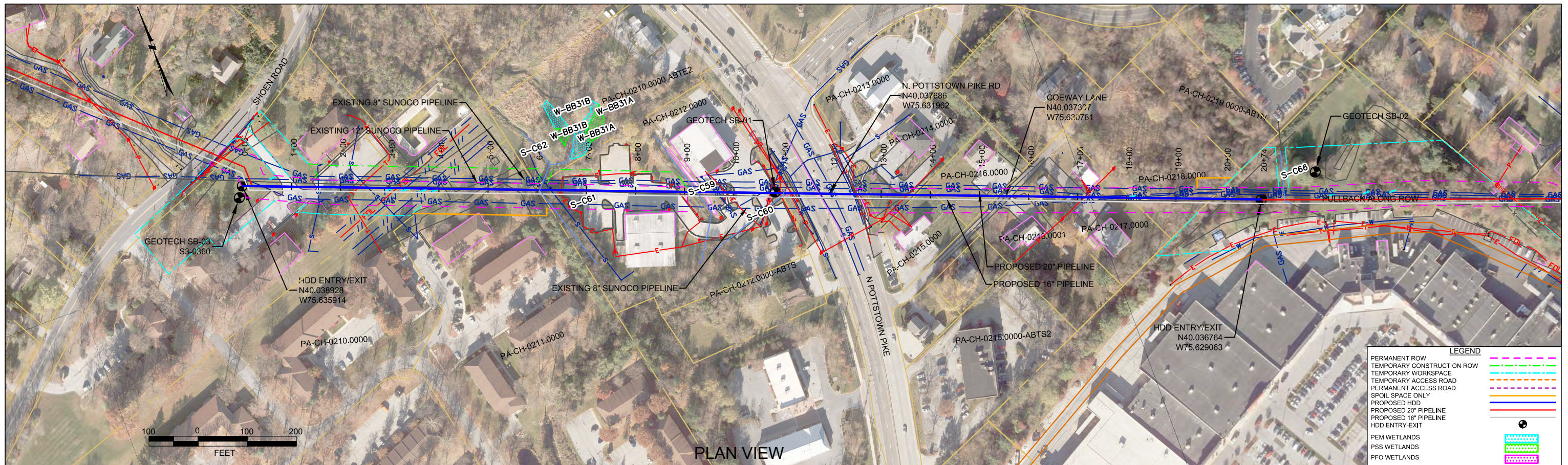


HDD PA-CH-0212.0000-RD (S-C61, S-C59, S-C60)

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 enter/exit 605 feet northwest of stream C61. The drill will pass 62 feet under this stream. Using the results of the geotechnical investigation, as well as several other data points, the entry/exit, angles, and depths have been configured to pass through the best substrates while maintaining pipe integrity (e.g., no large bends). The majority of the substrate that will be passed through is estimated to be silt, fine sand, silty sand and fractured dolomite.

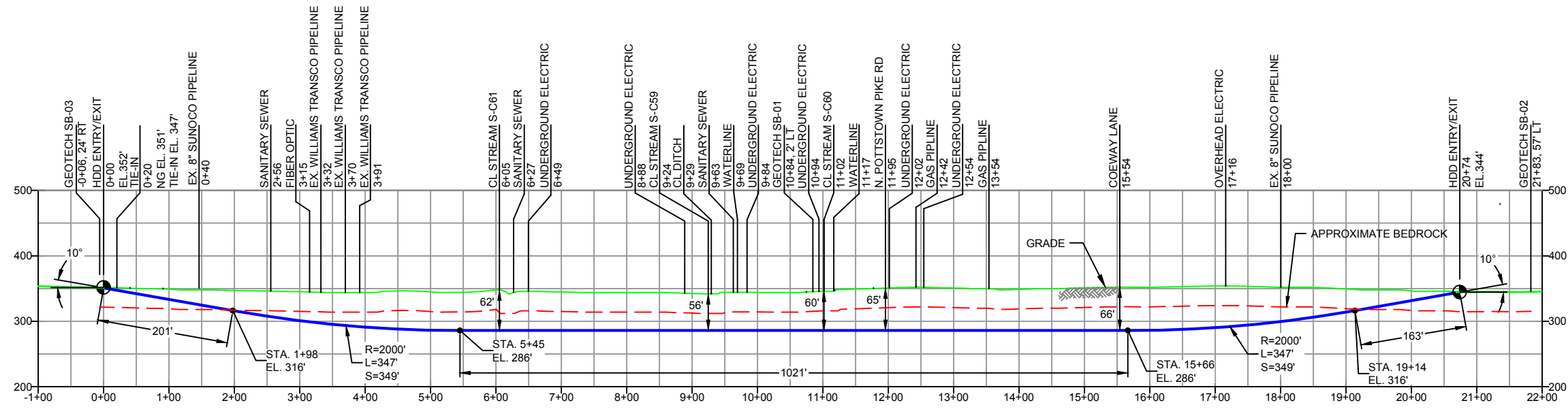
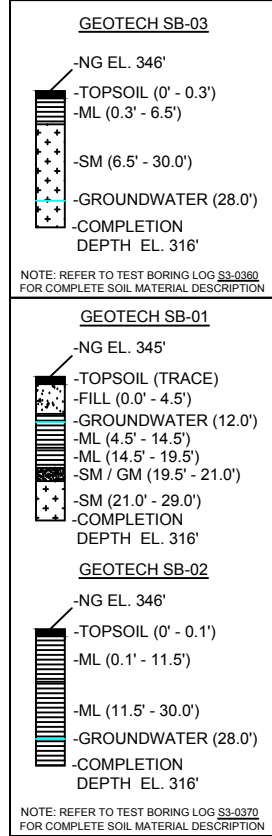
The drill will enter/exit 1084 feet northwest of stream C60. The drill will pass 60 feet under this stream. Using the results of the geotechnical investigation, as well as several other data points, the entry/exit, angles, and depths have been configured to pass through the best substrates while maintaining pipe integrity (e.g., no large bends). The majority of the substrate that will be passed through is estimated to be fractured dolomite.



PLAN VIEW

CHESTER COUNTY, PENNSYLVANIA - WEST WHITELAND TOWNSHIP
S3-0370

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-): 2074'
HDD PIPE LENGTH (S-): 2083'
20" x 0.456" W.T., X-65, API 5L, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
 - INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 - CARRIER PIPE NOT ENCASED
 - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
 - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
 - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

- 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	NO.	DESCRIPTION	NO.	DESCRIPTION	
ES-6.44	TO	ES-6.45	EROSION & SEDIMENT PLAN	EP1	REVISED PER PADEP COMMENTS
SHEET 26	TO	SHEET 26	AERIAL SITE PLAN	EP	
				D	ADDED GEOTECH INFO
				C	ISSUED FOR BID/DESIGN CHANGE
				B	ISSUED FOR BID
				A	ISSUED FOR REVIEW

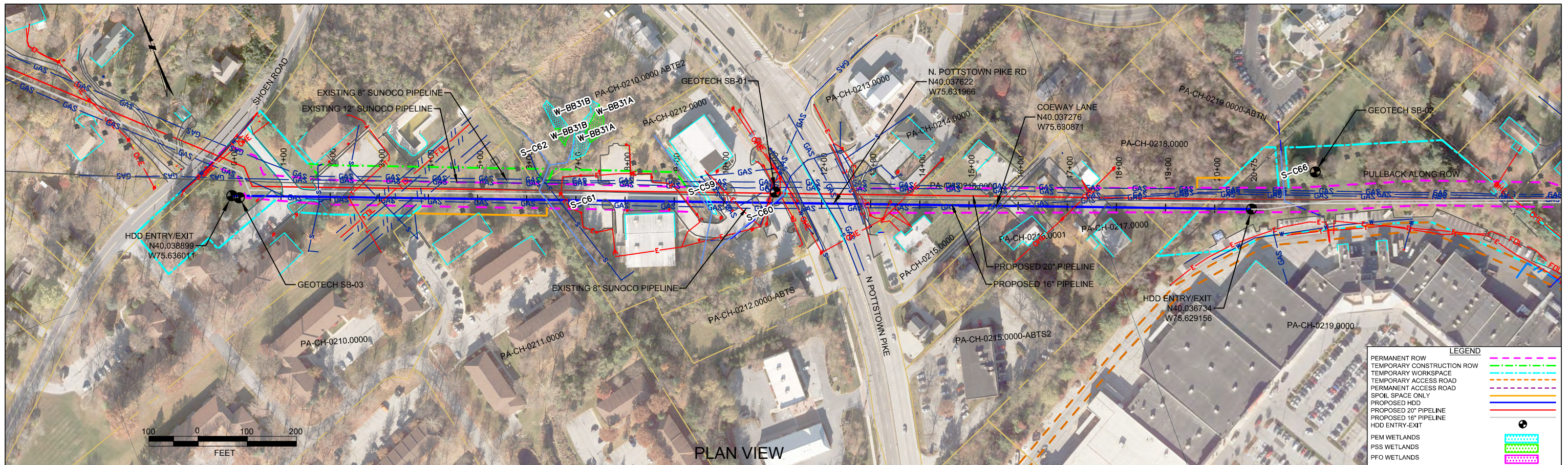
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
N POTTSTOWN PIKE
PENNSYLVANIA PIPELINE PROJECT

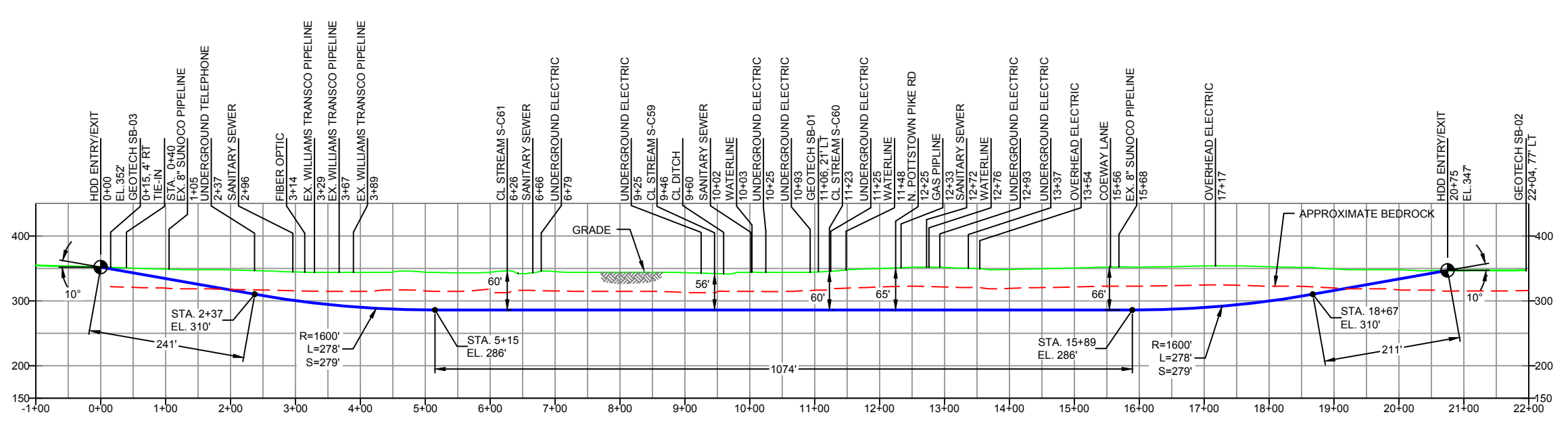
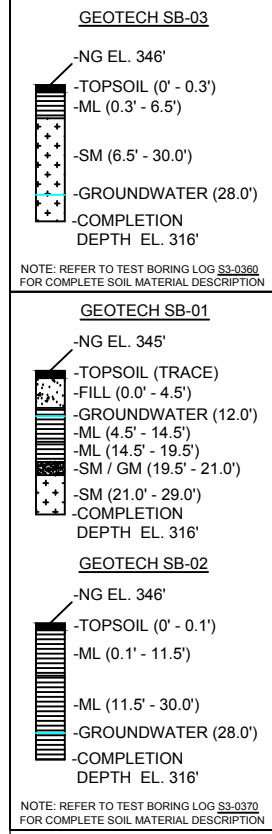
SCALE: 1"=200'
DWG. NO. PA-CH-0212.0000-RD



PLAN VIEW

CHESTER COUNTY, PENNSYLVANIA - WEST WHITELAND TOWNSHIP
S3-0370-16

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-): 2075'
HDD PIPE LENGTH (S-): 2084'
16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
 - INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 - CARRIER PIPE NOT ENCASED
 - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
 - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
 - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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

REF. DRAWING		REVISIONS	
ES-6.44	TO ES-6.45	EROSION & SEDIMENT PLAN	
SHEET 26	TO SHEET 26	AERIAL SITE PLAN	
		EP1	REVISED PER PADEP COMMENTS
		EP	
		B	ADDED GEOTECH INFO
		A	ISSUED FOR BID
DWG NO	DWG NO	DESCRIPTION	NO.

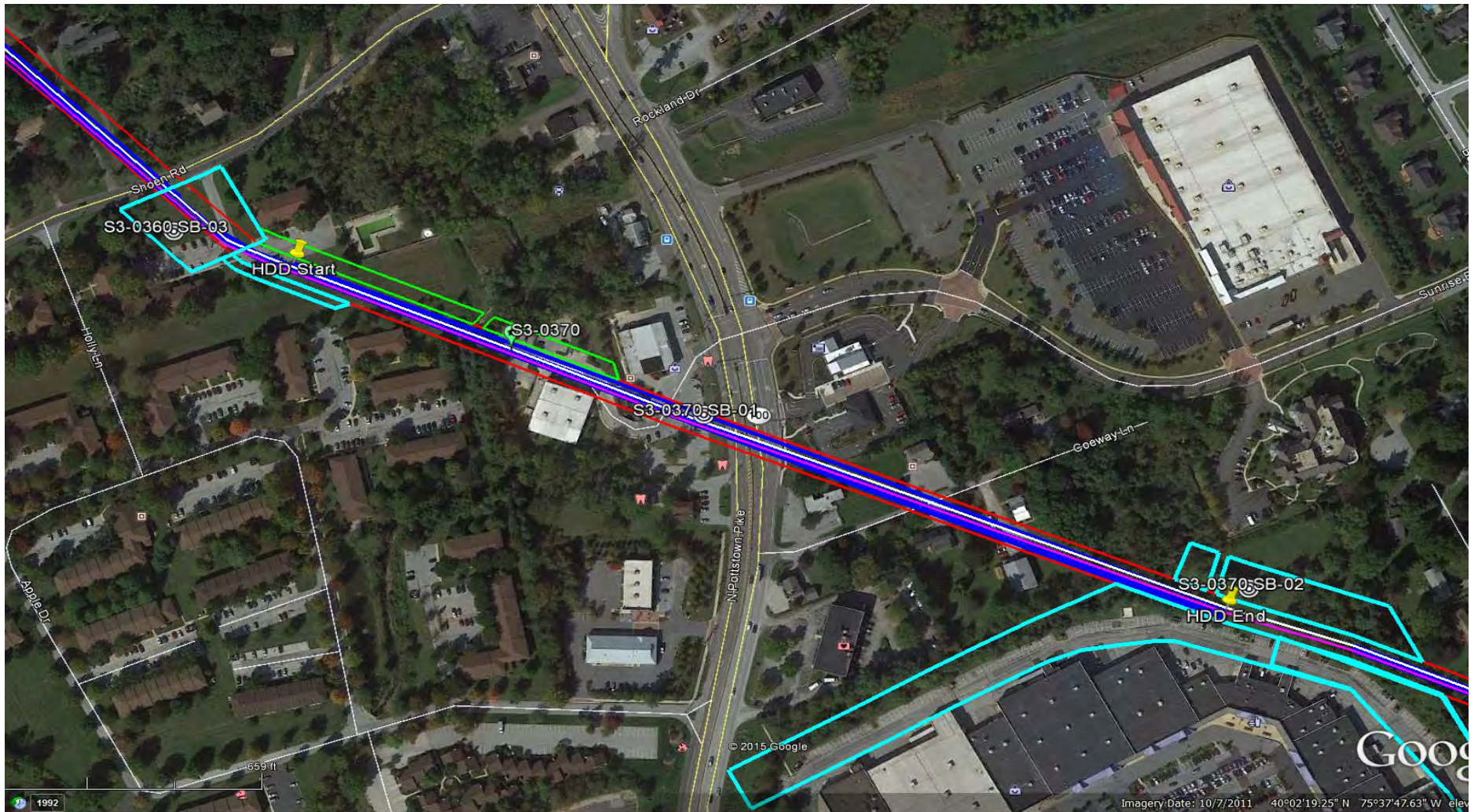
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
N POTTSTOWN PIKE
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' DWG. NO. PA-CH-0212.0000-RD-16



LEGEND:

⊙ Geotechnical Soil Boring (SB) Locations



GEOTECHNICAL BORING LOCATIONS
 HDD S3-0370
 CHESTER COUNTY, WEST WHITELAND 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: SHOEN ROAD, EXTON, PA			Page 1 of 1		
HDD No.: S3-0360		Dates(s) Drilled: 06-14-15		Inspector: J. COSTELLO	
Boring No.: SB-03		Drilling Method: SPT - ASTM D1586		Driller: GREGG	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): 28.0		Total Depth (ft): 30.0	
Boring Location Coordinates:			40° 2' 19.944" N		75° 38' 9.409" W

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (ft)	Strata (USCS)	Description of Materials	6" Increment Blows *				N	
	From	To	From	To									
			0.0	0.3			TOPSOIL (4")						
1	3.0	5.0	0.3		22	ML	YELLOWISH BROWN SILT WITH A LITTLE FINE SAND, TRACE FINE GRAVEL (USCS: ML).	1	6	7	9	13	
				6.5									
2	8.0	10.0	6.5		14	SM	DR WEATHERED TO A GRAY FINE TO COARSE SAND WITH SOME SILT, WITH A LITTLE FINE TO COARSE GRAVEL.	1	8	10	15	18	
3	13.0	15.0			16		DR WEATHERED TO A BROWNISH GRAY TO BROWN, FINE TO MEDIUM SAND WITH SOME SILT, TRACE UNWEATHERED FINE GRAVEL.	2	4	4	8	8	
4	18.0	20.0			14		YELLOWISH BROWN FINE TO COARSE SAND WITH SOME SILT, WITH A LITTLE UNWEATHERED FINE GRAVEL. (DR)	3	4	13	13	17	
5	23.0	25.0			25		DR WEATHERED TO A YELLOWISH BROWN TO REDDISH BROWN, FINE TO MEDIUM SAND, SOME SILT, WITH A LITTLE F-C GRAVEL.	1	4	8	9	12	
6	28.0	30.0			14	DR WEATHERED TO A YELLOWISH BROWN TO REDDISH BROWN, FINE TO MEDIUM SAND, SOME SILT, WITH A LITTLE F-C GRAVEL.	2	11	22	20	33		
				30.0									

Notes/Comments: Pocket Pentrometer Testing DR: DECOMPOSED ROCK
 S1: 3.25 TSF

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

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



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: SHOPS AT 344, EXTON, PA			Page 1 of 1		
HDD No.: S3-0370		Dates(s) Drilled: 06-15 & 7-31-15		Inspector: J. COSTELLO	
Boring No.: SB-01		Drilling Method: SPT - ASTM D1586		Driller: GREG	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): 12.0		Total Depth (ft): 29.8	
Boring Location Coordinates:			40° 2' 16.086" N		75° 37' 56.320" W

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N	
	From	To	From	To									
			0.0	0.0			TOPSOIL (TRACE)						
			0.0			ML (FILL)	HISTORICAL FILL - MATRIX OF FINE TO MEDIUM SAND, SILT, A LITTLE F-C GRAVEL, TRACE ASPHALT FRAGMENTS.						
1	3.0	5.0	4.5		14	ML	DARK BROWN SILT AND FINE SAND, TRACE FINE GRAVEL.	2	2	4	4	6	
2	8.0	10.0		14.5	24	ML	MOTTLED LIGHT BROWN AND GRAY SILT WITH SOME FINE SAND, TRACE FINE GRAVEL.	1	4	5	4	9	
3	13.0	15.0	14.5		24	ML	DR WEATHERED TO A BANDED GRAY, BROWN, AND WHITE SILT AND FINE SAND, TRACE FINE GRAVEL. (USCS: ML).	1	1	1	6	2	
4	18.0	19.5	19.0		8	SM/GM	DR WEATHERED TO A REDDISH BROWN FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, SOME SILT.	1	10	50		60	
5	23.0	25.0	21.0		8	SM	DR WEATHERED TO A BROWN FINE SAND AND SILT, WITH SILTY FINE GRAVEL LENSES.	1	1	1	1	2	
6	28.0	28.8		29.0	6	SM	DR WEATHERED TO A LAYERED GRAY AND BROWN FINE SAND AND SILT, WITH LAYERS OF UNWEATHERED ROCK FRAGS. (USCS: SM)	4	50/4"			>50	
<u>7/31/2015</u>							AUGER REFUSAL AT 29'.						
							<u>ROCK CORING</u>						
RUN 1	29.0	32.0	29.0		32	FRACTURED ROCK	LIGHT GRAY AND REDDISH BROWN INTENSELY FRACTURED	TCR: 89%, SCR: 29%, RQD: 11.8%					
							DOLOMITE						
RUN 2	32.0	34.0			24		VARIEGATED GRAY, RED, YELLOW VERY INTENSELY FRACTURED	TCR: 100%, SCR: 19%, RQD: 19%					
							DOLOMITE.						
RUN 3	34.0	37.0		37.0	36	MARbled WHITE, GRAY, BROWNISH RED INTENSELY FRACTURED	TCR: 100%, SCR: 43%, RQD: 31%						
						DOLOMITE.							
							<u>CORE TESTING RESULTS (RUN 1, DEPTH 30-30.5'):</u>						
							COMPRESSIVE STRENGTH: 2,040PSI						
							UNIT WEIGHT: 152.9 PCF						

Notes/Comments:
Pocket Pentrometer Testing
 S2: 2.0 TSF
 S3: 2.75 TSF
 DR: DECOMPOSED ROCK
 WET ON SPOON AT 12'.
 WATER LEVEL THROUGH AUGERS AT 12'.
 CAVED AT 16'.

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

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



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

TEST BORING LOG

Project Name: SUNOCO PENNSYLVANIA PIPELINE PROJECT			Project No.: 103IP3406		
Project Location: BEHIND FAIRVIEW PLAZA (SUPERCUTS), EXTON, PA			Page 1 of 1		
HDD No.: S3-0370	Dates(s) Drilled: 06-14-15		Inspector: E. WATT		
Boring No.: SB-02	Drilling Method: SPT - ASTM D1586		Driller: S. HOFFER		
Drilling Contractor: HAD DRILLING	Groundwater Depth (ft): 28.0		Total Depth (ft): 30.0		
Boring Location Coordinates:			40° 2' 12.471" N		75° 37' 42.989" W

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (ft)	Strata (USCS)	Description of Materials	6" Increment Blows *				N	
	From	To	From	To									
			0.0	0.1			TOPSOIL (1")						
1	3.0	5.0	0.1		21	ML	MOTTLED (SHADES OF BROWN) SILT AND FINE TO MEDIUM SAND, WITH A LITTLE FINE TO COARSE GRAVEL.	2	8	6	7	14	
2	8.0	10.0			22		BROWN SILT WITH A LITTLE FINE SAND. (USCS: ML).	2	3	3	5	6	
				11.5									
3	13.0	15.0	11.5		24	DR	DR WEATHERED TO A BROWN SILT WITH A LITTLE FINE SAND, TRACE FINE QUARTZ GRAVEL, TRACE MICA.	1	4	5	7	9	
4	18.0	19.5			24	ML	DR WEATHERED TO A BROWN AND BLACK SILT WITH A LITTLE FINE SAND, TRACE FINE GRAVEL.	2	5	9	15	14	
5	23.0	25.0			24		DR WEATHERED TO A BROWN TO ORANGE BROWN SILT AND FINE SAND, TRACE FINE QUARTZ GRAVEL. (USCS: ML).	2	4	4	5	8	
6	28.0	30.0		30.0	16		SAME.	3	4	6	9	10	

Notes/Comments:
Pocket Pentrometer Testing DR: DECOMPOSED ROCK
 8': 3.0 TSF 15': 2.5 TSF
 10': 3.75 TSF 18': 2.75 TSF
 13': 4.0 TSF

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

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

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0370

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.)		Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318)			USCS Classif. (ASTM D2487)
			From	To			Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	
S3-0360	SB-03	1	3.0	5.0	22.6	81.1	36	27	9	ML
		2	8.0	10.0	12.2	33.3	-	-	-	-
		3	13.0	15.0	16.5	35.8	-	-	-	-
		4	18.0	20.0	11.3	26.1	-	-	-	-
		5	23.0	25.0	16.3	29.3	-	-	-	-
S3-0370	SB-01	2	8.0	10.0	18.3	79.8	-	-	-	-
		3	13.0	15.0	41.2	69.8	44	28	16	ML
		4	18.0	19.5	12.0	22.4	-	-	-	-
		5	23.0	25.0	17.6	42.6	-	-	-	-
		6	28.0	29.8	22.0	45.9	39	27	12	SM
	SB-02	1	3.0	5.0	18.7	64.9	-	-	-	-
		2	8.0	10.0	28.3	85.4	45	37	8	ML
		4	18.0	19.5	26.0	88.2	-	-	-	-
		5	23.0	25.0	34.6	63.9	41	33	8	ML
		6	28.0	30.0	27.6	68.9	-	-	-	-

Rock Core Testing Results				
Boring No.	Core Run	Approximate Depth (ft)	Compressive Strength (psi)	Unit Weight (pcf)
S3-0370 SB-01	1	30.0-30.5	2,040	152.9

Notes:

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

**ROCK CORE DESCRIPTION SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0370**

Location	Boring No.	Core Run	Core Depth (ft)		TCR (%)	SCR (%)	RQD (%)	Depth (ft)		Weathering	Classification	Bedding Thickness (ft)	Color	Discontinuity Data
			From	To				From	To					
S3-0370	SB-01	1	29	32	89	29	12	29	34	Heavily	Dolostone	Massive	Gray	Rubble
		2	32	34	100	19	19							
		3	34	37	100	43	31	34	37	Moderate	Dolostone	Massive	Gray	Fractures ranging from 32° to 67°, Avg. 57°

**REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0370**

HDD No.	NAME	BORING NO.	REGIONAL GEOLOGY DESCRIPTION	GENERAL TOPOGRAPHIC SETTING	BEDROCK FORMATION	GENERAL ROCK TYPE	APPROX MAX FM THICKNESS (FT)	DEPTH TO ROCK (Ft bgs) based on nearby well drilling logs	NOTES / COMMENTS
S3-360		SB-03	Chickies Formation - Light-gray, hard, massive, Scolithus-bearing quartzite and quartz schist; thin, interbedded dark slate at top; conglomerate (Hellam Member) at base.	Generally level, slight slope to the south	Chickies Formation (Cambrian)	Quartzite, schist, slate, conglomerate	600	Ranges from 20 to 78 ft bgs, Avg. 51 ft bgs (.25 mile radius)	
S3-0370		SB-01	Ledger Formation - Light-gray, locally mottled, massive, pure, coarsely crystalline dolomite; siliceous in middle part.	Generally level, slight slope to the west	Ledger Formation (Cambrian)	Dolostone (Dolomite)	2,000	Ranges from 20 to 78 ft bgs, Avg. 51 ft bgs (.25 mile radius)	
		SB-02	Chickies Formation - Light-gray, hard, massive, Scolithus-bearing quartzite and quartz schist; thin, interbedded dark slate at top; conglomerate (Hellam Member) at base.	Generally level, slight slope to the west	Chickies Formation (Cambrian)	Quartzite, schist, slate, conglomerate	600	Ranges from 20 to 78 ft bgs, Avg. 56 ft bgs (.5 mile radius)	

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

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	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 ⁽¹⁾	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4: $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3			
		GP Poorly graded gravels, gravel-sand mixtures, little or no fines	Not meeting C_u or C_c requirements for GW					
		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	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		Atterberg limits above A line with I_p greater than 7			
	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			
			SP Poorly graded sands, gravelly sands, little or no fines		Not meeting C_u or C_c requirements for SW			
		Sands with fines (Appreciable amount of fines)	SM Silty sands, sand-silt mixtures		Atterberg limits below A Line or I_p less than 4	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		Atterberg limits above A line with I_p greater than 7			
						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 ± 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							
	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.