

**HORIZONTAL DIRECTIONAL DRILL ANALYSIS
HERMAN O.W. DRIVE CROSSING
PADEP SECTION 105 PERMIT NO.: E15-862
PA-CH-0127.0000-RD
(SPLP HDD No. S3-0320)**

**HERMAN O.W. DRIVE HDD
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(SPLP HDD No. S3-0320)**

This reanalysis of the horizontal directional drill (HDD) installation of a 20-inch diameter pipeline crossing Herman O.W. Drive in Uwchlan Township, Chester County, Pennsylvania has been completed in accordance with Condition No. 3 of the Stipulated Order issued under Environmental Hearing Board Docket No. 2017-009-L. Condition No. 3 stipulates, for HDDs initiated after the temporary injunction issued by the Pennsylvania Department of Environmental Protection (PADEP) Environmental Hearing Board on July 25, 2017, a reevaluation must be performed on HDDs for which an inadvertent return (IR) occurs during the installation of one pipe (20-inch or 16-inch diameter) where a second pipe will thereafter be installed in the same right-of-way (ROW).

The 16-inch HDD was initiated before the temporary injunction issued by the Pennsylvania Department of Environmental Protection (PADEP) Environmental Hearing Board on July 25, 2017. This HDD had a 15 gallon IR during pilot phase drilling; therefore, the installation of the second pipe (20-inch) requires reanalysis. The IR associated with the HDD of the 16-inch pipe was remediated. The HDD of the 16-inch pipeline is yet to be completed.

PIPE INFORMATION

20-Inch: 0.456 wall thickness; X-65

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 20-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.

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Specifics for the original permitted 20-inch HDD plan and profile (P & P) are discussed in the original permitted HDD design summary below. Specifics for the revised 20-Inch HDD P & P are discussed in the Redesigned Horizontal Directional Drill Design Summary at the end of this report.

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 20-INCH

- Horizontal length: 2,437 feet (ft).
- Entry/Exit angle: 10-14 degrees
- Maximum Depth of cover: 103 ft.
- Pipe design radius: 2,000 ft.

The original profile design factors are below the pipeline stress allowances for all points of analysis.

ROOT CAUSE ANALYSIS FOR THE 16-INCH PIPELINE INADVERTENT RETURN

During pilot phase drilling for installation of the 16-inch line a 15 gallon IR in uplands occurred when the pilot tool was 130 ft before the exit point. This is considered a “punch out” IR in the drilling industry. The IR occurred when the pilot bore was approaching the exit at the northwest side of the HDD and traveled through a thinning, relatively weak, overburden comprised of saprolite and weathered bedrock.

Due to the tool location of 2,307 ft distance from entry at the time of the IR, it is obvious that the drilling fluid pressures required to maintain return flows to the entry pit exceeded the retention strength of the bedrock and overburden; therefore root cause of the IR is poor rock/overburden strength while operating at normal drilling fluid pressure to maintain return flows.

GEOLOGIC ANALYSIS

HDD S3-0320 is located within the Piedmont Upland Section of the Piedmont Province, which is characterized by broad, rounded to flat-topped hills and shallow valleys. Based on information obtained from the National Resource Conservation Service Web Soil Survey database for Chester County, soils underlying HDD S3-0320 include the Nashaminy silt loam on 3 to 8 percent and on 8 to 15 percent slopes, the Califon loam on 3 to 8 percent slopes; the Gladstone gravelly loam on 3 to 8 percent slopes, and Urban land on 0 to 8 and 8 to 25 percent slopes. All of these soil types are derived from weathering of the underlying gneissic bedrock, with varying amounts of clay, silt, sand and gravel.

Bedrock underlying the area of HDD S3-0320 is predominantly Pre-Cambrian age gneiss differentiated as felsic & intermediate gneiss and banded mafic gneiss (PA GEODE). The felsic & intermediate gneiss is present within the approximate northwestern half of the profile and the banded mafic gneiss occurs within the approximate southeastern half of the profile. The contact between the two units trends northeast and occurs approximately at Station 13+60 on the proposed P & P. A Triassic age diabase dike passes through the banded mafic gneiss trending north-northeast and intersecting the alignment at approximately Station 16+15.

Deep vertical geotechnical cores were performed at both ends of the HDD profile in 2017. The east end core was drilled to a total depth of 160 feet. The upper seven feet were described as construction materials and a highly weathered saprolite was logged from 7 to 20 ft below ground surface (bgs). Rock coring began at 20 ft bgs. Most core recoveries were in a range from 74 to 100 percent. The only exception was a possible “fault zone” from 85 to 95 ft bgs where drilling fluids were lost and recovery was 20 to 30 percent. Rock cores from 20 to 95 ft bgs were described as being variably weathered, medium hard to soft, white,

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grey, brown and orange gneiss, with moderately dipping joints. RQDs for this interval ranged from 0 to 93 percent with most below 50 percent. From 95 ft bgs to total depth (160 ft bgs), the rocks were described as more competent white to dark grey, hard to very hard, gneiss with no jointing; and all recoveries were 100 percent. A more granite-like interval was noted from 142 to 155 ft bgs. After 95 ft bgs RQDs improved but were still variable, ranging from 34 to 100 percent, with most greater than 70 percent.

The west end core was drilled to a total depth of 112 feet. The upper 17 feet were described as sandy silt changing to poorly graded sand with depth. Rock coring began at 17 ft bgs. Highly weathered and fractured orange, brown and grey gneiss, with most core recovery at 42 to 50 percent, and most RQD at 0 to 22 percent, was logged from 17 to 67 ft bgs. From 67 ft bgs to the total depth of 112 feet, the rock was logged as more competent grey-brown to grey gneiss with 100 percent recovery, but with variable RQDs ranging from 26 to 70 percent.

Depth intervals for the Terracon rock cores were converted to approximate elevations using the estimated surface elevations indicated on the boring logs and compared to the proposed profile. This showed that the middle (deeper) 75 percent of the profile would be within the higher recovery and RQD zones indicated on the boring logs. Note that the higher RQD zones still showed variability in values. Values were as low as 26 percent for B6-8W and 34 percent for B6-8E. Approximately 25 percent of the profile represented by sections that are descending after entry and ascending before exit will be in weaker materials.

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

HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

Groundwater in the gneissic units around S3-0320 is stored in the unconsolidated weathered rock near the land surface, with lesser amount stored in the underlying bedrock fractures. Groundwater in this hydrogeologic setting moves through the weathered zone down into an interconnected network of joints, fractures, and faults.

Water well surface casing length can be an approximate predictor of the thickness of the weathered bedrock zone but is subject to over estimation given the fact that drillers often install casing some distance into competent bedrock and use 20-foot increments of casing. PAGWIS data indicates for wells within one mile of the HDD alignment, casing lengths averaged 43 feet and could be as long as 83 feet. The total depths of the wells ranged from 56 to 405 feet below ground surface (ft bgs) with only one depth greater than 288 ft bgs. Depth to bedrock ranged from 0 to 78 ft bgs and static water levels ranged from 0 to 40 ft bgs. Based on these well characteristics the water production zone for local wells could be approximated as the zone between 43 and 288 ft-bgs.

McGreavy and Sloto (1977) reported yields from the gneissic rocks in Chester County from 0 to 300 gallons per minute (gpm), with one anomalously high yield of 650 gpm. Domestic well listings from the aforementioned PAGWIS search showed the average yield was 13.5 gpm with a range from 1 to 75 gpm.

Groundwater was not encountered in three of the four Tetra Tech geotechnical test borings that were advanced to auger refusal at a maximum depth of 30 ft bgs. A water level of 25 ft bgs was recorded at boring S3-0320-01 located near the northwestern entry/exit that had auger refusal at 55 ft bgs and was advanced by rock coring to 61 ft bgs. Both logs for the deeper Terracon borings indicated groundwater was not encountered.

SPLP performed a preconstruction survey of landowners with all or part of their parcels falling within 450-feet of the S3-0320. No private water supplies were identified.

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

ADJACENT FEATURES ANALYSIS

This HDD is located in Uwchlan Township, Chester County, Pennsylvania. The pipeline alignment crosses under Herman O.W. Drive; Shamona Creek (stream S-H5) and its associated floodway; multiple commercial properties, and parallels Eagleview Blvd. The HDD alignment is within an existing SPLP permanent easement with one existing SPLP pipeline. This HDD location is set within urban commercial development for the majority of its length.

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

As a result of this outreach effort, zero (0) water wells have been identified within 450' of S3-0320. All properties within 450' of S3-0320 are connected to public water.

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 ft of any direction of this HDD location.

ALTERNATIVES ANALYSIS

As required by the Order, the reanalysis of HDD S3-0320 includes an evaluation of open cut alternatives and a re-route analysis. As part of the PADEP Chapter 105 permit process for the Mariner II East Project, SPLP developed and submitted for review a project-wide Alternatives Analysis. During the development and siting of the Project, SPLP considered several different routings, locations, and designs to determine whether there was a practicable alternative to the proposed impact. SPLP performed this determination through a sequential review of routes and design techniques, which concluded with an alternative that has the least environmental impacts, taking into consideration cost, existing technology, and logistics. The baseline route provided for the pipeline construction was to cross every wetland and stream on the project by open cut construction procedures. The Alternatives Analysis submitted to PADEP conceptually analyzed the potential feasibility of any alternative to baseline route trenched resource crossings (e.g., reroute, conventional bore, HDD). The decision-making processes for selection of the HDD instead of an open cut crossing methodology is discussed thoroughly in the submitted alternatives analysis and was an important part of the overall PADEP approval of HDD plans as currently permitted. As described below, the open cut and re-route analyses have confirmed the conclusions reached in the previously submitted Alternatives Analysis.

The HDD as originally permitted was designed to avoid direct impacts to multiple commercial properties, existing utilities, public infrastructure, and Shamona Creek.

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Open-cut Analysis

Sunoco Pipeline, LP (SPLP) specifications require a minimum of 48-inches of cover over the installed pipelines. The Pennsylvania Department of Transportation (PennDot) requires 60-inches of cover below public roadways.

The conversion of the planned HDD to open cut for its entire length is not possible. The planned HDD avoids open cut or other installation methods to cross two public roads; five (5) private commercial drives; nine (9) conflicting utility crossings, and a stream/floodway crossing.

Open cut construction in combination with other pipeline installation techniques is possible, but problematic, as discussed below.

The alteration of the current permitted route from HDD to open cut would require major modifications of the state Chapter 102 and Chapter 105 permits, and associated authorizations issued by the United States Army Corps of Engineers.

Use of Conventional Auger Bore

Planning for a conventional bore must account for the extent or width of the feature (road, stream, etc.) being bored under, as well as the length and width of the setup-entry pit for setting the boring equipment within while operating, and the receiving pit through which the product pipeline is pulled back through after the boring machinery exits.

Based on experience gained during construction of the Mariner II Pipeline project, conventional auger bores should be limited to approximately 200 linear ft at a time, or less, varying by the underlying substrate. Conventional auger bores for the 16-inch pipeline, attempted at longer distances, have at times had alignment drift and elevation deflections occur which have complicated installation.

Shamona Creek cannot be crossed by conventional auger bore due to the changes in elevation on both sides of the creek. As discussed above, at minimum two (2) conventional bores and the associated workspace requirements would be required for the crossings of public roads. If the five private drives cannot be negotiated to be crossed by open cut, then five additional bores would be required along with the workspaces for setup and receiving pits. For all five private drives, there is insufficient space to setup entry and receiving pits; therefore, they would have to be open cut, which would disrupt these businesses for the duration of activity until completion.

Comparing the level of direct effect to existing businesses by a bore/open cut work plan to a 15 gallon IR event, results in SPLP's opinion that the HDD remains the preferred pipeline installation method.

FlexBor Analysis

SPLP contractors attempted three (3) FlexBors and partially completed two of these to replace HDDs on the Mariner Project. One FlexBor failed in the pilot phase and was replaced with a conventional 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 regardless of length.

Direct Pipe Bore Analysis

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.

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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 it is attached to. 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. Unlike an HDD, this technology has no steering capability. Changes in direction are made by adjusting the cutting angle of the tool face which results in a maximum of 4 degrees radius between the point of entry and exit, varying by the length of the bore attempt. The shorter the bore, the less area for adjustment of depth or direction is available. The Direct Bore entry workspace requirements includes a 400 ft by 100 ft area for installation of the entry pit, hydraulic press, and casing assembly, plus approximately a 0.7 acre area for equipment power, fluids recycling, maintenance and supporting equipment.

SPLP's construction contractors have successfully completed one (1) Direct Pipe Bore approximately 925 ft on the Pennsylvania Pipeline Project at the crossing of the Frankston Branch of the Juniata River in Blair County. This Direct Pipe Bore was setup within a relatively flat area immediately outside the river floodplain and bored under the floodplain, wetlands, and river, exiting at the toe of a mountain slope.

Shamona Creek cannot be crossed by Direct Pipe bore due to the changes in elevation on both sides of the creek and equipment workspace requirements. Similar to the constraints for use of conventional auger bore; excepting that Direct Pipe bores have larger workspace requirements at the entry pit, an 883 ft Direct Bore to replace the east end of the HDD is possible. Proceeding northwest along the HDD alignment, no other adequate area exists for employment of this method until the crossing of Herman O.W. Drive; which could be crossed by conventional auger bore. As a result, an alternative construction plan of an 883 Direct Bore, and then open cut of Shamona Creek and all other open space with conventional bores of Herman O.W. Drive and two private drives, plus pipeline push or bore of all other conflicting utilities is feasible.

Comparing this plan of construction to a 15 gallon IR event, results in SPLP's opinion that the HDD remains the preferred pipeline installation method.

Re-Route Analysis

The general route of the Mariner II project in this area of the Commonwealth is from northwest to the southeast.

The pipeline route as currently permitted follows an existing SPLP easement paralleling Eagleview Blvd. Residential and commercial developments surround the area of S3-0320. Deviation of the proposed route would pass through numerous commercial and residential developments similar to the setting of the currently permitted alignment before any open undeveloped lands could be accessed. Any alternate route considered would deviate from the currently co-located SPLP easement and require the clearing of a new "greenfield" corridor and encroach on additional commercial and residential properties before it could rejoin the current route.

In summary, due to the urban setting surrounding the overall route of the Mariner II pipelines in this area, there is no practical alternative route that could avoid conflicts with existing development and similar geology. Since SPLP possesses no prior rights for multiple utility lines in any nearby existing corridor, nor any new corridor that could be developed, SPLP anticipates significant legal action to acquire a new easement.

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This re-route analysis conducted for the Herman O.W. Drive HDD is consistent with the conclusions reached in the alternatives analysis previously submitted to PADEP.

HORIZONTAL DIRECTIONAL DRILL REDESIGN

SPLP has considered all geologic data and the events during drilling of the 16-inch pipeline and has redesigned the 20-inch HDD profile. A summary of the redesign factors is provided below. The original and redesigned HDD P & P for the 20-inch pipeline are provided in Attachment 2.

Revised Horizontal Directional Drill Design Summary: 20-inch

- Horizontal length: 2,483 ft
- Entry/Exit angle: 14 – 16 degrees
- Maximum Depth of cover: 148 ft
- Pipe design radius: 2,200 – 2,700 ft

The redesigned HDD profile has maximized the exit angle to reduce the potential for an IR like the one that occurred during installation of the 16-inch pipeline. The remaining design factors are below the pipeline stress allowances for all points of analysis.

CONCLUSION

HDD specialists, geologists and engineers employed by SPLP have investigated the HDD design and subsurface geologic conditions and concluded that the revised HDD design for the 20-inch pipeline, as summarized herein, minimizes the risk of an IR that would impact Waters of the Commonwealth. Upland and punch out IRs are common on entry and exit of the drilling tools and in these cases, other measures are required to minimize IR potential. In particular, upon the start of this HDD, SPLP will employ the following HDD best management practices:

- SPLP will provide the drilling crew and company inspectors the location(s) data on potential zones of higher risk for fluid loss and IRs, including the area related to previous IR, and potential zones of fracture concentration identified by fracture trace analysis, so that monitoring can be enhanced when drilling through these locations.
- SPLP will mandate annular pressure monitoring during the drilling of the pilot hole, which assists in immediate identification of pressure changes indicative of loss of return flows or over pressurization of the annulus, to help manage development pressures that can induce an IR;
- SPLP inspectors will ensure that an appropriate diameter pilot tool, relative to the diameter of the drilling pipeline, is used to ensure adequate “annulus spacing” around the drilling pipeline exits to allow good return flows during the pilot drilling;
- SPLP will implement short-tripping of the reaming tools, as indicated by monitoring of return flows, to ensure an open annulus is maintained to manage the potential inducement of IRs;
- SPLP will require monitoring of the drilling fluid viscosity, such that fissures and fractures in the subsurface are sealed during the drilling process;

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- The drilling manager and SPLP drilling inspectors will monitor the tool face pressure while advancing towards exit to determine which mud pressures can be reduced to lower IR potential while completing the final footage for exiting of the pilot tool;

- During all drilling phases, the use of Loss Control Materials (LCMs) will be implemented upon detection of a LOC or indications of a potential IR are noted or an IR is observed. The use of LCMs, however, is less effective 70 ft-bgs. Accordingly, the preferred corrective action needed to address the presence of fractures or LOC at greater depths below ground will require grouting of the HDD annulus. Two types of grouting may be utilized for corrective actions to seal fractures. These are: 1) grouting using "neat cement"; and 2) grouting using a sand/cement mix. Neat cement grout is a slurry of Portland cement and water which is highly reactive to bentonite and induces solidification. The sand/cement grout mix is a slurry of mostly sand with a small percentage of Portland cement and activators that after setup results in a material having the competency of a friable sandstone or mortar. Both grouting actions require tripping out the drilling tool, and then tripping in with an open-ended drill stem to apply or inject the grout mixes. Either of these grouting actions may be implemented 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.

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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

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

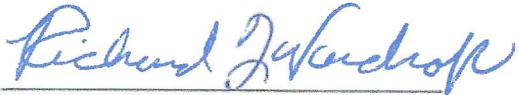


Larry J. Gremminger, CWB
Vice President – Environmental
Geotechnical Evaluation Leader
Mariner East 2 Pipeline Project

6-18-2019

Date:

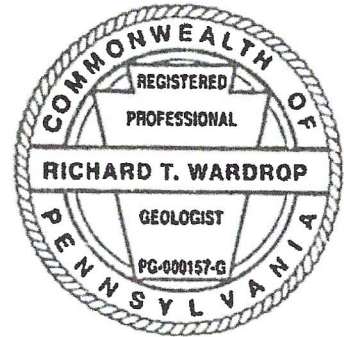
Pertaining to the practice of geology



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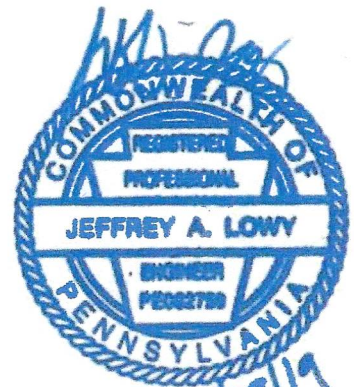
Pertaining to the pipeline stress and HDD geometry



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**ATTACHMENT 1
GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT**



HDD HYDROGEOLOGIC REEVALUATION REPORT

**Mariner Southeast II
Spread 6
HDD S3-0320
Herman O. W. Drive
Uwchlan Township, Chester County, Pennsylvania**

Prepared for:

Sunoco Pipeline, L.P.

Prepared by:

**Groundwater & Environmental Services, Inc.
440 Creamery Way, Suite 500
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June 2019



HDD HYDROGEOLOGIC REEVALUTION REPORT

**Mariner Southeast II
Spread 6
HDD S3-0320
Herman O. W. Drive
Uwchlan Township, Chester County, Pennsylvania**

June 2019

Prepared for:

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A handwritten signature in blue ink that reads "Richard T. Wardrop".

Richard T. Wardrop, P.G.
Principal Hydrogeologist

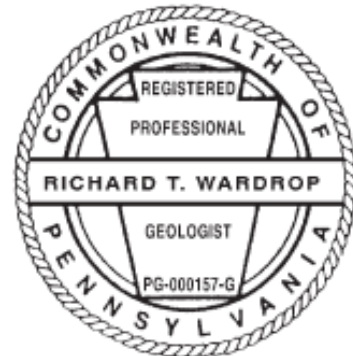
Reviewed by:

A handwritten signature in blue ink that reads "David J. Demko".

David J. Demko VP, P. G.
Program Manager

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By affixing my seal to this document, I am certifying that the geologic and hydrogeologic information is true and correct. I further certify 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.



June 18, 2019

Richard T. Wardrop, P. G.

Date

Lic. No. PG000157G

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ATTACHMENTS

- Attachment A. Plan and Profiles
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1.0 INTRODUCTION

Sunoco Pipeline, LP, (SPLP) retained Groundwater & Environmental Services, Inc. (GES) to prepare HDD Hydrogeologic Reevaluation Reports (HRRs) for horizontal directional drills (HDDs) for the Mariner Southeast II pipeline project. The project involves installation of a 20-inch and a 16-inch diameter natural gas liquid pipeline parallel to one another. This HRR is for installation of the 20-inch pipeline referred to as HDD S3-0320 Herman O. W. Drive. During the reaming phase of construction on 16-inch pipeline an inadvertent return (IR) occurred. According to the requirements of Stipulated Order EHB Docket No. 2017-009-L signed August 10, 2017, installation of the 20-inch pipeline requires a HDD Reevaluation, including this HRR, because the IR occurred during construction of the first of the two pipelines.

The discussion presented in this report compares the plan and profile (P & P) for HDD S3-0320 developed by Tetra Tech/Rooney, revised 10/21/16 (permitted profile) to the new proposed P & P (revised 5/24/19), and the as-built profile for the 16-inch line pilot bore that is 95 percent complete (see **Attachment A**). In terms of horizontal distance, the permitted profile is 2,437 feet long, the proposed profile is 2,483 feet long, and the completed 16-inch line will be similar to the proposed 20-inch line. The permitted profile has a horizontal distance of 2,437 feet, and both the proposed profile and projected 16-inch profile have a horizontal distance of 2,483 feet. The profile stationing on the land surface is slightly different between the permitted and proposed profiles as the northwest entry/exit on the permitted profile is approximately 22 feet southeast than on the other two profiles and the southeast entry/exit of the permitted profile is approximately 24 feet northwest than on the other two profiles. As shown in **Attachment A**, in map view the proposed 20-inch line will be installed over 20 feet south of the 16-inch line.

The alignment for HDD S3-0320 is in Uwchlan Township, Chester County, approximately 0.6 miles south of where Route I-76 passes over SR Route 100, and approximately 2.0 miles east of Marsh Creek Reservoir. A map depicting the location of the HDD with topographic information for the surrounding area is presented as **Figure 1**.

This report presents the following information:

- Geologic and hydrogeologic characteristics in the area of HDD S3-0320;
- Summaries of studies performed pertinent to reevaluation, including fracture trace analysis and geotechnical borings;
- A site conceptual model; and
- A reevaluation summary with conclusions.

The contents of this report were developed from interpretation of published information, field observations, and related field studies. From June to December 2015, Tetra Tech conducted a site geotechnical boring program. Additional geotechnical borings were advanced by Terracon in August and September 2017. Please note that GES did not oversee or direct either geotechnical boring program, including, but not limited to, the selection of number and location of borings, determination of surface elevations, target depths, observations of rock cores during drilling operations, or preparation of boring logs. The geotechnical reports, boring logs, and any core photographs that resulted from these programs were generated by SPLP's contractors. GES relied on these reports and incorporated their data into the general geologic and hydrogeologic framework for this hydrogeologic reevaluation report.

As described in the Stipulated Order (pages 3 and 4), the HRRs will provide information to eliminate, reduce, or control the release or IR of HDD drilling fluids to the surface of the ground or impact to water supplies at the location during HDD operations. The HRRs are not intended to evaluate the potential risks of adverse effects on man-made structures (ex. roadways, parking lots and buildings) proximal to the HDD alignment.

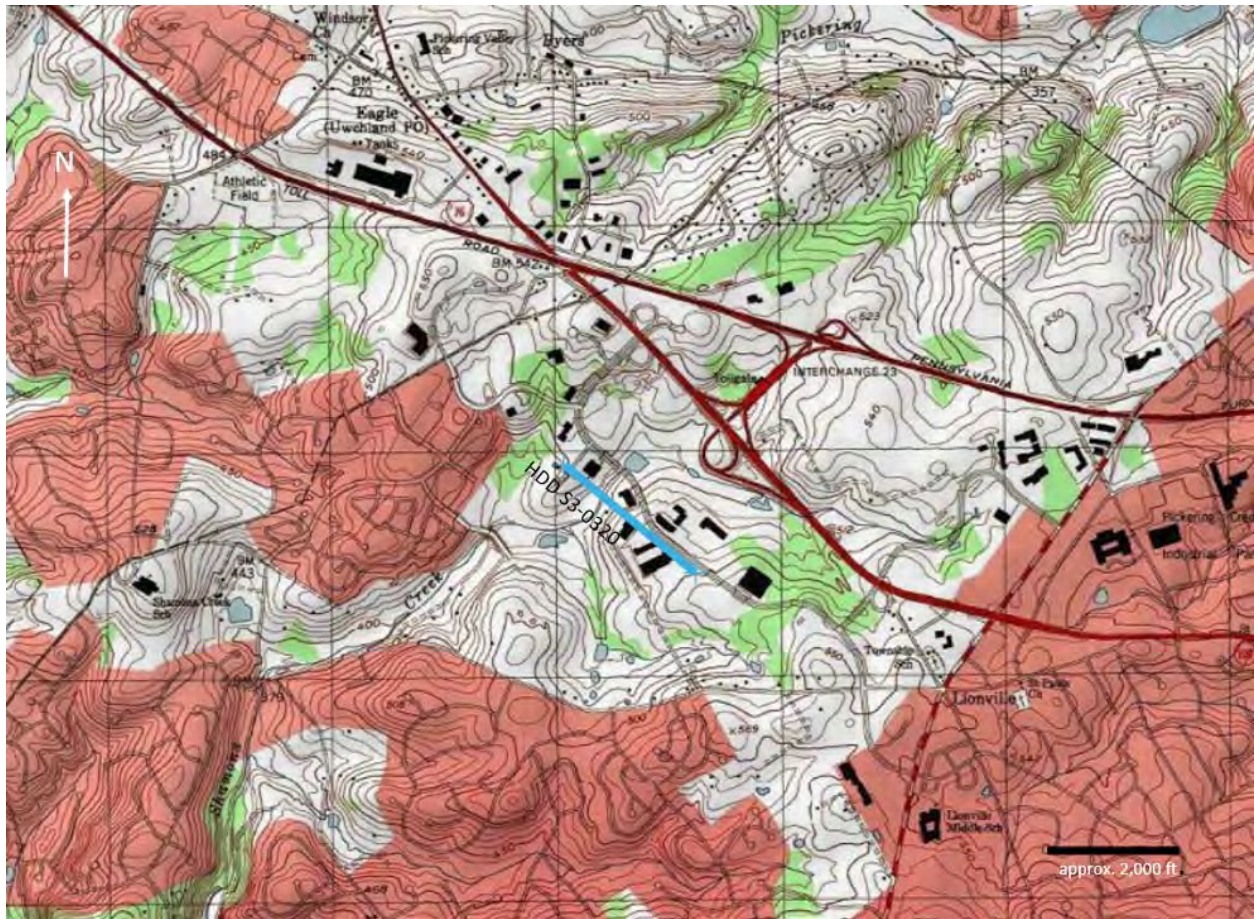


Figure 1. Site Location Map (modified from PaGEODE).



2.0 HDD GEOLOGY / HYDROGEOLOGY

2.1 Physiography

HDD S3-0320 is located within the Piedmont Upland Section of the Piedmont Province, which is characterized by broad, rounded to flat-topped hills and shallow valleys. The area surrounding the HDD is comprised of light industrial properties.

2.1.1 Topography

The topography along HDD S3-0320 has low relief. The northwestern entry/exit (Station 0+00) is at an elevation of 450 feet above mean sea level (ft amsl) for the permitted P & P and 445 ft amsl for the proposed P & P. Moving southeast along a relatively flat-topped hill the surface gradually lowers to an elevation of approximately 428 ft amsl where the profile passes below Shamona Creek (stream S-H5). From there, moving southeast, the surface gradually rises to approximately Station 14+50 (proposed profile) and a flat-topped hill at approximately 500 ft amsl, and generally stays at that level to the southeastern entry/exit.

2.1.2 Hydrology

The topographic surface local to the HDD is draining west. Stream S-H5 flows southwest where it crosses the alignment and is the main branch of Shamona Creek. Two unnamed tributaries to Shamona Creek meet the main branch approximately 0.4 miles southwest of the HDD and from there Shamona Creek flows southwest and south to its confluence with East Branch Brandywine Creek at Dowlin.

2.2 Geology

2.2.1 Soils

Based on information obtained from the National Resource Conservation Service Web Soil Survey database (USDA NRCS WSS) for Chester County, soils underlying HDD S3-0320 include the Nashaminy silt loam on 3 to 8 percent and on 8 to 15 percent slopes, the Califon loam on 3 to 8 percent slopes; the Gladstone gravelly loam on 3 to 8 percent slopes, and Urban land on 0 to 8 and 8 to 25 percent slopes. All of these soil types are derived from weathering of the underlying gneissic bedrock, with varying amounts of clay, silt, sand and gravel. All of the soils are considered well drained except for the Califon loam, which is considered moderately well drained. The depth of bedrock weathering to create these soils ranges from 5.5 to 8.25 feet and the depth to the water table ranges from 5.0 to greater than 6.7 feet. The soil present at the northwestern entry/exit is the Nashaminy silt loam on a 3 to 8 percent slope that transitions to a gravelly clay at approximately 6.2 feet. The soil present at the southeastern entry/exit is the Gladstone gravelly loam that transitions to sandy loam with depth.

2.2.2 Bedrock Lithology

Bedrock underlying the area of HDD S3-0320 is predominantly Pre-Cambrian age gneiss differentiated as felsic & intermediate gneiss, and banded mafic gneiss (PA GEODE). The felsic & intermediate gneiss is present within the approximate northwestern half of the profile and the banded mafic gneiss occurs within the approximate southeastern half of the profile. The contact between the two units trends northeast and occurs approximately at Station 13+60 on the proposed P & P. A Triassic age diabase dike passes through the banded mafic gneiss trending north-northeast and intersecting the alignment at approximately Station 16+15 (see **Figure 2** and **Attachment A**).

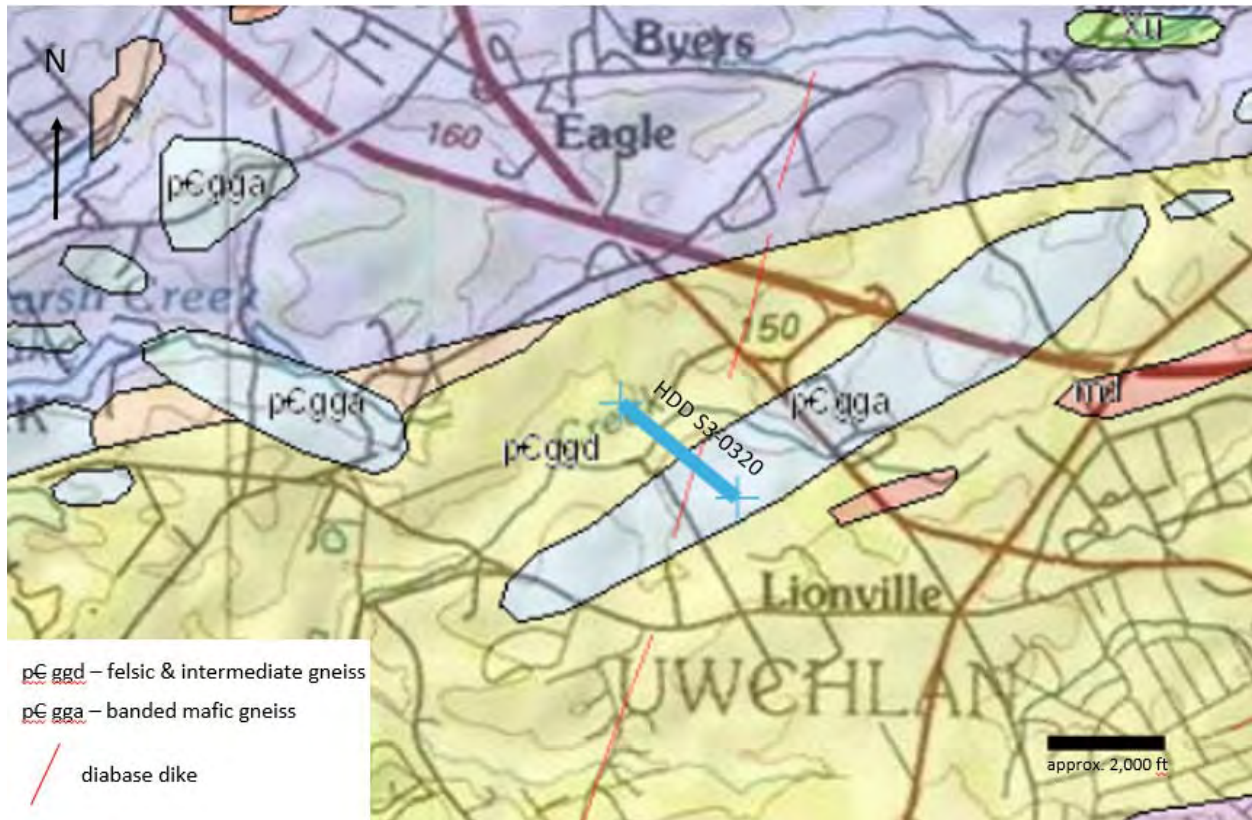


Figure 2. Bedrock Geology (modified from PaGEODE).

2.2.3 Structure

No major structural features have been mapped in proximity of the HDD S3-0320 alignment. The regional structural fabric and contact between the gneiss units trend northeast. Cross-Section A-A' in Berg, et. al. (1980) shows the local gneiss bodies dipping steeply to the south. The diabase dike is skew to the regional structural fabric, trending north-northeast.

Discontinuities in the form of joints, fractures and faults are imprinted in the bedrock units across the region. These features can act as conduits for groundwater movement and/or represent areas of weakness in the rock.

2.2.4 Fracture Trace Analysis

Fracture trace analysis using high altitude aerial photography was performed for the area of interest to identify potential zones of bedrock weakness along drill paths. Fracture traces (one mile in length or less) and lineaments (greater than one mile in length) can be the surficial expression on natural landscapes of vertical to near vertical zones of bedrock fracture concentration. Fracture trace analysis is partly subjective; therefore, every mapped fracture trace does not necessarily represent a zone of bedrock fracture concentration.

Figure 3 shows the fracture trace mapping conducted for this reevaluation. This mapping was performed using aerial stereographic pairs flown in the fall of 1937. As such, much of the land surface appears undeveloped and fracture traces are more easily seen. Three general orientations are present in the fracture traces proximal to the alignment: a north-northeast trending set, a west-northwest trending set and one trace trending north-northwest. Two north-northeast trending fracture traces cross the alignment. These traces are also plotted on the proposed P & P in **Attachment A**.



Figure 3. Fracture Trace Map.

2.2.5 Karst

Based on published geologic data, no karst features are anticipated within the LOD of HDD S3-0320. The potential of karst conditions is not anticipated because carbonate rock is not mapped proximal to the HDD alignment and no carbonate rock was logged in the geotechnical borings (see Section 2.2.8). The contact between the gneissic units and carbonate valley of Chester County begins two miles SE of the HDD alignment.

2.2.6 Mining

No historic or current, surface or deep, mineral mining operations have been identified in the area of the HDD in Uwchlan Township.

2.2.7 Rock Engineering Properties

The properties of the bedrock units as described in Geyer and Wilshusen (1982) are as follow:

Felsic & intermediate gneiss (ggd) [granodiorite and granodioritic gneiss]:

- No bedding.
- Joints / fractures occur in a blocky pattern, moderately developed, moderately abundant, irregular; widely spaced; open and moderately dipping.
- Difficult to excavate, expect large surface and near-surface boulders, slow drilling rates.

Banded mafic gneiss (gga) [gabbroic gneiss and gabbro]:

- Banding is poorly developed, massive in thickness.
- Joints / fractures are of an irregular pattern, moderately to poorly formed, of moderate abundance, widely to moderately spaced, irregular, steeply dipping and open.
- Difficult to excavate, slow drilling rates.

Diabase:

- No bedding
- Joints / fractures are well developed in a blocky pattern, of moderate abundance, regularly spaced, with moderate spacing, open and steeply dipping.
- Difficult to excavate, large boulders can create difficulty, slow drilling rate.

2.2.8 Results of Geotechnical Borings

Tetra Tech

In 2017, Tetra Tech advanced four (4) geotechnical boring proximal to the HDD S3-0320 alignment in support of designing the HDD. These include borings S3-0310 SB-03, S3-0320 SB-01, S3-0320 SB-2, and S3-0320 SB-03. S3-0310 SB-03 was located approximately 600 feet northwest of the northwest entry/exit for HDD S3-0320 on the north side of the right-of-way (ROW). S3-0320 SB-01 and S3-0320 SB-03 were located near the northwest and southeast entry/exits, respectively and S3-0320 SB-02 was located at the approximate midpoint on the HDD alignment. The logs for these borings are provided in **Attachment B**.

At each geotechnical boring location, split spoon samples were collected through a hollow stem auger. In general, the texture of the unconsolidated materials was silt and sand with little gravel derived from the weathering of gneissic bedrock. A few feet of silt and sand was logged near the surface in S3-0320 SB-01 and S3-0320 SB-3. Auger refusal was logged at 55 ft bgs in S3-0320 SB-01 and shallower in the other three boring ranging from 19 to 30 ft bgs. A zone of high split spoon blow counts (>50) occurred with depth and continued to auger refusal in all four boring. The top of this zone ranged from 18.5 to 30 ft bgs for the three borings located near HDD S3-0320 alignment. This zone is where larger gravel to boulder size material can be expected during excavation and during entry and exit of the HDDs. Groundwater was only encountered in S3-0320 SB-01; there a water level measurement of 25 ft bgs was taken through the hollow stem augers.

Bedrock coring was attempted at S3-0320 SB-01 from 53 to total boring depth at 61.3 feet. All of the core was described as decomposed weathered gneiss with 0 percent rock quality determination (RQD) values.

Terracon

In August and September 2017, Terracon advanced two geotechnical borings at HDD S3-0320 to further evaluate local geologic conditions. B6-8W was advanced near the northwest entry/exit and B6-8E was advanced near the southeast entry/exit. B6-8W was drilled to a total depth of 112 feet. The upper 17 feet were described as sandy silt changing to poorly graded sand with depth. Rock coring began at 17 ft bgs. Highly weathered and fractured orange, brown and grey gneiss, with most core recovery at 42 to 50 percent, and most RQD at 0 to 22 percent, was logged from 17 to 67 ft bgs. From 67 ft bgs to the total depth of 112 feet, the rock was logged as more competent grey-brown to grey gneiss with 100 percent recovery, but with variable RQDs ranging from 26 to 70 percent. The drill log noted that no water was encountered during advance of the boring.

Terracon boring B6-8E was drilled to a total depth of 160 feet. The upper seven feet were described as construction materials and a highly weathered saprolite was logged from 7 to 20 ft bgs. Rock coring began at 20 ft bgs. Most core recoveries were in a range from 74 to 100 percent. The only exception was a

possible “fault zone” from 85 to 95 ft bgs where drilling fluids were lost and recovery was 20 to 30 percent. Rock cores from 20 to 95 ft bgs were described as being variably weathered, medium hard to soft, white, grey, brown and orange gneiss, with moderately dipping joints. RQDs for this interval ranged from 0 to 93 percent with most below 50 percent. From 95 ft bgs to total depth (160 ft bgs), the rocks were described as more competent white to dark grey, hard to very hard, gneiss with no jointing; and all recoveries were 100 percent. A more granite-like interval was noted from 142 to 155 ft bgs. After 95 ft bgs RQDs improved but were still variable, ranging from 34 to 100 percent, with most greater than 70 percent.

Depth intervals for the Terracon rock cores were converted to approximate elevations using the estimated surface elevations indicated on the boring logs and compared to the proposed profile. This showed that the middle (deeper) 75 percent of the profile would be within the higher recovery and RQD zones indicated on the boring logs. Note however that the higher RQD zones still showed variability in values and values were as low as 26 percent for B6-8W and 34 percent for B6-8E. Approximately 25 percent of the profile represented by sections that are descending after entry and ascending before exit will be in weaker materials.

2.3 Hydrogeology

2.3.1 Occurrence of Groundwater

Most groundwater in the gneissic units of Chester County is stored in the unconsolidated weathered rock near the land surface with lesser amount stored in the underlying bedrock fractures. Based on soil borings and borings advanced into bedrock, groundwater has been encountered in both the soil/weathered bedrock zone and more competent bedrock, under water-table conditions. Groundwater aquifer recharge occurs vertically through the unconsolidated overburden materials and downward into the more competent bedrock horizon. The storage of groundwater and direction of groundwater flow in the more competent fractured bedrock is expected to occur in discontinuities (fractures) sometimes in zones of fracture concentration as indicated by mapped fracture traces.

Water well surface casing length can be an approximate predictor of the thickness of the weathered bedrock zone but is subject to over estimation given the fact that drillers often install casing some distance into competent bedrock and use 20-foot increments of casing. PAGWIS data indicates for wells within one mile of the HDD alignment, casing lengths averaged 43 feet and could be as long as 83 feet. The total depths of the wells ranged from 56 to 405 feet below ground surface (ft bgs) with only one depth greater than 288 ft bgs. Depth to bedrock ranged from 0 to 78 ft bgs and static water levels ranged from 0 to 40 ft bgs. Based on these well characteristics the water production zone for local wells could be approximated as a zone between 43 and 288 ft-bgs.

Most of the HDD S3-0320 alignment occupies upland terrane and is considered a groundwater recharge area. A local depression in the topography along the alignment is occupied by stream S-H5 and two small wetlands (W-JA2 and W-H2), and may represent a local, shallow groundwater discharge zone.

2.3.2 Well Yields and Water Levels

McGreavy and Sloto (1977) reported yields from the gneissic rocks in Chester County from 0 to 300 gallons per minute (gpm), with one anomalously high yield of 650 gpm. Domestic well listings from the aforementioned PAGWIS search showed the average yield was 13.5 gpm with a range from 1 to 75 gpm. The total depths of the wells ranged from 56 to 405 feet below ground surface (ft bgs) with only one depth greater than 288 ft bgs. Depth to bedrock ranged from 0 to 78 ft bgs and static water levels ranged from 0 to 40 ft bgs.

Groundwater was not encountered in three of the four Tetra Tech geotechnical test borings that were advanced to auger refusal at a maximum depth of 30 ft bgs. A water level of 25 ft bgs was recorded at

boring S3-0320-01 located near the northwestern entry/exit that had auger refusal at 55 ft bgs and was advanced by rock coring to 61 ft bgs. Groundwater level was not reported on either of the Terracon boring logs.

2.3.3 Ground Elevation between HDD entry/exits

The surface elevation for the permitted profile at the northwest entry/exit is 450 ft amsl and the surface elevations for the southeast entry/exit is 500 ft amsl. A water level measurement taken at boring S3-0320-01 in an upland area was 25 ft bgs or approximate elevation 420 ft amsl, similar to the elevation of stream S-H5 on the P & P. Assuming the water level under the upland area in the southeast part of the HDD alignment is 25 ft bgs, or approximate elevation 475 ft bgs there would be a theoretical hydraulic head difference between the southeastern part of the drill and the northwestern entry/exit of 25 feet. As the permitted and proposed P & Ps are similar, the equivalent head difference for the proposed profile is 30 feet. As such, the drilling plan for HDD S3-00320 should account for a potential groundwater discharge when the pilot boring is complete.

2.3.4 Water Supply Wells within 450 feet of Alignment

HDD-S3-0320 was included in the implementation of SPLP’s original 150-foot water supply survey and subsequent 450-foot water supply survey (see **Figure 4**). Certified letters were sent to land owners with parcels that intersect the 450-foot survey border. One owner responded with a request to have baseline

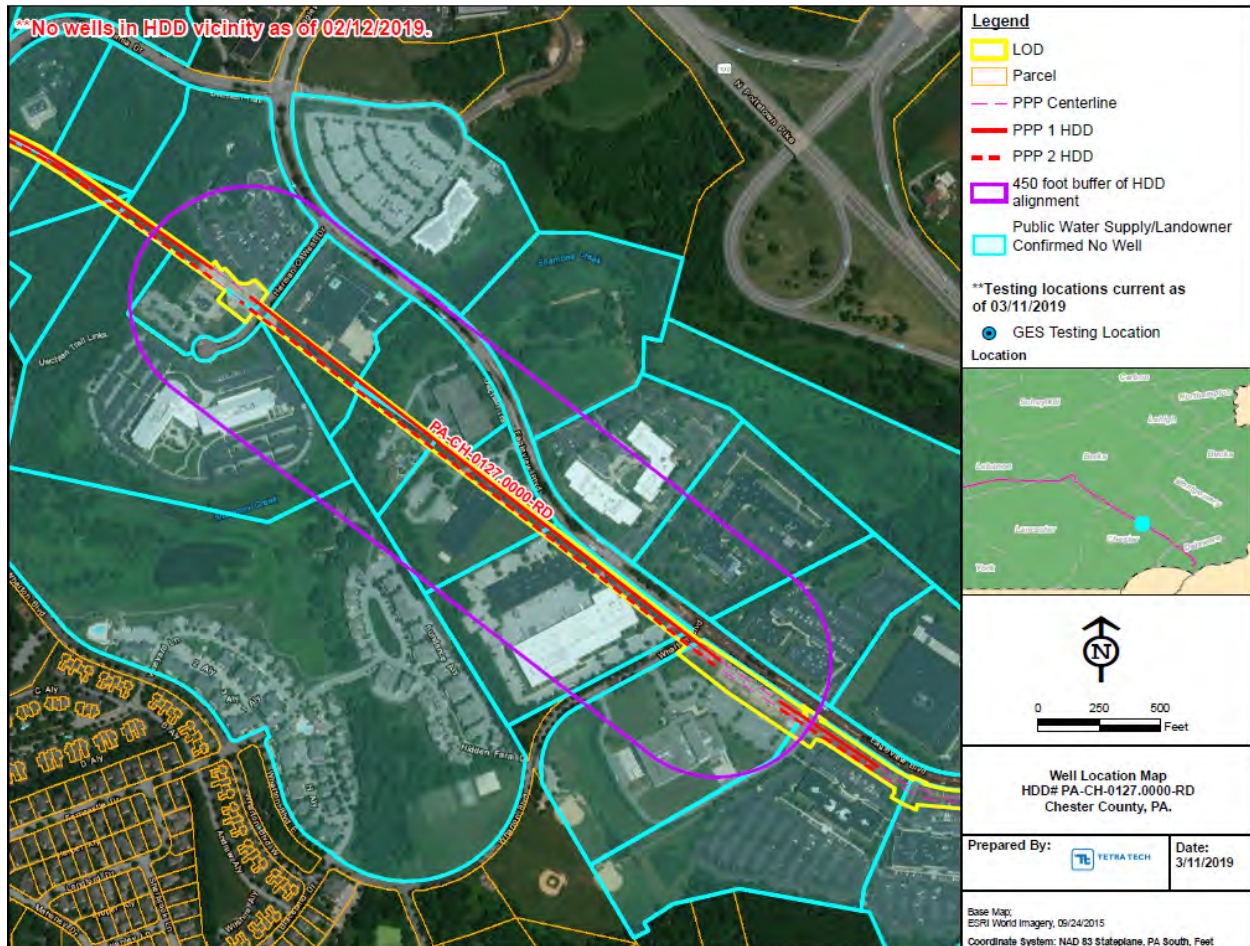


Figure 4. 450-foot Water Supply Survey.



water quality testing; however, it was determined that the residence was on public water. SPLP received no other affirmative responses and it is concluded that all landowners with parcels touching the 450-ft survey perimeter are on public water.

2.4 Summary of Geophysical Studies

No geophysical studies were performed for the design of HDD S3-0320, as there is no carbonate bedrock or associated karst terrane proximal to the alignment and this HDD was not the subject of additional geophysical studies being performed in Spread 6.

3.0 OBSERVATIONS TO DATE

3.1 On This HDD Alignment

The pilot boring for the 16-inch pipe installation began on 9/6/17 with a 9 7/8 inch bit. Partial and insignificant drilling fluid losses were noted during the pilot bore drilling on 10/3/17 (800 gallons), 10/11/17 (200 gallons), and 10/14/17 (500 gallons). The drill was advancing southeast to northwest and, in all three cases, the pilot bit was further northwest than the fracture traces shown on **Attachment A** when the loss of circulation (LOC) occurred. On 10/14/17, the pilot bit was less than 200 feet from the northwest entry/exit. After the LOC at that time it was decided not to exit the pilot bore but begin reaming with a 20-inch bit. Reaming proceeded from the southeast entry/exit point drilling northwest along the profile. By 12/14/17, the cutter had advanced to approximately Station 11+70 (proposed profile). The next day the driller removed the cutter and began tripping in tools to further advance the pilot boring. On 12/21/17 the pilot bore was advanced to approximately Station 1+30 and a depth of approximately 50 ft bgs when an IR occurred due north of Station 1+12 along the alignment, near the end of the pilot bore. Fifteen gallons of drilling fluid appeared on the edge of a macadam pathway running along the southeast side of Herman O. W. Drive, off the LOD. The IR was quickly contained and removed using squeegees and a vacuum truck. Subsequently, no additional drilling activity has occurred for the 16-inch line installation at HDD S3-0320.

The IR of 12/21/17 occurred near the northwest entry/exit where the overburden is thinning and the profile is rising to the surface. The as-built profile indicates approximately 50 feet of overburden in this zone. The geotechnical boring log for B6-8W suggests the zone of highly weathered and fractured bedrock is 67 feet thick there. In a general sense, drilling fluid pressures tend to increase at the end of HDD profiles as they approach exit, especially for longer HDDs. To summarize, it is believed that the cause of the IR that occurred during drilling of the pilot bore for the 16-inch line was a thinning, relatively weak, overburden as the pilot bore was ascending to the surface and annular pressure was increasing to maintain circulation.

3.2 On Other HDD Alignments in Similar Hydrogeologic Settings

ME II HDDs in a similar geologic setting as HDD S3-0320 (metamorphic bedrock in Chester County) include S3-0280, S3-0290, S3-300 and S3-0310 to the northwest and S3-0321, S3-0331, and S3-0350 to the southeast. IRs have occurred during drilling at S3-0290, S3-300, and S3-0331. These IRs have typically occurred where bedrock is densely fractured (sometimes indicated by a fracture trace or fracture trace intersection) or where the profile approaches an entry/exit point, closer to the surface, where overburden soil and weathered bedrock thins and there is less overburden strength to contain drilling fluid pressures. In some cases, IRs have occurred at the end of a pilot bore when annular pressure is increasing to maintain circulation back to the entry as distance increases and the profile is rising to exit causing overburden to thin and have a higher proportion of highly weathered and fractured bedrock or unconsolidated materials.

4.0 SUMMARY AND CONCLUSIONS OF HDD HYDROGEOLOGIC EVALUATION

4.1 HDD Site Conceptual Model

The land surface above HDD S3-0320 has relatively low relief. Other than the sections of profile approaching the entry/exits, the total overburden (soil, weathered bedrock and competent bedrock) is as much as 105 feet (permitted profile) or 148 feet (proposed profile). The overburden at Shamona Creek is approximately 35 feet (permitted profile) and 75 feet (proposed profile). Geotechnical boring B6-8W indicates highly weathered and fractured gneiss can occur to a depth of 67 feet. All of the ME II IRs that have occurred within the area of gneissic units in northwestern Chester County, to date, have occurred where overburden was thinning as the pilot bore was ascending along the profile to meet the surface at the exit location. This suggests the majority of the proposed profile for S3-00320 will have sufficient overburden to minimize the risks of LOCs and IRs. A direct example of this is the drilling of the pilot bore for 16-inch line installation at HDD S3-0320 that is nearly complete. The only IR that has occurred during this installation is where the pilot bit had been advanced to approximately 130 feet from exit at a depth of 50 feet.

Geologic conditions other than the weathered bedrock overburden that could affect HDD construction include loose blocks of competent bedrock in the lower portion of the weathered bedrock zone, potential vertical to near-vertical zones of bedrock fracture concentration manifested as mapped fracture traces and the north-northeast trending diabase dike that intersects the HDD S3-0320 profile. The approximate positions of the fracture traces and diabase dike are shown on **Attachment A**. The loose blocks of competent bedrock in the lower portion of the weathered bedrock zone are detached from the parent bedrock material and can make steering and drilling through these zones difficult. Zones of bedrock fracture concentration can represent preferred pathways for fluid migration contributing to LOCs and potentially IRs and the diabase dike can be very hard, making drilling difficult.

Regarding HDD hydrology, the surface elevation for profile HDD S3-0320 at the northwest entry/exit is 445 ft amsl and the surface elevations for the southeast entry/exit is 501 ft amsl (proposed profile). A water level measurement taken at geotechnical boring S3-0320-01 in an upland area was 25 ft bgs. Assuming the water level under the upland area in the southeast part of the HDD alignment is 25 ft bgs, or approximate elevation 475 ft bgs, there would be a theoretical hydraulic head difference of approximately 30 feet between the southeast portion of the drill and northwestern entry/exit. As such, the drilling plan for HDD S3-00320 should account for the occurrence of a potential groundwater discharge at the northwestern entry/exit once the pilot boring is completed.

SPLP's original 150-foot and subsequent 450-foot water supply surveys did not reveal any private or public water supply wells or public surface water withdrawal points proximal to the permitted profile; therefore, there is a very small risk of a water supply impact from HDD construction using the proposed profile for HDD S3-0320.

4.2 Conclusions and Recommendations

The drilling plan for HDD S3-0320 should account for a few conditions characteristic of the HDD profile geometry within the local geologic setting discussed within this HRR. Relatively weak overburden materials become thin near the entry/exit points increasing the risk of LOCs and an upland IR. Based on ME II construction experience within the gneissic units of northwestern Chester County there is minimal risk of an IR to a Waterway of the Commonwealth (WOC) from constructing the 20-inch line using the HDD S3-0320 proposed P & P. All of the ME II IRs that have occurred in this region, to date, are exit IRs where the overburden was relatively thin and there are no water resources in those portions of the HDD



S3-0320 profile. The thickness of overburden under Shamona Creek is 75 feet on the proposed profile, which is approximately 40 feet deeper than on the permitted profile.

The bottom parts of the weathered bedrock zone contain blocks of gneissic bedrock detached from parent bedrock that can be difficult to drill and steer through. The approximate location of fracture traces mapped for this reevaluation are plotted on the proposed profile on **Attachment A** and represent potential preferred pathways for fluid migration. Also shown on the proposed P & P is the approximate position of a diabase dike that could be very hard and difficult to drill through.

A theoretical hydraulic head difference of approximately 30 feet exists between the southeastern part of the drill and the northwestern entry/exit on profile HDD S3-0320. As such, the drilling plan for HDD S3-00320 should account for a potential groundwater discharge when the pilot boring is complete.

Based on information provided by, and the expertise of, the HDD team, as well as our experience with the relevant hydrogeology and geology, GES believes that implementation of proposed profile for HDD S3-0320 and best management practices that are part and parcel to the current ME II construction project represent minimal risk of IRs and LOCs and minimize the likelihood of an impact to the environment. Furthermore, based on such information, expertise and experience, GES believes that implementation of the HDD S3-0320 proposed profile, in conjunction with the absence of known private water supplies within 450 feet of the alignment, will greatly minimize the risk of any impact to a private water supply. In the unlikely event of an impact to a private water supply, SPLP will implement the procedures of the IR PPC Plan.

5.0 REFERENCES

Berg, T. M., Edmunds, W. E., Geyer, A. R., and others, compilers, 1980, Geologic map of Pennsylvania (2nd ed.): Pa Geol. Surv, 4th ser., Map 1, 3 sheets, scale 1:250,000.

Geyer, A. R. and J. P. Wilshusen, (rev. 1982) *Engineering Characteristics of the Rocks of Pennsylvania.*, Pa Geol. Surv., 4th ser., EGR-1, 300 p.

McGreavy, L. J. and R. A. Sloto (1977) *Ground-water resources of Chester County, Pennsylvania*, USGS, WRI 77-67, 76 p.

PaGEODE (Pennsylvania Department of Conservation and Natural Resources)
(<https://www.gis.dcnr.state.pa.us/geology/index.html>).

PAGWIS (Pennsylvania Groundwater Information System)
(Pennsylvania Department of Conservation and Natural Resources)
(<http://dcnr.state.pa.us/topogeo/groundwater/pagwis/records/index.htm>).

USDA NRCS WSS - Web Soil Survey
(United States Department of Agriculture, Natural Resources Conservation Service)
(<https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>).

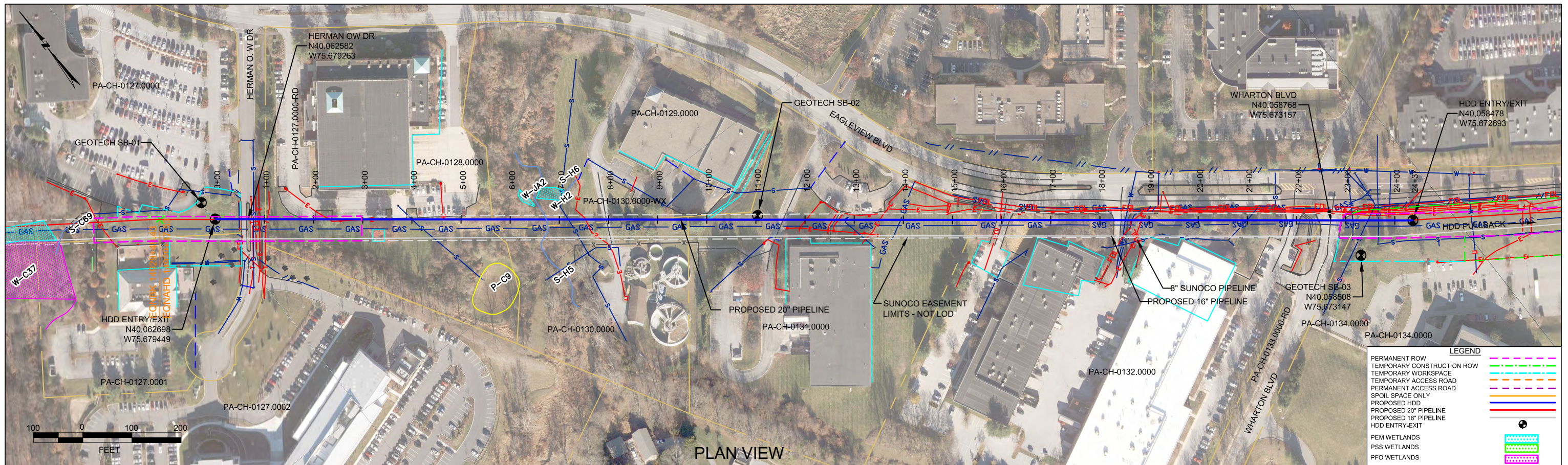


Attachment A

Plan and Profiles

HDD S3-0320 Permitted Plan and Profile, rev. 10/21/16

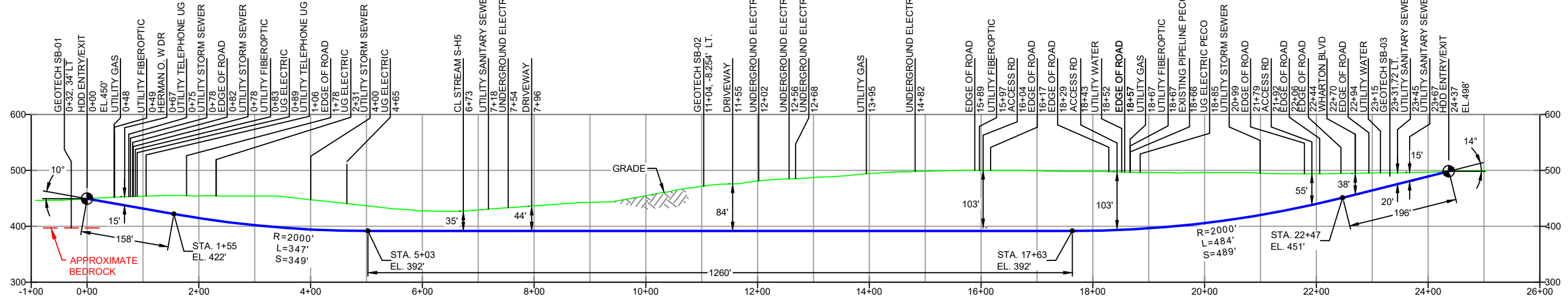
Proposed Plan and Profile, rev. 5/24/19, showing IR and geology



PLAN VIEW

CHESTER COUNTY, PENNSYLVANIA - UWCHLAN TOWNSHIP
S3-320

PROFILE VIEW



GEOTECH SB-01	GEOTECH SB-02	GEOTECH SB-03
-NG EL. 450'	-NG EL. 472'	-NG EL. 502'
-TOPSOIL (0' - 0.2')	-TOPSOIL (0' - 0.2')	-TOPSOIL (0' - 0.3')
-ML (0.2' - 9.0')	-SM (0.2' - 24.0')	-ML (0.3' - 6.5')
-GROUNDWATER (25.0')		-SM (6.5' - 18.5')
-SM (9.0' - 53.0')		-WEATHERED GNEISS
-WEATHERED GNEISS		(53.0' - 61.3')
-COMPLETION		-COMPLETION
DEPTH EL. 389'		DEPTH EL. 483'
	-AUGER REFUSAL	
	WEATHERED GNEISS-24.0')	
	-COMPLETION	
	DEPTH EL. 448'	

- 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-):2437'
HDD PIPE LENGTH (S-):2452'
20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
 - INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 - CARRIER PIPE NOT ENCASED.
 - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
 - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
 - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

- NOTE: REFER TO TEST BORING LOG S3-0320 FOR COMPLETE SOIL MATERIAL DESCRIPTION
- 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, 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.
 - 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-6.35	TO	ES-6.36	EROSION & SEDIMENT PLAN	EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	10/21/16
SHEET 20	TO	SHEET 21	AERIAL SITE PLAN	EP1	REVISED PER PADEP COMMENTS	MRS	05/18/16
				EP		MRS	11/13/15
				D	ADDED GEOTECH INFO	MRS	10/02/15
				C	ISSUED FOR BID	DLM	08/21/15
				B	ISSUED FOR BID	DLM	07/31/15
DWG NO		DWG NO	DESCRIPTION	NO.	DESCRIPTION	BY	DATE

**Sunoco Logistics
Partners L.P.**

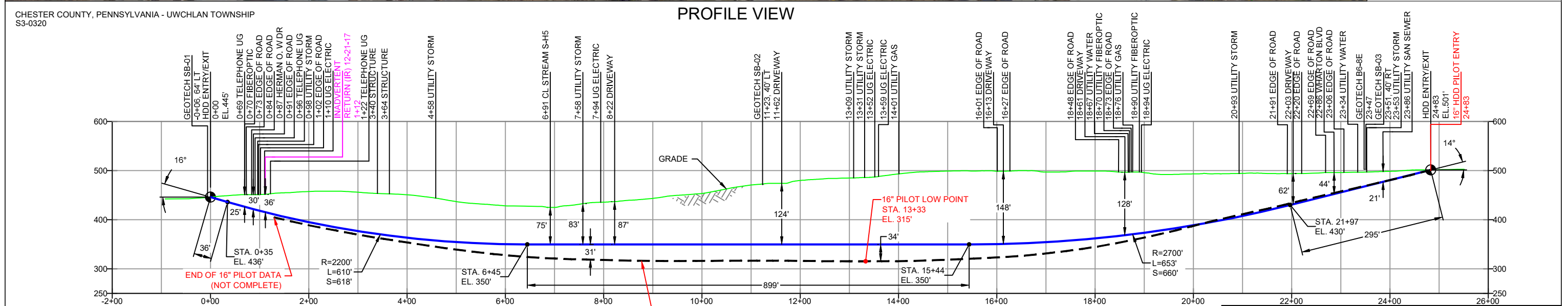
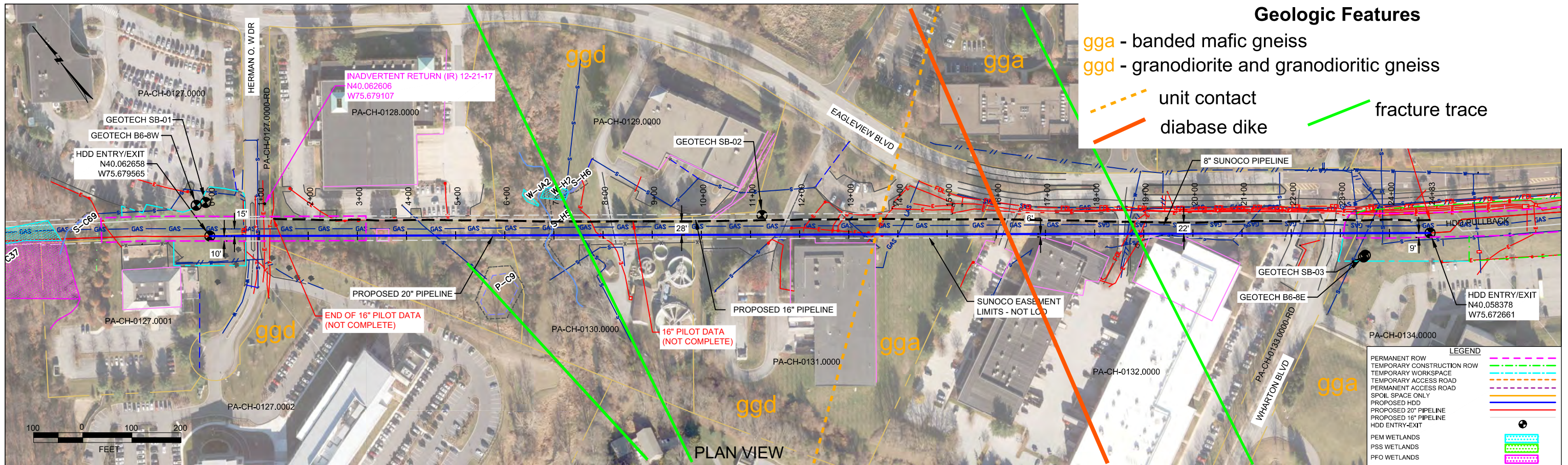
SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
HERMAN O. W DRIVE
PENNSYLVANIA PIPELINE PROJECT

TETRA TECH ROONEY
(303) 792-5911

SCALE: 1"=200'

DWG. NO: PA-CH-0127.0000-RD



GEOTECH SB-01	GEOTECH SB-02	GEOTECH SB-03
-NG EL. 450'	-NG EL. 472'	-NG EL. 502'
-TOPSOIL (0' - 0.2')	-TOPSOIL (0' - 0.2')	-TOPSOIL (0' - 0.3')
-ML (0.2' - 9.0')	-ML (0.3' - 6.5')	-ML (0.3' - 6.5')
-GROUNDWATER (25.0')	-SM (0.2' - 24.0')	-SM (6.5' - 18.5')
-SM (9.0' - 53.0')	-AUGER REFUSAL WEATHERED GNEISS-24.0')	-WEATHERED GNEISS GRAVEL (18.5' - 19.0')
-WEATHERED GNEISS (53.0' - 61.3')	-COMPLETION DEPTH EL. 448'	-COMPLETION DEPTH EL. 483'
-COMPLETION DEPTH EL. 389'		

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)=2483'
HDD PIPE LENGTH (S)=2508'
20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE 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.

GEOTECH B6-8W	GEOTECH B6-8E
-NG EL. 464'	-NG EL. 500'
-FILL - POORLY GRADED SAND W/ SILT (0.0' - 3.0')	-TOPSOIL (0' - 0.5')
-SILT W/ SAND ML (3.0' - 8.0')	-FILL - POORLY GRADED SAND W/ SILT AND GRAVEL (SP-SM) (0.5' - 7.0')
-POORLY GRADED SAND SP (8.0' - 17.0')	-HIGHLY WEATHERED ROCK (7.0' - 20.0')
-GNEISS (17.0' - 112.0')	-AUGER REFUSAL (18.0')
-BORING TERMINATED EL.352'	-GNEISS (20.0' - 160.0')
	-BORING TERMINATED EL.340'

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-6.35 TO ES-6.36	EROSION & SEDIMENT PLAN EP3 SWITCHED 20" CENTERLINE LOCATION, INCREASED DEPTH OF DRILL AND ADDED GEOTECH INFORMATION MRS 05/24/19 RMB 05/24/19 AMC 05/24/19
SHEET 20 TO SHEET 21	AERIAL SITE PLAN EP2 REVISED PER PADEP COMMENTS RECEIVED 09-06-16 MRS 10/21/16 RMB 10/21/16 AAW 10/21/16
	REVISED PER PADEP COMMENTS EP1 MRS 05/18/16 RMB 05/18/16 AAW 05/18/16
	ADDED GEOTECH INFO EP MRS 11/13/15 RMB 11/13/15 AAW 11/13/15
	ISSUED FOR BID C MRS 10/02/15 RMB 10/02/15 AAW 10/02/15
DWG NO	DESCRIPTION
DWG NO	DESCRIPTION

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
HERMAN O. W DRIVE
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' DWG. NO. PA-CH-0127.0000-RD

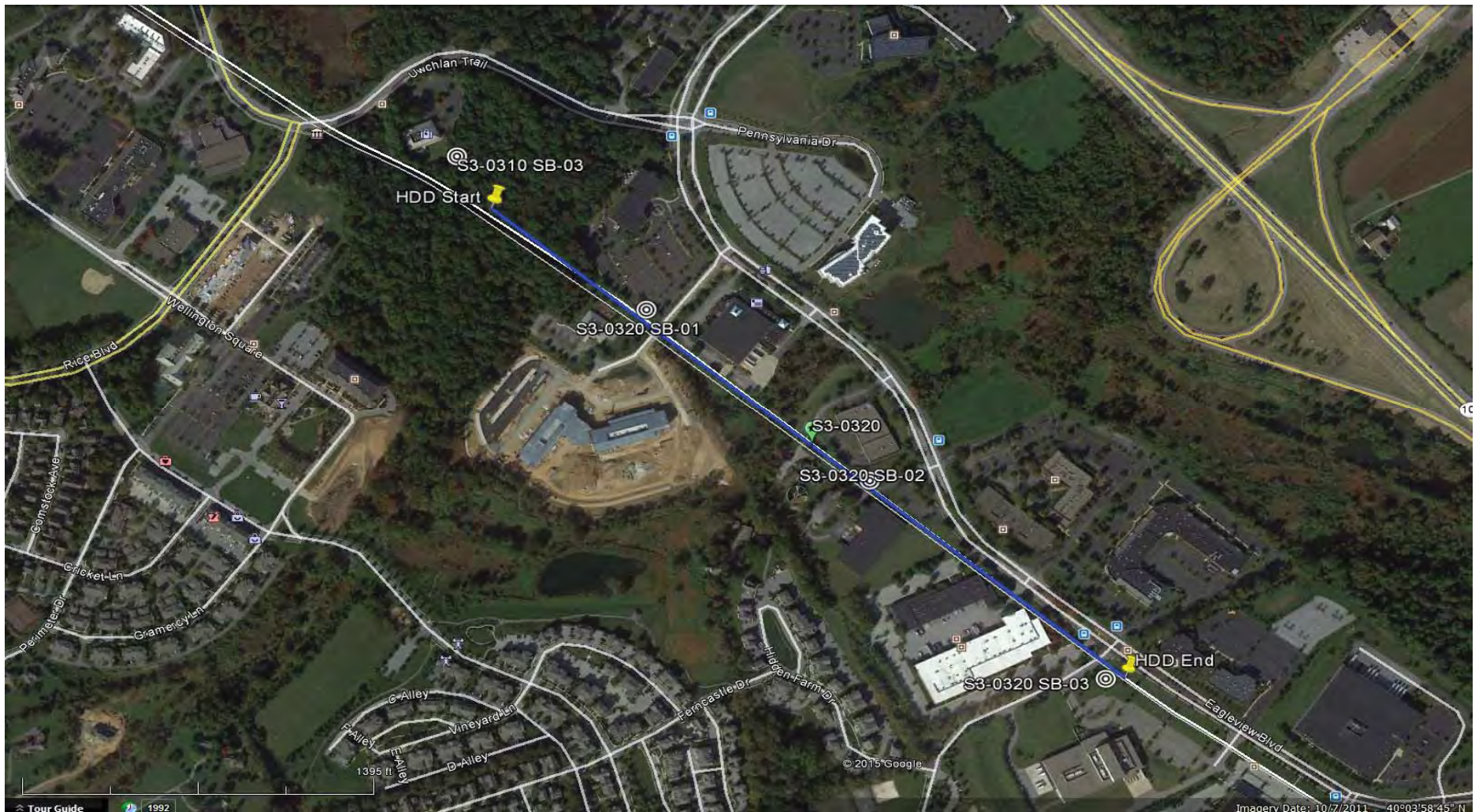


Attachment B

Geotechnical Reports

Tetra Tech, 2015

Terracon, August 2017



LEGEND:

⊙ Geotechnical Soil Boring (SB) Locations



GEOTECHNICAL BORING LOCATIONS
 HDD S3-0320
 CHESTER COUNTY, UWCHLAN TWP, PA
 SUNOCO PENNSYLVANIA PIPELINE PROJECT



TETRA TECH

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

TEST BORING LOG

Project Name: SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406	
Project Location: WORLED TRAVEL, Inc., 620 PENNSYLVANIA DRIVE, EXTON, PA		Page 1 of 1	
HDD No.: S3-0310	Dates(s) Drilled: 06-14-15	Inspector: E. WATT	
Boring No.: SB-03	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER	
Drilling Contractor: HAD DRILLING	Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 30.0	
Boring Location Coordinates: 40° 3' 52.538" N		75° 40' 55.207" W	

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (ft)	Strata (USCS)	Description of Materials	6" Increment Blows *				N		
	From	To	From	To										
			0.0	0.3			TOPSOIL (4")							
1	3.0	4.0	0.3		10	SM	BROWN AND LIGHT BROWN FINE TO MEDIUM SAND AND SILT, WITH A LITTLE FINE GRAVEL.	11	50/6"				>50	
2	8.0	9.9			23		DR WEATHERED TO A BROWN, LIGHT BROWN, WHITE F-M SAND, SOME SILT, TRACE UNWEATHERED F-GRAVEL (GNEISS). (USCS: SM)	25	14	21	50/5"			35
3	13.0	13.4	12.0		5	SM/GM	DR WEATHERED TO A LIGHT BROWN F-M SAND WITH SOME SILT, AND FINE TO COARSE UNWEATHERED GNEISS GRAVEL.	50/5"						>50
4	18.0	18.5	14.0		5		DR WEATHERED TO A WHITE AND LIGHT BROWN FINE SAND, A LITTLE SILT, WITH A LITTLE FINE UNWEATHERED GNEISS GRAVEL.	50/5"						>50
5	23.0	23.2			2	SM	DR WEATHERED TO A WHITE AND LIGHT BROWN FINE SAND, SOME SILT, WITH A LITTLE FINE UNWEATHERED GNEISS GRAVEL.	50/2"						>50
6	28.0	28.0		30.0	0		NO RECOVERY.	50/0"						>50
							AUGERED TO 30'.							
							CAVED AND DRY AT 26'.							

Notes/Comments: Pocket Pentrometer Testing DR: DECOMPOSED ROCK

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

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



TETRA TECH

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

TEST BORING LOG

Project Name: SUNOCO PENNSYLVANIA PIPELINE PROJECT			Project No.: 103IP3406		
Project Location: 568 VALLEYVIEW, DOWNINGTOWN, PA			Page 1 of 1		
HDD No.: S3-0320		Dates(s) Drilled: 06-14 & 08-02-15		Inspector: J. COSTELLO	
Boring No.: SB-01		Drilling Method: SPT - ASTM D1586		Driller: GREG/OGDEN	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): 25.0		Total Depth (ft): 30.0	
Boring Location Coordinates:			40° 3' 46.148" N		75° 40' 45.963" W

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N	
	From	To	From	To									
			0.0	0.2			TOPSOIL (2")						
1	3.0	5.0	0.2		22	ML	YELLOWISH BROWN SILT AND FINE SAND, TRACE FINE GRAVEL.	7	7	8	12	15	
				9.0									
2	8.0	10.0	9.0		25	SM	DR WEATHERED TO A VARI-COLORED (BRWN, REDDISH BRWN, GRAY, WHITE) F-M SAND AND SILT, TRACE FINE GRAVEL (USCS: SM).	1	2	7	8	9	
3	13.0	15.0			19		DR WEATHERED TO A BROWN TO REDDISH BROWN FINE TO MEDIUM SAND AND SILT, TRACE UNWEATHERED GNEISS GRAVEL.	1	7	11	11	18	
4	18.0	20.0			24		DR WEATHERED TO A BROWN TO REDDISH BROWN FINE TO MEDIUM SAND AND SILT, TRACE UNWEATHERED GNEISS GRAVEL.	1	5	9	12	14	
5	23.0	25.0			22		DR WEATHERED TO A BROWN, BLACK, GRAY, ORANGE BRWN F-M SAND AND SILT, TRACE UNWEATHERED GNEISS GRAVEL.(USCS: SM)	1	7	11	36	18	
6	28.0	28.8			5		DR WEATHERED TO A LIGHT BROWN AND GRAY, F-M SAND WITH SOME SILT, TRACE UNWEATHERED GNEISS GRAVEL.	12	50/3"				>50
7	33.0	35.0			13		DR, WHITE AND GRAY F-M SAND WITH A LITTLE SILT, WITH A LITTLE F-C GNEISS GRAVEL.	2	23	25	29	48	
(8/2/15)													
8	38.0	38.8			6		DR, WEATHERED TO A BROWN SILTY FINE SAND, TRACE F-C GRAVEL.	14	50/4"				>50
9	43.0	44.3			10		DR, VARIEGATED (WHITE, YELLOW, BROWN, RED) FINE TO MEDIUM SAND, A LITTLE SILT, WITH A LITTLE F-C GNEISS GRAVEL.	10	32	50/4"			>50
10	48.0	48.8			8		DR, VARIEGATED (WHITE, YELLOW, BROWN, RED) FINE TO MEDIUM SAND, A LITTLE SILT, WITH A LITTLE F-C GNEISS GRAVEL.	15	50/4"				>50
				53.0									
11	53.0	53.5	53.0		2	DECOMPOSED TO HIGHLY WEATH. GNEISS	HIGHLY WEATHERED GNEISS.	50/6"				>50	
							AUGER REFUSAL AT 55'.						
							ROCK CORING						
RUN 1	55.0	56.5			10		VARIEGATED GRAY, BROWN, BLACK, RED DECOMPOSED TO	TCR: 55.5%, SCR: 11.1%, RQD: 0%					
RUN 2	56.5	61.3		61.3	24	HIGHLY WEATHERED GNEISS.	TCR: 42%, SCR: 4%, RQD: 0%						
							COULD NOT ROCK CORE ANY DEEPER; BARRELL JAMBING.						
							WATER LEVEL THROUGH AUGERS AT 25'.						
							CAVED AT 28', WATER LEVEL ON CAVE AT 25'.						

Notes/Comments:
Pocket Pentrometer Testing
 S1: 3.5 TSF
 S2: 2.25 TSF
 DR: DECOMPOSED ROCK
ROCK CORE SAMPLES NOT LONG ENOUGH FOR COMPRESSIVE STRENGTH TESTING.

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

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



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: 420568 ' EAGLEVIEW BLVD, CH-0131, EXTON, PA			Page 1 of 1		
HDD No.: S3-0320	Dates(s) Drilled: 12-20-15		Inspector: J. COSTELLO		
Boring No.: SB-02	Drilling Method: SPT - ASTM D1586		Driller: E. OGDEN		
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 24.9		
Boring Location Coordinates:		40° 3'38.90"N	75°40'34.87"W		

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	0.2			TOPSOIL (2")						
1	3.0	5.0	0.2		6	SM	DR, BROWN FINE TO MEDIUM SAND AND SILT, MICACEOUS, TRACE	2	5	7	8	12	
							FINE GNEISS ROCK FRAGMENTS.						
2	8.0	10.0			20		DR, VARIEGATED YELLOWISH BROWN FINE TO MEDIUM SAND, SOME	2	4	7	13	11	
							SILT, MICACEOUS, A LITTLE F-C GNEISS ROCK FRAGS.						
3	13.0	15.0			24		SAME (USCS: SM)	7	13	18	21	31	
4	18.0	20.0			20		SAME	15	31	35	50	66	
5	23.0	24.9			20	DR, VARIEGATED YELLOWISH BROWN FINE TO MEDIUM SAND AND	7	18	27	50/5"	45		
				24.0			SILT, WITH A LITTLE F-C GNEISS ROCK FRAGS. (USCS: SM)						
							AUGER REFUSAL AT 24'. AUGER CUTTINGS INDICATE REFUSAL						
							MATERIAL TO BE PARTIALLY TO HIGHLY WEATHERED GNEISS.						
							CAVED AND DRY AT 20.5'.						

Notes/Comments:
Pocket Pentrometer Testing DR: DECOMPOSED ROCK
 S1: 3.5 TSF
 S2: 2.25 TSF

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

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

**ROCK CORE DESCRIPTION SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0320**

Location	Boring No.	Core Run	Core Depth (ft)		TCR (%)	SCR (%)	RQD (%)	Depth (ft)		Weathering	Classification	Bedding Thickness (ft)	Color	Discontinuity Data
			From	To				From	To					
S3-0320	SB-1	1	55	56.5	56	11	0	55	61.3	Heavily	Gneiss	Massive	Brown/ light gray	Rubble, no sample collected (not enough length needed to test for compressive strength)
		2	56.5	61.3	42	4	0							

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0320

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.)		Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318)			USCS Classif. (ASTM D2487)
			From	To			Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	
S3-0310	SB-03	1	3.0	4.0	10.6	44.7	-	-	-	-
		2	8.0	9.9	10.8	28.3	NV	NP	NP	SM
		4	18.0	18.5	4.9	20.1	-	-	-	-
		5	23.0	23.2	4.6	22.8	-	-	-	-
S3-0320	SB-01	2	8.0	10.0	15.0	44.5	NV	NP	NP	SM
		3	13.0	15.0	12.7	48.9	-	-	-	-
		4	18.0	20.0	16.9	41.9	-	-	-	-
		5	23.0	25.0	22.3	48.0	NV	NP	NP	SM
		6	28.0	28.8	6.2	24.0	-	-	-	-
		7	33.0	35.0	13.7	18.1	-	-	-	-
		8	38.0	38.8	12.4	43.6	-	-	-	-
	SB-02	1	3.0	5.0	23.3	43.2	-	-	-	-
		2	8.0	10.0	16.1	30.3	-	-	-	-
		3	13.0	15.0	12.2	23.3	NV	NP	NP	SM
		4	18.0	20.0	13.9	34.7	-	-	-	-
		5	23.0	24.9	22.0	46.1	32	25	7	SM
	SB-03	1	3.0	5.0	25.7	60.3	-	-	-	-
		2	8.0	10.0	27.7	47.8	40	27	13	SM
		3	13.0	15.0	10.3	33.6	-	-	-	-

Rock Core Testing Results				
Boring No.	Core Run	Approximate Depth (ft)	Compressive Strength (psi)	Unit Weight (pcf)
SB-01	1/2	Cores did not have sections of suitable length to perform compressive strength testing		

Notes:

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

**REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0320**

HDD No.	NAME	BORING NO.	REGIONAL GEOLOGY DESCRIPTION	GENERAL TOPOGRAPHIC SETTING	BEDROCK FORMATION	GENERAL ROCK TYPE	APPROX MAX FM THICKNESS (FT)	DEPTH TO ROCK (Ft bgs) based on nearby well drilling logs	NOTES / COMMENTS
S3-0310		SB-03	Felsic and intermediate gneiss - Medium grained, light pink to greenish gray; largely quartz, feldspar, and mica; commonly gneissic, containing alteration minerals; interfingers with gabbroic gneiss.	Gently sloping to the South	Felsic and intermediate gneiss (PreCambrian)	Felsic gneiss	No information found during literature review	Ranges from 30 to 95 ft bgs, Avg. 52 ft bgs (.5 mile radius)	
S3-320		SB-01	Felsic and intermediate gneiss - Medium grained, light pink to greenish gray; largely quartz, feldspar, and mica; commonly gneissic, containing alteration minerals; interfingers with gabbroic gneiss.	Generally level, slight slope to the west	Felsic and intermediate gneiss (PreCambrian)	Felsic gneiss	No information found during literature review	Ranges from 30 to 57 ft bgs, Avg. 44 ft bgs (.5 mile radius)	
		SB-02		Gently sloping to the NW	Felsic and intermediate gneiss (PreCambrian)			Ranges from 25 to 50 ft bgs, Avg. 38 ft bgs (.5 mile radius)	
		SB-03	Banded mafic gneiss - Dark, fine to medium grained; includes rocks of probable sedimentary origin; may be equivalent to "PZmgh."	Generally level, slightly sloping to the north	Banded mafic gneiss (PreCambrian)	Mafic gneiss		Ranges from 25 to 50 ft bgs, Avg. 42 ft bgs (.5 mile radius)	

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.

October 18, 2017



Directional Project Support, Inc.
33311 Lois Lane, Suite A
Magnolia, TX 77354

Attn: Mr. Robert Sessions
P: (318) 542 6657
E: fielduspl@hotmail.com

Re: Geotechnical Site Characterization
Mariner East 2 Pipeline Project
Spread 6 – Herman O.W. Drive
Commonwealth of Pennsylvania
Drawing #PA-CH-0127.0000-RD
PO #20170818
Terracon Project No. J217P078

Dear Mr. Sessions:

This letter provides a summary of the bedrock characterization for the Mariner East 2 Pipeline Project crossing to be located at Herman O.W. Drive (Drawing #PA-CH-0127.0000-RD) in the Commonwealth of Pennsylvania. Our services were performed in general accordance with our proposal number PJ2175108 dated July 28, 2017. Our scope of services included advancing two borings, designated as B6-8W and B6-8E, visual classification and photography of the rock core samples, and laboratory testing of representative rock samples.

Test borings B6-8W and B6-8E were drilled between August 29 and September 6, 2017 to depths of 112 and 160 feet, respectively, as shown on the attached **Test Boring Location Plan**. Bedrock typically consisted of metamorphic rock comprised of gneiss and migmatite. Final test boring logs documenting overburden soil and bedrock conditions, as well as photographs of the rock core samples, are attached.

Rock compressive strength testing was performed on samples from approximately 20-foot intervals within the bedrock strata at each boring location. As an exception to the planned 20-foot intervals, rock samples from B6-8W near 17, 37, and 57 feet were not tested due to highly weathered conditions. Unconfined compressive strength test results are shown on the attached reports.

Geotechnical Site Characterization

Mariner East 2 Pipeline – Spread 6 Herman O.W. Drive ■ Pennsylvania

Drawing #PA-CH-0127.0000-RD / PO #20170818

October 18, 2017 ■ Terracon Project No. J217P078



When laboratory soil testing results are available, we will submit a complete data report for the subject crossing. In the meantime, if you have questions, or if we may be of further service, please contact us.

Sincerely,

Terracon Consultants, Inc.

A handwritten signature in blue ink, appearing to read "Lawrence J. Dwyer".

Marc A. Gullison, E.I.T.
Staff Geotechnical Engineer

Lawrence J. Dwyer, P.E. (CT 15120)
Principal

A handwritten signature in blue ink, appearing to read "Erich Christiansen".

Erich Christiansen, P.E. (NJ 42266)
Senior Associate

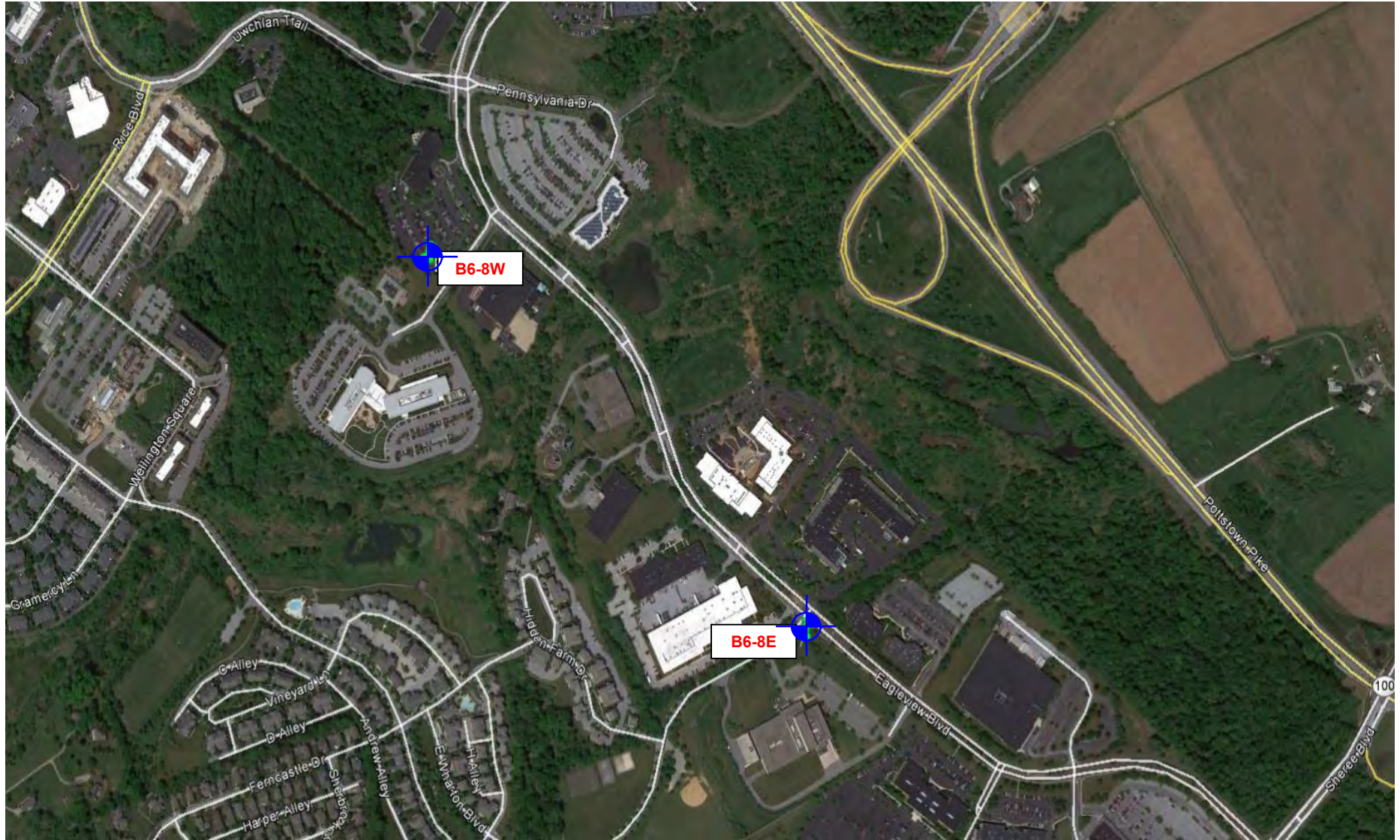
Attch:

TEST BORING LOCATION PLAN

EXPLORATION RESULTS (Boring Logs, Laboratory Data, Rock Core Photographs)

SUPPORTING INFORMATION (Unified Soil Classification System, Description of Rock Properties)

TEST BORING LOCATION PLAN



**APPROXIMATE
BORING
LOCATION**

DIAGRAM IS FOR GENERAL LOCATION
ONLY, AND IS NOT INTENDED FOR
CONSTRUCTION PURPOSES

Project Manager:	JGS	Project No.	J217P078
Drawn by:	SBL	Scale:	N.T.S.
Checked by:	LJD	File Name:	J217P078 BLP
Approved by:	LJD	Date:	September, 2017

Terracon
Consulting Engineers & Scientists

201 Hammer Mill Road Rocky Hill, Ct 06067
PH. (860) 721-1900 FAX. (860) 721-1939

TEST BORING LOCATION PLAN

Herman O.W. Drive HDD Cores B6-8W and B6-8E
PA-CH-0127.0000-RD
Chester County, Pennsylvania

Exhibit

A-2

EXPLORATION RESULTS

BORING LOG NO. B6-8W Herman O.W. Drive West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

GRAPHIC LOG	LOCATION PA-CH-0127.0000-RD 20170818 Latitude: 40.06284° Longitude: -75.6795° Approximate Surface Elev: 464 (Ft.) +/- ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
--------------------	---	--------------------	---------------------------------	--------------------	-----------------------	---------------------------	----------------	---------------------------	--------------------------------

DEPTH									
3.0	FILL - POORLY GRADED SAND WITH SILT , trace gravel, brown, medium dense	461+/-		X	14	4-5-5 N=10			
8.0	SILT WITH SAND (ML) , orange-brown, medium dense	456+/-	5		X	9-10-12 N=22			
17.0	POORLY GRADED SAND (SP) , trace silt, trace gravel, weathered rock, orange-light brown, dense	456+/-	10		X	10-18-20 N=38			
17.0	Begin rock core at 17 feet	447+/-	20		41		0	1 1 1 1 1	
22.0	Run 1, Very soft, very severely to completely weathered, brown/orange/white GNEISS, highly fractured throughout run, no joints could be measured	442+/-	25		25		0	1 1 1 1 2	
27.0	Run 2, Similar	437+/-	30		0		0	1 1 1	
	Run 3, No recovery								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS
<i>Not encountered</i>



Boring Started: 08-31-2017	Boring Completed: 09-06-2017
Drill Rig: Mobile B-57	Driller: Terracon/S. Bray
Project No.: J217P078	Exhibit: A-1

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 6.GPJ TERRACON DATATEMPLATE.GDT 10/13/17

BORING LOG NO. B6-8W Herman O.W. Drive West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 6.GPJ TERRACON DATATEMPLATE.GDT 10/13/17

GRAPHIC LOG	LOCATION PA-CH-0127.0000-RD 20170818 Latitude: 40.06284° Longitude: -75.6795° Approximate Surface Elev: 464 (Ft.) +/- ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Run 3, No recovery (<i>continued</i>)				0			1 1	
32.0		432+/-							
	Run 4, Very soft, very severely weathered, brown/orange GNEISS, highly fractured throughout run, no joints could be measured				44		0	1 1 1 2 2	
37.0		427+/-							
	Run 5, Similar				43		7	1 1 1 2 1	
42.0		422+/-							
	Run 6, Similar				47		22	1 1 1 1 2	
47.0		417+/-							
	Run 7, Soft to medium hard, severely weathered, brown/orange/gray GNEISS, highly fractured throughout run, no joints could be measured				50.5		0	1 1 1 2 1	
52.0		412+/-							
	Run 8, Similar, soft				34.5		0	1 1 1 1 2	
57.0		407+/-							
	Run 9, Moderately hard, severely to moderately weathered, brown/orange/gray GNEISS, primary joint set moderately dipping; secondary joint set high angle, very close				56		43	1 1 1	
60									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

WATER LEVEL OBSERVATIONS
Not encountered

201 Hammer Mill Rd
Rocky Hill, CT

Notes:	
Boring Started: 08-31-2017	Boring Completed: 09-06-2017
Drill Rig: Mobile B-57	Driller: Terracon/S. Bray
Project No.: J217P078	Exhibit: A-1

BORING LOG NO. B6-8W Herman O.W. Drive West

PROJECT: Mariner East Pipeline Borings

**CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354**

SITE: Spread 6

GRAPHIC LOG	LOCATION PA-CH-0127.0000-RD 20170818 Latitude: 40.06284° Longitude: -75.6795°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Approximate Surface Elev: 464 (Ft.) +/- ELEVATION (Ft.)								
DEPTH									
62.0	Run 9, Moderately hard, severely to moderately weathered, brown/orange/gray GNEISS, primary joint set moderately dipping; secondary joint set high angle, very close (<i>continued</i>)	402+/-			56			2 2	
67.0	Run 10, Moderately hard to hard, moderately weathered, brown/gray GNEISS, primary joint set moderately dipping; secondary joint set high angle, very close	397+/-			51		8	1 2 2 1 2	
72.0	Run 11, Soft to moderately hard, severely to moderately weathered, brown/gray SCHISTOSE GNEISS, primary joint set low angle; secondary joint set moderately dipping, close	392+/-			60		42	1 2 1 2 1	
77.0	Run 12, Moderately hard to hard, moderately weathered, brown/gray , coarse-grained GNEISS, primary joint set high angle; secondary joint set moderately dipping, close spacing, moderately wide	387+/-			60		64	1 2 2 1 2	
82.0	Run 13, Hard, very slightly weathered, gray, medium-grained GNEISS, primary joint set high angle, close, open	382+/-			60		70	1 2 2 2 1	
87.0	Run 14, Similar, slight weathering	377+/-			60		66	1 2 2 2 2	
	Run 15, Hard, fresh gray/dark gray, medium-grained GNEISS, primary joint set high angle, close, open				60		61	2 2 2	
		90							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

Not encountered



Boring Started: 08-31-2017

Boring Completed: 09-06-2017

Drill Rig: Mobile B-57

Driller: Terracon/S. Bray

Project No.: J217P078

Exhibit: A-1

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL -J217P078 - SPREAD 6.GPJ TERRACON DATATEMPLATE.GDT 10/13/17

BORING LOG NO. B6-8W Herman O.W. Drive West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

GRAPHIC LOG	LOCATION PA-CH-0127.0000-RD 20170818 Latitude: 40.06284° Longitude: -75.6795° Approximate Surface Elev: 464 (Ft.) +/- ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
DEPTH									
92.0	Run 15, Hard, fresh gray/dark gray, medium-grained GNEISS, primary joint set high angle, close, open <i>(continued)</i>	372+/-			60			2 2	
97.0	Run 16, Moderately hard, fresh, gray, medium-grained GNEISS, primary joint set high angle, very close, wide; secondary joint set vertical, very close, wide	367+/-			60		26	2 2 2 1 1	
102.0	Run 17, Moderately hard, very slightly weathered, medium-grained GNEISS, primary joint set low angle, close, moderately open; secondary joint set moderate angle, moderately close, open	362+/-			60		71	1 2 2 2 2	
107.0	Run 18, Moderately hard, fresh, dark gray/black medium to fine-grained GNEISS, primary joint set high angle, very close, wide	357+/-			60		28	2 2 2 2 3	
112.0	Run 19, Moderately hard, fresh, dark gray, medium-grained GNEISS, primary joint set high angle, close, open	352+/-			60		66	2 2 3 3 3	
	Boring Terminated at 112 Feet								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

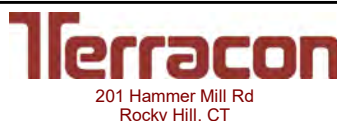
Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

Not encountered



Boring Started: 08-31-2017

Boring Completed: 09-06-2017

Drill Rig: Mobile B-57

Driller: Terracon/S. Bray

Project No.: J217P078

Exhibit: A-1

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 6.GPJ TERRACON DATATEMPLATE.GDT 10/13/17

BORING LOG NO. B6-8E Herman O.W. Drive East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

GRAPHIC LOG	LOCATION PA-CH-0127.0000-RD 20170818 Latitude: 40.058508° Longitude: -75.673147°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Approximate Surface Elev: 500 (Ft.) +/-								
	ELEVATION (Ft.)								
	DEPTH								
0.5	Topsoil	499.5+/-		X	14	2-3-3 N=6			
FILL - POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM) , with concrete and asphalt pieces, loose to medium dense									
7.0	Highly weathered rock, friable, light brown, very dense	493+/-		X	6	16-13-14 N=27			
10.0				X	12	24-25-36 N=61			
15.0				X	4	50/4"			
Refusal at 18 feet, rock core at 20 feet									
20.0	Run 1, Soft, moderately to severely weathered, brown and white, medium-grained, GNEISS, primary joint set, high angle; secondary joint set, vertical, very close, wide, highly fractured and weathered	480+/-		52			0	1 1 1 2 2	
25.0	Run 2, Similar	475+/-		52			0	1 1 1 1 2	
30.0		470+/-							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

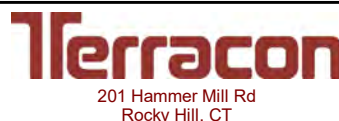
Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

Not encountered



Boring Started: 08-29-2017

Boring Completed: 08-31-2017

Drill Rig: Mobile B-57

Driller: Terracon/Scott

Project No.: J217P078

Exhibit: A-2

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 6.GPJ TERRACON DATATEMPLATE.GDT 10/13/17

BORING LOG NO. B6-8E Herman O.W. Drive East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

GRAPHIC LOG	LOCATION PA-CH-0127.0000-RD 20170818 Latitude: 40.058508° Longitude: -75.673147° Approximate Surface Elev: 500 (Ft.) +/- ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
DEPTH									
Run 3, Similar		35.0			60		8	1 1 2 2	
Run 4, Similar, gray		40.0			60		36	1 1 2 2	
Run 5, Similar, medium hard, some moderately dipping joints		45.0			44.5		14	1 1 2 2	
Run 6, Similar, very severely weathered at 47.5 to 48 feet		50.0			38.5		13	1 2 2 1 1	
Run 7, Medium hard, moderately weathered, gray, brown and white medium-grained, GNEISS, moderately dipping to vertical joints, close, wide		55.0			55		24	2 2 2 2 2	
Run 8, Similar		60.0			57		45	2 2 2 2 2	

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

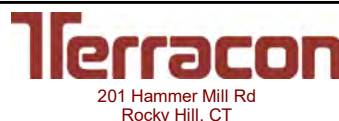
Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

Not encountered



Boring Started: 08-29-2017

Boring Completed: 08-31-2017

Drill Rig: Mobile B-57

Driller: Terracon/Scott

Project No.: J217P078

Exhibit: A-2

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 6.GPJ TERRACON DATATEMPLATE.GDT 10/13/17

BORING LOG NO. B6-8E Herman O.W. Drive East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

GRAPHIC LOG	LOCATION PA-CH-0127.0000-RD 20170818 Latitude: 40.058508° Longitude: -75.673147°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Approximate Surface Elev: 500 (Ft.) +/- ELEVATION (Ft.)								
DEPTH									
65.0	Run 9, Medium hard, moderately weathered, gray, brown and white, medium to coarse-grained, GNEISS, primary joints, moderately dipping to high angle, close, open	435+/-			60		93	2 3 3 2	
70.0	Run 10, Similar	430+/-			60		83	2 3 2 2 2	
75.0	Run 11, Soft, moderately to severely weathered, white and brown, coarse-grained, GNEISS, primary joints, moderate to high angle, very close, wide	425+/-			54.5		23	2 2 3 2	
80.0	Run 12, Similar	420+/-			51.5		37	2 3 2 2 2	
85.0	Run 13, Very soft, severely weathered, brown and orange, medium to coarse-grained, GNEISS, very close to wide joints	415+/-			45		7	2 2 2 1 1	
90.0	Run 14, Severely weathered rock, very little recovery Possible fault zone from 85 to 93.5 feet. After fault zone, used 500 gallons of water per 20 feet of coring.	410+/-			12		0	1 1 1 1 1	

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

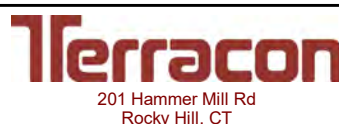
Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

Not encountered



Boring Started: 08-29-2017

Boring Completed: 08-31-2017

Drill Rig: Mobile B-57

Driller: Terracon/Scott

Project No.: J217P078

Exhibit: A-2

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 6.GPJ TERRACON DATATEMPLATE.GDT 10/13/17

BORING LOG NO. B6-8E Herman O.W. Drive East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

GRAPHIC LOG	LOCATION PA-CH-0127.0000-RD 20170818 Latitude: 40.058508° Longitude: -75.673147° Approximate Surface Elev: 500 (Ft.) +/- ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
DEPTH	ELEVATION (Ft.)								
95.0	405+/-	95			18		14	1 1 2 2	
Run 15, No recovery until 93.5 feet: Hard, slightly weathered, gray, medium grained, GNEISS, close to wide joints									
100.0	400+/-	100			60		90	2 2 2 3	
Run 16, Hard, fresh, gray and white, medium-grained, GNEISS, primary joints, moderately dipping, moderately close, moderately open									
105.0	395+/-	105			60		93	3 3 3 3	
Run 17, Similar, staining on joints									
110.0	390+/-	110			60		100	3 3 3 4	
Run 18, Very hard, fresh, gray and white, medium-grained, GNEISS, primary joints, moderately dipping, wide, slightly open									
115.0	385+/-	115			60		93	2 2 3 3	
Run 19, Very hard, fresh, gray and white, medium-grained, GNEISS, primary foliation joints, moderately dipping, secondary joints, high angle, close, moderately open									
120.0	380+/-	120			60		88	3 3 3 3	
Run 20, Similar									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

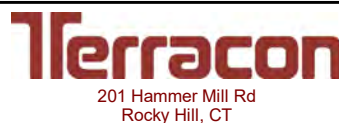
Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

Not encountered



Boring Started: 08-29-2017

Boring Completed: 08-31-2017

Drill Rig: Mobile B-57

Driller: Terracon/Scott

Project No.: J217P078

Exhibit: A-2

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 6.GPJ TERRACON DATATEMPLATE.GDT 10/13/17

BORING LOG NO. B6-8E Herman O.W. Drive East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

GRAPHIC LOG	LOCATION PA-CH-0127.0000-RD 20170818 Latitude: 40.058508° Longitude: -75.673147° Approximate Surface Elev: 500 (Ft.) +/- ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
DEPTH									
125.0	Run 21, Hard, fresh, gray and white, medium to coarse-grained, GNEISS, primary foliation joints, moderately dipping, secondary joints, high angle dipping, close, open	125			60		59	3 3 4 3 3	
130.0	Run 22, Similar	130			60		71	3 4 4 3 3	
135.0	Run 23, Similar	135			60		78	3 3 4 4 3	
140.0	Run 24, Similar	140			60		81	3 3 3 4 3	
145.0	Run 25, Very hard, fresh, gray and white, medium to coarse-grained, GNEISS, primary joints, moderately dipping, close, open Transitioning into granitic texture (migmatitic) at 142 feet	145			60		67	4 4 4 4 5	
150.0	Run 26, Very hard, fresh, gray, coarse-grained, MIGMATITE, no joints present, open on mechanical breaks	150			58.5		98	3 3 3 3 3	

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

Not encountered



Boring Started: 08-29-2017

Boring Completed: 08-31-2017

Drill Rig: Mobile B-57

Driller: Terracon/Scott

Project No.: J217P078

Exhibit: A-2

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 6.GPJ TERRACON DATATEMPLATE.GDT 10/13/17

BORING LOG NO. B6-8E Herman O.W. Drive East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

GRAPHIC LOG	LOCATION PA-CH-0127.0000-RD 20170818 Latitude: 40.058508° Longitude: -75.673147° Approximate Surface Elev: 500 (Ft.) +/- ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
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DEPTH	Run 27, Similar 155.0 345+/-	155			60		100	3 3 3 3	
	Run 28, Moderately hard to soft, fresh, gray and dark gray, medium to fine-grained, SCHISTOSE GNEISS, primary foliation joints, high angle, secondary joints, vertical, close, wide Transitioning to schistose texture at 157 feet Calcite veins between 157 and 160 feet 160.0 340+/-	160			60		34	3 3 2 2	

Boring Terminated at 160 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS
<i>Not encountered</i>



Boring Started: 08-29-2017	Boring Completed: 08-31-2017
Drill Rig: Mobile B-57	Driller: Terracon/Scott
Project No.: J217P078	Exhibit: A-2

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL. J217P078 - SPREAD 6.GPJ TERRACON_DATATEMPLATE.GDT 10/13/17

ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

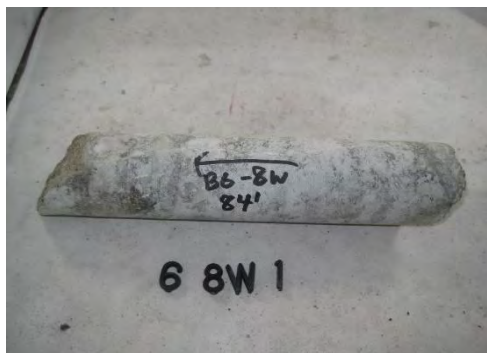
Boring No.: B6-8W
 Sample No.: 1
 Sample Depth: 84 feet
 Sampling Date: 8/31/17

Lithology : Gneiss
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 6 min

Diameter: 1.98 in
 Length: 4.52 in
 L/D: 2.28
 End Area: 3.08 in²

Maximum Axial Load at Failure: 19,850 lb
 Compressive Strength: 6,447 psi
 Compressive Strength: 44.45 Mpa
 Unit Weight 171 pcf

Before the Test



After the Test



Drawing # : PA-CH-0127.0000-RD
 PO # : 20170818
 Crossing : Herman O.W. Drive
 Spread : Spread 6

Project:	Mariner East Pipeline
Project No.	J217P078
Location:	Spread 6
Client :	Directional Project Support Inc.

Terracon
 77 Sundial Ave., Suite 401 W
 Manchester, New Hampshire

Performed by:	H. Whitford
Test Date:	10/17/2017
Reviewed By :	L. Dwyer
Review Date :	10/17/2017

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ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.: B6-8W
 Sample No.: 2
 Sample Depth: 90 feet
 Sampling Date: 8/31/17

Lithology : Gneiss
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 1 min

Diameter: 1.98 in
 Length: 4.42 in
 L/D: 2.23
 End Area: 3.08 in²

Maximum Axial Load at Failure: 4,220 lb
 Compressive Strength: 1,371 psi
 Compressive Strength: 9.45 Mpa
 Unit Weight 175 pcf

Before the Test



After the Test



Drawing # : PA-CH-0127.0000-RD
 PO # : 20170818
 Crossing : Herman O.W. Drive
 Spread : Spread 6

Project:	Mariner East Pipeline	<p style="margin: 0;">77 Sundial Ave., Suite 401 W Manchester, New Hampshire</p>	Performed by:	H. Whitford
Project No:	J217P078		Test Date:	10/17/2017
Location:	Spread 6		Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/17/2017

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ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

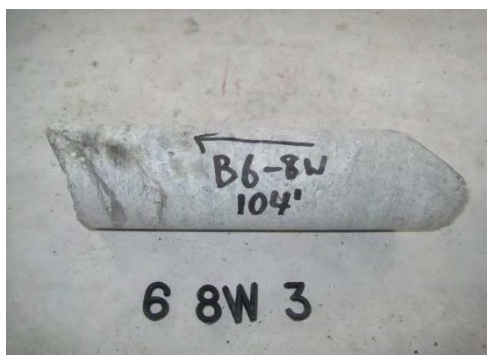
Boring No.: B6-8W
 Sample No.: 3
 Sample Depth: 104 feet
 Sampling Date: 8/31/17

Lithology : Gneiss
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 5 min

Diameter: 1.97 in
 Length: 4.53 in
 L/D: 2.30
 End Area: 3.05 in²

Maximum Axial Load at Failure: 16,320 lb
 Compressive Strength: 5,354 psi
 Compressive Strength: 36.92 Mpa
 Unit Weight 166 pcf

Before the Test



After the Test



Drawing # : PA-CH-0127.0000-RD
 PO # : 20170818
 Crossing : Herman O.W. Drive
 Spread : Spread 6

Project:	Mariner East Pipeline	<p style="margin: 0;">77 Sundial Ave., Suite 401 W Manchester, New Hampshire</p>	Performed by:	H. Whitford
Project No:	J217P078		Test Date:	10/17/2017
Location:	Spread 6		Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/17/2017

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ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.: B6-8E
 Sample No.: 1
 Sample Depth: 40 feet
 Sampling Date: 8/29/17

Lithology : Gneiss
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 2 min

Diameter: 1.97 in
 Length: 3.61 in
 L/D: 1.83
 End Area: 3.05 in²

Maximum Axial Load at Failure: 6,800 lb
 Compressive Strength: 2,231 psi
 Compressive Strength: 15.38 Mpa
 Unit Weight 163 pcf

Comments : Due to lack of available specimens, the length to diameter ratio of the tested specimen is not conformant with ASTM D7012. The results obtained during testing may differ from those obtained from the test specimens that meet the requirements.

Before the Test

After the Test



Drawing # : PA-CH-0127.0000-RD
 PO # : 20170818
 Crossing : Herman O.W. Drive
 Spread : Spread 6

Project:	Mariner East Pipeline
Project No.	J217P078
Location:	Spread 6
Client :	Directional Project Support Inc.

Terracon
 77 Sundial Ave., Suite 401 W
 Manchester, New Hampshire

Performed by:	A. Suprunenko
Test Date:	9/13/2017
Reviewed By :	L. Dwyer
Review Date :	10/17/2017

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ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

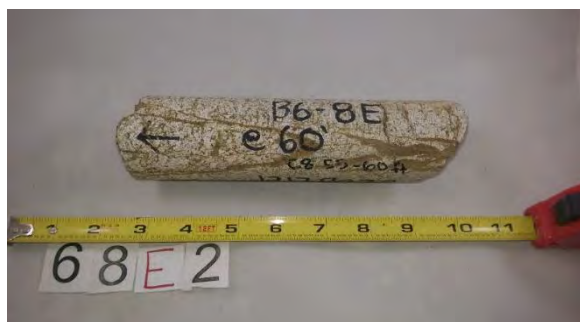
Boring No.: B6-8E
 Sample No.: 2
 Sample Depth: 60 feet
 Sampling Date: 8/29/17

Lithology : Gneiss
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 2 min

Diameter: 1.93 in
 Length: 4.30 in
 L/D: 2.23
 End Area: 2.93 in²

Maximum Axial Load at Failure: 6,930 lb
 Compressive Strength: 2,369 psi
 Compressive Strength: 16.33 Mpa
 Unit Weight 172 pcf

Before the Test



After the Test



Drawing # : PA-CH-0127.0000-RD
 PO # : 20170818
 Crossing : Herman O.W. Drive
 Spread : Spread 6

Project:	Mariner East Pipeline
Project No.	J217P078
Location:	Spread 6
Client :	Directional Project Support Inc.

Terracon
 77 Sundial Ave., Suite 401 W
 Manchester, New Hampshire

Performed by:	A. Suprunenko
Test Date:	9/13/2017
Reviewed By :	L. Dwyer
Review Date :	10/17/2017

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ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.: B6-8E
 Sample No.: 3
 Sample Depth: 80 feet
 Sampling Date: 8/29/17

Lithology : Gneiss
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 1 min

Diameter: 1.98 in
 Length: 3.73 in
 L/D: 1.88
 End Area: 3.08 in²

Maximum Axial Load at Failure: 1,890 lb
 Compressive Strength: 614 psi
 Compressive Strength: 4.23 Mpa
 Unit Weight 159 pcf

Comments : Due to lack of available specimens, the length to diameter ratio of the tested specimen is not conformant with ASTM D7012. The results obtained during testing may differ from those obtained from the test specimens that meet the requirements.

Before the Test

After the Test



Drawing # : PA-CH-0127.0000-RD
 PO # : 20170818
 Crossing : Herman O.W. Drive
 Spread : Spread 6

Project:	Mariner East Pipeline	<p style="margin: 0;">77 Sundial Ave., Suite 401 W Manchester, New Hampshire</p>	Performed by:	A. Suprunenko
Project No:	J217P078		Test Date:	9/13/2017
Location:	Spread 6		Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/17/2017

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ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.: B6-8E
 Sample No.: 4
 Sample Depth: 100 feet
 Sampling Date: 8/29/17

Lithology : Gneiss
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 11 min

Diameter: 1.94 in
 Length: 4.32 in
 L/D: 2.23
 End Area: 2.96 in²

Maximum Axial Load at Failure: 35,020 lb
 Compressive Strength: 11,847 psi
 Compressive Strength: 81.68 Mpa
 Unit Weight 193 pcf

Before the Test



After the Test

Photograph after the test is not available

Drawing # : PA-CH-0127.0000-RD
 PO # : 20170818
 Crossing : Herman O.W. Drive
 Spread : Spread 6

Project:	Mariner East Pipeline	<p style="margin: 0;">77 Sundial Ave., Suite 401 W Manchester, New Hampshire</p>	Performed by:	A. Suprunenko
Project No:	J217P078		Test Date:	9/13/2017
Location:	Spread 6		Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/17/2017

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ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.: B6-8E
 Sample No.: 5
 Sample Depth: 120 feet
 Sampling Date: 8/29/17

Lithology : Gneiss
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 10 min

Diameter: 1.99 in
 Length: 4.55 in
 L/D: 2.29
 End Area: 3.11 in²

Maximum Axial Load at Failure: 33,450 lb
 Compressive Strength: 10,755 psi
 Compressive Strength: 74.15 Mpa
 Unit Weight 167 pcf

Before the Test



After the Test



Drawing # : PA-CH-0127.0000-RD
 PO # : 20170818
 Crossing : Herman O.W. Drive
 Spread : Spread 6

Project:	Mariner East Pipeline
Project No.	J217P078
Location:	Spread 6
Client :	Directional Project Support Inc.

Terracon
 77 Sundial Ave., Suite 401 W
 Manchester, New Hampshire

Performed by:	A. Suprunenko
Test Date:	9/13/2017
Reviewed By :	L. Dwyer
Review Date :	10/17/2017

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ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.: B6-8E
 Sample No.: 6
 Sample Depth: 130 feet
 Sampling Date: 8/29/17

Lithology : Gneiss
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 0 min

Diameter: N/A in
 Length: N/A in
 L/D: N/A
 End Area: N/A in²

Maximum Axial Load at Failure: N/A lb
 Compressive Strength: N/A psi
 Compressive Strength: N/A Mpa
 Unit Weight N/A pcf

Specimen broke during preparation

Before the Test

After the Test



Drawing # : PA-CH-0127.0000-RD
 PO # : 20170818
 Crossing : Herman O.W. Drive
 Spread : Spread 6

Project:	Mariner East Pipeline	<p style="margin: 0;">77 Sundial Ave., Suite 401 W Manchester, New Hampshire</p>	Performed by:	A. Suprunenko
Project No:	J217P078		Test Date:	9/13/2017
Location:	Spread 6		Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/17/2017

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ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

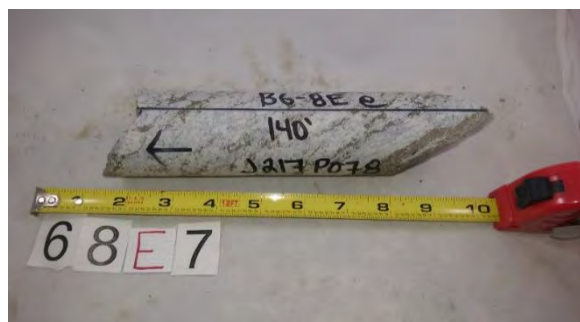
Boring No.: B6-8E
 Sample No.: 7
 Sample Depth: 140 feet
 Sampling Date: 8/29/17

Lithology : Gneiss
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 6 min

Diameter: 1.99 in
 Length: 4.41 in
 L/D: 2.22
 End Area: 3.11 in²

Maximum Axial Load at Failure: 19,690 lb
 Compressive Strength: 6,331 psi
 Compressive Strength: 43.65 Mpa
 Unit Weight 171 pcf

Before the Test



After the Test



Drawing # : PA-CH-0127.0000-RD
 PO # : 20170818
 Crossing : Herman O.W. Drive
 Spread : Spread 6

Project:	Mariner East Pipeline
Project No.	J217P078
Location:	Spread 6
Client :	Directional Project Support Inc.

Terracon
 77 Sundial Ave., Suite 401 W
 Manchester, New Hampshire

Performed by:	A. Suprunenko
Test Date:	9/13/2017
Reviewed By :	L. Dwyer
Review Date :	10/17/2017

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ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.: B6-8E
 Sample No.: 8
 Sample Depth: 150 feet
 Sampling Date: 8/29/17

Lithology : Migmatite
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 8 min

Diameter: 1.94 in
 Length: 4.53 in
 L/D: 2.34
 End Area: 2.96 in²

Maximum Axial Load at Failure: 25,250 lb
 Compressive Strength: 8,542 psi
 Compressive Strength: 58.90 Mpa
 Unit Weight 172 pcf

Before the Test



After the Test



Drawing # : PA-CH-0127.0000-RD
 PO # : 20170818
 Crossing : Herman O.W. Drive
 Spread : Spread 6

Project:	Mariner East Pipeline
Project No.	J217P078
Location:	Spread 6
Client :	Directional Project Support Inc.

Terracon
 77 Sundial Ave., Suite 401 W
 Manchester, New Hampshire

Performed by:	A. Suprunenko
Test Date:	9/13/2017
Reviewed By :	L. Dwyer
Review Date :	10/17/2017

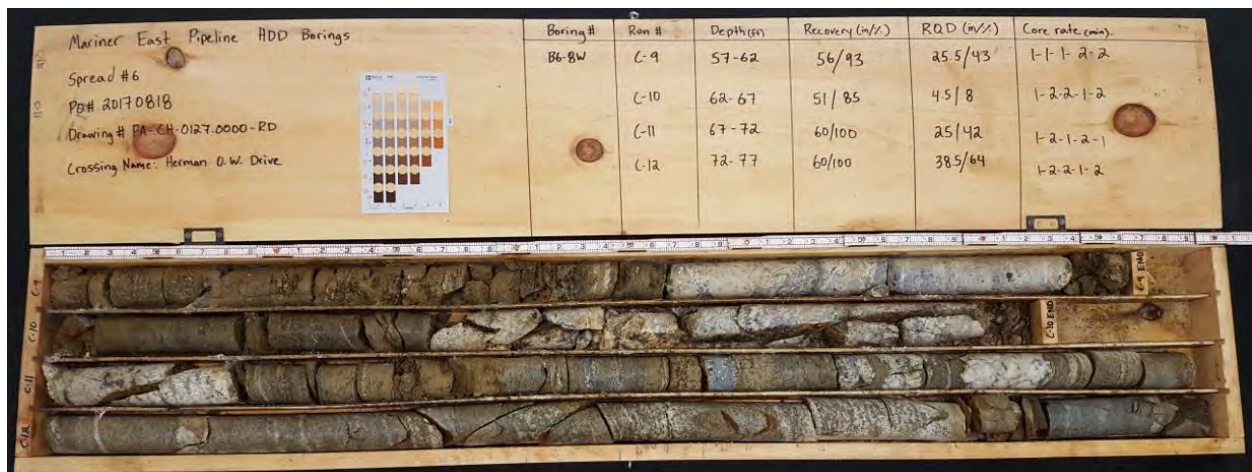
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Photograph 1: B6-8W, Samples C-1 to C-4 (17 to 37 feet)



Photograph 2: B6-8W, Samples C-5 to C-8 (37 to 57 feet)



Photograph 3: B6-8W, Samples C-9 to C-12 (57 to 77 feet)



Photograph 4: B6-8W, Samples C-13 to C-16 (77 to 97 feet)



Photograph 5: B6-8W, Samples C-17 to C-19 (97 to 112 feet)



Photograph 1: B6-8E, Samples C-1 to C-4 (20 to 40 feet)



Photograph 2: B6-8E, Samples C-5 to C-8 (40 to 60 feet)



Photograph 3: B6-8E, Samples C-9 to C-12 (60 to 80 feet)



Photograph 4: B6-8E, Samples C-13 to C-16 (80 to 100 feet)



Photograph 5: B6-8E, Samples C-17 to C-20 (100 to 120 feet)



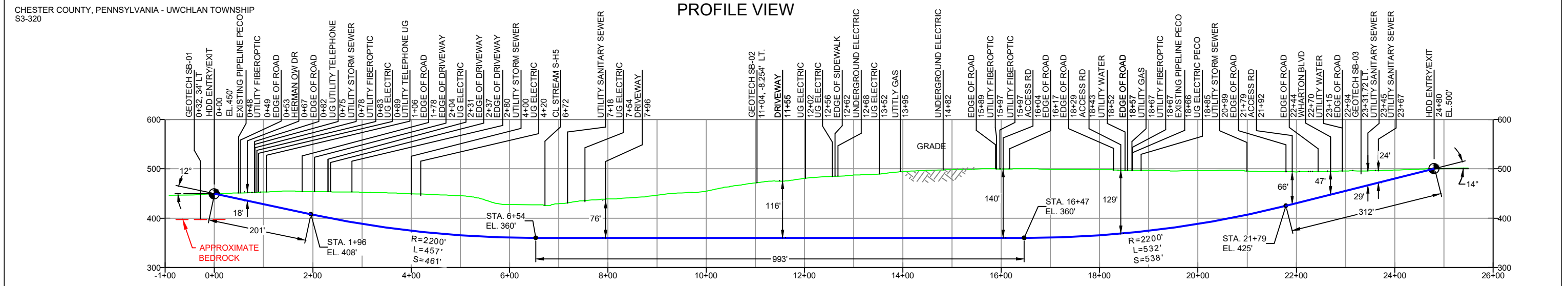
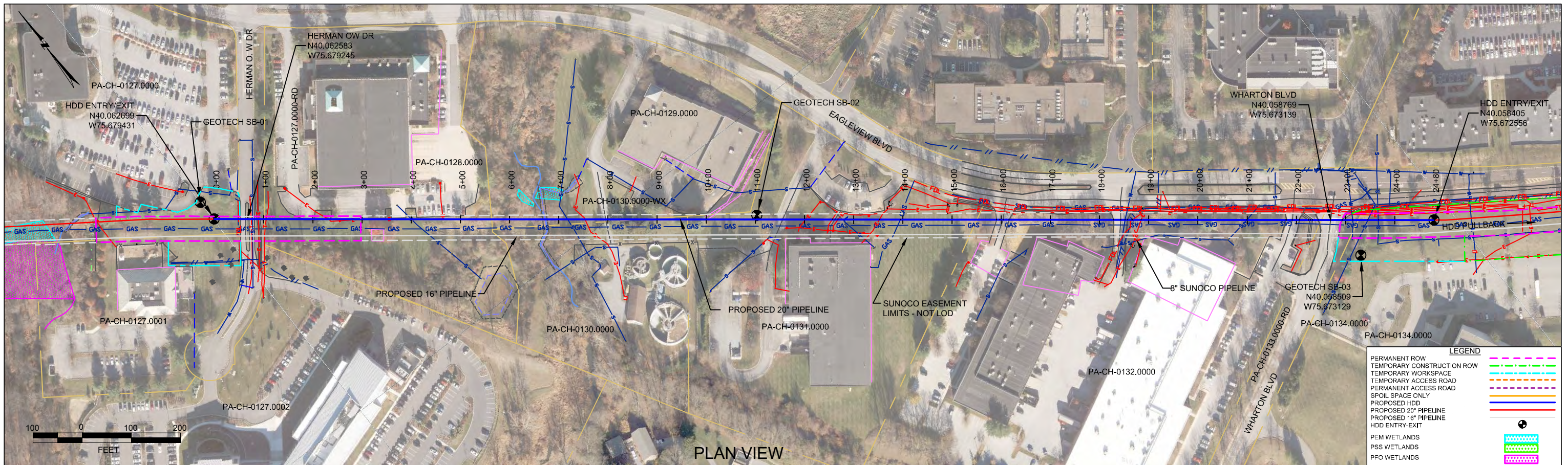
Photograph 6: B6-8E, Samples C-21 to C-24 (120 to 140 feet)



Photograph 7: B6-8E, Samples C-25 to C-28 (140 to 160 feet)

**HERMAN O.W. DRIVE HDD
PADEP SECTION 105 PERMIT NO. E15-862
PA-CH-0127.0000-RD
(SPLP HDD No. S3-0320)**

**ATTACHMENT 2
HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES**



GEOTECH SB-01	GEOTECH SB-02	GEOTECH SB-03
-NG EL. 450'	-NG EL. 472'	-NG EL. 502'
-TOPSOIL (0' - 0.2')	-TOPSOIL (0' - 0.2')	-TOPSOIL (0' - 0.3')
-ML (0.2' - 9.0')	-SM (0.2' - 24.0')	-ML (0.3' - 6.5')
-GROUNDWATER (25.0')		-SM (6.5' - 18.5')
-SM (9.0' - 53.0')		-WEATHERED GNEISS GRAVEL (18.5' - 19.0')
-WEATHERED GNEISS (53.0' - 61.3')	-AUGER REFUSAL WEATHERED GNEISS-24.0'	-WEATHERED GNEISS (18.5' - 19.0')
-COMPLETION DEPTH EL. 389'	-COMPLETION DEPTH EL. 448'	-COMPLETION DEPTH EL. 483'

- 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=): 2480'
HDD PIPE LENGTH (S=): 2505'
20" x 0.456" W.T., X-65, API5L PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE 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.

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 HEREIN 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.

REVISIONS					
NO.	DESCRIPTION	BY	DATE	CHK	DATE
7	DRILL ENTRY / EXIT LAT LONG UPDATE	MRS	03/31/17	RMB	03/31/17
6	REVISED PROFILE WITH 2017 LIDAR	DLM	02/23/17	RMB	02/23/17
5	DESIGN CHANGE (OZ HDD DESIGN RFI-0112)	DLM	01/10/17	RMB	01/10/17
4	UPDATED SUNOCO EASEMENT LIMITS - NOT LOD	DLM	10/24/16	RMB	10/24/16
3	REVISED PER ENGINEERING COMMENTS	MRS	08/12/16	RMB	08/12/16
2	DESIGN CHANGE	DLM	04/26/16	RMB	04/26/16

**Sunoco Logistics
Partners L.P.**

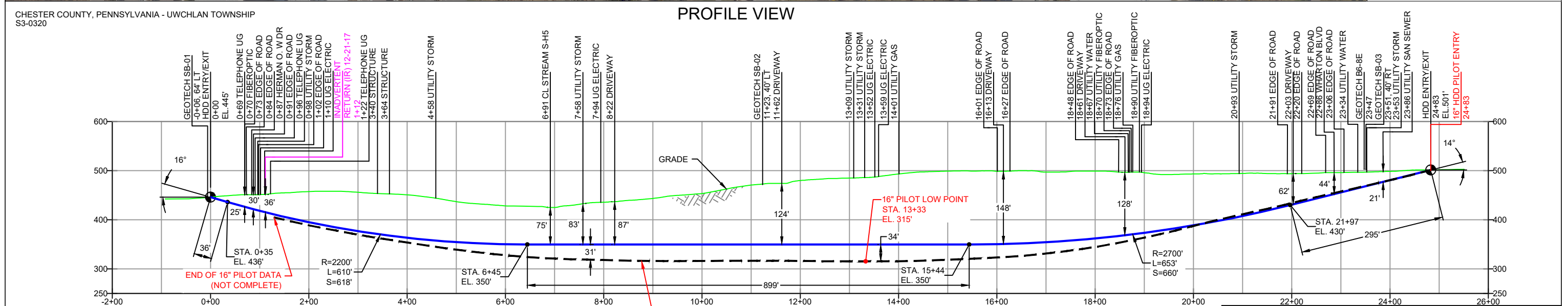
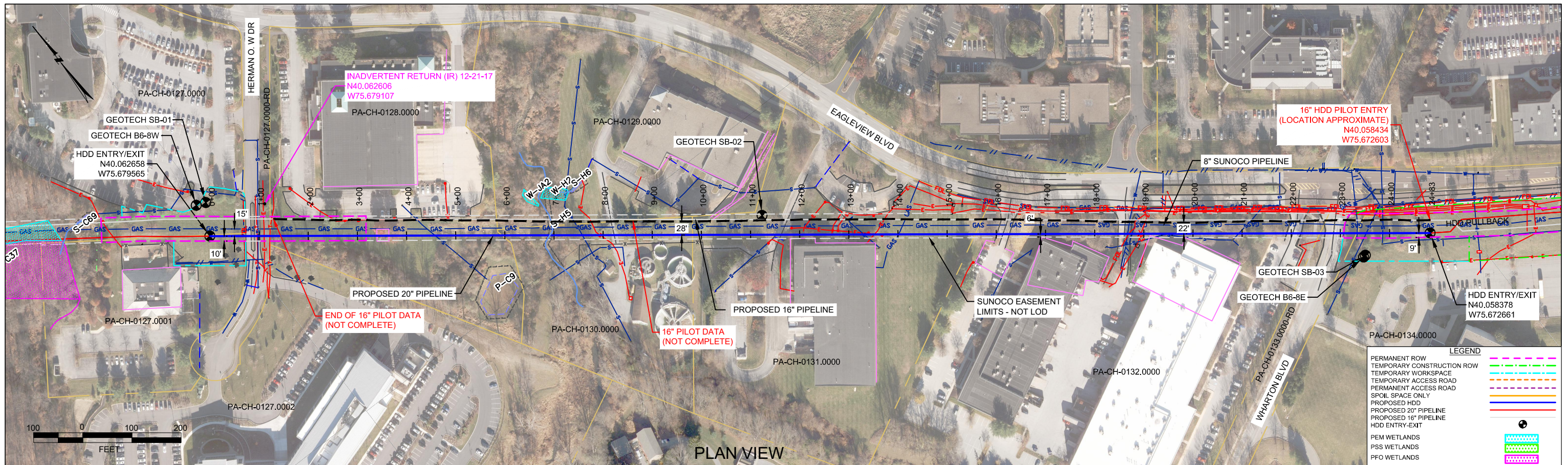
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
HERMAN O. W DRIVE
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' DWG. NUMBER: PA-CH-0127.0000-RD

Figure 1: Permitted 20-Inch HDD Plan and Profile



GEOTECH SB-01	GEOTECH SB-02	GEOTECH SB-03
<ul style="list-style-type: none"> NG EL. 450' -TOPSOIL (0' - 0.2') -ML (0.2' - 9.0') -GROUNDWATER (25.0') -SM (9.0' - 53.0') -WEATHERED GNEISS (53.0' - 61.3') -COMPLETION DEPTH EL. 389' 	<ul style="list-style-type: none"> NG EL. 472' -TOPSOIL (0' - 0.2') -ML (0.3' - 6.5') -SM (0.2' - 24.0') -AUGER REFUSAL WEATHERED GNEISS-24.0') -COMPLETION DEPTH EL. 448' 	<ul style="list-style-type: none"> NG EL. 502' -TOPSOIL (0' - 0.3') -ML (0.3' - 6.5') -SM (6.5' - 18.5') -WEATHERED GNEISS GRAVEL (18.5' - 19.0') -COMPLETION DEPTH EL. 483'

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)=2483'
 HDD PIPE LENGTH (S)=2508'
 20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
 COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE 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.

GEOTECH B6-8W	GEOTECH B6-8E
<ul style="list-style-type: none"> NG EL. 464' -FILL - POORLY GRADED SAND W/ SILT (0.0' - 3.0') -SILT W/ SAND ML (3.0' - 8.0') -POORLY GRADED SAND SP (8.0' - 17.0') -GNEISS (17.0' - 112.0') -BORING TERMINATED EL.352' 	<ul style="list-style-type: none"> NG EL. 500' -TOPSOIL (0' - 0.5') -FILL - POORLY GRADED SAND W/ SILT AND GRAVEL (SP-SM) (0.5' - 7.0') -HIGHLY WEATHERED ROCK (7.0' - 20.0') -AUGER REFUSAL (18.0') -GNEISS (20.0' - 160.0') -BORING TERMINATED EL.340'

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-6.35 TO ES-6.36	EROSION & SEDIMENT PLAN EP3 SWITCHED 20" CENTERLINE LOCATION, INCREASED DEPTH OF DRILL AND ADDED GEOTECH INFORMATION
SHEET 20 TO SHEET 21	AERIAL SITE PLAN EP2 REVISED PER PADEP COMMENTS RECEIVED 09-06-16
	EP1 REVISED PER PADEP COMMENTS
	EP ADDED GEOTECH INFO
	C ISSUED FOR BID

Figure 2. Revised 20-Inch HDD Plan and Profile

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
HERMAN O. W DRIVE
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

DWG. NO. PA-CH-0127.0000-RD