

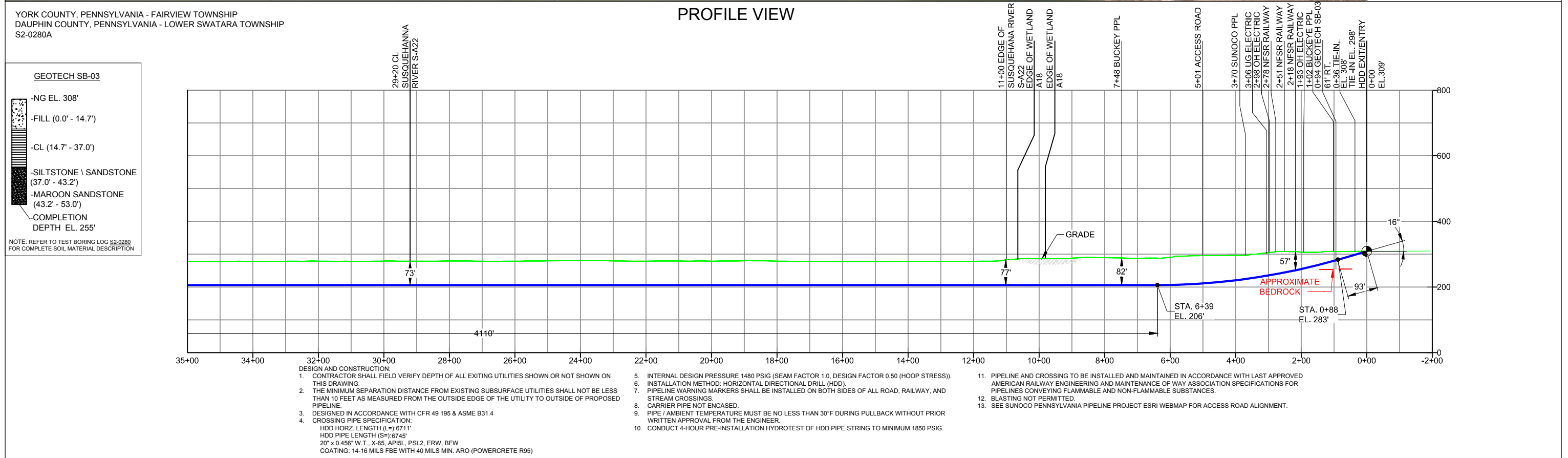
***HDD PA-YO-0063.0000-RR (S-A22)***

Given the design, the threat of inadvertent return has been reduced to the maximum extent practicable and in this case that threat is considered to be low. Implementing this design, along with adherence to the Pennsylvania Pipeline Project Inadvertent Return Contingency Plan will ensure inadvertent impacts, if they were to occur, are also minimized to the maximum extent.

The drill will pass 75' below the river. The geotechnical results, as well as other data points, were used to determine the entry/exit angles, and depths to pass through the best substrates while maintaining the pipe integrity (e.g., no large bends). According to the geotechnical report primary substrates being drilled through are sandstone beneath layers of silt and clays. Based on the geotechnical report and the drill profile minimal inadvertent returns are expected. Due to the river width additional inspection is recommended to observe for inadvertent returns.

Revised: February 6, 2017

The drill will enter/exit 1800 feet from the western edge of the Susquehanna River (S-A22) and enter/exit 1,050 feet from the eastern edge. The drill will enter/exit 800 feet from the western edge Stream H56 and enter/exit 5,900 feet from the eastern edge, crossing 42 feet below the stream.



**NOTES**

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

REF. DRAWING		REVISIONS	
ES-4.20	TO ES-4.04	NO.	DESCRIPTION
SHEET 13	SHEET 2	4	DESIGN CHANGE - RELOCATED DRILL ENTRY/EXIT
		3	REVISED PER ENGINEERING COMMENTS
		2	ADDED UTILITY CROSSING LABEL
		1	REVISED PER COMMENTS FROM REI REVIEW
		0	ISSUED FOR CONSTRUCTION

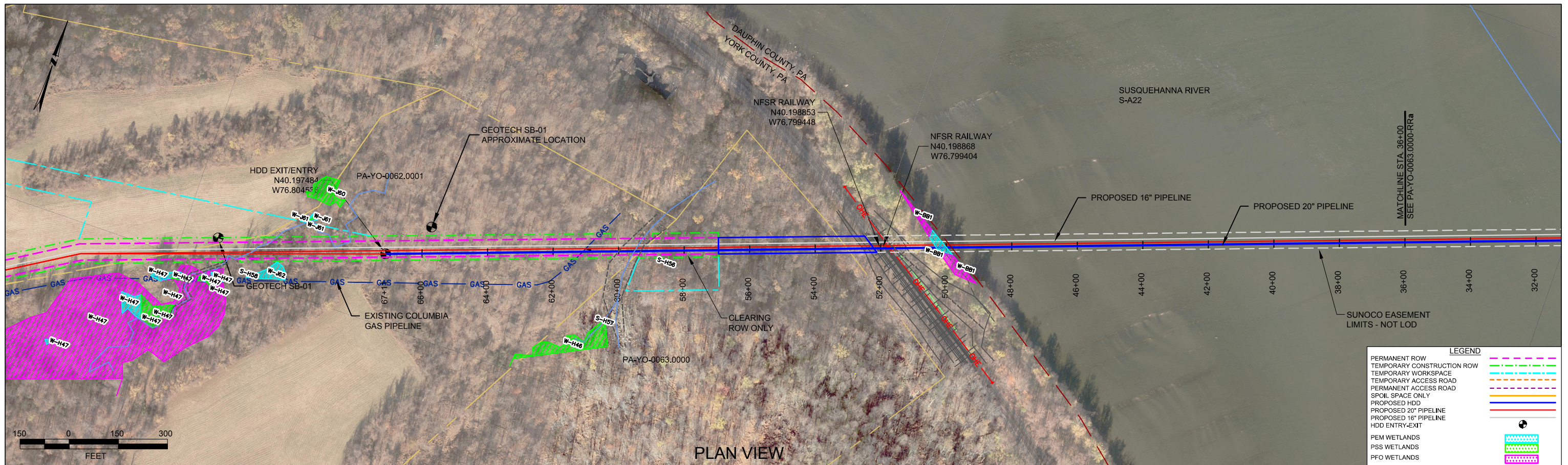
**Sunoco Logistics  
Partners L.P.**

**TETRA TECH ROONEY**  
(303) 792-5911

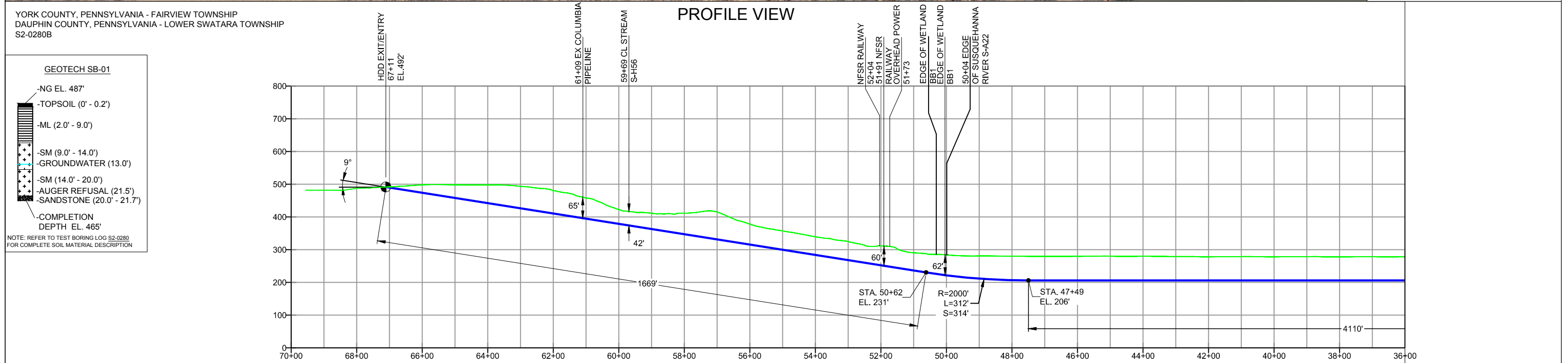
**SUNOCO PIPELINE, L.P.**

20-INCH HORIZONTAL DIRECTIONAL DRILL  
SUSQUEHANNA RIVER  
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=300'    DWG. NO: PA-YO-0063.0000-RRa

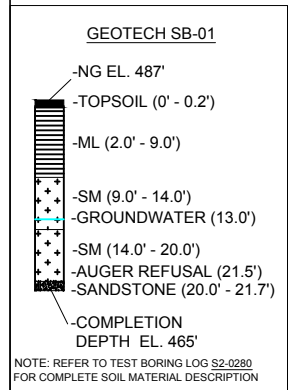


PLAN VIEW



PROFILE VIEW

YORK COUNTY, PENNSYLVANIA - FAIRVIEW TOWNSHIP  
 DAUPHIN COUNTY, PENNSYLVANIA - LOWER SWATARA TOWNSHIP  
 S2-0280B



- DESIGN AND CONSTRUCTION:
- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
  - THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
  - DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
  - CROSSING PIPE SPECIFICATION:  
 HDD HORZ. LENGTH (L)=6711'  
 HDD PIPE LENGTH (S)=6745'  
 20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW  
 COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
  - INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
  - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
  - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
  - CARRIER PIPE NOT ENCASED.
  - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
  - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
  - 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.
  - BLASTING NOT PERMITTED.
  - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

NOTES

- ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
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- SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING		REVISIONS	
ES-4.20	TO ES-4.04	NO.	DESCRIPTION
SHEET 13	TO SHEET 2	EP3	REVISED PER PADEP COMMENTS RECEIVED 01-30-17
		3	DESIGN CHANGE - RELOCATED DRILL ENTRY/EXIT
		2	REVISED PER ENGINEERING COMMENTS
		1	REVISED PER COMMENTS FROM REI REVIEW
		0	ISSUED FOR CONSTRUCTION

**Sunoco Logistics Partners L.P.**

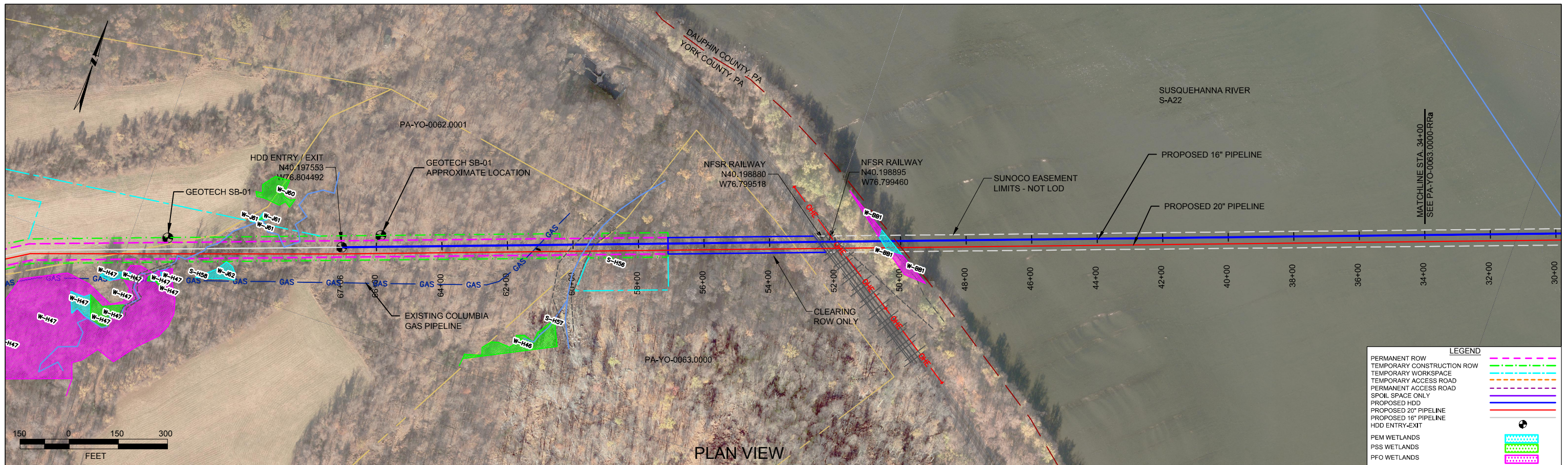
**TETRA TECH ROONEY**  
 (303) 792-5911

**SUNOCO PIPELINE, L.P.**

20-INCH HORIZONTAL DIRECTIONAL DRILL  
 SUSQUEHANNA RIVER  
 PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=300'    DWG. NO: PA-YO-0063.0000-RRb

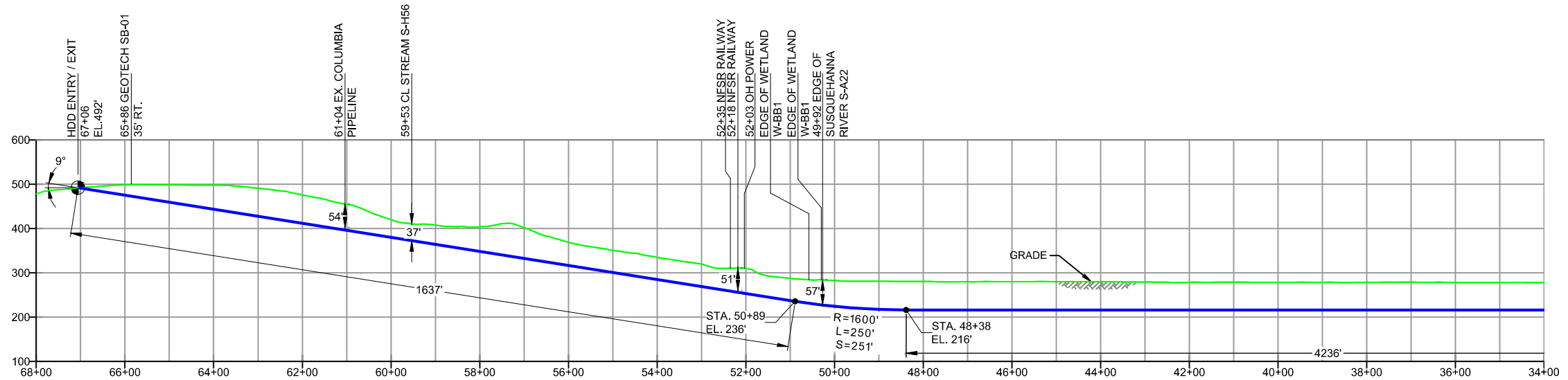
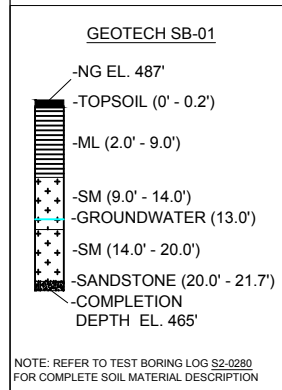




PLAN VIEW

YORK COUNTY, PENNSYLVANIA - FAIRVIEW TOWNSHIP  
 DAUPHIN COUNTY, PENNSYLVANIA - LOWER SWATARA TOWNSHIP  
 S2-0280B-16

PROFILE VIEW



- DESIGN AND CONSTRUCTION:
- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
  - THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
  - DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
  - CROSSING PIPE SPECIFICATION:  
 HDD HORZ. LENGTH (L)=6706'  
 HDD PIPE LENGTH (S)=6735'  
 16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW  
 COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
  - INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
  - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
  - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
  - CARRIER PIPE NOT ENCASED.
  - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
  - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
  - 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.
  - BLASTING NOT PERMITTED.
  - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

NOTES

- ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
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REF. DRAWING		REVISIONS	
ES-4.20	TO ES-4.04	NO.	DESCRIPTION
SHEET 13	TO SHEET 2	EP3	REVISED PER PADEP COMMENTS RECEIVED 01-30-17
		3	DESIGN CHANGE - RELOCATED DRILL ENTRY/EXIT
		2	REVISED PER ENGINEERING COMMENTS
		1	REVISED PER COMMENTS FROM REI REVIEW
		0	ISSUED FOR CONSTRUCTION

**Sunoco Logistics Partners L.P.**

**TETRA TECH ROONEY**  
 (303) 792-5911

**SUNOCO PIPELINE, L.P.**

16-INCH HORIZONTAL DIRECTIONAL DRILL  
 SUSQUEHANNA RIVER  
 PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=300'    DWG. NO: PA-YO-0063.0000-RRb-16



**LEGEND:**

⊙ Geotechnical Soil Boring (SB) Locations



GEOTECHNICAL BORING LOCATIONS  
 HDD S2-0280  
 YORK COUNTY, FAIRVIEW TOWNSHIP, AND  
 DAUPHIN COUNTY, LOWER SWATARA TOWNSHIP, PA  
 SUNOCO PENNSYLVANIA PIPELINE PROJECT



**TETRA TECH**

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

**TEST BORING LOG**

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT	Project No.:	103IP3406
Project Location:	WHITE HOUSE LAND, HIGHSPIRE, PA (HARRISBURG AIRPORT PROPERTY)	Page 1 of 1	
HDD No.:	S2-0280	Dates(s) Drilled:	11-05-14
Boring No.:	SB-01	Inspector:	E. WATT
Drilling Contractor:	HAD DRILLING	Drilling Method:	SPT - ASTM D1586
		Driller:	S. HOFFER
		Groundwater Depth (ft):	13.0
		Total Depth (ft):	21.7

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (ft)	Strata (USCS)	Description of Materials	6" Increment Blows *				N	
	From	To	From	To									
			0.0	2.0			TOPSOIL (24")						
1	3.0	5.0	2.0		14	ML	MOTTLED ORANGE AND REDDISH BROWN SILT WITH A LITTLE FINE SAND.	1	3	7	9	10	
2	8.0	10.0	9.0	14.0	15	SM	DARK GRAY FINE TO MEDIUM SAND WITH SOME SILT.	2	2	12	17	14	
3	13.0	15.0	14.0		19	SM	DR WEATHERED TO A GREENISH BROWN, GRAY, AND REDDISH BRWN FINE SAND AND SILT, TRACE FINE GRAVEL.	1	4	6	6	10	
4	18.0	19.0			12		DR WEATHERED TO A VARI-COLORED (GRAY, BROWN, WHITE) FINE TO MEDIUM SAND WITH SOME SILT.	2	50/6"				>50
5	21.5	21.7	20.0		2		GRAY AND BROWN MEDIUM TO COARSE SAND AND FINE TO COARSE SANDSTONE GRAVEL (PARTIALLY WEATHERED SANDSTONE).	50/2"					
				21.7									
							STARTED GRINDING AT 20'.						
							AUGER REFUSAL AT 21.5'.						
							WET ON SPOON AT 13'.						
							WATER LEVEL THROUGH AUGERS AT 14.5'.						
							CAVED AT 10', WATER LEVEL ON CAVE AT 4'.						

Notes/Comments:  
Pocket Pentrometer Testing DR: DECOMPOSED ROCK  
 S1: 2.5 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.



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**TEST BORING LOG**

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT	Project No.:	103IP3406
Project Location:	WHITE HOUSE LAND, HIGHSPIRE, PA (HARRISBURG AIRPORT PROPERTY)	Page 1 of 2	
HDD No.:	S2-0280	Dates(s) Drilled:	11-05/06-14
Boring No.:	SB-03	Inspector:	E. WATT
Drilling Contractor:	HAD DRILLING	Drilling Method:	SPT - ASTM D1586
		Driller:	S. HOFFER
		Groundwater Depth (ft):	NOT ENCOUNTERED
		Total Depth (ft):	53.0

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (ft)	Strata (USCS)	Description of Materials	6" Increment Blows *				N	
	From	To	From	To									
							NO DISCERNABLE TOPSOIL						
1	3.0	5.0	0.0		20	HISTORIC FILL (ML/SM)	DARK GRAY TO BLACK SILT AND FINE TO MEDIUM SAND WITH A LITTLE GRAVEL AND COAL (FILL)	6	8	5	6	13	
2	8.0	10.0			12		DARK GRAY TO BLACK SILT AND FINE TO MEDIUM SAND WITH A LITTLE GRAVEL AND COAL (FILL)	3	2	2	2	4	
3	13.0	15.0			17		DARK GRAY TO BLACK SILT AND FINE TO MEDIUM SAND WITH A LITTLE GRAVEL AND COAL (FILL)	WH	1	1	1	2	
				14.7			GRAVEL AND COAL (FILL)						
4	18.0	20.0	14.7		24		CL	MOTTLED GRAY AND BROWN SILTY CLAY, TRACE FINE SAND, AND A TRACE FINE GRAVEL (USCS: CL)	1	4	6	10	10
5	23.0	25.0			24			REDDISH BROWN TO MAROON SILTY CLAY WITH A LITTLE FINE SAND, AND A LITTLE FINE GRAVEL.	1	3	6	9	9
6	28.0	29.5			18			DR WEATHERED TO A REDDISH BROWN MICACEOUS SILTY CLAY, TRACE FINE SAND, AND TRACE UNWEATHERED GRAVEL.	6	21	50		>50
7	33.0	34.4			14			DR WEATHERED TO A REDDISH BROWN SILTY CLAY WITH A LITTLE TO SOME FINE SAND, TRACE UNWEATHERED FINE GRAVEL (USCS: CL).	6	13	50/5"		
				37.0									
8	38.0	38.6	37.0		8			WEATHERED REDDISH BROWN SILTSTONE.	30	50/2"			
9	43.0	43.2		43.2	2	PARTIALLY WEATHERED MAROON SANDSTONE.		50/2"					
							SEE PAGE 2 FOR ROCK CORE DATA						

Notes/Comments:  
Pocket Pentrometer Testing DR: DECOMPOSED ROCK  
 S4: 3.5 TSF  
 S5: 2 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.



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 Newark, Delaware 19713  
 302.738.7551  
 fax: 302.454.5988

**TEST BORING LOG**

Project Name:		SUNOCO PENNSYLVANIA PIPELINE PROJECT			Project No.: 103IP3406	
Project Location:		WHITE HOUSE LAND, HIGHSPIRE, PA (HARRISBURG AIRPORT PROPERTY)			Page 2 of 2	
HDD No.:	S2-0280	Dates(s) Drilled:	11-05/06-14	Inspector:	E. WATT	
Boring No.:	SB-03	Drilling Method:	SPT - ASTM D1586	Driller:	S. HOFFER	
Drilling Contractor:	HAD DRILLING		Groundwater Depth (ft):	NOT ENCOUNTERED		
				Total Depth (ft):	53.0	

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (ft)	Strata (USCS)	Description of Materials	6" Increment Blows *				N	
	From	To	From	To									
							<u>ROCK CORING</u>						
RUN 1	44.0	48.0	44.0		46	ROCK	MAROON SANDSTONE. ANGLED FRACTURE 44.65 TO 44.73, FRAC.	TCR: 96%, SCR: 83%, RQD: 72%					
				45.2			ZONE 45.08 TO 45.26.						
			45.2	45.4			CONGOMERATE LENSE.						
			45.4				REDDISH BROWN SANDSTONE, ANGLED FRACTURES 45.88-45.94,						
				47.0			FRACTURE ZONE 46.28-46.34. CALCITE VEIN 46.9.						
			47.0	47.2			CONGOMERATE LENSE.						
			47.2				REDDISH BROWN SANDSTONE. MECHANICAL BREAK 47.63, FRAC.						
				48.0			ZONE 47.87 TO 48.0.						
RUN 2	48.0	53.0	48.0		54		REDDISH BROWN SANDSTONE, FRAC. ZONE 48-48.5, ANGLED FRAC.	TCR: 90%, SCR: 57%, RQD: 48%					
				49.5			48.79-49.63.						
			49.5	49.7		CONGLOMERATE LENS, ANGLED FRAC. 49.55-49.63							
			49.7			RB SANDSTONE, FRAC. 50.2, ANGLED FRAC. 50.4-50.5, 50.57-50.66,							
				51.5		FRAC. 50.73.							
			51.5	51.9		MAROON SANDSTONE.							
			51.9	52.4		CONGLOMERATE LENS, FRAC. 52.0, ANGLED FRAC. 52.12-52.2.							
			52.4	52.5		MAROON SANDSTONE.							
			52.5	52.9		CONGLOMERATE LENS, ANGLED FRAC. 52.54-52.65.							
			52.9	53.0		MAROON SANDSTONE							
							<u>CORE TESTING RESULTS (DEPTH 49):</u>						
							COMPRESSIVE STRENGTH: 13,090 PSI						
							UNIT WEIGHT: 146.8 PCF						
							CAVED AT 41', DRY.						

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.

**GEOTECHNICAL LABORATORY TESTING SUMMARY  
SUNOCO PENNSYLVANIA PIPELINE PROJECT  
HDD S2-0280**

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.)		Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318)			USCS Classif. (ASTM D2487)
			From	To			Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	
S2-0280	SB-01	1	3.0	5.0	23.4	89.5	-	-	-	-
		2	8.0	10.0	16.3	24.9	-	-	-	-
		3	13.0	15.0	40.0	47.8	-	-	-	-
		4	18.0	19.0	29.8	28.8	-	-	-	-
	SB-03	2	8.0	10.0	31.2	57.9	-	-	-	-
		4	18.0	20.0	22.4	96.8	32	17	15	CL
		6	28.0	29.5	9.6	91.4	-	-	-	-
		7	33.0	34.4	11.6	80.2	30	20	10	CL
		8	38.0	38.6	7.0	55.7	-	-	-	-

Rock Core Testing Results				
Boring No.	Core Run	Approximate Depth (ft)	Compressive Strength (psi)	Unit Weight (pcf)
SB-03	2	49.0	13,090	146.8

**Notes:**

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

**REGIONAL GEOLOGY SUMMARY  
SUNOCO PENNSYLVANIA PIPELINE PROJECT  
HDD S2-0280**

HDD No.	NAME	BORING NO.	REGIONAL GEOLOGY DESCRIPTION	GENERAL TOPOGRAPHIC SETTING	BEDROCK FORMATION	GENERAL ROCK TYPE	APPROX MAX FM THICKNESS (FT)	DEPTH TO ROCK (Ft bgs) based on nearby well drilling logs	NOTES / COMMENTS
S2-0280	Susquehanna River	SB-01	Gettysburg Fm - reddish-brown to maroon silty mudstone and shale and soft, red-brown, medium- to fine-grained sandstone, with minor amounts of yellowish-brown shale and sandstone and thin beds of impure limestone.	Upland to river bank	Gettysburg Fm	Silty mudstone-shale-sandstone w/ some impure limestone	16,000	5-10	
		SB-02		Floodplain, Lowland, W. bank of river				20-30	
		SB-03		Lowland, W. of RR tracks					

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

**ROCK CORE DESCRIPTION SUMMARY  
SUNOCO PENNSYLVANIA PIPELINE PROJECT  
HDD S2-0280**

Location	Boring No.	Core Run	Core Depth (ft)		TCR (%)	SCR (%)	RQD (%)	Depth (ft)		Weathering	Classification	Bedding Thickness (ft)	Color	Discontinuity Data
			From	To				From	To					
S2-0280	SB-3	1	44	48	96	83	72	44	45	Slight	Silty Sandstone	Massive	Red	Single fracture, approximately 25°
								45	45.5	Moderate	Conglomerate	Laminar thin beds, well graded	Red	Near horizontal bedding
		2	48	53	90	57	48	45.5	52	Slight	Silty Sandstone	Massive	Red	Occasional conglomerate lens, fractures ranging from 0° to 45°, Avg. 21°
								52	53	Moderate	Conglomerate	Thin beds, less than 1"	Red to dark red	Bedding dip approximately 28°; few fractures along bedding surfaces

# FIELD DESCRIPTION AND LOGGING SYSTEM FOR SOIL EXPLORATION

## GRANULAR SOILS

(Sand, Gravel & Combinations)

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

### Particle Size Identification

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

### Relative Proportions

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

## COHESIVE SOILS

(Silt, Clay & Combinations)

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

### Plasticity

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

## ROCK

(Rock Cores)

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

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

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

**UNIFIED SOIL CLASSIFICATION SYSTEM [Casagrande (1948)]**

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

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