

### Bog Turtle Area HDDs

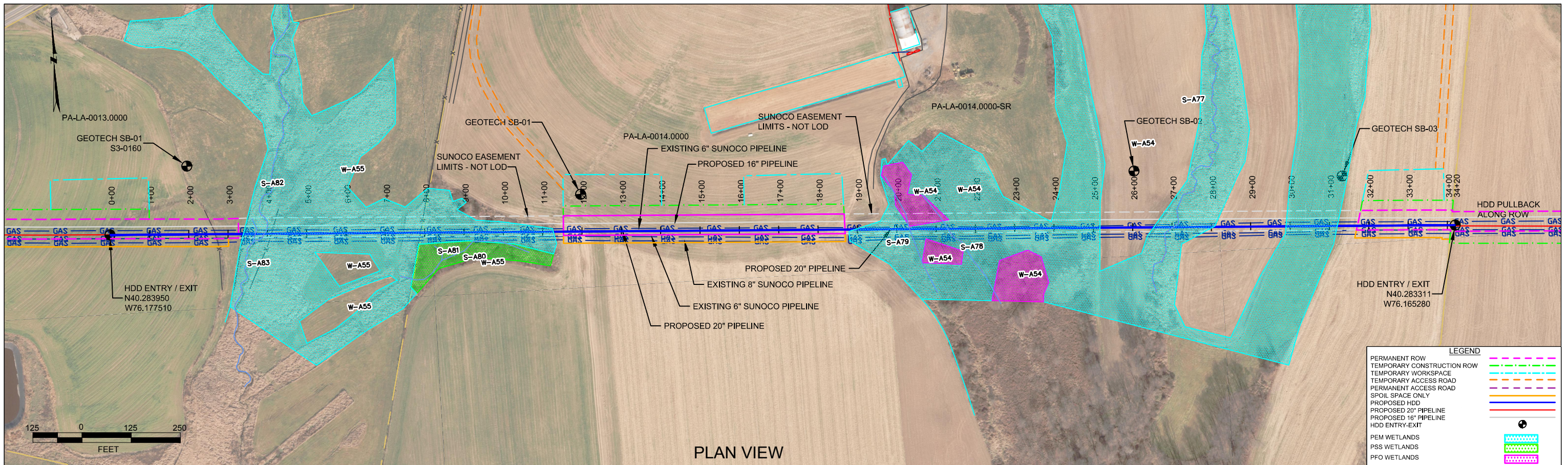
HDDs under bog turtle occupied wetlands is a primary avoidance measure. However, inadvertent return of drilling fluids to the surface of these wetlands is the primary threat to bog turtles. Therefore SPLP has implemented measures to ensure the potential for returns are reduced, including geotechnical investigations. At each of the bog turtle wetland, a summary of the HDD evaluation is provided below.

#### ***HDD PA-LA-0014.0000 (W-A55 and W-A54)***

After consideration of the all data points, including the sensitivity of the area and geotechnical results, the preliminary design of this drill has been found to be adequate for safe installation and operation (see Attachment A for the drill design and the geotechnical investigation report).

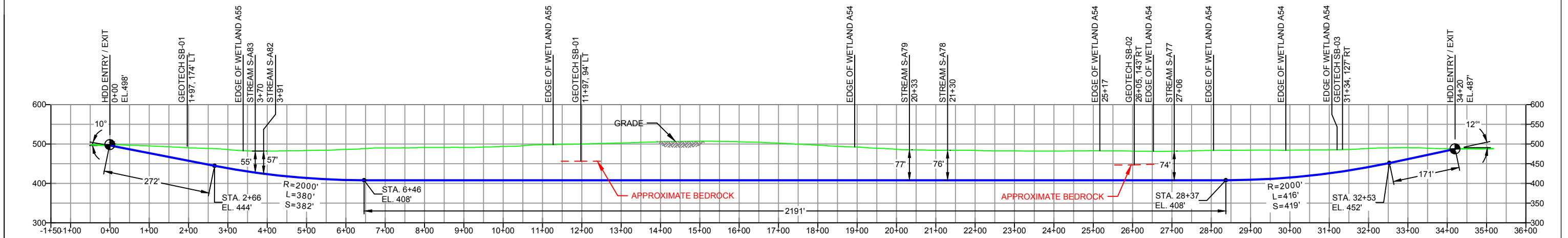
The drill would enter/exit 250 feet from the edge of the western most boundary of the wetland A55PEM. The drill would pass 25 feet under the western most boundary of wetland A55PEM and 60 feet under the eastern most boundary of Wetland A55PEM. Using the results of the geotechnical investigation, as well 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 and clay at the western end of the wetland and weathered sandstone beneath the central and eastern portion of the wetland.

The drill would continue beneath the western most boundary of the wetland A54PEM and would enter/exit 125 feet from the eastern most edge of wetland A54PEM. The drill would pass 60 feet under the western most boundary of wetland A54PEM and 20 feet under the eastern most boundary of Wetland A54PEM. 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 clay, silty clay and silty sand at the eastern end of the wetland and weathered siltstone/sandstone beneath the central and western portions of the wetland. Given the design, the threat of inadvertent return has been reduced to the maximum extent practicable. Implementing this design, along with adherence to the *Pennsylvania Pipeline Project Inadvertent Return Contingency Plan – with Special Bog Turtle Procedures* will ensure the bog turtle is not impacted as result of this HDD.



PLAN VIEW  
PROFILE VIEW

LANCASTER COUNTY, PENNSYLVANIA - WEST COCALICO TOWNSHIP  
S3-0161



<p><b>GEOTECH SB-01</b> -NG EL. 494' -TOPSOIL (0' - 0.1') -SM (0.1' - 21.5') -GROUNDWATER (15.0') -SC (21.5' - 26.0') -CL (26.0' - 30.0') -COMPLETION DEPTH EL. 464'</p> <p>NOTE: REFER TO TEST BORING LOG S3-0160 FOR COMPLETE SOIL MATERIAL DESCRIPTION</p>	<p><b>GEOTECH SB-01</b> -NG EL. 500' -TOPSOIL (0' - 0.7') -GROUNDWATER (17.0') -SM (13.5' - 44.0') -WEATHERED SILTSTONE/SANDSTONE (44.0' - 45.0') -COMPLETION DEPTH EL. 441'</p> <p>NOTE: REFER TO TEST BORING LOG S3-0170 FOR COMPLETE SOIL MATERIAL DESCRIPTION</p>	<p><b>GEOTECH SB-02</b> -NG EL. 485' -TOPSOIL (0' - 0.7') -GROUNDWATER (13.0') -SC (0.7' - 21.0') -CL (21.0' - 35.0') -WEATHERED SILTSTONE (35.0' - 44.0') -COMPLETION DEPTH EL. 441'</p> <p>NOTE: REFER TO TEST BORING LOG S3-0170 FOR COMPLETE SOIL MATERIAL DESCRIPTION</p>	<p><b>GEOTECH SB-03</b> -NG EL. 487' -TOPSOIL (0' - 0.3') -SM (0.3' - 11.5') -GROUNDWATER (6.0') -SC (11.5' - 30.0') -COMPLETION DEPTH EL. 457'</p> <p>NOTE: REFER TO TEST BORING LOG S3-0170 FOR COMPLETE SOIL MATERIAL DESCRIPTION</p>
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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 HORIZ. LENGTH (L=): 3420'  
HDD PIPE LENGTH (S=): 3435'  
20" x 0.456" W.T., X-65, API6L, 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-4.11	TO ES-4.13	EROSION & SEDIMENT PLAN	
SHEET 6	TO SHEET 8	AERIAL SITE PLAN	EP2 REVISED PER PADEP COMMENTS RECEIVED 09-06-16
			EP1 REVISED PER PADEP COMMENTS
			EP
			1 DESIGN CHANGE
			0 ISSUED FOR CONSTRUCTION
DWG NO.	DWG NO.	DESCRIPTION	NO.

BY	DATE	CHK	DATE	APP	DATE
DLM	10/24/16	RMB	10/24/16	AAW	10/24/16
JTW	05/18/16	RMB	05/18/16	AAW	05/18/16
MRS	02/26/16	RMB	02/26/16	AAW	02/26/16
MRS	02/24/16	RMB	02/24/16	AAW	02/24/16
MRS	01/21/16	RMB	01/21/16	AAW	01/21/16

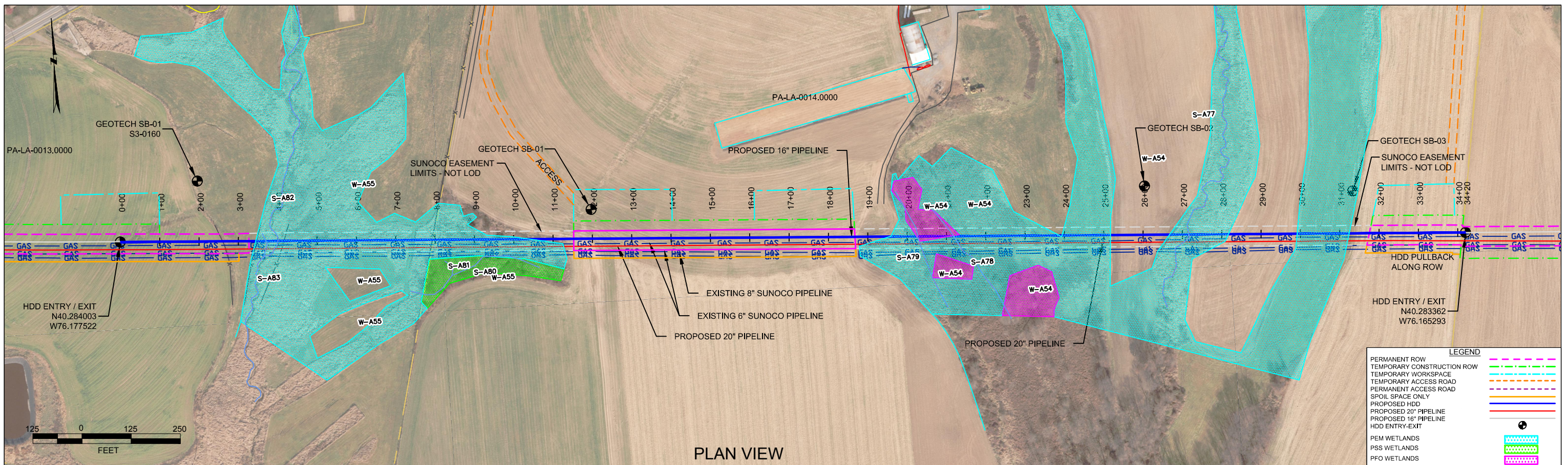
**Sunoco Logistics Partners L.P.**

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

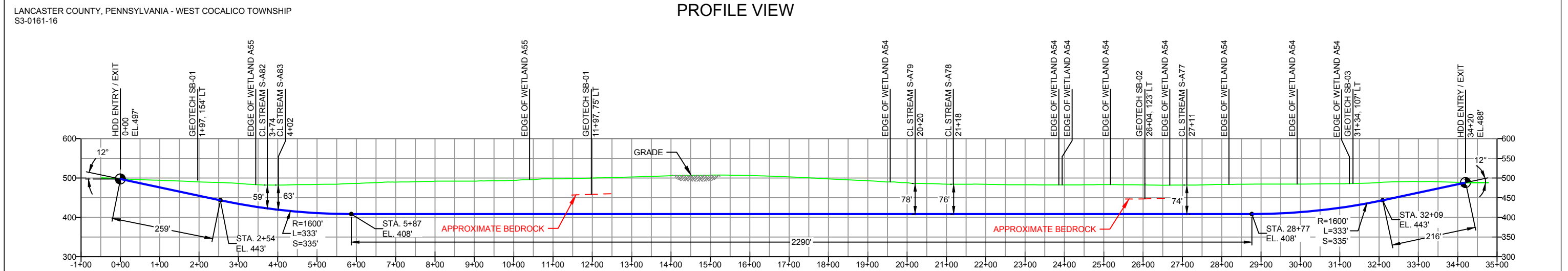
**SUNOCO PIPELINE, L.P.**

20-INCH HORIZONTAL DIRECTIONAL DRILL  
WETLAND A54 & A55  
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=250'    DWG. NO: PA-LA-0014.0000-SR

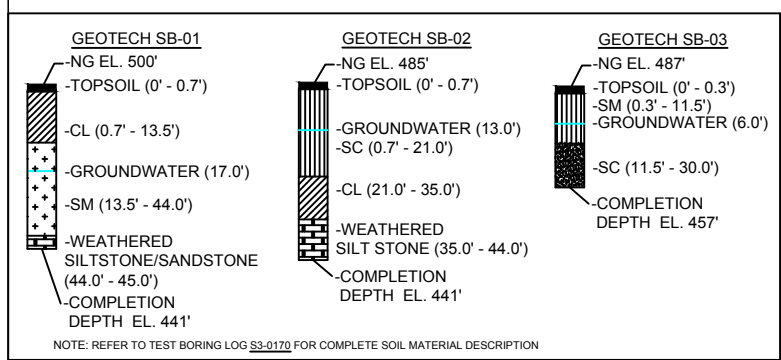


PLAN VIEW

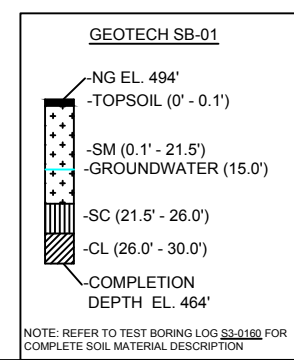


PROFILE VIEW

LANCASTER COUNTY, PENNSYLVANIA - WEST COCALICO TOWNSHIP  
S3-0161-16



- 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): 3170'  
HDD PIPE LENGTH (S): 3177'  
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.
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- 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.
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  - SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING		REVISIONS	
ES-4.11	TO	ES-4.13	EROSION & SEDIMENT PLAN
SHEET 6	TO	SHEET 8	AERIAL SITE PLAN
			EP2 REVISED PER PADEP COMMENTS RECEIVED 09-06-16
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		1	DESIGN CHANGE
		0	ISSUED FOR CONSTRUCTION
DWG NO	DWG NO	DESCRIPTION	NO.

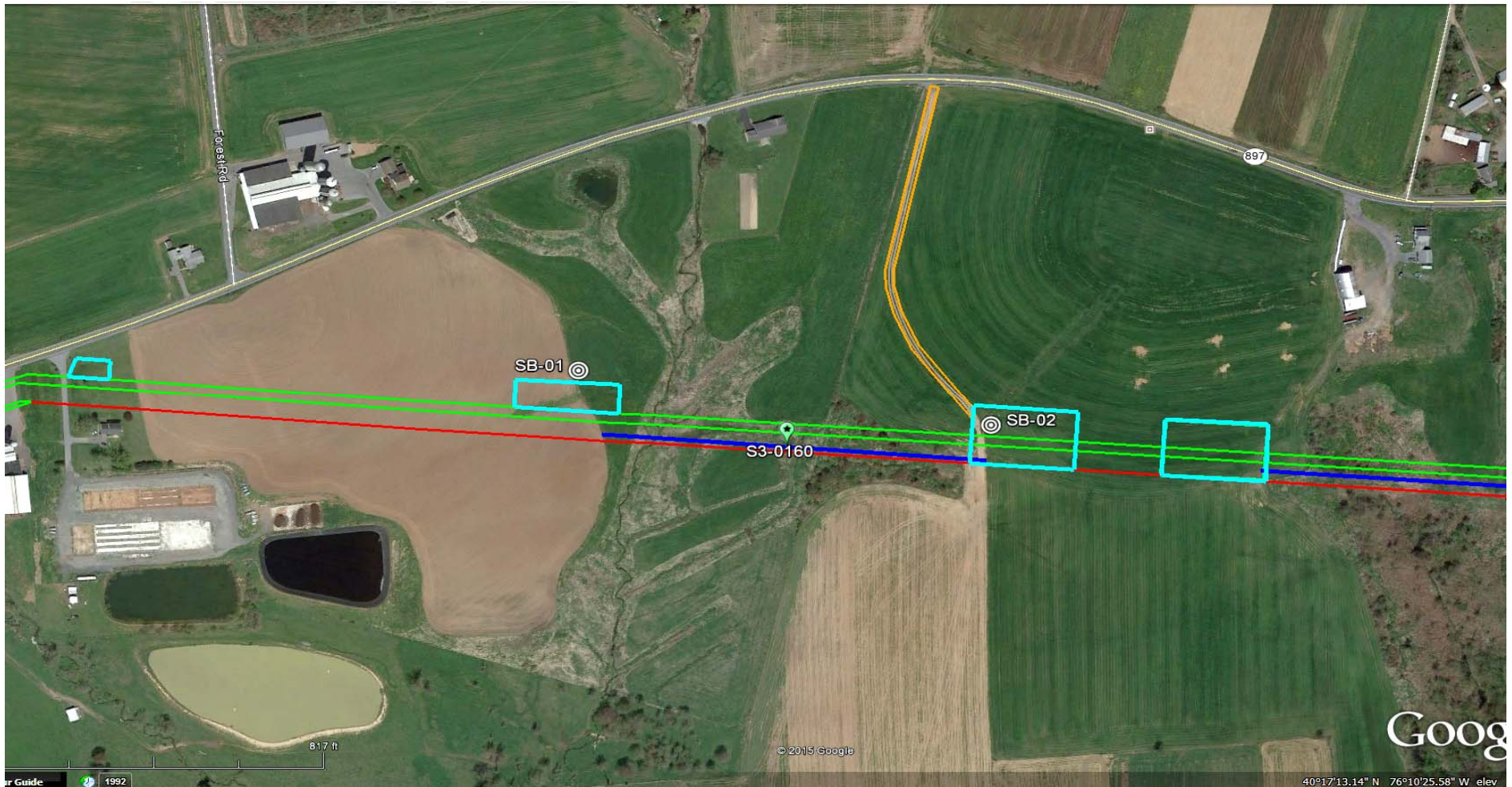
**Sunoco Logistics Partners L.P.**

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

**SUNOCO PIPELINE, L.P.**

16-INCH HORIZONTAL DIRECTIONAL DRILL  
WETLAND A54 & A55  
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=250'    DWG. NO: PA-LA-0014.000-SR-16



**LEGEND:**

⊙ Geotechnical Soil Boring (SB) Locations



GEOTECHNICAL BORING LOCATIONS

HDD S3-0160

LANCASTER COUNTY, WEST COCALICO 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:	RT 897, DENVER, PA	Page 1 of 1	
HDD No.:	S3-0160	Dates(s) Drilled:	12-13-14
Boring No.:	SB-01	Inspector:	E. WATT
Drilling Contractor:	HAD DRILLING	Drilling Method:	SPT - ASTM D1586
		Driller:	S. HOFFER
		Groundwater Depth (ft):	15.0
		Total Depth (ft):	30.0
Boring Location Coordinates:	40° 17' 3.801" N	76° 10' 36.352" 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		14	SM	REDDISH BROWN TO GRAYISH BROWN FINE TO MEDIUM SAND WITH A LITTLE SILT, TRACE FINE QUARTZ GRAVEL.	4	16	20	22	36	
2	8.0	10.0			24		REDDISH BROWN FINE TO COARSE SAND WITH SOME SILT, TRACE CONGLOMERATE MATRIX.	2	14	10	12	24	
3	13.0	14.5			18		REDDISH BROWN FINE SAND AND SILT, WITH A LITTLE CONGLOMERATE MATRIX.	4	25	50		75	
4	18.0	19.4			14		REDDISH BROWN FINE SAND AND SILT, WITH A LITTLE CONGLOMERATE MATRIX.	9	33	50/5"		>50	
				21.5									
5	23.0	23.9	21.5		10		SC	REDDISH BROWN FINE SAND AND SILTY CLAY, WITH A LITTLE FINE TO COARSE UNWEATHERED GRAVEL (USCS: SC)	2	50/5"			>50
				26.0									
6	28.0	28.8	26.0		9	CL	REDDISH BROWN SILTY CLAY AND FINE SAND, WITH A LITTLE FINE TO COARSE UNWEATHERED GRAVEL.	23	50/4"			>50	
				30.0									
							AUGERED TO 30'.						
							WET ON SPOON AT 15'.						
							WATER LEVEL THROUGH AUGERS AT 17'.						
							CAVED AT 28'.						

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: MIDDLECREEK WILDLIFE MANAGEMENT AREA, NEWMANSTOWN, PA			Page 1 of 1		
HDD No.: S3-0160		Dates(s) Drilled: 11-20-14		Inspector: E. WATT	
Boring No.: SB-02		Drilling Method: SPT - ASTM D1586		Driller: S. HOFFER	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): 17.0		Total Depth (ft): 53.0	
Boring Location Coordinates:			40° 17' 2.346" N		76° 10' 23.538" 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	0.7			TOPSOIL (8")							
1	3.0	5.0	0.7		24	CL	MAROON SILTY CLAY AND FINE SAND, TRACE QUARTZ FINE GRAVEL.	3	10	11	10		21	
2	8.0	10.0			8		MAROON MICACEOUS SILTY CLAY WITH SOME FINE SAND. (USCS: CL).	3	4	3	3		7	
				13.5		SM	MAROON FINE TO MEDIUM SAND WITH A LITTLE CLAYEY SILT, TRACE FINE GRAVEL.	28	50/5"				>50	
4	18.0	18.9			12		MAROON FINE TO MEDIUM SAND WITH A LITTLE CLAYEY SILT, TRACE FINE GRAVEL.	14	50/5"				>50	
5	23.0	25.0			16		MARRON FINE SAND WITH SOME CLAYEY SILT, TRACE CONGLOMERATE.	3	11	28	50		39	
6	28.0	29.0			11		MAROON FINE TO MEDIUM SAND WITH SOME CLAYEY SILT, TRACE CONGLOMERATE.	9	50/6"				>50	
7	33.0	34.0			12		MAROON FINE SAND AND CLAYEY SILT, TRACE CONGLOMERATE.	28	50/6"				>50	
8	38.0	38.9			8		MAROON FINE SAND AND CLAYEY SILT, TRACE CONGLOMERATE. (USCS: SM)	8	50/5"				>50	
9	43.0	43.9			10		MAROON MEDIUM TO COARSE SAND WITH SOME CLAYEY SILT, TRACE FINE QUARTZ GRAVEL.	12	50/5"				>50	
10	44.6	45.0	44.0	45.0	4		PARTIALLY WEATHERED SILTSTONE/SANDSTONE.	50/5"					>50	
								AUGER REFUSAL AT 44.6'.						
								ROCK CORING						
RUN 1	45.0	48.0	45.0		20	FRACTURED ROCK	HIGHLY FRACTURED AND WEATHERED REDDISH BROWN SILTSTONE.	TCR: 55%, SCR: 0%, RQD: 0%						
				49.3			HIGHLY FRACTURED AND WEATHERED MAROON SILTSTONE AND MEDIUM TO COARSE GRAINED SANDSTONE INTERBEDS.	TCR: 100%, SCR: 12%, RQD: 9%						
RUN 2	48.0	53.0	49.3		60		MODERATELY TO HIGHLY FRACTURED, MODERATELY WEATHERED MARRON SILTSTONE AND QUARTZ PEBBLE CONGLOMERATE.							
				51.3										
				53.0										

Notes/Comments: Pocket Pentrometer Testing S2: 0.5 TSF DR: DECOMPOSED ROCK WET ON SPOON AT 17' WATER LEVEL THROUGH AUGERS AT 18' CAVED AT 37'.

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 S3-0160**

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, %	
S3-0160	SB-01	2	8.0	10.0	10.9	29.2	-	-	-	-
		3	13.0	14.5	8.4	39.2	-	-	-	-
		4	18.0	19.4	7.0	41.2	-	-	-	-
		5	23.0	23.9	10.4	46.2	26	16	8	SC
		6	28.0	28.8	7.8	65.3	-	-	-	-
	SB-02 (Also S3-0170, SB-01)	2	8.0	10.0	16.7	78.1	27	16	11	CL
		4	18.0	18.9	11.3	19.7	-	-	-	-
		6	28.0	29.0	8.6	27.9	-	-	-	-
		8	38.0	38.9	10.7	44.4	18	18	NP	SM
		9	43.0	43.9	10.6	25.1	-	-	-	-

**Notes:**

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

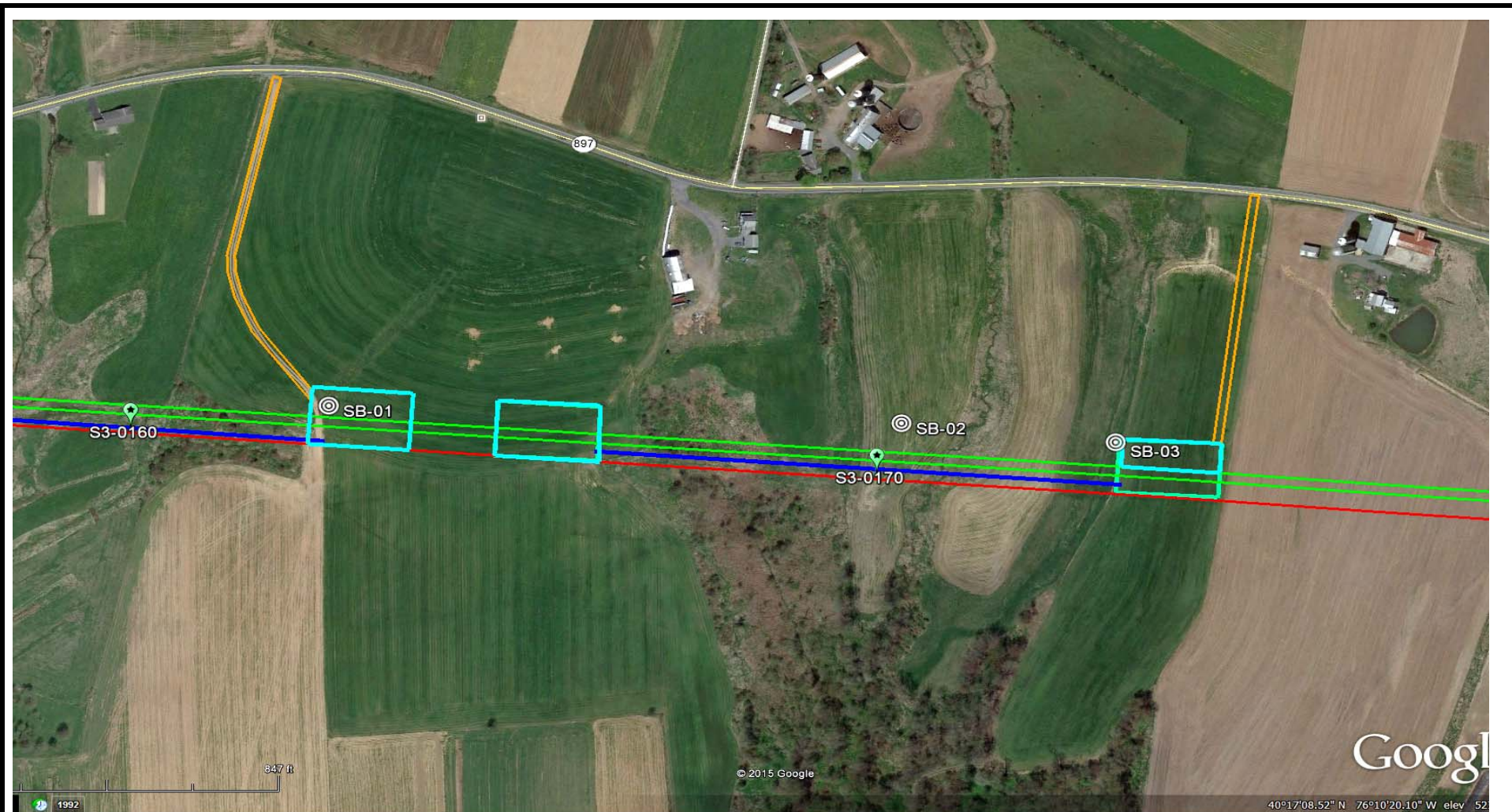
**REGIONAL GEOLOGY SUMMARY  
SUNOCO PENNSYLVANIA PIPELINE PROJECT  
HDD S3-0160**

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
S3-0160	Wetland A55	SB-01	<b>Hammer Creek Formation</b> - Gray and pale red, fine- to coarse-grained quartzose sandstone, siltstone, and mudstone	Lowland, wetlands area	Hammer Creek Fm	sandstone with quartz pebble conglomerate	9,360	50-70	
		SB-02							

*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 S3-0160**

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					
S3-0160	SB-2	1	45	48	55	0	0	45	48	Heavily	Siltstone	Massive	Red	Heavily fractured, ranging from 0° to 45°
		2	48	53	100	12	9	48	53	Heavily	Siltstone with interbedded Sandstone	Massive, bedding is gradational	Red	Heavily fractured, ranging from 0° to 65°



**LEGEND:**

⊙ Geotechnical Soil Boring (SB) Locations



GEOTECHNICAL BORING LOCATIONS

HDD S3-0170

LANCASTER COUNTY, WEST COCALICO 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: RT 897, DENVER, PA			Page 1 of 1		
HDD No.: S3-0170		Dates(s) Drilled: 11-20-14		Inspector: E. WATT	
Boring No.: SB-01		Drilling Method: SPT - ASTM D1586		Driller: S. HOFFER	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): 17.0		Total Depth (ft): 53.0	
Boring Location Coordinates:			40° 17' 2.346" N		76° 10' 23.538" 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	0.7			TOPSOIL (8")							
1	3.0	5.0	0.7		24	CL	MAROON SILTY CLAY AND FINE SAND, TRACE QUARTZ FINE GRAVEL.	3	10	11	10		21	
2	8.0	10.0			8		MAROON MICACEOUS SILTY CLAY WITH SOME FINE SAND. (USCS: CL).	3	4	3	3		7	
				13.5		SM	MAROON FINE TO MEDIUM SAND WITH A LITTLE CLAYEY SILT, TRACE FINE GRAVEL.	28	50/5"				>50	
4	18.0	18.9			12		MAROON FINE TO MEDIUM SAND WITH A LITTLE CLAYEY SILT, TRACE FINE GRAVEL.	14	50/5"				>50	
5	23.0	25.0			16		MARRON FINE SAND WITH SOME CLAYEY SILT, TRACE CONGLOMERATE.	3	11	28	50		39	
6	28.0	29.0			11		MAROON FINE TO MEDIUM SAND WITH SOME CLAYEY SILT, TRACE CONGLOMERATE.	9	50/6"				>50	
7	33.0	34.0			12		MAROON FINE SAND AND CLAYEY SILT, TRACE CONGLOMERATE.	28	50/6"				>50	
8	38.0	38.9			8		MAROON FINE SAND AND CLAYEY SILT, TRACE CONGLOMERATE. (USCS: SM)	8	50/5"				>50	
9	43.0	43.9			10		MAROON MEDIUM TO COARSE SAND WITH SOME CLAYEY SILT, TRACE FINE QUARTZ GRAVEL.	12	50/5"				>50	
10	44.6	45.0	44.0	45.0	4		PARTIALLY WEATHERED SILTSTONE/SANDSTONE.	50/5"					>50	
								AUGER REFUSAL AT 44.6'.						
								ROCK CORING						
RUN 1	45.0	48.0	45.0		20	FRACTURED ROCK	HIGHLY FRACTURED AND WEATHERED REDDISH BROWN SILTSTONE.	TCR: 55%, SCR: 0%, RQD: 0%						
				49.3			HIGHLY FRACTURED AND WEATHERED MAROON SILTSTONE AND MEDIUM TO COARSE GRAINED SANDSTONE INTERBEDS.	TCR: 100%, SCR: 12%, RQD: 9%						
RUN 2	48.0	53.0	49.3		60		MODERATELY TO HIGHLY FRACTURED, MODERATELY WEATHERED MARRON SILTSTONE AND QUARTZ PEBBLE CONGLOMERATE.							
				51.3										
				53.0										

Notes/Comments:  
Pocket Pentrometer Testing  
 S2: 0.5 TSF

WET ON SPOON AT 17'  
 WATER LEVEL THROUGH AUGERS AT 18'  
 CAVED AT 37'.

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: RT 897, DENVER, PA			Page 1 of 1		
HDD No.: S3-0170		Dates(s) Drilled: 02-06-15		Inspector: E. WATT	
Boring No.: SB-02		Drilling Method: SPT - ASTM D1586		Driller: S. HOFFER	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): 13.0		Total Depth (ft): 44.0	
Boring Location Coordinates:			40° 17' 1.883" N		76° 10' 5.380" 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	0.7			TOPSOIL (8")						
1	3.0	5.0	0.7		22	SC	MOTTLED (REDDISH BROWN, GRAY AND ORANGE BROWN) FINE TO MEDIUM SAND, WITH SOME SILTY CLAY, TRACE FINE GRAVEL.	3	7	11	14	18	
2	8.0	10.0			18		REDDISH BROWN FINE TO MEDIUM SAND WITH SOME SILTY CLAY, TRACE FINE GRAVEL.	3	2	4	5	6	
3	13.0	14.9			17		REDDISH BROWN FINE TO MEDIUM SAND AND SILTY CLAY, WITH A LITTLE UNWEATHERED ROCK FRAGMENTS. (USCS: SC)	13	27	44	50/5"	>50	
4	18.0	19.0			12		REDDISH BROWN FINE TO MEDIUM SAND AND SILTY CLAY, WITH A LITTLE UNWEATHERED ROCK FRAGMENTS. (USCS: SC)	11	50/6"			>50	
				21.0									
5	23.0	25.0	21.0		24		CL	REDDISH BRWON SILTY CLAY, TRACE FINE SAND, WITH TRACE UNWEATHERED ROCK FRAGMENTS. (USCS: CL).	15	27	25	35	52
6	28.0	28.8			10	REDDISH BRWON SILTY CLAY, TRACE FINE SAND, WITH TRACE UNWEATHERED ROCK FRAGMENTS.		20	50/4"			>50	
7	33.0	33.6			8	REDDISH BROWN SILTY CLAY AND FINE SAND, WITH A LITTLE UNWEATHERED ROCK FRAGMENTS. (USCS: CL).		30	50/2"			>50	
				35.0									
8	38.0	38.7	35.0		8	WEATHERED SILTSTONE	REDDISH BROWN HIGHLY WEATHERED SILTSTONE.	38	50/3"			>50	
9	43.0	43.7		44.0	7		REDDISH BROWN HIGHLY WEATHERED SILTSTONE.	25	50/3"			>50	
							AUGER REFUSAL AT 44'.						

Notes/Comments:  
Pocket Pentrometer Testing  
 S4 to S7: > 4 TSF

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

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



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

# TEST BORING LOG

Project Name: SUNOCO PENNSYLVANIA PIPELINE PROJECT			Project No.: 103IP3406		
Project Location: RT 897, DENVER, PA			Page 1 of 1		
HDD No.: S3-0170		Dates(s) Drilled: 12-13-14		Inspector: E. WATT	
Boring No.: SB-03		Drilling Method: SPT - ASTM D1586		Driller: S. HOFFER	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): 6.0		Total Depth (ft): 30.0	
Boring Location Coordinates:			40° 17' 1.365" N		76° 9' 58.579" 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 (3")					
1	3.0	5.0	0.3		11	SM	VARYING SHADES OF BROWN (TRACE WHITE) FINE TO COARSE SAND WITH A LITTLE SILT, TRACE FINE QUARTZ GRAVEL.	2	6	15	21	21
2	8.0	10.0			22		REDDISH BROWN FINE TO COARSE SAND WITH A LITTLE SILT, TRACE FINE GRAVEL.	4	12	13	18	25
				11.5		SC	REDDISH BROWN FINE TO MEDIUM SAND WITH SOME SILTY CLAY, WITH A LITTLE FINE TO COARSE GRAVEL.	16	26	25	35	51
3	13.0	15.0	11.5		17		REDDISH BROWN FINE TO MEDIUM SAND WITH SOME SILTY CLAY, WITH A LITTLE FINE TO COARSE GRAVEL.	10	50/3"			>50
4	18.0	18.8			9		REDDISH BROWN FINE TO MEDIUM SAND WITH SOME SILTY CLAY, WITH A LITTLE FINE TO COARSE GRAVEL.	8	50/3"			>50
5	23.0	23.7			5		REDDISH BROWN FINE TO MEDIUM SAND WITH SOME SILTY CLAY, WITH A LITTLE FINE TO COARSE GRAVEL.	11	20	50/3"		>50
6	28.0	29.3		30.0	0		NO RECOVERY					
							AUGERED TO 30'.					
							WET ON SPOON AT 13'.					
							WATER LEVEL THROUGH AUGERS AT 6'.					
							CAVED AT 27'.					

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 S3-0170**

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, %	
S3-0170	SB-01	2	8.0	10.0	16.7	78.1	27	16	11	CL
		4	18.0	18.9	11.3	19.7	-	-	-	-
		6	28.0	29.0	8.6	27.9	-	-	-	-
		8	38.0	38.9	10.7	44.4	18	18	NP	SM
		9	43.0	43.9	10.6	25.1	-	-	-	-
	SB-02	2	8.0	10.0	17.0	28.6	-	-	-	-
		3	13.0	14.9	9.6	41.2	28	20	8	SC
		5	23.0	25.0	17.7	92.5	27	16	11	CL
		6	28.0	28.8	10.9	98.7	-	-	-	-
		7	33.0	33.6	10.0	53.6	28	16	12	CL
	SB-03	1	3.0	5.0	12.5	18.3	-	-	-	-
		2	8.0	10.0	13.6	17.1	-	-	-	-
		3	13.0	15.0	9.8	23.4	-	-	-	-
		4	18.0	18.8	9.3	19.8	-	-	-	-
		5	23.0	23.7	10.5	24.6	-	-	-	-

Notes:

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

**REGIONAL GEOLOGY SUMMARY  
SUNOCO PENNSYLVANIA PIPELINE PROJECT  
HDD S3-0170**

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
S3-0170	Wetland A54	SB-01	<b>Hammer Creek Formation</b> - Gray and pale red, fine- to coarse-grained quartzose sandstone, siltstone, and mudstone	Lowland, wetlands area	Hammer Creek Fm	sandstone with quartz pebble conglomerate	9,360	50-70	
		SB-02						50-75	
		SB-03						50-70	

*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 S3-0170**

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					
S3-0170	SB-01	1	45	48	55	0	0	45	48	Heavily	Siltstone	Massive	Red	Heavily fractured, ranging from 0° to 45°
		2	48	53	100	12	9	48	53	Heavily	Siltstone with interbedded Sandstone	Massive, bedding is gradational	Red	Heavily fractured, ranging from 0° to 65°

# 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	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  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	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	
		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			
		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.