HORIZONTAL DIRECTIONAL DRILL ANALYSIS
CREEK ROAD/ CONODOGUINET CREEK CROSSING
PADEP SECTION 105 PERMIT NO.S: E21-449
PA-CU-0125.0000-WX & PA-CU-0125.0000-WX-16
(SPLP HDD No. S2-0181)

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This reanalysis of the horizontal directional drill (HDD) installation of a 16-inch and 20-inch diameter pipeline crossing under Creek Road and adjacent to Conodoguinet Creek, is in accordance with Stipulated Order issued under Environmental Hearing Board Docket No. 2017-009-L for HDDs listed on Exhibit 2 of the Stipulated Order. This HDD is number 13 on the list of HDDs included on Exhibit 2. This HDD was not initiated before the issuance of the Order.

PIPE INFORMATION

20-Inch: 0.456 wall thickness; X-65
16-Inch: 0.438 wall thickness; X-70

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

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 20-INCH

- Horizontal length: 1,230 foot (ft)
- Entry/Exit angle: 10-20 degrees
- Maximum Depth of cover: 48 ft
- Pipe design radius: 1600-2,000 ft

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 1,250 foot (ft)
- Entry/Exit angle: 10-20 degrees
- Maximum Depth of cover: 45 ft
- Pipe design radius: 1,400-1,600 ft

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

This HDD is situated in the Great Valley Section, also known locally as the Cumberland Valley Section, of the Ridge and Valley Physiographic Province. The geologic structure of the Ridge and Valley Physiographic Province is characterized by a series of alternating ridges formed on more resistant sandstones and quartzites, and valleys underlain by more easily eroded shales and limestones. The bedrock in the Ridge and Valley Province is severely folded with numerous anticlines and synclines, faults, and thrust faults. The site is underlain by the Ordovician age Martinsburg Formation, Lower Member (Oml). The Lower Member of the Martinsburg Formation in Cumberland County is composed of dark gray shale with thin interbeds of siltstone, metabentonite, and fine-grained sandstone. The shales and siltstones are typically thin-bedded to fissile, whereas the sandstones are fine-grained and thick to massive (Becher and Root, 1981; Geyer and Wilshusen, 1982; and, Low, et. al., 2002).
Although some thin-bedded limestone breccia and conglomerate units occur in the middle member of the Martinsburg Formation within 1.75 miles east of the HDD, no carbonate or karst geology was observed during the field reconnaissance or is mapped as being present at this HDD location. Based on the lack of karst geologic features the use of geophysical surveys during re-evaluation was considered but not implemented at this HDD location.

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

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HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

Geologic factors such as rock type, intergranular porosity, rock strata inclination, faults, joints, bedding planes, and solution channels affect groundwater movement and availability. According to Becher and Root (1981), the Martinsburg Formation is the uppermost rock unit in the vicinity of this HDD. Groundwater flow paths within the clastic rocks have both local and regional components, which are controlled by bedding, cleavage, and fractures in the rock. Locally, shallow groundwater discharges to the gaining portions of nearby streams such as Conodoguinet Creek, and deeper regional groundwater flow is toward points of regional groundwater discharge such as the Susquehanna River. Based on the geotechnical report and boring logs, groundwater was not encountered in SB-01 or SB-02, which were drilled to 35 feet below ground surface (bgs) and 11 feet bgs, respectively. In the recently completed geotechnical drilling, groundwater was measured in Boring B-01 at a depth of 138.5 feet bgs on August 22, 2017.
The groundwater flow direction in the overburden soils is presumed to mimic surface topography, which slopes gently to the south toward the unnamed tributary and Conodoguinet Creek. The unnamed tributary and Conodoguinet Creek are sustained by local shallow groundwater flow discharges. The unnamed tributary flows to the east beginning near the western exit point of the HDD and eventually discharges to the Conodoguinet Creek. The geotechnical report and boring logs show that no groundwater was present in the unconsolidated soils and the depth to water can be quite deep proximate to the HDD path based on a measured depth to water of 138.5 feet bgs. Based on the Pennsylvania Groundwater Information System (PaGWIS) database, 22 wells occur within the 0.5-mile radius of the HDD. These wells consist of 11 private supply wells, 6 groundwater monitoring wells, and 4 abandoned wells (likely former groundwater monitoring wells) and one “anode” well. The 6 groundwater monitoring wells and 4 abandoned wells are associated with the Turkey Hill gas station located at 1 Cranes Gap Road approximately 0.5 mile east of the HDD site in the Village of Schlusser. Based upon incomplete information in the PaGWIS database, the majority of the identified water wells were completed as 6-inch-diameter open-rock wells at depths ranging from 83 to 241 feet bgs, depth to bedrock ranges from 10 to 92 feet bgs, and well construction consists of 38 to 94 feet of steel casing with the open-rock portions of the wells extending from 31 feet to 202 feet bgs. Reported well yields range from 10 to 25 gallons per minute. Seven static water level measurements were reported and range from 20 to 60 feet bgs. Based on the geologic mapping available for the area, it appears that the majority of the wells identified above were completed in the Martinsburg Formation.

All the private water supply wells identified within a 0.5-mile radius of the HDD are constructed in bedrock indicating that none of these wells relies on the shallow unconsolidated overburden as a source of groundwater supply. The HDD profiles indicate that drilling will penetrate fractured bedrock at depths of up to 80 feet bgs. This depth interval is the same bedrock interval from which some of the wells are believed to derive their groundwater supplies (31 to 202 feet bgs); however, the PaGWIS database does not provide detailed information regarding the water-bearing zone depths penetrated by the wells. Given the lack of readily available water-bearing zone information, absence of identified groundwater supply wells within 1,000 feet of the proposed HDD, and local geologic structure, the potential for water supply impacts to occur as a result of the proposed HDD operations is considered to be negligible. The production zone for waters wells within bedrock is from the well bottom to highest point of water inflow from the water bearing seams, joints, and fractures in the rock formation.

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

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INADVERTENT RETURN (IR) DISCUSSION

HDD specialists for Sunoco Pipeline, L.P. (SPLP) reviewed the original design profiles for the 16 and 20-HDDs and determined there was an increased risk of an IR during the undercrossing of Creek Road and while parallel to the Conodoguient Creek channel due to the shallow depth of profile as summarized in the HDD design data above, and orientation of the profile centerline to the creek channel.

As presented and discussed in the conclusions section below, the profile for both the 16 and 20-inch pipelines have been re-orientated and redesigned longer in extent to allow for an increase in the profile depth below the creek, with a lateral shift to offset the HDD away from the creek channel.

The re-designed HDD profile has been relocated to the north beyond the Conodoguinet Creek and lengthened to allow for deeper crossings beneath the unnamed tributary stream, sanitary sewer, and culvert. The inclination of the entry and exit angles has been increased as a means to install the pipe through these protective soils, residual soils, and bedrock in closer proximity to the entry and exit points than the original, shorter profile. From a geologic perspective, the laterally adjusted, longer and deeper profile, in conjunction with the proposed engineering controls and drilling best management practices, will assist to reduce the risk of an IR.

The new geotechnical data utilized for this HDD reanalysis and redesign was obtained 1,500 ft downstream within the floodplain of Conodoguinet Creek at an equivalent setting. The geotechnical core results shows 14 ft of overburden above bedrock consisting of shale from initial bedrock down to HDD profile depth of -80 ft as shown on the geotechnical core data presented in the hydrogeological report in Attachment 1. Bedrock entry is into shale having a recovery value of 44 and RQD value of “0”. The rock integrity transitions at -30 ft to a recovery value of 100. This recovery value of 100 is consistent down the maximum depth of the HDD profile. The rock strength, RQD value, at 30 ft of depth is 31, and consistently improves with depth below ground until at profile depth the RQD value is 73. The increase in the profile depth, is by itself, a means to minimize the potential for IR’s to occur during these HDDs.

SPLP has a HDD crossing of Conodoguinet Creek in process approximately 1/5 mile downstream (east). As of the date of this reanalysis, this HDD has progressed 1,600 ft into the pilot phase of a 2,405 ft total HDD profile without an IR or other incidents.

ADJACENT FEATURES ANALYSIS

The crossing of Creek Road and Conodoguient Creek is located in Cumberland County, approximately 2.9 miles north of Carlisle, PA., and 0.4 miles west of Spring Road. At this location the pipeline route follows parallel to two (2) previously existing pipelines and a local electrical distribution line.

The general area surrounding the HDD includes unmanaged deciduous woodlands, pasture, croplands, individual homesites, and residential neighborhoods. The wooded area immediately north of the HDD, and north of Creek Road is owned by the township and managed as greenspace.

As noted previously, according to the PaGWIS database, 11 private water supply wells exist within 0.5 miles of the HDD profile. None of these wells, however, are located within 450 ft of the HDD profile.

SPLP has identified all landowners with property located within 450 ft of the HDD alignment. There are nineteen (19) individual landowners with properties located within 450 ft of the HDD alignment. SPLP sent each of these landowners a notice letter via both certified and first class mail on October 30, 2017, 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.

If any landowner with the 450 ft HDD alignment fails to respond by November 15, 2017, agents for SPLP will initiate direct contact by phone or in person to attempt to determine the potable water source for each landowner. Based on the response to the mailings and direct contact, the landowners with private water wells determined to be at risk during the HDD will be offered alternative water supplies until the HDD is complete.

ALTERNATIVES ANALYSIS

As required by the Order, the reanalysis of S2-0181 includes an evaluation of open cut alternatives and a re-route 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 several different routings, locations, and designs to determine whether there was a practicable alternative to the proposed impact. SPLP performed this determination through a sequential review of routes and design techniques, which concluded with an alternative that has the least environmental impacts, taking into consideration cost, existing technology, and logistics. The baseline route provided for the pipeline construction was to cross every wetland and stream on the project by open cut construction procedures. The Alternatives Analysis submitted to PADEP conceptually analyzed the potential feasibility of any alternative to baseline route trenched resource crossings (e.g., reroute, conventional bore, HDD). The decision-making processes for selection of the HDD instead of an open cut crossing methodology is discussed thoroughly in the submitted alternatives analysis and was an important part of the overall PADEP approval of HDD plans as currently permitted. As described below, the open cut and re-route analyses have confirmed the conclusions reached in the previously submitted Alternatives Analysis.

The revised 20-inch and 16-inch HDDs are 1,450 ft and 1,400 ft in horizontal length respectively and includes the crossing of one minor stream channel and Creek Road. The channel of Conodoguinet Creek occurs immediately south of the HDD centerline but does not overlie the HDD. Emergent wetlands occur immediately east and west of the eastern HDD entry/exit point.

Open-cut Analysis

SPLP's original plan of construction, which was replaced by the HDD's subject to this analysis, was a 0.65-mile-long conventional construction route north of the adjacent power line through the unmanaged woodlands owned by the township. The township utilized funding from the National Park Service (NPS) in part to acquire this tract, and the NPS retains the right of review regarding the granting of any encumbrances on this tract. This construction concept was pursued for an extended timeframe before being revised to an HDD alternative. The NPS was unwilling to grant an easement conventional construction to SPLP under any terms.

Re-Route Analysis

The pipeline route as currently permitted follows parallel to two (2) existing pipelines, and passes through a gap in the residential development across the larger area.

There are no existing utility corridors to the north or south that provide a practical alternative route. Any alternate route considered north or south of the existing utility corridor would require the clearing of a new "greenfield" corridor through existing woodlands and croplands, increase the number of stream crossings,

and possibly encroach on additional private residences before it could rejoin the current route. The pipeline route proceeds west to east, and in this area of Cumberland County, individual residences and residential developments occupy the landscape to the north for 2 miles before there is a gap in occurrence. Similar developments occur to the south for 1.4 miles until interrupted by Interstate 76, and then continue into the City of Carlisle.

In addition, SPLP proposed to cross the unmanaged woodlands owned by the township by HDD with a centerline immediately parallel to the electrical distribution line while crossing the township's tract. This HDD alternative construction concept was pursued for an extended timeframe before being revised to the current HDDs subject to this analysis. The NPS was unwilling to grant an easement to SPLP under any terms.

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

RECONSIDERATION OF THE HORIZONTAL DIRECTIONAL DRILL

SPLP HDD consultants reviewed the HDD designs and geotechnical data for this area. Based upon this review, it was determined that the risk of IRs to waters overlying the HDD could be reduced by increasing the depth of the original permitted HDD profile. Additional geologic investigation has been completed and utilized in the redesign of the planned HDD. The redesign adjusts the HDD profile deeper to place the HDD pathway through bedrock having better structural integrity than a shallower profile and increase the overall length of the HDD due to pipe design requirements. A summary of the redesign factors is provided below.

REVISED HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 20-INCH

- Horizontal length: 1,450 foot (ft)
- Entry/Exit angle: 12-15 degrees
- Maximum Depth of cover: 65 ft
- Pipe design radius: 2,400 ft

REVISED HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 1,400 foot (ft)
- Entry/Exit angle: 12-15 degrees
- Maximum Depth of cover: 80 ft
- Pipe design radius: 2,000 ft

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

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

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

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

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

- During the reaming phase, the use of Loss Control Materials can be implemented if indications of a potential IR are noted or an IR is observed; and

- If necessary, the pilot hole and reaming phases at the east point of entry for the HDD may utilize casing, hammered into the substrate down to structurally better rock, to prevent vertical or lateral movement of drilling fluids at shallow depths.

CONCLUSION

It is SPLP's intent to modify the original profile design and to pursue a deeper and longer HDD profile. Figures 1 and 3 in Attachment 2 presents the original HDD plan and profiles. Figures 2 and 4 presents the revised HDD plan and profiles.

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(SPLP HDD No. S2-0181)

ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT

RETTEW

We answer to you.

3020 Columbia Avenue, Lancaster, PA 17603 ● Phone: (800) 738-8395
E-mail: rettew@rettew.com ● Website: rettew.com

Engineers
Environmental Consultants
Surveyors
Landscape Architects
Safety Consultants

November 29, 2017

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

RE: Sunoco Pipeline, L.P. Pipeline Project - Mariner East II
Creek Road Horizontal Directional Drill Location (S2-0181)
Hydrogeological Re-Evaluation Report
North Middleton Township, Cumberland County, Pennsylvania
RETTEW Project No. 096302011

Dear Mr. Gordon:

RETTEW Associates, Inc. is pleased to provide the enclosed Hydrogeological Re-Evaluation Report for the Yellow Breeches Creek Horizontal Directional Drill (HDD) Location (S2-0181). This HDD Re-Evaluation Report was performed as required by the Corrected Stipulated Order dated August 10, 2017. Please note that the HDD Re-Evaluation Report for S2-0181 was prepared by Skelly and Loy, Inc. (Skelly & Loy) under subcontract to RETTEW. Mr. Douglas Hess, Director of Groundwater and Site Characterization Services, was the Professional Geologist (PG) at Skelly and Loy that supervised the work for this report.

If you have any questions regarding the Hydrogeological Re-Evaluation Report for HDD S2-0181, please do not hesitate to call Mr. Hess at (717) 232-1799.

Sincerely,

Matthew T. Bruckner, PG
Project Manager

Enclosure

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November 29, 2017

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

Re: Sunoco PA Pipeline Project Mariner East II, Creek Road/Conodoguinet Creek #1 Horizontal Directional Drill (HDD), Location (S2-0181)
Hydrogeological Re-evaluation Report
North Middleton Township, Cumberland County, Pennsylvania
Rettew Project No. 096302011

EXECUTIVE SUMMARY

1. The 20-inch and 16-inch S2-0181 Creek Road/Conodoguinet Creek #1 Horizontal Directional Drill (HDD) locations are included in the Corrected Stipulated Order of August 10, 2017, requiring re-evaluation, including a geologic report.

2. HDD Creek Road/Conodoguinet Creek #1 is underlain by sedimentary rocks of the Ordovician age Martinsburg Formation (Oml).

3. Geologic mapping, published reports, and field observations indicate a high degree of bedrock fracturing in the Martinsburg Formation characterized by irregularly spaced, generally open, highly developed joints with steeply dipping beds and dominant bedding-parallel fracture cleavage.

4. Water-bearing zones generally occur in secondary openings along bedding planes, joints, faults, and fractures. Water-bearing zones in the Martinsburg Formation are reported to be distributed within the first 100 feet of the subsurface but occur as deep as 350 feet below the ground surface (bgs).

5. To date, no HDD operations have been started at the Creek Road/Conodoguinet Creek #1 site for the proposed 20-inch or 16-inch pipelines.

6. Based on the hydro-structural characteristics of the underlying geology and the proposed HDD profiles within shallow unconsolidated soil materials and generally shallow bedrock, the Creek Road/Conodoguinet Creek #1 proposed 20-inch and 16-inch HDDs are susceptible to the inadvertent return of drilling fluids during HDD operations. A redesigned HDD profile and Best Management Practices (BMPs) during drilling operations will be used to reduce the risk of an inadvertent return (IR).

1.0 INTRODUCTION

The purpose of this report is to describe the hydrogeologic setting of the Creek Road/ Conodoguinet Creek #1 (S2-0181) HDD location on the Sunoco Pipeline, L.P. (SPLP) Pennsylvania Pipeline Project-Mariner East II (PPP-ME2) Project. The Creek Road/Conodoguinet Creek #1 HDD (the site) is located in North Middleton Township, Cumberland County, Pennsylvania. The site is located approximately 2.75 miles north of Carlisle and approximately 1.5 miles north of the Pennsylvania Turnpike (I-76). The HDD was designed to be drilled adjacent to Conodoguinet Creek and under Creek Road, a small tributary discharging to the Conodoguinet Creek, a sanitary sewer, and culvert (refer to **Figure 1**). This hydrogeologic report is part of the response to the Corrected Stipulated Order dated August 10, 2017, related to the potential for the inadvertent return of drilling fluids during proposed drilling operations.

HDD S2-0181 is located within the Great Valley Section of the Ridge and Valley Physiographic Province (Pennsylvania Department of Conservation and Natural Resources [PA DCNR], 2000). The dominant topography in areas underlain by the Martinsburg Formation is typified by alternating ridges formed on more resistant sandstones and quartzites and valleys of low relief underlain by more easily eroded shales and limestones. Local relief is low to moderate and ranges in the vicinity of the site from approximately 404 feet above mean sea level (AMSL) to 453 feet AMSL (Google Earth, 2017). The site is drained by both a shallow, unnamed tributary stream and the adjacent Conodoguinet Creek which flows from west to east along the proposed east-west HDD path. The unnamed tributary flows to the south across the western half of the HDD trace where it discharges into Conodoguinet Creek. The area surrounding the HDD consists predominantly of suburban residential properties with some small, interspersed areas of residual, semi-rural land uses (e.g., farming, agriculture).

The proposed re-designed 20-inch HDD entry point is at a surface elevation of 404 feet AMSL and forms a slightly concave HDD profile that slopes gently upward toward the west to an elevation of 453 feet AMSL at the HDD exit point. The proposed redesigned 20-inch HDD will cross under the single unnamed tributary stream and Creek Road at 43 feet bgs, the sanitary sewer at 29 feet bgs, and the culvert at 29 feet bgs. The proposed redesigned 16-inch HDD entry point is at a surface elevation of 405 feet AMSL sloping gently upward toward the west to an elevation of 448 feet AMSL at the HDD exit point. The 16-inch HDD will cross under Creek Road at 61 feet bgs, the single unnamed tributary stream at 58 feet bgs, the sanitary sewer at 60 feet bgs, and the culvert at 21 feet bgs. The proposed 20-inch and 16-inch HDDs are located between Stations 9956+00 and 9972+00 on the pipeline, for an overall horizontal length of 1,450 feet (20-inch HDD) and 1,400 feet (16-inch HDD). The proposed S2-0181 HDD locations are shown on **Figure 1**.

2.0 GEOLOGY AND SOILS

Twelve available published and online references were reviewed to evaluate the hydrogeology and soils present in the vicinity of the proposed Creek Road/Conodoguinet Creek

#1 HDD (S2-0181). Detailed descriptions of the soils and bedrock geology underlying S2-0181 are included in the following section.

According to the United States Department of Agriculture Soil Survey of Cumberland County, Pennsylvania, soils within 450 feet of the drill path for HDD S2-0181 consist of Atkins silt loam (Aw); Berks channery silt loam (BeB); Blairton silt loam (BpB); Middlebury soils (Mf); Monongahela silt loam, 3 to 8% slopes (MnB); Monongahela silt loam, 8 to 15% slopes (MnC); Purdy silt loam (Pu); Weikert very channery silt loam, 8 to 15% slopes (WeC); Weikert very channery silt loam, 15 to 25% slopes (WeD); and Weikert and Klinesville very shaly silt loams, 25 to 75% slopes (WkF). A site map showing the spatial distribution of the various soils along with the soil profile descriptions is included as **Attachment 1**.

The S2-0181 HDD site is situated in the Great Valley Section, also known locally as the Cumberland Valley Section, of the Ridge and Valley Physiographic Province. The geologic structure of the Ridge and Valley Physiographic Province is characterized by a series of alternating ridges formed on more resistant sandstones and quartzites and valleys underlain by more easily eroded shales and limestones. The bedrock in the Ridge and Valley Province is severely folded with numerous anticlines and synclines, faults, and thrust faults. The site is underlain by the Ordovician age Martinsburg Formation, Lower Member (Oml). The bedrock geology at the site is identified on **Figure 2**.

The Lower Member of the Martinsburg Formation in Cumberland County is composed of dark gray shale with thin interbeds of siltstone, metabentonite, and fine-grained sandstone. The shales and siltstones are typically thin-bedded to fissile, whereas the sandstones are fine-grained and thick to massive (Becher and Root, 1981; Geyer and Wilshusen, 1982; and, Low, et. al., 2002).

According to Geyer and Wilshusen (1982), fracturing in the Martinsburg Formation underlying the HDD S2-0181 site is typified by cleavage parallel to the bedding planes; however, irregularly spaced, naturally occurring fractures known as joints are also present. These joints are typically open and nearly vertical. The joint and bedding plane openings collectively provide a secondary porosity of low magnitude. The formation is moderately weathered to an approximate depth of 1 to 4 feet bgs. The topography is characterized as a valley of low relief dissected by ravines and small stream beds. Drainage patterns are typically dendritic and trellis. Natural slopes are steep and often unstable, with cut slope stability ranging from fair in the shale to good in the sandstone. The overlying soil mantle is generally thick. The formation is moderately easy to excavate in shale and difficult in sandstone. The rock reportedly provides good foundation stability if excavated to sound rock. The drilling rate is reasonably fast.

3.0 HYDROGEOLOGY

Bedrock geology ultimately influences the storage, transmission, and use of groundwater. Geologic factors such as rock type, intergranular porosity, rock strata inclination,

faults, joints, bedding planes, and solution channels affect groundwater movement and availability. According to Becher and Root (1981), the Martinsburg Formation is the uppermost rock unit in the vicinity of the HDD S2-0181. Groundwater flow paths within the clastic rocks have both local and regional components which are controlled by bedding, cleavage, and fractures in the rock. Locally, shallow groundwater discharges to the gaining portions of nearby streams such as Conodoguinet Creek, and deeper regional groundwater flow is toward points of regional groundwater discharge such as the Susquehanna River. Based on the geotechnical report and boring logs included as **Attachment 2**, groundwater was not encountered in SB-01 or SB-02, which were drilled to 35 feet bgs and 11 feet bgs, respectively. In the recently completed geotechnical drilling, groundwater was measured in Boring B-01 at a depth of 138.5 feet bgs on August 22, 2017.

The maximum reported well yield in the Martinsburg Formation is 200 gallons per minute (gpm). Water-bearing zones are commonly less than 100 feet in depth bgs, but occur as deep as 350 feet bgs (Taylor and Werkheiser, 1984). According to Becher and Root (1981), the frequency of water-bearing zones declines gradually to 350 feet bgs. Cleavage is important in creating water-bearing openings, particularly in the Martinsburg Formation where it provides numerous closely spaced, commonly minute openings which, individually, cannot provide much water to wells but, collectively, are capable of providing domestic supplies.

Well records from the PA DCNR Pennsylvania Groundwater Information System (PaGWIS) database were reviewed to identify domestic water supply wells located within a 0.5-mile radius of the proposed HDD right-of-way boundary (PaGWIS, 2017). The search identified 22 wells within the 0.5-mile radius of the HDD. These wells consist of 11 private supply wells, 6 groundwater monitoring wells, and 4 abandoned wells (likely former groundwater monitoring wells and one “anode” well). Ten (10) of the 22 identified wells consist of groundwater monitoring wells associated with the Turkey Hill gas station located at 1 Cranes Gap Road, approximately 0.5 mile east of the HDD site in the Village of Schlusser. A map showing the well locations relative to the proposed HDD location is included as **Figure 3**. Well construction details were not reported for all of the wells. Based on incomplete information in the PaGWIS database (**Figure 3**), it appears that the majority of the identified wells were completed as 6-inch-diameter open-rock wells at depths ranging from 83 to 241 feet bgs. The monitoring wells are shallow, 4-inch-diameter wells located at commercial properties and range in depth from 6 to 17 feet bgs. Based solely on the PaGWIS database, the depth to bedrock ranges from 10 to 92 feet bgs, and well construction consists of 38 to 94 feet of steel casing with the open-rock portions of the wells extending from 31 feet to 202 feet bgs. Reported well yields range from 10 to 25 gpm. Seven static water level measurements were recorded and range from 20 to 60 feet bgs. Based on the geologic mapping available for the area, it appears that the majority of the wells identified above were completed in the Martinsburg Formation.

4.0 FRACTURE TRACE ANALYSIS

Fracture traces are natural linear features that are unaffected by local topographic relief and, as a result, are considered surface manifestations of concentrated high-angle bedrock

fracturing. Fracture traces may be observed on aerial photographs as linear topography, straight stream segments, vegetation, or soil tonal alignments. The Web-based Pennsylvania Imagery Navigator and Google Earth Pro were used to access, download, and view aerial imagery of the HDD site. Ten series of historical aerial photographs were analyzed that included photography dated April 1994, March 1995, April 2003, September 2005, October 2006, March 2007, October 2008, September 2010, August 2012, and April 2016 (Pennsylvania Spatial Data Access [PASDA], 2017, and Google Earth Pro, 2017). Due to the degree and extent of residential development in the area, no fracture traces were discernible proximate to the HDD. According to Becher and Root (1981), three fracture traces were previously identified in the area north of the HDD site. Two of these mapped fracture traces are parallel and trend northeast-southwest at a low angle intersecting the HDD profile at locations approximately 250 and 350 feet east of the proposed HDD exit point (western end of HDD). A third fracture trace is mapped as trending northwest-southeast approximately 2,000 feet north of the HDD. The identified fracture traces are related to the primary geologic structure in the vicinity of the HDD site. The two northeast-southwest trending fracture traces are presented on both the Geology Map (**Figure 2**) and the Groundwater Well Location Map (**Figure 3**). The general surface drainage patterns near the HDD site are characterized by the linear stream reaches of the Conodoguinet Creek and several surface streams generally trending northwest-southeast and southwest-northeast which appear to reflect this local geologic structure.

5.0 GEOTECHNICAL EVALUATION

Three geotechnical borings were completed in 2016 and 2017 during the preliminary investigation of HDD S2-0181 and prior to initiating HDD operations. The three borings are located in the vicinity of the HDD limit of disturbance (LOD) as shown in **Attachment 2**. The boring logs and other supporting information are included as **Attachment 2**. The borings were completed to investigate soil, residual soil, and bedrock conditions using hollow-stem augers with split spoons for soil sampling and a core barrel/bit for rock coring.

The preliminary geotechnical investigation was performed in two phases. Two shallow borings (SB-01 and SB-02) were completed on October 24, 2016, and an additional boring (Boring B-01) was completed between August 21 and 22, 2017. SB-01 was located approximately 75 feet southeast of the proposed HDD exit point, and SB-02 was located 240 feet west of the proposed HDD entry point. Boring B-01 was located approximately 450 feet northwest of the proposed HDD exit point. The generalized subsurface profile observed in the borings is described as follows.

- **SB-01:** The top three inches consisted of topsoil. The interval from approximately 0.3 to 26.5 feet consisted of partially weathered SLATE and from 26.5 to 35.0 feet of moderately fractured SLATE. The total depth of the boring was 35.0 feet bgs. Groundwater was not encountered.

- **SB-02:** The top four inches consisted of topsoil. The interval from 0.3 to 11.0 feet consisted of SILT with a trace of fine sand. Partially weathered SLATE was found at 11.0 feet. The total depth of the soil boring was 11.0 feet bgs where auger refusal was encountered. Groundwater was not encountered.

- **B-01:** The upper 9.0 feet consisted of highly to completely weathered SHALE; from 9.0 to 128.5 feet was slightly weathered, very broken to massive SHALE; from 128.5 to 135.0 feet was slightly weathered, very broken to massive calcareous SHALE; from 135.0 to 138.0 feet was slightly weathered, broken to massive SHALE; and from 138.0 to 175.0 feet was weathered to slightly weathered, very broken to massive SHALE. Total depth of the boring was 175.0 feet. Groundwater was encountered at 138.5 feet bgs.

The boring logs indicate that the soil (weathered bedrock)/bedrock interface ranges from approximately 9 feet (B-01) to 25 feet (SB-01) bgs.

Please note that Skelly and Loy/RETTEW did not oversee or direct the geotechnical drilling programs associated with the S2-0181 HDD including, but not limited to, the selection of boring locations, determination of location, determination of surface elevation, target depths, observations of rock cores during drilling operations, and preparation of boring logs. The geotechnical reports, boring logs, and core photographs that resulted from these programs were generated by other Sunoco Pipeline, L.P. contractors. Skelly and Loy/RETTEW relied on these reports and incorporated their data into the general geologic and hydrogeologic framework of the analysis of proposed S2-0181 Creek Road/Conodoguinet Creek #1 HDD for this report.

6.0 FIELD OBSERVATIONS

Based on a site reconnaissance performed by a Skelly and Loy geologist on October 4, 2017, there are extensive bedrock exposures in the vicinity of the HDD exit point that occur in cut slopes along Creek Road. These bedrock exposures consist predominantly of dark gray shale with thin interbeds of siltstone, metabentonite, and fine-grained sandstone characteristic of the Lower Member of the Martinsburg Formation. The shales and siltstones are typically thin-bedded to fissile whereas the sandstones are fine-grained and thick to massive. Structural geologic measurements indicate that the intense fracturing of these rocks is dominantly controlled by regional northeast-trending cleavage. Field measurements along the cut slope exposures indicate that cleavage ranges from N25-30°E with dips ranging from 65°SE to vertical. Field measurements of bedrock strike ranged from N64-90°E with bedding dips of 40°SE to near vertical.

Jointing was observed to occur as rectangular sets in which the individual joints are vertical to nearly vertical and spaced from a few inches to a foot apart. The joint sets observed are both parallel and perpendicular to the strike of bedding with the perpendicular set being the

most pronounced. The measured orientation of the most abundant and closely spaced joint set ranges from N5°E to N14°E with dips ranging from 52°SE to 84°SE. A second bedding-parallel joint set ranged between N40°E and 70°E with high-angle dips between 60° and vertical. A third bedding-perpendicular joint set was measured to be between N35° and 50°W with a near-vertical dip.

According to available geologic mapping, the entire HDD bore path is underlain by bedrock mapped as the Lower Member of the Martinsburg Formation; this mapping is consistent with Skelly and Loy's field observations. Based on local topography and bedrock dip reported in the published literature (Dyson, 1967), the mean direction of cleavage dip is south between 30º and 90° with a mean of 65º to 70°, the major joint set strikes between N45°E and N62°E with dips varying between 65º and 80° northwest, and bedrock strike generally between 40° and 80° to the north-northeast which are consistent with the field observations and geologic measurements of the Martinsburg Formation near the HDD exit point. In addition to the unnamed tributaries and private water supplies, an additional potential environmental receptor of concern was identified within the defined 0.5-mile HDD buffer area. This potential receptor consists of a farm, livestock barns, and associated commercial property situated approximately 1,000 feet east of the HDD entry point.

7.0 GEOPHYSICAL SURVEY CONSIDERATIONS

Although some thin-bedded limestone breccia and conglomerate units occur in the middle member of the Martinsburg Formation within 1.75 miles east of the HDD, no carbonate or karst geology was observed during the field reconnaissance or is mapped as being present at this HDD location. Although the Corrected Stipulated Order states that the use of geophysical surveys should be considered in karst areas, based on the lack of karst geologic features and extensively fractured bedrock, the use of geophysical surveys during re-evaluation was considered but was ultimately not implemented at the Creek Road/Conodoguinet Creek #1 HDD location because the results of geophysical surveys would not likely provide additional information that would reduce the risk of an IR. In addition, results of geophysical surveys in karst terrains with the resolution necessary to image features that could affect the HDD are typically limited to the upper 20 to 50 feet of the ground surface. Based on our experience working in karst geology, the lack of mapped karst geology along the HDD trace and lack of continuous thick-bedded limestone units, the Martinsburg Formation is not deemed susceptible to the solution activity present in other more thickly bedded carbonate geologic formations in Pennsylvania. In our professional opinion, geophysical surveys would not provide additional information on the formational thickness, interbedded siltstone, metabentonite, fine-grained sandstone, siltstones, and thinly bedded fissile shales at depths greater than 50 feet bgs along the HHD profile. Geophysical survey data would not enhance the evaluation or reduce the risk of an IR.

8.0 CONCEPTUAL HYDROGEOLOGIC MODEL

Groundwater occurring in the watershed occupied by HDD Creek Road/Conodoguinet Creek #1 originates as precipitation or snowmelt. The precipitation infiltrates through the over-burden soils. As previously described, shallow groundwater generally occurs under unconfined conditions within the upper portion of the bedrock. Based on site-specific geotechnical data (Section 5) and information obtained from the PaGWIS database (Section 3), the groundwater table occurs within the upper portion of the bedrock (20 to 60 feet bgs) proximate to the HDD path and contributes flow to local shallow groundwater discharge zones supporting the unnamed tributary and Yellow Breeches Creek which cross above the HDD profile. Based on these limited site-specific data, it appears that the groundwater table also occurs within the unconsolidated overburden near the soil/bedrock interface. The available data suggest that the groundwater table proximate to the HDD path is relatively shallow and may exist in some areas of the overburden soils that contribute flow to these local shallow groundwater discharge zones given that several unnamed tributaries flow above (across) the HDD profile where they discharge to the Conodoguinet Creek. The thickness of the regolith and saturated regolith varies according to the underlying geohydrologic unit and topographic setting (Low, et. al, 2002).

Logs of the three geotechnical borings drilled from October 2016 through August 2017 indicated that the soil thickness near HDD S2-0181 ranges from approximately 9 to 25 feet and consists predominantly of silt, fine sand, and weathered shale and slate. Recorded descriptions of the bedrock core included slightly weathered and massive shale. Data tabulated for supply wells found in the PaGWIS database (**Figure 3**) within a 0.5-mile radius of the HDD trace recorded measured water levels in the bedrock aquifer ranging from 20 to 60 feet bgs. Although groundwater was not encountered in the two shallow geotechnical soil borings (SB-01 and SB-02) completed in the soil regolith, a depth to water measurement of 138.5 feet bgs was obtained from the geotechnical core boring (B-01) completed within the bedrock to a total depth of 175 feet bgs.

This formation is highly anisotropic, with the predominant flow direction parallel to bedrock strike. The transport of groundwater in the fractured bedrock is generally greatest within highly permeable fractures, and the orientation of bedding planes and fractures primarily influence the direction of groundwater flow. Some site-specific evaluation of the bedrock has been completed in the area proximate to the geotechnical boring completed along this HDD profile. No detailed characterization or groundwater flow modeling of the bedrock aquifer was performed as part of this hydrogeologic re-evaluation.

The groundwater flow direction in the overburden soils is presumed to mimic surface topography which slopes gently to the south toward the unnamed tributary and Conodoguinet Creek. The unnamed tributary and Conodoguinet Creek are sustained by local shallow ground-water flow discharges. The unnamed tributary flows to the east, beginning near the western exit point of the HDD, and eventually discharges to Conodoguinet Creek. The geotechnical report and boring logs included as **Attachment 2** show that no groundwater was present in the

unconsolidated soils and the depth to water can be quite deep proximate to the HDD path based on a measured depth to water of 138.5 feet bgs. Based on the PaGWIS database (Section 3), measured water levels in private supply wells located within 0.5-mile of the site range from 20 to 60 feet bgs. Based on this information, the uppermost groundwater table is presumed to occur within the uppermost bedrock or near the soil/bedrock interface under unconfined conditions.

9.0 CONCLUSIONS

Based on published geologic and hydrogeologic information, the S2-0181 Creek Road/ Conodoguinet Creek #1 HDD location is underlain by clastic sedimentary rocks (dark gray shale with thin interbeds of siltstone, metabentonite, and fine-grained sandstone) of the Lower Member of the Martinsburg Formation. Groundwater movement within these rocks is primarily through a network of interconnected secondary openings (e.g., fractures, joints, and faults) that were developed by external forces following deposition of the beds. Geotechnical rock core observations confirm that the local bedrock is fractured and comprised of steeply dipping joints and bedding planes. All of the private water supply wells identified in the vicinity of the HDD are constructed in bedrock, indicating that none of the domestic wells relies on the shallow unconsolidated overburden as a source of groundwater supply. The uppermost portion of the bedrock aquifer, and potentially the unconsolidated soils and weathered bedrock, provide sustainable groundwater discharge to the unnamed tributary and Conodoguinet Creek.

The proposed 20-inch and 16-inch HDD profiles are relatively shallow when compared to the land surface, unnamed stream, sanitary sewer, and culvert and pass through both the unconsolidated overburden and fractured bedrock. The weakest point of the profile is beneath the crossing of the unnamed tributary in the area of the identified fracture traces. Based on the hydro-structural characteristics of the underlying geology described in this report and the known HDD profile through shallow soils and bedrock, the Creek Road/Conodoguinet Creek #1 HDD site is susceptible to the inadvertent return of drilling fluids during HDD operations. The re-designed HDD profile has been relocated to the north beyond the Conodoguinet Creek and lengthened to allow for deeper crossings beneath the unnamed tributary stream, sanitary sewer, and culvert. The inclination of the entry and exit angles has been increased as a means to install the pipe through these protective soils, residual soils, and bedrock in closer proximity to the entry and exit points than the original, shorter profile. From a geologic perspective, the laterally adjusted, longer and deeper profile, in conjunction with the proposed engineering controls and/or drilling BMPs, will be used to reduce the risk of an IR.

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11.0 CERTIFICATION

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

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

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

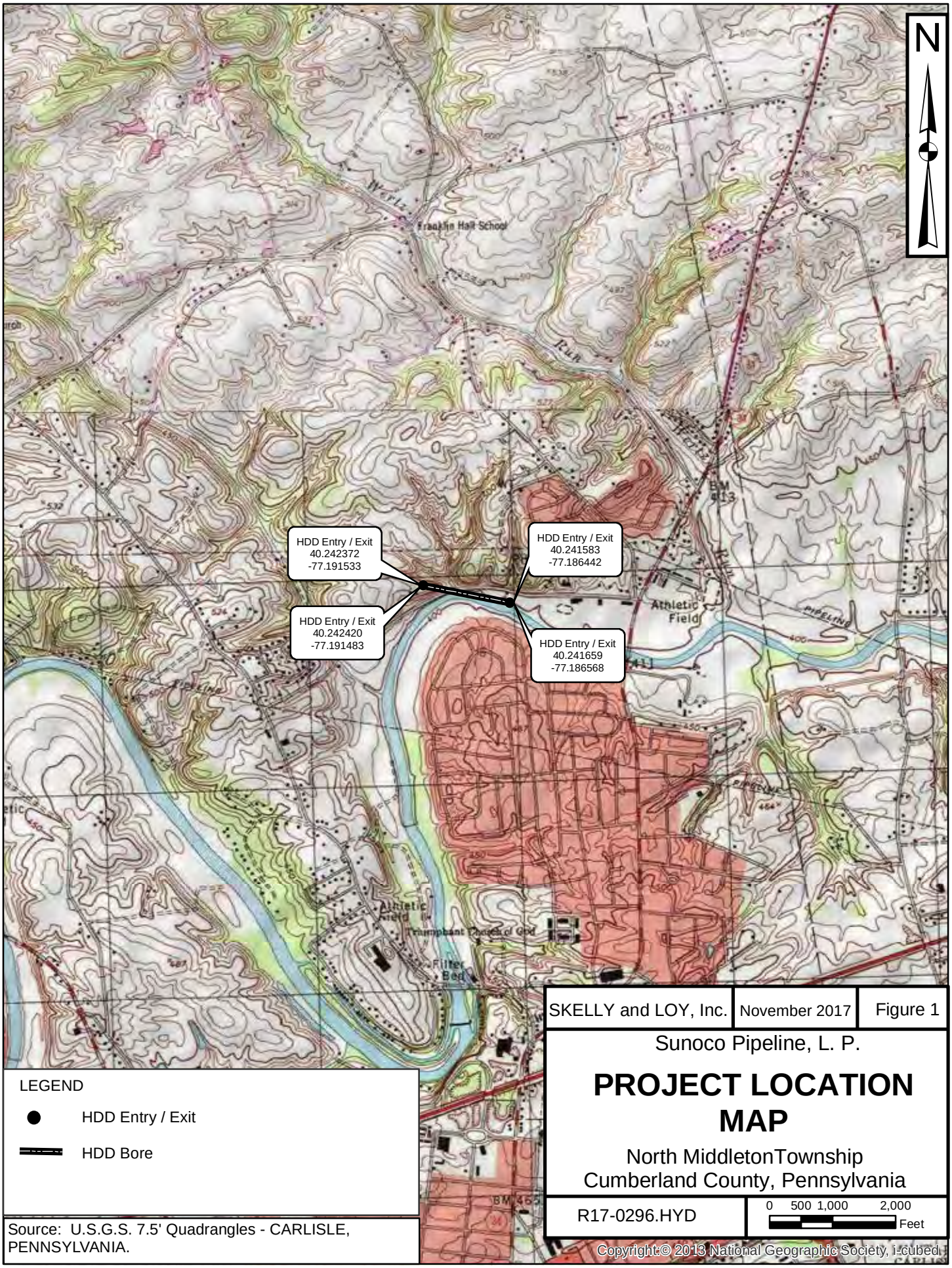
Sincerely yours,

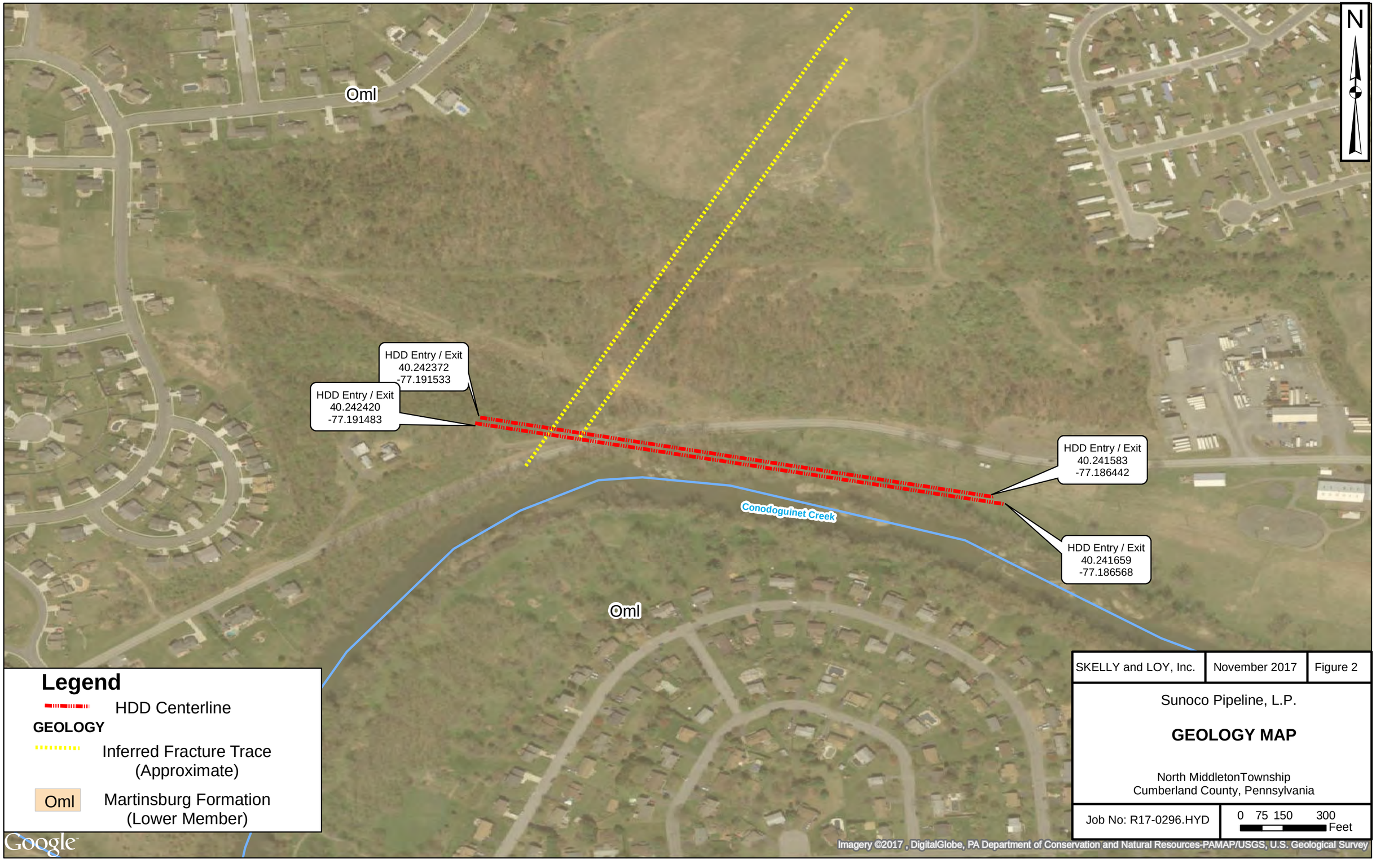
SKELLY and LOY, Inc.

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

Enclosure
cc: R17-0296.HYD
File: HYDROGEOLOGIC_REPORT-Creek Road_DJH (2017-11-29).docx

FIGURES


N
HDD Entry / Exit
40.242372
-77.191533
HDD Entry / Exit
40.241583
-77.186442
HDD Entry / Exit
40.242420
-77.191483
HDD Entry / Exit
40.241659
-77.186568
Franklin Hall School
Run
Athletic Field
Filter Bed
LEGEND
HDD Entry / Exit
HDD Bore
Source: U.S.G.S. 7.5' Quadrangles - CARLISLE, PENNSYLVANIA.
SKELLY and LOY, Inc.
November 2017
Figure 1
Sunoco Pipeline, L. P.
PROJECT LOCATION MAP
North MiddletonTownship
Cumberland County, Pennsylvania
R17-0296.HYD
0 500 1,000 2,000
Feet
Copyright© 2013 National Geographic Society, i-cubed



SKELLY and LOY, Inc.	November 2017	Figure 2

Sunoco Pipeline, L.P.

GEOLOGY MAP

North MiddletonTownship
Cumberland County, Pennsylvania

Job No: R17-0296.HYD	0 75 150 300 Feet

N

HDD Entry / Exit
40.242372
-77.191533

HDD Entry / Exit
40.241583
-77.186442

HDD Entry / Exit
40.242420
-77.191483

HDD Entry / Exit
40.241659
-77.186568

97696
97616
97647
17246
97521
515691
500218
515693
500238
515692
500217
515735
515734
500332
500333
97587
640168
547041
547043
97565
547028

Conodoguinet Creek
UNT to Conodoguinet Creek
Wertz Run
Conodoguinet
UNT

Legend

- Proposed HDD
- Inferred Fracture Trace (Approximate)
- 0.5 Mile Radius of Proposed HDD
- PAGWIS Well ID
- Parcel Boundary

Google

Imagery ©2017 NASA, TerraMetrics

SKELLY and LOY, Inc.	November 2017	Figure 3

Sunoco Pipeline, L.P.

WELL LOCATION MAP

North MiddletonTownship
Cumberland County, Pennsylvania

Job No: R17-0296.HYD

0 175 350 700 Feet

PA WellID	County	Municipali	Quad Name	WellAddres	Well ZipCod	DateDrille	TypeOfActi	Latitude DD	Longitude D	Driller	OriginalOw	WellUse	WaterUse	Well Depth_	TopOf Casin	Bottom OfCa	Casing Diam	Depth ToBed	Bedrock Not	Well Yield_	Static Wate	Water Level	Length OfTe	YieldMeasu	Salt waterZ	FormationN	PaperImage	Remark
547029	CUMBERLAND	NORTH MIDDLETON TWP.				2005-08-02	NEW WELL	40.2378	-77.19913	WHISLERS WELL DRILLING INC	Strickland Brothers Construction	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0				http://www.iframeapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM197796	
547028	CUMBERLAND	NORTH MIDDLETON TWP.				2005-08-03	NEW WELL	40.2381	-77.1984	WHISLERS WELL DRILLING INC	Strickland	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0				http://www.iframeapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM197795	
97565	CUMBERLAND	NORTH MIDDLETON TWP.	CARLISLE			1980-08-01	NEW WELL	40.2389	-77.19778	MERLE L GAYMAN	BRAUN G	WITHDRAWAL	DOMESTIC	150	0	94	6	92	False	10	50	110	2	VOLUMETRIC WATCH & BUCKET		MARTINSBURG FM (SHALE)		RT=HARD SH
547043	CUMBERLAND	NORTH MIDDLETON TWP.				2005-05-13	NEW WELL	40.2393	-77.19813	FUNKS DRILLING INC	Habitat for Humanity	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0				http://www.iframeapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM197810	Note: Coordinates are approximate. A second location based on the driller sketch was placed more than 500 feet away from this location.
547041	CUMBERLAND	NORTH MIDDLETON TWP.				2005-09-28	NEW WELL	40.2398	-77.20053	FUNKS DRILLING INC	Sorresso	WITHDRAWAL	DOMESTIC	0	0	0	0	0	False	0	0	0	0				http://www.iframeapps.dcnr.state.pa.us/topogeo/PaGWIS_search/DisplayReportImage.aspx?id=IM197808	
640168	CUMBERLAND	NORTH MIDDLETON TWP.		10 Maple Avenue Carlisle Pa		2016-03-09	NEW WELL	40.2399	-77.19952	FUNKS DRILLING INC	Strong	WITHDRAWAL		241	-1	39	6.25	0	False	25	60	0	0					
500333	CUMBERLAND			1 Cranes Gap Road Carlisle	17013	2012-01-19	NEW WELL	40.2422	-77.1795	ODYSSEY ENVIRONMENTAL SERVICES INC.	Dillon Real Estate Co	MONITORING		13	0	3	4	0	True	0	0	0	0					Well drilled and installed using CME 75 with 6 1/4" hsa
97587	CUMBERLAND	NORTH MIDDLETON TWP.	CARLISLE			1977-03-08	NEW WELL	40.2422	-77.18167	MERLE L GAYMAN	LEBO D	WITHDRAWAL	DOMESTIC	83	0	52	6	52	False	18	0	0	1	VOLUMETRIC WATCH & BUCKET		MARTINSBURG FM (SHALE)		C M=ROTARY
515735	CUMBERLAND	NORTH MIDDLETON TWP.		1 Cranes Gap Rd.	17013	2014-05-15	WELL ABANDONMENT	40.2422	-77.17952	ALLIED WELL DRILLING	Turkey Hill - Store 216	MONITORING	OTHER	6	0	0	0	0	False	0	0	0	0					Well was located at Turkey Hill located off Rt. 34 just north of Creek Rd. in Carlisle.
515734	CUMBERLAND	NORTH MIDDLETON TWP.		1 Cranes Gap Rd.	17013	2014-05-15	WELL ABANDONMENT	40.2422	-77.17946	ALLIED WELL DRILLING	Turkey Hill - Store 216	ANODE	OTHER	13	0	0	0	0	False	0	0	0	0					Well was located at Turkey Hill located off Rt. 34 just north of Creek Rd. in Carlisle.
500218	CUMBERLAND			1 Cranes Gap Road Carlisle	17013	2012-01-18	NEW WELL	40.2422	-77.17984	ODYSSEY ENVIRONMENTAL SERVICES INC.	Dillon Real Estate Co.	MONITORING		6	0	3	4	0	True	0	0	0	0					Well drilled and installed using CME 75 with 6 1/4" hsa
500217	CUMBERLAND			1 Cranes Gap Road Carlisle	17013	2012-01-18	NEW WELL	40.2422	-77.17957	ODYSSEY ENVIRONMENTAL SERVICES INC.	Dillon Real Estate Co.	MONITORING		17	0	7	4	0	True	0	0	0	0					Well drilled and installed using CME 75 with 6 1/4" hsa
500332	CUMBERLAND			1 Cranes Gap Road Carlisle	17013	2012-01-19	NEW WELL	40.2423	-77.17943	ODYSSEY ENVIRONMENTAL SERVICES INC.	Dillon Real Estate Co.	MONITORING		13	0	3	4	0	True	0	0	0	0					Well driled and installed using CMe 75 with 6 1/4" hsa
515693	CUMBERLAND	NORTH MIDDLETON TWP.		1 Cranes Gap Rd.	17013	2014-05-15	WELL ABANDONMENT	40.2423	-77.17941	ALLIED WELL DRILLING	Turkey Hill - Store 216	ABANDONED	OTHER	17	0	0	0	0	False	0	0	0	0					Well was located at Turkey Hill located off Rt. 34 just north of Creek Rd. in Carlisle.
515692	CUMBERLAND	NORTH MIDDLETON TWP.		1 Cranes Gap Rd.	17013	2014-05-15	WELL ABANDONMENT	40.2423	-77.17957	ALLIED WELL DRILLING	Turkey Hill - Store 216	ABANDONED	OTHER	13	0	0	0	0	False	0	0	0	0					Well was located at Turkey Hill located off Rt. 34 and north of Creek Rd. in Carlisle.
500268	CUMBERLAND			1 Cranes Gap Road Carlisle	17013	2012-01-18	NEW WELL	40.2423	-77.17949	ODYSSEY ENVIRONMENTAL SERVICES INC.	Dillon Real Estate Co.	MONITORING		17	0	7	4	0	True	0	0	0	0					Well drilled and installed using CME 75 with 6 1/4" hsa
515691	CUMBERLAND	NORTH MIDDLETON TWP.		1 Cranes Gap Rd.	17013	2014-05-15	WELL ABANDONMENT	40.2423	-77.17949	ALLIED WELL DRILLING	Turkey Hill - Store 216	ABANDONED	OTHER	17	0	0	0	0	False	0	0	0	0					Well was located at the Turkey Hill store off Rt. 34 just north of Creek Rd. in Carlisle.
97521	CUMBERLAND	NORTH MIDDLETON TWP.	CARLISLE			1982-05-01	NEW WELL	40.2428	-77.18333	WHISLERS WELL DRILLING INC	PREDIX L	WITHDRAWAL	DOMESTIC	175	0	75	6	60	False	25	40	0	0	ESTIMATED		MARTINSBURG FM (SHALE)		RT=HARD SH;LOT#2
17246	CUMBERLAND	NORTH MIDDLETON TWP.	CARLISLE			1966-10-08		40.2436	-77.17833	MERLE L GAYMAN	MAGEE RICHARD	WITHDRAWAL	DOMESTIC	223	0	38	6.3	0	False	12	36	0	0			MARTINSBURG FM (SHALE)		
97647	CUMBERLAND	NORTH MIDDLETON TWP.	CARLISLE			1967-01-01	NEW WELL	40.2447	-77.18111	MERLE L GAYMAN	MCALLISTER TOM	WITHDRAWAL	DOMESTIC	90	0	39	6	39	False	10	31	0	0	UNKNOWN		MARTINSBURG FM (SHALE)		
97616	CUMBERLAND	NORTH MIDDLETON TWP.	CARLISLE			1979-01-01	NEW WELL	40.2478	-77.18444	WHISLERS WELL DRILLING INC	AMSLEY R	WITHDRAWAL	DOMESTIC	198	0	42	6	25	False	20	20	0	0	ESTIMATED		MARTINSBURG FM (SHALE)		RT=BLUE SH
97696	CUMBERLAND	NORTH MIDDLETON TWP.	CARLISLE				NEW WELL	40.2486	-77.18667	HARRISBURG'S KOHL BROS INC	BEAVER HOMES	WITHDRAWAL	DOMESTIC	200	0	39	6	10	False	10	50	0	1	UNKNOWN		MARTINSBURG FM (SHALE)		

ATTACHMENT 1

United States Department of Agriculture

Natural Resources Conservation Service

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

Custom Soil Resource Report for Cumberland County, Pennsylvania

September 25, 2017

Preface

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

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

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

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

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

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

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Contents

How Soil Surveys Are Made

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

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

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

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

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

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

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

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

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

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

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

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

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

Soil Map

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

Custom Soil Resource Report
Soil Map

Map Scale: 1:3,690 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 50 100 200 300

Feet: 0 150 300 600 900

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

MAP LEGEND

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

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

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

Special Line Features

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

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: Cumberland County, Pennsylvania
Survey Area Data: Version 8, Sep 19, 2016

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

Date(s) aerial images were photographed: Aug 23, 2013—Feb 22, 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

Cumberland County, Pennsylvania (PA041)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
Aw	Atkins silt loam	6.8	12.6%
BeB	Berks channery silt loam, 3 to 8 percent slopes	0.9	1.8%
BpB	Blairton silt loam, 3 to 8 percent slopes	4.4	8.2%
Mf	Middlebury soils	1.1	2.0%
MnB	Monongahela silt loam, 3 to 8 percent slopes	5.2	9.7%
MnC	Monongahela silt loam, 8 to 15 percent slopes	1.1	2.1%
Pt	Pits and quarries	1.9	3.6%
Pu	Purdy silt loam	6.3	11.8%
W	Water	7.4	13.8%
WeC	Weikert very channery silt loam, 8 to 15 percent slopes	6.4	12.0%
WeD	Weikert very channery silt loam, 15 to 25 percent slopes	11.1	20.7%
WkF	Weikert and Klinesville very shaly silt loams, 25 to 75 percent slopes	1.0	1.8%
Totals for Area of Interest		**53.5**	**100.0%**

Map Unit Descriptions

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

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

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a

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

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

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

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

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

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

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

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

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

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

Cumberland County, Pennsylvania

Aw—Atkins silt loam

Map Unit Setting

National map unit symbol: r8tq
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

Barbour

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

Philo

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

Saprists

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

BeB—Berks channery silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2sgb5
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 7 inches: channery silt loam
Bw1 - 7 to 15 inches: channery silt loam
Bw2 - 15 to 28 inches: very channery silt loam
C - 28 to 36 inches: extremely channery silt loam
R - 36 to 46 inches: bedrock

Properties and qualities

Slope: 3 to 8 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 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Other vegetative classification: Dry Uplands (DU2)
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

BpB—Blairton silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: r8v3
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

Mf—Middlebury soils

Map Unit Setting

National map unit symbol: r8xt

Elevation: 800 to 840 feet
Mean annual precipitation: 30 to 40 inches
Mean annual air temperature: 45 to 54 degrees F
Frost-free period: 120 to 187 days
Farmland classification: All areas are prime farmland

Map Unit Composition

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

Description of Middlebury

Setting

Landform: Flood plains
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear, concave
Across-slope shape: Concave, linear
Parent material: Post glacial alluvium derived from sandstone and shale

Typical profile

H1 - 0 to 9 inches: silt loam
H2 - 9 to 36 inches: silt loam
H3 - 36 to 60 inches: stratified sand to gravelly sandy loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: About 12 to 36 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.1 inches)

Interpretive groups

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

Minor Components

Holly

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

MnB—Monongahela silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: r8xw
Elevation: 300 to 1,800 feet
Mean annual precipitation: 30 to 55 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 110 to 187 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

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

Description of Monongahela

Setting

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

Typical profile

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

Properties and qualities

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

Interpretive groups

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

Minor Components

Unadilla

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

Lakin

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

Wheeling

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

Holly

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

MnC—Monongahela silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: r8xx
Elevation: 300 to 2,000 feet
Mean annual precipitation: 35 to 55 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 120 to 180 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Monongahela and similar soils: 90 percent
Minor components: 2 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Monongahela

Setting

Landform: Stream terraces
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear

Across-slope shape: Linear
Parent material: Old alluvium derived from sedimentary rock

Typical profile

H1 - 0 to 9 inches: silt loam
H2 - 9 to 21 inches: silt loam
H3 - 21 to 46 inches: gravelly loam
H4 - 46 to 62 inches: gravelly loam

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 18 to 30 inches to fragipan
Natural drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.60 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.8 inches)

Interpretive groups

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

Minor Components

Purdy

Percent of map unit: 2 percent
Landform: Depressions
Landform position (two-dimensional): Toeslope
Down-slope shape: Linear
Across-slope shape: Concave
Hydric soil rating: Yes

Pt—Pits and quarries

Map Unit Setting

National map unit symbol: r8y9
Elevation: 300 to 1,300 feet
Mean annual precipitation: 35 to 50 inches
Mean annual air temperature: 44 to 57 degrees F
Frost-free period: 120 to 214 days
Farmland classification: Not prime farmland

Map Unit Composition

Pits, quarries: 90 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Pits, Quarries

Setting

Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Gravel and shale pits

Typical profile

H1 - 0 to 60 inches: bedrock

Properties and qualities

Slope: 0 to 80 percent
Depth to restrictive feature: 0 inches to lithic bedrock

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydric soil rating: No

Minor Components

Aquepts

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

Pu—Purdy silt loam

Map Unit Setting

National map unit symbol: r8yb
Elevation: 480 to 3,000 feet
Mean annual precipitation: 30 to 65 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 120 to 214 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Purdy

Setting

Landform: Terraces
Landform position (two-dimensional): Toeslope
Down-slope shape: Concave

Across-slope shape: Concave
Parent material: Slackwater terrace alluvium derived from sedimentary rock

Typical profile

H1 - 0 to 7 inches: silty clay loam
H2 - 7 to 40 inches: silty clay
H3 - 40 to 65 inches: silty clay

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: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Occasional
Available water storage in profile: High (about 9.0 inches)

Interpretive groups

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

Minor Components

Tyler

Percent of map unit: 8 percent
Hydric soil rating: No

Monongahela

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

Blairton

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

Ernest

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

W—Water

Map Unit Setting

National map unit symbol: r8yh
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 120 to 214 days
Farmland classification: Not prime farmland

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

Description of Water

Setting
Parent material: Rivers streams ponds

Properties and qualities
Runoff class: Negligible
Frequency of ponding: Frequent

WeC—Weikert very channery silt loam, 8 to 15 percent slopes

Map Unit Setting
National map unit symbol: 2v4vx
Elevation: 370 to 1,530 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): Nose slope
Down-slope shape: Convex
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 7 inches: very channery silt loam
Bw - 7 to 14 inches: very channery silt loam
C - 14 to 18 inches: extremely channery silt loam
R - 18 to 28 inches: bedrock

Properties and qualities
Slope: 8 to 15 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Natural drainage class: Somewhat excessively drained
Runoff class: Low
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
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): 4e
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Berks

Percent of map unit: 7 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: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

Brinkerton

Percent of map unit: 3 percent
Landform: Hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Concave
Hydric soil rating: Yes

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

Map Unit Setting

National map unit symbol: 2v4vy
Elevation: 320 to 1,320 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: Convex, linear
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 2 inches: very channery silt loam
Bw - 2 to 15 inches: very channery silt loam
C - 15 to 18 inches: extremely channery silt loam
R - 18 to 28 inches: bedrock

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 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 1.8 inches)

Interpretive groups

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

Minor Components

Berks

Percent of map unit: 6 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

Blairton

Percent of map unit: 6 percent
Landform: Hillslopes
Landform position (two-dimensional): Backslope

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

Ernest

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

WkF—Weikert and Klinesville very shaly silt loams, 25 to 75 percent slopes

Map Unit Setting

National map unit symbol: r8yn
Elevation: 300 to 1,600 feet
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Weikert and similar soils: 45 percent
Klinesville and similar soils: 35 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Weikert

Setting

Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Parent material: Acid residuum weathered from sedimentary rock

Typical profile

H1 - 0 to 6 inches: very channery silt loam
H2 - 6 to 17 inches: very channery silt loam
H3 - 17 to 21 inches: bedrock

Properties and qualities

Slope: 25 to 75 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium

Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Very low (about 1.3 inches)

Interpretive groups

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

Description of Klinesville

Setting

Landform: Hillsides
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Reddish residuum weathered from sedimentary rock

Typical profile

H1 - 0 to 5 inches: very channery silt loam
H2 - 5 to 15 inches: very channery silt loam
H3 - 15 to 19 inches: very channery silt loam
H4 - 19 to 23 inches: bedrock

Properties and qualities

Slope: 25 to 75 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Very low (about 1.4 inches)

Interpretive groups

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

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ATTACHMENT 2

LEGEND:

◎ Geotechnical Soil Boring (SB) Locations

TETRA TECH

GEOTECHNICAL BORING LOCATIONS
CONDOGOGUINET CREEK
CUMBERLAND COUNTY, NORTH MIDDLETON TWP, 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:	CONDODOGUINET CREEK, CARLISLE, PA			Page 1 of 1	
HDD No.:	CONDODOGUINET CREEK	Dates(s) Drilled: 10/24/16		Inspector:	M. ESPOSITO
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586		Driller:	S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): NOT ENCOUNTERED		Total Depth (ft):	35.0
Boring Location Coordinates:		40°14'31.78"N		77°11'29.15"W	

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.3			TOPSOIL (3")					
1	3.0	3.8	0.3		8	PARTIALLY WEATHERED SLATE	PARTIALL WEATHERED GRAYISH BROWN SLATE.	16	50/3"			
							(MATRIX OF F-C SAND AND F-C GRAVEL - SPOON DISTURBED)					
2	8.0	8.8			12		SAME	20	50/4"			
3	13.0	13.8			6		SAME	13	50/3"			
4	18.0	18.3			3		PARTIALL WEATHERED LIGHT GRAY SLATE.	50/3"				
							(MATRIX OF F-C SAND AND F-C GRAVEL - SPOON DISTURBED)					
5	23.0	23.2		25.0	2		SAME	50/2"				
							AUGER REFUSAL AT 25'.					
							ROCK CORING					
RUN 1	25.0	26.5	25.0	26.5	10	SLATE	PARTIALLY WEATHERED TO FRACTURED LIGHT GRAY SLATE	TCR: 56%, SCR: 50%, RQD: 33%				
RUN 2	26.5	30.75	26.5		51		MODERATELY FRACTURED LIGHT GRAY SLATE.	TCR: 100%, SCR: 90%, RQD: 72%				
RUN 2	30.75	35.0		35.0	51		MODERATELY FRACTURED LIGHT GRAY SLATE.	TCR: 100%, SCR: 98%, RQD: 66%				
							CAVED AT 18'.					
							CORE TESTING RESULTS (DEPTH 31.0 - 31.5'.):					
							COMPRESSIVE STRENGTH: 2,630 PSI					
							UNIT WEIGHT: 164.09 PCF					

Notes/Comments:

Pocket Pentrometer Testing

DR: DECOMPOSED ROCK

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

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

TETRA TECH
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:	CONDODOGUINET CREEK, CARLISLE, PA			Page 1 of 1	
HDD No.:	CONDODOGUINET CREEK	Dates(s) Drilled: 10/24/16		Inspector:	M. ESPOSITO
Boring No.:	SB-02	Drilling Method: SPT - ASTM D1586		Driller:	S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): NOT ENCOUNTERED		Total Depth (ft):	11.0
Boring Location Coordinates:		40°14'29.99"N		77°11'14.26"W	

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.3			TOPSOIL (4")					
1	3.0	5.0	0.3		17	ML	GRAY, SLIGHTLY MOTTLED SILT, TRACE FINE SAND. STIFF.	6	6	7	9	**13**
				8.0			(USCS: ML).					
2	8.0	8.2	8.0	11.0	2		GRAY PARTIALLY WEATHERED SLATE IN SPOON TIP.	50/2"				**>50**
							AUGER REFUSAL AT 11'. OFFSET BORING 8' TO THE WEST, AND AUGERED TO REFUSAL AT 9'.					
							CAVED AND DRY AT 8.5'.					

Notes/Comments:

Pocket Pentrometer Testing
S1: 3.5 TSF

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

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

ROCK CORE DESCRIPTION SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
CONDODOGUINET CREEK

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					
Condodoguinet Creek	SB-01	1	25	26.5	56	50	33	25	35.5	Slight	Slate (slightly calcarious)	Very thin	Gray	Fractures ranging from 32° to 82°, Avg. 48°; Fracturing along bedding planes
		2	26.5	30.75	100	90	72							
		3	30.75	35	100	98	66							

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
CONDODOGUINET CREEK

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)
Condodoguinet Creek	SB-01	1	3.0	3.8	5.4	17.5	-	-	-	-
		2	8.0	8.8	4.7	11.7	-	-	-	-
		3	13.0	13.8	3.8	4.6	-	-	-	-
		4	18.0	18.3	3.9	1.9	-	-	-	-
		5	23.0	23.2	6.8	6.1	-	-	-	-
	SB-02	1	3.0	5.0	23.1	92.5	40	28	12	ML
		2	8.0	8.2	23.9	90.9	-	-	-	-

Rock Core Testing Results				
Boring No.	Core Run	Approximate Depth (ft)	Compressive Strength (psi)	Unit Weight (pcf)
SB-01	3	31.0-31.5	2,630	164.1

Notes:

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

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
CONDODOGUINET CREEK

HDD IDENTIFICATION	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
Condodoguinet Creek	SB-01	Martinsburg Fm - buff-weathering, dark-gray to purple shale and slate with thin interbeds of siltstone, metabentonite, and fine-grained sandstone.	Steeply dipping south towards river	Martinsburg Fm	Shale and slate with interbedded siltstone	No information found during literature review	9-22	Borings located along erosional side of meander bend
	SB-02		Generally level					

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

FIELD DESCRIPTION AND LOGGING SYSTEM FOR SOIL EXPLORATION

GRANULAR SOILS

(Sand, Gravel & Combinations)

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

Relative Proportions

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

Particle Size Identification

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

COHESIVE SOILS

(Silt, Clay & Combinations)

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

Plasticity

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

ROCK

(Rock Cores)

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

RQD: Rock Quality Designation
TCR: Total Core Recovery
SCR: Solid Core Recovery

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).

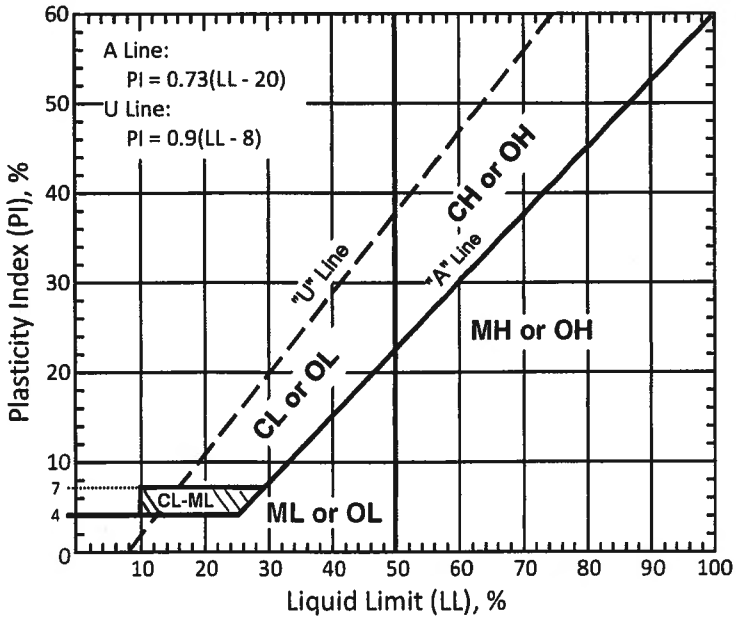
Groundwater observations were made at the times indicated. Groundwater elevations fluctuate throughout a given year, depending on actual field porosity and variations in seasonal and annual precipitation.

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.



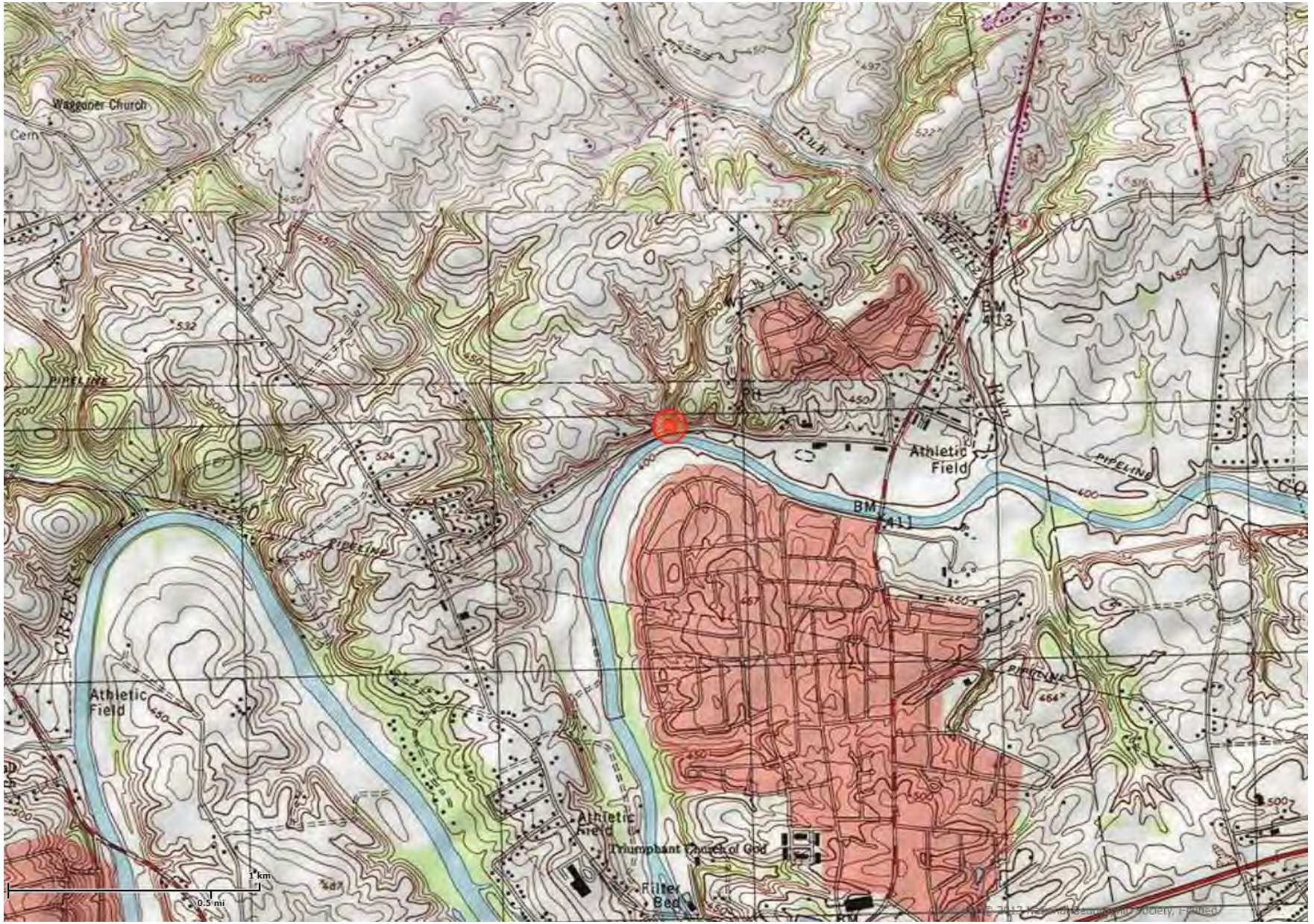
(1) Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC. well-graded gravel-sand mixture with clay binder.

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

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

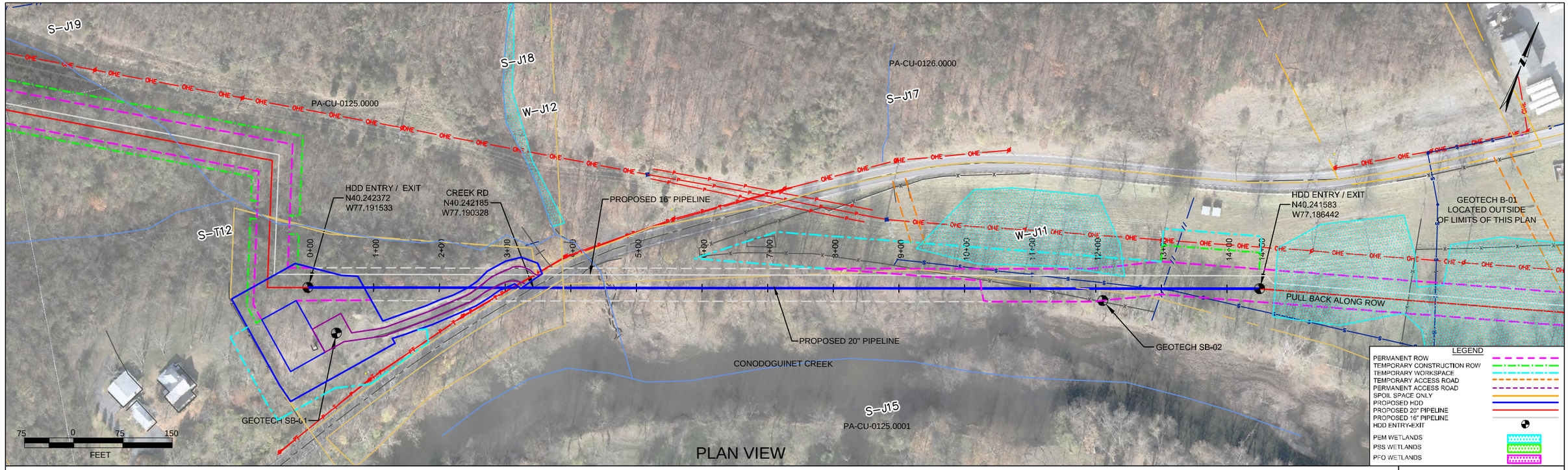
Figure 1: Site Vicinity Map

Make online reservations at
www.visitPAparks.com
or call toll-free 888-PA-PARKS



Created using PA DCNR Map Viewer

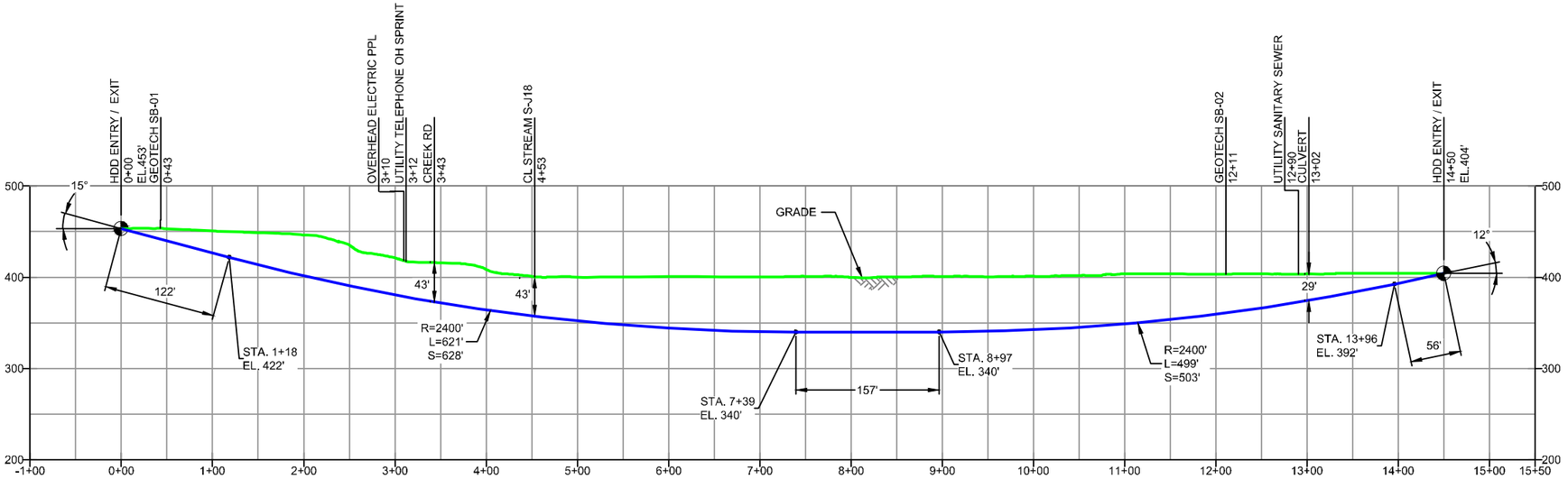
Map created on Thu Aug 24 2017



PLAN VIEW

PROFILE VIEW

CUMBERLAND COUNTY, PA - NORTH MIDDLETON TOWNSHIP
S2-0181



GEOTECH SB-01

-NG EL. 462'
-TOPSOIL (0' - 0.3')
-WEATHERED SLATE (0.3' - 25.0')
-AUGER REFUSAL (25.0')
-SLATE (25.0' - 35.0')
-COMPLETION DEPTH EL. 427'

GEOTECH SB-02

-NG EL. 404'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 8.0')
-AUGER REFUSAL (9.0')
-WEATHERED SLATE (8.0' - 11.0')
-COMPLETION DEPTH EL. 393'

NOTE: REFER TO TEST BORING LOG S2-0181 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-01

-NG EL. 402'
-ALLUVIUM-LEAN CLAY CL (0.0' - 2.0')
GROUNDWATER (5.6')
-ALLUVIUM-LEAN CLAY CL (2.0' - 6.0')
-RESIDUUM-SAND W/ GRAVEL SC (6.0' - 8.0')
-RESIDUUM-SILTY SAND SM (8.0' - 9.0')
-SHALE (9.0' - 105.0')
-BORING TERMINATED EL.297'

NOTE: REFER TO TEST BORING LOG B-01 INTERTEK PROJECT # 04911453 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=): 1450'
   HDD PIPE LENGTH (S=): 1466'
   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, 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.

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-4.48	TO	ES-4.50	EROSION & SEDIMENT PLAN
SHEET 30	TO	SHEET 31	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	DESIGN CHANGE / GEOTECH UPDATE - RELOCATED DRILL ENTRY / EXIT POINT - DESIGN BY DPS	MRS	11/29/17	RMB	11/29/17	CAG	11/29/17
EP		MRS	09/30/16	RMB	09/30/16	AAW	09/30/16
0	ISSUED FOR CONSTRUCTION	MRS	09/19/16	RMB	09/19/16	AAW	09/19/16

Sunoco Logistics Partners L.P.

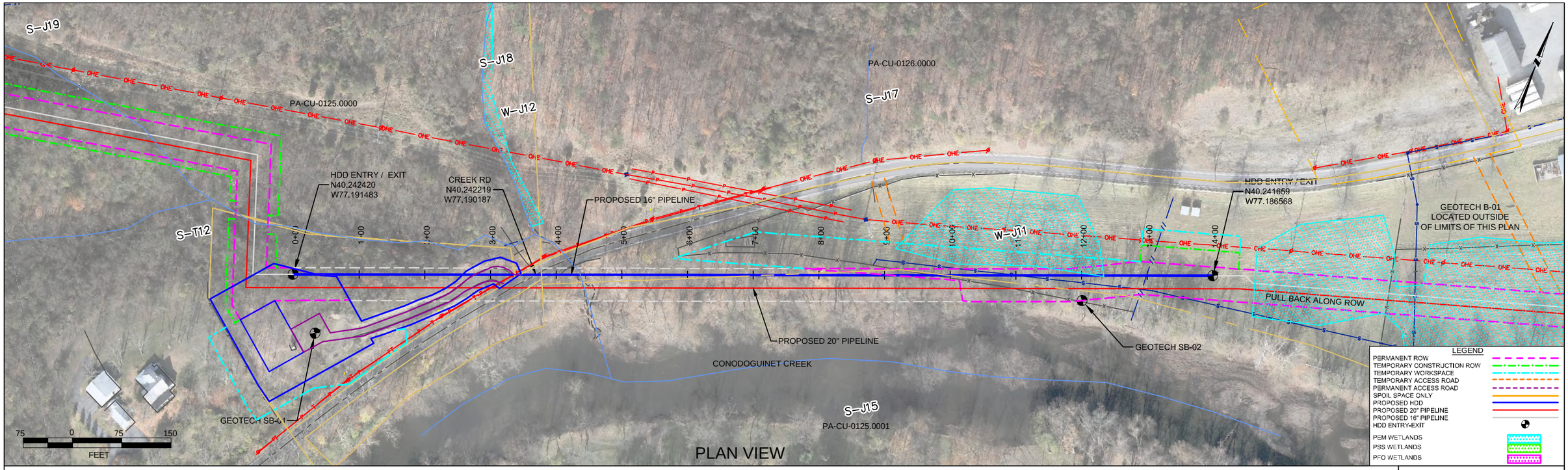
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
CREEK ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'

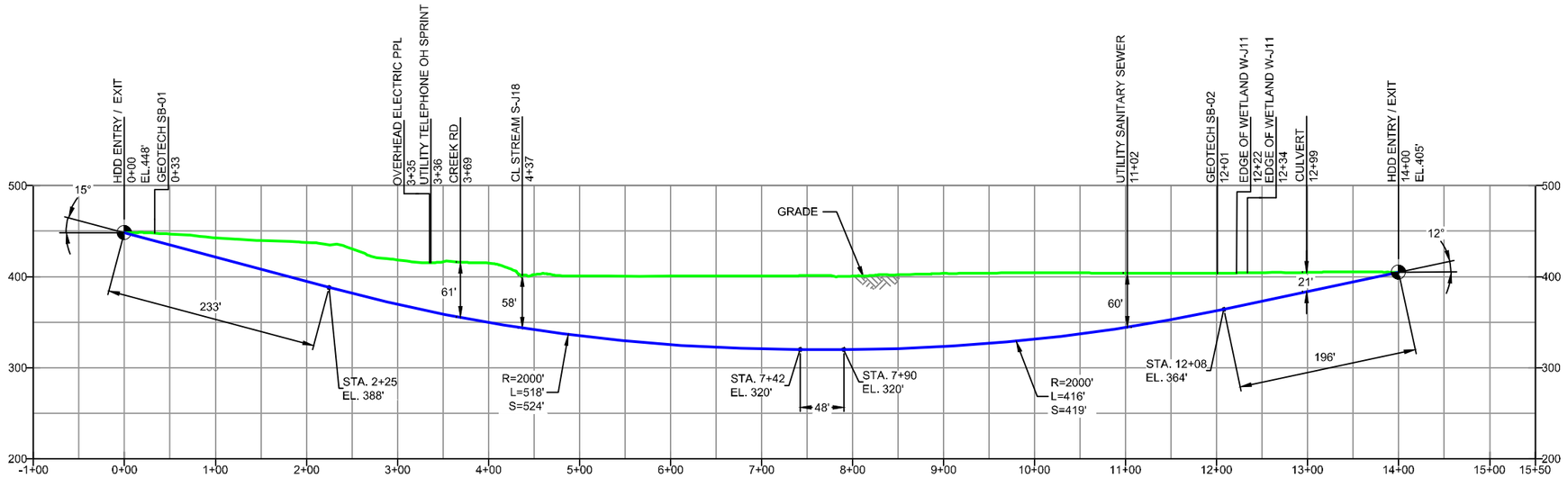
DWG. NUMBER: PA-CU-0125.0001-WX



PLAN VIEW

CUMBERLAND COUNTY, PA - NORTH MIDDLETON TOWNSHIP
S2-0181

PROFILE VIEW



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-NG EL. 404'
-TOPSOIL (0' - 0.3')
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NOTE: REFER TO TEST BORING LOG S2-0181 FOR COMPLETE SOIL MATERIAL DESCRIPTION

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-GROUNDWATER (5.6')
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-BORING TERMINATED EL.297'

NOTE: REFER TO TEST BORING LOG B-01 INTERTEK PROJECT # 04911453 FOR COMPLETE SOIL MATERIAL DESCRIPTION

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3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 1400'
   HDD PIPE LENGTH (S=): 1422'
   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).
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NOTES

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5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-4.48	TO	ES-4.50	EROSION & SEDIMENT PLAN
SHEET 30	TO	SHEET 31	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	DESIGN CHANGE / GEOTECH UPDATE - RELOCATED DRILL ENTRY / EXIT POINT - DESIGN BY DPS	MRS	11/29/17	RMB	11/29/17	CAG	11/29/17
EP		MRS	10/07/16	RMB	10/07/16	AAW	10/07/16
0	ISSUED FOR CONSTRUCTION	MRS	09/19/16	RMB	09/19/16	AAW	09/19/16

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
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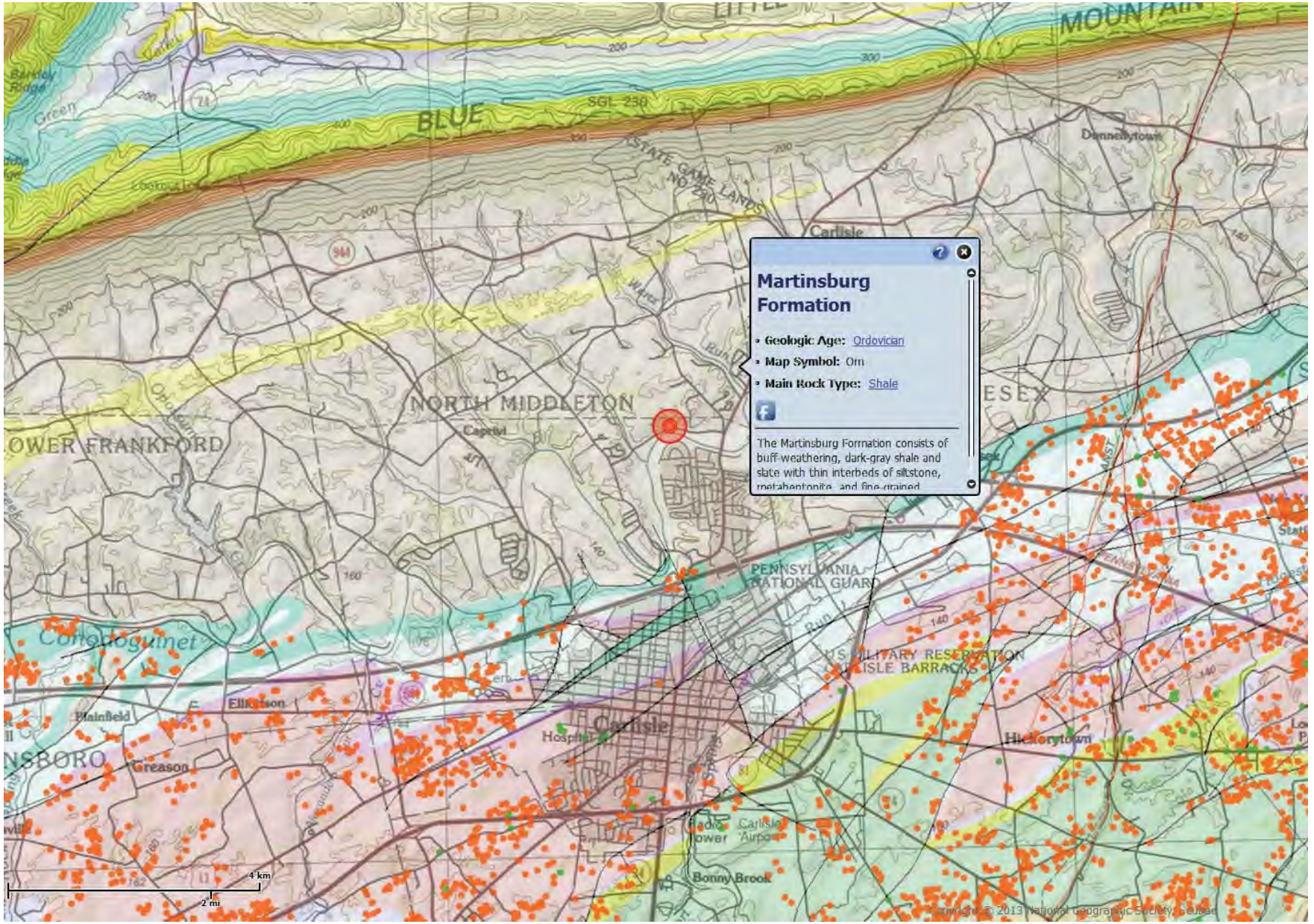
SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
CREEK ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'

DWG. NUMBER: PA-CU-0125.0001-WX-16

Figure 3: Site Geology Map



BORING B-01

DATE STARTED:	8/21/17	**DRILL COMPANY:**	Allied Well Drilling
DATE COMPLETED:	8/22/17	**DRILLER:** R. Miller	**LOGGED BY:** H. Patel
COMPLETION DEPTH	175.0 ft	**DRILL RIG:**	Diedrich D-50 Turbo
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water

Pre-Core		Not Enc.
8/21/2017 @ 12:00 p.m.		3 feet
8/22/2017 @ 1:35 p.m.		138.5 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0 25 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 2.0 4.0)	Additional Remarks
	0			S-1	16	**SHALE**-Gray-brown to black, sand- and gravel-sized particles, Highly to Completely Weathered		11-21-42-50/5" N=63		>>◎	
				R-1	8			RQD=0 Rec=30%			
				S-2	5			42-50/4"		>>◎	
	5			R-2	11	**SHALE**-Gray to dark gray, Very fine grained, Highly Weathered, very broken, moderately hard		RQD=0 Rec=22%			
				R-3	12	**SHALE**-Gray to dark gray-brown, Very fine grained, Weathered to Slightly Weathered, very broken to massive, moderately hard		RQD=0 Rec=100%			5 min.
	10			R-4	60			RQD=0 Rec=100%			
	15			R-5	60			RQD=15 Rec=100%			13 min.
	20			R-6	60			RQD=44 Rec=100%			14 min. 4 min. 3 min. 3 min. 3 min.
	25			R-7	60	**SHALE**-Dark gray to black, Very fine grained, Slightly Weathered, very broken to massive, moderately hard		RQD=87 Rec=100%			3 min. 4 min. 3 min. 3 min. 3 min.
	30										

Continued Next Page

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

PROJECT NO.: 04911454
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Creek Road (PPP4)
Cumberland Co., PA
PA-CU-0125.0001-WX/PO#20170816

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

BORING B-01

DATE STARTED:	8/21/17	**DRILL COMPANY:**	Allied Well Drilling
DATE COMPLETED:	8/22/17	**DRILLER:** R. Miller	**LOGGED BY:** H. Patel
COMPLETION DEPTH	175.0 ft	**DRILL RIG:**	Diedrich D-50 Turbo
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water

Pre-Core		Not Enc.
8/21/2017 @ 12:00 p.m.		3 feet
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BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0 / 25 / 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 / 2.0 / 4.0)	Additional Remarks
	30					**SHALE**-Dark gray to black, Very fine grained, Slightly Weathered, very broken to massive, moderately hard					2 min.
											3 min.
											3 min.
				R-8	60			RQD=97 Rec=100%			2 min.
											2 min.
	35										3 min.
											3 min.
											2 min.
				R-9	60			RQD=67 Rec=100%			2 min.
						Highly Weathered layer @ 37.8 feet (~ 3-1/2 inches thick)					3 min.
	40										2 min.
											2 min.
											3 min.
				R-10	60			RQD=95 Rec=100%			3 min.
											3 min.
	45										2 min.
											2 min.
											2 min.
				R-11	60			RQD=100 Rec=100%			3 min.
											2 min.
	50										2 min.
											3 min.
						Calcite seam @ 51.7 feet (~ 3/4 inch thick)					2 min.
				R-12	60			RQD=92 Rec=100%			3 min.
											2 min.
	55										2 min.
											2 min.
											3 min.
				R-13	60			RQD=83 Rec=100%			3 min.
											3 min.
	60					*Continued Next Page*					

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PROJECT NO.: 04911454
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Creek Road (PPP4)
Cumberland Co., PA
PA-CU-0125.0001-WX/PO#20170816

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

DATE STARTED:	8/21/17	**DRILL COMPANY:**	Allied Well Drilling
DATE COMPLETED:	8/22/17	**DRILLER:** R. Miller	**LOGGED BY:** H. Patel
COMPLETION DEPTH	175.0 ft	**DRILL RIG:**	Diedrich D-50 Turbo
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

BORING B-01

Water		
	Pre-Core	Not Enc.
	8/21/2017 @ 12:00 p.m.	3 feet
	8/22/2017 @ 1:35 p.m.	138.5 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0, 25, 50) STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	60					**SHALE**-Dark gray to black, Very fine grained, Slightly Weathered, very broken to massive, moderately hard					3 min.
											3 min.
											3 min.
				R-14	60	Highly Weathered seam @ 62.1 feet (~ 2-1/4 inches thick)		RQD=67 Rec=100%			3 min.
											3 min.
											3 min.
	65					**SHALE**-Gray to black, Very fine grained, Slightly Weathered, very broken to massive, moderately hard, trace calcite stringers					3 min.
											3 min.
											3 min.
				R-15	60			RQD=45 Rec=100%			3 min.
						Weathered/Highly Weathered layer @ 68.7 feet (~ 8-1/2 inches thick)					3 min.
	70										3 min.
											3 min.
											3 min.
				R-16	60			RQD=87 Rec=100%			3 min.
											2 min.
	75										3 min.
											3 min.
											3 min.
				R-17	60			RQD=72 Rec=100%			3 min.
											3 min.
	80										3 min.
											3 min.
											2 min.
				R-18	60			RQD=100 Rec=100%			2 min.
											2 min.
	85										3 min.
											3 min.
											3 min.
				R-19	60			RQD=100 Rec=100%			3 min.
											3 min.
	90					*Continued Next Page*					

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PROJECT NO.: 04911454
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DATE STARTED:	8/21/17	**DRILL COMPANY:**	Allied Well Drilling
DATE COMPLETED:	8/22/17	**DRILLER:** R. Miller	**LOGGED BY:** H. Patel
COMPLETION DEPTH	175.0 ft	**DRILL RIG:**	Diedrich D-50 Turbo
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water

Pre-Core		Not Enc.
8/21/2017 @ 12:00 p.m.		3 feet
8/22/2017 @ 1:35 p.m.		138.5 feet

BORING LOCATION:
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Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0 / 25 / 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 / 2.0 / 4.0)	Additional Remarks
	90					**SHALE**-Gray to black, Very fine grained, Slightly Weathered, very broken to massive, moderately hard, trace calcite stringers Very broken seam @ 91.5 feet (~ 1-3/4 inches thick)					3 min.
											3 min.
				R-20	60			RQD=83 Rec=100%			3 min.
											4 min.
											3 min.
	95										3 min.
											3 min.
				R-21	60			RQD=85 Rec=100%			4 min.
											3 min.
											3 min.
	100										3 min.
											3 min.
				R-22	60			RQD=100 Rec=100%			3 min.
											3 min.
											3 min.
	105										3 min.
											3 min.
				R-23	60			RQD=100 Rec=100%			3 min.
											2 min.
											3 min.
	110										2 min.
											3 min.
				R-24	60			RQD=100 Rec=100%			2 min.
											2 min.
											2 min.
	115										3 min.
											2 min.
				R-25	60			RQD=95 Rec=100%			3 min.
											3 min.
											2 min.
	120					*Continued Next Page*					

DATE STARTED:	8/21/17	**DRILL COMPANY:**	Allied Well Drilling
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ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

BORING B-01

Water		
	Pre-Core	Not Enc.
	8/21/2017 @ 12:00 p.m.	3 feet
	8/22/2017 @ 1:35 p.m.	138.5 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0, 25, 50) STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	120					**SHALE**-Gray to black, Very fine grained, Slightly Weathered, very broken to massive, moderately hard, trace calcite stringers					3 min.
											2 min.
				R-26	60			RQD=95 Rec=100%			3 min.
											2 min.
											2 min.
	125										3 min.
											2 min.
											2 min.
				R-27	60			RQD=93 Rec=100%			2 min.
						Calcareous SHALE-Dark gray to black, Very fine grained, Slightly Weathered, very broken to massive, moderately hard, trace calcite stringers, very weak reaction to 10% HCl					3 min.
	130										2 min.
											2 min.
											2 min.
				R-28	60			RQD=85 Rec=100%			3 min.
											2 min.
	135					**SHALE**-Dark gray, Very fine grained, Slightly Weathered, broken to massive, moderately hard, trace calcite stringers					2 min.
											2 min.
											2 min.
				R-29	60			RQD=62 Rec=100%			2 min.
						SHALE-Dark gray to black, Very fine grained, Weathered to Slightly Weathered, very broken to massive, moderately hard, trace calcite stringers					3 min.
	140										3 min.
											4 min.
						SHALE-Dark gray to black, Very fine grained, Slightly Weathered, very broken to massive, moderately hard, trace calcite stringers					5 min.
				R-30	60			RQD=63 Rec=100%			4 min.
											3 min.
	145					Calcite seam @ 145.6 feet (~ 3 inches thick)					3 min.
											4 min.
											3 min.
				R-31	60			RQD=88 Rec=100%			3 min.
											2 min.
	150					*Continued Next Page*					

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

PROJECT NO.: 04911454
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Creek Road (PPP4)
Cumberland Co., PA
PA-CU-0125.0001-WX/PO#20170816

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

BORING B-01

DATE STARTED:	8/21/17	**DRILL COMPANY:**	Allied Well Drilling
DATE COMPLETED:	8/22/17	**DRILLER:** R. Miller	**LOGGED BY:** H. Patel
COMPLETION DEPTH	175.0 ft	**DRILL RIG:**	Diedrich D-50 Turbo
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water

Pre-Core		Not Enc.
8/21/2017 @ 12:00 p.m.		3 feet
8/22/2017 @ 1:35 p.m.		138.5 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0, 25, 50) STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	150					**SHALE**-Dark gray to black, Very fine grained, Slightly Weathered, very broken to massive, moderately hard, trace calcite stringers					3 min.
											4 min.
				R-32	60			RQD=93 Rec=100%			3 min.
											3 min.
											2 min.
	155										2 min.
											2 min.
											2 min.
				R-33	60			RQD=97 Rec=100%			3 min.
											2 min.
	160										2 min.
											4 min.
											3 min.
				R-34	60			RQD=85 Rec=100%			3 min.
											3 min.
	165										3 min.
											2 min.
				R-35	60	**SHALE**-Gray to dark gray, Very fine grained, Weathered to Slightly Weathered, very broken to massive, moderately hard to hard, moderate amount of calcite		RQD=57 Rec=100%			4 min.
											3 min.
	170										3 min.
											3 min.
				R-36	60			RQD=17 Rec=100%			3 min.
											3 min.
	175					Test boring terminated @ 175 feet					3 min.

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

PROJECT NO.: 04911454
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Creek Road (PPP4)
Cumberland Co., PA
PA-CU-0125.0001-WX/PO#20170816

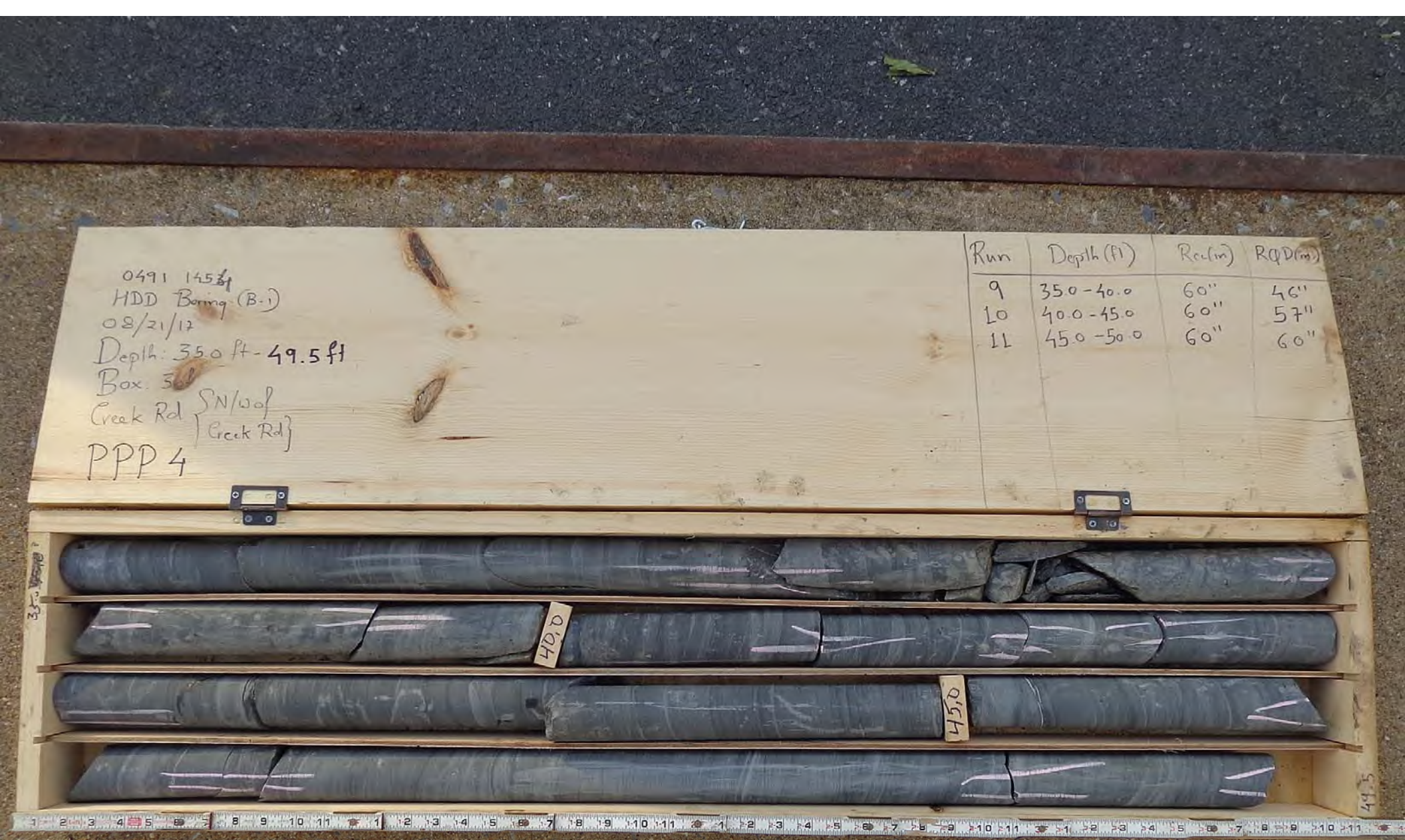
The stratification lines represent approximate boundaries. The transition may be gradual.

0491 1454
HDD Boring (B-1)
08/21/17
Depth: 1.9 ft - 21.5 ft
Box: 1 of
Creek Rd { W/N Side of Creek Rd }
PPP 4

Run	Depth (ft)	Rec (in)	RQD (in)
1	1.9 - 4.0	7.5 in	0 in
2	4.8 - 9.0	11.0 in	0 in
3	9.0 - 10.0	12.0 in	0 in
4	10.0 - 15.0	60.0 in	0 in
5	15.0 - 20.0	60.0 in	0 in
6	20.0 - 25.0	60.0 in	21.0 in

0491 1454
HDD Boring (B-1)
08/21/17
Depth: 21.5 ft – 35.0 ft
Box: 2 of
Creek Rd { W/N Side of Creek Rd }
PPP4

Run	Depth (ft)	Rec (in)	RQD (in)
7	25.0 - 30.0	60.0 in	52.0 in
8	30.0 - 35.0	60.0 in	58.0 in
~~9~~ 7	~~35.0 - 40.0~~		


0491 145
HDD Boring (B-1)
08/21/17
Depth: 35.0 ft - 49.5 ft
Box. 5
Creek Rd
SN/Wof
Creek Rd
PPP 4
Run | Depth (ft) | Rec(in) | RQD(in)
9 | 35.0 - 40.0 | 60" | 46"
10 | 40.0 - 45.0 | 60" | 57"
11 | 45.0 - 50.0 | 60" | 60"
40.0
45.0
49.5

0491 14504
HDD Boring (B-1)
08/21/17
Depth. 49.5ft - 63.5ft
Box: 4of
Creek Rd { N/W of Creek Rd }
PPP 4

Run	Depth (ft)	Rec (in)	RQD (in)
12	50.0 - 55.0	60"	55"
13	55.0 - 60.0	60"	50"
14	60.0 - 65.0	60"	40".


0411 1454
HDD Boring
Depth 63.5ft - 78.0ft
Box 5 of
Creek Rd
Run | Depth (ft) | Rec (in) | Rec%
15 | 65.0-70.0 | 60" | 27"
16 | 70.0-75.0 | 60" | 52"
17 | 75.0-80.0 | 60" | 43"
63.5
0.59
70.0
75.0
78.0


PPP 4
0491 1454
08/22/12
HDD Boring
Depth: 78.0 - 91.5
Box: 6 of
Creek Rd {N/W of Creek Rd
Run | Depth (ft) | Rec (in) | RQD
18 | 80.0-85.0 | 60" | 60"
19 | 85.0-90.0 | 60" | 60"
20 | 90.0-95.0 | 60" | 50"
78.0
80.0
85.0
85.0
90.0
91.5

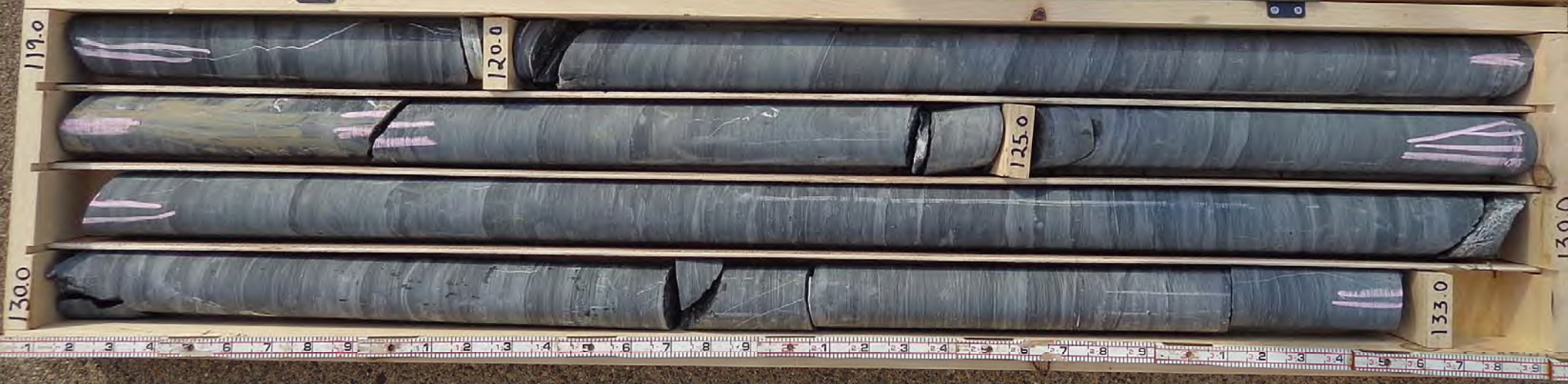

PPP 4
0491 1454
HDD Boring (B-1)
08/22/17
Depth: 91.5ft - 105.0ft
Box: 7 of
Creek Rd. {N/U of Creek Rd}
Run | Depth (ft) | Rec (in) | RQD
21 | 95.0-100.0 | 60" | 51"
22 | 100.0-105.0 | 60" | 60"
91.5
95.0
100.0
105.0

PPP 4
0491 1454
HDD Boring (B-1)
08/22/17
Depth: 105ft – 119ft
Box: 8 of
Creek Rd { N/W of Creek Rd }

Run	Depth (ft)	Rec (in)	RQD (in)
23*	105.0 - 110.0	60.0"	60.0"
24*	110.0 - 115.0	60.0"	60.0"
25	115.0 - 120.0	60.0"	57.0"

PPP4
0491 1454
HDD Boring (B-1)
08/22/17
Depth: 119ft - 133 ft
Box: 9 of
Creek Rd {N/W side of Creek Rd}

Run	Depth	Rec (in)	RQD (in)
26	120.0 - 125.0	60.0"	57.0"
27	125.0 - 130.0	60.0"	56.0"
28	130.0 - 135.0	60.0"	51.0"



PPP 4
0491 1454
HDD Boring (B-1)
08/22/17
Depth: ~~128ft~~ 133ft - 147.3ft
Box: 1 of 1
Creek Rd {PN/W side of Creek Rd}

Run	Depth (ft)	Rec (in)	RQD (in)
29	135.0 - 140.0	60"	37"
30	140.0 - 145.0	60"	38"
31	145.0 - 150.0	60"	53"


PPP 4
0491 1454
HDD Boring (B-1)
08/22/17
Depth: 147.3ft - 161.7ft
Box: 11 of
Creek Rd (N/W side of Guk Rd)
Run | Depth(ft) | Rec(in) | RQD(in)
32 | 150 - 155.0 | 60" | 56"
33 | 155 - 160.0 | 60" | 58"
34 | 160 - 165.0 | 60" | 51"
147.3
150.0
155.0
160.0
161.7


PPP4
0491 1454
HDD Boring (B-1)
08/23/17
Depth: 161.7ft - 175ft
Box: 12 of 12
Creek Road { N/W side of Creek Rd }
Run | Depth | Rec (in) | RQD (in)
35 | 165.0 - 170.0 | 60" | 34"
36 | 170.0 - 175.0 | 60" | 10"
165.0
161.7
170.0
175.0

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%

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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

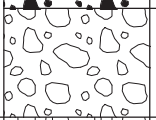
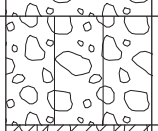
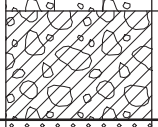
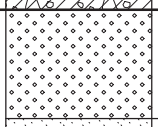
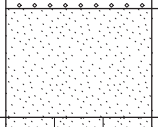
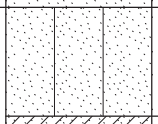
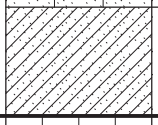
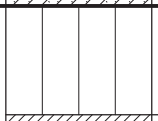
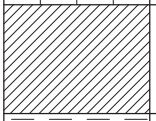
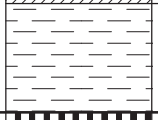
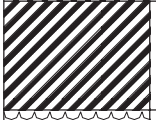
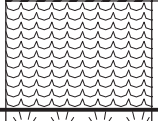
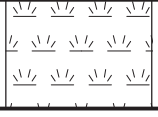
MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL -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

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

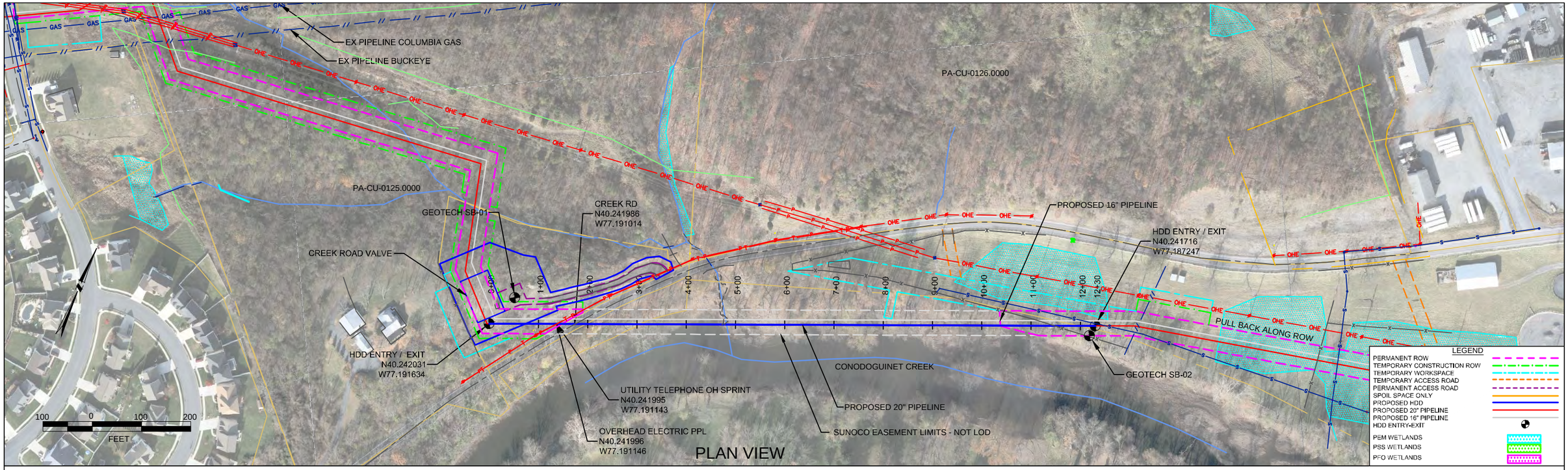
Hardness category	Typical range in unconfined compressive strength (MPa)	Strength value selected (MPa)	Field test on sample	Field test on outcrop
Soil*	< 0.60		Use USCS classifications	
Very soft rock or hard, soil-like material	0.60–1.25		Scratched with fingernail. Slight indentation by light blow of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

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

CREEK ROAD/ CONODOGUINET CREEK CROSSING
PADEP SECTION 105 PERMIT NO.S: E21-449
PA-CU-0125.0000-WX & PA-CU-0125.0000-WX-16
(SPLP HDD No. S2-0181)

ATTACHMENT 2

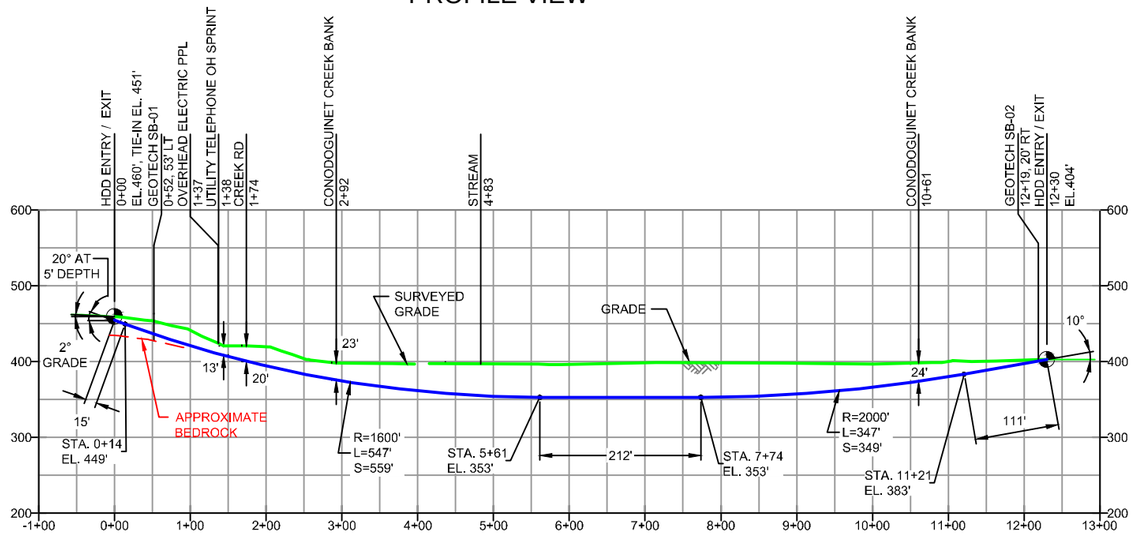
ORIGINAL AND REVISED HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES



PLAN VIEW

CUMBERLAND COUNTY, PA - NORTH MIDDLETON TOWNSHIP
S2-0181

PROFILE VIEW



GEOTECH SB-01

-NG EL. 462'
-TOPSOIL (0' - 0.3')
-WEATHERED SLATE (0.3' - 25.0')
-AUGER REFUSAL (25.0')
-SLATE (25.0' - 35.0')
-COMPLETION DEPTH EL. 427'

GEOTECH SB-02

-NG EL. 404'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 8.0')
-AUGER REFUSAL (9.0')
-WEATHERED SLATE (8.0' - 11.0')
-COMPLETION DEPTH EL. 393'

NOTE: REFER TO TEST BORING LOG S2-0181 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=):1230'
   HDD PIPE LENGTH (S=):1246'
   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, 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.

NOTES

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

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
6	DESIGN CHANGE - INCREASED VERTICAL CURVE RADIUS	MRS	04/24/17	RMB	04/24/17	CAG	04/24/17
5	REVISED PROFILE WITH 2017 LIDAR	MRS	03/14/17	RMB	03/14/17	CAG	03/14/17
4	CHANGED DRAWING NAME TO "CREEK ROAD"	MRS	03/06/17	RMB	03/06/17	CAG	03/06/17
3	DESIGN CHANGE (UPDATE TO PIPE LENGTH)	DLM	02/17/17	RMB	02/17/17	CAG	02/17/17
2	ADDED GEOTECH INFO	MRS	11/28/16	RMB	11/28/16	AAW	11/28/16
1	DESIGN CHANGE	MRS	10/10/16	RMB	10/10/16	AAW	10/10/16

Sunoco Logistics Partners L.P.

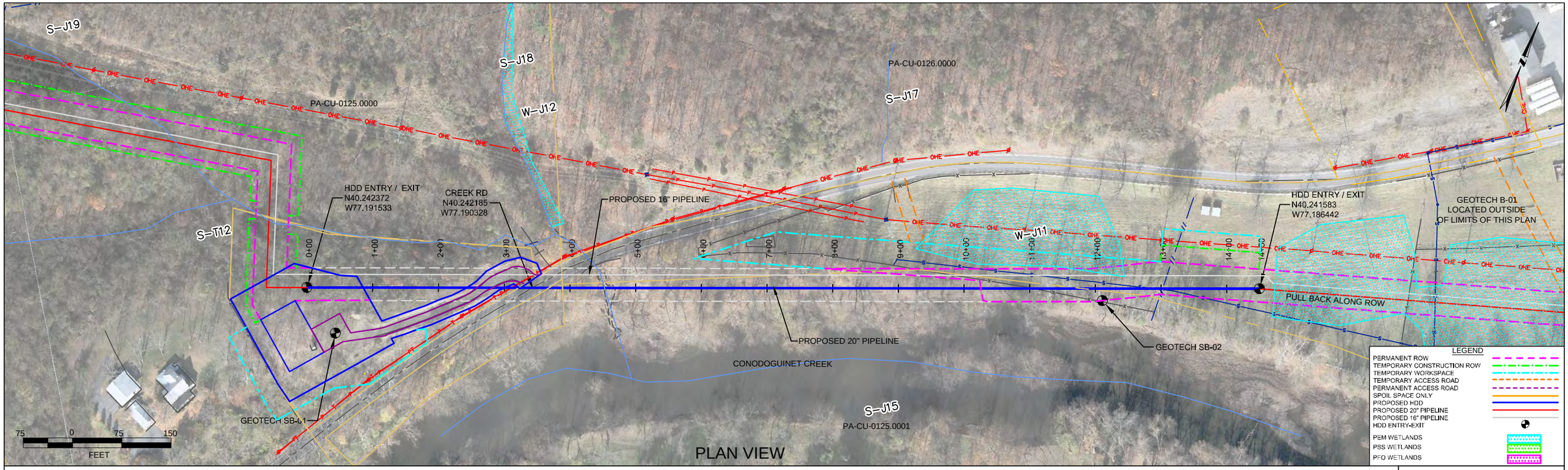
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
CREEK ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

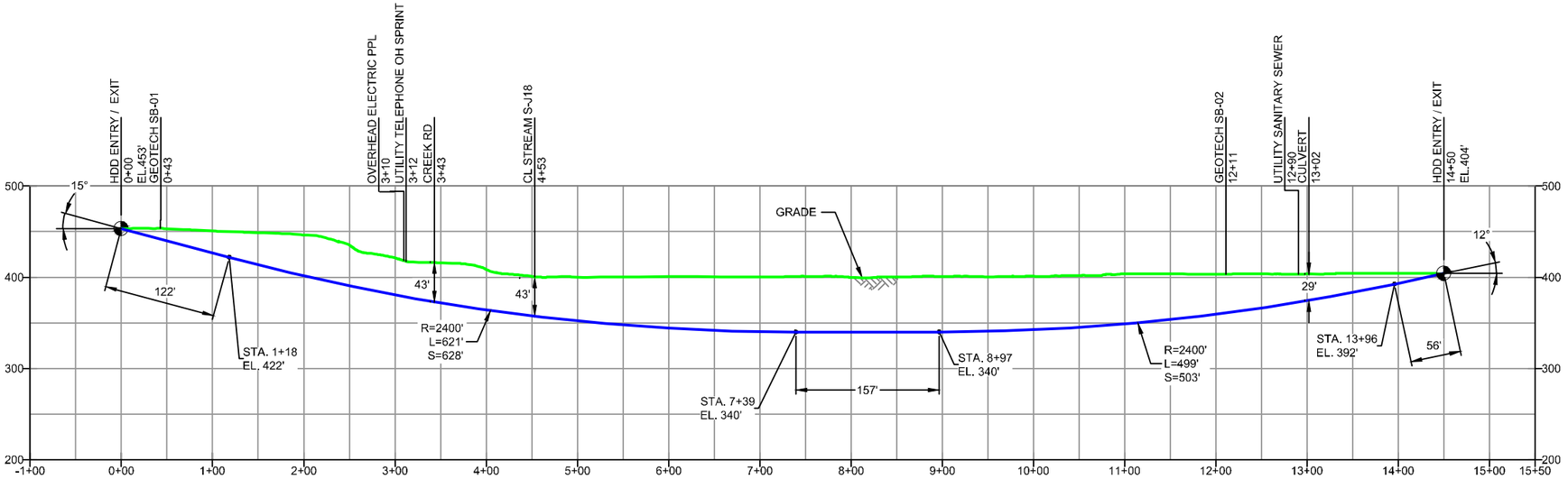
DWG. NUMBER: PA-CU-0125.0001-WX



PLAN VIEW

PROFILE VIEW

CUMBERLAND COUNTY, PA - NORTH MIDDLETON TOWNSHIP
S2-0181



GEOTECH SB-01

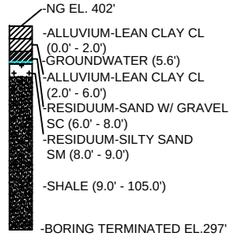
-NG EL. 462'
-TOPSOIL (0' - 0.3')
-WEATHERED SLATE (0.3' - 25.0')
-AUGER REFUSAL (25.0')
-SLATE (25.0' - 35.0')
-COMPLETION DEPTH EL. 427'

GEOTECH SB-02

-NG EL. 404'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 8.0')
-AUGER REFUSAL (9.0')
-WEATHERED SLATE (8.0' - 11.0')
-COMPLETION DEPTH EL. 393'

NOTE: REFER TO TEST BORING LOG S2-0181 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-01



NOTE: REFER TO TEST BORING LOG B-01 INTERTEK PROJECT # 04911453 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=): 1450'
   HDD PIPE LENGTH (S=): 1466'
   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, 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.

NOTES

1. ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
2. STATIONING IS BASED ON HORIZONTAL DISTANCES.
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5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-4.48	TO	ES-4.50	EROSION & SEDIMENT PLAN
SHEET 30	TO	SHEET 31	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	DESIGN CHANGE / GEOTECH UPDATE - RELOCATED DRILL ENTRY / EXIT POINT - DESIGN BY DPS	MRS	11/29/17	RMB	11/29/17	CAG	11/29/17
EP		MRS	09/30/16	RMB	09/30/16	AAW	09/30/16
0	ISSUED FOR CONSTRUCTION	MRS	09/19/16	RMB	09/19/16	AAW	09/19/16

Sunoco Logistics Partners L.P.

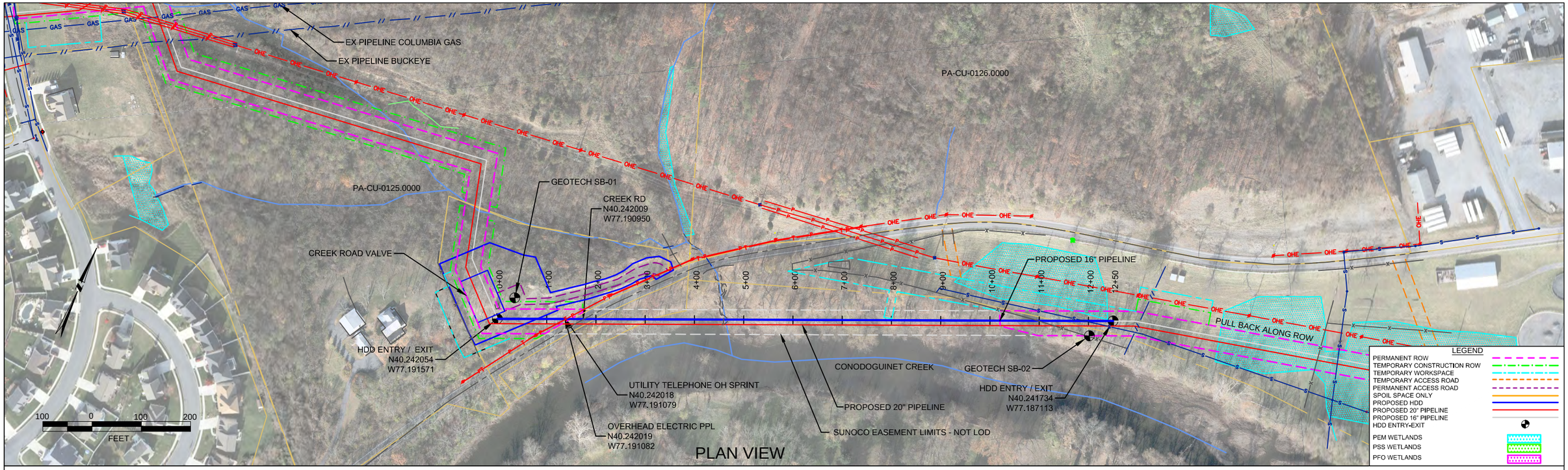
TETRA TECH ROONEY
(303) 792–5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
CREEK ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'

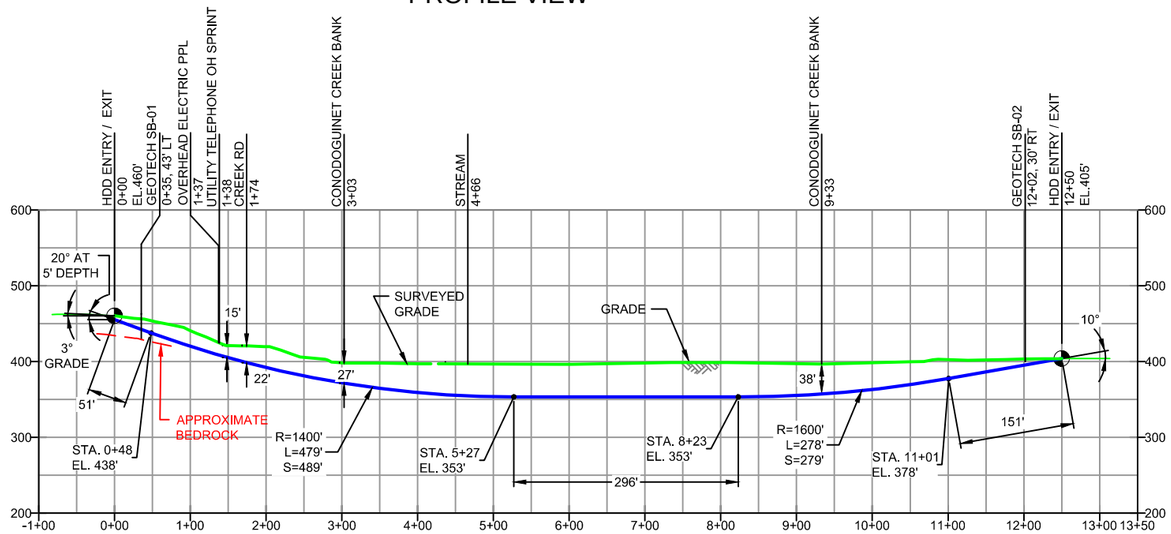
DWG. NUMBER: PA-CU-0125.0001-WX



PLAN VIEW

CUMBERLAND COUNTY, PA - NORTH MIDDLETON TOWNSHIP
S2-0181

PROFILE VIEW



GEOTECH SB-01

-NG EL. 462'
-TOPSOIL (0' - 0.3')
-WEATHERED SLATE (0.3' - 25.0')
-AUGER REFUSAL (25.0')
-SLATE (25.0' - 35.0')
-COMPLETION DEPTH EL. 427'

GEOTECH SB-02

-NG EL. 404'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 8.0')
-AUGER REFUSAL (9.0')
-WEATHERED SLATE (8.0' - 11.0')
-COMPLETION DEPTH EL. 393'

NOTE: REFER TO TEST BORING LOG S2-0181 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

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3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):1250'
   HDD PIPE LENGTH (S=):1266'
   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).
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11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
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NOTES

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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
3	REVISED PROFILE WITH 2017 LIDAR	MRS	03/14/17	RMB	03/14/17	CAG	03/14/17
2	CHANGED DRAWING NAME TO "CREEK ROAD"	MRS	03/06/17	RMB	03/06/17	CAG	03/06/17
1	ADDED GEOTECH INFO	MRS	11/28/16	RMB	11/28/16	AAW	11/28/16
0	ISSUED FOR CONSTRUCTION	MRS	10/10/16	RMB	10/10/16	AAW	10/10/16

Sunoco Logistics Partners L.P.

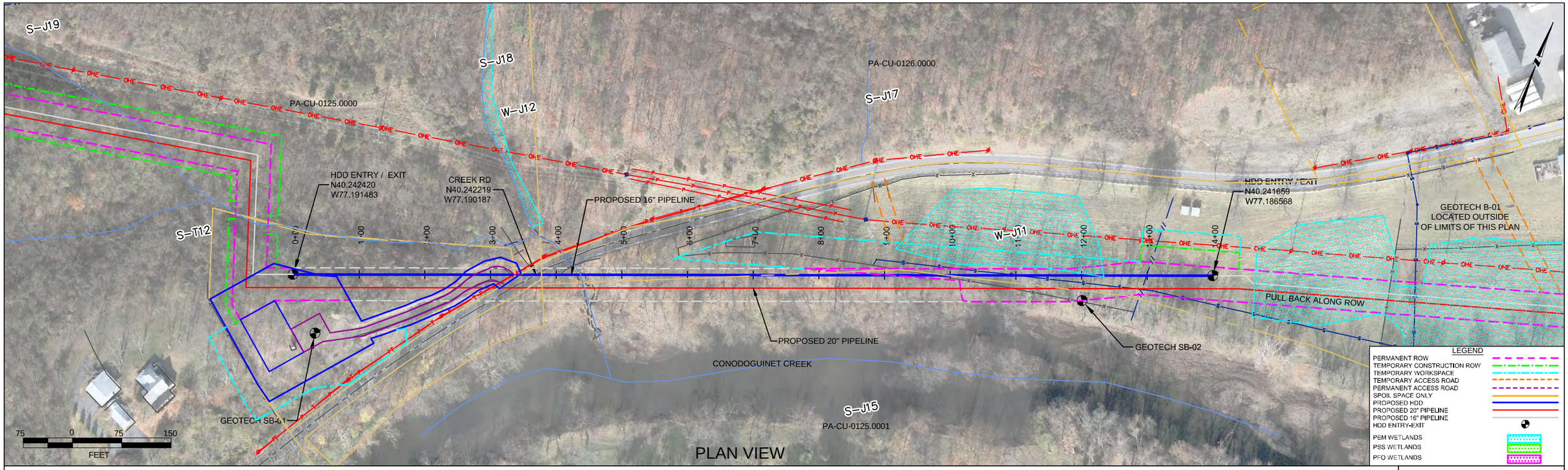
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
CREEK ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

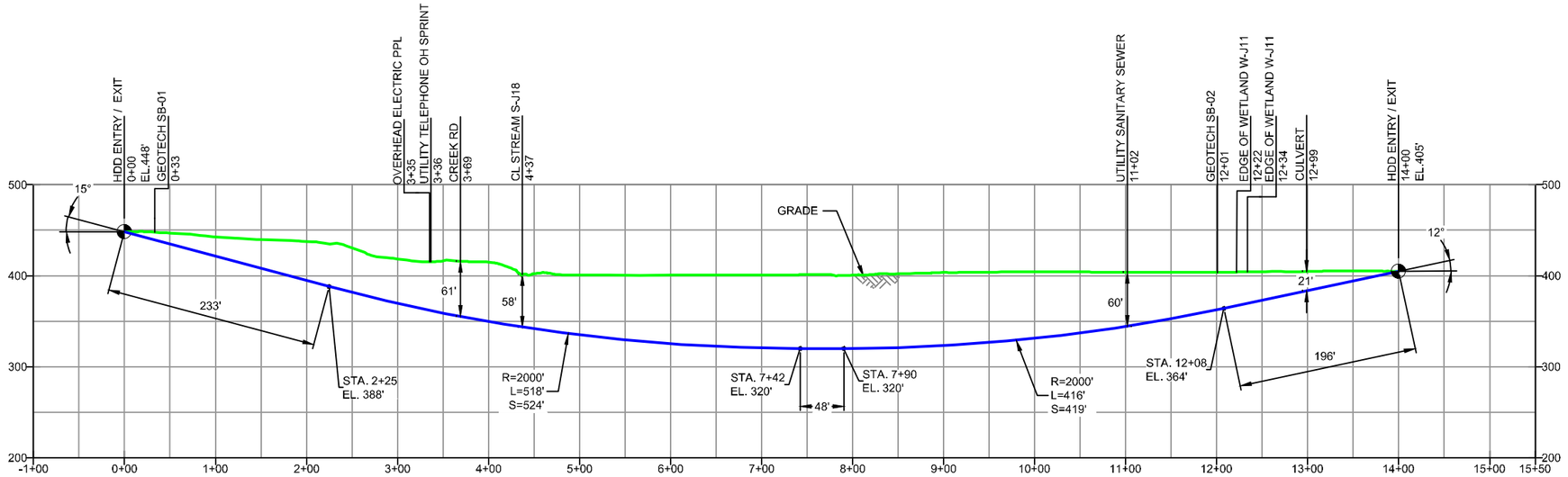
DWG. NO: PA-CU-0125.0001-WX-16



PLAN VIEW

PROFILE VIEW

CUMBERLAND COUNTY, PA - NORTH MIDDLETON TOWNSHIP
S2-0181



GEOTECH SB-01

-NG EL. 462'
-TOPSOIL (0' - 0.3')
-WEATHERED SLATE (0.3' - 25.0')
-AUGER REFUSAL (25.0')
-SLATE (25.0' - 35.0')
-COMPLETION DEPTH EL. 427'

GEOTECH SB-02

-NG EL. 404'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 8.0')
-AUGER REFUSAL (9.0')
-WEATHERED SLATE (8.0' - 11.0')
-COMPLETION DEPTH EL. 393'

NOTE: REFER TO TEST BORING LOG S2-0181 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-01

-NG EL. 402'
-ALLUVIUM-LEAN CLAY CL (0.0' - 2.0')
GROUNDWATER (5.6')
-ALLUVIUM-LEAN CLAY CL (2.0' - 6.0')
-RESIDUUM-SAND W/ GRAVEL SC (6.0' - 8.0')
-RESIDUUM-SILTY SAND SM (8.0' - 9.0')
-SHALE (9.0' - 105.0')
-BORING TERMINATED EL.297'

NOTE: REFER TO TEST BORING LOG B-01 INTERTEK PROJECT # 04911453 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

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3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 1400'
   HDD PIPE LENGTH (S=): 1422'
   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.
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NOTES

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2. STATIONING IS BASED ON HORIZONTAL DISTANCES.
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5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-4.48	TO	ES-4.50	EROSION & SEDIMENT PLAN
SHEET 30	TO	SHEET 31	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	DESIGN CHANGE / GEOTECH UPDATE - RELOCATED DRILL ENTRY / EXIT POINT - DESIGN BY DPS	MRS	11/29/17	RMB	11/29/17	CAG	11/29/17
EP		MRS	10/07/16	RMB	10/07/16	AAW	10/07/16
0	ISSUED FOR CONSTRUCTION	MRS	09/19/16	RMB	09/19/16	AAW	09/19/16

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
CREEK ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'

DWG. NUMBER: PA-CU-0125.0001-WX-16