

**HORIZONTAL DIRECTIONAL DRILL ANALYSIS
EAGLEVIEW BOULEVARD
PADEP SECTION 105 PERMIT NO. PA-CH-0135.0000-RD-16
(SPLP HDD# S3-0321)**

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This analysis of the horizontal directional drill (HDD) No. S3-0321, which is the installation of a 16-inch diameter pipeline parallel to Eagleview Boulevard in Chester County, Pennsylvania, is in accordance with Stipulated Order issued under EHB DOCKET NO. 2017-009-L for HDDs listed on Exhibit 2 of the Stipulated Order.

During the HDD installation of the 20-inch pipeline (PA-CH-0135.0000-SR) no inadvertent returns (IRs) of drilling fluids to the land surface occurred during the pilot phase, reaming phase, or during the pulling of the pipeline through the reamed profile.

HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY

- Horizontal length: 558 feet (ft)
- Entry angle: 8 degrees
- Depth of cover: 25 ft
- Pipe stress radius: 1,600 ft

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

Bedrock in the area of HDD S3-0321 is comprised of crystalline, Precambrian-aged weathered felsic gneiss and granodiorite of the Reading Prong. Regional fabric (relict bedding and structure) trends are to the northeast as depicted in the geologic map below. Two geotechnical borings placed along the HDD-0321 alignment were advanced to depths of 20 feet near the northwestern end and 30 feet near the southeastern end. Thus, the weathered overburden can range in thickness from 20 feet to over 30 feet. This material is primarily composed of weathered in-situ bedrock and has been logged according to USCS methods as ML (inorganic silts, fine sands and rock flour) underlain by SM (silty sands and sand/silt mixtures).

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

HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

The felsic gneiss/granodiorite unit mapped beneath the HDD S3-0321 location is identified as a unit of poor groundwater production. Soils maps suggest that groundwater may exist within the top 6 feet of grade, but daily reports from observation of earlier HDD activities at this location make no suggestion of notable groundwater production. This is consistent with the engineered surface water conveyances and the fine-grained weathered rock materials that comprise the site surface and shallow subsurface.

Median well yields for the bedrock in this geologic setting are reported as variable but approximately 20 gallons per minute (Geyer and Wilshusen, 1982).

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

ADJACENT FEATURES ANALYSIS

The horizontal directional drill (HDD) parallel to Eagleview Boulevard is located in approximately 1.8 miles west of the community of Lionville in Uwchlan Township.

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The pipeline route in this area of Chester County follows parallel to an existing Sunoco pipeline. At this location, commercial buildings, sidewalks, driveways, and various utilities (e.g. fiber optic lines, overhead and underground electric lines, sewage line, telephone line, and a gas line) are immediately adjacent to the existing permanent utility easement, parallel to and crossing perpendicular to the easement. The presence of these structures necessitated the HDD to avoid affects to pubic infrastructure and utilities at this location.

There are no official water well records indicating the presence of water wells within 450 ft of the proposed HDD. There are two (2) public water supplies within a one (1) mile radius.

INADVERTENT RETURNS DISCUSSION

No inadvertent returns occurred during the drilling and installation of the 20-inch diameter pipeline which precedes the 16-inch diameter pipeline installation.

ALTERNATIVES ANALYSIS

The proposed HDD is an alternative plan of installation to a conventional open trench construction plan to avoid direct affects to parallel and conflicting utilities and public infrastructure.

Open cut analysis

The HDD as planned is an alternate construction method to install a short segment of pipeline, 570 ft in length, as noted in the HDD summary above. Alternately, a conventional horizontal auger bore underneath the pubic road could be performed, but would require the excavation of an open trench of sufficient width and depth to set the boring machine below ground in line to auger a hole and pull the pipeline through. Considering the number and location of adjacent utilities, an excavation of sufficient size to accommodate the boring equipment could result in damages and disruption of service on these utilities; therefore the open cut alternative is dismissed.

Re-route analysis

In consideration that the installation of the preceding 20-inch diameter pipeline was completed without incident, the evaluation of an alternative route in a highly congested urban setting is dismissed.

CONCLUSION

As discussed above, no occurrence of an inadvertent return occurred during installation of the 20-inch pipeline.

Sunoco Pipeline, L.P has implemented mandatory annular pressure monitoring during the drilling of the pilot hole; short-tripping of the drilling tools to ensure an open annulus is maintained, and monitoring of the drilling fluid viscosity such that fissures and fractures in the subsurface are sealed during the drilling process. During the reaming phase, the use of Loss Control Materials can be implemented if indications of a potential IR are noted or an IR is observed.

Other than the implementation of these drilling practices and procedures, no changes to the HDD plans for the 16-inch pipeline are recommend or planned.

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(SPLP HDD# S3-0321)**

**ATTACHMENT 1
GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT**



HDD HYDROGEOLOGIC REEVALUATION REPORT

**Mariner East II
Spread 6
HDD S3-0321-16
Eagleview Boulevard
Uwchlan Township, Chester County, Pennsylvania**

Prepared for:

Sunoco Pipeline, L, P.

Prepared by:

Groundwater & Environmental Services, Inc.
440 Creamery Way, Suite 500
Exton, Pennsylvania 19341

September 2017



HDD HYDROGEOLOGIC REEVALUATION REPORT

**Mariner East II
Spread 6
HDD S3-0321-16
Eagleview Boulevard
Uwchlan Township, Chester County, Pennsylvania**

September 2017

Prepared For:

**Sunoco Pipeline, L. P.
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Prepared By:

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Christopher J. Mulry, P.G.
Principal Hydrogeologist

Reviewed By:

A handwritten signature in blue ink that reads 'Richard T. Wardrop'.

Richard T. Wardrop, P.G.
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By affixing my seal to this document, I am certifying that the 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.

Richard T. Wardrop

September 13, 2017

Richard T. Wardrop, P. G.

Lic. No. PG000157G

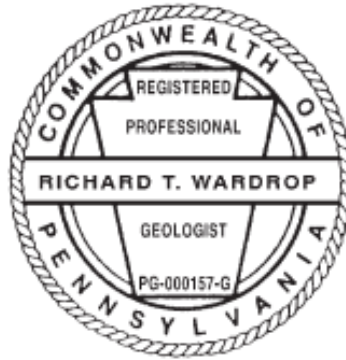




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- Figure 1. Site Location Map
- Figure 2. Regional Geologic Map
- Figure 3. Fracture Trace Analysis

1.0 INTRODUCTION

Sunoco Pipeline, L. P., (SPLP) retained Groundwater & Environmental Services, Inc. (GES) to prepare HDD Hydrogeologic Reevaluation Reports for horizontal directional drills (HDDs) listed on Exhibit 2 of Stipulated Order EHB Docket No. 2017-009-L signed August 10, 2017. This report discusses the hydrogeologic reevaluation for HDD S3-0321-16, adjacent to Eagleview Boulevard in Uwchlan Township, Chester County, PA. A map depicting the location of the HDD with topographic information on the surrounding area is presented as **Figure 1**.

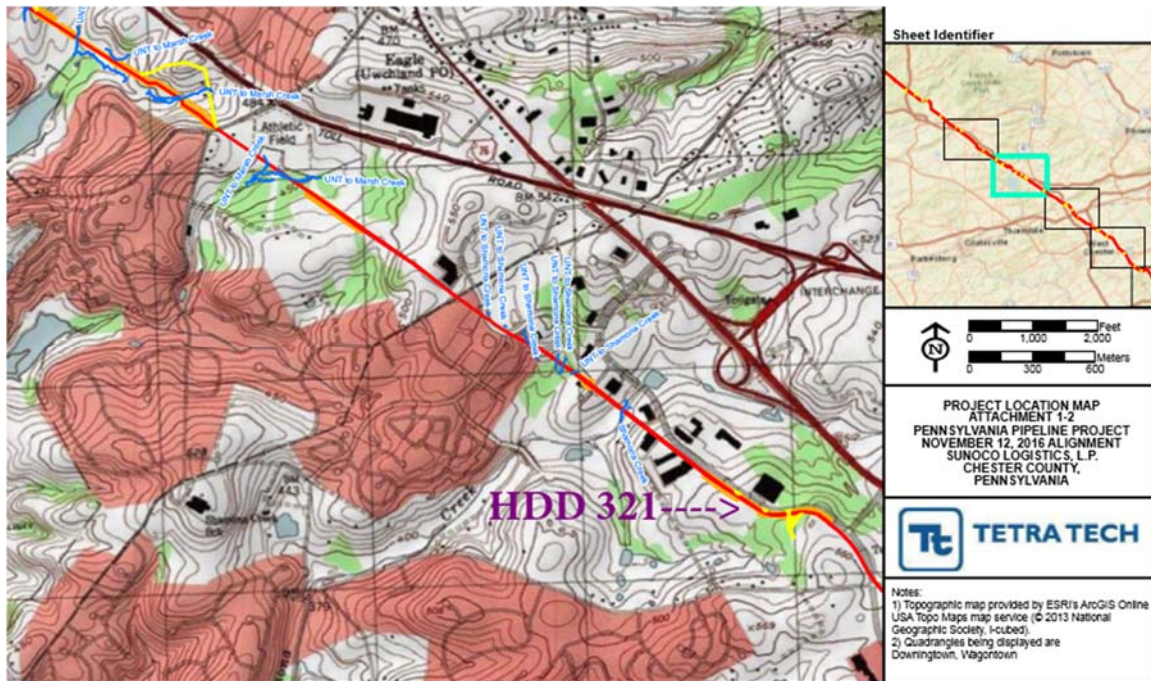


Figure 1. Site Location Map

This report presents the following information:

- Geologic and hydrogeologic characteristics in the area of the HDD;
- Summaries of studies performed pertinent to reevaluation, including fracture trace analysis; and
- A reevaluation summary with conclusions.

The contents of this report were developed from interpretation of published information, field observations, and related field studies.



2.0 HDD GEOLOGY / HYDROGEOLOGY

2.1 Physiography

2.1.1 Topography

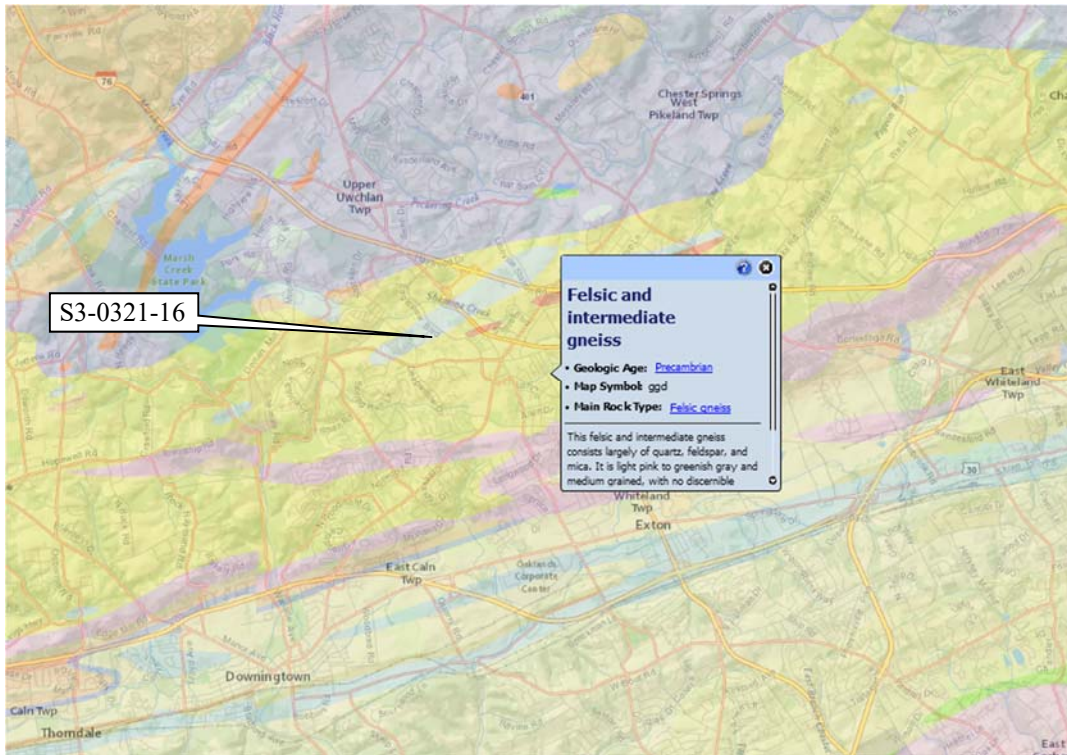
Topography in the area of HDD S3-0321-16 is quite flat with the ground surface elevation at the northwestern entry point identified as 510 feet above mean sea level (amsl) and the exit point 558 feet to the southeast at an elevation of 515 feet amsl. The HDD profile shows a slight rise between these points with overall elevation change of less than 10 feet. The entire HDD pathway and immediate surrounding areas are developed and grades may be engineered. The surface topography profile shows a slight upward slope from northwest to southeast. The HDD for the adjacent 20-inch line completed in July 2017 has an overall length of 570 feet. These observations are based on the most recent plans and profiles listed on the Rooney Engineering project web site dated February 23, 2017. The area surrounding the HDD is comprised of commercial properties with a residential community and recreation areas located to the southwest. The site location is depicted on **Figure 1**.

2.1.2 Hydrology

The nearest surface water body to the HDD location is Shamona Creek, located approximately 1,000 feet to the west and flowing southeast. Additional small ponds and related ephemeral streams are located in residential areas approximately 1,000 feet or more south of the HDD S3-0321-16 location.

2.2 Geology

Bedrock in the area of HDD S3-0321-16 is comprised of crystalline, Precambrian-aged weathered felsic gneiss and granodiorite of the Reading Prong. Regional fabric (relict bedding and structure) trends are to the northeast as depicted in the geologic map below. Two geotechnical borings placed along the HDD-0321 alignment were advanced to depths of 20 feet near the northwestern end and 30 feet near the southeastern end. Thus, the weathered overburden can range in thickness from 20 feet to over 30 feet. This material is primarily composed of weathered in-situ bedrock and has been logged according to Unified Soil Classification System (USCS) methods as ML (inorganic silts, fine sands and rock flour) underlain by SM (silty sands and sand/silt mixtures). **Figure 2** depicts regional bedrock geology. An additional fracture trace study was performed using available aerial photographs and yielded evidence of regional fracture traces trending approximately N12°E and N70°W; none are mapped in the immediate vicinity of the HDD S3-0321 bore. The S3-0321-16 HDD alignment is approximately N59°W.



(Modified from: PA DCNR Map Viewer <http://www.gis.dcnr.state.pa.us/maps/index.html>)

Figure 2. Regional Geologic Map

2.2.1 Published Information

Soils

Soils across the profile are mapped as GdA, or the Gladstone member of the regionally-extensive Urban land Udorthents (UugB) (NRCS Web Soil Survey [<http://websoilsurvey.nrcs.usda.gov>]). The Gladstone is described as silty clay loam underlain by weathered rock. This soil is described by the USDA as being typically found in hilly settings, well drained with moderate water storage. This Urban Udorthents and Gladstone soil horizon across the entire area of the profile and the USDA description indicates that bedrock is likely to be encountered at depths of 5 to 6 feet below grade.

Bedrock lithology

As noted, the S3-0321-16 HDD bore lies in an area of the Piedmont physiographic province of Pennsylvania mapped as a PreCambrian felsic gneiss and/or granodiorite of the Reading Prong. The map description is provided as “*This felsic and intermediate gneiss consists largely of quartz, feldspar, and mica. It is light pink to greenish gray and medium grained, with no discernible banding. It interfingers with gabbroic gneiss. Its thickness is unknown*” (Berg and others, 1980; Geyer and Wilshusen, 1982).

These rocks are metamorphosed crystalline units of unknown thickness and limited primary porosity. As shown in the regional geologic map compiled by Kochanov (2016), this felsic gneiss unit lies unconformably above the Chickies Quartzite and north of the imbricate faults defining the Chester Valley and Great Valley regions of southeastern Pennsylvania. No faults are mapped within approximately one mile of the HDD S3-0321-16 location. Additionally, the geotechnical logs and

daily reports from the installation of the adjacent 20-inch diameter line (completed August, 2017), indicates that bedrock was not encountered or penetrated during installation. The maximum HDD boring depth for HDD S3-0321-16 is approximately 25 feet below surface grade.

Mining

Dolostone of the Ledger Formation, which exists in fault contact beneath the Chickies Quartzite, are mined in nearby Downingtown, Exton and Malvern, to the southwest, south and east of the S3-0321-16 HDD location. None are within approximately 3 miles of the HDD site and are geologically distinct and unrelated.

Structure

As identified in the regional geologic map, gross structural trends for the HDD S3-0321-16 location include faulting and foliation patterns striking northeast to nearly east-west with additional nearly orthogonal (nearly north-south) brittle features interspersed. None of these regional features is mapped within close proximity (i.e., one mile) of the subject HDD location. A fracture trace study completed via analysis of stereo air photo pairs is shown below as **Figure 3** and demonstrates these regional patterns and relationships. The primary lineament trends are approximately N12°E and N70°W. The former aligns reasonably well with features identified on the geologic map, while the latter may match brittle features mapped east of the site – also evident on the regional geologic map.



Figure 3. Fracture Trace Analysis (approximate HDD S3-0321-16 location shown by shaded area)



Rock engineering properties

The Granitic Gneiss rock properties are as follows (Geyer and Wilshusen, 1982):

- Bedding is poorly developed, massive.
- Fracture joints have an irregular pattern and are moderately to poorly formed. They are further described as widely to moderately spaced with steep to vertical dips and open.
- Surface drainage is good.
- Joints provide a very low secondary porosity and low permeability. Median well yields are less than 20 gallons per minute (gpm).
- Drilling rates are slow.

2.2.2 Observations from HDDs Advanced in Area of Interest

No notable events were reported during the completion of the 20” line HDD S3-0321-16; which reported pilot bore completion on July 19, 2017 and installation of 20-inch pipe via pull-back on August 15, 2017. Immediately prior to the emergence of the pilot bit in the exit pit on July 19, 2017, a small volume of drilling mud (estimated to be 30 gallons) surfaced beneath the drilling pad within 30 feet of the exit point. This fluid was directed to the drill exit pit via removal of several pad planks. The bit depth below grade at that time was estimated to be less than 5 feet. This return event is readily associated with the shallow depth of the bore at this location and is not considered critical to the planned 16-inch diameter pipe installation.

2.2.3 Fracture Traces

As noted in *Section 2.2.1* above, a regional fracture trace analysis was conducted and identified nearly orthogonal pairs of fractures evident on a large-scale. Several fracture features were identified via air photo analysis within about ½ mile of the HDD S3-0321-16 location. Most are located to the north or west of the drill path and there is no indication they underlie or continue through the HDD path. In addition, as noted, the shallow depth of HDD S3-0321-16 makes it unlikely that bedrock will be penetrated during HDD completion.

2.3 Hydrogeology

The felsic gneiss/granodiorite unit mapped beneath the HDD S3-0321-16 location is identified as a unit of poor groundwater production. Soils maps suggest that groundwater may exist within the upper most 6 feet of the soil horizon, but daily reports from observation of earlier HDD activities at this location make no suggestion of notable groundwater production. This is consistent with the engineered surface water conveyances and the fine-grained weathered rock materials that comprise the site surface and shallow subsurface.

Median well yields for the bedrock in this geologic setting are reported as variable but approximately 20 gpm (Geyer and Wilshusen, 1982).

2.4 Studies Performed for Reevaluation

2.4.1 Relevant On-Site Observations

Notwithstanding, the surfacing of a small volume of drilling mud at the pad site as the drill for the 20” line for HDD S3-0321-16 was nearing the ground surface at completion, this site does not display geologic or developmental attributes that would denote an elevated risk for mud loss or



inadvertent returns of drilling fluids during completion of the contemplated second HDD boring. Further, prior HDD progressed at a moderate to rapid pace (less than three days to complete a 570 foot-long pilot bore) and did not appear to penetrate the underlying crystalline rock.

2.4.2 Geotechnical Borings

Two shallow geotechnical borings were completed by Tetra Tech along the HDD S3-0321-16 alignment and were advanced to depths of 20 feet near the northwestern end and 30 feet near the southeastern end. This material logged in both borings primarily composed of weathered in-situ bedrock and has been logged according to USCS methods as ML (inorganic silts, fine sands and rock flour) underlain by SM (silty sands and sand/silt mixtures). No new geotechnical borings were performed at this HDD location.

2.5 Study Results

2.5.1 Overburden Characteristics

See description above. Fine-grained soils comprised of in-situ weathered gneiss. In-situ rock weathering produces silts and clays with minor fine sand content. These fine-grained soils have moderate to high water retention and limited water storage capacity and would be expected to swell and mask any potential brittle features (i.e., fractures) that might remain in place from relict bedrock structure.

2.5.2 Bedrock Characteristics

Crystalline rock underlies the site. No fractures of regional influence or note have been identified in the immediate HDD S3-0321-16 location, nor is the proposed bore anticipated to reach the competent rock horizon.

2.5.3 Topographic Considerations

None of note. The site topography is flat and has been engineered for commercial development.

2.5.4 Hydrogeologic Factors

There is no groundwater production in the immediate site vicinity and no evidence of groundwater yield was observed during the installation of the HDD S3-0321-16 20-inch line. SPLP's residential water supply baseline sampling program identified property owners within 150 feet of the LOD and offered pre-construction water testing for those owners having an on-site water supply. This process identified no land owner who requested HDD S3-0321-16 pre-construction sampling of their wells. Furthermore, the Pennsylvania Groundwater Information System (PAGWIS) was queried for records of wells drilled within 450 feet of HDD S3-0321-16 and no records were produced.



3.0 SUMMARY AND CONCLUSIONS

The synthesis of regional and local geologic and development data for the HDD S3-0321-16 site does not suggest an elevated risk of drilling mud loss or inadvertent returns. No conditions were identified that would require modification of standard drilling procedures and precautions for the completion of the proposed 16-inch diameter line.



4.0 REFERENCES

Berg, et al., 1980, *Geologic Map of Pennsylvania*, Pennsylvania Geologic Survey, 4th Ser, Map 001.

Geyer, A. R. and J. P. Wilshusen, 1982 *Engineering Characteristics of the Rocks of Pennsylvania*. Pennsylvania Geologic Survey, 4th Ser., EGR-001.

Kochanov, W. E., 2016, Geology of part of the Chester Valley area, Chester, Delaware, Montgomery, and Philadelphia Counties, Pennsylvania, Pennsylvania Geologic Survey 4th. Ser., OFGA 16-01.0.

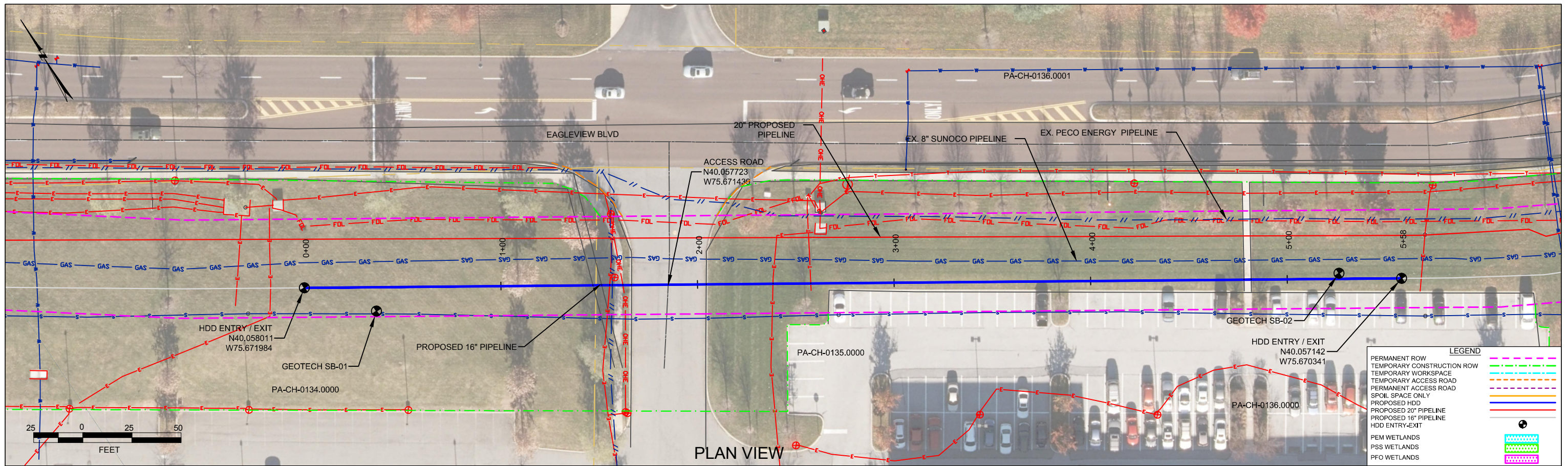
Pennsylvania groundwater information system (PaGWIS). Pennsylvania Geological Survey, <http://dcnr.state.pa.us/topogeo/groundwater/pagwis/records/index.htm>.

Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey, <https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>.

**EAGLEVIEW BOULEVARD
PADEP SECTION 105 PERMIT NO. PA-CH-0135.0000-RD-16
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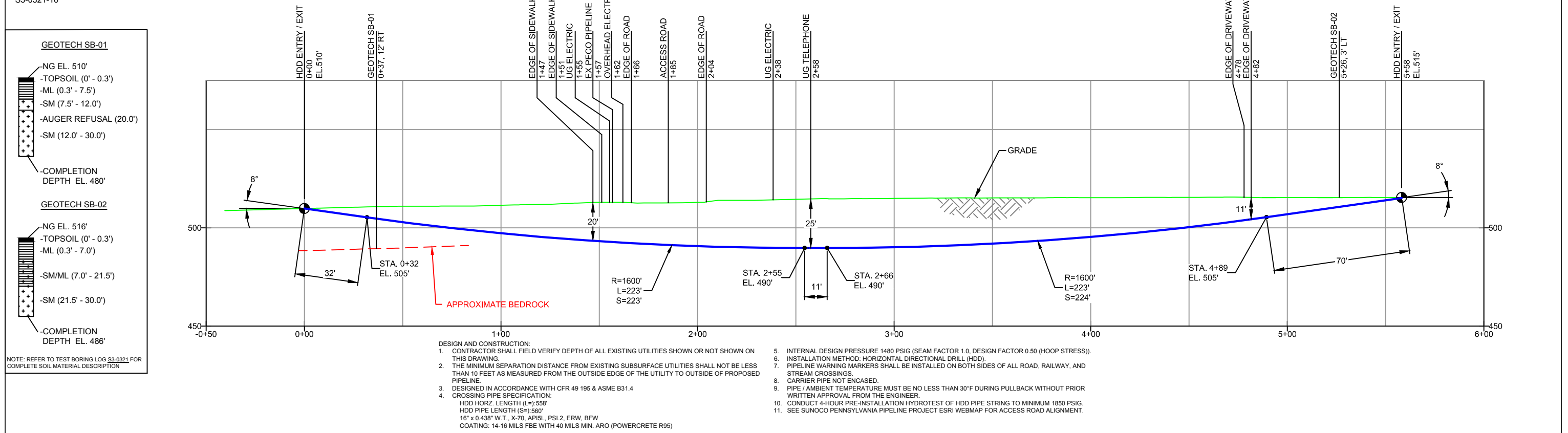
ATTACHMENT 2

ORIGINAL HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILE



CHESTER COUNTY, PENNSYLVANIA - UWCHLAN TOWNSHIP
 S3-0321-16

PROFILE VIEW



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.

REVISIONS		BY	DATE	CHK	DATE	APP	DATE
4	REVISED PROFILE WITH 2017 LIDAR	MRS	02/23/17	RMB	02/23/17	AMC	02/23/17
3	DESIGN CHANGE - LOWERED DRILL (PER OZ 20" HDD REDESIGN - RFI 0113)	MRS	02/03/17	RMB	02/03/17	AMC	02/03/17
2	ADDED GEOTECH INFO	MRS	11/28/16	RMB	11/28/16	AAW	11/28/16
1	REVISED PER ENGINEERING COMMENTS	MRS	08/12/16	RMB	08/12/16	AAW	08/12/16
0	ISSUED FOR CONSTRUCTION	MRS	04/23/16	RMB	04/23/16	AAW	04/23/16

Sunoco Logistics Partners L.P.

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SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
 EAGLEVIEW BLVD
 PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=50' DWG. NO. PA-CH-0135.0000-RD-16