

June 8, 2019

Via Electronic Mail

Mr. Scott R. Williamson
Program Manager, Waterways & Wetlands Program
Pennsylvania Department of Environmental Protection
Southcentral Regional Office
909 Elmerton Avenue
Harrisburg, PA 17110-8200

**Re: Responses to DEP Comments for Hydrogeological HDD Re-Evaluation Report
LeTort Spring Run 16" Horizontal Directional Drill Location (S2-0210-16)
Permit No. E21-449
Middlesex Township, Cumberland County**

Dear Mr. Williamson:

In compliance with the Corrected Stipulated Order dated August 10, 2017 a Re-Evaluation Report on the above-referenced horizontal directional drill (HDD) was submitted to the Pennsylvania Department of Environmental Protection (Department) on February 6, 2019. In a letter dated March 19, 2019, the Department requested further information. Please accept this letter as a response. Your requests are bolded below followed by the response. A revised Re-Evaluation Report is provided with this response.

- 1. As required by Paragraph 4 and 5 of the Environmental Hearing Board's August 10, 2017 Corrected Stipulated Order, SPLP failed to fully utilize information gathered during the HDD of the 20-inch bore as part of the HDD Re-evaluation for the 16-inch pipeline. Many small inadvertent returns occurred during the HDD activities for the 20-inch bore. Please gather geologic and drilling information collected by various site personnel during the 20-inch bore which can be used to synthesize a comprehensive history of each or groupings of events. The HDD re-evaluation report should discuss the operational or geologic cause of each inadvertent return, the magnitude of the inadvertent return(s) and associated loss of circulation, the best management practice used to contain and minimize the inadvertent return, and the drilling procedure or technique used to progress the boring.**

This information should then be used to describe why the chosen bore path for the 16-inch pipeline was determined and how such information has been used to minimize the potential for IR's to occur. Also, as part of the discussion of construction alternatives, include why HDD activity is still the preferred and chosen methodology for pipeline construction at this location.

SPLP utilized all information obtained during the drilling of the 20-inch HDD in our internal assessment and evaluation of the 16-inch HDD profile as revised; however, we understand that

our deductions from review of this information were not clearly conveyed in the Reevaluation Report. It should be noted that the Inadvertent Return (IR) information shown on Figure 1 in Attachment 2 presents the plan and cross section views of IR events that occurred during the 2017 pilot hole attempt and 2018 pilot hole drilling, reaming, and completion of this HDD. This figure presents the reality of events that occurred during this HDD in relation to the depth of profile and the allowed for correlation to monitoring data collected during active drilling.

SPLP reviewed the daily drilling reports, the geotechnical investigations, IR Restart Reports and the HDD Inspection Daily Reports, paying attention to intervals/days in which a partial or full loss of returns or an IR occurred. Specifically, the depth of the bit was compared to the geotechnical investigations to determine if the pilot tool and/or reamer was advancing through an interval of bedrock which was either highly fractured or weathered. Further, the annular and mud pressures were reviewed to identify any sudden changes in pressure, which could be utilized to approximate the competency of the bedrock.

A review of this information indicated that the losses in returns and IRs resulted from the 20-inch boring passing through intervals of weathered and/or fractured bedrock that also communicated with IRs associated with the original 2017 20-inch borehole. This communication resulted in IRs 1 through 6 identified on the redesigned 16-inch HDD profile (Figure 2) contained in Attachment 2 of the February 6, 2019 Re-Evaluation Report. The seventh IR identified on the redesigned the 16-inch HDD profile resulted from the 22-inch reamer passing through an interval of bedrock which was likely highly fractured and weathered as inferred from the regional strike and dip and the lithologic description in Boring B-1.

When an IR event occurred, drilling was stopped and an IR Restart report was prepared and submitted to the Department for review and approval. The specific details regarding the events, analysis of potential mitigation measures and the proposed corrective measures were provided to the Department in the Restart Report. HDD activity resumed once Department approval of the Restart Report and proposed corrective measures were received. To address these events, the drilling contractor complied with the Department's requests outlined in their approval and also installed loss control material (LCM) plugs at the intervals where the losses or IRs occurred and allowed the plugs to setup before advancing. Based on the occurrences of IRs, the use of the LCM plugs were only partially successful. When the LCM plugs were not successful in preventing the re-activations of the IRs, SPLP requested permission from the Department to convert the IR location into re-circulation points in which the existing IR pathway would be used to allow the drilling fluid to surface in a controlled manner within a containment structure. The containment structure also allowed the drilling contractor to collect and recycle the drilling fluid.

This information was utilized, along with the hydrogeologic evaluation, to evaluate the permitted 16-inch HDD for the likelihood of IRs during installation. Based on this review, it was determined that the permitted profile was susceptible to IRs. To reduce the potential of IRs during completion of the 16-inch HDD, the profile was redesigned and the entry and exit angles of the 16-inch HDD profile have been increased to allow the boring to advance through competent bedrock quicker and

closer to the entry/exit points. Further, the overall depth of the profile has been increased from a maximum depth of 133 feet below ground surface on the permitted 16-inch profile to 144 feet bgs on the redesigned 16-inch profile. This will allow for more of the boring to be advanced through bedrock containing higher rock quality designation (RQD) values. The RQD values for the 20-inch profile were generally considered good; however, to further reduced the potential of IRs during the installation of the 16-inch HDD, the profile was designed to intersect more competent bedrock and avoid intervals of bedrock which contained multiple fractures as identified in the 2017 geotechnical investigation.

As mentioned in the Alternative Analysis of the revised Re-Evaluation Report, despite the HDD methodology being classified as a “High Risk” activity, it was confirmed to be the preferred installation method because it will cause the least amount of potential/direct impact to the environment. Conventional auger boring would not be appropriate because of spacing constraints which prohibits the multiple conventional bores that would be necessary to advance under all the wetlands and stream. Direct pipe installation was also considered but based on the variability of the subsurface it could likely result in drift of the alignment and a failed bore attempt. Re-routing the pipeline is not a viable option, LeTort Spring Run would still need to be crossed and the bedrock that would be encountered would not be changed. A re-routing to the north would result in the pipeline passing through a high density commercial and residential area prior to connecting with an existing utility corridor, while a re-routing to the south would result in the creation of a new “greenfield” corridor through existing woodlands. Based on these factors, the HDD technique remains the best option for this location.

2. Once the items discussed above are developed, please discuss any operational provisions or changes proposed for the intervals where the previous inadvertent returns occurred. Also, discuss any drilling intervals along the proposed 16-inch drill path where increased vigilance may be warranted, i.e.: the P.G. working in concert with the HDD contractor as sensitive geologic zones are approached by the drill bit.

Prior to initiating the 16-inch pilot hole, the drilling contractor, environmental inspector and professional geologist will review the revised 16-inch profile and the 20-inch as built profile to pinpoint areas of potential concern. Further, SPLP will provide the drilling contractor with locations of potential concern along the 16-inch HDD profile, as identified during the review of the 20-inch HDD, the geotechnical investigation and the geophysical survey. As those areas are approached, additional efforts will be made such as increased monitoring of annular and/or mud pressure changes and increasing the frequency of drill path surveys to identify any surfacing of air, groundwater or drilling fluid in the event of a LOR. Further, the drilling contractor will evaluate the need to modify the characteristics of the drilling fluid (i.e., viscosity) and increase the frequency of swabbing the borehole to reduce the potential for cuttings to accumulate within the bore hole.

As detailed in the response to Item 1 above, in the event of a LOC or IR, the drilling contractor will install an LCM plug and allow it to cure for an appropriate length of time. Should the LCM plug be determined to be ineffective at sealing off the IR, the drilling contractor will trip the bottom hole assembly (i.e., mud motor, monel and bit/reamer) out of the borehole, install a packer assembly and trip the packer into the interval in which the LOC/IR occurred and pressure grout (cement-grout) the formation. The cement grout will be allowed to cure 24 hours prior to advancing the pilot bit/reamer through the plug and continue to advance the borehole.

3. In the re-evaluation report, please further discuss the site's standard operating procedures that are implemented upon the loss of circulation with special emphasis on how these provisions will minimize the occurrence and magnitude of an inadvertent return.

LOC are normal occurrences while advancing an HDD. A portion of the drilling fluid remains in the formation as it is absorbed into the walls of the HDD annulus as well as filling microfractures within the annulus and the formation. As noted in the HDD Inadvertent Return Assessment, Preparedness Prevention and Contingency Plan (Revised April 2018), notifications are made (based on occurrence) to the Department, public water suppliers within 450' and every landowner with a private water supply located within 450 feet of the HDD alignment that a LOC occurred and that their water supply may be impacted. If a significant LOC (i.e., greater than 30%) occurs, the drilling subcontractor will attempt to condition the borehole by modifying the drilling fluids and by swabbing the borehole. This will add in the removal of any cuttings which may have accumulated in the borehole resulting in an increase in annular pressure and an increase in potentially affecting the subsurface environment. Further, the drilling subcontractor will modify the advancement rates (i.e., penetration rate and travel speed) to prevent a plunger effect from occurring and will reduce the drilling fluid pumping pressures to the minimum pressure necessary to maintain the borehole and to transport cuttings back to the surface. Finally, the drilling contractor will amend the drilling fluid, as necessary, by adding approved LCMs to seal off any fractures, voids or zones of lost circulation.

In the event the LOC continues, the drilling subcontractor will trip out of the boring and initiate a push ream from the entry side to increase the size of the annulus and to regain circulation. By initiating a push ream, the size of the annular space will be increased which will result in an increase in borehole size and a corresponding decrease in annular pressure.

Should the losses continue to be recorded at above-normal levels subsequent to completing the push ream, the drilling subcontractor will trip in a packer assembly to the area of the LOC and install a grout (neat cement or cement and sand mixture) or LCM plug under pressure in an attempt to "squeeze" the grout/LCM into the formation and seal off the boring annulus. This will seal/fill any fractures or karst features immediately in communication with the borehole. The LCM and grout plug will be provided an adequate length of time to setup (minimum of 24 hours) prior to tripping the pilot tool or reamer into the borehole and resume drilling activities.

4. Provide further explanation of how the following statement applies to this HDD re-evaluation: “Pipe stress allowances are an integral part of the design calculations performed for each HDD.”

For steel pipe the “pipe stress allowance” is the amount of curvature that a piece or length of pipeline can bend without resulting in damages such as a “kink” or “crimp” in the wall of the pipe. The innate curvature ability of pipe is termed the “free stress radius”. The stress allowance of the pipe is determined by the ductility of the steel, wall thickness, and the diameter of the pipe. An HDD design is limited by the horizontal distance between the points of entry and exit and the free stress radius of the pipe.

Ductility of the steel used for pipelines is determined by the percentage of carbon within the steel. Generally steel pipe is categorized as either “low carbon” having less than 0.3% carbon content within the steel, or “high carbon” having greater than 3% carbon within the steel. As the carbon content within the steel used to make the pipe increases, the flexibility (ductility) of the pipe is decreased. The X70 16-inch pipe utilized on the Mariner project is a low carbon (high ductile) steel pipe.

The design of an HDD profile accounts for the free stress radius of the pipeline segment to be pulled into the drilled entry, through the entry radius of curvature at maximum horizontal depth, out the exit radius leaving maximum depth, and out the drilled exit; therefore, each HDD has a minimum of four (4) points of pipeline curvature to assess for pipeline stress. Additionally, a horizontally drilled profile is not a “perfect” pathway, especially when drilled through rock formations. The pilot tool cutting into the rock face has a larger cutting face than the drill stem pushing the tool forward, which results in flexibility of the tooling within the pilot hole, and as a result the pilot tool will drift in orientation as proceeding forward because the cutting tool will proceed easier into softer material while cutting due to natural variances in hardness of the materials being cut, whether they are soils or rock. Steering of the pilot tool is used to correct drifting as it occurs. As a result of this natural drifting during completion of the pilot hole, the entire length of the drilled pilot hole is assessed for stress allowances at three (3) joint intervals before reaming of the annulus is permitted. If errors during pilot drilling or reaming occur and a mid-point is identified that would breach the pipe stress allowance, then the use of an over-reamed annulus is assessed for breach of the stress allowance. In cases where an over-reamed annulus will not correct the stress problem, the HDD must be re-drilled.

All the information and the stress assessment procedures discussed above are incorporated into the profile design and implemented in analysis of the drilling profile to ensure the integrity of the pipeline as installed.

5. Please correct the inconsistency between the Entry/Exit Angles in the narrative and final profile drawings.

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The inconsistency between the entry/exit angles in the narrative of the report has been revised accordingly.

SPLP submits that we have been, and are, in complete compliance with the agreed terms and analysis requirements of the Order, as agreed to by the Department, and that no further analysis is required for the Department to consent to the start of this HDD. SPLP therefore requests that the Department approve the Reevaluation Report for LeTort Spring Run Crossing Horizontal Directional Drill (S2-0210) as soon as possible.

Sincerely,



Larry J. Gremminger, CWB
Vice-President – Environmental, Health & Safety
Energy Transfer Partners
Mariner East 2 Pipeline Project

**HORIZONTAL DIRECTIONAL DRILL ANALYSIS
LETORT SPRING RUN CROSSING
PADEP SECTION 105 PERMIT NO. E21-449
PA-CU-0136.0002-WX-16
(SPLP HDD S2-0210-16)**

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This reanalysis of the horizontal directional drill (HDD) installation of a 16-inch diameter pipeline that traverses under LeTort Spring Run in Middlesex Township, Cumberland County, Pennsylvania, is in accordance with the Stipulated Order issued under Environmental Hearing Board Docket No. 2017-009-L for HDDs listed on Exhibit 3 of the Stipulated Order. This HDD is number 8 on the list of HDDs included on Exhibit 3 of the Order.

PIPE INFORMATION

16-Inch: 0.438 wall thickness; X-70

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

For steel pipe the “pipe stress allowance” is the amount of curvature that a piece or length of pipeline can bend without resulting in damages such as a “kink” or “crimp” in the wall of the pipe. The innate curvature ability of pipe is termed the “free stress radius”. The stress allowances of the pipe is determined by the ductility of the steel, wall thickness, and the diameter of the pipe. An HDD design is limited by the horizontal distance between the points of entry and exit and the free stress radius of the pipe.

Ductility of the steel used for pipelines is determined by the percentage of carbon within the steel. Generally steel pipe is categorized as “low carbon” having less than 0.3% carbon content within the steel, and “high carbon” having greater than 3% carbon within the steel. As the carbon content within the steel used to make the pipe increases, the flexibility of the pipe is decreased. The X70 16-inch pipe utilized on the Mariner project is a low carbon steel pipe.

The design of an HDD profile accounts for the free stress radius of the pipeline segment to be pulled into the drilled entry, through the entry radius of curvature at maximum horizontal depth, out the exit radius leaving maximum depth, and out the drilled exit; therefore each HDD has a minimum of four (4) points of pipeline curvature to assess for pipeline stress. Additionally, a horizontally drilled profile is not a “perfect” pathway, especially when drilled through rock formations. The pilot tool cutting into the rock face has a larger cutting face than the drill stem pushing the tool forward, which results in flexibility of the tooling within the pilot hole, and as a result the pilot tool will drift in orientation as proceeding forward because the cutting tool will proceed easier into softer material while cutting due to natural variances in hardness of the materials being cut, whether they are soils or rock. Steering of the pilot tool is used to correct drifting as it occurs. As a result of this natural drifting during completion of the pilot hole, the entire length of the drilled pilot hole is assessed for stress allowances on three (3) joint intervals before reaming of the annulus is permitted. If errors during pilot drilling or reaming occur and a mid-point is identified that would breach the pipe stress allowance, then the use of an over-reamed annulus is assessed for breach of the stress allowance. In cases where an over-reamed annulus will not correct the stress problem, then the HDD has to be re-drilled.

All of the information and the stress assessment procedures discussed above are incorporated into the profile design and implemented in analysis of the drilling profile to ensure the integrity of the pipeline as installed.

Specifics for the original permitted 16-inch HDD plan and profile are discussed in the original permitted HDD design summary below. Specifics for the revised 16-Inch HDD plan and profile are discussed in the Redesigned Horizontal Directional Drill Design Summary at the end of this report.

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ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 1,633 feet (ft)
- Entry/Exit angle: 11 - 14 degrees
- Maximum Depth of cover: 72 ft
- Pipe design radius: 1,600 ft

This HDD profile design has relaxed entry and exit angles which allows for easy transition and tying into the conventionally laid pipeline. The radius of curvature to the horizontal run is below the allowable stress radius for the 16-inch pipeline, but is close enough to the tolerance level that any error in drilling could result in rejection of the drilled hole.

ROOT CAUSE ANALYSIS FOR THE 20-INCH PIPE INSTALLATION IR EVENTS

Based upon an analysis by the project geologists and drilling specialists, the occurrence of the five (5) IR events during the installation of the 20-inch pipe in May of 2017 at the LeTort Spring Run is likely to have been caused by the drilling contractor not maintaining a clean annulus, either by maintaining circulation to the entry pit, or tripping out the drilling tools to clean the pilot hole when circulation was lost. In summary, SPLP confirmed that a "closed and compacted annulus" was the root cause of the IRs to the land surface during the initial pilot hole attempt.

Restart approval was provided the Pennsylvania Department of Environmental Protection (PADEP) in April of 2018. During the second, and finally successful HDD of the 20-inch pipeline installation, nine (9) IRs or activation of prior IR locations occurred during the completion of the HDD.

The opinion of the drilling specialists is the occurrence of these IRs is likely due to the hydraulic fracturing of the bedrock above and below the original HDD profile resulting from the pilot hole attempt in 2017. Evidence to support this conclusion is the re-activation of prior IR locations, which despite the redesigned and deepened 20-inch profile, did not result in the drilling of a clean pilot hole in undisturbed geology.

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

HDD S2-0210 is located within the Great Valley Section, also known as the Cumberland Valley Section of the Ridge and Valley Physiographic Province (Pennsylvania Department of Conservation and Natural Resources [PA DCNR], 2000) underlain by very finely crystalline limestone with minor occurrences of dolomite and chert. Local topography is characterized by rolling valleys of low relief and natural slopes that are gentle and relatively stable. Geologic structures are characterized as thrust sheets, nappes, overturned folds and steeply inclined faults. Areas underlain by these rock units typically have good subsurface drainage and poor surface drainage where bedrock dissolution results in the development of bedrock pinnacles and solution cavities (e.g., sinkholes, voids, caves). Based on the United States Geological Survey (USGS) 7.5-Minute Carlisle Topographic Quadrangle (refer to Figure 1), the site is situated at an approximate elevation of 425 feet above mean sea level (AMSL). Surface topography at the site slopes west and east along the HDD to LeTort Spring Run. The major surface water feature is LeTort Spring Run which flows northeast and then northwest to Conodoguinet Creek.

The proposed HDD bore path passes beneath LeTort Spring Run. The area surrounding the eastern HDD entry/exit point consists predominantly of an open agricultural land interspersed with suburban residential properties and bordered by the Pennsylvania Turnpike, South Middlesex Road, and Interstate 81. The area surrounding the western HDD entry/exit point consists of a wooded area surrounded by interspersed

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commercial properties and open agricultural lands at the intersection of the Pennsylvania Turnpike and the Harrisburg Pike.

A non-invasive geophysical survey was performed at HDD S2-0210 from October 16 through October 23, 2017. The purpose of the geophysical survey was to determine the depth to bedrock, overburden thickness, and identify areas of solid and fractured rock. Seismic refraction, multichannel analysis of surface waves (MASW), and electrical resistivity methods were used during the survey. A summary is provided below.

Results of the seismic refraction survey generally indicated a stratigraphy comprised of unconsolidated material and competent bedrock. The seismic data suggests a generally consistent inferred bedrock surface of approximately 20 feet bgs. The contoured seismic data represents an average seismic velocity profile indicating a gradational interface between the unconsolidated material and competent bedrock. Given these findings and interpretation of the collected field data, bedrock pinnacles common in the St. Paul Group may extend above or below the inferred contour between the unconsolidated material and bedrock.

The results of the MASW survey indicated a two-layer stratigraphy similar to the seismic results. However, the shallow depth to bedrock and bedrock pinnacles limited the dispersion of the signal source. This resulted in a low signal to noise ratio, and did not provide effective imaging resolution within the apparent bedrock and fractured bedrock zones.

The electrical imaging data indicated a depth to bedrock of 15 to 30 feet bgs. High-resistivity zones represent competent bedrock and low-resistivity zones represent weathered or fractured bedrock. Three low-resistivity zones were identified during the survey and may represent more permeable bedrock fracture zones that could provide potential pathways for fluid transport.

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

HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

Bedrock geology ultimately influences the storage, transmission, and use of groundwater. Geologic factors such as rock type, intergranular porosity, rock strata inclination, faults, joints, bedding planes, and solution channels affect groundwater movement and availability. In general, groundwater generally occurs under unconfined conditions within the upper portion of the bedrock and under confined or semi-confined conditions in the deeper portions of the bedrock.

Groundwater at the site occurs in a fractured, solution-prone, carbonate bedrock aquifer system within the St. Paul Group. In carbonate rocks, water-bearing zones generally occur in solution-enhanced secondary openings that form along bedding planes, joints, faults and fractures. Most of the water-bearing zones penetrated by supply wells occur in individual fractures or groups of interconnected fractures that are sufficiently enlarged by dissolution for readily transporting groundwater.

The St. Paul Group is the uppermost rock unit near HDD S2-0210. Based upon Tetra Tech's geotechnical exploration activities completed in January of 2015, at Boring SB-01, located approximately 725 feet northeast of the HDD entry, groundwater was not encountered and auger refusal occurred at 15 feet below ground surface (bgs). At Boring SB-02, located approximately 30 feet southwest of the HDD exit, groundwater was encountered in at a depth of 11 feet bgs, and the completion depth was 28.2 feet bgs.

A more recent geotechnical report of exploration activities performed in June of 2017 included two (2) additional borings. Boring B-1, located approximately 100 feet southwest of the HDD exit, was completed to a total depth of 150.5 feet bgs with groundwater encountered at 9.0 feet bgs. Boring B-2, located approximately 100 feet

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northeast of the HDD entry, was completed to a total depth of 150.0 feet bgs with groundwater encountered at 16.3 feet bgs.

The average depth of water wells in the St. Paul Group is reported to be 384 feet with an average depth to water of 32 feet. Rocks of the St. Paul Group have a reported median sustained yield of 25 to 82 gallons/minute (gal/min) based on fracturing and solution openings. Sustained yields of large production wells are reportedly between 105 and 260 gal/min.

There are no known public or private water supply wells within 450 feet of the HDD profile. Attachment 1 provides an extensive discussion on the hydrogeology which informs this analysis.

ADJACENT FEATURES ANALYSIS

This HDD location is 0.5 miles southwest of Middlesex Township in Cumberland County, Pennsylvania. The pipeline alignment crosses under LeTort Spring Run for 0.24 miles east of the intersection of the Pennsylvania Turnpike and Harrisburg Pike to a location 0.18 miles west-northwest of the intersection of Interstate Highway 81 and the Pennsylvania Turnpike.

This HDD location is set under LeTort Spring Run (stream S-I48). The HDD also traverses beneath forested lands, agricultural lands, two ephemeral streams (S-I49 and S-I50), emergent wetland W-I31, and forested wetland W-I32. Streams S-I48, S-I49 and S-I50 both have a Chapter 93 Existing Use designation as High Quality-Cold Water Fisheries. Wetlands I31 and I32 are Exceptional Value wetlands.

There are no recorded public or private water supply wells within 450 feet of the HDD profile; however, subsequent to the 2018 Administrative Order, SPLP identified all landowners with property located within 450 feet of the HDD alignment and provided these landowners with a notice letter via both certified and first-class mail that included an offer to sample the landowner's private water supply/well in accordance with the terms of the Order and the Water Supply Assessment, Preparedness, Prevention and Contingency Plan. The letter also requested that each landowner contact the Right-of-Way agent for the local area and provide SPLP with information regarding: (1) whether the landowner has a well; (2) where that well is located, and its depth and size if known; and (3) whether the landowner would like to have the well sampled. In accordance with paragraph 10 of the Order, copies of the certified mail receipts for the letters sent to landowners have been provided to Karyn Yordy, Executive Assistant, Office of Programs at the Department's Central Office.

As a result of these communications with the landowners within 450 ft of the HDD profile, SPLP has verified that no private water supply wells exist within the specific HDD buffer area. To further avoid and mitigate any adverse effects from the HDD, and in accordance with the requirements of the Stipulated Order, SPLP will transmit a copy of this HDD analysis to all landowners having a property line within 450 feet of any direction of this HDD location.

ALTERNATIVES ANALYSIS

As stated in the Order, the second (16-inch-diameter) HDD pipeline installation at LeTort Spring Run is characterized as a "High Risk" HDD activity, and therefore PADEP requested an enhanced alternatives analysis for this HDD. As required by the Order, the reevaluation of HDD S2-0210 includes an analysis of alternatives, including open cut, conventional auger bore (CAB), FlexBor, Direct Pipe Bore, and potential re-routes. As part of the PADEP Chapter 105 permit process for the Pennsylvania Pipeline Project, SPLP developed and submitted for review a project-wide Alternatives Analysis. During the development and siting of the Project, SPLP considered several different routings, locations, and designs to determine whether there was a practicable alternative to the proposed impact. SPLP performed this determination through a sequential review of routes and design techniques, which concluded with an alternative that has the least environmental

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impacts, taking into consideration cost, existing technology, and logistics. The baseline route provided for the pipeline construction was to cross every wetland and stream on the project by open cut construction procedures. The Alternatives Analysis submitted to PADEP conceptually analyzed the potential feasibility of any alternative to baseline route trenched resource crossings (e.g., reroute, conventional bore, HDD). The decision-making processes for selection of the HDD instead of an open cut crossing methodology is discussed thoroughly in the submitted alternatives analysis and was an important part of the overall PADEP approval of HDD plans as currently permitted. As described below, the analyses of potential open cut, CAB, FlexBor, Direct Pipe Bore, and re-route alternatives have confirmed the conclusions reached in the previously submitted Alternatives Analysis.

HDD Alternative

Use of the originally-proposed HDD construction method across the entire current 2,028-foot-long crossing alignment (encompassing all workspace limits of disturbance) is a technically feasible and practicable alternative taking into consideration cost, existing technology, and logistics. The originally-proposed HDD construction method also minimizes total land impacts (2.24 acres) due to the limited areal extent of required workspace (see Figure 1 in Attachment 2), and moreover avoids direct impacts to the bed and banks, floodway, and floodplain of LeTort Spring Run (stream S-148) which is a PADEP Chapter 93 designated High Quality-Cold Water Fishery (HQ-CWF); the floodways of HQ-CWF streams S-149 and S-150; pond P-12; exceptional value (EV) wetland W-I31 (palustrine emergent wetland); EV wetland W-I32 (palustrine forested wetland); and EV wetland W-I33 (palustrine emergent wetland) (Tables 1a, 1b). This includes avoidance of PFO cover type conversion of EV wetland W-I32 and associated potential requirements for compensatory mitigation.

Table 1a. Horizontal Directional Drill (HDD) Alternative Impacts on Wetlands.

Wetland	Crossing Method	Cowardin Classification ¹	Exceptional Value (EV) Designation	Wetland Temp Impact (acres) ³	Wetland Perm Impact (acres) ³	PFO Cover Type Conversion ^{1,2} (acres)
W-I31	HDD	PEM	Yes	0 (0)	0 (0.004)	n/a
W-I32	HDD	PFO	Yes	0 (0)	0 (0.002)	0
W-I33	HDD	PEM	Yes	n/a	n/a	n/a

¹ PEM = palustrine emergent, PSS = palustrine scrub-scrub, PFO = palustrine forested, n/a = not applicable.

² Permanent conversion of PFO cover type to PEM cover type due to maintenance of permanent ROW.

³ Use of the HDD construction method avoids direct wetland impacts, therefore impacts are denoted as zero ("0"). Parentheses denote PADEP impact calculations for the area of pipeline installed beneath the wetlands.

Table 1b. Horizontal Directional Drill (HDD) Alternative Impacts on Waterbodies.

Stream	Crossing Method	Stream Dist. Length in Perm ROW (feet)	Stream Dist. Length in Temp ROW (feet)	Stream Perm Impact (sq. feet) ¹	Stream Temp Impact (sq. feet) ¹	PADEP Perm Floodway Impact (acres) ¹	PADEP Temp Floodway Impact (acres) ¹	Ch. 106 Perm Floodplain Impact (acres) ¹	Ch. 106 Temp Floodplain Impact (acres) ¹
S-148	HDD	0 (50)	0 (0)	0 (67)	0 (0)	0 (0)	0 (0)	0 (0.046)	0 (0.031)
S-149	HDD	n/a	n/a	n/a	n/a	0 (0.031)	0 (0.015)	n/a	n/a
S-150	HDD	n/a	n/a	n/a	n/a	0 (0.181)	0 (0.042)	n/a	n/a
P-12	HDD	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

¹ Use of the HDD construction method avoids direct stream impacts, therefore impacts are denoted as zero ("0"). Parentheses denote PADEP impact calculations for the area of pipeline installed beneath the streams and clearing workspaces that impacts the streams' floodways.

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Use of the originally-proposed HDD construction method is in compliance with the Pennsylvania Scenic Rivers Act and avoids significant impacts to other (non-wetland) environmental resources associated with LeTort Spring Run. Based on correspondence with the Pennsylvania Department of Conservation and Natural Resources (PDCNR) dated August 13, 2015, the proposed pipeline crossings of the LeTort Spring Run Pennsylvania Scenic Rivers Corridor System require compliance with Section 2 of the "Pennsylvania Scenic Rivers Act" of 1972, P.L. 1277, No 283 as amended May 7, 1982, P.L., No. 110. Specifically, the PDCNR included specific conditions regarding the pipeline crossings, including but not limited to:

- "Pipelines will be installed beneath...LeTort Spring Run...using horizontal directional drilling techniques."
- "No tree clearing will occur on the banks of the creek(s)."
- "No in-creek excavation or physical disturbance of the creek bed or banks."
- "All construction work areas will be set back from the creek as far as possible, and those work spaces that require tree/shrub clearing will be set back from the creek bank at least 250 feet."

Accordingly, the originally-proposed HDD construction method complies with the requirement to use horizontal directional drilling methods to install the 16-inch-diameter pipeline beneath the LeTort Spring Run Pennsylvania Scenic Rivers Corridor System, as well as avoids potential significant direct and indirect impacts to the stream and, as characterized by PDCNR, "related adjacent land areas, and associated outstanding aesthetic and recreational values of present and potential benefit to the citizens of Pennsylvania."

Additionally, as required by the Order, follow-up restoration monitoring of the previous IR events in LeTort Spring Run (stream S-148) and wetland W-132 is being conducted. Based on monitoring performed in May 2019, restoration of aquatic resources impacted by IRs is trending rapidly toward success (see enclosed photographs of restored LeTort Spring Run and wetland W-132 in Attachment 2). In the event an IR should occur in the aquatic resources above this HDD, restoration activities will occur immediately such that temporary impacts will be minimized to the greatest extent practicable.

Based on the results of this reevaluation, use of the originally-proposed HDD construction method to cross LeTort Spring Run: 1) is a technically feasible alternative; 2) is a practicable alternative taking into consideration cost, existing technology, and logistics; 3) is in compliance with required regulations and avoids potential significant impacts to other (non-wetland) environmental resources; and 4) results in the least environmental impact compared to the other technically-feasible and practicable alternatives analyzed. Therefore, the originally-proposed HDD construction method is the preferred and selected alternative for this crossing location.

Open Cut Alternative

Use of the open cut construction method across the entire current 2,028-foot-long crossing alignment, although technically feasible, is not a practicable alternative due to the requirement to use horizontal directional drill construction methods to install the 16-inch-diameter pipeline beneath the LeTort Spring Run Pennsylvania Scenic Rivers Corridor System in compliance with Section 2 of the Pennsylvania Scenic Rivers Act. Any open cut alternative crossing of LeTort Spring Run would be in non-compliance with the PDCNR's crossing-specific special conditions under the Pennsylvania Scenic Rivers Act, and result in potential significant direct and indirect impacts to the stream and, as characterized by PDCNR, "related adjacent land areas, and associated outstanding aesthetic and recreational values of present and potential benefit to the citizens of Pennsylvania." Therefore, any open cut alternative would require the use of horizontal directional drill (or potentially other trenchless) construction methods to cross the LeTort Spring Run Pennsylvania Scenic Rivers Corridor System at a minimum (see combination open cut/bore alternatives analyses below).

If a theoretical open cut construction method were practicable (see Figure 2 in Attachment 2), then use of this method would result in direct but temporary impacts to the bed and banks, floodway, and floodplain of LeTort

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Spring Run (stream S-I48) which is PADEP Chapter 93 designated HQ-CWF; direct but temporary impacts to the floodways of HQ-CWF streams S-I49 and S-I50; pond P-I2; EV wetland W-I31 (palustrine emergent wetland); EV wetland W-I32 (palustrine forested wetland), and EV wetland W-I33 (palustrine emergent wetland). SPLP specifications require a minimum of 48 inches of cover between the installed pipeline and the bottom of the watercourse. To meet this cover requirement, during trenched construction through LeTort Spring Run, an open cut workspace with a width up to 75 feet would be required to accommodate the pipelines and provide sufficient space for trench excavation, spoil storage, pipeline installation, and sufficient separation between pipelines (for integrity management). The assessed area of impact by this open cut plan would directly affect approximately 3.50 acres of land (primarily forested land, with some active agricultural land and paved parking area), 72 feet at the LeTort Spring Run crossing (stream S-I48), with 65 feet of forested wetland (wetland W-I32) adjacent to the west bank, and 139 feet of emergent wetland (wetland W-I31) adjacent to the east bank, as well as 24 feet of emergent wetland (wetland W-I33) at the western end of the crossing alignment. The assessed area of impact by this open cut plan would directly affect 0.13 acre of state water bottom, 0.18 acre of emergent wetland, and 0.18 acre forested wetland.

Table 2a. Open Cut Alternative Impacts on Wetlands.

Wetland	Crossing Method	Cowardin Classification ¹	Exceptional Value (EV) Designation	Wetland Temp Impact (acres)	Wetland Perm Impact (acres)	PFO Cover Type Conversion ^{1,2} (acres)
W-I31	Open Cut	PEM	Yes	0.038	0.141	n/a
W-I32	Open Cut	PFO	Yes	0.031	0.147	0.147
W-I33	Open Cut	PEM	Yes	0.003	0	n/a

¹ PEM = palustrine emergent, PSS = palustrine scrub-scrub, PFO = palustrine forested, n/a = not applicable.

² Permanent conversion of PFO cover type to PEM cover type due to maintenance of permanent ROW.

Table 2b. Open Cut Alternative Impacts on Waterbodies.

Stream	Crossing Method	Stream Dist. Length in Perm ROW (feet)	Stream Dist. Length in Temp ROW (feet)	Stream Perm Impact (sq. feet)	Stream Temp Impact (sq. feet)	PADEP Perm Floodway Impact (acres) ¹	PADEP Temp Floodway Impact (acres) ¹	Ch. 106 Perm Floodplain Impact (acres)	Ch. 106 Temp Floodplain Impact (acres)
S-148	Open Cut	72	38	3,600	1,900	0.218	0.133	0.212	0.096
S-149	Open Cut	n/a	n/a	n/a	n/a	0.040	0	n/a	n/a
S-150	Open Cut	57	40	114	80	0.181	0.106	n/a	n/a
P-I2	Open Cut	n/a	150	n/a	1,393	n/a	n/a	n/a	n/a

As mentioned above, use of the open cut crossing method through this area would result in impacts to EV wetlands W-I31, W-I32, and W-I33, including approximately 0.18 acre and 0.18 acre of impacts to emergent and forested wetland vegetative cover types, respectively. The HDD will largely avoid surface impacts to biological features, and as currently proposed results in no surface impacts to wetlands (impact avoidance) compared to the open cut alternative.

Open cut impacts to these resources would require modification of the state and federal permits. PADEP likely would require use of an approved dry open cut crossing method – such as the dam-and-pump construction method – as a best management practice to prevent downstream turbidity during construction activities across LeTort Spring Run and stream S-I50. PADEP also likely would require that fisheries biologists monitor the bypass section of the crossing area to ensure it is free of fish prior to and for the duration of open cut construction activities; and that captured fish species are handled through Pennsylvania Fish and Boat Commission (PAFBC) approved capture, handling, and reporting procedures and conditions. Based on the

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PAFBC classifications for LeTort Spring Run (Class A, wild trout-natural reproduction [TNR]) and stream S-150 (Drains to Class A, TNR), both streams require a construction moratorium between October 1 – April 1; a PAFBC waiver would be required if construction activities would occur during this construction moratorium period. In addition, a portage would be required to provide waterway navigation users access around the crossing area, which in turn would require an activity-specific aids to navigation (ATON) permit from PAFBC.

The open cut crossings of LeTort Spring Run and stream S-150 would require damming the stream using an upstream and downstream geotube, while simultaneously pumping around all stream flows, and pumping out of all produced groundwater discharge from the excavated shallow soil horizons and water seepage below the geotube dams installed in the channel for the entire duration of the open cut crossing event. Moreover, any produced groundwater in the open excavations would be pumped to a discharge filtration structure. The current feasible filtration ability, however, does not exceed 50 microns. Therefore, cloudy water (from suspended fine clay and silt particles) would be discharged downstream regardless of all control methods employed for the entire duration of the use of open cut construction techniques.

Although the above surface disturbances to the subject wetland and stream resources would be controlled and managed using the measures in SPLP's Impact Avoidance, Minimization, and Mitigation Plan and E&S Plan to a level that is temporary and minor, the open cut construction method is not permissible (under the Pennsylvania Scenic Rivers Act) therefore is not practicable, such that the required and preferred method would be to use a horizontal directional drill (or potentially an alternative trenchless) construction method to avoid these surface disturbances.

Based on the results of this reevaluation, use of the open cut construction method to cross LeTort Spring Run: 1) is a technically feasible alternative; 2) is not a practicable alternative taking into consideration cost, existing technology, and logistics (is not permissible); 3) would not comply with required regulations and would result in potential significant impacts to other (non-wetland) environmental resources; and 4) results in greater environmental impacts compared to the originally-proposed HDD construction method. Therefore, the open cut construction method is not the preferred or selected alternative for this crossing location.

Conventional Auger Bore (CAB) Alternative

Use of the conventional auger bore (CAB) construction method across the entire current 2,028-foot-long crossing alignment is neither technically feasible nor practicable due to the length limitations of this construction technology, as discussed below.

As discussed in the original Alternatives Analysis (Section 4.1.2 – Practicability Constraints in the Trenchless Construction Feasibility Analysis [TCFA]), auger boring was initially developed to cross under two-lane roadways with an average length of 40 feet and a maximum length of 70 feet. However, with demand for longer installations increasing, the current maximum extent for a CAB installation of a 16-inch-diameter pipeline is approximately 390 feet (note that 390 feet was used as an initial screening criterion in the TCFA). Accordingly, this crossing methodology should only be considered for avoidance of obstacles of somewhat less than 390 feet in length, and therefore would be considered not technically feasible for the current 2,028-foot-long crossing alignment. Based on experience gained during construction of the Mariner II Pipeline project, conventional auger bores should be limited to approximately 200 linear feet at a time, or less, varying by the underlying substrate. Conventional auger bores for the 16- and 20-inch pipelines, attempted at longer distances, have at times had alignment drift and elevation deflections which have complicated installation. Drift and deflection are safety concerns when boring adjacent to in-service pipelines and other utilities.

Finally, given use of the CAB construction method is technically limited to less than 200 linear feet at a time (and varying by the underlying substrate), due to the resource and other obstacle spacing constraints at the location of this HDD, there are no subset locations across the current 2,028-foot-long crossing alignment to feasibly employ this type of installation method.

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Based on the results of this reevaluation, use of the CAB construction method to cross LeTort Spring Run: 1) is not a technically feasible alternative; and 2) is not a practicable alternative taking into consideration cost, existing technology, and logistics. Therefore, the CAB construction method is not the preferred or selected alternative for this crossing location.

Combination Open-Cut/CAB Alternative

Given neither an open cut nor a CAB construction method alone is technically feasible nor practicable (see above), SPLP developed a theoretical combination open cut/CAB crossing alternative across the entire crossing alignment. This combination open cut/CAB crossing alternative was developed with consideration and incorporation of:

- best engineering design practices;
- requirements to use the horizontal directional drill (or at least an alternative trenchless) construction method to install the 16-inch-diameter pipeline beneath LeTort Spring Run;
- known areal extent and classification of existing PADEP-regulated wetlands, waterbodies, and floodplains/floodways, and objective to avoid or minimize surface disturbance to these resources;
- known areal extent and protection requirements of existing agency-regulated significant land use, cultural, and human environment resources, and objective to avoid or minimize surface disturbance to these resources;
- known existing topographic, geologic, and hydrogeologic conditions and constraints at and below the ground surface along and adjacent to the current 2,028-foot-long crossing alignment based on the *HDD Hydrogeologic Reevaluation Report*; and
- given these conditions and constraints, the objective to use the minimum linear extent of the CAB construction method (potentially) practicable.

Therefore, this theoretical alternative represents the most (potentially) practicable combination open cut/CAB crossing alternative available based on existing technology, logistics, and cost. A plan view drawing depicting this combination alternative is provided as Figure 2 in Attachment 2.

Description of Alternative

This theoretical combination alternative along the current 2,028-foot-long alignment crosses multiple surface and subsurface features, including from east to west: the floodway of stream S-I49, a fenceline, EV wetland W-I31 (palustrine emergent wetland), a sanitary sewer line, an overhead electric distribution line, LeTort Spring Run (stream S-I48) and associated floodway/floodplain, EV wetland W-I32 (palustrine forested wetland), an overhead electric distribution line, a public water line, EV wetland W-I33, an overhead electric distribution line, stream S-I50 and associated floodway, and a paved parking area. As depicted on the plan view drawing in Figure 2 in Attachment 2, this alternative would necessarily include one (1) CAB crossing of LeTort Spring Run and adjacent wetlands, whereas the remaining portions of the current pipeline alignment would be installed using the open cut construction method. Specifically, this alternative includes from east to west:

- An approximately 223-foot-long open cut construction method crossing of uplands (active agricultural land) that immediately abuts the CAB construction method receiving pit to the west;
- A 395-foot-long (not including 16-foot-long receiving pit and 60-foot-long bore pit) CAB crossing of LeTort Spring Run that also encompasses a fenceline, EV wetland W-I31 (palustrine emergent wetland), a sanitary sewer line, an overhead electric distribution line, and EV wetland W-I32 (palustrine forested wetland); and
- An approximately 1,410-foot-long open cut construction method crossing of uplands (forested land), including an overhead electric distribution line, a public water line, EV wetland W-I33, an overhead electric distribution line, stream S-I50 and associated floodway, and a paved parking area.

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Analysis of Alternative

This theoretical combination alternative was determined to be not technically feasible due to multiple constraints related to the CAB crossing of LeTort Spring Run and adjacent wetlands, including but not necessarily limited to technical limitations on maximum practicable CAB length and safety concerns related to bore pit depth, as discussed below.

As noted previously due to pipeline installation requirements, LeTort Spring Run, inclusive of its associated Pennsylvania Scenic Rivers Corridor System boundaries and adjacent wetlands, cannot be open cut and requires use of horizontal directional drill (or an alternative trenchless) construction method. Based on best engineering design parameters, the shortest practicable CAB crossing of LeTort Spring Run and associated resources is 395 feet (see Figure 3 in Attachment 2). As discussed above (see Conventional Auger Bore (CAB) Alternative), from a practicability standpoint, a CAB typically is technically limited to 200 feet in length varying by the underlying substrate (as opposed to the 390-foot length used as an initial screening criterion in the TCFA). Given the minimum length of the LeTort Spring Run and associated resources is 395 feet, use of the CAB construction method is not technically feasible at this location.

Based on existing topography and use of the minimum CAB length, the depths of the receiving pit and entry bore pit would be 16-17 and 16 feet, respectively. Bore pits of these depths present significant safety concerns for construction equipment, materials, and personnel, as pit walls would require extensive shoring and diligent monitoring to prevent failure or collapse during the lengthy boring process. In addition, at the entry bore pit, workspace is constrained to the north by pond P-12, to the south by the I-76/Pennsylvania Turnpike right-of-way, and to the east by the boundaries of the LeTort Spring Run Pennsylvania Scenic Rivers Corridor System and adjacent wetland W-132. Due to these constraints, the 16-foot-deep entry bore pit has the potential to encounter the groundwater table (of pond P-12 and wetland W-132) and experience flooding, resulting in significant safety concerns for construction equipment, materials, and personnel. Therefore, use of the CAB construction method is suboptimal at best with regard to safety of construction equipment, materials, and personnel at this location.

Finally, excavation of the entry bore pit also has the potential to encounter the root structure and damage overstory trees in the adjacent forested wetland W-132, an EV palustrine forested wetland that the CAB is intended to avoid. This excavation also has the potential to damage an existing underground infrastructure (public water line) located to the south of the pit. As a result, use of the CAB construction method is suboptimal at best with regard to avoidance of direct impacts to resources (EV palustrine forested wetlands, public water line) at this location.

If a theoretical combination open cut/CAB construction method were technically feasible (see Figure 2 in Attachment 2), then use of this method would result in direct but temporary and minor impacts to the bed and banks and floodway of one stream (stream S-150) that is a PADEP Chapter 93 designated HQ-CWF, and one EV wetland (wetland W-133, palustrine emergent wetland). SPLP specifications require a minimum of 48 inches of cover between the installed pipeline and the bottom of the watercourse. To meet this cover requirement during trenched construction through stream S-150, an open cut workspace with a width up to 75 feet would be required to accommodate the pipelines and provide sufficient space for trench excavation, spoil storage, pipeline installation, and sufficient separation between pipelines (for integrity management). The assessed area of impact by this open cut plan would directly affect approximately 2.84 acres of land (primarily forested land, with some active agricultural land and paved parking area), 114 feet at stream S-150, and 24 feet of EV emergent wetland (wetland W-133) at the western end of the crossing alignment. The assessed area of impact by this open cut/CAB plan would directly affect <0.01 acre of state water bottom and <0.01 acre of emergent wetland, and avoid direct impacts to forested wetland.

Open cut impacts to these resources would require modification of the state and federal permits. PADEP likely would require use of an approved dry open cut crossing method – such as the dam-and-pump construction method – as a best management practice to prevent downstream turbidity during construction activities across

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stream S-150. PADEP also likely would require that fisheries biologists monitor the bypass section of the crossing area to ensure it is free of fish prior to and for the duration of open cut construction activities; and that captured fish species are handled through PAFBC approved capture, handling, and reporting procedures and conditions. Based on the PAFBC classification for stream S-150 (Drains to Class A, TNR), both streams require a construction moratorium between October 1 – April 1; a PAFBC waiver would be required if construction activities would occur during this construction moratorium period. In addition, a portage would be required to provide waterway navigation users access around the crossing area, which in turn would require an activity-specific ATON permit from PAFBC.

The open cut crossing of stream S-150 would require damming the stream using an upstream and downstream geotube, while simultaneously pumping around all stream flows, and pumping out of all produced groundwater discharge from the excavated shallow soil horizons and water seepage below the geotube dams installed in the channel for the entire duration of the open cut crossing event. Moreover, any produced groundwater in the open excavations would be pumped to a discharge filtration structure. The current feasible filtration ability, however, does not exceed 50 microns. Therefore, cloudy water (from suspended fine clay and silt particles) would be discharged downstream regardless of all control methods employed for the entire duration of the use of open cut construction techniques.

Table 3a. Combination Open Cut/CAB Alternative Impacts on Wetlands.

Wetland	Crossing Method	Cowardin Classification ¹	Exceptional Value (EV) Designation	Wetland Temp Impact (acres) ³	Wetland Perm Impact (acres) ³	PFO Cover Type Conversion ^{1,2} (acres)
W-I31	CAB	PEM	Yes	0 (0)	0 (0.004)	n/a
W-I32	CAB	PFO	Yes	0 (0)	0 (0.002)	0
W-I33	Open Cut	PEM	Yes	0.003	0	n/a

¹ PEM = palustrine emergent, PSS = palustrine scrub-scrub, PFO = palustrine forested, n/a = not applicable.

² Permanent conversion of PFO cover type to PEM cover type due to maintenance of permanent ROW.

³ Use of the CAB construction method avoids direct wetland impacts, therefore impacts are denoted as zero ("0"). Parentheses denote PADEP impact calculations for the area of pipeline installed beneath the wetlands.

Table 3b. Combination Open Cut/CAB Alternative Impacts on Waterbodies.

Stream	Crossing Method	Stream Dist. Length in Perm ROW (feet)	Stream Dist. Length in Temp ROW (feet)	Stream Perm Impact (sq. feet) ¹	Stream Temp Impact (sq. feet) ¹	PADEP Perm Floodway Impact (acres) ¹	PADEP Temp Floodway Impact (acres) ¹	Ch. 106 Perm Floodplain Impact (acres) ¹	Ch. 106 Temp Floodplain Impact (acres) ¹
S-148	CAB	0 (50)	0 (0)	0 (67)	0 (0)	0 (0)	0 (0)	0 (0.046)	0 (0.031)
S-149	CAB	n/a	n/a	n/a	n/a	0 (0.031)	0 (0.042)	n/a	n/a
S-150	Open Cut	57	40	114	80	0.181	0.106	n/a	n/a
P-12	Open Cut	n/a	0	n/a	0	n/a	n/a	n/a	n/a

¹ Use of the CAB construction method avoids direct stream impacts, therefore impacts are denoted as zero ("0"). Parentheses denote PADEP impact calculations for the area of pipeline installed beneath the streams and clearing workspaces that impacts the streams' floodways.

Although the above surface disturbances to the subject wetlands and streams would be controlled and managed using the measures in SPLP's Impact Avoidance, Minimization, and Mitigation Plan and E&S Plan to a level that is temporary and minor, the preferred method would be to use a trenchless construction method to avoid these surface disturbances.

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Based on the results of this reevaluation, use of the combination open cut/CAB construction method to cross LeTort Spring Run: 1) is not a technically feasible alternative; 2) is not a practicable alternative taking into consideration cost, existing technology, and logistics; 3) due to CAB length limitations would not comply with required regulations and would result in potential significant impacts to other (non-wetland) environmental resources; and 4) results in greater environmental impacts compared to the originally-proposed HDD construction method. Therefore, the combination open cut/CAB construction method is not the preferred or selected alternative for this crossing location.

FlexBor Alternative

Use of the FlexBor construction method across the entire current 2,028-foot-long crossing alignment, or as an approximately 400-foot-long trenchless crossing alternative for LeTort Spring Run and adjacent wetlands, is neither technically feasible nor practicable due to the limitations of this existing technology, as discussed below.

SPLP contractors attempted three (3) FlexBors and partially completed two of these to replace HDDs on the Pennsylvania Pipeline Project. One FlexBor failed in the pilot phase and was replaced with a conventional auger bore under a highway and open cut construction. The two partially successful FlexBors completed the pilot phases, but both had difficulties completing the reaming phase. SPLP's analysis is that this technology is not perfected for larger diameter bore attempts.

Based on the results of this reevaluation, use of the FlexBor construction method to cross LeTort Spring Run: 1) is not a technically feasible alternative; and 2) is not a practicable alternative taking into consideration cost, existing technology, and logistics. Therefore, the FlexBor construction method is not the preferred or selected alternative for this crossing location.

Direct Pipe Bore Alternative

Use of the Direct Pipe Bore construction method across the entire current 2,028-foot-long crossing alignment, or as an approximately 400-foot-long trenchless crossing alternative for LeTort Spring Run and adjacent wetlands, is neither technically feasible nor practicable due to the limitations of this existing technology, as discussed below.

The Direct Pipe Bore method is also known as "microtunneling". This method of pipeline installation is a remote-controlled, continuously supported pipe jacking method. During the direct pipe installation, operations are managed by an operator in an above-ground control room alongside of the installation pit. Rock and soil cutting and removal occurs by drilling fluid injection through the cutting tool during rotation at the face of the bore, and the cuttings are forced into inlet holes in the crushing cone at the tool face for circulation to a recycling plant through a closed system. The entire operating system for this method of pipeline installation, including the cutting tool drive hydraulics, fluid injection, fluid return, and operating controls are enclosed inside the outside diameter bore pipe (or casing pipe) being installed. At the launching point/entry pit, the bore pipe is attached to a "jacking block" that hammers the bore pipe while the tool is cutting through the substrate or geology. The cutting tool face is marginally larger in diameter than the pipe to which it is attached. As a result, there is minimal annulus space, which minimizes the potential for drilling fluid returns or the production of groundwater returning back to the point of entry.

SPLP's construction contractors have successfully completed one (1) Direct Pipe Bore approximately 925 feet in length on the Pennsylvania Pipeline Project. However, the entire current HDD crossing alignment is approximately 2,028 feet in length, which exceeds the limits of Direct Pipe Bore technology.

SPLP also analyzed the option to employ a Direct Pipe Bore for the approximately 400-foot-long crossing of LeTort Spring Run and adjacent wetlands (see Figure 4 in Attachment 2). Although there is sufficient workspace outside of wetlands to feasibly establish a Direct Pipe Bore entry rig setup, the variability in the near subsurface geology was determined to likely result in drifting off alignment of this type of boring unit which

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would ultimately result in the geologic binding of the rock against the pipe casing and result in a failed bore attempt. The geology here is similar to the geology at the attempted Piney Creek Direct Pipe Bore crossing which failed.

Based on the results of this reevaluation, use of the Direct Pipe Bore construction method to cross LeTort Spring Run: 1) is not a technically feasible alternative; and 2) is not a practicable alternative taking into consideration cost, existing technology, and logistics. Therefore, the Direct Pipe Bore construction method is not the preferred or selected alternative for this crossing location.

Major Route Alternatives

As noted above, as part of the PADEP Chapter 105 permit process for the Pennsylvania Pipeline Project, SPLP developed and submitted for review a project-wide Alternatives Analysis. As part of the Alternatives Analysis (Section 3.3), SPLP evaluated a Major Route Alternative – the North Middleton/Mechanicsburg Southern Bypass Alternative – covering the area of analysis for the subject LeTort Spring Run crossing area. The initial planning route co-located with SPLP’s 8-inch pipeline corridor was determined to not be practicable due to obvious constraints and impacts that would occur along an approximately 15-mile-long pipeline segment in North Middleton, Middlesex, Silver Spring, Hampden, and Lower Allen Townships, Cumberland County. Specifically, the initial planning route would have crossed a heavily developed and populated area including residential and commercial uses in North Middleton and Mechanicsburg (see Alternatives Analysis, Appendix A: Figure 4 depicting the initial planning route). Accordingly, SPLP evaluated potential major route alternative corridors in this area that would allow co-location with other existing utility or other developed corridors, and avoid potential significant impacts on other (non-wetland) environmental resources and the subject developed and populated area.

The North Middleton/Mechanicsburg Bypass Alternative route involved two segments totaling approximately 15 miles, including a reroute of the pipeline to the north of the initial planning route and parallel to the existing Buckeye pipeline and electric transmission utility lines, and a reroute to the south of the Mechanicsburg area to a crossing of the Pennsylvania Turnpike to reconnect with the existing SPLP maintenance corridor before Rossmoyne Road (see Alternatives Analysis, Appendix A: Figure 4). This re-route alternative is approximately 15.8 miles long, and would result in an approximately 0.5 mile increase in pipeline length. This route alternative is co-located with existing utility corridors for the majority of its length and to the maximum extent practicable along the subject alignment. In both segments, the reroute parallels existing utility corridors to avoid heavily developed and congested residential and commercial areas in North Middleton and in the Mechanicsburg area. In addition to avoidance of these constructability constraints and properties, this reroute avoided areas that were congested with existing pipelines, power lines, and drainage systems, paralleling the Pennsylvania Turnpike for approximately 2 miles. This route was determined to be practicable with regard to current technology, cost, and logistics, and was selected as the proposed route.

New Potential Reroute Alternative (South Side I-76/Pennsylvania Turnpike)

As noted above (see Major Route Alternatives), as part of the PADEP Chapter 105 permit process for the Pennsylvania Pipeline Project, SPLP’s initial planning route was co-located with SPLP’s 8-inch pipeline corridor (see green route on Figure 5 in Attachment 2), but this route was determined to not be practicable due to obvious constraints and impacts that would occur along an approximately 15-mile-long pipeline segment in North Middleton, Middlesex, Silver Spring, Hampden, and Lower Allen Townships, Cumberland County. Accordingly, SPLP evaluated and selected a Major Route Alternative – the North Middleton/Mechanicsburg Southern Bypass Alternative – covering the area of analysis for the subject LeTort Spring Run crossing area.

As a result of adoption of this Major Route Alternative, the selected, proposed, and permitted route is largely co-located with I-76/Pennsylvania Turnpike, but an approximately 4.5-mile-long segment of this route in the vicinity of the LeTort Spring Run crossing area diverts from co-location with I-76/Pennsylvania Turnpike largely to avoid obvious constraints and impacts, and to accommodate HDD crossings of sensitive resources (LeTort

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Spring Run, I-81) before ultimately reconnecting (being co-located) with SPLP's 8-inch pipeline corridor (see purple route on Figure 5 in Attachment 2). Specifically, after diverting from SPLP's 8-inch pipeline corridor for a short distance (0.14 mile) to the southeast to co-locate with I-76/Pennsylvania Turnpike, this approximately 4.5-mile-long segment of the permitted route (from east to west):

- Is co-located with I-76/Pennsylvania Turnpike for HDD crossings of LeTort Spring Run and I-81 for approximately 0.77 mile;
- Turns to the northeast a short distance (approximately 0.26 mile) to reconnect (co-locate) with SPLP's 8-inch pipeline corridor;
- Is co-located with SPLP's 8-inch pipeline corridor for approximately 1.20 miles;
- Turns to the southeast, east, and southeast to co-locate with an electric distribution line/roadway, railroad/electric distribution line, and two electric transmission lines, respectively, for a total of approximately 1.02 miles; and
- Traverses east generally co-located on the north side of I-76/Pennsylvania Turnpike along property lines, electric distribution lines, and/or roadways, and ultimately turns south to cross I-76/Pennsylvania Turnpike, for approximately 1.27 miles.

As required by the Order, the reevaluation of HDD S2-0210 includes an analysis of alternatives, including new potential re-route alternatives in the vicinity of the LeTort Spring Run crossing area. Accordingly, SPLP considered new potential re-route alternatives that could replace the approximately 4.5-mile-long segment of the permitted route described above (see purple route on Figure 5 in Attachment 2). Specifically, SPLP evaluated a theoretical new re-route alternative that is approximately 3.7-miles long and entirely co-located on the south side of I-76/Pennsylvania Turnpike (see blue route on Figure 5 in Attachment 2).

It is important to note that given the general orientation of the Pennsylvania Pipeline Project in this area of the state is from west to east, and given the general north-south orientation of LeTort Spring Run, no practicable west-east oriented re-route alternative lies to the north or south of the proposed route that would not ultimately transect this stream and its associated Pennsylvania Scenic Rivers Corridor System. Shifting the permitted route to the north or south would result in new "greenfield" corridor through existing woodlands along LeTort Spring Run. A shift north would traverse a high density commercial and residential area prior to it adjoining with an existing utility corridor. A shift south would significantly increase woodland impacts and require crossing I-76/Pennsylvania Turnpike twice. In addition, the geology across the broader area, miles in extent, is karst; therefore, no reasonable re-route alternative is available in the vicinity of the permitted route that would avoid these subsurface geologic conditions.

Therefore, SPLP's evaluation and ultimate selection of a technically feasible and practicable route and construction methods in the vicinity of the LeTort Spring Run crossing area was focused on:

- Use of HDD (as required by PDCNR) to avoid LeTort Spring Run, including potential significant direct and indirect impacts to the stream, as well as its associated Pennsylvania Scenic Rivers Corridor System characterized by PDCNR as, "related adjacent land areas, and associated outstanding aesthetic and recreational values of present and potential benefit to the citizens of Pennsylvania."
- Use of HDD to avoid direct impacts to EV wetlands W-I30 (palustrine emergent wetland) and W-I31 (palustrine forested wetland), including PFO wetland cover type conversion;
- Use of HDD to avoid direct impacts to I-81 and South Middlesex Road;
- Use of a trenchless crossing method to avoid direct impacts to the Cumberland Valley Railroad Historic District and existing railroad tracks;
- Co-location with existing disturbed corridors to the maximum extent practicable;
- Avoiding and minimizing impacts on obvious constraints and impacts to existing industrial, commercial, and residential buildings and associated infrastructure to the maximum extent practicable; and
- Avoiding and minimizing impacts to other (non-wetland or significant) environmental resources to the maximum extent practicable.

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The permitted route (see purple route on Figure 5 in Attachment 2) meets all of these routing and construction method objectives, including technically feasible and practicable HDD crossings and alignments of LeTort Spring Run and I-81.

- Compared to the new potential re-route alternative, the permitted route possesses the following certain advantages:
 - Foremost, it meets all of the above-listed routing and construction method objectives, and **is** a technically feasible and practicable alternative with regard to the HDD crossings and alignments of LeTort Spring Run and I-81.
 - It avoids crossing LeTort Spring Run Wildlife Management Area and County Natural Heritage Inventory (CNHI) core habitat area, has a shorter crossing of the LeTort Spring Run CNHI supporting habitat area, and thus avoids the clearing of forest and placement of an HDD entry/exit site within CNHI core and supporting areas adjacent to LeTort Spring Run.
 - It is in compliance with the Pennsylvania Scenic Rivers Act, including PDCNR specific conditions required for the proposed pipeline crossings of the LeTort Spring Run Pennsylvania Scenic Rivers Corridor System.
 - It crosses one less (total of three) National Hydrography Dataset (NHD) mapped water feature; and
 - It is entirely co-located with SPLP's existing 20-inch-diameter (PPP 1) pipeline alignment, thus optimizing use of existing right-of-way (avoids creation of new right-of-way); and optimizes construction, restoration, and operational efficiency of both (20-inch and 16-inch diameter) pipelines.

- Compared to the new potential re-route alternative, the permitted route possesses the following certain disadvantages:
 - It is approximately 0.8 mile longer (total 4.5 miles long) and impacts approximately 5.0 acres of additional land (total 38.9 acres) based on a theoretical 75-foot-wide construction right-of-way along the entirety of both routes.
 - However, the entirety of the 16-inch-diameter pipeline impact area overlaps (is coincident with) the existing 20-inch-diameter (PPP 1) pipeline impact area, such that no new impact area would be required.
 - It crosses one additional (total of five) National Wetland Inventory (NWI) mapped feature; and
 - It has a longer crossing (but entirely co-located with existing disturbed corridors) of the Appalachian Trail Historic District buffer zone.

The new potential re-route alternative (see blue route on Figure 5 in Attachment 2) meets the majority of these routing and construction method objectives, however, it possesses certain fundamental disadvantages discussed below:

- Compared to the permitted route, the new potential re-route alternative possesses the following certain advantages:
 - It is approximately 0.8 mile shorter (total 3.7 miles long) and impacts approximately 5.0 acres less land (total 33.9 acres) based on a theoretical 75-foot-wide construction right-of-way along the entirety of both routes;
 - However, the entirety of the new potential re-route alternative impact area would be new, as it would not overlap the existing 20-inch-diameter (PPP 1) pipeline impact area.
 - It crosses one less (total of four) NWI feature; and

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- It has a shorter crossing (entirely co-located with existing disturbed corridors) of the Appalachian Trail Historic District buffer zone.
- Compared to the permitted route, the new potential re-route alternative possesses the following certain disadvantages:
 - Foremost, the theoretical HDD crossings and alignments of LeTort Spring Run and I-81 are potentially neither technically feasible nor practicable with regard to existing technology, cost, and logistics.
 - Specifically, the HDD alignment of LeTort Spring Run would cross the Wildlife Management Area associated with LeTort Spring Run, identified by the Pennsylvania Natural Heritage Program as a “locally significant area (that) consists of marshy floodplain habitat along this spring-fed tributary to the Conodoguinet Creek”, which provides “habitat for a variety of bird, reptile, and amphibian species.”
 - The HDD alignment crosses the LeTort Spring Run Wildlife Management Area and CNHI core habitat area, has a longer crossing of the LeTort Spring Run CNHI supporting habitat area, and thus results in the clearing of forest and placement of an HDD entry/exit site within CNHI core or supporting areas adjacent to LeTort Spring Run.
 - These direct impacts to the LeTort Spring Run Wildlife Management Area and CNHI core and supporting habitat areas is potentially in non-compliance with the Pennsylvania Scenic Rivers Act. Specifically, based on correspondence with the PDCNR dated August 13, 2015, the proposed pipeline crossings of the LeTort Spring Run Pennsylvania Scenic Rivers Corridor System require compliance with the following specific conditions:
 - “No tree clearing will occur on the banks of the creek(s).”
 - “All construction work areas will be set back from the creek as far as possible, and those work spaces that require tree/shrub clearing will be set back from the creek bank at least 250 feet.”
 - Additionally, the HDD alignment of I-81 would require a longer crossing, and require pipeline installation beneath an existing commercial building and parking lot which is not a practicable alignment.
 - It crosses one more (total of four) NHD mapped water feature;
 - It is not co-located with SPLP’s existing 20-inch-diameter (PPP 1) pipeline alignment, and requires a new separate right-of-way, thus increasing the project-wide impact area by 33.9 acres. This in turn increases construction, restoration, and operational costs and inefficiencies (related to separation of the 20-inch and 16-inch diameter pipelines).

Based on the results of this reevaluation, use of the new potential re-route alternative to cross LeTort Spring Run: 1) is likely not a technically feasible alternative; 2) is likely not a practicable alternative taking into consideration cost, existing technology, and logistics; 3) likely would not comply with required regulations and would result in potential significant impacts to other (non-wetland) environmental resources; and 4) results in greater environmental impacts compared to the originally-proposed HDD construction method. Therefore, the new potential re-route alternative is not the preferred or selected alternative for this crossing location.

Alternatives Analysis Conclusion

The results of this reevaluation Alternatives Analysis conducted for the LeTort Spring Run HDD confirms the conclusions reached in the previously submitted alternatives analysis. Specifically, use of the originally-proposed HDD construction method to cross LeTort Spring Run: 1) is a technically feasible alternative; 2) is a practicable alternative taking into consideration cost, existing technology, and logistics; 3) is in compliance with required regulations and avoids potential significant impacts to other (non-wetland) environmental resources; and 4) results in the least environmental impact compared to the other technically-feasible and practicable alternatives analyzed. Therefore, the originally-proposed HDD construction method is the preferred and selected alternative for this crossing location.

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REDESIGNED HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 1,950 feet
- Entry/Exit angle: 16 degrees
- Maximum Depth of cover: 144 feet
- Pipe design radius: 2,000 feet

The redesigned 16-inch HDD profile stays within all allowable stress tolerances for the pipeline. The 16 degree angle of entry and exit is at the maximum allowed for the break-over radius of curvature to be tied into the conventionally laid pipeline. The 2,000 radius for entering into and exiting out of the horizontal run is below the allowable stress radius which provides for some drift during drilling of the pilot hole. The horizontal run at 179 ft allows for correction of the pilot drill for targeting of the exit radius, or provides for trueing of the pilot hole in the event an intercept drill is required.

CONCLUSION

The 16-inch HDD profile has been re-designed to allow for a deeper crossing beneath LeTort Spring Run than was completed for the 20-inch pipeline installation. The inclination of the entry and exit angles has been increased in order to install the 16-inch pipe through protective soils, residual soils, and bedrock in closer proximity to the entry and exit points than the original shallower profile. From a geologic perspective, the deeper profile, in conjunction with the proposed engineering controls and/or drilling best management practices, will be used to reduce the risk of an IR. Attachment 2 presents the permitted 16-inch HDD Plan and Profile; the 20-inch "as built" profile with IR locations, and the redesigned 16-inch HDD Plan and Profile.

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

- SPLP will provide the drilling crew and company inspectors (UI, EI, PGs) the location(s) data on potential zones of higher risk for fluid loss and IRs, including the area related to previous IRs, and potential zones of fracture concentration identified by the fracture trace analysis along the drill path, so that monitoring can be enhanced when drilling through these locations;
- SPLP will mandate annular pressure monitoring (APM) during the drilling of the pilot hole, which assists in immediate identification of pressure changes indicative of loss of circulation (LOC) or over pressurization of the annulus, managing development pressures that can induce an IR;
- SPLP's drilling contractor will utilize the drilling and monitoring log data for the 20-inch HDD as guidance on approaching the potential zone where drilling fluids were lost during the 20-inch HDD, such that corrective action by injection of Loss Control Materials (LCMs), or grouting can be implemented if the APM or return of drilling fluids indicate a loss in the same general area of the profile, or elsewhere;
- SPLP inspectors will ensure that an appropriate diameter pilot tool, relative to the diameter of the drilling pipe, is used to ensure adequate "annulus spacing" around the drilling pipe exits to allow good return flows during the pilot drilling;
- SPLP will mandate short-tripping of the reaming tools to ensure an open annulus is maintained to manage the potential inducement of IRs;
- SPLP will implement short-tripping of the reaming tools as return flow monitoring indicates to ensure an open annulus is maintained to manage the potential inducement of IRs;

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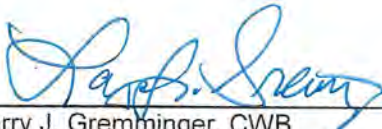
- SPLP will require monitoring of the drilling fluid viscosity, such that fissures and fractures in the subsurface are sealed during the drilling process;
- During all drilling phases, the use of Loss Control Materials (LCMs) will be considered if indications of a potential IR are noted or an IR is observed. The use of LCMs, however, is less effective below 70 ft of the ground surface. The AP below that depth can exceed the effective stabilization capability of LCMs. Accordingly, the preferred proactive corrective action needed to address the presence of fractures or unstable geology at greater depths below ground may require grouting of the HDD annulus. Two types of grouting will be utilized for corrective actions to seal fractures and stabilize zones of weak geology. These are: 1) grouting using "neat cement"; and 2) grouting using a sand/cement mix. Neat cement grout is a slurry of Portland cement and water. The sand/cement grout mix is a slurry of mostly sand with a small percentage of Portland cement and activators that after setup results in a material having the competency of a friable sandstone or mortar. Both grouting actions require tripping out the drilling tool, and then tripping in with an open-ended drill stem to apply or inject the grout mixes. Either of these grouting actions will be implement upon the first detection of an LOC with the selection of the treatment based upon the circumstances of the LOC, being small or large in magnitude indicative of a minor or major fracture.

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FEASIBILITY DETERMINATION

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

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

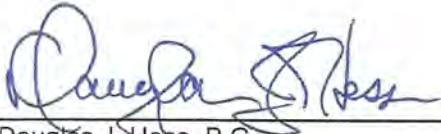


Larry J. Gremminger, CWB
Geotechnical Evaluation Leader
Mariner East 2 Pipeline Project

2/1/2019

Date

Pertaining to the practice of geology



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2/1/19

Date



Pertaining to the pipeline stress and HDD geometry



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2/1/19

Date



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ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT

January 30, 2019

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

Engineers

Environmental
Consultants

Surveyors

Landscape
Architects

Safety
Consultants

RE: Sunoco Pipeline, L.P. Pipeline Project-Mariner East II
LeTort Spring Run HDD S2-0210
PA-CU-0136.0002-WX-16
Hydrogeologic Re-Evaluation Report for 16-Inch Pipeline
Middlesex Township, Cumberland County, PA
RETTEW Project No. 096302011

EXECUTIVE SUMMARY

1. The Corrected Stipulated Order Dated August 10, 2017 requires a re-evaluation of the proposed 16-inch drill at the LeTort Spring Run horizontal directional drill (HDD) location S2-0210.
2. The site is underlain by finely crystalline limestone and dolomite of the St. Paul Group (Osp) which is typically characterized by good subsurface drainage; however areas of poor surface drainage exist where bedrock pinnacles and sinkhole development occur.
3. Water-bearing zones in the underlying geology generally occur in secondary openings along bedding planes, joints, faults, and fractures. The permeability of these features is enhanced by dissolution of the limestone and dolomite bedrock.
4. The average depth of water supply wells in the St. Paul Group is 384 feet below ground surface (bgs) with an average depth to water of 32 bgs. Water-bearing zones are abundant at shallow depths and typically extend to depths of approximately 250 feet bgs.
5. The HDD profile for the proposed 16-inch drill has been redesigned to increase its depth beneath the streams and wetlands.
6. Based on the hydro-structural characteristics of the underlying geology and occurrence of inadvertent returns (IRs) during the installation of the 20-inch pipe, the LeTort Spring Run HDD is susceptible to an IR of drilling fluids during HDD operations for the planned 16-inch drill. The redesigned 16-inch HDD profile and HDD best management practices during drilling operations will be used to reduce the risk of an IR.

1.0 INTRODUCTION

The purpose of this report is to describe the geologic and hydrogeologic setting of the LeTort Spring Run S2-0210 HDD location on the Sunoco Pipeline, L.P. (SPLP) Pennsylvania Pipeline Project-Mariner II East (PPP-ME2) Project. The LeTort Spring Run HDD is located in Middlesex Township, Cumberland County, Pennsylvania as shown on **Figure 1**. The HDD is located between the north side of Pennsylvania Interstate 76 and the Love's Travel Stop, and was designed to be drilled under LeTort Spring Run (S-I148), two small



streams (S-I149 and S-I150) and two wetlands (W-131 and W-132) as shown on **Figure 1**. This re-evaluation report is part of the response to the Corrected Stipulated Order dated August 10, 2017 related to the IR of drilling fluids that occurred on May 10 and May 19, 2017, and numerous subsequent IRs, during HDD operations for the 20-inch pipe, that was completed on September 25, 2018.

The 16-inch HDD profile was redesigned on December 11, 2018 to increase the depth of the HDD bore path crossing beneath the streams and wetlands. The redesigned west HDD entry/exit is at a surface elevation of approximately 436 feet above mean sea level (AMSL) and the redesigned east HDD entry/exit is at a surface elevation of approximately 428 feet AMSL. The HDD profile was extended to the east resulting in a total bore path/pipe length of 1,950 feet. The extended profile allows for deepening of the profile to approximately 115 feet below LeTort Spring Run (this is approximately 17 feet deeper than the 20-inch pipe). The existing 20-inch and proposed 16-inch S2-0210 HDD locations are shown on Figure 1 and the redesigned 16-inch profile is included as **Attachment 1**.

2.0 GEOLOGY AND SOILS

Based upon publications by the Pennsylvania Bureau of Topographic and Geologic Survey (PABTGS), the site is in the Great Valley Section of the Ridge and Valley Physiographic Province of Pennsylvania, and is underlain by very finely crystalline limestone with minor occurrences of dolomite and chert (Sevon, 2000). Local topography is characterized by rolling valleys of low relief and natural slopes that are gentle and relatively stable. Geologic structures are characterized as thrust sheets, nappes, overturned folds and steeply inclined faults. Areas underlain by these rock units typically have good subsurface drainage and poor surface drainage where bedrock dissolution results in the development of bedrock pinnacles and solution cavities (e.g., sinkholes, voids, caves). Based on the United States Geological Survey (USGS) 7.5-Minute Carlisle Topographic Quadrangle Map shown on **Figure 1**, the site is situated at an approximate elevation of 425 feet AMSL. Surface topography at the site slopes west and east along the HDD toward LeTort Spring Run. The major surface water feature is LeTort Spring Run which flows northeast and then northwest before discharging to Conodoguinet Creek.

The site geology is mapped as the St. Paul Group (Osp) as shown on **Figure 2** (Socolow, 1980). This geologic Group is described as buff-colored, finely crystalline magnesium limestone containing numerous layers of chert, high calcium limestone in part, and is approximately 900 feet in thickness (Root, 1978). The lower and upper parts of the Group are predominantly pure limestone except for minor amounts of dolomite. The middle part consists of darker, impure limestone and abundant interbedded dolomite and some dolomite interbeds. This Group is well bedded, fissile to flaggy in nature, and contains some thick-bedded sections. Most joints have a blocky pattern, with some having a platy pattern; but are moderately well developed, moderately to highly abundant and fairly to regularly spaced. There is a moderate distance between fractures, most fractures are open, and some are filled with calcite. Fractures are usually steeply dipping to vertical. This Group is moderately resistant to weathering and is slightly weathered to shallow depths; resulting in medium-sized blocks. The overlying mantle is moderately thick and in most places the bedrock-mantle interface is characterized by bedrock pinnacles. This Group is considered difficult to excavate due to the degree and extent of bedrock pinnacle development. Foundation stability is good, provided the excavation extends to sound bedrock and solution cavities are thoroughly investigated and mitigated. Subsurface drainage is good and is characterized by the development of sinkholes at the surface and caves at depth. Secondary porosity is provided by interconnections between joint and solution channel openings, and is moderate to high in magnitude; permeability of the Group is generally high (Geyer and Wilshusen, 1982).

According to the United States Department of Agriculture (USDA) Soil Survey of Cumberland County, Pennsylvania, soils within the vicinity of the LeTort Spring Run HDD consist of seven distinct soil units. A USDA map that depicts the mapped area, along with the soil profile descriptions, is included as **Attachment 2**.

3.0 HYDROGEOLOGY

Groundwater at the site occurs in a fractured, solution-prone, carbonate bedrock aquifer system within the St. Paul Group. In carbonate rocks, water-bearing zones generally occur in solution-enhanced secondary openings that form along bedding planes, joints, faults and fractures. Most of the water-bearing zones penetrated by supply wells occur in individual fractures or groups of interconnected fractures that are sufficiently enlarged by dissolution to provide pathways for the transport of groundwater.

The average depth of water supply wells in the St. Paul Group is reported to be 384 feet bgs with an average depth to water of 32 feet bgs. Rocks of the St. Paul Group have a reported median sustained yield of 82 gallons per minute (gpm) attributed to well-developed fractures and solution openings. Sustained yields of large capacity production wells are reportedly between 105 and 260 gpm. Although the maximum density of water-bearing zones is developed at shallow depths, these zones are nearly as abundant to depths of 250 feet bgs. Between 251 and 550 feet, water yielding zones are rare. However, in the 551- to 600-foot depth bgs range, the number of zones per 100 feet of hole evaluated is almost as great as in the shallower zone (Becher and Root, 1981).

Well records for 37 individual water supply wells within a 0.5-mile radius of the LeTort Spring Run HDD were obtained from the Pennsylvania Groundwater Information System (PaGWIS). The information obtained from these well records is summarized in the following table:

Well No.	Well Use	Casing Depth (feet)	Total Depth (feet)	Water Level (feet)	Yield (gpm)
97180	Domestic	34	173	24	15
97179	Domestic/Stock	43	348	35	10
97161	Domestic	80	140	52	18
97050	Domestic	126	375	22	9
97025	Domestic	101	296	8	50
97016	Domestic	70	465	35	12
97001	Domestic	42	120	25	5
96999	Domestic	102	125	Unknown	30
669948	Domestic	63	142	Unknown	12
669927	Domestic	40	400	300	1
669926	Domestic	31	150	Unknown	Unknown
669925	Domestic	40	100	40	1
669924	Domestic	20	300	Unknown	Unknown
561806	Domestic	35	50	Unknown	2
561354	Domestic	Unknown	Unknown	Unknown	Unknown
561348	Domestic	Unknown	Unknown	Unknown	Unknown
561341	Domestic	Unknown	Unknown	Unknown	Unknown

Well No.	Well Use	Casing Depth (feet)	Total Depth (feet)	Water Level (feet)	Yield (gpm)
561340	Domestic	Unknown	Unknown	Unknown	Unknown
561339	Domestic	Unknown	Unknown	Unknown	Unknown
561338	Domestic	Unknown	Unknown	Unknown	Unknown
561337	Domestic	Unknown	Unknown	Unknown	Unknown
561336	Domestic	Unknown	Unknown	Unknown	Unknown
561335	Domestic	Unknown	Unknown	Unknown	Unknown
561334	Domestic	Unknown	Unknown	Unknown	Unknown
561332	Domestic	Unknown	Unknown	Unknown	Unknown
561331	Domestic	Unknown	Unknown	Unknown	Unknown
561330	Domestic	Unknown	Unknown	Unknown	Unknown
561313	Domestic	Unknown	Unknown	Unknown	Unknown
561312	Domestic	Unknown	Unknown	Unknown	Unknown
561310	Domestic	Unknown	Unknown	Unknown	Unknown
561309	Domestic	Unknown	Unknown	Unknown	Unknown
561291	Domestic	Unknown	Unknown	Unknown	Unknown
561290	Domestic	Unknown	Unknown	Unknown	Unknown
561254	Domestic	Unknown	Unknown	Unknown	Unknown
324590	Domestic	84	140	40	30
320749	Domestic	84	405	Unknown	20
320736	Domestic	60	550	Unknown	3

As a condition of the corrected Stipulated Order, other Sunoco subcontractors researched private water supplies located within a 450-foot radius of the LeTort Spring Run HDD. No private wells were identified within the 450-foot radius. However, two supply wells were identified approximately 1,016 and 1,303 feet northeast of the proposed 16-inch HDD profile as shown on **Attachment 3**.

4.0 FRACTURE TRACE ANALYSIS

Fracture traces underlying, or in close proximity to the LeTort Spring Run HDD, were evaluated using historical aerial photographs from the years 1994 through 2016 (Google Earth, 2017), the Carlisle, PA USGS 7.5-Minute Topographic Quadrangle Map, and the Geologic Map of the Carlisle and Mechanicsburg Quadrangles, Cumberland County, Pennsylvania (Root, 1978). The aerial photographs and maps were used to approximate locations of natural linear features or lineaments expressed on the ground surface. The linear features may be the surficial representation of deeper fractures, joints, faults or bedding planes within the subsurface which can transmit groundwater through the fractured bedrock aquifer underlying the LeTort Spring Run HDD.

Figures 2 and 3 show the results of the fracture trace analysis overlain on the geologic map and aerial base map, respectively. Twelve fracture traces were identified in close proximity to the proposed LeTort Spring Run HDD. Four of the fracture traces trend approximately northwest-southeast, parallel to geologic strike. Eight of the fracture traces trend approximately northeast-southwest and may represent joint sets perpendicular to geologic strike. Nine of the fracture traces correspond with straight stream segments of LeTort Spring Run, and are likely associated with local geologic structure.

5.0 GEOTECHNICAL EVALUATION

Two geotechnical drilling investigations were performed at the site. The initial investigation was performed in January 2015 during the preliminary investigation of the LeTort Spring Run HDD and prior to initiating the 20-inch HDD operations. A second phase of geotechnical drilling was performed in June 2017. The 2015 test borings were advanced by hollow-stem auger drilling and NQ-sized wireline rock coring methods. These borings are designated as SB-01 and SB-02. The second phase test borings completed in 2017 were advanced using mud-rotary drilling and NQ-sized wireline rock coring methods. Soil, residual soil and weathered bedrock were sampled using split-spoon samplers. These borings are designated as B-1 and B-2. Geotechnical boring logs are included in **Attachment 1**.

Boring SB-01 was located approximately 725 feet northeast of the HDD entry. Boring SB-02 was located approximately 30 feet southwest of the HDD exit. Boring B-1 was located approximately 100 feet southwest of the HDD exit and Boring B-2 was placed approximately 100 feet northeast of the HDD entry. The locations of these borings are identified on **Figures 2 and 3**.

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

- Soil and residual soils vary from boring to boring; 15.0 feet at SB-01, 28.4 feet at SB-02, 7.5 feet at B-1, and 6.25 feet at B-2. Residual soils are described as follows:
 - **Boring SB-01:** SILT (ML), elastic SILT (MH) and some weathered limestone from the ground surface to 15 feet bgs. Auger refusal was encountered at 15 feet bgs. Groundwater was not encountered in this boring.
 - **Boring SB-02:** Elastic SILT (MH) with trace to some fine sand, trace fine rock fragments and limestone. The boring was completed to 30.0 feet bgs. Groundwater was encountered at 11.0 feet bgs.
 - **Boring B-1:** Lean CLAY (CL) from the ground surface to 3.5 feet bgs. A bedrock pinnacle was encountered and the split-spoon sampler was replaced with the coring equipment. Coring methods were used to advance the boring through the residuum to a depth of 7.5 feet bgs where bedrock was encountered.
 - **Boring B-2:** Lean CLAY (CL) with a trace of sand was encountered from the ground surface to two feet bgs. A rollerbit was used to advance the boring to refusal at 4.5 feet bgs. Bedrock was encountered at 6.25 feet bgs.
- From the initiation of coring operations to the total depth of the NQ cores, weathered bedrock and bedrock were encountered and are described as follows:
 - **Boring SB-01:** Rock coring was not completed at this location.
 - **Boring SB-02:** Rock coring was not completed at this location.
 - **Boring B-1:** B-1 was completed to a total depth of 150.5 feet bgs. From 7.5 to 124.0 feet bgs a light gray to black, very fine-grained, slightly to highly weathered dolomite was observed. Joints range from horizontal to nearly vertical with some quartz infilling. Three zones of highly weathered fractures with clay development were observed at 1) 10.7 to 11.9, 2) 15, and 3) 84.5 to 85 feet bgs. Within the dolomite, rock recoveries were poor to excellent (45% to 100%) and rock quality designations (RQDs) were poor to excellent (28% to 100%). From 124.0 feet bgs to the completion depth of 150.5 feet bgs, a light gray to gray limestone was encountered. The limestone was very fine-grained to fine-grained and slightly weathered. Joints range from horizontal to nearly vertical and weathered with some quartz infilling. Rock recoveries in the

- limestone were excellent (99% to 100%) and RQDs were fair to excellent (72% to 100%). Groundwater was encountered after coring operations at nine feet bgs.
- **Boring B-2:** B-2 was completed to a total depth of 150.0 feet bgs. From 6.25 feet to the completion depth of 150.0 feet bgs, a very fine to fine-grained dolomite was observed. The color of the dolomite varied from light gray to dark gray with some light gray to brown and light blue-gray observed in minor intervals. The dolomite was slightly to highly weathered. Joints range from horizontal to vertical with some quartz infilling and one small (0.25-inch) fracture with signs of clay development at 70.0 feet bgs. Recoveries were fair to excellent (74% to 100%) and RQDs were very poor to excellent (0% to 100%). Groundwater was encountered after coring operations at 16.3 feet bgs.

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

Boring	Sample Depth (feet bgs)	Compressive Strength (psi)
B-1	10-14	16,828
B-1	38-43	12,282
B-1	57-62	17,486
B-1	77-82	13,012
B-1	92-97	16,282
B-1	112-116	14,709
B-1	132-137	15,160
B-1	147-150	14,256
B-2	13-18	8,520
B-2	40-45	8,498
B-2	55-60	10,102
B-2	80-85	12,761
B-2	95-100	15,883
B-2	110-115	13,163
B-2	120-125	11,874

Please note that Skelly and Loy and RETTEW did not oversee or direct the geotechnical drilling program associated with HDD S2-0210 including but not limited to, the selection of boring locations and target depths, observations of rock cores during drilling operations, or preparation of boring logs. The geotechnical reports, boring logs, and core photographs that resulted from these programs were generated by other Sunoco Pipeline, L.P. contractors. Skelly and Loy and RETTEW relied on these reports and incorporated the data into the general geologic and hydrogeologic framework included in this report.

6.0 GEOPHYSICAL SURVEY

A non-invasive geophysical survey was performed at HDD S2-0210 from October 16 through October 23, 2017. The purpose of the geophysical survey was to determine the depth to bedrock, overburden thickness, and identify areas of solid and fractured rock. Seismic refraction, multichannel analysis of surface waves (MASW), and electrical resistivity methods were used during the survey. A summary is provided below.

Results of the seismic refraction survey generally indicated a stratigraphy comprised of unconsolidated material and competent bedrock. The seismic data suggests a generally consistent inferred bedrock surface of approximately 20 feet bgs. It should be noted that the contoured seismic data represents an average seismic velocity profile indicating a gradational interface between the unconsolidated material and competent bedrock. Given these findings and our interpretation of the collected field data, bedrock pinnacles common in the St. Paul Group may extend above or below the inferred contour between the unconsolidated material and bedrock.

The results of the MASW survey indicated a two-layer stratigraphy similar to the seismic results. However, the shallow depth to bedrock and bedrock pinnacles limited the dispersion of the signal source. This resulted in a low signal to noise ratio, and did not provide effective imaging resolution within the apparent bedrock and fractured bedrock zones.

The electrical imaging data indicated a depth to bedrock of 15 to 30 feet bgs. High-resistivity zones represent competent bedrock and low-resistivity zones represent weathered or fractured bedrock. Three low-resistivity zones were identified during the survey and may represent more permeable bedrock fracture zones that could provide potential pathways for fluid transport.

7.0 FIELD OBSERVATIONS

A. DECEMBER 29, 2017 FIELD INVESTIGATION

A field investigation was performed by RETTEW staff on December 29, 2017 to identify rock outcrops for fracture fabric analysis, evaluation and ground-truthing of the topographic expression of fracture traces identified during the desktop exercise, and to identify additional potential sensitive receptors to IRs. Readily accessible bedrock outcrops in the vicinity of the LeTort Spring Run HDD were not identified during the reconnaissance. Nine of the 12 fracture traces are coincident with linear stream segments of LeTort Spring Run. Three additional fracture traces exhibit similar topographic expression on the ground surface; however, these features do not correspond with the proximate stream segments of LeTort Spring Run. These fracture traces likely represent perpendicular joint sets and suggest that some sections of LeTort Spring Run are locally controlled by geologic structure. No additional sensitive receptors were identified.

B. FIELD OBSERVATIONS DURING 20-INCH HDD ACTIVITIES

Multiple IRs occurred during the installation of the 20-inch pipe using HDD methods. The first IR occurred on April 20, 2017 and subsequent IRs resulted in the Consent Order and Agreement referenced in this report. Details regarding any of the IRs of drilling fluids that occurred can be found in the HDD Daily Reports submitted to SPLP and/or the Pennsylvania Department of Environmental Protection (PA DEP). Since restart approval was granted by the PA DEP in April 2018, a summary and discussion of drilling

activity and other events that occurred during the 20-inch HDD pipeline installation (drilling from the east to the west) initiated on April 12, 2018 and completed on September 25, 2018 is provided below.

- **April 12, 2018:** Pretec initiated pilot drilling from east to west after PA DEP approval was granted to restart HDD operations at the site.
- **April 13, 2018:** Groundwater surfaced approximately 180 feet from the east entry point with the pilot bit at approximately 168 feet from the east entry point. An IR was reported per the HDD Inadvertent Return Assessment, Preparedness, Prevention and Contingency Plan (IR PPC Plan) Section 5.1.6.
- **April 26, 2018:** Pretec resumed pilot drilling following PA DEP restart approval.
- **May 8, 2018:** SPLP voluntarily shut down east side drilling due to previous voluntary shutdown of west side drilling.
- **May 10, 2018:** Pretec resumed drilling after a revised drilling plan was submitted to SPLP which included details for casing installation methods and introduction of Loss Control Materials (LCMs).
- **May 15, 2018:** IR reoccurred at the April 13, 2018 location. Pretec excavated and constructed a containment pit around the IR location to contain and pump drilling fluids back to the reclaimer. HDD operations were voluntarily shut down by SPLP for further evaluation.
- **May 16, 2018:** HDD activities were restarted. Pretec began installing protective 30-inch, 16-inch, and 12-inch diameter telescoped casing to increase borehole integrity and reduce the risk of IRs.
- **May 22, 2018:** PA DEP approved a minor modification to ESG0300015002 which discussed the use of existing containment best management practices (“Containment BMPs”) that were previously placed around previous IR locations encountered during the 2017 HDD operations. In its May 22, 2018 approval of the minor Chapter 102/105 permit modifications, the PA DEP required that SPLP submit a written request for approval to utilize the Containment BMPs for continuous control of HDD operations at the site (this written request was included in the Hydrogeologic Re-Evaluation Report submitted by SPLP to the PA DEP on June 1, 2018).
- **June 1, 2018:** SPLP submitted a revised Hydrogeologic Re-Evaluation Report to the PA DEP requesting restart approval of HDD operations and approval of the use of the Containment BMPs specified in the PA DEP’s May 22, 2018 Chapter 102/105 permit modifications approval.
- **June 5, 2018:** PA DEP approved both SPLP’s request to restart HDD operations and SPLP’s specifications for the installation of Containment BMPs to address the April 25, 2017 IRs (located on the west side of the HDD profile) and the May 15, 2018 IR (located on the east side of the HDD profile).
- **June 9, 2018:** Pretec implemented Containment BMPs specified in the June 1, 2018 Hydrogeologic Re-Evaluation Report. Pretec resumed HDD operations on the east side and removed both the 16-inch and 24-inch diameter protective casing from the borehole, leaving approximately 40 feet of 30-inch diameter protective surface casing at the east entry point. Pretec initiated reaming from east to west using a 22-inch diameter reaming bit.
- **June 13, 2018:** After reaming to 168 feet from the east entry point the reamer stopped advancing. Pretec pulled the rods, but the reamer bit, sub and pilot rod were stuck in the borehole.
- **June 14, 2018:** Pretec installed 16-inch diameter protective casing to a point 175 feet from the east entry point (this casing was removed on June 16, 2018). PA DEP also granted approval to SPLP to operate two HDD rigs independently from opposing ends of the HDD bore path, as requested by SPLP in the June 1, 2018 Hydrogeologic Re-Evaluation Report. This approval was granted until such time that the HDD rigs were hydraulically communicating.

- **June 15-20, 2018:** Pretec attempted unsuccessfully to retrieve the bit, sub, and pilot rod from the borehole.
- **June 24, 2018:** Part of a fishing tool was lost downhole when the drill string was pulled by American Augers DD-10 rig. Pretec replaced American Augers DD-10 rig with a UNI 250x400 rig. One unsuccessful fishing attempt was made with the UNI 250x400 rig before abandoning the borehole.
- **June 25, 2018:** Pretec began drilling a new offset borehole 5 feet south of the abandoned borehole (east side of HDD).
- **June 27, 2018:** The IR Containment BMP was reactivated during the new offset borehole drilling when the bit was 186 feet from the east entry point. Pretec began pumping drilling fluid back to the east entry pit where it was recirculated during pilot bit advancement.
- **July 7, 2018:** HDD operations from the east side were shut down due to an IR of less than one gallon that was observed within the former IR containment area (from 2017) located closest to the west bank of LeTort Spring Run. At the time of this IR, the pilot bit was 650 feet from the east entry point. HDD operations were shut down pending PA DEP restart approval.
- **July 20, 2018:** PA DEP grants SPLP approval to restart HDD operations.
- **July 21, 2018:** Pretec injects a 1,000-gallon LCM pill containing bentonite, MAGMA Fiber and AMC Plug into the east side bore.
- **July 22, 2018:** Pretec resumes east- and west-side pilot drilling.
- **July 25, 2018:** Pretec ceases east-side drilling so Precision can perform hydrostatic testing on pipe segment from LeTort (east side) to Appalachian Drive (east side). During pilot drilling from the west side only, two previous IRs were reactivated – one within a permitted IR Containment BMP (where the 4/25/17, 5/1/18 and 5/5/18 IRs occurred in quantities of less than five gallons), and one at the easternmost May 3, 2017 IR location (also less than 5 gallons). HDD operations were shut down immediately and the IRs cleaned up using a vacuum truck. At the time of these IRs, the pilot bit from the west-side drilling was 682 feet from the west entry point and 106 feet bgs.
- **August 2, 2018:** Lost approximately 70% circulation during drilling Joint #50, at a bit location 1,011 feet from east side entry point. Two IRs were observed on the west side of LeTort Spring Run. The first IR occurred in the permitted IR Containment BMP at STATION 10117+00 and the second IR occurred in an upland area on the west side of LeTort Spring Run at the same location the July 25, 2018 IR occurred. At the time of the IRs, the pilot bit was located at 1,021 feet from the east side entry point. Pretec stopped advancing the pilot bit and pumped 1,000 gallons of LCM into the borehole.
- **August 6, 2018:** During trip in activities, permitted IR Containment BMP at STATION 10117+00 was reactivated. Pretec pumped/recirculated drilling fluid from the containment area back to the west side reclaimer.
- **August 23, 2018:** A new IR was observed on the west side HDD at STATION 10113+32 (Note: this IR location has since been approved by the PA DEP as a permitted IR Containment BMP). Pretec cleaned up approximately 80 gallons of drilling fluid. Upon submittal of documentation to the PA DEP from Sunoco/ETP, the PA DEP grants restart approval to Sunoco/ETP.
- **August 24, 2018:** Pretec completed the pilot hole for the 20-inch HDD.
- **August 26, 2018:** Pretec began 22-inch diameter pull-ream from west to east.

- **September 4, 2018:** LOR of approximately 8,000 – 10,000 gallons of drilling fluid was reported by Pretec, at which time the 22-inch reamer bit was located 1,054 feet from the west side entry point. Pretec stopped operations and pumped 10,000 gallons of LCM into the borehole. During placement of the LCM and subsequent flushing of drill rods, an upland IR occurred at STATION 10122+21 (Note: this IR location has since been approved by the PA DEP as a permitted IR Containment BMP). Pretec cleaned up approximately 25 gallons of drilling fluid released to the ground surface using a vacuum truck.
- **September 5, 2018:** Pretec started 30-inch pull-reaming from west to east to open up the boring and improve returns.
- **September 11, 2018:** Pretec stopped pull-reaming with a 30-inch reamer bit at 1,039.5 feet from the west entry point and resumed pull-reaming with a 22-inch reamer bit from west to east.
- **September 13, 2018:** A new IR, located within LeTort Spring Run at STATION 10125+37, initially released approximately 2 gallons of drilling fluid into LeTort Spring Run. At the time of the IR, the 22-inch reamer bit was approximately 1,364 feet from the west entry point. Pretec cleaned up the release and drilling fluid that had settled on the stream bed using a vacuum truck. During subsequent placement of approximately 2,000 gallons of LCM into the borehole, the IR reactivated and an additional estimated 6 gallons of drilling fluid was released into LeTort Spring Run. This additional drilling fluid was also cleaned up by Pretec using a vacuum truck. As a result, an estimated total of 7 gallons of drilling fluid was released as a result of this IR. HDD operations ceased pending restart approval by the PA DEP.
- **September 14-25, 2018:** Upon restart approval, Pretec mobilized a drill rig to the west side and 22-inch pull-reaming was resumed from east to west and was completed on September 17, 2018. During the remainder of the 22-inch reaming, and during the 30-inch reaming (completed on September 19, 2018) and subsequent swab passes, reactivations of permitted IR Containment BMPs occurred but there were no new IRs. The 20-inch pipe was successfully pulled on September 25, 2018.

8.0 CONCEPTUAL HYDROGEOLOGIC MODEL AND CONCLUSION

Based on published geologic and hydrogeologic information, geotechnical borings, field observations and geophysical surveys, the LeTort Spring Run HDD is underlain by carbonate rocks of the St. Paul Group composed primarily of very finely crystalline limestone and dolomite. The hydrogeologic setting is dominated by groundwater flow that occurs in secondary openings along geologic features that include bedding planes, joints, faults and fractures. In these carbonate rocks, these well-developed secondary openings are enlarged or enhanced by dissolution to provide moderate to high permeability. Water-bearing zones, including those that supply water wells, generally occur at relatively shallow depths below the ground surface. Water-bearing zones in the St. Paul Group are abundant at shallow depths and typically extend to depths of approximately 250 feet bgs.

The originally proposed 16-inch HDD profile was relatively shallow at the entry and exit points and passed through both the unconsolidated overburden and fractured bedrock. Based on the hydro-structural characteristics of the underlying geology described in this report and the previous occurrence of IRs during installation of the 20-inch pipe, the LeTort Spring Run HDD site is susceptible to an IR of drilling fluids during HDD operations. As a result, the HDD profile has been redesigned to allow for deeper crossings

beneath the wetlands and streams. The revised profile is approximately 115 feet below LeTort Spring Run (this is approximately 17 feet deeper than the 20-inch pipe). The inclination of the entry and exit angles has been increased to allow the pipe to be installed through protective soils, residual soils, and bedrock, and in closer proximity to the entry and exit points than the original, shorter and shallower profile. From a geologic perspective, the longer and deeper profile, in conjunction with the proposed engineering controls and/or drilling best management practices, will be used to reduce the risk of an IR and/or a loss of drilling fluid. Drilling procedures should account for the variability in bedrock strength and fractures. This includes the immediate suspension of drilling activity, and concurrent assessment, at the initial sign of any drilling fluid loss in accordance with the procedures and Containment BMPs implemented by the ME II HDD program in the summer of 2018.

9.0 REFERENCES

- A.E. Becher and S.I. Root, 1981, *Groundwater and Geology of the Cumberland Valley, Cumberland County, Pennsylvania*, Pennsylvania Geological Survey, Water Resource Report 50.
- A.R. Geyer and J.P. Wilshusen, 1982, *Engineering Characteristics of the Rocks of Pennsylvania*, Pennsylvania Department of Environmental Resources, Office of Resource Management, Bureau of Topographic and Geologic Survey.
- Arthur Socolow, 1980, *Geologic Map of Pennsylvania*, Pennsylvania Department of Environmental Resources, Bureau of Topographic and Geologic Survey.
- Google Earth Pro, 2017, Version 7.3.2, accessed January 24, 2019.
- Pennsylvania Department of Conservation and Natural Resources, Pennsylvania Groundwater Information System (PaGWIS) database, website address: <http://www.dcnr.pa.gov/Conservation/Water/Groundwater/PAGroundwaterInformationSystem/Pages/default.aspx>, accessed January 24, 2019.
- S. I. Root, 1978, *Geology and Mineral Resources of the Carlisle and Mechanicsburg Quadrangles, Cumberland County, Pennsylvania*.
- United States Department of Agriculture, 2017, Natural Resources Conservation Service, Published Soil Surveys for Pennsylvania, Blair County, Pennsylvania: website address: <https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>, accessed January 9, 2018.
- United States Geological Survey, 20130620, USGS US Topo 7.5-minute map for Carlisle, PA 2013: USGS - National Geospatial Technical Operations Center (NGTOC).
- W.D. Sevon, 2000, *Physiographic Provinces of Pennsylvania*, Pennsylvania Bureau of Topographic and Geologic Survey, Harrisburg, Pennsylvania, Map 13.

10.0 CERTIFICATION

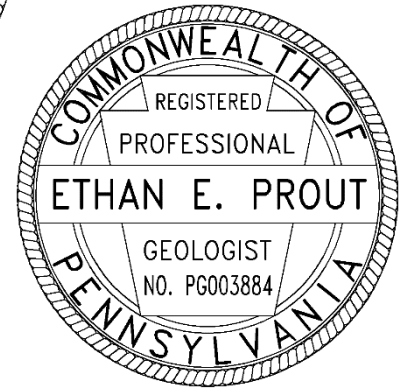
The studies and evaluations presented in this report (other than Section 5.0) were completed under the direction of a licensed professional geologist (PG) and are covered under the PG seals that follow.

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

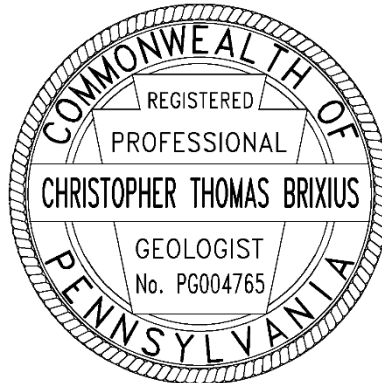
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Ethan E. Prout, PG
License No. PG003884

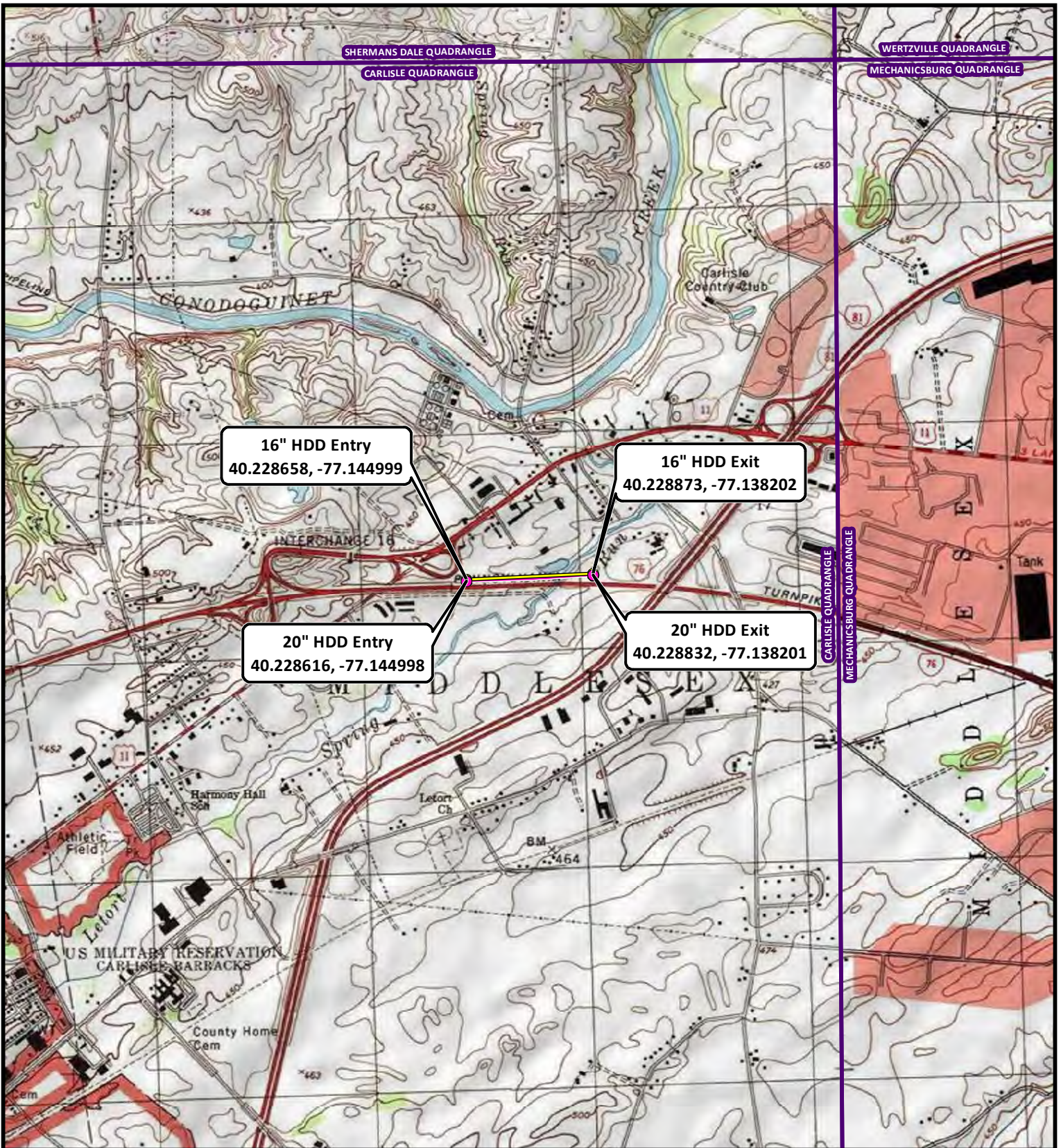


Christopher T. Brixius, PG
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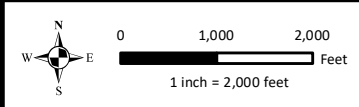
Enclosure

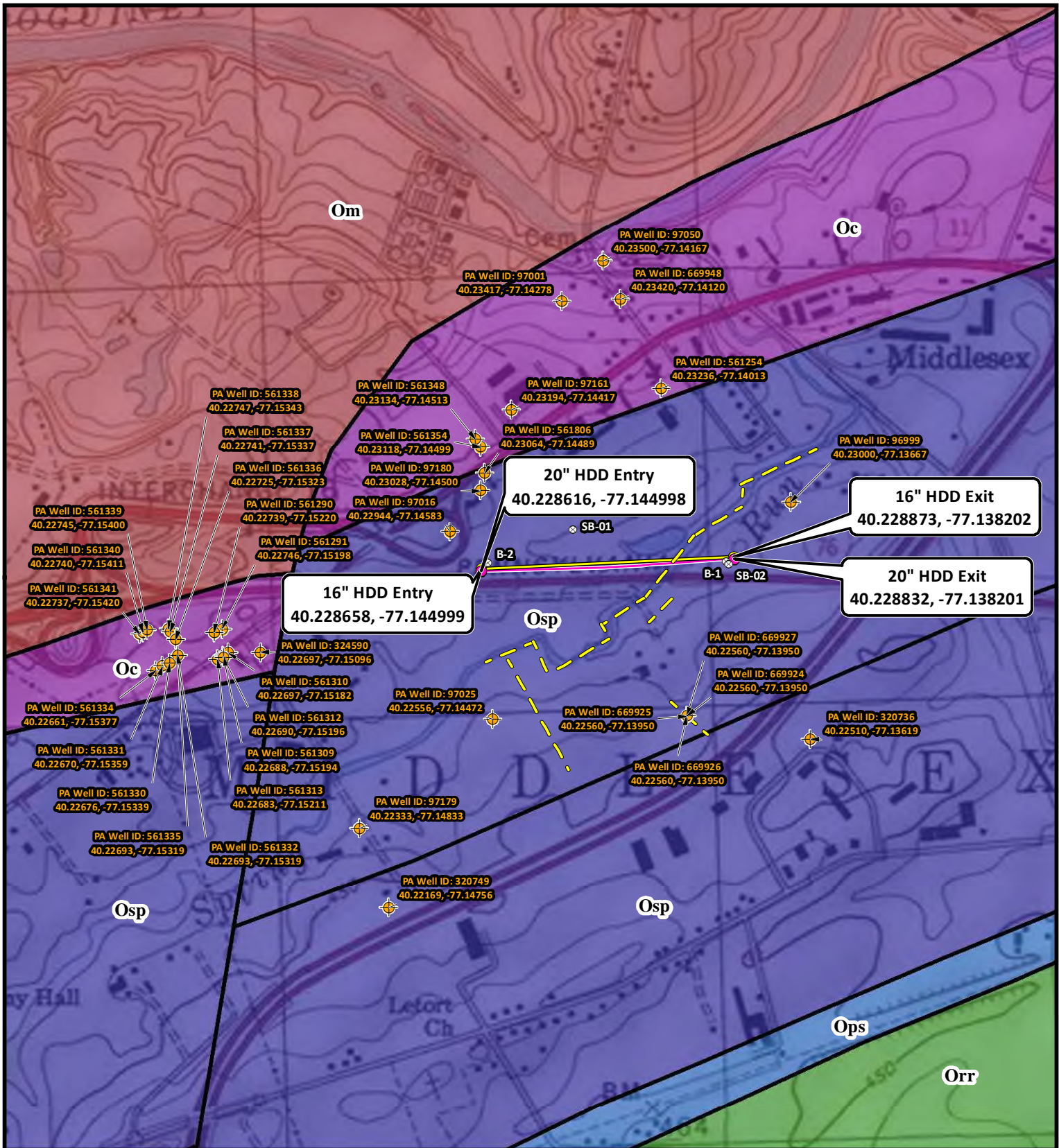
FIGURES



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

Sunoco Pipeline, L.P.
LeTort Spring Run HDD Location
 Figure 1 - Topographic Basemap
 Middlesex Township, Cumberland County, PA
 Project No. 096302011

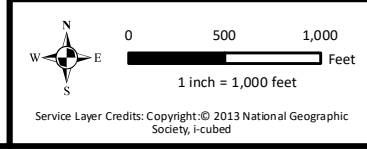




- Residential Well
- Soil Boring
- 16" HDD Entry/Exit
- 20" HDD Entry/Exit
- 16" HDD Profile
- 20" HDD Profile
- Inferred Fracture Trace

- Geologic Formation**
- Oc - Chambersburg Formation
 - Om - Martinsburg Formation
 - Ops - Pinesburg Station Formation
 - Orr - Rockdale Run Formation
 - Osp - St. Paul Group

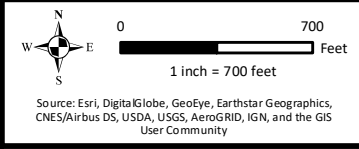
Sunoco Pipeline, L.P.
LeTort Spring Run HDD Location
 Figure 2 - Geologic Map
 Middlesex Township, Cumberland County, PA
 Project No. 096302011





- ◆ Residential Well
- 20" HDD Profile
- Soil Boring
- 16" HDD Entry/Exit
- 20" HDD Entry/Exit
- - - 16" HDD Profile
- - - Inferred Fracture Trace
- NHD Stream
- Road

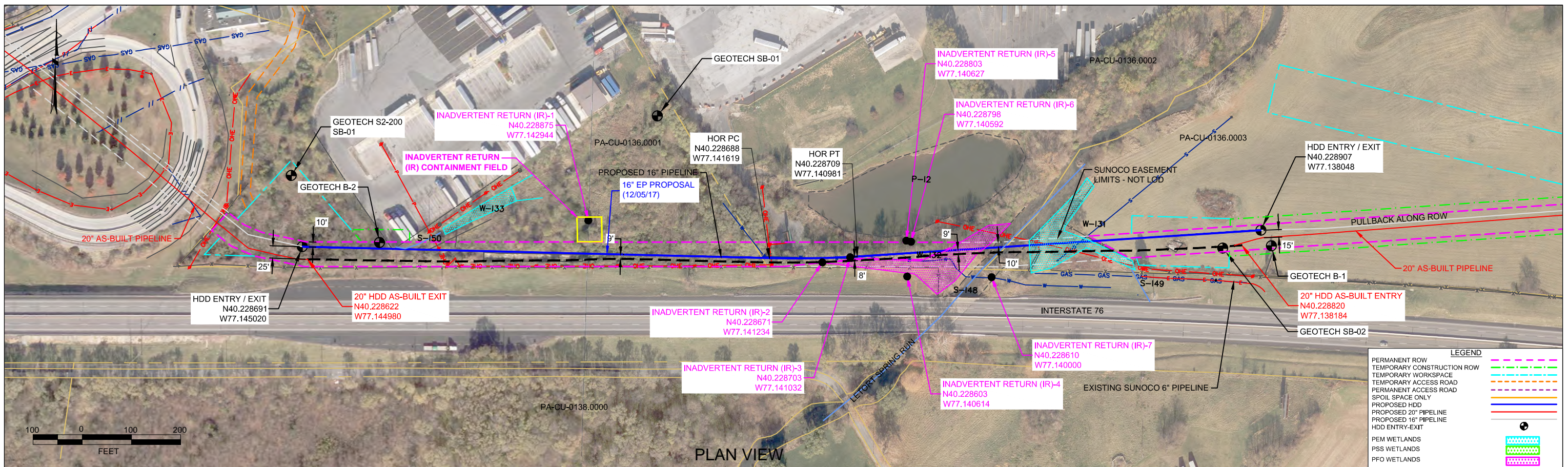
Sunoco Pipeline, L.P.
LeTort Spring Run HDD Location
Figure 3 - Aerial Basemap
 Middlesex Township, Cumberland County, PA
 Project No. 096302011



1/25/2019



ATTACHMENT 1
HDD PROFILES AND GEOTECHNICAL BORING LOGS



PLAN VIEW
PROFILE VIEW

LEGEND

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

CUMBERLAND COUNTY, PENNSYLVANIA - MIDDLESEX TOWNSHIP
S2-0210-16

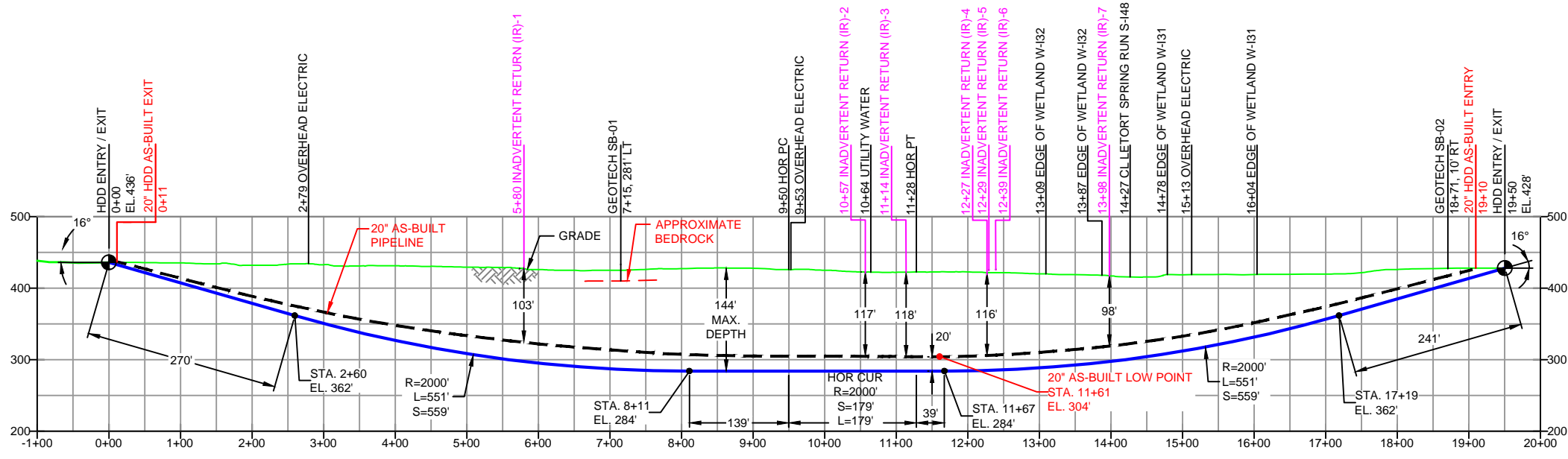
GEOTECH SB-01

- NG EL. 431'
- TOPSOIL (<1')
- ML (0.0' - 7.5')
- LIMESTONE (7.5' - 8.8')
- SILT (USCS:MH) (8.8' - 15.0')
- AUGER REFUSAL (15.0')
- COMPLETION DEPTH EL. 416'

GEOTECH SB-02

- NG EL. 427'
- TOPSOIL (0' - 0.1')
- GROUNDWATER (11.0')
- SILT (USCS:MH) (0.1' - 26.5')
- LIMESTONE (26.5' - 28.4')
- COMPLETION DEPTH EL. 399'

NOTE: REFER TO TEST BORING LOG S2-0200 FOR COMPLETE SOIL MATERIAL DESCRIPTION



GEOTECH B-2

- NG EL. 435'
- RESIDUUM-LEAN CLAY/SAND CL (0.0' - 6.5')
- SPOON REFUSAL (4.5')
- GROUNDWATER (16.3')
- BEDROCK-DOLOMITE CL (6.5' - 150')
- COMPLETION DEPTH EL. 285'

NOTE: REFER TO TEST BORING LOG B-2 INTERTEK / PSI PROJECT #04911412 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-1

- NG EL. 427'
- RESIDUUM-LEAN CLAY/SAND CL (0.0' - 3.5')
- RESIDUUM-BROWN CLAY WITH GRAVEL ROCK CL (3.5' - 7.5')
- GROUNDWATER (9.0')
- BEDROCK-DOLOMITE CL (7.5' - 150.5')
- COMPLETION DEPTH EL. 276.5'

NOTE: REFER TO TEST BORING LOG B-1 INTERTEK / PSI PROJECT #04911412 FOR COMPLETE SOIL MATERIAL DESCRIPTION

- DESIGN AND CONSTRUCTION:**
- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
 - THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
 - DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
 - CROSSING PIPE SPECIFICATION:
HDD HORZ. LENGTH (L=): 1950'
HDD PIPE LENGTH (S=): 1986'
16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
 - INTERNAL DESIGN PRESSURE 2100 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 - CARRIER PIPE NOT ENCASED.
 - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 2625 PSIG.
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
 - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
 - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

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

REF. DRAWING		REVISIONS	
ES-4.57	TO ES-4.58	DESCRIPTION	DATE
SHEET 36	SHEET 37	AERIAL SITE PLAN	
		DESIGN CHANGE - INCREASED DEPTH OF DRILL	MRS 12/11/18
		UPDATED NOTE 5 AND 10 PER INCREASED 16" MOP	MRS 04/10/18
		LOWERED DRILL AND RELOCATED ENTRY/EXIT - DESIGN CHANGE REQUESTED BY CLIENT	MRS 12/05/17
		REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS 10/07/16
		REVISED PER PADEP COMMENTS	MRS 05/10/16
			JTW 03/23/16
DWG NO	DWG NO	DESCRIPTION	NO.

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
LETORT SPRING RUN
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' DWG. NO. PA-CU-0136.0002-WX-16

Figure 1: Site Vicinity Map

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

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



Figure 2: Boring Location Plan

LaTort Spring Run (PPP4) - Cumberland Co, Pa

PSI Project No.: 04911412

(Boring locations are approximate; surveyed elevations/coordinates not provided or available)



DATE STARTED: 6/26/17 **DRILL COMPANY:** Eichelberger's, Inc.
DATE COMPLETED: 6/27/17 **DRILLER:** **LOGGED BY:** F. Hoffman
COMPLETION DEPTH: 150.5 ft **DRILL RIG:** Diedrich D-50 Track Rig
BENCHMARK: N/A **DRILLING METHOD:** Rollerbit/Rock Coring
ELEVATION: N/A **SAMPLING METHOD:** 2-in SS1.874-in Core
LATITUDE: n/a° **HAMMER TYPE:** Automatic
LONGITUDE: n/a° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael
REMARKS: Boring location selected in the field (no surveyed ground EL or coordinates provided)

BORING B-1

Water	▽ Pre-Coring	Not Enc.
	▽ Post-Coring	9 feet
	▽	

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STRENGTH, tsf	Additional Remarks
0				S-1	13	RESIDUUM- Medium Stiff, Brown, Lean CLAY with Sand, moist	CL	4-3-3-3 N=6	⊙		
5				R-1	27	RESIDUUM- A split-spoon sample was attempted from 5 to 7 feet; however, a pinnacle was encountered which bent the sampler making recovery of the sample impossible. Coring operations were initiated at 5 feet bgs with soil being encountered until approximately 7-1/2 feet bgs. Recovered soil consisted of brown clay with gravel-sized rock fragments. BEDROCK- Light gray to dark gray, Dolomite, Very fine-grained, Slightly Weathered to Weathered, diagonal to nearly vertical fractures Highly Weathered Zone from 9 to 9.1 feet. Weathered Fracture @ 10.3 feet (nearly vertical) Presumed soil zone from approximately 10.7 to 11.9 feet. No sample was recovered between these depths and it is assumed that the soil washed out of the core barrel. Weathered Fracture @ 11.9 feet (diagonal)	CL	RQD=28 Rec=45%			2 min. 2 min. 2 min. 3 min.
10				R-2	49	BEDROCK- Gray, Dolomite, Very fine-grained, Slightly Weathered, horizontal to diagonal fractures Appx. 1/4-inch thick soil seam @ 15 feet		RQD=60 Rec=81%			3 min. 3 min. 3 min. 5 min.
15				R-3	59	Weathered Fracture @ 19.1 feet (nearly horizontal) Weathered Fracture @ 20.9 feet (diagonal)		RQD=96 Rec=98%			3 min. 4 min. 4 min.
20				R-4	53	Weathered Fracture @ 22.8 feet (horizontal)		RQD=87 Rec=88%			3 min. 3 min. 3 min. 3 min.

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

PROJECT NO.: 04911412
PROJECT: Energy Transfer HDD (DPS)
LOCATION: LaTort Spring Run (PPP4)
 Carlisle
 Cumberland Co, PA

DATE STARTED: 6/26/17 **DRILL COMPANY:** Eichelberger's, Inc.
DATE COMPLETED: 6/27/17 **DRILLER:** **LOGGED BY:** F. Hoffman
COMPLETION DEPTH: 150.5 ft **DRILL RIG:** Diedrich D-50 Track Rig
BENCHMARK: N/A **DRILLING METHOD:** Rollerbit/Rock Coring
ELEVATION: N/A **SAMPLING METHOD:** 2-in SS1.874-in Core
LATITUDE: n/a° **HAMMER TYPE:** Automatic
LONGITUDE: n/a° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael
REMARKS: Boring location selected in the field (no surveyed ground EL or coordinates provided)

BORING B-1

Water	▽ Pre-Coring	Not Enc.
	▼ Post-Coring	9 feet
	▽	

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	STANDARD PENETRATION TEST DATA				Additional Remarks	
									N in blows/ft ©					
									Moisture, %					
									STRENGTH, tsf					
									X Moisture □ PL + LL ▲ Qu * Qp					
				R-5	48	BEDROCK - Gray, Dolomite, Very fine-grained, Highly Weathered, broken		RQD=81 Rec=100%						3 min. 3 min. 3 min. 4 min. 2 min.
	30			R-6	56	BEDROCK - Light gray to dark gray, Dolomite, Very fine-grained, Slightly Weathered, horizontal to nearly vertical fractures		RQD=68 Rec=93%						5 min. 5 min. 5 min. 3 min. 3 min.
	35			R-7	48	Highly Weathered Zone from 35.5 to 35.6 feet. Weathered Fracture @ 35.6 feet (horizontal) Weathered Fracture @ 36.2 feet (diagonal)		RQD=94 Rec=100%						3 min. 3 min. 4 min. 5 min. 3 min.
	40			R-8	60	Moderate Rx to 10%HCL		RQD=90 Rec=100%						3 min. 3 min. 4 min. 4 min.
	45			R-9	47	Highly Weathered Zone from 41.8 to 42.1 feet. Weathered Fracture @ 42.8 feet (diagonal, quartz in fracture) Weathered Fracture @ 43.4 feet (diagonal)		RQD=97 Rec=98%						3 min. 3 min. 4 min. 4 min.
	50			R-10	60	Weathered Fracture @ 49.5 feet (diagonal)		RQD=100 Rec=100%						4 min. 4 min.

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ELEVATION: N/A **SAMPLING METHOD:** 2-in SS1.874-in Core
LATITUDE: n/a° **HAMMER TYPE:** Automatic
LONGITUDE: n/a° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael
REMARKS: Boring location selected in the field (no surveyed ground EL or coordinates provided)

BORING B-1

Water Pre-Coring Not Enc.
 Post-Coring 9 feet

BORING LOCATION:
 See Boring Location Plan

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft @	Additional Remarks
									<input checked="" type="checkbox"/> Moisture <input type="checkbox"/> PL <input type="checkbox"/> <input type="checkbox"/> LL	STRENGTH, tsf <input checked="" type="checkbox"/> Qu <input type="checkbox"/> * Qp	
55			R-11		60	BEDROCK- Light gray to dark gray, Dolomite, Very fine-grained, Slightly Weathered, horizontal to nearly vertical fractures Weathered Fracture @ 55.5 feet (nearly vertical) Highly Weathered Zone from 55.6 to 56 feet. Weathered Fracture @ 56 feet (nearly horizontal) Moderate Rx to 10%HCL		RQD=88 Rec=100%			5 min. 3 min. 4 min.
60			R-12		60	Weathered Fracture @ 60.5 feet (horizontal)		RQD=98 Rec=100%			2 min. 5 min. 3 min. >>▲ Qu = 1249.4 tsf 4 min.
65			R-13		60	Weathered Fracture @ 66.8 feet (horizontal)		RQD=97 Rec=100%			3 min. 5 min. 2 min. 3 min.
70			R-14		60	Weathered Fracture @ 69.6 feet (diagonal)		RQD=100 Rec=100%			3 min. 3 min. 3 min. 3 min.
75			R-15		60	Weathered Fracture @ 71.6 feet (nearly horizontal) Weathered/Mechanical Fracture @ 75 feet (diagonal, broke when handled) Weathered Fracture @ 75.5 feet (diagonal) Weathered Fracture @ 76 feet (nearly vertical) Moderate Rx to 10%HCL		RQD=98 Rec=100%			5 min. 4 min. 3 min. 3 min. 2 min. 3 min. 5 min. >>▲ Qu = 927.0 tsf
Continued Next Page											



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COMPLETION DEPTH: 150.5 ft **DRILL RIG:** Diedrich D-50 Track Rig
BENCHMARK: N/A **DRILLING METHOD:** Rollerbit/Rock Coring
ELEVATION: N/A **SAMPLING METHOD:** 2-in SS1.874-in Core
LATITUDE: n/a° **HAMMER TYPE:** Automatic
LONGITUDE: n/a° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael
REMARKS: Boring location selected in the field (no surveyed ground EL or coordinates provided)

BORING B-1

Water	▽	Pre-Coring	Not Enc.
	▼	Post-Coring	9 feet
	▽		

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA				Additional Remarks
										N in blows/ft @				
	80			R-16	60	BEDROCK- Gray to light gray, Dolomite , Very fine-grained, Weathered to Highly Weathered Weathered Fracture @ 78.3 feet (nearly vertical) Weathered Fracture @ 79 feet (horizontal) Weathered Fracture @ 80.5 feet (nearly horizontal)		RQD=62 Rec=100%						5 min. 5 min. 4 min. 2 min. 3 min. 6 min.
	85			R-17	37	Weathered Fracture @ 82.4 feet (nearly vertical, soil in fracture) BEDROCK- Light gray to dark gray, Dolomite , Very fine-grained, Slightly Weathered, nearly horizontal to vertical fractures Weathered Fracture @ 84.4 feet (nearly vertical, soil in fracture) Soil Layer from 84.5 to 85 feet. Highly Weathered Zone from 85 to 85.5 feet. Broken/very broken layer from 85.5 to 86.6 feet; some quartz.		RQD=38 Rec=88%					5 min. 3 min. 6 min. 5 min.	
	90			R-18	60	Weathered Fracture @ 86.3 feet (nearly vertical) Developing Fracture @ 88.8 feet (vertical)		RQD=87 Rec=100%					4 min. 3 min. 5 min.	
	95			R-19	18			RQD=100 Rec=100%					4 min. 3 min. 5 min.	
	100			R-20	60			RQD=100 Rec=100%					5 min. 4 min. 4 min. 5 min. 4 min. 4 min.	
				R-21	60	Weathered Fracture @ 100.6 feet (nearly horizontal)		RQD=100 Rec=100%					4 min. 2 min. 4 min. 3 min. 4 min.	

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COMPLETION DEPTH: 150.5 ft **DRILL RIG:** Diedrich D-50 Track Rig
BENCHMARK: N/A **DRILLING METHOD:** Rollerbit/Rock Coring
ELEVATION: N/A **SAMPLING METHOD:** 2-in SS1.874-in Core
LATITUDE: n/a° **HAMMER TYPE:** Automatic
LONGITUDE: n/a° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael
REMARKS: Boring location selected in the field (no surveyed ground EL or coordinates provided)

BORING B-1

Water	▽ Pre-Coring	Not Enc.
	▼ Post-Coring	9 feet
	▽	

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft © X Moisture PL LL +	STRENGTH, tsf ▲ Qu * Qp	Additional Remarks
105			R-22		60	BEDROCK - Gray to dark gray, Dolomite , Very fine-grained, Slightly Weathered, horizontal to nearly vertical fractures Developing Fracture @ 104.2 feet (diagonal) Weathered Fracture @ 104.8 feet (diagonal) Weathered Fracture @ 105.7 feet (diagonal) Broken Zone from 105.7 to 107 feet.		RQD=73 Rec=100%				4 min. 5 min. 3 min. 4 min. 4 min.
110			R-23		55	Low Rx to 10%HCL Weathered Fracture @ 110.7 feet (horizontal) Developing Fracture @ 111.2 feet (nearly vertical) Weathered Fracture @ 111.8 feet (nearly horizontal) Broken Zone from 113.1 to 113.4 feet.		RQD=71 Rec=92%				4 min. 3 min. 5 min. 6 min. 3 min.
115			R-24		48	BEDROCK - Light gray to gray, Dolomite , Very fine-grained, Slightly Weathered, horizontal to nearly vertical fractures Developing Fracture @ 113.7 feet (nearly vertical) Developing Fractures @ 114.2 feet (horizontal & diagonal)		RQD=92 Rec=100%			>>▲ Qu = 1049.7 tsf	4 min. 5 min.
120			R-25		60	BEDROCK - Gray to dark gray, Dolomite , Very fine-grained, Slightly Weathered, horizontal to nearly vertical fractures (Little to No Rx to 10%HCl) Weathered Fracture @ 116.3 feet (nearly vertical) Developing Fracture @ 117.7 feet (nearly vertical)		RQD=73 Rec=100%				4 min. 4 min. 4 min. 3 min.
125			R-26		30	Weathered Fracture @ 118.4 feet (diagonal) Weathered Fracture @ 119.3 feet (nearly vertical) Weathered Fracture @ 119.4 feet (nearly horizontal)		RQD=30 Rec=100%				4 min. 4 min. 3 min.
125			R-27		42	BEDROCK - Gray to black, Dolomite , Very fine-grained, Slightly Weathered to Weathered, broken BEDROCK - Light gray to gray, Limestone , Very fine-grained to fine-grained, Slightly Weathered, horizontal to nearly vertical fractures (Low Rx to 10%HCl)		RQD=86 Rec=100%				4 min. 4 min. 4 min.
130			R-28		60	Weathered Zone from 128.6 to 128.8 feet.		RQD=72				4 min.

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BENCHMARK: N/A **DRILLING METHOD:** Rollerbit/Rock Coring
ELEVATION: N/A **SAMPLING METHOD:** 2-in SS1.874-in Core
LATITUDE: n/a° **HAMMER TYPE:** Automatic
LONGITUDE: n/a° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael
REMARKS: Boring location selected in the field (no surveyed ground EL or coordinates provided)

BORING B-1

Water
 ▽ Pre-Coring Not Enc.
 ▼ Post-Coring 9 feet
 ▽

BORING LOCATION:
 See Boring Location Plan

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft © X Moisture PL LL STRENGTH, tsf ▲ Qu * Qp	Additional Remarks
130						BEDROCK- Light gray to gray, Limestone , Very fine-grained to fine-grained, Slightly Weathered, horizontal to nearly vertical fractures (Low Rx to 10%HCl) Weathered Fracture @ 130.1 feet (diagonal) Weathered Zone from 131.3 to 131.7 feet. Multiple Developing Fractures from 137.6 to 138.5 feet (nearly vertical). Developing Fracture @ 139.2 feet (horizontal) Weathered Fracture @ 141.2 feet (nearly horizontal, quartz in fracture) Low to Moderate Rx to 10%HCL Developing Fracture from 144.6 to 146.3 feet (nearly vertical, broke when handled)	Rec=100%			4 min.	
				R-29	60		RQD=100 Rec=100%			>>▲ Qu = 1082.4 tsf	4 min.
										4 min.	
										4 min.	
				R-30	60		RQD=99 Rec=99%			4 min.	
										4 min.	
										4 min.	
				R-31	60		RQD=100 Rec=100%			4 min.	
										4 min.	
				R-32	42		RQD=100 Rec=100%			>>▲ Qu = 1016.7 tsf	3 min.
									5 min.		
									3 min.		
									5 min.		
									4 min.		
						Test boring terminated @ 150.5 feet					



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LATITUDE: n/a° **HAMMER TYPE:** Automatic
LONGITUDE: n/a° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael
REMARKS: Boring location selected in the field (no surveyed ground EL or coordinates provided)

BORING B-2

Water	▽ Pre-Coring	Not Enc.
	▼ Post-Coring	16.3 feet
	▽	

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STRENGTH, tsf	Additional Remarks
0				S-1	19	RESIDUUM -Brown, Lean CLAY, trace Sand, moist	CL	2-4-4-6 N=8	⊙		
5						Rollerbit Refusal @ 4.5 feet					
				R-1	31	BEDROCK - Gray, Dolomite , Very fine-grained, Highly Weathered, broken		RQD=0 Rec=74%			3 min. 2 min.
						Weathered Fracture @ 8.9 feet (diagonal)					2 min.
				R-2	52	BEDROCK - Light gray to gray, Dolomite , Very fine-grained, Slightly Weathered to Weathered, horizontal to vertical fractures		RQD=39 Rec=86%			3 min. 5 min. 3 min.
						Weathered Fracture @ 9.4 feet (nearly horizontal)					4 min.
						Weathered Fracture @ 9.5 feet (nearly horizontal, quartz in fracture)					>>▲ _{Qu} = 608.4 tsf 3 min.
						Developing Fractures @ 9.9 feet (nearly horizontal & vertical)					3 min.
						Weathered Fracture @ 10.2 feet (nearly horizontal)					2 min.
				R-3	60	BEDROCK - Light gray to gray, Dolomite , Very fine-grained, Slightly Weathered, horizontal to vertical fractures (Low Rx to 10%HCL)		RQD=97 Rec=99%			2 min. 2 min. 4 min.
						Developing Fractures from 15.2 to 16.4 feet (diagonal to nearly vertical)					3 min.
						Developing Fractures @ 16.8 feet (nearly vertical)					3 min. 1 min.
				R-4	30	Developing Fracture @ 17.5 feet (diagonal)		RQD=80 Rec=100%			3 min.
						Weathered Zone from 19.5 to 19.7 feet.					3 min.
						Weathered Zone from 20.5 to 21.5 feet.					2 min. 3 min. 3 min.
				R-5	47			RQD=76 Rec=87%			2 min. 3 min. 3 min.

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COMPLETION DEPTH: 150.0 ft **DRILL RIG:** Diedrich D-50 Track Rig
BENCHMARK: N/A **DRILLING METHOD:** Rollerbit/Rock Coring
ELEVATION: N/A **SAMPLING METHOD:** 2-in SS1.874-in Core
LATITUDE: n/a° **HAMMER TYPE:** Automatic
LONGITUDE: n/a° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael
REMARKS: Boring location selected in the field (no surveyed ground EL or coordinates provided)

BORING B-2

Water	▽ Pre-Coring	Not Enc.
	▼ Post-Coring	16.3 feet
	▽	

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STRENGTH, tsf	Additional Remarks
				R-6	60	BEDROCK - Light gray to gray, Dolomite , Very fine-grained, Slightly Weathered, horizontal to vertical fractures (Low Rx to 10%HCL) Weathered Fracture @ 27.2 feet (diagonal)		RQD=100 Rec=100%			3 min. 3 min. 3 min. 3 min. 3 min.
	30			R-7	60	Weathered Fracture @ 31.6 feet (diagonal) BEDROCK - Dark gray, Dolomite , Very fine-grained, Highly Weathered, very broken BEDROCK - Light gray to gray, Dolomite , Very fine-grained, Slightly Weathered, horizontal to diagonal fractures (Low to Moderate Rx to 10%HCL) Weathered Fracture @ 34.1 feet (nearly horizontal) Weathered Zone from 34.8 to 35 feet. Granular Weathered Zone from 35.7 to 36 feet.		RQD=77 Rec=100%			4 min. 5 min. 3 min. 5 min.
	35			R-8	60	Weathered Fracture @ 36.5 feet (nearly horizontal) Weathered Fracture @ 37.4 feet (diagonal) Weathered Fracture @ 37.8 feet (horizontal)		RQD=49 Rec=100%			4 min. 3 min. 3 min.
	40			R-9	60	BEDROCK - Dark gray to light gray-brown, Dolomite , Very fine-grained, Weathered to Highly Weathered, broken (Low to Moderate Rx to 10%HCL) BEDROCK - Gray to dark gray, Dolomite , Fine-grained to very fine-grained, Slightly Weathered, horizontal to nearly vertical fractures (Moderate Rx to 10%HCL)		RQD=97 Rec=100%			2 min. 2 min. 3 min. 4 min.
	45			R-10	60	Weathered Fracture @ 46.2 feet (horizontal) Weathered Fracture @ 50.8 feet (diagonal)		RQD=100 Rec=100%			>>▲ Q _u = 607.1 tsf 2 min. 3 min. 4 min. 4 min. 2 min. 3 min. 3 min.

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ELEVATION: N/A **SAMPLING METHOD:** 2-in SS1.874-in Core
LATITUDE: n/a° **HAMMER TYPE:** Automatic
LONGITUDE: n/a° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael
REMARKS: Boring location selected in the field (no surveyed ground EL or coordinates provided)

BORING B-2

Water	▽ Pre-Coring	Not Enc.
	▼ Post-Coring	16.3 feet
	▽	

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STRENGTH, tsf	Additional Remarks
80				R-17	60	BEDROCK- Light gray to dark gray, Dolomite , Fine-grained to very fine-grained, Slightly Weathered, horizontal to nearly vertical fractures		Rec=100%			2 min. 3 min. 3 min.
85				R-18	60	Developing Fractures @ 84.7 feet (nearly vertical) Weathered Fracture @ 85.3 feet (nearly vertical) Weathered Fracture @ 87.8 feet (diagonal)		RQD=98 Rec=100%			>>▲ Qu = 912.2 tsf 4 min. 3 min. 4 min.
90				R-19	58	Weathered Fracture @ 89.5 feet (diagonal) Weathered Fracture @ 90.6 feet (diagonal) Weathered Fracture @ 91.6 feet (diagonal) Weathered Fracture @ 92.3 feet (nearly horizontal)		RQD=88 Rec=100%			4 min. 3 min. 3 min. 4 min.
95				R-20	54	Weathered Fracture @ 94.3 feet (nearly horizontal) Developing Fracture @ 97.1 feet (diagonal) Weathered Fracture @ 98.8 feet (diagonal)		RQD=96 Rec=96%			4 min. 4 min. 3 min. 3 min.
100				R-21	54	Weathered Fracture @ 101.2 feet (diagonal) BEDROCK- Light blue-gray to gray, Dolomite , Fine-grained to very fine-grained, Slightly Weathered, horizontal to vertical fractures (Low Rx to 10%HCL)		RQD=94 Rec=100%			>>▲ Qu = 1136.8 tsf 4 min. 4 min. 5 min. 3 min.

Continued Next Page



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

PROJECT NO.: 04911412
PROJECT: Energy Transfer HDD (DPS)
LOCATION: LaTort Spring Run (PPP4)
 Carlisle
 Cumberland Co, PA

DATE STARTED: 6/28/17 **DRILL COMPANY:** Eichelberger's, Inc.
DATE COMPLETED: 6/29/17 **DRILLER:** **LOGGED BY:** F. Hoffman
COMPLETION DEPTH: 150.0 ft **DRILL RIG:** Diedrich D-50 Track Rig
BENCHMARK: N/A **DRILLING METHOD:** Rollerbit/Rock Coring
ELEVATION: N/A **SAMPLING METHOD:** 2-in SS1.874-in Core
LATITUDE: n/a° **HAMMER TYPE:** Automatic
LONGITUDE: n/a° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael
REMARKS: Boring location selected in the field (no surveyed ground EL or coordinates provided)

BORING B-2

Water	▽ Pre-Coring	Not Enc.
	▽ Post-Coring	16.3 feet
	▽	

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STRENGTH, tsf	Additional Remarks
105			R-22		12	Developing Fracture @ 103.5 feet (vertical) BEDROCK - Light blue-gray to gray, Dolomite , Fine-grained to very fine-grained, Slightly Weathered, horizontal to vertical fractures (Low Rx to 10%HCL) Developing Fracture @ 104.5 feet (nearly vertical)		RQD=100 Rec=100%			3 min. 2 min. 4 min.
			R-23		60	Weathered Fracture @ 109.6 feet (nearly horizontal, quartz in fracture) (Low to No Rx to 10%HCL)		RQD=100 Rec=100%			2 min. 3 min. 2 min.
110			R-24		60	Developing Fracture @ 113.4 feet (nearly vertical) Weathered Fractures @ 114.5 feet (horizontal & vertical)		RQD=88 Rec=100%			>> 3 min. 3 min. 2 min.
115			R-25		58	Weathered Fracture @ 116.9 feet (nearly horizontal) BEDROCK - Gray to dark gray, Dolomite , Very fine-grained, Weathered, nearly vertical to vertical fractures Highly Weathered Zone from 118.6 to 119 feet.		RQD=38 Rec=97%			3 min. 3 min. 4 min.
120			R-26		60	BEDROCK - Light blue-gray to gray, Dolomite , Fine-grained to very fine-grained, Slightly Weathered, nearly horizontal to vertical fractures Weathered Fracture @ 120.1 feet (nearly vertical) Weathered Fracture @ 120.7 feet (nearly horizontal) Weathered to Highly Weathered Zone from 121.1 to 121.5 feet. Weathered Fracture @ 121.8 feet (nearly vertical) Weathered Fracture @ 122 feet (nearly horizontal)		RQD=85 Rec=100%			2 min. 4 min. 4 min. 4 min.
125			R-27		58	Weathered Fracture @ 123.6 feet (nearly horizontal) Low Rx to 10%HCL Weathered Fracture @ 124 feet (diagonal) Weathered Fracture @ 124.5 feet		RQD=87 Rec=97%			>> 4 min. 4 min. 4 min. 4 min. 2 min. 3 min. 4 min.

Continued Next Page



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PROJECT NO.: 04911412
PROJECT: Energy Transfer HDD (DPS)
LOCATION: LaTort Spring Run (PPP4)
 Carlisle
 Cumberland Co, PA

DATE STARTED: 6/28/17 **DRILL COMPANY:** Eichelberger's, Inc.
DATE COMPLETED: 6/29/17 **DRILLER:** **LOGGED BY:** F. Hoffman
COMPLETION DEPTH: 150.0 ft **DRILL RIG:** Diedrich D-50 Track Rig
BENCHMARK: N/A **DRILLING METHOD:** Rollerbit/Rock Coring
ELEVATION: N/A **SAMPLING METHOD:** 2-in SS1.874-in Core
LATITUDE: n/a° **HAMMER TYPE:** Automatic
LONGITUDE: n/a° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** P. McMichael
REMARKS: Boring location selected in the field (no surveyed ground EL or coordinates provided)

BORING B-2

Water	▽	Pre-Coring	Not Enc.
	▼	Post-Coring	16.3 feet
	▽		

BORING LOCATION:
 See Boring Location Plan

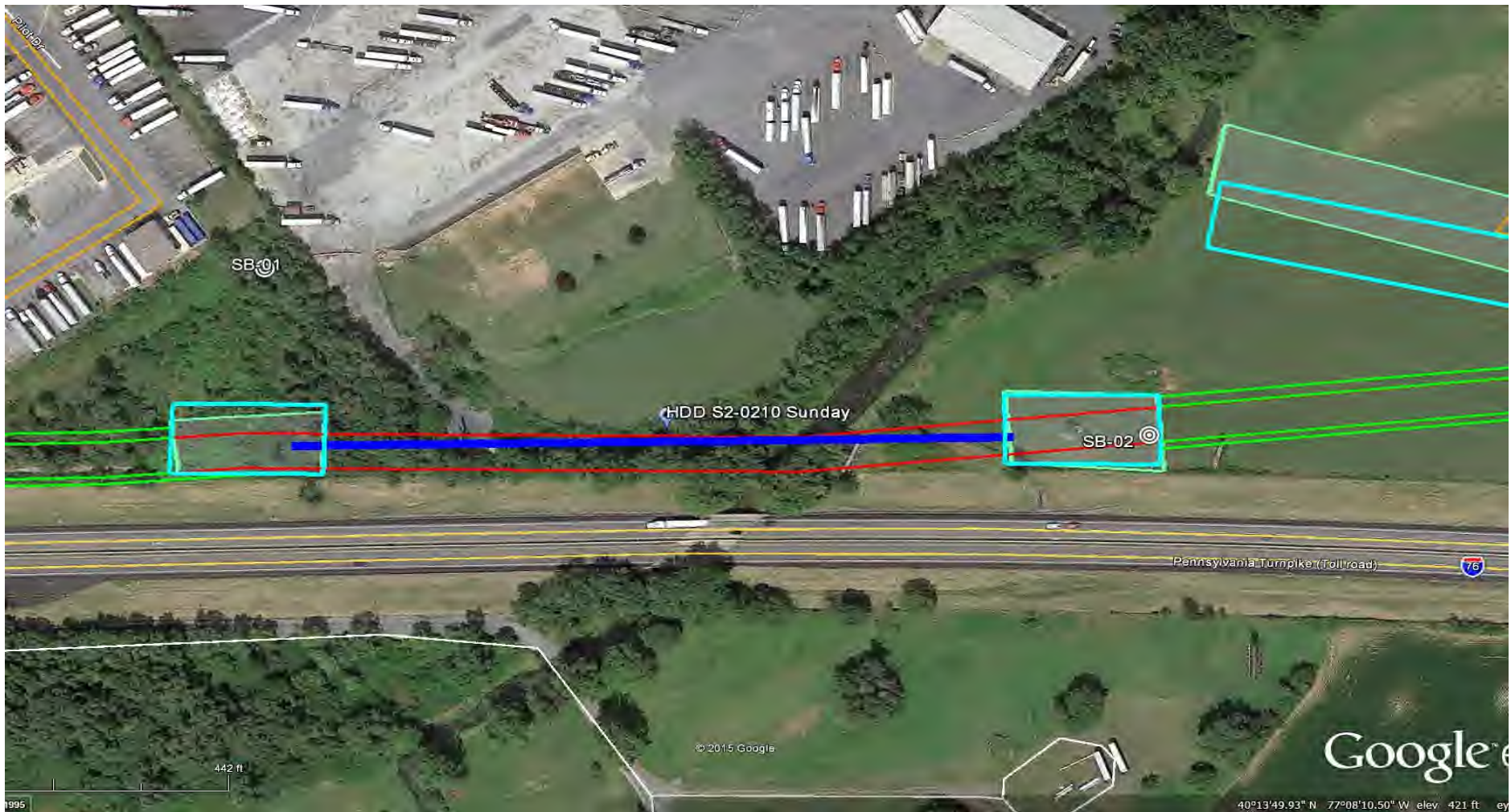
Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft © X Moisture □ PL + LL	STRENGTH, tsf ▲ Qu * Qp	Additional Remarks									
130		[Graphic Log: Brick pattern]	R-28	60	60	Developing Fracture @ 127.3 feet BEDROCK - Light blue-gray to gray, Dolomite , Fine-grained to very fine-grained, Slightly Weathered, nearly horizontal to vertical fractures Weathered Fracture @ 130.5 feet (diagonal) Weathered Fracture @ 132.6 feet (nearly vertical) Weathered Fracture @ 133 feet (nearly horizontal) Developing Fracture @ 133.5 feet (vertical)	RQD=77 Rec=100%	0	0	0	0	3 min.									
																		4 min.			
																					4 min.
																					4 min.
																					3 min.
135		[Graphic Log: Brick pattern]	R-29	60	60	Weathered Fracture @ 133 feet (nearly horizontal) Developing Fracture @ 133.5 feet (vertical)	RQD=100 Rec=100%	0	0	0	0										
																			4 min.		
																					5 min.
															Moderate Rx to 10%HCL						3 min.
																					4 min.
140		[Graphic Log: Brick pattern]	R-30	56	56	Weathered Fracture @ 141 feet (diagonal) Developing Fracture @ 141.8 feet (nearly vertical)	RQD=76 Rec=93%	0	0	0	0										
																				3 min.	
																					5 min.
																					3 min.
																					3 min.
145		[Graphic Log: Brick pattern]	R-31	24	24	Weathered Fracture @ 146.4 feet (diagonal)	RQD=90 Rec=100%	0	0	0	0										
																				4 min.	
															Weathered/Highly Weathered Zone from 147 to 147.6 feet. Weathered Fracture @ 147.6 feet (diagonal) Weathered Fracture @ 147.9 feet (diagonal)						3 min.
															Weathered Fracture @ 149.4 feet (horizontal) Weathered Fracture @ 150 feet (horizontal)						
															Weathered Fracture @ 150 feet (horizontal) Test boring terminated @ 150 feet						
150		[Graphic Log: Brick pattern]	R-32	36	36	Weathered Fracture @ 149.4 feet (horizontal) Weathered Fracture @ 150 feet (horizontal)	RQD=71 Rec=99%	0	0	0	0										



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PROJECT NO.: 04911412
PROJECT: Energy Transfer HDD (DPS)
LOCATION: LaTort Spring Run (PPP4)
 Carlisle
 Cumberland Co, PA

PSI PROJ#	Crossing Desc.	Boring ID	Core Box #	Top Depth of Rock Core (ft)	Length of Core (in)	Length of Capped Core (in)	Rock Core Diameter, D (in)	Load (lbs)	Compressive Strength (psi)	Compressive Strength (psf)	L/D Ratio	L/D Correction	L/D Corrected Strength (psi)	L/D Corrected Strength (psf)	Remarks (Core Mass in Grams)
04911412	Good Spring Water Stream	B-1	1	12.1	3.72	3.90	1.99	52,340	16,828	2,423,261	1.8693	0.9917	16,688	2,403,124	512.3g
04911412	Good Spring Water Stream	B-1	3	40.6	3.69	3.85	1.99	38,200	12,282	1,768,601	1.8543	0.9900	12,159	1,750,911	522.30
04911412	Good Spring Water Stream	B-1	4	58.5	3.73	3.88	1.99	54,390	17,487	2,518,173	1.8744	0.9923	17,352	2,498,707	509.40
04911412	Good Spring Water Stream	B-1	6	77.6	3.68	3.90	1.99	40,470	13,012	1,873,698	1.8492	0.9894	12,875	1,853,928	519.00
04911412	Good Spring Water Stream	B-1	7	92.8	3.72	3.89	1.99	50,640	16,282	2,344,554	1.8693	0.9917	16,146	2,325,071	522.20
04911412	Good Spring Water Stream	B-1	8	114.6	3.71	3.90	1.99	45,750	14,709	2,118,154	1.8643	0.9911	14,579	2,099,341	527.70
04911412	Good Spring Water Stream	B-1	10	133.0	3.72	3.83	1.99	47,150	15,160	2,182,972	1.8693	0.9917	15,034	2,164,832	526.60
04911412	Good Spring Water Stream	B-1	11	148.5	3.70	3.83	1.99	44,340	14,256	2,052,873	1.8593	0.9906	14,121	2,033,482	528.10
04911412	Good Spring Water Stream	B-2	1	13.4	3.72	3.99	1.99	26,500	8,520	1,226,909	1.8693	0.9917	8,449	1,216,713	524.11
04911412	Good Spring Water Stream	B-2	3	43.8	3.73	3.90	1.99	26,430	8,498	1,223,668	1.8744	0.9923	8,432	1,214,209	516.30
04911412	Good Spring Water Stream	B-2	4	57.8	3.76	3.88	1.99	31,420	10,102	1,454,697	1.8894	0.9941	10,042	1,446,053	522.70
04911412	Good Spring Water Stream	B-2	6	83.0	3.74	3.88	1.99	39,690	12,761	1,837,586	1.8794	0.9929	12,670	1,824,460	527.8 Vertical Hairline Fracture in Core
04911412	Good Spring Water Stream	B-2	7	95.3	3.76	3.90	1.99	49,400	15,883	2,287,143	1.8894	0.9941	15,789	2,273,553	532.90
04911412	Good Spring Water Stream	B-2	8	111.1	3.74	3.90	1.99	40,940	13,163	1,895,459	1.8794	0.9929	13,069	1,881,920	529.60
04911412	Good Spring Water Stream	B-2	9	123.2	3.77	3.90	1.99	36,930	11,874	1,709,802	1.8945	0.9947	11,810	1,700,689	529.70



LEGEND:

⊙ Geotechnical Soil Boring (SB) Locations



GEOTECHNICAL BORING LOCATIONS
 HDD S2-0210
 CUMBERLAND COUNTY, MIDDLESEX 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:	PILOT DRIVE, CARLISLE, PA	Page 1 of 1	
HDD No.:	S2-0210	Dates(s) Drilled:	01-25-15
Boring No.:	SB-01	Inspector:	E. WATT
Drilling Contractor:	HAD DRILLING	Drilling Method:	SPT - ASTM D1586
		Driller:	S. HOFFER
		Groundwater Depth (ft):	NOT ENCOUNTERED
		Total Depth (ft):	15.0

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (ft)	Strata (USCS)	Description of Materials	6" Increment Blows *				N	
	From	To	From	To									
			0.0	0.0			TOPSOIL (<1 ")						
1	3.0	5.0	0.0		15	ML	BROWN TO ORANGE BROWN SILT, TRACE FINE SAND (USCS: ML).	1	5	4	5		9
2	8.0	8.8	7.5	8.8	5		GRAY WEATHERED LIMESTONE?	24	50/3"				>50
							AUGER REFUSAL AT 8.5'. OFF-SET BORING 18' NW, AND AUGERED TO BELOW TEST DEPTH.						
3	13.0	15.0			6	MH	GRAY TO LIGHT BROWN SOFT ELASTIC SILT (USCS: MH).	1	1	1	2		2
4	15.0	15.0				TRACE	GRAY WEATHERED LIMESTONE?	50/0"					
							AUGER REFUSAL AT 15'. OFF-SET BORING AGAIN AND CONTINUOUSLY AUGERED TO REFUSAL AT 13.8'. REFUSAL MATERIAL MIGHT BE A RESULT OF BOULDERY SUBSURFACE CONDITIONS.						

Notes/Comments:

Pocket Penetrometer Testing

S1: 1.0 TSF

S2: 2.75 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.

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0210

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.)		Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318)			USCS Classif. (ASTM D2487)
			From	To			Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	
S2-0210	SB-01	1	3.0	5.0	23.5	92.4	35	27	8	ML
		3	13.0	15.0	53.5	87.9	55	34	21	MH
	SB-02	1	3.0	5.0	31.6	89.9	-	-	-	-
		2	8.0	8.8	36.2	97.0	54	36	18	MH
		3	13.0	15.0	31.8	92.9	53	31	22	MH
		4	18.0	20.0	38.9	75.9	-	-	-	-
		5	23.0	25.0	26.3	53.1	-	-	-	-
		6	28.0	28.4	11.2	36.1	-	-	-	-

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

**REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0210**

HDD No.	NAME	BORING NO.	REGIONAL GEOLOGY DESCRIPTION	GENERAL TOPOGRAPHIC SETTING	BEDROCK FORMATION	GENERAL ROCK TYPE	APPROX MAX FM THICKNESS (FT)	DEPTH TO ROCK (Ft bgs) based on nearby well drilling logs	NOTES / COMMENTS
S2-0210	Sunday	SB-01	St. Paul Group - consists of buff-colored magnesium limestone and very finely crystalline birdseye limestone at its top and base.	Level terrain	St. Paul Group	Crystalline limestone, chert, and dolomite (St. Paul)	1,500	Highly variable! 2-118, average DTB ~30 ft bgs	Yields: 8-60 gpm
		SB-02							Very finely crystalline, "birdseye" limestone at top and base, granular fossiliferous limestone, black chert, and dolomite in middle

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

FIELD DESCRIPTION AND LOGGING SYSTEM FOR SOIL EXPLORATION

GRANULAR SOILS

(Sand, Gravel & Combinations)

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

Particle Size Identification

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

Relative Proportions

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

COHESIVE SOILS

(Silt, Clay & Combinations)

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

Plasticity

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

ROCK

(Rock Cores)

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

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

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

UNIFIED SOIL CLASSIFICATION SYSTEM [Casagrande (1948)]

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

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



ATTACHMENT 2
SOIL RESOURCES MAP AND PROFILE DESCRIPTIONS



United States
Department of
Agriculture



Natural
Resources
Conservation
Service

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

Custom Soil Resource Report for Cumberland County, Pennsylvania

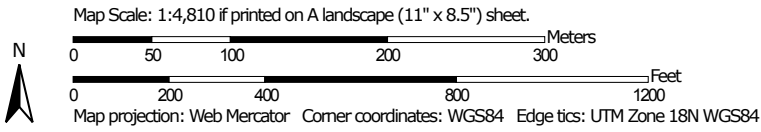
LeTort Spring Run HDD







































Custom Soil Resource Report Soil Map



Soil Map may not be valid at this scale.



MAP LEGEND

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

MAP INFORMATION

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

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

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

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

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

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

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

Soil Survey Area: Cumberland County, Pennsylvania
 Survey Area Data: Version 11, Nov 27, 2017

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

Date(s) aerial images were photographed: Jun 18, 2010—Sep 25, 2010

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BeB	Berks channery silt loam, 3 to 8 percent slopes	2.7	3.8%
HaA	Hagerstown silt loam, 0 to 3 percent slopes	35.1	48.0%
HaB	Hagerstown silt loam, 3 to 8 percent slopes	10.3	14.1%
HaC	Hagerstown silt loam, 8 to 15 percent slopes	0.7	1.0%
HcB	Hagerstown silt loam, rocky, 3 to 8 percent slopes	10.5	14.3%
Ub	Urban land and Udorthents	2.5	3.5%
Wa	Warners silt loam	11.2	15.4%
Totals for Area of Interest		73.2	100.0%

Map Unit Descriptions

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

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

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not

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mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

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

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

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

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

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

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

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

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

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

Cumberland County, Pennsylvania

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

Map Unit Setting

National map unit symbol: 2sgb5

Elevation: 320 to 3,570 feet

Mean annual precipitation: 37 to 50 inches

Mean annual air temperature: 47 to 56 degrees F

Frost-free period: 148 to 192 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Berks and similar soils: 85 percent

Minor components: 15 percent

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

Description of Berks

Setting

Landform: Ridges, mountain slopes

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

Landform position (three-dimensional): Upper third of mountainflank, side slope

Down-slope shape: Convex

Across-slope shape: Convex, linear

Parent material: Residuum weathered from shale and siltstone and/or fine grained sandstone

Typical profile

Ap - 0 to 7 inches: channery silt loam

Bw1 - 7 to 15 inches: channery silt loam

Bw2 - 15 to 28 inches: very channery silt loam

C - 28 to 36 inches: extremely channery silt loam

R - 36 to 46 inches: bedrock

Properties and qualities

Slope: 3 to 8 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

Natural drainage class: Well drained

Runoff class: Medium

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high
(0.06 to 5.95 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Calcium carbonate, maximum in profile: 1 percent

Gypsum, maximum in profile: 1 percent

Salinity, maximum in profile: Nonsaline (0.0 to 1.0 mmhos/cm)

Sodium adsorption ratio, maximum in profile: 1.0

Available water storage in profile: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 2e

Hydrologic Soil Group: B

Custom Soil Resource Report

Other vegetative classification: Dry Uplands (DU2)
Hydric soil rating: No

Minor Components

Weikert

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

Brinkerton

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

HaA—Hagerstown silt loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2tb05
Elevation: 310 to 1,750 feet
Mean annual precipitation: 37 to 45 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 155 to 205 days
Farmland classification: All areas are prime farmland

Map Unit Composition

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

Description of Hagerstown

Setting

Landform: Hills
Landform position (two-dimensional): Backslope, footslope, summit
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Parent material: Clayey residuum weathered from limestone

Typical profile

Ap - 0 to 10 inches: silt loam

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Bt1 - 10 to 21 inches: silty clay loam
Bt2 - 21 to 56 inches: silty clay
C - 56 to 73 inches: silty clay loam
R - 73 to 83 inches: bedrock

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 43 to 98 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Moderate (about 7.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 1
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Opequon

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

Carbo

Percent of map unit: 5 percent
Landform: Hills
Landform position (two-dimensional): Summit, backslope, shoulder
Landform position (three-dimensional): Crest, side slope
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Hydric soil rating: No

Nolin

Percent of map unit: 3 percent
Landform: Swales
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, talus
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Hydric soil rating: No

Funkstown

Percent of map unit: 2 percent
Landform: Valley floors
Landform position (two-dimensional): Toeslope

Custom Soil Resource Report

Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave, linear
Hydric soil rating: No

HaB—Hagerstown silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2rc98
Elevation: 600 to 1,750 feet
Mean annual precipitation: 37 to 45 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 155 to 190 days
Farmland classification: All areas are prime farmland

Map Unit Composition

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

Description of Hagerstown

Setting

Landform: Hills
Landform position (two-dimensional): Backslope, footslope, summit
Landform position (three-dimensional): Side slope, base slope, interfluvium
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Parent material: Clayey residuum weathered from limestone

Typical profile

Ap - 0 to 10 inches: silt loam
Bt1 - 10 to 21 inches: silty clay loam
Bt2 - 21 to 56 inches: silty clay
C - 56 to 73 inches: silty clay loam
R - 73 to 83 inches: bedrock

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 43 to 98 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified

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Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Opequon

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

Carbo

Percent of map unit: 5 percent
Landform: Hills
Landform position (two-dimensional): Summit, backslope, shoulder
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Hydric soil rating: No

Funkstown

Percent of map unit: 3 percent
Landform: Valley floors
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave, linear
Hydric soil rating: No

Timberville

Percent of map unit: 2 percent
Landform: Hills
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Head slope, base slope
Down-slope shape: Concave, linear
Across-slope shape: Convex, concave, linear
Hydric soil rating: No

HaC—Hagerstown silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2tb03
Elevation: 600 to 1,750 feet
Mean annual precipitation: 32 to 45 inches
Mean annual air temperature: 41 to 65 degrees F
Frost-free period: 155 to 181 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Hagerstown and similar soils: 85 percent

Minor components: 15 percent

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

Description of Hagerstown

Setting

Landform: Hillslopes

Landform position (two-dimensional): Backslope, shoulder

Landform position (three-dimensional): Side slope

Down-slope shape: Linear, convex, concave

Across-slope shape: Linear, convex

Parent material: Clayey residuum weathered from limestone and dolomite

Typical profile

Ap - 0 to 8 inches: silt loam

Bt1 - 8 to 19 inches: silty clay loam

Bt2 - 19 to 54 inches: silty clay

C - 54 to 71 inches: silty clay loam

R - 71 to 81 inches: bedrock

Properties and qualities

Slope: 8 to 15 percent

Depth to restrictive feature: 43 to 98 inches to lithic bedrock

Natural drainage class: Well drained

Runoff class: Medium

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)

Available water storage in profile: Moderate (about 7.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 3e

Hydrologic Soil Group: B

Hydric soil rating: No

Minor Components

Carbo

Percent of map unit: 8 percent

Landform: Hills

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

Landform position (three-dimensional): Crest, side slope

Down-slope shape: Linear, convex

Across-slope shape: Linear, convex

Hydric soil rating: No

Opequon

Percent of map unit: 5 percent

Landform: Ridges

Landform position (two-dimensional): Shoulder, summit

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Landform position (three-dimensional): Side slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Hydric soil rating: No

Clarksburg

Percent of map unit: 2 percent
Landform: Hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Linear
Across-slope shape: Concave
Hydric soil rating: No

HcB—Hagerstown silt loam, rocky, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: r8wn
Elevation: 460 to 1,500 feet
Mean annual precipitation: 30 to 45 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 140 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Hagerstown

Setting

Landform: Ridges
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Clayey residuum weathered from argillaceous limestone

Typical profile

H1 - 0 to 10 inches: silt loam
H2 - 10 to 19 inches: clay
H3 - 19 to 57 inches: clay

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 40 to 84 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches

Custom Soil Resource Report

Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.0 inches)

Interpretive groups

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

Ub—Urban land and Udorthents

Map Unit Setting

National map unit symbol: r8yg
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 120 to 215 days
Farmland classification: Not prime farmland

Map Unit Composition

Urban land: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Urban Land

Setting

Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Pavement, buildings and other artificially covered areas

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 10 inches to densic material
Runoff class: Very high

Interpretive groups

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

Minor Components

Udorthents, steep

Percent of map unit: 10 percent
Landform: Mountains
Landform position (two-dimensional): Summit, backslope
Landform position (three-dimensional): Mountaintop
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Wa—Warners silt loam

Map Unit Setting

National map unit symbol: r8yj
Elevation: 250 to 1,000 feet
Mean annual precipitation: 30 to 45 inches
Mean annual air temperature: 46 to 55 degrees F
Frost-free period: 140 to 210 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

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

Description of Warners

Setting

Landform: Depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Parent material: Carbonatic fine-silty alluvium

Typical profile

H1 - 0 to 12 inches: silt loam
H2 - 12 to 33 inches: silt loam
H3 - 33 to 62 inches: marl

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Very poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: Frequent
Frequency of ponding: Frequent
Calcium carbonate, maximum in profile: 90 percent
Available water storage in profile: High (about 11.0 inches)

Interpretive groups

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

Minor Components

Somewhat poorly drained soils

Percent of map unit: 5 percent







Hydric soil rating: No

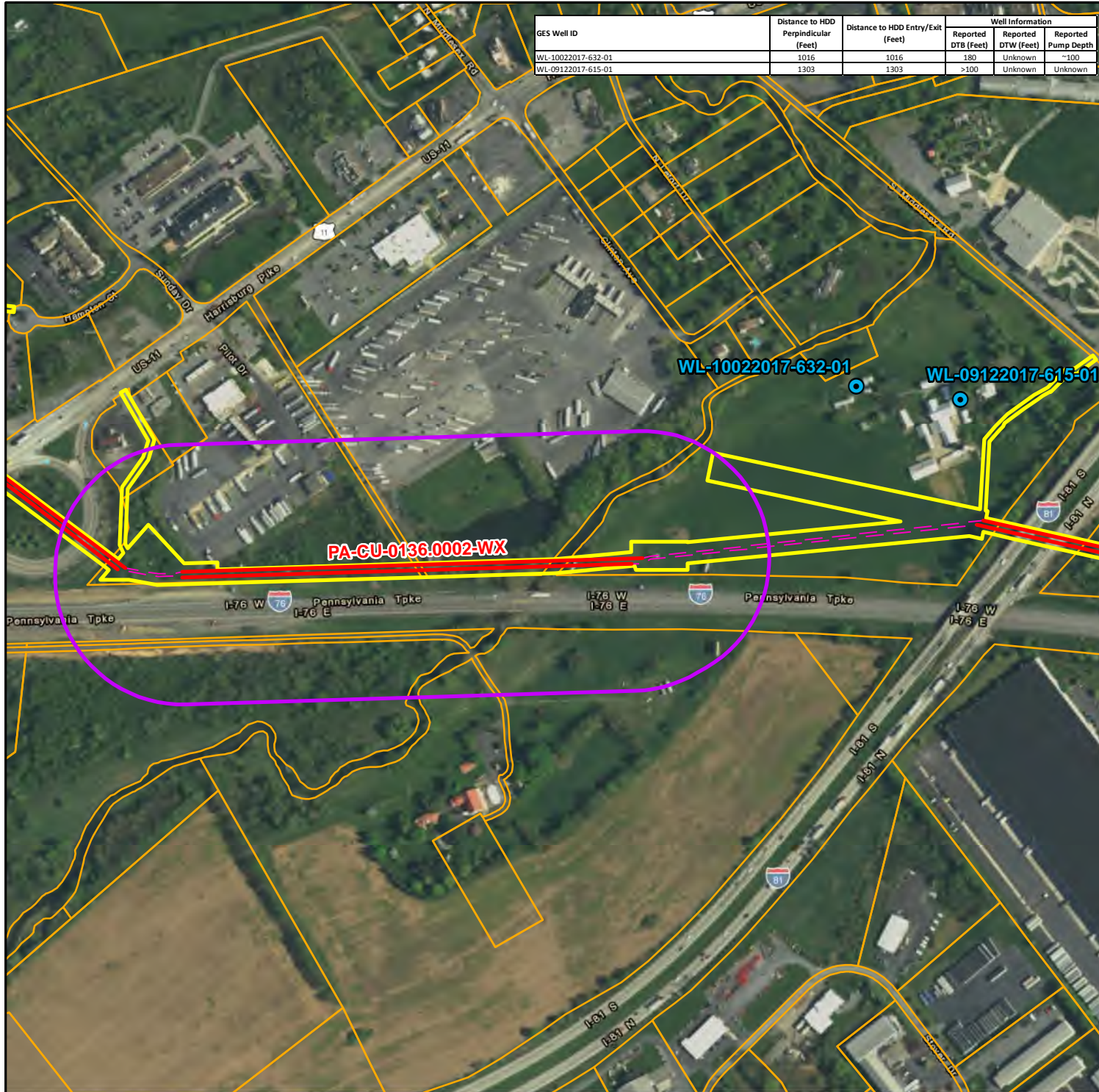


**ATTACHMENT 3
450-FOOT WELL SURVEY**

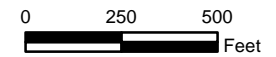
GES Well ID	Distance to HDD Perpendicular (Feet)	Distance to HDD Entry/Exit (Feet)	Well Information		
			Reported DTB (Feet)	Reported DTW (Feet)	Reported Pump Depth
WL-10022017-632-01	1016	1016	180	Unknown	~100
WL-09122017-615-01	1303	1303	>100	Unknown	Unknown

Legend

-  LOD
 -  Parcel
 -  PPP Centerline
 -  HDD
 -  450 foot buffer of HDD alignment
- **Testing locations current as of 11/27/2017**
-  GES Testing Location



Location



Well Location Map
HDD# PA-CU-0136.0002-WX
Cumberland County, PA.

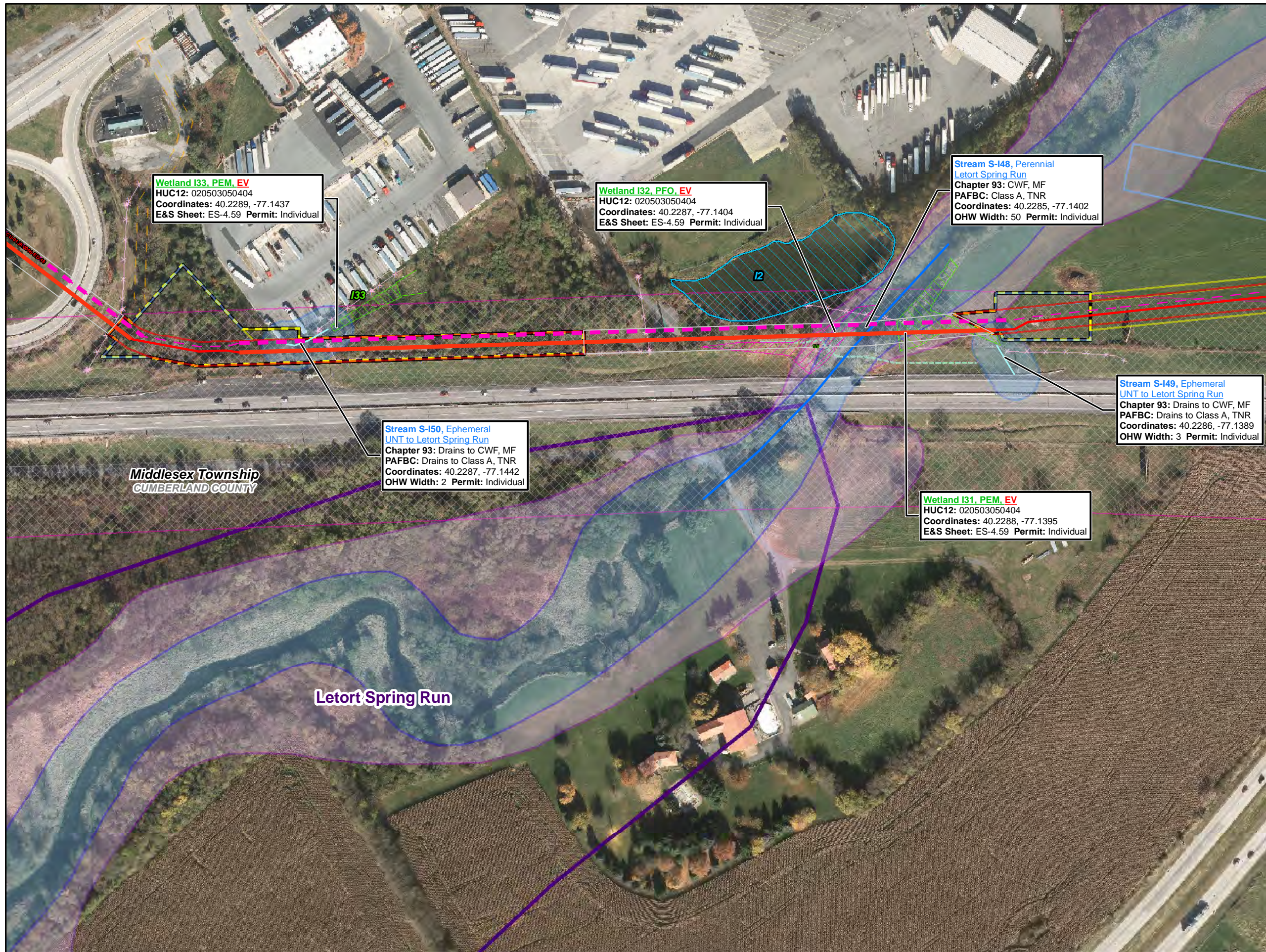
Prepared By: 	Date: 11/29/2017
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Base Map:
 ESRI World Imagery, 09/24/2015
 Coordinate System: NAD 83 Stateplane, PA South, Feet

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**HORIZONTAL DIRECTIONAL DRILL ANALYSIS
LETORT SPRING RUN CROSSING
PADEP SECTION 105 PERMIT NO. E21-449
PA-CU-0136.0002-WX-16
(SPLP HDD S2-0210-16)**

**ATTACHMENT 2
ALTERNATIVES ANALYSIS FIGURES**



Middlesex Township
CUMBERLAND COUNTY

Letort Spring Run

Wetland I33, PEM, EV
HUC12: 020503050404
Coordinates: 40.2289, -77.1437
E&S Sheet: ES-4.59 Permit: Individual

Wetland I32, PFO, EV
HUC12: 020503050404
Coordinates: 40.2287, -77.1404
E&S Sheet: ES-4.59 Permit: Individual

**Stream S-148, Perennial
Letort Spring Run**
Chapter 93: CWF, MF
PAFBC: Class A, TNR
Coordinates: 40.2285, -77.1402
OHW Width: 50 Permit: Individual

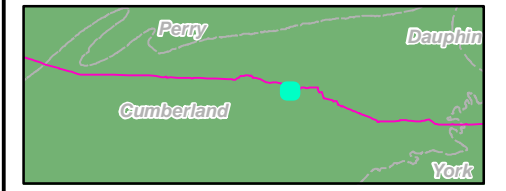
**Stream S-150, Ephemeral
UNT to Letort Spring Run**
Chapter 93: Drains to CWF, MF
PAFBC: Drains to Class A, TNR
Coordinates: 40.2287, -77.1442
OHW Width: 2 Permit: Individual

**Stream S-149, Ephemeral
UNT to Letort Spring Run**
Chapter 93: Drains to CWF, MF
PAFBC: Drains to Class A, TNR
Coordinates: 40.2286, -77.1389
OHW Width: 3 Permit: Individual

Wetland I31, PEM, EV
HUC12: 020503050404
Coordinates: 40.2288, -77.1395
E&S Sheet: ES-4.59 Permit: Individual

Legend

- PPP 1, HDD
- - - PPP 2, HDD
- PPP 1
- - - PPP 2
- ~ Ephemeral Stream
- ~ Perennial Stream
- Permanent ROW
- Temporary ROW
- ATWS
- Temporary Access Road
- HDD Alternative LOD
- ⊗ Pond
- ⊗ PEM Wetland
- ⊗ PFO Wetland
- - - Existing Electric Line
- - - Existing Water Line
- Chapter 105 Floodway
- Ch. 106 Floodplain Fringe
- Cultural Resources
- Wildlife Management Area



0 100 200
1 inch = 200 feet

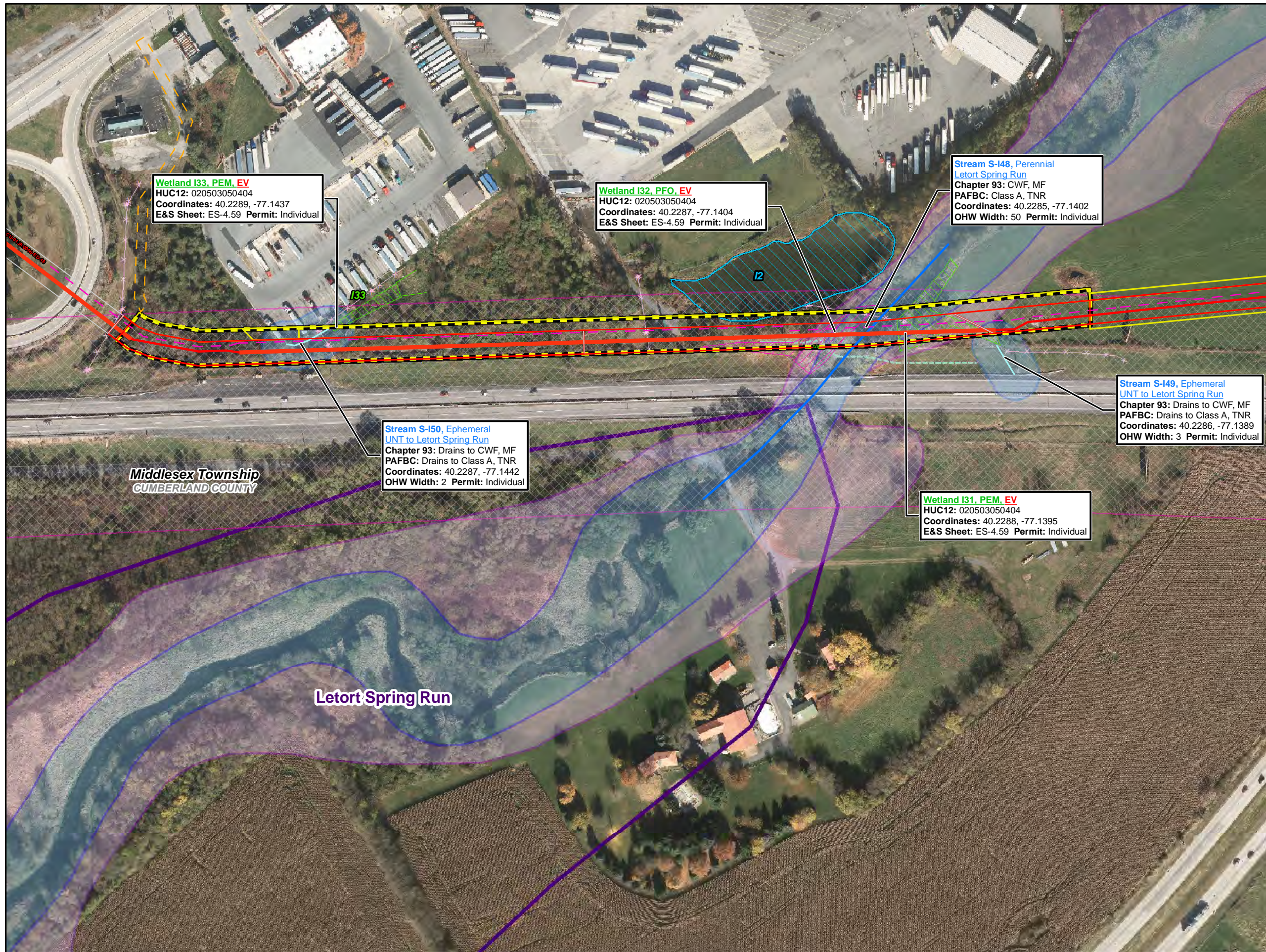


Figure 1.
PA-CU-0136.0002-WX-16
HDD Alternative LOD
Sunoco Pennsylvania Pipeline Project,
Cumberland County, PA.
Sheet 1 of 1

Prepared By: TETRA TECH	Date: 6/4/2019
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Base Map: SPLP 2014-2016, Roads from NRCS Geo-spatial Data Giveaway, 100-Year Floodplain from FEMA NFHL, downloaded 9/2016. Aquatics, TT 2013-2016.
Coordinate System: NAD 83 Stateplane, PA South, Feet

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- Legend**
- PPP 1, HDD
 - PPP 1
 - - - PPP 2
 - ~ Ephemeral Stream
 - ~ Perennial Stream
 - Permanent ROW
 - Temporary ROW
 - Temporary Access Road
 - Open Cut Alternative LOD
 - Pond
 - PEM Wetland
 - PFO Wetland
 - Existing Electric Line
 - Existing Water Line
 - Chapter 105 Floodway
 - Ch. 106 Floodplain Fringe
 - Cultural Resources
 - Wildlife Management Area

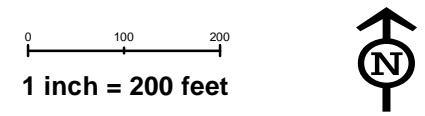
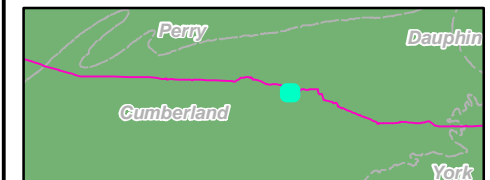


Figure 2
PA-CU-0136.0002-WX-16
Open Cut Alternative LOD
Sunoco Pennsylvania Pipeline Project,
Cumberland County, PA.
Sheet 1 of 1

Prepared By: TETRA TECH	Date: 6/4/2019
----------------------------	-------------------

Base Map: SPLP 2014-2016, Roads from NRCS Geo-spatial Data Giveaway, 100-Year Floodplain from FEMA NFHL, downloaded 9/2016. Aquatics, TT 2013-2016.
 Coordinate System: NAD 83 Stateplane, PA South, Feet

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Wetland I33, PEM, EV
 HUC12: 020503050404
 Coordinates: 40.2289, -77.1437
 E&S Sheet: ES-4.59 Permit: Individual

Wetland I32, PFO, EV
 HUC12: 020503050404
 Coordinates: 40.2287, -77.1404
 E&S Sheet: ES-4.59 Permit: Individual

**Stream S-148, Perennial
 Letort Spring Run**
 Chapter 93: CWF, MF
 PAFBC: Class A, TNR
 Coordinates: 40.2285, -77.1402
 OHW Width: 50 Permit: Individual

**Stream S-150, Ephemeral
 UNT to Letort Spring Run**
 Chapter 93: Drains to CWF, MF
 PAFBC: Drains to Class A, TNR
 Coordinates: 40.2287, -77.1442
 OHW Width: 2 Permit: Individual

**Stream S-149, Ephemeral
 UNT to Letort Spring Run**
 Chapter 93: Drains to CWF, MF
 PAFBC: Drains to Class A, TNR
 Coordinates: 40.2286, -77.1389
 OHW Width: 3 Permit: Individual

Wetland I31, PEM, EV
 HUC12: 020503050404
 Coordinates: 40.2288, -77.1395
 E&S Sheet: ES-4.59 Permit: Individual

**Middlesex Township
 CUMBERLAND COUNTY**

Letort Spring Run

- Legend**
- PPP 1, HDD
 - PPP 2, CAB
 - PPP 1
 - PPP 2
 - Ephemeral Stream
 - Perennial Stream
 - Permanent ROW
 - Temporary ROW
 - ATWS
 - Temporary Access Road
 - Bore Pits
 - Bore/Open Cut Alternative LOD
 - Pond
 - PEM Wetland
 - PFO Wetland
 - Existing Electric Line
 - Existing Water Line
 - Chapter 105 Floodway
 - Ch. 106 Floodplain Fringe
 - Cultural Resources
 - Wildlife Management Area

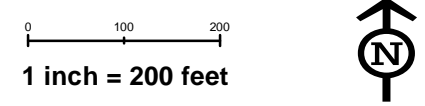
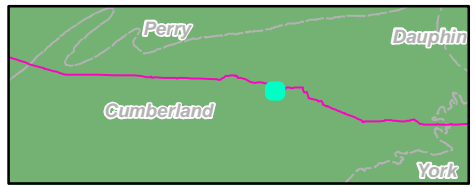


Figure 3.
**PA-CU-0136.0002-WX-16 Combination
 Open Cut/CAB Alternative LOD
 Sunoco Pennsylvania Pipeline Project,
 Cumberland County, PA.
 Sheet 1 of 1**

Prepared By: **TETRA TECH** **Date:** 6/4/2019

Base Map: SPLP 2014-2016, Roads from NRCS Geo-spatial Data Giveaway, 100-Year Floodplain from FEMA NFHL, downloaded 9/2016. Aquatics, TT 2013-2016.
 Coordinate System: NAD 83 Stateplane, PA South, Feet

C:\Users\stephanie.asea\ge\Documents\00_PPP\MD\Figures3_Letort_AugerBore.mxd LN



Wetland I33, PEM, EV
 HUC12: 020503050404
 Coordinates: 40.2289, -77.1437
 E&S Sheet: ES-4.59 Permit: Individual

Wetland I32, PFO, EV
 HUC12: 020503050404
 Coordinates: 40.2287, -77.1404
 E&S Sheet: ES-4.59 Permit: Individual

Stream S-148, Perennial
 Letort Spring Run
 Chapter 93: CWF, MF
 PAFBC: Class A, TNR
 Coordinates: 40.2285, -77.1402
 OHW Width: 50 Permit: Individual

Stream S-150, Ephemeral
 UNT to Letort Spring Run
 Chapter 93: Drains to CWF, MF
 PAFBC: Drains to Class A, TNR
 Coordinates: 40.2287, -77.1442
 OHW Width: 2 Permit: Individual

Stream S-149, Ephemeral
 UNT to Letort Spring Run
 Chapter 93: Drains to CWF, MF
 PAFBC: Drains to Class A, TNR
 Coordinates: 40.2286, -77.1389
 OHW Width: 3 Permit: Individual

Wetland I31, PEM, EV
 HUC12: 020503050404
 Coordinates: 40.2288, -77.1395
 E&S Sheet: ES-4.59 Permit: Individual

Middlesex Township
CUMBERLAND COUNTY

Letort Spring Run

- Legend**
- PPP 1, HDD
 - PPP 1
 - - - PPP 2
 - Direct Pipe
 - Bore Pits
 - ~ Ephemeral Stream
 - ~ Perennial Stream
 - Permanent ROW
 - Temporary ROW
 - Temporary Access
 - ▭ Direct Pipe/Open Cut Alternative
 - Pond
 - ◊ PEM Wetland
 - ◊ PFO Wetland
 - ✖ Existing Electric Line
 - Existing Water Line
 - Chapter 105 Floodway
 - Ch. 106 Floodplain Fringe
 - Cultural Resources
 - Wildlife Management Area

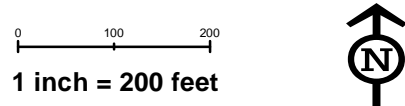
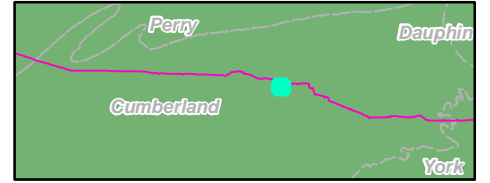
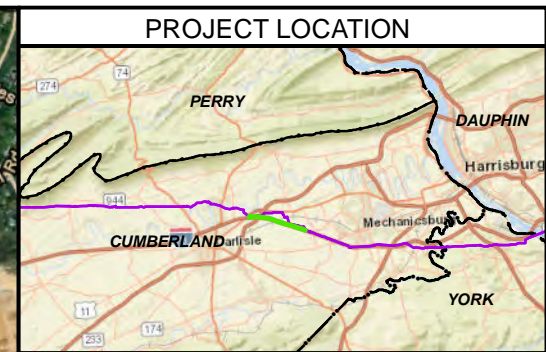


Figure 4.
PA-CU-0136.0002-WX-16
Direct Pipe Bore/Open Cut Alternative LOD
Sunoco Pennsylvania Pipeline Project,
Cumberland County, PA.
Sheet 1 of 1

Prepared By: TETRA TECH	Date: 6/4/2019
-----------------------------------	--------------------------

Base Map: SPLP 2014-2016, Roads from NRCS Geo-spatial Data Giveaway, 100-Year Floodplain from FEMA NFHL, downloaded 9/2016. Aquatics, TT 2013-2016.
 Coordinate System: NAD 83 Stateplane, PA South, Feet

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Legend

- Proposed/Permitted Route
- Potential Reroute Alternative
- Original Proposed Route (ME1)
- NWI
- CNHI Core
- CNHI Supporting
- Archeological Site
- Historic Districts
- Municipal Boundary
- Existing Electric Line

0 750 1,500 Feet



Figure 5.
Potential LeTort/I-81 Route Alternative

Prepared By:	Date:
TETRA TECH	05/2019

Base Map;
ESRI World Imagery, April 2017

Coordinate System: WGS 84

Sunoco Pipeline L.P.
Pennsylvania Pipeline Project
PA-CU-0136.0002 Middlesex Township
Cumberland County

PHOTOS FROM MAY 1 AND MAY 6, 2019

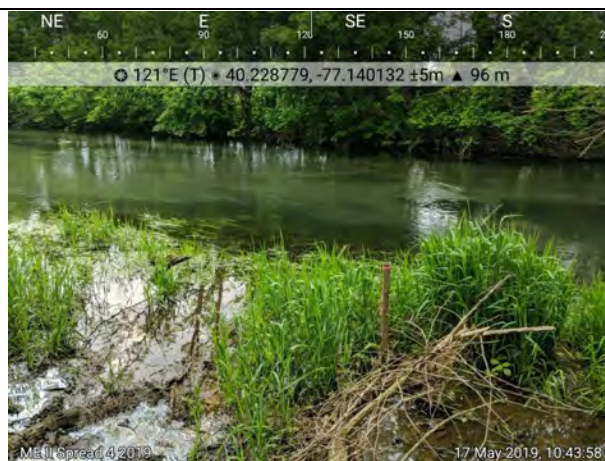
Facing southwest, area of west most IR within WL-I32PFO with containments removed.



Facing southwest, second area within WL-I32PFO with containments removed.



Facing southeast, Letort Spring Run S-I48 site of IR within resource with containment removed.



Facing east, Letort Spring Run S-I48 site of IR within resource with containment removed.



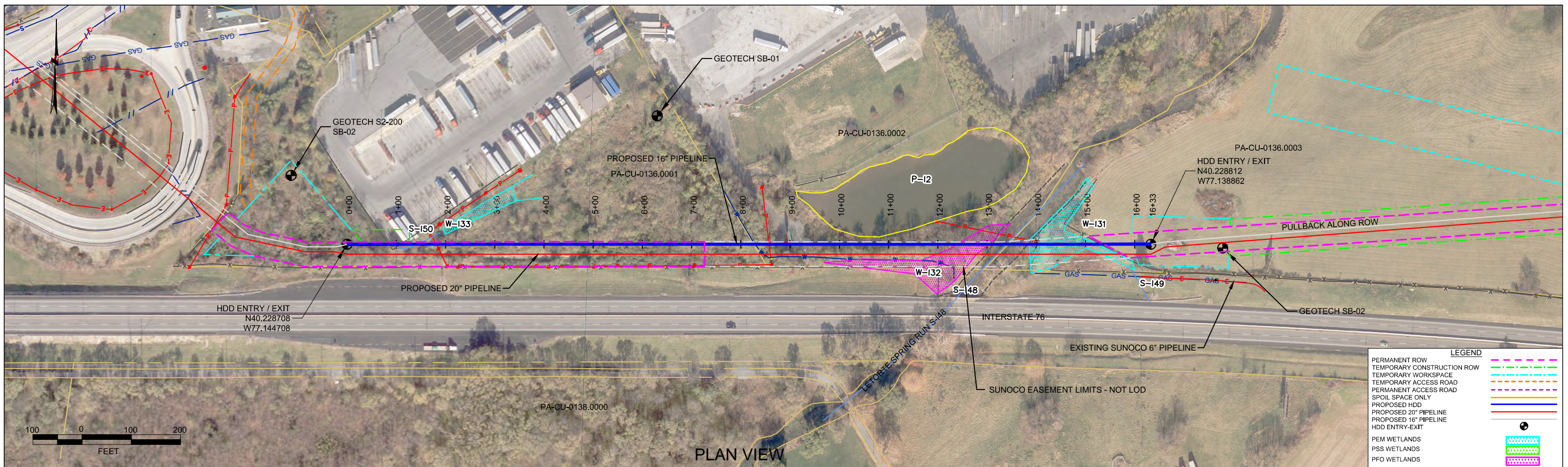
Facing northwest, IR site within WL-I32PFO nearest Letort Spring Run.



**HORIZONTAL DIRECTIONAL DRILL ANALYSIS
LETORT SPRING RUN CROSSING
PADEP SECTION 105 PERMIT NO. E21-449
PA-CU-0136.0002-WX-16
(SPLP HDD S2-0210-16)**

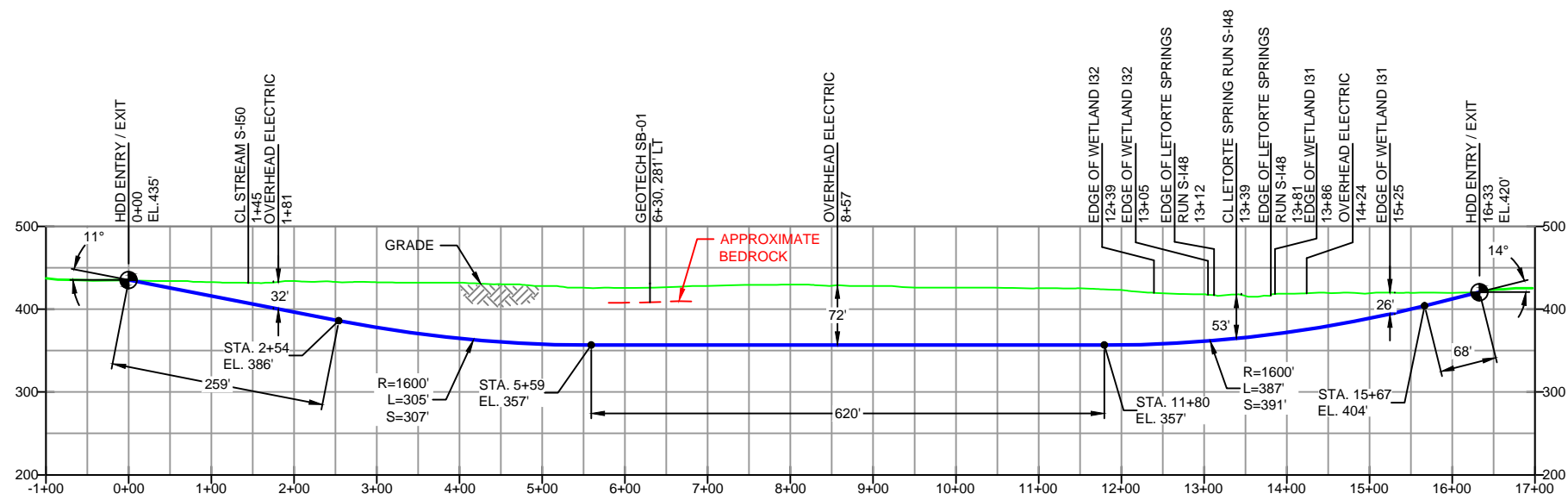
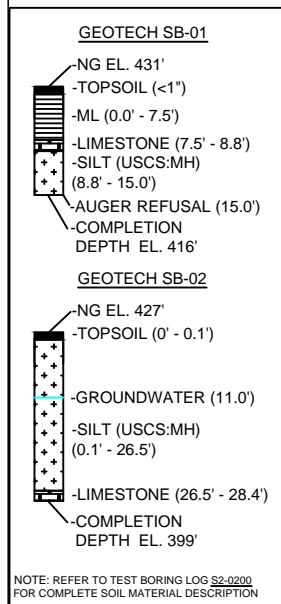
ATTACHMENT 3

2017 AND 2018 16-INCH HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES



CUMBERLAND COUNTY, PENNSYLVANIA - MIDDLESEX TOWNSHIP
S2-0210-16

PLAN VIEW
PROFILE VIEW



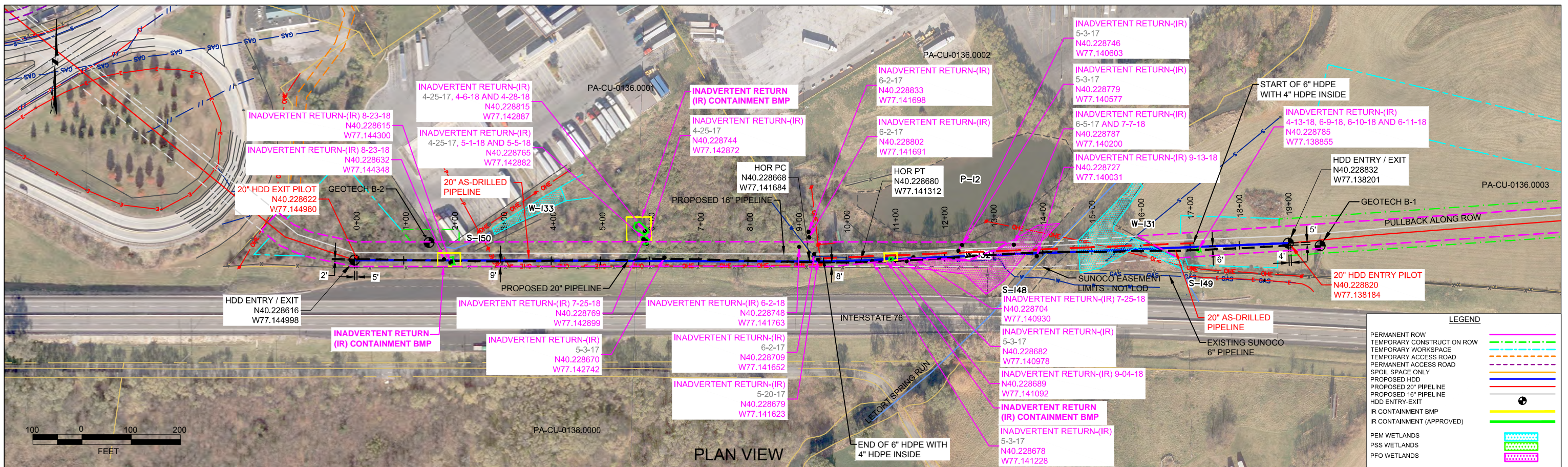
DESIGN AND CONSTRUCTION:

- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
- THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
- DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
- CROSSING PIPE SPECIFICATION:
 HDD HORZ. LENGTH (L=): 1633'
 HDD PIPE LENGTH (S=): 1645'
 16" x 0.438" W.T., X-70, API5L, PSL2, ERW, 8FW
 COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
- INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
- INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
- PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
- CARRIER PIPE NOT ENCASED.
- PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
- CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
- SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
- SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
- SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

Figure 1: Permitted 16-Inch HDD Plan and Profile

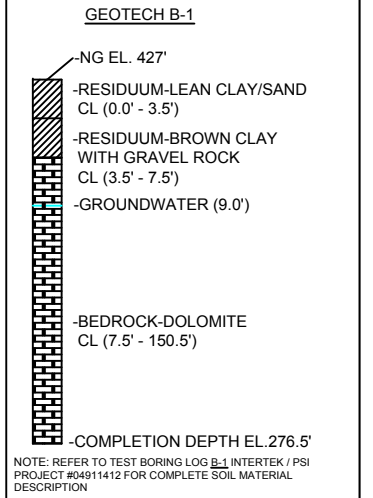
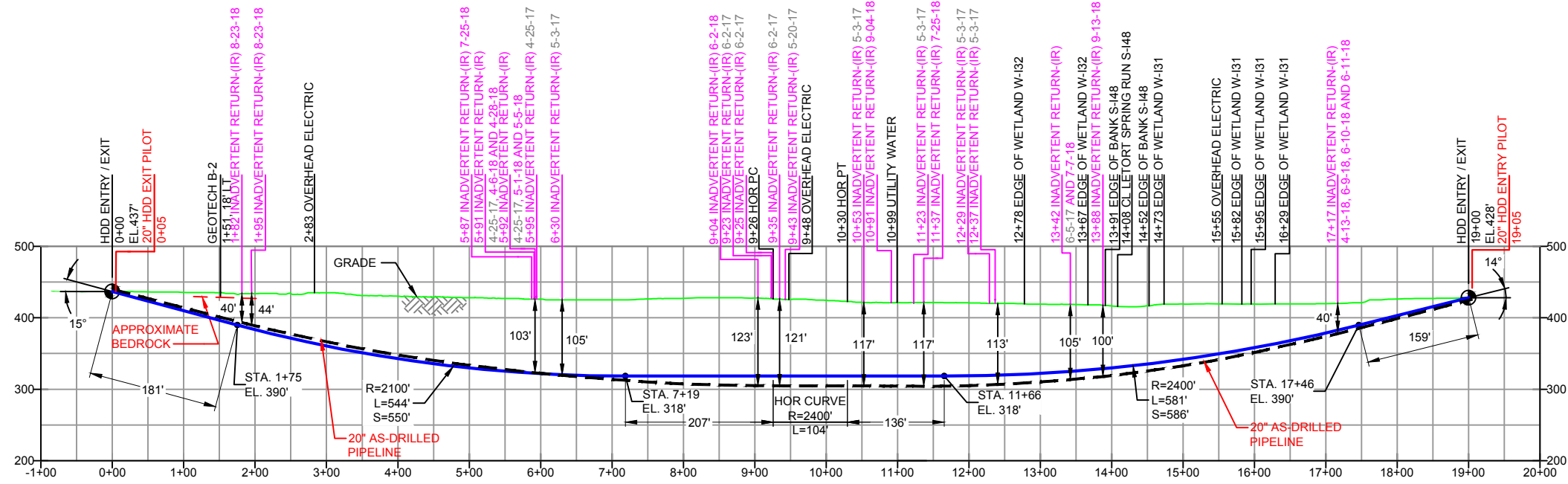
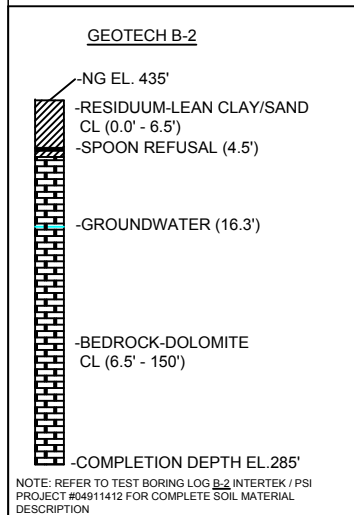
NOTES		REF. DRAWING		REVISIONS						SUNOCO PIPELINE, L.P.				
1. ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83 2. STATIONING IS BASED ON HORIZONTAL DISTANCES. 3. ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, LP ARE NOT RESPONSIBLE FOR LOCATION OF FOREIGN UTILITIES SHOWN IN PLOT PLAN OR PROFILE. THE INFORMATION SHOWN HEREON IS FURNISHED WITHOUT LIABILITY ON THE PART OF ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, LP. FOR ANY DAMAGES RESULTING FROM ERRORS OR OMISSIONS THEREIN. 4. CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING. 5. SUNOCO EMERGENCY HOTLINE NUMBER IS 811-900-786-7440.		ES-4.57	TO ES-4.58	EROSION & SEDIMENT PLAN	EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	10/07/16	RMB	10/07/16	AAW	10/07/16	16-INCH HORIZONTAL DIRECTIONAL DRILL LETORTE SPRINGS RUN PENNSYLVANIA PIPELINE PROJECT	
		SHEET 36	TO SHEET 37	AERIAL SITE PLAN	EP1	REVISED PER PADEP COMMENTS	MRS	05/10/16	RMB	05/10/16	AAW	05/10/16		
					EP		JTW	03/23/16	RMB	03/23/16	AAW	03/23/16	SCALE: 1"=200' DWG. NO: PA-CU-0136.0002-WX-16	
					B	ADDED GEOTECH INFO	MRS	09/15/15	RMB	09/15/15	AAW	09/15/15		
					A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15		
		DWG NO	DWG NO	DESCRIPTION	NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE		





CUMBERLAND COUNTY, PENNSYLVANIA - MIDDLESEX TOWNSHIP
S2-0210

PROFILE VIEW



- DESIGN AND CONSTRUCTION:
- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
 - THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
 - DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
 - CROSSING PIPE SPECIFICATION:
HDD HORZ. LENGTH (L=): 1900'
HDD PIPE LENGTH (S=): 1921'
20" x 0.456" W.T., X-65, API6L, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCURE R95)
 - INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 - CARRIER PIPE NOT ENCASED.
 - PIPE AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
 - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
 - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.
 - CONTRACTOR SHALL CONTINUOUSLY MONITOR THE ANNULAR PRESSURE INSIDE THE PILOT HOLE USING A DOWNHOLE PRESSURE RECORDER DURING THE PILOT PHASE OF THE DRILL AND HE SHALL ACT ON THAT INFORMATION TO FURTHER REDUCE THE LIKELIHOOD OF INADVERTENT RETURNS.

HDD IR OVERLAY

Figure 2. 20-Inch As Drilled HDD Plan and Profile with IR Data

NOTES		REF. DRAWING		REVISIONS		SUNOCO PIPELINE, L.P.		
1. ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83 STATIONING IS BASED ON HORIZONTAL DISTANCES.		ES-4.57	TO ES-4.58	EP11	ADDED ADDITIONAL IR INFORMATION (9-13-18)	MRS	09/13/18	09/13/18
2. ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, L.P. 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, L.P. FOR ANY DAMAGES RESULTING FROM ERRORS OR OMISSIONS THEREIN.		SHEET 36	TO SHEET 37	EP10	ADDED ADDITIONAL IR INFORMATION (9-04-18)	MRS	09/05/18	09/05/18
3. CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.				EP9	ADDED ADDITIONAL IR AND AS-DRILLED INFORMATION	MRS	08/31/18	08/31/18
4. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.				EP8	UPDATED AS-DRILLED INFORMATION	MRS	08/23/18	08/23/18
				EP7	ADDED 6" POLY PIPE AND AS-DRILLED INFORMATION	MRS	08/13/18	08/13/18
				EP6	ADDED ADDITIONAL IR AND AS-DRILLED INFORMATION	MRS	07/26/18	07/26/18
DWG NO.	DWG NO.	DESCRIPTION	NO.	DESCRIPTION	BY	DATE	CHK	DATE

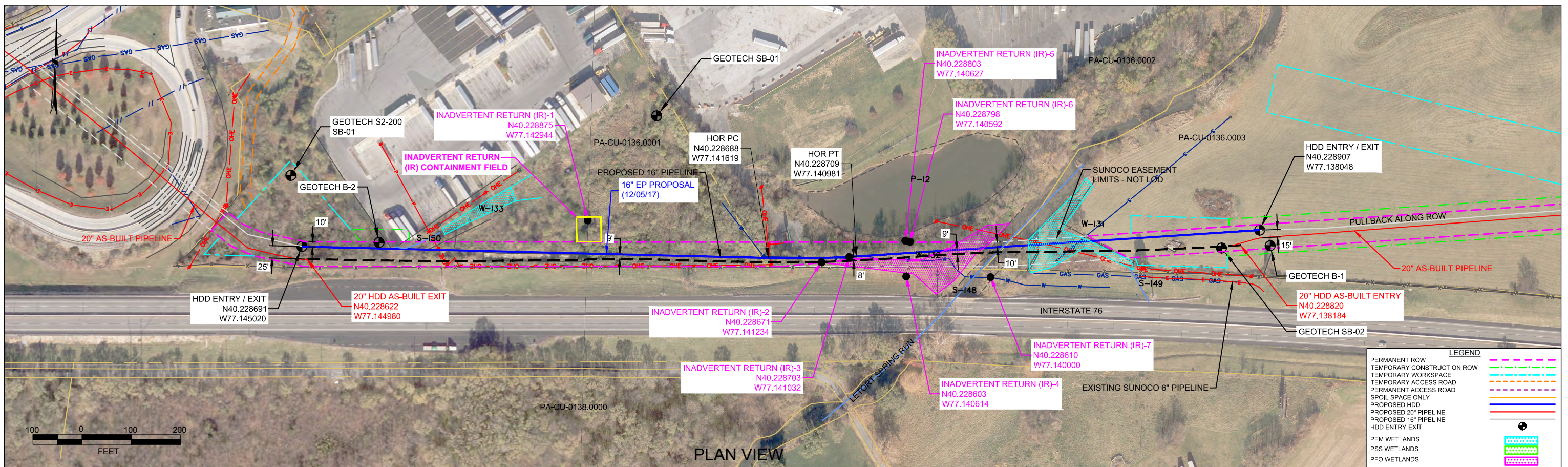
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

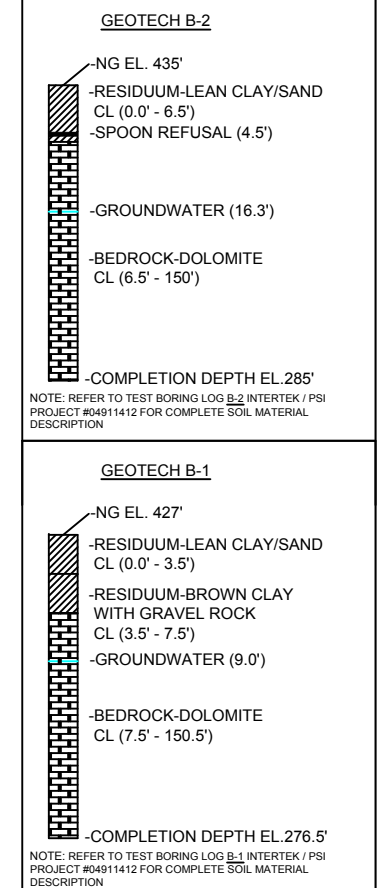
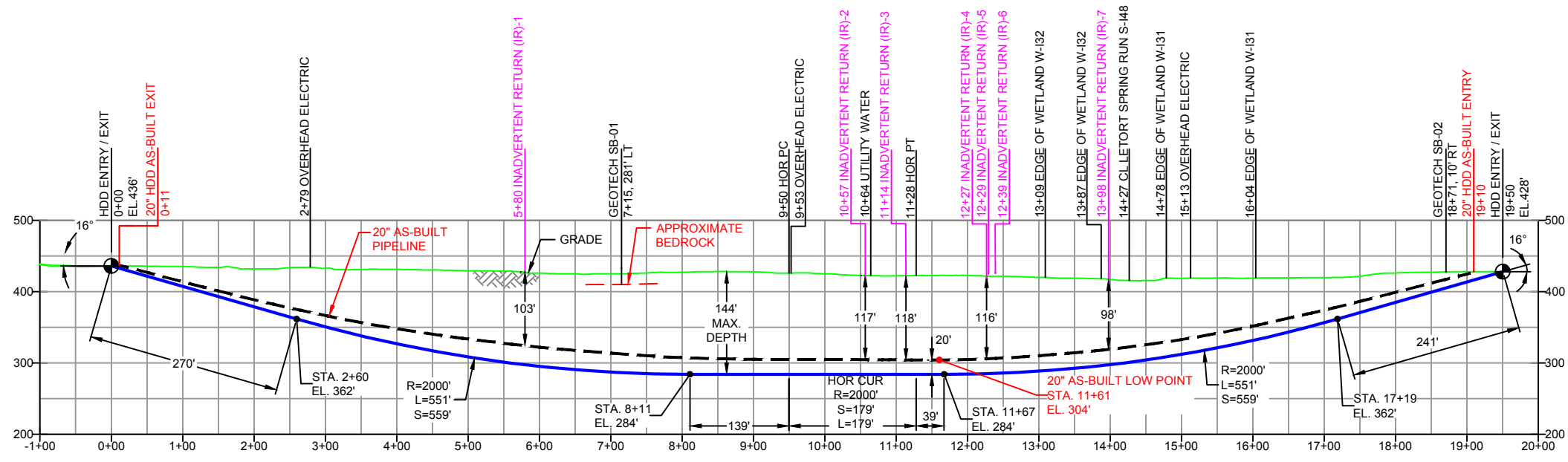
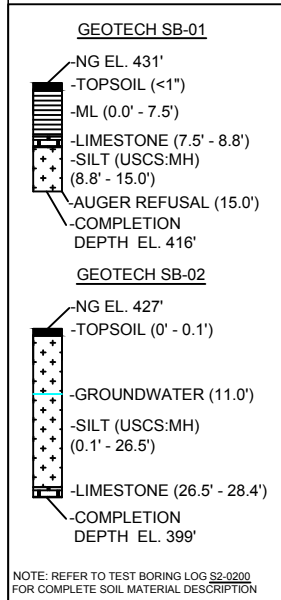
HORIZONTAL DIRECTIONAL DRILL
LETORT SPRING RUN
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' DWG. NUMBER: PA-CU-0136.0002-WX



CUMBERLAND COUNTY, PENNSYLVANIA - MIDDLESEX TOWNSHIP
S2-0210-16

PLAN VIEW
PROFILE VIEW



- DESIGN AND CONSTRUCTION:
- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
 - THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
 - DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
 - CROSSING PIPE SPECIFICATION:
HDD HORZ. LENGTH (L=): 1950'
HDD PIPE LENGTH (S=): 1986'
16" x 0.438" W.T., X-70, APISL, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
 - INTERNAL DESIGN PRESSURE 2100 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 - CARRIER PIPE NOT ENCASED.
 - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 2625 PSIG.
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
 - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
 - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

Figure 3. 2018 Redesigned 16-Inch HDD Plan and Profile

NOTES		REF. DRAWING		REVISIONS		SUNOCO PIPELINE, L.P.						
1. ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83		ES-4.57	TO ES-4.58	EROSION & SEDIMENT PLAN	EP5	DESIGN CHANGE - INCREASED DEPTH OF DRILL	MRS	12/11/18	RMB	12/11/18	AMC	12/11/18
2. STATIONING IS BASED ON HORIZONTAL DISTANCES.		SHEET 36	TO SHEET 37	AERIAL SITE PLAN	EP4	UPDATED NOTE 5 AND 10 PER INCREASED 16" MOP	MRS	04/10/18	RMB	04/10/18	CAG	04/10/18
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.					EP3	LOWERED DRILL AND RELOCATED ENTRY/EXIT - DESIGN CHANGE REQUESTED BY CLIENT	MRS	12/05/17	RMB	12/05/17	CAG	12/05/17
4. CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.					EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	10/07/16	RMB	10/07/16	AAW	10/07/16
5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.					EP1	REVISED PER PADEP COMMENTS	MRS	05/10/16	RMB	05/10/16	AAW	05/10/16
DWG NO.	DWG NO.	DESCRIPTION	NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE	SCALE: 1"=200'	



SUNOCO PIPELINE, L.P.
HORIZONTAL DIRECTIONAL DRILL
LETORT SPRING RUN
PENNSYLVANIA PIPELINE PROJECT
SCALE: 1"=200'
DWG. NO. PA-CU-0136.0002-WX-16