HORIZONTAL DIRECTIONAL DRILL ANALYSIS
BLACKLOG CREEK CROSSING
PADEP SECTION 105 PERMIT NO.: E31-234
PA-HU-0106.0000-RD-16
(SPLP HDD No. S2-0154-16)

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This reanalysis of the horizontal directional drill (HDD) installation of a 16-inch diameter pipeline that traverses Blacklog Creek in Shirley Township, Huntingdon County, Pennsylvania is in accordance with Condition No. 3 of the Stipulated Order issued under Environmental Hearing Board Docket No. 2017-009-L. Condition No. 3 stipulates, for HDDs initiated after the temporary injunction issued by the Pennsylvania Department of Environmental Protection (PADEP) Environmental Hearing Board on July 25, 2017, a reanalysis must be performed on HDDs for which an inadvertent return (IR) occurs during the installation of one pipeline (20-inch or 16-inch diameter) where a second pipeline will thereafter be installed in the same right-of-way (ROW).

The 20-inch HDD was initiated after July 25, 2017 and an IR occurred during its installation, thereby necessitating a reevaluation before the installation of the second pipeline (16-inch) can commence. The IRs associated with the HDD of the 20-inch pipeline were remediated and installation of the 20-inch pipeline is complete.

The 16-inch pipeline HDD is referred to herein as HDD S2-0154-16.

PIPELINE INFORMATION

16-Inch: 0.438 wall thickness; X-70

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

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 1,185 feet (ft)
- Entry/Exit angle: 12-14 degrees
- Maximum depth of cover: 45 ft
- Depth of cover under Blacklog Creek: 40ft
- Depth of cover under wetlands: 30 ft'
- Pipeline design radius: 1,600 ft

ROOT CAUSE ANALYSIS FOR THE 20-INCH PIPELINE INSTALLATION IR

The three (3) IR events during the installation of the 20-inch pipeline occurred during drilling of the pilot hole. Based on the location of the IR above the HDD profile, pilot tool location, and setting in the landscape and underlying geology, the IR likely resulted from the presence of jointed and fractured bedrock with low to high angle joints within the formation at this location in the profile that allowed for the movement of drilling fluids to the land surface. No IRs occurred during the reaming phase and installation of the 20-inch pipeline.

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

HDD S2-0154-16 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. Local topography is characterized by

northeast to southwest trending succession of long narrow ridges and broad to narrow valleys, with some karst terrain. The HDD site straddles the axis of a northeast/southwest trending anticline.

Karst geology is not present at this HDD location. SPLP possesses a complete geologic profile from drilling of the 20-inch pipeline and vertical geotechnical cores. No further information is needed to assess the 16-inch HDD.

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

HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

Groundwater along the HDD occurs in a fractured clastic sedimentary bedrock aquifer system within the geology described in the preceding section. In these rock types of Huntingdon 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.

A review of published data on water wells provided information on the hydrogeology underlying the HDD profile. The reported depths of 38 domestic and nondomestic wells in the Reedsville Formation ranged from 31 to 435 feet below ground surface (bgs). The median depth for domestic and nondomestic wells was 130 feet. Well yields ranged from 1 to 50 gallons per minute (gpm) and the median well yield was 12 gpm for domestic wells and 20 gpm for nondomestic wells

Well records reviewed within a 0.5-mile radius of the HDD location were obtained from the Pennsylvania Groundwater Information System, only one well was identified; the depth of the well was 112 ft.

SPLP subcontractors have researched private water supplies within 450 feet of this HDD. One water supply well was identified within the 450-foot buffer of the alignment; however, a second water supply well was located on a parcel within 450’ of the HDD, but the location of the well itself was approximately 520 feet from the HDD alignment. The reported depths for these wells range from 60 to 179 feet bgs. Information regarding depth to water was not known for either of these wells.

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

INADVERTENT RETURN (IR) DISCUSSION

As discussed above, the occurrence of the three (3) IR events during the pilot phase of the 20-inch pipeline are likely to have been caused by the shallow depth of profile and presence of jointed and fractured bedrock with low to high angle joints within the formation at the point of the IR, as indicated by geologic mapping, published reports and field observations.

HDD specialists for SPLP reviewed the original HDD designs summarized above, available geologic/ geotechnical data, field reports related to IR events that occurred during installation of the 20” pipeline, and the hydro-structural characteristics of the underlying geology, and have adjusted to the profile for the 16-inch pipeline.

The 16-inch HDD profile has been lengthened and deepened to provide additional cover beneath the stream (Black Log Creek) and wetlands that underlie the HDD profile, and the entry/exit angles have been increased to allow the HDD to enter into and exit out of more competent bedrock as quick as

practicable. The redesigned HDD profile and HDD best management practices during drilling operations will be used to reduce and manage the risk of an IR.

ADJACENT FEATURES ANALYSIS

The crossing of Blacklog Creek (stream S-K94) is located in Shirley Township, Huntingdon County, approximately 5.3 miles (mi) southeast of the community of Allenport, Pennsylvania. The pipeline route follows parallel to an existing SPLP easement and crosses under Blacklog Creek from approximately 0.3 mi south/southwest of the intersection of State Road 2017 and State Road 2012, in Shirley Township.

This HDD location is set under one stream and two wetlands. Stream S-K94 (Blacklog Creek) is designated as a high quality coldwater fishery and migratory fishery under Pennsylvania Code Chapter 93 and is classified as an approved trout water and stocked trout water. Wetlands K69 and K70 are not designated as exceptional value wetlands; however, both wetland provide buffers and are riparian to Blacklog Creek. Wetland K69 has multiple components, with vegetation classes of emergent and scrub-shrub. Wetland K70 is a forested wetland. This HDD avoids surficial impacts to: stream S-K94 (Blacklog Creek), designated as a coldwater fishery that also is an approved trout water and stocked trout water, and wetlands K69 and K70. Additionally, this HDD avoids surficial impacts to the floodway of stream S-K94, a Federal Emergency Management Agency (FEMA) 100-year floodplain (Chapter 106 area), forested and scrub-shrub wetlands, and State Road 2017.

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

As a result of these communications, one water supply well was identified within the 450-foot buffer of the alignment. A second water supply well was located on a parcel within 450' of the HDD; however the location of the well itself is approximately 520 feet from the HDD alignment. A map depicting the location of these water wells is provided within the Hydrogeology Report included as Attachment 1 of this reevaluation.

To further avoid and mitigate any adverse effects from the HDD to private water wells, and in accordance with the requirements of the Stipulated Order, SPLP will transmit a copy of this HDD analysis to all landowners having a property line within 450 feet of any direction of this HDD location.

ALTERNATIVES ANALYSIS

As part of the PADEP Chapter 105 permit process for the Mariner II East Project, SPLP developed and submitted for review a project-wide Alternatives Analysis. During the development and siting of the project, SPLP considered a number of different routings, locations, and designs to determine whether there was a practicable alternative to the proposed route. SPLP performed this determination through a sequential review of routes and design techniques, which concluded with an alternative that has the least environmental impacts, taking into consideration cost, existing technology and logistics. The baseline route provided for the pipeline construction was to cross every wetland and stream on the project by open

cut construction procedures. The Alternatives Analysis submitted to PADEP conceptually analyzed the potential feasibility of any alternative to baseline route trenched resource crossings (e.g., reroute, conventional bore, HDD). The decision-making processes for selection of the HDD instead of an open cut crossing methodology is discussed thoroughly in the submitted alternatives analysis and was an important part of the overall PADEP approval of HDD plans as currently permitted. As described below, the open cut and re-route analyses have confirmed the conclusions reached in the previously submitted Alternatives Analysis.

The proposed HDD is an alternative plan of installation to a conventional open trench construction plan to avoid impacts to Blacklog Creek (stream S-K94), a high quality coldwater fishery and migratory fishery, and conversion of scrub-shrub and forested wetlands (wetlands K69 and K70, respectively). Additionally, it avoids direct affects to the floodway of Blacklog Creek, a FEMA 100-year floodplain (Chapter 106 area), Blacklog Valley Road, and a parallel utility. Alteration of the current permitted route and plans for installation would require major modifications of the state Chapter 102 and Chapter 105 permits, and authorization issued by the U.S. Army Corps of Engineers.

Open-cut and Conventional Bore Analysis

SPLP specifications require a minimum of 48-inches of cover over the installed pipeline below ground and below the bottom of watercourses. To meet this cover requirement, construction through the one stream and two wetlands at this location would require a minimum authorized open cut work space 75 ft in width to accommodate the 16-inch pipeline, allowing for the pipeline to be installed with sufficient separation for integrity management. The assessed area of impact by this open cut plan would directly affect: 1,600 square feet of state water bottoms; 0.22 acre of floodway; 0.99 acre of wetlands, including 0.20 acre of forested wetland conversion; 0.63 acre of FEMA floodplain (Chapter 106 area); and 0.37 acre of forested woodlands.

A conventional auger bore is a practical means of pipeline installation where the topography is conducive, groundwater is manageable, and the length is ideally less than 200 ft, varying by substrate conditions at the location. The horizontal length of this crossing (1,185 ft) is beyond the technically practicable limits of an auger bore to complete regardless of substrate conditions.

In summary, a combination of open-cut and conventional bores is not feasible as an alternative to the Blacklog Creek HDD.

Re-Route Analysis

This pipeline route as currently permitted follows an existing SPLP pipeline easement. Although another existing utility easement is located to the north in the vicinity of this HDD, it deviates in a northwesterly direction away from the existing SPLP pipeline easement. To reconnect with the SPLP pipeline easement, new “greenfield” impacts through forested lands between the other utility easement and the SPLP pipeline easement would be necessary. A re-route to the north would result in additional environmental impacts and is therefore not considered a practicable re-route option. Although the Buckeye utility easement is approximately 950 feet to the southwest and parallels the SPLP pipeline easement, use of this easement is not a practicable re-route option given it would still transect Blacklog Creek (stream S-K94), its associated floodway, a FEMA 100-year floodplain (Chapter 106 area), scrub-shrub and/or forested wetlands, and the same forested woodlands.

This re-route analysis conducted for the Blacklog Creek HDD confirms the conclusions reached in the previously submitted alternatives analysis.

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HORIZONTAL DIRECTIONAL DRILL REDESIGN

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

Revised Horizontal Directional Drill Design Summary: 16-inch

- Horizontal length: 1,395 ft
- Entry/Exit angle: 16-17 degrees
- Maximum Depth of cover: 70 ft
- Depth below Blacklog Creek: 67 ft
- Depth below wetlands: 47-67 ft
- Pipeline design radius: 2,000 ft

CONCLUSION

The redesigned HDD extends the profile by 210 ft, increases the entry and exit angles, and adjusts the HDD profile deeper to minimize the risk of drilling fluid loss and IRs.

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

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

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

- SPLP will mandate short-tripping of the reaming tools to ensure an open annulus is maintained to manage the potential inducement of IRs;

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

- During all drilling phases, the use of Loss Control Materials (LCMs) will be implemented upon detection of a Loss of Circulation (LOC) or indications of a potential IR are noted or an IR is observed. The use of LCMs, however, is less effective below 70 ft of the ground surface. This HDD has greater than 70 ft of elevation difference between the western exit and the bottom of the HDD profile; therefore the AP below that depth can exceed the effective stabilization capability of LCMs. Accordingly, the preferred corrective action needed to address the presence of fractures or Losses of Circulation at greater depths below ground will require grouting of the HDD annulus. Two types of grouting will be utilized for corrective actions to seal fractures and stabilize zones of weak geology. These are: 1) grouting using "neat cement"; and 2) grouting using a sand/cement

mix. Neat cement grout is a slurry of Portland cement and water which is highly reactive to bentonite and induces solidification. The sand/cement grout mix is a slurry of mostly sand with a small percentage of Portland cement and activators that after setup results in a material having the competency of a friable sandstone or mortar. Both grouting actions require tripping out the drilling tool, and then tripping in with an open-ended drill stem to apply or inject the grout mixes.

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FEASIBILITY DETERMINATION

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

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

2-17-2019
Date

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

Pertaining to the practice of geology

2/17/18
Date

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

Pertaining to the pipeline stress and HDD geometry

2/16/19
Date

Jeffrey A. Lowy, P.E.
License No. PE 082759
Rooney Engineering, Inc.
Civil Engineer

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ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT

RETTEW

We answer to you.

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Engineers
Environmental Consultants
Surveyors
Landscape Architects
Safety Consultants

February 13, 2019

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

RE: Sunoco Pipeline, LP Pipeline Project - Mariner East II
SR 2017/Blacklog Creek HDD (S2-0154), PA-HU-0106.0000-RD-16
Hydrogeological Re-Evaluation Report for the 16-Inch Pipeline
Shirley Township, Huntingdon County, Pennsylvania
RETTEW Project No. 096302011

EXECUTIVE SUMMARY

1. This hydrogeologic re-evaluation report was prepared as a result of inadvertent returns (IRs) that occurred when the SR 2017/Blacklog Creek horizontal directional drill (HDD) location S2-0154 20-inch pilot boring was being advanced. A root cause analysis determined that the IRs were likely caused by the presence of jointed and fractured bedrock with low to high angle joints within the underlying geologic formation.
2. The site is underlain by clastic sedimentary rocks of the Ordovician-age Reedsville Formation (Or).
3. Water-bearing zones generally occur in secondary openings along bedding planes, joints, faults, and fractures. Most of the water-bearing zones occur in individual fractures or groups of interconnected fractures.
4. Reported median well depth in the Reedsville Formation is 130 feet below the ground surface (bgs). Based on published information, well yields range from 1 to 50 gallons per minute (gpm) with a median well yield of 12 gpm for domestic wells and 20 gpm for nondomestic wells.
5. The HDD profile for the proposed 16-inch HDD has been redesigned to increase its depth beneath the stream and wetland resources.
6. Based on the hydro-structural characteristics of the underlying geology, information obtained during installation of the 20-inch pipe, IRs that occurred during installation of the 20-inch HDD pilot boring, and the permitted SR 2017/Blacklog Creek 16-inch HDD profile within shallow unconsolidated soil materials and generally shallow bedrock, the proposed 16-inch HDD is susceptible to an IR of drilling fluids during HDD operations. A redesigned 16-inch HDD profile and proactive HDD best management practices will be used during drilling operations 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 SR 2017/Blacklog Creek S2-0154 horizontal directional drill (HDD) location on the Sunoco Pipeline, L.P. (SPLP) Pennsylvania Pipeline Project - Mariner East II (PPP-ME2) Project. The SR 2017/Blacklog Creek HDD is located in

Shirley Township, Huntingdon County, Pennsylvania as shown on **Figure 1**. The HDD was originally designed to be drilled under two wetlands (W-K69 and W-K70), Blacklog Creek (S-K94), and SR 2017/Blacklog Valley Road. The redesigned 16-inch HDD profile crosses beneath these same features. This hydrogeologic re-evaluation report was prepared as a result of the inadvertent returns (IRs) that occurred as the SR 2017/Blacklog Creek HDD 20-inch pipeline pilot boring was being advanced.

The permitted 16-inch HDD profile was redesigned on January 24, 2019. The overall length of the HDD profile and the inclination of the entry and exit angles has been increased to increase the amount of cover under sensitive receptors and to install the boring into bedrock quicker than the original, shorter and shallower profile. The redesigned western HDD entry/exit is at a surface elevation of approximately 899 feet above mean sea level (AMSL) and the redesigned eastern HDD entry/exit is at an elevation of approximately of 863 feet AMSL. The permitted HDD profile was extended 210 feet to the east and west resulting in a new horizontal length of 1,395 feet and a new boring/pipe length of 1,421 feet. The inclination of the western and eastern entry/exit angles has been increased to approximately 17^{o} and 16^{o}, respectively, to allow the pipe to be installed through the soils and bedrock in closer proximity to the entry and exit points, and to deepen the profile to approximately 67 feet below Blacklog Creek (this is approximately 20 feet deeper than the as-built 20-inch pipe). The locations of the as-built 20-inch and proposed 16-inch, SR 2017/Blacklog Creek HDD profiles are shown on **Figure 1**, and the redesigned 16-inch profile detail 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). The SR 2017/Blacklog HDD site straddles the axis of a northeast-southwest trending anticline. Based on the United States Geologic Survey (USGS) 7.5-Minute Aughwick Topographic Quadrangle Map shown on **Figure 1**, the site is situated at an approximate elevation range of 900 to 860 feet AMSL. Surface topography at the site slopes to the east and west along the HDD profile toward Blacklog Creek. The major surface water feature proximate to the SR2017/Blacklog Creek HDD is Blacklog Creek which flows to the southwest before discharging into Shade Creek and ultimately into Aughwick Creek.

The site geology for the SR 2017/Blacklog Creek HDD profile is mapped as the Ordovician-age Reedsville Formation (Or) as shown on **Figure 2** (Berg and Dodge, 1981). The Reedsville Formation consists of moderately well bedded dark-gray shale containing thin sandy to silty shale interbeds and some siltstone and sandstone layers near the top of the formation. The sandstone layers near the top of the formation have graded beds and are very fossiliferous, while the shale beds tend to be fissile to thick bedded. The thickness of the Reedsville Formation ranges from 1,000 to 2,000 feet (Taylor et al., 1982). The formation is moderately well bedded with thin beds. The joints, which have a seamy to platy pattern, are well developed and highly abundant, are variably spaced with a close distance between fractures. The joints are open and steeply dipping. The joints, bedding and fracture-plane openings provide a secondary porosity of low magnitude and low permeability. This formation is slightly resistant to weathering and is typically moderately to highly weathered to a moderate to deep depth. Weathering results in loose rubble containing individual fragments with shapes ranging from pencil-like to

rectangular plates with an overlying thin soil mantle. From an engineering standpoint, excavation is classified as moderately easy, although slight rebound may be a special problem. Drilling rates are typically classified as fast; however, sandy shale interbeds could reduce the penetration rate. Cut-slope stability is fair due to rapid disintegration once the formation is exposed to moisture. Foundation stability is good, as long as the excavation reaches sound material. Surface drainage is good (Geyer and Wilshusen, 1982).

According to the United States Department of Agriculture (USDA) Soil Surveys of Huntingdon County, Pennsylvania, soils in the vicinity of the SR 2017/Blacklog Creek HDD consist of seven separate soil units. A USDA map that depicts the mapped area, along with the soil profile descriptions, is included as **Attachment 2**.

3.0 HYDROGEOLOGY

Groundwater at the site occurs in a fractured clastic sedimentary bedrock aquifer system within the geology described above. 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 (Taylor et al., 1982).

A review of published data on water wells provided information on the hydrogeology underlying the HDD profile. Reported depths of domestic and nondomestic wells in the Reedsville Formation range from 31 to 435 feet below ground surface (bgs). The median depth reported for domestic and nondomestic wells was 130 feet. Well yields of 38 water wells ranged from 1 to 50 gallons per minute (gpm) with a median well yield of 12 gpm for domestic wells and 20 gpm for nondomestic wells. The limited data available regarding well yields indicates that abundant water-bearing zones are available in the 50- to 150-foot depth range bgs. A few water-bearing zones are present at depths below 200 feet bgs, with the deepest reported zone at 350 feet bgs (Taylor et al., 1982).

A water well records search of the Pennsylvania Groundwater Information System (PaGWIS, January 15, 2018) was completed within a 0.5-mile radius of the SR 2017/Blacklog Creek HDD. Only one well record was available within the 0.5 search radius and is summarized below. The well location is shown on **Figures 2** and **3.**

Well No.	Well Use	Casing Depth	Total Depth	Water Level	Yield
116609	Domestic	28 feet	112 feet	20 feet	100 gpm

In January 2019, other Sunoco subcontractors researched private water supplies within a 450-foot radius of the SR 2017/Blacklog Creek HDD. One private water supply well was identified within the 450-foot buffer of the alignment; however, a second water supply well was located approximately 521 feet perpendicular to the HDD alignment. The reported depths for these wells range from 60 to 179 feet bgs. Information regarding depth to water and well yield was not known for either of these additional wells. In addition to the two water supply wells, a spring was identified 1,056 feet from the eastern HDD entry/exit. A map of these spring and well locations is included as **Attachment 3**.

4.0 FRACTURE TRACE ANALYSIS

Fracture traces underlying, or in close proximity to, the SR 2017/Blacklog Creek HDD were evaluated using historical aerial photographs from the years 1994 through 2015 (Google Earth, 2017), the

Aughwick, PA USGS 7.5 Minute Quadrangle Topographic Map, the Frankstown 7.5 Minute Quadrangle Geologic Map (Berg and Dodge, 1981), and the 2007 digital color orthophoto (PASDA, 2007-2008). The aerial photographs and maps were used to approximate the 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 SR 2017/Blacklog HDD.

Figures 2 and **3** show the results of the fracture trace analysis overlain on the geologic map and aerial base map, respectively. Twelve fracture traces were identified in close proximity to the proposed SR 2017/Blacklog Creek 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, several of the fracture traces trend approximately northeast-southwest (NE-SW) and perpendicular to the HDD alignment. Additional fracture traces were identified in an approximately west-east (W-E) orientation crossing the prominent fracture traces and generally parallel to the HDD alignment. The W-E fracture lineaments are presumed to be stress-related joint sets. General surface drainage patterns near the site are characterized by linear stream reaches oriented NE-SW or W-E that also reflect the local geologic structure. Blacklog Creek flows generally NE-SW.

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 SR 2017/Blacklog Creek HDD and prior to initiating the 20-inch HDD operations. A second phase of geotechnical drilling was performed in September and October of 2017. The 2014 test borings were advanced by hollow-stem auger drilling methods to a maximum depth of approximately 30 feet bgs or until auger refusal. NQ-sized wireline rock coring methods were utilized in borings that were continued past auger refusal. 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 investigative phases were sampled using split-spoon samplers. Geotechnical boring logs are included in **Attachment 1**.

Boring SB-01 was located approximately 100 feet northeast of the western HDD entry/exit. Boring SB-02 was located approximately 375 feet northwest of the eastern entry/exit point. Boring B-01 was located approximately 80 feet to the northeast of the western HDD entry/exit, and Boring B-02 was located approximately 130 feet to the northwest of the eastern HDD entry/exit. 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; 26.3 feet bgs at SB-01, 15 feet bgs at SB-02, 15.2 feet bgs at B-01, and 15.4 feet bgs at B-02. The residual soils are described as follows:
    - **Boring SB-01**: Silty CLAY (CL) with some fine sand, trace fine gravel, partially weathered gray SHALE. Auger refusal was encountered at 26 feet bgs. Groundwater was not encountered.
    - **Boring SB-02:** Clayey fine to medium SAND (SC), with some silty clay and a little fine sandstone gravel, partially weathered gray to greenish-gray SHALE. Auger refusal was encountered at 15 feet bgs. Groundwater was encountered at 11 feet.

- **Boring B-01:** Stiff to very stiff, moist, lean CLAY (CL) with sand and trace shale fragments, medium dense, moist, clayey SAND (SC) with shale fragment, weathered sandy SHALE sampled as very dense, dry, poorly graded GRAVEL (GP). Auger refusal was encountered at approximately 15.2 feet bgs. Groundwater was not encountered.
- **Boring B-02:** Stiff, moist, sandy lean CLAY (CL) with trace shale fragments, weathered sandy SHALE sampled as very dense, dry, poorly graded GRAVEL (GP). Auger refusal occurred at approximately 15.4 feet bgs. Groundwater was not encountered.

- 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 SB-01:** Rock coring was not completed at this location.
  - **Boring SB-02:** SB-02 was completed to a total depth of 25 feet bgs. A dark gray highly fractured shale with pyrite deposits was encountered from 15 to 25 feet bgs. Calcite deposits were identified at depths of 24.4, 24.5 and 24.7 feet bgs. Rock recoveries were between 70% to 80% and rock quality designations (RQD) were very poor (0).
  - **Boring B-01:** B-01 was completed to a depth of 150 feet. From 15.2 to 150 feet bgs, dark gray very fine to fine-grained, very thin to thickly bedded, weathered to slightly weathered, soft to moderately hard SHALE was observed. A complete loss of drill fluids occurred at 51 feet bgs. Vertical fractures were observed at the following intervals: 72.7-74.1 and 86-87 feet bgs. Broken and vertical fractures were observed between 121-131 feet bgs, while a highly broken interval was encountered between 136.4-137.2 feet bgs. Rock recoveries ranged from 97-100%. RQDs were very poor (0) to excellent (100). The weakest RQDs were in the weathered rock/competent rock transition zone (0) from 15.2 to 16 feet bgs and the broken and vertical fractured zone (27) between 121 and 131 feet bgs. RQDs were fair (62 to 66) from 16 to 31 feet bgs. Groundwater was observed at 45.5 feet bgs at the completion of coring operations.
  - **Boring B02:** B-02 was completed to a total depth of 150 feet bgs. From 15.4 to 150 feet bgs, a dark gray, very fine to fine-grained, very thinly to thickly bedded, weathered, medium to moderately hard, SHALE was observed. Vertical fractures were observed at the following intervals: 41-42.2 and 88.4-89.8 feet bgs. Broken intervals were observed from 44.1-46, 90.2-91, and 139.4-140.4 feet bgs. Rock recoveries ranged from 75-100%. RQDs were very poor (0) to excellent (100). The weakest RQDs were in the weathered rock/competent rock transition zone (0 to 13) from 15.4 to 23 feet bgs and the vertically fractured and broken interval (14) between 41 and 46 feet bgs. Groundwater was not encountered during coring operations.

Unconfined compressive strength testing was performed on 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	16.5	470.12
B-01	24.4	329.08
B-01	34.3	257.72

Boring	Sample Depth (feet bgs)	Compressive Strength (tons per square foot)
B-01	44.1	250.97
B-01	54	426.96
B-01	64.1	599.58
B-01	73	398.28
B-01	84	294.85
B-01	94.4	560.53
B-01	104.3	461.68
B-01	114	442.15
B-01	124	244.78
B-01	137	441.67
B-01	144	287.86
B-02	21.5	77.08
B-02	31.3	476.31
B-02	42.4	349.36
B-02	52.4	508.32
B-02	61.8	598.49
B-02	72.1	395.66
B-02	82.3	447.63
B-02	91.7	296.45
B-02	102.2	252.99
B-02	112.2	462.51
B-02	122.2	231.26
B-02	132	626.80
B-02	141.4	200.78

Please note that RETTEW Associates, Inc. or Skelly and Loy did not oversee or direct the geotechnical drilling program associated with HDD S2-0154 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 CONSIDERATIONS

The use of geophysical surveys during the site hydrogeologic re-evaluation was considered but was ultimately not implemented because the results of geophysical surveys would be unlikely to provide additional information that would reduce the risk of an IR. Based on the lack of carbonate geology mapped at the site and site-specific geologic observations obtained during completion of the 20-inch HDD operations, the data generated from geophysical surveys will not reduce the risk of an IR.

7.0 FIELD OBSERVATIONS

Michels Directional Crossings (Michels) completed the drilling for the installation of the 20-inch pipeline. Michels initiated drilling on October 5, 2017, from the western entry/exit point utilizing the original HDD profile. From October 5 to October 10, 2017, Michels advanced the pilot hole to a trajectory of approximately 462 feet. On October 9, 2018, Michels reported a loss of returns (LOR) of 200 gallons when the pilot hole had been advanced approximately 360 feet from the western entry point and was 34 feet bgs. Michels swabbed the hole and was able to regain full returns. On October 10, 2017, with the pilot bit at approximately 462 feet from the western entry point, an IR of approximately 5,000 to 10,000 gallons was observed within Wetland K69. All drilling activities were stopped and Michels initiated cleanup and containment activities. On October 20, 2017, Michels injected approximately 7 cubic yards of cement grout into the existing pilot hole in an effort to seal the fracture(s) that had led to the IR and also as a means to abandon the pilot boring. Following the grouting operation, Michels demobilized their equipment from the site.

On March 9, 2018, Michels re-initiated pilot hole drilling, this time from the eastern entry exit point utilizing a revised profile, dated March 8, 2018, that was longer and deeper than the original profile. On March 10, 2018, an IR of approximately 25-50 gallons occurred within 10 feet of the eastern entry pit, completely within the limits of disturbance (LOD) and not impacting any Waters of the Commonwealth. The lead environmental inspector gave permission for Michels to construct a new returns pit at the location of the IR and continue drilling activities that day. From March 10, 2018 to March 23, 2018, Michels advanced the pilot hole to a trajectory of 955 feet from the eastern entry point. Sporadic LORs were observed on March 16, 17, 19, 20, 22, and 23, 2018, with the LORs ranging from 50 to 736 gallons per day on these dates. On March 23, 2018, a small 10 to 12 fluid ounce IR was observed within Wetland K69. All drilling activities were suspended until the Pennsylvania Department of Environmental Protection (PA DEP) approved the resumption of pilot hole advancement. SPLP's HDD team proposed the use of cement grout installed through a non-expanding packer to reduce the risk of further IRs. On May 3, 2018, following PA DEP approval to resume pilot hole activities, Michels pumped 2.5 cubic yards of cement grout through a non-expanding packer on the end of the drill string at located 941 feet from the eastern entry point. No additional IRs occurred following the installation of the cement grout and the pilot hole was completed on May 18, 2018. Cuttings observed during the completion of the borehole consisted of overburden, weathered shale, dark gray to brown shale and trace calcite in the form of vein (fracture) filling.

Michels completed various ream and swab passes between May 21st and June 19th, 2018, and the 20-inch product line was pulled through the completed boring on June 19th, 2018.

8.0 CONCEPTUAL HYDROGEOLOGIC MODEL AND CONCLUSION

Based on published geologic and hydrogeologic information, results of the two geotechnical investigations and field observations during the completion of the 20-inch HDD, the SR 2017 HDD is underlain by clastic sedimentary rocks of the Reedsville Formation. 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. Most of the water-bearing zones occur in individual fractures or groups of interconnected fractures that can be sufficiently enlarged by dissolution of the bedrock. Median well depth in the Reedsville Formation is 130 feet bgs. Well yields ranged from 1 to 50 gpm with a median well yield of 12 gpm for domestic wells and 20 gpm for nondomestic wells.

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 (Blacklog Creek, StreamK-94). 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 SR 2017/Blacklog HDD is susceptible to an IR of drilling fluids during HDD operations. As a result, the proposed 16-inch HDD profile was redesigned to allow for a deeper crossing beneath the referenced stream and wetlands. The revised profile is approximately 67 feet below Blacklog Creek (this is approximately 20 feet deeper than the as-built 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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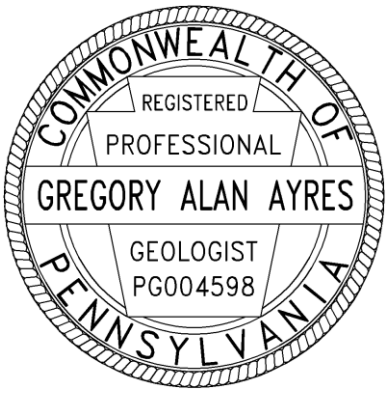
10.0 CERTIFICATION

The studies and evaluations presented in this report (other than Section 5.0) were completed under the direction of a licensed professional geologist (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

Gregory A. Ayres, PG
License No. PG004598

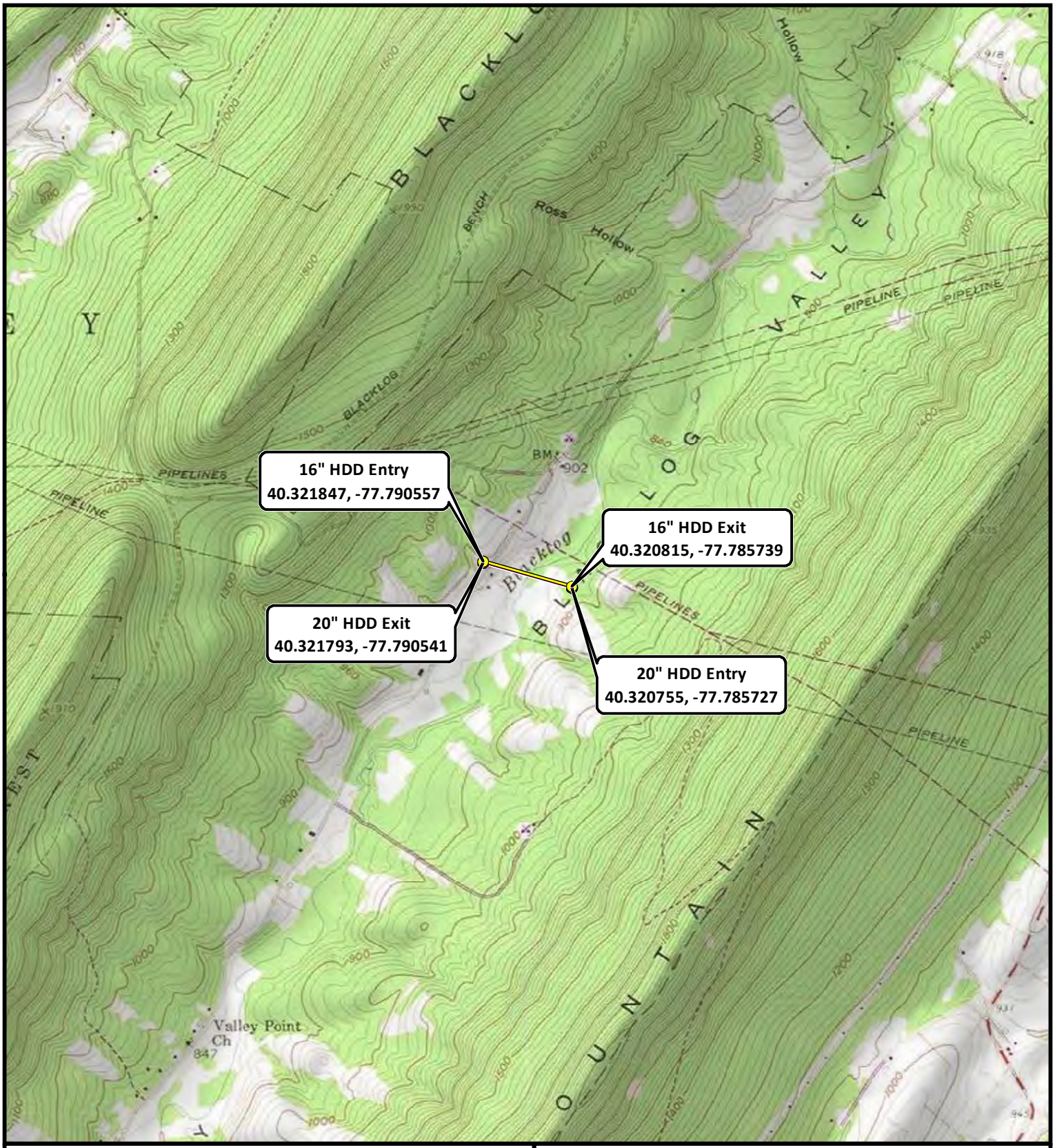


Enclosures

Z\Shared\Projects\09630\096302008 - Spread 3\GS\Re-Evaluations\Blacklog Creek\Black Log Hydro Re-Eval_Final_02-13-19.docx

RETTEW

FIGURES



16" HDD Entry/Exit

20" HDD Entry/Exit

16" HDD Profile

20" HDD Profile

Aughwick, PA USGS 7.5' Topographic Quadrangle

1/29/2019

Sunoco Pipeline, L.P.

S.R. 2017

Figure 1 - Topographic Basemap

Shirley Township, Huntingdon County, PA

Project No. 096302011

N

W E

S

0 2,000 Feet

1 inch = 2,000 feet

Sunoco Logistics Partners L.P.

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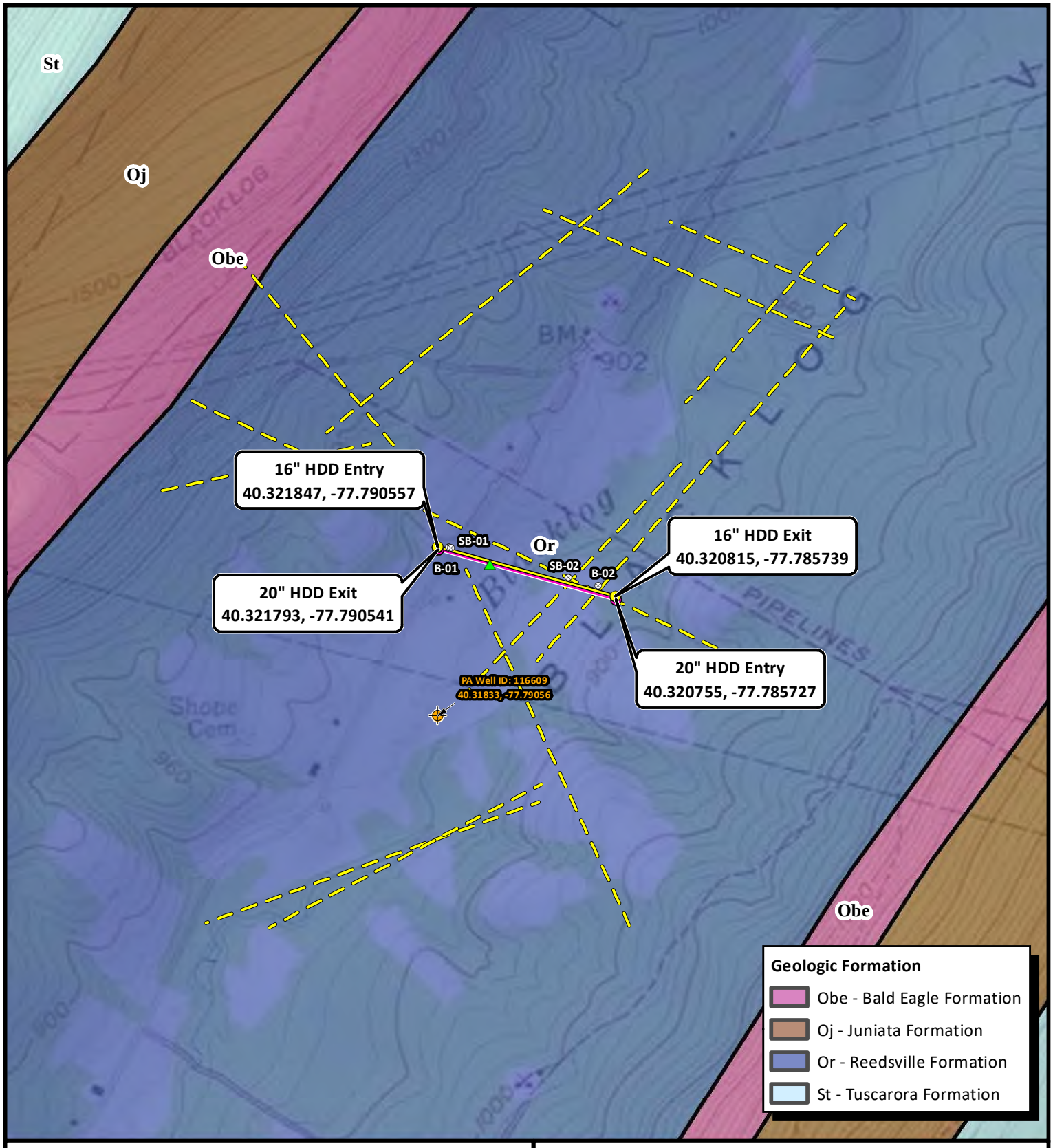

Inadvertent Return
Soil Boring
Residential Well
16" HDD Entry/Exit
20" HDD Entry/Exit
16" HDD Profile
20" HDD Profile
Inferred Fracture Trace

Aughwick, PA USGS 7.5' Topographic Quadrangle 1/29/2019

Sunoco Pipeline, L.P.

S.R. 2017

Figure 2 - Geologic Map

Shirley Township, Huntingdon County, PA

Project No. 096302011

N W E S

0 1,000 Feet

1 inch = 1,000 feet

Sunoco Logistics Partners L.P.

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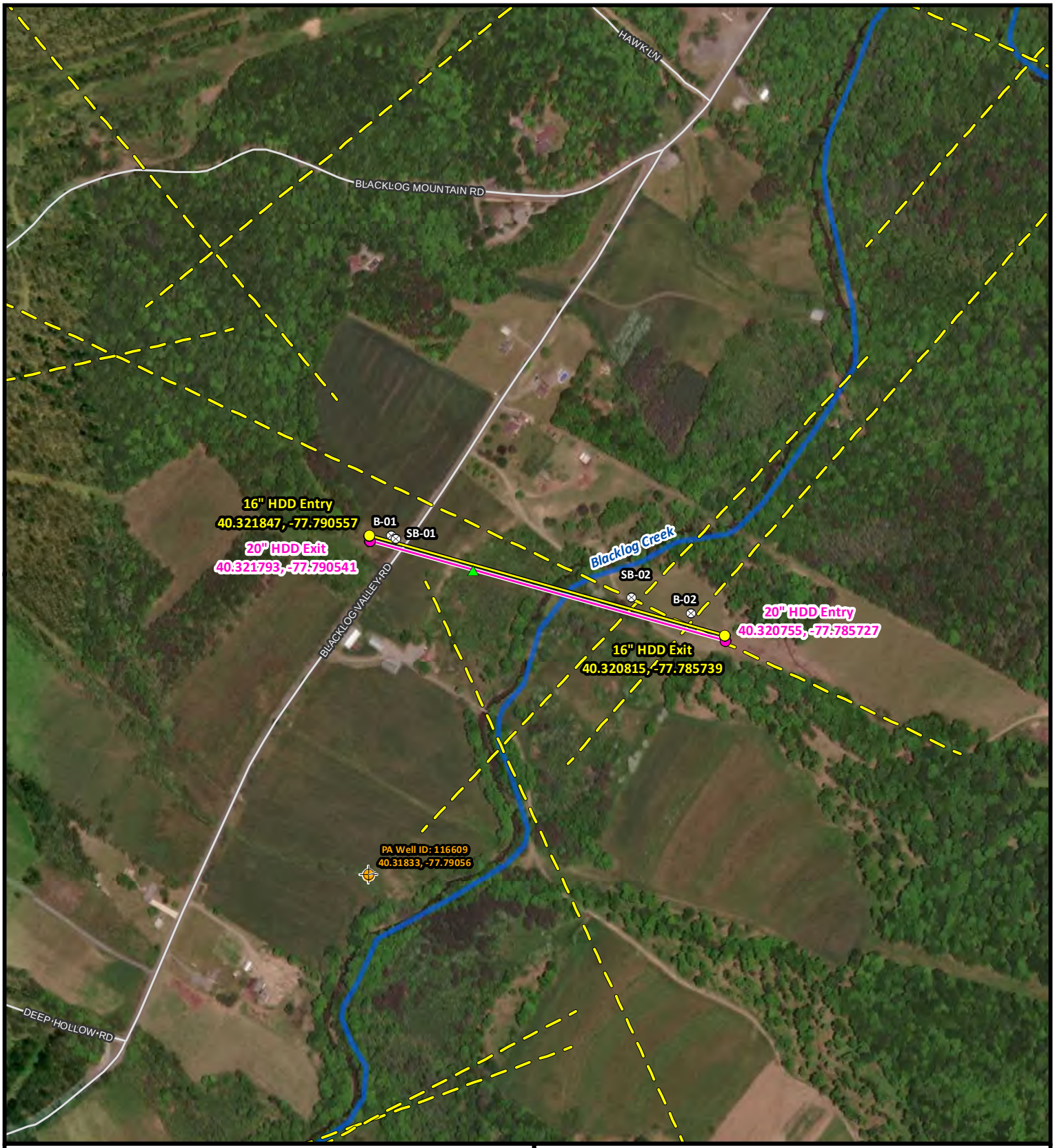

Inadvertent Return
Residential Well
Boring Location
16" HDD Entry/Exit
20" HDD Entry/Exit
16" HDD Profile
20" HDD Profile
Inferred Fracture Trace
NHD Stream
Road

1/29/2019

Sunoco Pipeline, L.P.

S.R. 2017

Figure 3 - Aerial Basemap

Shirley Township, Huntingdon County, PA

Project No. 096302011

N
W E
S

0 500 Feet

1 inch = 500 feet

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

Sunoco Logistics Partners L.P.

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RETTEW

ATTACHMENT 1
HDD PROFILES AND GEOTECHNICAL BORING LOGS

HUNTINGDON COUNTY PENNSYLVANIA, SHIRLEY TOWNSHIP
S2-0154-16

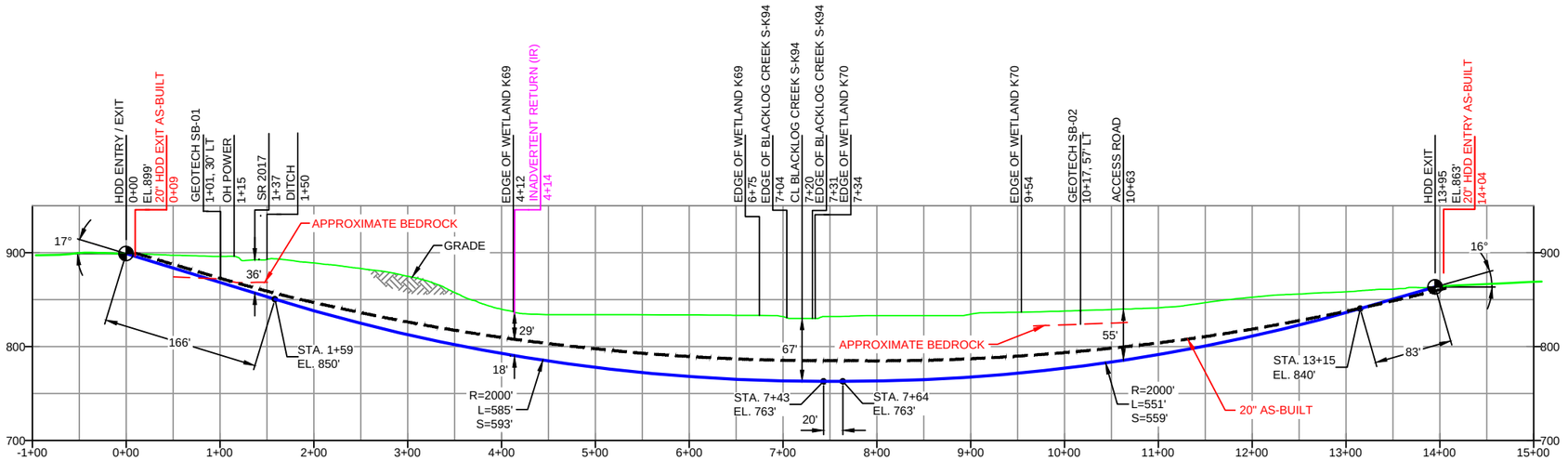
PA-HU-0106.0000
PA-HU-0107.0000
PA-HU-0105.0000
SR 2017
TEMP ACCESS RD
BLACKLOG CREEK
GEOTECH SB-01
GEOTECH B-01
GEOTECH SB-02
GEOTECH B-02
SUNOCO EASEMENT LIMITS - NOT LOD
CL BLACKLOG CREEK S-K94
N40.321314
W77.788069
PROPOSED 16" PIPELINE
HDD EXIT
N40.320815
W77.785739
PULLBACK ALONG ROW
HDD ENTRY / EXIT
N40.321847
W77.790557
20" AS-BUILT
20" HDD EXIT AS-BUILT
N40.321793
W77.790541
EXISTING 8" SUNOCO PIPELINE
INADVERTENT RETURN - (IR) CONTAINMENT FIELD
INADVERTENT RETURN (IR)
N40.321485
W77.789148
20" HDD ENTRY AS-BUILT
N40.320755
W77.785727
W-BB114
W-BB115
S-K94
W-K69
W-K70
S-M1
W-M1
S-K95

LEGEND
PERMANENT ROW
TEMPORARY CONSTRUCTION ROW
TEMPORARY WORKSPACE
TEMPORARY ACCESS ROAD
PERMANENT ACCESS ROAD
SPOIL SPACE ONLY
PROPOSED HDD
PROPOSED 20" PIPELINE
PROPOSED 16" PIPELINE
HDD ENTRY-EXIT
PEM WETLANDS
PSS WETLANDS
PFO WETLANDS

75 0 75 150
FEET

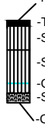
PLAN VIEW

PROFILE VIEW



GEOTECH SB-01

GEOTECH SB-02



NOTE: REFER TO TEST BORING LOG S2-0154 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-01

NOTE: REFER TO TEST BORING LOG B-01 INTERTEK PROJECT #08031074 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-02

NOTE: REFER TO TEST BORING LOG B-02 INTERTEK PROJECT #08031074 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 1395'
   HDD PIPE LENGTH (S=): 1421'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 2100 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 2625 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-3.73	TO	ES-3.73	EROSION & SEDIMENT PLAN
SHEET 44	TO	SHEET 44	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP7	DESIGN CHANGE PER DPS	MRS	01/24/19	RMB	01/24/19	CAG	01/24/19
EP6	ADDED LOD IR CONTAINMENT FIELD BOUNDARY	MRS	06/01/18	RMB	06/01/18	CAG	06/01/18
EP5	UPDATED NOTE 5 AND 10 PER INCREASED 16" MOP	MRS	04/10/18	RMB	04/10/18	CAG	04/10/18
EP4	MODIFIED ATWS PER LAND ACQUISITION	MRS	03/27/18	RMB	03/27/18	CAG	03/27/18
EP3	RELOCATED DRILL ENTRY/EXIT - DESIGN PER MICHELS	MRS	01/08/18	RMB	01/08/18	CAG	01/08/18
EP2	REVISED PER PADEP COMMMENTS RECIVED 09-06-16	DLM	10/07/16	RMB	10/07/16	AAW	10/07/16

Sunoco Logistics Partners L.P.

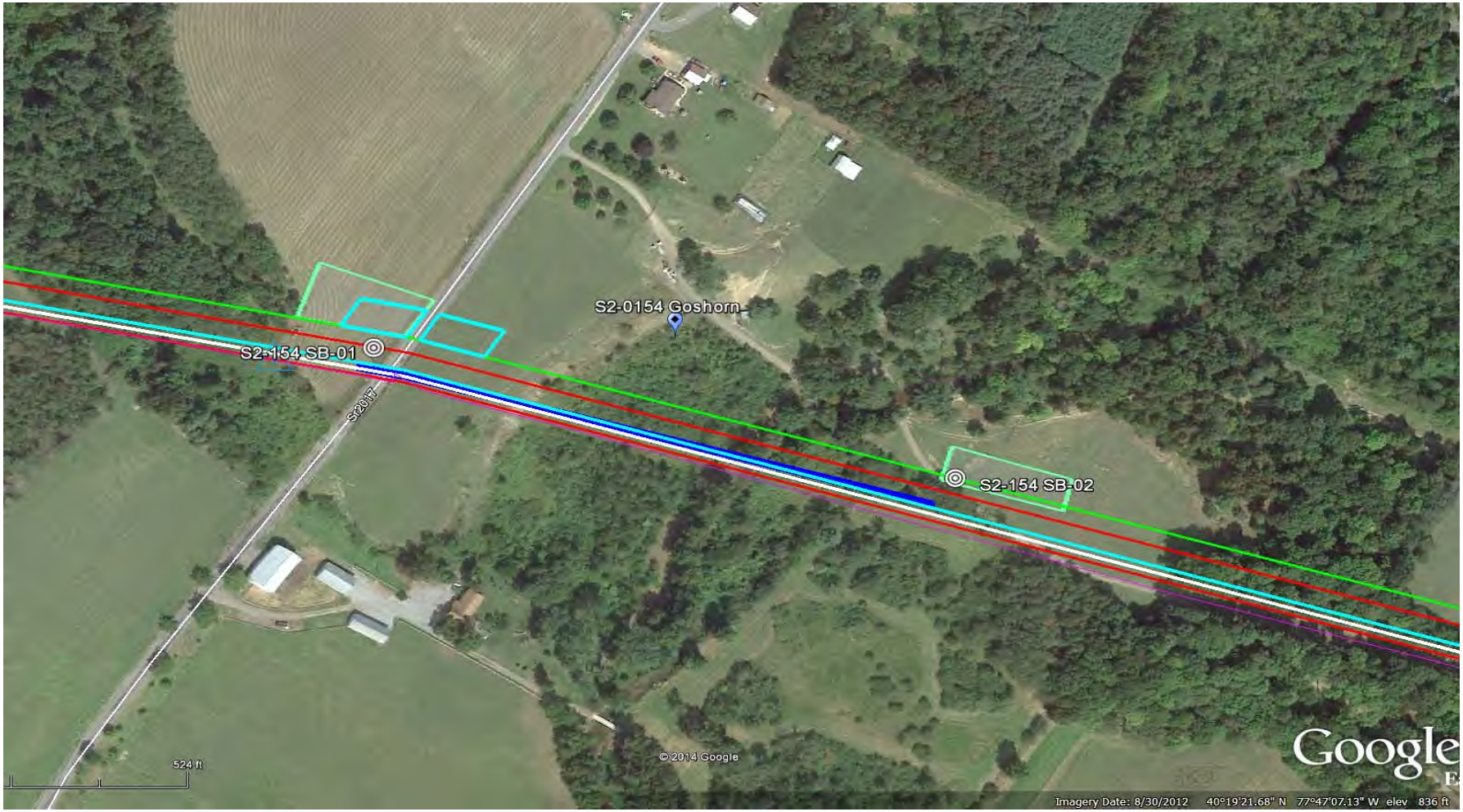
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
SR 2017
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'

DWG. NO: PA-HU-0106.0000-RD-16



LEGEND:

Geotechnical Soil Boring (SB) Locations

TETRA TECH

GEOTECHNICAL BORING LOCATIONS
HDD S2-0154
HUNTINGDON COUNTY, SHIRLEY 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:	16443 BLACKLOG VALLEY ROAD, ORBISONIA, PA		Page 1 of 1
HDD No.:	S2-0154	Dates(s) Drilled: 10-12-14	Inspector: E. WATT
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 26.3

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.3			TOPSOIL (4").					
1	3.0	5.0	0.3		15		DR WEATHERED TO A BROWN, ORANGE BROWN AND LIGHT GRAY	4	9	10	12	**19**
							SILTY CLAY AND FINE SAND, SOME OXIDATION LENSES.					
2	8.0	10.0			13		DR WEATHERED TO A TAN TO BROWN SILTY CLAY WITH SOME	1	11	15	18	**26**
						CL	FINE SAND. (USCS: CL)					
3	13.0	14.5			13		DR WEATHERED TO A BROWN SILTY CLAY WITH SOME FINE SAND,	1	27	50		**77**
							TRACE FINE GRAVEL (FISSILE). (USCS: CL)					
4	18.0	19.1			9		DR WEATHERED TO A BROWN SILTY CLAY WITH SOME FINE SAND,	4	50	50/1"		**>50**
				22.0			TRACE FINE GRAVEL (FISSILE).					
5	23.0	23.2	22.0		1		PARTIALLY WEATHERED GRAY SHALE	50/2"				**>50**
6	26.0	26.3		26.3	3		PARTIALLY WEATHERED GRAY SHALE.	50/3"				**>50**
							AUGER REFUSAL AT 26'.					
							STARTED GRINDING AT 22'.					
							CAVED AND DRY AT 23'.					

Notes/Comments:

Pocket Pentrometer Testing
S1: 4 TSF
S2: >4 TSF
S3: >4 TSF

DR: DECOMPOSED ROCK

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

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

TETRA TECH
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:	16443 BLACKLOG VALLEY ROAD, ORBISONIA, PA		Page 1 of 1
HDD No.:	S2-0154	Dates(s) Drilled: 10-12-14	Inspector: E. WATT
Boring No.:	SB-02	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 11.0	Total Depth (ft): 25.0

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.3			TOPSOIL (4").					
1	3.0	5.0	0.3	3.5	21	SC	BROWN AND GRAY CLAYEY FINE TO MEDIUM SAND (USCS: SC).	5	10	14	16	**24**
2	8.0	10.0	3.5		17	SC	DR WEATHERED TO A VARI-COLORED FINE TO MEDIUM SAND, WITH	4	21	30	28	**51**
				13.6			SOME SILTY CLAY, AND A LITTLE FINE SANDSTONE GRAVEL.					
3	13.0	13.9	13.6	15.0	9		PARTIALLY WEATHERED GRAY TO GREENISH GRAY SHALE.	5	50/5"			**>50**
							AUGER REFUSAL AT 15.0'.					
							ROCK CORING					
RUN 1	15.0	20.0			42	ROCK	HIGHLY FRACTURED DARK GRAY SHALE WITH PYRITE DEPOSITS.	TCR: 70%, SCR: 2%, RQD: 0%				
RUN 2	20.0	25.0			48		HIGHLY FRACTURED DARK GRAY SHALE WITH PYRITE DEPOSITS,	TCR: 80%, SCR: 8%, RQD: 0%				
							WITH CALCITE DEPOSITS AT 24.4', 24.5', AND 24.7'.					
							WET TON SPOON AT 11'					
							WATER LEVELS THROUGH AUGERS AT 13.5'					
							CAVED AT 15'.					

Notes/Comments:
Pocket Pentrometer Testing
S1: .4 TSF

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 S2-0154

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.) From	Depth of Sample (ft.) To	Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318) Liquid Limit, %	Atterburg Limits (ASTM D4318) Plastic Limit, %	Atterburg Limits (ASTM D4318) Plasticity Index, %	USCS Classif. (ASTM D2487)
S2-0154	SB-01	1	3.0	5.0	20.2	63.2	-	-	-	-
		2	8.0	10.0	14.3	74.0	31	20	11	CL
		3	13.0	14.5	13.4	72.8	32	21	10	CL
		6	26.0	26.3	3.8	23.6	-	-	-	-
	SB-02	1	3.0	5.0	11.2	41.9	28	18	10	SC
		2	8.0	10.0	14.4	28.6	-	-	-	-
		3	13.0	13.9	9.0	23.2	-	-	-	-

Notes:

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

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0154

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
S2-0154	Goshorn	SB-01 SB-02	**Reedsville Formation** - consists of dark-gray shale containing thin sandy to silty shale and siltstone interbeds, and it has an upper fossiliferous sandstone.	Rolling hills (ridge & valley)	Reedsville Fm.	Shale-siltstone		18-59	

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.

ROCK CORE DESCRIPTION SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0154

Location	Boring No.	Core Run	Core Depth (ft)		TCR (%)	SCR (%)	RQD (%)	Depth (ft)		Weathering	Classification	Bedding Thickness (ft)	Color	Discontinuity Data
			From	To				From	To					
S2-0154	SB-2	1	15	20	70	1.6	0	15	20	Slight	Limestone	Massive	Gray to Dark Gray	Heavily fractured, significant mechanical fracturing, wildly varying dip angles in range of 0° to 60°
S2-0154	SB-2	2	20	25	80	8	0	20	25	Slight	Limestone	Massive	Gray to Dark Gray	Heavily fractured, significant mechanical fracturing, Avg. Dip 45°, calcite filling of some thin fractures

FIELD DESCRIPTION AND LOGGING SYSTEM FOR SOIL EXPLORATION

GRANULAR SOILS

(Sand, Gravel & Combinations)

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

Relative Proportions

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

Particle Size Identification

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

COHESIVE SOILS

(Silt, Clay & Combinations)

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

Plasticity

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

ROCK

(Rock Cores)

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

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

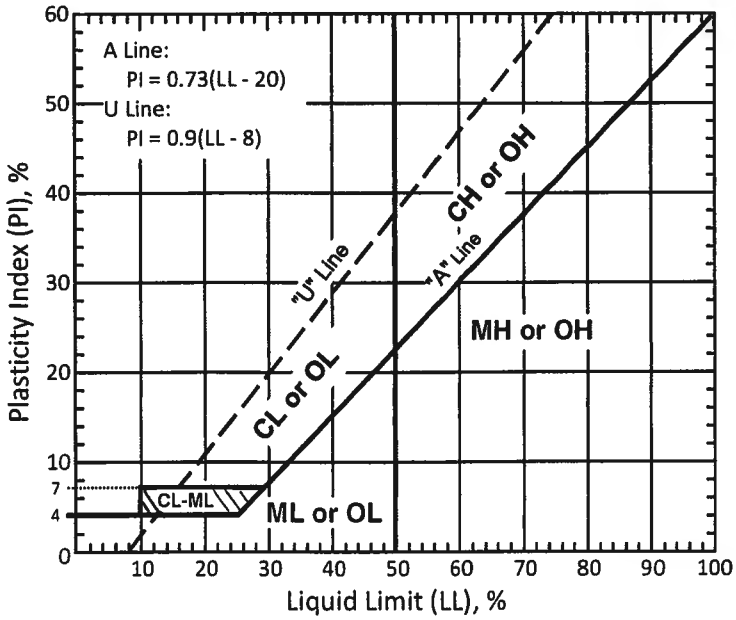
Groundwater observations were made at the times indicated. Groundwater elevations fluctuate throughout a given year, depending on actual field porosity and variations in seasonal and annual precipitation.

UNIFIED SOIL CLASSIFICATION SYSTEM [Casagrande (1948)]

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

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

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



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

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Figure 1: Site Vicinity Plan

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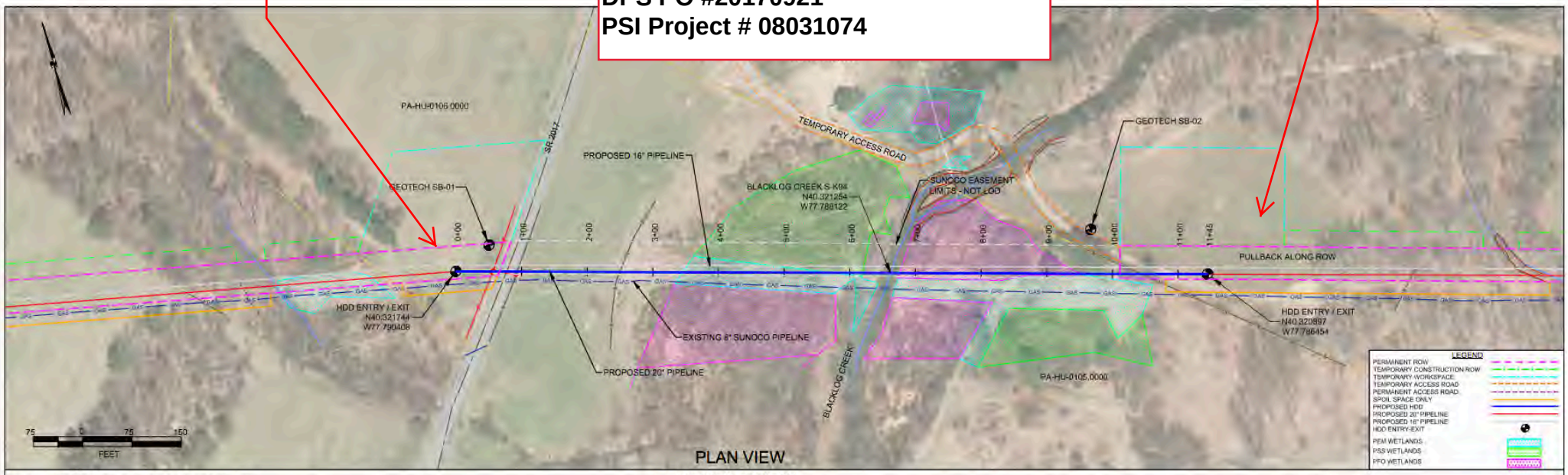
Created using PA DCNR Map Viewer

Map created on Fri Oct 6 2017

GEO BORE #1 (150 FT)

FIGURE 2: Boring Location Plan
SR 2017 - PPP3
DPS PO #20170921
PSI Project # 08031074

GEO BORE #2 (150 FT)



PLAN VIEW

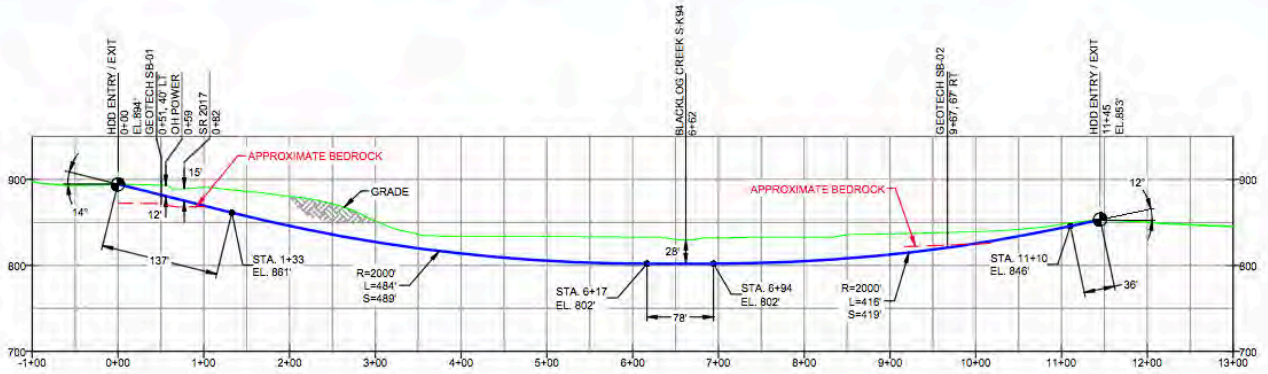
PROFILE VIEW

HUNTINGDON COUNTY PENNSYLVANIA, SHIRLEY TOWNSHIP
S2-0154

GEOTECH SB-01
-NG EL. 898'
-TOPSOIL (0' - 0.3')
-CL (0.3' - 22.0')
-SHALE (22.0' - 26.3')
-COMPLETION DEPTH EL. 872'

GEOTECH SB-02
-NG EL. 837'
-TOPSOIL (0' - 0.3')
-SC (0.3' - 3.5')
-SC (3.5' - 13.6')
-GROUNDWATER (11.0')
-SHALE (13.6' - 15.0')
-COMPLETION DEPTH EL. 822'

NOTE: REFER TO TEST BORING LOG S2-0154 FOR COMPLETE SOIL MATERIAL DESCRIPTION.



DESIGN AND CONSTRUCTION:
1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=) 1145'
   HDD PIPE LENGTH (L=) 1159'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE: 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1950 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

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

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
2	REVISED PROFILE WITH 2017 LIDAR	MRS	03/21/17	RMB	03/21/17	CAG	03/21/17
1	REVISED PER ENGINEERING COMMENTS	MRS	08/26/16	RMB	08/26/16	AAW	08/26/16
0	ISSUED FOR CONSTRUCTION	MRS	12/22/15	RMB	12/22/15	AAW	12/22/15

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY (303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
SR 2017
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150' DWG. NUMBER: PA-HU-0106.0000-RD

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Figure 3: Site Geology Plan

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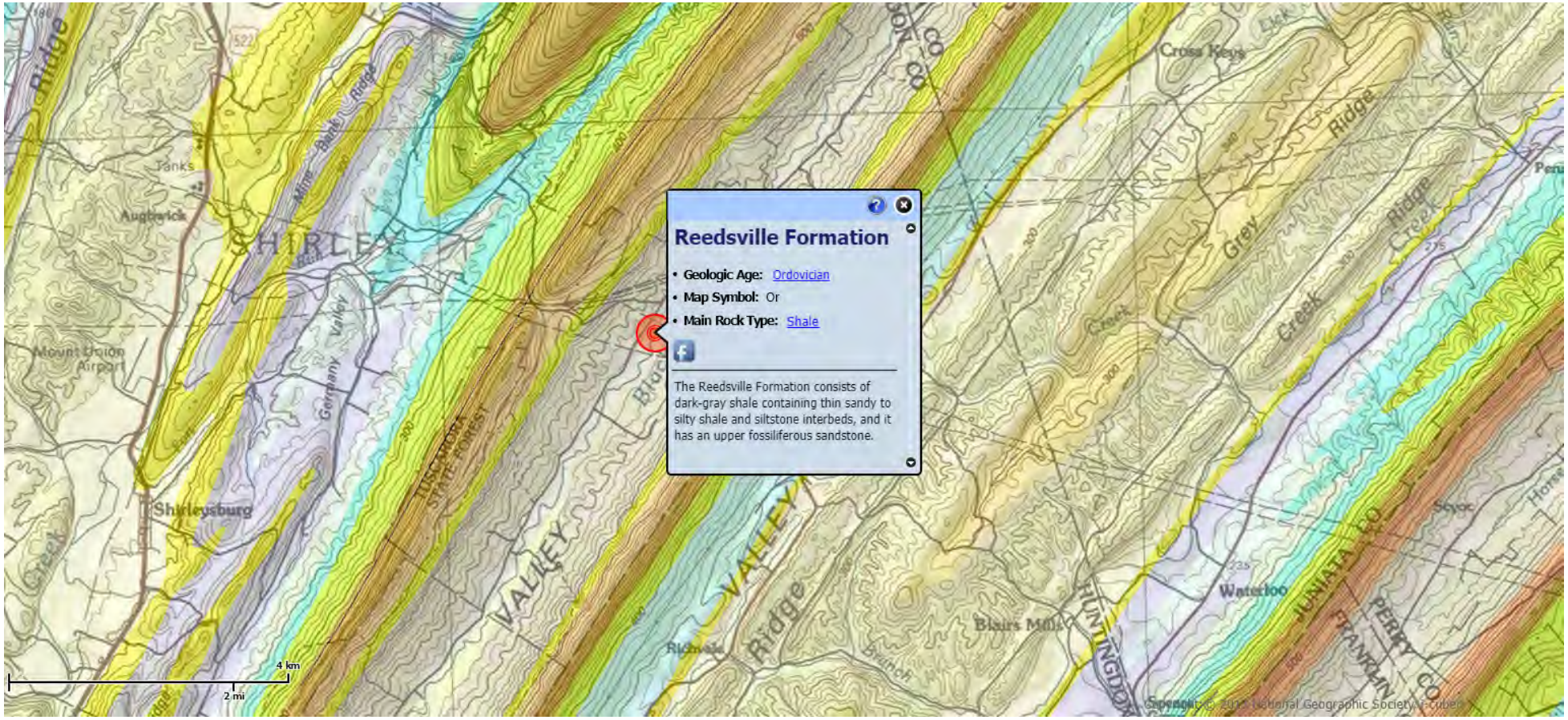

Created using PA DCNR Map Viewer

Map created on Fri Oct 6 2017

BORING B-01

DATE STARTED:	9/27/17	**DRILL COMPANY:**	PSI, Inc.
DATE COMPLETED:	9/28/17	**DRILLER:** R. Weaver	**LOGGED BY:** C.Lehman
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	CME 55x300
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:

Water

Pre-Core	None Enc.
Upon Completion	45.5 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 ◎ Moisture × PL ◪ LL ✚ (0, 25, 50) STRENGTH, tsf Qu ▲ Qp ✳ (0, 2.0, 4.0)	Additional Remarks
	0			S-1	18	**RESIDUUM** - Stiff to very stiff, moist, light gray and light brown, **Lean CLAY**, with Sand, trace Shale Fragments	CL	5-6-6 N=12	22		
	5			S-2	18	**RESIDUUM** - Medium dense, moist, light gray and light brown, **Clayey SAND**, with Shale Fragments	SC	6-7-11 N=18	20		LL = 43 PL = 26 Fines=23.0%
	10			S-3	5	**WEATHERED ROCK** - Very dense, dry, gray and gray brown, **Sandy SHALE**, (sampled as a Poorly Graded Gravel)	GP	50/4"		>>◎	
	15			S-4	1	Auger refusal encountered at approximately 15.2 feet		50/2"		>>◎	
				R-1	10	**BEDROCK** - Dark gray, **SHALE**, very fine to fine grained, very thin bedded, weathered to slightly weathered, soft to medium hard (3-5)		RQD=0 Rec=100%		>>◎	3 min.
				R-2	60	**BEDROCK** - Dark gray, **SHALE**, very fine to fine grained, thin to medium bedded, weathered to slightly weathered, soft to medium hard (3-5)		RQD=62 Rec=100%		>>◎	3 min.
	20										5 min.
											2 min.
											2 min.
											2 min.
											2 min.
	25			R-3	120			RQD=66 Rec=100%		>>◎	2 min.
											2 min.
											2 min.
											2 min.
											2 min.
	30										2 min.

Q_u = 470.1 tsf, 175.5 pcf

Q_u = 329.1 tsf, 174.0 pcf

Continued Next Page

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

PROJECT NO.: 08031074
PROJECT: Energy Transfer HDD (DPS)
LOCATION: SR-2017 (PPP3) Huntingdon Co., PA
PA-HU-0106.0000-RD/PO#20170921

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

DATE STARTED:	9/27/17	**DRILL COMPANY:**	PSI, Inc.
DATE COMPLETED:	9/28/17	**DRILLER:** R. Weaver	**LOGGED BY:** C.Lehman
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	CME 55x300
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	None Enc.	
Upon Completion	45.5 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 ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	35			R-4	120	**BEDROCK** - Dark gray, **SHALE**, very fine to fine grained, thin to thick bedded, weathered to slightly weathered, soft to medium hard (3-5)		RQD=88 Rec=100%			2 min. 1 min. 1 min. 3 min. >> ▲ Q_u = 257.7 tsf 174.7 pcf 2 min. >> ◎ 2 min. 1 min. 2 min. 3 min. 2 min.
	40										2 min. 2 min. 2 min. 2 min. >> ▲ Q_u = 251.0 tsf 176.5 pcf 2 min.
	45			R-5	120			RQD=97 Rec=100%			>> ◎ 2 min. 2 min. 2 min. 2 min. 2 min.
	50					Complete loss of drilling fluids at approximately 51 feet					2 min. 2 min. 2 min. 2 min. >> ▲ Q_u = 427.0 tsf 176.5 pcf 2 min.
	55			R-6	120			RQD=96 Rec=100%			>> ◎ 2 min. 2 min. 2 min. 1 min. 1 min. 2 min.
	60										

Continued Next Page

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BORING B-01

DATE STARTED:	9/27/17	**DRILL COMPANY:**	PSI, Inc.
DATE COMPLETED:	9/28/17	**DRILLER:** R. Weaver	**LOGGED BY:** C.Lehman
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	CME 55x300
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

Water

Pre-Core	None Enc.
Upon Completion	45.5 feet

BORING LOCATION:
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, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ — Moisture ×, PL ◪, LL ✚ (0, 25, 50); STRENGTH, tsf Qu ▲, Qp ✳ (0, 2.0, 4.0)	Additional Remarks
	65			R-7	120	**BEDROCK** - Dark gray, **SHALE**, very fine to fine grained, thin to thick bedded, weathered to slightly weathered, soft to medium hard (3-5)		RQD=92 Rec=100%			3 min. 2 min. Qu = 599.6 tsf 176.2 pcf 2 min. 2 min. 2 min. 2 min. 2 min. 2 min.
	70					Vertical fracture from 72.7 to 74.1 feet					2 min. 2 min. Qu = 398.3 tsf 176.7 pcf 2 min. 2 min.
	75			R-8	120			RQD=72 Rec=100%			2 min. 2 min. 2 min. 2 min. 2 min.
	80										1 min. 2 min. 2 min. Qu = 294.8 tsf 174.4 pcf 2 min.
	85			R-9	120	Vertical fracture from 86 to 87 feet		RQD=80 Rec=100%			1 min. 2 min. 2 min. 2 min. 1 min.
	90										2 min. 2 min.

Continued Next Page

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PROJECT: Energy Transfer HDD (DPS)
LOCATION: SR-2017 (PPP3) Huntingdon Co., PA
PA-HU-0106.0000-RD/PO#20170921

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

BORING B-01

DATE STARTED:	9/27/17	**DRILL COMPANY:**	PSI, Inc.
DATE COMPLETED:	9/28/17	**DRILLER:** R. Weaver	**LOGGED BY:** C.Lehman
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	CME 55x300
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:

Water
- Pre-Core: None Enc.
- Upon Completion: 45.5 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 ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	95			R-10	120	**BEDROCK** - Dark gray, **SHALE**, very fine to fine grained, very thin bedded, weathered to slightly weathered, medium to moderately hard (4-6)		RQD=96 Rec=100%			1 min. 2 min. >> Q_u = 560.5 tsf, 176.8 pcf 2 min. >> ◎ 1 min. 2 min. 1 min. 2 min.
	100										2 min. 2 min. 2 min. 1 min. 1 min. >> Q_u = 461.7 tsf, 175.0 pcf 1 min.
	105			R-11	120			RQD=94 Rec=100%			>> ◎ 1 min. 2 min. 2 min. 2 min. 2 min.
	110										2 min. 2 min. 2 min. 1 min. >> Q_u = 442.2 tsf, 176.6 pcf 2 min.
	115			R-12	120			RQD=84 Rec=100%			>> ◎ 2 min. 2 min. 2 min. 2 min. 2 min.
	120					Broken and vertical fractures throughout run					2 min. 2 min. 2 min. >>

Continued Next Page

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

PROJECT NO.: 08031074
PROJECT: Energy Transfer HDD (DPS)
LOCATION: SR-2017 (PPP3) Huntingdon Co., PA
PA-HU-0106.0000-RD/PO#20170921

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

BORING B-01

DATE STARTED:	9/27/17	**DRILL COMPANY:**	PSI, Inc.
DATE COMPLETED:	9/28/17	**DRILLER:** R. Weaver	**LOGGED BY:** C.Lehman
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	CME 55x300
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:

Water

Pre-Core	None Enc.
Upon Completion	45.5 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 ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf Qu ▲ / Qp ✳ (0, 2.0, 4.0)	Additional Remarks
	125			R-13	116	**BEDROCK** - Dark gray, **SHALE**, very fine to fine grained, very thin bedded, weathered to slightly weathered, medium to moderately hard (4-6)		RQD=27 Rec=97%		>> ▲ Qu = 244.8 tsf ◎ 175.1 pcf	2 min. 3 min. 7 min. 2 min. 2 min.
	130										2 min. 2 min. 2 min. 2 min. 2 min. 5 min.
	135			R-14	120	Highly broken from 136.4 to 137.2 feet		RQD=63 Rec=100%		>> ◎ >> ▲ Qu = 441.7 tsf 176.2 pcf	2 min. 2 min. 2 min. 2 min. 2 min. 2 min. 2 min.
	140										2 min. 2 min. 2 min. 2 min.
	145			R-15	108			RQD=100 Rec=100%		>> ▲ Qu = 287.9 tsf ◎ 177.1 pcf	2 min. 1 min. 2 min. 2 min. 2 min. 2 min.
	150					Boring terminated at approximately 150 feet					2 min.

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08031074
SR2017
PPP3
B-1
Box 1 of –
9/27/17
PRE-CORE DRY
Run | Depth | Rec. | RQD
R-1 | 15.2 - 16.0 | 0.8 | 0.0
2 | 16.0 - 21.0 | 5.0 | 3.1
3 | 21.0 - 31.0 | 10.0 | 6.6
TOP
16.0
21.0


80310744
SR2017
PPP-3
B-1
Box 2 of —
9-28-17
RUN | DEPTH | REC | RQD
3 | 21.0-31.0 | 10.0 | 6.6
4 | 31.0-41.0 | 10.0 | 8.8
5 | 41.0-51.0 | 10.0 | 9.7
31.0
41.0


5803107A
9-26-17
B-1
Bop 3 of —
PPP-3
BR 2017
RUN | DEPTH | REC | RQD
5 | 41.0-51.0 | 10.0 | 9.7
6 | 51.0-61.0 | 10.0 | 9.6
TOP
STO


08031074
SR 2097
PPP3
B-1
Box 4 of _
9/28/17
Run | Depth | Rec. | RQD
R-6 | 51.0-61.0 | 10.0 | 9.6
R-7 | 61.0-71.0 | 10.0 | 9.2
R-8 | 71.0-81.0 | 10.0 | 7.2
TOP
61.0
71.0


08031074
SR2017
PPP3
B-1
Box 5 of _
9/28/17
Run | Depth | Rec. | RQD
R-8 | 71.0 - 81.0 | 10.0 | 7.2
R-9 | 81.0 - 91.0 | 10.0 | 8.0
Top
81.0


08031074
SR2017
PPP3
B-1
Box 6 of _
9/28/17
Run | Depth | Rec. | RQD
R-9 | 81.0-91.0 | 10.0 | 8.0
R-10 | 91.0-101.0 | 10.0 | 9.6
R-11 | 101.0-111.0 | 10.0 | 9.4
TOP
91.0
101.0


D8031074
SR 2017
PPP3
B-1
Box 3 of —
9/28/17
Run | Depth | Rec. | RQD
R-11 | 101.0-111.0 | 10.0 | 9.4
R-12 | 111.0-121.0 | 10.0 | 8.4
TOP
111.0


08031074
SR2017
PPP3
B-1
Box 8 of _
9/28/17
Run | Depth | Rec | RQD
R-12 | 111.0 - 121.0 | 10.0 | 84
R-13 | 121.0 - 131.0 | 9.7 | 2.7
R-14 | 131.0 - 141.0 | 10.0 | 6.3
TOP
121.0
131.0


08031074
SR2017
PPP3
B-1
Box 9 of _
9/28/17
Run | Depth | Rec. | RQD
R-14 | 131.0-141.0 | 10.0 | 6.3
R-15 | 141.0-150.0 | 9.0 | 9.0
TOP
141.0


08031074
SR 2017
PPP3
B-1
Box 10 of 10
9/28/17
Run | Depth | Rec. | RQD
R-15 | 141.0 - 150.0 | 9.0 | 9.0
EOB
TOP
150.0

BORING B-02

DATE STARTED:	9/29/17	**DRILL COMPANY:**	PSI, Inc.
DATE COMPLETED:	10/2/17	**DRILLER:** R. Weaver	**LOGGED BY:** C.Lehman
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	CME 55x300
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:

Water — Pre-Core: None Enc. feet; Upon Completion

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 ◎ / Moisture / PL / LL / STRENGTH, tsf Qu / Qp	Additional Remarks
	0			S-1	18	**COLLUVIUM** - Stiff, moist, light brown, **Sandy Lean CLAY**, trace Shale Fragments		6-6-8 N=14	15		LL = 49 PL = 33 Fines=51.8%
	5			S-2	17		CL	6-8-15 N=23	18		
	10			S-3	17	**WEATHERED ROCK** - Very dense, dry, light brown and gray brown, **Sandy SHALE**, (sampled as a Poorly Graded Gravel)	GP	16-36-50/4"			
	15			S-4	5	**WEATHERED ROCK** - Very dense, dry, gray, **Sandy SHALE**, (sampled as a Poorly Graded Gravel) Auger refusal encountered at approximately 15.4 feet	GP	50/4"			>>
				R-1	18	**BEDROCK** - Dark gray, **SHALE**, very fine to fine grained, very thin bedded, weathered, medium hard (3-4)		RQD=0 Rec=75%			>> 2 min. 2 min. 3 min.
				R-2	29			RQD=0 Rec=92%			>> 2 min. 3 min.
	20			R-3	28			RQD=13 Rec=77%			2 min. Q_u = 77.1 tsf >> 2 min. 2 min.
				R-4	36	**BEDROCK** - Dark gray, **SHALE**, very fine to fine grained, very thin to medium bedded, weathered, medium to moderately hard (4-6)		RQD=87 Rec=100%			2 min. >> 2 min. 2 min. 2 min.
	25			R-5	54			RQD=52 Rec=90%			1 min. >> 1 min. 3 min.
	30										

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PROJECT: Energy Transfer HDD (DPS)
LOCATION: SR-2017 (PPP3) Huntingdon Co., PA
PA-HU-0106.0000-RD/PO#20170921

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

BORING B-02

DATE STARTED:	9/29/17	**DRILL COMPANY:**	PSI, Inc.
DATE COMPLETED:	10/2/17	**DRILLER:** R. Weaver	**LOGGED BY:** C.Lehman
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	CME 55x300
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:

Water: Pre-Core None Enc. | Upon Completion 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 ◎ / Moisture ✕ / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf Qu ▲ Qp ✳ (0, 2.0, 4.0)	Additional Remarks
						BEDROCK - Dark gray, **SHALE**, very fine to fine grained, very thin to medium bedded, weathered, medium to moderately hard (4-6)					>> Q_u = 476.3 tsf, 169.8 pcf; 1 min.
											1 min.
											1 min.
											2 min.
	35										1 min.
				R-6	101			RQD=47 Rec=84%			>> ◎ 2 min.
											2 min.
											2 min.
											3 min.
	40										1 min.
						Vertical fracture from 41 to 42.2 feet					2 min.
											1 min. >> Q_u = 349.4 tsf, 169.5 pcf
				R-7	50			RQD=14 Rec=84%			>> ◎ 1 min.
						Broken from 44.1 to 46 feet					2 min.
	45										2 min.
											2 min.
											2 min.
											2 min.
				R-8	60			RQD=92 Rec=100%			>> ◎ 2 min.
											2 min.
	50										2 min.
						BEDROCK - Dark gray, **SHALE**, very fine to fine grained, medium to very thick bedded, weathered, medium to moderately hard (4-6)					2 min.
											2 min. >> Q_u = 508.3 tsf, 156.8 pcf; 1 min.
											1 min.
											1 min.
	55										1 min.
				R-9	120			RQD=100 Rec=100%			>> ◎ 1 min.
											1 min.
											1 min.
											1 min.
	60										1 min.
											1 min. >> Q_u = 598.5 tsf

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PROJECT: Energy Transfer HDD (DPS)
LOCATION: SR-2017 (PPP3) Huntingdon Co., PA
PA-HU-0106.0000-RD/PO#20170921

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

BORING B-02

DATE STARTED:	9/29/17	**DRILL COMPANY:**	PSI, Inc.
DATE COMPLETED:	10/2/17	**DRILLER:** R. Weaver	**LOGGED BY:** C.Lehman
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	CME 55x300
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:

Water: Pre-Core None Enc. feet; Upon Completion 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 ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf Qu ▲ Qp ✳ (0, 2.0, 4.0)	Additional Remarks
	65			R-10	116	**BEDROCK** - Dark gray, **SHALE**, very fine to fine grained, medium to very thick bedded, weathered, medium to moderately hard (4-6)		RQD=90 Rec=97%			159.3 pcf
	70										Q_u = 395.7 tsf 172.5 pcf
	75			R-11	120			RQD=100 Rec=100%			
	80										Q_u = 447.6 tsf 156.7 pcf
	85			R-12	118			RQD=36 Rec=98%			
						Vertical fracture from 88.4 to 89.8 feet					
	90					Broken from 90.2 to 91 feet					Q_u = 296.5 tsf 170.2 pcf

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LOCATION: SR-2017 (PPP3) Huntingdon Co., PA
PA-HU-0106.0000-RD/PO#20170921

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BORING B-02

DATE STARTED:	9/29/17	**DRILL COMPANY:**	PSI, Inc.
DATE COMPLETED:	10/2/17	**DRILLER:** R. Weaver	**LOGGED BY:** C.Lehman
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	CME 55x300
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:

Water: Pre-Core None Enc.; Upon Completion 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 ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf Qu ▲ Qp ✳ (0, 2.0, 4.0)	Additional Remarks
	95			R-13	120	**BEDROCK** - Dark gray, **SHALE**, very fine to fine grained, medium to very thick bedded, weathered, medium to moderately hard (4-6)		RQD=99 Rec=100%		>>◎	1 min.
	100									>>▲	1 min. Q_u = 253.0 tsf 171.6 pcf
	105			R-14	120			RQD=100 Rec=100%		>>◎	1 min.
	110									>>▲	1 min. Q_u = 462.5 tsf 170.6 pcf
	115			R-15	120			RQD=100 Rec=100%		>>◎	1 min.
	120									>>▲	1 min. Q_u = 231.3 tsf 173.3 pcf

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intertek psi Total Quality Assured.
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PA-HU-0106.0000-RD/PO#20170921

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BORING B-02

DATE STARTED:	9/29/17	**DRILL COMPANY:**	PSI, Inc.
DATE COMPLETED:	10/2/17	**DRILLER:** R. Weaver	**LOGGED BY:** C.Lehman
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	CME 55x300
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:

Water: Pre-Core — None Enc. feet; Upon Completion

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 ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf Qu ▲ / Qp ✳ (0, 2.0, 4.0)	Additional Remarks
	125			R-16	119	**BEDROCK** - Dark gray, **SHALE**, very fine to fine grained, medium to very thick bedded, weathered, medium to moderately hard (4-6)		RQD=79 Rec=99%		>>◎	1 min. 1 min. 1 min. 1 min. 1 min. 2 min.
	130									>>▲	2 min. 1 min. Q_u = 626.8 tsf 162.3 pcf 1 min. 1 min.
	135			R-17	120			RQD=79 Rec=100%		>>◎	1 min. 1 min. 1 min. 1 min. 1 min.
	140					Broken from 139.4 to 140.4 feet				>>▲	1 min. 1 min. Q_u = 200.8 tsf 189.4 pcf 1 min. 1 min.
	145			R-18	108			RQD=98 Rec=100%		>>◎	1 min. 1 min. 1 min. 1 min. 1 min.
	150					Boring terminated at approximately 150 feet					1 min.

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LOCATION: SR-2017 (PPP3) Huntingdon Co., PA
PA-HU-0106.0000-RD/PO#20170921

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08031074
SR2017
PPP3
B-2
Box 1 of _
9/29/17
Run | Depth | Rec. | RQD
R-1 | 15.4 - 17.5 | 1.5 | 0.0
R-2 | 17.4 - 20.0 | 2.4 | 0.0
R-3 | 20.0 - 23.0 | 2.3 | 0.4
R-4 | 23.0 - 26.0 | 3.0 | 2.6
R-5 | 26.0 - 31.0 | 4.5 | 2.6
R-6 | 31.0 - 41.0 | 8.4 | 4.7
TOP
15.4
20.0
17.5
23.0
26.0
31.0
30.0


08031074
SR2017
PPP3
B-2
Box 2 of _
10/2/17
Run | Depth | Rec. | RQD
R-6 | 31.0-41.0 | 8.4 | 4.7
R-7 | 41.0-46.0 | 4.2 | 0.7
R-8 | 46.0-51.0 | 5.0 | 4.6
TOP
41.0
46.0


08031074
SR2017
PPP3
B-2
Box 3 of _
10/2/17
Run | Depth | Rec. | RQD
R-8 | 46.0 - 51.0 | 5.0 | 4.6
R-9 | 51.0 - 61.0 | 10.0 | 10.0
R-10 | 61.0 - 71.0 | 9.7 | 9.0
Top
51.0
61.0


03031074
SR2017
PPP3
B-2
Box 4 of –
10/2/17
Run | Depth | Rec | RQD
R-10 | 61.0 – 71.0 | 9.7 | 9.0
R-11 | 71.0 - 81.0 | 10.0 | 10.0
TOP
71.0
72


08039074
SR2017
DPP3
B-2
Box 5 of _
10/3/17
Run | Depth | Rec. | RQD
R-11 | 71.0 - 81.0 | 10.0 | 10.0
R-12 | 81.0 - 91.0 | 9.8 | 3.6
R-13 | 91.0 - 101.0 | 10.0 | 9.9
TOP
81.0
91.0


08081074
SR2017
PPP3
B-2
Box 6 of
10/3/17
Run | Depth | Rec | RQD
R-13 | 91.0 - 101.0 | 10.0 | 9.9
R-14 | 101.0 - 111.0 | 10.0 | 10.0
TOP
121.0


0803 1074
SR 2017
PPP3
B-2
Box 3 of _
1013117
Run | Depth | Rec. | RQD
R-14 | 101.0 - 111.0 | 10.0 | 10.0
R-15 | 111.0 - 121.0 | 10.0 | 10.0
R-16 | 121.0 - 131.0 | 9.9 | 7.9
TOP
111.0
121.0


08031074
SR2017
PPP3
B-2
Box 8 of _
10/3/17
Run | Depth | Rec. | RQD
R-16 | 121.0 - 131.0 | 9.9 | 7.9
R-17 | 131.0 - 141.0 | 10.0 | 7.9
TOP
131.0


0803107H
SR 2017
PPP3
B-2
Box 9 of _
10/3/17
Run | Depth | Rec | RQD
R-17 | 131.0 - 141.0 | 10.0 | 7.9
R-18 | 141.0 - 150.0 | 9.0 | 8.8
TOP
141.0
150.0

GENERAL NOTES

SAMPLE IDENTIFICATION

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

DRILLING AND SAMPLING SYMBOLS

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

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

SOIL PROPERTY SYMBOLS

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

RELATIVE DENSITY OF COARSE-GRAINED SOILS

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

ANGULARITY OF COARSE-GRAINED PARTICLES

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

GRAIN-SIZE TERMINOLOGY

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

PARTICLE SHAPE

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

RELATIVE PROPORTIONS OF FINES

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

GENERAL NOTES

(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

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

MOISTURE CONDITION DESCRIPTION

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

RELATIVE PROPORTIONS OF SAND AND GRAVEL

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

STRUCTURE DESCRIPTION

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

SCALE OF RELATIVE ROCK HARDNESS

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

ROCK BEDDING THICKNESSES

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

ROCK VOIDS

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

GRAIN-SIZED TERMINOLOGY

(Typically Sedimentary Rock)

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

ROCK QUALITY DESCRIPTION

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

Degree of Brokeness

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

DEGREE OF WEATHERING

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

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

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

SOIL CLASSIFICATION CHART

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

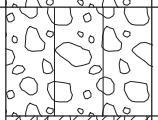
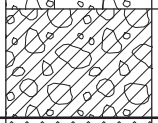
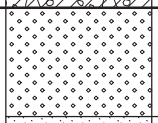
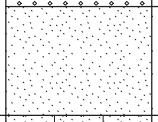
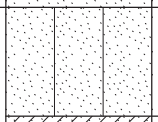
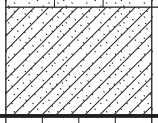
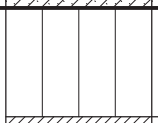
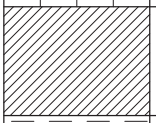
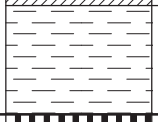
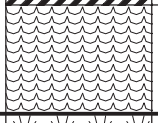
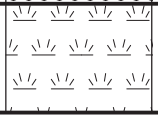
MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50%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

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.

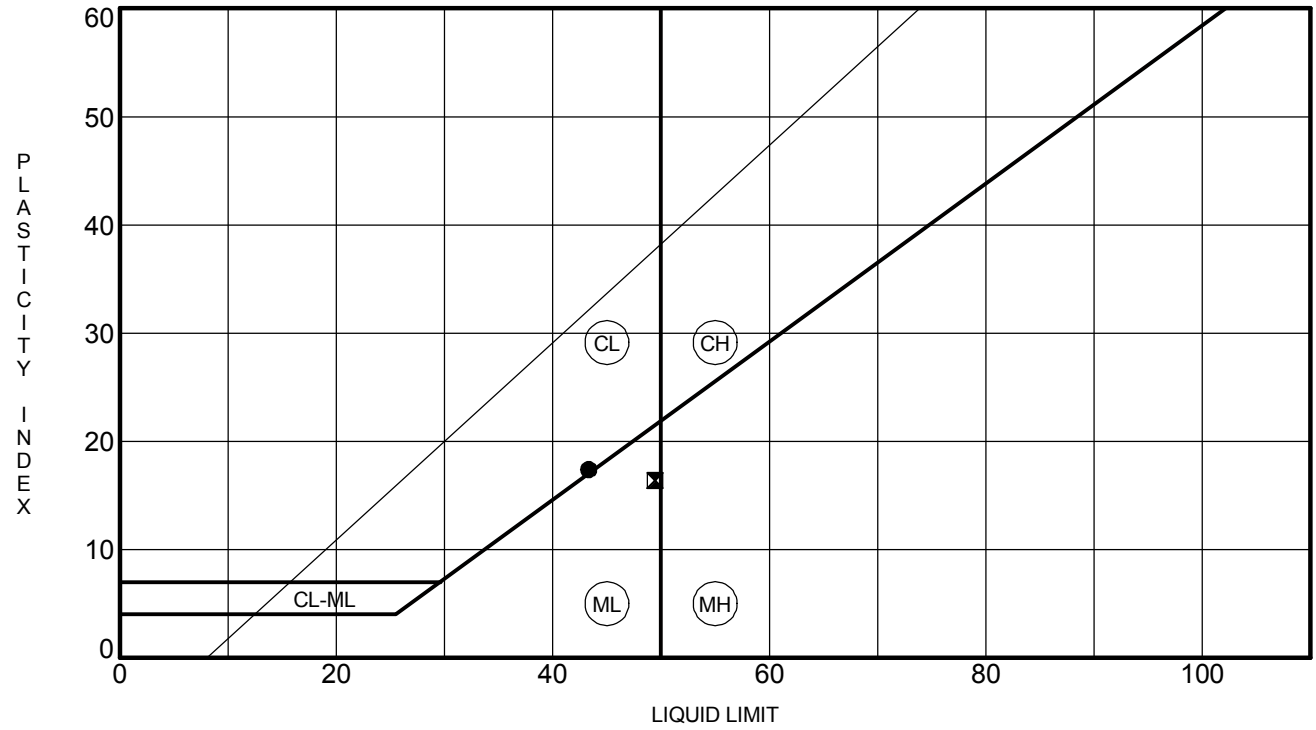
Laboratory Summary Sheet

Borehole	Approx. Depth	Liquid Limit	Plastic Limit	Plasticity Index	Qu (tsf)	%<#200 Sieve	Est. Specific Gravity	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
B-01	1							22			
B-01	6	43	26	17		23.0%		20			
B-01	16.5				470.12						
B-01	24.4				329.08						
B-01	34.3				257.72						
B-01	44.1				250.97						
B-01	54				426.96						
B-01	64.1				599.58						
B-01	73				398.28						
B-01	84				294.85						
B-01	94.4				560.53						
B-01	104.3				461.68						
B-01	114				442.15						
B-01	124				244.78						
B-01	137				441.67						
B-01	144				287.86						
B-02	1	49	33	16		51.8%		15			
B-02	6							18			
B-02	21.5				77.08						
B-02	31.3				476.31						
B-02	42.4				349.36						
B-02	52.4				508.32						
B-02	61.8				598.49						
B-02	72.1				395.66						
B-02	82.3				447.63						
B-02	91.7				296.45						
B-02	102.2				252.99						
B-02	112.2				462.51						
B-02	122.2				231.26						
B-02	132				626.80						
B-02	141.4				200.78						

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

Summary of Laboratory Results

PSI Job No.: 08031074
Project: SR2017 PPP3 Pipeline Huntingdon Co.
Location: SR-2017
Shirley Township
Huntingdon Co., PA



	Boring	Depth (ft)	LL	PL	PI	Fines	Classification (*Visual)
●	**B-01**	**6.0**	**43**	**26**	**17**	**23.0**	
⊠	**B-02**	**1.0**	**49**	**33**	**16**	**51.8**	

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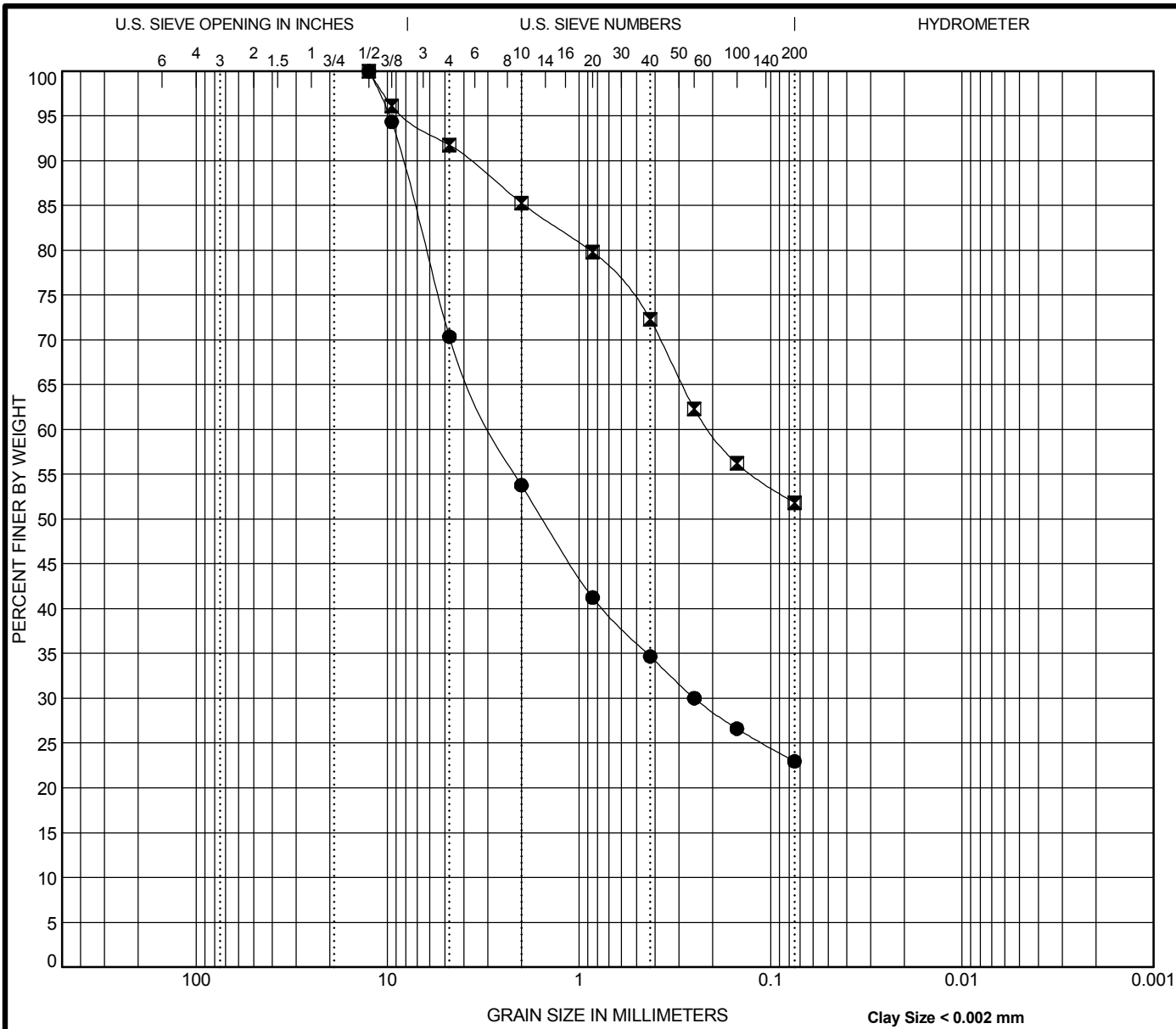
ATTERBERG LIMIT RESULTS

PSI Job No.: 08031074
Project: SR2017 PPP3 Pipeline Huntingdon Co.
Location: SR-2017
Shirley Township



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	B-01	6.0		43	26	17		
⊠	B-02	1.0		49	33	16		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-01	6.0	12.5	2.767	0.25		29.6	47.4	23.0	
⊠	B-02	1.0	12.5	0.206			8.2	39.9	51.8	

Professional Service Industries, Inc.
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Telephone: (412) 922-4000
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GRAIN SIZE DISTRIBUTION

Project: SR2017 PPP3 Pipeline Huntingdon Co.
PSI Job No.: 08031074
Location: SR-2017
Shirley Township

Slake Test

08031074 B-1 R-2 17.1’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 3 & 4, 2017

Test Fluid: Distilled Water

Initial Ph: 5.06

Final Ph: 8.18

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

08031074 B-1 R-3 24.2’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 3 & 4, 2017

Test Fluid: Distilled Water

Initial Ph: 5.06

Final Ph: 7.95

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

08031074 B-1 R-4 34.0’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 3 & 4, 2017

Test Fluid: Distilled Water

Initial Ph: 5.06

Final Ph: 8.41

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

08031074 B-1 R-5 44.6’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 3 & 4, 2017

Test Fluid: Distilled Water

Initial Ph: 5.06

Final Ph: 8.21

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

08031074 B-1 R-6 54.8’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 3 & 4, 2017

Test Fluid: Distilled Water

Initial Ph: 5.06

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

08031074 B-1 R-7 64.0’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 3 & 4, 2017

Test Fluid: Distilled Water

Initial Ph: 5.06

Final Ph: 7.29

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

08031074 B-1 R-8 74.4’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 3 & 4, 2017

Test Fluid: Distilled Water

Initial Ph: 5.06

Final Ph: 7.55

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

08031074 B-1 R-9 84.4’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 3 & 4, 2017

Test Fluid: Distilled Water

Initial Ph: 5.06

Final Ph: 8.56

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

08031074 B-1 R-10 94.0’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 3 & 4, 2017

Test Fluid: Distilled Water

Initial Ph: 5.06

Final Ph: 8.59

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

08031074 B-1 R-11 104.0’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 3 & 4, 2017

Test Fluid: Distilled Water

Initial Ph: 5.06

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

Slake Test

08031074 B-1 R-12 114.9’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 3 & 4, 2017

Test Fluid: Distilled Water

Initial Ph: 5.06

Final Ph: 8.21

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

08031074 B-1 R-13 124.4’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 3 & 4, 2017

Test Fluid: Distilled Water

Initial Ph: 5.06

Final Ph: 8.10

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

08031074 B-1 R-14 135.0'

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 3 & 4, 2017

Test Fluid: Distilled Water

Initial Ph: 5.06

Final Ph: 6.86

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

08031074 B-1 R-15 144.4’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 3 & 4, 2017

Test Fluid: Distilled Water

Initial Ph: 4.96

Final Ph: 8.10

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

08031074 B-2 R-1 16.0’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 10 & 11, 2017

Test Fluid: Distilled Water

Initial Ph: 5.53

Final Ph: 6.30

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

08031074 B-2 R-3 22.1’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 10 & 11, 2017

Test Fluid: Distilled Water

Initial Ph: 5.53

Final Ph: 7.07

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

08031074 B-2 R-6 32.3’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 10 & 11, 2017

Test Fluid: Distilled Water

Initial Ph: 5.53

Final Ph: 8.03

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

08031074 B-2 R-7 42.9’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 10 & 11, 2017

Test Fluid: Distilled Water

Initial Ph: 5.53

Final Ph: 6.05

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

08031074 B-2 R-9 52.1’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 10 & 11, 2017

Test Fluid: Distilled Water

Initial Ph: 5.31

Final Ph: 8.26

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

08031074 B-2 R-10 62.3’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 10 & 11, 2017

Test Fluid: Distilled Water

Initial Ph: 5.31

Final Ph: 7.78

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

08031074 B-2 R-11 72.6’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 10 & 11, 2017

Test Fluid: Distilled Water

Initial Ph: 5.31

Final Ph: 8.41

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

08031074 B-2 R-12 82.7’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 10 & 11, 2017

Test Fluid: Distilled Water

Initial Ph: 5.31

Final Ph: 8.46

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

08031074 B-2 R-13 92.3’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 10 & 11, 2017

Test Fluid: Distilled Water

Initial Ph: 5.31

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

08031074 B-2 R-14 101.7’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 10 & 11, 2017

Test Fluid: Distilled Water

Initial Ph: 5.31

Final Ph: 8.25

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

08031074 B-2 R-15 112.0’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 10 & 11, 2017

Test Fluid: Distilled Water

Initial Ph: 5.31

Final Ph: 8.13

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

08031074 B-2 R-16 122.7’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 10 & 11, 2017

Test Fluid: Distilled Water

Initial Ph: 5.31

Final Ph: 8.40

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

08031074 B-2 R-17 132.4’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 10 & 11, 2017

Test Fluid: Distilled Water

Initial Ph: 5.31

Final Ph: 8.43

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

08031074 B-2 R-18 142.3’

Start

2 Minute: Slake Index 6

4 Hour: Slake Index 6

8 Hour: Slake Index 6

24 Hour: Slake Index 6

Test date: October 10 & 11, 2017

Test Fluid: Distilled Water

Initial Ph: 5.31

Final Ph: 8.72

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

RETTEW

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 Huntingdon County, Pennsylvania

SR 2017/Black Log HDD Soils

January 19, 2019

Preface

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

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

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

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

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

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

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Contents

How Soil Surveys Are Made

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

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

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

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

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

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

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

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

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

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

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

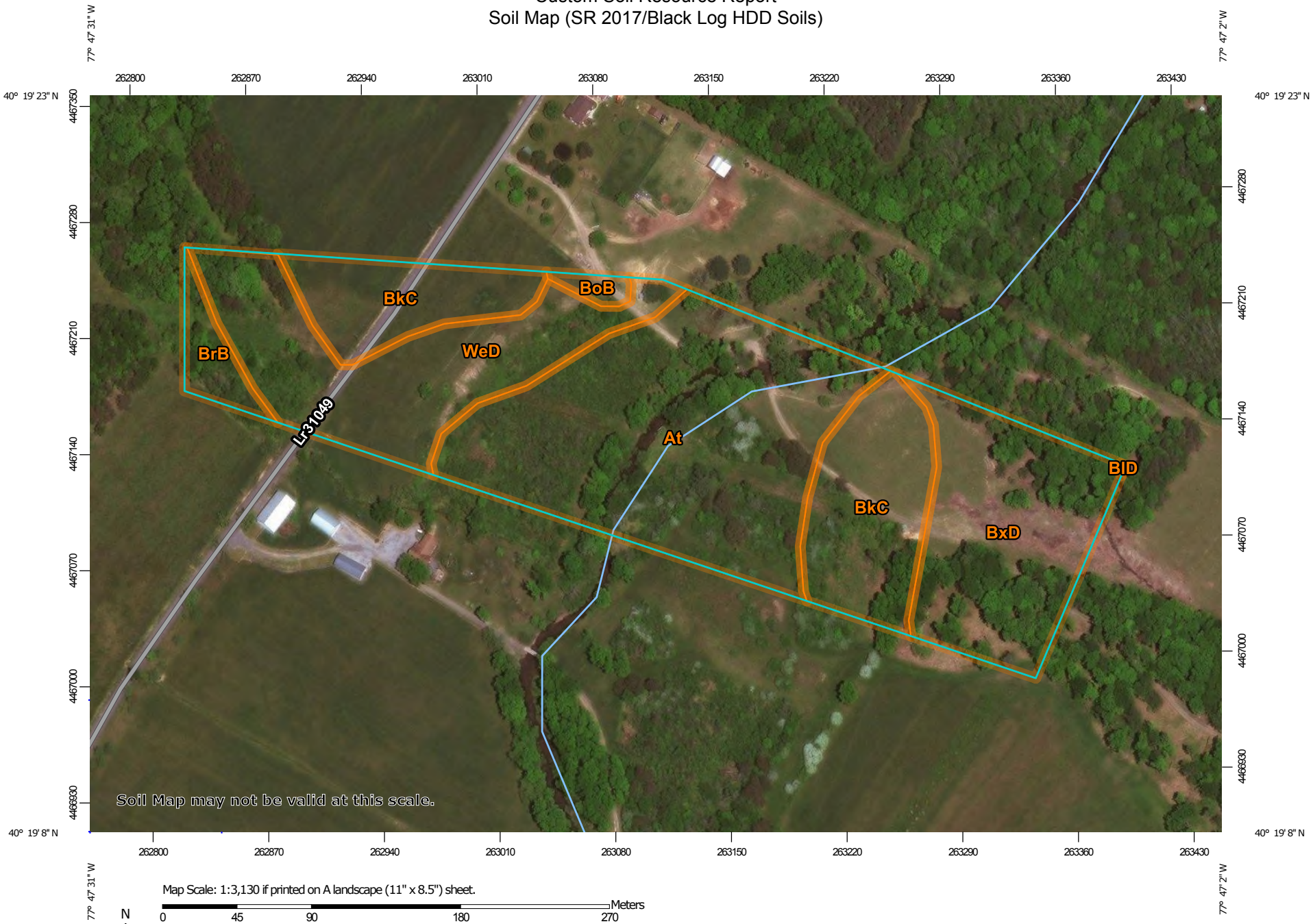
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

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

Soil Map

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

Custom Soil Resource Report
Soil Map (SR 2017/Black Log HDD Soils)



Map Scale: 1:3,130 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 45 90 180 270

Feet: 0 150 300 600 900

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

MAP LEGEND

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

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

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

Special Line Features

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

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

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

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

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

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

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

Soil Survey Area: Huntingdon County, Pennsylvania
Survey Area Data: Version 12, Sep 18, 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 (SR 2017/Black Log HDD Soils)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
At	Atkins silt loam	6.9	36.4%
BkC	Berks channery silt loam, 8 to 15 percent slopes	3.9	20.5%
BlD	Berks-Weikert channery silt loams, 15 to 25 percent slopes	0.0	0.0%
BoB	Blairton silt loam, 2 to 8 percent slopes	0.2	0.9%
BrB	Brinkerton silt loam, 3 to 8 percent slopes	0.5	2.8%
BxD	Buchanan extremely stony loam, 8 to 25 percent slopes	3.6	19.0%
WeD	Weikert channery silt loam, 15 to 25 percent slopes	3.8	20.3%
Totals for Area of Interest		**18.9**	**100.0%**

Map Unit Descriptions (SR 2017/Black Log HDD Soils)

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

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

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

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

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

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

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

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

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

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

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

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

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

Huntingdon County, Pennsylvania

At—Atkins silt loam

Map Unit Setting

National map unit symbol: l5yc
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

BkC—Berks channery silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2sgcg
Elevation: 320 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: Farmland of statewide importance

Map Unit Composition

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

Description of Berks

Setting

Landform: Ridges, mountain slopes
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Upper third of mountainflank, 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

Ap - 0 to 8 inches: channery silt loam
Bw1 - 8 to 14 inches: very channery silt loam
Bw2 - 14 to 26 inches: very channery silt loam
C - 26 to 36 inches: extremely channery silt loam
R - 36 to 46 inches: bedrock

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 5.95 in/hr)
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 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Other vegetative classification: Dry Uplands (DU2), Dry Uplands (DU3)
Hydric soil rating: No

Minor Components

Weikert

Percent of map unit: 10 percent
Landform: Ridges
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Other vegetative classification: Droughty Shales (SD2)
Hydric soil rating: No

Brinkerton

Percent of map unit: 5 percent
Landform: Ridges
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
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)
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
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

BoB—Blairton silt loam, 2 to 8 percent slopes

Map Unit Setting

National map unit symbol: l5yr
Elevation: 300 to 1,300 feet
Mean annual precipitation: 35 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 120 to 214 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

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

Description of Blairton

Setting

Landform: Depressions
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Head slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Local silty colluvium derived from shale and siltstone over acid silty residuum weathered from shale and siltstone

Typical profile

H1 - 0 to 9 inches: silt loam
H2 - 9 to 22 inches: channery silty clay loam
H3 - 22 to 26 inches: very channery loam
H4 - 26 to 30 inches: bedrock

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Somewhat poorly drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 6 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C/D
Hydric soil rating: No

Minor Components

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

BrB—Brinkerton silt loam, 3 to 8 percent slopes

Map Unit Setting
National map unit symbol: l5yv
Elevation: 300 to 3,000 feet
Mean annual precipitation: 30 to 65 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 120 to 217 days
Farmland classification: Not prime farmland

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

Description of Brinkerton

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

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

Properties and qualities
Slope: 3 to 8 percent
Depth to restrictive feature: 15 to 34 inches to fragipan
Natural drainage class: Poorly drained
Runoff class: Very high

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.4 inches)

Interpretive groups

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

Minor Components

Ernest

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

Laidig

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

Berks

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

Atkins

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

Philo

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

BxD—Buchanan extremely stony loam, 8 to 25 percent slopes

Map Unit Setting

National map unit symbol: l5z0

Elevation: 400 to 3,800 feet
Mean annual precipitation: 34 to 60 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 120 to 180 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Buchanan, Extremely Stony

Setting

Landform: Mountain slopes, valley sides
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Lower third of mountainflank, base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Parent material: Mountain slope colluvium derived from sedimentary rock

Typical profile

A - 0 to 6 inches: very gravelly loam
Bt1 - 6 to 19 inches: channery clay loam
Bt2 - 19 to 29 inches: gravelly sandy clay loam
Bx - 29 to 49 inches: gravelly sandy clay loam
C - 49 to 60 inches: very gravelly loam

Properties and qualities

Slope: 8 to 25 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: 22 to 32 inches to fragipan
Natural drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 6 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.0 inches)

Interpretive groups

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

Minor Components

Laidig

Percent of map unit: 12 percent
Hydric soil rating: No

Andover, extremely stony

Percent of map unit: 3 percent
Landform: Depressions
Landform position (two-dimensional): Footslope, toeslope

Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

WeD—Weikert channery silt loam, 15 to 25 percent slopes

Map Unit Setting

National map unit symbol: 2v4vs
Elevation: 340 to 4,040 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

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

Description of Weikert

Setting

Landform: Ridges
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
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 low to high (0.06 to 6.00 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

Berks

Percent of map unit: 9 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

Ernest

Percent of map unit: 3 percent
Landform: Hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

Wharton

Percent of map unit: 2 percent
Landform: Ridges
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Interfluve, side slope, head slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: No

Hartleton

Percent of map unit: 1 percent
Landform: Ridges
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Hydric soil rating: No

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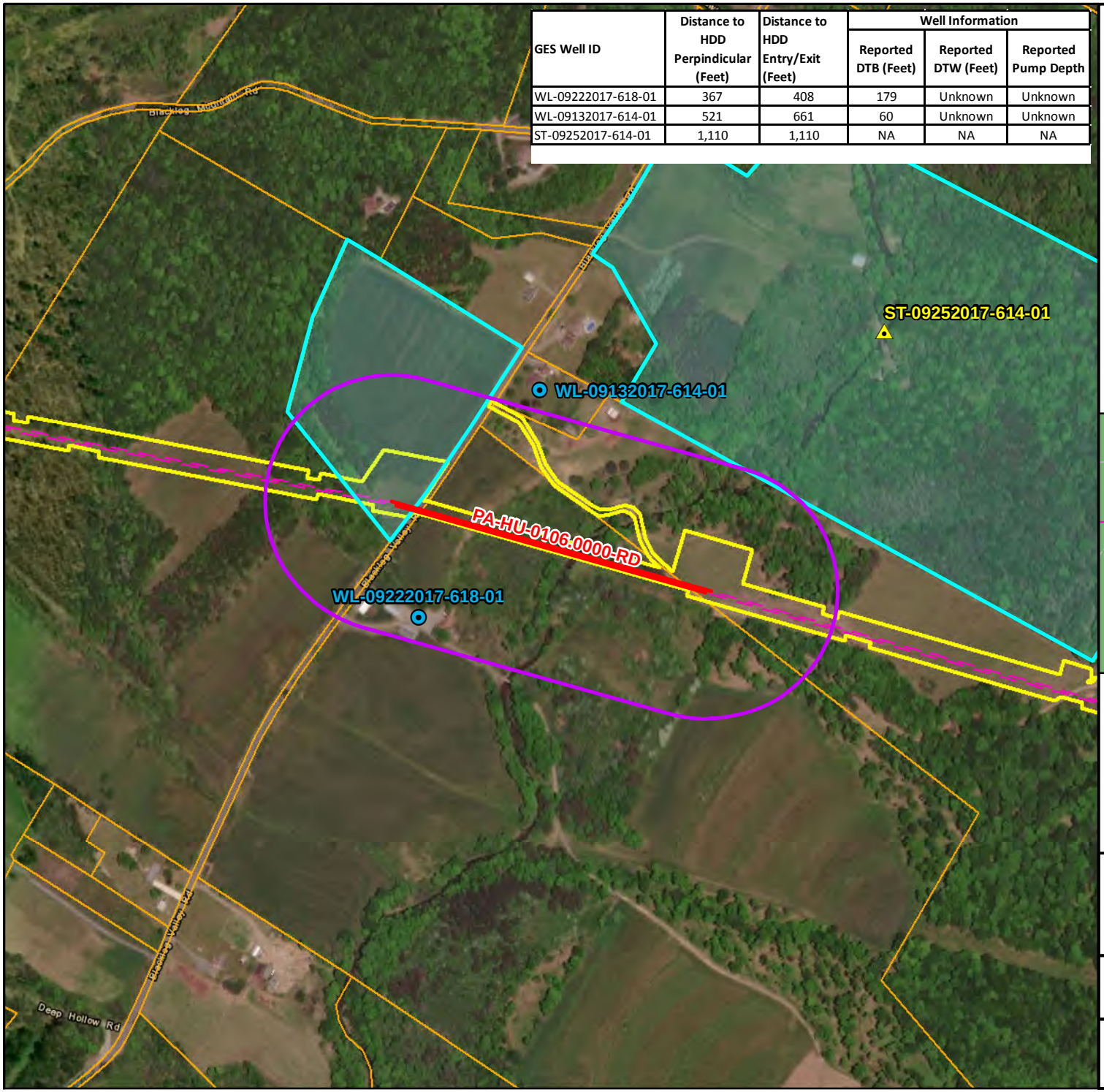
RETTEW

ATTACHMENT 3
450-FOOT WELL SURVEY



GES Well ID	Distance to HDD Perpindicular (Feet)	Distance to HDD Entry/Exit (Feet)	Well Information		
			Reported DTB (Feet)	Reported DTW (Feet)	Reported Pump Depth
WL-09222017-618-01	367	408	179	Unknown	Unknown
WL-09132017-614-01	521	661	60	Unknown	Unknown
ST-09252017-614-01	1,110	1,110	NA	NA	NA

Legend

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

****Testing locations current as of 07/30/2018**

- GES Testing Location
- GES Stream Testing Location

Location

N

0 250 500
Feet

Well Location Map
HDD# PA-HU-0106.0000-RD
Huntingdon County, PA.

Prepared By: TETRA TECH

Date: 1/10/2019

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

Coordinate System: NAD 83 Stateplane, PA South, Feet

P:\GIS\projects\112\0\0358-PPP\MXD\WellLocations\WellLocation_PA_HU_0106_0000.mxd JL

HORIZONTAL DIRECTIONAL DRILL ANALYSIS
BLACKLOG CREEK CROSSING
PADEP SECTION 105 PERMIT NO.: E31-234
PA-HU-0106.0000-RD-16
(SPLP HDD No. S2-0154-16)

ATTACHMENT 2

HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES

PA-HU-0106.0000

PA-HU-0107.0000

PA-HU-0105.0000

SR 2017

TEMP ACCESS RD

BLACKLOG CREEK

GEOTECH SB-01

HDD EXIT AS-DRILLED PILOT
N40.321793
W77.790541

HDD ENTRY / EXIT
N40.321786
W77.790467

SUNOCO EASEMENT
LIMITS - NOT LOD

EXISTING 8" SUNOCO PIPELINE

BLACKLOG CREEK S-K94
N40.321280
W77.788099

INADVERTENT RETURN (IR)
N40.321200
W77.789300

PROPOSED 16" PIPELINE

GEOTECH SB-02

HDD ENTRY AS-DRILLED PILOT
N40.320755
W77.785727

PULLBACK ALONG ROW

HDD ENTRY / EXIT
N40.320908
W77.786375

20" AS-DRILLED PILOT

W-BB114 W-BB114 W-BB114

W-BB115 S-K94

S-K94 S-K94

W-K69 W-K69 W-K69

W-K70 W-K70 W-K70 W-K70

S-M1 W-M1

0+00 1+09 2+00 3+00 4+00 5+00 6+00 7+00 8+00 9+00 10+00 11+00 11+85

GAS

75 0 75 150
FEET

LEGEND

- PERMANENT ROW
- TEMPORARY CONSTRUCTION ROW
- TEMPORARY WORKSPACE
- TEMPORARY ACCESS ROAD
- PERMANENT ACCESS ROAD
- SPOIL SPACE ONLY
- PROPOSED HDD
- PROPOSED 20" PIPELINE
- PROPOSED 16" PIPELINE
- HDD ENTRY-EXIT
- PEM WETLANDS
- PSS WETLANDS
- PFO WETLANDS

PLAN VIEW

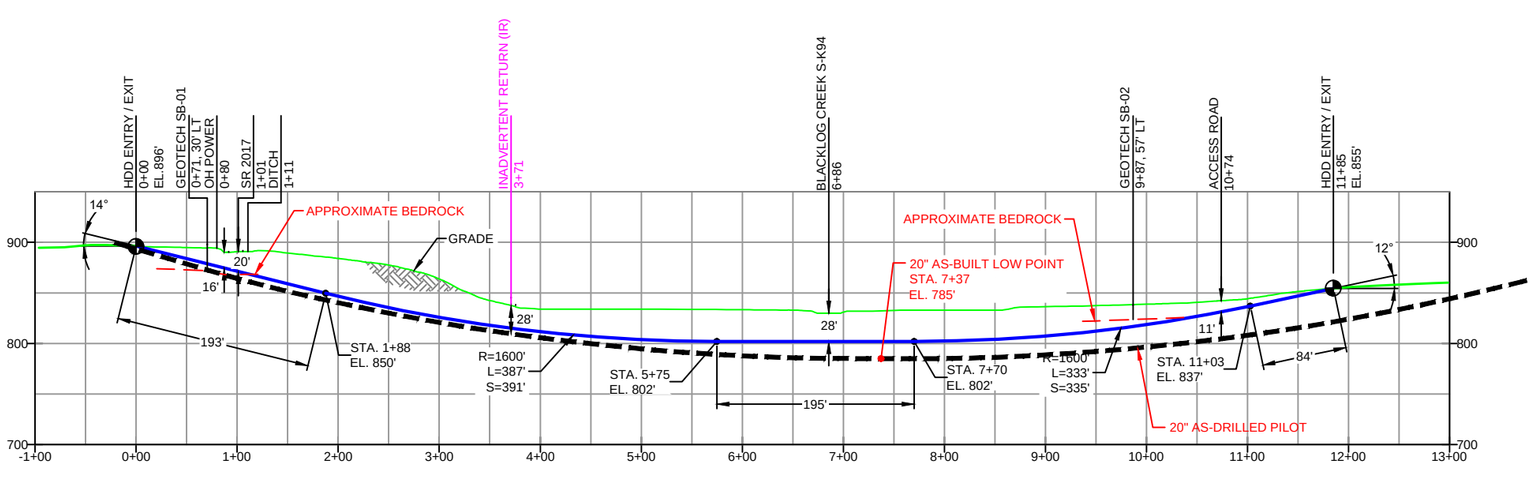
PROFILE VIEW

HUNTINGDON COUNTY PENNSYLVANIA, SHIRLEY TOWNSHIP
S2-0154-16

GEOTECH SB-01
-NG EL. 898'
-TOPSOIL (0' - 0.3')
-CL (0.3' - 22.0')
-SHALE (22.0' - 26.3')
-COMPLETION DEPTH EL. 872'

GEOTECH SB-02
-NG EL. 837'
-TOPSOIL (0' - 0.3')
-SC (0.3' - 3.5')
-SC (3.5' - 13.6')
-GROUNDWATER (11.0')
-SHALE (13.6' - 15.0')
-COMPLETION DEPTH EL. 822'

NOTE: REFER TO TEST BORING LOG S2-0154 FOR COMPLETE SOIL MATERIAL DESCRIPTION



DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):1185'
   HDD PIPE LENGTH (S=):1198'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

Figure 1. Permitted 16-Inch HDD Plan and Profile with 20-Inch IR Data

NOTES

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

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
2	REVISED PROFILE WITH 2017 LIDAR	MRS	03/21/17	RMB	03/21/17	CAG	03/21/17
1	REVISED PER ENGINEERING COMMENTS	MRS	08/26/16	RMB	08/26/16	AAW	08/26/16
0	ISSUED FOR CONSTRUCTION	MRS	12/22/15	RMB	12/22/15	AAW	12/22/15

Sunoco Logistics Partners L.P.

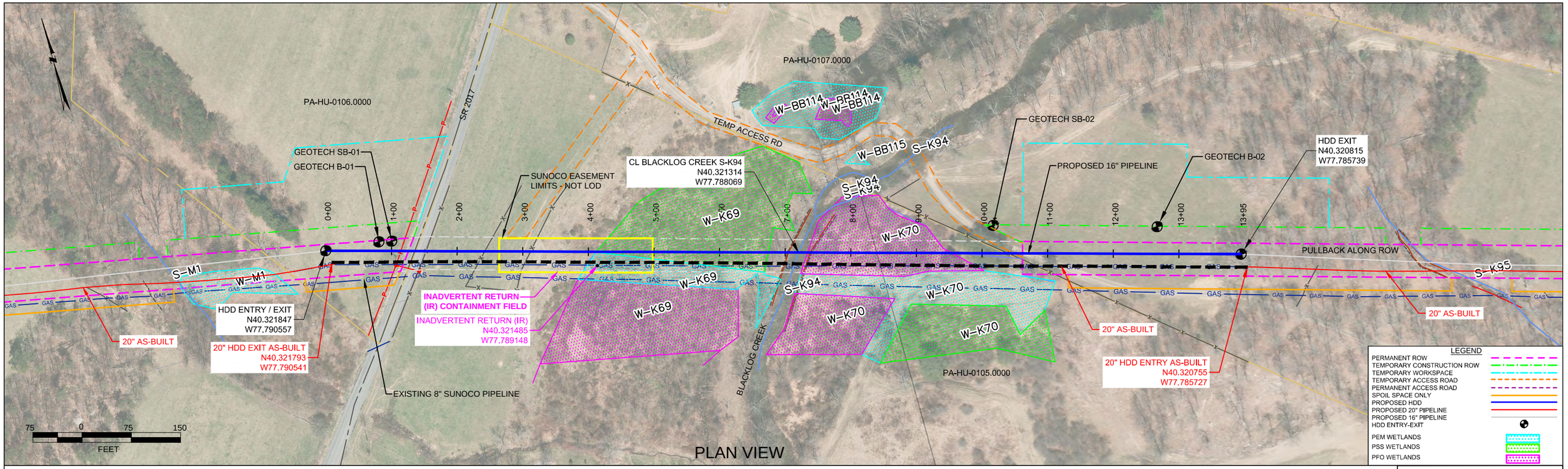
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
SR 2017
PENNSYLVANIA PIPELINE PROJECT

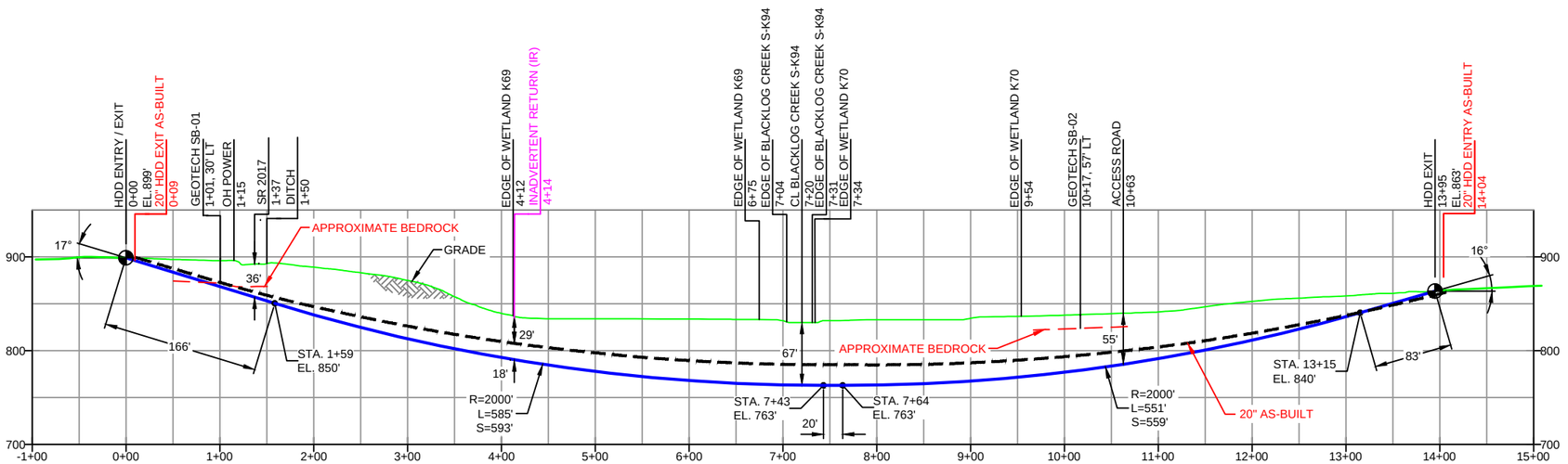
SCALE: 1"=150'

DWG. NO: PA-HU-0106.0000-RD-16



PLAN VIEW

PROFILE VIEW



HUNTINGDON COUNTY PENNSYLVANIA, SHIRLEY TOWNSHIP
S2-0154-16

GEOTECH SB-01

- NG EL. 898'
- TOPSOIL (0' - 0.3')
- CL (0.3' - 22.0')
- SHALE (22.0' - 26.3')
- COMPLETION DEPTH EL. 872'

GEOTECH SB-02

- NG EL. 837'
- TOPSOIL (0' - 0.3')
- SC (0.3' - 3.5')
- SC (3.5' - 13.6')
- GROUNDWATER (11.0')
- SHALE (13.6' - 15.0')
- COMPLETION DEPTH EL. 822'

NOTE: REFER TO TEST BORING LOG S2-0154 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-01

- NG EL. 898'
- RESIDUUM-LEAN CLAY CL (0.0' - 3.0')
- RESIDUUM-CLAYEY SAND SC (3.0' - 10.0')
- WEATHERED ROCK GP (10.0' - 15.0')
- GROUNDWATER (45.5')
- BEDROCK SHALE (15.0' - 150.0')
- BORING TERMINATED EL.748'

NOTE: REFER TO TEST BORING LOG B-01 INTERTEK PROJECT #08031074 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-02

- NG EL. 855'
- COLUVIUM-SANDY LEAN CLAY CL (0.0' - 3.0')
- WEATHERED ROCK SANDY SHALE GP (10.0' - 15.0')
- BEDROCK SHALE (15.0' - 150.0')
- BORING TERMINATED EL.748'

NOTE: REFER TO TEST BORING LOG B-02 INTERTEK PROJECT #08031074 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 1395'
   HDD PIPE LENGTH (S=): 1421'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 2100 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 2625 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

Figure 2. Revised 16-Inch HDD Plan and Profile

NOTES

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

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-3.73	TO	ES-3.73	EROSION & SEDIMENT PLAN
SHEET 44	TO	SHEET 44	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP7	DESIGN CHANGE PER DPS	MRS	01/24/19	RMB	01/24/19	CAG	01/24/19
EP6	ADDED LOD IR CONTAINMENT FIELD BOUNDARY	MRS	06/01/18	RMB	06/01/18	CAG	06/01/18
EP5	UPDATED NOTE 5 AND 10 PER INCREASED 16" MOP	MRS	04/10/18	RMB	04/10/18	CAG	04/10/18
EP4	MODIFIED ATWS PER LAND ACQUISITION	MRS	03/27/18	RMB	03/27/18	CAG	03/27/18
EP3	RELOCATED DRILL ENTRY/EXIT - DESIGN PER MICHELS	MRS	01/08/18	RMB	01/08/18	CAG	01/08/18
EP2	REVISED PER PADEP COMMMENTS RECIVED 09-06-16	DLM	10/07/16	RMB	10/07/16	AAW	10/07/16

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
SR 2017
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150' | DWG. NO: PA-HU-0106.0000-RD-16