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Project No. ASA91-020-00  
July 17, 1991

Mr. Charles Daugherty  
The PB/MK Team  
Redbird Business Center, Building 5  
5610 Redbird Center Drive, Suite 400  
Dallas, Texas 75237

Re.: Geotechnical Report  
Arrowhead Road  
Superconducting Super Collider

Dear Mr. Daugherty:

Submitted here is a report of subsurface conditions along the proposed Arrowhead Road right-of-way in Ellis County, Texas. This report has been prepared for the use of The PB/MK Team for design purposes in accordance with accepted Geotechnical Engineering practices.

#### FIELD EXPLORATION AND LABORATORY TESTS

Borings Subsurface conditions at the site were evaluated by six borings drilled at the locations shown on the Plans of Borings, Plates 1 and 2. The number of borings included in this study and their field locations were selected by The PB/MK Team. Grid coordinates and surface elevations for the boring locations were provided by PB/MK, and are shown on the individual boring logs. The borings were drilled in accordance with ASTM D 420 procedures to depths ranging from 3.0 to 18.2 ft below existing grades using a rotary drilling rig.

A field log was prepared for each boring by a staff geologist. Each log contains information concerning the boring method, drill crew, time of drilling, samples attempted and recovered, indications of the presence of various materials such as silt, clay, gravel, sand or rock, and observations of ground water.

The final logs represent our interpretation of the contents of the field logs for the purpose delineated by our client. The final logs are included in the Illustrations section of this report, Plates 3 through 8. A key to classification terms and symbols used on the logs appears on Plate 9.

Sampling The following samples were collected as a part of our subsurface exploration procedures:

<u>Type of Sample</u>	<u>ASTM Procedure</u>	<u>Number Collected</u>
Auger	D 1452	1
Split-Spoon		45
Undisturbed Shelby Tube	D 1587	9

Representative portions of all auger, spoon and tube samples were sealed to reduce moisture loss, placed in protective containers, and transported to our laboratory for testing.

Laboratory Testing In the laboratory, each sample was inspected and classified by a geotechnical engineer. The geotechnical engineering properties of the strata were evaluated by the following tests:

<u>Type of Test</u>	<u>Procedure</u>	<u>Number Conducted</u>
Natural Moisture Content	ASTM D 2216	8
Atterberg Limits	ASTM D 2217 ASTM D 4318	4
Unit Dry Weight	ASTM D 2166	2
Sieve Analysis (-200)	ASTM D 2217 ASTM D 422	3

The results of all laboratory tests are presented in graphical or numerical form on the appropriate boring log.

#### GENERAL SITE AND SUBSURFACE CONDITIONS

Existing Conditions In general, the proposed roadway relocation traverses open, gently rolling terrain with sparse to dense grass ground cover. Borings AH-1 and AH-5 were located in dry creek beds.

Stratigraphy The soils/rock penetrated in the test borings can be divided into four generalized strata that possess similar physical and engineering characteristics, as described below.

Stratum I consists of brown and dark brown clays and extends to depths ranging from 0.2 to 3.0 ft below existing grades in the test borings. These clays are indicated to be plastic to highly plastic, with measured liquid limits varying from 51 to 76 percent and plasticity indices varying from 28 to 52. Designated as CH soils under the Unified Soil Classification System (USCS), clays of this plasticity are generally recognized to possess high shrink/swell potential. These clays exhibit hard consistencies.

Stratum II consists of tan, argillaceous, weathered limestone of the Austin Chalk Formation and generally extends to the termination depths of the borings (exceptions being Borings AH-1 and AH-5).

Stratum III consists of tan to dark brown clays with limestone fragments and calcareous deposits, and extends to depths of 15 ft below existing grades in Borings AH-1 and AH-5. Not surprisingly, these borings were located in dry creek beds, suggesting that the clays were derived from reworking forces and weathering associated with past flow in the creeks. These clays are indicated to be plastic, with a measured liquid limit of 53 percent and a corresponding plasticity index of 34. These clays exhibit stiff to very stiff consistencies.

Stratum IV consists of light gray, argillaceous, unweathered limestone of the Austin Chalk formation and extends to at least the 15.3 ft termination depth of Boring AH-5.

Ground Water Ground water was not encountered either during or immediately upon completion of the drilling operations. Ground water seepage may exist on a transient basis beneath the roadway site, particularly at shallow depths within or on top of the Stratum II weathered limestone and/or Stratum III clays following periods of heavy precipitation.

\* \* \* \* \*

The following illustrations are attached and complete this report:

Plates 1 and 2	Plans of Borings
Plates 3 through 8	Logs of Borings
Plate 9	Key to Terms and Symbols

We appreciate the opportunity to be of service to you on this project. Please call should you have questions concerning the contents of this report, or other aspects of the project.

Very truly yours,

RABA-KISTNER CONSULTANTS, INC.

*A. Scot Harrell*

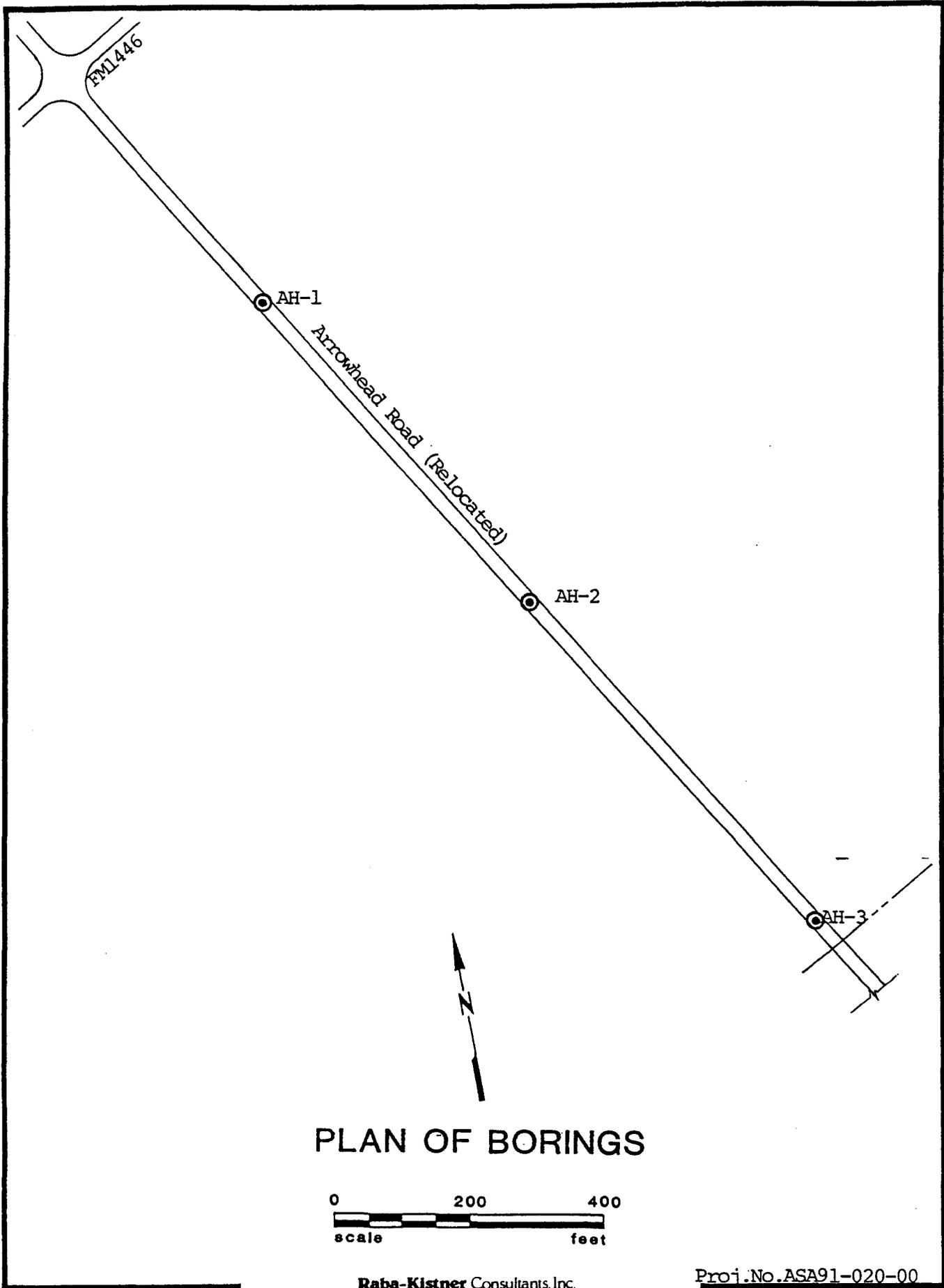
A. Scot Harrell, P.E.  
Project Manager



ASH/cad

Copies submitted: Above (4)

I L L U S T R A T I O N S



### PLAN OF BORINGS





**LOG OF BORING NO. AH-1**  
**E1 SITE - ARROWHEAD ROAD - SSC PROJECT**  
**WAXAHACHIE, TEXAS**



**Raba-Kistner**  
 Consultants, Inc.

**DRILLING METHOD:** Hollow Stem Auger

**LOCATION:** N6817003.95 / E2448732.23

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	⊗ UNCONF. COMPRESSION, tsf							%-200
				10	20	30	40	50	60	70	
				PLASTIC LIMIT			WATER CONTENT		LIQUID LIMIT		
	SURFACE ELEVATION: 731.10'										
0-3.0'	CLAY, Hard, Highly Plastic, Black to Dark Brown, Slightly Moist with traces of roots - interbedded with limestone fragments		97	4.5	4.5	4.5					87
3.0-10.0'	LIMESTONE, Weathered, Argillaceous, Soft, Fine to Medium Grained, Light Gray to White with traces of roots - abundant medium brown, plastic, hard, clay lenses increasing with depth - with traces of calcite crystals slightly fossiliferous from 5' to 6'	A B C D E F G H									
10.0-15.0'	CLAY, Stiff, Plastic, Light Tan, Moist with traces of limestone fragments - limestone lenses at 13' and 13.5'	I J									
15.0-20.0'	LIMESTONE, Weathered, Argillaceous, Soft, Light Gray to White, Moist										
20.0-30.0'	START: 7:30 AM END: 9:45 AM										
30.0-35.0'	GEOLOGIST: DANIEL G. MEDINA										
35.0-40.0'	DRILL CREW: RAY JOHNSON JAMES JONES JOHN SALMON										
40.0-50.0'	BLOW COUNTS PER 6 IN.: A = 15/19/27 B = 26/31/19/3.5" C = 14/19/15 D = 13/14/10 E = 4/7/6 F = 4/3/5 G = 3/6/9 H = 3/3/11 I = 18/12/6 J = 3/3/6										

DEPTH DRILLED: 18.2'	DEPTH TO WATER: Dry	PROJ. No. ASA91-020-00
DATE DRILLED: 7-10-91	DATE MEASURED: 7-10-91	PLATE 3

**LOG OF BORING NO. AH-2**  
**E1 SITE - ARROWHEAD ROAD - SSC PROJECT**  
**WAXAHACHIE, TEXAS**



**Raba-Kistner**  
 Consultants, Inc.

**DRILLING METHOD:** Hollow Stem Auger

**LOCATION:** N6816491.08 / E2449043.43

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	⊗ UNCONF. COMPRESSION, tsf							X-200
				10	20	30	40	50	60	70	
				PLASTIC LIMIT		WATER CONTENT		LIQUID LIMIT			
	SURFACE ELEVATION: 746.00'										
	CLAY, Hard, Plastic, Dark Gray to Dark Brown, Dry with abundant limestone fragments and some roots 0.2'	A	4.5								
5	LIMESTONE, Weathered, Argillaceous, Soft to Medium Hard, Light Gray to White, Dry with light tan stains and abundant hard, tan clay partings - slightly fossiliferous at 2.7' - close partings at 3.5'	B C D E F G H I J									
15	START: 10:10 AM END: 11:20 AM										
20	GEOLOGIST: DANIEL G. MEDINA										
25	DRILL CREW: RAY JOHNSON JAMES JONES JOHN SALMON										
30	BLOW COUNTS PER 6 IN.:										
35	A = 50/3" B = 50/2" C = 35/50 D = 50/3" E = 50/2" F = 50/3" G = 50/2" H = 50/3" I = 50/3" J = 50/3"										
40											
45											
50											

<b>DEPTH DRILLED:</b> 5.3'	<b>DEPTH TO WATER:</b> Dry	<b>PROJ. No.</b> ASA91-020-00
<b>DATE DRILLED:</b> 7-10-91	<b>DATE MEASURED:</b> 7-10-91	<b>PLATE</b> 4

**LOG OF BORING NO. AH-3**  
**E1 SITE - ARROWHEAD ROAD - SSC PROJECT**  
**WAXAHACHIE, TEXAS**



**Raba-Kistner**  
 Consultants, Inc.

**DRILLING**

**METHOD:** Hollow Stem Auger

**LOCATION:** N6815939.68 / E2449378.19

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	⊗ UNCONF. COMPRESSION, tsf							X-200	
				PLASTIC LIMIT		WATER CONTENT		LIQUID LIMIT				
				10	20	30	40	50	60	70		
	SURFACE ELEVATION: 749.90'			4.5	●	+	+	+	+			
5	CLAY, Hard, Plastic, Dark Brown, Dry with traces of roots and vegetation - with large amounts of weathered limestone 1.4'	A										
	LIMESTONE, Weathered, Argillaceous, Fossiliferous, Soft to Moderately Hard, Light Gray to White, Dry with traces of tan staining becomes harder with depth tan at 3' partings at 3.3'	B C D E F G										
15	AUGER REFUSAL AT 5.3' START: 5:30 PM END: 6:40 PM											
20	GEOLOGIST: DANIEL G. MEDINA											
25	DRILL CREW: RAY JOHNSON JAMES JONES JOHN SALMON											
30	BLOW COUNTS PER 6 IN.:											
	A = 13/19/22											
	B = 50/4"											
	C = 50/3"											
	D = 50/3"											
	E = 50/3.5"											
	F = 50/2.5"											
	G = 50/3"											
40												
45												
50												

DEPTH DRILLED: 5.3'	DEPTH TO WATER: Dry	PROJ. No. ASA91-020-00
DATE DRILLED: 7-9-91	DATE MEASURED: 7-9-91	PLATE 5

LOG OF BORING NO. AH-4  
 E1 SITE - ARROWHEAD ROAD - SSC PROJECT  
 WAXAHACHIE, TEXAS



**Raba-Kistner**  
 Consultants, Inc.

**DRILLING METHOD:** Hollow Stem Auger

**LOCATION:** N6812964.01/ E2451739.00

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	⊗ UNCONF. COMPRESSION, tsf							X-200									
				10		20		30		40		50		60		70				
				PLASTIC LIMIT		WATER CONTENT		LIQUID LIMIT												
	SURFACE ELEVATION: 743.40'																			
	CLAY, Hard, Plastic, Dark Brown to Brown, Dry with traces of weathered limestone and roots 1.3'		4.5																	
5	LIMESTONE, Weathered, Argillaceous, Soft to Moderately Hard, Fine Grained, Light Gray with traces of black clay and roots glauconite particles at 2.4' AUGER REFUSAL AT 5'																			
10																				
15	START: 11:50 AM END: 1:40 PM																			
20	GEOLOGIST: DANIEL G. MEDINA																			
25	DRILL CREW: RAY JOHNSON JAMES JONES JOHN SALMON																			
30	BLOW COUNTS PER 6 IN.: A = 50/3" B = 50/3.5" C = 50/3" D = 50/1.5" E = 50/1" F = 50/1" G = 50/2"																			
35																				
40																				
45																				
50																				

DEPTH DRILLED: 5.0'	DEPTH TO WATER: Dry	PROJ. No. ASA91-020-00
DATE DRILLED: 7-9-91	DATE MEASURED: 7-9-91	PLATE 6

LOG OF BORING NO. AH-5  
E1 SITE - ARROWHEAD ROAD - SSC PROJECT  
WAXAHACHIE, TEXAS



**Raba-Kistner**  
Consultants, Inc.

**DRILLING METHOD:** Hollow Stem Auger

**LOCATION:** N6812149.26/ E2452228.04

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	⊗ UNCONF. COMPRESSION, tsf			X-200				
				10	20	30		40	50	60	70
				PLASTIC LIMIT		WATER CONTENT		LIQUID LIMIT			
	SURFACE ELEVATION: 726.40'			+	+	+	+	+	+		
5	CLAY, Hard, Plastic, Black to Dark Brown, Dry with traces of weathered limestone fragments and roots 0.9'	A B C		●							
10	LIMESTONE, Weathered, Argillaceous, Fossiliferous, Soft, Light Gray to Light Tan with traces of roots - interbedded with glauconite particles - becomes clayey with traces of limestone and glauconite particles at 4.5' 5.5'	D E F G H		●	+	+	+	+	+	77	
20	CLAY, Stiff to Very Stiff, Plastic, Medium Tan to Dark Brown, Moist with traces of limestone fragments and calcareous lenses - increasing amount of calcareous material at 9' - hard with calcareous concretions at 12' 15'	I									
30	LIMESTONE, Unweathered, Argillaceous, Soft to Moderately Hard, Light Gray, Dry with light tan stains AUGER REFUSAL AT 15.3' START: 2:10 PM END: 4:20 PM										
35	GEOLOGIST: DANIEL G. MEDINA										
40	DRILL CREW: RAY JOHNSON JAMES JONES JOHN SALMON										
45	BLOW COUNTS PER 6 IN.: A = 19/23/23 B = 18/14/16 C = 10/10/8 D = 4/6/9 E = 5/10/11 F = 7/8/11 G = 10/22/50/4.5" H = 19/20/34/5" I = 50/4"										
50											

DEPTH DRILLED: 15.3'	DEPTH TO WATER: Dry	PROJ. No. ASA91-020-00
DATE DRILLED: 7-9-91	DATE MEASURED: 7-9-91	PLATE 7

LOG OF BORING NO. AH-6  
 E1 SITE - ARROWHEAD ROAD - SSC PROJECT  
 WAXAHACHIE, TEXAS



**Raba-Kistner**  
 Consultants, Inc.

**DRILLING METHOD:** Hollow Stem Auger

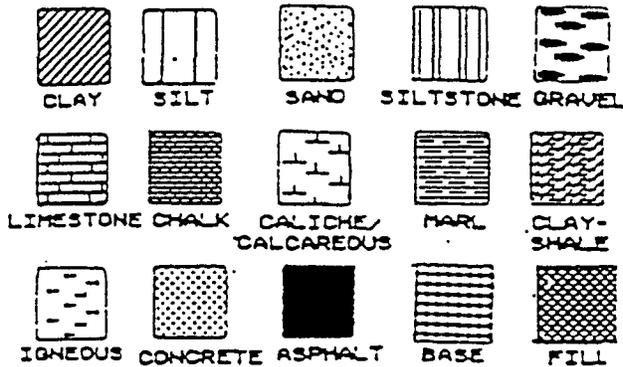
**LOCATION:** N6811561.65 / E2452579.43

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, Pcf	⊗ UNCONF. COMPRESSION, tsf							X-200										
				10		20		30		40		50		60		70					
				PLASTIC LIMIT		WATER CONTENT		LIQUID LIMIT													
	SURFACE ELEVATION: 737.00'			10	20	30	40	50	60	70											
	CLAY, Hard, Highly Plastic, Dark Brown to Brown, Slightly Moist with traces of weathered limestone and roots 1.5'	A	89 4.5				+														96
5	LIMESTONE, Weathered, Argillaceous, Soft, Dark Tan to Light Gray, Dry with traces of calcite crystals black clay parting at 2.5' 2.8'	B																			
10	LIMESTONE, Unweathered, Light Gray to White, Dry with some calcareous clay AUGER REFUSAL AT 3'																				
15																					
20	START: 4:40 PM END: 5:10 PM																				
25	GEOLOGIST: DANIEL G. MEDINA																				
30	DRILL CREW: RAY JOHNSON JAMES JONES JOHN SALMON																				
35																					
40	BLOW COUNTS PER 6 IN.: A = 17/16/34/5" B = 50/1.5"																				
45																					
50																					

DEPTH DRILLED: 3.0'	DEPTH TO WATER: Dry	PROJ. No. ASA91-020-00
DATE DRILLED: 7-9-91	DATE MEASURED: 7-9-91	PLATE 8

# SYMBOLS AND TERMS USED ON BORING LOGS

## SOIL OR ROCK TYPES (shown in symbols column)



## SAMPLER TYPES (shown in sample column)



## STRENGTH TEST RESULTS

- Pocket Penetrometer
- Torvane
- Unconfined Compression

## TRIAxIAL COMPRESSION

- Unconsolidated-undrained
- Consolidated-undrained
- $C$  Cohesion (Total)
- $\phi$  Angle of Internal Friction (Total)
- $c$  Cohesion (Effective)
- $\phi$  Angle of Internal Friction (Effective)

NOTE: Values symbolized on boring logs represent shear strengths unless otherwise noted.

## TERMS DESCRIBING CONSISTENCY, CONDITION OR TEXTURE

Terms used in this report to describe soils with regard to their consistency or conditions are in general accordance with the discussion presented in Article 45 of SOIL MECHANICS IN ENGINEERING PRACTICE, Terzaghi and Peck, John Wiley & Sons, Inc. 1967, using the most reliable information available from the field and laboratory investigations. Terms used for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in Technical Memorandum No. 3-357, Waterways Experiment Station, March 1953.

## TERMS CHARACTERIZING SOIL STRUCTURE

Slickensided	having inclined planes of weakness that are slick and glossy in appearance
Fissured	containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical
Laminated	composed of thin layers of varying colors and texture
Interbedded	composed of alternate layers of different soil types
Calcareous	containing appreciable quantities of calcium carbonate
Well graded	having wide range in grain sizes and substantial amounts of all intermediate particle sizes
Poorly graded	predominantly of one grain size, or having a range of sizes with some intermediate size missing

## TERMS DESCRIBING CONSISTENCY OR CONDITION

RELATIVE DENSITY		COHESIVE STRENGTH			PLASTICITY	
Penetration Resistance, blows per ft:	Relative Density	Penetration Resistance, blows per ft:	Consistency	Cohesion TSF	Plasticity Index	Degree of Plasticity
0-4	Very loose	0-2	Very Soft	0-0.125	0-5	None
4-10	Loose	2-4	Soft	0.125-0.25	5-10	Low
10-30	Medium Dense	4-8	Firm	0.25-0.5	10-20	Moderate
30-50	Dense	8-15	Stiff	0.5-1.0	20-40	Plastic
>50	Very Dense	15-30	Very Stiff	1.0-2.0	>40	Highly Plastic
		>30	Hard	>2.0		

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above because of planes of weakness or cracks in the soil. The consistency ratings of such soils are based on penetrometer readings.