HORIZONTAL DIRECTIONAL DRILL ANALYSIS
NORFOLK SOUTHERN RAILROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E65-973
PA-WM1-0088.0000-RR
(SPLP HDD# S1B-0250)

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This reanalysis of the horizontal directional drill (HDD) installation of a 20-inch diameter pipeline crossing under stream S199, Penn Avenue, Norfolk Southern Railroad, and Depot Street (south to north), HDD No. S1B-0250, has been completed in accordance with paragraphs 4 and 5 of the Stipulated Order (Order) issued under Environmental Hearing Board Docket No. 2017-009-L. This HDD is number 3 on the list of HDDs included on Exhibit 2 of the Order

PIPE INFORMATION

20-Inch: 0.456 wall thickness; X-65

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

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 20-INCH

- Horizontal length: 2,093 foot (ft)
- Entry/Exit angle: 15-20 degrees
- Maximum Depth of cover: 99 ft
- Depth of cover under Brush Creek: 38 ft
- Pipe design radius: 2,000 ft

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

Bedrock in the area of HDD S1B-0250 consists of the cyclic sedimentary rocks of the Glenshaw Formation, part of the Conemaugh Group. It contains repeated sequences of sandstone, siltstone, shale, claystone (including red beds), limestone, and coal. Shale is the primary rock type. 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. Nickelsen and Hough (1967) conducted regional mapping of joints in shale, coal, and sandstone in the Appalachian Plateau. In the vicinity of HDD S2-0080, 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.

Based on published geologic data, no karst features are anticipated within the region of HDD S1B-0250 as limestone units are relatively thin and discontinuous in the Glenshaw Formation; therefore the use of geophysics was not considered for this HDD reanalysis.

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

HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

There is very little primary porosity associated with the sedimentary rocks of western Pennsylvania for the storage and movement of groundwater. The primary occurrence of groundwater in the Glenshaw Formation is associated with the interconnected network of secondary porosity features characteristic of the bedrock. These include bedrock joints and fractures, faults, and bedding plane partings.

A static water level of 115 feet was estimated for geotechnical boring B1-4W, with perched water detected at 14.6 and 31.5 feet. A static water level of 31.4 feet was noted in boring B1-4E. A Pennsylvania Groundwater Information System (PAGWIS) search for domestic supply wells within 450 feet of the HDD ROW did not produce a single well record from which a static water level could be

reported. A PAGWIS search was performed for water supply wells within 450 feet of the HDD ROW, which produced no records. A search of all Glenshaw formation domestic wells in Westmoreland County produced a listing of 287 records. The range of well yields was from 0.5 to 200 gallons per minute (gpm) with an average of approximately 9.6 gpm. The production zone for waters wells in a bedrock formation is from the well bottom to highest point of water inflow from the water bearing seams, joints, and fractures in the rock formation.

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

INADVERTENT RETURNS DISCUSSION

On June 27, 2017, during an initial attempt to drill this HDD, a loss of circulation occurred at approximately 910 feet out and at approximately 99 ft bgs. The driller noted a void in the boring from 910 feet to 929 feet, drilling north to south. This pilot hole proved difficult to steer and multiple attempts were made to pull rods back and reenter the boring on the correct alignment. During verification of the tracking data for the pilot hole in progress, it was discovered that the 12-inch line was not accurately located and resurveying was required. Drilling was suspended on July 15, 2017 in order to reevaluate the drill design in relation to the verified location of the Mariner I pipeline and based upon the verification data, a new profile was designed to ensure safety during installation of the proposed 20-inch pipeline.

To date, all of the IRs in Spreads 1 and 2 for the Mariner II pipeline 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. The majority have occurred during entries and exits through alluvium, colluvium and soils developed on top weathered bedrock. In general, the IRs have been related to shallow overburden (especially under water bodies), large elevation changes between entries and entry/exits, coarse grained unconsolidated materials near the surface (such as alluvium and mine spoil), deep coal mines, and the interconnectivity of open bedrock structural features that is difficult to predict.

The results of the core borings at the entry and exit points show the HDD will encounter variable bedrock strength conditions as depth to profile increases. During the transition to maximum depth the recovery values vary from 40 to 60 and RQD varies from 60 to 100. At maximum depth of profile, which is also the depth of profile under the railroad and Brush Creek the rock layer has an recovery value of 60 and RQD of 100. This is indicative of moderate to good overall rock quality which assists in suppression of IRs.

The redesign of the HDD will not prevent all IRs. IR's are common on entry and exit of the drilling tool, and other measures are required to minimize IR potential as described in the *Reconsideration of the Horizontal Directional Drill* section below.

ADJACENT FEATURES ANALYSIS

The crossing of Brush Creek (stream S199) is located immediately south of Penn Avenue, approximately 200 feet west of the intersection with 18th Street. This location is approximately 0.5 miles east of Penn, Pennsylvania.

This location is set primarily within a residential area, however there are industrial buildings in the immediate vicinity, and the Norfolk Southern railroad line crosses perpendicular to the pipeline route approximately 500 feet north of the Brush Creek crossing. The path of the revised HDD is in close proximity to residences along six streets in the community of Jeanette.

As noted above, a PAGWIS search was performed for water supply wells within 450 feet of the HDD ROW, which produced no records, and there are no other publicly available records that indicate the presence of any private water wells within 450 ft of the HDD. In accordance with the terms of the Order, SPLP has identified all landowners with property located within 450 ft of the HDD alignment. There are fifty-eight (58) 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 it's 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.

If any landowner with the 450 ft HDD alignment fails to respond November 15, 2017, agents for SPLP will initiate direct contact by phone or in person to attempt to determine the potable water source for each landowner. Based on the response to the mailings and direct contact, the landowners with private water wells determined to be at risk during the HDD will be offered alternative water supplies until the HDD is complete.

ALTERNATIVES ANALYSIS

As required by the Order, the reanalysis of S1B-0250 included 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.

In addition, as discussed in the Alternatives 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. The Norfolk Southern Railroad HDD is co-located within an existing SPLP pipeline ROW and rerouting would cause new greenfield impacts.

As described below, several alternatives to the previously permitted HDD were evaluated.

The proposed HDD alternative is the primary plan of installation to cross Penn Avenue, the Norfolk Southern railroad, and the extremely steep slope leading to Brush Creek from the south. The HDD also was designed to minimize impact to a Chapter 93 designated trout stocked fishery.

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Open-cut Analysis

Conversion to open cut would result in direct but temporary impacts to PADEP designated trout stocked fisheries. 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 stream S199, 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 12" pipeline for integrity management. The assessed area of impact by this open cut plan would directly affect 0.063 acres of state water bottom and 0.143 acres of Federal Emergency Management Agency designated 100-year floodway. Stream S199 (Brush Creek) is a 35-foot-wide perennial stream. To make this conventional crossing would require the damming the stream using a 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. Although the temporary impacts would be controlled and managed using these appropriate mitigation measures, the preferred method is to drill below these resources and avoid direct impacts and associated long term effects.

Additional impacts at this site would be significant erosion and sediment controls on the hillslope leading into Brush Creek from the south, possibly distracting traffic on Penn Avenue.

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. The Norfolk Southern Railroad Crossing HDD is co-located within the existing SPLP 12" pipeline ROW and rerouting would cause new greenfield impacts. In addition, given the size, length, and general perpendicular direction of Brush Creek, no practicable re-route option lies to the east or west of the proposed route that would not ultimately cross Brush Creek, or the Norfolk Southern railroad.

RECONSIDERATION OF THE HORIZONTAL DIRECTIONAL DRILL

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 increases 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: 2,528 foot (ft)
- Entry/Exit angle: 11-14 degrees
- Maximum Depth of cover: 100 ft
- Depth of cover under Brush Creek: 84 ft
- Pipe design radius: 2,200 ft

This redesign of the HDD will not eliminate the risk of all IRs. IR's are common on entry and exit of the drilling tool, and other measures are required to minimize IR potential. In particular, upon the restart of this HDD, Sunoco will employ the following HDD best management practices:

- 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 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 of the pilot hole may be implemented;

- If necessary, the pilot hole and reaming phases at the point of entry for the HDD may utilize casing, hammered into the substrate down to structurally better rock, to prevent vertical or lateral movement of drilling fluids at shallow depths; and

CONCLUSION

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

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(SPLP HDD# S1B-0250)

ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT

HDD HYDROGEOLOGIC REEVALUATION REPORT

Mariner East II
Spread 1
HDD S1B-0250
Norfolk Southern RR
Penn Borough, Jeannette, and Hempfield Townships, Westmoreland County, Pennsylvania

Prepared for:

Sunoco Pipeline, L.P.

Prepared by:

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

November 2017

HDD HYDROGEOLOGIC REEVALUTION REPORT

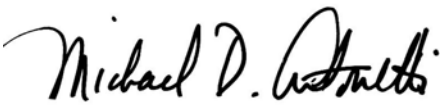
Mariner East II
Spread 1
HDD S1B-0250
Norfolk Southern RR
Penn Borough, Jeannette, and Hempfield Townships, Westmoreland County, Pennsylvania

November 2017

Prepared for:

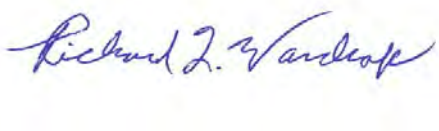
Sunoco Pipeline, L.P.
535 Fritztown Road
Sinking Spring, Pennsylvania 19608

Prepared by:



Michael D. Antonetti, P.G.
Sr. Project Manager

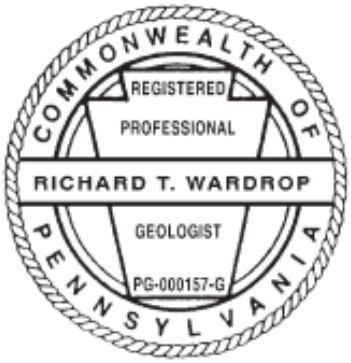
Reviewed by:



Richard T. Wardrop, P. G.
Principle Hydrogeologist

Groundwater & Environmental Services, Inc.
440 Creamery Way, Suite 500
Exton, Pennsylvania 19341
(610) 458-1077

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



November 10, 2017

Richard T. Wardrop, P. G. Date

Lic. No. PG000157G

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1.0 INTRODUCTION

Sunoco Logistics Pipeline, L. P. (SPLP) retained Groundwater & Environmental Services, Inc. (GES) to prepare HDD Hydrogeological Reevaluation Reports (HRR) for certain higher-risk horizontal directional drilling (HDD) locations listed on Exhibit 2 of Stipulated Order EHB Docket No. 2017-009-L signed August 10, 2017. This report discusses the HRR for the 20-inch HDD S1B-0250, Norfolk Southern Railroad, PA-WM1-0088.0000-RR (HDD S1B-0250), near the Norfolk Southern RR in Penn Borough, Jeanette, and Hempfield Townships, Westmoreland County, PA. A map depicting the location of the HDD with topographic information on the surrounding area is presented as **Figure 1**. The HDD started drilling on June 6, 2017 and stopped for reevaluation on July 7, 2017. This HRR addresses the original plan and profile (original plan) for HDD S1B-0250 presented in the IR PPC Plan for Westmoreland County (rev. 9/30/16) and a proposed revised plan prepared by Tetra Tech Rooney (rev. 8/29/17).

As described in the Stipulated Order (pages 3 and 4), the HRRs will provide information to eliminate, reduce, or control the release or inadvertent return (IR) of HDD drilling fluids to the surface of the ground or impact to water supplies at the location during HDD operations.

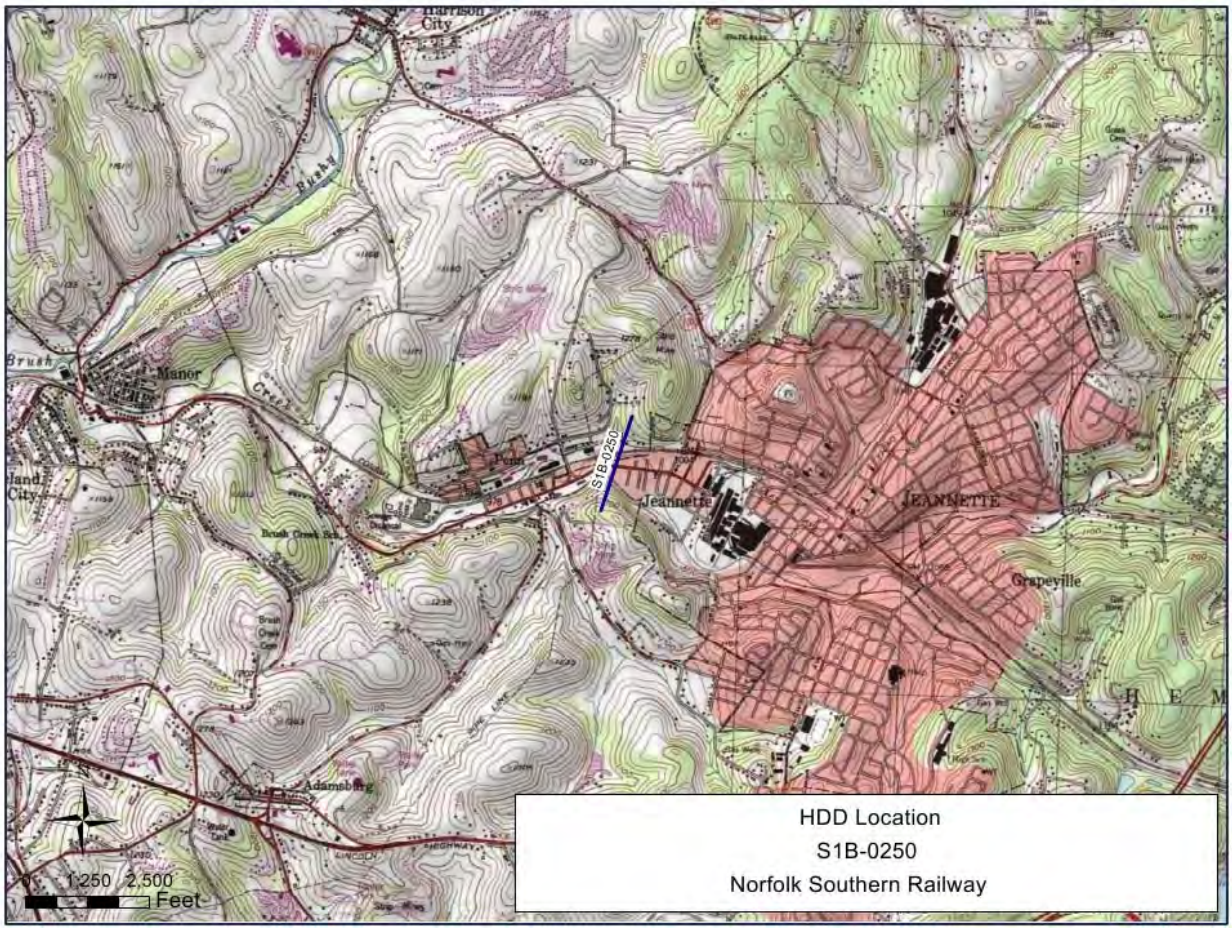

Figure 1. Site Location Map (modified from USGS Irwin 7.5 minute Topo Quad. Map)

This report presents the following information:

- Geologic and hydrogeologic characteristics in the area of HDD S1B-0250;
- 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 June 2013 and more recently by Terracon Consultants, Inc. (Terracon), in August 2017 in support of the HDD S1B-0250 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 soil, rock cores and water levels 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

The discussion presented in this report is based on an alignment and profile developed by Tetra Tech/Rooney, revised on 9/30/16 (original boring). During the reevaluation, GES was provided with a revised boring profile revised 8/29/17 (revised boring). The revised boring profile was developed to increase the depth of the borehole along the southern entry/exit point by extending the southwest entry/exit point and making the profile longer. The purpose of this adjustment is to minimize the risk of inadvertent returns (IRs) by redesigning HDD S1B-0250 deeper into competent bedrock. For the purpose of this assessment, GES utilized both HDD designs to evaluate the hydrogeologic conditions at HDD S1B-0250.

2.1 Physiography

HDD S1B-0250 is located within the Allegheny Mountain Section of the Appalachian Plateaus Province, which is characterized by wide ridges separated by broad valleys.

2.1.1 Topography

The site location in the area topographic setting is depicted on **Figure 1**. As shown on the original plan and profile (**Attachment A**) the topography in the area of HDD S1B-0250 is relatively flat at the northern entry/exit point, sloping down gently as it progresses south to a low point at Brush Creek, then sloping upward and increasing elevation up to the southern entry/exit point. In map view, the alignment is generally continuous broad curve concave to the east. The HDD is located between Stations 2210+00 and 2230+00 using the statewide stationing scheme and has an overall length of 2,040 feet. The area surrounding the HDD is comprised of mixed commercial, residential, and undeveloped properties.

The original profile was approximately 2,028 feet long. Station ran north to south with the eastern entry exit at 1068 feet above mean sea level (amsl), Norfolk Southern Railroad at station 8+35 (elevation 985 ft amsl), Brush Creek at station 13+05 (elevation 965 ft amsl), and southern entry/exit at station 20+38 (evaluation 1,145 ft amsl). The revised profile is 2,528 feet long as the northern entry/exit is extended approximately 34 feet north and the southern entry/exit is extended 456 feet south. Stationing on the revised profile begins at 0+00 at the northern entry/exit as opposed to -0+34. The revised profile is intended to reduce inadvertent return (IR) risk by deepening the boring, such as moving the depth under Brush Creek from 35 feet to approximately 84 feet and moving the depth under the flood plain, north of Brush Creek, from approximately 70 feet to 100 feet. On the original profile the distance between the ME I 12-inch line and proposed ME II 20-inch line is approximately 35 feet of less in the vertical dimension. On the revised profile the 20-inch line is separated by greater distance south of Station 14+00, ranging from approximately 35 to 150 feet vertical separation. The 20-inch profile runs coincident to the 12-inch moving north from Station 11+00 then becomes deeper but does not achieve vertical separation more than approximately 37 feet before the northern entry/exit.

2.1.2 Hydrology

The original HDD S1B-0250 alignment crossed Brush Creek (S199). Local feeder streams collect and flow into Brush Creek along the alignment. The stream then flows approximately 8.1 miles northwest before merging with Turtle Creek.

2.2 Geology

2.2.1 Soils

Soils across the profile are comprised of a channery silt loam on the slopes and upland portions, and silt loam grading to a sandy loam with cobbles. Northern and southern entry/exit points are likely to encounter bedrock at an approximate depth of 3 feet below grade. The soil horizon across the central area of the profile are likely to encounter bedrock at greater than 6 feet below grade. Soils along the profile are well

drained with shallow groundwater at less than 3 feet below grade along the lowland portion of the profile. The water table is reported at greater than 6 feet below grade at the northern and southern entry/exit points (see **USDA**, WSS http:\\websoilsurvey.nrcs.usda.gov for Westmoreland County, PA).

2.2.2 Bedrock Lithology

Bedrock in the area of HDD S1B-0250 consists of the cyclic sedimentary rocks of the Glenshaw Formation, part of the Conemaugh Group. It contains repeated sequences of sandstone, siltstone, shale, claystone (including red beds), limestone, and coal. Shale is the primary rock type. **Figure 2** is a map depicting the bedrock formations in the area of HDD S1B-0250.

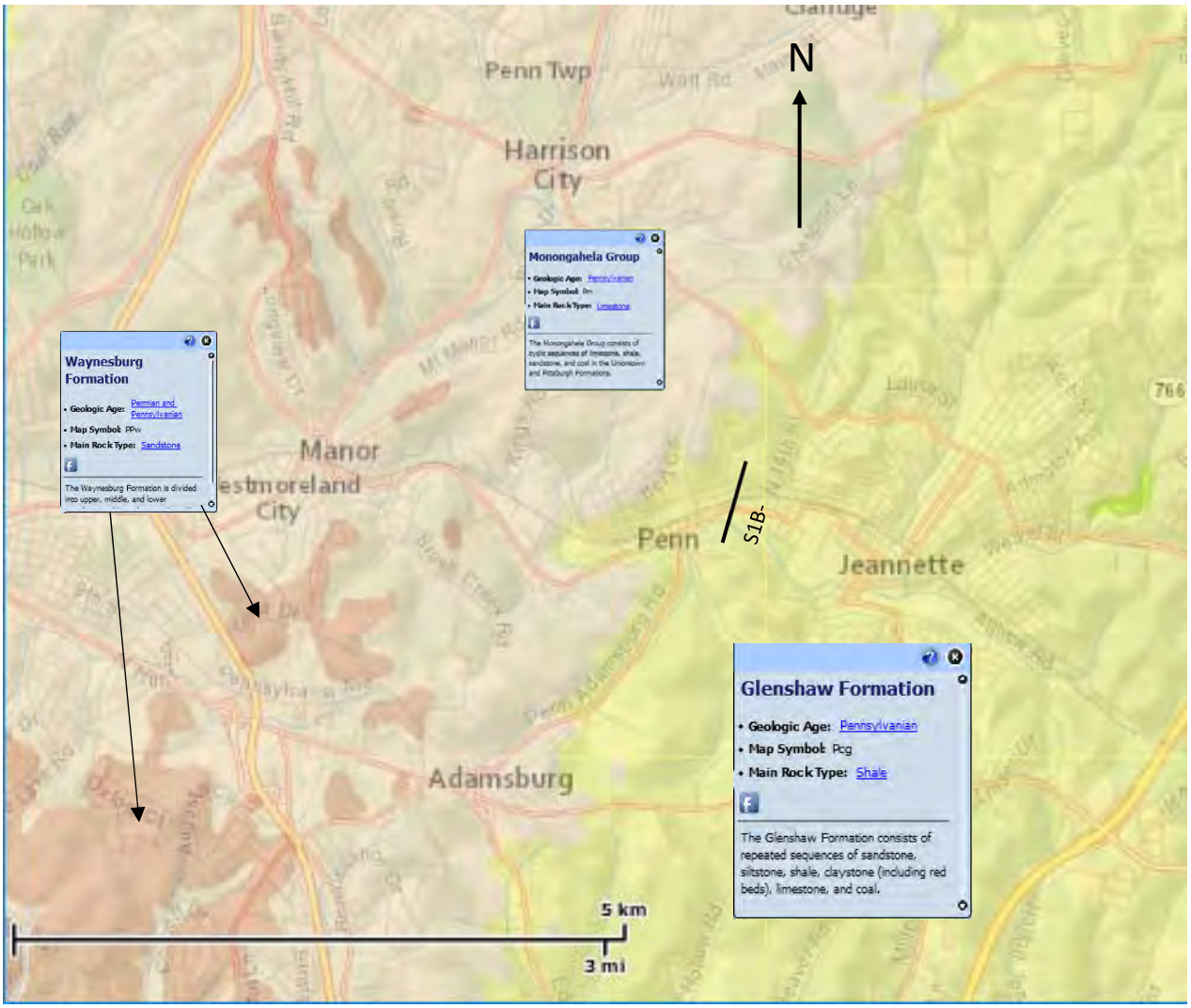

Figure 2. Site Geologic Map (modified from PA DCNR Map Viewer, http://www.gis.dcnr.state.pa.us/maps/index.html)

2.2.3 Structure

Figure 3 shows HDD S1B-0250 boring in association with the on the eastern limb of the Port Royal (Irwin) Syncline and the western limb of the Grapeville Anticline. 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. Nickelsen and Hough (1967) conducted regional mapping of joints in shale, coal, and sandstone in the Appalachian Plateau. In the vicinity of HDD S2-0080, 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.

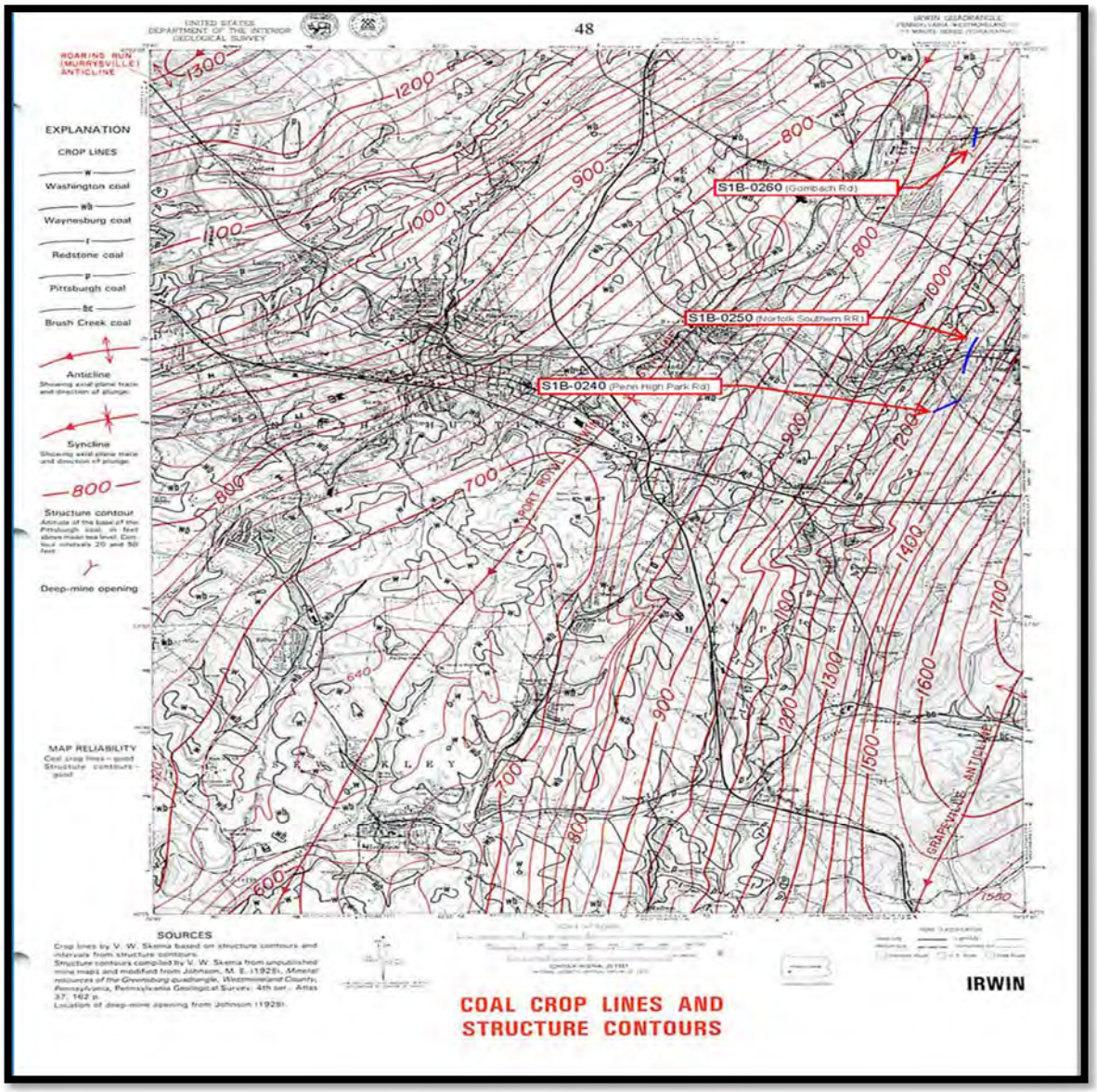

Figure 3. Coal Crop Lines and Structure Contours (modified from Skema, 1988)

2.2.4 Fracture Trace Analysis

A 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 (1 mile in length or less) and lineaments (greater than 1 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 4 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 therefore; fracture traces are more easily seen. Several fracture trace orientations are shown

on **Figure 4**. Two general sets of orientations are present in the mapped fracture traces. Most traces are oriented with trends between NNW and NNE. Two traces are oriented NW and one is oriented NE.

Figure 4. Fracture Trace Map

The proposed path of the revised boring is shown in red on **Figure 4** and two of the mapped fracture traces intersect the drill path in the middle part of the alignment.

2.2.5 Karst

Based on published geologic data, no karst features are anticipated within the region of HDD S1B-0250 as limestone units are relatively thin and discontinuous in the Glenshaw Formation.

2.2.6 Mining

Published information indicate that the region has been exposed to extensive deep mining of the Pittsburgh Coal (Skema, 1988 and Pennsylvania Mine Atlas http://www.minemaps.psu.edu/). **Figure 5** illustrates the extent of base Pittsburgh mining proximal to the HDD. As shown, the limits of deep mining occur due west and north of the HDD but do not underlie the HDD. This was confirmed by searching the Pennsylvania Mine Atlas site and the PADEP eMap site (http://www.depgis.state.pa.us/emappa/) for active mining permits.

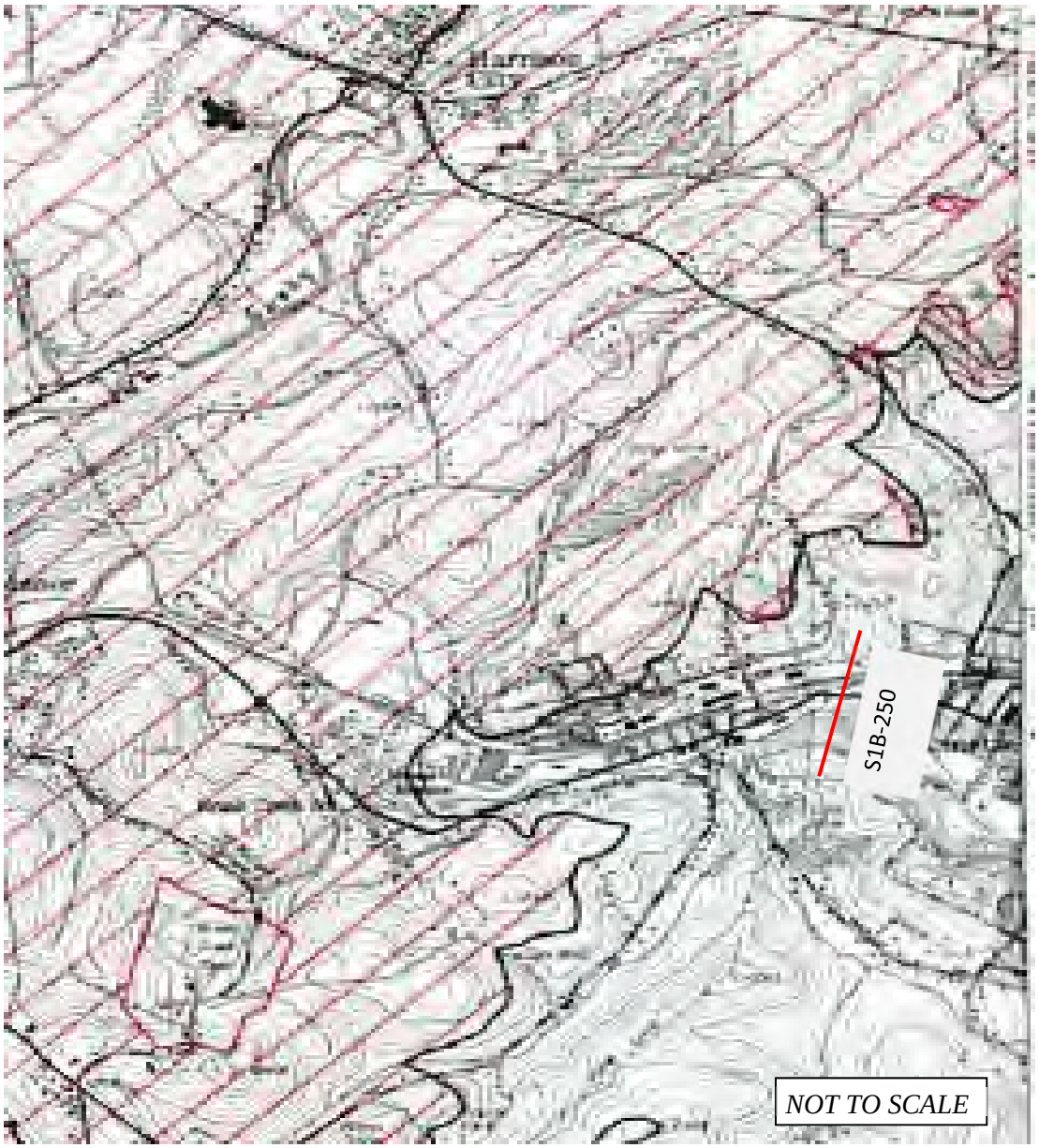

Figure 5. Mined Areas of Pittsburgh Coal (modified from Skema, 1988)

2.2.7 Rock Engineering Properties

The Conemaugh Group rock properties are as follows (Geyer and Wilshusen 1982):

- Mostly well bedded; thickness of beds varies with lithology, ranging from a fraction of an inch to several feet; very poor bedding in underclay; sandstone may be massive; shale is thin and fissile; limestone is thin.
- Joints are poorly to moderately well formed; open and vertical; closely to moderately spaced; moderate distribution; effects of faulting may be severe; subsidence fractures may be encountered where underground coal and clay mining has taken place.
- Drilling rates (vertical) are moderate to fast.

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 weathering, whereas, claystone, shale, and coal weather extensively and deeply.
- Fast to moderate drilling rate (vertical).

2.2.8 Results of Geotechnical Borings

Original Geotechnical Borings

Prior to construction of HDD S1B-0250, two geotechnical boring (HDD-015A and HDD-15B) were advanced. HDD-15A was located 103 feet west of the alignment at Station 11+72 and HDD-15B was located 25 feet east of the alignment at Station 5+79. Data collected from near surface samples indicated fine grained soils weathered from mudstones. Auger refusal was encountered at 17.5 feet below ground surface (ft bgs) in HDD-15A and at 23.5 ft bgs at HDD-15B. HDD-15A was advanced by coring to a final depth of 33.5 feet. The two 5-foot cores of claystone had rock quality designations (RQDs) of 23% and 69% that increased with depth. A static water level was obtained from HDD-15A at approximate elevation 957 ft amsl. No coring was performed at HDD-15B and the boring did not go deep enough to intersect the local water table.

Recent Terracon Geotechnical Borings

The TerraCon geotechnical report for HDD S1B-0250 was issued on October 9, 2017 and included data collected during the advance of two new geotechnical borings, B1-4W drilled at the southern entry/exit on the revised plan and profile and B1-4E, drilled at the northern entry/exit. B1-4W and B1-4E were drilled to 318 and 242 feet, respectively.

Boring B1-4E is located near the northern entry/exit point where the surface elevation is approximately 1,068 ft amsl while B1-4W was located near the southern entry/exit point at a surface elevation of approximately 1,172 ft amsl. Soil was encountered for the first 13.5 feet in B-4E and was described as fat clay with rock fragments. At 13.5 ft bgs the boring encountered a highly weathered bedrock zone with clay seams and split spoon refusal was encountered at 14.0 ft bgs. At boring B1-4W the first 8.5 ft bgs was described as lean clay, transitioning to a highly weathered shale. Competent bedrock as encountered at 24 ft bgs.

At boring B1-4W perched groundwater was encountered in the weathered shale at 14.6 ft on the second day of drilling (August 10, 2017); however, a second, much deeper water level was recorded at 115 ft bgs (approximate elevation 1,057 ft amsl) on August 15, 2017. Multiple water level measurements obtained during the advance of B1-4E were consistently around 31.5 feet bgs (approximate elevation 1,036.5 ft amsl).

Bedrock was encountered in boring B1-4E at 13.5 ft bgs and coring began there. The bedrock is predominantly described as soft, severely to moderately weathered, reddish-brown to gray mudstone with very thin bedding and occasional beds of limestone and sandstone. Low angle fractures (designated as joints on the log) were noted with very close to close spacing, tight to slightly open, and smooth to slickensided surfaces. Intermittent occurrences of sandstone and limestone are noted throughout the core as was low angle fracturing. Weathering was noted throughout the column as were iron stained fractures. After an initial upper zone of low RQDs from 12 to 27 ft bgs, RQDs varied widely over a range from 0%

to 100%. From 42 ft to total depth at 242 ft bgs, fifteen of forty 5-foot core runs had RQDs less than 50%. Sample recovery was lost between 59 and 70.2 feet, which may indicate a highly fracture zone or void. A zone of elevated RQDs (all 90% or greater) is noted for the interval between 82 and 117 ft bgs.

Competent bedrock was encountered in boring B1-4W at 24 feet bgs (1,148 ft amsl) and includes sequences of predominantly mudstone with occasional thin interbeds of limestone, sandstone and shale. The bottom interval, 253 ft to the total depth of 318 ft bgs was logged as shale and siltstone. Highly fractured zones consisting of high angle to vertical fractures were more common in this boring throughout the column. Recovery was consistently high ranging from 80% to 100% with most values over 90%. RQDs varied widely throughout the cored bedrock ranging from 47% to 100%. A zone of lower RQDs is noted from 83 to 128 ft bgs, ranging from 47% to 78%. Zones of elevated RQDs are noted from 128 to 168 ft bgs and from 268 to 318 ft bgs, ranging from 83% to 100%.

2.3 Hydrogeology

2.3.1 Occurrence of Groundwater

There is very little primary porosity associated with the sedimentary rocks of western Pennsylvania for the storage and movement of groundwater. The primary occurrence of groundwater in the Glenshaw Formation is associated with the interconnected network of secondary porosity features characteristic of the bedrock. These include bedrock joints and fractures, faults, and bedding plane partings.

2.3.2 Ground Elevation Between HDD Entry/Exits

On the revised profile, the elevation at the northern entry/exit point is 1,068.00 feet amsl and the elevation of the southern entry/exit point is 1,086 feet amsl, for an elevation difference of 18 feet. Moving south down the slope from the northern entry/exit point, the surface elevation drops gradually across the Norfolk and Southern Railway and flattens on the flood plain of Brush Creek at an approximate elevation ranging from 960 to 975 ft amsl. The topography then gradually slopes upward from the stream to the south, up a wooded hill, over a small ridge Station 20+50 and then gradually slopes downward to the southern entry/exit point at Station 25+28.

2.3.3 Water Levels

A static water level of 115 feet was estimated for geotechnical boring B1-4W, with perched water detected at 14.6 and 31.5 feet. A static water level of 31.4 feet was noted in boring B1-4E. A search for domestic supply wells within 450 feet of the HDD ROW did not produce a single well record from which a static water level could be reported.

2.3.4 Well Yields

A Pennsylvania Groundwater Information System (PAGWIS) search of all Glenshaw formation domestic wells in Westmoreland County produced a listing of 287 records. The range of well yields was from 0.5 to 200 gallons per minute (gpm) with an average of approximately 9.6 gpm.

2.3.5 Water Supply Wells Near HDD

SPLP performed a preconstruction survey of land owners for the ME II project within 150 feet of the ROW and no land owners responded positively to an offer to have their wells tested. In addition, a PAGWIS search was performed for water supply wells within 450 feet of the HDD ROW, which produced no records. However, the path of the revised drill is in close proximity to residences along six streets in Jeanette. Moving south to north these include Kifer Hill Road, Carterway Lane, Penn Avenue, Depot Street, Cardinal Lane and Wood Lane. Given the history of this site in terms of IRs voids encountered, loss of fluids, and the variability of rock strength with depth, a door-to-door survey may better define the presence/absence of domestic potable wells proximal to the ROW.

2.4 Summary of Geophysical Studies

No geophysical studies were performed at this location. Though the Glenshaw formation contains some limestone beds, development of karst terrane is not characteristic of these limestone. In addition, as stated in **Section 2.2.6** there is not historic or current deep mining under the location of the planned boring.

3.0 OBSERVATIONS TO DATE

3.1 On This HDD Alignment

3.1.1 ME I

It has been reported that there were four locations along the alignment of the ME I 12-inch pipeline where drilling fluids were observed at the surface. These occurred at the approximate positions of Stations 0+40, 12+20, 13+40 and 17+40 along the ME II revised plan and profile. At each location, the overburden between the surface and the 12-inch line is estimated to be less than 50 feet, except for Station 12+20 where the overburden was approximately 80 feet.

3.1.2 ME II

On June 27, 2017, during an initial attempt to drill HDD S1B-0250, a loss of circulation occurred at approximately 910 feet out and at approximately 99 ft bgs. The driller noted a void in the boring from 910 feet to 929 feet, drilling north to south. On the same day, a release of drilling fluids was noted under the drill pad and onto the LOD. This IR was controlled after initial discovery and continued through July 2, 2017, when drilling was halted. The release was fully contained. This pilot proved difficult to steer and multiple attempts were made to pull rods back and reenter the boring on the correct alignment. At one point it was discovered that the 12-inch line was not accurately located and resurveying was required. Drilling was suspended on July 15, 2017 in order to reevaluate the drill design.

3.2 On Other HDD Alignments in Similar Hydrogeologic Settings

3.2.1 ME I

The closest borings to HD S1B-0250 are HDD S1B-0240 Penn High Park and HDD S1B-0260 Gombach Road. The geologic and hydrogeologic setting is considered similar to these HDDs. During the installation of the ME I pipeline at each of these sites, no IRs were reported.

3.2.2 ME II

All of the IRs to date in Spreads 1 and 2 for the ME II pipeline 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. In general, the IRs have been related to shallow overburden (especially under water bodies), large elevation changes between entries and entry/exits, coarse grained unconsolidated materials near the surface (such as alluvium and mine spoil), deep coal mines, and the interconnectivity of open bedrock structural features that is difficult to predict.

The installations of HDD S1B-0240 Penn High Park and HDD S1B-0260 Gombach Road for ME II have not been initiated yet.

4.0 SUMMARY AND CONCLUSIONS OF HDD HYDROGEOLOGIC EVALUATION

4.1 HDD Site Conceptual Model

Based on the information provided in this reevaluation report, the revised drilling path for HDD S1B-0250 will encounter Glenshaw Formation sedimentary bedrock between 10 and 20 ft bgs at the entry/exit points. The soils described in four borings around the entry/exit points are relatively cohesive and transition into weathered mudstones. Therefore, entries and exits should be accomplished with minimal risks of IRs. Static groundwater level measurements have been sparse and variable. Assuming the measurements at B1-4E are accurate, the water level elevation at the north entry/exit point should be approximately 1,035 ft amsl. Assuming Brush Creek is a local groundwater discharge point the drill should be below the water table for most of the drill. The elevation change between the entry/exit points is not large and the profile is relatively symmetric, becoming horizontal near the middle, therefore, the risk of creating a groundwater drain, causing excessive groundwater discharge and lowering of the local water table is minimal. An ME II preconstruction survey for properties within 150 feet of the ROW and PAGWIS search for domestic wells located greater than 450 feet from the ROW produced no records of domestic water supplies proximal to the HDD. However, these tools cannot guarantee no domestic wells occur proximal to the alignment and the proposed boring will cross under six roadways in residential neighborhoods where domestic wells may serve as water supplies.

Examination of rock core description and RQD values for the two more recent geotechnical borings indicate the competency of bedrock is highly variable in the area of HDD-S1B-0250. Both core borings were advanced below the elevation of the lowest elevation along the revised HDD boring profile. Zones of both low and high RQDs occurred throughout the two boreholes. RQD variability was particularly high in B4-1E, located near the northern entry/exit, for which three runs of 0% RQD were recorded after the initial zone of low recovery and RQD seen just below the soil/bedrock interface. The revised profile crosses over two fracture traces further indicating the potential to encounter zones of low strength bedrock while installing the 20-inch pipe. Four IRs occurred during the construction of ME I in areas where the overburden was thin. Lastly, during advance of the initial pilot hole for ME II, the driller recognized one or more large voids from 865 to 929 feet south from the northern entry/exit point.

Steering was difficult during the initial pilot boring and there was uncertainty regarding the horizontal and vertical position of the active 12-inch which had to be relocated for purposes of the reevaluation. A loss of mud to the LOD did occur under and next to the drilling pad at the northern entry/exit point during the initial pilot hole; however, this IR was easily controlled and its occurrence is to be expected for any HDD when the drill bit is close to the surface in unconsolidated materials.

On the original profile the distance between the ME I 12-inch line and proposed ME II 20-inch line is approximately 35 feet or less in the vertical dimension. On the revised profile the 20-inch line is separated by greater distance south of Station 14+00, ranging from approximately 35 to 150 feet vertical separation. The 20-inch profile runs coincident to the 12-inch moving north from Station 11+00 then becomes deeper but does not achieve vertical separation more than approximately 37 feet before the northern entry/exit.

The newly established profile for the active 12-inch line was compared to the revised profile for the 20-inch line. These occurred at the approximate positions of Stations 0+40, 12+20, 13+40 and 17+40 along the ME II revised plan and profile. At each location, the overburden between the surface and the 12-inch line is estimated to be less than 50 feet, except for Station 12+20 where the overburden was approximately 80 feet.

4.2 Recommendations

If the revised profile is adopted for HDD S1B-0250, the results of two core borings at either entry/exit point show the drill indicate variable bedrock strength conditions will be encountered with depth. Two fracture traces cross the path of the drill as well, indicating potential for weaker rock zones. Trenching does not appear to be a viable alternative as the excavation would have to cross Brush Creek, Penn Avenue, the Norfolk Southern Railroad, and Depot street. The drilling plan for this HDD should account for this variability. North of Station14+00 on the revised profile the proposed path for the 20-inch line is not that much deeper than the ME I 12-inch line and IRs occurred at stations 13+50 and 12+20 during installation of the 12-inch line. Due to rock conditions and drilling history for this site, an elevated level of IR inspection is warranted, especially at Brush Creek. Although the pre-construction 150-foot survey and PAGWIS search did not identify local water users, the alignment of HDD S1B-0250 is in close proximity to residential dwellings along several roadways in Jeanette; therefore, a door-to-door survey should be implemented to determine the presence or absence of any domestic water supplies that could potentially be impacted by HDD activities.

5.0 REFERENCES

Pennsylvania Geological Survey. Pennsylvania groundwater information system (PaGWIS). Pennsylvania Geological Survey, 4th series, SQL database, http://dcnr.state.pa.us/topogeo/groundwater/pagwis/records/index.htm.

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Nickelsen, R. P. and Hough, V. D. (1967) *Jointing in the Appalachian Plateau of Pennsylvania*, GSA Bull. v. 78, p. 609-630.

PA DCNR (Department of Conservation and Natural Resources) Map Viewer (http://www.gis.dcnr.state.pa.us/maps/index.html).

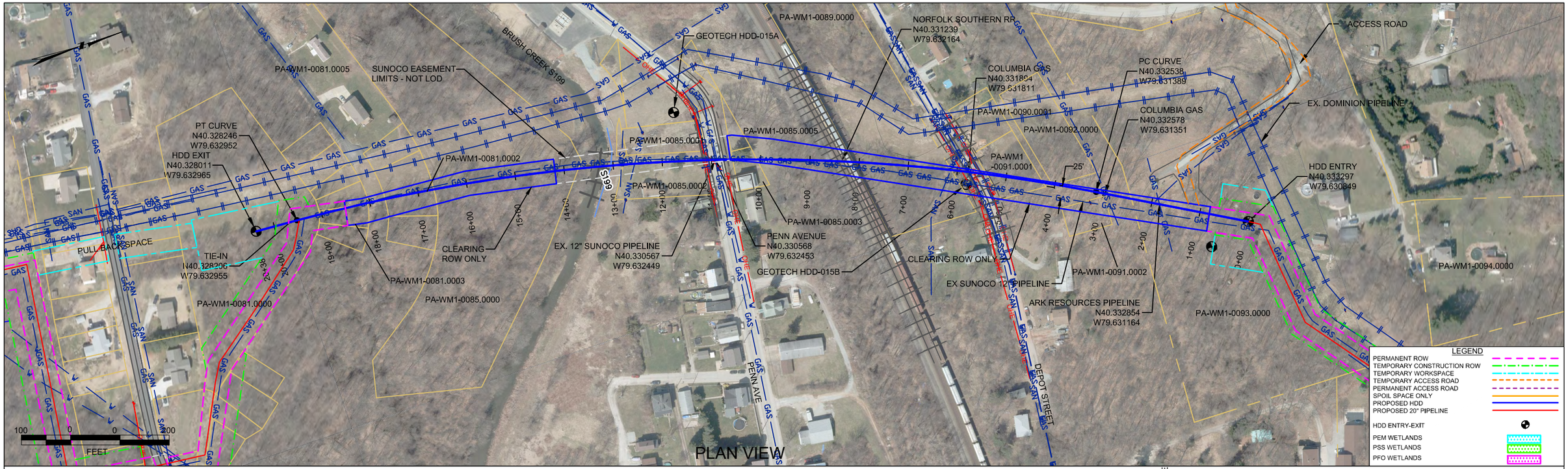
Penn State Mine Atlas (http://www.minemaps.psu.edu).

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), Irwin, Pennsylvania, 1:24,000 topographic quadrangle map, rev. 1982.

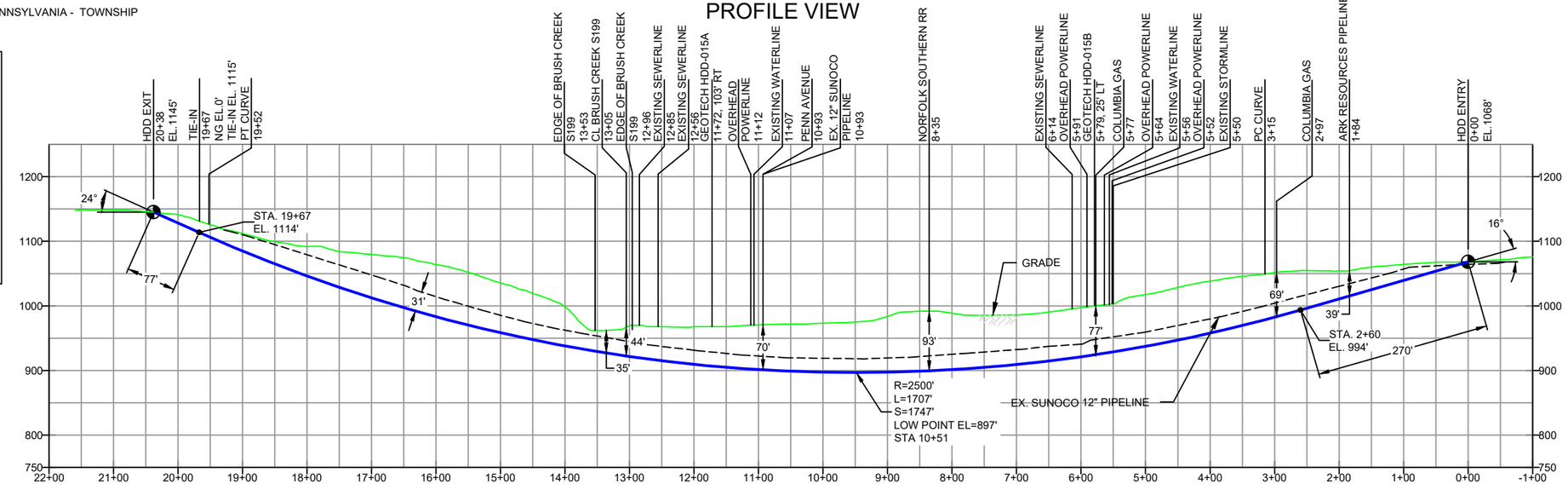
Attachment A

Original and Revised Plan and Profile



WESTMORELAND COUNTY, PENNSYLVANIA - TOWNSHIP
S1B-0250

PROFILE VIEW



GEOTECH HDD-15A

- -NG EL. 968'
- -CL (0.0' - 7.0')
- -SM (7.0' - 12.0')
- -GROUNDWATER (11.0')
- -CL (12.0' - 15.0')
- -WEATHERED CLAYSTONE (15.0' - 23.5')
- -GRAY/RED CLAYSTONE (23.5' - 33.5')
- -COMPLETION DEPTH EL. 935'

NOTE: REFER TO TEST BORING LOG HDD-15A 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=): 2038'
   HDD PIPE LENGTH (S=): 2039'
   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. PIPELINE AND CROSSING TO BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH LAST APPROVED AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION SPECIFICATIONS FOR PIPELINES CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES.
12. BLASTING NOT PERMITTED.
13. 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.

REF. DRAWING

ES-1.43	TO	ES-1.44	EROSION & SEDIMENT PLAN	
SHEET 32	TO	SHEET 33	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	MRS	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/20/16	RMB	05/20/16	AAW	05/20/16
EP		JTW	03/15/16	RMB	03/15/16	AAW	03/15/16

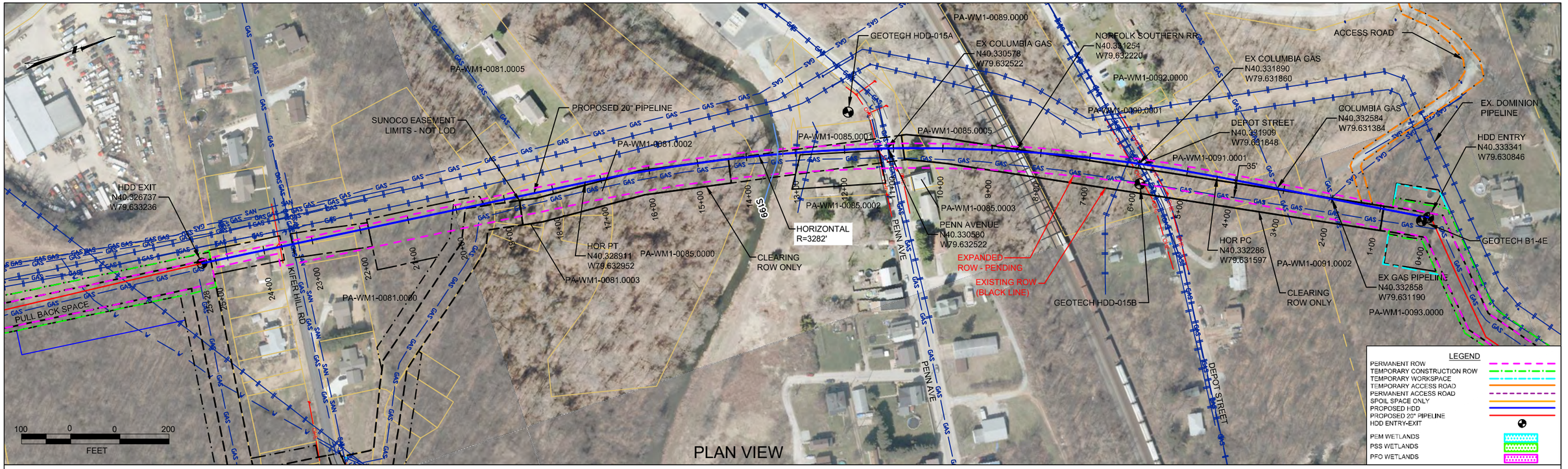
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
NORFOLK SOUTHERN RAILWAY
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' | DWG. NO: PA-WM1-0088.0000-RR



WESTMORELAND COUNTY, PENNSYLVANIA - HEMPFIELD\ JEANNETTE\ PENN TOWNSHIP
S1B-0250

PROFILE VIEW

GEOTECH HDD-15A

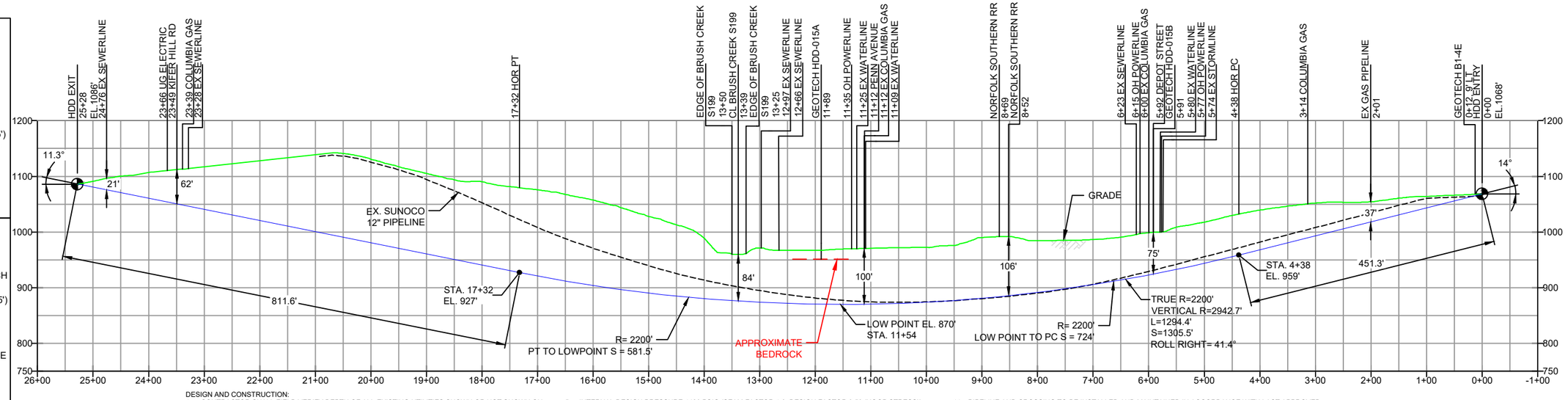
- -NG EL. 968'
- -CL (0.0' - 7.0')
- -SM (7.0' - 12.0')
- -GROUNDWATER (11.0')
- -CL (12.0' - 15.0')
- -WEATHERED CLAYSTONE (15.0' - 23.5')
- -GRAY/RED CLAYSTONE (23.5' - 33.5')
- -COMPLETION DEPTH EL. 935'

NOTE: REFER TO TEST BORING LOG HDD-15A FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B1-4E

- -NG EL. 1068'
- -FAT CLAY W/ GRAVEL CH (0.0' - 8.5')
- -FAT CLAY CH (8.5' - 13.5')
- -GROUNDWATER (31.3')
- -WEATHERED ROCK MUDSTONE/SANDSTONE (13.5' - 242')
- -BORING TERMINATED EL.826'

NOTE: REFER TO TEST BORING LOG B1-4E TERRACON INC. PROJECT # J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION



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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=):2528'
   HDD PIPE LENGTH (S=):2568'
   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.
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12. BLASTING NOT PERMITTED.
13. 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

DWG NO		DWG NO	DESCRIPTION
ES-1.43	TO	ES-1.44	EROSION & SEDIMENT PLAN
SHEET 32	TO	SHEET 33	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP3	DESIGN CHANGE - RELOCATED DRILL ENTRY/EXIT	MRS	08/29/17	RMB	08/29/17	CAG	08/29/17
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	05/20/16	RMB	05/20/16	AAW	05/20/16
EP		JTW	03/15/16	RMB	03/15/16	AAW	03/15/16

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
NORFOLK SOUTHERN RAILWAY
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

DWG. NUMBER: PA-WM1-0088.0000-RR

Attachment B

Geotechnical Boring Logs

Source: Topo data from USGS DLG; Roads from DelDOT

N
W E
S

Figure

Boring Locations HDD-15A/15B
Sunoco Mariner East Project
Westmoreland County, PA

0 250 500 1,000 Feet

1 inch = 500 feet

Tetra Tech, Inc.
Phone: (302) 738-7551
Toll Free: (800) 462-0910
www.tetratech.com

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

TEST BORING LOG

Project Name: SUNOCO MARINER EAST | Project No.: 103IP2762

Project Location: WESTMORELAND COUNTY, PA | Page 1 of 1

Test Boring No.: HDD-15A | Dates(s) Drilled: 06/14/13 | Inspector: E. WATT

Drilling Contractor: CONNELLY | Drilling Method: SPT - ASTM D1586 | Driller: T. REDMAN

Surface Elevation (ft): | Groundwater Depth (ft): 11 | Total Depth (ft): 17.7

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
1	3.5	5.0	0.0		10	CL	BROWN SILTY CLAY, FRAGMENTS OF GRAVEL IN TIP.	4	4	5	9
				7.0							
2	8.5	10.0	7.0		15	SM	MOTTLED DARK GRAY AND BROWN FINE TO MEDIUM SAND	4	8	11	19
				12.0			WITH SOME SILT. POSSIBLE COAL LEANSE AT 9.7'.				
3	13.5	13.9	12.0		18	CL	GRAY TO DARK GRAY SILITY CLAY, TRACE FINE SAND.	17	22	27	49
				15.0			USCS: CL				
4	17.5	17.7	15.0	17.7	1		LIGHT GRAY PARTIALLY WEATHERED CLAYSTONE.	50/2"			
							AUGER REFUSAL AT 17.5'.				
							WET ON SPOON AT 20'.				
							WATER LEVEL THROUGH AUGERS AT 11'.				

Notes/Comments:

Pocket Pentrometer Testing

S3: >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.

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

TEST BORING LOG

Project Name: SUNOCO MARINER EAST			Project No.: 103IP2762
Project Location: WESTMORELAND COUNTY, PA			Page 1 of 1
Test Boring No.: HDD-15A CORING	Dates(s) Drilled: 09/11/13	Inspector:	E. WATT
Drilling Contractor: CONNELLY	Drilling Method: SPT - ASTM D1586	Driller:	K. KERSH
Surface Elevation (ft):	Groundwater Depth (ft):	Total Depth (ft): 33.5	

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	18.5			CONTINUOUS AUGERING. SEE BORING LOG HDD-15A.		
1	18.5	19.0	18.5	23.5			GRAY PARTIALLY WEATHERED CLAYSTONE.	50/6"	
							AUGER REFUSAL AT 23.5'.		
							ROCK CORING		
RUN 1	23.5	28.5	23.5			ROCK	100% RECOVERY, 21% RQD: GREENISH GRAY AND RED CLAYSTONE.		
RUN 2	28.5	33.5				ROCK	100% RECOVERY, 69% RQD: GRAY TO GREENISH GRAY AND RED CLAYSTONE.		
				33.5					

Notes/Comments:

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 302.454.5088

TEST BORING LOG

Project Name: SUNOCO MARINER EAST			Project No.: 103IP2762
Project Location: WESTMORELAND COUNTY, PA			Page 1 of 1
Test Boring No.: HDD-15B	Dates(s) Drilled: 06/13/13	Inspector: E. WATT	
Drilling Contractor: CONNELLY	Drilling Method: SPT - ASTM D1586	Driller: T. REDMAN	
Surface Elevation (ft):	Groundwater Depth (ft): Not Encountered	Total Depth (ft): 5.7	

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	2.0		CL	BROWN SILTY CLAY (AUGER CUTTINGS)		
1	3.5	3.9	2.0				LIGHT GRAY TO BROWN PARTIALLY WEATHERED SILTSTONE.	50/5"	
2	5.5	5.7		5.7			LIGHT GRAY PARTIALLY WEATHERED SILTSTONE.	50/2"	
							AUGER REFUSAL AT 5.5'.		

Notes/Comments:
Pocket Pentrometer Testing

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

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

October 9, 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 1 – Norfolk Southern Railway
Commonwealth of Pennsylvania
Drawing #PA-WM1-0088.0000-RR
PO #20170804-8
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 Norfolk Southern Railway (Drawing #PA-WM1-0088.0000-RR) 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 B1-4W and B1-4E, visual classification and photography of the rock core samples, and laboratory testing of representative rock samples.

Test borings, B1-4W and B1-4E were drilled between August 9 and 24, 2017 to depths of 318 and 242 feet, respectively as shown on the attached **Test Boring Location Plan**. Bedrock typically consisted of interlayered sedimentary rock comprised of mudstone, siltstone, sandstone, shale, 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. 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.

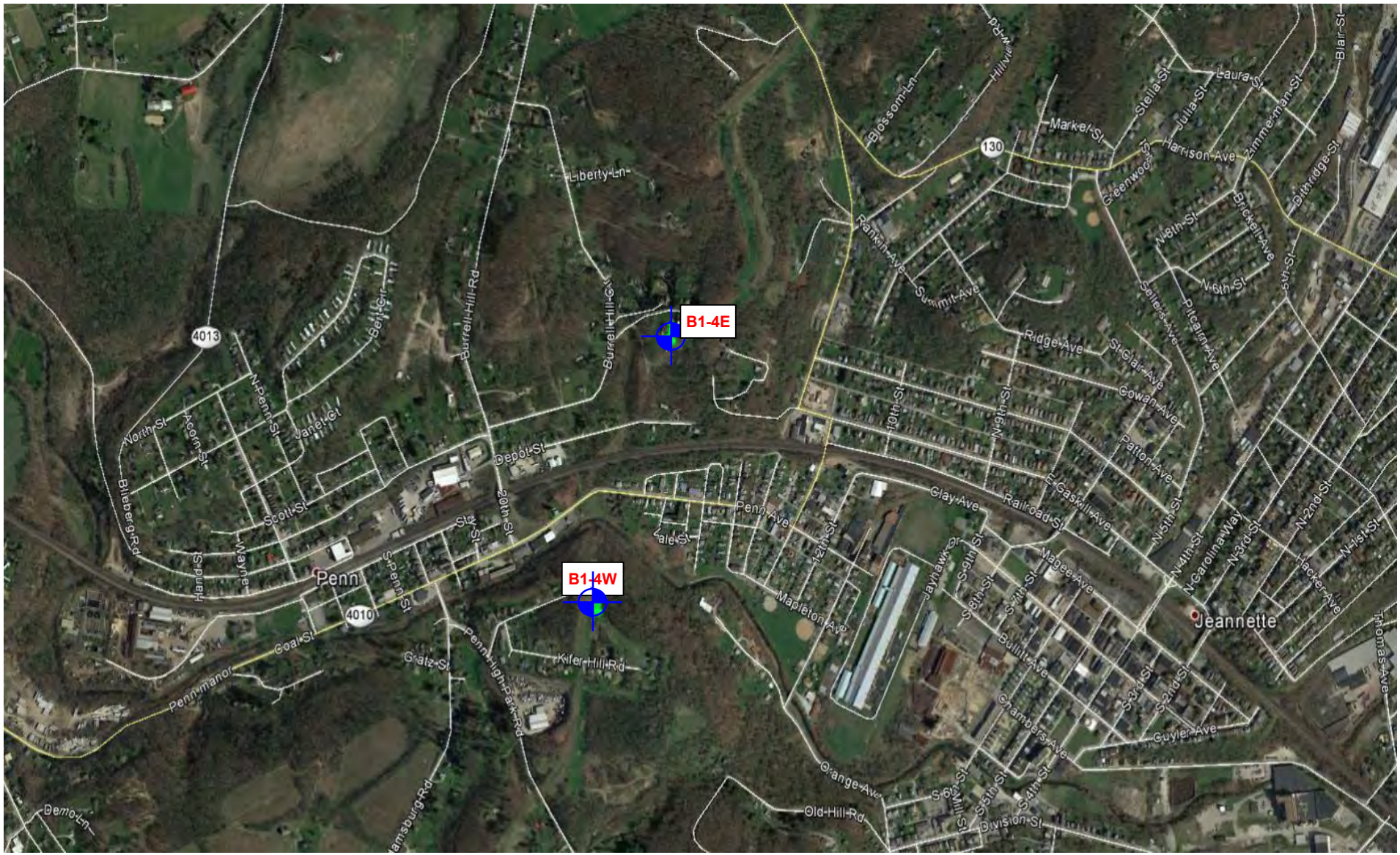
Marc A. Gullison, E.I.T.
Staff Geotechnical Engineer

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

Norfolk Southern Railway HDD Cores B1-4W and B1-4E
PA-WM1-0088.0000-RR
Westmoreland County, Pennsylvania

Exhibit

A-2

EXPLORATION RESULTS

BORING LOG NO. B1-4W Norfolk Southern Railway West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION

Latitude: 40.328° Longitude: -79.632974°

Approximate Surface Elev: 1172 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	Sample Type	Recovery (In.)	Field Test Results	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
		LEAN CLAY (CL), trace sand, trace gravel, brown to gray, medium dense, (completely weathered shale)						
				15	3-8-10 N=18			18
8.5	1163.5+/-							
		Soft, severely to very severely weathered, brown to gray SHALE		11	17-50/5"			NA
				9	17-50/3"			NA
				3	50/3"			NA
24.0	1148+/-			2	50/2"			NA
		Run 1, Soft, very severely weathered, brown to gray MUDSTONE, very thin bedding, close joint spacing, tight, slickensides		40		66	1.75 1.25 1.75 1.5	
28.0	1144+/-							
		Run 2, Similar		60			1.75	

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:

WATER LEVEL OBSERVATIONS

- 14.6' on 8/10/17
- 31.5' on 8/11/17
- 115' 8/15/17

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/9/2017 | Boring Completed: 8/21/2017
Drill Rig: CME-850X | Driller: Terracon/Manny R.
Project No.: J217P078

BORING LOG NO. B1-4W Norfolk Southern Railway West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION

Latitude: 40.328° Longitude: -79.632974°

Approximate Surface Elev: 1172 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
		Run 2, Similar *(continued)*	60	90	1 1 1 1.75
33.0	1139+/-				
		Run 3, Similar At 37.3 to 37.8 feet: highly fractured	60	67	0.75 1 1.25 1.25 1.75
38.0	1134+/-				
		Run 4, Similar	60	80	1.25 1.5 1.25 1 1.5
43.0	1129+/-				
		Run 5, Similar At 43 to 43.2 feet, 46 to 47 feet: Highly fractured	48	52	2 2.25 1.75 1.25 3.75
48.0	1124+/-				
		Run 6, Similar At 48.8 to 49.0, 50.6 to 51.0 feet: highly fractured	60	73	.75 1.25 1 1.5 2
53.0	1119+/-				
		Run 7, Similar	60	83	2 1.5 1.5 1.5 0.75
58.0	1114+/-				
			60		0.75

DEPTH (Ft.): 35, 40, 45, 50, 55, 60

WATER LEVEL OBSERVATIONS: ▽

SAMPLE TYPE: solid bar

FIELD TEST RESULTS: 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:

WATER LEVEL OBSERVATIONS

▽ *14.6' on 8/10/17*
▽ *31.5' on 8/11/17*
▼ *115' 8/15/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/9/2017 | Boring Completed: 8/21/2017
Drill Rig: CME-850X | Driller: Terracon/Manny R.
Project No.: J217P078

BORING LOG NO. B1-4W Norfolk Southern Railway West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION

Latitude: 40.328° Longitude: -79.632974°

Approximate Surface Elev: 1172 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
		Run 8, Similar to 62 feet At 62 feet: Soft to moderately hard, brown to gray SILTSTONE, thin bedding, close to moderately close joint spacing, tight to slightly open	60	60	1.25 1.5 1.75 1.25
63.0	1109+/-	*(continued)*			
		Run 9, Similar At 67.3 to 67.5 feet: high angle iron stained joint At 63.2 to 65.7 feet: calcareous zone	60	88	0.75 1 0.75 1.25 1.75
68.0	1104+/-				
		Run 10, Similar At 68.4 to 68.6; 70.2 to 70.3; 71.5 to 72.7 feet: high angle iron stained joints	60	80	1 0.75 0.75 1.5 1.25
73.0	1099+/-				
		Run 11, Similar At 72.9 to 73.0, 75 to 75.1 feet: high angle iron stained joints	60	92	0.5 1.5 1.5 2 2
78.0	1094+/-				
		Run 12, Similar	55	95	.75 .75 2.5 1 2
83.0	1089+/-				
		Run 13, Similar to 84.7 feet At 84.7 feet: Moderately hard, slightly weathered, gray, SANDSTONE, interbedded with siltstone, thin bedding, close to moderately close joint spacing, slightly open to tight	60	78	1.25 1.5 1 .75 .5
88.0	1084+/-				
			60		1.02

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

WATER LEVEL OBSERVATIONS

SAMPLE TYPE

FIELD TEST RESULTS

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:

WATER LEVEL OBSERVATIONS

- *14.6' on 8/10/17*
- *31.5' on 8/11/17*
- *115' 8/15/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/9/2017 | Boring Completed: 8/21/2017

Drill Rig: CME-850X | Driller: Terracon/Manny R.

Project No.: J217P078

BORING LOG NO. B1-4W Norfolk Southern Railway West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION
Latitude: 40.328° Longitude: -79.632974°
Approximate Surface Elev: 1172 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
		Run 14, Similar At 91.8 feet: Soft, severely weathered, red brown to gray MUDSTONE, very thinly bedded, joints very close to close, tight *(continued)*	60		77	1.43 1.25 1.23 2.42	
93.0	1079+/-						
		Run 15, Similar	60		47	2.5 2.75 3 2.25 3.25	
98.0	1074+/-						
		Run 16, Similar At 99 to 99.4 feet: highly fractured At 98 to 98.2, 100.2 to 100.3, 100.8 to 101.1 feet: high angle slickenside joints	60		59	2.20 2 1.75 2 2	
103.0	1069+/-						
		Run 17, Similar At 105 to 105.6 feet: highly fractured	60		65	2 2.25 1.75 2 2.25	
108.0	1064+/-						
		Run 18, Similar At 110 to 110.3 feet: high angle joint	60		60	2.75 3 2 1.75 2	
113.0	1059+/-						
		Run 19, Similar At 115.1 to 115.5 feet: washed out At 116.1 to 116.6 feet: high angle joints	55		55	2.5 4.5 4.75 2.25 2.5	
118.0	1054+/-						
		Run 20, Similar At 120.4 to 120.7, 121.3 to 121.8 feet: high angle joints	60			1	

DEPTH (Ft.): 95, 100, 105, 110, 115, 120

WATER LEVEL OBSERVATIONS: ▼ at 115

SAMPLE TYPE: solid bar

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:

WATER LEVEL OBSERVATIONS

- ▽ *14.6' on 8/10/17*
- ▽ *31.5' on 8/11/17*
- ▼ *115' 8/15/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/9/2017 Boring Completed: 8/21/2017
Drill Rig: CME-850X Driller: Terracon/Manny R.
Project No.: J217P078

BORING LOG NO. B1-4W Norfolk Southern Railway West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION

Latitude: 40.328° Longitude: -79.632974°

Approximate Surface Elev: 1172 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
		Run 20, Similar At 120.4 to 120.7, 121.3 to 121.8 feet: high angle joints *(continued)*	60	70	1.75 1.75 1.75 1.75
123.0	1049+/-				
		Run 21, Moderately hard, slightly weathered, gray SILTSTONE, interbedded with sandstone, very thin bedding, close joints, slightly open At 126.2 to 127.7 feet: high angle iron stained joint	60	70	1.5 1.5 1.5 1.25 1.75
128.0	1044+/-				
		Run 22, Moderately hard, slightly weathered, gray SILTSTONE, interbedded with sandstone, very thin bedding, moderately close joint spacing, slightly open	60	100	1.5 1.25 1.5 1.25 1.5
133.0	1039+/-				
		Run 23, Similar, except no sandstone beds	60	96	1 1 1 1 1
138.0	1034+/-				
		Run 24, Similar	60	100	1.75 1.75 1.5 1.35 1.5
143.0	1029+/-				
		Run 25, Moderately hard, slightly weathered, gray SILTSTONE, thin bedding, moderately close joint spacing, slightly open	63	100	1.5 1.75 1.25 1.5 1.75
148.0	1024+/-				
		Run 26, Hard, slightly weathered, gray SILTSTONE, thin bedding, moderately close joint spacing, tight	58		1

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

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:

WATER LEVEL OBSERVATIONS

- *14.6' on 8/10/17*
- *31.5' on 8/11/17*
- *115' 8/15/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/9/2017 | Boring Completed: 8/21/2017
Drill Rig: CME-850X | Driller: Terracon/Manny R.
Project No.: J217P078

BORING LOG NO. B1-4W Norfolk Southern Railway West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION
Latitude: 40.328° Longitude: -79.632974°
Approximate Surface Elev: 1172 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
		Run 26, Hard, slightly weathered, gray SILTSTONE, thin bedding, moderately close joint spacing, tight *(continued)*	58	100	1.75 1.5 1.5 1.25
153.0	1019+/-				
		Run 27, Similar	60	100	1.5 1.25 1.25 1.25 1.25
158.0	1014+/-				
		Run 28, Similar	60	100	1.75 1 1.5 1.75 1.5
163.0	1009+/-				
		Run 29, Similar to 165 feet At 165 feet: Hard, black SHALE, thin bedding, close joint spacing, slightly to moderately open	60	83	1.5 1.5 2 1.5 1.75
168.0	1004+/-				
		Run 30, Similar to 169.3 feet At 169.3 feet:Medium hard, moderately to highly weathered, gray MUDSTONE, thin bedding, close joint spacing, open to moderately wide From 169.9 to 170 feet: highly fractured zone At 168.5, 169.5, 174.3, 172.1 feet: angled joint, highly stained	59	98	1.75 1.5 1.75 1.75 1.75
173.0	999+/-				
		Run 31, Hard to moderately hard, slightly weathered, gray, MUDSTONE, thin bedding, close joint spacing, moderately open	62	78	1.75 2 2.25 1.75 1.75
178.0	994+/-				
			61		1.25

DEPTH (Ft.): 155, 160, 165, 170, 175, 180

WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | 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:

WATER LEVEL OBSERVATIONS

- *14.6' on 8/10/17*
- *31.5' on 8/11/17*
- *115' 8/15/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/9/2017 | Boring Completed: 8/21/2017
Drill Rig: CME-850X | Driller: Terracon/Manny R.
Project No.: J217P078

BORING LOG NO. B1-4W Norfolk Southern Railway West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION

Latitude: 40.328° Longitude: -79.632974°

Approximate Surface Elev: 1172 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
		Run 32, Similar to 179 feet		62	1.5 1.75 1.75 2.25
		At 179 feet: Medium to soft, severely weathered, red with gray, MUDSTONE, close joint spacing, open	61		
183.0	989+/-	From 179.5 to 180 feet: highly fractured zone			
		At 181.6 and 182.4 feet angled fractures *(continued)*			
		Run 33, Similar to 186.3 feet			
		At 186.3 feet: Hard, slightly weathered, gray with red and white, MUDSTONE, thin bedding, close joint spacing, moderately open	61	76	2.5 2.5 3 3 2.5
188.0	984+/-				
		Run 34, Similar to 192 feet			
		At 192 feet: Moderately weathered, black SHALE, thin bedding, close joint spacing, moderately open	56	85	2 2 2 2.5 3
193.0	979+/-				
		Run 35, Moderately hard, slightly weathered, gray with white, MUDSTONE, thin bedding, moderately close joint spacing, slightly open	60	96	1.25 1.5 1.5 1.5 2.75
198.0	974+/-				
		Run 36, Medium to soft, moderately to highly weathered, gray with white, MUDSTONE, close joint spacing, slightly to moderately open			
		At 201.2 to 201.5 feet: high angle iron stained joint	58	60	1.75 2 2.25 2.25 1.75
203.0	969+/-				
		Run 37, Hard to moderately hard, slightly weathered, gray with white and red SILTSTONE, with clayey and limy fragments, thin bedding close joint spacing, slightly open			
		At 203.6 to 206.3 feet: high angle iron stained joint	61	100	1.25 1.75 1.5 1.25 1.25
208.0	964+/-				
		Run 38, Hard to medium, moderately to highly weathered, red with gray MUDSTONE, thin bedding, moderately close joint spacing, slightly open	60		1.5

DEPTH (Ft.): 185, 190, 195, 200, 205, 210

WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | 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:

WATER LEVEL OBSERVATIONS

- *14.6' on 8/10/17*
- *31.5' on 8/11/17*
- *115' 8/15/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/9/2017 | Boring Completed: 8/21/2017
Drill Rig: CME-850X | Driller: Terracon/Manny R.
Project No.: J217P078

BORING LOG NO. B1-4W Norfolk Southern Railway West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION

Latitude: 40.328° Longitude: -79.632974°

Approximate Surface Elev: 1172 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
		Run 38, Hard to medium, moderately to highly weathered, red with gray MUDSTONE, thin bedding, moderately close joint spacing, slightly open *(continued)*	60	100	1.75 1.75 2.25 2.5
213.0	959+/-				
		Run 39, Medium to soft, highly weathered, red MUDSTONE, very thin bedding, close joint spacing, open At 213.5, 214 and 214.6 feet: high angle iron stained joint At 217 to 218 feet: highly fractured	60	61	2.25 2 2.75 3.25 3.75
218.0	954+/-				
		Run 40, Similar	61	60	2.75 5.25 4.25 4.5 4.5
223.0	949+/-				
		Run 41, Similar From 227 to 228 feet: black with yellowish gray At 223.9 and 225 feet: angle joint	60	93	2.75 3.25 3.25 4.5 4.5
228.0	944+/-				
		Run 42, Similar to 232 feet At 232 feet: Hard, slightly weathered, gray SILTSTONE, thin bedding, close joint spacing, slightly open	58	90	3.25 3.5 3.5 1.5 1
233.0	939+/-				
		Run 43, Hard to medium, slightly to medium weathered, gray with red SILTSTONE, with 2 to 3-inch seams of reddish mudstone, thin bedding, close to moderately close joint spacing, moderately open At 234.5, 236, 237.5 feet: angled, stained joint	62	98	1.25 1.25 1.75 1.5 1.75
238.0	934+/-				
		Run 44, Hard, slightly weathered, gray with red and yellow SILTSTONE, thin bedding, wide joint spacing, slightly open	57		1

DEPTH (Ft.): 215, 220, 225, 230, 235, 240

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:

WATER LEVEL OBSERVATIONS

- *14.6' on 8/10/17*
- *31.5' on 8/11/17*
- *115' 8/15/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/9/2017 | Boring Completed: 8/21/2017
Drill Rig: CME-850X | Driller: Terracon/Manny R.
Project No.: J217P078

BORING LOG NO. B1-4W Norfolk Southern Railway West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION
Latitude: 40.328° Longitude: -79.632974°
Approximate Surface Elev: 1172 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
		Run 44, Hard, slightly weathered, gray with red and yellow SILTSTONE, thin bedding, wide joint spacing, slightly open *(continued)*	57	95	1.75 2 1.75 2.75
243.0	929+/-				
		Run 45, Similar to 247 feet At 247 feet: Hard, slightly to moderately weathered, gray with red SILTSTONE, with mudstone layer, thin bedding, close joint spacing, open to moderately wide At 246.2 to 246.9 feet: highly fractured	61	93	1.25 1.5 1.5 2 2.25
248.0	924+/-				
		Run 46, Moderately hard, olive with red brown SHALE, very thin bedding, slightly fractured At 249.3 to 251.7 feet: Moderately hard, slightly weathered, red, brown and olive SHALE, very thin bedding, horizontal to low angle joints At 251.7 feet: Moderately hard.olive gray and gray SHALE, with sand lenses and pyrite filling	58	70	4 7 7.5 6.5 4
253.0	919+/-				
		Run 47, Similar from 251.7 feet	55	86	3 3 2.5 2 2.5
258.0	914+/-				
		Run 48, Similar to 260 feet At 260 feet: Hard, laminated, gray SILTSTONE, interbedded with shale and sandstone	60	70	2.5 1.5 4 4 4
263.0	909+/-				
		Run 49, Hard, slightly to moderately weathered, gray and brown, medium-grained SHALE, with conglomerate, clastic, low angle joints	60	67	5 4 4.5 2.5 3
268.0	904+/-				
			60		2

DEPTH (Ft.): 245, 250, 255, 260, 265, 270

WATER LEVEL OBSERVATIONS: —

SAMPLE TYPE: ■

FIELD TEST RESULTS: —

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:

WATER LEVEL OBSERVATIONS

- *14.6' on 8/10/17*
- *31.5' on 8/11/17*
- *115' 8/15/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/9/2017 | Boring Completed: 8/21/2017
Drill Rig: CME-850X | Driller: Terracon/Manny R.
Project No.: J217P078

BORING LOG NO. B1-4W Norfolk Southern Railway West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION
Latitude: 40.328° Longitude: -79.632974°
Approximate Surface Elev: 1172 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
		Run 50, Similar At 267.7 feet: Hard, very fine-grained, gray SILTSTONE, thin bedding, horizontal joints, moderately close *(continued)*		60	93	1.5 1.5 3 2.5
273.0	899+/-					
		Run 51, Similar At 276.5 feet: Hard, gray SHALE, thin bedding, with clasts and sandstone stringers	275	57	89	2 1.5 1.5 2.5 2.5
278.0	894+/-					
		Run 52, Similar At 278.5 feet: Hard, gray SILTSTONE, trace worm fossil tunnels, joints high angle	280	60	94	2 2 1.5 2 2
283.0	889+/-					
		Run 53, Hard, gray SHALE, thin bedding, with clasts and sandstone stringers	285	60	92	1.5 1.5 1.5 2 2.5
288.0	884+/-					
		Run 54, Similar	290	57	100	1.5 1.5 1.5 1.5 2
293.0	879+/-					
		Run 55, Similar	295	60	100	4 3 3 3 4.5
298.0	874+/-					
		Run 56, Similar At 302.5 feet: Hard, gray-olive SHALE, thin bedding, carbonaceous	300	60		4

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:

WATER LEVEL OBSERVATIONS

- *14.6' on 8/10/17*
- *31.5' on 8/11/17*
- *115' 8/15/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/9/2017 | Boring Completed: 8/21/2017
Drill Rig: CME-850X | Driller: Terracon/Manny R.
Project No.: J217P078

BORING LOG NO. B1-4W Norfolk Southern Railway West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION
Latitude: 40.328° Longitude: -79.632974°
Approximate Surface Elev: 1172 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
		Run 56, Similar			3
		At 302.5 feet: Hard, gray-olive SHALE, thin bedding, carbonaceous *(continued)*	60	100	3 3 4.5
303.0	869+/-				
		Run 57, Similar			4
			60	100	4 3.5 3 3.5
308.0	864+/-				
		Run 58, Similar			3.5
		At 312.0 feet: Hard, dark gray SHALE, thin bedding, high angle joints, widely spaced	58	96	2.5 2.5 3 4
313.0	859+/-				
		Run 59, Similar			2.5
			54	83	2 2.5 2.5 3
318.0	854+/-				
		Boring Terminated at 318 Feet			

DEPTH (Ft.): 305, 310, 315

WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | Penetrometer Test (tsf)

GRAPHIC LOG

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:

WATER LEVEL OBSERVATIONS

- 14.6' on 8/10/17
- 31.5' on 8/11/17
- 115' 8/15/17

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/9/2017 | Boring Completed: 8/21/2017
Drill Rig: CME-850X | Driller: Terracon/Manny R.
Project No.: J217P078

BORING LOG NO. B1-4E Norfolk Southern Railway East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION

Latitude: 40.333299° Longitude: -79.630838°

Approximate Surface Elev: 1068 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description
0	1068+/-	**FAT CLAY WITH GRAVEL (CH)**, with rock fragments, brown with orange seams, very stiff
8.5	1059.5+/-	**FAT CLAY (CH)**, with rock fragments, dark brown to brown with orange seams, stiff
13.5	1054.5+/-	
14.0	1054+/-	Weathered rock, greenish gray with orange seams, very dense
		Run 1, Hard, highly weathered, gray MUDSTONE, thin bedding, close spacing, moderately open to open
17.0	1051+/-	
		Run 2, Similar
22.0	1046+/-	
		Run 3, Similar, moderately dipping joint at 23.6 feet
27.0	1041+/-	
		Run 4, Similar

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
5		15	6-10-11 N=21			4+
10		14	8-5-8 N=13			3.5
15		7	50/3"			
		34		0	2 2 2	
20		57		22	2.75 1.5 1.5 1.75 1.5	
25		54		35	2 1.25 1.25 1 1	
30		60		71	1.5 2 1	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

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:

Additional water level observations:
31.3' on 8/23/17
31.3' on 8/24/17 at boring completion

WATER LEVEL OBSERVATIONS

- *31.5' on 8/19/17*
- *31.8' on 8/21/17*
- *31.4' on 8/22/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/18/2017 Boring Completed: 8/24/2017

Drill Rig: Diedrich D-50 Driller: Terra Testing, Inc.

Project No.: J217P078

BORING LOG NO. B1-4E Norfolk Southern Railway East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION

Latitude: 40.333299° Longitude: -79.630838°

Approximate Surface Elev: 1068 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
		Run 4, Similar *(continued)*	60		1 1.25
32.0	1036+/-				
		Run 5, Similar	59	58	1.5 1.25 1.75 2 1.75
37.0	1031+/-				
		Run 6, Similar	54	63	1.75 1.25 .75 1 1
42.0	1026+/-				
		Run 7, No recovery	0	0	2 1.25 1 1 1
47.0	1021+/-				
		Run 8, Moderately hard, slightly weathered, gray, fine to medium-grained SANDSTONE, thin bedding, low angle joints, close spacing, slightly open, rough, planar At 48.4 feet: Soft, severely weathered, reddish-brown to gray MUDSTONE, very thin bedding, low angle joints, very close to close spacing, tight to slightly open, smooth to slickensided joints	42	30	2.25 3.25 4 7.75 4
52.0	1016+/-	Lost recovery 50.2 to 50.7 feet			
		Run 9, Similar High angle, rough, iron stained joints at 53.1 to 53.2 feet and 52.4 to 52.6 feet Lost recovery 56.5 to 57.0 feet	54	33	8.25 3.25 3.5 5 5
57.0	1011+/-				
		Run 10, Similar Lost recovery 59.0 to 60.2 feet	45	0	4.25 5.25 4.75

DEPTH (Ft.): 35, 40, 45, 50, 55, 60

WATER LEVEL OBSERVATIONS

SAMPLE TYPE

FIELD TEST RESULTS

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:

Additional water level observations:
31.3' on 8/23/17
31.3' on 8/24/17 at boring completion

WATER LEVEL OBSERVATIONS

- *31.5' on 8/19/17*
- *31.8' on 8/21/17*
- *31.4' on 8/22/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/18/2017 | Boring Completed: 8/24/2017

Drill Rig: Diedrich D-50 | Driller: Terra Testing, Inc.

Project No.: J217P078

BORING LOG NO. B1-4E Norfolk Southern Railway East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

DEPTH	ELEVATION (Ft.)	LOCATION	DEPTH (Ft.)	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
		Latitude: 40.333299° Longitude: -79.630838°				
		Approximate Surface Elev: 1068 (Ft.) +/-				
		Run 10, Similar		45		5.25 5.25
62.0	1006+/-	Lost recovery 59.0 to 60.2 feet *(continued)*				
		Run 11, Similar				
		Lost recovery 65.8 to 66.7 feet	65	48	32	4.75 6.25 6 4.5 6
67.0	1001+/-					
		Run 12, Similar				
		Lost recovery 69.9 to 70.2 feet	70	55	25	7.5 7.45 7.25 8.25 7.25
72.0	996+/-					
		Run 13, Medium soft to soft, moderately to highly weathered, brownish red to gray MUDSTONE, very thin to thin bedding, close joints, slightly to moderately open	75	44	15	10 10.75 10 11.5 12
77.0	991+/-					
		Run 14, Similar to 78.3 feet				
		At 78.3 feet: Hard, slightly weathered, gray MUDSTONE, thin bedding, moderately close joints, slightly open, moderately dipping joint at 80.5 feet	80	58	63	12 10 6.5 5.75 5
82.0	986+/-					
		Run 15, Similar, gray with red				
			85	60	96	5.25 4.5 3.5 2.25 4
87.0	981+/-					
		Run 16, Similar		60		2 2.75 2.25
			90		100	

GRAPHIC LOG | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | 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:

Additional water level observations:
31.3' on 8/23/17
31.3' on 8/24/17 at boring completion

WATER LEVEL OBSERVATIONS

- *31.5' on 8/19/17*
- *31.8' on 8/21/17*
- *31.4' on 8/22/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/18/2017 | Boring Completed: 8/24/2017

Drill Rig: Diedrich D-50 | Driller: Terra Testing, Inc.

Project No.: J217P078

BORING LOG NO. B1-4E Norfolk Southern Railway East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION

Latitude: 40.333299° Longitude: -79.630838°

Approximate Surface Elev: 1068 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
		Run 16, Similar *(continued)*	60		2 2
92.0	976+/-				
		Run 17, Similar to 93.5 feet, gray with red From 93.5 to 102.0 feet: Similar, fine to medium grained, MUDSTONE, close joints Limestone bed at 96 to 97 feet	60	93	2 2.25 2.25 1.75 1.75
97.0	971+/-				
		Run 18, Similar	60	100	1.5 1.75 2 1.75 2
102.0	966+/-				
		Run 19, Hard, slightly to medium weathered, gray MUDSTONE, close to moderately close joints, slightly to moderately open	60	90	1.5 2.5 1.75 2 2
107.0	961+/-				
		Run 20, Similar Limestone bed at 108.4 to 108.5 feet	60	97	2 1.75 2 1.75 2
112.0	956+/-				
		Run 21, Similar Limestone bed at 112.0 to 112.1 feet	60	93	2.25 1.25 1.75 2.5 2
117.0	951+/-				
			57	28	3.25 2.75 5.75

DEPTH (Ft.): 95, 100, 105, 110, 115, 120

WATER LEVEL OBSERVATIONS

SAMPLE TYPE

FIELD TEST RESULTS

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:

Additional water level observations:
31.3' on 8/23/17
31.3' on 8/24/17 at boring completion

WATER LEVEL OBSERVATIONS

- *31.5' on 8/19/17*
- *31.8' on 8/21/17*
- *31.4' on 8/22/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/18/2017 | Boring Completed: 8/24/2017

Drill Rig: Diedrich D-50 | Driller: Terra Testing, Inc.

Project No.: J217P078

BORING LOG NO. B1-4E Norfolk Southern Railway East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION

Latitude: 40.333299° Longitude: -79.630838°

Approximate Surface Elev: 1068 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
		Run 22, Similar to 117.4 feet		57		5.25 5.5
122.0	946+/-	At 117.4 feet: Hard, medium to highly weathered, black SHALE, thin bedding, close joints, slightly open to open				
		At 121.3 feet: Soft, gray MUDSTONE *(continued)*				
		Run 23, Hard to medium, highly weathered, gray with black LIMESTONE, close to moderately close joints, open	125	51	72	9.25 13.75 3.25 2.75 2
127.0	941+/-					
		Run 24, Soft to medium, highly weathered, gray and brownish red, MUDSTONE with interbedded limestone, very thin bedding, close joints, open	130	51	26	5 3.25 3.75 5.5 5.5
132.0	936+/-					
		Run 25, Medium to soft, highly weathered, gray and red with bluish gray MUDSTONE, very thin bedding, close joints, slightly open to open	135	60	70	5.5 4.75 4 3.75 2.25
137.0	931+/-					
		Run 26, Medium to soft, highly weathered, gray to red MUDSTONE, very thin bedding, close joints, slightly open to open, high angled joint at 140.1 feet	140	58	46	5.75 8.25 7.75 6 3.5
142.0	926+/-					
		Run 27, Similar, brownish red to 143.3 feet, then gray with red, moderately dipping joint at 142.5 feet	145	60	72	5 2.75 10.75 3 1.75
147.0	921+/-					
		Run 28, Similar, brownish red to gray with red	150	54	75	3.5 4.5 6

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:

Additional water level observations:
31.3' on 8/23/17
31.3' on 8/24/17 at boring completion

WATER LEVEL OBSERVATIONS

- 31.5' on 8/19/17
- 31.8' on 8/21/17
- 31.4' on 8/22/17

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/18/2017 Boring Completed: 8/24/2017

Drill Rig: Diedrich D-50 Driller: Terra Testing, Inc.

Project No.: J217P078

BORING LOG NO. B1-4E Norfolk Southern Railway East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION

Latitude: 40.333299° Longitude: -79.630838°

Approximate Surface Elev: 1068 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
		Run 28, Similar, brownish red to gray with red *(continued)*	54		7 3
152.0	916+/-				
		Run 29, Similar to 153 feet At 153 feet: Hard, moderately weathered, gray LIMESTONE, thin bedding, close joints, slightly open At 155.6 feet: Medium to soft, highly weathered, gray MUDSTONE, very thin bedding, open, very close to close joints	56	65	5 5 4.25 3.5 4
157.0	911+/-				
		Run 30, Soft, highly weathered, gray with red MUDSTONE, very thin bedding, close joints, moderately open to open, changes to brownish red at 159.5 feet	56	66	5 3 7.5 3 5.75
162.0	906+/-				
		Run 31, Similar, red with gray	56	68	5.25 3 4 7.75 4
167.0	901+/-				
		Run 32, Similar, with interbedded limestone	59	30	9.25 9.75 11.5 4.75 5.75
172.0	896+/-				
		Run 33, Similar to 173.9 feet, highly weathered from 173.0 to 173.9 feet At 173.9 feet: Hard, slightly weathered, bluish gray MUDSTONE, thin bedding, close joints, slightly open	55	20	9.25 10.25 12.25 6.5 3
177.0	891+/-				
		Run 34, Similar, highly weathered from 180.6 to 182.0 feet	53	23	12.5 3.5 5.75

DEPTH (Ft.): 155, 160, 165, 170, 175, 180

WATER LEVEL OBSERVATIONS: —

SAMPLE TYPE: ■

FIELD TEST RESULTS:

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:

Additional water level observations:
31.3' on 8/23/17
31.3' on 8/24/17 at boring completion

WATER LEVEL OBSERVATIONS

- *31.5' on 8/19/17*
- *31.8' on 8/21/17*
- *31.4' on 8/22/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/18/2017 | Boring Completed: 8/24/2017

Drill Rig: Diedrich D-50 | Driller: Terra Testing, Inc.

Project No.: J217P078

BORING LOG NO. B1-4E Norfolk Southern Railway East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION

Latitude: 40.333299° Longitude: -79.630838°

Approximate Surface Elev: 1068 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
		Run 34, Similar, highly weathered from 180.6 to 182.0 feet *(continued)*	53		12.25 10.75
182.0	886+/-				
		Run 35, Similar to 186 feet, severely weathered from 186.0 to 186.3 feet At 186.3 feet: Hard, slightly weathered, bluish gray SANDSTONE, thin bedding, close joints	60	53	6 7.5 8 7.75 10.5
187.0	881+/-				
		Run 36, Hard, slightly weathered, gray, SANDSTONE, thin bedding, close joints, slightly open From 189 to 189.3 feet: Medium-grained, reddish colored	60	93	4.5 6.5 4.25 3.5 2.75
192.0	876+/-				
		Run 37, Hard, slightly weathered, bluish gray, MUDSTONE, thin bedding, close joints, slightly open to open, with interbedded limestone from 196 to 197 feet	60	75	5.75 9.25 6.5 4.25 3
197.0	871+/-				
		Run 38, Similar, severely weathered from 198.8 to 199.7 feet At 201 feet: SANDSTONE, gray with red	60	61	6.75 5.5 14.5 3.25 2
202.0	866+/-				
		Run 39, Hard, slightly to moderately weathered, bluish gray SANDSTONE, thin bedding, close joints, slightly open	60	92	1.75 1.75 3.5 1.25 1.75
207.0	861+/-				
		Run 40, Similar to 209.4 feet At 209.6 feet: Medium hard to hard, slightly to moderately weathered, gray MUDSTONE, thin bedding, close joints, slightly open	58	71	3 1.5 5.75

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:

Additional water level observations:
31.3' on 8/23/17
31.3' on 8/24/17 at boring completion

WATER LEVEL OBSERVATIONS

- *31.5' on 8/19/17*
- *31.8' on 8/21/17*
- *31.4' on 8/22/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/18/2017 | Boring Completed: 8/24/2017

Drill Rig: Diedrich D-50 | Driller: Terra Testing, Inc.

Project No.: J217P078

BORING LOG NO. B1-4E Norfolk Southern Railway East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION

Latitude: 40.333299° Longitude: -79.630838°

Approximate Surface Elev: 1068 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
212.0	856+/-				58			6.25 5.5	
Run 41, Similar to 213 feet At 213 feet: Soft, severely weathered, brownish red, MUDSTONE, very thin bedding, very close joints, open Poor recovery from 213 to 217 feet		215			37		0	11 14 20.25 16.25 11.25	
217.0	851+/-								
Run 42, Similar to 218.3 feet, brownish red to gray, severely weathered At 218.3 feet: Moderately hard to hard, moderately weathered, bluish gray, MUDSTONE with limestone beds, thin bedding, close joints, slightly open to open		220			51		0	11.75 10 6.5 5.5 2.5	
222.0	846+/-								
Run 43, Similar		225			60		95	2.5 4.25 5.5 6 3.5	
227.0	841+/-								
Run 44, Similar		230			60		90	5 5.75 4.75 5.75 3.5	
232.0	836+/-								
Run 45, Similar		235			58		90	3 4.25 3.5 4.25 4	
237.0	831+/-								
Run 46, Similar		240			58		96	4.25 3.25 3.25	

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:

Additional water level observations:
31.3' on 8/23/17
31.3' on 8/24/17 at boring completion

WATER LEVEL OBSERVATIONS

- *31.5' on 8/19/17*
- *31.8' on 8/21/17*
- *31.4' on 8/22/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/18/2017 | Boring Completed: 8/24/2017

Drill Rig: Diedrich D-50 | Driller: Terra Testing, Inc.

Project No.: J217P078

BORING LOG NO. B1-4E Norfolk Southern Railway East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

GRAPHIC LOG	LOCATION / DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Latitude: 40.333299° Longitude: -79.630838° Approximate Surface Elev: 1068 (Ft.) +/-									
	Run 46, Similar *(continued)*					58			4.25 5.25	
	242.0	826+/-								
	Boring Terminated at 242 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:

WATER LEVEL OBSERVATIONS

- *31.5' on 8/19/17*
- *31.8' on 8/21/17*
- *31.4' on 8/22/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/18/2017 | Boring Completed: 8/24/2017
Drill Rig: Diedrich D-50 | Driller: Terra Testing, Inc.
Project No.: J217P078

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

Boring No.:	B1-4W	Lithology :	Mudstone
Sample No.:	1	Moisture Content :	As received
Sample Depth:	44 feet	Lab Temperature :	70° F
Sampling Date:	8/19/17	Loading Rate:	55 psi/s
		Time to Failure:	0 min

Diameter:	N/A in	Maximum Axial Load at Failure:	N/A lb
Length:	N/A in	Compressive Strength:	N/A psi
L/D:	N/A	Compressive Strength:	N/A Mpa
End Area:	N/A in^2	Unit Weight	N/A pcf

Highly weathered - unable to test specimen

Before the Test

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon		Performed by:	A.Suprunenko
Project No.	J217P078			Test Date:	9/13/2017
Location:	Spread 1			Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/9/2017

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

Boring No.:	B1-4W	Lithology :	Mudstone
Sample No.:	1	Moisture Content :	As received
Sample Depth:	39 feet	Lab Temperature :	70° F
Sampling Date:	8/19/17	Loading Rate:	55 psi/s
		Time to Failure:	6 min

Diameter:	1.94 in	Maximum Axial Load at Failure:	18,720 lb
Length:	3.80 in	Compressive Strength:	6,333 psi
L/D:	1.96	Compressive Strength:	43.66 Mpa
End Area:	2.96 in^2	Unit Weight	174 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

Photograph before the test is not available

After the Test

Photograph after the test is not available

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon		Performed by:	A.Suprunenko
Project No.	J217P078			Test Date:	9/13/2017
Location:	Spread 1			Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/9/2017

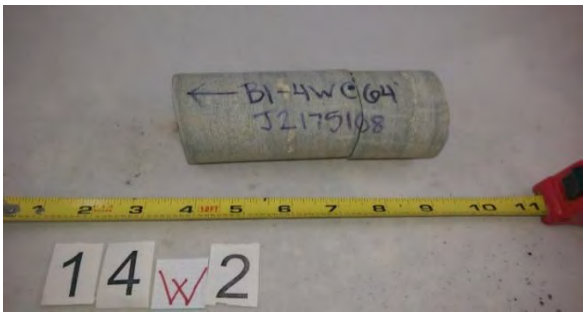
ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.:	B1-4W	Lithology :	Siltstone
Sample No.:	2	Moisture Content :	As received
Sample Depth:	64 feet	Lab Temperature :	70° F
Sampling Date:	8/19/17	Loading Rate:	55 psi/s
		Time to Failure:	13 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	42,960 lb
Length:	2.98 in	Compressive Strength:	13,812 psi
L/D:	1.50	Compressive Strength:	95.23 Mpa
End Area:	3.11 in^2	Unit Weight	167 pcf

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

Before the Test



After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	9/13/2017
Location:	Spread 1		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/9/2017

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

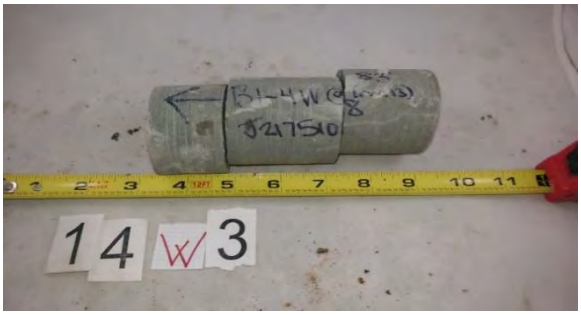
Boring No.:	B1-4W	Lithology :	Siltstone
Sample No.:	3	Moisture Content :	As received
Sample Depth:	83 feet	Lab Temperature :	70° F
Sampling Date:	8/19/17	Loading Rate:	55 psi/s
		Time to Failure:	0 min

Diameter:	N/A in	Maximum Axial Load at Failure:	N/A lb
Length:	N/A in	Compressive Strength:	N/A psi
L/D:	N/A	Compressive Strength:	N/A Mpa
End Area:	N/A in^2	Unit Weight	N/A pcf

Specimen broke during preparation

Before the Test

After the Test



Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon		Performed by:	A.Suprunenko
Project No.	J217P078			Test Date:	9/13/2017
Location:	Spread 1			Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/9/2017

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

Boring No.:	B1-4W	Lithology :	Mudstone
Sample No.:	4	Moisture Content :	As received
Sample Depth:	103 feet	Lab Temperature :	70° F
Sampling Date:	8/19/17	Loading Rate:	55 psi/s
		Time to Failure:	0 min

Diameter:	N/A in	Maximum Axial Load at Failure:	N/A lb
Length:	N/A in	Compressive Strength:	N/A psi
L/D:	N/A	Compressive Strength:	N/A Mpa
End Area:	N/A in^2	Unit Weight	N/A pcf

Highly weathered - unable to test specimen

Before the Test

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

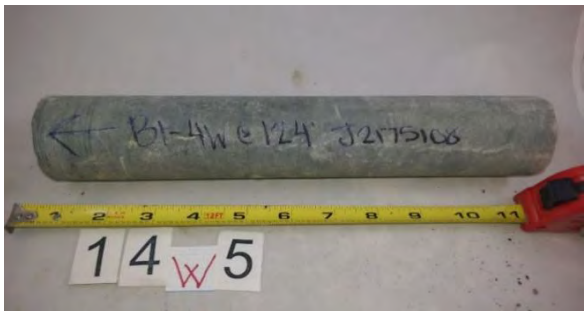
Project:	Mariner East Pipeline	Terracon		Performed by:	A.Suprunenko
Project No.	J217P078			Test Date:	9/13/2017
Location:	Spread 1			Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/9/2017

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

Boring No.:	B1-4W	Lithology :	Siltstone
Sample No.:	5	Moisture Content :	As received
Sample Depth:	124 feet	Lab Temperature :	70° F
Sampling Date:	8/19/17	Loading Rate:	55 psi/s
		Time to Failure:	5 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	17,150 lb
Length:	4.45 in	Compressive Strength:	5,570 psi
L/D:	2.25	Compressive Strength:	38.40 Mpa
End Area:	3.08 in^2	Unit Weight	171 pcf

Before the Test



After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	9/13/2017
Location:	Spread 1		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/9/2017

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

Boring No.:	B1-4W	Lithology :	Siltstone
Sample No.:	6	Moisture Content :	As received
Sample Depth:	145 feet	Lab Temperature :	70° F
Sampling Date:	8/19/17	Loading Rate:	55 psi/s
		Time to Failure:	0 min

Diameter:	N/A in	Maximum Axial Load at Failure:	N/A lb
Length:	N/A in	Compressive Strength:	N/A psi
L/D:	N/A	Compressive Strength:	N/A Mpa
End Area:	N/A in^2	Unit Weight	N/A pcf

Specimen broke during preparation

Before the Test

After the Test

Drawing # :	PA-WM1-0088.0000-RR
PO # :	20170804-8
Crossing :	Norfolk Southern Railway
Spread :	Spread 1

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	9/13/2017
Location:	Spread 1		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/9/2017

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

Boring No.:	B1-4W	Lithology :	Siltstone
Sample No.:	7	Moisture Content :	As received
Sample Depth:	164 feet	Lab Temperature :	70° F
Sampling Date:	8/19/17	Loading Rate:	55 psi/s
		Time to Failure:	0 min

Diameter:	N/A in	Maximum Axial Load at Failure:	N/A lb
Length:	N/A in	Compressive Strength:	N/A psi
L/D:	N/A	Compressive Strength:	N/A Mpa
End Area:	N/A in^2	Unit Weight	N/A pcf

Specimen broke during preparation

Before the Test

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon		Performed by:	A.Suprunenko
Project No.	J217P078			Test Date:	9/13/2017
Location:	Spread 1			Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/9/2017

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

Boring No.:	B1-4W	Lithology :	Mudstone
Sample No.:	8	Moisture Content :	As received
Sample Depth:	187 feet	Lab Temperature :	70° F
Sampling Date:	8/19/17	Loading Rate:	55 psi/s
		Time to Failure:	0 min

Diameter:	N/A in	Maximum Axial Load at Failure:	N/A lb
Length:	N/A in	Compressive Strength:	N/A psi
L/D:	N/A	Compressive Strength:	N/A Mpa
End Area:	N/A in^2	Unit Weight	N/A pcf

Specimen broke during preparation. Target depth range is too fractured to assign second test.

Before the Test

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon		Performed by:	A.Suprunenko
Project No.	J217P078			Test Date:	9/13/2017
Location:	Spread 1			Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/9/2017

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

Boring No.:	B1-4W	Lithology :	Siltstone
Sample No.:	9	Moisture Content :	As received
Sample Depth:	204 feet	Lab Temperature :	70° F
Sampling Date:	8/19/17	Loading Rate:	55 psi/s
		Time to Failure:	0 min

Diameter:	N/A in	Maximum Axial Load at Failure:	N/A lb
Length:	N/A in	Compressive Strength:	N/A psi
L/D:	N/A	Compressive Strength:	N/A Mpa
End Area:	N/A in^2	Unit Weight	N/A pcf

Specimen broke during preparation

Before the Test

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	9/13/2017
Location:	Spread 1		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/9/2017

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

Boring No.:	B1-4W	Lithology :	Siltstone
Sample No.:	9a	Moisture Content :	As received
Sample Depth:	232 feet	Lab Temperature :	70° F
Sampling Date:	8/19/17	Loading Rate:	55 psi/s
		Time to Failure:	10 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	34,210 lb
Length:	3.13 in	Compressive Strength:	10,999 psi
L/D:	1.57	Compressive Strength:	75.84 Mpa
End Area:	3.11 in^2	Unit Weight	167 pcf

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

Before the Test

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon	Performed by:	H. Whitford
Project No.	J217P078		Test Date:	10/9/2017
Location:	Spread 1		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/9/2017

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

Boring No.:	B1-4W	Lithology :	Siltstone
Sample No.:	10	Moisture Content :	As received
Sample Depth:	242 feet	Lab Temperature :	70° F
Sampling Date:	8/19/17	Loading Rate:	55 psi/s
		Time to Failure:	0 min

Diameter:	N/A in	Maximum Axial Load at Failure:	N/A lb
Length:	N/A in	Compressive Strength:	N/A psi
L/D:	N/A	Compressive Strength:	N/A Mpa
End Area:	N/A in^2	Unit Weight	N/A pcf

Specimen broke during preparation

Before the Test

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078	77 Sundial Ave., Suite 401 W	Test Date:	9/13/2017
Location:	Spread 1	Manchester, New Hampshire	Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/9/2017

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

Boring No.:	B1-4W	Lithology :	Shale
Sample No.:	11	Moisture Content :	As received
Sample Depth:	257 feet	Lab Temperature :	70° F
Sampling Date:	8/19/17	Loading Rate:	55 psi/s
		Time to Failure:	7 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	22,100 lb
Length:	4.35 in	Compressive Strength:	7,106 psi
L/D:	2.19	Compressive Strength:	48.99 Mpa
End Area:	3.11 in^2	Unit Weight	166 pcf

Before the Test

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Performed by:	A.Suprunenko
Project No.	J217P078	Test Date:	9/13/2017
Location:	Spread 1	Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	Review Date :	10/9/2017

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

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

Boring No.:	B1-4W	Lithology :	Siltstone
Sample No.:	12	Moisture Content :	As received
Sample Depth:	269.5 feet	Lab Temperature :	70° F
Sampling Date:	8/19/17	Loading Rate:	55 psi/s
		Time to Failure:	7 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	22,590 lb
Length:	4.44 in	Compressive Strength:	7,337 psi
L/D:	2.24	Compressive Strength:	50.58 Mpa
End Area:	3.08 in^2	Unit Weight	168 pcf

Before the Test

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon	Performed by:	W. Shedd
Project No.	J217P078		Test Date:	10/7/2017
Location:	Spread 1		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/9/2017

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

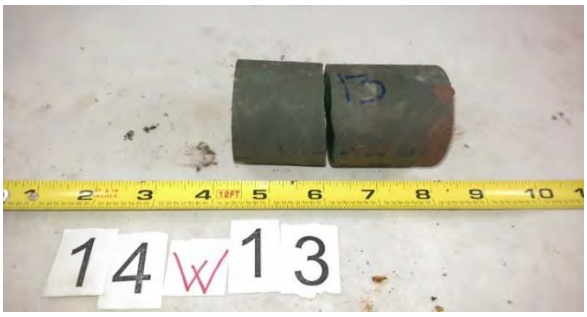
Boring No.:	B1-4W	Lithology :	Siltstone
Sample No.:	12	Moisture Content :	As received
Sample Depth:	276 feet	Lab Temperature :	70° F
Sampling Date:	8/19/17	Loading Rate:	55 psi/s
		Time to Failure:	0 min

Diameter:	N/A in	Maximum Axial Load at Failure:	N/A lb
Length:	N/A in	Compressive Strength:	N/A psi
L/D:	N/A	Compressive Strength:	N/A Mpa
End Area:	N/A in^2	Unit Weight	N/A pcf

Specimen broke during preparation

Before the Test

After the Test



Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon		Performed by:	A.Suprunenko
Project No.	J217P078			Test Date:	9/13/2017
Location:	Spread 1			Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/9/2017

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

Boring No.:	B1-4E	Lithology :	Mudstone
Sample No.:	1	Moisture Content :	As received
Sample Depth:	33.5 feet	Lab Temperature :	70° F
Sampling Date:	8/18/17	Loading Rate:	55 psi/s
		Time to Failure:	11 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	35,890 lb
Length:	4.43 in	Compressive Strength:	11,656 psi
L/D:	2.24	Compressive Strength:	80.37 Mpa
End Area:	3.08 in^2	Unit Weight	159 pcf

Before the Test

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078	77 Sundial Ave., Suite 401 W	Test Date:	9/13/2017
Location:	Spread 1	Manchester, New Hampshire	Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/9/2017

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

Boring No.:	B1-4E	Lithology :	Sandstone
Sample No.:	2	Moisture Content :	As received
Sample Depth:	48 feet	Lab Temperature :	70° F
Sampling Date:	8/18/17	Loading Rate:	55 psi/s
		Time to Failure:	9 min

Diameter:	1.97 in	Maximum Axial Load at Failure:	29,860 lb
Length:	4.12 in	Compressive Strength:	9,796 psi
L/D:	2.09	Compressive Strength:	67.54 Mpa
End Area:	3.05 in^2	Unit Weight	159 pcf

Before the Test

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon		Performed by:	H. Whitford
Project No.	J217P078			Test Date:	10/9/2017
Location:	Spread 1			Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/9/2017

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

Boring No.:	B1-4E	Lithology :	Mudstone
Sample No.:	3	Moisture Content :	As received
Sample Depth:	63 feet	Lab Temperature :	70° F
Sampling Date:	8/18/17	Loading Rate:	55 psi/s
		Time to Failure:	2 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	7,910 lb
Length:	4.56 in	Compressive Strength:	2,569 psi
L/D:	2.30	Compressive Strength:	17.71 Mpa
End Area:	3.08 in^2	Unit Weight	163 pcf

Before the Test

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	9/13/2017
Location:	Spread 1		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/9/2017

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

Boring No.:	B1-4E	Lithology :	Mudstone
Sample No.:	4	Moisture Content :	As received
Sample Depth:	94 feet	Lab Temperature :	70° F
Sampling Date:	8/18/17	Loading Rate:	55 psi/s
		Time to Failure:	13 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	41,470 lb
Length:	4.38 in	Compressive Strength:	13,468 psi
L/D:	2.21	Compressive Strength:	92.86 Mpa
End Area:	3.08 in^2	Unit Weight	162 pcf

Before the Test

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	9/13/2017
Location:	Spread 1		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/9/2017

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

Boring No.:	B1-4E	Lithology :	Mudstone
Sample No.:	5	Moisture Content :	As received
Sample Depth:	114 feet	Lab Temperature :	70° F
Sampling Date:	8/18/17	Loading Rate:	55 psi/s
		Time to Failure:	10 min

Diameter:	1.95 in	Maximum Axial Load at Failure:	32,070 lb
Length:	2.78 in	Compressive Strength:	10,738 psi
L/D:	1.43	Compressive Strength:	74.04 Mpa
End Area:	2.99 in^2	Unit Weight	166 pcf

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

Before the Test

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon		Performed by:	A.Suprunenko
Project No.	J217P078			Test Date:	9/13/2017
Location:	Spread 1			Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/9/2017

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

Boring No.:	B1-4E	Lithology :	Mudstone
Sample No.:	6	Moisture Content :	As received
Sample Depth:	134 feet	Lab Temperature :	70° F
Sampling Date:	8/18/17	Loading Rate:	55 psi/s
		Time to Failure:	7 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	21,720 lb
Length:	4.48 in	Compressive Strength:	7,054 psi
L/D:	2.26	Compressive Strength:	48.64 Mpa
End Area:	3.08 in^2	Unit Weight	169 pcf

Before the Test

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078	77 Sundial Ave., Suite 401 W	Test Date:	9/13/2017
Location:	Spread 1	Manchester, New Hampshire	Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/9/2017

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

Boring No.:	B1-4E	Lithology :	Limestone
Sample No.:	7	Moisture Content :	As received
Sample Depth:	155 feet	Lab Temperature :	70° F
Sampling Date:	8/18/17	Loading Rate:	55 psi/s
		Time to Failure:	6 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	19,610 lb
Length:	4.38 in	Compressive Strength:	6,369 psi
L/D:	2.21	Compressive Strength:	43.91 Mpa
End Area:	3.08 in^2	Unit Weight	166 pcf

Before the Test

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	9/13/2017
Location:	Spread 1		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/9/2017

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

Boring No.:	B1-4E	Lithology :	Mudstone
Sample No.:	8	Moisture Content :	As received
Sample Depth:	171 feet	Lab Temperature :	70° F
Sampling Date:	8/18/17	Loading Rate:	55 psi/s
		Time to Failure:	0 min

Diameter:	N/A in	Maximum Axial Load at Failure:	N/A lb
Length:	N/A in	Compressive Strength:	N/A psi
L/D:	N/A	Compressive Strength:	N/A Mpa
End Area:	N/A in^2	Unit Weight	N/A pcf

Specimen broke during preparation

Before the Test

Photograph before preparation is not available

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon	Performed by:	H. Whitford
Project No.	J217P078		Test Date:	10/9/2017
Location:	Spread 1		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/9/2017

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

Boring No.:	B1-4E	Lithology :	Mudstone
Sample No.:	10	Moisture Content :	As received
Sample Depth:	194 feet	Lab Temperature :	70° F
Sampling Date:	8/18/17	Loading Rate:	55 psi/s
		Time to Failure:	5 min

Diameter:	1.97 in	Maximum Axial Load at Failure:	17,620 lb
Length:	4.45 in	Compressive Strength:	5,781 psi
L/D:	2.26	Compressive Strength:	39.86 Mpa
End Area:	3.05 in^2	Unit Weight	168 pcf

Note: Photograph after the test is mislabeled as 3-2E

Before the Test

Photograph before the test is not available

After the Test

Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	9/13/2017
Location:	Spread 1		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/9/2017

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

Boring No.:	B1-4E	Lithology :	Mudstone
Sample No.:	11	Moisture Content :	As received
Sample Depth:	198 feet	Lab Temperature :	70° F
Sampling Date:	8/18/17	Loading Rate:	55 psi/s
		Time to Failure:	4 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	14,800 lb
Length:	4.37 in	Compressive Strength:	4,807 psi
L/D:	2.21	Compressive Strength:	33.14 Mpa
End Area:	3.08 in^2	Unit Weight	169 pcf

Before the Test

After the Test

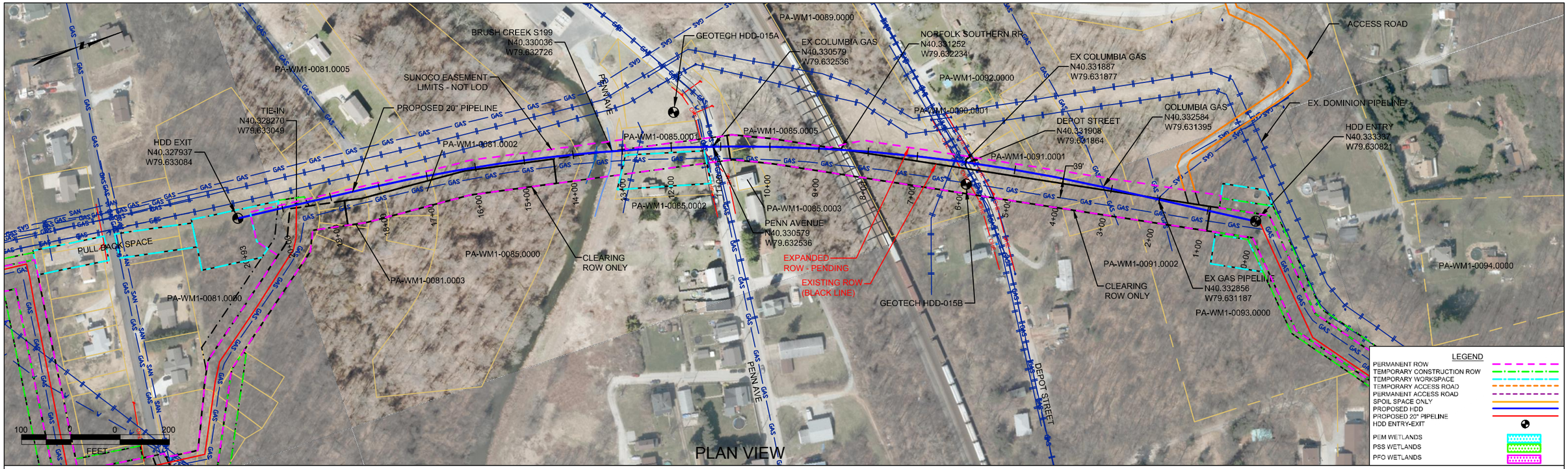
Drawing # : PA-WM1-0088.0000-RR
PO # : 20170804-8
Crossing : Norfolk Southern Railway
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078	77 Sundial Ave., Suite 401 W	Test Date:	9/13/2017
Location:	Spread 1	Manchester, New Hampshire	Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/9/2017

NORFOLK SOUTHERN RAILROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E65-973
PA-WM1-0088.0000-RR
(SPLP HDD# S1B-0250)

ATTACHMENT 2

ORIGINAL AND REVISED HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILE



PLAN VIEW

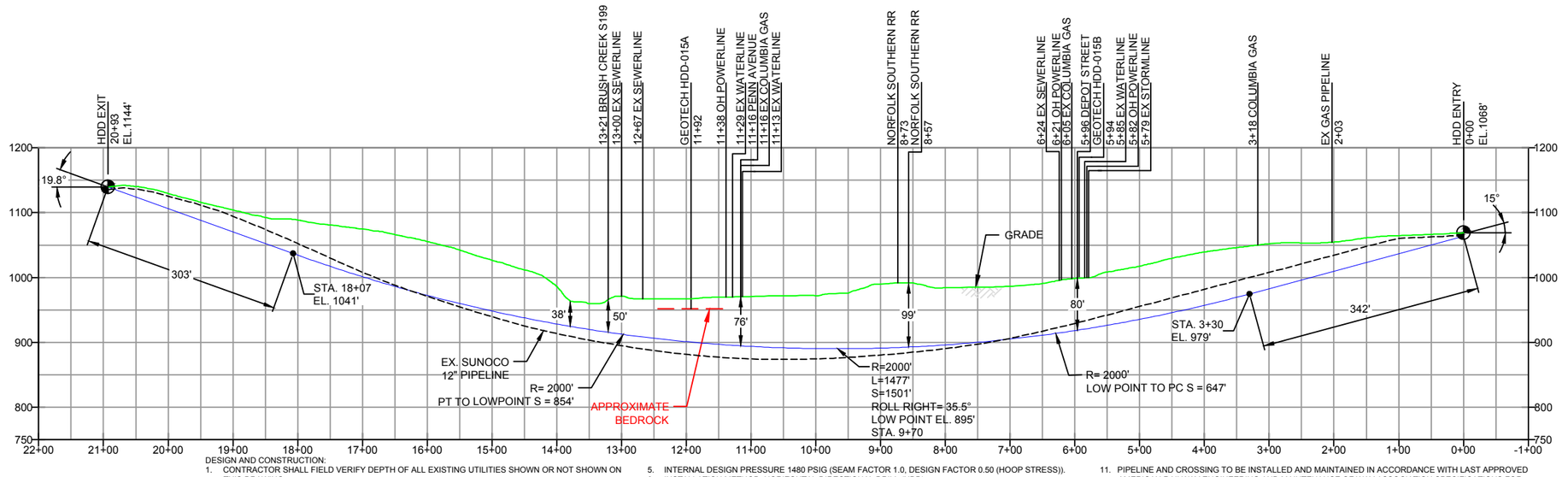
PROFILE VIEW

WESTMORELAND COUNTY, PENNSYLVANIA - HEMPFIELD\ JEANNETTE\ PENN TOWNSHIP
S1B-0250

GEOTECH HDD-15A

-NG EL. 968'
-CL (0.0' - 7.0')
-SM (7.0' - 12.0')
-GROUNDWATER (11.0')
-CL (12.0' - 15.0')
-WEATHERED CLAYSTONE (15.0' - 23.5')
-GRAY/RED CLAYSTONE (23.5' - 33.5')
-COMPLETION DEPTH EL. 935'

NOTE: REFER TO TEST BORING LOG HDD-15A 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=): 2093'
   HDD PIPE LENGTH (S=): 2147'
   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. PIPELINE AND CROSSING TO BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH LAST APPROVED AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION SPECIFICATIONS FOR PIPELINES CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES.
12. BLASTING NOT PERMITTED.
13. 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 NAVD88.
2. STATIONING IS BASED ON HORIZONTAL DISTANCES.
3. ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, LP ARE NOT RESPONSIBLE FOR LOCATION OF FOREIGN UTILITIES SHOWN IN PLOT PLAN OR PROFILE. THE INFORMATION SHOWN HEREON IS FURNISHED WITHOUT LIABILITY ON THE PART OF ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, LP, FOR ANY DAMAGES RESULTING FROM ERRORS OR OMISSIONS THEREIN.
4. CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.
5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
6	DESIGN CHANGE - RELOCATED DRILL ENTRY/EXIT	MRS	07/12/17	RMB	07/12/17	CAG	07/12/17
5	DRILL ENTRY / EXIT LAT LONG UPDATE	MRS	04/03/17	RMB	04/03/17	CAG	04/03/17
4	DESIGN CHANGE (LOWER DRILL) & REVISED PROFILE W/ 2017 LIDAR	DLM	03/13/17	RMB	03/13/17	CAG	03/13/17
3	REVISED PER ENGINEERING COMMENTS	DLM	08/19/16	RMB	08/19/16	AAW	08/19/16
2	ADDED "CLEARING ROW ONLY" ANNOTATION	MRS	03/24/16	RMB	03/24/16	AAW	03/24/16
1	REVISED PER COMMENTS FROM REI REVIEW 12-18-15	MRS	12/18/15	RMB	12/18/15	AAW	12/18/15

Sunoco Logistics Partners L.P.

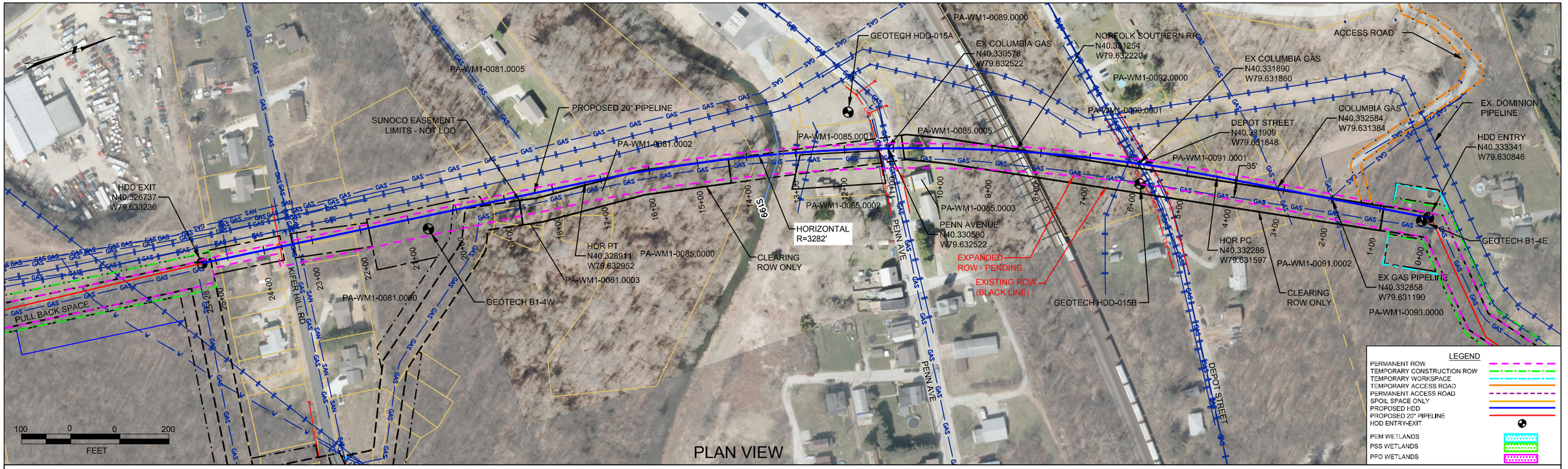
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
NORFOLK SOUTHERN RAILWAY
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

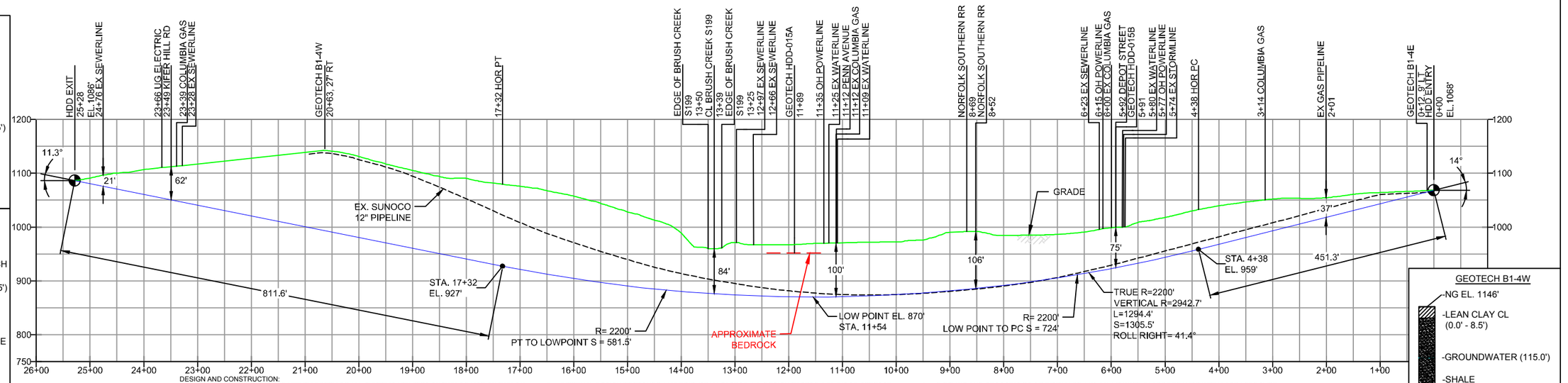
DWG. NUMBER: PA-WM1-0088.0000-RR



PLAN VIEW

PROFILE VIEW

WESTMORELAND COUNTY, PENNSYLVANIA - HEMPFIELD\ JEANNETTE\ PENN TOWNSHIP
S1B-0250



GEOTECH HDD-15A

-NG EL. 968'
-CL (0.0' - 7.0')
-SM (7.0' - 12.0')
-GROUNDWATER (11.0')
-CL (12.0' - 15.0')
-WEATHERED CLAYSTONE (15.0' - 23.5')
-GRAY/RED CLAYSTONE (23.5' - 33.5')
-COMPLETION DEPTH EL. 935'

NOTE: REFER TO TEST BORING LOG HDD-15A FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B1-4E

-NG EL. 1068'
-FAT CLAY W/ GRAVEL CH (0.0' - 8.5')
-FAT CLAY CH (8.5' - 13.5')
-GROUNDWATER (31.3')
-WEATHERED ROCK MUDSTONE/SANDSTONE (13.5' - 242')
-BORING TERMINATED EL.826'

NOTE: REFER TO TEST BORING LOG B1-4E TERRACON INC. PROJECT # J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B1-4W

-NG EL. 1146'
-LEAN CLAY CL (0.0' - 8.5')
-GROUNDWATER (115.0')
-SHALE MUDSTONE/SANDSTONE (8.5' - 318.0')
-BORING TERMINATED EL.828'

NOTE: REFER TO TEST BORING LOG B1-4W TERRACON INC. 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=):2528'
   HDD PIPE LENGTH (S=):2568'
   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. PIPELINE AND CROSSING TO BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH LAST APPROVED AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION SPECIFICATIONS FOR PIPELINES CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES.
12. BLASTING NOT PERMITTED.
13. 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-1.43	TO	ES-1.44	EROSION & SEDIMENT PLAN	
SHEET 32	TO	SHEET 33	AERIAL SITE PLAN	

DWG NO		DWG NO	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP3	DESIGN CHANGE - RELOCATED DRILL ENTRY/EXIT	MRS	08/29/17	RMB	08/29/17	CAG	08/29/17
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	05/20/16	RMB	05/20/16	AAW	05/20/16
EP		JTW	03/15/16	RMB	03/15/16	AAW	03/15/16

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SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
NORFOLK SOUTHERN RAILWAY
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

DWG. NUMBER: PA-WM1-0088.0000-RR