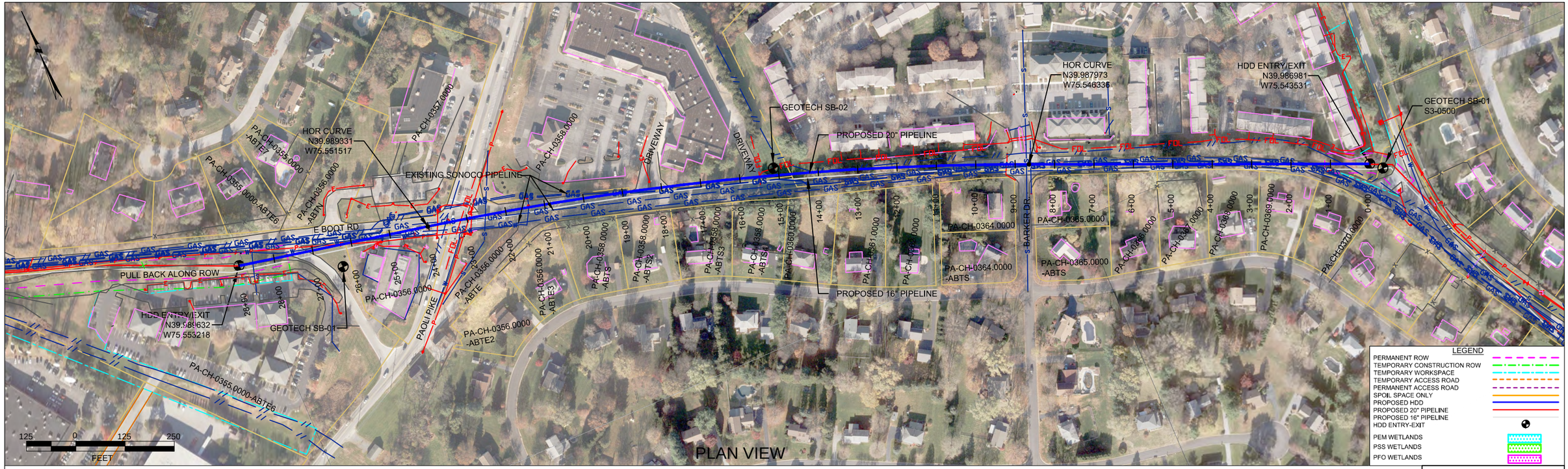
HDD PA-CH-0355.0000-RD (E Boot Road)

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.

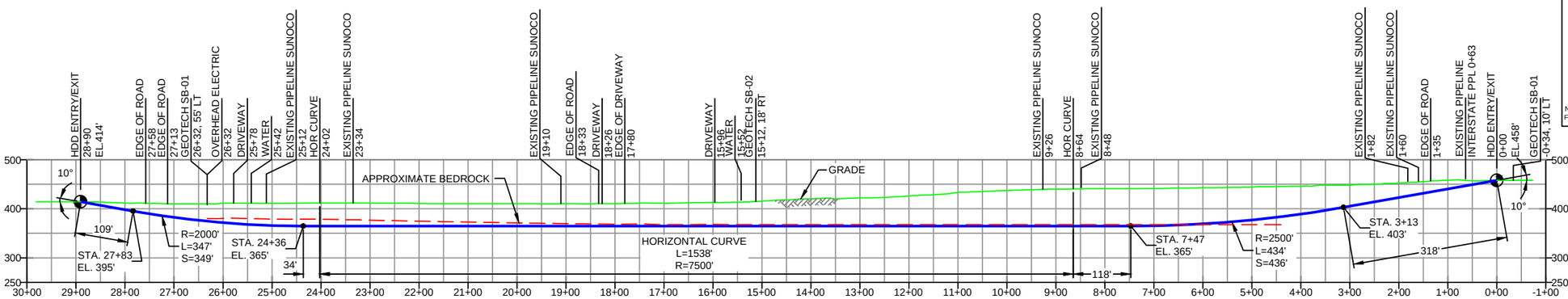
The drill will enter/exit 490 feet northwest of E Boot Road. The drill will continue under E Boot Road for approximately 2250 feet. This point is 150 feet northwest of the southeast entry/exit point. The drill will pass between 20 and 80 feet under this road. Using the results of the geotechnical investigation, 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 schist.



PLAN VIEW

CHESTER COUNTY, PENNSYLVANIA - EAST GOSHEN TOWNSHIP
S3-0490

PROFILE VIEW



GEOTECH SB-01
-NG EL. 408'
-TOPSOIL (0' - 0.2')
-ML (0.2' - 11.5')
-GROUNDWATER (12.0')
-SM (11.5' - 21.5')
-SM (21.5' - 30.0')
-COMPLETION DEPTH EL. 378'

GEOTECH SB-02
-NG EL. 415'
-TOPSOIL (0' - 0.2')
-ML (0.2' - 14.6')
-GROUNDWATER (28.0')
-SM (14.6' - 46.0')
-WEATHERED SCHIST (14.6' - 46.0')
-COMPLETION DEPTH EL. 378'

NOTE: REFER TO TEST BORING LOG S3-0490 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH SB-01
-NG EL. 459'
-TOPSOIL (0' - 0.2')
-GROUNDWATER (8.0'?)
-SM (0.2' - 24.0')
-SM (24.0' - 30.0')
-COMPLETION DEPTH EL. 429'

NOTE: REFER TO TEST BORING LOG S3-0500 FOR COMPLETE SOIL MATERIAL DESCRIPTION

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=):2890'
   HDD PIPE LENGTH (S=):2901'
   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.

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-6.62	TO	ES-6.64	EROSION & SEDIMENT PLAN	
SHEET 41	TO	SHEET 42	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP1	REVISED PER PADEP COMMENTS	JTW	05/10/16	RMB	05/10/16	AAW	05/10/16
EP		MRS	11/13/15	RMB	11/13/15	AAW	11/13/15
D	ADDED GEOTECH INFO	MRS	10/01/15	RMB	10/01/15	AAW	10/01/15
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	RTT	03/26/15	RMB	03/26/15	AAW	03/26/15

Sunoco Logistics Partners L.P.

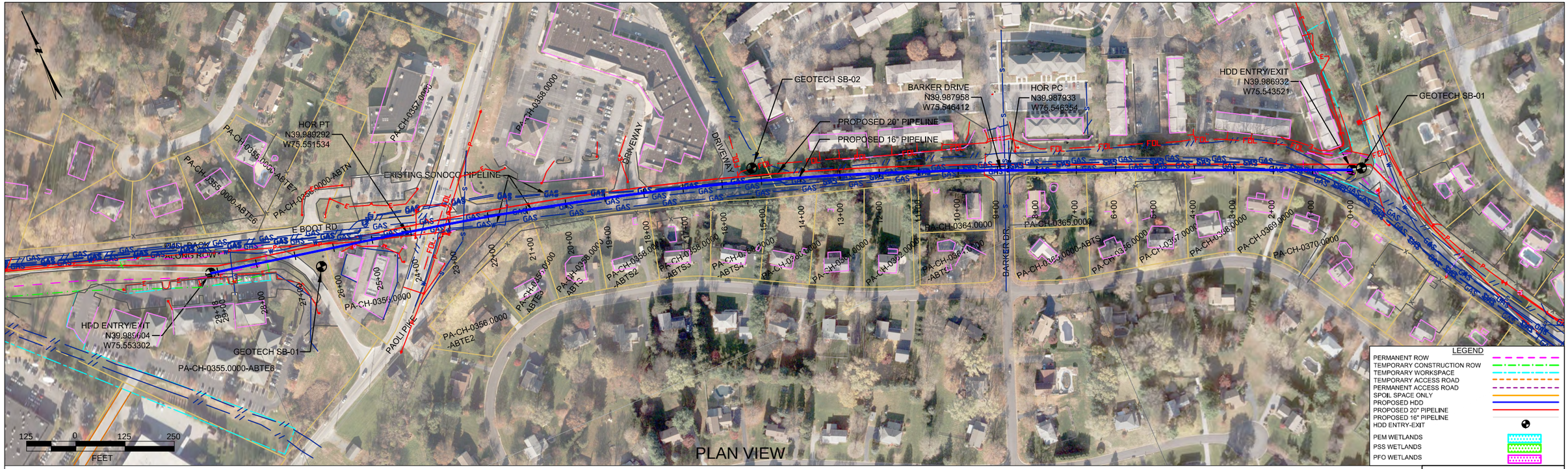
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
E BOOT RD/ PAOLI PIKE
PENNSYLVANIA PIPELINE PROJECT

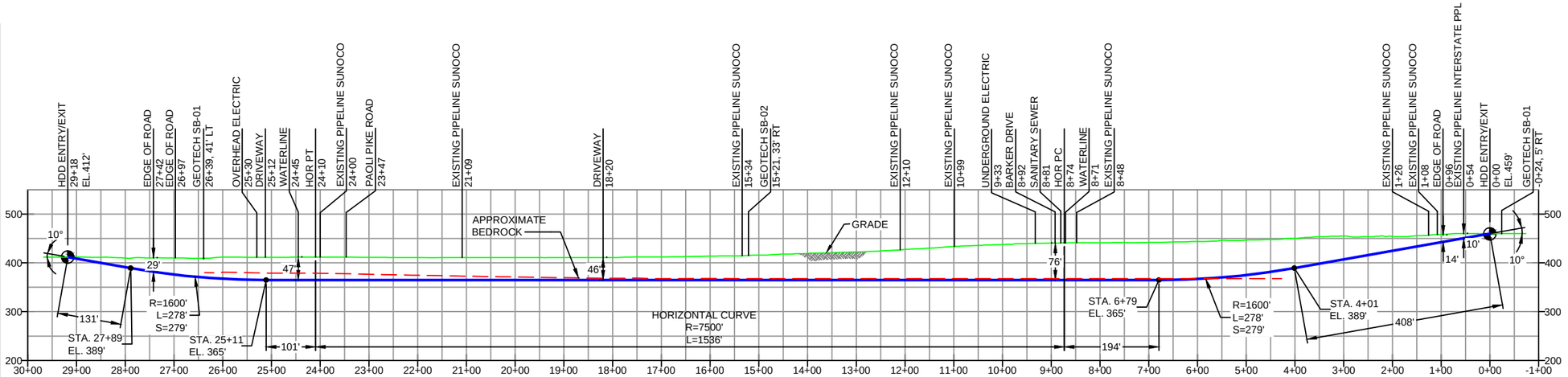
SCALE: 1"=250'

DWG. NO: PA-CH-0355.0000-RD

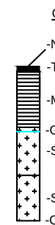


PLAN VIEW

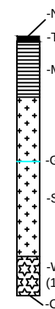
PROFILE VIEW



GEOTECH SB-01

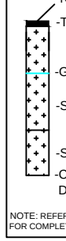


GEOTECH SB-02



NOTE: REFER TO TEST BORING LOG S3-0490 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH SB-01



NOTE: REFER TO TEST BORING LOG S3-0500 FOR COMPLETE SOIL MATERIAL DESCRIPTION

CHESTER COUNTY, PENNSYLVANIA - EAST GOSHEN TOWNSHIP
S3-0490-16

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=):2918'
   HDD PIPE LENGTH (S=):2928'
   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.
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NOTES

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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

DWG NO		DWG NO	DESCRIPTION
ES-6.62	TO	ES-6.64	EROSION & SEDIMENT PLAN
SHEET 41	TO	SHEET 42	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP1	REVISED PER PADEP COMMENTS	JTW	05/10/16	RMB	05/10/16	AAW	05/10/16
EP		MRS	11/13/15	RMB	11/13/15	MRS	11/13/15
B	ADDED GEOTECH INFO	MRS	10/01/15	RMB	10/01/15	AAW	10/01/15
A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15

Sunoco Logistics Partners L.P.

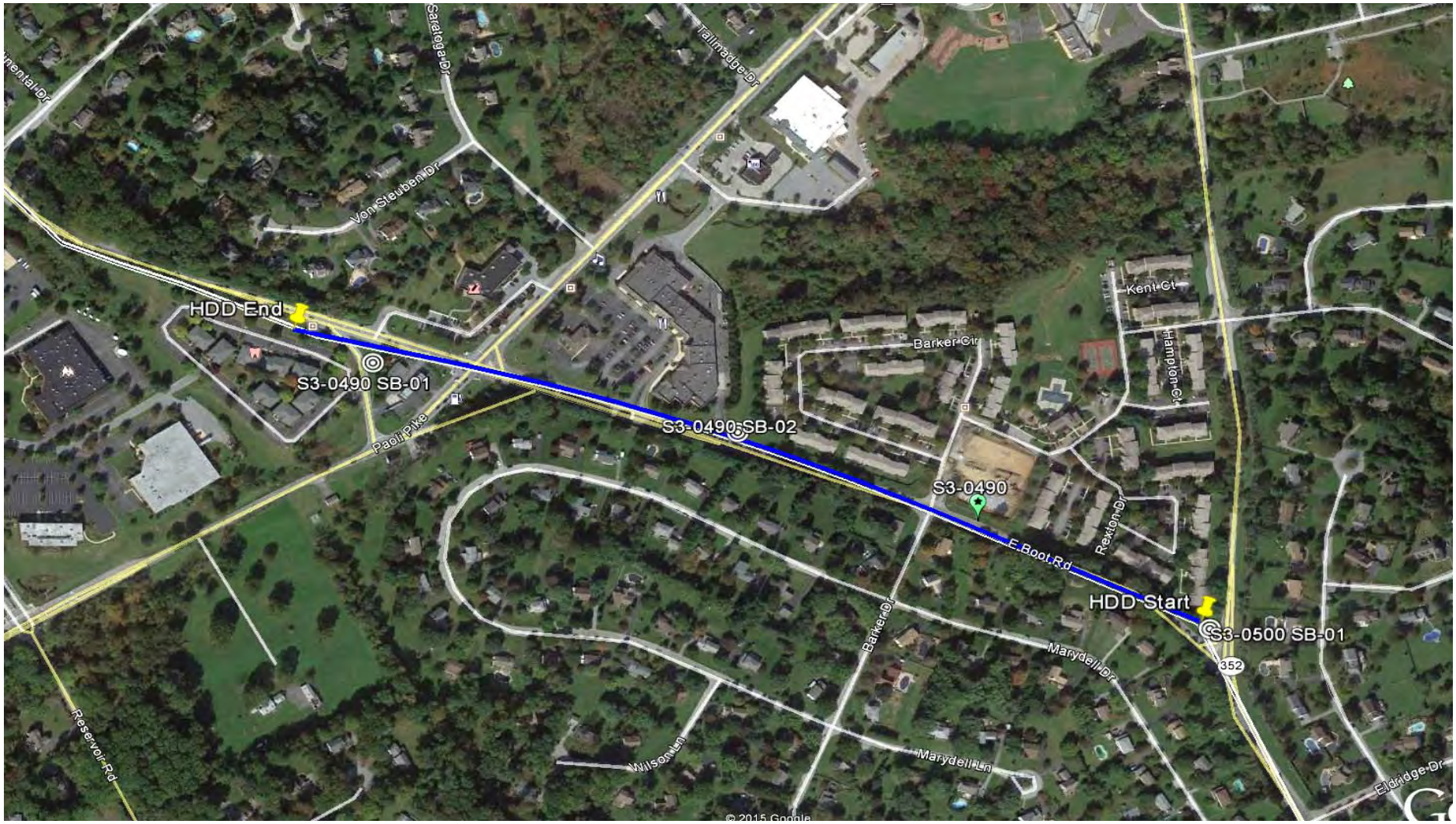
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
E BOOT RD/ PAOLI PIKE
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=250'

DWG. NO: PA-CH-0355-0000-RD-16



LEGEND:

◎ Geotechnical Soil Boring (SB) Locations

TETRA TECH

GEOTECHNICAL BORING LOCATIONS
HDD S3-0490
CHESTER COUNTY, EAST GOSHEN 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:	1494 BOOT ROAD, WEST CHESTER, PA		Page 1 of 1
HDD No.:	S3-0490	Dates(s) Drilled: 06-26-15	Inspector: E. WATT
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 12.0	Total Depth (ft): 30.0
Boring Location Coordinates:		39° 59' 21.569" N	75° 33' 8.447" 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	0.2			TOPSOIL (2")					
1	3.0	5.0	0.2		17	ML	MOTTLED BROWN AND GRAY MICACEOUS SILT WITH SOME FINE	1	1	3	4	**4**
							SAND.					
2	8.0	10.0			24		BROWN SILT/CLAY WITH A TRACE FINE SAND.	2	6	7	12	**13**
				11.5								
3	13.0	15.0	11.5		21	SM	DR, VARIEGATED BROWN FINE TO MEDIUM SAND AND SILT.	3	4	4	6	**8**
							(USCS: SM).					
4	18.0	20.0			22		DR, VARIEGATED BROWN FINE TO MEDIUM SAND AND SILT.	1	2	7	13	**9**
				21.5								
5	23.0	24.5	21.5		14	SM	DR GNEISS, BRWON FINE TO MEDIUM SAND AND SILT, TRACE	6	32	50/5"		**>50**
							FINE ROCK FRAGS.					
6	28.0	29.0			8		DR GNEISS, BROWN AND GRAY FINE TO MEDIUM SAND, SOME	20	50/5"			**>50**
				30.0			SILT, TRACE FINE TO COARSE ROCK FRAGS.					
							AUGERED TO 30'.					
							WET ON SPOON AT 18'.					
							WATER LEVEL THROUGH AUGERS AT 12'.					
							CAVED AT 28', WATER ON CAVE AT 13'.					

Notes/Comments:

Pocket Pentrometer Testing
8': 3.0 TSF
10': 2.0 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:	GOSHEN VILLAGE SHOPPING CENTER, WEST CHESTER, PA		Page 1 of 1
HDD No.:	S3-0490	Dates(s) Drilled: 06-26& 8-1-15	Inspector: E. WATT/COSTELLO
Boring No.:	SB-02	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER/E. OGDEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 28.0	Total Depth (ft): 30.0
Boring Location Coordinates:		39° 59' 19.294" N	75° 32' 54.362" 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	0.2			TOPSOIL (2")					
1	3.0	5.0	0.2		10	ML	BROWN SILT WITH A LITTLE FINE SAND.	1	2	3	10	**5**
2	8.0	10.0			23		BROWN SILT, TRACE TO A LITTLE FINE SAND. THIN LENSE OF	3	5	5	7	**10**
				14.6			PARTIALLY WEATHERED GNIESS 8.9 TO 9'. (USCS: ML).					
3	13.0	15.0	14.6		24	SM	DR, VERIEGATED LIGHT TO ORANGE BROWN AND WHITE MICACEOUS	2	4	6	6	**10**
							FINE TO MEDIUM SAND AND SILT, TRACE F-C ROCK FRAGS.					
4	18.0	20.0			24		DR, VARIEGATED BROWN MICACEOUS FINE SAND AND SILT	2	5	7	10	**12**
							(USCS: SM).					
5	23.0	25.0			24		DR, VARIEGATED BROWN MICACEOUS FINE SAND WITH SOME SILT,	3	6	10	12	**16**
							TRACE FINE ROCK FRAGS.					
6	28.0	30.0			24		DR, VARIEGATED BROWN MICACEOUS FINE SAND WITH SOME SILT,	4	11	15	25	**26**
							TRACE FINE ROCK FRAGS.					
7	33.0	35.0					DR, VARIEGATED WHITE AND BROWN FINE TO MEDIUM SAND WITH	12	12	13	18	**25**
(8/1/15)							SOME SILT, TRACE FINE SCHIST FRAGS. (USCS: SM).					
8	38.0	40.0					DR, VARIEGATED WHITE AND BROWN FINE TO MEDIUM SAND WITH	2	11	12	15	**23**
							SOME SILT, TRACE FINE SCHIST FRAGS.					
9	43.0	45.0					DR, VARIEGATED WHITE AND BROWN FINE TO MEDIUM SAND WITH	2	17	31	50	**48**
				46.0			SOME SILT, TRACE FINE SCHIST FRAGS.					
							AUGER REFUSAL AT 46'.					
							<u>ROCK CORING</u>					
RUN 1	46.0	51.0	46.0		15		DECOMPOSED AND HIGHLY WEATHERED GRAY AND WHITE SCHIST	TCR: 25%, SCR: 0%, RQD: 0%				
RUN 1	51.0	55.0		55.0	28		DECOMPOSED AND HIGHLY WEATHERED GRAY AND WHITE SCHIST	TCR: 58%, SCR: 0%, RQD: 0%				
							CORE TESTING NOT PERFORMED; INSUFFICIENT LENGTHS.					
							WET ON SPOON AT 28'					
							WATER LEVEL THROUGH AUGERS AT 28'.					
							CAVED AT 27', WATER ON CAVE AT 25'.					

Notes/Comments:

<u>Pocket Pentrometer Testing</u>
8': 3.5 TSF
10': 2.0 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:	INTERSECTION OF BOOT ROAD AND N. CHESTER ROD, WEST CHESTER, PA		Page 1 of 1
HDD No.:	S3-0500	Dates(s) Drilled: 08-03-15	Inspector: J. COSTELLO
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586	Driller: E. OGDON
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): SEE BELOW	Total Depth (ft): 30.0
Boring Location Coordinates:		39° 59' 12.903" N	75° 32' 36.309" 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	0.2			TOPSOIL (2")					
1	3.0	5.0	0.2		12		DARK REDDISH BROWN FINE TO MEDIUM SAND WITH SOME SILT,	8	9	7	6	**16**
							TRACE F-C GRAVEL.					
2	8.0	10.0			15		DR, VARIEGATED (BROWN, YELLOW, WHITE, RED) FINE TO MEDIUM	2	4	5	12	**9**
						SM	SAND AND SILT, TRACE FINE SCHIST FRAGS. (USCS: SM).					
3	13.0	15.0			4		DR, VARIEGATED (BROWN, YELLOW, WHITE, RED) FINE TO MEDIUM	7	8	10	9	**18**
							SAND WITH SOME SILT, TRACE FINE SCHIST FRAGS.					
4	18.0	20.0			16		DR, VARIEGATED (BROWN, YELLOW, WHITE, RED) FINE TO MEDIUM	2	8	21	23	**29**
				24.0			SAND WITH A LITTLE SILT, TRACE FINE SCHIST FRAGS.					
5	23.0	25.0	24.0		16		DR, VARIEGATED GRAYS FINE TO COARSE SAND WITH A LITTLE SILT,	10	18	27	50/4"	**45**
						SM	WITH A LITTLE F-C SCHIST FRAGS.					
6	28.0	30.0			10		DR, VARIEGATED GRAYS FINE TO COARSE SAND WITH A LITTLE SILT,	12	27	31	50/5"	**58**
				30.0			WITH A LITTLE F-C SCHIST FRAGS.					
							PERCHED(?) WATER AT 8'.					
							CAVED AND DRY AT 26.4'.					

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 S3-0490

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					
S3-0490	SB-2	1	46	51	25	0	0	46	55	Heavily	Gneiss	Massive	Light brown/ white	Rubble, no sample collected
		2	51	55	58	0	0							

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0490

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)
S3-0490	SB-01	2	8.0	10.0	23.8	90.1	-	-	-	-
		3	13.0	15.0	45.4	47.5	33	24	9	SM
		4	18.0	20.0	31.7	41.4	-	-	-	-
		5	23.0	24.5	15.1	45.2	-	-	-	-
		6	28.0	29.0	7.3	20.4	-	-	-	-
	SB-02	2	8.0	10.0	24.1	78.6	32	25	7	ML
		3	13.0	15.0	22.4	39.5	-	-	-	-
		4	18.0	20.0	24.0	45.9	29	25	4	SM
		5	23.0	25.0	23.2	34.3	-	-	-	-
		6	28.0	30.0	19.4	32.2	-	-	-	-
		7	33.0	35.0	19.6	36.8	31	25	6	SM
		8	38.0	40.0	15.2	25.8	-	-	-	-
		9	43.0	45.0	17.4	31.7	-	-	-	-
S3-0500	SB-01	1	3.0	5.0	10.4	25.3	-	-	-	-
		2	8.0	10.0	39.5	42.3	35	26	9	SM
		4	18.0	20.0	6.7	19.5	-	-	-	-
		5	23.0	25.0	8.6	19.3	-	-	-	-

Notes:

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

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0490

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
S3-0490	SB-01	Felsic gneiss - Light, medium grained; includes rocks of probable sedimentary origin.	Generally level	Felsic gneiss (Precambrian age)	Felsic gneiss; Secondary - paragneiss	Unknown	Ranges from 19 to 110 ft bgs, Avg. 51 ft bgs (.5 mile radius)	
	SB-02		Generally level, slightly sloping to the north					
S3-0500	SB-01		Gently sloping to the North				Bedrock depth information not available within .5 mile radius, likely similar to other formation wells, avg. from approx. 30 to 50 ft bgs	

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).

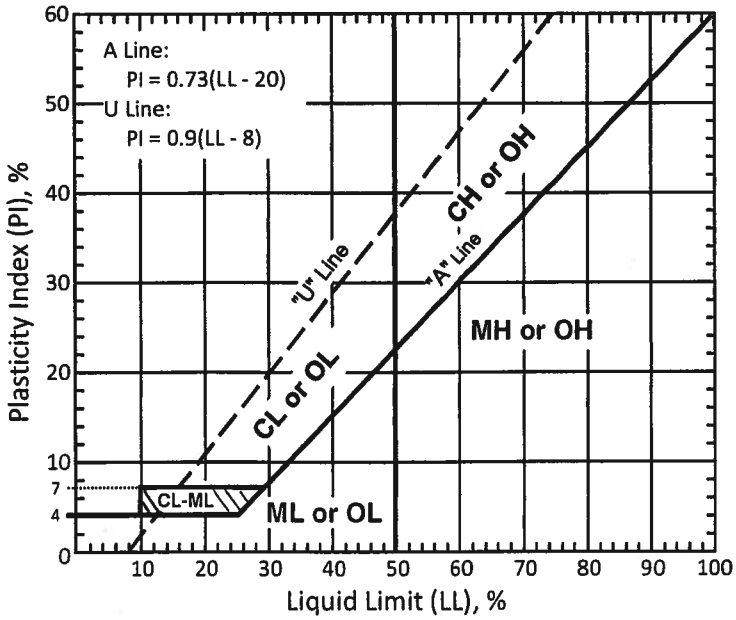
Groundwater observations were made at the times indicated. Groundwater elevations fluctuate throughout a given year, depending on actual field porosity and variations in seasonal and annual precipitation.

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.