AN EVALUATION OF THE UTILITY OF FOUR IN-SITU TEST METHODS FOR TRANSMISSION LINE FOUNDATION DESIGN

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(ABSTRACT)

A major powerline is typically supported by many widely spaced structures. Each structure is, in turn, supported by a foundation or foundations. The prevailing philosophy behind transmission structure design to date has been based on the notion that information for geotechnical conditions is sparse and relatively simple in nature. Within this context, it is useful to note that one mile of construction for a routine lattice tower line, can involve twenty five to thirty separate foundations. More accurate soils data can allow for more efficient (smaller) foundation designs with consequent reductions in construction and material costs for the construction.

This research examines four existing in-situ soil strength testing methods; standard penetration test (SPT), the cone penetrometer (CPT), the flat plate dilatometer (DMT), and the pressuremeter (PMT). Soils data were collected at eight separate sites using each of the devices. The test sites were chosen to mirror soil conditions encountered within the service territory of Virginia Power, the project sponsor. A total of 19 standard soil borings, 30 cone penetrometer soundings, 26 dilatometer soundings, and 33 pressuremeter tests were undertaken in residual, alluvial and marine clay soil conditions.

The testing program was conducted with five areas of concern: (1) comparison of the penetration/ stiffness data from the four tests, (2) comparison of values of undrained shear strength and angle of internal friction developed from each of the test methods, (3) determination if pressuremeter data can be correlated to and thereby developed from one of the more rapid tests, (4) comparison of indirect soil type identifications from the cone and dilatometer with laboratory identifications from the standard borings, (5) development of information on the relative effort required for each test.

Comparison of the penetration resistance stiffness data produced useful correlations among the CPT and DMT, with the SPT data yielding more erratic results. Shear strength data was most consistent for the marine clay sites, while the CPT and DMT returned useful friction angle data in the alluvial sands. PMT data correlated well to both the CPT and DMT test results. Correlation of PMT results to the SPT was more erratic. Indirect soil identification from the CPT and DMT was fully adequate for transmission line foundation design purposes, and finally, useful comparative data on the relative testing time required for the four in-situ tests was developed.

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Dr. Tom Brandon provided valuable and timely assistance in writing the data acquisition programs for the various test instruments, and allowed me free run of his lab for almost six months. John Pappas was a major help with both teaching me to operate the pressuremeter and with pure old brute strength when it was most needed. Thanks to both of them.

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CHAPTER I

Introduction

A major powerline is typically supported by many widely spaced structures. Each structure is, in turn, supported by a foundation, the type of which varies depending upon the nature of the ground conditions and loads imposed on it. The prevailing philosophy behind transmission structure design to date has been based on the notion that information for geotechnical conditions is sparse and relatively simple in nature. Within this context, it is useful to note that one mile of construction for a routine lattice tower line, can involve twenty five to thirty separate foundations. Thus, improvements in either the efficiency or accuracy of soils information collection can have large consequences in powerline construction economics. More accurate soils data can allow for more efficient (smaller) foundation designs with consequent reductions in construction and material costs for the construction.

Design methods for powerline foundations were generally developed in conjunction with the field of soil mechanics. Methods progressed from "rule of thumb" formulas used for wood poles to rational design approaches for more sophisticated lattice tower and single shaft structure foundations. Through all of these developments, the standard penetration test (SPT) remained the principal basis for determining soils information for design. Under the sponsorship of the Electric Power Research Institute (EPRI), design programs were developed in the 1970's and 1980's that make use of pressuremeter data. However, the pressuremeter has not yet come into widespread use and the required pressuremeter information is commonly estimated from standard penetration test data.

The objective of this research was to examine four existing in-situ soil strength testing methods in an attempt to improve both the efficiency and accuracy of soils information gathering for powerline foundation design. The four tests considered were the standard penetration test, the cone penetrometer, the flat plate dilatometer, and the pressuremeter. Soils data were collected at eight separate sites using each of the devices. The test sites were chosen to mirror soil conditions encountered within the service territory of Virginia Power, the project sponsor. A total of 19 standard soil borings, 30 cone penetrometer soundings, 26 dilatometer soundings, and 33 pressuremeter tests were undertaken. Test depths ranged from thirty to forty-five feet.

The testing program had five main objectives:

1. Comparison the penetration resistance/ stiffness data from the four tests.
2. Comparison of values of undrained shear strength and angle of internal friction developed from each of the test methods.
3. Determine whether pressuremeter modulus could be correlated to and thereby developed from one of the more rapid tests.
4. Comparison of indirect soil type identifications from the cone and dilatometer with laboratory identifications from the standard borings.
5. Development of information on the relative effort required for each test.

To insure valid comparisons, the testing was performed in a grid pattern with only sufficient distance separating the different probes to avoid overlapping zones of influence. This approach attempted to minimize the variation in soil properties from test to test. Also, all of the testing was completed with the same operator and drill rig to minimize another possible source of variation. Procedures and support equipment were developed to streamline testing operations in an effort to obtain accurate comparisons of the total effort required for each test.

As a result of the testing, it was hoped to find more efficient methods for developing soils data for foundation design. Particularly, the desire was to develop sufficient confidence in the newer soil testing methods to integrate them into the foundation design process as it applies to transmission lines.

Chapter II reviews both the history of transmission line foundation design methods and the four tests employed. Chapter III describes the different types of equipment used and the calibration methods employed to ensure consistency of results. Site locations and characteristics are described in Chapter IV. The results of both the field and laboratory testing programs are presented in Chapter V. In Chapter VI the correlations among the tests, to soils data, soils identifications, and testing effort comparisons are described and summarized. Finally, in Chapter VII the conclusions are presented. Appendices follow containing raw test data for each site.

Chapter II

BACKGROUND

2.1 Introduction

Powerline structure foundations have generally been designed using information from widely spaced soil borings. To improve geotechnical information for transmission line foundation design four different in-situ soil strength tests were compared in this investigation, including the standard penetration test, cone penetrometer, dilatometer, and pressuremeter. Background on transmission line structure foundation loadings and the in-situ tests are discussed in this chapter.

2.2 Transmission Line Foundation, Background

This section provides background on the loading conditions and design approaches for transmission line foundations. The discussion is organized as:

2.2.1 Loading conditions
2.2.2 Design practices
2.2.3 Soils investigation practices

2.2.1 Loading Conditions

Transmission line structures fall into four basic types, lattice towers, single shaft structures, frames, and guyed structures. Lattice structures are statically determinate pinned structures that impose vertical compression or tension and horizontal shear loads on their foundations. Single pole structure foundations resist large overturning moments, vertical compression and horizontal loads. Frame structure foundations again carry horizontal and vertical loads and moments. Guyed towers are supported by axially tensioned guy wires with the guy foundations resisting tension and possibly horizontal load. The center shaft of a guyed structure applies vertical and horizontal loads to the foundation but is generally pinned to eliminate moments (Rodgers, et al; 1989).

Transmission line loadings are governed by the National Electric Safety Code (NESC) (NESC, 1989) with load cases modified to suit local conditions in a utility's service area. In the mountains of Virginia, NESC heavy ice loading commonly controls line designs, while on the coast of North Carolina hurricane wind is usually the controlling load.

In the design process applicable safety factors are applied to the structure loadings and the foundation is designed with a factor of safety of one. Lines are not designed to withstand all possible loadings. It is assumed that a high energy event such as a tornado will destroy the structures contacted, since it is more economical to bear the cost of structure and foundation repair or replacement than to design for localized extreme loadings.

The design case may represent either a short or long term load. Steady state loadings from dead weight, differential conductor tension, or the resultant of a line angle are long term loads. Transient loading from ice shedding or wind are short term conditions. Loading can also come from construction or maintenance activities, and judgement is needed to determine the proper design case for each type loading (Rodgers, et al; 1989). The soil parameters for short term loadings in cohesive soils are obtained from undrained tests, while those for cohesionless soils are from drained tests. Drained soil conditions apply in all cases to the long term loadings.

As an illustration of loading variation, Table 2.1 compares daily load to design loads for a series of double circuit 230 kilovolt (KV) lattice towers. Daily

TABLE 2.1

Foundation Loading

Daily Load vs Design Load: Percent

LINE ANGLE	UPLIFT LOAD	COMPRESSION LOAD	HORIZONTAL LOAD
0 deg.	11.2%	9.5%	9.5%
1.5 deg.	7.7%	10.8%	10.8%
10.5 deg.	4.4%	19.2%	19.2%
52.5 deg.	20.0%	30.1%	28.7%
90.0 deg.	28.1%	55.6%	35.3%

load was taken as a five mile per hour wind while NESC hurricane loading was the controlling or design load in this case. The heavy angle towers carry a much larger percentage of the design case as a long term load.

2.2.2 Design Practices

Transmission line foundation design has gradually evolved with improvements in the state-of-the-art of the field of soil mechanics. In the late 1950's Virginia Power based the design of powerline foundations on rules of thumb and early analytical models. Embedment depth for pole structures was set at ten percent of the pole height plus an additional two feet. Lattice towers were supported on grillage foundations with the uplift capacity determined by dead weight of soil.

The development of large capacity drilling machines circa 1964 made possible the use of drilled pier foundations for transmission line structures. With the change in foundation types, new analysis procedures were adopted.

2.2.2.1 Design for Overturning Moments

Single shaft steel poles became commercially available in the early 1960's. Their large overturning moments and drilled pier foundations outmoded the old "10% + 2" approach to embedment depth. In the summer of 1968 Mr. T.E. Rodgers of Virginia Power and Dr. R.D. Krebs of Virginia Tech extended the work of Broms (1964) and Brinch Hansen (1961) to pole foundations. The original papers dealt with small lateral loads on piles with large axial loads, but this was later modified for large lateral and moment loadings. Although no papers were published from the work, by 1971 Va. Power had developed a proprietary foundation design program that accounted for a stratified soil profile for moment resisting foundations. In parallel work, DiGiogia published an analysis model for the lateral foundation resistance in layered soil systems (DiGiogia, 1971).

Continued interest in the laterally loaded drilled piers led to a major research effort funded by The Electric Power Research Institute (EPRI) which involved a series of fourteen full size drilled pier foundation tests which were loaded to failure. The results were used to develop the Pier Analysis and Design for Lateral Loads (PADLL) computer program (Davidson, 1982).

PADLL has now been incorporated as the Moment Foundation Analysis and Design (MFAD) program into EPRI's TLWorkstation^{Tm} (Bragg, DiGiogia and Rojas-Gonzales, 1989). The workstation is a comprehensive computer software package for the design of transmission lines (Trautmann, Kulhawy, and Longo, 1989).

2.2.2.2 Design for Axial Loads

A Virginia Power internal economic study led to the replacement of grillage foundations with drilled pier foundations for lattice towers in the early 1960's. The contribution skin friction to the uplift resistance of piles and piers was incorporated into the design for tower foundations on a transmission line project in Norfolk, Va, and the improved design approach was then integrated into Va. Power's standard practice.

In the late 1970's, EPRI began a comprehensive investigation of current design practices for tower foundation design. It was initiated to study all aspects of axially loaded foundations and was placed under the direction of with Dr. F.H. Kulhawy of Cornell University.

One of the first efforts involved a state of the practice report (Kulhawy et al, 1983). As a continuation of the project, a computer program for Compression and Uplift Foundation Analysis and Design (CUFAD) was developed and incorporated into the TLWorkstation^{TM} (Trautmann et al, 1989). The program allows consideration of undrained or drained analysis, drilled shaft or spread footing foundations, layered soil profiles, and compression or uplift loading. CUFAD is presently in use at Virginia Power. A more recent version of CUFAD has recently been introduced which incorporates an expert system to assist the user in soil parameter selection.

2.2.3 Soils Investigation Practices

Both of the design and analysis programs mentioned above rely on accurate soils data. Input for MFAD includes values of pressuremeter modulus (E_p), unit weight (γ), angle of internal friction (ϕ), cohesion or undrained shear strength (S_u), and an adhesion factor (α) (Bragg et al, 1989). CUFAD requires the same information excepting the pressuremeter modulus, but adding the need for the coefficient of at rest lateral earth pressure (K_0) and the overconsolidation ratio (OCR) (Trautmann et al, 1989).

To facilitate the determination of the soil parameters for the CUFAD program, a draft report has recently been prepared which presents a comprehensive overview of soil property assessment (Kulhawy and Mayne, 1990). The report compiles published information on numerous correlations among soil parameters and laboratory or in-situ tests.

Virginia Power's current practice is to design transmission line foundations using standard penetration test data from widely spaced borings. Typically, one boring is taken for every half mile of transmission line. Soils data are then extrapolated to cover several separate structure locations.

2.3 Standard Penetration Test (SPT), Background

This section provides background information on the standard penetration test. Items to be discussed are as follows:

2.3.1 Standard penetration test history

2.3.2 SPT procedure

2.3.3 Interpretation of SPT results

2.3.4 SPT advantages and disadvantages

2.3.1 Standard Penetration Test History

The standard penetration test is an outgrowth of wash boring techniques used around the turn of the century. In 1902 in order to recover dry soil samples, Col. C.R. Gow began driving an open ended 1 inch pipe into the soil. Col. Gow was involved in installing "Gow" caissons for foundations. In 1927, after the Charles R. Gow Co. had been purchased by The Raymond Concrete Pile Co., a 2 inch split barrel sampler was designed to replace the 1 inch pipe. By the early 1930's the 140 pound drop weight and 30 inch fall had also been standardized. In 1954 the recording of the blows needed to drive the sample each of three separate 6 inch increments came into acceptance. The original purpose of the SPT was to measure soil density by a standard procedure. The information was then used for the design and construction of caisson foundations (Fletcher, 1965).

2.3.2 SPT Procedure

Standard penetration test procedure is covered under ASTM D 1586-84, standard method for Penetration Test and Split Barrel Sampling of Soils (ASTM, Section 4, 1989).

To perform the test a borehole of diameter between 2.2 and 6.5 inches is advanced to the test depth. The drill assembly is then removed from the hole. A 2.0 inch outside diameter(OD) by 1 3/8 inch inside diameter(ID) split barrel sampler is attached to flush joint steel drill rod and lowered into the hole. Minimum drill rod size is "A" rod with OD and ID of 1 5/8 and 1 1/8 inches respectively. "N" size rod may also be used with negligible effect on the test results (ASTM D 1586-84).

A 140 pound hammer is attached to the top of the sampling string and the entire assembly is rested on the bottom of the hole. The drill rods are marked in three 6 inch increments and the hammer is dropped a standard 30 inch distance to advance the sampler. The number of blows to drive the sampler each 6 inches are counted. The last two values are totaled to give the standard penetration blow count, N.

2.3.3 Interpretation of SPT Results

Basic reduction of SPT data involves only adding the two blow counts for the last 12 inches of sampler penetration. However, to properly interpret the results, it is desirable to obtain a normalized representation of the N value accounting for variation of hammer energy and the effects of overburden pressure.

The energy of the hammer system varies with the type of hammer being used. A hammer with a perfectly free drop would have an energy equal to its weight multiplied by the drop height, or an efficiency of 100%. Measurements in the field typically show less than 100% efficiency (Schmertmann, 1980); (Kovacs, 1981). The widely used safety hammer has been shown to have an efficiency of about 60%, and this is accepted in practice as a reference value (Seed and Idriss, 1982). Blow count values at this energy level are denoted by the symbol N_{60}. Adjustments are made for other hammer efficiencies as follows:

$N_{60} = Nm * (ER/60)$

ER = energy ratio for the given hammer

Nm = the measured blow count

Measurements generally show efficiency levels of 45% for donut hammers, and close to 100% for trip hammers.

To account for overburden pressure, Peck, et al. (1974) recommend normalizing N values to an confining pressure of one ton per square foot (tsf). Normalized SPT values are symbolized as N_1, with the calculation made as follows:

$$N_1 = C_n * N$$

$C_n = 2 / (1 + (\sigma'_v/p_a))$ (Skempton, 1986)

σ'_v = effective overburden pressure (tsf)

p_a = atmospheric pressure = 1 tsf

Accounting for both the energy and overburden pressure leads to the expression presented by Seed and Idriss (1982).

$$N_{1\text{-}60} = N_m * C_n * (ER/60)$$

Present practice at Virginia Power in applying blow count to design follows the recommendations set forth by Davidson in the 1982 EPRI report EL_2197, "Laterally Loaded Drilled Pier Research" (Davidson, 1982). Chart solutions are presented to correct for the effect of overburden pressure. The drilling contractors employed by Virginia Power use safety hammers, therefore no correction is made for hammer efficiency.

Table 2.2

Soil Properties vs. Blow Count, N

PROPERTIES FOR COHESIONLESS SOILS

	N blows/ft	Dr %	χ pcf	υ deg
Very Loose	<4	<20	<90	<30
Loose	4-10	20-40	90-100	30-35
Medium Dense	10-30	40-60	100-112	35-40
Dense	30-50	60-80	112-125	40-45
Very Dense	>50	80-100	>125	>45

PROPERTIES FOR COHESIVE SOILS

	N blows/ft	q_u ksf	S_u ksf
Very Soft	<2	<0.5	<0.25
Soft	2-4	0.5-1.0	0.25-0.5
Medium	4-8	1.0-2.0	0.5-1.0
Stiff	8-15	2.0-4.0	1.0-2.0
Very Stiff	15-30	4.0-8.0	2.0-8.0
Hard	>30	>8.0	>4.0

(from Terzaghi & Peck, 1967, and Nixon, 1982)

Numerous correlations of the SPT to other soil properties or design values have been developed. By the nature of the test the correlations are empirical but are supported by large data bases of practical experience. Terzaghi and Peck (1967) present relationships concerning relative density (D_r) and N for sands, and unconfined compressive strength (q_u) for cohesive soils. Table 2.2 gives the correlations of Terzaghi and Peck as adapted by Nixon (1982). The correlation of blow count to the strength of clay is typically considered less reliable than that between the blow count and sand density.

For a full review of correlations between the SPT and other soil properties see the reference by Kulhawy and Mayne, 1990. In any design using only SPT data judgement is required in considering the inherent variability of the test method.

2.3.4 SPT Advantages and Disadvantages

The SPT equipment is readily available to most exploratory drilling contractors in the United States and they are accustomed to performing the test. The SPT provides a soil sample for visual classification and for laboratory testing, and finally, the equipment is simple and rugged.

There are many variables in the SPT which can affect the results. For example, the drop height of the hammer is only approximately controlled based on visual observations of the operator. Also, the size, speed, and condition of the cathead used to lift the hammer affect the hammer's rate of fall. Finally, friction in the rope sheaves can reduce the energy of the hammer drop. Most variables that effect the test and are not fully controlled have the effect of raising the blow count, leading to higher or unconservative soil strength estimates (Schmertmann, 1976); (Kulhawy and Mayne, 1990).

2.4 Cone Penetration Test (CPT), Background

This section provides background information on the cone penetration test. Items to be discussed are as follows:

2.4.1 Cone penetration test history
2.4.2 CPT procedure
2.4.3 Interpretation of CPT results
2.4.4 CPT advantages and disadvantages

2.4.1 Cone Penetration Test History

The early history of the cone penetrometer was recently well documented by Broms and Flodin (1988). Much of the following discussion was drawn from this paper.

The Dutch cone penetration test was developed about 1930 in Holland by the Department of Public Works for checking the thickness and bearing capacity of hydraulic fill. This cone had a 60^{o} and 10 cm^2 tip angle and area, characteristics that persist in today's cones. The cone had no friction sleeve and was hand operated, limiting penetration depth to about 3 meters (10 ft). By 1936 the Delft Laboratory of Soil Mechanics had helped develop a hand ratchet operated cone with a capacity of 25 kN (3 tons).

Development work on the cone continued primarily in Holland through the 1930's and 1940's. By 1942 the tip resistance of the cone had been related to the bearing capacity of driven piles. Capacity reached 10 metric tons by 1948, allowing penetration depths up to 30 meters (98 ft).

A major development came in 1953 with Begemann's introduction of the mechanical 150 cm^2 friction sleeve immediately above the cone tip. Tip and

sleeve were advanced in separate increments to obtain the separate readings. Initially, the friction sleeve reading was used to measure an adhesion value which could be used in design of friction piles. Later, in 1965, Begemann proposed the friction ratio concept which is defined as the ratio of the friction sleeve reading and the tip resistance. It was found that this value could be used to help classify soil stratigraphy and type.

An early electrical cone penetrometer was patented in 1948 which allowed electronic monitoring of the tip resistance. An electric cone with separate friction recording was in use by 1957. In 1965, Fugro developed the electric cone as commonly used today. This improvement allowed continuous monitoring of the tip and sleeve resistance using automated data acquisition techniques, which significantly enhanced test efficiency. Following the introduction of the electric cone, capabilities have been added to measure pore pressures, seismic wave velocities, temperature, cone inclinations, and in some cases, a device to take water samples (Baligh, et al., 1981; Campanella and Robertson, 1981; Baldi, et al., 1988; DeRuiter, 1982; Mitchell, 1988). Today the cone is well accepted in geotechnical practice, although some of the more recent capabilities are still in development.

2.4.2 CPT Procedure

Cone penetration testing is covered under ASTM specification D 3441-86, and it addresses both mechanical and friction cones. The specification addresses the dimensional tolerances of the instrument and rods, and states that the cone should be advanced steadily at a rate of between 10 and 20 mm/s. The thrust equipment must be capable of maintaining a constant rate of cone advance as the required thrust varies with penetration resistance.

An electric friction cone test consists of advancing the cone steadily to the required test depth and recording data as the test proceeds. Data from the tip and sleeve load cells can be recorded on a strip chart or digitized and stored using a computer. At the extension limit of the thrust equipment, the test is halted long enough to retract the equipment and add another section of cone rod. The test then proceeds.

2.4.3 Interpretation of CPT Results

Empirical relationships have been developed using tip resistance (Q_c), side friction (f_s), and the friction ratio ($F_r = f_s/Q_c$) for the identification of soil types. As with SPT data, it is helpful to normalize cone data for the effect of overburden pressure. The normalized tip resistance ($Q_{c,1}$) is calculated as follows:

$$Q_{c,1} = C_q * Q_c$$

and

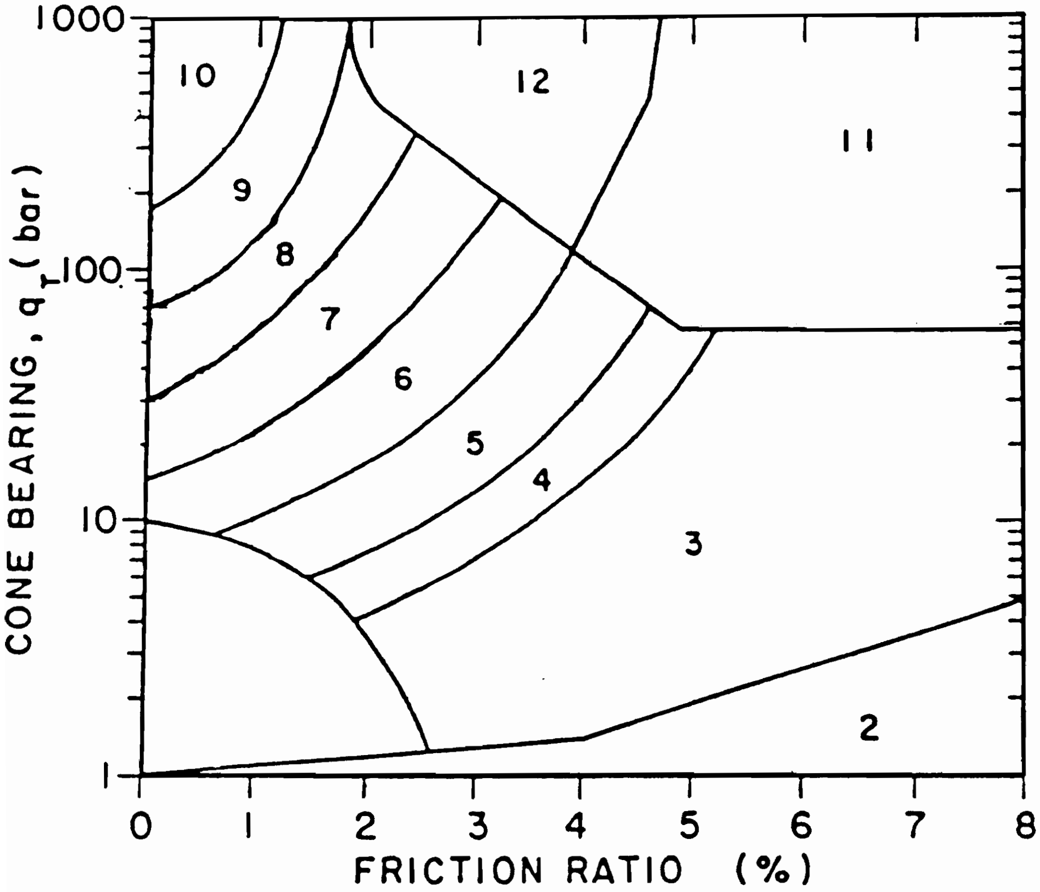
$$C_q = 2 / (1 + (\sigma'_v/p_a)$$

as for C_n in section 2.3.3.

Figure 2.1 shows a representative chart for soil classification using CPT data.

Relationships have also been produced to allow determination of friction angle, cohesion, and a variety of other soil properties from cone test data. Figure 2.2 illustrates the relationship between Q_c and friction angle and Figure 2.3 gives bearing capacity recommendations based on Q_c. A comprehensive review of available correlations is presented by Kulhawy and Mayne (1990).

2.4.4 CPT Advantages and Disadvantages



Zone	Soil Behavior Type
1	sensitive fine grained
2	organic material
3	clay
4	silty clay to clay
5	clayey silt to silty clay
6	sandy silt to clayey silt
7	silty sand to sandy silt
8	sand to silty sand
9	sand
10	gravelly sand to sand
11	very stiff fine grained*
12	sand to clayey sand*

** overconsolidated or cemented*

Figure 2.1 Soil Classification from CPT Data
(after Robertson & Campanella, 1984)

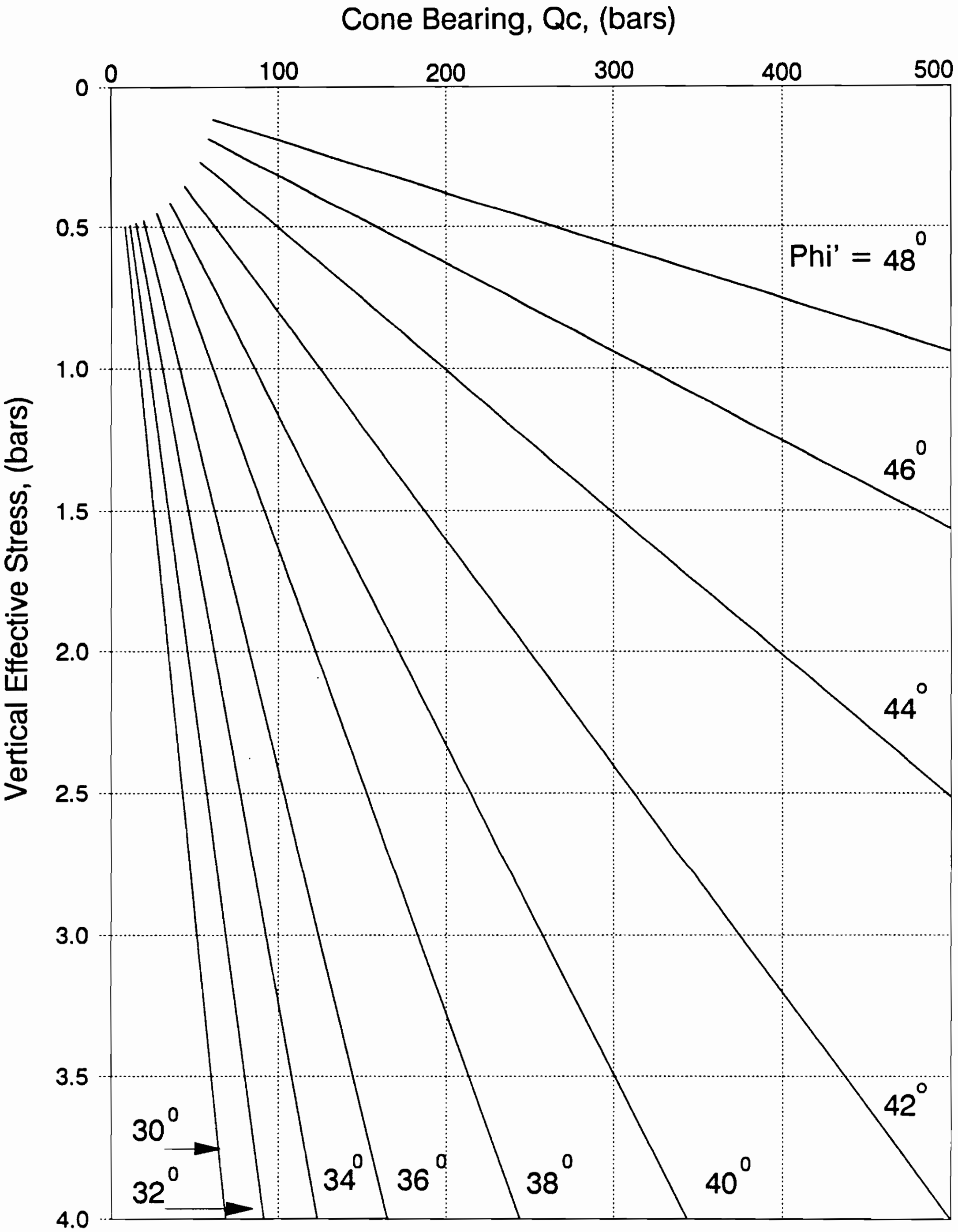


Figure 2.2 Determination of Friction Angle from Qc

(After Robertson & Campanella, 1982)

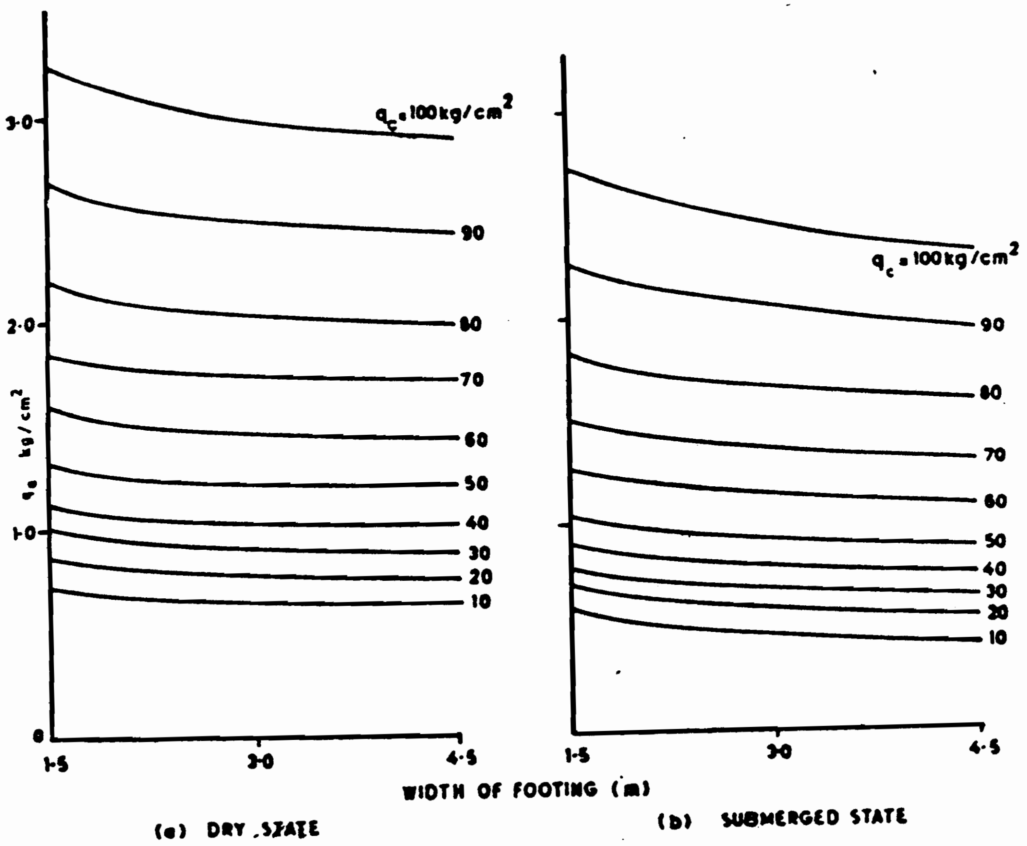


Figure 2.3 Bearing Capacity from Q_C (after Goel, 1982)

The primary advantage of the cone penetrometer is that it provides a continuous record of the soil conditions. Using empirical correlations, stratigraphy and an estimate of soil properties can be developed. The test can be rapidly performed, allowing more information to be gathered for the same expenditure of time versus other tests. It also offers the capability to be automated and allows computer data acquisition.

The cone does not provide soil samples for visual identification or for lab testing. Thus it is not uncommon to supplement cone testing with an SPT or conventional boring. Problems can develop if very dense soil layers are present because the thrust may exceed the capacity of the push rig or damage the cone. It is also possible for the cone to be forced off vertical by some underground obstruction.

Used in suitable soils and with caution concerning equipment damage, the cone penetrometer has shown itself as an efficient method of developing site stratigraphy.

2.5 Dilatometer Modulus Test (DMT), Background

This section provides background information on the dilatometer modulus test. Items to be discussed are as follows:

- 2.5.1 Dilatometer history
- 2.5.2 DMT procedure
- 2.5.3 Interpretation of DMT results
- 2.5.4 DMT advantages and disadvantages

2.5.1 Dilatometer History

Marchetti (1976) developed the original dilatometer as a test to measure a soil modulus (E_S) for laterally loaded driven piles. The original apparatus had a blade width of 80mm, thickness of 20mm and had a 60mm diameter membrane on each face.

Later development has refined the dimensions of and applications for the instrument. The dilatometer in its present form is a 96mm by 15mm flat plate with a 60mm membrane mounted flush on one side (Marchetti, 1980) (see Figure 2.4). The 1980 paper gave dilatometer test results at seven sites, with soil types ranging from overconsolidated clays to loose sands. Correlations were extended beyond studies of E_S to include soil type, K_0, OCR, S_u, and m_v, the one dimensional tangent modulus.

Since its introduction, the use of the dilatometer has been extended to many different soil types. Table 2.3 shows materials tested to date as presented by Lutenegger in his 1988 status report on the DMT (Lutenegger, 1988). The range of applications continues to expand as dilatometer testing becomes more common in engineering practice.

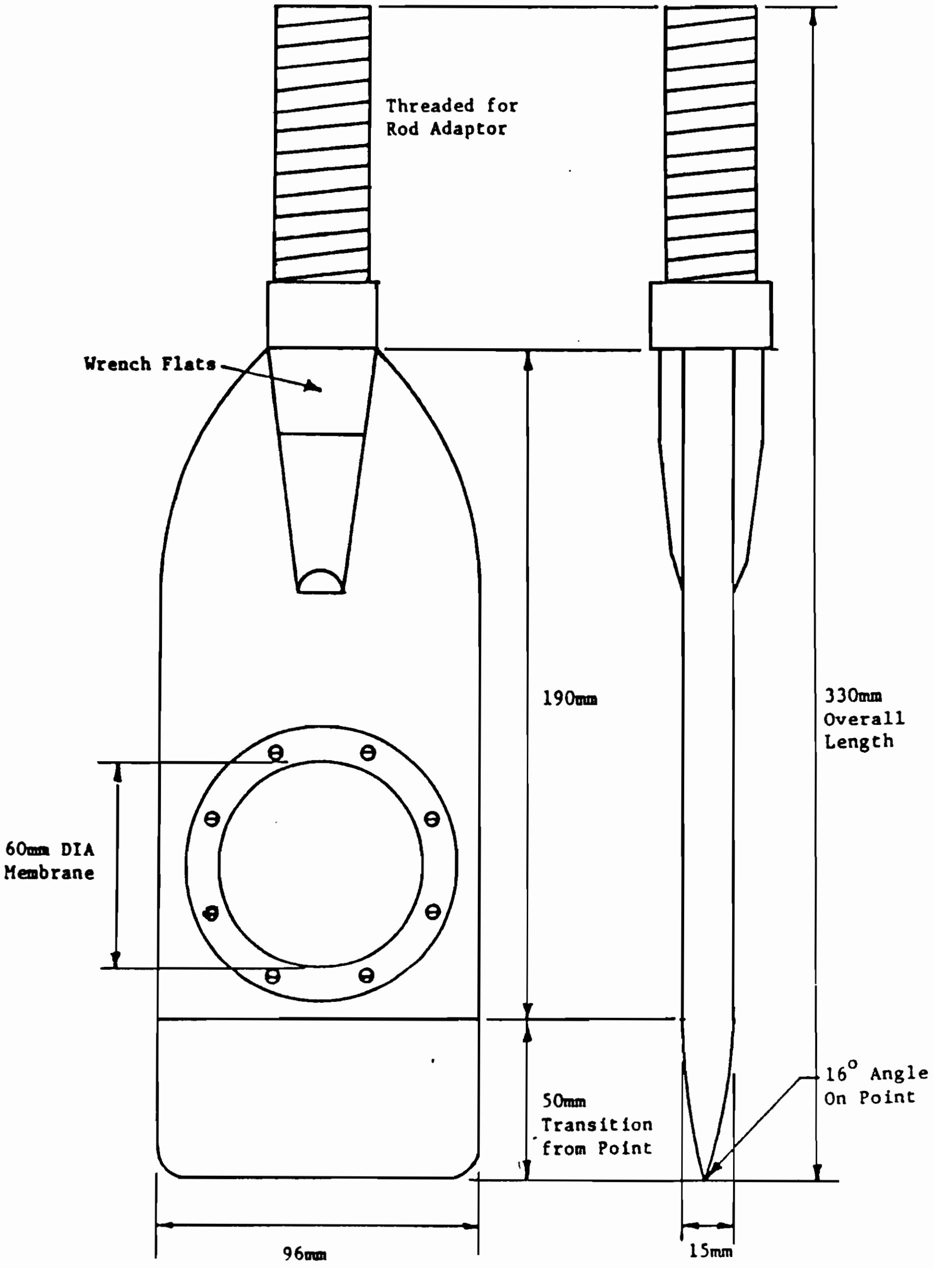


Figure 2.4 Diagram of the Dilatometer Blade

Table 2.3
MATERIALS TESTED TO DATE WITH DMT

Material	Reference
sensitive marine clay	Lacasse & Lunne (1983) Fabius (1985) Bechai et al. (1986) Hayes (1986) Lutenegger & Timian (1986) Lutenegger (1987)
soft non-sensitive clay	Minkov et al. (1984) Ming-Fang (1986) Saye & Lutenegger (1988)
lacustrine clays glacial tills and/ or very stiff OC clays sand	Chan & Morgenstern (1986) Davidson & Boghrat (1983) Schmertmann & Crapps (1983) Powell & Uglow (1986) Schmertmann (1982) Baldi et al. (1986) Clough & Goeke (1986) Lacasse & Lunne (1986) Schmertmann et al. (1986)
deltaic silt	Campanella & Robertson (1983) Konrad et al. (1985)
loess	Lutenegger & Donchev (1983) Hammandshiev & Lutenegger (1985) Lutenegger (1986)
peat	Hayes (1983) Kaderabek et al. (1986)
compacted fill	Borden et al. (1985)
industrial slime	GPE (1984)
soft/medium rock	Sonnenfeld et al. (1985)

(After Lutenegger, 1988)

2.5.2 DMT Procedure

Dilatometer testing is covered under ASTM Suggested Method for Performing the Flat Dilatometer Test (Schmertmann, 1986).

The DMT was designed to use the same rods and thrust equipment for cone penetration testing. The test consists of pushing the instrument into the ground, stopping at the desired test elevation and expanding the membrane into the soil. A switch behind the membrane signals initial movement and the 1.0mm full expansion of the membrane. A pneumatic electric cable threaded through the rods carries both gas pressure and membrane switch signals from the blade to the control unit.

Prior to beginning a test, two membrane calibration readings are taken. The ΔA measurement determines the pressure necessary to fully seat the membrane in the blade. The ΔB reading accounts for the pressure required to fully expand the membrane. The two initial calibrations allow removal of membrane stiffness from data reduction.

As the blade is advanced soil pressure seats the membrane firmly in the instrument causing the control panel buzzer to sound. To conduct a test, the blade is stopped, load removed from the rod string, and membrane inflation begun. The initial membrane movement interrupts the buzzer signal. This pressure reading is called the "A" value. Membrane expansion continues to the full displacement of 1.0mm at which point the buzzer signal returns. The pressure at full displacement is the "B" reading. Pressure is then released slowly until the membrane reseats in the blade. Pressure at signal return upon seating is the "C" reading. The pressure should be regulated so that the three readings follow within 15 to 30 seconds of each other. After completion of a test sequence the blade is advanced and the cycle is repeated. Figure 2.5 shows the membrane expansion cycle.

2.5.3 Interpretation of DMT Results

Data reduction for the dilatometer relies mainly on empirical correlations using three parameters calculated from the DMT pressure readings. Knowledge of the water table elevation and an estimate of vertical effective stress are needed. Schmertmann also developed a method from bearing capacity theory for calculating the friction angle for sands, but a measurement of rod thrust prior to stopping to begin each test is needed for the calculation. If no thrust measurements are available, it is possible to infer the thrust data from a parallel cone penetration test (Schmertmann, 1982).

Use of A, B, water pressure (u_0), and σ_{v0} give the following dilatometer values are as follows:

$$P_0 = A + \Delta A \text{ correction}$$

$$P_1 = B + \Delta B \text{ correction}$$

Material index; $I_D = (P_1 - P_0)/(P_0 - u_0)$

Horizontal stress index; $K_D = (P_0 - u_0)/\sigma'_{v0}$

Dilatometer modulus; $E_D = 34.7\,(P_1 - P_0)$

The constant 34.7 used in calculating E_D is a function of the membrane geometry.

Table 2.4 gives soil parameters inferred from the calculated dilatometer coefficients. Full details of the derivations are given in the dilatometer manual (Schmertmann, 1988).

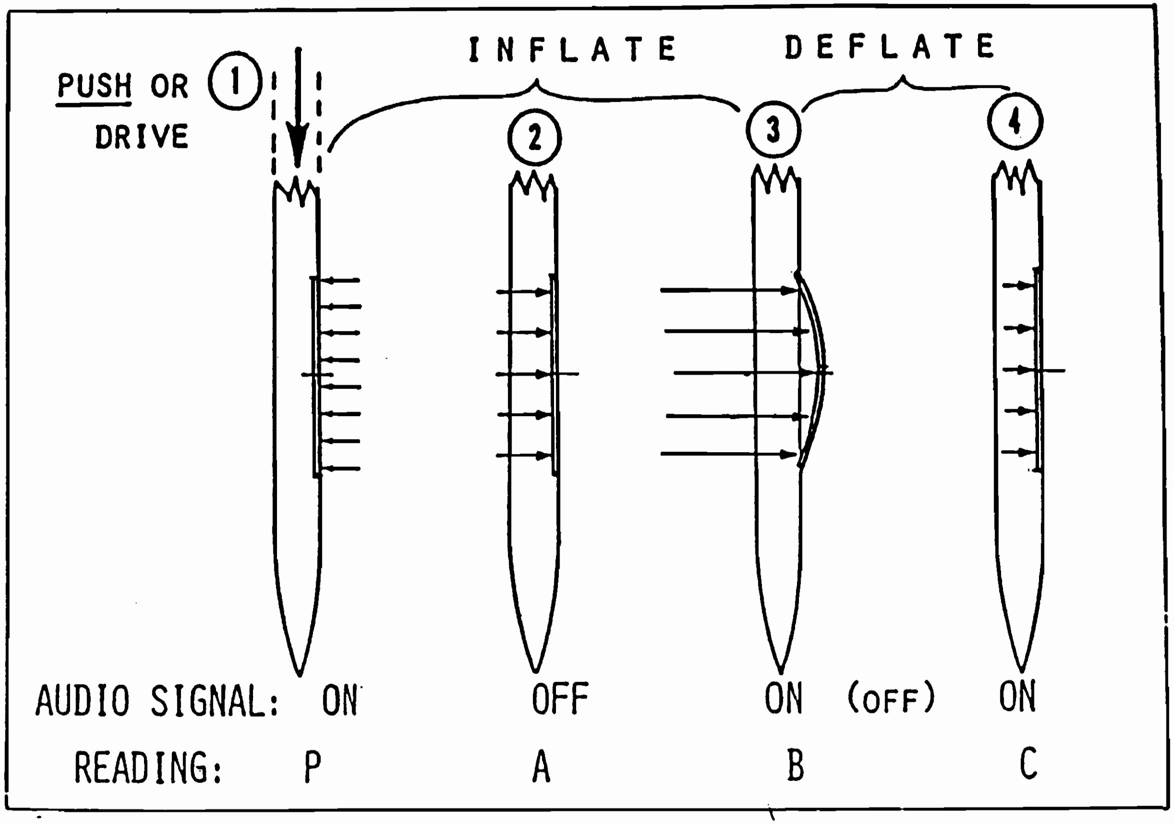


Figure 2.5 DMT Membrane Inflation Sequence (after Schmertmann, 1988)

TABLE 2.4

SOIL PARAMETERS FROM DMT DATA

Soil Parameter	DMT Index	Reference
S_u, (clays)	I_D, K_D	Marchetti (1980)
ϕ', (sands)	I_D, K_D and thrust or Q_c	Schmertmann (1982) & Marchetti (1985)
K_0, (clays)	I_D, K_D	Marchetti ('80, '86)
K_0, (sands)	K_D, thrust	Schmertmann (1982)
OCR, (clays)	I_D, K_D	Marchetti (1980)
OCR, (sands)	K_D, thrust	GPE (1983)
M	I_D, E_D, K_D	Marchetti (1980)

(After Lutenegger, 1988)

Use of the C reading is still under investigation but seems useful for determining pore pressures, leading to calculation of the water table depth in sands and the over consolidation ratio in clays (Lutenegger, 1988).

GPE, Inc., the dilatometer supplier in the U.S., developed a computer program for reduction of test data. Figure 2.6 shows an example of the program output with the different soil parameters that are calculated.

2.5.4 DMT Advantages and Disadvantages

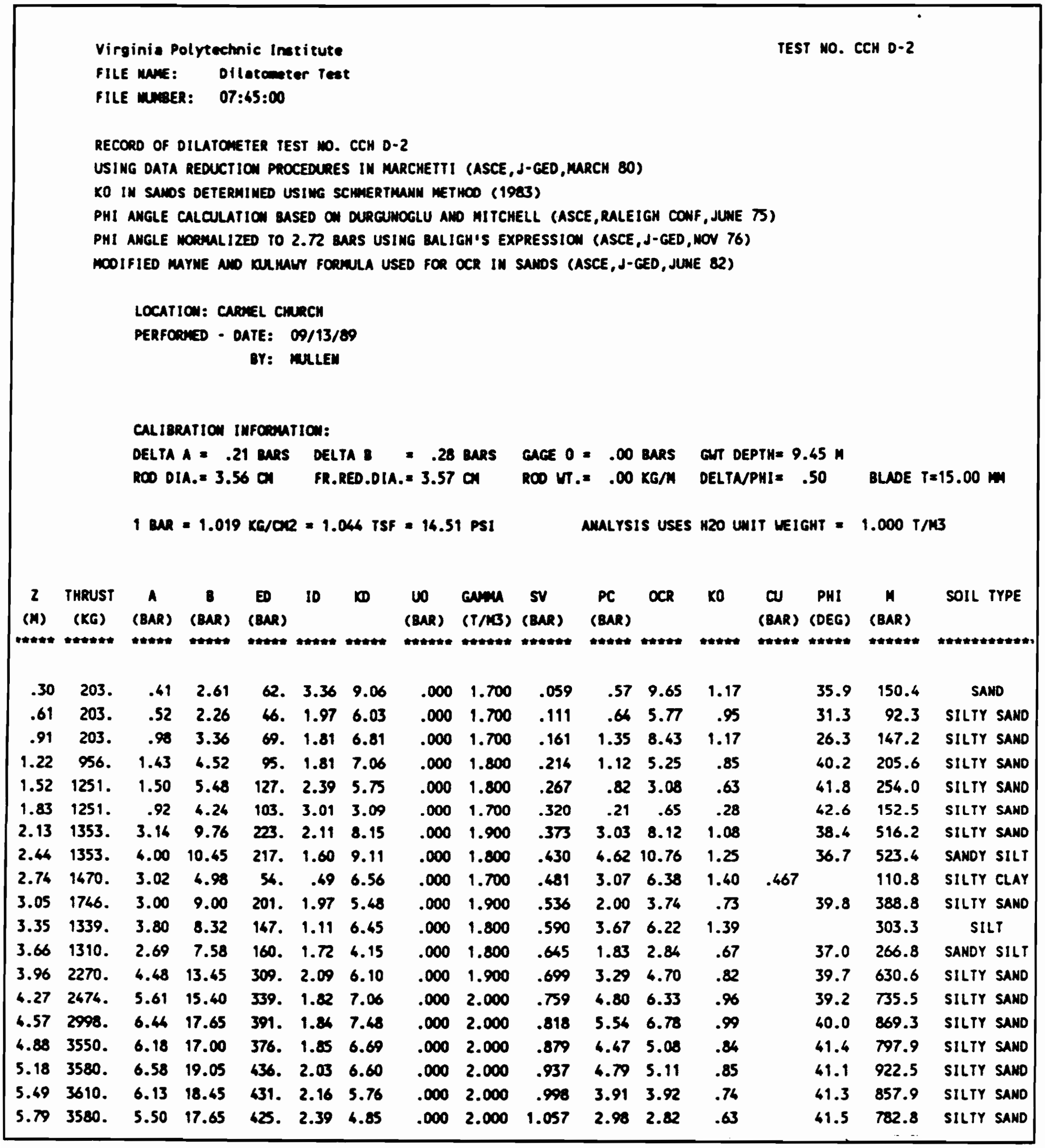
The test is simple, rapid to perform and gives repeatable results. The actual instrument is rugged and easy to repair, requiring only hand tools for all but major damage. Correlations have been developed for many soil types, giving basic geotechnical parameters.

Like the cone penetrometer, the DMT does not return a soil sample for testing, and the test is not in wide usage. The various correlations used with the DMT are still being verified and full confidence in the results for all soils remains to be developed. From a practical perspective, dense soils or gravel can tear the membrane, stopping a sounding. Also, dense soils can block advance of the probe (Kulhawy & Mayne, 1990).

2.6 Pressuremeter Test (PMT), Background

This section provides background information on the pressuremeter test. Items to be discussed are as follows:

2.6.1 Pressuremeter test history
2.6.2 PMT procedure
2.6.3 Interpretation of PMT results
2.6.4 PMT advantages and disadvantages



```
        Virginia Polytechnic Institute                                                TEST NO. CCH D-2
        FILE NAME:     Dilatometer Test
        FILE NUMBER:   07:45:00

        RECORD OF DILATOMETER TEST NO. CCH D-2
        USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
        KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
        PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
        PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
        MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

            LOCATION: CARMEL CHURCH
            PERFORMED - DATE:  09/13/89
                          BY:  MULLEN


            CALIBRATION INFORMATION:
            DELTA A =  .21 BARS   DELTA B    =  .28 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 9.45 M
            ROD DIA.= 3.56 CM     FR.RED.DIA.= 3.57 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50      BLADE T=15.00 MM

            1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3


  Z   THRUST    A      B     ED     ID    KD      U0    GAMMA    SV      PC    OCR     KO     CU    PHI      M      SOIL TYPE
 (M)   (KG)   (BAR)  (BAR)  (BAR)                (BAR) (T/M3)  (BAR)  (BAR)                 (BAR) (DEG)   (BAR)
***** ****** *****  *****  ***** ***** *****  ****** ****** ******  ***** *****   *****  ***** *****  ******  ************


  .30   203.    .41   2.61    62.  3.36  9.06   .000  1.700   .059    .57  9.65   1.17          35.9   150.4      SAND
  .61   203.    .52   2.26    46.  1.97  6.03   .000  1.700   .111    .64  5.77    .95          31.3    92.3   SILTY SAND
  .91   203.    .98   3.36    69.  1.81  6.81   .000  1.700   .161   1.35  8.43   1.17          26.3   147.2   SILTY SAND
 1.22   956.   1.43   4.52    95.  1.81  7.06   .000  1.800   .214   1.12  5.25    .85          40.2   205.6   SILTY SAND
 1.52  1251.   1.50   5.48   127.  2.39  5.75   .000  1.800   .267    .82  3.08    .63          41.8   254.0   SILTY SAND
 1.83  1251.    .92   4.24   103.  3.01  3.09   .000  1.700   .320    .21   .65    .28          42.6   152.5   SILTY SAND
 2.13  1353.   3.14   9.76   223.  2.11  8.15   .000  1.900   .373   3.03  8.12   1.08          38.4   516.2   SILTY SAND
 2.44  1353.   4.00  10.45   217.  1.60  9.11   .000  1.800   .430   4.62 10.76   1.25          36.7   523.4   SANDY SILT
 2.74  1470.   3.02   4.98    54.   .49  6.56   .000  1.700   .481   3.07  6.38   1.40   .467          110.8   SILTY CLAY
 3.05  1746.   3.00   9.00   201.  1.97  5.48   .000  1.900   .536   2.00  3.74    .73          39.8   388.8   SILTY SAND
 3.35  1339.   3.80   8.32   147.  1.11  6.45   .000  1.800   .590   3.67  6.22   1.39                 303.3      SILT
 3.66  1310.   2.69   7.58   160.  1.72  4.15   .000  1.800   .645   1.83  2.84    .67          37.0   266.8   SANDY SILT
 3.96  2270.   4.48  13.45   309.  2.09  6.10   .000  1.900   .699   3.29  4.70    .82          39.7   630.6   SILTY SAND
 4.27  2474.   5.61  15.40   339.  1.82  7.06   .000  2.000   .759   4.80  6.33    .96          39.2   735.5   SILTY SAND
 4.57  2998.   6.44  17.65   391.  1.84  7.48   .000  2.000   .818   5.54  6.78    .99          40.0   869.3   SILTY SAND
 4.88  3550.   6.18  17.00   376.  1.85  6.69   .000  2.000   .879   4.47  5.08    .84          41.4   797.9   SILTY SAND
 5.18  3580.   6.58  19.05   436.  2.03  6.60   .000  2.000   .937   4.79  5.11    .85          41.1   922.5   SILTY SAND
 5.49  3610.   6.13  18.45   431.  2.16  5.76   .000  2.000   .998   3.91  3.92    .74          41.3   857.9   SILTY SAND
 5.79  3580.   5.50  17.65   425.  2.39  4.85   .000  2.000  1.057   2.98  2.82    .63          41.5   782.8   SILTY SAND
```

Figure 2.6 DMT Output Data

2.6.1 Pressuremeter Test History

The first pressuremeter was developed in the 1930's and is attributed to Kogler. The basic idea of the test is to create a clean hole with a minimum of disturbance, insert the cylindrical probe in the hole, and expand a membrane that surrounds the probe against the soil. In its most elemental form, the information from the test consists of the pressure-volume relationship obtained as the membrane is pressed into the soil (this is commonly known as the pressuremeter curve). In the original concept, geotechnical information was to be obtained using cavity expansion equations from the theory of elasticity. Soil parameters were backcalculated from the theory using the information from the pressuremeter curve.

The Kogler pressuremeter did not prove to be a popular tool. However, in 1955, Menard re-introduced the idea of the pressuremeter, and developed a probe that could be used in practice. The new probe was filled with water and was expanded using pressure applied to the water column at the ground surface. The pressuremeter curve was developed using the applied pressures and the volume expansion developed from the water column movements. The Menard probe was subsequently commercialized, and has been used widely in geotechnical practice, particularly in France. The development of the Menard pressuremeter and the attendant theory for its use is described by Baguelin, et al. (1972) and Gambin (1990).

After Menard introduced his first version of the probe, he made further improvements until it evolved into the version that is used today. He also formalized procedures for reducing the data from the pressuremeter curve so as to obtain the modulus and strength of the soil, and lateral stress in the soil. In the

1960's Menard published a set of "rules" that were intended to extend the utility of the pressuremeter data so that through empirical correlations the geotechnical engineer could directly obtain geotechnical parameters. The Menard rules have been extended based on further correlations with observed performance by Baguelin, et al. (1986) and Briaud (1990).

Menard's work has had its greatest influence in France where the basic pressuremeter is regularly used in practice. This approach is less appreciated outside of France, although in certain applications and certain regions of the U.S., it finds regular use (Clough, et al., 1990). Reluctance to adopt the Menard approach in the U.S. can be attributed to: (1) Concern over the effects of disturbance induced during opening the hole for the test; (2) Lack of background on the procedures used to develop the rules; and (3) The development of competitive testing tools which can be used more simply than the pressuremeter (e.g., the cone or dilatometer).

In an effort to address the issue of disturbance caused by separately opening the hole and subsequently introducing the pressuremeter, a self-boring pressuremeter was developed simultaneously in England (Hughes and Wroth, 1972) and France (Baguelin, et al., 1972). This device was designed to drill itself into the ground, all the while maintaining direct contact with the soil. The English version also offered the improvement of measuring the probe expansion pressure with a pressure cell in the probe, and providing for monitoring the movements of the membrane using electric strain arms. This ultimately allowed for automation of the test, and computerized data acquisition. Today this probe has been improved to allow for multiple point measurement of membrane movement, and monitoring of excess pore pressures in the soil if desired. However, although the self-boring pressuremeter theoretically offered an improvement of the test, it is not widely used because of the complexity of the equipment, and the high level of skills needed to operate it in such a way as to obtain high quality data (Mair and Woods, 1987; Clough, et al., 1990).

The trend in use of the pressuremeter in the U.S. is towards speciality applications. The basic advantage of the device is that it is the only tool that allows for a rigorous analysis of soil parameters including modulus, strength and coefficient of lateral earth pressure. Unfortunately, in many cases, unless the quality of the data are high, the results can be misleading. The one parameter that seems to be relatively immune to the effects of disturbance is the soil stiffness, if this parameter is determined using an unloading-reloading process (Mair and Woods, 1987). This finding is important in that soil stiffness is an important design parameter, particularly in stiff and dense soils. Few other reliable alternatives are available for a satisfactory determination of the soil stiffness. Present research is being directed towards how this parameter can be best determined, within the context of a cost effective test procedure (Pappas, 1990; Lien, 1990).

2.6.2 PMT Procedure

Pressuremeter testing procedures for Menard type tests in pre-bored holes are covered under ASTM D4719-87. The specification covers both hydraulic and electric probes and stress or strain controlled testing. A hydraulic probe is typical of the Menard type device. It has flexible cell walls and is expanded using water under pressure. An electric probe is one which uses electronic devices to monitor cell pressure and membrane movements. For this research an electric probe was used to perform stress controlled tests in prebored holes.

In addition to specifying calibration procedures for the probe and attendant hardware, ASTM D 4719-87 is designed to ensure that a borehole for the probe is prepared with the minimum possible disturbance. The hole is to be not more than 20% larger in diameter than the pressuremeter and drilling operations should cause the least possible disturbance of the soil and hole wall. The hole may be opened by rotary drilling, tube sampling, use of continuous flight augers, core drilling, hand augering, etc. provided the end result is within the specifications. Testing is to be done immediately following hole preparation.

During an electric pressuremeter test the probe is inflated with nitrogen and readings of pressure and membrane displacement are recorded into a portable computer at intervals during the test. After reaching either the expansion or pressure limits of the probe, pressure is bled off and the pressuremeter removed from the hole. The testing cycle is repeated at each desired depth.

2.6.3 Interpretation of PMT Results

Pressuremeter tests have been used to determine engineering properties for both cohesive and granular soils. Initial shear modulus (G_i), unload-reload modulus (G_{ur}), and in-situ horizontal stress state (K_o) can be calculated for sands and clays. Additionally, undrained shear strength (S_u), and the coefficient of horizontal consolidation (C_h) can be developed for cohesive materials. For sands, the angle of internal friction (ϕ) , the angle of dilation (ψ), and in-situ pore pressures may also be calculated. Lateral earth pressure has proven a difficult parameter to obtain. In all cases, K_o can only be developed from self boring tests. A prebored test causes sufficient disturbance of the in-situ horizontal stresses to make determination of σ_{ho} questionable. Only high quality self-boring tests appear to produce consistent values (Mair and Woods, 1987).

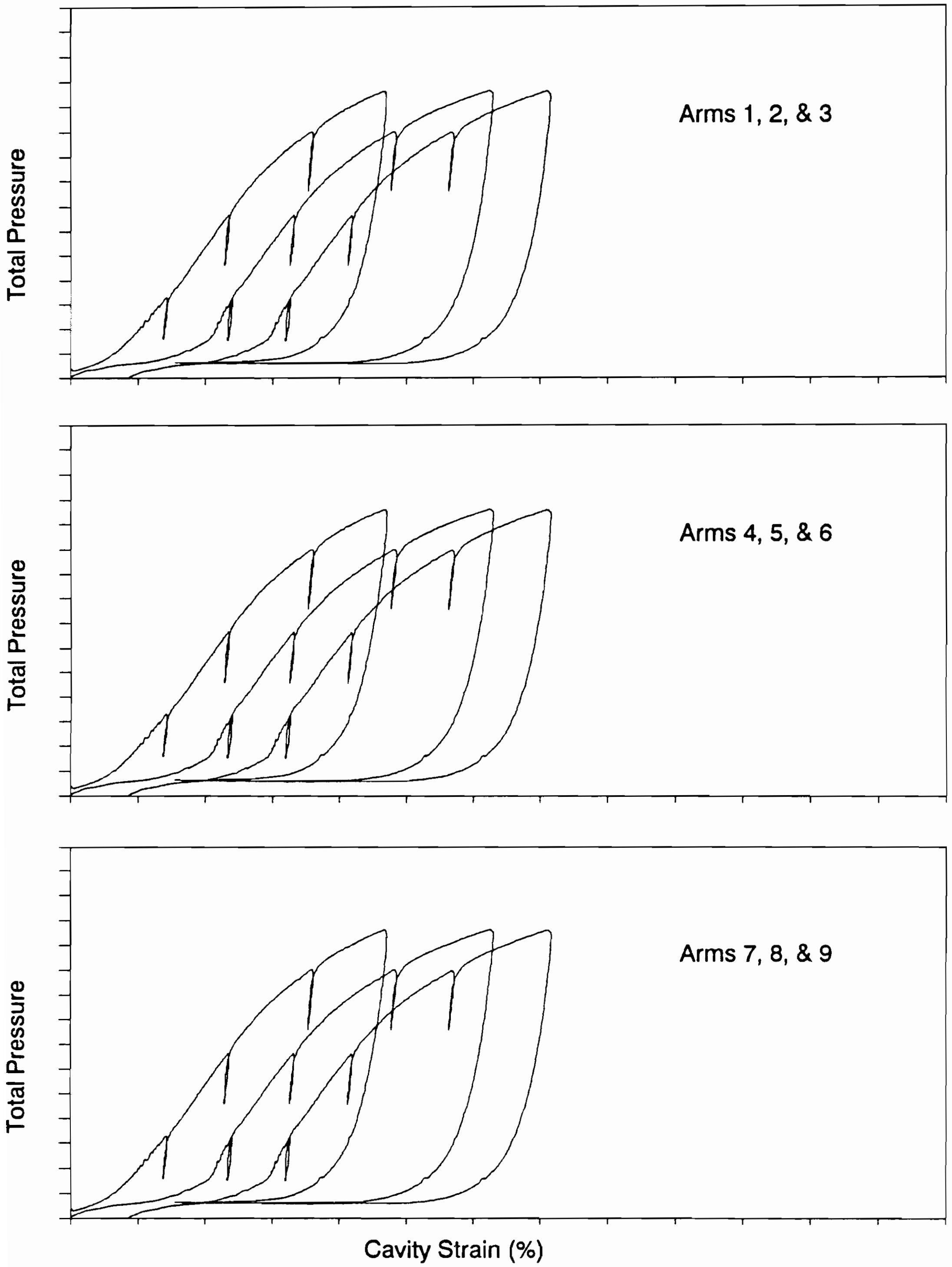


Figure 2.7 Example of 9 Arm Pressuremeter Test Results

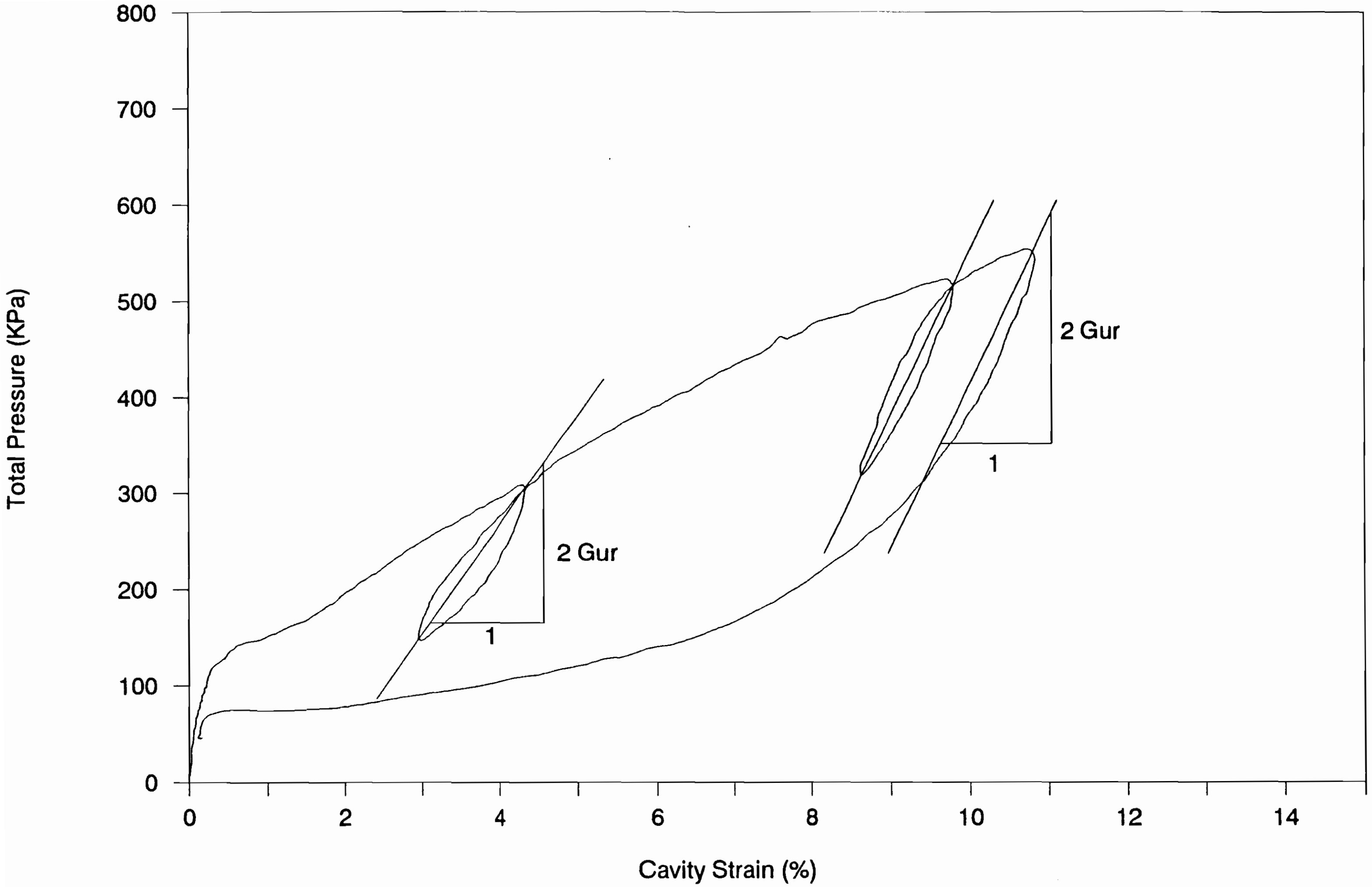


Figure 2.8 Determination of Gur from PMT Data

All pressuremeter tests performed for this research used prebored holes and focused on determining G_{ur}. A typical test is shown in Figure 2.7. The unload-reload modulus is determined from the pressuremeter test plot as shown in Figure 2.8. A line of best fit is drawn through all unload-reload loops performed and through the final unload curve.

The method of Gibson and Anderson (1961) can be used to calculate S_u for cohesive soils. Test data are plotted as pressure versus $\ln(\Delta V/V)$ with the slope of the plot determining S_u (see Figure 2.9). As all tests were recorded in terms of strain instead of volume change, the following conversion was used:

$$\ln(\Delta V/V) = \ln(1-(1+\epsilon)^{-2})$$

The disturbance involved in prebored pressuremeter tests is such that it is impractical to determine ϕ (Mair and Woods, 1987), therefore only G_{ur} was determined for the granular materials tested in this investigation.

2.6.4 PMT Advantages and Disadvantages

There are two main advantages of the pressuremeter. First, it can be used to obtain soil modulus, soil strength and lateral stress from a rigorous theoretical approach. Second, the pressuremeter tests a relatively large mass of soil as compared to other approaches. This tends to average or integrate soil properties over a larger area than the SPT, CPT, or DMT. The wider area tested helps to avoid anomalous results from small pockets of differing materials as are commonly found in residual soils. It also tends to de-emphasize the effect of fissures and fractures, effects which can dominate the results of laboratory tests.

On the other hand, the accuracy of the data obtained in a pressuremeter test is highly dependent on careful hole preparation and operator skill. Coarse

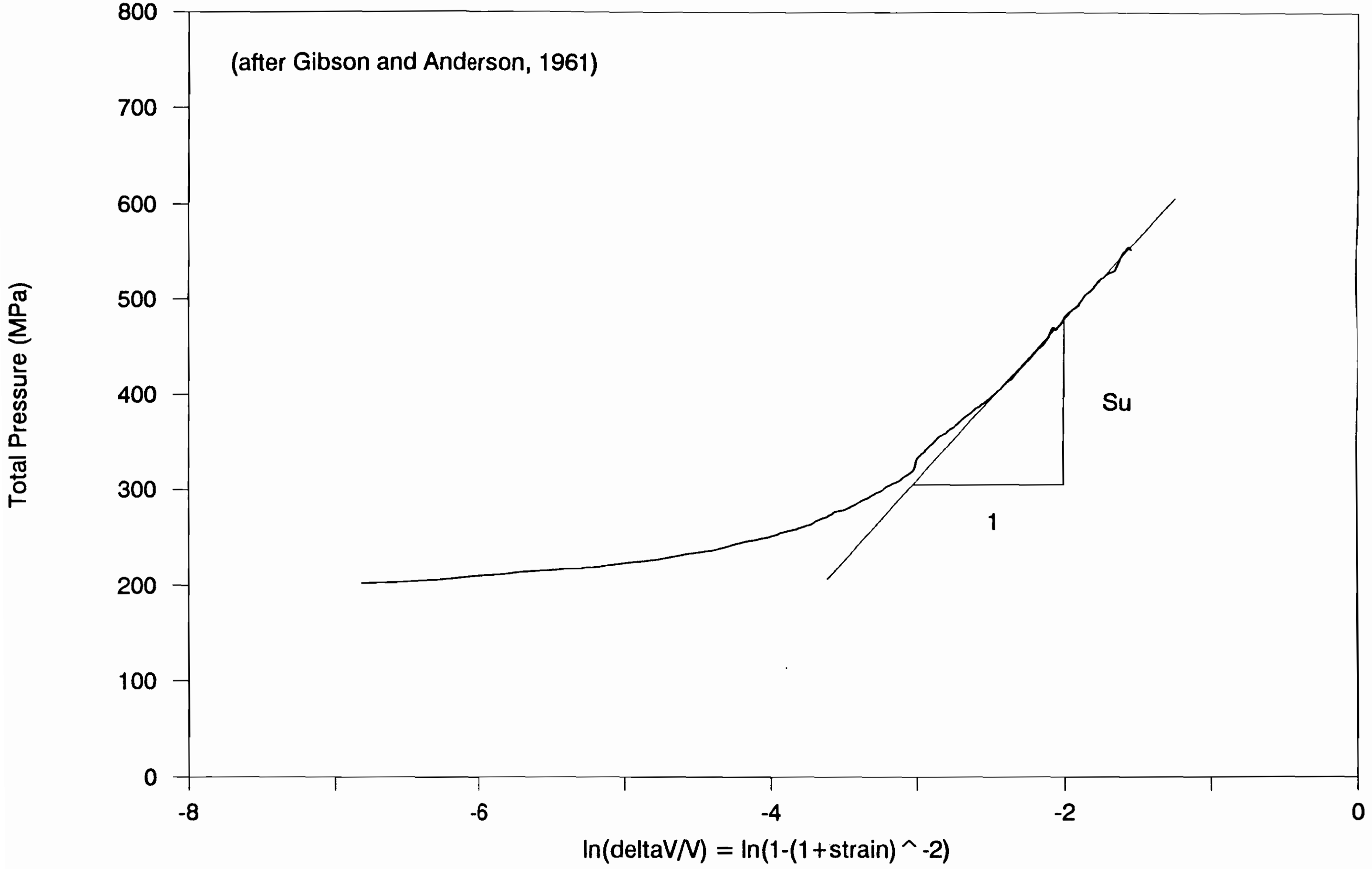

(after Gibson and Anderson, 1961)

Figure 2.9 Determination of Su from PMT Data material in the soil profile can block advance of selfboring pressuremeters. The pressuremeter is not a primary soil exploration tool, and prior knowledge of site stratigraphy is required to make proper use of pressuremeter testing. Finally, pressuremeter testing is time consuming compared to other test methods, and the data cost is high.

2.7 Summary

Transmission line foundation design methods have developed along with the field of geotechnical engineering. There are now computer based design programs like MFAD and CUFAD that can handle varied soil conditions and layered profiles. However, the programs are only as good as the soils data available to support them.

Although the programs , particularly MFAD, were developed assuming that pressuremeter data would be available as input, pressuremeter usage in practice has not advanced as quickly as the design methods. Current practice at Virginia Power is to estimate both PMT data and other soils information from correlations with the SPT blow count. Because of the uncertainty involved, design engineers typically choose conservative values for the required soil parameters.

In-situ soil testing methods have advanced in conjunction with the growth of geotechnical engineering. The CPT and PMT have been in use for over three decades and usage of the instruments in different materials continues to expand. The DMT is approximately 10 years old and was originally calibrated in seven different coastal sands or clays in Italy. The use of the instruments has recently been expanded to a variety of soils, including the residual category.

Although considerable work has been done on development of the individual test devices, much less experience is available where they are tested against one another in a variety of soil conditions. Further, relatively little effort has been expended in consideration of the use of the newer tools for design of transmission tower foundations. In this regard there are questions related to data quality and quantity as well as efficiency for each of the tests. This investigation is directed to this end. A particular emphasis is placed on use of the devices in residual soils, a material where practice has focused largely towards use of the SPT.

Chapter III

DESCRIPTION OF EQUIPMENT AND TEST PROCEDURES

3.1 Introduction

Four different types of insitu devices were used for the research, including the cone penetrometer, the pressuremeter, the dilatometer, and the standard penetration apparatus for the SPT. Of these, the cone penetrometer and pressuremeter were on hand in the Virginia Tech geotechnical laboratories. The dilatometer was purchased specifically for the research, and the standard penetration driven sampler system was rented as part of an agreement reached for the drill rig used for the study. Except for the SPT equipment, work was needed in some measure for all of the test devices, in part to adapt them to the drill rig, and in part to improve efficiency of the testing program. Details of the test equipment, the adaptations made to use them, their calibrations, and the test procedures used are discussed in this chapter. Also discussed are the lab procedures employed for soil classification and mechanical property determination. Table 3.1 lists the ASTM standards followed in conducting the field and lab testing.

3.2 Drilling and Support Equipment

The drilling and support equipment consisted of the following:

3.2.1 Drill rig

3.2.2 Drill rod

3.2.3 Drill bits

3.2.4 Trailer and tables

Table 3.1
Applicable ASTM Standards

Designation	Title
	Field Testing
D 1586-84	Standard Method for Penetration Test and Split-Barrel Sampling of Soils
D 1587-83	Standard Practice for Thin-Walled Tube Sampling of Soils
D 3441-86	Standard Test Method for Deep, Quasi-Static, Cone and Friction-Cone Penetration Tests of Soil
D 4719-87	Standard Test Method for Pressuremeter Testing of Soils Proposed Suggested Method for Performing the Flat Plate Dilatometer Test
	Lab Testing
D 422-63	Standard Method For Particle Analysis of Soils
D 854-83	Standard Test Method for Specific Gravity of Soils
D 2216-80	Standard Method for Laboratory Determination of Water Content of Soil, Rock, and Soil-Aggregate Mixtures
D 2487-85	Standard Test Method for Classification of Soils for Engineering Purposes
D 4318-84	Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

3.2.1 Drill Rig

A Failing 1250 drill rig mounted on a 1962 International tandem axle prime mover was rented from the H. & E. Corp. of Richmond, Virginia (see Figure 3.1). Standard penetration test equipment, shelby tube sampling, and necessary drilling supplies were supplied with the rig. The rig was oversize for the drilling requirements of the research. However, the 30,000 pound total weight provided necessary reaction for cone and dilatometer testing.

The Failing 1250 is a rotary/mud type drill rig. The drill works and mud pump are powered by the 563 cubic inch gasoline main truck engine through a transfer gearbox. A rotary table at the rear of the rig turns a 3 3/8 inch diameter by 26 foot long kelly, allowing a maximum drill stroke of 21 feet. The 35 foot total mast height and two winch lines make it possible to handle up to 50 feet of drill pipe without laying any on the ground.

The four piston positive displacement mud pump circulated a bentonite slurry drilling mud to flush cuttings from the borehole. A welded metal, portable sump acted as a reservoir for the mud. The sump had three chambers. As the mud circulated from the borehole at one end to the pump suction hose at the other, the cuttings gradually settled from the slurry. The cleaned mud was then pumped back through the kelly to the bottom of the borehole.

3.2.2 Drill Rod

All drilling was done using standard "N" series drill rod. The rod has an outside diameter of 2.375 inches, comes in 10 foot lengths and is joined using three thread per inch pin couplings. Two three foot and one five foot length of rod were also used as needed to adjust the position of the hammer prior to standard penetration testing.

Figure 3.1 Drill Rig and Support Equipment

3.2.3 Drill Bits

Soil conditions were soft enough that all drilling was done with drag type drill bits. The bits were baffled so that drilling mud exited the bit toward the side of the hole. This prevented the drilling mud from eroding the bottom of the borehole ahead of the bit. Borehole size averaged approximately 5 inches. In all cases, the hole was larger than the three inch thin wall shelby tubes used for sampling.

3.2.4 Trailer and Tables

A six by ten foot enclosed single axle trailer was used to carry test equipment that could not be placed on the drill rig. The trailer was equipped with a folding table for the data acquisition equipment during testing. A Honda EM1600X generator supplied power to electrical outlets for the computer, constant voltage power supply, and hand tools as needed. Also included in the support equipment was a trestle table built to a comfortable working height for standing. The table was used for soil sample processing and classification as well as additional working space. A 5 horsepower portable water pump and required hoses was carried to get water for the drilling operation.

3.3 Standard Penetration Testing and Sampling

Equipment used for the drilling, standard penetration testing, and sampling operations were as follows:

3.3.1 Split barrel samplers
3.3.2 Safety hammer
3.3.3 Thin wall tube samplers
3.3.4 300 pound hammer and 3 inch sampler

3.3.1 Split Barrel Samplers

Two split barrel samplers as specified in ASTM D 1586-84 were used for collecting soil samples and recording blow counts (Figure 3.2). The samplers had a 2.00 inch outside diameter with a 1.50 inch inside diameter and a barrel length of 21 inches. A finger type sample retainer was used. The retainer functioned adequately in all soils sampled for this project. Barrel liners were not used.

Using two samplers helped expedite the testing. As one sampler was processed and cleaned, the second was ready for use. Sampling could proceed almost as rapidly as the borehole could be advanced.

3.3.2 Safety Hammer

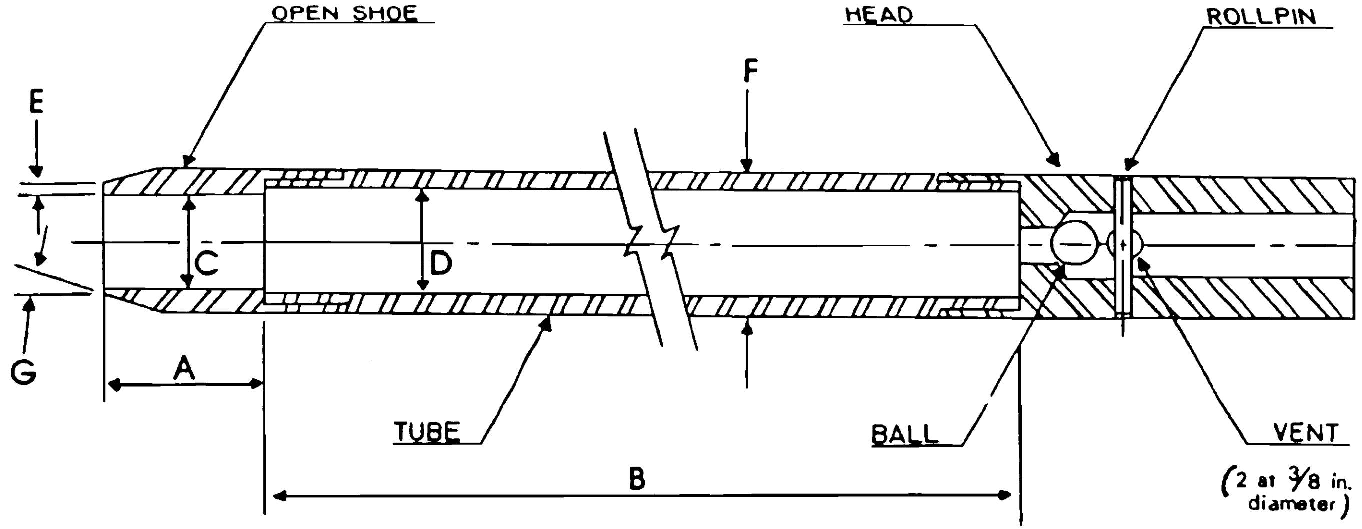
All blow counts and samples were taken using a 140 pound safety hammer as supplied by the H. & E. Corp. The hammer had characteristics designed in accordance with ASTM D 1586. Final hammer weight of 140 pounds was independently certified.

3.3.3 Thin Wall Tube Samplers

Thin wall tube samplers as described in ASTM D 1587 were used to obtain undisturbed samples for lab testing. The 3 inch O.D. tubes were advanced with an attachment head that screwed to the bottom of the drill string. The tube samplers were retained to the head by four 3/8 inch hex head set screws.

3.3.4 300 Pound Hammer and 3 Inch Sampler

This sampler and hammer system is normally used in cases where a driven sample is to be obtained in stiff or gravelly soils. For this work it was used as a means of opening the hole for pressuremeter tests in the residual soils and stiff



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 − 0.00 in. (38.1 ± 1.3 − 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 − 0.00 in. (50.8 ± 1.3 − 0.0 mm)
G = 16.0° to 23.0°

The 1½ in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retainers may be used to retain soil samples.

Figure 3.2 Split Spoon Sampler Diagram

clays. The size of the hole opened by this sampler is only 0.25 inches (3mm) larger than that of the diameter of the pressuremeter with its membrane on. The large safety hammer and samplers were obtained from the Ohio River District of the U.S. Corps of Engineers. No attempt was made to calibrate the large hammer as it exceeded the capacity of the tester. Otherwise the same procedures were used as for the 140 pound hammer and 2 inch sampler.

3.4 Hammer Calibration

Calibration techniques were used for the SPT apparatus to determine as accurately as possible how much energy was delivered to the sampler. The calibration was performed according to ASTM Standard D 4633-86 using a Binary Instruments, Inc. Model 102 calibrator as rented from G.P.E., Inc. of Gainesville, Florida. The system consists of a 40,000 pound capacity dynamic load cell and electronic instrumentation to interpret the load cell data. The load cell is mounted immediately below the hammer and in line with the drill rod. As the hammer falls, a force level of 3,000 pounds triggers the electronics to begin recording the hammer blow. Maximum force is approximately 20,000 pounds. As the force returns to zero, recording stops and the energy efficiency and duration of the blow are displayed.

As a check on the operation of the system, a series of "cut string" or free fall hammer tests were performed. These tests indicated that the system was indicating average efficiencies of 117%. After consultation with G.P.E., Inc. it was determined that final calibration results could be scaled by a factor of 100%/117% or 85%.

Best calibration results are obtained when the total length of the drill string exceeds 40 feet. For shorter lengths the return of the first compression pulse from the sampler artificially shortens the measured duration of the hammer blow. Using data from 57 calibrations of rod strings longer than 40 feet the average efficiency of the hammer was found to be 50%. This includes the correction from the "cut string" tests.

The average efficiency usually reported for a safety hammer is 60% (Seed and Idriss, 1982). The calibration results indicate a slightly lower value for the system used in this research which is attributable to the 35 foot height of the drill rig mast. The rope length used for the hammer is approximately 80 feet as compared with 20 to 30 feet for a "normal" standard penetration test setup. It appears that the inertia of the additional rope length used in the high mast reduced the hammer efficiency.

3.5 Testing Procedure

Standard exploratory drilling procedure was used for soil sampling, standard penetration testing, and thin wall tube sampling. Drilling and SPT sampling are covered under ASTM D 1586, and ASTM D 1587 covers thin wall tube sampling.

At the start of testing, the rig was leveled, the mast raised, and the mud sump positioned under the back of the rig. Using the 5 horsepower portable water pump and three 55 gallon drums in the back of a pickup truck, water was hauled to the rig. Available surface water was used whenever possible. An initial load of 150 gallons of water was mixed with 100 pounds of commercially available bentonite drilling mud. Drilling began when the mud had mixed thoroughly.

The hole was drilled to an initial depth of 1.5 feet. This ensured that the mud sump sealed to the ground and that drilling fluid was returning. Starting at 1.5 feet standard penetration tests and soil samples were taken continuously to

45 feet. A SPT was run, the hole was advanced through that test area, drilling stopped, and another test run. Split barrel samplers were alternated so a clean one was always ready for use.

Samples were stored in freezer strength "ziploc" plastic bags. The entire sample from each test was retained. Sample bags were marked with the boring number, depth, blow count, and date, and stored by boring in a larger plastic bag.

Site stratigraphy was developed from the first hole at each site. A second borehole was then made to get additional SPT data and take thin wall tube samples from layers of interest. To obtain tube samples the tube push head with tube replaced the drill bit. Usually the weight of the kelly was sufficient to push the sampler, but if this was not the case, the rig's hydraulic down pressure was used. After allowing the sampler to hold in place for approximately 10 minutes, it was rotated twice and withdrawn. The ends were then sealed with wax, plastic end caps, and duct tape.

3.6 Cone Penetration Testing

The equipment used for cone penetration testing was as follows:

3.6.1 Cone penetrometer and cable
3.6.2 Data acquisition system
3.6.3 Depth measurement
3.6.4 Cone rods
3.6.5 Push-pull assembly

3.6.1 Cone Penetrometer and Cable

All cone testing was performed using a standard electric resistance cone manufactured by Fugro, Inc. A typical electric cone penetrometer is shown in

Figure 3.3. The five ton capacity cone measured tip resistance and sleeve friction. Cone tip area was 10 cm^2 with a sleeve area of 142 cm^2. Three pairs of the wires exited the cone. One pair supplied the 10 volt power signal, the second carried the tip resistance data, and the third monitored the sleeve friction.

The cone connected to the data acquisition system using a ten wire cable as supplied by Hogentogler, Inc. The cable was similar in appearance to a yellow heavy duty extension cord. Approximately 140 feet of cable length was used. This provided adequate slack for rod handling and positioning the data acquisition system safely.

3.6.2 Data Acquisition System

The data acquisition system was built around a Toshiba Model 3100 portable computer. Because the basic computer chassis has no slot for additional computer cards, a Toshiba Model PA7310U/E expansion chassis was acquired.

A MetraByte Corporation DAS 8 data acquisition and control interface card converted the analog signal from the cone to digital information to be stored in the computer. A MetraByte EXP-16 universal expansion interface read the three channels of data from the DAS 8 and transferred them to the computer.

The data acquisition was controlled by software written by Dr. T.L. Brandon of Virginia Tech. The program recorded initial data for each test, graphically displayed the test in progress, and recorded the data as an ASCII file at the completion of testing.

3.6.3 Depth Measurement

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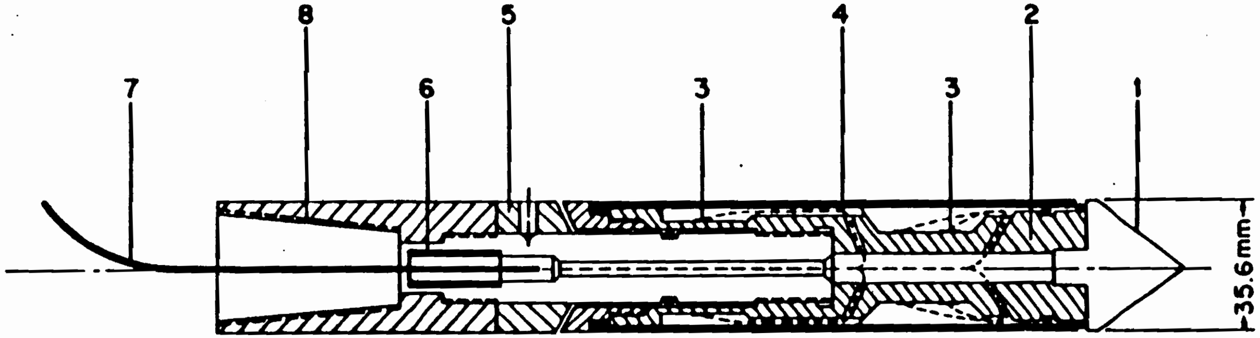


1 Conical point (10 cm^2)
2 Load cell
3 Strain gages
4 Friction sleeve (150 cm^2)
5 Adjustment ring
6 Waterproof bushing
7 Cable
8 Connection with rods

Figure 3.3 Cone Penetrometer Diagram

Martin (1990) developed a magnetic trigger to signal the data acquisition system to take a reading and this system was used for the present work. As the cone test advanced readings were made approximately every centimeter. A manual switch disabled the depth ticker to allow for rod additions.

3.6.4 Cone Rods

Seventeen one meter (39.3 inch) sections of standard cone rod were purchased from Hogentogler for a previous project (Martin, 1990). The rod has an outside diameter of 1.40 inches and an inside diameter of 0.875 inches. Ends are taper threaded in a standard cone rod thread allowing faster rod assembly.

A wheeled rod rack was developed for this project. The rod rack with the pre-strung cable was secured at the front of the trailer for travel and for convenience during other work. For cone testing the rods were moved to the rear of the trailer for easy handling.

3.6.5 Push-Pull Assembly

For research in 1988, Mr. H. Hamilton of the H. & E. Corp. and Virginia Tech personnel developed a special bracket to push the cone with the Failing 1250 drill rig (Martin, 1990). The bracket was needed because it was not possible to push the cone in line with the kelly. The bracket mounted an NW box thread six inches away from the kelly. Attached to the NW thread were cone rod thread adapters supplied by Hogentogler, Inc.

An eighteen inch long piece of schedule 80 steel pipe was split lengthwise. Flanges were welded along the split with holes for four 3/4 inch bolts per side. Three semicircular stiffeners on each section of pipe supported the flanges. Plates welded along the centerline of one pipe section extended sufficiently to attach the NW box thread adapter. Arms stabilized the bracket against the drill rig mast to prevent its twisting under load. Eighty grit abrasive screen was inserted between the bracket and the kelly to ensure good grip. With the Hogentogler assembly in place, the cone rod then cleared the back of the rotary table. A stabilizer mounted to the rotary table reduced unsupported rod length to prevent buckling.

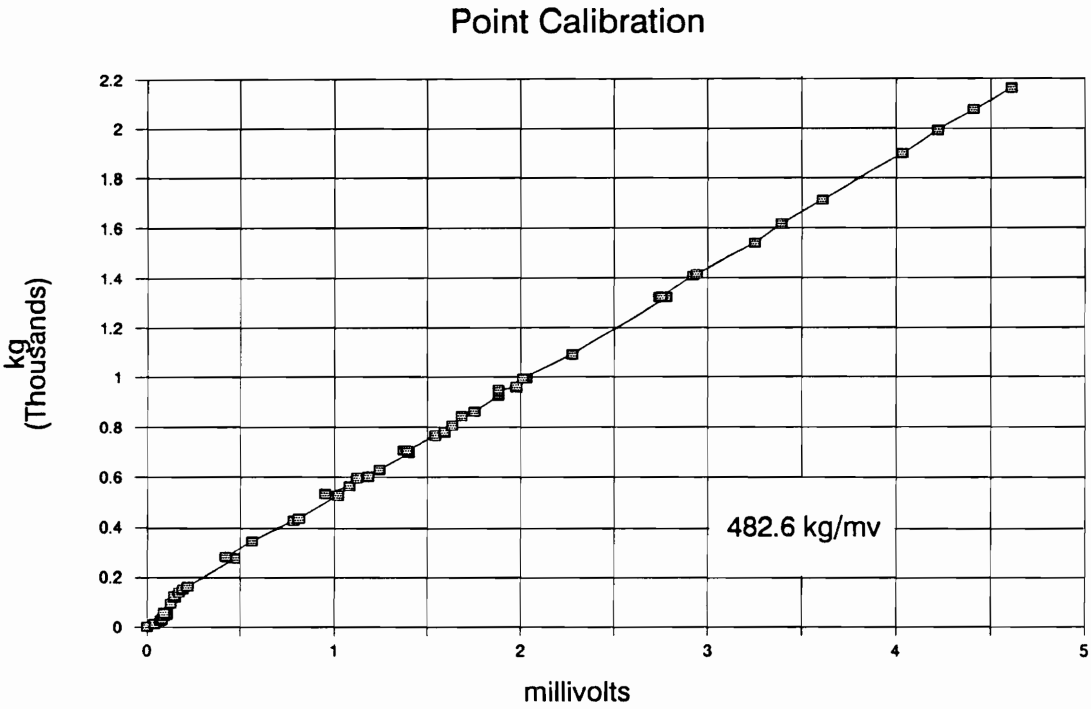
3.7 Cone Calibration

Prior to field testing the cone was calibrated to find the appropriate load/voltage values of the tip and sleeve. Calibration was performed on an MTS machine located in the Geotechnical laboratory of Virginia Tech. Using a 5000 pound Hottinger Baldwin Measurement, Inc. load cell various loads were applied to the tip or sleeve, and load and voltage were recorded for each increment. A line of best fit was then fitted to the data with the slope being the calibration factor. Calibration for the tip was 482.6 kg/mv with the sleeve at 117.0 kg/mv. The calibration curves are shown in Figure 3.4.

3.8 Cone Test Procedure

Cone penetration testing was conducted in accordance with ASTM D3441-79 as it applies to an electric penetrometer. At the start of testing, the rig was positioned and the mast raised. The rear of the rig was leveled, raised and blocked so that the weight of the rear axles hung from the frame of the rig, which added to the available reaction for cone testing.

The cone was attached to the first two sections of rod and buried in the ground. While the cone reached a stable temperature, the bracket was attached to the kelly. The depth ticker was fastened to the mast and its string clipped to



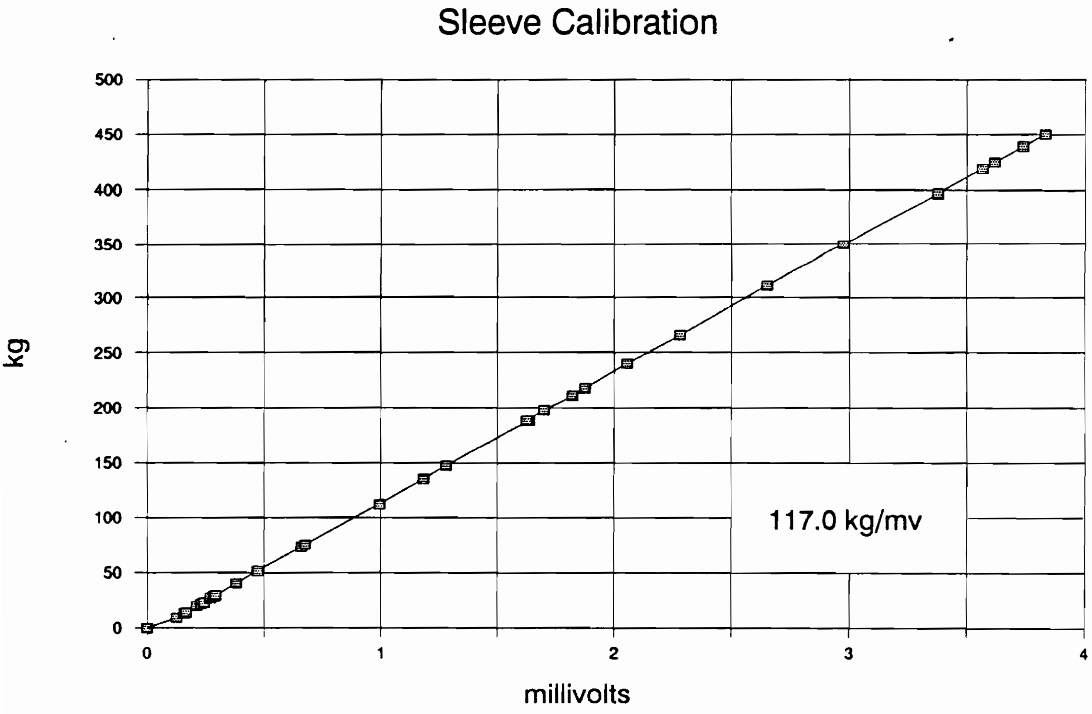


Figure 3.4 Cone Penetrometer Calibrations

the bracket. The data acquisition system was started and checked for proper operation. The system was powered by the Honda EM1600X generator. After the cone temperature stabilized it was supported unloaded and the tip and sleeve channels zeroed.

The cone was placed through the stabilizer, fitted into the push socket on the bracket and the tip placed on the ground surface. The cone was then advanced in one meter increments at a rate of 2 cm. per second. The rate was set using the hand throttle at the rear of the drill rig. As each section of cone rod was added, the data acquisition system was stopped and started using the manual switch on the depth ticker.

Whenever possible cone tests were carried to the limit of the available rods. Soil conditions occasionally prevented reaching the full depth of 45 feet. The rig operator watched the graphical test display to avoid overloading the cone. At full depth the test was stopped and the test data recorded to a computer disk.

For cone removal, the pull fixtures were attached to the bracket and the cone withdrawn from the ground. It was possible to extract the rod in two meter lengths, speeding up the operation. The rods were then stacked in the rack for storage.

3.9 Dilatometer Testing

The equipment used for dilatometer testing was as follows:

3.9.1 Dilatometer blades and accessories

3.9.2 Dual gage control unit

3.9.3 Load cell

3.9.1 Dilatometer Blades and Accessories

A complete, production dilatometer set was purchased from G.P.E., Inc. for use in this project. The design and operation of the dilatometer is as explained in Chapter II. The contents of the production package are as follows:

2-high strength stainless steel blades
1-dual gage control unit
20-high strength membranes
2-standard cables, 18m & 34m
2-extendable 24m cables
1-nitrogen regulator with tubing
1-40cf nitrogen tank
1-electrical ground cable
1-CPT rod adaptor
1-N rod adaptor
2-CPT rod slotted couplers
1-box of tools & spare parts

The contents of the set were designed well. During two months of field testing everything needed for dilatometer testing and repair was found in the materials supplied.

3.9.2 Dual Gage Control Unit

The control unit supplied for this testing was the first one that had been produced to incorporate a gage minder and separate low pressure gage in one unit. The minder served to automatically shut off a gage that is used to monitor the pressures during the test that are in the low pressure range (0-10 kPa).

Previously the low pressure gage had to be disconnected manually during testing when pressures exceeded 10 kPa.

3.9.3 Load Cell

The thrust acting to push the dilatometer can be used with the other dilatometer information to calculate the friction angle of a cohesionless soil. In the conventional practice the thrust is measured at the top of the rod and rod friction is estimated and subtracted from the total. This process leaves much to be desired. For this project a load cell was designed to measure thrust immediately behind the dilatometer blade.

The load cell was derived from plans supplied by Professor J.K. Mitchell and his graduate student T. Massood, of the University of California at Berkeley. After modifying the plans to simplify production, the cell was produced by the Virginia Tech Civil Engineering Department Shop. PH 17-4 stainless steel was used and given a H-900 heat treatment after machining. This material provided a good mix between ultimate strength and toughness. Details of the load cell are shown in Figure 3.5.

Strain gages were attached to allow direct reading of the load applied to the cell and the strain induced in the measurement module. MicroMeasurements type WA-06-125TB-350 gages were attached with A-610 glue.

Data acquisition was accomplished for the dilatometer using the same system used for the cone penetrometer. Two channels monitored the cell output and the depth ticker. Dr. T.L. Brandon supplied a program to automatically record load cell data and to manually record the dilatometer sounding data as each test was run.

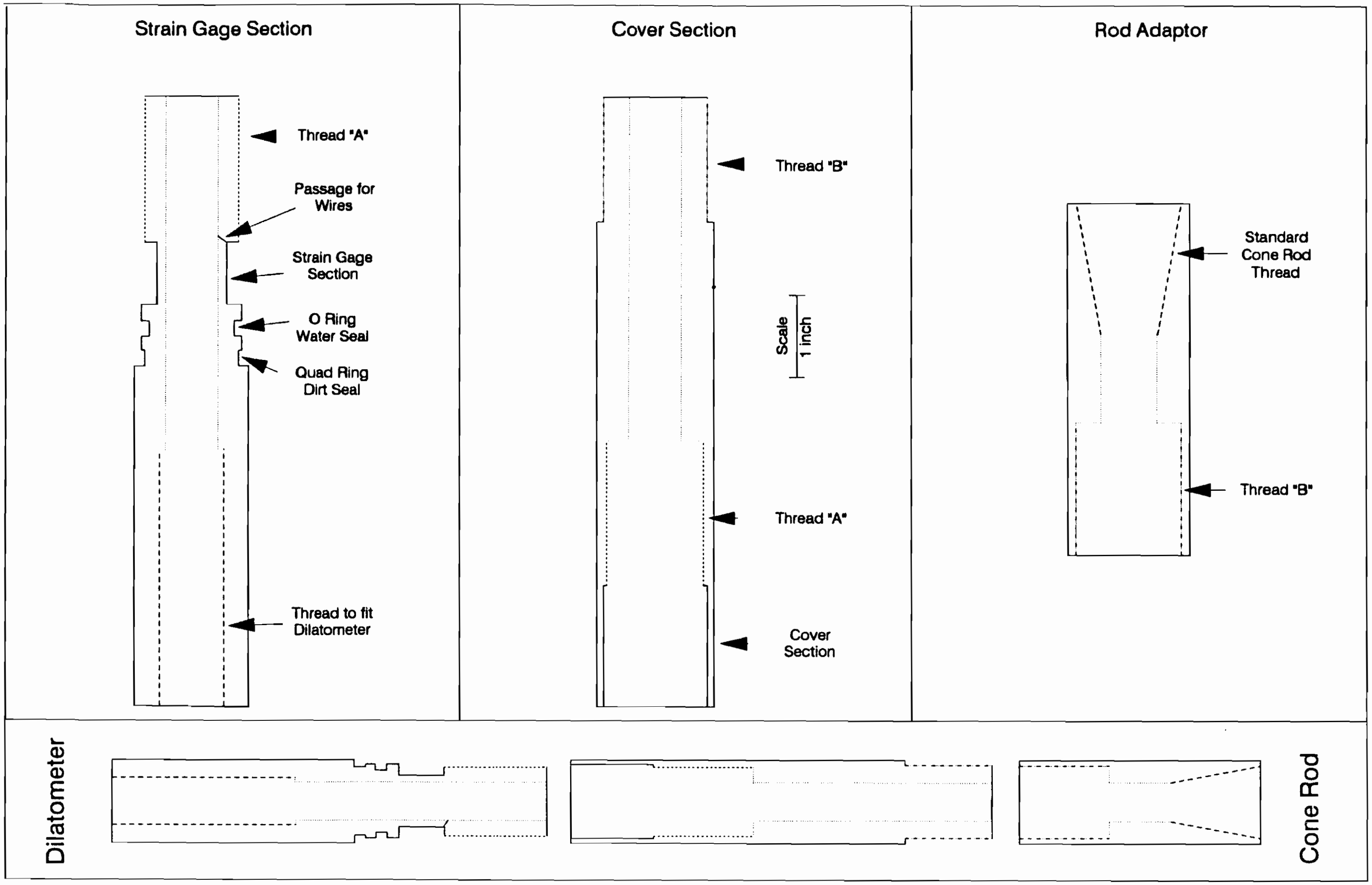


Figure 3.5 Dilatometer Load Cell

3.10 Dilatometer Calibration

The dilatometer load cell calibration was performed in the same manner as described for the cone penetrometer. Results are shown in Figure 3.6. The constant for the cell was 655.1 lb/mv.

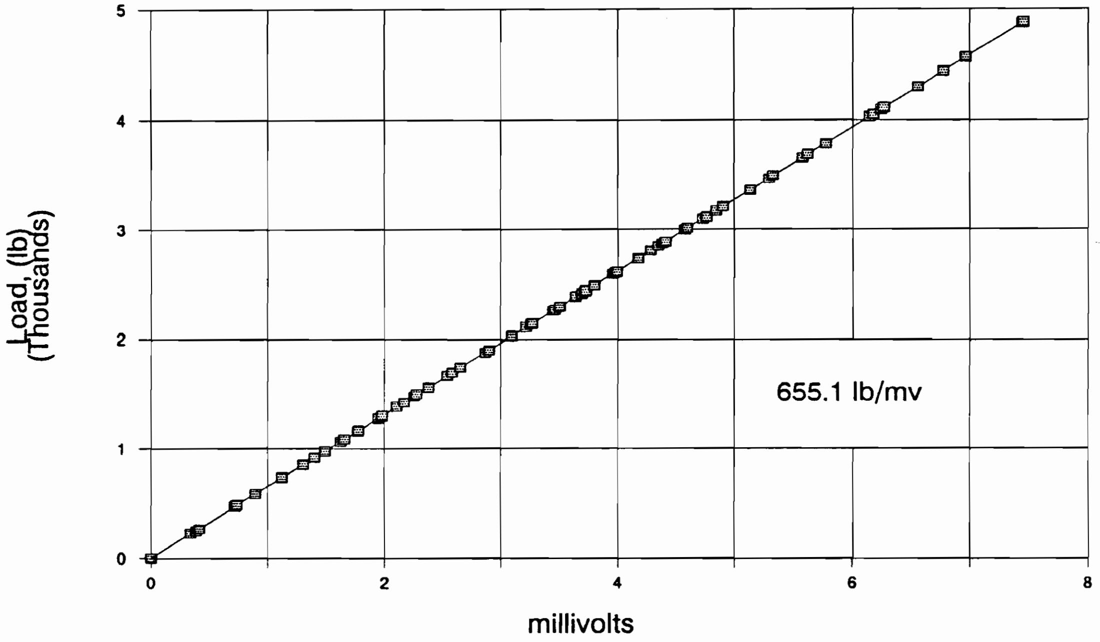
3.11 Dilatometer Test Procedure

Dilatometer testing consists of inserting the probe to the desired depth, stopping to take the A, B, and C readings as described in Chapter II, and advancing to the next test depth. The procedure for using the drill rig and dilatometer are identical to those described for the cone penetrometer. The dilatometer pneumatic electric cable replaces the cone cable in the rods. The large portable table was placed next to the driller's station to hold the dilatometer control panel.

To initiate the test, the blade was attached to the rods, gas supply connections are made, and membrane calibrations were checked. The dilatometer was then placed in the rod stabilizer and inserted into the push bracket. Load was applied until the membrane center was at the ground surface. From this reference location one foot depth reference marks were chalked on the rods.

DMT readings were made in one foot increments. As a chalked depth mark reached the ground surface penetration was stopped. The kelly was raised to unload the rod string and the operator shifted from the rig controls to the DMT control panel on the table next to the rig. The DMT procedure calls for the A reading to be obtained within 15 to 30 seconds after advance stops. The B reading should follow within another 15 to 30 seconds. The operator called out the readings to an assistant who recorded them into the computer or onto a data

Original Calibration



Calibration After Repair

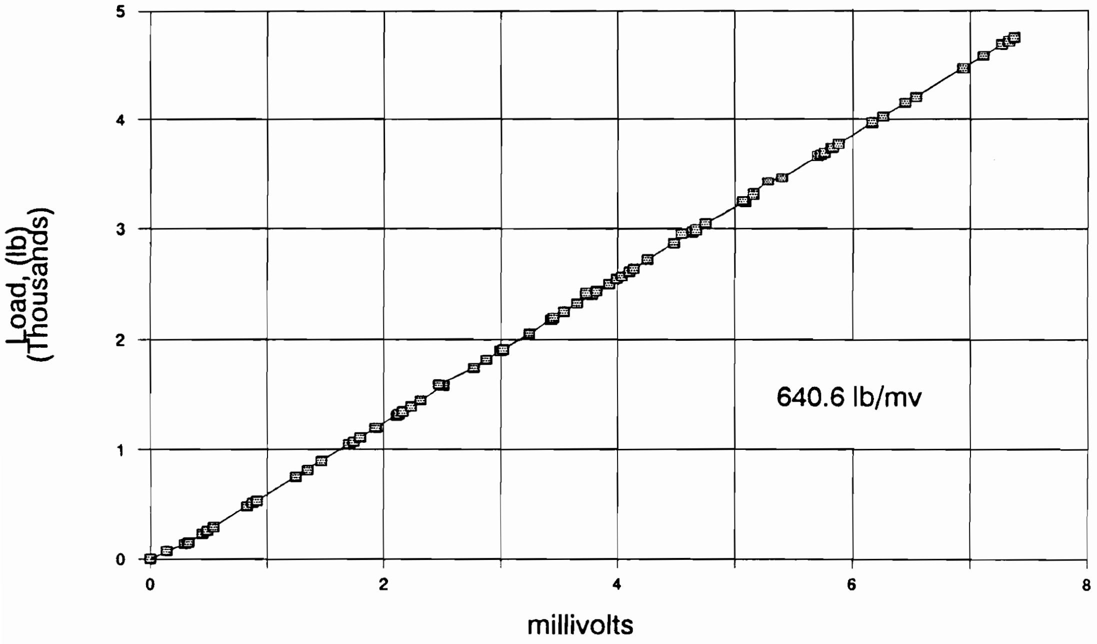


Figure 3.6 Dilatometer Load Cell Calibrations

form. The sequence was the repeated each foot. Available rod length limited test depth to 45 feet.

Once the load cell and computer data acquisition system was developed preliminary tests were run at the Kipp's Farm site near Virginia Tech. The residual soil at this site is stiff, and on the second sounding the load cell bent and had to be repaired and recalibrated. Results of the recalibration are also shown in Figure 3.6. Thereafter, the load cell was only used for soils where penetration resistances were within the acceptable limit. This limited its use to one site at which cohesionless soils were found, the Carmel Church site.

3.12 Pressuremeter Testing

Details of the pressuremeter equipment are given by Pappas (1990). This instrument is a one-of-a-kind device and was developed to allow it to be used in self-boring or pre-boring modes. However, self-boring in stiff soil is slow and inefficient, and not all of the data obtained is needed for transmission tower foundation design. In this effort testing concentrated use in the pre-boring mode. At two of the test sites self boring pressuremeter test results were available from previous investigations, allowing for a comparison to the data obtained using the more practical methods applied in this work.

For this research the instrument was used only in holes that were opened by driving a spoon sampler which created holes that were only 0.25 inches larger than the pressuremeter diameter. For reasons explained in Section 2.6.1, it was thought that even with the disturbance created by opening the hole that the soil modulus and strength could be reasonably estimated from the test results. Equipment used includes:

3.12.1 Pressuremeter

3.12.2 Data acquisition

3.12.3 Casing

3.12.4 Pressuremeter protection

3.12.5 Control panel

3.12.1 Pressuremeter

The pressuremeter was designed at Virginia Tech in 1986, and fabricated by the firm Cambridge Insitu for use on another project. A combined pressure and data cable connects the pressuremeter to both the control panel and the data acquisition system. The pressuremeter (see Figure 3.7, Pappas, 1990) is a hollow rigid cylinder 60 inches long and 2.75 inches in diameter. The body consists of an electronics section and a strain arm and membrane section. The membrane is approximately 15 inches long and mounts flush with the outside of the cylinder. Beneath the membrane are nine strain arms arranged in three levels with the arms spaced 120^{o} apart. As the membrane expands the arms follow the interior and measure membrane displacement. In the electronics section are a 16 channel analog multiplexer and 8 bit microprocessor. The electronics convert the strain arm and total pressure cell data to a digital signal for transmission through a shielded cable to a portable computer. Digitizing the data downhole provides a clean signal with minimal chance of a disruption from outside interference.

3.12.2 Data acquisition

Data from the strain arms and pressure cell are converted to a digital signal by a circuit board contained in the probe, and the signal is transmitted up the cable to the serial port of a computer. The computer used for the CPT and DMT was also used for this testing, with simple modification. The expansion chassis

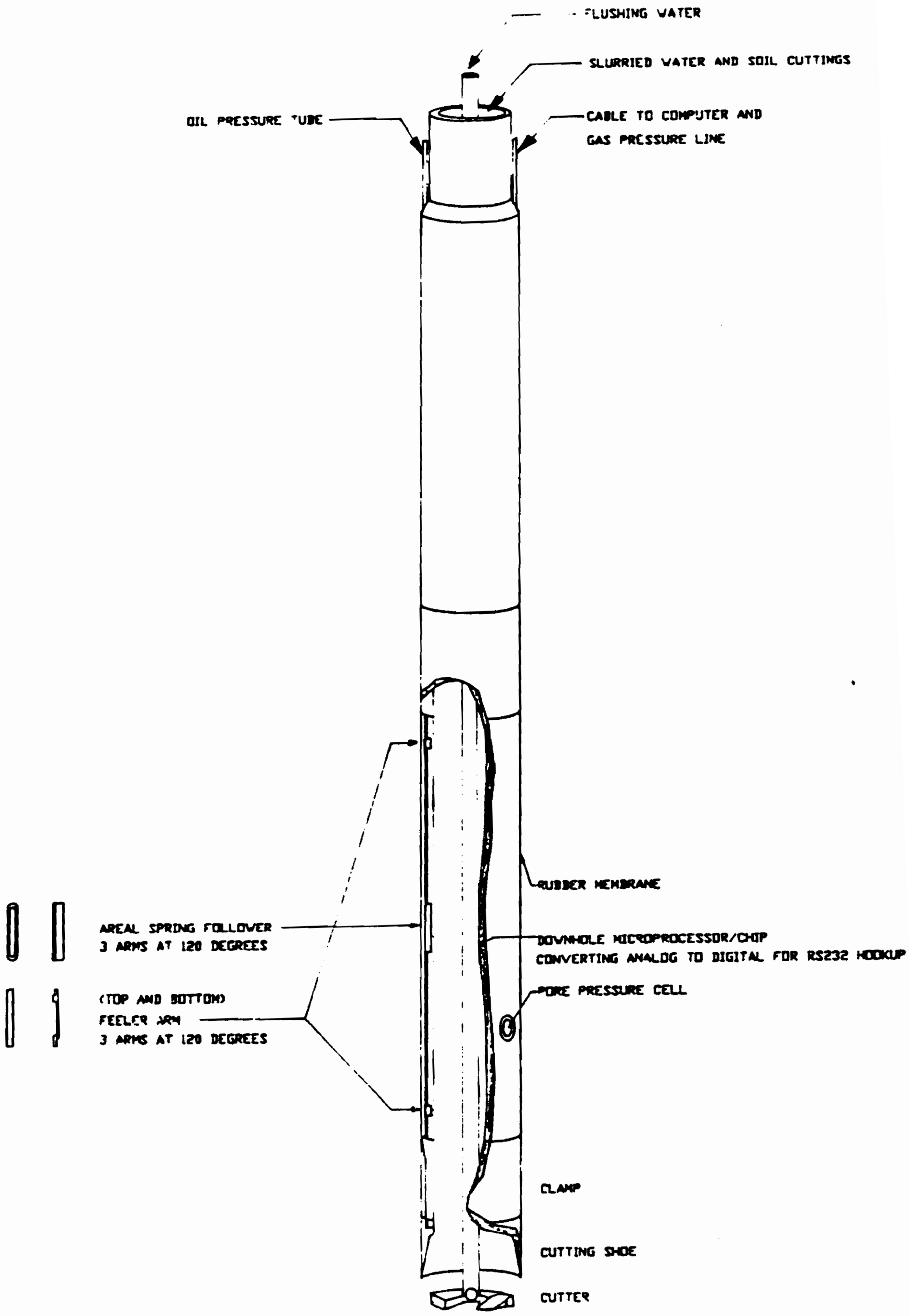


Figure 3.7 Pressuremeter Diagram

containing the EXP-16 and DAS-8 cards was omitted from the system and data were read directly from the RS232 serial port of the Toshiba 3100. A software package developed by Dr. T.L. Brandon was used to monitor the ten channels of data obtained during a test, and displayed the test results graphically while recording the data to a disk.

3.12.3 Casing

The pressuremeter was inserted using standard EX drill casing screwed to the top of the probe. The casing has an outside diameter of 1.5 inches and came in five foot lengths. Sections were added as needed to reach the test depth.

3.12.4 Pressuremeter Protection

The pressuremeter membrane can be inadvertently damaged during preliminary operations before it is placed into the ground. To minimize this possibility, a protective cover was made, consisting of a five foot length of standard 4 inch schedule 40 PVC pipe capped with an end cap. The pressuremeter was kept in the pipe during setup.

3.12.5 Control Panel

The pressuremeter test was controlled using a two gage control panel. A needle valve allowed nitrogen to be introduced to the probe at a controlled rate. The panel had low and high pressure gages to monitor the pressure. From 0 to 100 psi. the low gage was used. At 100 psi. this gage was manually isolated to prevent its being damaged. Further testing was controlled with a 0 to 500 psi. gage. A ball valve allowed for the rapid release of pressure if necessary.

3.13 Pressuremeter Calibration

There are two separate types of calibration needed for the pressuremeter. After repair or disassembly the nine strain arms and the pressure cell must be recalibrated. Every several tests or after a membrane change, membrane stiffness is recorded.

Calibration of the strain arms is performed without the membrane in place. A micrometer is mounted over each strain arm to be calibrated. As the arm is displaced a known amount the voltage reading for the arm's strain gages is recorded. A straight line fit is used to find the constant for each arm.

After replacing the membrane, the same general procedure is repeated for the pressure cell calibration. A protective cover is placed over the PMT to limit membrane expansion. Then an external pressure gage is used to apply pressure in known increments. The output of the total pressure cell is read and the constant determined.

To account for the membrane stiffness, the pressuremeter is inflated in air. The data acquisition system records the movements of the nine arms and the pressure. These values give the amount of test stiffness in soil that is attributable to the membrane and not soil response.

3.14 Test procedure

The first step involved starting the data acquisition system and conducting a membrane calibration. This not only provided a needed calibration, but also assured that the system was working properly. Next, the hole was opened using the 3 inch driven sampler. To open the test hole the drill rig was prepared as described for standard penetration testing. The same drilling procedures were used as with the SPT, although the hole for the pressuremeter was made with the

3 inch sampler and the 300 pound hammer. It was necessary to conduct two tests in succession to open a three foot hole to completely cover the membrane. After the second sampler was inserted it was left in place until the pressuremeter was removed from the protective cover and suspended from one of the winches. As rapidly as possible the sampler was removed and the probe lowered into the hole. This process was found necessary to minimize the possibility of hole collapse or partial hole closure in some of the overconsolidated clay deposits. The hole would occasionally swell closed sufficiently that it was necessary to use the kelly to firmly seat the pressuremeter.

The pressuremeter work was focused towards a determination of the unload-reload modulus values of the soil. In this process pressure was increased at approximately 0.5 psi. per minute to a value of 50 psi. At this point, the pressure was reduced to 25 psi. and thence increased back to 50 psi. Pressure was varied at approximately 1 psi per minute during the unloading and reloading. Additional loops were run in 50 psi. increments up to the 8mm. expansion limit of the membrane. The maximum pressure was released at 1 psi. per minute to obtain a final unload curve.

3.15 Laboratory Testing

Laboratory tests were performed to help in classifying soil types at the test sites and to determine the mechanical properties of those soils. Testing was conducted in accordance with the applicable ASTM specifications and results are reported in Chapter V. The following lab tests were conducted:

3.15.1 Moisture content determination

3.15.2 Grain size analysis

3.15.3 Atterberg limits

3.15.4 Soils classification

3.15.1 Moisture Content Determination

A soon as possible after sample extraction, all SPT samples were tested for moisture content. A representative portion of each sample was weighed, placed in a 105^{o} C oven overnight, and weighed again after drying, allowing calculation of the moisture content.

3.15.2 Grain Size Analysis

Grain size analyses, including hydrometer testing, were performed on all samples retrieved from one boring at each site. Samples were first soaked overnight in a dispersant solution and then subjected to a 24 hour hydrometer analysis to determine the distribution of particles finer than the #200 sieve. After completion of the hydrometer analysis, the samples were washed over the #200 sieve and the portion retained was dried and weighed. Finally, a mechanical sieve analysis was conducted on the material retained on the #200 sieve.

In order to complete calculations for the hydrometer analysis portion of the grain size analysis it was also necessary to determine the specific gravity of the soil samples. Representative samples of the strata identified from the boring logs were tested and the specific gravity data were then used to complete reduction of the grain size analyses.

3.15.3 Atterberg Limits

Split spoon samples were also used to determine Atterberg limits. Each sample was tested to determine if the soil was plastic, and if so to develop the Atterberg limits data.

3.15.4 Soils Classification

After completing the lab testing, the test data were combined with the field boring logs to classify the soil samples. Classification was done in accordance with ASTM D 2487-85, Standard Test Method for Classification of Soils for Engineering Purposes, which mirrors the Unified Soils Classification System.

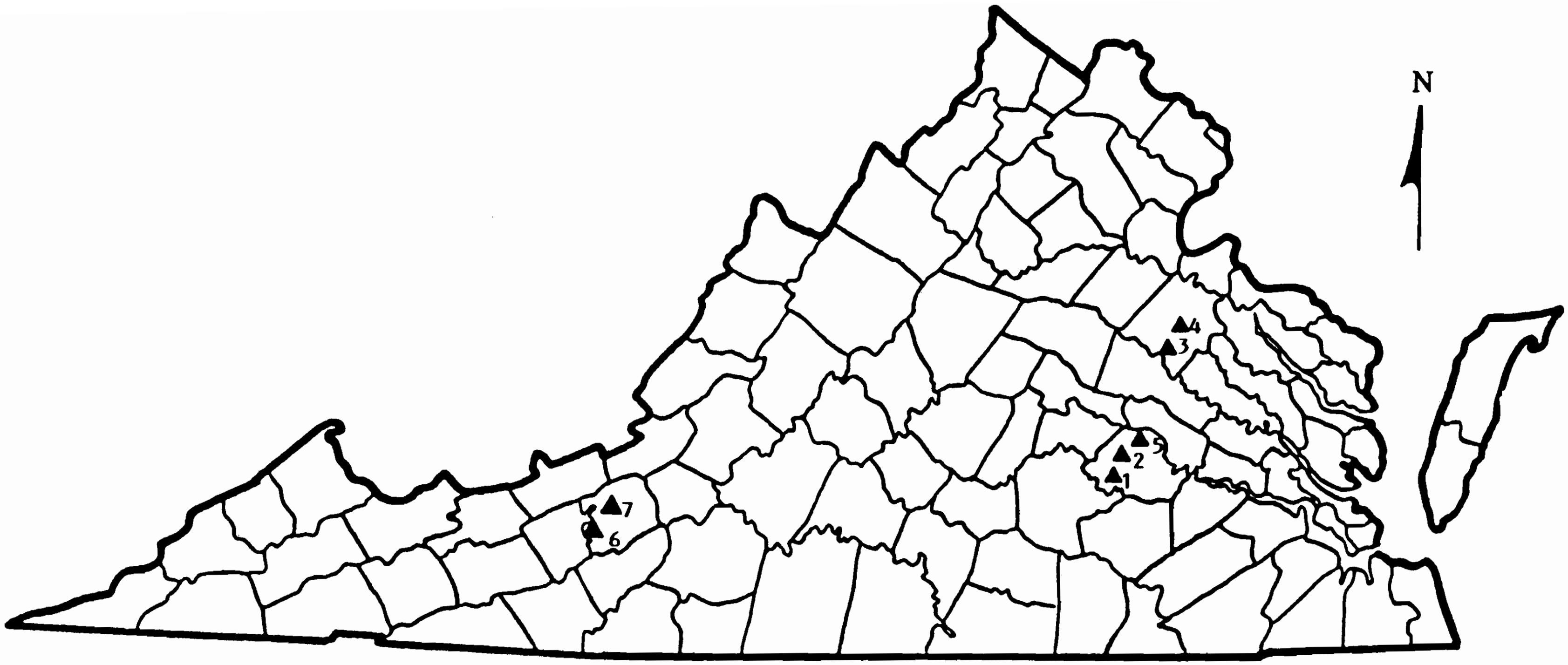
Chapter IV

SITE LOCATIONS AND CHARACTERISTICS

4.1 Introduction

The service territory of Virginia Power stretches from the Valley of Virginia eastward across the mountains and piedmont to the Atlantic coastal plain. Soil conditions span the full range from residual soils over limestone in the valley to coastal marine deposits. The seven test sites covered the full range of foundation construction conditions encountered in these different environments.

This chapter gives the location and background on the soil conditions at each of the seven sites investigated. The soil conditions at the sites fall into three categories; alluvial soils, marine silt/clay deposits, and residual soils. Four of the sites are located on Virginia Power rights of way. The other three sites were chosen in view of: (1) soil conditions that fit the profile of other Virginia Power sites; (2) the availability of data that could be used to characterize the soils; and (3) the availability of alternative forms of insitu test data. In each case, the latter three sites had been subject to previous testing by investigators from the geotechnical program of Virginia Tech. The previous testing served to provide useful data for comparison to this investigation, and increased efficiency since most of the elementary classification work had been completed. Figure 4.1 shows the seven site locations on a map of Virginia. Details of the soil conditions are given in Chapter VI.



1. Winterpock
2. Plantation Pipeline
3. Carmel Church
4. Ladysmith
5. Schnabel
6. Pepper's Ferry
7. Kip's Farm

Figure 4.1 Test Site Locations

4.2 Alluvial Soil Sites

The Pepper's Ferry and Carmel Church sites contain young alluvial deposits. The Pepper's Ferry site near Radford, Va. borders the New River and consists of flood plain deposits. The Carmel Church site north of Richmond, Va. is an alluvially deposited coastal plain sand.

4.2.1 Pepper's Ferry

The Pepper's Ferry site is located on the Radford North, Va. 7.5 minute quadrangle map. Testing was done in a pasture in the north west corner of the intersection of state Route 114 and the New River. The town of Centerville is 1 mile to the north east, and Radford is 2.5 miles south west of the field. Figure 4.2 shows the site location.

The soils are alluvial in nature and were derived from the New River. The test location, a terrace approximately 20 feet above the river level, contains soils consisting of dark brown sandy clay flood plain deposits with some mica content. Bedrock is 20 to 25 feet below the ground surface, and the groundwater table is found at a depth of 12 feet. No references were found concerning the geology of the site.

Virginia Tech has had an ongoing test program at the site due to its convenience to the school and unusual soil conditions. The alluvial soils contrast with the predominant residual soil found in the Blacksburg area.

4.2.2 Carmel Church

The Carmel Church site was chosen as representative of the alluvially deposited sands found in the coastal plain of Virginia. The site is located on the Ruther Glen, Va. 7.5 minute quadrangle map 1.8 miles south east of Ruther Glen.

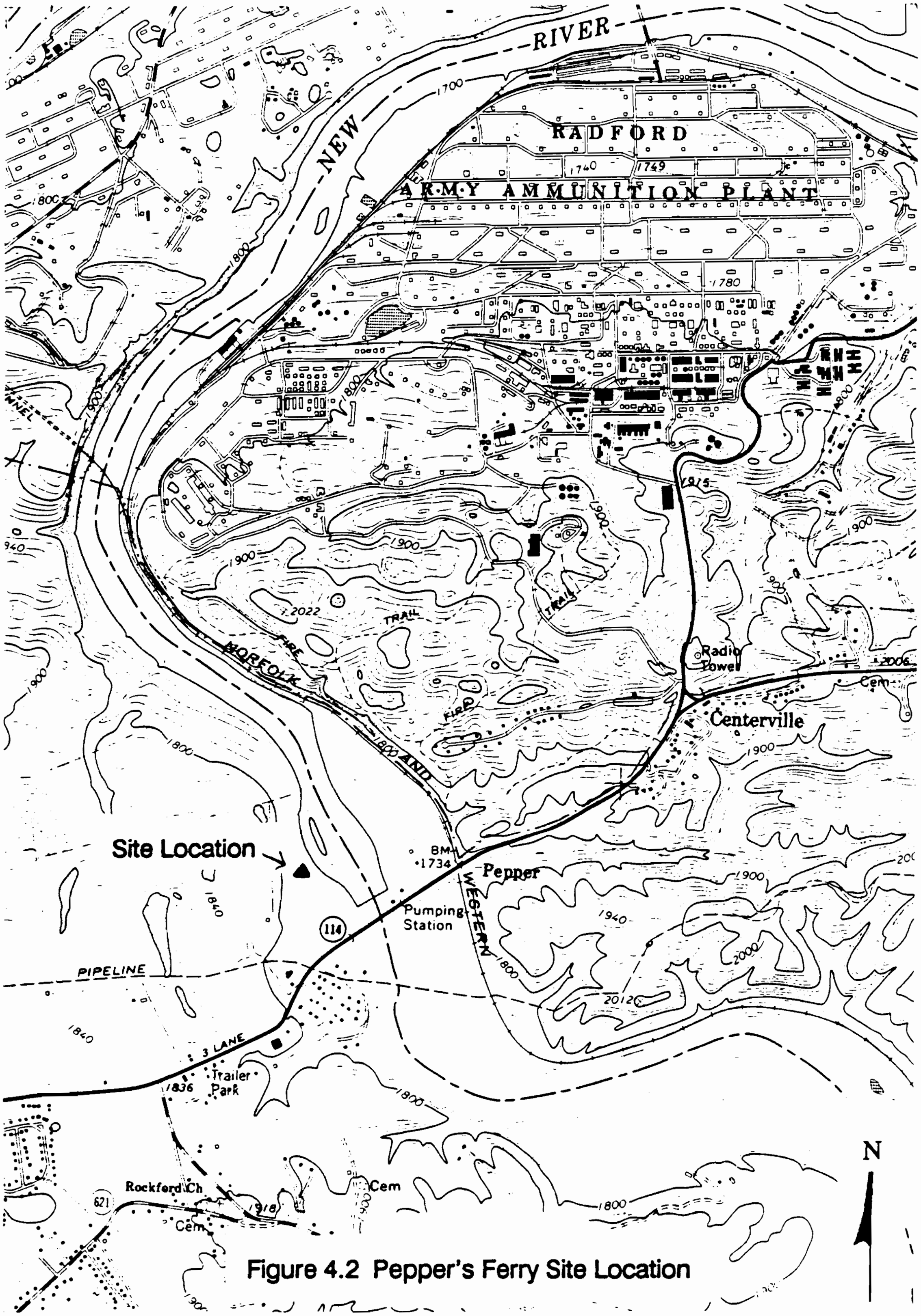


Figure 4.2 Pepper's Ferry Site Location

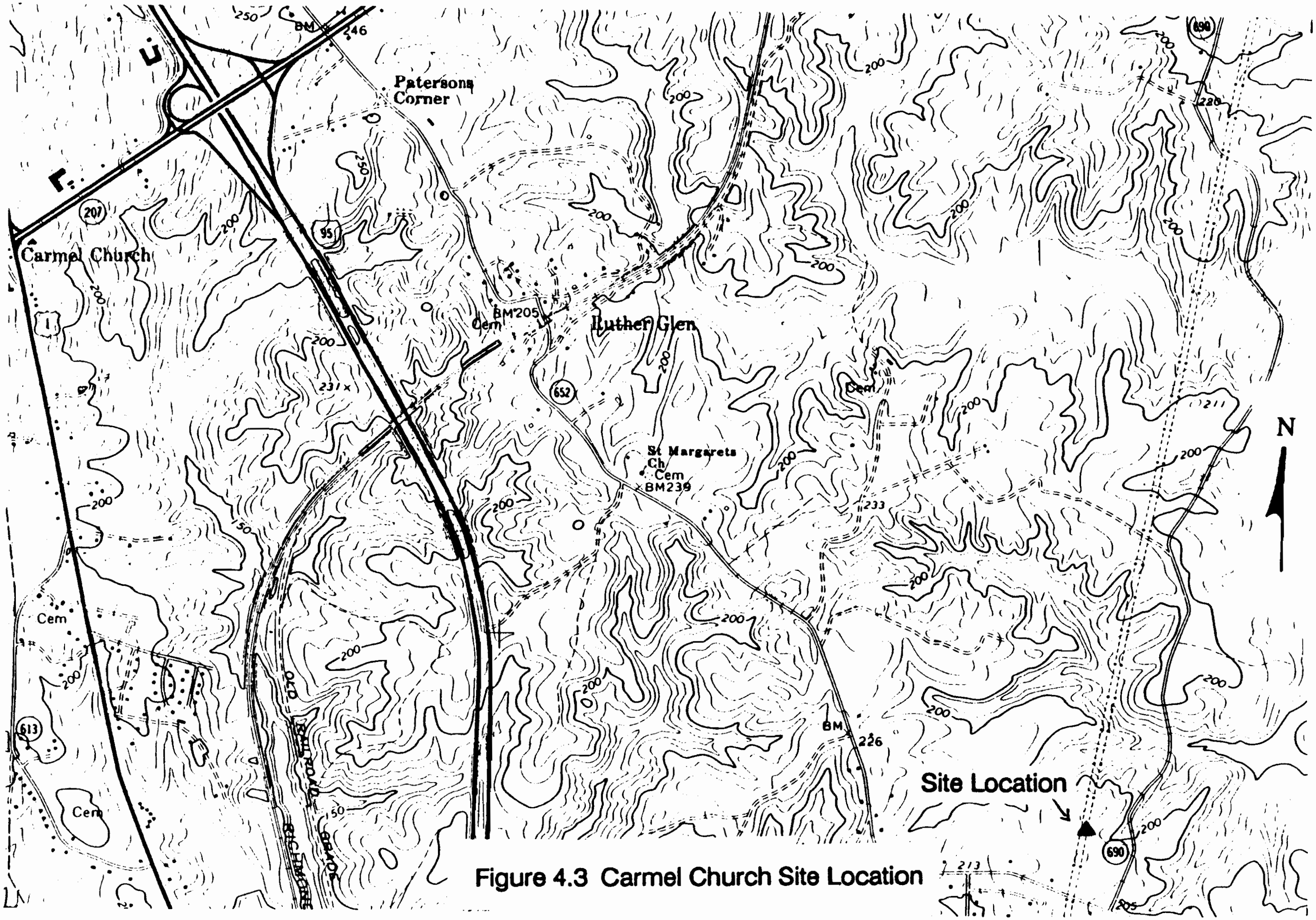


Figure 4.3 Carmel Church Site Location

As shown in Figure 4.3, the site location is approximately 30 miles due north of Richmond, Va. The Carmel Church exit is the nearest access from Interstate 95 to the site.

Testing was done on the right of way of the existing Virginia Power Fredricksburg to Elmont transmission line. The test area lies on a bluff above a tributary of Reedy Creek. The entire area is a series of sandy ridges cut by small streams forming drainage channels. Soils are clayey sands grading to sands that extend below the depth of this exploration. The water table at this site was approximately 31 feet below the ground surface. Again, no published geologic data was found for the site.

4.3 Marine Deposits

Two test locations are underlain by over consolidated marine clays. The first of these is on the grounds of Schnabel Engineering Associates in Richmond Va. and is identified as the Schnabel site. The area is underlain by a Miocene clay that has been studied previously by several groups. This soil is important to foundation design in Richmond in that it forms the primary bearing layer for piles and piers for larger buildings in Richmond.

The second marine clay site is the Ladysmith test area located in an area of abandoned gravel pits bordering the South River. A layer of sand and gravel covers a deposit of overconsolidated clay. Material properties for the marine clay are similar to those at the Schnabel site.

4.3.1 Schnabel Site

The Schnabel site is located in the parking lot of Schnabel Engineering Assoc. in Richmond, Va. The tests were conducted approximately 100 feet north east of the corner of Canal and Foushee Street (see Figure 4.4).

The Miocene clay that is found at this site underlies much of Richmond. General studies of the clay have been reported by Casagrande (1965) and Martin and Drahos (1986). The clay is stiff and overconsolidated and classifies as a CL to CH material by the Unified Soil Classification System. It has unique characteristics in that it is sensitive and shows only a few isolated slickensides. It was the sensitivity that first brought it to the attention of Casagrande. Foundation design in the clay had been traditionally conservative and based on SPT blow counts. The blow counts were very low for such a stiff material, and it was Casagrande who pointed out that it was due to the sensitivity of the clay, which fell in the range of 2 to 10. Casagrande was able to show that more reasonable design methods could be attained if proper testing procedures were used. Pressuremeter testing of the clay and field observations of foundation performance as reported by Martin and Drahos (1986) confirmed Casagrande's hypothesis.

More recently, work in the Miocene has been performed by Virginia Tech, with a major portion of the effort directed at the Schnabel site (Mayu, 1987; Lien, 1990). This work reported overconsolidation ratio values from 2.8 to 5.0, and undrained shear strength values raning from 2 to 5 bars. Excavation for the parking lot brought the ground surface down to seven feet above the Miocene clay, allowing easy access for testing. The groundwater table is approximately 10 feet below the surface.

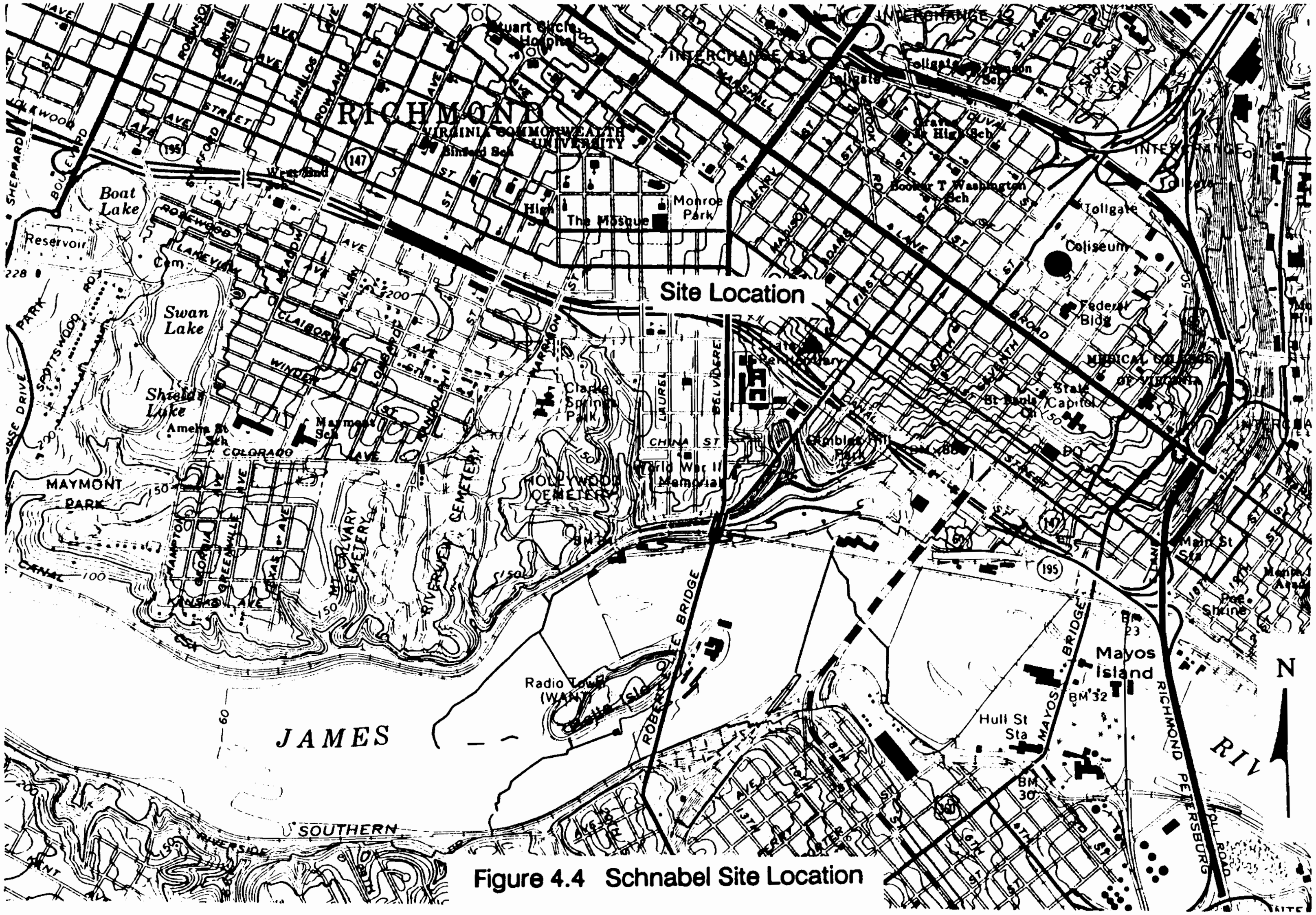


Figure 4.4 Schnabel Site Location

4.3.2 Ladysmith

The Ladysmith site is located on the Woodford, Va. 7.5 minute quadrangle map off of state Route 638. St. Johns Church, the nearest landmark of any size, is 1.4 miles south. Richmond is approximately 38 miles south as indicated in the location map shown on Figure 4.5. The site name was taken from the nearest exit off Interstate 95.

The test area is in the flood plain of the South River, east of the fall line. Testing was done in a grassed area bordering a man-made pond. Soil conditions are characterized by alluvial sand and gravel deposits over marine clays. There are several abandoned gravel pits within a mile of the site. The clay deposit at this site exhibits characteristics similar to the Calvert formation at the Schnabel site. However, no published geologic information could be found describing the Ladysmith site. The water table was 2 feet below the ground surface.

4.4 Residual Soils

Much of Virginia Power's service territory is underlain by residual soils. Three test locations were chosen as representative of these soils, with sites located in the Valley of Virginia and the piedmont. The Kipp's Farm site near Blacksburg has residual sandy silts or clays over a limestone bedrock. The Plantation Pipeline and Winterpock Tap sites near Richmond have sandy silt soils formed from the weathering of a micaceous schist parent rock.

4.4.1 Kipp's Farm

The Kipp's Farm site is located approximately three miles south west of Blacksburg on state Route 657, and consists of a grassed knoll in a pasture. Figure 4.6 shows the location of the site on a portion of the Blacksburg, Va. quad

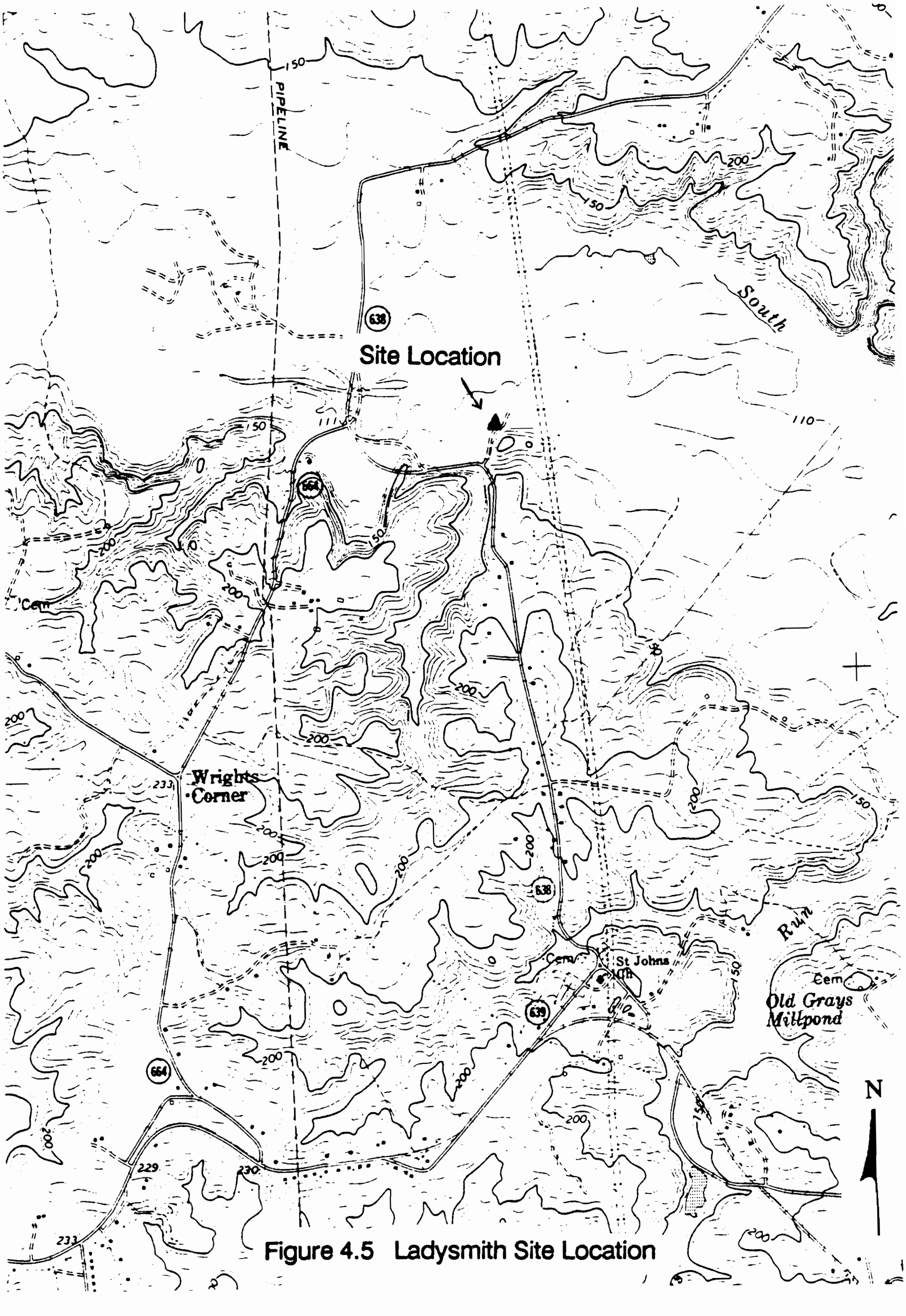


Figure 4.5 Ladysmith Site Location

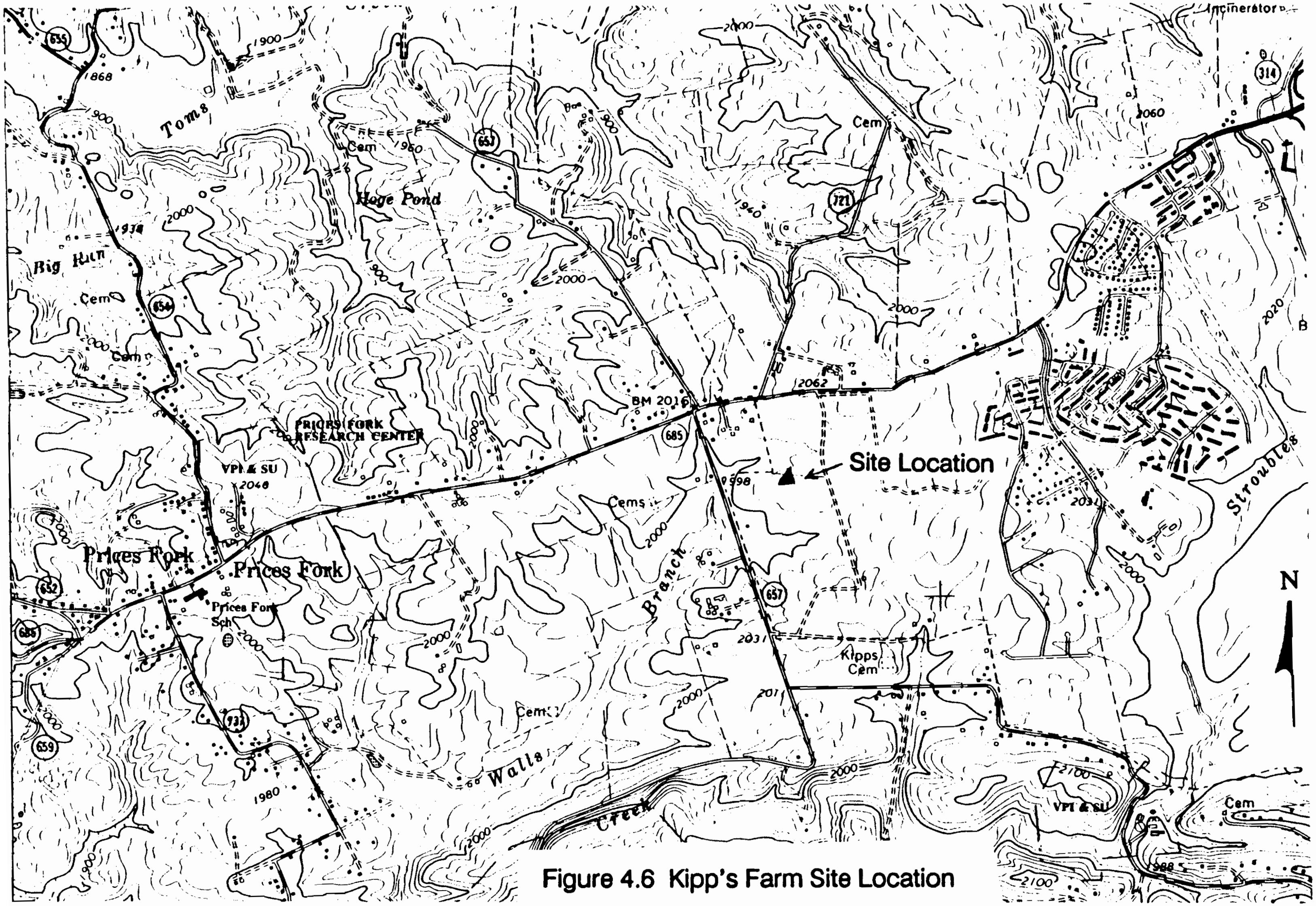


Figure 4.6 Kipp's Farm Site Location

map. A considerable amount of information is available for this site from the work of Pappas (1990) and Mayu (1987).

The Kipp's Farm soils were formed by the in place weathering of the parent rock and are mainly high plastic silts and silty sands. The underlying bedrock is a Cambrian age dolomite interbedded with layers of quartzose sand. The rock depth varied from 20 to 36 feet within the 150 foot long test area. Groundwater was found at a depth of 23 feet during the testing.

4.4.2 Plantation Pipeline and Winterpock Tap

Both the Plantation Pipeline and Winterpock Tap sites are located on the Hallsboro, Va. quad map approximately 14 miles south west of Richmond, Va (see Figures 4.7 and 4.8). The sites were chosen to represent different strength levels of the same piedmont residual soils. Test areas were located on the right of way of Virginia Power's Winterpock Tap Transmission line. The line was under construction at the time of testing. The Plantation Pipeline site is north of Route 360 along Route 604. The Winterpock Tap site is south of 360 off of Route 654.

Both sites were on the tops of small knolls overlooking the drainage of Swift Creek. Soils at the sites are sandy silts formed by the in place weathering of the parent micaceous schist. Weathering had progressed further at the Plantation Pipeline site than at the Winterpock Tap site, leading to both softer and siltier soils. Groundwater depth is 8.0 feet at the Plantation Pipeline site and 16.0 feet at Winterpock Tap.

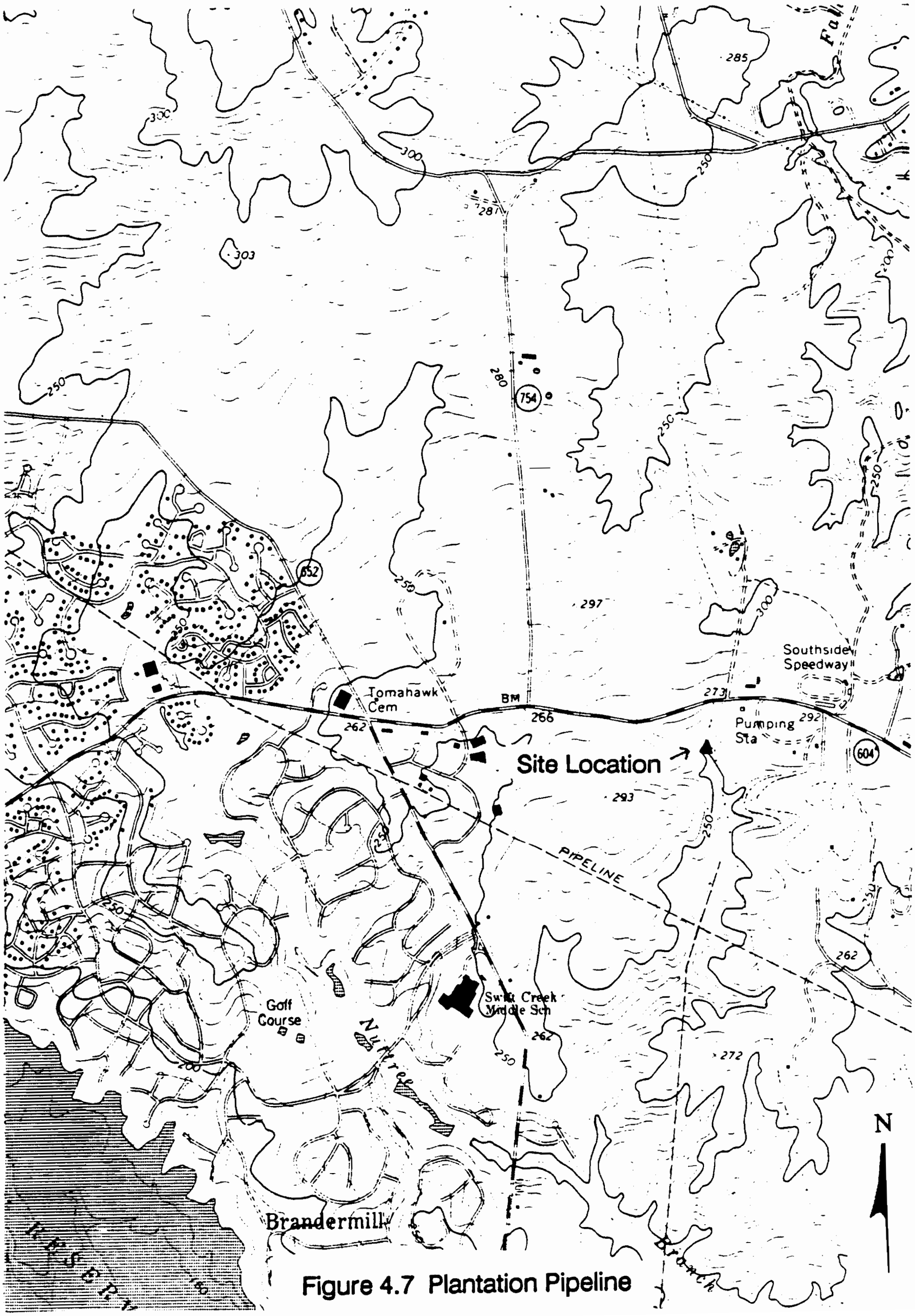


Figure 4.7 Plantation Pipeline

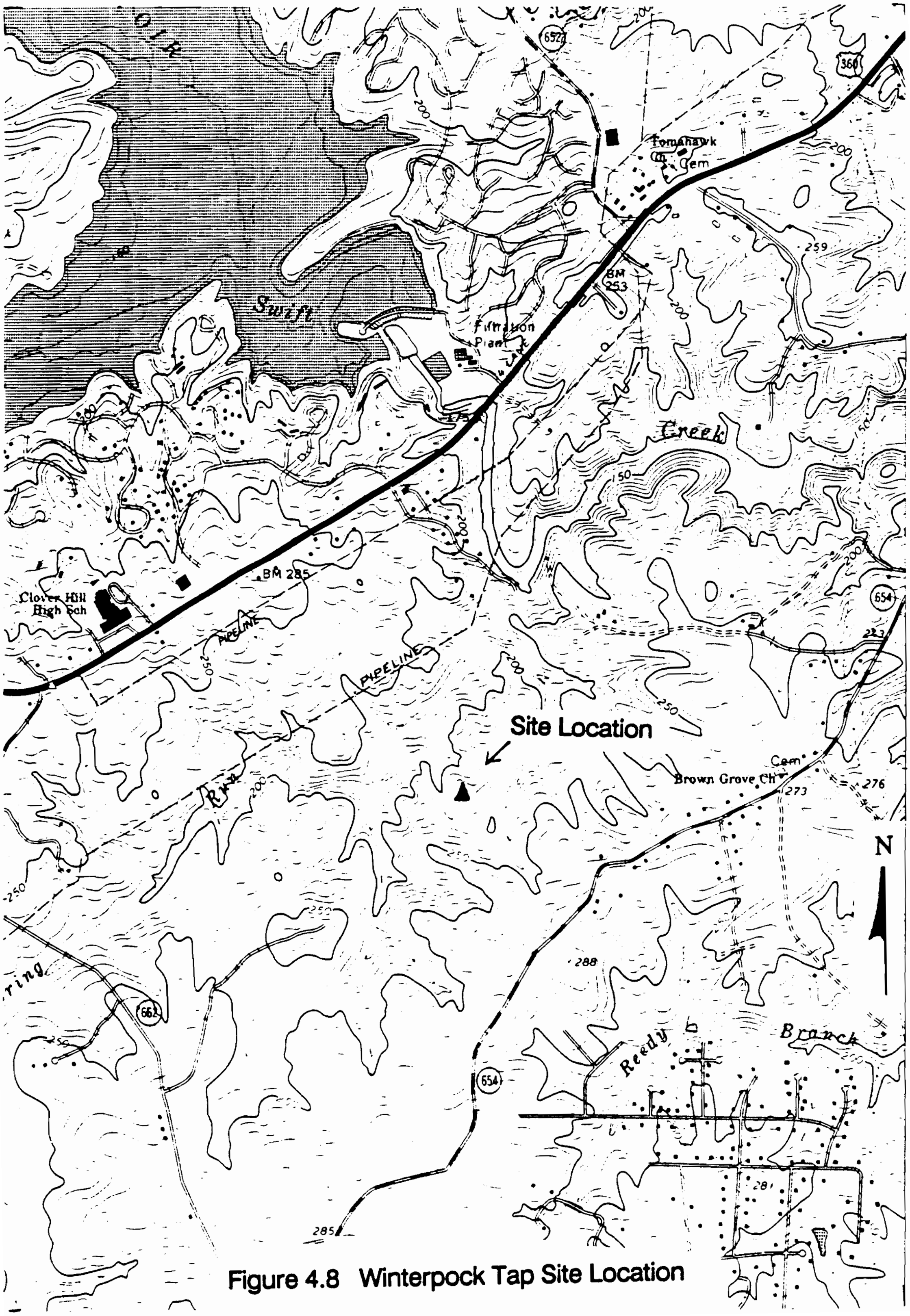


Figure 4.8 Winterpock Tap Site Location

Chapter V

TESTING PROGRAM AND RESULTS

5.1 Introduction

The first stage of the field work was performed in April and May of 1989. Preliminary field data reduction was conducted as the investigation progressed. When necessary to verify questionable results, additional testing was included in the second phase of the work performed in August and September of 1989. Full reduction of the data was begun at the completion of the field testing.

The field testing program served three purposes: (1) to provide data for each in-situ test at each site, (2) to collect soil samples for lab testing, and (3) to provide comparative test duration information. Tests were performed on a ten foot square grid system in order to minimize soil condition variation between individual holes without having the zone of influence of each test overlap. When additional tests were necessary to verify previous results grid spacing was reduced to five feet.

Moisture contents were determined on the SPT samples as soon as possible after extraction. The full lab test series was begun upon completion of field testing, with grain size determinations, hydrometer analysis, Atterberg limits, and specific gravity determinations being performed.

Details of the field and laboratory tests are presented in this chapter. With the volume of data generated as much information as possible is presented graphically. In addition to the visual presentation, a discussion of the soil conditions and test results at each site is included. Also discussed are any peculiarities encountered during testing at the sites; difficulties in drilling, sampling, penetration testing or probe advance.

5.2 Data Reduction Methods

To obtain maximum utility from the information collected while reducing the volume to manageable proportions, several approaches were employed depending on the specific test. Discussion of the methods is presented as follows:

5.2.1 Standard penetration testing
5.2.2 Cone penetration testing
5.2.3 Dilatometer soundings
5.2.4 Pressuremeter tests
5.2.5 Lab test results

5.2.1 Standard Penetration Testing

General practice for the contractors providing drilling services for Virginia Power is to present SPT data as recorded. The data is not normalized and no energy correction is required to N_{60} as safety hammers are used. The same approach is followed in this chapter.

The samples from one boring at each site were classified according to ASTM D 2487-85 to provide soil type information. The N_{60} data for each boring at a site were plotted against depth. Different symbols were used to distinguish between the 140# hammer/ 2 inch sampler borings for soil sample collection and the 300# hammer/ 3 inch sampler holes for pressuremeter testing. For use in developing correlations in Chapter VI, N_{60} data was converted to the normalized or N_{160} blow count. Each data point was used; no attempt was made to average blow counts among the borings at a site.

5.2.2 Cone Penetration Testing

As with the blow counts, cone tip resistance (Q_C) and friction ratio (f_r) in this chapter are presented as recorded and plotted against depth. As applicable, the recorded Q_c as normalized to $Q_{c,1}$ for use in Chapter VI.

With three to five cone tests at each site and with data recorded at three hundredths of a foot intervals, the volume of information is large. To arrive at a useful representation of the cone results at a site, the tests were averaged to produce one test record for use in comparisons. Information from the averaged record was also used with the soil classification chart as shown in Figure 2.1 to arrive at soil types from the CPT data.

The data are presented in two forms. To illustrate the variability or consistency at a site all cone results are plotted in superposition. Also shown is the average result used for calculations. If a site was heterogeneous it was possible to revert to the single closest cone result for comparison to other tests.

5.2.3 Dilatometer Soundings

As with the cone, dilatometer sounding records at each site were averaged to produce a representative record for the site. Dilatometer modulus (ED) was plotted versus depth in both superimposed and averaged forms to represent the DMT results at each location.

The DMT data reduction program provides a soil classification as part of the output. This classification is determined using the calculated value of the material index (ID) for each test increment. The average value of ID at each depth was used to provide soil classifications.

5.2.4 Pressuremeter Tests

Pressuremeter test results were reduced to arrive at a single value of the unload-reload modulus (G_{ur}) at each test depth. Data from the nine arms of the pressuremeter were averaged to produce one value of G_{ur} for each unload/reload loop and the final unload curve. These values were then combined into a single modulus value and plotted against depth.

One of the advantages of the pressuremeter is the large test footprint as compared to the other test methods. Testing a larger area integrates the results over an area the size of the membrane, minimizing the effects of local variations in soil properties. The data reduction approach employed makes full use of this aspect of pressuremeter testing.

5.2.5 Lab Test Results

The lab test results appear in two forms. The individual results are presented as a chart of the Atterberg limits, percent passing the #200 sieve, D_{50}, and coefficient of uniformity (C_u) plotted with depth. For each sample tested the Atterberg limits are also shown on the plasticity chart.

The results were also instrumental in determining the soil classifications under ASTM D 2487-85 and therefore appear indirectly in the table of soil identifications for each test location. These data provide the control values for comparison to the indirect soil identifications from the CPT and DMT.

5.3 Alluvial Soil Sites

The field and lab test results at both the Pepper's Ferry and Carmel Church sites were consistent within the site. Results of the testing at the alluvial soil sites are discussed in the following order:

5.3.1 Pepper's Ferry

Testing was conducted on the standard ten foot grid at this site with no need for additional tests. Two SPT borings, three cone tests and three DMT soundings were completed. No pressuremeter tests were attempted. Details of the field and lab testing are listed in Table 5.1, with test locations as indicated in Figure 5.1.

A soil profile as derived from the SPT holes showed a relatively simple site stratigraphy (Figure 5.2). The top five feet of the Pepper's Ferry site consisted of brown silty sand. This changed at five feet to a clay with sand and mica that continues downward to approximately 18 feet. At 18 feet a one to three foot thick layer of sand and gravel overlay the rock surface which varied from 18.5 to 23 feet within the test area. Blow counts were in the range of 10 blows per foot in the upper 10 feet and fall below 10 from 10 to 12 feet. In the lower portions of the profile the blow counts reached 20 blows per foot.

Although no pressuremeter testing was performed at Pepper's Ferry, the other three in-situ tests mirrored the same soil penetration resistance/stiffness and classification profile. SPT, CPT, and DMT results consistently showed the top five feet of silty sand as denser than the underlying clay (Figures 5.3 to 5.7). The tests also reflected a decrease in clay stiffness with depth until it began to increase slightly at the top of the sand and gravel layer found above bedrock.

Lab testing for this site was performed by Castro (1989) and consisted of 18 moisture content determinations, 22 grain size analyses and 18 Atterberg limit determinations (Figures 5.8 and 5.9). Soil identifications made from the lab tests, CPT, and DMT are given in Table 5.2. The classifications from the SPT samples and lab testing were consistent with data from the CPT, although the CPT allowed for finer distinctions than the lab classifications. However, the DMT identified the clay with sand layer as a sandy silt. The Atterberg limits for this soil plot immediately above the A line dividing silt from clay. This suggests that the break point between sandy silt and silty clay for the DMT identification needs further calibration.

Soil conditions at the Pepper's Ferry site were sufficiently soft or loose that no difficulty was encountered in the testing program. All testing was terminated on bedrock, which was encountered at depths from 18 to 21 feet. Dilatometer sounding PFD-1 appeared to encounter a depression in the bedrock and advanced to a depth of 23 feet. The dilatometer data indicated that the materials in the pocket were extremely soft.

Table 5.1
Pepper's Ferry Site Testing Program

Field Testing

Test no.	Depth ft.	Samples/ readings	Duration hr.	Comment
Borings				
PFB-1	20.5	12	2.5	rock @ 20.5 ft.
PFB-2	19.5	10	2.0	rock @ 19.5 ft.
Cone Penetration Tests				
PFC-1	18.2	n/a	0.5	rock @ 18.2 ft.
PFC-2	19.8	n/a	0.5	rock @ 19.8 ft.
PFC-3	19.1	n/a	0.5	rock @ 19.1 ft.
Dilatometer Soundings				
PFD-1	19.0	19	0.6	
PFD-2	23.0	22	0.9	
PFD-3	18.5	19	0.7	

Laboratory Testing

Moisture Content	Specific Gravity	Gr size w/hyd	Atterberg Limits
18	1	22	18

(lab testing for this site performed by Castro (1989))

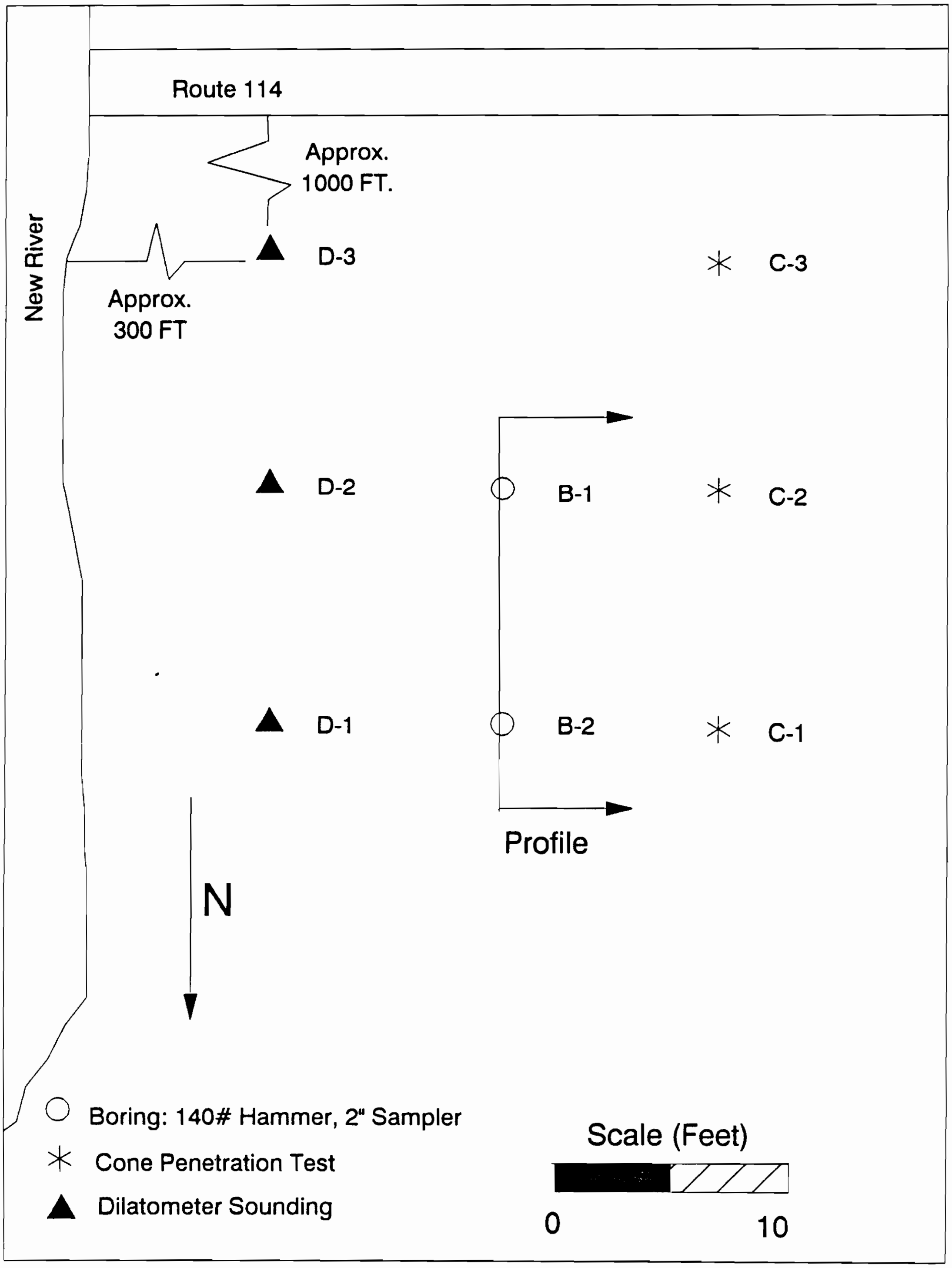


Figure 5.1 Pepper's Ferry Test Location Map

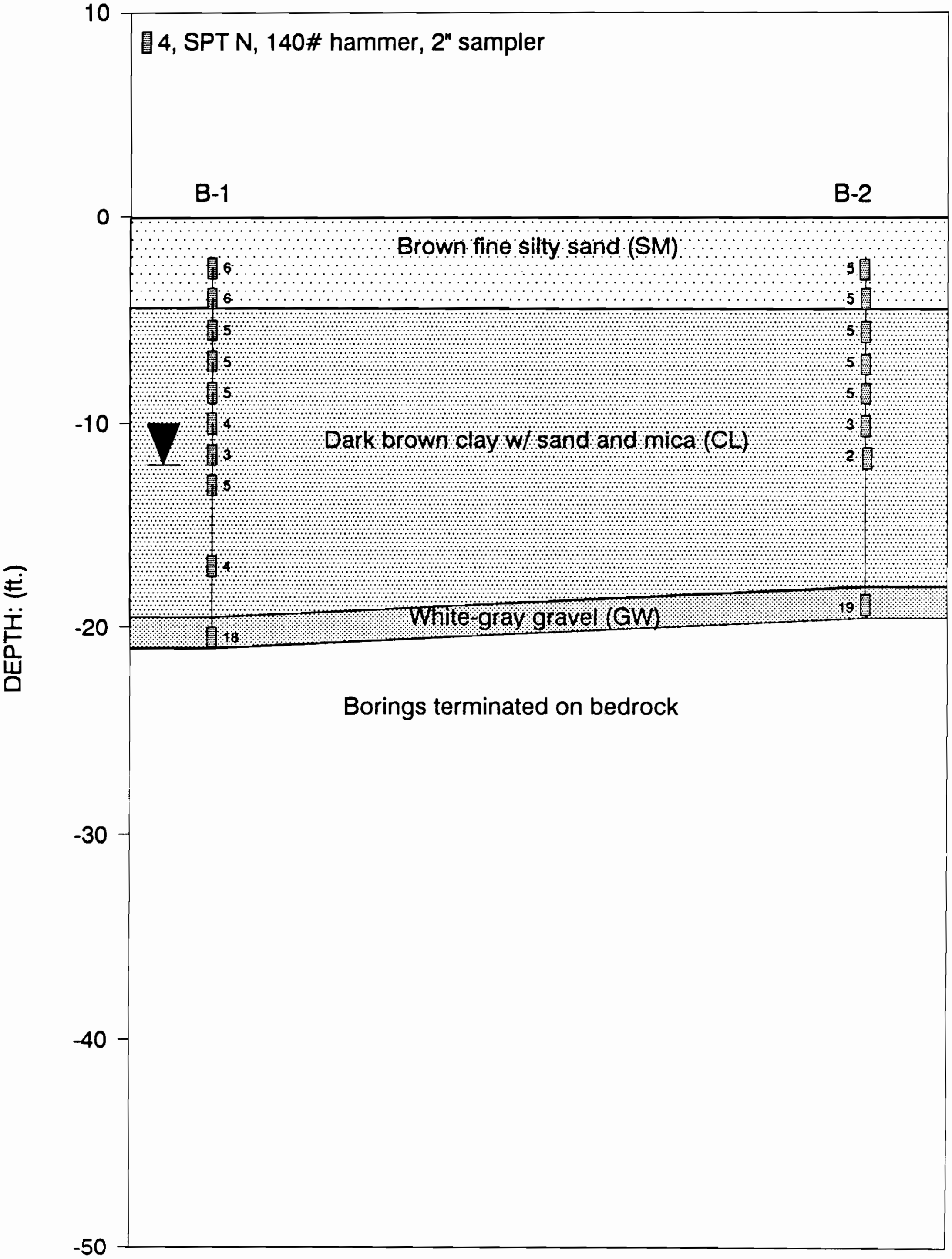


Figure 5.2 Pepper's Ferry Soil Profile

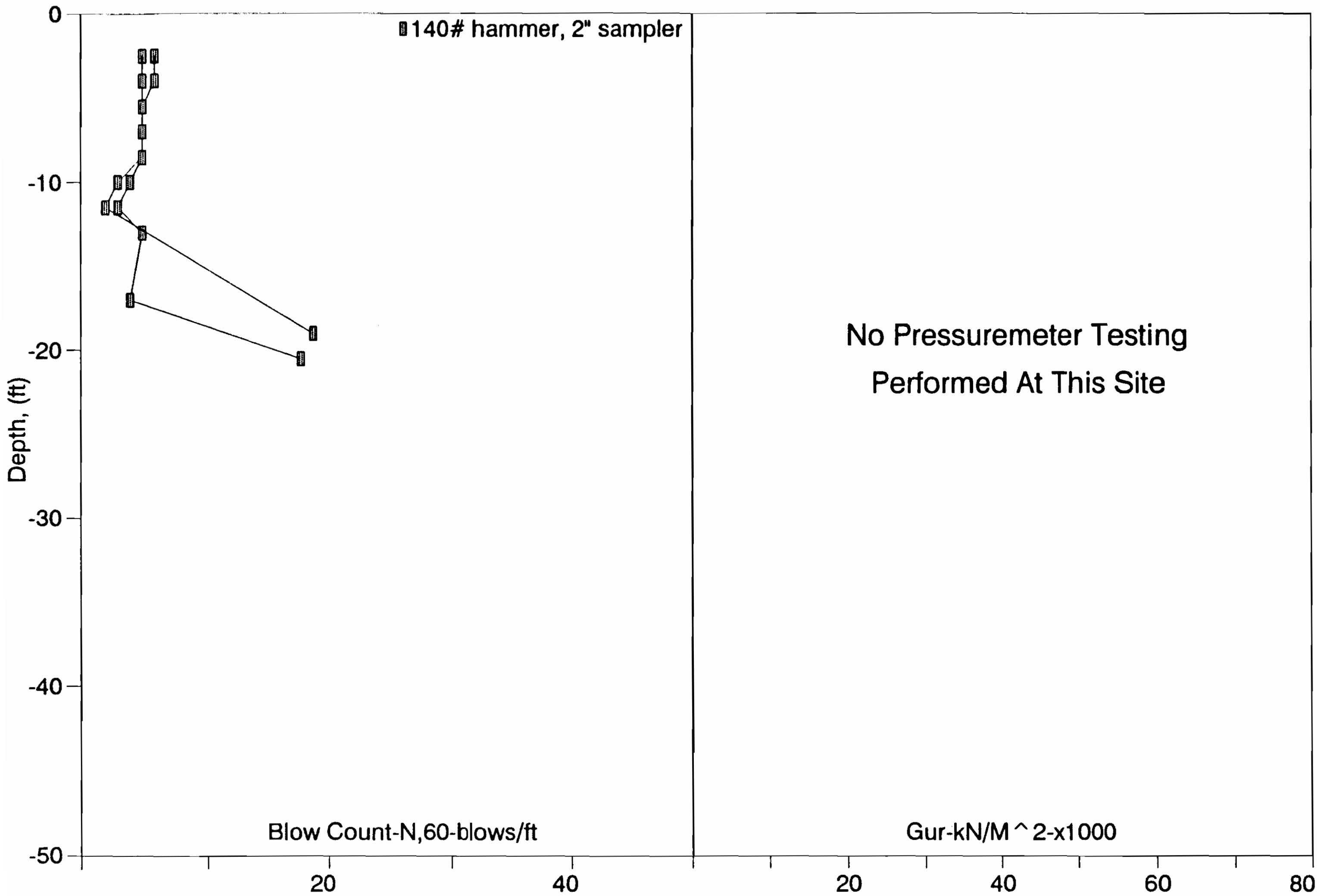


Figure 5.3 Pepper's Ferry: N60

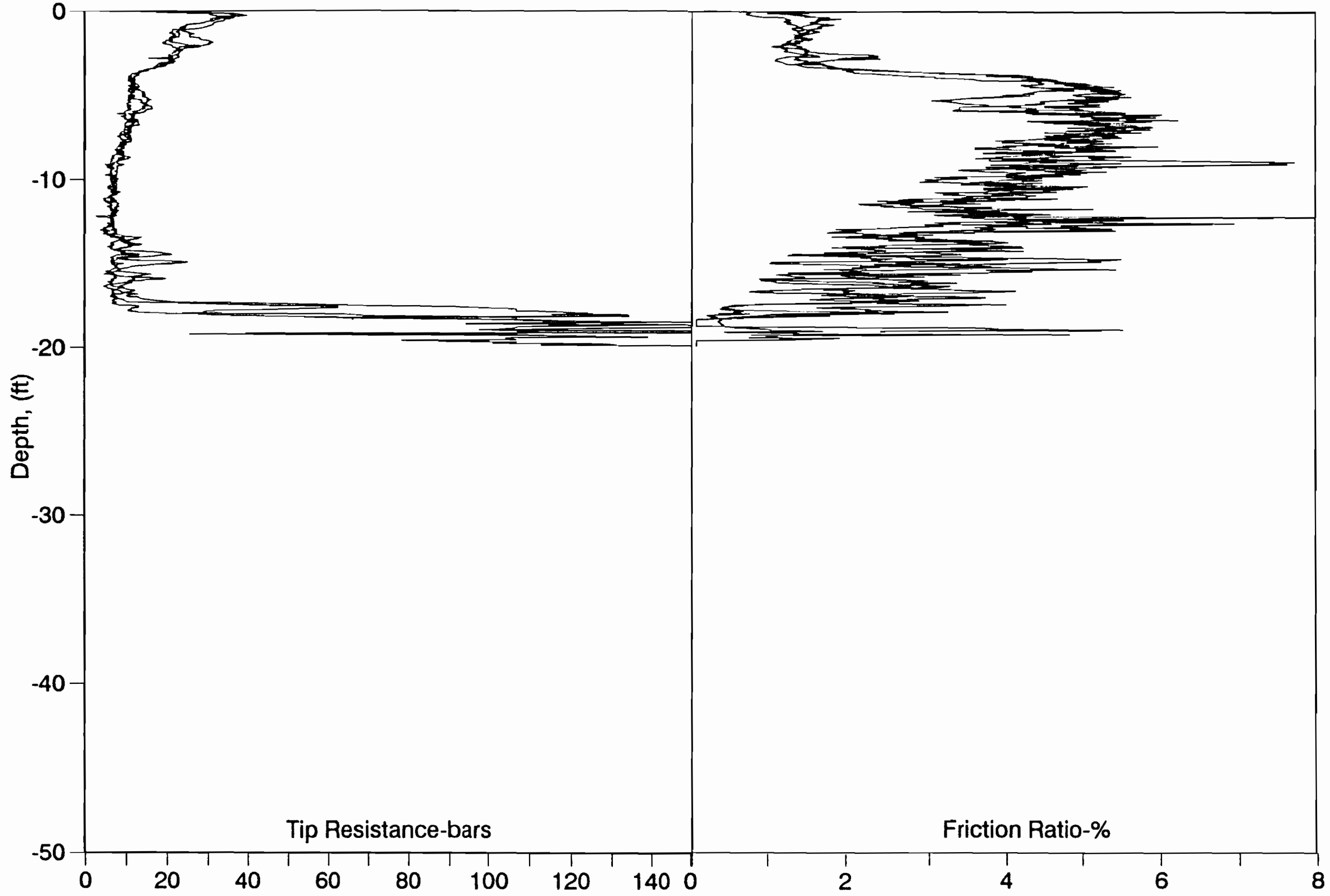


Figure 5.4 Pepper's Ferry: All Cone Tests

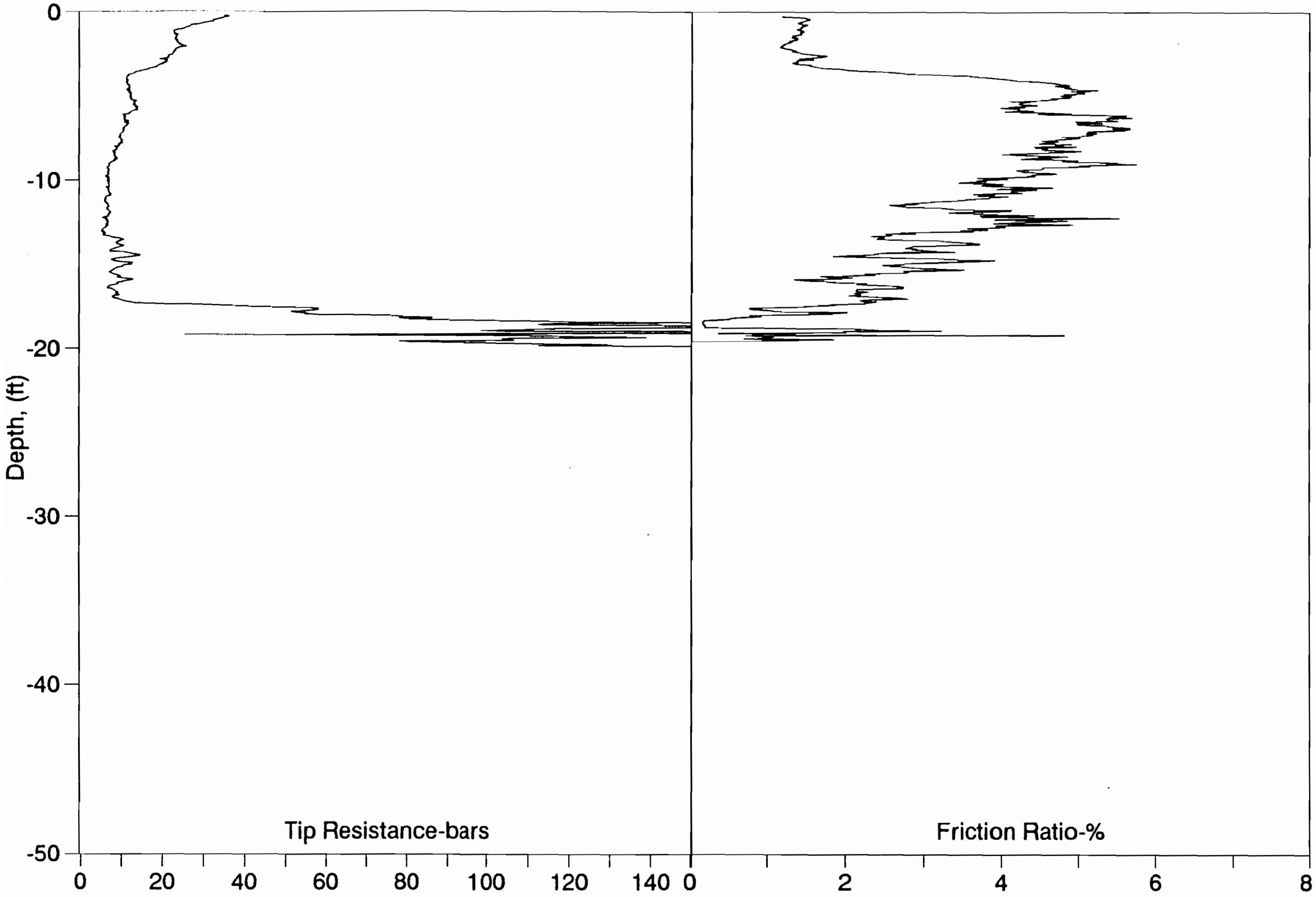


Figure 5.5 Pepper's Ferry: Cone Test Averages

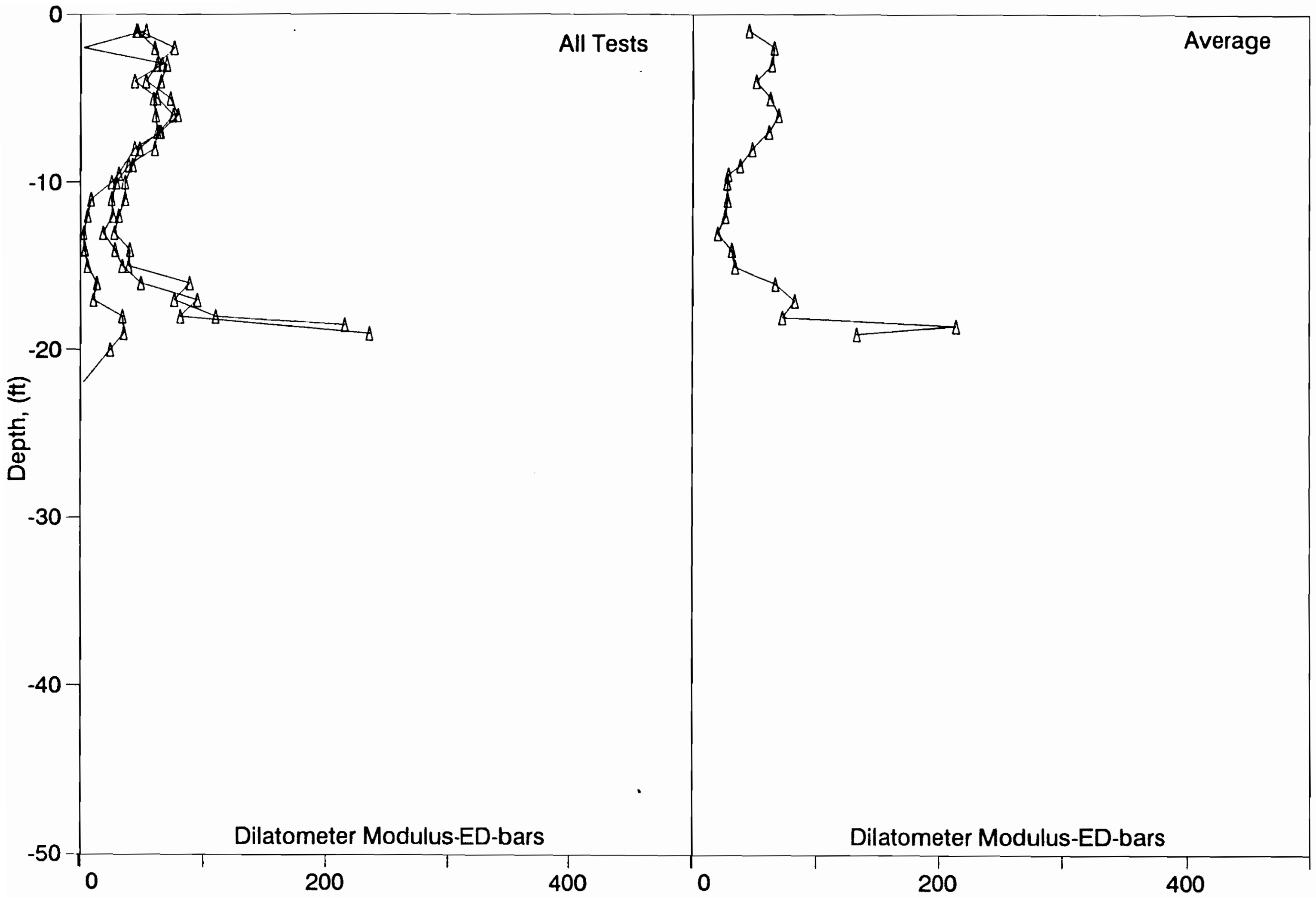


Figure 5.6 Pepper's Ferry: Dilatometer Soundings

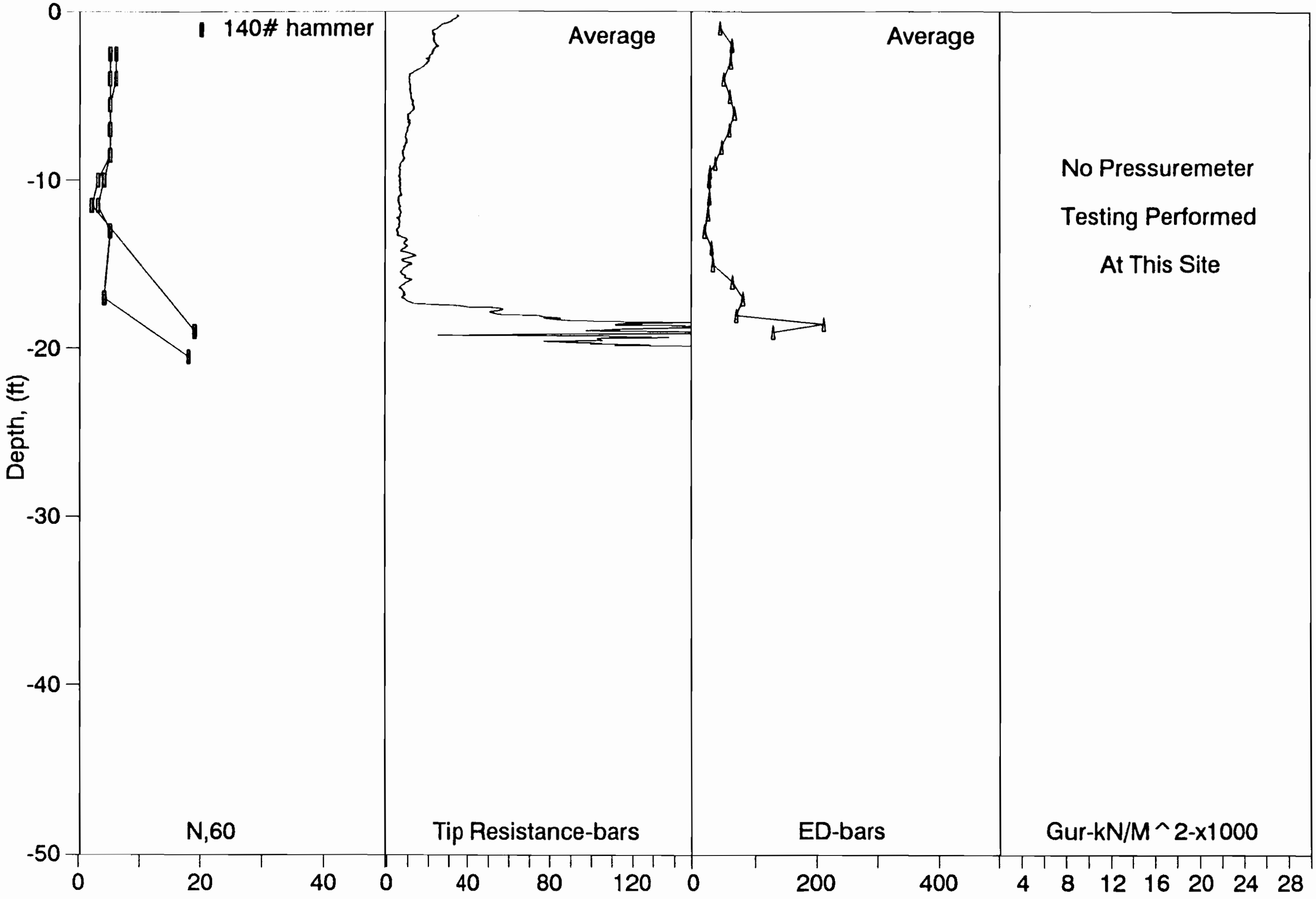


Figure 5.7 Pepper's Ferry: All In-Situ Tests

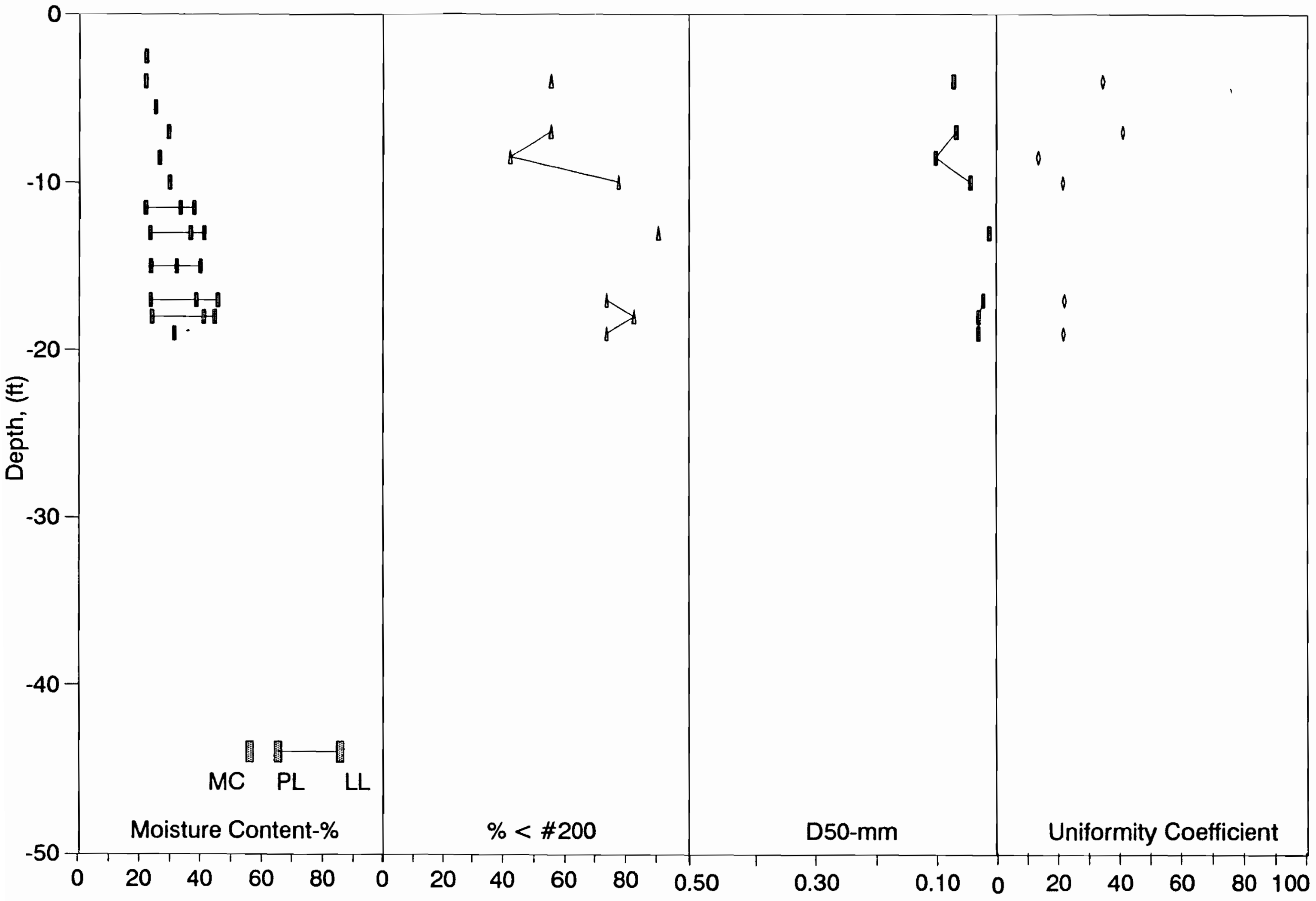


Figure 5.8 Pepper's Ferry: Lab Test Results

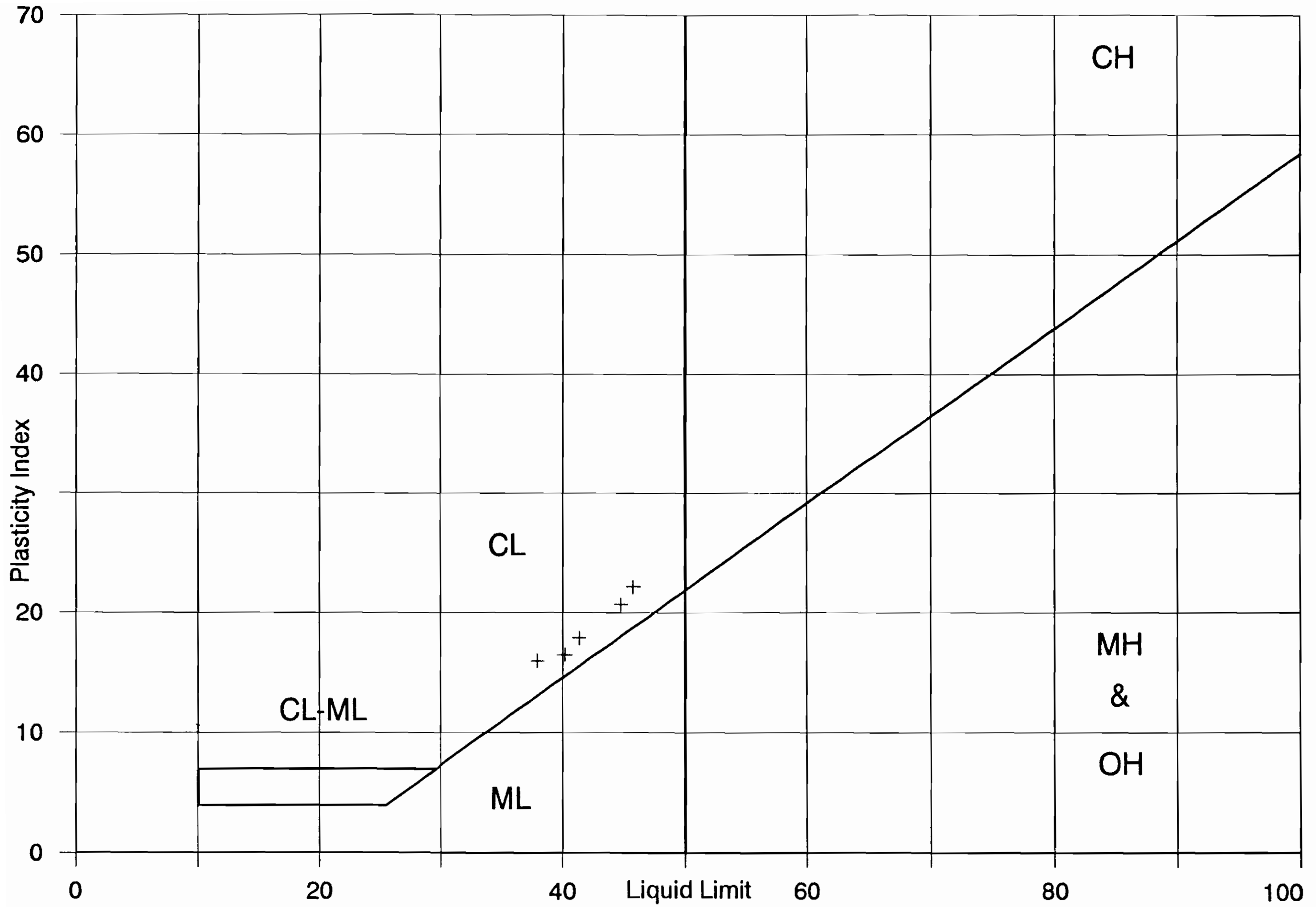


Figure 5.9 Pepper's Ferry: Plasticity Chart

Table 5.2

PEPPER'S FERRY SOIL CLASSIFICATIONS

Depth (ft)	ASTM D 2487 Classification	CPT Classification	DMT Classification
- 2.5	SM Silty Sand	Sandy Silt to Clayey Silt	Silty Sand
- 4.0	SM Silty Sand	Clay	Sandy Silt
- 5.5	CL Clay w/Sand	Silty Clay to Clay	Sandy Silt
- 7.0	CL Clay w/Sand	Clay	Sandy Silt
- 8.5	CL Clay w/Sand	Clay	Sandy Silt
-10.0	CL Clay w/Sand	Clay	Sandy Silt
-11.5	CL Clay w/Sand	Silty Clay to Clay	Clayey Silt
-13.0	CL Clay w/Sand	Clay	Silty Clay
-15.0	CL Clay w/Sand	Clayey Silt to Silty Clay	Silty Clay
-17.0	CL Clay w/Sand	Silty Clay to Clay	Sandy Silt
-18.0	CL Clay w/Sand	Sand to Silty Sand	Silty Sand
-19.0	GW Gravel	Sand to Silty Sand	Sand

5.3.2 Carmel Church

A major problem with testing at Carmel Church was the proximity to energized transmission lines. Even with proper grounding procedures and adequate electrical clearances, currents were induced into the drill rig and rods making it difficult to handle the drilling tools. The test series at this site (Table 5.3) was arranged linearly as shown in Figure 5.10 to maintain maximum clearance from the power lines.

Using the SPT and lab test results a soil profile was developed as shown in Figure 5.11. Soils at the Carmel Church site span the range from clayey sand to gravel. The top six to eight feet classified as a brown clayey sand, with the soils changing to an orange silty sand at about eight feet. This transition was evident in both the lab test results (Figures 5.17 and 5.18) and in a reduction of the CPT friction ratio at the depth of transition. Below eight feet the soil remained a silty sand until encountering a gravel layer between 32 and 35 feet. However, the color of the silty sand changed from orange to white-pink at approximately 23 feet. From 35 to 38 feet the soil was a yellow-white sand with silt, and below 38 feet the material type reverted to a yellow-white silty sand.

A total of three SPT borings, five cone penetration tests, three DMT soundings and five pressuremeter tests were conducted. The CPT, DMT and pressuremeter methods clearly identified regions of increase in the soil penetration resistance/stiffness profile (Figures 5.12 to 5.16). Between 15 and 20 feet the profile shows a uniform twofold increase in penetration resistance/stiffness. Between 20 and 25 feet, the penetration resistance/stiffness profile generally graded back to the initial values. Between 37 and 43 feet the CPT and DMT penetration resistance/stiffness showed another increase followed again by a decrease (pressuremeter testing did not extend to 37 feet). SPT blow count also approximately followed the trend of the other forms of penetration resistance. However, the patterns of increases and decreases were not as clearly distinguished.

Due to the constraints of working between energized electric lines the test pattern at Carmel Church was more wide spread than at any of the other sites. In light of the test dispersion, it is interesting that the SPT, CPT, and DMT traces were all very consistent and were mirrored by the PMT data. During lab testing, 65 moisture content determinations, 2 specific gravity tests, 27 grain size analyses, and 17 Atterberg limit determinations were completed (Figures 5.17 and 5.18). Soil classification from the lab test results , the CPT and DMT agreed reasonably well (Table 5.4). All of the classifications identified the soils as sands with some content of fines. The cone tended to identify a slightly coarser material than the lab results or DMT, indicating sand or sand to silty sand instead of silty sand.

Drilling and cone penetration testing at the Carmel Church site proceeded to total depth without trouble. Upon switching to dilatometer testing, the penetration resistance of the larger instrument caused the push bracket to slip on the drill rig kelly. It was necessary to add additional bolts to the bracket to complete the testing. All of the tests indicated a layer of gravel from 32 to 35 feet. During cone and dilatometer testing it was possible to feel a substantial change in probe advance upon encountering the gravel. Minimal difficulties occurred during pressuremeter testing.

High humidity during one day of testing interfered with the data acquisition system. Testing was abandoned until the circuit boards could be dried in front of the motel room air-conditioner.

Table 5.3
Carmel Church Site Testing Program
Field Testing

Test no.	Depth ft.	Samples/ readings	Duration hr.	Comment
Borings				
CCHB-1	44.5	28	10	
CCHB-2	44.5	28	10	
CCHB-3	29.5	10	n/a	for PMT tests
Cone Penetration Tests				
CCHC-1	45.2	n/a	1.0	
CCHC-2	44.8	n/a	1.0	
CCHC-3	45.2	n/a	1.0	
CCHC-4	42.6	n/a	0.9	
CCHC-5	45.4	n/a	0.9	
Dilatometer Soundings				
CCHD-1	45.0	45	1.3	load cell used
CCHD-2	45.0	45	1.5	load cell used
CCHD-3	abandoned for computer problems			
CCHD-4	45.0	45	2.0	load cell used
Pressuremeter Tests				
CCHP-1	4.5	1 loop	1.0	complete test
CCHP-2	10.5	2 loops	1.3	complete test
CCHP-3	16.5	3 loops	1.9	complete test
CCHP-4	22.5	1 loop	1.3	complete test
CCHP-5	28.5	2 loops	1.0	complete test

Laboratory Testing

Moisture Content	Specific Gravity	Gr size w/hyd	Atterberg Limits
65	2	27	17

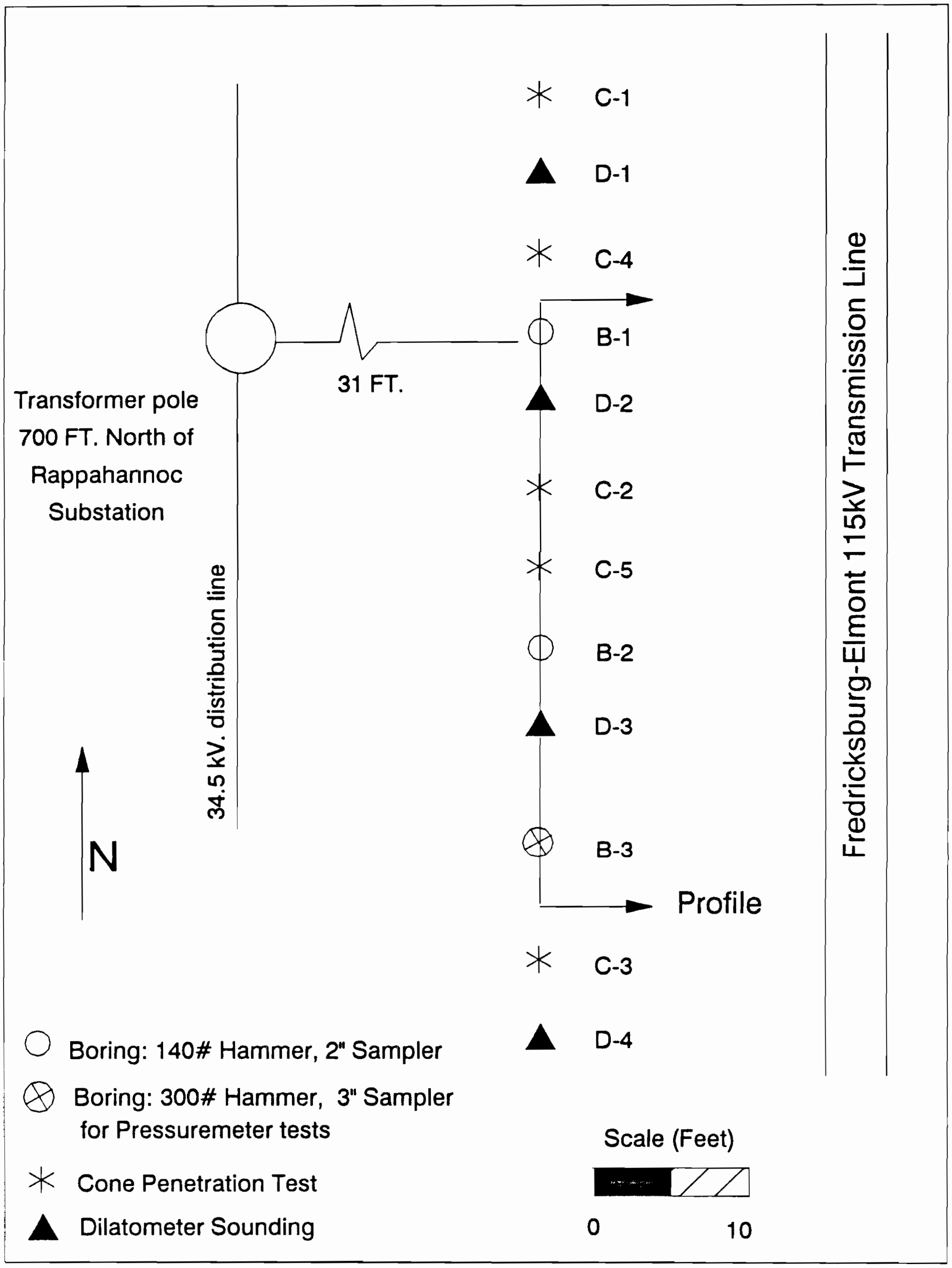


Figure 5.10 Carmel Church Test Location Map

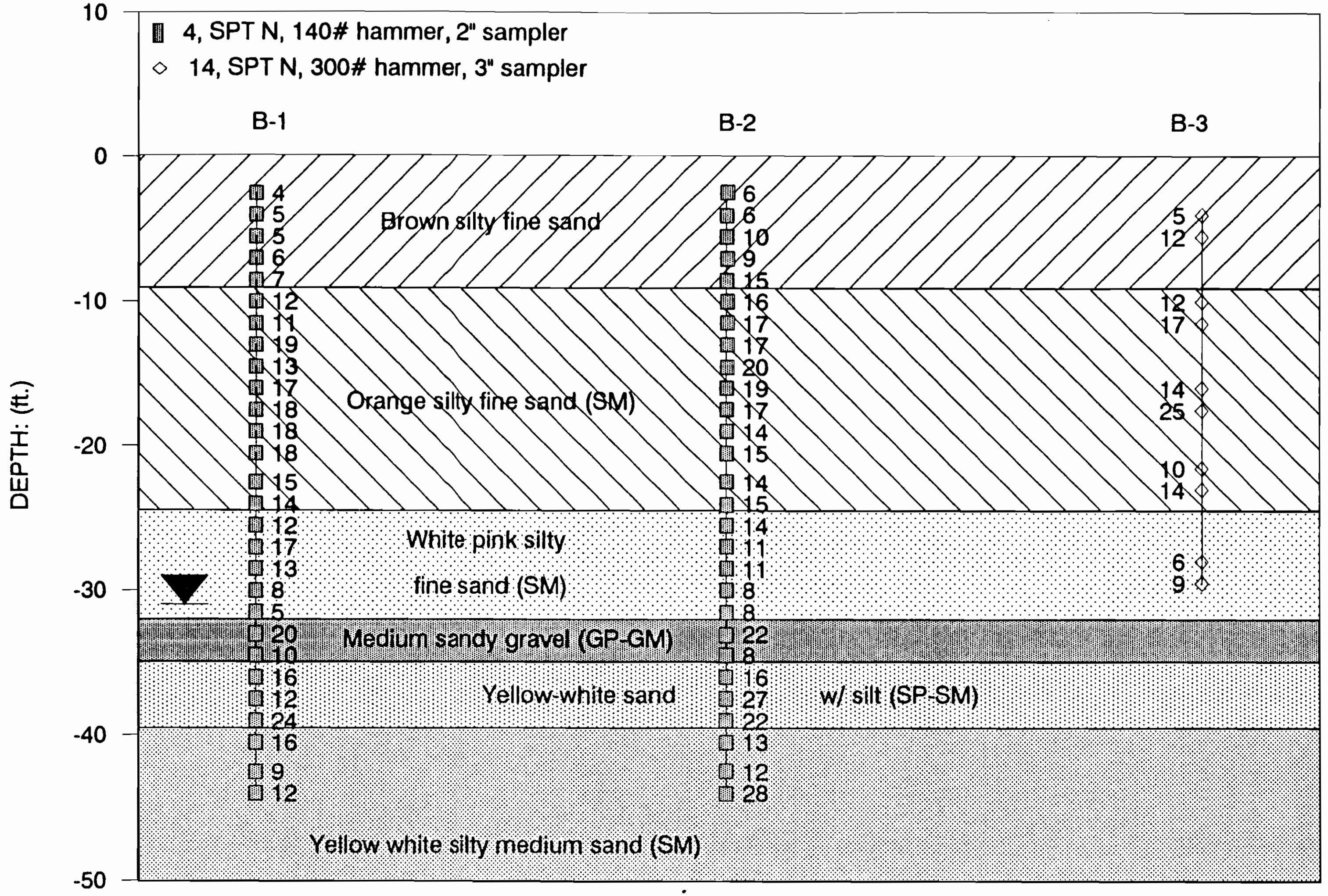


Figure 5.11 Carmel Church Soil Profile

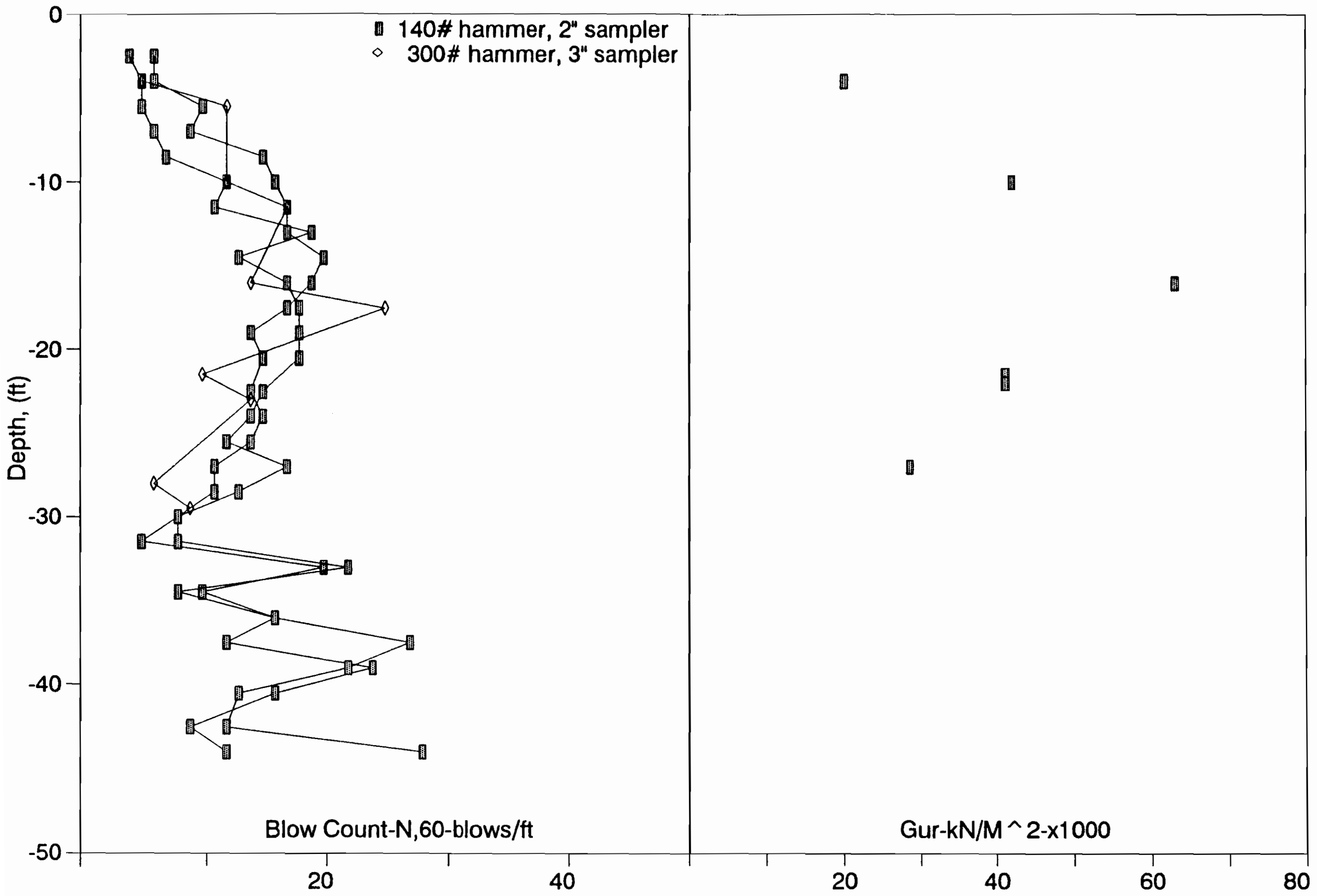


Figure 5.12 Carmel Church: N60 and Gur

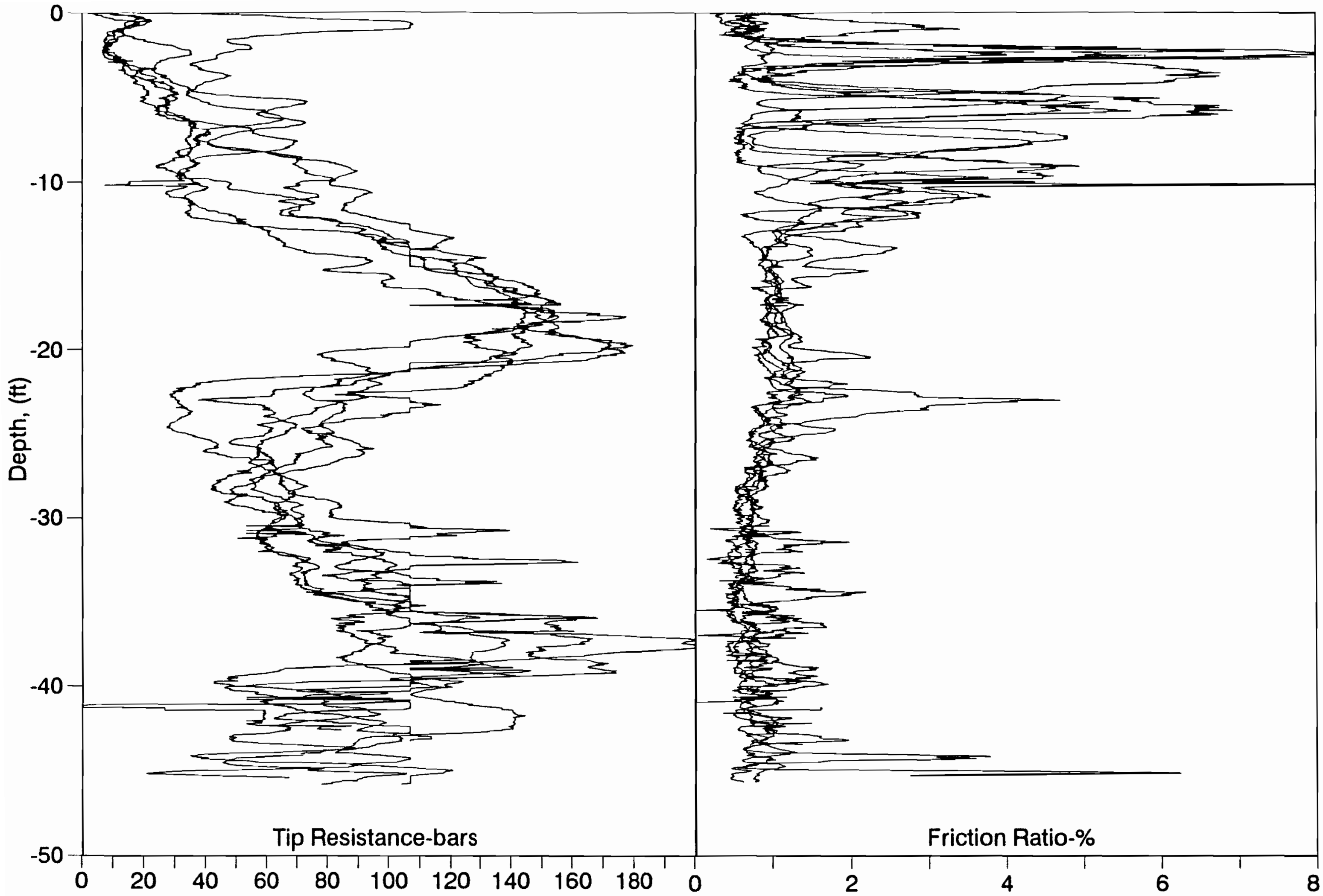


Figure 5.13 Carmel Church: All Cone Tests

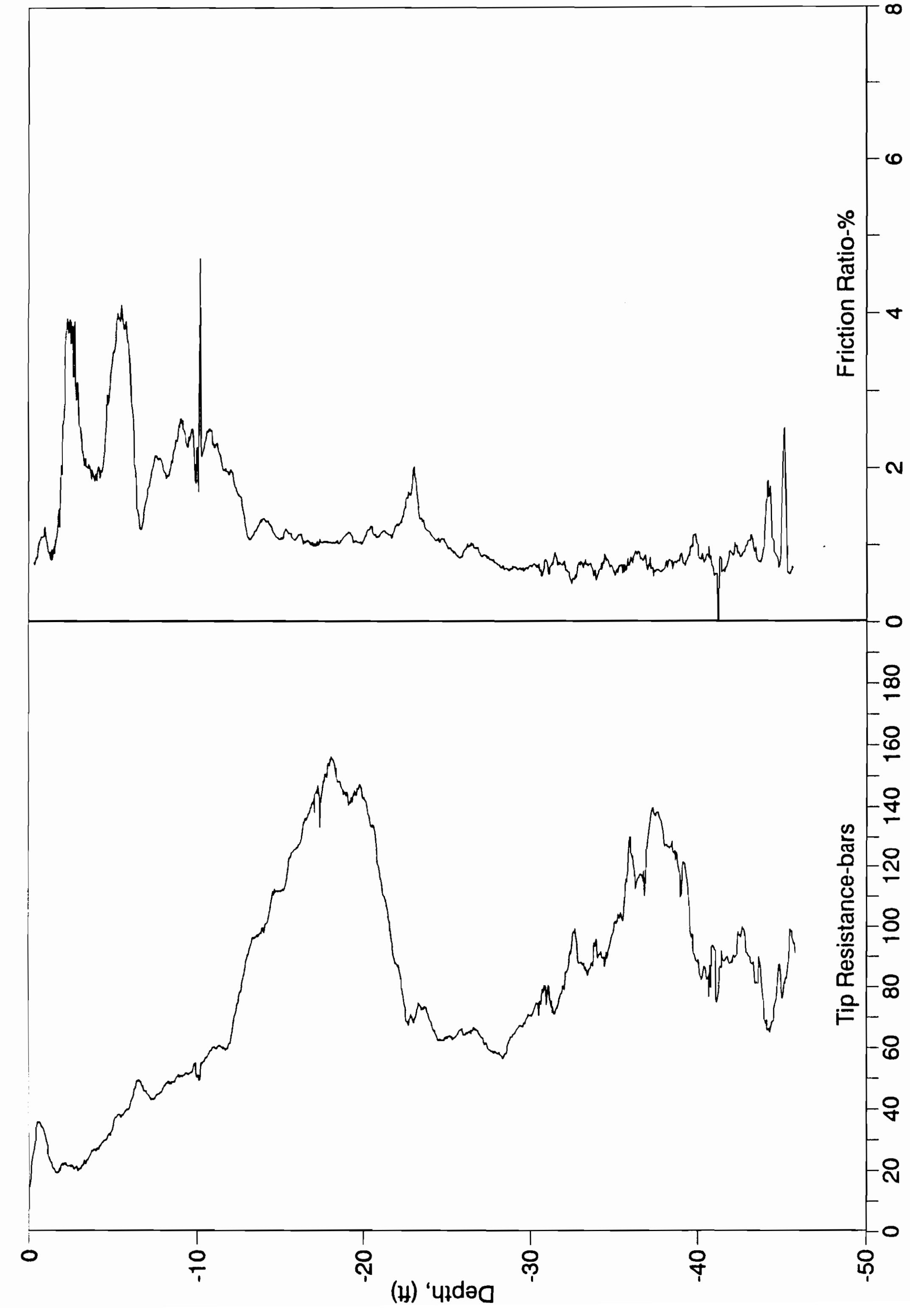


Figure 5.14 Carmel Church: Cone Test Averages

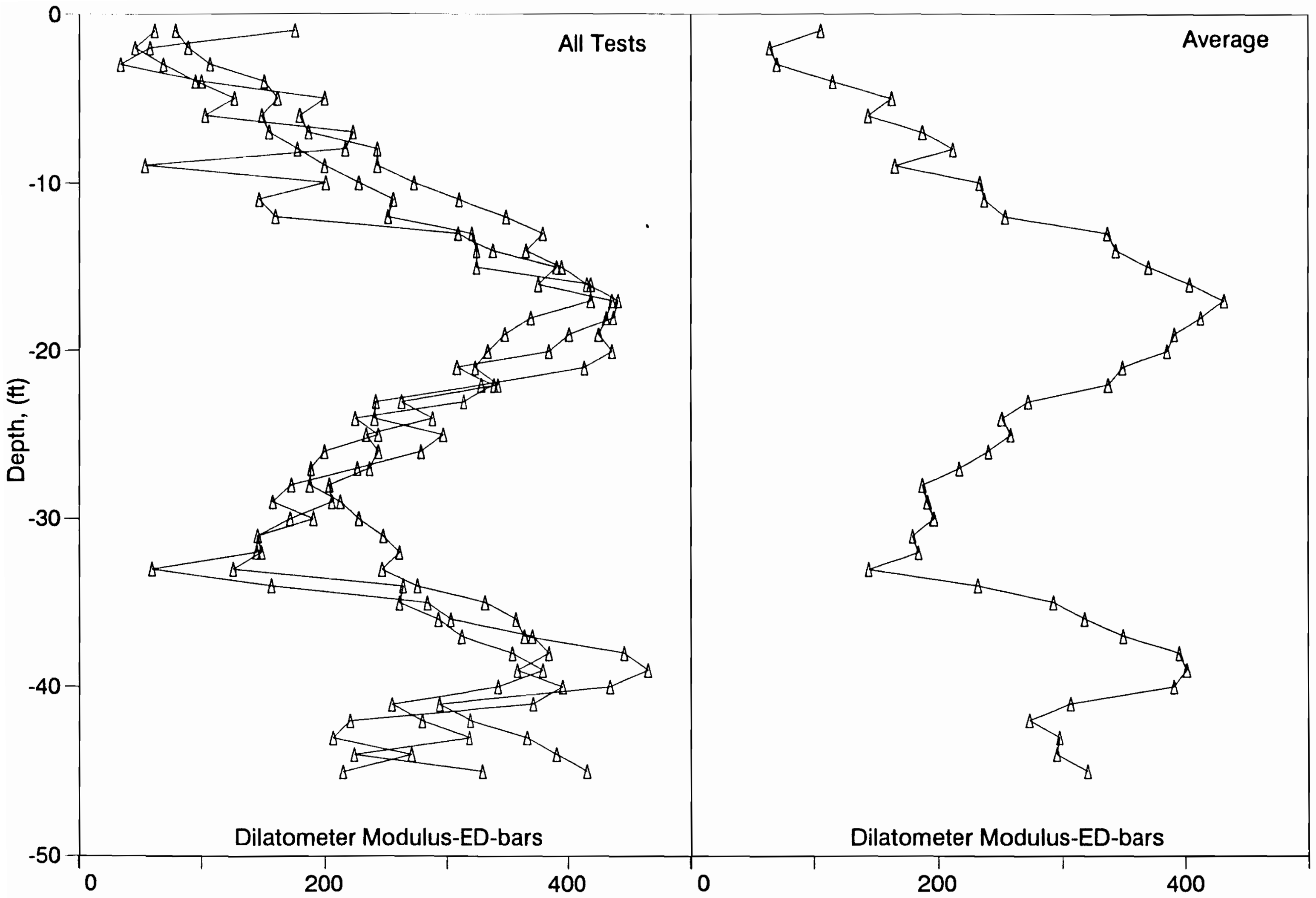


Figure 5.15 Carmel Church: Dilatometer Soundings

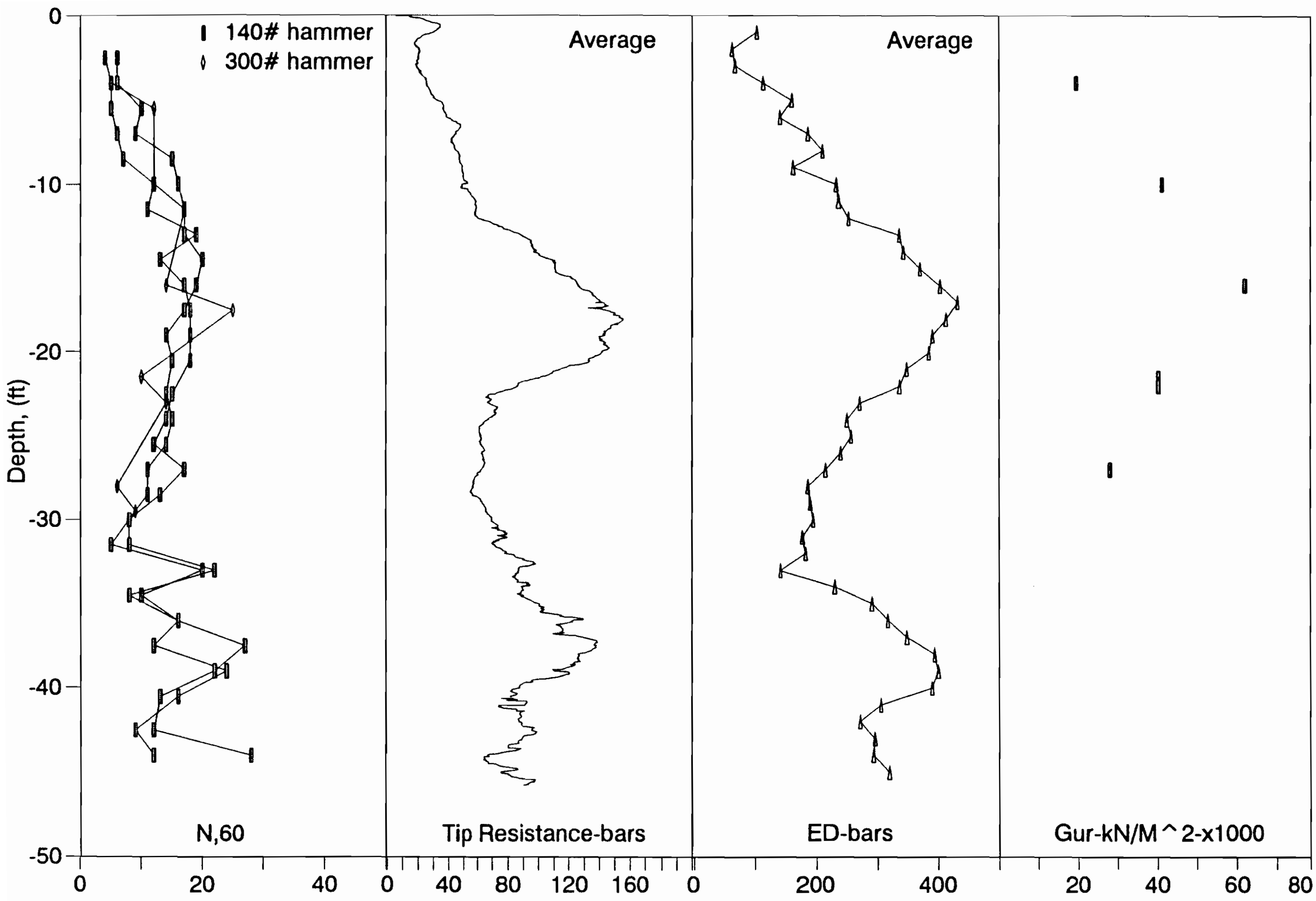


Figure 5.16 Carmel Church: All In-Situ Tests

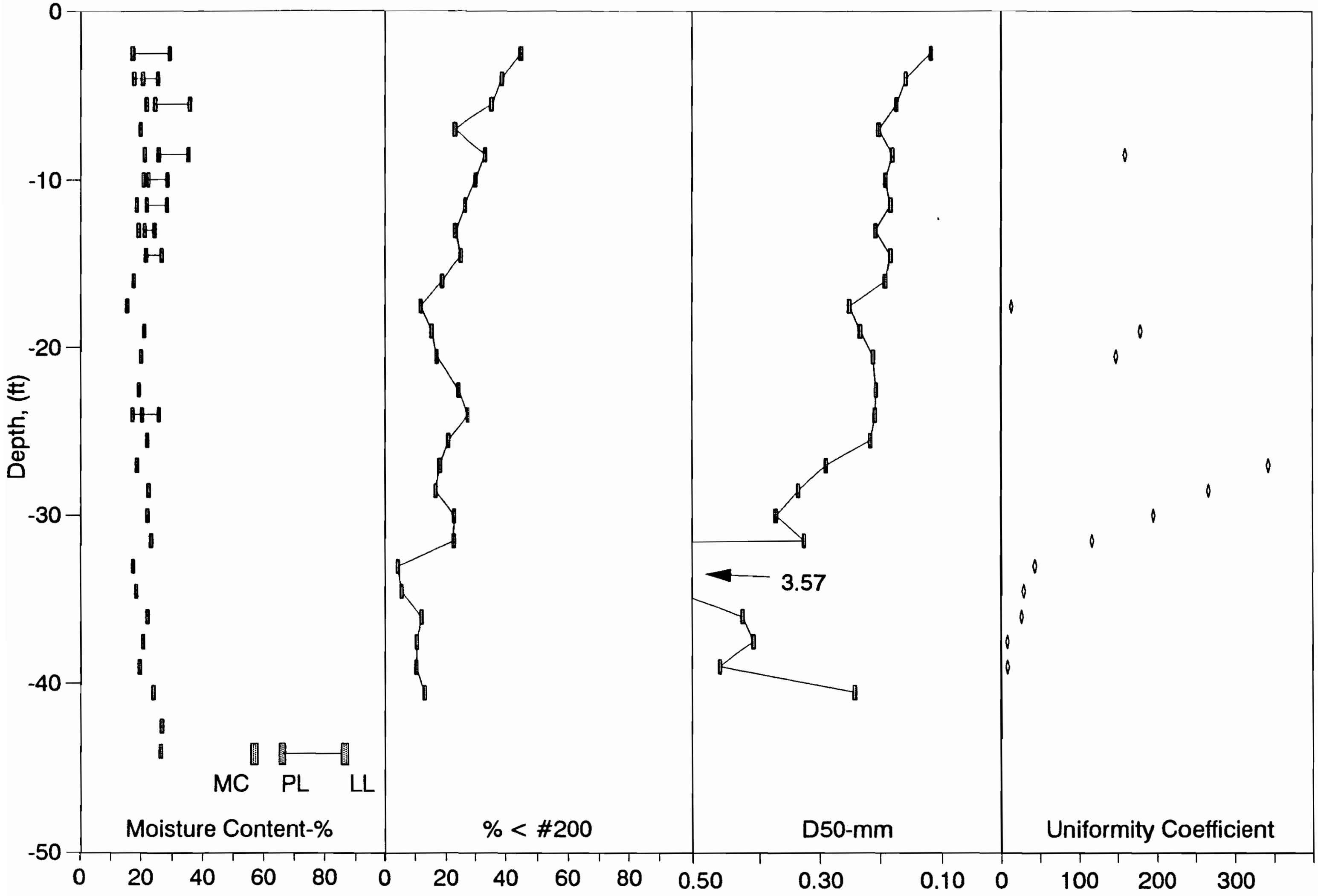


Figure 5.17 Carmel Church: Lab Test Results

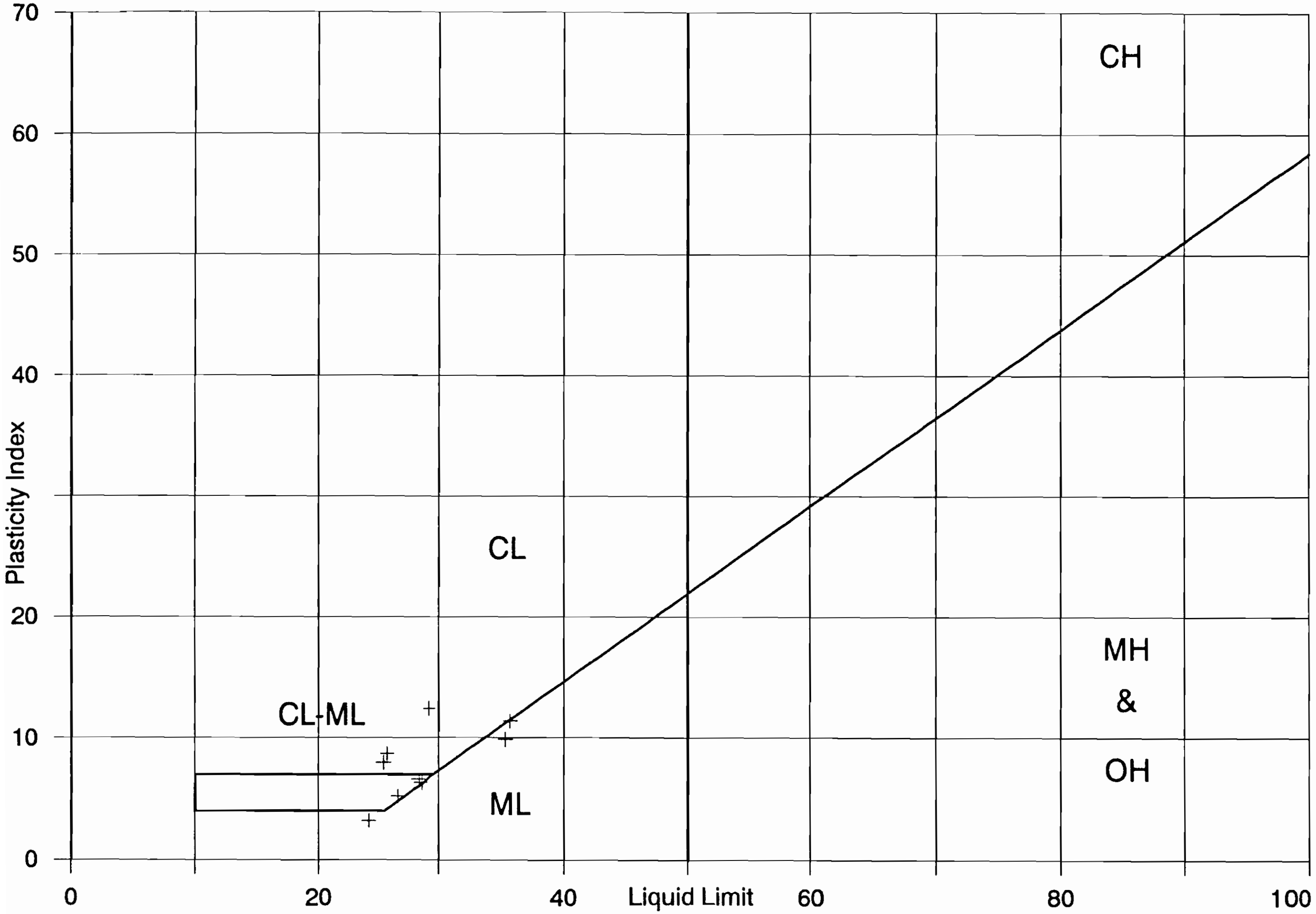


Figure 5.18 Carmel Church: Plasticity Chart

Table 5.4

CARMEL CHURCH SOIL CLASSIFICATIONS

Depth (ft)	ASTM D 2487 Classification	CPT Classification	DMT Classification
- 2.5	SC Clayey Sand	Sandy Silt to Sandy Silt	Silty Sand
- 4.0	SC Clayey Sand	Sandy Silt to Clayey Silt	Silty Sand
- 5.5	SC Clayey Sand	Silty Clay to Clay	Silty Sand
- 7.0	SM Silty Sand	Silty Sand to Sandy Silt	Silty Sand
- 8.5	SM Silty Sand	Sandy Silty to Clayey Silt	Silty Sand
- 10.0	SM Silty Sand	Silty Sand to Sandy Silt	Silty Sand
- 11.5	SM Silty Sand	Silty Sand to Sandy Silt	Silty Sand
- 13.0	SM Silty Sand	Sand to Silty Sand	Silty Sand
- 14.5	SM Silty Sand	Sand to Silty Sand	Sandy Silt
- 16.0	SM Silty Sand	Sand	Silty Sand
- 17.5	SW-SM Sand w/Silt	Sand	Silty Sand
- 19.0	SM Silty Sand	Sand	Silty Sand
- 20.5	SM Silty Sand	Sand	Silty Sand
- 22.5	SM Silty Sand	Silty Sand to Sandy Silt	Silty Sand
- 24.0	SM Silty Sand	Silty Sand to Sandy Silt	Silty Sand
- 25.5	SM Silty Sand	Sand to Silty Sand	Silty Sand
- 27.0	SM Silty Sand	Sand to Silty Sand	Silty Sand
- 28.5	SM Silty Sand	Sand to Silty Sand	Silty Sand
- 30.0	SM Silty Sand	Sand to Silty Sand	Silty Sand
- 31.5	SM Silty Sand	Sand to Silty Sand	Silty Sand
- 33.0	SW Sand w/Gravel	Sand to Silty Sand	Sand
- 34.5	SW-SM Sand w/Silt & Gravel	Sand to Silty Sand	Sand
- 36.0	SW-SM Sand w/Silt	Sand	Silty Sand
- 37.5	SP-SM Sand w/Silt	Sand	Silty Sand
- 39.0	SP-SM Sand w/Silt	Sand	Silty Sand
- 40.5	SM Silty Sand	Sand to Silty Sand	Silty Sand
- 44.0	SM Silty Sand	Silty Sand to Sandy Silt	Silty Sand

5.4 Marine Clay Sites

The primary characteristic of both the Schnabel and Ladysmith sites is the layer of overconsolidated marine clay found beneath the surficial soils. Discussion of the test results, soil conditions, and testing difficulties at each test area are as follows:

5.4.1 Schnabel
5.4.2 Ladysmith
5.4.3 Marine clay site testing difficulties

5.4.1 Schnabel

Although some difficulties were encountered in testing at this site, no additional field work was necessary beyond the standard ten foot grid pattern of field tests (Figure 5.19). For this investigation, one 300# hammer/ 3inch sampler boring, three cone tests, three DMT soundings, and three pressuremeter tests were conducted (Table 5.5). Additional test data are available from Lien (1990) and Mayu(1987). The Schnabel site soil profile showed two distinct layers (Figure 5.20). A surface layer of orange gray clayey sand had a thickness of 6 feet. Beneath this 6 foot surface layer is a deposit of gray green Miocene clay extending to and beyond the 30 foot depth of testing. This soil classified as a fat clay under ASTM D 2487-85.

Depth of in-situ testing varied, with the spoon sampling and pressuremeter testing being completed at 18 feet or less, and CPT and DMT continuing to just over 30 feet. The results of all in-situ tests were consistent, presumably because of the homogeneous nature of the Miocene clay. The SPT tests were performed only with the 300# hammer and the 3 inch sampler, but even these data reflected the same pattern as the CPT, DMT, and PMT.

A point of interest in the test profiles was an increase in penetration resistance/stiffness to a depth of about 19 feet followed by a decrease beyond this (Figures 5.21 to 5.25). While the lab tests were not performed below 20 feet, the test data at 17 and 19 feet indicated that a change in properties was occuring. In this area the liquid limit of the soil decreased by 15%, the natural moisture content decreased by 10%, and the percentage of material larger than the #200 sieve increased by 10%, indicating more granular material in the deposit.

The CPT data showed that the f_r steadily decreased to about 18 feet, falling from a value over 4% in the upper profile to less than 1% at 18 feet. The 1% f_r value at 18 feet suggests that a sandy or silty lense was encountered at that depth. The f_r below 18 feet increases to about 1.5% to 2.0%, indicating that the soil became more clayey. This is typical in the Miocene clay, which is known to vary between clays, silty clays, and silts (Martin and Drahos, 1987). The increasing clay content was supported by the fact that the tip resistance of the cone decreased below 20 feet.

From the samples from the one boring at this site, 11 moisture content determinations, 2 specific gravity tests, 11 grain size analyses, and 11 Atterberg limit determinations were performed (Figures 5.26 and 5.27). Visual and lab classification of the soil agreed reasonably well with the DMT results, although the DMT indicated slightly siltier conditions than the lab results (Table 5.6). The CPT results tended to classify the soil as even siltier with some sand content. It appears that the highly overconsolidated and stiff nature of the clay disguised the high plastic nature of the clay as far as concerns identification by the CPT and DMT.

Table 5.5
Schnabel Site Testing Program

Field Testing

Test no.	Depth ft.	Samples/ readings	Duration hr.	Comment
Borings				
SNBB-1	19.5	12	n/a	for PMT tests
Cone Penetration Tests				
SNBC-1	30.3	n/a	0.5	
SNBC-2	31.6	n/a	0.5	
SNBC-3	31.7	n/a	0.5	
Dilatometer Soundings				
SNBD-1	30.0	30	1.3	
SNBD-2	abandoned, test in old boring hole			
SNBD-3	30.0	30	1.1	
SNBD-4	30.0	30	1.1	
Pressuremeter Tests				
SNBP-1	9.0	2 loops	1.0	mem. rupture
SNBP-2	15.0	3 loops	2.8	complete test
SNBP-3	16.5	5 loops	2.0	mem. rupture

Laboratory Testing

Moisture Content	Specific Gravity	Gr size w/hyd	Atterberg Limits
11	2	11	11

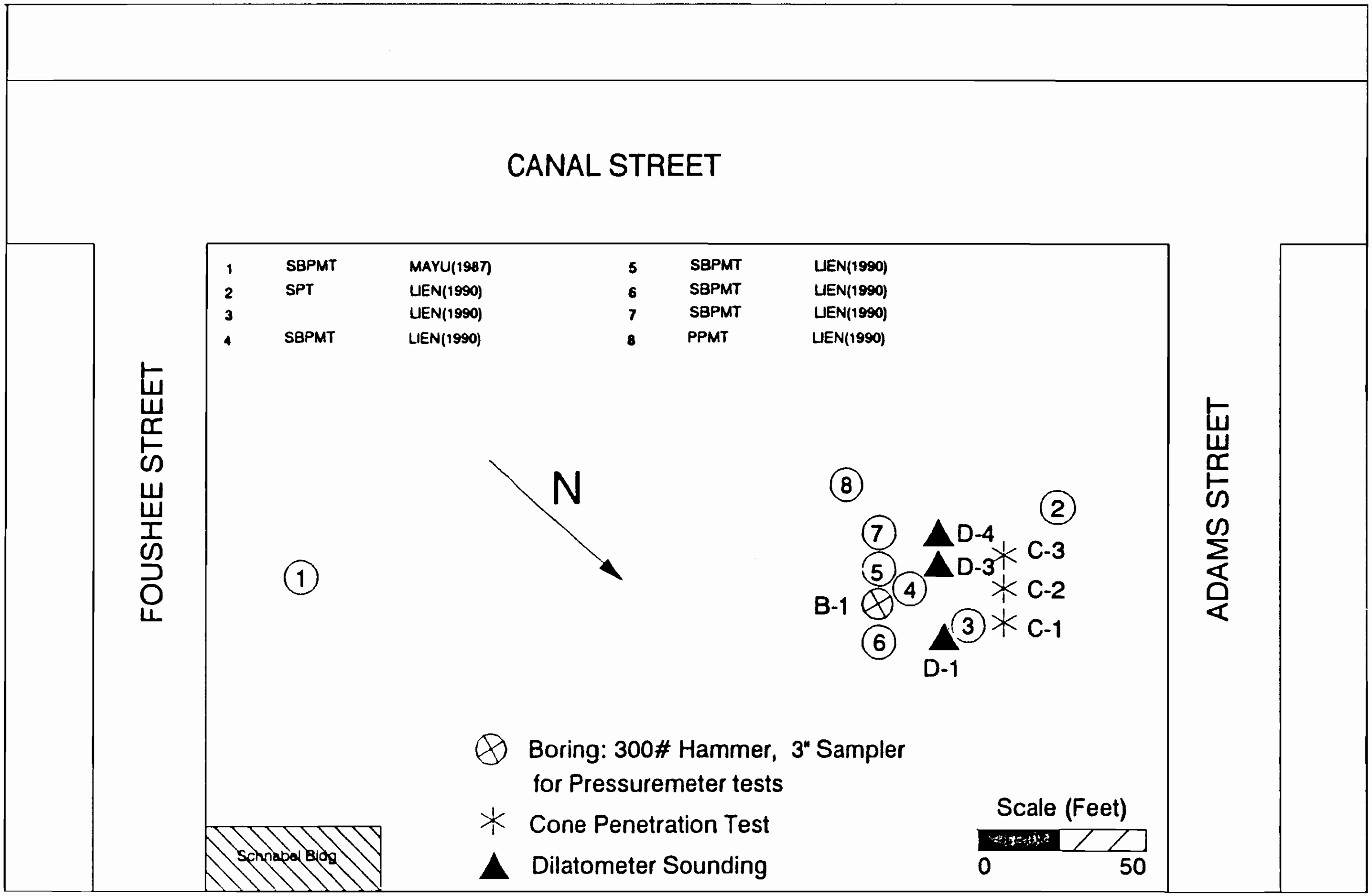


Figure 5.19 Schnabel Test Location Map

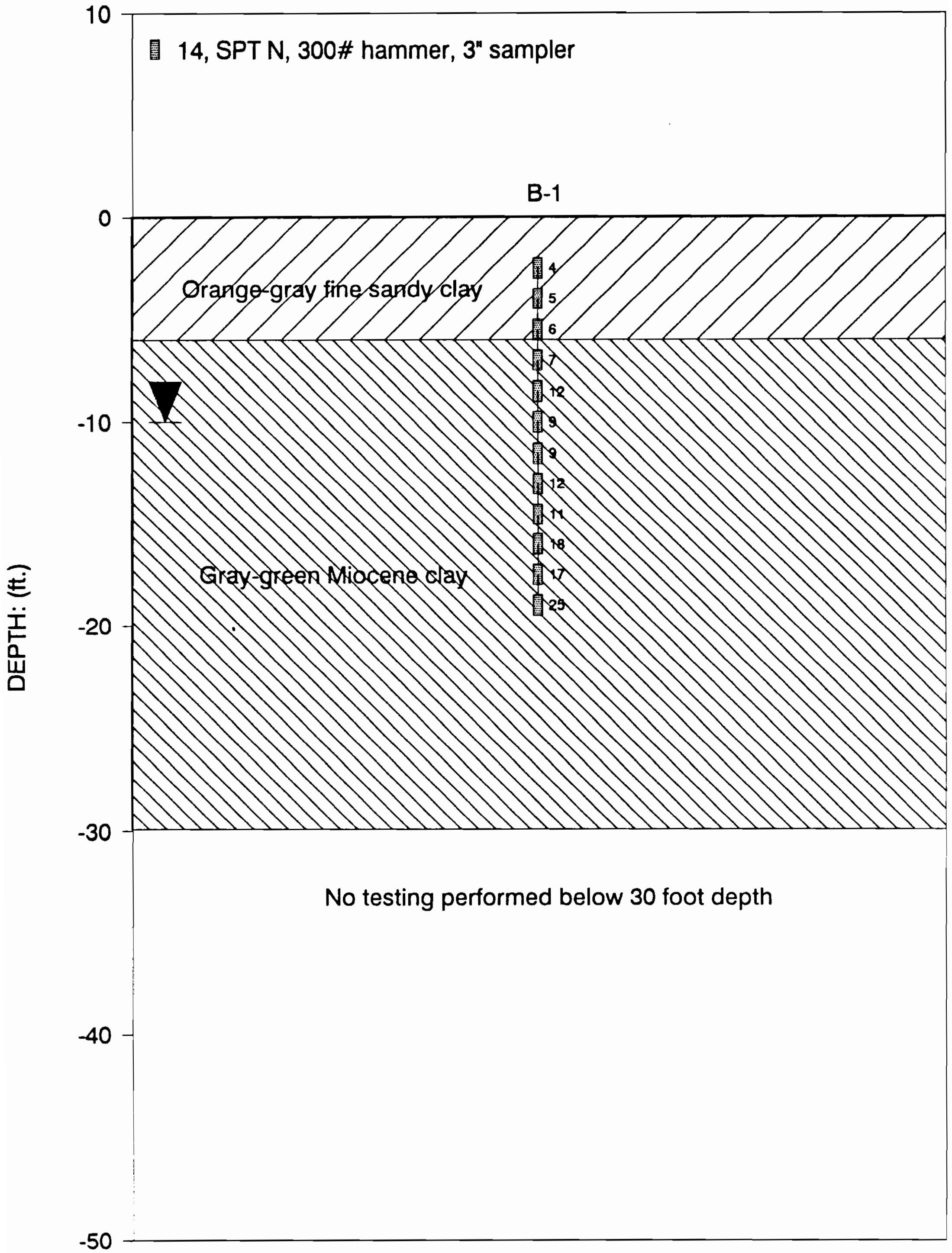


Figure 5.20 Schnabel Soil Profile

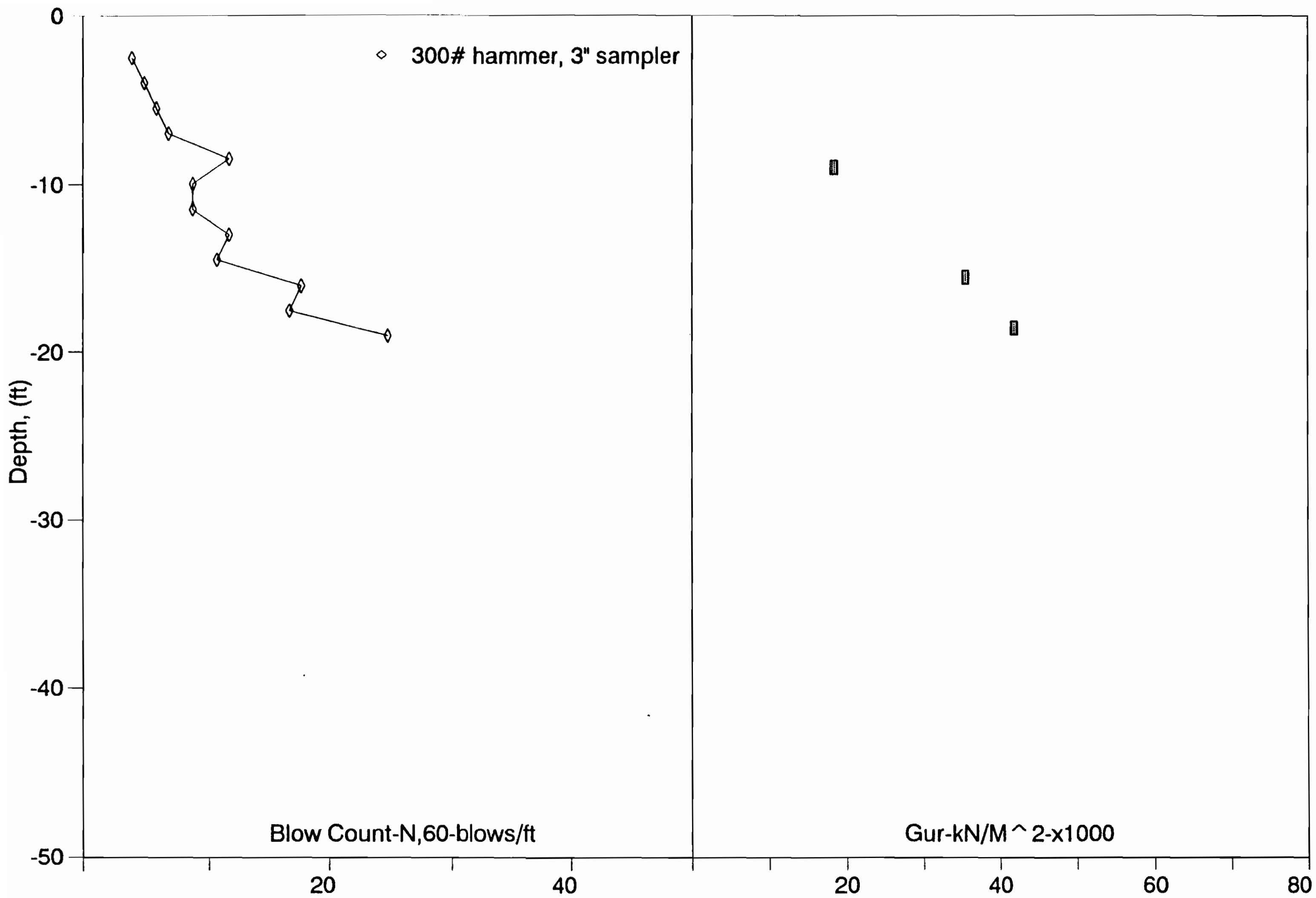


Figure 5.21 Schnabel: N60 and Gur

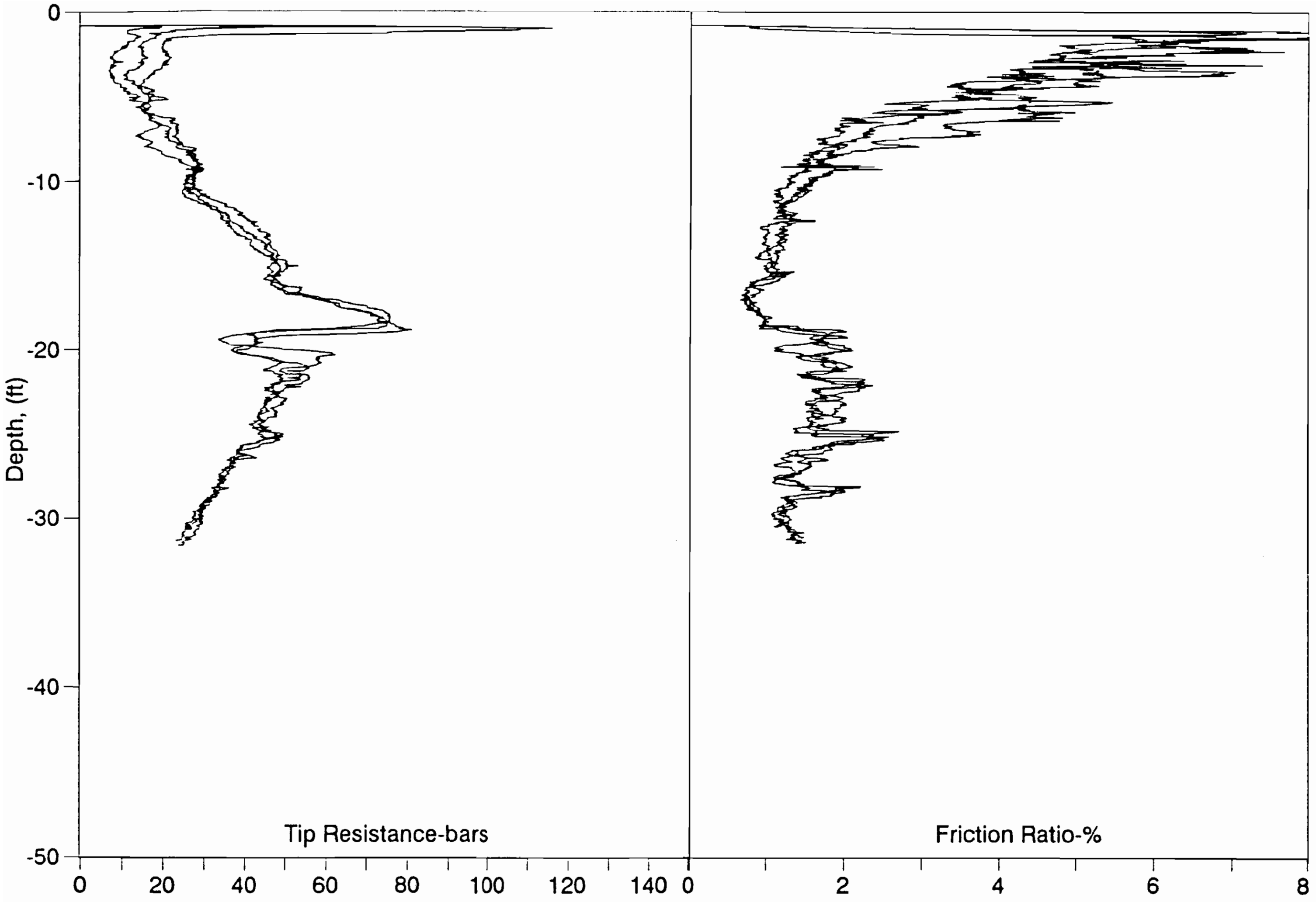


Figure 5.22 Schnabel: All Cone Tests

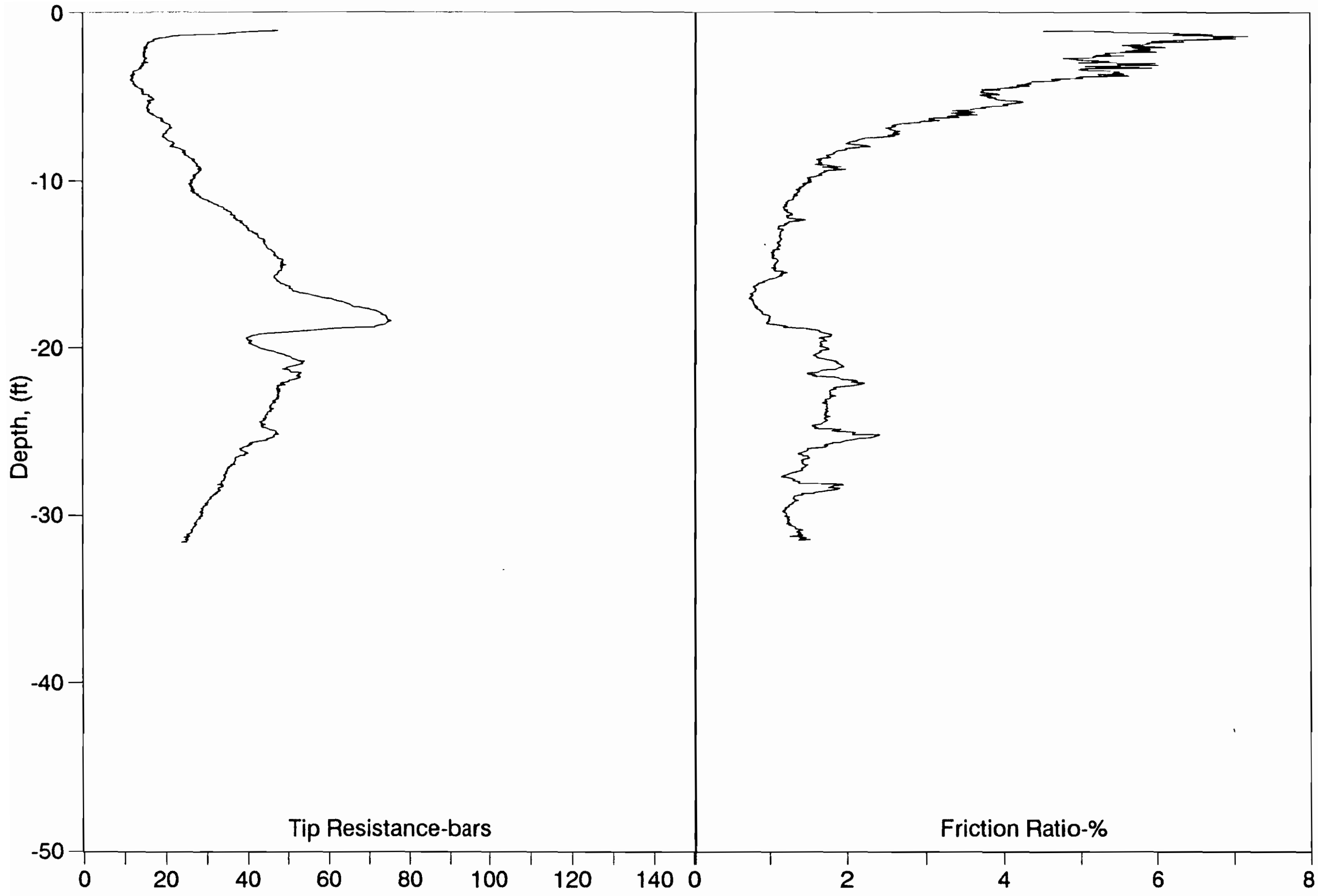


Figure 5.23 Schnabel: Cone Test Averages

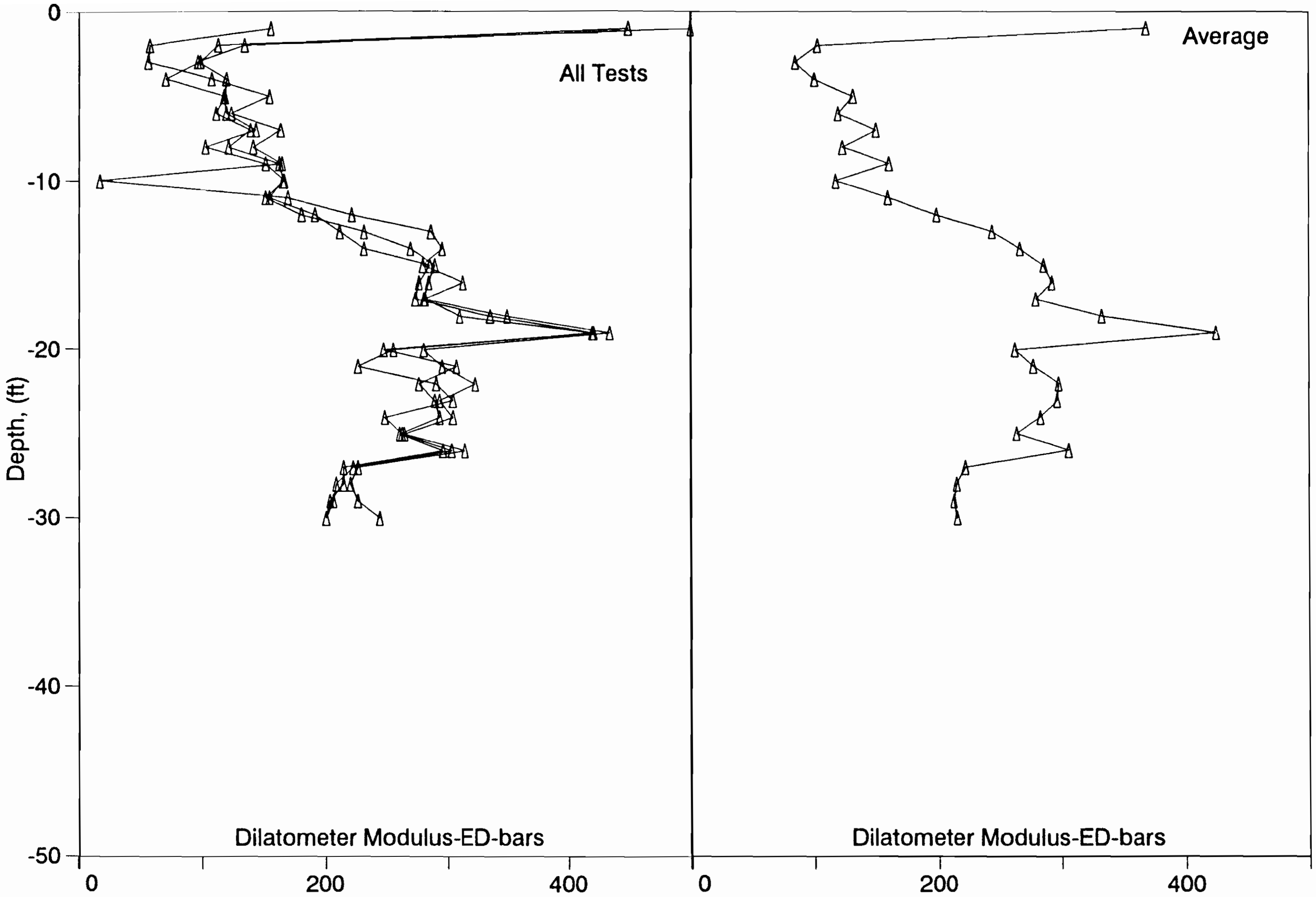


Figure 5.24 Schnabel: Dilatometer Soundings

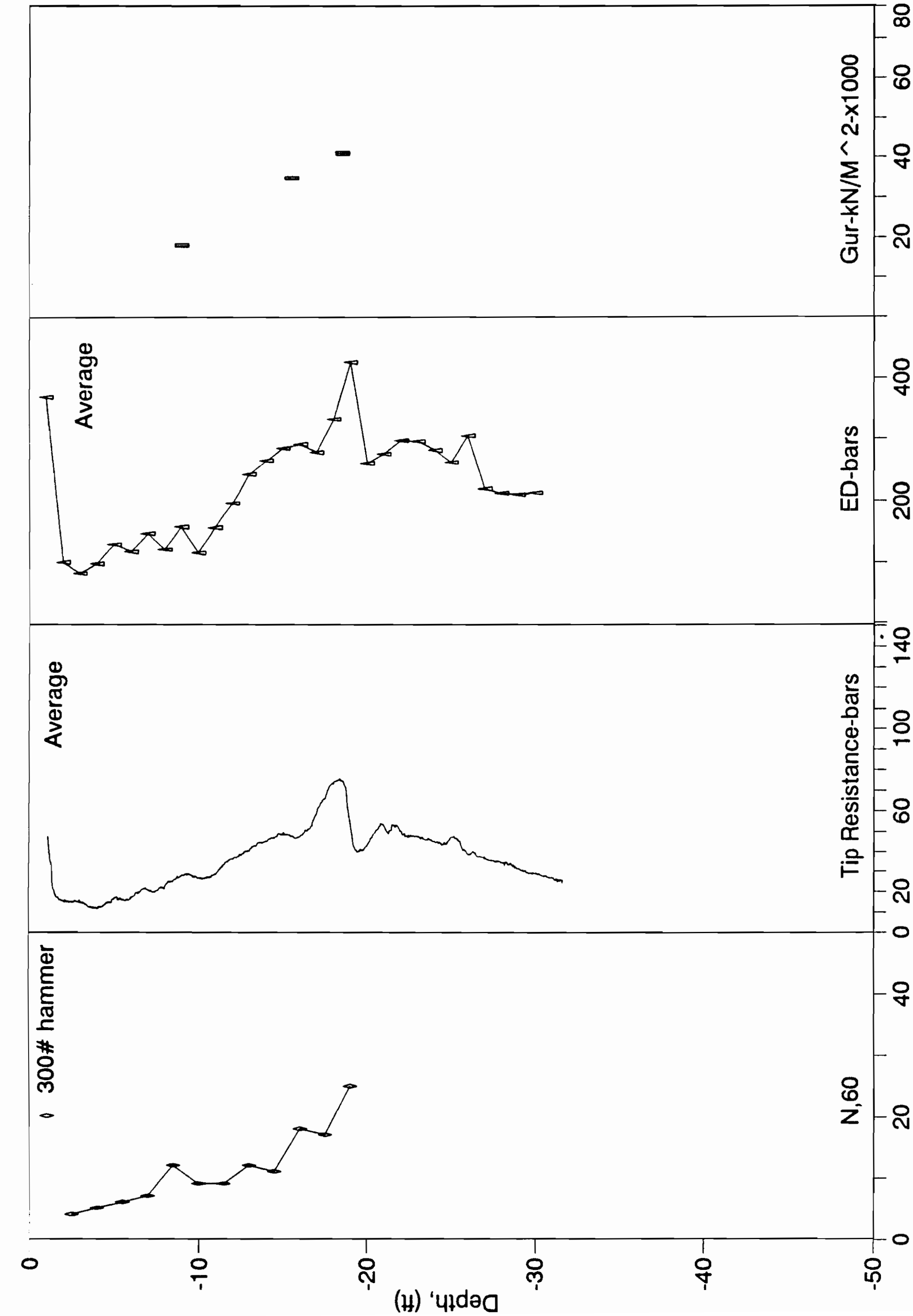


Figure 5.25 Schnabel: All In-Situ Tests

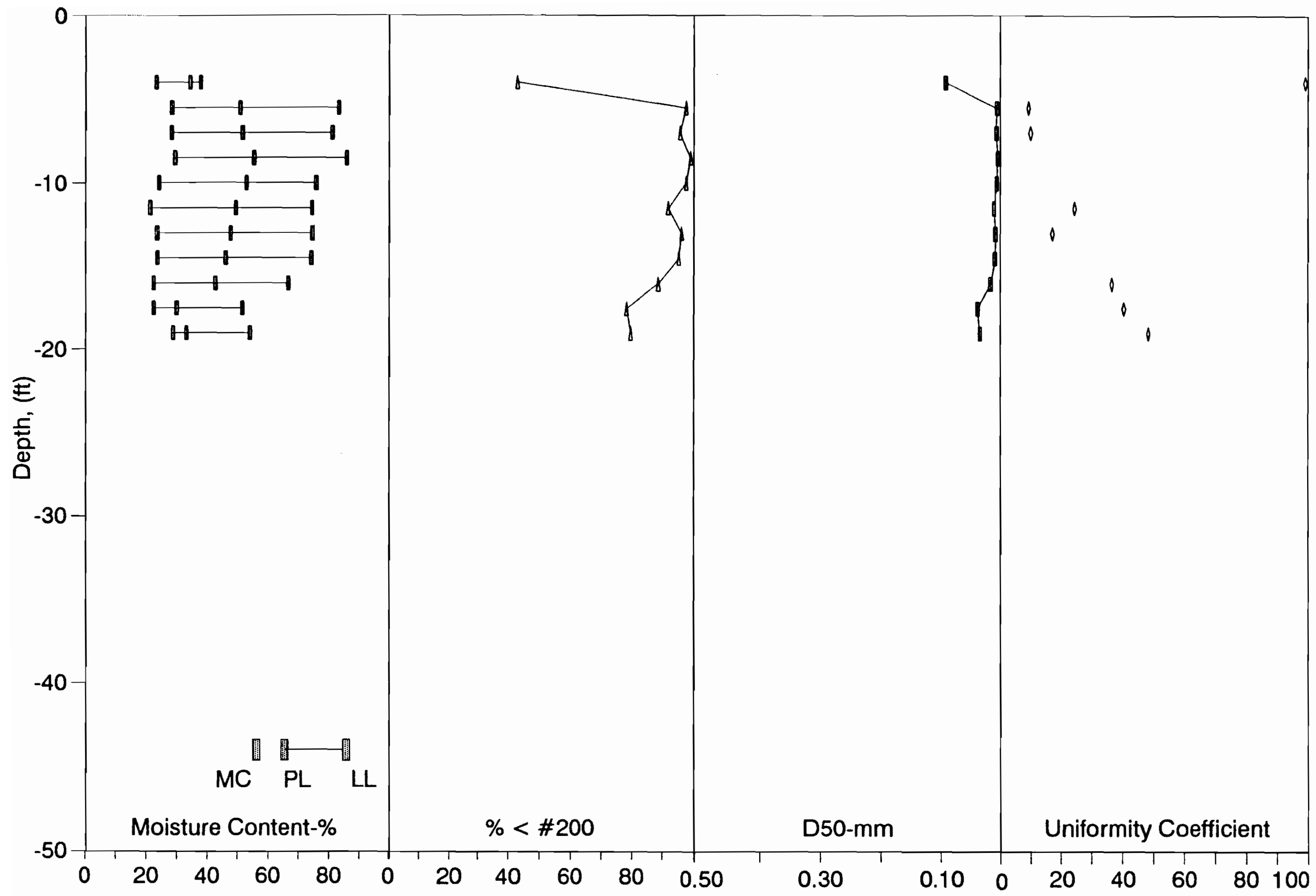


Figure 5.26 Schnabel: Lab Test Results

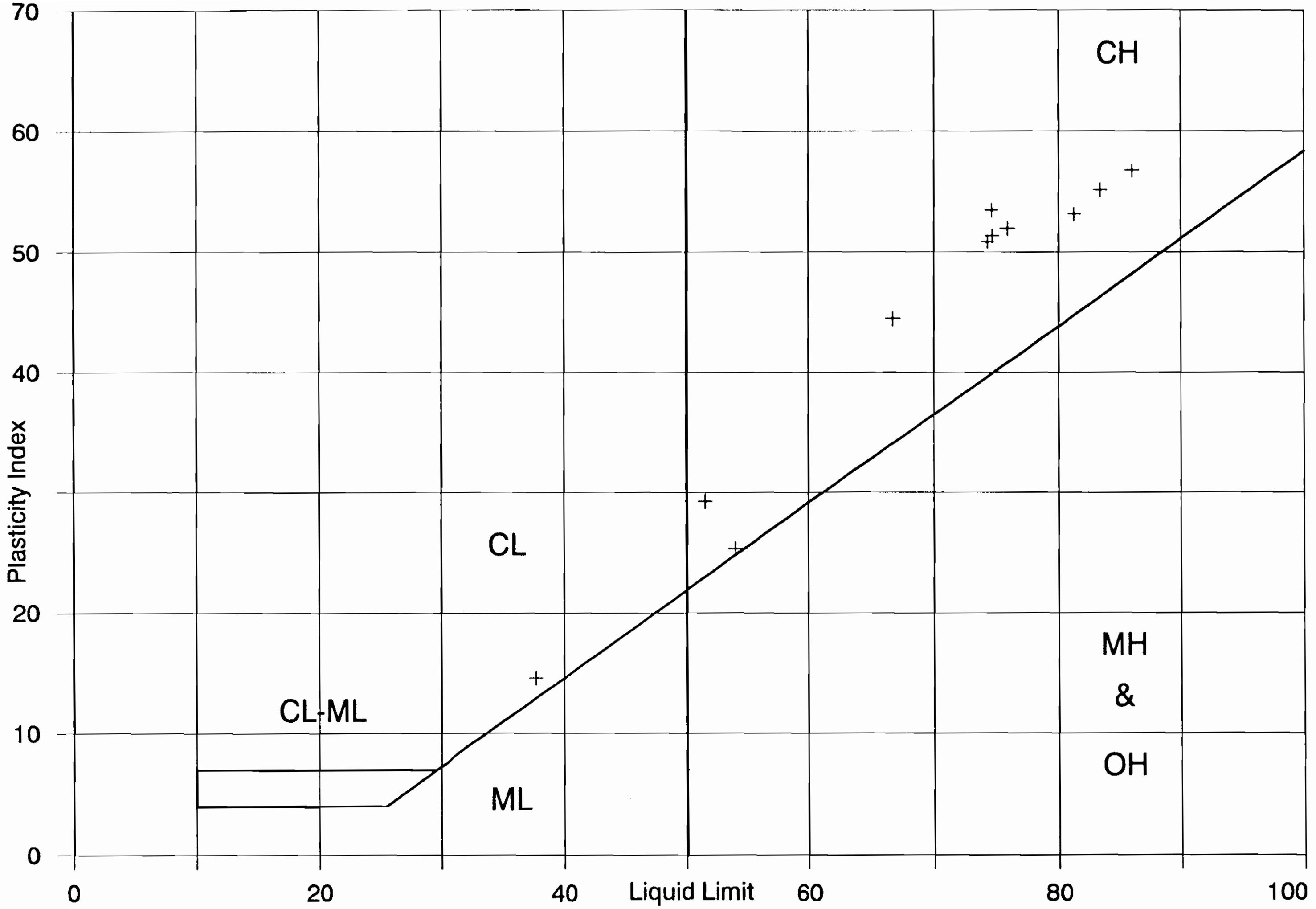


Figure 5.27 Schnabel: Plasticity Chart

Table 5.6

SCHNABEL SOIL CLASSIFICATIONS

Depth (ft)	ASTM D 2487 Classification	CPT Classification	DMT Classification
- 4.0	SC Clayey Sand	Clay	Silt
- 5.5	CH Fat Clay	Clay	Silt
- 7.0	CH Fat Clay	Clayey Silty to Silty Clay	Clayey Silt
- 8.5	CH Fat Clay	Sandy Silty to Clayey Silt	Silty Clay
-10.0	CH Fat Clay	Sandy Silty to Clayey Silt	Clay
-11.5	CH Fat Clay	Silty Sand to Sandy Silt	Silty Clay
-13.0	CH Fat Clay	Silty Sand to Sandy Silt	Silty Clay
-14.5	CH Fat Clay	Silty Sand to Sandy Silt	Silty Clay
-16.0	CH Fat Clay	Silty Sand to Sandy Silt	Silty Clay
-17.5	CH Fat Clay w/Sand	Sand to Silty Sand	Silty Clay
-19.0	CH Fat Clay w/Sand	Silty Sand to Sandy Silt	Silty Clay

5.4.2 Ladysmith

The standard test pattern of three borings, two for SPT data and one for PMT testing, three cone tests and three DMT soundings was completed at the Ladysmith site. Details of the field and lab tests conducted are given in Table 5.7 and were located as shown in Figure 5.28.

Sampling logging from SPT testing indicated a clearly defined soil profile (Figure 5.29). The top 2 feet at the Ladysmith site appear to be a gray clayey sand fill for a gravel road around a man made pond. Below the fill a layer of gray sandy clay to clayey sand extends to approximately the 5 foot level. From 5 to 10 feet, the soil grades through 3 feet of white gray sand into a yellow-white gravel layer. At 10 feet the soil changes abruptly to a green marine silty clay similar to the Miocene clay at the Schnabel site.

As at the Schnabel site the test results were consistent, with the SPT, CPT, and DMT testing presenting a common picture of the soil consistency. All of the tests indicated an increase in the penetration resistance/stiffness profile at approximately 21 feet that continued to 28 feet before again decreasing (Figures 5.30 to 5.34). The penetration resistance/stiffness increase was accompanied by a drop in the natural moisture content, a small increase in sand content, and a decrease in plasticity (Figures 5.35 and 5.36). In making the penetration resistance/stiffness comparisons among the tests it should be noted that the SPT data is questionable because of testing problems as discussed in Section 5.4.3.

Comparison of the test results between Schnabel and Ladysmith reveal penetration resistance/stiffness levels at Ladysmith approximately twice those in the Schnabel clay. The soil at Ladysmith also has a higher liquid limit and plasticity index.

The pattern of soil identifications from lab and field data as described for the Schnabel site was similar to that found for Ladysmith. From the 27 moisture content determinations, 1 specific gravity test, 16 grain size analyses and 15 Atterberg limit determinations (Table 5.7), lab soil classification contrasted with the in-situ test identifications with the DMT indicating conditions as slightly siltier than actuality and the CPT showing a sandy silt (Table 5.8).

Table 5.7
Ladysmith Site Testing Program

Field Testing

Test no.	Depth ft.	Samples/ readings	Duration hr.	Comment
Borings				
LSMB-1	29.0	16	6.0	
LSMB-2	14.0	7	5.0	
LSMB-3	16.5	4	n/a	for PMT tests
Cone Penetration Tests				
LSMC-1	30.0	n/a	0.6	removal problem
LSMC-2	29.6	n/a	0.5	
LSMC-3	22.0	n/a	0.5	bracket slipped
Dilatometer Soundings				
LSMD-1	9.0	9	membrane ripped @ 9.5 ft	
LSMD-2	30.0	30	1.5	
LSMD-3	30.0	30	1.1	
LSMD-4	30.0	30	1.3	
Pressuremeter Tests				
LSMP-1	15.0	2 loops	1.0	mem. rupture

Laboratory Testing

Moisture Content	Specific Gravity	Gr size w/hyd	Atterberg Limits
27	1	16	15

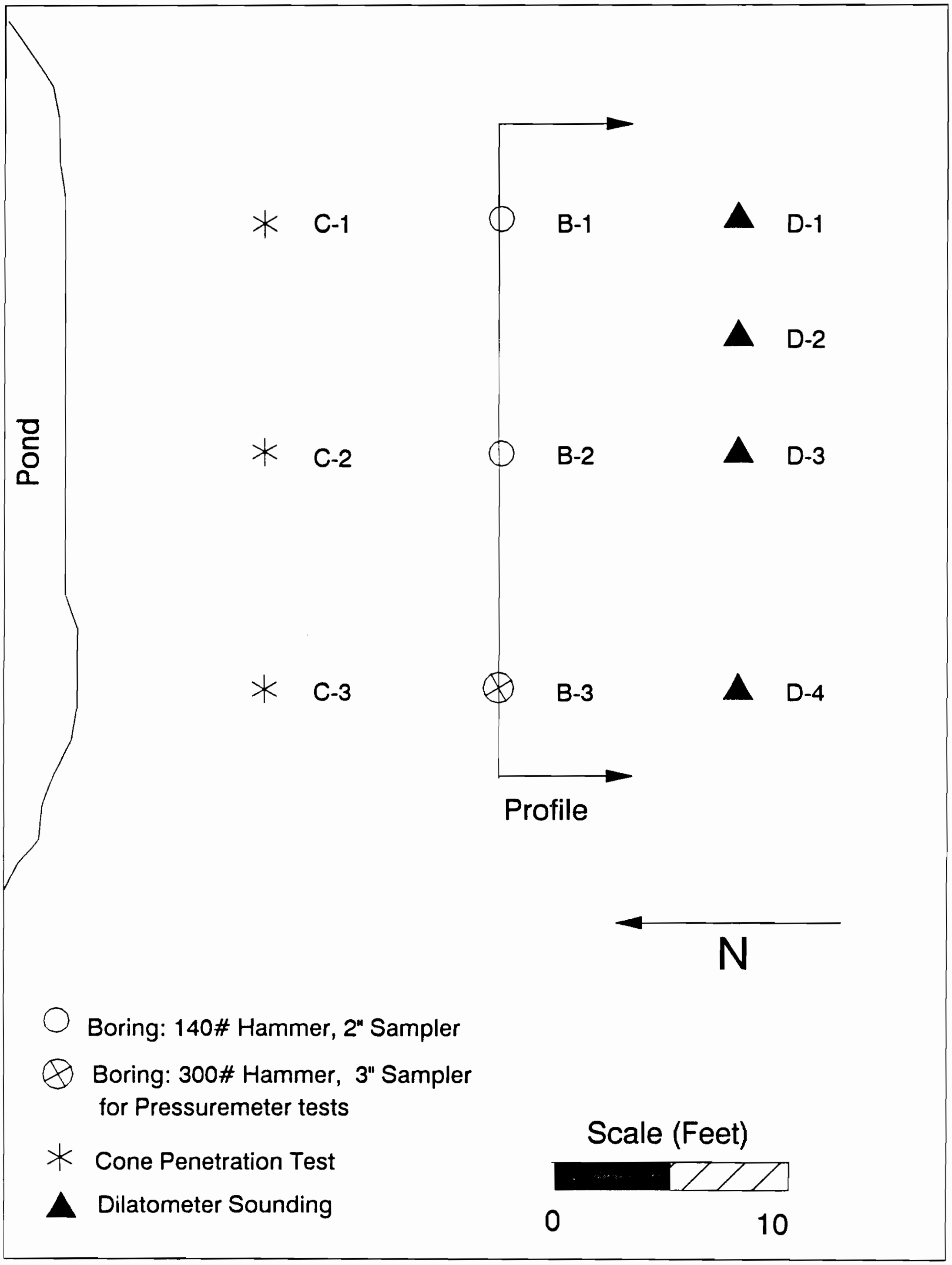


Figure 5.28 Ladysmith Test Location Map

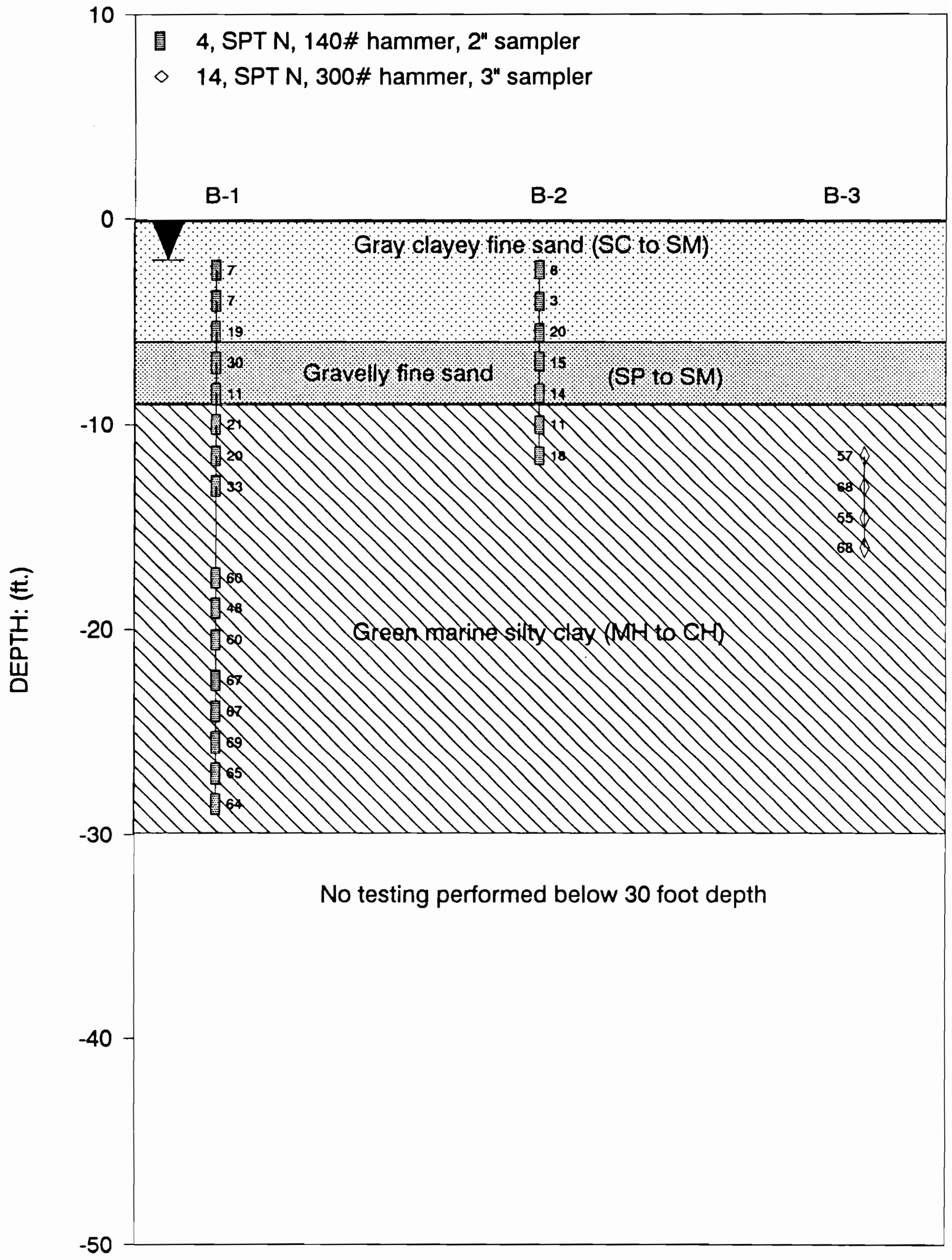


Figure 5.29 Ladysmith Soil Profile

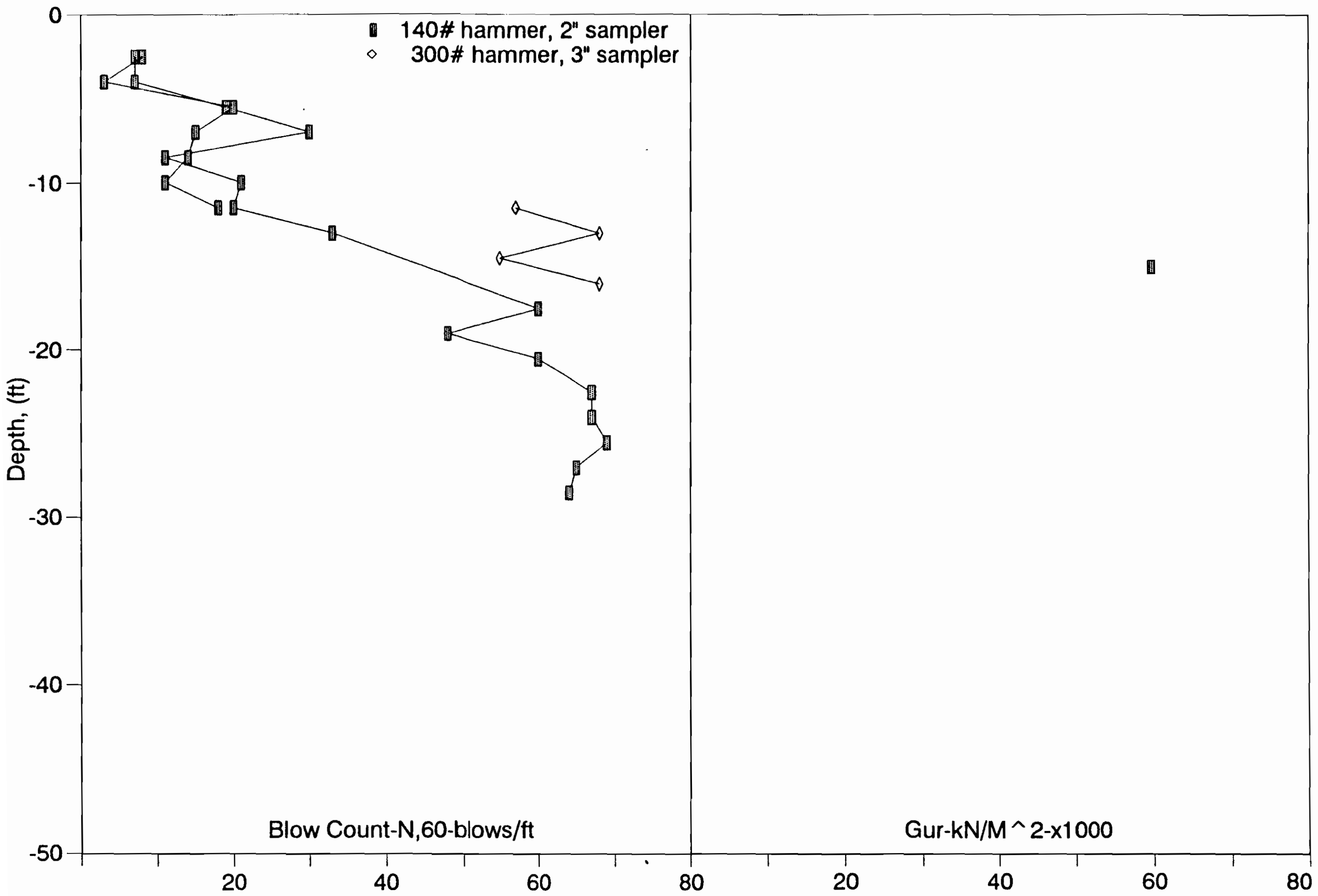


Figure 5.30 Ladysmith: N60 and Gur

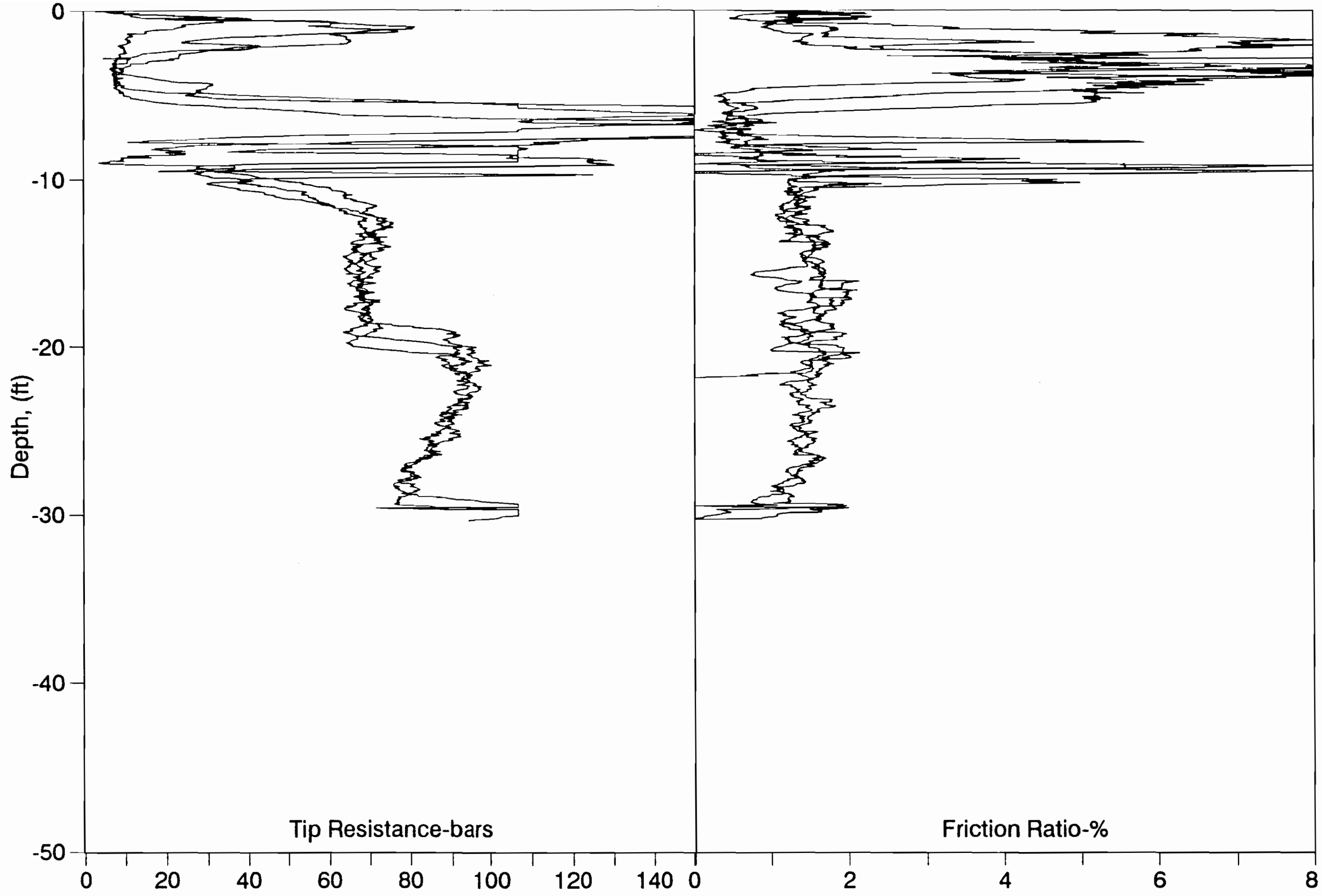


Figure 5.31 Ladysmith: All Cone Tests

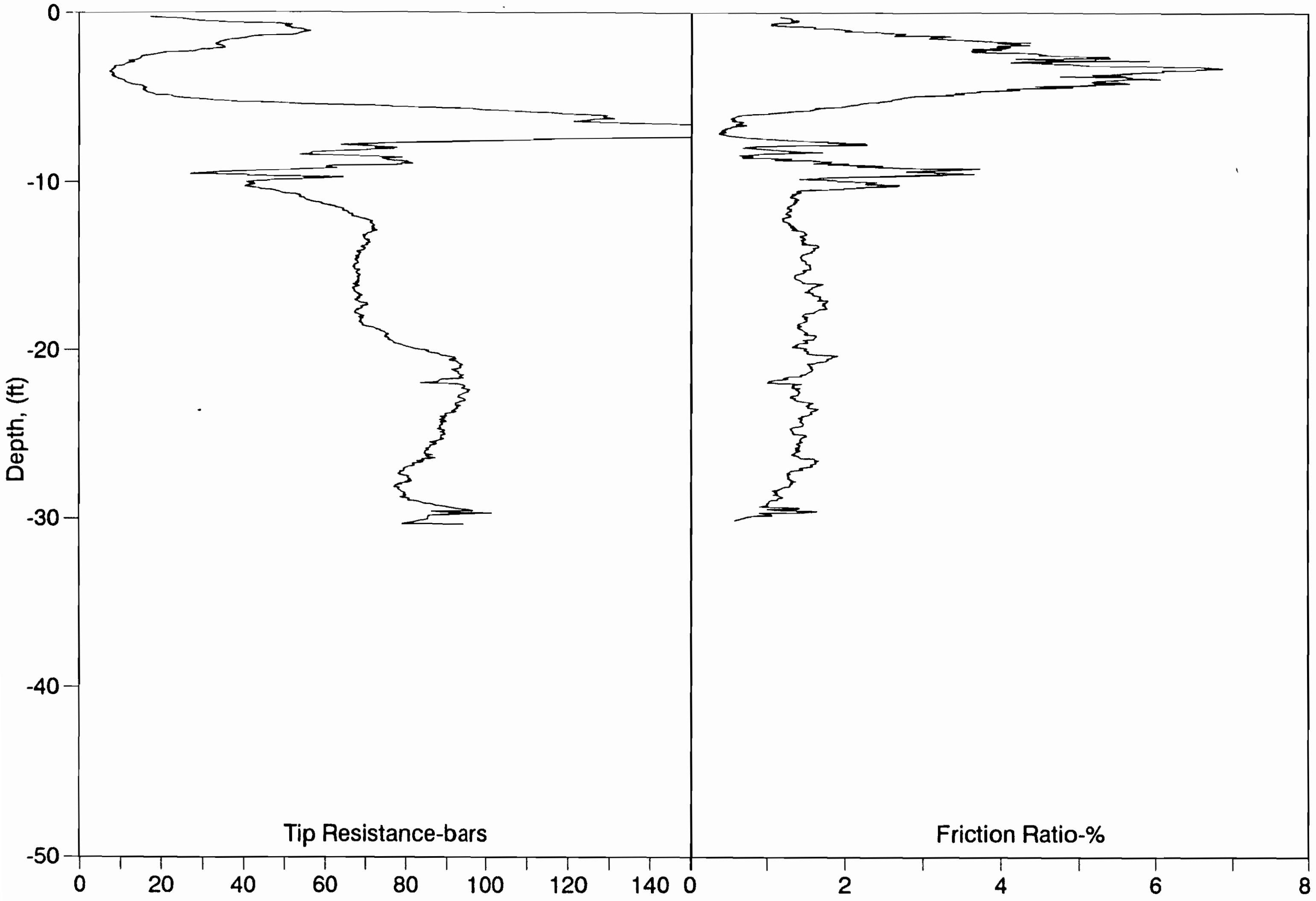


Figure 5.32 Ladysmith: Cone Test Averages

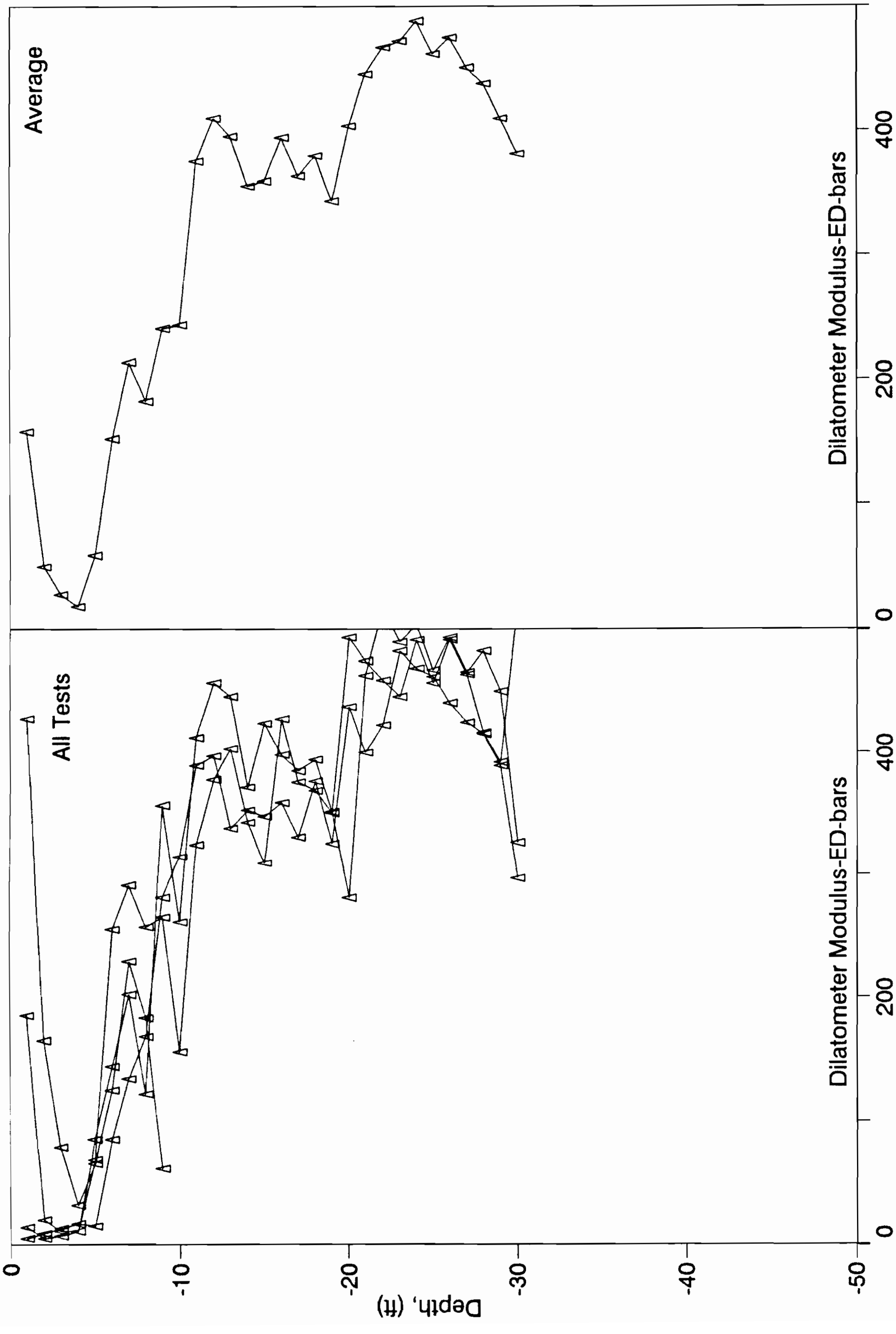


Figure 5.33 Ladysmith: Dilatometer Soundings

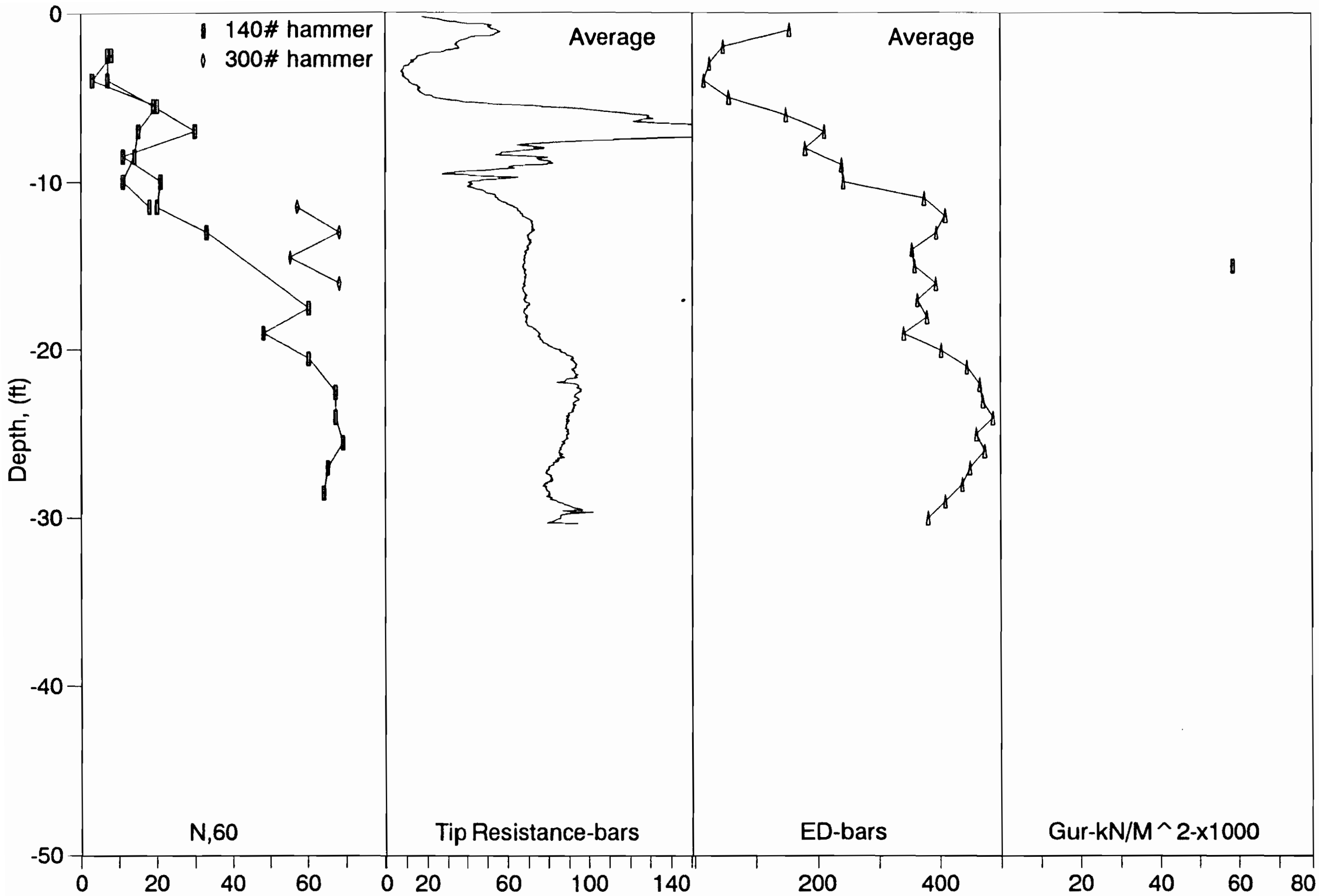


Figure 5.34 Ladysmith: All Insitu Tests

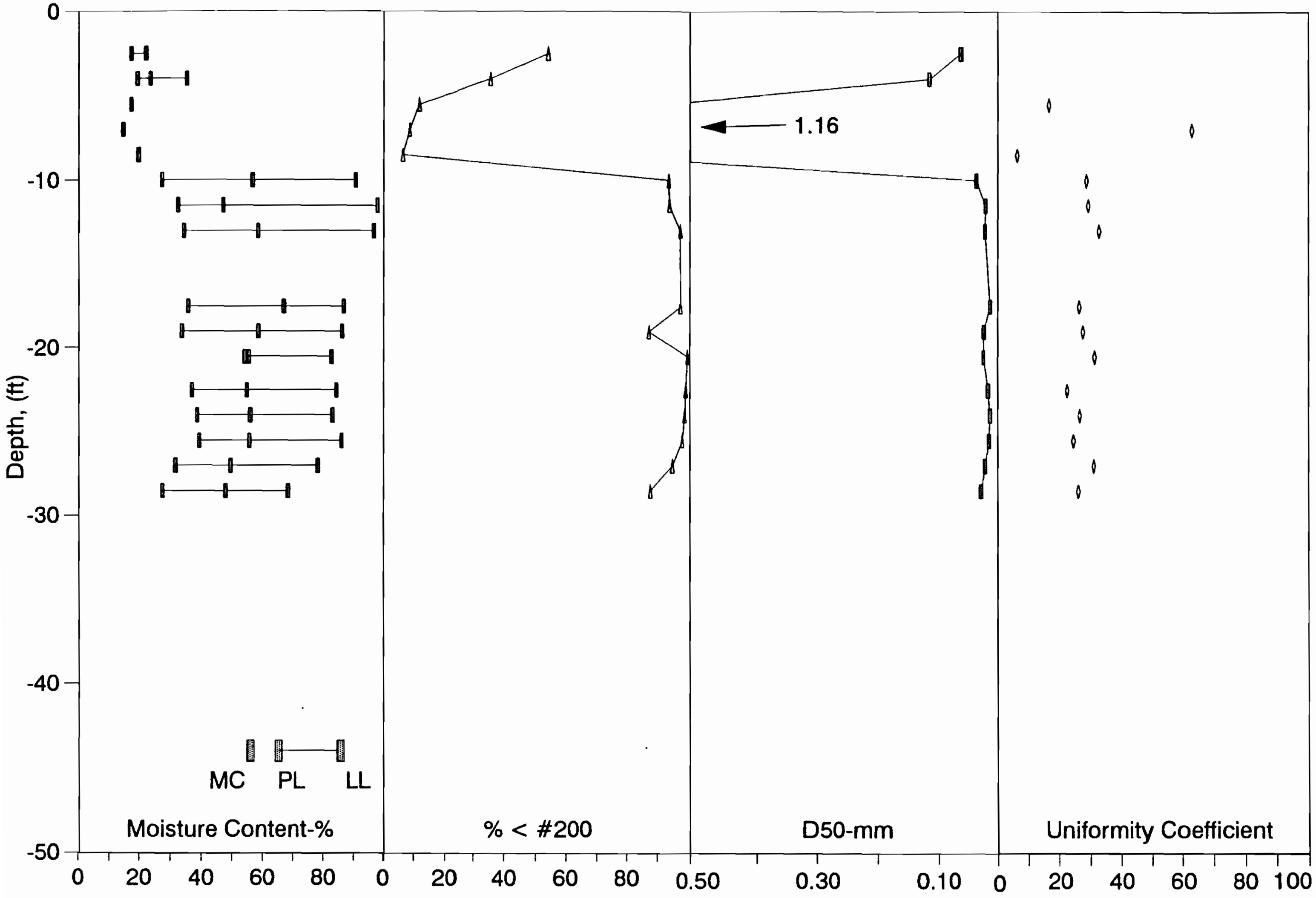


Figure 5.35 Ladysmith: Lab Test Results

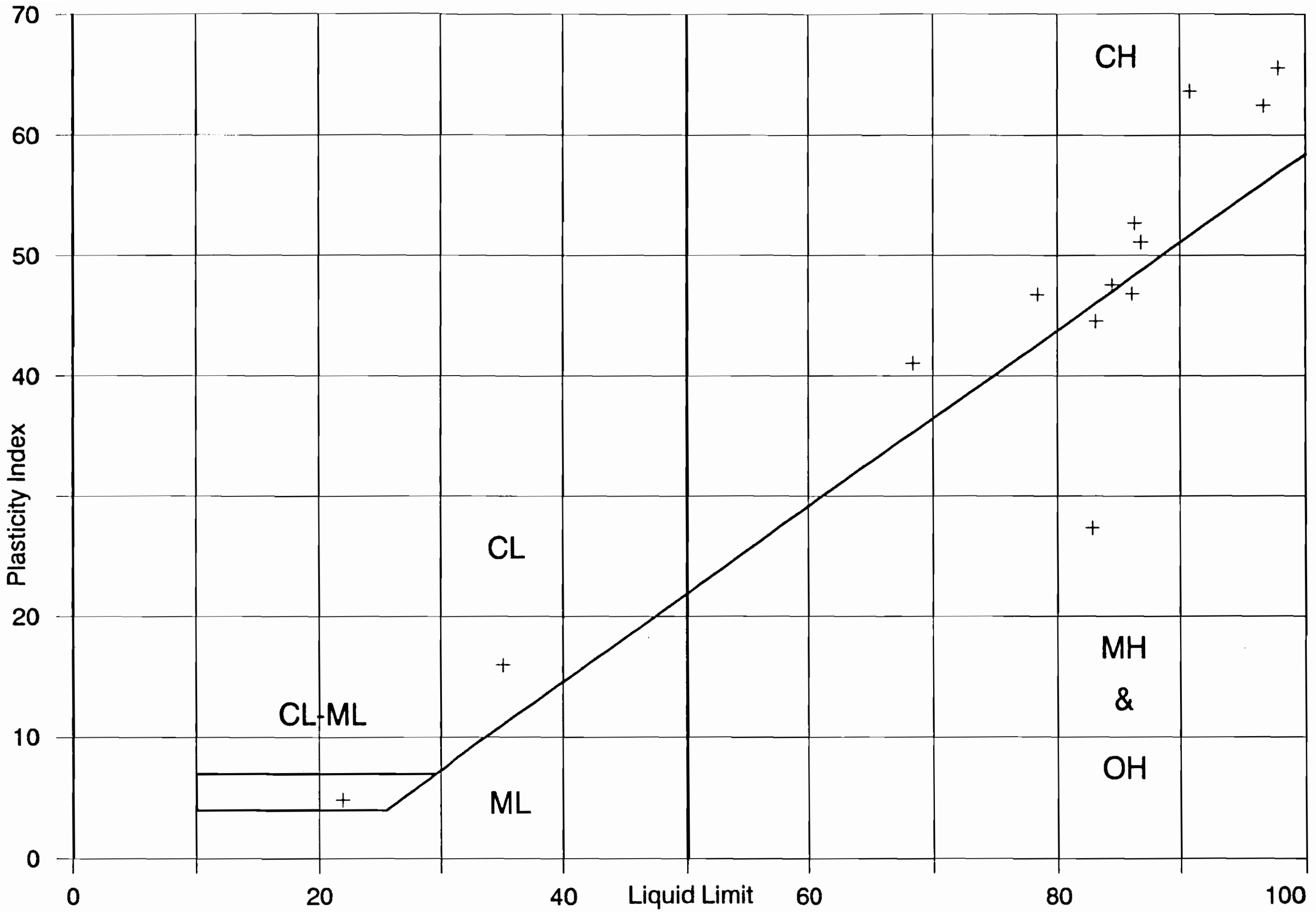


Figure 5.36 Ladysmith: Plasticity Chart

Table 5.8

LADYSMITH SOIL CLASSIFICATIONS

Depth (ft)	ASTM D 2487 Classification	CPT Classification	DMT Classification
- 2.5	CL-ML Sandy Silty Clay	Clay	Sandy Silt
- 4.0	CS Clayey Sand	Clay	Silty Clay
- 5.5	SP-SM Sand w/Silt	Silty Sand to Sandy Silt	Sand
- 7.0	SW-SM Sand w/Silt & Gravel	Sand	Sand
- 8.5	SW-SM Sand w/Silt & Gravel	Sand to Silty Sand	Sand
-10.0	CH Fat Clay	Sandy Silt to Clayey Silt	Clayey Silt
-11.5	CH Fat Clay	Silty Sand to Sandy Silt	Silty Clay
-13.0	CH Fat Clay	Silty Sand to Sandy Silt	Silty Clay
-17.5	CH Fat Clay	Silty Sand to Sandy Silt	Silty Clay
-19.0	CH Fat Clay	Silty Sand to Sandy Silt	Silty Clay
-20.5	MH Elastic Silt	Silty Sand to Sandy Silt	Silty Clay
-22.5	MH Elastic Silt	Sand to Silty Sand	Silty Clay
-24.0	MH Elastic Silt	Silty Sand to Sandy Silt	Silty Clay
-25.5	MH Elastic Silt	Silty Sand to Sandy Silt	Silty Clay
-27.0	CH Fat Clay	Silty Sand to Sandy Silt	Silty Clay
-28.5	CH Fat Clay	Sand to Silty Sand	Silty Clay

5.4.3 Marine Clay Site Testing Difficulties

Difficulties were encountered testing the marine deposits at both the Ladysmith and Schnabel sites. The first tests attempted were cone tests at the Ladysmith site. Although tip resistance displayed on the computer screen remained moderate (90 bars), as test depth increased, it became increasing more difficult to advance the cone. Refusal occurred at a depth of 30 feet during the first test. After stopping the test, the usual procedure was followed with backup computer data files being made and the computer secured from testing. When extraction was attempted, the front end of the drill lifted off the ground. The soil had swelled around the cone rod, locking it in place while the computer was being secured. This behavior is believed to be caused by the presence of high lateral stresses in the overconsolidated clay at the site. Mayu (1987) previously measured large lateral stresses at the Schnabel site using a self boring pressuremeter. He obtained K_0 values above 10 in some cases. Extraction was accomplished with the aid of a 100 ton capacity hollow stem hydraulic jack.

For the remaining cone and dilatometer tests at the Ladysmith and Schnabel sites extraction was started immediately upon completion of the test. Test depths were also limited to 30 feet. Using these procedures it was possible to complete the testing without again resorting to the hollow stem jack.

Similar difficulties also occurred at the Schnabel site, and they affected boring, sampling, and pressuremeter operations. Standard penetration testing appeared to proceeded normally for the first 12 inches. However, penetration would then stop completely during the last 6 inch increment of sampler advance. The sampler appeared to fill with soil and then bounce without advancing further. Opening the split spoons became difficult as the soils swelled and jammed the threads. Upon opening the spoon with pipe wrenches, it was possible to see a series of rings around the sample representing each hammer blow. The problem with the spoon testing might have been overcome by using a 30 inch barrel instead of the 22 inch barrels available for this work. These would have allowed more room for the sample.

Attempts were made to obtain thin wall tube samples at each site. No tubes were recovered at Ladysmith, with one successful attempt in three tries at Schnabel. The soil swelled around the tubes locking them in place. The tube head ripped through the metal tube when extraction was attempted.

Successful insertion of the pressuremeter required opening the hole quickly and inserting the probe immediately after removing the sampler. Two 3" split spoon samples were taken in succession to open the hole. The second was left in place until the pressuremeter was hanging in the drill rig leads ready for insertion. Upon removal of the second spoon the pressuremeter was immediately lowered into the hole. It was still necessary to seat the probe by pushing it into position with the drill rig kelly. Extraction was also difficult, with two of the drill rig winches being required to break the probe free.

5.5 Residual Soil Sites

Residual soils are known to be characterized by a variable nature. At Kipp's Farm, rock depth varied from 22 feet to below 45 feet in the span of 150 feet. There were also layers of sandstone or shale encountered at random depths. The Winterpock site revealed a band of denser materials running through the center of the test area, with a seam of weathered white sandstone changing in thickness and depth from WPKB-1 to WPKB-2. Only the Plantation Pipeline site seemed to have fairly uniform soil conditions. Weathering appeared to have progressed further at the Plantation Pipeline site than the others, leading to more homogeneous soil conditions. No particular difficulties were encountered during testing other than dealing with the variability of the soils.

The first cone tests of the entire testing program were performed at the Plantation Pipeline and Winterpock Tap sites. The friction ratio values for tests PLPC-1 through PLPC-3 and WPKC-1 appeared too low due to improper adjustment of the friction sleeve zero value. Additional cone tests were run at both sites during later testing and provided more reasonable data. Results of testing at the residual soil sites are discussed in the following order:

5.5.1 Kipp's Farm Hilltop Area
5.5.2 Kipp's Farm Hillside Area
5.5.3 Plantation Pipeline
5.5.4 Winterpock Tap

5.5.1 Kipp's Farm Hilltop Area

The test locations for both Kipp's Farm test areas are shown in Figure 5.37. Testing at the hilltop area followed the standard 10 foot grid spacing and included two borings, three cone penetration tests, three DMT soundings and six attempted pressuremeter tests with four successes (Table 5.9).

At the hilltop area, the soils exhibited a general trend from elastic/high plasticity silts at the surface that gradually became less plastic and less weathered with depth. The materials grade into silts and then silt with sand as the depth increases. However, there were anomalous pockets of sandstone and sand, and considerable variation in layer thickness between the two borings. In a distance of 10 feet, the thickness of the top layer of red-orange silt varied from 13 feet in boring B-1 to 21 feet in boring B-3 (Figure 5.38). Below the surface layer found a tan-brown silt with sand was found extending to 26 feet deep in B-1 and 28 feet deep in B-3. Both borings then showed a layer of white sand to a depth of approximately 30 feet. Below 30 feet, a mixed deposit of tan brown clayey silt to silty clay with sandstone gravel extended to bedrock at 36.5 feet in B-1 and below test depth in B-3.

With such variability, only rough correlations existed among the in-situ tests instead of the more definite relationships shown in the sites discussed previously. In fact, there was scatter in the data from the same in-situ test performed in different locations. At this area penetration resistance/stiffness increased gradually to approximately 10 feet, and then declined steadily until rock was encountered at from 36 to 41 feet (Figures 5.39 to 5.43). SPT and DMT data were roughly equivalent, with the CPT giving a more erratic profile apparently identifying individual pockets of unweathered rock. With four data points for the pressuremeter it appeared to follow the same pattern as the other tests, but drawing conclusions is difficult.

Soil identifications from the lab tests and the cone and dilatometer were reasonably consistent, although the f_r from the CPT exhibited substantially greater variability than the alluvial or marine clay sites. For soil identification, 33 moisture content determinations, 2 specific gravity tests, 21 grain size analyses and 21 Atterberg limit determinations were conducted (Figures 5.44 and 5.45). Both in-situ tests indicated a higher clay content for the soils than did lab results, but did detect the increase in sand content with increasing depth (Table 5.10).

Table 5.9

Kipp's Farm, Hilltop Area Testing Program

Field Testing

Test no.	Depth ft.	Samples/ readings	Duration hr.	Comment
Borings				
KFB-1	36.5	20	8.0	rock @ 36.5 ft.
KFB-3	35.0	13	n/a	for PMT tests
Cone Penetration Tests				
KFC-3	24.4	n/a	0.4	rock @ 24.6 ft.
KFC-4	44.5	n/a	0.8	
KFC-5	39.8	n/a	0.7	rock @ 39.8 ft.
Dilatometer Soundings				
KFD-1	23.5	46	1.5	load cell used
KFD-2	37.0	37	1.5	load cell bent
KFD-3	33.0	33	1.5	
Pressuremeter Tests				
KFP-1	4.5	none	n/a	circuit fault
KFP-2	10.5	2 loops	2.3	complete test
KFP-3	18.0	2 loops	2.0	complete test
KFP-4	22.5	none	n/a	mem. rupture
KFP-5	30.5	1 loop	1.3	complete test
KFP-6	33.5	2 loops	2.5	complete test

for additional data see Pappas(1990) and Mayu(1987)

Laboratory Testing

Moisture Content	Specific Gravity	Gr size w/hyd	Atterberg Limits
33	2	21	21

for additional data see Pappas(1990) and Mayu(1987)

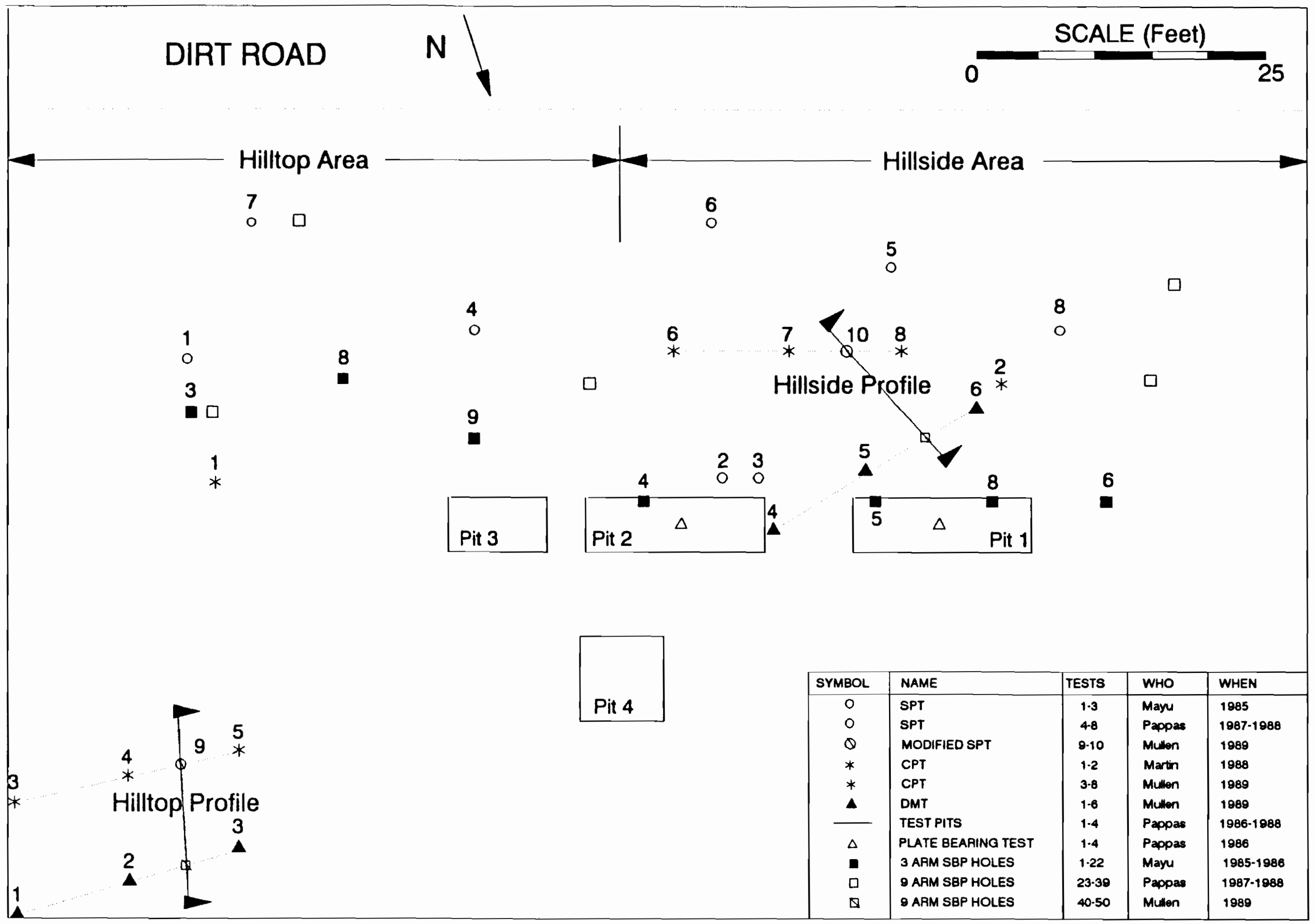


Figure 5.37 Kipp's Farm Test Location Map

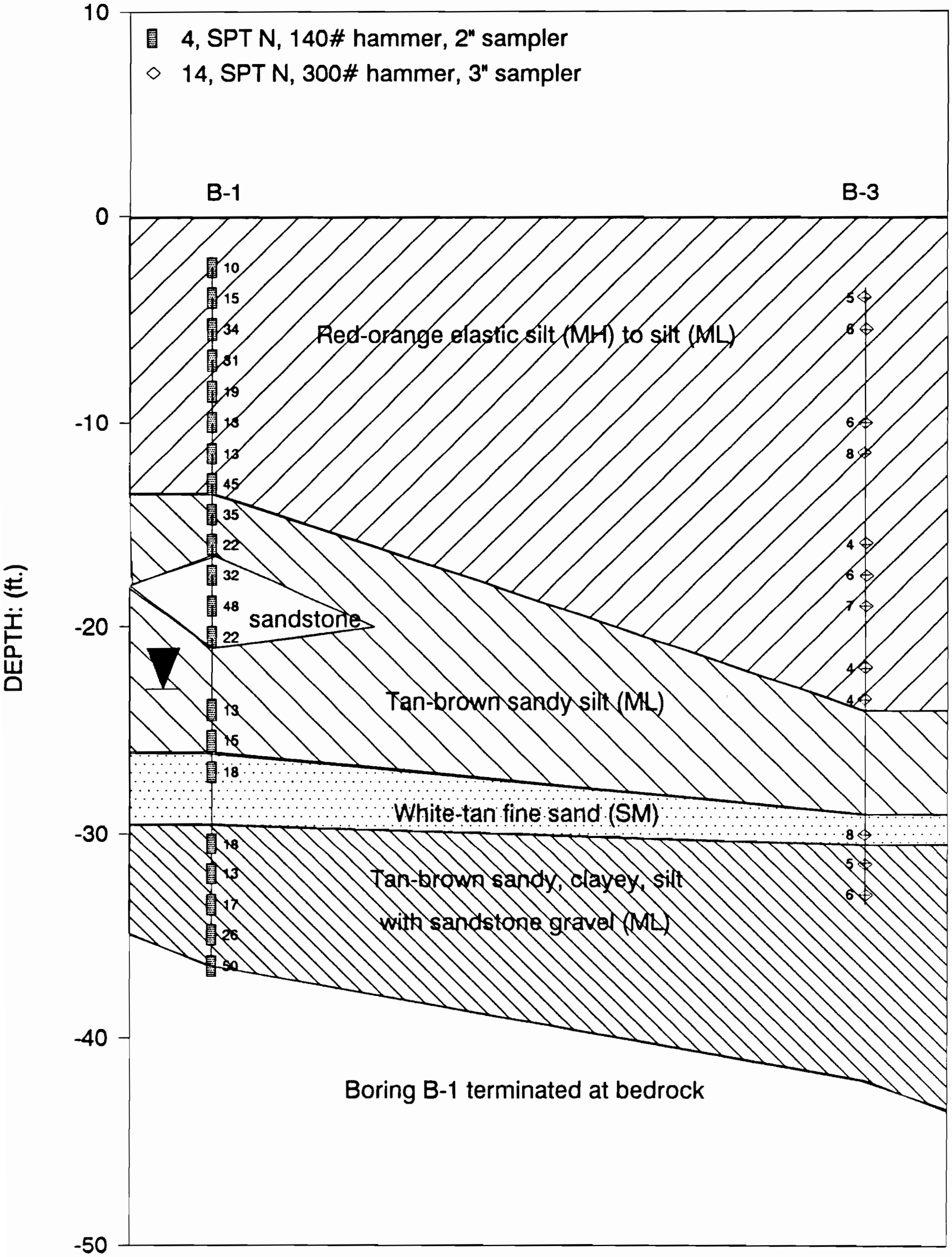


Figure 5.38 Kipp's Farm Hilltop Area Soil Profile

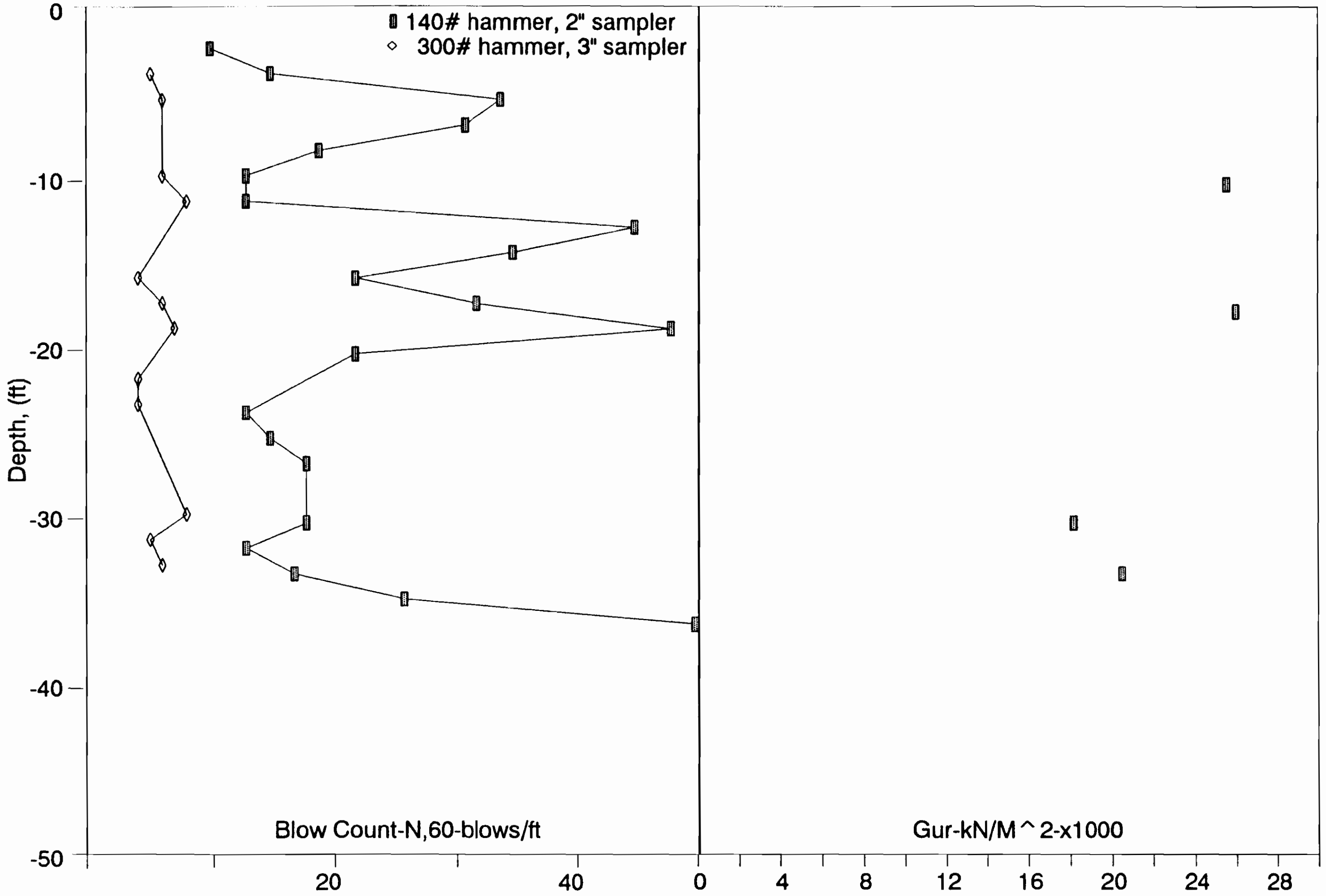


Figure 5.39 Kipp's Farm, Hilltop: N60 and Gur

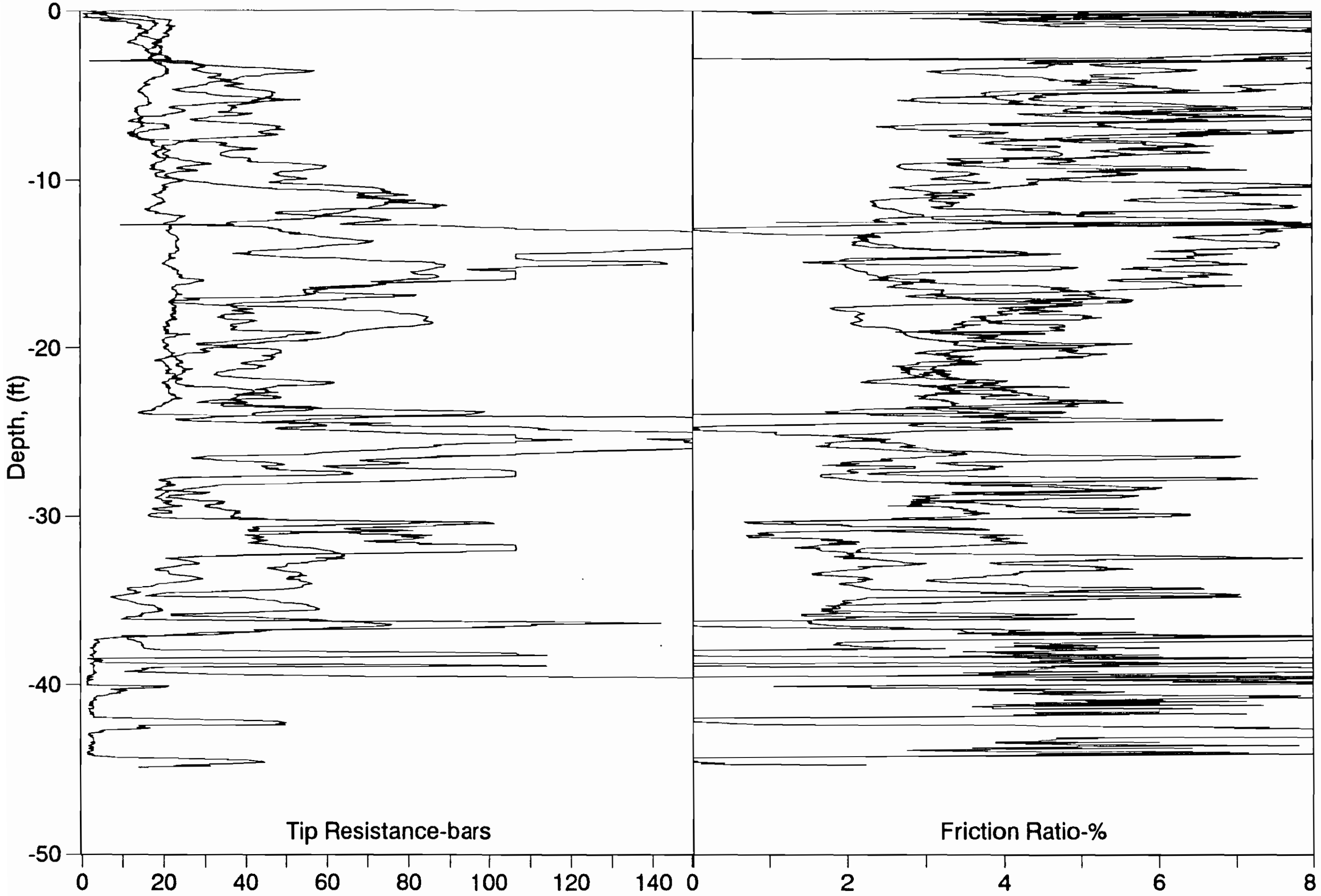


Figure 5.40 Kipp's Farm, Hilltop: All Cone Tests

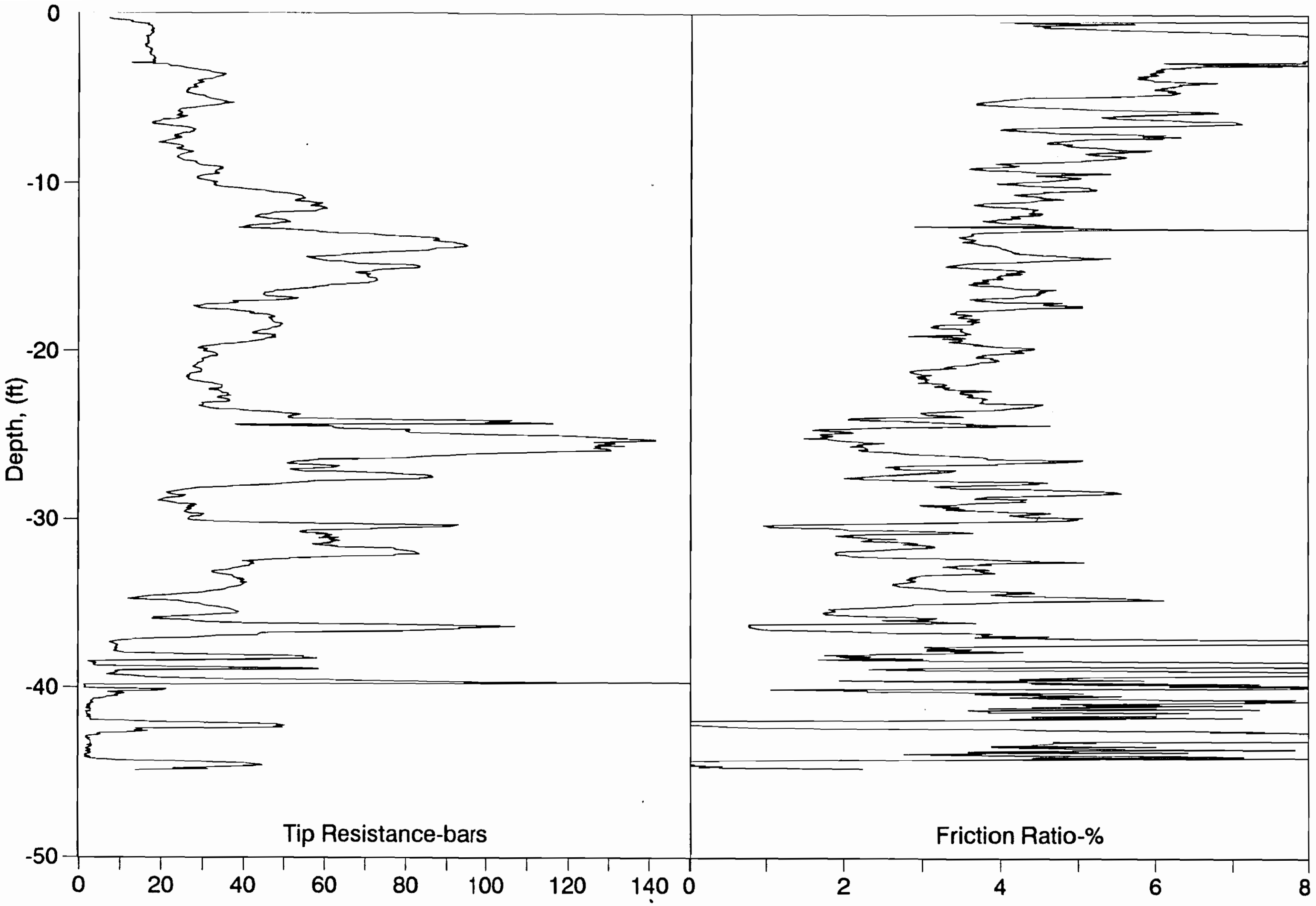


Figure 5.41 Kipp's Farm, Hilltop: Cone Test Averages

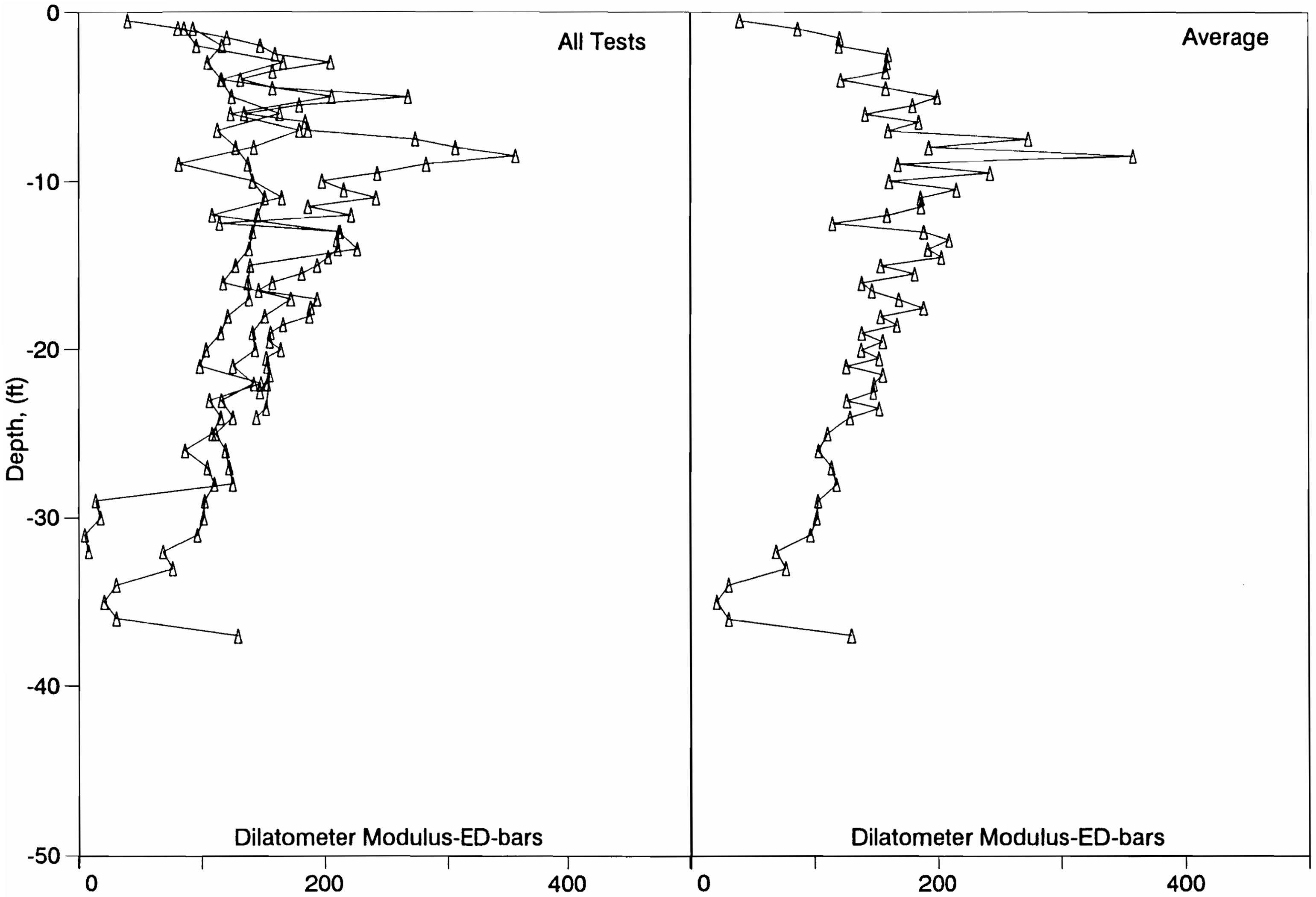


Figure 5.42 Kipp's Farm, Hilltop: Dilatometer Soundings

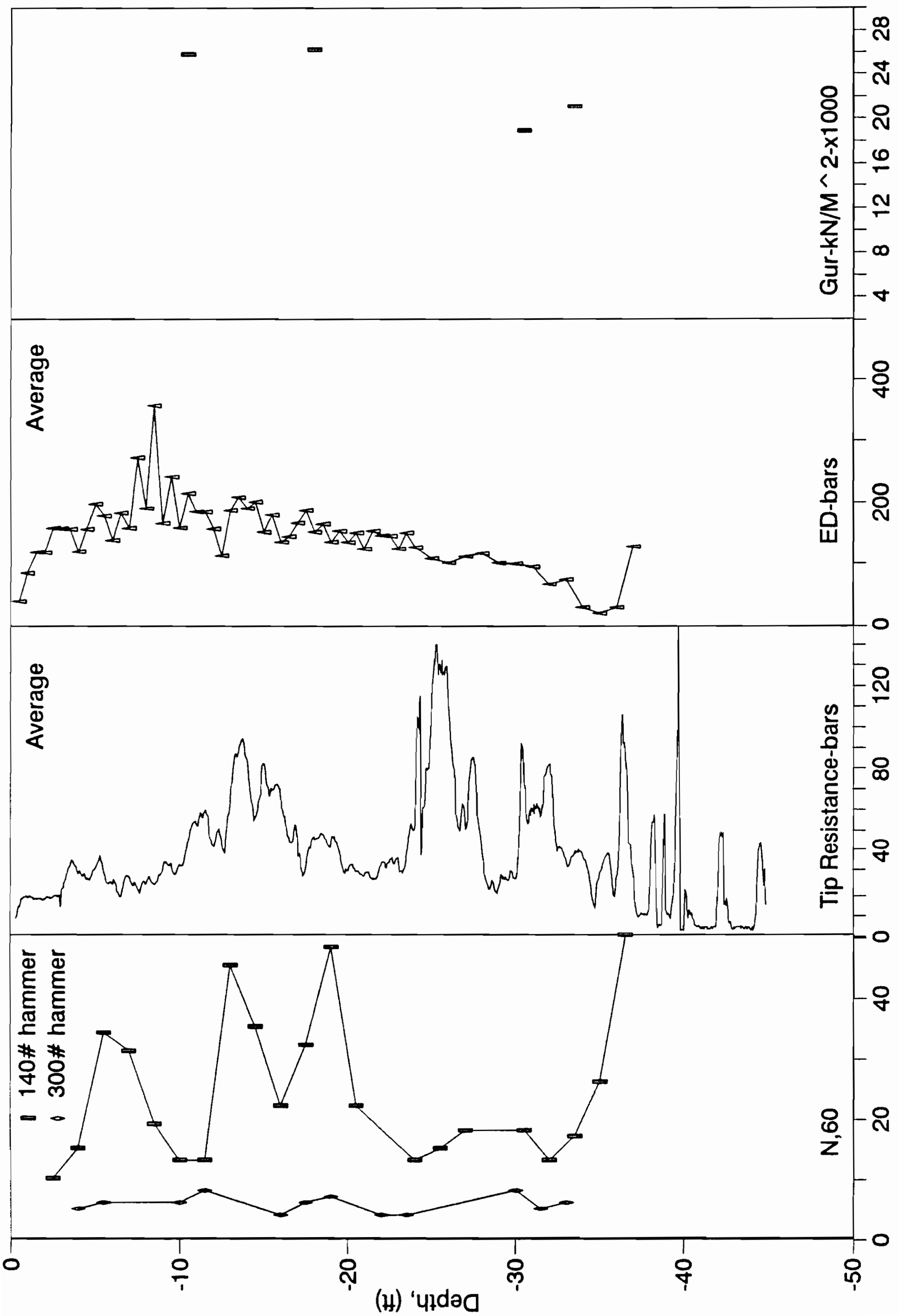


Figure 5.43 Kipp's Farm, Hilltop: All In-Situ Tests

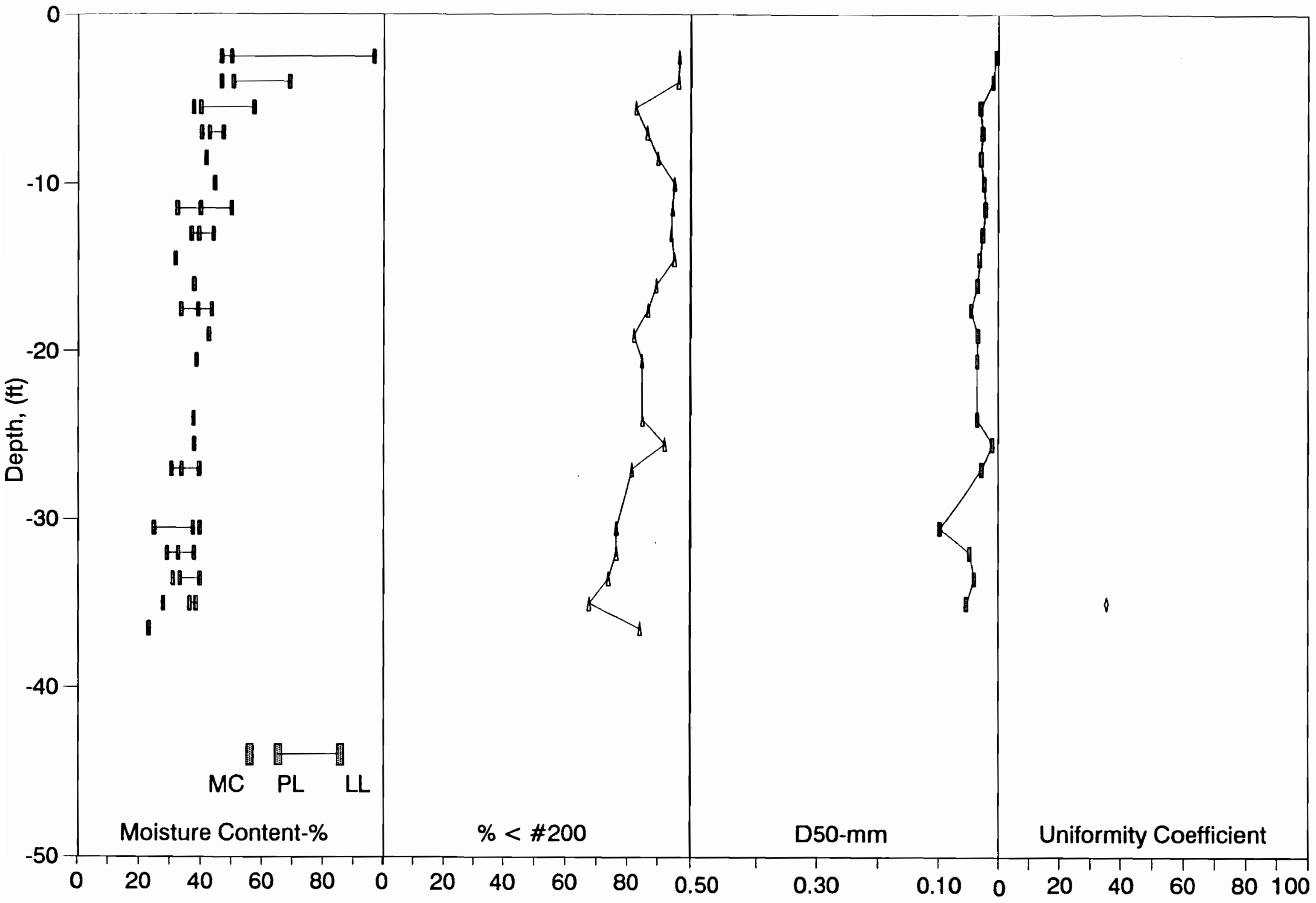


Figure 5.44 Kipp's Farm, Hilltop: Lab Test Results

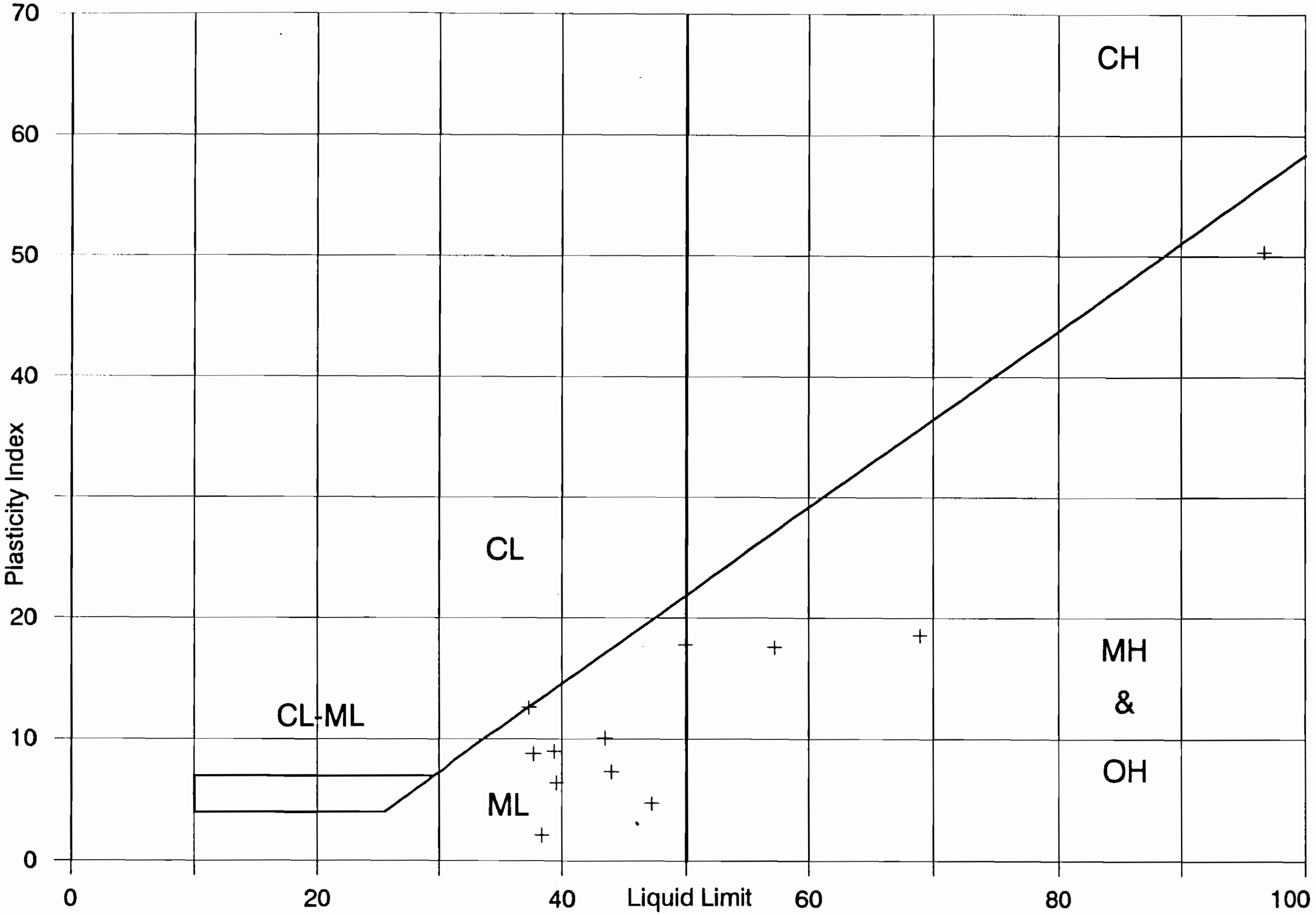


Figure 5.45 Kipp's Farm, Hilltop: Plasticity Chart

Table 5.10

KIPP'S FARM HILLTOP AREA SOIL CLASSIFICATIONS

Depth (ft)	ASTM D 2487 Classification	CPT Classification	DMT Classification
- 2.5	MH Elastic Silt	Clay	Sandy Silt
- 4.0	MH Elastic Silt	Clay	Clayey Silt
- 5.5	MH Elastic Silt w/Sand	Silt	Clay
- 7.0	ML Silt	Clay	Clayey Silt
- 8.5	ML Silt	Clay	Silt
-10.0	ML Silt	Clayey Silt to Silty Clay	Clayey Silt
-11.5	ML Silt	Clayey Silt to Silty Clay	Clayey Silt
-13.0	ML Silt	Clayey Silt to Silty Clay	Clayey Silt
-14.5	ML Silt	Silty Clay to Clay	Silt
-16.0	ML Silt	Clay Silt to Silty Clay	Clayey Silt
-17.5	ML Silt	Clayey Silt to Silty Clay	Silt
-19.0	ML Silt w/Sand	Clayey Silt to Silty Clay	Clayey Silt
-20.5	ML Silt w/Sand	Clayey Silt to Silty Clay	Clayey Silt
-24.0	ML Silt w/Sand	Silty Sand to Sandy Silt	Silty Clay
-25.5	ML Silt	Silty Sand to Sandy Silt	Silty Clay
-27.0	ML Silt w/Sand	Sandy Silt to Clayey Silt	Clayey Silt
-30.5	ML Silt w/Sand	Silty Sand to Sandy Silt	Silt
-32.0	ML Silt w/Sand	Silty Sand to Sandy Silt	Sandy Silt
-33.5	ML Silt w/Sand	Sandy Silt to Clayey Silt	Sandy Silt
-35.0	ML Sandy Silt	Clayey Silt to Silty Clay	Silty Sand
-36.5	ML Silty w/Sand	Sand to Silty Sand	Silty Sand

5.5.2 Kipp's Farm Hillside Area

The testing pattern varied slightly from standard at the hillside test area. Boring B-2 and all cone testing were completed prior to planting of the summer corn crop. The dilatometer tests and the boring for pressuremeter testing were moved slightly to minimize crop damage. All tests were still conducted within 30 feet of each other (Figure 5.37). Details of the two borings, three cone penetration tests, three DMT soundings and six pressuremeter tests are shown in Table 5.11.

The soil profile for the hillside area (Figure 5.46) was even more variable than the hilltop profile located 150 feet away. A surface layer of red-orange silty clay or elastic silt extended to 8 feet in B-2 and 10.5 feet in B-4. Below the clay/ elastic silt a deposit of orange-brown silt extended to 21 feet in B-2 and 16 feet in B-4. Next encountered was a layer of yellow-orange silt continuing to approximately 24 feet in both borings. From 24 feet a tan-brown sandy silt was found to 32 feet in boring B-2 and continued below the final depth of B-4. From 32 to 38 feet, B-2 identified a light brown sandy silt and then encountered a pocket of white silty sand from 38 to 40.5 feet. Below the sand was a brown silty sand. Boring B-2 was terminated with the loss of drilling fluid return at a depth of approximately 42 feet. This would indicate a void or fissure at that depth.

The hillside area penetration resistance/stiffness profile remained reasonable constant to approximately 20 feet and then increased gradually to about double the original penetration resistance/stiffness. In-situ test values remained fairly high for 10 feet and then decreased from 30 to 40 feet (Figures 5.47 to 5.51). Rock depth varied from 38 to 44 feet within the various tests. The SPT and DMT data mirrored each other fairly well. Cone data were again erratic and the trends of PMT soil stiffness roughly followed the SPT blow counts and

DMT modulus value. As with the soil profile, the test results varied significantly from point to point.

Soil identifications from the 33 moisture content determinations, 2 specific gravity tests, 25 grain size analyses and 25 Atterberg limits determinations (Figures 5.52 and 5.53) compared well with the CPT and DMT classifications (Table 5.12). As at the hilltop area, f_r values from the cone were scattered and the CPT and DMT tests indicated a greater clay content for the soils than was obtained in the lab testing. At this area, the CPT failed to identify the increasing sand in the profile until encountering the sand layer at 39 feet. The DMT did identify the increase in the granular nature of the soil as depth increased.

Table 5.11
Kipp's Farm Hillside Area Testing Program

Field Testing

Test no.	Depth ft.	Samples/ readings	Duration hr.	Comment
Borings				
KFB-2	41.0	25	8.0	void @ 41.5 ft
KFB-4	36.0	12	n/a	for PMT tests
Cone Penetration Tests				
KFC-6	41.5	n/a	0.7	rock @ 41.0 ft.
KFC-7	44.8	n/a	0.9	
KFC-8	38.8	n/a	0.7	rock @ 38.2 ft.
Dilatometer Soundings				
KFD-4	45.0	45	1.8	
KFD-5	45.0	45	2.0	
KFD-6	37.2	37	1.8	rock @ 37.2 ft.
Pressuremeter Tests				
KFP-7	4.5	3 loops	1.8	complete test
KFP-8	10.5	2 loops	1.5	complete test
KFP-9	16.5	1 loop	1.3	complete test
KFP-10	22.0	1 loop	1.3	complete test
KFP-11	28.5	2 loops	1.0	complete test
KFP-12	34.5	2 loops	1.4	complete test

for additional data see Pappas(1990) and Mayu(1987)

Laboratory Testing

Moisture Content	Specific Gravity	Gr size w/hyd	Atterberg Limits
33	2	25	25

for additional data see Pappas(1990) and Mayu(1987)

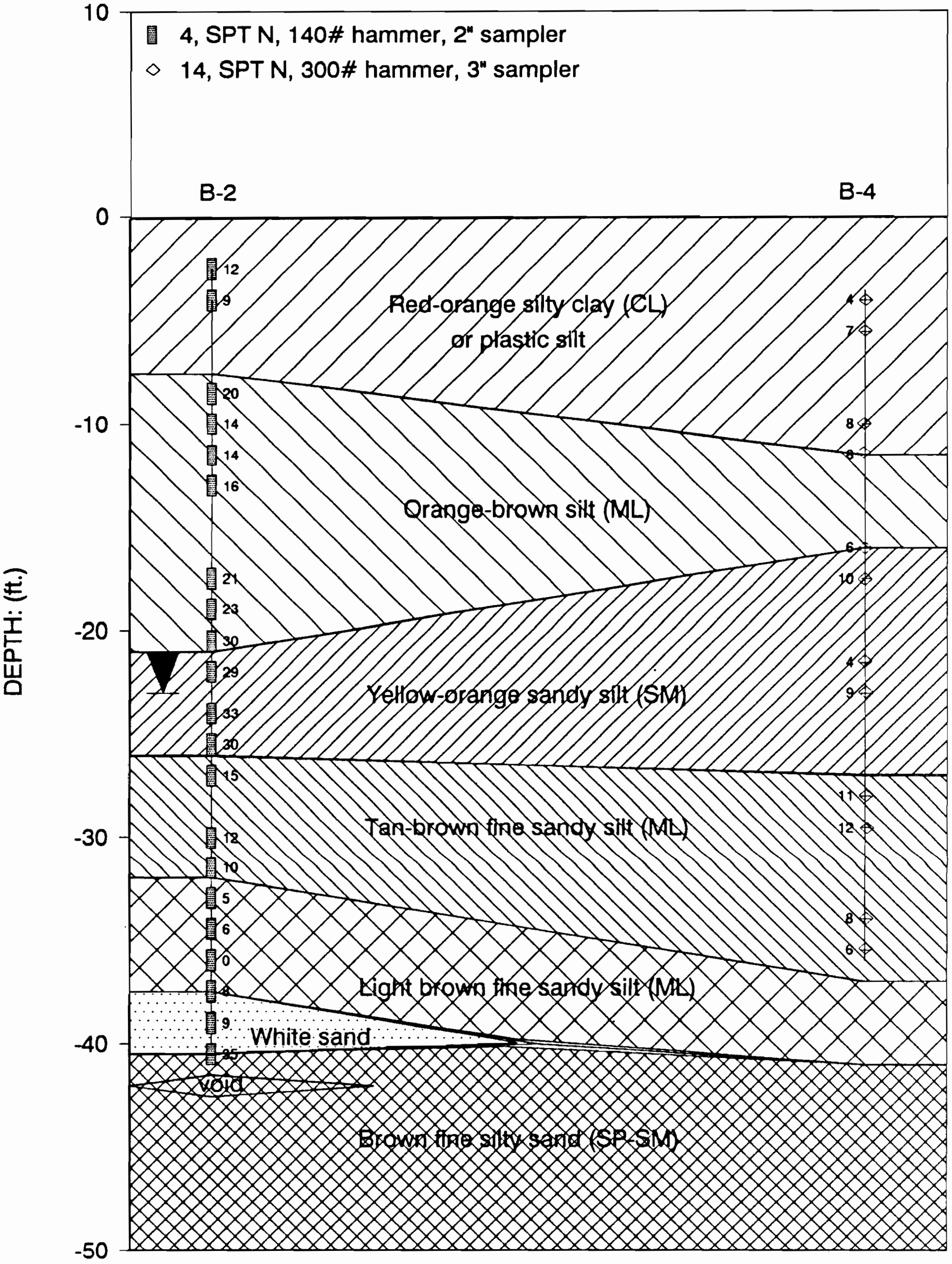


Figure 5.46 Kipp's Farm Hillside Area Soil Profile

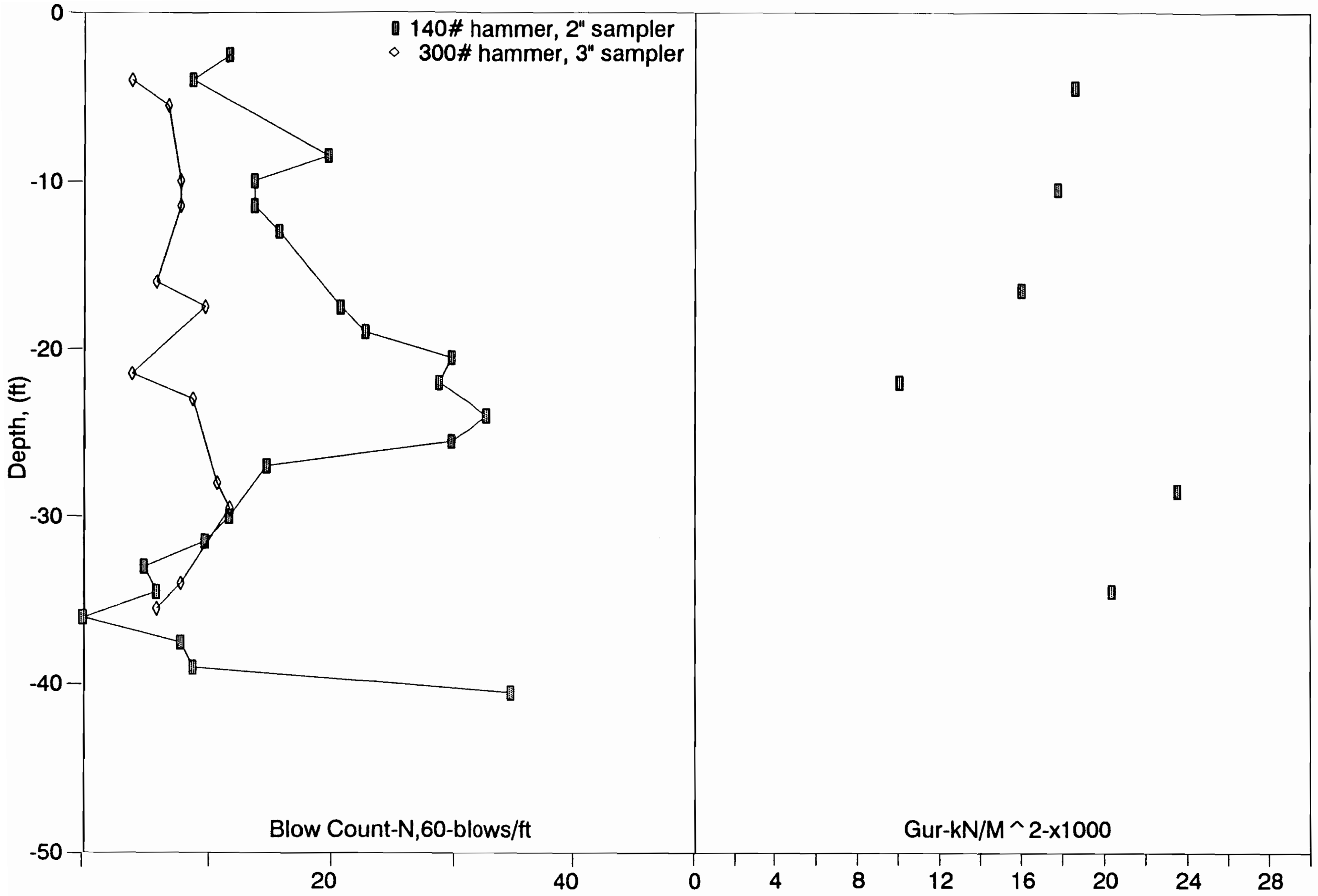


Figure 5.47 Kipp's Farm, Hillside: N60 and Gur

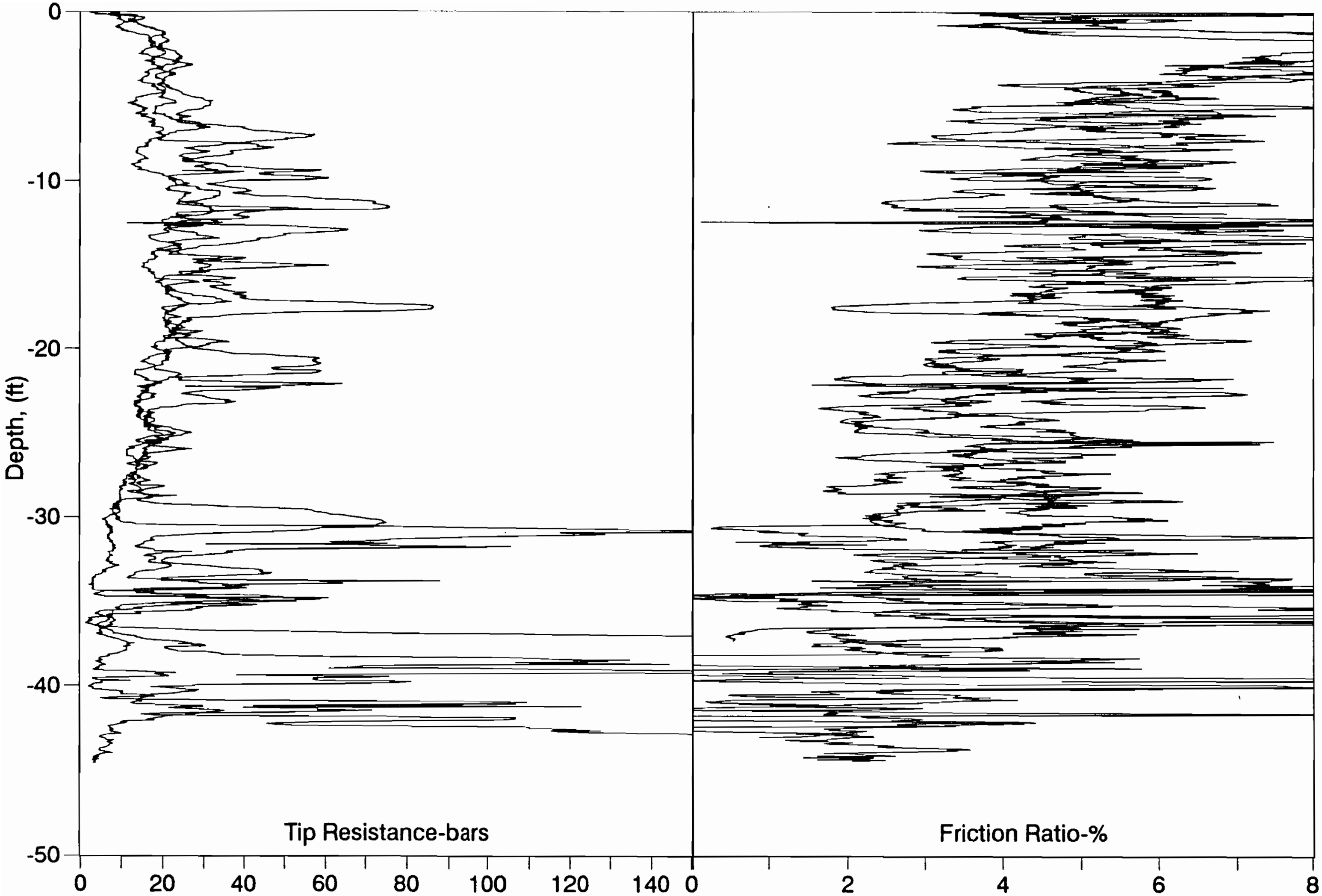


Figure 5.48 Kipp's Farm, Hillside: All Cone Tests

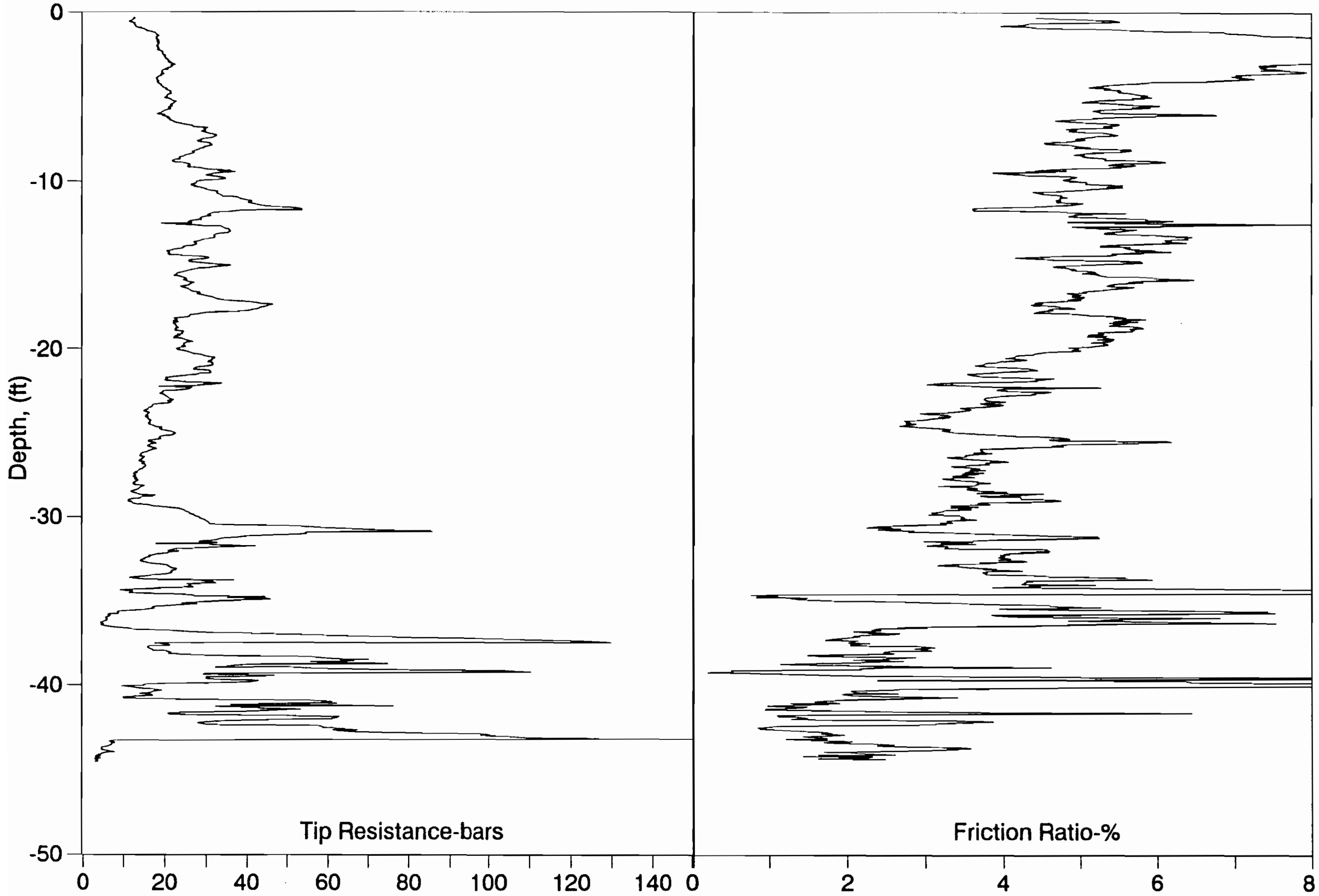


Figure 5.49 Kipp's Farm, Hillside: Cone Test Averages

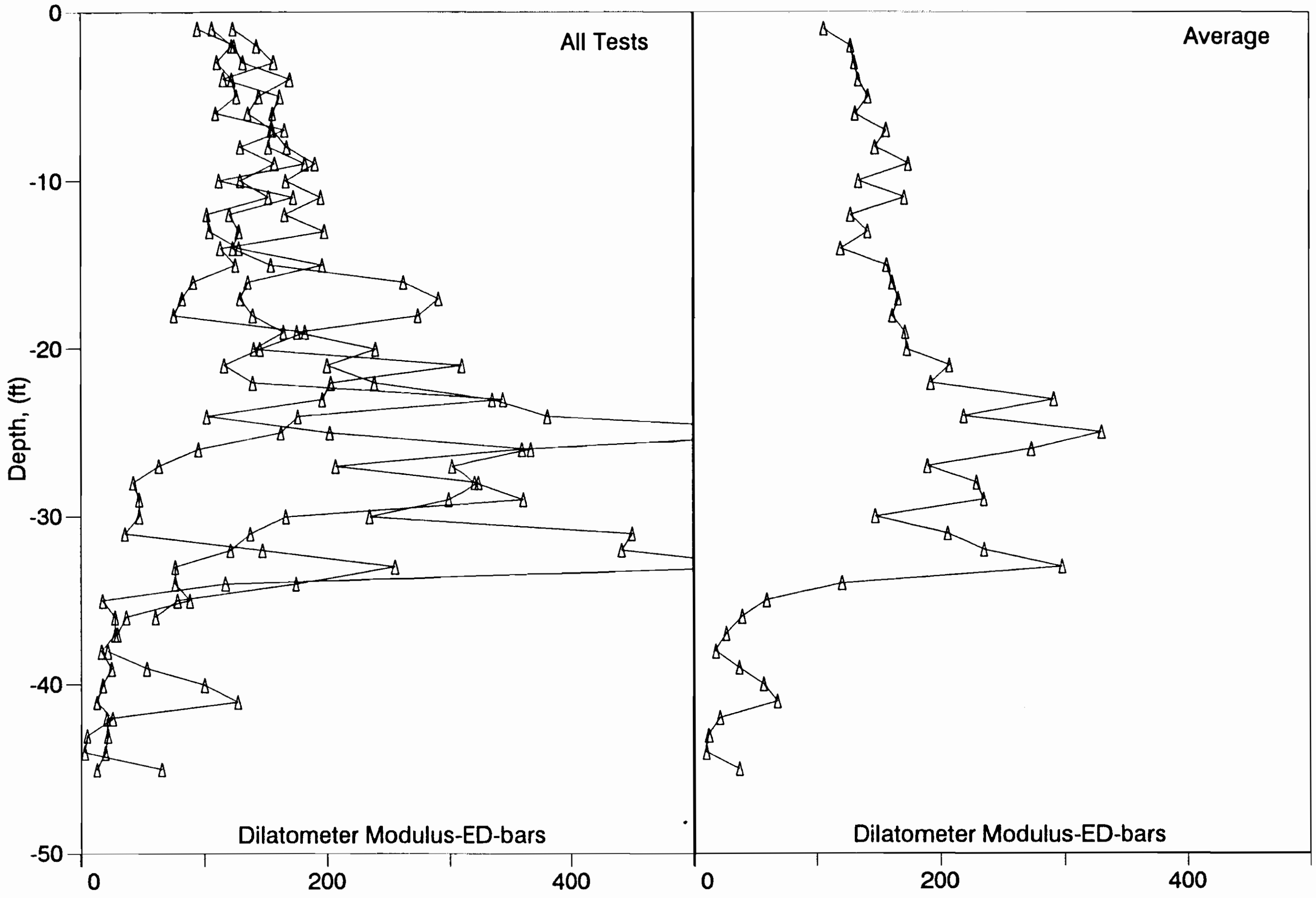


Figure 5.50 Kipp's Farm, Hillside: Dilatometer Soundings

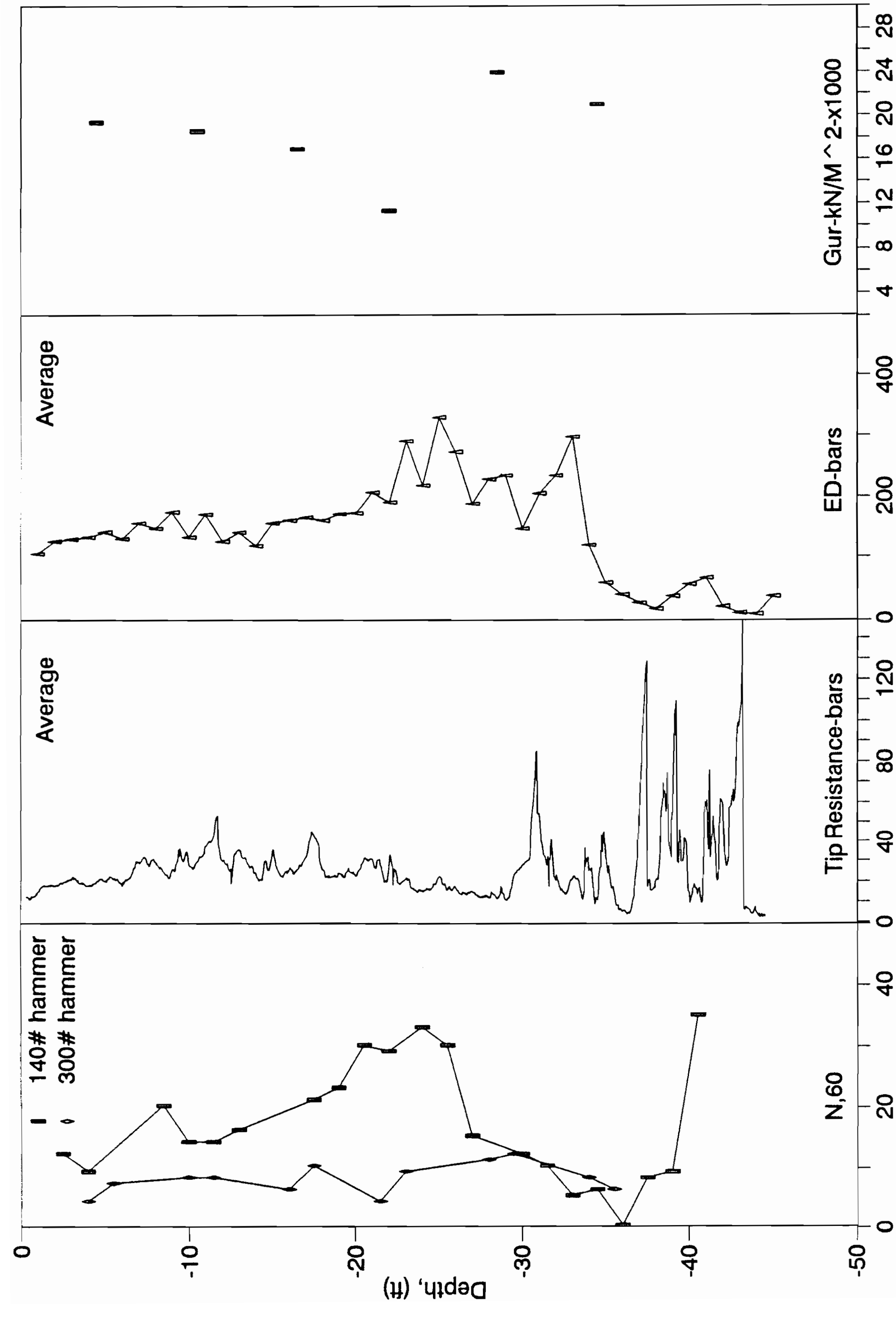


Figure 5.51 Kipp's Farm, Hillside: All In-Situ Tests

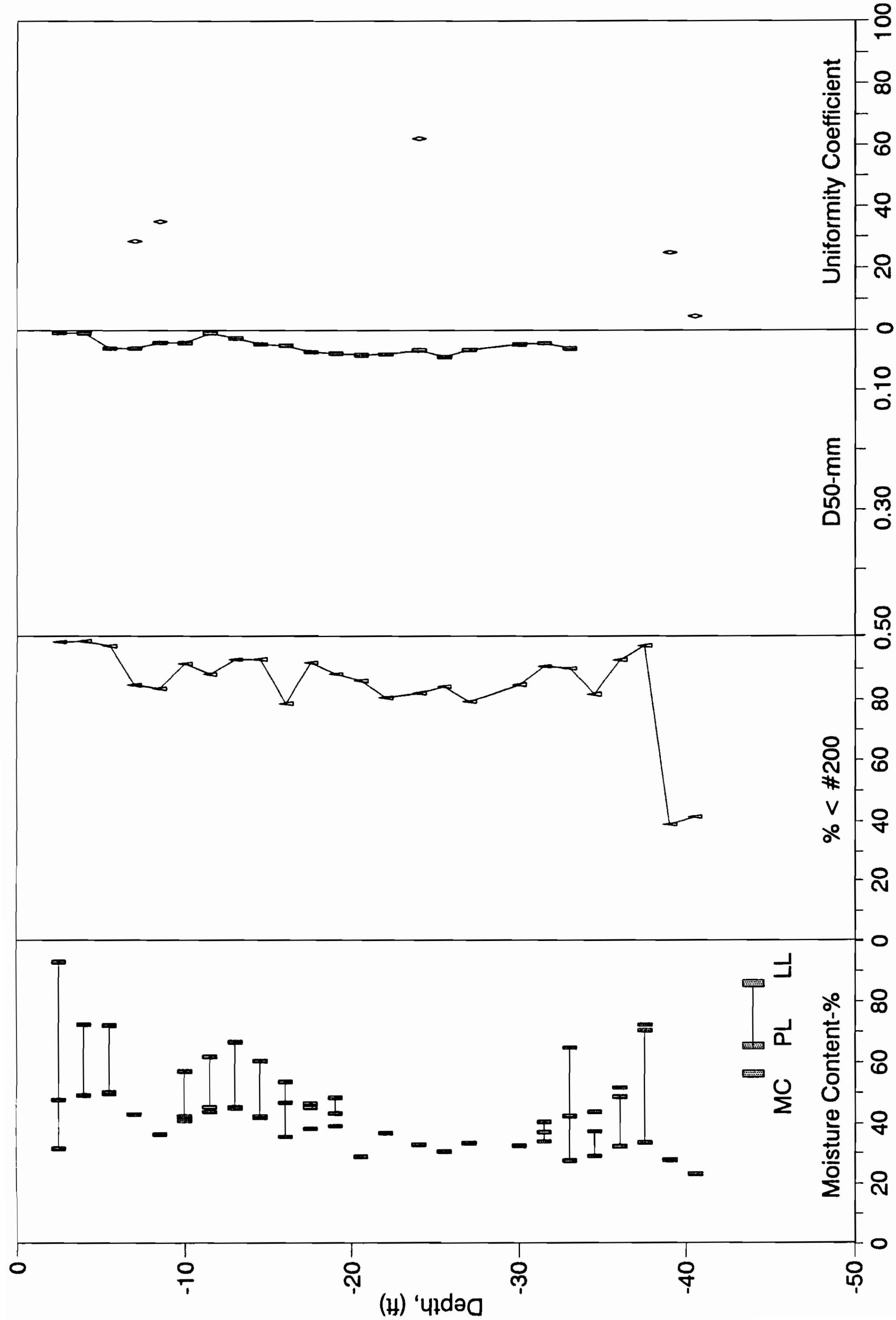


Figure 5.52 Kipp's Farm, Hillside: Lab Test Results

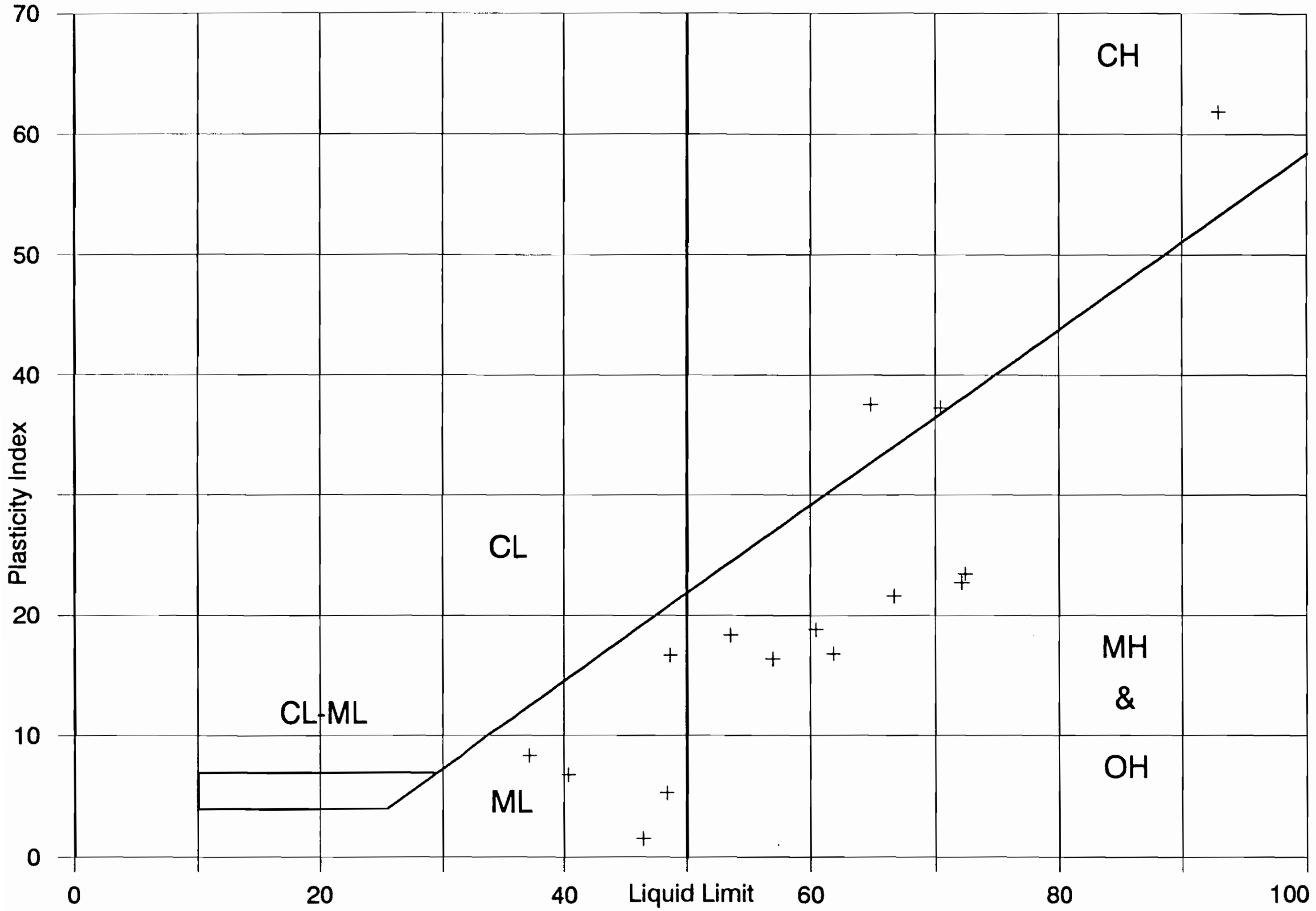


Figure 5.53 Kipp's Farm, Hillside: Plasticity Chart

Table 5.12

KIPP'S FARM HILLSIDE AREA SOIL CLASSIFICATIONS

Depth (ft)	ASTM D 2487 Classification		CPT Classification	DMT Classification
- 2.5	CH	Fat Clay	Clay	Sandy Silt
- 4.0	MH	Elastic Silt	Clay	Silt
- 5.5	MH	Elastic Silt	Clay	Silt
- 7.0	ML	Silt w/Sand	Clay	Clayey Silt
- 8.5	ML	Silt w/Sand	Clay	Clayey Silt
-10.0	MH	Elastic Silt	Clay	Clayey Silt
-11.5	MH	Elastic Silt	Clayey Silt to Silty Clay	Clayey Silt
-13.0	MH	Elastic Silt	Clay	Clayey Silt
-14.5	MH	Elastic Silt	Clay	Silt
-16.0	MH	Elastic Silt w/Sand	Clay	Sandy Silt
-17.5	ML	Silt	Silty Clay to Clay	Sandy Silt
-19.0	ML	Silt	Clay	Sandy Silt
-20.5	ML	Silt	Silty Clay to Clay	Sandy Silt
-22.0	ML	Silt w/Sand	Clayey Silt to Silty Clay	Sandy Silt
-24.0	ML	Silt w/Sand	Clayey Silt to Silty Clay	Silty Sand
-25.5	ML	Silt w/Sand	Clay	Silty Sand
-27.0	ML	Silt w/Sand	Silty Clay to Clay	Sandy Silt
-30.0	ML	Silt w/Sand	Clayey Silt to Silty Clay	Silty Sand
-31.5	ML	Silt	Clayey Silt to Silty Clay	Silty Sand
-33.0	CH	Fat Clay	Silty Clay to Clay	Sand
-34.5	ML	Silt w/Sand	Clay	Silty Sand
-36.0	ML	Silt	Clay	Sandy Silt
-37.5	CH	Fat Clay	Clayey Silt to Silty Clay	Sandy Silt
-39.0	SM	Silty Sand	Silty Sand to Sandy Silt	Silty Sand
-40.5	SM	Silty Sand	Clayey Silt to Silty Clay	Sand

5.5.3 Plantation Pipeline

The two residual soil sites southwest of Richmond provided an interesting study of the same material at different stages of weathering. Soils at both sites were derived from the in place weathering of a parent micaceous schist. The Plantation Pipeline Site is located along a stream bed in a generally low area. The water table was 8 feet below the surface. The Winterpock Tap test area is situated on a bluff overlooking a stream and had ground water at 16 feet. Weathering appeared to have progressed much further at Plantation Pipeline than at Winterpock Tap.

Testing at the Plantation Pipeline site was spaced on the standard grid with two additional cone penetration tests performed between the DMT soundings (see Figure 5.54). As indicated in the introduction, questionable friction ratio results in the first CPT tests performed led to the addition of the extra cone tests. In all, three borings, five cone tests, three DMT soundings, and five pressuremeter tests were completed at this site (Table 5.13).

Soil conditions were fairly uniform as indicated in the boring profile shown in Figure 5.55. From the ground surface a red-orange elastic silt extended to 16.5 feet, with the color then changing to brown-orange and the elastic silt continuing to 21 feet. At 21 feet the soil changed to a tan-yellow silt with sand that extends to 28 feet. From 28 feet to beyond the depth of testing the soil was a yellow-green sandy silt. However, as the SPT samples were retrieved, it was obvious that soils tended to grade continuously from one strata to the next. As depth increased the soils became less weathered, less plastic and more granular. The most obvious change between layers was the color change. Material properties did not change as abruptly. At the lower depths the structure of the parent micaceous silt was readily apparent in the spoon samples.

The penetration resistance/stiffness profile at Plantation Pipeline showed a consistent trend of decrease after passing through a desiccated crust at the surface. The values fell to the lowest at approximately 23 to 25 feet. Below this they then increased as the profile became progressively less weathered (Figures 5.56 to 5.60). There was close agreement among the results of all four in-situ tests. Beyond identifying the same penetration resistance/stiffness profile, the SPT, CPT, and DMT all identified a thin hard layer at approximately 28 feet. No pressuremeter testing was performed at that depth, but the other tests agreed well. Friction ratio values from the CPT were erratic.

The 45 moisture content determinations, 2 specific gravity tests, 25 grain size analyses and 21 Atterberg limit determinations completed during lab testing indicate the soil at Plantation Pipeline exhibits some plasticity to a depth of 30 feet (Figures 5.61 and 5.62). The percent passing the #200 sieve grades from 80% at the surface to 55% at 40 feet. The samples also had a high mica content remaining from the parent rock. The progress of weathering can be traced in the decrease in plasticity and increase in granular content with depth. Finer, more plastic materials were found nearer the surface.

Field boring logs primarily identified soils as sandy to silty clays and it is possible that the mica content imparted a slick or clayey feel to the samples. Lab testing showed the Plantation Pipeline soils to be primarily elastic silt to sandy silt (Table 5.14). The DMT appeared to classify the soils one step too fine, the elastic silts became silty clays. The CPT followed the same pattern, with the elastic silt identified as a clay. Both visual/manual soil identification and classification from the CPT and DMT appeared to be confused by the high percentage of mica found in the soils. The slick feel of the mica caused the driller to report a higher clay content in the field boring logs than was obtained in the lab testing. It was interesting that the CPT and DMT data mirrored the trend of identifying the soils as clayier than actual conditions.

Table 5.13
Plantation Pipeline Site Testing Program

Field Testing

Test no.	Depth ft.	Samples/ readings	Duration hr.	Comment
Borings				
PLPB-1	39.5	25	12.0	
PLPB-2	39.5	15	10.0	
PLPB-3	35.5	12	n/a	for PMT tests
Cone Penetration Tests				
PLPC-1	45.7	n/a	1.0	questionable f_r
PLPC-2	45.6	n/a	0.9	questionable f_r
PLPC-3	45.8	n/a	0.7	questionable f_r
PLPC-4	44.8	n/a	0.8	
PLPC-5	42.0	n/a	0.6	
Dilatometer Soundings				
PLPD-1	45.0	45	2.3	
PLPD-2	45.0	45	2.3	
PLPD-3	45.0	45	2.3	
Pressuremeter Tests				
PLPP-1	4.5	n/a	n/a	circuit fault
PLPP-2	10.5	2 loops	1.3	complete test
PLPP-3	18.0	2 loops	1.0	complete test
PLPP-4	22.5	2 loops	1.1	complete test
PLPP-5	28.5	2 loops	1.2	complete test
PLPP-6	34.5	2 loops	1.3	complete test

Laboratory Testing

Moisture Content	Specific Gravity	Gr size w/hyd	Atterberg Limits
45	2	25	21

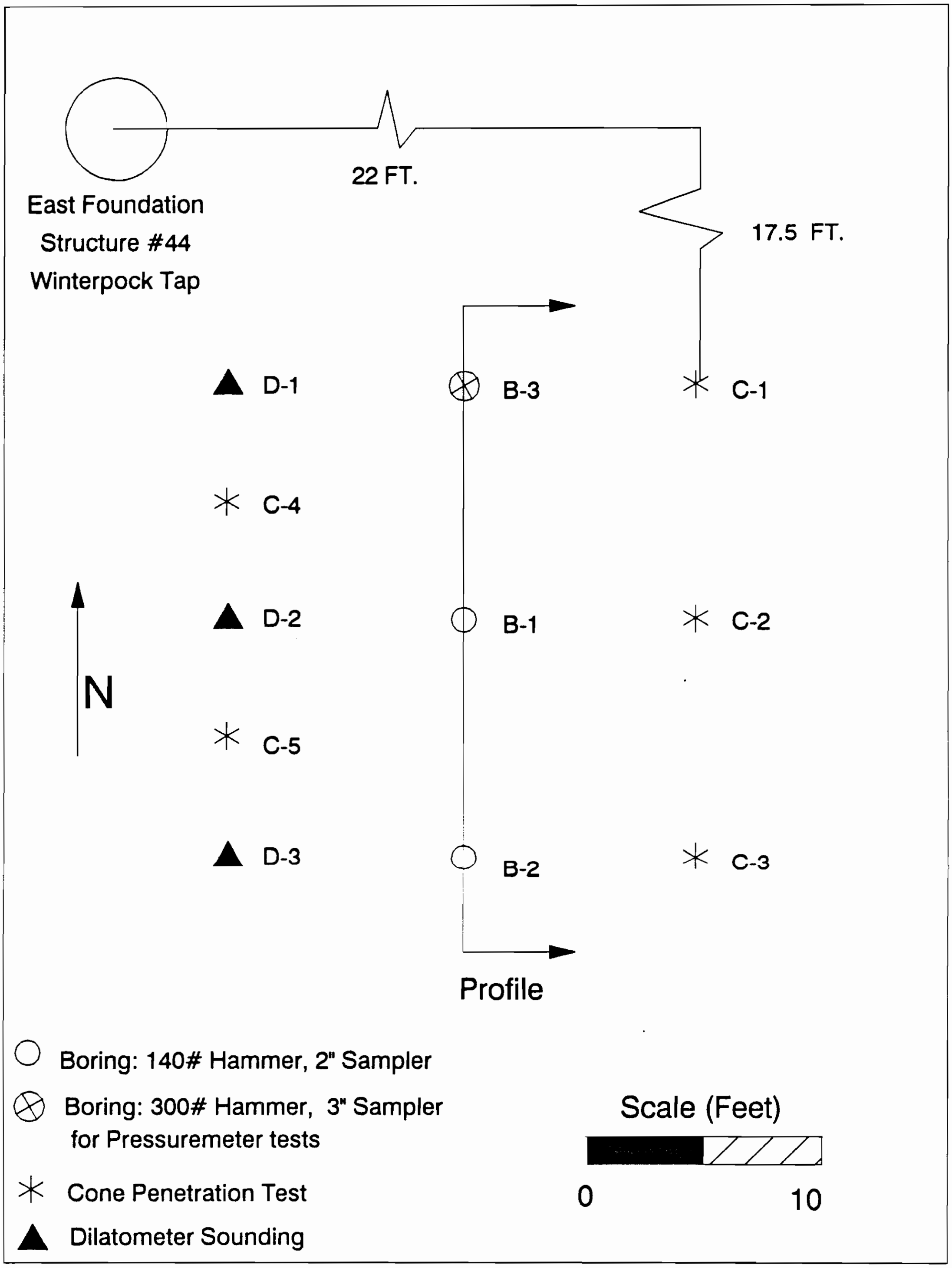


Figure 5.54 Plantation Pipeline Test Location Map

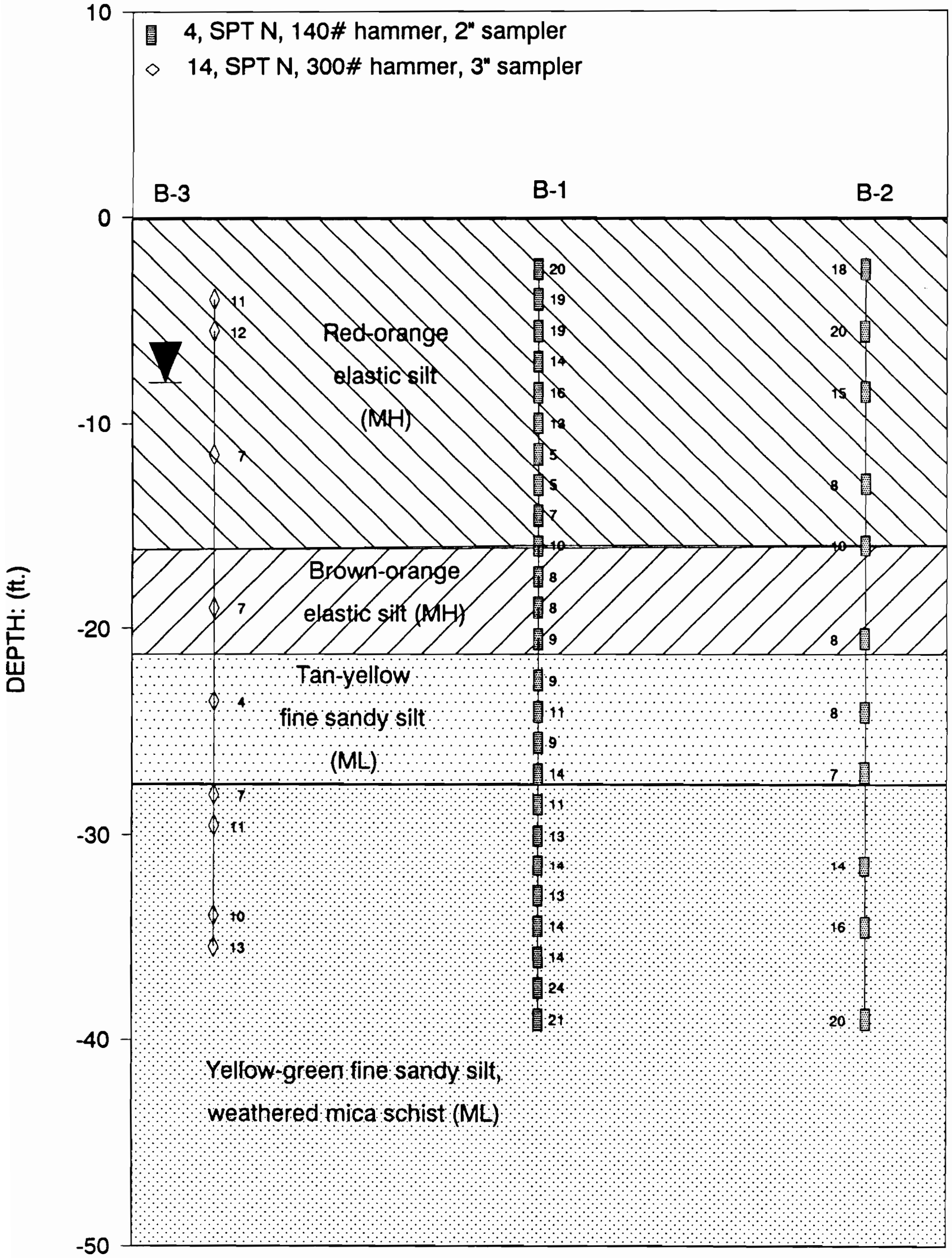


Figure 5.55 Plantation Pipeline Soil Profile

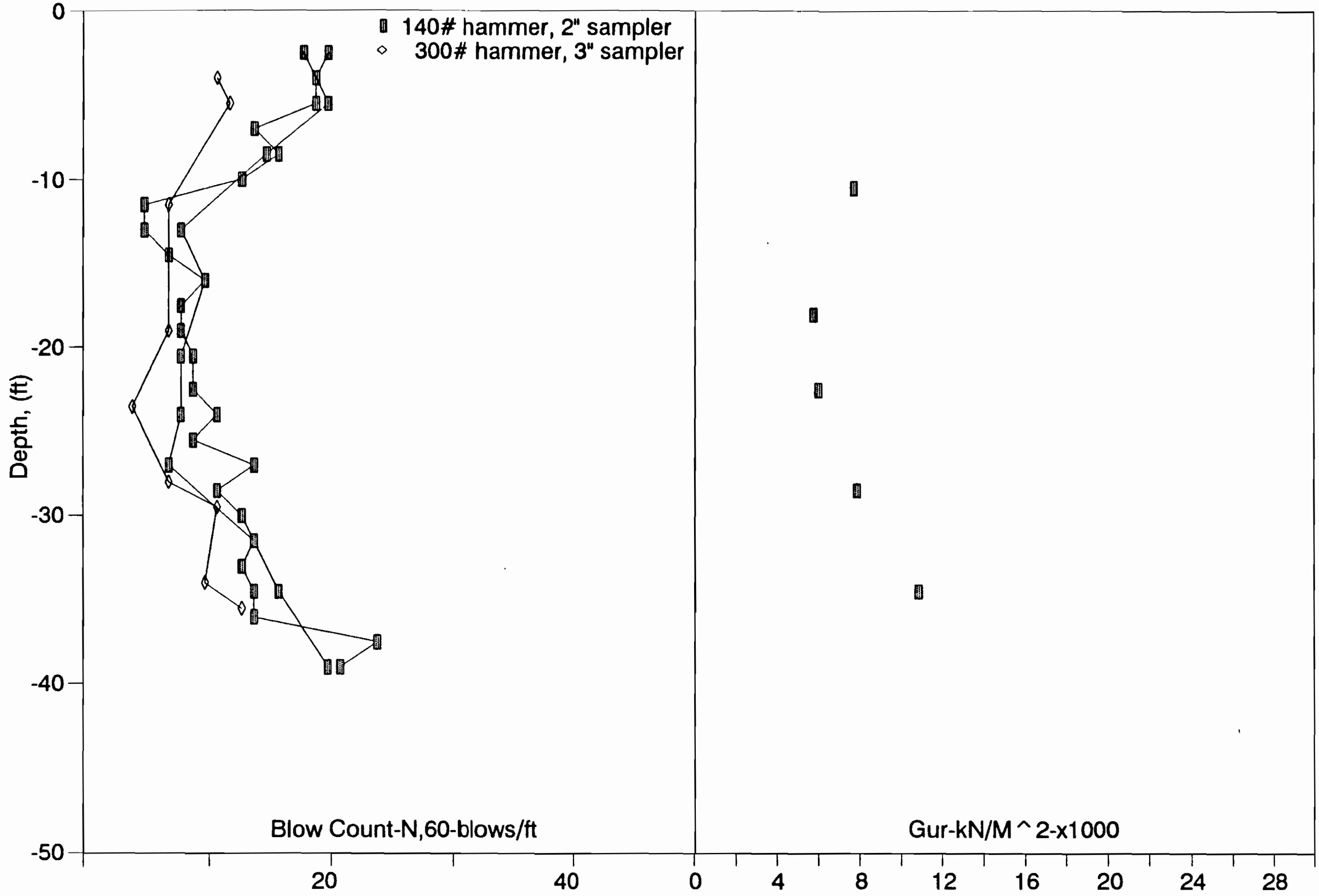


Figure 5.56 Plantation Pipeline: N60 and Gur

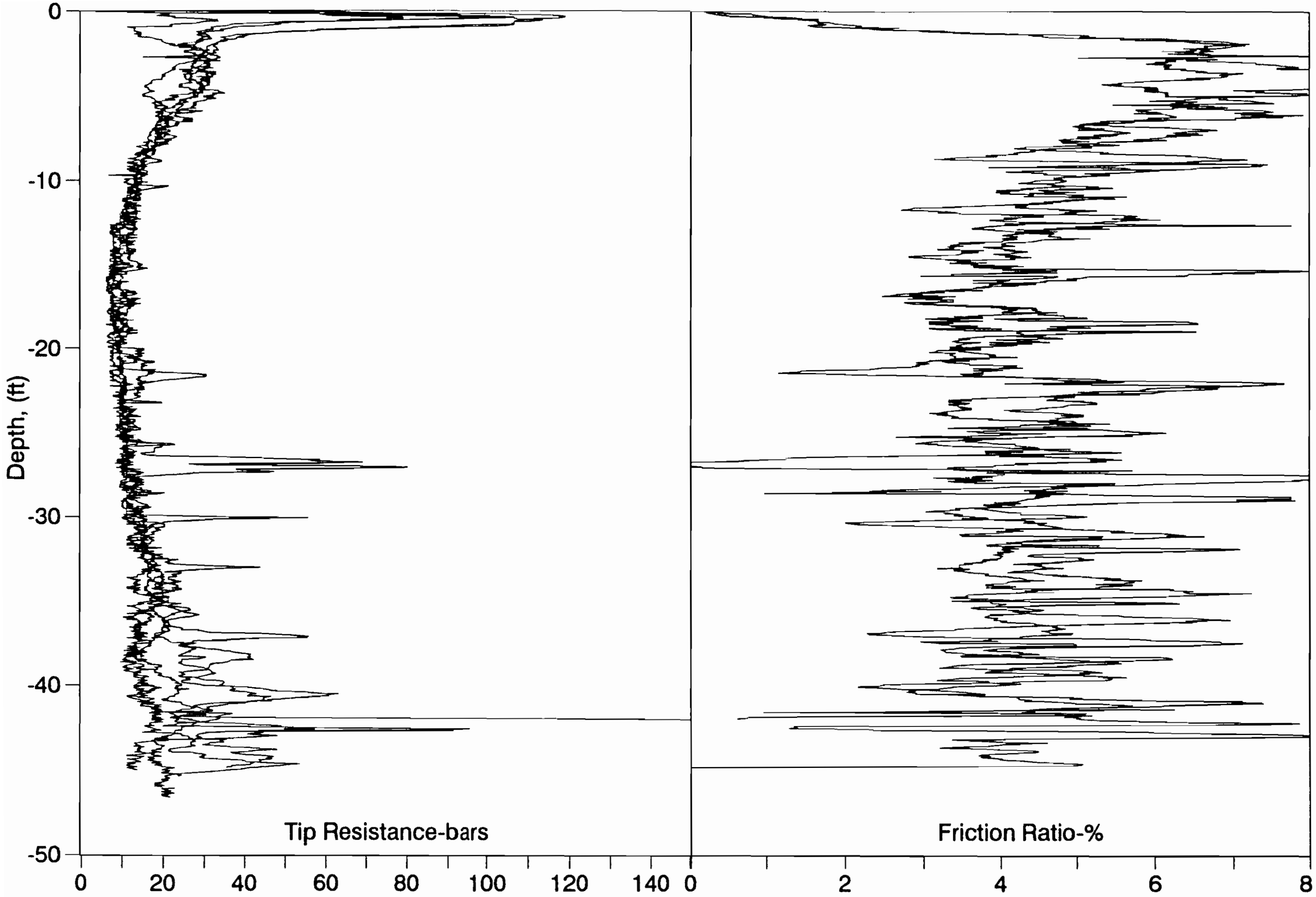


Figure 5.57 Plantation Pipeline: All Cone Tests

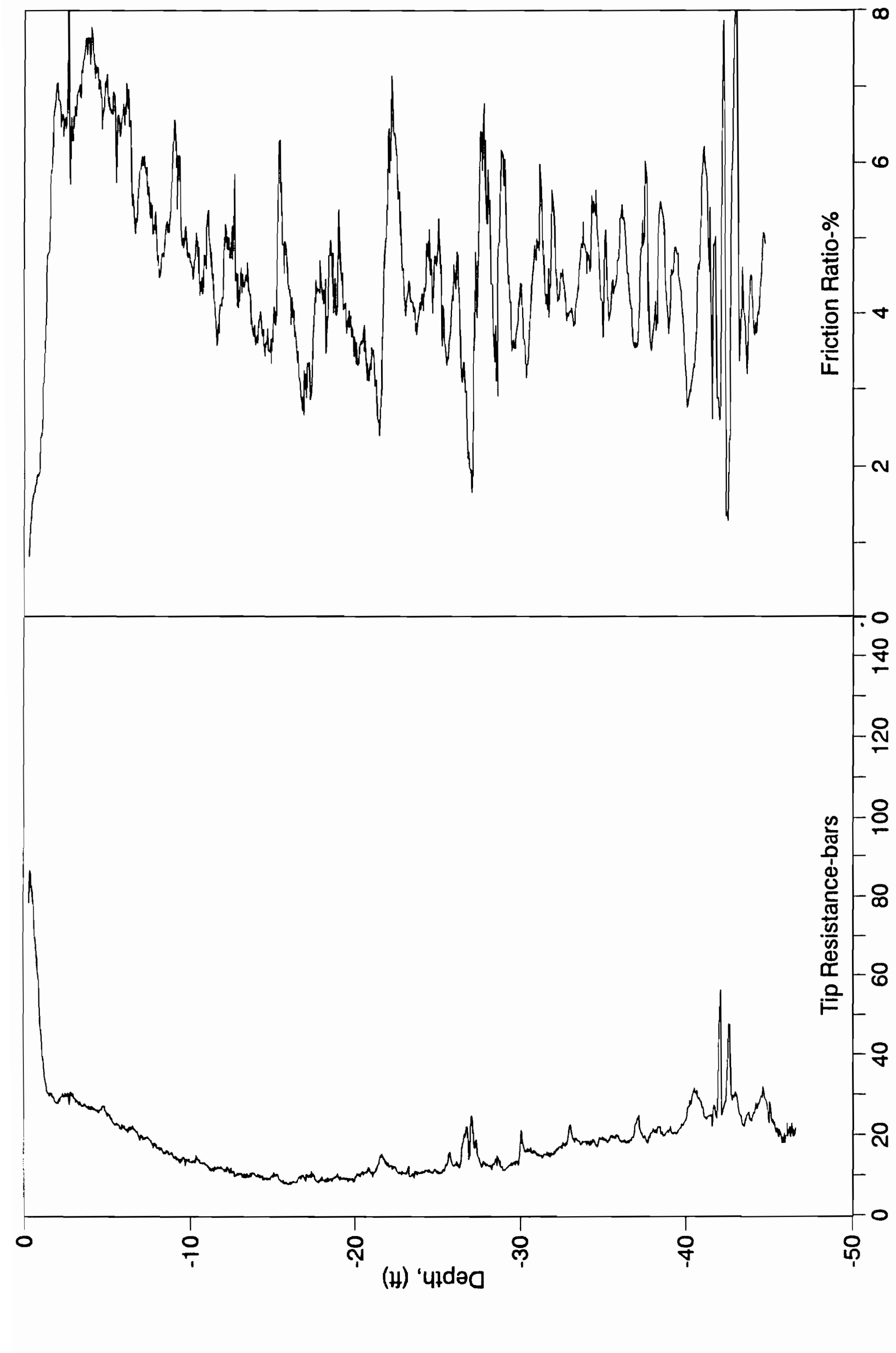


Figure 5.58 Plantation Pipeline: Cone Test Averages

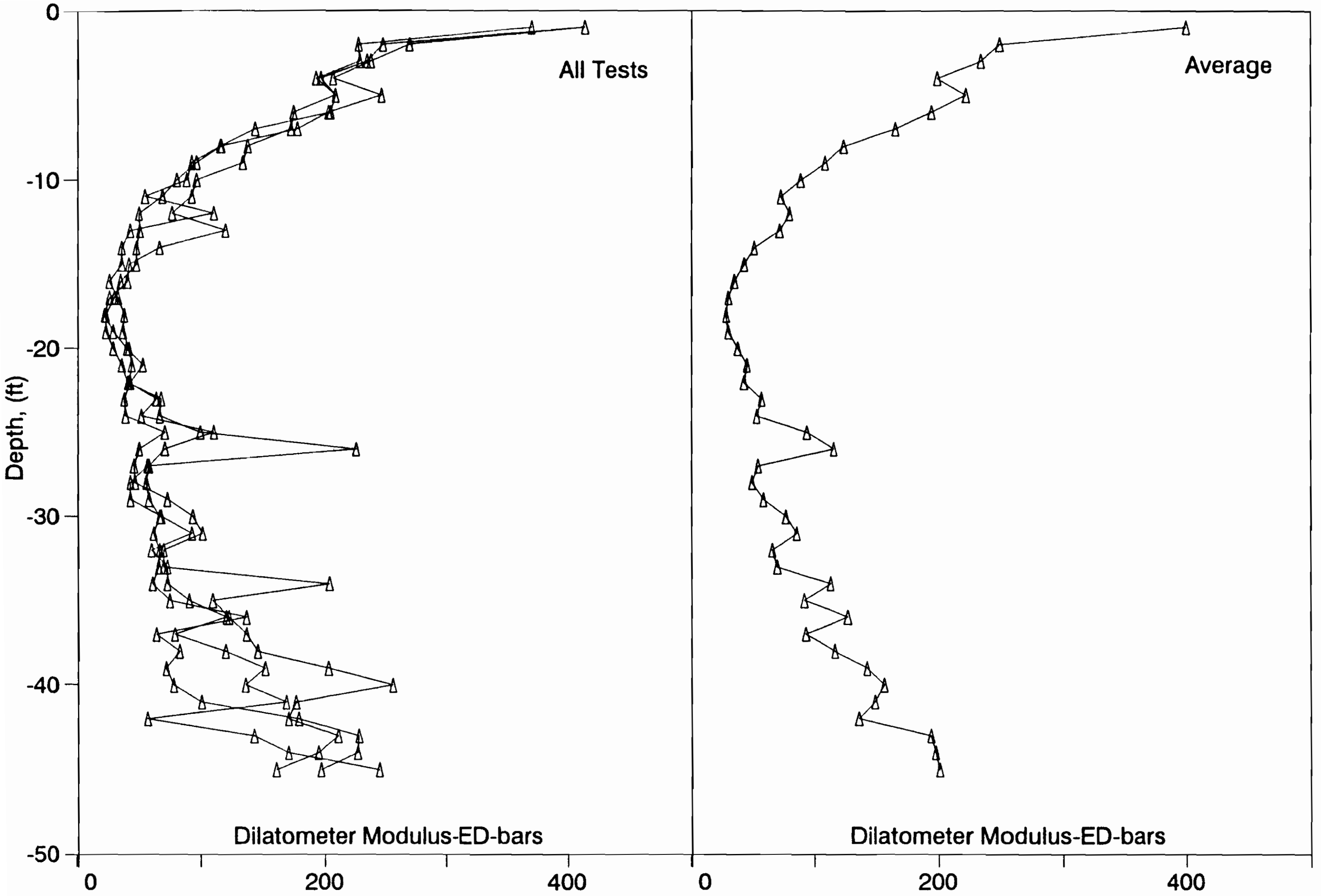


Figure 5.59 Plantation Pipeline: Dilatometer Soundings

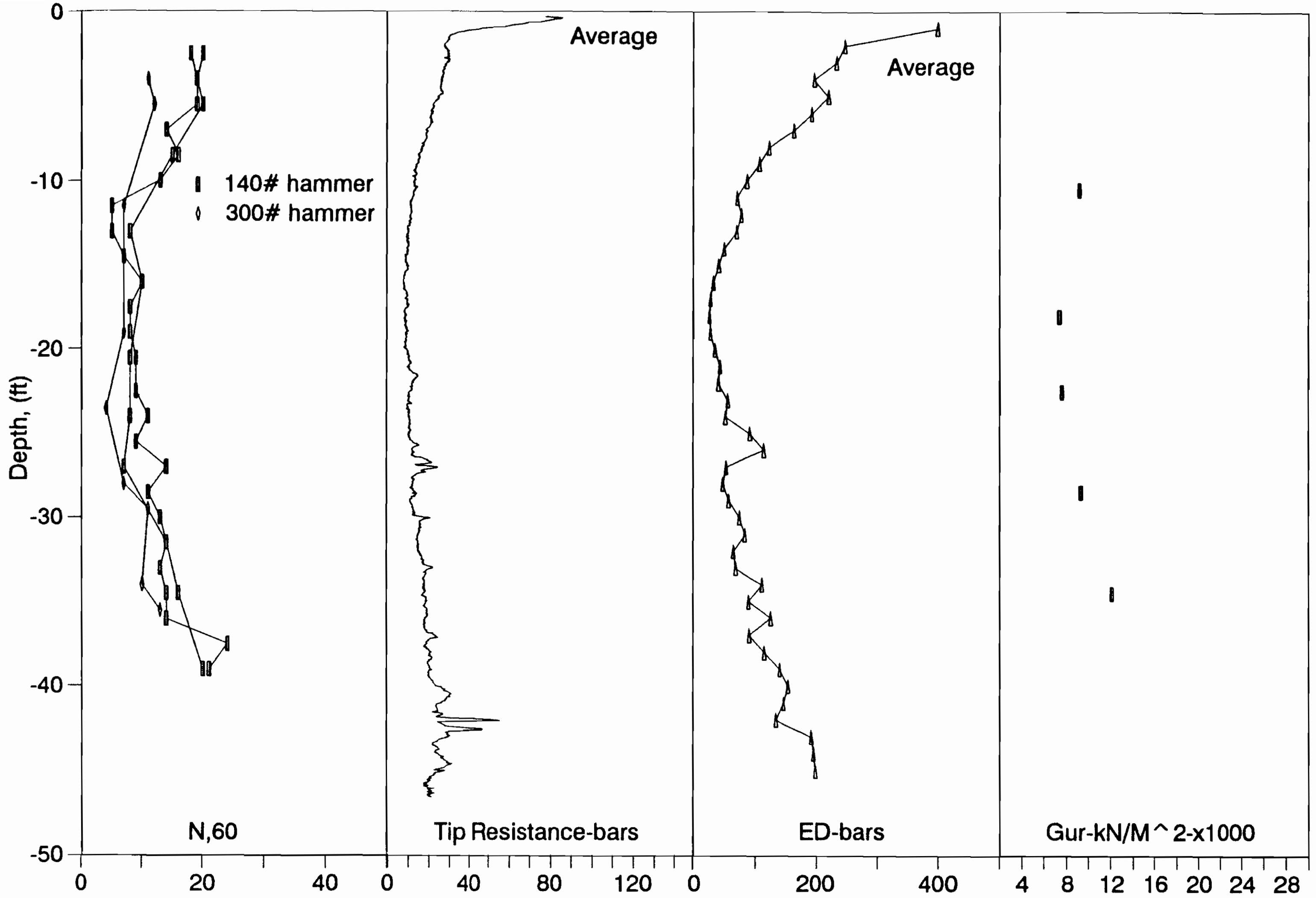


Figure 5.60 Plantation Pipeline: All In-Situ Tests

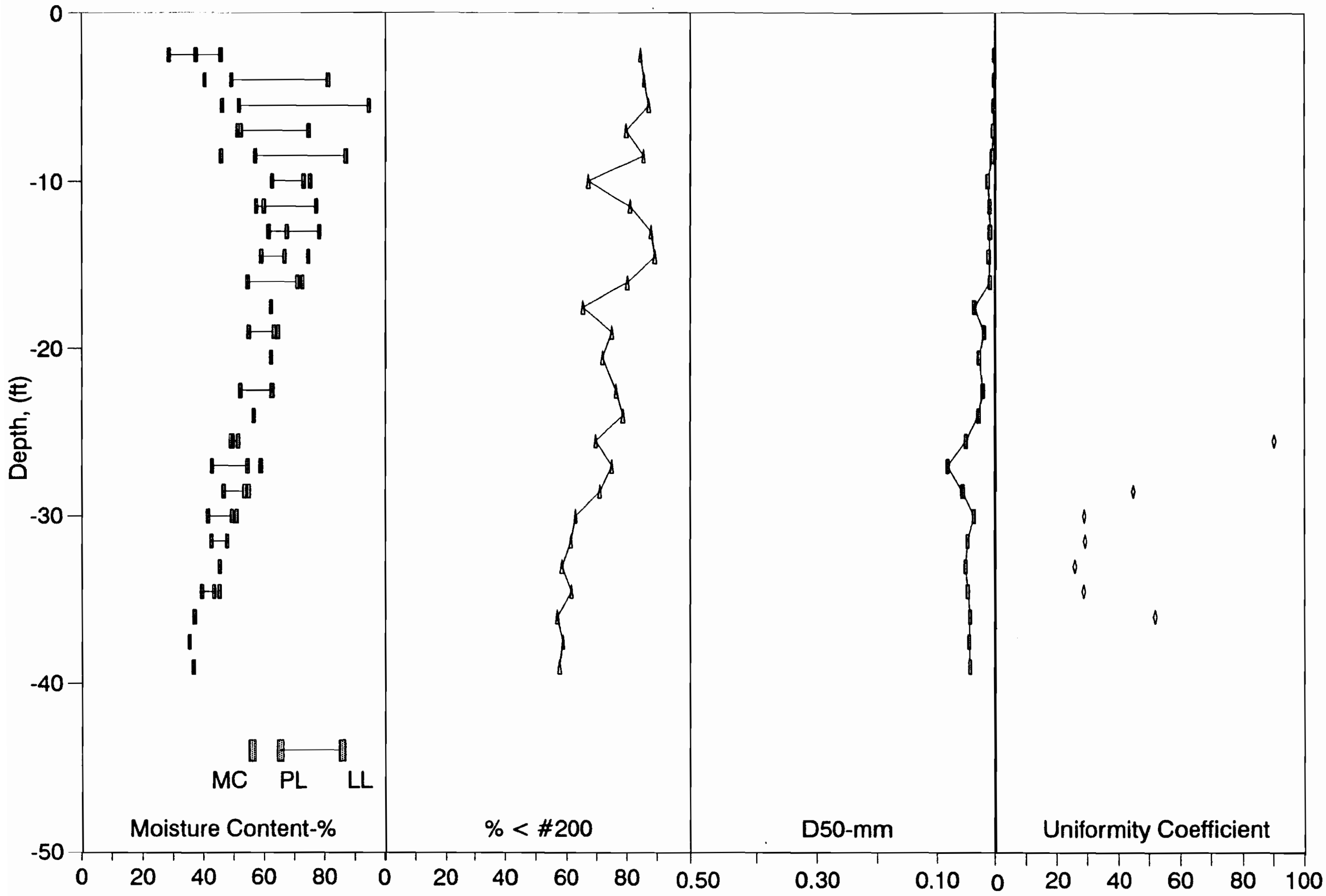


Figure 5.61 Plantation Pipeline: Lab Test Results

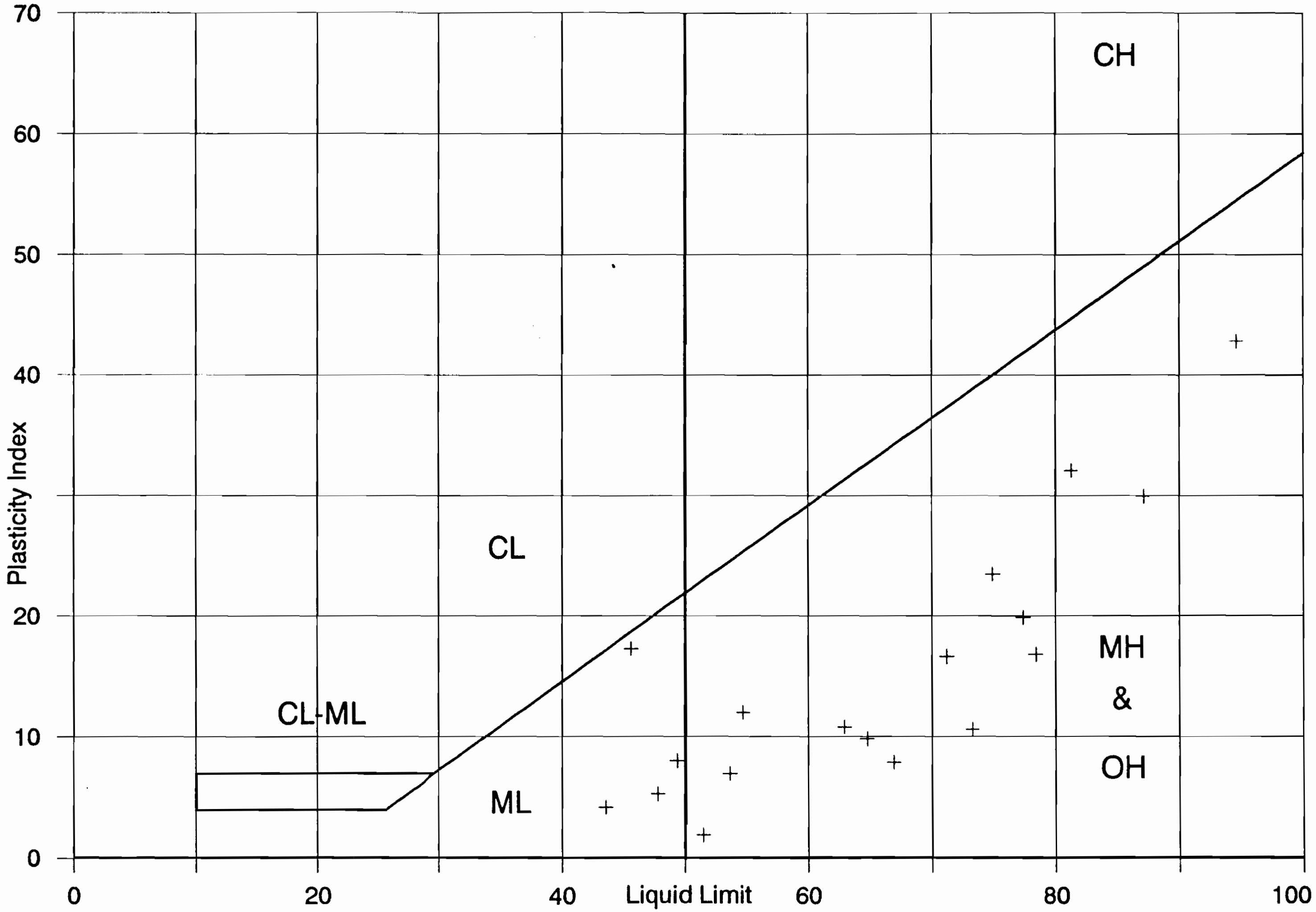


Figure 5.62 Plantation Pipeline: Plasticity Chart

Table 5.14

PLANTATION PIPELINE SOIL CLASSIFICATIONS

Depth (ft)	ASTM D 2487 Classification	CPT Classification	DMT Classification
- 2.5	ML Silt w/Sand Clay	Clay	Sandy Silt
- 4.0	MH Elastic Silt	Clay	Silt
- 5.5	MH Elastic Silt	Clay	Silt
- 7.0	MH Elastic Silt w/Sand	Clay	Clayey Silt
- 8.5	MH Elastic Silt	Clay	Clayey Silt
-10.0	MH Sandy Elastic Silt	Clay	Clayey Silt
-11.5	MH Elastic Silt w/Sand	Clay	Clayey Silt
-13.0	MH Elastic Silt	Clay	Clayey Silt
-14.5	MH Elastic Silt	Clay	Silty Clay
-16.0	MH Elastic Silt w/Sand	Clay	Silty Clay
-17.5	ML Sandy Silt	Clay	Silty Clay
-19.0	MH Elastic Silt	Clay	Silty Clay
-22.5	MH Elastic Silt w/Sand	Clay	Silty Clay
-25.5	MH Sandy Elastic Silt	Silty Clay to Clay	Silt
-27.0	MH Elastic Silt w/Sand	Sandy Silt to Clayey Silt	Clayey Silt
-28.5	MH Elastic Silt w/Sand	Clayey Silt to Silty Clay	Clayey Silt
-30.0	ML Sandy Silt	Silty Clay to Clay	Clayey Silt
-31.5	ML Sandy Silt	Silty Clay to Clay	Clayey Silt
-33.0	ML Sandy Silt	Silty Clay to Clay	Clayey Silt
-34.5	ML Sandy Silt	Clayey Silt	Clay
-36.0	ML Sandy Silt	Clay	Silt
-37.5	ML Sandy Silt	Clay	Clayey Silt
-39.0	ML Sandy Silt	Silty Clay to Clay	Clayey Silt

5.5.4 Winterpock Tap

Testing at the Winterpock Tap site was also spaced on the standard grid and included two additional cone penetration tests, also for the reasons as noted above (Figure 5.63). In all, three borings, five cone tests, three DMT soundings, and six pressuremeter tests were completed at Winterpock Tap (Table 5.15).

The soil profile at this site (Figure 5.64) generally mirrored the Plantation Pipeline test area, and the soils were derived from same micaceous schist. However, weathering had not progressed as far at the Winterpock site as at the Plantation Pipeline area, and areas of slightly weathered rock appear, as well as the soil layers being of a less uniform thickness. Borings B-1, B-2, and B-3 all indicated a surface layer of red-orange elastic silt. In B-1 and B-2, a layer of white silty sand began at 12 and 9 feet respectively. The white sand did not appear in B-3. Below the sand was a layer of brown-orange silty sand that appeared similar to the brown-orange elastic silt found at the same depth at Plantation Pipeline. However, at Winterpock, the material was less weathered and classified as a silty sand. Finally, a yellow-green silty sand began at 20 feet in all three borings. In appearance the silty sand mirrored the sandy silt that began at 21 feet at the Plantation Pipeline site , except that it was in a less weathered state. The silty sand extended below the depth of testing.

As at the Plantation Pipeline site, the penetration resistance/stiffness profile at Winterpock Tap also decreased through a desiccated crust reaching the lowest values at approximately 20 feet, and then increasing with depth as the material became less weathered (Figures 5.65 to 5.69). However, the penetration resistance/stiffness values were approximately twice as high as at Plantation Pipeline and test results were more erratic. Both conditions support the theory that the soils at Winterpock Tap were less weathered and of a more variable nature. All four of the in-situ test methods showed good correlations in the nature of the penetration resistance/stiffness profiles.

In the course of lab testing, 59 moisture content determinations, 2 specific gravity tests, 24 grain size analyses, and 4 Atterberg limit determinations were performed for soil identification purposes. Only the top 4.5 feet at Winterpock Tap were found to be plastic. Below that depth the material changed to a silty sand with the percentage passing the #200 sieve varying from 80% at 5 feet down to 30% at 45 feet (Figures 5.70 and 5.71)

Soil identification results followed the same pattern as at Plantation Pipeline. The high mica content of the soil again appeared to cause both visual/manual examination and CPT and DMT data to identify the soils as clayier than actuality. The field boring logs identified the soils as sandy clays, the CPT data indicated silty clay to clay, and DMT soil identification indicated sandy silt or silt. The lab tests showed below 7 feet the soils classified as a silty sand. The results of the soil classifications are given in Table 5.16.

Table 5.15
Winterpock Tap Site Testing Program

Field Testing

Test no.	Depth ft.	Samples/ readings	Duration hr.	Comment
Borings				
WPKB-1	36.5	23	10.0	rock @ 36.5 ft
WPKB-2	44.5	24	12.0	
WPKB-3	36.0	12	n/a	for PMT tests
Cone Penetration Tests				
WPKC-1	36.2	n/a	0.8	questionable f_r
WPKC-2	45.6	n/a	0.7	
WPKC-3	45.3	n/a	0.7	
WPKC-4	32.7	n/a	0.6	rock @ 32.7 ft
WPKC-5	43.8	n/a	0.4	
Dilatometer Soundings				
WPKD-1	45.0	45	2.3	
WPKD-2	19.0	45	2.3	rock @ 19.0 ft
WPKD-3	45.0	45	2.3	
Pressuremeter Tests				
WPKP-1	4.5	1 loop	0.8	mem. rupture
WPKP-2	10.5	1 loop	0.9	complete test
WPKP-3	17.0	2 loops	1.3	complete test
WPKP-4	22.5	2 loops	1.1	circuit fault
WPKP-5	27.0	2 loops	1.2	complete test
WPKP-6	35.0	2 loops	1.1	circuit fault

Laboratory Testing

Moisture Content	Specific Gravity	Gr size w/hyd	Atterberg Limits
59	2	24	4

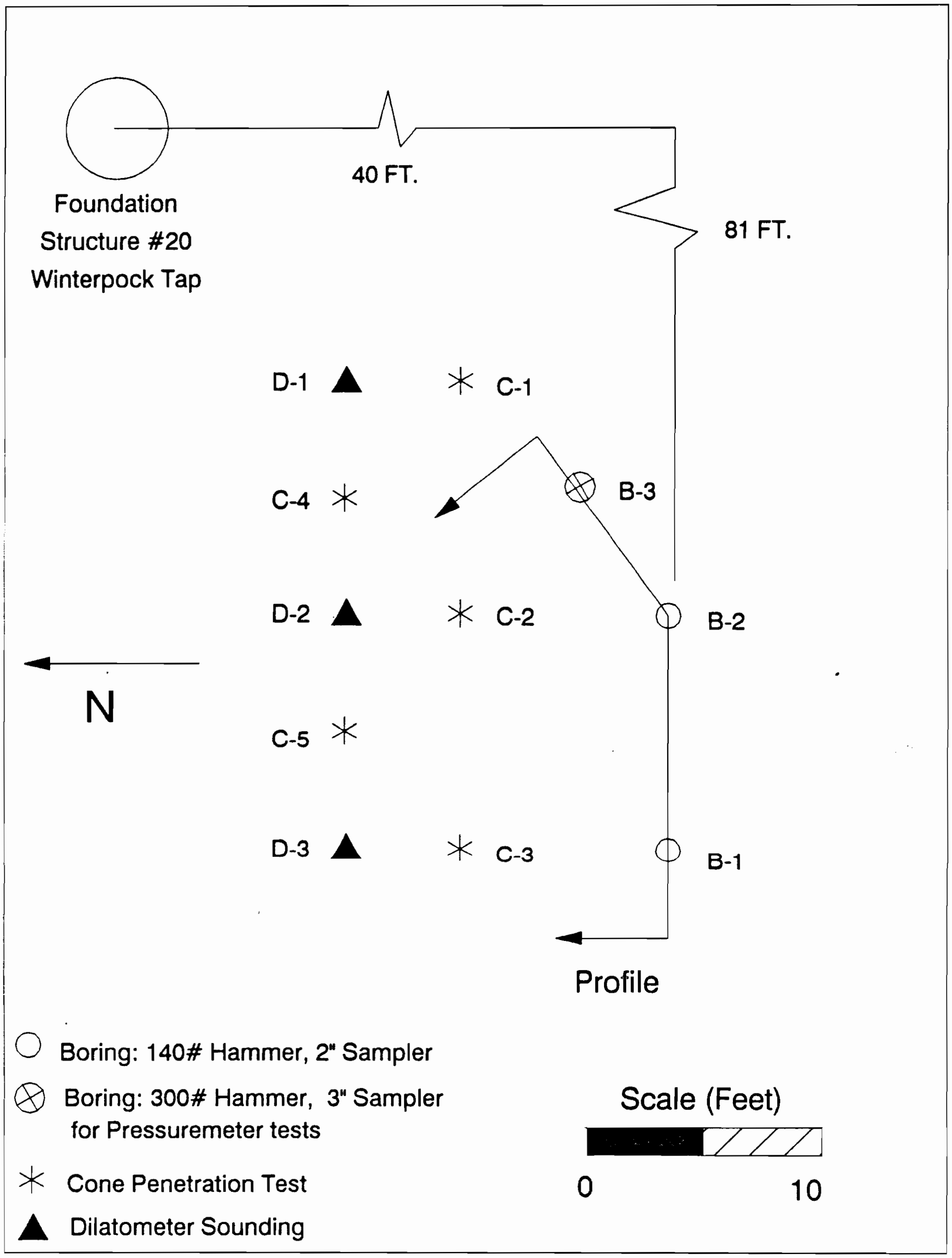


Figure 5.63 Winterpock Tap Test Location Map

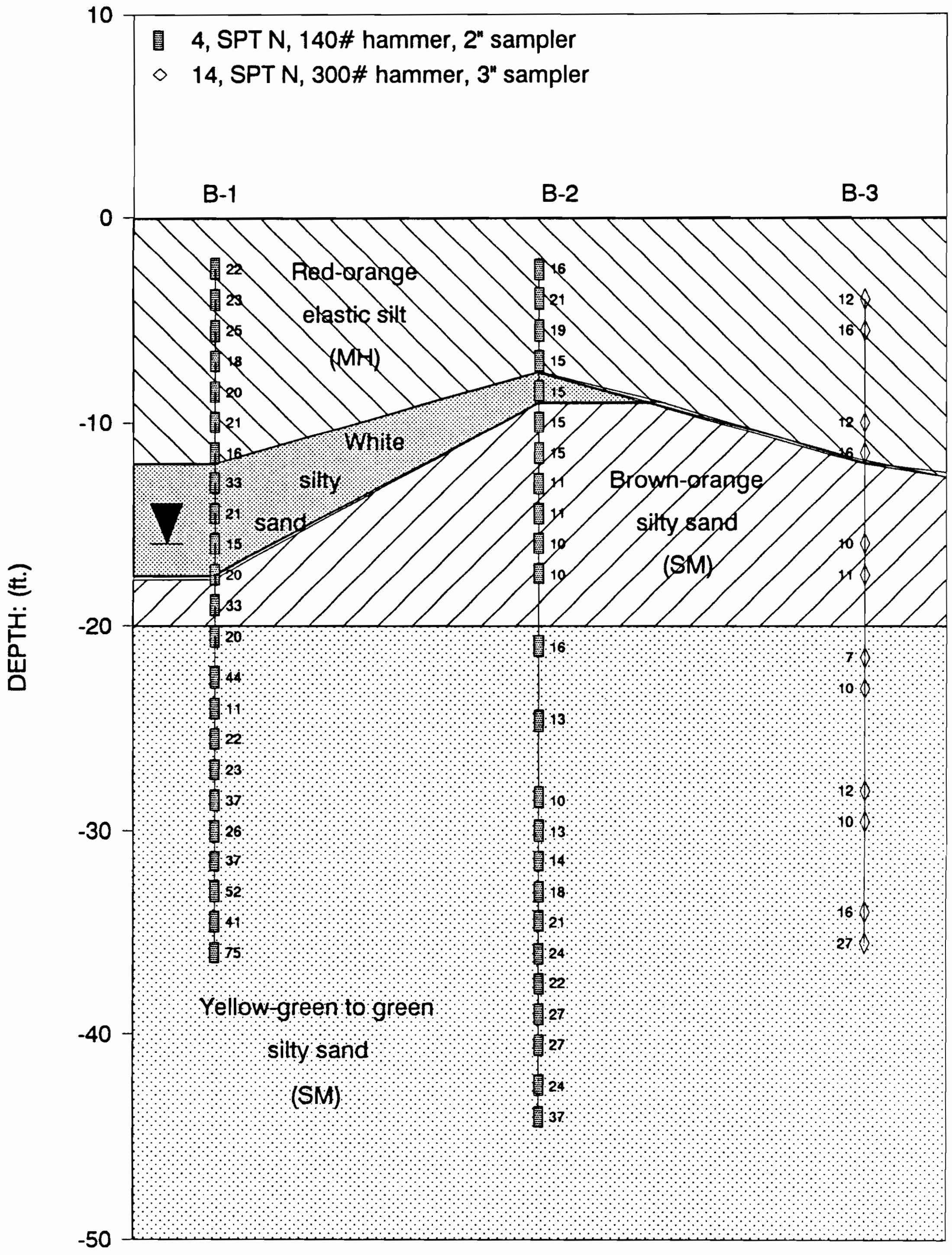


Figure 5.64 Winterpock Tap Soil Profile

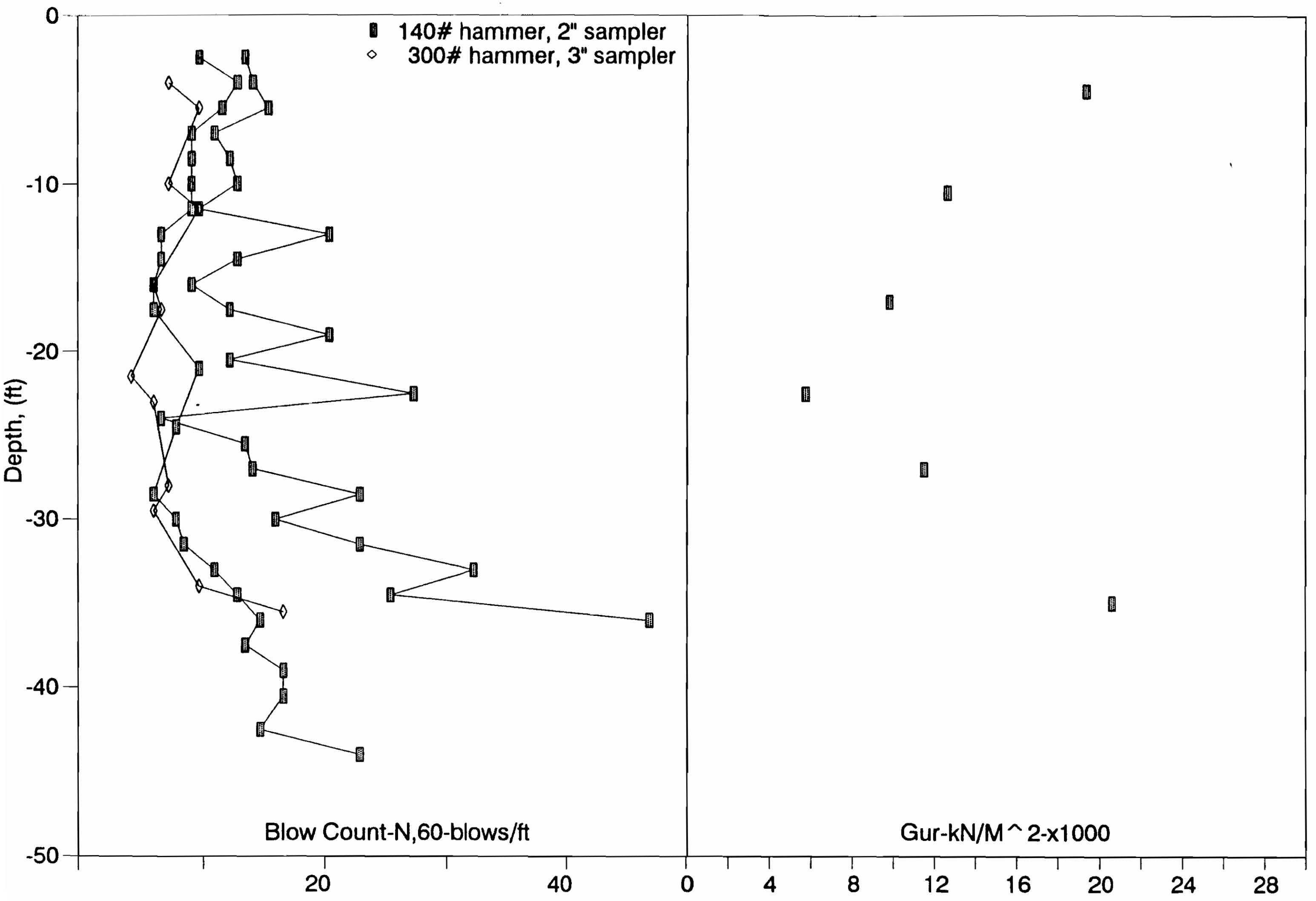


Figure 5.65 Winterpock Tap: N60 and Gur

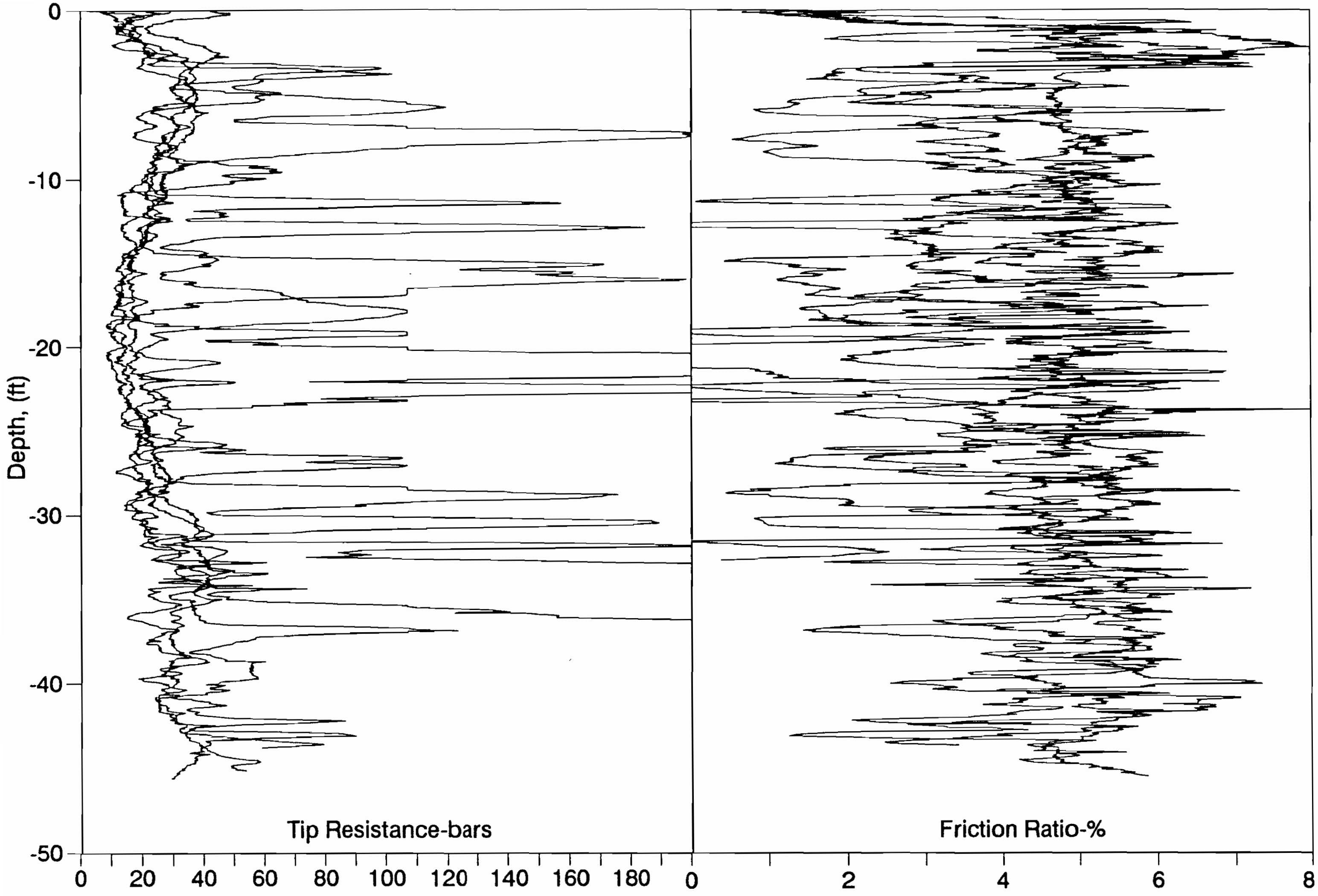


Figure 5.66 Winterpock Tap: All Cone Tests

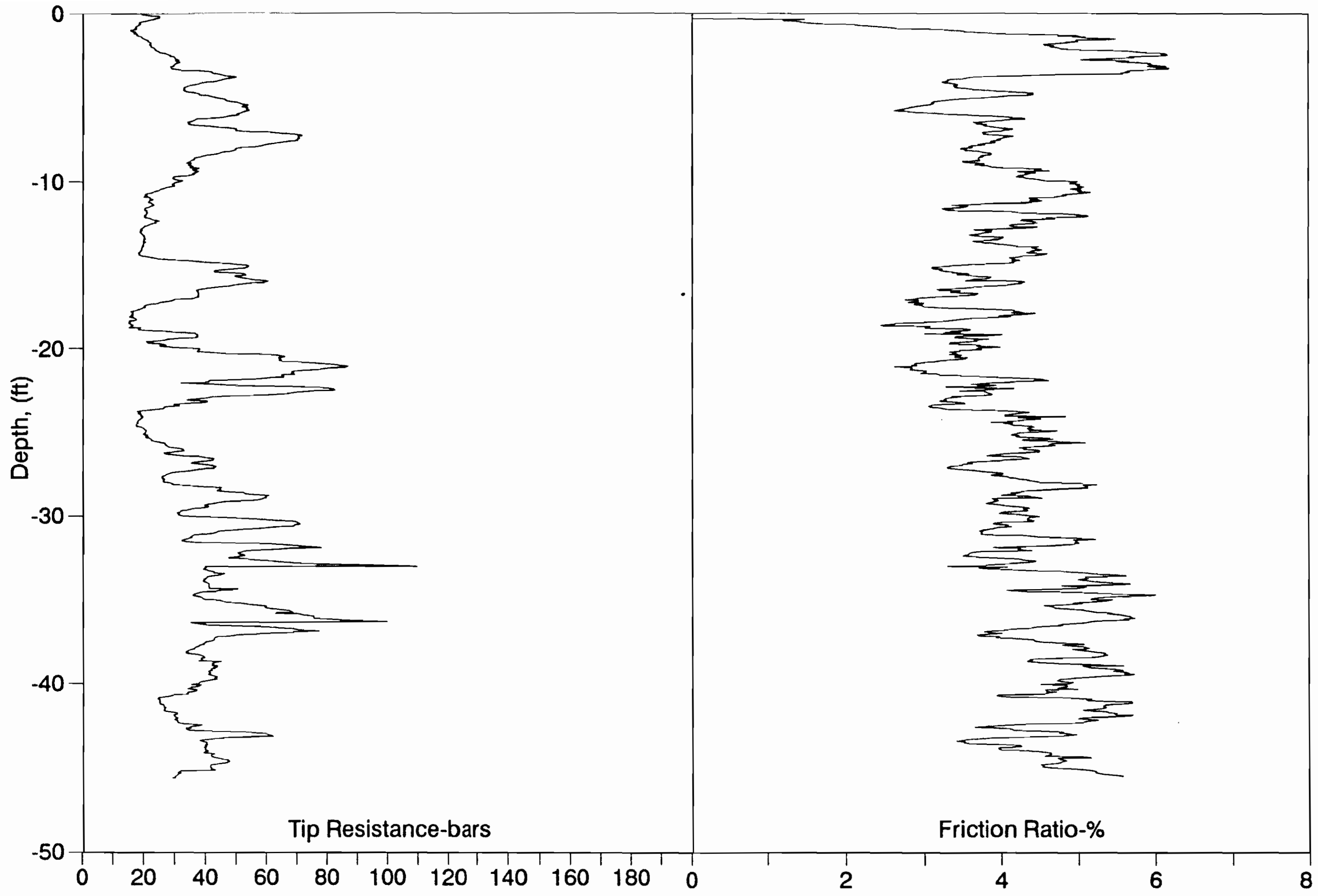


Figure 5.67 Winterpock Tap: Cone Test Averages

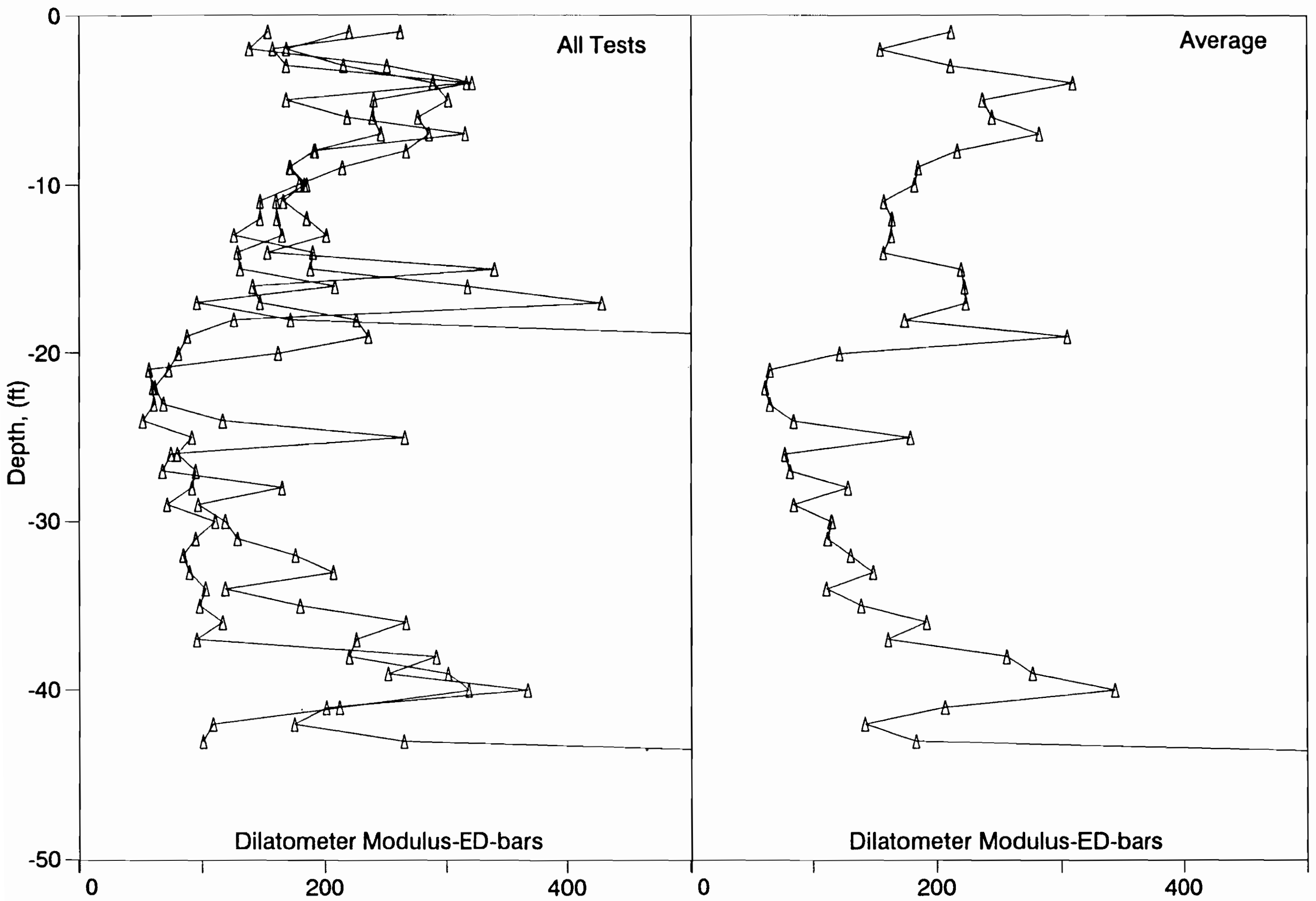


Figure 5.68 Winterpock Tap: Dilatometer Soundings

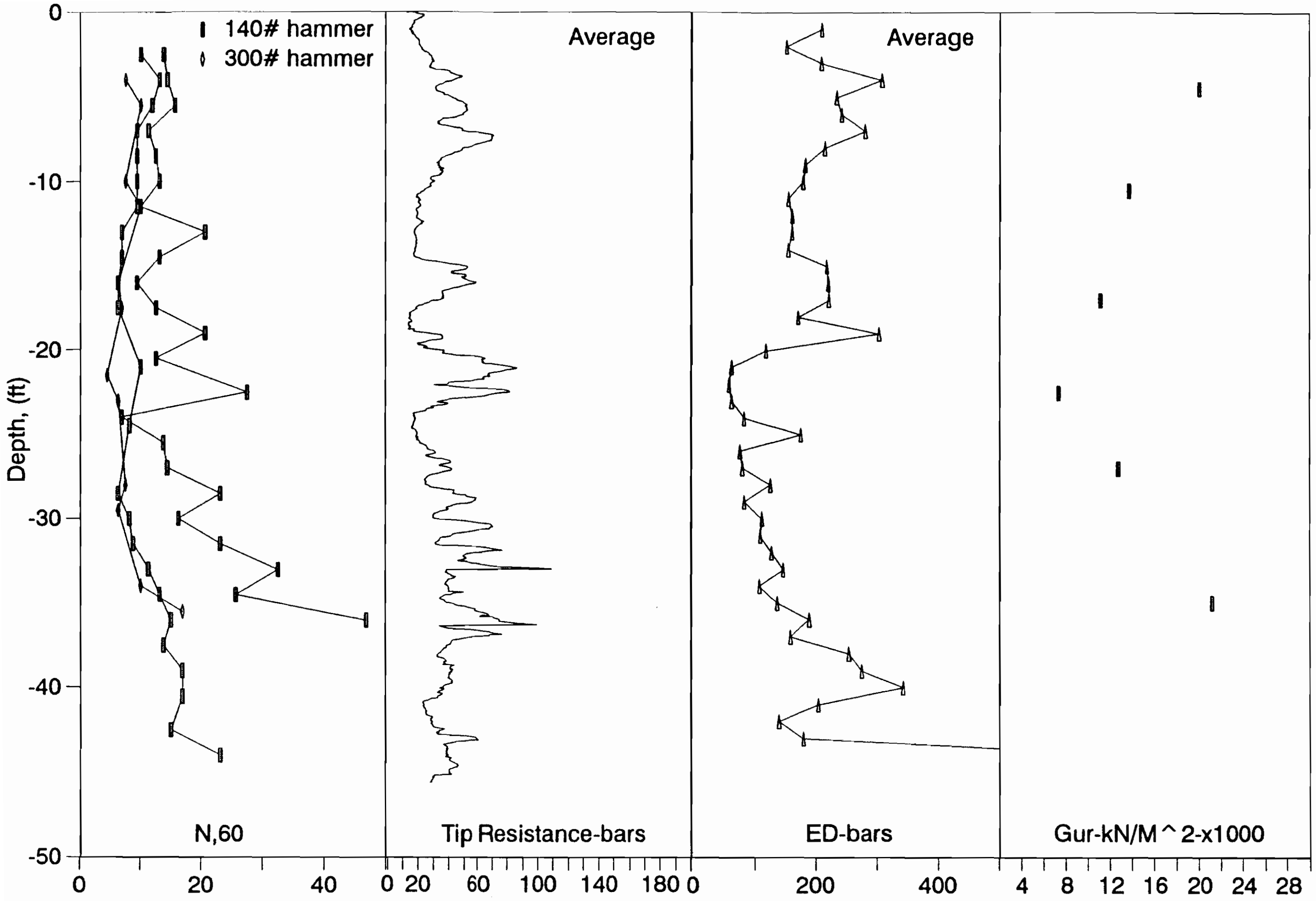


Figure 5.69 Winterpock Tap: All In-Situ Tests

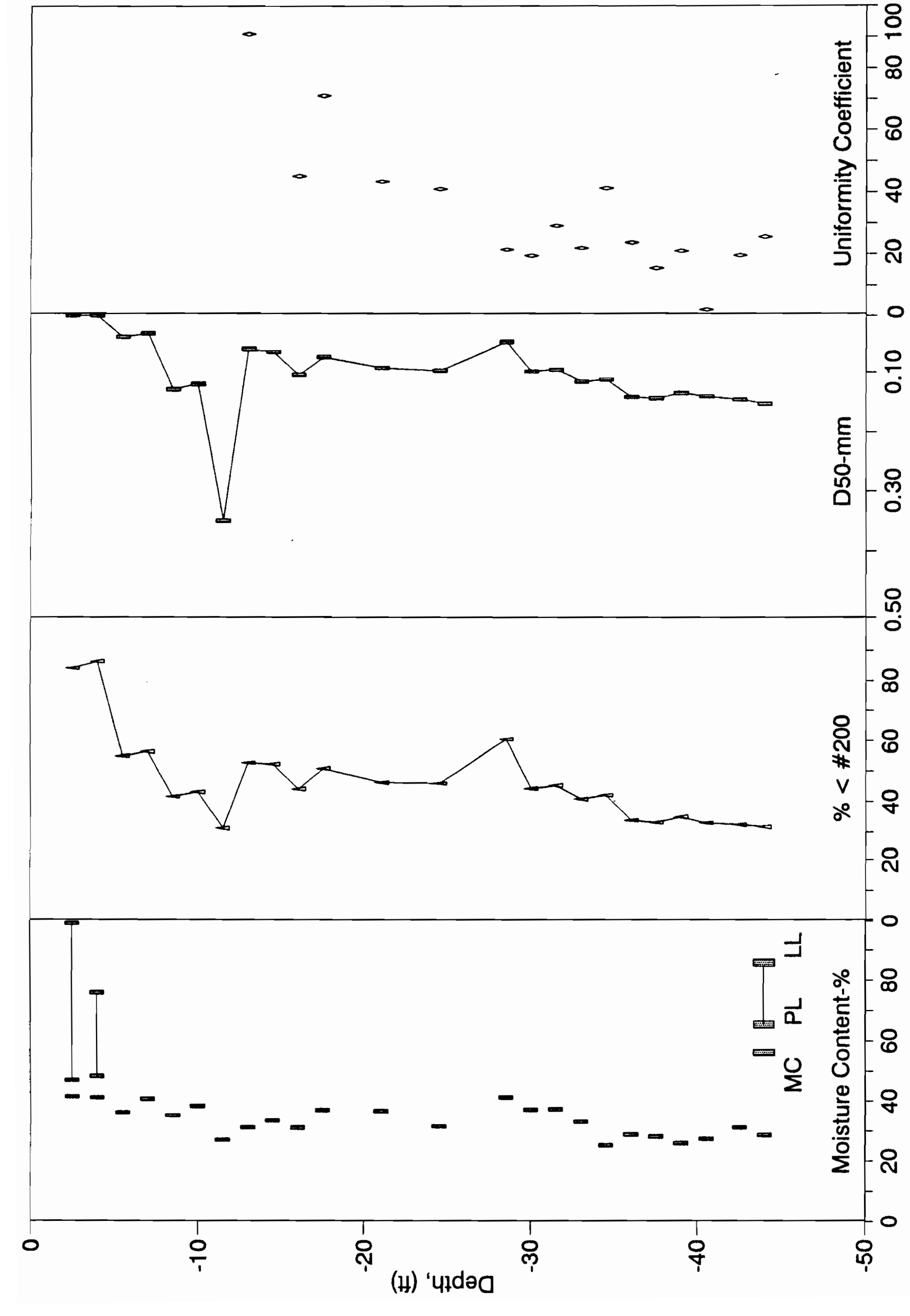


Figure 5.70 Winterpock Tap: Lab Test Results

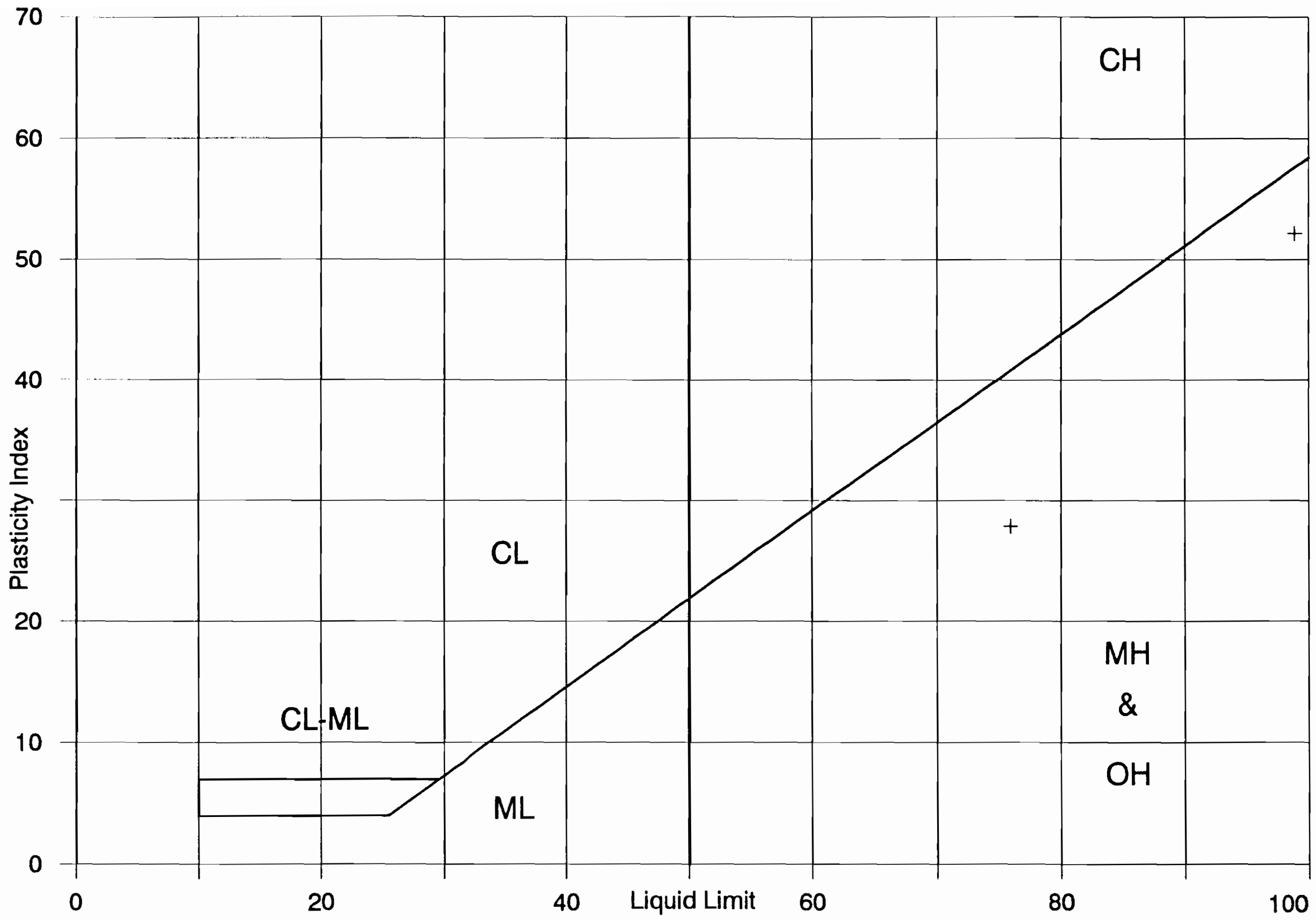


Figure 5.71 Winterpock Tap: Plasticity Chart

Table 5.16

WINTERPOCK TAP SOIL CLASSIFICATIONS

Depth (ft)	ASTM D 2487 Classification	CPT Classification	DMT Classification
- 2.5	MH Elastic Silt w/Sand	Clay	Sandy Silt
- 4.0	MH Elastic Silt	Clayey Silt to Silty Clay	Sandy Silt
- 5.5	ML Sandy Silt	Sandy Silt to Clayey Silt	Silt
- 7.0	ML Sandy Silt	Clayey Silt to Silty Clay	Sandy Silt
- 8.5	SM Silty Sand	Clayey Silt to Silty Clay	Silt
-10.0	SM Silty Sand	Clay	Silt
-11.5	SM Silty Sand	Silty Clay to Clay	Silt
-13.0	SM Silty Sand	Silty Clay to Clay	Silt
-14.5	SM Silty Sand	Silty Clay to Clay	Silt
-16.0	SM Silty Sand	Clayey Silt to Silty Clay	Sandy Silt
-17.5	SM Silty Sand	Silty Clay to Clay	Sandy Silt
-21.0	SM Silty Sand	Sandy Silt to Clayey Silt	Sandy Silt
-24.5	SM Silty Sand	Clay	Silt
-28.5	SM Silty Sand	Silty Clay to Clay	Clayey Silt
-30.0	SM Silty Sand	Silty Clay to Clay	Clayey Silt
-31.5	SM Silty Sand	Silty Clay to Clay	Clayey Silt
-33.0	SM Silty Sand	V. Stiff Fine Gr. (O.C. or Cemented)	Clayey Silt
-34.5	SM Silty Sand	Clay	Silt
-36.0	SM Silty Sand	V. Stiff Fine Gr. (O.C. or Cemented)	Silt
-37.5	SM Silty Sand	Silty Clay to Clay	Sandy Silt
-39.0	SM Silty Sand	Clay	Silt
-40.5	SM Silty Sand	Silty Clay to Clay	Silt
-42.5	SM Silty Sand	Clay	Silt
-44.0	SM Silty Sand	Silty Clay to Clay	Silty Sand

5.6 Summary

The testing program included the major soil types encountered across the service territory of Virginia Power. Soil deposits of alluvial, marine, and residual origin were tested. The Pepper's Ferry site soils were river deposited sandy clays, while the Carmel Church test area contained alluvial silty sands to sands. Overconsolidated marine clays underlay both the Schnabel and Ladysmith test areas. Two types of residual soils were also encountered during the testing. The Kipp's Farm test areas represented Valley of Virginia residual silty clays or clayey silts over limestone bedrock. Plantation Pipeline and Winterpock Tap soils displayed two different stages in the weathering of a piedmont micaceous schist. At Winterpock Tap the soils were predominantly silty sands, while Plantation Pipeline area soils had weathered further into elastic silts and sandy silts.

At all of the sites the penetration resistance/ stiffness profiles developed from the four in-situ test instruments were roughly comparable. At sites where the soils were homogeneous the results agreed closely among the tests. As the soil conditions became less uniform, the in-situ test results became more scattered. At the Kipp's Farm areas soils varied sufficiently that scatter developed among individual test profiles in each category of in-situ test. However, even with the scatter, the four in-situ tests appeared to be saying the same thing in different ways.

Soils identification from lab results, the CPT, and DMT were reasonably close at all sites. Depending on site conditions, both the CPT and DMT tended to either underestimate or overestimate the clay content or fineness of the soils by about one soil classification. Both tests consistently erred in the same direction at a given site.

The testing program was accomplished without major difficulties. The marine clays tended to swell into the borehole slowing testing, and some variability from test location to location was encountered at the residual soil sites. Otherwise, field work went smoothly with only minor equipment repairs delaying the testing. Table 5.17 presents a summary of the total field and lab testing program.

Table 5.17
Test Program Summary

	# of Test Attempts	# of Tests Complete	Total Depth.	Samples/ readings
Borings	19	19	617.5 ft	308
Cone Penetration Tests	30	30	1116.8 ft	n/a
Dilatometer Soundings	26	25	849.2 ft	871
Pressuremeter Tests	33	30	n/a	n/a

Laboratory Testing

Moisture Content	Specific Gravity	Gr size w/hyd	Atterberg Limits
291	14	171	132

Chapter VI

Interpretation of In-situ Test Results, Parameter Correlation, and Testing Efficiency

6.1 Introduction

The intent of this research was to improve the quality of soil information and geotechnical testing efficiency for transmission line foundation design. Following completion of the field program the results of the four in-situ tests were compared both to check existing correlations among the tests and to develop specific new relationships for the foundation conditions encountered by Virginia Power. The time and effort required for each test was also recorded to allow for comparisons of time expended versus amount of data obtained. Results of the various comparisons are presented in this chapter.

As in Chapter V, as much information as possible is presented graphically or in tables. In preparing the graphs the following abbreviations were used for the site names as shown in Table 6.1.

6.2 Correlation Methods

The correlations were approached on three levels. The first level was the comparison of the stiffness/ penetration resistance profile from each test and the second compared either undrained shear strength (S_u) or angle of internal friction (ϕ) calculated from test data. Because the powerline foundation design programs CUFAD and MFAD depend on values of pressuremeter modulus, the third level of correlation attempted to relate pressuremeter unload/reload modulus to parameters from the SPT, CPT, and DMT data.

Table 6.1
Site Name Abbreviations

Site Name	Abbreviation
Carmel Church	CCH
Kipp's Farm; hilltop area	KFT
Kipp's Farm; hillside area	KFS
Ladysmith	LSM
Pepper's Ferry	PF
Plantation Pipeline	PLP
Schnabel	SNB
Winterpock Tap	WPK

Where possible previously published correlations were used as a basis for further refinement. Otherwise the linear data regression capabilities of Lotus 123 were used to compare the data from the various tests, and draw conclusions about the validity of the comparisons. Non-linear curve fitting methods were also attempted, but did not produce correlations that were any better than those from the linear regression model.

The site data were grouped by predominate soil type as: (1) Carmel Church and Pepper's Ferry were combined as alluvial soil sites; (2) Ladysmith and Schnabel shared similar overconsolidated marine clay soil conditions; and (3) the residual soil sites of Kipp's Farm Plantation Pipeline, and Winterpock Tap. A further breakdown was found useful for the residual soil sites because the Kipp's Farm soils are not as weathered or as fully developed as those at Plantation Pipeline and Winterpock Tap. Notably the residual soils at Plantation Pipeline and Winterpock Tap also contained more mica than those at Kipp's Farm.

Correlations were considered in terms of the soil grouping as well as in terms of the combined data set. Each correlation calculation generated a line of best fit and a value of the coefficient of determination (r^2). Where applicable, the line of best fit is presented in standard algebraic slope-intercept form as follows.

$Y = mX + b$ with,

X = the known value
Y = the desired value
m = the slope of the line of best fit
b = the Y axis intercept

Values of the coefficient of determination vary from zero to one. An r^2 of 1 indicates a perfect correlation between the two values, while r^2 of 0 indicates no correlation.

In addition to plotting the line of best fit for the overall results of each comparison, the 90% confidence limits for the data are also included on the applicable graph. The limits indicated the range of values that can be expected with 90% confidence. The narrower the band of the confidence limits, the more reliable the correlation.

6.3 Correlations Between Dilatometer Modulus and Penetration Resistances

The results of the SPT, CPT, and DMT testing were compared to each other to determine if the different tests indicated similar trends in the stiffness/ penetration resistance. The blow counts and cone tip resistance values were normalized to account for the effects of overburden pressure, giving values of $N_{1,60}$ and $Q_{c,1}$. The dilatometer data reduction program accounts for overburden in calculating the dilatometer modulus (ED). Therefore no adjustment to ED was required.

6.3.1 Correlation of CPT Tip Resistance (Q_c) to Standard Penetration Test Blow Count (N_{60})

The cone tip resistance and standard penetration test blow count have been found to be related as a function of soil grain size. The ratio of Q_c/N for tests in this investigation are plotted against the D_{50} of the soil on a log scale, which is included in Figure 6.1. The data show considerable scatter regardless of site or soil grouping, but there is a general trend for Q_c/N to increase with D_{50}. This follows a trend that has been reported by Kulhawy and Mayne (1990). The scatter in the present values exceeds that reported by Kulhawy and Mayne (1990), particularly for the residual soils. Notably, the Kulhawy and Mayne study did not include residual soils.

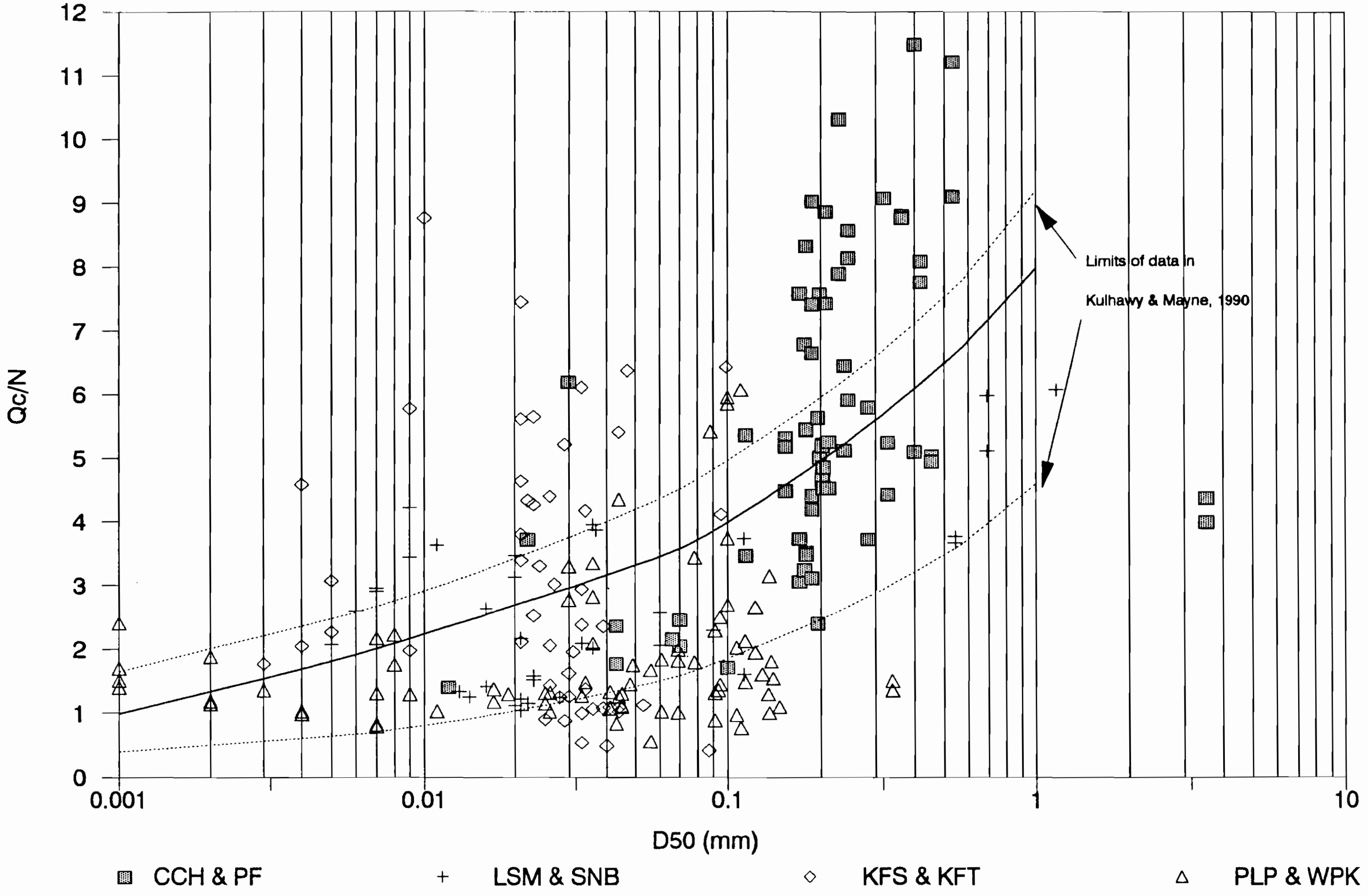


Figure 6.1 Qc/N60 versus D50

6.3.2 Correlation of Dilatometer Modulus (ED) to Normalized Standard Penetration Test Blow Count ($N_{1,60}$)

Mayne and Frost (1988) have published a correlation of ED to SPT blow count that follows a power curve with ED increasing as N increases. For a series of tests in residual sandy silts, the equation reported was:

$$\text{ED (bars)} = 220 * N^{0.82} \qquad (1)$$

Of the data from the present investigation, that from the alluvial soil sites best agrees with Equation 1 (Figure 6.2). The marine clay sites yielded ED values that correlated reasonably well with N, but the trends were different than at the alluvial sites (Figure 6.2). The data from the residual soil sites showed considerable scatter, and only a very crude trend was exhibited of ED increasing with N. At sites where ED did correlate well with N, a linear relationship seemed to fit the trends better than a power law. The homogeneous soils at the marine clay sites exhibit the strongest relationship with an r^2 value of 0.60 indicating some correlation. Results of the regression analysis are given in Table 6.2.

6.3.3 Correlation of Dilatometer Modulus (ED) to Normalized Cone Tip Resistance ($Q_{c,1}$)

The dilatometer modulus and cone tip resistance appeared to correlate reasonably well from visual inspection of the in-situ test traces presented in Chapter V. An increase in cone tip resistance was mirrored with a corresponding increase in the dilatometer modulus. Plots of ED and $Q_{c,1}$ for the different soil groups are shown in Figure 6.3. Both the alluvial soil sites and the marine clay sites yielded good correlations, but again the residual soil sites show much more

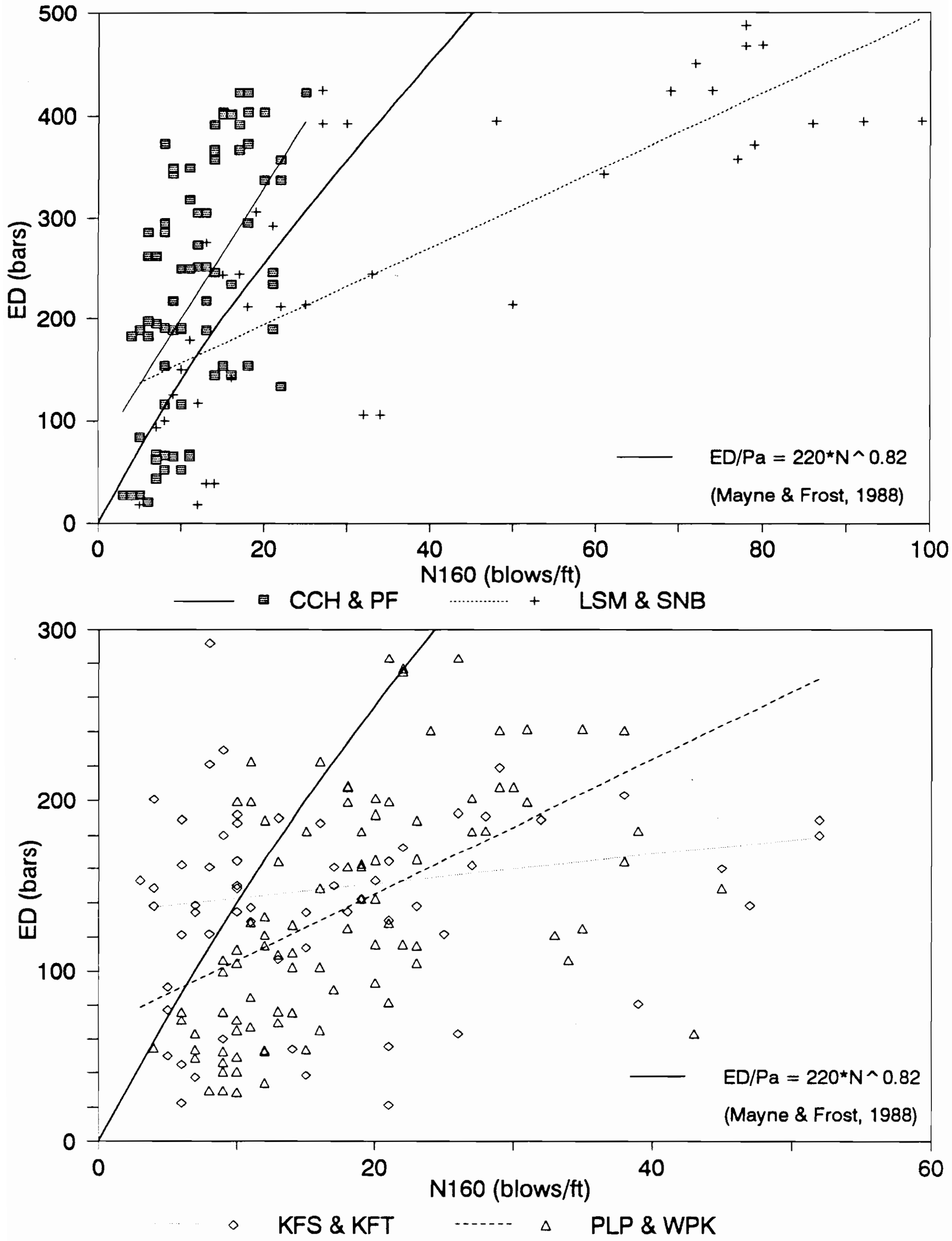


Figure 6.2 ED versus N160, Individual Sites

Table 6.2

Correlation of ED to $N_{1,60}$

$X = N_{1,60}$ blows/ft
$Y = ED$ bars

Site Location	r^2	Slope* m	Intercept* b
CCH & PF	0.326	13.01	69.3
LSM & SNB	0.603	3.81	117.7
KSF & KFT	0.024	0.86	134.3
PLP & WPK	0.286	3.92	67.0
ALL SITES	0.237	3.33	119.5
ALL SITES EXCEPT KIPP'S FARM	0.271	3.61	121.0

* For straight line fit.

scatter. The data from the Kipp's Farm site is the most erratic, and the best fit line actually shows a decrease in ED with $Q_{c,1}$.

Parameters for the straight lines fitted to the data from the different soil groupings are given in Table 6.3. The largest r^2 value was obtained at the alluvial soil sites (0.72) and the smallest at the Kipp's Farm site (0.01). Figure 6.4 provides a plot of ED and $Q_{c,1}$ values excluding the Kipp's Farm data. The results tend to cluster around a single straight line fit, although a wide range of ED values actually exist for any particular value of $Q_{c,1}$.

6.3.4 Summary of Penetration Resistance Correlations

The correlations between stiffness and penetration resistance values would be expected to be approximate at best given the nature of these parameters. The present results bear this out. It is also apparent that N yields a poorer correlation with ED than does $Q_{c,1}$. This is likely related to the crude nature of the SPT procedures. Notably, more scatter clearly exists for the residual soil sites than the others, and there is less consistency in the data for the Kipp's Farm residual soil than there is at the Plantation Pipeline or Winterpock Tap.

These findings are important and reflect the materials at the different sites. Residual soils are by nature more erratic than the others, and those at Kipp's Farm are especially a problem since the weathering profile is only poorly developed. This leads to natural scatter in the test data, and attempts at correlating data from two tests are often not fruitful.

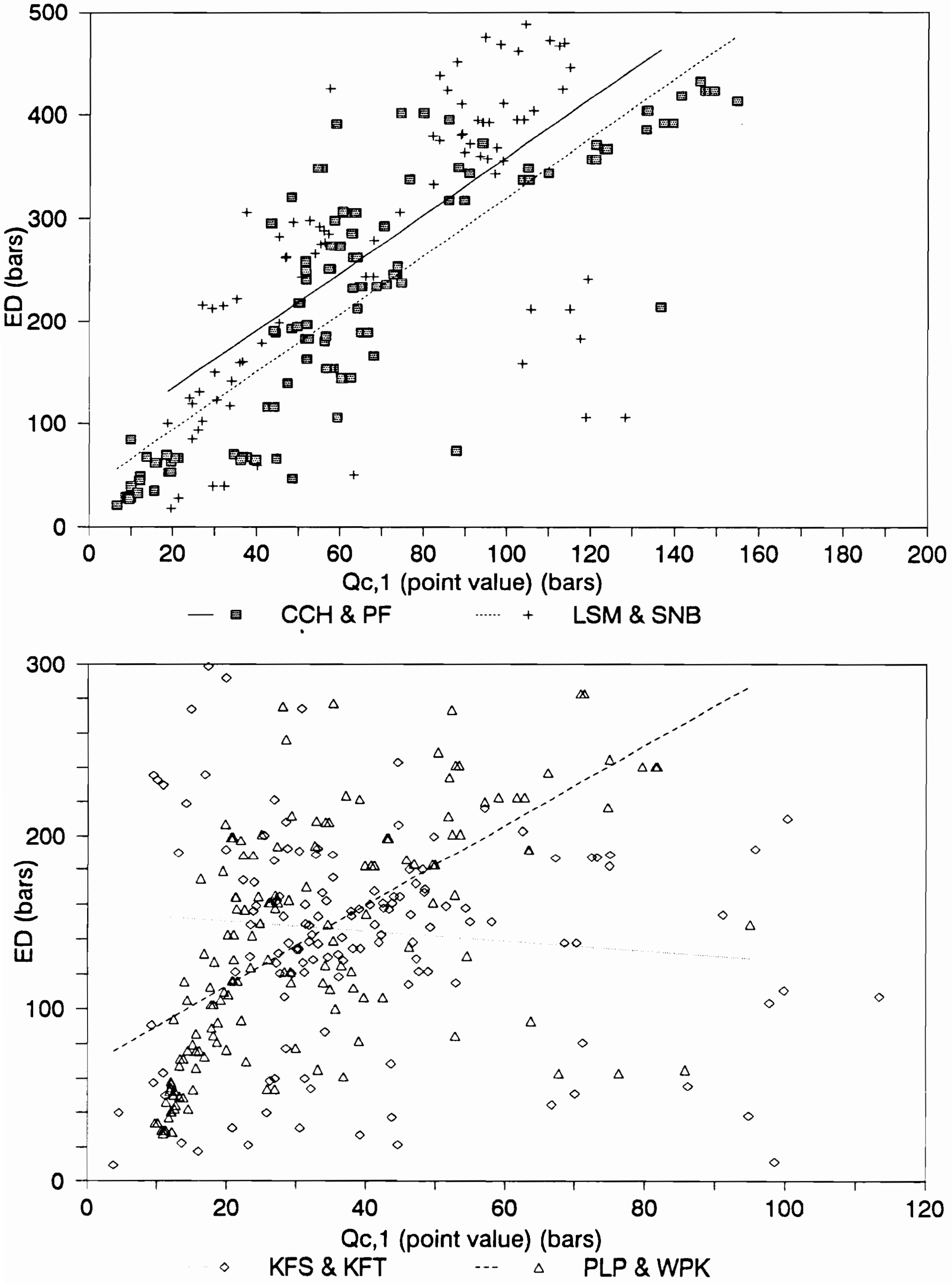


Figure 6.3 ED versus Qc,1 , Individual Sites

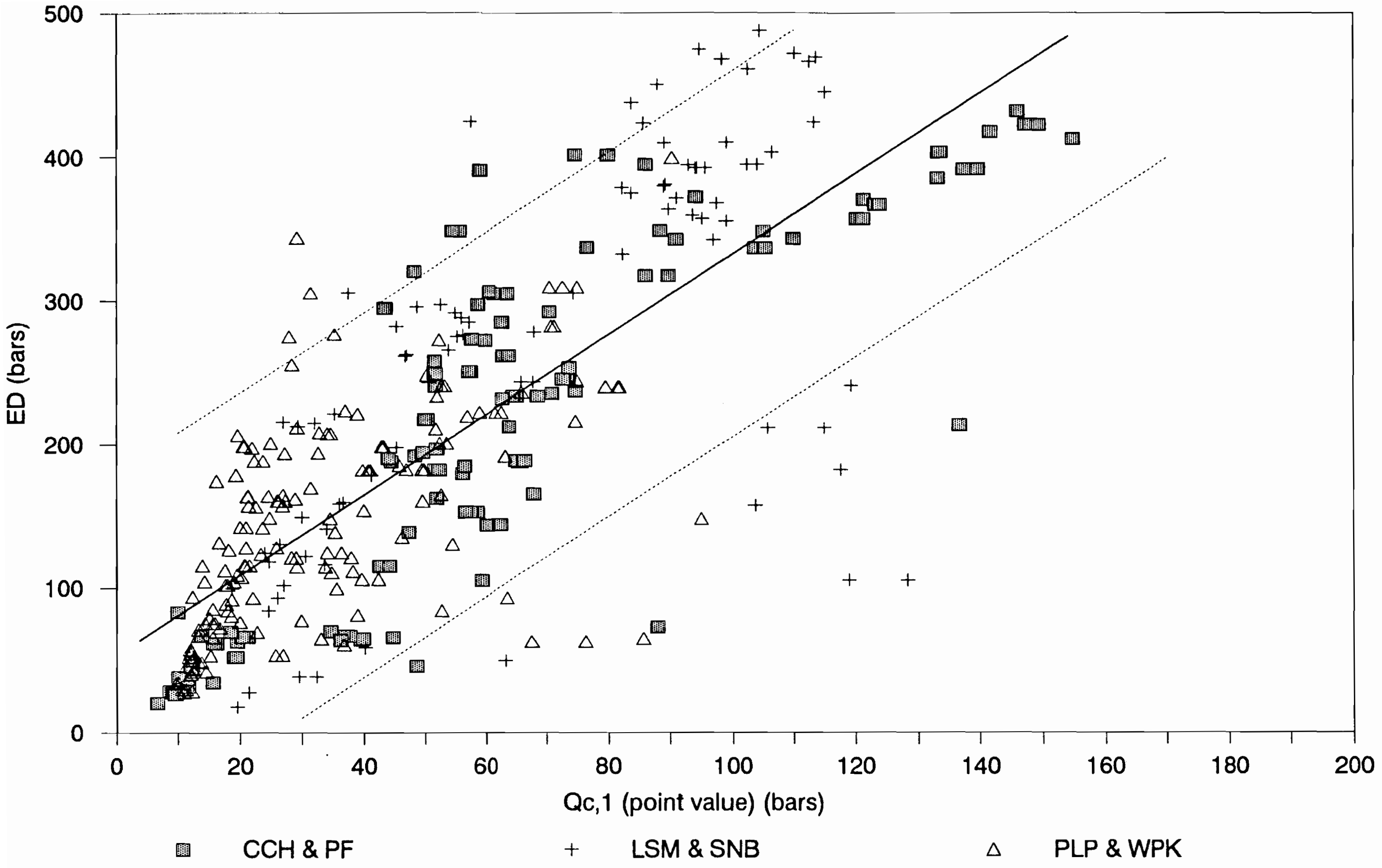


Figure 6.4 ED versus Qc,1, All Sites Except Kipp's Farm

Table 6.3

Correlation of ED to $Q_{c,1}$

$X = Q_{c,1}$ bars

$Y = ED$ bars

Site Location	r^2	Slope m	Intercept b
CCH & PF	0.724	2.836	37.0
LSM & SNB	0.466	2.811	78.2
KSF & KFT	0.009	-0.283	156.1
PLP & WPK	0.376	2.321	67.0
ALL SITES	0.490	2.453	64.8
ALL SITES EXCEPT KIPP'S FARM	0.625	2.798	53.0

6.4 Correlation of Overconsolidation Ratio (OCR) from Laboratory Testing to Dilatometer Data

Reduction of the dilatometer test data returns a calculated overconsolidation ratio profile as part of the data reduction program. At the Schnabel and Kipp's Farm sites laboratory OCR information was available for comparison to the DMT calculated values of OCR. Otherwise, it was only possible to consider if the OCR profile presented by the DMT test results seemed reasonable.

For the alluvial sites, DMT testing yielded OCR values decreasing from values of 8 to 0.1 with depth. The soils at Pepper's Ferry at depth would appear to be fully consolidated, and the DMT OCR values as low as 0.1 would appear to be misleading. The calculated OCR values at Carmel Church agreed better than was the case at Pepper's Ferry. An OCR of about 8 were obtained at a depth of 4.0 feet and OCR values thereafter decreased steadily to approximately 1.0 at 26.0 ft.

OCR values from the DMT testing at the marine clay sites appeared nonsensical. Laboratory testing of the Schnabel site clay indicated OCR values of between 2.8 and 5.0 (Mayu 1987). However, values of OCR calculated from the DMT data ranged from 15.7 to over 100. Very high values of OCR were also obtained at the Ladysmith site, in some cases approaching 325. The reasons for this response are not clear. However, it would appear that the soil conditions at the marine clay sites fell outside the parameters for which the empirical OCR calculations using DMT test results were developed.

The pattern of calculated OCR values at Kipp's Farm indicated an overconsolidated crust with OCR values approaching 50 at a depth of 3 feet. The OCR then decreased steadily with depth to approximately 1.0 at 25 feet.

Consolidation test results reported by Pappas (1990) produced OCR values approaching 40 for the near surface soils at Kipp's Farm. The DMT calculation of OCR seems to be fairly reasonable for the residual soils at Kipp's Farm.

At the Plantation Pipeline and Winterpock Tap sites, the calculated OCR values from DMT data presented a profile of overconsolidated surficial soils trending to normally consolidated with depth. At both sites, the data indicated larger OCR values in an overconsolidated crust varying from 8 to 12 feet deep. Below that depth the OCR values ranged from 1 to 5 with average values of approximately 2.5.

Although the profile of calculated OCR values made sense in most cases, the absolute value of the results typically were not reliable. It would appear that the soils involved in this test program were not compatible with those used to establish the empirical data base for the dilatometer OCR calculation procedures.

6.5 Correlations Among Calculated Values of Undrained Shear Strength (S_u)

Values of the undrained shear strength of the various clayey soil deposits were calculated from the SPT, CPT, and DMT test data. The existing method for determining S_u from SPT data as described in Chapter II was followed for the standard borings. The dilatometer data reduction program provided an estimate of S_u for any soils that was classified by the program as silt or clay.

Robertson and Campanella (1983) suggest that S_u can be calculated from cone tip resistance (Q_c) using the equation:

$$S_u = (Q_c - \sigma_{vo})/N_k$$

where Q_c = cone tip resistance

σ_{vo} = total overburden stress

N_k = cone bearing factor.

Q_c and σ_{vo} are available from the test data and boring logs. Robertson and Campanella (1982) suggest a value of N_k = 15 for "normal" clays and N_k = 10 for sensitive clays. Lien (1990) found that N_k = 10 produced good agreement with lab S_u values for the Schnabel site, a reasonable conclusion in view of the sensitive nature of the clays there. Consequently, N_k = 10 was used for the similar soils at the Schnabel and Ladysmith sites and N_k = 15 was used for the remaining test locations.

Plots of the calculated values of S_u versus depth for the three test methods and seven applicable sites are shown in Figures 6.5 to 6.8. Also shown is an abbreviated version of the site soil profiles as presented in Chapter V. Due to the granular soils at the Carmel Church site no undrained shear strength values were calculated for that location.

6.5.2 Site Undrained Shear Strength Profiles

The alluvial soil sites yielded only a small amount of undrained shear strength data. At Pepper's Ferry, the soils between 5.0 and 18.0 ft. in depth classified as clays. Otherwise, the soils at Pepper's Ferry and Carmel Church were sands or clayey sands and as such the shear strength would be controlled by the angle of internal friction. The water table at Pepper's Ferry was found at 12.0 ft., and 32 ft. at Carmel Church.

At Pepper's Ferry the calculated values of S_u remained reasonably constant with depth (Figure 6.5) for all test methods although the SPT data exhibited the largest scatter. S_u values based on the SPT blow count also were the largest of the set. SPT S_u's about double those from the other tests. S_u values interpreted from the CPT data followed the same patterns with depth as those obtained from the SPT data. However, peak values of S_u from the CPT test

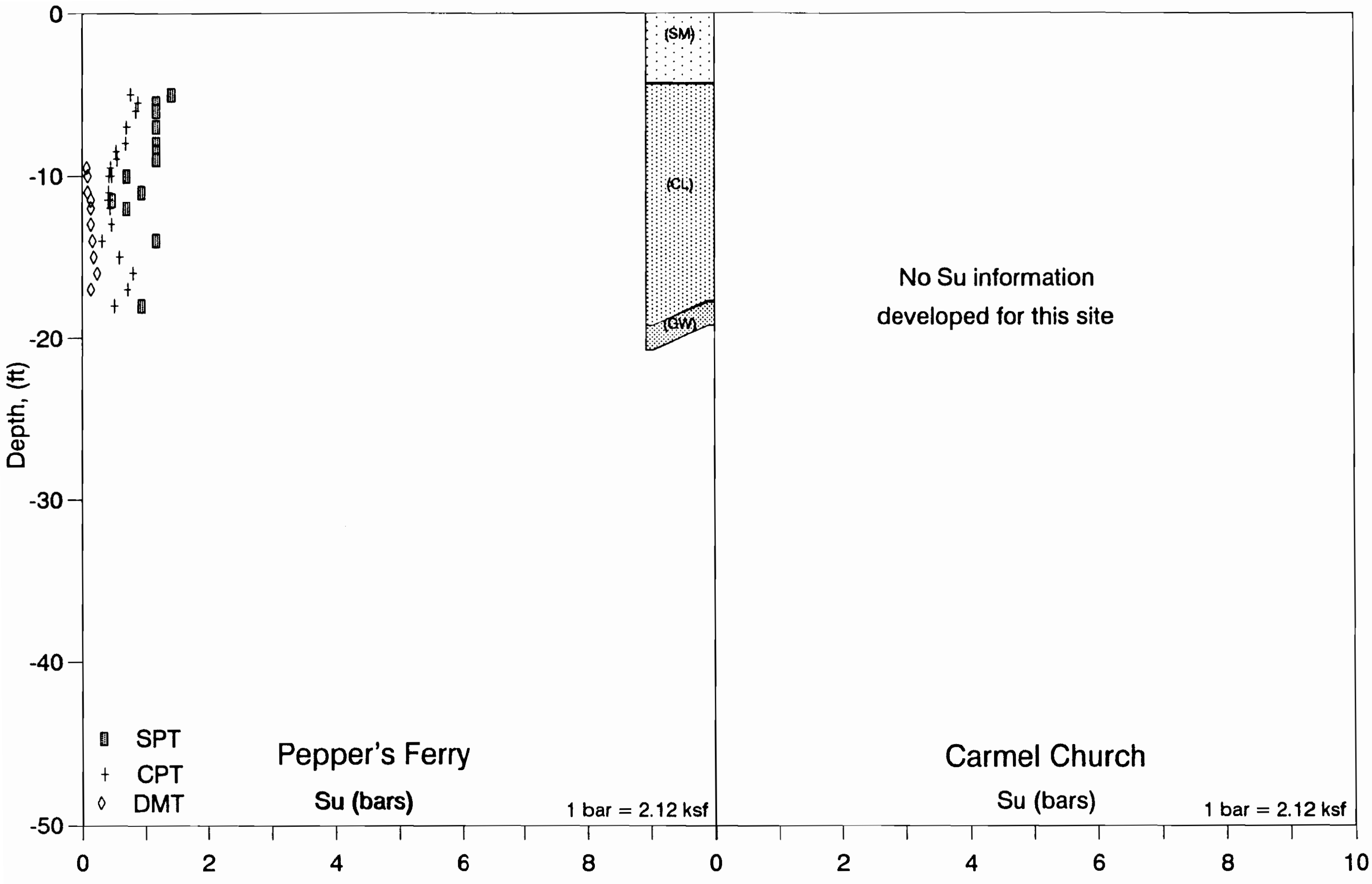


Figure 6.5 Alluvial Sites, Su from In-situ Tests

results were lower than 1.0 bars while those from the SPT data were higher than this. Also, the CPT S_u values showed less scatter than those from the SPT. For the soils from 9.0 to 18.0 feet, the S_u values interpreted from the dilatometer were below 0.2 bars. The DMT data reduction program did not assign values of S_u for other portions of the soil profile.

The marine clay sites soil profiles both contained saturated clays. At Schnabel, the clays extended from 5.0 ft. to the limit of testing at 30.0 ft., while at Ladysmith the clay soils were found from 10.0 ft to 30.0 ft. The water table at both sites was above the surface of the clay layers.

The S_u profiles at the Schnabel site determined from the three in-situ tests were consistent; all indicated S_u values of approximately 1.5 bars at 5.0 ft, followed by an approximate linear increase to between 6 and 8 bars at 18.5 ft (Figure 6.6). No SPT data were collected below 18.5 ft., but from that depth, the S_u data from both the CPT and DMT decreases in a linear pattern to about 3 bars at 30.0 ft. This pattern of increasing S_u values followed by decreasing ones as shown by the CPT and DMT is supported by self-boring pressuremeter results reported by Lien (1990).

The range of calculated shear strength values at the Schnabel site also agree in general with the results of several high quality laboratory shear strength investigations for the Richmond miocene clay. While the laboratory tests were not performed on samples from the Schnabel site, they were conducted on miocene clay soil in the general vicinity. Reported S_u values from 2 to 5 bars were obtained for unconsolidated-undrained triaxial test results on the shelby tube or block samples of the clay. (Casagrande, 1965, Martin and De Stephen, 1983, Mayu and Clough, 1990). Values shown in Figure 6.6 for the in-situ tests of this investigation range from 0.5 to 8 bars. In Table 6.4 the data from the laboratory

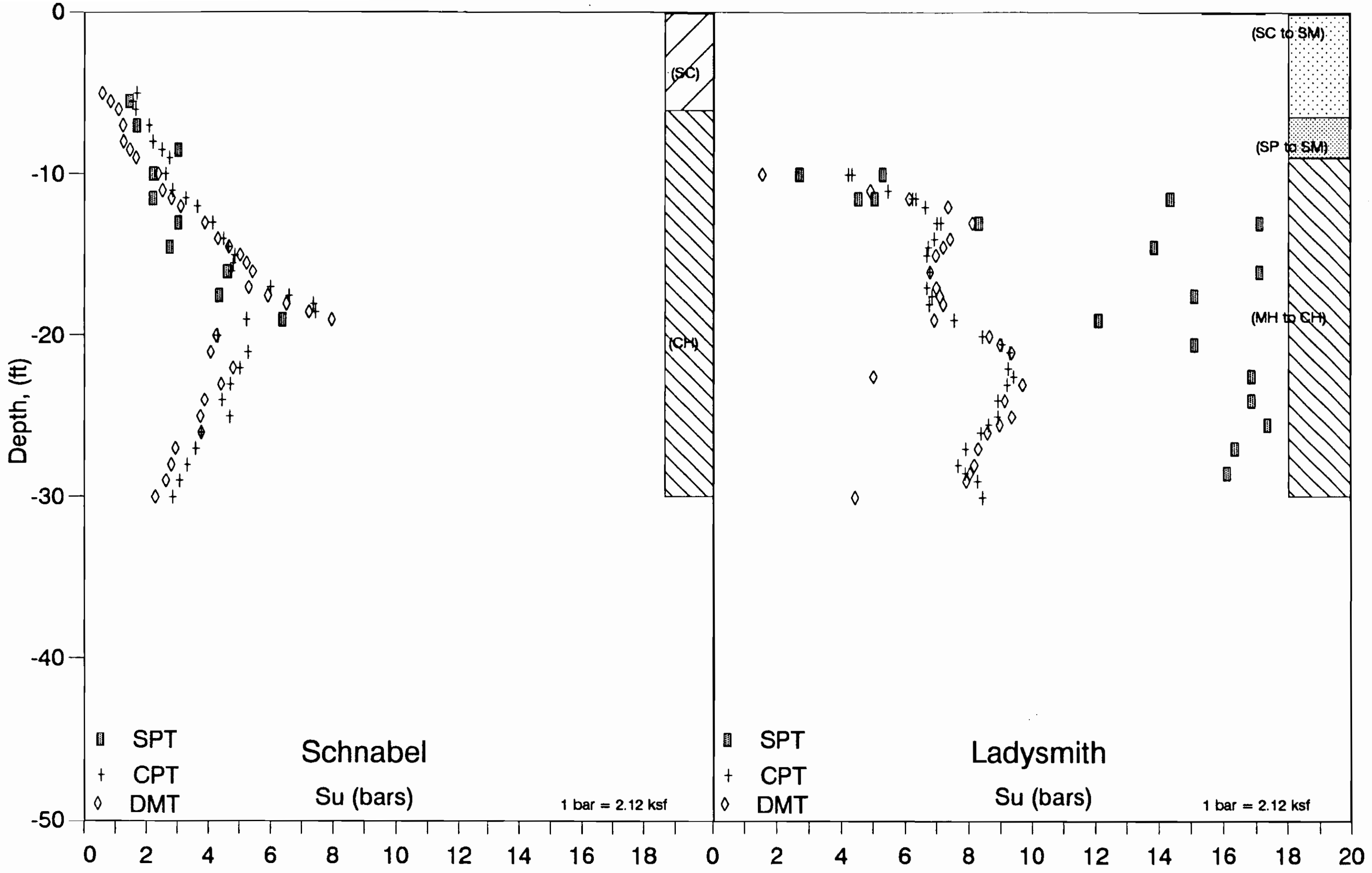


Figure 6.6 Marine Clay Sites, Su from In-situ Tests

and field tests are arranged to compare findings for the "upper" and "lower" units of the miocene clay. These two units are distinguished by different Atterberg Limits, with the upper miocene being more plastic than the lower miocene clay. At the Schnabel site the break between the upper and lower units occurs at about 20 feet.

It is notable that while the values of S_u obtained from the in-situ tests are in general agreement with the trend of the laboratory tests, the range for the in-situ tests is greater than for the laboratory tests. In some instances a higher range may simply be indicative of greater scatter. However, in this case the in-situ test S_u values are very consistent in magnitudes and trends with depth. Thus, it is believed that the in-situ tests have more successfully captured the natural variation in the miocene clay strength than the laboratory tests. Laboratory tests are typically performed only on selected samples, and it is not possible to know before-hand if the weakest and strongest soil regions were selected. In contrast, the CPT or DMT with their frequent to continuous measurement of soil properties, are able to define where the weakest and strongest layers are found. This is perfectly illustrated by the data at the Schnabel site (see Figure 6.6).

The pattern of agreement in the calculated S_u values from the three in-situ tests was followed at the Ladysmith site in the upper soil layers to a depth of 13.5 ft. Below this depth, difficulties were encountered in conducting standard penetration tests and artificially high blow count values were obtained. This led to subsequently high calculated values of the shear strength from the SPT relative to the values for the other tests. The S_u data from the CPT and DMT were

Table 6.4

Published Values of S_u for the Miocene Clay

Source	Soil Type	Lab S_u (bars)
Casagrande (1965)	Upper Miocene Lower Miocene	2.17-2.42 3.15-4.35
Martin and De Stephen (1983)	Lower Miocene	2.37-4.36
Mayu and Clough (1990)	Lower Miocene (block sample)	2.70-4.93

Present Investigation

Soil Type	CPT S_u (bars)	DMT S_u (bars)	SPT S_u (bars)
Upper Miocene	1.70-6.60	0.56-5.35	1.50-6.30
Lower Miocene	3.11-8.16	2.24-7.86	no data

consistent and show an increase in shear strength from 4.5 bars at 10.0 to 6.5 bars at 14.0 ft. From 14.0 to 20.0 the profiles are linear to 20.0 ft. where S_u values increase to approximately 9.0 bars. Shear strength values then decrease to 7.5 bars at 30.0 ft. As at the Schnabel site, the calculated S_u data for the CPT and DMT agree very well.

The residual soils at the Kipp's Farm site classified as sandy silts, low plasticity silts, high plasticity silts, and low plasticity clays. Typically, they are only partially saturated, and their permeability is such as to lead to drainage during the loading of most of the in-situ tests. As such, the application interpretation methods for S_u theories based on saturated-undrained behavior is questionable. Nonetheless, S_u values were calculated from the Kipp's Farm data in an attempt to determine the general magnitude of the of predicted strengths.

Results of the shear strength calculations for both the Hilltop and Hillside areas are presented in Figure 6.7. For comparison S_u values reported from unconsolidated-undrained triaxial test results on block samples range from 1.0 to 3.4 bars (Pappas 1990). The SPT data showed extreme scatter for both areas, with calculated S_u values from 1.0 to 9.0 bars.. S_u values determined using Q_c values at each 0.5 to 1.0 ft. depth interval also exhibited considerable scatter, ranging from 0.8 to 9.0 bars. Notably, both the SPT and CPT lead to loading a small area of the soil with a hard or soft spot in the profile producing an exaggerated penetration resistance profile and a corresponding erratic profile of calculated shear strength.

At the Kipp's Farm site, dilatometer values of the calculation of S_u showed a more consistent profile than from the CPT or SPT, with average values of S_u of approximately 0.8 to 1.2 bars. However, the DMT shear strength values also do not appear to vary with changes in the soil profile. The test does not appear well

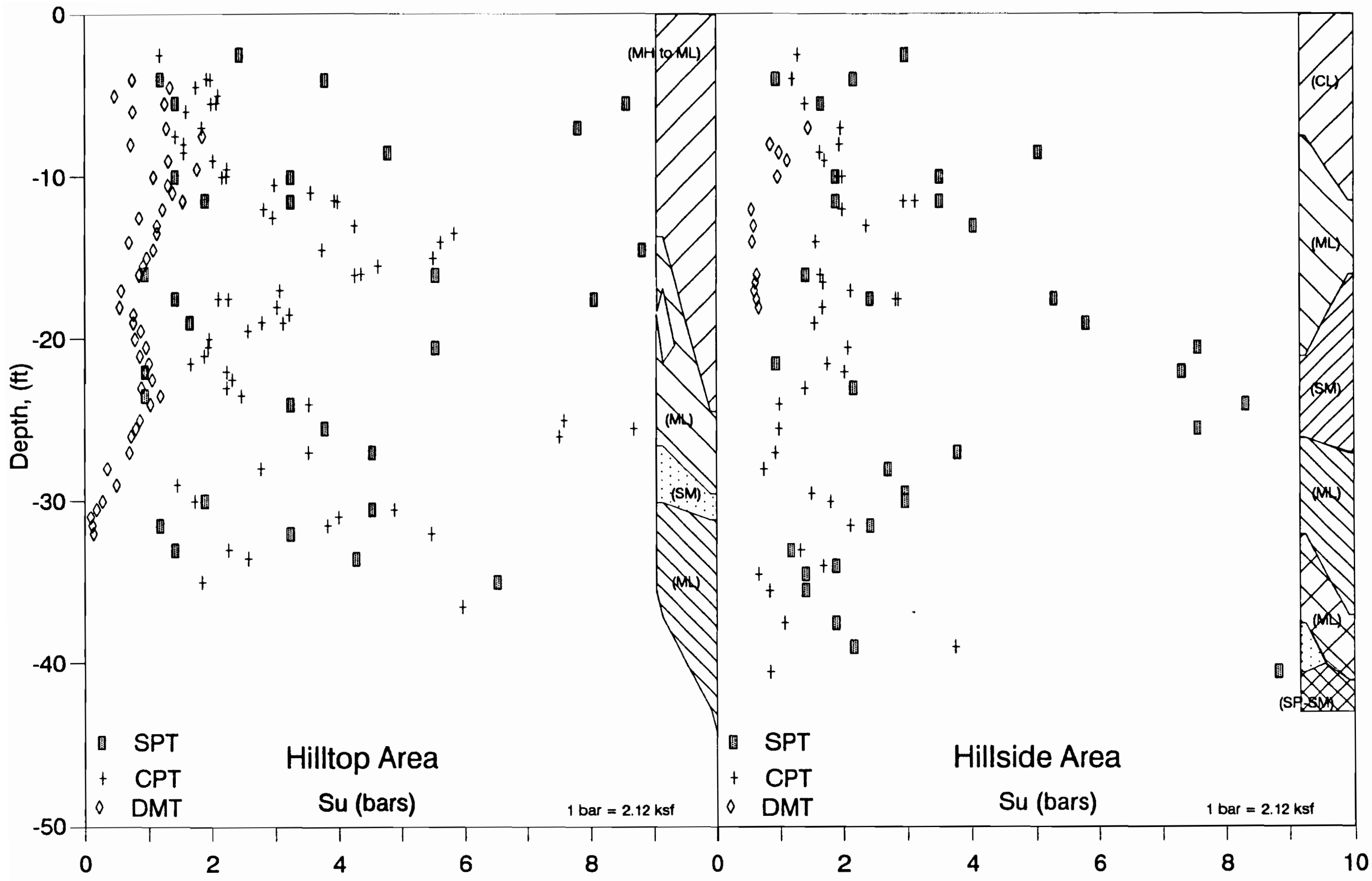


Figure 6.7 Kipp's Farm, Su from In-situ Tests

calibrated to determining S_u information in the mixed profile of the Kipp's Farm residual soil site, as shown by the published range in S_u values from 1.0 to 3.4 bars.

At the more weathered residual soil profile found at the Plantation Pipeline site, there appeared to be better agreement among the values of S_u calculated from the in-situ tests than at Kipp's Farm. Soils at the Plantation Pipeline site classified as low and high plastic silts for the full depth of the soil profile and the water table depth was 8 ft., producing conditions for the soils which were more consistent with the assumptions used in the strength data reduction methods.

Values of undrained shear strength calculated from the three tests at the Plantation Pipeline site indicated the same general shear strength profile (Figure 6.8). Strength values decrease from the surface to minimum values at approximately 15 ft. The high strength in the upper soils are likely due to overconsolidation by desiccation. From 15 feet, the CPT and SPT data indicate an increase in shear strength with increasing depth. Throughout the profile, the SPT results yielded calculated S_u values approximately twice those developed from the CPT and DMT, and showed considerable scatter in the results. S_u values from the CPT and DMT data presented a more uniform picture of the shear strength profile than the SPT. However, the calculated values of S_u from the DMT are also approximately one half of those calculated from the CPT.

The Winterpock Tap site soils classified as silts only in the top 10 ft. From 10 ft. to the limits of testing the soils were silty sands, and the water table was found at a depth of 16.0 ft. The unsaturated silts in the top 10 ft. of the profile yielded little useful information concerning undrained shear strength of the soils from any of the tests (Figure 6.8).

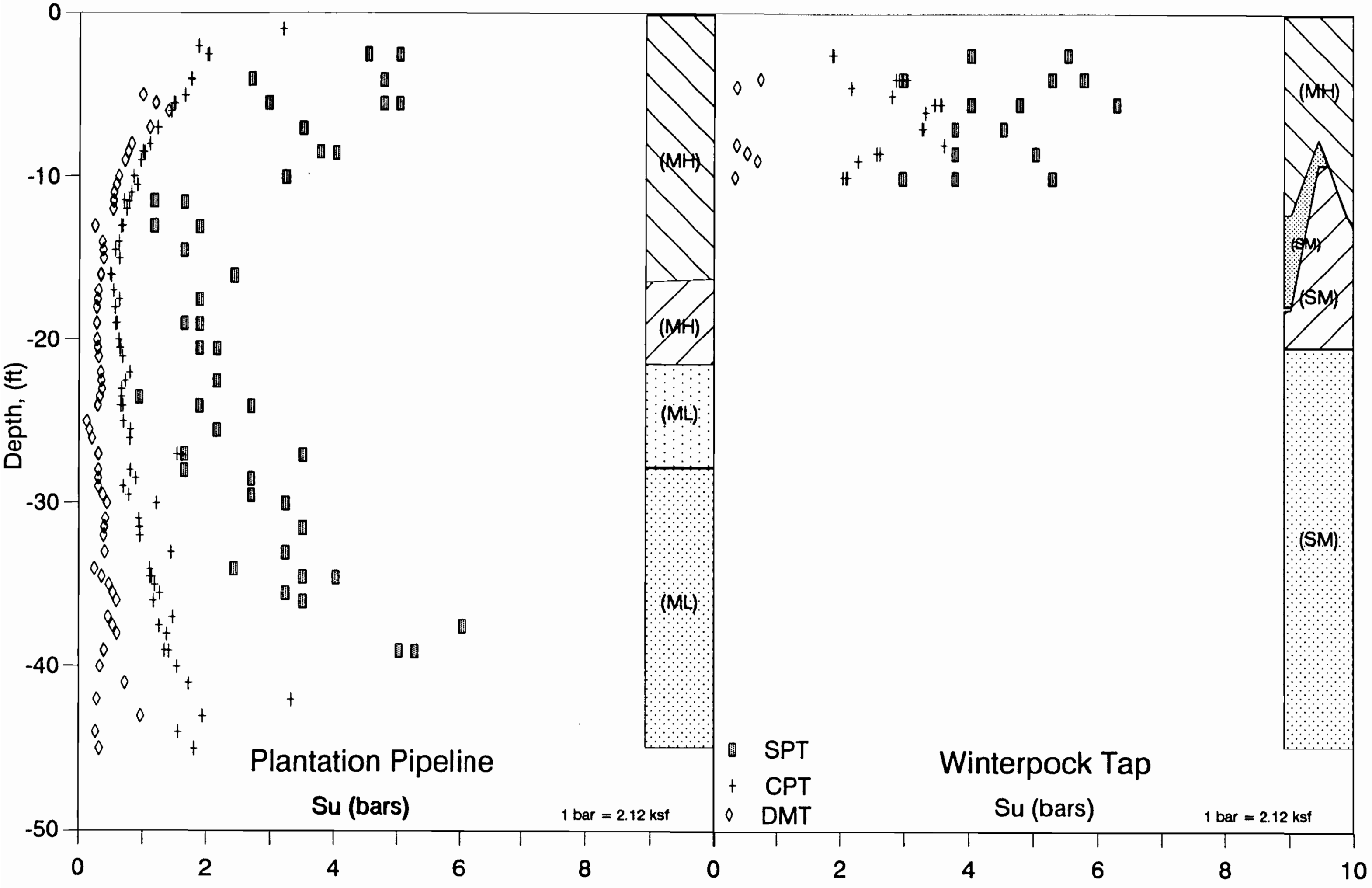


Figure 6.8 Residual Soil Sites, Su from In-situ Tests

6.5.3 Correlation of S_u Calculated from the CPT and DMT

Figure 6.9 shows plots of S_u values determined from the various sites for the DMT results versus those obtained from CPT results. Only in the case of the marine clay sites does there appear to be agreement between the two sets of results. Figure 6.10 gives a direct comparison of only the S_u values from the marine clay sites. The two sets of data yield points that fall close to the "truth line," the case of 1:1 agreement. This is encouraging in that for the marine clays the conditions for determining S_u values best agree with those used in the methods of data reduction (undrained behavior, saturated conditions).

The lack of agreement at the other sites may be attributed to two factors: (1) conditions, which are not consistent with assumptions of the data reduction procedures; and, (2) lack of experience, particularly with the DMT, in residual soils.

6.5.4 Summary of Undrained Shear Strength Profiles and Correlations

Methods of determining undrained shear strength from insitu tests assume undrained behavior under saturated conditions. The saturated marine clay test sites produced the most consistent and reasonable results, and those sites have subsurface conditions that best model the behavior assumptions. At the Schnabel and Ladysmith sites, the CPT and DMT yielded essentially a 1 to 1 correlation in calculated S_u values.

As site conditions diverged from the underlying assumptions of the data reduction procedures, the consistency of shear strength determinations degraded. Individual test profiles became more erratic and agreement among the test methods also became less consistent.

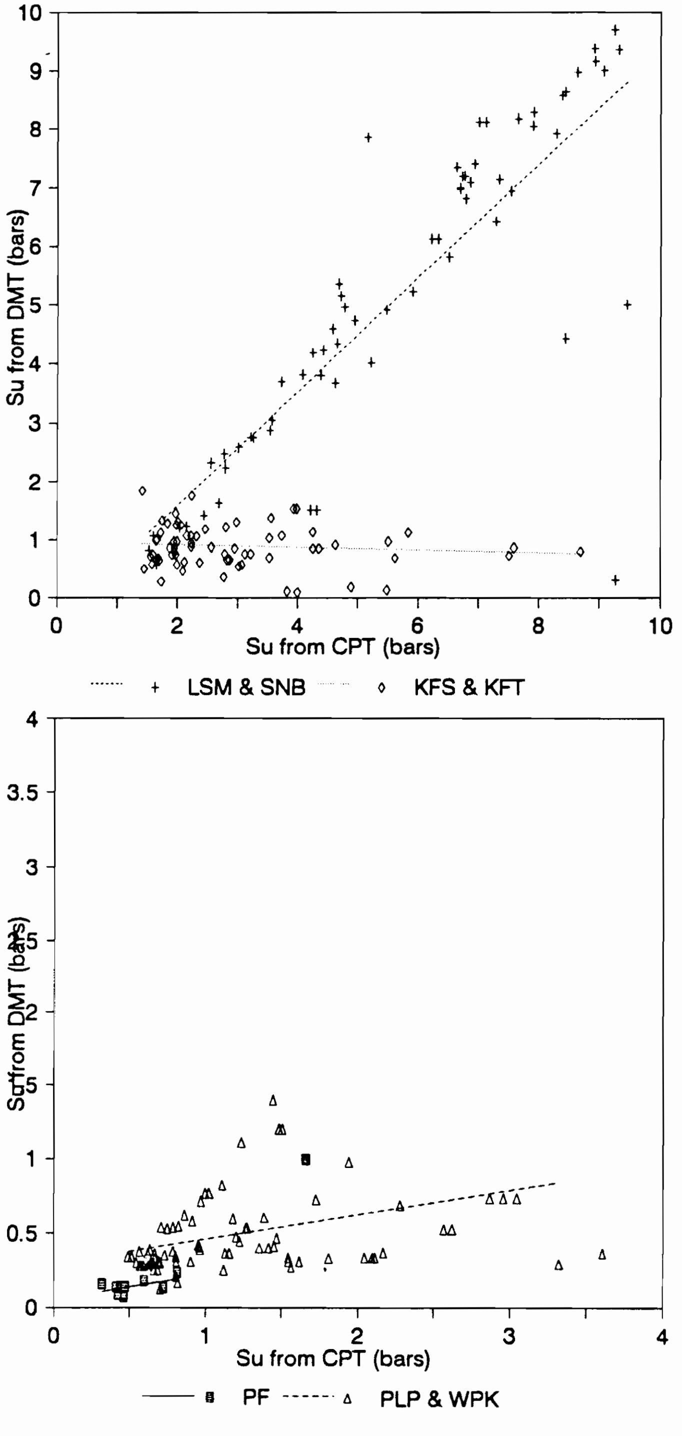


Figure 6.9 Su from CPT and DMT, Individual Sites

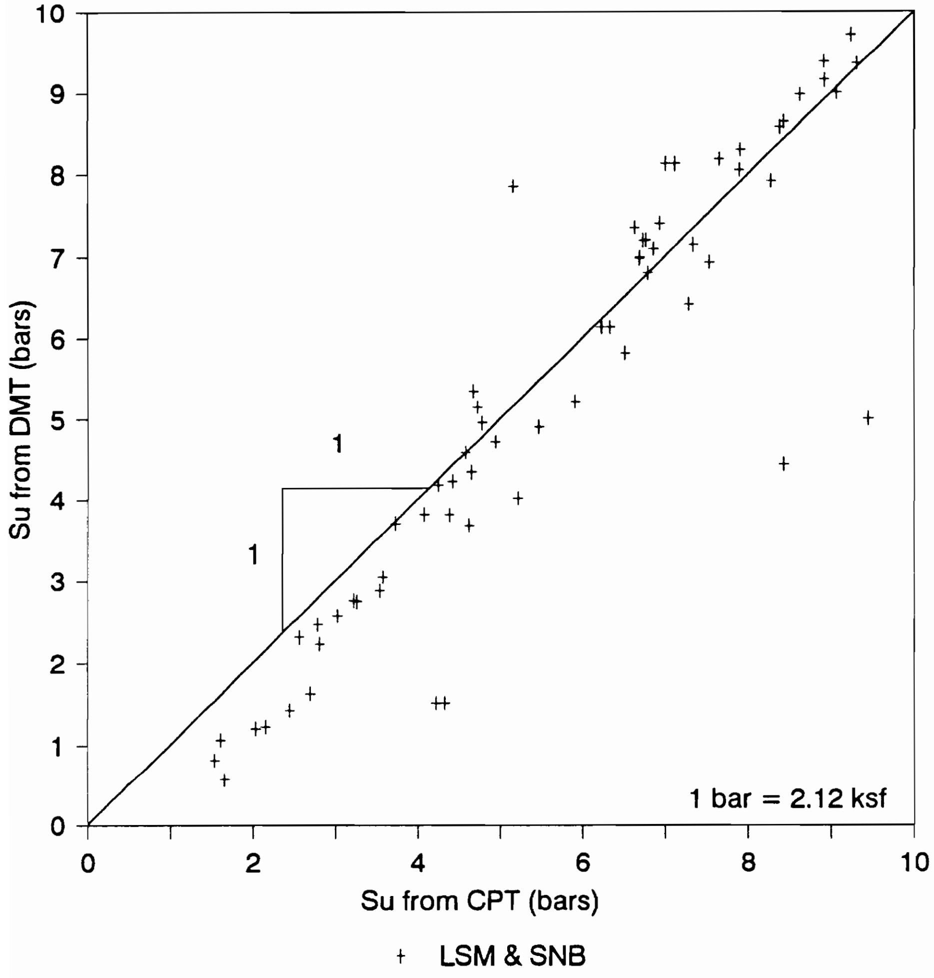


Figure 6.10 Su from CPTand DMT, Marine Clay Sites Only

6.6 Correlations Between Calculated Values of Angle of Internal Friction (ϕ) at the Carmel Church Site

As noted in Chapter II, the friction angle of a sandy soil can be determined from the results of the SPT, CPT, and DMT tests. In Chapter III it was pointed out that a special load cell was designed for the DMT so that friction angle could be determined. Calculated ϕ values are plotted versus depth for the three in-situ tests. The results show good agreement between the DMT and CPT friction angle information. However, the ϕ values calculated from SPT blow counts produced consistently lower friction angles and exhibited more scatter than those from the CPT or DMT (Figure 6.11). Correlation of the CPT or DMT ϕ angle values with those from the SPT produce almost no relationship. The r^2 value for either case is less than 0.1 (Table 6.5).

The CPT and DMT friction angles correlate well (Figure 6.12, Table 6.6), with values of $r^2 = 0.82$. It should also be noted that the ϕ values are consistently higher than those generated from the SPT data. Because the newer tests are known to generally yield improved soil parameters vis a vis the SPT, this finding suggests that current Virginia Power practice for estimating the angle of internal friction is conservative and can be adjusted upward.

6.7 Correlations to PMT Unload/ Reload Modulus, (G_{ur})

Due to the time and effort involved in pressuremeter testing and the need for pressuremeter modulus values for the CUFAD and MFAD programs, it was considered useful to correlate G_{ur} to parameters from a more rapid test. Herein, G_{ur} values were compared to parameters from the three other in-situ tests.

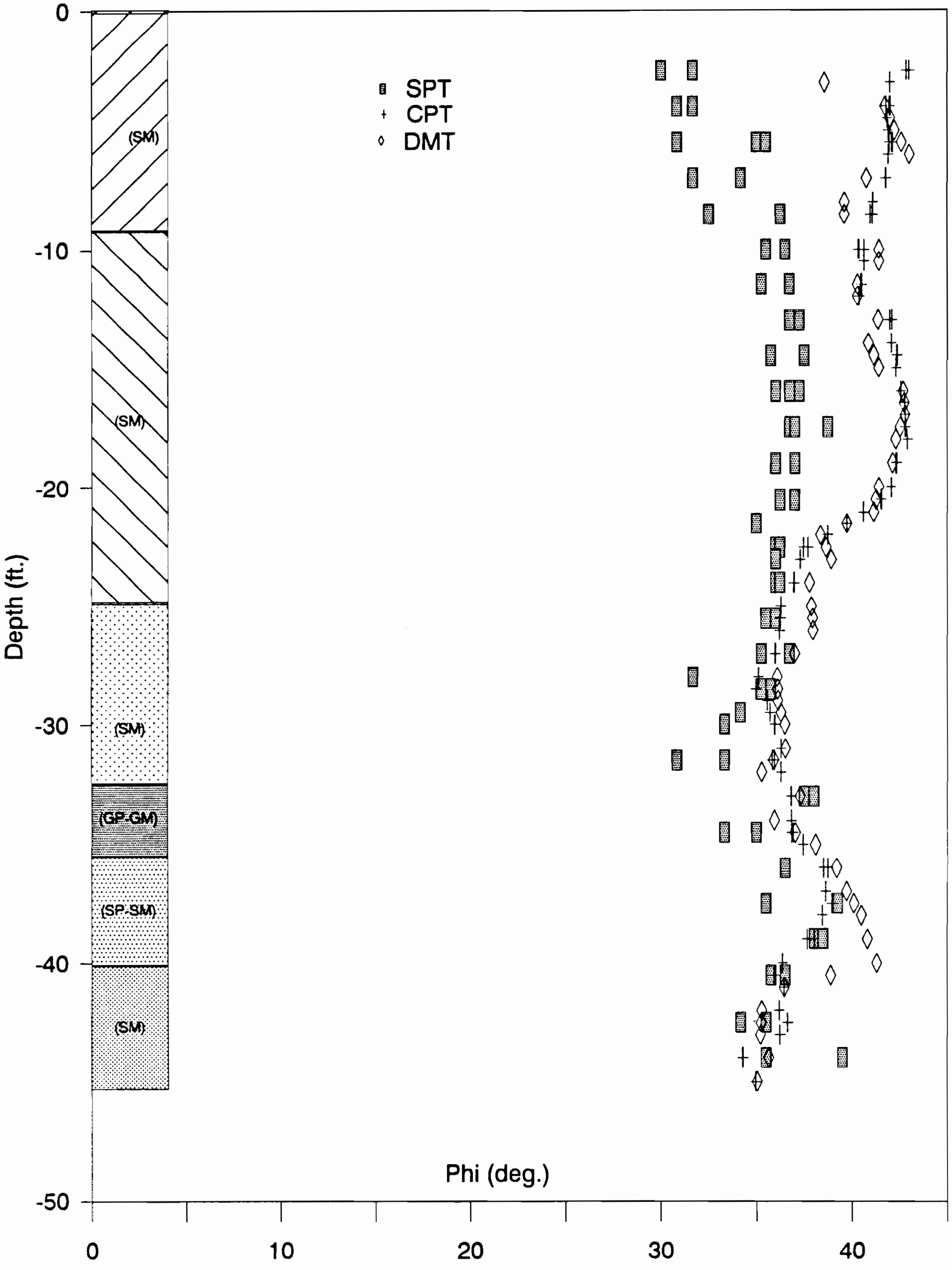


Figure 6.11 Carmel Church, Phi from In-situ Tests

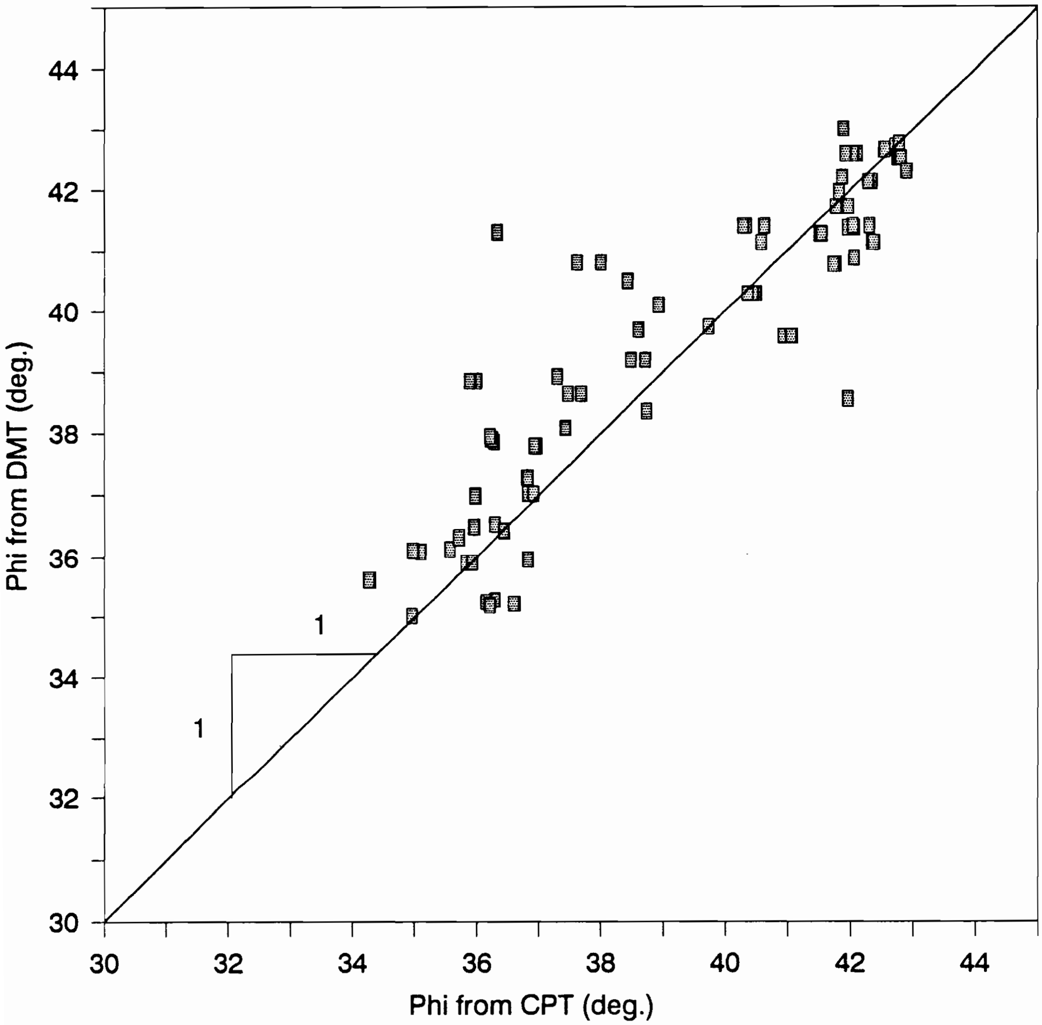


Figure 6.12 Carmel Church, Phi from DMT vs. CPT

Table 6.5

Carmel Church Site
Angle of Internal Friction From SPT, CPT, and DMT

X = ϕ degrees
Y = ϕ degrees

Correlation	r^2	Slope m	Intercept b
SPT (x) vs CPT (y)	0.004	-0.085	42.2
SPT (x) vs DMT (y)	0.086	0.361	26.4
CPT (x) vs DMT (y)	0.816	0.805	7.9

It should be noted that the G_{ur} values developed in the testing effort in this research are true shear moduli and not the often used pressuremeter modulus. Should it be desired, G_{ur} can be converted to a pressuremeter unload-reload elastic modulus through the following equation:

$$E_{ur} = 2*(1+\nu)*G_{ur} \qquad (2)$$

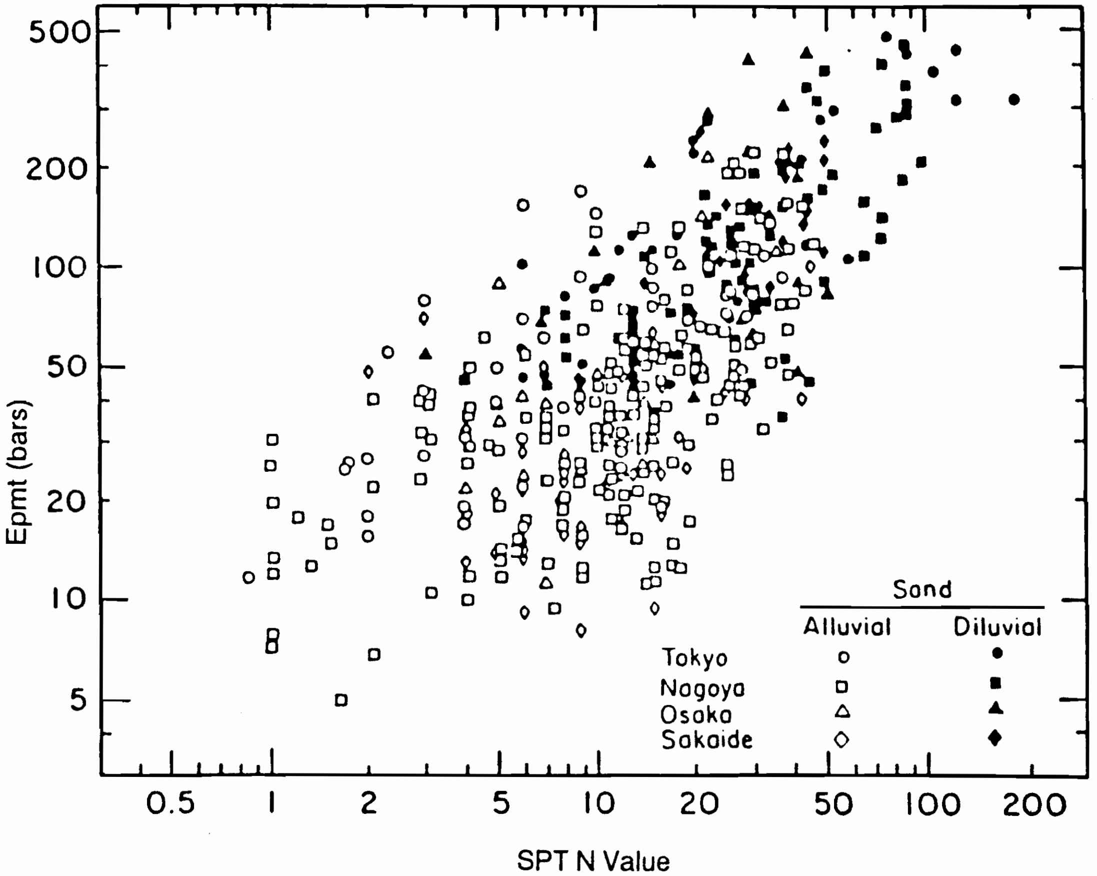
with,

ν = Poisson's Ratio

Values of Poisson's ratio are commonly assumed to be between 0.33 and 0.5. The upper value represents an incompressible material. Menard used ν = 0.33 in his work.

It should be noted that the elastic modulus developed using equation 2 is an unload-reload value and as such, does not compare directly to the customary "pressuremeter modulus". The pressuremeter modulus is normally determined from a portion of the primary loading curve and would be lower than that obtained from an unload-reload response. Kulhawy and Mayne (1990) presented comparisons of pressuremeter modulus to SPT blow count developed by Ohya, 1982, (Figure 6.13). The values of E_{ur} that were developed from the present research plot outside the limits of the existing correlations because they are higher than the conventional pressuremeter modulus. The stiffer modulus values correspond to the fact that using the unload-reload response reflects less influence of disturbance caused by probe insertion than the primary load response.

At the Kipp's Farm site, self-boring and pre-bored pressuremeter tests have been completed (Pappas 1991 and Mayu 1987). In theory the self boring tests are of higher quality than the pre-bored tests since less soil disturbance should occur during probe insertion. The probe is advanced by slowly boring a



(After Ohya, 1982)

Figure 6.13 Pressuremeter Modulus (Epmt) versus Blow Count (N) hole the same diameter as the pressuremeter. The instrument is advanced as the hole progresses preventing the soil from moving toward the opening. Theoretically, the soil stress conditions remain at the in-situ or undisturbed values. However, probe advance is sufficiently slow as to be impractical for production uses.

Testing under the present research was accomplished using test holes opened by driving a 3 inch split spoon sampler with a 300 pound hammer. While this obviously induces disturbance in the soil to be tested, the performance of the test in such a manner as to obtain the unload-reload response is expected to counter some of the impact of the disturbance.

G_{ur} values from pressuremeter tests using the three insertion methods at the Kipp's Farm site methods are plotted in Figure 6.14. At Kipp's Farm the G_{ur} values developed in the split spoon holes fall in the lower range of the G_{ur} data from the other two insertion methods, but are still within the limits of the data. This response is considered encouraging and it supports the idea that determination of an unload-reload modulus appears to negate some of the effects of hole disturbance during probe insertion.

Also shown in Figure 6.14 is a comparison of previously completed self-bored tests at the Schnabel site (Mayu 1987) with the pre-bored tests from this investigation. Consideration of these data indicate that in the sensitive soils at the Schnabel site hole disturbance has a larger effect on the G_{ur} values. The G_{ur} data from the holes opened with the split spoon mirror the data from the self-boring tests, but at somewhat lower values. The reduction in modulus value would indicate a greater effect from hole disturbance in the sensitive marine clay than was found in the Kipp's Farm residual soils.

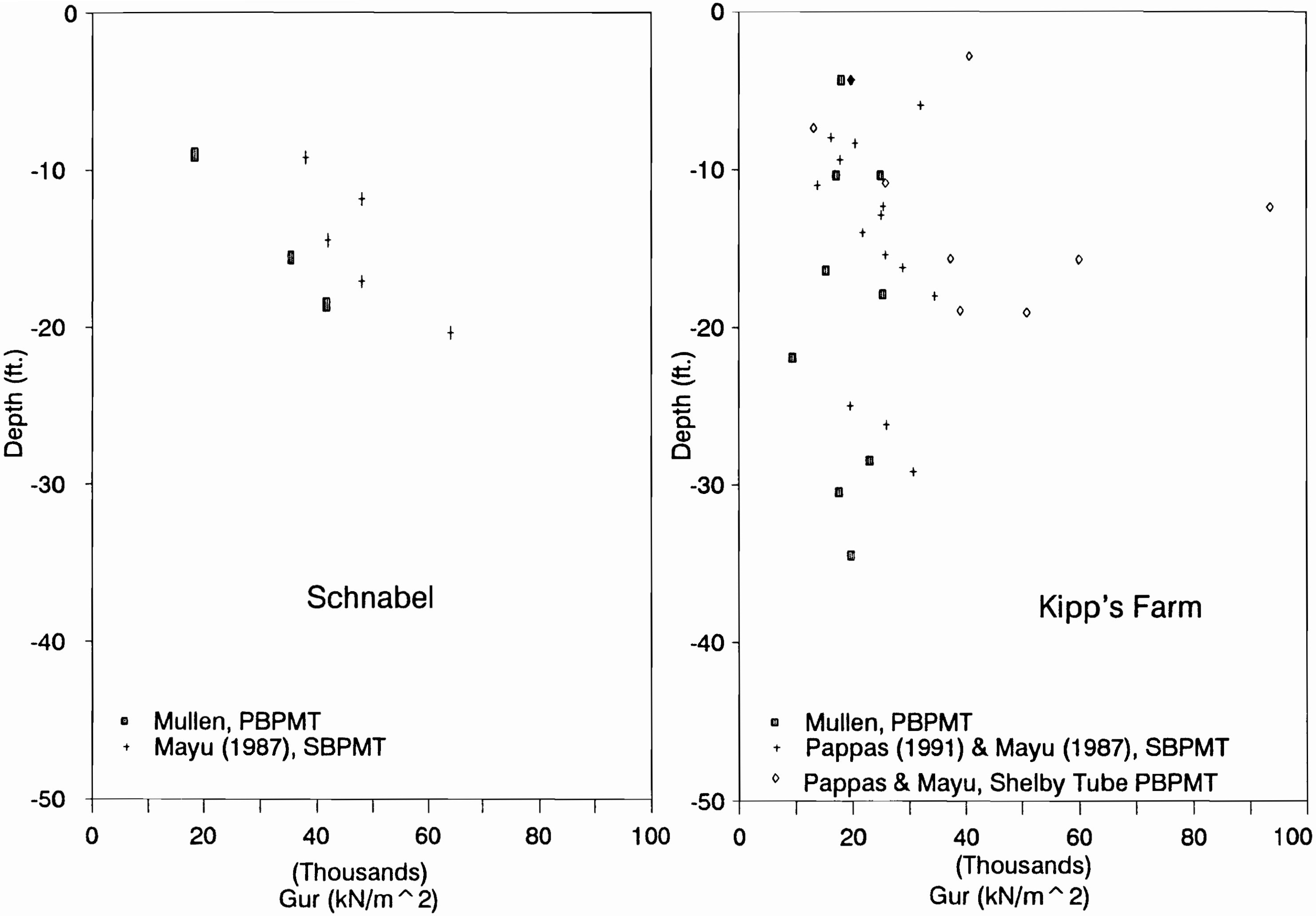


Figure 6.14 SBPMT Compared to PBPMT

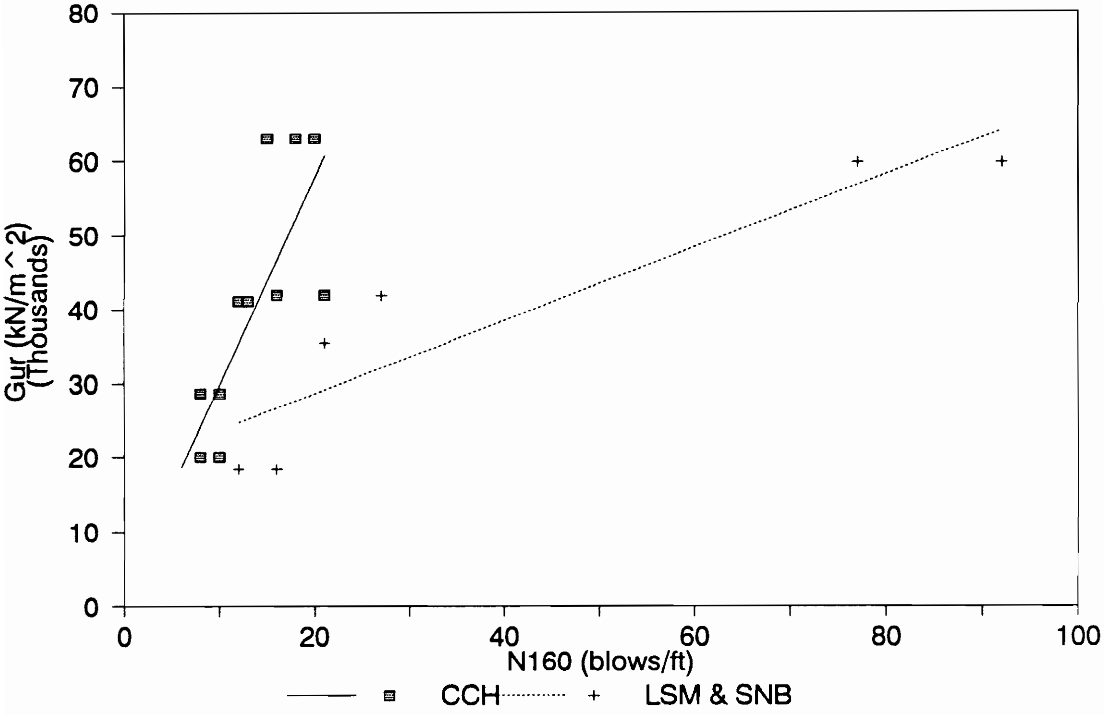
All correlations for the pressuremeter in the present research were developed using G_{ur} directly. No attempt was made to convert to a pressuremeter modulus since this introduces an unknown element into the calculations.

6.7.1 Correlation of PMT Unload-Reload Modulus (G_{ur}) to the SPT Blow Count ($N_{1,60}$)

Pressuremeter unload-reload values are plotted against $N_{1,60}$ values for the different soil groupings in Figure 6.15. The blow counts showed surprisingly good correlation with the G_{ur} values at the Carmel Church, Ladysmith, and Schnabel sites. An increase in blow count was mirrored with a related increase in G_{ur}, although the slope of the correlation is much steeper for the sands at Carmel Church than for the marine clays at Schnabel and Ladysmith. The same general pattern of increase of pressuremeter modulus E_{pmt} with increased $N_{1,60}$ is shown in the correlations presented by Ohya.

The Plantation Pipeline and Winterpock sites gave a poor correlation between G_{ur} and $N_{1,60}$ and there no useful correlation appeared at the Kipp's Farm site. The Plantation Pipeline and Winterpock Tap data reveal some trends for an increase in G_{ur} with increased $N_{1,60}$, but with less increase in G_{ur} for a given increase in $N_{1,60}$ than for the marine clay soils.

Overall, as the variability of SPT data within a site increased, the agreement with the PMT unload-reload modulus degraded. The best relationship was found in the most homogeneous soil profiles such as Carmel Church, Schnabel, and Ladysmith (Table 6.6). It appears that correlations between G_{ur} and the SPT blow count can be developed on a site specific basis, but that a global correlation is not feasible.



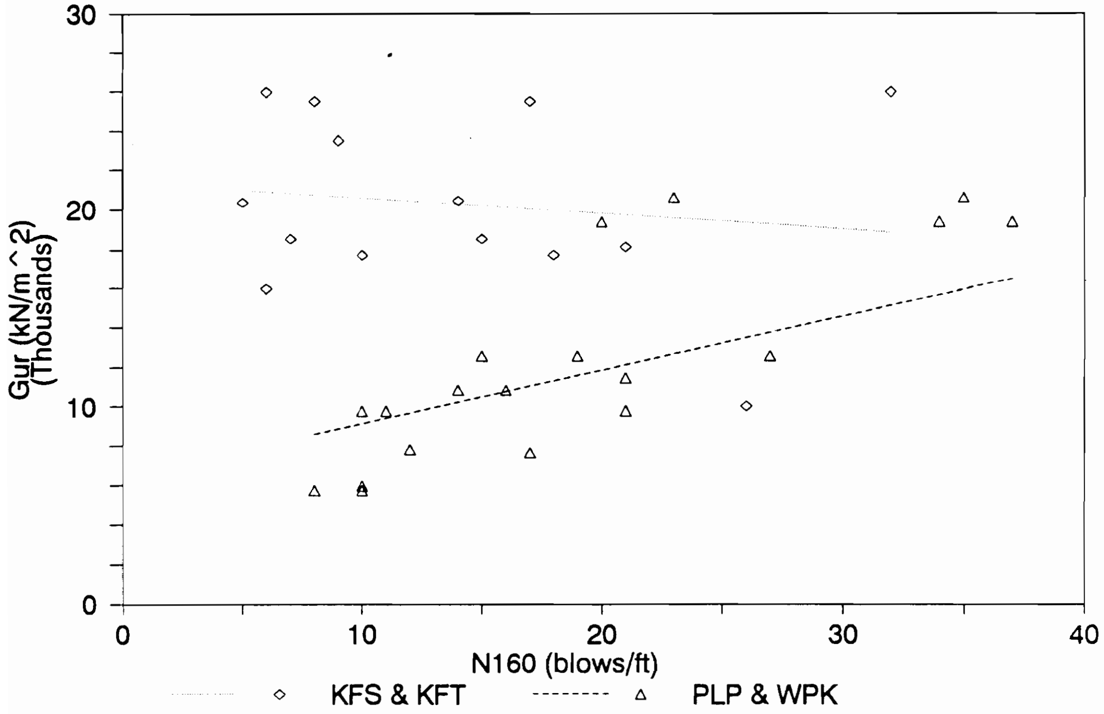


Figure 6.15 Gur versus N160, Individual Sites

Table 6.6

Correlation of G_{ur} to SPT

$X = N_{1,60}$ blows/ft
$Y = G_{ur}$ kN/m^2

Site Location	r^2	Slope m	Intercept b
CCH	0.641	2798.7	1,914
LSM & SNB	0.842	494.1	18,775
KSF & KFT	0.020	-78.6	21,383
PLP & WPK	0.279	270.9	6,453
ALL SITES	0.145	388.4	16,523
ALL SITES EXCEPT KIPP'S FARM	0.150	410.2	16,641

6.7.2 Correlation PMT Unload-Reload Modulus (G_{ur}) to the Dilatometer Modulus (ED)

One of the advantages of the pressuremeter is that it tests a larger volume of soil than any of the other three in-situ tests. In an attempt to mirror this behavior with the DMT, values of dilatometer modulus (ED) were averaged from those taken at the centerline of the pressuremeter membrane and one foot above and below the centerline. Using this procedure, very good correlations between ED and G_{ur} were developed in three of the four soil types tested (Figure 6.16). The alluvial soil, marine clay, and Plantation Pipeline and Winterpock Tap residual soil sites all yielded useful correlations. Data for the Kipp's Farm site residual soils failed to produce any useful agreement between the tests due to the scatter in the test results.

The data show that an increase in ED was mirrored by an increase in the G_{ur} value. The marine clay and Carmel Church sites show similar relationship between ED and G_{ur}. The regression lines have nearly the same slope and position. The weathered mica schist materials also exhibited a positive slope to the correlation, but the modulus values were lower than for the alluvial or marine soils. All three of the useful correlations had a coefficient of determination (r^2) greater than 0.6, with the values at the alluvial soil and marine clay sites above 0.8. The correlations are all fairly strong, and in consistent units G_{ur} mirrors the absolute value of ED. It appears that values of G_{ur} increase with an increase in the dilatometer modulus and could be developed directly from ED with a reasonable degree of confidence (Figure 6.17 and Table 6.7).

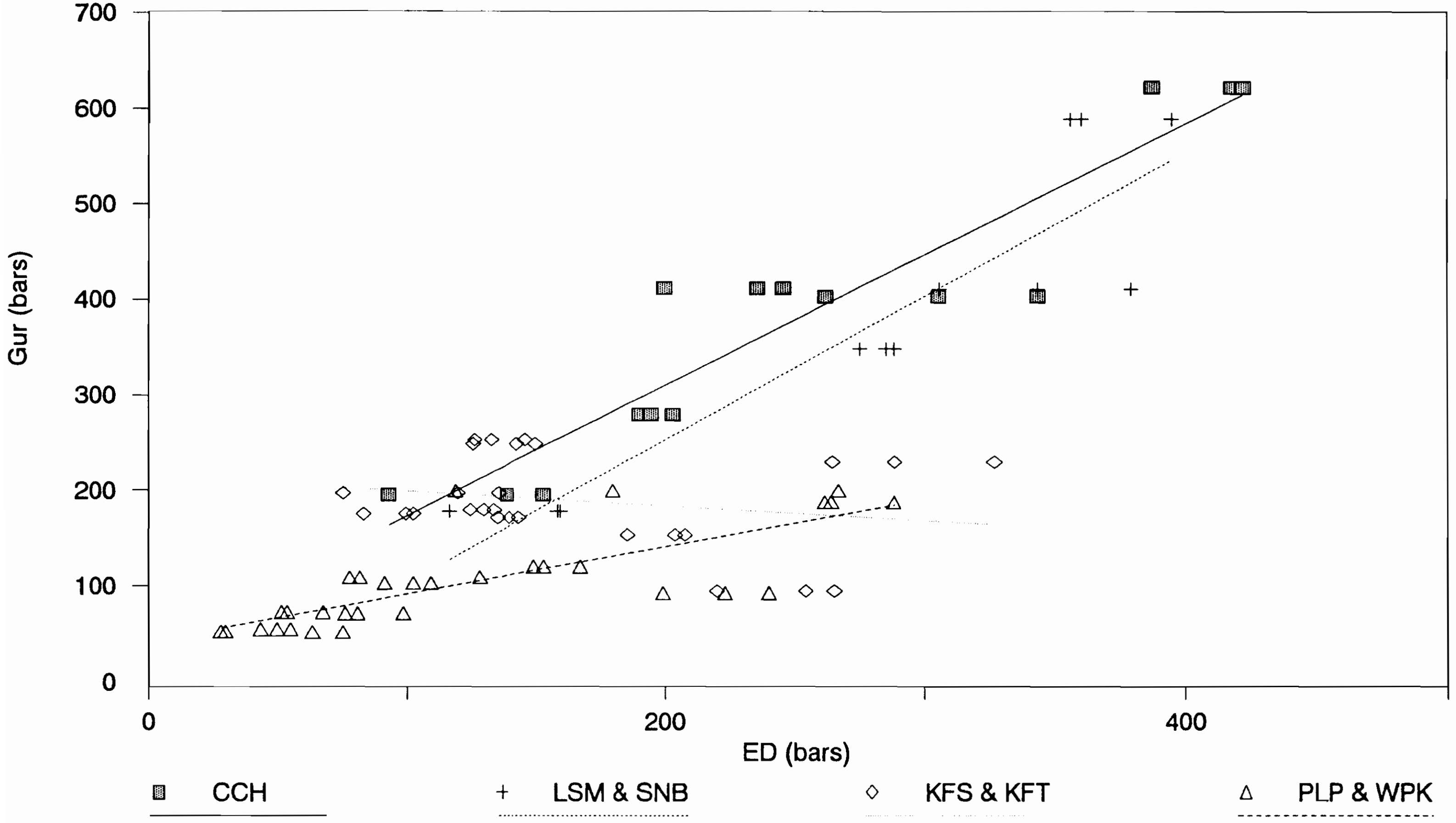


Figure 6.16 Gur versus ED, Individual Sites

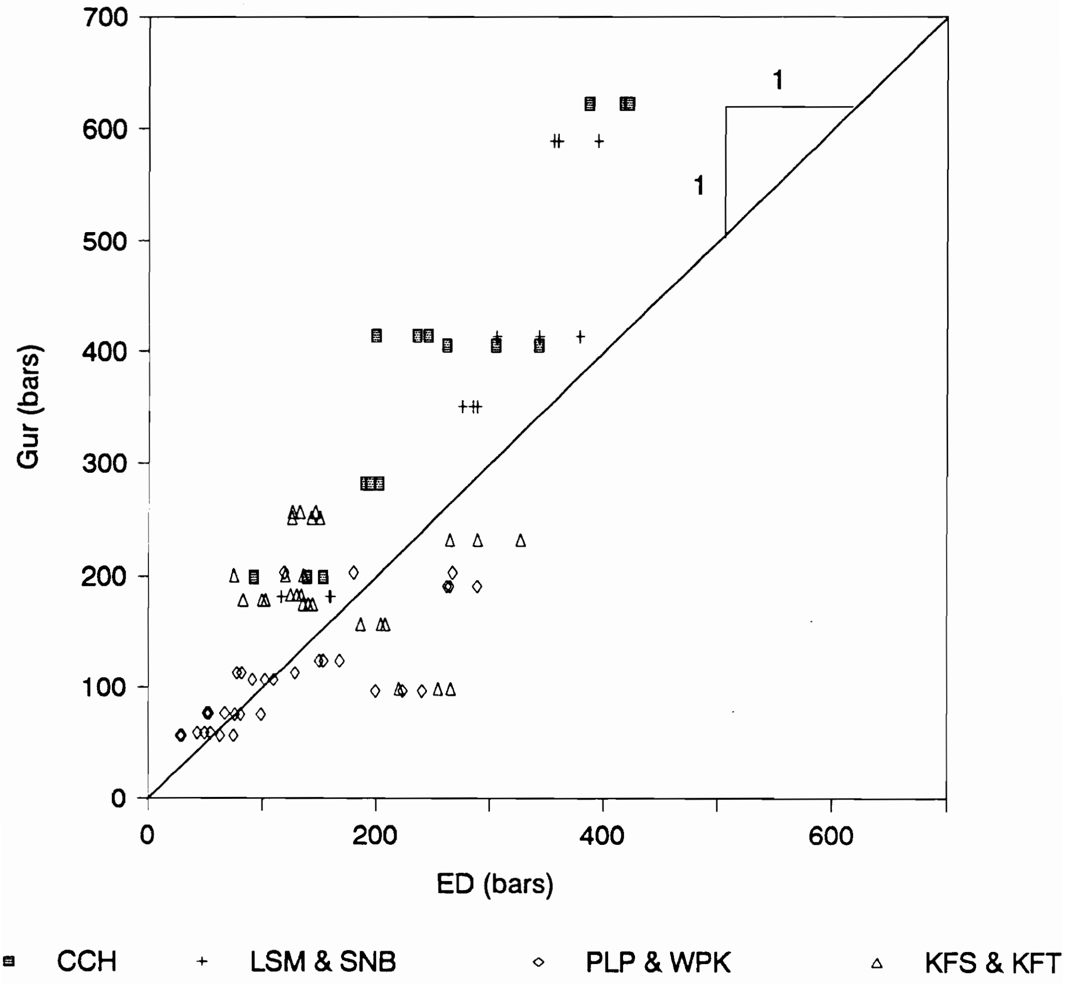


Figure 6.17 Absolute Value Comparison of Gur and ED

Table 6.7

Correlation of G_{ur} to Dilatometer Modulus ED

X = ED bars
Y = G_{ur} bars

Site Location	r^2	Slope m	Intercept b
CCH	0.878	1.36	41.0
LSM & SNB	0.836	1.50	-43.3
KSF & KFT	0.046	-0.16	218.5
PLP & WPK	0.608	0.49	46.8
ALL SITES	0.651	1.17	8.0
ALL SITES EXCEPT KIPP'S FARM	0.794	1.36	-22.9

The slopes of the various site correlation lines also were reasonably close, indicating a common relationship not strongly dependent on soil type (Table 6.8). This shows promise in determining G_{ur} from normalized average cone tip resistance (Figure 6.19).

6.7.3 Correlation PMT Unload-Reload Modulus (G_{ur}) to the CPT Tip Resistance

On initial inspection of the data, there was little expectation of finding a correlation between the cone tip resistance and G_{ur}. The cone is a penetration test loads only a small volume of soil in comparison to the pressuremeter. Further, test results are in terms of penetration resistance as opposed to stiffness. As expected, initial attempts at producing a relationship between Q_c and G_{ur} showed little promise. However, two changes improved the correlation greatly. First, a normalized or $Q_{c,1}$ value was used. Then in an attempt to mirror the large area tested by the PMT, a two foot average of the normalized cone tip resistance was calculated. The average was centered at the pressuremeter membrane centerline. The results showed that G_{ur} increases directly with $Q_{c,1}$. Plots of all the sites are given in Figure 6.18. Excellent agreement was found between $Q_{c,1}$ (2' avg) and G_{ur} at the marine clay sites and at Carmel Church. The relationship was evident but weaker at Plantation Pipeline and Winterpock Tap, but not obvious at Kipp's Farm. The overall correlation for all sites was good with r^2 of 0.726, and could be improved to a value of 0.828 with the exclusion of the Kipp's Farm results.

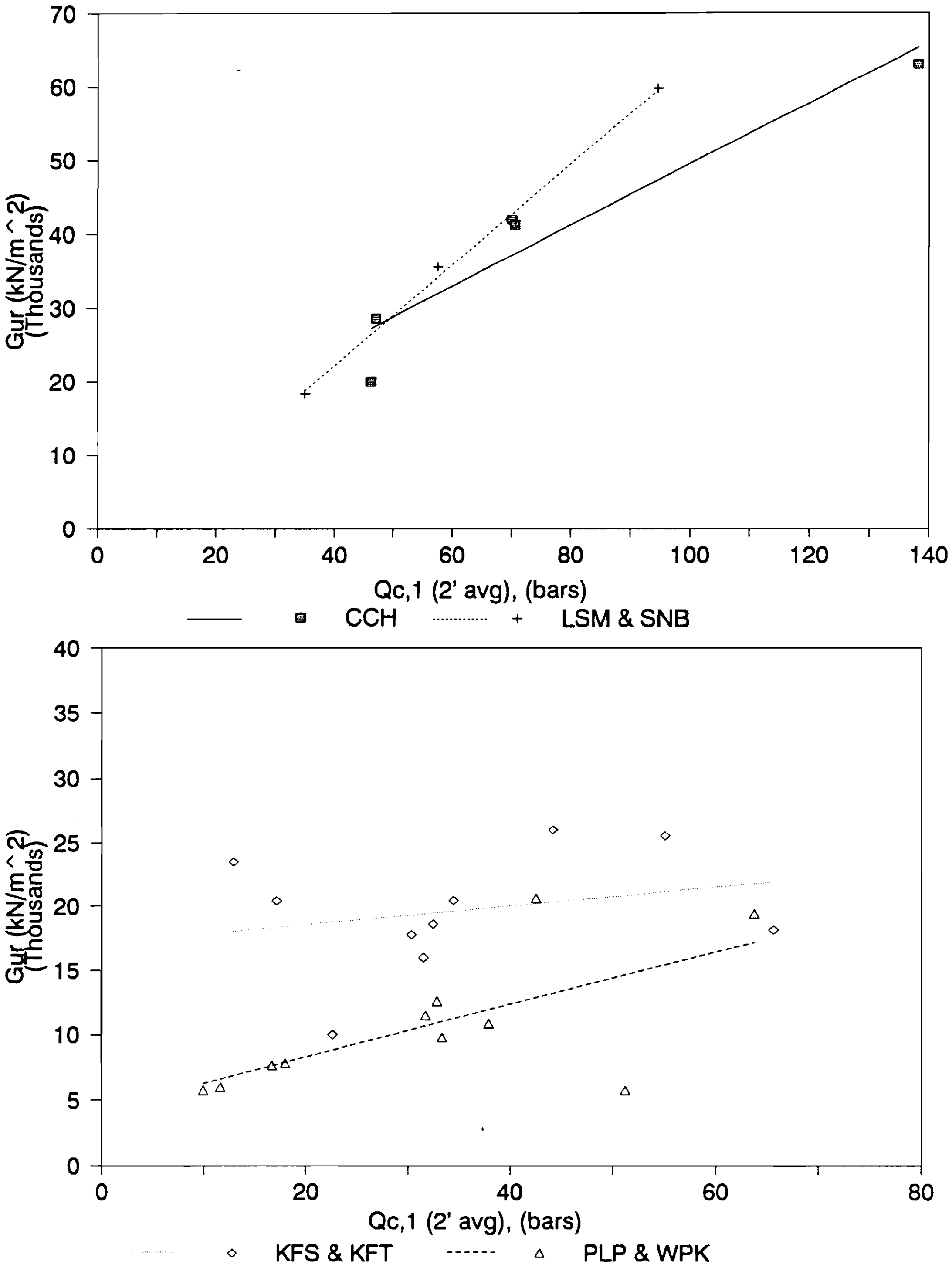


Figure 6.18 Gur versus Qc,1 (2' avg), Individual Sites

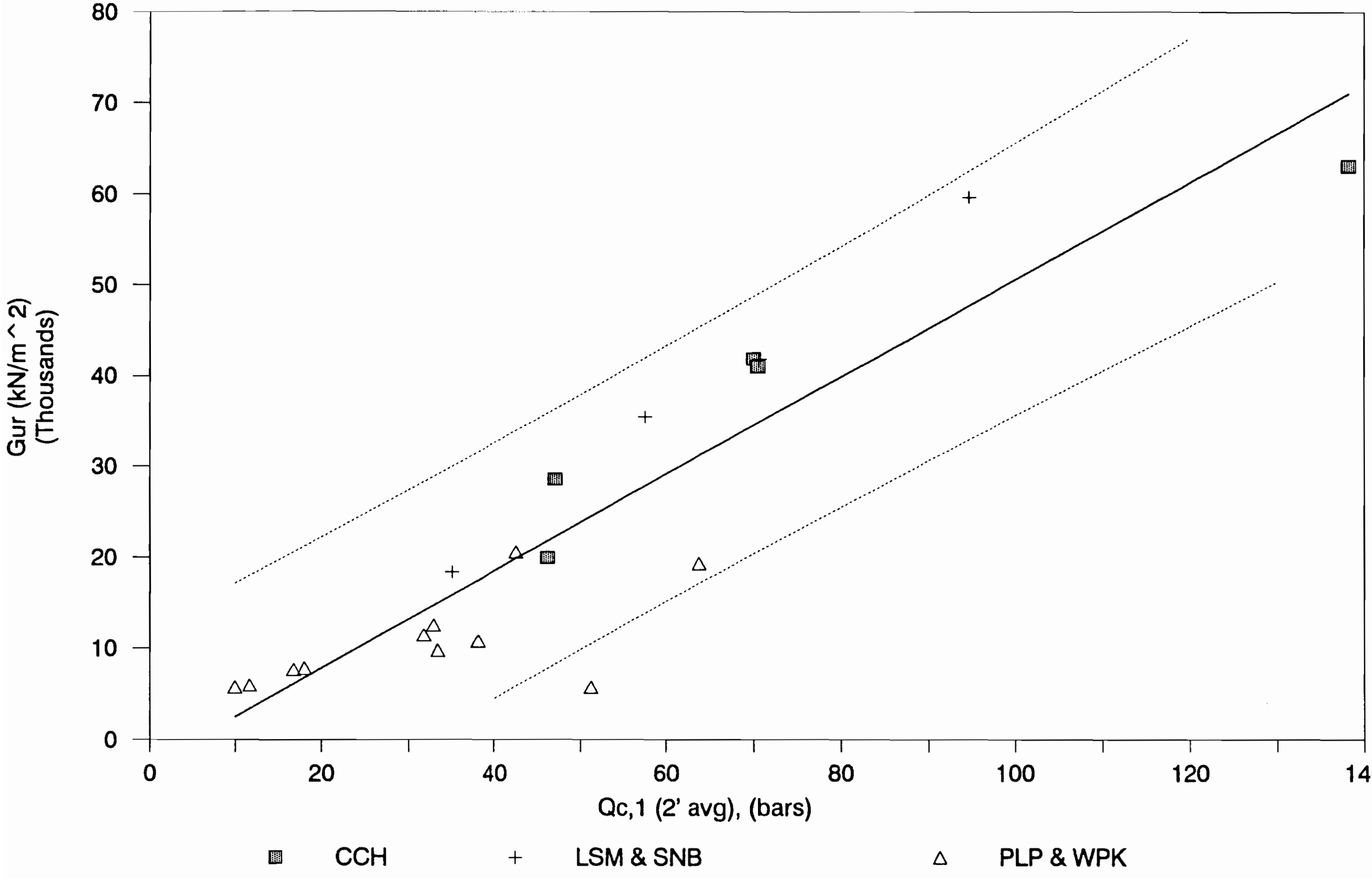


Figure 6.19 Gur versus Qc,1 (2' avg), All Sites Except Kipp's Farm

Table 6.8

Correlation of G_{ur} to CPT

$X = Q_n$ (2' avg) bars

$Y = G_{ur}$ kN/m^2

Site Location	r^2	Slope m	Intercept b
CCH	0.910	413.3	8,211
LSM & SNB	0.996	682.3	-5,108
KSF & KFT	0.062	72.3	17,126
PLP & WPK	0.426	201.7	4,278
ALL SITES	0.7265	465.3	1,573
ALL SITES EXCEPT KIPP'S FARM	0.829	534.5	-2,785

6.8 Soils Identification from In-Situ Testing

Soils identification from the CPT and DMT were compared with actual soil classifications developed from the SPT samples. General agreement of the identifications was good, with both the CPT and DMT tending to err in the same direction. The tests usually identified the soils as one grade either finer or coarser than the actual conditions (Table 6.9).

The Plantation Pipeline, Winterpock Tap, and Pepper's Ferry soils all had significant amounts of mica present. At these sites the CPT and DMT tended to identify the soils as one grade finer than actual conditions. Silts were identified as clays, or sandy silts as silts. As noted in Chapter V, the field boring logs also represented soils as more plastic than the actual case. The mica imparted a slick or clayey feel to the samples that caused the samples to be identified as clayier than they actually were. Apparently the in-situ tests results were similarly skewed by the presence of mica.

At the remainder of the sites, soil identifications were generally one step coarser than actual conditions. Silts were identified as sandy silts or sands as coarse sands. This pattern broke down only at the extremely variable Kipp's Farm site. Soils in the hillside test area again classified as coarser than lab identifications. However, the hilltop area gave inconclusive results. At the Kipp's Farm Hilltop area, the CPT and DMT classified the soils as either coarser or finer than lab data.

In identifying the various soils encountered, there is a trade off between time expended and accuracy of the identification. With lab testing performed to support identifying soils under ASTM D 2487-85 it is possible to break soils down into more than 50 soil types. However, the lab work is time consuming. For soil classification from CPT data, the chart presented by Robertson and Campanella

(1983) provides 14 possible soil classifications and DMT procedure presently has only 7 soil types included. In increasing the speed of data acquisition the CPT and DMT sacrifice some definition. However, the soil identifications still seem more than adequate for transmission line foundation design.

Another consideration is the accuracy of the supporting data developed from the tests. Although identifications from lab testing of the SPT soil samples can be very accurate, the soil strength data is subject to considerable scatter. The cone and dilatometer give adequate estimates of soil type, but with less scatter to the calculated soil strength parameters.

6.9 Testing Effort

The testing program was conducted by one crew using one drill rig. During the testing records were maintained on the time and effort required to complete each test. This information has been reduced to a "time per foot of soils information" value for each of the tests (Table 6.10). Although the time for each test may not reflect actual durations for a professional crew, the relative values of test duration should be useful. Also, the crew was intimately familiar with the operation and maintenance of all the test equipment which helped keep lost time to a minimum.

Present transmission line soils investigation practice uses the SPT as the standard test. The duration for SPT testing was taken as the baseline or 100% value for comparison to the other tests. The CPT only required approximately 8% as long as the SPT to develop one foot of soil profile. The DMT required 19% of the SPT time, while the PMT took about 400% as long as standard soil borings. It should be noted that the PMT used in this investigation was a research grade tool and was not designed for production testing. However, the nature of PMT testing

Table 6.9

Soils Identification from In-Situ Tests

	compared to the SPT, soils ID from the	
Site	CPT is	DMT is
Pepper' Ferry	finer	finer
Carmel Church	coarser	exact
Schnabel	coarser	coarser
Ladysmith	coarser	coarser
KF: Hilltop	variable	variable
KF: Hillside	coarser	coarser
Plantation Pipeline	finer	finer
Winterpock Tap	finer	finer

Table 6.10

Summary of Testing Effort

Test	Total testing	Total time	Unit Effort	Percent of SPT
SPT	409.5 ft	95.5 hr	14.0 min/ft	100.0%
CPT	1,116.8 ft	20.8 hr	1.1 min/ft	7.8%
DMT	849.2 ft	38.1 hr	2.7 min/ft	19.3%
PMT	30 tests	57.0 hr	1.9 hr/test (2 ft per test)	407.0%

is still more time consuming than the other test methods. Either the CPT or DMT offer a significant improvement over present testing practice provided soil conditions are suitable.

6.10 Summary

Several correlations were found among both the various in-situ tests and the strength or modulus values developed from the tests. Generally, the SPT produced the poorest relationships due to the variable nature of the test itself. Correlation improved with use of the CPT and DMT.

The accuracy of the correlations also varied depending on the soil types. Agreement among the tests was best at the sites with homogeneous soil conditions. The Ladysmith and Schnabel sites with uniform marine clays gave the most consistent soil parameters. The Carmel Church test area alluvial sands were also reasonable uniform and produced consistent data.

Testing at the residual soil sites led to more erratic results than for the coastal plain materials. The Plantation Pipeline and Winterpock Tap sites with fully developed soil profiles gave better results than those at Kipp's Farm. Correlations of parameters at these sites were of variable value.

Variability of soils conditions did not appear to limit the ability of the in-situ tests to identify soil types. Within the variations discussed above, each test produced good agreement within a site as to the soil classifications. Both the CPT and DMT appear capable of developing accurate soil profile information more rapidly than the SPT.

CHAPTER VII

Conclusions

7.1 Introduction

Conclusions drawn from the testing program and suggestions for incorporating the results into design practice are discussed in this chapter. Also covered are possible causes of scatter in the results and suggestions for further work.

7.2 Discussion of Consistency in Results of SPT, CPT, and DMT

Of the three penetration tests considered, the best correlations were found for the cone penetrometer and the dilatometer , and those correlations were the most consistent at the marine clay sites. This result makes sense on two levels. First, the CPT and DMT are less susceptible to operator error than the SPT. Variations in rope tension, cat head speed, operator performance, and hammer alignment can all affect SPT test results, while the CPT is not affected greatly by the insertion rate provided advance is within ASTM specifications. The DMT also is relatively unaffected by the details of insertion, however, some operator experience is required for consistency in conducting the test cycle.

The SPT, CPT, and DMT all test approximately the same volume of soil. The SPT has a diameter of 2 inches, the diameter of the CPT is approximately 1.8 inches, and the DMT membrane is 2.4 inches in diameter. Therefore, it seems reasonable that the test with the least variability in test performance would return the most consistent results.

The strength correlations were also directly related to the uniformity of the soil. Thus, the best results were obtained for the homogeneous marine clay sites. The level of correlation decreased somewhat in the alluvial soils at the Pepper's Ferry and Carmel Church sites. More scatter appeared in the data for the weathered residual schist soils at Plantation Pipeline and Winterpock Tap. Finally, the extremely variable residual soils profile at the Kipp's Farm test areas produced little in the way of consistent correlations. The degree of scatter of the data from the residual soil sites made it difficult to obtain correlations between results of any of the tests, particularly with blow counts of the SPT.

7.3 Conclusions

The results of the testing program can be cast in terms of five areas of concern:

1. Comparison of the penetration/ stiffness data from the four tests.
2. Comparison of values of undrained shear strength and angle of internal friction developed from each of the test methods.
3. Determination if pressuremeter data can be correlated to and thereby developed from one of the more rapid tests.
4. Comparison of indirect soil type identifications from the cone and dilatometer with laboratory identifications from the standard borings.
5. Development of information on the relative effort required for each test.

7.3.1 Penetration Resistance/ Stiffness

Penetration resistance is obtained in the SPT and CPT test, through the measured blow counts and cone tip resistances respectively. Penetration resistance is at least indirectly thought to be related to soil stiffness. Direct measurement of soil stiffness is obtained from the dilatometer modulus and the PMT shear modulus respectively. There is an interest in determining if there are relationships to be obtained between penetration resistance and soil stiffness. This was done on two levels: (1) Trends with depth - do the devices indicate changes in soil conditions similarly?; (2) Absolute values - do the devices provide consistent results in magnitude of parameters?

At the alluvial soil and marine clay sites the trends of the penetration resistance/ stiffness profiles were extremely consistent. Particularly in the marine clays at Schnabel and Ladysmith CPT, DMT, and PMT profiles presented the same picture. An increase in the value by one test was mirrored by a similar increase in the other test results. The SPT results also correlated well, except for the zone at Ladysmith where testing difficulties were encountered causing erratic SPT data.

The same pattern of agreement continued in the alluvial sands at Carmel Church and the river floodplain clays at Pepper's Ferry. The test results presented a consistent profile of penetration resistance/ stiffness versus depth at Carmel Church. The CPT, DMT, and PMT results agreed well with slightly more scatter exhibited in the SPT data. Although no pressuremeter testing was conducted at Pepper's Ferry, the other three tests yielded consistent penetration resistance profiles.

The residual sites presented a less consistent picture than the other sites. Where the weathered soil profile was fully developed such as at Plantation pipeline, the four test methods returned relatively consistent profiles of the soil stiffness. As the soils became less weathered, the agreement among the tests decreased. The Winterpock Tap soils were sufficiently weathered that reasonable agreement among the test profiles with depth was found. Some scatter in the data was caused by inclusions of unweathered material.

At Kipp's Farm the test results did not correlate well. The soil profile was young and sufficiently unweathered that soil properties changed dramatically from location to location. For example, even with the same test method, tests conducted on a 10 foot spacing yielded different results. Scatter among the different test methods was consequently greater. Isolated inclusions of shale, limestone and sandstone in the soil profile created wide variations in the penetration resistance/ stiffness profiles.

When the data for all the test methods and sites were reviewed for correlation purposes, it was found that the useful correlations could be developed using straight line interpolation methods. In particular, an almost 1 to 1 relationship was found between the dilatometer modulus and the pressuremeter shear modulus when data was reduced to the same units (bars). A similar linear relationship was found between ED and $Q_{c,1}$, and $Q_{c,1}$ and G_{ur} regardless of soil type. The CPT, DMT, and SPT also yielded the same absolute values of S_u for the marine clay sites where saturated- undrained conditions applied.

The correlations developed fit reasonably well within the range of comparable published relationships. Comparison of the SPT and CPT with soil grain size (Q_c/N versus D_{50}) followed the general trend of published results, but with more data scatter attributable to the variable residual soil conditions included in this investigation. A similar pattern as found in the correlation of the dilatometer modulus and SPT blow count. Only the general trend of relationships for pressuremeter information can be compared as the G_{ur} values developed in this work are not directly comparable to the customary values of E_{pmt}. However, for both pressuremeter values there is a pattern of increase in G_{ur} of E_{pmt} with an increase in resistance in the other in-situ tests.

7.3.2 Undrained Shear Strength and Angle of Internal Friction

Strength values could be interpreted from the SPT, CPT, and DMT results. Only in the case of the marine clays at the Schnabel site were there laboratory data available to compare to the field tests. At the Schnabel and Ladysmith sites where saturated, undrained shear strength theory clearly applied, the shear strengths from the various tests correlated well. The CPT and DMT produced an almost one to one correlation for computed shear strength. The SPT also correlated well, except for a portion of the Ladysmith soil profile where testing difficulties produced artificially high blow counts. Estimating S_u from SPT data for soils where the saturated - undrained analysis is appropriate appears to work well.

At the residual soil sites, undrained shear strengths estimated from the field data did not correlate well. The data scatter at the Kipp's Farm residual farm site made it impossible to generate useful correlations among calculated shear strengths. It should be noted that residual soils commonly exhibit both cohesion and friction, so theories relating purely to undrained shear strength of clays are not fully applicable. Also, the soils at Kipp's Farm and Winterpock Tap were above the water table for much of the testing profile. This renders the assumption of saturated conditions invalid.

Plantation Pipeline site soils were the most homogeneous of the four residual soil sites, were saturated below a depth of 6.0 feet, and produced the most consistent correlations of undrained shear strength. In the mixed soil profiles of the residual soil sites a consistent pattern developed with the DMT yielding the lowest calculated S_u parameters, followed by the CPT, and with the SPT generating the highest S_u data. Although there was considerable scatter in the data, the relative pattern of test results remained consistent. This would suggest that present Virginia Power practice of developing undrained shear strength values from blow count data in mixed soils may be unconservative. The SPT produced higher shear strength estimates than the other two tests.

In the sandy soils of the Carmel Church site estimates were made of angle of internal friction. Results from the DMT, CPT, and SPT correlated reasonably well. The Carmel Church soils classified as sands with small portions of silt or clay material. These conditions made the assumption of drained conditions for calculating the angle of internal friction in sands valid. Particularly the values from the CPT and DMT were very close, and consistently higher than those calculated from the SPT. This suggests the possibility of using larger values of the angle of internal friction than those developed from the SPT for design purposes at Virginia Power.

7.3.3 Correlations to Pressuremeter Data

One of the most encouraging findings in this research was the excellent correlation between the pressuremeter unload-reload shear modulus (G_{ur}) and normalized cone tip resistance averaged over a 2 foot length. The average of the normalized cone tip resistance was used to mirror the length of the zone tested by the pressuremeter membrane. The correlation worked most consistently in the Schnabel and Ladysmith marine clays. Results were also consistent in the sands at Carmel Church and the silts and sandy silts at Plantation Pipeline and Winterpock Tap. Only at Kipp's Farm was the data extremely scattered, and even there the same apparent trend of agreement held. Thus, the most rapid test apparently provides a means of estimating G_{ur}.

Correlations between pressuremeter G_{ur} and the dilatometer modulus (ED) were nearly as strong as those for the cone tip resistance. Again, the agreement of the correlations held across the four general soil types and eight sites, with only the residual soils at Kipp's Farm producing considerable scatter. The slopes and magnitudes of the correlations were comparable, with the dilatometer modulus correlating on an almost 1 to 1 basis when identical units were employed. Results indicated good agreement between the dilatometer and the pressuremeter.

The standard penetration test produced useful correlations to the pressuremeter shear modulus only in the highly consistent marine clays and the Carmel Church alluvial sands. However, the slope of the correlation lines at these sites differed sufficiently to suggest the correlations were site specific. Otherwise there was sufficient scatter in the residual soil data that useful correlations could not be developed. Again, the Kipp's Farm site was extremely variable, with Plantation Pipeline and Winterpock Tap producing only somewhat better results.

7.3.4 Soil Identification

Results from both the CPT and DMT provided soil identifications that agreed well with those from lab test results. The in-situ soil classifications appear to be more than adequate for soil identification for design purposes. In micaceous soils the in-situ tests identified the soils as finer than they actually were. The mica imparted a slick or clayey feel to the soil that caused manual field identification as finer than reality. The in-situ test results appeared to follow the same trend in the identification of micaceous soil. However, in spite of this apparent problem, classification using CPT or DMT results is consistent and close enough for design of transmission line foundations.

7.3.5 Relative Effort Among the Four In-Situ Tests

Records of the time required for testing were kept during testing with the four in-situ tests in order to compare the efficiency of the different methods. This information was reduced to a "time per foot of soils data", with the SPT used as the 100% or reference value. This decision reflects current Virginia Power soil investigation practice, and provided a basis for comparison. If a test other than the SPT generated comparable or better information more rapidly a value judgement becomes possible between investigation expense and the level of soil data collected. Either the same expenditures can be made for more accurate soil information, leading to possible savings in foundation construction cost, or less can be spent to continue with the same level of soils data.

Developing a continuous soil profile with the CPT required less than 10% of the work required to produce the same information with the SPT. It is possible to develop shear strength information, friction angle values, and soil classifications from CPT results. Also, as discussed above it appears possible to correlate CPT results to the pressuremeter G_{ur}. The DMT took less than 20% of the effort of the SPT and also provides the same general information as the cone, including the same level of correlation to G_{ur}.

The pressuremeter used in this investigation required the most time to develop information of any of the probes, and it yielded only very specific data, primarily the value of G_{ur}. This device is obviously not intended for day-to day application, but is necessary to provide a data base that cannot be obtained otherwise. As experience is developed with more productive devices like the CPT or DMT where results can be correlated to pressuremeter results, then the use of the pressuremeter can be minimized.

7.4 Design Suggestions

The results of the testing indicate that using the CPT or DMT as a primary investigation method would allow gathering considerably more soils information for the same expenditure in testing effort than is now the case. Also, soil strength data developed from either test appears more consistent than the correlations to SPT blow count presently being employed. However, further laboratory data is required to ensure that all three test methods are well correlated to actual in-situ soil strength parameters. Tests could be performed more frequently providing soils information closer to each foundation site. Particularly with the CPT it would appear economical to conduct a sounding at each tower location. The high level of confidence in the soils data from such a testing program would allow for less conservative foundation designs with the consequent savings in construction costs.

The CPT or DMT should not completely replace the standard penetration test. At critical locations such as angle and dead end structures, a standard boring would be prudent to visually identify the soils. Also, cobbles, gravel, and extremely dense soils are not suitable for penetration testing. The combination of rotary drilling and driven sampling in a SPT boring can develop information where the CPT and DMT would be blocked. In addition, in extremely variable soil conditions loss of a split barrel sampler costs considerably less than the loss of a cone or dilatometer blade.

As discussed in section 7.3.5, the pressuremeter appears useful as a control method for special soil conditions, and for research to expand the correlations to the CPT and DMT.

7.5 Suggestions for Additional Investigation

Additional work is needed to verify the shear strength data and overconsolidation ratio information from the in-situ tests with laboratory soil strength and consolidation tests. This investigation developed sufficient information on soil index properties and grainsize information. However, the field shear strengths need verification with lab test results. Lab test data could also help further extend the in-situ information to the mixed soil conditions of residual soils. The present approaches worked best in the limit cases of pure sand or pure clay.

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APPENDIX A

PEPPER'S FERRY

PEPPER'S FERRY: FIELD BORING LOGS

BORING B-1
CONTINUOUS SAMPLING TO ROCK
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 5/30/89

WATER TABLE = 12.0 FT.

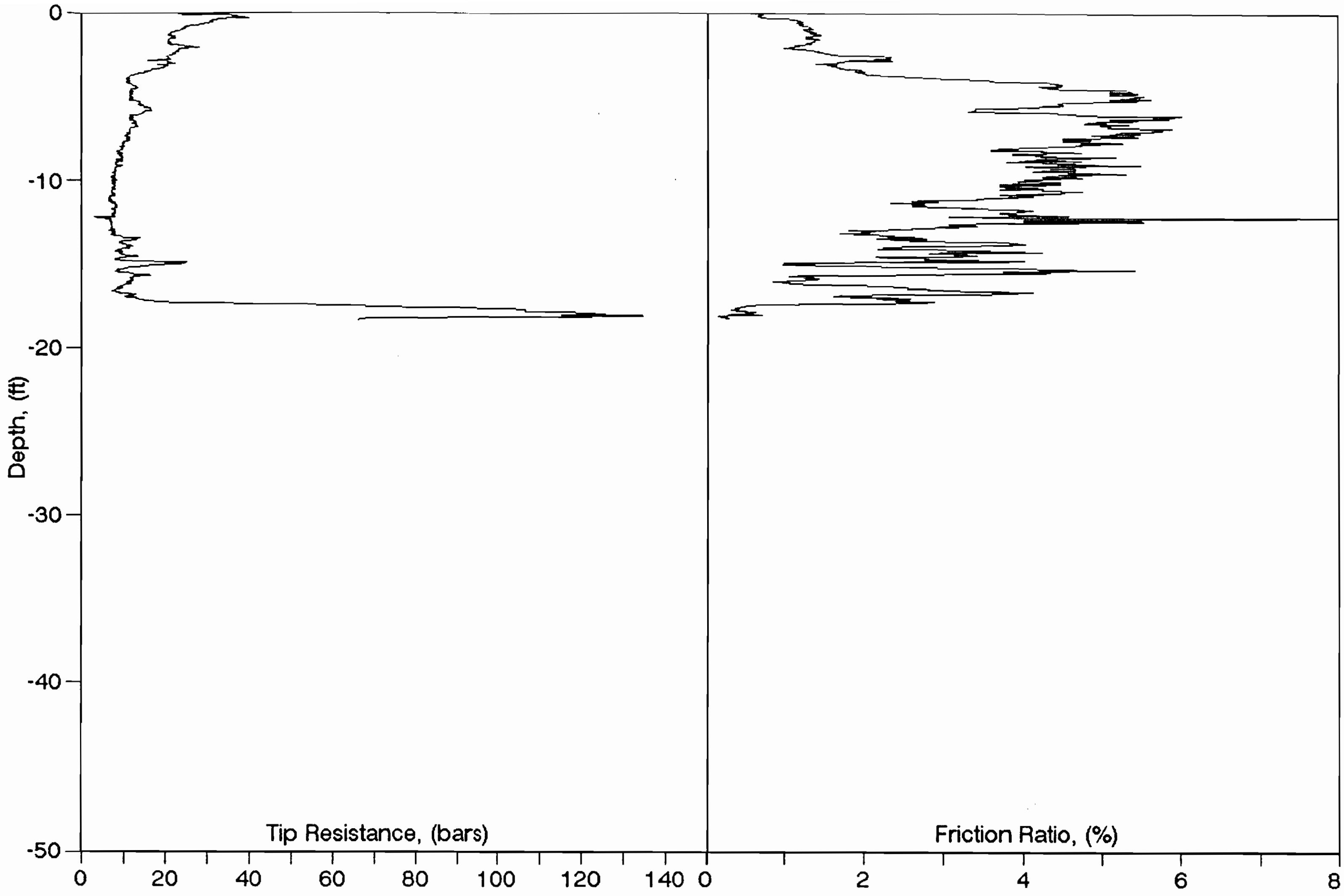
DEPTH IN FT. from	to	BLOW COUNT blows per 6 in.	DESCRIPTION
1.5 -	3.0	1 - 3 / 3	loose brown silty fine sand
3.0 -	4.5	2 - 2 / 4	loose dark brown silty fine sand
4.5 -	6.0	2 - 2 / 3	medium dark brown fine sandy silt w/ mica
6.0 -	7.5	2 - 2 / 3	same
7.5 -	9.0	1 - 2 / 3	same
9.0 -	10.5	1 - 2 / 2	same
10.5 -	12.0	1 - 1 / 2	same, soft
12.0 -	13.5	1 - 2 / 3	same, medium
14.0 -	16.0	* - * / *	---tube sample---
16.0 -	17.5	2 - 2 / 2	same
17.5 -	19.5	* - * / *	---tube sample---
19.5 -	21.0	12 - 10 / 8	medium white, gray gravel: GW
21.0 -	*	* - * / *	---END OF BORING ON ROCK---

PEPPER'S FERRY: FIELD BORING LOGS

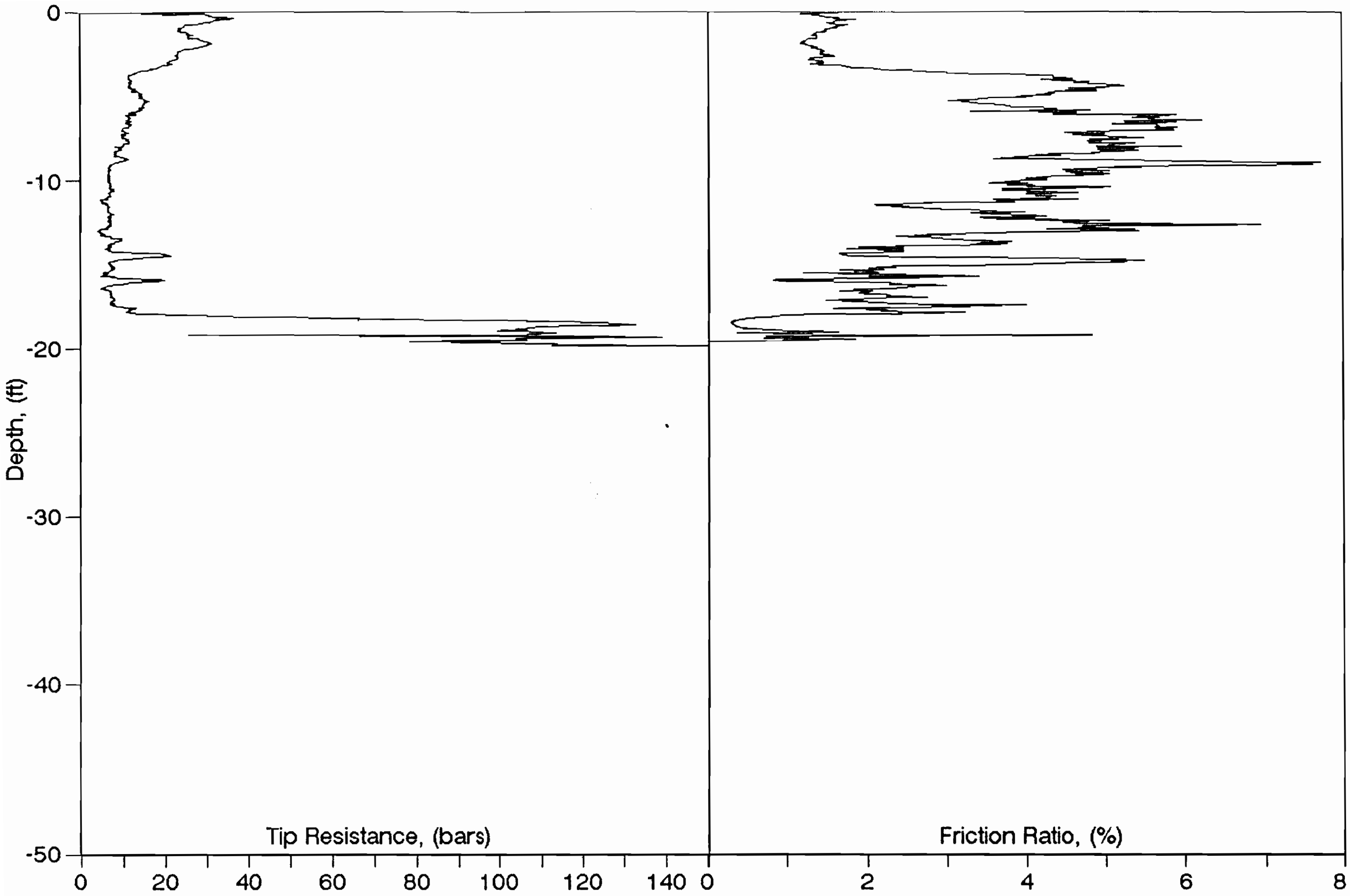
BORING B-2
CONTINUOUS SAMPLING TO ROCK
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 5/30/89

WATER TABLE = 12.0 FT.

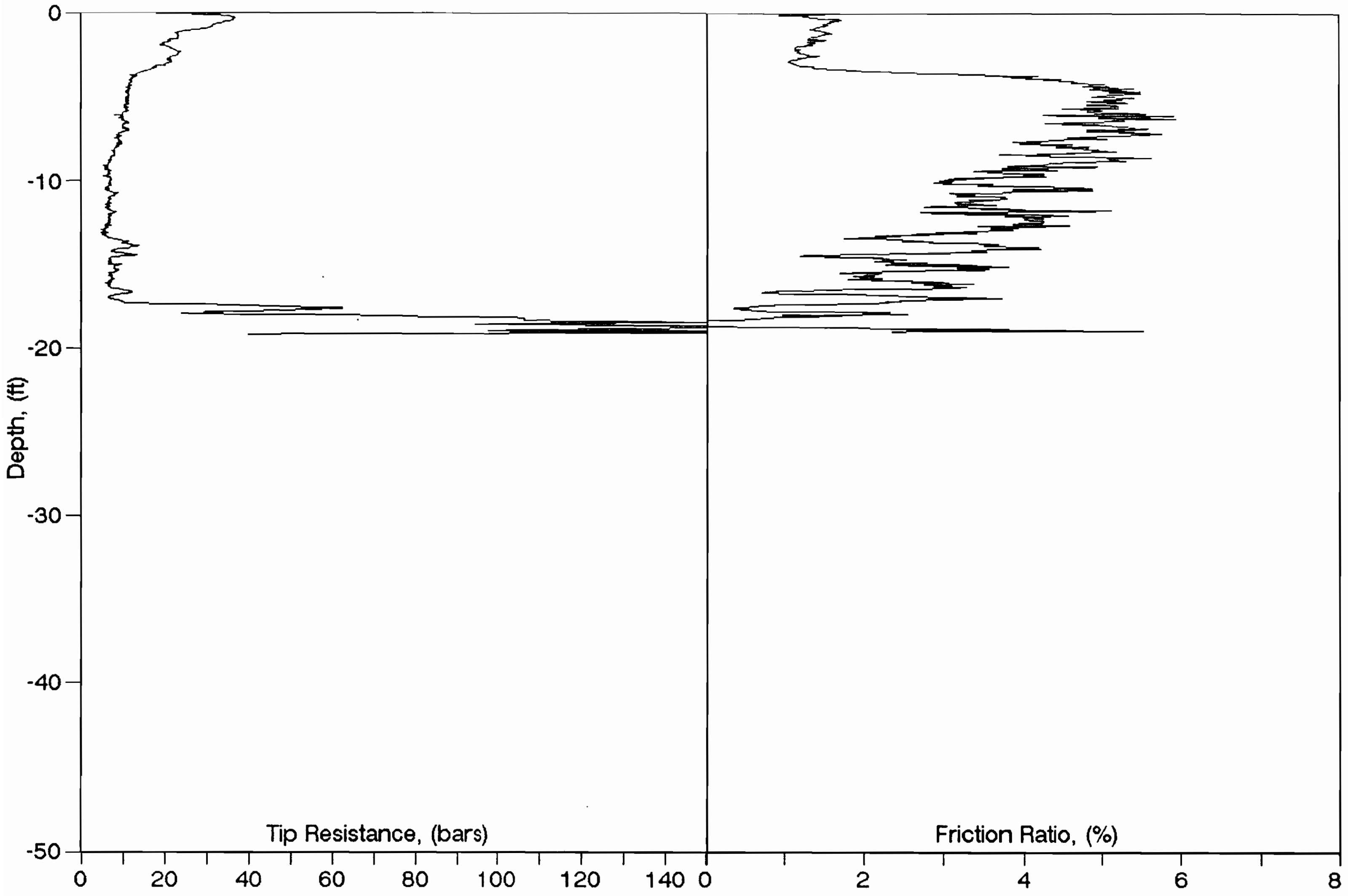
DEPTH IN FT. from	to	BLOW COUNT blows per 6 in.	DESCRIPTION
1.5 -	3.0	2 - 2 / 3	loose brown silty fine sand
3.0 -	4.5	2 - 2 / 3	loose dark brown silty fine sand
4.5 -	6.0	2 - 2 / 3	medium dark brown fine sandy silt w/ mica
6.0 -	7.5	1 - 2 / 3	same
7.5 -	9.0	1 - 2 / 3	same
9.0 -	10.5	1 - 1 / 2	same
10.5 -	12.0	1 - 1 / 1	same, soft
12.0 -	14.0	* - * / *	---tube sample---
14.0 -	16.0	* - * / *	---tube sample, no recovery---
16.0 -	18.0	* - * / *	---tube sample---
18.0 -	19.5	12 - 12 / 7	medium white, gray gravel: GW (loss of circulation)
			---END OF BORING---



Pepper's Ferry: Cone Test PFC-1 06/01/89



Pepper's Ferry: Cone Test PFC-2 06/01/89



Pepper's Ferry: Cone Test PFC-3 06/01/89

```
Virginia Polytechnic Institute                                              TEST NO. PEPFR D-1
FILE NAME:     Dilatometer Test
FILE NUMBER:   17:25:00

RECORD OF DILATOMETER TEST NO. PEPFR D-1
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

     LOCATION: PEPPER'S FERRY
     PERFORMED - DATE:  8/22/89
                  BY:  MULLEN

     CALIBRATION INFORMATION:
     DELTA A =  .19 BARS   DELTA B    =  .23 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 3.65 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50      BLADE T=15.00 MM

     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI         ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3

  Z   THRUST     A      B    ED    ID    KD      UO  GAMMA    SV     PC    OCR     KO    CU    PHI      M      SOIL TYPE
 (M)   (KG)   (BAR)  (BAR) (BAR)               (BAR) (T/M3)  (BAR)  (BAR)               (BAR) (DEG)   (BAR)
***** ******  *****  ***** ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******  ************

  .30   371.    .31   1.93   44.  2.86  7.46    .000  1.700   .059                                     98.1  SILTY SAND
  .61   361.    .74   3.18   74.  2.56  7.49    .000  1.700   .111     .7   6.2    .93         38.4   164.9  SILTY SAND
  .91   308.    .92   3.00   60.  1.70  6.45    .000  1.600   .159    1.0   6.0    .96         34.0   125.9  SANDY SILT
 1.22   170.    .81   2.64   51.  1.59  4.47    .000  1.600   .208     .9   4.4    .90         26.3    88.7  SANDY SILT
 1.52   182.   1.10   3.48   71.  1.73  4.67    .000  1.600   .255    1.3   5.2    .98         24.3   126.8  SANDY SILT
 1.83   182.   1.33   3.87   77.  1.57  4.63    .000  1.700   .305    1.7   5.7   1.03         22.0   135.9  SANDY SILT
 2.13   161.   1.26   3.41   63.  1.33  3.85    .000  1.600   .354    1.7   4.8    .99         20.1    98.8  SANDY SILT
 2.44   132.    .39   1.97   42.  2.33  1.29    .000  1.700   .404     .6   1.4    .61         23.6    35.9  SILTY SAND

 2.89   103.    .11   1.32   29.  3.18   .54    .000  1.700   .479     .5    .9    .56         22.0    24.5  SILTY SAND
 3.05   107.   -.02   1.03   23.  4.78   .27    .000  1.700   .506     .4    .8    .51         23.1    19.5     SAND
 3.35           .13    .71    6.   .54   .56    .000  1.500   .553     .1    .1    .03   .025           5.0     MUD
 3.66           .11    .60    3.   .25   .49    .001  1.500   .598     .1    .1   -.01   .023           2.2     MUD
 3.96           .09    .50   -0.  -.04          .030  P01 =    .28  PO =    .28  P1 =     .27               QUESTIONABLE
 4.27           .10    .54    1.   .09   .36    .061  1.500   .627     .0    .1   -.09   .016            .6     MUD
 4.57           .24    .73    3.   .22   .52    .090  1.500   .642     .1    .1    .01   .026           2.2     MUD
 4.88           .22    .94   11.  1.15   .42    .121  1.500   .657     .1    .1   -.05                  9.3     MUD
 5.18           .44   1.09    8.   .52   .70    .150  1.500   .672     .1    .2    .10   .040           7.1     MUD
 5.49  1027.    .39   1.69   32.  2.60   .51    .181  1.700   .690     .1    .1    .12         40.5    27.3  SILTY SAND
 5.79  1908.    .32   1.64   33.  3.71   .36    .210  1.700   .711                                     27.9     SAND
 6.10           .14   1.16   22. 10.58   .08    .240  1.700   .732                                     18.6     SAND

 6.71           .23    .61   -1.  -.33          .300  P01 =    .42  PO =    .42  P1 =     .38               QUESTIONABLE
 7.01           .24    .60   -2.  -.60          .330  P01 =    .43  PO =    .43  P1 =     .37               QUESTIONABLE
END OF SOUNDING
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Virginia Polytechnic Institute                                    TEST NO. PEPFR D-2
FILE NAME:     Dilatometer Test
FILE NUMBER:   18:30:00

RECORD OF DILATOMETER TEST NO. PEPFR D-2
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

     LOCATION: PEPPER'S FERRY
     PERFORMED - DATE:  8/22/89
                  BY:  MULLEN

     CALIBRATION INFORMATION:
     DELTA A =  .20 BARS   DELTA B    =  .23 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 3.65 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50     BLADE T=15.00 MM

     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3

  Z   THRUST   A      B     ED    ID    KD     UO    GAMMA   SV     PC   OCR    KO    CU   PHI     M     SOIL TYPE
 (M)   (KG)  (BAR) (BAR) (BAR)              (BAR) (T/M3) (BAR)  (BAR)              (BAR) (DEG)  (BAR)
***** ****** ***** ***** ***** ***** *****  ****** ****** ******  ***** *****  ***** ***** ***** ******  ************

  .30  371.    .36  1.98   43.  2.50  8.48   .000  1.700  .059                               102.0  SILTY SAND
  .61  361.    .91  2.94   58.  1.63  9.43   .000  1.600  .109   1.1  10.4  1.21        37.1  142.5  SANDY SILT
  .91  308.    .90  3.10   64.  1.84  6.41   .000  1.700  .158    .9   5.9   .95        34.2  134.2  SILTY SAND
 1.22  170.    .59  2.18   42.  1.66  3.52   .000  1.600  .208    .6   3.0   .74        28.1   63.5  SANDY SILT
 1.52  182.    .99  3.08   60.  1.57  4.34   .000  1.600  .255   1.2   4.5   .93        25.0  102.7  SANDY SILT
 1.83  182.   1.10  3.52   73.  1.74  3.95   .000  1.600  .304   1.3   4.2   .92        23.7  117.3  SANDY SILT
 2.13  161.   1.13  3.27   62.  1.44  3.55   .000  1.600  .351   1.4   4.1   .93        21.0   93.1  SANDY SILT
 2.44         1.09  2.78   46.  1.08  3.07   .000  1.600  .400    .8   2.0   .80               60.9     SILT
 2.74          .93  2.46   40.  1.07  2.41   .000  1.600  .447    .6   1.3   .65               43.5     SILT
 3.05          .95  2.30   34.   .88  2.23   .000  1.600  .495    .6   1.2   .60  .125         33.1  CLAYEY SILT
 3.35         1.05  2.41   34.   .81  2.22   .000  1.600  .542    .6   1.2   .60  .136         33.1  CLAYEY SILT
 3.66         1.03  2.25   29.   .70  2.02   .001  1.600  .590    .6   1.0   .55  .131         25.0  CLAYEY SILT
 3.96         1.26  2.37   25.   .51  2.30   .030  1.600  .608    .8   1.2   .62  .159         24.6  SILTY CLAY
 4.27         1.53  3.00   38.   .68  2.58   .061  1.600  .626    .9   1.5   .69  .190         42.4  CLAYEY SILT
 4.57         2.05  3.50   37.   .51  3.27   .090  1.700  .645   1.4   2.2   .84  .262         50.3  SILTY CLAY
 4.88  154.   1.18  4.00   87.  2.20  1.71   .121  1.800  .668   1.4   2.1   .79        18.7   75.9  SILTY SAND
 5.18         1.89  4.35   74.  1.16  2.66   .150  1.700  .690   1.1   1.6   .71               88.2     SILT
 5.49 1027.   1.91  5.30  108.  1.74  2.50   .181  1.700  .711    .9   1.3   .45        37.8  127.7  SANDY SILT
 5.63 1761.   1.40  7.71  214.  5.55  1.54   .194  1.800  .722    .1    .1   .11        43.4  187.3     SAND
END OF SOUNDING
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        Virginia Polytechnic Institute                                           TEST NO. PEPFR D-3
        FILE NAME:     Dilatometer Test
        FILE NUMBER:   19:20:00

        RECORD OF DILATOMETER TEST NO. PEPFR D-3
        USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
        KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
        PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
        PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
        MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

            LOCATION: PEPPER'S FERRY
            PERFORMED - DATE:  8/22/89
                         BY:  MULLEN


            CALIBRATION INFORMATION:
            DELTA A =  .19 BARS   DELTA B    =  .23 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 3.65 M
            ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50     BLADE T=15.00 MM

            1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI         ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3

  Z   THRUST    A      B     ED    ID    KD      U0    GAMMA    SV      PC    OCR     KO     CU    PHI      M       SOIL TYPE
 (M)   (KG)   (BAR)  (BAR)  (BAR)                 (BAR)  (T/M3)  (BAR)   (BAR)                 (BAR)  (DEG)  (BAR)
***** ****** *****  *****  ***** ***** *****   ****** ****** ******   ***** *****   *****  ***** *****  ******  ************

  .30   371.    .48   2.29    51.  2.43 10.18    .000  1.700   .059                                         127.5   SILTY SAND
  .61          1.14   1.54    -1.  -.02          .000  P01 =  1.33   P0 =   1.33   P1 =   1.31                     QUESTIONABLE
  .91   308.   1.10   3.40    68.  1.65  7.58    .000  1.600   .158    1.3   8.3   1.12          33.0  153.1   SANDY SILT
 1.22   170.    .89   3.03    63.  1.82  4.78    .000  1.700   .208    1.0   5.0    .95          25.7  112.9   SILTY SAND
 1.52   182.    .88   2.86    57.  1.65  3.87    .000  1.600   .257    1.0   3.7    .85          25.9   90.4   SANDY SILT
 1.83   182.    .96   3.00    59.  1.59  3.50    .000  1.600   .305    1.1   3.5    .84          24.6   88.1   SANDY SILT
 2.13   161.   1.20   3.28    60.  1.33  3.71    .000  1.600   .352    1.6   4.4    .96          20.5   92.6   SANDY SILT
 2.44   132.   1.20   3.21    58.  1.27  3.27    .000  1.600   .401    1.8   4.4    .98          17.1   81.3   SANDY SILT
 2.74          1.08   2.51    37.   .87  2.72    .000  1.600   .448     .7   1.6    .72   .145          43.8   CLAYEY SILT
 3.05          1.10   2.26    27.   .62  2.52    .000  1.600   .497     .7   1.4    .68   .146          29.4   CLAYEY SILT
 3.35          1.14   2.20    23.   .52  2.39    .000  1.600   .544     .7   1.3    .64   .149          24.1   SILTY CLAY
 3.66          1.21   2.29    24.   .51  2.31    .001  1.600   .592     .7   1.3    .62   .156          24.0   SILTY CLAY
 3.96          1.30   2.16    16.   .32  2.36    .030  1.600   .609     .8   1.3    .64   .165          16.4      CLAY
 4.27          1.44   2.56    26.   .48  2.44    .061  1.600   .627     .9   1.4    .66   .177          26.9   SILTY CLAY
 4.57          1.73   3.02    32.   .51  2.77    .090  1.600   .645    1.1   1.7    .73   .213          37.5   SILTY CLAY
 4.88          2.20   3.91    47.   .61  3.32    .121  1.700   .665    1.5   2.2    .85   .275          64.4   CLAYEY SILT
 5.18   131.   1.70   4.68    93.  1.67  2.35    .150  1.700   .686    2.5   3.7    .96          13.6  104.2   SANDY SILT
 5.49  1027.   1.90   4.48    79.  1.26  2.55    .181  1.700   .707     .9   1.3    .46          37.8   91.1   SANDY SILT
 5.79  1908.   1.19   8.04   234.  7.96  1.16    .210  1.800   .729                                         199.1      SAND
END OF SOUNDING
```

PEPPER'S FERRY:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	BORING #	N60	N160	Qc (pt) bar
-1.0				25.8
-2.0				24.9
-2.5	B-2	5	9	22.7
-2.5	B-1	6	11	22.7
-3.0				21.0
-4.0	B-2	5	8	11.5
-4.0	B-1	6	10	11.8
-5.0				12.3
-5.5	B-1	5	8	13.6
-5.5	B-2	5	8	13.1
-6.0				12.1
-7.0	B-1	5	7	11.0
-7.0	B-2	5	7	10.7
-8.0				8.6
-8.5	B-2	5	7	8.6
-8.5	B-1	5	7	8.7
-9.0				7.3
-9.5				6.9
-10.0	B-2	3	4	7.5
-10.0	B-1	4	5	6.8
-11.0				6.7
-11.5	B-2	2	3	7.2
-11.5	B-1	3	4	7.2
-12.0				7.6
-13.0	B-1	5	6	5.4
-14.0				9.5
-15.0				12.8
-16.0				11.5
-17.0	B-1	4	5	8.4
-18.0				74.9
-18.5				117.7
-19.0	B-2	19	22	165.9

PEPPER'S FERRY:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Qn (pt) bar	ED bar	Gur kN/M^2	D50 (mm)
-1.0	48.6	46		
-2.0	44.8	66		
-2.5	39.9	65		
-2.5	39.9	65		
-3.0	36.2	64		
-4.0	19.1	52		0.070
-4.0	19.5	52		0.070
-5.0	19.6	63		
-5.5	21.2	66		
-5.5	20.4	66		
-6.0	18.5	70		
-7.0	16.2	62		0.066
-7.0	15.8	62		0.066
-8.0	12.3	49		
-8.5	12.0	44		0.100
-8.5	12.2	44		0.100
-9.0	10.1	39		
-9.5	9.3	29		
-10.0	9.9	28		0.043
-10.0	9.1	28		0.043
-11.0	8.7	29		
-11.5	9.2	28		
-11.5	9.2	28		
-12.0	9.6	27		
-13.0	6.7	21		0.012
-14.0	11.7	32		
-15.0	15.6	35		
-16.0	13.8	67		
-17.0	10.0	84		0.022
-18.0	88.0	73		
-18.5	136.7	214		
-19.0	192.9	134		0.030

PEPPER'S FERRY:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Qc (pt) /N	Su DMT	Su N60 (bars)	Nk = 15 Su Qc (bars)
-1.0				
-2.0				
-2.5			1.182	1.501
-2.5			1.418	1.501
-3.0				
-4.0	2.46		1.182	0.755
-4.0	2.05		1.418	0.771
-5.0				
-5.5			1.182	0.887
-5.5			1.182	0.852
-6.0				
-7.0	2.16		1.182	0.708
-7.0	2.16		1.182	0.687
-8.0				
-8.5	1.71		1.182	0.543
-8.5	1.71		1.182	0.552
-9.0		0.073		0.458
-9.5				0.428
-10.0	2.37	0.090	0.709	0.464
-10.0	1.78	0.090	0.945	0.422
-11.0		0.143		0.410
-11.5		0.143	0.473	0.441
-11.5		0.143	0.709	0.445
-12.0		0.144		0.469
-13.0	1.41	0.162	1.182	0.317
-14.0		0.184		0.595
-15.0		0.238		0.812
-16.0		0.138		0.722
-17.0	3.72		0.945	0.516
-18.0				
-18.5				
-19.0	6.21		4.789	11.010

PEPPER'S FERRY:
LAB DATA
SUMMARY
FROM B-1.

DEPTH (ft)	SPECIFIC GRAVITY	D60 (mm)	D50 (mm)	D10 (mm)	Cu
-2.5	2.65				
-4.0	2.65	0.090	0.070	0.003	35
-5.5	2.65				
-7.0	2.65	0.090	0.066	0.002	41
-8.5	2.65	0.110	0.100	0.008	14
-10.0	2.65	0.061	0.043	0.003	22
-11.5	2.65				
-13.0	2.65		0.012		
-15.0	2.65				
-17.0	2.65	0.040	0.022	0.002	22
-18.0	2.65		0.030		
-19.0	2.65	0.044	0.030	0.002	22

PEPPER'S FERRY:
LAB DATA
SUMMARY
FROM B-1.

DEPTH (ft)	%-200	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	MOISTURE CONTENT %
-2.5					22.1%
-4.0	55.0%				22.0%
-5.5					25.2%
-7.0	55.0%				29.5%
-8.5	42.0%				26.5%
-10.0	77.0%				29.8%
-11.5		37.9%	22.0%	15.9%	33.4%
-13.0	90.0%	41.3%	23.5%	17.8%	36.8%
-15.0		40.1%	23.7%	16.4%	32.2%
-17.0	73.0%	45.7%	23.6%	22.1%	38.7%
-18.0	82.0%	44.7%	24.1%	20.6%	41.1%
-19.0	73.0%				31.4%

APPENDIX B

CARMEL CHURCH

CARMEL CHURCH: FIELD BORING LOGS

BORING B-1
CONTINUOUS SAMPLING TO 45 FT.
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 5/08/89

WATER TABLE = 31.0 FT.

DEPTH IN FT. from	to	BLOW COUNT blows per 6 in.	DESCRIPTION
1.5 -	3.0	1 - 2 / 2	loose brown clayey fine sand
3.0 -	4.5	2 - 2 / 3	same, loose, grading orange
4.5 -	6.0	2 - 2 / 3	loose light orange clayey fine sand
6.0 -	7.5	3 - 3 / 3	loose light orange fine sand w/ traces of clay
7.5 -	9.0	3 - 3 / 4	same, loose
9.0 -	10.5	4 - 5 / 7	same, medium
10.5 -	12.0	5 - 5 / 6	medium orange white silty fine sand
12.0 -	13.5	5 - 9 / 10	same, medium
13.5 -	15.0	6 - 6 / 7	medium yellow-white fine sand
15.0 -	16.5	6 - 8 / 9	same, medium, some medium sand
16.5 -	18.0	8 - 8 / 10	same, medium
18.0 -	19.5	8 - 8 / 10	same, medium
19.5 -	21.0	8 - 7 / 11	same, medium
21.5 -	23.0	5 - 7 / 8	same, medium
23.0 -	24.5	5 - 6 / 8	same, medium
24.5 -	26.0	6 - 6 / 6	same, medium
26.0 -	27.5	7 - 7 / 10	medium white fine sand
27.5 -	29.0	6 - 6 / 7	same, medium
29.0 -	30.5	5 - 4 / 4	same, loose
30.5 -	32.0	2 - 2 / 3	loose white fine sand w/ quartz gravel

CARMEL CHURCH: FIELD BORING LOGS

BORING B-1
CONTINUOUS SAMPLING TO 45 FT.
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 5/08/89

WATER TABLE = 31.0 FT.

DEPTH IN FT.		BLOW COUNT			DESCRIPTION
from	to	blows per 6 in.			
32.0 -	33.5	3 -	10 /	10	medium white fine sand w/ gravel (hard drilling @ 33')
33.5 -	35.0	6 -	5 /	5	medium white fine sand w/ gravel
35.0 -	36.5	3 -	7 /	9	same, medium
36.5 -	38.0	4 -	4 /	8	same, medium
38.0 -	39.5	5 -	9 /	15	medium yellow and white medium sand
39.5 -	41.0	7 -	8 /	8	same, medium
41.5 -	43.0	2 -	3 /	6	same, medium: clay lense @ 42 ft.
43.0 -	44.5	2 -	3 /	9	same, medium

---END OF BORING---

CARMEL CHURCH: FIELD BORING LOGS

BORING B-2
CONTINUOUS SAMPLING TO 45 FT.
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 5/09/89

WATER TABLE = 31.0 FT.

DEPTH IN FT. from	to	BLOW COUNT blows per 6 in.			DESCRIPTION
1.5-	3.0	1 -	2 /	4	loose brown clayey fine sand
3.0-	4.5	1 -	2 /	4	same, loose
4.5-	6.0	3 -	4 /	6	same, loose
6.0-	7.5	3 -	4 /	5	same, loose
7.5-	9.0	5 -	7 /	8	medium orange fine sand
9.0-	10.5	4 -	7 /	9	same, medium
10.5-	12.0	6 -	8 /	9	same, medium
12.0-	13.5	6 -	9 /	8	same, medium
13.5-	15.0	6 -	9 /	11	same, medium
15.0-	16.5	7 -	9 /	10	medium white fine sand w/ quartz gravel
16.5-	18.0	7 -	8 /	9	same, medium, no gravel
18.0-	19.5	7 -	6 /	8	medium orange white fine sand
19.5-	21.0	6 -	7 /	8	medium orange fine sand
21.5-	23.0	5 -	6 /	8	same, medium
23.0-	24.5	5 -	6 /	9	medium orange and white fine sand
24.5-	26.0	6 -	7 /	7	medium white and pink fine sand
26.0-	27.5	5 -	5 /	6	same, medium
27.5-	29.0	5 -	5 /	6	same, medium
29.0-	30.5	4 -	4 /	4	same, loose, w/ quartz gravel
30.5-	32.0	2 -	4 /	4	same, loose

CARMEL CHURCH: FIELD BORING LOGS

BORING B-2
CONTINUOUS SAMPLING TO 45 FT.
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 5/09/89

WATER TABLE = 31.0 FT.

DEPTH IN FT.		BLOW COUNT	DESCRIPTION
from	to	blows per 6 in.	
32.0 -	33.5	5 - 12 / 10	same, medium, more gravel
33.5 -	35.0	4 - 3 / 5	loose yellow white fine sand w/ some gravel
35.0 -	36.5	7 - 8 / 8	same, medium
36.5 -	38.0	6 - 10 / 17	medium yellow, white, pink fine sand w/ tr quartz gravel
38.0 -	39.5	9 - 9 / 13	medium orange white fine sand w/ gravel
39.5 -	41.0	3 - 6 / 7	medium white fine sand
41.5 -	43.0	5 - 6 / 6	medium orange fine sand
43.0 -	44.5	7 - 12 / 16	same, medium

---END OF BORING---

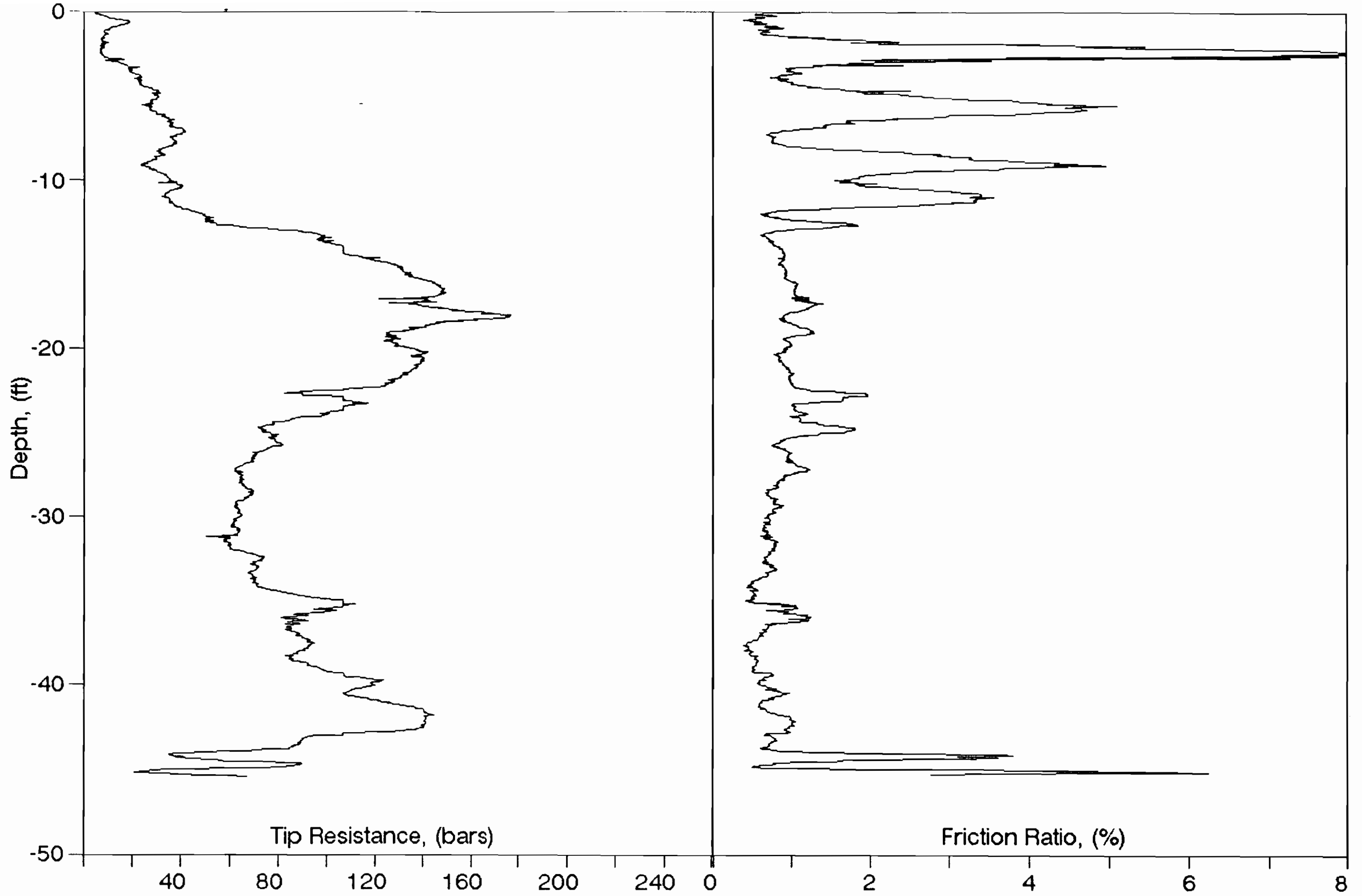
CARMEL CHURCH: FIELD BORING LOGS

BORING B-3
SAMPLING AND PRESSUREMETER TESTING TO 30 FT.
SAMPLES TAKEN WITH 300# HAMMER AND 3" SAMPLER
DRILLED 9/14/89 TO 9/15/89

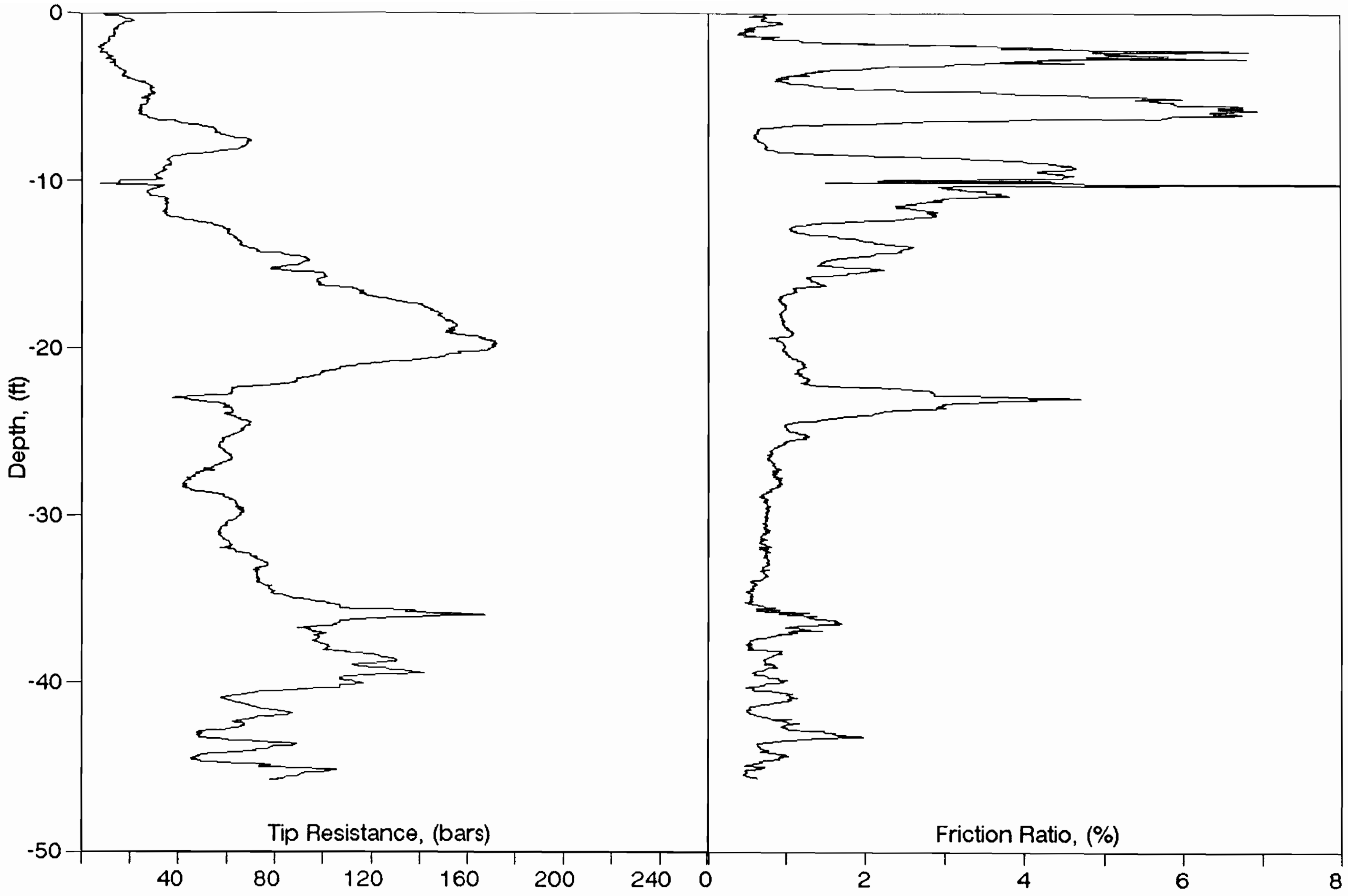
WATER TABLE = 31.0 FT.

DEPTH IN FT.		BLOW COUNT			DESCRIPTION
from	to	blows per 6 in.			
3.0 -	4.5	2 -	2 /	3	loose reddish-brown clayey fine sand w/some roots
4.5 -	6.0	3 -	5 /	7	same, medium
9.0 -	10.6	3 -	5 /	7	medium red, white, yellow, brown clayey fine sand
10.5 -	12.0	6 -	8 /	9	same
15.0 -	16.5	5 -	7 /	7	medium yellow-white slightly silty fine sand w/ quartz gravel
16.5 -	18.0	8 -	12 /	13	same
20.5 -	22.0	4 -	4 /	6	medium yellow, white, pink silty fine-medium sand
22.5 -	24.0	4 -	7 /	7	same
27.0 -	28.5	3 -	2 /	4	loose pink and white medium-fine sand
28.5 -	30.0	4 -	5 /	4	same

---END OF BORING---



Carmel Church: Cone Test CCHC-1 5/08/89



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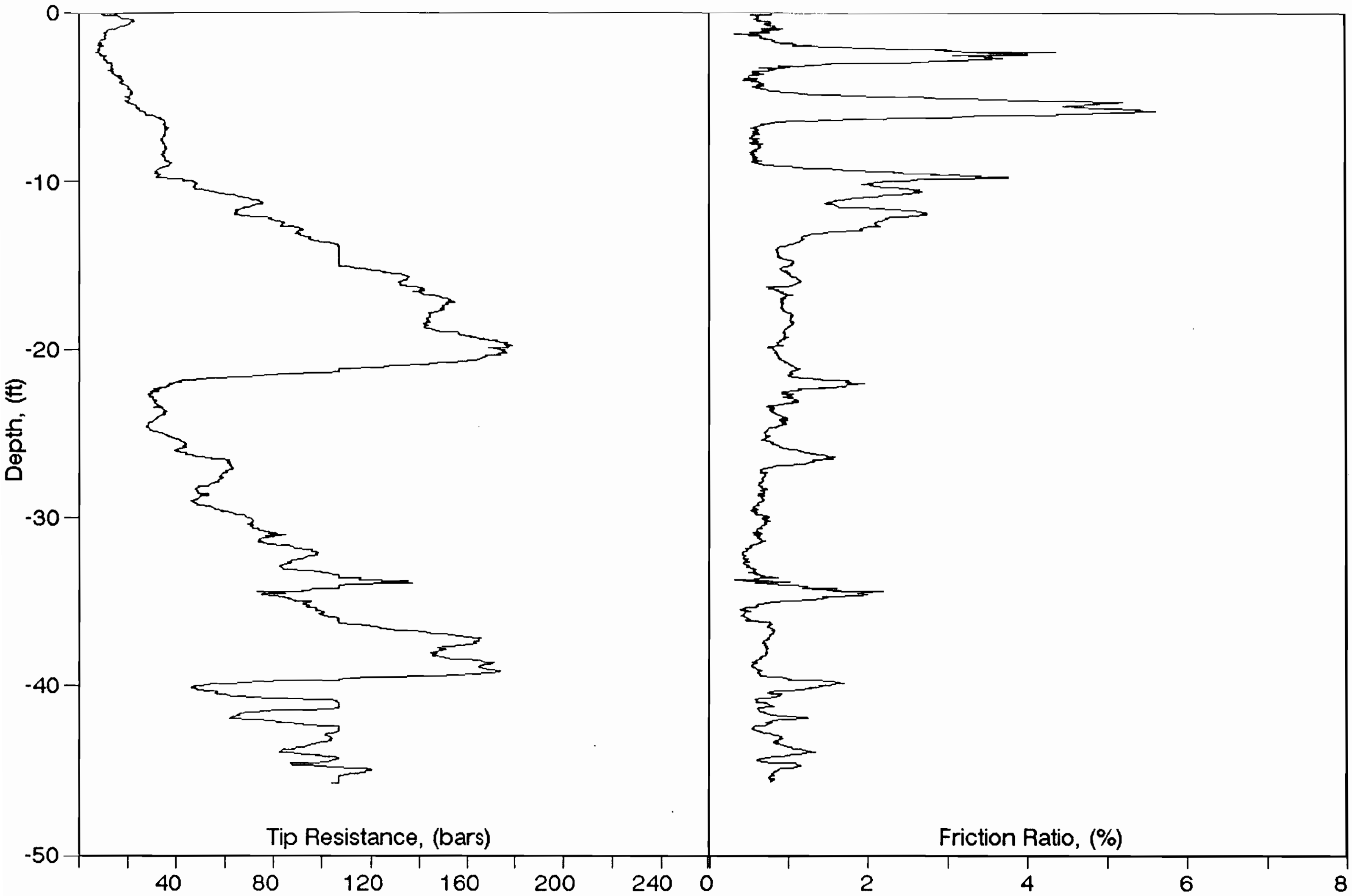

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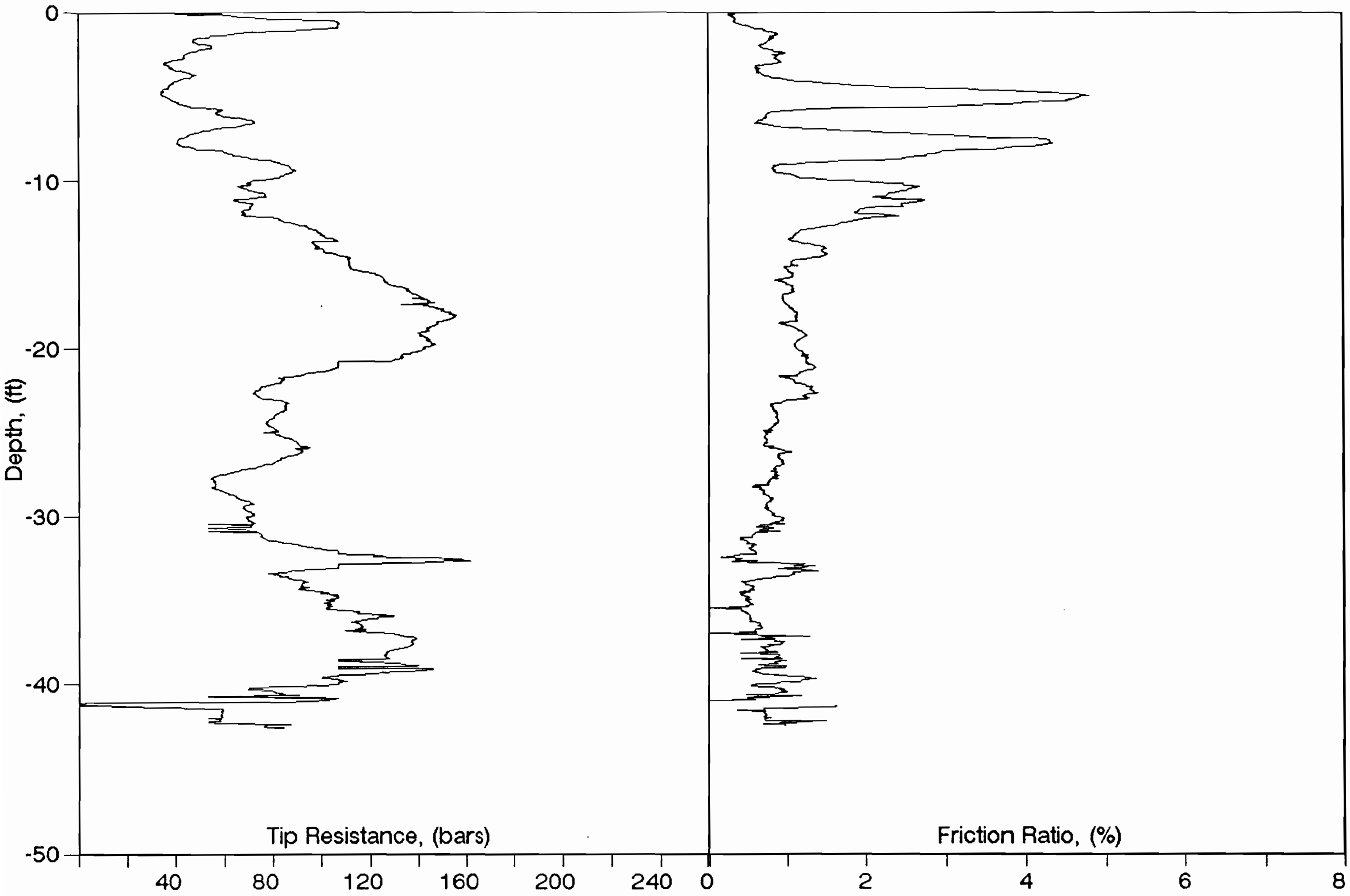

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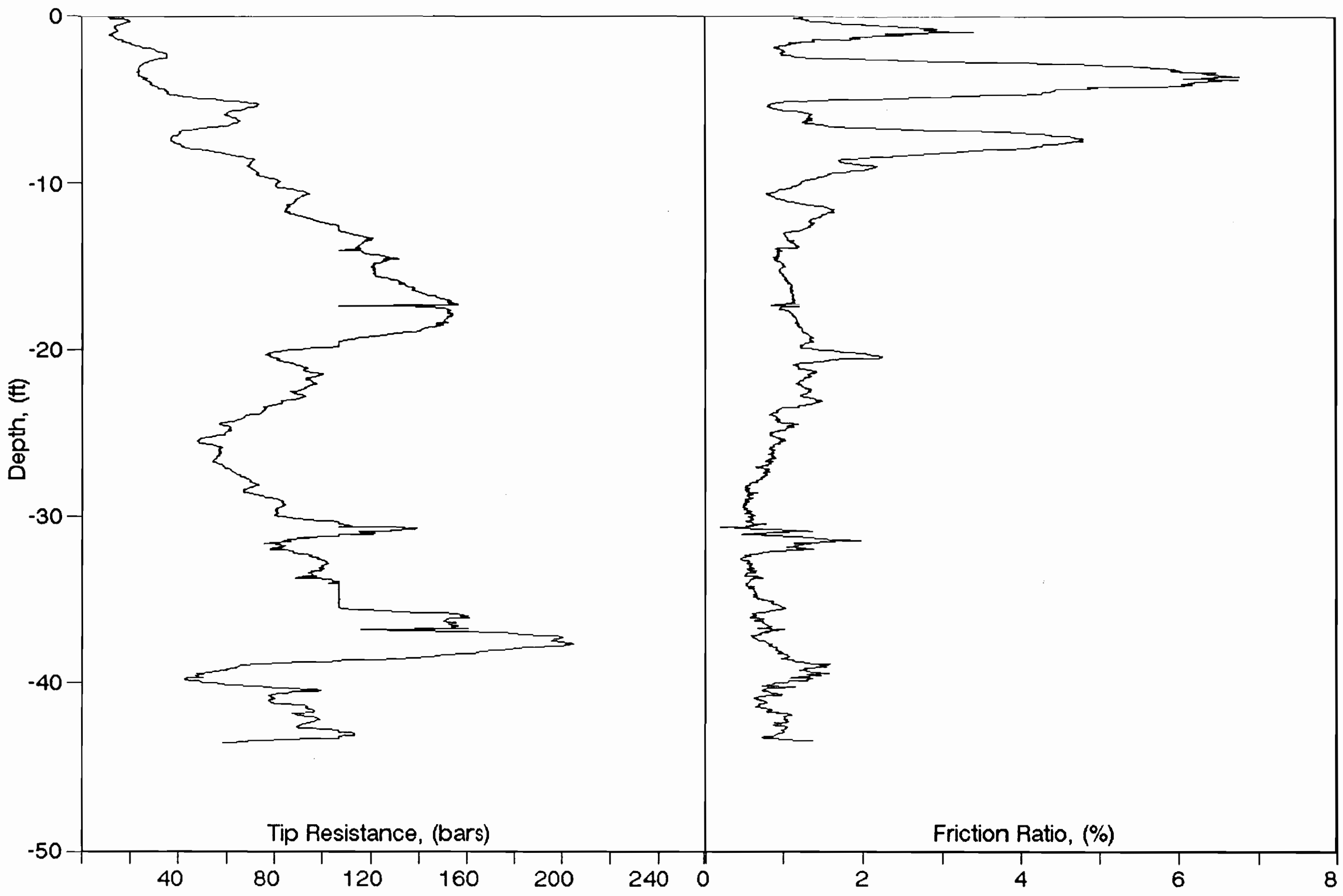

Carmel Church: Cone Test CCHC-5 09/12/89

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Virginia Polytechnic Institute                                                  TEST NO. CCH D-1
FILE NAME:     Dilatometer Test
FILE NUMBER:   16:20:00

RECORD OF DILATOMETER TEST NO. CCH D-1
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

    LOCATION: CARMEL CHURCH
    PERFORMED - DATE:  09/13/89
                  BY:  MULLEN

    CALIBRATION INFORMATION:
    DELTA A =  .21 BARS   DELTA B     =  .25 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 9.45 M
    ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM      ROD WT.=  .00 KG/M   DELTA/PHI=  .50      BLADE T=15.00 MM

    1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3

  Z    THRUST    A      B      ED    ID    KD     U0    GAMMA   SV     PC    OCR    KO     CU   PHI      M     SOIL TYPE
 (M)    (KG)  (BAR)  (BAR)  (BAR)                (BAR) (T/M3) (BAR)  (BAR)              (BAR) (DEG)  (BAR)
***** ****** *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******  ************

  .30   611.   .61   3.23    79.  3.19 12.07   .000  1.700   .059                                  210.8   SILTY SAND
  .61   757.   .82   3.71    89.  2.81  8.21   .000  1.700   .111                                  205.9   SILTY SAND
  .91  1164.  1.31   4.70   107.  2.24  8.47   .000  1.800   .162     .5   2.9    .57         45.8  250.6   SILTY SAND
 1.22  1164.  2.08   6.68   151.  2.09  9.60   .000  1.800   .217    1.8   8.4   1.06         42.1  371.4   SILTY SAND
 1.52  1280.  2.46   7.37   162.  1.91  9.02   .000  1.900   .271    2.2   8.0   1.04         41.6  389.6   SILTY SAND
 1.83  1280.  1.51   6.07   149.  2.84  4.62   .000  1.800   .328     .5   1.5    .42         43.3  272.1   SILTY SAND
 2.13  1164.  1.96   6.68   155.  2.29  5.14   .000  1.800   .381    1.1   2.9    .63         40.9  293.5   SILTY SAND
 2.44  1106.  2.14   7.48   178.  2.43  4.84   .000  1.800   .435    1.3   2.9    .64         39.7  327.5   SILTY SAND
 2.74  1251.  2.24   8.18   200.  2.64  4.44   .000  1.900   .490    1.2   2.4    .58         40.3  354.6   SILTY SAND
 3.05  1484.  2.59   9.31   228.  2.64  4.54   .000  1.900   .548    1.3   2.4    .58         40.8  409.6   SILTY SAND
 3.35  1746.  3.06  10.55   256.  2.53  4.83   .000  1.900   .604    1.6   2.6    .60         41.3  472.9   SILTY SAND
 3.66  1892.  3.86  11.25   252.  1.95  5.63   .000  1.900   .662    2.5   3.8    .73         40.7  495.3   SILTY SAND
 3.96  2445.  5.21  14.50   322.  1.86  6.93   .000  2.000   .719    3.9   5.4    .86         41.3  692.9   SILTY SAND
 4.27  2561.  5.83  15.25   326.  1.68  7.18   .000  1.950   .779    4.6   5.9    .91         40.9  712.9   SANDY SILT
 4.57  2648.  5.78  15.20   326.  1.70  6.63   .000  1.950   .836    4.2   5.1    .84         41.1  688.0   SANDY SILT
 4.88  3288.  6.50  18.45   419.  1.97  6.84   .000  2.000   .896    4.5   5.0    .83         42.3  898.0   SILTY SAND
 5.18  3260.  5.30  17.25   419.  2.44  5.17   .000  2.000   .955    2.5   2.7    .59         43.0  796.4   SILTY SAND
 5.49  3026.  5.38  16.00   370.  2.10  5.00   .000  2.000  1.016    2.8   2.8    .62         42.1  687.6   SILTY SAND
 5.79  2677.  4.92  14.95   349.  2.16  4.33   .000  2.000  1.075    2.5   2.4    .58         41.3  602.0   SILTY SAND
 6.10  2707.  4.70  14.35   335.  2.17  3.92   .000  2.000  1.136    2.2   2.0    .53         41.3  547.6   SILTY SAND
 6.40  2969.  5.12  14.50   325.  1.92  4.09   .000  2.000  1.195    2.5   2.1    .54         41.6  539.5   SILTY SAND
 6.71  2299.  5.87  15.75   343.  1.76  4.47   .000  1.950  1.255    3.9   3.1    .69         38.7  595.7   SANDY SILT
 7.01  2037.  3.52  11.20   263.  2.25  2.57   .000  1.900  1.312    1.7   1.3    .44         39.3  329.6   SILTY SAND
 7.32  2008.  3.79  12.15   288.  2.30  2.63   .000  1.900  1.369    1.9   1.4    .47         38.8  368.4   SILTY SAND
 7.62  1950.  3.52  10.40   234.  1.98  2.39   .000  1.900  1.425    1.8   1.2    .45         38.6  271.8   SILTY SAND
 7.92  2008.  3.50  10.65   244.  2.08  2.28   .000  1.900  1.481    1.7   1.2    .43         38.7  274.7   SILTY SAND
 8.23  1863.  3.39  10.35   237.  2.08  2.13   .000  1.900  1.539    1.8   1.1    .44         37.9  251.9   SILTY SAND
 8.53  1601.  2.88   8.94   204.  2.09  1.76   .000  1.900  1.595    1.6   1.0    .42         36.9  181.4   SILTY SAND
 8.84  1485.  2.51   8.62   206.  2.43  1.47   .000  1.900  1.653    1.5    .9    .40         36.4  175.0   SILTY SAND
 9.14  1310.  2.09   7.28   172.  2.41  1.21   .000  1.800  1.707    1.4    .8    .39         35.5  146.5   SILTY SAND
 9.45  1164.  1.24   5.71   146.  3.37   .71   .000  1.800  1.762    1.0    .6    .34         35.1  124.2      SAND
 9.75   844.  1.14   5.59   145.  3.74   .63   .029  1.800  1.786    1.2    .7    .39         32.4  123.6      SAND
10.06  1019.   .51   2.61    60.  2.98   .32   .060  1.700  1.808     .8    .4    .31         34.6   50.8   SILTY SAND
10.36  1193.  1.33   6.09   157.  3.65   .68   .089  1.800  1.830    1.0    .6    .34         35.1  133.2      SAND
10.67  1863.  1.94  10.20   284.  4.99   .88   .120  1.900  1.856     .9    .5    .29         38.4  241.6      SAND
10.97  2270.  3.63  12.40   303.  2.66  1.74   .149  1.900  1.883    1.6    .9    .38         38.7  285.4   SILTY SAND
11.28  2735.  4.00  14.65   371.  3.04  1.84   .180  1.900  1.910    1.5    .8    .35         40.0  382.8   SILTY SAND
11.58  2794.  4.48  15.50   385.  2.80  2.04   .209  2.000  1.938    1.8    .9    .38         39.9  422.8   SILTY SAND
11.89  2852.  4.14  14.45   359.  2.86  1.84   .239  1.900  1.967    1.5    .8    .35         40.2  363.8   SILTY SAND
12.19  3463.  5.26  16.60   396.  2.45  2.33   .269  2.000  1.995    1.9   1.0    .38         41.1  469.5   SILTY SAND
12.50  2299.  4.52  15.20   372.  2.74  1.94   .299  1.900  2.024    2.1   1.1    .42         38.1  389.5   SILTY SAND
12.80  1804.  4.08  10.60   221.  1.74  1.79   .329  1.800  2.049    2.3   1.1    .46         36.0  190.3   SANDY SILT
13.11  1106.  3.86  10.00   207.  1.74  1.65   .359  1.800  2.073    2.8   1.4    .55         31.4  175.9   SANDY SILT
13.41  1833.  3.30  11.20   271.  2.84  1.31   .389  1.900  2.098    1.7    .8    .38         36.8  230.4   SILTY SAND
13.72  1135.  3.70  10.05   215.  1.93  1.50   .419  1.900  2.126    2.6   1.2    .52         31.8  182.4   SILTY SAND
END OF SOUNDING
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Virginia Polytechnic Institute                                                          TEST NO. CCH D-2
FILE NAME:     Dilatometer Test
FILE NUMBER:   07:45:00

RECORD OF DILATOMETER TEST NO. CCH D-2
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

     LOCATION: CARMEL CHURCH
     PERFORMED - DATE:  09/13/89
                  BY:  MULLEN


     CALIBRATION INFORMATION:
     DELTA A =  .21 BARS   DELTA B    =  .28 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 9.45 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50      BLADE T=15.00 MM

     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3


  Z   THRUST    A      B      ED     ID    KD      U0   GAMMA    SV      PC   OCR     KO     CU    PHI      M        SOIL TYPE
 (M)   (KG)  (BAR)  (BAR)  (BAR)                (BAR) (T/M3) (BAR)   (BAR)                (BAR) (DEG)   (BAR)
***** ****** *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******   ************

  .30  203.    .41   2.61    62.  3.36  9.06    .000  1.700   .059     .5   8.5   1.08          38.5   150.4      SAND
  .61  203.    .52   2.26    46.  1.97  6.03    .000  1.700   .111     .6   5.4    .91          33.4    92.3   SILTY SAND
  .91  203.    .98   3.36    69.  1.81  6.81    .000  1.700   .161    1.3   7.9   1.13          28.1   147.2   SILTY SAND
 1.22  956.   1.43   4.52    95.  1.81  7.06    .000  1.800   .214     .9   4.4    .75          42.2   205.6   SILTY SAND
 1.52 1251.   1.50   5.48   127.  2.39  5.75    .000  1.800   .267     .6   2.2    .51          43.8   254.0   SILTY SAND
 1.83 1251.    .92   4.24   103.  3.01  3.09    .000  1.700   .320     .0    .1    .09          45.2   152.5   SILTY SAND
 2.13 1353.   3.14   9.76   223.  2.11  8.15    .000  1.900   .373    2.8   7.4   1.02          40.1   516.2   SILTY SAND
 2.44 1353.   4.00  10.45   217.  1.60  9.11    .000  1.800   .430    4.3  10.1   1.20          38.4   523.4   SANDY SILT
 2.74 1470.   3.02   4.98    54.   .49  6.56    .000  1.700   .481    3.1   6.4   1.40   .467          110.8   SILTY CLAY
 3.05 1746.   3.00   9.00   201.  1.97  5.48    .000  1.900   .536    1.7   3.2    .66          41.6   388.8   SILTY SAND
 3.35 1339.   3.80   8.32   147.  1.11  6.45    .000  1.800   .590    3.7   6.2   1.39                 303.3      SILT
 3.66 1310.   2.69   7.58   160.  1.72  4.15    .000  1.800   .645    1.6   2.5    .61          38.9   266.8   SANDY SILT
 3.96 2270.   4.48  13.45   309.  2.09  6.10    .000  1.900   .699    2.9   4.1    .76          41.4   630.6   SILTY SAND
 4.27 2474.   5.61  15.40   339.  1.82  7.06    .000  2.000   .759    4.4   5.7    .90          40.9   735.5   SILTY SAND
 4.57 2998.   6.44  17.65   391.  1.84  7.48    .000  2.000   .818    5.0   6.1    .92          41.7   869.3   SILTY SAND
 4.88 3550.   6.18  17.00   376.  1.85  6.69    .000  2.000   .879    3.8   4.4    .76          43.1   797.9   SILTY SAND
 5.18 3580.   6.58  19.05   436.  2.03  6.60    .000  2.000   .937    4.2   4.4    .77          42.8   922.5   SILTY SAND
 5.49 3610.   6.13  18.45   431.  2.16  5.76    .000  2.000   .998    3.3   3.3    .66          43.1   857.9   SILTY SAND
 5.79 3580.   5.50  17.65   425.  2.39  4.85    .000  2.000  1.057    2.4   2.3    .55          43.3   782.8   SILTY SAND
 6.10 3405.   6.55  19.00   436.  2.04  5.51    .000  2.000  1.118    3.9   3.4    .69          42.0   847.7   SILTY SAND
 6.40 2940.   6.14  18.00   414.  2.06  4.91    .000  2.000  1.177    3.6   3.1    .67          40.9   762.0   SILTY SAND
 6.71 2212.   4.76  14.30   330.  2.10  3.65    .000  2.000  1.238    2.6   2.1    .57          39.3   516.3   SILTY SAND
 7.01 1717.   3.08  10.20   242.  2.35  2.28    .000  1.900  1.295    1.5   1.2    .44          38.3   279.1   SILTY SAND
 7.32 1863.   3.50  10.60   241.  2.05  2.50    .000  1.900  1.353    1.8   1.3    .46          38.4   291.3   SILTY SAND
 7.62 2095.   4.16  12.80   297.  2.16  2.81    .000  1.900  1.409    2.2   1.5    .49          38.8   394.6   SILTY SAND
 7.92 2066.   4.34  12.50   279.  1.93  2.84    .000  1.900  1.465    2.4   1.6    .51          38.3   369.0   SILTY SAND
 8.23 1630.   3.27  10.00   227.  2.07  2.08    .000  1.900  1.523    1.8   1.2    .46          36.9   236.7   SILTY SAND
 8.53 1251.   2.33   7.57   173.  2.17  1.46    .000  1.900  1.579    1.5   1.0    .43          35.2   147.1   SILTY SAND
 8.84 1222.   1.98   6.82   158.  2.32  1.21    .000  1.800  1.635    1.3    .8    .40          35.2   134.7   SILTY SAND
 9.14 1368.   2.16   7.89   191.  2.61  1.25    .000  1.900  1.689    1.3    .8    .39          35.9   162.3   SILTY SAND
 9.45 1193.   1.12   5.61   146.  3.72   .65    .000  1.800  1.746     .9    .5    .33          35.5   123.9      SAND
 9.75 1251.   1.90   6.48   149.  2.29  1.06    .029  1.800  1.769    1.3    .8    .39          35.1   126.7   SILTY SAND
10.06 1310.   1.78   5.74   126.  2.07   .98    .060  1.800  1.793    1.2    .7    .37          35.5   107.5   SILTY SAND
10.36 1222.   2.47  10.20   264.  3.41  1.23    .089  1.900  1.818    1.6    .9    .42          34.3   224.2      SAND
10.67 1455.   2.21   9.85   261.  3.86  1.05    .120  1.900  1.846    1.3    .7    .36          36.1   221.4      SAND
10.97 2357.   3.63  12.15   293.  2.56  1.76    .149  1.900  1.872    1.6    .8    .37          39.1   275.0   SILTY SAND
11.28 2357.   4.00  13.05   312.  2.49  1.90    .180  1.900  1.900    1.8    .9    .40          38.8   312.2   SILTY SAND
11.58 2532.   4.18  14.40   355.  2.77  1.92    .209  1.900  1.926    1.8    .9    .39          39.3   368.9   SILTY SAND
11.89 2735.   4.33  15.25   380.  2.90  1.93    .239  1.900  1.954    1.7    .9    .37          39.8   403.6   SILTY SAND
12.19 3260.   3.64  13.55   343.  3.18  1.57    .269  1.900  1.980    1.0    .5    .27          41.5   306.2   SILTY SAND
12.50 1804.   2.87  10.35   255.  3.02  1.21    .299  1.900  2.007    1.4    .7    .36          37.1   216.5   SILTY SAND
12.80 1368.   4.02  12.20   280.  2.30  1.73    .329  1.900  2.034    2.6   1.3    .50          33.6   250.8   SILTY SAND
13.11 1950.   4.30  13.55   319.  2.48  1.80    .359  1.900  2.061    2.2   1.1    .44          36.7   304.1   SILTY SAND
13.41 1106.   3.50  10.15   224.  2.15  1.44    .389  1.900  2.088    2.5   1.2    .51          31.8   190.8   SILTY SAND
13.72 1572.   4.18  13.75   331.  2.71  1.66    .419  1.900  2.115    2.4   1.1    .47          34.7   300.3   SILTY SAND
END OF SOUNDING
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Virginia Polytechnic Institute                                                        TEST NO. CCH D-4
FILE NAME:     Dilatometer Test
FILE NUMBER:   09:30:00

RECORD OF DILATOMETER TEST NO. CCH D-4
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

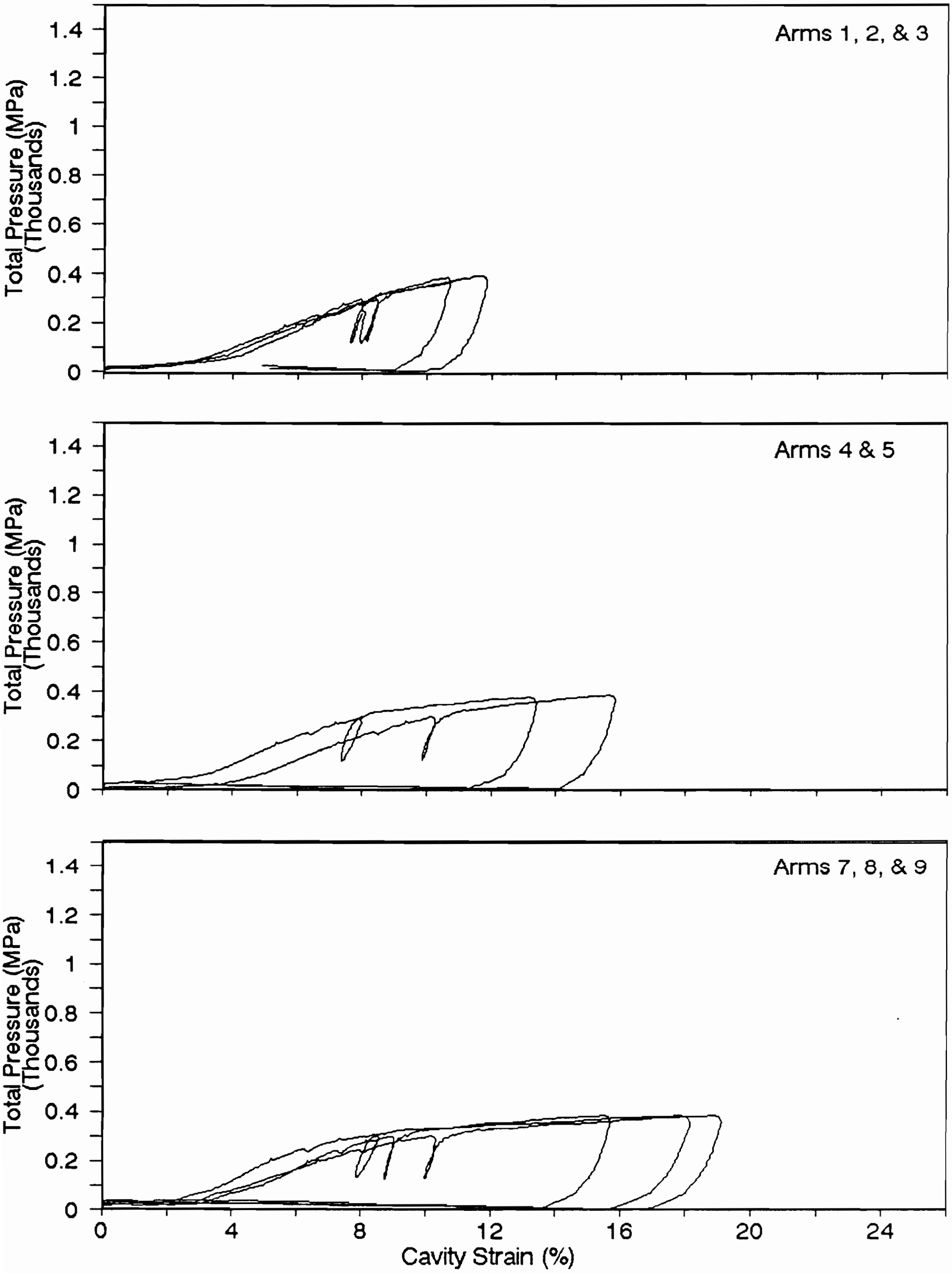
     LOCATION: CARMEL CHURCH
     PERFORMED - DATE:  09/14/89
                   BY:  MULLEN


     CALIBRATION INFORMATION:
     DELTA A =  .21 BARS   DELTA B    =  .23 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 9.45 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50     BLADE T=15.00 MM

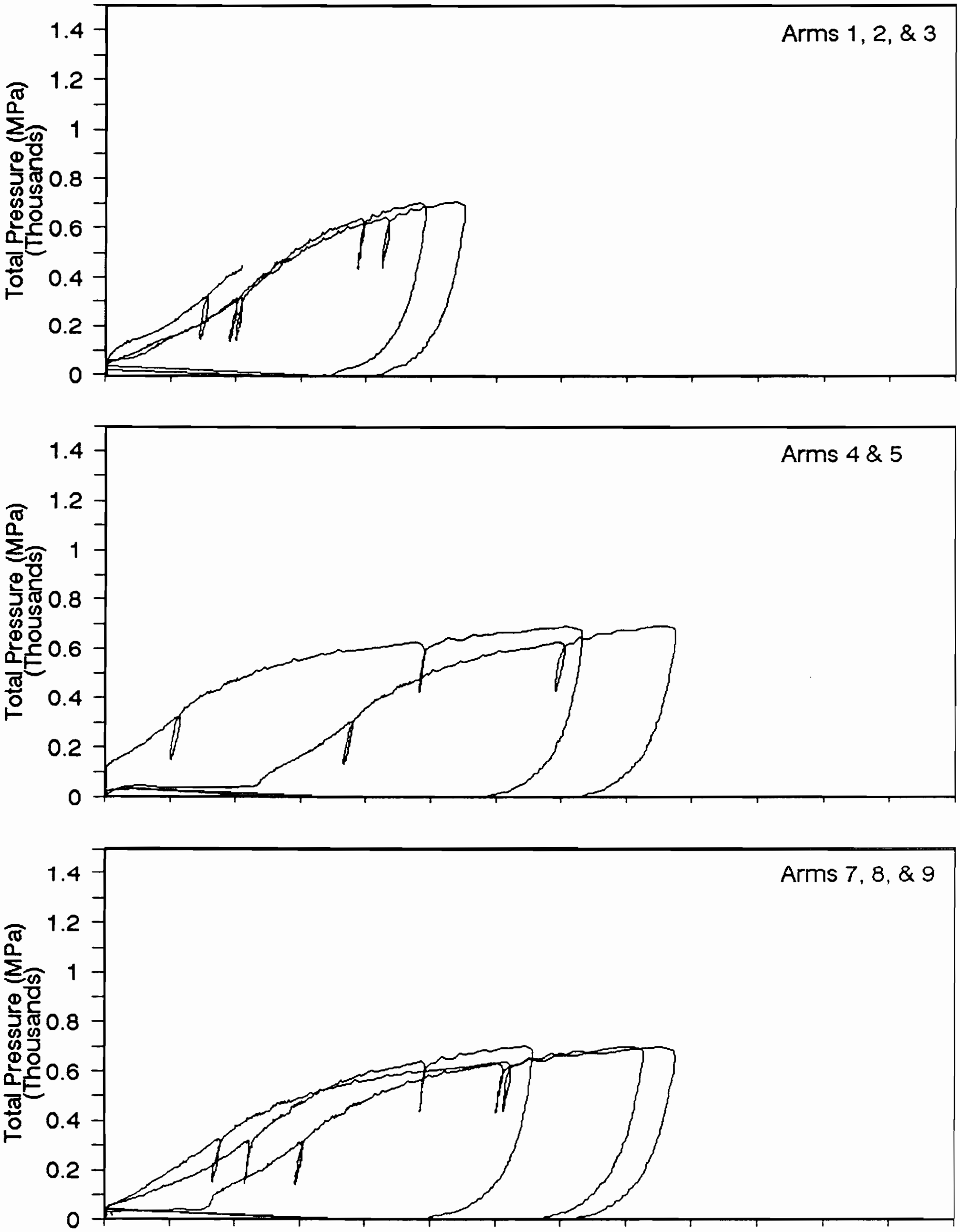
     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3


  Z   THRUST    A      B      ED     ID    KD      U0   GAMMA    SV      PC   OCR     K0     CU   PHI      M       SOIL TYPE
 (M)   (KG)  (BAR)  (BAR)  (BAR)                (BAR) (T/M3)  (BAR)  (BAR)               (BAR) (DEG)   (BAR)
***** ****** *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******  ************

  .30   815.   1.66   6.94   176.  3.12 27.59    .000  1.800   .059                                    610.3  SILTY SAND
  .61   466.    .60   2.64    58.  2.30  6.50    .000  1.700   .112     .4   3.4    .65         41.8   122.8  SILTY SAND
  .91   466.    .29   1.66    34.  2.15  2.79    .000  1.700   .162     .1    .5    .24         41.8    44.8  SILTY SAND
 1.22   728.   1.09   4.28   100.  2.48  5.39    .000  1.800   .216     .6   2.9    .62         40.9   194.7  SILTY SAND
 1.52  1222.   2.51   8.44   200.  2.36  9.06    .000  1.900   .270    2.2   8.3   1.06         41.2   482.0  SILTY SAND
 1.83  1251.   2.70   8.08   180.  1.95  8.12    .000  1.900   .328    2.3   7.1    .99         40.5   414.9  SILTY SAND
 2.13  1542.   3.06   8.64   187.  1.79  7.88    .000  1.800   .382    2.5   6.4    .94         41.3   426.0  SANDY SILT
 2.44  1601.   3.50  10.60   243.  2.07  7.70    .000  1.900   .439    2.9   6.5    .95         40.7   547.7  SILTY SAND
 2.74  1688.   4.05  11.15   243.  1.78  7.97    .000  1.800   .493    3.6   7.3   1.01         40.1   554.3  SANDY SILT
 3.05  2008.   3.73  11.65   273.  2.20  6.49    .000  1.900   .549    2.4   4.4    .77         41.8   573.0  SILTY SAND
 3.35  2270.   5.19  14.15   310.  1.80  8.21    .000  1.950   .606    4.5   7.4   1.02         41.0   718.0  SANDY SILT
 3.66  2619.   6.00  16.05   350.  1.76  8.61    .000  1.950   .665    5.4   8.1   1.06         41.3   825.7  SANDY SILT
 3.96  2852.   6.59  17.45   380.  1.74  8.69    .000  1.950   .723    6.0   8.2   1.07         41.4   898.4  SANDY SILT
 4.27  2561.   6.06  16.55   366.  1.83  7.37    .000  2.000   .783    4.9   6.3    .94         40.8   809.8  SILTY SAND
 4.57  3021.   6.93  18.20   395.  1.72  7.85    .000  1.950   .841    5.8   6.9    .98         41.4   895.4  SANDY SILT
 4.88  3172.   5.65  17.50   416.  2.26  5.87    .000  2.000   .901    3.2   3.6    .69         42.6   836.4  SILTY SAND
 5.18  3522.   6.80  19.35   441.  1.99  6.67    .000  2.000   .960    4.5   4.7    .80         42.5   936.2  SILTY SAND
 5.49  3317.   7.02  19.45   437.  1.90  6.50    .000  2.000  1.021    4.9   4.8    .82         41.7   914.9  SILTY SAND
 5.79  3172.   6.06  17.50   401.  2.02  5.30    .000  2.000  1.080    3.5   3.2    .67         41.8   764.6  SILTY SAND
 6.10  2939.   6.18  17.20   385.  1.90  5.14    .000  2.000  1.140    3.8   3.3    .69         40.9   722.4  SILTY SAND
 6.40  2415.   3.80  12.70   308.  2.48  2.99    .000  1.900  1.198    1.6   1.3    .44         40.9   435.1  SILTY SAND
 6.71  1892.   5.53  15.30   340.  1.86  4.19    .000  2.000  1.257    3.8   3.0    .70         37.1   571.4  SILTY SAND
 7.01  2270.   4.79  13.85   314.  1.98  3.47    .000  2.000  1.316    2.6   2.0    .55         39.2   474.5  SILTY SAND
 7.32  1484.   3.54  10.15   225.  1.88  2.50    .000  1.900  1.375    2.2   1.6    .52         36.2   268.8  SILTY SAND
 7.62  1513.   3.55  10.70   244.  2.06  2.39    .000  1.900  1.431    2.1   1.5    .51         36.2   286.0  SILTY SAND
 7.92  1542.   2.84   8.78   200.  2.08  1.87    .000  1.900  1.487    1.6   1.1    .43         36.9   188.6  SILTY SAND
 8.23  1426.   2.66   8.30   189.  2.09  1.69    .000  1.900  1.545    1.6   1.0    .43         36.2   161.1  SILTY SAND
 8.53  1397.   2.27   7.88   188.  2.44  1.39    .000  1.900  1.601    1.4    .8    .40         36.2   160.1  SILTY SAND
 8.84  1572.   2.60   8.88   213.  2.44  1.52    .000  1.900  1.659    1.5    .9    .40         36.8   180.9  SILTY SAND
 9.14  1804.   2.20   8.91   228.  3.14  1.22    .000  1.900  1.715    1.1    .6    .33         38.1   194.2  SILTY SAND
 9.45  2095.   2.46   9.70   248.  3.06  1.31    .000  1.900  1.773    1.1    .6    .32         39.0   210.6  SILTY SAND
 9.75  2037.   2.99  10.60   261.  2.68  1.56    .029  1.900  1.799    1.4    .8    .37         38.4   222.1  SILTY SAND
10.06  2736.   1.40   8.62   247.  5.88   .66    .060  1.800  1.825     .3    .1    .14         41.8   210.0     SAND
10.36  2008.   2.54  10.55   276.  3.48  1.23    .089  1.900  1.850    1.1    .6    .32         38.5   234.4     SAND
10.67  2590.   3.67  13.25   333.  2.91  1.76    .120  1.900  1.877    1.4    .8    .35         39.8   326.4  SILTY SAND
10.97  2648.   3.94  14.20   358.  2.94  1.84    .149  1.900  1.904    1.5    .8    .36         39.8   366.5  SILTY SAND
11.28  2910.   4.38  14.85   365.  2.69  2.02    .180  1.900  1.931    1.7    .9    .37         40.3   394.9  SILTY SAND
11.58  3725.   4.28  16.95   446.  3.50  1.87    .209  2.000  1.959    1.0    .5    .27         42.3   465.7     SAND
11.89  4045.   5.20  18.40   465.  2.96  2.28    .239  2.000  1.990    1.4    .7    .32         42.4   563.0  SILTY SAND
12.19  3579.   5.41  17.75   434.  2.63  2.36    .269  2.000  2.019    1.9    .9    .37         41.3   524.2  SILTY SAND
12.50  1513.   4.50  13.00   294.  2.11  1.96    .299  1.900  2.048    2.8   1.4    .52         34.1   290.4  SILTY SAND
12.80  1775.   3.69  12.90   320.  2.94  1.51    .329  1.900  2.074    2.0    .9    .42         36.2   271.8  SILTY SAND
13.11  2386.   5.64  16.15   367.  2.12  2.37    .359  2.000  2.103    3.0   1.4    .49         37.5   428.3  SILTY SAND
13.41  2677.   6.02  17.20   391.  2.13  2.49    .389  2.000  2.133    3.0   1.4    .49         38.3   474.3  SILTY SAND
13.72  2838.   6.43  18.30   416.  2.12  2.61    .419  2.000  2.163    3.2   1.5    .49         38.6   523.6  SILTY SAND
END OF SOUNDING
```



Carmel Church: Pressuremeter Test CCHP-1 09/14/89



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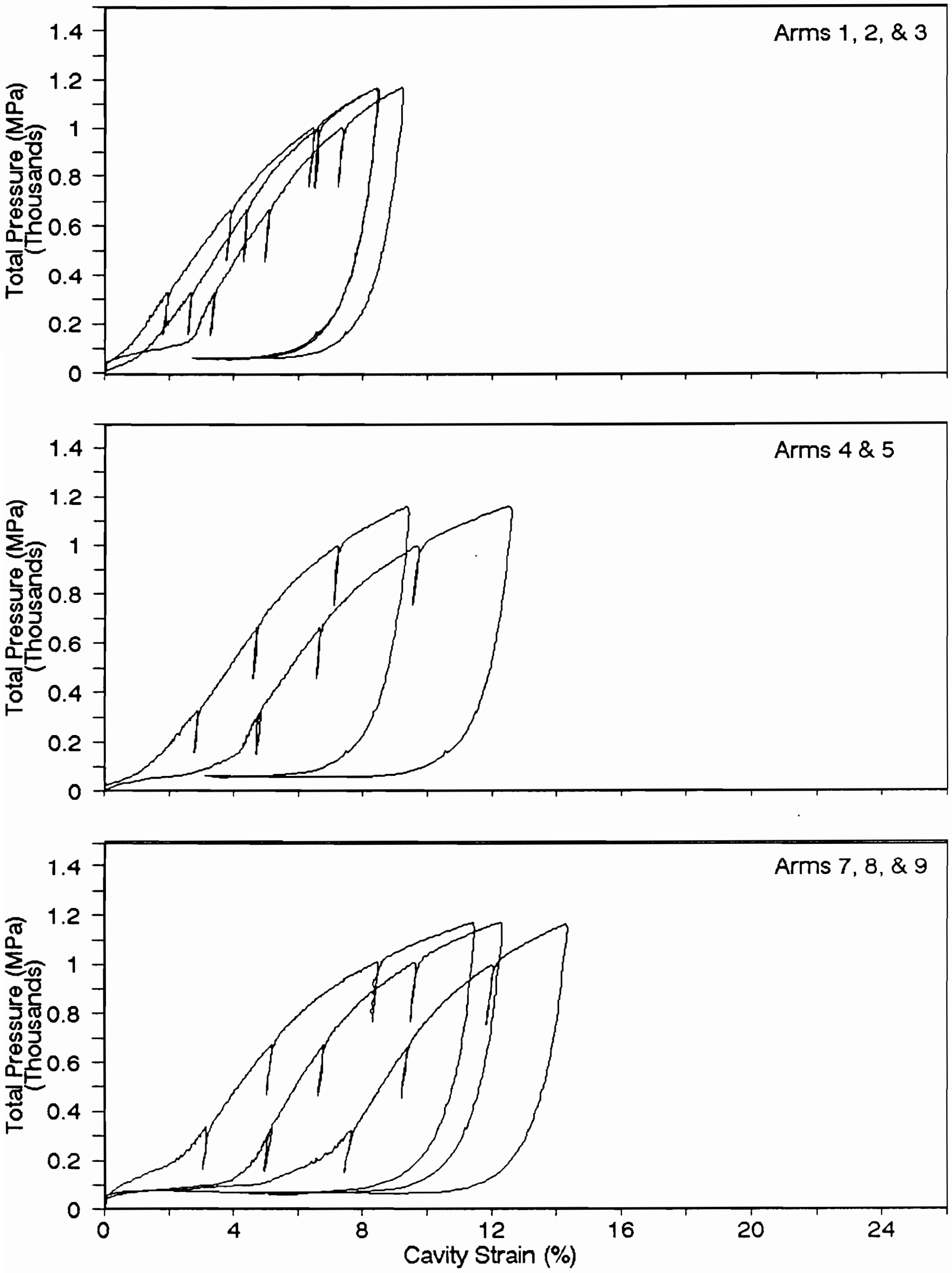

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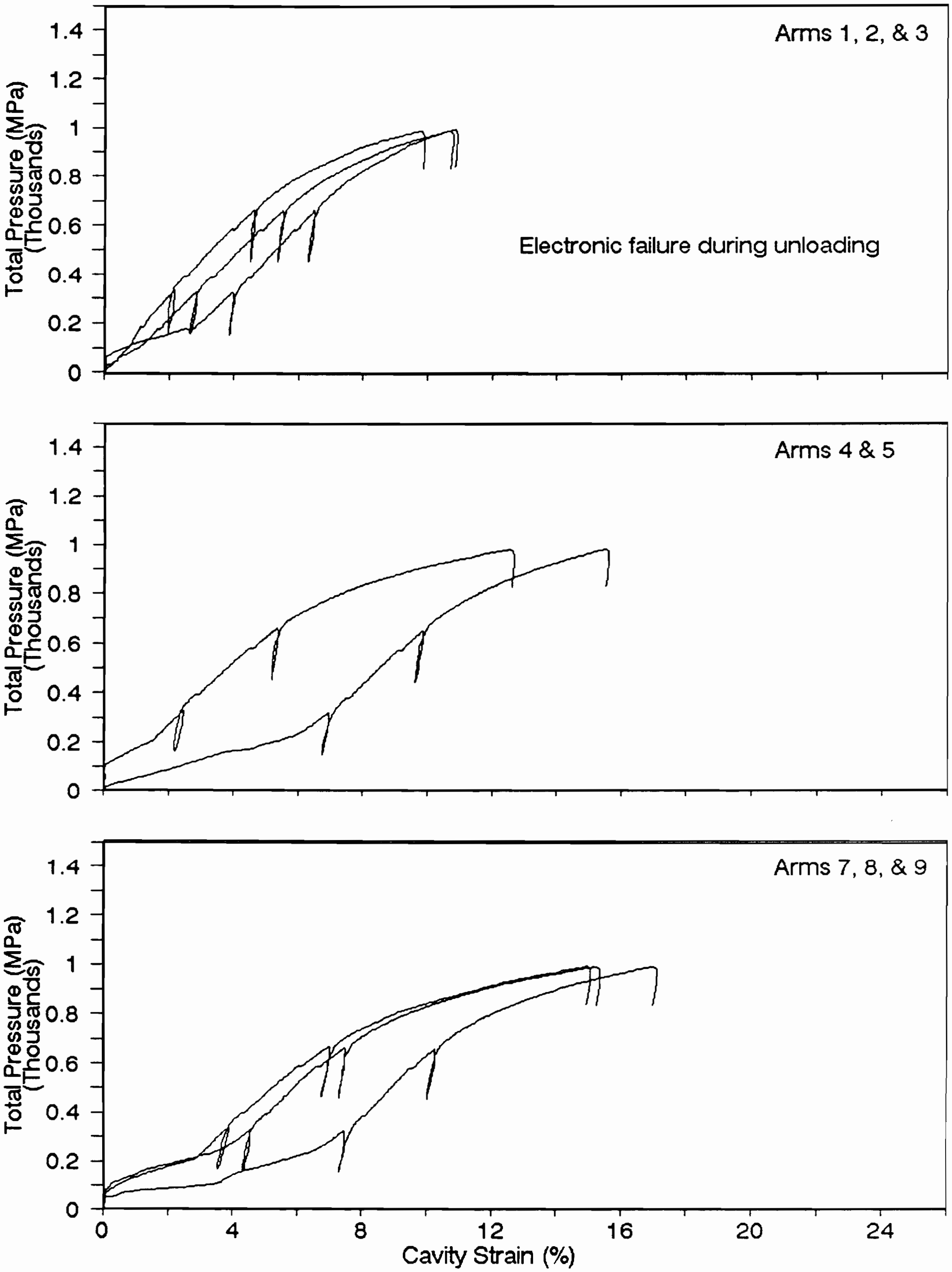
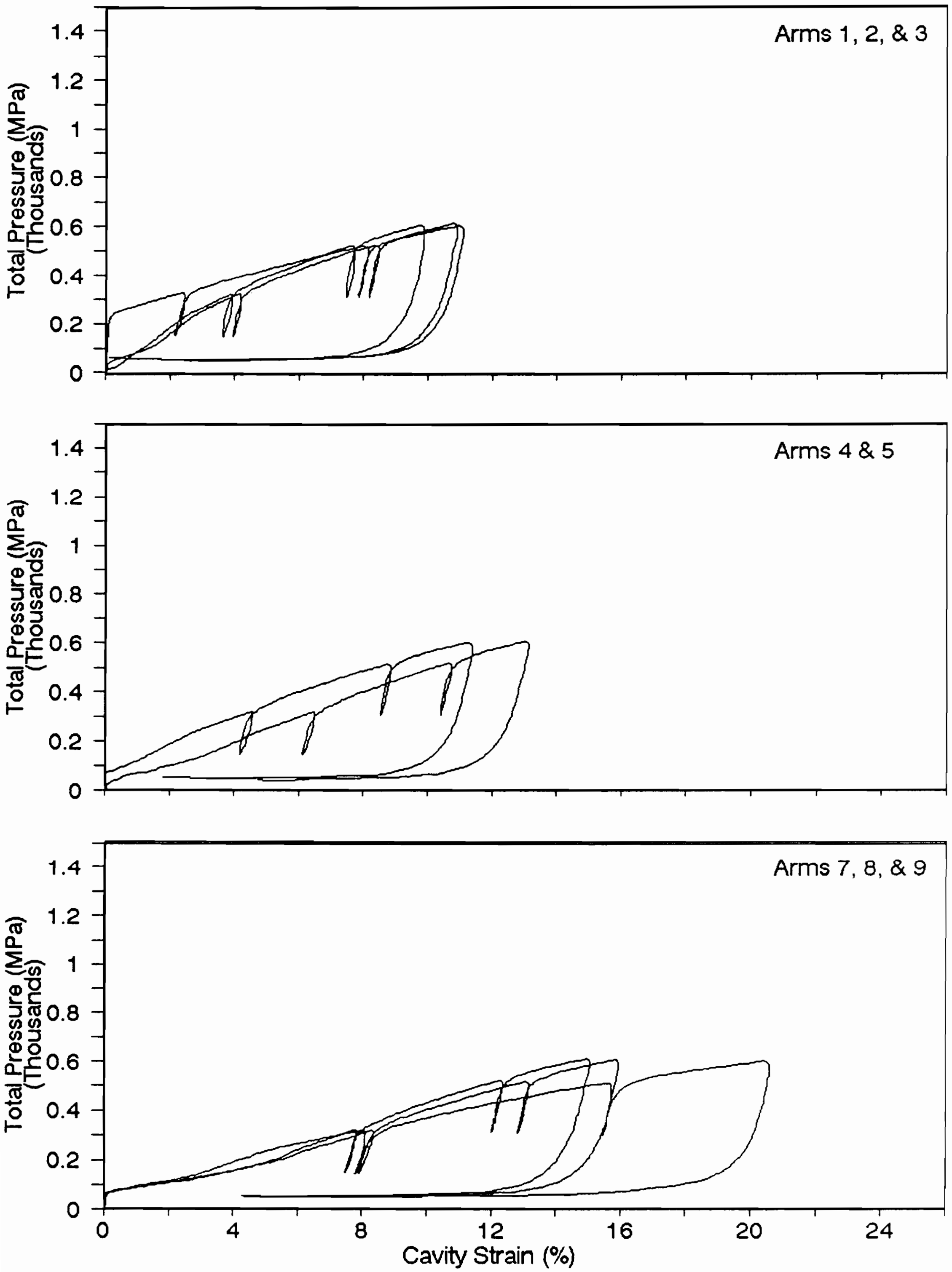


Carmel Church: Pressuremeter Test CCHP-4 09/15/89



Carmel Church: Pressuremeter Test CCHP-5 09/15/89

CARMEL CHURCH:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	BORING #	N60 blows/ft	N160 blows/ft	Qc (pt) bar
-1.0				31.5
-2.0				22.0
-2.5	B-1	4	7	21.5
-2.5	B-2	6	11	20.8
-3.0				20.1
-4.0	B-1	5	8	26.6
-4.0	B-3	5	8	25.9
-4.0	B-2	6	10	26.9
-4.5				29.4
-5.0				33.0
-5.5	B-1	5	8	38.0
-5.5	B-2	10	15	37.3
-5.5	B-3	12	18	36.7
-6.0				40.0
-7.0	B-1	6	9	45.5
-7.0	B-2	9	13	45.1
-8.0				46.0
-8.5	B-1	7	10	47.6
-8.5	B-2	15	21	48.6
-9.0				50.6
-10.0	B-3	12	16	53.0
-10.0	B-1	12	16	50.4
-10.0	B-2	16	21	49.9
-10.5				55.8
-11.0				59.7
-11.5	B-1	11	14	59.8
-11.5	B-2	17	21	59.8
-11.5	B-3	17	21	59.2
-12.0				61.0
-13.0	B-2	17	20	88.9
-13.0	B-1	19	22	90.2
-14.0				97.5
-14.5	B-1	13	14	108.3
-14.5	B-2	20	22	109.3
-15.0				111.1
-16.0	B-3	14	15	126.4
-16.0	B-1	17	18	126.1
-16.0	B-2	19	20	126.4

CARMEL CHURCH:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Qn (pt) bar	ED bar	Gur kN/M^2	D50 (mm)	Qc (pt) /N
-1.0	59.4	106			
-2.0	39.5	64			
-2.5	37.8	67		0.115	5.36
-2.5	36.6	67		0.115	3.46
-3.0	34.6	70			
-4.0	43.8	115		0.154	5.32
-4.0	42.6	115		0.154	5.18
-4.0	44.2	115		0.154	4.48
-4.5	47.4	139	20021		
-5.0	52.0	163			
-5.5	58.5	154		0.170	7.59
-5.5	57.6	154		0.170	3.73
-5.5	56.6	154		0.170	3.06
-6.0	60.3	144			
-7.0	66.0	188		0.198	7.58
-7.0	65.5	188		0.198	5.02
-8.0	64.1	213			
-8.5	65.1	189		0.177	6.80
-8.5	66.6	189		0.177	3.24
-9.0	68.0	166			
-10.0	68.6	234		0.187	4.42
-10.0	65.2	234		0.187	4.20
-10.0	64.6	234		0.187	3.12
-10.5	71.0	236	41970		
-11.0	74.7	238			
-11.5	73.5	246		0.179	5.44
-11.5	73.4	246		0.179	3.52
-11.5	72.7	246		0.179	3.48
-12.0	73.7	254			
-13.0	103.7	337		0.203	5.23
-13.0	105.3	337		0.203	4.75
-14.0	109.9	344			
-14.5	120.2	357		0.179	8.33
-14.5	121.2	357		0.179	5.46
-15.0	121.3	371			
-16.0	133.6	404		0.187	9.03
-16.0	133.3	404		0.187	7.42
-16.0	133.6	404		0.187	6.65

CARMEL CHURCH:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Phi DMT	Phi SPT	Phi Qc
-1.0		0.0	48.1
-2.0			
-2.5	31.8	30.0	43.0
-2.5	31.8	31.7	42.9
-3.0	38.6		42.0
-4.0	41.7	30.8	41.9
-4.0	41.7	30.8	41.8
-4.0	41.7	31.7	42.0
-4.5	42.0		41.8
-5.0	42.2		41.9
-5.5	42.6	30.8	42.1
-5.5	42.6	35.0	42.1
-5.5	42.6	35.5	41.9
-6.0	43.0		41.9
-7.0	40.8	31.7	41.8
-7.0	40.8	34.2	41.7
-8.0	39.6		41.1
-8.5	33.2	32.5	41.0
-8.5	33.2	36.3	41.1
-9.0			
-10.0	41.4	35.5	40.6
-10.0	41.4	35.5	40.4
-10.0	41.4	36.5	40.3
-10.5	34.4		40.6
-11.0			
-11.5	33.9	35.3	40.5
-11.5	33.9	36.8	40.5
-11.5	33.9	36.8	40.5
-12.0	40.3		40.4
-13.0	41.4	36.8	42.0
-13.0	41.4	37.3	42.1
-14.0	40.9		42.1
-14.5	41.1	35.8	42.4
-14.5	41.1	37.5	42.4
-15.0	41.4		42.3
-16.0	42.7	36.0	42.6
-16.0	42.7	36.8	42.6
-16.0	42.7	37.3	42.6

CARMEL CHURCH:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	BORING #	N60 blows/ft	N160 blows/ft	Qc (pt) bar
-16.5				135.9
-17.0				142.4
-17.5	B-2	17	17	145.9
-17.5	B-1	18	18	146.7
-17.5	B-3	25	25	147.9
-18.0				155.7
-19.0	B-2	14	14	144.5
-19.0	B-1	18	17	142.2
-20.0				141.9
-20.5	B-2	15	14	133.1
-20.5	B-1	18	17	133.9
-21.0				114.9
-21.5	B-3	10	9	101.0
-22.0				86.2
-22.5	B-2	14	12	72.7
-22.5	B-1	15	13	69.8
-23.0	B-3	14	12	69.3
-24.0	B-1	14	12	68.1
-24.0	B-2	15	13	68.0
-24.0				67.6
-25.0				62.5
-25.5	B-1	12	10	63.1
-25.5	B-2	14	11	63.4
-26.0				64.1
-27.0	B-2	11	9	63.9
-27.0	B-1	17	13	63.4
-28.0	B-3	6	5	57.7
-28.5	B-2	11	8	57.7
-28.5	B-1	13	10	57.6
-29.0				64.1
-29.5	B-3	9	7	66.5
-30.0	B-2	8	6	70.5
-30.0	B-1	8	6	70.2
-31.0				77.6
-31.5	B-1	5	4	71.6
-31.5	B-2	8	6	72.6
-32.0				78.7
-33.0	B-1	20	14	87.5

CARMEL CHURCH:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Qn (pt) bar	ED bar	Gur kN/M^2	D50 (mm)	Qc (pt) /N
-16.5	141.5	418	63093		
-17.0	146.0	432			
-17.5	147.2	422		0.245	8.58
-17.5	148.1	422		0.245	8.15
-17.5	149.4	422		0.245	5.92
-18.0	154.8	413			
-19.0	139.6	392		0.228	10.32
-19.0	137.3	392		0.228	7.90
-20.0	133.2	385			
-20.5	123.2	367		0.207	8.87
-20.5	123.9	367		0.207	7.44
-21.0	105.0	349			
-21.5	91.0	343			
-22.0	76.6	338			
-22.5	63.8	305	41090	0.202	5.20
-22.5	61.3	305	41090	0.202	4.66
-23.0	60.0	273			
-24.0	57.6	251		0.204	4.86
-24.0	57.5	251		0.204	4.54
-24.0	57.2	251			
-25.0	51.6	258			
-25.5	51.5	250		0.212	5.26
-25.5	51.8	250		0.212	4.53
-26.0	51.8	241			
-27.0	50.4	218		0.284	5.81
-27.0	50.0	218		0.284	3.73
-28.0	44.5	188			
-28.5	44.0	190	28609	0.328	5.24
-28.5	44.0	190		0.328	4.43
-29.0	48.4	192			
-29.5	49.7	195			
-30.0	52.1	197		0.364	8.81
-30.0	51.9	197		0.364	8.77
-31.0	56.2	180			
-31.5	51.6	183		0.318	14.31
-31.5	52.4	183		0.318	9.08
-32.0	56.5	185			
-33.0	62.3	144		3.537	4.37

CARMEL CHURCH:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Phi DMT	Phi SPT	Phi Qc
-16.5	42.7		42.7
-17.0	42.8		42.8
-17.5	42.5	36.8	42.8
-17.5	42.5	37.0	42.8
-17.5	42.5	38.8	42.8
-18.0	42.3		42.9
-19.0	42.1	36.0	42.4
-19.0	42.1	37.0	42.3
-20.0	41.4		42.1
-20.5	41.3	36.3	41.5
-20.5	41.3	37.0	41.6
-21.0	41.1		40.6
-21.5	39.8	35.0	39.8
-22.0	38.4		38.8
-22.5	38.7	36.0	37.7
-22.5	38.7	36.3	37.5
-23.0	38.9	36.0	37.3
-24.0	37.8	36.0	37.0
-24.0	37.8	36.3	37.0
-24.0	37.8		36.9
-25.0	37.9		36.3
-25.5	37.9	35.5	36.2
-25.5	37.9	36.0	36.3
-26.0	38.0		36.2
-27.0	37.0	35.3	36.0
-27.0	37.0	36.8	36.0
-28.0	36.1	31.7	35.1
-28.5	36.1	35.3	35.0
-28.5	36.1	35.8	35.0
-29.0	36.1		35.6
-29.5	36.3	34.2	35.7
-30.0	36.5	33.3	36.0
-30.0	36.5	33.3	36.0
-31.0	36.5		36.3
-31.5	35.9	30.8	35.8
-31.5	35.9	33.3	35.9
-32.0	35.3		36.3
-33.0	37.3	37.5	36.8

CARMEL CHURCH:
IN-SITU TEST
DATA SUMMARY

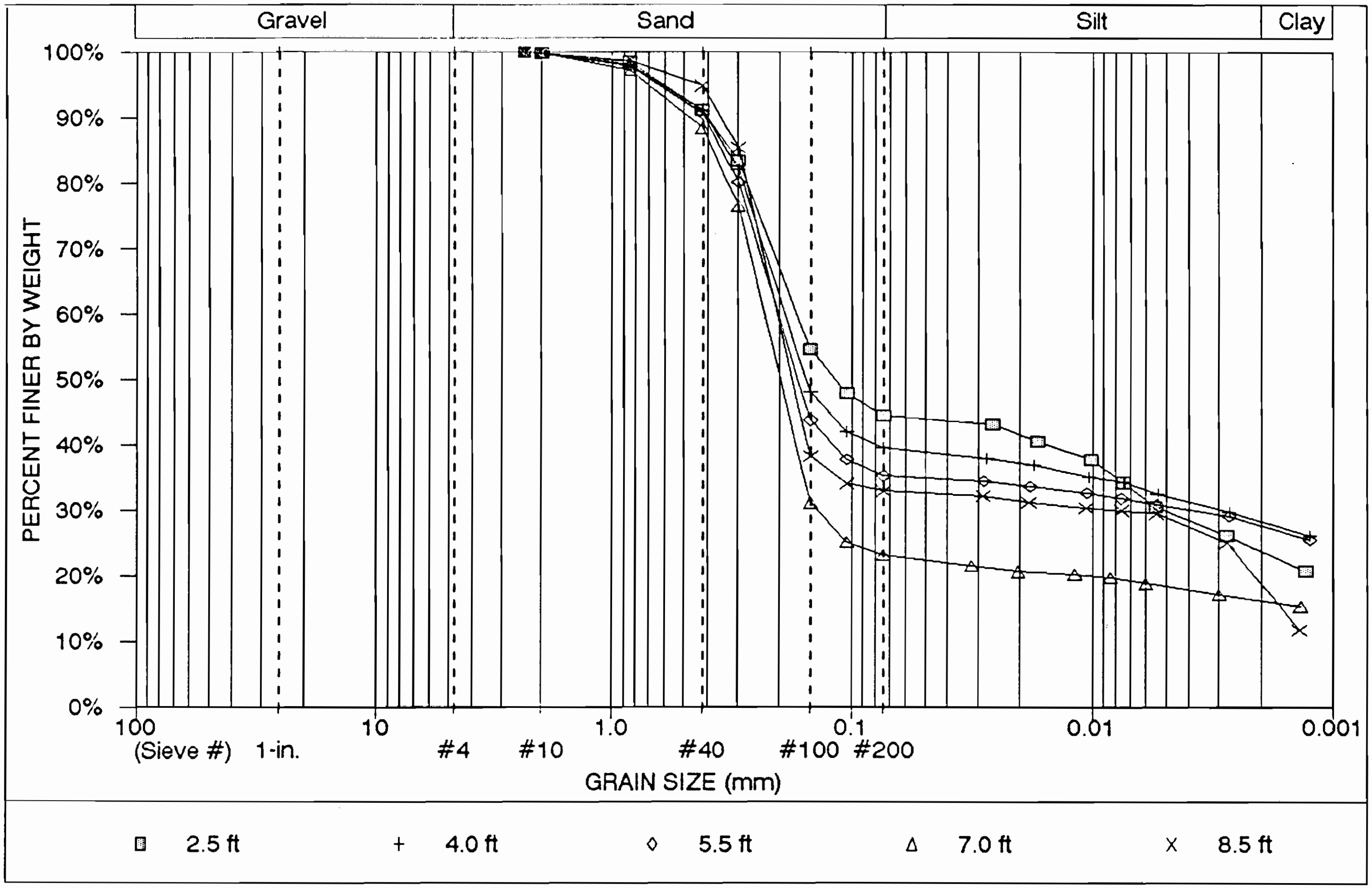
DEPTH ft.	BORING #	N60 blows/ft	N160 blows/ft	Qc (pt) bar
-33.0	B-2	22	16	87.9
-34.0				89.0
-34.5	B-2	8	6	89.7
-34.5	B-1	10	7	91.1
-35.0				100.9
-36.0	B-2	16	11	129.6
-36.0	B-1	16	11	124.3
-37.0				128.7
-37.5	B-1	12	8	137.8
-37.5	B-2	27	18	137.8
-38.0				126.6
-39.0	B-2	22	15	110.7
-39.0	B-1	24	16	118.8
-40.0				88.6
-40.5	B-2	13	9	84.0
-40.5	B-1	16	11	82.0
-41.0				91.7
-42.0				88.1
-42.5	B-1	9	6	96.5
-42.5	B-2	12	8	96.1
-43.0				90.3
-44.0	B-1	12	8	67.7
-44.0	B-2	28	18	67.5
-45.0				75.8

CARMEL CHURCH:
IN-SITU TEST
DATA SUMMARY

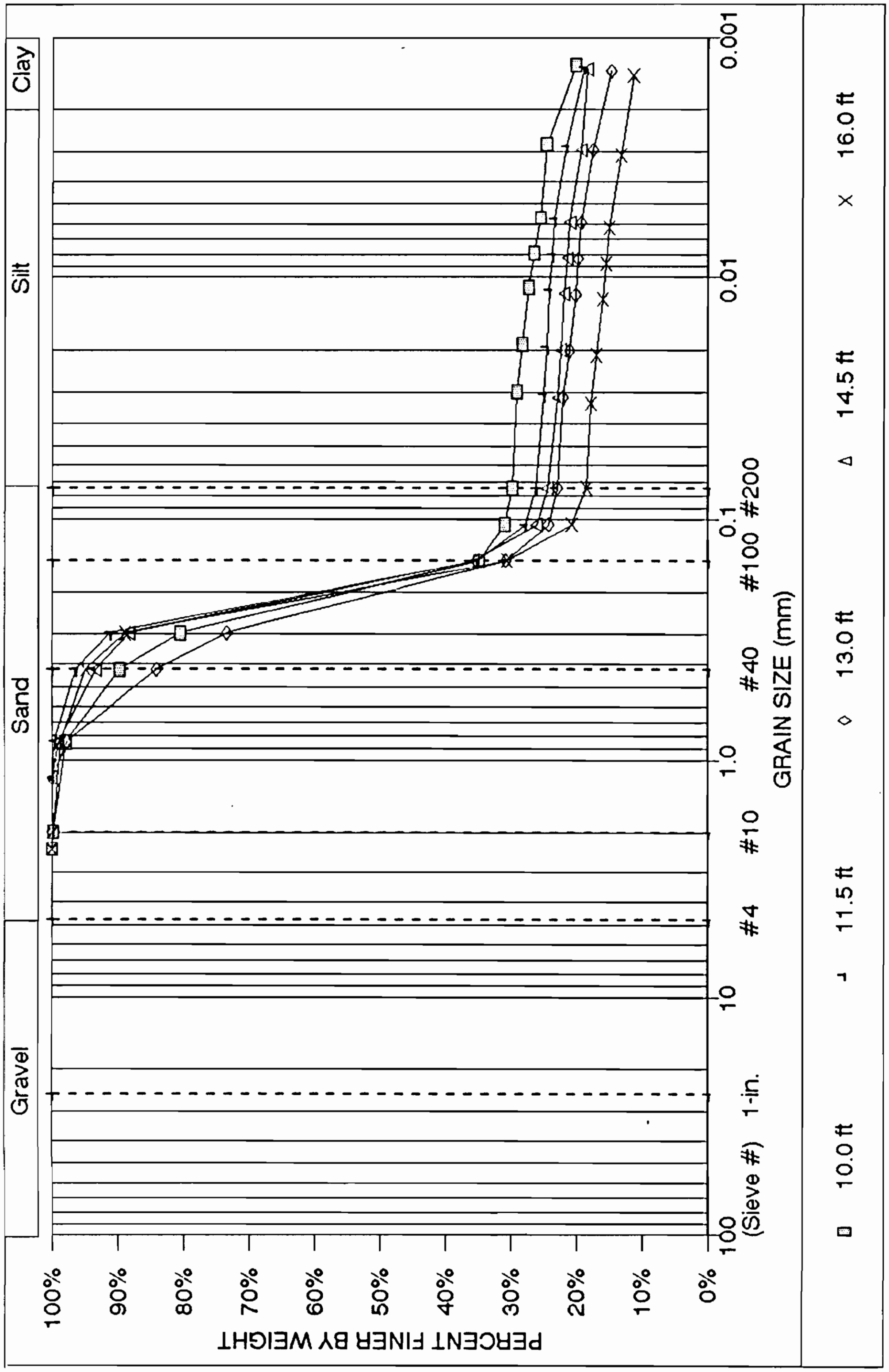
DEPTH ft.	Qn (pt) bar	ED bar	Gur kN/M^2	D50 (mm)	Qc (pt) /N
-33.0	62.6	144		3.537	4.00
-34.0	62.9	232			
-34.5	63.0	263		0.533	11.21
-34.5	64.0	263		0.533	9.11
-35.0	70.5	293			
-36.0	89.8	318		0.418	8.10
-36.0	86.1	318		0.418	7.77
-37.0	88.4	349			
-37.5	94.2	372		0.401	11.49
-37.5	94.1	372		0.401	5.10
-38.0	86.1	395			
-39.0	74.6	401		0.456	5.03
-39.0	80.0	401		0.456	4.95
-40.0	59.1	391			
-40.5	55.7	349		0.237	6.46
-40.5	54.5	349		0.237	5.13
-41.0	60.6	307			
-42.0	57.7	274			
-42.5	62.9	286			
-42.5	62.7	286			
-43.0	58.7	298			
-44.0	43.6	295		0.195	5.64
-44.0	43.4	295		0.195	2.41
-45.0	48.3	321			

CARMEL CHURCH:
IN-SITU TEST
DATA SUMMARY

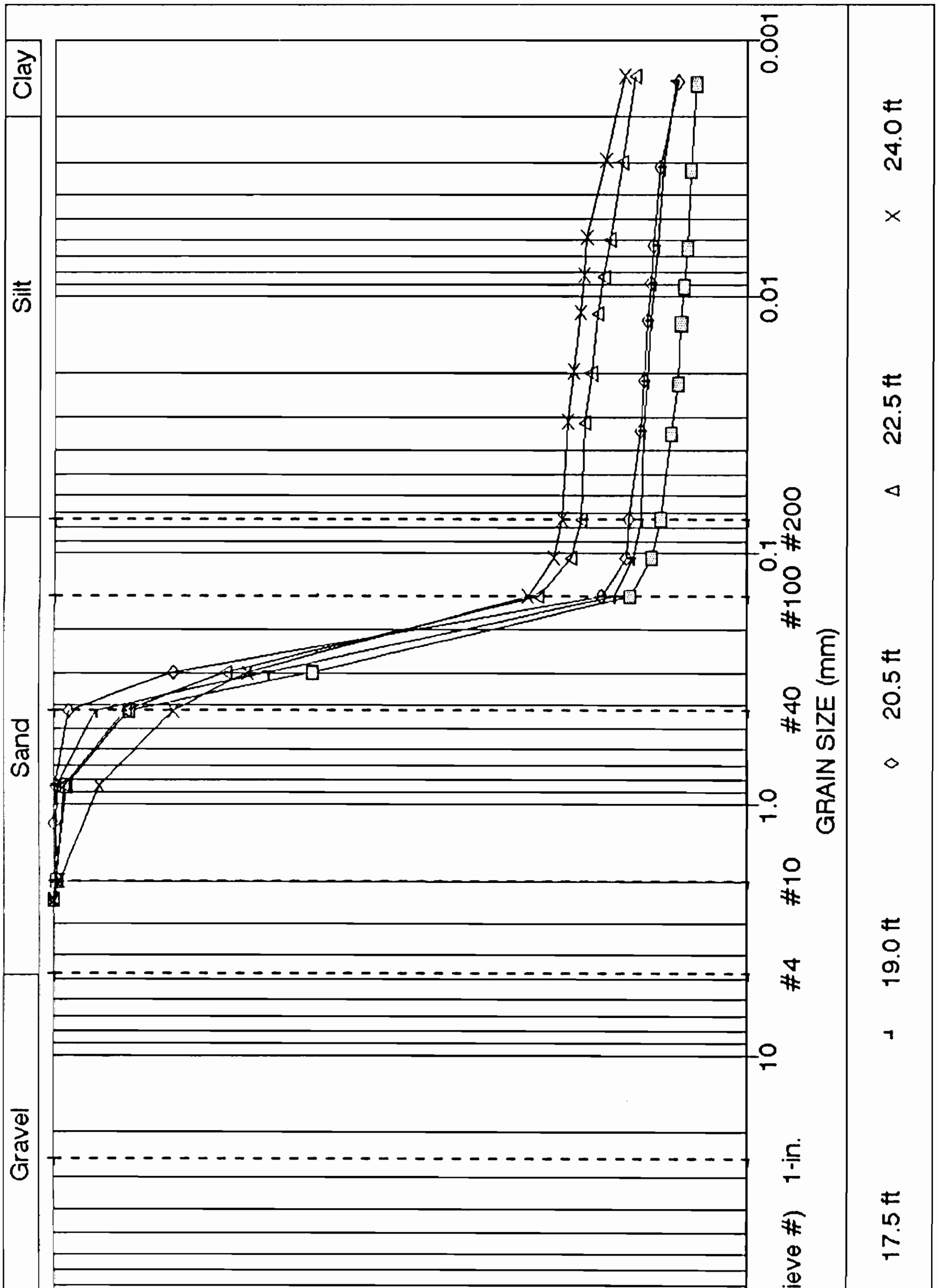
DEPTH ft.	Phi DMT	Phi SPT	Phi Qc
-33.0	37.3	38.0	36.8
-34.0	36.0		36.8
-34.5	37.0	33.3	36.8
-34.5	37.0	35.0	36.9
-35.0	38.1		37.4
-36.0	39.2	36.5	38.7
-36.0	39.2	36.5	38.5
-37.0	39.7		38.6
-37.5	40.1	35.5	39.0
-37.5	40.1	39.3	39.0
-38.0	40.5		38.5
-39.0	40.8	38.0	37.6
-39.0	40.8	38.5	38.0
-40.0	41.3		36.3
-40.5	38.9	35.8	36.0
-40.5	38.9	36.5	35.9
-41.0	36.4		36.5
-42.0	35.3		36.2
-42.5	35.2	34.2	36.6
-42.5	35.2	35.5	36.6
-43.0	35.2		36.2
-44.0	35.6	35.5	34.3
-44.0	35.6	39.5	34.3
-45.0	35.0		35.0



Carmel Church: Grain Size Data



Carmel Church: Grain Size Data



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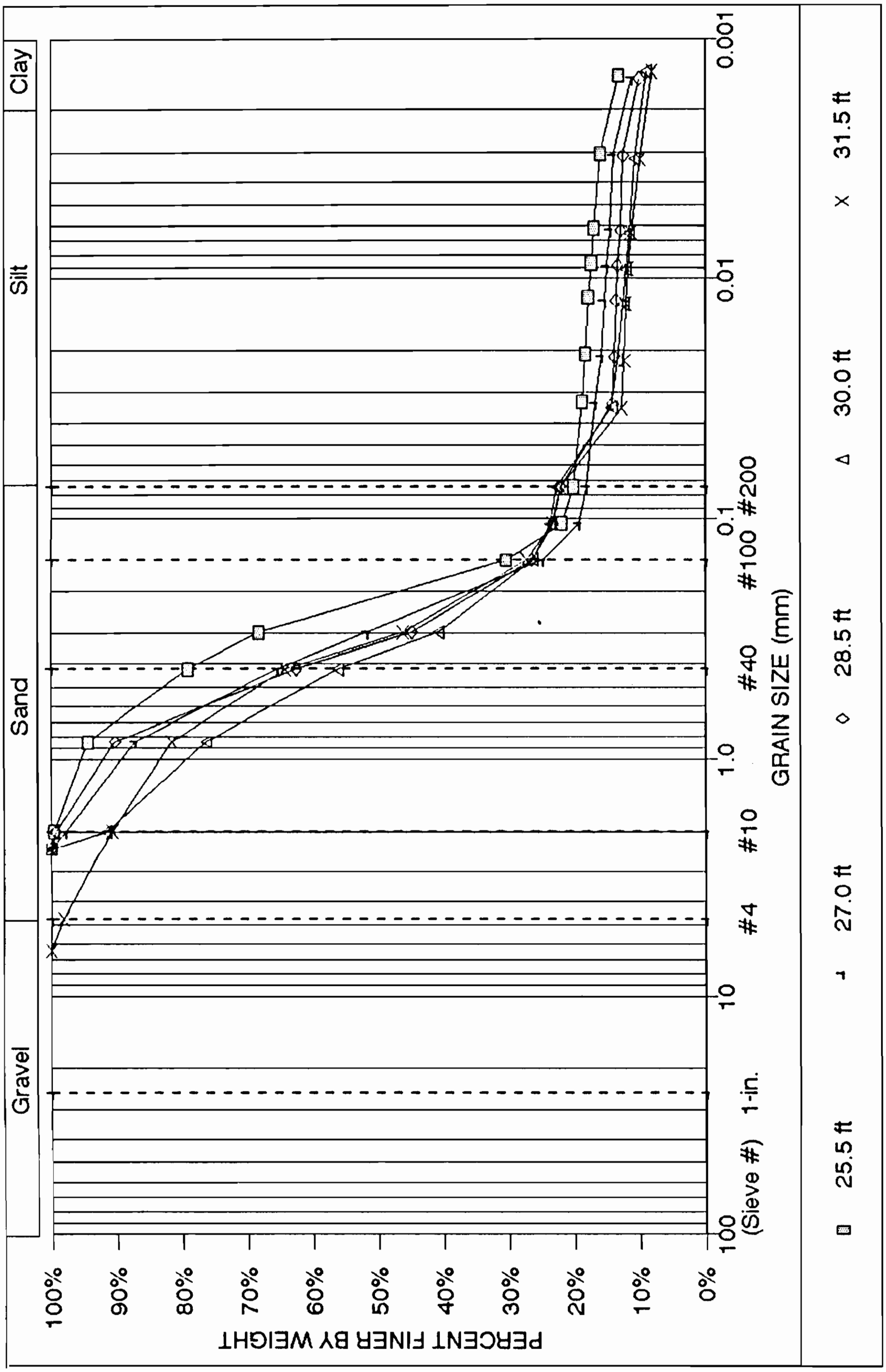
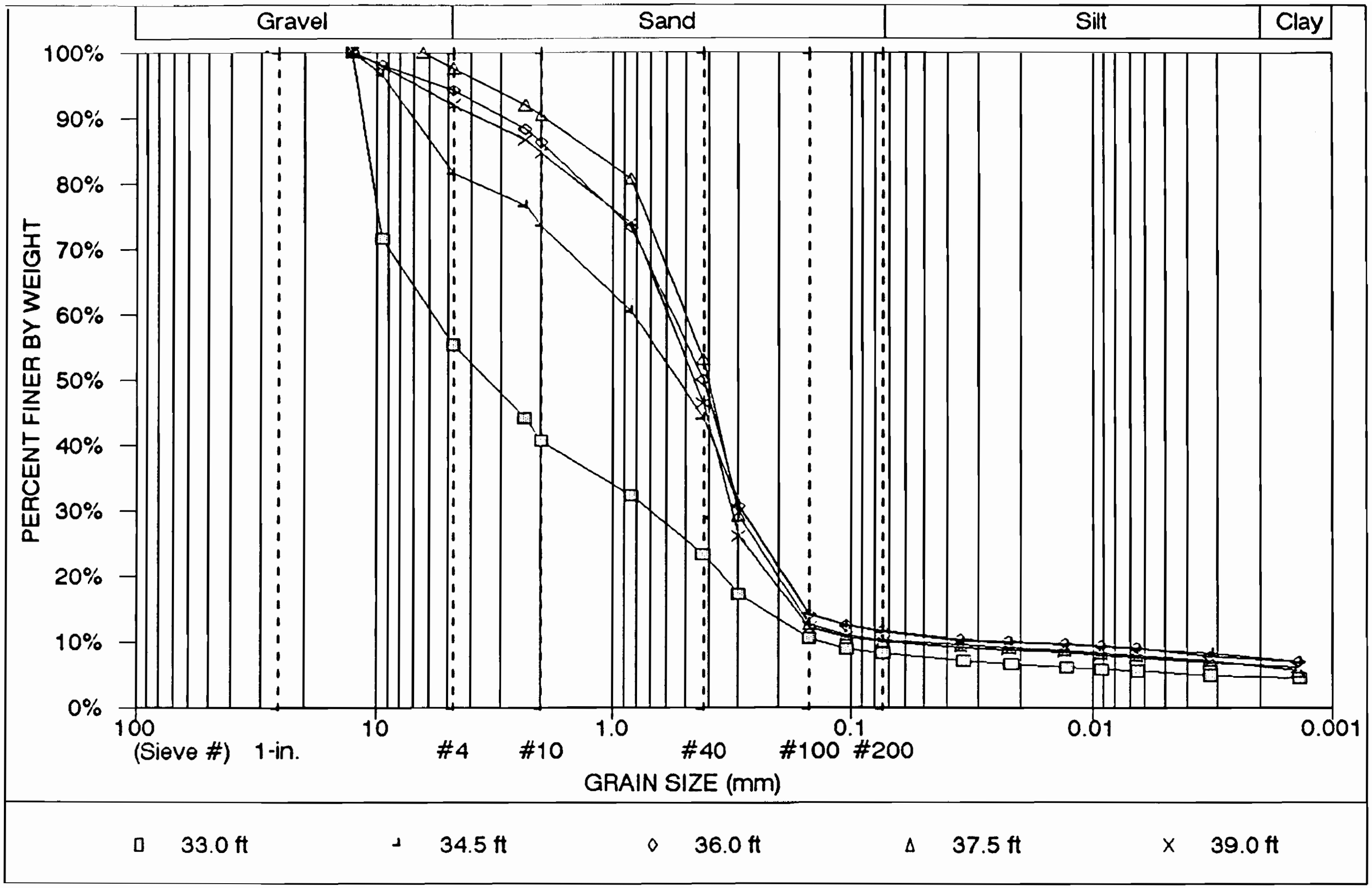
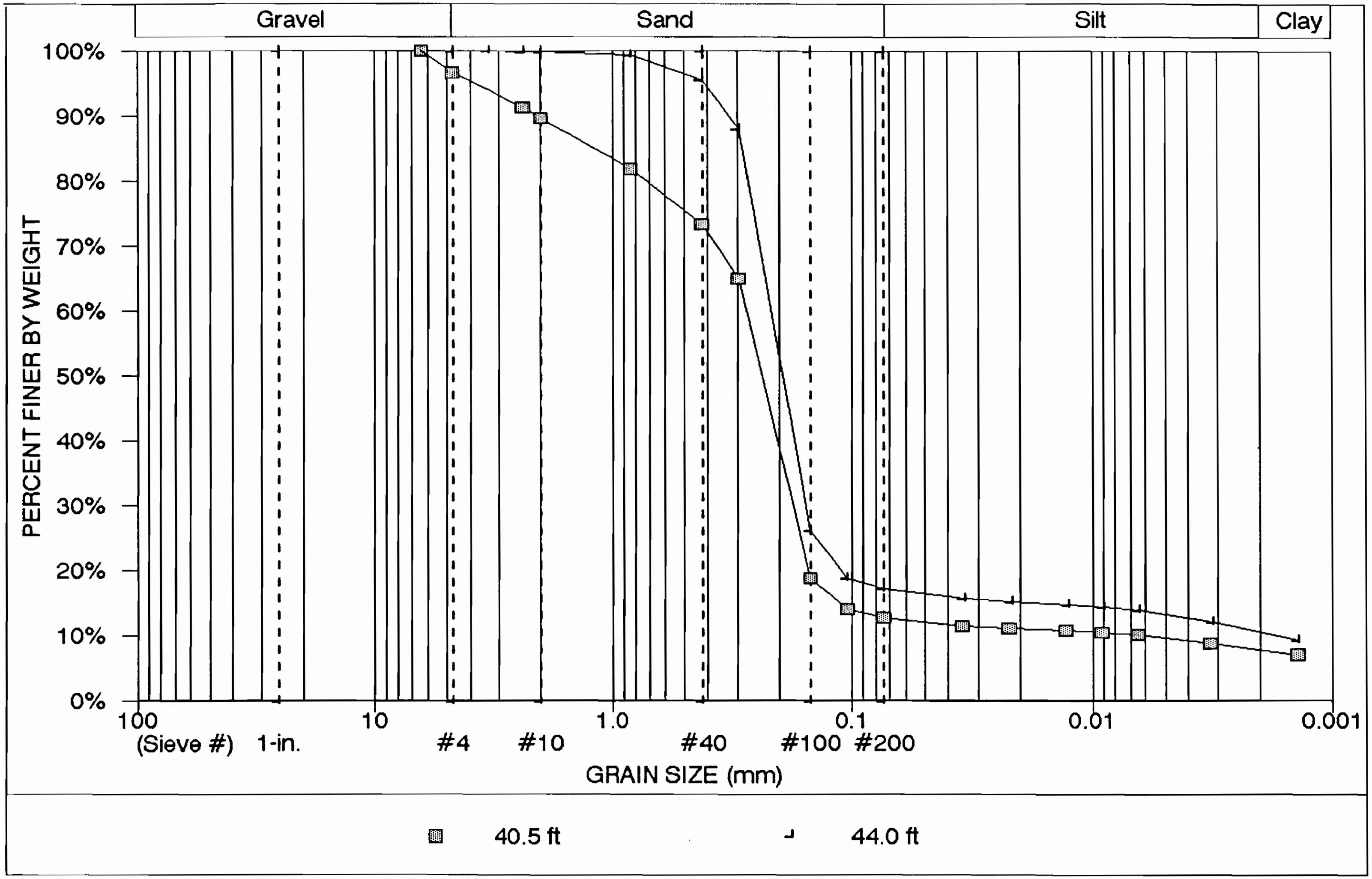


Carmel Church: Grain Size Data



Carmel Church: Grain Size Data



Carmel Church: Grain Size Data

CARMEL CHURCH:
LAB DATA
SUMMARY.
FROM B-1

DEPTH (ft)	SPECIFIC GRAVITY	D60 (mm)	D50 (mm)	D10 (mm)	Cu
-2.5	2.685	0.168	0.115		
-4.0	2.685		0.154		
-5.5	2.685		0.170		
-7.0	2.685		0.198		
-8.5	2.685	0.204	0.177	0.001	161
-10.0	2.685		0.187		
-11.5	2.685		0.179		
-13.0	2.685		0.203		
-14.5	2.685		0.179		
-16.0	2.650		0.187		
-17.5	2.650	0.285	0.245	0.022	13
-19.0	2.650	0.261	0.228	0.001	180
-20.5	2.650	0.230	0.207	0.002	149
-22.5	2.650		0.202		
-24.0	2.650		0.204		
-25.5	2.650		0.212		
-27.0	2.650	0.361	0.284	0.001	344
-28.5	2.650	0.396	0.328	0.001	267
-30.0	2.650	0.473	0.364	0.002	196
-31.5	2.650	0.385	0.318	0.003	117
-33.0	2.650	5.702	3.357	0.130	44
-34.5	2.650	0.811	0.533	0.028	29
-36.0	2.650	0.561	0.418	0.021	27
-37.5	2.650	0.494	0.401	0.065	8
-39.0	2.650	0.585	0.456	0.074	8
-40.5	2.650	0.275	0.237	0.006	44
-42.5					
-44.0		0.218	0.195	0.002	122

CARMEL CHURCH:
LAB DATA
SUMMARY.
FROM B-1

DEPTH (ft)	%-200	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	MOISTURE CONTENT %
-2.5	44.3%	29.1%	16.8%	12.3%	17.1%
-4.0	38.2%	25.3%	17.4%	7.9%	20.3%
-5.5	34.8%	35.7%	24.4%	11.3%	21.6%
-7.0	22.4%	NP			19.6%
-8.5	32.8%	35.3%	25.5%	9.8%	21.1%
-10.0	29.7%	28.4%	22.2%	6.2%	20.6%
-11.5	26.1%	28.2%	21.7%	6.5%	18.4%
-13.0	22.7%	24.1%	21.0%	3.1%	19.0%
-14.5	24.3%	26.5%	21.4%	5.1%	21.4%
-16.0	18.3%	NP			17.3%
-17.5	11.4%	NP			15.2%
-19.0	15.0%	NP			20.8%
-20.5	16.5%	NP			19.7%
-22.5	23.6%	NP			19.1%
-24.0	26.9%	25.6%	17.0%	8.6%	20.1%
-25.5	20.3%	NP			21.8%
-27.0	17.5%	NP			18.5%
-28.5	16.2%	NP			22.3%
-30.0	22.2%	NP			22.0%
-31.5	22.1%	NP			23.1%
-33.0	4.0%	NP			17.2%
-34.5	5.3%	NP			18.2%
-36.0	11.7%	NP			22.0%
-37.5	10.1%	NP			20.5%
-39.0	9.9%	NP			19.3%
-40.5	12.6%	NP			23.8%
-42.5		NP			26.6%
-44.0	17.13%	NP			26.2%

APPENDIX C

SCHNABEL

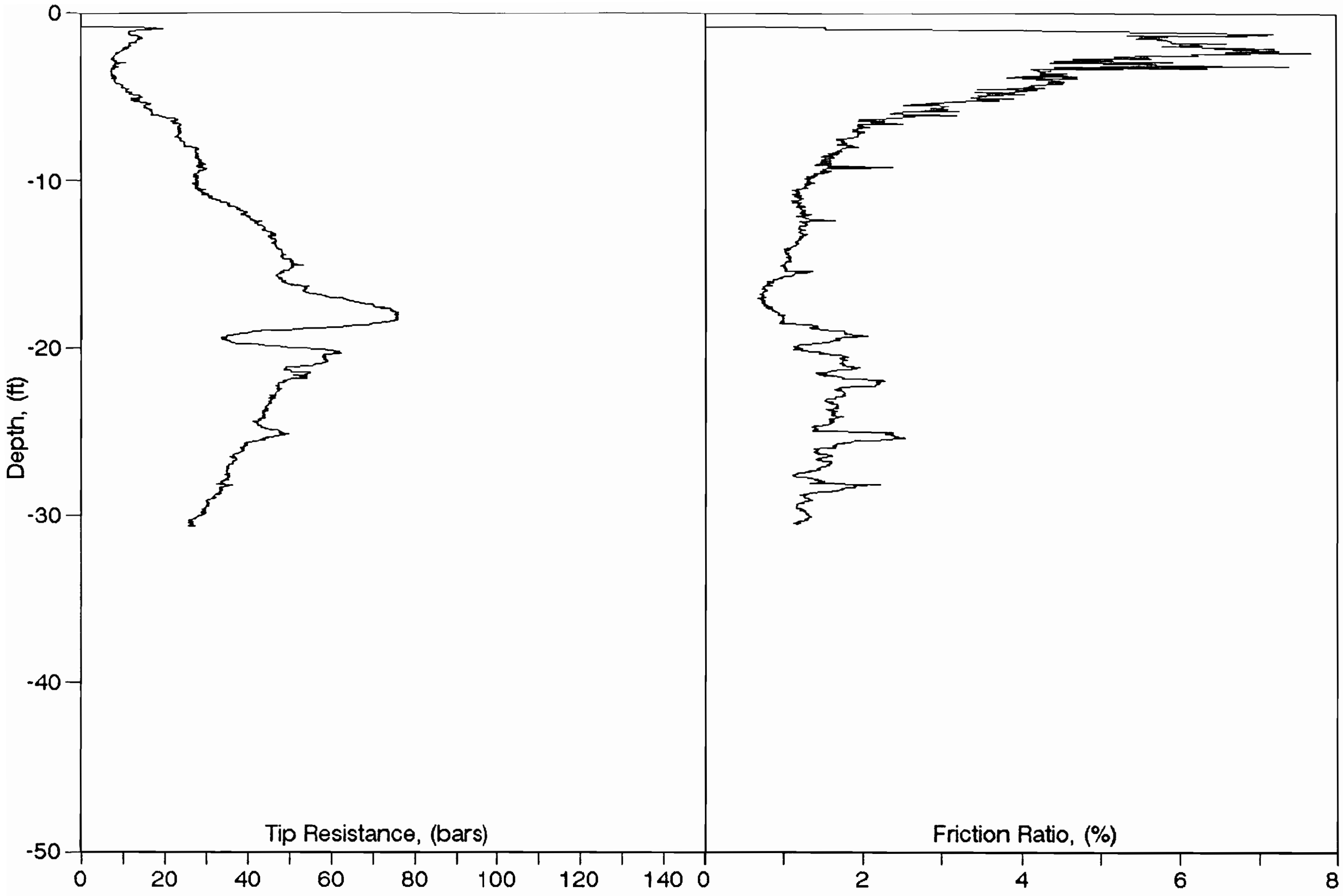
SCHNABEL: FIELD BORING LOG

BORING B-1
SAMPLING AND PRESSUREMETER TESTING TO 21.5 FT.
SAMPLES TAKEN WITH 300# HAMMER AND 3" SAMPLER
DRILLED 9/22/89 TO 9/25/89

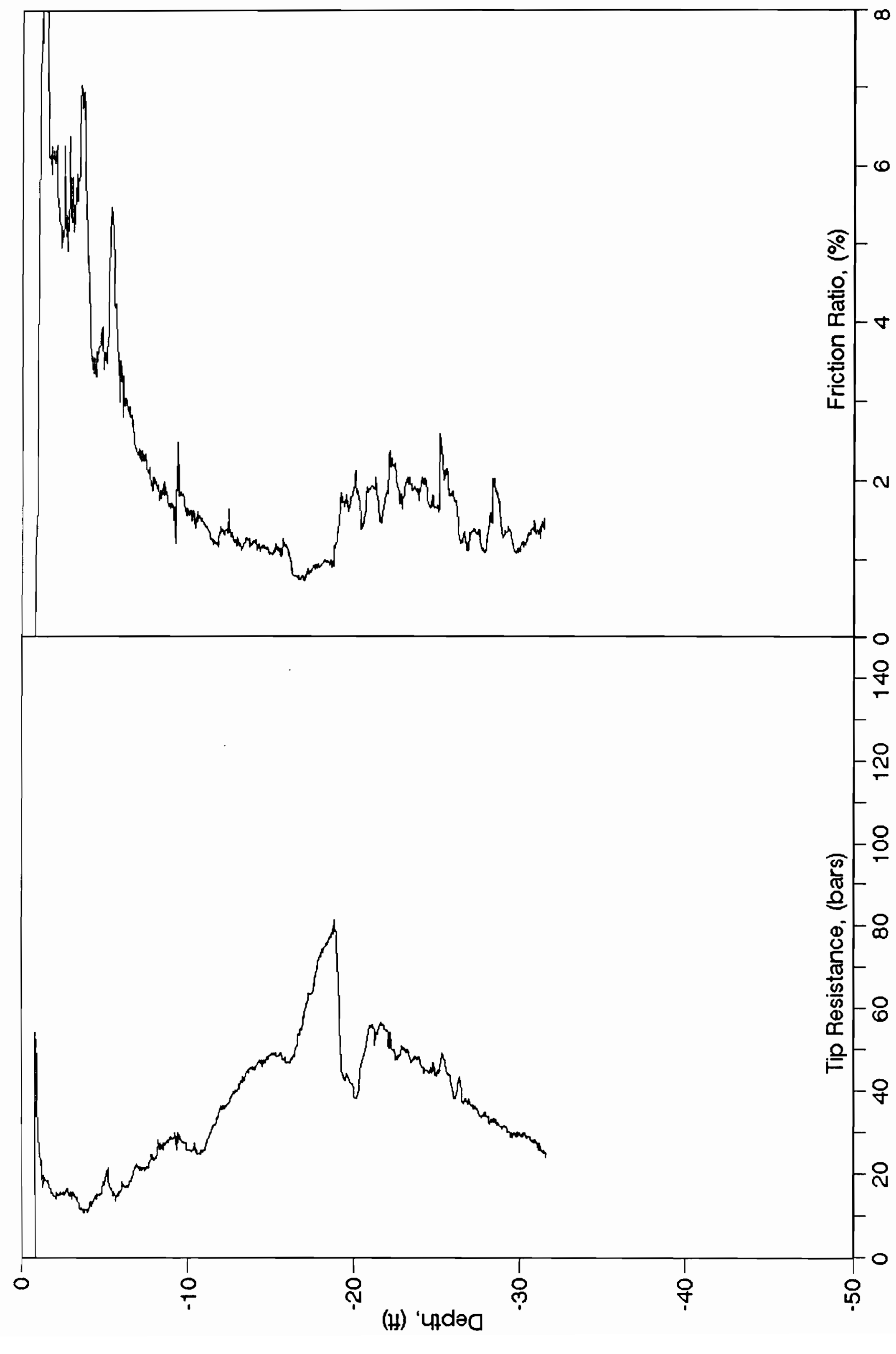
WATER TABLE = 10.0 FT.

DEPTH IN FT.		BLOW COUNT	DESCRIPTION
from	to	blows per 6 in.	
1.5 -	3.0	1 - 2 / 2	soft brown clay
3.0 -	4.5	1 - 2 / 3	medium orange-grey fine sandy clay
4.5 -	6.0	1 - 2 / 4	same to 6'6", then grey miocene clay
6.0 -	7.5	2 - 3 / 4	medium grey miocene clay
7.5 -	9.0	2 - 2 / 10	same, stiff
9.0 -	10.5	3 - 4 / 5	same
10.5 -	12.0	1 - 2 / 7	same
12.0 -	13.5	3 - 5 / 7	same
13.5 -	15.0	2 - 3 / 8	same
15.0 -	16.5	5 - 8 / 10	same, very stiff
16.5 -	18.0	3 - 4 / 13	same
18.0 -	19.5	6 - 10 / 15	same

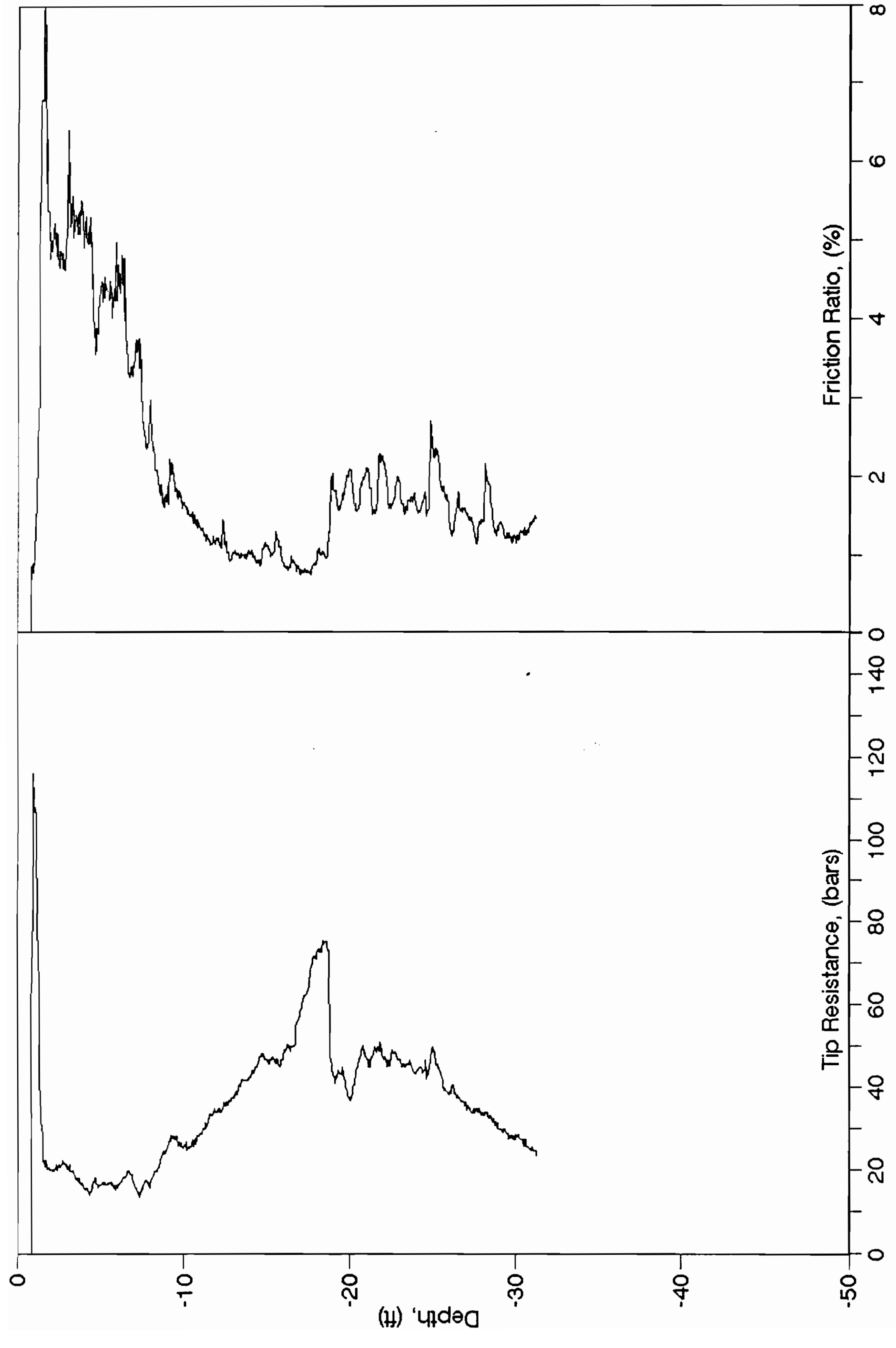
---END OF BORING---



Schnabel: Cone Test SNBC-1 05/18/89



Schnabel: Cone Test SNBC-2 05/18/89



Schnabel: Cone Test SNBC-3 05/18/89

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Virginia Polytechnic Institute                                                  TEST NO. SNB D-1
FILE NAME:     Dilatometer Test
FILE NUMBER:   09:45:00

RECORD OF DILATOMETER TEST NO. SNB D-1
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

     LOCATION: SCHNABEL
     PERFORMED - DATE:  09/21/89
                   BY:  MULLEN


     CALIBRATION INFORMATION:
     DELTA A =  .19 BARS   DELTA B    =  .33 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 3.05 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50     BLADE T=15.00 MM

     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3


  Z   THRUST    A      B     ED    ID    KD     UO    GAMMA    SV     PC    OCR     KO     CU    PHI     M      SOIL TYPE
 (M)   (KG)   (BAR)  (BAR)  (BAR)                (BAR)  (T/M3)  (BAR)  (BAR)                 (BAR)  (DEG)  (BAR)
***** ******  *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******  ************

  .30   757.   2.40   7.21   156.  1.90 40.26   .000  1.900   .059                                   596.9  SILTY SAND
  .61          2.50   4.61    58.   .64 22.95   .000  1.700   .114    5.1  45.0   3.00   .528          190.4  CLAYEY SILT
  .91          2.09   4.18    57.   .75 13.44   .000  1.700   .164    3.2  19.5   2.20   .390          159.0  CLAYEY SILT
 1.22          2.58   6.06   108.  1.19 12.17   .000  1.700   .216    3.6  16.7   2.07                 289.6     SILT
 1.52   235.   3.04   7.82   155.  1.48 11.30   .000  1.800   .267   12.9  48.3   1.95          16.2   406.0  SANDY SILT
 1.83          7.63  11.55   124.   .47 23.66   .000  1.900   .323   15.3  47.2   3.06  1.561          410.7  SILTY CLAY
 2.13          8.83  13.85   164.   .54 23.19   .000  1.900   .379   17.3  45.7   3.02  1.785          540.5  SILTY CLAY
 2.44          8.78  13.20   142.   .47 20.08   .000  1.900   .437   16.0  36.5   2.78  1.718          449.0  SILTY CLAY
 2.74          9.10  14.15   165.   .52 18.38   .000  1.900   .493   15.7  31.8   2.65  1.736          507.8  SILTY CLAY
 3.05         12.00  13.00    17.   .04 22.15   .000  1.800   .549   23.4  42.6   2.94  2.441           56.9   OFF CHART
 3.35         13.81  19.00   170.   .36 23.92   .029  1.900   .574   27.6  48.0   3.07  2.810          565.9  SILTY CLAY
 3.66         16.40  23.00   222.   .39 26.87   .060  2.050   .604   34.8  57.5   3.28  3.417          761.1  SILTY CLAY
 3.96         20.05  28.45   287.   .42 31.12   .089  2.050   .635   45.9  72.4   3.56  4.316         1026.3  SILTY CLAY
 4.27         21.00  29.65   296.   .41 30.99   .120  2.050   .667   47.9  71.9   3.55  4.510         1057.7  SILTY CLAY
 4.57         24.05  32.25   280.   .34 33.98   .149  2.050   .698   57.9  83.0   3.73  5.294         1023.6     CLAY
 4.88         24.80  33.95   314.   .37 33.41   .180  2.050   .730   59.0  80.8   3.70  5.422         1145.2  SILTY CLAY
 5.18         24.80  33.05   282.   .33 32.07   .209  2.050   .761   57.7  75.9   3.62  5.370         1014.9     CLAY
 5.49         29.20  38.25   311.   .31 36.24   .239  2.050   .793   72.7  91.8   3.87  6.519         1155.9     CLAY
 5.79         33.50  45.55   420.   .37 39.89   .269  2.050   .823   87.8 106.6   4.07  7.635         1600.5  SILTY CLAY
 6.10         19.65  27.20   256.   .38 22.43   .299  2.050   .855   37.1  43.4   2.97  3.863          836.3  SILTY CLAY
 6.40         19.05  25.80   227.   .35 20.99   .329  2.050   .886   34.7  39.1   2.86  3.682          726.8  SILTY CLAY
 6.71         21.00  29.50   291.   .41 22.25   .359  2.050   .918   39.4  42.9   2.95  4.105          947.0  SILTY CLAY
 7.01         22.05  30.95   305.   .41 22.58   .389  2.050   .949   41.6  43.9   2.98  4.322          998.8  SILTY CLAY
 7.32         20.00  27.35   249.   .37 19.80   .419  2.050   .981   35.1  35.8   2.76  3.791          783.1  SILTY CLAY
 7.62         18.65  26.40   263.   .42 17.82   .448  2.050  1.012   30.7  30.3   2.60  3.426          802.6  SILTY CLAY
 7.92         21.05  29.90   304.   .43 19.51   .478  2.050  1.043   36.4  34.9   2.74  3.955          950.8  SILTY CLAY
 8.23         16.70  23.35   223.   .40 14.96   .508  2.050  1.075   24.8  23.1   2.35  2.924          643.5  SILTY CLAY
 8.53         15.95  22.20   209.   .39 13.85   .538  2.050  1.106   22.6  20.5   2.24  2.733          586.3  SILTY CLAY
 8.84         15.75  21.95   207.   .40 13.26   .568  2.050  1.138   21.8  19.1   2.19  2.663          572.7  SILTY CLAY
 9.14         14.30  20.35   201.   .43 11.67   .598  1.900  1.166   18.3  15.7   2.02  2.328          533.2  SILTY CLAY
END OF SOUNDING
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Virginia Polytechnic Institute                                                     TEST NO. SNB D-3
FILE NAME:     Dilatometer Test
FILE NUMBER:   13:50:00

RECORD OF DILATOMETER TEST NO. SNB D-3
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

     LOCATION: SCHNABEL
     PERFORMED - DATE:  09/21/89
                   BY:  MULLEN

     CALIBRATION INFORMATION:
     DELTA A =  .18 BARS   DELTA B    =  .30 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 3.05 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50     BLADE T=15.00 MM

     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3

  Z   THRUST   A      B     ED     ID    KD     UO    GAMMA   SV      PC   OCR     KO     CU    PHI      M       SOIL TYPE
 (M)   (KG)  (BAR)  (BAR)  (BAR)                (BAR) (T/M3) (BAR)  (BAR)               (BAR) (DEG)  (BAR)
***** ****** *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******  ***********

  .30          3.10  15.90   449.  4.86 45.15    .000  1.900   .059                                  1762.8      SAND
  .61          3.94   7.52   113.   .82 34.39    .000  1.800   .115     9.8  84.6   3.76   .888        414.5   CLAYEY SILT
  .91          3.33   6.54    99.   .85 20.05    .000  1.800   .168     6.1  36.4   2.78   .660        314.2   CLAYEY SILT
 1.22          2.64   5.06    71.   .75 12.29    .000  1.700   .222     3.8  17.0   2.09   .472        190.5   CLAYEY SILT
 1.52          4.24   7.95   118.   .80 15.60    .000  1.800   .273     6.7  24.6   2.41   .783        343.7   CLAYEY SILT
 1.83          4.40   8.18   120.   .78 13.47    .000  1.800   .328     6.4  19.6   2.21   .782        334.5   CLAYEY SILT
 2.13          5.78  10.20   144.   .72 15.13    .000  1.800   .381     9.0  23.5   2.36  1.051        415.2   CLAYEY SILT
 2.44          6.08   9.38   103.   .48 14.05    .000  1.800   .436     9.1  20.9   2.26  1.096        289.9   SILTY CLAY
 2.74          9.74  14.40   152.   .45 19.82    .000  1.900   .490    17.5  35.8   2.76  1.895        479.4   SILTY CLAY
 3.05         12.65  17.70   167.   .38 23.00    .000  1.900   .548    24.7  45.2   3.01  2.553        547.6   SILTY CLAY
 3.35         12.75  17.40   152.   .34 22.10    .029  1.900   .574    24.4  42.4   2.94  2.545        493.9      CLAY
 3.66         14.50  19.95   181.   .36 23.89    .060  1.900   .602    28.8  47.9   3.07  2.939        602.0   SILTY CLAY
 3.96         17.25  24.10   232.   .39 27.00    .089  2.050   .630    36.6  58.0   3.29  3.589        798.5   SILTY CLAY
 4.27         20.00  27.90   270.   .40 29.73    .120  2.050   .662    44.6  67.4   3.47  4.253        954.7   SILTY CLAY
 4.57         22.20  30.65   290.   .38 31.49    .149  2.050   .693    51.1  73.7   3.58  4.784       1041.4   SILTY CLAY
 4.88         24.65  32.95   285.   .34 33.45    .180  2.050   .725    58.7  81.0   3.70  5.397       1038.0      CLAY
 5.18         24.00  32.20   281.   .34 31.19    .209  2.050   .756    54.9  72.6   3.56  5.156       1006.1      CLAY
 5.49         28.50  38.60   351.   .36 35.48    .239  2.050   .788    70.0  88.8   3.82  6.312       1296.5   SILTY CLAY
 5.79         34.30  46.70   434.   .37 41.05    .269  2.050   .819    91.3 111.5   4.14  7.870       1666.4   SILTY CLAY
 6.10         21.20  29.40   281.   .39 24.32    .299  2.050   .851    41.9  49.3   3.10  4.251        939.9   SILTY CLAY
 6.40         20.85  29.45   296.   .42 23.02    .329  2.050   .882    39.9  45.2   3.01  4.112        973.1   SILTY CLAY
 6.71         25.35  34.75   325.   .38 27.06    .359  2.050   .914    53.2  58.2   3.29  5.216       1118.8   SILTY CLAY
 7.01         22.10  30.65   294.   .39 22.75    .389  2.050   .945    41.9  44.4   2.99  4.341        963.9   SILTY CLAY
 7.32         20.35  29.20   305.   .45 20.16    .419  2.050   .977    35.9  36.8   2.79  3.860        964.9   SILTY CLAY
 7.62         19.20  26.95   265.   .41 18.43    .448  2.050  1.008    32.2  32.0   2.65  3.559        815.5   SILTY CLAY
 7.92         19.40  28.55   316.   .49 17.98    .478  2.050  1.038    31.9  30.7   2.61  3.556        965.1   SILTY CLAY
 8.23         16.70  23.40   227.   .41 15.00    .508  2.050  1.070    24.8  23.2   2.35  2.924        653.6   SILTY CLAY
 8.53         15.95  22.50   221.   .42 13.88    .538  2.050  1.101    22.6  20.5   2.25  2.730        621.6   SILTY CLAY
 8.84         15.25  21.95   227.   .45 12.84    .568  2.050  1.133    20.6  18.2   2.14  2.548        620.2   SILTY CLAY
 9.14         13.40  20.60   245.   .56 10.86    .598  2.050  1.164    16.3  14.0   1.94  2.124        631.3   SILTY CLAY
END OF SOUNDING
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Virginia Polytechnic Institute                                                 TEST NO. SNB D-4
FILE NAME:     Dilatometer Test
FILE NUMBER:   15:20:00

RECORD OF DILATOMETER TEST NO. SNB D-4
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTHANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

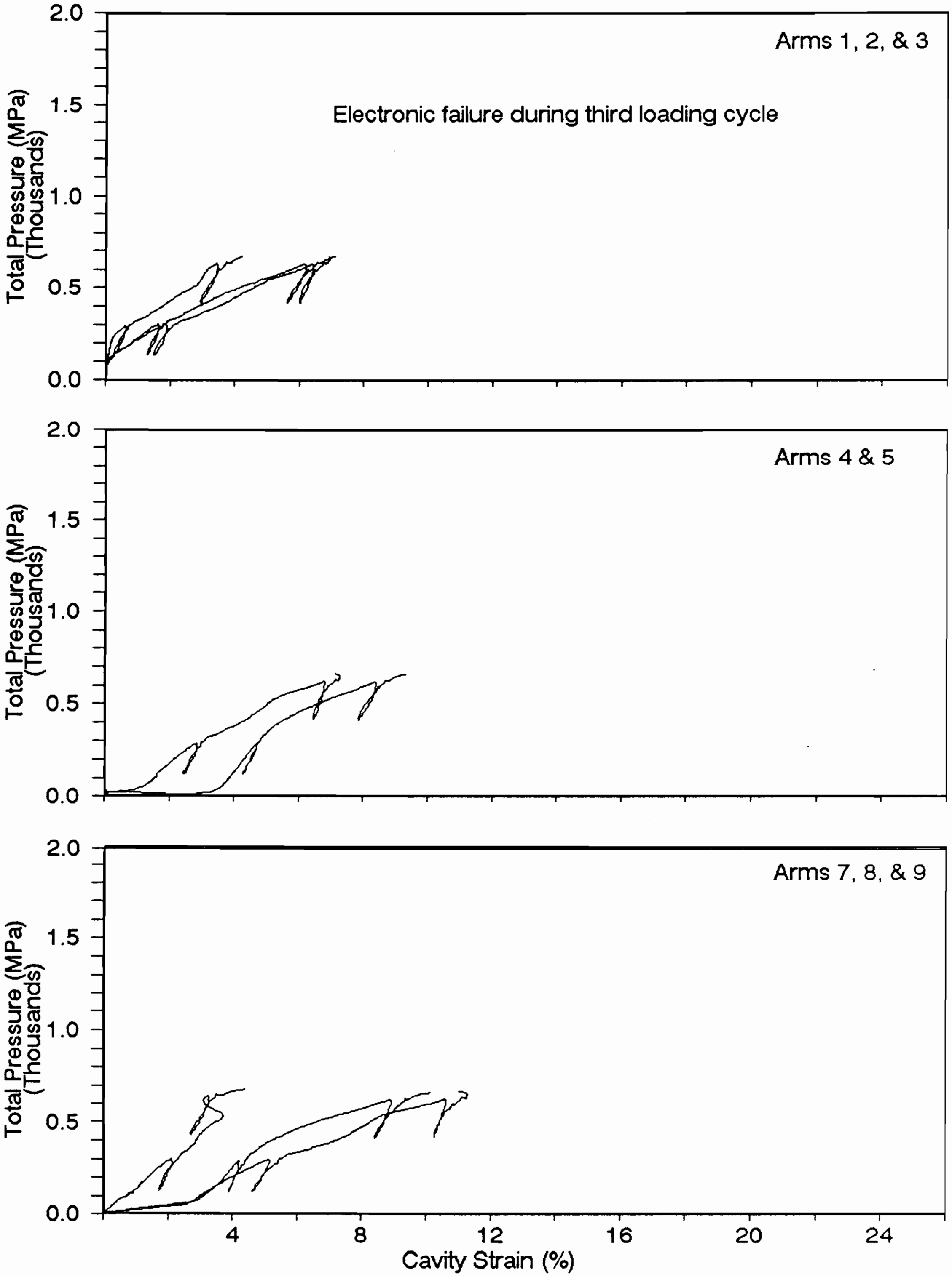
     LOCATION: SCHNABEL
     PERFORMED - DATE:  09/21/89
                   BY:  MULLEN


     CALIBRATION INFORMATION:
     DELTA A =  .19 BARS   DELTA B    =  .30 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 3.05 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50      BLADE T=15.00 MM

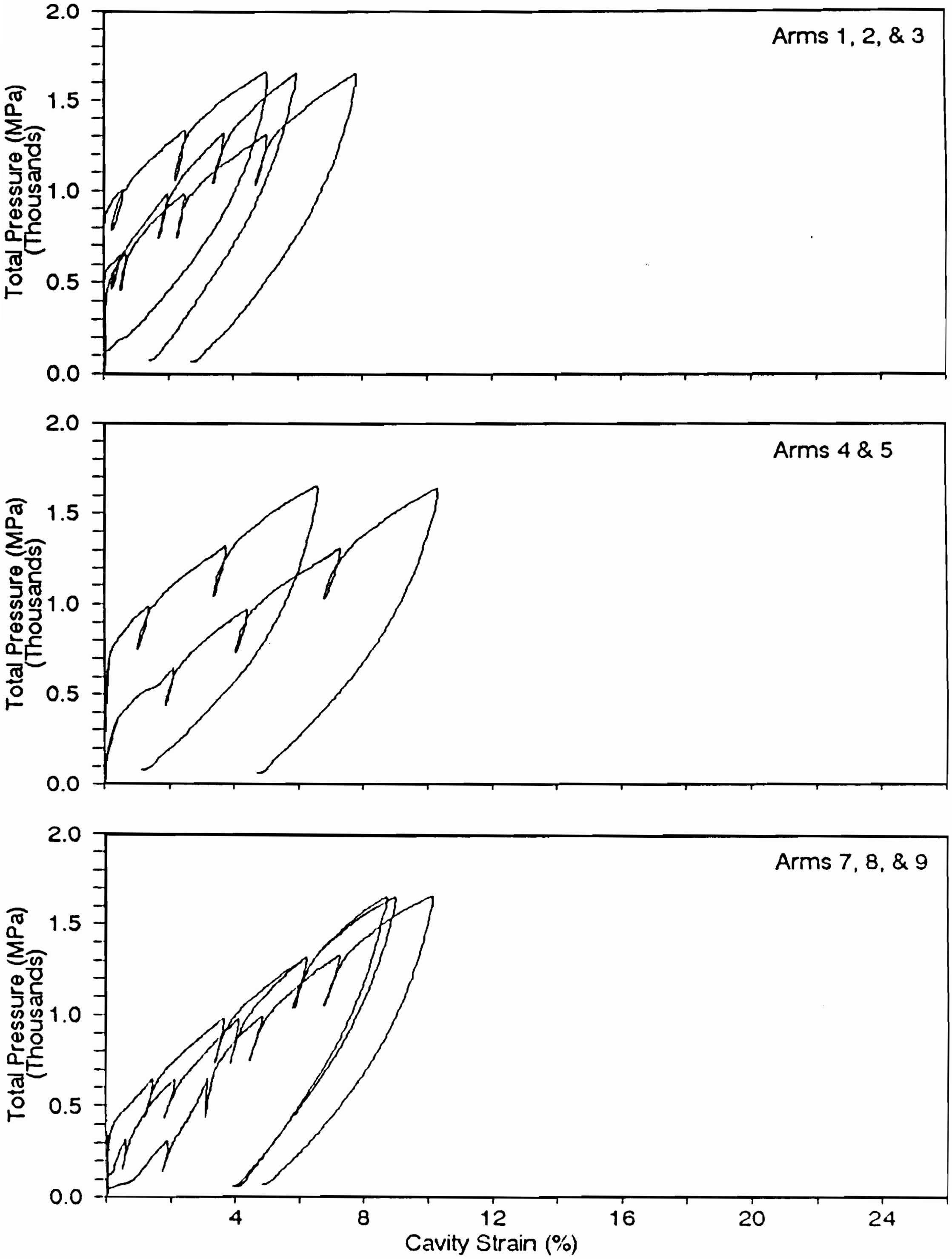
     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3


  Z   THRUST    A      B      ED    ID    KD      UO    GAMMA   SV      PC    OCR     KO     CU    PHI      M       SOIL TYPE
 (M)   (KG)   (BAR)  (BAR)  (BAR)                (BAR)  (T/M3) (BAR)   (BAR)                (BAR) (DEG)  (BAR)
***** ****** *****  *****  ***** ***** *****   ****** ****** ******  ***** *****   *****   ***** *****  ******   ***********

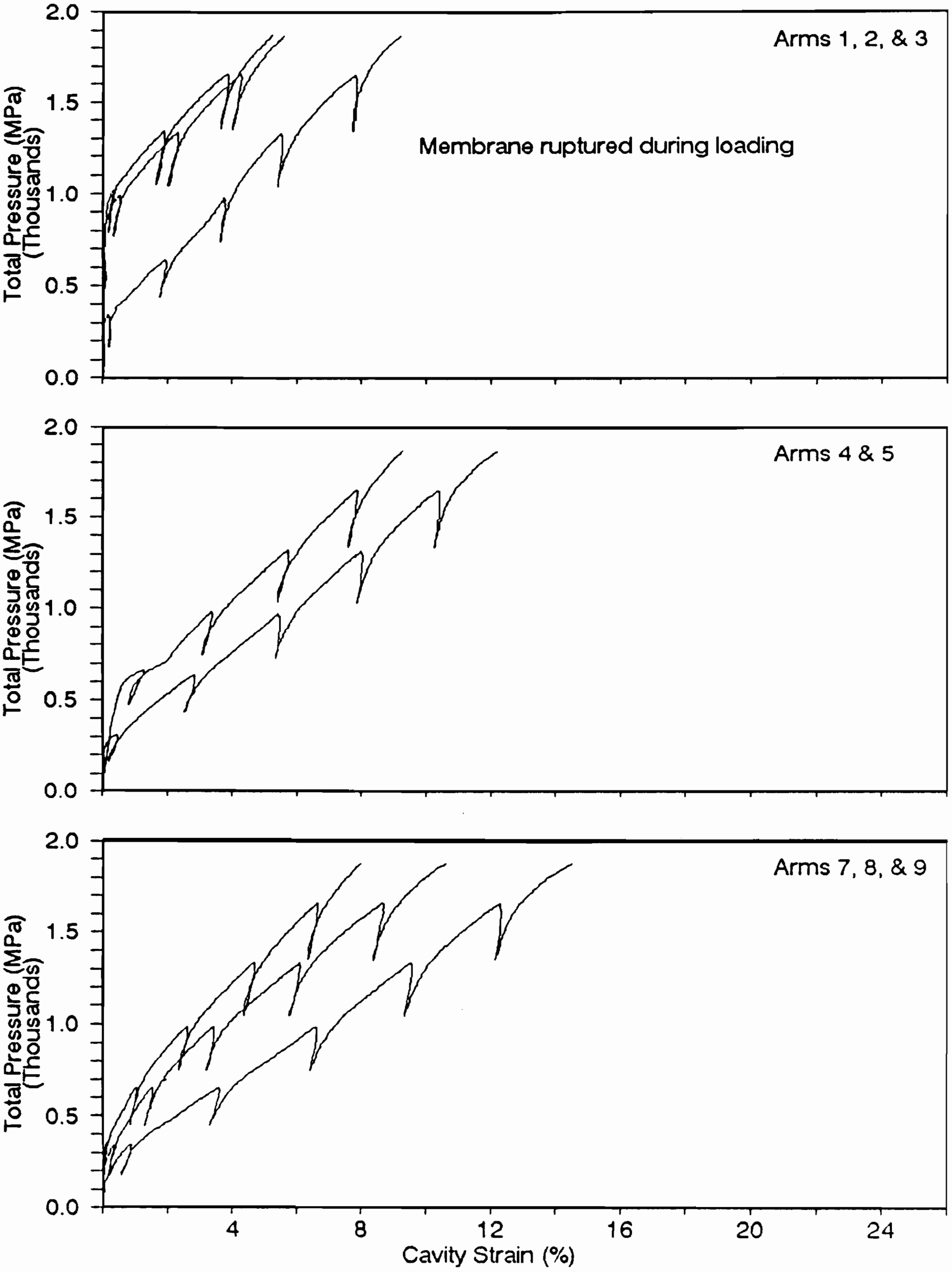
  .30          2.80  17.00   500.  6.25 39.06    .000  1.900   .059                                     1893.2      SAND
  .61          4.87   9.06   135.   .80 42.29    .000  1.800   .115    13.5 116.8   4.20  1.150          521.1   CLAYEY SILT
  .91          4.38   7.52    97.   .63 26.37    .000  1.800   .168     9.4  55.9   3.25   .930          330.0   CLAYEY SILT
 1.22          3.67   7.44   120.   .93 16.57    .000  1.800   .223     6.0  27.1   2.49                 355.9      SILT
 1.52          4.79   8.54   119.   .71 17.45    .000  1.800   .276     8.1  29.4   2.57   .911          359.6   CLAYEY SILT
 1.83          4.71   8.28   112.   .68 14.35    .000  1.800   .331     7.2  21.6   2.29   .854          318.9   CLAYEY SILT
 2.13          4.62   8.94   140.   .87 12.03    .000  1.800   .384     6.3  16.4   2.06   .796          373.3   CLAYEY SILT
 2.44          5.11   8.95   122.   .69 11.70    .000  1.800   .439     6.9  15.7   2.03   .878          323.3   CLAYEY SILT
 2.74          7.00  11.95   163.   .67 14.11    .000  1.950   .494    10.4  21.1   2.27  1.249          459.2   CLAYEY SILT
 3.05         10.20  15.25   166.   .47 18.40    .000  1.900   .552    17.6  31.9   2.65  1.947          511.3   SILTY CLAY
 3.35         10.70  15.45   155.   .42 18.40    .029  1.900   .579    18.4  31.9   2.65  2.040          477.6   SILTY CLAY
 3.66         13.95  19.70   192.   .40 22.79    .060  1.900   .606    27.0  44.5   2.99  2.793          628.6   SILTY CLAY
 3.96         17.10  23.40   212.   .36 26.64    .089  2.050   .635    36.0  56.8   3.27  3.553          725.6   SILTY CLAY
 4.27         18.75  25.60   232.   .36 27.75    .120  2.050   .667    40.3  60.5   3.34  3.928          803.2   SILTY CLAY
 4.57         22.20  30.55   286.   .38 31.31    .149  2.050   .698    51.0  73.1   3.57  4.780         1025.4   SILTY CLAY
 4.88         24.10  32.20   277.   .34 32.52    .180  2.050   .730    56.6  77.5   3.65  5.242         1002.8      CLAY
 5.18         24.00  32.00   274.   .33 31.04    .209  2.050   .761    54.8  72.1   3.55  5.154          977.5      CLAY
 5.49         29.00  38.75   337.   .34 35.94    .239  2.050   .793    71.8  90.6   3.85  6.452         1252.1      CLAY
 5.79         35.00  47.05   421.   .35 41.71    .269  2.050   .823    94.1 114.3   4.17  8.073         1622.4   SILTY CLAY
 6.10         21.90  29.20   248.   .33 25.08    .299  2.050   .855    44.2  51.7   3.16  4.440          836.3      CLAY
 6.40         21.45  30.40   308.   .43 23.57    .329  2.050   .886    41.6  46.9   3.05  4.257         1020.8   SILTY CLAY
 6.71         23.90  32.00   277.   .34 25.43    .359  2.050   .918    48.5  52.8   3.18  4.850          938.2      CLAY
 7.01         22.20  30.65   290.   .39 22.76    .389  2.050   .949    42.2  44.4   2.99  4.365          950.9   SILTY CLAY
 7.32         20.05  28.60   294.   .44 19.79    .419  2.050   .981    35.0  35.7   2.76  3.788          924.0   SILTY CLAY
 7.62         21.30  28.95   261.   .36 20.44    .448  2.050  1.012    38.0  37.6   2.81  4.068          828.7   SILTY CLAY
 7.92         19.60  28.25   297.   .45 18.13    .478  2.050  1.043    32.5  31.1   2.63  3.608          910.7   SILTY CLAY
 8.23         16.15  22.55   215.   .40 14.45    .508  2.050  1.075    23.5  21.9   2.30  2.802          613.4   SILTY CLAY
 8.53         16.20  22.60   215.   .40 14.07    .538  2.050  1.106    23.2  21.0   2.26  2.787          607.9   SILTY CLAY
 8.84         15.15  21.25   204.   .41 12.74    .568  2.050  1.138    20.4  18.0   2.13  2.532          557.8   SILTY CLAY
 9.14         14.00  20.00   201.   .43 11.42    .598  1.900  1.166    17.7  15.1   2.00  2.264          527.1   SILTY CLAY
END OF SOUNDING
```



Schnabel: Pressuremeter Test SNBP-1 09/22/89



Schnabel: Pressuremeter Test SNBP-2 09/22/89



Schnabel: Pressuremeter Test SNBP-3 09/25/89

SCHNABEL:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	BORING #	N60	N160	Qc (pt) bar
-1.0				51.6
-2.0				15.1
-2.5	B-1	4	7	14.9
-3.0				14.3
-4.0	B-1	5	8	11.5
-5.0				16.8
-5.5	B-1	6	9	15.6
-6.0				16.4
-7.0	B-1	7	10	20.7
-8.0				22.0
-8.5	B-1	12	16	24.9
-9.0				27.4
-10.0	B-1	9	12	26.1
-11.0				28.4
-11.5	B-1	9	11	32.8
-12.0				36.3
-13.0	B-1	12	15	41.4
-14.0				44.9
-14.5	B-1	11	13	46.5
-15.0				48.5
-15.5				48.0
-16.0	B-1	18	21	47.5
-17.0				59.9
-17.5	B-1	17	19	65.9
-18.0				73.7
-18.5				74.2
-19.0	B-1	25	27	52.4
-20.0				43.4

SCHNABEL: IN-SITU TEST DATA SUMMARY

DEPTH ft.	Qn (pt) bar	ED bar	Gur kN/M^2	D50 N
-1.0	97.5	368		
-2.0	27.1	102		
-2.5	26.1	93		
-3.0	24.6	84		
-4.0	18.8	100		0.09
-5.0	26.4	131		
-5.5	24.0	125		0.006
-6.0	24.7	119		
-7.0	30.0	149		0.007
-8.0	30.5	122		
-8.5	34.0	141		0.005
-9.0	36.7	160	18411	
-10.0	33.7	117		0.007
-11.0	36.0	159		
-11.5	41.2	179		0.011
-12.0	45.3	198		
-13.0	50.7	244		0.009
-14.0	53.9	266		
-14.5	55.3	276		0.009
-15.0	57.2	285		
-15.5	56.0	289	35537	
-16.0	55.0	292		0.016
-17.0	68.1	279		
-17.5	74.3	306		0.037
-18.0	82.3	333		
-18.5	82.2	379	41885	
-19.0	57.5	425		0.033
-20.0	46.8	262		

SCHNABEL:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Qc (pt) /N	Su DMT	Su N60 (bars)	Nk = 10 Su Qc (bars)
-1.0				
-2.0		0.855		1.501
-2.5		0.758	0.945	1.474
-3.0		0.660		1.415
-4.0	2.30	0.157	1.182	1.128
-5.0		0.565		1.652
-5.5	2.60	0.815	1.418	1.531
-6.0		1.066		1.605
-7.0	2.96	1.211	1.654	2.032
-8.0		1.231		2.152
-8.5	2.07	1.429	2.971	2.442
-9.0		1.627		2.690
-10.0	2.90	2.314	2.160	2.559
-11.0		2.465		2.779
-11.5	3.64	2.757	2.160	3.217
-12.0		3.050		3.575
-13.0	3.45	3.819	2.971	4.077
-14.0		4.230		4.422
-14.5	4.23	4.592	2.701	4.581
-15.0		4.953		4.782
-15.5		5.153		4.724
-16.0	2.64	5.354	4.537	4.677
-17.0		5.227		5.912
-17.5	3.88	5.827	4.285	6.516
-18.0		6.428		7.288
-18.5		7.144		7.343
-19.0	2.10	7.859	6.301	5.156
-20.0		4.185		4.250

SCHNABEL:
IN-SITU TEST
DATA SUMMARY

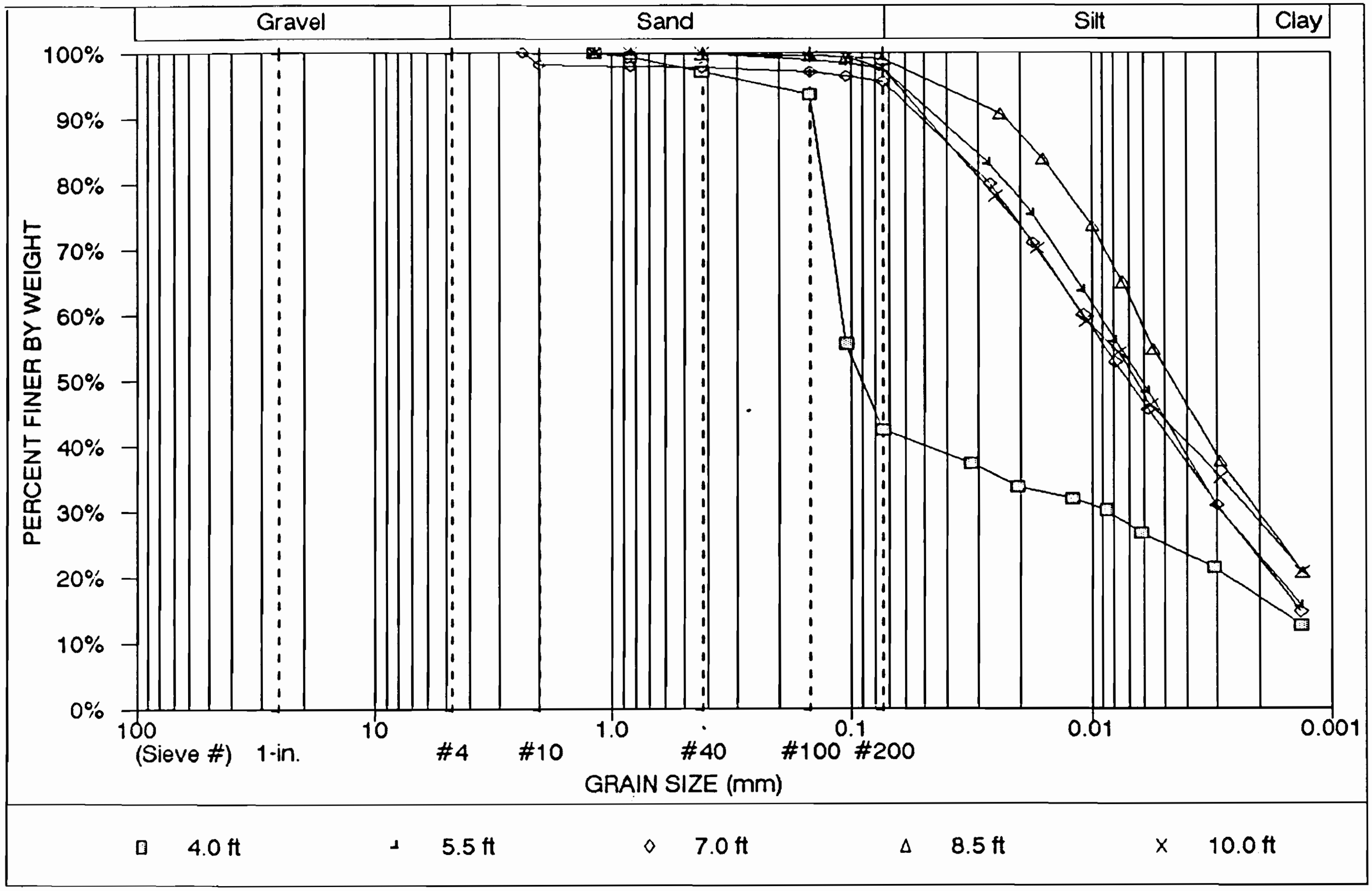
DEPTH ft.	BORING #	N60	N160	Qc (pt) bar
-21.0				53.0
-22.0				50.4
-23.0				47.5
-24.0				44.8
-25.0				47.3
-26.0				38.3
-27.0				36.5
-28.0				33.7
-29.0				31.3
-30.0				29.2

SCHNABEL:
IN-SITU TEST
DATA SUMMARY

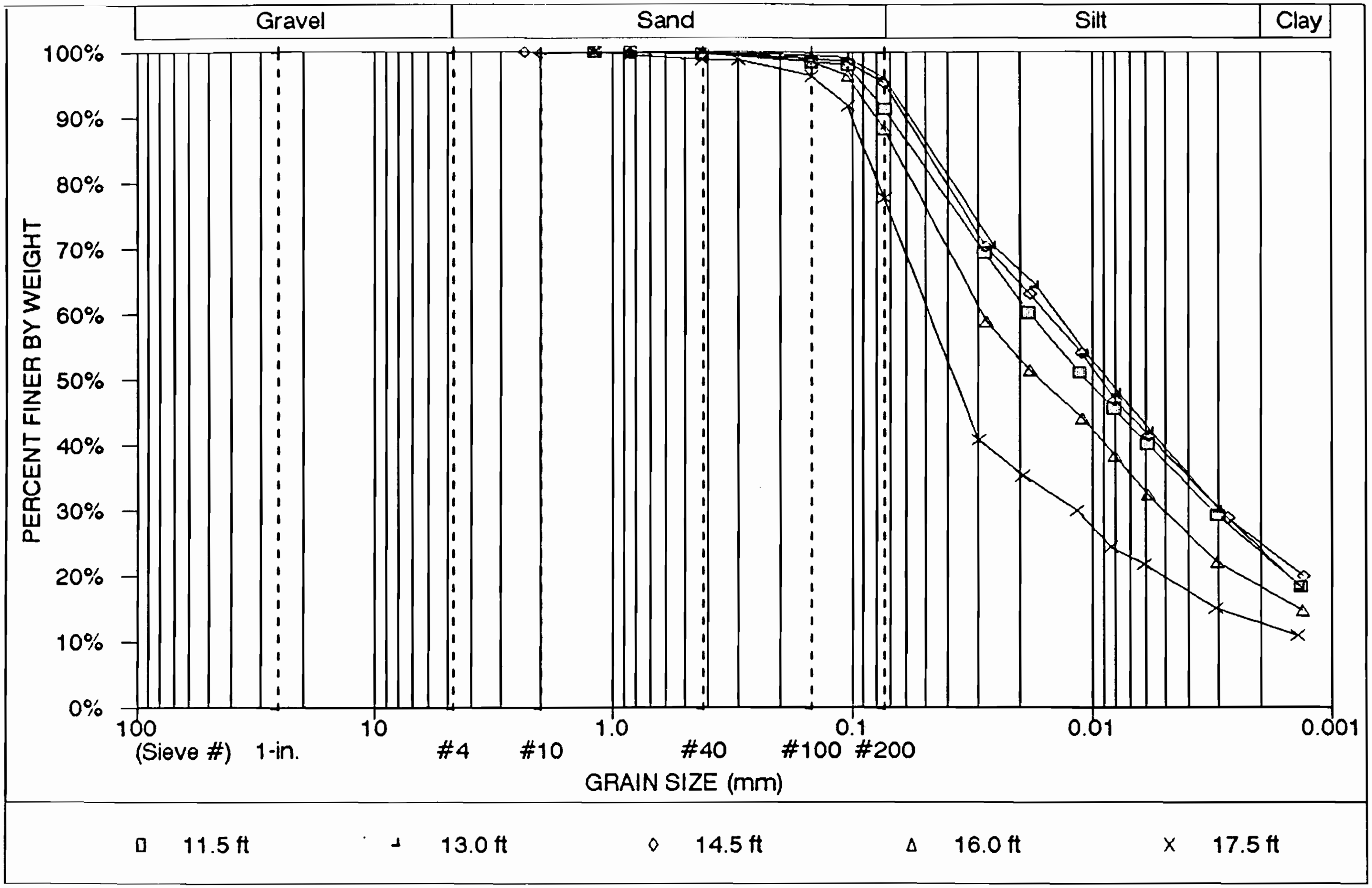
DEPTH ft.	Qn (pt) bar	ED bar	Gur kN/M^2	D50 N
-21.0	56.3	277		
-22.0	52.6	298		
-23.0	48.7	296		
-24.0	45.3	283		
-25.0	47.0	263		
-26.0	37.5	306		
-27.0	35.2	222		
-28.0	32.0	215		
-29.0	29.3	213		
-30.0	27.0	216		

SCHNABEL:
IN-SITU TEST
DATA SUMMARY

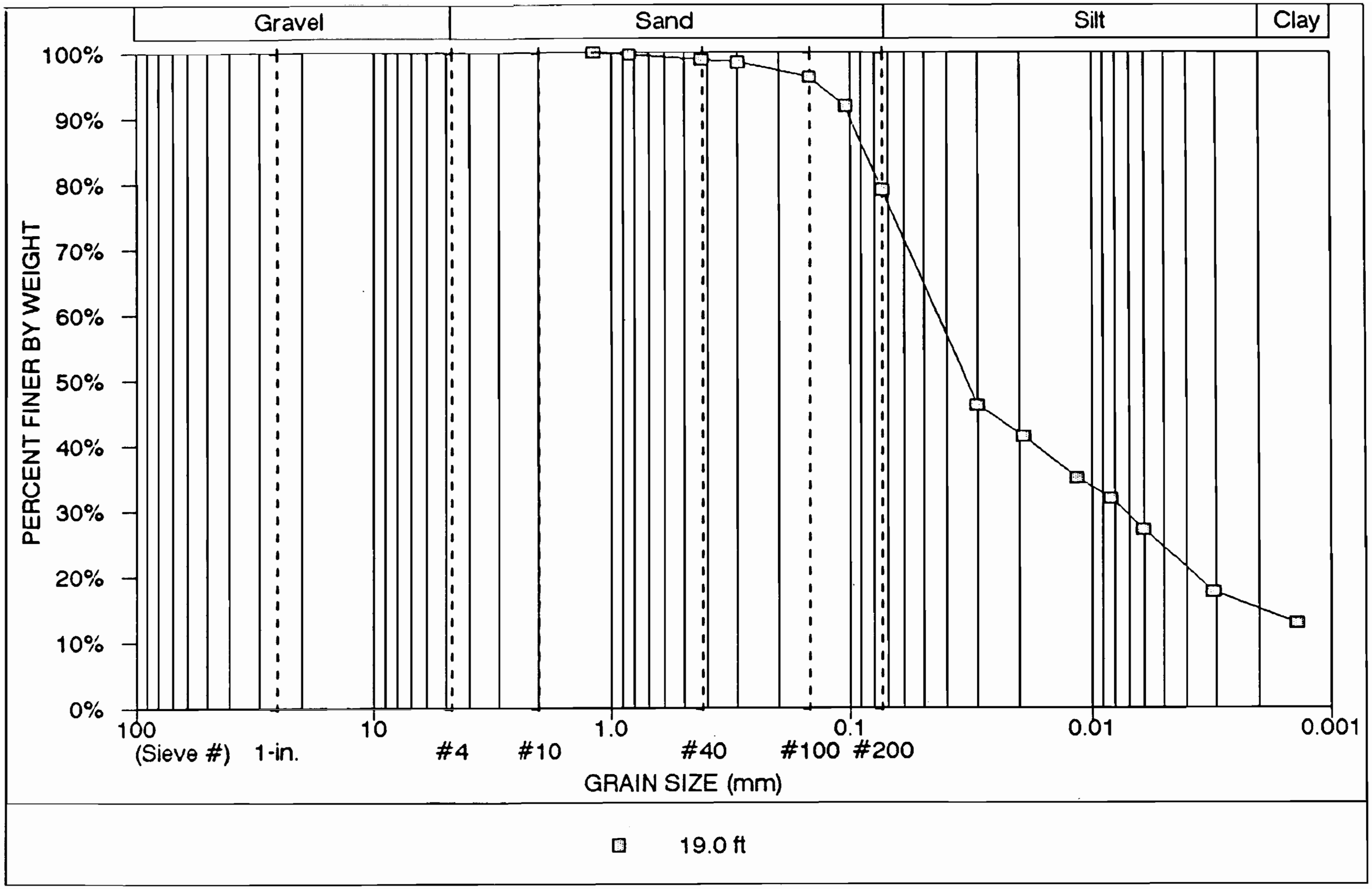
DEPTH ft.	Qc (pt) /N	Su DMT	Su N60 (bars)	Nk = 10 Su Qc (bars)
-21.0		4.017		5.216
-22.0		4.724		4.948
-23.0		4.343		4.652
-24.0		3.813		4.384
-25.0		3.684		4.625
-26.0		3.706		3.726
-27.0		2.883		3.538
-28.0		2.750		3.260
-29.0		2.581		3.019
-30.0		2.239		2.804



Schnabel: Grain Size Data



Schnabel: Grain Size Data



Schnabel: Grain Size Data

SCHNABEL:
LAB DATA
SUMMARY
FROM B-1.

DEPTH (ft)	SPECIFIC GRAVITY	D60 (mm)	D50 (mm)	D10 (mm)	Cu
-4.0	2.731	0.110	0.090	0.001	99
-5.5	2.757	0.009	0.006	0.001	9
-7.0	2.757	0.011	0.007	0.001	10
-8.5	2.757		0.005		
-10.0	2.757		0.007		
-11.5	2.757	0.018	0.011	0.001	24
-13.0	2.757	0.014	0.009	0.001	17
-14.5	2.757		0.009		
-16.0	2.757	0.029	0.016	0.001	36
-17.5	2.757	0.048	0.037	0.001	40
-19.0	2.757	0.043	0.033	0.001	48

SCHNABEL:
LAB DATA
SUMMARY
FROM B-1.

DEPTH (ft)	%-200	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	MOISTURE CONTENT %
-4.0	42.3%	37.7%	23.2%	14.5%	34.2%
-5.5	97.5%	83.4%	28.3%	55.1%	50.8%
-7.0	95.5%	81.3%	28.2%	53.1%	51.6%
-8.5	99.0%	86.0%	29.3%	56.7%	55.4%
-10.0	97.6%	75.9%	24.0%	51.9%	52.9%
-11.5	91.4%	74.6%	21.2%	53.4%	49.4%
-13.0	96.0%	74.7%	23.4%	51.3%	47.7%
-14.5	95.0%	74.3%	23.5%	50.8%	46.0%
-16.0	88.2%	66.7%	22.3%	44.4%	42.6%
-17.5	77.6%	51.5%	22.3%	29.2%	29.8%
-19.0	79.0%	54.0%	28.7%	25.3%	33.0%

APPENDIX D

LADY SMITH

LADYSMITH: FIELD BORING LOGS

BORING B-1
CONTINUOUS SAMPLING TO 30 FT.
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 5/17/89

WATER TABLE = 2.0 FT.

DEPTH IN FT.		BLOW COUNT	DESCRIPTION
from	to	blows per 6 in.	
1.5 -	3.0	3 - 4 / 3	medium gray fine sandy clay (possible fill)
3.0 -	4.5	1 - 3 / 4	same, medium, more sand
4.5 -	6.0	3 - 8 / 11	medium gray fine sand
6.0 -	7.5	16 - 17 / 13	medium gray fine sand w/ gravel
7.5 -	9.0	4 - 4 / 7	same, medium, w/trace of gravel
9.0 -	10.5	11 - 11 / 10	same, layer change @ 9.0" to very stiff green silt
10.5 -	12.0	3 - 7 / 13	same, very stiff
12.0 -	13.5	6 - 11 / 22	same, very stiff
13.5 -	15.5	* - * / *	--tube sample attempted-- tube ripped from sample head
16.5 -	18.0	9 - 10 / 50	same, very stiff
18.0 -	19.5	11 - 14 / 34	same, very stiff
19.5 -	21.0	8 - 19 / 41	same, very stiff
21.5 -	23.0	15 - 17 / 50	same, very stiff
23.0 -	24.5	9 - 17 / 50	same, very stiff
24.5 -	26.0	9 - 19 / 50	same, very stiff
26.0 -	27.5	10 - 15 / 50	same, very stiff
27.5 -	29.0	8 - 22 / 42	same, very stiff

---END OF BORING---

LADYSMITH: FIELD BORING LOGS

BORING B-2
CONTINUOUS SAMPLING TO 14 FT.
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 5/17/89

WATER TABLE = 2.0 FT.

DEPTH IN FT.		BLOW COUNT	DESCRIPTION
from	to	blows per 6 in.	
1.5 -	3.0	3 - 4 / 4	medium brown gray fine sandy clay (possible fill)
3.0 -	4.5	1 - 2 / 1	soft gray fine sandy clay
4.5 -	6.0	2 - 8 / 12	medium gray clayey fine sand
6.0 -	7.5	11 - 9 / 6	medium gray fine sand w/ gravel
7.5 -	9.0	4 - 7 / 7	same, medium, w/trace of gravel
9.0 -	10.5	4 - 4 / 7	same, layer change @ 9.0" to very stiff green silt
10.5 -	12.0	2 - 9 / 9	same, very stiff
12.0 -	14.0	* - * / *	tube attempted, no recovery

---END OF BORING---

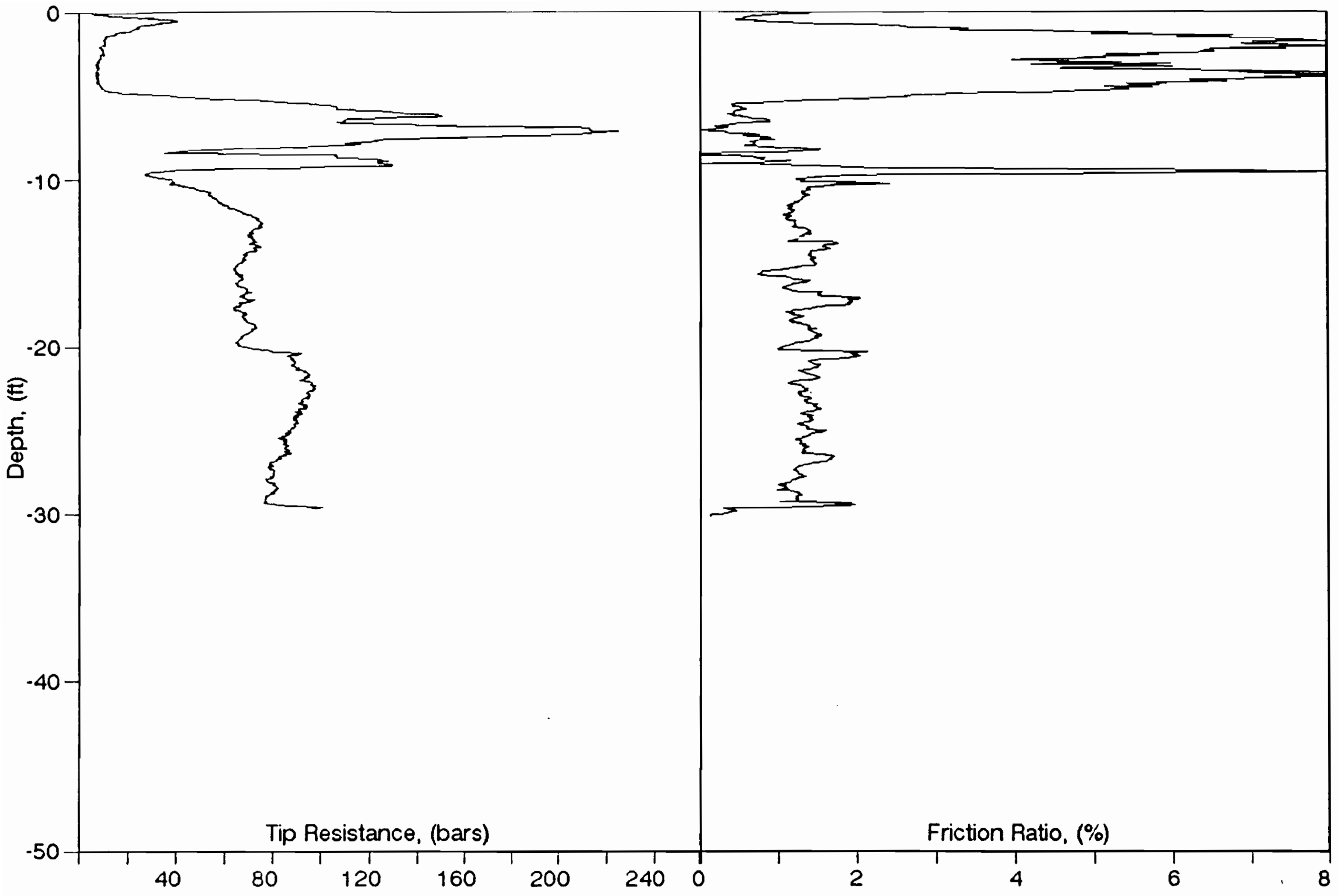
LADYSMITH: FIELD BORING LOGS

BORING B-3
SAMPLING AND PRESSUREMETER TESTING TO 16.5 FT.
SAMPLES TAKEN WITH 300# HAMMER AND 3" SAMPLER
DRILLED 9/19/89

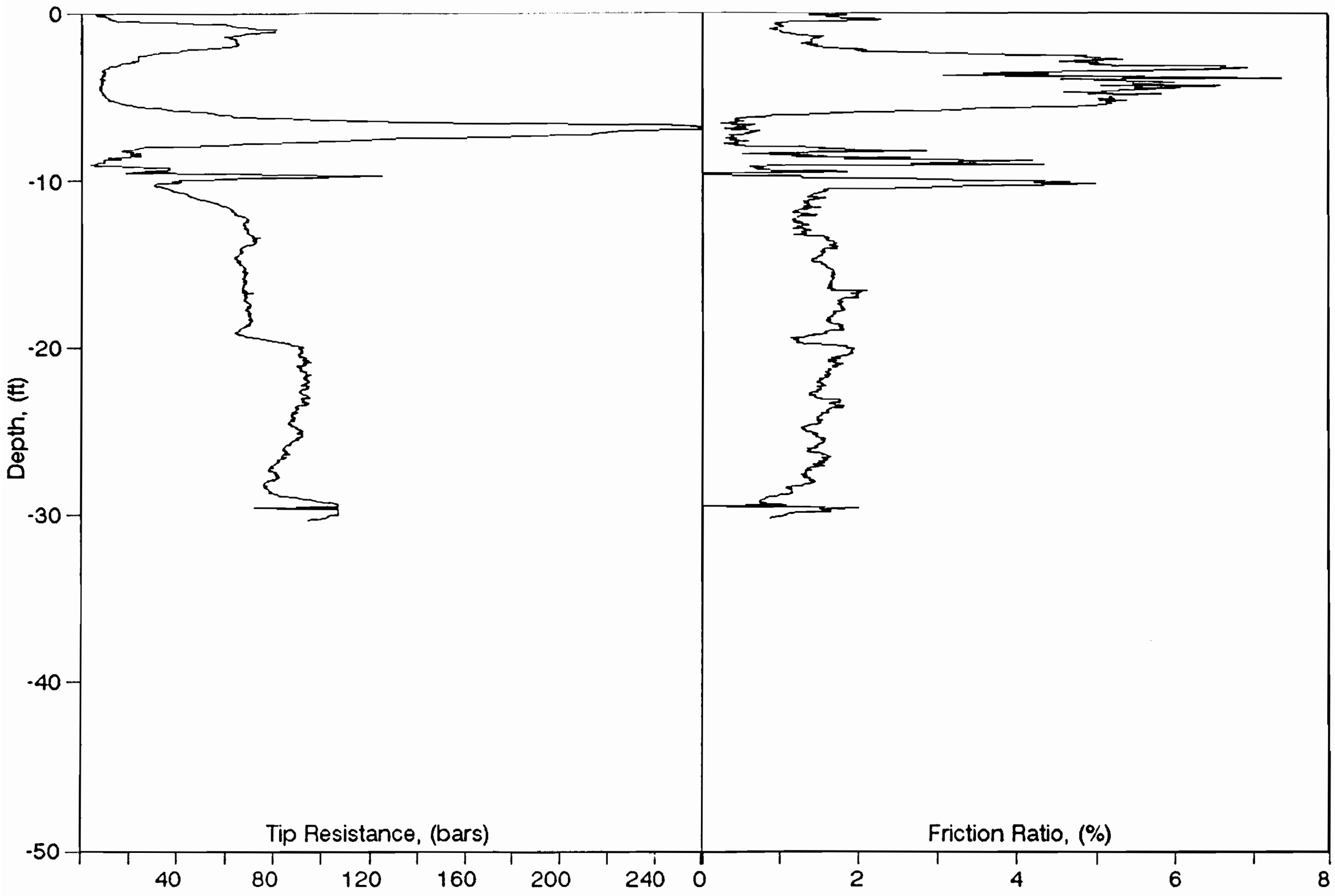
WATER TABLE = 2.0 FT.

DEPTH IN FT. from	to	BLOW COUNT blows per 6 in.	DESCRIPTION
10.5-	12.0	2 - 7 / 50	hard gray-green clay
12.0-	13.5	9 - 18 / 50	same
13.5-	15.0	4 - 5 / 50	same
15.0-	16.5	9 - 18 / 50	same

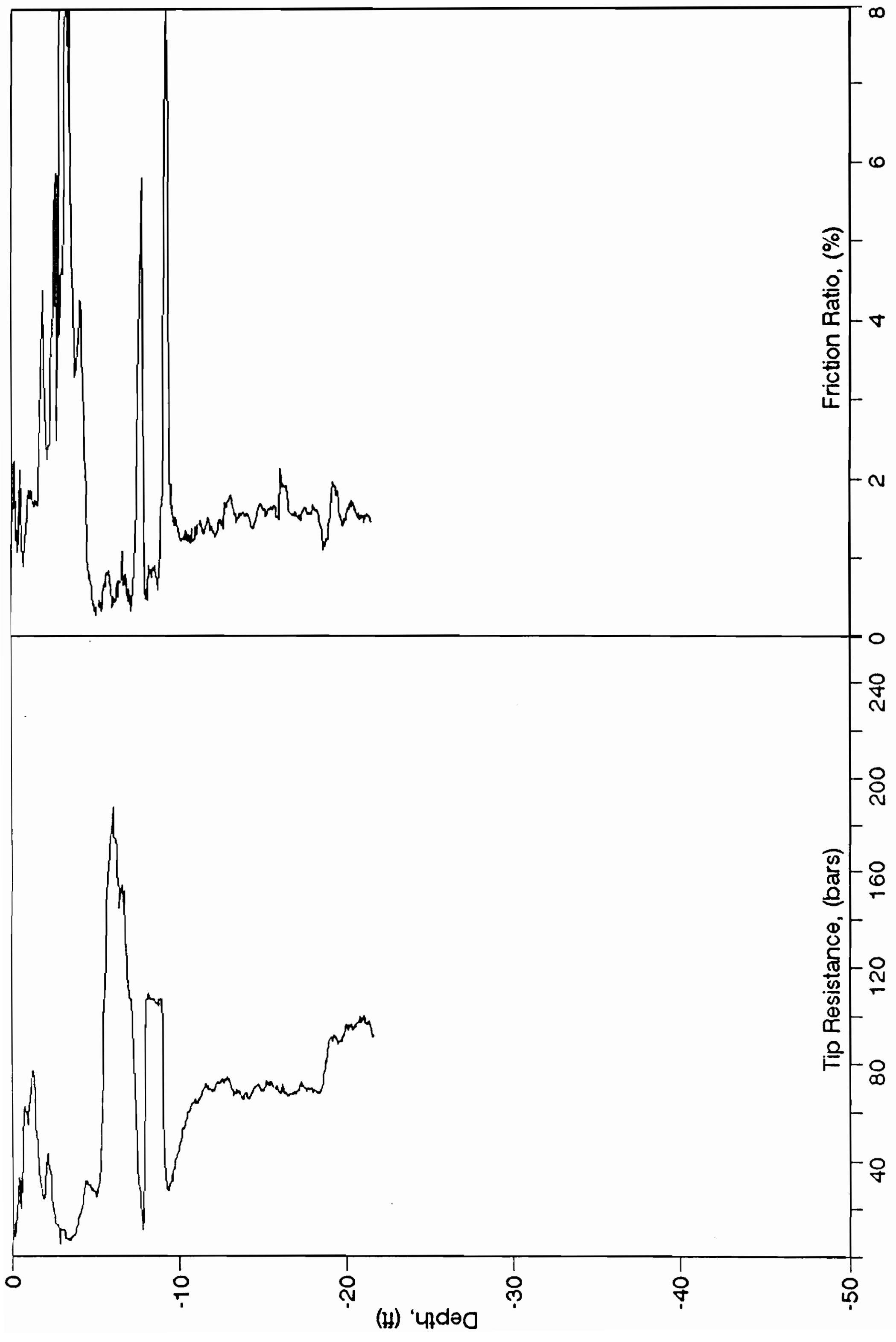
---END OF BORING---



Ladysmith: Cone Test LSMC-1 05/11/90



Ladysmith: Cone Test LSMC-2 05/12/90



Ladysmith: Cone Test LSMC-3 05/12/90

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Virginia Polytechnic Institute                                                   TEST NO. LSM D-1
FILE NAME:     Dilatometer Test
FILE NUMBER:   10:40:00

RECORD OF DILATOMETER TEST NO. LSM D-1
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

     LOCATION: LADYSMITH
     PERFORMED - DATE:  09/18/89
                  BY:  MULLEN

     CALIBRATION INFORMATION:
     DELTA A =  .20 BARS   DELTA B    =  .22 BARS   GAGE 0 =  .00 BARS   GWT DEPTH=  .61 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50     BLADE T=15.00 MM

     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3

  Z   THRUST    A      B      ED     ID    KO       UO   GAMMA    SV      PC    OCR     KO     CU   PHI      M       SOIL TYPE
 (M)   (KG)   (BAR)  (BAR)  (BAR)               (BAR) (T/M3)  (BAR)  (BAR)                (BAR) (DEG)  (BAR)
***** ****** *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******  ************

  .30 2502.   3.80  15.95   427.  3.61 57.86    .000  1.900   .059                                   1778.7     SAND
  .61 1251.   1.18   6.12   165.  4.11 10.01    .000  1.800   .115                                    411.9     SAND
  .91  466.   1.46   4.06    79.  1.50 11.08    .029  1.700   .137    2.0  14.7   1.45         36.3   206.3   SANDY SILT
 1.22  203.   1.24   2.54    32.   .69  8.50    .060  1.600   .157    1.5   9.6   1.66   .211          74.9   CLAYEY SILT
 1.52  552.    .66   2.89    66.  2.79  3.86    .089  1.700   .176     .2   1.3    .40         41.2   109.5   SILTY SAND
 1.83 2328.    .52   4.38   125.  8.43  2.17    .120  1.700   .198                                    146.9     SAND
 2.13 5121.   1.67   8.37   229.  4.69  6.40    .149  1.800   .220                                    483.5     SAND
 2.44 3638.   1.96   7.40   183.  3.05  7.09    .180  1.800   .244                                    402.6   SILTY SAND
 2.74 2998.    .59   2.71    62.  3.60  1.86    .209  1.700   .266                                     64.5     SAND
END OF SOUNDING
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TEST NO. LSM D-1            (CONTINUED)                                                   PAGE  1
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Virginia Polytechnic Institute TEST NO. LSM D-2
FILE NAME: Dilatometer Test
FILE NUMBER: 13:17:00

RECORD OF DILATOMETER TEST NO. LSM D-2
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

LOCATION: LADYSMITH
PERFORMED - DATE: 09/18/89
BY: MULLEN

CALIBRATION INFORMATION:
DELTA A = .21 BARS DELTA B = .25 BARS GAGE 0 = .00 BARS GWT DEPTH= .61 M
ROD DIA.= 3.56 CM FR.RED.DIA.= 1.91 CM ROD WT.= .00 KG/M DELTA/PHI= .50 BLADE T=15.00 MM

1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI ANALYSIS USES H2O UNIT WEIGHT = 1.000 T/M3

Z (M)	THRUST (KG)	A (BAR)	B (BAR)	ED (BAR)	ID	KD	UO (BAR)	GAMMA (T/M3)	SV (BAR)	PC (BAR)	OCR	KO	CU (BAR)	PHI (DEG)	M (BAR)	SOIL TYPE
*****	******	*****	*****	*****	*****	*****	******	******	******	*****	*****	*****	*****	*****	******	***********
.30		-.10	.50	5.	1.43	1.75	.000	1.500	.059						4.3	MUD
.61		.21	.91	9.	.62	3.90	.000	1.500	.105	.3	2.8	.97	.053		13.4	MUD
.91		.71	1.54	13.	.45	7.22	.029	1.600	.121	.9	7.4	1.49	.132		29.2	SILTY CLAY
1.22		1.04	1.96	17.	.41	8.39	.060	1.600	.139	1.3	9.4	1.65	.184		38.9	SILTY CLAY
1.52		1.30	2.16	15.	.30	8.94	.089	1.600	.157	1.6	10.3	1.71	.224		34.8	CLAY
1.83	1720.	.70	3.49	85.	3.63	3.82	.120	1.700	.177						141.2	SAND
2.13	2700.	1.38	5.51	134.	3.06	6.33	.149	1.800	.199						281.2	SILTY SAND
2.44	1042.	1.84	6.92	168.	2.96	7.35	.180	1.800	.223	1.1	4.9	.80		42.0	375.7	SILTY SAND
2.74	1079.	2.69	10.85	281.	3.51	9.30	.209	1.900	.248	2.3	9.1	1.12		40.3	683.7	SAND
3.05		8.34	17.45	315.	1.15	28.53	.239	1.950	.276	17.5	63.2	3.39			1100.8	SILT
3.35		16.25	27.40	389.	.72	51.12	.269	2.100	.306	48.1	157.0	4.65	3.872		1575.4	CLAYEY SILT
3.66		26.05	37.40	397.	.45	74.98	.299	2.050	.339	96.7	285.3	5.69	6.918		1748.7	SILTY CLAY
3.96		30.00	39.75	338.	.33	79.53	.329	2.050	.370	115.7	312.8	5.86	8.126		1510.7	CLAY
4.27		28.25	38.40	353.	.37	68.73	.359	2.050	.402	100.1	249.1	5.44	7.355		1526.9	SILTY CLAY
4.57		27.00	37.00	348.	.38	60.88	.389	2.050	.433	89.2	206.1	5.10	6.807		1463.4	SILTY CLAY
4.88		27.20	37.50	359.	.39	57.02	.419	2.050	.465	86.5	186.1	4.93	6.736		1487.2	SILTY CLAY
5.18		29.10	38.65	331.	.34	57.32	.448	2.050	.496	93.0	187.6	4.94	7.230		1375.5	CLAY
5.49		30.20	41.00	377.	.37	55.76	.479	2.050	.528	94.8	179.7	4.87	7.435		1554.8	SILTY CLAY
5.79		28.80	38.20	326.	.33	50.24	.508	2.050	.558	85.3	152.7	4.61	6.909		1312.1	CLAY
6.10		35.20	47.65	437.	.37	58.05	.539	2.050	.590	113.0	191.4	4.97	8.750		1819.5	SILTY CLAY
6.40		37.00	48.45	400.	.32	58.09	.568	2.050	.621	119.0	191.6	4.98	9.217		1668.0	CLAY
6.71		40.35	52.40	422.	.31	60.29	.599	2.050	.653	132.6	203.0	5.07	10.150		1773.9	CLAY
7.01		40.05	53.75	482.	.36	56.96	.628	2.050	.684	127.1	185.8	4.93	9.903		2000.6	SILTY CLAY
7.32		38.10	51.40	468.	.36	51.68	.658	2.050	.716	114.3	159.7	4.68	9.179		1897.1	SILTY CLAY
7.62		40.35	53.45	461.	.34	52.53	.688	2.050	.747	122.3	163.8	4.72	9.772		1874.6	CLAY
7.92		38.05	50.60	440.	.34	47.48	.717	2.050	.778	108.8	139.9	4.47	8.969		1750.9	CLAY
8.23		37.80	49.90	424.	.33	45.29	.748	2.050	.810	105.2	129.9	4.36	8.802		1666.8	CLAY
8.53		37.45	49.30	415.	.33	43.19	.777	2.050	.841	101.5	120.7	4.25	8.611		1612.3	CLAY
8.84		35.60	46.75	389.	.33	39.49	.808	2.050	.873	91.6	104.9	4.05	7.992		1480.2	CLAY
9.14		51.40	60.00	297.	.17	55.74	.837	2.050	.904	162.3	179.6	4.87	12.729		1223.9	CLAY

END OF SOUNDING

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Virginia Polytechnic Institute                                                    TEST NO. LSM D-3
FILE NAME:     Dilatometer Test
FILE NUMBER:   15:45:00

RECORD OF DILATOMETER TEST NO. LSM D-3
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

     LOCATION: LADYSMITH
     PERFORMED - DATE:  09/18/89
                   BY:  MULLEN

     CALIBRATION INFORMATION:
     DELTA A =  .20 BARS   DELTA B    =  .43 BARS   GAGE 0 =  .00 BARS   GWT DEPTH=  .61 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50      BLADE T=15.00 MM

     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3

   Z  THRUST     A      B     ED    ID    KD      UO  GAMMA     SV     PC   OCR     KO     CU   PHI       M     SOIL TYPE
  (M)   (KG)  (BAR)  (BAR)  (BAR)               (BAR) (T/M3)  (BAR)  (BAR)                (BAR) (DEG)   (BAR)
***** ****** ***** ***** ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******  ************

  .30   792.   -.15    .86    14. 12.87   .53    .000  1.700   .059                                     11.8     SAND
  .61          -.15    .61     5.  3.14   .40    .000  1.500   .108                                      4.0     MUD
  .91           .68   1.51     7.   .25  6.87    .029  1.500   .122     .8   6.9   1.44   .126          15.4     MUD
 1.22           .94   1.86    11.   .29  7.74    .060  1.500   .138    1.1   8.3   1.56   .164          23.6     MUD
 1.52   340.    .71   3.24    69.  2.75  4.67    .089  1.700   .155     .5   3.0    .66         36.9   126.5   SILTY SAND
 1.83  1720.   1.78   9.42   255.  4.88  8.48    .120  1.800   .178                                    601.9     SAND
 2.13  2700.   2.09  10.70   291.  4.81  8.58    .149  1.900   .203                                    688.1     SAND
 2.44  1042.   2.17   9.85   257.  4.03  7.97    .180  1.900   .230    1.4   6.2    .91         41.4   591.7     SAND
 2.74  1079.   2.69  10.60   265.  3.30  9.02    .209  1.900   .257    2.2   8.7   1.09         40.2   639.2   SILTY SAND
 3.05          7.54  12.45   156.   .62 25.56    .239  1.950   .285   15.2  53.2   3.19  1.515         528.4   CLAYEY SILT
 3.35         19.45  29.00   325.   .49 60.19    .269  2.050   .315   63.7 202.5   5.07  4.879        1364.8   SILTY CLAY
 3.66         27.00  38.00   378.   .41 76.14    .299  2.050   .347  101.3 292.2   5.73  7.208        1670.7   SILTY CLAY
 3.96         30.10  41.80   403.   .40 77.94    .329  2.050   .377  114.4 303.1   5.80  8.085        1792.5   SILTY CLAY
 4.27         28.20  38.25   343.   .36 67.35    .359  2.050   .409   98.8 241.3   5.38  7.305        1477.8   SILTY CLAY
 4.57         27.60  36.70   309.   .33 61.30    .389  2.050   .440   91.7 208.4   5.12  6.985        1301.3     CLAY
 4.88         26.60  38.95   427.   .48 54.62    .419  2.050   .472   82.2 174.1   4.82  6.487        1754.0   SILTY CLAY
 5.18         28.00  38.95   376.   .40 54.13    .448  2.050   .503   86.3 171.6   4.79  6.833        1541.2   SILTY CLAY
 5.49         29.90  40.65   369.   .36 54.41    .479  2.050   .535   92.6 173.0   4.81  7.314        1513.2   SILTY CLAY
 5.79         29.20  39.45   351.   .36 50.20    .508  2.050   .566   86.3 152.6   4.61  6.995        1411.6   SILTY CLAY
 6.10         35.40  49.55   493.   .41 57.51    .539  2.050   .598  112.8 188.6   4.95  8.759        2047.3   SILTY CLAY
 6.40         38.80  52.45   474.   .36 60.08    .568  2.050   .629  127.0 201.9   5.07  9.729        1991.3   SILTY CLAY
 6.71         42.20  55.40   458.   .32 62.31    .599  2.050   .661  141.2 213.7   5.16 10.700        1938.3     CLAY
 7.01         39.50  52.35   445.   .33 55.60    .628  2.050   .692  123.8 179.0   4.86  9.715        1836.3     CLAY
 7.32         37.30  51.40   491.   .39 49.98    .658  2.050   .724  109.7 151.5   4.60  8.895        1974.6   SILTY CLAY
 7.62         38.10  51.25   456.   .36 49.02    .688  2.050   .755  110.9 147.0   4.55  9.052        1826.9   SILTY CLAY
 7.92         36.20  50.30   491.   .40 44.57    .717  2.050   .785   99.6 126.7   4.32  8.367        1921.4   SILTY CLAY
 8.23         35.85  49.20   463.   .39 42.41    .748  2.050   .817   95.9 117.3   4.21  8.183        1792.6   SILTY CLAY
 8.53         36.25  48.30   416.   .34 41.38    .777  2.050   .848   95.7 112.9   4.15  8.235        1599.7     CLAY
 8.84         33.40  44.80   392.   .35 36.64    .808  2.050   .880   82.2  93.4   3.89  7.340        1463.5   SILTY CLAY
 9.14         36.95  51.85   520.   .42 39.07    .837  2.050   .911   94.0 103.2   4.03  8.233        1970.6   SILTY CLAY
END OF SOUNDING
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Virginia Polytechnic Institute                                                       TEST NO. LSM D-4
FILE NAME:     Dilatometer Test
FILE NUMBER:   17:12:00

RECORD OF DILATOMETER TEST NO. LSM D-4
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

     LOCATION: LADYSMITH
     PERFORMED - DATE:  09/18/89
                   BY:  MULLEN


     CALIBRATION INFORMATION:
     DELTA A =  .19 BARS   DELTA B    =  .44 BARS   GAGE 0 =  .00 BARS   GWT DEPTH=  .61 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50      BLADE T=15.00 MM

     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3


  Z   THRUST     A       B      ED     ID    KD      U0    GAMMA     SV      PC    OCR     K0     CU    PHI       M      SOIL TYPE
 (M)   (KG)    (BAR)   (BAR)   (BAR)                (BAR)  (T/M3)  (BAR)   (BAR)                  (BAR)  (DEG)   (BAR)
***** ******   *****   *****   ***** ***** *****   ****** ****** ******   ***** *****   *****   ***** *****  ******   ************

  .30   792.    2.84    8.56    185.  1.93 47.04     .000  1.900    .059                                       735.5   SILTY SAND
  .61            .86    2.03     20.   .55  9.11     .000  1.600    .112     1.2  10.7   1.74   .164            47.3   SILTY CLAY
  .91           1.19    2.13     11.   .24 10.40     .029  1.500    .128     1.7  13.1   1.88   .222            28.7      MUD
 1.22           1.50    1.98     -5.  -.09           .060  P01 =    1.70    P0 =  1.69   P1 =   1.54                  QUESTIONABLE
 1.52   340.    1.14    4.10     85.  2.18  6.84     .089  1.700    .164     1.1   6.6   1.00           34.3    182.5   SILTY SAND
 1.83  1720.    2.04    6.63    144.  2.17 10.22     .120  1.800    .187     1.0   5.2    .78           46.0    363.6   SILTY SAND
 2.13  2700.    1.64    7.82    202.  4.15  6.66     .149  1.800    .211                                        434.1      SAND
 2.44  1042.    1.20    5.19    122.  3.38  4.43     .180  1.800    .235      .2    .9    .31           44.1    219.6      SAND
 2.74  1079.    2.71   13.15    357.  4.68  8.46     .209  1.900    .260     2.0   7.5   1.02           40.5    841.7      SAND
 3.05          13.15   20.95    261.   .59 43.98     .239  2.050    .290    36.0 124.1   4.29  3.035          1019.4   SILTY CLAY
 3.35          23.00   34.95    412.   .53 69.72     .269  2.050    .321    81.7 254.7   5.48  5.975          1789.4   SILTY CLAY
 3.66          29.35   42.50    456.   .46 81.15     .299  2.050    .353   113.8 322.8   5.93  7.944          2044.7   SILTY CLAY
 3.96          30.55   43.40    445.   .43 77.70     .329  2.050    .384   115.7 301.6   5.79  8.184          1977.4   SILTY CLAY
 4.27          29.15   40.00    372.   .38 68.53     .359  2.050    .415   103.0 247.9   5.43  7.577          1609.4   SILTY CLAY
 4.57          28.35   40.60    423.   .44 61.77     .389  2.050    .446    94.1 210.8   5.14  7.149          1788.3   SILTY CLAY
 4.88          28.85   40.40    398.   .41 58.70     .419  2.050    .478    93.1 194.7   5.00  7.188          1661.3   SILTY CLAY
 5.18          28.35   39.55    385.   .40 54.13     .448  2.050    .509    87.4 171.6   4.79  6.915          1578.5   SILTY CLAY
 5.49          28.55   40.00    394.   .41 51.22     .479  2.050    .541    85.2 157.5   4.66  6.860          1595.3   SILTY CLAY
 5.79          29.00   39.30    352.   .36 49.29     .508  2.050    .572    84.8 148.3   4.56  6.911          1412.9   SILTY CLAY
 6.10          34.15   42.50    281.   .24 55.32     .539  2.050    .604   107.2 177.5   4.85  8.430          1158.7      CLAY
 6.40          37.00   50.30    462.   .37 56.68     .568  2.050    .635   117.1 184.4   4.91  9.134          1912.3   SILTY CLAY
 6.71          40.40   55.30    520.   .38 58.90     .599  2.050    .667   130.6 195.8   5.01 10.065          2172.7   SILTY CLAY
 7.01          38.95   53.00    489.   .37 54.23     .628  2.050    .698   120.1 172.1   4.80  9.499          2005.0   SILTY CLAY
 7.32          39.00   53.45    504.   .38 51.86     .658  2.050    .730   117.1 160.5   4.69  9.393          2043.5   SILTY CLAY
 7.62          39.05   52.50    467.   .36 49.84     .688  2.050    .761   114.8 150.9   4.59  9.317          1878.1   SILTY CLAY
 7.92          36.40   50.55    493.   .40 44.47     .717  2.050    .792   100.0 126.3   4.32  8.407          1927.4   SILTY CLAY
 8.23          35.00   48.40    465.   .40 41.05     .748  2.050    .823    91.8 111.5   4.14  7.915          1785.3   SILTY CLAY
 8.53          34.60   48.45    482.   .42 39.03     .777  2.050    .854    88.0 103.1   4.03  7.711          1825.2   SILTY CLAY
 8.84          37.40   50.35    449.   .36 40.80     .808  2.050    .886    97.9 110.4   4.12  8.455          1719.8   SILTY CLAY
 9.14          50.40   60.00    327.   .19 53.75     .837  2.050    .917   155.7 169.7   4.78 12.349          1337.4      CLAY
END OF SOUNDING
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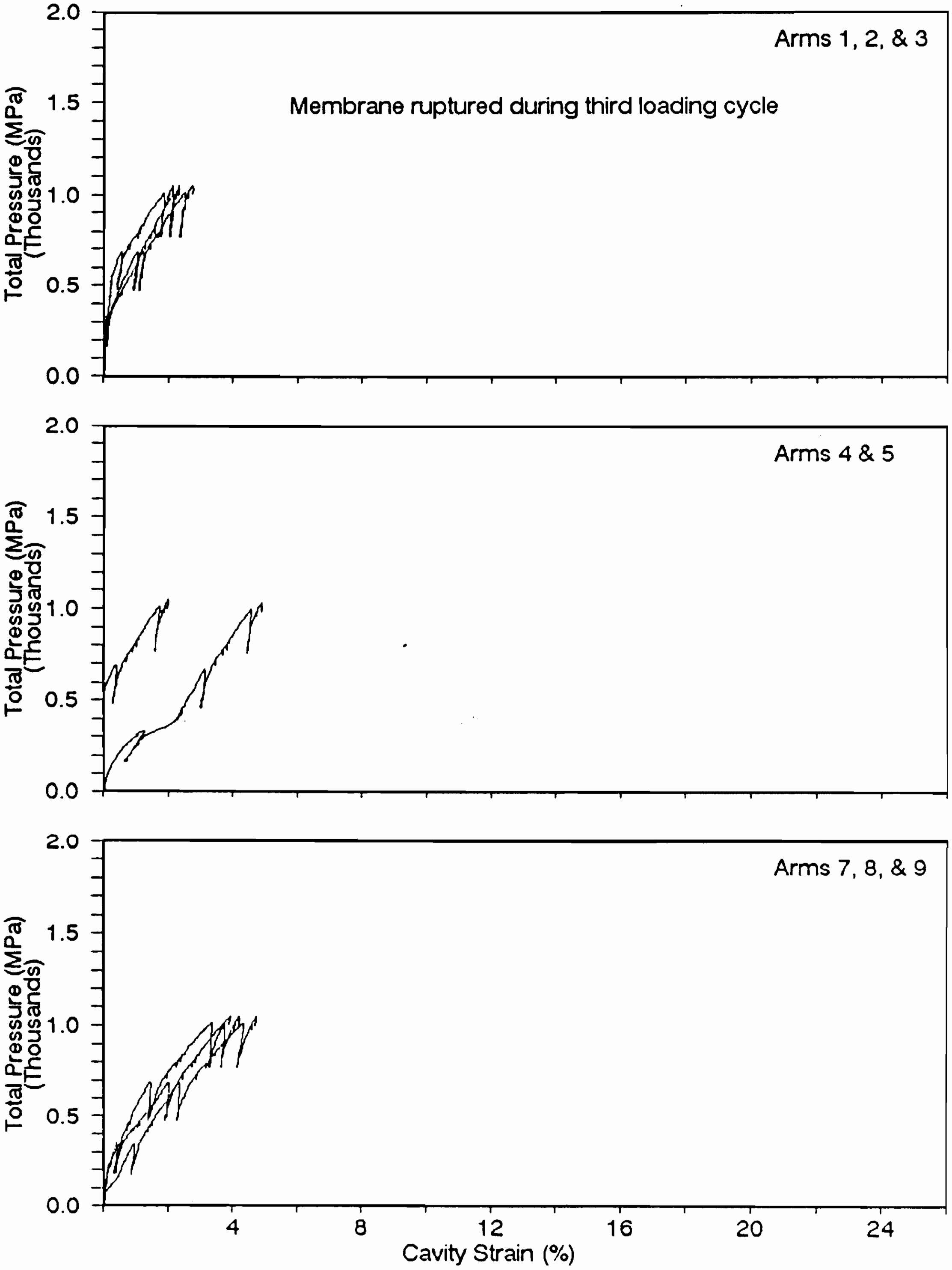


Ladysmith: Pressuremeter Test LSMP-1 09/20/89

LADYSMITH: IN-SITU TEST DATA SUMMARY

DEPTH ft.	BORING #	N60	N160	Qc (pt) bar
-1.0				54.9
-2.0				35.2
-2.5	B-1	7	13	18.1
-2.5	B-2	8	14	16.5
-3.0				12.1
-4.0	B-2	3	5	11.2
-4.0	B-1	7	12	11.2
-5.0				23.3
-5.5	B-1	19	32	69.8
-5.5	B-2	20	34	75.4
-6.0				120.0
-7.0	B-2	15	25	195.5
-7.0	B-1	30	50	182.4
-8.0				72.5
-8.5	B-1	11	18	65.8
-8.5	B-2	14	22	71.6
-9.0				75.0
-10.0	B-2	11	17	43.6
-10.0	B-1	21	33	42.4
-11.0				55.0
-11.5	B-2	18	27	62.6
-11.5	B-1	20	30	62.6
-11.5	B-3	57	86	63.7
-12.0				66.7
-13.0	B-1	33	48	71.6
-13.0	B-3	68	99	70.5
-14.0				69.8
-14.5	B-3	55	77	67.8
-15.0				67.4
-16.0	B-3	68	92	68.4
-17.0				67.5
-17.5	B-1	60	79	69.1
-18.0				68.3
-19.0	B-1	48	61	76.0
-20.0				84.9
-20.5	B-1	60	74	91.3

LADYSMITH: IN-SITU TEST DATA SUMMARY

DEPTH ft.	Qn (pt) bar	ED bar	Gur kN/M^2	D50 (mm)
-1.0	103.7	158		
-2.0	63.4	50		
-2.5	32.3	39		0.06
-2.5	29.5	39		0.06
-3.0	21.4	28		
-4.0	19.6	18		0.113
-4.0	19.6	18		0.113
-5.0	40.2	59		
-5.5	118.9	106		0.542
-5.5	128.4	106		0.542
-6.0	202.5	152		
-7.0	323.6	214		1.164
-7.0	301.9	214		1.164
-8.0	117.6	183		
-8.5	105.7	212		0.692
-8.5	115.0	212		0.692
-9.0	119.3	241		
-10.0	67.9	244		0.036
-10.0	66.1	244		0.036
-11.0	83.8	375		
-11.5	94.2	393		0.02
-11.5	94.1	393		0.02
-11.5	95.7	393		0.02
-12.0	99.1	410		
-13.0	104.0	395		0.021
-13.0	102.4	395		0.021
-14.0	99.1	356		
-14.5	95.2	358		
-15.0	93.6	360	59732	
-16.0	92.9	395		
-17.0	89.8	364		
-17.5	91.1	372		0.022
-18.0	89.0	380		
-19.0	97.1	343		0.023
-20.0	106.3	404		
-20.5	113.2	425		0.023

LADYSMITH:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Qc (pt) /N	Su DMT	Su N60 (bars)	Nk = 10 Su Qc (bars)
-1.0				5.483
-2.0		0.054		3.509
-2.5	2.58	0.087	1.654	1.793
-2.5	2.06	0.087	1.890	1.640
-3.0		0.120		1.193
-4.0	3.74	0.181	0.709	1.108
-4.0	1.60	0.181	1.654	1.108
-5.0		0.056		2.319
-5.5	3.67		4.789	6.963
-5.5	3.77		5.041	7.521
-6.0				11.977
-7.0	13.03		3.781	19.531
-7.0	6.08		7.562	18.217
-8.0				7.229
-8.5	5.98		2.701	6.559
-8.5	5.12		3.511	7.137
-9.0				7.474
-10.0	3.96	1.517	2.701	4.328
-10.0	2.02	1.517	5.293	4.216
-11.0		4.909		5.472
-11.5	3.48	6.133	4.537	6.230
-11.5	3.13	6.133	5.041	6.226
-11.5	1.12	6.133	14.367	6.335
-12.0		7.357		6.636
-13.0	2.17	8.132	8.318	7.125
-13.0	1.04	8.132	17.140	7.009
-14.0		7.412		6.937
-14.5	1.23	7.196	13.863	6.736
-15.0		6.980	0.000	6.693
-16.0	1.01	6.804	17.140	6.791
-17.0		6.993		6.697
-17.5	1.15	7.098	15.123	6.863
-18.0		7.203		6.777
-19.0	1.58	6.938	12.099	7.541
-20.0		8.646		8.433
-20.5	1.52	9.003	15.123	9.070

LADYSMITH:
IN-SITU TEST
DATA SUMMARY

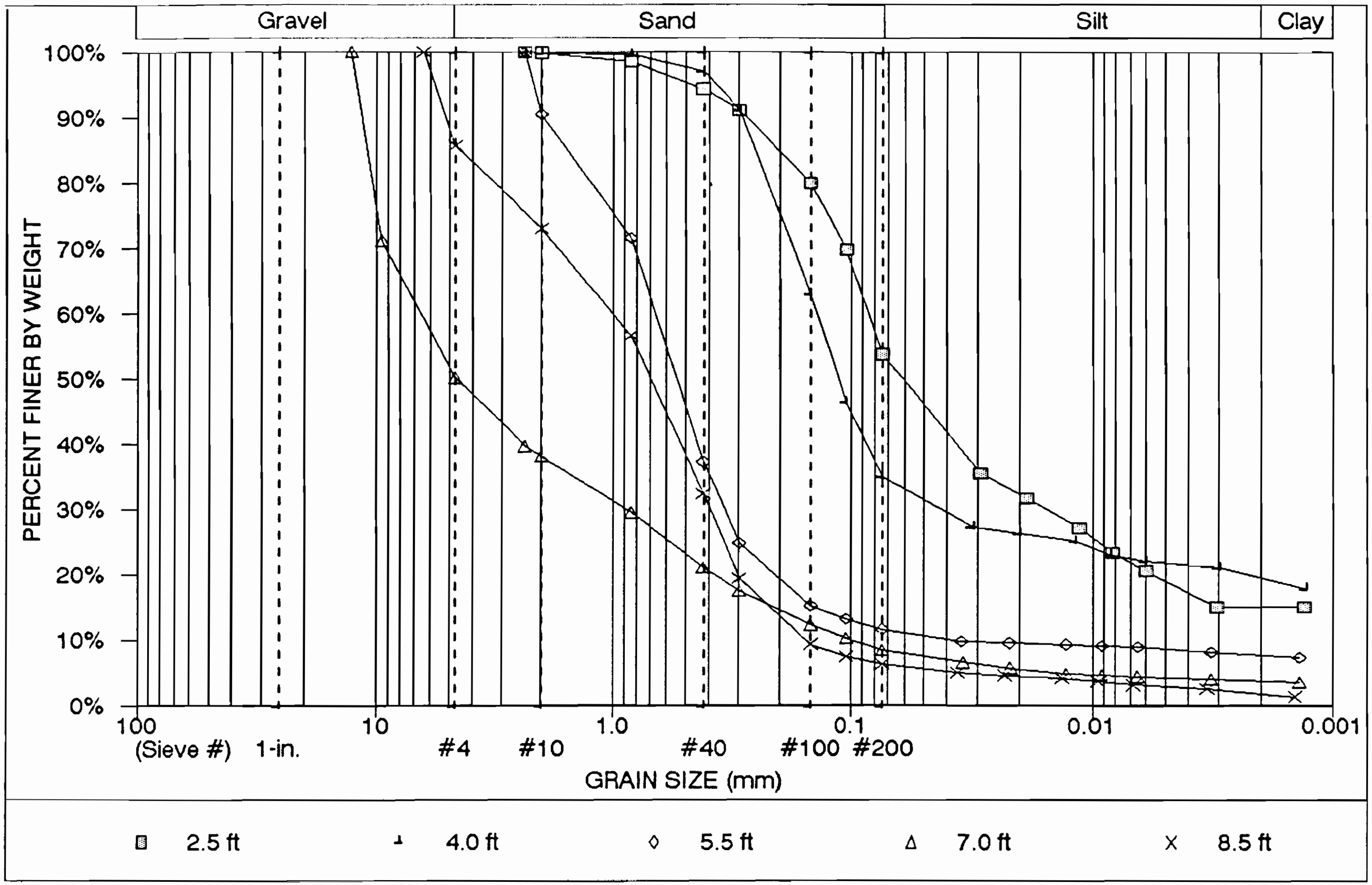
DEPTH ft.	BORING #	N60	N160	Qc (pt) bar
-21.0				93.7
-22.0				93.3
-22.5	B-1	67	80	95.1
-23.0				93.1
-24.0	B-1	67	78	90.0
-25.0				89.9
-25.5	B-1	69	78	87.1
-26.0				84.6
-27.0	B-1	65	72	79.9
-28.0				77.4
-28.5	B-1	64	69	79.9
-29.0				83.7
-30.0				85.3

LADYSMITH:
IN-SITU TEST
DATA SUMMARY

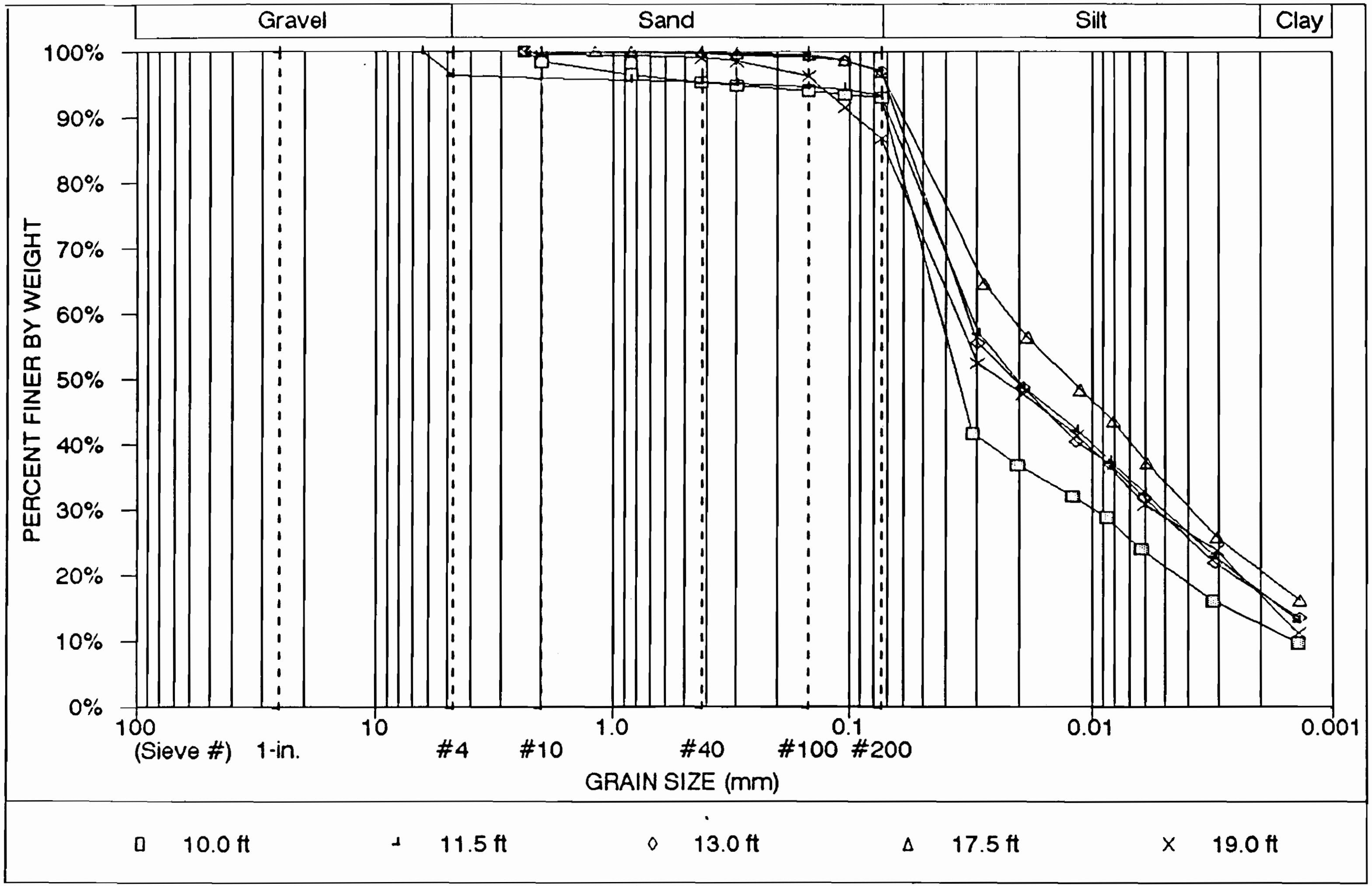
DEPTH ft.	Qn (pt) bar	ED bar	Gur kN/M^2	D50 (mm)
-21.0	115.1	445		
-22.0	112.4	467		
-22.5	113.6	469		0.016
-23.0	110.1	472		
-24.0	104.4	488		0.013
-25.0	102.5	461		
-25.5	98.4	468		0.014
-26.0	94.8	475		
-27.0	88.0	451		0.021
-28.0	83.8	438		
-28.5	85.7	424		0.028
-29.0	89.1	410		
-30.0	89.3	381		

LADYSMITH:
IN-SITU TEST
DATA SUMMARY

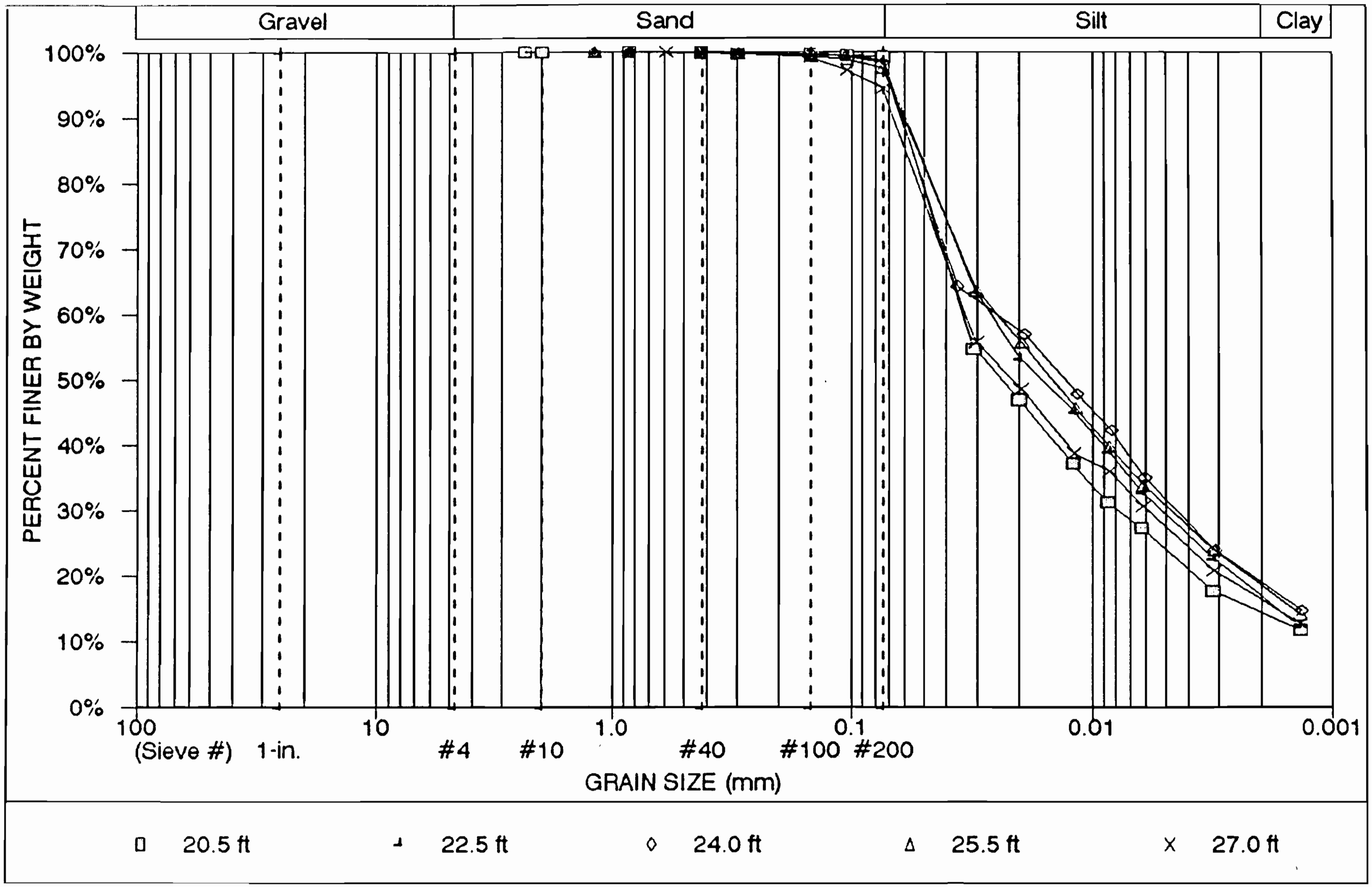
DEPTH ft.	Qc (pt) /N	Su DMT	Su N60 (bars)	Nk = 10 Su Qc (bars)
-21.0		9.360		9.309
-22.0		0.305		9.265
-22.5	1.42	5.005	16.888	9.447
-23.0		9.706		9.241
-24.0	1.34	9.156	16.888	8.925
-25.0		9.380		8.917
-25.5	1.26	8.981	17.392	8.632
-26.0		8.581		8.385
-27.0	1.23	8.300	16.383	7.911
-28.0		8.186		7.658
-28.5	1.25	8.057	16.131	7.902
-29.0		7.929		8.282
-30.0		4.437		8.436



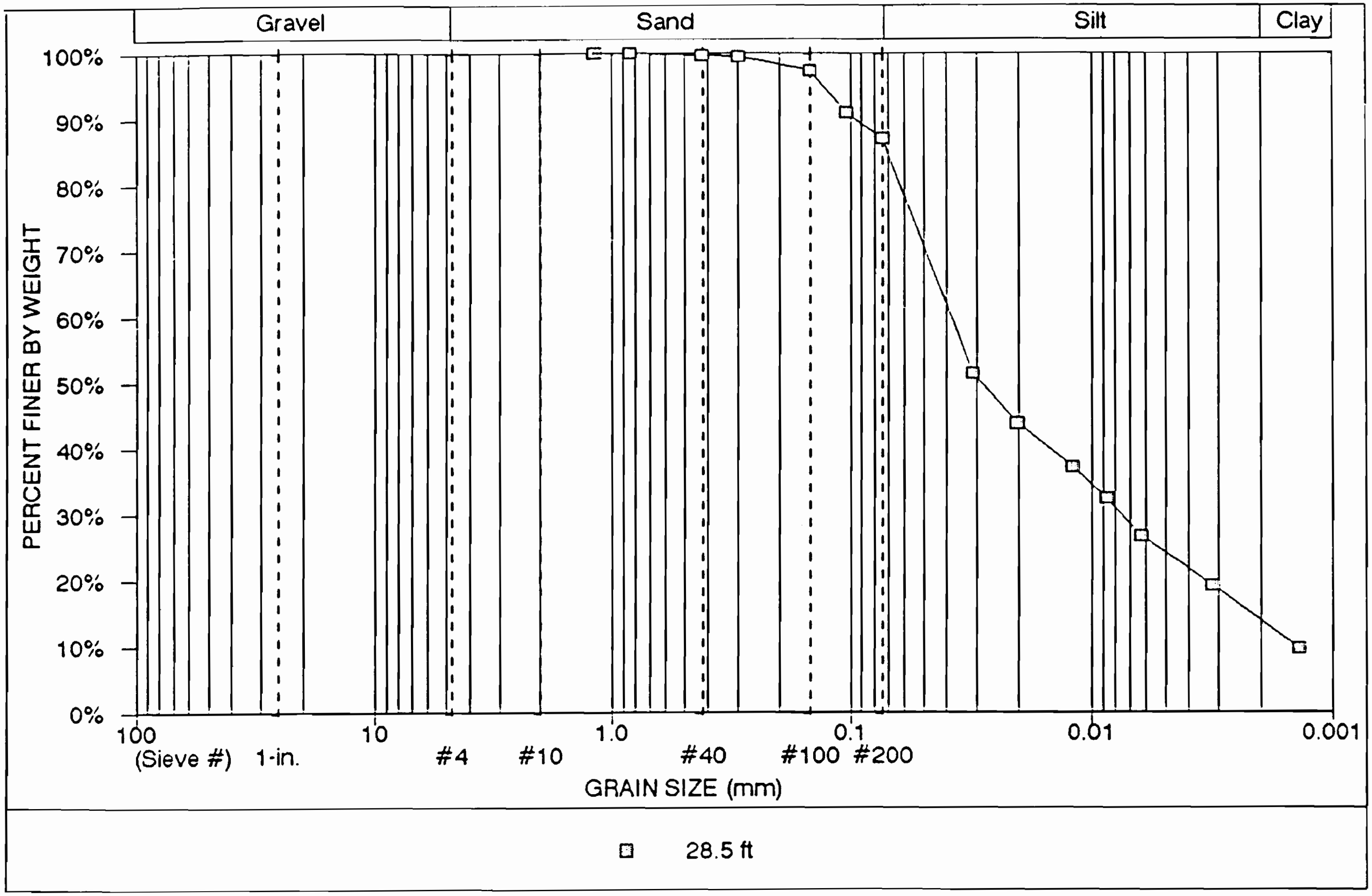
Ladysmith: Grain Size Data



Ladysmith: Grain Size Data



Ladysmith: Grain Size Data



Ladysmith: Grain Size Data

LADYSMITH:
LAB DATA
SUMMARY
FROM B-1.

DEPTH (ft)	SPECIFIC GRAVITY	D60 (mm)	D50 (mm)	D10 (mm)	Cu
-2.5	2.685		0.060		
-4.0	2.685		0.113		
-5.5	2.650	0.661	0.542	0.040	17
-7.0	2.650	6.486	1.164	0.103	63
-8.5	2.650	0.986	0.692	0.157	6
-10.0	2.704	0.042	0.036	0.001	29
-11.5	2.704	0.031	0.020	0.001	29
-13.0	2.704	0.033	0.021	0.001	33
-17.5	2.704	0.022	0.012	0.001	26
-19.0	2.704	0.036	0.023	0.001	28
-20.5	2.704	0.034	0.023	0.001	31
-22.5	2.704	0.026	0.016	0.001	23
-24.0	2.704	0.024	0.013	0.001	27
-25.5	2.704	0.024	0.014	0.001	24
-27.0	2.704	0.033	0.021	0.001	31
-28.5	2.704	0.038	0.028	0.001	26

LADYSMITH:
LAB DATA
SUMMARY
FROM B-1.

DEPTH (ft)	%-200	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	MOISTURE CONTENT %
-2.5	53.8%	21.9%	17.2%	4.7%	17.2%
-4.0	34.9%	35.1%	19.2%	15.9%	23.4%
-5.5	11.6%	NP			17.2%
-7.0	8.3%	NP			14.5%
-8.5	6.2%	NP			19.5%
-10.0	93.0%	90.8%	27.2%	63.6%	56.7%
-11.5	93.3%	97.9%	32.4%	65.5%	47.1%
-13.0	96.8%	96.7%	34.3%	62.4%	58.5%
-17.5	96.9%	86.8%	35.7%	51.1%	67.1%
-19.0	86.6%	86.3%	33.7%	52.6%	58.6%
-20.5	99.3%	82.8%	55.5%	27.3%	54.1%
-22.5	98.7%	84.4%	36.9%	47.5%	54.9%
-24.0	98.3%	83.1%	38.6%	44.5%	56.0%
-25.5	97.5%	86.1%	39.3%	46.8%	55.7%
-27.0	94.2%	78.3%	31.6%	46.7%	49.6%
-28.5	87.0%	68.4%	27.4%	41.0%	47.9%

APPENDIX E

KIPP'S FARM HILLTOP AREA

KIPP'S FARM, HILLTOP AREA: FIELD BORING LOGS

BORING B-1
SAMPLING TO 37 FT.
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 6/21/89

WATER TABLE = 23.0 FT.

DEPTH IN FT. from	to	BLOW COUNT blows per 6 in.	DESCRIPTION
1.5 -	3.0	3 - 4 / 6	stiff yellow-red clayey silt: structure evident
3.0 -	4.5	2 - 5 / 10	same, stiff
4.5 -	6.0	5 - 16 / 18	hard yellow-red clayey silt w/ rock fragments
6.0 -	7.5	7 - 13 / 18	same, hard: grading sandier
7.5 -	9.0	7 - 9 / 10	same,very stiff
9.0 -	10.5	5 - 7 / 6	same, stiff: sandier, more yellow
10.5 -	12.0	2 - 5 / 8	stiff yellow-red clayey silt
12.0 -	13.5	8 - 20 / 25	same, hard, sandier: layer change @ 13.5 ft.
13.5 -	15.0	8 - 15 / 20	hard light tan sandy silt: lense to 15.0 ft.
15.0 -	16.5	8 - 10 / 12	very stiff tan-brown clayey silt
16.5 -	18.0	5 - 12 / 20	same, hard, sandstone seam
18.0 -	19.5	10 - 22 / 26	same, hard
19.5 -	21.0	7 - 11 / 11	same, very stiff
21.0 -	23.0	* - * / *	---shelby tube---
23.0 -	24.5	7 - 6 / 7	same, stiff
24.5 -	26.0	3 - 7 / 8	same, stiff
26.0 -	27.5	6 - 8 / 10	medium white fine sand: lense
27.5 -	29.5	* - * / *	---shelby tube---: layer change @ 29.5 ft.
29.5 -	31.0	17 - 11 / 7	very stiff tan-brown clayey silt w/ white sandstone gravel
31.0 -	32.5	4 - 5 / 8	same, stiff: grading sandier

KIPP'S FARM, HILLTOP AREA: FIELD BORING LOGS

BORING B-1
SAMPLING TO 37 FT.
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 6/21/89

WATER TABLE = 23.0 FT.

DEPTH IN FT. from	to	BLOW COUNT blows per 6 in.	DESCRIPTION
32.5 -	34.0	3 - 7 / 10	very stiff tan brown sandy silt: saprolite
34.0 -	35.5	8 - 13 / 13	same, very stiff
35.5 -	37.0	10 - 50 / *	ROCK @ 36.5 ft

---END OF BORING---

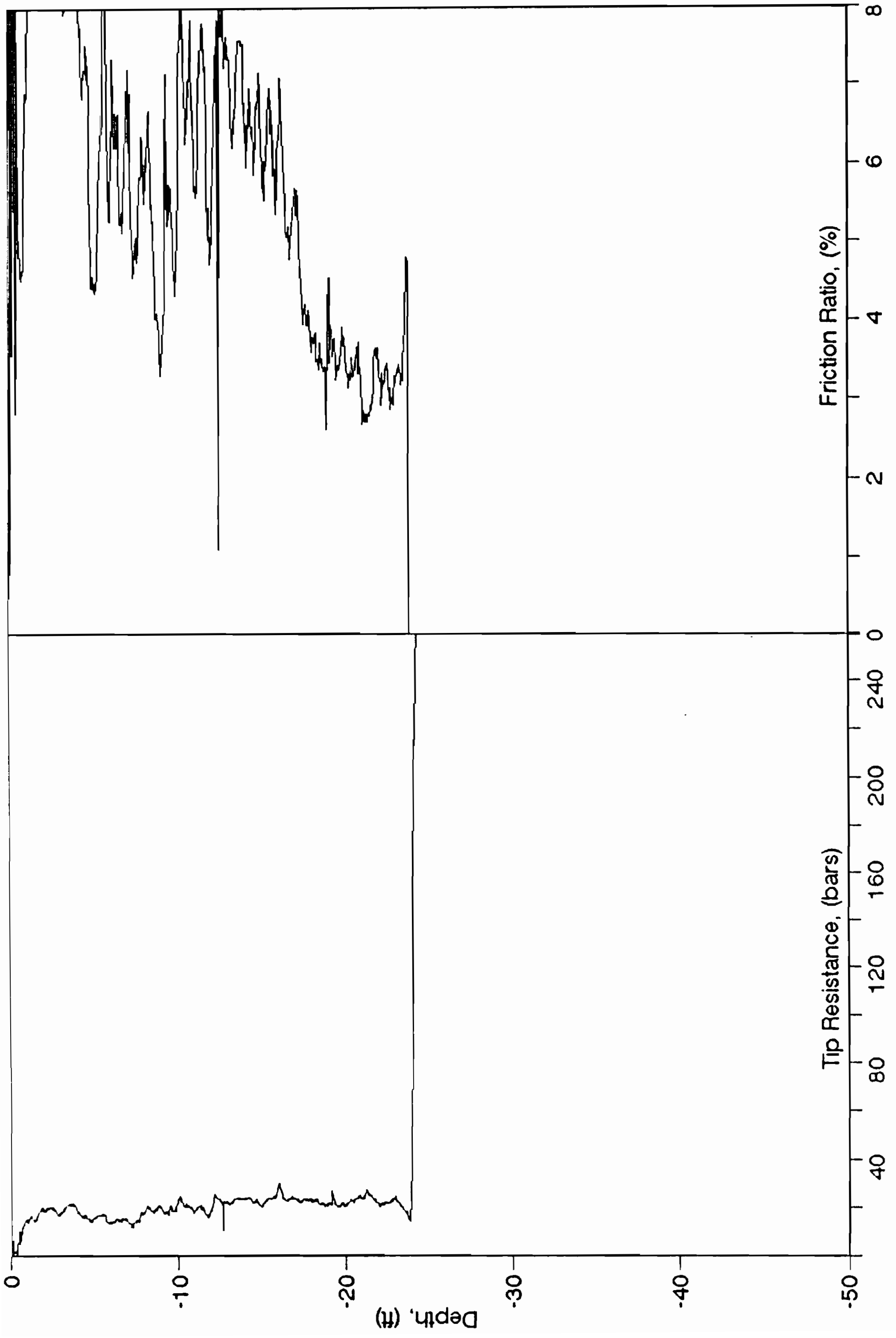
KIPP'S FARM, HILLTOP AREA: FIELD BORING LOGS

BORING B-3
SAMPLING AND PRESSUREMETER TESTING TO 35 FT.
SAMPLES TAKEN WITH 300# HAMMER AND 3" SAMPLER
DRILLED 8/8/ TO 8/11/89

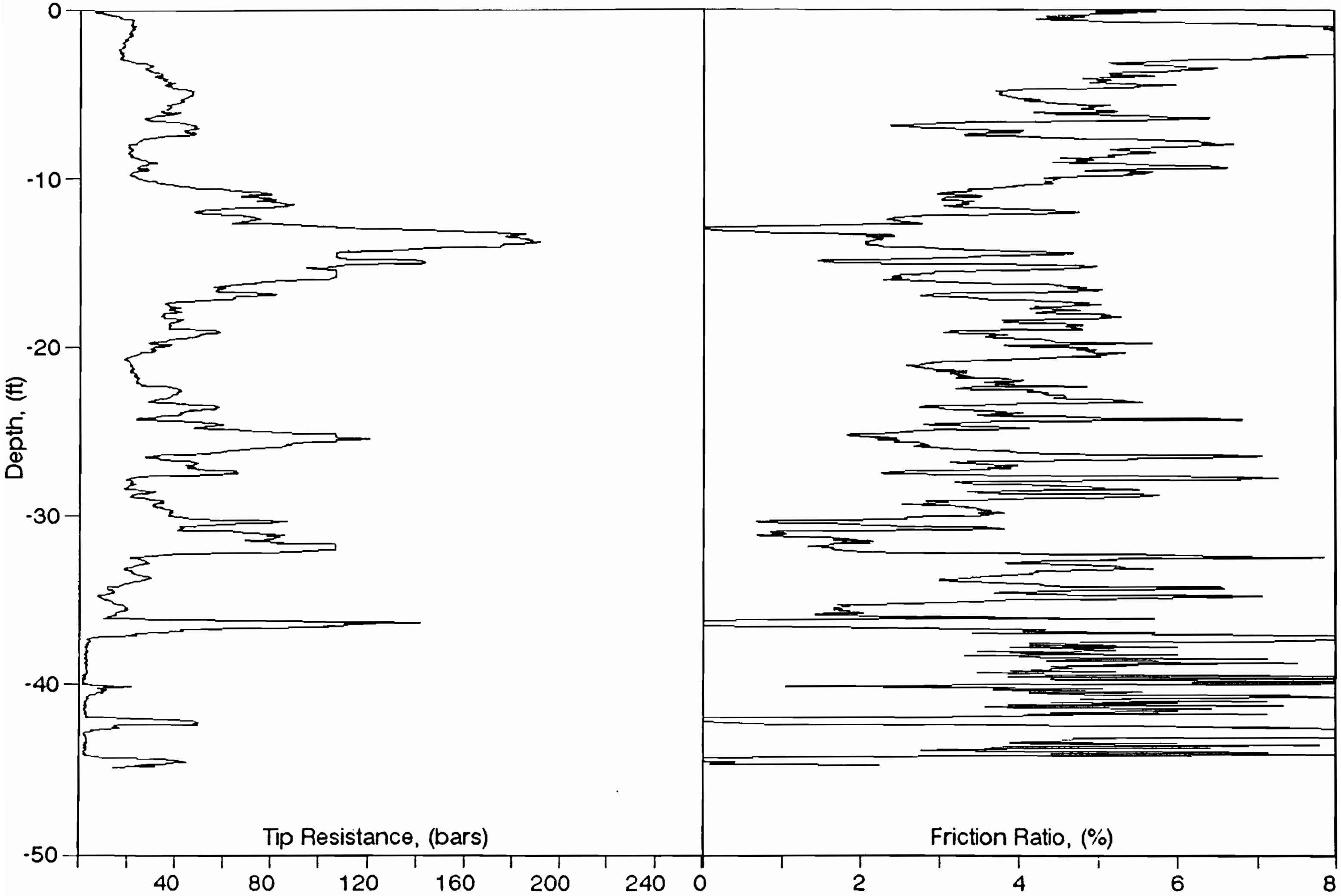
WATER TABLE = 23.0 FT.

DEPTH IN FT.		BLOW COUNT	DESCRIPTION
from	to	blows per 6 in.	
3.0-	4.5	2 - 2 / 3	orange brown calyey silt
4.5-	6.0	2 - 3 / 3	same
9.0-	10.5	2 - 3 / 3	red-orange silty clay w/ white streaks
10.5-	12.0	3 - 3 / 5	same
15.0-	16.5	2 - 2 / 2	red-orange silty clay
16.5-	18.0	2 - 3 / 3	same
18.0-	19.5	3 - 3 / 4	same
21.0-	22.5	2 - 2 / 2	red-orange white silty clay
22.5-	24.0	2 - 2 / 2	same
29.0-	30.5	2 - 3 / 5	white tan silty sand
30.5-	32.0	3 - 2 / 3	same, shale layer @ 31' 6"
32.0-	33.5	3 - 2 / 4	tan silty fine sand
33.5-	35.0	6 - 16 / 20	same to 34', then gravel

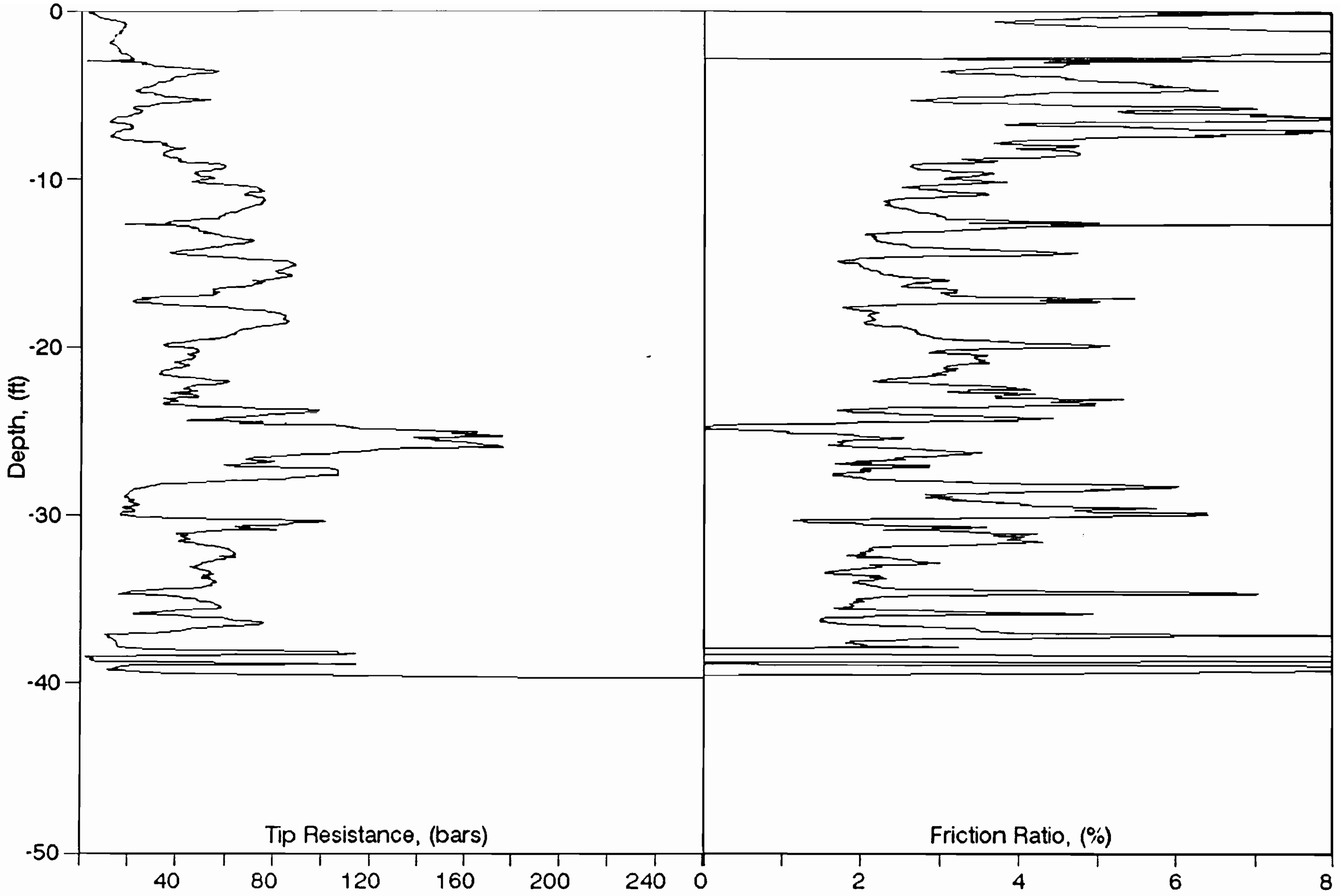
---END OF BORING---



Kipp's Farm, Hilltop Area: Cone Test KFTC-3 06/05/89



Kipp's Farm, Hilltop Area: Cone Test KFTC-4 06/05/89



Kipp's Farm, Hilltop Area: Cone Test KFTC-5 06/05/89

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Virginia Polytechnic Institute                                              TEST NO. KF D-1
FILE NAME:     Dilatometer Test
FILE NUMBER:    15:30:09

RECORD OF DILATOMETER TEST NO. KF D-1
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GEO,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GEO,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GEO,JUNE 82)

     LOCATION: KIPP'S FARM: HILLTOP AREA
     PERFORMED - DATE:  08/02/89
                   BY:  MULLEN


     CALIBRATION INFORMATION:
     DELTA A =  .17 BARS   DELTA B    =  .30 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 7.01 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50      BLADE T=15.00 MM

     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3

  Z   THRUST    A      B      ED    ID    KD     UO    GAMMA   SV     PC    OCR     KO     CU   PHI      M       SOIL TYPE
 (M)   (KG)   (BAR)  (BAR)  (BAR)                (BAR) (T/M3) (BAR)  (BAR)                (BAR) (DEG)  (BAR)
***** ****** *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******  ***********

  .15           .42   2.00    40.  2.18 19.09   .000  1.700   .028                                  125.9   SILTY SAND
  .30   799.   1.00   3.70    81.  2.21 19.96   .000  1.700   .053                                  256.3   SILTY SAND
  .46   741.   1.70   5.50   121.  2.05 20.96   .000  1.800   .081                                  388.3   SILTY SAND
  .61   907.   2.41   6.95   148.  1.80 22.35   .000  1.700   .106    5.1  48.1   2.62         40.6  483.7   SANDY SILT
  .76  1043.   2.85   7.70   160.  1.64 21.09   .000  1.800   .133    5.9  44.2   2.51         40.2  511.7   SANDY SILT
  .91  1319.   3.91  10.00   205.  1.55 23.85   .000  1.800   .159    9.2  57.8   2.87         39.8  680.4   SANDY SILT
 1.07  1360.   5.05   9.85   158.   .91 26.68   .000  1.800   .188   10.7  56.9   3.27               541.0      SILT
 1.22  1229.   5.90  10.00   132.   .65 27.51   .000  1.800   .214   12.8  59.7   3.32  1.247        457.4   CLAYEY SILT
 1.37  1043.   6.40  11.20   158.   .72 26.17   .000  1.950   .243   13.4  55.2   3.23  1.329        538.1   CLAYEY SILT
 1.52  1444.   6.58  14.40   268.  1.21 23.51   .000  1.950   .271   18.0  66.5   2.99         35.8  886.2   SANDY SILT
 1.68  1049.   6.40  11.80   180.   .82 20.93   .000  1.950   .302   11.8  39.0   2.85  1.251        574.7   CLAYEY SILT
 1.83  1160.   5.70   9.87   135.   .68 17.30   .000  1.800   .329    9.5  29.0   2.56  1.072        407.0   CLAYEY SILT
 1.98  1160.   5.95  11.50   185.   .91 16.42   .000  1.950   .357    9.5  26.7   2.48               549.6      SILT
 2.13  1449.   8.00  13.60   187.   .68 20.50   .000  1.950   .386   14.6  37.7   2.82  1.558        594.3   CLAYEY SILT
 2.29  1483.   9.40  17.40   274.   .86 22.07   .000  1.950   .417   17.6  42.3   2.94  1.843        891.5   CLAYEY SILT
 2.44  1763.  10.00  18.90   307.   .91 21.89   .000  1.950   .445   18.6  41.8   2.93               995.7      SILT
 2.59  1876.  10.40  20.70   358.  1.02 21.26   .000  1.950   .474   18.9  39.9   2.88              1151.2      SILT
 2.74  1751.  10.40  18.65   283.   .80 20.25   .000  1.950   .503   18.6  37.0   2.80  1.998        898.0   CLAYEY SILT
 2.90  1571.   9.50  16.65   243.   .75 17.50   .000  1.950   .533   15.7  29.5   2.57  1.766        737.5   CLAYEY SILT
 3.05  1476.   6.55  12.45   198.   .88 11.47   .000  1.950   .562    8.6  15.3   2.00  1.098        520.3   CLAYEY SILT
 3.20  1294.   7.60  14.00   216.   .83 12.65   .000  1.950   .591   10.5  17.8   2.12  1.304        588.2   CLAYEY SILT
 3.35  1447.   8.95  16.05   242.   .79 14.19   .000  1.950   .619   13.2  21.2   2.27  1.578        683.9   CLAYEY SILT
 3.51  1355.   8.80  14.40   187.   .62 13.40   .000  1.950   .650   12.6  19.4   2.20  1.542        519.1   CLAYEY SILT
 3.66  1314.   7.90  14.45   222.   .82 11.44   .000  1.950   .679   10.3  15.2   2.00  1.321        582.0   CLAYEY SILT
 3.81  1069.   5.48   9.10   115.   .60  7.79   .000  1.800   .705    5.9   8.3   1.57   .849        257.5   CLAYEY SILT
 3.96  1031.   7.08  13.40   213.   .88  9.48   .000  1.950   .734    8.3  11.3   1.78  1.129        521.4   CLAYEY SILT
 4.11  1143.   7.13  13.35   210.   .86  9.19   .000  1.950   .763    8.2  10.8   1.74  1.130        506.0   CLAYEY SILT
 4.27  1153.   7.09  13.35   211.   .87  8.79   .000  1.950   .793    8.0  10.1   1.70  1.110        499.9   CLAYEY SILT
 4.42  1130.   6.95  13.00   203.   .86  8.32   .000  1.950   .822    7.6   9.2   1.64  1.075        470.6   CLAYEY SILT
 4.57  1170.   6.80  12.60   194.   .83  7.88   .000  1.950   .851    7.2   8.5   1.58  1.039        438.8   CLAYEY SILT
 4.72  1118.   6.18  11.65   182.   .86  6.94   .000  1.950   .879    6.1   7.0   1.45   .916        388.3   CLAYEY SILT
 4.88  1034.   5.64  10.45   158.   .81  6.16   .000  1.800   .908    5.3   5.8   1.34   .815        317.9   CLAYEY SILT
 5.03     1.   4.68   9.18   147.   .91  4.98   .000  1.800   .934    3.9   4.1   1.16               264.1      SILT
 5.18  1003.   5.05  10.85   194.  1.13  5.16   .000  1.800   .961   ,4.2   4.4   1.19               358.1      SILT
 5.33   393.   5.18  10.85   189.  1.07  5.16   .000  1.800   .987   '4.3   4.4   1.19               348.9      SILT
 5.49   915.   4.38  10.00   188.  1.26  4.23   .000  1.800  1.015    3.9   3.8    .83         31.2  310.5   SANDY SILT
 5.64   903.   5.50  10.55   167.   .88  5.22   .000  1.800  1.042    4.7   4.5   1.20   .761        308.1   CLAYEY SILT
 5.79   929.   5.38  10.15   157.   .85  4.99   .000  1.800  1.068    4.5   4.2   1.16   .738        281.9   CLAYEY SILT
 5.94   810.   6.19  10.95   156.   .73  5.61   .000  1.800  1.095    5.5   5.0   1.26   .875        299.0   CLAYEY SILT
 6.10   790.   6.36  11.35   165.   .75  5.60   .000  1.950  1.126    5.6   5.0   1.26   .897        314.8   CLAYEY SILT
 6.25   741.   6.72  11.40   153.   .66  5.79   .000  1.950  1.154    6.1   5.2   1.29   .958        297.8   CLAYEY SILT
 6.40   741.   7.29  12.00   154.   .61  6.13   .000  1.950  1.183    6.8   5.7   1.34  1.055        308.7   CLAYEY SILT
 6.55   741.   7.04  11.80   156.   .64  5.77   .000  1.950  1.212    6.3   5.2   1.28  1.003        303.0   CLAYEY SILT
 6.71   741.   7.14  11.85   154.   .63  5.71   .000  1.950  1.242    6.4   5.1   1.27  1.015        297.7   CLAYEY SILT
 6.86   741.   7.41  11.95   148.   .58  5.81   .000  1.900  1.270    6.7   5.3   1.29  1.059        288.1   SILTY CLAY
 6.55   741.   7.04  11.80   156.   .64  5.78   .000  1.950  1.211    6.3   5.2   1.28  1.003        303.1   CLAYEY SILT

 7.16   741.   8.18  12.85   153.   .54  6.20   .015  1.900  1.311    7.7   5.8   1.35  1.186        307.5   SILTY CLAY
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  Z   THRUST    A      B     ED    ID    KD     U0    GAMMA    SV      PC    OCR     K0     CU    PHI     M       SOIL TYPE
 (M)   (KG)   (BAR)  (BAR)  (BAR)               (BAR)  (T/M3)  (BAR)   (BAR)                (BAR) (DEG)  (BAR)
***** ****** *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******  ************

 7.32   741.   8.40  12.85   145.   .50  6.29    .030  1.900  1.326    7.9   6.0    1.36  1.222         293.7   SILTY CLAY
END OF SOUNDING
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Virginia Polytechnic Institute TEST NO. KF D-2
FILE NAME: Dilatometer Test
FILE NUMBER: 10:43:13

RECORD OF DILATOMETER TEST NO. KF D-2
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

LOCATION: KIPP'S FARM: HILLTOP AREA
PERFORMED - DATE: 08/03/89
BY: MULLEN

CALIBRATION INFORMATION:
DELTA A = .17 BARS DELTA B = .30 BARS GAGE 0 = .00 BARS GWT DEPTH= 7.01 M
ROD DIA.= 3.56 CM FR.RED.DIA.= 1.91 CM ROD WT.= .00 KG/M DELTA/PHI= .50 BLADE T=15.00 MM

1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI ANALYSIS USES H2O UNIT WEIGHT = 1.000 T/M3

Z (M)	THRUST (KG)	A (BAR)	B (BAR)	ED (BAR)	ID	KD	UO (BAR)	GAMMA (T/M3)	SV (BAR)	PC (BAR)	OCR	KO	CU (BAR)	PHI (DEG)	M (BAR)	SOIL TYPE
*****	******	*****	*****	*****	*****	*****	******	******	******	*****	*****	*****	*****	*****	******	************
.30		1.22	4.04	86.	1.94	21.57	.000	1.800	.059						276.4	SILTY SAND
.61	802.	1.81	4.92	96.	1.50	16.46	.000	1.700	.112	2.8	25.4	1.88		41.3	285.9	SANDY SILT
.91	1182.	4.46	9.50	167.	1.09	26.88	.000	1.800	.164	9.4	57.6	3.28			572.1	SILT
1.22	1112.	4.83	8.50	117.	.69	22.15	.000	1.800	.219	9.3	42.6	2.94	.971		379.3	CLAYEY SILT
1.52	1465.	6.82	12.95	206.	.89	24.50	.000	1.950	.274	13.6	49.8	3.12	1.380		690.5	CLAYEY SILT
1.83	1238.	6.13	10.00	124.	.58	18.53	.000	1.800	.331	10.7	32.2	2.66	1.176		382.1	SILTY CLAY
2.13	1358.	7.00	12.40	180.	.75	17.94	.000	1.950	.386	11.8	30.6	2.61	1.318		548.4	CLAYEY SILT
2.44	1184.	6.85	11.25	143.	.60	15.32	.000	1.950	.445	10.7	24.0	2.38	1.249		415.8	CLAYEY SILT
2.74	765.	5.38	8.10	82.	.43	10.86	.000	1.800	.500	7.0	14.0	1.94	.913		211.4	SILTY CLAY
3.05	927.	6.08	10.45	142.	.68	10.91	.000	1.800	.555	7.8	14.1	1.94	1.018		366.9	CLAYEY SILT
3.35	1190.	8.13	13.15	166.	.59	13.24	.000	1.900	.610	11.6	19.1	2.18	1.424		458.5	SILTY CLAY
3.66	915.	6.98	10.45	109.	.45	10.51	.000	1.800	.666	8.9	13.3	1.90	1.166		278.4	SILTY CLAY
3.96	1153.	7.97	14.25	212.	.78	10.88	.000	1.950	.721	10.1	14.1	1.94	1.319		546.2	CLAYEY SILT
4.27	1078.	5.14	11.85	227.	1.31	6.42	.000	1.800	.778	5.3	6.8	1.05		32.9	469.9	SANDY SILT
4.57	1043.	6.20	10.50	140.	.65	7.43	.000	1.800	.831	6.4	7.8	1.52	.944		306.6	CLAYEY SILT
4.88	1014.	5.93	10.20	138.	.68	6.67	.000	1.800	.886	5.8	6.5	1.42	.879		289.0	CLAYEY SILT
5.18	851.	5.18	9.47	139.	.78	5.49	.000	1.800	.939	4.5	4.8	1.24	.731		263.5	CLAYEY SILT
5.49	741.	4.83	8.66	122.	.73	4.86	.000	1.800	.994	4.0	4.0	1.14	.664		216.3	CLAYEY SILT
5.79	727.	4.48	8.13	116.	.74	4.29	.000	1.800	1.047	3.4	3.3	1.04	.598		190.1	CLAYEY SILT
6.10	656.	4.20	7.52	104.	.71	3.84	.000	1.800	1.101	3.0	2.8	.96	.547		158.4	CLAYEY SILT
6.40	654.	4.86	8.04	99.	.58	4.24	.000	1.800	1.154	3.7	3.2	1.03	.650		160.0	SILTY CLAY
6.71	682.	6.08	10.65	149.	.71	5.00	.000	1.800	1.209	5.0	4.2	1.16	.836		268.1	CLAYEY SILT
7.01	650.	5.82	9.24	107.	.53	4.63	.000	1.800	1.262	4.7	3.7	1.10	.793		183.8	SILTY CLAY
7.32	704.	6.49	10.15	116.	.52	5.03	.030	1.800	1.287	5.4	4.2	1.17	.896		208.7	SILTY CLAY
7.62	700.	6.48	9.95	109.	.49	4.92	.060	1.800	1.310	5.3	4.1	1.15	.887		193.7	SILTY CLAY
7.92	632.	5.41	8.28	87.	.47	4.03	.089	1.800	1.334	4.0	3.0	.99	.704		137.1	SILTY CLAY
8.23	643.	5.51	8.86	105.	.56	3.99	.120	1.800	1.358	4.0	2.9	.98	.708		163.5	SILTY CLAY
8.53	646.	5.49	9.02	111.	.60	3.88	.149	1.800	1.382	3.9	2.8	.96	.695		170.5	SILTY CLAY
8.84	591.	4.58	7.87	103.	.67	3.15	.180	1.800	1.406	2.9	2.0	.82	.546		135.8	CLAYEY SILT
9.14	635.	2.96	6.22	102.	1.05	1.95	.209	1.700	1.428	1.4	1.0	.53			88.6	SILT
9.45	617.	3.08	6.22	97.	.97	1.99	.239	1.700	1.449	1.4	1.0	.54			85.8	SILT
9.75	741.	1.58	3.94	69.	1.43	.94	.269	1.700	1.470	1.2	.8	.43		31.8	58.5	SANDY SILT
10.06	741.	1.64	4.22	77.	1.58	.94	.299	1.700	1.491	1.3	.8	.44		31.7	65.3	SANDY SILT
10.36	282.	1.08	2.39	31.	1.00	.58	.329	1.600	1.510	.2	.1	.04			26.0	SILT
10.67	236.	.53	1.58	21.	1.95	.20	.359	1.700	1.530	1.2	.8	.57		22.7	18.0	SILTY SAND
10.97	178.	.51	1.82	31.	3.54	.16	.389	1.700	1.551	1.3	.8	.62		19.9	26.0	SAND
11.28	1199.	3.00	7.03	130.	1.45	1.64	.419	1.700	1.572	1.7	1.1	.46		34.5	110.3	SANDY SILT

END OF SOUNDING

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Virginia Polytechnic Institute                                              TEST NO. KF D-3
FILE NAME:     Dilatometer Test
FILE NUMBER:   09:15:00

RECORD OF DILATOMETER TEST NO. KF D-3
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

     LOCATION: KIPP'S FARM: HILLTOP AREA
     PERFORMED - DATE:  08/04/89
                   BY:  MULLEN


     CALIBRATION INFORMATION:
     DELTA A =  .17 BARS   DELTA B     =  .24 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 7.01 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50      BLADE T=15.00 MM

     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3


  Z   THRUST   A      B     ED     ID    KD     U0    GAMMA   SV      PC    OCR    KO     CU    PHI     M      SOIL TYPE
 (M)   (KG)  (BAR)  (BAR)  (BAR)                (BAR) (T/M3) (BAR)  (BAR)                 (BAR) (DEG)  (BAR)
***** ****** *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******   ***********

  .30   799.  1.36   4.31    93.  1.90 23.78   .000  1.800   .059                                     307.3   SILTY SAND
  .61   855.  2.69   6.32   117.  1.25 24.05   .000  1.700   .112    6.7  59.6   2.91          38.9   390.8   SANDY SILT
  .91         2.59   5.89   105.  1.16 16.12   .000  1.700   .162    4.2  25.9   2.45                 310.8     SILT
 1.22         3.38   6.98   116.   .99 15.73   .000  1.800   .216    5.4  25.0   2.42                 340.4     SILT
 1.52  1455.  2.66   6.50   125.  1.35  9.90   .000  1.800   .269    2.5   9.2   1.11          42.2   311.2   SANDY SILT
 1.83         5.13  10.05   164.   .93 15.70   .000  1.800   .323    8.0  24.9   2.41                 481.0     SILT
 2.13         5.38   8.88   113.   .60 14.34   .000  1.800   .376    8.1  21.6   2.29   .971          319.9   CLAYEY SILT
 2.44         5.28   9.19   128.   .70 12.24   .000  1.800   .431    7.3  16.9   2.08   .913          343.2   CLAYEY SILT
 2.74         5.96  10.15   138.   .67 12.27   .000  1.800   .484    8.2  17.0   2.09  1.029          371.0   CLAYEY SILT
 3.05         6.48  10.80   142.   .64 11.98   .000  1.800   .539    8.8  16.3   2.06  1.111          380.5   CLAYEY SILT
 3.35         6.78  11.35   152.   .65 11.35   .000  1.950   .594    8.9  15.0   1.99  1.145          397.1   CLAYEY SILT
 3.66         7.02  11.45   146.   .60 10.70   .000  1.950   .653    8.9  13.7   1.92  1.169          375.5   CLAYEY SILT
 3.96         6.09  10.40   142.   .68  8.56   .000  1.800   .709    6.8   9.7   1.67   .960          332.7   CLAYEY SILT
 4.27         6.18  10.40   139.   .65  8.07   .000  1.800   .763    6.7   8.8   1.61   .960          316.6   CLAYEY SILT
 4.57         6.09  10.00   128.   .60  7.45   .000  1.800   .816    6.4   7.8   1.52   .930          280.4   CLAYEY SILT
 4.88         5.76   9.41   118.   .59  6.62   .000  1.800   .871    5.6   6.5   1.41   .856          245.3   SILTY CLAY
 5.18         6.50  11.65   173.   .77  6.95   .000  1.950   .926    6.5   7.0   1.46   .966          367.9   CLAYEY SILT
 5.49         6.52  11.10   152.   .68  6.58   .000  1.950   .986    6.3   6.4   1.40   .960          314.9   CLAYEY SILT
 5.79         6.44  10.75   142.   .64  6.16   .000  1.800  1.041    6.0   5.8   1.34   .935          284.9   CLAYEY SILT
 6.10         6.39  10.75   144.   .65  5.81   .000  1.800  1.096    5.8   5.3   1.29   .914          279.9   CLAYEY SILT
 6.40         6.32  10.20   126.   .58  5.50   .000  1.800  1.148    5.6   4.8   1.24   .895          238.6   SILTY CLAY
 6.71         6.87  11.20   143.   .60  5.68   .000  1.950  1.206    6.1   5.1   1.27   .977          274.2   CLAYEY SILT
 7.01         6.19   9.80   117.   .54  4.92   .000  1.800  1.261    5.1   4.1   1.15   .854          206.7   SILTY CLAY
 7.32         6.88  10.75   126.   .53  5.33   .030  1.800  1.285    5.9   4.6   1.21   .962          233.8   SILTY CLAY
 7.62         6.23   9.71   112.   .52  4.73   .060  1.800  1.309    5.0   3.8   1.12   .844          193.7   SILTY CLAY
 7.92         5.74   9.43   120.   .61  4.25   .089  1.800  1.332    4.3   3.2   1.03   .751          193.9   CLAYEY SILT
 8.23         5.38   9.17   123.   .67  3.88   .120  1.800  1.357    3.8   2.8    .96   .683          188.9   CLAYEY SILT
 8.53         3.52   7.40   126.  1.08  2.44   .149  1.800  1.380    1.9   1.4    .66                 138.9     SILT
 8.84         -.13    .68    14. -2.87         .180  P01 =   .02   P0 =    .04   P1 =    .44               QUESTIONABLE
 9.14         -.15    .79    18. -2.80         .209  P01 =  -.01   P0 =    .02   P1 =    .55               QUESTIONABLE
 9.45         -.14    .42     5.  -.72         .239  P01 =   .02   P0 =    .03   P1 =    .18               QUESTIONABLE
 9.75         -.13    .50     8.  -.96         .269  P01 =   .03   P0 =    .04   P1 =    .26               QUESTIONABLE
END OF SOUNDING
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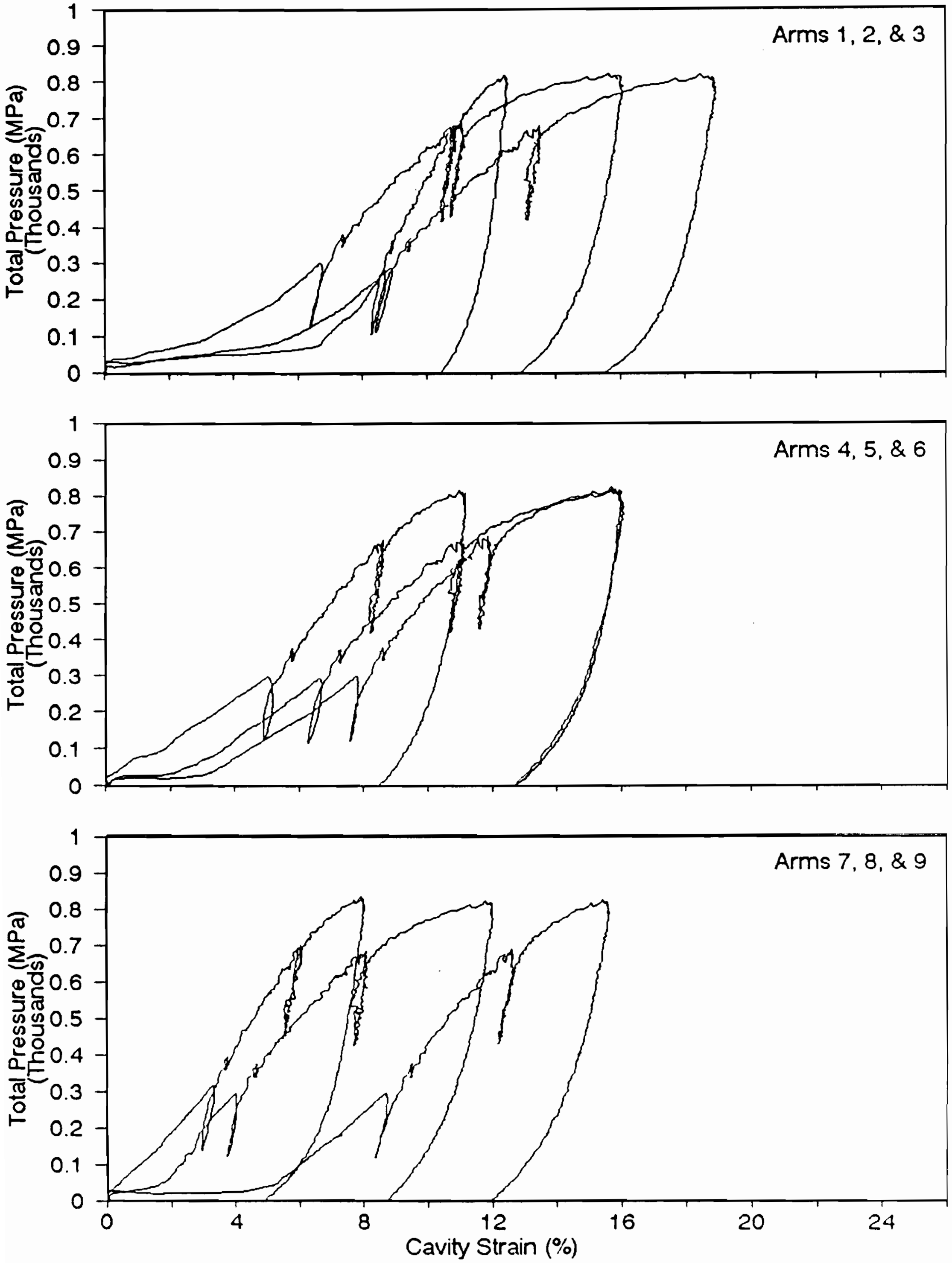
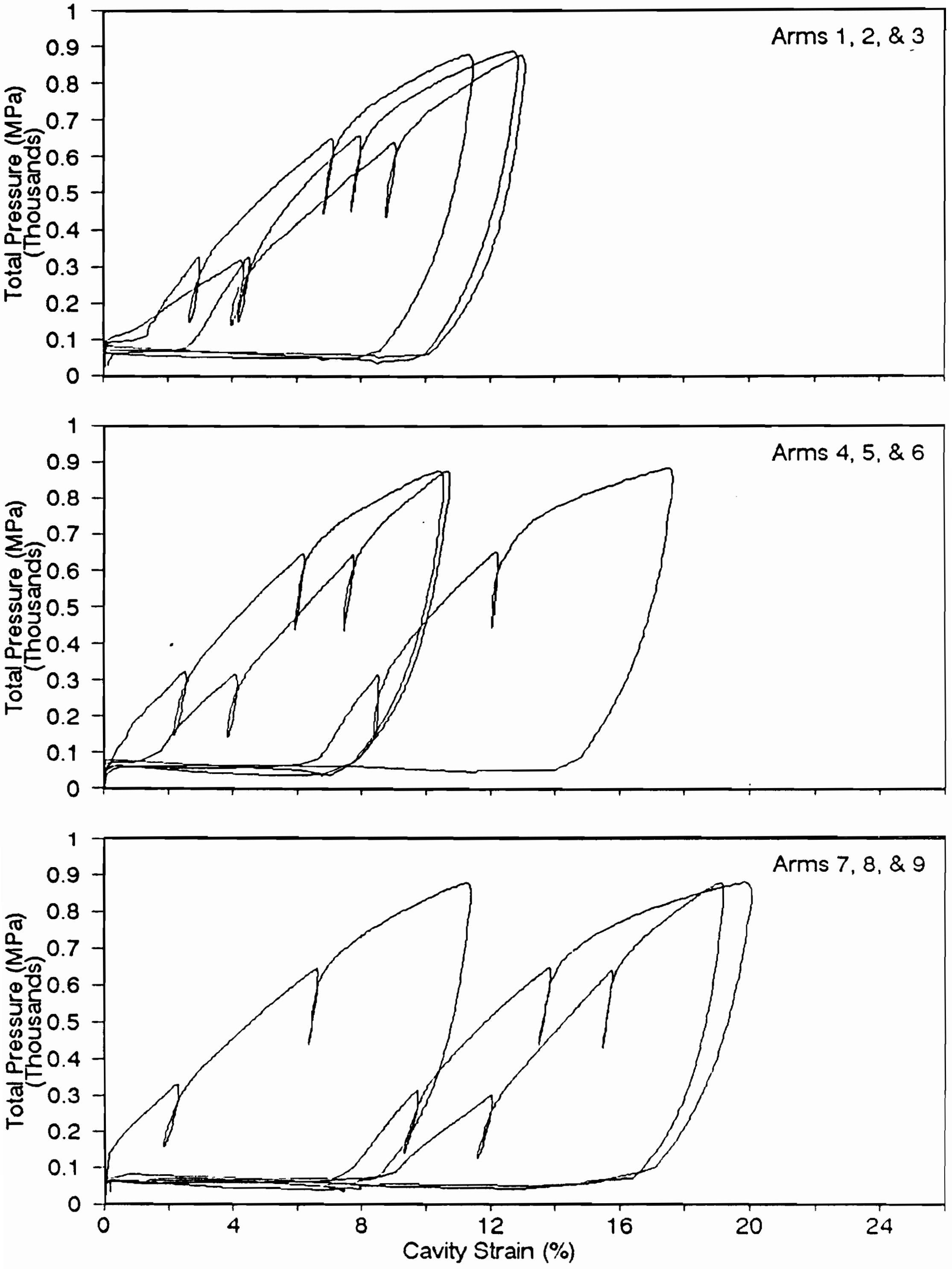
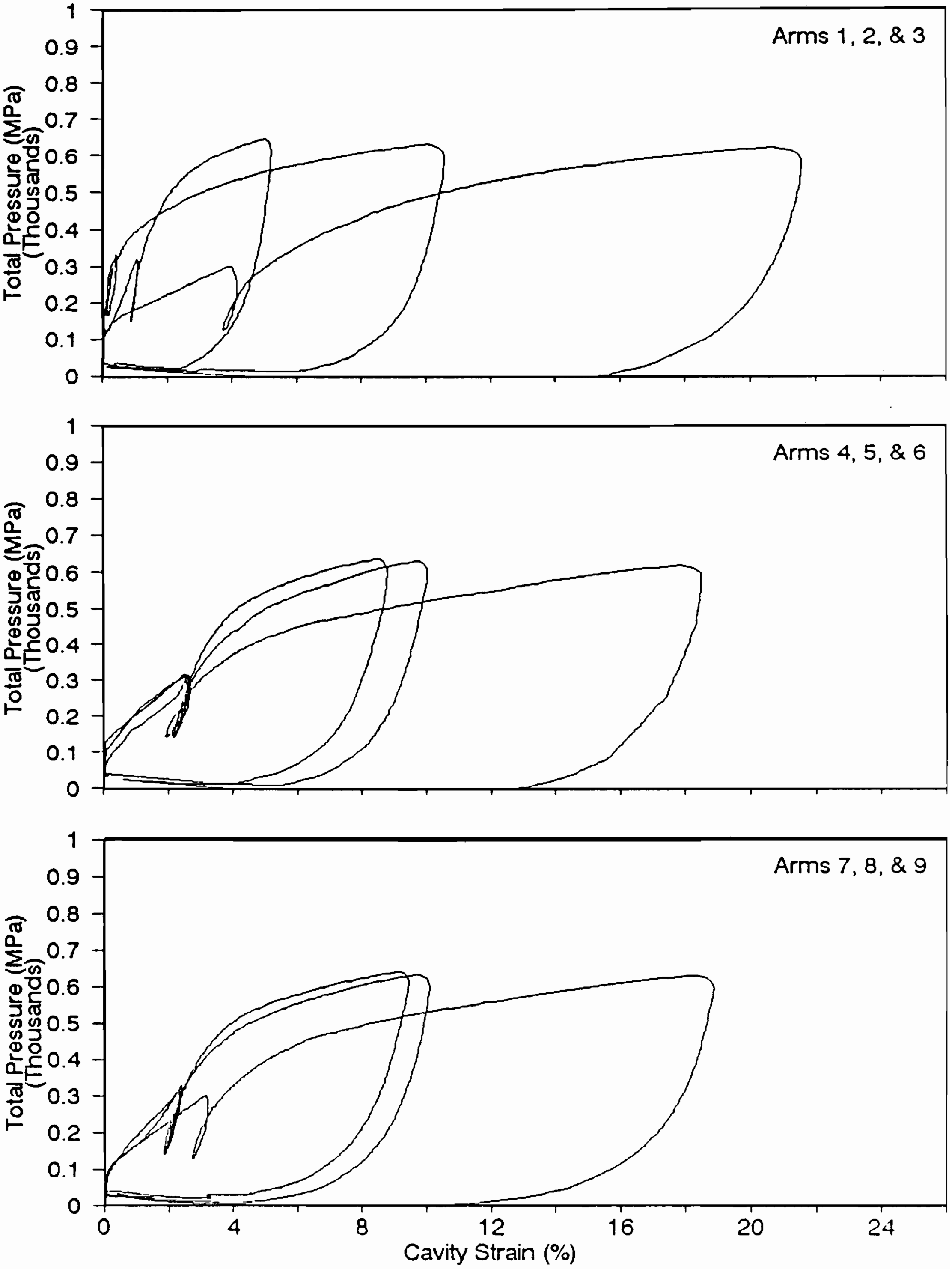


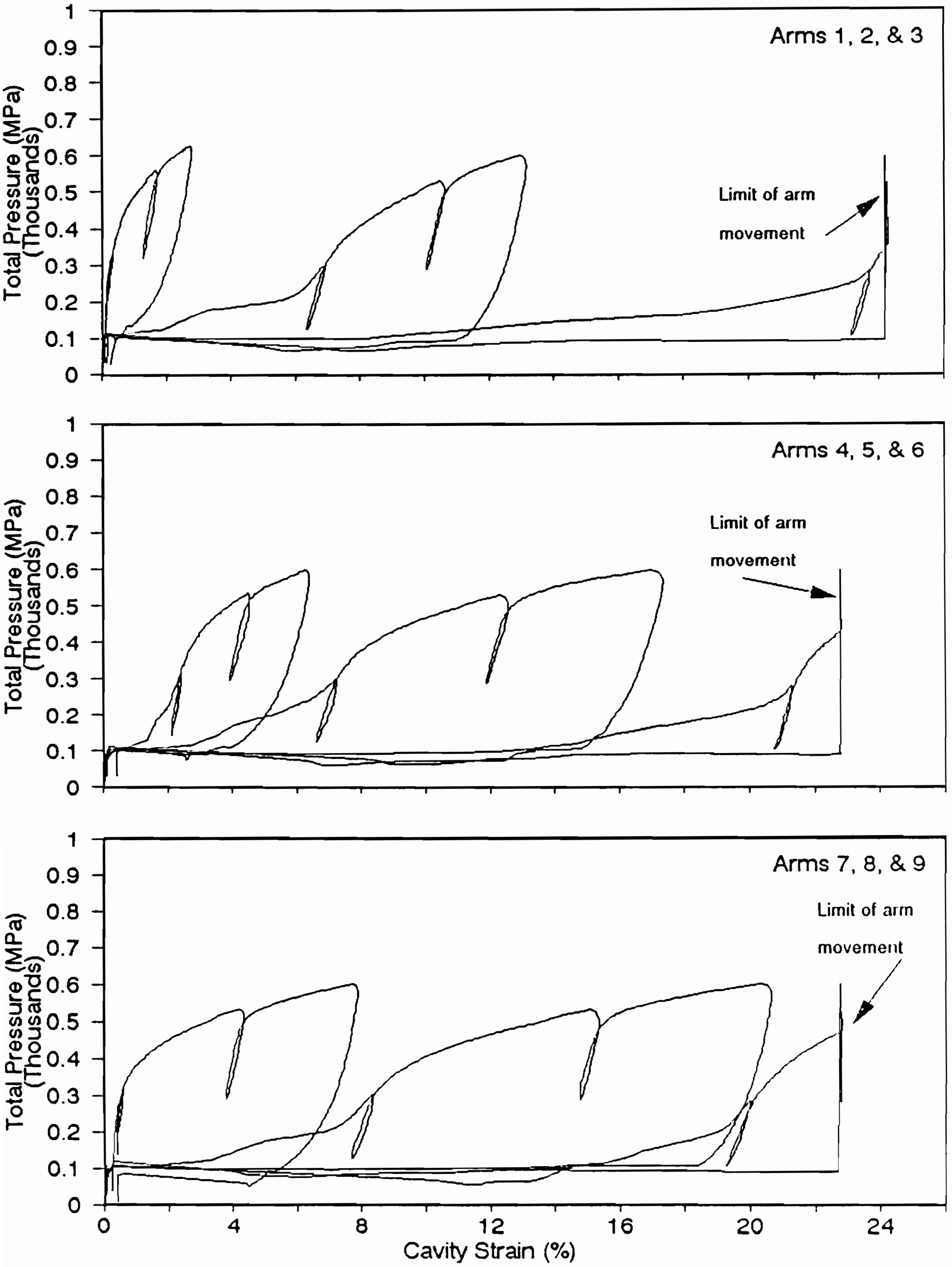
Kipp's Farm, Hilltop Area: Pressuremeter Test KFTP-2 08/08/89



Kipp's Farm, Hilltop Area: Pressuremeter Test KFTP-3 08/09/89



Kipp's Farm, Hilltop Area: Pressuremeter Test KFTP-5 08/11/89



Kipp's Farm, Hilltop Area: Pressuremeter Test KFTP-6 08/11/89

KIPP'S FARM,
HILLTOP AREA:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	BORING #	N60	N160	Qc (pt) bar
-0.5				13.2
-1.0				18.0
-1.5				16.8
-2.0				16.3
-2.5	B-1	10	18	17.7
-3.0				14.0
-3.5				32.3
-4.0	B-3	5	8	28.9
-4.0	B-1	15	25	29.8
-4.5				26.4
-5.0				31.6
-5.5	B-3	6	9	31.3
-5.5	B-1	34	52	30.1
-6.0				24.2
-6.5				18.1
-7.0	B-1	31	45	28.0
-7.5				21.7
-8.0				23.8
-8.5	B-1	19	26	23.8
-9.0				30.7
-9.5				34.1
-10.0	B-3	6	8	33.9
-10.0	B-1	13	17	32.9
-10.5				45.4
-11.0				54.0
-11.5	B-3	8	10	59.7
-11.5	B-1	13	16	60.4
-12.0				42.9
-12.5				45.1
-13.0	B-1	45	52	64.5
-13.5				88.4
-14.0				85.1
-14.5	B-1	35	38	56.9
-15.0				83.4
-15.5				70.4

KIPP'S FARM, HILLTOP AREA: IN-SITU TEST DATA SUMMARY

DEPTH ft.	Qn (pt)) barr	ED bar	Gur kN/M^2	D50 (mm)
-0.5	25.7	40.0		
-1.0	34.1	86.7		
-1.5	31.1	121.0		
-2.0	29.3	120.3		
-2.5	31.2	160.0		0.003
-3.0	24.2	159.0		
-3.5	54.3	158.0		
-4.0	47.6	121.7		0.009
-4.0	48.9	121.7		0.009
-4.5	42.5	158.0		
-5.0	49.7	199.7		
-5.5	48.1	180.0		0.029
-5.5	46.2	180.0		0.029
-6.0	36.5	141.0		
-6.5	26.7	185.0		
-7.0	40.5	160.0		0.025
-7.5	30.7	274.0		
-8.0	33.0	192.7		
-8.5	32.3	358.0		0.028
-9.0	41.1	167.7		
-9.5	44.5	243.0		
-10.0	43.7	160.7		0.023
-10.0	42.4	160.7		0.023
-10.5	57.0	216.0	25521	
-11.0	67.2	186.7		
-11.5	72.4	187.0		0.021
-11.5	73.2	187.0		0.021
-12.0	51.5	159.0		
-12.5	52.9	115.0		
-13.0	75.0	189.0		0.026
-13.5	100.3	210.0		
-14.0	95.7	192.3		
-14.5	62.5	203.0		0.03
-15.0	91.1	154.0		
-15.5	74.9	182.0		

KIPP'S FARM,
HILLTOP AREA:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Qc (pt)/ N	Su Dilly	Su N60 (bars)	Nk = 15 Su Qc (bars)
-0.5				
-1.0				
-1.5				
-2.0				
-2.5	1.77		2.431	1.171
-3.0				
-3.5				
-4.0	5.78	0.739	1.182	1.914
-4.0	1.98	0.739	3.781	1.970
-4.5		1.329		1.745
-5.0		0.460		2.087
-5.5	5.22	1.251	1.418	2.066
-5.5	0.88	1.251	8.570	1.985
-6.0		0.749		1.593
-6.5				
-7.0	0.90	1.282	7.814	1.840
-7.5		1.843		1.422
-8.0		0.721		1.555
-8.5	1.25		4.789	1.558
-9.0		1.313		2.014
-9.5		1.766		2.237
-10.0	5.66	1.076	1.418	2.226
-10.0	2.53	1.076	3.241	2.157
-10.5		1.304		2.986
-11.0		1.382		3.561
-11.5	7.46	1.542	1.890	3.936
-11.5	4.65	1.542	3.241	3.983
-12.0		1.219		2.813
-12.5		0.849		2.959
-13.0	1.43	1.136	11.342	4.255
-13.5		1.130		5.844
-14.0		0.690		5.622
-14.5	1.63	1.075	8.822	3.739
-15.0		0.971		5.507
-15.5		0.916		4.632

KIPP'S FARM,
HILLTOP AREA:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	BORING #	N60	N160	Qc (pt) bar
-16.0	B-3	4	4	66.3
-16.0	B-1	22	23	64.7
-16.5				47.5
-17.0				47.0
-17.5	B-3	6	6	32.5
-17.5	B-1	32	32	34.9
-18.0				46.4
-18.5				49.4
-19.0	B-3	7	7	42.9
-19.0	B-1	48	47	47.9
-19.5				39.6
-20.0				30.5
-20.5	B-1	22	20	30.3
-21.0				29.3
-21.5				26.3
-22.0	B-3	4	4	34.7
-22.5				36.1
-23.0				34.7
-23.5	B-3	4	3	38.3
-24.0	B-1	13	11	54.3
-25.0				115.2
-25.5	B-1	15	13	131.6
-26.0				114.0
-27.0	B-1	18	15	54.3
-28.0				43.0
-29.0				22.5
-30.0	B-3	8	9	26.7
-30.5	B-1	18	21	74.1
-31.0				60.7
-31.5	B-3	5	6	58.1
-32.0	B-1	13	15	83.0
-33.0	B-3	6	5	35.5
-33.5	B-1	17	14	40.1
-34.0				38.3
-35.0	B-1	26	21	29.3

KIPP'S FARM,
HILLTOP AREA:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Qn (pt)) barr	ED bar	Gur kN/M^2	D50 (mm)
-16.0	70.2	138.0		0.033
-16.0	68.5	138.0		0.033
-16.5	49.2	147.0		
-17.0	48.4	168.7		
-17.5	32.7	189.0		0.044
-17.5	35.1	189.0		0.044
-18.0	46.4	154.0	25979	
-18.5	48.3	167.0		
-19.0	41.8	138.3		0.033
-19.0	46.7	138.3		0.033
-19.5	37.8	156.0		
-20.0	28.9	137.7		
-20.5	28.1	153.0		0.034
-21.0	27.1	126.3		
-21.5	23.8	156.0		
-22.0	31.3	148.7		
-22.5	31.8	148.0		
-23.0	30.9	126.7		
-23.5	33.1	153.0		
-24.0	47.2	129.0		0.034
-25.0	99.8	110.5		
-25.5	113.4	107.0		0.01
-26.0	97.7	103.5		
-27.0	46.1	114.0		0.027
-28.0	36.1	118.5		
-29.0	26.2	58.5		
-30.0	31.2	60.0		
-30.5	86.1	55.5	18145	0.095
-31.0	70.0	51.0		
-31.5	66.7	44.8		
-32.0	94.8	38.5		0.047
-33.0	28.5	77.0		
-33.5	32.1	54.0	20459	0.039
-34.0	30.5	31.0		
-35.0	23.1	21.0		0.053

KIPP'S FARM, HILLTOP AREA: IN-SITU TEST DATA SUMMARY

DEPTH ft.	Qc (pt)/ N	Su Dilly	Su N60 (bars)	Nk = 15 Su Qc (bars)
-16.0	16.56	0.850	0.945	4.358
-16.0	2.94	0.850	5.545	4.253
-16.5				3.107
-17.0		0.566		3.069
-17.5	5.41		1.418	2.100
-17.5	1.09		8.066	2.262
-18.0		0.541		3.024
-18.5		0.761		3.221
-19.0	6.12	0.757	1.654	2.788
-19.0	1.00	0.757	12.099	3.122
-19.5		0.875		2.566
-20.0		0.786		1.957
-20.5	1.38	0.958	5.545	1.940
-21.0		0.867		1.879
-21.5		1.003		1.671
-22.0		0.943	0.945	2.233
-22.5		1.059		2.322
-23.0		0.883		2.231
-23.5		1.186	0.945	2.464
-24.0	4.18	1.027	3.241	3.533
-25.0		0.866		7.594
-25.5	8.77	0.797	3.781	8.684
-26.0		0.728		7.512
-27.0	3.02	0.696	4.537	3.531
-28.0		0.348		2.773
-29.0		0.493		1.451
-30.0		0.275	1.890	1.730
-30.5	4.12	0.183	4.537	4.894
-31.0		0.090		4.001
-31.5		0.110	1.182	3.826
-32.0	6.38	0.130	3.241	5.481
-33.0			1.418	2.270
-33.5	2.36		4.285	2.576
-34.0				
-35.0	1.13		6.553	1.850

KIPP'S FARM,
HILLTOP AREA:
IN-SITU TEST
DATA SUMMARY

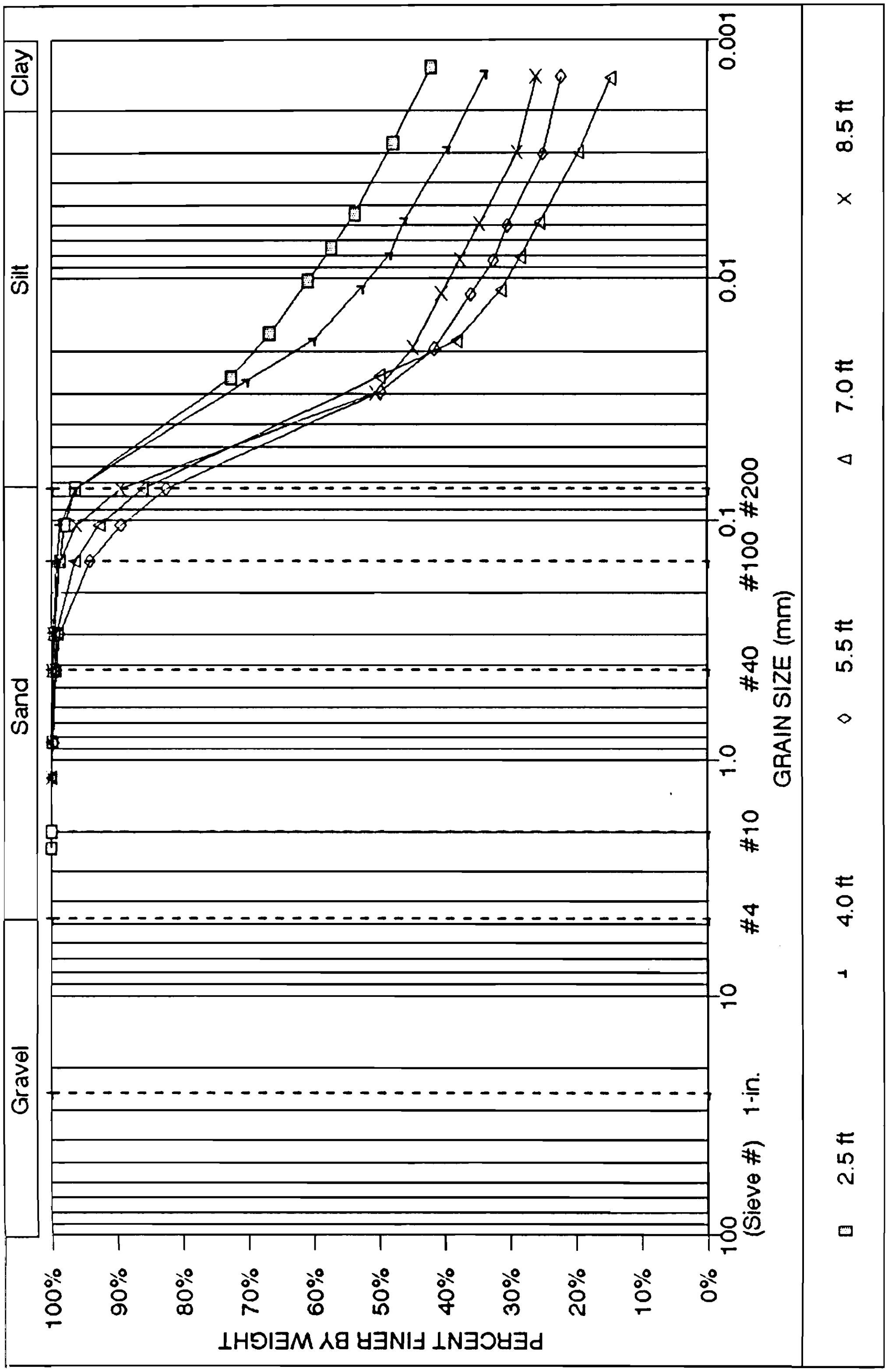
DEPTH ft.	BORING #	N60	N160	Qc (pt) bar
-36.0				26.6
-36.5	B-1	50	39	91.1
-37.0				29.9

KIPP'S FARM,
HILLTOP AREA:
IN-SITU TEST
DATA SUMMARY

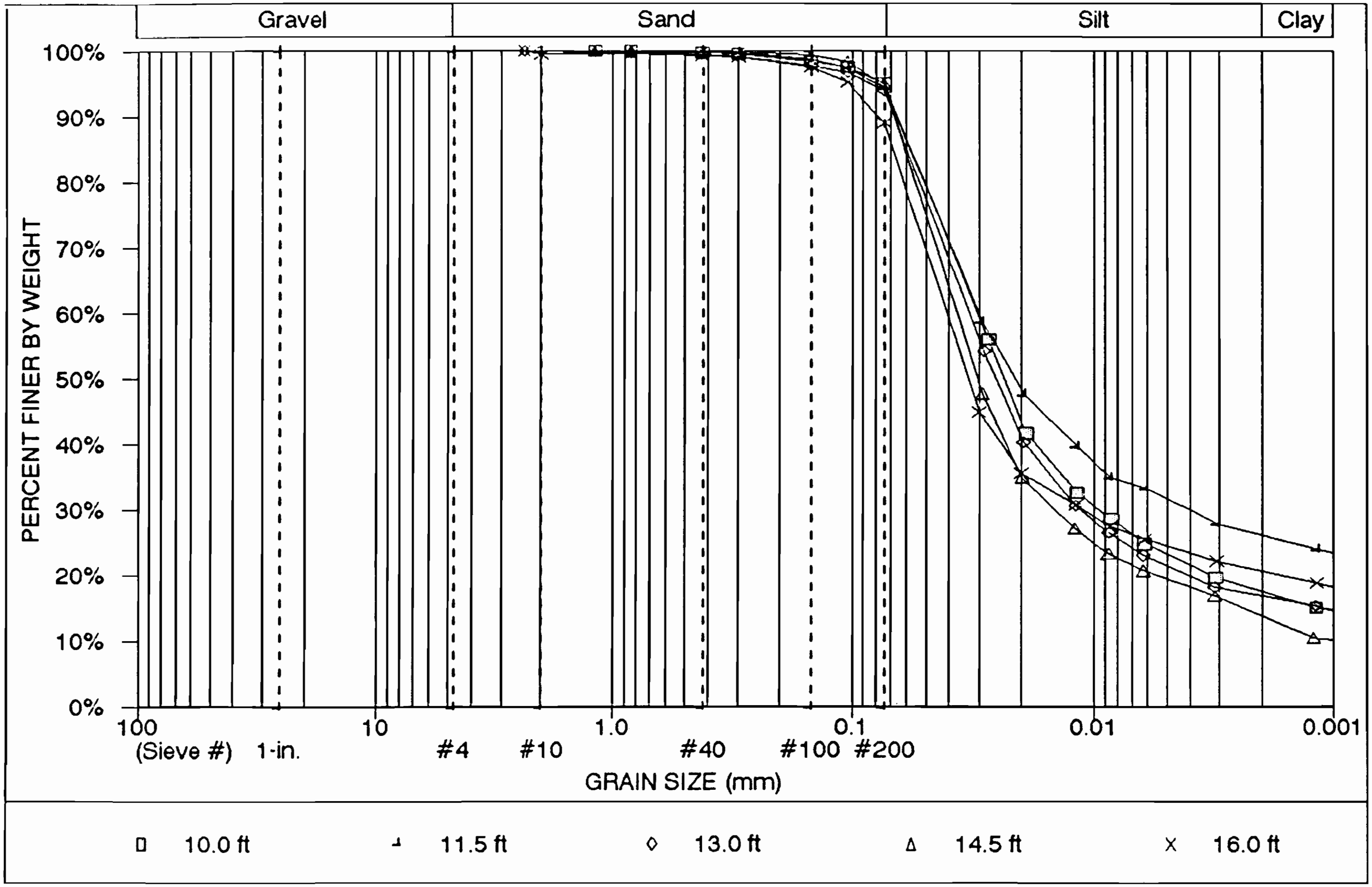
DEPTH ft.	Qn (pt)) barr	ED bar	Gur kN/M^2	D50 (mm)
-36.0	20.8	31.0		
-36.5	71.1	80.5		
-37.0	23.3	130.0		

KIPP'S FARM,
HILLTOP AREA:
IN-SITU TEST
DATA SUMMARY

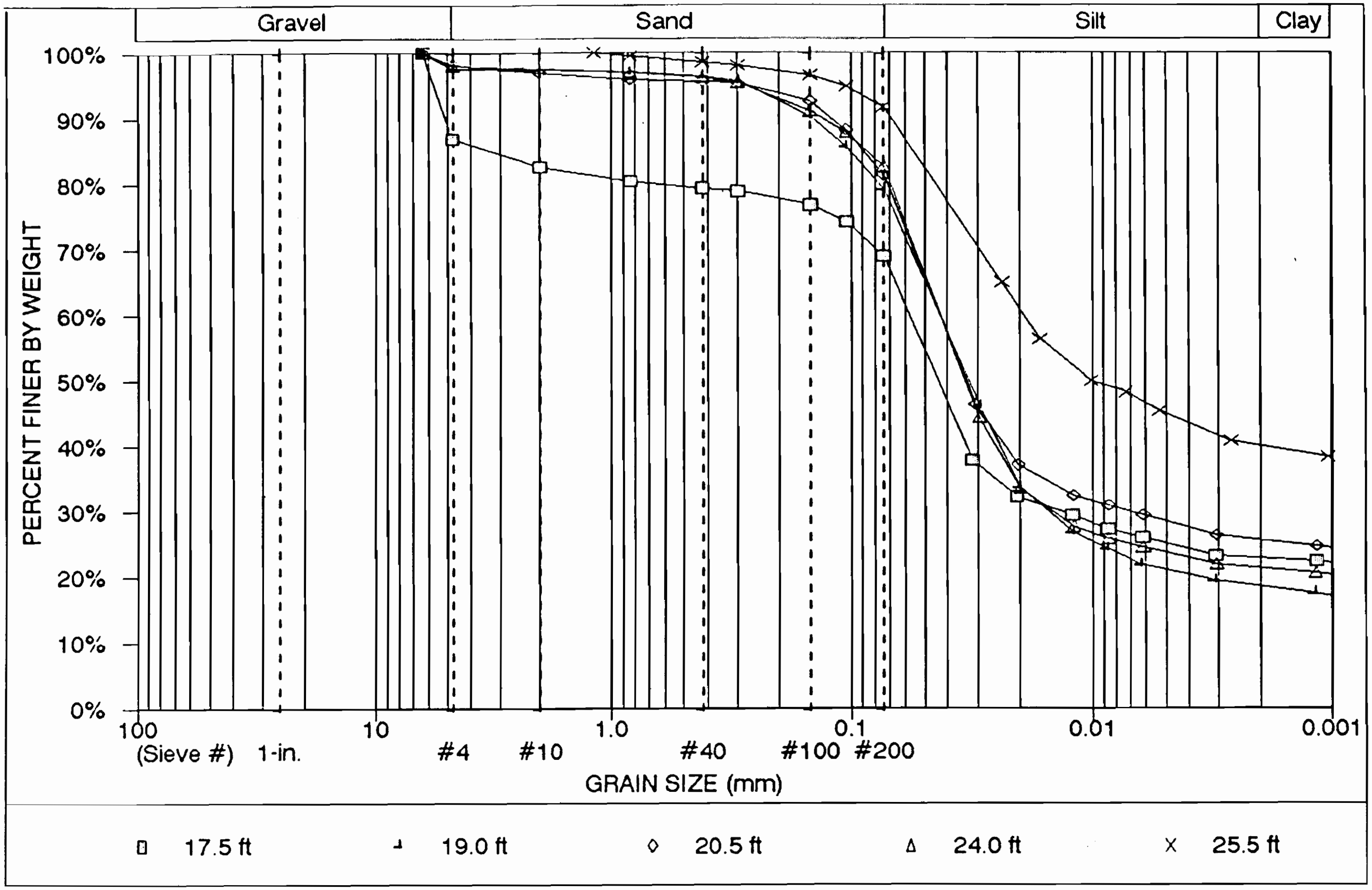
DEPTH ft.	Qc (pt)/ N	Su Dilly	Su N60 (bars)	Nk = 15 Su Qc (bars)
-36.0				
-36.5			12.603	5.970
-37.0				



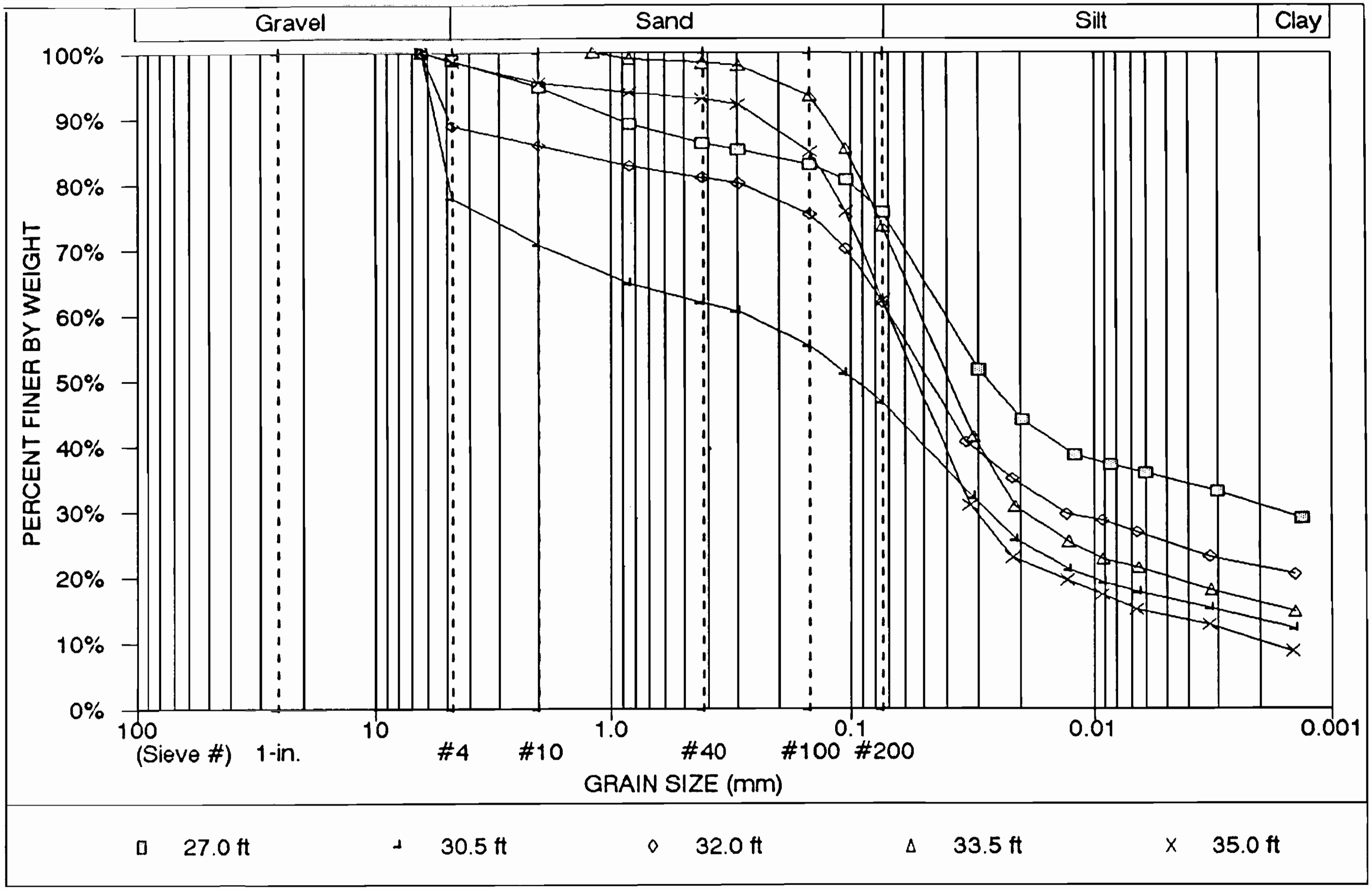
Kipp's Farm, Hilltop Area: Grain Size Data



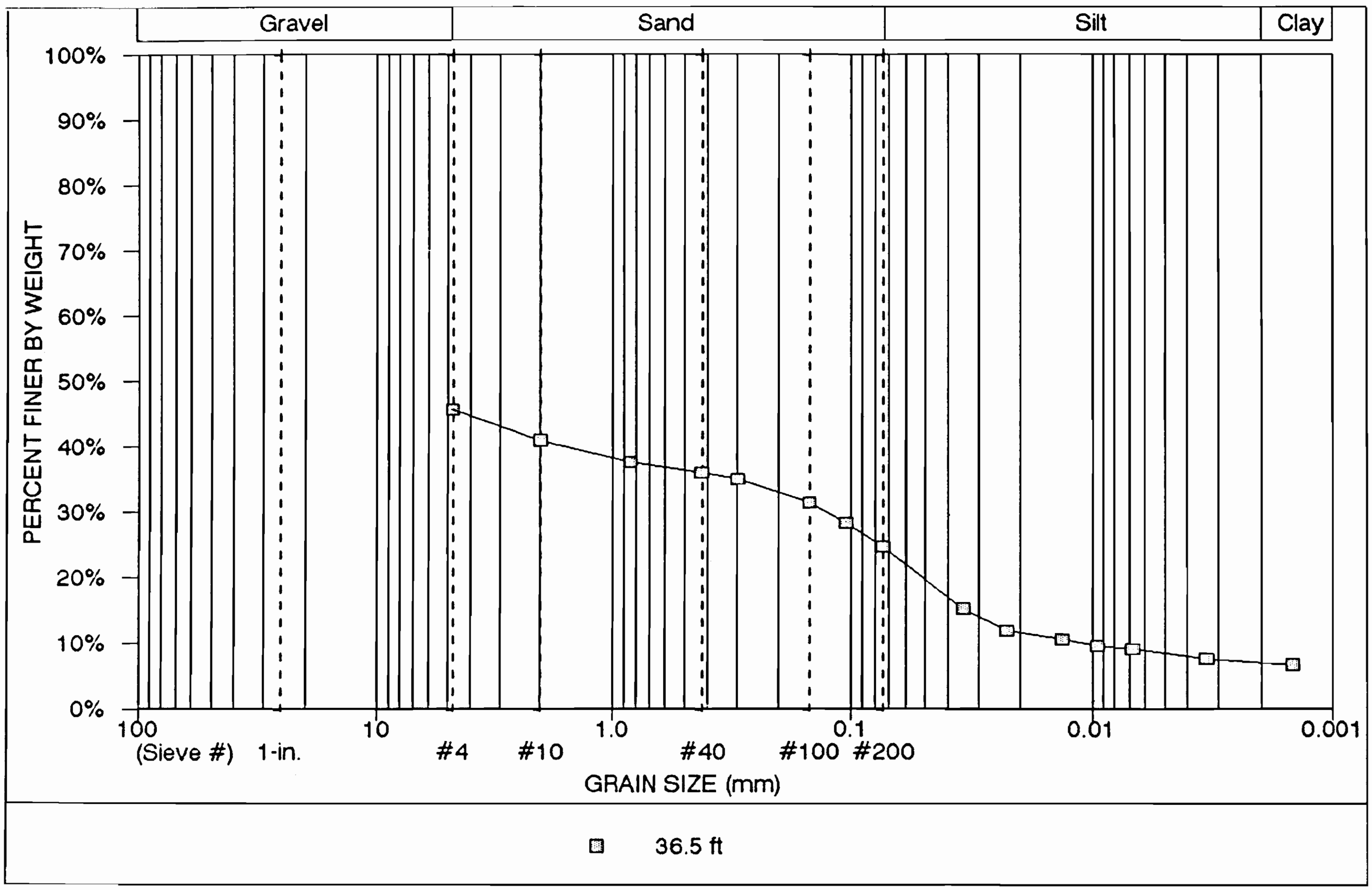
Kipp's Farm, Hilltop Area: Grain Size Data



Kipp's Farm, Hilltop Area: Grain Size Data



Kipp's Farm, Hilltop Area: Grain Size Data



Kipp's Farm, Hilltop Area: Grain Size Data

KIPP'S FARM,
HILLTOP AREA:
LAB DATA
SUMMARY
FROM B-1.

DEPTH (ft)	SPECIFIC GRAVITY	D60 (mm)	D50 (mm)	D10 (mm)	Cu
-2.5	2.684		0.003		
-4.0	2.684		0.009		
-5.5	2.684		0.029		
-7.0	2.684		0.025		
-8.5	2.684		0.028		
-10.0	2.684		0.023		
-11.5	2.684		0.021		
-13.0	2.684		0.026		
-14.5	2.684		0.030		
-16.0	2.684		0.033		
-17.5	2.684		0.044		
-19.0	2.684		0.033		
-20.5	2.684		0.034		
-24.0	2.684		0.034		
-25.5	2.684		0.010		
-27.0	2.702		0.027		
-30.5	2.702		0.095		
-32.0	2.702		0.047		
-33.5	2.702		0.039		
-35.0	2.702	0.069	0.053	0.002	35
-36.5	2.702				

KIPP'S FARM,
HILLTOP AREA:
LAB DATA
SUMMARY
FROM B-1.

DEPTH (ft)	%-200	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	MOISTURE CONTENT %
-2.5	96.5%	96.7%	46.4%	50.3%	49.8%
-4.0	96.3%	68.9%	50.4%	18.5%	46.4%
-5.5	82.4%	57.2%	39.7%	17.5%	37.3%
-7.0	86.1%	47.1%	42.5%	4.6%	40.0%
-8.5	89.4%	NP			41.5%
-10.0	95.0%	NP			44.3%
-11.5	94.3%	49.9%	32.2%	17.7%	39.7%
-13.0	93.9%	43.9%	36.7%	7.2%	39.2%
-14.5	94.9%	NP			31.6%
-16.0	88.9%	NP			37.6%
-17.5	86.3%	43.4%	33.4%	10.0%	38.9%
-19.0	81.8%	NP			42.4%
-20.5	84.4%	NP			38.4%
-24.0	84.6%	NP			37.5%
-25.5	91.7%	NP			37.7%
-27.0	81.0%	39.3%	30.4%	8.9%	33.7%
-30.5	75.9%	37.3%	24.8%	12.5%	39.5%
-32.0	76.0%	37.7%	29.0%	8.7%	32.6%
-33.5	73.6%	39.5%	33.2%	6.3%	30.9%
-35.0	67.0%	38.3%	36.3%	2.0%	27.8%
-36.5	83.7%	NP			23.0%

APPENDIX F

KIPP'S FARM
HILLSIDE AREA

KIPP'S FARM, HILLSIDE AREA: FIELD BORING LOGS

BORING B-2
SAMPLING TO 41 FT.
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 6/22-23/89

WATER TABLE = 23.0 FT.

DEPTH IN FT. from	to	BLOW COUNT blows per 6 in.	DESCRIPTION
3.0-	4.5	1 - 2 / 2	red-orange sandy silt
4.5-	6.0	3 - 3 / 4	red-orange silty clay w/ calcite
9.0-	10.5	4 - 4 / 4	tan, white, yelow, black banded silty fine sand
10.5-	12.0	3 - 4 / 4	same to 11' 6", then orange brown silty clay
15.0-	16.5	2 - 2 / 4	orange brown banded silty clay to 16', then fine sandy silt
16.5-	18.0	4 - 4 / 6	tan-yellow silty fine sand
20.5-	22.0	1 - 1 / 3	orange tan silty clay w/ black stripes & traces of sand
22.0-	23.5	3 - 4 / 5	same w/ layer of shale @ 23' 6"
27.0-	28.5	4 - 6 / 5	tan silty fine sand with black streaks
28.5-	30.0	2 - 5 / 7	same
33.0-	34.5	3 - 2 / 6	tan silty fine sand
34.5-	36.0	5 - 3 / 3	same

---END OF BORING---

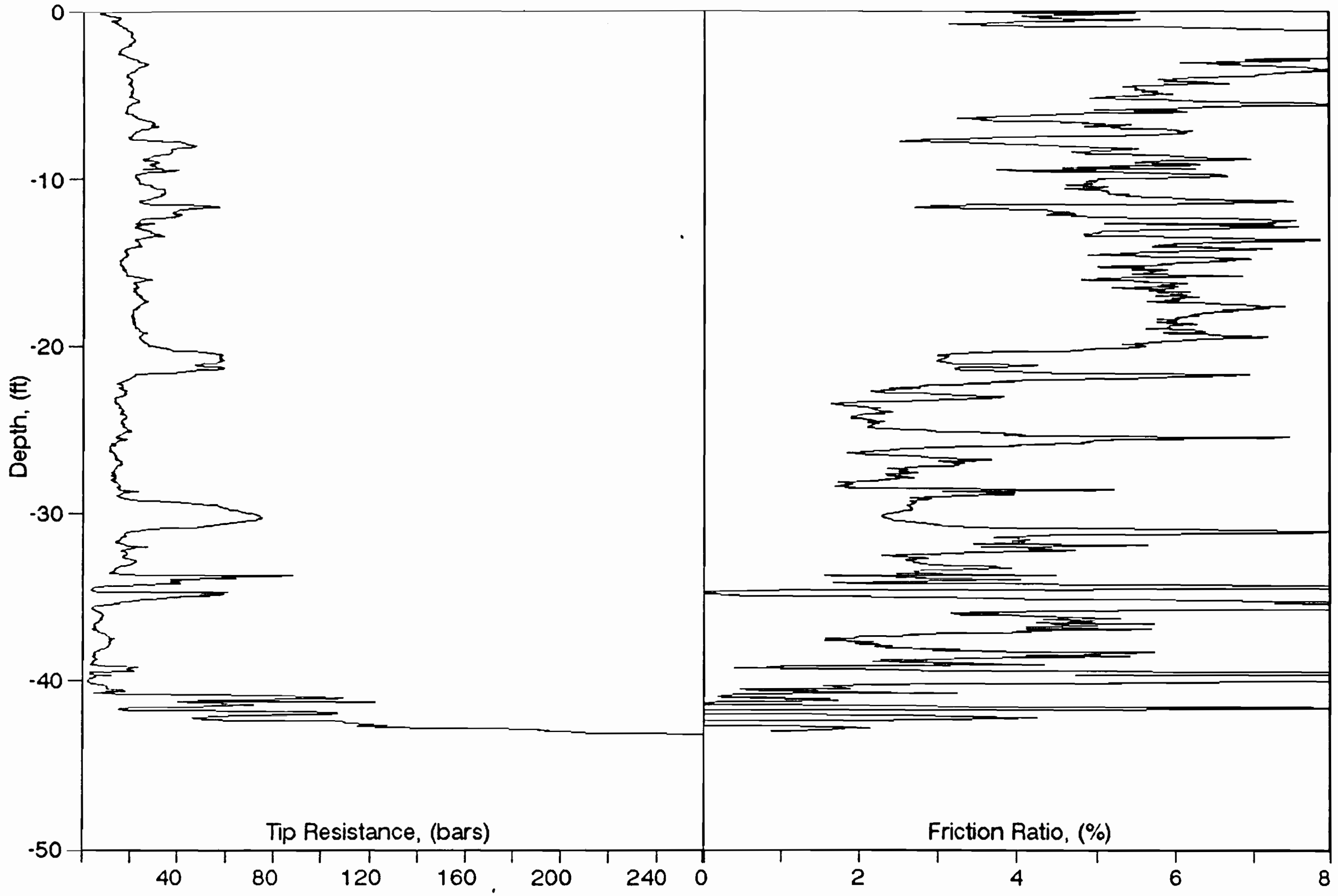
KIPP'S FARM, HILLSIDE AREA: FIELD BORING LOGS

BORING B-4
SAMPLING AND PRESSUREMETER TESTING TO 36 FT.
SAMPLES TAKEN WITH 300# HAMMER AND 3" SAMPLER
DRILLED 8/14/ TO 8/18/89

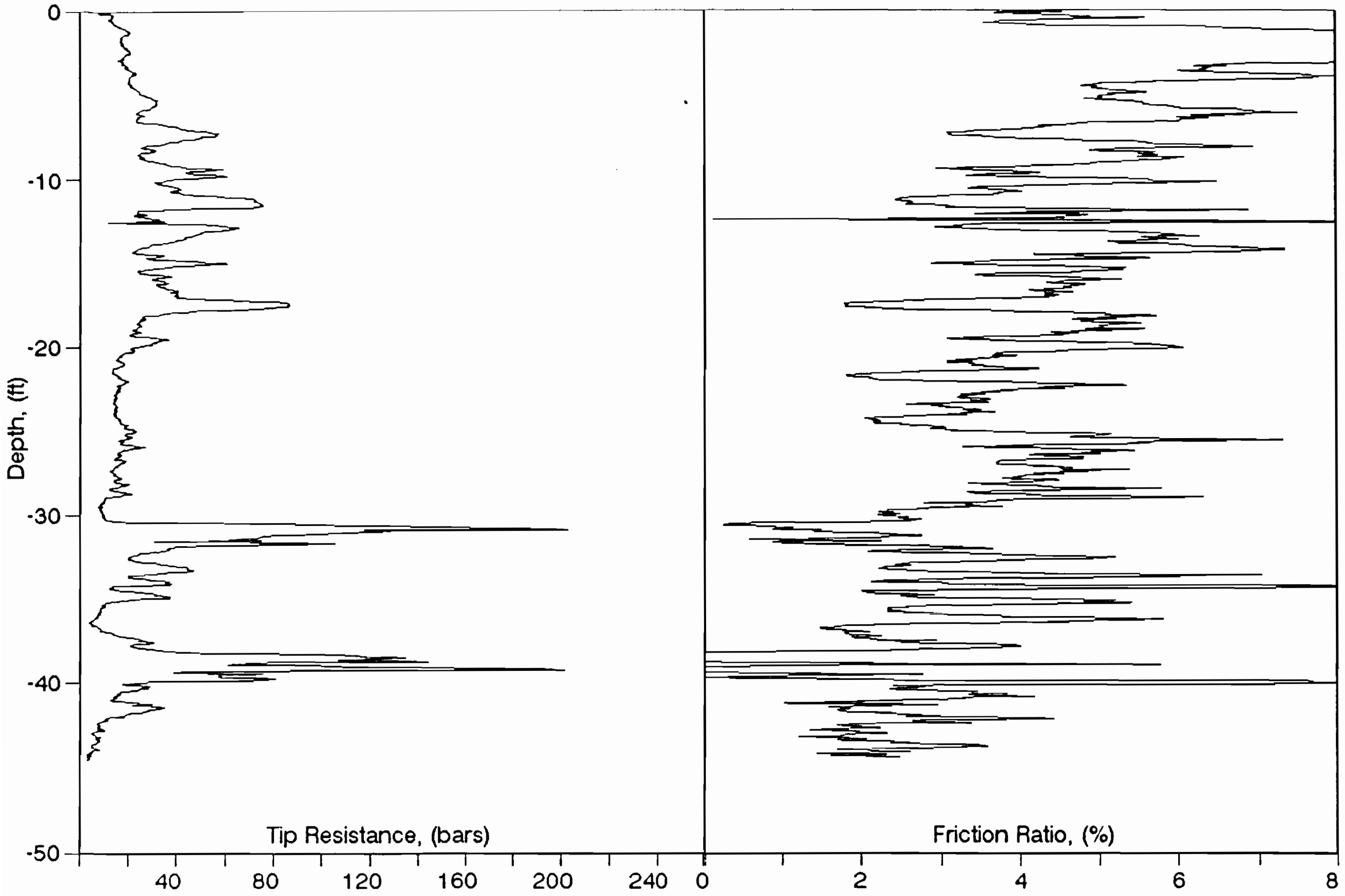
WATER TABLE =
23.0 ft.

DEPTH IN FT.		BLOW COUNT	DESCRIPTION
from	to	blows per 6 in.	
3.0-	4.5	1 - 2 / 2	red-orange sandy silt
4.5-	6.0	3 - 3 / 4	red-orange silty clay w/ calcite
9.0-	10.5	4 - 4 / 4	tan, white, yelow, black banded silty fine sand
10.5-	12.0	3 - 4 / 4	same to 11' 6", then orange brown silty clay
15.0-	16.5	2 - 2 / 4	orange brown banded silty clay to 16', then fine sandy silt
16.5-	18.0	4 - 4 / 6	tan-yellow silty fine sand
20.5-	22.0	1 - 1 / 3	orange tan silty clay w/ black stripes & traces of sand
22.0-	23.5	3 - 4 / 5	same w/ layer of shale @ 23' 6"
27.0-	28.5	4 - 6 / 5	tan silty fine sand with black streaks
28.5-	30.0	2 - 5 / 7	same
33.0-	34.5	3 - 2 / 6	tan silty fine sand
34.5-	36.0	5 - 3 / 3	same

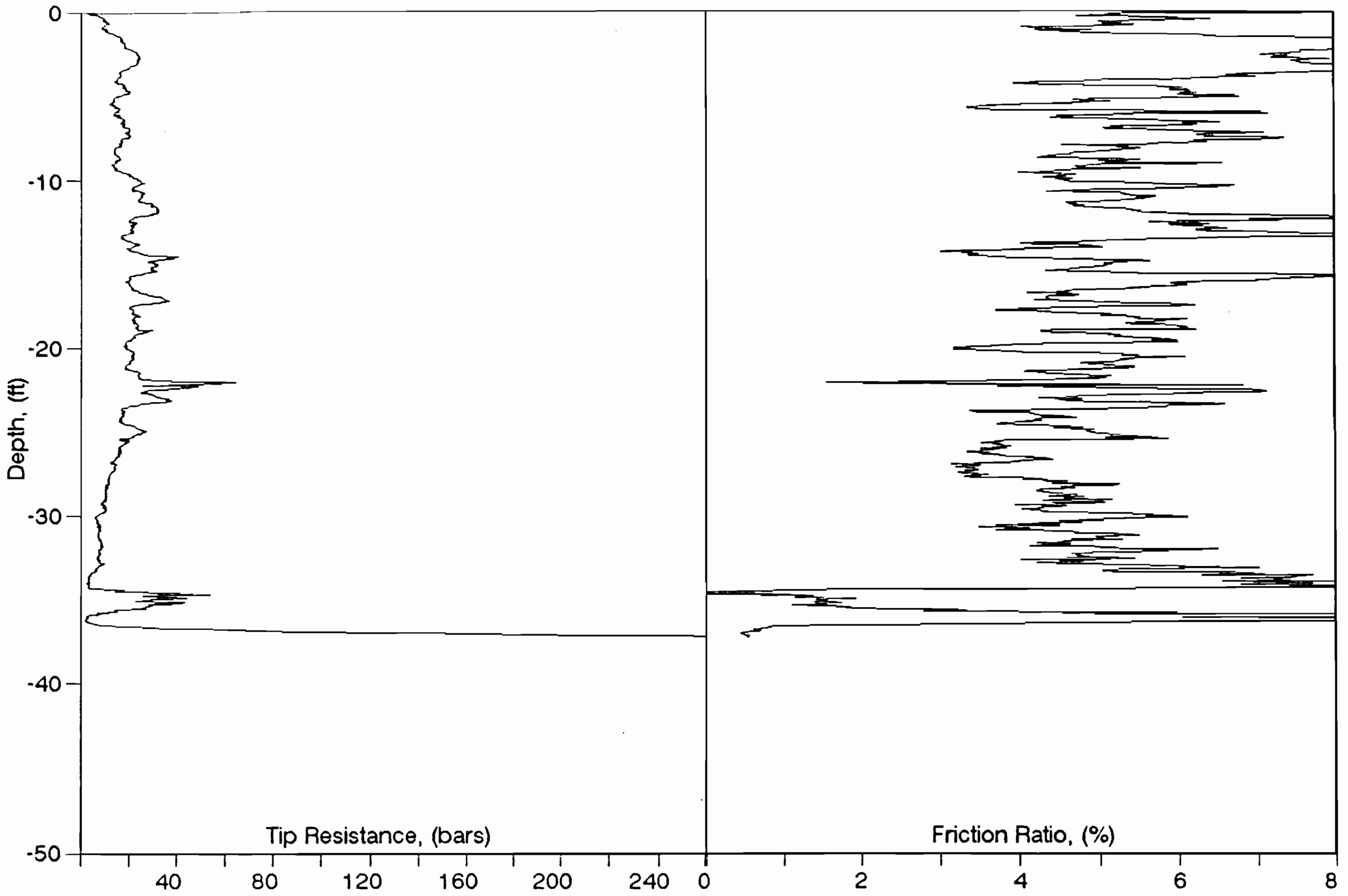
---END OF BORING---



Kipp's Farm, Hillside Area: Cone Test KFSC-6 06/05/89



Kipp's Farm, Hillside Area: Cone Test KFSC-7 06/05/89



Kipp's Farm, Hillside Area: Cone Test KFSC-8   06/05/89

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Virginia Polytechnic Institute                                                          TEST NO. KF D-4
FILE NAME:      Dilatometer Test
FILE NUMBER:    12:25:00

RECORD OF DILATOMETER TEST NO. KF D-4
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

     LOCATION: KIPP'S FARM: HILLSIDE AREA
     PERFORMED - DATE:  08/04/89
                 BY:  MULLEN


     CALIBRATION INFORMATION:
     DELTA A =  .16 BARS   DELTA B    =  .25 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 7.01 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50     BLADE T=15.00 MM

     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI            ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3


    Z THRUST      A      B     ED    ID    KD      U0  GAMMA     SV     PC   OCR     KO     CU   PHI       M   SOIL TYPE
  (M)   (KG)  (BAR)  (BAR)  (BAR)              (BAR) (T/M3)  (BAR)  (BAR)                (BAR) (DEG)   (BAR)
***** ******  *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******   ************

  .30   205.   1.53   4.48    93.  1.71 26.49    .000  1.700   .059    6.7 114.1   3.51         25.2   316.7   SANDY SILT
  .61   244.   2.73   6.52   123.  1.30 24.24    .000  1.800   .112   22.2 197.6   3.42         18.3   411.1   SANDY SILT
  .91          3.18   7.17   130.  1.19 19.13    .000  1.800   .165    5.6  33.9   2.71                406.2      SILT
 1.22          4.29   9.31   168.  1.15 19.18    .000  1.800   .220    7.5  34.0   2.71                523.5      SILT
 1.52          4.69   9.02   143.   .88 17.05    .000  1.800   .273    7.7  28.3   2.53   .875         429.2   CLAYEY SILT
 1.83          5.54   9.62   134.   .70 16.83    .000  1.800   .328    9.1  27.7   2.52  1.034         400.2   CLAYEY SILT
 2.13          5.57  10.20   154.   .80 14.50    .000  1.800   .381    8.4  22.0   2.30   .996         438.4   CLAYEY SILT
 2.44          6.59  11.55   166.   .73 14.90    .000  1.950   .438   10.0  22.9   2.34  1.185         477.0   CLAYEY SILT
 2.74          5.94  11.55   189.   .93 11.79    .000  1.950   .495    7.9  15.9   2.04                503.2      SILT
 3.05          7.00  11.95   165.   .69 12.50    .000  1.950   .555    9.7  17.4   2.11  1.206         448.5   CLAYEY SILT
 3.35          6.51  12.25   194.   .87 10.46    .000  1.950   .612    8.1  13.2   1.89  1.065         493.8   CLAYEY SILT
 3.66          5.88  10.80   164.   .81  8.69    .000  1.800   .669    6.6   9.9   1.68   .923         387.5   CLAYEY SILT
 3.96          6.04  11.85   197.   .96  8.19    .000  1.950   .724    6.5   9.0   1.62                452.5      SILT
 4.27          4.78   8.26   112.   .67  6.13    .000  1.800   .781    4.5   5.7   1.34   .697         223.7   CLAYEY SILT
 4.57          3.42   7.22   124.  1.04  4.09    .000  1.800   .834    2.5   3.1   1.00                198.7      SILT
 4.88          3.86   6.73    90.   .66  4.38    .000  1.800   .889    3.0   3.4   1.06   .522         148.6   CLAYEY SILT
 5.18          3.79   6.41    81.   .60  4.08    .000  1.800   .942    2.9   3.0   1.00   .505         127.3   CLAYEY SILT
 5.49          3.54   5.97    74.   .59  3.62    .000  1.700   .995    2.5   2.5    .91   .459         107.3   SILTY CLAY
 5.79          4.82  10.20   181.  1.10  4.52    .000  1.800  1.047    3.7   3.6   1.08                310.1      SILT
 6.10          5.49   9.85   144.   .76  4.95    .000  1.800  1.101    4.5   4.1   1.15   .752         257.1   CLAYEY SILT
 6.40          4.09   7.67   115.   .81  3.54    .000  1.800  1.154    2.8   2.4    .90   .519         167.6   CLAYEY SILT
 6.71          5.50   9.71   138.   .73  4.52    .000  1.800  1.209    4.3   3.6   1.08   .738         234.5   CLAYEY SILT
 7.01   288.   3.96  13.85   345.  2.73  2.89    .000  1.900  1.264    5.9   4.7   1.02         15.8   483.0   SILTY SAND
 7.32   213.   3.98   9.18   175.  1.30  3.00    .030  1.800  1.290    9.9   7.7   1.12         11.3   230.6   SANDY SILT
 7.62   283.   3.30   8.14   161.  1.46  2.42    .060  1.800  1.313    4.6   3.5    .94         16.7   181.7   SANDY SILT
 7.92          3.89   6.87    94.   .70  2.87    .089  1.800  1.337    2.3   1.8    .76   .461         115.0   CLAYEY SILT
 8.23          2.47   4.59    62.   .74  1.78    .120  1.700  1.359    1.1    .8    .48   .259          53.0   CLAYEY SILT
 8.53          2.04   3.58    41.   .59  1.45    .149  1.700  1.380     .8    .6    .38   .202          35.0   SILTY CLAY
 8.84          1.92   3.59    46.   .72  1.31    .180  1.700  1.401     .7    .5    .34   .182          39.0   CLAYEY SILT
 9.14          1.63   3.30    46.   .87  1.07    .209  1.600  1.421     .5    .4    .25   .143          39.0   CLAYEY SILT
 9.45          1.41   2.74    34.   .75   .89    .239  1.600  1.439     .4    .3    .18   .115          28.5   CLAYEY SILT
 9.75          2.14   6.57   146.  2.31  1.25    .269  1.800  1.459                                    124.5   SILTY SAND
10.06   280.   1.38   8.80   255.  8.27   .60    .299  1.800  1.484    1.5   1.0    .61         22.8   217.1      SAND
10.36   364.    .87   6.03   173. 10.75   .31    .329  1.700  1.506    1.1    .7    .49         26.6   147.1      SAND
10.67   461.   1.49   4.00    77.  1.86   .78    .359  1.700  1.527    1.5   1.0    .53         27.2    65.0   SILTY SAND
10.97    81.   1.13   3.16    59.  2.07   .53    .389  1.700  1.548    2.3   1.5    .87          9.0    50.2   SILTY SAND
11.28          -.24    .51    12.  -.68           .419  P01 =    -.10  P0 =   -.08  P1 =     .26               QUESTIONABLE
11.58   269.    .54   1.50    20.  2.58   .14    .448  1.700  1.590    1.2    .7    .53         23.9    17.0   SILTY SAND
11.89   823.   1.04   2.89    52.  2.33   .40    .479  1.700  1.611     .8    .5    .34         33.3    44.6   SILTY SAND
12.19   172.    .44   3.70    99. 31.09   .06    .508  1.700  1.631    1.3    .8    .61         19.8    84.1      SAND
                                                        P01 =     .46  P0 =    .60  P1 =    3.45
12.50   621.   1.02   4.88   126.  7.73   .28    .539  1.700  1.653     .9    .6    .38         30.9   106.8      SAND
12.80          1.50   2.42    19.   .50   .64    .568  1.600  1.672     .3    .2    .07   .088          15.8   SILTY CLAY
13.11          1.00   1.96    20.  1.08   .32    .599  1.600  1.690     .1    .1   -.12                 17.0      SILT
13.41          1.04   1.94    18.   .94   .32    .628  1.600  1.708     .1    .1   -.12                 15.2      SILT
13.72          1.45   2.16    11.   .34   .54    .658  1.500  1.725     .2    .1    .02   .074           9.3      MUD
END OF SOUNDING
```

Virginia Polytechnic Institute
FILE NAME: Dilatometer Test
FILE NUMBER: 02:32:00

TEST NO. KF D-5

RECORD OF DILATOMETER TEST NO. KF D-5
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

LOCATION: KIPP'S FARM: HILLSIDE AREA
PERFORMED - DATE: 08/04/89
BY: MULLEN

CALIBRATION INFORMATION:
DELTA A = .17 BARS   DELTA B = .30 BARS   GAGE 0 = .00 BARS   GWT DEPTH= 7.01 M
ROD DIA.= 3.56 CM   FR.RED.DIA.= 1.91 CM   ROD WT.= .00 KG/M   DELTA/PHI= .50   BLADE T=15.00 MM

1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI   ANALYSIS USES H2O UNIT WEIGHT = 1.000 T/M3

Z (M)	THRUST (KG)	A (BAR)	B (BAR)	ED (BAR)	ID	KD	UO (BAR)	GAMMA (T/M3)	SV (BAR)	PC (BAR)	OCR	KO	CU (BAR)	PHI (DEG)	M (BAR)	SOIL TYPE
*****	******	*****	*****	*****	*****	*****	******	******	******	*****	*****	*****	*****	*****	******	************
.30	205.	1.61	5.44	122.	2.19	27.32	.000	1.800	.059	7.5	126.6	3.62		24.6	422.6	SILTY SAND
.61	244.	3.70	8.03	141.	1.10	32.32	.000	1.800	.114	8.7	76.8	3.63			507.8	SILT
.91	320.	3.69	8.42	155.	1.23	21.87	.000	1.800	.167	27.5	164.9	3.15		18.6	503.0	SANDY SILT
1.22	273.	3.48	7.09	114.	.94	15.77	.000	1.800	.222	5.6	25.1	2.42			335.3	SILT
1.52		5.73	10.60	160.	.81	20.69	.000	1.800	.275	10.5	38.3	2.83	1.121		511.2	CLAYEY SILT
1.83		7.30	12.00	154.	.61	21.89	.000	1.950	.332	13.9	41.8	2.93	1.452		499.6	CLAYEY SILT
2.13		7.08	11.75	153.	.63	18.10	.000	1.950	.389	12.1	31.1	2.62	1.343		468.5	CLAYEY SILT
2.44		9.04	13.65	151.	.48	20.12	.000	1.900	.448	16.4	36.6	2.79	1.764		476.9	SILTY CLAY
2.74		7.32	12.75	181.	.72	14.36	.000	1.950	.504	10.9	21.7	2.29	1.304		513.8	CLAYEY SILT
3.05		5.69	9.20	111.	.56	10.17	.000	1.800	.561	7.1	12.6	1.86	.943		278.7	SILTY CLAY
3.35		6.18	11.35	171.	.81	9.92	.000	1.950	.616	7.5	12.2	1.83	1.004		426.7	CLAYEY SILT
3.66		5.71	9.45	119.	.60	8.49	.000	1.800	.673	6.4	9.5	1.66	.903		277.8	CLAYEY SILT
3.96		6.70	10.65	127.	.55	9.22	.000	1.800	.726	7.9	10.8	1.75	1.079		306.4	SILTY CLAY
4.27		6.78	10.60	122.	.52	8.68	.000	1.800	.781	7.7	9.9	1.68	1.077		287.5	SILTY CLAY
4.57		7.97	12.65	153.	.56	9.49	.000	1.900	.836	9.5	11.3	1.78	1.287		375.2	SILTY CLAY
4.88	382.	2.55	10.20	262.	3.19	2.64	.000	1.900	.893	2.4	2.7	.79		24.6	351.6	SILTY SAND
5.18	477.	3.59	12.05	291.	2.50	3.54	.000	1.900	.949	3.7	3.9	.90		24.6	455.3	SILTY SAND
5.49	411.	3.95	11.95	274.	2.11	3.72	.000	1.900	1.007	4.9	4.8	1.00		21.2	434.3	SILTY SAND
5.79	352.	2.48	7.73	174.	2.08	2.27	.000	1.900	1.063	2.6	2.5	.80		22.7	195.5	SILTY SAND
6.10	352.	3.71	10.75	239.	1.94	3.17	.000	1.900	1.121	4.8	4.3	.98		19.2	340.5	SILTY SAND
6.40	442.	2.88	8.82	199.	2.07	2.36	.000	1.900	1.177	2.9	2.4	.78		24.3	230.8	SILTY SAND
6.71	420.	3.40	10.40	238.	2.11	2.63	.000	1.900	1.235	3.7	3.0	.85		22.2	300.2	SILTY SAND
7.01	320.	4.51	14.20	336.	2.29	3.27	.000	2.000	1.292	7.4	5.7	1.06		15.8	496.0	SILTY SAND
7.32	236.	6.42	17.35	381.	1.82	4.56	.030	2.000	1.323	46.9	35.5	1.36		8.6	670.2	SILTY SAND
7.62	314.	6.60	24.40	631.	3.11	4.32	.060	2.000	1.352	19.7	14.6	1.26		12.1	1118.5	SILTY SAND
7.92	249.	3.46	13.80	360.	3.40	2.21	.089	1.900	1.380	4.8	3.4	.95		15.3	427.2	SAND
8.23	223.	3.23	9.35	206.	1.98	2.13	.120	1.900	1.407	5.1	3.6	.97		13.9	217.0	SILTY SAND
8.53	191.	4.06	13.45	325.	2.58	2.54	.149	1.900	1.434	9.4	6.6	1.08		10.4	412.8	SILTY SAND
8.84	183.	5.02	13.70	299.	1.87	3.14	.180	2.000	1.463	23.1	15.8	1.20		8.1	421.9	SILTY SAND
9.14	414.	3.50	10.40	234.	2.15	2.11	.209	1.900	1.491	3.6	2.4	.82		21.6	248.5	SILTY SAND
9.45	872.	3.80	16.60	449.	4.16	2.05	.239	1.900	1.518	2.5	1.7	.60		30.8	505.0	SAND
9.75	352.	4.82	17.40	441.	3.09	2.66	.269	2.000	1.546	6.2	4.0	.98		16.9	595.8	SILTY SAND
10.06	311.	1.54	17.55	566.	25.75	.40	.299	1.800	1.573	1.4	.9	.55		24.3	481.3	SAND
10.36	405.	1.92	5.58	116.	2.09	1.00	.329	1.800	1.597	2.0	1.2	.62		24.6	98.8	SILTY SAND
10.67		1.45	2.35	16.	.36	.77	.359	1.600	1.618	.4	.2	.13	.107		13.3	SILTY CLAY
10.97	90.	.70	1.89	26.	1.70	.27	.389	1.600	1.636	1.8	1.1	.80		11.5	22.3	SANDY SILT
11.28		.94	2.11	26.	1.12	.40	.419	1.600	1.654	.1	.1	-.06			21.7	SILT
11.58		1.36	2.25	15.	.42	.63	.448	1.600	1.672	.3	.2	.07	.088		13.0	SILTY CLAY
11.89	914.	.69	1.79	23.	1.89	.21	.479	1.700	1.692	.7	.4	.30		34.3	19.5	SILTY SAND
12.19	191.	.41	1.32	16.	9.30	.03	.508	1.700	1.712	1.3	.8	.59		20.6	13.6	SAND
12.50		.54	1.31	11.	2.02	.09	.539	1.500	1.730						9.3	MUD
12.80	722.	.46	1.60	24.	24.86	.02	.568	1.700	1.748	.7	.4	.31		32.6	20.7	SAND
13.11		.35	.91	3.	-1.14		.599	P01 =	.52	PO =	.52	P1 =	.61			QUESTIONABLE
13.41		.59	1.09	1.	.24	.07	.628	1.500	1.784	.0	.0	-.36	.006		.9	MUD
13.72	73.	.71	2.94	64.	13.84	.07	.658	1.700	1.802	1.7	.9	.81		9.8	54.5	SAND

END OF SOUNDING

Virginia Polytechnic Institute TEST NO. KF D-6
FILE NAME: Dilatometer Test
FILE NUMBER: 09:00:00

RECORD OF DILATOMETER TEST NO. KF D-6
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

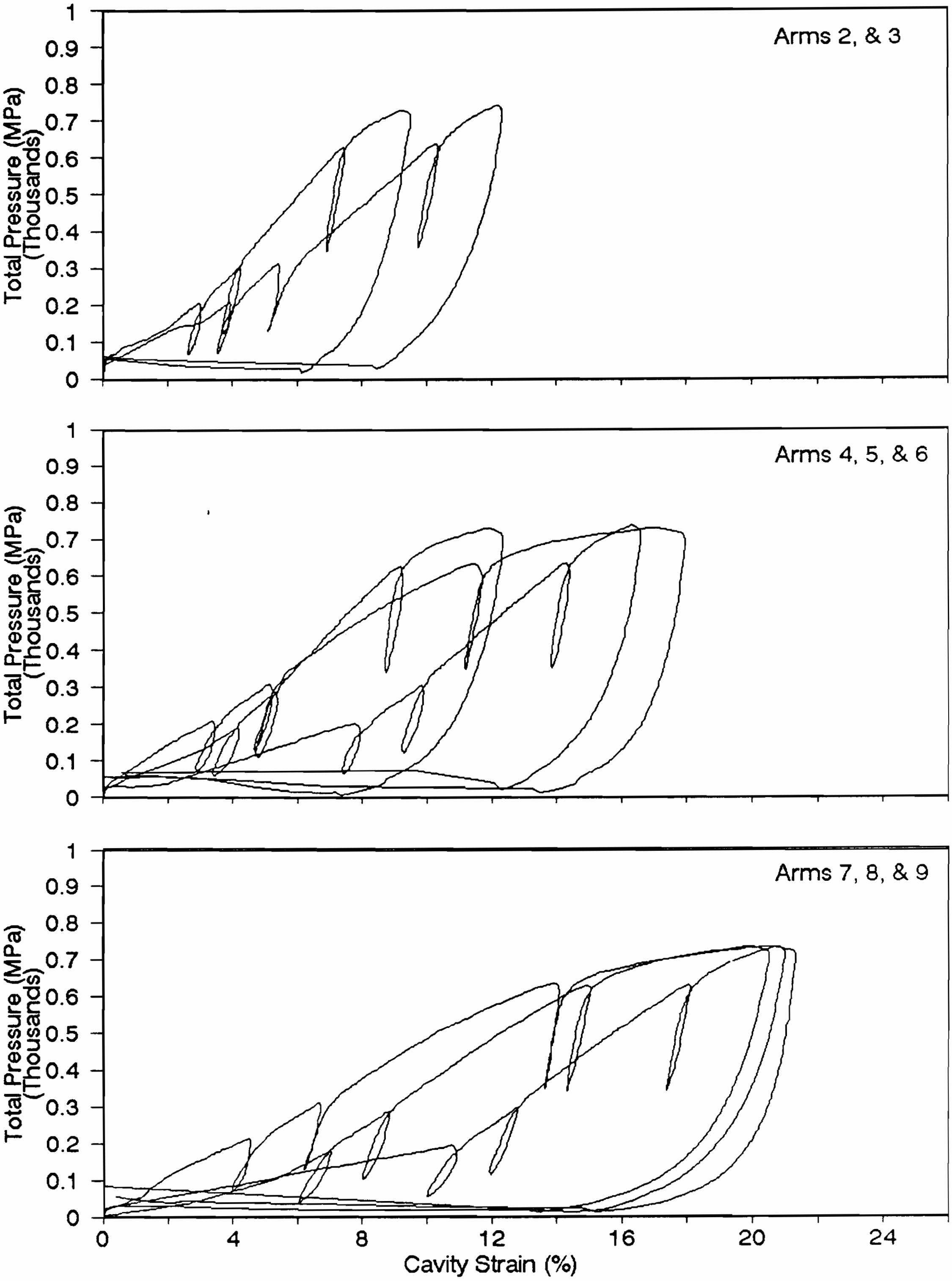
LOCATION: KIPP'S FARM: HILLSIDE AREA
PERFORMED - DATE: 08/05/89
BY: MULLEN

CALIBRATION INFORMATION:
DELTA A = .16 BARS DELTA B = .24 BARS GAGE 0 = .00 BARS GWT DEPTH= 7.01 M
ROD DIA.= 3.56 CM FR.RED.DIA.= .19 CM ROD WT.= .10 KG/M DELTA/PHI= .50 BLADE T=15.00 MM

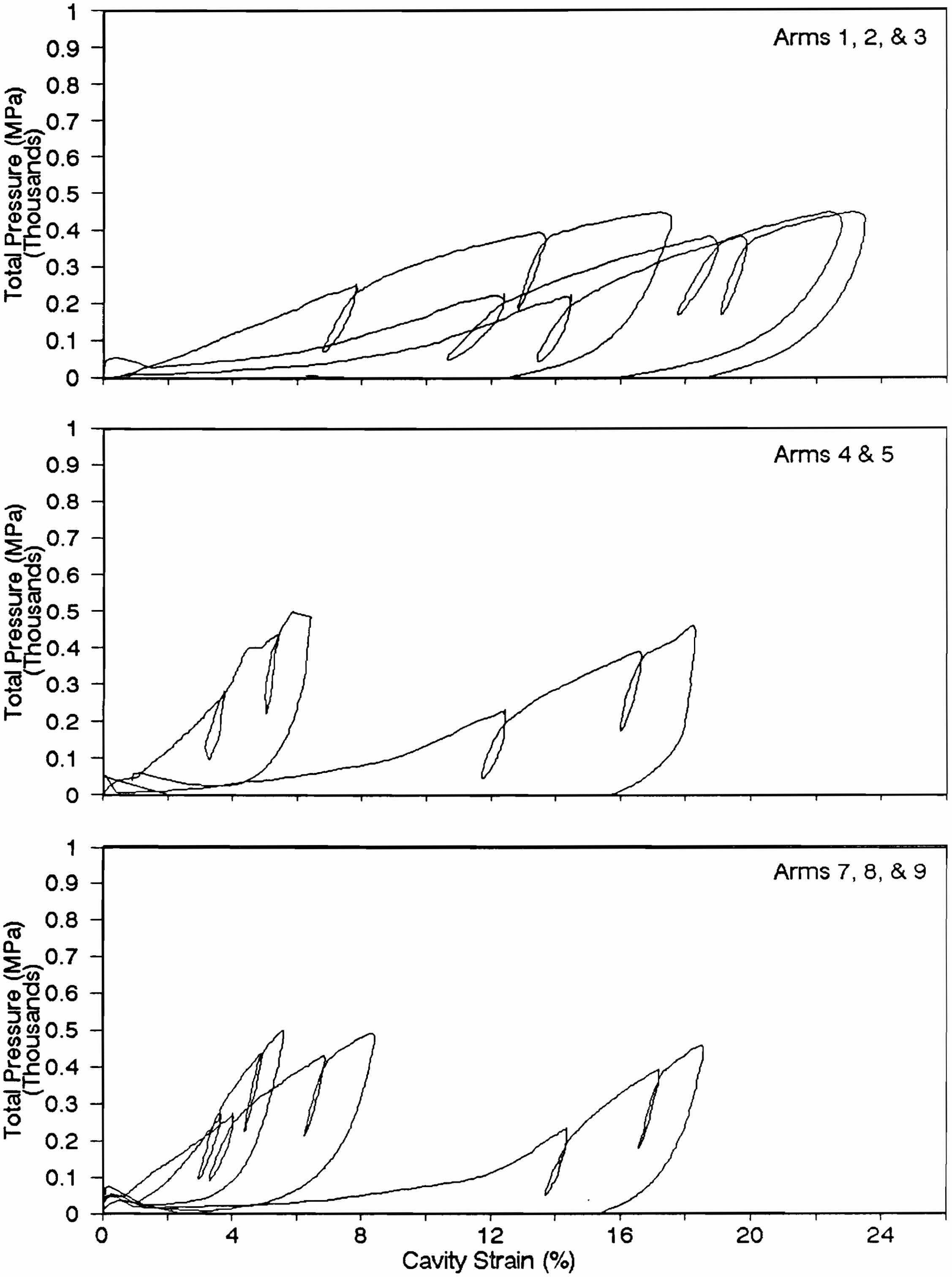
1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI ANALYSIS USES H2O UNIT WEIGHT = 1.000 T/M3

Z (M)	THRUST (KG)	A (BAR)	B (BAR)	ED (BAR)	ID	KD	UO (BAR)	GAMMA (T/M3)	SV (BAR)	PC (BAR)	OCR	KO	CU (BAR)	PHI (DEG)	M (BAR)	SOIL TYPE
.30	257.	1.52	4.81	105.	1.98	26.03	.000	1.800	.059	5.3	90.7	3.36		30.0	358.6	SILTY SAND
.61	271.	2.72	6.43	121.	1.28	23.86	.000	1.800	.114	16.8	147.5	3.33		20.6	400.8	SANDY SILT
.91	320.	2.39	5.78	109.	1.31	14.52	.000	1.700	.165	5.9	35.4	2.10		25.9	310.8	SANDY SILT
1.22		3.18	6.89	121.	1.09	14.53	.000	1.800	.219	4.8	22.0	2.31			344.1	SILT
1.52		3.39	7.21	125.	1.06	12.45	.000	1.800	.272	4.7	17.3	2.10			337.3	SILT
1.83		2.86	6.23	108.	1.09	8.84	.000	1.700	.325	3.3	10.2	1.70			257.3	SILT
2.13		7.56	12.45	164.	.63	19.80	.000	1.950	.378	13.5	35.8	2.76	1.463		514.8	CLAYEY SILT
2.44		5.08	8.99	128.	.73	11.63	.000	1.800	.436	6.8	15.6	2.02	.865		338.0	CLAYEY SILT
2.74		6.46	11.15	156.	.70	13.05	.000	1.950	.491	9.2	18.7	2.16	1.126		430.2	CLAYEY SILT
3.05		5.84	9.75	128.	.63	10.63	.000	1.800	.548	7.4	13.6	1.91	.973		327.2	CLAYEY SILT
3.35		4.86	9.41	151.	.91	8.01	.000	1.800	.601	5.2	8.7	1.60			344.3	SILT
3.66		3.91	7.09	101.	.74	6.00	.000	1.800	.656	3.6	5.5	1.32	.569		200.6	CLAYEY SILT
3.96		4.17	7.39	103.	.71	5.91	.000	1.800	.709	3.8	5.4	1.31	.604		201.9	CLAYEY SILT
4.27		4.13	8.02	127.	.89	5.39	.000	1.800	.763	3.6	4.7	1.22	.580		238.9	CLAYEY SILT
4.57	449.	4.09	9.83	195.	1.41	4.88	.000	1.800	.816	5.5	6.7	1.10		22.5	350.7	SANDY SILT
4.88		4.69	8.78	134.	.83	5.36	.000	1.800	.871	4.1	4.6	1.22	.657		251.3	CLAYEY SILT
5.18		4.50	8.42	128.	.82	4.85	.000	1.800	.924	3.7	4.0	1.14	.616		226.9	CLAYEY SILT
5.49		5.00	9.20	138.	.80	5.08	.000	1.800	.979	4.2	4.3	1.17	.690		251.2	CLAYEY SILT
5.79	352.	2.26	7.14	163.	2.14	2.13	.000	1.800	1.032	2.3	2.2	.76		23.6	174.6	SILTY SAND
6.10	352.	1.38	5.59	139.	2.96	1.24	.000	1.800	1.087	1.4	1.3	.60		26.0	118.0	SILTY SAND
6.40	442.	4.69	13.60	310.	2.02	3.87	.000	2.000	1.142	6.2	5.4	1.04		20.4	500.9	SILTY SAND
6.71	411.	4.21	10.15	202.	1.42	3.41	.000	1.800	1.200	5.5	4.6	.99		20.0	293.7	SANDY SILT
7.01	320.	3.28	9.04	195.	1.77	2.53	.000	1.800	1.253	4.2	3.3	.92		18.7	233.7	SANDY SILT
7.32	236.	.88	4.06	101.	3.35	.68	.030	1.700	1.276	1.4	1.1	.62		22.2	86.1	SAND
7.62	314.	1.50	7.41	201.	4.37	1.02	.060	1.800	1.298	1.6	1.3	.63		23.8	170.6	SAND
7.92	249.	3.54	14.00	367.	3.40	2.35	.089	1.900	1.323	4.9	3.7	.96		15.3	455.1	SAND
8.23	223.	4.92	13.60	302.	1.91	3.36	.120	2.000	1.352	15.0	11.1	1.18		10.4	445.3	SILTY SAND
8.53	191.	5.76	15.00	322.	1.74	3.86	.149	1.950	1.381	42.5	30.8	1.29		7.5	513.7	SANDY SILT
8.84	183.	4.10	14.40	361.	2.90	2.54	.180	1.900	1.409	9.7	6.9	1.09		10.2	469.8	SILTY SAND
9.14	414.	1.78	6.70	165.	3.15	1.05	.209	1.800	1.434	1.7	1.2	.59		25.9	140.0	SILTY SAND
9.45	872.	1.88	6.00	136.	2.42	1.11	.239	1.800	1.458	1.2	.9	.42		33.2	115.2	SILTY SAND
9.75	352.	2.21	5.89	120.	1.78	1.31	.269	1.700	1.480	2.3	1.6	.70		22.7	101.6	SANDY SILT
10.06	311.	1.93	4.40	75.	1.29	1.12	.299	1.700	1.502	2.2	1.4	.69		21.8	64.1	SANDY SILT
10.36	405.	1.54	4.00	75.	1.71	.83	.329	1.700	1.522	1.6	1.1	.57		25.8	63.8	SANDY SILT
10.67	512.	1.74	4.54	87.	1.77	.92	.359	1.700	1.544	1.6	1.0	.53		27.9	74.3	SANDY SILT
10.97	90.	1.38	2.74	35.	.91	.71	.389	1.600	1.563	.3	.2	.10			29.7	SILT
11.28	734.	.89	2.07	28.	1.38	.37	.419	1.600	1.581	.8	.5	.35		32.7	24.2	SANDY SILT

END OF SOUNDING



Kipp's Farm, Hillside Area: Pressuremeter Test KFSP-7 08/14/89



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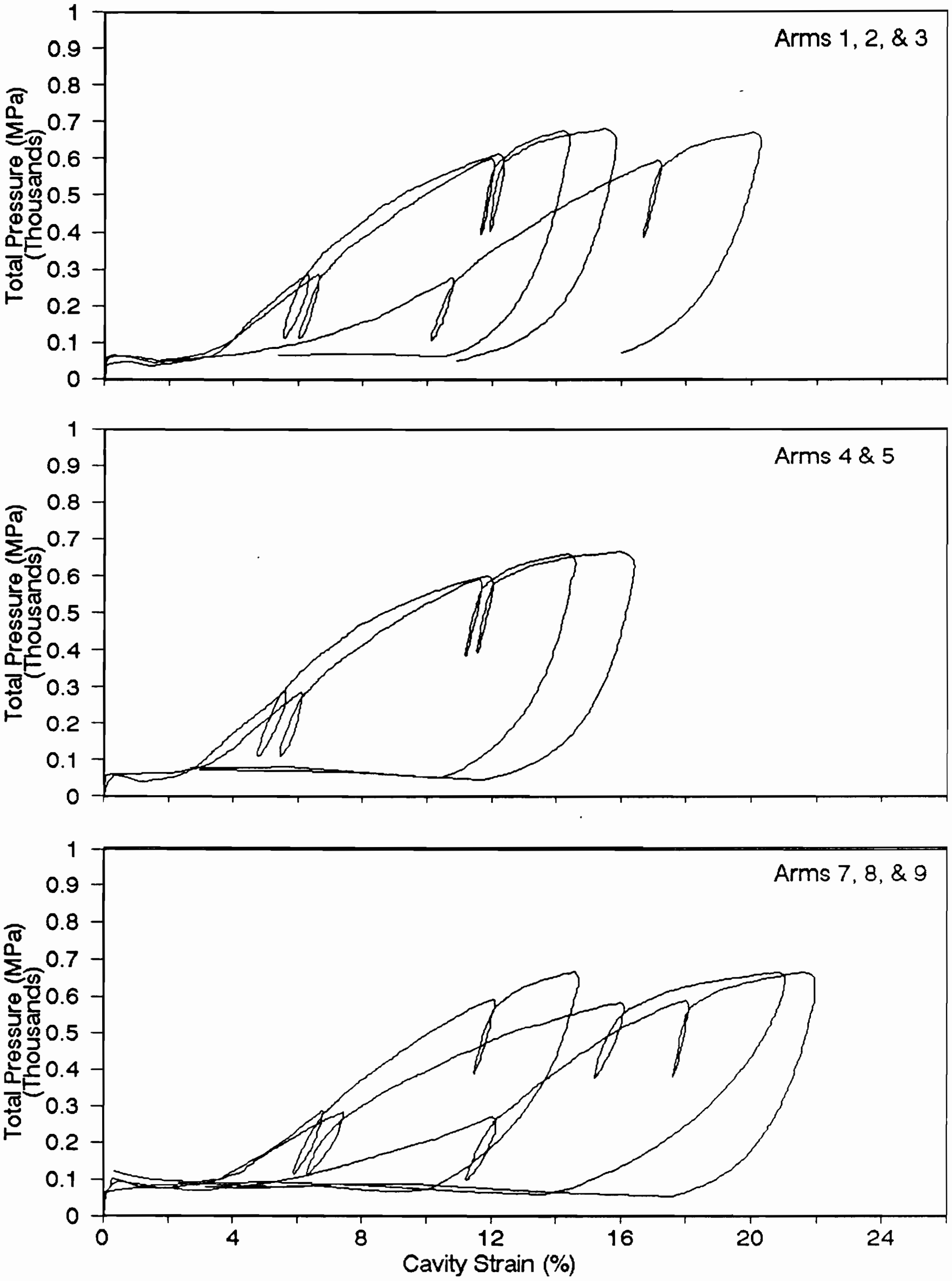

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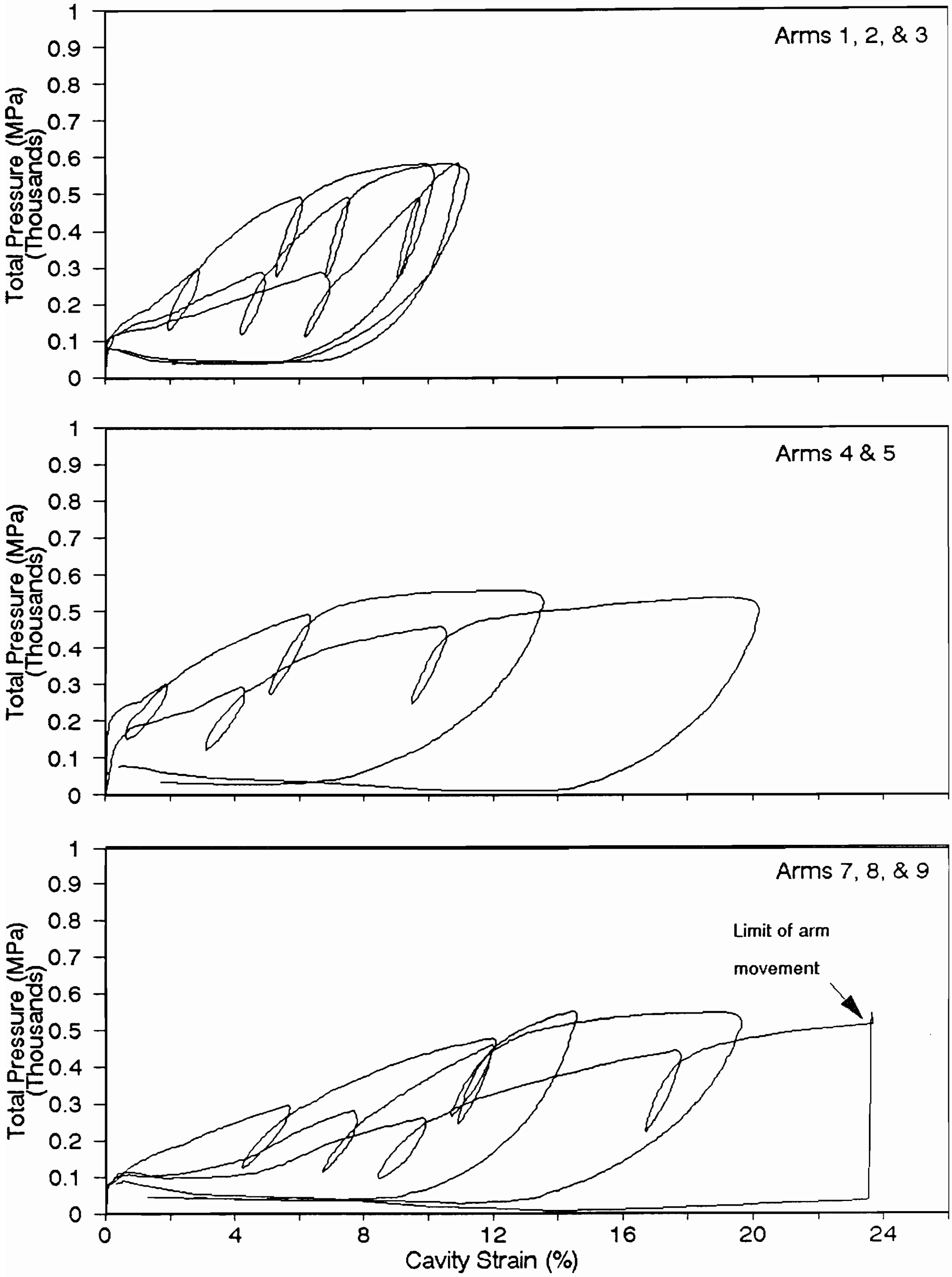

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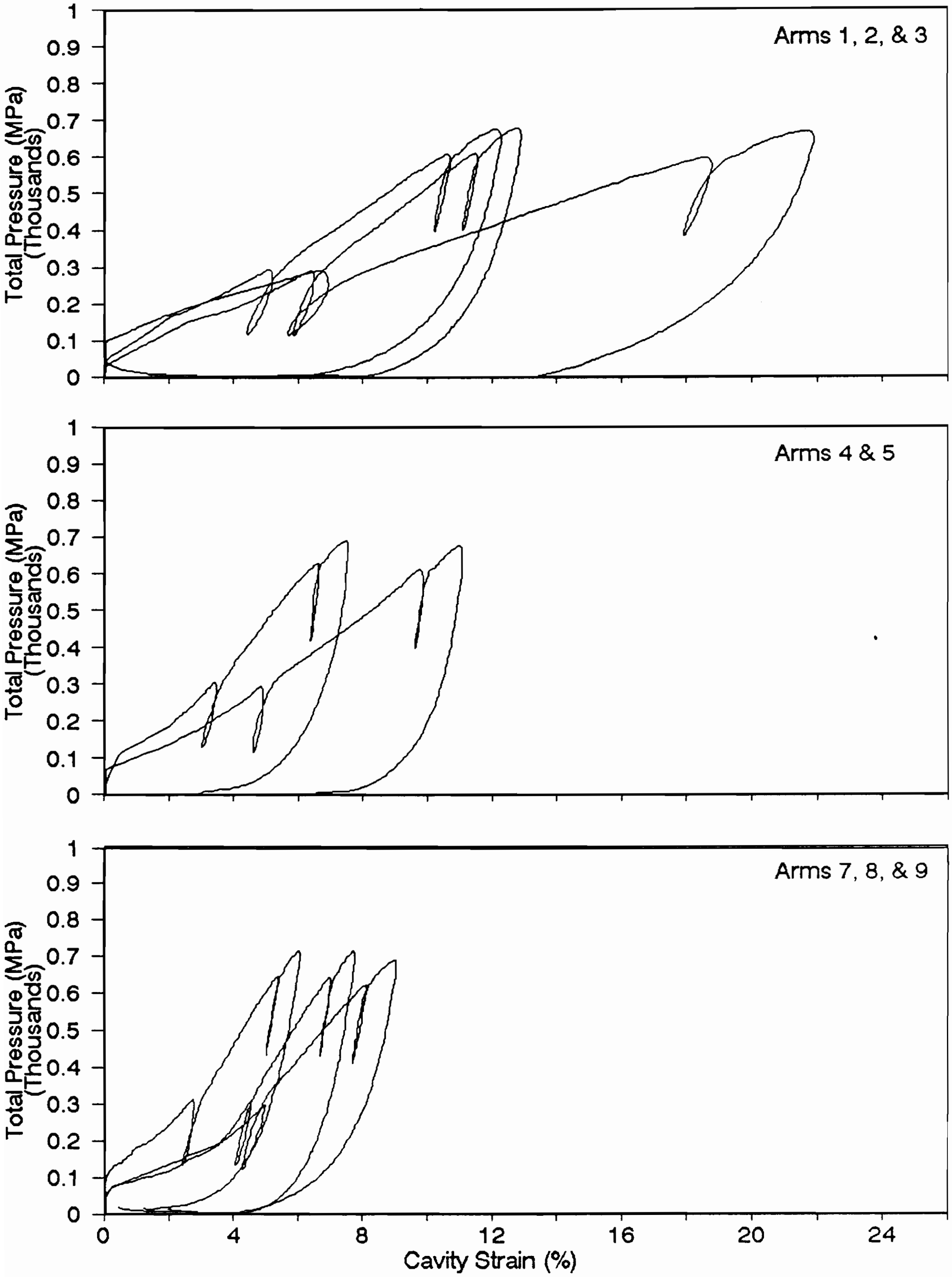
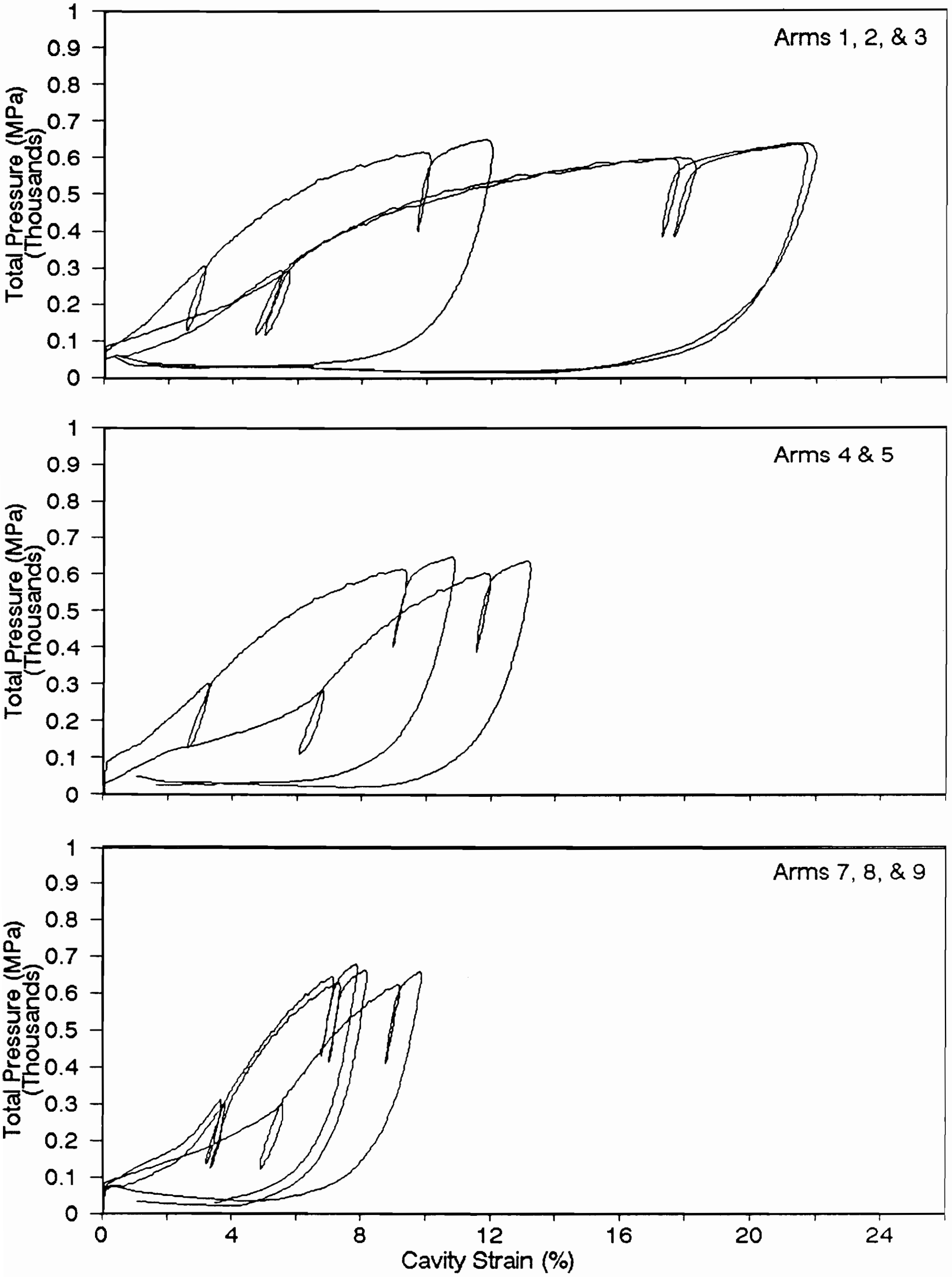


Kipp's Farm, Hillside Area: Pressuremeter Test KFSP-11 08/18/89



Kipp's Farm, Hillside Area: Pressuremeter Test KFSP-12 08/18/89

KIPP'S FARM,
HILLSIDE AREA:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	BORING #	N60	N160	Qc (pt) bar
-1.0				15.0
-2.0				18.1
-2.5	B-2	12	21	19.7
-3.0				21.0
-4.0	B-4	4	7	18.3
-4.0	B-2	9	15	18.5
-4.5				19.8
-5.0				20.5
-5.5	B-4	7	11	21.5
-6.0				18.2
-7.0				29.9
-8.0				29.7
-8.5	B-2	20	27	25.2
-9.0				26.3
-10.0	B-4	8	10	30.5
-10.0	B-2	14	18	29.6
-10.5				30.0
-11.0				37.9
-11.5	B-4	8	10	45.0
-11.5	B-2	14	17	47.5
-12.0				30.6
-13.0	B-2	16	19	36.3
-14.0				24.5
-15.0				35.6
-16.0	B-4	6	6	25.6
-16.5				26.3
-17.0				32.7
-17.5	B-4	10	10	44.0
-17.5	B-2	21	21	43.3
-18.0				26.3
-19.0	B-2	23	22	24.4
-20.0				23.5
-20.5	B-2	30	28	32.3
-21.0				30.6
-21.5	B-4	4	4	27.7

KIPP'S FARM,
HILLSIDE AREA:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Qn (pt)) barr	ED bar	Gur kN/M^2	D50 (mm)
-1.0	28.3	107		
-2.0	32.4	128		
-2.5	34.5	130		
-3.0	36.0	131		
-4.0	30.0	134		0.004
-4.0	30.3	134		0.004
-4.5	31.8	139	18576	
-5.0	32.2	143		
-5.5	33.1	137		0.005
-6.0	27.4	132		
-7.0	43.3	157		
-8.0	41.2	148		
-8.5	34.3	162		0.03
-9.0	35.2	175		
-10.0	39.2	135		0.021
-10.0	38.1	135		0.021
-10.5	37.9	153	17745	
-11.0	47.1	172		
-11.5	54.9	150		0.021
-11.5	58.0	150		0.021
-12.0	36.7	128		
-13.0	42.2	142		0.005
-14.0	27.6	120		
-15.0	39.0	157		
-16.0	27.2	162		0.023
-16.5	27.5	164	15982	
-17.0	33.7	167		
-17.5	44.8	164		0.026
-17.5	44.0	164		0.026
-18.0	26.4	162		
-19.0	23.9	173		0.036
-20.0	22.3	174		
-20.5	30.3	191		0.039
-21.0	28.4	208		
-21.5	25.3	200		

KIPP'S FARM, HILLSIDE AREA: IN-SITU TEST DATA SUMMARY

DEPTH ft.	Qc (pt) /N	Su DMT (bars)	Su N60 (bars)	Nk = 15 Su Qc (bars)
-1.0				
-2.0				
-2.5			2.971	1.301
-3.0				
-4.0	4.58		0.945	1.207
-4.0	2.05		2.160	1.217
-4.5				
-5.0				
-5.5	3.08		1.654	1.416
-6.0				
-7.0		1.463		1.968
-8.0		0.865		1.950
-8.5	1.26	0.996	5.041	1.646
-9.0		1.126		1.723
-10.0	3.81	0.973	1.890	1.994
-10.0	2.12	0.973	3.511	1.938
-10.5				
-11.0				
-11.5	5.62		1.890	2.955
-11.5	3.40		3.511	3.127
-12.0		0.569		1.993
-13.0	2.27	0.604	4.033	2.373
-14.0		0.580		1.579
-15.0				
-16.0	4.27	0.657	1.418	1.651
-16.5		0.637		1.691
-17.0		0.616		2.117
-17.5	4.40	0.653	2.431	2.870
-17.5	2.06	0.653	5.293	2.821
-18.0		0.690		1.685
-19.0	1.06		5.797	1.559
-20.0				
-20.5	1.08		7.562	2.076
-21.0				
-21.5			0.945	1.766

KIPP'S FARM,
HILLSIDE AREA:
IN-SITU TEST
DATA SUMMARY

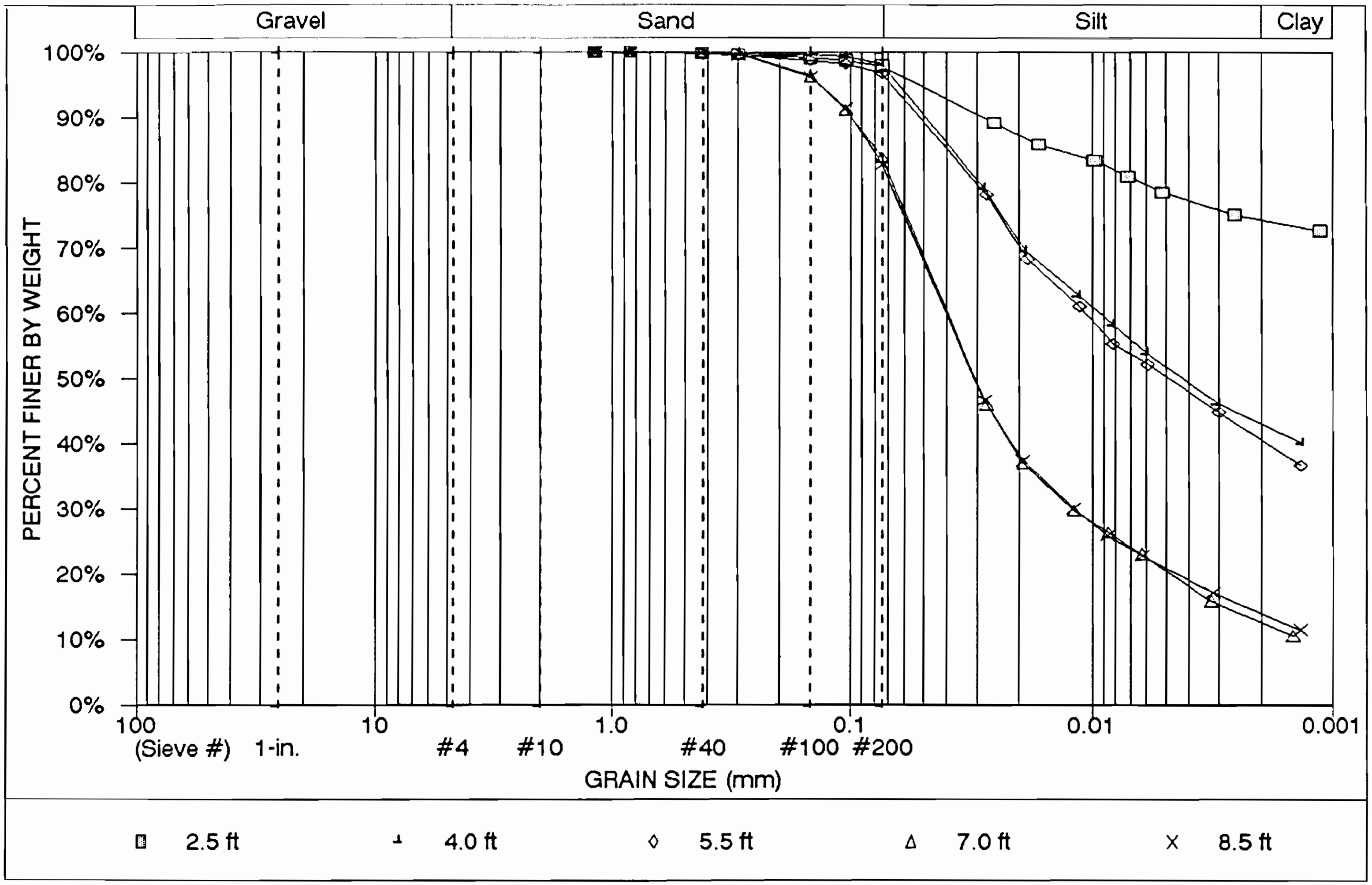
DEPTH ft.	BORING #	N60	N160	Qc (pt) bar
-22.0	B-2	29	26	31.6
-23.0	B-4	9	8	22.4
-24.0	B-2	33	29	16.2
-25.0				22.9
-25.5	B-2	30	26	16.2
-26.0				17.4
-27.0	B-2	15	13	15.4
-28.0	B-4	11	9	13.0
-28.5				11.9
-29.0				11.4
-29.5	B-4	12	10	24.1
-30.0	B-2	12	10	28.6
-31.0				55.1
-31.5	B-2	10	8	33.1
-32.0				21.0
-33.0	B-2	5	4	21.7
-34.0	B-4	8	6	26.9
-34.5	B-2	6	5	11.8
-35.0				34.5
-35.5	B-4	6	5	14.4
-36.0	B-2			5.8
-37.0				51.4
-37.5	B-2	8	6	17.8
-38.0				20.9
-39.0	B-2	9	7	58.0
-40.0				12.8
-40.5	B-2	35	26	14.6
-41.0				58.7
-42.0				60.4
-43.0				103.7
-44.0				5.2
-45.0				

KIPP'S FARM,
HILLSIDE AREA:
IN-SITU TEST
DATA SUMMARY

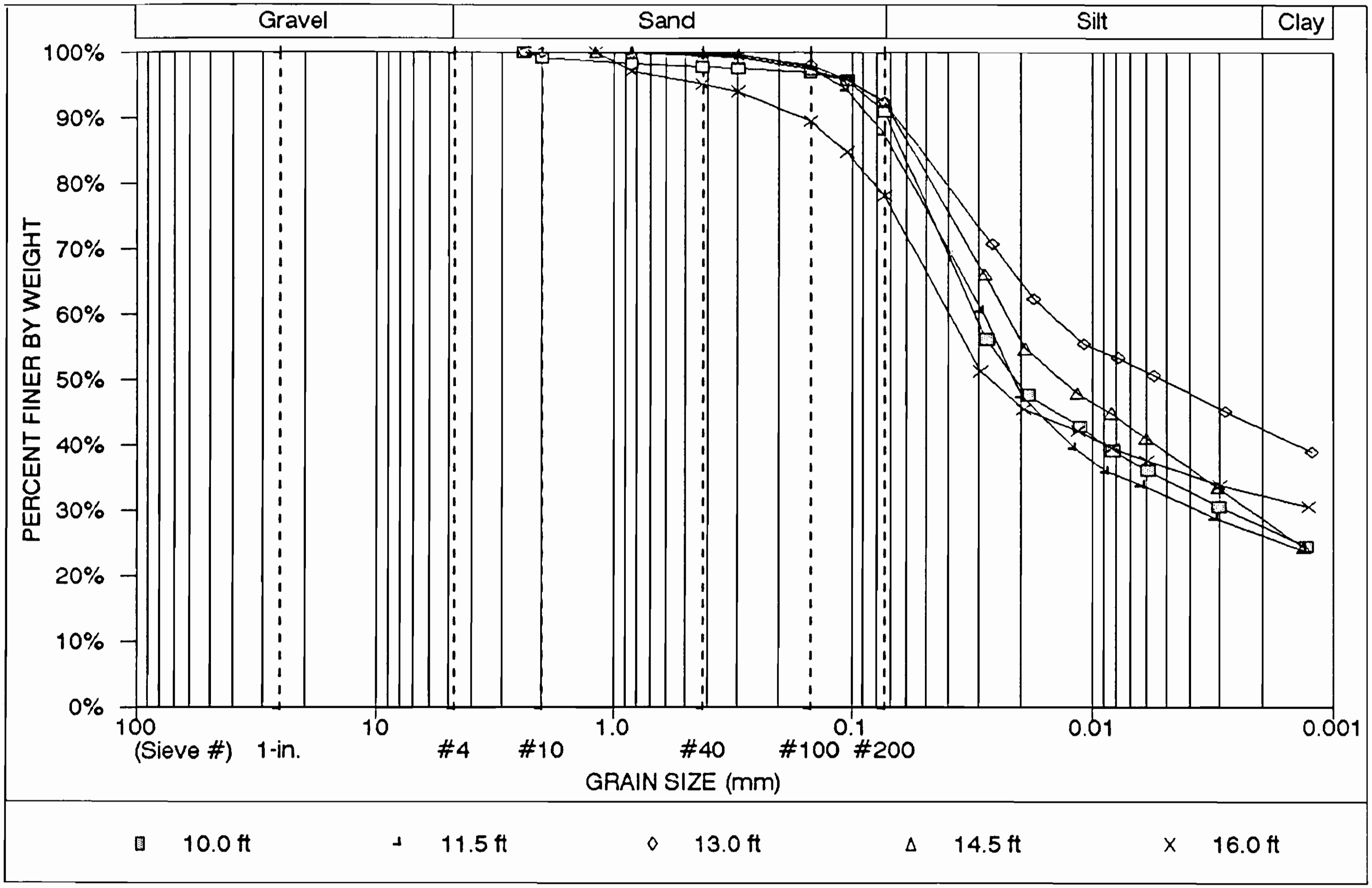
DEPTH ft.	Qn (pt)) barr	ED bar	Gur kN/M^2	D50 (mm)
-22.0	28.6	193	10021	0.041
-23.0	19.8	292		
-24.0	14.1	219		0.04
-25.0	19.7	331		
-25.5	13.9	302		0.033
-26.0	14.8	274		
-27.0	13.0	190		0.044
-28.0	10.8	229		
-28.5	9.9	232	23516	
-29.0	9.4	235		
-29.5	19.8	192		
-30.0	23.4	148		0.033
-31.0	44.6	206		
-31.5	26.7	221		0.024
-32.0	16.8	236		
-33.0	17.2	299		0.022
-34.0	21.2	121		
-34.5	9.2	91	20354	0.031
-35.0	26.9	60		
-35.5	11.2	50		
-36.0	4.5	40		
-37.0	39.2	27		
-37.5	13.5	22		
-38.0	15.9	18		
-39.0	43.7	38		0.099
-40.0	9.5	58		
-40.5	10.9	63		0.087
-41.0	43.6	69		
-42.0	44.6	22		
-43.0	98.5	12		
-44.0	3.8	10		
-45.0		38		

KIPP'S FARM, HILLSIDE AREA: IN-SITU TEST DATA SUMMARY

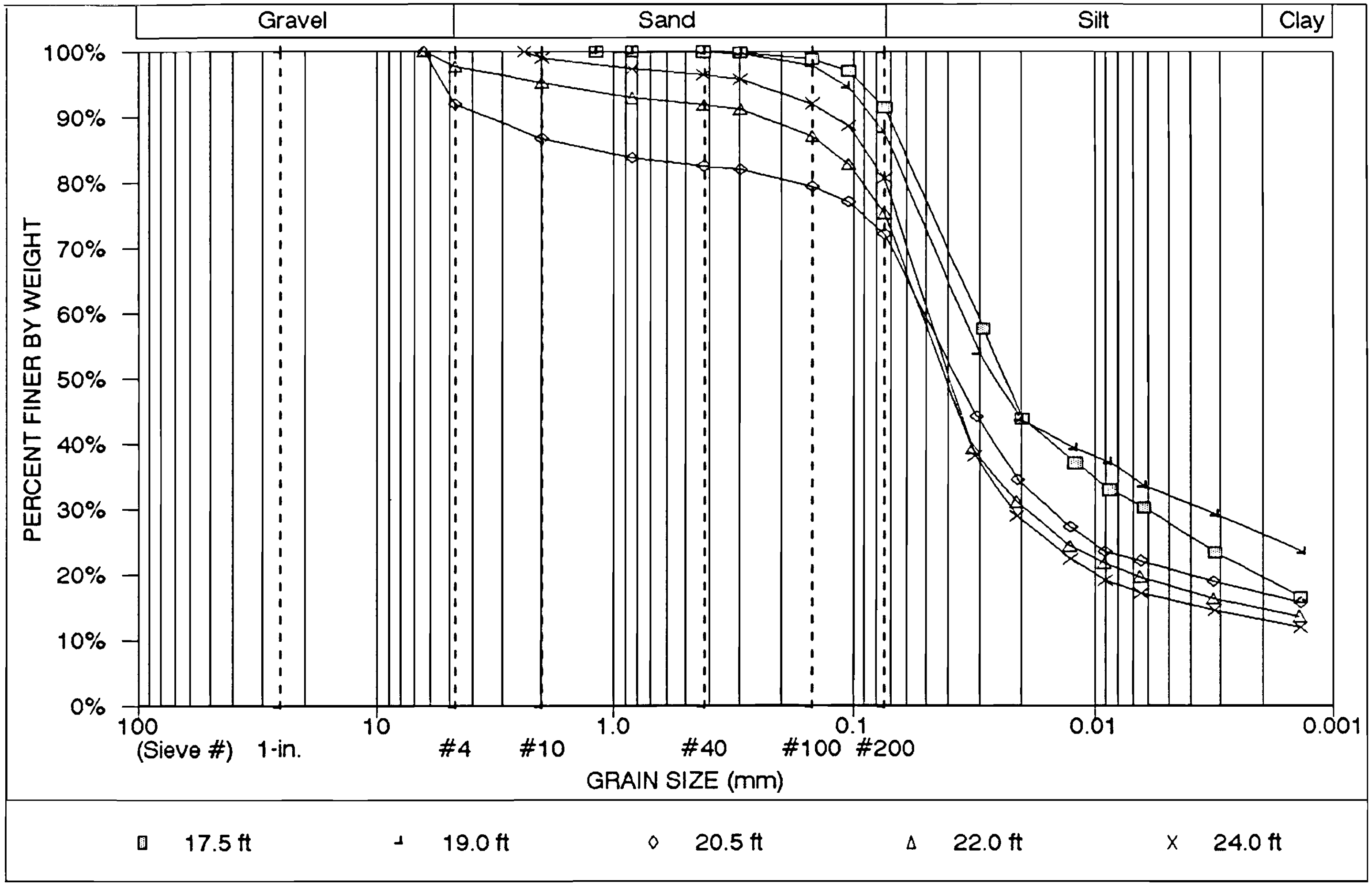
DEPTH ft.	Qc (pt) /N	Su DMT (bars)	Su N60 (bars)	Nk = 15 Su Qc (bars)
-22.0	1.09		7.310	2.028
-23.0			2.160	1.412
-24.0	0.49		8.318	0.996
-25.0				
-25.5	0.54		7.562	0.994
-26.0				
-27.0	1.03		3.781	0.935
-28.0			2.701	0.771
-28.5				
-29.0				
-29.5			2.971	1.512
-30.0	2.39		2.971	1.813
-31.0				
-31.5	3.31		2.431	2.108
-32.0				
-33.0	4.33		1.182	1.344
-34.0			1.890	1.691
-34.5	1.96		1.418	0.682
-35.0				
-35.5			1.418	0.852
-36.0				
-37.0				
-37.5			1.890	1.076
-38.0				
-39.0	6.44		2.160	3.755
-40.0				
-40.5	0.42		8.822	0.864
-41.0				
-42.0				
-43.0				
-44.0				
-45.0				



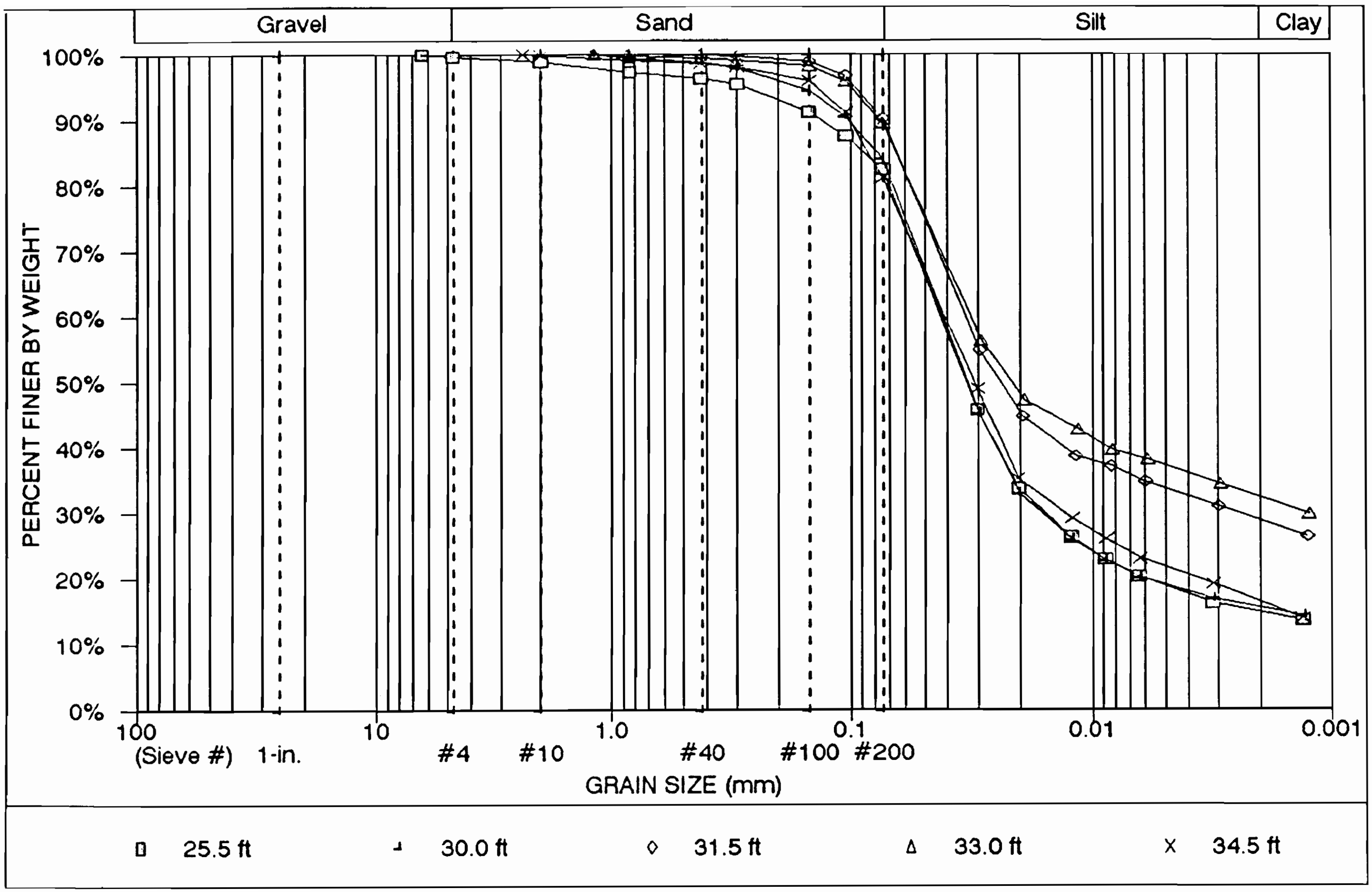
Kipp's Farm, Hillside Area: Grain Size Data



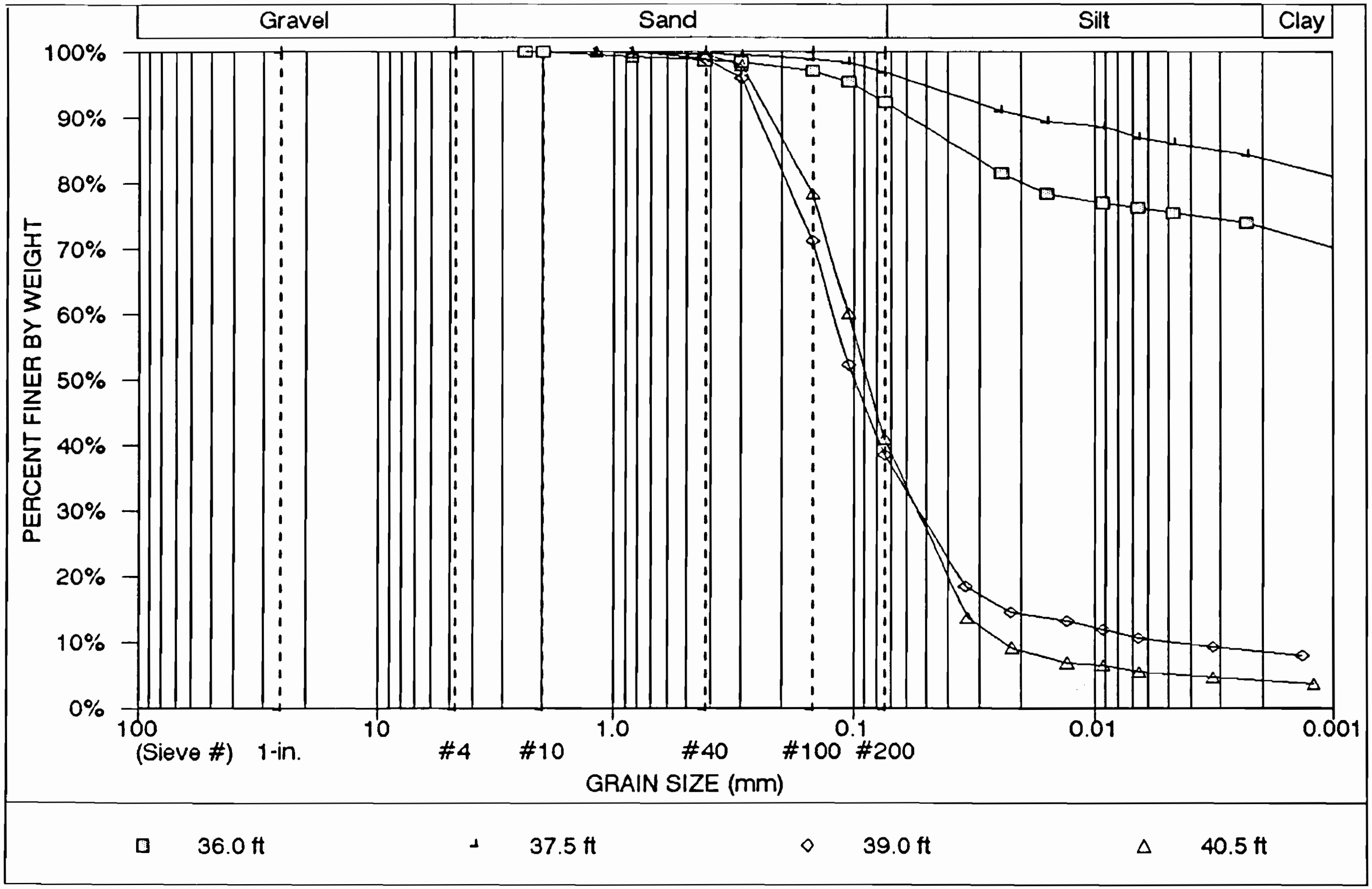
Kipp's Farm, Hillside Area: Grain Size Data



Kipp's Farm, Hillside Area: Grain Size Data



Kipp's Farm, Hillside Area: Grain Size Data



Kipp's Farm, Hillside Area: Grain Size Data

KIPP'S FARM,
HILLSIDE AREA:
LAB DATA
SUMMARY
FROM B-2.

DEPTH (ft)	SPECIFIC GRAVITY	D60 (mm)	D50 (mm)	D10 (mm)	Cu
-2.5	2.661				
-4.0	2.661		0.004		
-5.5	2.661		0.005		
-7.0	2.661	0.039	0.030	0.001	29
-8.5	2.661	0.040	0.030	0.001	35
-10.0	2.661		0.021		
-11.5	2.661		0.021		
-13.0	2.661		0.005		
-14.5	2.661		0.013		
-16.0	2.661		0.023		
-17.5	2.661		0.026		
-19.0	2.661		0.036		
-20.5	2.661		0.039		
-22.0	2.661		0.041		
-24.0	2.661	0.048	0.040	0.001	62
-25.5	2.661		0.033		
-27.0	2.691		0.044		
-30.0	2.691		0.033		
-31.5	2.691		0.024		
-33.0	2.691		0.022		
-34.5	2.691		0.031		
-36.0	2.691				
-37.5	2.691				
-39.0	2.691	0.121	0.099	0.005	25
-40.5	2.691	0.105	0.087	0.024	4

KIPP'S FARM,
HILLSIDE AREA:
LAB DATA
SUMMARY
FROM B-2.

DEPTH (ft)	%-200	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	MOISTURE CONTENT %
-2.5	98.1%	92.9%	31.1%	61.8%	47.5%
-4.0	98.3%	72.4%	49.0%	23.4%	49.0%
-5.5	96.6%	72.1%	49.5%	22.6%	50.0%
-7.0	84.0%	NP			42.7%
-8.5	82.8%	NP			36.0%
-10.0	91.1%	56.9%	40.6%	16.3%	42.0%
-11.5	87.5%	61.8%	45.1%	16.7%	43.5%
-13.0	92.3%	66.6%	45.1%	21.5%	44.8%
-14.5	92.5%	60.4%	41.7%	18.7%	42.1%
-16.0	78.0%	53.5%	35.2%	18.3%	46.6%
-17.5	91.4%	46.4%	45.0%	1.4%	38.0%
-19.0	87.6%	48.3%	43.1%	5.2%	38.8%
-20.5	85.3%	NP			28.5%
-22.0	80.0%	NP			36.5%
-24.0	81.5%	NP			32.5%
-25.5	83.5%	NP			30.3%
-27.0	78.7%	NP			33.0%
-30.0	84.1%	NP			32.2%
-31.5	90.2%	40.3%	33.6%	6.7%	36.9%
-33.0	89.5%	64.8%	27.3%	37.5%	42.2%
-34.5	81.1%	37.1%	28.8%	8.3%	43.6%
-36.0	92.3%	48.6%	32.0%	16.6%	51.6%
-37.5	96.7%	70.4%	33.2%	37.2%	72.4%
-39.0	38.3%	NP			27.5%
-40.5	40.9%	NP			22.8%

APPENDIX G
PLANTATION PIPELINE

PLANTATION PIPELINE: FIELD BORING LOGS

BORING B-1
CONTINUOUS SAMPLING TO 40 ft.
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 4/25-26/89

WATER TABLE = 8.0 FT.

DEPTH IN FT. from	to	BLOW COUNT blows per 6 in.	DESCRIPTION
1.5-	3.0	3 - 8 / 12	very stiff red-orange clayey silt w/traces of sand
3.0-	4.5	5 - 7 / 12	same, very stiff
4.5-	6.0	5 - 7 / 12	same, very stiff, grading redder
6.0-	7.5	3 - 6 / 8	same, stiff
7.5-	9.0	2 - 8 / 8	same, very stiff
9.0-	10.5	2 - 5 / 8	stiff orange red clayey silt, grading wetter
10.5-	12.0	1 - 2 / 3	same, medium
12.0-	13.5	2 - 2 / 3	same, medium
13.5-	15.0	1 - 2 / 5	same, medium
15.0-	16.5	2 - 4 / 6	stiff brown-orange clayey silt w/ tr. of mica
16.5-	18.0	3 - 3 / 5	same, medium, w/brown nodules: layer changed @ 16.0 ft.
18.0-	19.5	2 - 3 / 5	same, medium
19.5-	21.0	2 - 3 / 6	same, stiff, w/ tr. of gravel
21.5-	23.0	2 - 3 / 6	stiff white tan clayey silt w/ tr. of sand & mica
23.0-	24.5	3 - 5 / 6	same, stiff, w/ tr. of gravel
24.5-	26.0	2 - 3 / 6	stiff tan-yellow fine sandy silt w/ blk streaks & mica
26.0-	27.5	4 - 5 / 9	same, stiff: (2" lense white mediun sand @ 27'-3")
27.5-	29.0	3 - 4 / 7	stiff yellowish geeen fine sandy silt w/ tr mica, gravel, blk. seams
29.0-	30.5	2 - 5 / 8	same, stiff, no gravel
30.5-	32.0	3 - 5 / 9	same, stiff

PLANTATION PIPELINE: FIELD BORING LOGS

BORING B-1
CONTINUOUS SAMPLING TO 40 ft.
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 4/25-26/89

WATER TABLE = 8.0 FT.

DEPTH IN FT. from	to	BLOW COUNT blows per 6 in.	DESCRIPTION
32.0 -	33.5	3 - 6 / 7	same, stiff
33.5 -	35.0	3 - 5 / 9	same, stiff
35.0 -	36.5	3 - 5 / 9	same, stiff
36.5 -	38.0	5 - 10 / 14	very stiff brown fine sandy silt, evident rock bedding planes
38.0 -	39.5	4 - 9 / 12	same, very stiff

-END OF BORING-

PLANTATION PIPELINE: FIELD BORING LOGS

BORING B-2
SAMPLING AND TUBE COLLECTION TO 40 ft.
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 4/27/89

WATER TABLE = 8.0 FT.

DEPTH IN FT.		BLOW COUNT	DESCRIPTION
from	to	blows per 6 in.	
1.5 -	3.0	3 - 8 / 10	very stiff red-orange clayey silt w/traces of gravel
4.5 -	6.0	4 - 8 / 12	same, very stiff
7.5 -	9.0	3 - 7 / 8	same, very stiff, loss of drilling mud return @ 7.5'
9.0 -	11.0	* - * / *	same: tube sample taken
12.0 -	13.5	2 - 4 / 4	medium brown-orange fine sandy silt w/tr. gravel & black lines
15.0 -	16.5	3 - 4 / 6	same,stiff, w/ tr. mica
16.5 -	18.5	* - * / *	same: tube sample taken
19.5 -	21.0	2 - 4 / 4	medium brown fine sandy silt w/ black streaks
23.0 -	24.5	2 - 4 / 4	brown medium white fine sandy silt w/ black streaks
26.0 -	27.5	2 - 3 / 4	medium orange fine sandy silt w/ black streaks
27.5 -	29.5	* - * / *	same: tube sample taken
30.5 -	32.0	3 - 7 / 7	stiff yellowish green fine sandy silt w/ mica
33.5 -	35.0	4 - 7 / 9	same, very stiff
35.0 -	37.0	* - * / *	same: tube sample taken
38.0 -	39.5	5 - 9 / 11	same, very stiff, w/ mica & black and white streaks

-END OF BORING-

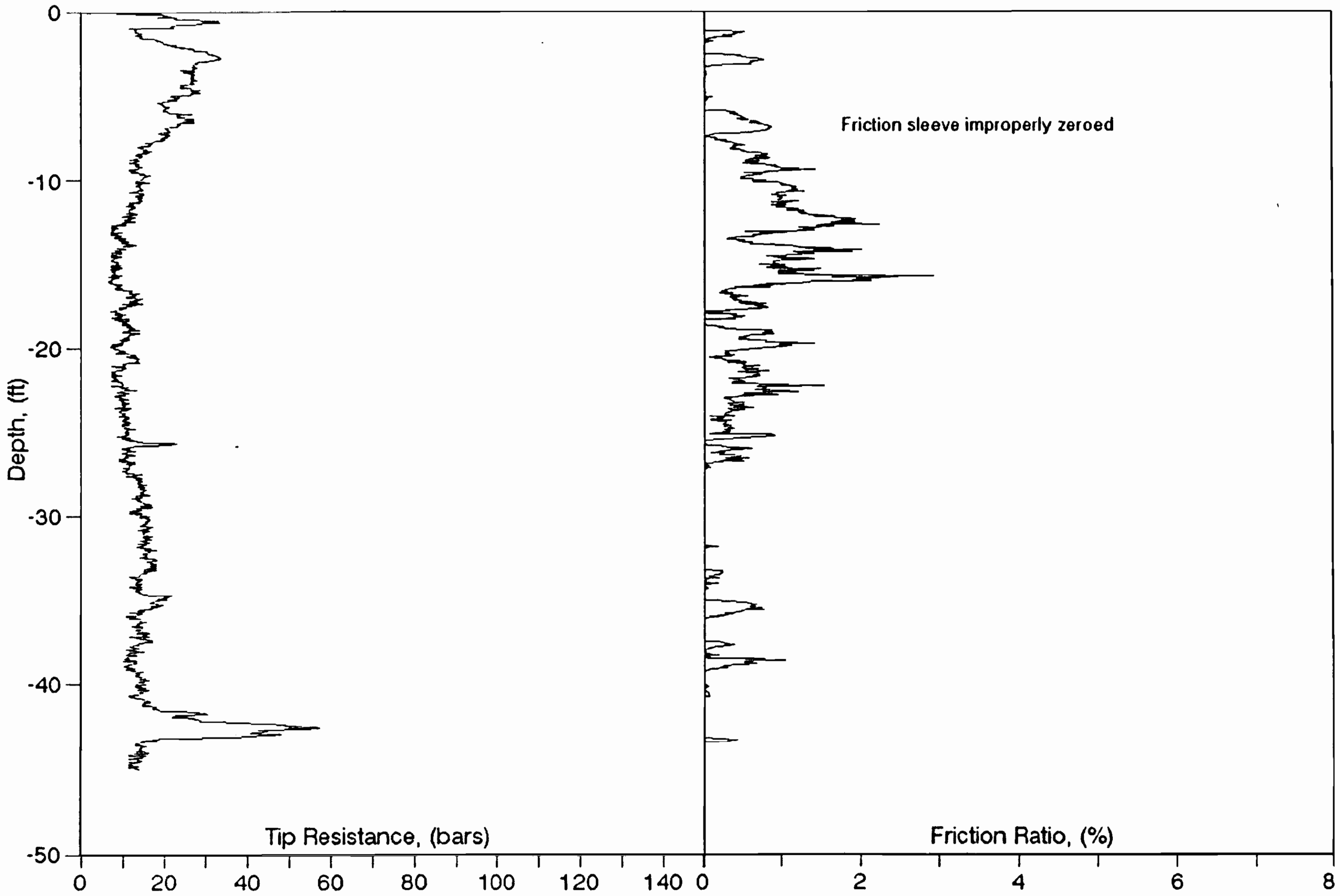
PLANTATION PIPELINE: FIELD BORING LOGS

BORING B-3
SAMPLING AND PRESSUREMETER TESTING TO 35 FT.
SAMPLES TAKEN WITH 300# HAMMER AND 3" SAMPLER
DRILLED 8/30/89 TO 9/1/89

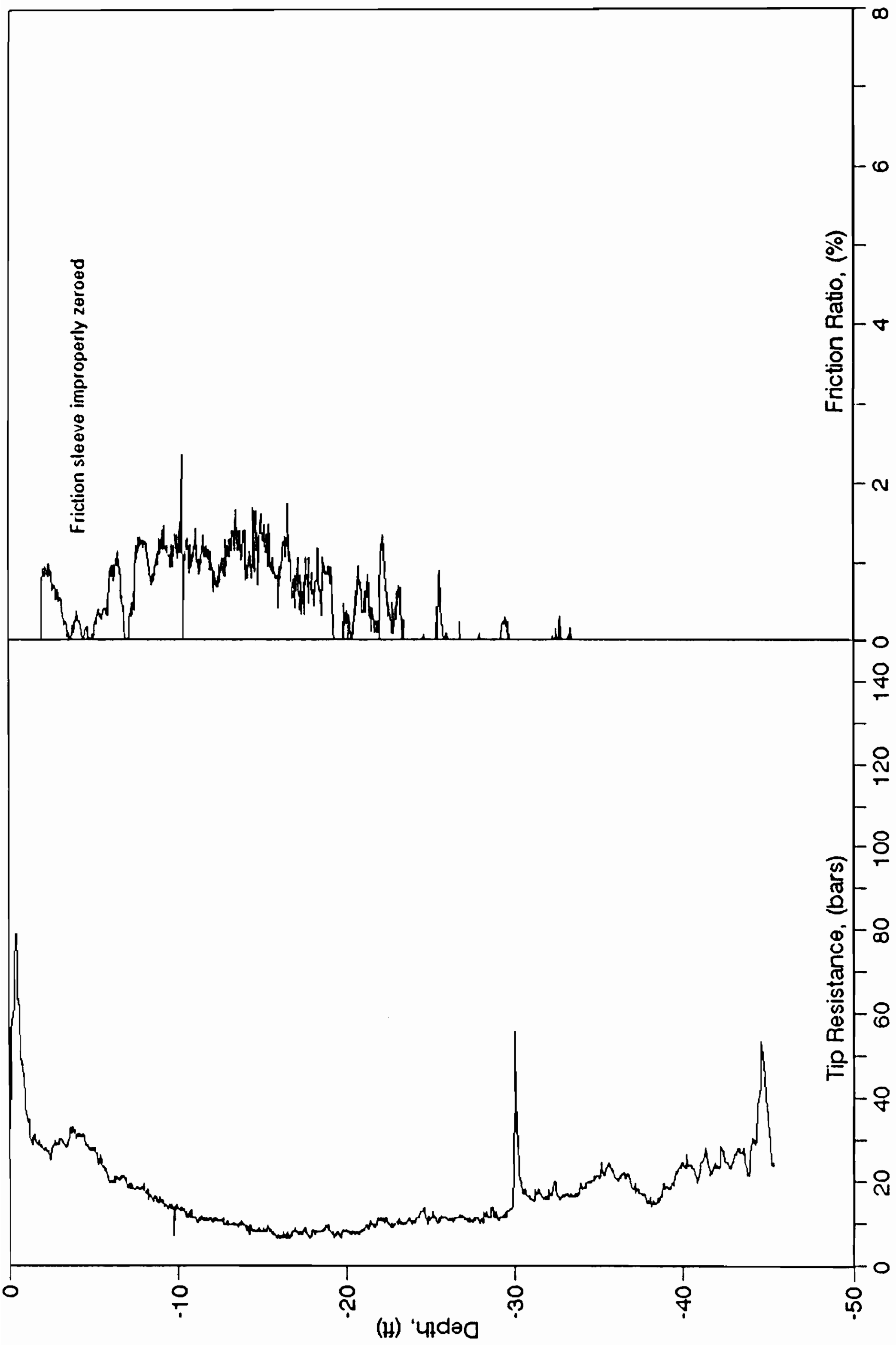
WATER TABLE = 8.0 FT.

DEPTH IN FT.		BLOW COUNT	DESCRIPTION
from	to	blows per 6 in.	
3.0 -	4.5	2 - 5 / 6	stiff red-orange fine sandy clayey silt (saprolite)
4.5 -	6.0	6 - 6 / 6	same
8.6 -	10.6	* - * / *	tube sample: red-orange fine sandy clayey silt
10.5 -	12.0	3 - 4 / 3	same, medium
16.0 -	18.0	* - * / *	tube sample: red-orange fine sandy clayey silt
18.0 -	19.5	3 - 3 / 4	no sample recovery
20.5 -	22.5	* - * / *	tube sample: yellow-red fine sandy silty clay w/ mica
22.5 -	24.0	2 - 2 / 2	no sample recovery
27.0 -	28.5	2 - 3 / 4	medium green-yellow sandy clay w/black stripes: decomposed granite
28.5 -	30.0	5 - 5 / 6	same, stiff
33.0 -	34.5	3 - 4 / 6	stiff green-yellow fine sandy clay w/some gravel: decomposed granite
34.5 -	36.0	5 - 7 / 6	same w/gravel seam @ 35'0", soft above gravel

---END OF BORING---



Plantation Pipeline: Cone Test PLPC-1 04/28/89



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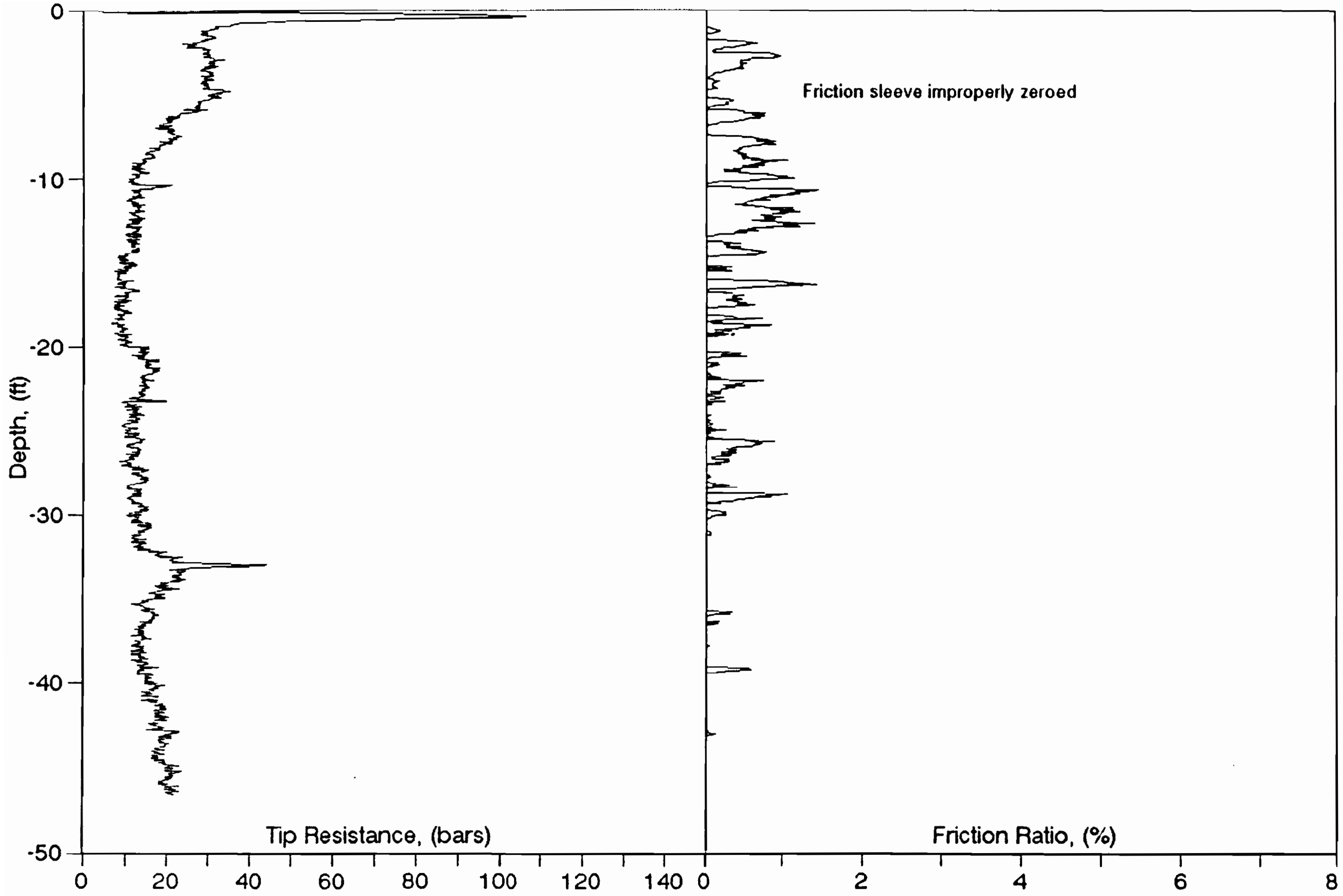
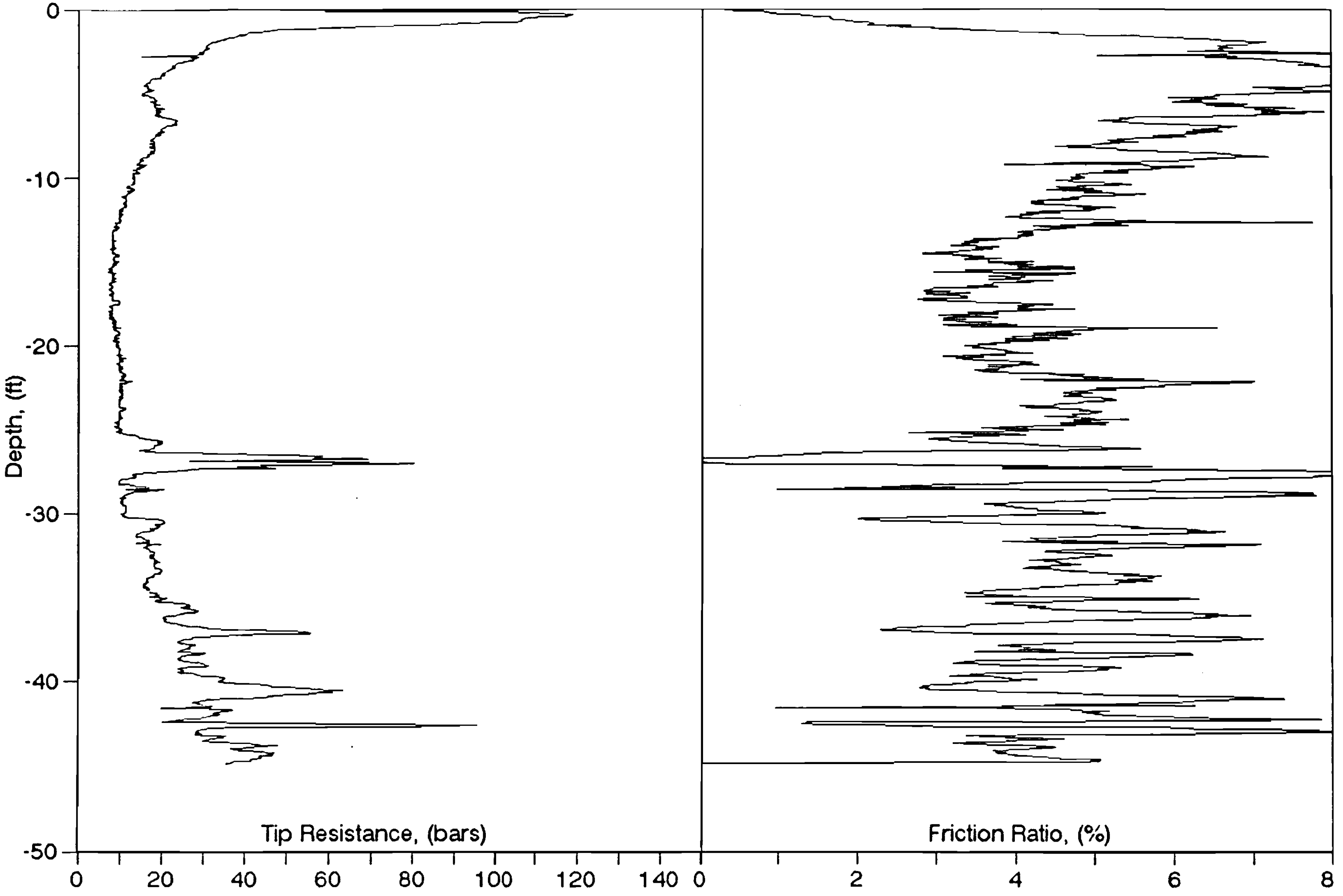
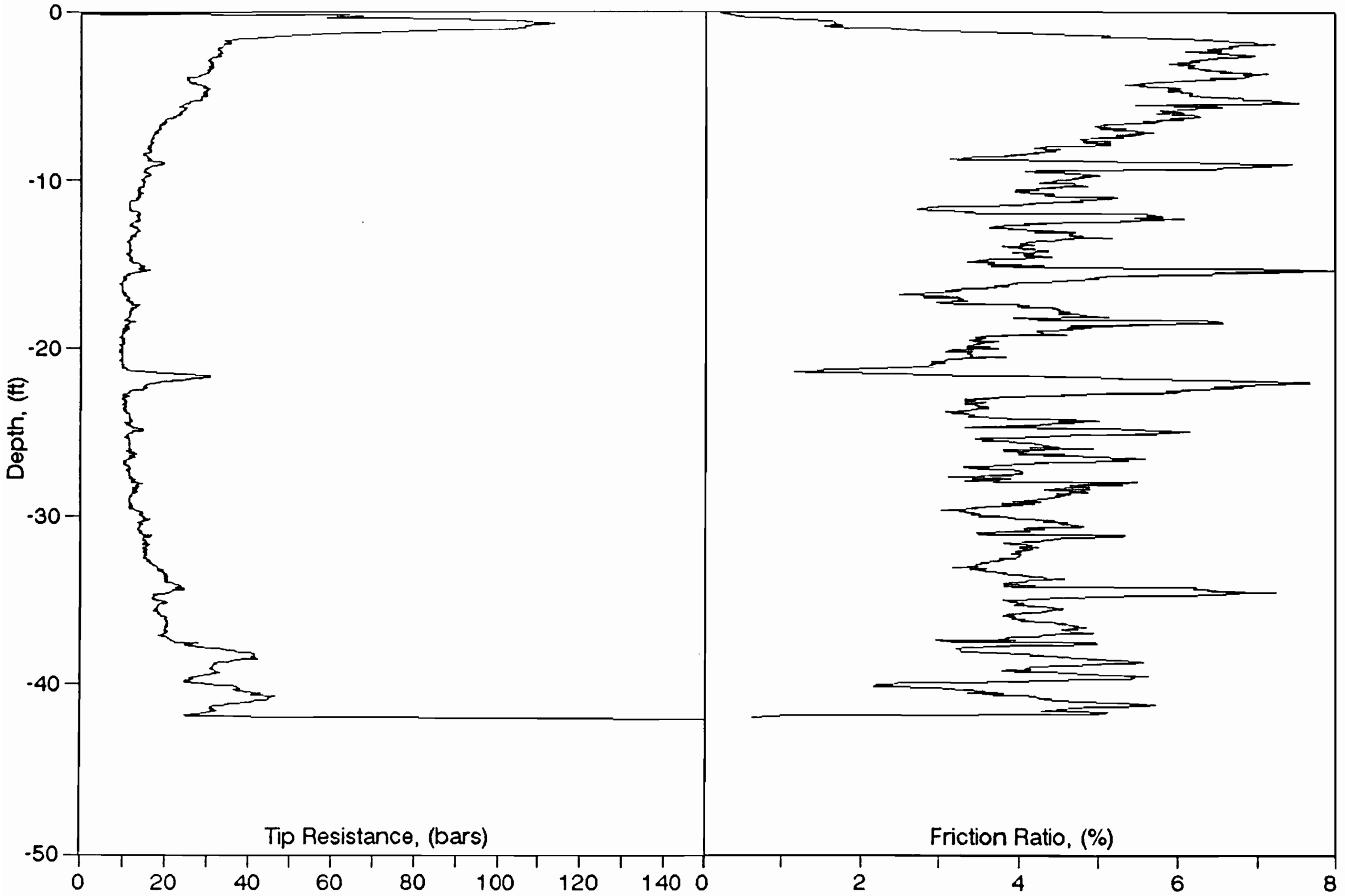


Plantation Pipeline: Cone Test PLPC-3 04/28/89



Plantation Pipeline: Cone Test PLPC-4 08/30/89



Plantation Pipeline: Cone Test PLPC-5 08/30/89

Virginia Polytechnic Institute TEST NO. PLP D-1
FILE NAME: Dilatometer Test
FILE NUMBER: 09:05:00

RECORD OF DILATOMETER TEST NO. PLP D-1
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

LOCATION: PLANTATION PIPELINE
PERFORMED - DATE: 08/29/89
BY: MULLEN

CALIBRATION INFORMATION:
DELTA A = .21 BARS DELTA B = .24 BARS GAGE 0 = .00 BARS GWT DEPTH= 2.44 M
ROD DIA.= 3.56 CM FR.RED.DIA.= 1.91 CM ROD WT.= .00 KG/M DELTA/PHI= .50 BLADE T=15.00 MM

1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI ANALYSIS USES H2O UNIT WEIGHT = 1.000 T/M3

Z (M)	THRUST (KG)	A (BAR)	B (BAR)	ED (BAR)	ID	KD	UO (BAR)	GAMMA (T/M3)	SV (BAR)	PC (BAR)	OCR	KO	CU (BAR)	PHI (DEG)	M (BAR)	SOIL TYPE
.30	734.	4.57	15.20	371.	2.50	72.39	.000	2.000	.059	40.1	679.7	8.88		32.3	1622.4	SILTY SAND
.61	417.	4.48	11.20	228.	1.50	37.47	.000	1.800	.117	54.9	470.2	4.97		20.3	856.8	SANDY SILT
.91	440.	5.46	12.20	229.	1.23	31.14	.000	1.950	.172	82.0	476.9	4.28		17.8	819.4	SANDY SILT
1.22		5.70	11.45	193.	.99	24.40	.000	1.950	.231	11.5	49.5	3.11			645.9	SILT
1.52		6.86	13.05	209.	.89	23.49	.000	1.950	.289	13.5	46.7	3.04	1.381		692.0	CLAYEY SILT
1.83		6.68	12.75	205.	.89	18.99	.000	1.950	.348	11.7	33.5	2.70	1.276		636.2	CLAYEY SILT
2.13		5.32	9.72	144.	.78	13.22	.000	1.800	.403	7.7	19.0	2.18	.941		397.9	CLAYEY SILT
2.44		4.38	8.02	116.	.76	9.67	.000	1.800	.458	5.4	11.7	1.80	.723		286.7	CLAYEY SILT
2.74		3.88	6.87	93.	.68	8.17	.029	1.800	.482	4.3	9.0	1.62	.615		212.3	CLAYEY SILT
3.05		3.89	6.79	89.	.66	7.74	.060	1.800	.506	4.2	8.3	1.56	.605		199.9	CLAYEY SILT
3.35		3.23	5.18	55.	.48	6.20	.089	1.700	.528	3.1	5.8	1.35	.478		109.9	SILTY CLAY
3.66		3.68	7.19	111.	.89	6.57	.120	1.800	.551	3.5	6.4	1.40	.536		231.6	CLAYEY SILT
3.96		2.78	4.41	43.	.45	4.86	.149	1.700	.573	2.3	4.0	1.14	.382		75.7	SILTY CLAY
4.27		2.52	3.96	36.	.42	4.21	.180	1.700	.594	1.9	3.2	1.02	.331		58.2	SILTY CLAY
4.57		2.66	4.09	36.	.39	4.25	.209	1.700	.615	2.0	3.2	1.03	.347		57.9	SILTY CLAY
4.88		2.30	3.47	26.	.34	3.52	.239	1.600	.635	1.5	2.4	.89	.283		37.5	CLAY
5.18		2.42	3.77	33.	.41	3.54	.269	1.700	.654	1.6	2.4	.90	.294		47.1	SILTY CLAY
5.49		2.72	4.21	38.	.42	3.82	.299	1.700	.675	1.9	2.7	.95	.333		57.4	SILTY CLAY
5.79		2.63	4.10	37.	.44	3.54	.329	1.700	.696	1.7	2.4	.90	.312		53.3	SILTY CLAY
6.10		2.61	4.22	42.	.51	3.35	.359	1.700	.717	1.6	2.2	.86	.301		58.3	SILTY CLAY
6.40		2.84	4.50	44.	.49	3.53	.389	1.700	.738	1.8	2.4	.89	.330		63.1	SILTY CLAY
6.71		2.94	4.53	42.	.45	3.52	.419	1.700	.759	1.8	2.4	.89	.339		59.4	SILTY CLAY
7.01		3.10	5.31	64.	.67	3.56	.448	1.700	.779	1.9	2.5	.90	.352		92.7	CLAYEY SILT
7.32		2.51	4.40	52.	.70	2.71	.479	1.700	.801	1.3	1.6	.72	.257		61.4	CLAYEY SILT
7.62	166.	2.78	6.29	111.	1.38	2.84	.508	1.700	.821	4.3	5.3	1.05		12.9	141.8	SANDY SILT
7.92		3.30	5.70	71.	.71	3.41	.538	1.700	.842	1.9	2.3	.87	.361		99.9	CLAYEY SILT
8.23		3.18	5.21	58.	.60	3.18	.568	1.700	.863	1.8	2.1	.82	.339		76.3	CLAYEY SILT
8.53		3.18	5.18	56.	.60	3.07	.598	1.700	.884	1.7	2.0	.80	.332		72.9	SILTY CLAY
8.84		3.10	5.13	58.	.64	2.88	.628	1.700	.905	1.6	1.8	.76	.314		70.6	CLAYEY SILT
9.14		3.70	5.98	67.	.61	3.41	.658	1.700	.926	2.1	2.3	.87	.397		93.3	CLAYEY SILT
9.45		3.53	5.69	62.	.61	3.13	.688	1.700	.947	1.9	2.0	.81	.365		81.7	CLAYEY SILT
9.75		3.51	5.79	67.	.66	3.01	.717	1.700	.968	1.8	1.9	.79	.355		84.9	CLAYEY SILT
10.06		3.88	6.14	66.	.58	3.29	.748	1.700	.989	2.1	2.2	.85	.405		89.7	SILTY CLAY
10.36		3.68	5.81	61.	.58	3.00	.777	1.700	1.010	1.9	1.9	.79	.369		77.5	SILTY CLAY
10.67		3.87	6.37	75.	.68	3.08	.808	1.700	1.031	2.0	2.0	.80	.388		96.9	CLAYEY SILT
10.97		5.56	9.77	137.	.83	4.51	.837	1.800	1.053	3.7	3.6	1.08	.639		232.2	CLAYEY SILT
11.28		4.08	6.29	64.	.55	3.10	.868	1.700	1.076	2.1	2.0	.81	.409		83.3	SILTY CLAY
11.58		4.40	7.13	83.	.67	3.28	.897	1.800	1.098	2.4	2.2	.84	.448		113.1	CLAYEY SILT
11.89		4.20	6.63	72.	.61	3.02	.927	1.700	1.121	2.1	1.9	.79	.413		91.9	CLAYEY SILT
12.19		4.29	6.89	78.	.66	3.01	.957	1.700	1.141	2.2	1.9	.79	.419		99.8	CLAYEY SILT
12.50		4.70	7.91	101.	.77	3.25	.987	1.800	1.164	2.5	2.1	.84	.470		136.8	CLAYEY SILT
12.80		6.00	11.35	179.	1.04	4.17	1.017	1.800	1.188	3.7	3.1	1.02			290.6	SILT
13.11		9.08	15.80	228.	.83	6.53	1.047	1.950	1.214	7.7	6.3	1.40	1.172		472.8	CLAYEY SILT
13.41		8.32	15.00	227.	.92	5.75	1.077	1.950	1.242	6.5	5.2	1.28			441.3	SILT
13.72		8.20	14.05	197.	.81	5.53	1.107	1.950	1.271	6.2	4.9	1.25	.998		374.1	CLAYEY SILT

END OF SOUNDING

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Virginia Polytechnic Institute                                                      TEST NO. PLP D-2
FILE NAME:     Dilatometer Test
FILE NUMBER:   13:00:00

RECORD OF DILATOMETER TEST NO. PLP D-2
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

     LOCATION: PLANTATION PIPELINE
     PERFORMED - DATE:  08/29/89
                   BY:  MULLEN


     CALIBRATION INFORMATION:
     DELTA A =  .20 BARS   DELTA B    =  .23 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 2.44 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50     BLADE T=15.00 MM

     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3


  Z   THRUST    A      B     ED    ID    KD     UO   GAMMA   SV      PC   OCR    KO    CU   PHI      M      SOIL TYPE
 (M)   (KG)   (BAR)  (BAR)  (BAR)               (BAR) (T/M3) (BAR)   (BAR)               (BAR) (DEG)  (BAR)
***** ****** *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  ***** ***** *****  ******  ***********

  .30          5.62  17.40   414.  2.27 89.03   .000  2.000   .059                                   1889.8  SILTY SAND
  .61          6.12  13.35   248.  1.19 50.22   .000  1.950   .119   18.2 152.7   4.61                997.9     SILT
  .91          5.78  12.65   235.  1.20 32.06   .000  1.950   .176   13.4  75.8   3.62                845.4     SILT
 1.22          5.70  11.55   197.  1.01 23.87   .000  1.950   .236   11.3  47.8   3.07                656.4     SILT
 1.52          7.78  13.95   209.   .78 26.24   .000  1.950   .293   16.3  55.4   3.24 1.610          713.8  CLAYEY SILT
 1.83          7.31  12.55   175.   .69 20.62   .000  1.950   .353   13.4  38.1   2.83 1.433          558.2  CLAYEY SILT
 2.13          6.83  12.00   173.   .73 16.57   .000  1.950   .410   11.1  27.1   2.49 1.268          514.3  CLAYEY SILT
 2.44          5.30   9.51   138.   .75 11.37   .000  1.800   .467    7.0  15.1   1.99  .902          361.1  CLAYEY SILT
 2.74          4.87   8.98   134.   .80  9.90   .029  1.800   .491    5.9  12.1   1.83  .797          333.8  CLAYEY SILT
 3.05          4.58   7.66    97.   .61  8.91   .060  1.800   .515    5.3  10.3   1.71  .733          230.0  CLAYEY SILT
 3.35          4.40   7.38    93.   .61  8.14   .089  1.800   .538    4.8   8.9   1.61  .685          212.7  CLAYEY SILT
 3.66          4.17   6.71    77.   .53  7.36   .120  1.800   .563    4.3   7.6   1.51  .632          168.1  SILTY CLAY
 3.96          3.08   6.79   120.  1.16  5.06   .149  1.800   .586    2.5   4.3   1.17                218.3     SILT
 4.27          3.21   5.47    67.   .61  5.15   .180  1.700   .609    2.7   4.4   1.19  .437          121.4  CLAYEY SILT
 4.57          3.29   4.87    42.   .37  5.12   .209  1.700   .630    2.7   4.3   1.18  .448           76.0  SILTY CLAY
 4.88          3.06   4.62    41.   .40  4.55   .239  1.700   .651    2.3   3.6   1.09  .400           69.7  SILTY CLAY
 5.18          2.46   3.59    26.   .31  3.52   .269  1.600   .670    1.6   2.4    .89  .298           36.4     CLAY
 5.49          2.18   3.21    22.   .31  2.98   .299  1.600   .688    1.3   1.9    .78  .249           27.5     CLAY
 5.79          2.36   3.59    29.   .38  3.10   .329  1.600   .706    1.4   2.0    .81  .269           37.9  SILTY CLAY
 6.10          2.57   4.10    40.   .49  3.25   .359  1.700   .726    1.5   2.1    .84  .292           54.0  SILTY CLAY
 6.40          2.64   4.53    53.   .64  3.19   .389  1.700   .746    1.5   2.1    .82  .294           70.8  CLAYEY SILT
 6.71          2.80   4.40    43.   .49  3.29   .419  1.700   .768    1.7   2.2    .85  .314           57.9  SILTY CLAY
 7.01          3.09   4.56    38.   .39  3.54   .448  1.700   .788    1.9   2.4    .90  .354           54.4  SILTY CLAY
 7.32          3.10   4.60    39.   .41  3.42   .479  1.700   .810    1.9   2.3    .87  .348           54.6  SILTY CLAY
 7.62          3.40   5.79    71.   .69  3.61   .508  1.700   .830    2.1   2.5    .91  .382          104.3  CLAYEY SILT
 7.92          2.69   4.49    50.   .63  2.68   .538  1.700   .851    1.3   1.6    .71  .270           57.6  CLAYEY SILT
 8.23          2.71   4.39    46.   .58  2.61   .568  1.700   .872    1.3   1.5    .70  .268           51.2  SILTY CLAY
 8.53          2.72   4.44    47.   .60  2.53   .598  1.700   .893    1.3   1.4    .68  .263           51.3  SILTY CLAY
 8.84          3.36   5.80    73.   .75  3.10   .628  1.700   .914    1.8   2.0    .81  .347           95.9  CLAYEY SILT
 9.14          4.32   7.33    94.   .73  3.99   .658  1.800   .936    2.7   2.9    .98  .488          147.1  CLAYEY SILT
 9.45          4.09   7.32   102.   .85  3.60   .688  1.800   .961    2.4   2.5    .91  .441          150.0  CLAYEY SILT
 9.75          3.80   6.16    70.   .64  3.24   .717  1.700   .983    2.1   2.1    .84  .395           94.8  CLAYEY SILT
10.06          3.70   6.04    70.   .66  3.04   .748  1.700  1.004    1.9   1.9    .79  .373           89.5  CLAYEY SILT
10.36          5.91  11.95   204.  1.17  4.92   .777  1.800  1.026    4.2   4.1   1.15                367.9     SILT
10.67          5.11   8.57   110.   .73  4.14   .808  1.800  1.050    3.3   3.1   1.01  .574          177.1  CLAYEY SILT
10.97          5.24   9.04   123.   .80  4.13   .837  1.800  1.074    3.3   3.1   1.01  .585          197.1  CLAYEY SILT
11.28          5.80  10.00   137.   .80  4.50   .868  1.800  1.098    3.9   3.5   1.08  .666          232.5  CLAYEY SILT
11.58          6.41  10.85   146.   .76  4.91   .897  1.800  1.122    4.6   4.1   1.15  .759          260.0  CLAYEY SILT
11.89          7.41  13.40   203.   .91  5.58   .927  1.950  1.148    5.7   5.0   1.25                387.6     SILT
12.19          7.99  15.45   256.  1.07  5.85   .957  1.950  1.176    6.3   5.3   1.30                503.8     SILT
12.50          7.50  12.80   177.   .79  5.37   .987  1.950  1.205    5.6   4.7   1.22  .911          331.8  CLAYEY SILT
12.80          7.32  12.45   171.   .79  5.08  1.017  1.950  1.233    5.3   4.3   1.17  .871          310.8  CLAYEY SILT
13.11          8.54  14.75   211.   .82  5.87  1.047  1.950  1.262    6.8   5.4   1.30 1.066          413.0  CLAYEY SILT
13.41          6.93  12.70   195.   .97  4.49  1.077  1.950  1.290    4.5   3.5   1.07                330.3     SILT
13.72          5.90  10.75   161.   .97  3.62  1.107  1.800  1.317    3.3   2.5    .91                239.0     SILT
END OF SOUNDING
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Virginia Polytechnic Institute                                                              TEST NO. PLP D-3
FILE NAME:      Dilatometer Test
FILE NUMBER:    15:40:00

RECORD OF DILATOMETER TEST NO. PLP D-3
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

     LOCATION: PLANTATION PIPELINE
     PERFORMED - DATE:  08/29/89
                   BY:  MULLEN

     CALIBRATION INFORMATION:
     DELTA A =  .21 BARS   DELTA B    =  .23 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 2.44 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50     BLADE T=15.00 MM

     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3

   Z   THRUST    A      B      ED     ID    KD      U0   GAMMA     SV      PC   OCR     KO     CU   PHI       M      SOIL TYPE
  (M)   (KG)   (BAR)  (BAR)  (BAR)                (BAR)  (T/M3)  (BAR)  (BAR)                (BAR) (DEG)  (BAR)
***** ******   *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******   ************

   .30   734.   5.25  17.05   414.  2.44 82.92    .000  2.000   .059   61.8 *****  10.20         29.8  1863.6   SILTY SAND
   .61   417.   5.30  13.15   270.  1.51 43.16    .000  1.950   .119  139.0 *****   5.72         17.1  1048.7   SANDY SILT
   .91   440.   5.38  12.35   238.  1.30 29.82    .000  1.950   .176   71.0 402.4   4.11         18.2   840.9   SANDY SILT
  1.22          6.53  12.65   207.   .92 27.38    .000  1.950   .236   14.0  59.3   3.32                714.7      SILT
  1.52          7.03  14.25   247.  1.03 23.53    .000  1.950   .293   13.7  46.8   3.05                817.7      SILT
  1.83          7.54  13.55   203.   .78 21.19    .000  1.950   .353   14.0  39.7   2.87  1.483         651.7   CLAYEY SILT
  2.13          6.18  11.50   178.   .83 14.99    .000  1.950   .410    9.5  23.2   2.35  1.119         512.7   CLAYEY SILT
  2.44          4.98   8.63   117.   .67 10.77    .000  1.800   .467    6.5  13.8   1.93   .843         300.6   CLAYEY SILT
  2.74          4.50   7.61    97.   .62  9.27    .029  1.800   .491    5.4  10.9   1.75   .734         235.6   CLAYEY SILT
  3.05          3.42   6.07    81.   .67  6.72    .060  1.800   .515    3.4   6.6   1.42   .515         168.6   CLAYEY SILT
  3.35          3.23   5.57    69.   .61  6.06    .089  1.700   .537    3.0   5.6   1.33   .473         137.6   CLAYEY SILT
  3.66          2.98   4.79    50.   .48  5.38    .120  1.700   .558    2.6   4.7   1.22   .423          93.0   SILTY CLAY
  3.96          2.78   4.61    51.   .53  4.79    .149  1.700   .579    2.3   3.9   1.13   .379          88.4   SILTY CLAY
  4.27          2.52   4.29    48.   .56  4.14    .180  1.700   .600    1.9   3.1   1.01   .328          77.3   SILTY CLAY
  4.57          2.84   4.60    48.   .50  4.47    .209  1.700   .621    2.2   3.5   1.07   .373          80.5   SILTY CLAY
  4.88          2.71   4.10    35.   .38  4.10    .239  1.700   .642    2.0   3.1   1.00   .347          54.9   SILTY CLAY
  5.18          2.58   3.83    30.   .34  3.74    .269  1.700   .663    1.8   2.7    .94   .319          44.1      CLAY
  5.49          2.24   3.30    23.   .31  3.11    .299  1.600   .682    1.4   2.0    .81   .260          29.4      CLAY
  5.79          2.28   3.36    23.   .32  3.04    .329  1.600   .700    1.3   1.9    .79   .260          29.8      CLAY
  6.10          2.31   3.55    29.   .40  2.95    .359  1.600   .718    1.3   1.8    .77   .257          36.4   SILTY CLAY
  6.40          2.70   4.14    36.   .42  3.35    .389  1.700   .738    1.6   2.2    .86   .309          50.3   SILTY CLAY
  6.71          3.14   4.71    41.   .41  3.79    .419  1.700   .759    2.1   2.7    .95   .371          62.0   SILTY CLAY
  7.01          3.29   5.60    68.   .66  3.80    .448  1.700   .779    2.1   2.7    .95   .382         103.0   CLAYEY SILT
  7.32          2.76   5.04    67.   .81  3.00    .479  1.700   .801    1.5   1.9    .78   .292          85.9   CLAYEY SILT
  7.62          2.64   5.83   100.  1.31  2.68    .508  1.700   .821                                     121.5   SANDY SILT
  7.92          5.31  11.95   226.  1.39  5.54    .538  1.800   .843                                     434.9   SANDY SILT
  8.23          3.08   5.09    57.   .62  3.05    .568  1.700   .866    1.7   1.9    .80   .323          73.5   CLAYEY SILT
  8.53          3.16   4.77    43.   .45  3.06    .598  1.700   .887    1.7   1.9    .80   .332          54.8   SILTY CLAY
  8.84          2.70   4.32    43.   .56  2.45    .628  1.700   .908    1.2   1.4    .66   .257          45.5   SILTY CLAY
  9.14          4.09   6.39    68.   .55  3.82    .658  1.700   .929    2.6   2.7    .95   .459         102.6   SILTY CLAY
  9.45          4.12   7.11    93.   .76  3.69    .688  1.800   .952    2.5   2.6    .93   .451         138.4   CLAYEY SILT
  9.75          3.97   6.05    60.   .51  3.47    .717  1.700   .974    2.3   2.4    .88   .427          84.6   SILTY CLAY
 10.06          4.21   6.66    73.   .59  3.59    .748  1.700   .995    2.5   2.5    .91   .455         106.2   SILTY CLAY
 10.36          3.81   6.26    73.   .67  3.09    .777  1.700  1.016    2.0   2.0    .81   .385          95.4   CLAYEY SILT
 10.67          4.40   7.34    91.   .71  3.54    .808  1.800  1.038    2.5   2.4    .90   .467         131.5   CLAYEY SILT
 10.97          5.11   8.88   121.   .81  4.06    .837  1.800  1.062    3.2   3.0   1.00   .567         192.9   CLAYEY SILT
 11.28          3.50   6.10    79.   .83  2.52    .868  1.700  1.085    1.6   1.4    .68   .319          87.2   CLAYEY SILT
 11.58          5.46   9.18   120.   .75  4.16    .897  1.800  1.107    3.5   3.1   1.02   .609         192.5   CLAYEY SILT
 11.89          6.63  11.25   152.   .77  5.04    .927  1.800  1.131    4.8   4.2   1.17   .791         275.0   CLAYEY SILT
 12.19          5.43   9.60   136.   .87  3.89    .957  1.800  1.155    3.3   2.8    .97   .584         210.7   CLAYEY SILT
 12.50          6.76  11.85   169.   .85  4.88    .987  1.800  1.179    4.7   4.0   1.14   .790         300.8   CLAYEY SILT
 12.80   748.    .98   2.99    57. 17.39   .08   1.017  1.700  1.201     .4    .3    .25         35.0    48.6      SAND
 13.11          6.24  10.60   143.   .79  4.25   1.047  1.800  1.224    4.0   3.2   1.03   .692         233.5   CLAYEY SILT
 13.41          7.08  12.20   171.   .82  4.79   1.077  1.800  1.247    4.9   3.9   1.13   .818         299.6   CLAYEY SILT
 13.72          8.39  15.55   245.   .99  5.62   1.107  1.950  1.274    6.4   5.0   1.26                470.9      SILT
END OF SOUNDING
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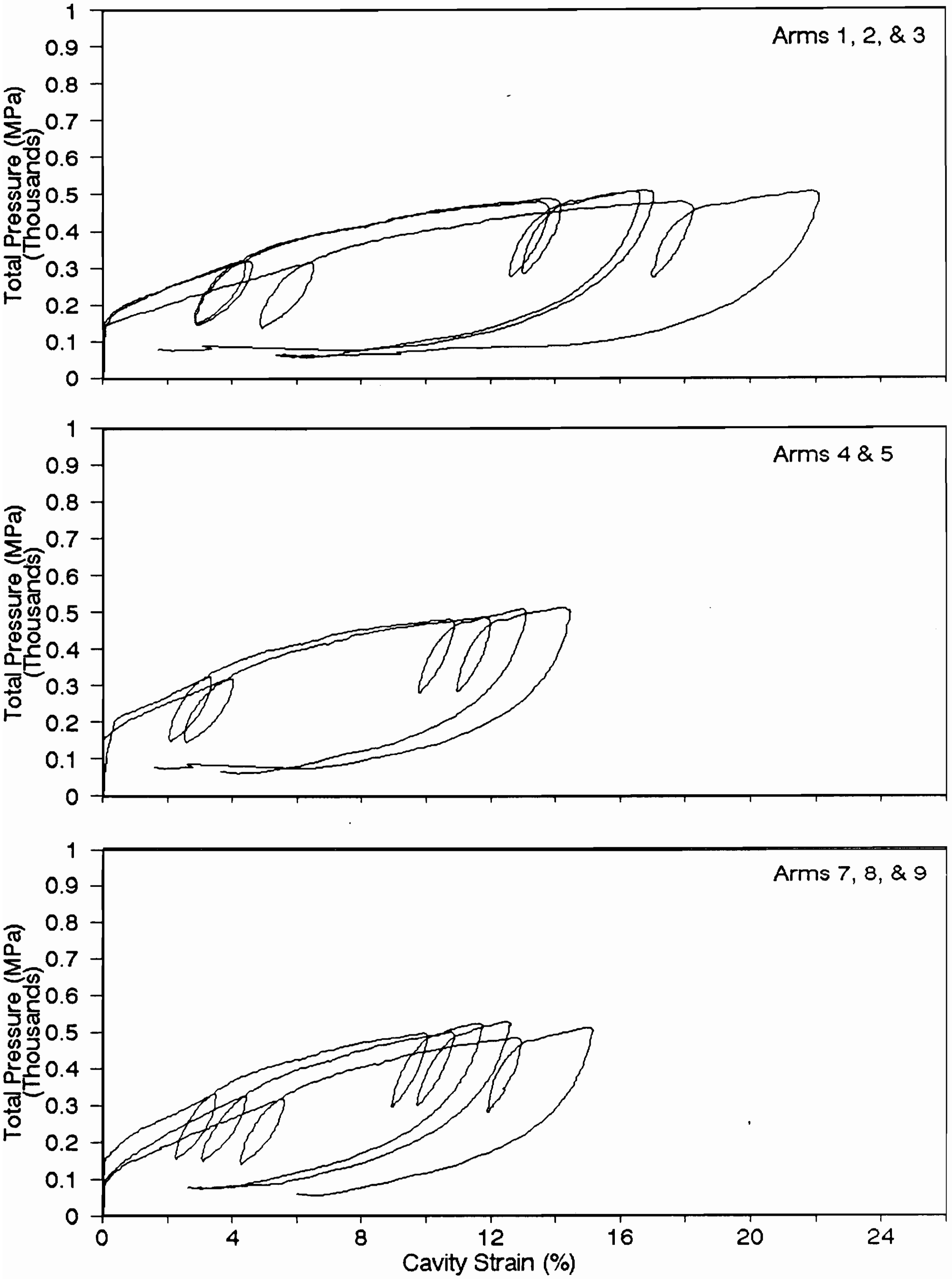
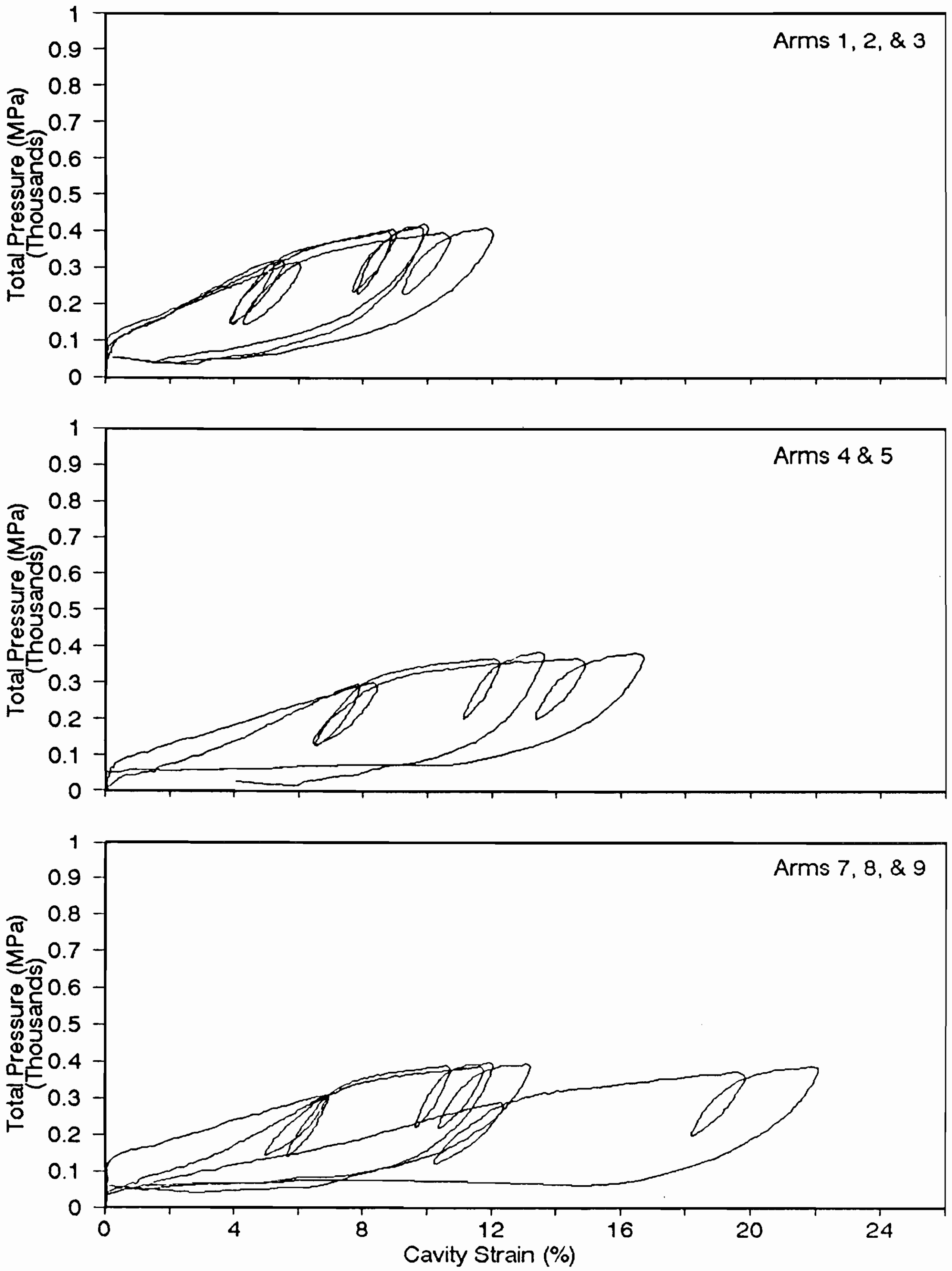


Plantation Pipeline: Pressuremeter Test PLPP-2 08/31/89



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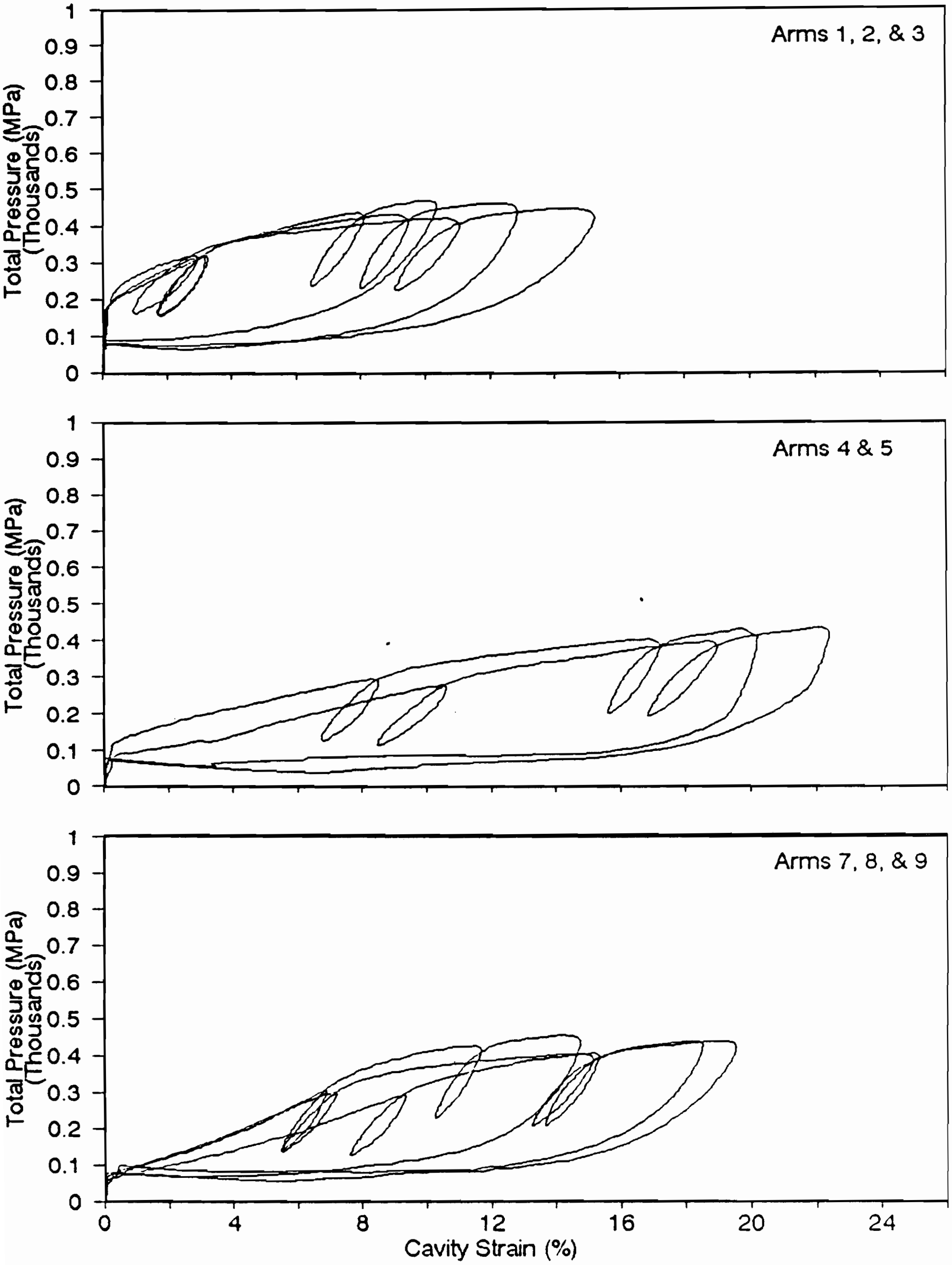

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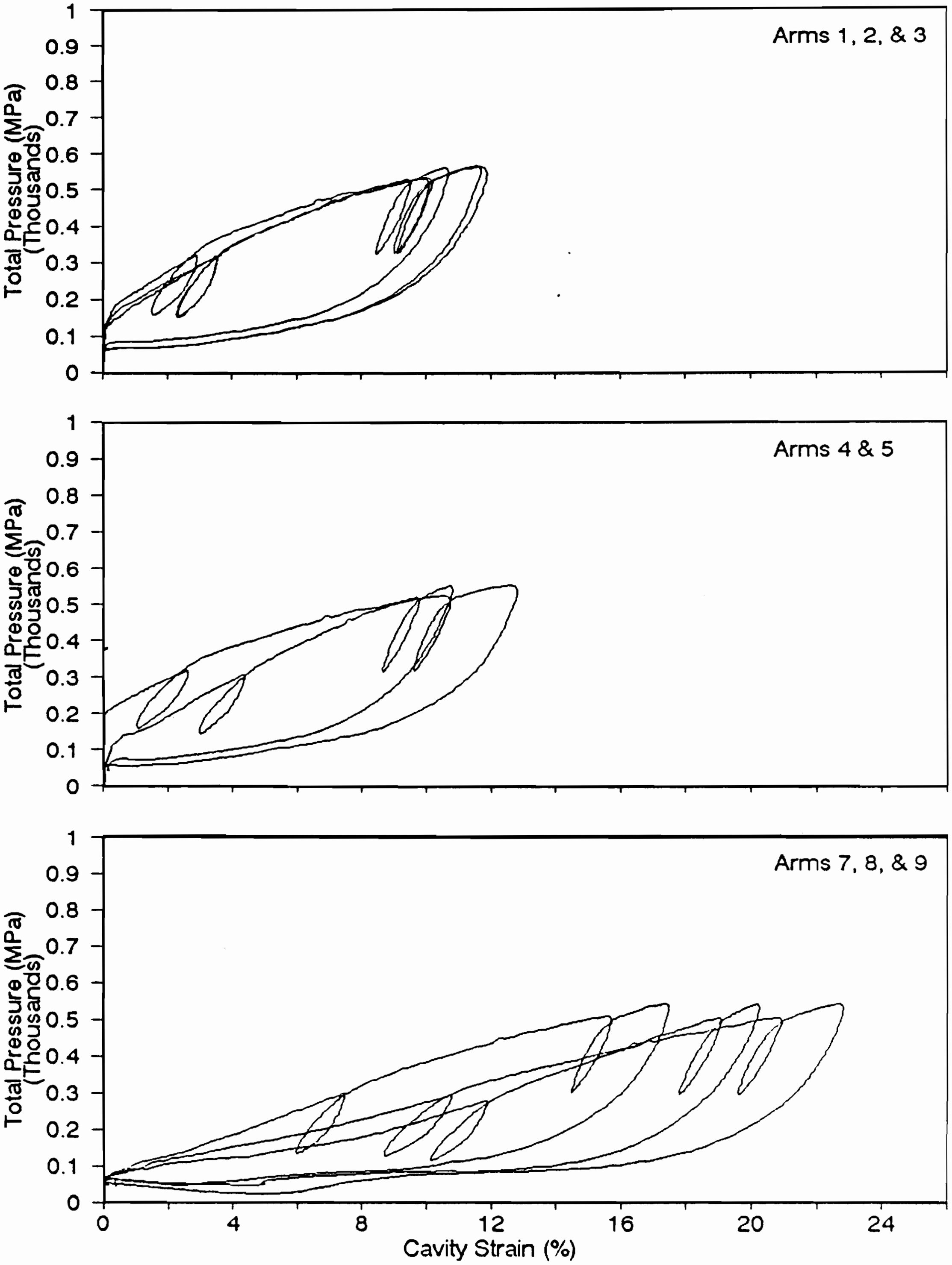
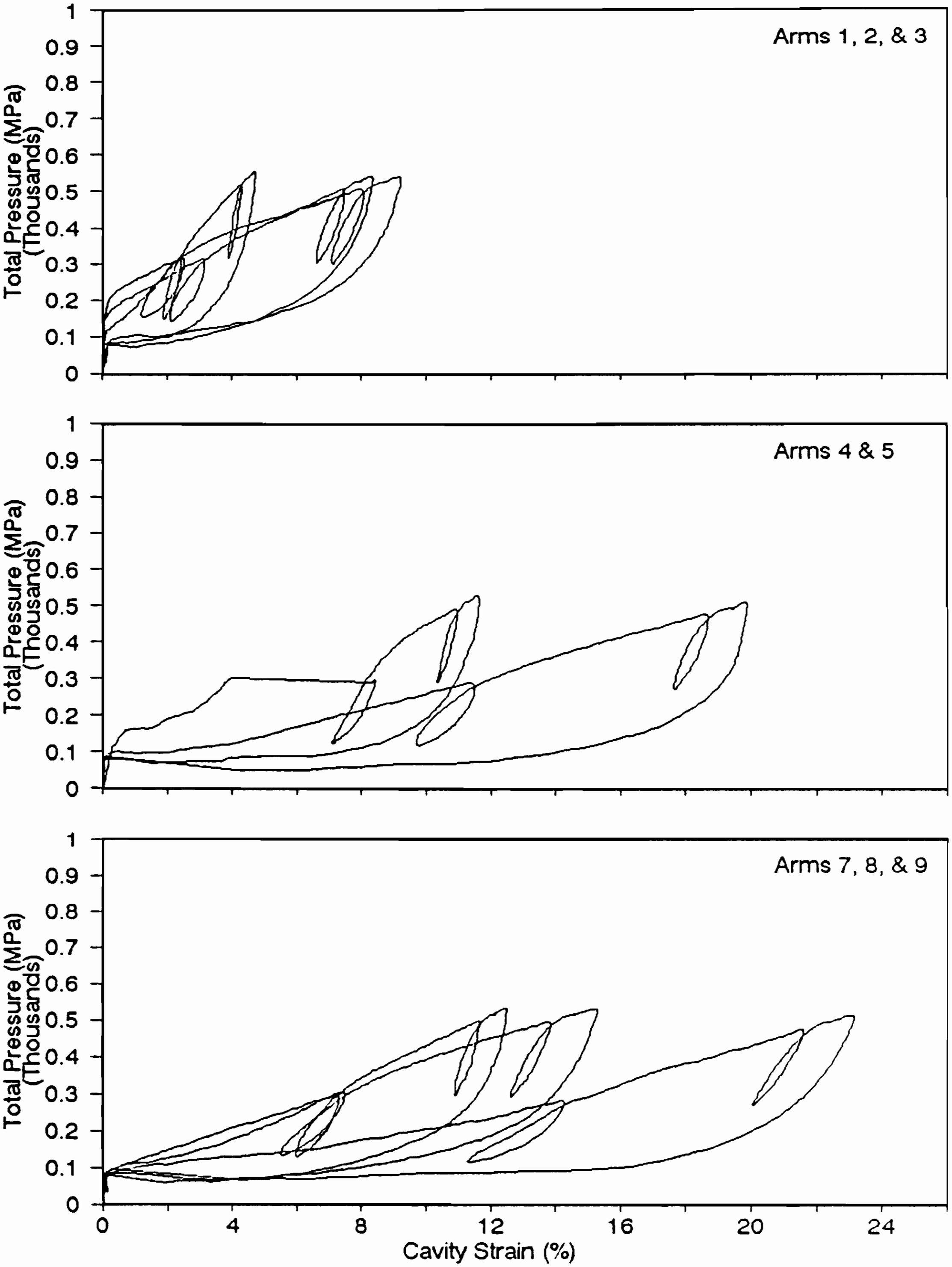


Plantation Pipeline: Pressuremeter Test PLPP-5 08/31/89



Plantation Pipeline: Pressuremeter Test PLPP-6 09/01/89

PLANTATION
PIPELINE:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	BORING #	N60	N160	Qc (pt) bar
-1.0				47.8
-2.0				28.1
-2.5	B-2	18	31	30.6
-2.5	B-1	20	35	30.3
-3.0				30.5
-4.0	B-3	11	18	26.5
-4.0	B-1	19	31	26.6
-5.0				25.2
-5.5	B-3	12	18	22.5
-5.5	B-1	19	29	22.6
5.5	B-2	20	30	22.9
-6.0				22.0
-7.0	B-1	14	20	18.9
-8.0				17.1
-8.5	B-2	15	20	15.4
-8.5	B-1	16	22	15.8
-9.0				15.0
-10.0	B-1	13	17	13.4
-10.5				14.2
-11.0				12.9
-11.5	B-1	5	6	11.2
-11.5	B-3	7	9	12.3
-12.0				11.8
-13.0	B-1	5	6	10.9
-13.0	B-2	8	10	10.5
-14.0				9.9
-14.5	B-1	7	9	9.1
-15.0				10.2
-16.0	B-1	10	12	8.0
-16.0	B-2	10	12	8.3
-17.0				8.8
-17.5	B-1	8	10	10.2
-18.0				9.2
-19.0	B-3	7	8	9.6
-19.0	B-1	8	9	9.4
-20.0				10.1

PLANTATION
PIPELINE:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Qn (pt)) barr	ED bar	Gur kN/M^2	D50 (mm)
-1.0	90.3	400		
-2.0	50.3	249		
-2.5	53.3	241		0.001
-2.5	52.8	241		0.001
-3.0	51.9	234		
-4.0	42.9	199		0.001
-4.0	43.2	199		0.001
-5.0	39.0	222		
-5.5	34.1	208		0.002
-5.5	34.1	208		0.002
5.5	34.6	208		0.002
-6.0	32.6	194		
-7.0	26.9	165		0.003
-8.0	23.4	124		
-8.5	20.9	116		0.004
-8.5	21.5	116		0.004
-9.0	20.2	108		
-10.0	17.8	89		0.011
-10.5	18.6	81	7672	
-11.0	16.8	72		
-11.5	14.4	76		0.008
-11.5	16.0	76		0.008
-12.0	15.1	79		
-13.0	13.8	71		0.007
-13.0	13.3	71		0.007
-14.0	12.4	50		
-14.5	11.3	46		0.009
-15.0	12.5	42		
-16.0	9.7	34		0.007
-16.0	10.1	34		0.007
-17.0	10.6	30		
-17.5	12.2	29		0.033
-18.0	10.9	28	5750	
-19.0	11.3	30		0.017
-19.0	11.0	30		0.017
-20.0	11.7	37		

PLANTATION
PIPELINE:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Qc (pt) /N	Su DMT	Su N60 (bars)	Nk = 15 Su Qc (bars)
-1.0				3.184
-2.0				1.866
-2.5	1.70		4.537	2.028
-2.5	1.51		5.041	2.007
-3.0				
-4.0	2.41		2.701	1.749
-4.0	1.40		4.789	1.760
-5.0		0.997		1.659
-5.5	1.88	1.197	2.971	1.481
-5.5	1.19	1.197	4.789	1.483
5.5	1.14	1.197	5.041	1.503
-6.0		1.397		1.443
-7.0	1.35	1.109	3.511	1.236
-8.0		0.823		1.109
-8.5	1.03	0.769	3.781	0.997
-8.5	0.99	0.769	4.033	1.025
-9.0		0.715		0.968
-10.0	1.03	0.618	3.241	0.861
-10.5		0.582		0.912
-11.0		0.545		0.822
-11.5	2.23	0.538	1.182	0.708
-11.5	1.76	0.538	1.654	0.786
-12.0		0.530		0.747
-13.0	2.17	0.254	1.182	0.686
-13.0	1.31	0.254	1.890	0.661
-14.0		0.365		0.622
-14.5	1.30	0.377	1.654	0.567
-15.0		0.389		0.636
-16.0	0.80	0.343	2.431	0.489
-16.0	0.83	0.343	2.431	0.512
-17.0		0.304		0.544
-17.5	1.27	0.292	1.890	0.632
-18.0		0.281		0.566
-19.0	1.38	0.280	1.654	0.596
-19.0	1.17	0.280	1.890	0.578
-20.0		0.283		0.624

PLANTATION
PIPELINE:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	BORING #	N60	N160	Qc (pt) bar
-20.5	B-2	8	9	10.5
-20.5	B-1	9	10	10.4
-21.0				11.1
-22.0				12.8
-22.5	B-1	9	10	11.7
-23.0				10.7
-23.5	B-3	4	4	10.8
-24.0	B-2	8	9	10.6
-24.0	B-1	11	12	11.2
-25.0				11.4
-25.5	B-1	9	10	13.1
-26.0				12.9
-27.0	B-2	7	7	24.1
-27.0	B-1	14	15	25.1
-28.0	B-3	7	7	13.0
-28.5	B-1	11	12	14.4
-29.0				11.4
-29.5	B-3	11	11	12.7
-30.0	B-1	13	13	19.3
-31.0				15.2
-31.5	B-1	14	14	15.3
-31.5	B-2	14	14	15.3
-32.0				15.4
-33.0	B-1	13	13	22.8
-34.0	B-3	10	10	17.8
-34.5	B-1	14	14	18.4
-34.5	B-2	16	16	17.9
-35.0				19.0
-35.5	B-3	13	13	20.1
-36.0	B-1	14	14	18.7
-37.0				23.1
-37.5	B-1	24	23	20.1
-38.0				21.9
-39.0	B-2	20	19	21.5
-39.0	B-1	21	20	22.4
-40.0				24.3

PLANTATION
PIPELINE:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Qn (pt)) barr	ED bar	Gur kN/M^2	D50 (mm)
-20.5	12.1	41		0.025
-20.5	12.0	41		0.025
-21.0	12.7	44		
-22.0	14.5	42		
-22.5	13.2	49	5973	0.019
-23.0	12.1	57		
-23.5	12.0	55		
-24.0	11.8	53		0.026
-24.0	12.5	53		0.026
-25.0	12.4	94		
-25.5	14.3	105		0.048
-26.0	13.9	116		
-27.0	25.8	54		0.078
-27.0	26.9	54		0.078
-28.0	13.8	49		
-28.5	15.2	53	7823	0.091
-29.0	12.0	58		
-29.5	13.2	67		
-30.0	20.0	76		0.034
-31.0	15.6	86		
-31.5	15.6	76		0.045
-31.5	15.6	76		0.045
-32.0	15.6	66		
-33.0	22.8	70		0.049
-34.0	17.6	113		
-34.5	18.1	102	10836	0.045
-34.5	17.7	102		0.045
-35.0	18.7	92		
-35.5	19.6	110		
-36.0	18.2	127		0.041
-37.0	22.1	93		
-37.5	19.1	105		0.043
-38.0	20.7	116		
-39.0	20.1	142		0.041
-39.0	21.0	142		0.041
-40.0	22.5	157		

PLANTATION
PIPELINE:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Qc (pt) /N	Su DMT	Su N60 (bars)	Nk = 15 Su Qc (bars)
-20.5	1.31	0.297	1.890	0.651
-20.5	1.15	0.297	2.160	0.643
-21.0		0.311		0.689
-22.0		0.341		0.803
-22.5	1.30	0.352	2.160	0.729
-23.0		0.363		0.664
-23.5		0.331	0.945	0.666
-24.0	1.33	0.299	1.890	0.654
-24.0	1.02	0.299	2.701	0.696
-25.0		0.127		0.702
-25.5	1.45	0.169	2.160	0.817
-26.0		0.210		0.801
-27.0	3.44	0.310	1.654	1.547
-27.0	1.79	0.310	3.511	1.616
-28.0		0.309	1.654	0.808
-28.5	1.31	0.308	2.701	0.902
-29.0		0.306		0.700
-29.5		0.377	2.701	0.785
-30.0	1.48	0.448	3.241	1.223
-31.0		0.419		0.950
-31.5	1.10	0.406	3.511	0.959
-31.5	1.10	0.406	3.511	0.959
-32.0		0.392		0.964
-33.0	1.75	0.411	3.241	1.453
-34.0		0.251	2.431	1.118
-34.5	1.31	0.364	3.511	1.155
-34.5	1.12	0.364	4.033	1.127
-35.0		0.476		1.199
-35.5		0.537	3.241	1.272
-36.0	1.34	0.597	3.511	1.178
-37.0		0.465		1.468
-37.5	0.84	0.535	6.049	1.264
-38.0		0.605		1.384
-39.0	1.07	0.401	5.041	1.355
-39.0	1.07	0.401	5.293	1.416
-40.0		0.334		1.544

PLANTATION
PIPELINE:
IN-SITU TEST
DATA SUMMARY

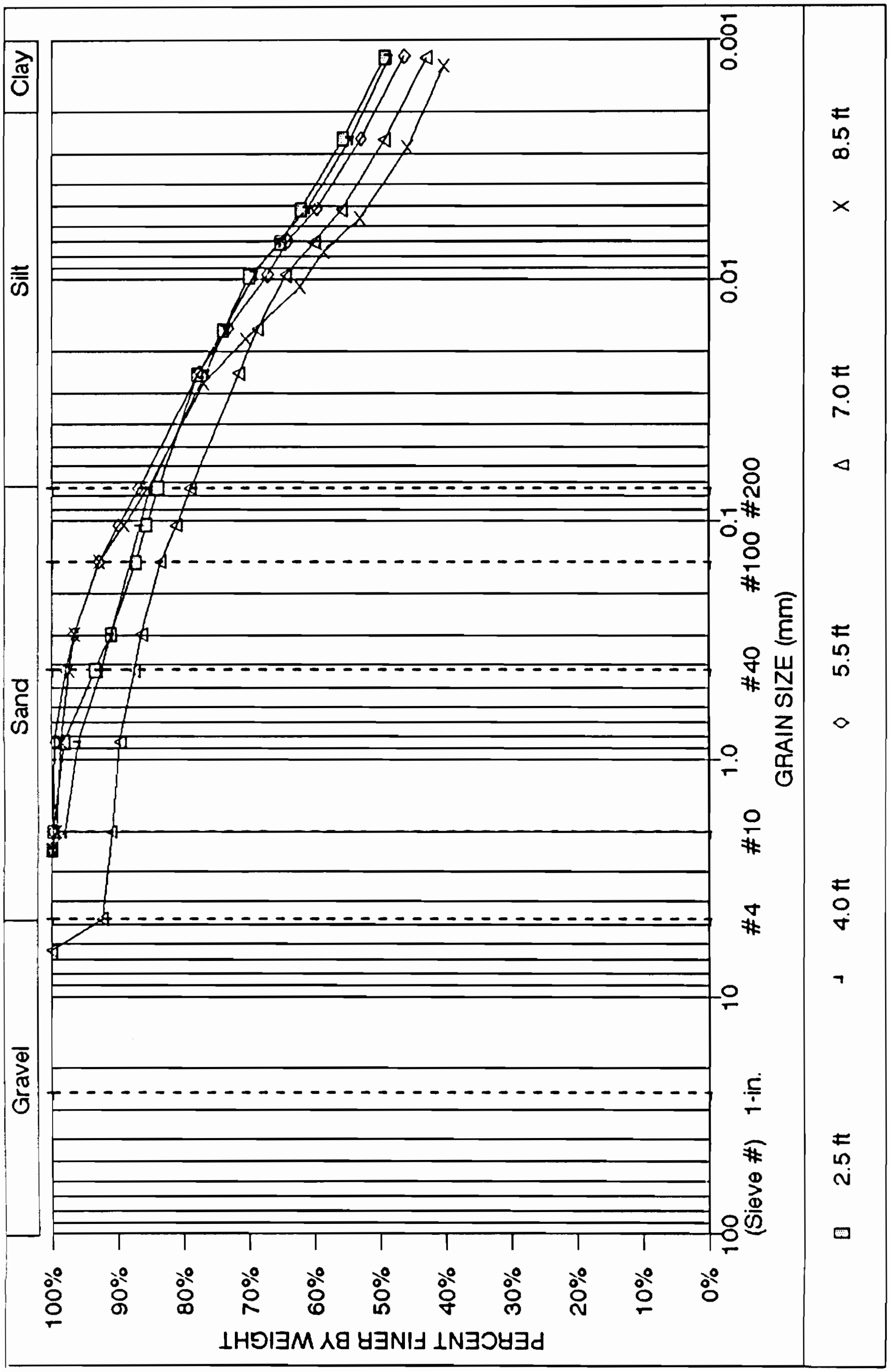
DEPTH ft.	BORING #	N60	N160	Qc (pt) bar
-41.0				27.1
-42.0				51.0
-43.0				30.3
-44.0				24.7
-45.0				28.4

PLANTATION
PIPELINE:
IN-SITU TEST
DATA SUMMARY

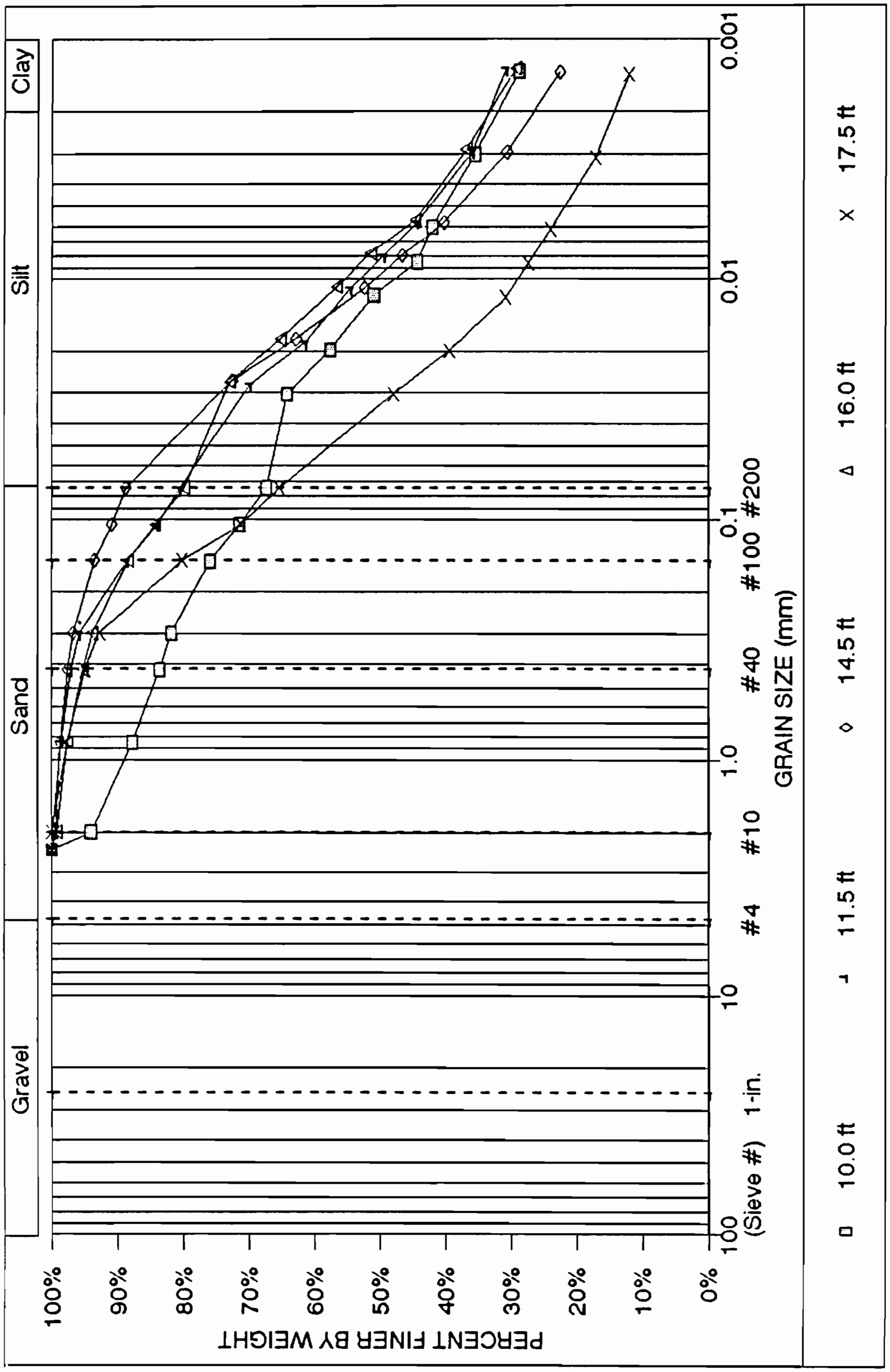
DEPTH ft.	Qn (pt)) barr	ED bar	Gur kN/M^2	D50 (mm)
-41.0	24.8	149		
-42.0	46.2	136		
-43.0	27.2	194		
-44.0	21.9	198		
-45.0	24.9	201		

PLANTATION
PIPELINE:
IN-SITU TEST
DATA SUMMARY

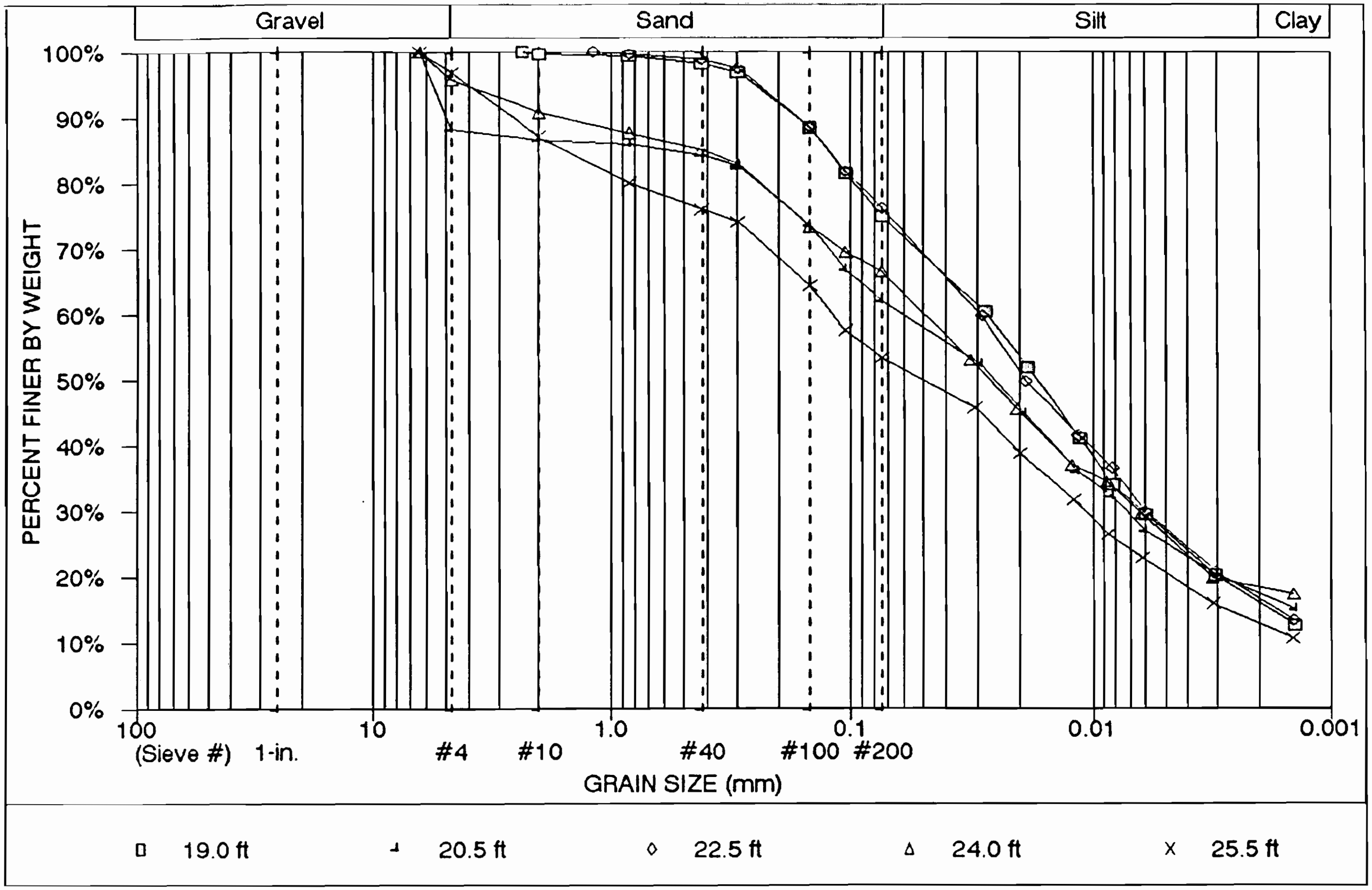
DEPTH ft.	Qc (pt) /N	Su DMT	Su N60 (bars)	Nk = 15 Su Qc (bars)
-41.0		0.724		1.728
-42.0		0.290		3.321
-43.0		0.977		1.941
-44.0		0.273		1.564
-45.0		0.333		1.810



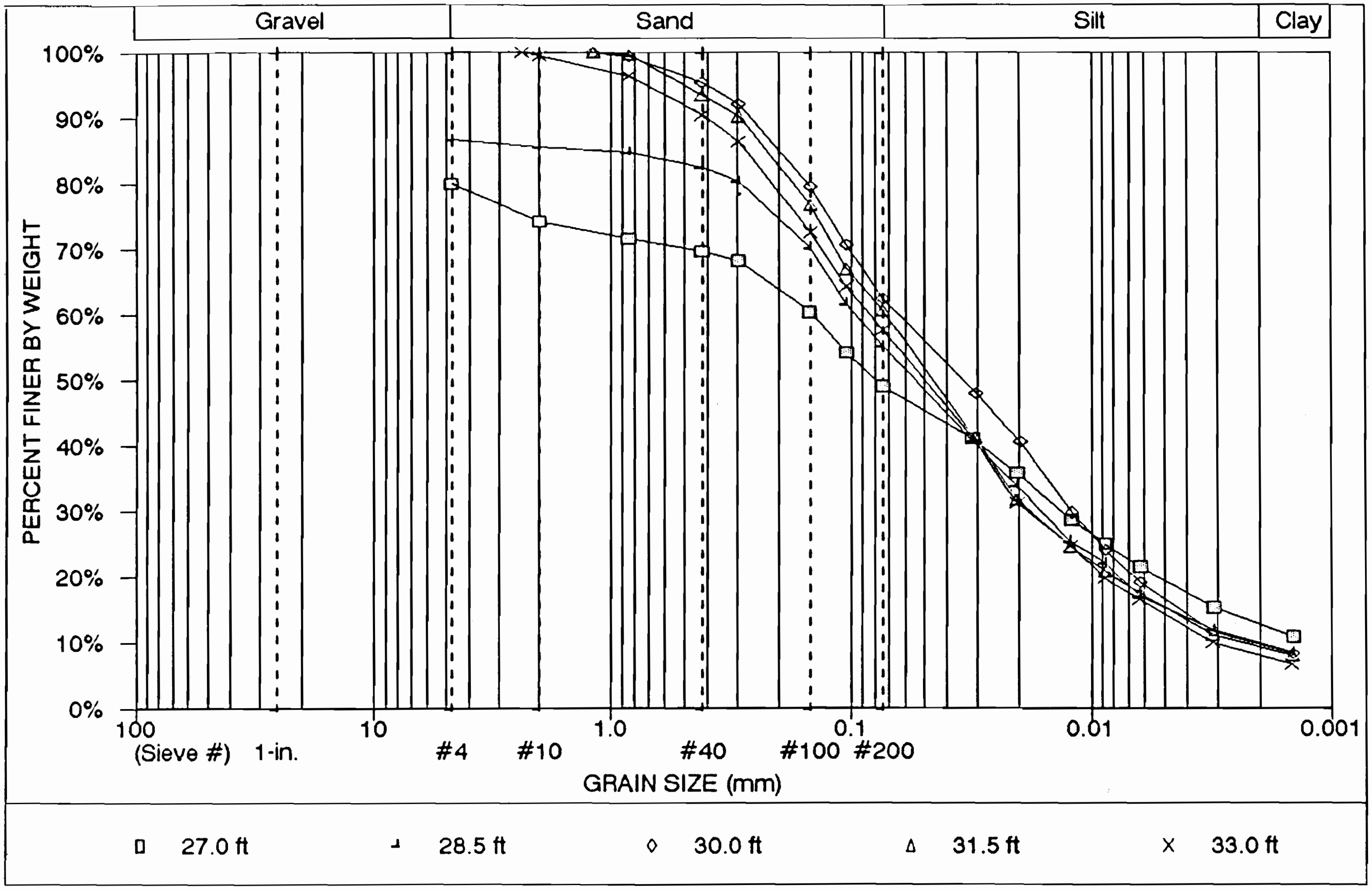
Plantation Pipeline: Grain Size Data



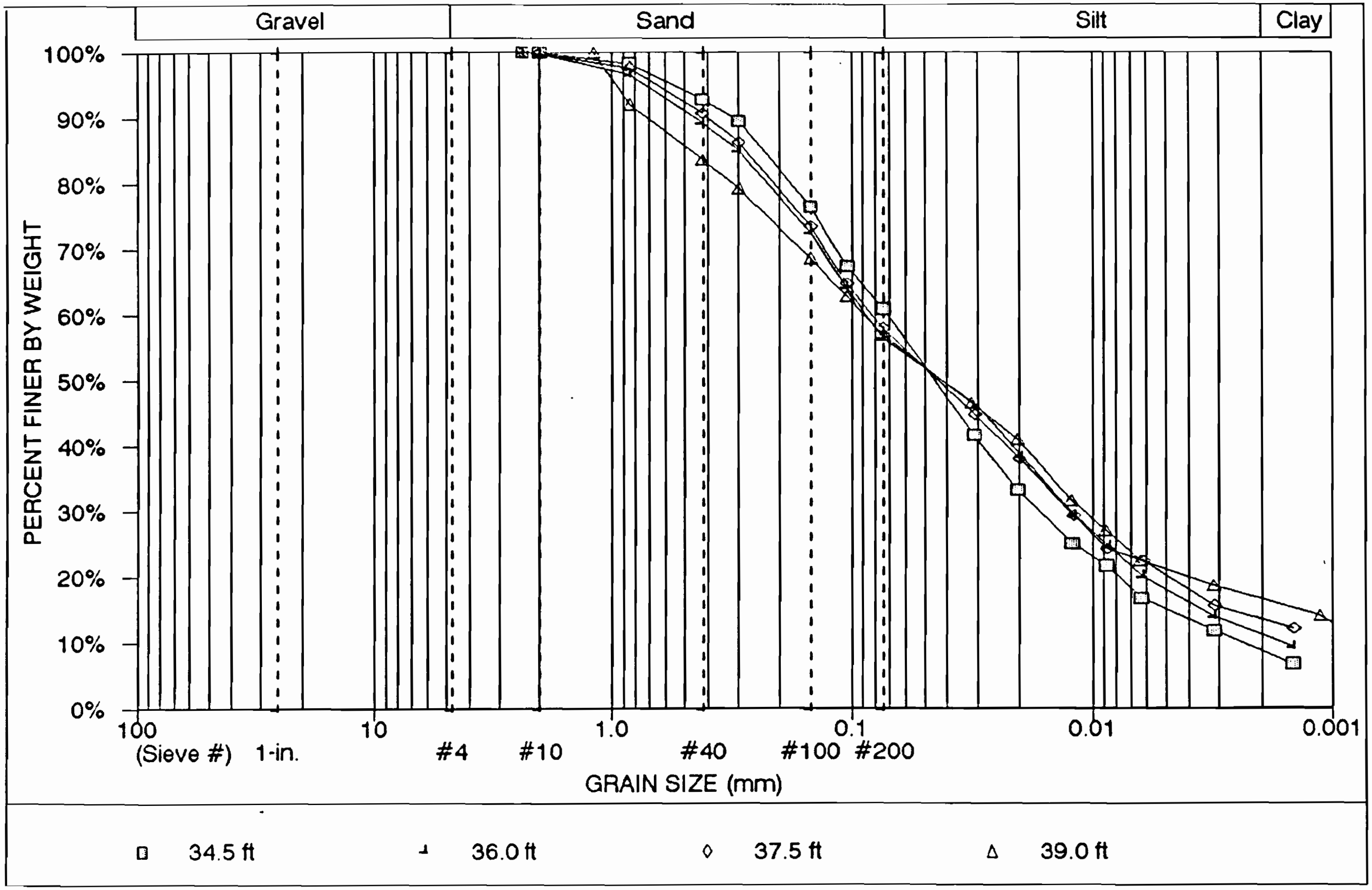
Plantation Pipeline: Grain Size Data



Plantation Pipeline: Grain Size Data



Plantation Pipeline: Grain Size Data



Plantation Pipeline: Grain Size Data

PLANTATION
PIPELINE:
LAB DATA
SUMMARY
FROM B-1.

DEPTH (ft)	SPECIFIC GRAVITY	D60 (mm)	D50 (mm)	D10 (mm)	Cu
-2.5	2.778		0.001		
-4.0	2.778		0.001		
-5.5	2.778		0.002		
-7.0	2.778		0.003		
-8.5	2.778		0.004		
-10.0	2.778		0.011		
-11.5	2.778		0.008		
-13.0	2.778		0.007		
-14.5	2.778		0.009		
-16.0	2.778		0.007		
-17.5	2.778		0.033		
-19.0	2.778		0.017		
-20.5	2.778		0.025		
-22.5	2.778		0.019		
-24.0	2.778		0.026		
-25.5	2.778	0.117	0.048	0.001	90
-27.0	2.778	0.144	0.078	0.001	114
-28.5	2.778	0.091	0.054	0.002	45
-30.0	2.778	0.063	0.034	0.002	29
-31.5	2.778	0.071	0.045	0.002	29
-33.0	2.778	0.083	0.049	0.003	26
-34.5	2.778	0.070	0.045	0.002	29
-36.0	2.778	0.086	0.041	0.002	52
-37.5	2.778		0.043		
-39.0	2.778		0.041		

PLANTATION
PIPELINE:
LAB DATA
SUMMARY
FROM B-1.

DEPTH (ft)	%-200	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	MOISTURE CONTENT %
-2.5	83.8%	45.6%	28.4%	17.2%	37.4%
-4.0	85.1%	81.2%	49.2%	32.0%	40.3%
-5.5	86.7%	94.6%	51.8%	42.8%	46.1%
-7.0	79.1%	74.8%	51.4%	23.4%	52.4%
-8.5	85.0%	87.1%	57.2%	29.9%	45.9%
-10.0	66.8%	73.2%	62.7%	10.5%	75.3%
-11.5	80.4%	77.3%	57.5%	19.8%	60.0%
-13.0	87.5%	78.3%	61.6%	16.7%	67.6%
-14.5	88.7%	66.9%	59.1%	7.8%	74.7%
-16.0	79.5%	71.1%	54.6%	16.5%	72.8%
-17.5	65.1%	NP			62.4%
-19.0	74.7%	64.7%	55.0%	9.7%	63.3%
-20.5	71.4%	INSUFFICIENT SAMPLE			62.4%
-22.5	76.0%	62.9%	52.2%	10.7%	62.6%
-24.0	78.2%	INSUFFICIENT SAMPLE			56.6%
-25.5	69.1%	51.5%	49.7%	1.8%	49.0%
-27.0	74.6%	54.7%	42.8%	11.9%	59.0%
-28.5	70.4%	53.6%	46.7%	6.9%	55.0%
-30.0	62.6%	49.4%	41.5%	7.9%	51.0%
-31.5	61.0%	47.8%	42.6%	5.2%	47.8%
-33.0	57.9%	NP			45.4%
-34.5	61.2%	43.5%	39.4%	4.1%	45.3%
-36.0	56.5%	NP			37.0%
-37.5	58.3%	NP			35.3%
-39.0	57.1%	NP			36.6%

APPENDIX H

WINTERPOCK TAP

WINTERPOCK TAP: FIELD BORING LOGS

BORING B-1
CONTINUOUS SAMPLING TO 36 ft.
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 5/03/89

WATER TABLE = 16.0 FT.

DEPTH IN FT.		BLOW COUNT	DESCRIPTION
from	to	blows per 6 in.	
1.5-	3.0	3 - 8 / 14	very stiff orange fine sandy silt w/ tr. mica
3.0-	4.5	6 - 10 / 13	same, grading redder
4.5-	6.0	7 - 10 / 15	dense red-white clayey fine sand to 5'-6", below 5'-6", same as above
6.0-	7.5	5 - 7 / 11	very stiff orange clayey silt w/mica
7.5-	9.0	4 - 6 / 14	very stiff orange clayey silt w/mica, evident structure
9.0-	10.5	3 - 9 / 12	same to 10', then, yellow brown fine silty sand w/mica
10.5-	12.0	4 - 7 / 9	very stiff brown & white med to fine sandy silt
12.0-	13.5	5 - 17 / 16	dense brown green sl. silty med. to coarse sand w/ white spots
13.5-	15.0	10 - 10 / 11	same, medium
15.0-	16.5	6 - 7 / 8	same, medium, w/brown nodules: layer changed @ 16.0 ft.
16.5-	18.0	3 - 7 / 13	same, medium, change @ 17'-9" back to brown green sl. silty med. coarse sand
18.0-	19.5	6 - 9 / 24	same, dense, with only fine sand
19.5-	21.0	9 - 8 / 12	same, @ 20' change to very stiff yellow green silt w/ mica
21.5-	23.0	9 - 20 / 24	same, change @ 22' to dense brown & white med. to coarse sand
23.0-	24.5	7 - 4 / 7	stiff green brown fine sandy silt w/ mica
24.5-	26.0	6 - 8 / 14	same, very stiff
26.0-	27.5	3 - 10 / 13	same, very stiff
27.5-	29.0	6 - 13 / 24	hard green brown fine sandy silt w/ mica & black stripes
29.0-	30.5	4 - 9 / 17	same, very stiff
30.5-	32.0	5 - 12 / 25	same, hard

WINTERPOCK TAP: FIELD BORING LOGS

BORING B-1
CONTINUOUS SAMPLING TO 36 ft.
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 5/03/89

WATER TABLE = 16.0 FT.

DEPTH IN FT.		BLOW COUNT	DESCRIPTION
from	to	blows per 6 in.	
32.0 -	33.5	17 - 24 / 28	same, hard, grading browner
33.5 -	35.0	8 - 16 / 25	same, hard
35.0 -	36.5	9 - 18 /50/5	same, hard

-END OF BORING-

WINTERPOCK TAP: FIELD BORING LOGS

BORING B-2
CONTINUOUS SAMPLING TO 45 FT.
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 5/03-04/89

WATER TABLE = 16.0 FT.

DEPTH IN FT. from	to	BLOW COUNT blows per 6 in.	DESCRIPTION
1.5-	3.0	5 - 6 / 10	very stiff orange clay w/ tr fine sand
3.0-	4.5	4 - 7 / 14	same, very stiff
4.5-	6.0	5 - 8 / 11	medium brown orange fine sandy silt w/mica
6.0-	7.5	4 - 7 / 8	same, medium
7.5-	9.0	4 - 6 / 9	stiff white sandy silt
9.0-	10.5	4 - 6 / 9	same, stiff
10.5-	12.0	8 - 8 / 7	same, stiff
12.0-	13.5	3 - 5 / 6	stiff orange silt w/ tr mica w/ black specs
13.5-	15.0	3 - 4 / 7	stiff orange fine sandy silty clay
15.0-	16.5	4 - 4 / 6	stiff orange fine sandy silt w/ mica
16.5-	18.0	4 - 4 / 6	same, stiff
18.0-	20.0	* - /	---shelby tube sample---
20.0-	21.5	4 - 6 / 10	very stiff yellow green fine sandy silt w/ mica & black stripes
21.5-	23.5	* - /	---shelby tube sample---
23.5-	25.0	4 - 5 / 8	same, stiff, more mica
25.5-	27.5	* - /	---shelby tube sample---
27.5-	29.0	3 - 5 / 5	stiff dark green & white fine sandy silt w/ black stripes
29.0-	30.5	2 - 5 / 8	stiff green brown fine sandy silt w/ mica
30.5-	32.0	3 - 5 / 9	same,stiff
32.0-	33.5	4 - 6 / 12	same, very stiff

WINTERPOCK TAP: FIELD BORING LOGS

BORING B-2
CONTINUOUS SAMPLING TO 45 FT.
SAMPLES TAKEN WITH 140# HAMMER AND 2" SAMPLER
DRILLED 5/03-04/89

WATER TABLE = 16.0 FT.

DEPTH IN FT.		BLOW COUNT	DESCRIPTION
from	to	blows per 6 in.	
33.5 -	35.0	5 - 10 / 11	same, very stiff
35.0 -	36.5	6 - 10 / 14	same, very stiff
36.5 -	38.0	5 - 9 / 13	same, very stiff
38.0 -	39.5	6 - 11 / 16	same, very stiff
39.5 -	41.0	7 - 12 / 15	same, very stiff
41.5 -	43.0	5 - 8 / 16	same, very stiff
43.0 -	44.5	8 - 12 / 25	same, hard

---END OF BORING---

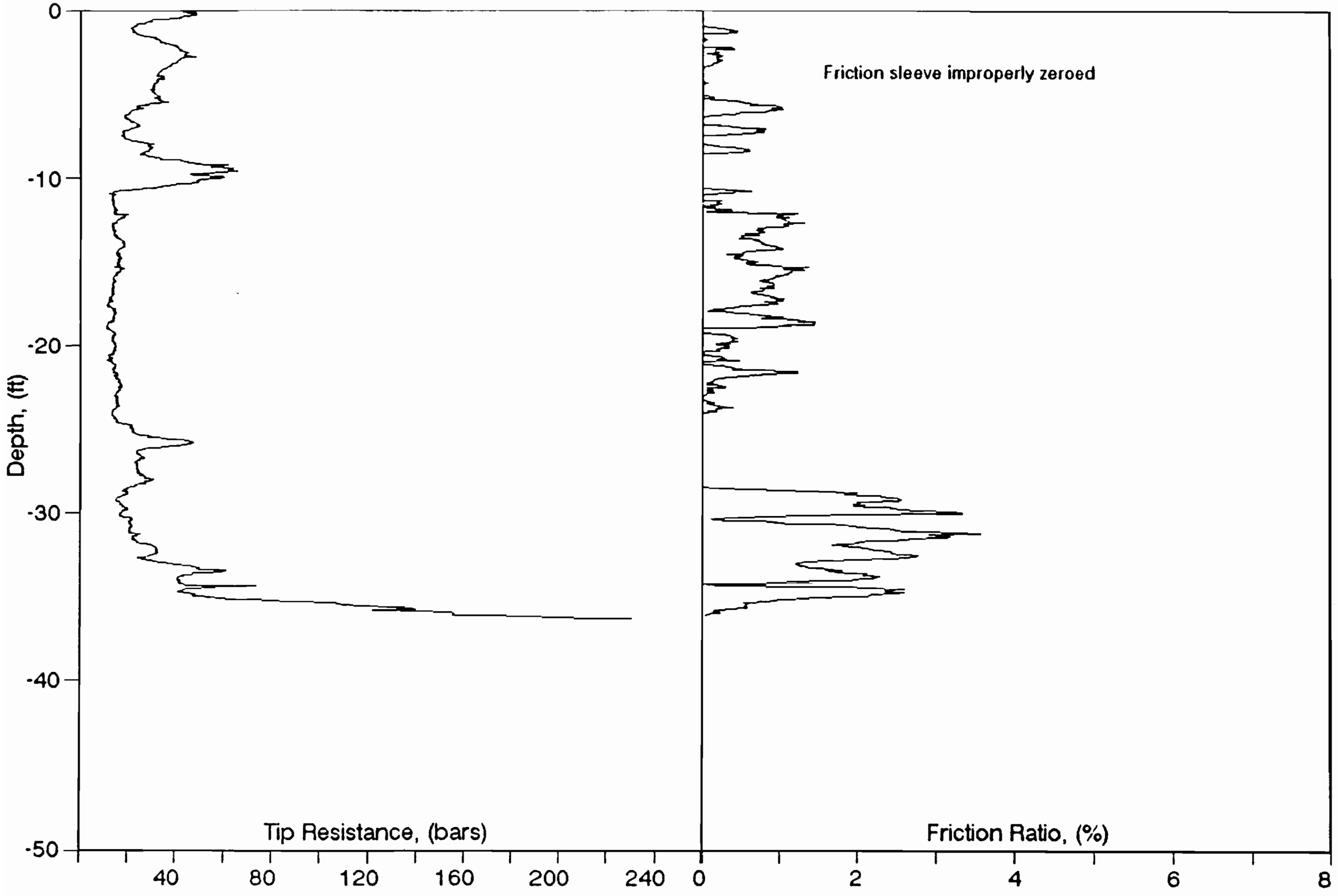
WINTERPOCK TAP: FIELD BORING LOGS

BORING B-3
SAMPLING AND PRESSUREMETER TESTING TO 35 FT.
SAMPLES TAKEN WITH 300# HAMMER AND 3" SAMPLER
DRILLED 9/6/ TO 9/7/89

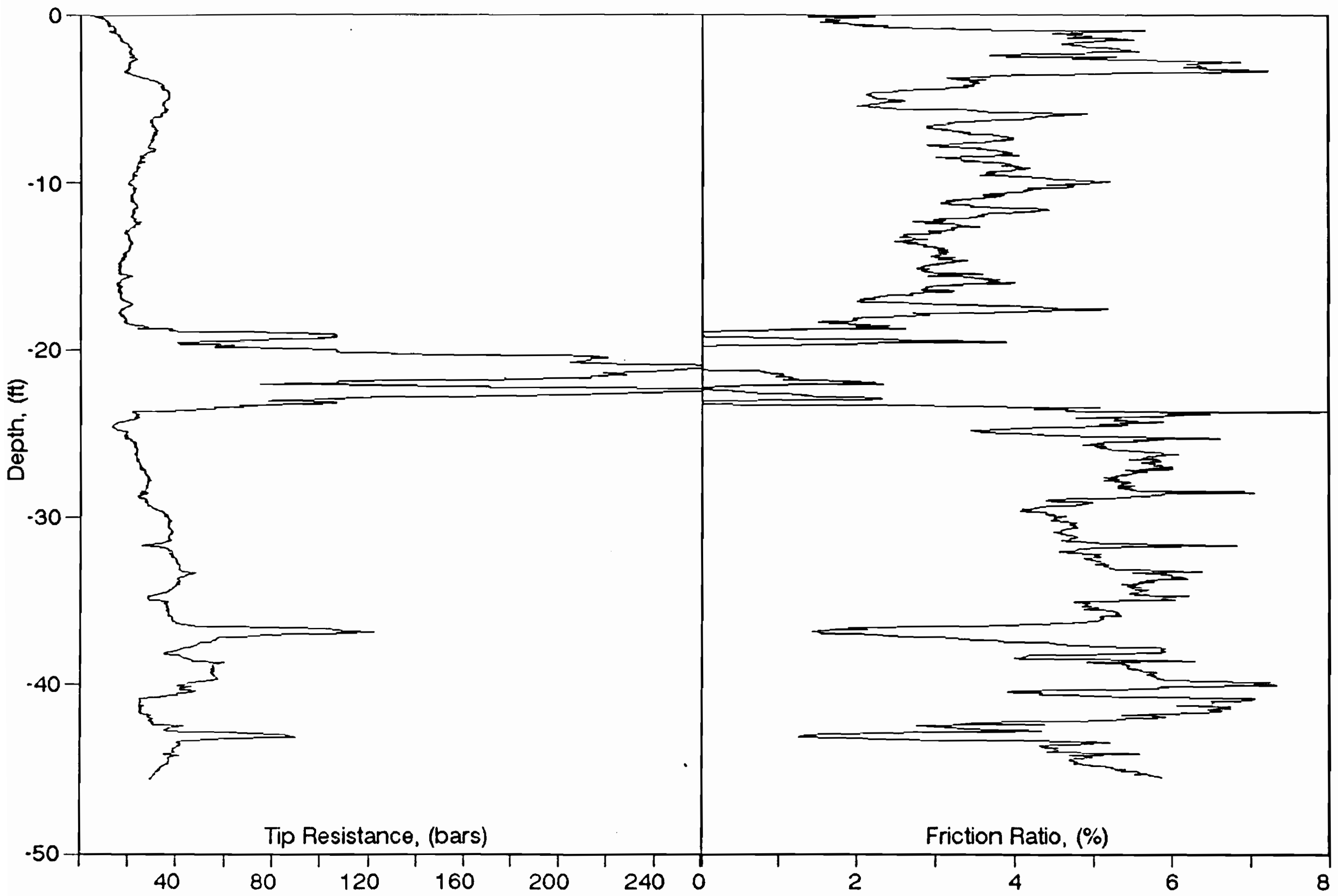
WATER TABLE = 16.0 FT.

DEPTH IN FT.		BLOW COUNT	DESCRIPTION
from	to	blows per 6 in.	
3.0 -	4.5	3 - 5 / 7	stiff red clayey silt w/ orange stripes (saprolite)
4.5 -	6.0	3 - 7 / 9	same, some gravel @ 5'0"
9.0 -	10.5	4 - 5 / 7	stiff red clayey silt w/ tan stripes
10.5 -	12.0	8 - 8 / 8	same
15.0 -	16.5	3 - 5 / 5	stiff red-green clayey silt w/ much mica
16.5 -	18.0	4 - 5 / 6	same
20.5 -	22.0	2 - 3 / 4	medium brown-green w/ black nodules: decomposed granite
22.0 -	23.5	4 - 5 / 5	same
27.0 -	28.5	3 - 4 / 8	stiff brown-green sandy silt w/black nodules: decomposed granite
28.5 -	30.0	3 - 4 / 6	same w/ 1" gravel (soft lense above gravel)
33.0 -	34.5	3 - 6 / 10	very stiff brown-green sandy silt w/black nodules: decomposed granite
34.5 -	36.0	7 - 12 / 15	same

---END OF BORING---



Winterpock Tap: Cone Test WPKC-1 05/02/89



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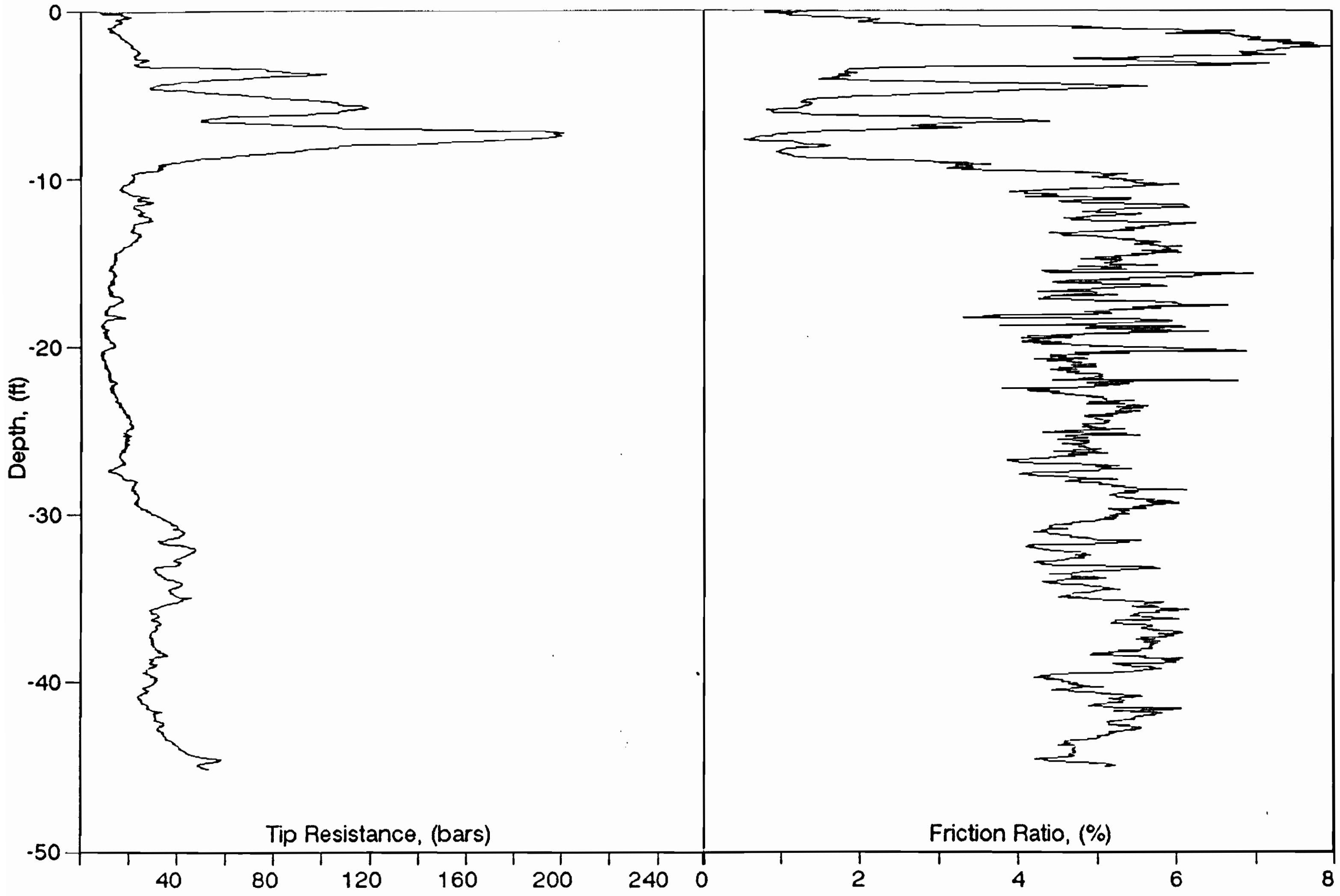

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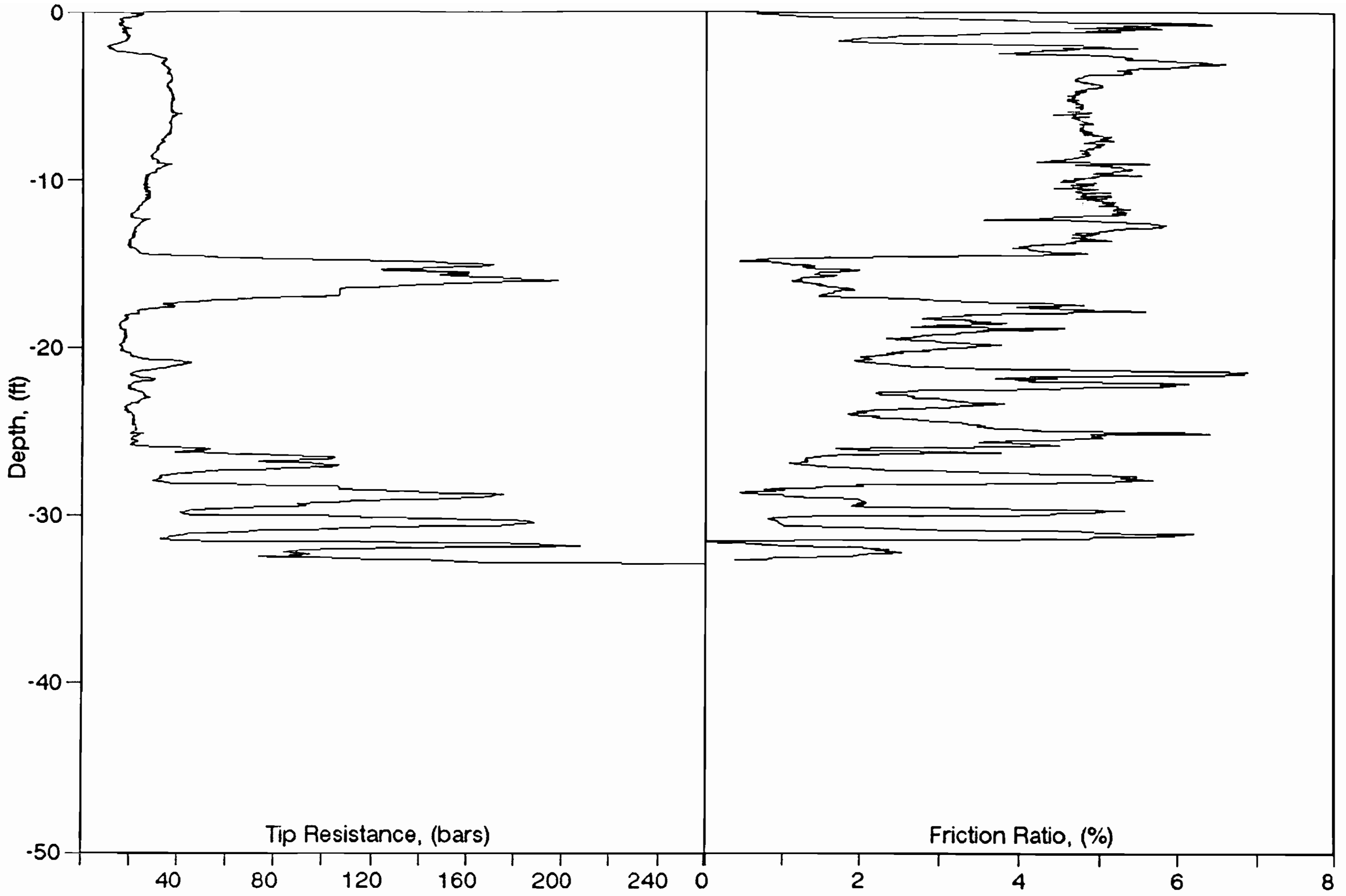

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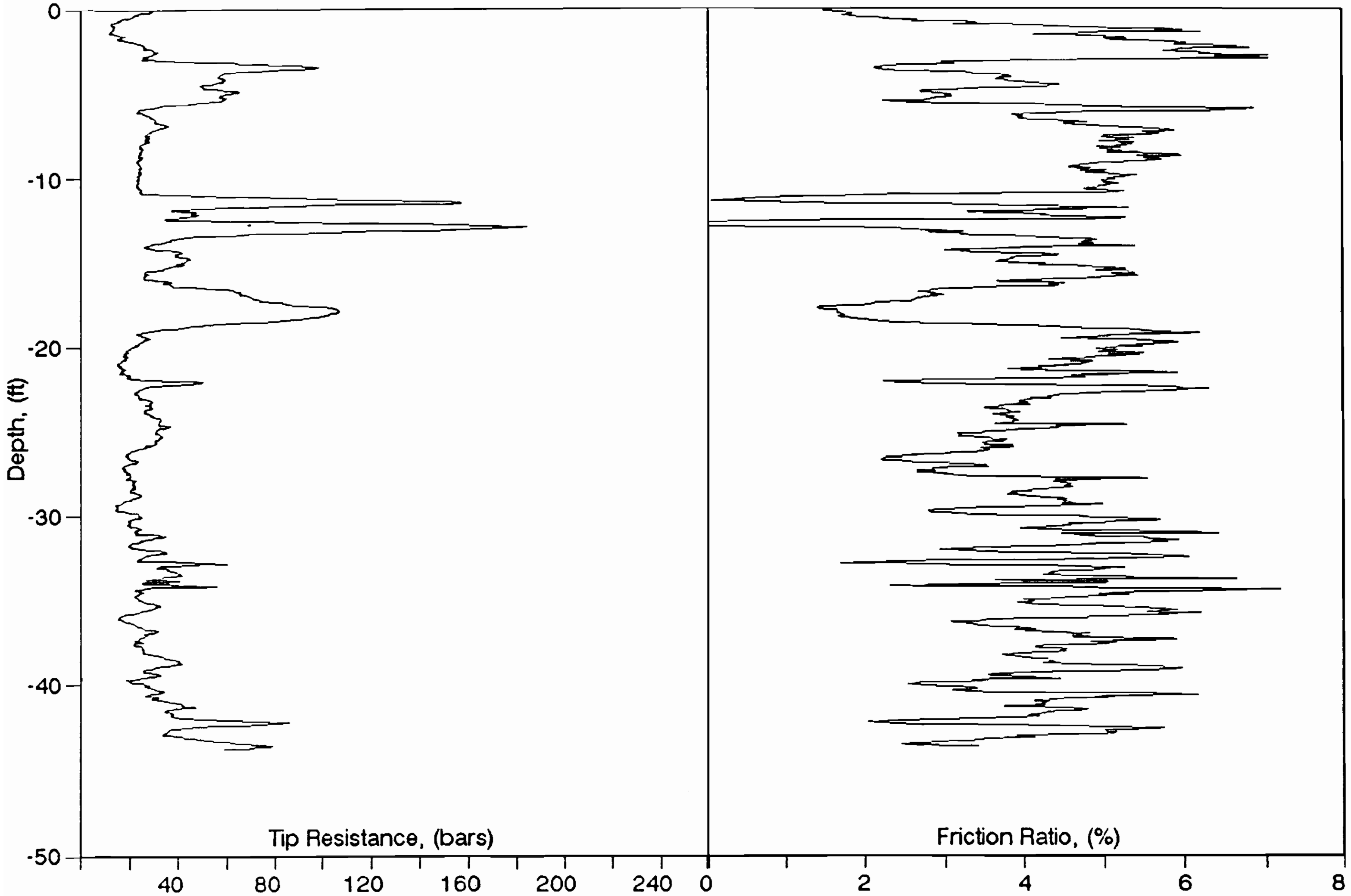

Winterpock Tap: Cone Test WPKC-5 09/01/89

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Virginia Polytechnic Institute                                          TEST NO. WPK D-1
FILE NAME:      Dilatometer Test
FILE NUMBER:    14:07:00

RECORD OF DILATOMETER TEST NO. WPK D-1
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GEO,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GEO,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GEO,JUNE 82)

     LOCATION: WINTERPOCK TAP
     PERFORMED - DATE:  09/05/89
                   BY:  MULLEN

     CALIBRATION INFORMATION:
     DELTA A =  .21 BARS   DELTA B   =  .21 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 4.90 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM    ROD WT.=  .00 KG/M   DELTA/PHI=  .50      BLADE T=15.00 MM

     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3

    Z  THRUST    A      B      ED    ID    KD     UO   GAMMA    SV     PC   OCR     KO     CU   PHI      M      SOIL TYPE
  (M)   (KG)  (BAR)  (BAR)  (BAR)               (BAR) (T/M3) (BAR)  (BAR)               (BAR) (DEG)  (BAR)
***** ****** *****  *****  ***** ***** *****  ****** ****** ****** ***** *****  *****  ***** *****  ******  ************

   .30   238.  4.09  10.55   220.  1.59 67.76   .000  1.800   .059  ***** *****   8.78          9.3   948.8   SANDY SILT
   .61   329.  3.49   8.52   168.  1.40 30.50   .000  1.800   .114   33.4 293.7   4.14         19.9   597.2   SANDY SILT
   .91         6.74  13.05   215.   .93 39.39   .000  1.950   .169   17.7 104.5   4.05                815.1      SILT
  1.22         9.60  17.95   289.   .88 41.24   .000  1.950   .228   25.6 112.3   4.15  2.207        1109.9   CLAYEY SILT
  1.52         9.95  18.65   302.   .89 34.11   .000  1.950   .286   23.9  83.5   3.74  2.179        1104.7   CLAYEY SILT
  1.83         8.52  16.55   277.   .96 24.20   .000  1.950   .345   16.9  48.9   3.10                925.2      SILT
  2.13         8.08  16.35   286.  1.04 19.62   .000  1.950   .402   14.2  35.3   2.75                897.6      SILT
  2.44         7.40  15.15   267.  1.06 15.69   .000  1.950   .462   11.5  24.9   2.41                781.5      SILT
  2.74         6.71  13.00   214.   .93 12.76   .000  1.950   .519    9.4  18.0   2.14                584.1      SILT
  3.05         5.71  11.05   179.   .91  9.85   .000  1.800   .576    6.9  12.0   1.82                445.4      SILT
  3.35         5.30   9.75   147.   .80  8.44   .000  1.800   .629    5.9   9.4   1.65   .837         341.8   CLAYEY SILT
  3.66         4.76   9.21   147.   .89  6.97   .000  1.800   .684    4.8   7.0   1.46   .717         313.8   CLAYEY SILT
  3.96   276.  2.76   6.64   126.  1.30  3.80   .000  1.800   .737    4.0   5.4   1.04         19.0   195.5   SANDY SILT
  4.27   283.  3.18   8.82   190.  1.75  3.95   .000  1.800   .792    4.9   6.1   1.08         17.9   307.8   SANDY SILT
  4.57         7.63  13.20   188.   .71  8.95   .000  1.950   .847    8.8  10.4   1.72  1.213         448.0   CLAYEY SILT
  4.88   822.  4.07  13.25   319.  2.39  4.24   .000  1.900   .905    3.5   3.8    .83         31.0   549.5   SILTY SAND
  5.18   511.  7.22  19.40   428.  1.81  7.29   .027  2.000   .935   19.6  21.0   1.50         17.5   942.8   SILTY SAND
  5.49         4.27   8.16   126.   .86  4.41   .058  1.800   .963    3.3   3.4   1.06   .570         211.8   CLAYEY SILT
  5.79         3.20   6.04    88.   .79  3.25   .087  1.700   .985    2.1   2.1    .84   .398         120.1   CLAYEY SILT
  6.10         3.16   5.80    81.   .74  3.12   .118  1.700  1.006    2.0   2.0    .81   .386         106.6   CLAYEY SILT
  6.40         3.18   5.60    73.   .67  3.06   .147  1.700  1.027    2.0   1.9    .80   .385          94.1   CLAYEY SILT
  6.71         3.16   5.29    62.   .58  2.96   .178  1.700  1.048    1.9   1.8    .78   .377          78.1   SILTY CLAY
  7.01         3.08   5.40    69.   .67  2.80   .207  1.700  1.069    1.8   1.7    .74   .357          83.0   CLAYEY SILT
  7.32         3.14   6.78   117.  1.15  2.70   .237  1.800  1.091    1.7   1.6    .72                141.5      SILT
  7.62   298.  6.03  13.75   266.  1.37  5.02   .267  1.950  1.117   22.4  20.1   1.34         11.8   486.2   SANDY SILT
  7.92         3.53   6.02    75.   .65  2.93   .296  1.700  1.142    2.1   1.8    .77   .404          93.9   CLAYEY SILT
  8.23         3.46   5.76    68.   .61  2.79   .327  1.700  1.163    2.0   1.7    .74   .389          81.8   CLAYEY SILT
  8.53         6.30  11.25   165.   .80  5.00   .356  1.800  1.185    5.0   4.2   1.16   .820         297.0   CLAYEY SILT
  8.84         4.60   7.67    97.   .65  3.55   .387  1.800  1.209    3.0   2.4    .90   .545         139.2   CLAYEY SILT
  9.14         5.42   9.10   119.   .68  4.10   .416  1.800  1.233    3.8   3.1   1.00   .665         188.9   CLAYEY SILT
  9.45         5.79   9.75   129.   .69  4.28   .447  1.800  1.257    4.1   3.3   1.04   .715         210.8   CLAYEY SILT
  9.75         7.16  12.40   176.   .76  5.19   .476  1.950  1.283    5.7   4.4   1.19   .929         322.1   CLAYEY SILT
 10.06         7.91  14.00   207.   .81  5.59   .506  1.950  1.312    6.5   5.0   1.26  1.042         394.9   CLAYEY SILT
 10.36         4.10   7.79   119.   .95  2.70   .536  1.800  1.338    2.1   1.6    .72                141.5      SILT
 10.67         7.00  12.35   180.   .81  4.69   .566  1.950  1.364    5.2   3.8   1.11   .871         311.5   CLAYEY SILT
 10.97         8.56  16.30   267.   .98  5.61   .596  1.950  1.392    7.0   5.0   1.26                512.6      SILT
 11.28         7.52  14.15   226.   .96  4.78   .626  1.950  1.421    5.5   3.9   1.12                398.4      SILT
 11.58         6.75  13.20   220.  1.05  4.14   .656  1.950  1.449    4.5   3.1   1.01                356.6      SILT
 11.89        10.45  19.15   302.   .91  6.47   .686  1.950  1.478    9.2   6.2   1.39                622.2      SILT
 12.19        12.20  21.40   320.   .82  7.46   .715  2.100  1.508   11.8   7.8   1.53  1.721         705.2   CLAYEY SILT
 12.50         9.60  15.85   212.   .70  5.70   .746  1.950  1.539    7.9   5.1   1.27  1.254         409.4   CLAYEY SILT
 12.80         5.50   8.92   109.   .66  3.06   .775  1.800  1.565    3.0   1.9    .80   .585         141.0   CLAYEY SILT
 13.11         4.60   7.78   101.   .75  2.43   .806  1.800  1.589    2.2   1.4    .66   .447         107.1   CLAYEY SILT
 13.21   631.  3.62   8.31   156.  1.60  1.75   .816  1.800  1.597    2.7   1.7    .65         27.2   132.2   SANDY SILT
END OF SOUNDING


TEST NO. WPK D-1               (CONTINUED)                                                       PAGE  1
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Virginia Polytechnic Institute                                                     TEST NO. WPK D-2
FILE NAME:     Dilatometer Test
FILE NUMBER:   12:50:00

RECORD OF DILATOMETER TEST NO. WPK D-2
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GED,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

     LOCATION: WINTERPOCK TAP
     PERFORMED - DATE:  09/05/89
                   BY:  MULLEN

     CALIBRATION INFORMATION:
     DELTA A =  .21 BARS   DELTA B    =  .21 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 4.90 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50     BLADE T=15.00 MM

     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3

  Z   THRUST   A      B     ED    ID    KD     UO    GAMMA   SV     PC   OCR    KO     CU   PHI     M     SOIL TYPE
 (M)   (KG)  (BAR) (BAR) (BAR)              (BAR) (T/M3) (BAR)  (BAR)               (BAR) (DEG) (BAR)
***** ****** ***** ***** ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** ***** ******  ************

  .30   238.  2.14  6.77  153.  2.07 36.26   .000  1.800   .059   17.2 290.9  4.75         22.3  570.6  SILTY SAND
  .61   329.  3.20  7.41  138.  1.24 28.31   .000  1.800   .114   23.5 206.2  3.84         21.4  481.3  SANDY SILT
  .91         6.70 14.00  251.  1.10 38.86   .000  1.950   .169   17.3 102.3  4.02               948.8     SILT
 1.22   652.  6.22 15.50  323.  1.55 26.23   .000  1.950   .228   35.1 153.6  3.57         24.1 1101.7  SANDY SILT
 1.52         7.40 14.40  240.   .95 25.49   .000  1.950   .286   15.1  53.0  3.19               811.7     SILT
 1.83         7.48 14.45  239.   .93 21.34   .000  1.950   .345   13.9  40.2  2.88               767.9     SILT
 2.13         6.87 14.05  246.  1.05 16.75   .000  1.950   .402   11.1  27.5  2.51               736.1     SILT
 2.44         6.09 11.75  191.   .91 13.08   .000  1.950   .462    8.6  18.7  2.17               525.8     SILT
 2.74         6.07 11.20  172.   .82 11.64   .000  1.950   .519    8.1  15.6  2.02  1.033        453.7  CLAYEY SILT
 3.05         6.09 11.60  185.   .88 10.45   .000  1.950   .578    7.6  13.2  1.89  1.005        471.4  CLAYEY SILT
 3.35         5.33 10.15  160.   .87  8.40   .000  1.800   .634    5.9   9.4  1.65   .838        372.5  CLAYEY SILT
 3.66         5.10  9.95  161.   .91  7.39   .000  1.800   .688    5.3   7.7  1.52               354.5     SILT
 3.96         5.25 10.20  165.   .91  7.06   .000  1.800   .741    5.3   7.2  1.47               354.9     SILT
 4.27         4.74  8.71  129.   .78  5.99   .000  1.800   .796    4.4   5.5  1.32   .691        256.3  CLAYEY SILT
 4.57         4.43  8.45  131.   .85  5.25   .000  1.800   .849    3.8   4.5  1.20   .625        242.7  CLAYEY SILT
 4.88         5.48 11.60  208.  1.11  5.98   .000  1.800   .904    5.0   5.5  1.32               413.3     SILT
 5.18         4.32  7.38   96.   .63  4.70   .027  1.800   .929    3.5   3.8  1.11   .595        166.2  CLAYEY SILT
 5.49         5.30 10.45  172.   .95  5.47   .058  1.800   .954    4.6   4.8  1.24               326.6     SILT
 5.79   414. 10.70 27.40  593.  1.71 10.19   .087  2.100   .982  279.3 284.5  2.00          9.6 1493.7  SANDY SILT
END OF SOUNDING
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Virginia Polytechnic Institute                                                    TEST NO. WPK D-3
FILE NAME:     Dilatometer Test
FILE NUMBER:   09:25:00

RECORD OF DILATOMETER TEST NO. WPK D-3
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GEO,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
PHI ANGLE CALCULATION BASED ON DURGUNOGLU AND MITCHELL (ASCE,RALEIGH CONF,JUNE 75)
PHI ANGLE NORMALIZED TO 2.72 BARS USING BALIGH'S EXPRESSION (ASCE,J-GEO,NOV 76)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GEO,JUNE 82)

     LOCATION: WINTERPOCK TAP
     PERFORMED - DATE:  09/05/89
                   BY:  MULLEN


     CALIBRATION INFORMATION:
     DELTA A =  .21 BARS   DELTA B    =  .24 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 4.90 M
     ROD DIA.= 3.56 CM     FR.RED.DIA.= 1.91 CM     ROD WT.=  .00 KG/M   DELTA/PHI=  .50     BLADE T=15.00 MM

     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI         ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3

    Z THRUST      A      B     ED     ID     KD      UO  GAMMA     SV     PC    OCR     KO     CU    PHI       M  SOIL TYPE
  (M)   (KG)  (BAR)  (BAR)  (BAR)                 (BAR) (T/M3)  (BAR)  (BAR)                 (BAR)  (DEG)   (BAR)
***** ******  *****  *****  *****  *****  *****  ****** ****** ******  *****  *****  *****  *****  *****  ******  ************

  .30   261.   3.57  11.20   262.   2.20  57.98    .000  1.900   .059  207.1  *****   7.52          14.3  1089.3  SILTY SAND
  .61   329.   3.69   8.44   157.   1.23  31.97    .000  1.800   .115   44.8  388.8   4.34          18.7   564.0  SANDY SILT
  .91   442.   3.66   8.72   168.   1.33  21.63    .000  1.800   .168   14.5   85.9   2.98          25.2   542.6  SANDY SILT
 1.22   652.   7.08  16.25   318.   1.34  30.42    .000  1.950   .225   65.3  289.8   4.13          21.5  1128.9  SANDY SILT
 1.52          6.00  11.05   168.    .81  21.32    .000  1.800   .281   11.3   40.1   2.88  1.189          539.1  CLAYEY SILT
 1.83          6.61  13.05   218.    .96  19.32    .000  1.950   .338   11.6   34.4   2.72                 681.7     SILT
 2.13   740.   4.51  13.65   317.   2.13  10.87    .000  1.900   .394    7.0   17.8   1.60          30.8   816.6  SILTY SAND
 2.44          6.23  11.95   192.    .90  13.64    .000  1.950   .453    9.0   20.0   2.22  1.098          536.5  CLAYEY SILT
 2.74          6.00  11.15   171.    .83  11.76    .000  1.800   .508    8.1   15.9   2.03  1.024          454.4  CLAYEY SILT
 3.05          5.58  11.05   183.    .95   9.84    .000  1.800   .563    6.8   12.0   1.82                 454.4     SILT
 3.35          6.19  11.20   166.    .78   9.99    .000  1.950   .618    7.6   12.3   1.84  1.015          415.2  CLAYEY SILT
 3.66          6.41  11.95   185.    .84   9.40    .000  1.950   .677    7.6   11.2   1.77  1.031          452.0  CLAYEY SILT
 3.96   279.   4.63  10.60   201.   1.27   6.23    .000  1.800   .732   16.6   22.7   1.44          13.3   409.4  SANDY SILT
 4.27          4.40   9.05   153.   1.00   5.59    .000  1.800   .787    3.9    5.0   1.26                 293.7     SILT
 4.57   719.   5.59  15.40   341.   1.84   6.32    .000  2.000   .843    7.2    8.6   1.19          26.4   705.1  SILTY SAND
 4.88          3.70   8.01   141.   1.09   4.13    .000  1.800   .901    2.8    3.1   1.01                 227.9     SILT
 5.18   511.   3.18   7.67   147.   1.34   3.41    .027  1.800   .926    3.2    3.5    .85          26.2   213.4  SANDY SILT
 5.49   235.   2.96   9.60   226.   2.32   2.94    .058  1.900   .952    4.3    4.6   1.01          16.0   312.0  SILTY SAND
 5.79   414.   3.63  10.55   236.   1.98   3.50    .087  1.900   .979    4.1    4.2    .95          22.2   358.2  SILTY SAND
 6.10   521.   3.72   8.61   162.   1.30   3.57    .118  1.800  1.005    3.9    3.9    .90          25.1   241.4  SANDY SILT
 6.40          3.94   5.96    57.    .42   3.82    .147  1.700  1.027    2.8    2.7    .95   .508           86.6  SILTY CLAY
 6.71          3.36   5.47    60.    .53   3.16    .178  1.700  1.048    2.1    2.0    .82   .408           79.7  SILTY CLAY
 7.01          3.20   5.33    61.    .57   2.92    .207  1.700  1.069    1.9    1.8    .77   .377           75.8  SILTY CLAY
 7.32          3.38   5.26    52.    .46   3.01    .237  1.700  1.090    2.1    1.9    .79   .400           66.1  SILTY CLAY
 7.62          4.14   7.12    92.    .67   3.56    .267  1.800  1.112    2.7    2.5    .90   .503          133.3  CLAYEY SILT
 7.92          3.58   6.23    80.    .68   2.98    .296  1.700  1.134    2.1    1.9    .78   .411          101.5  CLAYEY SILT
 8.23          3.81   6.86    95.    .77   3.08    .327  1.800  1.157    2.3    2.0    .80   .437          123.7  CLAYEY SILT
 8.53          4.06   7.03    92.    .70   3.21    .356  1.800  1.181    2.5    2.1    .83   .469          123.2  CLAYEY SILT
 8.84          3.21   5.64    72.    .71   2.44    .387  1.700  1.203    1.6    1.4    .66   .339           76.7  CLAYEY SILT
 9.14          4.50   8.00   111.    .77   3.38    .416  1.800  1.225    2.8    2.3    .86   .519          155.6  CLAYEY SILT
 9.45          4.44   7.51    95.    .68   3.26    .447  1.800  1.250    2.7    2.1    .84   .506          129.5  CLAYEY SILT
 9.75          4.20   6.97    85.    .64   3.00    .476  1.800  1.273    2.4    1.9    .78   .465          107.2  CLAYEY SILT
10.06          4.28   7.21    90.    .67   2.97    .506  1.800  1.298    2.4    1.9    .78   .469          114.1  CLAYEY SILT
10.36          4.33   7.60   103.    .77   2.92    .536  1.800  1.321    2.4    1.8    .77   .467          128.7  CLAYEY SILT
10.67          4.46   7.60    98.    .71   2.95    .566  1.800  1.346    2.5    1.8    .77   .481          123.3  CLAYEY SILT
10.97          4.29   7.96   117.    .90   2.73    .596  1.800  1.369    2.2    1.6    .73                 140.4     SILT
11.28   888.   4.19   7.28    96.    .76   2.61    .626  1.800  1.393    2.1    1.5    .70   .428          109.5  CLAYEY SILT
11.58   514.   4.94  13.40   292.   2.05   2.89    .656  1.900  1.418    4.8    3.4    .89          22.5   392.3  SILTY SAND
11.89          8.02  15.40   252.   1.01   4.98    .686  1.950  1.447    6.0    4.1   1.16                 455.3     SILT
12.19         10.30  20.85   368.   1.14   6.30    .715  1.950  1.475    8.8    6.0   1.36                 751.7     SILT
12.50          7.03  13.00   201.    .93   4.14    .746  1.950  1.503    4.7    3.1   1.01                 324.7     SILT
12.80          6.01  11.25   175.    .97   3.40    .775  1.800  1.529    3.5    2.3    .87                 248.0     SILT
13.11          7.48  15.20   265.   1.17   4.19    .806  1.950  1.556    4.9    3.2   1.02                 434.7     SILT
13.41   594.  10.15  31.60   765.   2.60   5.34    .835  2.150  1.587   21.5   13.5   1.31          16.6  1483.6  SILTY SAND
13.56   675.   3.02  19.75   593.  10.91    .98    .850  1.900  1.600    1.6    1.0    .49          30.1   504.2     SAND
END OF SOUNDING
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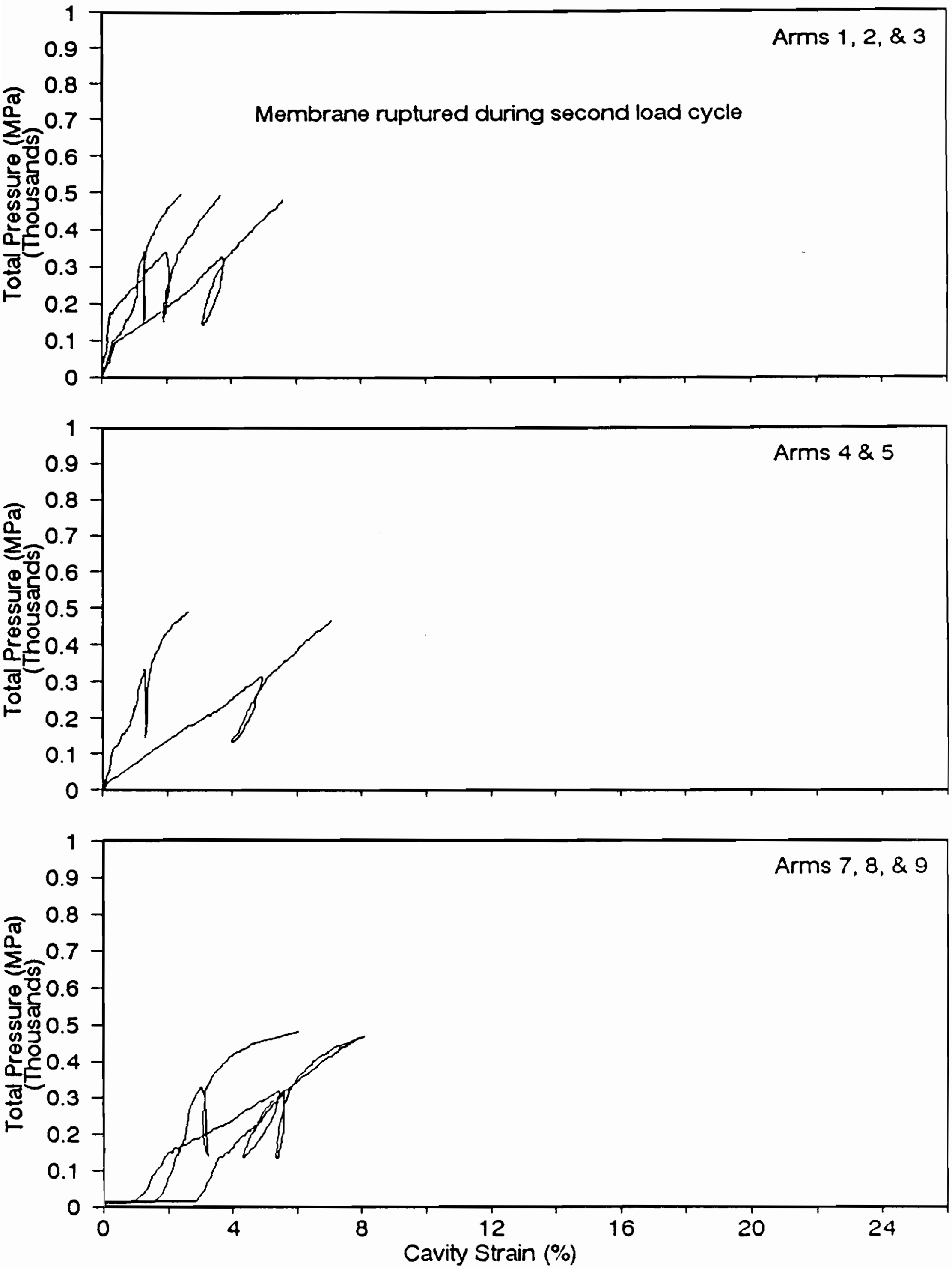
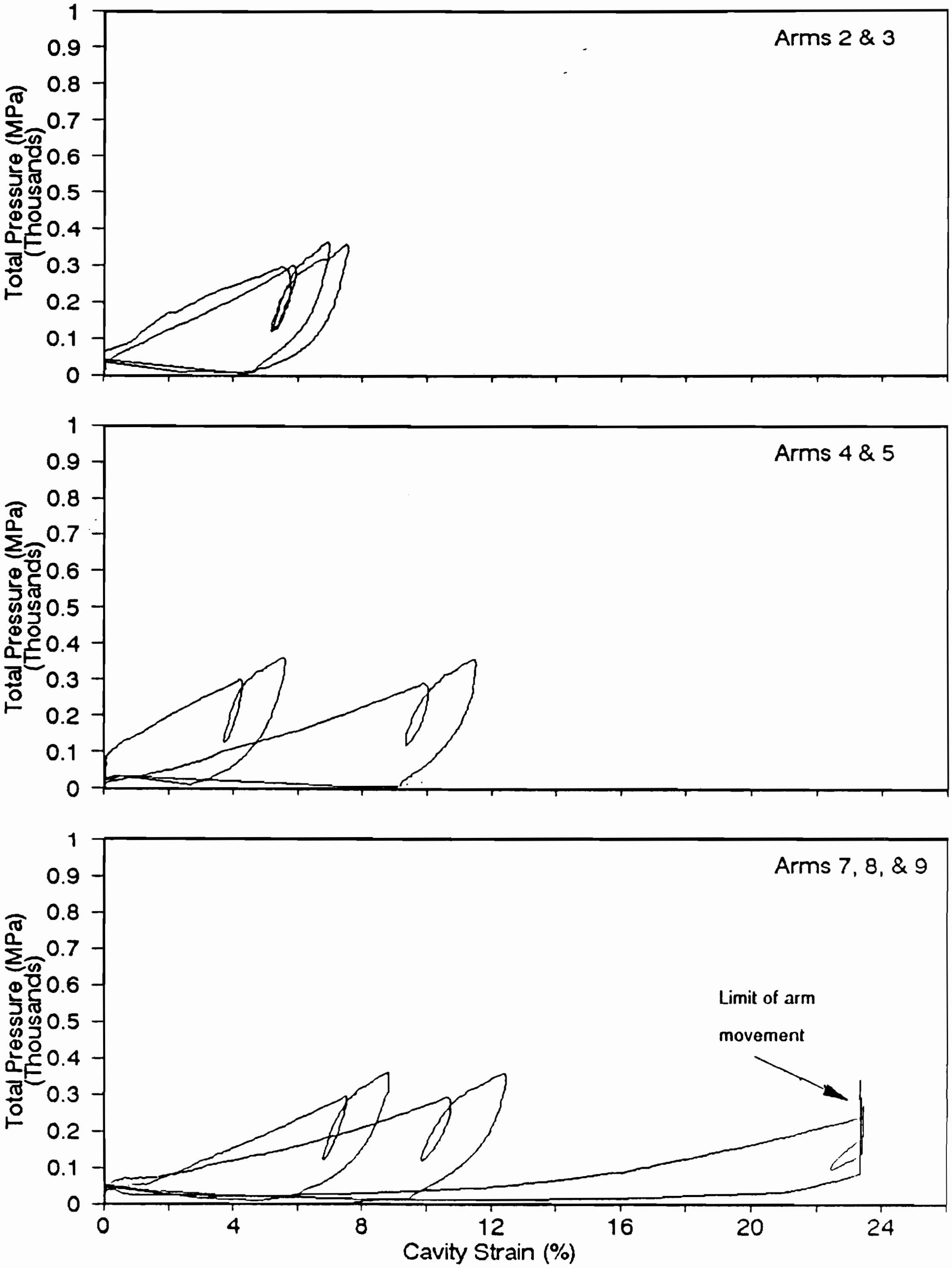
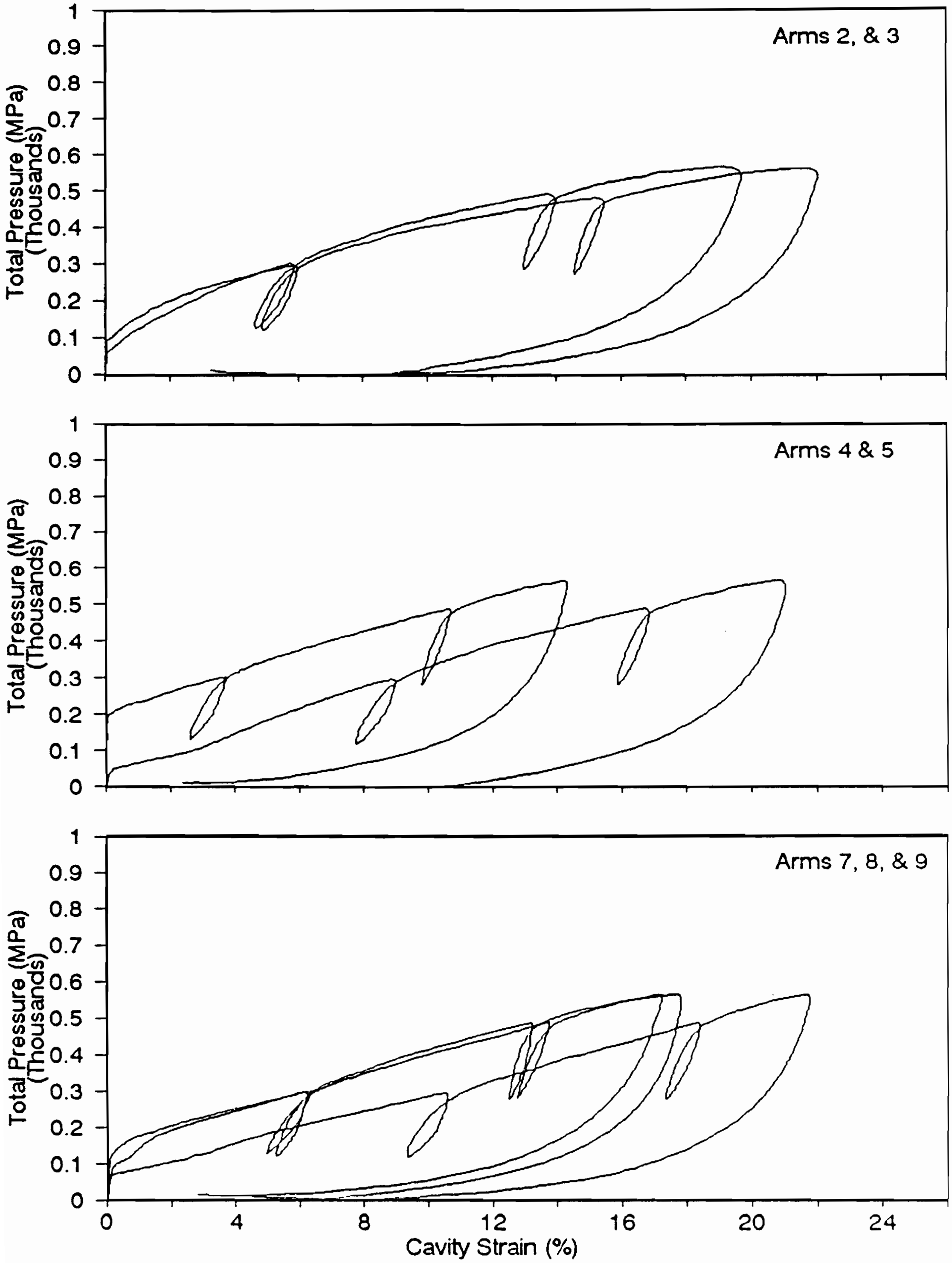


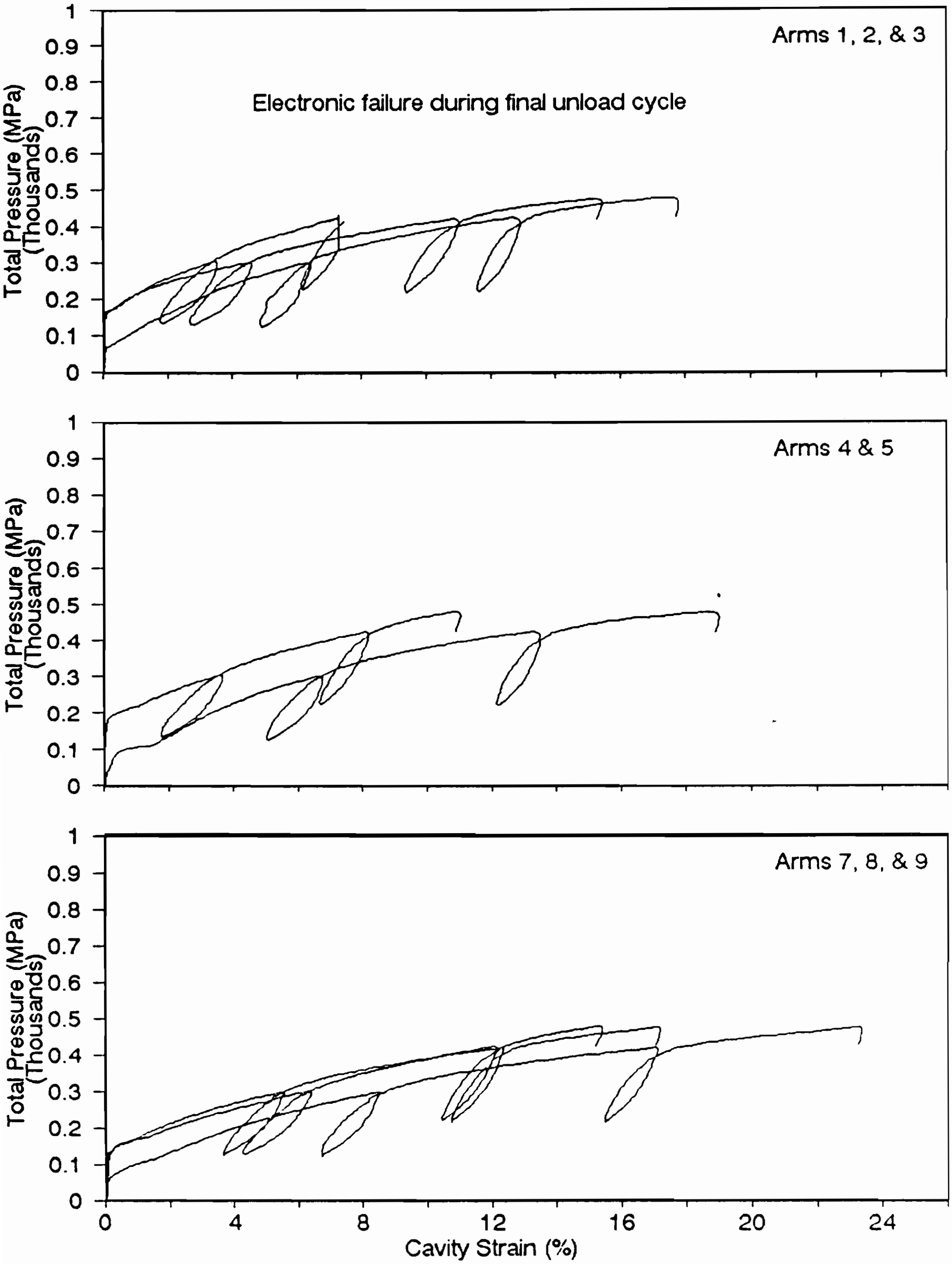
Winterpock Tap: Pressuremeter Test WPKP-1 09/06/89



Winterpock Tap: Pressuremeter Test WPKP-2 09/07/89



Winterpock Tap: Pressuremeter Test WPKP-3 09/07/89



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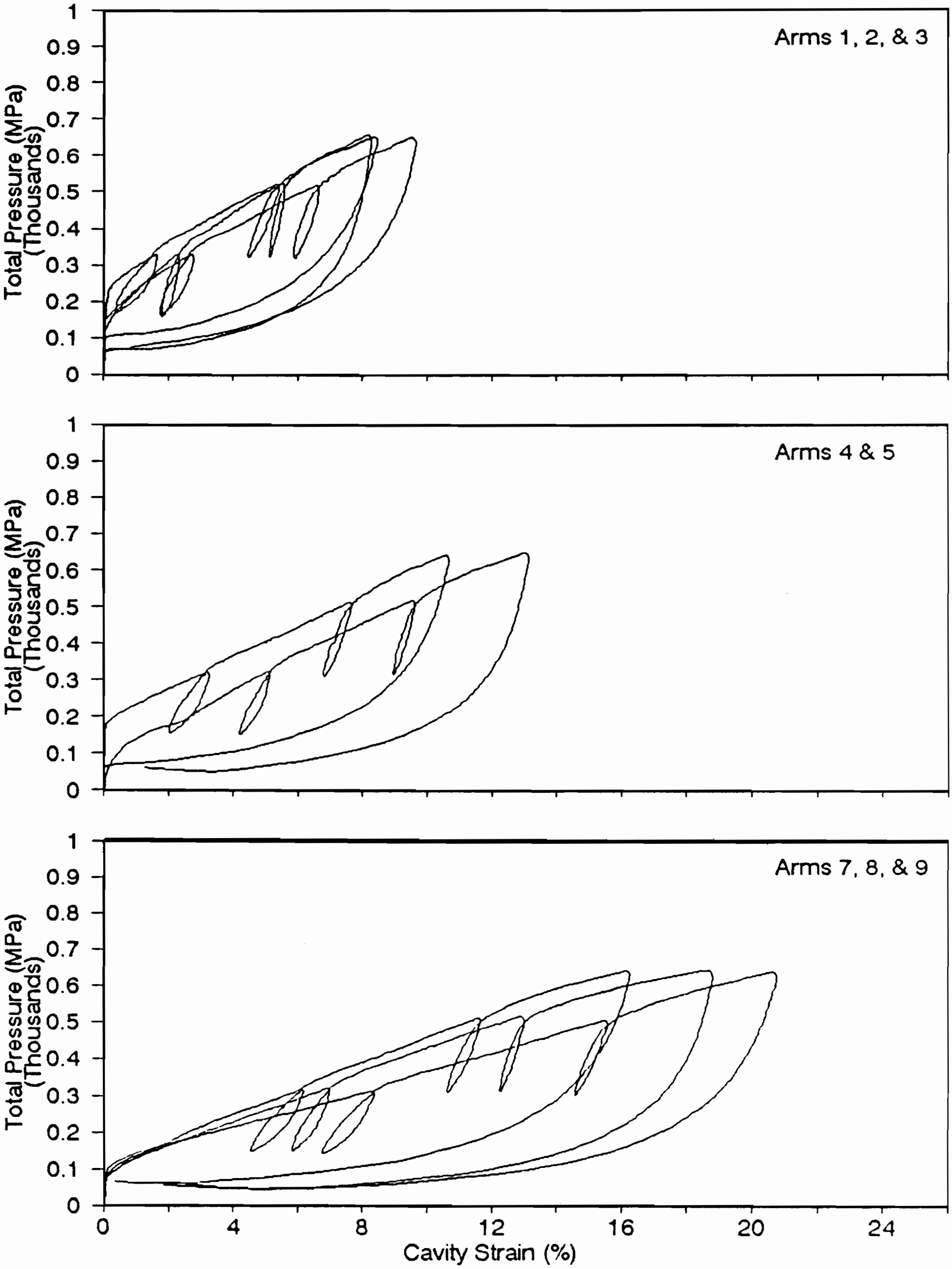
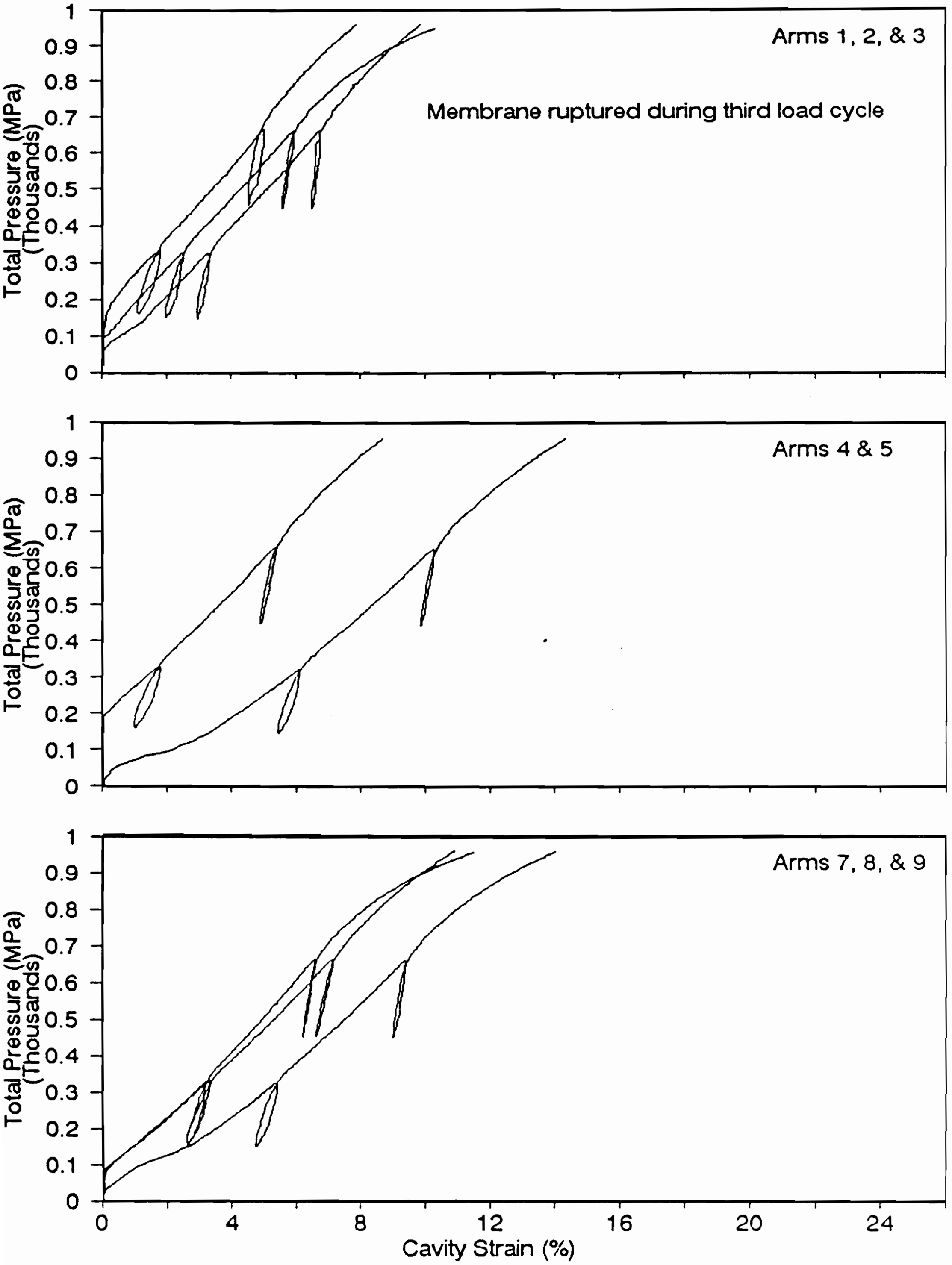


Winterpock Tap: Pressuremeter Test WPKP-5 09/07/89



Winterpock Tap: Pressuremeter Test WPKP-6 09/07/89

WINTERPOCK TAP:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	BORING #	N60	N160	Qc (pt) bar
-1.0				15.4
-2.0				22.3
-2.5	B-2	16	28	28.5
-2.5	B-1	22	39	28.2
-3.0				30.2
-4.0	B-3	12	20	45.9
-4.0	B-2	21	34	44.6
-4.0	B-1	23	37	43.2
-4.5				32.8
-5.0				42.4
-5.5	B-3	16	24	53.6
-5.5	B-2	19	29	53.7
-5.5	B-1	25	38	52.3
-6.0				50.3
-7.0	B-2	15	21	49.5
-7.0	B-1	18	26	49.9
-8.0				54.5
-8.5	B-2	15	20	39.8
-8.5	B-1	20	27	39.0
-9.0				34.7
-10.0	B-3	12	15	32.3
-10.0	B-2	15	19	32.0
-10.0	B-1	21	27	31.3
-10.5				25.1
-11.0				21.8
-11.5	B-2	15	18	22.6
-11.5	B-3	16	19	21.6
-11.5	B-1	16	19	21.5
-12.0				20.6
-13.0	B-2	11	13	18.4
-13.0	B-1	33	38	18.5
-14.0				19.2
-14.5	B-2	11	12	20.3
-14.5	B-1	21	23	21.5
-15.0				52.6
-16.0	B-3	10	11	59.6
-16.0	B-2	10	11	58.6

WINTERPOCK TAP:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Qn (pt) bar	ED bar	Gur kN/M^2	D50 (mm)
-1.0	29.2	212		
-2.0	40.0	154		
-2.5	49.9	183		
-2.5	49.5	183		
-3.0	51.8	211		
-4.0	74.9	310		
-4.0	72.7	310		
-4.0	70.5	310		
-4.5	52.3	273	19363	
-5.0	66.1	237		
-5.5	81.5	241		0.036
-5.5	81.8	241		0.036
-5.5	79.6	241		0.036
-6.0	74.9	245		
-7.0	70.8	283		0.030
-7.0	71.3	283		0.030
-8.0	74.7	217		
-8.5	53.5	201		0.123
-8.5	52.4	201		0.123
-9.0	45.8	186		
-10.0	41.1	182		0.100
-10.0	40.7	182		0.114
-10.0	39.8	182		0.114
-10.5	31.4	170	12578	
-11.0	26.9	158		
-11.5	27.3	161		0.340
-11.5	26.2	161		0.340
-11.5	26.0	161		0.340
-12.0	24.5	164		
-13.0	21.2	164		0.056
-13.0	21.3	164		0.056
-14.0	21.4	157		
-14.5	22.3	189		0.061
-14.5	23.7	189		0.061
-15.0	57.0	220		
-16.0	62.7	223		0.100
-16.0	61.6	223		0.100

WINTERPOCK TAP:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Qc (pt) / N	Su DMT	Su N60 (bars)	Nk = 15 Su Qc (bars)
-1.0				
-2.0				
-2.5			4.033	1.890
-2.5			5.545	1.872
-3.0				
-4.0		0.736	2.971	3.047
-4.0		0.736	5.293	2.958
-4.0		0.736	5.797	2.867
-4.5		0.368		2.172
-5.0				2.811
-5.5	3.35		4.033	3.550
-5.5	2.83		4.789	3.560
-5.5	2.09		6.301	3.464
-6.0			0.000	3.330
-7.0	3.30		3.781	3.276
-7.0	2.77		4.537	3.298
-8.0		0.366		3.604
-8.5	2.65	0.526	3.781	2.621
-8.5	1.95	0.526	5.041	2.567
-9.0		0.686		2.280
-10.0	2.69	0.335	2.971	2.114
-10.0	2.13	0.335	3.781	2.095
-10.0	1.49	0.335	5.293	2.046
-10.5		0.616		1.633
-11.0		0.897		1.415
-11.5	1.51	0.740	3.781	1.462
-11.5	1.35	0.740	4.033	1.399
-11.5	1.35	0.740	4.033	1.392
-12.0		0.583		1.331
-13.0	1.68		2.701	1.179
-13.0	0.56		8.318	1.186
-14.0		0.230		1.224
-14.5	1.84	0.422	2.701	1.297
-14.5	1.03	0.422	5.293	1.381
-15.0		0.613		3.451
-16.0	5.96		2.431	3.916
-16.0	5.86		2.431	3.848

WINTERPOCK TAP:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	BORING #	N60	N160	Qc (pt) bar
-16.0	B-1	15	16	56.1
-17.0				35.7
-17.5	B-2	10	10	19.9
-17.5	B-3	11	11	20.0
-17.5	B-1	20	21	20.2
-18.0				15.9
-19.0	B-1	33	33	31.1
-20.0				38.1
-20.5	B-1	20	20	64.2
-21.0	B-2	16	16	86.9
-21.5	B-3	7	7	69.0
-22.0				37.7
-22.5	B-1	44	43	78.5
-23.0	B-3	10	10	34.3
-24.0	B-1	11	11	18.9
-24.5	B-2	13	12	17.6
-25.0				20.5
-25.5	B-1	22	21	22.3
-26.0				32.0
-27.0	B-1	23	21	42.2
-28.0	B-3	12	11	28.2
-28.5	B-2	10	9	43.6
-28.5	B-1	37	34	46.5
-29.0				58.2
-29.5	B-3	10	9	39.4
-30.0	B-2	13	12	32.5
-30.0	B-1	26	23	37.7
-31.0				43.0
-31.5	B-2	14	12	32.0
-31.5	B-1	37	33	33.0
-32.0				62.1
-33.0	B-2	18	16	109.5
-33.0	B-1	52	45	39.8
-34.0	B-3	16	14	40.5
-34.5	B-2	21	18	42.6
-34.5	B-1	41	35	39.9
-35.0				41.6

WINTERPOCK TAP:
IN-SITU TEST
DATA SUMMARY

DEPTH ft.	Qn (pt) bar	ED bar	Gur kN/M^2	D50 (mm)
-16.0	59.0	223		0.100
-17.0	37.0	224	9785	
-17.5	20.5	199		0.069
-17.5	20.6	199		0.069
-17.5	20.8	199		0.069
-18.0	16.2	175		
-19.0	31.4	306		
-20.0	37.9	122		
-20.5	63.7	93		
-21.0	85.7	65		0.088
-21.5	67.7	63		
-22.0	36.8	61		
-22.5	76.3	63	5728	
-23.0	33.1	65		
-24.0	18.1	85		
-24.5	16.7	132		0.093
-25.0	19.4	179		
-25.5	21.0	128		
-26.0	29.9	78		
-27.0	39.0	82	11461	
-28.0	25.9	129		
-28.5	39.7	107		0.044
-28.5	42.4	107		0.044
-29.0	52.8	85		
-29.5	35.6	100		
-30.0	29.2	115		0.094
-30.0	33.8	115		0.094
-31.0	38.2	112		
-31.5	28.3	121		0.091
-31.5	29.1	121		0.091
-32.0	54.5	131		
-33.0	95.0	149		0.111
-33.0	34.5	149		0.111
-34.0	34.8	111		
-34.5	36.4	125		0.107
-34.5	34.1	125		0.107
-35.0	35.3	139	20605	

WINTERPOCK TAP:
IN-SITU TEST
DATA SUMMARY

				Nk = 15
DEPTH ft.	Qc (pt) /N	Su DMT	Su N60 (bars)	Su Qc (bars)
-16.0	3.74		3.781	3.683
-17.0		0.198		2.317
-17.5	1.99	0.194	2.431	1.265
-17.5	1.82	0.194	2.701	1.270
-17.5	1.01	0.194	5.041	1.284
-18.0		0.190		0.996
-19.0		0.133	8.318	2.008
-20.0		0.193		2.470
-20.5		0.320	5.041	4.214
-21.0	5.43	0.447	4.033	5.724
-21.5		0.420	1.654	4.531
-22.0		0.393		2.443
-22.5		0.380	11.090	5.164
-23.0		0.367	2.431	2.213
-24.0		0.200	2.701	1.185
-24.5	1.35	0.226	3.241	1.099
-25.0		0.252		1.292
-25.5		0.330	5.545	1.411
-26.0		0.408		2.057
-27.0		0.413	5.797	2.733
-28.0		0.645	2.971	1.803
-28.5	4.36	0.543	2.431	2.825
-28.5	1.26	0.543	9.326	3.022
-29.0		0.442		3.802
-29.5		0.517	2.431	2.548
-30.0	2.50	0.592	3.241	2.086
-30.0	1.45	0.601	6.553	2.433
-31.0		0.611		2.785
-31.5	2.29	0.654	3.511	2.052
-31.5	0.89	0.654	9.326	2.115
-32.0		0.697		4.055
-33.0	6.08	0.756	4.537	7.211
-33.0	0.77	0.756	13.107	2.566
-34.0		0.234	4.033	2.611
-34.5	2.03	0.455	5.293	2.750
-34.5	0.97	0.455	10.334	2.573
-35.0		0.676		2.684

WINTERPOCK TAP:
IN-SITU TEST
DATA SUMMARY

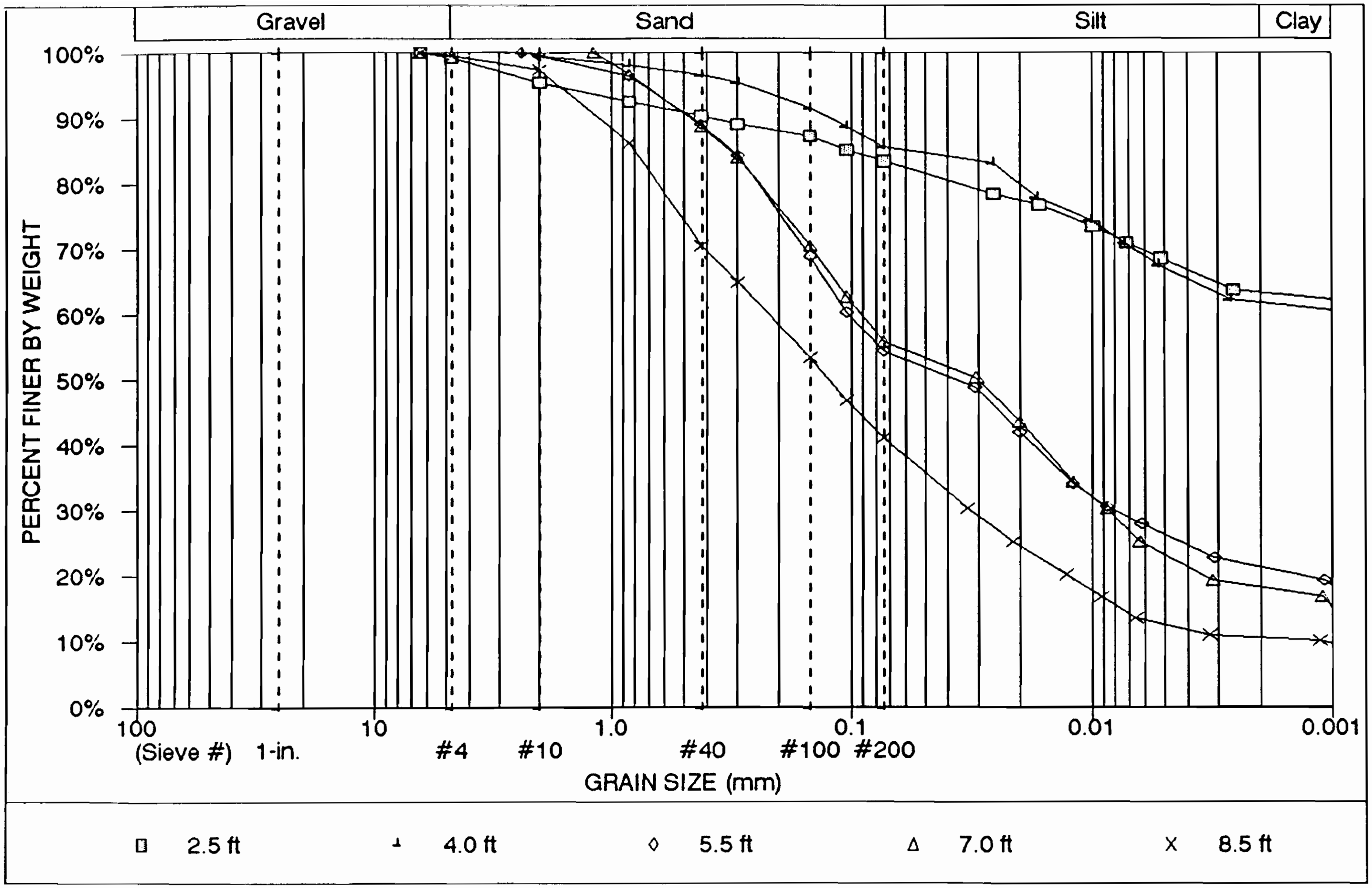
DEPTH ft.	BORING #	N60	N160	Qc (pt) bar
-35.5	B-3	27	23	62.4
-36.0	B-2	24	20	75.5
-36.0	B-1	75	63	75.3
-37.0				59.7
-37.5	B-2	22	18	39.7
-38.0				34.5
-39.0	B-2	27	22	43.3
-40.0				36.4
-40.5	B-2	27	22	34.9
-41.0				24.9
-42.0				30.1
-42.5	B-2	24	19	37.0
-43.0				60.3
-44.0	B-2	37	29	40.8

WINTERPOCK TAP:
IN-SITU TEST
DATA SUMMARY

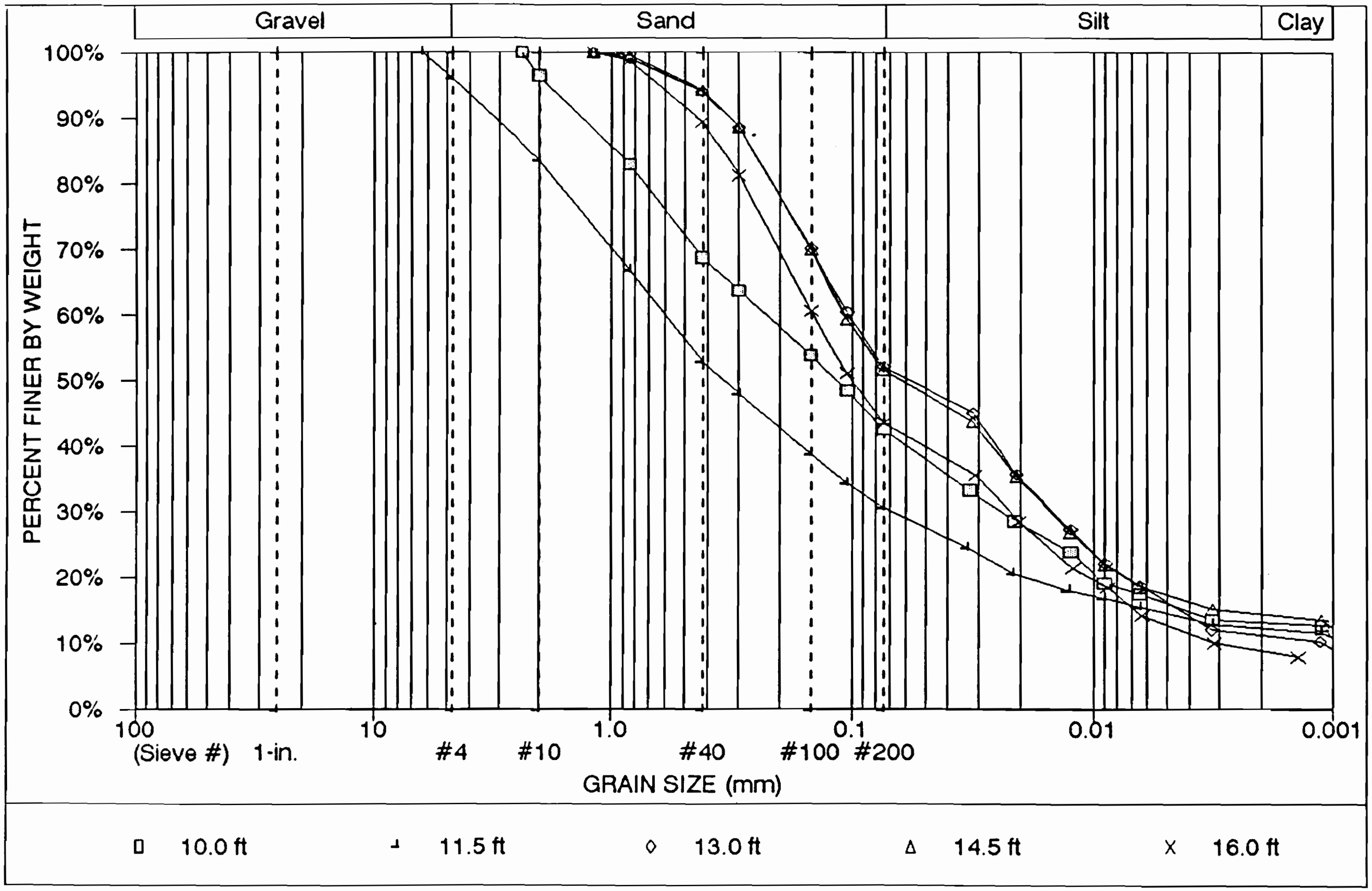
DEPTH ft.	Qn (pt) bar	ED bar	Gur kN/M^2	D50 (mm)
-35.5	52.7	166		
-36.0	63.4	192		0.136
-36.0	63.3	192		0.136
-37.0	49.6	161		
-37.5	32.8	209		0.138
-38.0	28.4	256		
-39.0	35.2	277		0.129
-40.0	29.2	344		
-40.5	27.9	275		0.135
-41.0	19.7	207		
-42.0	23.6	142		
-42.5	28.9	163		0.140
-43.0	46.9	183		
-44.0	31.5	765		0.147

WINTERPOCK TAP:
IN-SITU TEST
DATA SUMMARY

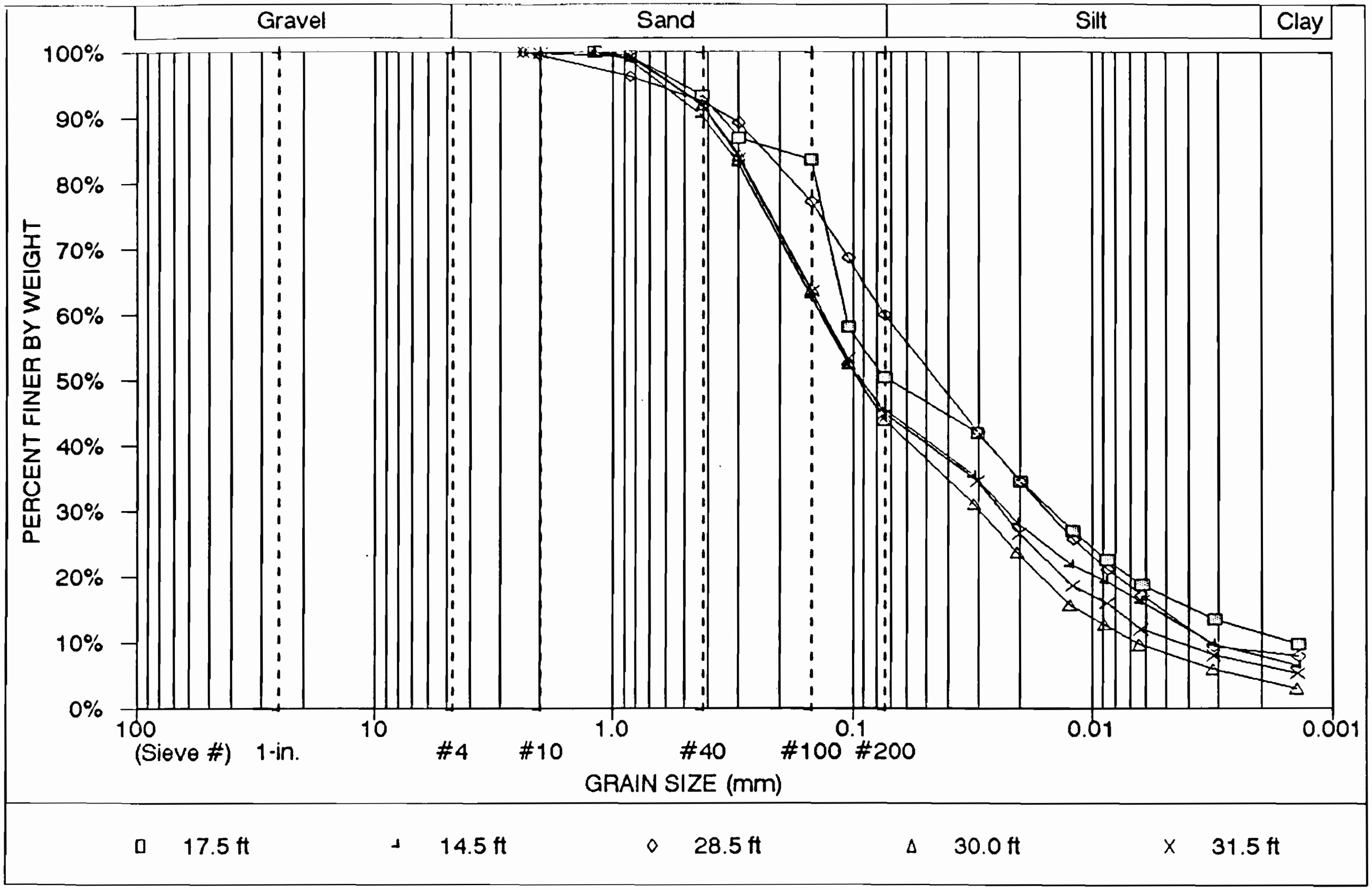
DEPTH ft.	Qc (pt) / N	Su DMT	Su N60 (bars)	Nk = 15 Su Qc (bars)
-35.5			6.805	4.068
-36.0	3.15		6.049	4.940
-36.0	1.00		18.904	4.931
-37.0		0.214		3.886
-37.5	1.81		5.545	2.554
-38.0				2.205
-39.0	1.60		6.805	2.788
-40.0		0.861		2.326
-40.5	1.29	0.744	6.805	2.228
-41.0		0.627		1.557
-42.0		0.293		1.904
-42.5	1.54	0.258	6.049	2.363
-43.0		0.224		3.917
-44.0	1.10		9.326	2.613



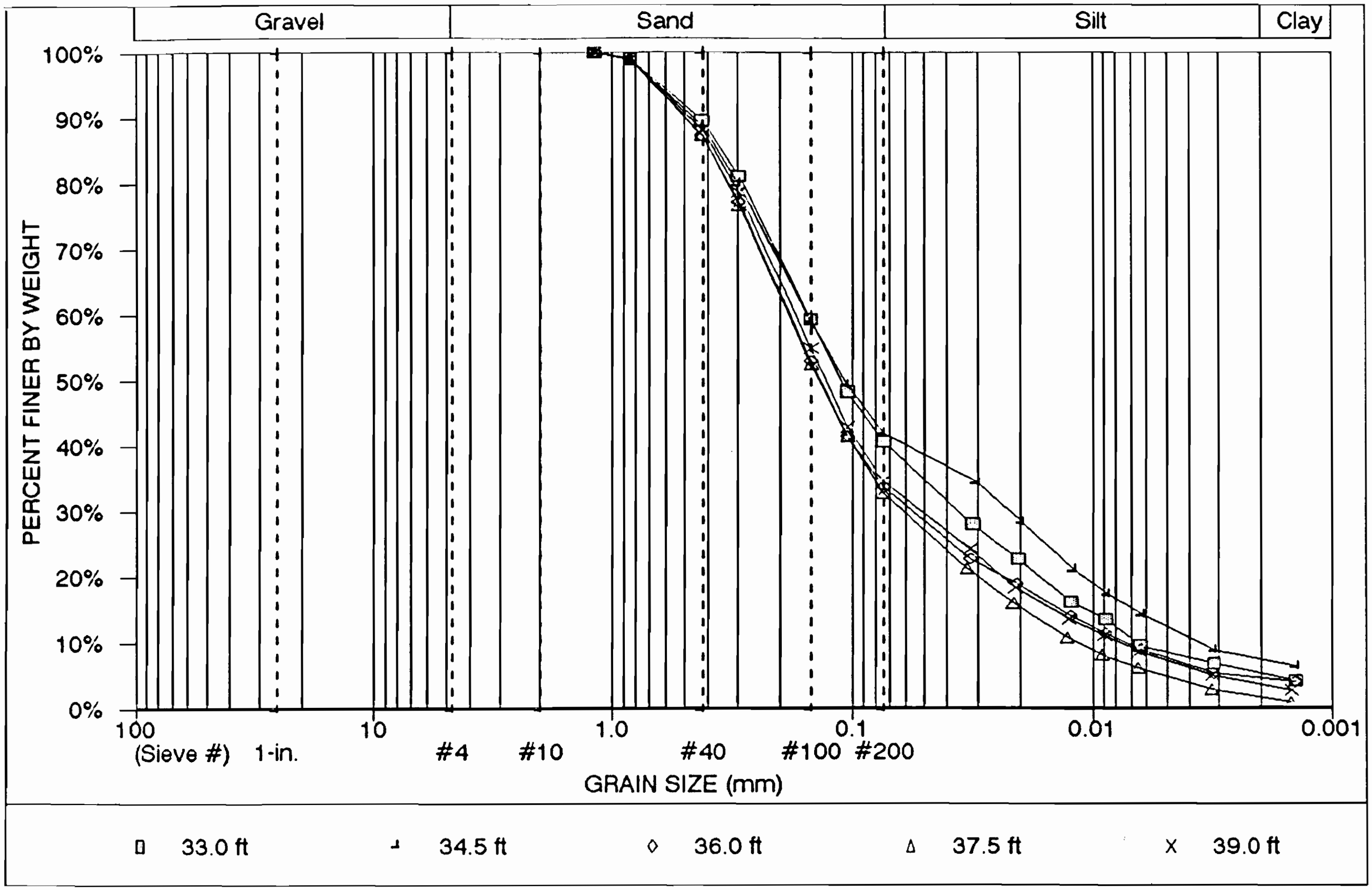
Winterpock Tap: Grain Size Data



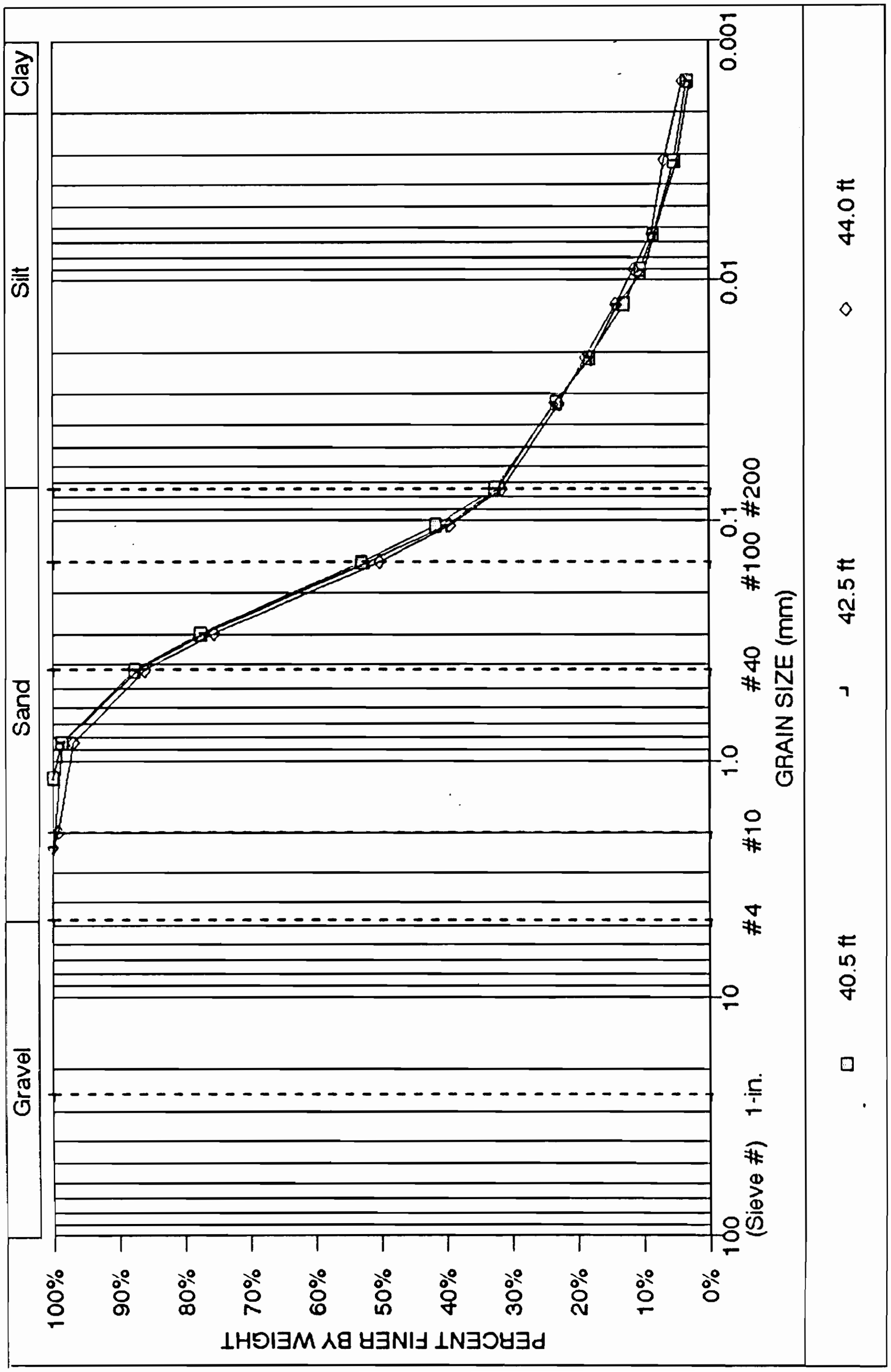
Winterpock Tap: Grain Size Data



Winterpock Tap: Grain Size Data



Winterpock Tap: Grain Size Data



Winterpock Tap: Grain Size Data

WINTERPOCK TAP:
LAB DATA
SUMMARY
FROM B-1.

DEPTH (ft)	SPECIFIC GRAVITY	D60 (mm)	D50 (mm)	D10 (mm)	Cu
-2.5	2.736				
-4.0	2.736				
-5.5	2.736		0.036		
-7.0	2.736		0.030		
-8.5	2.736	0.219	0.123	0.001	195
-10.0	2.736	0.223	0.114	0.001	235
-11.5	2.736	0.592	0.340	0.001	638
-13.0	2.736	0.102	0.056	0.001	91
-14.5	2.736	0.107	0.061	0.001	132
-16.0	2.736	0.145	0.100	0.003	45
-17.5	2.736	0.107	0.069	0.002	71
-21.0	2.783	0.127	0.088	0.003	44
-24.5	2.783	0.135	0.093	0.003	41
-28.5	2.783	0.073	0.044	0.003	22
-30.0	2.783	0.131	0.094	0.007	20
-31.5	2.783	0.131	0.091	0.004	29
-33.0	2.783	0.152	0.111	0.007	22
-34.5	2.783	0.154	0.107	0.004	41
-36.0	2.783	0.181	0.136	0.008	24
-37.5	2.783	0.184	0.138	0.012	16
-39.0	2.783	0.172	0.129	0.008	21
-40.5	2.783	0.181	0.135	0.087	2
-42.5	2.783	0.185	0.140	0.009	20
-44.0	2.783	0.194	0.147	0.008	26

WINTERPOCK TAP:
LAB DATA
SUMMARY
FROM B-1.

DEPTH (ft)	%-200	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	MOISTURE CONTENT %
-2.5	83.29%	98.9%	46.8%	52.1%	41.3%
-4.0	85.63%	75.9%	48.1%	27.8%	40.9%
-5.5	54.36%	NP			35.9%
-7.0	55.85%	NP			40.5%
-8.5	41.05%	NP			35.1%
-10.0	42.52%	NP			38.0%
-11.5	30.61%	NP			26.8%
-13.0	52.19%	NP			31.0%
-14.5	51.73%	NP			33.3%
-16.0	43.52%	NP			31.0%
-17.5	50.40%	NP			36.7%
-21.0	45.61%	NP			36.3%
-24.5	45.33%	NP			31.4%
-28.5	59.98%	NP			41.0%
-30.0	43.71%	NP			36.8%
-31.5	44.73%	NP			37.0%
-33.0	40.33%	NP			33.0%
-34.5	41.56%	NP			25.0%
-36.0	33.36%	NP			28.7%
-37.5	32.58%	NP			28.0%
-39.0	34.33%	NP			25.7%
-40.5	32.44%	NP			27.2%
-42.5	31.93%	NP			31.0%
-44.0	31.15%	NP			28.5%

APPENDIX I

CORRELATION DATA SUMMARY

2' AVERAGE OF CONE TIP RESISTANCE vs. PRESSUREMETER Gur COMPARISON DATA SUMMARY

SITE	DEPTH (ft)	Qc (bars)	Qn (bars)	Qn(2' avg) (bars)	Gur (kN/M^2)
CARMEL	-4.5	29.4	47.4	46.1	20,021
CHURCH	-10.5	55.8	71.0	70.1	41,970
	-16.5	135.9	141.5	138.2	63,093
	-22.5	72.7	63.8	70.5	41,090
	-28.5	57.7	44.0	47.0	28,609
SCHNABEL	-9.0	27.4	36.7	35.0	18,411
	-15.5	48.0	56.0	57.5	35,537
	-18.5	74.2	82.2	70.7	41,885
LADSMITH	-15.0	67.4	93.6	94.7	59,732
KIPP'S FARM:	-10.5	45.4	57.0	55.2	25,521
HILLTOP AREA	-18.0	46.4	46.4	44.2	25,979
	-30.5	74.1	86.1	65.7	18,145
	-33.5	40.1	32.1	34.5	20,459
KIPP'S FARM:	-4.5	19.8	31.8	32.5	18,576
HILLSIDE AREA	-10.5	30.0	37.9	30.3	17,745
	-16.5	26.3	27.5	31.5	15,982
	-22.0	31.6	28.6	22.6	10,021
	-28.5	11.9	9.9	12.9	23,516
	-34.5	11.8	9.2	17.1	20,354
PLANTATION	-10.5	14.2	18.6	16.7	7,672
PIPELINE	-18.0	9.2	10.9	9.9	5,750
	-22.5	11.7	13.2	11.6	5,973
	-28.5	14.4	15.2	18.0	7,823
	-34.5	18.4	18.1	38.0	10,836

2' AVERAGE OF CONE TIP RESISTANCE vs. PRESSUREMETER Gur COMPARISON DATA SUMMARY

SITE	DEPTH (ft)	Qc (bars)	Qn (bars)	Qn(2' avg) (bars)	Gur (kN/M^2)
WINTERPOCK	-4.5	32.8	52.3	63.8	19,363
TAP	-10.5	25.1	31.4	32.9	12,578
	-17.0	35.7	37.0	33.4	9,785
	-22.5	78.5	76.3	51.2	5,728
	-27.0	42.2	39.0	31.7	11,461
	-35.0	41.6	35.3	42.6	20,605

DILATOMETER MODULUS (ED) vs. PRESSUREMETER Gur
COMPARISON DATA SUMMARY

SITE	DEPTH (ft)	ED (bars)	Gur (kN/M^2)
CARMEL		93	20201
CHURCH	4.5	139	20201
		154	20201
		200	41970
	10.5	236	41970
		246	41970
		387	63093
	16.5	418	63093
		422	63093
		343	41090
	22.5	305	41090
		262	41090
		203	28609
	28.5	190	28609
		195	28609
SCHNABEL		160	18411
	9.0	117	18411
		159	18411
		276	35537
	15.5	289	35537
		286	35537
		306	41885
	18.5	379	41885
		343	41885
LADYSMITH		356	59732
	15.0	360	59732
		395	59732

DILATOMETER MODULUS (ED) vs. PRESSUREMETER Gur
COMPARISON DATA SUMMARY

SITE	DEPTH (ft)	ED (bars)	Gur (kN/M^2)
KIPP'S FARM:		126	25521
HILLTOP AREA	10.5	151	25521
		143	25521
		147	25979
	18.0	133	25979
		127	25979
		103	18145
	30.5	100	18145
		83	18145
KIPP'S FARM:		134	18576
HILLSIDE AREA	4.5	125	18576
		130	18576
		144	17745
	10.5	140	17745
		136	17745
		186	15902
	16.5	204	15902
		208	15902
		255	10021
	22.0	220	10021
		266	10021
		289	23576
	28.5	327	23576
		265	23576
		136	20354
	34.5	120	20354
		75	20354

DILATOMETER MODULUS (ED) vs. PRESSUREMETER Gur
COMPARISON DATA SUMMARY

SITE	DEPTH (ft)	ED (bars)	Gur (kN/M^2)
PLANTATION PIPELINE	10.5	99	7672
		81	7672
		76	7672
	18.0	30	5750
		28	5750
		30	5750
	22.5	43	5973
		49	5973
		55	5973
	28.5	51	7823
		53	7823
		67	7823
	34.5	91	10836
		102	10836
		110	10836
WINTERPOCK TAP	4.5	289	19363
		265	19363
		262	19363
	10.5	168	12578
		154	12578
		150	12578
	17.0	223	9785
		199	9785
		240	9785
	22.5	63	5728
		63	5728
		75	5728

DILATOMETER MODULUS (ED) vs. PRESSUREMETER Gur
COMPARISON DATA SUMMARY

SITE	DEPTH (ft)	ED (bars)	Gur (kN/M^2)
		78	11461
	27.0	82	11461
		129	11461
		119	20605
	35.0	180	20605
		267	20605

SPT BLOW COUNT (N160) vs. PRESSUREMETER Gur
COMPARISON DATA SUMMARY

SITE	DEPTH (ft)	N60 (blows/ft)	N160 (blows/ft)	Gur (kN/M^2)
CARMEL CHURCH	-4.0	5	8	20,021
	-4.0	5	8	20,021
	-4.0	6	10	20,021
	-10.0	12	16	41,970
	-10.0	12	16	41,970
	-10.0	16	21	41,970
	-16.0	14	15	63,093
	-16.0	17	18	63,093
	-16.0	19	20	63,093
	-22.5	14	12	41,090
	-22.5	15	13	41,090
	-28.5	11	8	28,609
	-28.5	13	10	28,609
SCHNABEL	-8.5	12	16	18,411
	-10.0	9	12	18,411
	-16.0	18	21	35,537
	-19.0	25	27	41,885
LADYSMITH	-14.5	55	77	59,732
	-16.0	68	92	59,732
KIPP'S FARM: HILLTOP AREA	-10.0	6	8	25,521
	-10.0	13	17	25,521
	-17.5	6	6	25,979
	-17.5	32	32	25,979
	-30.5	18	21	18,145
	-33.5	17	14	20,459
KIPP'S FARM: HILLSIDE AREA	-4.0	4	7	18,576
	-4.0	9	15	18,576
	-10.0	8	10	17,745
	-10.0	14	18	17,745
	-16.0	6	6	15,982
	-22.0	29	26	10,021
	-28.0	11	9	23,516
	-34.5	6	5	20,354

SPT BLOW COUNT (N160) vs. PRESSUREMETER Gur COMPARISON DATA SUMMARY

SITE	DEPTH (ft)	N60 (blows/ft)	N160 (blows/ft)	Gur (kN/M^2)
PLANTATION PIPELINE	-10.0	13	17	7,672
	-17.5	8	10	5,750
	-19.0	7	8	5,750
	-22.5	9	10	5,973
	-28.5	11	12	7,823
	-34.5	14	14	10,836
	-34.5	16	16	10,836
WINTERPOCK TAP	-4.0	12	20	19,363
	-4.0	21	34	19,363
	-4.0	23	37	19,363
	-10.0	12	15	12,578
	-10.0	15	19	12,578
	-10.0	21	27	12,578
	-17.5	10	10	9,785
	-17.5	11	11	9,785
	-17.5	20	21	9,785
	-22.5	44	43	5,728
	-27.0	23	21	11,461
	-34.5	41	35	20,605
	-35.5	27	23	20,605

N160 vs. ED
STIFFNESS COMPARISON DATA SUMMARY

SITE	DEPTH (ft)	N160 (blows/ft)	ED (bars)
CARMEL CHURCH	-2.5	7	67
	-2.5	11	67
	-4.0	8	115
	-4.0	8	115
	-4.0	10	115
	-5.5	8	154
	-5.5	15	154
	-5.5	18	154
	-7.0	9	188
	-7.0	13	188
	-8.5	10	189
	-8.5	21	189
	-10.0	16	234
	-10.0	16	234
	-10.0	21	234
	-11.5	14	246
	-11.5	21	246
	-11.5	21	246
	-13.0	20	337
	-13.0	22	337
	-14.5	14	357
	-14.5	22	357
	-16.0	15	404
	-16.0	18	404
	-16.0	20	404
	-17.5	17	422
	-17.5	18	422
	-17.5	25	422
	-19.0	14	392
	-19.0	17	392
	-20.5	14	367
	-20.5	17	367
	-21.5	9	343
	-22.5	12	305
	-22.5	13	305
	-23.0	12	273
	-24.0	12	251
	-24.0	13	251
	-25.5	10	250
	-25.5	11	250
	-27.0	9	218
	-27.0	13	218
	-28.0	5	188
	-28.5	8	190
CARMEL CHURCH	-28.5	10	190
	-29.5	7	195
	-30.0	6	197
	-30.0	6	197
	-31.5	4	183
	-31.5	6	183
	-33.0	14	144
	-33.0	16	144
	-34.5	6	263
	-34.5	7	263
	-36.0	11	318
	-36.0	11	318
	-37.5	8	372
	-37.5	18	372
	-39.0	15	401
	-39.0	16	401
	-40.5	9	349
	-40.5	11	349
	-42.5	6	286
	-42.5	8	286
	-44.0	8	295
	-44.0	18	295
PEPPER'S FERRY	-2.5	9	65
	-2.5	11	65
	-4.0	8	52
	-4.0	10	52
	-5.5	8	66
	-5.5	8	66
	-7.0	7	62
	-7.0	7	62
	-8.5	7	44
	-8.5	7	44
	-10.0	4	28
	-10.0	5	28
	-11.5	3	28
	-11.5	4	28
	-13.0	6	21
	-17.0	5	84
	-19.0	22	134

N160 vs. ED
STIFFNESS COMPARISON DATA SUMMARY

SITE	DEPTH (ft)	N160 (blows/ft)	ED (bars)
SCHNABEL	-2.5	7	93
	-4.0	8	100
	-5.5	9	125
	-7.0	10	149
	-8.5	16	141
	-10.0	12	117
	-11.5	11	179
	-13.0	15	244
	-14.5	13	276
	-16.0	21	292
	-17.5	19	306
	-19.0	27	425
LADYSMITH	-2.5	13	39
	-2.5	14	39
	-4.0	5	18
	-4.0	12	18
	-5.5	32	106
	-5.5	34	106
	-7.0	25	214
	-7.0	50	214
	-8.5	18	212
	-8.5	22	212
	-10.0	17	244
	-10.0	33	244
	-11.5	27	393
	-11.5	30	393
	-11.5	86	393
	-13.0	48	395
	-13.0	99	395
	-14.5	77	358
	-16.0	92	395
	-17.5	79	372
	-19.0	61	343
	-20.5	74	425
	-22.5	80	469
	-24.0	78	488
	-25.5	78	468
	-27.0	72	451
	-28.5	69	424
KIPP'S FARM: HILLTOP AREA	-4.0	8	122
	-4.0	25	122
	-5.5	9	180
	-5.5	52	180
	-7.0	45	160
	-8.5	26	358
	-10.0	8	161
	-10.0	17	161
	-11.5	10	187
	-11.5	16	187
	-13.0	52	189
	-14.5	38	203
	-16.0	4	138
	-16.0	23	138
	-17.5	6	189
	-17.5	32	189
	-19.0	7	138
	-19.0	47	138
	-20.5	20	153
	-22.0	4	149
	-23.5	3	153
	-24.0	11	129
	-25.5	13	107
	-27.0	15	114
	-30.0	9	60
	-30.5	21	56
	-31.5	6	45
	-32.0	15	39
	-33.0	5	77
	-33.5	14	54
	-35.0	21	21
	-36.5	39	81
KIPP'S FARM: HILLSIDE AREA	-2.5	21	130
	-4.0	7	134
	-4.0	15	134
	-5.5	11	137
	-8.5	27	162
	-10.0	10	135
	-10.0	18	135

N160 vs. ED
STIFFNESS COMPARISON DATA SUMMARY

SITE	DEPTH (ft)	N160 (blows/ft)	ED (bars)	SITE	DEPTH (ft)	N160 (blows/ft)	ED (bars)
KIPP'S FARM: HILLSIDE AREA	-11.5	10	150	PLANTATION PIPELINE	-17.5	10	29
	-11.5	17	150		-19.0	8	30
	-13.0	19	142		-19.0	9	30
	-16.0	6	162		-20.5	9	41
	-17.5	10	164		-20.5	10	41
	-17.5	21	164		-22.5	10	49
	-19.0	22	173		-23.5	4	55
	-20.5	28	191		-24.0	9	53
	-21.5	4	200		-24.0	12	53
	-22.0	26	193		-25.5	10	105
	-23.0	8	292		-27.0	7	54
	-24.0	29	219		-27.0	15	54
	-25.5	26	302		-28.0	7	49
	-27.0	13	190		-28.5	12	53
	-28.0	9	229		-29.5	11	67
	-29.5	10	192		-30.0	13	76
	-30.0	10	148		-31.5	14	76
	-31.5	8	221		-31.5	14	76
	-33.0	4	299		-33.0	13	70
	-34.0	6	121		-34.0	10	113
	-34.5	5	91		-34.5	14	102
	-35.5	5	50		-34.5	16	102
	-37.5	6	22		-35.5	13	110
	-39.0	7	38		-36.0	14	127
	-40.5	26	63		-37.5	23	105
					-39.0	19	142
PLANTATION PIPELINE	-2.5	31	241		-39.0	20	142
	-2.5	35	241				
	-4.0	18	199	WINTERPOCK TAP	-2.5	28	183
	-4.0	31	199		-2.5	39	183
	-5.5	18	208		-4.0	20	310
	-5.5	29	208		-4.0	34	310
	5.5	30	208		-4.0	37	310
	-7.0	20	165		-5.5	24	241
	-8.5	20	116		-5.5	29	241
	-8.5	22	116		-5.5	38	241
	-10.0	17	89		-7.0	21	283
	-11.5	6	76		-7.0	26	283
	-11.5	9	76		-8.5	20	201
	-13.0	6	71		-8.5	27	201
	-13.0	10	71		-10.0	15	182
	-14.5	9	46		-10.0	19	182
	-16.0	12	34		-10.0	27	182
	-16.0	12	34		-11.5	18	161

N160 vs. ED
STIFFNESS COMPARISON DATA SUMMARY

SITE	DEPTH (ft)	N160 (blows/ft)	ED (bars)
WINTERPOCK TAP	-11.5	19	161
	-11.5	19	161
	-13.0	13	164
	-13.0	38	164
	-14.5	12	189
	-14.5	23	189
	-16.0	11	223
	-16.0	11	223
	-16.0	16	223
	-17.5	10	199
	-17.5	11	199
	-17.5	21	199
	-19.0	33	306
	-20.5	20	93
	-21.0	16	65
	-21.5	7	63
	-22.5	43	63
	-23.0	10	65
	-24.0	11	85
	-24.5	12	132
	-25.5	21	128
	-27.0	21	82
	-28.0	11	129
	-28.5	9	107
	-28.5	34	107
	-29.5	9	100
	-30.0	12	115
	-30.0	23	115
	-31.5	12	121
	-31.5	33	121
	-33.0	16	149
	-33.0	45	149
	-34.0	14	111
	-34.5	18	125
	-34.5	35	125
	-35.5	23	166
	-36.0	20	192
	-36.0	63	192
	-37.5	18	209
	-39.0	22	277
	-40.5	22	275
	-42.5	19	163

Qn vs. ED
STIFFNESS COMPARRISON DATA SUMMARY

SITE	DEPTH (ft)	Qn (bars)	ED (bars)
CARMEL	-1.0	59.4	106
CHURCH	-2.0	39.5	64
	-2.5	37.8	67
	-2.5	36.6	67
	-3.0	34.6	70
	-4.0	43.8	115
	-4.0	42.6	115
	-4.0	44.2	115
	-4.5	47.4	139
	-5.0	52.0	163
	-5.5	58.5	154
	-5.5	57.6	154
	-5.5	56.6	154
	-6.0	60.3	144
	-7.0	66.0	188
	-7.0	65.5	188
	-8.0	64.1	213
	-8.5	65.1	189
	-8.5	66.6	189
	-9.0	68.0	166
	-10.0	68.6	234
	-10.0	65.2	234
	-10.0	64.6	234
	-10.5	71.0	236
	-11.0	74.7	238
	-11.5	73.5	246
	-11.5	73.4	246
	-11.5	72.7	246
	-12.0	73.7	254
	-13.0	103.7	337
	-13.0	105.3	337
	-14.0	109.9	344
	-14.5	120.2	357
	-14.5	121.2	357
	-15.0	121.3	371
	-16.0	133.6	404
	-16.0	133.3	404
	-16.0	133.6	404
	-16.5	141.5	418
	-17.0	146.0	432
	-17.5	147.2	422
	-17.5	148.1	422
	-17.5	149.4	422
	-18.0	154.8	413
	-19.0	139.6	392
CARMEL	-19.0	137.3	392
CHURCH	-20.0	133.2	385
	-20.5	123.2	367
	-20.5	123.9	367
	-21.0	105.0	349
	-21.5	91.0	343
	-22.0	76.6	338
	-22.5	63.8	305
	-22.5	61.3	305
	-23.0	60.0	273
	-24.0	57.6	251
	-24.0	57.5	251
	-24.0	57.2	251
	-25.0	51.6	258
	-25.5	51.5	250
	-25.5	51.8	250
	-26.0	51.8	241
	-27.0	50.4	218
	-27.0	50.0	218
	-28.0	44.5	188
	-28.5	44.0	190
	-28.5	44.0	190
	-29.0	48.4	192
	-29.5	49.7	195
	-30.0	52.1	197
	-30.0	51.9	197
	-31.0	56.2	180
	-31.5	51.6	183
	-31.5	52.4	183
	-32.0	56.5	185
	-33.0	62.3	144
	-33.0	62.6	144
	-34.0	62.9	232
	-34.5	63.0	263
	-34.5	64.0	263
	-35.0	70.5	293
	-36.0	89.8	318
	-36.0	86.1	318
	-37.0	88.4	349
	-37.5	94.2	372
	-37.5	94.1	372
	-38.0	86.1	395
	-39.0	74.6	401
	-39.0	80.0	401
	-40.0	59.1	391

Qn vs. ED
STIFFNESS COMPARRISON DATA SUMMARY

SITE	DEPTH (ft)	Qn (bars)	ED (bars)
CARMEL CHURCH	-40.5	55.7	349
	-40.5	54.5	349
	-41.0	60.6	307
	-42.0	57.7	274
	-42.5	62.9	286
	-42.5	62.7	286
	-43.0	58.7	298
	-44.0	43.6	295
	-44.0	43.4	295
	-45.0	48.3	321
PEPPER'S FERRY	-1.0	48.6	46
	-2.0	44.8	66
	-2.5	39.9	65
	-2.5	39.9	65
	-3.0	36.2	64
	-4.0	19.1	52
	-4.0	19.5	52
	-5.0	19.6	63
	-5.5	21.2	66
	-5.5	20.4	66
	-6.0	18.5	70
	-7.0	16.2	62
	-7.0	15.8	62
	-8.0	12.3	49
	-8.5	12.0	44
	-8.5	12.2	44
	-9.0	10.1	39
	-9.5	9.3	29
	-10.0	9.9	28
	-10.0	9.1	28
	-11.0	8.7	29
	-11.5	9.2	28
	-11.5	9.2	28
	-12.0	9.6	27
	-13.0	6.7	21
	-14.0	11.7	32
	-15.0	15.6	35
	-16.0	13.8	67
	-17.0	10.0	84
	-18.0	88.0	73
	-18.5	136.7	214
LADY-SMITH	-1.0	103.7	158
	-2.0	63.4	50
LADY-SMITH	-2.5	32.3	39
	-2.5	29.5	39
	-3.0	21.4	28
	-4.0	19.6	18
	-4.0	19.6	18
	-5.0	40.2	59
	-5.5	118.9	106
	-5.5	128.4	106
	-8.0	117.6	183
	-8.5	105.7	212
	-8.5	115.0	212
	-9.0	119.3	241
	-10.0	67.9	244
	-10.0	66.1	244
	-11.0	83.8	375
	-11.5	94.2	393
	-11.5	94.1	393
	-11.5	95.7	393
	-12.0	99.1	410
	-13.0	104.0	395
	-13.0	102.4	395
	-14.0	99.1	356
	-14.5	95.2	358
	-15.0	93.6	360
	-16.0	92.9	395
	-17.0	89.8	364
	-17.5	91.1	372
	-18.0	89.0	380
	-19.0	97.1	343
	-20.0	106.3	404
	-20.5	113.2	425
	-21.0	115.1	445
	-22.0	112.4	467
	-22.5	113.6	469
	-23.0	110.1	472
	-24.0	104.4	488
	-25.0	102.5	461
	-25.5	98.4	468
	-26.0	94.8	475
	-27.0	88.0	451
	-28.0	83.8	438
	-28.5	85.7	424
	-29.0	89.1	410
	-30.0	89.3	381

Qn vs. ED
STIFFNESS COMPARRISON DATA SUMMARY

SITE	DEPTH (ft)	Qn (bars)	ED (bars)	SITE	DEPTH (ft)	Qn (bars)	ED (bars)
SCHNABEL	-1.0	97.5	368	KIPP'S FARM: HILLTOP AREA	-0.5	25.7	40.0
	-2.0	27.1	102		-1.0	34.1	86.7
	-2.5	26.1	93		-1.5	31.1	121.0
	-3.0	24.6	84		-2.0	29.3	120.3
	-4.0	18.8	100		-2.5	31.2	160.0
	-5.0	26.4	131		-3.0	24.2	159.0
	-5.5	24.0	125		-3.5	54.3	158.0
	-6.0	24.7	119		-4.0	47.6	121.7
	-7.0	30.0	149		-4.0	48.9	121.7
	-8.0	30.5	122		-4.5	42.5	158.0
	-8.5	34.0	141		-5.0	49.7	199.7
	-9.0	36.7	160		-5.5	48.1	180.0
	-10.0	33.7	117		-5.5	46.2	180.0
	-11.0	36.0	159		-6.0	36.5	141.0
	-11.5	41.2	179		-6.5	26.7	185.0
	-12.0	45.3	198		-7.0	40.5	160.0
	-13.0	50.7	244		-7.5	30.7	274.0
	-14.0	53.9	266		-8.0	33.0	192.7
	-14.5	55.3	276		-8.5	32.3	358.0
	-15.0	57.2	285		-9.0	41.1	167.7
	-15.5	56.0	289		-9.5	44.5	243.0
	-16.0	55.0	292		-10.0	43.7	160.7
	-17.0	68.1	279		-10.0	42.4	160.7
	-17.5	74.3	306		-10.5	57.0	216.0
	-18.0	82.3	333		-11.0	67.2	186.7
	-18.5	82.2	379		-11.5	72.4	187.0
	-19.0	57.5	425		-11.5	73.2	187.0
	-20.0	46.8	262		-12.0	51.5	159.0
	-21.0	56.3	277		-12.5	52.9	115.0
	-22.0	52.6	298		-13.0	75.0	189.0
	-23.0	48.7	296		-13.5	100.3	210.0
	-24.0	45.3	283		-14.0	95.7	192.3
	-25.0	47.0	263		-14.5	62.5	203.0
	-26.0	37.5	306		-15.0	91.1	154.0
	-27.0	35.2	222		-15.5	74.9	182.0
	-28.0	32.0	215		-16.0	70.2	138.0
	-29.0	29.3	213		-16.0	68.5	138.0
	-30.0	27.0	216		-16.5	49.2	147.0
					-17.0	48.4	168.7
					-17.5	32.7	189.0
					-17.5	35.1	189.0
					-18.0	46.4	154.0
					-18.5	48.3	167.0
					-19.0	41.8	138.3
					-19.0	46.7	138.3

Qn vs. ED
STIFFNESS COMPARRISON DATA SUMMARY

SITE	DEPTH (ft)	Qn (bars)	ED (bars)	SITE	DEPTH (ft)	Qn (bars)	ED (bars)
KIPP'S FARM: HILLTOP AREA	-19.5	37.8	156.0	KIPP'S FARM: HILLSIDE AREA	-10.5	37.9	153
	-20.0	28.9	137.7		-11.0	47.1	172
	-20.5	28.1	153.0		-11.5	54.9	150
	-21.0	27.1	126.3		-11.5	58.0	150
	-21.5	23.8	156.0		-12.0	36.7	128
	-22.0	31.3	148.7		-13.0	42.2	142
	-22.5	31.8	148.0		-14.0	27.6	120
	-23.0	30.9	126.7		-15.0	39.0	157
	-23.5	33.1	153.0		-16.0	27.2	162
	-24.0	47.2	129.0		-16.5	27.5	164
	-25.0	99.8	110.5		-17.0	33.7	167
	-25.5	113.4	107.0		-17.5	44.8	164
	-26.0	97.7	103.5		-17.5	44.0	164
	-27.0	46.1	114.0		-18.0	26.4	162
	-28.0	36.1	118.5		-19.0	23.9	173
	-29.0	26.2	58.5		-20.0	22.3	174
	-30.0	31.2	60.0		-20.5	30.3	191
	-30.5	86.1	55.5		-21.0	28.4	208
	-31.0	70.0	51.0		-21.5	25.3	200
	-31.5	66.7	44.8		-22.0	28.6	193
	-32.0	94.8	38.5		-23.0	19.8	292
	-33.0	28.5	77.0		-24.0	14.1	219
	-33.5	32.1	54.0		-25.0	19.7	331
	-34.0	30.5	31.0		-25.5	13.9	302
	-35.0	23.1	21.0		-26.0	14.8	274
	-36.0	20.8	31.0		-27.0	13.0	190
	-36.5	71.1	80.5		-28.0	10.8	229
	-37.0	23.3	130.0		-28.5	9.9	232
					-29.0	9.4	235
KIPP'S FARM: HILLSIDE AREA	-1.0	28.3	107		-29.5	19.8	192
	-2.0	32.4	128		-30.0	23.4	148
	-2.5	34.5	130		-31.0	44.6	206
	-3.0	36.0	131		-31.5	26.7	221
	-4.0	30.0	134		-32.0	16.8	236
	-4.0	30.3	134		-33.0	17.2	299
	-4.5	31.8	139		-34.0	21.2	121
	-5.0	32.2	143		-34.5	9.2	91
	-5.5	33.1	137		-35.0	26.9	60
	-6.0	27.4	132		-35.5	11.2	50
	-7.0	43.3	157		-36.0	4.5	40
	-8.0	41.2	148		-37.0	39.2	27
	-8.5	34.3	162		-37.5	13.5	22
	-9.0	35.2	175		-38.0	15.9	18
	-10.0	39.2	135		-39.0	43.7	38
	-10.0	38.1	135		-40.0	9.5	58

Qn vs. ED
STIFFNESS COMPARRISON DATA SUMMARY

SITE	DEPTH (ft)	Qn (bars)	ED (bars)
KIPP'S FARM: HILLSIDE AREA	-40.5	10.9	63
	-41.0	43.6	69
	-42.0	44.6	22
	-43.0	98.5	12
	-44.0	3.8	10
PLANTATION PIPELINE	-1.0	90.3	400
	-2.0	50.3	249
	-2.5	53.3	241
	-2.5	52.8	241
	-3.0	51.9	234
	-4.0	42.9	199
	-4.0	43.2	199
	-5.0	39.0	222
	-5.5	34.1	208
	-5.5	34.1	208
	5.5	34.6	208
	-6.0	32.6	194
	-7.0	26.9	165
	-8.0	23.4	124
	-8.5	20.9	116
	-8.5	21.5	116
	-9.0	20.2	108
	-10.0	17.8	89
	-10.5	18.6	81
	-11.0	16.8	72
	-11.5	14.4	76
	-11.5	16.0	76
	-12.0	15.1	79
	-13.0	13.8	71
	-13.0	13.3	71
	-14.0	12.4	50
	-14.5	11.3	46
	-15.0	12.5	42
	-16.0	9.7	34
	-16.0	10.1	34
	-17.0	10.6	30
	-17.5	12.2	29
	-18.0	10.9	28
	-19.0	11.3	30
	-19.0	11.0	30
	-20.0	11.7	37
	-20.5	12.1	41
	-20.5	12.0	41
	-21.0	12.7	44
PLANTATION PIPELINE	-22.0	14.5	42
	-22.5	13.2	49
	-23.0	12.1	57
	-23.5	12.0	55
	-24.0	11.8	53
	-24.0	12.5	53
	-25.0	12.4	94
	-25.5	14.3	105
	-26.0	13.9	116
	-27.0	25.8	54
	-27.0	26.9	54
	-28.0	13.8	49
	-28.5	15.2	53
	-29.0	12.0	58
	-29.5	13.2	67
	-30.0	20.0	76
	-31.0	15.6	86
	-31.5	15.6	76
	-31.5	15.6	76
	-32.0	15.6	66
	-33.0	22.8	70
	-34.0	17.6	113
	-34.5	18.1	102
	-34.5	17.7	102
	-35.0	18.7	92
	-35.5	19.6	110
	-36.0	18.2	127
	-37.0	22.1	93
	-37.5	19.1	105
	-38.0	20.7	116
	-39.0	20.1	142
	-39.0	21.0	142
	-40.0	22.5	157
	-41.0	24.8	149
	-42.0	46.2	136
	-43.0	27.2	194
	-44.0	21.9	198
	-45.0	24.9	201
WINTERPOCK TAP	-1.0	29.2	212
	-2.0	40.0	154
	-2.5	49.9	183
	-2.5	49.5	183
	-3.0	51.8	211
	-4.0	74.9	310

Qn vs. ED
STIFFNESS COMPARRISON DATA SUMMARY

SITE	DEPTH (ft)	Qn (bars)	ED (bars)
WINTER-POCK TAP	-4.0	72.7	310
	-4.0	70.5	310
	-4.5	52.3	273
	-5.0	66.1	237
	-5.5	81.5	241
	-5.5	81.8	241
	-5.5	79.6	241
	-6.0	74.9	245
	-7.0	70.8	283
	-7.0	71.3	283
	-8.0	74.7	217
	-8.5	53.5	201
	-8.5	52.4	201
	-9.0	45.8	186
	-10.0	41.1	182
	-10.0	40.7	182
	-10.0	39.8	182
	-10.5	31.4	170
	-11.0	26.9	158
	-11.5	27.3	161
	-11.5	26.2	161
	-11.5	26.0	161
	-12.0	24.5	164
	-13.0	21.2	164
	-13.0	21.3	164
	-14.0	21.4	157
	-14.5	22.3	189
	-14.5	23.7	189
	-15.0	57.0	220
	-16.0	62.7	223
	-16.0	61.6	223
	-16.0	59.0	223
	-17.0	37.0	224
	-17.5	20.5	199
	-17.5	20.6	199
	-17.5	20.8	199
	-18.0	16.2	175
	-19.0	31.4	306
	-20.0	37.9	122
	-20.5	63.7	93
	-21.0	85.7	65
	-21.5	67.7	63
	-22.0	36.8	61
	-22.5	76.3	63
	-23.0	33.1	65
WINTER-POCK TAP	-24.0	18.1	85
	-24.5	16.7	132
	-25.0	19.4	179
	-25.5	21.0	128
	-26.0	29.9	78
	-27.0	39.0	82
	-28.0	25.9	129
	-28.5	39.7	107
	-28.5	42.4	107
	-29.0	52.8	85
	-29.5	35.6	100
	-30.0	29.2	115
	-30.0	33.8	115
	-31.0	38.2	112
	-31.5	28.3	121
	-31.5	29.1	121
	-32.0	54.5	131
	-33.0	95.0	149
	-33.0	34.5	149
	-34.0	34.8	111
	-34.5	36.4	125
	-34.5	34.1	125
	-35.0	35.3	139
	-35.5	52.7	166
	-36.0	63.4	192
	-36.0	63.3	192
	-37.0	49.6	161
	-37.5	32.8	209
	-38.0	28.4	256
	-39.0	35.2	277
	-40.0	29.2	344
	-40.5	27.9	275
	-41.0	19.7	207
	-42.0	23.6	142
	-42.5	28.9	163
	-43.0	46.9	183

UNDRAINED SHEAR STRENGTH (Su) FROM IN-SITU TESTS COMPARISON VALUE DATA SUMMARY

SITE	DEPTH (ft)	SPT (bars)	CPT (bars)	DMT (bars)
PEPPER'S	-5.0	1.418	0.771	
FERRY	-5.5	1.182	0.887	
	-6.0	1.182	0.852	
	-7.0	1.182	0.708	
	-8.0	1.182	0.687	
	-8.5	1.182	0.543	
	-9.0	1.182	0.552	
	-9.5		0.458	0.073
	-10.0		0.428	
	-10.0	0.709	0.464	0.090
	-11.0	0.945	0.422	0.090
	-11.5		0.410	0.143
	-11.5	0.473	0.441	0.143
	-12.0	0.709	0.445	0.143
	-13.0		0.469	0.144
	-14.0	1.182	0.317	0.162
	-15.0		0.595	0.184
	-16.0		0.812	0.238
	-17.0		0.722	0.138
	-18.0	0.945	0.516	
SCHNABEL	-5.0		1.652	0.565
	-5.5	1.418	1.531	0.815
	-6.0		1.605	1.066
	-7.0	1.654	2.032	1.211
	-8.0		2.152	1.231
	-8.5	2.971	2.442	1.429
	-9.0		2.690	1.627
	-10.0	2.160	2.559	2.314
	-11.0		2.779	2.465
	-11.5	2.160	3.217	2.757
	-12.0		3.575	3.050
	-13.0	2.971	4.077	3.819
	-14.0		4.422	4.230
	-14.5	2.701	4.581	4.592
	-15.0		4.782	4.953
	-15.5		4.724	5.153
	-16.0	4.537	4.677	5.354
	-17.0		5.912	5.227

UNDRAINED SHEAR STRENGTH (Su) FROM IN-SITU TESTS
COMPARISON VALUE DATA SUMMARY

SITE	DEPTH (ft)	SPT (bars)	CPT (bars)	DMT (bars)
SCHNABEL	-17.5	4.285	6.516	5.827
	-18.0		7.288	6.428
	-18.5		7.343	7.144
	-19.0	6.301	5.156	7.859
	-20.0		4.250	4.185
	-21.0		5.216	4.017
	-22.0		4.948	4.724
	-23.0		4.652	4.343
	-24.0		4.384	3.813
	-25.0		4.625	3.684
	-26.0		3.726	3.706
	-27.0		3.538	2.883
	-28.0		3.260	2.750
	-29.0		3.019	2.581
	-30.0		2.804	2.239
LADYSMITH	-10.0	2.701	4.328	1.517
	-10.0	5.293	4.216	1.517
	-11.0		5.472	4.909
	-11.5	4.537	6.230	6.133
	-11.5	5.041	6.226	6.133
	-11.5	14.367	6.335	6.133
	-12.0		6.636	7.357
	-13.0	8.318	7.125	8.132
	-13.0	17.140	7.009	8.132
	-14.0		6.937	7.412
	-14.5	13.863	6.736	7.196
	-15.0		6.693	6.980
	-16.0	17.140	6.791	6.804
	-17.0		6.697	6.993
	-17.5	15.123	6.863	7.098
	-18.0		6.777	7.203
	-19.0	12.099	7.541	6.938
	-20.0		8.433	8.646
	-20.5	15.123	9.070	9.003
	-21.0		9.309	9.360
	-22.0		9.265	0.305
	-22.5	16.888	9.447	5.005
	-23.0		9.241	9.706

UNDRAINED SHEAR STRENGTH (Su) FROM IN-SITU TESTS
COMPARISON VALUE DATA SUMMARY

SITE	DEPTH (ft)	SPT (bars)	CPT (bars)	DMT (bars)
LADYSMITH	-24.0	16.888	8.925	9.156
	-25.0		8.917	9.380
	-25.5	17.392	8.632	8.981
	-26.0		8.385	8.581
	-27.0	16.383	7.911	8.300
	-28.0		7.658	8.186
	-28.5	16.131	7.902	8.057
	-29.0		8.282	7.929
	-30.0		8.436	4.437
KIPP'S	-2.5	2.431	1.171	
FARM:	-4.0	1.182	1.914	0.739
HILLTOP	-4.0	3.781	1.970	0.739
AREA	-4.5		1.745	1.329
	-5.0		2.087	0.460
	-5.5	1.418	2.066	1.251
	-5.5	8.570	1.985	1.251
	-6.0		1.593	0.749
	-7.0	7.814	1.840	1.282
	-7.5		1.422	1.843
	-8.0		1.555	0.721
	-8.5	4.789	1.558	
	-9.0		2.014	1.313
	-9.5		2.237	1.766
	-10.0	1.418	2.226	1.076
	-10.0	3.241	2.157	1.076
	-10.5		2.986	1.304
	-11.0		3.561	1.382
	-11.5	1.890	3.936	1.542
	-11.5	3.241	3.983	1.542
	-12.0		2.813	1.219
	-12.5		2.959	0.849
	-13.0	11.342	4.255	1.136
	-13.5		5.844	1.130
	-14.0		5.622	0.690
	-14.5	8.822	3.739	1.075
	-15.0		5.507	0.971
	-15.5		4.632	0.916
	-16.0	0.945	4.358	0.850

UNDRAINED SHEAR STRENGTH (Su) FROM IN-SITU TESTS
COMPARISON VALUE DATA SUMMARY

SITE	DEPTH (ft)	SPT (bars)	CPT (bars)	DMT (bars)
KIPP'S FARM: HILLTOP AREA	-16.0	5.545	4.253	0.850
	-17.0		3.069	0.566
	-17.5	1.418	2.100	
	-17.5	8.066	2.262	
	-18.0		3.024	0.541
	-18.5		3.221	0.761
	-19.0	1.654	2.788	0.757
	-19.0	12.099	3.122	0.757
	-19.5		2.566	0.875
	-20.0		1.957	0.786
	-20.5	5.545	1.940	0.958
	-21.0		1.879	0.867
	-21.5		1.671	1.003
	-22.0	0.945	2.233	0.943
	-22.5		2.322	1.059
	-23.0		2.231	0.883
	-23.5	0.945	2.464	1.186
	-24.0	3.241	3.533	1.027
	-25.0		7.594	0.866
	-25.5	3.781	8.684	0.797
	-26.0		7.512	0.728
	-27.0	4.537	3.531	0.696
	-28.0		2.773	0.348
	-29.0		1.451	0.493
	-30.0	1.890	1.730	0.275
	-30.5	4.537	4.894	0.183
	-31.0		4.001	0.090
	-31.5	1.182	3.826	0.110
	-32.0	3.241	5.481	0.130
	-33.0	1.418	2.270	
	-33.5	4.285	2.576	
	-35.0	6.553	1.850	
	-36.5	12.603	5.970	
KIPP'S FARM: HILLSIDE AREA	-2.5	2.971	1.301	
	-4.0	0.945	1.207	
	-4.0	2.160	1.217	
	-5.5	1.654	1.416	
	-7.0		1.968	1.463

UNDRAINED SHEAR STRENGTH (Su) FROM IN-SITU TESTS
COMPARISON VALUE DATA SUMMARY

SITE	DEPTH (ft)	SPT (bars)	CPT (bars)	DMT (bars)
KIPP'S FARM: HILLSIDE AREA	-8.0		1.950	0.865
	-8.5	5.041	1.646	0.996
	-9.0		1.723	1.126
	-10.0	1.890	1.994	0.973
	-10.0	3.511	1.938	0.973
	-11.5	1.890	2.955	
	-11.5	3.511	3.127	
	-12.0		1.993	0.569
	-13.0	4.033	2.373	0.604
	-14.0		1.579	0.580
	-16.0	1.418	1.651	0.657
	-16.5		1.691	0.637
	-17.0		2.117	0.616
	-17.5	2.431	2.870	0.653
	-17.5	5.293	2.821	
	-18.0		1.685	
	-19.0	5.797	1.559	
	-20.5	7.562	2.076	
	-21.5	0.945	1.766	
	-22.0	7.310	2.028	
	-23.0	2.160	1.412	
	-24.0	8.318	0.996	
	-25.5	7.562	0.994	
	-27.0	3.781	0.935	
	-28.0	2.701	0.771	
	-29.5	2.971	1.512	
	-30.0	2.971	1.813	
	-31.5	2.431	2.108	
	-33.0	1.182	1.344	
	-34.0	1.890	1.691	
	-34.5	1.418	0.682	
	-35.5	1.418	0.852	
	-37.5	1.890	1.076	
	-39.0	2.160	3.755	
	-40.5	8.822	0.864	
PLANTATION PIPELINE	-1.0		3.184	
	-2.0		1.866	
	-2.5	4.537	2.028	

UNDRAINED SHEAR STRENGTH (Su) FROM IN-SITU TESTS
COMPARISON VALUE DATA SUMMARY

SITE	DEPTH (ft)	SPT (bars)	CPT (bars)	DMT (bars)
PLANTATION	-2.5	5.041	2.007	
PIPELINE	-4.0	2.701	1.749	
	-4.0	4.789	1.760	
	-5.0		1.659	0.997
	-5.5	2.971	1.481	1.197
	-5.5	4.789	1.483	1.197
	-5.5	5.041	1.503	1.197
	-6.0		1.443	1.397
	-7.0	3.511	1.236	1.109
	-8.0		1.109	0.823
	-8.5	3.781	0.997	0.769
	-8.5	4.033	1.025	0.769
	-9.0		0.968	0.715
	-10.0	3.241	0.861	0.618
	-10.5		0.912	0.582
	-11.0		0.822	0.545
	-11.5	1.182	0.708	0.538
	-11.5	1.654	0.786	0.538
	-12.0		0.747	0.530
	-13.0	1.182	0.686	0.254
	-13.0	1.890	0.661	0.254
	-14.0		0.622	0.365
	-14.5	1.654	0.567	0.377
	-15.0		0.636	0.389
	-16.0	2.431	0.489	0.343
	-16.0	2.431	0.512	0.343
	-17.0		0.544	0.304
	-17.5	1.890	0.632	0.292
	-18.0		0.566	0.281
	-19.0	1.654	0.596	0.280
	-19.0	1.890	0.578	0.280
	-20.0		0.624	0.283
	-20.5	1.890	0.651	0.297
	-20.5	2.160	0.643	0.297
	-21.0		0.689	0.311
	-22.0		0.803	0.341
	-22.5	2.160	0.729	0.352
	-23.0		0.664	0.363
	-23.5	0.945	0.666	0.331

UNDRAINED SHEAR STRENGTH (Su) FROM IN-SITU TESTS COMPARISON VALUE DATA SUMMARY

SITE	DEPTH (ft)	SPT (bars)	CPT (bars)	DMT (bars)
PLANTATION	-24.0	1.890	0.654	0.299
PIPELINE	-24.0	2.701	0.696	0.299
	-25.0		0.702	0.127
	-25.5	2.160	0.817	0.169
	-26.0		0.801	0.210
	-27.0	1.654	1.547	0.310
	-27.0	3.511	1.616	0.310
	-28.0	1.654	0.808	0.309
	-28.5	2.701	0.902	0.308
	-29.0		0.700	0.306
	-29.5	2.701	0.785	0.377
	-30.0	3.241	1.223	0.448
	-31.0		0.950	0.419
	-31.5	3.511	0.959	0.406
	-31.5	3.511	0.959	0.406
	-32.0		0.964	0.392
	-33.0	3.241	1.453	0.411
	-34.0	2.431	1.118	0.251
	-34.5	3.511	1.155	0.364
	-34.5	4.033	1.127	0.364
	-35.0		1.199	0.476
	-35.5	3.241	1.272	0.537
	-36.0	3.511	1.178	0.597
	-37.0		1.468	0.465
	-37.5	6.049	1.264	0.535
	-38.0		1.384	0.605
	-39.0	5.041	1.355	0.401
	-39.0	5.293	1.416	0.401
	-40.0		1.544	0.334
	-41.0		1.728	0.724
	-42.0		3.321	0.290
	-43.0		1.941	0.977
	-44.0		1.564	0.273
	-45.0		1.810	0.333
WINTERPOCK	-2.5	4.033	1.890	
TAP	-2.5	5.545	1.872	
	-4.0	2.971	3.047	0.736
	-4.0	5.293	2.958	0.736

UNDRAINED SHEAR STRENGTH (Su) FROM IN-SITU TESTS
COMPARISON VALUE DATA SUMMARY

SITE	DEPTH (ft)	SPT (bars)	CPT (bars)	DMT (bars)
WINTERPOCK	-4.0	5.797	2.867	0.736
TAP	-4.5		2.172	0.368
	-5.0		2.811	
	-5.5	4.033	3.550	
	-5.5	4.789	3.560	
	-5.5	6.301	3.464	
	-6.0	0.000	3.330	
	-7.0	3.781	3.276	
	-7.0	4.537	3.298	
	-8.0		3.604	0.366
	-8.5	3.781	2.621	0.526
	-8.5	5.041	2.567	0.526
	-9.0		2.280	0.686
	-10.0	2.971	2.114	0.335
	-10.0	3.781	2.095	0.335
	-10.0	5.293	2.046	0.335

VITAE

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Education:	BS, Civil Engineering Virginia Military Institute, 1976
	MS, Civil Engineering University of Virginia, 1983
Professional	Virginia Professional Engineer License #12221 American Society of Civil Engineers
Employment:	
Aug.'90 present	Assistant Professor, Civil Engineering Texas Tech University, Lubbock, TX
Aug.'87 Aug.'90	Graduate Research Assistant V.P.I. & SU, Blacksburg, Virginia
May '86 Aug.'87	Budget Analyst, Virginia Power, East Richmond District office. I planned and tracked the budget for a 100+ person service and construction office
Jan.'82	Supervisor, Transmission and Substation Siting, Virginia Power, Richmond, VA. My section located, investigated and licensed transmission line and substation facilities throughout the Virginia Power service territory.
Jan.'78 Jan '82	Engineer, Virginia Power, Transmission and Distribution Engineering, Richmond, VA. My work involved the design and construction inspection of transmission line structures and foundations. Several projects required the field design of foundations while working with contrac forces.
Jan.'77 Jan.'78	Staff Engineer, Soil & Material Engineers, Spartanburg, SC. S & ME is a full service geotechnical and materials testing firm.
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