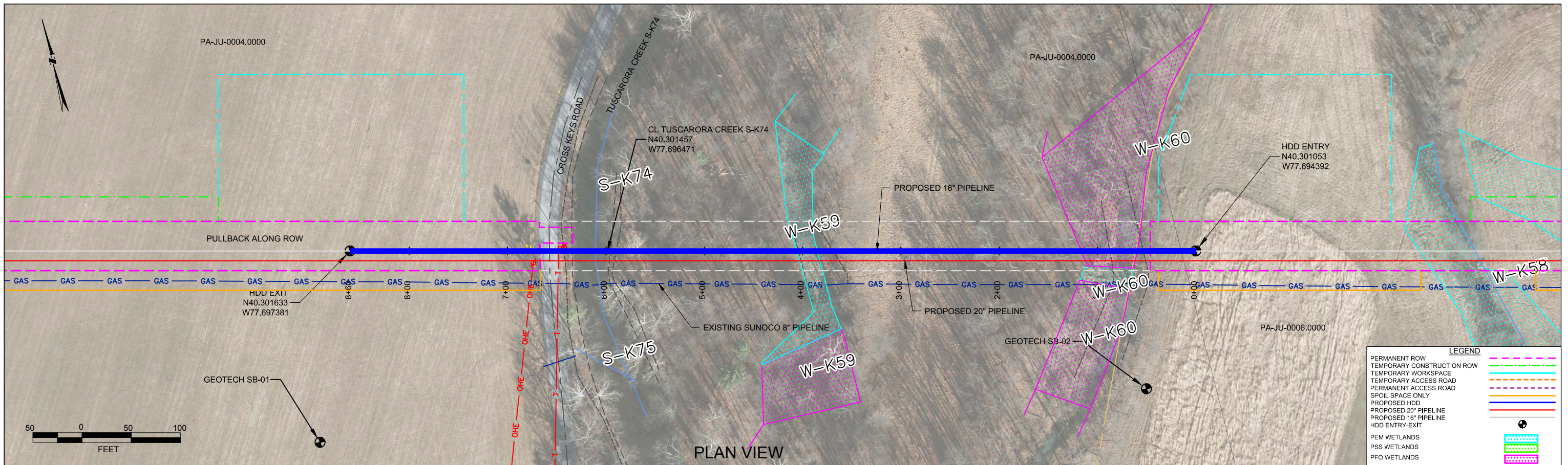
Base Map:
 ESRI World Imagery, 09/24/2015
 Coordinate System: NAD 83 Stateplane, PA South, Feet



C:\GIS\workspace\Tetra\Projects\PA\PA\WellLocations\WellLocations_PA_JU_0004_0000.mxd

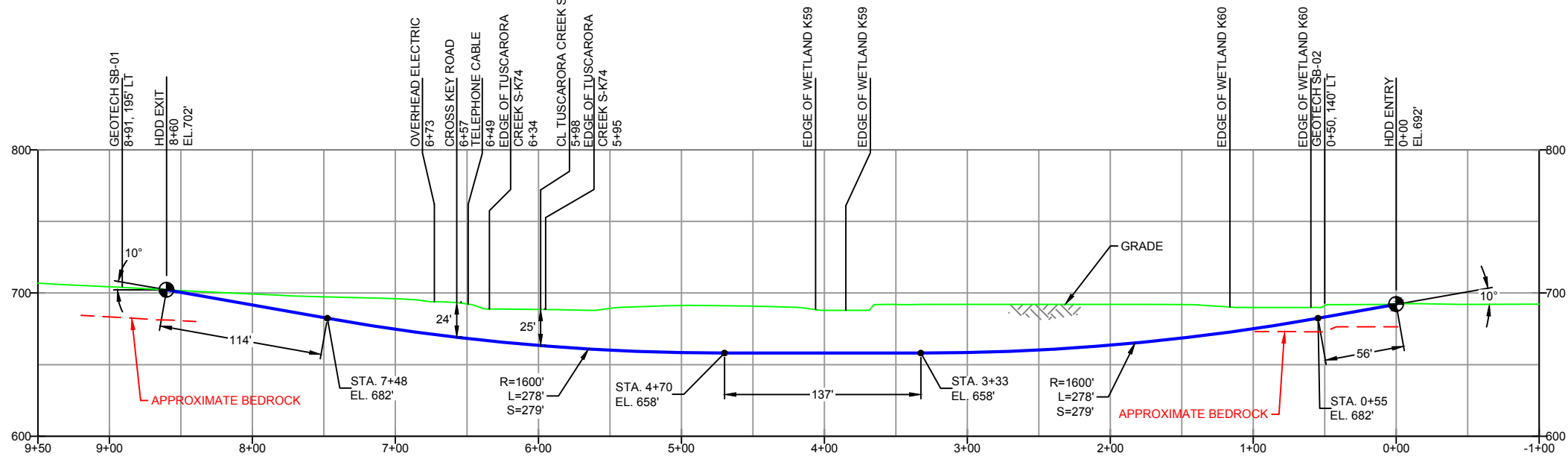
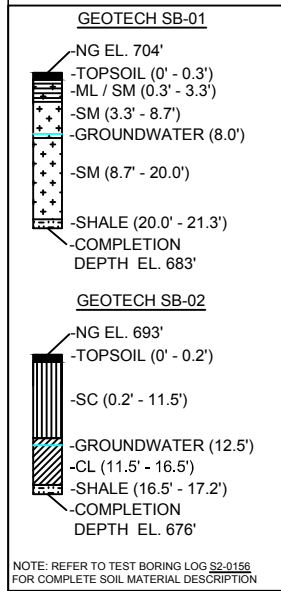
**OLD MILL ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E34-136
PA-JU-0004.0000-WX-16
(SPLP HDD No. S2-0156-16)**

**ATTACHMENT 2
PERMITTED 16-INCH HDD PLAN AND PROFILE
REVISED 16-INCH HDD PLAN AND PROFILE**



JUNIATA COUNTY PENNSYLVANIA, LACK TOWNSHIP
S2-0156-16

PROFILE VIEW

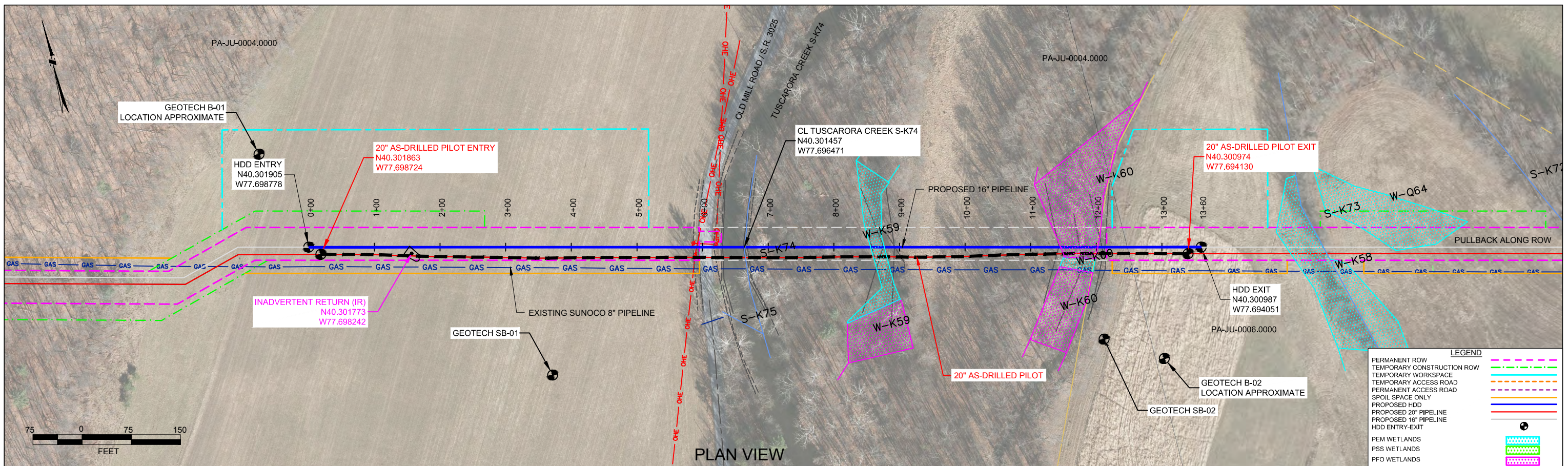


DESIGN AND CONSTRUCTION:

- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
- THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
- DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
- CROSSING PIPE SPECIFICATION:
HDD HORZ. LENGTH (L)=860'
HDD PIPE LENGTH (S)=865'
16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
- INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
- INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
- PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
- CARRIER PIPE NOT ENCASED.
- PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
- CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
- SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
- SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
- SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

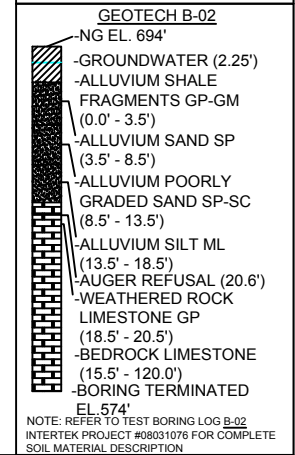
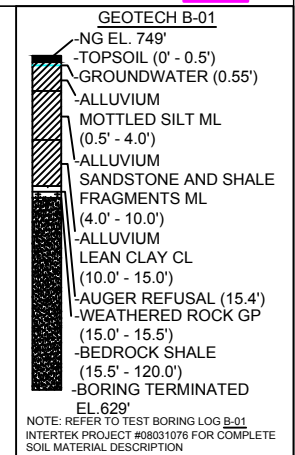
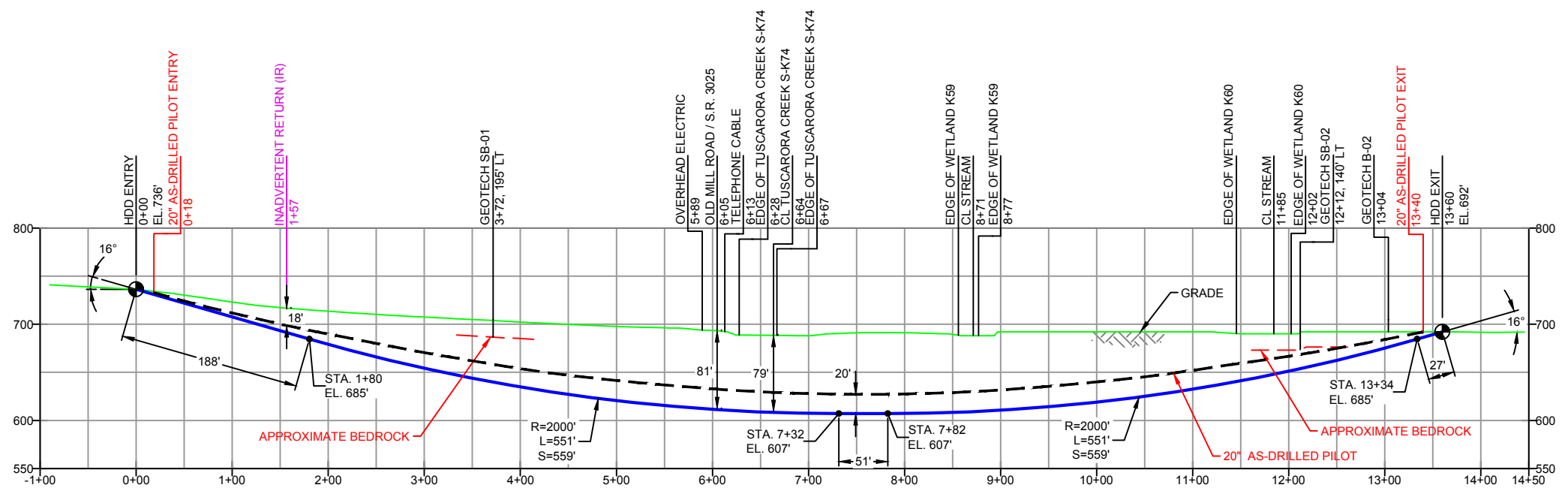
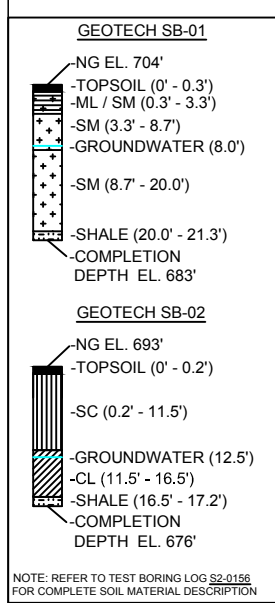
Figure 1. Original/Permitted 16-Inch HDD Plan and Profile

NOTES		REF. DRAWING		REVISIONS						SUNOCO PIPELINE, L.P.				
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.		ES-3.05	TO ES-3.05	EROSION & SEDIMENT PLAN	EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	DLM	10/07/16	RMB	10/07/16	AAW	10/07/16	16-INCH HORIZONTAL DIRECTIONAL DRILL CROSS KEYS RD PENNSYLVANIA PIPELINE PROJECT	
		SHEET 3	TO SHEET 3	AERIAL SITE PLAN	EP1	REVISED PER PADEP COMMENTS	JTW	05/18/16	RMB	05/18/16	AAW	05/18/16		
					EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16	SCALE: 1"=100' DWG. NO: PA-JU-0004.0000-WX-16	
					B	ADDED GEOTECH INFO	MRS	09/14/15	RMB	09/14/15	AAW	09/14/15		
					A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15	SUNOCO LOGISTICS Partners L.P. TETRA TECH ROONEY (303) 792-5911	
		DWG NO	TO DWG NO	DESCRIPTION	NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE		



JUNIATA COUNTY PENNSYLVANIA, LACK TOWNSHIP
S2-0156-16

PROFILE VIEW



- DESIGN AND CONSTRUCTION:
- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
 - THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
 - DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
 - CROSSING PIPE SPECIFICATION:
HDD HORZ. LENGTH (L)=1360'
HDD PIPE LENGTH (S)=1383'
16" x 0.438" W.T. X-70, API5L, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
 - INTERNAL DESIGN PRESSURE 2100 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 - CARRIER PIPE NOT ENCASED.
 - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 2625 PSIG.
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
 - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
 - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

Figure 2. Redesigned 16-Inch HDD Plan and Profile

NOTES

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

REF. DRAWING		REVISIONS	
ES-3.05	TO	NO.	DESCRIPTION
ES-3.05	TO SHEET 3	EP5	UPDATED NOTE 5 AND 10 PER INCREASED 16" MOP AND ADDED GEOTECH
		EP4	MODIFIED ENTRY SIDE ATWS TO MATCH LAND ACQUISITION
		EP3	RELOCATED ENTRY/EXIT AND INCREASED DEPTH OF DRILL PER CLIENT REQUEST
		EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16
		EP1	REVISED PER PADEP COMMENTS
		EP	
DWG NO	DWG NO	NO.	DESCRIPTION

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
BERRY RIDGE ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'
DWG. NO: PA-JU-0004.000-WX-16