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Geotechnical Investigation in Pajaro, California

by

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INTRODUCTION

Following the October 17, 1989 Loma Prieta earthquake many liquefaction-related ground failures in the Pajaro-Watsonville area were observed. One of the areas that experienced liquefaction, as shown by the eruption of sand boils, is located on Granite Construction Company property in the town of Pajaro. Between July and September, 1993, the USGS conducted a subsurface investigation at the Granite Construction Company to define the soil stratigraphy in an area that experienced liquefaction.

ACKNOWLEDGMENTS

Thanks goes to Granite Construction Company for permission to drill on their property, and especially to Charlotte Conover, of Granite Construction Company, for her assistance. John Tinsley III logged the samples in the field. Coyn Criley provided drilling assistance and tested the samples in the laboratory.

METHODS

Cone penetration test

In the cone penetration test (CPT) an electronic cone is pushed into the soil to measure the resistance at the tip (qc) and along a sleeve (fs) located above the tip. These resistances can be used to define the stratigraphy and are an aid in further testing. We used a 10-ton subtraction cone with a single element strain gauge. The strain gauge is located in a 1.4 in (3.6 cm) diameter instrument that has a 60°, 10-cm^2 tip and a 150 cm^2 sleeve. The ratio (Rf) between qc and fs is an indicator of soil type. Resistances are measured every 10 cm and digitally recorded as the cone is advanced 2-cm per second. The equipment used and the procedures followed in this investigation conform to guidelines suggested by the American Society of Testing and Materials (ASTM), in ASTM D3441-79 (ASTM, 1983).

Standard penetration test

The SPT is a dynamic penetration test that measures penetration resistance and obtains a sample for field inspection and laboratory testing. The SPT procedures follow the guidelines set by D1586-67 (ASTM, 1983). Modifications for use with hollow-stem augers (10 in i.d., 25.4 cm; 4 in i.d., 10.2 cm) are described in Youd and Bennett (1983). A Mobile "ADO standard penetration sampler" (2 in o.d., 5.1 cm; 1.4 in i.d., 3.5 cm) with split liners was used to obtain samples. The sampler is advanced by dropping a 140 lb (63.6 kg) Mobile "In hole hammer" 30 in (76.2 cm). The number of blows to advance the sampler in three 6 in (15.2 cm) intervals is recorded. The first interval is for seating the sampler, the sum of the blow counts for the second and third intervals is referred to as the penetration resistance (N) in blows per foot. The hammer is raised and dropped using a Mobile "Safe-T-Driver" hoist. When the hammer is lifted 30 in (76.2 cm) the hoist is rapidly reversed, throwing off cable and allowing the hammer to fall freely. The overall efficiency of the hammer-hoist system is 68 percent (Douglas and Strutynsky, 1984). Decisions about where to sample are based on the CPT-defined stratigraphy. Samples were examined in the field for stratification and color (Munsell, 1975) and sampled for water content then returned to the laboratory for index tests.

Laboratory Methods

When samples are returned to the laboratory, water content is measured (D2216-80, ASTM, 1983) and subsamples are taken for grain size measurements (D422-63, ASTM, 1983). Samples are classified according to the Unified Soil Classification System (D2488-69, ASTM, 1983) as modified by Howard (1984).

RESULTS

Based on CPT, SPT, and index tests, logs for each of the four soundings are shown in figures 3-6. Results of index tests are listed in Table 1.

BIBLIOGRAPHY

American Society for Testing and Materials, 1983, Annual book of ASTM standards, soil and rock; building stones, section 4,: American Society for Testing and Materials, Philadelphia, Pennsylvania, 734 p.

Douglas, Bruce J. and Strutynsky, Andrew I., 1984, Cone penetrometer test, pore pressure measurement and SPT hammer energy calibration for liquefaction hazard assessment:Earth Technology Corporation, Long Beach, California, USGS contract n. 14-08-001-19105, project n. 83-101

Howard, Amster K., 1984, The revised ASTM standard on the description and identification of soils (visual-manual procedure): Geotechnical Testing Journal, American Society of Testing and Materials, vol. 10, no. 4, pp. 229-234

Munsell Soil Color Chart, 1975, MacBeth division of Kollmorgen Corporation, Baltimore, Maryland

Youd, T. Leslie, and Bennett, Michael J., 1983, Liquefaction sites, Imperial Valley, California; Journal of Geotechnical Engineering, American Society of Civil engineers, vol. 109, no. 3, pp. 440-457

CAPTIONS

Figure 1. This map shows the general location of the test site in Pajaro, California. The map is a combination of the USGS Watsonville West and East 7.5 min quad maps at 1:24,000.

Figure 2. This map shows the positions of the CPT soundings, SPT boring, and sand boil samples. Locations are based on the California Coordinate System, zone 4. For general reference only, the line that connects soundings 125 and 126 is 90 ft (27.4 m) east of the railroad tracks that run outside of the equipment yard. Sounding 126 is 36 ft (11 m) south of the center line of the levee road that runs outside of the equipment yard. Sounding 124 is 24.5 ft (7.5 m) southeast of service yard fence, between 2 large storage bins. Sounding 123 is 36 ft (11 m) north of main service yard building and 54 ft (16.5 m) west of white building. All soundings are behind service yard fence.

Figure 3. Log of sounding 123

Figure 4. Log of sounding 124

Figure 5. Log of sounding 125

Figure 6. Log of sounding 126

Table 1. Pajaro sample collection.

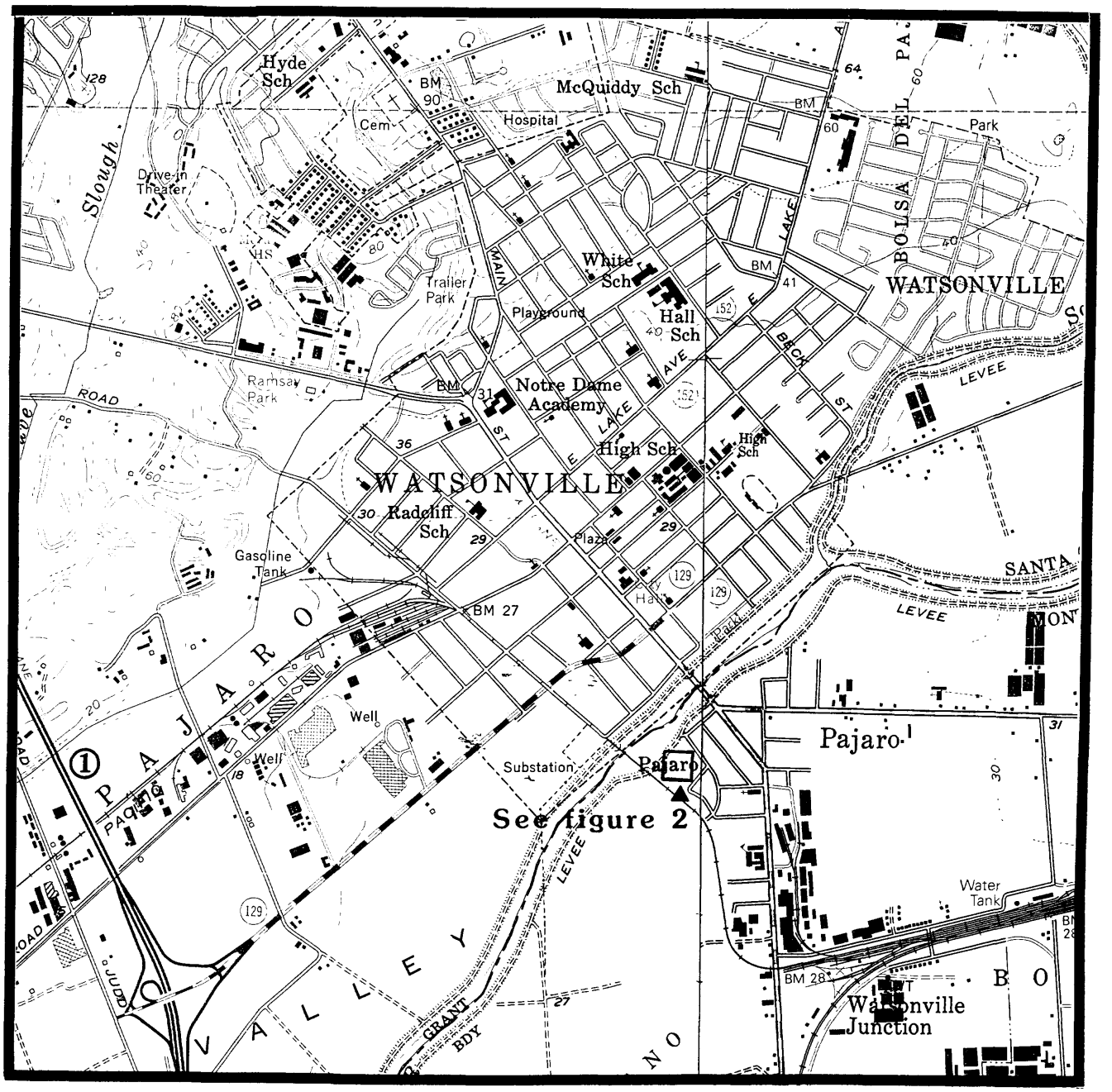

Hyde Sch
McQuiddy Sch
Hospital
Cem
Park
Slough
Drive-in Theater
Trailer Park
White Sch
Hall Sch
Playground
WATSONVILLE
Ramsay Park
Notre Dame Academy
High Sch
Radcliff Sch
Plaza
Gasoline Tank
BM 27
Well
Substation
Pajaro
See figure 2
LEVEE
Water Tank
Watsonville Junction
PAJARO VALLEY
MAIN ST
LAKE AVE
BECK ST
ROAD
GRANT
JUDD
SCALE 1:24 000
1 MILE
7000 FEET
1 KILOMETER
CONTOUR INTERVAL 20 FEET
SUPPLEMENTARY CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
CALIF
QUADRANGLE LOCATION
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
State Route

Figure 1.

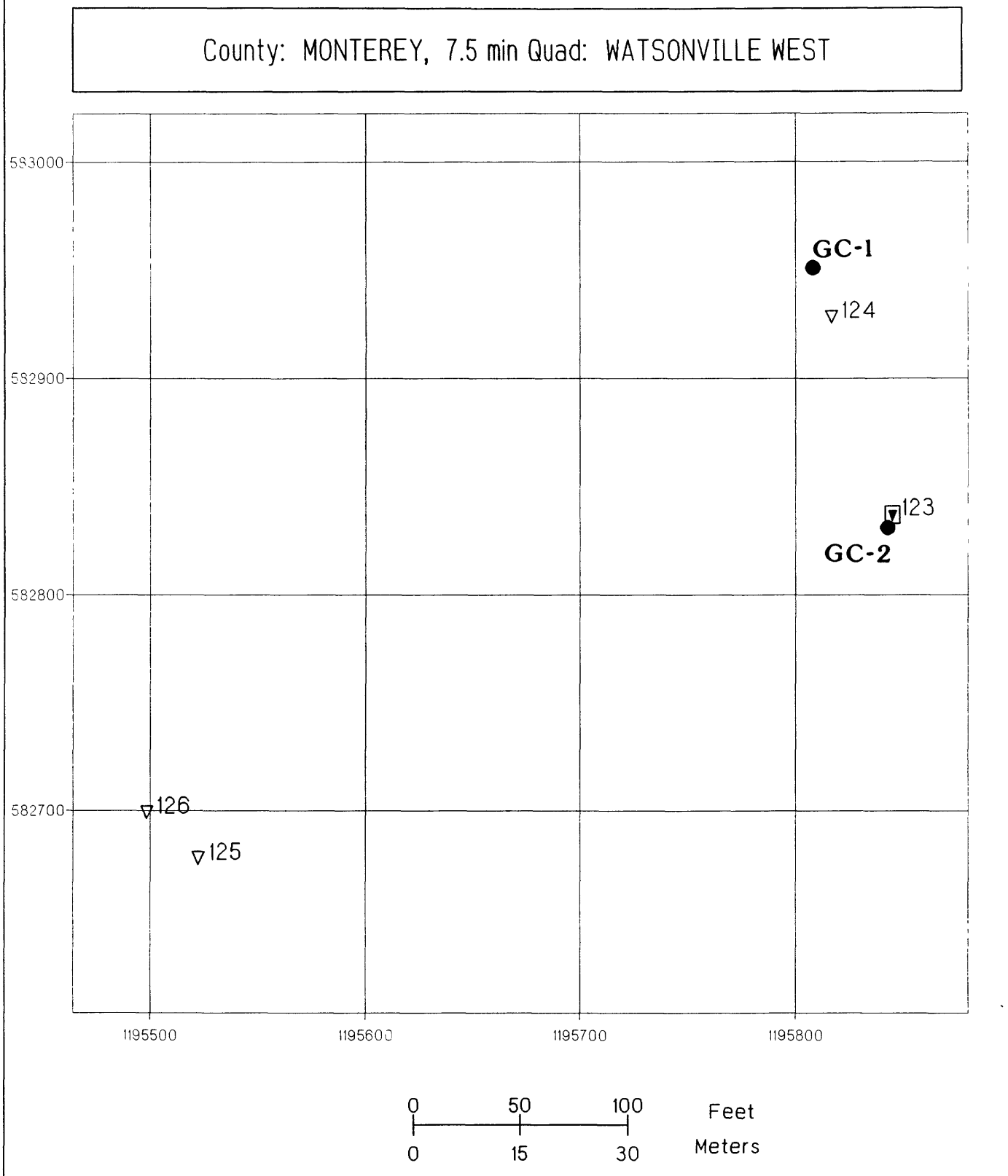

County: MONTEREY, 7.5 min Quad: WATSONVILLE WEST
583000
582900
582800
582700
1195500
1195600
1195700
1195800
GC-1
124
123
GC-2
126
125
0
50
100
Feet
0
15
30
Meters
LOCATION: PAJARO, MONTEREY COUNTY, CALIFORNIA
▽=CPT
▣=CPT and SPT
●=SURFACE SAMPLE

Figure 2.

USGS GEOTECHNICAL LOG

HOLE NUMBER 123

LOCATION GRANITE CONSTRUCTION (GRA)

DATE DRILLED CPT: 7/22/93; SPT: 9/9/93

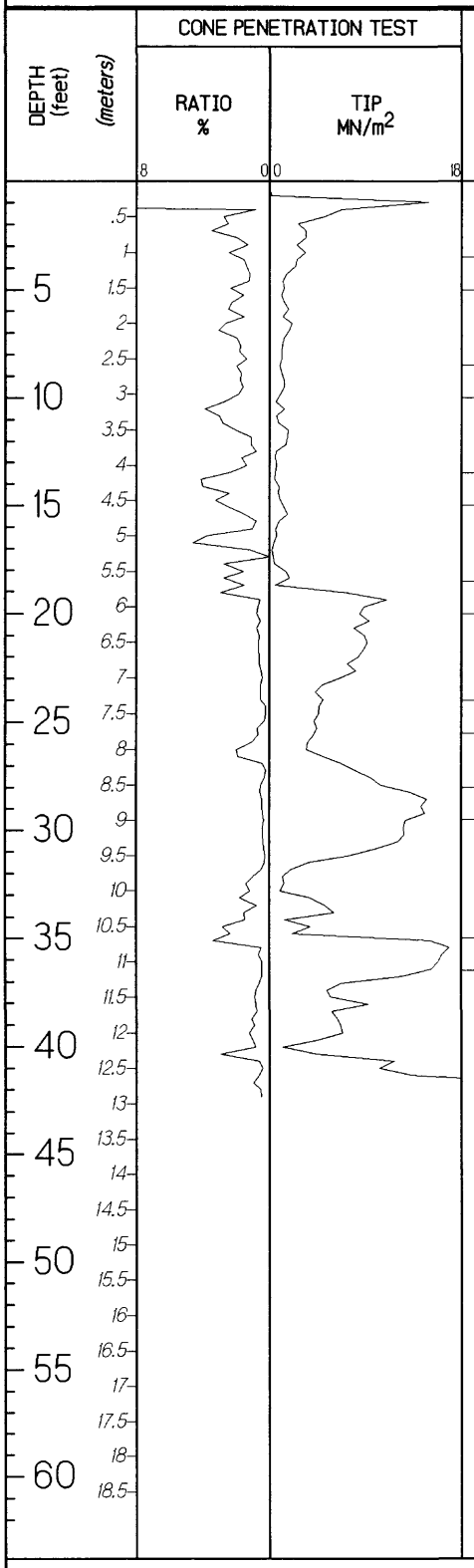
PERSONNEL L: TINSLEY, D: BENNETT/CRILEY

PROJECT NEHRP, MONTEREY BAY LIQUEFACTION STUDIES

COORDINATES X: 1195845, Y: 582837

GROUNDWATER 16.5 ft.; 5.0 m

ELEVATION 26 ft.; 7.9 m MSL



SPT - N	GRAIN SIZE D_{50} (mm)	GRAIN SIZE FINES (%)	CLASS	LIQ-RESIS	GRAPHIC LOG	SOIL DESCRIPTION	MAP CLASSIFICATION
						Fill, gravel, pounded through with hammer for CPT	
						Silty sand, olive brown, 2.5Y4/4, soft, not sticky or plastic, micaeous	
6	0.046	70	ML	D		Silt, olive brown, 2.5Y4/4, micaeous, with occassional clay seams to 6 mm and one sandy seam 3 mm, not sticky or plastic, finely laminated, no fossils or chemical precipitates, disseminated CO_3, ucs=1.5 ksc	
2	0.043	76	ML	D		Silt with sand, 2.5Y4/2, dark grayish brown (moist), slightly sticky and plastic, few tabular root pores, FeO lines root pores, and disseminated CO_3 in matrix, friable,ucs=0.8 ksc; and clay, light olive brown, 2.5Y5/4, with common medium distinct mottles, reddish brown, 5YR4/4 (moist)	
2	0.044	75	ML	D			
14	0.195	11	SP-SM	L		Silt with sand, dark grayish brown, to olive brown, 2.5Y4/3 (moist), slightly sticky and plastic, micaeous, one long root sampled, no chemical precipitates, finely bedded with thin laminae defined by very fine sand seams, ucs=0.8 ksc	
8	0.225 0.150	8 27	SP-SM SM	L		Sand, olive gray, 5Y4/2, well sorted, not sticky or plastic, no chemical precipiates, no fossils or organics, one 2-cm thick clay parting, dark grayish brown, 2.5Y4/2, ucs=2.1 ksc	
12	0.316	6	SP-SM	L		Top 1/2, sand, brown, 5Y4/2, micaeous, thinly bedded, not slightly or plastic, no chemical precipitates, fossils, or organics; and bottom 1/2, dark greenish gray, 5GY4/1, sand, not sticky or plastic, thinly laminated as above	
16	0.261	11	SP-SM	H*		Sand, very dark gray, 5Y3/1, micaeous, massive, well sorted, fines upward from gravelly sand, detrital ^{14}C as roots, trace CO_3 in ^{14}C zone, ucs=1.2 ksc	
						Sand, dark gray, 5Y4/1, micaeous, massive, coarsening upward, friable to slightly dense, not sticky or plastic, no root pores, few disseminated organics/charcoal	
						End of sounding, 42.7 ft, 13 m	

REMARKS: On top of sand boil, next to equipment.
ucs= unconfined compressive strength, kg/cm^2, pocket penetrometer

Figure 3

USGS GEOTECHNICAL LOG

HOLE NUMBER 124

LOCATION GRANITE CONSTRUCTION (GRA)

DATE DRILLED CPT: 7/22/93

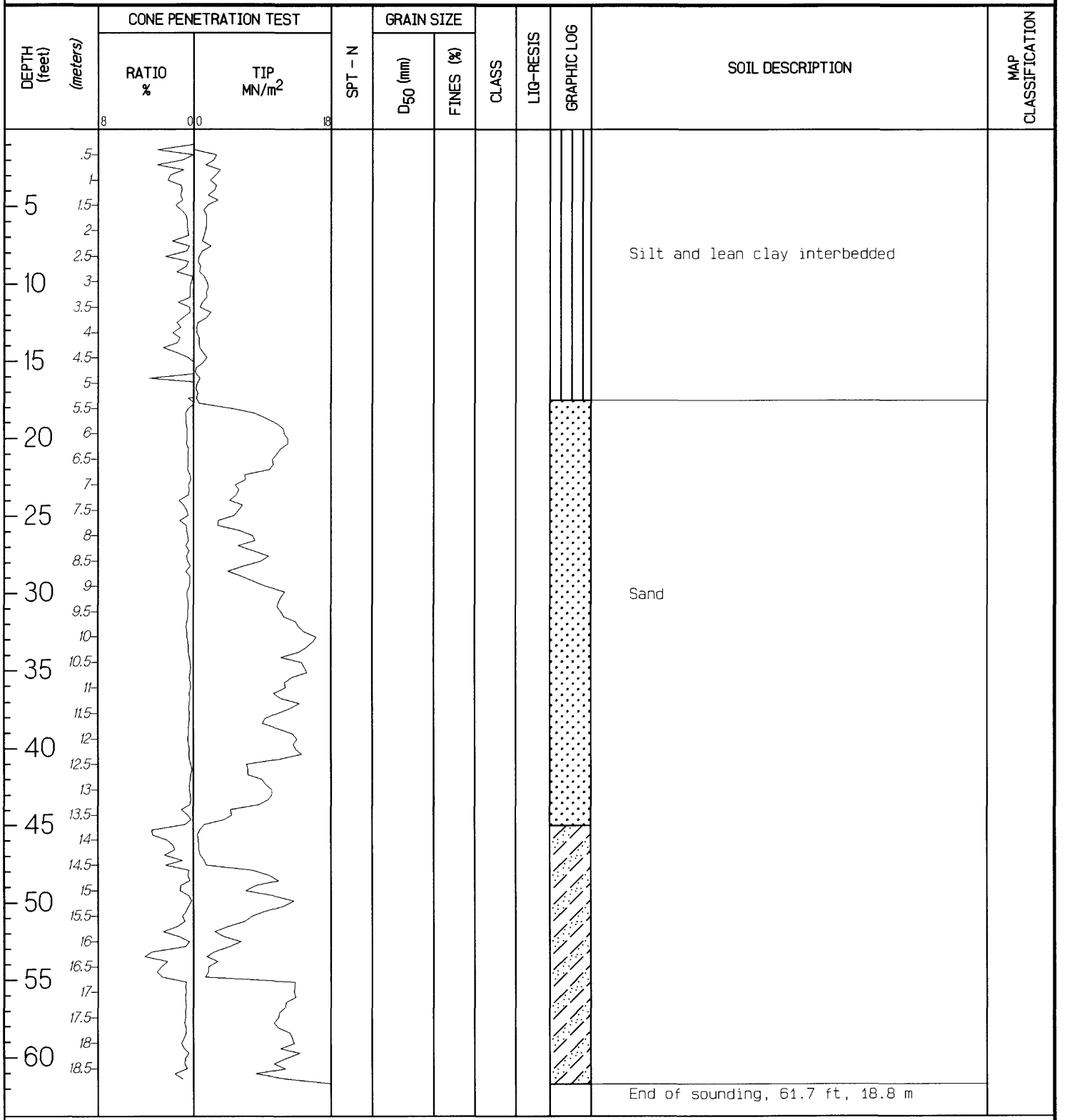
PERSONNEL D: BENNETT/CRILEY

PROJECT NEHRP, MONTEREY BAY LIQUEFACTION STUDIES

COORDINATES X: 1195817, Y: 582928

GROUNDWATER

ELEVATION 26 ft.; 7.9 m MSL



REMARKS: Very close to sandboil, between storage bins

Figure 4

USGS GEOTECHNICAL LOG

HOLE NUMBER 125

LOCATION GRANITE CONSTRUCTION (GRA)

DATE DRILLED CPT: 7/22/93

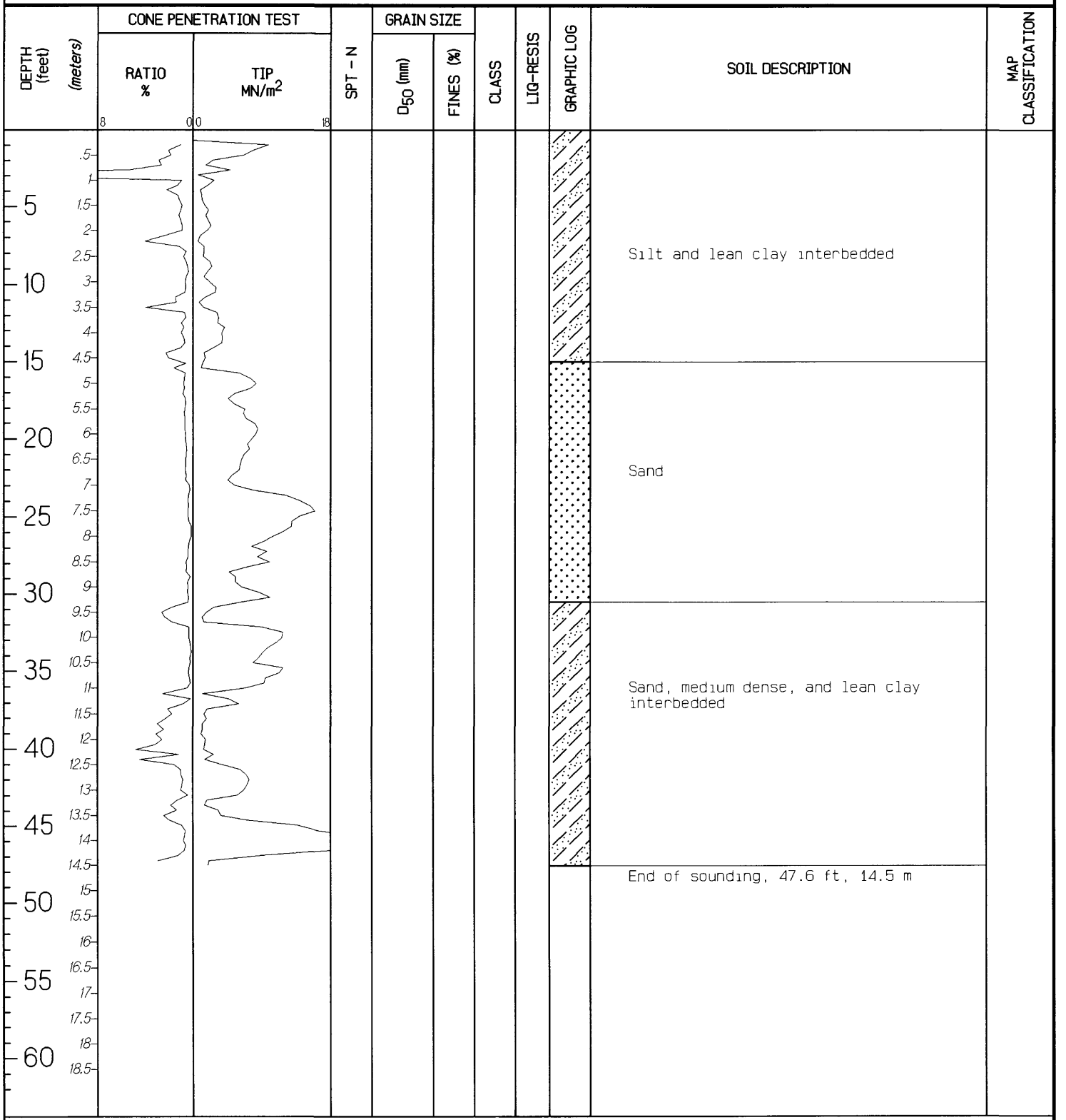
PERSONNEL D: BENNETT/CRILEY

PROJECT NEHRP, MONTEREY BAY LIQUEFACTION STUDIES

COORDINATES X: 1195523, Y: 582678

GROUNDWATER

ELEVATION 26 ft.; 7.9 m MSL



REMARKS:

Figure 5

USGS GEOTECHNICAL LOG

HOLE NUMBER 126

LOCATION GRANITE CONSTRUCTION (GRA)

DATE DRILLED CPT: 7/22/93

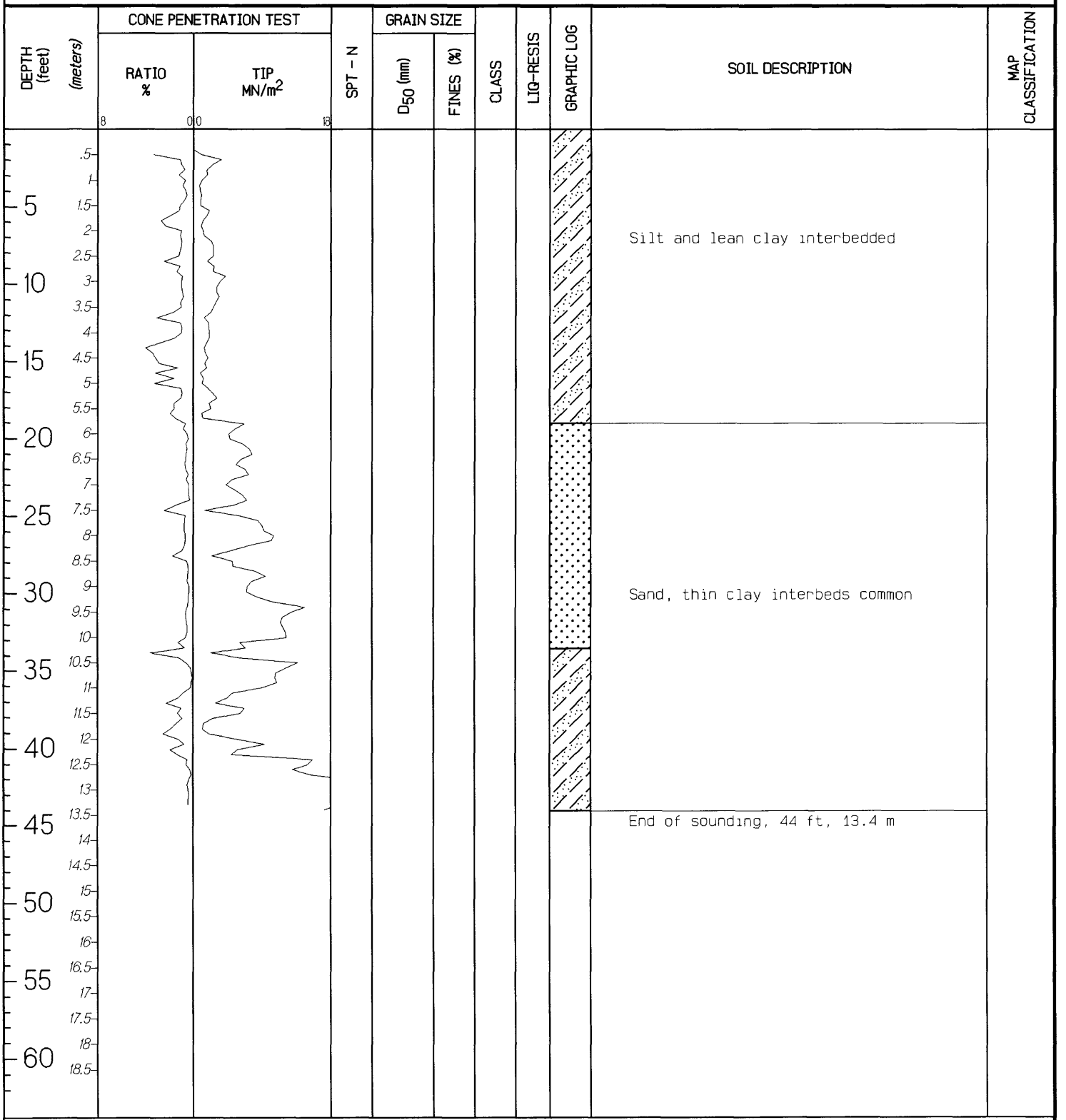
PERSONNEL D: BENNETT/CRILEY

PROJECT NEHRP, MONTEREY BAY LIQUEFACTION STUDIES

COORDINATES X: 1195499, Y: 582699

GROUNDWATER

ELEVATION 26 ft.; 7.9 m MSL



REMARKS:

Figure 6

PAJARO SAMPLE COLLECTION

Table 1.

LOCATION	DEPTH (ft)	SPT N	DEPTH RANGE	G	S	M	C	D50	Cu	UNIFIED SOIL CLASSIFICATION	
GRANITE											
GC-1 (124)	0 sand boil		Surface	0	71	23	6	0.127	14	SM	Silty SAND
GC-2 (123)	0 sand boil		Surface	0	87	10	3	0.205	4.4	SM	Silty SAND
123-2	4.5	6	3.5-5	0	30	60	10	0.046	14	ML	Sandy silt
123-4	9.5	2	8.5-10	0	24	64	12	0.043	14	ML	SILT with sand
123-7	14.5	2	13.5-15	0	25	61	14	0.044	19	ML	SILT with sand
123-8	19.5	14	18.5-20	0	89	11		0.195	3.1	SP-SM	SAND with silt
123-9	24.3		24-25.5	0	92	8		0.225	2.8	SP-SM	SAND with silt
123-10	25	8	24-25.5	0	73	18	9	0.150	30	SM	Silty SAND
123-13	29	12	28-29.5	0	94	6		0.316	2.7	SP-SM	SAND with silt
123-14	36	16	35-36.5	0	89	11		0.261	5.4	SP-SM	SAND with silt

Sand boil samples collected by John Tinsley III

G=GRAVEL (>4.75 mm)
S=SAND (4.75-0.075 mm)
M=SILT (0.075-0.005 mm)
C=CLAY (<0.005 mm)
Cu=D60/D10
D50=MEDIAN GRAIN SIZE