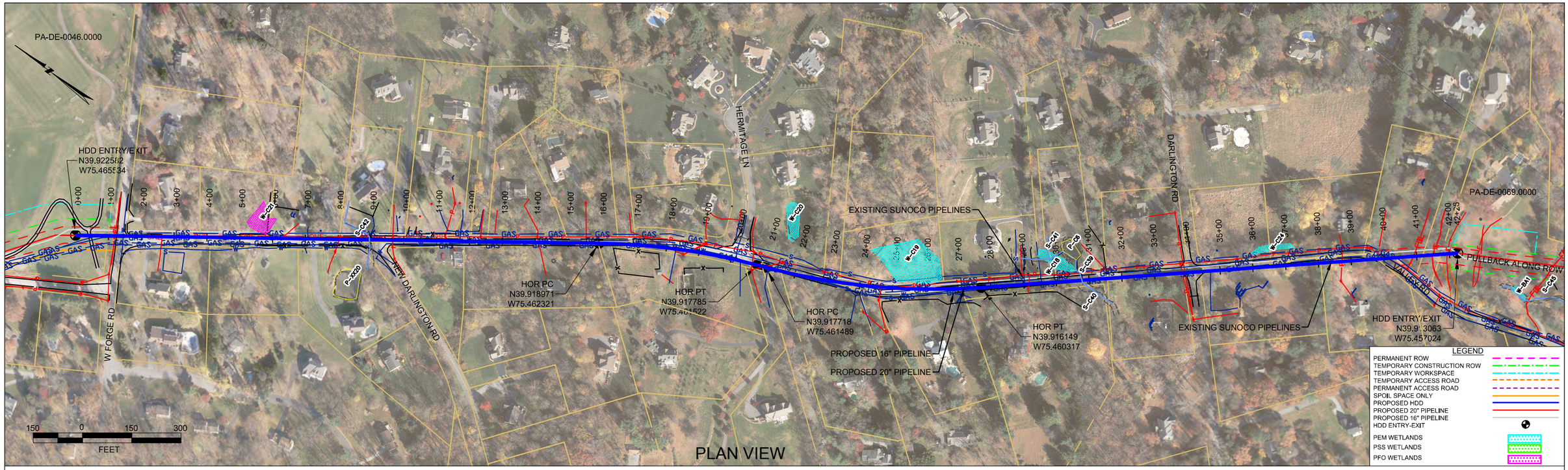
HDD PA-DE-0046.0000-RD (S-C42, S-C40)

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.

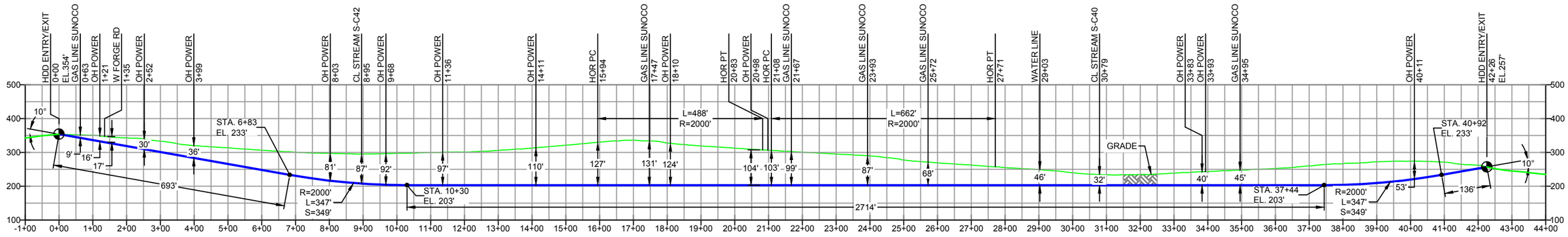
The drill will enter/exit 895 feet northwest of stream C42. The drill will pass 87 feet under this stream. Using the results of the geotechnical investigation, as well as several other data points, the entry/exit, angles, and depths have been configured to pass through the best substrates while maintaining pipe integrity (e.g., no large bends). The majority of the substrate that will be passed through is estimated to be silty sand northwest of the stream, and clay and silty sand southeast of the stream.

The drill will enter/exit 3079 feet northwest of stream C40. The drill will pass 32 feet under this stream. The southeast entry/exit point is 1147 feet southeast of 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 silty sand northwest of the stream, and silty sand and gneiss southeast of the stream.



PLAN VIEW

PROFILE VIEW



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=):4226'
   HDD PIPE LENGTH (S=):4242'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

DELAWARE COUNTY PENNSYLVANIA, MIDDLETOWN TOWNSHIP
S3-0591

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-6.11	TO	ES-6.14	EROSION & SEDIMENT PLAN	
SHEET 7	TO	SHEET 9	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP1	REVISED PER PADEP COMMENTS	MRS	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
C	ISSUED FOR BID	DLM	08/21/15	RMB	08/21/15	AAW	08/21/15
B	ISSUED FOR BID	DLM	07/31/15	RMB	07/31/15	AAW	07/31/15
A	ISSUED FOR REVIEW	JAM	03/18/15	RMB	03/27/15	AAW	03/27/15

Sunoco Logistics Partners L.P.

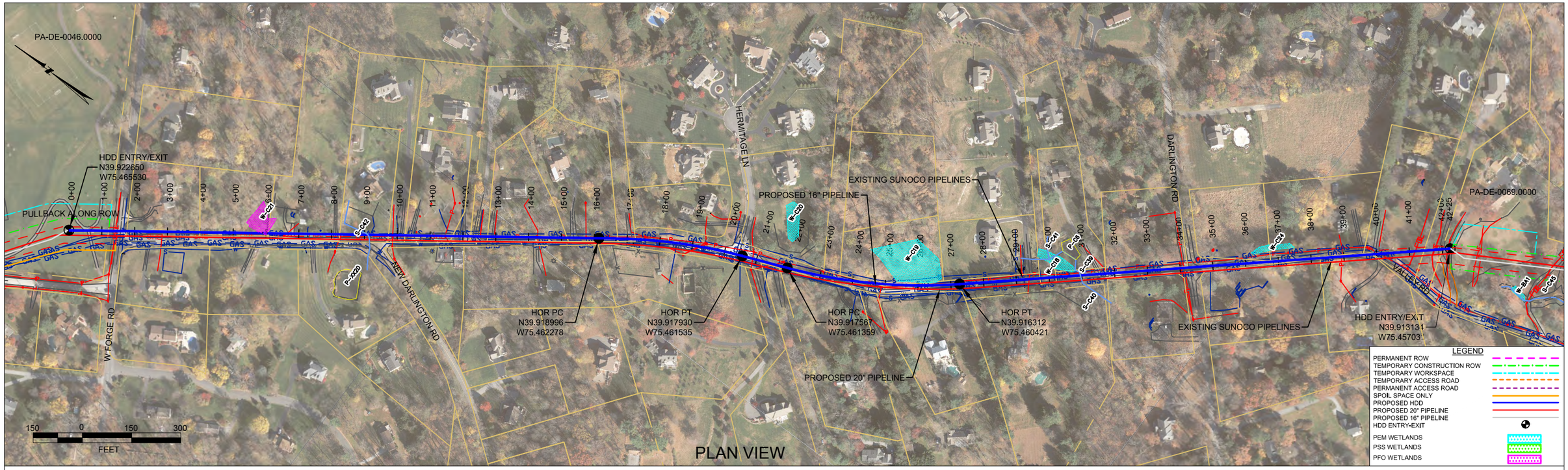
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
VALLEY ROAD
PENNSYLVANIA PIPELINE PROJECT

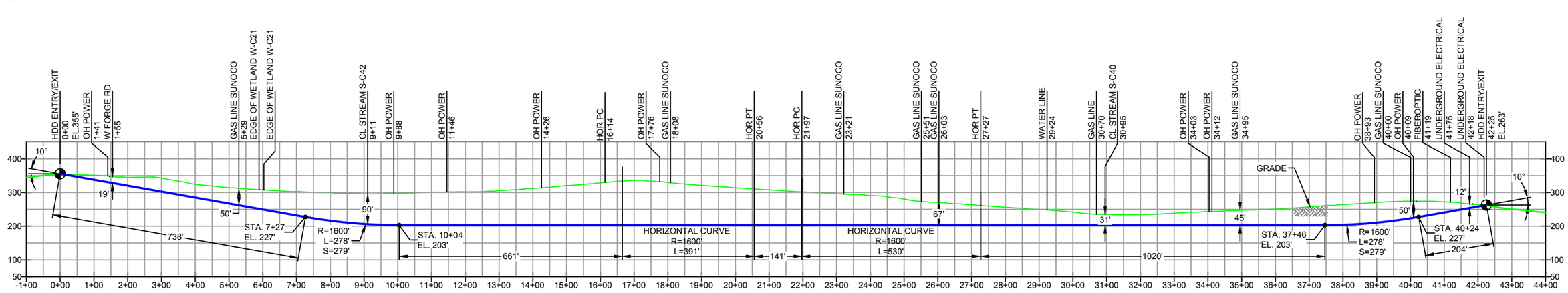
SCALE: 1"=300'

DWG. NO: PA-DE-0046.0000-RD



PLAN VIEW

PROFILE VIEW



DESIGN AND CONSTRUCTION:

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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=):4225'
   HDD PIPE LENGTH (S=):4243'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

DELAWARE COUNTY PENNSYLVANIA, MIDDLETOWN TOWNSHIP
S3-0591-16

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-6.11	TO	ES-6.14	EROSION & SEDIMENT PLAN
SHEET 7	TO	SHEET 9	AERIAL SITE PLAN

DWG NO		DWG NO	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP1	REVISED PER PADEP COMMENTS	MRS	05/20/16	RMB	05/20/16	AAW	05/20/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15

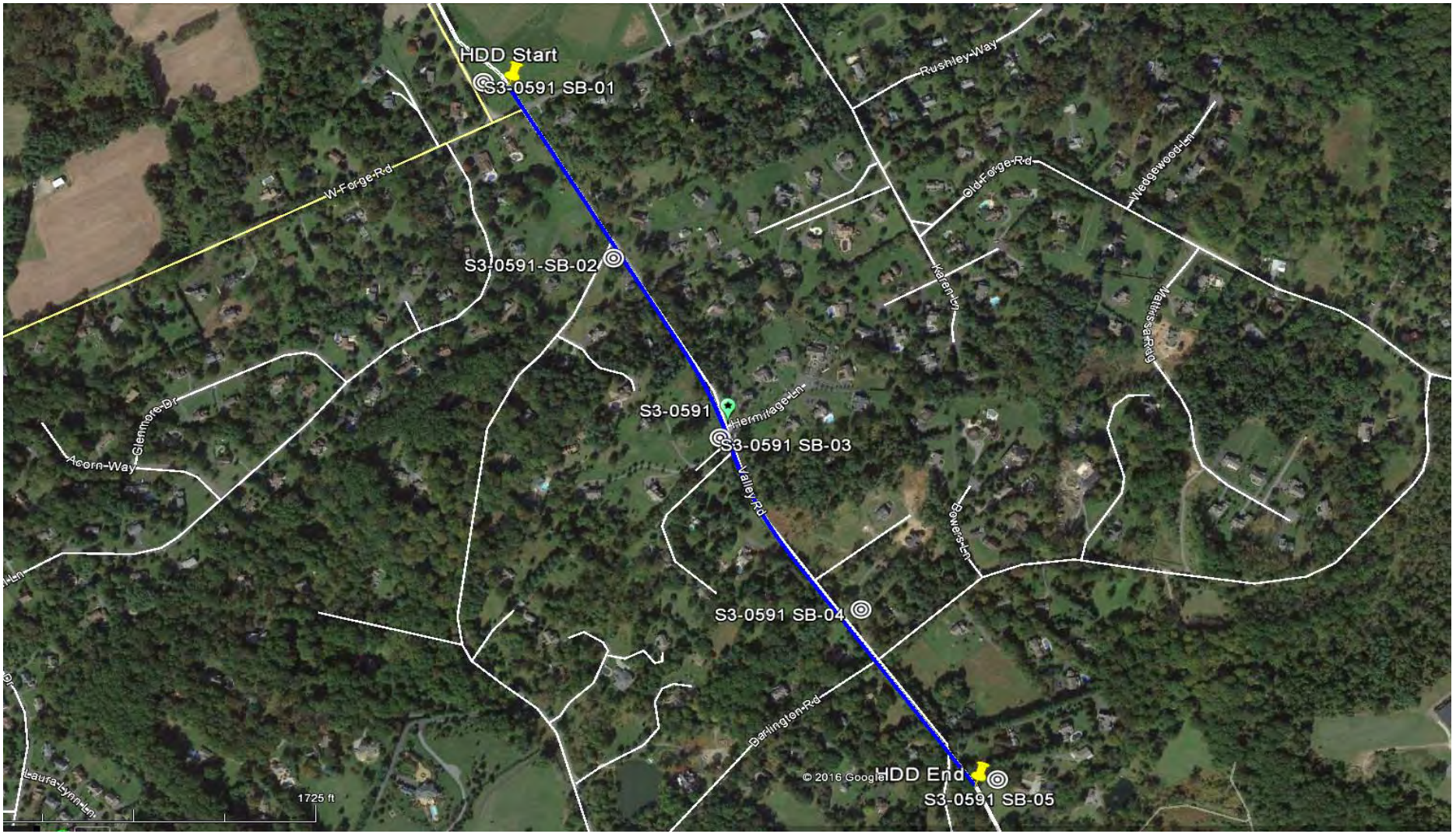
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
VALLEY ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=300' | DWG. NO: PA-DE-0046.0000-RD-16



LEGEND:

Geotechnical Soil Boring (SB) Locations

TETRA TECH

GEOTECHNICAL BORING LOCATIONS
HDD S3-0591
DELAWARE COUNTY, MIDDLETOWN TWP, 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:	438 VALLEY ROAD, MIDDLETOWN TWP. PARK, PA		Page 1 of 1
HDD No.:	S3-0591	Dates(s) Drilled: 02-25-16	Inspector: E. WATT
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586	Driller: D. BOLZE
Drilling Contractor:	CSC	Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 29.9
Boring Location Coordinates:		39° 55' 21.35" N	75° 27' 57.43" W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
							AUGERED TO REFUSAL AT 2'. COMMENCED ROCK CORE.					
RUN 1	2.0	5.5	2.0	3.6	23	BOULDER?	UNFRACTURED GNEISS	TCR: 55%, SCR: 50%, RQD: 44%				
			3.6	4.0			INTENSELY FRACTURED GNEISS					
			4.0	5.5			NO RECOVERY (SOIL)					
							SWITCHED TO ROLLERBIT AND DRIVE CASING					
1	8.0	10.0			<1		PIECES OF GNIESS GRAVEL	24	16	9	8	**25**
2	13.0	15.0			0	SM	NO RECOVERY	12	17	20	20	**37**
3	15.0	17.0			3		DR, GRAY MICACEOUS FINE TO MEDIUM SAND WITH SOME SILT.	15	13	10	8	**23**
4	18.0	20.0			12		DR, GRAY MICACEOUS FINE TO MEDIUM SAND WITH SOME SILT.	5	6	7	11	**13**
				21.5			(USCS: SM)					
5	23.0	24.8	21.5		21	SM	DR, BLACK AND DARK GRAY MICACEOUS FINE TO MEDIUM SAND	11	36	47	50/3"	**83**
							WITH SOME SILT, TRACE UNWEATHERED GNEISS GRAVEL.					
6	28.0	29.9			22		DR, VARIEGATED (GRAY, BROWN, TAN, WHITE) FINE TO MEDIUM	11	15	34	50/5"	**49**
				29.9			SAND, TRACE UNWEATHERED GNEISS GRAVEL.					
							CORE TESTING RESULTS (DEPTH 3-3.5'):					
							COMPRESSIVE STRENGTH: 12,232 PSI					
							UNIT WEIGHT: 185.1 PCF					

Notes/Comments:
Pocket Pentrometer Testing

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.

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:	328 VALLEY ROAD, MEDIA, PA		Page 1 of 1
HDD No.:	S3-0591	Dates(s) Drilled: 12-15-15	Inspector: J. COSTELLO
Boring No.:	SB-02	Drilling Method: SPT - ASTM D1586	Driller: E. OGDEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): SEE BELOW	Total Depth (ft): 18.5
Boring Location Coordinates:		39°55'12.91"N	75°27'49.14"W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.3			TOPSOIL (3")					
1	3.0	5.0	0.3		11	ML	GRAY SILT, SOFT, ORGANIC ODOR.	1	1	1	2	**2**
							(USCS: ML).					
2	8.0	10.0			4		GRAY SILT.	3	4	3	5	**7**
				11.5								
3	13.0	14.2	11.5		24	SM	DR, GRAY TO DARK GRAY MICACEOUS FINE SAND WITH SOME	6	25	50/2"		**>50**
							SILT. (USCS: SM).					
4	18.0	18.4		18.5	3		SAME	50/5"				**>50**
							AUGER REFUSAL AT 18.5'.					
							WATER LEVEL THROUGH AUGERS AT 10'. COULD BE PERCHED					
							OVER ROCK.					
							CAVED AND WET AT 12'.					

Notes/Comments:
Pocket Pentrometer Testing
S1: 0.50 TSF

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.

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:	250 VALLEY ROAD, MEDIA, PA		Page 1 of 1
HDD No.:	S3-0591	Dates(s) Drilled: 10-31-15	Inspector: J. COSTELLO
Boring No.:	SB-03	Drilling Method: SPT - ASTM D1586	Driller: E. OGDEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 35.0	Total Depth (ft): 40.0
Boring Location Coordinates:		39°55'4.07"N	75°27'42.03"W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.1			TOPSOIL (1.5")					
1	3.0	5.0	0.1		8		BROWN FINE TO MEIDUM SAND AND SILT, WITH A LITTLE FINE TO	1	4	6	10	**10**
							COARSE GRAVEL.					
2	8.0	10.0			15		DR, YELLOWISH BROWN AND WHITE FINE SAND AND SILT, TRACE	1	4	6	11	**10**
							FINE ROCK FRAGS.					
3	13.0	15.0			22		DR, VARIEGATED BROWN, GRAY, WHITE FINE SAND AND SILT, TRACE	1	4	6	8	**10**
							FINE ROCK FRAGS.					
4	18.0	20.0			24		SAME	1	5	8	11	**13**
						SM						
5	23.0	25.0			21		SAME (USCS: SM)	3	8	11	13	**19**
6	28.0	30.0			24		SAME, INCREASED ROCK FRAGMENTS.	1	8	21	42	**29**
7	33.0	34.4			18		DR, VARIEGATED BROWN, GRAY, WHITE FINE SAND AND SILT, SOME	4	22	50/5"		**>50**
							FINE TO COARSE ROCK FRAGMENTS.					
8	38.0	38.8			6		SAME	22	50/4"			**>50**
				40.0								
							AUGER REFUSAL AT 40'.					
							WATER LEVEL THROUGH AUGERS AT 35'.					
							CAVED AT 35'.					

Notes/Comments:
Pocket Pentrometer Testing

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.

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:	361 DARLINGTON ROAD, MEDIA, PA		Page 1 of 1
HDD No.:	S3-0591	Dates(s) Drilled: 10-30/31-15	Inspector: J. COSTELLO
Boring No.:	SB-04	Drilling Method: SPT - ASTM D1586	Driller: E. OGDEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 28.0	Total Depth (ft): 38.0
Boring Location Coordinates:		39° 54' 55.66" N	75° 27' 32.92" W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.1			TOPSOIL (1.5")					
1	3.0	5.0	0.1		17	ML	DR, LAYERING OF BROWN AND GRAY SILT WITH SOME FINE SAND.	2	6	8	14	**14**
				6.0								
2	8.0	10.0	6.0		24	SM	DR, BROWN WITH BLACK NODULES FINE TO MEDIUM WITH SOME	4	13	14	18	**27**
							SILT.					
3	13.0	15.0			16		DR, VARIEGATED BROWN, WHITE, GRAY FINE TO MEDIUM SAND	2	15	16	21	**31**
							AND SILT, TRACE FINE GRAVEL. (USCS: SM)					
4	18.0	20.0			21		DR, BROWN AND DARK BROWN LAMINATED FINE TO MEDIUM SAND	2	6	12	22	**18**
				23.5			AND SILT.					
5	23.0	24.3	23.5		10	SM	DR, BROWN AND DARK BROWN LAMINATED FINE TO MEDIUM SAND	22	50	50/3"		**>50**
							WITH SOME SILT, TRACE F-C ROCK FRAGS.					
6	28.0	28.8			12		DR, BROWN AND DARK BROWN LAMINATED FINE TO MEDIUM SAND	6	50/3"			**>50**
				31.0			WITH SOME SILT, TRACE F-C ROCK FRAGS.					
							AUGER REFUAL AT 31'.					
							ROCK CORING					
RUN 1	31.0	36.0	31.0		46	ROCK	FRACTURED WHITE, PINK, GRAY GNIESS	TCR: 77%, SCR: 77%, RQD: 53%				
RUN 2	36.0	38.0		38.0	0		NO RECOVERY (DECOMPOSED GNEISS - SOIL)	TCR: 0%, SCR: 0%, RQD: 0%				
							RAN OUT OF WATER AT 38'. DISCONTINUED CORING.					
							CORE TESTING RESULTS (DEPTH 31.5-32'):					
							COMPRESSIVE STRENGTH: 6,170 PSI					
							UNIT WEIGHT: 160.7 PCF					

Notes/Comments:

Pocket Pentrometer Testing

S1: > 4 TSF

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.

TETRA TECH
240 Continental Drive, Suite 200
Newark, Delaware 19713
302.738.7551
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TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	143 VALLEY ROAD, MEDIA, PA		Page 1 of 1
HDD No.:	S3-0591	Dates(s) Drilled: 11-02-15	Inspector: J. COSTELLO
Boring No.:	SB-05	Drilling Method: SPT - ASTM D1586	Driller: E. OGDEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 30.0
Boring Location Coordinates:		39° 54' 47.39" N	75° 27' 24.05" W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.1			TOPSOIL (1.0")					
1	3.0	5.0	0.1		14		DR, BROWN AND WHITE FINE TO COARSE SAND , SOME SILT, WITH A	4	2	4	4	**6**
							LITTLE F-C GRAVEL.					
2	8.0	10.0			20		DR, VARIEGATED BROWN, RED, BLACK, WHITE FINE SAND AND SILT	1	2	3	5	**5**
							TRACE MIICA, TRACE FINE GRAVEL. (USCS: SM)					
3	13.0	15.0			24		SAME	1	2	4	6	**6**
						SM						
4	18.0	20.0			17		DR, VARIEGATED BROWN, GRAY, WHITE FINE TO MEDIUM SAND WITH	2	9	9	11	**18**
							SOME SILT, TRACE ROCK FRAGS, TRACE MICA					
5	23.0	25.0			21		DR, VARIEGATED BROWN, GRAY, WHITE FINE TO MEDIUM SAND WITH	1	4	5	7	**9**
							SOME SILT, TRACE ROCK FRAGS, TRACE MICA					
6	28.0	30.0			20		DR, VARIEGATED BROWN, GRAY, WHITE FINE TO MEDIUM SAND	2	5	7	11	**12**
				30.0			AND SILT, TRACE ROCK FRAGS, TRACE MICA (USCS: SM)					
							CAVED AND DRY AT 26'.					

Notes/Comments:
Pocket Pentrometer Testing

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.

ROCK CORE DESCRIPTION SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0591

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					
S3-0591	SB-01	1	2	5.5	55	50	44	2	5.5	Slight	Gneiss	Massive	Light gray/ gray	One massive piece, foliation dipping approx. 24°
S3-0591	SB-04	1	31	36	77	77	53	31	36	Slight	Gneiss	Massive	White/pink/ dark gray	Fractures ranging from 8° to 30°, Avg. 21°

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0591

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.) From	Depth of Sample (ft.) To	Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318) Liquid Limit, %	Atterburg Limits (ASTM D4318) Plastic Limit, %	Atterburg Limits (ASTM D4318) Plasticity Index, %	USCS Classif. (ASTM D2487)
S3-0591	SB-01	3	15.0	17.0	40.1	35.9	-	-	-	-
		4	18.0	20.0	27.9	35.0	36	27	9	SM
		5	23.0	24.8	10.5	24.1	-	-	-	-
		6	28.0	29.9	15.2	24.3	-	-	-	-
	SB-02	1	3.0	5.0	29.3	93.8	42	29	14	ML
		3	13.0	14.2	26.0	34.6	NV	NP	NP	SM
		4	18.0	18.4	16.3	31.4	-	-	-	-
	SB-03	2	8.0	10.0	18.3	47.0	-	-	-	-
		3	13.0	15.0	17.1	47.2	-	-	-	-
		5	23.0	25.0	13.4	35.5	28	23	5	SM
		6	28.0	30.0	16.5	39.9	-	-	-	-
		7	33.0	34.4	12.9	39.6	29	23	6	SM
		8	38.0	38.8	8.1	45.3	-	-	-	-
	SB-04	1	3.0	5.0	15.2	79.1	-	-	-	-
		2	8.0	10.0	11.1	32.1	-	-	-	-
		3	13.0	15.0	17.1	39.2	-	-	-	-
		4	18.0	20.0	18.2	42.1	NL	NP	NV	SM
		5	23.0	24.3	8.7	29.9	-	-	-	-
		6	28.0	28.8	9.5	25.9	-	-	-	-
	SB-05	1	3.0	5.0	7.1	24.8	-	-	-	-
		2	8.0	10.0	17.5	41.6	30	24	6	SM
		3	13.0	15.0	19.5	35.1	-	-	-	-
		4	18.0	20.0	10.1	23.8	-	-	-	-
		6	28.0	30.0	17.1	42.7	31	25	6	SM

Rock Core Testing Results				
Boring No.	Core Run	Approximate Depth (ft)	Compressive Strength (psi)	Unit Weight (pcf)
SB-01	1	3.0 - 3.5	12,232	185.1
SB-04	1	31.5 - 32.0	6,170	160.7

Notes:

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

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0591

HDD No.	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
S3-0591	SB-01	Felsic gneiss - Light, medium grained; includes rocks of probable sedimentary origin.	Generally level, slightly sloping to the south	Felsic gneiss (Precambrian age)	Felsic gneiss; Secondary - paragneiss	No information found during literature review	Ranges from 14 to 75 ft bgs, Avg. 40 ft bgs (.5 mile radius)	All part of Glenarm Supergroup a name given to provincial series of pre-Cambrian metamorphosed sedimentary rocks present in northern VA, MD, southeastern PA, western NJ, and possibly southeastern NY. Rocks from this assemblage consists of a thick sequence of metasedimentary rock and include the following formations; Setters metaquartzite, Cockeysville marble, Wissahickon Schist (along with subset of the Octoraro schist), Peters Creek metaquartzite and meta siltstones and the Peach Bottom Clate (Geology of Pennsylvania SP-1, 1999) . Drilling in these formations generally difficult to very difficult except where fractures and weathered exposed zones present.
	SB-02		Generally level, slightly sloping to the south					
	SB-03		Gently sloping to the southeast					
	SB-04		Gently sloping to the west					
	SB-05		Gently sloping to the south					

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)

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

Relative Proportions

Description Term	*Percent*
Trace	1 - 10
Little	11 - 20
Some	21 - 35
And	36 - 50

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)	

COHESIVE SOILS

(Silt, Clay & Combinations)

Consistency	***N (blows)****
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

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

ROCK

(Rock Cores)

Rock Quality Designation (RQD), %	***Rock Quality Description***
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).

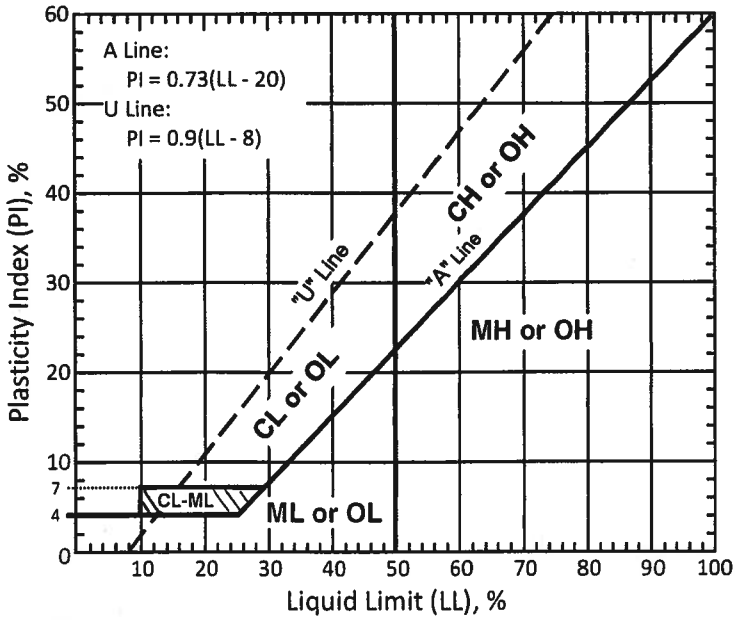
Groundwater observations were made at the times indicated. Groundwater elevations fluctuate throughout a given year, depending on actual field porosity and variations in seasonal and annual precipitation.

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	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, gravely 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	

Major Divisions		Group Symbols	Typical Descriptions
Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silts 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
	Silts 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

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.



(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.