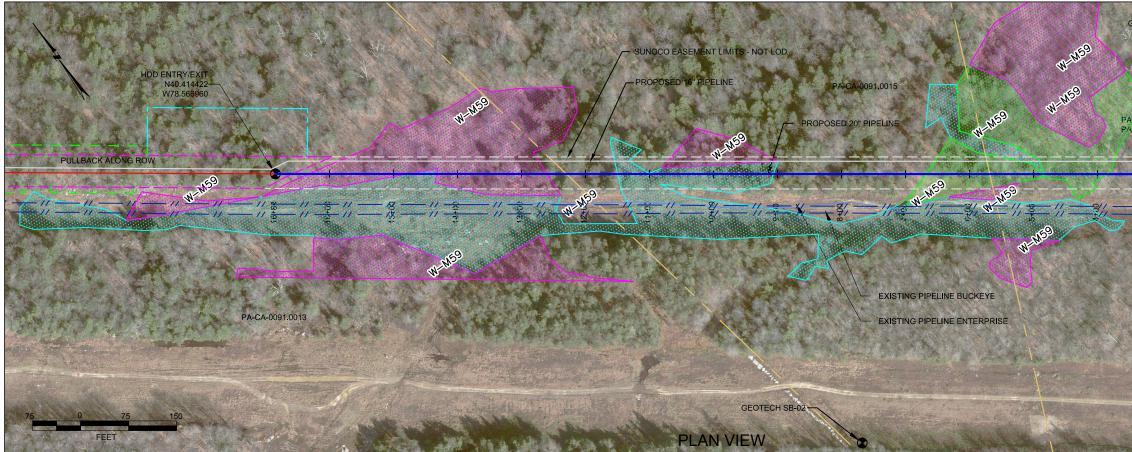
HDD PA-CA-0091.0016-RD (W-M59, and W-L62)

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.

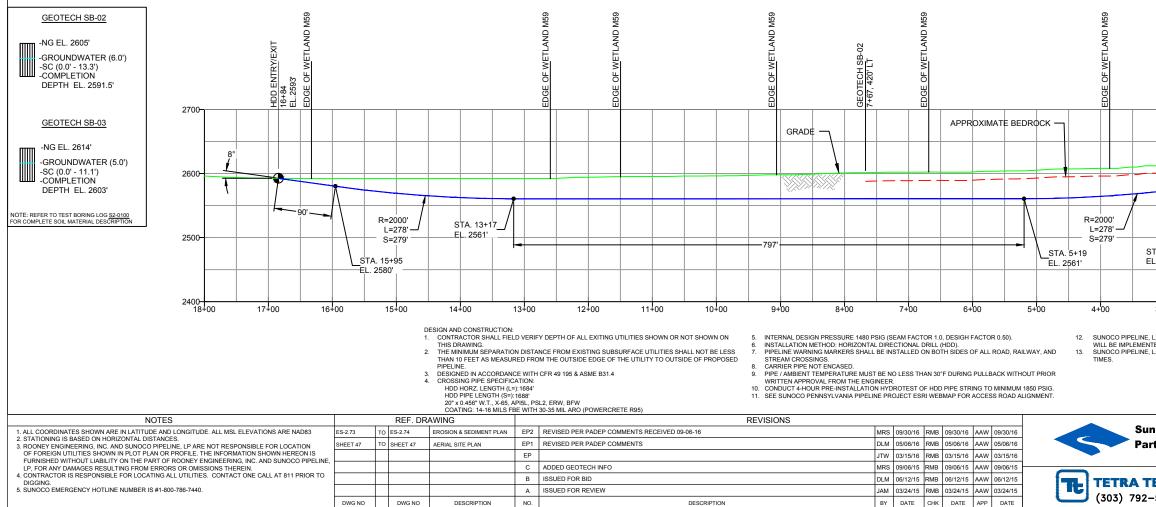
The drill will enter/exit 50 feet northwest of wetland M59. The drill will pass 5 feet under the northwestern most boundary of the wetland and 45 feet under the southeastern most boundary of the wetland. The drill will enter/exit 384 feet southeast of the southeastern most boundary of wetland M59. Using 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 clayey sand and silty clay.

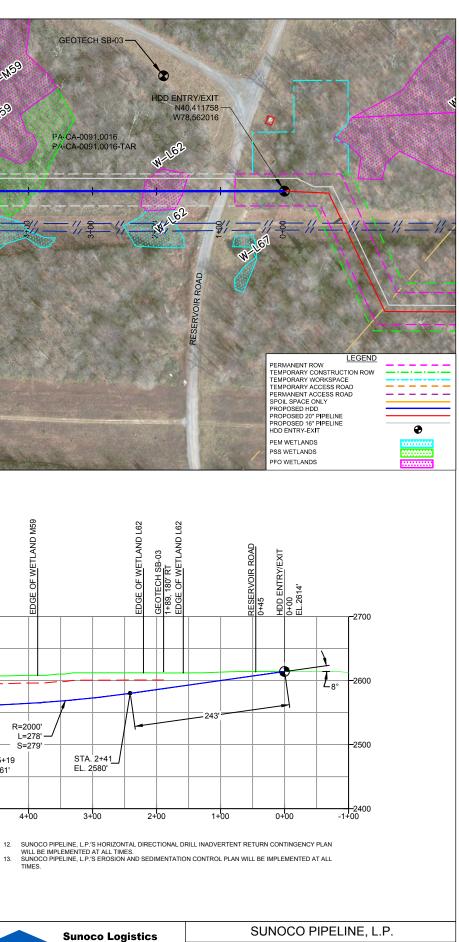
The drill will enter/exit 1460 feet northwest of wetland L62. The drill will pass 30 feet under the northwestern most boundary of the wetland and 20 feet under the southeastern most boundary of the wetland. The drill will enter/exit 160 feet southeast of wetland L62. Using the results of the geotechnical 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 clayey sand and silty clay.



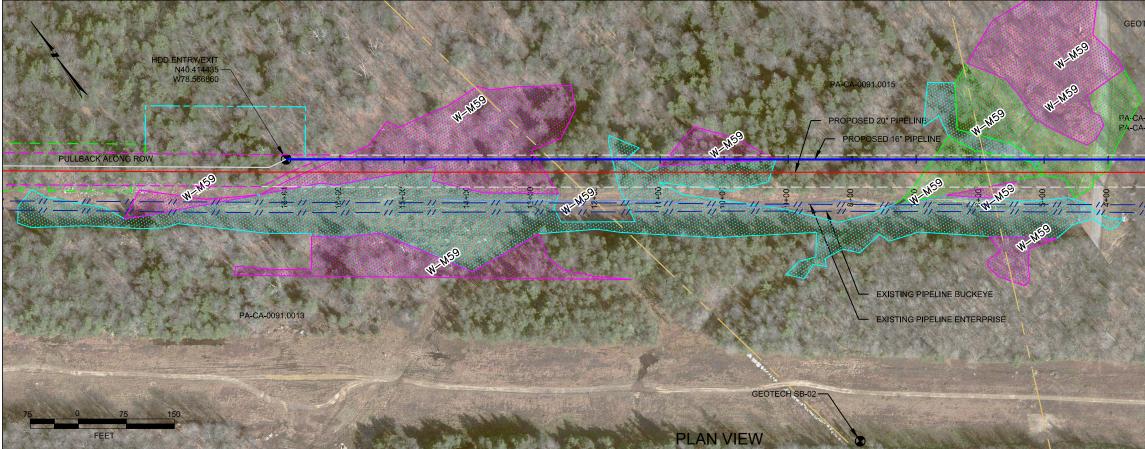
CAMBRIA COUNTY, PENNSYLVANIA - JUANITA/WASHINGTON TOWNSHIP S2-0100

PROFILE VIEW



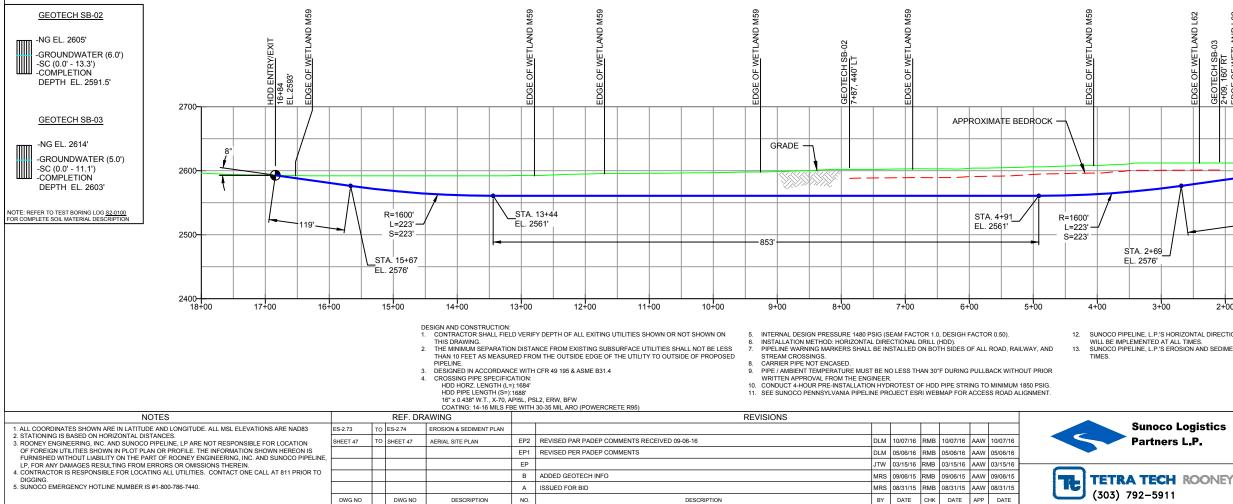


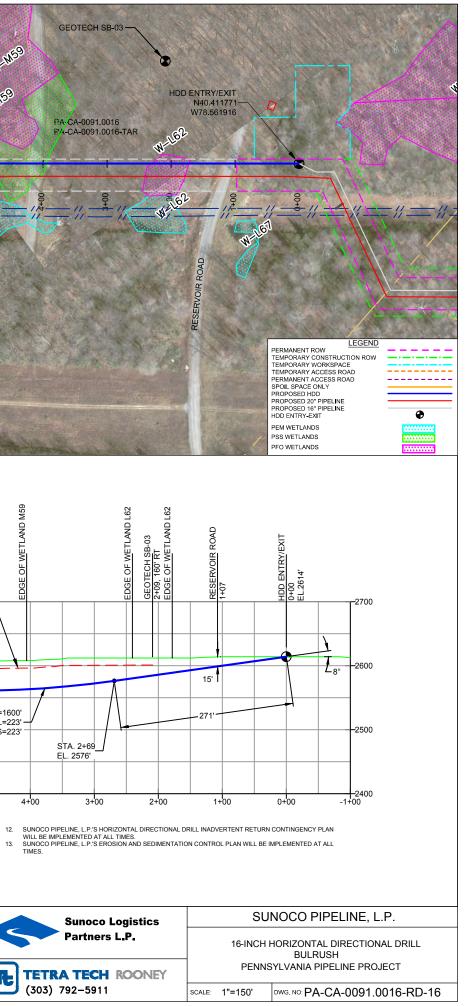
tners L.P.		20-INCH H	HORIZONTAL DIRECTIONAL DRILL BULRUSH
ECH ROONEY		PENNS	YLVANIA PIPELINE PROJECT
5911	SCALE:	1"=150'	DWG. NO: PA-CA-0091.0016-RD

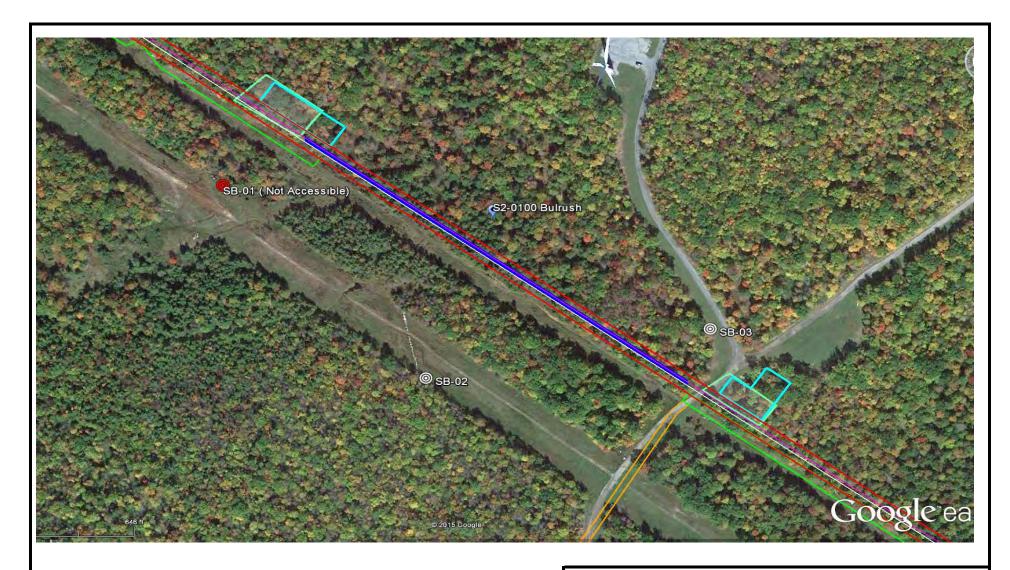


CAMBRIA COUNTY, PENNSYLVANIA - JUANITA/WASHINGTON TOWNSHIP S2-0100-16

PROFILE VIEW







LEGEND:

(6) Geotechnical Soil Boring (SB) Locations



GEOTECHNICAL BORING LOCATIONS HDD S2-0100 CAMBRIA COUNTY, WASHINGTON TOWNSHIP, PA SUNOCO PENNSYLVANIA PIPELINE PROJECT

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TETRA TECH

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

TEST BORING LOG

Project	t Name:		SUNOC	O PENN	SYLVA	NIA PI	PELINE PROJECT		Project	No.: 10)3IP34	406		
Project	t Locatio	n:	MOUNT	AIN ROA	AD, LIL	LY, PA			Page 1	of 1				
HDD N	lo.:		S2-0100)			Dates(s) Drilled: 01-12-15	Inspector:	E. WAT	Т				
Boring	No.:		SB-01				Drilling Method: SPT - ASTM D1586	Driller:	S. HOF	FER				
Drilling	Contrac	tor:	HAD DF	RILLING			Groundwater Depth (ft):	Total Depth (ft):						
Sample No.	Sample I From	Depth (ft) To	Strata D	Depth (ft) To	Recov. (in)	Strata	Description of Materia	lls		6" In	creme	ent Blov	vs *	Ν
					_	()								
							SOIL BORING NOT PERFORMED. COULD NOT	ACCESS LOCATIO	N					
							DUE TO WETLANDS, AND PERMISSION TO C	ROSS TEXAS						
							EASTERN ROW WAS DENIED. BASED ON R	EGIONAL GEOLOG	SIC					
							INFORMATION, SUBSURFACE CONDITIONS	AT SB-01 ARE						
							LIKELY TO BE SIMILAR TO SB-02 AND SB-03.							
N L - 1	es/Comm													
	Pocket F	Pentrome	eter Testi				DR: DECOMPOSED ROCK							
Strata	(USCS)	Designat	ions are	approxim	nated b	ased o	n visual review, except where indicated in Des	cription of Materia	ls.					

* 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

oject	Name:		SUNOC	O PENN	SYLVA	NIA PI	PELINE PROJECT		Project	No.: 1	03IP34	406		
	Location	n:	MOUNT	AIN ROA	AD, LIL	LY, PA			Page 1					
DD No			S2-0100)			Dates(s) Drilled: 01-12-15	Inspector:	E. WAT					
oring I			SB-02				Drilling Method: SPT - ASTM D1586	Driller:	S. HOF	FER				
illing	Contrac		HAD DR		1	T	Groundwater Depth (ft): 6.0	Total Depth (ft)	: 13.3					T
mple No.	Sample [From	Depth (ft) To	Strata D From	Depth (ft) To	Recov. (in)	Strata	Description of Mat	erials		6" lr	creme	ent Blo	ws *	N
			0.0	0.0			NO DISCERNABLE TOPSOIL							
1	3.0	5.0	0.0		14		ORANGE BROWN CLAYEY FINE SAND WIT	H A TRACE		2	10	10	10	2
							UNWEATHERED FINE SANDSTONE GRAV	EL.						
2	8.0	10.0			13	SC	BROWN FINE TO MEDIUM CLAYEY SAND V	/ITH A LITTLE FINE	то	4	25	21	21	4
							COARSE SANDSTONE GRAVEL. USCS: S	С						
3	13.0	13.3		13.3	3		LIGHT BROWN FINE TO MEDIUM SAND WIT	H SOME SILTY CLA	Y.	50/3"				
							AUGER REFUSAL AT 13'.							
							WATER LEVEL THROUGH AUGERS AT 6.0'.							-
							CAVED AT 9', WATER LEVEL ON CAVE AT 5	·.						
														-
														-
-														-
-														
														-
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														-
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T														
	s/Comm			1								1		
<u>F</u>	Pocket F	Pentrome	eter Testii	ng			DR: DECOMPOSED ROCK							

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

Name:		SUNOC	O PENN	SYLVA	NIA PI	PELINE PROJECT		Project N	No.: 10)3IP34	106		
Location	n:	MOUNT	AIN ROA	AD, LIL	LY, PA			Page 1 o	of 1				
lo.:		S2-0100				Dates(s) Drilled: 01-12-15	Inspector:	E. WAT	Г				
No.:		SB-03				Drilling Method: SPT - ASTM D1586	Driller:	S. HOFF	ER				
Contrac	tor:				-	Groundwater Depth (ft): 5.0 Total Depth (ft): 11.							1
Sample I From	Depth (ft) To	Strata D From	epth (ft) To	Recov. (in)	Strata	Description of Mate	rials		6" In	creme	ent Blo	ws *	Ν
		0.0	0.0			NO DISCERNABLE TOPSOIL							
3.0	5.0	0.0		7		ORANGE BROWN FINE CLAYEY SAND WITH	A TRACE OF		1	2	9	10	11
						FINE SANDSTONE GRAVEL.							
8.0	9.7			12	SC	BROWN FINE TO MEDIUM SAND WITH SOME	E SILTY CLAY, WITH	IA	3	21	28	50/2"	49
						LITTLE FINE TO COARSE SANDSTONE GR	AVEL. USCS: SC).						
11.0	11 1		11 1	0	-				50/1"				
11.0									00/1				
						AUGER REFUSAL AT 11'. OFF-SET BORING	15' NW AND						
						CONTINUOULSY AUGERED TO REFUSAL AT	11.						
						WET ON SPOON AT 6'.							
						WATER LEVEL THROUGH AUGERS AT 5'.							
						CAVED AT 11' (BOTH BORINGS)							
						WATER LEVEL ON CAVE AT 5'.							
es/Comm	nents:	1	1	1	1	1						1	
		eter Testir	ng			DR: DECOMPOSED ROCK							
	Locatio o.: No.: Contrac Sample I From 3.0 8.0 11.0	Location: O.: No.: Contractor: Sample Depth (ft) From To 3.0 5.0 8.0 9.7 8.0 9.7 11.0 11.1 11.0 11.1 11.0 11.1 11.0 11.0	Location: MOUNT o.: S2-0100 No.: SB-03 Contractor: HAD DR Sample Depth (ft) Strata D From To From 3.0 5.0 0.0 3.0 5.0 0.0 3.0 5.0 0.0 8.0 9.7 1 11.0 11.1 1 11.0 11.1 1 11.0 11.1 1 11.0 11.1 1 11.0 11.1 1 11.0 11.1 1 11.0 11.1 1 11.0 11.1 1 11.0 11.1 1 11.0 11.1 1 11.0 11.1 1 11.0 11.1 1 11.0 11.1 1 11.0 11.1 1 11.0 11.1 1 11.0 11.1 1 11.0 11.1 1 11.0	Location: MOUNTAIN RO/ o.: S2-0100 No.: SB-03 Contractor: HAD DRILLING Sample Deptn (ft) Strata Depth (ft) From To To Samol 0.0 0.0 3.0 5.0 0.0 0.0 3.0 5.0 0.0 1 8.0 9.7 1 1 11.0 11.1 1 1 11.0 11.1 1 1 11.0 11.1 1 1 11.0 11.1 1 1 11.0 11.1 1 1 11.0 11.1 1 1 11.0 11.1 1 1 11.1 1 1 1 11.1 1 1 1 11.1 1 1 1 11.1 1 1 1 11.1 1 1 1 11.1 1 1 1 11.1 1 1<	Location: MOUNTAIN ROAD, LIL o.: S2-0100 No.: SB-03 Contractor: HAD DRILLING Sample Depth (ft) Strata Depth (ft) Sog € From To From To 3.0 5.0 0.0 0.0 7 8.0 9.7 11.0 11.1 0 11.0 11.1 11.1 0 1 11.0 11.1 11.1 0 1 11.0 11.1 11.1 0 1 11.0 11.1 11.1 0 1 11.0 11.1 11.1 0 1 11.0 11.1 1 1 1 11.0 11.1 1 1 1 11.0 1 1 1 1 11.0 1 1 1 1 11.0 1 1 1 1 11.0 1 1 1 1 11.0 1 1 1 1	Location: MOUNTAIN ROAD, LILLY, PA o.: S2-0100 No.: SB-03 Contractor: HAD DRILLING Sample Depth (ft) Strata Depth (ft) § (ft) From To From To 3.0 5.0 0.0 0.0 7 8.0 9.7 12 Sc 11.0 11.1 11.1 0 1 11.0 11.1 11.1 0 1 11.0 11.1 11.1 0 1 11.0 11.1 11.1 0 1 11.0 11.1 11.1 0 1 11.0 11.1 1 1 1 11.0 11.1 1 1 1 11.0 11.1 1 1 1 11.1 1 1 1 1 11.1 1 1 1 1 11.1 1 1 1 1 11.1 1 1 1 1 11.1 </td <td>Location: MOUNTAIN ROAD, LILLY, PA 0: S2-0100 Dates(s) Drilled: 01-12-15 No: SB-03 Drilling Method: SPT - ASTM D1586 Contractor: HAD DRILLING Groundwater Depth (ft) Social Sector Sec</td> <td>Location: MOUNTAIN ROAD, LILLY, PA o.: S2-0100 Dates(s) Drilled: 01-12-15 Inspector: No.: S8-03 Drilling Method: SPT - ASTM D1586 Driller: Contractor: HAD DRILLING Groundwater Depth (ft): 5.0 Total Depth (ft): Sample Depth (ft) Strata Depth (ft) Secondart Secondart (Laster Secondart Secondart</td> <td>Location: MOUNTAIN ROAD, LILLY, PA Page 1 0: S2-010 Dates(s) Drilled: 01-12-15 Inspector: E.WAT Contractor: HAD DRILLING South Depth (ft) State Origing Method: SPT - ASTM 01586 Driller: S. HOF Sample Depth (ft) State Groundwater Depth (ft): 5.0 Total Depth (ft): 11.1 State Description of Materials Total Depth (ft): 11.1 Sample Depth (ft) State No DISCERNABLE TOPSOIL Total Depth (ft): 11.1 State Description of Materials Total Depth (ft): 11.1 3.0 5.0 0.0 0 7 File State Description of Materials Total Depth (ft): 11.1 3.0 5.0 0.0 0 7 Inspector: File State Description of Materials Description of Materials 11.0 11.1 11.1 0 NO DISCERNABLE TO PCOARSE SANDSTONE GRAVEL. USCS: SC) NO RETURN. 11.0 11.1 11.1 0 AUGER REFUSAL AT 11'. OFF-SET BORING 15' NW AND CONTINUOULSY AUGERED TO REFUSAL AT 11. USCAVED AT 11' (BOTH BORINGS)</td> <td>Location: MOUNTAIN ROAD, LILLY, PA Page 1 of 1 c: \$2.010 Dates(s) Dilited: 01-12-15 Inspector: E.WATT Contractor: HAD DRILLING Groundwater Depth (ft): 5.0 Total Depth (ft): 11.1 Total Depth (ft): 11.1 Sampe Depth (ft) Strate Depth (ft): 5.0 Total Depth (ft): 11.1 Total Depth (ft): 11.1 Total Depth (ft): 11.1 Sampe Depth (ft) Strate Depth (ft): 5.0 Description of Materials 6* In 1.0 0.0 0.0 7 Strate Depth (ft): 5.0 Total Depth (ft): 11.1 3.0 5.0 0.0 7 Strate Depth (ft): 11.1 File SANDSTONE GRAVEL. E 8.0 9.7 12 Strate Depth (ft): 11.1 Strate Depth (ft): 11.1</td> <td>Location: MOUNTAIN ROAD, LILLY, PA Page 1 of 1 0:: \$2-010 Dates(s) Drilled: 01-12-15 Inspector: E. WATT Contractor: HAD DRILING Groundwater Depth (t): 5.0 Total Depth (t): 11.1 Image 1 of 1 Sample Depth (t) Situla Depth (t) Situla Depth (t): 5.0 Total Depth (t): 11.1 Image 1 of 1 0.0</td> <td>Lacation: MOUNTAIN ROAD, LILLY, PA Page 1 of 1 Page 1 of 1 ::::::::::::::::::::::::::::::::::::</td> <td>Location: MOUNTAIN ROAD, LILLY, PA Page 1 of 1 c: \$2010 Date(s) Driled: 01-12-15 Inspector: E. WATT U Contractor: HAD DRILING Groundwater Depth (ft): 5.0 Total Depth (ft): 11.1 U U S. HOFFER Uses(s) S. HOFFER S. HOFFER USEs(s) S. HOFFER USEs(s) S. HOFFER USEs(s) S. HOFFER S. HOFFER<</td>	Location: MOUNTAIN ROAD, LILLY, PA 0: S2-0100 Dates(s) Drilled: 01-12-15 No: SB-03 Drilling Method: SPT - ASTM D1586 Contractor: HAD DRILLING Groundwater Depth (ft) Social Sector Sec	Location: MOUNTAIN ROAD, LILLY, PA o.: S2-0100 Dates(s) Drilled: 01-12-15 Inspector: No.: S8-03 Drilling Method: SPT - ASTM D1586 Driller: Contractor: HAD DRILLING Groundwater Depth (ft): 5.0 Total Depth (ft): Sample Depth (ft) Strata Depth (ft) Secondart Secondart (Laster Secondart	Location: MOUNTAIN ROAD, LILLY, PA Page 1 0: S2-010 Dates(s) Drilled: 01-12-15 Inspector: E.WAT Contractor: HAD DRILLING South Depth (ft) State Origing Method: SPT - ASTM 01586 Driller: S. HOF Sample Depth (ft) State Groundwater Depth (ft): 5.0 Total Depth (ft): 11.1 State Description of Materials Total Depth (ft): 11.1 Sample Depth (ft) State No DISCERNABLE TOPSOIL Total Depth (ft): 11.1 State Description of Materials Total Depth (ft): 11.1 3.0 5.0 0.0 0 7 File State Description of Materials Total Depth (ft): 11.1 3.0 5.0 0.0 0 7 Inspector: File State Description of Materials Description of Materials 11.0 11.1 11.1 0 NO DISCERNABLE TO PCOARSE SANDSTONE GRAVEL. USCS: SC) NO RETURN. 11.0 11.1 11.1 0 AUGER REFUSAL AT 11'. OFF-SET BORING 15' NW AND CONTINUOULSY AUGERED TO REFUSAL AT 11. USCAVED AT 11' (BOTH BORINGS)	Location: MOUNTAIN ROAD, LILLY, PA Page 1 of 1 c: \$2.010 Dates(s) Dilited: 01-12-15 Inspector: E.WATT Contractor: HAD DRILLING Groundwater Depth (ft): 5.0 Total Depth (ft): 11.1 Total Depth (ft): 11.1 Sampe Depth (ft) Strate Depth (ft): 5.0 Total Depth (ft): 11.1 Total Depth (ft): 11.1 Total Depth (ft): 11.1 Sampe Depth (ft) Strate Depth (ft): 5.0 Description of Materials 6* In 1.0 0.0 0.0 7 Strate Depth (ft): 5.0 Total Depth (ft): 11.1 3.0 5.0 0.0 7 Strate Depth (ft): 11.1 File SANDSTONE GRAVEL. E 8.0 9.7 12 Strate Depth (ft): 11.1 Strate Depth (ft): 11.1	Location: MOUNTAIN ROAD, LILLY, PA Page 1 of 1 0:: \$2-010 Dates(s) Drilled: 01-12-15 Inspector: E. WATT Contractor: HAD DRILING Groundwater Depth (t): 5.0 Total Depth (t): 11.1 Image 1 of 1 Sample Depth (t) Situla Depth (t) Situla Depth (t): 5.0 Total Depth (t): 11.1 Image 1 of 1 0.0	Lacation: MOUNTAIN ROAD, LILLY, PA Page 1 of 1 Page 1 of 1 ::::::::::::::::::::::::::::::::::::	Location: MOUNTAIN ROAD, LILLY, PA Page 1 of 1 c: \$2010 Date(s) Driled: 01-12-15 Inspector: E. WATT U Contractor: HAD DRILING Groundwater Depth (ft): 5.0 Total Depth (ft): 11.1 U U S. HOFFER Uses(s) S. HOFFER S. HOFFER USEs(s) S. HOFFER USEs(s) S. HOFFER USEs(s) S. HOFFER S. HOFFER<

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 S2-0100

	Test				Water	Percent	Atterburg Limits (ASTM D4318)			USCS
HDD	Boring	Sample	Depth of Sample (ft.)		Content, %	Silts/Clays, %	Liquid Plastic		Plasticity	Classif.
No.	No.	No.	From To (/		(ASTM D2216)	(ASTM D1140)	Limit, %	Limit, %	Index, %	(ASTM D2487)
		1	3.0	5.0	13.0	47.9	-	-	-	-
	SB-02	2	8.0	10.0	11.2	40.3	36	23	13	SC
S2-0100		3	13.0	13.3	16.6	33.7	-	-	-	-
		1	3.0	5.0	13.1	40.3	-	-	-	-
	SB-03	2	8.0	9.7	14.0	33.9	35	22	13	SC

Notes:

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

REGIONAL GEOLOGY SUMMARY SUNOCO PENNSYLVANIA PIPELINE PROJECT HDD S2-0100

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
S2-0100	Bulrush	SB-02	Pottsville Formation - consists mainly of well- to very well cemented, medium- grained to conglomeratic sandstone beds (ranging in thickness from about 10 to 70 feet), with minor amounts of siltstone, claystone, shale, and thin coals.	Upland Plateau	Pottsville	Sandstone with minor amounts of siltstone, claystone, shale, and thin coal	1,600	15-20	Limited boring data available, nearest boring log for location ~1.75-mile from drill location

<u>Note</u> : 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>	Particle Si	ize Identifica	tion
Very Loose	5 or less		8 in. diamet	
Loose	6 to 10	Boulders	0 0.0	
Medium Dense	11 to 30	Cobbles	3 to 8 in. di	ameter
Dense	31to 50	Gravel	Coarse (C)	3 in. to ¾ in. sieve
Very Dense	51 or more		Fine (F)	¾ in. to No. 4 sieve
Very Dense	51 01 11016	Sand	Coarse (C)	No. 4 to No. 10 sieve
				(4.75mm-2.00mm)
Relative Proportion	ons		Medium	No. 10 to No. 40 sieve
Description Term	<u>Percent</u>		(M)	(2.00mm – 0.425mm)
Trace	1 - 10			No. 40 to No. 200 sieve
Little	11 - 20			(0.425 – 0.074mm)
Some	21 - 35	Silt/Clav	Less Than a	. , , .
And	36 - 50	-, ,		
Little Some	11 - 20 21 - 35	Silt/Clay	Fine (F) Less Than a	No. 40 to No. 200 sieve (0.425 – 0.074mm) No. 200 sieve (<0.074mm)

COHESIVE SOILS

(Silt, Clay & Combinations)

<u>Consistency</u>	<u>N (blows)*</u>	Plasticity	
Very Soft	3 or less	Degree of Plasticity	Plasticity Index
Soft	4 to 5	None to Slight	0 - 4
Medium Stiff	6 to 10	Slight	5 - 7
Stiff	11 to 15	Medium	8- 22
Very Stiff	16 to 30	High to Very High	> 22
Hard	31 or more	6 , 6	

ROCK

(Rock Cores)

Rock	Rock					
Quality Designation	Quality <u>Descripti</u>					
<u>(RQD), %</u>	<u>on</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 Divisi	ons	Group Symbols	Typical Descriptions		Laboratory Classification	ons	
	n is larger	Clean gravel (Little or no fines)	GW	Well-graded gravels, gravel- sand mixtures, little or no fines	nbols ⁽¹⁾	$C_{u=\frac{D_{60}}{D_{10}}}$ greater than 4: $C_{c=\frac{1}{10}}$	$(D_{30})^2_{D_{10} \times D_{60}}$ between 1 and 3	
(6	Gravels More than half of coarse fraction is larger than No. 4 sieve size	Clean (Little or	GP	Poorly graded gravels, gravel- sand mixtures, little or no fines	d gravet from grain size curve. dction smaller than No. 200 sieve), classified as follows: GW, GP, SW, SP GM. GC, SM, SC Borderline cases requiring dual symbols ⁽¹⁾	Not meeting C_u or C_c requiren	nents for GW	
o. 200 sieve	Gra n half of co than No. 4	Gravel with fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures	grain size grain size ithan No. 2 illows: /, SP , SC ases requiri	Atterberg limits below A Line or I $_{\rm P}$ less than 4	Limits plotting in hatched zone with I p between 4 and 7 are	
d Soils ger than Ne	More tha	Gravel v (Appre amount	GC	Clayey gravels, gravel-sand-clay mixtures	gravel from gravel from tion smaller assified as fr W, GP, SW M. GC, SM orderline c	Atterberg limits above A line with I _p greater than 7	borderline cases requiring use of dual symbols	
Coarse Grained Soils if material is larger tha	maller than	SW Well graded sands, gravel sands, little o fines	sands, gravely sands, little or no	of sand and of fines (fract ed soils are cla percent G t percent B t percent B	$C_{u=\frac{D_{60}}{D_{10}}}$ greater than 6: $C_{c=\frac{1}{10}}$	$(D_{30})2$ $D_{10} \times D_{60}$ between 1 and 3		
Coarse Grained Soils (More than half of material is larger than No. 200 sieve)	Sands (More than half of coarse fraction is smaller than No. 4 Sieve)	Clean sands (Little or no fines)	SP	Poorly graded sands, gravelly sands, 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 s)	Not meeting C_u or C_c require	ments for SW	
(We	S half of coa No.	th fines ciable of fines)	SM	Silty sands, sand- silt mixtures	Determ bepending	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	
	(More than I	Sands with fines (Appreciable amount of fines)	SC	Clayey sands, sand-clay mixtures		Atterberg limits above A line with I _p greater than 7		
Major	Divisions	Group Symbols	Туріса	Descriptions	For soils plotting nea When w _L is near 50	rly on A line use dual symbols i.e ., l _p use CL-CH or ML-MH. Take near as	= 29.5, w _L =60 gives CH-MH. ± 2 percent.	
	ys han 50)	ML	sands, rock f	s and very fine lour, silty or clayey r clayey silts with ly	60 <u></u> A Lir	e:		
200 sieve)	silts and clays d limit less than 50)	CL	plasticity, gra	ys of low to medium velly clays , sandy ays, lean clays	50 U Lii	1	ON I	
ls r than No.	Silt (Liquid li	OL	Organic silts clays of low	and organic silty plasticity	% (Id) X		N ^o O ^N	
Fine-grained soils (More than half of material is smaller than No. 200	iquid limit 50)	мн		s, micaceous or s fine sandy or silty silts	Plasticity Index (PI), %	NUR A	MH or OH	
Fir half of mat	Fine-gramod re than half of material is sm Silts and Clays (Liquid limit greater than 50)	СН	Inorganic cla fat clays	ys of high plasticity,				
More than	Silts ar 9	ОН	Organic clays plasticity, org	s of medium to high anic silts		CL-ML ML or OL		
)	Highly organic soils	Pt	Peat and oth soils	er highly organic		0 20 30 40 50 6 Liquid Limit (LL	0 70 80 90 100),%	

(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.