HORIZONTAL DIRECTIONAL DRILL ANALYSIS
GOLDFINCH LANE CROSSING
PADEP SECTION 105 PERMIT NO.: E11-352
PA-CA-0016.0000-RD and PA-CA-0016.0000-RD-16
(SPLP HDD No. S2-0069)

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This reanalysis of the horizontal directional drill (HDD) of the Sunoco Pipeline, LP (SPLP) 16-inch and 20-inch diameter pipeline crossing of streams S-N41 and S-N42 (both unnamed tributaries to Hinckston Run), Wetlands N25, N26, and N27, and Goldfinch Lane in Jackson Township, Cambria County, is in accordance with Stipulated Order issued under Environmental Hearing Board Docket No. 2017-009-L for HDDs listed on Exhibit 2 of the Stipulated Order. This HDD is number 5 on the list of HDDs included on Exhibit 2. This HDD was not initiated before the issuance of the Order.

PIPE INFORMATION

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

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

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 20-INCH

- Horizontal length: 1,325 foot (ft)
- Entry/Exit angle: 15 degrees
- Maximum Depth of cover: 50 ft
- Depth under Goldfinch Lane: 37 ft
- Depth under streams: 29-48 ft
- Depth under wetlands: 30-50 ft
- Pipe design radius: 2,000 ft

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 1,325 foot (ft)
- Entry/Exit angle: 15 degrees
- Maximum Depth of cover: 52 ft
- Depth under Goldfinch Lane: 39 ft
- Depth under streams: 29-48 ft
- Depth under wetlands: 40-50 ft
- Pipe design radius: 1,600 ft

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

Bedrock underlying the area of HDD S2-0069 belongs to the Pennsylvanian age Glenshaw Formation, part of the Conemaugh Group. It primarily consists of thinly bedded, fossiliferous marine limestone and clay, shale; red claystone; locally massive, fine- to coarse-grained sandstone; minor amounts of freshwater limestone, and thin coal (McElroy, 1998). The base of the Glenshaw Formation is at the top of the Upper Freeport coal, which is part of the Allegheny Group, immediately below the Conemaugh Group. Bedrock underlying the area immediately south of the western end of the HDD S2-0069 is the Pennsylvanian age Casselman Formation, also part of the Conemaugh Group. The Casselman Formation consists of thin-bedded claystone and siltstone; locally massive, fine- to medium-grained sandstone; freshwater limestone; and thin non-persistent coal (McElroy, 1998).

Based on published geologic data, no karst features are anticipated within the subsurface profile associated with this HDD; therefore, the use of geophysics assessments was considered but not conducted because this type of assessment would provide no additional data for use in the analysis of this HDD.

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

Coal Mining and Subsidence

Although coal mining has occurred in the past in this region, a review of published mining and geological data verifies that no documented mining has occurred under the planned profiles for HDD S2-0069. The limit of deep Lower Kittanning coal mining is approximately 155 ft north at its closest point, near the west entry/exit point for these HDDs. The mine roof is over 550 ft below ground surface, and the mine void is approximately 4.5 ft.

SPLP mine geologist and mine engineers have completed a review of the HDD profiles in relation to the nearby deep coal mining. Using a 35 degree angle of draw from the horizontal limits of the mine roof, results in a determination that more than half of the planned profile lays within the "tension zone" of a potential subsidence trough, with the nearest point of the profiles occurring within the tension zone at a 15 degree angle of draw from the mine void.

The analysis provided by the mine engineers provides the following information:

> *The response of the overburden from trough subsidence can generally be divided into four zones. Zone 1 is a highly rubbleized, caved zone typically extending upward 6 to 10 times the coal seam thickness. Zone 2 is a fractured zone defined by massive block-type caving and vertical fracturing typically extending 24 to 30 times the coal seam height. Zone 3 is a zone of increased groundwater storage with dilated fractures (dilated zone or continuous deformation zone) and horizontal movements along weak-strong rock interfaces typically extending 30 to 60 times the seam thickness. Some researchers indicate that above zone 3, the rock mass is constrained and no significant rock fracturing occurs. Zone 4 is the development of surface cracks, usually related to the movement of longwall panels.*
>
> *Based on a review of the available mine mapping, the planned HDD does not directly cross mined or proposed mined areas. However, Mine 31 was mined within 150 feet (straight line horizontal distance) of the planned HDD. Based on the mine maps, some mined areas appear to have been retreat mined (hatched workings) and if so, it is likely that subsidence would have already occurred. In other areas, the mine maps do not conclusively indicate whether retreat mining occurred so there is a potential for unplanned subsidence (open coal pillars).*
>
> *Using the overburden zones described above and maximum coal thickness of 60 inches, the highly rubbleized zone can extend 50 feet above the mined area; the fractured zone can extend 150 feet above the mined area; and the dilated fractures and horizontal movements can extend 300 feet above the mined area. The lowest elevation of either HDD (which is not directly over the mine workings) is the 16-inch line at 1659 ft amsl, which is at least 420 feet above the mine, and above the dilated fracture and horizontal movement zone.*

SPLP pipeline engineering concludes from the analysis above that any future affects from mine subsidence would have minimal affects to the pipelines installed by HDD at this location. During installation through the profile, the pipelines are stressed upward to the land surface at each end, and the reamed void that each pipe is pulled through has five (5) inches of free space surrounding the pipe wall. Considering that the maximum potential subsidence affect would occur at the west end of the profile and then decrease along the profile as proceeding east, any such subsidence would only decrease stress on the pipe segments, and would not jeopardize their integrity.

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HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

Groundwater in Cambria County is in aquifers comprised of both the unconsolidated sediments and bedrock, and can also occur as perched water. In the bedrock, groundwater occurs and flows primarily in fractures and bedding-plane partings creating an interconnected network of secondary porosity features. The type of lithology and the number and extent of fractures and interconnections influence the flow rate and direction of flow. In general, the depth range for water-bearing zones in the Casselman and Glenshaw Formations is from 0 to 250 feet. In general, groundwater flow proximal to HDD S2-0069 moves along gradients established by a water table surface that is a subdued reflection of the local topography.

The Pennsylvania Groundwater Information System (PaGWIS) identified four domestic supply wells within 1,000 feet of the HDD alignment. For these four wells, the well depths ranged from 75 to 125 feet. Initial water level measurements were available for two of the wells with values of 60 and 88 feet deep. SPLP performed a pre-construction survey of landowners within 450 feet of the ROW at HDD-S2-0069. The results being reported here are current as of 1/22/18 and as of that date one water supply, a spring, has been identified within the 450-foot survey limit. Four other supplies (two springs and two wells) have been identified outside the 450-foot limit. The depths of the two verified water wells were 124 and 250 feet.

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

INADVERTENT RETURNS DISCUSSION

An HDD has not been initiated at this location.

Sunoco Pipeline, L.P. (SPLP) HDD consultants reviewed the HDD design and geotechnical data for this area and determined that the risk of IRs to the waters and wetlands overlying the HDD could be reduced by increasing the depth of the HDD. The revised profile is anticipated to be installed into more competent shale, sandstone, and mudstone with tighter fractures and better rock quality designations (RQDs), thus reducing the risk of IRs.

The results of the new geotechnical core borings at the entry and exit points show the revised HDD profile will encounter and transition through shale and mudstone in the east portion and mudstone and sandstone in the west portion. Overall rock quality parameters improve as depth below ground increases. The west core data show mudstone at top of bedrock with a recovery value of 96, and RQD value of 42, improving as depth increases with recovery values consistently at 96-100 and RQD values ranging from 70-95. At maximum profile depth the recovery value is 100 and RQD value is 89. This is indicative of moderate to good overall rock integrity and strength at profile depth. The east core data shows the top of bedrock as limestone with a recovery value of 58 and RQD value of 58. Proceeding to profile depth the HDD will enter and progress through primarily mudstone with recovery values consistently at 100, and RQD values ranging from 73 to 100. At maximum profile depth the recovery value is 100 and RQD value is 93, indicative of moderate to good overall rock integrity and strength at profile depth.

At maximum depth of profile, the geotechnical data is indicative of good overall rock quality, which assists in suppression of IRs. As such, the revised profiles present a reduced risk of creating an IR.

ADJACENT FEATURES ANALYSIS

This HDD location is approximately 1.2 miles northwest of Vinco, Pennsylvania. This location is set primarily within a rural area, with both agricultural lands and forest land prevalent. The HDD would cross under two streams and three wetlands. The crossing of streams S-N41 and S-N42 is located

approximately 70 feet southeast and 155 feet northwest, respectively, of Goldfinch Lane from approximately 640 feet south of the intersection of Goldfinch Lane with Benshoff Hill Road. The crossing of wetlands N27 and N26 are located west of Goldfinch Lane. The crossing of Wetland N25 is located east of Goldfinch Lane.

SPLP has identified all landowners with property located within 450 ft of the HDD alignment. There are six (6) individual landowners with properties located within 450 ft of the HDD alignment. SPLP sent each of these landowners a notice letter via both certified and first class mail on October 30, 2017, that included an offer to sample the landowner's private water supply/well in accordance with the terms of the Order and the Water Supply Assessment, Preparedness, Prevention and Contingency Plan. The letter also requested that each landowner contact the Right-of-Way agent for the local area and provide SPLP with information regarding: (1) whether the landowner has a well; (2) where that well is located, and its depth and size if known; and (3) whether the landowner would like to have the well sampled. In accordance with paragraph 10 of the Order, copies of the certified mail receipts for the letters sent to landowners have been provided to Karyn Yordy, Executive Assistant, Office of Programs at the Department's Central Office.

A review of water supplies on properties within 450 ft of the HDD profiles has been completed. To date, one private water supply, a spring, occurs at 77 ft north of the approximate middle of the HDD profiles. A water supply illustration is provided in Attachment 2

Prior to the start of these HDDs, SPLP will contact this water supply owner to discuss the potential effects of the HDD to this water supply, and offer temporary water supply during the construction activity. If post-construction, impacts to this water supply attributable to pipeline construction are observed, then SPLP will provide for replacement water supply service until the water supply from this spring returns to pre-construction conditions.

ALTERNATIVES ANALYSIS

As required by the Order, the reanalysis of S2-0069 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 a number of 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.

Open-cut Analysis

Conversion to open cut would result in direct but temporary impacts to streams and wetlands. Streams S-N41 and S-N42 drain to PADEP Chapter 93 High Quality Coldwater Fisheries (HQ-CWF) and coldwater fisheries (CWF), respectively. Streams S-N41 and S-N42 both drain to a Pennsylvania Fish and Boat Commission (PAFBC) approved trout water (ATW) and stocked trout stream (STS). Wetland N25 is comprised of palustrine scrub-shrub (PSS) wetlands. Wetland N26 is partially comprised of PSS

wetlands. Wetlands N26 and N27 are palustrine emergent (PEM) wetlands. SPLP specifications require a minimum of 48-inches of cover over the installed pipeline beneath the bottom of the watercourse. To meet this cover requirement, during construction through all affected aquatic resources (streams S-N41 and S-N42 and wetlands N25, N26, and N27), an open cut workspace with a width of 75 feet would be required to accommodate pipeline and provide sufficient space for trench excavation, spoil storage, and allowing the pipeline to be installed with sufficient separation from the existing 8" pipeline for integrity management.

The assessed area of impact by this open cut plan would directly affect approximately 0.659 acres of wetland, with 0.444 acres of PSS disturbance, which would require on-site replanting or off-site mitigation. The change would also effect 0.006 acres of stream bed and 0.250 acres of PADEP-regulated floodway. Both affected streams have an intermittent flow regime and are tributary to PAFBC-designated waters that are suitable quality for stocking trout. One of the streams is a PADEP Chapter 93 designed High Quality Cold Water Fishery. If water was present during construction, to make this conventional crossing would require damming the stream using an upstream and downstream geotube, while simultaneously pumping around all stream flows, and pumping out of all produced groundwater discharge from the excavated shallow soil horizons and water seepage below the geotube dams installed in the channel for the entire duration of the open cut crossing event.

A conventional auger bore cannot replace this HDD due the length limitations of this technology and change in elevation across its length. When considering the use of conventional auger bore to replace portions of this HDD, Goldfinch Lane, streams N41 and N42, and wetlands N25 and N26 occur together geographically and are subset below the surrounding topography. To bore these features in a single bore, would require excavating a pit greater than 50 ft deep on the east side of Goldfinch Lane, wetland N25, and stream N41. This depth requirement is unsafe without mining a substantial area around the pit to ensure safe slope and worker conditions, and a receiving pit would have to be excavated through wetland N27 greater than 50 ft in depth and then back sloped for worker safety. In summary, no direct effects to these resources can be avoided by conventional auger bore due to the entry pit, and exit/pull back pit required to employ this construction method.

Re-Route Analysis

In accordance with state and federal guidance, SPLP has routed the Project to be co-located with existing pipeline and other utility corridors to avoid new "greenfield" routing alignments, to the maximum extent practicable. This avoids and minimizes new and permanent impacts on previously undisturbed land, land use encumbrance, and site-specific and cumulative impacts on land, environmental, and community resources. Moreover, SPLP's experience on previous crossings has demonstrated that the resource can be restored successfully from temporary construction impacts when existing utility corridors are used. The Goldfinch Lane Crossing HDD is co-located with the existing SPLP 8" pipeline which was installed by conventional construction methods. Rerouting away from the exiting easement would cause new greenfield impacts or expansion of other existing alternative corridors.

An existing electrical transmission corridor occurs 0.4 miles south of the SPLP easement. This easement does not intersect, originate, or proceed in the general direction of the existing SPLP easement and therefore is not a viable alternate to this HDD.

Two (2) existing utility corridors occur north of this HDD at 1.0 miles and 1.5 miles north respectively. The most northern corridor does not intersect, originate, or proceed in the general direction of the SPLP easement and is therefore not a viable alternative to this HDD. The second corridor at 1.0 miles north intersects the existing SPLP route 3.9 miles to the west, and re-intersects the SPLP route 3.7 miles to the east and as such presents a viable 7.4 mile long alternative route for consideration to the current HDD location. Review of topographic maps and aerial photography reveals that this route would not result in a decrease in total number of streams crossed for equivalent miles of route. At minimum, 1,800 foot of

wetland occurs on this route, and this route crosses through the middle of a high density residential area on the east side of William Penn Road, approximately 1.4 miles north of SPLP's crossing point. Due to the presence of the natural resources and residential occurrences, this potential alternative does not present any advantage over the current route and HDD location.

RECONSIDERATION OF THE HORIZONTAL DIRECTIONAL DRILL

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

Revised Horizontal Directional Drill Design Summary: 20-inch

- Horizontal length: 1,545 foot (ft)
- Entry/Exit angle: 15-16 degrees
- Maximum Depth of cover: 60 ft
- Depth under Goldfinch Lane: 39 ft
- Depth under streams: 34-48 ft
- Depth under wetlands: 34-50 ft
- Pipe design radius: 2,000 ft

Revised Horizontal Directional Drill Design Summary: 16-inch

- Horizontal length: 1,570 foot (ft)
- Entry/Exit angle: 15 degrees
- Maximum Depth of cover: 67 ft
- Depth under Goldfinch Lane: 59 ft
- Depth under streams: 52-67 ft
- Depth under wetlands: 52-70 ft
- Pipe design radius: 1,600 ft

As shown on Figure 2, the redesigned HDD profile for the 20-inch pipeline is 237 ft longer, with a depth of cover below the streams and wetlands increased by 25-30 ft from the permitted design. In addition, the entry/exit angles have been increased allowing for a sharper and quicker descent into more competent rock. As shown on Figure 4 the redesigned HDD profile for the 16-inch pipeline is 99 ft longer, with a depth of cover below the streams and wetlands increased by 19-21 ft and designed for a sharp and quick entry and exit from the horizontal depth.

The redesign of the HDD will not prevent all IRs. IRs are common on entry and exit of the drilling tool and other measures are required to minimize IR potential. In particular, upon the start of these HDDs, Sunoco 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 IRs, and potential zones of fracture concentration identified by the fracture trace analysis along the drill path, so that monitoring can be enhanced when drilling through these locations;

- SPLP will require and enforce the use of annular pressure monitoring during the drilling of the pilot holes, which assists in immediate identification of pressure changes indicative of loss of return flows or over pressurization of the annulus to manage development of pressures that can induce an IR;

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

- SPLP will implement short-tripping of the reaming tools as return flow monitoring indicates to ensure an open annulus is maintained to manage the potential inducement of IRs;

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

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

- If LCMs prove ineffective to mitigate loss of returns or IRs, then grouting may be implemented, and

- If necessary, the pilot hole and reaming phases of the HDD may utilize casing, hammered into the substrate down to structurally better rock, to prevent lateral movement of drilling fluids.

CONCLUSION

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

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ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT

HDD HYDROGEOLOGIC REEVALUATION REPORT

Mariner East II
Spread 2
HDD S2-0069
Goldfinch Lane
Jackson Township, Cambria County, Pennsylvania

Prepared for:

Sunoco Pipeline, L.P.

Prepared by:

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

January 2018

HDD HYDROGEOLOGIC REEVALUTION REPORT

Mariner East II
Spread 2
HDD S2-0069
Goldfinch Land
Jackson Township, Cambria County, Pennsylvania

January 2018

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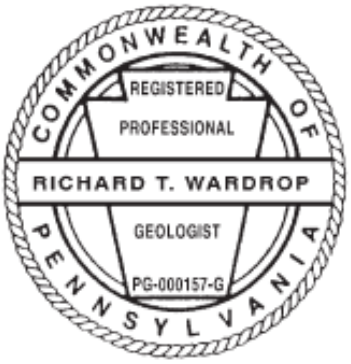
By affixing my seal to this document, I am certifying that the information is true and correct. I further certify I am licensed to practice in the Commonwealth of Pennsylvania and that it is within my professional expertise to verify the correctness of the information.



January 25, 2018

Richard T. Wardrop, P. G. — date

Lic. No. PG000157G

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TABLES

Table 1. Local Water Supply Information

ATTACHMENTS

Attachment A. Original and Revised Plan and Profile
Attachment B. Geotechnical Report

1.0 INTRODUCTION

Sunoco Pipeline, L.P., (SPLP) retained Groundwater & Environmental Services, Inc. (GES) to prepare HDD Hydrogeologic Reevaluation Reports (HRRs) 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 S2-0069 and HDD S2-0069-16 (the 20-inch and 16-inch HDDs for this location, respectively), hereinafter collectively referred to as HDD S2-0069. The planned alignment for HDD S2-0069 is located between Benson Hill Road and William Penn Ave (Route 271) in Jackson Township, Cambria County, Pennsylvania.

The discussion presented in this report is based on an alignment and profiles developed by Tetra Tech/Rooney, revised on March 17, 2017 (original profile). GES has also been provided proposed alternative profiles for HDD S2-0069 (revised profiles) (see **Attachment A**). The revised profiles, prepared by Tetra Tech/Rooney show revision dates of on September 21, 2017, for the 20-inch profile and October 30, 2017, for the 16-inch profile. The western entry/exit points remained the same, from original to revised, for both profiles. The 20-inch HDD profile was extended by moving the eastern entry/exit point 220 feet east onto higher ground. The 16-inch HDD profile was extended by moving the eastern entry/exit point 245 feet east onto higher ground. The purpose of extending the HDDs is to minimize the risk of IRs by installing the pipes deeper into competent bedrock. For the 20-inch pipe, the low elevation of the profile did not change from original to revised and was maintained at 1,679 feet above mean sea level (ft amsl). However, the pipe curvature was changed to increase depth of overburden below water features. For the 16-inch pipe, the low elevation of the profile was deepened 20 feet from 1,679 ft amsl to 1,659 ft amsl allowing for larger overburden thicknesses under water features. For the purpose of this assessment, GES utilized both HDD originals to evaluate the hydrogeologic conditions at HDD S2-0069.

A map depicting the location of the HDD with topographic information for the surrounding area is presented as **Figure 1**.

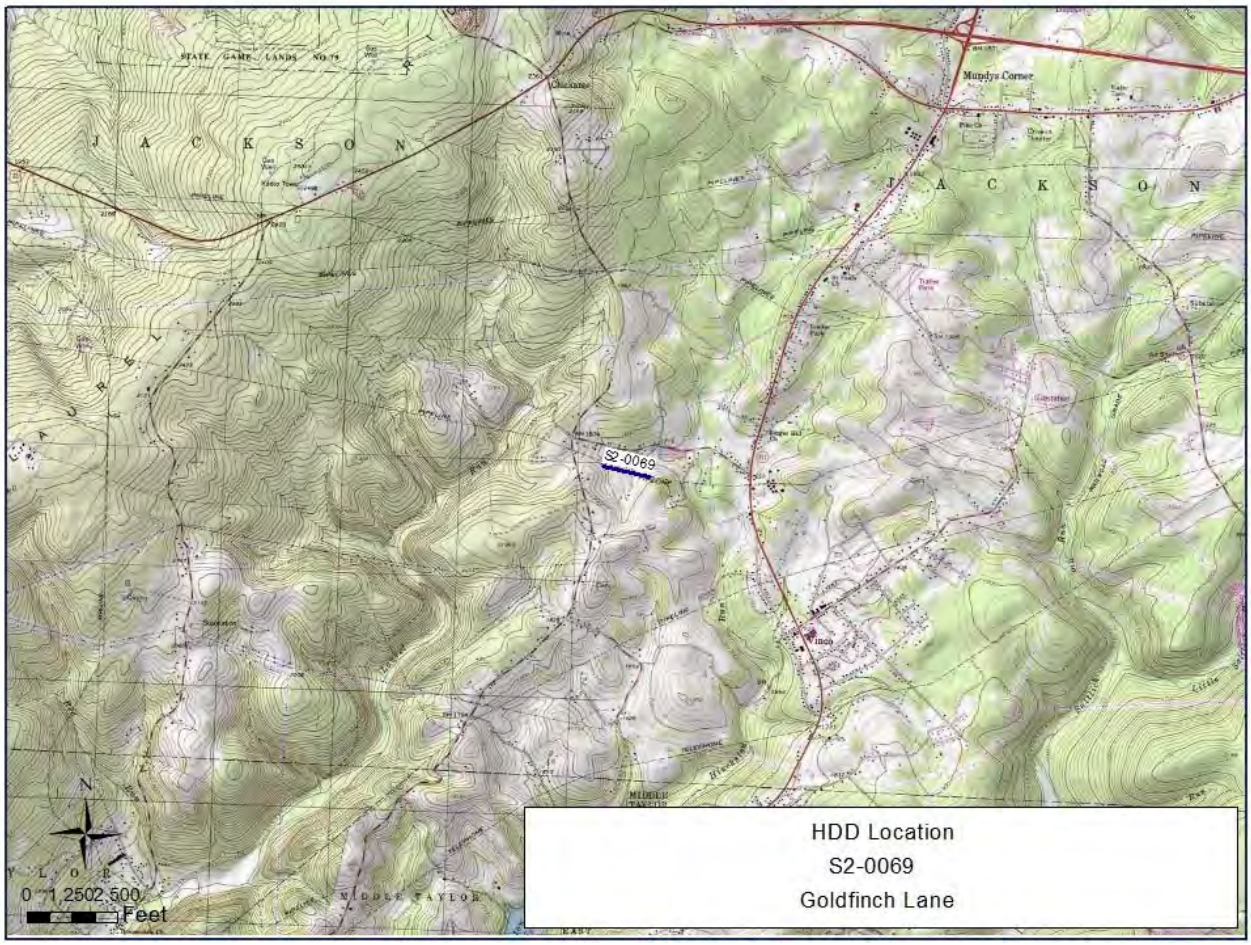

Figure 1. Site Location Map (modified from USGS Nanty Glo 1:24,000 Topo. Quad., rev. 1982)

This report presents the following information:

- Geologic and hydrogeologic characteristics in the area of HDD S2-0069;
- 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. Site geotechnical boring programs were conducted by Tetra Tech in April 2015, and more recently by Terracon Consultants, Inc. (Terracon) in August 2017, in support of the HDD S2-0069 reevaluation. Please note that GES did not oversee or direct either geotechnical drilling 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 the two SPLP contractors. GES relied on these reports and incorporated their data into the general geologic and hydrogeologic framework for this hydrogeologic reevaluation report.

2.0 HDD GEOLOGY / HYDROGEOLOGY

2.1 Physiography

HDD S2-0069 is located within the Allegheny Mountain section of the Appalachian Physiographic Province, which consists of wide ridges separated by broad valleys and ridge elevations decreasing to the northwest. Local relief between valley floors and the ridges typically range from 200 to 300 feet. The Conemaugh River is the only major stream draining Cambria County; the southern half of Cambria County is drained by tributaries of the Conemaugh River.

2.1.1 Topography

The topography along HDD S2-0069 consists of rolling hills with moderate relief and flat areas adjacent to local water features. The original profile is a concave bore on the eastern and western ends with a straight run at the base of the bore for both the 16- and 20-inch pipelines. The surface elevations at the western entry/exit of the 20-inch pipeline and the 16-inch pipeline (N40.416839 / W78.875656) are 1,805 and 1,806 ft amsl, respectively. Surface topography gradually declines in an easterly direction to 1,710 ft amsl at stream S-N41, then increases to a surface elevation of 1,757 ft amsl at the eastern entry/exit for the 20-inch pipeline. The surface elevation at the eastern entry/exit for the 16-inch pipeline is 1,750 ft amsl. The overall length of HDD S2-0069 on the original profiles are 1,325 feet for the 20-inch and 1,330 feet for the 16-inch.

The revised profile is the same general shape as the original profile, but the overall length is increased to 1,545 feet for the 20-inch pipeline and 1,570 feet for the 16-inch pipeline. The western entry/exit locations for the revised HDD S2-0069 profiles are the same as the original profiles. On the revised HDD S2-0069 profiles, the surface elevations at the eastern entry/exit of the 20-inch pipeline and the 16-inch pipeline are 1,789 and 1,787 ft amsl, respectively.

The surrounding area is comprised of rural, residential and agricultural properties. The site location is depicted on **Figure 1**.

2.1.2 Hydrology

The nearest surface water bodies to the HDD S2-0069 location include streams S-N42 (which crosses the drill path at 6+90 on the original profile) and S-N41 (which crosses the drill path at 9+33). These streams are tributary to Hinckston Run that runs south to the Hinckston Run Reservoir, approximately 2 miles south of HDD S2-0069. Wetlands that cross the drill path include W-N27, W-N26 and W-N25. The original profile has the eastern entry/exit at 390 feet east of stream S-N41 and both the 16- and 20-inch pipelines will cross 29 feet below it. The revised HDD S2-0069 profile has the eastern entry/exit at 612 feet east of stream S-N41 and the 20-inch pipeline will cross 34 feet below, whereas the eastern entry/exit for the 16-inch pipeline is 637 feet east of stream S-N41 and will cross 52 feet below.

2.2 Geology

2.2.1 Soils

Based on information obtained from the National Resource Conservation Service Web Soil Survey database (USDA NRCS Web Soil Survey for Cambria County [http:\\websoilsurvey.nrcs.usda.gov]), soils along the path of HDD S2-0069 can range from 2.5 to 6 feet thick. Overburden is primarily composed of poorly to well drained fine-loamy colluvium and residuum from weathered siltstone, sandstone, and shale. These soils are moderately to well-drained and groundwater is reported to be at 1.5 to greater than 7 feet below ground surface (ft bgs).

Descriptions on soil boring logs SB-01 and SB-02 provided by Tetra Tech (**Attachment B**) report soils consisting of low-plasticity clay (CL) and sand with some silty clay (SC).

2.2.2 Bedrock Lithology

Bedrock underlying the area of HDD S2-0069 belongs to the Pennsylvanian age Glenshaw Formation, part of the Conemaugh Group. It primarily consists of thinly bedded, fossiliferous marine limestone and clay, shale; red claystone; locally massive, fine- to coarse-grained sandstone; minor amounts of freshwater limestone, and thin coal (McElroy, 1998). The base of the Glenshaw Formation is at the top of the Upper Freeport coal, which is part of the Allegheny Group, immediately below the Conemaugh Group. Bedrock underlying the area immediately south of the western end of the HDD S2-0069 is the Pennsylvanian age Casselman Formation, also part of the Conemaugh Group. The Casselman Formation consists of thin-bedded claystone and siltstone; locally massive, fine- to medium-grained sandstone; freshwater limestone; and thin non-persistent coal (McElroy, 1998). **Figure 2** is a map depicting site bedrock geology for the area surrounding HDD S2-0069 (McElroy, 1998). The red structure contours are associated with the base of the Lower Kittanning Coal (Allegheny Group).

The overburden beneath HDD S2-0069 ranges from 15 to 30 feet thick based on test borings SB-01 and SB-02 and nearby water well drilling logs and is primarily composed of brown and light gray silty clay with fine sand and trace gravel. Light brown and gray fine sand with some silty clay was also present above weathered bedrock. Weathered bedrock consisted of light brown and gray sandstone and shale.

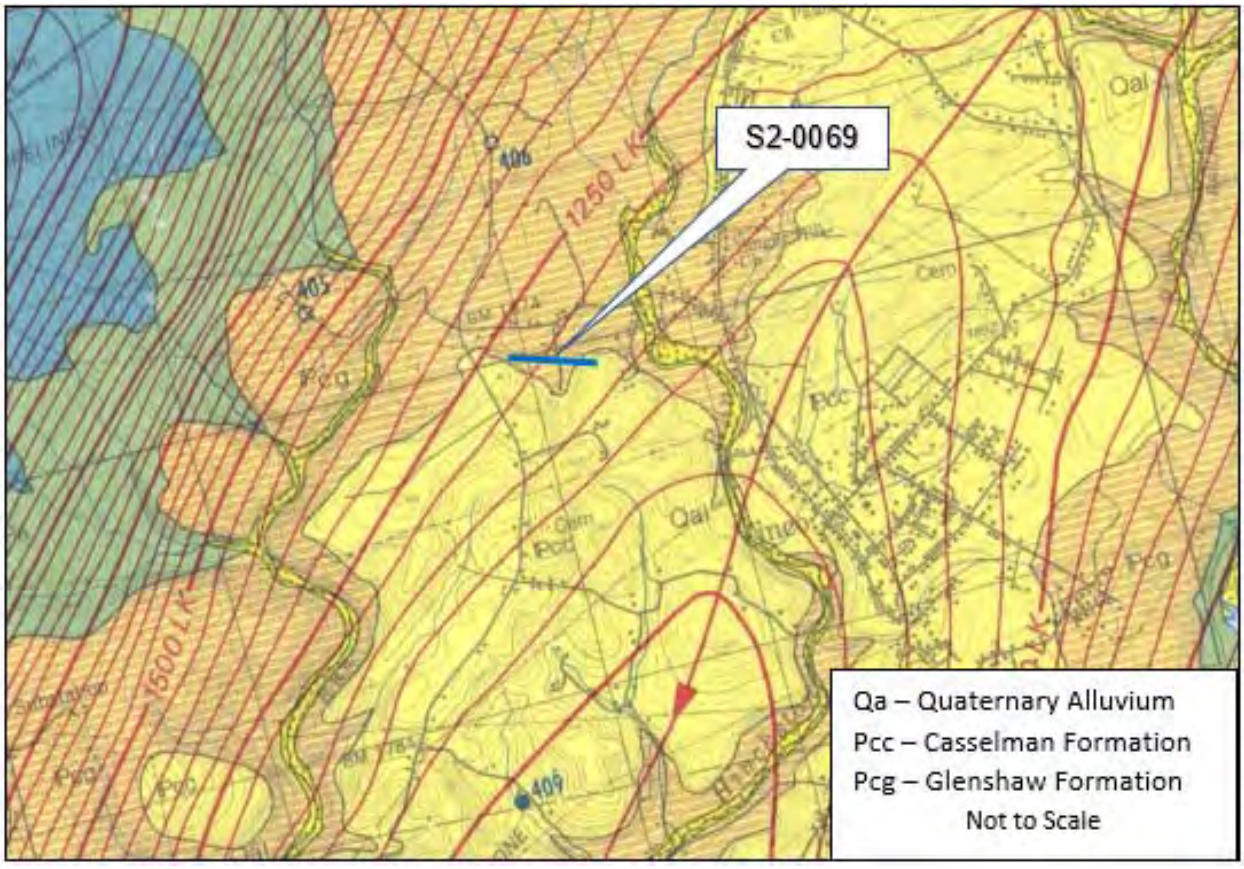

Figure 2. Site Geology Map and Structure Contour Map of the Lower Kittanning Coal
(modified from McElroy, 1998)

2.2.3 Structure

McElroy (1998) provides structure contour maps for persistent coal beds in Cambria County. Structurally, the HDD S2-0069 drill path is located on the western flank of the Johnstown syncline. The axial plane

trace of the Johnstown syncline is located just east of the eastern end of HDD S2-0069 and plunges to the south-southwest at a gradient of 0.015 feet/foot in the vicinity of the drill path. The amplitude of folds in the Allegheny Mountain section are typically 2,000 feet with bedrock dipping at approximately 7.5 degrees (McElroy, 1998). **Figure 2** shows the HDD S2-0069 location on the structure contour map.

Discontinuities in the form of joints and faults are imprinted in the broadly folded bedrock in the region. These fractures can act as conduits for groundwater movement and/or represent areas of weakness in the rock. Fold axes can be areas of increased density of fracturing (McElroy, 1998). Nickelsen and Hough (1967) conducted regional mapping of joints in shale, coal and sandstone in the Appalachian Plateau. In the vicinity of HDD S2-0069, two systematic joint sets were mapped with approximate trends of west-northwest and northwest. Less frequent non-systematic joints were mapped approximately orthogonal to the systematic joints.

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) are the surficial expression on natural landscapes of 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 a fracture trace map prepared for this reevaluation. This mapping was performed using aerial stereographic pairs flown in the spring of 1939. As such, much of the land surface appears undeveloped providing an unobstructed view of fracture traces. Four general orientations are present in the set of fracture traces. One of the orientations generally matches the northwest-trending, systematic joint set mapped by Nickelsen and Hough (1967). The majority of the fracture traces mapped in this area are perpendicular to this set, trending northeast (non-systematic joint set). A third pattern is generally oriented north to south and a fourth orientation is east-northeast.

The proposed path of the revised profile is shown in red on **Figure 3** and transects four of the mapped fracture traces. Two of these traces intersect at the approximate location of the drill path at both ends and two cross in the middle of the profile Fracture trace intersections can be areas of enhanced groundwater production and associated weakness in the bedrock.

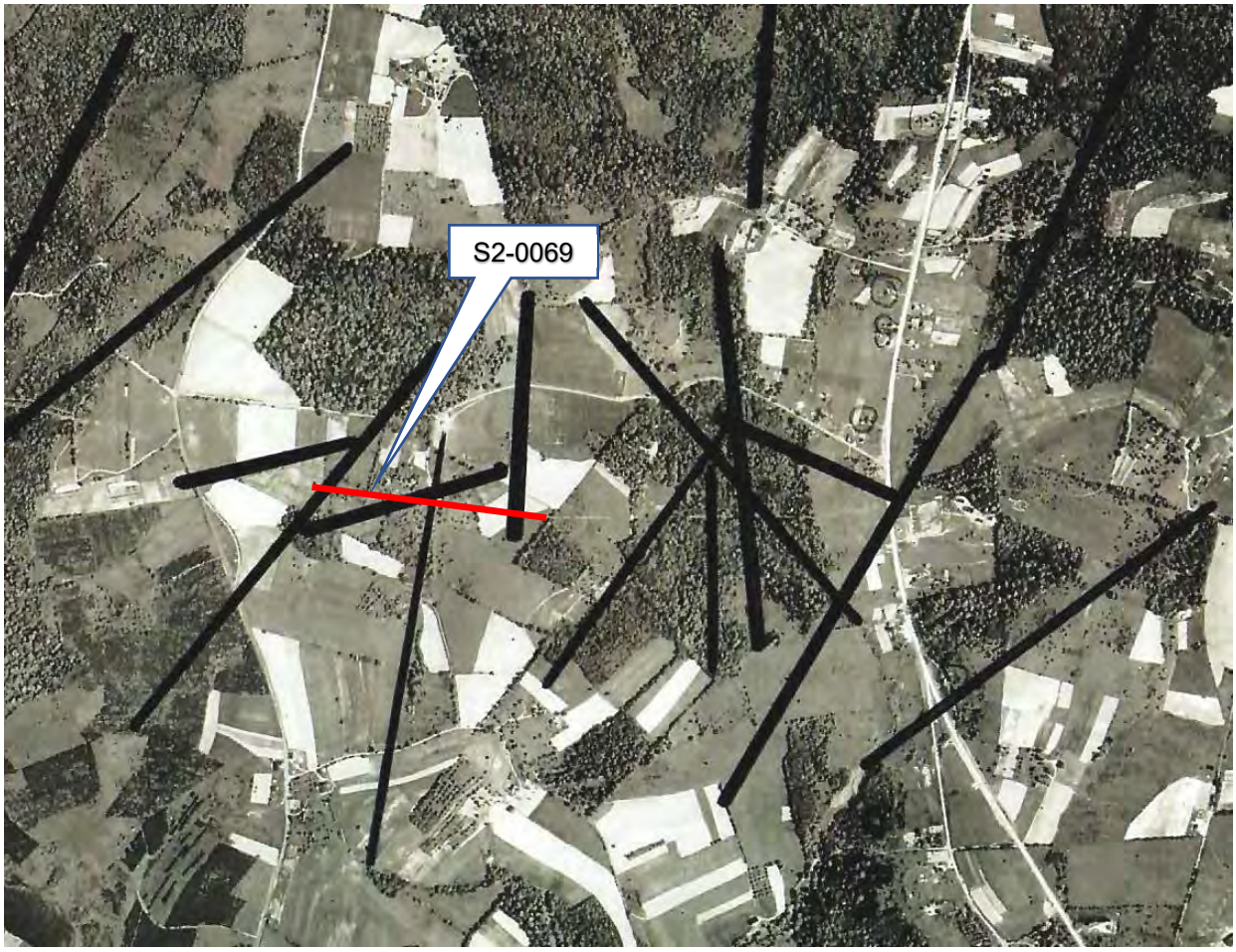

Figure 3. Fracture Trace Map

2.2.5 Karst

Based on published geologic data, no karst features are anticipated within the LOD of HDD S2-0069. Limestone was observed in geotechnical boring B2-2E, east of the eastern entry/exit point along the original profile. However, karst conditions are not anticipated because limestone within the Glenshaw Formation is moderately resistant to weathering. The observed limestone unit is 14-feet thick with primary jointing slightly to moderately open.

2.2.6 Mining

Although coal mining has been extensive in this region, a review of published mining and geological data indicate that no documented mining has occurred within the LOD of HDD S2-0069. Glover (1990) shows the limit of deep Lower Kittanning coal mining approximately 175 feet from HDD S2-0069 to the north, at its closest point near the western entry/exit (see **Figure 4)**. The absence of deep mining was confirmed by searches using the Pennsylvania Mine Map Atlas web site (http://www.minemaps.psu.edu/) for abandoned mines and PADEP eMapPA for web site (http://www.depgis.state.pa.us/emappa/) for current mine permitting and by visiting DEP's District Mining Office in California, PA.

Figure 4 shows a portion of the mine map for the Mine 31-B Seam and approximate position of the revised 20-inch line profile for HDD S2-0069. The lowest elevation on the revised profile for the 16-inch line is 1,659 ft amsl, 20 feet below the lowest elevation for the revised 20-inch profile. The highest estimated elevation of the mine roof, at the southern edge of the mine, proximal to the HDD, is 1,239 ft amsl.

Therefore, in a vertical sense, at a minimum, the mine roof is separated from the 16-inch profile by a distance of 420 feet.

An assessment of subsidence potential was performed by projecting a 35-degree angle of draw from the southern limit of mining and the estimated elevation of the top of the mine void at that location. Projecting upward and south, an estimate of the limit of subsidence potential in map view was derived (see **Figure 4**).

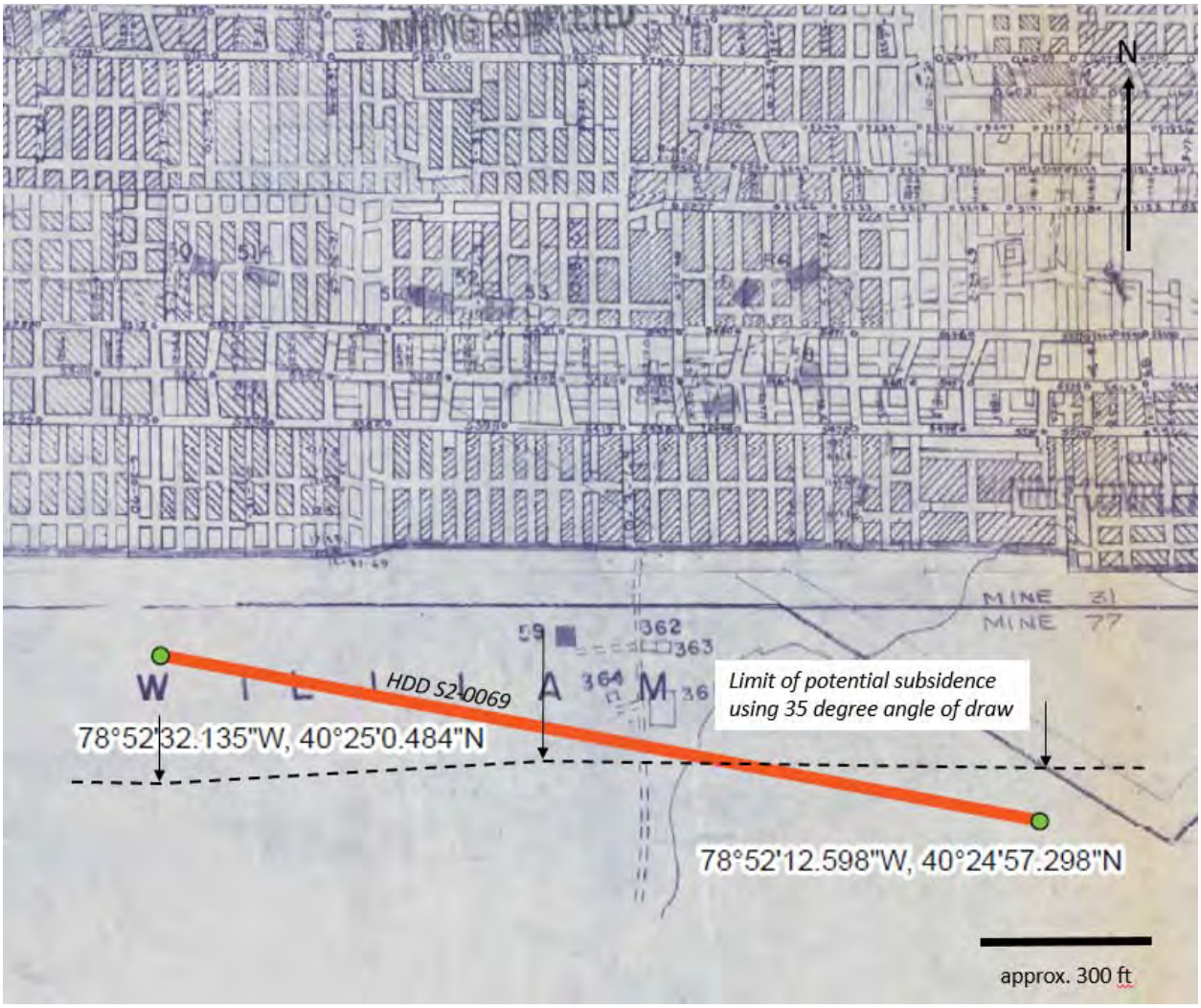

Figure 4. Limits of Lower Kittanning Coal (B) Seam, Mine 31 and potential subsidence.
(modified from base map provided by PADEP, 2017)

As shown, more than half of the planned alignment is inside (north of) the limit of potential subsidence using a 35-degree angle of draw. The line is not straight because the limit was estimated at three points along the profile and there were different estimates of cover above the mine void at each point. These estimates of cover were determined using the elevation of land surface over the southern limit of mine and the estimated top of mine void projected. Pipe design and pipe installation procedures should account for a degree of subsidence associated with eventual full collapse of the 4.5 foot estimated mine void space at the elevation of the HDD profiles.

2.2.7 Rock Engineering Properties

The Glenshaw Formation rock properties are as follows (Geyer and Wilshusen 1982):

- Well bedded; thick to massive sandstone, well bedded to nodular limestone, thin and fissile shale, and very poor bedded claystone.
- Joints are poorly to moderately well formed; open and vertical; closely to moderately spaced; and moderate distribution.
- Sandstone, siltstone, and limestone are moderately resistant to weathering, whereas claystone, shale, and coal weather extensively and deeply.
- Fast to moderate drilling rate.

The Casselman Formation rock properties are as follows (Geyer and Wilshusen, 1982):

- Well-bedded; sandstone is thick bedded to massive; shale is thin and fissile; claystone bedding is very poor; limestone varies from nodular to well-bedded.
- Poor to moderately well-formed joints; open and vertical; moderately spaced and distributed.
- Moderate to Fast drilling rate.

2.2.8 Results of Geotechnical Borings

Two geotechnical borings (SB-01 and SB-02) were installed in May 2015 as part of the original profile to depths of 28.1 ft bgs and 30.0 ft bgs, respectively. Boring SB-01 is located at Station 0+51 of the original profile plan with a surface elevation of approximately 1,791 ft amsl. Boring SB-02 is located at Station 13+10 with a surface elevation of approximately 1,740 ft amsl. In August 2017, two additional borings, B2-2E and B2-2W were installed as part of the revised profile to depths of 128.5 and 177 ft bgs, respectively. Boring B2-2E is located at Station 13+25 of the original profile with a surface elevation of 1,757 ft amsl. Boring B2-2W is located at Station 0+00 of the original profile with a surface elevation of approximately 1,802 ft amsl.

Sandstone bedrock was encountered in SB-01 at a depth of 28 ft bgs beneath a 6.5-foot layer of sandy clay and a 21.5-ft layer of silts and clays. Shale bedrock was encountered in SB-02 at a depth of 28.5 ft bgs beneath a 5-foot layer of sandy clay beneath a 23.5 ft layer of silts and clays. Groundwater was encountered at 25 ft bgs at SB-02 only.

Boring B2-2E was advanced on August 8, 2017 at the eastern entry/exit location (Station 13+25, original profile) from a surface elevation of approximately 1,757 ft amsl and to a depth of 128.5 feet. This is 50 feet below the lowest elevation of the original profile. Unconsolidated overburden was comprised of predominantly weathered claystone to approximately 25 ft bgs. The top interval of competent rock was predominantly limestone. This occurred from the top of the cored bedrock (approximately 24 ft bgs) to 38.5 ft bgs. The remainder of the boring was comprised of predominantly claystone to the final depth of 128.5 feet. Thirty-five feet of shale was logged interbedded with the claystone from a depth of 53.5 to 88.8 ft bgs. A water level taken from B2-2E was recorded at 52 ft bgs.

The cored rock at B2-2E showed high bedrock core recoveries, ranging from 87 to 100 percent, RQDs ranged from 53 to 100 percent over all cores. One weaker rock zone was noted between 78.5 and 103.8 ft bgs where RQDS ranged from 68 to 73 percent. The last 15 feet of core showed variability in the RQD data ranging as low as 54 percent for the final 5-foot run. Static groundwater was measured at 52 ft bgs (1,705 ft amsl).

Boring B2-2W was advanced on August 10, 2017 at Station 0+00 from a surface elevation of 1,806 ft amsl and to a depth of 177 feet (1,629 ft amsl). This is 50 feet below the lowest elevation of the original profile. Unconsolidated overburden was comprised of clay, fill, and highly weathered black shale to 8.5 ft bgs weathered shale to 18.5 ft bgs and clay with limestone residual to 30.5 ft bgs. The cored bedrock was

comprised of variably weathered claystone, shale and sandstone. A thick sandstone interval occurred between 45.5 and 85.5 ft bgs. An accurate water level measurement was not obtained prior to abandoning the borehole; however, it is known that groundwater was greater than 100 ft bgs.

The cored rock at B2-2W showed high bedrock core recoveries, ranging from 80 to 100 percent with most measuring 100 percent. RQDs showed a high degree of variability within the upper bedrock to a depth of 40.5 feet, ranging from 7 to 85 percent. Beyond 40.5 to the total depth of the boring at 177 ft bgs RQD values were mostly high, ranging from 83 to 100 percent. A zone of lower RQDs was observed from 90.5 to 105.5 in shale and claystone ranging from 60 to 70 percent.

2.3 Hydrogeology

In general, groundwater flow proximal to HDD S2-0069 moves along gradients established by a water table surface that is a subdued reflection of the local topography. The alignment of the S2-0069 HDD passes west-northwest to east-southeast perpendicular to the axis of a shallow valley with entry/exit points on the valley walls and the HDD passing under the valley bottom. Groundwater flow across the alignment is predicted to be easterly coming off the west valley slope, westerly coming off the east valley slope and northerly across the central portion of the alignment after flow lines converge from the west and east. The valley holds headwater tributaries to Hinckston Run (S-N41 and S-N42) and wetlands W-N25, W-N26, and W-N27. The lowest surface elevation along the profile is at approximately 1720 ft amsl at stream S-N41. Compared to the surface elevation of Hinckston Run across HDD S2-0070 to the east, N-41 stands approximately 75 feet higher. The density of stream channels and wetlands indicates the drill may pass through a local groundwater discharge zone.

2.3.1 Occurrence of Groundwater

Groundwater in Cambria County is in aquifers comprised of both the unconsolidated sediments and bedrock, and can also occurs as a perched water table. In the bedrock, groundwater occurs and flows primarily in fractures and bedding-plane partings creating an interconnected network of secondary porosity features. The type of lithology and the number and extent of fractures and interconnections influence the flow rate and direction of flow. In general, the depth range for water-bearing zones in the Casselman and Glenshaw Formations is from 0 to 250 feet.

Based on data contained in the geotechnical borings for HDD S2-0069, groundwater was not detected in the HDD S2-0069 SB-1 boring but was detected at a depth of 25 feet in SB-2 (above bedrock), and at 100 ft bgs in B2-2W and 52 ft bgs in B2-2E. Low-angle/horizontal joints were observed parallel to bedding with clay in-filling throughout the latter two cores. High-angle, vertical joints and highly weathered zones were observed throughout the B2-2E core in the limestone, claystone, and shale from 43.5 to 101 ft bgs. These joints, fractures, and weathered zones may represent preferred pathways for groundwater flow.

2.3.2 Ground Elevation between HDD entry/exits

The surface elevation of the eastern entry/exit in the original profile for the 20-inch pipeline is 1,757 ft amsl and the elevation of the western exit/entry is 1,805 ft amsl, with a profile bottom elevation of 1,679 ft amsl. The revised profile for the 20-inch pipeline has the same western entry/exit surface elevation and bottom elevation as the original profile, but the eastern entry/exit surface elevation is 1,789 ft amsl.

The surface elevation of the eastern entry/exit in the original profile for the 16-inch pipeline is 1,750 ft amsl and the elevation of the western exit/entry is 1,806 ft amsl, with a profile bottom elevation of 1,679 ft amsl. The revised profile for the 16-inch pipeline has the same western entry/exit surface elevation, but the eastern entry/exit surface elevation is 1,787 ft amsl and the bottom elevation is 1,659 ft amsl.

2.3.3 Water Level

Groundwater was encountered at 25 ft bgs in boring SB-02, installed at Station 13+10. Static groundwater was measured at 100 ft bgs in boring B2-2W at Station 0+00 and at 52 ft bgs in boring B2-2E at Station 13+25.

The Pennsylvania Groundwater Information System (PaGWIS) identified four domestic supply wells within 1,000 feet of the HDD alignment. For these four wells the well depths ranged from 75 to 125 feet. Initial water level measurements were available for two of the wells with values of 60 and 88 feet deep.

2.3.4 Well Yields

Published median well yields (Geyer and Wilshusen 1982) are highly variable depending on local effective porosity in the Conemaugh Group and have ranged from 1 to 357 gpm. McElroy (1998) notes that median yield of wells drilled into the Glenshaw Formation is 12 gpm with a range from 0 to 30 gpm and median yield of wells drilled into the Casselman formation is 10 gpm with a range from 0 to 32 gpm. Based on the results of a PaGWIS database search, yields from wells drilled into the Glenshaw Formation and within 1,000 feet of HDD S2-0069 range from 8 to 15 gpm. The well yields reported for the four wells described in Section 2.3.3 ranged from 8 to 15 gpm.

2.3.5 450-foot Water Supply Survey

SPLP performed a pre-construction survey of landowners within 450 feet of the ROW at HDD-S2-0069. The results being reported here are current as of 1/22/18 and as of that date one water supply, a spring, has been identified within the 450-foot survey limit. Four other supplies (two springs and two wells) have been identified outside the 450-foot limit. Information associated with each identified water supply is listed on Table 1. The depths of the two water wells were 124 and 250 feet.

Table 1. Local Water Supply Information

GES Well ID	Distance to HDD Perpindicular (Feet)	Distance to HDD Entry/Exit (Feet)	Well Information		
			Reported DTB (Feet)	Reported DTW (Feet)	Reported Pump Depth
SP-03072017-520-01	77	602	NA	NA	NA
SP-11142017-614-02	880	897	NA	NA	NA
SP-11092017-634-02	803	977	NA	NA	NA
WL-11062017-614-01	480	480	124	Unknown	Unknown
WL-11132017-636-01	589	589	250	Unknown	Unknown

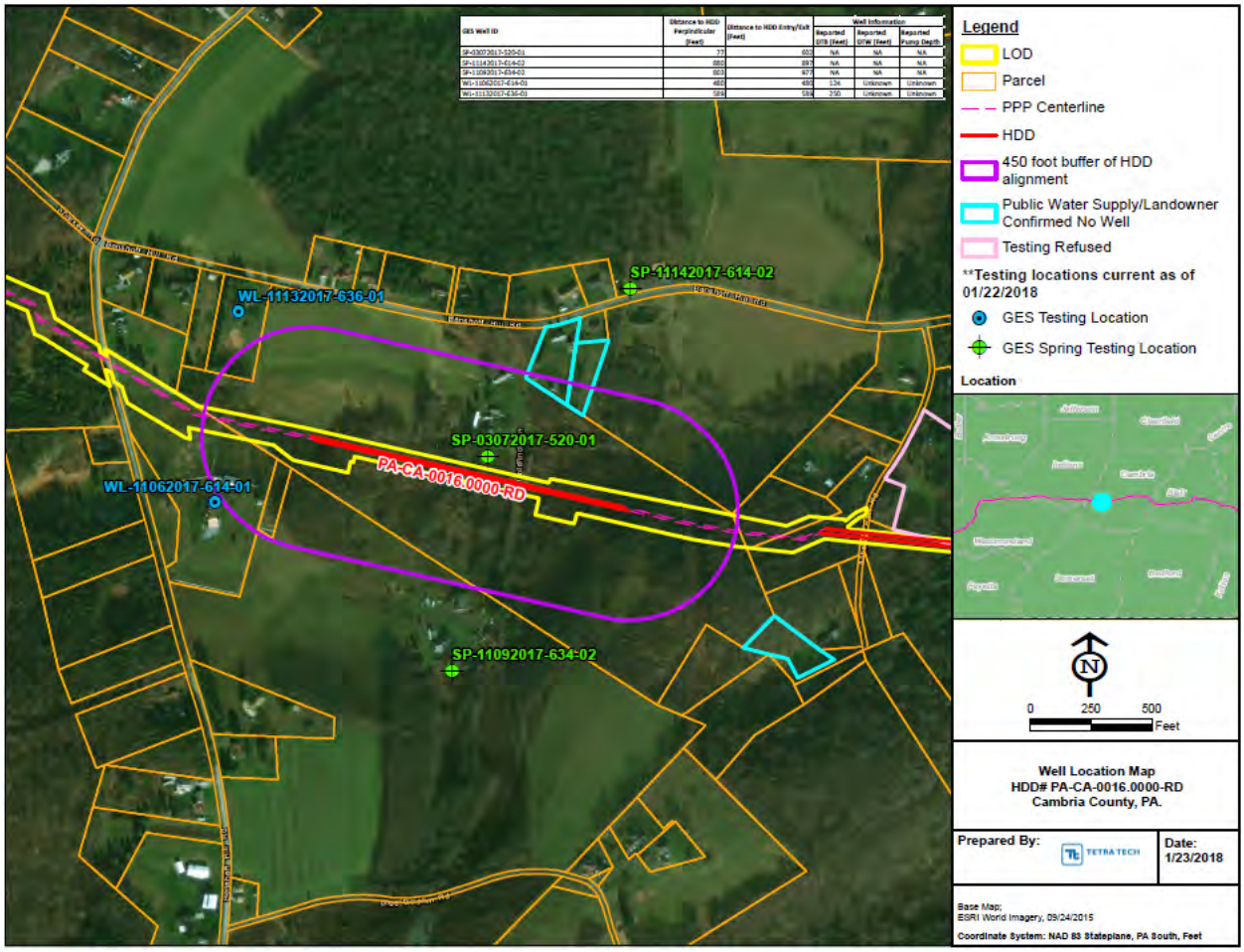

Figure 5. Preconstruction Groundwater Supply Sampling Locations.

2.3.6 Mine Pools

Water filled sections of local abandoned coal mines, or mine pools, act as groundwater sinks in the region. According to PADEP, mine pools are known to exist within Mine 31, north of the proposed HDD (see Figure 4) and south and east of the HDD in Mine 72 and Mine 77, respectively. HDD installation procedures need to account for any adverse effects a large volume loss of drilling fluid return (LOR) would have from raising the water level in local and regional mine pools. Raising the mine pool level could cause higher than normal flow from known mine pool discharges or the appearance of a new mine discharge point. However, the risk of an adverse effect on a mine pool is small at this location as the HDD does not overly any mine and current loss of return procedures call for suspension of drilling and determination of cause if a LOR does occur; therefore, the volume of loss would be small.

2.4 Summary of Geophysical Studies

No geophysical studies were conducted for this reevaluation as there is no indication of karst development in the area and deep mining has not been identified directly beneath the HDD alignment.

3.0 OBSERVATIONS TO DATE

3.1 On This HDD Alignment

3.1.1 ME I

No IRs were reported along the alignment of the HDD S2-0069 drill on the list of IRs for ME I documented in the IR PPC Plan for Cambria County. The existing SPLP pipeline at this location was installed by conventional construction methods.

3.1.2 ME II

No drilling activities have been initiated at HDD S2-0069 as part of the ME II pipeline installation.

3.2 On Other HDD Alignments in Similar Hydrogeologic Settings

3.2.1 ME I

No IRs were reported on the list of IRs for ME I documented in the IR PPC Plan for sites underlain by Glenshaw Formation bedrock.

3.2.2 ME II

To date, MEII pipeline installations within the Glenshaw Formation have been completed at the following HDD locations:

- S2-0016 Livermore Road – 20”
- S2-0050 Buffalo-Pittsburgh Highway (Rt. 119) – 20”
- S2-0060 Rt. 22 William Penn Highway – 20”
- S2 -0062 Wetland (Clair Road) – 20”

All of the IRs in Spreads 1 and 2 for the ME II pipeline to date have occurred while drilling through the cyclic sequences of sandstone, shale, limestone, clays seams and coal present within western Pennsylvania bedrock formations, including the Allegheny Group, Casselman Formation, Glenshaw Formation, Monongahela Group, and Waynesburg Formation. Entries and exits pass through alluvium, colluvium and soils developed on top weathered bedrock and mine spoils. In general, the IRs have been related to shallow overburden (especially under water bodies), large elevation changes between entries and exits, coarse grained unconsolidated materials near the surface (such as alluvium and mine spoil), and the interconnectivity of open bedrock structural features that is difficult to predict.

An IR occurred during the HDDS2-0016 Livermore Road – 20”. The root causes for this IR were limited overburden over the drill (38 feet) while passing under the Spruce Run flood plain along the central part of the drill and a large elevation difference between the two exit/entry points and the flood plain (approximately 77 ft and 213 ft). IRs did not occur during the other three 20-inch installations.

An IR did occur during the16-inch installation at S2-0050 Buffalo-Pittsburgh Highway (Rt. 119). The IR was related to large elevation changes between entries and exits and previously unidentified interconnected bedrock structural features. A relatively slow persistent loss of drilling fluid eventually filled the available secondary pore space along a path from the boring to the IR. This slow, persistent loss was caused by plugging at the reamer and the buildup of fluid pressure behind the reamer, within an upward sloping borehole.

4.0 SUMMARY AND CONCLUSIONS OF HDD HYDROGEOLOGIC EVALUATION

4.1 HDD Site Conceptual Model

The profile for HDD S2-0069 is relatively symmetric with entry/exits points located on elevated ground west and east of the flood plain of stream S-N41, tributaries, and associated wetlands, central to the alignment (see **Attachment A**). The central lowland area that is above most of the HDD profile is a local groundwater discharge zone; however, the water table may be deeper than stream level at S-N41 (i.e. a losing stream) and a large percentage of the drill may be above the piezometric surface for the bedrock aquifer, but below a potential perched water table in the central portion of the drill. Water level data is too scarce to verify these assumptions. On the revised plans the western entry/exit points are approximately 95 feet above S-N41 (both 20- and 16-inch pipes) and the eastern/entry points are approximately 78 feet above the stream. Based on the information provided in this reevaluation report, the revised drilling paths for HDD S2-0069 will encounter bedrock of the Glenshaw Formation throughout the majority of profile with approximately 24 to 28 feet of overburden soils proximal to the entry/exit points.

The planned borehole crosses beneath two streams and three wetland complexes. On the revised profiles the minimum depth from a water resource to the boring is approximately 34 feet along the western edge of wetland W-N27 (for both the 16-inch and 20-inch drill) and 34 feet at S-N41 (20-inch bore only). Assuming the soil depths from the geotechnical borings are representative across the profiles, the thickness of bedrock above the drills at these locations is thin, on the order of 6 to 10 feet. For the 16-inch HDD, the difference in depth of the bore between the original and revised profile in the central part of the HDD is only an increase of approximately 20 feet, from elevation 1679 to 1659 ft amsl. The bottom elevation of the 20-inch line is unchanged between the original and revised versions, at 1679 ft amsl.

The possibility of the pilot holes for HDD S2-0069 creating a drain causing excessive groundwater discharge at both exit/entry point, and an associated lowering of the local water table, is low because the entry/exit points are both at higher elevations than the water table along the entire path.

The log for geotechnical boring B2-2E (located approximately 220 feet west of the revised eastern entry/exit point), drilled in August 2017, shows the top of the boring contained high blow count material comprised of weathered rock with fat clay to refusal at 28.5 ft bgs. The log for boring B2-2W (located approximately 283 feet west of the revised western entry/exit) shows approximately 8.5 feet of fat clay at the surface becoming high blow count highly weathered shale, mudstone and limestone to a depth of refusal at approximately 24 feet. The more cohesive overburden, as identified at B2-2W, represents reduced IR risk upon entry/exit and where it occurs above bedrock along the profiles; whereas the more coarse material, as identified at B2-2E, represents greater IR risk.

Bedrock cores were obtained at geotechnical borings B2-2E along the eastern part of the profile and at B2-2W along the west part of the profile. RQD values were generally higher for B2-2W after a depth of 40.5 feet, ranging from 60 to 100 percent with most values above 80 percent. A zone of weaker rock was indicated by the cores from 95.5 to 105.5 ft bgs. RQD values for B2-2E varied over a wide range for all cores, ranging from 54 to 100 percent with 40 percent of the values below 80 percent. The path of the profile crosses four mapped fracture traces reinforcing the indication that rock strength is variable, and zones of weaker bedrock may be encountered multiple times along the drill. IR risk will be elevated at streams and wetlands where overburden soil is mostly weathered bedrock, where bedrock is thin between the profile and top of rock and where the RQDs for the bedrock are low.

To date, the results of the 450-foot water supply survey show one spring with 450 feet of the alignments, located approximately 77 feet to the north.

An abandoned Lower Kittanning coal deep mine (Bethlem Coal Corp., Mine 31) exists due north of the HDD alignments. Over half of the alignments fall inside a potential mine subsidence zone defined using a 35-degree angle of draw. Mine pools are known to exist within Mine 31, north of the proposed HDD and south and east of the HDD in Mine 72 and Mine 77, respectively. HDD installation procedures need to prevent any adverse effects on mine pool levels caused by a large loss of drilling fluid return (LOR). Such adverse effects would include raising the mine pool level causing higher than normal flow at known mine pool discharges or the appearance of a new mine discharge point. However, the risk of an adverse effect on a mine pool is small at this location as the HDD does not overly any mine and current loss of return procedures call for suspension of drilling and determination of cause if a LOR does occur; therefore, the volume of loss would be small.

4.2 Conclusions and Recommendations

Based on this hydrogeologic reevaluation and assessment of the revised profiles, the overburden at the western edge of wetland W-N27 (for both the 16-inch and 20-inch drill) and at S-N41 (20-inch bore only) will be approximately 34 feet. The bedrock portion of the overburden at these locations is estimated to be 6 to 10 feet, and both the rock and soil strength are variable across the profile. As such, the HDD drilling plan should specifically account for these conditions.

Based on the current results for the 450-foot water supply survey procedures should be implemented to protect one spring within the survey limit. Additional supplies may be identified in the future that would require equal consideration during the installation of both pipes at HDD S2-069.

Over half of the alignments falls inside a potential mine subsidence zone defined using a 35-degree angle of draw. As such, pipe design and pipe installation procedures should account for some degree of subsidence associated with eventual collapse of overlying bedrock into the mine void space.

5.0 REFERENCES

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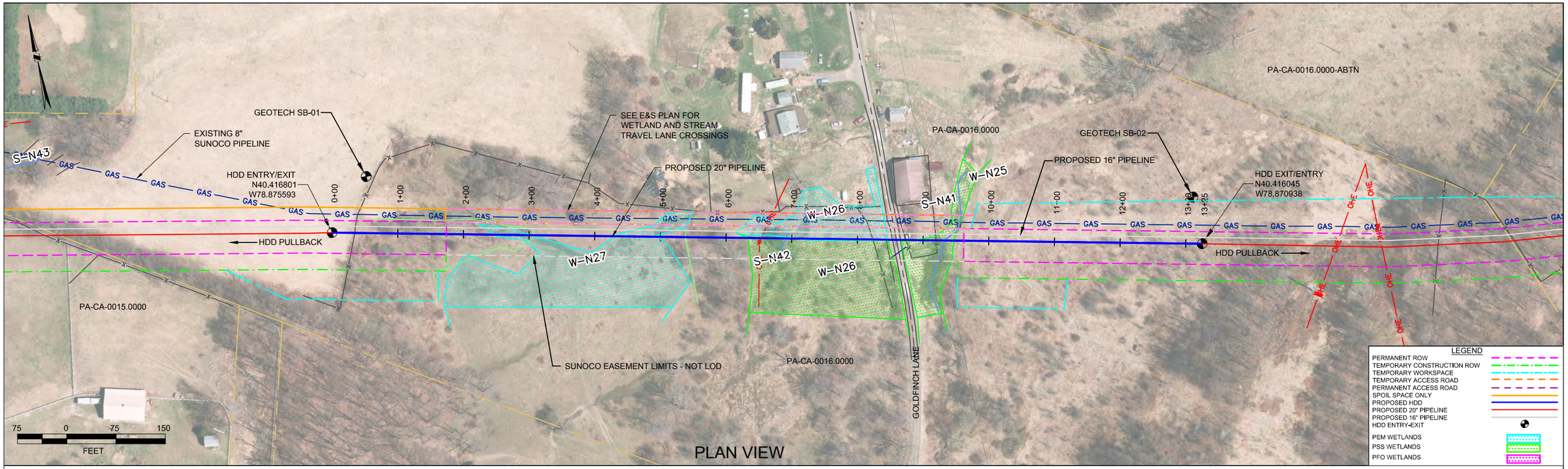
USDA NRCS WSS, United States Department of Agriculture, Natural Resources Conservation Service – Web Soil Survey for Cambria County. (https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx).

USGS (United States Geological Survey), Nanty Glo, Pennsylvania, 1:24,000 topographic quadrangle map, rev. 1982.

Attachment A

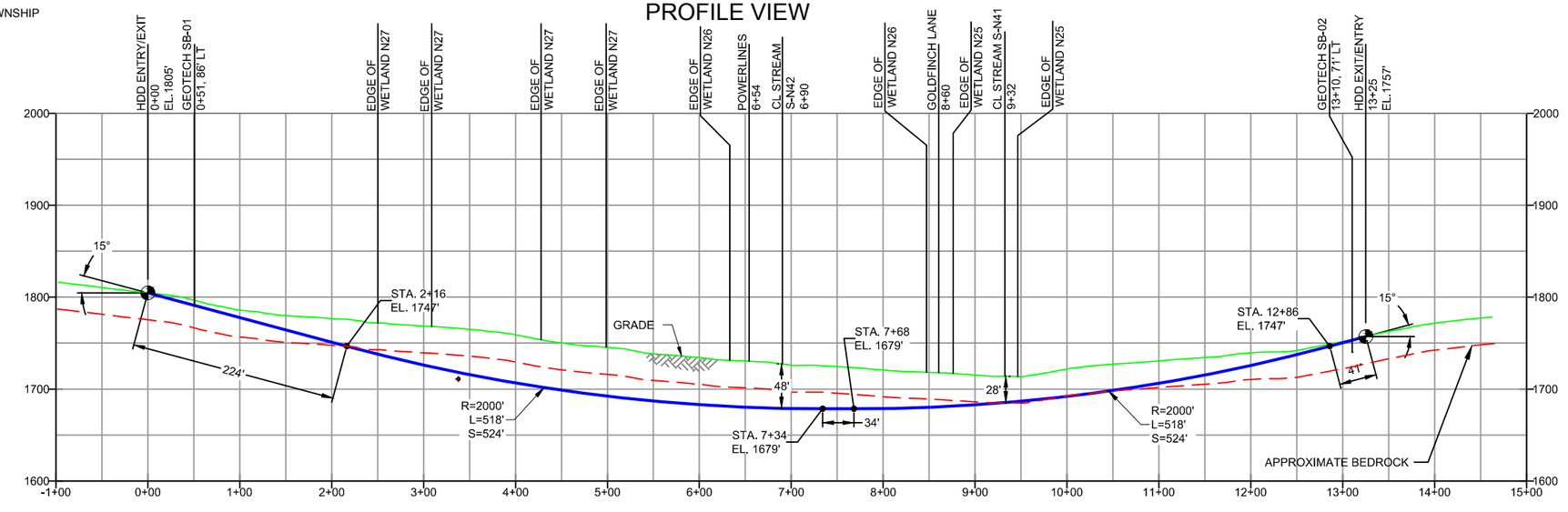
Original and Revised Plan and Profile



PLAN VIEW

CAMBRIA COUNTY PENNSYLVANIA, JACKSON TOWNSHIP
S2-0069

PROFILE VIEW



GEOTECH SB-01

-NG EL. 1791'
-TOPSOIL (0' - 0.3')
-SC/CL (0.3' - 6.5')
-CL (6.5' - 21.5')
-SC (21.5' - 28.0')
-SANDSTONE (28.0' - 28.1')
-COMPLETION DEPTH EL. 1163'

GEOTECH SB-02

-NG EL. 1740'
-TOPSOIL (0' - 0.5')
-CL (0.5' - 23.5')
-GROUNDWATER (25.0')
-SC (23.5' - 28.5')
-SHALE (28.5' - 30.0')
-COMPLETION DEPTH EL. 1710'

NOTE: REFER TO TEST BORING LOG S2-0069 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXITING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):1325'
   HDD PIPE LENGTH (S=):1347'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-2.14	TO	ES-2.15	EROSION & SEDIMENT PLAN
SHEET 9	TO	SHEET 9	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		DLM	03/15/16	RMB	03/15/16	AAW	03/15/16
C	ADDED GEOTECH INFO	MRS	09/04/15	RMB	09/04/15	AAW	09/04/15
B	ISSUED FOR BID	DLM	07/31/15	RMB	07/31/15	AAW	07/31/15
A	ISSUED FOR REVIEW	RTT	3/18/15	RMB	3/18/15	AAW	3/18/15

Sunoco Logistics Partners L.P.

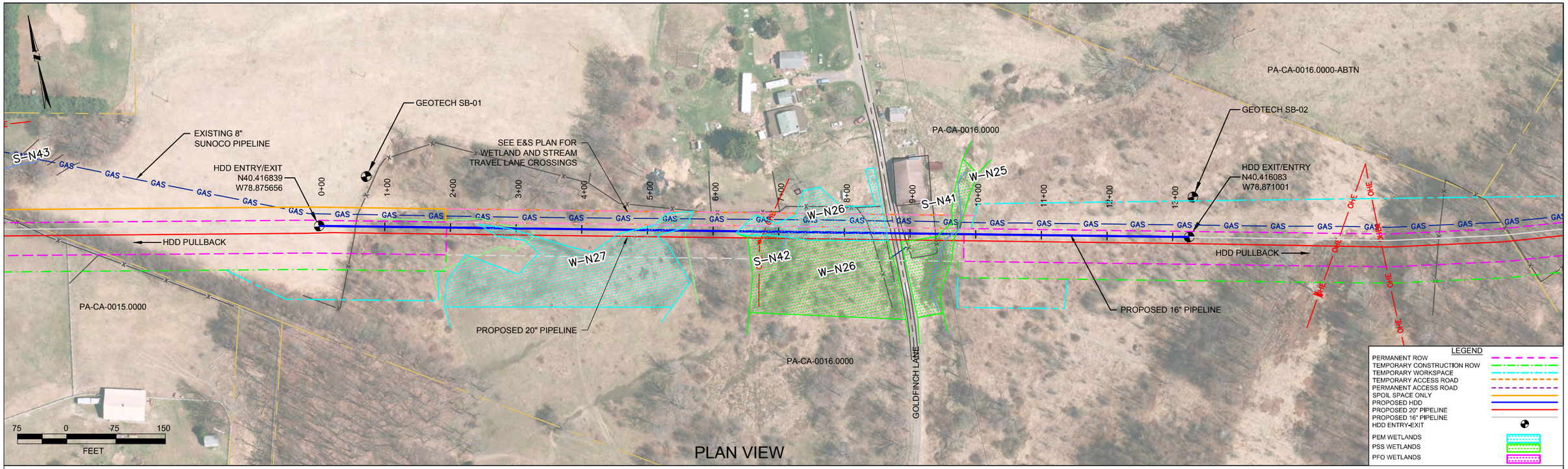
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
GOLDFINCH LANE
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'

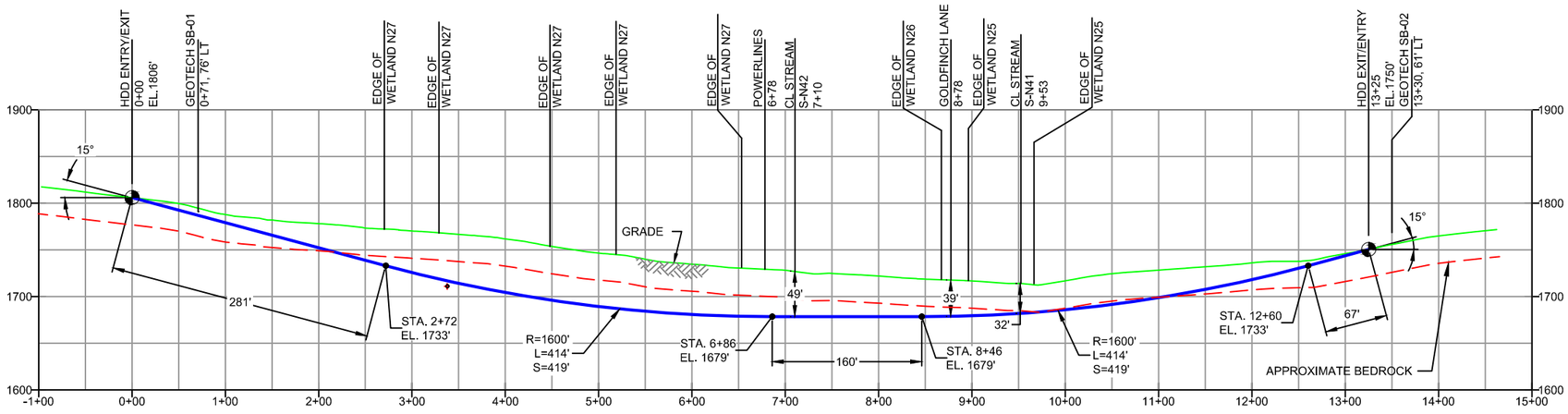
DWG. NO: PA-CA-0016.0000-RD



PLAN VIEW

PROFILE VIEW

CAMBRIA COUNTY PENNSYLVANIA, JACKSON TOWNSHIP
S2-0069-16



GEOTECH SB-01

GEOTECH SB-02

NOTE: REFER TO TEST BORING LOG S2-0069 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXITING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):1325'
   HDD PIPE LENGTH (S=):1346'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
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NOTES

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

REF. DRAWING

ES-2.14	TO	ES-2.15	EROSION & SEDIMENT PLAN	
SHEET 9	TO	SHEET 9	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	DLM	10/07/16	RMB	10/07/16	AAW	10/07/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		DLM	03/15/16	RMB	03/15/16	AAW	03/15/16
B	ADDED GEOTECH INFO	MRS	09/06/15	RMB	09/06/15	AAW	09/06/15
A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15

Sunoco Logistics Partners L.P.

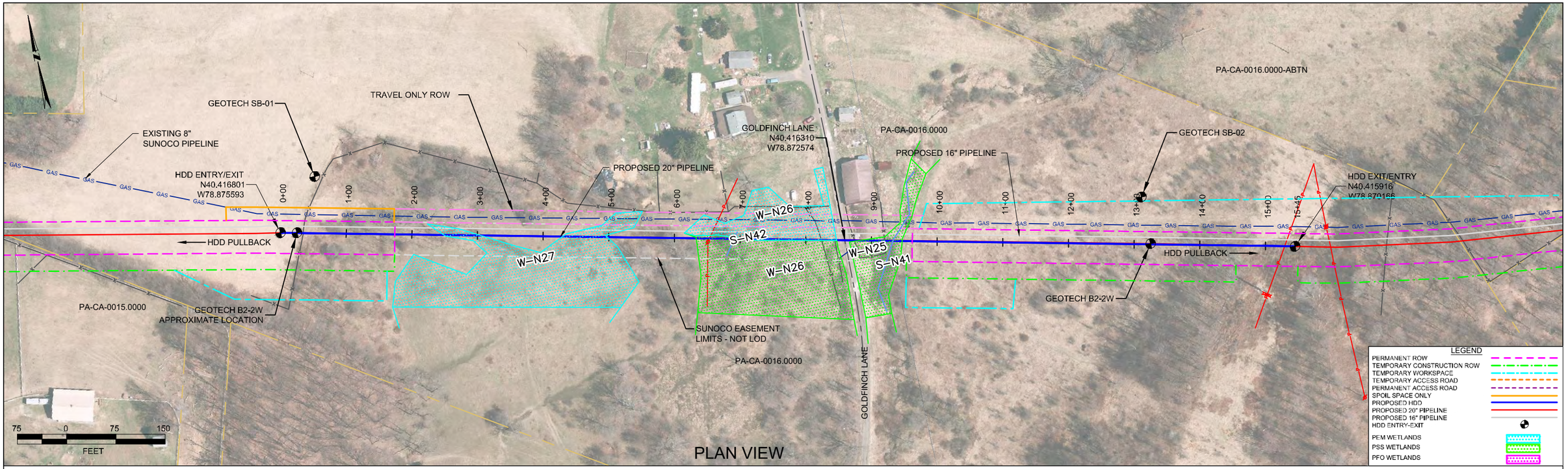
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
GOLDFINCH LANE
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'

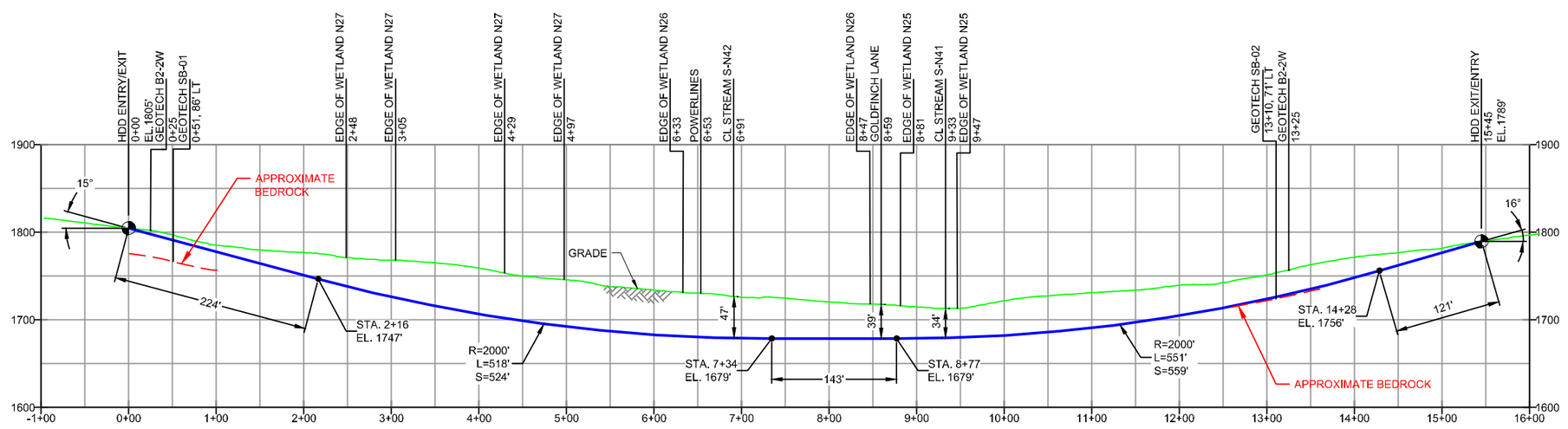
DWG. NO: PA-CA-0016.0000-RD-16



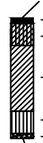
PLAN VIEW

CAMBRIA COUNTY PENNSYLVANIA, JACKSON TOWNSHIP
S2-0069

PROFILE VIEW



GEOTECH SB-01



-NG EL. 1791'
-TOPSOIL (0' - 0.3')
-SC/CL (0.3' - 6.5')
-CL (6.5' - 21.5')
-SC (21.5' - 28.0')
-SANDSTONE (28.0' - 28.1')
-COMPLETION DEPTH EL. 1163'

GEOTECH SB-02

-NG EL. 1740'
-TOPSOIL (0' - 0.5')
-CL (0.5' - 23.5')
-GROUNDWATER (25.0')
-SC (23.5' - 28.5')
-SHALE (28.5' - 30.0')
-COMPLETION DEPTH EL. 1710'

NOTE: REFER TO TEST BORING LOG S2-0069 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B2-2W

-NG EL. 1757'
-FAT CLAY CL (0.0' - 8.5')
-WEATHERED MUDSTONE SANDSTONE/SHALE (8.5' - 177.0')
-GROUNDWATER (100.0')
-BORING TERMINATED EL.1580'

NOTE: REFER TO TEST BORING LOG B2-2W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B2-2E

-NG EL. 1802'
-WEATHERED ROCK (0.0' - 28.5')
-GROUNDWATER (52.5')
-LIMESTONE/MUDSTONE (28.5' - 128.5')
-BORING TERMINATED EL.1673.5'

NOTE: REFER TO TEST BORING LOG B2-2E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

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3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 1545'
   HDD PIPE LENGTH (S=): 1571'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

NOTES
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REF. DRAWING

ES-2.14	TO	ES-2.15	EROSION & SEDIMENT PLAN	
SHEET 9	TO	SHEET 9	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP3	RELOCATED DRILL ENTRY/EXIT - DESIGN CHANGE PER DPS	MRS	09/21/17	RMB	09/21/17	CAG	09/21/17
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		DLM	03/15/16	RMB	03/15/16	AAW	03/15/16
C	ADDED GEOTECH INFO	MRS	09/04/15	RMB	09/04/15	AAW	09/04/15
B	ISSUED FOR BID	DLM	07/31/15	RMB	07/31/15	AAW	07/31/15

Sunoco Logistics Partners L.P.

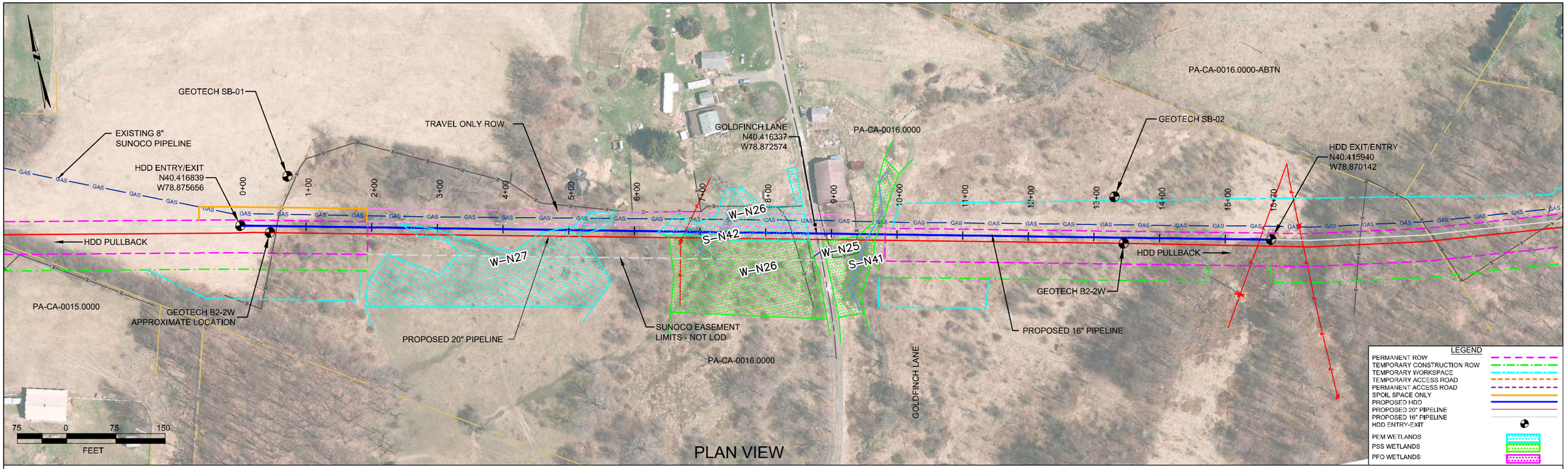
TETRA TECH ROONEY
(303) 792–5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
GOLDFINCH LANE
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'

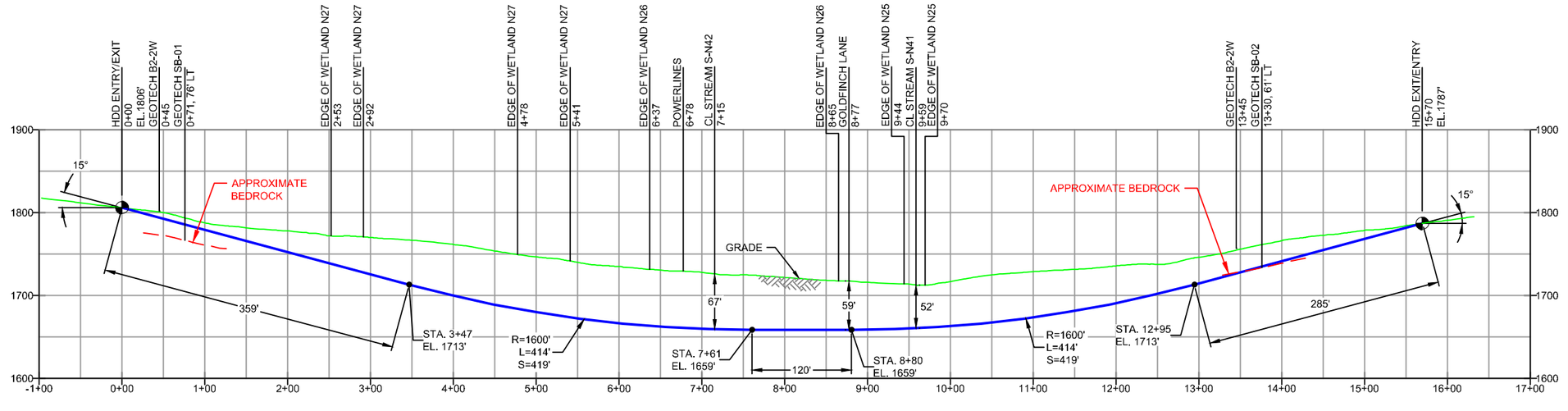
DWG. NUMBER: PA-CA-0016.0000-RD



PLAN VIEW

CAMBRIA COUNTY PENNSYLVANIA, JACKSON TOWNSHIP
S2-0069-16

PROFILE VIEW



GEOTECH SB-01

GEOTECH SB-02

NOTE: REFER TO TEST BORING LOG S2-0069 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B2-2W

NOTE: REFER TO TEST BORING LOG B2-2W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B2-2E

NOTE: REFER TO TEST BORING LOG B2-2E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:
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3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 1570'
   HDD PIPE LENGTH (S=): 1602'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
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NOTES

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REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-2.14	TO	ES-2.15	EROSION & SEDIMENT PLAN
SHEET 9	TO	SHEET 9	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP3	RELOCATED DRILL ENTRY/EXIT - DESIGN CHANGE PER DPS	MRS	10/30/17	RMB	10/30/17	CAG	10/30/17
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	DLM	10/07/16	RMB	10/07/16	AAW	10/07/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/18/16	RMB	05/18/16	AAW	05/18/16
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B	ADDED GEOTECH INFO	MRS	09/06/15	RMB	09/06/15	AAW	09/06/15
A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792–5911

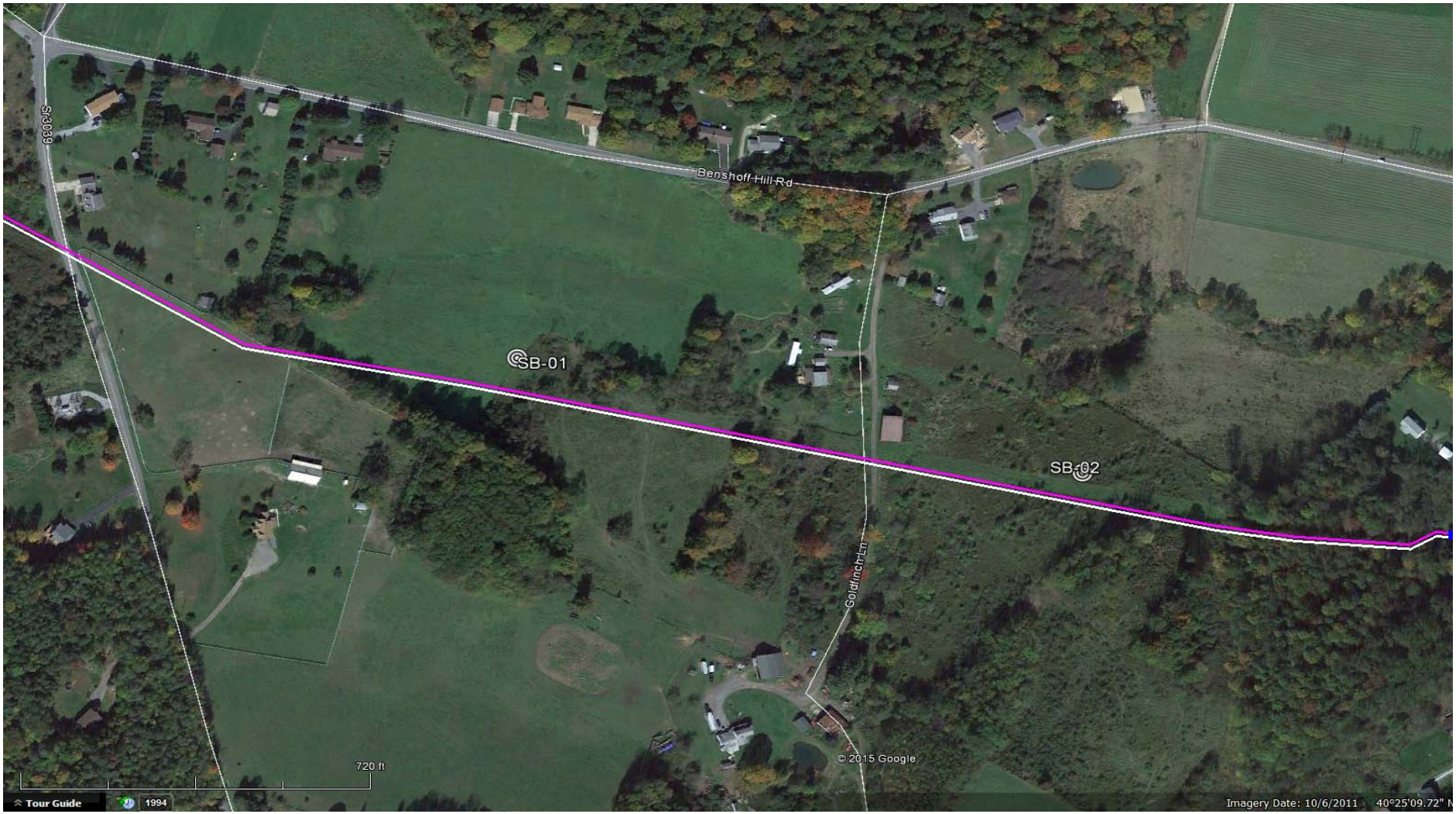
SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
GOLDFINCH LANE
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150' | DWG. NO: PA-CA-0016.0000-RD-16

Attachment B

Geotechnical Report



LEGEND:

◎ Geotechnical Soil Boring (SB) Locations

TETRA TECH

GEOTECHNICAL BORING LOCATIONS
HDD S2-0069
CAMBRIA COUNTY, JACKSON TOWNSHIP, PA
SUNOCO PENNSYLVANIA PIPELINE PROJECT

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

TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	GOLDFINCH LAND, JOHNSTOWN, PA		Page 1 of 1
HDD No.:	S2-0069	Dates(s) Drilled: 04-15-15	Inspector: E. WATT
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 28.1
Boring Location Coordinates:		40° 25' 1.213" N	78° 52' 31.261" W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.3			TOPSOIL (3")					
1	3.0	5.0	0.3		10	SC/ CL	BROWN SILTY CLAY AND FINE SAND, WITH A LITTLE FINE	2	6	10	8	**16**
				6.5			GRAVEL.					
2	8.0	10.0	6.5		24	CL	LIGHT BROWN AND BROWN SILTY CLAY WITH SOME FINE SAND AND	2	5	6	10	**11**
							FINE GRAVEL. (USCS: CL).					
3	13.0	14.9			24		VARIOUS SHADES OF BROWN SILTY CLAY AND FINE SAND WITH	3	22	42	50/5"	**64**
							A LITTLE F-C GRAVEL. (WEATHERED SANDSTONE)					
4	18.0	20.0			24		LIGHT BROWN SILTY CLAY AND FINE SAND, WITH A LITTLE FINE	13	31	45	50	**76**
				21.5			TO COARSE GRAVEL (USCS: CL). (WEATHERED SANDSTONE)					
5	23.0	23.9	21.5		10	SC	LIGHT BROWN FINE SAND WITH SOME SILTY CLAY, WITH A LITTLE	3	50/5"			**>50**
				28.0			FINE TO COARSE GRAVEL. (WEATHERED SANDSTONE)					
6	28.0	28.1	28.0	28.1	1		PARTIALLY WEATHERED LIGHT BROWN SANDSTONE.	50/1"				**>50**
							AUGER REFUSAL AT 28'.					
							DRY AND CAVED AT 26'.					

Notes/Comments:

Pocket Pentrometer Testing
S1: > 4.0 TSF
S2: 2.25 TSF
S3: > 4.0 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.

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:	GOLDFINCH LAND, JOHNSTOWN, PA		Page 1 of 1
HDD No.:	S2-0069	Dates(s) Drilled: 04-14-15	Inspector: E. WATT
Boring No.:	SB-02	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 25.0	Total Depth (ft): 30.0
Boring Location Coordinates:		40° 24' 58.477" N	78° 52' 15.375" W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.5			TOPSOIL (6")					
1	3.0	5.0	0.5		14		BROWN SILTY CLAY WITH SOME FINE SAND, TRACE F-GRAVEL	1	3	4	4	**7**
							(USCS: CL).					
2	8.0	10.0			24		BROWN MOTTLED SILTY CLAY AND FINE SAND, TRACE F-GRAVEL.	1	4	7	10	**11**
						CL						
3	13.0	15.0			24		LIGHT BROWN SILTY CLAY WITH A LITTLE FINE SAND AND A LITTLE	8	20	22	33	**42**
							FINE GRAVEL. (USCS: CL).					
4	18.0	20.0			24		LIGHT BROWN SILTY CLAY, TRACE FINE GRAVEL.	1	8	17	27	**25**
				23.5								
5	23.0	25.0	23.5		24	SC	LIGHT GRAY TO GRAY FINE SAND WITH SOME SILTY CLAY, WITH	5	10	35	30	**45**
				28.5			SOME LAYERS OF UNWEATHERED ROCK (PART FISSILE SHALE).					
6	28.0	28.8	28.5	30.0	8		BROWN AND GRAY PARTIALY WEATHERED SHALE.	5	50/4"			**>50**
							AUGERED TO 30'.					
							WET ON SPOON AT 27'.					
							WATER LEVEL THROUGH AUGERS AT 25'.					
							CAVED AT 27.5', WATER LEVEL ON CAVE AT 24'.					

Notes/Comments:

Pocket Pentrometer Testing
S2: 1.25 TSF
S3 (13'): 2.25 TSF
S3 (14'): > 4 TSF

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

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

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0069

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.) From	Depth of Sample (ft.) To	Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318) Liquid Limit, %	Atterburg Limits (ASTM D4318) Plastic Limit, %	Atterburg Limits (ASTM D4318) Plasticity Index, %	USCS Classif. (ASTM D2487)
S2-0069	SB-01	1	3.0	5.0	17.6	50.6	-	-	-	-
		2	8.0	10.0	21.9	72.0	39	22	17	CL
		3	13.0	14.9	5.9	60.0	-	-	-	-
		4	18.0	20.0	7.2	56.7	38	21	17	CL
		5	23.0	23.9	7.3	37.7	-	-	-	-
	SB-02	1	3.0	5.0	24.3	78.1	35	22	13	CL
		2	8.0	10.0	17.2	55.1	-	-	-	-
		3	13.0	15.0	21.7	73.0	35	22	13	CL
		4	18.0	20.0	20.0	91.6	-	-	-	-
		5	23.0	25.0	9.0	27.7	-	-	-	-
		6	28.0	28.8	10.9	23.2	-	-	-	-

Notes:

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

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0069

HDD No.	NAME	BORING NO.	REGIONAL GEOLOGY DESCRIPTION	GENERAL TOPOGRAPHIC SETTING	BEDROCK FORMATION	GENERAL ROCK TYPE	APPROX MAX FM THICKNESS (FT)	DEPTH TO ROCK (Ft bgs) based on nearby well drilling logs	NOTES / COMMENTS
S2-0069	Goldfinch Ln.	SB-01 SB-02	**Glenshaw Formation** - Cyclic sequences of shale, sandstone, red beds, and thin limestone and coal; includes four marine limestone or shale horizons; red beds are involved in landslides; base is at top of Upper Freeport coal.	Rolling hills, moderate relief	Glenshaw	Shale-sandstone with limestone-clastic-coal	280-375	15 to 27	Yields range from 5 to 15 gpm

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 11, 2017 (Revised November 20, 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 2 – Goldfinch Lane
Commonwealth of Pennsylvania
Drawing #PA-CA-0016.0000-RD
PO #20170804-11
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 Goldfinch Lane (Drawing #PA-CA-0016.0000-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 B2-2W and B2-2E, visual classification and photography of the rock core samples, and laboratory testing of representative rock samples.

Test borings, B2-2W and B2-2E were drilled between August 8 and 11, 2017 to depths of 177.0 and 128.5 feet, respectively as shown on the attached **Test Boring Location Plan**. Bedrock typically consisted of interlayered sedimentary rock comprised of mudstone, shale, sandstone, and limestone. 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, a rock sample from B2-2E near 48 feet was not tested due highly fractured and fissile rock. Unconfined compressive strength test results are shown on the attached reports.

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.

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

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

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

N

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

Goldfinch Lane HDD Cores B2-2W and B2-2E
PA-CA-0016.0000-RD
Cambria County, Pennsylvania

Exhibit

A-2

EXPLORATION RESULTS

BORING LOG NO. B2-2W Goldfinch Lane West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 2

LOCATION PA-CA-0016.0000-RD
20170804-11
Latitude: 40.41684° Longitude: -78.87651°

Approximate Surface Elev: 1805 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
		FILL - FAT CLAY (CL), with rock fragments (highly weathered black shale), silt, trace organic matter, dark brown, stiff						
				16	4-3-6 N=9			2.25
8.5	1796.5+/-		5					
		Highly weathered shale, black		16	18-33- 50/4"			3.5
			10					
				5	50/5"			0.25
18.5	1786.5+/-		15					
		Weathered mudstone and shale with interbedded limestone, gray		2	50/2"			
			20					
24.0	1781+/-			0	50/0"			
		Run 1, Hard, highly weathered, light gray, MUDSTONE with interbedded limestone, thick bedding, widely spaced joints, tight		18		100		
25.5	1779.5+/-		25					
		Run 2, Medium hard to soft, slightly weathered, light gray, MUDSTONE with interbedded limestone, thin bedding, close joints, open		58		42		
			30					

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:
Core rates not recorded

WATER LEVEL OBSERVATIONS

▽ >100' AB

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 08-10-2017 | Boring Completed: 08-11-2017

Drill Rig: Acker Renegade | Driller: Terracon/Willie D.

Project No.: J217P078 | Exhibit: A-1

BORING LOG NO. B2-2W Goldfinch Lane West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 2

LOCATION PA-CA-0016.0000-RD
20170804-11
Latitude: 40.41684° Longitude: -78.87651°
Approximate Surface Elev: 1805 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	RECOVERY (In.)	RQD (%)
30.5	1774.5+/-			
Run 3, Hard, slightly weathered, light gray, MUDSTONE with interbedded limestone, thin to medium bedding, close to moderately close joints, slightly open			60	85
35.5	1769.5+/-	35		
Run 4, Similar to 36.8 feet At 36.8 feet: Medium to hard, moderately to highly weathered, gray to dark gray, MUDSTONE with interbedded shale, thin bedding, close joints, open to moderately open, with fossil and clay seams			59	7
40.5	1764.5+/-	40		
Run 5, Hard, slightly to moderately weathered, dark to light gray SANDSTONE, thin to medium bedding, close to moderately close joints, slightly open			61	90
45.5	1759.5+/-	45		
Run 6, Medium hard, slightly weathered, olive gray, fine-grained SANDSTONE, medium bedding, moderately close joints, slightly open			59	95
50.5	1754.5+/-	50		
Run 7, Hard, moderately weathered, bluish gray, fine-grained SANDSTONE, thin to medium bedding, close to moderately close joints, moderately open			59	82
55.5	1749.5+/-	55		
Run 8, Similar			59	82
		60		

GRAPHIC LOG | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | Core rate (min/ft) | Penetrometer Test (tsf)

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:
Core rates not recorded

WATER LEVEL OBSERVATIONS

▽ *>100' AB*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 08-10-2017 | Boring Completed: 08-11-2017

Drill Rig: Acker Renegade | Driller: Terracon/Willie D.

Project No.: J217P078 | Exhibit: A-1

BORING LOG NO. B2-2W Goldfinch Lane West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 2

LOCATION PA-CA-0016.0000-RD
20170804-11
Latitude: 40.41684° Longitude: -78.87651°
Approximate Surface Elev: 1805 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Run / Description	DEPTH (Ft.)	RECOVERY (In.)	RQD (%)
60.5	1744.5+/-	Run 9, Similar, medium bedding, moderately close	65	60	100
65.5	1739.5+/-	Run 10, Similar, medium bedding, moderately close	70	60	100
70.5	1734.5+/-	Run 11, Similar	75	57	93
75.5	1729.5+/-	Run 12, Hard, slightly weathered, bluish gray, medium-grained SANDSTONE, medium bedding, moderately close joints, tight	80	61	100
80.5	1724.5+/-	Run 13, Similar to 82.8 feet From 82.8 to 88 feet: Hard, moderately weathered, black, SHALE, thin bedding, close joints From 88 to 88.5 feet: Medium-grained SANDSTONE	85	59	83
85.5	1719.5+/-	Run 14, Slightly weathered, black with white, SHALE, medium bedding, moderately close joints, moderately open	90	60	95

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:
Core rates not recorded

WATER LEVEL OBSERVATIONS

▽ *>100' AB*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 08-10-2017 | Boring Completed: 08-11-2017
Drill Rig: Acker Renegade | Driller: Terracon/Willie D.
Project No.: J217P078 | Exhibit: A-1

BORING LOG NO. B2-2W Goldfinch Lane West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 2

LOCATION PA-CA-0016.0000-RD
20170804-11
Latitude: 40.41684° Longitude: -78.87651°
Approximate Surface Elev: 1805 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Run	RECOVERY (In.)	RQD (%)
90.5	1714.5+/-			
		Run 15, Hard to medium, slightly to moderately weathered, black, SHALE, medium bedding, close to moderately close joints	58	58
95.5	1709.5+/-			
		Run 16, Hard to medium hard, moderately to highly weathered gray with white, MUDSTONE with interbedded limestone, thin bedding, close joints, open to moderately open	60	70
100.5	1704.5+/-			
		Run 17, Hard to medium hard, moderately to highly weathered gray with white, MUDSTONE with interbedded limestone, thin bedding, close joints, open to moderately open	60	66
105.5	1699.5+/-			
		Run 18, From 105 to 108.5 feet: Moderately weathered, gray MUDSTONE with lime, medium bedding, moderately close joints, moderately open From 108.5 to 110.5 feet: Moderately weathered, bluish gray, fine-grained SANDSTONE, thin bedding, close joints, moderately open	60	100
110.5	1694.5+/-			
		Run 19, From 110.5 to 114 feet: Hard, slightly weathered, bluish gray, SANDSTONE, thin bedding, close joints, moderately open From 114 to 115.5 feet: Hard, slightly weathered, gray with white and brown MUDSTONE, thin bedding, close joints, moderately open	60	95
115.5	1689.5+/-			
		Run 20, Hard, slightly weathered, gray with brown/purple, MUDSTONE, thin bedding, close joints, open to moderately open	60	88

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:
Core rates not recorded

WATER LEVEL OBSERVATIONS

▽ >100' AB

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 08-10-2017 | Boring Completed: 08-11-2017

Drill Rig: Acker Renegade | Driller: Terracon/Willie D.

Project No.: J217P078 | Exhibit: A-1

BORING LOG NO. B2-2W Goldfinch Lane West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 2

LOCATION PA-CA-0016.0000-RD
20170804-11
Latitude: 40.41684° Longitude: -78.87651°
Approximate Surface Elev: 1805 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	RECOVERY (In.)	RQD (%)
120.5	1684.5+/-				
		Run 21, Hard, slightly weathered, dark gray to black, MUDSTONE with interbedded shale, thin bedding, close joints, slightly open		60	89
125.5	1679.5+/-		125		
		Run 22, Similar		59	98
130.5	1674.5+/-		130		
		Run 23, Hard, slightly weathered, black with white SHALE, thin bedding, close joints, open to moderately open		57	83
135.5	1669.5+/-		135		
		Run 24, Hard, slightly weathered, black with white SHALE, medium bedding, moderately close joints, slightly open		60	100
140.5	1664.5+/-		140		
		Run 25, Hard, slightly weathered, black with white SHALE, thick bedding, widely spaced joints, tight		59	98
145.5	1659.5+/-		145		
		Run 26, Hard, slightly weathered, black SHALE, thick bedding, close joints, slightly open		59	98
			150		

GRAPHIC LOG | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | Core rate (min/ft) | Penetrometer Test (tsf)

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:
Core rates not recorded

WATER LEVEL OBSERVATIONS

▽ *>100' AB*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 08-10-2017 | Boring Completed: 08-11-2017
Drill Rig: Acker Renegade | Driller: Terracon/Willie D.
Project No.: J217P078 | Exhibit: A-1

BORING LOG NO. B2-2W Goldfinch Lane West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 2

LOCATION PA-CA-0016.0000-RD
20170804-11
Latitude: 40.41684° Longitude: -78.87651°
Approximate Surface Elev: 1805 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Run / Description	DEPTH (Ft.)	RECOVERY (In.)	RQD (%)
150.5	1654.5+/-	Run 27, Hard, slightly weathered, black SHALE, thick bedding, widely spaced joints, tight	155	58	97
155.5	1649.5+/-	Run 28, Similar	160	60	100
160.5	1644.5+/-	Run 29, Hard, slightly weathered, black with gray SHALE, medium bedding, moderately close joints	165	53	88
165.5	1639.5+/-	Run 30, Hard, slightly weathered, black with gray SHALE, thin bedding, close joints, slightly open	170	60	100
170.5	1634.5+/-	Run 31, Similar	175	48	80
175.5	1629.5+/-	Run 32, Similar		18	100
177.0	1628+/-	***Boring Terminated at 177 Feet***			

GRAPHIC LOG | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | Core rate (min/ft) | Penetrometer Test (tsf)

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:
Core rates not recorded

WATER LEVEL OBSERVATIONS

▽ >100' AB

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 08-10-2017 | Boring Completed: 08-11-2017

Drill Rig: Acker Renegade | Driller: Terracon/Willie D.

Project No.: J217P078 | Exhibit: A-1

BORING LOG NO. B2-2E Goldfinch Lane East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 2

LOCATION

Latitude: 40.416045° Longitude: -78.870938°

Approximate Surface Elev: 1757 (Ft.) +/-

DEPTH ELEVATION (Ft.)

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS
0			Weathered rock, with fat clay, dark gray with reddish brown layers, very dense
5		16	40-43-50/4"
10		2	50/2"
15		3	50/3"
20		5	50/5"
25		12	9-29-50/1"
28.5			1728.5+/-
30		0 35	Run 1, Hard, slightly to moderately weathered, light gray, LIMESTONE, thin bedding, close joints, slightly open 50/0"

Similar, dark gray to black with light gray limestone fragments

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

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:
Core rates not recorded

WATER LEVEL OBSERVATIONS

52' AB

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/8/2017 Boring Completed: 8/9/2017

Drill Rig: Acker Renegade Driller: Terracon/Willie D.

Project No.: J217P078

BORING LOG NO. B2-2E Goldfinch Lane East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 2

LOCATION

Latitude: 40.416045° Longitude: -78.870938°

Approximate Surface Elev: 1757 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)
		Run 1, Hard, slightly to moderately weathered, light gray, LIMESTONE, thin bedding, close joints, slightly open *(continued)*	35	58
33.5	1723.5+/-			
		Run 2, Hard, slightly to moderately weathered, light gray, LIMESTONE, thin bedding, close joints, moderately open, 1-inch clay seam at 34.5 feet	60	83
38.5	1718.5+/-			
		Run 3, Moderately to medium hard, moderate to highly weathered, light gray MUDSTONE, thin bedding, close joints, moderately open Vertical fractures at 43.8 and 44.4 feet 1-inch clay seam at 44.3 feet	60	63
43.5	1713.5+/-			
		Run 4, Hard, slight to moderately weathered, gray MUDSTONE, thin to medium bedding, close joints, moderately open	60	85
48.5	1708.5+/-			
		Run 5, Hard, slightly weathered, dark gray MUDSTONE, thin to medium bedding, close joints, moderately open	60	86
53.5	1703.5+/-			
		Run 6, Hard, black SHALE, thin to medium bedding, close to moderately close joints, slightly open, severely weathered from 58 to 58.5 feet	59	86
58.5	1698.5+/-			
		Run 7, Similar, vertical joint from 60.8 to 61.3	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

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:
Core rates not recorded

WATER LEVEL OBSERVATIONS

▽ *52' AB*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/8/2017 | Boring Completed: 8/9/2017
Drill Rig: Acker Renegade | Driller: Terracon/Willie D.
Project No.: J217P078

BORING LOG NO. B2-2E Goldfinch Lane East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 2

LOCATION

Latitude: 40.416045° Longitude: -78.870938°

Approximate Surface Elev: 1757 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)
		Run 7, Similar, vertical joint from 60.8 to 61.3 *(continued)*	60	85
63.5	1693.5+/-			
		Run 8, Hard, slightly weathered, black SHALE, thick bedding, widely spaced joints, slightly open	59	90
68.5	1688.5+/-			
		Run 9, Similar, slightly to moderately weathered	60	95
73.5	1683.5+/-			
		Run 10, Similar	60	100
78.5	1678.5+/-			
		Run 11, Moderately hard, moderately to highly weathered, black SHALE, thin bedding, close joints, moderately open, severely weathered from 80 to 80.5 feet	58	66
83.5	1673.5+/-			
		Run 12, Moderately hard, moderately to severely weathered, black SHALE, thin bedding, close joints Coal seam from 83.5 to 84 feet Severely weathered from 87.8 to 88.5 feet	60	73
88.5	1668.5+/-			
			60	

DEPTH (Ft.): 65, 70, 75, 80, 85, 90

WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | Core rate (min/ft) | Penetrometer Test (tsf)

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

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:
Core rates not recorded

WATER LEVEL OBSERVATIONS

52' AB

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/8/2017 | Boring Completed: 8/9/2017

Drill Rig: Acker Renegade | Driller: Terracon/Willie D.

Project No.: J217P078

BORING LOG NO. B2-2E Goldfinch Lane East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 2

LOCATION

Latitude: 40.416045° Longitude: -78.870938°

Approximate Surface Elev: 1757 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)
		Run 13, Medium hard, moderately to severely weathered, gray, MUDSTONE with interbedded limestone, thin bedding, close joints Severely weathered from 93 to 93.5 feet *(continued)*	60	68
93.5	1663.5+/-			
		Run 14, Similar Vertical joint from 97.8 to 98.5 feet Severely weathered from 97.8 to 98.5 feet	60	70
98.5	1658.5+/-			
		Run 15, Moderately hard, moderately to severely weathered, light gray, MUDSTONE with interbedded limestone, thin bedding, close joints	60	73
103.5	1653.5+/-			
		Run 16, Hard, very slightly weathered, light gray, MUDSTONE with interbedded limestone, thick bedding, widely spaced joints, tight	60	100
108.5	1648.5+/-			
		Run 17, Similar	52	86
113.5	1643.5+/-			
		Run 18, Medium hard, slightly weathered, light gray, MUDSTONE, thick bedding, close joints Severely weathered from 115.5 to 118.5 feet	57	70
118.5	1638.5+/-			
		Run 19, Hard, slightly weathered, dark gray with red, MUDSTONE, thin bedding, close joints	60	

Core rate (min/ft) | Penetrometer Test (tsf) | FIELD TEST RESULTS | WATER LEVEL OBSERVATIONS | SAMPLE TYPE

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

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:
Core rates not recorded

WATER LEVEL OBSERVATIONS

52' AB

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/8/2017 | Boring Completed: 8/9/2017

Drill Rig: Acker Renegade | Driller: Terracon/Willie D.

Project No.: J217P078

BORING LOG NO. B2-2E Goldfinch Lane East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 2

LOCATION

Latitude: 40.416045° Longitude: -78.870938°

Approximate Surface Elev: 1757 (Ft.) +/-

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Run 19, Hard, slightly weathered, dark gray with red, MUDSTONE, thin bedding, close joints *(continued)*					60		93		
	123.5	1633.5+/-								
	Run 20, Moderately hard to hard, moderately weathered, gray with yellow, MUDSTONE with interbedded limestone, thin bedding, close joints		125			59		53		
	128.5	1628.5+/-								
	Boring Terminated at 128.5 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

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:
Core rates not recorded

WATER LEVEL OBSERVATIONS

▽ *52' AB*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/8/2017 Boring Completed: 8/9/2017

Drill Rig: Acker Renegade Driller: Terracon/Willie D.

Project No.: J217P078

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

Boring No.:	B2-2W	Lithology :	Sandstone
Sample No.:	1	Moisture Content :	As received
Sample Depth:	44 feet	Lab Temperature :	70° F
Sampling Date:	8/10/17	Loading Rate:	55 psi/s
		Time to Failure:	6 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	21,240 lb
Length:	4.52 in	Compressive Strength:	6,829 psi
L/D:	2.27	Compressive Strength:	47.08 Mpa
End Area:	3.11 in^2	Unit Weight	170 pcf

Before the Test

After the Test

Drawing # : PA-CA-0016.0000-RD
PO # : 20170804-11
Crossing : Goldfinch Lane
Spread : Spread 2

Project:	Mariner East Pipeline	Terracon	Performed by:	H. Whitford
Project No.	J217P078		Test Date:	10/10/2017
Location:	Spread 2		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/10/2017

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

Boring No.:	B2-2W	Lithology :	Sandstone
Sample No.:	2	Moisture Content :	As received
Sample Depth:	65 feet	Lab Temperature :	70° F
Sampling Date:	8/10/17	Loading Rate:	55 psi/s
		Time to Failure:	12 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	39,410 lb
Length:	4.45 in	Compressive Strength:	12,671 psi
L/D:	2.24	Compressive Strength:	87.36 Mpa
End Area:	3.11 in^2	Unit Weight	165 pcf

Before the Test

After the Test

Drawing # :	PA-CA-0016.0000-RD
PO # :	20170804-11
Crossing :	Goldfinch Lane
Spread :	Spread 2

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	10/3/2017
Location:	Spread 2		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/10/2017

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

Boring No.:	B2-2W	Lithology :	Shale
Sample No.:	3	Moisture Content :	As received
Sample Depth:	84 feet	Lab Temperature :	70° F
Sampling Date:	8/10/17	Loading Rate:	55 psi/s
		Time to Failure:	10 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	31,880 lb
Length:	4.24 in	Compressive Strength:	10,250 psi
L/D:	2.13	Compressive Strength:	70.67 Mpa
End Area:	3.11 in^2	Unit Weight	166 pcf

Photographs are mislabeled as 2-2W-2

Before the Test

After the Test

Drawing # :	PA-CA-0016.0000-RD
PO # :	20170804-11
Crossing :	Goldfinch Lane
Spread :	Spread 2

Project:	Mariner East Pipeline	Terracon	Performed by:	H. Whitford
Project No.	J217P078		Test Date:	10/10/2017
Location:	Spread 2		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/10/2017

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

Boring No.:	B2-2W	Lithology :	Mudstone
Sample No.:	4	Moisture Content :	As received
Sample Depth:	103 feet	Lab Temperature :	70° F
Sampling Date:	8/10/17	Loading Rate:	55 psi/s
		Time to Failure:	3 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	10,650 lb
Length:	4.69 in	Compressive Strength:	3,459 psi
L/D:	2.37	Compressive Strength:	23.85 Mpa
End Area:	3.08 in^2	Unit Weight	171 pcf

Before the Test

After the Test

Drawing # :	PA-CA-0016.0000-RD
PO # :	20170804-11
Crossing :	Goldfinch Lane
Spread :	Spread 2

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	10/3/2017
Location:	Spread 2		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/10/2017

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

Boring No.:	B2-2W	Lithology :	Mudstone
Sample No.:	5	Moisture Content :	As received
Sample Depth:	118 feet	Lab Temperature :	70° F
Sampling Date:	8/10/17	Loading Rate:	55 psi/s
		Time to Failure:	6 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	18,830 lb
Length:	4.46 in	Compressive Strength:	6,115 psi
L/D:	2.25	Compressive Strength:	42.16 Mpa
End Area:	3.08 in^2	Unit Weight	172 pcf

Photographs are mislabeled as 2-2W-3

Before the Test

After the Test

Drawing # :	PA-CA-0016.0000-RD
PO # :	20170804-11
Crossing :	Goldfinch Lane
Spread :	Spread 2

Project:	Mariner East Pipeline	Terracon	Performed by:	H. Whitford
Project No.	J217P078		Test Date:	10/10/2017
Location:	Spread 2		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/10/2017

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

Boring No.:	B2-2W	Lithology :	Mudstone
Sample No.:	6	Moisture Content :	As received
Sample Depth:	126 feet	Lab Temperature :	70° F
Sampling Date:	8/10/17	Loading Rate:	55 psi/s
		Time to Failure:	6 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	18,260 lb
Length:	4.57 in	Compressive Strength:	5,930 psi
L/D:	2.31	Compressive Strength:	40.89 Mpa
End Area:	3.08 in^2	Unit Weight	176 pcf

Before the Test

After the Test

Drawing # :	PA-CA-0016.0000-RD
PO # :	20170804-11
Crossing :	Goldfinch Lane
Spread :	Spread 2

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	10/3/2017
Location:	Spread 2		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/10/2017

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

Boring No.:	B2-2W	Lithology :	Shale
Sample No.:	7	Moisture Content :	As received
Sample Depth:	136 feet	Lab Temperature :	70° F
Sampling Date:	8/10/17	Loading Rate:	55 psi/s
		Time to Failure:	11 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	35,190 lb
Length:	4.37 in	Compressive Strength:	11,314 psi
L/D:	2.20	Compressive Strength:	78.01 Mpa
End Area:	3.11 in^2	Unit Weight	170 pcf

Before the Test

After the Test

Drawing # :	PA-CA-0016.0000-RD
PO # :	20170804-11
Crossing :	Goldfinch Lane
Spread :	Spread 2

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	10/3/2017
Location:	Spread 2		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/10/2017

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

Boring No.:	B2-2E	Lithology :	Shale
Sample No.:	2	Moisture Content :	As received
Sample Depth:	67 feet	Lab Temperature :	70° F
Sampling Date:	8/9/17	Loading Rate:	55 psi/s
		Time to Failure:	3 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	9,980 lb
Length:	3.47 in	Compressive Strength:	3,209 psi
L/D:	1.74	Compressive Strength:	22.12 Mpa
End Area:	3.11 in^2	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

Photographs are mislabeled as 2-2E-1

After the Test

Drawing # :	PA-CA-0016.0000-RD
PO # :	20170804-11
Crossing :	Goldfinch Lane
Spread :	Spread 2

Project:	Mariner East Pipeline	Terracon	Performed by:	H. Whitford
Project No.	J217P078		Test Date:	10/10/2017
Location:	Spread 2		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/10/2017

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

Boring No.:	B2-2E	Lithology :	Shale
Sample No.:	3	Moisture Content :	As received
Sample Depth:	80 feet	Lab Temperature :	70° F
Sampling Date:	8/9/17	Loading Rate:	55 psi/s
		Time to Failure:	5 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	15,860 lb
Length:	4.41 in	Compressive Strength:	5,151 psi
L/D:	2.23	Compressive Strength:	35.51 Mpa
End Area:	3.08 in^2	Unit Weight	163 pcf

Before the Test

After the Test

Drawing # :	PA-CA-0016.0000-RD
PO # :	20170804-11
Crossing :	Goldfinch Lane
Spread :	Spread 2

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	10/3/2017
Location:	Spread 2		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/10/2017

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

Boring No.:	B2-2E	Lithology :	Shale
Sample No.:	4	Moisture Content :	As received
Sample Depth:	86 feet	Lab Temperature :	70° F
Sampling Date:	8/9/17	Loading Rate:	55 psi/s
		Time to Failure:	3 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	9,460 lb
Length:	N/A in	Compressive Strength:	3,072 psi
L/D:	N/A	Compressive Strength:	21.18 Mpa
End Area:	3.08 in^2	Unit Weight	N/A pcf

Specimen length is not available. Photographs mislabeled as 2-2E-2.

Before the Test

After the Test

Drawing # :	PA-CA-0016.0000-RD
PO # :	20170804-11
Crossing :	Goldfinch Lane
Spread :	Spread 2

Project:	Mariner East Pipeline	Terracon	Performed by:	H. Whitford
Project No.	J217P078		Test Date:	10/10/2017
Location:	Spread 2		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/10/2017

Photograph 1: B2-2W, Samples C-1 to C-2 (24 to 25.5 feet)

Photograph 2: B2-2W, Samples C-3 to C-4 (25.5 to 35.5 feet)

Photograph 3: B2-2W, Samples C-5 to C-6 (35.5 to 45.5 feet)

Photograph 4: B2-2W, Samples C-7 to C-8 (45.5 to 55.5 feet)

Photograph 5: B2-2W, Samples C-9 to C-10 (55.5 to 65.5 feet)

Photograph 6: B2-2W, Samples C-11 to C-12 (65.5 to 75.5 feet)

Photograph 7: B2-2W, Samples C-13 to C-14 (75.5 to 85.5 feet)

Photograph 8: B2-2W, Samples C-15 to C-16 (85.5 to 95.5 feet)

Photograph 9: B2-2W, Samples C-17 to C-18 (95.5 to 105.5 feet)

Photograph 10: B2-2W, Samples C-19 to C-20 (105.5 to 115.5 feet)

Photograph 11: B2-2W, Samples C-21 to C-22 (115.5 to 125.5 feet)

Photograph 12: B2-2W, Samples C-23 to C-24 (125.5 to 135.5 feet)

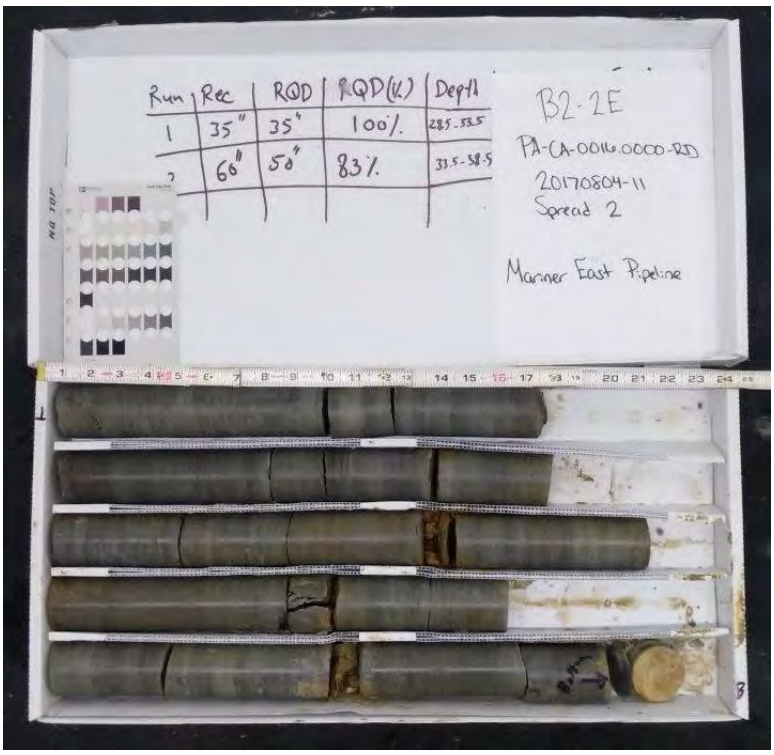
Photograph 13: B2-2W, Samples C-25 to C-26 (135.5 to 145.5 feet)

Photograph 14: B2-2W, Samples C-27 to C-28 (145.5 to 155.5 feet)

Photograph 15: B2-2W, Samples C-29 to C-30 (155.5 to 165.5 feet)

Photograph 16: B2-2W, Samples C-27 to C-28 (165.5 to 175.5 feet)

Photograph 17: B2-2W, Samples C-29 to C-30 (175.5 to 177 feet)



Photograph 1: B2-2E, Samples C-1 to C-2 (28.5 to 38.5 feet)

Photograph 2: B2-2E, Samples C-3 to C-4 (38.5 to 48.5 feet)

Photograph 3: B2-2E, Samples C-5 to C-6 (48.5 to 58.5 feet)

Photograph 4: B2-2E, Samples C-7 to C-8 (58.5 to 68.5 feet)

Photograph 5: B2-2E, Samples C-9 to C-10 (68.5 to 78.5 feet)

Photograph 6: B2-2E, Samples C-11 to C-12 (78.5 to 88.5 feet)

Photograph 7: B2-2E, Samples C-13 to C-14 (88.5 to 98.5 feet)

Photograph 8: B2-2E, Samples C-15 to C-16 (98.5 to 108.5 feet)

Photograph 9: B2-2E, Samples C-17 to C-18 (108.5 to 118.5 feet)

Photograph 10: B2-2E, Samples C-19 to C-20 (118.5 to 128.5 feet)

SUPPORTING INFORMATION

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ³ 4 and 1 £ Cc £ 3 [E]		GW	Well-graded gravel [F]
			Cu < 4 and/or 1 > Cc > 3 [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ³ 6 and 1 £ Cc £ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3 [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A"		CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried	< 0.75	OL	Organic clay [K,L,M,N] / Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried	< 0.75	OH	Organic clay [K,L,M,P] / Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ³ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ³ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ³ 30% plus No. 200 predominantly sand, add "sandy" to group name.

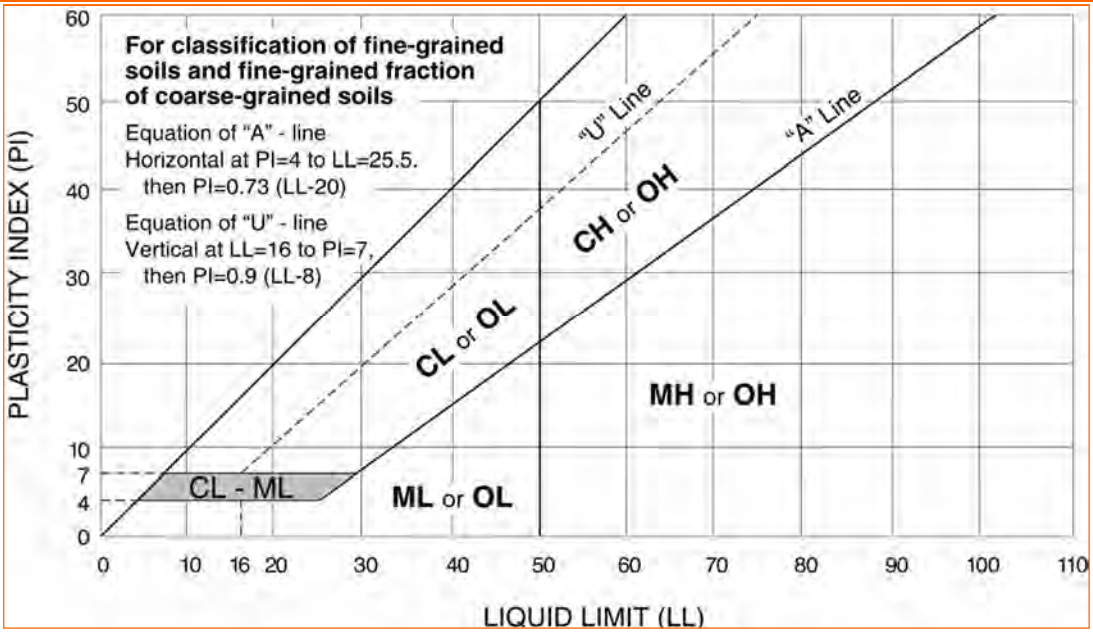
[M] If soil contains ³ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ³ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



DESCRIPTION OF ROCK PROPERTIES

WEATHERING	
Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very Slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately Severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very Severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" no discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.
HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)	
Very Hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately Hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very Soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding, and Foliation Spacing in Rock [1]

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

1. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designator (RQD) [1]

RQD, as a percentage	Diagnostic description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

1. RQD (given as a percentage) = length of core in pieces 4 inches and longer / length of run

Joint Openness Descriptors

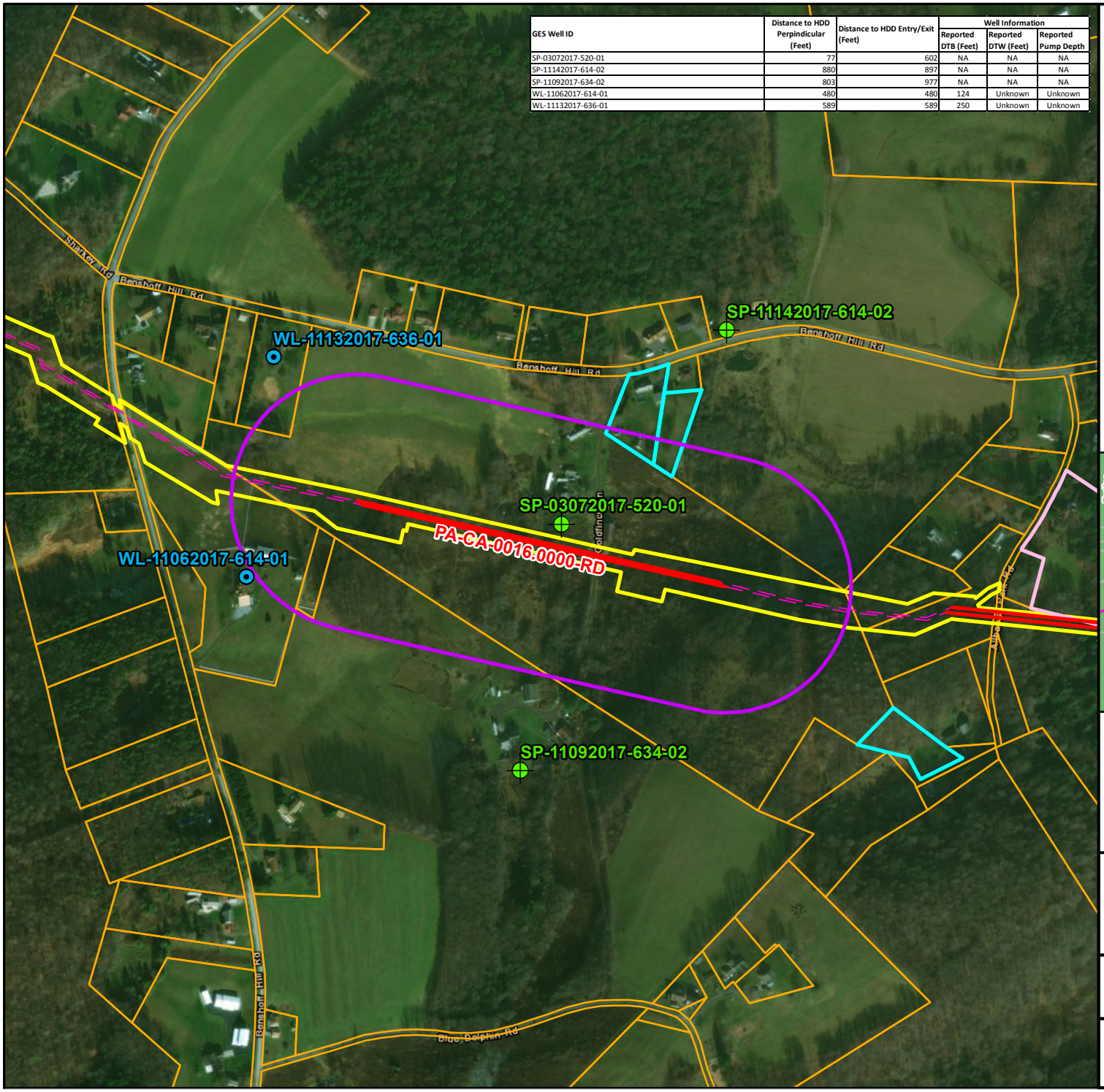
Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.

GOLDFINCH LANE CROSSING
PADEP SECTION 105 PERMIT NO.: E11-352
PA-CA-0016.0000-RD and PA-CA-0016.0000-RD-16
(SPLP HDD No. S2-0069)

ATTACHMENT 2

WATER SUPPLY ILLUSTRATION



GES Well ID	Distance to HDD Perpindicular (Feet)	Distance to HDD Entry/Exit (Feet)	Well Information		
			Reported DTB (Feet)	Reported DTW (Feet)	Reported Pump Depth
SP-03072017-520-01	77	602	NA	NA	NA
SP-11142017-614-02	880	897	NA	NA	NA
SP-11092017-634-02	803	977	NA	NA	NA
WL-11062017-614-01	480	480	124	Unknown	Unknown
WL-11132017-636-01	589	589	250	Unknown	Unknown

Legend

- LOD
- Parcel
- PPP Centerline
- HDD
- 450 foot buffer of HDD alignment
- Public Water Supply/Landowner Confirmed No Well
- Testing Refused

****Testing locations current as of 01/22/2018**

- GES Testing Location
- GES Spring Testing Location

Location

0 250 500

Feet

Well Location Map
HDD# PA-CA-0016.0000-RD
Cambria County, PA.

Prepared By: TETRA TECH

Date: 1/23/2018

Base Map;
ESRI World Imagery, 09/24/2015

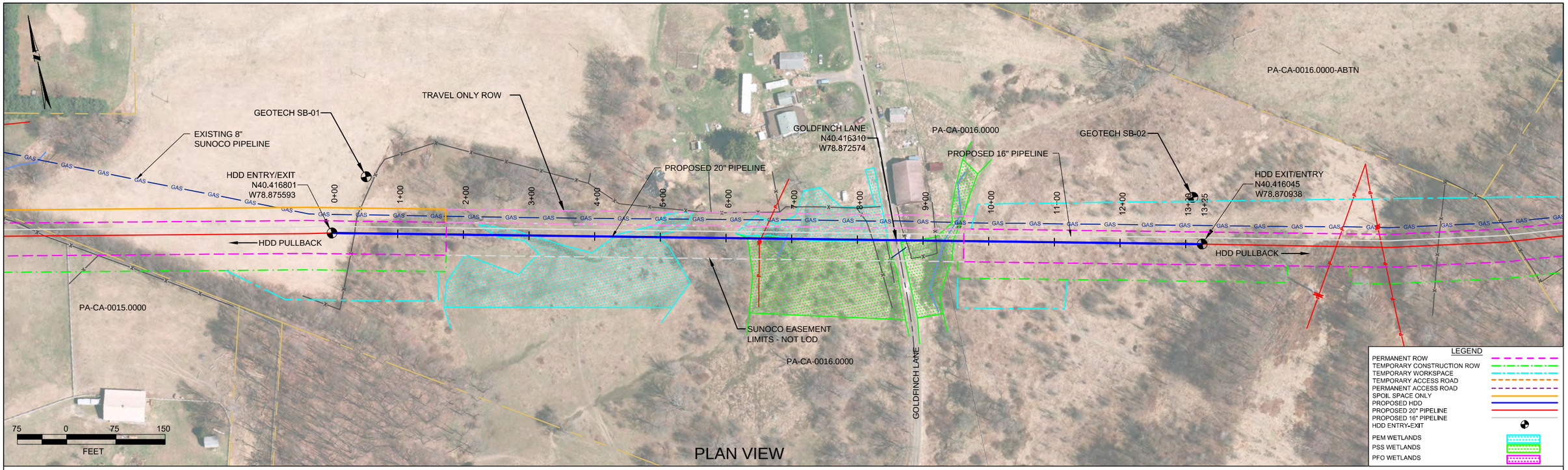
Coordinate System: NAD 83 Stateplane, PA South, Feet

P:\GIS\projects\112\0\0938-PFP\MXD\WellLocations\WellLocation_PA_CA_0016_0000.mxd JL

GOLDFINCH LANE CROSSING
PADEP SECTION 105 PERMIT NO.: E11-352
PA-CA-0016.0000-RD and PA-CA-0016.0000-RD-16
(SPLP HDD No. S2-0069)

ATTACHMENT 3

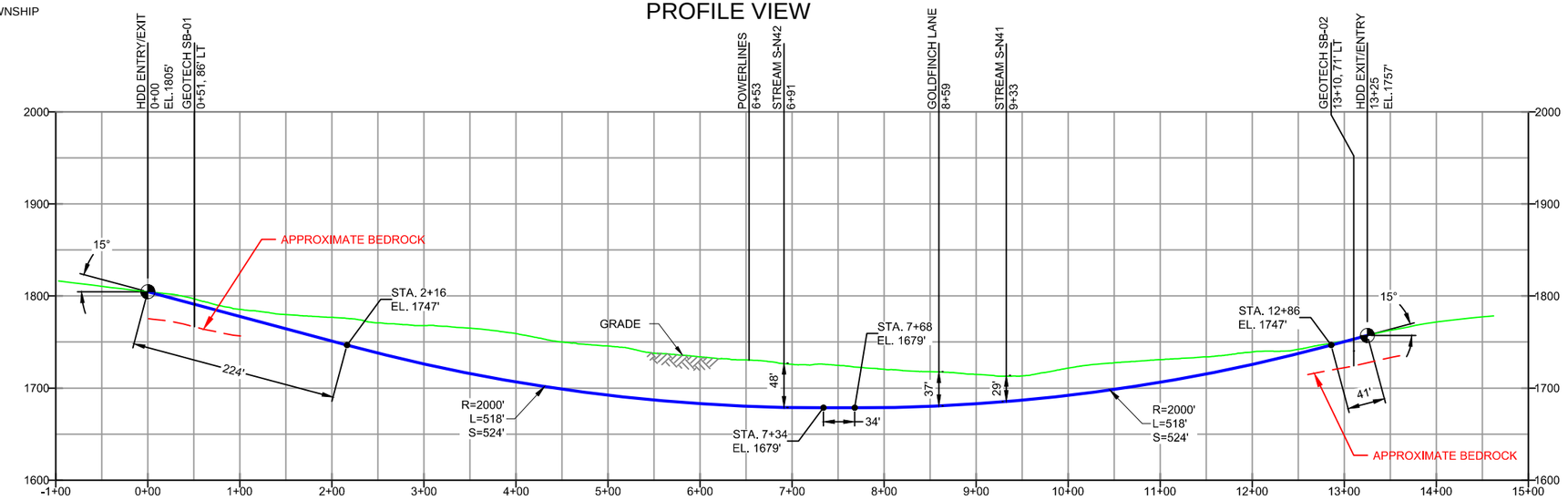
ORIGINAL AND REVISED HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES



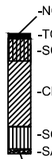
PLAN VIEW

CAMBRIA COUNTY PENNSYLVANIA, JACKSON TOWNSHIP
S2-0069

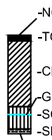
PROFILE VIEW



GEOTECH SB-01



GEOTECH SB-02



NOTE: REFER TO TEST BORING LOG S2-0069 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):1325'
   HDD PIPE LENGTH (S=): 1347'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

NOTES

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

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
3	REVISED PROFILE WITH 2017 LIDAR	MRS	03/17./17	RMB	03/17./17	CAG	03/17./17
2	REVISED PER ENGINEERING COMMENTS	MRS	08/26/16	RMB	08/26/16	AAW	08/26/16
1	ADDED "TRAVEL ONLY ROW" ANNOTATION	MRS	02/15/16	RMB	02/15/16	AAW	02/15/16
0	ISSUED FOR CONSTRUCTION	MRS	12/21/15	RMB	12/21/15	AAW	12/21/15

Sunoco Logistics Partners L.P.

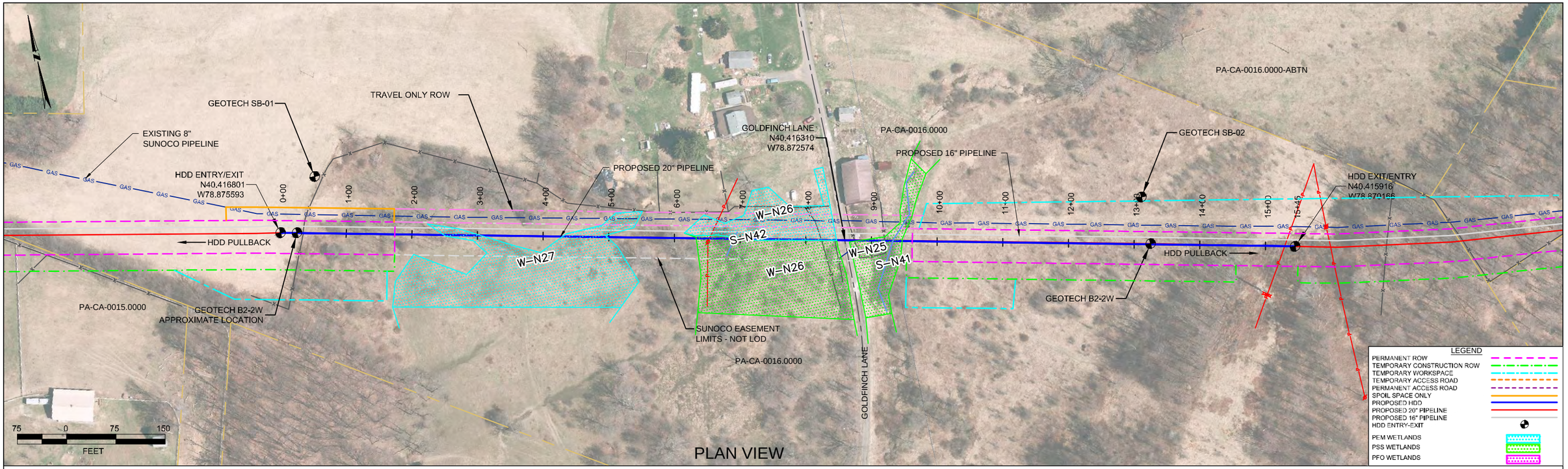
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
GOLDFINCH LANE
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'

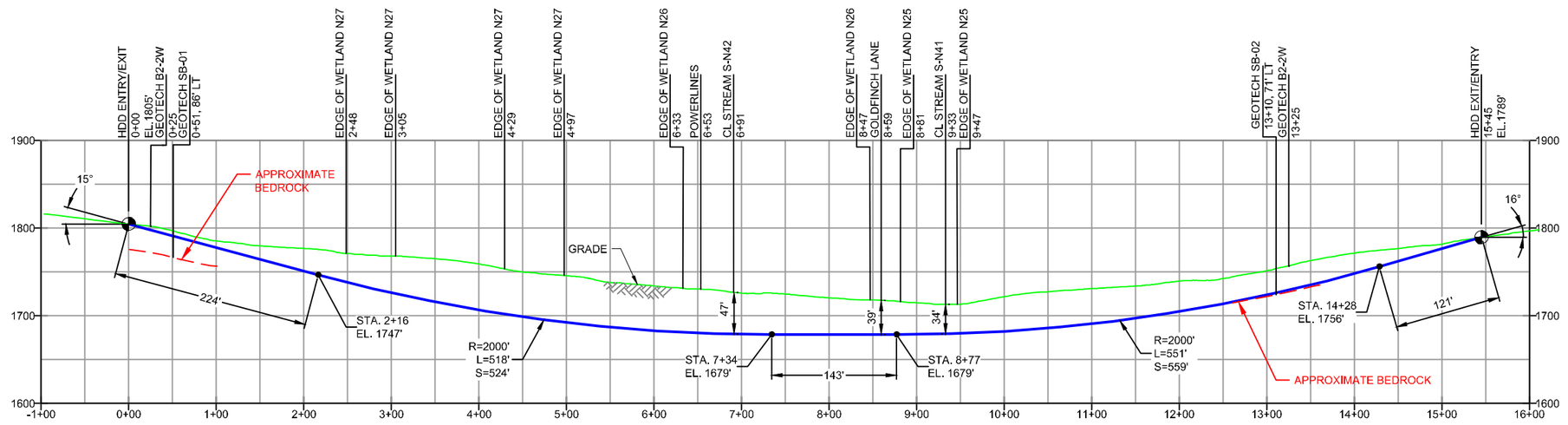
DWG. NUMBER: PA-CA-0016.0000-RD



PLAN VIEW

CAMBRIA COUNTY PENNSYLVANIA, JACKSON TOWNSHIP
S2-0069

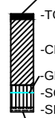
PROFILE VIEW



GEOTECH SB-01

-NG EL. 1791'
-TOPSOIL (0' - 0.3')
-SC/CL (0.3' - 6.5')
-CL (6.5' - 21.5')
-SC (21.5' - 28.0')
-SANDSTONE (28.0' - 28.1')
-COMPLETION DEPTH EL. 1163'

GEOTECH SB-02



-NG EL. 1740'
-TOPSOIL (0' - 0.5')
-CL (0.5' - 23.5')
-GROUNDWATER (25.0')
-SC (23.5' - 28.5')
-SHALE (28.5' - 30.0')
-COMPLETION DEPTH EL. 1710'

NOTE: REFER TO TEST BORING LOG S2-0069 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B2-2W

-NG EL. 1757'
-FAT CLAY CL (0.0' - 8.5')
-WEATHERED MUDSTONE SANDSTONE/SHALE (8.5' - 177.0')
-GROUNDWATER (100.0')
-BORING TERMINATED EL.1580'

NOTE: REFER TO TEST BORING LOG B2-2W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B2-2E

-NG EL. 1802'
-WEATHERED ROCK (0.0' - 28.5')
-GROUNDWATER (52.5')
-LIMESTONE/MUDSTONE (28.5' - 128.5')
-BORING TERMINATED EL.1673.5'

NOTE: REFER TO TEST BORING LOG B2-2E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:
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3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 1545'
   HDD PIPE LENGTH (S=): 1571'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
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11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

NOTES

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

REF. DRAWING

ES-2.14	TO	ES-2.15	EROSION & SEDIMENT PLAN
SHEET 9	TO	SHEET 9	AERIAL SITE PLAN
DWG NO		DWG NO	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP3	RELOCATED DRILL ENTRY/EXIT - DESIGN CHANGE PER DPS	MRS	09/21/17	RMB	09/21/17	CAG	09/21/17
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		DLM	03/15/16	RMB	03/15/16	AAW	03/15/16
C	ADDED GEOTECH INFO	MRS	09/04/15	RMB	09/04/15	AAW	09/04/15
B	ISSUED FOR BID	DLM	07/31/15	RMB	07/31/15	AAW	07/31/15

Sunoco Logistics Partners L.P.

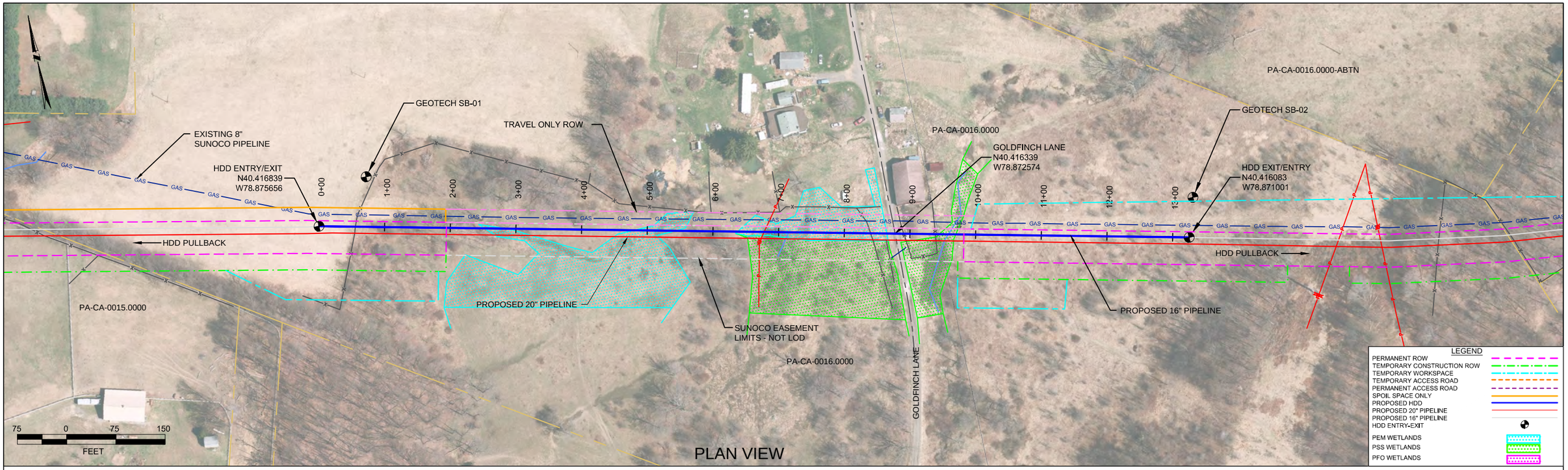
TETRA TECH ROONEY
(303) 792–5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
GOLDFINCH LANE
PENNSYLVANIA PIPELINE PROJECT

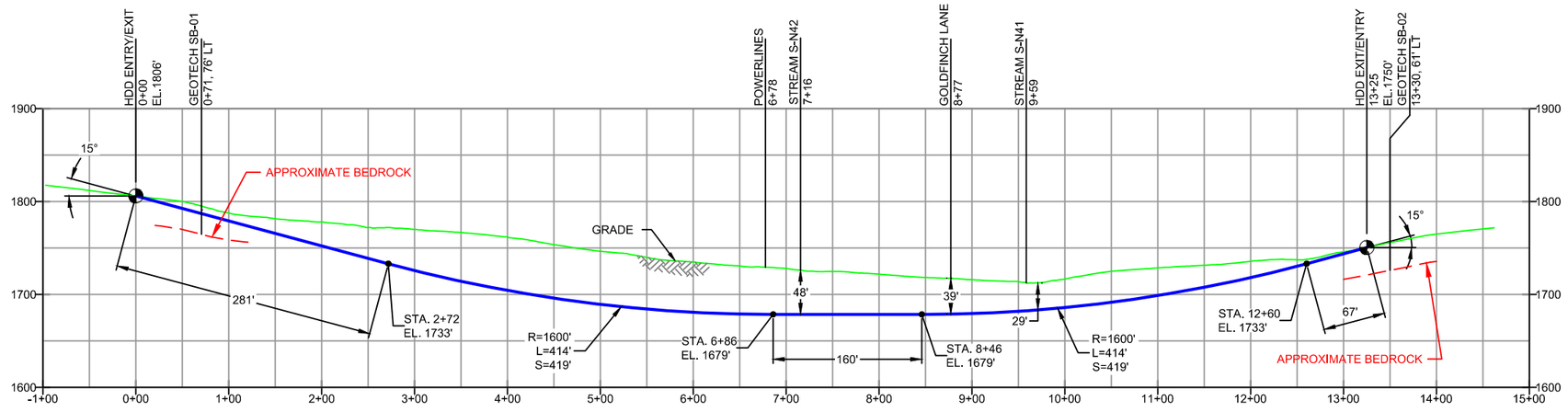
SCALE: 1"=150'

DWG. NUMBER: PA-CA-0016.0000-RD

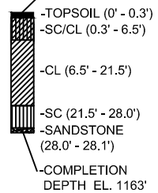


CAMBRIA COUNTY PENNSYLVANIA, JACKSON TOWNSHIP
S2-0069-16

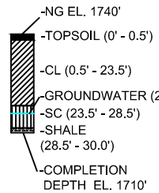
PROFILE VIEW



GEOTECH SB-01



GEOTECH SB-02



NOTE: REFER TO TEST BORING LOG S2-0069 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

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3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):1325'
   HDD PIPE LENGTH (S=): 1346'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
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NOTES

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REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
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2	REVISED PER ENGINEERING COMMENTS	MRS	08/26/16	RMB	08/26/16	AAW	08/26/16
1	ADDED "TRAVEL ONLY ROW" ANNOTATION	MRS	02/15/16	RMB	02/15/16	AAW	02/15/16
0	ISSUED FOR CONSTRUCTION	MRS	12/21/15	RMB	12/21/15	AAW	12/21/15

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
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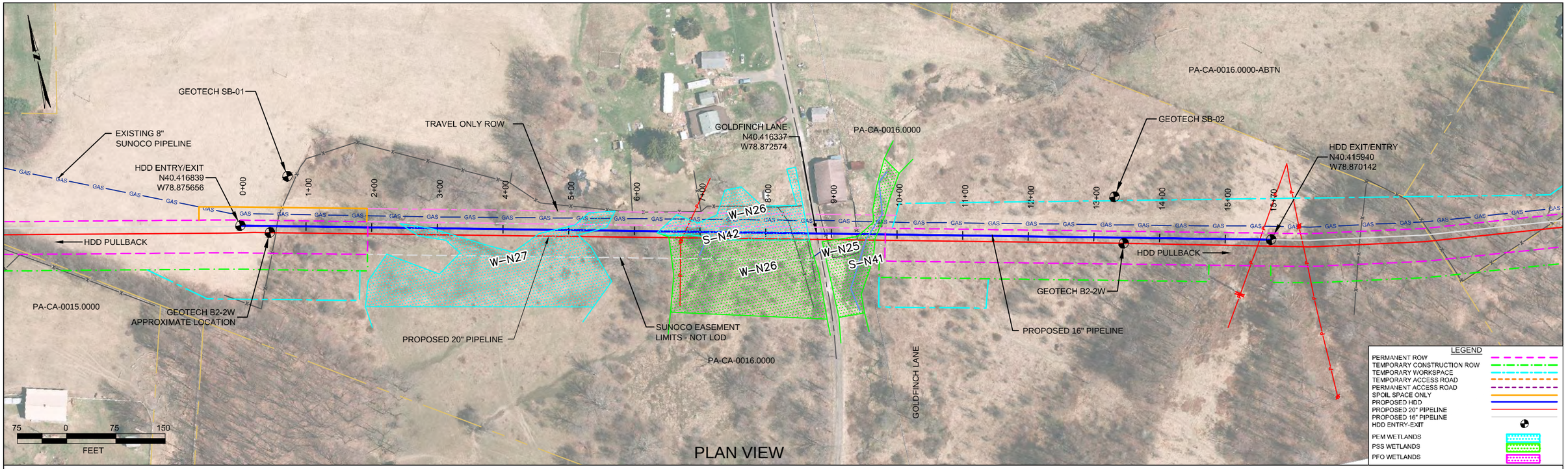
SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
GOLDFINCH LANE
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'

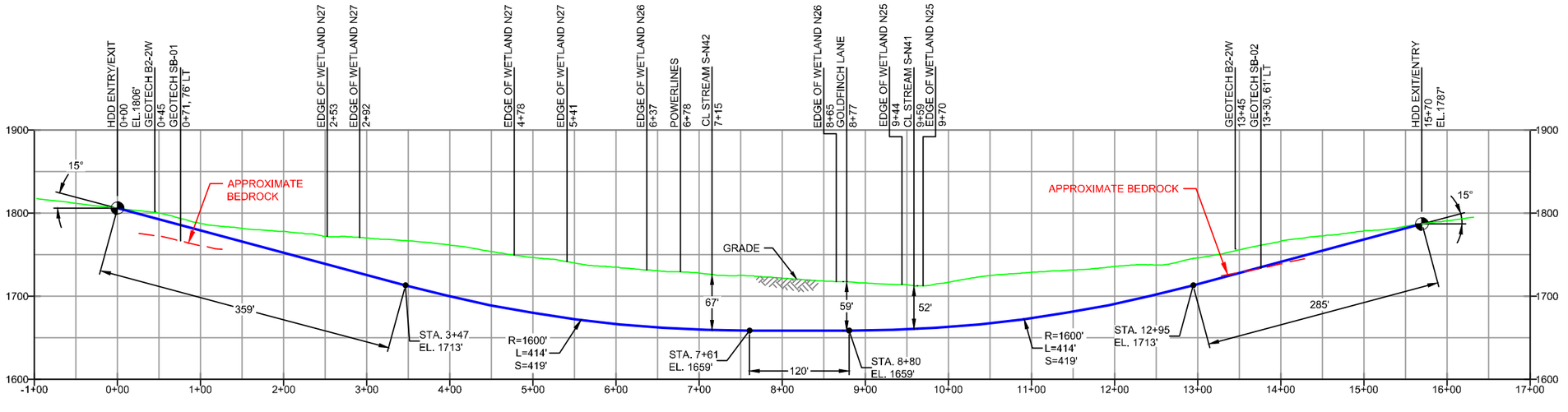
DWG. NO: PA-CA-0016.0000-RD-16



PLAN VIEW

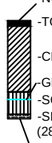
CAMBRIA COUNTY PENNSYLVANIA, JACKSON TOWNSHIP
S2-0069-16

PROFILE VIEW



GEOTECH SB-01

GEOTECH SB-02



NOTE: REFER TO TEST BORING LOG S2-0069 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B2-2W

NOTE: REFER TO TEST BORING LOG B2-2W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B2-2E

NOTE: REFER TO TEST BORING LOG B2-2E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

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4. CROSSING PIPE SPECIFICATION:
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   HDD PIPE LENGTH (S=): 1602'
   16" x 0.438" W.T., X-70, APISL, PSL2, ERW, BFW
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REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-2.14	TO	ES-2.15	EROSION & SEDIMENT PLAN
SHEET 9	TO	SHEET 9	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP3	RELOCATED DRILL ENTRY/EXIT - DESIGN CHANGE PER DPS	MRS	10/30/17	RMB	10/30/17	CAG	10/30/17
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EP1	REVISED PER PADEP COMMENTS	MRS	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		DLM	03/15/16	RMB	03/15/16	AAW	03/15/16
B	ADDED GEOTECH INFO	MRS	09/06/15	RMB	09/06/15	AAW	09/06/15
A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15

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SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
GOLDFINCH LANE
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150' | DWG. NO: PA-CA-0016.0000-RD-16