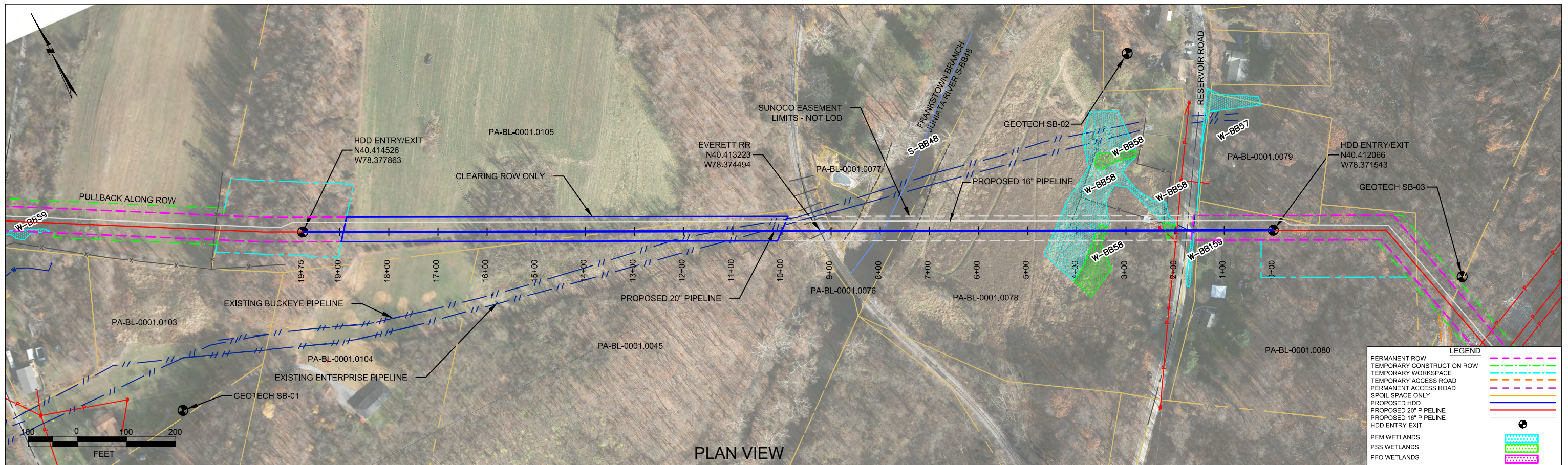


HDD PA-BL-0001.0048-RR (S-BB48) (W-BB58)

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 *medium*. 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 1155 feet from the edge of the western most boundary of the stream S-BB48. The drill will travel beneath stream S-BB48 for 120 feet. 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 calcareous shale. The drill will continue beneath the eastern most boundary of the stream S-BB48 and will travel 280 feet from the eastern most edge of stream S-BB48 to the western most edge of wetland W-BB58. The drill will pass 105 feet under the wetland W-BB58 starting at the western most boundary. The majority of the substrate that will be passed through is estimated to be calcareous shale. The drill will continue beneath wetland W-BB48 and will enter/exit 350 feet from the eastern most edge of wetland W-BB48.

With the water level in the geotechnical bores at 14 feet and the drill going through calcareous shale and limestone the environmental risk for inadvertent returns is medium. As such it is recommended that additional inspection in the area surrounding the drill be in place to monitor for potential inadvertent returns along the drill.



PLAN VIEW

LEGEND

- PERMANENT ROW
- TEMPORARY CONSTRUCTION ROW
- TEMPORARY WORKSPACE
- TEMPORARY ACCESS ROAD
- PERMANENT ACCESS ROAD
- SPOIL SPACE ONLY
- PROPOSED HDD
- PROPOSED 20" PIPELINE
- PROPOSED 16" PIPELINE
- HDD ENTRY-EXIT
- PEM WETLANDS
- PSS WETLANDS
- PFO WETLANDS

BLAIR COUNTY, PENNSYLVANIA - BLAIR TOWNSHIP
S2-0121

PROFILE VIEW

GEOTECH SB-01

- NG EL. 1070'
- TOPSOIL (0' - 0.3')
- CL (0.3' - 21.5')
- GROUNDWATER (11.0')
- CL (21.5' - 30.0')
- COMPLETION DEPTH EL. 1040'

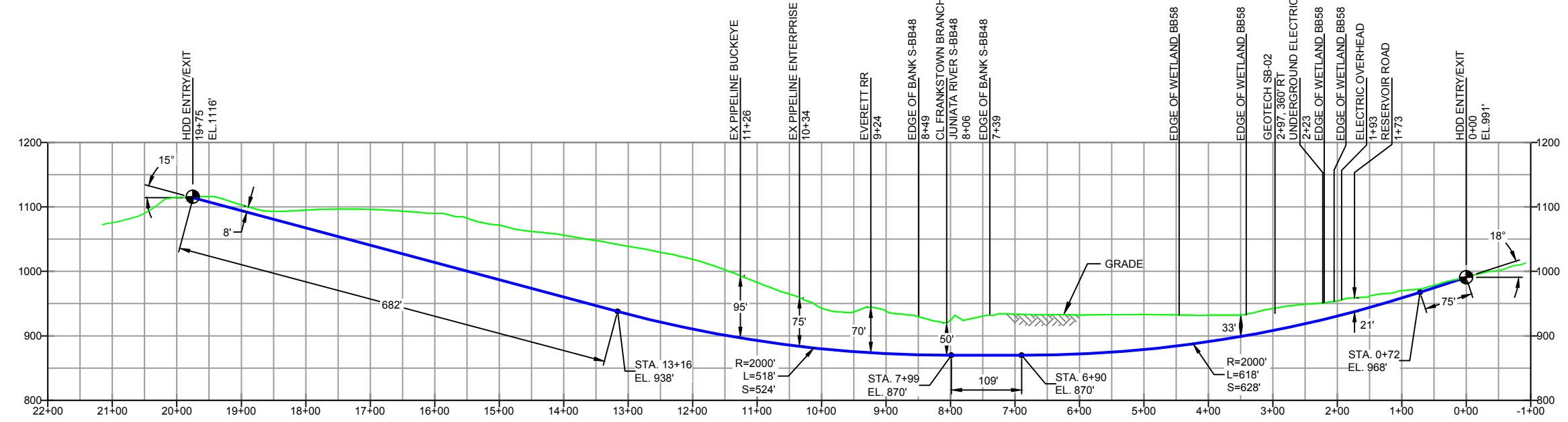
GEOTECH SB-02

- NG EL. 935'
- TOPSOIL (0' - 0.7')
- CL (0.7' - 8.0')
- GC (8.0' - 9.0')
- CL (9.0' - 14.0')
- GROUNDWATER (13.0')
- GM/SM (14.0' - 21.0')
- COMPLETION DEPTH EL. 914'

GEOTECH SB-03

- NG EL. 935'
- ML (0.0' - 8.0')
- SM (8.0' - 9.8')
- COMPLETION DEPTH EL. 925'

NOTE: REFER TO TEST BORING LOG S2-0121 FOR COMPLETE SOIL MATERIAL DESCRIPTION



- 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=): 1975'
HDD PIPE LENGTH (S=): 2018'
20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
 - INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 - CARRIER PIPE NOT ENCASED.
 - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
 - PIPELINE AND CROSSING TO BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH LAST APPROVED AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION SPECIFICATIONS FOR PIPELINES CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES.
 - BLASTING NOT PERMITTED.
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

NOTES

- ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
- 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-3.32	TO	ES-3.34	EROSION & SEDIMENT PLAN	EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16
SHEET 20	TO	SHEET 20	AERIAL SITE PLAN	EP1	REVISED PER PADEP COMMENTS
				EP	
				C	ADDED GEOTECH INFO
				B	ISSUED FOR BID
				A	ISSUED FOR REVIEW

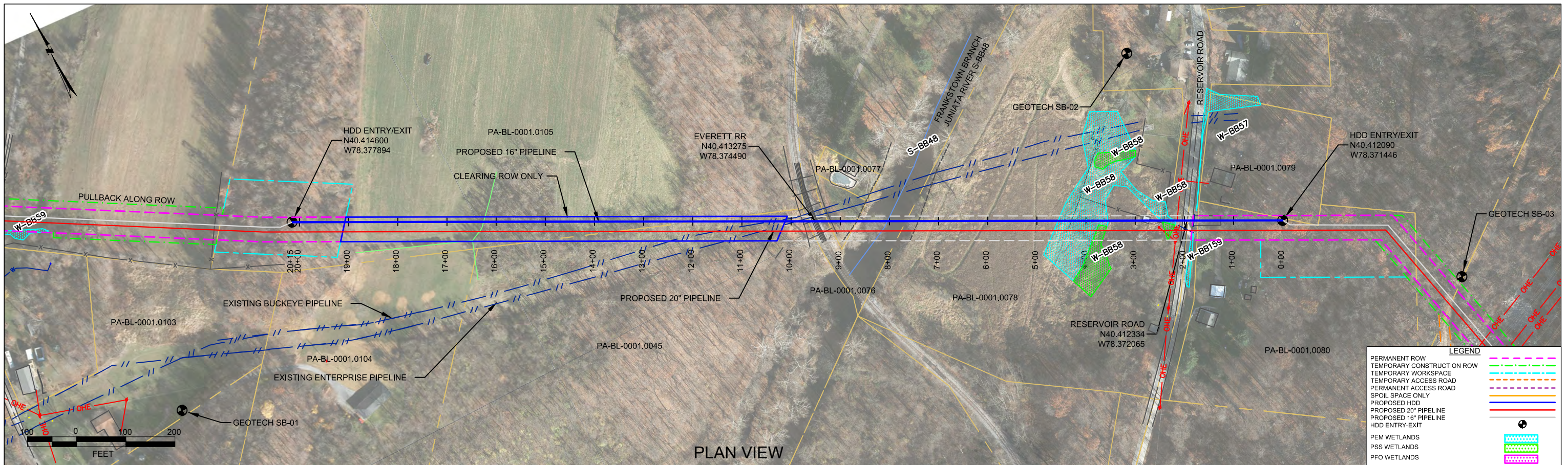
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
EVERETT RR/ RESERVIOR RD
PENNSYLVANIA PIPELINE PROJECT

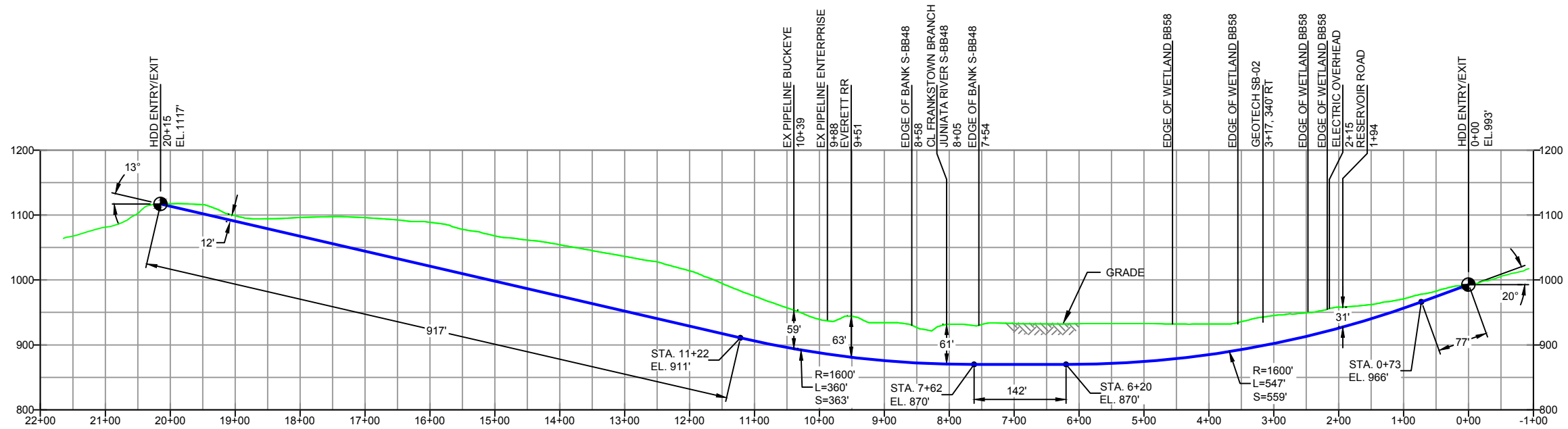
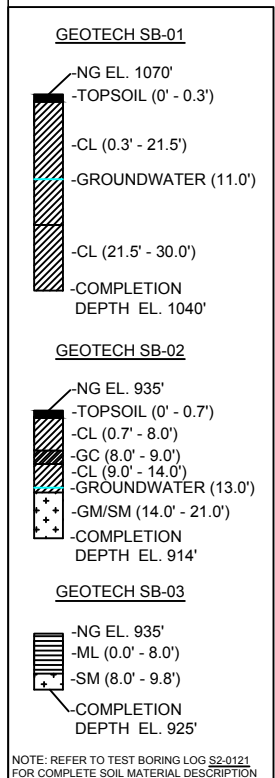
SCALE: 1"=200' DWG. NO. PA-BL-0001.0048-RR



PLAN VIEW

BLAIR COUNTY, PENNSYLVANIA - BLAIR TOWNSHIP
S2-0121-16

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=): 2015'
HDD PIPE LENGTH (S=): 2058'
16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
- INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
- INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
- PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
- CARRIER PIPE NOT ENCASED.
- PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
- CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
- PIPELINE AND CROSSING TO BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH LAST APPROVED AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION SPECIFICATIONS FOR PIPELINES CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES.
- BLASTING NOT PERMITTED.
- SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

NOTES

- ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
- 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

ES-3.32	TO	ES-3.34	EROSION & SEDIMENT PLAN
SHEET 20	TO	SHEET 20	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	DLM	10/07/16	RMB	10/07/16	AAW	10/07/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		MRS	11/13/15	RMB	11/13/15	AAW	11/13/15
B	ADDED GEOTECH INFO	MRS	09/03/15	RMB	09/03/15	AAW	09/03/15
A	ISSUED FOR BID	MRS	08/14/15	RMB	08/14/15	AAW	08/14/15

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
EVERETT RR/ RESERVIOR RD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' DWG. NO: PA-BL-0001.0048-RR-16



LEGEND:

⊙ Geotechnical Soil Boring (SB) Locations



TETRA TECH

GEOTECHNICAL BORING LOCATIONS
 HDD S2-0121
 BLAIR COUNTY, BLAIR 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: t396, HOLLIDAYSBURG, PA		Page 1 of 1
HDD No.: S2-0121	Dates(s) Drilled: 04-22-15	Inspector: E. WATT
Boring No.: SB-01	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor: HAD DRILLING	Groundwater Depth (ft): 11.0	Total Depth (ft): 30.0
Boring Location Coordinates:		40° 24' 50.193" N 78° 22' 45.249" 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		13	CL	MOTTLED (SHADES OF BROWN) SILTY CLAY WITH SOME FINE SAND, TRACE FINE GRAVEL.	2	5	5	5	10	
2	8.0	10.0			19		BROWN SILTY CLAY WITH A LITTLE FINE SAND, TRACE FINE GRAVEL.	2	3	3	6	6	
3	13.0	15.0			24		MOTTLED (RED, LIGHT GRAY, BROWN) SILTY CLAY (USCS: CL)	2	4	8	11	12	
4	18.0	20.0			24		LIGHT BROWN SILTY CLAY, TRACE F-C GRAVEL	1	3	5	9	8	
				21.5									
5	23.0	25.0	21.5		18		CL	LIGHT BROWN, GRAY, REDDISH BROWN, SILTY CLAY WITH SOME FINE SAND, WITH A LITTLE F-C SHALE FRAGMENTS (USCS: CL)	2	6	10	11	16
6	28.0	30.0			18	LIGHT BROWN, GRAY, REDDISH BROWN, SILTY CLAY WITH SOME FINE SAND, WITH A LITTLE F-C SHALE FRAGMENTS.		11	14	17	13	31	
				30.0									

Notes/Comments:
Pocket Pentrometer Testing
 S1: 2.5 TSF 15': > 4 TSF
 8': 1.5 TSF 19': 3.25 TSF
 10': 0.75 TSF 20': 1.75 TSF
 13': 1.0 TSF 24': 2.5 TSF

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

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



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: RESERVOIR ROAD, HOLLIDAYSBURG, PA			Page 1 of 1		
HDD No.: S2-0121		Dates(s) Drilled: 04-22-15		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): 21.0	
Boring Location Coordinates:			40° 24' 47.940" N		78° 22' 18.857" 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		19	CL	MOTTLED (REDDISH BROWN, BROWN, GRAY) SILTY CLAY WITH SOME FINE SAND.	1	5	5	10	10	
			8.0										
			8.0	9.0		GC	CLAYEY GRAVEL LENSE (ANGULAR QUARTZ, FINE TO COARSE)						
2	8.0	10.0	9.0		10	CL	MOTTLED BROWN AND GRAY SILTY CLAY WITH SOME FINE SAND, TRACE TO LITTLE FINE TO COARSE GRAVEL. (USCS: CL)	22	22	10	12	32	
			14.0										
3	13.0	14.7	14.0		17	GM/SM	DARK GRAY DECOMPOSED LIMESTONE, WEATHERED TO A F-C GRAVEL, SOME F-M SAND, SOME SILT.	8	9	40	50/2"	49	
4	18.0	18.5			4		DARK GRAY DECOMPOSED LIMESTONE, WEATHERED TO A F-C GRAVEL, SOME F-M SAND, SOME SILT.	50/6"				>50	
			21.0										
							AUGER REFUSAL AT 21'.						
							WET ON SPOON AT 14'						
							WATER LEVEL THROUGH AUGERS AT 13'						
							CAVED AT 14', WATER LEVEL ON CAVE AT 9'.						

Notes/Comments:
Pocket Pentrometer Testing
 4': 3.5 TSF
 9': > 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: RESERVOIR ROAD, HOLLIDAYSBURG, PA			Page 1 of 1		
HDD No.: S2-0121		Dates(s) Drilled: 09-12-15		Inspector: E. WATT	
Boring No.: SB-03		Drilling Method: SPT - ASTM D1586		Driller: M.HYNES	
Drilling Contractor: HYNES		Groundwater Depth (ft): NOT ENCOUNTERED		Total Depth (ft): 9.8	
Boring Location Coordinates:			40° 24' 40.873" N		78° 22' 13.688" W

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N	
	From	To	From	To									
							NO TOPSOIL						
1	3.0	5.0	0.0		9	ML	FILL: MATRIX OF SILT, FINE TO MEDIUM SAND, FINE TO COARSE GRAVEL. (USCS: ML).	6	3	3	8	6	
2	8.0	9.8		9.8	14	SM	ORANGE BROWN, LIGHT BROWN, AND LIGHT GRAY FINE TO MEDIUM SAND AND SILT, WITH A LITTLE F-C GRAVEL. (POTENTIAL FILL).	8	12	23	50/3"	35	
							AUGER REFUSAL AT 10'.						
							FIVE ATTEMPTS WERE MADE TO DRILL THROUGH FILL ZONE WITH NO SUCCESS (ATTEMPTS WERE MADE ALONG EDGE OF ACCESS ROAD). DEEPEST AT THESE ATTEMPTS WAS 3' BEFORE HITTING REFUSAL. DECISION BY TT/REI WAS TO ABANDON THIS LOCATION.						

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.

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0121

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
S2-0120		SB-02	Keyser/Tonoloway Fm -dark-gray, highly fossiliferous, crystalline to nodular limestone with shaly limestone near its top. Wills Creek Fm -variegated gray, grayish-red, yellowish-gray and greenish-gray calcareous shale with interbedded limestone, dolomite, and sandstone zones	Upland to mid-ridge	Keyser / Tonoloway Fm- Wills Creek Fm	Shale - calcareous shale-siltston- limestone-dolomite (Tonoloway) to Claystone-silty claystone- argillaceous limestone (Wills)	400	3-13	
S2-0121	Reservoir Road	SB-01	Onondaga and Old Port Formation (undivided) consists of two members - the upper Selinsgrove Limestone and the lower calcerous Needmore Shale.	Ridge & Valley	Onondaga-Old Port	Limestone and calcareous shale with occasional chert	100-200	4-32	
		SB-02	Wills Creek Fm -variegated gray, grayish-red, yellowish-gray and greenish-gray calcareous shale with interbedded limestone, dolomite, and sandstone zones		Wills Creek Fm	Calcareous shale	445-620	12-28	
		SB-03	Clinton Group -contains the Keefer and Rose Hill Formations. The <u>Keefer Formation</u> is a light-gray to yellowish-brown, very fine to coarse-grained, fossiliferous, siliceous sandstone that is locally hematitic or conglomeratic. It is well bedded with beds thin to thick and crossbedded. It is about 24 to 55 feet thick. The <u>Rose Hill Formation</u> is a light-olive-gray shale, with some siltstone and two grayish-red to reddish-black sandstone units. The upper shale contains interbedded limestone.		Clinton Group (Keefer and Rose Hill Fms)	sandstone to siltstone (Keefer) to shale with siltston (Rose Hill)	890	12-28	

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.

**GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0121**

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.)		Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318)			USCS Classif. (ASTM D2487)
			From	To			Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	
S2-0120	SB-02	1	3.0	5.0	6.5	17.0	-	-	-	-
		3	13.0	15.0	10.8	11.0	-	-	-	-
		4	18.0	20.0	6.1	20.0	-	-	-	-
		5	23.0	25.0	13.4	33.3	-	-	-	-
		6	28.0	30.0	7.7	19.2	-	-	-	-
S2-0121	SB-01	1	3.0	5.0	20.9	76.5	-	-	-	-
		2	8.0	10.0	18.6	82.9	-	-	-	-
		3	13.0	15.0	20.1	99.4	38	20	19	CL
		4	18.0	20.0	31.7	95.7	-	-	-	-
		5	23.0	25.0	24.6	73.2	41	24	17	CL
	SB-02	1	3.0	5.0	15.7	71.6	-	-	-	-
		2	8.0	10.0	15.3	74.7	39	22	17	CL
		3	13.0	14.7	7.9	25.0	-	-	-	-
		4	18.0	18.5	3.7	18.3	-	-	-	-
	SB-03	1	3.0	5.0	17.2	69.9	31	24	7	ML
2		8.0	9.8	5.1	39.7	-	-	-	-	

Notes:

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

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

Relative Proportions

<u>Description Term</u>	<u>Percent</u>
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)

<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 ⁽¹⁾					
		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 ± 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.