HORIZONTAL DIRECTIONAL DRILL ANALYSIS
CROSSINGS OF WETLANDS A54 & A55 (BOG TURTLE WETLANDS)
PADEP SECTION 105 PERMIT NO.:
PA-LA-0014.0000-SR-16
(SPLP HDD# S3-0161)

CROSSINGS OF WETLANDS A54 & A55 (BOG TURTLE WETLANDS)
PADEP SECTION 105 PERMIT NO.:
PA-LA-0014.0000-SR-16
(SPLP HDD# S3-0161)

This analysis of the horizontal directional drill (HDD) installation of a 16-inch diameter pipeline crossing under Wetlands A54 & A55 is in accordance with Stipulated Order issued under EHB DOCKET NO. 2017-009-L for HDDs listed on Exhibit 3 of the Stipulated Order.

During the HDD installation of the 20-inch pipeline (PA-LA-0014.0000-SR), two (2) inadvertent returns (IRs) of drilling fluids to the land surface occurred and were reported to the Pennsylvania Department of Environmental Protection. Both of these IR events occurred during the pilot phase of the HDD. Each IR was located in an upland area immediately adjacent to the receiving pit and occurring right before the exiting of the drilling tool. No IRs occurred during the reaming phase of the HDD, or during the pulling of the pipeline through the reamed profile.

HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 3,420 ft
- Entry/Exit angle: 12 degrees
- Depth of cover: 78 ft
- Pipe design radius: 1,600 ft

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

Geyer and Bolles (1979) reported that the HDD of Wetlands A54 & A55 is situated in the northern portion of the Gettysburg-Newark Lowland Section of the Piedmont Physiographic Province. In eastern Pennsylvania, this portion of the Gettysburg-Newark Lowland Physiographic Province is underlain by sedimentary rocks of the Newark Group. These sedimentary rocks were deposited in a fault-bounded rift basin, commonly referred to as the Newark Basin during late Triassic through early Jurassic time (Root and MacLachlan, 1999). The rocks comprising the Newark Basin often exhibit a reddish color and consist principally of conglomerate, arkose, sandstone, siltstone, argillite, and shale. Locally, the sedimentary sequence is interbedded with basaltic lava flows and is intruded by diabase dikes and sills.

According to Poth (1977) and Berg and Dodge (1981), the area in the vicinity of the HDD of Wetlands A54 & A55 is underlain by clastic rocks (i.e., siltstone/sandstone and shale) that are mapped as the Hammer Creek formation of Triassic age. The Hammer Creek formation in Lancaster County is comprised primarily of red and brown shale, siltstone, sandstone, and conglomerates. The shales and siltstones are typically thin to medium-bedded, whereas the sandstones are very fine- to coarse-grained and thin to thick-bedded. The conglomerates are thick bedded with clasts/interbeds of quartz, quartzite, sandstone, siltstone, limestone, and shale. The rocks of the Newark Basin generally dip an average of 20° to the north-northwest. The geologic structure of the Gettysburg-Newark Lowland Physiographic Province consists principally of a north-northwestward dipping homocline (Newport, 1971).

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

HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

Groundwater movement within the bedrock underlying the Lancaster County area 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. Some fractures may parallel the bedding planes. These fractures, however, are generally narrow and are not considered to be an important mechanism in the movement of groundwater. The most important openings for the movement of groundwater in the subsurface are the nearly vertical joint planes that intersect each other at various angles. These vertical joints provide an interconnected series of channels through which groundwater can flow. One north-south oriented fault is mapped as crossing the HDD path approximately 725 ft east of the HDD entry point.

According to Wood (1980) groundwater within the clastic rocks of Lancaster County occurs under both unconfined (i.e., water table) and confined (i.e., artesian) conditions. In general, groundwater generally occurs under unconfined conditions within the upper portion of the aquifer, and under confined or semiconfined conditions in the deeper portions of the aquifer. Groundwater flow paths within the clastic rocks have both local and regional components. Locally, shallow groundwater discharges to the gaining portions of nearby streams and deeper regional groundwater flow is toward points of regional groundwater discharge such as the Schuylkill River. Groundwater divides may be different for each zone of groundwater flow, and therefore may not coincide with surface water divides. Based on our review of available reference sources, no regional water table mapping is available for the HDD Wetlands A54 & A55 site or surrounding area.

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

INADVERTENT RETURNS DISCUSSION

As illustrated on Figure 1 in Attachment 2, the HDD profile for the 16-inch pipeline has a maximum depth of 74 to 78 ft below the ground surface in the horizontal run, and is within bedrock for 2,955 ft of its length.

As discussed in the introduction above, the two IRs reported during the pilot phase of the 20-inch HDD occurred near the point of exit. IRs near the entry and exit points while drilling the pilot hole are not uncommon, and these events are not indicative of any fault in the design of the HDD or poor drilling practices.

ADJACENT FEATURES ANALYSIS

HDD S3-0161 is located in rural Lancaster County, approximately 1.7 miles west of the community of Blainsport and 18 miles north-northeast of Lancaster, Pennsylvania. The pipeline route in this area of Lancaster County follows parallel to two (2) previously existing Sunoco pipelines.

The HDD profile passes under two (2) wetlands and five (5) streams. Both wetlands have a population of “bog turtles” (***Glyptemys muhlenbergii***), a state and federal protected species.

The nearest residence is 580 ft north of the HDD alignment.

Well records from the Pennsylvania Department of Conservation and Natural Resources (PA DCNR) Pennsylvania Groundwater Information System (PaGWIS) database were reviewed to identify domestic water supply wells located within 450 ft of the proposed HDD right-of-way (ROW) boundary (PaGWIS, 2017). The search did not identify any wells within the 450 ft buffer zone. However, the search did identify two (2) domestic (private) supply wells, and one supply well for watering livestock located approximately 450 ft northwest of the HDD exit point.

CROSSINGS OF WETLANDS A54 & A55 (BOG TURTLE WETLANDS)
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ALTERNATIVES ANALYSIS

The proposed HDD is an alternative plan of installation to a conventional open trench construction plan.

Open-cut Analysis

Implementation of an open cut construction plan would result in direct effects to two wetlands and five streams, and potentially result in the "take" of state and federal protected species.

In comparison to the two minor IRs that occurred in uplands discussed previously, there are no discernable benefits to an open cut construction plan due to the presence of regulated and protected natural resources.

Re-Route Analysis

No practicable re-route option lies to the north or south of the proposed route that would not transect the same waterways transected by the proposed route. Additional assessments for waters, wetlands, and listed species would have to be completed to ascertain the absence or presence of regulated or protected resources.

Any reroute considered would deviate away from the existing utility easement and would necessitate acquiring a new utility easement creating a new encumbrance on all affected private landowners.

CONCLUSION

As discussed above, the occurrence of the IRs during the drilling of the pilot hole for the 20-inch pipeline is not indicative of any fault in the design of the HDD or poor drilling practices, and by all industry standards the HDD for the 20-inch pipeline at this location was a success.

As an additional best practice, Sunoco Pipeline, L.P has implemented mandatory annular pressure monitoring during the drilling of the pilot hole; short-tripping of the drilling tools to ensure an open annulus is maintained, and 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.

Other than the implementation of the above described drilling practices and procedures, no changes to the HDD plans for the 16-inch pipeline at this location are recommended or planned.

CROSSINGS OF WETLANDS A54 & A55 (BOG TURTLE WETLANDS)
PADEP SECTION 105 PERMIT NO.:
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(SPLP HDD# S3-0161)

ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT

RETTEW

We answer to you.

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Engineers

Environmental Consultants

Surveyors

Landscape Architects

Safety Consultants

September 13, 2017

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

RE: Sunoco Pipeline, L.P. Pipeline Project - Mariner East II
Wetland A54 & A55 Horizontal Directional Drill Location (S3-0161)
Hydrogeological Re-Evaluation Report
West Cocalico Township, Lancaster County, Pennsylvania
RETTEW Project No. 096302011

Dear Mr. Gordon:

RETTEW Associates, Inc. is pleased to provide the enclosed Hydrogeological Re-Evaluation Report for the Wetland A54 & A55 Horizontal Directional Drill (HDD) Location (S3-0161). This HDD Re-Evaluation Report was performed as required by the Stipulated Order dated August 8, 2017. Please note that the HDD Re-Evaluation Report for S3-0161 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 S3-0161, please do not hesitate to call Mr. Hess at (717) 232-1799.

Sincerely,

Matthew T. Bruckner, PG

Enclosure

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September 13, 2017

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

Re: Sunoco PA Pipeline Project Mariner East II Wetlands A54 & A55 Horizontal Directional Drill (HDD) Location (S3-0161) Hydrogeological Re-evaluation Report West Cocalico Township, Lancaster County, Pennsylvania Rettew Project No. 096302011

EXECUTIVE SUMMARY

1. The S3-0161 Wetland A54 & A55 Horizontal Directional Drill (HDD) location is included in the Stipulated Order August 8, 2017, requiring re-evaluation, including a geologic report.

2. Wetland A54 & A55 is underlain by sedimentary rocks of the Hammer Creek Formation.

3. Geologic mapping, reports, and field observations indicate typically open and steeply dipping beds with regularly spaced jointing and fracturing.

4. Water-bearing zones generally occur in secondary openings along bedding planes, joints, faults and fractures. Water-bearing zones in the Hammer Creek Formation are reported to be distributed within the first 200 feet of the subsurface, with the greatest density of water-bearing zones occurring within the upper 100 feet of the subsurface.

5. The proposed HDD bore path is relatively shallow compared with the land surface, wetlands (A54 & A55), and the streambeds of unnamed tributaries (Streams S-A77, S-A78, S-A79, S-A82, and S-A83).

6. To date, HDD operations at the Wetland A54 & A55 site have involved drilling, installation, and completion of the 20-inch pipeline. A summary of available drilling observations and reported inadvertent returns (IRs) is included with this HDD re-evaluation report.

7. Based on the hydro-structural characteristics of the underlying geology, the occurrence of two IRs near the exit of the pilot hole, and proposed bore path through shallow unconsolidated soil materials and within shallow bedrock, the Wetland A54 & A55 16-inch HDD is similarly susceptible to the inadvertent return of drilling fluids during HDD operations.

1. INTRODUCTION

The purpose of this report is to describe the hydrogeologic setting of the Wetland A54 & A55 (S3-0161) HDD location on the Sunoco Pipeline, L.P. (SPLP) Pennsylvania Pipeline Project-Mariner East II (PPP-ME2) Project. HDD Wetland A54 & A55 is located in West Cocalico Township, Lancaster County, Pennsylvania. The site is located southeast of the intersection of Forest Road and State Route 897. This HDD was designed to be drilled under the stream channels of several unnamed tributaries discharging to Cocalico Creek and Blue Lake, in addition to two large wetland areas (refer to **Figure 1**). This hydrogeologic report is part of the response to the Stipulated Order dated August 8, 2017, related to the potential for the inadvertent return of drilling fluids during proposed drilling operations.

HDD Wetland A54 & A55 is located within the Gettysburg-Newark Lowland Section of the Piedmont Physiographic Province (Pennsylvania Department of Conservation and Natural Resources [DCNR], 2000). The dominant topography is typified by rolling lowlands, shallow valleys, and isolated hills. Local relief is low to moderate and ranges within the site from approximately 498 feet above mean sea level (AMSL) to 487 feet AMSL (Google Earth, 2017). The site is drained by two large wetland areas fed by shallow unnamed tributary streams which flow from north to south through the western and eastern thirds of the proposed west-east HDD path. The unnamed tributary streams flow approximately 0.7 mile southward from the site and discharge into Cocalico Creek and Blue Lake. In addition, a farm pond is located within approximately 350 feet of the western end of the HDD. The area surrounding the HDD consists of rural properties and land uses (e.g., farming, agriculture).

The HDD entry point is at a surface elevation of 498 feet AMSL forming a slightly concave HDD profile that slopes gently upward toward the east to an elevation of 487 feet AMSL at the HDD exit point. The HDD will cross several streams at the following depths: Stream S-A77 (74 feet below ground surface [bgs]), Stream S-A78 (76 feet bgs), Stream S-A79 (77 feet bgs), Stream S-A82 (52 feet bgs), and Stream S-A83 (48 feet bgs). The HDD is located between Stations 13016+30 and 13041+00 on the pipeline, for an overall horizontal length of 3,420 feet. The location of HDD Wetland A54 & A55 is shown on **Figure 1**.

2. GEOLOGY AND SOILS

Twenty available published and on-line references were reviewed to evaluate the geology and soils present in the vicinity of HDD Wetland A54 & A55. Detailed descriptions of the soils and bedrock geology underlying HDD Wetland A54 & A55 are included in the following sections.

According to the United States Department of Agriculture Soil Survey of Lancaster County, Pennsylvania, soils at the site within 450 feet of the drill path of the S3-0161 HDD consist of Abbottstown silt loam (AbB), Bowmansville silt loam (Bo), Bucks silt loam (BuB), Holly silt loam (Hg), Ungers loam (UaB), and Readington silt loam (RaB). A site map showing the spatial distribution of the various soils along with the soil profile descriptions is included as **Attachment 1**.

Geyer and Bolles (1979) reported that the HDD Wetland A54 & A55 site is situated in the northern portion of the Gettysburg-Newark Lowland Section of the Piedmont Physiographic Province. In eastern Pennsylvania, this portion of the Gettysburg-Newark Lowland Physiographic Province is underlain by sedimentary rocks of the Newark Group. These sedimentary rocks were deposited in a fault-bounded rift basin, commonly referred to as the Newark Basin during late Triassic through early Jurassic time (Root and MacLachlan, 1999). The rocks comprising the Newark Basin often exhibit a reddish color and consist principally of conglomerate, arkose, sandstone, siltstone, argillite, and shale. Locally, the sedimentary sequence is interbedded with basaltic lava flows and is intruded by diabase dikes and sills.

According to Poth (1977) and Berg and Dodge (1981), the area in the vicinity of HDD Wetland A54 & A55 is underlain by clastic rocks (i.e., siltstone/sandstone and shale) that are mapped as the Hammer Creek formation of Triassic age. The Hammer Creek formation in Lancaster County is comprised primarily of red and brown shale, siltstone, sandstone, and conglomerates. The shales and siltstones are typically thin to medium-bedded, whereas the sandstones are very fine- to coarse-grained and thin to thick-bedded. The conglomerates are thick bedded with clasts/interbeds of quartz, quartzite, sandstone, siltstone, limestone, and shale. The rocks of the Newark Basin generally dip an average of 20° to the north-northwest. The geologic structure of the Gettysburg-Newark Lowland Physiographic Province consists principally of a north-northwestward dipping homocline (Newport, 1971).

According to Geyer and Wilshusen (1982), the Hammer Creek Formation underlying the HDD Wetland A54 & A55 site has moderately developed, moderately abundant, regularly spaced, naturally occurring fractures known as joints. These joints are typically open and steeply dipping. The joint and bedding plane openings collectively provide a secondary porosity of moderate magnitude and a permeability of low to moderate magnitude. The formation is moderately resistant to weathering and is characterized by rough terrain of high relief. Natural slopes are generally steep and stable. The overlying soil mantle is moderately thick. The shales comprising the formation are highly weathered to a moderate depth, whereas the areas underlain by sandstones and conglomerates exhibit much less weathering. The unweathered portions of the Hammer Creek formation are usually difficult to excavate. The rock reportedly provides good foundation stability. Drilling rates are typically slow due to the presence of quartz pebble conglomerate and in areas where rock is adjacent to diabase intrusions.

3. HYDROGEOLOGY

Groundwater movement within the bedrock underlying the Lancaster County area 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. Some fractures may parallel the bedding planes. These fractures, however, are generally narrow and are not considered to be an important mechanism in the movement of groundwater. The most important openings for the movement of groundwater in the subsurface are the nearly vertical joint planes that intersect each other at various angles. These vertical joints provide an interconnected series of channels through which groundwater can flow. One north-south oriented fault is mapped as crossing the HDD path approximately 725 feet east of the HDD entry point. This structural feature is identified on the geologic mapping included as **Figure 2**. The pore spaces within the bedrock matrix are relatively small (Poth, 1977, and Wood, 1980). As a result, primary porosity and permeability within the clastic rocks underlying the Lancaster County area are virtually nonexistent. The secondary porosity of the rock is determined by the number and size of the openings, whereas the secondary permeability is a reflection of the degree of interconnection of the openings.

Bedrock geology ultimately influences the storage, transmission, and use of groundwater. Geologic factors such as rock type, intergranular porosity, rock strata inclination, faults, joints, bedding planes, and solution channels affect groundwater movement and availability. According to Wood (1980) groundwater within the clastic rocks of Lancaster County occurs under both unconfined (i.e., water table) and confined (i.e., artesian) conditions. In general, groundwater generally occurs under unconfined conditions within the upper portion of the aquifer, and under confined or semiconfined conditions in the deeper portions of the aquifer. The groundwater flow system is conceptualized by Wood (1980) as a series of sedimentary beds with relatively high transmissivity separated by beds exhibiting lower transmissivities. This sequence of beds exhibit different hydraulic properties that collectively act as a series of alternating aquifers and confining or semi-confining units forming a leaky multi-aquifer system (LMAS). Groundwater flow paths within the clastic rocks have both local and regional components. Locally, shallow groundwater discharges to the gaining portions of nearby streams and deeper regional groundwater flow is toward points of regional groundwater discharge such as the Schuylkill River. Groundwater divides may be different for each zone of groundwater flow, and therefore may not coincide with surface water divides. Based on our review of available reference sources, no regional water table mapping is available for the HDD Wetland A54 & A55 site or surrounding area. As a result, no water table mapping was available for review or inclusion with this HDD re-evaluation report.

The direction of groundwater flow within the clastic rocks of Lancaster County is largely controlled by the hydraulic gradient and spatial variability of hydraulic conductivity. The groundwater flow system in the clastic rocks is highly anisotropic with the predominant flow direction parallel to the strike of the rock beds (Poth, 1977). The movement of groundwater in the fractured bedrock is generally greatest in highly permeable fractures and the orientation of bedding planes and fractures strongly influence the direction of groundwater flow within the aquifer (Sloto and Schreffler, 1994). Wells drilled to the same depth along strike generally penetrate the same water-bearing zones, whereas wells drilled to the same depth several hundred feet down dip of each other rarely intersect the same water bearing beds. The potential for well interference related to pumping is generally greatest for wells aligned parallel to strike, rather than in wells drilled in the direction of dip (i.e., perpendicular to strike). Wells spaced less than 2,000 feet apart along strike often experience interference effects (Newport, 1971). The cones of depression induced by pumping wells are usually elliptical in nature rather than circular, with the long axis orientated parallel to the strike of the rock bedding (Sloto and Schreffler, 1994). No groundwater modeling was performed for the area surrounding HDD Wetland A54 & A55.

The success of a water supply well drilled into a bedrock formation is dependent on the number and size of the natural openings encountered by the well bore as well as the degree to which these fissures are interconnected. Poth (1977) reports that the Hammer Creek formation in Lancaster County is generally a reliable source of small to moderate supplies of groundwater. Hall (1934) reports that water-bearing fractures contained in the Hammer Creek formation generally decrease in size and number with depth. A study of the Brunswick formation (Hammer Creek equivalent) in Berks and Montgomery Counties by Longwill and Wood (1965) suggests that, if groundwater yields of 100 gallons per minute (gpm) or more are desired, wells should be drilled to depths of at least 200 feet bgs. This same study suggests that wells drilled to depths between 200 and 550 feet are the most likely to obtain maximum yields of groundwater. Sufficient water for domestic purposes can be obtained from wells drilled 40 to 500 feet below the ground surface. Poth (1977) reports that groundwater yields from domestic water supply wells completed in the Hammer Creek Formation in Lancaster County range from 5 to 94 gpm, with a median yield of 16 gpm.

According to Low, et al (2002), the depths of water-bearing zones range from 5 to 445 feet below land surface. Fifty percent (50%) of the 544 water-bearing zones were penetrated at a depth of less than 90 feet with 90% of the water-bearing zones occurring at a depth of less than 197 feet. The greatest density of water-bearing zones is from 51 to 100 feet below land surface. The density of water-bearing zones encountered at depths greater than 301 feet are based on the presence of 6 or fewer water-bearing zones per 50-foot interval. The overall density of water-bearing zones in the Hammer Creek Formation is 0.67 per 50-feet of well depth.

Well records from the Pennsylvania Department of Conservation and Natural Resources (PA DCNR) Pennsylvania Groundwater Information System (PaGWIS) database were reviewed to identify domestic water supply wells located within 450 feet of the proposed HDD right-of-way (ROW) boundary (PaGWIS, 2017). The search did not identify any wells within the 450 foot buffer zone. However, the search did identify two domestic (private) supply wells, and one supply well for watering livestock located approximately 450 feet northwest of the HDD exit point. A map showing the well locations relative to the proposed HDD is included as **Figure 3**. Based solely on the PaGWIS database (**Figure 3**), it appears that the identified wells were completed in the Hammer Creek Formation at depths ranging from 119 to 260 feet below grade. The livestock well is described as a 6-inch diameter well with steel casing to 58 feet bgs and was completed as an open rock well from 58 feet to 119 feet bgs. The two domestic wells were constructed with PVC perforated well screens of 90 feet and 130 feet in length. These three wells reportedly yield from 18 to 75 gpm. The reported depth to bedrock ranges from 50 to 74 feet below grade. One static water level measurement of 8 feet was recorded in the livestock well. Based on the geologic mapping available for the area it appears that all wells identified above were completed in the Hammer Creek Formation.

4. FRACTURE TRACE ANALYSIS

Fracture traces are defined as concentrated areas of high angle bedrock fracturing that form linear features that can be identified using topographic mapping and aerial photography. One fracture trace at the site was interpreted on a northwest to southeast trend passing very close to the HDD entry point. A second fracture trace was interpreted approximately 800 feet to the north of the entry point and trends on a southwest to northeast orientation. These features are likely related to the primary geologic structure of the site discussed above. The approximate locations of these fracture traces were copied from Plate 1, Part 2, in Wood (1980) and are depicted on the Geology Map included as **Figure 2**. These fracture trace locations or their associated degree of topographic expression were not verified in the field; however, general surface drainage patterns near the HDD are characterized by linear stream reaches in a NE-SW or W-E trend. Several surface streams flow generally NW-SE and SW-NE which appear to reflect this local geologic structure.

5. GEOTECHNICAL EVALUATION

Four geotechnical borings were completed from November 20, 2014 through February 6, 2015 during the preliminary investigation of HDD S3-0161 and prior to initiating HDD operations. The four borings are located along the north side of the HDD limit of disturbance (LOD). The borings were completed to investigate soil, residual soil, and shallow weathered bedrock conditions using hollow-stem auger drilling methods. An NQ core barrel/bit was used for rock coring.

Please note that two different geotechnical investigations were performed, one in the vicinity of Wetland A55, and the second in the vicinity of Wetland A54. Two borings, SB-01 and SB-02, were completed on December 13, 2014 and November 20, 2014 respectively, as part of the HDD S3-0160 (Wetland A55) geotechnical investigation. SB-01 (HDD S3-0160) was located along the west side of Wetland A55, approximately 200 feet east of the HDD entry point. SB-02 (HDD S3-0160) was located approximately 1,170 feet east of the HDD entry point, on the east side of Wetland A55.

The generalized subsurface profile observed in these two borings completed at the Wetland A55 site can be described as follows.

- **SB-01**: 21.5 feet of SILTY SANDS overlying 4.5 feet of CLAYEY SANDS, overlying 4.0 feet INORGANIC CLAY. The total depth of this boring was 30.0 feet, underlying bedrock was not encountered.

- **SB-02**: 13.5 feet of SILTY CLAY and FINE SAND overlying 31.1 feet of SILTY, CLAYEY SAND. Depth to bedrock was 44.6 feet. The underlying bedrock was described as weathered and fractured red/brown and maroon SILTSTONE, coarse grained SANDSTONE, and QUARTZ PEBBLE CONGLOMERATE. Total depth of the boring was 53.0 feet.

The boring logs indicate that the soil/weathered bedrock interface ranges from greater than 30 feet (SB-01) to 44.6 feet (SB-02) bgs. According to the Unified Soil Classification System (USCS), the soils consist of silty sand (SM) above clayey sands (SC) and silty, sandy clay (CL) in SB-01. In SB-02, approximately 13.5 feet of silty clay with fine sand (CL) was present above 31.1 feet of sand and clayey silt (SM), with weathered, red/brown siltstone and sandstone from 44.6 feet to the total depth of 53.0 feet. No new geotechnical borings were performed at this HDD location. No geophysical studies were performed at this location. The geotechnical report for S3-0160 is provided as **Attachment 2**.

Below the auger refusal depth to the total depth of the NQ cores, bedrock was encountered and was described as follows:

- **SB-02**: From 45 to 53 feet, highly fractured and weathered, reddish brown and maroon, siltstone, and siltstone with interbedded sandstone bedrock. Rock recovery was moderately good to excellent (55% to 100%) and rock quality designations (RQD) were very poor (0% to 9%). The lowest RQDs were observed from 45 to 48 feet with fractures ranging from 0-45 degrees in heavily weathered and fractured siltstone.

The second geotechnical investigation was completed in the vicinity of Wetland A54 and is documented as a boring associated with HDD S3-0170, which is apparently a duplication of the HDD number for the HDD 897 boring. Three boring logs are included in this reevaluation report, however, one boring log, labeled SB-01 is the same boring log as SB-02 (HDD S3-0160, Wetland A55), described above. SB-01 was completed on November 20, 2014; SB-02 was completed on February 6, 2015; and SB-03 was completed on December 13, 2014.

SB-01 (Wetland A54) is located approximately 1,170 feet east of the HDD entry point in between Wetland A55 and Wetland A54. SB-02 (Wetland A54) is located approximately 2,600 feet east of the HDD entry point in an upland area between two of the branches of Wetland A54. SB-03 is located approximately 3,130 feet east of the entry point and approximately 10 feet inside the easternmost extent of Wetland A54.

The generalized subsurface profile observed in these three borings completed at the Wetland A55 site can be described as follows.

- **SB-01**: 13.5 feet of SILTY CLAY and FINE SAND overlying 31.1 feet of SILTY, CLAYEY SAND. Depth to bedrock was 44.6 feet. The underlying bedrock was described as weathered and fractured red/brown and maroon SILTSTONE, coarse grained SANDSTONE, and QUARTZ PEBBLE CONGLOMERATE. Total depth of the boring was 53.0 feet.

- **SB-02:** 18 feet of CLAYEY SAND overlying 14 feet of SILTY CLAY, overlying 6 feet of highly weathered reddish brown SILTSTONE. Auger refusal and total depth of the boring was at 44 feet.

- **SB-03**: 11.5 feet of SILTY SAND overlying 18.5 feet of CLAYEY SANDS. Total depth of the boring was 30 feet, bedrock was not encountered in this boring.

The boring logs indicate that the soil/weathered bedrock interface ranges from greater than 30 feet (SB-03) to 44 feet (SB-02) bgs. According to the USCS, the soils consist of silty clay with fine sand (CL) above silty, clayey sand (SM) in SB-01. The soils in SB-02 consist of clayey sand (SC) overlying silty clay with a trace of fine sand (CL). SB-03 consists of silty sand (SM) above clayey sand (SC). Additional geotechnical borings including rock cores are currently being completed at this HDD location. An additional geotechnical report is pending. No geophysical studies were performed at this location. The geotechnical report for S3-0170 (Wetland A54) is provided as **Attachment 2**.

Two additional borings were completed on September 7 and 8, 2017 (Geo Bore No. 1) and August 31 and September 5 and 6, 2017 (Geo Bore No. 2). Geo Bore No. 1 was drilled immediately adjacent to the HDD S3-0161 entry point on the west side of Wetland A55, and Geo Bore No. 2 was drilled at the exit point for HDD S3-0161.

- **Geo Bore No. 1:** Geo Bore No. 1 was completed to a total depth of 150 feet with top of bedrock encountered at approximately 55 feet bgs. The bedrock consists of red/brown, fractured SILTSTONE and/or fine grained SANDSTONE from 55 feet to approximately 75.5 feet. Between 75 and 80 feet bgs., a bed of CONGLOMERATE was encountered, reddish brown SILTSTONE from approximately 79.4 feet to 86.7 feet, red/ brown and gray CONGLOMERATE from 86.7 feet to 130 feet, red brown siltstone/sandstone from 130 to approximately 140 feet, and red/brown and gray CONGLOMERATE from 140 to 150 feet.

- **Geo Bore No. 2:** Geo Bore No. 2 was completed to a total depth of 130.2 feet bgs with the top of bedrock encountered at 49.2 feet. The bedrock consists of fractured and moderately weathered gray and red/brown CONGLOMERATE from 49.2 to approximately 69.2 feet, and red brown SILTSONE and fine grained SANDSTONE with some CONGLOMERATE from 69.2 feet to the finished depth of 130.2 feet.

The summary descriptions of Geo Bore Nos. 1 and 2 were derived from photographs of the core boxes which are also provided in **Attachment 2.** To date, a geotechnical report with boring logs has not been received.

Please note that Skelly and Loy did not oversee or direct the geotechnical drilling programs associated with S3-0161, including but not limited to, the selection of boring locations and target depths, observations of rock cores during drilling operations, or preparation of boring logs. The geotechnical reports, boring logs, and core photographs that resulted from these programs were generated by other Sunoco contractors. Skelly and Loy relied on these reports and incorporated their data into the general geologic and hydrogeologic framework of the analysis of Wetland A54 & A55 HDD (S3-0161) for this report.

6. FIELD OBSERVATIONS

As part of the preconstruction and active construction monitoring of Wetlands A54 and A55 for known sensitive species inhabiting these wetlands, Skelly and Loy has been conducting on-site studies in and adjacent to Wetlands A54 and A55 since July 2016. This ongoing monitoring effort was prescribed by the United States Fish and Wildlife Service (USFWS) and Pennsylvania Fish and Boat Commission (PFBC), and has included weekly preconstruction shallow groundwater monitoring (via shallow well and stream sampling sites), daily monitoring of the same while HDD operations are occurring, daily monitoring for potential IRs, and routine monitoring (via telemetry) of sensitive species in the wetlands proximate to the pipeline. Additionally, continuous seismic monitoring equipment has been in place since April 2017, to monitor for changes from ambient (baseline) conditions as a result of the HDD. To date, these monitoring efforts have not detected any changes to the shallow groundwater or surface water flow associated with Wetlands A54 or A55, nor has there been any detectable seismic activity related to the HDD operations. The sensitive species on-site remain in their natural, preferred habitat and seem unaffected by the HDD that has already taken place.

There were no bedrock exposures in the vicinity of the site that would allow for structural geologic measurements. According to available geologic mapping, the last 327 feet of the HDD is underlain by bedrock characterized as conglomeratic sandstone. Based on local topography and bedrock dip reported in the published literature (Newport 1971; and Wood, 1980), bedrock strike is generally to the north-northeast (20° to 70°). With the exception of the unnamed tributaries and previously mapped wetland areas, no additional environmental receptors of concern were noted within the defined 450-foot HDD buffer area.

Two IRs have occurred during HDD operations. The first IR occurred on June 17, 2017, and involved less than 100 gallons of drilling fluid at the point when the HDD was within 77 feet of the ground surface and approximately 500 feet from the HDD exit point. The second IR occurred on June 21, 2017, and involved an estimated 100 to 200 gallons of drilling fluid in an upland agricultural field. The second IR was located 100 feet east of A54 at Station 13047+04 or approximately 3,230 feet from the entry point (approximately 190 feet from the HDD exit point) in an area within approximately 37 feet of the ground surface. IR containment areas were constructed at each IR location near the eastern end of the HDD for the purpose of performing remedial activities. The occurrence of IRs in the vicinity of an HDD entry or exit is not uncommon. The approximate origins of the above IRs are identified on the HDD profile included as **Attachment 3**.

A visual survey of local wells was performed by viewing neighboring properties from within the permitted HDD ROW and through available physical access along public roads. Although a number of local domestic water supply wells were observed on properties immediately north of the HDD and parallel to State Route 897, none were identified within 450 feet of the HDD ROW. However, the results of this visual reconnaissance effort identified two domestic supply wells and one well used for watering livestock to be located near the HDD.

7. CONCEPTUAL HYDROGEOLOGIC MODEL

Groundwater occurring in the watershed occupied by HDD Wetland A54 & A55 originates as precipitation or snowmelt. The precipitation infiltrates through the overburden soils. As previously described, shallow groundwater generally occurs under unconfined conditions within the upper portion of the bedrock LMAS. Due to the lack of site-specific data, it was not determined if the groundwater table occurs within the soils or bedrock. It is assumed that the groundwater table proximate to the HDD path is relatively shallow, and may exist in some areas of the overburden soils that contribute flow to these local shallow groundwater discharge zones given that several unnamed tributaries flow above (across) the HDD profile. Logs of the four geotechnical borings drilled from November 2014 through February 2015 indicated that the soil thickness near HDD Wetland A54 & A55 ranges from approximately 13.5 to 21.5 feet, and consist predominantly of silty sands, clayey sands, silty clay, fine sand, clayey sand, and inorganic clay. Recorded descriptions for the bedrock cores included siltstone, sandstone, and quartz pebble conglomerate. Data tabulated for a livestock supply well found in the PaGWIS database (**Figure 3**) located approximately 450 feet northwest of the HDD exit point had a measured water level of approximately 8 feet below grade.

This formation is highly anisotropic with the predominant flow direction parallel to bedrock strike. No local interbeds of basaltic lava flows or intrusions of diabase dikes or sills were identified proximate to this HDD. The transport of groundwater in the fractured bedrock is generally greatest within highly permeable fractures. The orientation of the bedding planes and fractures primarily influence the direction of groundwater flow (Sloto and Schreffler, 1994). Wells drilled to the same depths along bedrock strike generally penetrate the same water-bearing zones, whereas wells drilled to the same depth several hundred feet down dip of each other rarely intersect the same water-bearing zones. Some site-specific evaluation of the bedrock has been completed in the area proximate to the geotechnical borings completed along this HDD profile. No detailed characterization or groundwater flow modeling of the bedrock aquifer was performed as part of this hydrogeologic re-evaluation.

The groundwater flow direction in the overburden soils is presumed to mimic surface topography which slopes gently toward each of the wetland areas and unnamed tributaries to Cocalico Creek and Blue Lake. Wetland areas where local shallow groundwater flow discharges are located in two areas: 1) near the western end of the HDD, and 2) near the eastern end of the HDD trace. The unnamed tributaries flow southward near the center of the HDD trace and eventually discharge into Cocalico Creek and Blue Lake located approximately 0.7 mile south of the HDD site. The groundwater table is presumed to occur within these overburden materials under unconfined conditions.

8. CONCLUSIONS

Based on published geologic and hydrogeologic information, the Wetland A54 & A55 HDD location is underlain by clastic sedimentary rocks (siltstone/sandstone and shale) of the Hammer Creek 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 have confirmed that the local bedrock is fractured and comprised of steeply dipping bedding planes. All of the water supply wells identified in the vicinity of the HDD are constructed in the deeper bedrock portion of the LMAS indicating that none of the domestic wells rely on the shallow (uppermost) LMAS that provides a source of sustaining discharge to the wetlands and unnamed tributaries to Cocalico Creek. The HDD profile extends entirely within both the shallow unconsolidated materials and weathered to highly weathered bedrock. Based on the hydro-structural characteristics of the underlying geology described in this report and the proposed HDD profile, the Wetland A54 & A55 16-inch HDD is susceptible to the inadvertent return of drilling fluids during HDD operations, similar to those that occurred during the installation of the 20-inch pipeline.

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10.0 CERTIFICATION

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

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

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

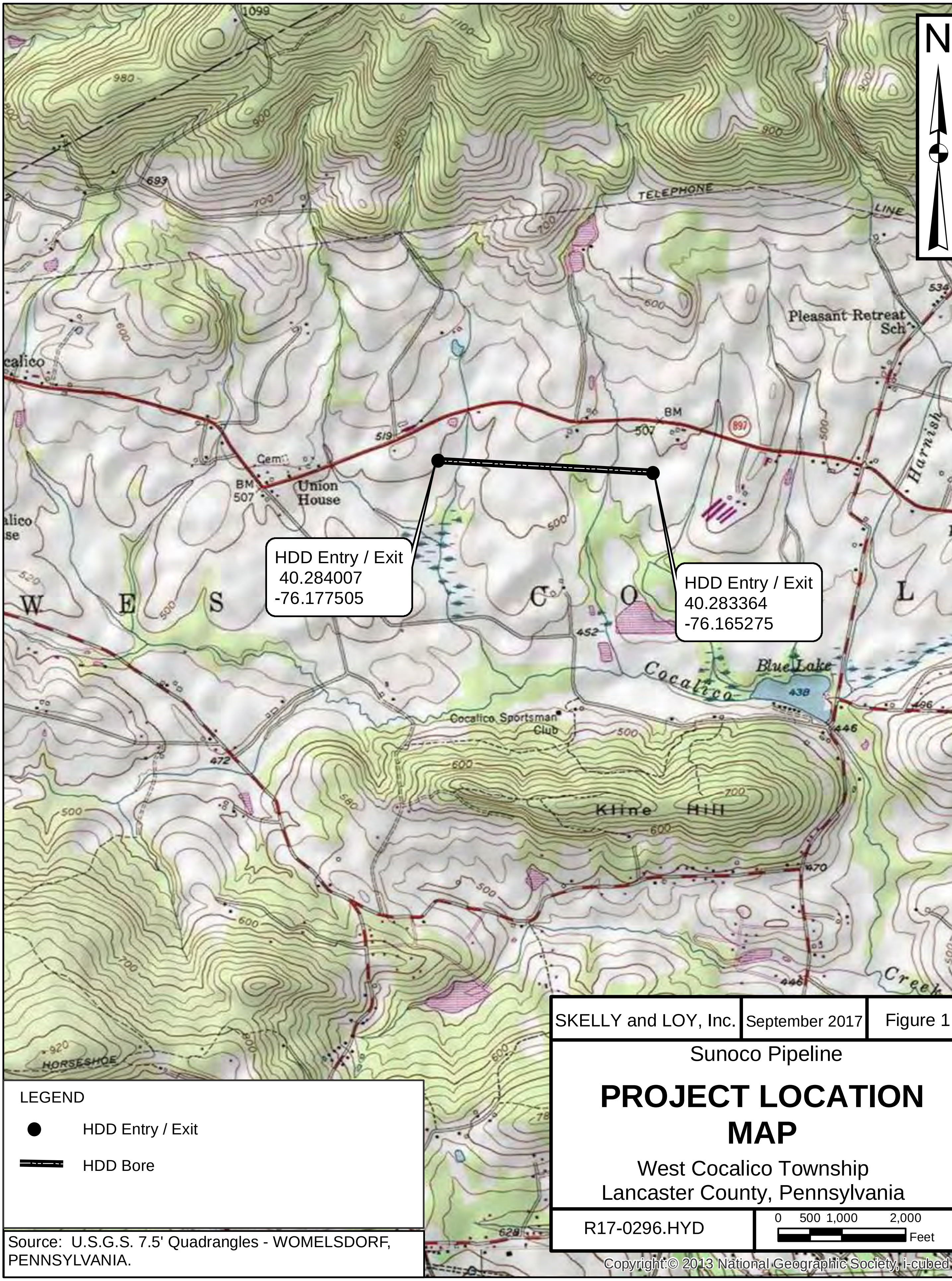
Sincerely yours,

SKELLY and LOY, Inc.

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

Enclosure
cc: R17-0296.HYD
File: HYDROGEOLOGIC_REPORT-Wetlands A54 A55_DJH - FINAL.docx

FIGURE 1 -
SITE LOCATION MAP



LEGEND

● HDD Entry / Exit

HDD Bore

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

SKELLY and LOY, Inc.	September 2017	Figure 1

Sunoco Pipeline

PROJECT LOCATION MAP

West Cocalico Township
Lancaster County, Pennsylvania

R17-0296.HYD

0 500 1,000 2,000 Feet

FIGURE 2 -
GEOLOGY MAP

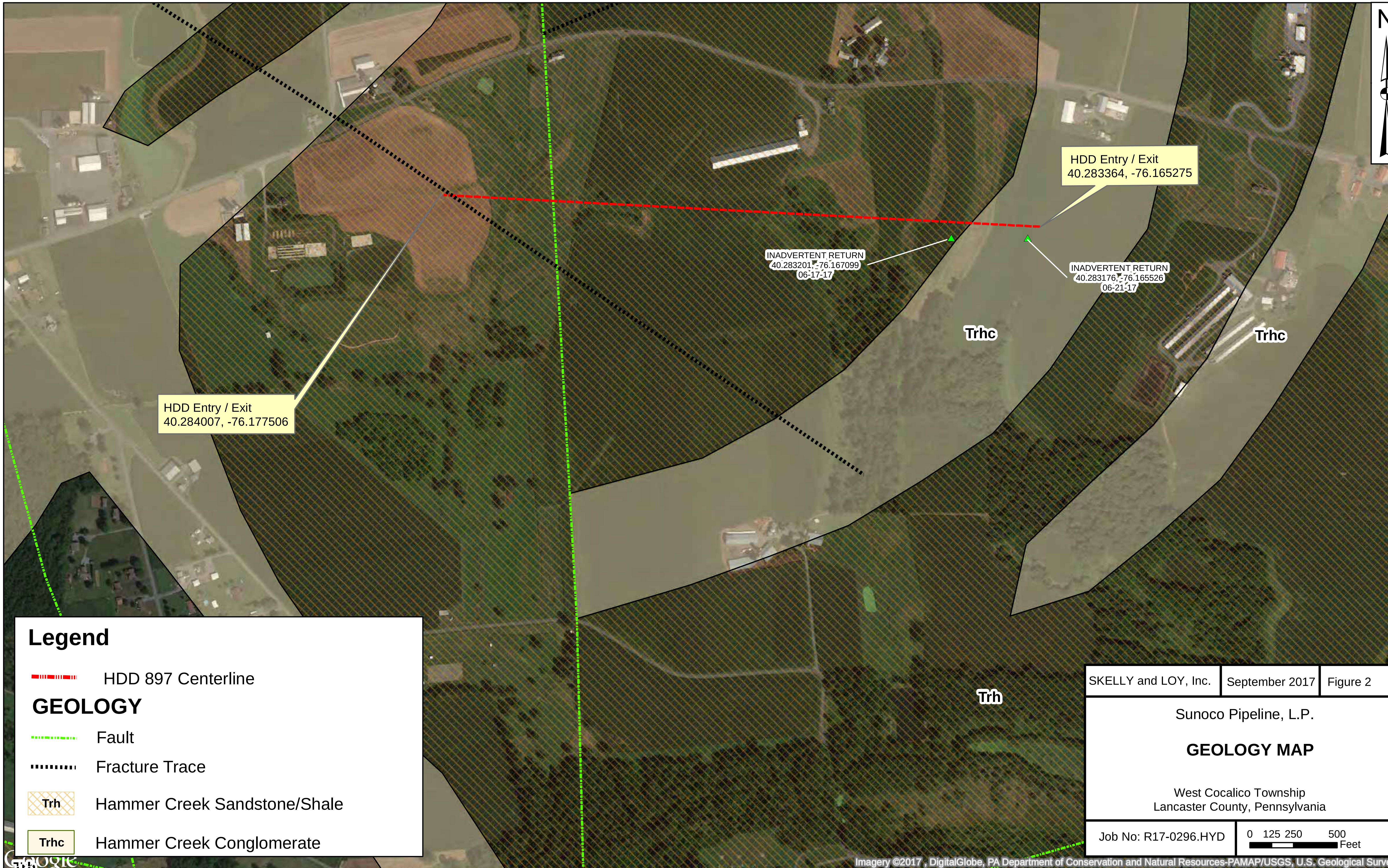

N
HDD Entry / Exit
40.283364, -76.165275
HDD Entry / Exit
40.284007, -76.177506
INADVERTENT RETURN
40.283201, -76.167099
06-17-17
INADVERTENT RETURN
40.283176, -76.165526
06-21-17
Trhc
Trhc
Trh
Legend
HDD 897 Centerline
GEOLOGY
Fault
Fracture Trace
Trh Hammer Creek Sandstone/Shale
Trhc Hammer Creek Conglomerate
SKELLY and LOY, Inc.
September 2017
Figure 2
Sunoco Pipeline, L.P.
GEOLOGY MAP
West Cocalico Township
Lancaster County, Pennsylvania
Job No: R17-0296.HYD
0 125 250 500 Feet
Imagery ©2017 , DigitalGlobe, PA Department of Conservation and Natural Resources-PAMAP/USGS, U.S. Geological Survey

FIGURE 3 -
WELL LOCATION MAP


N
PA Well ID
536495
PA Well ID
184077
PA Well ID
511001
1
2
3
4
5
6
7
HDD Entry / Exit
40.284007, -76.177506
HDD Entry / Exit
40.283364, -76.165275
INADVERTENT RETURN
40.283201,-76.167099
06-17-17
INADVERTENT RETURN
40.283176,-76.165526
06-21-17
Legend
Pipline Centerline
450 ' Buffer of Pipeline Centerline
1
Parcel Boundary and Map ID
SKELLY and LOY, Inc.
September 2017
Figure 3
Sunoco Pipeline, L.P.
WELL LOCATION MAP
West Cocalico Township
Lancaster County, Pennsylvania
Job No: R17-0296.HYD
0 75 150 300
Feet
Imagery ©2017 , DigitalGlobe, PA Department of Conservation and Natural Resources-PAMAP/USGS

DEPARTMENT OF CONSERVATION & NATURAL RESOURCES
BUREAU OF TOPOGRAPHIC AND GEOLOGIC SURVEY
WATER WELL PROGRAM
3240 Schoolhouse Rd
Middletown, PA 17057
717-702-2017

WATER WELL INFORMATION REPORT

PA Well ID: **184077** Local Well ID: **5727N** Local Permit #:

LOCATION INFORMATION

Owner:	**LEININGER VERNON**	Original Paper Record Image Available:	**No**
Address of Well:			
County:	**LANCASTER**		
Municipality:	**WEST COCALICO TWP.**		
Latitude:	**40.28583**	Coordinate Method:	
Longitude:	**-76.16722**	Data Reliability:	**LOCATION MAY NOT BE ACCURATE (WWI paper)**
Description of Well Location and Other Notes:			

WELL CONSTRUCTION INFORMATION

Well Driller:	**ROBERT D GRANT**	License:	**0128**	Driller Well ID:
Type of Activity:	**New Well**	Date Drilled:	**8/2/1979**	Drilling Method:
Well Depth (ft):	**119**	Well Finish:	**OPEN HOLE**	

CASING

Top (ft)	Bottom (ft)	Diameter (in)	Casing Material	Seal Top	Seal Bottom	Seal Type
0	**58**	**6**				

GROUNDWATER AND GEOLOGICAL INFORMATION

Well Yield (GPM - gal per min):	**18**	Yield Measurement Method:	**VOLUMETRIC, WATCH & BUCKET**
Water Level when not pumped: (ft below land surface)	**8**	Water Level after yield test: (ft below land surface)	**99**
Length of Yield Test (minutes):	**0.5**	Saltwater Zone (ft):	

Use of Well: **WITHDRAWAL** Use of Water: **STOCK**

LEVELS WHERE WATER ENTERS WELL

Top (ft)	Bottom (ft)	Yield (GPM)
72		
99		
116		

Depth to Bedrock (ft): **50** Was Well Drilled Into Bedrock? **Yes**

Date Printed: **9/11/2017**

DEPARTMENT OF CONSERVATION & NATURAL RESOURCES
BUREAU OF TOPOGRAPHIC AND GEOLOGIC SURVEY
WATER WELL PROGRAM
3240 Schoolhouse Rd
Middletown, PA 17057
717-702-2017

WATER WELL INFORMATION REPORT

PA Well ID: **511001** Local Well ID: Local Permit #:

LOCATION INFORMATION

Owner:	**Dan Martin**	Original Paper Record Image Available:	**No**
Address of Well:	**1615 West Route 897 17517**		
County:	**LANCASTER**		
Municipality:	**WEST COCALICO TWP.**		
Latitude:	**40.28512**	Coordinate Method:	**GPS - Global Positioning System**
Longitude:	**-76.16994**	Data Reliability:	
Description of Well Location and Other Notes:			

WELL CONSTRUCTION INFORMATION

Well Driller:	**SENSENIG & WEAVER WELL DRILLING**	License:	**1539**	Driller Well ID:	**37310**
Type of Activity:	**New Well**	Date Drilled:	**12/5/2013**	Drilling Method:	**AIR ROTARY**
Well Depth (ft):	**260**	Well Finish:	**SCREEN**		

WELL SIZE

Top (ft)	Bottom (ft)	Diameter (in)
0	80	10
80	260	6

CASING

Top (ft)	Bottom (ft)	Diameter (in)	Casing Material	Seal Top	Seal Bottom	Seal Type
0	81	6	COATED STEEL			

WELL LINER

Top (ft)	Bottom (ft)	Diameter (in)	PVC Type
70	260	4.5	Perforated

GROUNDWATER AND GEOLOGICAL INFORMATION

Well Yield (GPM - gal per min):	**75**	Yield Measurement Method:	**VOLUMETRIC, WATCH & BUCKET**
Water Level when not pumped: (ft below land surface)		Water Level after yield test: (ft below land surface)	
Length of Yield Test (minutes):		Saltwater Zone (ft):	
Use of Well:	**WITHDRAWAL**	Use of Water:	**DOMESTIC**

MATERIALS WELL PENETRATES

Top (ft)	Bottom (ft)	Description
0	**70**	**Subsoil**
70	**260**	**Red Shale**

LEVELS WHERE WATER ENTERS WELL

Top (ft)	Bottom (ft)	Yield (GPM)
90	**90**	**25**
119	**119**	**25**
130	**130**	**25**

Depth to Bedrock (ft): **70** Was Well Drilled Into Bedrock? **Yes**

Date Printed: **9/11/2017**

DEPARTMENT OF CONSERVATION & NATURAL RESOURCES
BUREAU OF TOPOGRAPHIC AND GEOLOGIC SURVEY
WATER WELL PROGRAM
3240 Schoolhouse Rd
Middletown, PA 17057
717-702-2017

WATER WELL INFORMATION REPORT

PA Well ID: **536495** Local Well ID: Local Permit #:

LOCATION INFORMATION

Owner:	**Ben Martin**	Original Paper Record Image Available:	**No**
Address of Well:	**2200 West Route 897 17517**		
County:	**LANCASTER**		
Municipality:	**WEST COCALICO TWP.**		
Latitude:	**40.28645**	Coordinate Method:	**Commercial Street Atlas Program**
Longitude:	**-76.17151**	Data Reliability:	
Description of Well Location and Other Notes:			

WELL CONSTRUCTION INFORMATION

Well Driller:	**SENSENIG & WEAVER WELL DRILLING**	License:	**1539**	Driller Well ID:	**38584**
Type of Activity:	**New Well**	Date Drilled:	**10/23/2014**	Drilling Method:	**AIR ROTARY**
Well Depth (ft):	**200**	Well Finish:	**SCREEN**		

WELL SIZE

Top (ft)	Bottom (ft)	Diameter (in)
0	**79**	**10**
79	**200**	**6**

CASING

Top (ft)	Bottom (ft)	Diameter (in)	Casing Material	Seal Top	Seal Bottom	Seal Type
0	**80**	**6**	**PVC OR OTHER PLASTIC**	**74**	**79**	**BENTONITE CHIPS OR PELLETS**

WELL LINER

PACKER

Top (ft)	Bottom (ft)	Diameter (in)	PVC Type	Top (ft)	Bottom (ft)	Sealant in Interval
70	**200**	**4.5**	**Perforated**	**79**	**80**	**No**

GROUNDWATER AND GEOLOGICAL INFORMATION

Well Yield (GPM - gal per min):	**60**	Yield Measurement Method:	**VOLUMETRIC, WATCH & BUCKET**
Water Level when not pumped: (ft below land surface)		Water Level after yield test: (ft below land surface)	
Length of Yield Test (minutes):		Saltwater Zone (ft):	
Use of Well:	**WITHDRAWAL**	Use of Water:	**DOMESTIC**

MATERIALS WELL PENETRATES

Top (ft)	Bottom (ft)	Description
0	**74**	**Brown Shale**
74	**120**	**Bedrock**
120	**200**	**Red Shale**

LEVELS WHERE WATER ENTERS WELL

Top (ft)	Bottom (ft)	Yield (GPM)
145	**145**	**45**
195	**195**	**15**

Depth to Bedrock (ft): **74** Was Well Drilled Into Bedrock? **Yes**

Date Printed: **9/11/2017**

PAWellID	County	Municipality	QuadName	Well Address	Well ZipCode	DateDrilled	TypeOf Activity	Latitude DD	Longitude DD	Driller	OriginalOwner	WellUse	WaterUse	Well Depth(ft)	TopOf Casing(ft)	BottomOf Casing(ft)	Casing Diameter (in)	DepthTo Bedrock(ft)	Bedrock Not Reached	Well Yield (gpm)	Static Water Level(ft)	WaterLevel AfterYield Test(ft)	LengthOf Test(min)	Yield Measurement Method	Saltwater Zone(ft)	Formation Name	Paper Image Link	Remark
536495	LANCASTER	WEST COCALICO TWP.	WOMELSDORF	2200 West Route 897	17517	10/23/2014	NEW WELL	40.28645	-76.17151	SENSENIG & WEAVER WELL DRILLING	Martin	WITHDRAWAL	DOMESTIC	200	0	80	6	74	False	60				VOLUMETRIC WATCH & BUCKET				
511001	LANCASTER	WEST COCALICO TWP.		1615 West Route 897	17517	12/5/2013	NEW WELL	40.28512	-76.16994	SENSENIG & WEAVER WELL DRILLING	Martin	WITHDRAWAL	DOMESTIC	260	0	81	6	70	False	75				VOLUMETRIC WATCH & BUCKET				
184077	LANCASTER	WEST COCALICO TWP.	WOMELSDORF			8/2/1979	NEW WELL	40.28583	-76.16722	ROBERT D GRANT	LEININGER VERNON	WITHDRAWAL	STOCK	119	0	58	6	50	False	18	8	99	0.5	VOLUMETRIC WATCH & BUCKET		HAMMER CREEK FORMATION		

ATTACHMENT 1 -
SITE SOILS

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

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

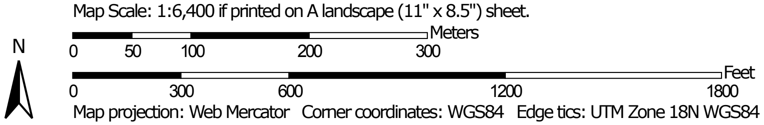
Custom Soil Resource Report for

Lancaster County, Pennsylvania

September 6, 2017

Custom Soil Resource Report
Soil Map

Map Scale: 1:6,400 if printed on A landscape (11" x 8.5") sheet.



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

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

Date(s) aerial images were photographed: Mar 26, 2011—Mar 27, 2011

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.

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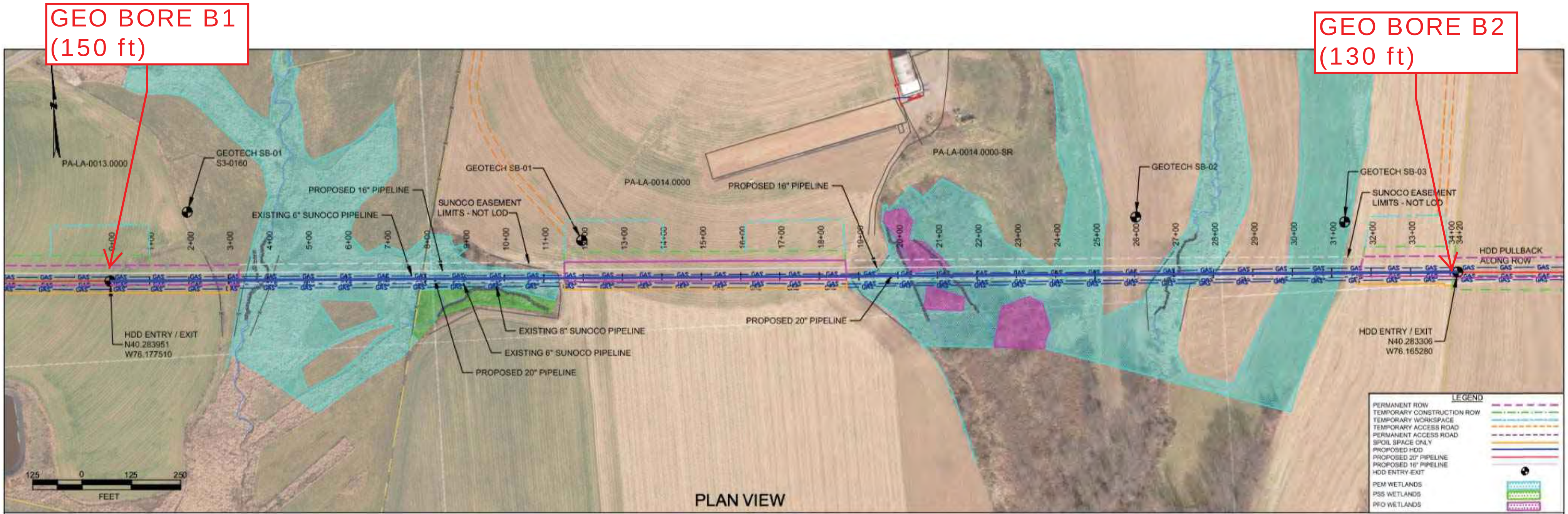
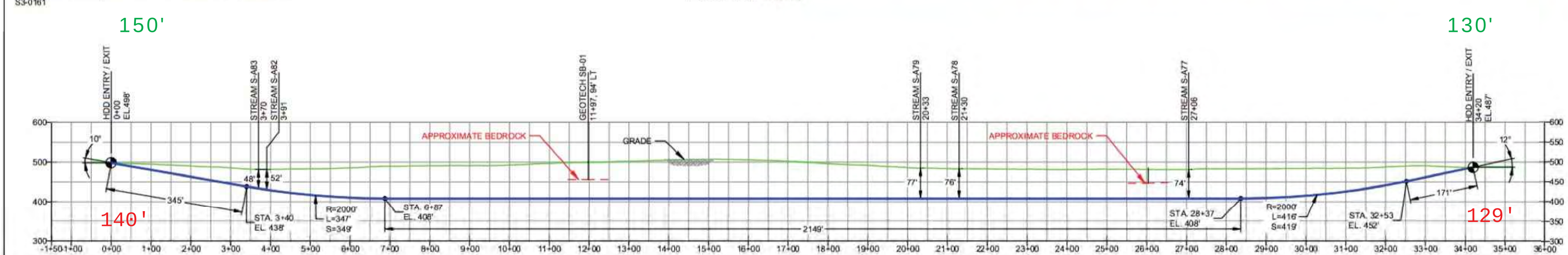
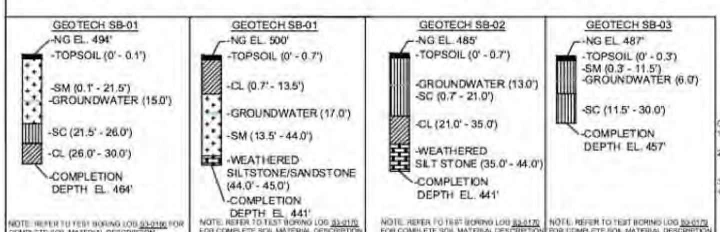
ATTACHMENT 2 - GEOTECH



LANCASTER COUNTY, PENNSYLVANIA - WEST COCALICO TOWNSHIP
S3-0161

PROFILE VIEW





DESIGN AND CONSTRUCTION:
1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXITING 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=): 3420'
   HDD PIPE LENGTH (S=): 3433'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS))
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD)
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

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	REVISED PROFILE WITH 2017 LIDAR	MRS	02/15/17	RMB	02/15/17	AAW	02/15/17
5	REMOVE PULLBACK LABEL WEST END	DLM	10/24/16	RMB	10/24/16	AAW	10/24/16
4	REVISED PER ENGINEERING COMMENTS	DLM	08/19/16	RMB	08/19/16	AAW	08/19/16
3	DESIGN CHANGE (DRILL 20' DEEPER)	DLM	08/10/16	RMB	08/10/16	AAW	08/10/16
2	DESIGN CHANGE	DLM	08/05/16	RMB	08/05/16	AAW	08/05/16
1	DESIGN CHANGE	MRS	04/12/16	RMB	04/12/16	AAW	04/12/16

Sunoco Logistics Partners L.P.

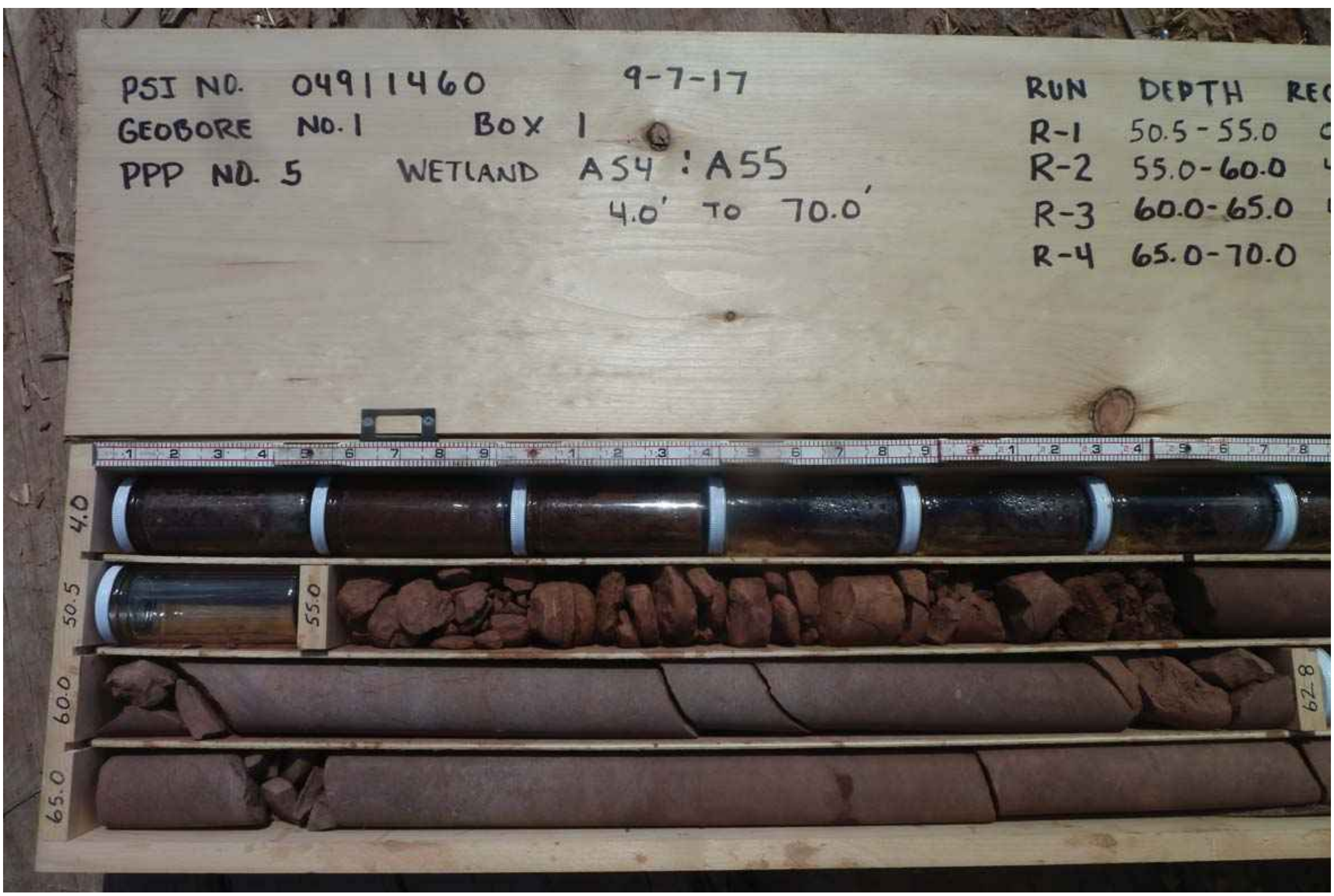
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
WETLAND A54 & A55
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=250'
DWG. NUMBER: PA-LA-0014.0000-SR


PSI NO. 04911460 9-7-17
GEOBORE NO. 1 BOX 1
PPP NO. 5 WETLAND A54 : A55
4.0' TO 70.0'
RUN DEPTH REC. RQD
R-1 50.5-55.0 0.0 0.0
R-2 55.0-60.0 4.5 2.3
R-3 60.0-65.0 4.4 3.3
R-4 65.0-70.0 3.2
TIME (MIN. - SEC.)
6-50, 4-13, 3-07, 3-55, 3-40
4-30, 6-06, 4-55, 4-05, 7-05
4-58, 5-52, 3-45, 8-10, 6-15
6-40, 2-40, 2-50, 3-30, 4-00
4.0
50.5
55.0
60.0
62.8
63.3
65.0
70.0


PSI NO. 04911460 9-7-17
GEOBORE NO. 1 BOX 1
PPP NO. 5 WETLAND A54 : A55
4.0' TO 70.0'
RUN DEPTH
R-1 50.5-55.0
R-2 55.0-60.0
R-3 60.0-65.0
R-4 65.0-70.0
4.0
50.5
55.0
60.0
62.8
65.0


UN DEPTH REC. RQD
-1 50.5-55.0 0.0 0.0
R-2 55.0-60.0 4.5 2.3
R-3 60.0-65.0 4.4 3.3
-4 65.0-70.0 5.0 3.2
TIME (MIN. – SEC.)
6-50, 4-13, 3-07, 3-55, 3-40
4-30, 6-06, 4-55, 4-05, 7-05
4-58, 5-52, 3-45, 8-10, 6-15
6-40, 2-40, 2-50, 3-30, 4-00
60.0
62.8
63.3
65.0
70.0


90.0
95.0
100.0
105.0
PSI NO. 04911460 9-7-17
GEOBORE NO. 1 BOX 2
PPP NO. 5 WETLAND A54 / A55
70.0' TO 90.0'
RUN DEPTH REC. RQD
R-5 70.0-75.0 5.0 5.0
R-6 75.0-80.0 2.8 2.0
R-7 80.0-85.0 5.0 3.2
R-8 85.0-90.0 5.0 4.5
TIME (MIN. – SEC.)
4-02, 2-38, 2-48, 3-07, 2-40
2-40, 2-35, 1-40, 2-17, 3-58
4-05, 3-40, 3-45, 3-25, 5-15
5-45, 3-10, 2-57, 2-36, 3-02
70.0
75.0
80.0
85.0
90.0


PSI NO. 04911460
9-7-17
GEOBORE NO. 1
BOX 2
PPP NO. 5
WETLAND A54 ; A55
70.0' TO 90.0'
RUN DEPTH REC.
R-5 70.0-75.0 5.0
R-6 75.0-80.0 2.8
R-7 80.0-85.0 5.0
R-8 85.0-90.0 5.0
70.0
75.0
80.0


DEPTH REC. RQD
70.0-75.0 5.0 5.0
75.0-80.0 2.8 2.0
80.0-85.0 5.0 3.2
85.0-90.0 5.0 4.5
TIME (MIN.-SEC.)
4-02, 2-38, 2-48, 3-07, 2-40
2-40, 2-35, 1-40, 2-17, 3-58
4-05, 3-40, 3-45, 3-25, 5-15
5-45, 3-10, 2-57, 2-36, 3-02
75.0
80.0
85.0
90.0


PSI NO. 04911460
GEOBORE NO. 1 BOX 3
PPP 5 WETLAND A54 & A55
90.0' TO 110.0'
RUN DEPTH REC. RQD TIME (MIN.-SEC.)
R-9 90.0-95.0 5.0 4.6 3-00, 2-34, 2-43, 3-02, 2-43
R-10 95.0-100.0 5.0 4.4 3-28, 2-12, 2-20, 3-18, 3-17
R-11 100.0-105.0 5.0 4.6 3-05, 3-30, 3-00, 2-47, 3-15
R-12 105.0-110.0 5.0 4.5 3-10, 2-50, 3-05, 3-00, 3-58
90.0
95.0
100.0
105.0
110.0


PSI NO. 04911460
GEOBORE NO. 1 BOX 3
PPP 5 WETLAND A54 & A55
90.0' TO 110.0'
RUN DEPTH
R-9 90.0-95.0
R-10 95.0-100.0
R-11 100.0-105.0
R-12 105.0-110.0
90.0
95.0
100.0
105.0

N DEPTH REC. RQD TIME (MIN.-SEC.)
-9 90.0-95.0 5.0 4.6 3-00, 2-34, 2-43, 3-02, 2-43
-10 95.0-100.0 5.0 4.4 3-28, 2-12, 2-20, 3-18, 3-17
-11 100.0-105.0 5.0 4.6 3-05, 3-30, 3-00, 2-47, 3-15
-12 105.0-110.0 5.0 4.5 3-10, 2-50, 3-05, 3-00, 3-58
95.0
100.0
105.0
110.0

PSI NO. 04911460 9-7-17/9-8-17
GEOBORE NO. 1 BOX 4
PPP NO. 5 WETLAND A54 : A55
110.0' TO 130.0'
RUN DEPTH REC. RQD. TIME (MIN.-SEC.)
R-13 110.0-115.0 4.2 3.8 1-56, 2-06, 4-18, 2-00, 2-32
R-14 115.0-120.0 5.0 4.4 3-45, 2-25, 2-50, 3-02, 2-43
R-15 120.0-125.0 5.0 3.7 2-35, 2-35, 2-35, 2-35, 2-10
R-16 125.0-130.0 4.9 3.8 4-32, 3-30, 3-20, 3-28, 2-50
110.0
110.3
111.0
115.0
120.0
125.0
130.0


PSI NO. 04911460
9-7-17/9-8-17
RUN DEPTH
GEOBORE NO. 1
BOX 4
R-13 110.0-115.
R-14 115.0-120.
PPP NO. 5
WETLAND A54 ; A55
R-15 120.0-125.
110.0' TO ~~125.0'~~ 130.0'
R-16 125.0-130.
110.0
110.3
111.0
115.0
120.0
125.0


N DEPTH REC. RQD. TIME (MIN. — SEC.)
-13 110.0-115.0 4.2 3.8 1-56, 2-06, 4-18, 2-00, 2-32
-14 115.0-120.0 5.0 4.4 3-45, 2-25, 2-50, 3-02, 2-43
-15 120.0-125.0 5.0 3.7 2-35, 2-35, 2-35, 2-35, 2-10
-16 125.0-130.0 ~~4.6~~ 4.9 3.8 4-32, 3-30, 3-20, 3-28, 2-50
115.0
120.0
125.0
130.0


PSI NO. 04911460
9-8-17
GEOBORE NO. 1
BOX 5
PPP NO. 5 WETLAND A54; A55
130.0' To 150.0'
RUN DEPTH REC. RQD. TIME (MIN. - SEC.)
R-17 130.0-135.0 4.9 4.6 4-16, 3-01, 3-00, 3-13, 2-32
R-18 135.0-140.0 5.0 3.4 4-42, 3-47, 4-00, 3-05, 3-20
R-19 140.0-145.0 5.0 4.2 3-50, 3-25, 3-02, 3-38, 4-13
R-20 145.0-150.0 5.0 5.0 4-36, 3-46, 3-48, 2-50, 3-34
130.0
135.0
140.0
145.0
150.0

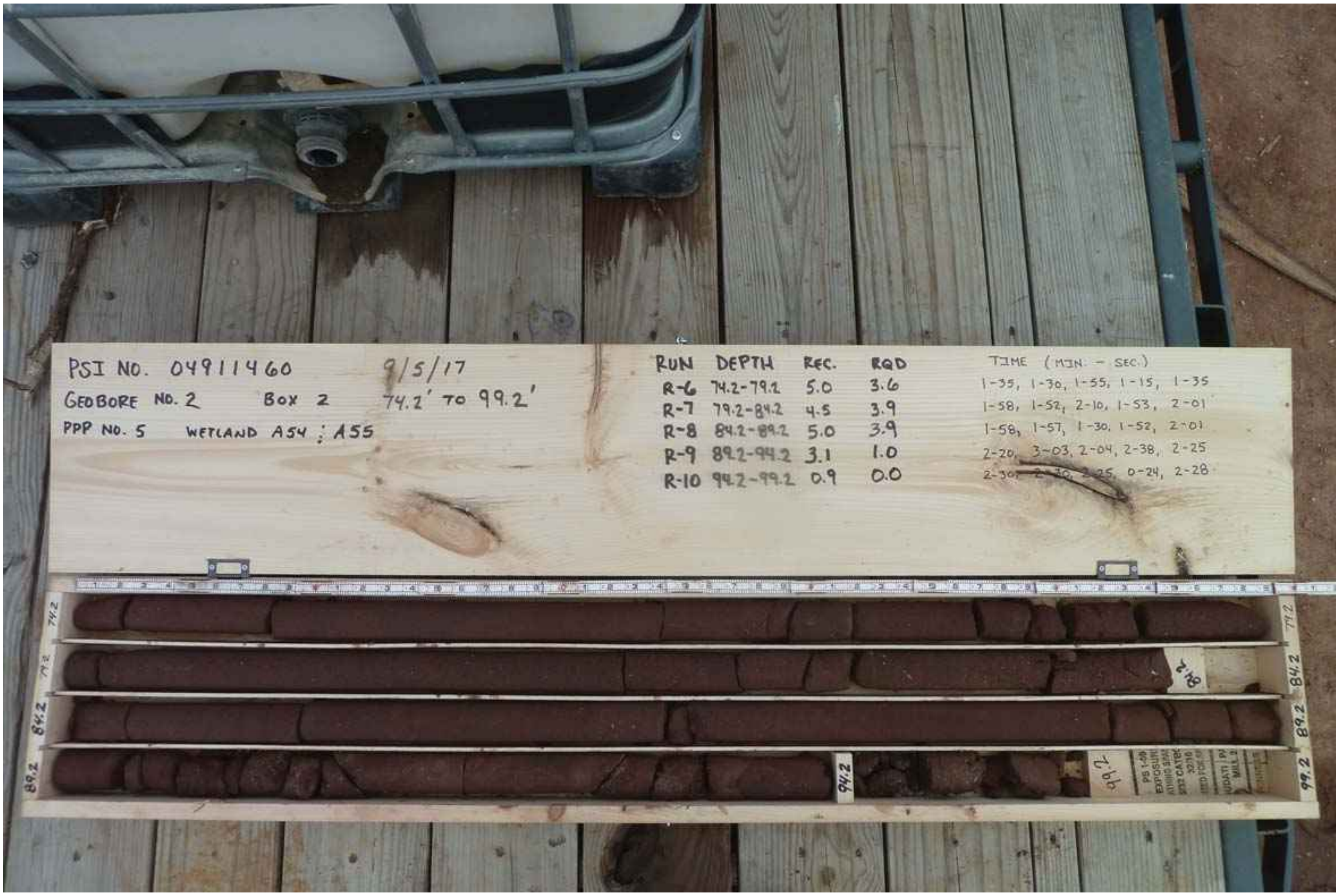

PSI NO. 04911460
9-8-17
GEOBORE NO. 1
BOX 5
PPP NO. 5 WETLAND A54; A55
130.0' To 150.0'
RUN
R-17
R-18
R-19
R-20
130.0
135.0
140.0
145.0


RUN DEPTH REC. RQD. TIME (MIN. - SEC.)
R-17 130.0-135.0 4.9 4.6 4-16, 3-01, 3-00, 3-13, 2-32
R-18 135.0-140.0 5.0 3.4 4-42, 3-47, 4-00, 3-05, 3-20
R-19 140.0-145.0 5.0 4.2 3-50, 3-25, 3-02, 3-38, 4-13
R-20 145.0-150.0 5.0 5.0 4-36, 3-46, 3-48, 2-50, 3-34
135.0
140.0
145.0
150.0


PSI NO. 04911460 8·31·17 / 9·5·17
GEOBORE NO. 2 BOX 1 4.0' TO 74.2'
PPP NO. 5 WETLAND A54 & A55
RUN DEPTH REC RQD TIME (MIN. - SEC.)
R-1 49.2-54.2 2.7 1.7 1-33, 3-35, 3-23, 1-15, 3-07
R-2 54.2-59.2 3.6 1.2 4-13, 2-37, 0-45, 1-46, 2-44
R-3 59.2-64.2 3.2 2.3 1-10, 1-35, 3-07, 3-13, 3-0
R-4 64.2-69.2 2.0 0.0 1-28, 1-12, 2-19, 3-31
R-5 69.2-74.2 2.7 1.9 2-39, 2-11, 1-45, 2-05, 1-40
4.0
49.2
54.2
59.2
64.2
69.2
74.2


PSI NO. 04911460
8.31.17 / 9.5.17
GEOBORE NO. 2
BOX 1
4.0' TO 74.2'
PPP NO. 5
WETLAND A54 & A55
RUN
R-1 49.2-
R-2 54.2
R-3 59.2
R-4 64.2
R-5 69.2
4.0
49.2
54.2
59.2
64.2
69.2


RUN DEPTH REC RQD TIME (MIN. - SEC.)
R-1 49.2-54.2 2.7 1.7 1-33, 3-35, 3-23, 1-15, 3-07
R-2 54.2-59.2 3.6 1.2 4-13, 2-37, 0-45, 1-46, 2-44
R-3 59.2-64.2 3.2 2.3 1-10, 1-35, 3-07, 3-13, 3-0
R-4 64.2-69.2 2.0 0.0 1-28, 1-12, 1-41, 2-19, 3-31
R-5 69.2-74.2 2.7 1.9 2-39, 2-11, 1-45, 2-05, 1-40
49.2
54.2
64.2
74.2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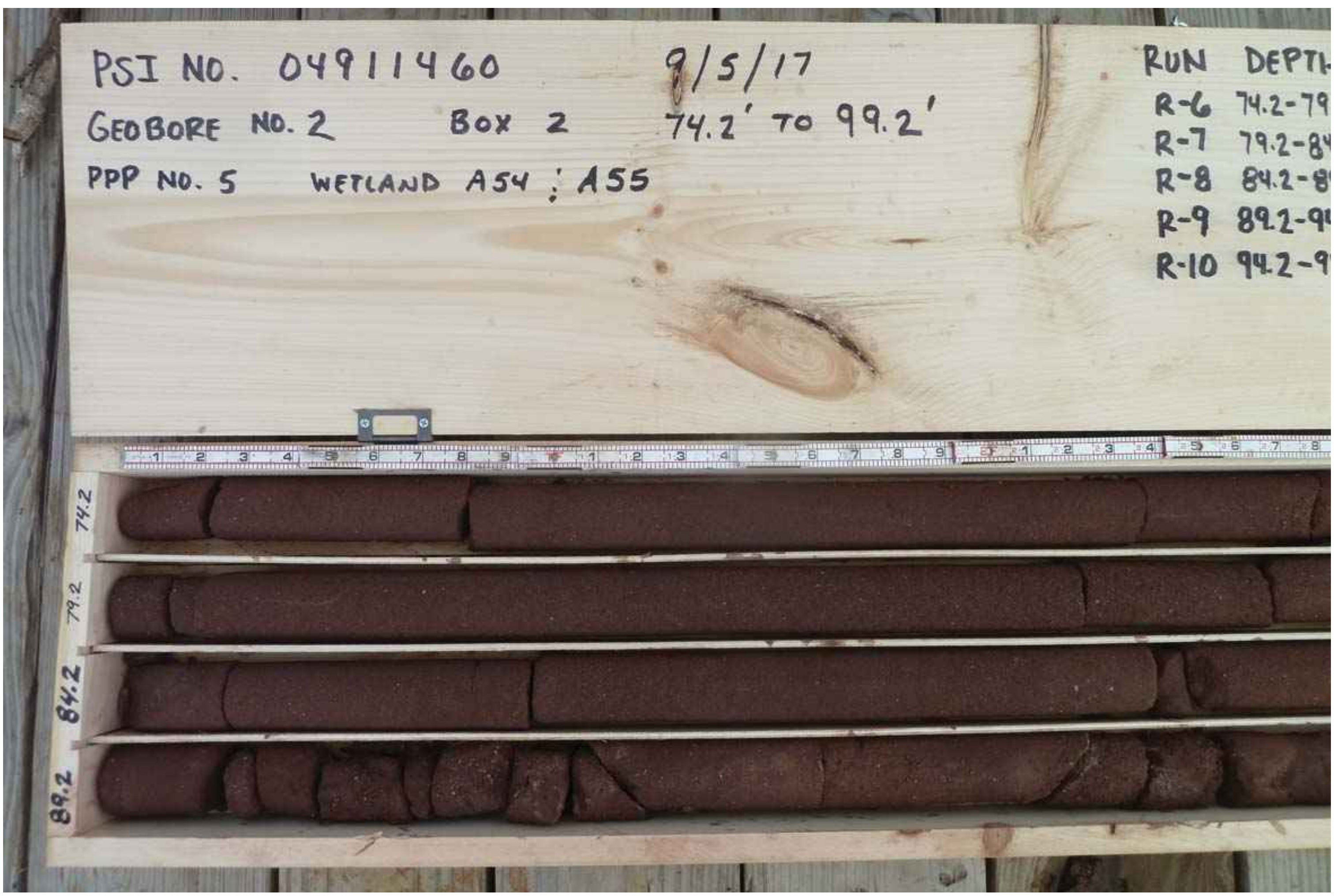
9/5/17
GEOBORE NO. 2 BOX 2
74.2' TO 99.2'
PPP NO. 5 WETLAND A54 ; A55
RUN DEPTH REC. RQD
R-6 74.2-79.2 5.0 3.6
R-7 79.2-84.2 4.5 3.9
R-8 84.2-89.2 5.0 3.9
R-9 89.2-94.2 3.1 1.0
R-10 94.2-99.2 0.9 0.0
TIME (MIN. - SEC.)
1-35, 1-30, 1-55, 1-15, 1-35
1-58, 1-52, 2-10, 1-53, 2-01
1-58, 1-57, 1-30, 1-52, 2-01
2-20, 3-03, 2-04, 2-38, 2-25
0-24, 2-28
74.2
79.2
84.2
89.2
94.2
99.2


PSI NO. 04911460
9/5/17
GEOBORE NO. 2 BOX 2
74.2' TO 99.2'
PPP NO. 5 WETLAND A54 ; A55
RUN
R-6
R-7
R-8
R-9
R-10
74.2
79.2
84.2
89.2


RUN DEPTH REC. RQD TIME (MIN. - SEC.)
R-6 74.2-79.2 5.0 3.6 1-35, 1-30, 1-55, 1-15, 1-35
R-7 79.2-84.2 4.5 3.9 1-58, 1-52, 2-10, 1-53, 2-01
R-8 84.2-89.2 5.0 3.9 1-58, 1-57, 1-30, 1-52, 2-01
R-9 89.2-94.2 3.1 1.0 2-20, 3-03, 2-04, 2-38, 2-25
R-10 94.2-99.2 0.9 0.0 2-30, 2-30, 2-25, 0-24, 2-28
79.2
84.2
89.2
99.2
94.2


PSI NO. 04911460
GEOBORE NO. 2 BOX 3
PPP NO. 5 WETLAND A54 ; A55
99.2' TO 124.2'
RUN DEPTH REC RQD TIME (MIN. - SEC.)
R-11 99.2-104.2 3.5 2.1 5-20, 3-45, 2-53, 1-30, 3-44
R-12 104.2-109.2 3.5 1.1 3-30, 1-15, 1-05, 1-20, 3-47
R-13 109.2-114.2 4.6 3.7 2-10, 1-50, 4-25, 1-56, 2-10
R-14 114.2-119.2 1.8 0.5 1-50, 1-28, 3-00, 4-15
R-15 119.2-124.2 5.0 3.2 3-45, 1-50, 2-55, 3-30, 3-45
104.2
109.2
114.2
119.2
124.2


PSI NO. 04911460
9-5-17/9-6-17
RUN
GEOBORE NO. 2
BOX 3
99.2' TO 124.2'
PPP NO. 5
WETLAND A54 ; A55
R-11
R-12
R-13
R-14
R-15
99.2'
109.2
114.2


RUN DEPTH REC RQD
R-11 99.2-104.2 3.5 2.1
R-12 104.2-109.2 3.5 1.1
R-13 109.2-114.2 4.6 3.7
R-14 114.2-119.2 1.8 0.5
R-15 119.2-124.2 5.0 3.2
TIME (MIN. - SEC.)
5-20, 3-45, 2-53, 1-30, 3-44
3-30, 1-15, 1-05, 1-20, 3-47
2-10, 1-50, 4-25, 1-56, 2-10
1-50, 1-28, 2-32, 3-00, 4-15
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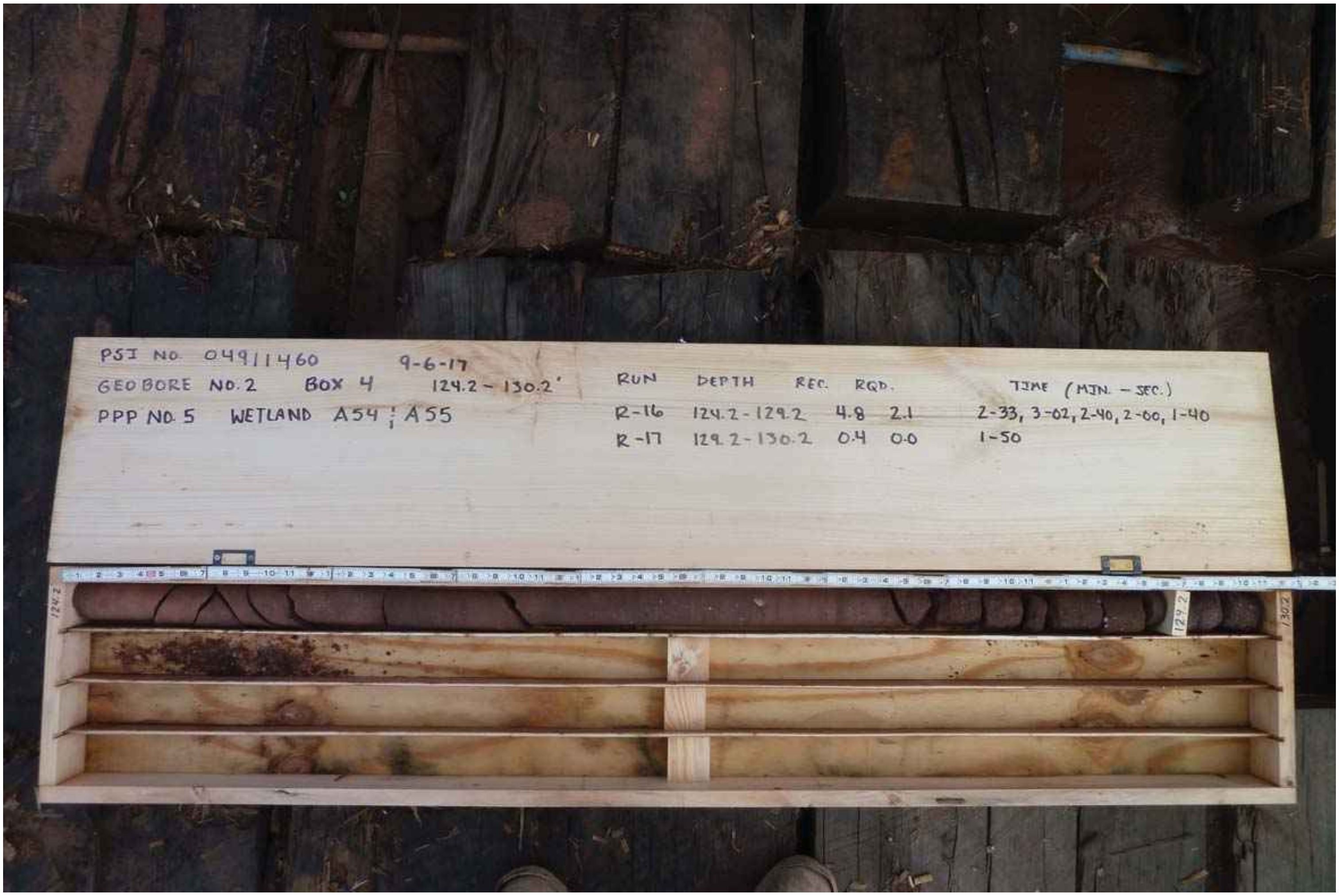
104.2
109.2
114.2
119.2
124.2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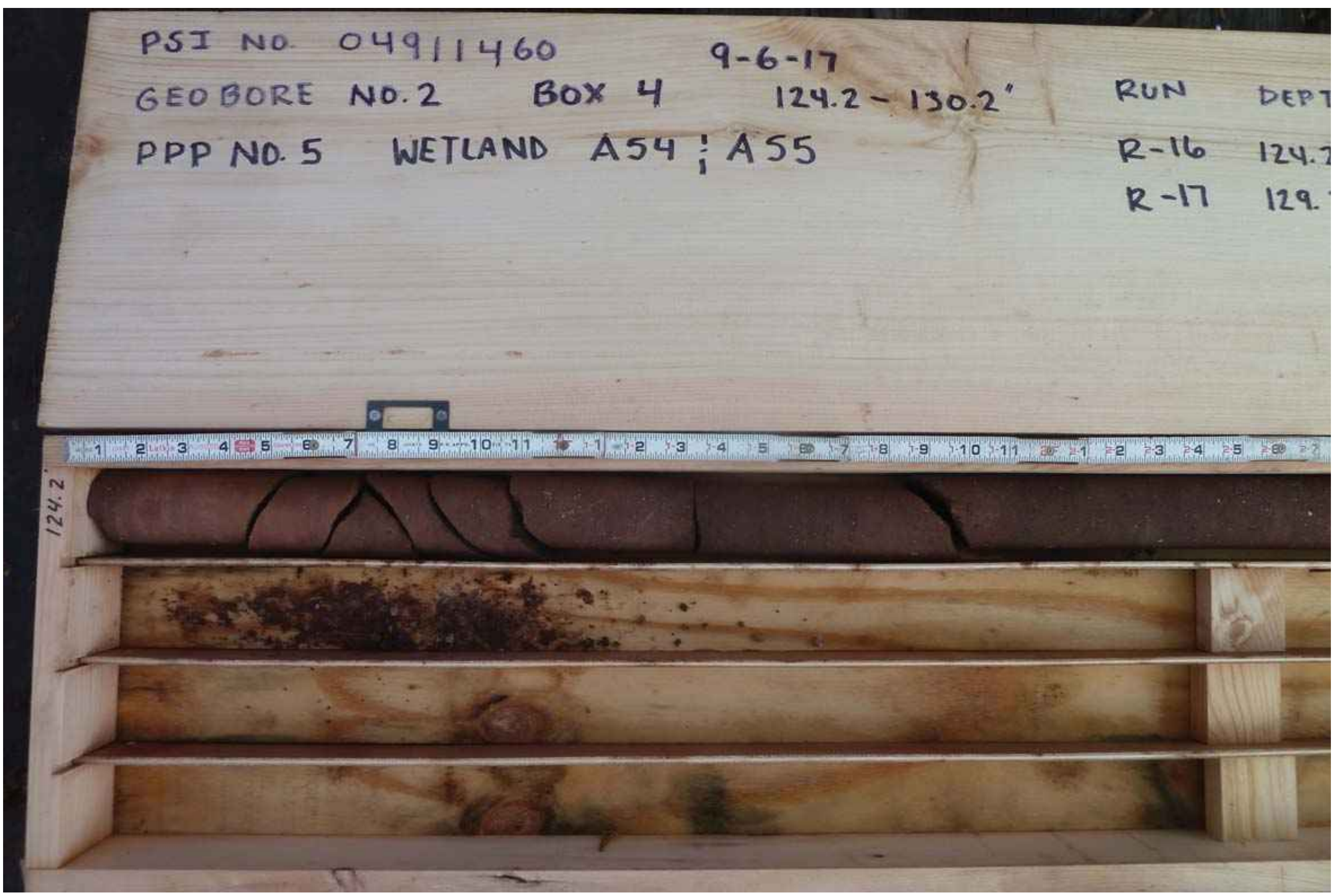
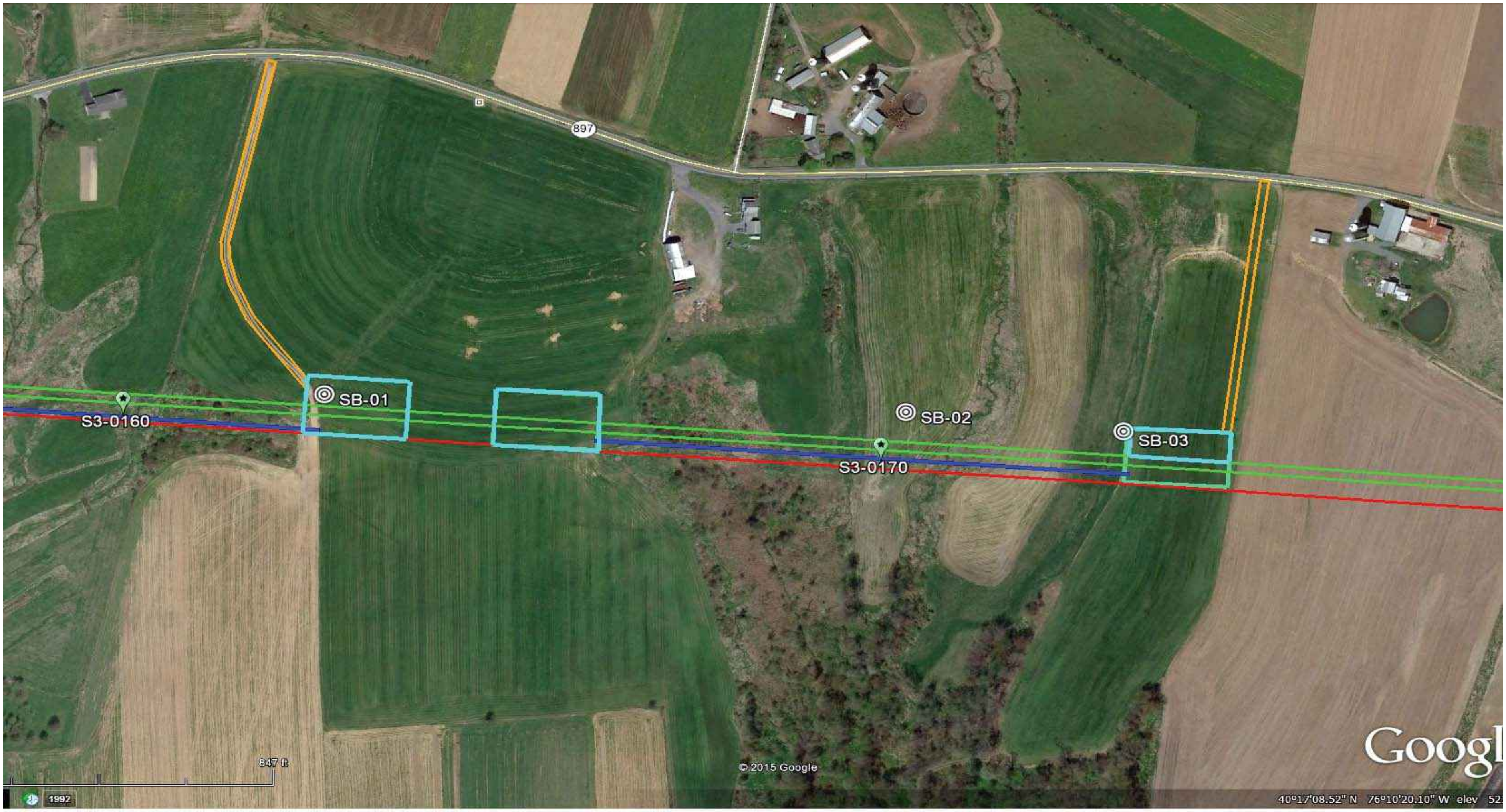
GEOBORE NO. 2 BOX 4 124.2 - 130.2'
PPP NO. 5 WETLAND A54 ; A55
RUN DEPTH REC. RQD. TIME (MIN. - SEC.)
R-16 124.2-129.2 4.8 2.1 2-33, 3-02, 2-40, 2-00, 1-40
R-17 129.2-130.2 0.4 0.0 1-50
124.2
129.2
130.2


PSI NO. 04911460 9-6-17
GEOBORE NO. 2 BOX 4 124.2 - 130.2'
PPP NO. 5 WETLAND A54 ; A55
RUN
R-16
R-17
124.2


RUN DEPTH REC. RQD. TIME (MIN. - SEC.)
R-16 124.2 - 129.2 4.8 2.1 2-33, 3-02, 2-40, 2-00, 1-40
R-17 129.2 - 130.2 0.4 0.0 1-50
129.2
130.2



LEGEND:

◎ Geotechnical Soil Boring (SB) Locations

TETRA TECH

GEOTECHNICAL BORING LOCATIONS

HDD S3-0170

LANCASTER COUNTY, WEST COCALICO TOWNSHIP, PA

SUNOCO PENNSYLVANIA PIPELINE PROJECT

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

TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	RT 897, DENVER, PA		Page 1 of 1
HDD No.:	S3-0170	Dates(s) Drilled: 11-20-14	Inspector: E. WATT
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 17.0	Total Depth (ft): 53.0
Boring Location Coordinates:		40° 17' 2.346" N	76° 10' 23.538" 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	0.7			TOPSOIL (8")					
1	3.0	5.0	0.7		24	CL	MAROON SILTY CLAY AND FINE SAND, TRACE QUARTZ FINE	3	10	11	10	**21**
							GRAVEL.					
2	8.0	10.0			8		MAROON MICACEOUS SILTY CLAY WITH SOME FINE SAND.	3	4	3	3	**7**
				13.5			(USCS: CL).					
3	13.0	13.9	13.5		11	SM	MAROON FINE TO MEDIUM SAND WITH A LITTLE CLAYEY SILT, TRACE	28	50/5"			**>50**
							FINE GRAVEL.					
4	18.0	18.9			12		MAROON FINE TO MEDIUM SAND WITH A LITTLE CLAYEY SILT, TRACE	14	50/5"			**>50**
							FINE GRAVEL.					
5	23.0	25.0			16		MARRON FINE SAND WITH SOME CLAYEY SILT, TRACE	3	11	28	50	**39**
							CONGLOMERATE.					
6	28.0	29.0			11		MAROON FINE TO MEDIUM SAND WITH SOME CLAYEY SILT, TRACE	9	50/6"			**>50**
							CONGLOMERATE.					
7	33.0	34.0			12		MAROON FINE SAND AND CLAYEY SILT, TRACE CONGLOMERATE.	28	50/6"			**>50**
8	38.0	38.9			8		MAROON FINE SAND AND CLAYEY SILT, TRACE CONGLOMERATE.	8	50/5"			**>50**
							(USCS: SM)					
9	43.0	43.9			10		MAROON MEDIUM TO COARSE SAND WITH SOME CLAYEY SILT,	12	50/5"			**>50**
				44.0			TRACE FINE QUARTZ GRAVEL.					
10	44.6	45.0	44.0	45.0	4		PARTIALLY WEATHERED SILTSTONE/SANDSTONE.	50/5"				**>50**
							AUGER REFUSAL AT 44.6'.					
							ROCK CORING					
RUN 1	45.0	48.0	45.0		20	FRACTURED ROCK	HIGHLY FRACTURED AND WEATHERED REDDISH BROWN	TCR: 55%, SCR: 0%, RQD: 0%				
				49.3			SILTSTONE.					
RUN 2	48.0	53.0	49.3		60		HIGHLY FRACTURED AND WEATHERED MAROON SILTSTONE AND	TCR: 100%, SCR: 12%, RQD: 9%				
				51.3			MEDIUM TO COARSE GRAINED SANDSTONE INTERBEDS.					
			51.3				MODERATELY TO HIGHLY FRACTURED, MODERATELY WEATHERED					
				53.0			MARRON SILTSTONE AND QUARTZ PEBBLE CONGLOMERATE.					

Notes/Comments:

Pocket Pentrometer Testing
S2: 0.5 TSF

WET ON SPOON AT 17'
WATER LEVEL THROUGH AUGERS AT 18'
CAVED AT 37'.

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.

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TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	RT 897, DENVER, PA		Page 1 of 1
HDD No.:	S3-0170	Dates(s) Drilled: 02-06-15	Inspector: E. WATT
Boring No.:	SB-02	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 13.0	Total Depth (ft): 44.0
Boring Location Coordinates:		40° 17' 1.883" N	76° 10' 5.380" 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	0.7			TOPSOIL (8")					
1	3.0	5.0	0.7		22	SC	MOTTLED (REDDISH BROWN, GRAY AND ORANGE BROWN) FINE TO MEDIUM SAND, WITH SOME SILTY CLAY, TRACE FINE GRAVEL.	3	7	11	14	**18**
2	8.0	10.0			18	SC	REDDISH BROWN FINE TO MEDIUM SAND WITH SOME SILTY CLAY, TRACE FINE GRAVEL.	3	2	4	5	**6**
3	13.0	14.9			17	SC	REDDISH BROWN FINE TO MEDIUM SAND AND SILTY CLAY, WITH A LITTLE UNWEATHERED ROCK FRAGMENTS. (USCS: SC)	13	27	44	50/5"	**>50**
4	18.0	19.0		21.0	12	SC	REDDISH BROWN FINE TO MEDIUM SAND AND SILTY CLAY, WITH A LITTLE UNWEATHERED ROCK FRAGMENTS. (USCS: SC)	11	50/6"			**>50**
5	23.0	25.0	21.0		24	CL	REDDISH BRWON SILTY CLAY, TRACE FINE SAND, WITH TRACE UNWEATHERED ROCK FRAGMENTS. (USCS: CL).	15	27	25	35	**52**
6	28.0	28.8			10	CL	REDDISH BRWON SILTY CLAY, TRACE FINE SAND, WITH TRACE UNWEATHERED ROCK FRAGMENTS.	20	50/4"			**>50**
7	33.0	33.6		35.0	8	CL	REDDISH BROWN SILTY CLAY AND FINE SAND, WITH A LITTLE UNWEATHERED ROCK FRAGMENTS. (USCS: CL).	30	50/2"			**>50**
8	38.0	38.7	35.0		8	WEATHERED SILTSTONE	REDDISH BROWN HIGHLY WEATHERED SILTSTONE.	38	50/3"			**>50**
9	43.0	43.7		44.0	7	WEATHERED SILTSTONE	REDDISH BROWN HIGHLY WEATHERED SILTSTONE.	25	50/3"			**>50**
							AUGER REFUSAL AT 44'.					

Notes/Comments:

Pocket Pentrometer Testing

S4 to S7: > 4 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.

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TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT	Project No.: 103IP3406	
Project Location:	RT 897, DENVER, PA	Page 1 of 1	
HDD No.:	S3-0170	Dates(s) Drilled: 12-13-14	Inspector: E. WATT
Boring No.:	SB-03	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 6.0	Total Depth (ft): 30.0
Boring Location Coordinates:		40° 17' 1.365" N	76° 9' 58.579" W

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
	From	To	From	To								
			0.0	0.3			TOPSOIL (3")					
1	3.0	5.0	0.3		11	SM	VARYING SHADES OF BROWN (TRACE WHITE) FINE TO COARSE SAND WITH A LITTLE SILT, TRACE FINE QUARTZ GRAVEL.	2	6	15	21	**21**
2	8.0	10.0		11.5	22	SM	REDDISH BROWN FINE TO COARSE SAND WITH A LITTLE SILT, TRACE FINE GRAVEL.	4	12	13	18	**25**
3	13.0	15.0	11.5		17	SC	REDDISH BROWN FINE TO MEDIUM SAND WITH SOME SILTY CLAY, WITH A LITTLE FINE TO COARSE GRAVEL.	16	26	25	35	**51**
4	18.0	18.8			9	SC	REDDISH BROWN FINE TO MEDIUM SAND WITH SOME SILTY CLAY, WITH A LITTLE FINE TO COARSE GRAVEL.	10	50/3"			**>50**
5	23.0	23.7			5	SC	REDDISH BROWN FINE TO MEDIUM SAND WITH SOME SILTY CLAY, WITH A LITTLE FINE TO COARSE GRAVEL.	8	50/3"			**>50**
6	28.0	29.3		30.0	0	SC	NO RECOVERY	11	20	50/3"		**>50**
							AUGERED TO 30'.					
							WET ON SPOON AT 13'.					
							WATER LEVEL THROUGH AUGERS AT 6'.					
							CAVED AT 27'.					

Notes/Comments:

Pocket Pentrometer Testing

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

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

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0170

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, %	Plastic Limit, %	Plasticity Index, %	USCS Classif. (ASTM D2487)
S3-0170	SB-01	2	8.0	10.0	16.7	78.1	27	16	11	CL
		4	18.0	18.9	11.3	19.7	-	-	-	-
		6	28.0	29.0	8.6	27.9	-	-	-	-
		8	38.0	38.9	10.7	44.4	18	18	NP	SM
		9	43.0	43.9	10.6	25.1	-	-	-	-
	SB-02	2	8.0	10.0	17.0	28.6	-	-	-	-
		3	13.0	14.9	9.6	41.2	28	20	8	SC
		5	23.0	25.0	17.7	92.5	27	16	11	CL
		6	28.0	28.8	10.9	98.7	-	-	-	-
		7	33.0	33.6	10.0	53.6	28	16	12	CL
	SB-03	1	3.0	5.0	12.5	18.3	-	-	-	-
		2	8.0	10.0	13.6	17.1	-	-	-	-
		3	13.0	15.0	9.8	23.4	-	-	-	-
		4	18.0	18.8	9.3	19.8	-	-	-	-
		5	23.0	23.7	10.5	24.6	-	-	-	-

Notes:

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

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0170

HDD No.	NAME	BORING NO.	REGIONAL GEOLOGY DESCRIPTION	GENERAL TOPOGRAPHIC SETTING	BEDROCK FORMATION	GENERAL ROCK TYPE	APPROX MAX FM THICKNESS (FT)	DEPTH TO ROCK (Ft bgs) based on nearby well drilling logs	NOTES / COMMENTS
S3-0170	Wetland A54	SB-01	**Hammer Creek Formation** - Gray and pale red, fine- to coarse-grained quartzose sandstone, siltstone, and mudstone	Lowland, wetlands area	Hammer Creek Fm	sandstone with quartz pebble conglomerate	9,360	50-70	
		SB-02						50-75	
		SB-03						50-70	

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

ROCK CORE DESCRIPTION SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0170

Location	Boring No.	Core Run	Core Depth (ft)		TCR (%)	SCR (%)	RQD (%)	Depth (ft)		Weathering	Classification	Bedding Thickness (ft)	Color	Discontinuity Data
			From	To				From	To					
S3-0170	SB-01	1	45	48	55	0	0	45	48	Heavily	Siltstone	Massive	Red	Heavily fractured, ranging from 0° to 45°
		2	48	53	100	12	9	48	53	Heavily	Siltstone with interbedded Sandstone	Massive, bedding is gradational	Red	Heavily fractured, ranging from 0° to 65°

FIELD DESCRIPTION AND LOGGING SYSTEM FOR SOIL EXPLORATION

GRANULAR SOILS
(Sand, Gravel & Combinations)

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

Relative Proportions

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

Particle Size Identification

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

COHESIVE SOILS
(Silt, Clay & Combinations)

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

Plasticity

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

ROCK
(Rock Cores)

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

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

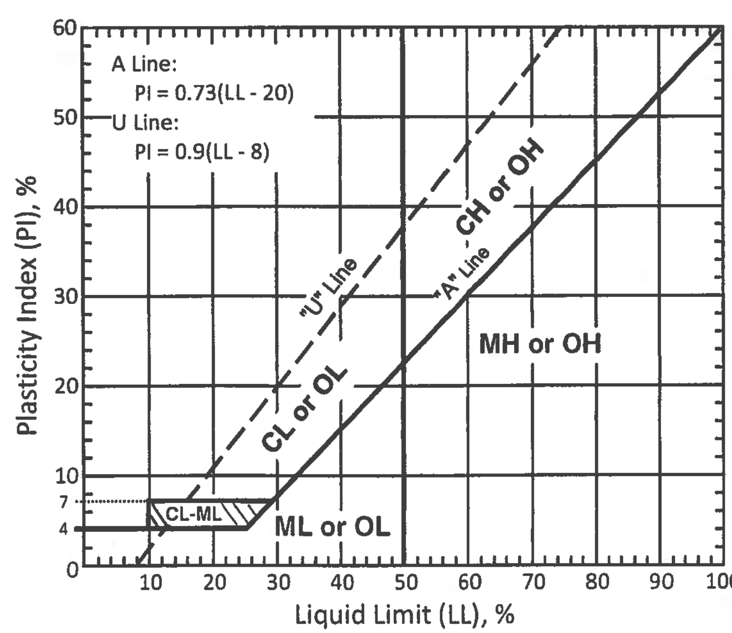
Groundwater observations were made at the times indicated. Groundwater elevations fluctuate throughout a given year, depending on actual field porosity and variations in seasonal and annual precipitation.

UNIFIED SOIL CLASSIFICATION SYSTEM [Casagrande (1948)]

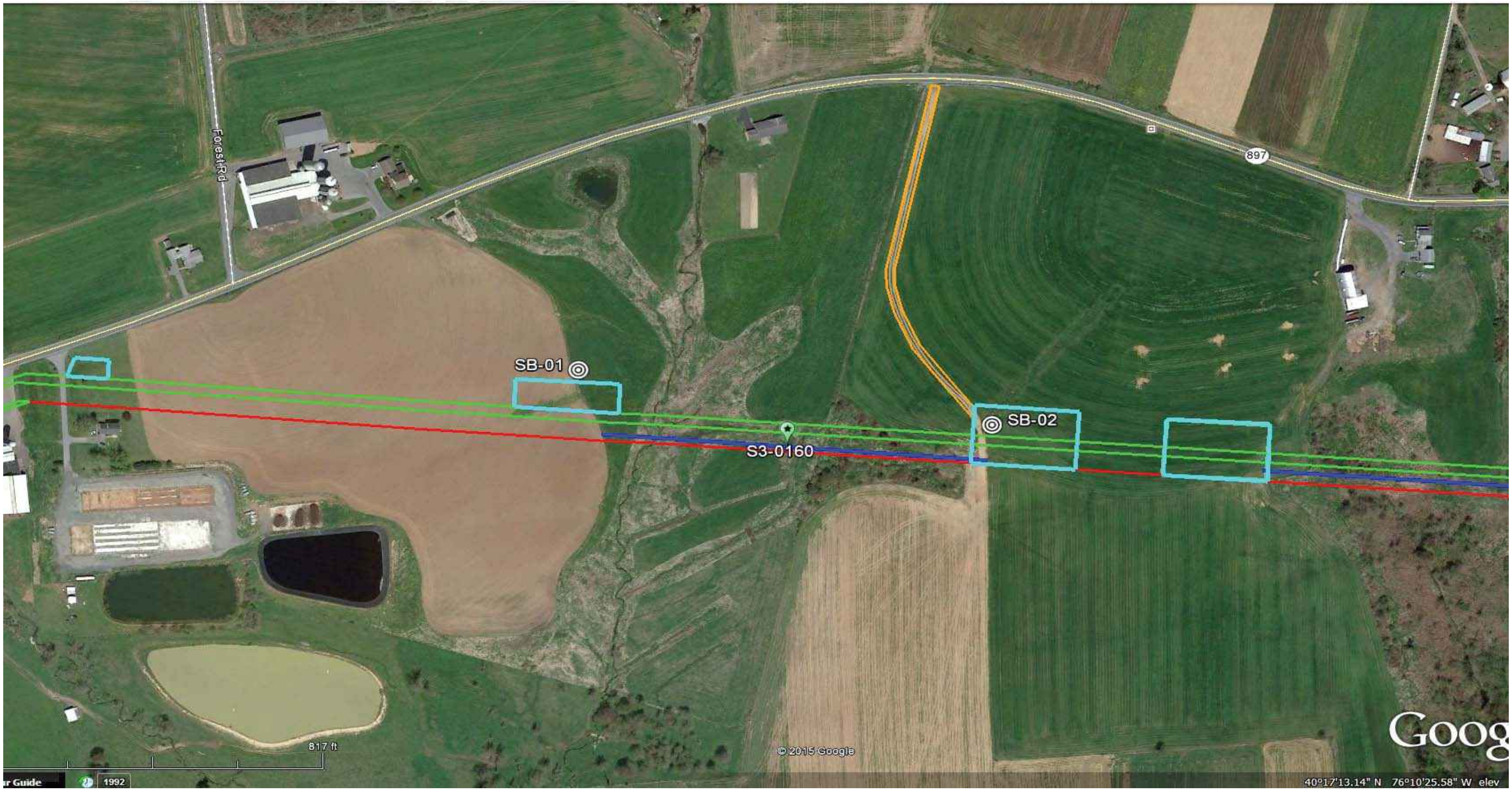
Major Divisions			Group Symbols	Typical Descriptions	Laboratory Classifications		
Coarse Grained Soils (More than half of material is larger than No. 200 sieve)	Gravels More than half of coarse fraction is larger than No. 4 sieve size	Clean gravel (Little or no fines)	GW	Well-graded gravels, gravel-sand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



LEGEND:

◎ Geotechnical Soil Boring (SB) Locations

TETRA TECH

GEOTECHNICAL BORING LOCATIONS
HDD S3-0160
LANCASTER COUNTY, WEST COCALICO TOWNSHIP, PA
SUNOCO PENNSYLVANIA PIPELINE PROJECT

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TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT			Project No.: 103IP3406	
Project Location:	RT 897, DENVER, PA			Page 1 of 1	
HDD No.:	S3-0160	Dates(s) Drilled: 12-13-14	Inspector:	E. WATT	
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586	Driller:	S. HOFFER	
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 15.0	Total Depth (ft):	30.0	
Boring Location Coordinates:		40° 17' 3.801" N	76° 10' 36.352" 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	0.1			TOPSOIL (<1")					
1	3.0	5.0	0.1		14	SM	REDDISH BROWN TO GRAYISH BROWN FINE TO MEDIUM SAND WITH	4	16	20	22	**36**
							A LITTLE SILT, TRACE FINE QUARTZ GRAVEL.					
2	8.0	10.0			24		REDDISH BROWN FINE TO COARSE SAND WITH SOME SILT, TRACE	2	14	10	12	**24**
							CONGLOMERATE MATRIX.					
3	13.0	14.5			18		REDDISH BROWN FINE SAND AND SILT, WITH A LITTLE	4	25	50		**75**
							CONGLOMERATE MATRIX.					
4	18.0	19.4			14		REDDISH BROWN FINE SAND AND SILT, WITH A LITTLE	9	33	50/5"		**>50**
				21.5			CONGLOMERATE MATRIX.					
5	23.0	23.9	21.5		10	SC	REDDISH BROWN FINE SAND AND SILTY CLAY, WITH A LITTLE	2	50/5"			**>50**
				26.0			FINE TO COARSE UNWEATHERED GRAVEL (USCS: SC)					
6	28.0	28.8	26.0		9	CL	REDDISH BROWN SILTY CLAY AND FINE SAND, WITH A LITTLE	23	50/4"			**>50**
				30.0			FINE TO COARSE UNWEATHERED GRAVEL.					
							AUGERED TO 30'.					
							WET ON SPOON AT 15'.					
							WATER LEVEL THROUGH AUGERS AT 17'.					
							CAVED AT 28'.					

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.

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TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT			Project No.: 103IP3406
Project Location:	MIDDLECREEK WILDLIFE MANAGEMENT AREA, NEWMANSTOWN, PA			Page 1 of 1
HDD No.:	S3-0160	Dates(s) Drilled: 11-20-14	Inspector:	E. WATT
Boring No.:	SB-02	Drilling Method: SPT - ASTM D1586	Driller:	S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 17.0	Total Depth (ft):	53.0
Boring Location Coordinates:		40° 17' 2.346" N	76° 10' 23.538" 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	0.7			TOPSOIL (8")					
1	3.0	5.0	0.7		24	CL	MAROON SILTY CLAY AND FINE SAND, TRACE QUARTZ FINE	3	10	11	10	**21**
							GRAVEL.					
2	8.0	10.0			8		MAROON MICACEOUS SILTY CLAY WITH SOME FINE SAND.	3	4	3	3	**7**
				13.5			(USCS: CL).					
3	13.0	13.9	13.5		11	SM	MAROON FINE TO MEDIUM SAND WITH A LITTLE CLAYEY SILT, TRACE	28	50/5"			**>50**
							FINE GRAVEL.					
4	18.0	18.9			12		MAROON FINE TO MEDIUM SAND WITH A LITTLE CLAYEY SILT, TRACE	14	50/5"			**>50**
							FINE GRAVEL.					
5	23.0	25.0			16		MARRON FINE SAND WITH SOME CLAYEY SILT, TRACE	3	11	28	50	**39**
							CONGLOMERATE.					
6	28.0	29.0			11		MAROON FINE TO MEDIUM SAND WITH SOME CLAYEY SILT, TRACE	9	50/6"			**>50**
							CONGLOMERATE.					
7	33.0	34.0			12		MAROON FINE SAND AND CLAYEY SILT, TRACE CONGLOMERATE.	28	50/6"			**>50**
8	38.0	38.9			8		MAROON FINE SAND AND CLAYEY SILT, TRACE CONGLOMERATE.	8	50/5"			**>50**
							(USCS: SM)					
9	43.0	43.9			10		MAROON MEDIUM TO COARSE SAND WITH SOME CLAYEY SILT,	12	50/5"			**>50**
				44.0			TRACE FINE QUARTZ GRAVEL.					
10	44.6	45.0	44.0	45.0	4		PARTIALLY WEATHERED SILTSTONE/SANDSTONE.	50/5"				**>50**
							AUGER REFUSAL AT 44.6'.					
							<u>ROCK CORING</u>					
RUN 1	45.0	48.0	45.0		20	FRACTURED ROCK	HIGHLY FRACTURED AND WEATHERED REDDISH BROWN	TCR: 55%, SCR: 0%, RQD: 0%				
				49.3			SILTSTONE.					
RUN 2	48.0	53.0	49.3		60		HIGHLY FRACTURED AND WEATHERED MAROON SILTSTONE AND	TCR: 100%, SCR: 12%, RQD: 9%				
				51.3			MEDIUM TO COARSE GRAINED SANDSTONE INTERBEDS.					
			51.3				MODERATELY TO HIGHLY FRACTURED, MODERATELY WEATHERED					
				53.0			MARRON SILTSTONE AND QUARTZ PEBBLE CONGLOMERATE.					

Notes/Comments:

<u>Pocket Pentrometer Testing</u>
S2: 0.5 TSF

DR: DECOMPOSED ROCK

WET ON SPOON AT 17'
WATER LEVEL THROUGH AUGERS AT 18'
CAVED AT 37'.

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

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

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0160

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.)		Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318)			USCS Classif. (ASTM D2487)
			From	To			Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	
S3-0160	SB-01	2	8.0	10.0	10.9	29.2	-	-	-	-
		3	13.0	14.5	8.4	39.2	-	-	-	-
		4	18.0	19.4	7.0	41.2	-	-	-	-
		5	23.0	23.9	10.4	46.2	26	16	8	SC
		6	28.0	28.8	7.8	65.3	-	-	-	-
	SB-02 (Also S3-0170, SB-01)	2	8.0	10.0	16.7	78.1	27	16	11	CL
		4	18.0	18.9	11.3	19.7	-	-	-	-
		6	28.0	29.0	8.6	27.9	-	-	-	-
		8	38.0	38.9	10.7	44.4	18	18	NP	SM
		9	43.0	43.9	10.6	25.1	-	-	-	-

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

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0160

HDD No.	NAME	BORING NO.	REGIONAL GEOLOGY DESCRIPTION	GENERAL TOPOGRAPHIC SETTING	BEDROCK FORMATION	GENERAL ROCK TYPE	APPROX MAX FM THICKNESS (FT)	DEPTH TO ROCK (Ft bgs) based on nearby well drilling logs	NOTES / COMMENTS
S3-0160	Wetland A55	SB-01	**Hammer Creek Formation** - Gray and pale red, fine- to coarse-grained quartzose sandstone, siltstone, and mudstone	Lowland, wetlands area	Hammer Creek Fm	sandstone with quartz pebble conglomerate	9,360	50-70	
		SB-02							

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

ROCK CORE DESCRIPTION SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0160

Location	Boring No.	Core Run	Core Depth (ft)		TCR (%)	SCR (%)	RQD (%)	Depth (ft)		Weathering	Classification	Bedding Thickness (ft)	Color	Discontinuity Data
			From	To				From	To					
S3-0160	SB-2	1	45	48	55	0	0	45	48	Heavily	Siltstone	Massive	Red	Heavily fractured, ranging from 0° to 45°
		2	48	53	100	12	9	48	53	Heavily	Siltstone with interbedded Sandstone	Massive, bedding is gradational	Red	Heavily fractured, ranging from 0° to 65°

FIELD DESCRIPTION AND LOGGING SYSTEM FOR SOIL EXPLORATION

GRANULAR SOILS

(Sand, Gravel & Combinations)

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

Relative Proportions

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

Particle Size Identification

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

COHESIVE SOILS

(Silt, Clay & Combinations)

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

Plasticity

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

ROCK

(Rock Cores)

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

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

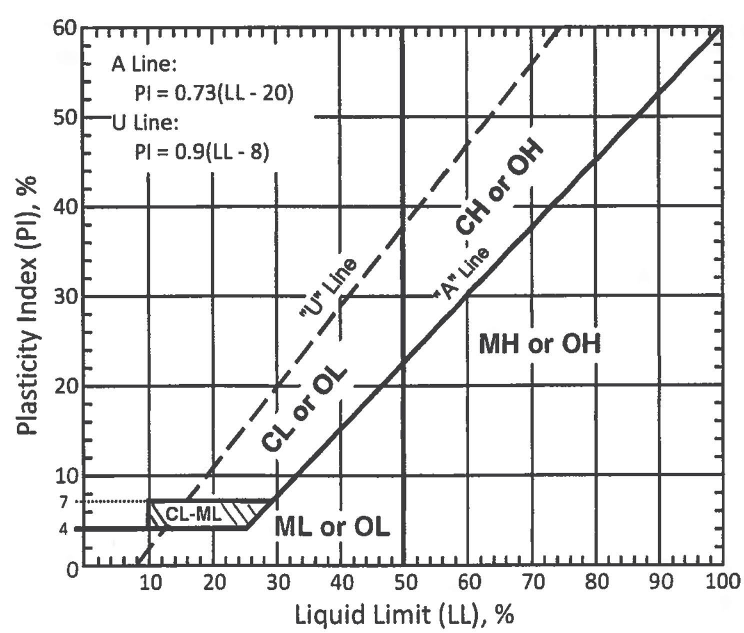
Groundwater observations were made at the times indicated. Groundwater elevations fluctuate throughout a given year, depending on actual field porosity and variations in seasonal and annual precipitation.

UNIFIED SOIL CLASSIFICATION SYSTEM [Casagrande (1948)]

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

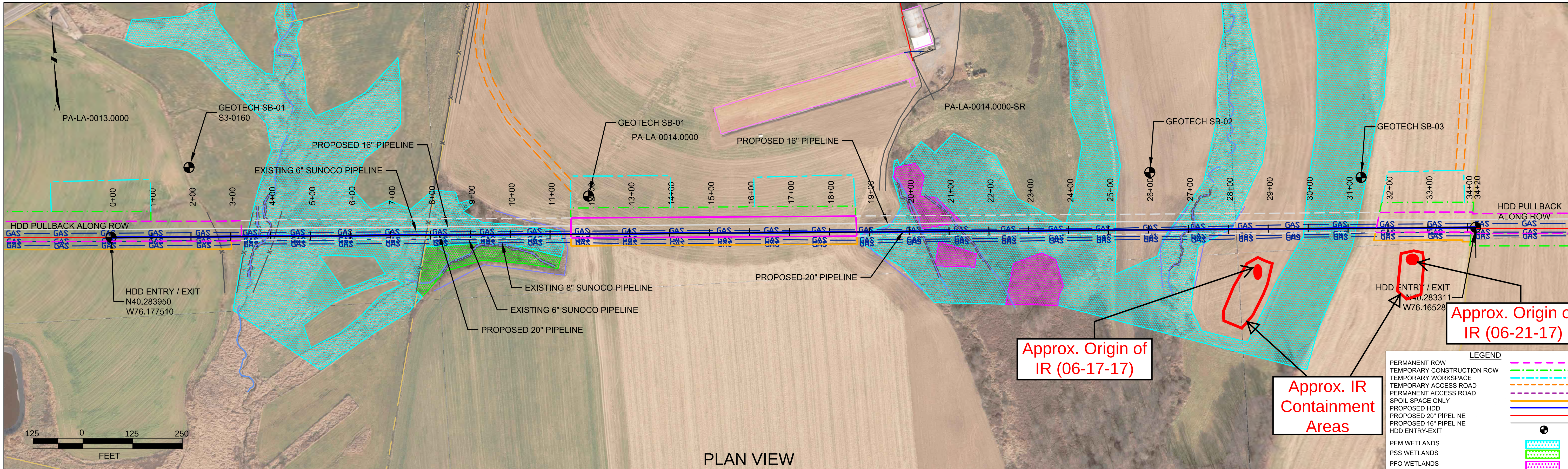
Major Divisions		Group Symbols	Typical Descriptions
Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silts and clays (Liquid limit less than 50)	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity
		CL	Inorganic 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.

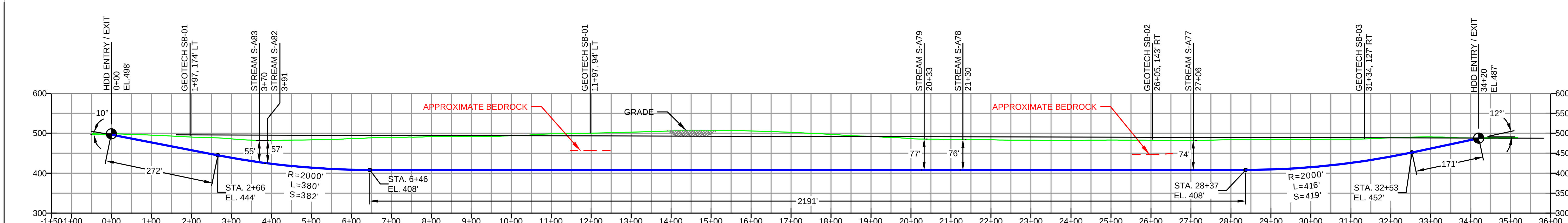
ATTACHMENT 3 -
APPROXIMATE IR LOCATION MAP



PLAN VIEW

LANCASTER COUNTY, PENNSYLVANIA - WEST COCALICO TOWNSHIP
S3-0161

PROFILE VIEW



GEOTECH SB-01
- -NG EL. 494'
- -TOPSOIL (0' - 0.1')
- -SM (0.1' - 21.5')
- -GROUNDWATER (15.0')
- -SC (21.5' - 26.0')
- -CL (26.0' - 30.0')
- -COMPLETION DEPTH EL. 464'

NOTE: REFER TO TEST BORING LOG S3-0160 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH SB-01
- -NG EL. 500'
- -TOPSOIL (0' - 0.7')
- -CL (0.7' - 13.5')
- -GROUNDWATER (17.0')
- -SM (13.5' - 44.0')
- -WEATHERED SILTSTONE/SANDSTONE (44.0' - 45.0')
- -COMPLETION DEPTH EL. 441'

NOTE: REFER TO TEST BORING LOG S3-0170 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH SB-02
- -NG EL. 485'
- -TOPSOIL (0' - 0.7')
- -GROUNDWATER (13.0')
- -SC (0.7' - 21.0')
- -CL (21.0' - 35.0')
- -WEATHERED SILT STONE (35.0' - 44.0')
- -COMPLETION DEPTH EL. 441'

NOTE: REFER TO TEST BORING LOG S3-0170 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH SB-03
- -NG EL. 487'
- -TOPSOIL (0' - 0.3')
- -SM (0.3' - 11.5')
- -GROUNDWATER (6.0')
- -SC (11.5' - 30.0')
- -COMPLETION DEPTH EL. 457'

NOTE: REFER TO TEST BORING LOG S3-0170 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:
1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXITING 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=): 3420'
   HDD PIPE LENGTH (S=): 3435'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

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
4	DESIGN CHANGE	DLM	08/10/16	RMB	08/10/16	AAW	08/10/16
3	DESIGN CHANGE	DLM	08/05/16	RMB	08/05/16	AAW	08/05/16
2	DESIGN CHANGE	DLM	04/12/16	RMB	04/12/16	AAW	04/12/16
1	DESIGN CHANGE	MRS	02/24/16	RMB	02/24/16	AAW	02/24/16
0	ISSUED FOR CONSTRUCTION	MRS	01/21/16	RMB	01/21/16	AAW	01/21/16

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

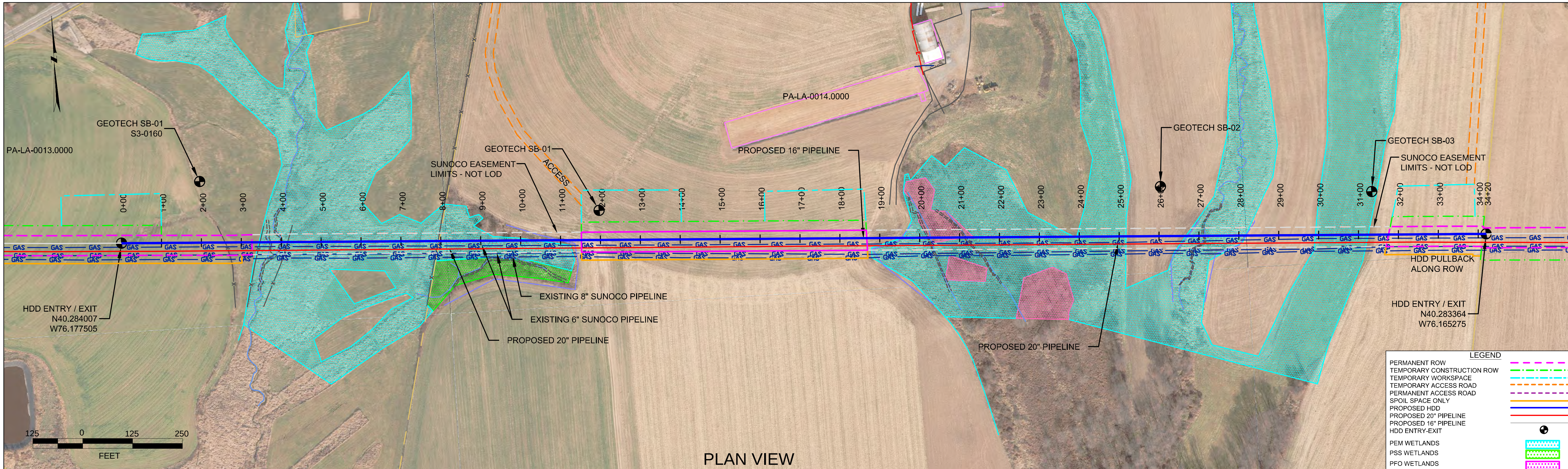
HORIZONTAL DIRECTIONAL DRILL
WETLAND A54 & A55
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=250'
DWG. NUMBER: PA-LA-0014.0000-SR

CROSSINGS OF WETLANDS A54 & A55 (BOG TURTLE WETLANDS)
PADEP SECTION 105 PERMIT NO.:
PA-LA-0014.0000-SR-16
(SPLP HDD# S3-0161)

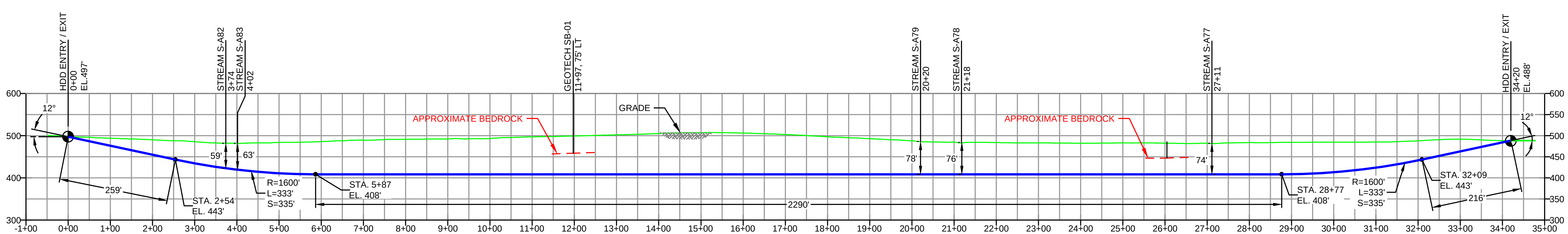
ATTACHMENT 2

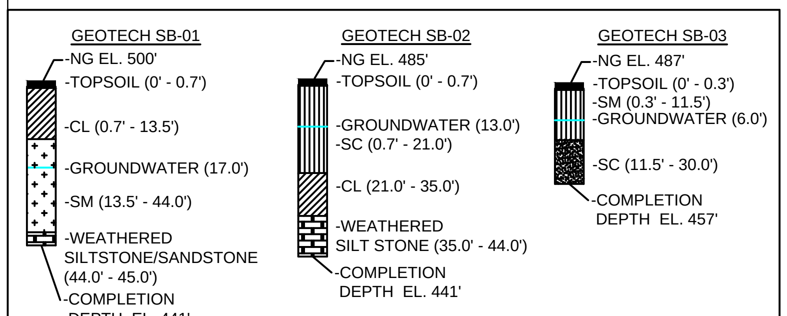
HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILE



LANCASTER COUNTY, PENNSYLVANIA - WEST COCALICO TOWNSHIP
S3-0161-16

PROFILE VIEW





NOTE: REFER TO TEST BORING LOG S3-0170 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXITING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
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3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):3420'
   HDD PIPE LENGTH (S=):3435'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
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12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
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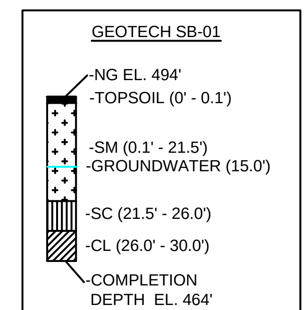

NOTE: REFER TO TEST BORING LOG S3-0160 FOR COMPLETE SOIL MATERIAL DESCRIPTION

NOTES

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

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
6	REVISED PROFILE WITH 2017 LIDAR	MRS	02/15/17	RMB	02/15/17	AAW	02/15/17
5	REVISED PER ENGINEERING COMMENTS	DLM	10/24/16	RMB	10/24/16	AAW	10/24/16
4	REVISED PER ENGINEERING COMMENTS	MRS	08/19/16	RMB	08/19/16	AAW	08/19/16
3	DESIGN CHANGE (HDD ENTRY / EXIT MOVED EAST)	MRS	08/15/16	RMB	08/15/16	AAW	08/15/16
2	DESIGN CHANGE	DLM	04/12/16	RMB	04/12/16	AAW	04/12/16
1	DESIGN CHANGE	MRS	02/24/16	RMB	02/24/16	AAW	02/24/16

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