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F-Area Geotechnical Characterization Report (U)

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Executive Summary and Report

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F-Area Geotechnical Characterization Report (U)

Site Geotechnical Services Department

Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

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SAVANNAH RIVER SITE

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Approvals:

M. R. Lewis — 9/30/96

M. R. Lewis, Manager, Geotechnical Engineering, SGS Department — Date

L. A. Salomone — 9/30/96

L. A. Salomone, Site Chief Geotechnical Engineer, SGS Department — Date

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

A geotechnical study has been completed in the F-Area at the Savannah River Site (SRS) in South Carolina. The study consisted of reviewing previous geotechnical and geologic data and reports, and performing subsurface field explorations, field and laboratory testing, and engineering analyses. The purpose of this investigation was to characterize the foundation material in the F-Area. The objectives of the study were to establish the site-specific geological conditions, obtain representative engineering properties of the subsurface and the fill materials under structural loads, evaluate the lateral and vertical extent of soft zones, slope stability, liquefaction potential, and potential settlements of subsurface materials. This work was done in compliance with DOE Order 420.1.

Background

The F-Area is located in the General Separation Area (GSA) of the central part of the SRS (see Figure ES-1). F-Area can be described as three sub-areas: F-Separations, F-Tank Farm, and balance of the F-Area. Primary facilities in the F-Separations consist of F-Canyon, Naval Fuel Facility, Sand Filters, and proposed site for the Actinide Packaging and Storage Facility. F-Tank Farm consists of 22 high-level radioactive waste tanks; these tanks were built of carbon steel and reinforced concrete. The balance of the F-Area contains Service Area and outlying areas. Figure ES-2 shows the aerial view of the F-Area, with F-Separations in the northern portion and F-Tank Farm in the southwestern portion of the area.

Investigations

The field investigations and testing included the following:

- 40 piezocone penetration test soundings (CPTU), 38 of which were seismic piezocone penetration test soundings (SCPTU) used to determine shear-wave velocities using the down-hole technique
- 12 exploratory boreholes, to a maximum depth of 180 feet, from which samples were retrieved for laboratory testing
- one shallow high resolution seismic reflection survey consisting of three lines
- incorporating data from 98 existing boreholes from previous investigations.

In the laboratory, representative samples of the various strata were classified with respect to their plasticity and gradation characteristics, natural water content, and density. Triaxial shear and consolidation tests were performed to define the strength and the compressibility of the soils under static loads. Since the soils in F-Area were found to be very similar to those soils previously tested in H-Area, new laboratory tests for dynamic strength and properties were not required, and the test results from H-Area and other sitewide studies were used.

Geology and Shallow Stratigraphy

Eocene and Miocene sediments within the GSA (i.e., F-Area, H-Area, and the Burial Grounds) consist of unconsolidated deposits of sands, and silty to clayey sands. Shallow sediments of the Altamaha, Tobacco Road, and Upper Dry Branch Formations are generally silty to clayey sands. Carbonate-rich horizons, of Eocene age, are found sporadically in the lower Dry Branch and underlying Santee Formations. These carbonate horizons are interspersed with sands and clays in a complex manner. In general, these carbonate buildups (layers) appear to be oriented northeast-southwest and parallel the strike of the coastal shoreline at the time of deposition.

Weight of rod and occasional rod drops have occurred in calcareous sediments as described in numerous drilling reports for the GSA. Most of these "soft zones" are sediment-filled with a fine-grained sand. In F-area, these sediments are prevalent especially in the F-Tank Farm area. Grouting programs initiated by the Corps of Engineers (COE) in the 1950's to remediate these soft zones prior to construction were followed by successive remediation programs as new groups of tanks were constructed. An evaluation of soft zones, carbonate and calculated "grout takes" show conditions comparable to other areas of SRS that have been grouted.

Exploratory work completed during this investigation, supplemented with information from previous work in the F-area, show subsurface conditions to be directly comparable to the H-Tank Farm. A direct comparison of the shallow stratigraphy and average engineering properties between the F and H Areas has shown these areas to be similar.

Embankment Fill and Slope Stability

Slope stability analyses for the embankment fill in the F-Tank Farm were completed for static and pseudostatic conditions. The analysis included an evaluation of F-Area soil-strength parameters for use in other F-Area calculations. The results of the stability analyses show that the embankment slope is stable under the conditions analyzed. Predicted seismic slope deformation is negligible.

Liquefaction

The liquefaction potential of the soils at the site was evaluated both qualitatively and quantitatively. The results showed that neither the Tobacco Road nor Dry Branch

Formations are susceptible to liquefaction for the Performance Category (PC) 3 ground-motion discussed in Section 4.1.1. Measured shear wave velocities, grain size, and plasticity results from each formation show that potential for seismic liquefaction is very low. Quantitatively, the stress approach shows that the potential for seismic liquefaction in the Tobacco Road and Dry Branch Formations is negligible.

Bearing Capacity

Bearing capacities of the soils were computed for various foundations in the F-Separations and F-Tank Farm. Results indicated that the soils in the F-Area generally provide adequate strength for the foundations with static loading up to 6 ksf. However, for certain configurations of foundation on the fill, the average allowable bearing capacity may only be 1.7 ksf. For proposed new foundations bearing on fill, site specific-evaluations are recommended, because the quality of the fill is suspect.

Expected Settlement

An assessment of settlements of tanks and other structures bearing on natural deposits in F-Area was performed using actual measured performance data. Based on evaluation of this data, it is concluded that the soils at F-Area are slightly to moderately over-consolidated, and, settlement is not a concern for structures with static loading not exceeding 6 ksf.

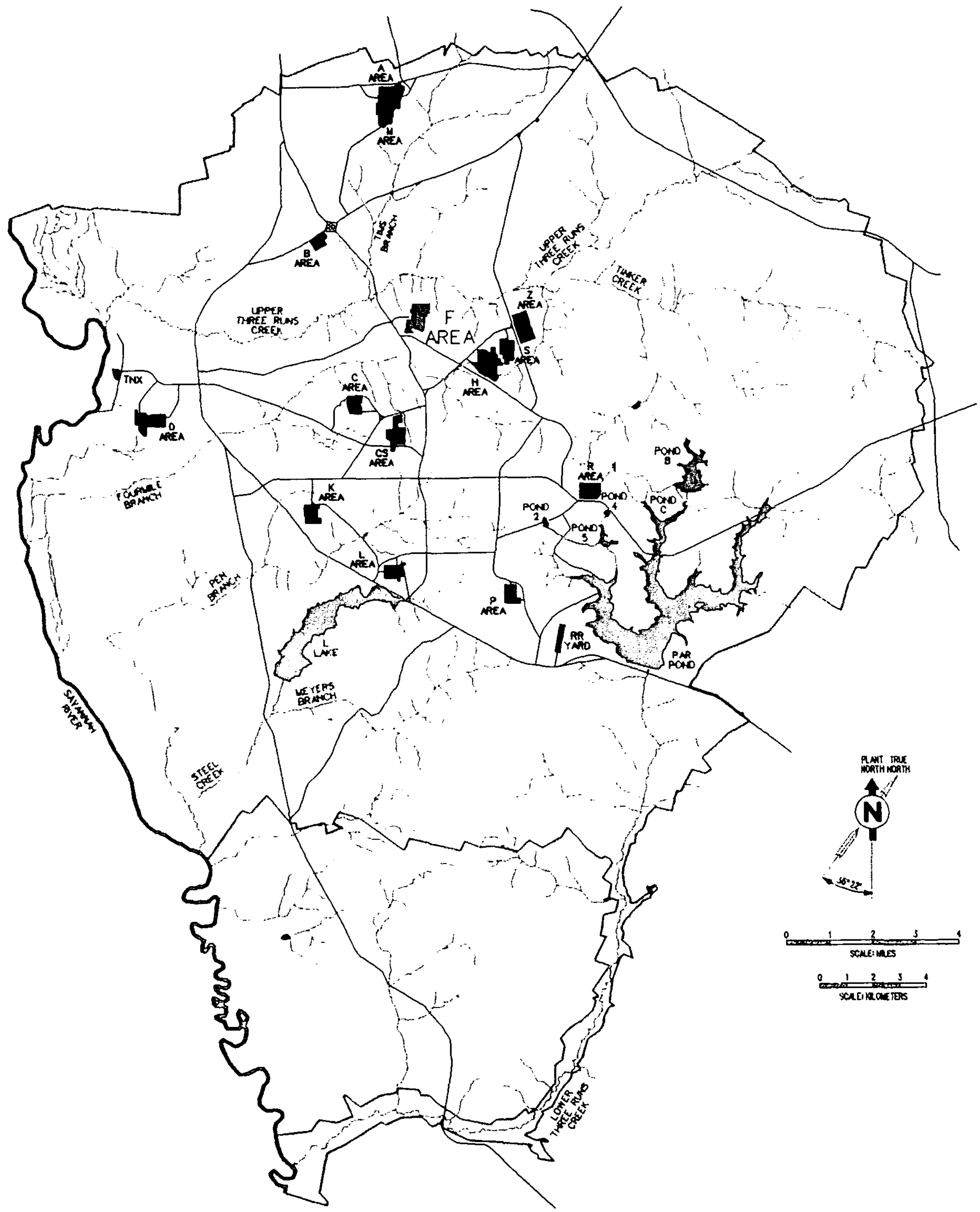

Figure ES-1 Savannah River Site Map

Figure ES-2 F-Area Aerial View

TABLE OF CONTENTS

TABLE OF CONTENTS

VOLUME 1

VOLUME 4

VOLUME 5

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF PLATES

LIST OF PLATES

ACRONYMS, SYMBOLS
AND TERMINOLOGY

LIST OF ACRONYMS, SYMBOLS AND TERMINOLOGY

A_m	maximum crest acceleration
a_{max}	peak horizontal ground acceleration
APSF	Actinide Packaging and Storage Facility
ARA	Applied Research Associates
arkosic	a sandstone or sand containing more than 25% feldspar
ASTM	American Society for Testing Materials
A_y	yield acceleration
B	foundation width
biomoldic	composed of, or containing shell molds
bpf	blows per foot
BSRI	Bechtel Savannah River, Inc.
c	total cohesion
c'	effective cohesion
calcareous	containing calcium carbonate
carbonate	a compound containing the radical CO_3^{+2}
CBR	California Bearing Ratio Test
C_c	cmpression index
CD	consolidated drained triaxial test
Cenozoic	Geological Era from 65 mybp to present
cf	cubic feet
CH	highly plastic clay
clastic	consisting of fragments of rock that have been transported
CLSM	Controlled Low Strength Material
C_n	vertical effective stress correction factor for SPT-N
COE	Corps of Engineers
CPT	cone penetration test sounding
CPTU	piezocone penetration test sounding
C_r	recompression index (static settlement)
Cretaceous	Geological Period from 136 mybp to 65 mybp
CSRE	cyclic stress ratio generated by the earthquake

CSRL	cyclic stress ratio required to induce liquefaction in the soil
CU	consolidated undrained triaxial test
Cv	coefficient of consolidation
C_w	water table correction factor
D	foundation depth
D_{50}	mean grain size
DB1	Dry Branch Layer 1
DB1/DB3	Dry Branch Layers 1 through 3
DB2	Dry Branch Layer 2
DB3	Dry Branch Layer 3
DB4	Dry Branch Layer 4
DB4/DB5	Dry Branch Layers 4 through 5
DB5	Dry Branch Layer 5
DBE	Design Basis Earthquake
deltaic	of, or produced by, deltas
Devonian	Geological Period from 395 mybp to 345 mybp
DOE	Department of Energy
D_r	relative density
DuPont	E. I. DuPont de Nemours, Inc.
D_w	depth of the groundwater table
DWPF	Defense Waste Processing Facility
EBE	Evaluation Basis Earthquake
El	Elevation relative to Mean Sea Level
e_o	initial void ratio
Eocence	Geological Epoch from 38 mybp to 54 mybp
EPRI	Electric Power Research Institute
facies	general appearance of one part of a rock or sedimentary body
feldspathic	containing feldspar
fluvial	produced by river action
fps	feet per second
fr or FR	CPT friction ratio
FS	factor of safety

ft	foot or feet
g	acceleration of gravity
G	shear modulus
GC	Green Clay
GEI	Geotechnical Engineers, Inc.
glauconite	a green mineral closely related to the micas, commonly of marine origin
G_{max}	low strain shear modulus
GSA	General Separations Area
GWT	groundwater table
H	layer thickness
HCl	hydrogen chloride
HLW	High Level Waste
Holocene	Geological Epoch from 10,000 years to present
HTF	H-Area Tank Farm
Hz	Hertz, cycles per second
Ip	plastic index
ISO	International Standards Organization
ITP	In-Tank Precipitation Facility
Jurassic	Geological Period from 190 mybp to 136 mybp
K	modulus of subgrade reaction
kaolin	a common hydrous, aluminum silicate, clay mineral
kaolinitic	of or containing kaolin
KASS	K-Area Soil Stabilization
kip	1,000 pounds
km	kilometer
ksf	Kips per square foot
L	foundation length
LAW	Law Engineering
LETCO	Law Engineering Testing Company
lignite	a brown-black, low grade coal
lithofacies	the rock record of any sedimentary environment

LL	liquid limit
LLNL	Lawrence Livermore National Laboratory
M	Magnitude
m/sec	meters per second
Mesozoic	Geological Era from 225 mybp to 65 mybp
MH	high plasticity silt
micaceous	containing mica
Miocene	Geological Epoch from 26 mybp to 7 mybp
ML	low plasticity silt
mm	millimeter
MRCE	Mueser Rutledge Consulting Engineers
MRJD	Mueser, Rutledge, Johnston, & DeSimone
MRWJ	Mueser, Rutledge, Wentworth, & Johnston
MSL	mean sea level, ft
mybp	million years before present
N-value	Sum of second and third set of recorded blows from the SPT
N_1	SPT N-value normalized to 1 tsf
$(N_1)_{60}$	SPT N-value normalized to 1 tsf and 60% max. hammer energy ratio
N_c, N_q, and N_γ	bearing capacity factors
NRC	Nuclear Regulatory Commission
OCR	overconsolidation ratio
OD	outside diameter
Oligocene	Geological Epoch from 38 mybp to 26 mybp
Ordovician	Geological Period from 500 mybp to 430 mybp
P	P-wave, compressional seismic wave
p - q	total stress path strength parameters
p' - q'	effective stress path strength parameters
Paleocene	Geological Epoch from 65 mybp to 54 mybp
Paleozoic	Geological Era from 570 mybp to 225 mybp
PC	Performance Category
p_c	preconsolidation pressure

pcf	pounds per cubic foot
pci	pounds per cubic inch
Pennsylvanian	Geological Period from 325 mybp to 280 mybp
Permian	Geological Period from 280 mybp to 225 mybp
pga	peak ground acceleration
PI	plasticity index
PL	plastic limit
Pleistocene	Geological Epoch from 2.5 mybp to 10,000 years before present
Pliocene	Geological Epoch from 7 mybp to 2.5 mybp
psf	pounds per square foot
psi	Pounds per square inch
PSV	pseudospectral velocity
PTL	Pittsburgh Testing Laboratories
Q	crustal structure
QA	quality assurance
Q_a	allowable bearing pressure
q_c or Q_c	CPT tip resistance
$(q_c)_1$	CPT tip resistance normalized to 1 ton per square foot
QC	quality control
Quaternary	Geological Period from 2.5 mybp to present
RBOF	Receiving Basin for Offsite Fuel
RCA	Radiologically Controlled Areas
Recent	Geological Epoch from 10,000 years to present (i.e., Holocene)
RSA	rock spectral acceleration
RTF	Replacement Tritium Facility
r_u	pore water pressure ratio = $\Delta u/\sigma_0'$
SAIC	Science Application International Corporation
SC	clayey sand
S_c, S_q, and S_γ	shape factors
SCPTU	seismic piezocone penetration test sounding
SEP	Separations

SGS	Site Geotechnical Services
siliciclastic	Composed predominately of clastic sediments rich in silica
SM	silty Sand
SP	poorly graded sand
SPT	Standard Penetration Test
SRP	Standard Review Plan
SRS	Savannah River Site
SSE	Safe Shutdown Earthquake
ST	Shelby tube (soil sampling)
ST	Santee/Tinker Formation
ST1	Santee/Tinker Formation Layer 1
ST2	Santee/Tinker Formation Layer 2
STD	standard
t	time
TCC	Test controlled compaction
terrigenous	Deposited in or on the earth's crust
Tertiary	Geological Period from 65 mybp to 2.5 mybp
TR1	Tobacco Road Layer 1
TR1A	Tobacco Road Layer 1A
TR1B	Tobacco Road Layer 1B
TR2	Tobacco Road Layer 2
TR3	Tobacco Road Layer 3
TR3/TR4	Tobacco Road Layers 3 through 4
TR4	Tobacco Road Layer 4
Triassic	Geological Period from 225 mybp to 190 mybp
tsf	tons per square foot
TX	triaxial
UD	undisturbed
UHS	Uniform Hazard Spectra
US	United States
USACOE	United States Army Corps of Engineers

USNRC	U. S. Nuclear Regulatory Commission
UU	Unconsolidated Undrained Triaxial Test
v_s	S-wave velocity
$(v_s)_1$	S-wave velocity normalized to 1 ton per square foot
WC	water content (moisture content)
WSRC	Westinghouse Savannah River Company
Z_w	distance from the foundation to the groundwater
α	total stress path angle
α'	effective stress path angle
Δp	change in load or applied load
ΔS	settlement
ε	shear strain
ε_r	reference strain
ϕ	total friction angle
ϕ'	effective friction angle
γ	unit weight of soil
γ_s	submerged unit weight of soil
ρ	mass density of the soil
σ_1, σ_3	principal normal stresses
σ_o'	initial effective vertical stress
σ_v'	effective vertical stress
σ_{vo}	initial total vertical stress
τ	shear stress
υ	Poisson's ratio

1. INTRODUCTION

A geotechnical program has been completed in F-Area at the Savannah River Site (SRS) in South Carolina. The program consisted of a literature search for relevant technical data, field exploration, field and laboratory testing, and analyses. Figure 1.0-1 shows the layout of the F-Area.

This geotechnical program also integrated information from several recent geotechnical investigations and studies: F-Canyon Geotechnical Investigation; F-Tank Farm Geotechnical Investigation; Actinide Packaging and Storage Facility; F-Area Structural settlement review; and F-Area backfill study.

This geotechnical program was performed by SRS Engineering and Construction Services Division, Site Geotechnical Services (SGS) Department; in conformance with DOE Order 420.1 (DOE, 1995b) and Procedure Manual E7, "Conduct of Engineering and Technical Support," Procedure No. 3.60, "Technical Report" (WSRC, 1996e).

1.1 Purpose and Objectives

The purpose of the investigation was to obtain geotechnical information to characterize the foundation materials in F-Area under static and dynamic loading conditions. The geotechnical engineering objectives of the investigation were to

- define the subsurface stratigraphy
- obtain representative engineering properties of the subsurface and fill materials
- assess the behavior of the subsurface and fill materials under structural loads
- evaluate the lateral and vertical extent of soft zones
- evaluate the slope stability
- determine potential settlement

Five major areas of study and analyses were completed and are presented in this report: Seismology; Geology; Behavior of Fill Materials; Settlement of Foundation Soils; and Slope Stability.

1.1.1 Report Organization

This report is organized in the following sequence: Executive Summary; Table of Contents; List of Tables; List of Figures; List of Plates; Acronyms, Symbols, and Terminology; text; appendices; tables; figures; plates; and attachments.

The text of this report includes seven sections. These sections are: Section 1, Introduction; Section 2, Subsurface Conditions; Section 3, Engineering Properties; Section 4, Engineering Evaluations; Section 5, Summary; Section 6, Conclusions and Recommendations; and Section 7, References.

Appendices of this report include: Appendix A, Summary of Previous Investigations; Appendix B, Seismology; Appendix C, Geology; Appendix D, Subsurface Exploration; and Appendix E, Laboratory Testing.

Subsequent to the appendices are tables, figures, and attachments. Attachments of this report include: Attachment I, Borehole Logs; Attachment II, Laboratory Test Results; and Attachment III, Cone Penetration Test Soundings.

This report is divided into five volumes: Volume 1 contains the Executive Summary, text, tables, figures, and appendices; Volume 2 contains the maps; Volume 3 contains the cross-sections; Volume 4 contains Attachments I and II; and Volume 5 contains Attachment III.

1.2 Background

F-Area is located in the General Separation Area (GSA) of the central part of SRS, at the north of Road C and Road E intersection. F-Area can be described as three sub-areas, F-Separations, F-Tank Farm, and balance of the F-Area. Primary facilities in F-Separations consist of F-Canyon, Naval Fuel Facility, Sand Filters, and proposed site for the Actinide Packaging and Storage Facility (APSF). Primary facilities in F-Tank Farm consist of waste storage tanks, pump pits, and diversion boxes. The balance of the F-Area contains service area and outlying areas.

Section 1.2.1 describes the F-Tank Farm, Section 1.2.2 describes the F-Separations, and section 1.2.3 describes the balance of F-Area.

1.2.1 F-Tank Farm

The F-Tank Farm is located in the south-west portion of the F-area. Figure 1.2-1 shows an aerial view of the F-Tank Farm.

A total of 22 high-level radioactive waste tanks are located in the F-Area Tank Farm. These tanks were built of carbon steel and reinforced concrete. Four different types of waste storage tanks are used at SRS and three of these types are used in the F-Area Tank Farm. Figure 1.2-2 shows the locations of the F-Area tanks. Figure 1.2-3 shows three types of tanks for the F-Area Tank Farm. Type I consists of a 5-foot-high secondary pan. Type III consists of a full-height secondary tank. Type IIIA is a variation of Type III with a moderately inclined roof and additional reinforcing steel in the concrete. Type IV consists of a single steel wall and supported by prestressed concrete. F-Area Tank farm includes eight Type I tanks, No. 1 through 8; ten Type III Tanks, No. 25 through 28, 33, 34, and 44 through 47; and four Type IV Tanks, No. 17 through 20.

Three different forms of waste are stored in these tanks: concentrated saltcake resulting from evaporation operations, sludge, and supernate. Each tank contains a different amount of waste. The present content level of each tank is shown in Figure 1.2-4. All Type III Tanks in the F-Area Tank Farm are active, while Type I and Type IV tanks are inactive (WSRC, 1995b).

1.2.2 F-Separations

The F-Area Separations facilities occupy the northern section of F-Area. Figure 1.2-5 shows the layout of these facilities. Major Separation Facilities include Building 221-F, F-Canyon; Building 247-F, Naval Fuel Facility; Building 235-F, Plutonium Fabrication Facility; Buildings 294-1F and 294-2F, Sand Filters; and the proposed APSF.

F-Canyon is located in the western part of F-Separations. Figure 1.2-6 shows the aerial view of the facility.

The Naval Fuel Facility is located in the northern part of the F-Separations. Figure 1.2-7 shows the aerial view of the facility.

Two sand filters are located in the south eastern part of F-Separations. Building 294-1F sand filter is located south west of Building 235-F. Building 294-2F sand filter is located north of Building 235-F.

The proposed APSF will be located in the north eastern part of the F-Separations. Figure 1.2-8 shows the site of the APSF. The APSF will provide for stabilization and repacking of Special Nuclear Material for interim term storage. The APSF will consist of a reinforced concrete-hardened structure and an administrative area.

1.2.3 The Balance of F-Area

The balance of F-Area consists of the service facilities located in the south east section of F-Area and all the miscellaneous facility locations outside the F-Area fence.

1.3 Summary of Previously Reported Geotechnical Information

The review of the existing information contained in the various geotechnical reports revealed that there is a wide range of existing subsurface data and results of laboratory testing known for many facilities in F-Area. However, there are also several major structures or facilities for which very little actual in-situ information is now available.

For example, there are no compaction test records or lab test data available from the original construction of the tank farm fills. Similarly, the available information for other structures constructed in the 1950's through 1970's consists primarily of foundation drilling and grouting records to confirm suitable foundation bearing capacity. Furthermore, the quality of the majority of the historical information, compared to the current standards, cannot be verified.

The detailed results of this review of all the available previous information can be found in Appendix A, and all reports are also listed in detail in Section 7, References.

1.4 Seismology and Geology

Seismology relevant to the F-Area geotechnical characterization is discussed in Appendix B. The regional stratigraphy of SRS is described in Appendix C, while more detailed F-Area specific stratigraphy is discussed in Section 2.

1.5 Subsurface Exploration and Laboratory Testing

Various techniques were used in the F-Area to characterize the subsurface strata and the properties of the soils. Appendices D and E discuss the subsurface exploration and laboratory testing, respectively.

1.6 Quality Assurance

Quality related activities performed by WSRC/BSRI organizations during the Geotechnical Investigation were controlled in accordance with the WSRC QA Program as delineated in WSRC Procedure Manual 1Q, Quality Assurance Manual. Activities performed by SGS personnel were also controlled via compliance to the applicable administrative and technical procedures contained in WSRC Procedure Manual E9, Site Geotechnical Services.

Cone Penetration Testing was controlled in accordance with the Quality Assurance Plan for WSRC Subcontract AB53066-N with Applied Research & Associates, Inc., Revision

0, and the Quality Assurance Program for Piezo/Seismic Cone Penetration Tests. Subcontractor compliance with their implementing procedures and instructions (ARA-Q-101 through 107) also ensured the integrity of CPT results and interpretations.

Soils testing performed by Law Engineering was accomplished through compliance with the Law Engineering QA Program as delineated in their QA manual, Law Engineering Quality Assurance Manual, Revision 0, applicable Work and Test Procedures, and applicable national/industry test standards (as specified in procurement specification).

Geophysical logging quality related activities were performed by Schlumberger in accordance with Attachment 1 to Procurement Specification No. K-SPC-G-00015 and their ISO 9001-certified Quality Assurance Program.

Surface Seismic Reflection Survey quality related activities were performed by SCUREF in accordance with the QA provisions contained in the WSRC Purchase Order No. AA00900T (Task 166) and the requirements of SRS Procedure Manual E9 procedure SGS-SC-304, Surface Seismic Reflection Data Acquisition and Processing.

Core logging quality related activities performed by Science Applications International Corporation (SAIC) at the SRS Core Laboratory were conducted in accordance with the QA requirements contained in Purchase Order No. C001019P (Task Order #4).

SGS QA provided quality oversight over all quality related activities of the geotechnical investigation. SGS QA oversight activities included the review and approval of all technical and quality procedures and instructions developed specifically for the investigation; review of engineering calculations; monitoring field, sample handling, and soil testing laboratory activities; and providing direct QA oversight over seismic piezocone penetration testing activities.

QA/QC activities were also performed by Law Engineering and Applied Research & Associates personnel as prescribed in their respective QA plans, QA programs, and QA technical procedures.

1.7 Work Schedule and Personnel

The F-Area geotechnical Investigation report was initiated in February 1996 and completed in September 1996. Calculations were performed to analyze field and laboratory data, obtain soil properties, and evaluate engineering behaviors. These calculations were prepared and documented in accordance with E7 manual. All work was laboratory data, obtain soil properties, and evaluate engineering behaviors. These calculations were prepared and documented in accordance with E7 manual. All work was performed by the Site Geotechnical Services (SGS) with assistance from on-site soils laboratory Raytheon personnel for field activities. Personnel and responsibilities were:

Lawrence A. Salomone, SRS Chief Geotechnical Engineer, Manager of SGS, Savannah River Site: responsible for all geotechnical, geologic, and seismologic work and project review;

Michael R. Lewis, Manager, Geotechnical Engineering, SGS, Savannah River Site: overall technical direction of the SGS geotechnical program, also performed report checking;

Matthew E. Maryak, Manager, Site Characterization, SGS, Savannah River Site: overall technical direction of the SGS geologic and seismologic program;

Paul F. Brown, Peter L. Chau, Randy J. Cumbest, Lenny D. Duke, Mike J. Hasek, Chris Kramer, Luther James, Jr., Ernie L. Joines, Richard C. Lee, William T. Li, Mike D. McHood, Walt J. Rabe, Chester Q. Reeves, Todd E. Ross, Christine M. Rothammer, Frank H. Syms, L. Bruce Triplett, and Douglas E. Wyatt: investigation, analysis and report preparation;

Jeff Bergamyer and Terry D. Harrison: Quality Assurance;

Sue Q. Smoak, Patti G. Thomas, and Anne Wood: administrative support; and

Eric T. Alexander, Jim H. Haney, and Walt W. Reck: technical support.

SECTION 2

2. SUBSURFACE CONDITIONS

Information obtained from the field exploration program described in Appendix D, as well as, existing boring data compiled from various foundation investigations as summarized in Appendix A, have been used to characterize the subsurface conditions in F-Area. The shallow subsurface soils (surface to about 180 feet in depth) of F-Area have been characterized based upon engineering properties and groundwater conditions while the deep stratigraphy (about 180 feet to 1100 feet) has been characterized from nearby deep well information. Existing boring information and data collected under this program was entered into the Site Geotechnical Services Oracle database for the purpose of this characterization and future use as needed. This section will provide a discussion of the shallow subsurface in terms of physical properties, geologic depositional history and deep stratigraphy to complete the soil column above basement rock. Section 3.0 will provide a complete summary of engineering properties for the shallow layers and compare properties between the F-Area and H-Area.

Fourteen subsurface cross-sections have been developed to show the shallow engineering stratigraphy; three cross-sections in the F-Tank Farm area to show details of the structural fill surrounding the F-Area tanks; and the remaining eleven show the shallow subsurface from ground surface to a depth of about 180 feet. The following Map and Cross-Section Index tables provide a list of the maps and generalized engineering profiles (Plates), along with orientation, scale, map or figure number and associated critical facilities.

The maps and cross-sections (Plates) are referenced in the following sections. Additional Plates have been included as general reference.

MAP INDEX

TITLE	PLATE NO.	SCALE
Exploration Summary Map	1	1:200
Structural Fill Thickness Map	2	1:100
TR3/TR4 Layer Surface Contour Map	3	1:100
TR3/TR4 Layer Isopach Contour Map	4	1:100
DB1/DB3 Layer Surface Contour Map	5	1:100
DB1/DB3 Layer Isopach Contour Map	6	1:100
DB4/DB5 Layer Surface Contour Map	7	1:100
DB4/DB5 Layer Isopach Contour Map	8	1:100
Carbonate Distribution Map	9	1:100

MAP INDEX (cont'd)

ST Layer Surface Contour Map	10	1:100
Groundwater Table Contour Map	11	1:200
Grout Take/Soft Zone/Carbonate Distribution Map (Separations)	12	1:50
Grout Take/Soft Zone/Carbonate Distribution Map (HLW)	13	1:50
Grout Take Distribution Map (Separations)	14	1:50
Grout Take Distribution Map (HLW)	15	1:50
Soft Zone Distribution Map	16	1:100
Grout Take/Soft Zone/Carbonate Distribution Map	17	1:100
Soft Zone Distribution Map (HLW)	18	1:50
Soft Zone Distribution Map (Separations)	19	1:50
Grout Take Distribution Map	20	1:100
Pre-construction Topography Map	21	1:200
Existing Topography Map	22	1:200
Cross-Section Cut Line Location Map	23	1:100

CROSS-SECTION INDEX

SECTION	ORIENTATION	ASSOCIATED STRUCTURES	PLATE NO.
A-A'	West-East	772-1F, 247-F, Actinide Facility	24
B-B'	West-East	772-F, 221-F, 232-F, 235-F	25
C-C'	West-East	221-F, 294-F, 294-1F	26
D-D'	West-East	Tanks 19, 20, 3 and 4	27
E-E'	West-East	Tanks 44, 25,7 and 8	28
F-F'	West-East	Tanks 47, 28, 33 and 34	29
G-G'	North-South	Tanks 28, 27, 26, 25, 20 and 18	30
H-H'	North-South	Tanks 34, 8, 6, 4 and 2	31
I-I'	North-South	717-F, 704-F, 772-F	32
J-J'	North-South	221-F	33
K-K'	North-South	294-F, 232-F, 247-F	34
L-L'	West-East	Tanks 44, 25, 7 and 8	35
M-M'	North-South	Tanks 28, 27, 26, 25, 20 an 18	36
N-N'	North-South	Tanks 34, 8, 6, 4 and 2	37

2.1 Shallow Engineering Stratigraphy of F-Area

The shallow subsurface has been established primarily from interpreted SCPTU measurements including tip resistance, friction ratio, shear wave velocity, and pore pressure signatures as well as correlations with adjacent soil boring data. This layering system closely follows the system developed for the ITP/ HTF Geotechnical Investigation (WSRC 1995b).

The layer nomenclature follows a numerical system with layer numbers increasing from top to bottom. Because large areas exist where structural fill has been placed, fill has been used to delineate these intervals as a distinct layer. The remaining layers closely correspond to geologic formations with the exception of the upper most layers (TR1 and TR2). Some upper portion of the layers TR1 and/or TR2 layers are most probably the Altamaha Formation overlying the Tobacco Road Formation, however, due to the similar material properties and irregular erosional surface which separates these units, differentiating them is difficult. In some parts of the F-Area, the TR1 and TR2 layers have been subdivided to recognize sublayers with distinct soil properties (TR1A, TR2A, and TR2B). The TR3 and TR4 layers correspond to the lower portion of the Tobacco Road Formation and were combined into a TR3/TR4 layer because of their similarities determined from laboratory test results. Layers in the Dry Branch Formation were labeled DB1 through DB5, respectively. Layers DB1 through DB3 were combined into a DB1/DB3 layer because of similar properties. Likewise, layers DB4 and DB5 were combined into a DB4/DB5 layer. The Santee/Tinker Formation, is the most variable layer in the shallow subsurface. It has been subdivided into the ST1 and ST2 layer where practical. Otherwise the Santee/Tinker Formation has been labeled ST. The green clay, which is an informal stratigraphic interval at the SRS, is considered the basal unit for the shallow engineering stratigraphy and is labeled as GC. This geologic unit is locally continuous and provides a reliable marker bed. The Green Clay overlays the Congaree Formation which is predominantly dense silty sands.

The following sections describe the physical attributes used to delineate each layer, as well as, depositional environment and lithologic variability. A brief summary of average SCPTU data, SPT N-values and laboratory determined properties are also presented in the following sections for the purpose of describing average attributes of these layers. Table E-3 provides a full list of average engineering properties and ranges. A full discussion on engineering properties determined for these layers, as well as, a statistical comparison with properties determined for correlating layers in H tank farm are presented in Section 3.0.

2.1.1 Structural Fill

Major facilities such as the F-Canyon and F-Tank Farm (Figures 1.2-1 and 1.2-6) were founded on native soils with structural fill material used to backfill the remaining excavation. Figure 2.1-1 shows the open excavation of the F-Canyon structure and placement of the cell mat foundations. Figure 2.1-2 shows the excavation for Tanks No 27 and 28 in the tank farm and the placement of the tank foundation concrete. However, minor facilities, particularly in the F-Tank Farm, are founded on structural fill that in some cases is up to 40 feet thick. Nearly all existing boring data, as shown on Plate 1, was collected prior to construction for foundation design and remediation efforts as summarized in Appendix A. Thus, the structural fill has been primarily characterized from boring data, laboratory tests and SCPTU soundings performed as part of this investigation.

2.1.1.1 Structural Fill in F-Tank Farm

The F-Tank Farm can be described as groups of tanks imbedded within zones of structural fill composed primarily of compacted silty and clayey sands (see Figure 1.2-1). This backfill material was used after tank construction to provide shielding and a relatively impermeable zone around the tanks. The compacted fill also provided stable tank farm yard area for ease of access and proper surface drainage.

Plate 2 shows the F-Tank Farm in plan view, and depicts the approximate contours of depths for the structural fill in each of the tank groups. Plates 35 through 37 represent cross sections through the tank farm which indicate: (1) the depth of excavation from original grade lines, (2) the thickness of structural backfill around the tanks and (3) the final slope configuration for the tank yard areas as estimated from construction photographs, design drawings, and as-built topographic maps.

Figure 1.2-2 shows the numerical designations for each of the waste tanks in F-Area. Because of continuing operational requirements, the tank groups were constructed at different times in overall tank farm development. In general, the structural fill in the two large eight-tank farm areas extends from the foundation levels at approximately El. 245 feet MSL to the top of the tank domes, or about 25 feet thick for Tanks No. 1 through No. 8 and 33 feet deep for Tanks No. 25 through No. 28 and No. 44 through No. 47. Depth of fill in the four-tank group area for Tanks No. 17 through No. 20 and for the two-tank pair Tanks No. 33 and No. 34 is approximately 33 feet, starting from foundation levels, El. 234 and El. 250 feet MSL, respectively. The soil materials used for backfill were selected specifically for the good compaction capability and are relatively uniform, silty, and clayey sands (SM and SC). Plate 2 represents estimated fill thickness (isopach) contours for the F-Tank Farm.

2.1.1.2 Fill Design and Placement Criteria

The fill used for structural backfill of the tanks in the tank farm was required to be "test controlled compaction" (TCC) by the original construction documents furnished to the grading contractor by DuPont. This standard specification for structural fill was defined per DuPont Standard Engineering Specification, (SC-5E): "Fill, Test-Controlled Compaction", as described below (DuPont, 1988):

The essential elements of SC-5E for TCC were:

- Materials - Approved with no rock > 3 inches,
- Placing - Successive loose layers < 12 inches thick, and
- Compaction - Dry density > 95% of maximum by ASTM-D 1557.

Inspections using moisture-density tests such as the rubber-balloon, sand-cone, or nuclear densometer were to be done in accordance with the following minimum daily schedule (whichever requires the greatest number of tests):

- once for every layer of fill, or
- once for every 100 cubic yards of fill placed, or
- once every 3500 square feet of fill placed,

Samples will be taken at the bottom one third of each compacted layer.

Fill sections failing to meet the above criteria, were to be removed and replaced or reworked until satisfactory to DuPont. Borrow for use as TCC fill was to be approved prior to use.

2.1.1.3 Available Fill Test Records and Information

Foundations for structures generally required TCC fill materials as described above. A review of the project files and a thorough search of the construction records revealed that very little construction fill compaction test data is now available. The actual recorded construction data for the field control compaction testing is not available from site archives. However, a report prepared by Mueser-Rutledge Consulting Engineers for DuPont in 1986 for F-Area Containment Building for Pump Pits and Diversion Boxes provides an example of the compaction test results that were achieved during the construction operations for the F-Tank Farm (Mueser, 1986).

Compaction test results for several projects from backfilling operations, as reported by Pittsburgh Testing Laboratories (PTL), were used by Mueser to evaluate the existing fills. The purpose of the study was to use the original compaction test records to determine the potential support of new containment structures on shallow footings. This report covers several earlier projects in F-Area related to the tank farm construction activities. It summarizes the results of the fill qualification tests and provides estimates of settlement in existing backfill areas in support of new proposed structural loads.

Mueser-Rutledge compiled all available PTL compaction test data for the surrounding backfill and provided profile plots showing the number of tests at various depths adjacent to the proposed structures (see Figures 2.1-3 through 2.1-5). This study documents that sufficient tests were performed to control the fill quality at each proposed structure location. The conclusion of the investigation by Mueser was that there was sufficient test information to demonstrate confidence that the fill had been placed in accordance with the specification requirements.

In December 1993, a steam line break near Tank 28 prompted an excavation and evaluation of the compacted fill. The results showed that the fill was poorly compacted with compaction test results in the range of 80 to 85% of ASTM D1557. It is likely that because piping, electrical and other utilities were embedded within the fill as it was placed, compaction around these areas was difficult to achieve. As with other large fills onsite, it has been concluded that the compaction of the fill is not consistent, thus leaves the quality of fill in any one area suspect.

2.1.1.4 Properties of Fill

In order to characterize the existing conditions of the fill, the exploratory program included both SCPTU soundings and SPT borings in various locations in the fill. Because groups of tanks were constructed at different times, the large excavations resulted in "pockets" of fill roughly surrounding four groups of tanks. Plate 2 shows a fill thickness map constructed from information derived from construction photographs, and drawings. Exploratory SPT borings and SCPTU soundings were located around the tank groups to provide information on each pocket of fill, as well as, delineate the thickness and lateral extent of fill. It should be noted that Plate 2 shows thickness contours with surface being zero thickness and that each tank group is founded at a different elevation. Three subsurface cross sections (Plates 35 through 37) show profile views of the tank groups and interpreted fill geometry. Fill layer attributes are given below, while laboratory-derived soil properties from this investigation as well as existing data compiled from previous investigations are summarized in Table E-2.

Fill Layer Attributes

LAYER	AVG THICK (ft)	AVG TOP El (MSL)	AVG BOT El (MSL)	AVG q_c (tsf)	AVG Vs (ft/sec)	AVG FR%	AVG SPT N Value	AVG q_c/N	AVG PI%	AVG % FINES	USCS
FILL	36.8	281.7	245.0	112	978	2	23	4.9	15	25	SC

2.1.2 TR1 Layer (Altamaha Formation)

The TR1 layer is most probably the Altamaha Formation consisting of red, purple and brown poorly sorted sands ranging from fine to gravel size. The depositional environment of these sediments is characterized as high energy fluvial such as river and stream channels. The base of the Altamaha is distinguished by an irregular erosional surface and can reach thicknesses of up to 70 feet at the SRS. In F-Area, this layer ranges in thickness from roughly 14 feet to nearly 36 feet thick. In the F-Tank Farm, the TR1 layer is only present in areas outside of excavation limits where structural fill has been placed.

The TR1 layer is characterized by a zone of moderate SCPTU tip resistances and relatively high friction ratios. The TR1 layer is generally more cohesive and less dense than the lower TR1A layer. TR1 layer attributes are given below, while laboratory test results are summarized in Table E-2.

TR1 Layer Attributes

LAYER	AVG THICK (ft)	AVG TOP El (MSL)	AVG BOT El (MSL)	AVG q_c (tsf)	AVG Vs (ft/sec)	AVG FR%	AVG SPT N Value	AVG q_c/N	AVG PI%	AVG % FINES	USCS
TR1	24.9'	*	278.0	91	1455	4	25	3.6	17	33	SC

* Not presented due to the variability induced by cut and fill from natural grade

2.1.3 TR1A, TR2A, TR2B, TR3 and TR4 Layers (Tobacco Road Formation)

The TR1A, TR2A, TR2B, TR3 and TR4 layers have been used to differentiate the Tobacco Road Formation. Sediments of the Tobacco Road Formation were deposited in low energy shallow marine transitional environments such as tidal flats. Much of the sediments are laminated or otherwise bioturbated red, purple and brown poorly sorted sands and clayey sands.

The TR1A, TR2A, and TR2B layers are predominantly sands and clayey sands as determined by laboratory classification tests. Soils of the TR1A layer are distinguished from the underlying TR2A layer by lower tip resistances. TR2B has an increased tip resistance and notably lower sleeve friction resulting in a lower friction ratio. The upper contact of the TR3/TR4 layer is defined by a marked decrease in SCPTU tip resistance and an increase in both the friction ratio and pore pressure measurements. Because of similar material properties determined from laboratory testing as part of the ITP/HTF investigation (WSRC, 1995b), the TR3 and TR4 layers were combined into the TR3/TR4 layer. The TR3/TR4 layer is seen on the SCPTU logs as a zone having moderate SCPTU tip resistances and moderate friction ratios. As determined by laboratory classification tests, the TR3/TR4 layer is predominantly clays and sandy clays. This layer is a fairly consistent marker bed in both the SCPTU signature and boring samples. In F-Area, the top of the TR3/TR4 layer ranges from about El. 210 feet MSL on the west and east sides of the area to about 220 feet MSL in the central and north central portion of the area, see Plate 3. Thickness of this layer ranges from around 5 feet on the eastern side of the area to around 10 feet thick over the balance of the area, see Plate 4.

TR1A, TR2A, TR2B and TR3/TR4 Layer Attributes

LAYER	AVG THICK (ft)	AVG TOP El (MSL)	AVG BOT El (MSL)	AVG q_c (tsf)	AVG Vs (ft/sec)	AVG FR%	AVG SPT N Value	AVG q_c/N	AVG PI%	AVG % FINES	USCS
TR1A	19.1	278.0	261.0	120	1348	2	25	4.8	14	30	SC
TR2A	25.0	261.0	232.5	147	1256	2	28	5.3	10	17	SC
TR2B	19.3	232.5	213.4	201	1254	1	36	5.6	18	19	SC
TR3/4	9.7	213.4	203.8	55	1074	2	18	3.1	58	64	CH

2.1.4 DB1-DB5 Layers (Dry Branch Formation)

The DB1 through DB5 layers comprise the Irwinton Sand Member, Tan Clay and Griffins Landing Member of the Dry Branch Formation. The DB1 through DB3 layers correspond to the Irwinton Sands. The DB4/DB5 layer comprises the Tan Clay and Griffins Landing Member of the Dry Branch however, the later has not been found in the F-Area. The Dry Branch Formation consists of sands and clays deposited in a transitional sequence between near shore and bay or lagoon environments.

Because of similar material properties, the predominately sandy soils of the DB1 through DB3 layers were combined into the DB1/DB3 layer. On the SCPTU logs, the DB1/DB3 layer is a zone of variable, but generally high, SCPTU tip resistances and low friction ratios. In general, pore pressures are low or slightly above hydrostatic. As shown on Plate 5, the top elevation of the DB1/DB3 layer in the F-Area ranges from around El. 190 MSL in the south and north-western portion of the area to around El. 210 MSL in the central and north-eastern part of the area. Thickness of this layer ranges from 25 to 35 feet thick in the F-Tank Farm thinning to around 20 feet thick on the north-western corner of the area, see Plate 6.

The soils of the DB4 and DB5 interval are much more plastic than the overlying Irwinton Sand (DB1/DB3) and the underlying Santee/Tinker Formation (ST). These layers have been combined as the DB4/DB5 layer and correspond to the Tan Clay unit of the Dry Branch Formation. The DB4/DB5 layer has moderate to low tip resistances and moderate friction ratios. Similar to the TR3/TR4 layer, the DB4/DB5 layer is a fairly consistent marker bed that is locally continuous in the F-Area. As shown in Plate 7, the top of this layer ranges from about El. 200 to 210 MSL on the northern end of F-Area dipping to around 195 feet MSL on the southern end of the area. The thickness of this layer ranges from 6 feet on the south-eastern side of the area to around 15 feet thick on the north-western corner of F-Area, see Plate 8.

DB1/DB3 and DB4/DB5 Layer Attributes

LAYER	AVG THICK (ft)	AVG TOP El (MSL)	AVG BOT El (MSL)	AVG q_c (tsf)	AVG Vs (ft/sec)	AVG FR%	AVG SPT N Value	AVG q_c/N	AVG PI%	AVG % FINES	USCS
DB1/3	27.6	203.8	175.3	172	1157	1	33	5.2	19	14	SC
DB4/5	6.8	175.3	166.7	61	1140	2	28	2.2	15	22	SC

2.1.5 ST1, ST2 and ST layers (Santee Limestone /Tinker Formation)

The Santee/Tinker Formations represent the most complex geologic unit in the shallow subsurface of F-Area. It is depositionally complex and highly variable in both its lithology and material properties. The layer consists of complex sequences of limestones, carbonate muds, carbonate sands, and muddy sands.

The contact between the Santee/Tinker Formation and the overlying Dry Branch Formation is generally seen on the SCPTU logs as a sharp decrease in the pore pressure measurement. This layer is characterized by thin, alternating layers of low and high SCPTU tip resistances and friction ratios. Characteristically, SCPTU soundings in this layer show a pronounced sawtooth trace due to large variations in the SCPTU tip resistances over relatively small vertical intervals. This highly variable pattern suggests interfingering of alternating lenses of clayey and silty sands with more resistant, silica-cemented sediments and less resistant, calcareous sediments, and appears to be a result of rapid lateral and vertical changes in the nature of the materials originally deposited in this interval. This layer was initially subdivided into the ST1, ST2 and where undifferentiated, ST was used to define the interval. The ST1 layer was characterized by a higher tip resistance than the underlying ST2 layer. The ST1, ST2 and ST layers were later combined and Santee or ST is used to refer to this layer in general.

In F-Area and elsewhere at SRS, the Santee has been a primary focus of foundation investigations. In fact, nearly all foundation remediation programs have targeted the Santee because of drilling problems such as lost drill fluid circulation or rod drops. A discussion of remediation programs is provided in Appendix A.

In F-Area, the Santee is rich in carbonates as shown on Plate 9 where a high concentration of carbonate sediments are clustered in and around the F-Tank Farm. Plate 9 presents all boring locations which indicate carbonate sediments. All existing boring logs were reviewed for any notes of shell fragments, limestone, or positive reaction with hydrogen chloride (HCl) all of which would be an indication of carbonate present in the subsurface. Plate 10 shows a surface contour map of the top of the Santee. In F-Area, the top of the Santee averages around El. 160 feet MSL in the F-Tank Farm, around 170 feet MSL in the north-western side of F-Area reaching its highest elevation of around 180 in the central northern portion of the area near the 247-F structure.

ST1, ST2 and ST Layer Attributes

LAYER	AVG THICK (ft)	AVG TOP El (MSL)	AVG BOT El (MSL)	AVG q_c (tsf)	AVG Vs (ft/sec)	AVG FR%	AVG SPT N Value	AVG q_c/N	AVG PI%	AVG % FINES	USCS
ST1/ST	19.1	166.7	149.9	131	1353	2	47	2.8	18	29	SC**
ST2	9.6	149.9	138.3	*	*	*	*	*	*	*	SC**

* These properties were not subdivided for determining average engineering properties.

**Soil classifications are based on the clastic portions of the sediments but may contain large amounts of calcareous material.

2.1.6 GC (Green Clay)

The green clay is an informal stratigraphic name at SRS for stiff, green to gray clays, silts, and clayey sands that are commonly found at the base of the Santee/Tinker Formation. This layer is locally continuous at F-Area and has been used to define the lower boundary of the shallow stratigraphy. Layer elevations and thicknesses have been determined from those borings and soundings that penetrate this layer. Most borings and SCPTU soundings do not reach or penetrate the GC layer. The top of the layer ranges from around El. 126 feet MSL in the south and north-western portions of the area to a high of around 140 feet MSL in the east-central part of the area. This is consistent with the correlating Gordon Confining Unit as mapped by Aadland (1995).

GC Layer Attributes

LAYER	AVG THICK (ft)	AVG TOP El (MSL)	AVG BOT El (MSL)	AVG q_c (tsf)	AVG Vs (ft/sec)	AVG FR%	AVG SPT N Value	AVG q_c/N	AVG PI%	AVG % FINES	USCS
GC	6.8	138.3	130.8	58	1675	2	21	2	47	39	SC

2.2 Groundwater Conditions

Groundwater data was derived from water table monitoring wells located in various locations around and within F-Area. As shown on Plate 11, the average water table elevation from the last four readings taken over a one year period, range from El. 225 feet MSL in the central part of the area to El. 220 MSL on the western and northern ends of F-

Area. Water table gradients in F-Area are largely controlled by Upper Three Runs Creek located immediately north of the F-Area and extend radially to the west and north. As shown on Figure 2.2-1, two wells BGO-29D and FSL-1D were used to construct a hydrograph of water table level fluctuation over the last six years while well NBG-5 data reflects data for the past ten years. NBG-5 shows a total fluctuation of about 6 feet between 1990 and 1993. Fluctuations range from 2 to 6 feet and appear to be cyclic.

2.3 Soft Zone and Carbonate Sediment Relationships and Distribution

Weight of rod and occasional rod drops have been described in numerous drilling reports for monitoring wells and geotechnical borings located in the central part of the SRS. Early subsurface investigations performed by the USACOE frequently described these zones as soft zones, or even voids, and numerous subsequent subsurface investigations have described these same conditions at the SRS. These soft zones typically occur in the carbonate-bearing sediments of the Santee Limestone, Utley Limestone, and the Griffins Landing Member of the lower Dry Branch Formation. The prevailing assumption about the origin of these soft zones is dissolutioning of carbonate-rich, clastic sediments, resulting in vugular porosity (open pore space). When drilling these zones, the drill rod meets little shear resistance and drops (USACOE, 1951). However, much of the time, recovery of soil in the sampler precludes the zone from being characterized as a void.

Soft zones generally defined by SPT-N values ≤ 5 or SCPTU tip resistance ≤ 15 tsf are generally restricted to the lower Dry Branch Formation (DB4/DB5 layer) and the Santee/Tinker Formation (ST layer). As shown on Plate 16, soft zones and carbonates mapped within the F-Area represent pre-remediation (grouting) conditions in the F-Tank Farm and F-Canyon areas.

Of the exploratory borings and SCPTU soundings performed in the F-Tank Farm as part of this investigation, one boring (F-SEP-B6) and seven SCPTU soundings (F-TNK-C3, F-TNK-C6, F-TNK-C9, F-TNK-C12, F-TNK-C13, F-TNK-C16, and F-TNK-C17) penetrated the Santee. F-SEP-B6 located about 90 feet south of Tank 33 encountered low SPT N-values, weight of rod and rod drops and lost circulation between El. 164.5 feet MSL and 158.5 feet MSL. Soil samples from this zone were described as tan very fine, loose, silty sands. Although carbonates were not noted in this boring, these observations are consistent with similar drilling observations in the general area. Of the SCPTU soundings, F-TNK-C16 and F-TNK-C17 showed indications of soft zones in the Santee based upon low tip resistances, sleeve friction and near hydrostatic pore pressures. The SCPTU soundings are located about 60 feet west of Tank 47 and about 300 feet north of

Tank 2 respectively. These locations as shown on Plate 13 are outside of the grout hole patterns beneath the tank groups. F-TNK-C3 located between tanks 45 and 26, which as indicated on Plate 13 is located in an area of highly concentrated soft zones and carbonate sediments prior to remediation, did indicate a soft zone within the DB4/DB5 layer. The remaining SCPTU soundings did not indicate soft zones within the Santee,

On the separations side of F-Area, five borings (FB-1, FB-2, F-SEP-B13.1, and F-SEP-8 and F-SEP-8.1) and eighteen SCPTU soundings (F-SEP-C1, F-SEP-C2, F-SEP-C6, F-SEP-C7, F-SEP-C8, F-SEP-C9, F-SEP-C10, F-SEP-C11, F-SEP-C12, F-SEP-C13, F-SEP-C15A, F-SEP-C17, F235-C1, F235-C2, F235-C3, F235-C4, F235-C5, and F235-C6,) penetrated the Santee as part of this investigation. Boring FB-2 was an undisturbed sample boring which did not collect SPT N-value data. Boring FB-1 located in the north-eastern corner of F-Area had low SPT N-values and weight of rod drop from El. 155 feet MSL to about El. 146 feet MSL. Soils from this interval were described as tan very fine silty and clayey sand with traces of shell fragments. Boring F-SEP-8 and F-SEP-8.1 located about 80 feet south-east of the F-Canyon recorded low SPT N-values and weight of rod drop from about El. 187 feet MSL to about El. 179 feet MSL. Boring F-SEP-8.1 was required to redrill this interval because of excessive rod drop under the weight of rod while sampling this interval in boring F-SEP-B8. Soil samples from this interval were described as calcareous silty fine sand and well graded medium to coarse calcareous sands. SCPTU soundings performed within fifteen feet of borings FB-1 and F-SEP-B8.1 (F235-C2 and F-SEP-C8 respectively) indicated soft zones in these same intervals. Of the eighteen SCPTU soundings, F-SEP-C6, F-SEP-C8, F-SEP-C10, F-SEP-C13, F235-C2 and F235-C6 showed indications of soft zones. Of these, all except F-SEP-C8 were located in the Santee. F-SEP-C6 had indications of soft zones in both the DB4/DB5 layer as well as the Santee.

Indications of soft zones in F-Area are generally in areas where carbonate bearing sediments are existing within the lower portion of the Dry Branch Formation (DB4/DB5) or Santee. These observations are consistent with similar data from the H Tank Farm and elsewhere in the central part of the SRS.

2.4 Summary of Remediation Programs in F-Area

In 1951, the U. S. Army Corps of Engineers (USACOE) initiated an investigation of the Savannah River Plant area to characterize the subsurface conditions (USACOE 1951). One primary focus of this investigation became the carbonate bearing Santee Formation. Because soft/loose zones were commonly encountered within the carbonate bearing stratum, a foundation grouting program was initiated in 1952 to pump grout into these zones for stabilization. Grouting included all reactor structures, the first four H-Area waste tanks, the first eight F-Area waste tanks and both the F and H-Canyons. In summary, the grouting method involved mud rotary drilling a straight boring and if drill fluid was lost during the drilling or a sudden drop in the drill rod occurred, the hole was pressure grouted. If neither occurred, the hole was simply abandoned by tremie grouting.

Further remediation programs followed into the late 1970's as new tank clusters were constructed in the F-Tank Farm. The latest remediation programs at SRS involved foundation grouting for the K-Area Cooling Tower and the K-Area Soil Stabilization (KASS) program in the early 1990's. Grout takes computed by estimating the theoretical grout hole volume and subtracting it from the total volume of grout pumped were compiled in the KASS project report for a statistical comparison between programs. This comparison has been updated with F-Area data and as indicated on Figure 2.3-1, grout takes for F-Area are statistically similar to other remediation programs. Plates 12 and 13 have been compiled form existing boring information to show the distribution of grout takes, as well as the distribution of soft zones and carbonate sediments.

2.4.1 F-Canyon Foundation Remediation

Plate 14 shows the pattern of drilled borings at the F-Canyon and associated grout takes. As indicated on Plate 14, two isolated areas required pressure grouting. Of the 18 holes pressure grouted, the range in number of batches per hole (1 batch estimated at 10.5 cubic feet) was from 1 to 61 with an average of 13.4 batches (or 140.7 cubic feet) per hole. This is slightly greater than 3 times the theoretical volume of the hole calculated for a four inch diameter hole, 160 feet deep.

2.4.2 F-Tank Farm Remediation

Similar to the F-Canyon remediation program, the F-Tank Farm subsurface was remediated under various programs starting with the initial program which included the F tank Nos. 1 through 8. Subsequent remediation programs of other tank groups within F-Tank Farm also targeted the Santee Formation. These programs have been summarized in Appendix A. Prior to tank construction in F-Area, 244 borings were drilled and grouted in the F-Tank Farm (see Plate 20).

2.5 Faults and Subsurface Structure

Currently, there are no faults classified as active at SRS or in the immediate vicinity (40 km radius). There are several inactive subsurface faults rooted in the crystalline rock beneath the SRS. One such fault, the Pen Branch fault, has been extensively studied and is known to be a very old structure, posing no seismic hazard threat (Stieve et al., 1995; Stephenson and Stieve, 1992; Stieve et al., 1991; Price et al., 1989). Other faults have not been studied as extensively, but investigators suggest that they are not seismogenic nor significantly large structures and do not deform very young sediments. Still other potential faults in the subsurface are known to exist, but the documentation of their age and lateral extent is very limited.

Faults in the General Separations Area (GSA) of SRS are commonly observed along the flanks of carbonate buildup (Aadland et al., 1991). There are three possible mechanisms that explain the relation between faulting and the distribution of the carbonate buildup. The first mechanism suggests that non-tectonic faulting occurred due to slumping of the overlying sediments above carbonate buildups as dissolution progressed within, or along the fringes, of the carbonate body. In this mechanism, consolidation of the leached residual sediment occurred under lithostatic load, causing thinning of the stratigraphic column in the carbonate section (WSRC, 1994b). Above the zone of dissolutioning, a general loosening of the overlying sediments may have also occurred as these predominately sandy materials raveled, relaxed, and subsided. For example, Siple (1967) speculated that dissolutioning of calcareous material in the Santee Limestone occurred at the SRS, causing subsidence or slumping of overlying beds and the formation of shallow surface depressions. He noted that voids and loosely compacted sediments were encountered during well drilling and that large amounts of cement grout were used to stabilize the subsurface before construction of heavy structures. The second mechanism consists of small-scale faulting and folding of the Coastal Plain sediments by Tertiary tectonic activity. Several regional basement structures have been interpreted as uplifts or gentle folds and may be indicative of continued crustal movement in the Miocene age. Because of a marked strength contrast between the more rigid limestone and the adjacent, softer, unconsolidated sediments, a series of secondary faults may have formed along the fringes of carbonate bodies when basement faulting was refracted as it propagated to the surface. The last mechanism is simply a combination of the first two mechanisms. In this mechanism, local disruption of confining clay layers along tectonic fault planes may have removed barriers to groundwater migration and exacerbated the amount of leaching and subsequent slumping in pre-existing, fault-controlled orientations (WSRC, 1995b).

2.6 Deep Stratigraphy

Since no F-Area borings have been made to bedrock, the bedrock elevation was estimated from borings located in the Burial Ground and H-Area both lying to the east of F-Area. The deepest well close to the F-Area is P-28TA which is located to the east of the area. Stratigraphy from this well has been determined primarily from geophysical logs and have been correlated with other wells in the area. A bedrock elevation of -611.9 MSL was determined using known bedrock elevations in deep borings MMP-2A-SB located south of the H Tank Farm and DRB-3 which is between F and H-Area. Appendix C provides detailed discussion of the deep stratigraphy.

SECTION 3

3. ENGINEERING PROPERTIES

Engineering properties were derived using laboratory test data gathered from the current and previous investigations, empirical relationships, and engineering judgment. Section 3.1 presents the static properties of the soils underlying F-Area. Section 3.2 discusses the dynamic properties of these subsurface soils.

3.1 Static Properties

Field and laboratory tests were performed to evaluate the static properties of the soils underlying F-Area. In-situ measurements such as the SPT N-value and SCPTU data (tip resistance, shear wave velocity, friction ratio, and pore pressure) were obtained in the field. Laboratory tests were performed on soil samples obtained in the field during the current investigation in order to determine static properties such as strength, compressibility, water content, particle size, and Atterberg limits. These field and laboratory test results were combined with results from previous investigations in order to create a database. A tabular format of the available laboratory data used in the F-Area evaluation is found in Tables E-2 through E-4 located in Appendix E of this report.

3.1.1 In-Situ Properties

3.1.1.1 SCPTU results

Comparisons were made with SCPTU data between F-Area and ITP. Figure 3.1-1 is a plot of the average corrected tip resistance versus elevation for data collected at ITP and for SCPTU soundings completed near F-Canyon. The figure shows that, aside from offset in elevation, the average corrected tip resistance for a given engineering layer at F-Area is higher than that at ITP.

Figures 3.1-2 through 3.1-7 are histogram plots of the natural log of SCPTU tip resistance, by layer, for HTF, ITP and F-Area. The log distribution and average of SCPTU tip resistance (q_c) are quite similar, indicating that the soil has about the same strength and density in the three different areas. One major exception is the Fill histogram showing a right-skewed distribution indicating higher strengths in the fill at F-Area than at ITP or HTF.

3.1.1.2 SPT results

Figure 3.1-8 is a plot of the distance above or below the Tobacco Road / Dry Branch interface versus SPT N-value for the new borings completed during the present investigation and also from ITP. The plot was created by assuming the bottom of the TR3/TR4 layer was at an elevation of zero. The points appearing above zero, or positive, are N-values for the soil above the bottom of the Tobacco Road. Point appearing below zero, or negative, are N-values below the bottom of the Tobacco Road Formation.

Although there is a large amount of scatter in the data, there is a general pattern that is similar for both areas. Both show low N-values of about 10 to 40 in the upper elevations or those above zero. Below zero, both F-Area and ITP show a wide scatter of values with increasing depth.

3.1.2 Laboratory Index Tests and SCPTU and SPT Relationships

The percent fines determined from laboratory tests was plotted versus the SCPTU friction ratio in Figure 3.1-9 along with best fit lines. Only the data from F-Area is presented. Ignoring the outlying points, most of which are in the TR3/TR4 layer near the top of the plot, the best fit line for F-Area would be nearly parallel to the ITP best fit line. Figure 3.1-10 plots q_c /N versus the percent fines for F-Area and ITP. Except for one outlying point (TR3/TR4) the data match well with higher q_c/N ratios for sandier soils and lower ratio for clayey type soils which is expected. The TR3/TR4 layer appears to have lower friction ratios and yet higher fines content in F-Area than at ITP which is the reason for some of the outlying points.

Generalized average elevation, Poisson's ratio, total unit weight, and shear wave velocities for each of the engineering layers are shown in Figure 3.1-11. The separations section and tank farm section were separated out because of the fill in the tank farm and differing surface elevations but the average properties apply to both sections. For comparison, Figure 3.1-12 and 3.1-13 plot similar data for ITP and HTF respectively. Unit weights for a given engineering layer are similar for all three sites.

3.1.3 Consolidation Properties

Comparisons between F-Area and ITP were made by plotting the compression index, C_c (as determined from consolidation tests) versus moisture content, initial void ratio, percent fines, and the plasticity index. These plots are provided as Figures 3.1-14 through 3.1-17, respectively. Also plotted on each of the four figures are best fit lines with their corresponding equations for data from F-Area and from the ITP/HTF investigation. The best fit lines have similar slopes and intercepts, indicating that the compressibility characteristics between F-Area and ITP/HTF are similar. The compression index was also plotted versus elevation in Figure 3.1-18. There is very little scatter in the data at both F-Area and ITP for the sandier soils in the TR1 through TR3/TR4 layers. However, a much wider range exists in the clayey DB4/DB5 layers. The range of values for a given layer are consistent between F-Area and ITP, further indication that the soils between the two area are similar.

The overconsolidation ratio, OCR, is plotted versus depth in Figure 3.1-19 for F-Area and ITP. The general trend is for the OCR to decrease with depth. Both areas appear to follow this same trend. Typically, between EL. 325 feet and 225 feet MSL, the OCR varies between 1 and 5. Below EL. 225 feet MSL, the range is much narrower and is typically between 1 and 2 with some layers exhibiting characteristics of underconsolidation.

Figure 3.1-20 plots the OCR versus depth with the OCR calculated using several different methods. The OCR as determined from the consolidation tests fall closer to the CPT MIN line and the lower ITP RANGE curve. However, due to sample disturbance and the nature of the material (sands), the OCR determined by consolidation tests are difficult to determine as compared to in-situ methods of determining the OCR. Because of the similarities in the compressibility characteristics that exist between F-Area and ITP, the range of OCR values reported in Figure 3.1-7 for ITP can also be applied to F-Area.

3.1.4 Conclusions

Table 3.1-1 contains average material properties for each of the engineering layers evaluated for F-Area discussed in Section 2. The table contains properties determined from consolidation tests, strength tests, and classification tests as well as SPT and SCPTU data determined in the field. Tables E-2 and E-3 were used to determine the laboratory data summarized in Table 3.1-1. For comparison, Table 3.1-2 contains similar soil properties from the ITP/HTF investigation (WSRC, 1995b).

The static soil properties at F-Area are similar to those at ITP. Results from both laboratory and field tests show that the compressibility characteristics of the soils at F-Area and ITP are similar. The index test results such as the Atterberg limits and grain size tests show similar results between the two areas. Comparing the in-situ static properties, such as N-value, SCPTU tip resistance, and q_c/N, indicate that the two sites are alike.

Some notable exceptions might be in the TR3/TR4 layer where the liquid limit, plastic limit, water content and percent fines tend to be much higher in F-Area than at ITP. The Atterberg limits and percent fines are much higher at ITP than F-Area for the DB4/DB5 layer.

3.2 Dynamic Properties

Dynamic responses of the soil are governed primarily by the shear modulus and damping characteristics of the soil. Shear moduli are computed based on field measurement and laboratory tests. Field measurements provide the in-situ shear wave velocities at various depths, and the laboratory tests determine the wet densities of different types of soils. Reductions of shear moduli and damping ratios due to strain levels are based on an extensive study of nonlinear dynamic soil properties conducted previously (WSRC, 1996b).

3.2.1 Shear Wave Velocities

Shear wave velocities are measured using several techniques including cross-hole seismic surveying and down-hole seismic surveying. Travel times for the shear waves at different depths between two points are recorded. The shear wave velocity v_s is then computed by:

v_s = distance between the two locations / the travel time for the shear wave.

By averaging the wave velocities at selected depth intervals around a specific location, a shear wave velocity profile can be established. Figure 3.2-1 shows the mean shear wave velocity profile for F-Canyon. Shear wave velocity profile for ITP in H-Area is also presented in the same figure for comparison.

3.2.2 Shear Modulus

The shear modulus is defined as the ratio of the shear stress to the shear strain. The shear modulus equals its maximum at very low shear strain and decreases when the shear strain increases. The maximum shear modulus for the soil at a specific depth is computed as:

$$G_{max} = \rho \, v_s^{\,2}$$

where ρ is the mass density of the soil and defined as:

$$\rho = \gamma / g$$

where γ is the unit weight of the soil and g is the gravitational acceleration.

Extensive study (WSRC, 1996b) performed on soils at SRS has concluded that the ratio of shear modulus to the maximum shear modulus can be defined as a function of strain:

$$G/G_{max} = 1 / (1 + \varepsilon / \varepsilon_r)$$

where ε is the desired value of shear strain and ε_r is the reference strain. Table 3.2-1 provided the recommended reference strains for various soils at the SRS. Figure 3.2-2 shows the plot of recommended G/G_{max} ratio versus strain.

3.2.3 Damping Ratios

Due to the curvilinear stress-strain relationship of the soil, the damping ratio is a function of the strain. The study referred in the previous section also provides the relationship between damping ratio and strain. Table 3.2-2 provides the recommended damping ratio versus strain relationship for various soils at SRS. Figure 3.2-3 shows the plot of recommended damping ratio versus strain.

SECTION 4

4. ENGINEERING EVALUATIONS

The analyses described in the following sections were performed in accordance with applicable DOE standards and guides. Where no standard or guide existed, criteria were developed according to standard engineering practice.

4.1 Seismic Ground Response

Implementation of DOE-STD-1023 (1995a) and development of design basis earthquake (DBE) ground motions are currently underway at SRS. At the present time, the bedrock spectra (see Appendix B) are available for F-Area and will be used for the ground motion assessments in this report. Development of the ground motions are described in the next section. Based on the rock spectra, time histories and site specific soil spectra were developed for the F-Canyon in June of 1996 (WSRC, 1996a). The F-Canyon analysis is described in Section 4.1.1.

4.1.1 F-Canyon Ground Response Analysis

The technical approach for the F-Canyon soil response analysis was to develop rock spectra and then match several time histories with different phasing to the rock spectra. Ground response analysis was then performed using multiple soil profile models representing conditions beneath F-Canyon.

Probabilistic uniform hazard rock spectra (UHS) and deterministic 1886 Charleston earthquake rock spectra were developed in accordance with DOE-STD-1023 (1995a). The matching time histories were generated in accordance with the USNRC Standard Review Plan (1990). Details regarding the development of the rock spectra is contained in Appendix B.

The subsurface models for the F-Canyon facility were based on investigations in F-Area and on SRS area-wide investigations. The shallow profile (less than about 150 feet deep) was based on canyon-specific investigation, while the deep profile (greater than about 150 feet deep) was based on SRS area-wide investigations.

The shallow profile was based on five site-specific seismic piezocone penetration tests (SCPTU) designated F-SEP-C2, -C9, -C12, -C14, and -C15A (ARA, 1996). The SCPTUs were selected based on proximity to the F-Canyon Building, and were used to determine stratigraphy and shear wave velocity in the shallow profile. These and other F-Area SCPTU data are discussed further in Section 3.

Since no deep shear wave velocities have been measured in F-Area, the deep profile was based on four deep holes drilled into basement rock in the central portion of the SRS where shear wave velocities have been measured. Two of the holes are at the confirmatory drilling site (CFD-1 and CFD-18), one hole at H-area (MMP-2A-SB) and one hole at K-area (MMP-3-SB) (Agbabian Associates, 1992a, 1992b, and 1994).

Dynamic properties were assigned based on formation identification and the corresponding dynamic properties developed specifically for SRS (WSRC, 1996b). The normalized shear modulus and damping ratio versus shear strain relationships used are discussed in Section 3.2.

The 5 shallow and 4 deep profiles were combined to create 20 soil columns for dynamic ground response analysis. Analysis for the F-Canyon was performed using the computer program SHAKE-91 (Idriss and Sun, 1992). The input motions matching the spectra described in Appendix B were used to excite the soil models. The matching time histories were generated in accordance with the USNRC Standard Review Plan (1990). Site specific response spectra for free-field (i.e., ground surface adjacent to the canyon building) and within the soil profile at the base of the canyon building (20 feet deep) were obtained. More details regarding the convolution analysis is contained in the summary report (WSRC, 1996c).

Figure 4.1-1 presents the mean, and the upper and lower bound free-field spectral accelerations and the target input rock spectrum for the probabilistic PC-3 input motions. Figure 4.1-2 presents the mean, and the upper and lower bound free-field spectral accelerations and the target input rock spectrum for the deterministic historic earthquake check for the PC-3. This check is the 1886 Charleston 50th percentile earthquake.

4.2 Liquefaction and Dynamic Settlement

4.2.1 Methodology

The liquefaction susceptibility of the subsurface materials in F-Area were evaluated using both qualitative and quantitative approaches. These included a simplified shear wave velocity approach, the criteria for clayey soils, and the traditional strength approach. Comparisons of the performance of older aged sand deposits in past earthquakes has been discussed previously in the ITP/HTF Geotechnical Investigation in nearby H-Area. The methodologies for the liquefaction assessment have been discussed in detail in the HTF/ITP report (WSRC, 1995b).

4.2.2 Evaluations and Results

4.2.2.1 Clayey Soils

Liquid and plastic limits, plasticity index, natural water content for 263 samples from F-Area were selected to check their liquefaction potential according to the criteria for clayey soils. Test data are plotted in Figure 4.2-1. By inspection, the application of the criteria to the individual sample for which complete data are available show that the vulnerability of the clayey sands to seismic liquefaction is negligible in F-Area. The 12 points which lie in the "Test" zone are listed on the figure. Eliminating the points which are considered either too deep or too clayey results in 4 points which may be potentially liquefiable. These points were not tested for clay content, however, the layers, in general, have average clay contents which would further preclude the samples from being potentially liquefiable.

4.2.2.2 Shear Wave Velocity Approach

The geophysical surveys carried out in F-Area yield the average and normalized shear wave velocity values for the various soil layers given in Table 4.2-1. Based on this data and with reference to Figures 4.2-2 through 4.2-5, the following is concluded:

1. Seed et al.'s (1983) chart (Figure 4.2-2) indicates that materials between depths of 50 - 100 feet with an average shear wave velocity equal to about 1075 fps would have a cyclic stress ratio resistance against liquefaction of 0.325. Maximum expected cyclic stress ratios at the site in the event of a PC-3 earthquake are less than 0.09 which is well below 0.325. Thus, the liquefaction potential at this site is expected to be nonexistent.

2. The normalized shear wave velocities presented in Table 4.2-1 used in combination with Kayen et al.'s (1992) chart (Figure 4.2-3) show that Tobacco Road and Dry Branch soils (TR1 through DB4/DB5) with normalized velocities between 220 m/sec (725 fps) and 430 m/sec (1410 fps) would require a cyclic stress ratio in excess of 0.24 to liquefy. This is much greater than the cyclic ratio expected to be generated by the earthquake motions (0.09) for liquefaction to occur. Therefore, no liquefaction is predicted by this method.

Stokoe et al.'s (1995) chart (Figure 4.2-4) would show that for shear wave velocities greater than 500 fps, the required ground acceleration that causes liquefaction is 0.25 g.

At F-Area, average shear wave velocities are significantly greater than this value (See Table 4.2-1 for F-Area shear wave data), and the maximum expected peak ground acceleration (0.14 g) is nearly half the quoted value. Therefore, this criterion precludes liquefaction at the site.

In conclusion, the observations made by Seed, Idriss, and Arango (1983), Kayen et al., (1992), and Stokoe et al., (1988) indicate liquefaction in F-Area will not occur for the PC-3 earthquake motion analyzed.

4.2.2.3 The Stress Method

The stress method of liquefaction analysis is based on the "Simplified Procedure" developed by Seed and Idriss (1971). However, site-specific liquefaction susceptibility curves developed as part of the recent investigations at RTF and ITP (BSRI, 1993; and WSRC, 1995b; respectively) have been used.

For a given SCPTU tip resistance value and depth, the simplified methodology compares the cyclic stress ratio generated by the earthquake (CSRE) to the cyclic stress ratio required to induce liquefaction in the soil (CSRL). The soil is considered to be susceptible to liquefaction in zones where CSRE exceeds CSRL with an appropriate factor of safety. (A factor of safety of 1.15 was applied for this report).

Seed et al., (1983) have outlined a simple technique to estimate CSRE which does not require site-specific dynamic analyses. This technique uses the peak horizontal ground acceleration at the surface, the ratio of the total and effective vertical stresses, and a stress reduction factor, to calculate CSRE as a function of depth. However, dynamic analyses are preferable where shear wave velocities have been measured and dynamic moduli and damping curves have been developed. Modulus and damping curves have not been specifically developed for F-Area, but have been developed for SRS in general (WSRC, 1996b). Dynamic analyses were performed as part of the geotechnical investigation using the 1-D program SHAKE (Schnabel, Lysmer, and Seed, 1972).

Many correction factors exist to account for the differences in state of stress, age, and disturbance of soil samples. For example, a soil with an OCR of 3 would be less susceptible to liquefaction than a soil with an OCR of 2. Similarly, soils obtained using the best undisturbed sampling methods still exhibit strength loss do to disturbance. Researchers have found as much as a 30% reduction of strength due to soil disturbance (Seed, Singh, and Chan, 1979). For the analyses performed in F-Area, these correction factors are recognized, however, for conservatism were not considered.

Detailed geotechnical characterizations at RTF and ITP suggest that the Tobacco Road sediments are significantly less susceptible to liquefaction than the recent sediments defining the standard liquefaction susceptibility curves proposed by Seed et al. (1983). (The Tobacco Road Formation is about 40 million years old (late Eocene), whereas the sediments in the Seed et al. (1983) database are much younger and are generally less than 10,000 years old (Holocene)). Age correction factors were not considered in the analysis, however the site specific CSRL curves have age effects inherently built in.

To account for significant differences in the genesis, age, and composition of the older SRS sediments, it was decided at the onset of the F-Area investigation to use the site-specific CSRL curves for the Tobacco Road Formation developed at RTF and ITP. These curves are considered to be more representative of the SRS soils. These curves were used with the SCPTU soundings at F-Area for the analysis of the F-Canyon.

4.2.2.3.1 Evaluation of Factors of Safety Against Initial Liquefaction

The cyclic shear stresses calculated from the response analyses were compared with the cyclic strengths as determined from the in-situ SCPTU tip resistance and the factors of safety against the initial liquefaction were calculated for each of the 5 selected soil columns near F-Canyon. These five SCPTUs are representative of all 40 SCPTUs pushed in the F-Area Separations and Tank Farm. Figures 4.2-6 through 4.2-10 show the results of the liquefaction analyses performed on the five SCPTUs. The results indicate that for a PC-3 seismic event, liquefaction will not occur. Settlements resulting from liquefaction/partial liquefaction will be less than 1/2 inch in F-Area.

4.2.3 Conclusions

Several independent approaches to define the seismic liquefaction potential of the Tobacco Road and Dry Branch Formation soils have been presented above. The results show that for the PC-3 ground motion used, the factor of safety against initial liquefaction is high, and therefore, liquefaction is not expected to occur. Dynamic settlements resulting from partial pore pressure increase are expected to be less than 1/2 inch.

4.3 Measured Settlement

F-Area includes twenty-two waste storage tanks and numerous structures. Survey points were attached to all of the tanks and some of the structures, such as diversion boxes and pump pits, for which elevation surveys were performed and are listed in Tables 4.3-1 and 4.3-2.

The survey period for the tanks and structures is relatively short and has lasted continuously from November 1991 through May 1996. Many sources were investigated for locating the survey data prior to 1991, however, none was found. Consequently, field elevation measurements provide only 4.5 years of semiannual data. Perhaps most importantly, no survey information was found for Structure 221F (F-Canyon).

A review of the data in Tables 4.3-1 and 4.3-2 shows very small settlement magnitudes during the 4.5-year period. Most of the tanks and structures indicate settlement (negative value) and a few indicate rebound (positive values) over the last 1 to 1.5 years. Figures 4.3-1 and 4.3-2 show this situation more clearly and elaborates with four values of settlement:

1. the average settlement as of April 1996,
2. the maximum average settlement during the 4.5-year survey period,
3. the differential settlement as of April 1996, and
4. the maximum differential settlement during the 4.5-year survey period.

The values referred to as "average" consist of all similarly positioned survey points on a structure or tank measured on the same date. Figures 4.3-3 and 4.3-4 show the inconsistency in the settlement data and is exemplary in illustrating the similar log-time settlement trends for all tanks and structures. Given the small magnitudes of non-trending movement, the data are within the range of numerous types of errors, including uncorrected temperature effects and systematic surveyor error, and are unusable for any analyses at this time. However, as discussed earlier, the ground conditions in F-Area are similar to those in H-area. Therefore, the long-term settlements of major structures will be about the same as the similar structures in H-Area. Since the long-term settlements predicted for the H-Area tanks were 1/2 inch in 30 years, tanks in F-Area are expected to settle the same amount in 30 years.

4.4 Bearing Capacity

Static and dynamic bearing capacities for different foundations were evaluated. These foundations include rectangular, strip, and circular shapes of various sizes at various depths and locations in F-Separations and F-Tank Farm. The following sections describe the methodology used in the analyses, evaluation, and conclusions of the evaluation.

4.4.1 Methodology

Two methods were used to determine the bearing capacity of the soils. Section 4.4.1.1 describes the method using the strength properties of the soil. Section 4.4.1.2 describes the method based on a given settlement of the foundation.

4.4.1.1 Bearing Capacity based on Soil Strength

The following equations originated by Terzaghi and later modified by others were used for computing the bearing capacity Q_a (Fang, 1991):

$$Q_a = N_c\, S_c\, c + N_q\, S_q\, q + N_\gamma\, S_\gamma\, \gamma B/2$$

N_c, N_q, and N_γ are the bearing capacity factors:

$$N_c = \cot\phi\,(N_q - 1)$$
$$N_q = e^{\pi \tan\phi}\,\tan^2(\pi/4 + \phi/2)$$
$$N_\gamma = 2(N_q + 1)\tan\phi\,\tan(\pi/4 + \phi/5),$$
$$= 1.5(N_q - 1)\tan\phi, \text{ or}$$
$$= e^{0.73\phi - 1.646}, \text{ for strip footing.}$$

The smallest N_γ was used for the applicable analyses.

S_c, S_q, and S_γ are the shape factors for rectangular foundations:

$$S_c = 1 + (B/L)(N_q / N_c)$$
$$S_q = 1 + (B/L)\tan\phi$$
$$S_\gamma = 1 - 0.4\, B/L$$

where B is the width of the foundation and L is the length of the foundation. For circular foundations, B/L is equal to 1.

If the distance from the foundation to the groundwater elevation, Z_w, is less than the foundation width B, then the effective density of the soil below the foundation base is taken as:

$$\gamma_s + (\gamma - \gamma_s)\, Z_w/B$$

where γ_s is the submerged unit weight of soil and Z_w is the distance from the foundation to the groundwater elevation.

4.4.1.2 Bearing Capacity Based on settlement

Bearing pressures corresponding to a given settlement were also computed using the SPT N-values (Peck, 1974). The N-values were corrected for effective overburden pressure by multiplying a correction factor C_n:

$$C_n = 1 / (\sigma_v')^{1/2}$$

Allowable bearing pressures were then determined using the chart in Figure 4.4-1. If the depth of the groundwater table D_w is less than the sum of the foundation depth D and width B, then the bearing pressures were also adjusted for water table depth using the water table correction factor C_w:

$$C_w = 0.5 + 0.5\, D_w /(D + B).$$

4.4.2 Evaluations

Average soil strength parameters provided in Table 3.1-1 were used to evaluate the bearing capacities corresponding to the strength of the soils. A safety factor of 3 was considered for the static bearing capacity and 2.25 for the dynamic bearing capacities.

Average SPT N-values provided in Table 3.1-1 were also used to evaluate the bearing capacities corresponding a given settlement. Allowable bearing pressures corresponding to a one-inch settlement were considered for individual footings and two-inch settlement was considered for large foundations.

In the F-Separations, bearing capacities of the TR1 formation were considered for the foundations. In the F-Tank Farm, bearing capacities of the TR1 formation were considered for the waste tanks and bearing capacities of the fill were provided for the rectangular and strip foundations. By comparing the bearing pressures computed using the strength of the soil and the anticipated settlement, the smaller value was chosen as the allowable bearing pressure of the soil.

4.4.3 Results

The results show that the average soil bearing capacity in the F-Separations ranges from 1.9 to 4.2 ksf, depend on the configurations and locations of the foundations. Figures 4.4-

2 through 4.4-4 show the bearing capacities of rectangular, strip, and circular foundations at the F-Separations with various sizes and depths.

In the F-Tank Farm, average bearing capacity for rectangular and strip varies from 1.7 to 5.9 ksf and the average bearing capacity for waste tanks is 4.6 ksf. Figures 4.4-5 and 4.4-6 show the bearing capacities for rectangular and strip foundations at the F-Tank Farm with various sizes and depths. The dynamic soil bearing capacity is considered 33 percent more than the static bearing capacity.

The results show that the soils in the F-Area generally provide adequate strength supporting the foundations. Although in certain fill locations in the F-Tank Farm, the average bearing capacity may be less than 2 ksf.

4.5 Evaluation of Fill

As shown in Figures 4.4.5 and 4.4.6, allowable average bearing capacities for narrow foundations at shallow depths on the fill is 1.7 ksf. Based on the variations of the results provided by the tests, bearing capacities for other configurations of foundation on fill can also be less than 2 ksf.

For proposed new foundations bearing on fill, site specific-evaluations are recommended, because the quality of the fill is suspect. The extent and type of testing required should be based on a case by case evaluation of available information, structure design criteria, and the schedule and budget considerations.

4.6 Slope Stability

The criteria for evaluating slope stability are:

Condition	Required Factor of Safety	Methodology
Static	1.5	Circular slip surfaces using Simplified Bishop methods; strength parameters based on triaxial test results and Standard Penetration Test (SPT) correlations.
Dynamic	1.1 (Evaluation also based on slope deformation)	Pseudostatic procedure by Makdisi and Seed (1978), with horizontal acceleration of 0.2 g and vertical acceleration of 0.08 g; Strength parameters based on triaxial test results and SPT correlations.

4.6.1 Methodology

The stability of the slope in the vicinity of Tanks 19, 20 and 25 was evaluated using limit equilibrium techniques for static and pseudostatic conditions. The computer program SLOPE/W (GEO-SLOPE, 1994) was used in the analysis; the analysis was verified using project-qualified SRS computer program GEOSLOPE (GEOCOMP, 1994). SLOPE/W analyzes a user-specified array of circular failure surfaces. GEOSLOPE generates random failure surfaces based on an input range of slip-surface endpoints.

The circular surfaces were analyzed using the Simplified Bishop's method. The Bishop's simplified method with pseudostatic earthquake forces is a standard calculation method within the geotechnical profession. This method assumes a circular slip surface divided into several vertical slices for computational purposes. The program solves for static equilibrium. The interslice shear force is neglected for this method, so that the resultant interslice force is always horizontal. Earthquake forces are simulated by applying a force, equal to the weight of each slice times the seismic coefficient, to the center of each slice--this is the pseudostatic method. Once the slice normal and shear forces are statically resolved, the factor of safety is calculated as the sum of rotating moments (due to gravity and earthquake loads) divided by the sum of resisting moments (due to maximum shear resistance along the bottom of each slice). The SLOPE/W and GEOSLOPE programs can quickly calculate factors of safety for a large number of slip surfaces, so the worst-case slip surface (with the lowest factor of safety) is found through trial and error.

In addition to horizontal seismic loads, a vertical pseudostatic load equal to 40 percent of the horizontal load was applied to the GEOSLOPE model to simulate the worst-case effect of vertical loading simultaneous with horizontal loading. Two vertical load cases were analyzed: upward load and downward load.

4.6.2 Geometry and Stratigraphy Used for Slope Stability Analyses

The slope was modeled based on the results of three cross-section surveys in the vicinity of the tanks. The three surveyed cross sections were nearly identical; each was approximately 18 feet high and 35 feet long. The slope is gabion-faced, but the stabilizing effects of the gabions were conservatively neglected in the analyses.

Best estimate soil properties were used for the evaluation of each cross-section and are found in Table 3.1-1. Soil properties were derived from review of triaxial test results and field SPT and SCPTU results. The determination of soil-strength parameters was based on layer-wide combination of data, but was conservative to allow for localized variations in soil properties. Both the quantity and scatter of laboratory data were considered in the evaluation for soil-strength parameters.

4.6.3 Analyses

4.6.3.1 Soil Strength Parameters

Soil strength parameters are based on interpretation of data from three main sources:

<u>Laboratory Triaxial Testing</u>

Effective and total strength parameters for F-Area soil layers were determined by plotting a best-fit line through laboratory triaxial test results. Lambe and Whitman (1969) demonstrate this technique using the stress-path parameters p and q. In this approach, p' is the average effective normal stress, and q' is the corresponding effective shear stress at failure--this is the top of Mohr's effective-stress failure circle. Likewise, p and q (without the prime (') symbol) refer to the corresponding points on Mohr's total-stress failure circle. Mohr's failure cycle is depicted in Figure 4.6-1.

While the symbols and diagram in the following discussion refer to total stress, the discussion also applies to effective stress analysis, in which all stress variables have the prime (') symbol.

Note that α is defined by the dashed line that crosses through the top of Mohr's circle, and that ϕ is defined by the failure envelope that is tangent to Mohr's circle at failure.

When the data from several triaxial tests is combined, a best-fit line through the tops of the Mohr's failure circles is determined. For granular materials, the line is approximated to pass through the origin; whereas for the TR3/TR4 total-stress analysis, the best-fit line crosses the shear-stress axis, and the intercept is interpreted to be cohesion (c). Once α is determined from this best-fit line, then ϕ is determined using the following relationship:

$$\tan \alpha = \sin \phi.$$

SPT Correlations

SPT correlations (Bowles, 1988) were also used in determining the effective friction angle (ϕ'). This correlation is often based on the average SPT N-value; however, for this site it was based on the average SPT N-value minus the standard deviation for each layer. This is because the correlation is intended for site-wide use across F-Area, and local variations in shear strength may exist. Also, the SPT correlation was originally developed for granular material. Since site soils consist primarily of silty sands and clayey sands, it is appropriate to use this conservative approach. The Bowles correlation for fine sands was used based on the high fines contents of the materials.

Seismic Piezocone Penetration Test (SCPTU) Correlations

To verify the triaxial results and SPT correlations, the effective friction angle ϕ' was also determined using results from several representative SCPTUs for soils above the groundwater table. Two SCPTU correlations were used (Robertson and Campanella, 1983). The range of SCPTU results was consistent with the triaxial and SPT results.

The final recommendation for strength properties is based on an evaluation of the triaxial test results and the SPT and SCPTU correlations--including the quantity and scatter of the data.

4.6.3.2 Static Factor of Safety

The static slope stability analysis performed as described in section 4.6.1, with FILL-layer strength parameters determined as described in section 4.6.3.1 resulted in a static factor of safety against slope failure of 2.0. Since this is greater than the minimum requirement of 1.5, the slope is considered safe under static conditions.

4.6.3.3 Pseudostatic Factor of Safety

The pseudostatic factor of safety, calculated as described in Section 4.6.1 is 1.3. Since this is greater than the minimum requirement of 1.1, the slope is considered safe against seismic slope failure. The additional vertical upward and vertical downward load cases did not have significantly different results; the factor of safety remained 1.3.

4.6.3.4 Seismic Slope Deformation

Earthquake-induced slope deformations are estimated using the method proposed by Makdisi and Seed (1977).

The yield acceleration was determined by performing slope stability analyses for several seismic coefficients. This defines the relationship between seismic coefficient and factor of safety. The yield acceleration is the seismic coefficient that corresponds to a factor of safety of 1.0.

For this slope, the yield acceleration (A_y) is 0.37 g. Using the maximum crest acceleration of 0.2 g, the ratio of yield acceleration to maximum crest acceleration is:

$$A_y/A_m = 0.37g/0.2g = 1.85$$

Based on the Makdisi and Seed correlations (1977), an A_y/A_m ratio of 1.85 will result in significantly less than 1 centimeter of slope deformation.

4.6.4 Conclusions

The static and seismic factors of safety are greater than the minimum requirements; therefore the slope is qualified against static and seismic slope failure. In addition, the analysis determined that seismic slope deformation based on the input ground accelerations is negligible.

SECTION 5

5. SUMMARY

A new study, including field and laboratory testing, field performance data, geological, seismological, and geotechnical engineering investigations, has been completed that provides the necessary generic data for evaluating the performance of the subsurface soil materials in F-Area. The subsurface conditions were characterized based on a series of investigations that included: SPT borings, piezocone penetration test soundings, surface geophysical surveys, evaluation of structure performance data, laboratory testing, and evaluation of data from previous studies at SRS. The results of these evaluations, together with geotechnical engineering analyses, are presented in this report and are summarized in the following subsections.

5.1 Soil Spectra

Site specific rock spectra developed in accordance with DOE STD 1023 was used for the evaluation of foundation stability. The spectra and time histories were developed for the F-Canyon in June of 1996 (WSRC, 1996a). Using the developed time histories convolution analysis was performed as described in Section 4.1.1.

5.2 Subsurface Conditions

Subsurface conditions at F-Area are typical for the GSA and are comparable to conditions identified at the ITP facility within the H-Tank Farm (WSRC, 1995b). Shallow engineering stratigraphy defined for F-Area correlates closely with the stratigraphy defined for the H-Tank Farm. Average engineering soil properties for these stratigraphic layers are also about the same. Carbonate sediments and associated soft zones prior to remediation are very dense, underlying the F-Tank Farm and have been noted sporadically throughout F-Area. These sediments have been remediated prior to construction and evaluation of these programs with similar remediation programs in other areas of SRS show similar results.

5.3 Liquefaction and Dynamic Settlement

The liquefaction potential of the soils at the site was evaluated both qualitatively and quantitatively (Section 4.2). The results showed that neither the Tobacco Road nor Dry Branch Formations are susceptible to liquefaction for the PC-3 ground motion spectrum. Measured shear wave velocities, grain size, and plasticity results from each formation show that the potential for seismic liquefaction is very low. Quantitatively, the stress approach (Section 4.2) shows that the potential for seismic liquefaction in the Tobacco

Road and Dry Branch Formations is negligible. Settlements resulting from liquefaction or partial liquefaction will be less than 1/2 inch.

5.4 Measured Settlement

An assessment of settlements of tanks and other structures bearing on natural deposit in the F-Area was performed. Based on the actual measured performance data, it is concluded that the soils at F-Area will behave similarly to the soils in H-Area. Thus, the long-term settlements of major structures are estimated to be 1/2 inch over the next 30 years. Evaluations of settlements also indicate that for structures with loads not exceed 6 ksf, the settlements are excepted to be less than one inch.

5.5 Bearing Capacity

Bearing capacities of the soils were computed for various foundations in the F-Separations and F-Tank Farm. Results obtained from two different approaches were evaluated: bearing capacities computed using the strength properties of the soil, and bearing capacities corresponding to a given settlement. Evaluation results indicate that the soils in the F-Area generally provide adequate strength for the foundations with a static loading up to 6 ksf. Generally, the average allowable bearing capacity of the fill was found to be greater than 4 ksf. However, in the F-Tank Farm, for foundations less than 4 feet wide, with embedment depths of less than 2 feet, the average allowable bearing capacity of fill is 1.7 ksf.

5.6 Engineered Fill

Engineered fills were evaluated for the F-Area. It is concluded that for certain configurations of foundation on the fill, the average allowable bearing capacity is only 1.7 ksf. For proposed new foundations bearing on fill, site specific-evaluations are recommended, because the quality of the fill is suspect.

5.7 Slope Stability

Slope stability analyses for the embankment fill were completed for static and pseudostatic conditions. The analysis included an evaluation of F-Area soil-strength parameters for use in other F-Area calculations. The results of the stability analyses show that the embankment slope is stable under the conditions analyzed. Predicted seismic slope deformation is negligible.

SECTION 6

6. CONCLUSIONS AND RECOMMENDATIONS

The shallow stratigraphy and average engineering properties determined for F-Area are directly comparable to those determined for the H-Tank Farm (WSRC, 1995b). Geologic conditions are also directly comparable between these two areas. The F-Tank Farm shows very similar conditions within the lower portion of the Dry Branch Formation (DB4/DB5 layers) and Santee (ST) to those within the ITP area of the H-Tank Farm. The F-Tank Farm and F-Canyon structure were grouted prior to construction; thus subsurface conditions can be expected to be somewhat the same or better in these areas.

Bearing capacities of the soils in F-Area generally provide adequate strength for the foundations with static loading up to 6 ksf. However, for certain configurations of foundation on the fill, the average allowable bearing capacity is lower than 2 ksf. For proposed new foundations bearing on fill, site specific-evaluations are recommended, because the quality of the fill is suspect.

Design and construction of new PC-3 and higher or heavily loaded structures in F-Area should not require extensive geotechnical characterization. However, because of the current seismic qualification requirements to comply with DOE criteria, a limited program of field testing to confirm dynamic soil properties may be required to obtain baseline subsurface information such that a site-specific comparison with results of this investigation can be made.

It is recommended that all tanks and major structures in the F-Tank Farm continue to be periodically monitored for settlement. Settlement results should be compiled and reviewed by competent geotechnical and structural engineers. Trigger values of settlement (static and dynamic) should be established to signal when additional analysis and/or action should be initiated.

Because of continued operations within the F and H Areas, it is recommended that the geotechnical information from this report and from the ITP/HTF Geotechnical Investigation be summarized and condensed into a report entitled, "F/H Area Geotechnical Data Reference Guide." This guide would provide recommended soil input parameters for new foundation design, as well as summarize the input parameters for dynamic analysis of existing and new structures. Furthermore, this document would incorporate geotechnical evaluations made for the structural fill; such as criteria for the use of Controlled Low Strength Material (CLSM) and excavation guide parameters, as well as summarize the structural settlement data compiled to date, and periodically update newly acquired data.

SECTION 7

7. REFERENCES

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APPENDIX A

A. PREVIOUSLY REPORTED GEOTECHNICAL INVESTIGATION

Numerous geotechnical investigations have been conducted in F-Area since the early 1950's. Previously reported geotechnical investigation results for F-Area are summarized below, organized into three sub-sections: F-Tank Farm, F-Separations, and the balance of F-Area. The specific reference listed in Section 7 are noted after each report heading.

A.1 F-Tank Farm

A.1.1 SRP Foundation Investigation, F and H Areas (USACOE, 1951)

This investigation was performed primarily for Building 221-F (see Section A.2.1), but it also included three undisturbed borings in the F-Tank Farm, Building 241-F. Foundation exploration there consisted of three undisturbed borings, SPT split-spoon borings, and numerous "fish tail" borings, to an average depth of 40 feet. Selected samples from each undisturbed hole were tested for physical soil properties. Laboratory tests included triaxial shear, consolidation, permeability, and classification tests. Computed settlement for the worst condition was 0.1 to 0.4 inch for the F-Area Powerhouse and 0.3 to 0.9 inch for Building 221-F.

Results from permeability testing and shear strength tests were utilized to compute slope stability for the 241 buildings. It was found that slopes of 1 on 1 yielded a factor of safety of 1.7. The water table remained substantially constant at an elevation of 226 feet MSL, from May 1951 through October 1951, with negligible fluctuations. In general, it was concluded that the area investigated presents no serious foundation problems.

A.1.2 Foundation Investigation, Waste Storage Facilities, Building 241-F (Woodward-Clyde & Associates, 1969)

This investigation was conducted to provide recommendations for the design and construction of foundations for two proposed waste storage tanks. Eleven borings were drilled in the footprint of Tank Nos. 33 and 34. Laboratory tests were performed to investigate the physical properties, permeability, strength, and compressibility. The investigation and analyses concluded that the average contact pressure of the foundation slab be limited to a maximum of 7,000 psf. It was also concluded that the heave or compression of the foundation material is not likely to exceed about 0.25 inch, and the resultant angular deformation of the structure will be negligible. The subsoils between the tank foundation at El. 243.0 feet MSL and the average groundwater level (El. 225.0 feet MSL) will not significantly inhibit the percolation of effluent leakage and eventual contamination of the groundwater system. As a result of the study, it was recommended that construction of an impervious deformable barrier be considered. Barrier features, such as a bentonite liner or a clay blanket, could be placed during subgrade preparation and backfilling to preclude groundwater contamination.

A.1.3 Radioactive Waste Storage Tanks, Subsurface Geologic Investigations (Tanks 1 through 6, 8 and 17 through 20) Areas 200 H and F (John A. Blume & Associates, 1971)

This investigation was conducted to determine the geotechnical properties and boundary conditions necessary for Phase II seismic analysis of the tanks considering soil-structure interaction. In F-Area, two borings in different tank farm clusters were drilled to a depth of about 250 feet below the ground surface at each location. Detailed logs of the drill holes were included in the report. Standard penetration test (SPT) split spoons and Shelby tubes were used to obtain disturbed and undisturbed samples for laboratory testing. Down-hole geophysical surveys were performed in each of the drill holes to determine the shear wave velocity of the soils. Geophysical surveys, using surface reconnaissance-type seismic refraction techniques, were also performed primarily to determine near surface lateral continuity of wave propagation conditions and the respective compressional wave velocities. Laboratory tests consisted of classification tests, unconfined compression tests, and cyclic triaxial shear tests. This investigation provided two sets of dynamic elastic properties, one set to be used for modeling Tanks 1 through 8, and the other set to be used for modeling Tanks 17 though 20.

A.1.4 Buildings 641-1F and 241-21F, Containment Building for Pump Pits and Diversion Boxes (Mueser, January 1986)

This investigation was performed to review quality of the existing fill material surrounding pump pits and diversion boxes and to provide recommendations on its suitability to support proposed new loads to be imposed by containment structures in the waste storage tank yard area This study involved the review all available field compaction records for locations near Building 641-1F and Building 241-21F, which were built and backfilled between 1967 and 1981 with the depth of fill ranging from 19 to 41 feet. Building 641-1F consists of Pump Pit 1 and Diversion Box 2. Building 241-21F consists of Pump Pits 2 and 3 and Diversion Box 4. The backfill surrounding these buildings was not originally intended as structural backfill.

A summary table of the available compaction test results is presented in the report which indicates that the modified Proctor maximum dry densities for all backfill soils was generally between 114 and 125 pcf, with corresponding optimum water contents of 17 and 11 percent. All tests, except one, were determined to be as specified in ASTM D1557, which is the modified Proctor compaction test.

A large majority of tests for the F-Area fills were found to have passed the requirement of 95% of modified Proctor. It was determined that, based on the wealth of compaction test data available, the proposed containment building's foundation would bear on a fill of good quality. It was concluded that the fill could support spread footings loaded to 2,000 psf, and isolated column footing settlements were estimated to be 0.25 to 0.5 inch, with maximum differential settlements on the order of 0.25 inch.

A.1.5 Additional Reports for Tank Farm Area

The following additional foundation investigation reports, issued to DuPont by their consultants; Mueser, Rutledge, Wentworth, and Johnston; and the grouting contractor; Girdler Foundation and Exploration Company, contain the results of the various drilling and grouting programs that were performed over the extended construction period from 1955 through 1984 to evaluate and improve the existing subsurface conditions in the tank farm areas prior to erection of the tanks:

- "Foundation Investigation Building 241-F Additional High Level Waste Storage Tanks, Project 9S 1493 FY75, Tank Nos. 25 through 28, Projects FY77, Tank Nos. 44 through 47, Savannah River Plant," May 1975 (MRWJ 1975a)
- "Building 241-F, New High-Level Waste Storage Tank Nos. 52 and 55" (MRWJ, 1977a)
- "F-Area Waste Tank Borings 241-14F-1 through 241-14F-8" (Mueser, 1975c)
- "Field Drilling and Grouting Operations, Building 241-F, Additional High Level Waste Storage Tanks, Projects 9S1493, FY 75, Tank Nos. 25 through 28, FY 77, Tank Nos. 44 through 47" (Mueser, 1975b)
- Field Drilling Records and Grouting Operations, Building 241-F, New High-Level Waste Storage Tanks, Projects 9S1747 and 860606 FY79 Tank Nos. 52 through 55 (Mueser, 1977b)
- "F-Area Tank Farm Sinkhole Southeast of Tank 28," January 1994 (WSRC, 1994c)

A.2 F-Separations

A.2.1 Building 221-F, Foundation Investigation (USACOE, 1951)

An investigation was performed to determine the conditions for the foundation of Building 221-F and certain adjacent areas. This investigation included undisturbed borings, SPT split- spoon borings, and numerous "fish tail" borings, to an average depth of 40 feet. One piezometer was also installed in the F-Canyon Area. Laboratory tests included triaxial shear, consolidation, permeability, and classification tests. Settlement analyses were performed for the 221-F building and for the F-Powerhouse. The results of the computation for the worst condition was 0.1 to 0.4 inch for the F-Area Powerhouse and 0.3 to 0.9 inch for Building 221-F. Results from permeability tests and shear strength tests were also provided. The water table remained substantially constant at an elevation of 226 feet MSL, from May 1951 through October 1951, with negligible fluctuations. In general, it was concluded that the area investigated presents no serious foundation problems

A.2.2 Proposed Building 772-4F and Smokestack (Soil and Materials Engineers, 1989)

This investigation was conducted to provide foundation and earthwork recommendations for the proposed Building 772-4F. Six test borings were drilled extending to depths ranging from 20 to 40 feet below grade. Standard penetration tests were performed and one undisturbed sample was obtained. Laboratory tests were performed consisting of Atterberg limits, grain size analyses and a consolidated undrained triaxial test. In general, the natural soil consisted of surfical sandy clay to clay sand underlain by silty sand. The biggest variation in subsurface conditions exists because of the presence of fill that is variable in quantity and quality. This report recommended that either the fill soils be excavated and properly recompacted or that deep foundations be used along the western side to carry foundation loads below the fill. Other than along the western side of the building, the natural soils are suitable for supporting a structure on shallow foundations, with recommend bearing pressure of 5,000 psf. The anticipated settlement is 0.5 to 0.75 inches.

A.2.3 Buildings 701-2F and 701-14F (Westinghouse Environmental and Geotechnical Services Inc., 1990)

This investigation was conducted to provide recommendations for proposed Buildings 701-2F and 701-14 F. Four borings were drilled to approximately 25 feet deep. Standard Penetration Tests were performed and split tube samples were collected. Laboratory tests consisted of grain size analyses, Atterberg limits, and a California Bearing Ratio tests. A representative sample of the proposed fill material was also tested using Standard Proctor Compaction Method per ASTM D-698.

This investigation estimated that using an assumed bearing pressure of 3,000 psf, the existing fill soil will have a factor of safety against shear failure in excess of 3. The anticipated foundation settlement at Building 701-2F and 701-14F will not exceed 0.67 inch and 0.75 inch, respectively. The modulus of subgrade, K, is approximately 100,000 pcf.

A.2.4 Soil Analysis Report, Airborne Radiation Removal Building, 772-4F (Metcalf & Eddy, 1992)

This investigation was conducted by Metcalf & Eddy, Inc. to provide foundation recommendations for the design of the stack for the Airborne Radiation Removal Building 772-4F. Two borings were drilled to depths of 50 to 100 feet. Standard Penetration Tests were performed and split spoon and undisturbed Shelby tube samples were collected.

It was found that the subsurface conditions consist of approximately 10 to 12 feet of medium dense, silty sand underlain by at least 90 feet of medium dense, fine to medium sand with a variable amount of silt and thin lenses of stiff silt. Groundwater was encountered at a depth of 90 feet. The net allowable bearing pressure is 5,000 psf. The estimated average settlement of the stack foundation is 0.5 inch. The estimated permanent angular distortion was not to exceed the allowable limit of 1/250. The fill encountered during the July 1989 investigation (Section A.2.2) in the same area was not evident in this investigation.

A.2.5 Naval Fuel Facility, Building 247-F (Mueser Rutledge Johnston and DeSimone, 1981)

The following two investigations were performed for the Naval Fuel Facility in December 1981:

- Naval Reactor Fuel Material Facility, 200 F-Area, Building 247-F, SRS, December 1981

This investigation was conducted by Mueser, Rutledge, Johnston and DeSimone, Consulting Engineers to provide recommendations for foundations for the proposed Building 247-F; a one-story manufacturing facility, without a basement. A total of fourteen borings were completed, ranging from 110 to 150 feet deep. Standard penetration tests were performed, with split-spoon and undisturbed samples being collected for laboratory testing.

It was determined from the boring data and soil sample testing that the subsurface conditions consist of Tertiary sediments of interbedded sand and clay layers, with the first 140 to 160 feet consisting of generally compact sands and highly desiccated clays. These deposits are underlain by a lower Tertiary deposit, known as the McBean Formation, that has been found in other site areas to include leached calcareous soils, occasionally resulting in potential voids and "soft soil" zones. Field personnel noted only sporadic "drill rod drops", low split-spoon penetration resistances, and loss of drilling fluid. Undisturbed samples were recovered where low split-spoon penetrations were noted. The borings were extended through the McBean Formation and terminated in the very compact upper Cretaceous sediments. The groundwater level was approximately 84 feet below the existing surface (El. 309 MSL), or 77 feet below the proposed building foundation level (El. 302 MSL). There was no evidence of surface depressions at the proposed building site.

Laboratory tests consisted of: (1) soil identification tests such as grain size, Atterberg limits and natural moisture content; (2) strength tests - several consolidated undrained triaxial shear samples from each stratum; (3) consolidation test - one consolidation test was performed on a sample from the McBean Formation hard clay layer at 230 feet depth, and it was found to be preconsolidated.

It was concluded that the building could be founded on natural materials after the existing topsoil and loose fill had been removed. The spread footings would have a safe design allowable bearing capacity of three tons per square foot. Maximum settlement of footings supported on the natural soils will be less than one inch. Post-construction differential settlement should be less than 0.5 inch between columns. Design of the stack foundation under wind loading was limited to a maximum allowable bearing pressure of two tons per square foot for conservatism.

- 200 F-Area, Site Period Analysis, December 1981 (Geotechnical Engineers Inc., 1981),

  This report was prepared for DuPont at the request of Mueser-Rutledge, for determination of the characteristic site period for F-Area, based on the Uniform Building Code Standard No. 23-1 procedure (WSRC, 1995a).

  The average soil profiles used in the study were from borings F-101 through F-114 in the proposed Naval Fuel building site. Shear wave velocities used were based on a previous study by GEI for the subsoils at Building 221-H in June 1979. The computer program SHAKE (Schnable, 1972) was used with the artificial Housner spectrum earthquake scaled to 0.1 g and 0.2 g as input. The results of the study recommended that, for a maximum depth of 500 feet of soil, the characteristic site period should be assumed to be in the range of 1.5 to 2.0 seconds.

A.2.6 Sand Filter Structure, Building 294-2F (Law Engineering Testing Co., 1983)

An investigation was conducted by Law Engineering Testing Company to provide foundation recommendations for the sand filter located north of Building 235-F. In addition, Geotechnical Engineering, Inc. conducted an evaluation of dynamic soil properties of the site.

Ten soil borings were drilled to depths ranging from 75 feet to 200 feet below the ground surface. Standard penetration testing and split-spoon tube samples were collected. Laboratory testing included Atterberg limits, grain size analysis, natural moisture content, triaxial shear, unconfined compression, and consolidation testing.

No loss of drilling mud or sudden drops of drill rods were observed during drilling. Also, no unusual amounts of grout were required to fill borings upon completion. Groundwater level was about 75 feet below the ground surface, approximately 220 feet MSL.

The net allowable bearing pressure was recommended as 3,000 psf for undisturbed soil above El. 285 feet MSL and 5,000 psf below El. 285 feet MSL. The modulus of subgrade reaction, K, is 345,000 pcf.

The study by Geotechnical Engineers, Inc. dated June 1983, was conducted to evaluate dynamic soil properties for the F-Area Sand Filter Structure. The recommended values for maximum shear modulus, Gmax, ranging from 7,500 to 6,500 ksf, depending on the depth, were determined using both field and laboratory tests. Also included in the report were the variations of shear modulus and damping versus shear strain.

An additional letter report, dated August 1983, entitled "200F Area JB Line Special Recovery Sand Filter Soils Investigation", was issued by DuPont which summarized design conditions and described the field testing by Law Engineering and the dynamic soil property investigation by Geotechnical Engineers Inc. for the project. This report gives the geotechnical recommendations for excavation and backfill operations. It gives the soil bearing values for conventional footings on various soil foundation materials. The modulus of subgrade reaction, K = 345,000 pcf, is specified, and active and at rest pressures are given for design use, as detailed above.

A.3 The Balance of F-Area

The reports listed below, available in the SGS "soils files", contain project-specific geotechnical information concerning the design recommendations which were obtained at various times prior to construction of a given facility. For any new proposed project or facility in locations outlying the F-Tank Farm or F-Separations, it is recommended that before any additional subsurface exploration program is implemented, existing data be thoroughly researched in order to minimize redundant subsurface testing. Also, the initial project criteria for evaluation of any proposed new facility should consider the relative location and any available geotechnical data from previous nearby activities.

The following tabulation of reports is grouped by relative purpose and general location in F-Area:

- "Seepage and Retention Basins," H. Perry Holcomb, December 1977
- "F-/H-Area Seepage Basins Field Logs/Borings H-155 to H-157," USACOE, March 1952
- "F-/H-Area Seepage Basin Decommissioning Combined Scope of Work for a CAC," Rev. 3, July 1988, DuPont, Co.
- "Radioactive Performance Objectives for Closure and/or Remediation of Existing Burial Grounds and F- and H-Area Seepage Basins," WSRC, June 1989
- "F-/H-Area Steam Line Report of Subsurface Investigation and Geotechnical Engineering Evaluation", Rev. 1, Chas. T. Main, August 1988
- "Report of Velocity Survey F and H Areas," Shannon and Wilson, July 1971
- "Foundation Investigation Delta Program Savannah River Plant," Mueser, Rutledge, Wentworth & Johnston, July 1973

- "MWMF Closure and F & H Seepage Basins Clay Caps Savannah River Site, South Carolina," Mueser Rutledge Consulting Engineers, July 1991
- Heaving Foundations in Caustic Storage Area 211F and 211H, Mueser, Rutledge, Johnston & Desimone, July 1984.

APPENDIX B

B. SEISMOLOGY

B.1 Seismic Evaluations

The Generic Safety Analysis Report (SAR) (WSRC, 1995c) contains a detailed description of SRS seismic hazards, a summary of applicable DOE seismic standards, and a history of the earthquake design basis development for SRS facilities. The reader is referred to that document for the seismology background.

Development of design basis earthquake (DBE) ground motions are currently underway at SRS. The new design basis spectra will meet the requirements of DOE Standard 1020 (1994) and 1023 (1995a). The new spectra will be developed for the bedrock/soil interface and for soil free-surface. Specification of design motions at both bedrock and free-surface will facilitate the engineering use of either smoothed surface spectrum or soil response by convolution analysis. At the present time, the bedrock spectra are available for F-Area and will be used for the ground motion assessments in this report. Development of the rock motions are described in the next section.

B.2 F-Canyon Rock Spectra Development

Site-specific bedrock spectra/time histories were developed for the F-Canyon facility in June 1996 (WSRC, 1996d). These facility-specific spectra meet DOE-STD-1023 (1995a) requirements for a mean based spectrum that has an annual probability of exceedance of 5×10^{-4} (PC-3). The bedrock design basis spectrum was derived by averaging the Electric Power Research Institute (EPRI) (NEI, 1994) and Lawrence Livermore National Laboratory (LLNL, 1996) mean uniform hazard spectrum (UHS), appropriate for bedrock conditions at the SRS. Following DOE-STD-1023 (1995a), the bedrock hazard spectrum was broadened by using two deterministically-derived spectral shapes; one anchored at the average of 5 to 10 Hz and the other at the average of 1 to 2.5 Hz. The spectral shapes were derived from Random Vibration Theory (RVT) (Boore, 1983) models of ground motion for average earthquake magnitudes and distances controlling the 5 to 10 and 1 to 2.5 Hz seismic hazard. These earthquake magnitudes ranged from 5.4 to 5.7 (M_w) and distances 70 to 105 km. The smoothed envelope of the bedrock scaled spectra and the averaged UHS constitute the F-Canyon site-specific bedrock DBE spectrum. Similarly, an 1×10^{-4} bedrock spectrum was derived for the purposes of performance assessment of the F-Canyon structure (WSRC, 1996d).

DOE-STD-1023 (1995a) also requires a deterministic ground motion check using the largest historical earthquake within 200 km having a moment magnitude greater than 6. For the SRS, this check was conducted for ground motions associated with a repeat of the 1886 Charleston earthquake (Mw = 7.5) (WSRC, 1996d). Following DOE-STD-1023 (1995a), these PC-3 ground motions are median estimates.

APPENDIX C

C. GEOLOGY

Basement lithologies at SRS consist primarily of crystalline igneous and metamorphic rocks, possible Late Precambrian to Late Paleozoic age, and of Early to Middle Mesozoic (Triassic to Jurassic) rocks that occur in isolated, fault-bounded basins either exposed within the crystalline belts or buried beneath the coastal plain sediments (WSRC, 1994b).

The Coastal Plain stratigraphic section is divided into several formations and groups based principally on age and lithology. Sediments range in age from Late Cretaceous through Tertiary. The lithostratigraphic sequence at the General Separations Area (GSA) is composed mostly of terrigenous clastic sediments interspersed with carbonate-rich clastic sediments and limestones. The clastic facies consist of gravel, pebbly sand, clayey sand, silt, clay, and sandy clay. The calcareous facies consist of calcareous sand and mud, limestone, sandy limestone, and sandy and muddy limestone. These Cretaceous through Tertiary sediments are described in the following sections and depicted in Figure C-1, beginning with the deepest formations and progressing to the surficial sediments. The following subsections discuss the regional stratigraphy of SRS, while more detailed F-Area specific stratigraphy is discussed in Section 2 of the report.

C.1 Cretaceous Sediments

The Cape Fear Formation is the basal unit of the Coastal Plain stratigraphic section and is composed of poorly sorted, silty-to-clayey quartz sand and interbedded clay. The sand is arkosic in places. Muscovite and iron sulfide are also present. The Cape Fear Formation is more indurated than the other Cretaceous formations because of the high clay content and abundance of cristobalite in the sediment matrix. Sand is commonly medium-grained, but ranges from very fine to coarse-grained. Pebbly zones are present in many parts of the section.

The Cape Fear Formation is about 30 feet thick at the northwestern SRS boundary and thickens to more than 180 feet near the southeastern boundary. The environment of deposition has been interpreted as upper delta plain (Prowell et al., 1985).

The Middendorf Formation unconformably overlies the Cape Fear Formation with a sharp, distinct contact. This formation is dominantly a medium to coarse-grained quartz sand with moderate to good sorting. Pebbly zones are common as well as clay clasts. Some parts of the unit are feldspathic, micaceous, and lignitic zones. The sand of the Middendorf Formation is much cleaner and less indurated than sand in the Cape Fear

Formation. Cross-bedding is well developed in the lower part of the section in some areas. A clay layer up to 80 feet thick forms the top of the formation. Another clay-rich zone is present near the middle of the formation in places at SRS. In the northern part of SRS, the formation is highly colored and composed mostly of sand. The thick clay bodies observed downdip within SRS are missing in the north, although clay interbeds up to 2 feet in thickness are present.

The formation is approximately 130 feet thick near the northwestern boundary of SRS and thickens to more than 180 feet near the southeastern boundary. The Middendorf Formation at SRS was probably deposited in fluvial and deltaic environments (Prowell et al., 1985).

The Black Creek Formation is composed of sand, silt, and clay. The upper part of the formation is mostly clay and silt, while the lower part consists of silty micaceous sand. Sorting is generally moderate to poor. The sand is micaceous and becomes lignitic in the central and southwestern parts of SRS. Layers of pebbles and clay clasts are common. Feldspathic zones are present. The upper, clayey, silty section of the Black Creek Formation is divided into three lithofacies, each trending across SRS from southwest to northeast. The northwestern lithofacies is a massive 20 to 40 feet thick clay that is highly oxidized. The Black Creek Formation in the central part of SRS is dominantly dark to light, micaceous silty sand with thin interbeds of clay. The southeastern lithofacies is also fine-grained and consists mostly of dark clay interlaminated with silt. Dark, fine- to medium-grained, fining-upward sand is present within the unit. Iron sulfides are common.

The Black Creek Formation is about 110 feet thick at the northwestern boundary of SRS and thickens to more than 250 feet near the southeastern boundary of the site. Most of the Black Creek Formation was probably deposited in a lower delta plain environment, except for the light-colored sand in the northwestern part of SRS, which was probably deposited in an upper delta plain environment.

The Peedee Formation is dark, glauconitic, fine-grained sand and silt with marine fossils (dinoflagellates). The deposits in the vicinity of SRS are referred to as the Steel Creek Member of the Peedee Formation. The lower part of the Steel Creek Member is sandy with a pebble-rich zone at its base suggesting a basal unconformity. This lower section consists of poorly to well-sorted, fine- to coarse-grained quartz sand and silty sand and is very micaceous in places. The upper part of the Steel Creek Member is a clay that varies from more than 50 feet to less than 3 feet in thickness at SRS. Fining upward sands are interbedded with the clay in some areas. Steel Creek Member probably formed in an upper delta plain environment in the southwest and in a lower delta plain in the northeast. It is about 110 feet thick at the northwestern SRS boundary and 130 feet thick at the southeastern boundary.

C.2 Tertiary Sediments

C.2.1 Paleocene

The Sawdust Landing Formation, the lowermost Paleocene unit, rests unconformably on Cretaceous sediments and consists mostly of yellow, orange, tan and gray, poorly sorted, micaceous, silty, and clayey quartz sand interbedded with gray clay. It is locally feldspathic, and iron sulfide and lignite are common in the darker sections.

The overlying Lang Syne Formation consists of dark gray and black lignitic clay and poorly to moderately sorted, micaceous, lignitic, silty quartz sand and pebbly sand. Glauconite is common in the southeastern part of the unit. Feldspar occurs locally, and iron sulfide and cristobalite are common in the darker colored part of the unit.

The Snapp Formation, the uppermost Paleocene unit, consists typically of light gray, tan, orange, and yellow, medium-to coarse-grained quartz sand and pebbly sand interbedded with kaolinitic clay. Dark muscovite and lignite-bearing sand is less common. The Snapp in the northwest part of SRS is a less silty, better sorted sand with thinner clay interbeds.

The depositional environment for Paleocene unit grades from upper to lower delta plain (deltaic) and marginal marine from northwest to southeast across SRS.

C.2.2 Eocene

The Fourmile Formation of Fallaw and Price (1995) is a tan, orange, yellow, brown, and white, fine to coarse, moderately well-sorted, loose sand. Pebbly zones are common. Clay layers are characteristically found near the middle and top of the unit. It is characteristically about 30 feet thick at SRS. The presence of glauconite and dinoflagellate assemblages suggest a shallow marine environment of deposition.

The Congaree Formation unconformably overlies the Fourmile Formation and consists of well sorted, well rounded, and fine- to coarse-grained quartz sand. Thin clay laminae occur throughout the formation, but are more common in the lower part. In some areas a thin clay-rich glauconite-bearing layer separates the Congaree from the underlying Fourmile Formation. Pebble layers, clay clasts, and glauconite are locally present. Both siliceous and calcareous cement have been observed in the upper part of the Congaree Formation at SRS. The unit increases in thickness from about 60 feet on the northwest to about 80 feet in the southeast, and is interpreted as a shallow marine environment of deposition.

The Warley Hill Member (Fallaw and Price, 1995) overlies the Congaree Formation. It consists of variable clay, clayey sand, and silty fine-to medium-grained quartz sand and locally contains glauconite. Thickness varies from a few inches to 15 feet. The Warley Hill is sometimes included in the informal hydrostratigraphic unit known as the "green clay."

The Tinker-Santee-Blue Bluff Formation overlies the Warley Hill interval and includes three distinct lithofacies. The light colored, moderately to well sorted, fine to coarse, sometimes calcareous quartz sands that predominate towards the north and northwestern parts of SRS have been termed the Tinker Formation (Fallaw and Price, 1995). The amount of calcareous material within the Tinker Formation increases from northwest to southeast across SRS and grades into the Santee Limestone towards the southeast. The Santee Limestone consists of cream-colored, micritic to shelly, partially indurated to indurated, biomoldic limestone, indicative of an open, unrestricted shallow marine environment. To the southwest, the Blue Bluff unit consists of clayey and silty, laminated, calcilutite, calcareous clays and calcareous quartz sands indicating a more restricted environment and a more proximal position to a siliciclastic source. Previously, the Tinker-Santee-Blue Bluff interval was termed the McBean Formation or McBean Member of the Lisbon Formation, or the Santee Formation (Siple, 1967; Colquhoun et al., 1983; Prowell, et. al., 1985).

The Clinchfield Formation overlies the Tinker Formation and consists of fine- to coarse-grained, locally calcareous, quartz sand. An indurated, bioclastic and biomoldic, glauconitic limestone facies, commonly containing abundant echinoid fragments (Periarchis lyelli), is designated as the Utley Limestone Member. The amount of calcareous material increases downdip (i.e., to the southeast).

The Dry Branch Formation overlies the Clinchfield Formation. The Dry Branch Formation has been subdivided into the Griffins Landing, Twiggs Clay, and the Irwinton Sand Members. The Griffins Landing Member is a distinctive carbonate-bearing facies that interfingers with the Twiggs Clay Member which consists of clay beds of variable thickness interbedded with clayey sand. The Griffins Landing is characterized by the presence of *Crassostrea gigantissima* often found in growth positions. These carbonate occurrences are discontinuous and probably represent oyster beds developed in a back barrier or transitional environment, and the clays probably represent marsh and tidal flat deposits. The Irwinton Sand Member contains moderately-to well-sorted quartz sand, locally interlaminated with clay. In general, the Irwinton Sand generally maintains a superior stratigraphic position to Twiggs Clay and the Griffins Landing Members. The entire formation thickens from about 50 feet near the northwestern boundary of SRS to approximately 80 feet to the southeast.

The Tobacco Road Formation conformably overlies the Dry Branch Formation. A coarse layer that may contain a flat pebble conglomerate is characteristic at the contact point between the two formations. The formation typically contains moderately- to poorly-sorted, red, brown to variegated purple and orange, quartz sand with clay stringers. Trace fossils, especially burrows of Ophiomorpha, are locally abundant. Pebble layers and muscovite are distributed locally throughout the formation. A heavy mineral concentration, sometimes present at this boundary, may produce radioactivity that assists in identifying the contact on gamma-ray logs.

C.2.3 Younger than Eocene

The 'Upland Unit' is an informal stratigraphic term that has been applied to local deposits that outcrop at higher elevations in the coastal plain of southwestern South Carolina (Nystrom and Willoughby, 1982; Nystrom et al., 1986). Units in a similar stratigraphic position in Georgia are usually called the Altamaha Formation (Dall and Harris, 1892 [fide Huddleston, 1988]). Outcrops and surface exposures are very common in the SRS area. Dark red, brown, orange, poorly sorted clayey to silty sand locally contains lenses and layers of conglomerate, pebbly sand and clay. Cross bedding and white flecks that may be weathered feldspar are locally common. The Upland Unit, locally up to 70 feet thick, is generally fluvial and forms a scoured, erosional surface on the Tobacco Road Formation. The age of this unit has not been definitively determined, and correlation with similar deposits in the region is not yet clear. Prowell, et. al. (1985) and Nystrom et al. (1986) have proposed a Miocene age. Work in progress (Colquhoun, 1994) suggests that at least, in part, the age of sediments in this interval may be as old as Late Eocene.

APPENDIX D

D. SUBSURFACE EXPLORATION

Subsurface information in F-Area is available from pre-construction boreholes drilled for the initial foundation investigations, post construction soils investigations, and from two recently completed exploratory programs. Between November 1995 and July 1996, an exploration program was completed in F-Area to obtain additional subsurface information to compliment existing data, as well as, provide information where data did not exist. Between August and September of 1995, a field exploration program for the new Consolidated Repackaging facility was completed. This information has been included as part of the overall F-Area investigation as presented in this report. The primary intent of the two recent exploration programs was to acquire adequate subsurface information to characterize the subsurface conditions in terms of static and dynamic properties. This was accomplished by developing a shallow engineering stratigraphy for the F-Area and comparing the subsurface conditions directly with extensive characterization previously completed in the H-Tank Farm (WSRC, 1995b).

The new exploration programs consisted of a series of SPT and undisturbed (UD) sample boreholes and Seismic Piezocone Penetration Test soundings (SCPTU) performed at selected locations in several areas around F-Area to develop preliminary subsurface characterization and perform a preliminary engineering analysis. SPT boreholes and CPT probes were paired so that a site-specific comparison of results could be obtained. Further, the deeper stratum lying beneath F-Area was investigated with surface geophysical techniques to obtain the geometry, relative depths and structure of these units.

In summary, the following boreholes and information acquired as part of this investigation have been used for the characterization of the subsurface materials within F-Area:

- 40 SCPTU soundings,
- 12 SPT/UD boreholes,
- 98 pre-existing soil borings, and
- Shallow High Resolution Seismic Reflection Survey, consisting of 3 separate lines

Plate 1 shows the locations of the boreholes/SCPTU soundings, as well as the pre-existing borehole locations. Test methods, equipment, and general field procedures, are summarized in the following sections.

D.1 Field Test Location and Clearance

The selection of the borehole locations, CPT probes, and other field work was based primarily on the following criteria and factors:

- Facility layout restrictions
- Data coverage
- Existing data availability
- Type of data required
- Under-and-above ground interferences
- Operation restrictions
- Radiological (RCA) versus non-radiological area

Approval of the selected location for the field work was preceded by a series of work coordination steps as summarized below (the organization responsible for each step is noted in parentheses):

- Selection of general area based upon the factors listed above (SGS),
- Preliminary interference research (Construction Layout),
- Ground penetrating radar survey (Operations Department),
- Preparation of work package (SGS),
- Work Process Control (Operations Department),
- Field survey (Construction Layout), and
- Radiological work control (Health Protection).

This detailed site clearance routine was essential for safe field operations. Any obstacles or restrictions encountered in any step during this process required the relocation of the proposed borehole or penetration location, and therefore the re-initiation of the process. Close coordination with each facility within F-Area was maintained throughout the field investigation, which facilitated the field program.

D.2 Equipment and Field Test Methods

Table D-1 provides information on sampling methods and general information pertaining to completed boreholes and depths for the field exploration phases. All equipment used in the field investigations met applicable ASTM standards and site standards and procedures as listed below:

- WSRC E9 SGS-GT-202 - Drilling Practices,
- WSRC E9 SGS-GT-203 - Sample Preparation, Handling and Storage,
- WSRC E9 SGS-GT-206 - Engineering Soil Descriptions,
- WSRC E9 SGS-GT-207 - Field Log Preparation,
- WSRC E9 SGS-GT-210 - Standard Penetration Test,
- WSRC E9 SGS-GT-211 - Cone Penetration Test Soundings,
- WSRC 3Q5 Manual - Hydrogeologic Data Collection, and
- ASTM D1587-83 (ASTM 1996) - Thin-walled Tube Sampling of Soils (Shelby).

D.2.1 Exploration Contractor(s) and Equipment

Two drilling contractors were utilized for the borings, SPT testing and undisturbed soil sampling (Shelby tubes). One CPT contractor was used for all CPT soundings. A description of the scope of each contractor and the equipment used is provided below.

D.2.1.1 Applied Research Associates (ARA)

Applied Research Associates (ARA) performed all SCPTU field and data processing activities. The CPT rig and operating crew performed all testing for the F-Area investigation including the Consolidated Repackaging Facility investigation. The rig and crew have been used extensively on recent geotechnical programs at SRS including the ITP/HTF investigation, RTF, KASS, Par Pond, and others. The CPT rig used for this investigation is described below.

Mac I

The Mac I CPT rig is a 22 ton rig capable of 30 ton mass push when fully ballasted. The push rod and piezocone utilized conformed with ASTM D3441 (ASTM 1996) consistent with WSRC E9 SGS-GT-211 - Cone Penetration Test Soundings. This rig was equipped with a hydraulic skid coupled to the surface beneath the rig for generating a shear wave source. Compressional waves were generated with a hydraulic vertical hammer located on the outside of the rig. All components were controlled by the operator.

D.2.1.2 Graves Environmental

Graves Environmental, Inc., performed the drilling and sampling for borings F-SEP-B8, F-SEP-B8.1, F-SEP-B13.1, and F-SEP-B6. All Graves Environmental drillers involved with the drilling and sampling activities were experienced, and also had been involved with numerous geotechnical investigations at the SRS including the ITP/HTF investigation. The drilling equipment utilized is described below.

Failing 1500

The Failing 1500 drill rig is gas-driven with a 40-foot mast. The rig has a 23-foot Kelly assembly which allows for a 20-foot stroke and is capable of mud rotary, augering, and rotary coring techniques. The drill string is controlled by the Kelly arrangement, as well as, by a mechanical winch. This rig was used for all deeper borings requiring mud rotary.

D.2.1.3 Environmental Exploration

Environmental Exploration performed the drilling and sampling of borings FB-1 and FB-2 as part of the Actinide Packaging and Storage Facility investigation in August 1995. They were used for drilling the shallow SPT/UD borings in the F-Tank Farm (F-TNK-B3, F-TNK-B8, F-TNK-B13, F-TNK-B16, F-TNK-B20 and F-SEP-B13). The rig utilized is described below.

Mobile B-57

The Mobile B-57 is a truck-mounted drill rig with a 30-foot mast and a five-foot Kelly stroke. The rig is capable of auger and mud rotary drilling, however it was only used for augering to support the shallow sampling required in the structural fill.

D.2.2 Standard Penetration Test (SPT)

Continuous SPT with intermittent shelby tube samples, were performed in 12 boreholes (See Sections D.2.1.2 and D.2.1.3). Continuous SPT testing was performed by driving the split spoon sampler 18 inches, unless refusal per ASTM D 1586-84 (ASTM 1996) was met, retrieving the sampler, reaming the 18-inch sampled interval, then performing the next SPT.

Tests were performed in accordance with WSRC E9 SGS-GT-210 using a standard 24-inch long by 2-inch outside diameter (OD), split-spoon sampler with a 2-foot bleeder and check valve located above the sampler, NX drill stem, and a 140-lb safety hammer falling 30 inches. SPT N-values were determined by adding the number of blows required to drive the split-spoon sampler the last 12 inches of the standard 18-inch drive.

The general test procedure, as noted in sequence, is outlined below:

1. Split spoon is lowered into nominal 4-inch diameter borehole,
2. Depth is checked and any rod settlement noted,
3. Six-inch intervals, totaling 18 inches, are marked on the drill rod above the turntable,
4. Sampler is driven by blows applied using a 30-inch stroke with the rope wrapped twice over the cathead,
5. Sampler retrieved and recovery noted,
6. Sampled interval reamed out to nominal 4 inches, and
7. Process repeated.

Prior to each SPT test, the Geotechnical Oversight professional verified that the spoon was properly assembled, making sure the bleeder and check valve were clean and the drive shoe was in good condition.

D.2.3 Undisturbed Sampling

Undisturbed soil samples were obtained for laboratory testing with direct push shelby tubes. The selection of the sampling interval was based on the results of previously pushed SCPTU soundings located within 10 to 15 feet from the boring. Sampling intervals were based upon the following:

- Clayey zones within the Tobacco Road Formation (TR3/TR4),
- Clayey zones within the Dry Branch Formation (DB4/DB5), and
- Low tip resistance zones within the structural fill at the F-Tank Farm.

A sampling plan was developed for each borehole. Drilling requirements for undisturbed sampling boreholes required that fluid pressures be kept as low as practical, while maintaining fluid return up the borehole. Drill bits with side discharge, or, in the case of tricone bits, with bottom deflectors, were required for reaming and advancing the borehole.

D.2.3.1 Direct Push Shelby Tube

Direct push Shelby tubes were used for sampling cohesive soil layers. The shelby tubes used were either brass or galvanized steel with a 3 inch OD, 0.065 inch wall thickness, and a length of 30 inches. Sampling was performed in accordance with ASTM D1587 (ASTM 1996).

In the deeper borings (F-SEP-B8, F-SEP-B8.1, F-SEP-B13.1 and F-SEP-B6) drilling was accomplished by mud rotary methods to the predetermined sampling depth. The drill stem was then tripped out and the bit removed. The Shelby tube head with a ball check valve was then attached and lowered to the bottom of the borehole. Borehole depth was checked against the drilled depth and noted. The maximum push length was marked on the drill stem and the rod hydraulically advanced a full 24 inches or until 600 psi hydraulic pressure was reached. Once the advance was made, the tube was allowed to sit for 5 minutes. When ready to retrieve the sample, the drill string was rotated about 90 degrees to shear the sample off the surrounding soil. Shallower borings (F-TNK-B3, F-TNK-B8, F-TNK-B13, F-TNK-B16, F-TNK-B20, and F-SEP-B13) were augered. The augers were advanced with a center plug in place at the bottom of the auger bit. Sampling was performed as described above for mud rotary borings.

When each sample was brought out of the borehole, the bottom and top were capped with plastic slip-on caps. If a gap was noted between the bottom tube edge and sample, a filler material was placed in the gap prior to placing the cap. Details of final sample preparation are provided in Section D.3.

D.2.4 Piezocone Penetration Soundings

CPT, including seismic (SCPT), were performed in accordance with ASTM D 3441 (ASTM 1996). The CPT was used because of the relatively quick and clean operation, which is of significant importance in RCAs and because of its ability to provide a continuous soil profile, which is important when defining the extent of soft and/or loose soil zones. In general, all CPTU soundings included shear wave velocity surveys at 3-foot intervals. Target depths were based upon the estimated elevation of the top of the Congaree Formation (average depth is approximately El. 120 feet MSL). However, actual depths varied, depending upon ground surface elevations and subsurface conditions. Refusal was defined as a tip stress of 1,800 psi or reaching the capacity of the hydraulic push system.

D.2.5 Surface Seismic Reflection Survey

Three seismic reflection profiles were acquired around the eastern, northern, and western perimeters of F-Area and along the steam line access to C Road. The eastern profile tied to well P-28. All profiles were recorded employing a 96 channel split-spread configuration with a 60 foot near offset and 420 foot far offset on 5 foot source and receiver intervals to yield nominal 48 fold data. The VIBROSEIS seismic source employed a 6 second sweep from 50 to 200 Hertz with 4 stacks per source position. These parameters allowed imaging of events in Coastal Plain sequences from approximately top of the Congaree to basement in order to resolve structure and relative depth of these units. The location of the seismic lines is shown in Plate 1.

D.2.6 Borehole and Penetration Abandonment

Abandonment of boreholes and CPT soundings was performed per WSRC Manual 3Q5, Hydrogeologic Data Collection (WSRC, 1992) Chapters 6, 9, and 10. The standard grout mix consisted of the following:

- One sack Type 1 Portland Cement (94 lb sack),
- Two pounds of dry sodium bentonite, and
- 6.5 to 7.5 gallons of potable water.

All boreholes were abandoned immediately upon completion of testing. Grouting was accomplished via the tremie method. The grout pipe was lowered to the bottom of the borehole and grout was injected until the borehole fluid was displaced and grout returned to the surface. All boreholes were grouted to the surface and topped off until the column remained static.

Cone penetrometer soundings were abandoned by pressure grouting thorough a push rod which was re-pushed down to the bottom of the sounding. A grout tube extending to the bottom of the push rod was used to pump grout into the hole as the push rod was retracted. Holes were topped off until the column remained static.

D.3 Sample Preparation, Handling, Storage, Transportation, and Control

In general, all undisturbed samples were prepared and handled in accordance with WSRC E9 SGS-GT-203 - Sample Preparation, Handling and Storage. Shelby tubes were checked for conformance with ASTM D1587-83 (ASTM 1996).

A sample storage area was established near the site. Access to samples was limited to geotechnical personnel only and was controlled by lock and key. The undisturbed samples were maintained in vertical tube boxes capable of holding four tubes as prescribed by ASTM D 4220 (ASTM 1996). The storage area was maintained between 60 and 70 degrees Fahrenheit.

Once the samples were obtained, the samples were trimmed, measured, and sealed. Plastic caps were placed over both ends of each tube, then taped and each tube labeled. For SPT boreholes, a sample was collected from the top and bottom of the sample spoon. If a material change occurred within the sample, additional samples were collected, as appropriate. Samples were placed in 8-ounce glass jars. The tops were closed tightly, wrapped, sealed with electrical tape, and samples were labeled on both the jar and the lid.

All soil samples selected for testing were turned over to Law Engineering for transporting to the laboratory in Atlanta. All tube samples tested by Law Engineering in Atlanta were transported in tube boxes and were maintained in a vertical position.

APPENDIX E

E. LABORATORY TESTING

Laboratory testing was performed for the F-Area investigation in parallel with the field investigation described in the preceding section. The objective of the laboratory testing program was to characterize the physical and engineering properties of the site soils for design purposes. Specifically, the laboratory program was designed to determine:

- Index properties, including classification, moisture content, unit weight, plasticity, and grain size distribution,
- Static strength in undrained and drained triaxial compression,
- Consolidation properties, and
- Compaction characteristics.

The laboratory work was performed by Law Engineering of Atlanta, Georgia and consisted primarily of classification, triaxial strength, and consolidation tests. Laboratory tests performed previously at the site by USACOE (1951), MRWJ (1973, 1975, 1977), Blume (1971), Woodward-Clyde (1969), Geotechnical Engineers (1983), Law Engineering (1983), and MRJD (1981) were also used to establish the engineering properties of the soils in F-Area.

Table E-1 lists the standards and procedures used to perform the recent laboratory work for F-Area. The individual laboratory test results performed for this F-Area investigation are presented in Attachment 2. Laboratory test results performed for the previous projects within F-Area are available in the project files at SRS.

In general, the selection of samples for laboratory testing at F-Area was based on the soil classification from the field borehole logs and from the SCPTU soundings performed during the F-Area investigation. Reassignment of testing, when necessary, was based on observations made in the laboratory.

E.1 Test Laboratory Quality Assurance

The Law Engineering (LAW) QA Manager was responsible for ensuring the quality of laboratory testing activities at the LAW test laboratory in Atlanta. Testing activities included sample handling and storage; sample chain-of-custody integrity; procedure development; software verification, validation and control; calibration of test equipment; testing; and data recording.

SGS QA performed a surveillance of testing, sample handling and control, equipment calibration, and documentation and record control activities at the LAW test laboratory. Nonconformances were identified, but were corrected and actions were taken to preclude recurrence of the anomalies.

E.2 Testing Program

A summary of the laboratory testing performed at F-Area during this investigation and from previous investigations is as follows.

- Visual classification in the laboratory and natural moisture content determinations on nearly all soil samples,
- sets of Atterberg Limits,
- specific gravity tests,
- grain size analyses,
- unconsolidated-undrained triaxial (TX-UU) strength tests,
- consolidated-drained triaxial (TX-CD) strength tests,
- consolidated-undrained triaxial (TX-CU) strength tests,
- one-dimensional consolidation tests, and
- density tests.

Table E-2 summarizes the static test results at F-Area. A statistical summary of the laboratory tests is provided in Table E-3. Table E-4 summarizes the results of all current and previous consolidation tests. The dry density, water content, and initial void ratio reported in Table E-4 denote values obtained from the field prior to saturation. The results of these tests, together with laboratory tests results from other areas at SRS and field performance data, formed the basis for the representative soil properties as given in Section 3.

In general, all tests for current F-Area investigation were performed in accordance with the standards and procedures listed in Table E-1. Specific deviations, or enhancements for testing on the F-Area soils, to those listed in Table E-1 are provided in the following sections.

E.2.1 Static Triaxial Tests

Static triaxial tests for F-Area were performed to determine the shear strength and elastic moduli of the material over a range of confining stresses for both total and effective stress conditions. Unconsolidated-undrained (TX-UU) and consolidated-undrained (TX-CU) tests were performed in accordance with ASTM D2850 (ASTM 1996) and ASTM D4767 (ASTM 1996), respectively. All consolidated-undrained tests were consolidated isotropically to the effective overburden stress with back-pressure saturation to a B-value (pore pressure parameter) of 0.95 or greater. These test results are reported in Attachment 2.

TABLES

TABLES

Table 3.1-1 Average Soil Properties at F-Area

	FILL	TR1	TR1A	TR2A	TR2B	TR3/TR4	DB1/DB3	DB4/DB5	ST	GC
Description	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG
SPT N-value, N	23	25	25	28	36	18	33	15	47	21
SPT N-value (corrected for overburden), N1	21	33	19	19	19	8	14	6	17	7
Shear wave velocity (ft/sec)	978	1455	1348	1256	1254	1074	1157	1140	1353	1675
Corrected tip resistance (tsf)	112	91	120	147	201	55	172	61	131	58
Friction ratio	2	4	2	2	1	2	1	2	2	2
Qc / N (uncorrected)	4.9	3.7	4.8	5.2	5.5	3.1	5.1	4.1	2.8	2.7
Percent fines	25	33	30 **	17	19	64	14	22	29	39
Percent clay	21	18	33 **	10	8	40	12	20	24	3
Mean grain size, D50 (mm)	0.22	0.23	0.12	0.27	0.36	-	0.34	0.29	0.22	0.11
Plasticity index, PI (%)	15	17	14	10	18	58	19	28	18	47
Liquid limit, LL (%)	32	38	36	33	41	96	44	48	40	83
Dry density (pcf)	104	106	96	101	98	76	99	85	87	91
Water content, w (%)	13	15	19	17	22	51	27	39	29	32
Wet density (pcf)	117	122	114	122	123	108	124	118	116	121
Specific gravity	2.71	2.67	2.67	2.69	2.73	2.69	2.68	2.71	2.69	2.61
Void ratio, Eo	0.64	0.57	0.75	0.68	0.80	1.37	0.75	1.06	0.97	0.82
At-rest lat. earth press. coefficient, Ko (NC)	0.47	0.44	0.47	0.47	0.48	0.50	0.44	0.56	0.48	0.53
At-rest lat. earth press. coefficient, Ko (OC)	0.49	1.04	0.60	0.44	0.52	0.63	0.52	0.55	0.53	0.48
Overconsolidation ratio, OCR	1.1	4.6	1.6	0.9	1.2	1.6	1.3	1.0	1.2	0.8
Compression index, Cc	0.08	0.12	0.08	0.07	0.05	0.85	0.27	0.55	0.31	0.31
Re-compression index, Cr	0.009	0.011	0.009	0.011	-	0.14	0.11	0.053	0.042	0.035
Consolidation coefficient, Cv (ft^2/day)	1.2	0.6	0.3	0.3	-	0.5	-	0.6	1.0	0.4
Total cohesion, C (ksf)	-	-	-	-	-	0.75	0	0	-	-
Total friction angle, ϕ	-	-	-	-	-	13	17	17	-	-
Effective cohesion, C' (ksf)	0	0	0	0	0	0	0	0	0	0
Effective friction angle, ϕ'	32	34	32	32	31	30	30	28	31	28
Elastic Modulus, E (tsf)	363	353	395	447	565	265	514	258	565	295
* Shear Modulus, static, G (tsf)	145	141	158	179	226	106	206	102	226	118

* Poison's ratio, ν = 0.225 for Fill, TR1, TR1A, and TR2A. ν = 0.47 for remaining layers

** 58 samples used to compute average fines, 3 samples used to compute average clay

Table 3.1-2 Average Soil Properties at H-Area

DESCRIPTION	FILL	TR1	TR2	TR3/TR4	DB1/DB3	DB4	DB5	ST
	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG
SPT N-VALUE	25	27	31	15	32	17	20	58
SHEAR WAVE VELOCITY, ft/s	1059	1187	1226	1193	1128	978	1055	1251
CONE TIP RESISTANCE, Qc, tsf	48	57	168	52	174	48	50	111
FRICTION RATIO	8	5	1	3	1	2	2	1
Qc/N	1.9	2.1	5.4	3.5	5.4	2.8	2.5	1.9
PERCENT FINES (<.074mm)	40	38	17	23	11	34	45	25
PERCENT SILT	8	16	7	9	3	10	13	12
PERCENT CLAY (<.002mm)	32	22	10	14	8	24	32	13
PLASTICITY INDEX, %	34	47	18	25	23	67	47	31
LIQUID LIMIT, %	58	76	37	45	45	90	70	55
PLASTICITY INDEX (-200 MATERIAL), %	57	79	47	101	110	140	88	78
LIQUID LIMIT (-200 MATERIAL), %	96	120	84	144	148	179	131	112
DRY DENSITY, pcf	104	99	104	102	98	85	72	88
WATER CONTENT, %	19	22	22	22	25	39	47	32
WET DENSITY, pcf	124	121	126	125	122	114	105	116
SPECIFIC GRAVITY	2.67	2.68	2.66	2.68	2.69	2.68	2.65	2.67
VOID RATIO	0.609	0.684	0.629	0.625	0.719	1.103	1.523	0.876
AT-REST LAT. EARTH PRESS. COEFF	0.40	0.44	0.52	0.46	0.44	0.78	0.52	0.44
OVERCONSOLIDATION RATIO	1.48	3.02	4.29	1.89	2.10	0.95	1.26	1.26
COMPRESSION INDEX	0.18	0.25	0.51	0.17	0.33	0.72	1.14	0.42
RE-COMPRESSION INDEX	0.02	0.04	0.13	0.03	0.05	0.13	0.19	0.06
COEFF. OF CONSOLIDATION, ft^2/day	2.78	1.32	0.20	2.30	1.82	0.53	0.68	1.27
TOTAL COHESION, ksf	2.5	1.1	1.5	1.9	-	-	-	-
TOTAL FRICTION ANGLE, deg	0	16	23	13	-	-	-	-
EFFECTIVE COHESION, ksf	0	0	0	0	0	0	0	0
EFFECTIVE FRICTION ANGLE, deg	37	34	29	33	34	13	29	34

Table 3.2-1 Reference Strain

Formation Description	**Reference Strain ε_r (%)**
Stiff Upland Sands	0.021
Tobacco Road and Snapp Sands	0.044
Dry Branch, Santee, Warley Hill, and Congaree Sands	0.077
Four Mile Sands and any other Unrepresented Shallow Sands	0.066
Shallow Clays	0.148
Deep Sands	0.111
Deep Clays	0.230

Table 3.2-2 Damping Ratio versus Shear Strain

Strain	Formation						
(%)	A	B	C	D	E	F	G
0.00001	1.059	0.625	0.825	0.674	1.296	0.489	0.992
0.0001	1.059	0.625	0.825	0.674	1.296	0.489	0.992
0.0002	1.103	0.647	0.835	0.687	1.292	0.497	0.990
0.0003	1.151	0.670	0.846	0.702	1.293	0.505	0.991
0.0005	1.248	0.717	0.871	0.733	1.300	0.524	0.995
0.001	1.493	0.835	0.936	0.811	1.326	0.570	1.013
0.002	1.973	1.070	1.070	0.970	1.389	0.665	1.054
0.003	2.434	1.300	1.205	1.127	1.456	0.759	1.097
0.005	3.302	1.747	1.470	1.435	1.594	0.945	1.186
0.01	5.201	2.790	2.108	2.171	1.938	1.398	1.410
0.02	8.165	4.605	3.281	3.505	2.603	2.251	1.851
0.03	10.407	6.139	4.336	4.686	3.233	3.039	2.276
0.05	13.639	8.614	6.162	6.692	4.392	4.453	3.080
0.1	18.317	12.799	9.605	10.363	6.820	7.289	4.856
0.2		17.425	13.951	14.825	10.356	11.179	7.671
0.3			16.683		12.884	13.799	9.833
0.5					16.317	17.210	12.995

Formation Description

A. Stiff Upland Sands
B. Tobacco Road and Snapp Sands
C. Dry Branch, Santee, Warley Hill, and Congaree Sands
D. Four Mile Sands and any other Unrepresented Shallow Sands
E. Shallow Clays
F. Deep Sands
G. Deep Clays

Table 4.2-1 Average and Normalized Shear Wave Velocities by Layers in F-Area

Average Shear Wave Velocity

Layer	Avg. V_S ft/s	Max V_S ft/s	Min V_S ft/s	Std Dev ft/s	No. of Points
FILL	978	1380	660	136	107
TR1	1455	1970	640	285	107
TR1A	1348	1810	1000	184	148
TR2A	1256	1750	910	134	271
TR2B	1254	1860	780	181	213
TR3/TR4	1074	1490	730	203	112
DB1/DB3	1157	1620	600	194	266
DB4/DB5	1140	1620	600	248	74
ST	1353	3000	520	392	176
GC	1675	4450	920	1108	18

Average Normalized Shear Wave Velocity

Layer	Avg. V_S		Max V_S		Min V_S		Std Dev		No. of Points
	ft/s	m/s	ft/s	m/s	ft/s	m/s	ft/s	m/s	
FILL	920	280	1519	463	611	186	42	138	107
TR1	1410	430	1992	607	705	215	95	313	107
TR1A	1154	352	1843	562	736	224	69	228	148
TR2A	960	292	1323	403	711	217	28	93	271
TR2B	880	268	1288	393	538	164	36	117	213
TR3/TR4	728	222	1018	310	499	152	42	136	112
DB1/DB3	768	234	1051	320	394	120	40	131	266
DB4/DB5	734	224	1068	326	391	119	49	162	74
ST	854	260	1826	557	335	102	74	243	176
GC	1044	318	2830	863	584	178	214	702	18

Table 4.3-1 F-Area Waste Storage Tank Settlement Summary

Tank Number	Settlement (inches) as of 04/96		Settlement (inches) during Survey Period	
	Differential	Average	Maximum Differential	Maximum Average
1	-0.14	-0.06	-0.14	-0.11
2	-0.04	-0.04	-0.04	-0.11
3	-0.02	-0.02	-0.05	-0.12
4	-0.04	-0.05	-0.05	-0.05
5	-0.01	-0.05	-0.03	-0.07
6	-0.05	-0.09	-0.06	-0.09
7	-0.09	-0.02	-0.10	-0.07
8	-0.03	-0.09	-0.04	-0.09
17	-0.03	0.03	-0.03	-0.04
18		0.04		-0.03
19	-0.06	0.03	-0.06	-0.03
20	-0.05	0.10	-0.05	0.01
25	-0.02	-0.04	-0.04	-0.08
26	-0.04	-0.04	-0.04	-0.07
27	-0.03	-0.06	-0.05	-0.06
28	-0.04	0.03	-0.04	0.00
33	-0.03	-0.04	-0.05	-0.08
34	-0.02	-0.01	-0.03	-0.08
44	-0.03	-0.02	-0.03	-0.07
45	-0.03	-0.09	-0.03	-0.14
46	-0.05	-0.10	-0.06	-0.14
47	-0.03	0.01	-0.03	-0.06

Note: negative settlement values indicate downward movement

Table 4.3-2 F-Area Structure Settlement Summary

Structure Number	Settlement (inches) as of 04/96		Settlement (inches) during Survey Period	
	Differential	Average	Maximum Differential	Maximum Average
FDB-1	-0.02	-0.02	-0.03	-0.05
FDB-2	-0.04	-0.02	-0.05	-0.05
FDB-3	-0.03	-0.06	-0.03	-0.07
FDB-5	-0.01	0.00	-0.02	-0.03
FDB-6	-0.02	0.04	-0.06	0.00
F-1	-0.05	-0.02	-0.05	-0.08
F-2	-0.03	-0.09	-0.06	-0.11
CTS	-0.03	0.06	-0.03	-0.01
FDB-4/PP-2 and 3	-0.10	-0.02	-0.10	-0.03
Catch Tank	-0.02	-0.01	-0.03	-0.03

Note: negative settlement values indicate downward movement

Table D-1 Exploration Point Summary

	Exploration ID	Type	Facility	Northing	Easting	Surface Elevation (feet MSL)	Total Depth (feet)
BOREHOLES	F-SEP-B6	SPT/UD	Tank Farm	76612.7	53026.2	284.0	167.0
	F-SEP-B8	SPT/UD	Separations	78129.1	53507.2	301.0	179.5
	F-SEP-B8.1	SPT/UD	Separations	78129.1	53515.2	301.0	133.0
	F-SEP-B13	SPT/UD	Separations	79081.1	54107.1	300.9	65.0
	F-SEP-B13.1	SPT/UD	Separations	79081.1	54112.1	302.0	174.0
	F-TNK-B3	SPT/UD	Tank Farm	76974.0	52700.0	285.5	44.5
	F-TNK-B-8	SPT/UD	Tank Farm	77459.5	52765.6	269.5	49.0
	F-TNK-B13	SPT/UD	Tank Farm	77332.2	53302.8	279.1	49.0
	F-TNK-B16	SPT/UD	Tank Farm	76738.1	52482.6	282.7	45.5
	F-TNK-B20	SPT/UD	Tank Farm	77200.7	52686.2	268.7	49.0
	FB-1	SPT	Repack	79182.3	54917.9	290.6	156.5
	FB-2	UD	Repack	79101.5	54920.0	292.2	151.0
PIEZO CONE PENETROMETER TESTS	F-SEP-C1	SCPTU	Separations	79322.9	53353.5	310.8	159.0
	F-SEP-C2	SCPTU	Separations	78771.0	53951.8	311.3	171.3
	F-SEP-C3	SCPTU	Separations	78231.0	54620.7	315.3	116.0
	F-SEP-C4	SCPTU	Separations	78203.2	54278.6	319.5	112.0
	F-SEP-C5	SCPTU	Separations	78203.5	54260.6	319.9	113.0
	F-SEP-C6	SCPTU	Separations	78398.8	54504.2	313.7	182.0
	F-SEP-C7	SCPTU	Separations	78651.7	54490.0	309.1	169.0
	F-SEP-C8	SCPTU	Separations	78128.1	53523.9	301.2	136.0
	F-SEP-C9	SCPTU	Separations	79192.1	53654.4	309.7	149.7
	F-SEP-C10	SCPTU	Separations	79583.7	54266.4	289.5	151.0
	F-SEP-C11	SCPTU	Separations	78944.5	54279.0	305.4	170.0
	F-SEP-C12	SCPTU	Separations	79011.2	53523.0	309.8	176.8
	F-SEP-C13	SCPTU	Separations	79063.3	54147.2	302.0	172.0
	F-SEP-C14	SCPTU	Separations	78696.1	53422.3	309.3	153.3
	F-SEP-C15	SCPTU	Separations	78369.6	53770.0	309.8	N/A
	F-SEP-C15A	SCPTU	Separations	78387.7	53769.7	309.8	159.8
	F-SEP-C16	SCPTU	Separations	77869.0	54830.5	322.1	156.0
	F-SEP-C17	SCPTU	Separations	78831.2	53739.8	310.1	180.0
	F-TNK-C1	SCPTU	Tank Farm	76990.3	52512.0	285.0	40.0
	F-TNK-C2	SCPTU	Tank Farm	77103.6	52512.8	284.7	39.7
	F-TNK-C3	SCPTU	Tank Farm	76987.2	52699.7	285.5	160.5
	F-TNK-C4	SCPTU	Tank Farm	77137.0	52742.0	285.2	40.2
	F-TNK-C5	SCPTU	Tank Farm	77581.7	52574.5	284.5	79.5
	F-TNK-C6	SCPTU	Tank Farm	76640.3	53005.4	284.3	164.3
	F-TNK-C7	SCPTU	Tank Farm	77493.2	53061.8	287.2	17.2
	F-TNK-C8	SCPTU	Tank Farm	77459.5	52765.6	269.6	84.6
	F-TNK-C9	SCPTU	Tank Farm	76801.8	53212.8	284.1	136.1
	F-TNK-C10	SCPTU	Tank Farm	76783.9	52881.6	286.9	124.9
	F-TNK-C11	SCPTU	Tank Farm	76953.4	53199.9	281.3	121.3
	F-TNK-C12	SCPTU	Tank Farm	77251.8	53309.2	277.5	147.5
	F-TNK-C13	SCPTU	Tank Farm	77332.7	53302.8	279.7	132.7
	E-TNK-C14	SCPTU	Tank Farm	77272.8	52891.5	268.8	38.8
	F-TNK-C15	SCPTU	Tank Farm	77253.0	53018.2	278.1	78.1
	F-TNK-C16	SCPTU	Tank Farm	76752.1	52482.6	283.4	98.4
	F-TNK-C17	SCPTU	Tank Farm	77642.9	53211.4	292.0	128.0
	F235-C1	SCPTU	Repack	79230.3	54976.9	290.5	159.0
	F235-C2	SCPTU	Repack	79182.3	54927.8	290.4	157.0
	F235-C3	SCPTU	Repack	79098.7	55040.4	294.0	166.0
	F235-C4	SCPTU	Repack	79111.5	54929.9	292.2	154.0
	F235-C5	SCPTU	Repack	7928.2	55069.5	291.3	156.3
	F235-C6	SCPTU	Repack	79226.1	54871.7	289.7	155.7

SPT - Standard Penetration Test Borehole
UD - Undisturbedd Sampling Borehole
SCPTU - Seismic Piezocone Penetration Test

Table E-1 Standard Laboratory Testing Procedures

Test Description	Procedure
Determining the dry and wet density of soil volume contained in thin wall tube samples	TP-4A-ITP
Dry preparation of soil samples for particle size analysis and determination of soil constants	ASTM D421-85
Particle size analysis	ASTM D422-90
Specific gravity of soils	ASTM D854-92
Amount of material in soils finer than No. 200 sieve	ASTM D1140-92
Laboratory determination of moisture content of soil, rock, and aggregate mixtures	ASTM D2216-92
Liquid limit, plastic limit, and plasticity of soils	ASTM D4318-95
Wet preparation of soil	ASTM D2217-85
Classification of soils for engineering purposes	ASTM D2487-93
Description of soils (visual-manual procedure)	ASTM D2488-93
One-dimensional consolidation properties of soils	ASTM D2435-90
Consolidated-undrained triaxial compression test on cohesive soils	ASTM D4767-88
Unconsolidated, undrained strength of cohesive soils	ASTM D2850-95
Consolidated-drained triaxial tests	EM-1110-2-1906

Table E-2 Summary of Laboratory Test Results

PROJECT: F-Area / F-Canyon

Layer	Borehole	North	East	Type	Depth	Elev.	Lab	D50	Sand	Fines	Silt	Clay	LL	PL	PI	SG	Water Content				Dry Density				Wet	Void Ratio		
							Class										Aver.	(tube)	(tx)	(con)	Aver.	tube	(tx)	(con)	Density	Aver	(con)	(tx)
					(feet)	(feet)			(%)	(%)	(%)	(%)	(%)	(%)	(%)		(%)	(%)	(%)	(%)	(pcf)	(pcf)	(pcf)	(pcf)	(pcf)			
Layer	Borehole	North	East	Samp	Depth	Elev	CLASSlab	D50	Sand	Fines	Silt	Clay	LL	PL	PI	SG	MC	MC0	txMC	conMC	DD	DD0	txDD	conDD	WD	Eo	conE0	txE0
TR1	200F-B-10U	79980	54690	ST	11	268.2	CL						42	19	23	2.65	19	19	17	21						0.58	0.58	
TR3/TR4	200F-B-10U	79980	54690	ST	68	211.2	MH						95	69	26	2.71	69	76	78	53						1.56	1.56	
TR3/TR4	200F-B-10U	79980	54690	ST	71	208.2	MH						138	109	29	2.76	87	76	84	100						2.87	2.87	
ST	200F-B-10U	79980	54690	ST	128	151.2	CH						57	29	28	2.7	45	44		45						1.25	1.25	
ST	200F-B-10U	79980	54690	ST	133	146.2	CL						50	23	27	2.7	37	36		37						1.01	1.01	
TR2A	200F-B-12U	79880	54890	ST	38	235.4	SC										11	11	11									
TR3/TR4	200F-B-12U	79880	54890	PS	63	210.4	ML										30	31	29									
TR3/TR4	200F-B-12U	79880	54890	PS	66	207.4	MH						148	66	82	2.65	71	69	66	78						2.08	2.08	
DB1/DB3	200F-B-12U	79880	54890	ST	86	187.4	SM-SC						36	28	8	2.68	29	29	28	30						0.85	0.85	
DB4/DB5	200F-B-12U	79880	54890	ST	95	178.4	CH						52	19	33	2.72	36	35		37						1.03	1.03	
ST	200F-B-12U	79880	54890	ST	123	150.4	SM-SC						42	27	15	2.69	33	32		33						0.94	0.94	
ST	200F-B-12U	79880	54890	PS	127	146.4	CL						43	23	20	2.69	30	29		30						0.83	0.83	
ST	200F-B-12U	79880	54890	ST	136	137.4	CL						43	22	21	2.67	26	25		26						0.72	0.72	
TR3/TR4	200F-B-14U	79880	55090	ST	63	208.3	MH						80	53	27	2.7	42	44		39						1.21	1.21	
TR3/TR4	200F-B-14U	79880	55090	ST	67	204.3	SC						27	23	4	2.69	28	27		28						0.81	0.81	
TR1	200F-G-1U	80130	54875	ST	10	262.4	SC										13	13										
TR1	200F-G-1U	80130	54875	ST	13	259.4	SM										11	11										
GC	F-103U	79380	54405	ST	152.9	143.5	CH						58	29	29		36	33	33	41						0.753	0.753	
GC	F-107U	79130	54135	ST	173	136.1	CH-SM						99	32	67		40	41	38.8									
DB1/DB3	F-111U	79025	54105	ST	112.9	197	SM		92	8							25	25	24.7									
DB1/DB3	F-113U	79025	54425	ST	83	216.8	SC		54	45							29	29	29.3									
TR1	F-114UP	79141	54260	ST	5.9	301.9	CL						40	25	15		18	18	18.3									
TR1	F-114UP	79141	54260	ST	7.9	299.9	CL										16	16	16.2									
TR1	F-114UP	79141	54260	ST	9.9	297.9	SC										17	17	17.8									
TR1	F-114UP	79141	54260	ST	12.5	295.3	SC										19	19										
TR1	F-114UP	79141	54260	ST	17	290.8	SM-SC		56	44							26	26	25.5									
TR1	F-114UP	79141	54260	ST	19	288.8	SC										22	22										
TR1A	F-114UP	79141	54260	ST	95.5	212.3	CH										48	48										
TR3/TR4	F-114UP	79141	54260	ST	98	209.8	CH						144	39	105		65	64	66									
TR3/TR4	F-114UP	79141	54260	ST	100	207.8	CH										63	63										
TR3/TR4	F-114UP	79141	54260	ST	100	207.8	SC										28	28										
TR3/TR4	F-114UP	79141	54260	ST	102	205.8	SC						64	29	35		33	33	33.3									
DB1/DB3	F-114UP	79141	54260	ST	104	203.8	SC										32	32										
DB1/DB3	F-114UP	79141	54260	ST	106	201.8	SC										20	20	20									
DB1/DB3	F-114UP	79141	54260	ST	106	201.8	SP-SC		82	18																		
TR3/TR4	241-14F-1	76270	52800	SS	79.3	204.4	CH						157	33	124		57	57										
TR3/TR4	241-14F-1	76270	52800	SS	84.3	199.4	CH						93	20	73		47	47										
TR3/TR4	241-14F-2	76815	52785	SS	39.3	246.9	CH						96	37	59		33	33										
TR3/TR4	241-14F-2	76815	52785	SS	84.3	201.9	CH						108	30	78		40	40										
TR3/TR4	241-14F-3U	76490	52785	ST	26.5	261.4	CH						56	28	28		24	23	24									
TR3/TR4	241-14F-3U	76490	52785	ST	84.3	203.6	CH						137	44	93		68	66										
TR2A	241-14F-4	77070	52785	SS	55.8	234	SM						30	21	9		14	14										
TR2A	241-14F-5U	76880	52725	ST	50	236.7	SM										16	16										
TR2B	241-14F-5U	76880	52725	ST	60	226.7	SP-SC										17	17										
TR2B	241-14F-5U	76880	52725	ST	69.5	217.2	SM										26	26										
TR3/TR4	241-14F-5U	76880	52725	ST	84.3	202.4	CH						69	35	34		85	85										
DB1/DB3	241-14F-5U	76880	52725	ST	100	186.7	SC						135	62	73		66	68		64						1.02	1.02	
DB1/DB3	241-14F-5U	76880	52725	ST	114.3	172.4	SP						65	24	41		27	26		27						0.489	0.489	
DB1/DB3	241-14F-5U	76880	52725	ST	134.2	152.5	SM										33	33										
TR3/TR4	241-14F-6	76695	52600	SS	79.3	207.1	CH						125	48	77		74	74										
TR3/TR4	241-14F-6	76695	52600	SS	89.3	197.1	CH						66	24	42		30	30										
TR3/TR4	241-14F-9	77070	52600	SS	94.3	194.2	CH						160	56	104		95	95										
TR2A	241-55F-1U	77070	52333	ST	53	238.9	SM										20		20									
TR3/TR4	241-55F-1U	77070	52333	ST	96	195.9	CH						116	41	75		47	47		46						0.812	0.812	
TR3/TR4	241-55F-1U	77070	52333	ST	96	195.9	SM-SC										23		23									
DB1/DB3	241-55F-1U	77070	52333	ST	106	185.9	SC										27		27									
ST	241-55F-1U	77070	52333	ST	122	169.9	SM										26		26									
TR3/TR4	241-55F-4U	76815	52333	ST	86.1	205	SC										28		28									

Table E-2 Summary of Laboratory Test Results (cont'd)

PROJECT: F-Area / F-Canyon

Layer	Borehole	North	East	Type	Depth (feet)	Elev. (feet)	Lab Class	D50	Sand (%)	Fines (%)	Silt (%)	Clay (%)	LL (%)	PL (%)	PI (%)	SG	Water Content Aver. (%)	Water Content (tube) (%)	Water Content (tx) (%)	Water Content (con) (%)	Dry Density Aver. (pcf)	Dry Density tube (pcf)	Dry Density (tx) (pcf)	Dry Density (con) (pcf)	Wet Density (pcf)	Void Ratio Aver	Void Ratio (con)	Void Ratio (tx)
TR3/TR4	241-55F-4U	76815	52333	ST	95.6	195.5	MH										94	95		92						1.433	1.433	
TR3/TR4	241-55F-4U	76815	52333	ST	95.6	195.5	SC										54	54	54									
DB4/DB5	241-55F-4U	76815	52333	ST	118.8	172.3	MH										58	51	47	77						1.191	1.191	
TR2B	DH4	77000	53190	SS	53.5	220.7	SW-SM		93	7			NP	NP	NP		15	14.8										
TR2B	DH4	77000	53190	SS	58.5	215.7	MH		2	98			85	38	47		39	38.8										
TR3/TR4	DH4	77000	53190	ST	68.5	205.7	CL										23	22.6			95.8				117.45			
TR3/TR4	DH4	77000	53190	SS	78.5	195.7	CH		49	51			67	21	46		39	39.2										
DB1/DB3	DH4	77000	53190	SS	98.5	175.7	SW-SM		92	8			NP	NP	NP		17	17.1										
DB1/DB3	DH4	77000	53190	SS	108.5	165.7	SM		78	22			27	24	3		19	18.8										
TR1	FU-1	79125	53475		4	304	CL		60	40			41	20	21	2.63	14	14.5	13.1		104.2		104.2		117.85			
TR1	FU-1	79125	53475		4	304											14		14.4		101		101		115.54			
TR1	FU-1	79125	53475		4	304											17		16.5		102		102		118.83			
TR1	FU-1	79125	53475		5	303	SC		64	36			34	19	15		12	11.6										
TR1	FU-1	79125	53475		7	301	SC		66	34			40	19	21		12	12.3										
TR1	FU-1	79125	53475		8.4	299.6	SM		62	38			42	28	14	2.69	13		12.5		111		111		124.88	0.501		
TR1	FU-1	79125	53475		8.4	299.6											13		12.5		110		110		123.75			
TR1	FU-1	79125	53475		8.4	299.6											13		13		108		108		122.04			
TR1	FU-1	79125	53475		10	298	SC		69	31			37	20	17	2.69	12	11.5								0.505		
TR1	FU-1	79125	53475		11.5	296.5	SC		64	36			36	19	17	2.64	15		15.3		108		108		124.52			
TR1	FU-1	79125	53475		11.5	296.5											15		14.9		112		112		128.69			
TR1	FU-1	79125	53475		11.5	296.5											15		15.4		106		106		122.32			
TR1	FU-1	79125	53475		13	295	SC		67	33			36	19	17	2.68	15	14.5			102.7				117.59	0.628		
TR1	FU-1	79125	53475		14.1	293.9	SM		67	33			24	22	2		14	13.5										
TR1	FU-1	79125	53475		16	292	CL		55	45			36	23	13		18	18.2										
TR1	FU-1	79125	53475		17.1	290.9	ML		61	39			31	26	5		16	16.2										
TR1	FU-1	79125	53475		19	289	SC		68	32			40	23	17		13	13.3										
TR1	FU-1	79125	53475		20.1	287.9	SC		68	32			48	24	24	2.57	15	14.9			97.6				112.14	0.726		
TR1	FU-1	79125	53475		22	286	SC		69	31			37	21	16		14	13.9										
TR1	FU-1	79125	53475		23.1	284.9	SC		71	29			49	26	23		15	15.2										
TR1	FU-1	79125	53475		25	283	CL		60	40			49	25	24		18	17.9										
TR1	FU-1	79125	53475		26.1	281.9	SC		67	33			40	24	16		17	16.9										
TR1	FU-1	79125	53475		29	279	SC		74	26			36	18	18		10	9.5										
TR1	FU-1	79125	53475		31	277	SC		72	28			31	22	9		11	11.3										
TR1A	FU-1	79125	53475		32.1	275.9	SC		76	24			39	24	15		14	13.8										
TR1A	FU-1	79125	53475		34	274	SC		80	20			32	22	10	2.59	15	15			96.6				111.09	0.724		
TR1A	FU-1	79125	53475		35.1	272.9	SC		84	16			29	19	10		11	11										
TR1A	FU-1	79125	53475		37	271	SC		69	31			26	19	7		11	10.7										
TR1A	FU-1	79125	53475		38.1	269.9	SC		77	23			27	19	8	2.63	13	12.7			98.2				110.67	0.684		
TR1A	FU-1	79125	53475		41	267	SC		68	32			49	21	28	2.66	21	21			96.2				116.4	0.726		
TR1A	FU-1	79125	53475		41	267	SM		80	20			NP	NP	NP	2.68	13	12.7			91.4				103.01	0.83		
TR1A	FU-1	79125	53475		43	265	SC		77	23			25	15	10		11	11										
TR1A	FU-1	79125	53475		44.1	263.9	SC		78	22			25	19	6		11	10.5										
TR1A	FU-1	79125	53475		46	262	SM		82	18			26	26	0	2.71	10	10.1										
TR1A	FU-1	79125	53475		49	259	SC		77	23			23	18	5	2.7	12	12.4										
TR1A	FU-1	79125	53475		52	256	SC		62	38			30	18	12	2.62	17	16.7										
TR1A	FU-1	79125	53475		52	256	CL		57	43			40	25	15		28	25.9										
TR1A	FU-1	79125	53475		53.3	254.7	CL		57	43			50	26	24													
TR1A	FU-1	79125	53475		53.3	254.7	SC		70	30			34	24	10	2.68	25	25.3			93.8				117.28	0.785		
TR1A	FU-1	79125	53475		55	253	SC		69	31			26	16	10		16	15.5										
TR1A	FU-1	79125	53475		56.1	251.9	SC		80	20			34	25	9		16	15.5										
TR1A	FU-1	79125	53475		58	250	SC		69	31			26	17	9		14	14.2										
TR2A	FU-1	79125	53475		59.1	248.9	SC		79	21			33	24	9		16	15.7										
TR2A	FU-1	79125	53475		65	243	SC		86	14			30	22	8		17	16.7										
TR2A	FU-1	79125	53475		70	238	SC		77	23			39	22	17		22	22.4										
TR2A	FU-1	79125	53475		75	233	SM		84	16			27	24	3	2.71	25	25			90.2				112.75	0.833		
TR2A	FU-1	79125	53475		76	232	ML		93	7			36	26	10		22	22.4										
TR2B	FU-1	79125	53475		85.1	222.9	SC		82	18			47	22	25		23	23.2										
TR2B	FU-1	79125	53475		90	218	SM		89	11			29	26	3		21	21.2										
TR2B	FU-1	79125	53475		93	215	SC		87	13			36	21	15		20	19.7										
TR2B	FU-1	79125	53475		94.2	213.8	SC		94	6			36	24	12		18	16.3										

Table E-2 Summary of Laboratory Test Results (cont'd)

PROJECT: F-Area / F-Canyon

Layer	Borehole	North	East	Type	Depth	Elev.	Lab Class	D50	Sand	Fines	Silt	Clay	LL	PL	PI	SG	Water Content Aver.	Water Content (tube)	Water Content (tx)	Water Content (con)	Dry Density Aver.	Dry Density tube	Dry Density (tx)	Dry Density (con)	Wet Density	Void Ratio Aver	Void Ratio (con)	Void Ratio (tx)
					(feet)	(feet)			(%)	(%)	(%)	(%)	(%)	(%)	(%)		(%)	(%)	(%)	(%)	(pcf)	(pcf)	(pcf)	(pcf)	(pcf)			
TR2B	FU-1	79125	53475		96	212	SC		74	26			43	18	25		27	27.4										
TR2B	FU-1	79125	53475		97	211	SP		98	2			NP	NP	NP	2.83	23	23.3			94.8				116.89	0.791		
TR2B	FU-1	79125	53475		99	209	SC		86	14			62	18	44		24	23.8										
TR2B	FU-1	79125	53475		103	205	SC		83	17			37	24	13		23	22.7										
TR2B	FU-1	79125	53475		103.8	204.2	SC		2	98			35	17	18		26	25.5										
TR3/TR4	FU-1	79125	53475		105.2	202.8	CH		34	66			151	48	103		54	54.2										
TR3/TR4	FU-1	79125	53475		106	202	CH		2	98			140	56	84	2.62	64	64.4			60.7				99.791	1.59		
TR3/TR4	FU-1	79125	53475		107.2	200.8	CH		71	29			162	71	91		68	67.6										
TR3/TR4	FU-1	79125	53475		109	199	CH		33	67			111	23	88		56	55.8										
TR3/TR4	FU-1	79125	53475		110.2	197.8	CH		59	41			108	30	78	2.65	41	40.9			75.9				106.94	1.17		
TR3/TR4	FU-1	79125	53475		112	196	CH		44	56			100	44	56		49	49.3										
TR3/TR4	FU-1	79125	53475		118	190	MH		57	43			92	43	49		49	48.9										
TR3/TR4	FU-1	79125	53475		119.2	188.8	MH		53	47			78	34	44		27	26.6										
DB1/DB3	FU-1	79125	53475		130	178	SC		96	4			41	20	21	2.71	21	20.5			100				120.5	0.691		
DB1/DB3	FU-1	79125	53475		140	168	SC		78	22			33	22	11		27	26.8										
DB1/DB3	FU-1	79125	53475		140.9	167.1	SM		88	12			NP	NP	NP		23	23.2										
DB1/DB3	FU-1	79125	53475		150	158	SM		81	19			NP	NP	NP	2.6	28	28.4			91.4				117.38	0.775		
ST	FU-1	79125	53475		160.4	147.6	SC		63	37			53	27	26		33	32.5										
ST	FU-1	79125	53475		160.9	147.1	CH		60	40			56	28	28	2.61	32	31.7			81.9				107.86	0.85		
ST	FU-1	79125	53475		170	138	SM		77	23			38	29	9		30	29.8										
ST	FU-1	79125	53475		171.2	136.8	SM		65	35			47	29	18		29	29										
TR1	FU-2	78642	53475		9.3	300.8	SC		62	38			42	18	24	2.67	15	15.1			106.8					0.56		
TR1	FU-2	78642	53475		17.5	292.6	SC		77	23			30	21	9	2.66	13	14.4	11.4		106.1		106		119.79	0.565		
TR1	FU-2	78642	53475		17.5	292.6											14		14.3		111		111		126.87			
TR1	FU-2	78642	53475		17.5	292.6											14		14.3		108		108		123.44			
TR1A	FU-2	78642	53475		35	275.1	SC		87	13			30	23	7	2.74	10	9.8			91.6				100.58	0.808		
TR1A	FU-2	78642	53475		50	260.1	SM		82	18			28	27	1	2.67	22	22			99.4				121.27	0.677		
TR2A	FU-2	78642	53475		70	240.1	SM		62	38			30	25	5	2.7	22	21.6			98.4				119.65	0.713		
DB1/DB3	FU-2	78642	53475		129.1	181	SC		80	20			33	20	13	2.65	24	23.8			100.7				124.67	0.65		
TR1	FU-3	78310	54381		7.5	310.9	CH		32	68			61	28	33	2.72	20		19.8		93		93		111.41	0.864		
TR1	FU-3	78310	54381		8.3	310.1	CH		27	73			55	29	26	2.79	21	21.2			98.8				119.75	0.763		
TR1A	FU-3	78310	54381		33.1	285.3	SC		64	36			48	29	19		20	19.5			98.5				117.71	0.716		
TR1A	FU-3	78310	54381		49.2	269.2	SC		87	13			32	19	13	2.67	11	10.8			95.2				105.48	0.75		
TR2B	FU-3	78310	54381		98.2	220.2	SM		88	12			27	26	1	2.65	26	26.4			91.8				116.04	0.801		
TR3/TR4	FU-3	78310	54381		109	209.4	CH		8	92			89	40	49	2.69	43	43.4			76.4				109.56	1.2		
DB1/DB3	FU-3	78310	54381		118	200.4	SM		82	18			29	23	6	2.74	23	23.1			97.6				120.15	0.752		
TR1	F-50	78900	54730		1	293.7			90	9							5	5.4										
TR1	F-50	78900	54730		6	288.7	SC		59	40			44	19	25		19	18.9										
TR1	F-50	78900	54730		13.5	281.2			70	30							19	18.7										
TR1A	F-50	78900	54730		28.5	266.2			55	45							22	21.8										
TR1A	F-50	78900	54730		38.5	256.2			86	14							20	20.4										
TR1	F-51	78830	54730		3.5	294.9			93	7							16	15.6										
TR1	F-51	78830	54730		7	291.4	SC		59	41			38	18	20		20	20										
TR1	F-51	78830	54730		8.5	289.9			62	38			39	21	18		19	18.6										
TR1	F-51	78830	54730		13.5	284.9			65	35							21	20.9										
TR1	F-51	78830	54730		18.5	279.9	SC		73	27			35	16	19		17	16.9										
TR1A	F-51	78830	54730		23.5	274.9			76	24							16	16.4										
TR1A	F-51	78830	54730		33.5	264.9			76	24							21	21										
TR2B	F-51	78830	54730		73.5	224.9			90	10							26	25.5										
DB1/DB3	F-51	78830	54730		108.5	189.9			90	10							24	23.9										
DB1/DB3	F-51	78830	54730		118.5	179.9			84	16							30	29.7										
ST	F-51	78830	54730		138.5	159.9			90	10							35	35.2										
ST	F-51	78830	54730		143.5	154.9	SC		54	34			26	17	9		30	29.5										
ST	F-51	78830	54730		148.5	149.9	SM		47	30			25	17	7		22	21.8										
ST	F-51	78830	54730		163.5	134.9			67	32			37	14	23		23	23.1										
TR1	F-52	78900	54825		10	285.6	SC		61	38			44	21	23		18	17.6										
TR1A	F-52	78900	54825		25	270.6			88	12			NP	NP	NP		19	19.3										
TR1A	F-52	78900	54825		27	268.6	SC		62	37			35	21	14		21	20.8										
TR2A	F-52	78900	54825		38.5	257.1			87	13							21	20.6										
TR2A	F-52	78900	54825		53.5	242.1			92	8							19	18.9										

Table E-2 Summary of Laboratory Test Results (cont'd)

PROJECT: F-Area / F-Canyon

Layer	Borehole	North	East	Type	Depth (feet)	Elev. (feet)	Lab Class	D50	Sand (%)	Fines (%)	Silt (%)	Clay (%)	LL (%)	PL (%)	PI (%)	SG	Water Content Aver. (%)	Water Content (tube) (%)	Water Content (tx) (%)	Water Content (con) (%)	Dry Density Aver. (pcf)	Dry Density tube (pcf)	Dry Density (tx) (pcf)	Dry Density (con) (pcf)	Wet Density (pcf)	Void Ratio Aver	Void Ratio (con)	Void Ratio (tx)
TR3/TR4	F-52	78900	54825		78.5	217.1	CH		26	74			80	26	54		49	48.8										
DB1/DB3	F-52	78900	54825		98.5	197.1			93	7							20	19.5										
DB1/DB3	F-52	78900	54825		113.5	182.1	SC		69	31			40	19	21		28	27.8										
ST	F-52	78900	54825		138.5	157.1			48	42			25	16	9		17	16.8										
ST	F-52	78900	54825		148.5	147.1	SC		27	46			53	23	30		28	28.2										
ST	F-52	78900	54825		158.5	137.1			72	23			29	17	12		21	21.1										
CG	F-52	78900	54825		178.5	117.1			91	9							20	20.3										
TR1	F-53	78830	54825		8.5	290.6			65	35			24	14	10		18	18.1										
TR1A	F-53	78830	54825		18.5	280.6			81	19							15	14.8										
TR1A	F-53	78830	54825		28.5	270.6			80	20							24	24										
TR1	F-54	78880	54875		3.5	293.1			89	11							13	13.3										
TR1A	F-54	78880	54875		8.5	288.1			73	27			22	17	5		18	18.2										
TR1A	F-54	78880	54875		13.5	283.1	SC		63	35			40	20	20		19	18.5										
TR1A	F-54	78880	54875		18.5	278.1			82	18							16	15.8										
TR1A	F-54	78880	54875		33.5	263.1			79	21							17	17.1										
TR1A	F-55	79050	54834		3.5	287.8			82	18							12	12.4										
TR1A	F-55	79050	54834		6	285.3			77	22							17	17										
TR1A	F-55	79050	54834		12	279.3	SC		67	33			36	18	18		17	17.2										
TR1A	F-55	79050	54834		15	276.3	SC		59	41			54	24	30		18	18										
TR1A	F-55	79050	54834		17	274.3	SC		70	30			35	19	16		15	15.4										
TR1A	F-55	79050	54834		22	269.3	SC		55	45			47	22	25		25	25										
TR1A	F-55	79050	54834		25	266.3	SM		81	19			NP	NP	NP													
TR1A	F-55	79050	54834		27	264.3			81	19							24	24										
TR2A	F-55	79050	54834		38.5	252.8			88	12							19	18.6										
TR3/TR4	F-55	79050	54834		73.5	217.8	CH		9	91			99	38	61		79	78.7										
TR1	F-63	75960	53270	ST	10	273.3			54	46			40	24	16		16	16.3										
TR1	F-63	75960	53270	ST	10	273.3			77	20			27	20	7		11	11										
TR1	F-63	75960	53270	SS	20	263.3			80	20			36	22	14		16	15.7										
TR2A	F-63	75960	53270	SS	30	253.3			82	18			30	29	1		21	20.9										
TR2A	F-63	75960	53270	SS	50	233.3			92	8			NP	NP	NP													
TR1	F-64	76115	53075	SS	2.5	277.7			81	19			NP	NP	NP		9	9										
TR1	F-64	76115	53075	SS	15	265.2			59	41			40	25	15													
TR2A	F-64	76115	53075	SS	30	250.2			80	20			29	27	2		20	20.4										
TR2A	F-64	76115	53075	SS	40	240.2			87	13			NP	NP	NP													
TR1	F-65	76240	53060	SS	10	270.5							32	25	7		18	17.7										
TR2A	F-65	76240	53060	SS	35	245.5			82	18			NP	NP	NP													
TR2A	F-65	76240	53060	SS	45	235.5			90	10			NP	NP	NP		16	16.2										
TR1	F-66	76070	53310	ST	9	267.6			68	32			30	18	12		16	16.7	14.3		115		115		131.45	0.438		0.438
TR1	F-66	76070	53310	ST	9	267.6																						
TR1	F-66	76070	53310	ST	9	267.6																						
TR1	F-66	76070	53310	SS	10	266.6			85	15			NP	NP	NP		15	15.4										
TR2A	F-66	76070	53310	SS	25	251.6			79	21			NP	NP	NP		17	16.8										
TR2A	F-66	76070	53310	SS	35	241.6			70	30			37	17	20		21	21										
TR1	F-56	77684	53342	SS	15	280.4	SC		58	41																		
TR1	F-56	77684	53342	SS	30	265.4	CL		39	61			38	20	18		29	28.7										
DB1/DB3	F-56	77684	53342	SS	110	185.4	SP		91	9																		
DB4/DB5	F-56	77684	53342	SS	120	175.4	SC		72	28																		
ST	F-56	77684	53342	SS	135	160.4	SC		56	39			29	16	13		19	19.4										
ST	F-56	77684	53342	SS	150	145.4	SC		64	36			22	17	5		24	23.7										
GC	F-56	77684	53342	SS	170	125.4	MH		39	61			93	48	45		26	26.4										
TR1	F-57	77813	53240	SS	10	283.8	SC		62	38			40	23	17		20	20.4										
TR1	F-57	77813	53240	SS	20	273.8	SM		83	17			24	18	6		17	17.3										
TR1	F-57	77813	53240	SS	30	263.8	SM		79	21			23	19	4		19	19.2										
TR2B	F-57	77813	53240	SS	70	223.8	SP		91	8																		
DB1/DB3	F-57	77813	53240	SS	90	203.8	SC		81	19																		
DB1/DB3	F-57	77813	53240	SS	110	183.8	SP		94	6																		
ST	F-57	77813	53240	SS	135	158.8	SC		66	28			23	14	9		20	20.2										
ST	F-57	77813	53240	SS	145	148.8	SC		70	29			47	27	20		37	36.9										
CG	F-57	77813	53240	SS	190	103.8	SM		85	15																		
TR1	F-58	77840	53280	SS	7	288.8	SC		41	38			20	18	2		17	17.2										

Table E-2 Summary of Laboratory Test Results (cont'd)

PROJECT: F-Area / F-Canyon

Layer	Borehole	North	East	Type	Depth (feet)	Elev. (feet)	Lab Class	D50	Sand (%)	Fines (%)	Silt (%)	Clay (%)	LL (%)	PL (%)	PI (%)	SG	Water Content Aver. (%)	Water Content (tube) (%)	Water Content (tx) (%)	Water Content (con) (%)	Dry Density Aver. (pcf)	Dry Density tube (pcf)	Dry Density (tx) (pcf)	Dry Density (con) (pcf)	Wet Density (pcf)	Void Ratio Aver	Void Ratio (con)	Void Ratio (tx)
TR1	F-58	77840	53280	SS	10	285.8	SC		48	30			46	25	21		23	22.7										
TR1	F-59	77893	53278	ST	7	287.6	SC		64	31			28	15	13		17	17.1										
TR1	F-59	77893	53278	ST	7	287.6																						
TR1	F-59	77893	53278	ST	7	287.6																						
TR1	F-59	77893	53278	SS	9	285.6	SC		69	31			41	20	21		17	17.1										
TR1	F-60	77895	53360	ST	7	288.3	SC		59	41			41	26	15		18	18										
TR1	F-60	77895	53360	ST	7	288.3																						
TR1	F-60	77895	53360	ST	7	288.3																						
TR1	F-60	77895	53360	SS	9	286.3	SC		60	40							19	18.9										
TR1	F-46	79200	53285	SS	1	309.6			91	9							8	7.8										
TR1	F-46	79200	53285	SS	3.5	307.1			81	19							9	8.6										
TR1	F-46	79200	53285	SS	6	304.6	SC		92	34			34	16	18		15	14.7										
TR1	F-47	79260	53400	SS	3.5	307.4	SC		68	25			24	13	11		8	8.2										
TR1	F-47	79260	53400	SS	6	304.9	SC		57	42			32	22	10		16	15.6										
TR1	F-48	79145	53400	SS	1	309.63			87	13							5	4.9										
TR1	F-48	79145	53400	SS	3.5	307.13	SC		66	31			30	14	16		12	12.1										
TR1	F-48	79145	53400	SS	6	304.63	SC		67	30			25	15	10		13	12.5										
TR1	F-48	79145	53400	SS	8.5	302.13	SC		56	43			38	15	23		18	17.8										
TR1	F-48	79145	53400	SS	13.5	297.13			58	27							13	12.8										
TR1	F-49	79200	53378	SS	3.5	307.1			73	21			NP	NP	NP		3	2.5										
TR1	F-49	79200	53378	SS	13.5	297.1	SC		64	36			44	20	24		13	13.1										
TR1	F-49	79200	53378	SS	23.5	287.1	SC		74	26			42	22	20		12	12.3										
TR1	200F-B-25	78835	54300	SS	6	304.5			64	36			26	15	11		12	12										
TR1	200F-B-25	78835	54300	ST	9	301.5			62	38			26	17	9		16		15.7		110		110		127.27			
TR1	200F-B-25	78835	54300	ST	9	301.5																						
TR1	200F-B-25	78835	54300	ST	9	301.5																						
TR1	200F-B-25	78835	54300	SS	11	299.5			63	37			42	20	22		15	15										
TR1	200F-B-25	78835	54300	SS	13	297.5			73	27			31	21	10		15	15										
TR1A	200F-B-25	78835	54300	SS	28.5	282			71	29			36	19	17		16	16										
TR1A	200F-B-25	78835	54300	ST	39	271.5			74	26			39	34	5		25		24.9		92.3		92.3		115.28			
TR1A	200F-B-25	78835	54300	ST	39	271.5																						
TR1A	200F-B-25	78835	54300	ST	39	271.5																						
TR1A	200F-B-25	78835	54300	SS	41	269.5			63	37			NP	NP	NP		23	23										
TR2A	200F-B-25	78835	54300	ST	53	257.5			78	22			NP	NP	NP	2.66	13		12.9	12.8	109		109		123.06	0.522	0.522	
TR2A	200F-B-25	78835	54300	ST	53	257.5																						
TR2A	200F-B-25	78835	54300	ST	53	257.5																						
TR2A	200F-B-25	78835	54300	SS	55	255.5			81	19			NP	NP	NP		15	15										
TR2A	200F-B-25	78835	54300	ST	65.5	245			59	41			NP	NP	NP	2.68	19		19	18.8	99		99		117.81	0.665	0.665	
TR2A	200F-B-25	78835	54300	ST	65.5	245																						
TR2A	200F-B-25	78835	54300	ST	65.5	245																						
TR2A	200F-B-25	78835	54300	SS	67.5	243			75	25			41	26	15		20	20										
TR2B	200F-B-25	78835	54300	SS	78.5	232			88	12			NP	NP	NP		25	25										
TR3/TR4	200F-B-25	78835	54300	ST	84	226.5			26	74			77	35	41		71		70.6		62.8		62.8		107.14			
TR3/TR4	200F-B-25	78835	54300	ST	84	226.5																						
TR3/TR4	200F-B-25	78835	54300	ST	84	226.5																						
TR3/TR4	200F-B-25	78835	54300	SS	86	224.5			3	97							73	73										
TR3/TR4	200F-B-25	78835	54300	ST	95	215.5			36	64			64	30	34		46		45.8		71.6		71.6		104.39			
TR3/TR4	200F-B-25	78835	54300	ST	95	215.5																						
TR3/TR4	200F-B-25	78835	54300	ST	95	215.5																						
TR3/TR4	200F-B-25	78835	54300	SS	97	213.5			51	49			62	31	31		34	34										
DB1/DB3	200F-B-25	78835	54300	SS	103.5	207			85	15			NP	NP	NP		25	25										
TR1	200F-B-24	78835	54370	SS	3.5	306.9			70	29			23	16	7		9	9										
TR1	200F-B-24	78835	54370	SS	8.5	301.9			62	38			33	13	20		15	15										
TR1A	200F-B-24	78835	54370	SS	28.5	281.9			35	65			53	24	29		23	23										
TR1A	200F-B-24	78835	54370	SS	38.5	271.9			48	52			46	20	26		28	28										
TR2A	200F-B-24	78835	54370	SS	53.5	256.9			86	14			NP	NP	NP		14	14										
TR2A	200F-B-24	78835	54370	SS	58.5	251.9			82	18			NP	NP	NP		19	19										
TR2A	200F-B-24	78835	54370	SS	68.5	241.9			76	24			41	31	10		32	32										
TR2B	200F-B-24	78835	54370	SS	78.8	231.6			87	13			NP	NP	NP		25	25										
TR3/TR4	200F-B-24	78835	54370	SS	83.5	226.9			64	36			48	19	29		38	38										

Table E-2 Summary of Laboratory Test Results (cont'd)

PROJECT: F-Area / F-Canyon

Layer	Borehole	North	East	Type	Depth	Elev.	Lab Class	D50	Sand	Fines	Silt	Clay	LL	PL	PI	SG	Water Content Aver.	Water Content (tube)	Water Content (tx)	Water Content (con)	Dry Density Aver.	Dry Density tube	Dry Density (tx)	Dry Density (con)	Wet Density	Void Ratio Aver	Void Ratio (con)	Void Ratio (tx)
					(feet)	(feet)			(%)	(%)	(%)	(%)	(%)	(%)	(%)		(%)	(%)	(%)	(%)	(pcf)	(pcf)	(pcf)	(pcf)	(pcf)			
TR3/TR4	200F-B-24	78835	54370	SS	88.5	221.9			4	96							81	81										
TR3/TR4	200F-B-24	78835	54370	SS	93.5	216.9			59	41			71	24	47		37	37										
DB1/DB3	200F-B-24	78835	54370	SS	103.5	206.9			92	8							27	27										
DB1/DB3	200F-B-24	78835	54370	SS	113.5	196.9			87	13			NP	NP	NP		25	25										
DB1/DB3	200F-B-24	78835	54370	SS	123.5	186.9			94	6			NP	NP	NP		24	24										
DB1/DB3	200F-B-24	78835	54370	SS	133.5	176.9			86	14			NP	NP	NP		28	28										
ST	200F-B-24	78835	54370	SS	143.5	166.9			82	18			NP	NP	NP		21	21										
TR3/TR4	200F-B-26	78794	54335	SS	83.5	228.5			92	8							23	23										
TR3/TR4	200F-B-26	78794	54335	SS	88.5	223.5			3	97			118	37	81		80	80										
TR3/TR4	200F-B-26	78794	54335	SS	98.5	213.5			53	47			68	31	37		49	49										
DB1/DB3	200F-B-26	78794	54335	SS	108.5	203.5			93	7			NP	NP	NP		24	24										
DB1/DB3	200F-B-26	78794	54335	SS	118.5	193.5			91	9			NP	NP	NP		31	31										
DB1/DB3	200F-B-26	78794	54335	SS	128.5	183.5			91	9			NP	NP	NP		26	26										
DB4/DB5	200F-B-26	78794	54335	SS	133.5	178.5			70	30			36	24	12		29	29										
ST	200F-B-26	78794	54335	SS	138.5	173.5			91	9			NP	NP	NP		15	15										
ST	200F-B-26	78794	54335	SS	143.5	168.5			83	17			NP	NP	NP		20	20										
ST	200F-B-26	78794	54335	SS	153.5	158.5			94	6			NP	NP	NP		44	44										
ST	200F-B-26	78794	54335	SS	158.5	153.5			71	29			56	26	30		31	31										
TR1	FHS-1	75819	51332	ST	3	282.1	SC									2.66	17		16.5		112.1		112.1		130.6	0.48		0.48
TR1	FHS-1	75819	51332	ST	3	282.1																						
TR1	FHS-1	75819	51332	ST	3	282.1											16		15.9		113.2		113.2		131.2	0.466		0.466
TR1	FHS-4	75459	53877	ST	0	265.9	SC									2.69	7		6.9		105.5		105.5		112.78	0.582		0.582
TR1	FHS-4	75459	53877	ST	0	265.9											19		19		96.5		96.5		114.84	0.732		0.732
TR1	FHS-4	75459	53877	ST	0	265.9											15		15.2		106.8		106.6		122.8	0.574		0.574
TR1	FHS-8	73435	57196	ST	1.5	281.2										2.69	20		19.6		103.2		103.2		123.43	0.626		0.626
TR1	FHS-8	73435	57196	ST	1.5	281.2											18		17.5		111.6		111.6		131.13	0.505		0.505
TR1	FHS-8	73435	57196	ST	1.5	281.2																						
TR1	FHS-1	75819	51332	SS	5	280.1	SC		58	42			36	20	16		16	16.4										
TR1	FHS-4	75459	53877	SS	3.5	262.4	SM		63	32			40	29	11		14	13.8										
TR1	FHS-4	75459	53877	SS	7.5	258.4	SM/SC		51	48							21	20.5										
TR1	FHS-5	74980	54664	SS	15	254	SM/SC		66	34							17	16.8										
TR1	FHS-6	74390	55633	SS	2.5	272.6	SM		45	37			46	31	15		16	16.3										
TR1	FHS-6	74390	55633	SS	10.5	264.6	CH		35	65			55	27	28		26	26.3										
TR1	FHS-7	73906	56397	ST	4.5	265	SC		62	32			34	23	11		19		18.5		108.8		108.8		128.93	0.508		0.508
TR1	FHS-7	73906	56397	ST	4.5	265																						
TR1	FHS-7	73906	56397	ST	4.5	265																						
TR1	FHS-8	73435	57196	SS	7.5	275.2	SM		58	42			54	31	23		23	22.8										
TR1	FHS-9	72970	57990	SS	0	287.8	SC		53	43			32	16	16		16	16.3										
TR1	FHS-9	72970	57990	ST	6	281.8	SC		65	35			49	26	21	2.63	18		18.2		108.7		108.7		128.48	0.51		0.51
TR1	FHS-9	72970	57990	ST	6	281.8																						
TR1	FHS-9	72970	57990	ST	6	281.8											18		17.9		110.4		110.4		130.16	0.486		0.486
TR1	FHS-9	72970	57990	SS	12.5	275.3	SC		65	35			56	26	30		18	17.9										
TR1	FHS-10	72512	58753	ST	3	266.9	SM		57	42			34	26	8		12		11.6		110.7		110.7		123.54	0.483		0.483
TR1	FHS-10	72512	58753	ST	3	266.9											22		22.3		105.5		105.5		129.03	0.556		0.556
TR1	FHS-10	72512	58753	ST	3	266.9											16		16.1		114		114		132.35	0.305		0.305
TR1	FHS-10	72512	58753	SS	10	259.9	SM/SC		61	38							15	15.4										
TR1	FHS-11	72354	59159	SS	12.5	253.7	SM/SC		53	44							22	21.8										
TR1	FHS-12	72679	59970	ST	1.5	274.2	SC		49	51			36	24	12		18		17.5		101.6		101.6		119.38	0.597		0.597
TR1	FHS-12	72679	59970	ST	1.5	274.2											12		12.3		106.6		106.6		119.71	0.522		0.522
TR1	FHS-12	72679	59970	ST	1.5	274.2											20		20.1		105.8		105.8		127.07	0.552		0.552
TR1	F-SEP-B6	76612.7	53026.2	SS	15.5	268.5	SC	0.31	81	19			30	18	12		15											
TR2A	F-SEP-B6	76612.7	53026.2	ST	54	230	SM	0.27	85.7	14.1	5.3	8.8	NP	NP	NP		18	17.5			117.1				137.7			
TR3/TR4	F-SEP-B6	76612.7	53026.2	SS	81	203	CH		8	92			93	30	63		65											
TR3/TR4	F-SEP-B6	76612.7	53026.2	SS	82.5	201.5	CH		34.1	65.9			79	25	54		51											
TR3/TR4	F-SEP-B6	76612.7	53026.2	ST	84	200	SC	0.08	50.2	49.8	13.2	36.6	58	22	36	2.7	40	37.4		42.5	80.3	84		76.6	115.4	1.199	1.199	
TR3/TR4	F-SEP-B6	76612.7	53026.2	SS	88	196	SM	0.2	72.8	27.2	5.6	21.6	NP	NP	NP		36											
DB1/DB3	F-SEP-B6	76612.7	53026.2	SS	96	188	SM	0.33	87.7	12.3			NP	NP	NP		29											
DB1/DB3	F-SEP-B6	76612.7	53026.2	SS	99	185	SC	0.33	83.6	16.4	2.9	13.5	35	21	14		32											
DB1/DB3	F-SEP-B6	76612.7	53026.2	SS	103.5	180.5	SP-SM	0.33	90.1	9.9			NP	NP	NP		27											
DB1/DB3	F-SEP-B6	76612.7	53026.2	SS	108	178	SP-SM	0.37	93.4	6.6	4.5	2.1	NP	NP	NP		20											

Table E-2 Summary of Laboratory Test Results (cont'd)

PROJECT: F-Area / F-Canyon

Layer	Borehole	North	East	Type	Depth (feet)	Elev. (feet)	Lab Class	D50	Sand (%)	Fines (%)	Silt (%)	Clay (%)	LL (%)	PL (%)	PI (%)	SG	Water Content Aver. (%)	Water Content (tube) (%)	Water Content (tx) (%)	Water Content (con) (%)	Dry Density Aver. (pcf)	Dry Density tube (pcf)	Dry Density (tx) (pcf)	Dry Density (con) (pcf)	Wet Density (pcf)	Void Ratio Aver	Void Ratio (con)	Void Ratio (tx)
DB4/DB5	F-SEP-B6	76612.7	53026.2	SS	120.5	163.5	SM	0.21	81.8	18.2	3.1	15.1	NP	NP	NP		37											
DB4/DB5	F-SEP-B6	76612.7	53026.2	SS	123.5	160.5	SM	0.18	86.4	13.6	3	10.6	NP	NP	NP		43											
ST	F-SEP-B6	76612.7	53026.2	SS	128.5	155.5	SM	0.14	83	17	8.2	8.8	NP	NP	NP		31											
ST	F-SEP-B6	76612.7	53026.2	SS	136	148	SC	0.17	74.9	25.1			35	19	16		32											
ST	F-SEP-B6	76612.7	53026.2	SS	141	143	SC	0.2	80.7	19.3	9.8	9.5	36	23	13		36											
ST	F-SEP-B6	76612.7	53026.2	ST	148	136	SC	0.19	75.3	24.7	8.3	16.4	34	21	13	2.7	33		32.3	33.1	86.5		87.2	85.8	115.37	0.9469	0.9618	0.932
ST	F-SEP-B6	76612.7	53026.2	ST	148	136	SC										31		31		88.4		88.4		115.8	0.907		0.907
ST	F-SEP-B6	76612.7	53026.2	ST	148	136	SC										33		32.5		87.2		87.2		115.54	0.932		0.932
ST	F-SEP-B6	76612.7	53026.2	SS	153	131	CH	0.04	29.5	70.5	36.7	33.8	55	24	31		38											
TR1	F-SEP-B8	78129.1	53507.2	SS	7	294	SC	0.15	54.3	42.3			50	23	27		20											
TR1	F-SEP-B8	78129.1	53507.2	SS	13	288	SC	0.42	75.1	22.8	3.5	19.3	60	21	39	2.66	17											
TR1A	F-SEP-B8	78129.1	53507.2	SS	22	279	SC	0.12	74.7	25.3			30	21	9		19											
TR1A	F-SEP-B8	78129.1	53507.2	SS	28	273	SM	0.11	73.7	26.3			30	23	7		24											
TR2A	F-SEP-B8	78129.1	53507.2	SS	34	267	SC	0.17	80.8	19.2			32	20	12		20											
TR2A	F-SEP-B8	78129.1	53507.2	SS	43.5	257.5	SC	0.18	85.2	14.8			35	19	16		25											
TR2A	F-SEP-B8	78129.1	53507.2	SS	44.5	256.5	SM	0.19	81.2	14.1			NP	NP	NP		18											
TR2B	F-SEP-B8	78129.1	53507.2	SS	60	241	SC	0.29	82.7	17.3	3.4	13.9	40	21	19	2.72	18											
TR2B	F-SEP-B8	78129.1	53507.2	SS	66	235	SC	0.31	81	19			33	20	13		24											
TR2B	F-SEP-B8	78129.1	53507.2	SS	70.5	230.5	SP-SM	0.38	92.3	7.7			NP	NP	NP		21											
TR3/TR4	F-SEP-B8	78129.1	53507.2	ST	78	223										2.67	30	37.2	23.2		88.3	81.3	95.3		111.5	0.748		0.748
TR3/TR4	F-SEP-B8	78129.1	53507.2	ST	78	223											34		33.6		81.5		81.5		108.88	1.045		1.045
TR3/TR4	F-SEP-B8	78129.1	53507.2	ST	78	223											60		60.2		62.5		62.5		100.13	1.669		1.669
TR3/TR4	F-SEP-B8	78129.1	53507.2	ST	80	221	MH		6.6	93.4			87	43	44		62	58		65.6	62.9	65.7		60.1	103.8	1.739	1.739	
TR3/TR4	F-SEP-B8	78129.1	53507.2	SS	82	219	CH		9.1	90.9	17.2	73.7	95	32	63	2.65	61											
DB1/DB3	F-SEP-B8	78129.1	53507.2	SS	89.5	211.5	SM	0.22	80.8	19.2			35	25	10		30											
DB1/DB3	F-SEP-B8	78129.1	53507.2	ST	99	202	SC	0.31	70.8	29.2	6.6	22.6	30	21	9		37	37.1			91.5	91.5			125.5			
DB1/DB3	F-SEP-B8	78129.1	53507.2	SS	103.5	197.5	SP-SM	0.4	92.3	7.7			NP	NP	NP		24											
DB1/DB3	F-SEP-B8	78129.1	53507.2	SS	109.5	191.5	SP-SM	0.57	91.5	8.3			NP	NP	NP		22											
DB4/DB5	F-SEP-B8	78129.1	53507.2	SS	114	187	SC	0.29	79.7	20.3			49	18	31		31											
ST	F-SEP-B8	78129.1	53507.2	SS	125	176	SM	1.86	47.5	14.7							17											
ST	F-SEP-B8	78129.1	53507.2	SS	132.5	168.5	SM	0.22	76.9	15							24											
ST	F-SEP-B8	78129.1	53507.2	SS	135	166	SM	0.14	57.9	22.7			NP	NP	NP		20											
ST	F-SEP-B8	78129.1	53507.2	SS	141.5	159.5	SC	0.12	56.8	33.9			27	19	8		22											
ST	F-SEP-B8	78129.1	53507.2	SS	149	152	SC-SM	0.14	55.1	23.1			21	14	7	2.69	23											
ST	F-SEP-B8	78129.1	53507.2	SS	155	146	SC	0.12	57.5	18.5			26	16	10	2.75	25											
ST	F-SEP-B8	78129.1	53507.2	SS	158	143	CL	0.06	48.9	50.7	23.4	27.3	28	18	10	2.68	25											
ST	F-SEP-B8	78129.1	53507.2	SS	164	137	CL		41.8	55.8			31	18	13		27											
ST	F-SEP-B8	78129.1	53507.2	SS	167	134	SM	0.1	50.3	39.7							39											
ST	F-SEP-B8	78129.1	53507.2	SS	173	128	SM	0.18	34.2	37.3							21											
ST	F-SEP-B8	78129.1	53507.2	SS	176	125	SM	0.07	50.2	49.8	24.9	24.9	NP	NP	NP	2.8	31											
ST	F-SEP-B8	78129.1	53507.2	SS	177.5	123.5	MH	0.01	32.2	66.7	22.3	44.4	53	30	23	2.6	42											
DB4/DB5	F-SEP-B8.1	78129.1	53515.2	ST	118	183											23	22.5		22.9	103.9	107		100.8	131.2	0.645	0.645	
TR2B	F-SEP-B13.1	79081.1	54112.1	ST	63	239	SC	0.19	76.3	23.7			29	20	9		25	24.9			110.1	110.1			137.5			
DB1/DB3	F-SEP-B13.1	79081.1	54112.1	ST	93	209	SP-SM	0.3	92.2	7.8			NP	NP	NP	2.68	19	18.5			113.3	113.3			134.3			
DB1/DB3	F-SEP-B13.1	79081.1	54112.1	SS	96	206	SP-SM	0.33	89.8	10.2	4.6	5.6	NP	NP	NP		23											
DB4/DB5	F-SEP-B13.1	79081.1	54112.1	ST	110	192	SC	0.12	57	43	8.5	34.5	55	18	37	2.7	43	42	41.2	46.5	74.97	76.5	76.7	71.7	108.8	1.274	1.3499	1.198
DB4/DB5	F-SEP-B13.1	79081.1	54112.1	ST	110	192	SC										49		48.6		77.5		77.5		115.17	1.174		1.174
ST	F-SEP-B13.1	79081.1	54112.1	SS	129.5	172.5	SC	0.5	78.6	21.4	3.5	17.9	63	28	35		33											
ST	F-SEP-B13.1	79081.1	54112.1	SS	134	168	SM	0.24	50.8	29.2							37											
ST	F-SEP-B13.1	79081.1	54112.1	SS	150.5	151.5	SC	0.16	75	25	4.7	20.3	40	22	18		36											
ST	F-SEP-B13.1	79081.1	54112.1	ST	163	139	CH	0.01	29.3	70.7	22.7	48	64	22	42		41	34.1		42.2	81.5	88.2		74.8	118.3	1.2959	1.2959	
ST	F-SEP-B13.1	79081.1	54112.1	SS	166.5	135.5	SC	0.24	62.4	36.3	11.1	25.2	50	25	25		28											
FILL	F-TNK-B3	76974	52700	SS	7.5	278	SC	0.13	63.7	35.4	7	28.4	37	15	22	2.7	12											
FILL	F-TNK-B3	76974	52700	SS	12	273.5	SM	0.21	77.9	21.9			NP	NP	NP		10											
FILL	F-TNK-B3	76974	52700	SS	16.5	269	SC-SM	0.23	78.1	21.9	4.9	17	26	19	7	2.71	11											
FILL	F-TNK-B3	76974	52700	SS	22.5	263	SC-SM	0.27	84.1	15.9			23	17	6		10											
FILL	F-TNK-B3	76974	52700	ST	27.5	258	SC	0.25	85.2	14.8			29	20	9		14	13.7	13.9	13	108.1	106.9	110.7	106.7	121.5	0.537	0.551	0.523
FILL	F-TNK-B3	76974	52700	SS	29.5	256	SC	0.2	77	23			27	16	11		13											
FILL	F-TNK-B3	76974	52700	SS	34	251.5	SC	0.27	78	22	5.1	16.9	27	14	13	2.73	14											
FILL	F-TNK-B3	76974	52700	SS	37	248.5	SM	0.2	79.3	20.7			NP	NP	NP	2.73	12											

Table E-2 Summary of Laboratory Test Results (cont'd)

PROJECT: F-Area / F-Canyon

Layer	Borehole	North	East	Type	Depth	Elev.	Lab Class	D50	Sand	Fines	Silt	Clay	LL	PL	PI	SG	Water Content				Dry Density				Wet	Void Ratio		
																	Aver.	(tube)	(tx)	(con)	Aver.	tube	(tx)	(con)	Density	Aver	(con)	(tx)
					(feet)	(feet)			(%)	(%)	(%)	(%)	(%)	(%)	(%)		(%)	(%)	(%)	(%)	(pcf)	(pcf)	(pcf)	(pcf)	(pcf)			
TR2A	F-TNK-B3	76974	52700	SS	41.5	244	SM	0.19	82.3	17.7			NP	NP	NP		12											
TR2A	F-TNK-B3	76974	52700	SS	43	242.5	SM	0.29	85.2	14.8	3.6	11.2	NP	NP	NP	2.73	9											
TR1	F-TNK-B8	77459.5	52765.6	SS	6	263.5	SM	0.26	83.4	15.8			NP	NP	NP		8											
TR1	F-TNK-B8	77459.5	52765.6	ST	7.5	262	SM	0.24	76.3	23.7	9.1	14.6	NP	NP	NP	2.7	11				102.7	102.7			113.5			
TR1	F-TNK-B8	77459.5	52765.6	SS	11	258.5	SM	0.25	81.4	18.6							10											
TR1	F-TNK-B8	77459.5	52765.6	SS	17.5	252	SC	0.18	72.3	27.7	4.6	23.1	37	17	20		12											
TR2A	F-TNK-B8	77459.5	52765.6	SS	22	247.5	SM	0.22	83.8	16.2			NP	NP	NP		12											
TR2A	F-TNK-B8	77459.5	52765.6	SS	25	244.5	SM	0.34	87.4	12.6			NP	NP	NP		9											
TR2A	F-TNK-B8	77459.5	52765.6	SS	28	241.5	SM	0.26	84.5	15.5	3.4	12.1	NP	NP	NP		10											
TR2A	F-TNK-B8	77459.5	52765.6	SS	32.5	237	SM	0.26	85.8	14.2			32	24	8		10											
TR2A	F-TNK-B8	77459.5	52765.6	SS	35.5	234	SP-SM	0.25	90.9	9.1	2.6	6.5	NP	NP	NP		10											
TR2A	F-TNK-B8	77459.5	52765.6	SS	38.5	231	SP-SM	0.52	93.9	5.9							9											
TR2B	F-TNK-B8	77459.5	52765.6	SS	43	226.5	SP	0.55	95.7	4.3	2.2	2.1	NP	NP	NP		3											
TR2B	F-TNK-B8	77459.5	52765.6	SS	46	223.5	SP	0.59	97.1	2.9							17											
FILL	F-TNK-B13	77332.2	53302.8	SS	6	273.1	SC	0.21	62.7	31.1			40	21	19		16											
FILL	F-TNK-B13	77332.2	53302.8	SS	10.5	268.6	SC	0.23	66.2	25			34	16	18		14											
FILL	F-TNK-B13	77332.2	53302.8	SS	15	264.1	SC	0.23	76.2	23			32	15	17		13											
FILL	F-TNK-B13	77332.2	53302.8	SS	18	261.1											12	12.1	11.6		105.5	105.2	105.7		118	0.595		0.595
FILL	F-TNK-B13	77332.2	53302.8	SS	18	261.1											12		12.1		108.6		108.6		121.74	0.552		0.552
FILL	F-TNK-B13	77332.2	53302.8	SS	21.5	257.6	SC	0.3	84.5	14.4			30	20	10		16											
FILL	F-TNK-B13	77332.2	53302.8	SS	24.5	254.6	SM	0.36	87.7	12.3			NP	NP	NP		8											
FILL	F-TNK-B13	77332.2	53302.8	ST	27.5	251.6	SM	0.33	79	21			NP	NP	NP	2.68	14	8.6		15.2	91.1	97		85.2	105.3	0.962	0.962	
TR2A	F-TNK-B13	77332.2	53302.8	SS	31	248.1	SC	0.16	78.7	21.3			36	22	14		16											
TR2A	F-TNK-B13	77332.2	53302.8	SS	37	242.1	SM	0.25	85.8	14.2			29	25	4		13											
TR2A	F-TNK-B13	77332.2	53302.8	SS	41.5	237.6	SP-SM	0.28	90.9	9.1			NP	NP	NP		10											
TR2A	F-TNK-B13	77332.2	53302.8	SS	46	233.1	SP-SM	0.32	88.8	11.2			NP	NP	NP		11											
FILL	F-TNK-B16	76738.1	52482.6	SS	6	276.7	SC	0.11	60.9	39.1			42	18	24		17											
FILL	F-TNK-B16	76738.1	52482.6	SS	10.5	272.2	SC	0.1	53.1	46.9	20.3	28.6	41	17	24	2.75	16											
FILL	F-TNK-B16	76738.1	52482.6	SS	18	264.7	SC	0.15	72.5	27.5			33	19	14		14											
FILL	F-TNK-B16	76738.1	52482.6	ST	21	261.7										2.7	14		13.9		112.6		112.6		128.25	0.496		0.496
FILL	F-TNK-B16	76738.1	52482.6	SS	24.5	258.2	SC	0.13	66.7	33			33	21	12		15											
FILL	F-TNK-B16	76738.1	52482.6	SS	29	253.7	SC	0.13	67.3	32.5			35	16	19		14											
FILL	F-TNK-B16	76738.1	52482.6	ST	32	250.7	SC	0.15	67.5	32.5			27	14	13	2.63	13			13	107.6			107.6	121.59	0.526	0.526	
FILL	F-TNK-B16	76738.1	52482.6	SS	35.5	248.2	SC	0.1	63.9	36.1			34	17	17		15											
FILL	F-TNK-B16	76738.1	52482.6	SS	38.5	244.2	SC	0.13	65.2	34	7.2	26.8	33	16	17	2.72	15											
TR2A	F-TNK-B16	76738.1	52482.6	SS	44	238.7	SP-SM	0.24	90.1	9.9			NP	NP	NP		9											
FILL	F-TNK-B20	77200.7	52686.4	SS	7.5	259.3	SM	0.23	79.6	20.4	4.3	16.1	NP	NP	NP		10											
FILL	F-TNK-B20	77200.7	52686.4	SS	12	254.8	SC	0.21	69.8	30.2			30	14	16		16											
FILL	F-TNK-B20	77200.7	52686.4	SS	16.5	250.3	SC	0.21	69.9	29.1	5.9	23.2	34	14	20		13											
FILL	F-TNK-B20	77200.7	52686.4	ST	21	245.8	SC	0.22	83.6	16.4	3.3	13.1	27	19	8	2.7	12	11.7		12.3	102.9	105		100.7	117.3	0.6739	0.6739	
FILL	F-TNK-B20	77200.7	52686.4	SS	23	243.8	SM	0.23	80.6	19.1			NP	NP	NP		12											
FILL	F-TNK-B20	77200.7	52686.4	SS	29	237.8											12	10.2	13.5		99.5	100.4	98.6		110.6	0.71		0.71
FILL	F-TNK-B20	77200.7	52686.4	SS	29	237.8											8		8.2		100.2		100.2		108.42	0.682		0.682
FILL	F-TNK-B20	77200.7	52686.4	SS	31	235.8	SM	0.24	80.3	19.7							13											
FILL	F-TNK-B20	77200.7	52686.4	SS	35.5	231.3	SM	0.18	79.3	20.7			NP	NP	NP		17											
FILL	F-TNK-B20	77200.7	52686.4	SS	40	226.8	SM	0.56	86.9	13.1			NP	NP	NP		11											
TR2A	F-TNK-B20	77200.7	52686.4	SS	44.5	222.3	SC	0.22	80.6	19.4	2.9	16.5	35	21	14		18											
TR1	FB-1	79812.34	54917.86	SS	16	274.55		0.14	67.5	32.5																		
TR1A	FB-1	79812.34	54917.86	SS	20	270.55			49.4	50.6																		
TR1A	FB-1	79812.34	54917.86	SS	25	265.55		0.15	74.4	25.6																		
TR1A	FB-1	79812.34	54917.86	SS	28	262.55		0.14	74.2	25.8																		
TR1A	FB-1	79812.34	54917.86	SS	31	259.55		0.11	70.2	29.8																		
TR1A	FB-1	79812.34	54917.86	SS	32	258.55		0.075	49.2	50.8																		
TR1A	FB-1	79812.34	54917.86	SS	34	256.55			46	54																		
TR2A	FB-1	79812.34	54917.86	SS	41	249.55		0.18	80.6	19.4																		
TR2A	FB-1	79812.34	54917.86	SS	46	244.55		0.17	79.5	20.5																		
TR2A	FB-1	79812.34	54917.86	SS	52	238.55		0.29	84.9	15.1																		
TR2A	FB-1	79812.34	54917.86	SS	56	234.55		0.2	80.8	19.2																		
TR2A	FB-1	79812.34	54917.86	SS	58	232.55		0.44	90.8	9.2																		
TR2B	FB-1	79812.34	54917.86	SS	64	226.55		0.54	79	21																		

Table E-2 Summary of Laboratory Test Results (cont'd)

PROJECT: F-Area / F-Canyon

Layer	Borehole	North	East	Type	Depth	Elev.	Lab Class	D50	Sand	Fines	Silt	Clay	LL	PL	PI	SG	Water Content Aver.	Water Content (tube)	Water Content (tx)	Water Content (con)	Dry Density Aver.	Dry Density tube	Dry Density (tx)	Dry Density (con)	Wet Density	Void Ratio Aver	Void Ratio (con)	Void Ratio (tx)
					(feet)	(feet)			(%)	(%)	(%)	(%)	(%)	(%)	(%)		(%)	(%)	(%)	(%)	(pcf)	(pcf)	(pcf)	(pcf)	(pcf)			
TR2B	FB-1	79812.34	54917.86	SS	68	222.55		0.3	85.9	14.1																		
TR2B	FB-1	79812.34	54917.86	SS	71	219.55		0.26	86.9	13.1																		
TR2B	FB-1	79812.34	54917.86	SS	77	213.55		0.24	86.7	12.8																		
TR2B	FB-1	79812.34	54917.86	SS	83	207.55		0.46	88.4	10.8																		
TR3/TR4	FB-1	79812.34	54917.86	SS	86	204.55			7.3	92.7																		
DB1/DB3	FB-1	79812.34	54917.86	SS	88	202.55		0.28	71.1	28.9																		
DB1/DB3	FB-1	79812.34	54917.86	SS	91	199.55		0.4	92.4	7.6																		
DB1/DB3	FB-1	79812.34	54917.86	SS	95	195.55		0.29	88.4	11.6																		
DB1/DB3	FB-1	79812.34	54917.86	SS	100	190.55		0.23	86.4	13.6																		
DB1/DB3	FB-1	79812.34	54917.86	SS	103	187.55		0.42	86.6	13.4																		
DB1/DB3	FB-1	79812.34	54917.86	SS	106	184.55		0.41	92.7	7.3																		
DB4/DB5	FB-1	79812.34	54917.86	SS	112	178.55		0.42	89.6	9																		
DB4/DB5	FB-1	79812.34	54917.86	SS	113	177.55		0.5	87.9	11.9																		
ST	FB-1	79812.34	54917.86	SS	119	171.55		0.18	87.2	12.6																		
ST	FB-1	79812.34	54917.86	SS	125	165.55		0.16	80.8	18.8																		
ST	FB-1	79812.34	54917.86	SS	127	163.55		0.17	86	14																		
ST	FB-1	79812.34	54917.86	SS	128	162.55		0.25	89	11																		
ST	FB-1	79812.34	54917.86	SS	134	156.55		0.16	86.9	13.1																		
ST	FB-1	79812.34	54917.86	SS	136	154.55		0.15	83.9	15.8																		
ST	FB-1	79812.34	54917.86	SS	140	150.55		0.15	77.7	20.8																		
ST	FB-1	79812.34	54917.86	SS	143	147.55		0.14	69.9	30.1																		
GC	FB-1	79812.34	54917.86	SS	145	145.55		0.11	62.9	37.1																		
GC	FB-1	79812.34	54917.86	SS	151	139.55		0.09	56.8	43.2																		
TR1	FB-2	79101.5	54920.0	ST	7	285.18	SP	0.19	97.4	2.6	1.9	0.7	NP	NP	NP		3		3.2		91.8		91.8		94.738	0.735		0.735
TR1	FB-2	79101.5	54920.0	ST	7	285.18											6		5.6		93.4		93.4		98.63	0.705		0.705
TR1	FB-2	79101.5	54920.0	ST	13	279.18	SC	0.24	76.5	23.5	1.6	21.9	35	16	19	2.72	16		15.4	15.9	112.8		114.8	110.7	132.48	0.5055	0.532	0.479
TR1	FB-2	79101.5	54920.0	ST	15	277.18	SC	0.11	63.5	36.5	6.6	29.9	44	17	27		17		17.4		113.7		113.7		133.48	0.444		0.444
TR1	FB-2	79101.5	54920.0	ST	15	277.18											19		19		108.3		108.3		128.88	0.516		0.516
TR1	FB-2	79101.5	54920.0	ST	15	277.18											21		20.5		103.5		103.5		124.72	0.586		0.586
TR1A	FB-2	79101.5	54920.0	ST	25	267.18	SC	0.09	69.6	30.4	8.9	21.5	38	22	16		18		17.9		100.7		100.7		118.73	0.705		0.705
TR1A	FB-2	79101.5	54920.0	ST	25	267.18											19		18.7		99.8		99.8		118.46	0.72		0.72
TR1A	FB-2	79101.5	54920.0	ST	27	265.18	SM	0.1	69.1	30.9	11.9	19	30	23	7	2.68	20		21.3	18	97.1		98.8	95.4	119.84	0.724	0.754	0.694
TR1A	FB-2	79101.5	54920.0	ST	29	263.18	CH		28.7	71.3	14.3	57	82	28	54		25		24.5		97.1		97.1		120.89	0.73		0.73
TR1A	FB-2	79101.5	54920.0	ST	29	263.18											22		22.2		94.4		94.4		115.36	0.779		0.779
TR1A	FB-2	79101.5	54920.0	ST	29	263.18											20		19.9		92.2		92.2		110.55	0.822		0.822
TR2A	FB-2	79101.5	54920.0	ST	50	242.18	SC	0.26	85.8	14.2	2.9	11.3	31	21	10		24	23.9			94.6	94.6			117.2			
TR2A	FB-2	79101.5	54920.0	ST	60	232.18	SP-SC	0.62	93.9	6.1	1.6	4.5	30	20	10	2.65	19	19.4		19.4	101.4	104.6		98.2	125	0.689	0.689	
TR2B	FB-2	79101.5	54920.0	ST	75	217.18	SM	0.23	85.6	14.4	5.4	9	30	23	7		24	24.4			97.2	97.2			120.9			
TR3/TR4	FB-2	79101.5	54920.0	ST	83	209.18	SC	0.27	66.5	33.5	7.1	26.4	59	19	40	2.73	24	23.7		23.7	91.85	86.9		96.8	107.6	0.761	0.761	
DB1/DB3	FB-2	79101.5	54920.0	ST	100	192.18	SC	0.23	75.4	24.3	7.6	16.7	37	19	18		25	24.9			99.7	99.7			124.5			
ST	FB-2	79101.5	54920.0	ST	120	172.18	SP-SM	0.19	88.6	11.4	1	10.4	NP	NP	NP		26	25.9			95.7	95.7			120.5			
GC	FB-2	79101.5	54920.0	ST	147	145.18	SM	0.12	86.6	13.4	10.8	2.8	NP	NP	NP	2.61	27	24.9		28.6	91.45	97		85.9	121.1	0.895	0.895	

Table E-2 Summary of Laboratory Test Results (cont'd)

PROJECT: F-Area / F-Canyon

Layer	Borehole	North	East	Type	Depth (feet)	Elev. (feet)	Test Type	qu (ksf)	C' (tx) (ksf)	Phi' (tx)	s1' (tx) (ksf)	s3' (tx) (ksf)	Pore Pressure (tx) (ksf)	Back Pressure (tx) (ksf)	C (tx) (ksf)	Phi (tx)	s1 (tx) (ksf)	Deviator (tx) (ksf)	s3 (tx) (ksf)	FStrn (tx) (%)	Po (ksf)	Pc (ksf)	OCR	Cc	Cr	Cv
Layer	Borehole	North	East	Samp	Depth	Elev	TYPE	qu	txC'	Phi'	Sig1p	Sig3p	txPP	txBP	txC	Phi	Sig1	Sig1-Sig3	Sig3	FStrn	Po	Pc	OCR	Cc	Cr	Cv
TR1	200F-B-10U	79980	54690	ST	11	268.2	CU										6.6	5.6	1		1.4	5.8	4.14	0.139	0.017	
TR3/TR4	200F-B-10U	79980	54690	ST	68	211.2	CU										14.2	8.2	6		8.2	14.6	1.78	0.72	0.065	
TR3/TR4	200F-B-10U	79980	54690	ST	71	208.2	CU										13.6	7.4	6.2		8.4	13.4	1.60	1.8	0.312	
ST	200F-B-10U	79980	54690	ST	126	151.2															11.8	7.6	0.64	0.48	0.06	
ST	200F-B-10U	79980	54690	ST	133	146.2															12.2	6.4	0.52	0.35	0.03	
TR2A	200F-B-12U	79880	54890	ST	38	235.4	CU										17.8	13.6	4.2							
TR3/TR4	200F-B-12U	79880	54890	PS	63	210.4	CU										12.2	6.4	5.8							
TR3/TR4	200F-B-12U	79880	54890	PS	66	207.4	CU										12.6	6.6	6		8.4	12.2	1.45	1.2	0.032	
DB1/DB3	200F-B-12U	79880	54890	ST	86	187.4	CU										21.4	14.6	6.8		8.8	18	2.05	0.19	0.017	
DB4/DB5	200F-B-12U	79880	54890	ST	95	178.4															9.8	9.4	0.98	0.35	0.035	
ST	200F-B-12U	79880	54890	ST	123	150.4															11.2	14.2	1.27	0.255	0.03	
ST	200F-B-12U	79880	54890	PS	127	146.4															11.6	13.8	1.19	0.25	0.025	
ST	200F-B-12U	79880	54890	ST	136	137.4															12.6	36	2.86	0.256	0.033	
TR3/TR4	200F-B-14U	79880	55090	ST	63	208.3															7.4	15	2.03	0.55	0.13	
TR3/TR4	200F-B-14U	79880	55090	ST	67	204.3															7.6	14	1.84	0.24	0.03	
TR1	200F-G-1U	80130	54875	ST	10	262.4	CU										8.2	6.8	1.4							
TR1	200F-G-1U	80130	54875	ST	13	259.4	CU										7.6	6.2	1.6							
GC	F-103U	79380	54405	ST	152.9	143.5	CU										32.38	21.14	11.24	1.8	14.6	18.2	1.25	0.5	0.05	
GC	F-107U	79130	54135	ST	173	136.1	CU										23.64	10.84	12.8	3.5						
DB1/DB3	F-111U	79025	54105	ST	112.9	197	CU										31.12	21.2	9.92	7.2						
DB1/DB3	F-113U	79025	54425	ST	83	216.8	CU										13.58	5.66	7.92	4						
TR1	F-114UP	79141	54260	ST	5.9	301.9	CU										8.96	8.36	0.6	2.7						
TR1	F-114UP	79141	54260	ST	7.9	299.9	CU										9	8.2	0.8	4.5						
TR1	F-114UP	79141	54260	ST	9.9	297.9	CU										8.58	7.58	1	2.7						
TR1	F-114UP	79141	54260	ST	12.5	295.3																				
TR1	F-114UP	79141	54260	ST	17	290.8	CU										9.4	7.7	1.7	1.3						
TR1	F-114UP	79141	54260	ST	19	288.8																				
TR1A	F-114UP	79141	54260	ST	95.5	212.3																				
TR3/TR4	F-114UP	79141	54260	ST	98	209.8	CU										13.62	4.56	9.06	3						
TR3/TR4	F-114UP	79141	54260	ST	100	207.8																				
TR3/TR4	F-114UP	79141	54260	ST	100	207.8											17.68	8.46	9.22	3.6						
TR3/TR4	F-114UP	79141	54260	ST	102	205.8	CU																			
DB1/DB3	F-114UP	79141	54260	ST	104	203.8											32.36	23	9.36	2.8						
DB1/DB3	F-114UP	79141	54260	ST	106	201.8	CU																			
DB1/DB3	F-114UP	79141	54260	ST	106	201.8																				
TR3/TR4	241-14F-1	76270	52800	SS	79.3	204.4																				
TR3/TR4	241-14F-1	76270	52800	SS	84.3	199.4																				
TR3/TR4	241-14F-2	76815	52785	SS	39.3	246.9																				
TR3/TR4	241-14F-2	76815	52785	SS	84.3	201.9																				
TR3/TR4	241-14F-3U	76490	52785	ST	26.5	261.4	CU										9.2	6.6	2.6							
TR3/TR4	241-14F-3U	76490	52785	ST	84.3	203.8																				
TR2A	241-14F-4	77070	52785	SS	55.8	234																				
TR2A	241-14F-5U	76880	52725	ST	50	236.7																				
TR2B	241-14F-5U	76880	52725	ST	60	226.7																				
TR2B	241-14F-5U	76880	52725	ST	69.5	217.2																				
TR3/TR4	241-14F-5U	76880	52725	ST	84.3	202.4																				
DB1/DB3	241-14F-5U	76880	52725	ST	100	186.7															10	28	2.80	1.2	0.28	
DB1/DB3	241-14F-5U	76880	52725	ST	114.3	172.4															10.8	10.8	1.00	0.22	0.03	
DB1/DB3	241-14F-5U	76880	52725	ST	134.2	152.5																				
TR3/TR4	241-14F-6	76695	52600	SS	79.3	207.1																				
TR3/TR4	241-14F-6	76695	52600	SS	89.3	197.1																				
TR3/TR4	241-14F-9	77070	52600	SS	94.3	194.2																				
TR2A	241-55F-1U	77070	52333	ST	53	238.9	UU										16.18	10.68	5.52							
TR3/TR4	241-55F-1U	77070	52333	ST	96	195.9															10.2	19	1.88	0.74	0.21	
TR3/TR4	241-55F-1U	77070	52333	ST	96	195.9	UU										21.4	13.2	8.2							
DB1/DB3	241-55F-1U	77070	52333	ST	106	185.9	UU										17.68	8.92	8.74							
ST	241-55F-1U	77070	52333	ST	122	169.9	UU										20.1	10.54	9.56							
TR3/TR4	241-55F-4U	76815	52333	ST	86.1	205	UU										17.92	10.28	7.86							

Table E-2 Summary of Laboratory Test Results (cont'd)

PROJECT: F-Area / F-Canyon

Layer	Borehole	North	East	Type	Depth (feet)	Elev. (feet)	Test Type	qu (ksf)	C' (tx) (ksf)	Phi' (tx)	s1' (tx) (ksf)	s3' (tx) (ksf)	Pore Pressure (tx) (ksf)	Back Pressure (tx) (ksf)	C (tx) (ksf)	Phi (tx)	s1 (tx) (ksf)	Deviator (tx) (ksf)	s3 (tx) (ksf)	FStrn (tx) (%)	Po (ksf)	Pc (ksf)	OCR	Cc	Cr	Cv
TR3/TR4	241-55F-4U	76815	52333	ST	95.6	195.5															10.2	17.4	1.71	1.93	0.44	
TR3/TR4	241-55F-4U	76815	52333	ST	95.6	195.5	UU										13.72	5.54	8.18							
DB4/DB5	241-55F-4U	76815	52333	ST	118.8	172.3	UU										11.46	2.04	9.42		11.8	9.2	0.78	1.24	0.09	
TR2B	DH4	77000	53190	SS	53.5	220.7																				
TR2B	DH4	77000	53190	SS	58.5	215.7																				
TR3/TR4	DH4	77000	53190	ST	68.5	205.7	UC	2.45							1.22											
TR3/TR4	DH4	77000	53190	SS	78.5	195.7																				
DB1/DB3	DH4	77000	53190	SS	98.5	175.7																				
DB1/DB3	DH4	77000	53190	SS	108.5	165.7																				
TR1	FU-1	79125	53475		4	304	DS		0.8	38																
TR1	FU-1	79125	53475		4	304	DS																			
TR1	FU-1	79125	53475		4	304	DS																			
TR1	FU-1	79125	53475		5	303																				
TR1	FU-1	79125	53475		7	301																				
TR1	FU-1	79125	53475		8.4	299.6	UU								0.76	32	8.8	6.8	2							
TR1	FU-1	79125	53475		8.4	299.6	UU										12	9	3							
TR1	FU-1	79125	53475		8.4	299.6	UU										15.2	11.2	4							
TR1	FU-1	79125	53475		10	298															1.2	3	2.5	0.097		
TR1	FU-1	79125	53475		11.5	296.5	CD		1.08	31	10	2														
TR1	FU-1	79125	53475		11.5	296.5	CD				13	3														
TR1	FU-1	79125	53475		11.5	296.5	CD				16	4														
TR1	FU-1	79125	53475		13	295																				
TR1	FU-1	79125	53475		14.1	293.9																				
TR1	FU-1	79125	53475		16	292																				
TR1	FU-1	79125	53475		17.1	290.9																				
TR1	FU-1	79125	53475		19	289																				
TR1	FU-1	79125	53475		20.1	287.9															2.42	6.2	2.6	0.148		
TR1	FU-1	79125	53475		22	286																				
TR1	FU-1	79125	53475		23.1	284.9																				
TR1	FU-1	79125	53475		25	283																				
TR1	FU-1	79125	53475		26.1	281.9																				
TR1	FU-1	79125	53475		29	279																				
TR1	FU-1	79125	53475		31	277																				
TR1A	FU-1	79125	53475		32.1	275.9																				
TR1A	FU-1	79125	53475		34	274															4.1	9.4	2.3	0.055		
TR1A	FU-1	79125	53475		35.1	272.9																				
TR1A	FU-1	79125	53475		37	271																				
TR1A	FU-1	79125	53475		38.1	269.9															4.44	9	2.0	0.113		
TR1A	FU-1	79125	53475		41	267															4.86			0.102		
TR1A	FU-1	79125	53475		41	267															4.86			0.064		
TR1A	FU-1	79125	53475		43	265																				
TR1A	FU-1	79125	53475		44.1	263.9																				
TR1A	FU-1	79125	53475		46	262																				
TR1A	FU-1	79125	53475		49	259																				
TR1A	FU-1	79125	53475		52	256																				
TR1A	FU-1	79125	53475		52	256																				
TR1A	FU-1	79125	53475		53.3	254.7																				
TR1A	FU-1	79125	53475		53.3	254.7															6.16			0.123		
TR1A	FU-1	79125	53475		55	253																				
TR1A	FU-1	79125	53475		56.1	251.9																				
TR1A	FU-1	79125	53475		58	250																				
TR2A	FU-1	79125	53475		59.1	248.9																				
TR2A	FU-1	79125	53475		65	243																				
TR2A	FU-1	79125	53475		70	238																				
TR2A	FU-1	79125	53475		75	233															8.52			0.074		
TR2A	FU-1	79125	53475		76	232																				
TR2B	FU-1	79125	53475		85.1	222.9																				
TR2B	FU-1	79125	53475		90	218																				
TR2B	FU-1	79125	53475		93	215																				
TR2B	FU-1	79125	53475		94.2	213.8																				

Table E-2 Summary of Laboratory Test Results (cont'd)

PROJECT: F-Area / F-Canyon

Layer	Borehole	North	East	Type	Depth (feet)	Elev. (feet)	Test Type	qu (ksf)	C' (tx) (ksf)	Phi' (tx)	s1' (tx) (ksf)	s3' (tx)' (ksf)	Pore Pressure (tx) (ksf)	Back Pressure (tx) (ksf)	C (tx) (ksf)	Phi (tx)	s1 (tx) (ksf)	Deviator (tx) (ksf)	s3 (tx) (ksf)	FStm (tx) (%)	Po (ksf)	Pc (ksf)	OCR	Cc	Cr	Cv
TR2B	FU-1	79125	53475		96	212																				
TR2B	FU-1	79125	53475		97	211															10.3	12	1.2	0.041		
TR2B	FU-1	79125	53475		99	209																				
TR2B	FU-1	79125	53475		103	205																				
TR2B	FU-1	79125	53475		103.8	204.2																				
TR3/TR4	FU-1	79125	53475		105.2	202.8																				
TR3/TR4	FU-1	79125	53475		106	202															10.7	14.4	1.3	1.12		
TR3/TR4	FU-1	79125	53475		107.2	200.8																				
TR3/TR4	FU-1	79125	53475		109	199																				
TR3/TR4	FU-1	79125	53475		110.2	197.8															10.84	10	0.9	0.56		
TR3/TR4	FU-1	79125	53475		112	196																				
TR3/TR4	FU-1	79125	53475		118	190																				
TR3/TR4	FU-1	79125	53475		119.2	188.8																				
DB1/DB3	FU-1	79125	53475		130	178															11.72	12	1.0	0.04		
DB1/DB3	FU-1	79125	53475		140	168																				
DB1/DB3	FU-1	79125	53475		140.9	167.1																				
DB1/DB3	FU-1	79125	53475		150	158															13	11.6	0.9	0.122		
ST	FU-1	79125	53475		160.4	147.6																				
ST	FU-1	79125	53475		160.9	147.1															13.6	20.8	1.5	0.44		
ST	FU-1	79125	53475		170	138																				
ST	FU-1	79125	53475		171.2	136.8																				
TR1	FU-2	78642	53475		9.3	300.8																				
TR1	FU-2	78642	53475		17.5	292.6	CD		0.8	30	8.8	2														
TR1	FU-2	78642	53475		17.5	292.6	CD				12	3														
TR1	FU-2	78642	53475		17.5	292.6	CD				14.8	4														
TR1A	FU-2	78642	53475		35	275.1															4.26			0.053		
TR1A	FU-2	78642	53475		50	260.1															5.96	10.4	1.7	0.095		
TR2A	FU-2	78642	53475		70	240.1															8.36			0.074		
DB1/DB3	FU-2	78642	53475		129.1	181															12.88			0.061		
TR1	FU-3	78310	54381		7.5	310.9	UC	5.6																		
TR1	FU-3	78310	54381		8.3	310.1															1	3.4	3.4	0.1		
TR1A	FU-3	78310	54381		33.1	285.3															4	5	1.3	0.096		
TR1A	FU-3	78310	54381		49.2	269.2															5.84	6	1.0	0.085		
TR2B	FU-3	78310	54381		98.2	220.2															9.76			0.058		
TR3/TR4	FU-3	78310	54381		109	209.4															10.3	20.2	2.0	0.69		
DB1/DB3	FU-3	78310	54381		118	200.4															10.8	3	0.3	0.046		
TR1	F-50	78900	54730		1	293.7																				
TR1	F-50	78900	54730		6	288.7																				
TR1	F-50	78900	54730		13.5	281.2																				
TR1A	F-50	78900	54730		28.5	266.2																				
TR1A	F-50	78900	54730		38.5	256.2																				
TR1	F-51	78830	54730		3.5	294.9																				
TR1	F-51	78830	54730		7	291.4																				
TR1	F-51	78830	54730		8.5	289.9																				
TR1	F-51	78830	54730		13.5	284.9																				
TR1	F-51	78830	54730		18.5	279.9																				
TR1A	F-51	78830	54730		23.5	274.9																				
TR1A	F-51	78830	54730		33.5	264.9																				
TR2B	F-51	78830	54730		73.5	224.9																				
DB1/DB3	F-51	78830	54730		108.5	189.9																				
DB1/DB3	F-51	78830	54730		118.5	179.9																				
ST	F-51	78830	54730		138.5	159.9																				
ST	F-51	78830	54730		143.5	154.9																				
ST	F-51	78830	54730		148.5	149.9																				
ST	F-51	78830	54730		163.5	134.9																				
TR1	F-52	78900	54825		10	285.6															1.1	11	10	0.14	0.011	
TR1A	F-52	78900	54825		25	270.6																				
TR1A	F-52	78900	54825		27	268.6																				
TR2A	F-52	78900	54825		38.5	257.1																				
TR2A	F-52	78900	54825		53.5	242.1																				

Figure E-2 Summary of Laboratory Test Results (cont'd)

PROJECT: F-Area / F-Canyon

Layer	Borehole	North	East	Type	Depth (feet)	Elev. (feet)	Test Type	qu (ksf)	C' (tx) (ksf)	Phi' (tx)	s1' (tx) (ksf)	s3' (tx) (ksf)	Pore Pressure (tx) (ksf)	Back Pressure (tx) (ksf)	C (tx) (ksf)	Phi (tx)	s1 (tx) (ksf)	Deviator (tx) (ksf)	s3 (tx) (ksf)	FStim (tx) (%)	Po (ksf)	Pc (ksf)	OCR	Cc	Cr	Cv
TR3/TR4	F-52	78900	54825		78.5	217.1																				
DB1/DB3	F-52	78900	54825		98.5	197.1																				
DB1/DB3	F-52	78900	54825		113.5	182.1																				
ST	F-52	78900	54825		138.5	157.1																				
ST	F-52	78900	54825		148.5	147.1																				
ST	F-52	78900	54825		158.5	137.1																				
CG	F-52	78900	54825		178.5	117.1																				
TR1	F-53	78830	54825		8.5	290.6																				
TR1A	F-53	78830	54825		18.5	280.6																				
TR1A	F-53	78830	54825		28.5	270.6																				
TR1	F-54	78880	54875		3.5	293.1																				
TR1A	F-54	78880	54875		8.5	288.1																				
TR1A	F-54	78880	54875		13.5	283.1																				
TR1A	F-54	78880	54875		18.5	278.1																				
TR1A	F-54	78880	54875		33.5	263.1																				
TR1A	F-55	79050	54834		3.5	287.8																				
TR1A	F-55	79050	54834		6	285.3																				
TR1A	F-55	79050	54834		12	279.3																				
TR1A	F-55	79050	54834		15	276.3																				
TR1A	F-55	79050	54834		17	274.3															1.8	4.8	2.7	0.056	0.005	
TR1A	F-55	79050	54834		22	269.3																				
TR1A	F-55	79050	54834		25	266.3																				
TR1A	F-55	79050	54834		27	264.3															3	1.5	0.5	0.046	0.007	
TR2A	F-55	79050	54834		38.5	252.8																				
TR3/TR4	F-55	79050	54834		73.5	217.8																				
TR1	F-63	75960	53270	ST	10	273.3																				
TR1	F-63	75960	53270	ST	10	273.3																				
TR1	F-63	75960	53270	SS	20	263.3																				
TR2A	F-63	75960	53270	SS	30	253.3																				
TR2A	F-63	75960	53270	SS	50	233.3																				
TR1	F-64	76115	53075	SS	2.5	277.7																				
TR1	F-64	76115	53075	SS	15	265.2																				
TR2A	F-64	76115	53075	SS	30	250.2																				
TR2A	F-64	76115	53075	SS	40	240.2																				
TR1	F-65	76240	53060	SS	10	270.5																				
TR2A	F-65	76240	53060	SS	35	245.5																				
TR2A	F-65	76240	53060	SS	45	235.5																				
TR1	F-66	76070	53310	ST	9	267.6	UU								0.5	34	3.75	3.25	0.5							
TR1	F-66	76070	53310	ST	9	267.6	UU										5.7	4.69	1.01							
TR1	F-66	76070	53310	ST	9	267.6	UU										9.02	7	2.02							
TR1	F-66	76070	53310	SS	10	266.6																				
TR2A	F-66	76070	53310	SS	25	251.6																				
TR2A	F-66	76070	53310	SS	35	241.6																				
TR1	F-56	77684	53342	SS	15	280.4																				
TR1	F-56	77684	53342	SS	30	265.4																				
DB1/DB3	F-56	77684	53342	SS	110	185.4																				
DB4/DB5	F-56	77684	53342	SS	120	175.4																				
ST	F-56	77684	53342	SS	135	160.4																				
ST	F-56	77684	53342	SS	150	145.4																				
GC	F-56	77684	53342	SS	170	125.4																				
TR1	F-57	77813	53240	SS	10	283.8																				
TR1	F-57	77813	53240	SS	20	273.8																				
TR1	F-57	77813	53240	SS	30	263.8																				
TR2B	F-57	77813	53240	SS	70	223.8																				
DB1/DB3	F-57	77813	53240	SS	90	203.8																				
DB1/DB3	F-57	77813	53240	SS	110	183.8																				
ST	F-57	77813	53240	SS	135	158.8																				
ST	F-57	77813	53240	SS	145	148.8																				
CG	F-57	77813	53240	SS	190	103.8																				
TR1	F-58	77840	53280	SS	7	288.8																				

Table E-2 Summary of Laboratory Test Results (cont'd)

PROJECT: F-Area / F-Canyon

Layer	Borehole	North	East	Type	Depth (feet)	Elev. (feet)	Test Type	qu (ksf)	C' (tx) (ksf)	Phi' (tx)	s1' (tx) (ksf)	s3' (tx) (ksf)	Pore Pressure (tx) (ksf)	Back Pressure (tx) (ksf)	C (tx) (ksf)	Phi (tx)	s1 (tx) (ksf)	Deviator (tx) (ksf)	s3 (tx) (ksf)	FStm (tx) (%)	Po (ksf)	Pc (ksf)	OCR	Cc	Cr	Cv
TR1	F-58	77840	53280	SS	10	285.8																				
TR1	F-59	77893	53278	ST	7	287.6	CU								0.79	19	3.6	2.85	0.75							
TR1	F-59	77893	53278	ST	7	287.6	CU										5.2	3.7	1.5							
TR1	F-59	77893	53278	ST	7	287.6	CU										8.6	5.6	3							
TR1	F-59	77893	53278	SS	9	285.6																				
TR1	F-60	77895	53360	ST	7	288.3	CU								1.85	19	6.6	5.85	0.75							
TR1	F-60	77895	53360	ST	7	288.3	CU										8.5	7	1.5							
TR1	F-60	77895	53360	ST	7	288.3	CU										11	8	3							
TR1	F-60	77895	53360	SS	9	286.3																				
TR1	F-46	79200	53285	SS	1	309.6																				
TR1	F-46	79200	53285	SS	3.5	307.1																				
TR1	F-46	79200	53285	SS	6	304.6																				
TR1	F-47	79260	53400	SS	3.5	307.4																				
TR1	F-47	79260	53400	SS	6	304.9																				
TR1	F-48	79145	53400	SS	1	309.63																				
TR1	F-48	79145	53400	SS	3.5	307.13																				
TR1	F-48	79145	53400	SS	6	304.63																				
TR1	F-48	79145	53400	SS	8.5	302.13																				
TR1	F-48	79145	53400	SS	13.5	297.13																				
TR1	F-49	79200	53378	SS	3.5	307.1																				
TR1	F-49	79200	53378	SS	13.5	297.1																				
TR1	F-49	79200	53378	SS	23.5	287.1																				
TR1	200F-B-25	78835	54300	SS	6	304.5																				
TR1	200F-B-25	78835	54300	ST	9	301.5	CU								0.9	19	1.7	1.4	0.3							
TR1	200F-B-25	78835	54300	ST	9	301.5	CU										3.25	2.05	1.2							
TR1	200F-B-25	78835	54300	ST	9	301.5	CU										7.5	4.25	3.25							
TR1	200F-B-25	78835	54300	SS	11	299.5																				
TR1	200F-B-25	78835	54300	SS	13	297.5																				
TR1A	200F-B-25	78835	54300	SS	28.5	282																				
TR1A	200F-B-25	78835	54300	ST	39	271.5	CU								1.3	8	3.6	2.9	0.7							
TR1A	200F-B-25	78835	54300	ST	39	271.5	CU										6.2	4	2.2							
TR1A	200F-B-25	78835	54300	ST	39	271.5	CU										11.3	4.9	6.4							
TR1A	200F-B-25	78835	54300	SS	41	269.5																				
TR2A	200F-B-25	78835	54300	ST	53	257.5	CU								0.8	24	2	1.7	0.3		5.6	5	0.89	0.11	0.019	
TR2A	200F-B-25	78835	54300	ST	53	257.5	CU										3.6	2.5	1.1							
TR2A	200F-B-25	78835	54300	ST	53	257.5	CU										9.2	6	3.2							
TR2A	200F-B-25	78835	54300	SS	55	255.5																				
TR2A	200F-B-25	78835	54300	ST	65.5	245	CU								0.5	14	2.4	1.7	0.7							
TR2A	200F-B-25	78835	54300	ST	65.5	245	CU										5	2.8	2.2							
TR2A	200F-B-25	78835	54300	ST	65.5	245	CU										11.7	5.2	6.5							
TR2A	200F-B-25	78835	54300	SS	67.5	243																				
TR2B	200F-B-25	78835	54300	SS	78.5	232																				
TR3/TR4	200F-B-25	78835	54300	ST	84	226.5	CU								1.9	4	4.9	4.2	0.7							
TR3/TR4	200F-B-25	78835	54300	ST	84	226.5	CU										11.6	5.1	6.5							
TR3/TR4	200F-B-25	78835	54300	ST	84	226.5	CU										13.9	5.2	8.7							
TR3/TR4	200F-B-25	78835	54300	SS	86	224.5																				
TR3/TR4	200F-B-25	78835	54300	ST	95	215.5	CU								1.9	3	4.8	4.1	0.7		10	15.5	1.55	0.71	0.046	
TR3/TR4	200F-B-25	78835	54300	ST	95	215.5	CU										11.3	4.9	6.4							
TR3/TR4	200F-B-25	78835	54300	ST	95	215.5	CU										13.5	4.8	8.7							
TR3/TR4	200F-B-25	78835	54300	SS	97	213.5																				
DB1/DB3	200F-B-25	78835	54300	SS	103.5	207																				
TR1	200F-B-24	78835	54370	SS	3.5	306.9																				
TR1	200F-B-24	78835	54370	SS	8.5	301.9																				
TR1A	200F-B-24	78835	54370	SS	28.5	281.9																				
TR1A	200F-B-24	78835	54370	SS	38.5	271.9																				
TR2A	200F-B-24	78835	54370	SS	53.5	256.9																				
TR2A	200F-B-24	78835	54370	SS	58.5	251.9																				
TR2A	200F-B-24	78835	54370	SS	68.5	241.9																				
TR2B	200F-B-24	78835	54370	SS	78.8	231.6																				
TR3/TR4	200F-B-24	78835	54370	SS	83.5	226.9																				

Table E-2 Summary of Laboratory Test Results (cont'd)

PROJECT: F-Area / F-Canyon																										
													Pore	Back												
Layer	Borehole	North	East	Type	Depth	Elev.	Test	qu	C'	Phi'	s1'	s3'	Pressure	Pressure	C	Phi	s1	Deviator	s3	FStrn	Po	Pc	OCR	Cc	Cr	Cv
							Type		(tx)	(tx)	(tx)	(tx)	(tx)	(tx)	(tx)	(tx)	(tx)	(tx)	(tx)	(tx)						
					(feet)	(feet)		(ksf)	(ksf)		(ksf)	(ksf)	(ksf)	(ksf)	(ksf)		(ksf)	(ksf)	(ksf)	(%)	(ksf)	(ksf)				
TR3/TR4	200F-B-24	78835	54370	SS	88.5	221.9																				
TR3/TR4	200F-B-24	78835	54370	SS	93.5	216.9																				
DB1/DB3	200F-B-24	78835	54370	SS	103.5	206.9																				
DB1/DB3	200F-B-24	78835	54370	SS	113.5	196.9																				
DB1/DB3	200F-B-24	78835	54370	SS	123.5	186.9																				
DB1/DB3	200F-B-24	78835	54370	SS	133.5	176.9																				
ST	200F-B-24	78835	54370	SS	143.5	166.9																				
TR3/TR4	200F-B-26	78794	54335	SS	83.5	228.5																				
TR3/TR4	200F-B-26	78794	54335	SS	88.5	223.5																				
TR3/TR4	200F-B-26	78794	54335	SS	98.5	213.5																				
DB1/DB3	200F-B-26	78794	54335	SS	108.5	203.5																				
DB1/DB3	200F-B-26	78794	54335	SS	118.5	193.5																				
DB1/DB3	200F-B-26	78794	54335	SS	128.5	183.5																				
DB4/DB5	200F-B-26	78794	54335	SS	133.5	178.5																				
ST	200F-B-26	78794	54335	SS	138.5	173.5																				
ST	200F-B-26	78794	54335	SS	143.5	168.5																				
ST	200F-B-26	78794	54335	SS	153.5	158.5																				
ST	200F-B-26	78794	54335	SS	158.5	153.5																				
TR1	FHS-1	75819	51332	ST	3	282.1	UU								0.5	25	4.01	3	1.01							
TR1	FHS-1	75819	51332	ST	3	282.1	UU										8.06	5.03	3.03							
TR1	FHS-1	75819	51332	ST	3	282.1	UU										11.23	6.18	5.05							
TR1	FHS-4	75459	53877	ST	0	265.9	UU								0.4	19	3.2	2.19	1.01							
TR1	FHS-4	75459	53877	ST	0	265.9	UU										5.18	2.15	3.03							
TR1	FHS-4	75459	53877	ST	0	265.9	UU										14.53	9.48	5.05							
TR1	FHS-8	73435	57196	ST	1.5	281.2	UU								0	35.5	3.56	2.55	1.01							
TR1	FHS-8	73435	57196	ST	1.5	281.2	UU										11.19	8.16	3.03							
TR1	FHS-8	73435	57196	ST	1.5	281.2	UU										19.16	14.11	5.05							
TR1	FHS-1	75819	51332	SS	5	280.1																				
TR1	FHS-4	75459	53877	SS	3.5	262.4																				
TR1	FHS-4	75459	53877	SS	7.5	258.4																				
TR1	FHS-5	74980	54664	SS	15	254																				
TR1	FHS-6	74390	55633	SS	2.5	272.6																				
TR1	FHS-6	74390	55633	SS	10.5	264.6																				
TR1	FHS-7	73906	56397	ST	4.5	265	UU								0.8	26	4.83	3.82	1.01							
TR1	FHS-7	73906	56397	ST	4.5	265	UU										9.83	6.8	3.03							
TR1	FHS-7	73906	56397	ST	4.5	265	UU										15.2	10.16	5.04							
TR1	FHS-8	73435	57196	SS	7.5	275.2																				
TR1	FHS-9	72970	57990	SS	0	287.8																				
TR1	FHS-9	72970	57990	ST	6	281.8	UU								0.4	33	4.7	3.69	1.01							
TR1	FHS-9	72970	57990	ST	6	281.8	UU										11.87	8.84	3.03							
TR1	FHS-9	72970	57990	ST	6	281.8	UU										18.5	13.44	5.06							
TR1	FHS-9	72970	57990	SS	12.5	275.3																				
TR1	FHS-10	72512	58753	ST	3	266.9	UU								0.6	27	4.44	3.43	1.01							
TR1	FHS-10	72512	58753	ST	3	266.9	UU										8.82	5.79	3.03							
TR1	FHS-10	72512	58753	ST	3	266.9	UU										17.14	12.08	5.06							
TR1	FHS-10	72512	58753	SS	10	259.9																				
TR1	FHS-11	72354	59159	SS	12.5	253.7																				
TR1	FHS-12	72679	59970	ST	1.5	274.2	UU								0.2	21	2.43	1.43	1							
TR1	FHS-12	72679	59970	ST	1.5	274.2	UU										5.36	2.36	3							
TR1	FHS-12	72679	59970	ST	1.5	274.2	UU										10.88	5.88	5							
TR1	F-SEP-B6	76612.7	53026.2	SS	15.5	268.5																				
TR2A	F-SEP-B6	76612.7	53026.2	ST	54	230																				
TR3/TR4	F-SEP-B6	76612.7	53026.2	SS	81	203																				
TR3/TR4	F-SEP-B6	76612.7	53026.2	SS	82.5	201.5																				
TR3/TR4	F-SEP-B6	76612.7	53026.2	ST	84	200																9.6	15	1.6	0.53	0.092	0.4
TR3/TR4	F-SEP-B6	76612.7	53026.2	SS	88	196																				
DB1/DB3	F-SEP-B6	76612.7	53026.2	SS	96	188																				
DB1/DB3	F-SEP-B6	76612.7	53026.2	SS	99	185																				
DB1/DB3	F-SEP-B6	76612.7	53026.2	SS	103.5	180.5																				
DB1/DB3	F-SEP-B6	76612.7	53026.2	SS	108	176																				

Table E-2 Summary of Laboratory Test Results (cont'd)

PROJECT: F-Area / F-Canyon

Layer	Borehole	North	East	Type	Depth (feet)	Elev. (feet)	Test Type	qu (ksf)	C' (tx) (ksf)	Phi' (tx)	s1' (tx) (ksf)	s3' (tx) (ksf)	Pore Pressure (tx) (ksf)	Back Pressure (tx) (ksf)	C (tx) (ksf)	Phi (tx)	s1 (tx) (ksf)	Deviator (tx) (ksf)	s3 (tx) (ksf)	FStrn (tx) (%)	Po (ksf)	Pc (ksf)	OCR	Cc	Cr	Cv
DB4/DB5	F-SEP-B6	76612.7	53026.2	SS	120.5	163.5																				
DB4/DB5	F-SEP-B6	76612.7	53026.2	SS	123.5	160.5																				
ST	F-SEP-B6	76612.7	53026.2	SS	128.5	155.5																				
ST	F-SEP-B6	76612.7	53026.2	SS	136	148																				
ST	F-SEP-B6	76612.7	53026.2	SS	141	143																				
ST	F-SEP-B6	76612.7	53026.2	ST	148	136	CUw/PP		0	35.8	8.8	3.6	6.4	2.7	0	20.9	12.5	5.2	7.30		13.4	16	1.2	0.19	0.02	1.6
ST	F-SEP-B6	76612.7	53026.2	ST	148	136	CUw/PP				19.6	5.1	8.8	3.1			25.3	14.5	10.80							
ST	F-SEP-B6	76612.7	53026.2	ST	148	136	CUw/PP				19.6	4.5	12.8	2.9			29.5	15.1	14.40							
ST	F-SEP-B6	76612.7	53026.2	SS	153	131																				
TR1	F-SEP-B8	78129.1	53507.2	SS	7	294																				
TR1	F-SEP-B8	78129.1	53507.2	SS	13	288																				
TR1A	F-SEP-B8	78129.1	53507.2	SS	22	279																				
TR1A	F-SEP-B8	78129.1	53507.2	SS	28	273																				
TR2A	F-SEP-B8	78129.1	53507.2	SS	34	267																				
TR2A	F-SEP-B8	78129.1	53507.2	SS	43.5	257.5																				
TR2A	F-SEP-B8	78129.1	53507.2	SS	44.5	256.5																				
TR2B	F-SEP-B8	78129.1	53507.2	SS	60	241																				
TR2B	F-SEP-B8	78129.1	53507.2	SS	66	235																				
TR2B	F-SEP-B8	78129.1	53507.2	SS	70.5	230.5																				
TR3/TR4	F-SEP-B8	78129.1	53507.2	ST	78	223	CUw/PP		0	32.9	3.91	1.24	3.57	3.66	0.63	13.2	3.82	2.68	1.14							
TR3/TR4	F-SEP-B8	78129.1	53507.2	ST	78	223	CUw/PP				3.61	1.27	4.55	3.51			4.65	2.34	2.31							
TR3/TR4	F-SEP-B8	78129.1	53507.2	ST	78	223	CUw/PP				5.16	1.31	5.8	3.66			7.3	3.85	3.45							
TR3/TR4	F-SEP-B8	78129.1	53507.2	ST	80	221																				
TR3/TR4	F-SEP-B8	78129.1	53507.2	SS	82	219																				
DB1/DB3	F-SEP-B8	78129.1	53507.2	SS	89.5	211.5																				
DB1/DB3	F-SEP-B8	78129.1	53507.2	ST	99	202																				
DB1/DB3	F-SEP-B8	78129.1	53507.2	SS	103.5	197.5																				
DB1/DB3	F-SEP-B8	78129.1	53507.2	SS	109.5	191.5																				
DB4/DB5	F-SEP-B8	78129.1	53507.2	SS	114	187																				
ST	F-SEP-B8	78129.1	53507.2	SS	125	176																				
ST	F-SEP-B8	78129.1	53507.2	SS	132.5	168.5																				
ST	F-SEP-B8	78129.1	53507.2	SS	135	166																				
ST	F-SEP-B8	78129.1	53507.2	SS	141.5	159.5																				
ST	F-SEP-B8	78129.1	53507.2	SS	149	152																				
ST	F-SEP-B8	78129.1	53507.2	SS	155	146																				
ST	F-SEP-B8	78129.1	53507.2	SS	158	143																				
ST	F-SEP-B8	78129.1	53507.2	SS	164	137																				
ST	F-SEP-B8	78129.1	53507.2	SS	167	134																				
ST	F-SEP-B8	78129.1	53507.2	SS	173	128																				
ST	F-SEP-B8	78129.1	53507.2	SS	176	125																				
ST	F-SEP-B8	78129.1	53507.2	SS	177.5	123.5																				
DB4/DB5	F-SEP-B8.1	78129.1	53515.2	ST	118	183															11.6	9.5	0.82	0.15	0.0083	0.32
TR2B	F-SEP-B13.1	79081.1	54112.1	ST	63	239																				
DB1/DB3	F-SEP-B13.1	79081.1	54112.1	ST	93	209																				
DB1/DB3	F-SEP-B13.1	79081.1	54112.1	SS	96	206																				
DB4/DB5	F-SEP-B13.1	79081.1	54112.1	ST	110	192	CUw/PP		0	21.5	11.1	4.9	8.8	2.9			17	6.2	10.80		11.1	14.5	1.31	0.44	0.08	0.85
DB4/DB5	F-SEP-B13.1	79081.1	54112.1	ST	110	192	CUw/PP				7.7	3.9	13.4	2.9			18.2	3.8	14.40							
ST	F-SEP-B13.1	79081.1	54112.1	SS	129.5	172.5																				
ST	F-SEP-B13.1	79081.1	54112.1	SS	134	168																				
ST	F-SEP-B13.1	79081.1	54112.1	SS	150.5	151.5																				
ST	F-SEP-B13.1	79081.1	54112.1	ST	163	139															14.3	3.6	0.25	0.25	0.094	0.35
ST	F-SEP-B13.1	79081.1	54112.1	SS	166.5	135.5																				
FILL	F-TNK-B3	76974	52700	SS	7.5	278																				
FILL	F-TNK-B3	76974	52700	SS	12	273.5																				
FILL	F-TNK-B3	76974	52700	SS	16.5	269																				
FILL	F-TNK-B3	76974	52700	SS	22.5	263																				
FILL	F-TNK-B3	76974	52700	ST	27.5	258	UU								4.25	0	12	8.5	3.5		3.4	4	1.18	0.07	0.005	0.42
FILL	F-TNK-B3	76974	52700	SS	29.5	256																				
FILL	F-TNK-B3	76974	52700	SS	34	251.5																				
FILL	F-TNK-B3	76974	52700	SS	37	248.5																				

Table E-2 Summary of Laboratory Test Results (cont'd)

PROJECT: F-Area / F-Canyon

Layer	Borehole	North	East	Type	Depth (feet)	Elev. (feet)	Test Type	qu (ksf)	C' (tx) (ksf)	Phi' (tx)	s1' (tx) (ksf)	s3' (tx) (ksf)	Pore Pressure (tx) (ksf)	Back Pressure (tx) (ksf)	C (tx) (ksf)	Phi (tx)	s1 (tx) (ksf)	Deviator (tx) (ksf)	s3 (tx) (ksf)	FStm (tx) (%)	Po (ksf)	Pc (ksf)	OCR	Cc	Cr	Cv
TR2A	F-TNK-B3	76974	52700	SS	41.5	244																				
TR2A	F-TNK-B3	76974	52700	SS	43	242.5																				
TR1	F-TNK-B8	77459.5	52765.6	SS	6	263.5																				
TR1	F-TNK-B8	77459.5	52765.6	ST	7.5	262																				
TR1	F-TNK-B8	77459.5	52765.6	SS	11	258.5																				
TR1	F-TNK-B8	77459.5	52765.6	SS	17.5	252																				
TR2A	F-TNK-B8	77459.5	52765.6	SS	22	247.5																				
TR2A	F-TNK-B8	77459.5	52765.6	SS	25	244.5																				
TR2A	F-TNK-B8	77459.5	52765.6	SS	28	241.5																				
TR2A	F-TNK-B8	77459.5	52765.6	SS	32.5	237																				
TR2A	F-TNK-B8	77459.5	52765.6	SS	35.5	234																				
TR2A	F-TNK-B8	77459.5	52765.6	SS	38.5	231																				
TR2B	F-TNK-B8	77459.5	52765.6	SS	43	226.5																				
TR2B	F-TNK-B8	77459.5	52765.6	SS	46	223.5																				
FILL	F-TNK-B13	77332.2	53302.8	SS	6	273.1																				
FILL	F-TNK-B13	77332.2	53302.8	SS	10.5	268.6																				
FILL	F-TNK-B13	77332.2	53302.8	SS	15	264.1																				
FILL	F-TNK-B13	77332.2	53302.8	SS	18	261.1	CUw/PP		0	33.6	10.8	3.1	4.8	4.3	0.18	29.8	11.3	7.7	3.60							
FILL	F-TNK-B13	77332.2	53302.8	SS	18	261.1	CUw/PP				5.7	1.7	4.4	4.3			5.8	4	1.80							
FILL	F-TNK-B13	77332.2	53302.8	SS	21.5	257.6																				
FILL	F-TNK-B13	77332.2	53302.8	SS	24.5	254.6																				
FILL	F-TNK-B13	77332.2	53302.8	ST	27.5	251.6																3.4	2.7	0.79	0.09	0.012	2.2
TR2A	F-TNK-B13	77332.2	53302.8	SS	31	248.1																				
TR2A	F-TNK-B13	77332.2	53302.8	SS	37	242.1																				
TR2A	F-TNK-B13	77332.2	53302.8	SS	41.5	237.6																				
TR2A	F-TNK-B13	77332.2	53302.8	SS	46	233.1																				
FILL	F-TNK-B16	76738.1	52482.6	SS	6	276.7																				
FILL	F-TNK-B16	76738.1	52482.6	SS	10.5	272.2																				
FILL	F-TNK-B16	76738.1	52482.6	SS	18	264.7																				
FILL	F-TNK-B16	76738.1	52482.6	ST	21	261.7	UU								3.44	0	9.4	6.88	2.52							
FILL	F-TNK-B16	76738.1	52482.6	SS	24.5	258.2																				
FILL	F-TNK-B16	76738.1	52482.6	SS	29	253.7																				
FILL	F-TNK-B16	76738.1	52482.6	ST	32	250.7																4	3.4	0.85	0.1	0.012	0.08
FILL	F-TNK-B16	76738.1	52482.6	SS	35.5	248.2																				
FILL	F-TNK-B16	76738.1	52482.6	SS	38.5	244.2																				
TR2A	F-TNK-B16	76738.1	52482.6	SS	44	238.7																				
FILL	F-TNK-B20	77200.7	52686.4	SS	7.5	259.3																				
FILL	F-TNK-B20	77200.7	52686.4	SS	12	254.8																				
FILL	F-TNK-B20	77200.7	52686.4	SS	16.5	250.3																				
FILL	F-TNK-B20	77200.7	52686.4	ST	21	245.8																2.6	3.8	1.46	0.07	0.007	2
FILL	F-TNK-B20	77200.7	52686.4	SS	23	243.8																				
FILL	F-TNK-B20	77200.7	52686.4	SS	29	237.8	CUw/PP		0	33.7	13.3	3.7	6.1	4.2	0	26.5	15.2	9.5	5.70							
FILL	F-TNK-B20	77200.7	52686.4	SS	29	237.8	CUw/PP				5.3	1.4	5.7	4.3			6.7	3.8	2.90							
FILL	F-TNK-B20	77200.7	52686.4	SS	31	235.8																				
FILL	F-TNK-B20	77200.7	52686.4	SS	35.5	231.3																				
FILL	F-TNK-B20	77200.7	52686.4	SS	40	226.8																				
TR2A	F-TNK-B20	77200.7	52686.4	SS	44.5	222.3																				
TR1	FB-1	79812.34	54917.86	SS	16	274.55																				
TR1A	FB-1	79812.34	54917.86	SS	20	270.55																				
TR1A	FB-1	79812.34	54917.86	SS	25	265.55																				
TR1A	FB-1	79812.34	54917.86	SS	28	262.55																				
TR1A	FB-1	79812.34	54917.86	SS	31	259.55																				
TR1A	FB-1	79812.34	54917.86	SS	32	258.55																				
TR1A	FB-1	79812.34	54917.86	SS	34	256.55																				
TR2A	FB-1	79812.34	54917.86	SS	41	249.55																				
TR2A	FB-1	79812.34	54917.86	SS	46	244.55																				
TR2A	FB-1	79812.34	54917.86	SS	52	238.55																				
TR2A	FB-1	79812.34	54917.86	SS	56	234.55																				
TR2A	FB-1	79812.34	54917.86	SS	58	232.55																				
TR2B	FB-1	79812.34	54917.86	SS	64	226.55																				

Table E-2 Summary of Laboratory Test Results (cont'd)

PROJECT: F-Area / F-Canyon

Layer	Borehole	North	East	Type	Depth (feet)	Elev. (feet)	Test Type	qu (ksf)	C' (tx) (ksf)	Phi' (tx)	s1' (tx) (ksf)	s3' (tx) (ksf)	Pore Pressure (tx) (ksf)	Back Pressure (tx) (ksf)	C (tx) (ksf)	Phi (tx)	s1 (tx) (ksf)	Deviator (tx) (ksf)	s3 (tx) (ksf)	FStm (tx) (%)	Po (ksf)	Pc (ksf)	OCR	Cc	Cr	Cv
TR2B	FB-1	79812.34	54917.86	SS	68	222.55																				
TR2B	FB-1	79812.34	54917.86	SS	71	219.55																				
TR2B	FB-1	79812.34	54917.86	SS	77	213.55																				
TR2B	FB-1	79812.34	54917.86	SS	83	207.55																				
TR3/TR4	FB-1	79812.34	54917.86	SS	86	204.55																				
DB1/DB3	FB-1	79812.34	54917.86	SS	88	202.55																				
DB1/DB3	FB-1	79812.34	54917.86	SS	91	199.55																				
DB1/DB3	FB-1	79812.34	54917.86	SS	95	195.55																				
DB1/DB3	FB-1	79812.34	54917.86	SS	100	190.55																				
DB1/DB3	FB-1	79812.34	54917.86	SS	103	187.55																				
DB1/DB3	FB-1	79812.34	54917.86	SS	106	184.55																				
DB4/DB5	FB-1	79812.34	54917.86	SS	112	178.55																				
DB4/DB5	FB-1	79812.34	54917.86	SS	113	177.55																				
ST	FB-1	79812.34	54917.86	SS	119	171.55																				
ST	FB-1	79812.34	54917.86	SS	125	165.55																				
ST	FB-1	79812.34	54917.86	SS	127	163.55																				
ST	FB-1	79812.34	54917.86	SS	128	162.55																				
ST	FB-1	79812.34	54917.86	SS	134	156.55																				
ST	FB-1	79812.34	54917.86	SS	136	154.55																				
ST	FB-1	79812.34	54917.86	SS	140	150.55																				
ST	FB-1	79812.34	54917.86	SS	143	147.55																				
GC	FB-1	79812.34	54917.86	SS	145	145.55																				
GC	FB-1	79812.34	54917.86	SS	151	139.55																				
TR1	FB-2	79101.5	54920.0	ST	7	285.18	CD		0	36.5	2.02	0.5		4.32												
TR1	FB-2	79101.5	54920.0	ST	7	285.18	CD				7.85	2		4.32												
TR1	FB-2	79101.5	54920.0	ST	13	279.18	UU							0	1.10		3.75	2.19	1.56		1.6	8	5.13	0.08	0.005	0.6
TR1	FB-2	79101.5	54920.0	ST	15	277.18	CUw/PP		0.05	34.7	13.78	3.75	0.14	2.89	1.81	15.5	11.03	10.03	1.0							
TR1	FB-2	79101.5	54920.0	ST	15	277.18	CUw/PP				8.23	2.24	2.64	2.88			7.99	5.99	2.0							
TR1	FB-2	79101.5	54920.0	ST	15	277.18	CUw/PP				10.47	2.75	4.13	2.88			11.72	7.72	4.0							
TR1A	FB-2	79101.5	54920.0	ST	25	267.18	CUw/PP		0	34.1	10.11	2.83	2.12	2.95	1.04	29	9.28	7.27	2.0							
TR1A	FB-2	79101.5	54920.0	ST	25	267.18	CUw/PP				15.35	4.32	2.53	2.85			15.03	11.03	4.0							
TR1A	FB-2	79101.5	54920.0	ST	27	265.18	UU							0	3.41		10.05	6.81	3.24		3.2	4.2	1.30	0.09	0.015	0.25
TR1A	FB-2	79101.5	54920.0	ST	29	263.18	CD		0.7	26	5.02	1		2.88												
TR1A	FB-2	79101.5	54920.0	ST	29	263.18	CD				7.04	2		3.6												
TR1A	FB-2	79101.5	54920.0	ST	29	263.18	CD				12.58	4		2.88												
TR2A	FB-2	79101.5	54920.0	ST	50	242.18																				
TR2A	FB-2	79101.5	54920.0	ST	60	232.18															7.2			0.03	0.0038	0.3
TR2B	FB-2	79101.5	54920.0	ST	75	217.18																				
TR3/TR4	FB-2	79101.5	54920.0	ST	83	209.18															9.5	12	1.27	0.22	0.019	0.5
DB1/DB3	FB-2	79101.5	54920.0	ST	100	192.18																				
ST	FB-2	79101.5	54920.0	ST	120	172.18																				
GC	FB-2	79101.5	54920.0	ST	147	145.18															13.3	4.7	0.35	0.11	0.019	0.4

Table E-3 Statically Summary of Laboratory Test Results

Description	Fill					TR1				
	MIN	AVG	MAX	COUNT	STDEV	MIN	AVG	MAX	COUNT	STDEV
SPT N-value	6	23	49	74	11	2	25	81	353	13
SPT N-value (corrected for overburden)	5	21	46	74	9	3	33	216	342	22
Shear wave velocity (ft/sec)	660	978	1380	107	136	640	1455	1970	107	285
Corrected tip resistance (tsf)	0	112	444	4742	84	2	91	286	5792	51
Friction ratio	0	2	247	4742	4	0	4	22	5792	2
Qc / N (uncorrected)	-	4.9	-	-	-	-	3.7	-	-	-
Percent fines	12.3	26.1	46.9	30	8.5	2.6	33.0	73.0	97	12.0
Percent clay	13.1	21.0	28.4	8	5.9	0.7	18.3	29.9	6	9.9
Mean grain size, D50 (mm)	0.10	0.22	0.56	30	0.09	0.11	0.23	0.42	11	0.09
Plasticity index, PI	6	15	24	21	5.4	2	17	39	76	7.2
Liquid limit, LL	23	32	42	21	5.1	20	38	61	76	9.0
Dry density (pcf)	91.1	104.0	112.6	9	6.4	91.8	106.1	115.0	42	5.9
Water content, w (%)	8.2	13.1	17.1	35	2.2	2.5	15.5	28.7	126	4.4
Wet density (pcf)	105.3	117.0	128.3	9	7.4	94.7	122.4	133.5	41	8.5
Specific gravity	2.63	2.71	2.75	10	0.03	2.57	2.67	2.79	18	0.05
Void ratio, Eo	0.50	0.64	0.96	9	0.14	0.31	0.57	0.86	32	0.11
At-rest lat. earth press. coefficient, Ko (NC)	-	0.47	-	-	-	-	0.44	-	-	-
At-rest lat. earth press. coefficient, Ko (OC)	-	0.49	-	-	-	-	1.04	-	-	-
Overconsolidation ratio, OCR	0.8	1.1	1.5	4	-	2.5	4.6	10.0	6	-
Compression index, Cc	0.07	0.083	0.1	4	-	0.08	0.117	0.148	6	-
Re-compression index, Cr	0.005	0.009	0.01	4	-	0.005	0.011	0.02	3	-
Consolidation coefficient, Cv	0.08	1.2	2.2	4	-	0.6	0.6	0.6	1	-
Total cohesion, C (ksf)	-	-	-	-	-	-	-	-	-	-
Total friction angle, ϕ	-	-	-	-	-	-	-	-	-	-
Effective cohesion , C' (ksf)	-	0	-	-	-	-	0	-	-	-
Effective friction angle, ϕ'	-	32	-	-	-	-	34	-	-	-

Table E-3 Statically Summary of Laboratory Test Results (cont'd)

Description	TR1A					TR2A				
	MIN	AVG	MAX	COUNT	STDEV	MIN	AVG	MAX	COUNT	STDEV
SPT N-value	10	25	56	98	9	10	28	90	447	10
SPT N-value (corrected for overburden)	6	19	54	98	8	6	19	65	447	8
Shear wave velocity (ft/sec)	1000	1348	1810	148	184	910	1256	1750	271	134
Corrected tip resistance (tsf)	21	120	332	5157	63	1	147	379	9786	54
Friction ratio	0	2	8	5157	2	0	2	69	9786	1
Qc / N (uncorrected)	-	4.8	-	-	-	-	5.2	-	-	-
Percent fines	12.0	29.7	71.3	58	12.7	5.9	16.5	41.0	49	7.1
Percent clay	19.0	32.5	57.0	3	21.3	4.5	10.1	16.5	7	3.9
Mean grain size, D50 (mm)	0.09	0.12	0.15	7	0.02	0.16	0.27	0.62	25	0.11
Plasticity index, PI	0	14	54	37	10.3	1	10	20	20	5.2
Liquid limit, LL	22	36	82	37	11.7	27	33	41	20	4.1
Dry density (pcf)	91.4	95.9	100.7	16	3.0	90.2	101.4	117.1	7	9.0
Water content, w (%)	9.8	18.6	48.0	54	6.3	8.5	16.7	32.0	45	5.3
Wet density (pcf)	100.6	113.9	121.3	16	6.4	112.8	121.9	137.7	7	8.0
Specific gravity	2.59	2.67	2.74	12	0.04	2.65	2.69	2.73	6	0.03
Void ratio, Eo	0.68	0.75	0.83	15	0.05	0.52	0.68	0.83	5	0.11
At-rest lat. earth press. coefficient, Ko (NC)	-	0.47	-	-	-	-	0.47	-	-	-
At-rest lat. earth press. coefficient, Ko (OC)	-	0.60	-	-	-	-	0.44	-	-	-
Overconsolidation ratio, OCR	0.5	1.6	2.7	8	-	0.9	0.9	0.9	1	-
Compression index, Cc	0.046	0.082	0.123	12	-	0.03	0.072	0.11	4	-
Re-compression index, Cr	0.005	0.009	0.02	3	-	0.0038	0.0114	0.02	2	-
Consolidation coefficient, Cv	0.25	0.3	0.25	1	-	0.3	0.3	0.3	1	-
Total cohesion, C (ksf)	-	-	-	-	-	-	-	-	-	-
Total friction angle, ϕ	-	-	-	-	-	-	-	-	-	-
Effective cohesion, C' (ksf)	-	0	-	-	-	-	0	-	-	-
Effective friction angle, ϕ'	-	32	-	-	-	-	32	-	-	-

Table E-3 Statically Summary of Laboratory Test Results (cont'd)

Description	TR2B					TR3/TR4				
	MIN	AVG	MAX	COUNT	STDEV	MIN	AVG	MAX	COUNT	STDEV
SPT N-value	8	36	161	287	20	4	18	41	107	7
SPT N-value (corrected for overburden)	4	19	81	287	10	2	8	18	107	3
Shear wave velocity (ft/sec)	780	1254	1860	213	181	730	1074	1490	112	203
Corrected tip resistance (tsf)	2	201	464	7950	78	13	65	285	3936	45
Friction ratic	0	1	8	7950	1	0	2	7	3936	1
Qc / N (uncorrected)	-	5.5	-	-	-	-	3.1	-	-	-
Percent fines	2.0	18.8	98.0	28	23.1	8.0	63.6	98.0	30	25.9
Percent clay	2.1	8.3	13.9	3	5.9	21.6	39.6	73.7	4	23.6
Mean grain size, D50 (mm)	0.19	0.36	0.59	12	0.14	-	-	-	-	-
Plasticity index, PI	1	18	47	14	13.7	4	58	124	43	26.7
Liquid limit, LL	27	41	85	14	15.7	27	96	162	43	33.8
Dry density (pcf)	91.8	98.5	110.1	4	8.1	60.7	75.9	95.8	12	12.2
Water content, w (%)	3.4	22.3	38.8	24	6.3	22.6	50.8	95.0	58	19.8
Wet density (pcf)	116.0	122.8	137.5	4	10.0	99.8	107.7	117.5	12	5.4
Specific gravity	2.65	2.73	2.83	3	0.09	2.62	2.69	2.76	12	0.04
Void ratio, Eo	0.79	0.80	0.80	2	0.01	0.75	1.37	2.87	16	0.56
At-rest lat. earth press. coefficient, Ko (NC)	-	0.48	-	-	-	-	0.50	-	-	-
At-rest lat. earth press. coefficient, Ko (OC)	-	0.52	-	-	-	-	0.63	-	-	-
Overconsolidation ratio, OCR	1.2	1.2	1.2	1	-	0.9	1.6	2.0	13	-
Compression index, Cc	0.041	0.050	0.058	2	-	0.22	0.85	1.93	13	-
Re-compression index, Cr	-	-	-	0	-	0.019	0.14	0.44	10	-
Consolidation coefficient, Cv	-	-	-	0	-	0.4	0.5	0.5	2	-
Total cohesion, C (ksf)	-	-	-	-	-	-	0.75	-	-	-
Total friction angle, ϕ	-	-	-	-	-	-	13	-	-	-
Effective cohesion, C' (ksf)	-	0	-	-	-	-	0	-	-	-
Effective friction angle, ϕ'	-	31	-	-	-	-	30	-	-	-

Table E-3 Statically Summary of Laboratory Test Results (cont'd)

Description	DB1/DB3					DB4/DB5				
	MIN	AVG	MAX	COUNT	STDEV	MIN	AVG	MAX	COUNT	STDEV
SPT N-value	5	33	106	336	19	0	15	39	72	8
SPT N-value (corrected for overburden)	2	14	43	336	8	0	6	15	72	3
Shear wave velocity (ft/sec)	600	1157	1620	266	194	600	1140	1620	74	248
Corrected tip resistance (tsf)	3	172	506	10069	95	1	61	353	3060	62
Friction ratio	0	1	9	10069	1	0	2	23	3060	2
Qc / N (uncorrected)	-	5.1	-	-	-	-	4.1	-	-	-
Percent fines	4.0	14.2	45.0	43	8.3	9.0	21.8	43.0	8	11.3
Percent clay	2.1	12.1	22.6	5	8.3	10.6	20.1	34.5	3	12.7
Mean grain size, D50 (mm)	0.22	0.34	0.57	17	0.09	0.12	0.29	0.50	6	0.15
Plasticity index, PI	3	19	73	13	18.8	12	28	37	4	11.1
Liquid limit, LL	27	44	135	13	28.8	36	48	55	4	8.4
Dry density (pcf)	91.4	99.2	113.3	7	7.4	75.0	85.6	103.9	3	16.0
Water content, w (%)	17.1	26.7	66.0	40	7.7	22.7	38.7	58.3	9	10.8
Wet density (pcf)	117.4	123.9	134.3	7	5.5	108.6	118.3	131.2	3	11.6
Specific gravity	2.60	2.68	2.74	6	0.05	2.70	2.71	2.72	2	0.01
Void ratio, Eo	0.49	0.76	1.02	7	0.17	0.65	1.06	1.27	5	0.25
At-rest lat. earth press. coefficient, Ko (NC)	-	0.44	-	-	-	-	0.56	-	-	-
At-rest lat. earth press. coefficient, Ko (OC)	-	0.52	-	-	-	-	0.55	-	-	-
Overconsolidation ratio, OCR	0.3	1.3	2.8	6	-	0.8	1.0	1.3	4	-
Compression index, Cc	0.04	0.268	1.2	7	-	0.15	0.55	1.24	4	-
Re-compression index, Cr	0.017	0.109	0.28	3	-	0.0083	0.05	0.09	4	-
Consolidation coefficient, Cv	-	-	-	0	-	0.32	0.6	0.85	2	-
Total cohesion, C (ksf)	-	0	-	-	-	-	0	-	-	-
Total friction angle, ϕ	-	17	-	-	-	-	17	-	-	-
Effective cohesion, C' (ksf)	-	0	-	-	-	-	0	-	-	-
Effective friction angle, ϕ'	-	34	-	-	-	-	26	-	-	-

Table E-3 Statically Summary of Laboratory Test Results (cont'd)

Description	ST					GC				
	MIN	AVG	MAX	COUNT	STDEV	MIN	AVG	MAX	COUNT	STDEV
SPT N-value	0	47	175	434	31	3	21	59	31	13
SPT N-value (corrected for overburden)	0	17	70	434	11	1	7	19	31	4
Shear wave velocity (ft/sec)	520	1353	3000	176	392	920	1675	4450	18	1108
Corrected tip resistance (tsf)	0	131	660	6841	106	5	58	215	810	26
Friction ratio	0	2	19	6841	2	0	2	7	810	1
Qc / N (uncorrected)	-	2.8	-	-	-	-	2.7	-	-	-
Percent fines	6.0	29.0	70.7	51	15.4	13.4	38.7	61.0	4	19.7
Percent clay	8.8	23.9	48.0	12	12.9	2.8	2.8	2.8	1	-
Mean grain size, D50 (mm)	0.01	0.22	1.86	30	0.32	0.09	0.11	0.12	3	0.02
Plasticity index, PI	5	18	42	34	9.4	29	47	67	3	19.1
Liquid limit, LL	21	40	64	34	12.9	58	83	99	3	22.1
Dry density (pcf)	81.5	86.9	95.7	6	5.2	91.5	91.5	91.5	1	-
Water content, w (%)	15.0	28.9	44.5	51	7.3	26.4	32.2	39.9	4	6.7
Wet density (pcf)	107.9	115.6	120.5	6	4.3	121.1	121.1	121.1	1	-
Specific gravity	2.60	2.69	2.80	12	0.05	2.61	2.61	2.61	1	-
Void ratio, Eo	0.72	0.97	1.30	10	0.18	0.75	0.82	0.90	2	0.10
At-rest lat. earth press. coefficient, Ko (NC)	-	0.48	-	-	-	-	0.53	-	-	-
At-rest lat. earth press. coefficient, Ko (OC)	-	0.53	-	-	-	-	0.48	-	-	-
Overconsolidation ratio, OCR	0.3	1.2	2.9	8	-	0.4	0.8	1.2	2	-
Compression index, Cc	0.19	0.31	0.48	8	-	0.11	0.31	0.5	2	-
Re-compression index, Cr	0.02	0.04	0.09	7	-	0.019	0.035	0.05	2	-
Consolidation coefficient, Cv	0.35	1.0	1.6	2	-	0.4	0.4	0.4	1	-
Total cohesion, C (ksf)	-	-	-	-	-	-	-	-	-	-
Total friction angle, ϕ	-	-	-	-	-	-	-	-	-	-
Effective cohesion , C' (ksf)	-	0	-	-	-	-	0	-	-	-
Effective friction angle, ϕ'	-	31	-	-	-	-	28	-	-	-

Table E-4 Summary of Consolidation Parameters

Sample Identification				Classification Properties																	
				USCS	Gradation				Atterberg Limits				Water	Dry	Initial Void	Eff. Over-	Eff. Precon.	Over-consol	Comp-	Recomp-	Coeff. of Cons
Layer	Borehole	Elev ft	Depth ft	Group Symbol	Sand %	Fines %	Silt %	Clay %	LL %	PL %	PI %	SG	Cont. %	Dens. pcf	Ratio	burden ksf	Stress ksf	Ratio OCR	Index Cv	Index Cr	Cv ft^2/day
FILL	F-TNK-B3	258.0	27.5	SC	85.2	14.8			29	20	9		14	108.1	0.54	3.4	4	1.18	0.07	0.005	0.42
FILL	F-TNK-B13	251.6	27.5	SM	79	21			NP	NP	NP	2.68	14	91.1	0.96	3.4	2.7	0.79	0.09	0.012	2.2
FILL	F-TNK-B16	250.7	32.0	SC	67.5	32.5			27	14	13	2.63	13	107.6	0.53	4	3.4	0.85	0.1	0.012	0.08
FILL	F-TNK-B20	245.8	21.0	SC	83.6	16.4	3.3	13.1	27	19	8	2.7	12	102.9	0.67	2.6	3.8	1.46	0.07	0.007	2
TR1	FU-3	310.1	8.3	CH	27	73			55	29	26	2.79	21	98.8	0.76	1	3.4	3.4	0.1		
TR1	FU-1	298.0	10.0	SC	69	31			37	20	17	2.69	12		0.51	1.2	3	2.5	0.097		
TR1	FU-1	287.9	20.1	SC	68	32			48	24	24	2.57	15	97.6	0.73	2.42	6.2	2.6	0.148		
TR1	F-52	285.6	10.0	SC	61	38			44	21	23		18			1.1	11	10	0.14	0.011	
TR1	FB-2	279.2	13.0	SC	76.5	23.5	1.6	21.9	35	16	19	2.72	16	112.75	0.51	1.6	8	5.10	0.08	0.005	0.6
TR1	200F-B-10U	268.2	11.0	CL					42	19	23	2.65	19		0.58	1.4	5.8	4.14	0.139	0.017	
TR1A	FU-3	285.3	33.1	SC	64	36			48	29	19		20	98.5	0.72	4	5	1.3	0.096		
TR1A	F-55	276.3	15.0	SC	59	41			54	24	30		18			1.8	4.8	2.7	0.056	0.005	
TR1A	FU-2	275.1	35.0	SC	87	13			30	23	7	2.74	10	91.6	0.81	4.26			0.053		
TR1A	FU-1	274.0	34.0	SC	80	20			32	22	10	2.59	15	96.6	0.72	4.1	9.4	2.3	0.055		
TR1A	FU-1	269.9	38.1	SC	77	23			27	19	8	2.63	13	98.2	0.68	4.44	9	2.0	0.113		
TR1A	FU-3	269.2	49.2	SC	87	13			32	19	13	2.67	11	95.2	0.75	5.84	6	1.0	0.085		
TR1A	FU-1	267.0	41.0	SC	68	32			49	21	28	2.66	21	96.2	0.73	4.86			0.102		
TR1A	FU-1	267.0	41.0	SM	80	20			NP	NP	NP	2.68	13	91.4	0.83	4.86			0.064		
TR1A	F-55	266.3	25.0	SM	81	19			NP	NP	NP					3	1.5	0.5	0.046	0.007	
TR1A	FB-2	265.2	27.0	SM	69.1	30.9	11.9	19	30	23	7	2.68	20	97.1	0.72	3.2	4.2	1.30	0.09	0.015	0.25
TR1A	FU-2	260.1	50.0	SM	82	18			28	27	1	2.67	22	99.4	0.68	5.96	10.4	1.7	0.095		
TR1A	FU-1	254.7	53.3	SC	70	30			34	24	10	2.68	25	93.6	0.79	6.16			0.123		
TR2A	200F-B-25	257.5	53.0		78	22			NP	NP	NP	2.66	13	109	0.52	5.6	5	0.89	0.11	0.019	
TR2A	FU-2	240.1	70.0	SM	62	38			30	25	5	2.7	22	98.4	0.71	8.36			0.074		
TR2A	FU-1	233.0	75.0	SM	84	16			27	24	3	2.71	25	90.2	0.83	8.52			0.074		
TR2A	FB-2	232.2	60.0	SP-SC	93.9	6.1	1.6	4.5	30	20	10	2.65	19	101.4	0.69	7.2			0.03	0.0038	0.3
TR2B	FU-3	220.2	98.2	SM	88	12			27	26	1	2.65	26	91.8	0.80	9.76			0.058		
TR2B	FU-1	211.0	97.0	SP	98	2			NP	NP	NP	2.83	23	94.8	0.79	10.3	12	1.2	0.041		
TR3/TR4	200F-B-25	215.5	95.0		36	64			64	30	34		46	71.6		10	15.5	1.55	0.71	0.046	
TR3/TR4	200F-B-10U	211.2	68.0	MH					95	69	26	2.71	69		1.56	8.2	14.6	1.78	0.72	0.065	
TR3/TR4	FU-3	209.4	109.0	CH	8	92			89	40	49	2.69	43	76.4	1.20	10.3	20.2	2.0	0.69		
TR3/TR4	FB-2	209.2	83.0	SC	66.5	33.5	7.1	26.4	59	19	40	2.73	24	91.85	0.76	9.5	12	1.27	0.22	0.019	0.5
TR3/TR4	200F-B-14U	208.3	63.0	MH					80	53	27	2.7	42		1.21	7.4	15	2.03	0.55	0.13	
TR3/TR4	200F-B-10U	208.2	71.0	MH					138	109	29	2.76	87		2.87	8.4	13.4	1.60	1.8	0.312	
TR3/TR4	200F-B-12U	207.4	66.0	MH					148	66	82	2.65	71		2.08	8.4	12.2	1.45	1.2	0.032	
TR3/TR4	200F-B-14U	204.3	67.0	SC					27	23	4	2.69	28		0.81	7.6	14	1.84	0.24	0.03	
TR3/TR4	FU-1	202.0	106.0	CH	2	98			140	56	84	2.62	64	60.7	1.59	10.7	14.4	1.3	1.12		
TR3/TR4	F-SEP-B6	200.0	84.0	SC	50.2	49.8	13.2	36.6	58	22	36	2.7	40	80.3	1.20	9.6	15	1.6	0.53	0.092	0.4
TR3/TR4	FU-1	197.8	110.2	CH	59	41			108	30	78	2.65	41	75.9	1.17	10.84	10	0.9	0.56		
TR3/TR4	241-55F-1U	195.9	96.0	CH					116	41	75		47		0.81	10.2	19	1.86	0.74	0.21	
TR3/TR4	241-55F-4U	195.5	95.6	MH									94		1.43	10.2	17.4	1.71	1.93	0.44	
DB1/DB3	FU-3	200.4	118.0	SM	82	18			29	23	6	2.74	23	97.6	0.75	10.8	3	0.3	0.046		
DB1/DB3	200F-B-12U	187.4	86.0	SM-SC					36	28	8	2.68	29		0.85	8.8	18	2.05	0.19	0.017	
DB1/DB3	241-14F-5U	186.7	100.0	SC					135	62	73		66		1.02	10	28	2.80	1.2	0.28	
DB1/DB3	FU-2	181.0	129.1	SC	80	20			33	20	13	2.65	24	100.7	0.65	12.88			0.061		
DB1/DB3	FU-1	178.0	130.0	SC	96	4			41	20	21	2.71	21	100	0.69	11.72	12	1.0	0.04		
DB1/DB3	241-14F-5U	172.4	114.3	SP					65	24	41		27		0.49	10.8	10.8	1.00	0.22	0.03	
DB1/DB3	FU-1	158.0	150.0	SM	81	19			NP	NP	NP	2.6	28	91.4	0.78	13	11.6	0.9	0.122		
DB4/DB5	F-SEP-B13.1	192.0	110.0	SC	57	43	8.5	34.5	55	18	37	2.7	43	75.0	1.27	11.1	14.5	1.31	0.44	0.08	0.85
DB4/DB5	F-SEP-B8.1	183.0	118.0										23	103.9	0.65	11.6	9.5	0.82	0.15	0.0083	0.32
DB4/DB5	200F-B-12U	178.4	95.0	CH					52	19	33	2.72	36		1.03	9.6	9.4	0.98	0.35	0.035	
DB4/DB5	241-55F-4U	172.3	118.8	MH									58		1.19	11.8	9.2	0.78	1.24	0.09	
ST	200F-B-10U	151.2	128.0	CH					57	29	28	2.7	45		1.25	11.8	7.6	0.64	0.48	0.06	
ST	200F-B-12U	150.4	123.0	SM-SC					42	27	15	2.69	33		0.94	11.2	14.2	1.27	0.255	0.03	
ST	FU-1	147.1	160.9	CH	60	40			56	28	28	2.61	32	81.9	0.85	13.6	20.8	1.5	0.44		
ST	200F-B-12U	146.4	127.0	CL					43	23	20	2.69	30		0.83	11.6	13.8	1.19	0.25	0.025	
ST	200F-B-10U	146.2	133.0	CL					50	23	27	2.7	37		1.01	12.2	6.4	0.52	0.35	0.03	
ST	F-SEP-B13.1	139.0	163.0	CH	29.3	70.7	22.7	48	64	22	42		41	81.5	1.30	14.3	3.6	0.25	0.25	0.094	0.35
ST	200F-B-12U	137.4	136.0	CL					43	22	21	2.67	26		0.72	12.6	36	2.86	0.256	0.033	
ST	F-SEP-B6	136.0	148.0	SC	75.3	24.7	8.3	16.4	34	21	13	2.7	33	86.5	0.95	13.4	16	1.2	0.19	0.02	1.6
GC	FB-2	145.2	147.0	SM	86.6	13.4	10.6	2.8	NP	NP	NP	2.61	27	91.45	0.90	13.3	4.7	0.35	0.11	0.019	0.4
GC	F-103U	143.5	152.9	CH					58	29	29		36		0.75	14.6	18.2	1.25	0.5	0.05	

FIGURES

FIGURES

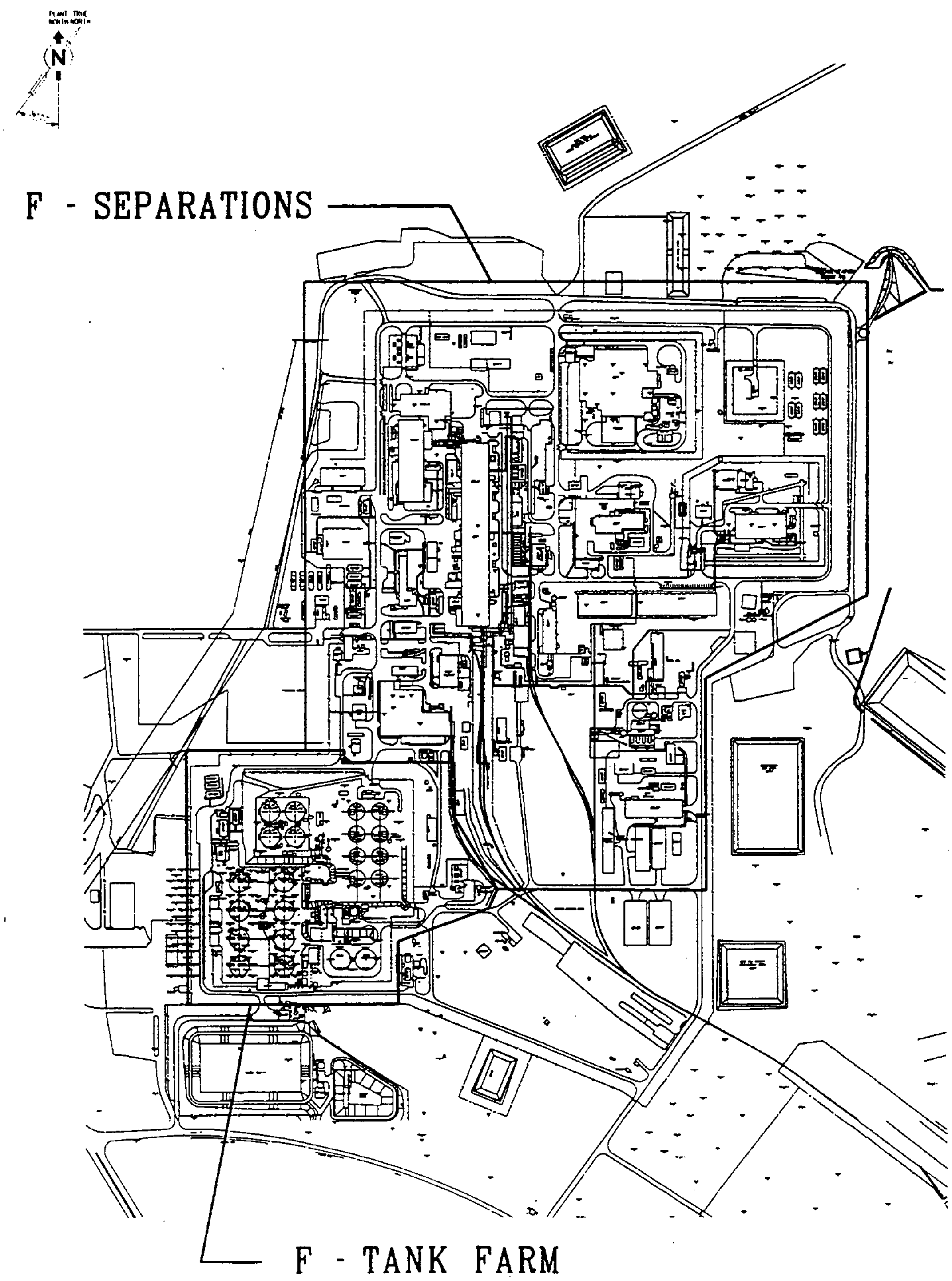


Figure 1.0-1 F-Area Map

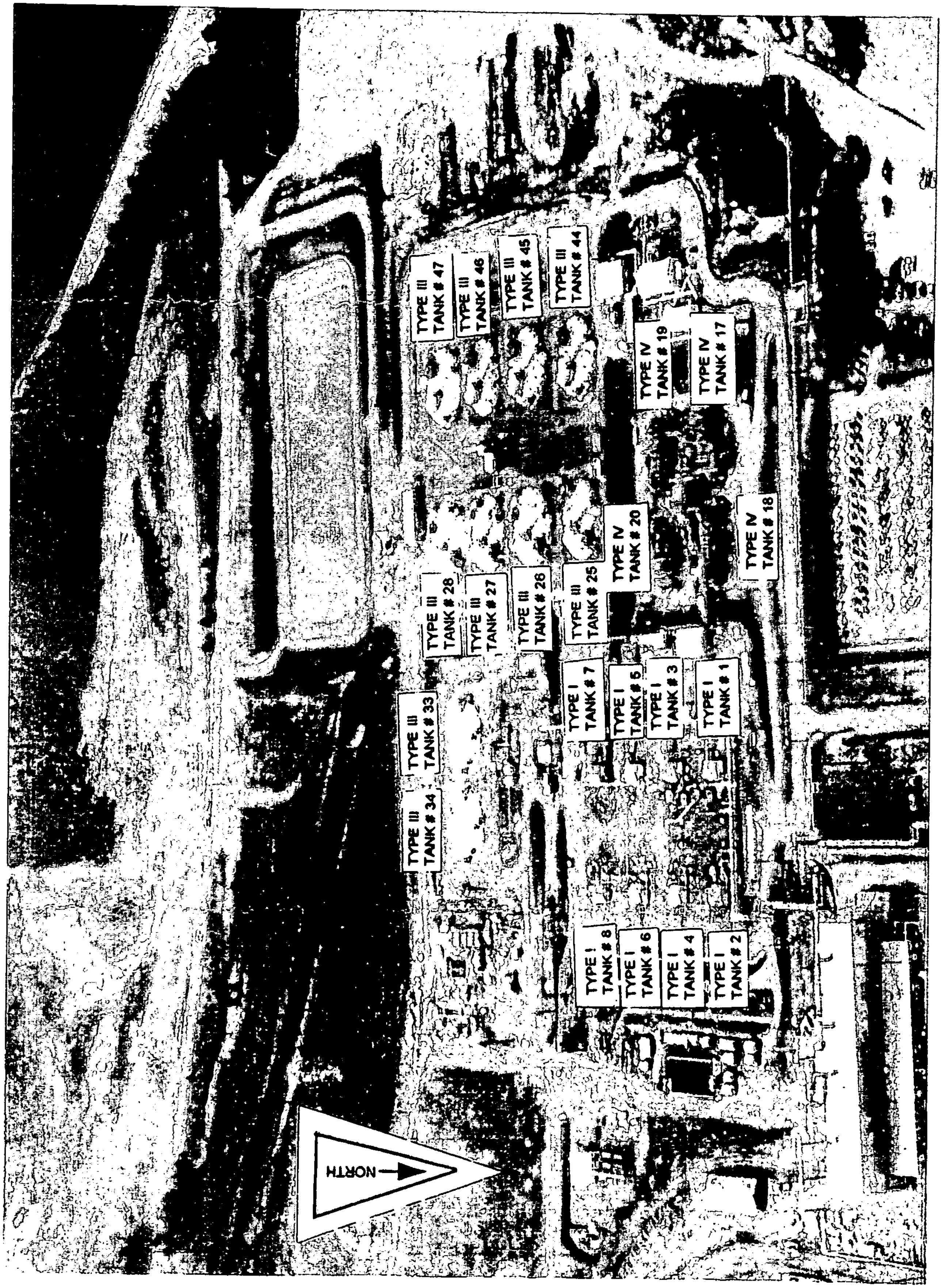


Figure 1.2-1 F-Tank Farm Aerial View

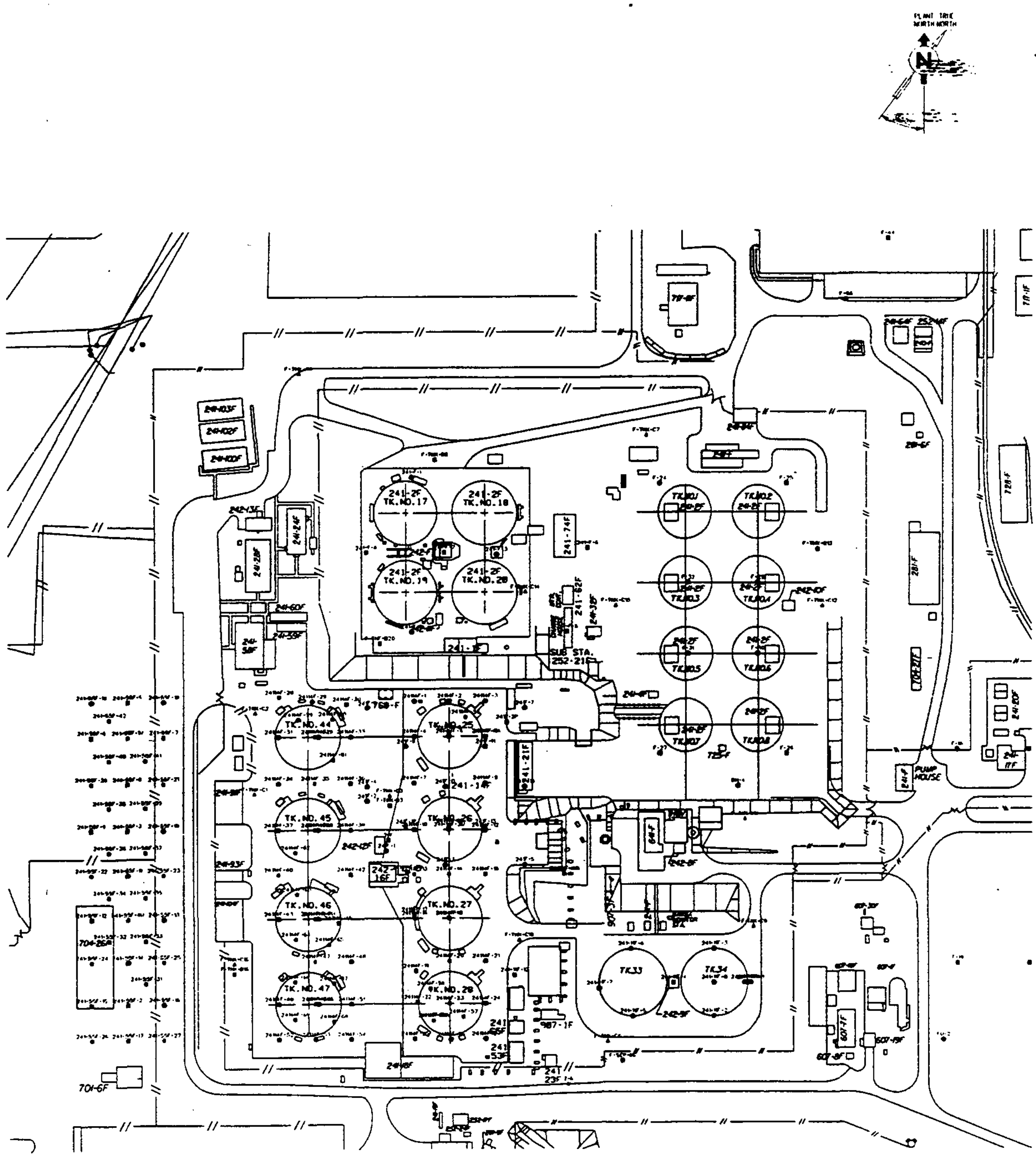


Figure 1.2-2 F-Tank Farm Layout

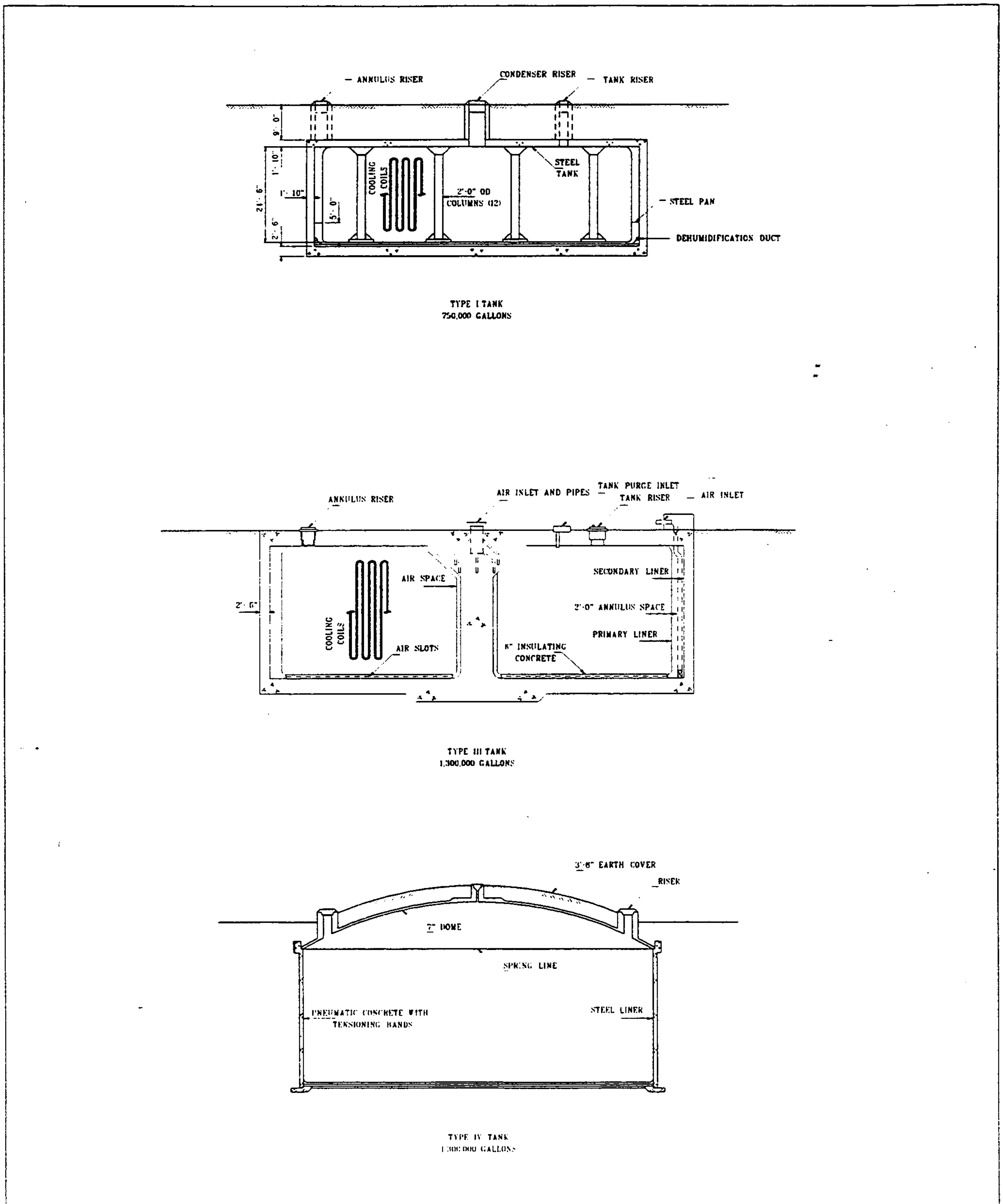


Figure 1.2-3 Tank Configurations

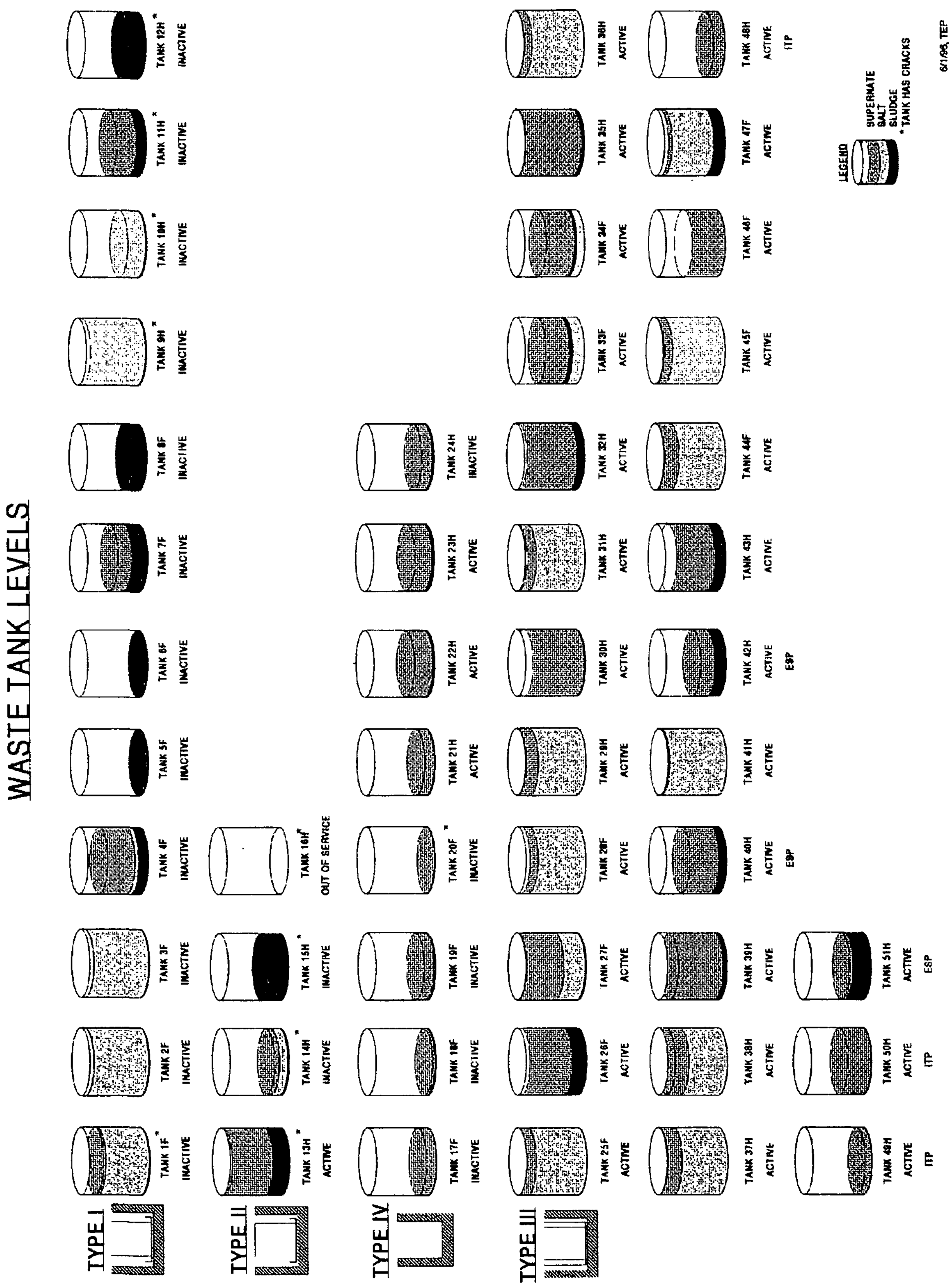


Figure 1.2-4 Disturibution of Waste in Tanks

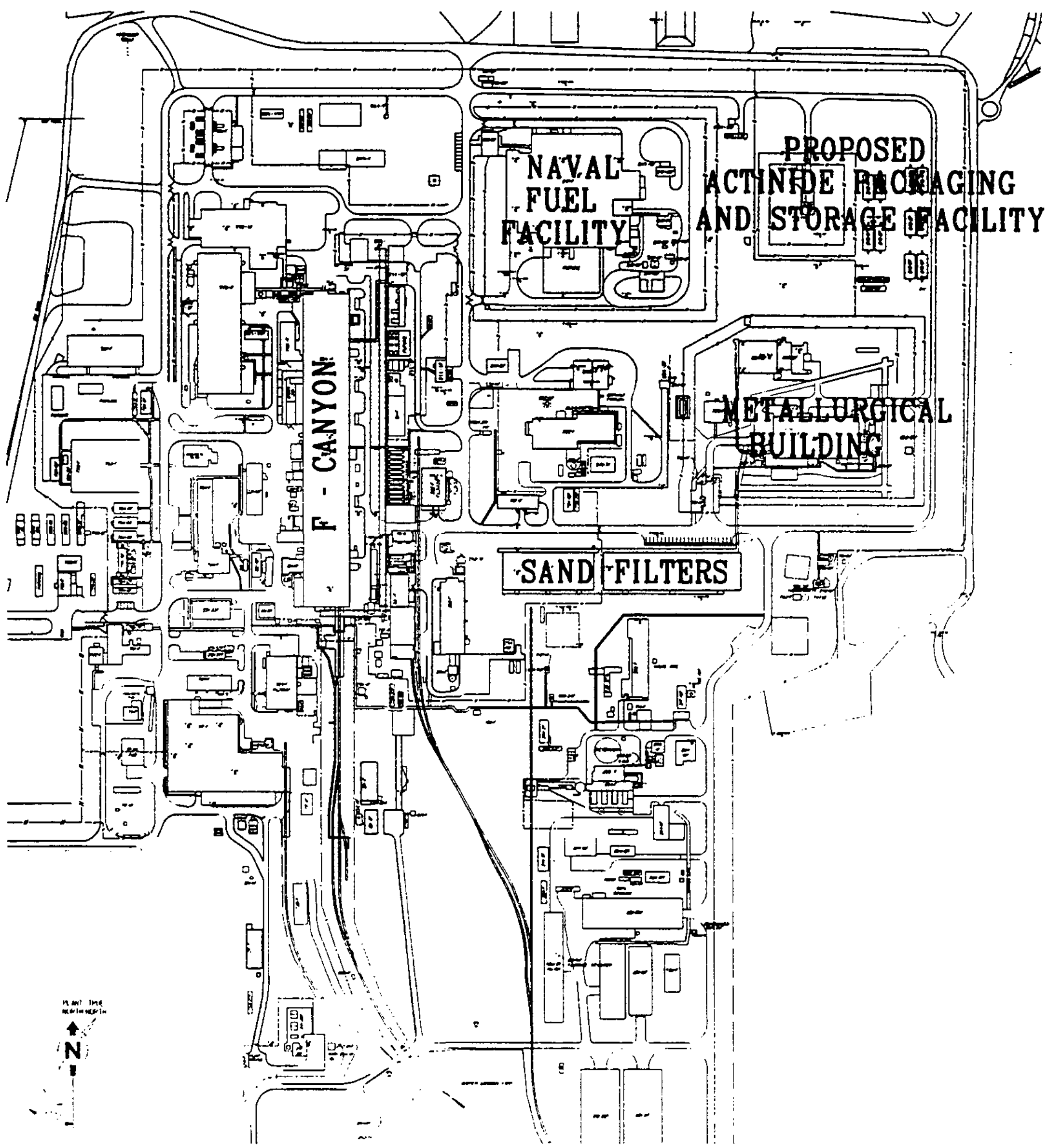


Figure 1.2-5 F-Separations Facility Layout

Figure 1.2-6 F-Canyon Aerial View

Figure 1.2-7 Naval Fuel Facility Aerial View

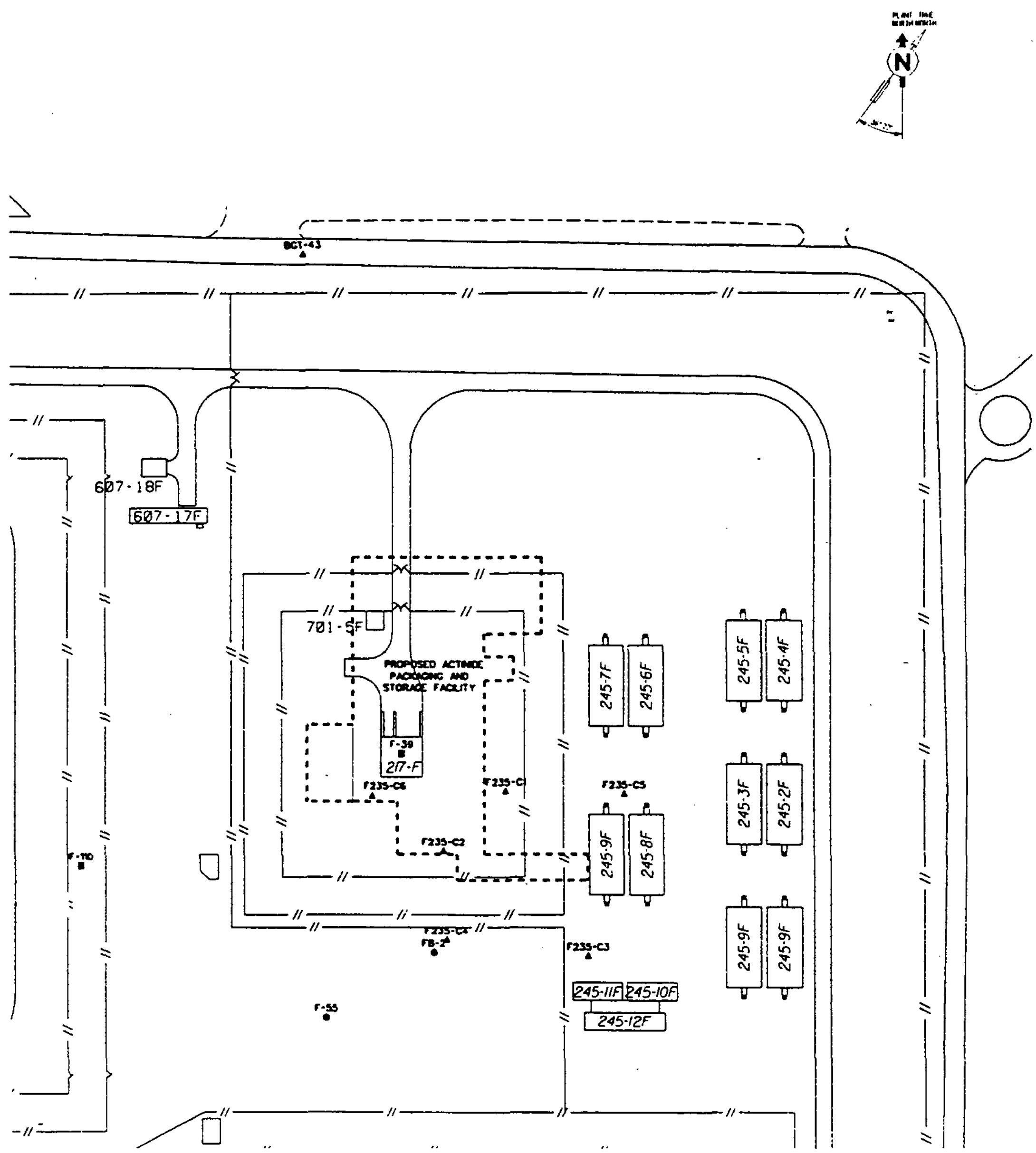


Figure 1.2-8 Site for Proposed Actinide Packaging and Storage Facility

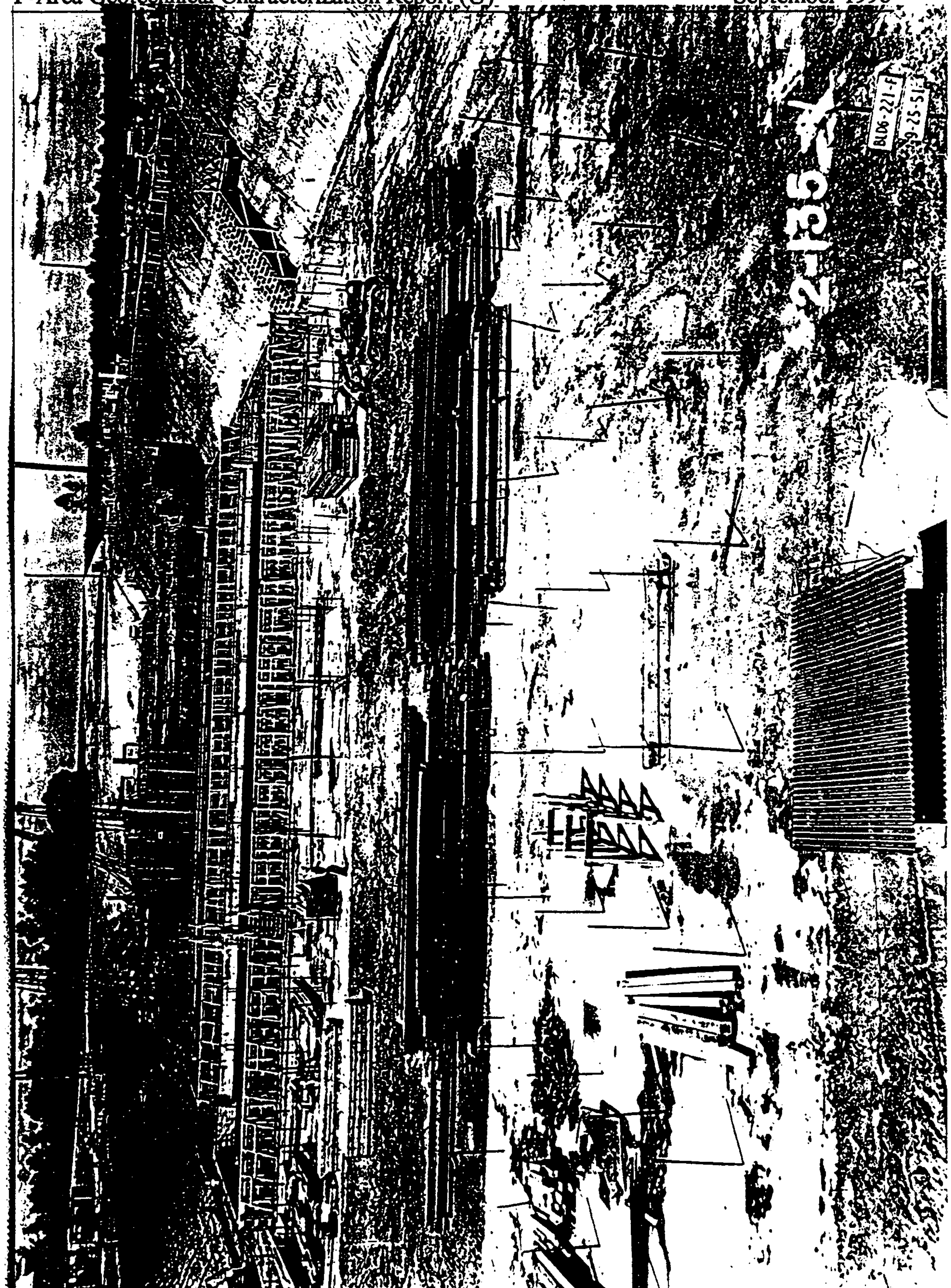


Figure 2.1-1 F-Canyon Foundation Excavation

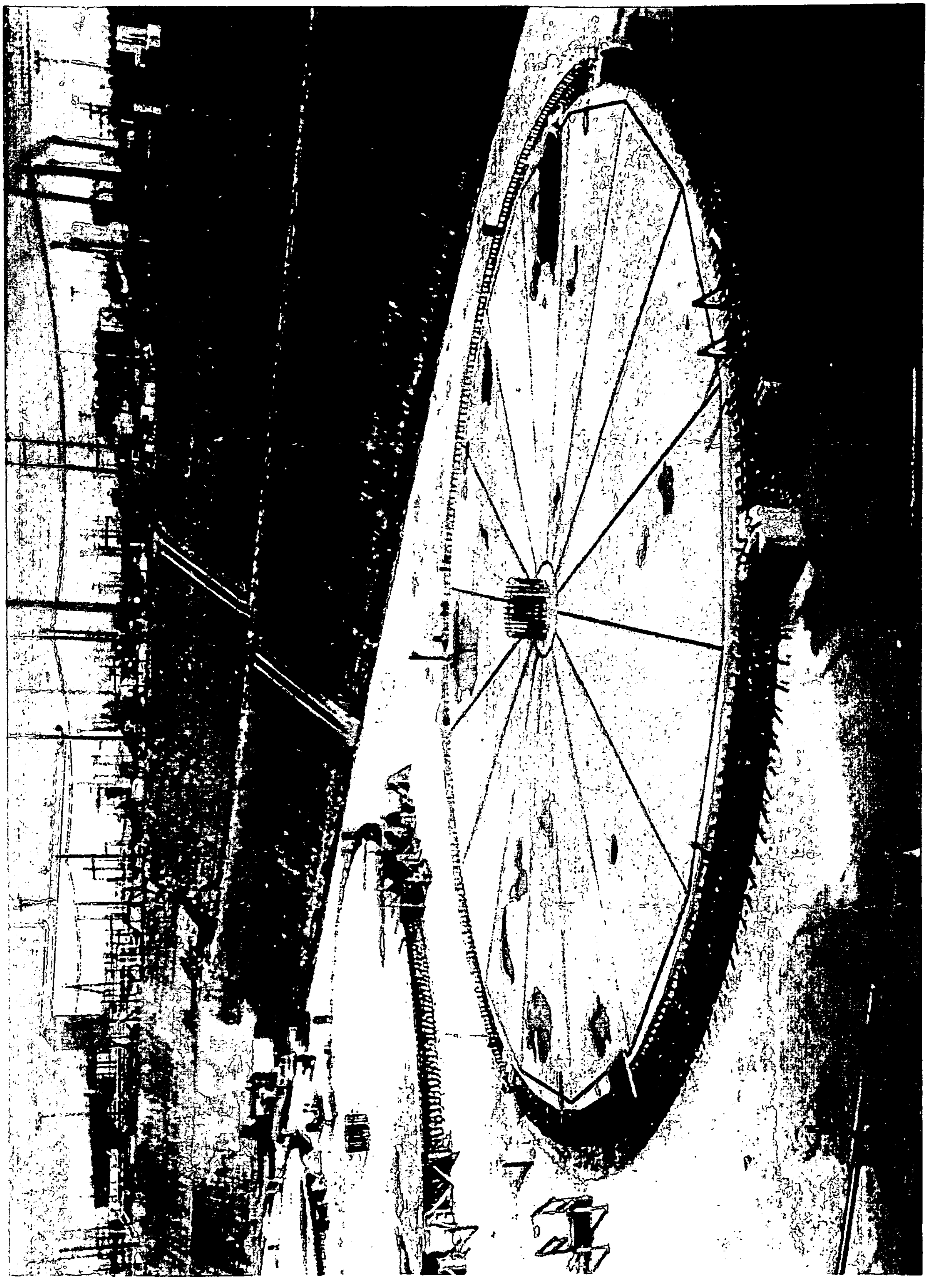


Figure 2.1-2 Tank Foundation Excavation

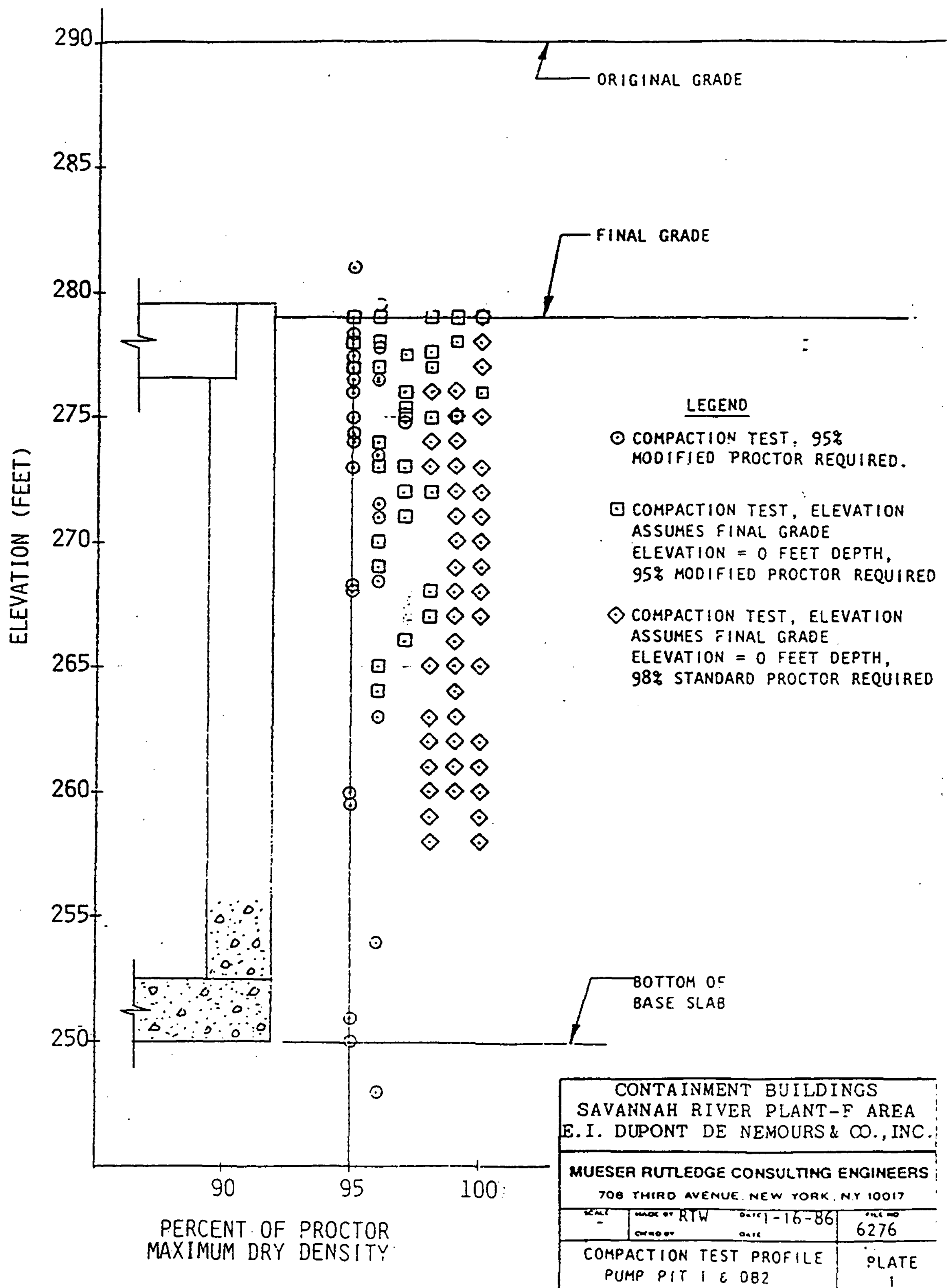


Figure 2.1-3 Compaction Test Profile for PP1 and DB2

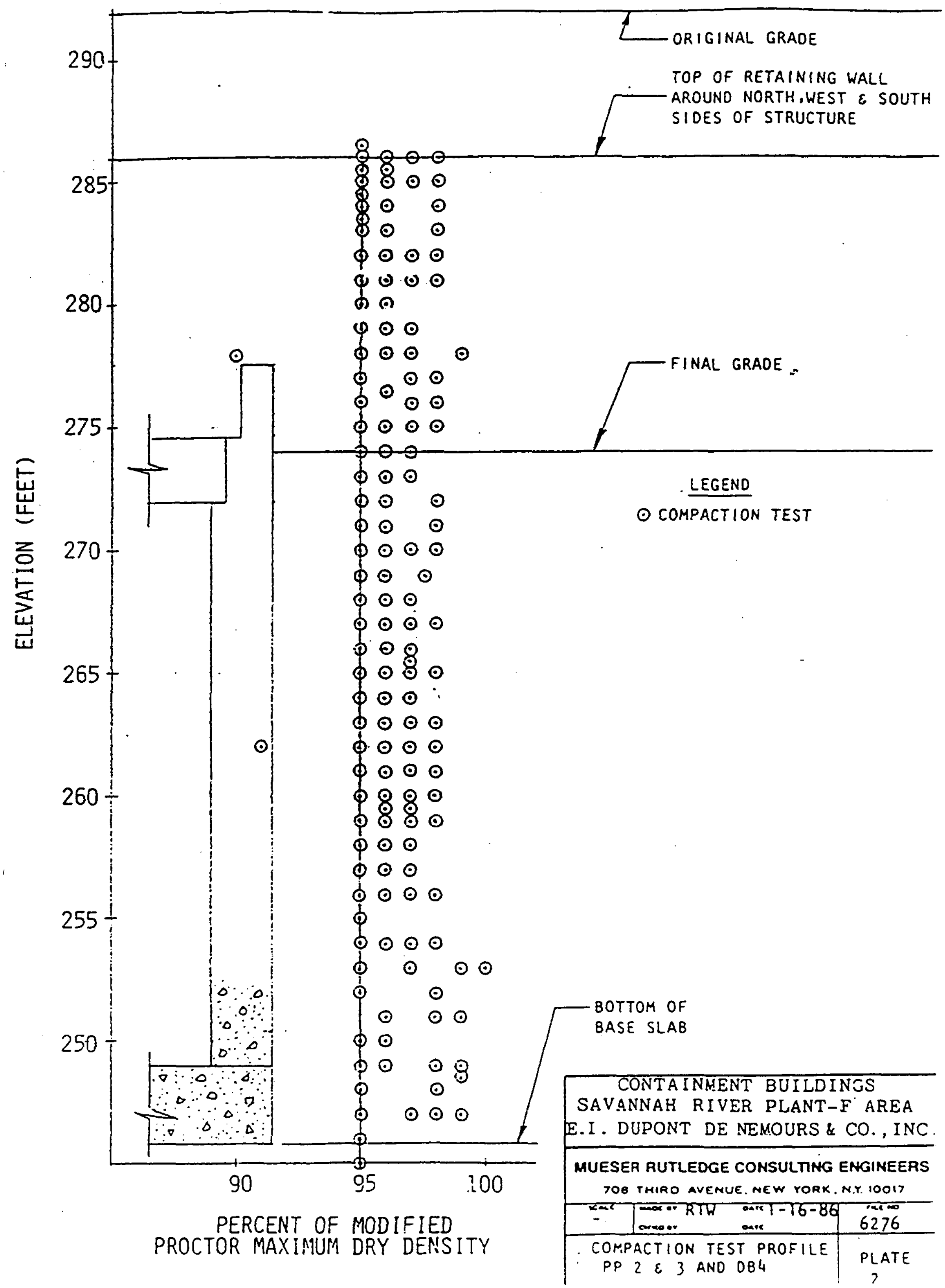


Figure 2.1-4 Compaction Test Profile for PP2, PP3, and DB4

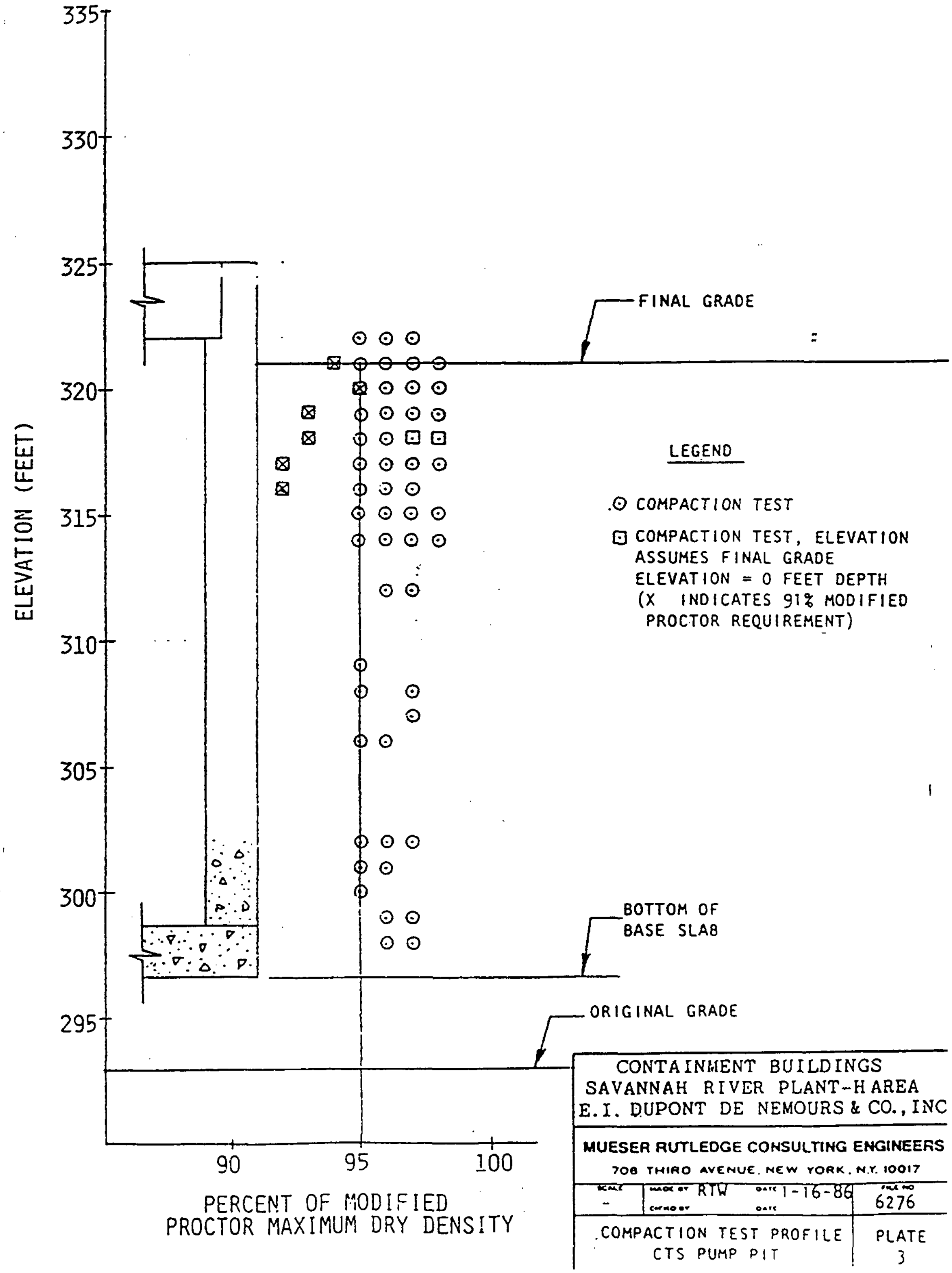


Figure 2.1-5 Compaction Test Profile for CTS Pump Pit

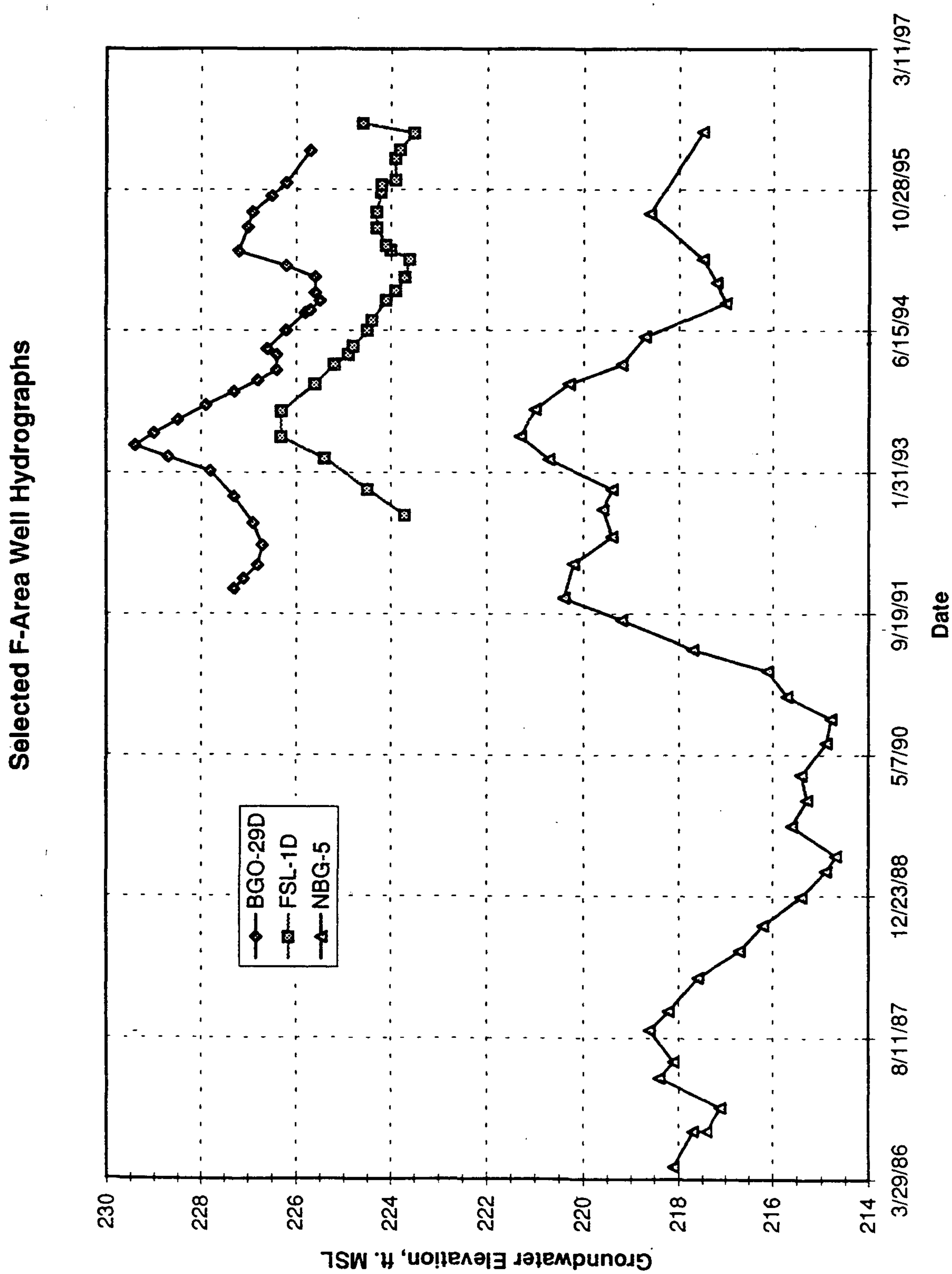
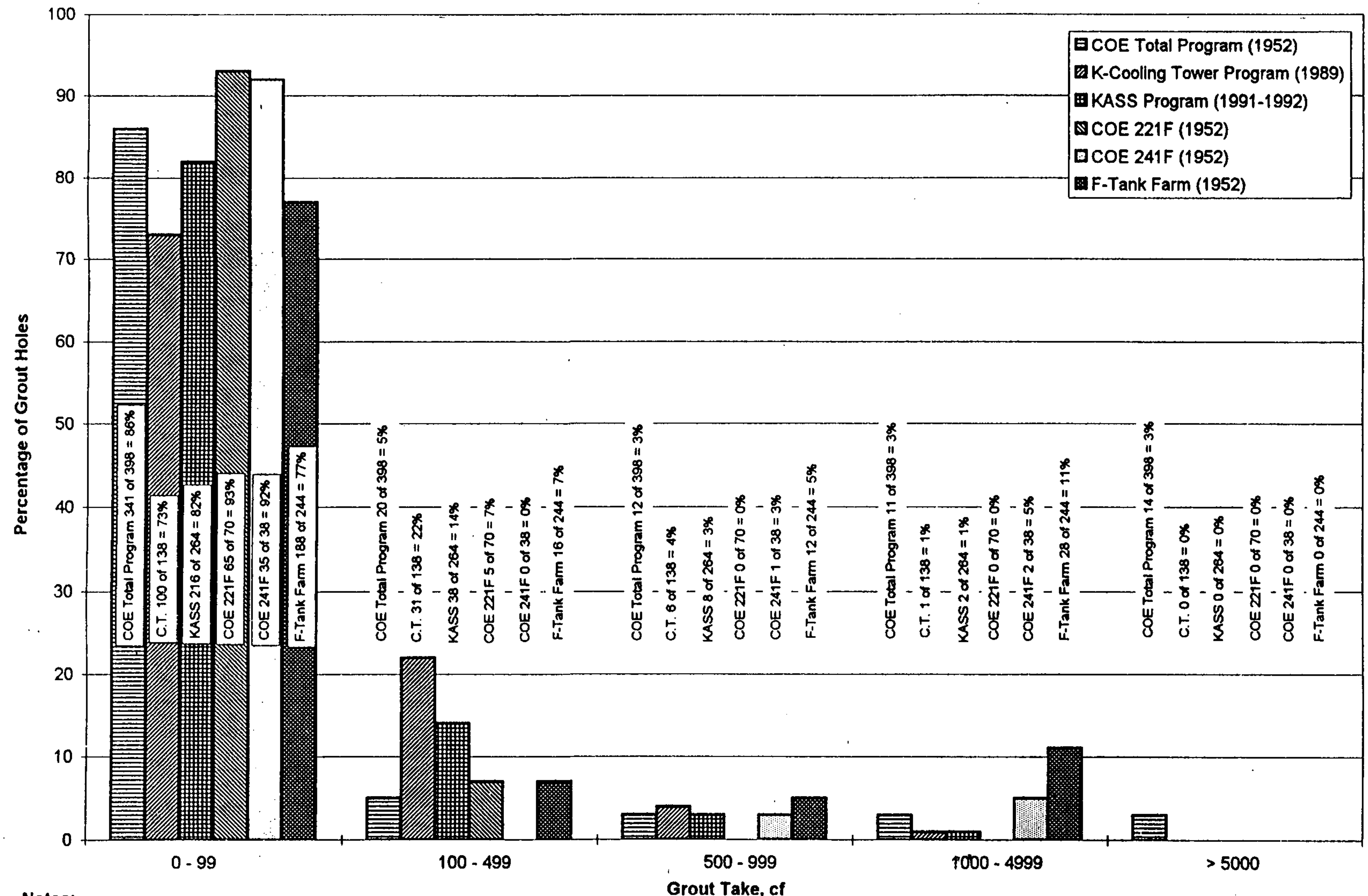


Figure 2.2-1 F-Area Monitoring Well Hydrograph



Notes:

1. In COE Program, 91 of 398 were grouted. The remaining 307 holes wee not grouted because they did not lose significant drill fluid during drilling. Those 307 holes would likely have had grout takes less than 100 cubic feet and are included in the 0-99 category.
2. Total number of COE holes is a best estimate by GEI based on review of existing COE grouting data.

Figure 2.3-1 Grout Take Histogram

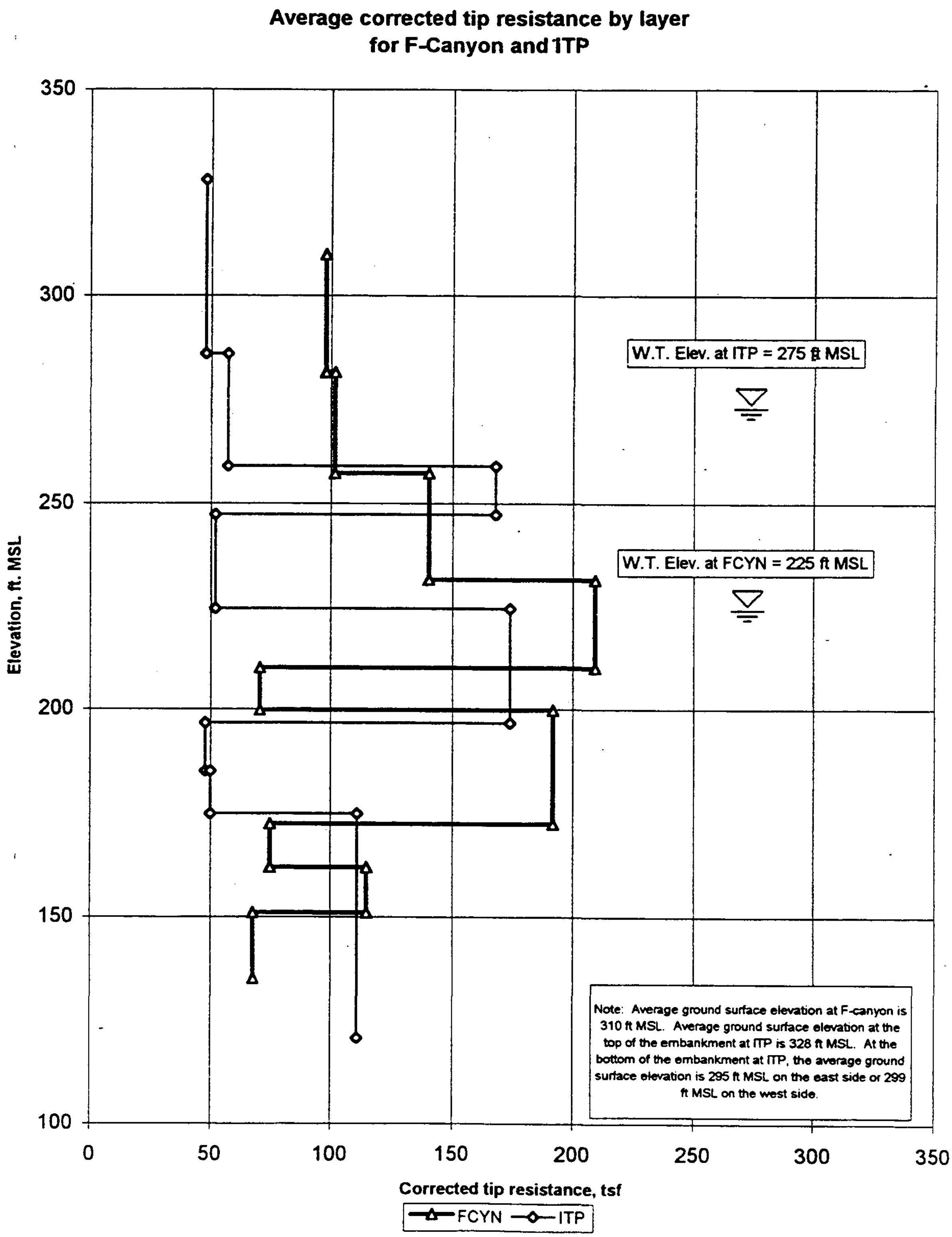


Figure 3.1-1 Elevation versus Average Corrected Tip Resistance for F-Area and ITP

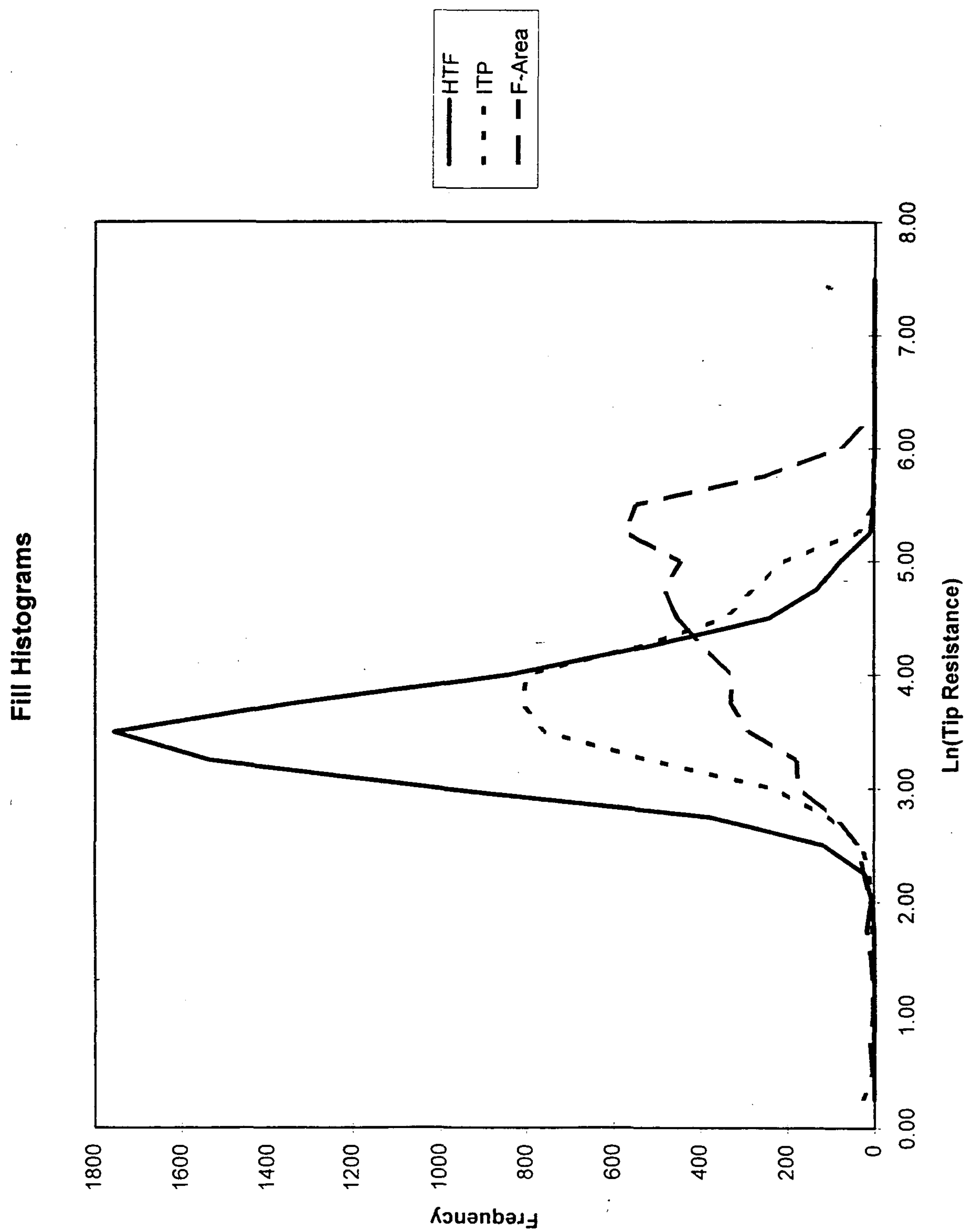


Figure 3.1-2 CPT Histograms for HTF and ITP Fill versus F-Area Fill

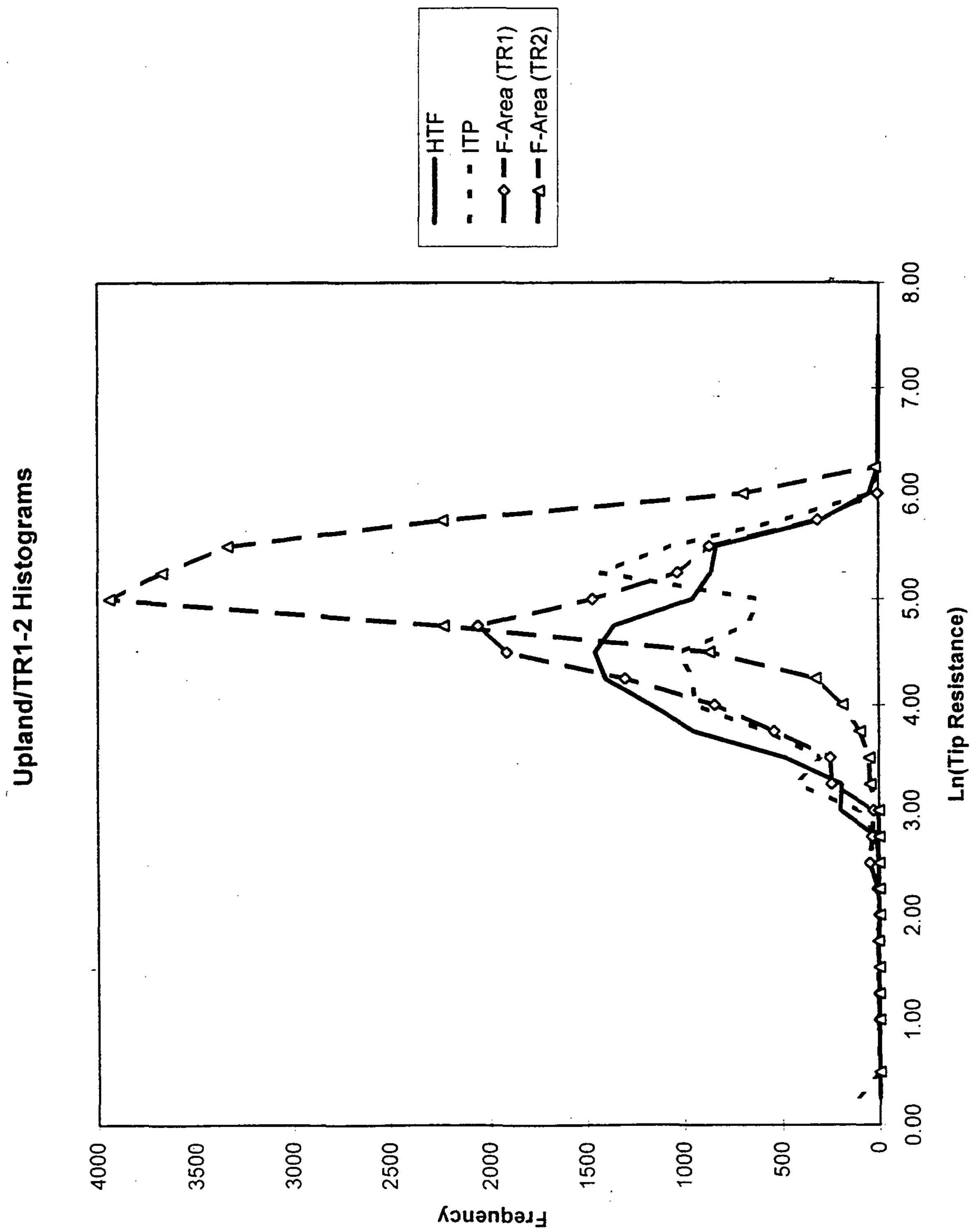


Figure 3.1-3 CPT Histograms for HTF and ITP Upland versus F-Area TR1/TR2

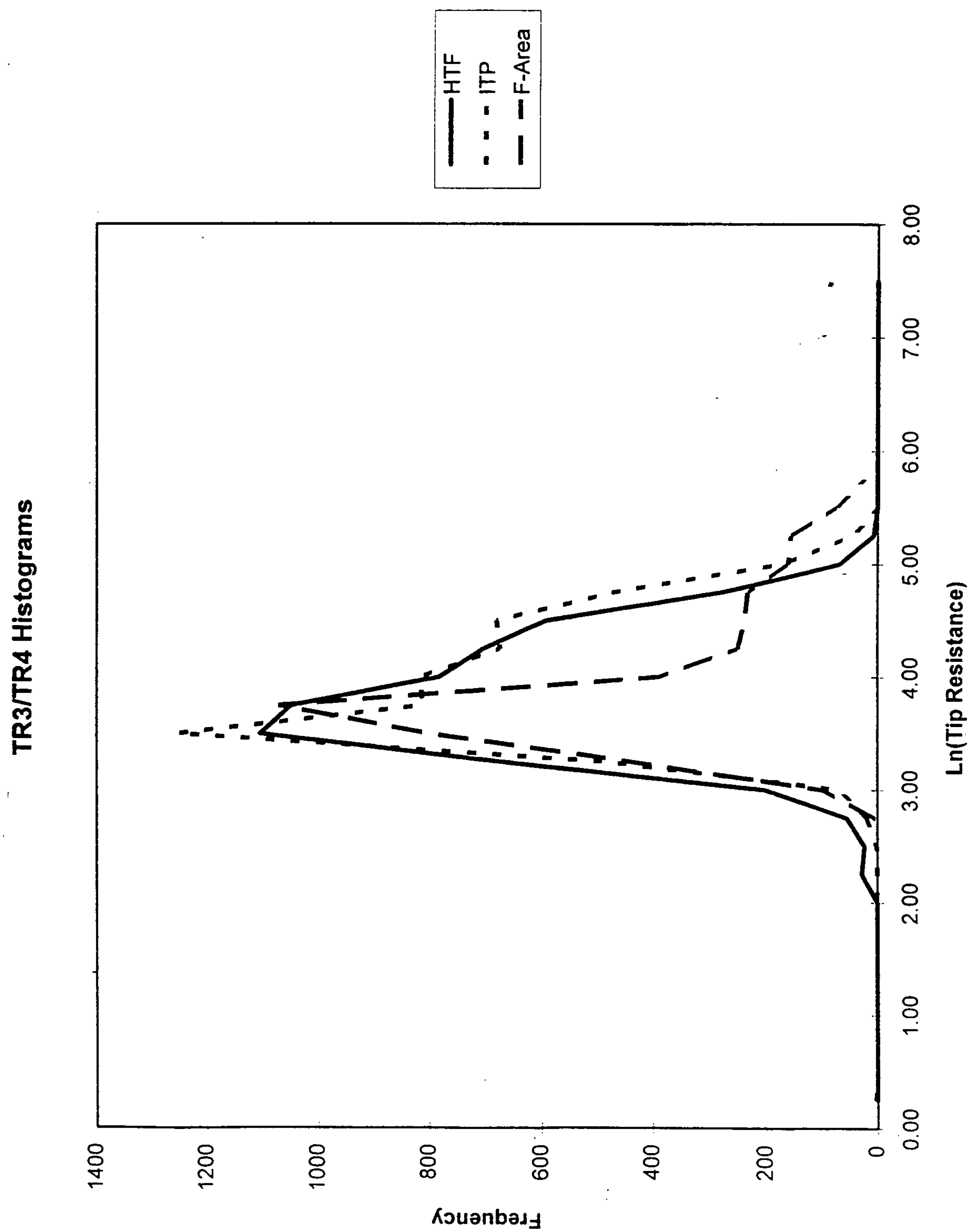


Figure 3.1-4 CPT Histograms for HTF and ITP TR3/TR4 versus F-Area TR3/TR4

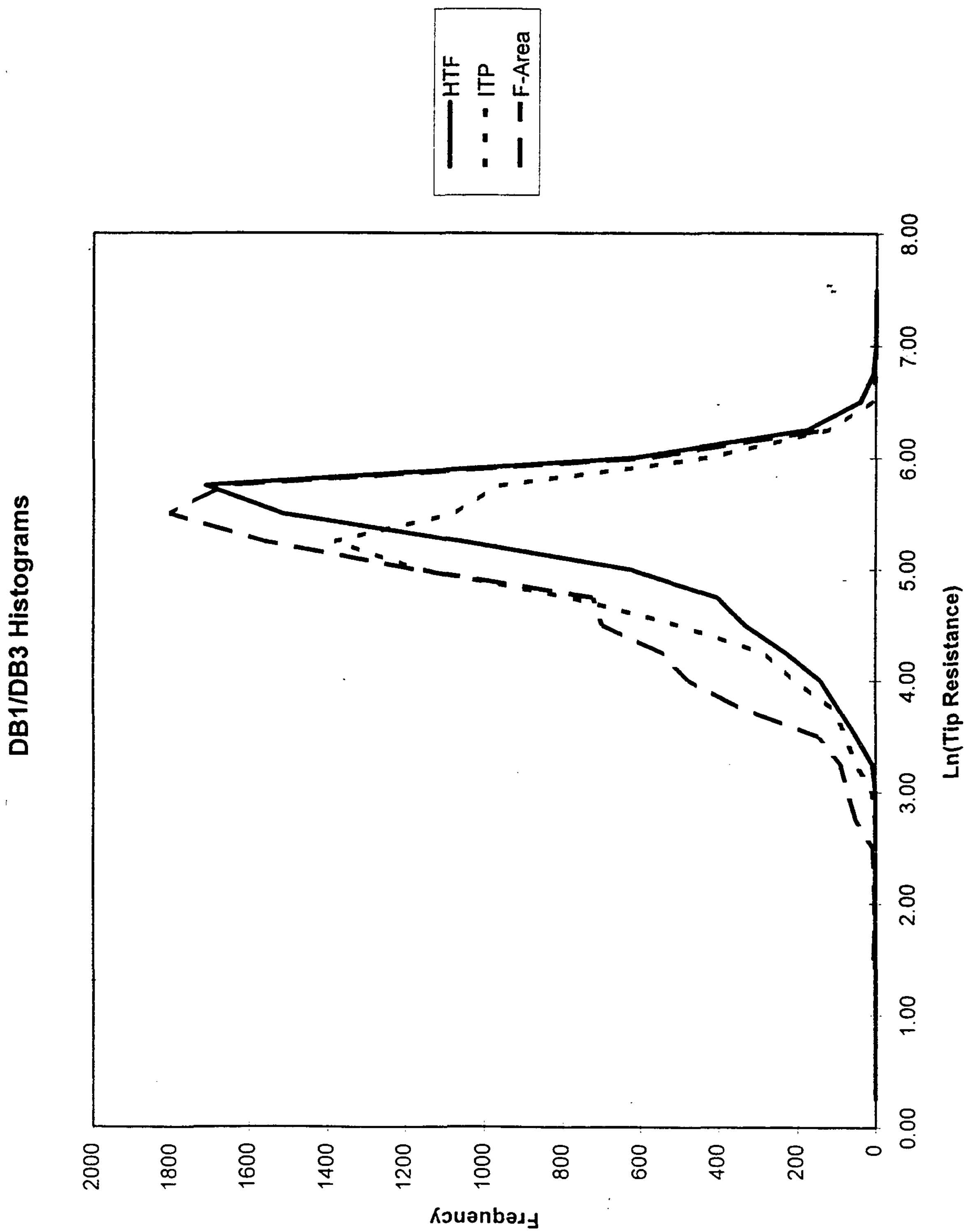


Figure 3.1-5 CPT Histograms for HTF and ITP DB1/DB3 versus F-Area DB1/DB3

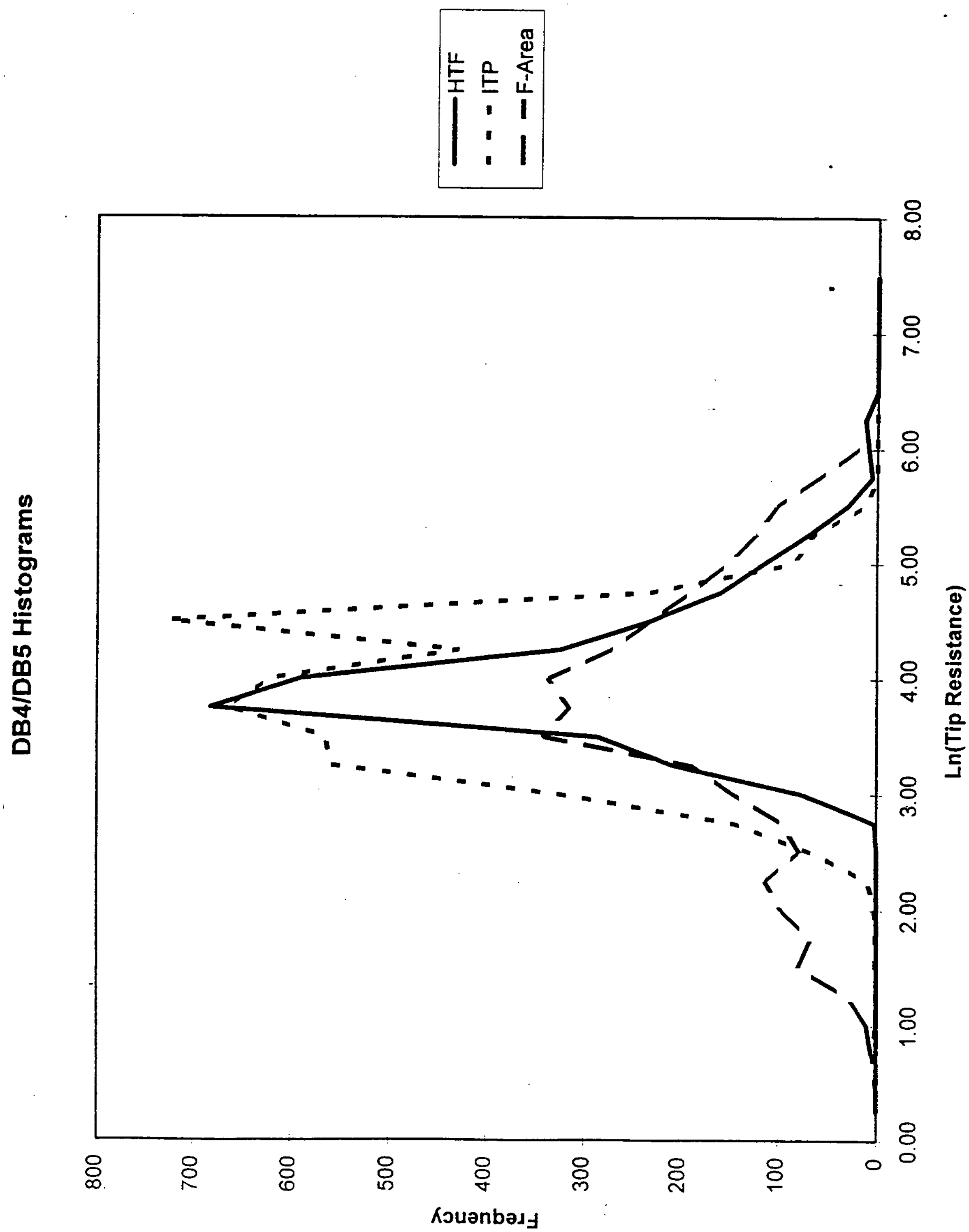


Figure 3.1-6 CPT Histograms for HTF and ITP DB4/DB5 versus F-Area DB4/DB5

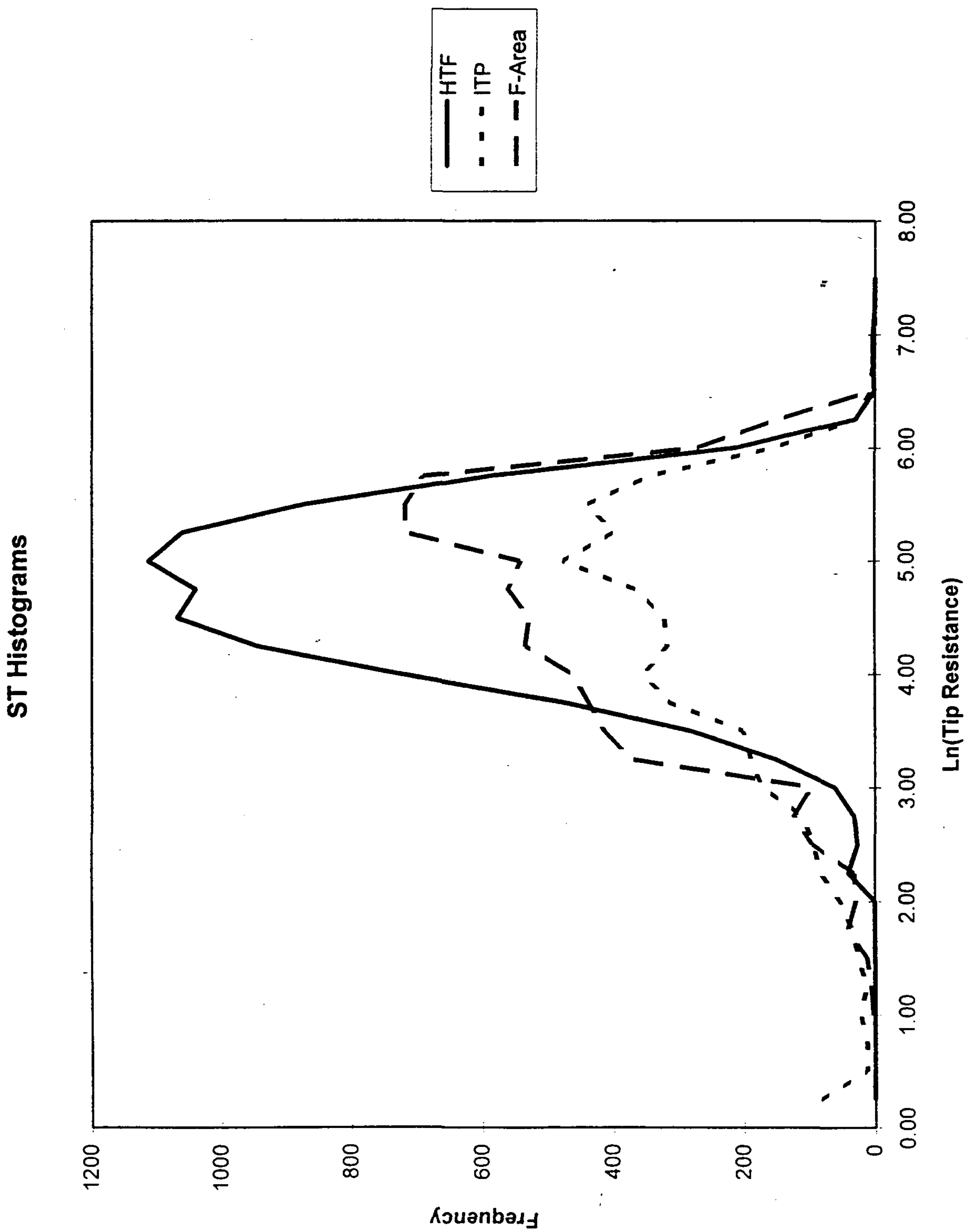


Figure 3.1-7 CPT Histograms for HTF and ITP ST versus F-Area ST

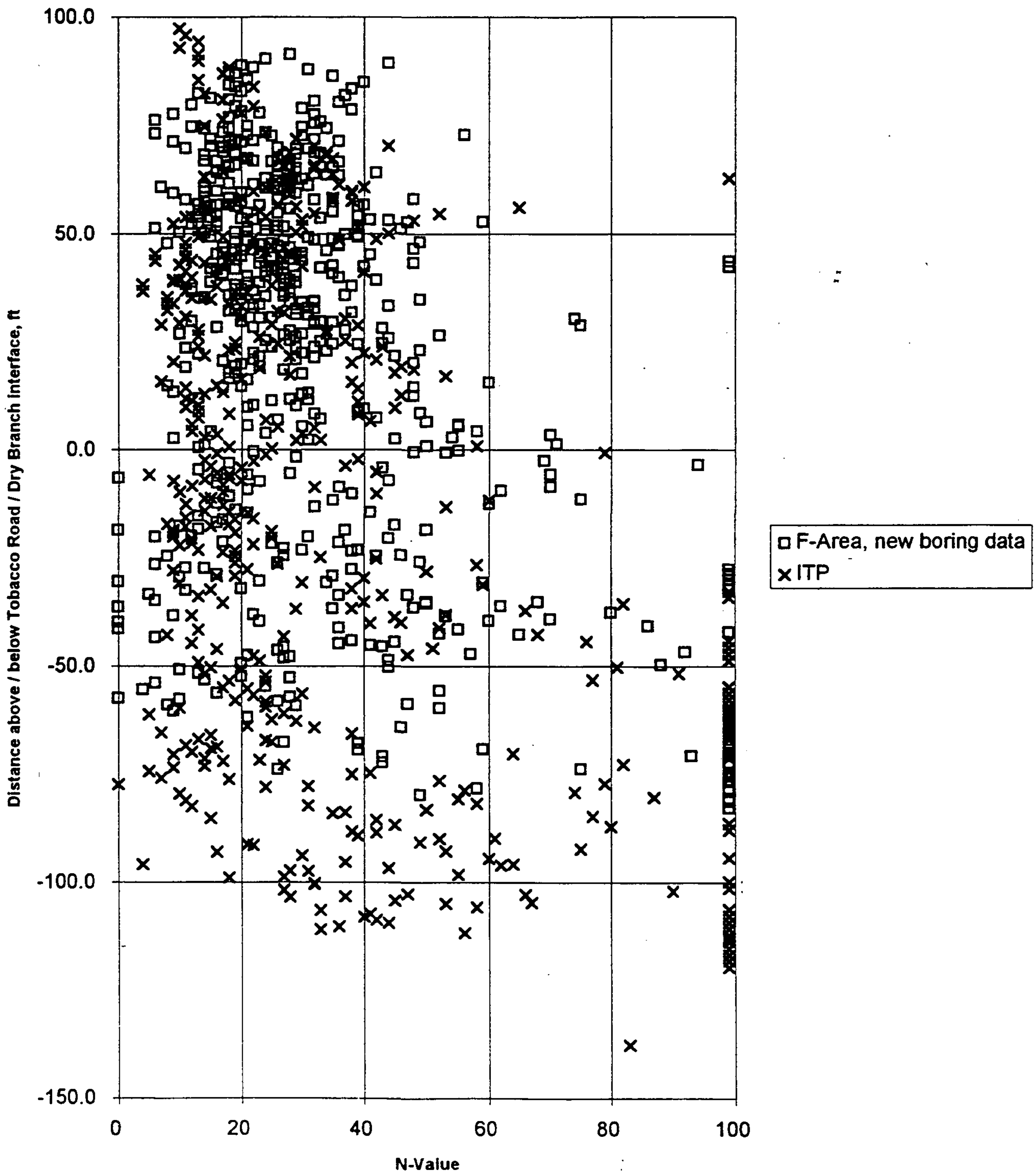


Figure 3.1-8 Distance above / below Tobacco Road / Dry Branch Interface versus SPT N-value for new F-Area Borings and ITP Borings

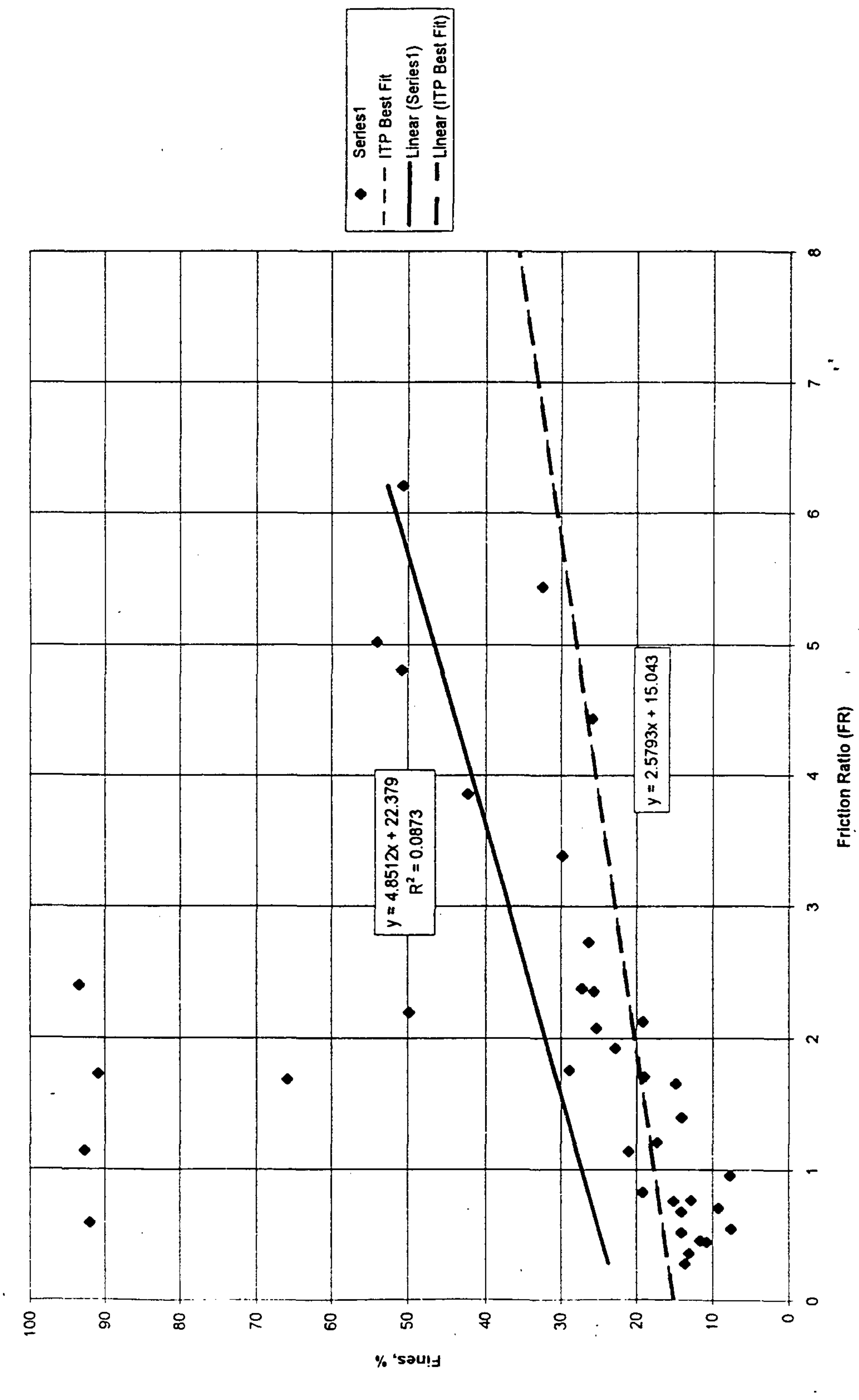


Figure 3.1-9 Percent Fines versus Friction Ratio for F-Area and ITP

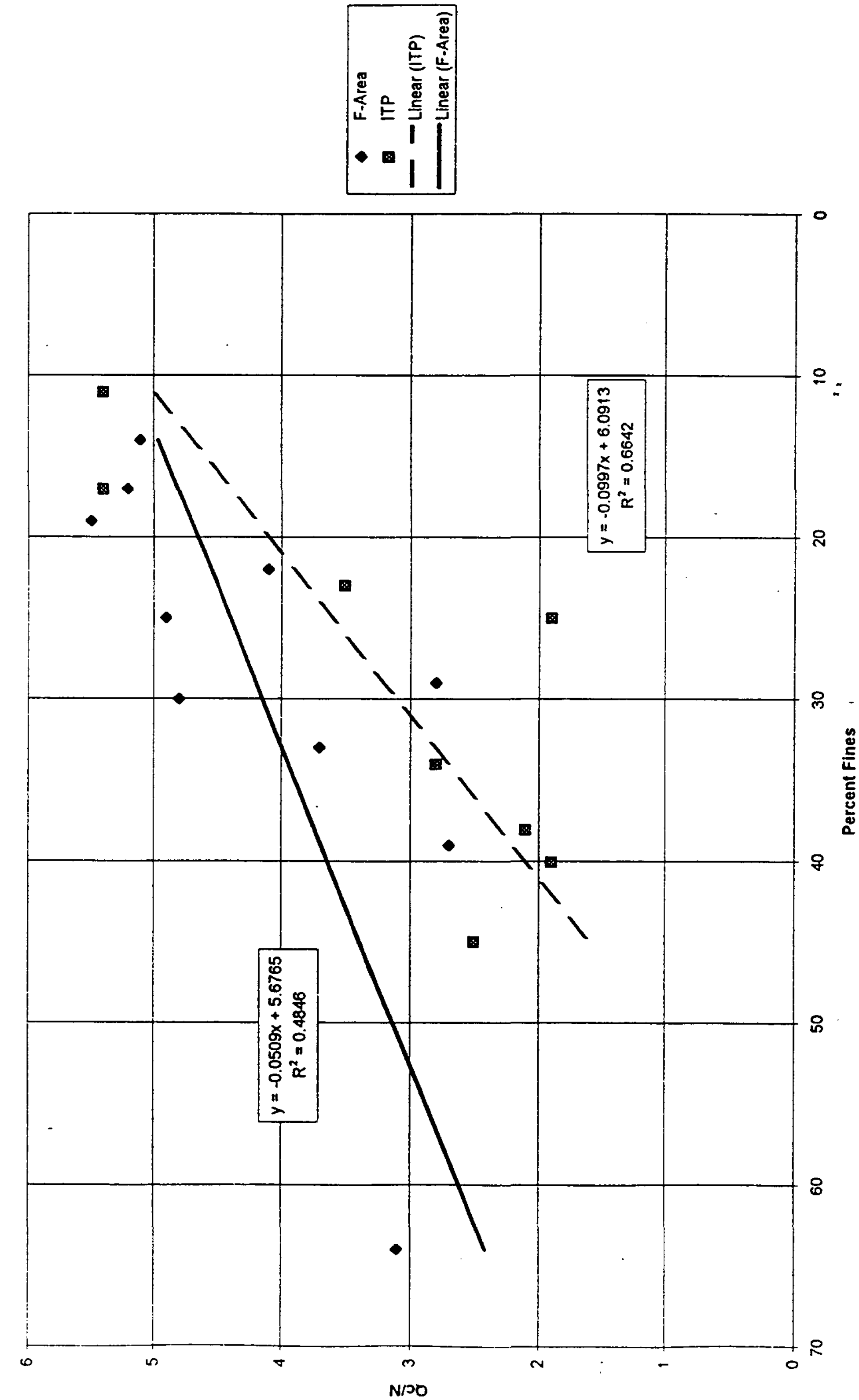


Figure 3.1-10 Qc/N versus Percent Fines for F-Area and ITP

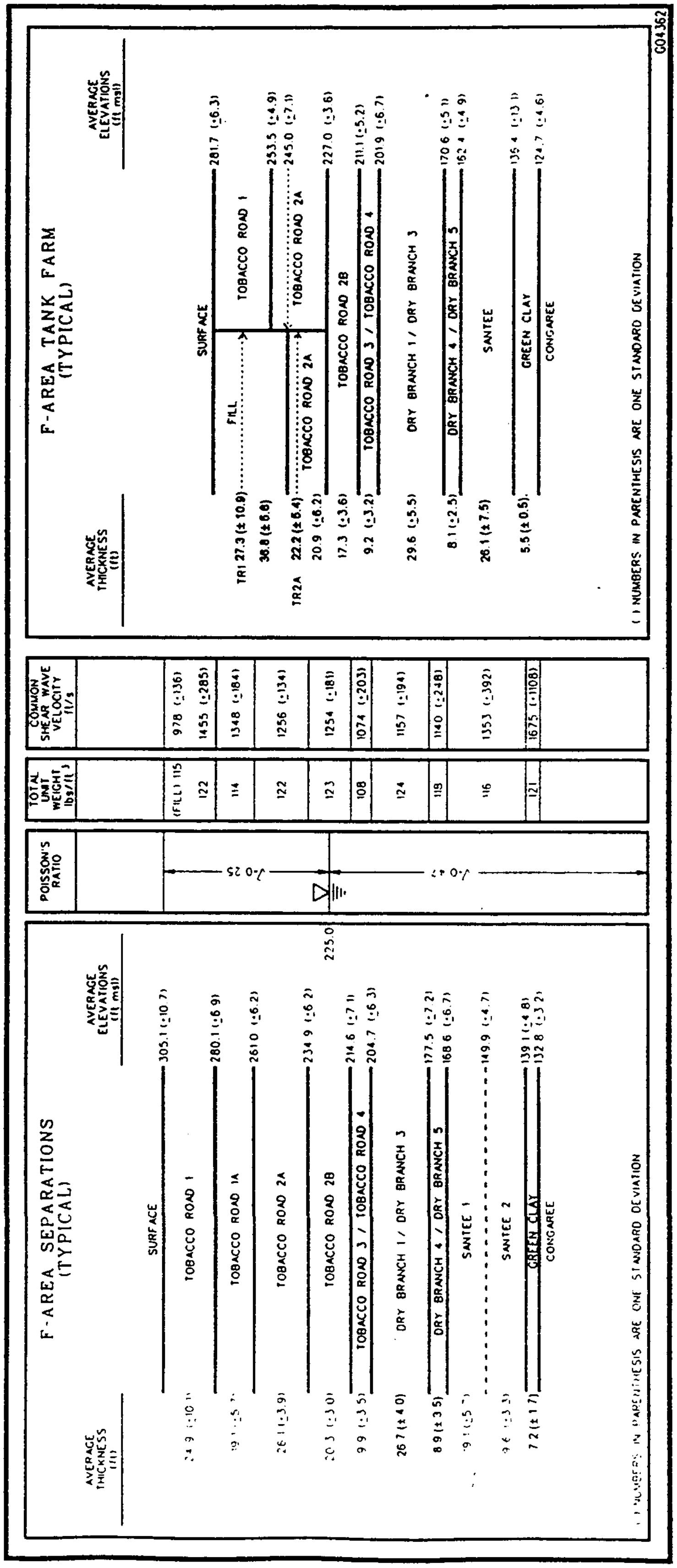


Figure 3.1-11 Idealized Cross-Section Showing Mean Shear Wave Velocities, Poisson's Ratios, and Unit Weights for Layers at F-Area

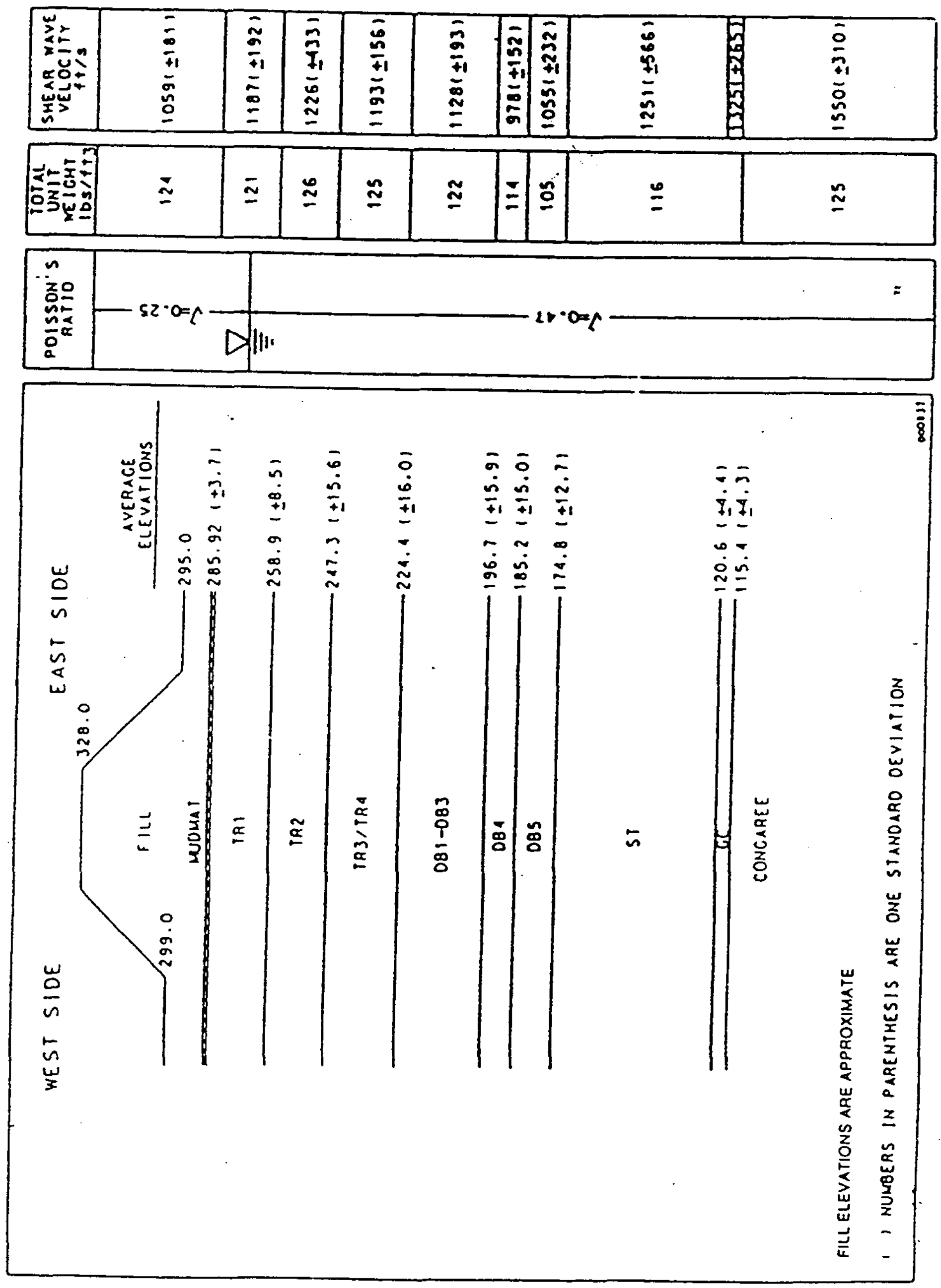


Figure 3.1-12 Idealized Cross-Section Showing Mean Shear Wave Velocities, Poisson's Ratios, and Unit Weights for Layers at ITP

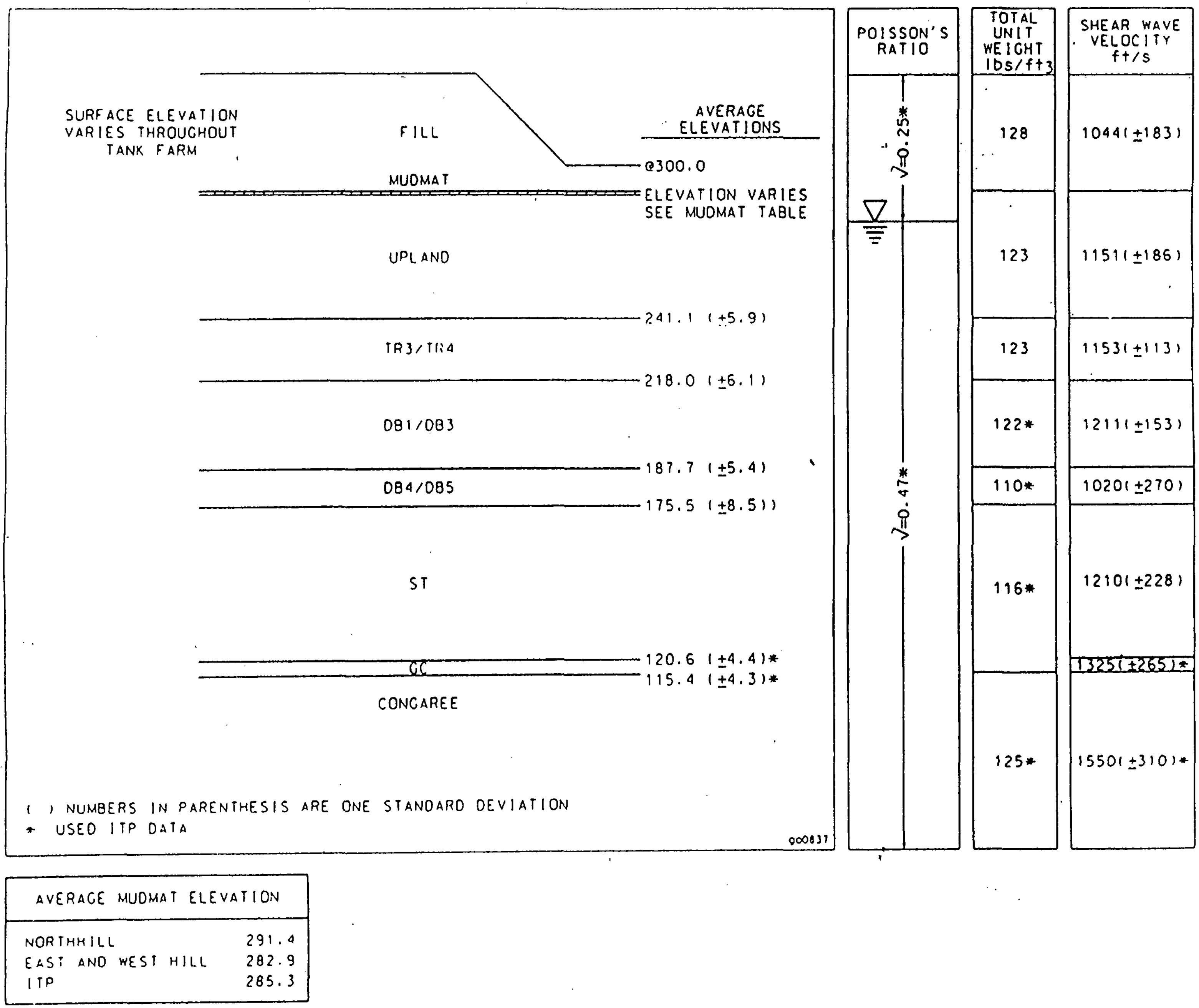


Figure 3.1-13 Idealized Cross-Section Showing Mean Shear Wave Velocities, Poisson's Ratios, and Unit Weights for Layers at HTF

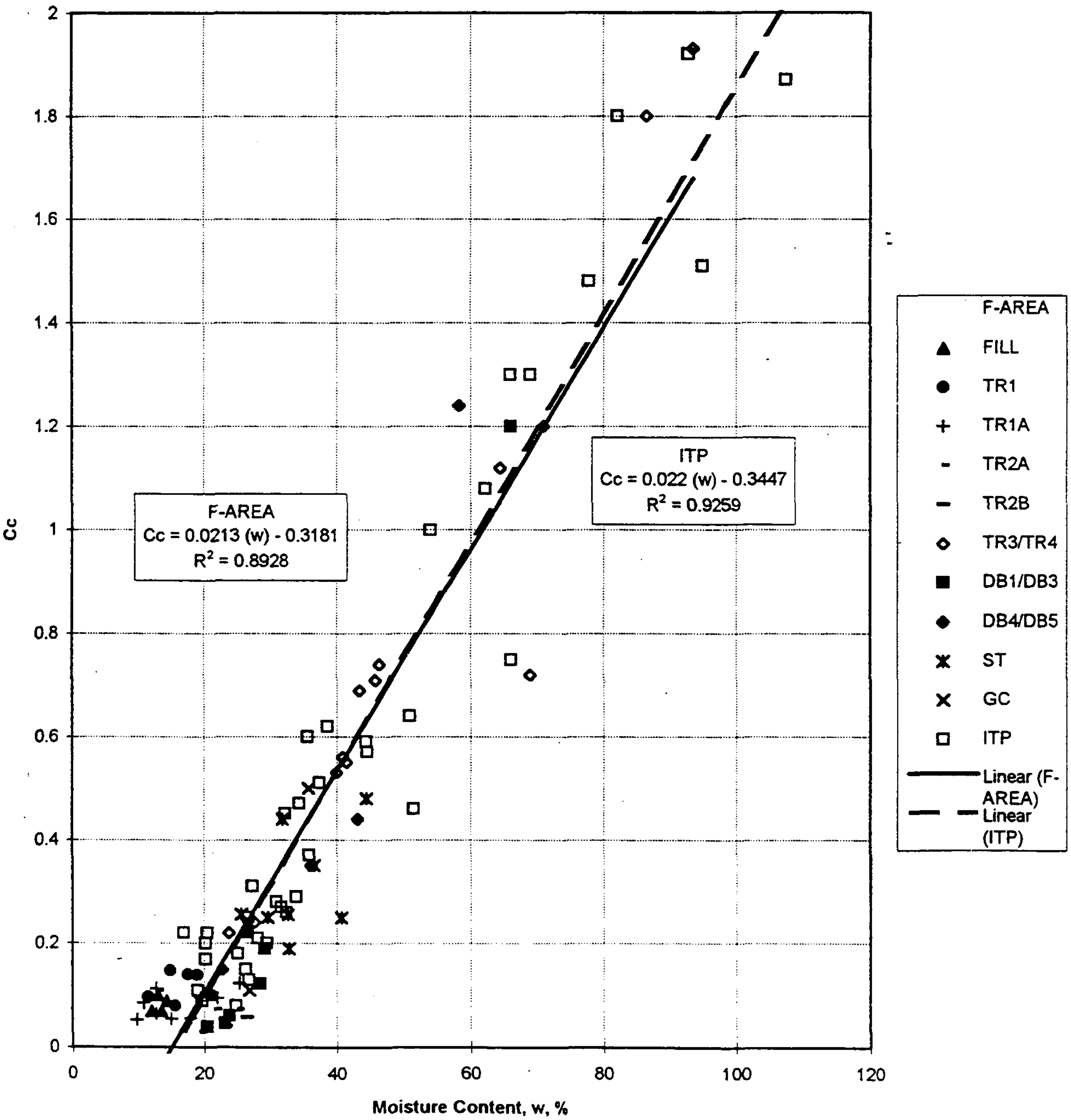


Figure 3.1-14 Compression Index versus Moisture Content for F-Area and ITP

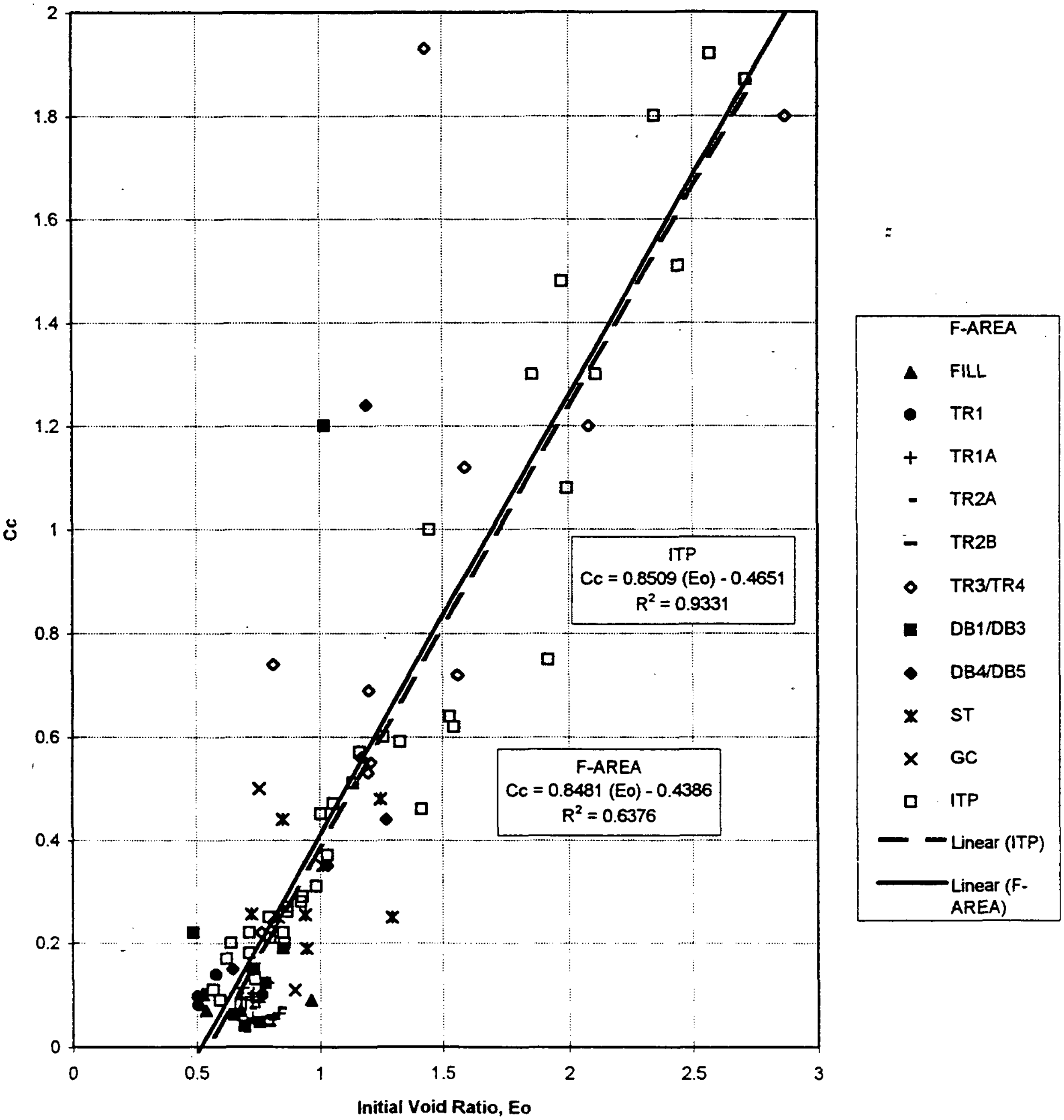


Figure 3.1-15 Compression Index versus Initial Void Ratio for F-Area and ITP

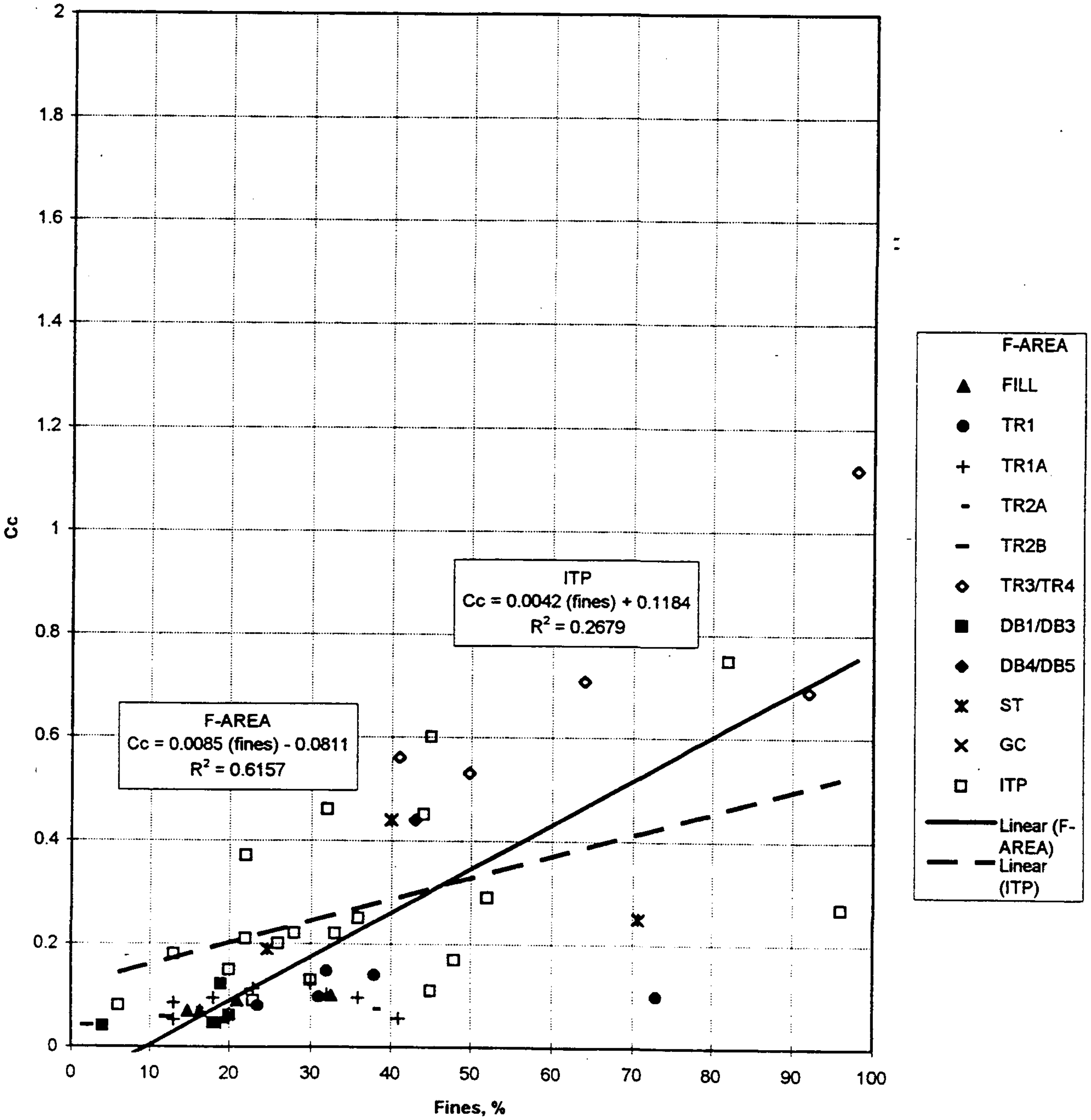


Figure 3.1-16 Compression Index versus Percent Fines for F-Area and ITP

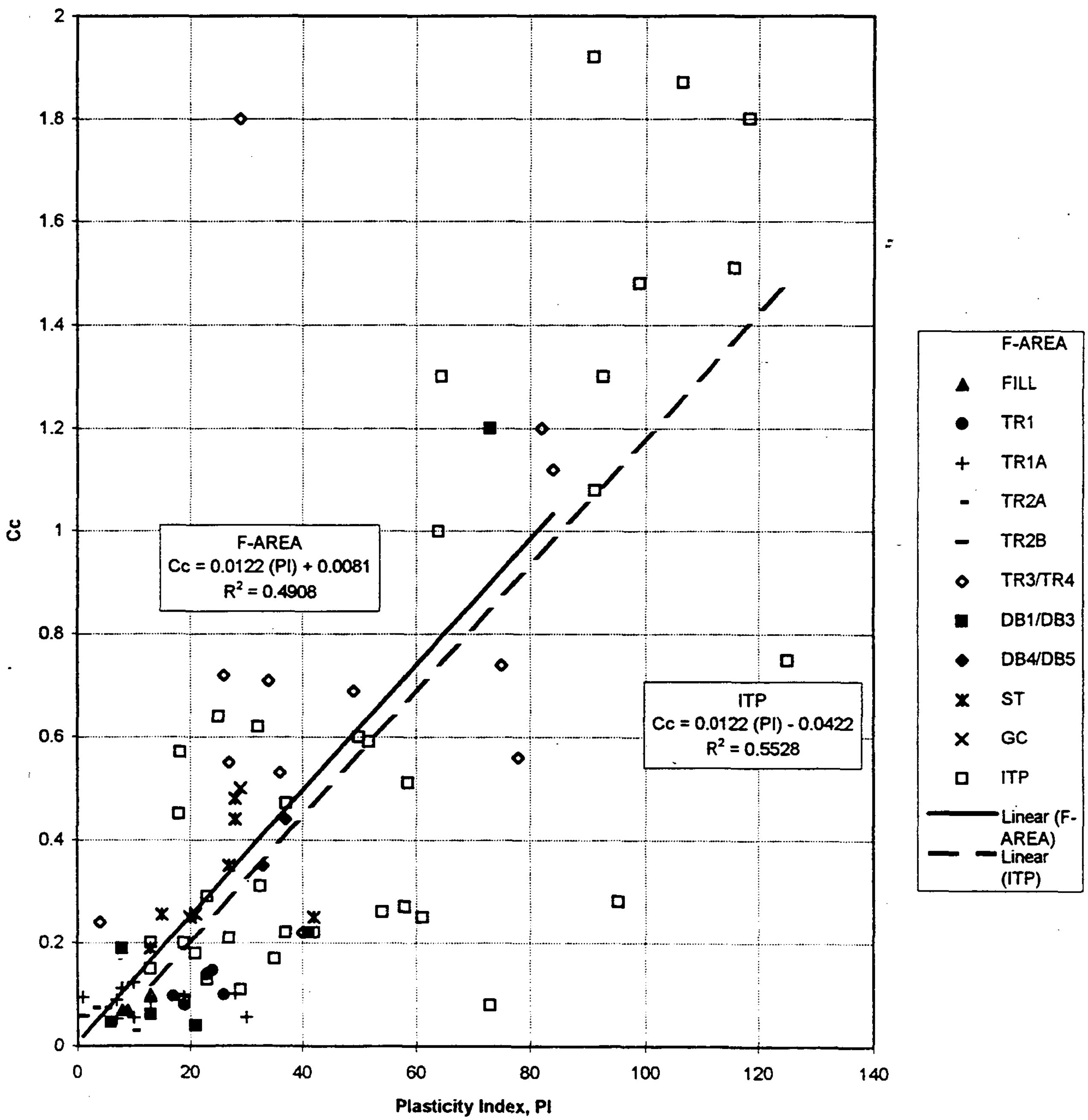


Figure 3.1-17 Compression Index versus Plasticity Index for F-Area and ITP

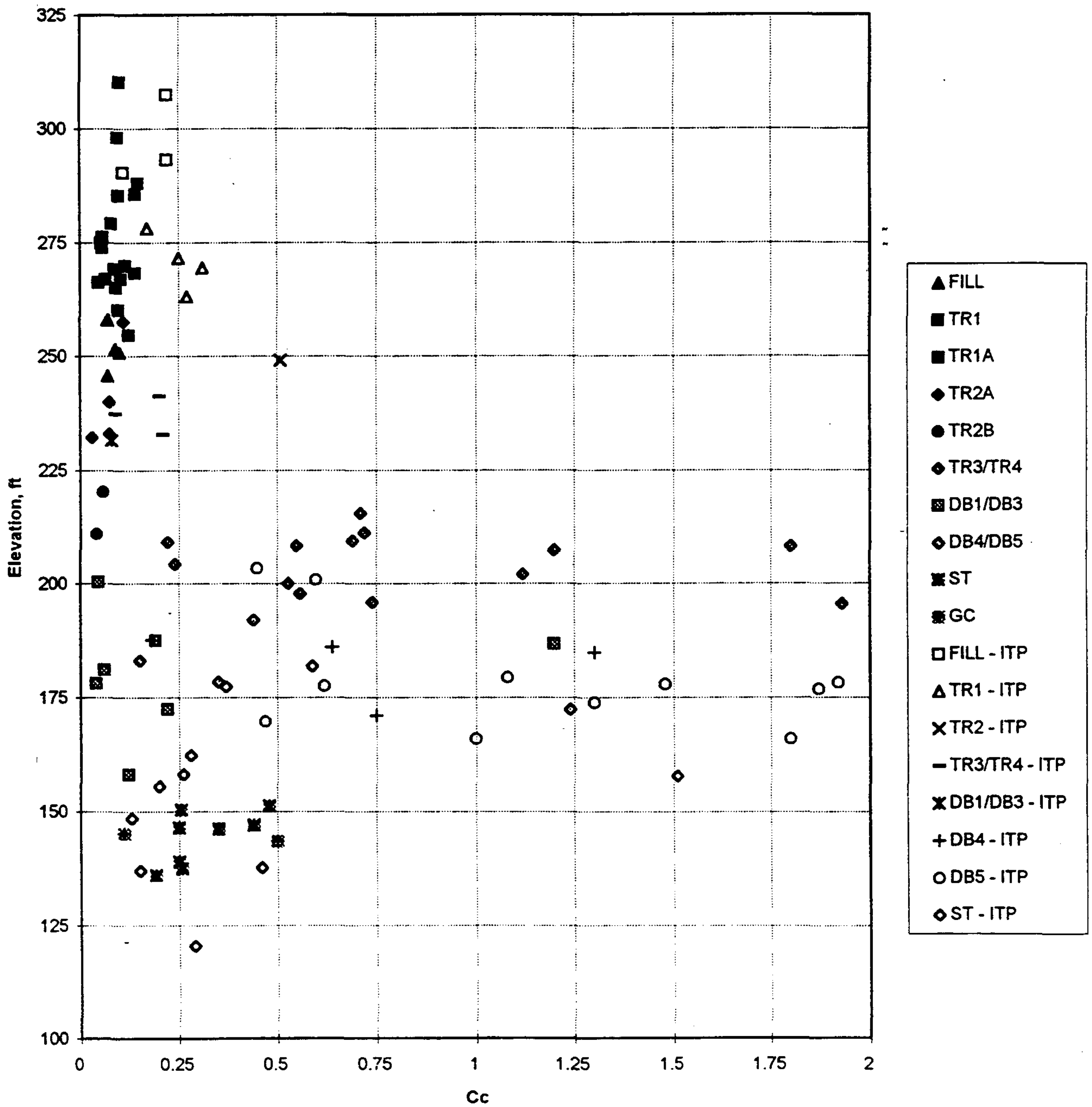


Figure 3.1-18 Elevation versus Compression Index for F-Area and ITP

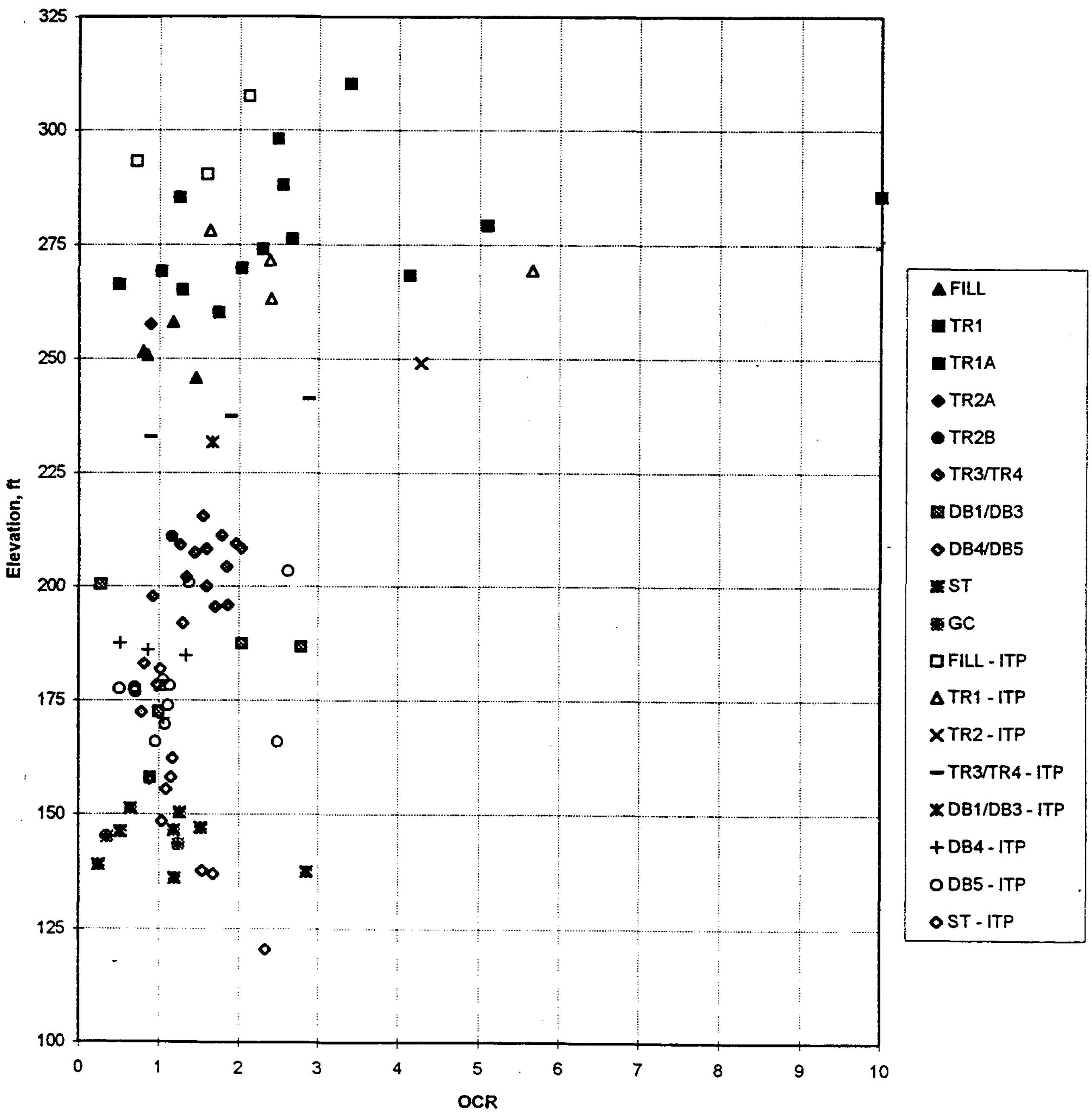


Figure 3.1-19 Elevation versus OCR for F-Area and ITP

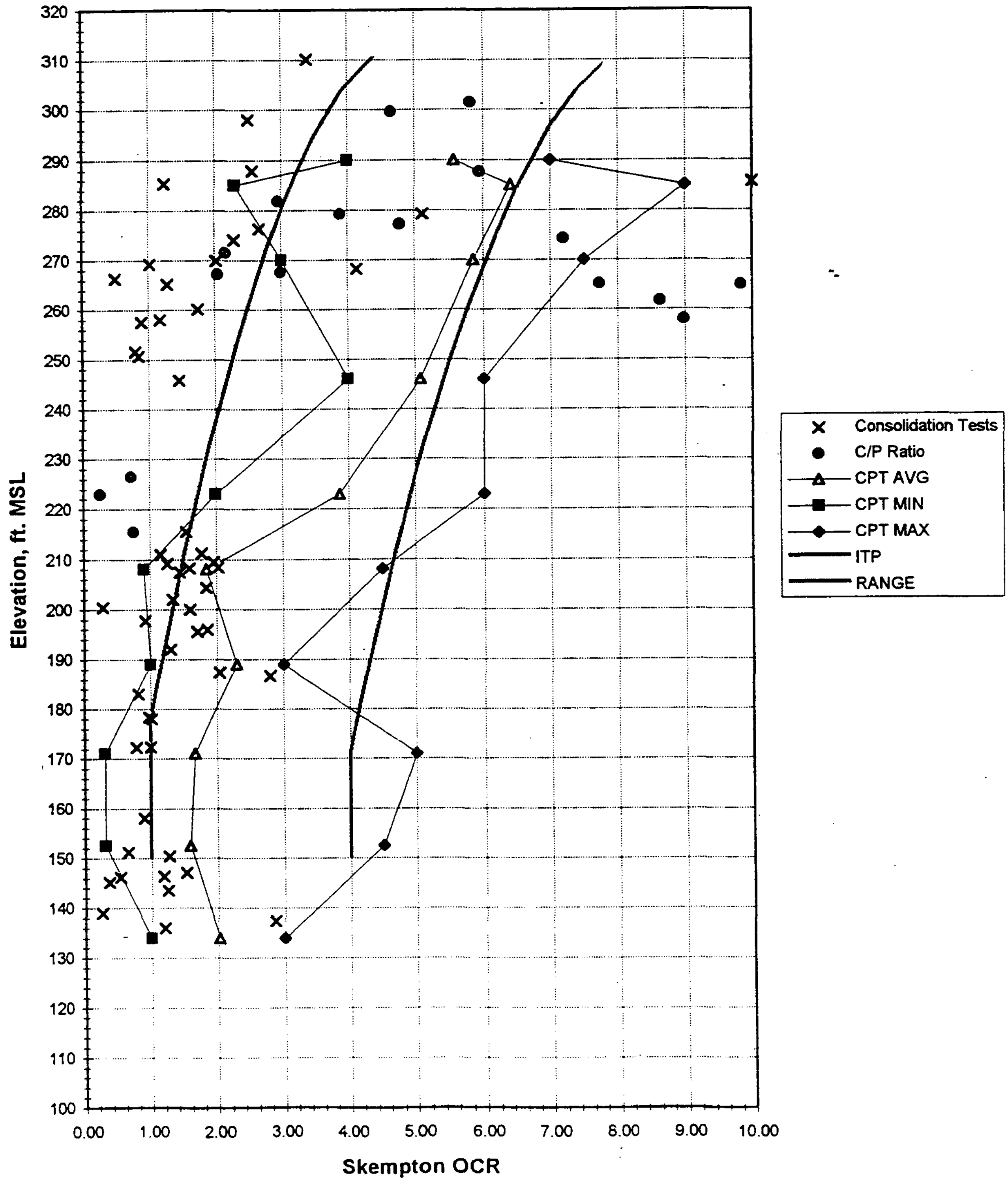


Figure 3.1-20 Elevation versus OCR Determined from Laboratory and Field Methods for F-Area and ITP

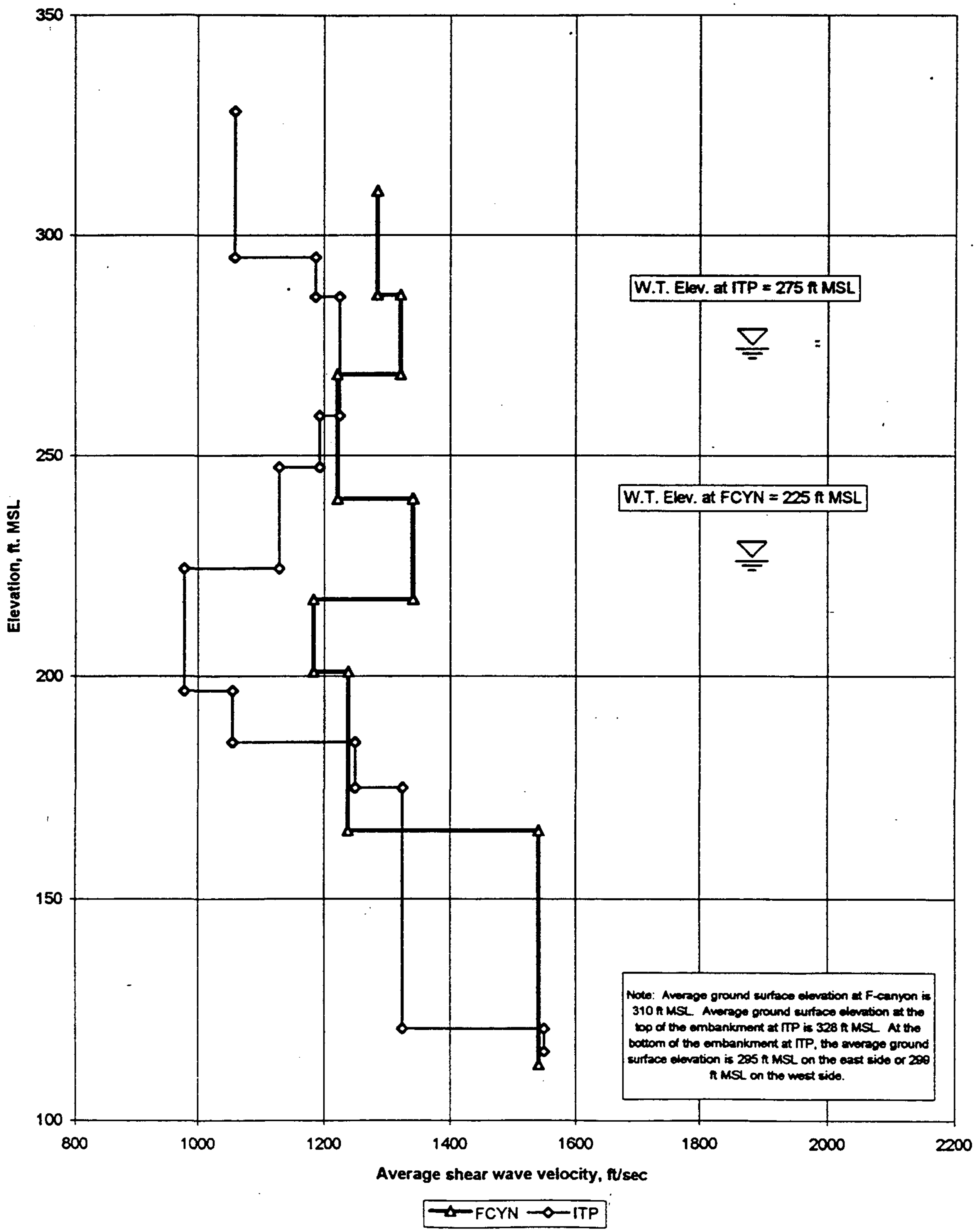


Figure 3.2-1 Mean Shear Wave Velocity Profiles for F-Canyon and ITP

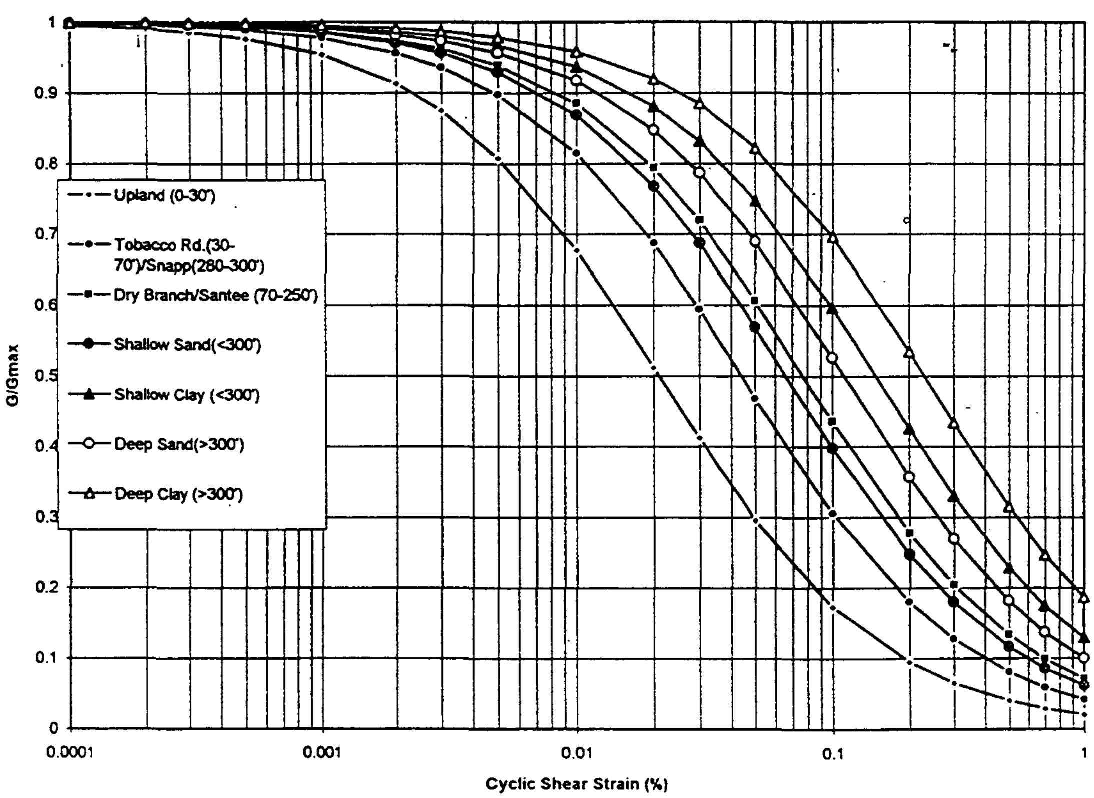


Figure 3.2-2 Shear Modulus Reduction with Cyclic Shear Strain Amplitude

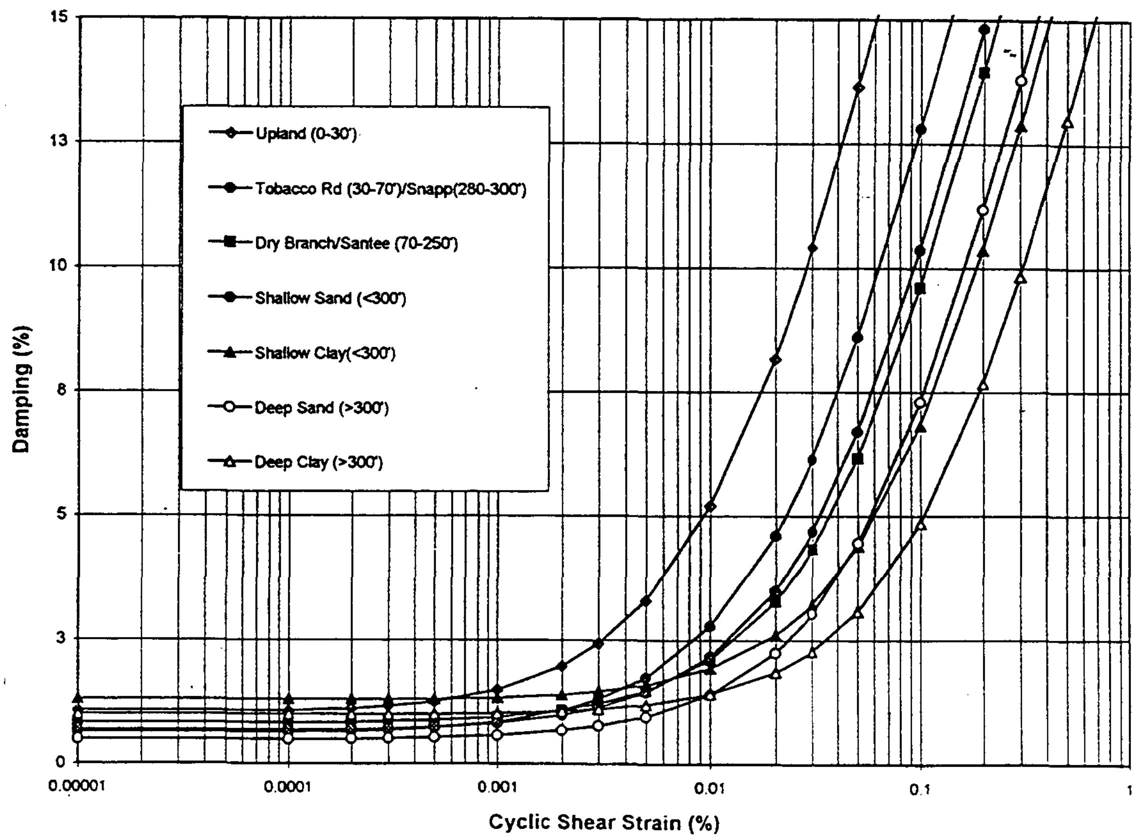


Figure 3.2-3 Variation of Damping Ratios with Cyclic Shear Strain Amplitude

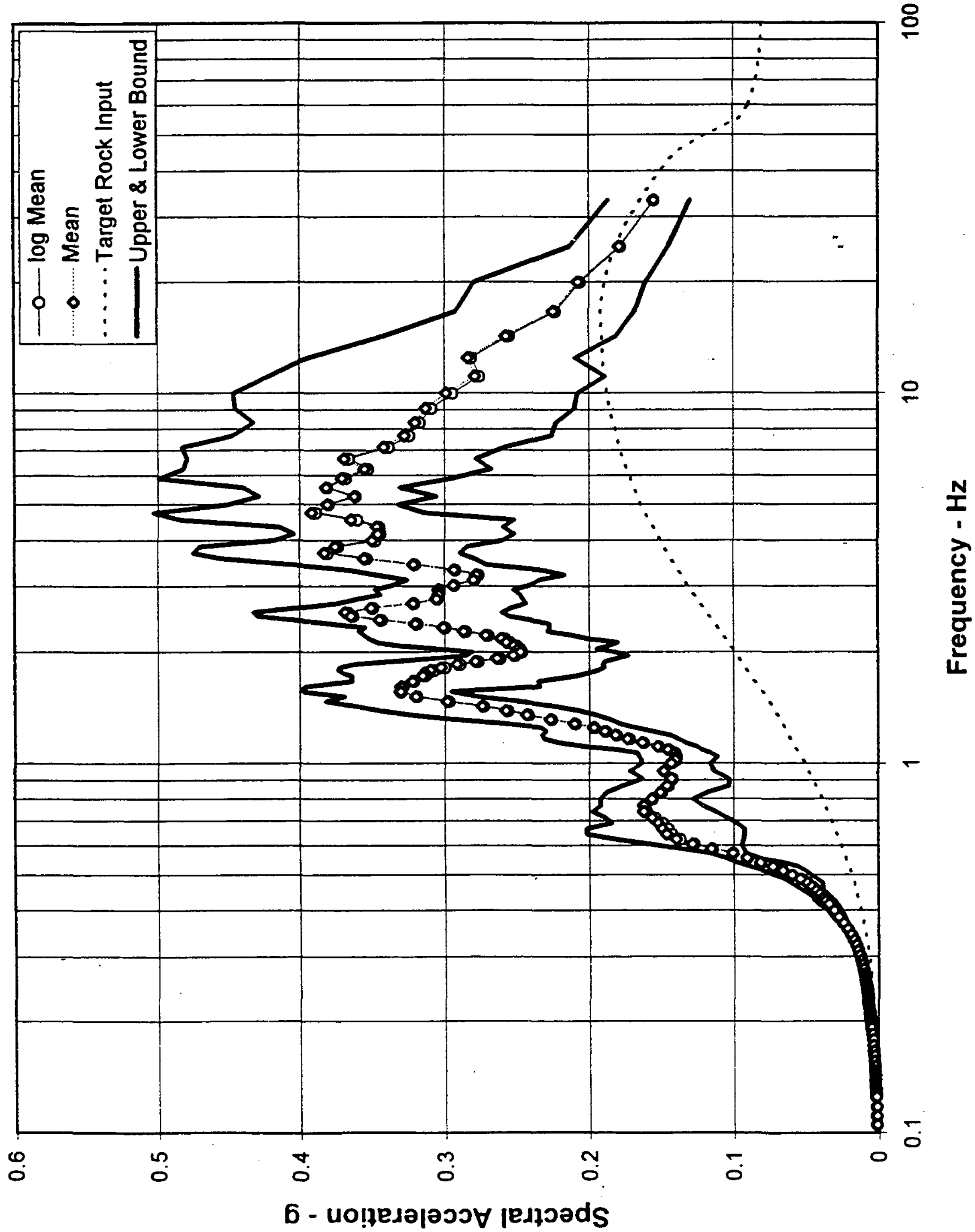


Figure 4.1-1 F-Canyon Probabilistic Free-Field Spectral Accelerations for Performance Category 3, 5% Damping

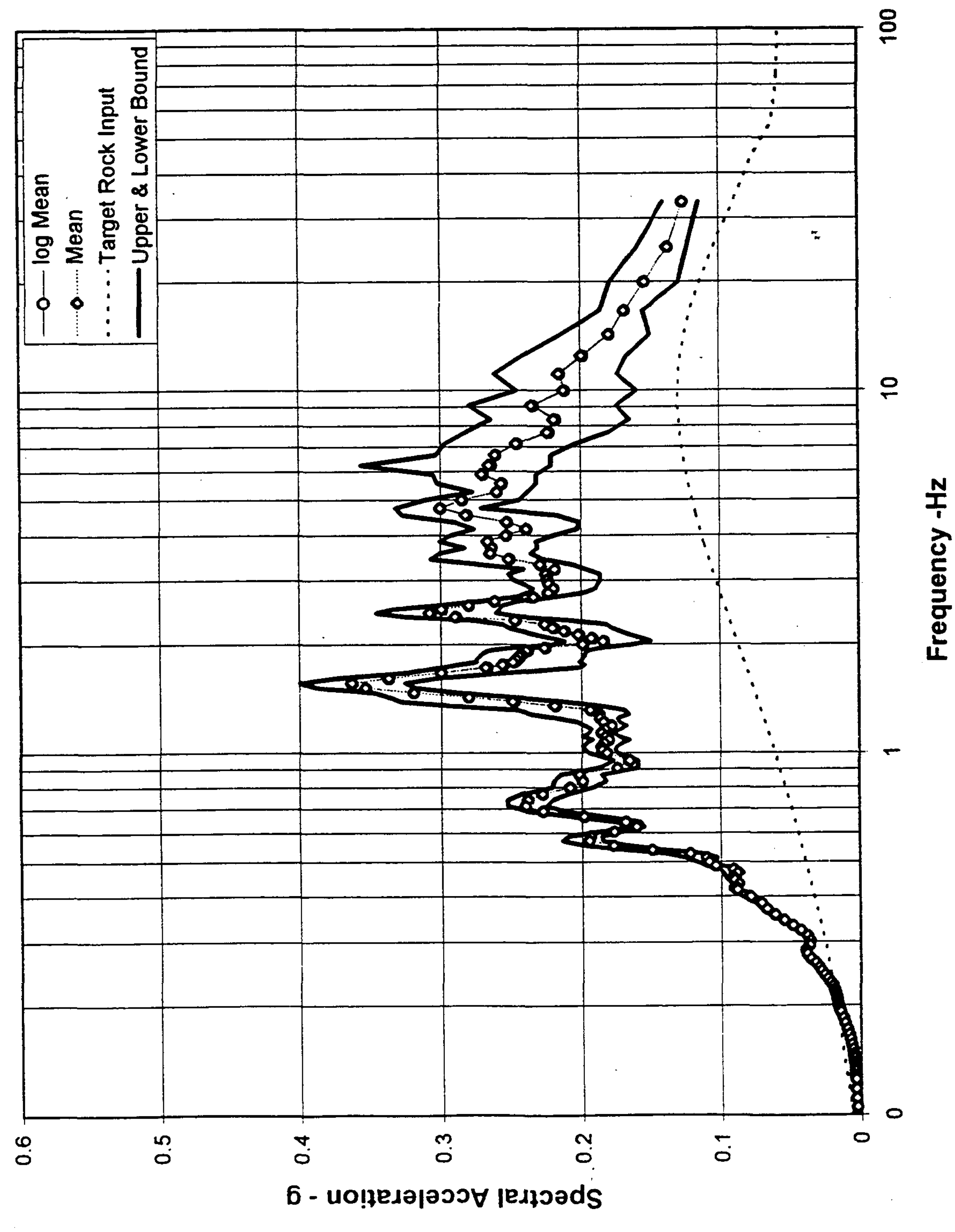
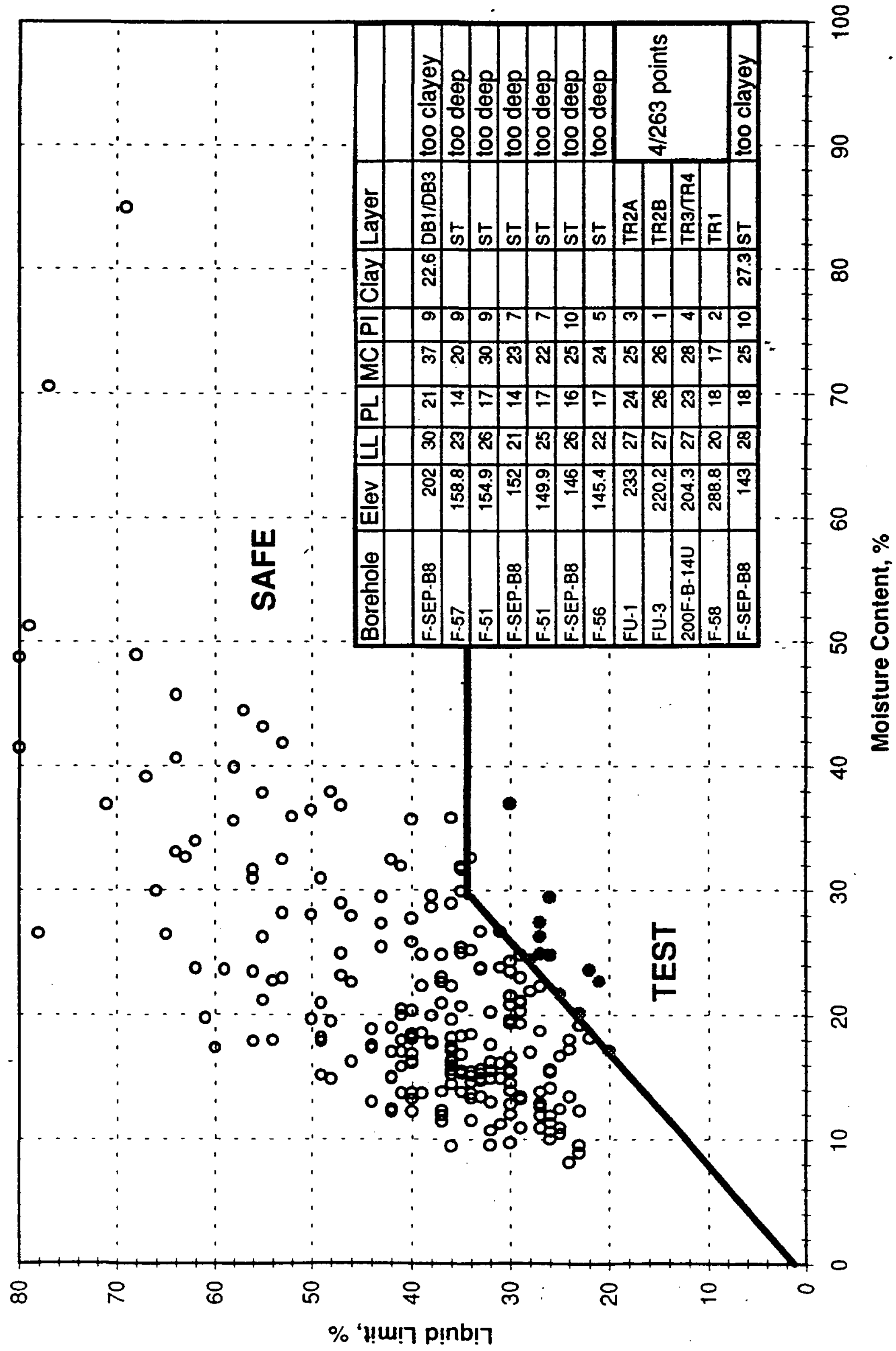
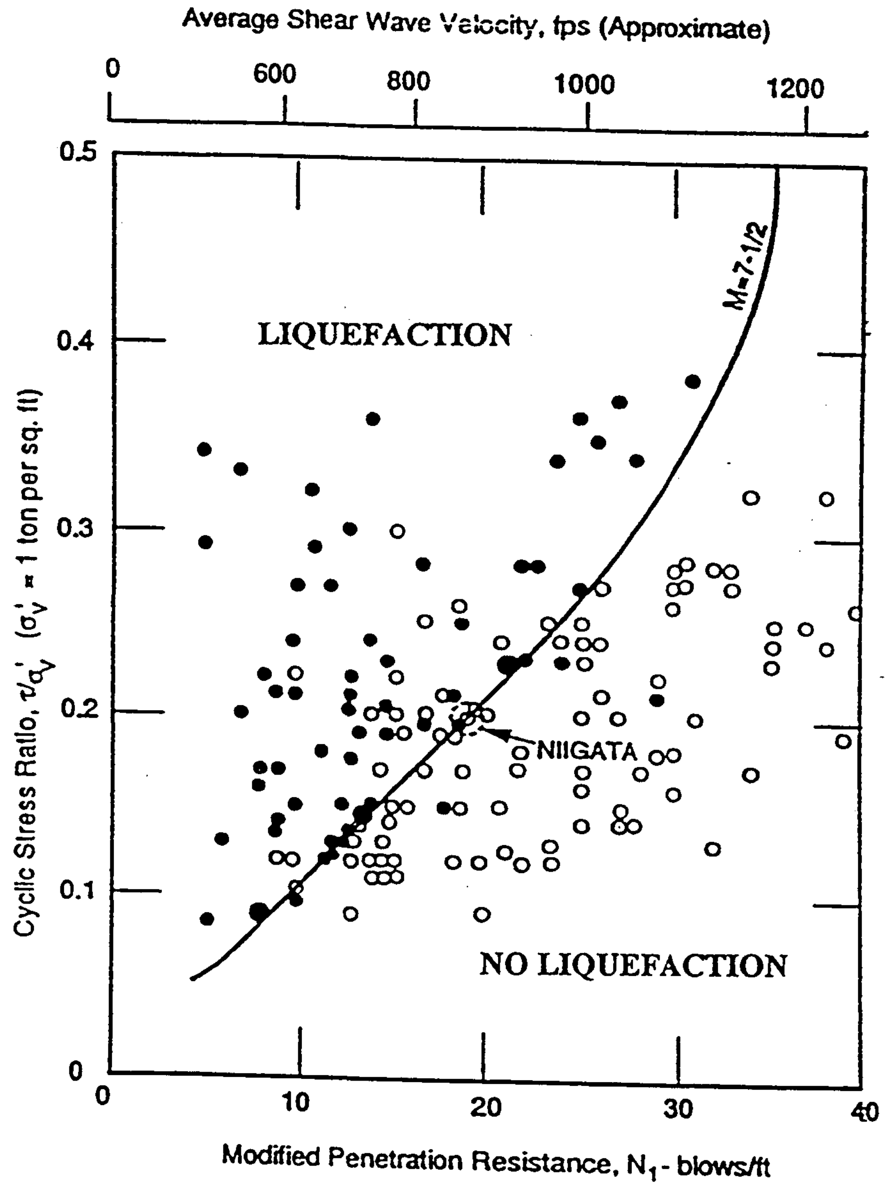


Figure 4.1-2 F-Canyon Deterministic Free-Field Spectral Accelerations for Performance Category 3, 5% Damping



Borehole	Elev	LL	PL	MC	PI	Clay	Layer	
F-SEP-B8	202	30	21	37	9	22.6	DB1/DB3	too clayey
F-57	158.8	23	14	20	9		ST	too deep
F-51	154.9	26	17	30	9		ST	too deep
F-SEP-B8	152	21	14	23	7		ST	too deep
F-51	149.9	25	17	22	7		ST	too deep
F-SEP-B8	146	26	16	25	10		ST	too deep
F-56	145.4	22	17	24	5		ST	too deep
FU-1	233	27	24	25	3		TR2A	4/263 points
FU-3	220.2	27	26	26	1		TR2B	
200F-B-14U	204.3	27	23	28	4		TR3/TR4	
F-58	288.8	20	18	17	2		TR1	
F-SEP-B8	143	28	18	25	10	27.3	ST	too clayey

Figure 4.2-1 Evaluation of F-Area Soils Using Chinese Criteria for Clayey Soils

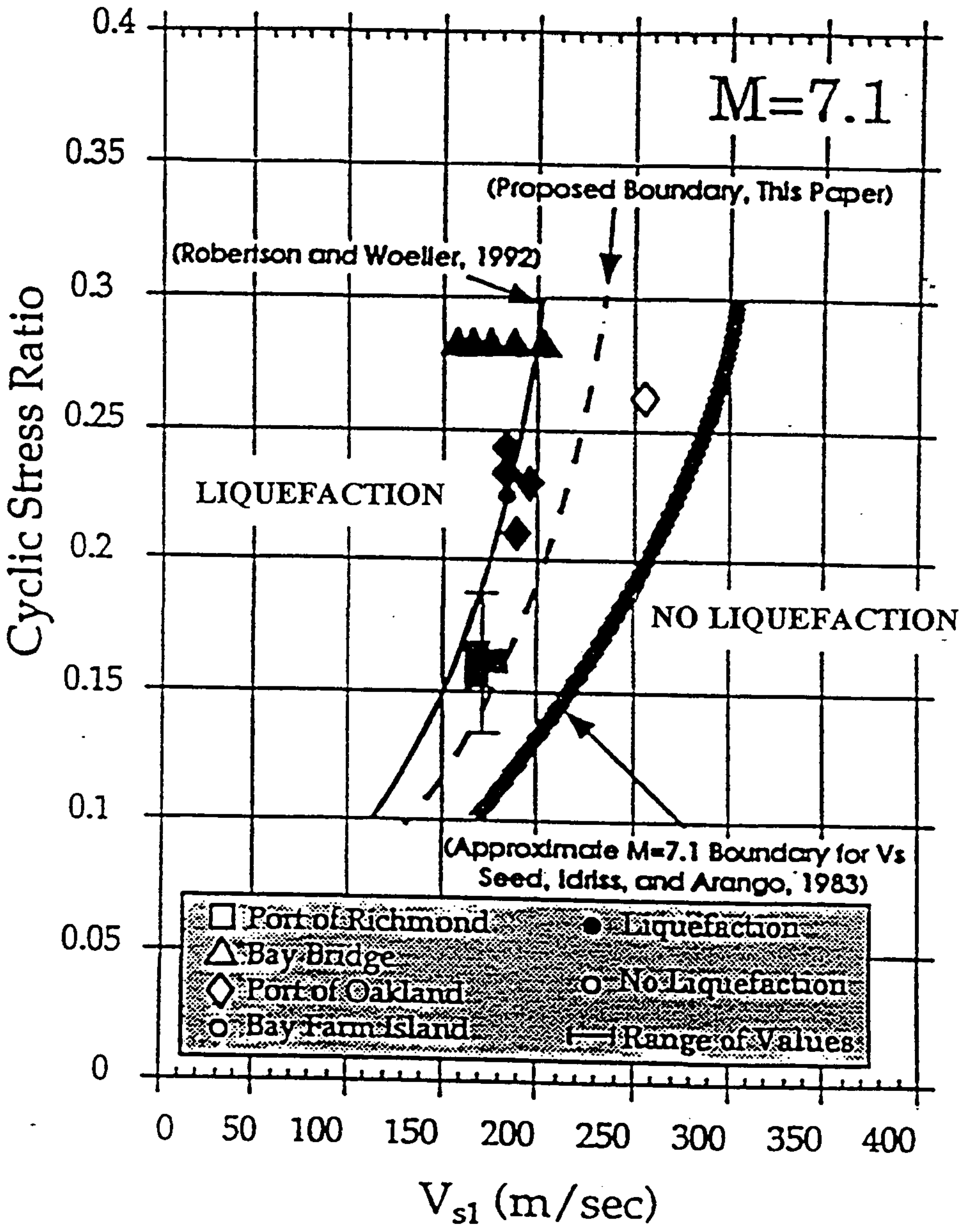


Ref.: Seed, Idriss, and Arango, (1983)

LEGEND

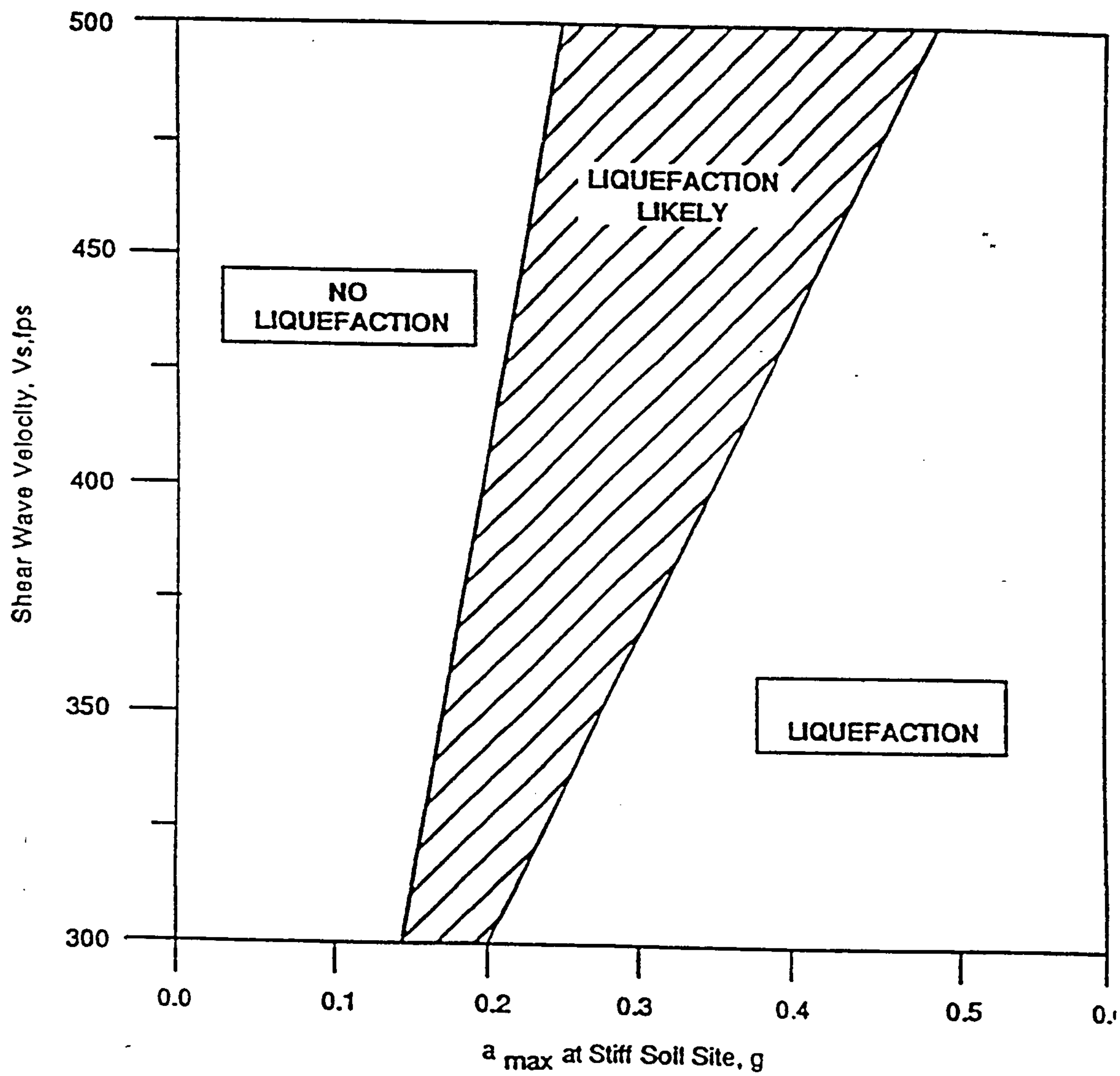
- ● Limits set by Chinese Code (1974)
- • Liquefaction
- o No Liquefaction

Figure 4.2-2 Correlation between Field Liquefaction of Sands, Penetration Resistance, and Shear Wave Velocity



Ref.: Kayen et al. (1992)

Figure 4.2-3 Correlation between Normalized Shear Wave Velocity and Cyclic Stress Ratio Causing Liquefaction



Ref.: Stokoe et al., (1988)

Figure 4.2-4 Liquefaction Potential Chart Based on Shear Wave Velocity of a Sand Layer and 20 Cycles of Strong Motion

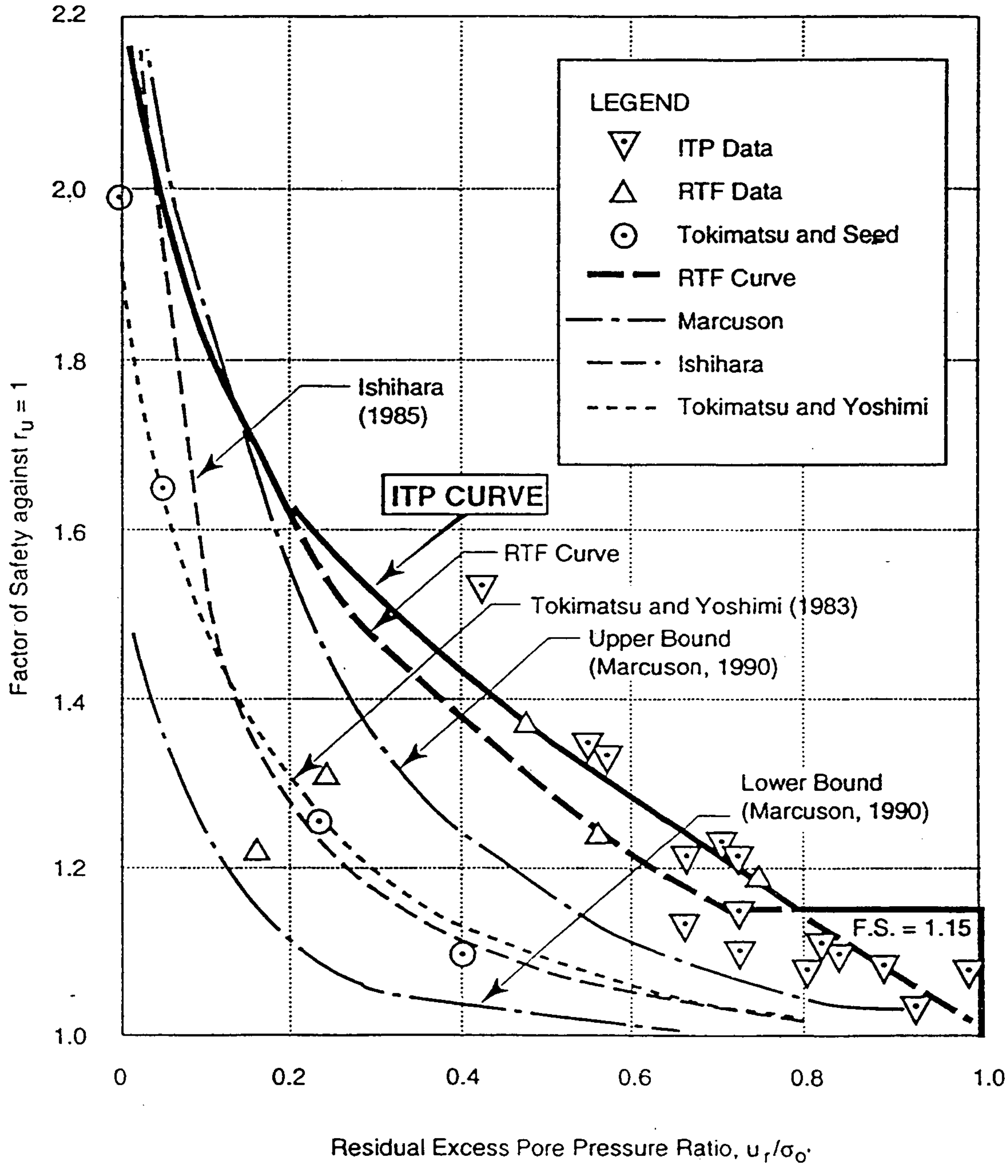


Figure 4.2-5 Relationship between Factor of Safety against Initial Liquefaction and Residual Excess Pore Water Pressure Ratio

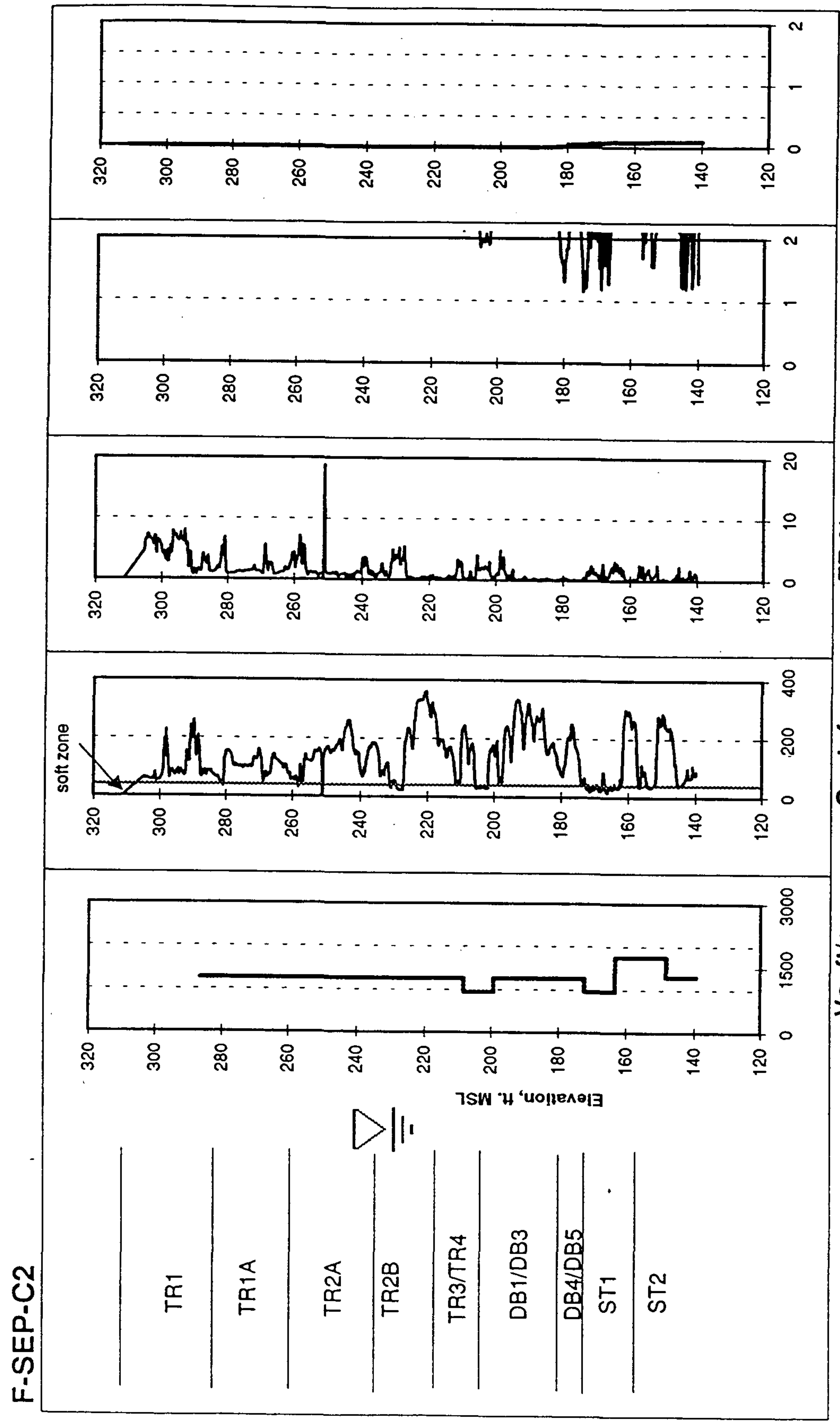


Figure 4.2-6 Results of the Liquefaction Analyses Performed for SCPTU Location F-SEP-C2

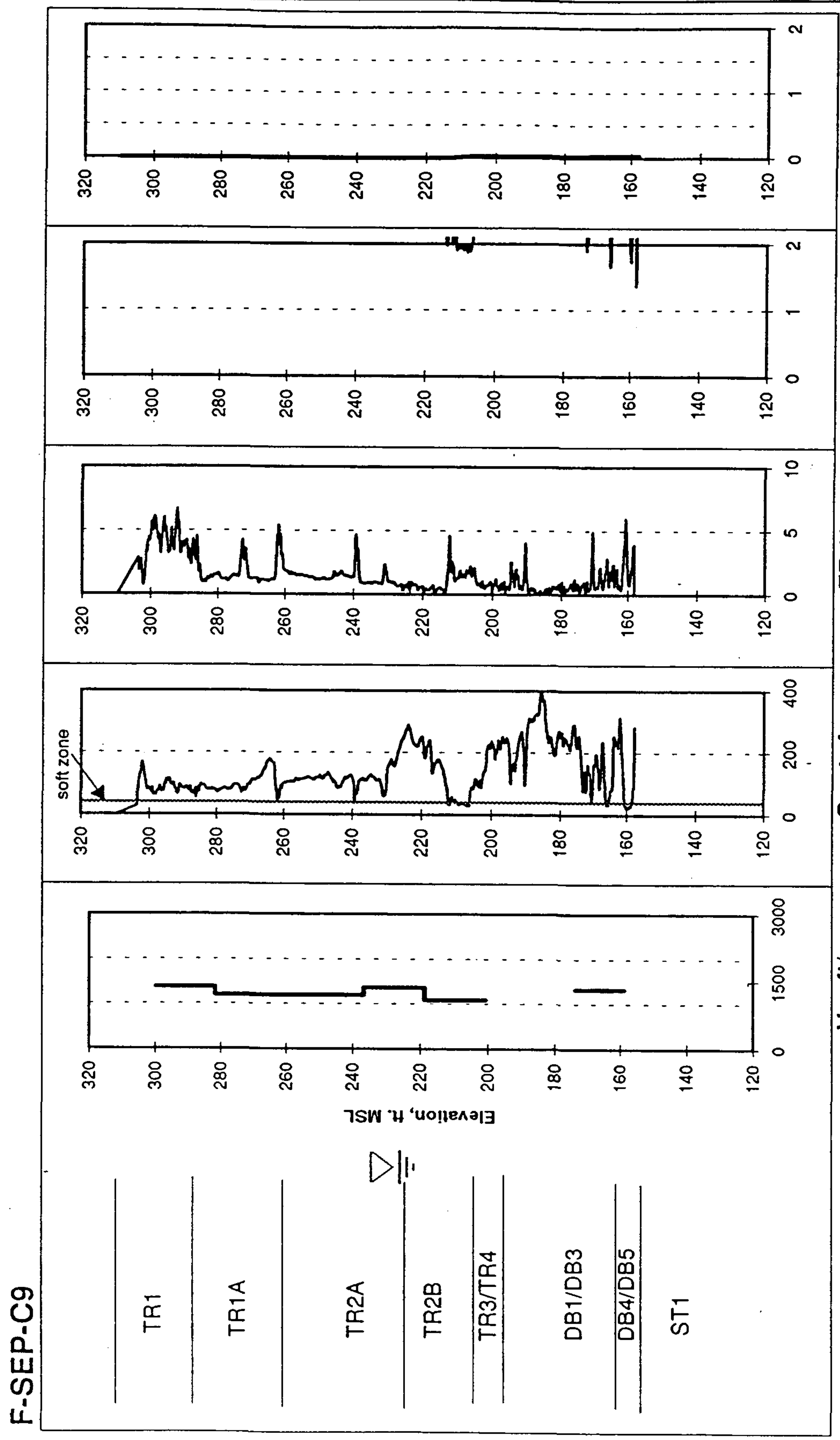


Figure 4.2-7 Results of the Liquefaction Analyses Performed for SCPTU Location F-SEP-C9

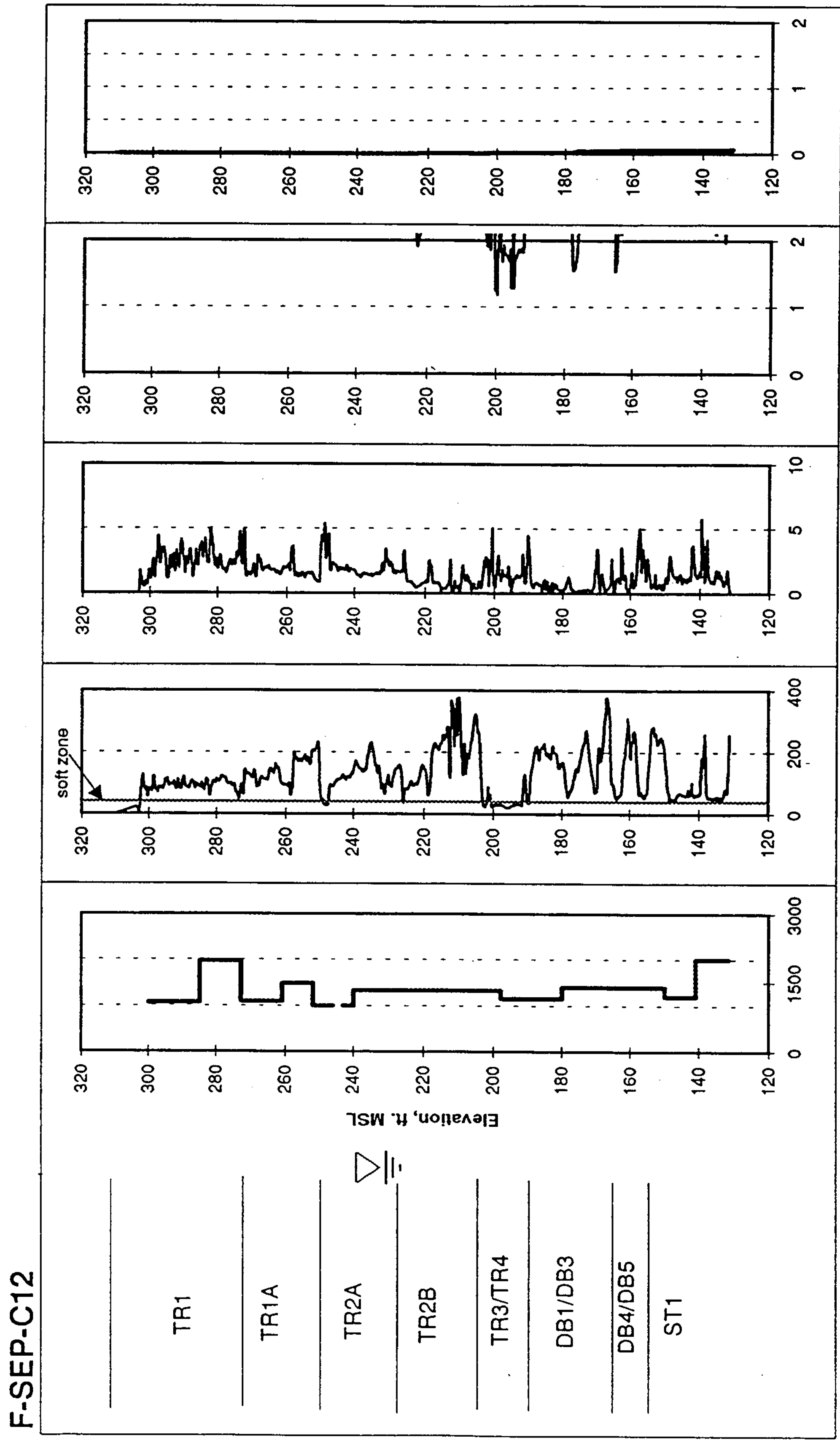


Figure 4.2-8 Results of the Liquefaction Analyses Performed for SCPTU Location F-SEP-C12

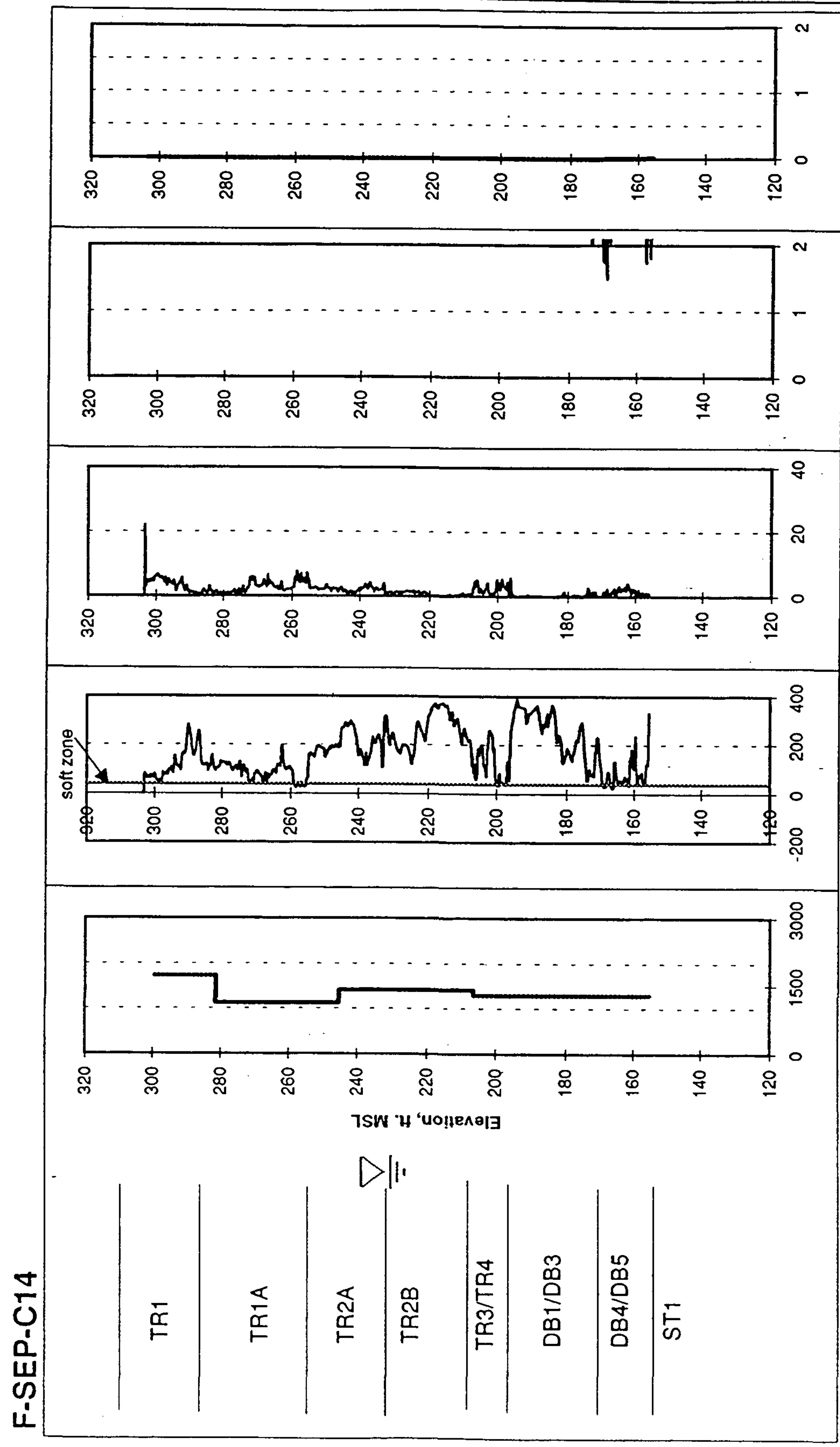


Figure 4.2-9 Results of the Liquefaction Analyses Performed for SCPTU Location F-SEP-C14

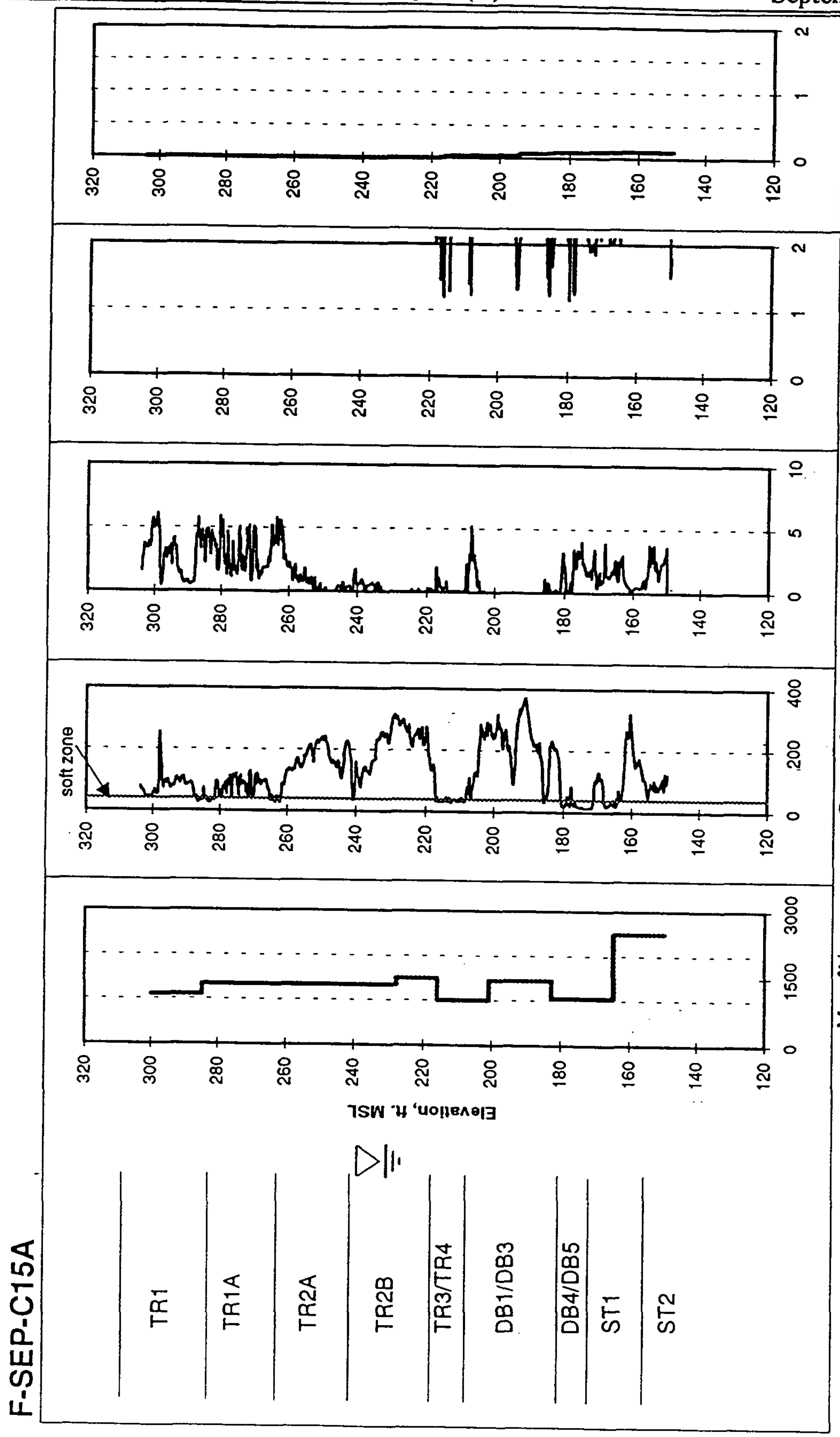


Figure 4.2-10 Results of the Liquefaction Analyses Performed for SCPTU Location F-SEP-C15A

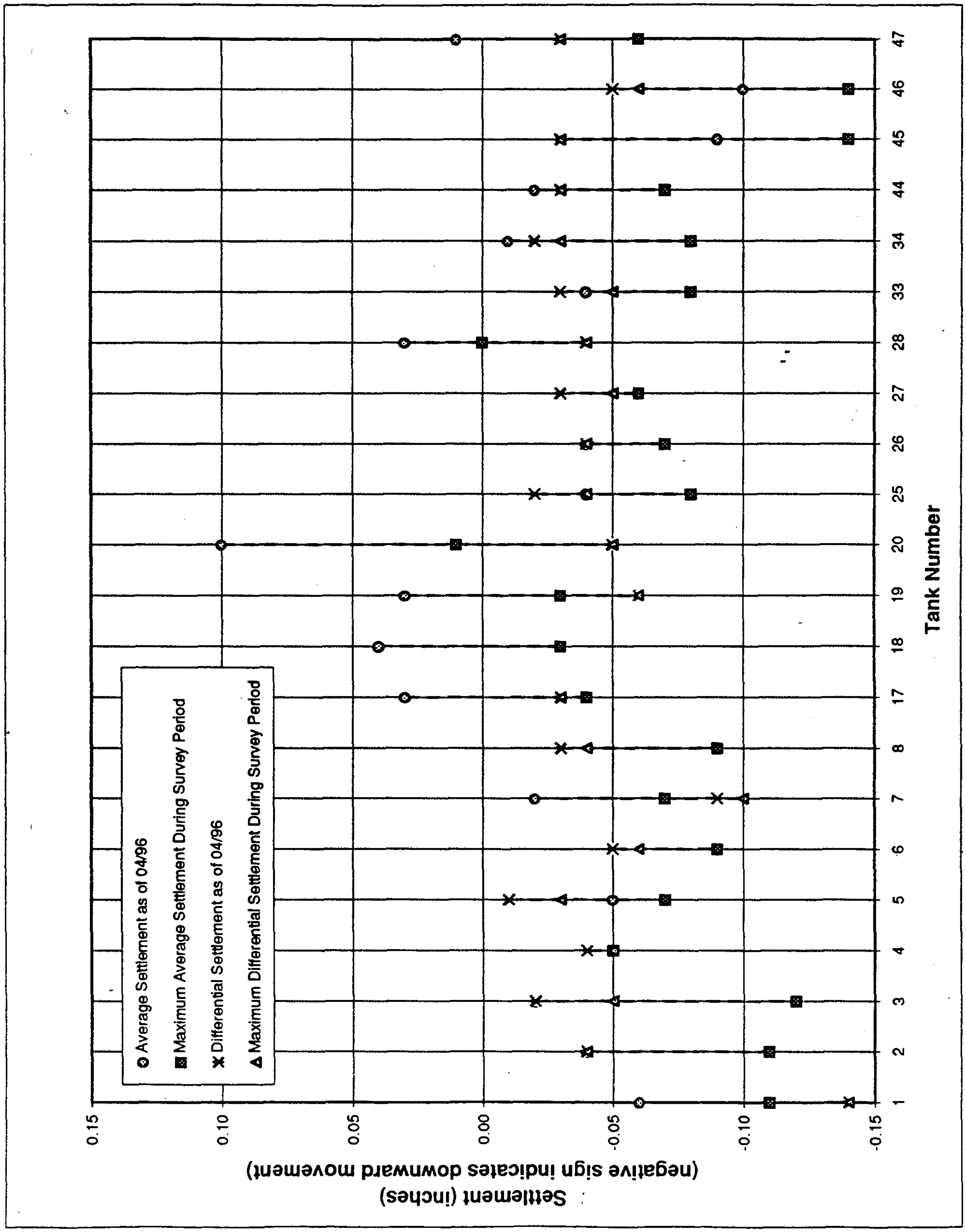


Figure 4.3-1 Settlement Magnitudes for F-Area Waste Storage Tanks

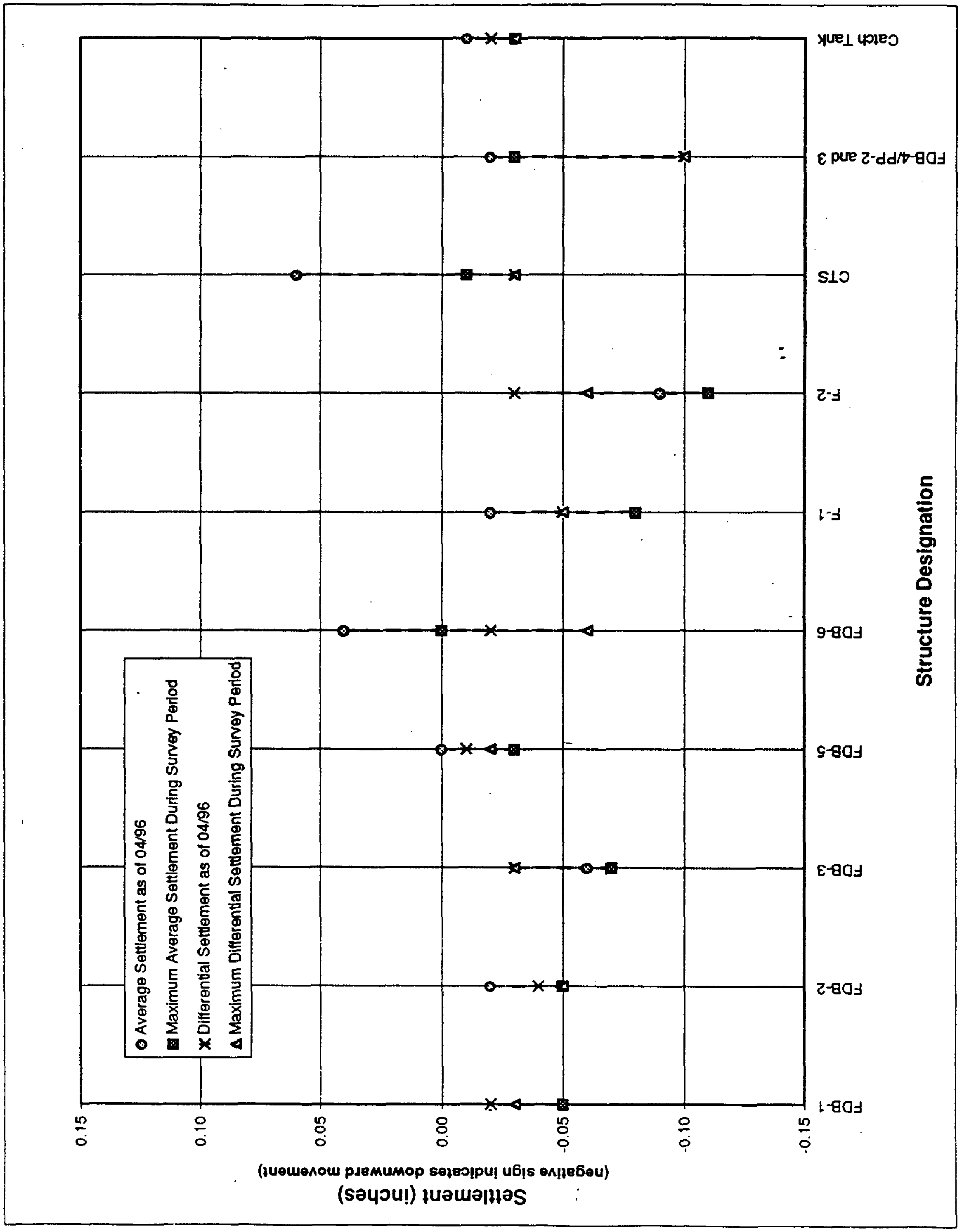


Figure 4.3-2 Settlement Magnitudes for F-Area Structures

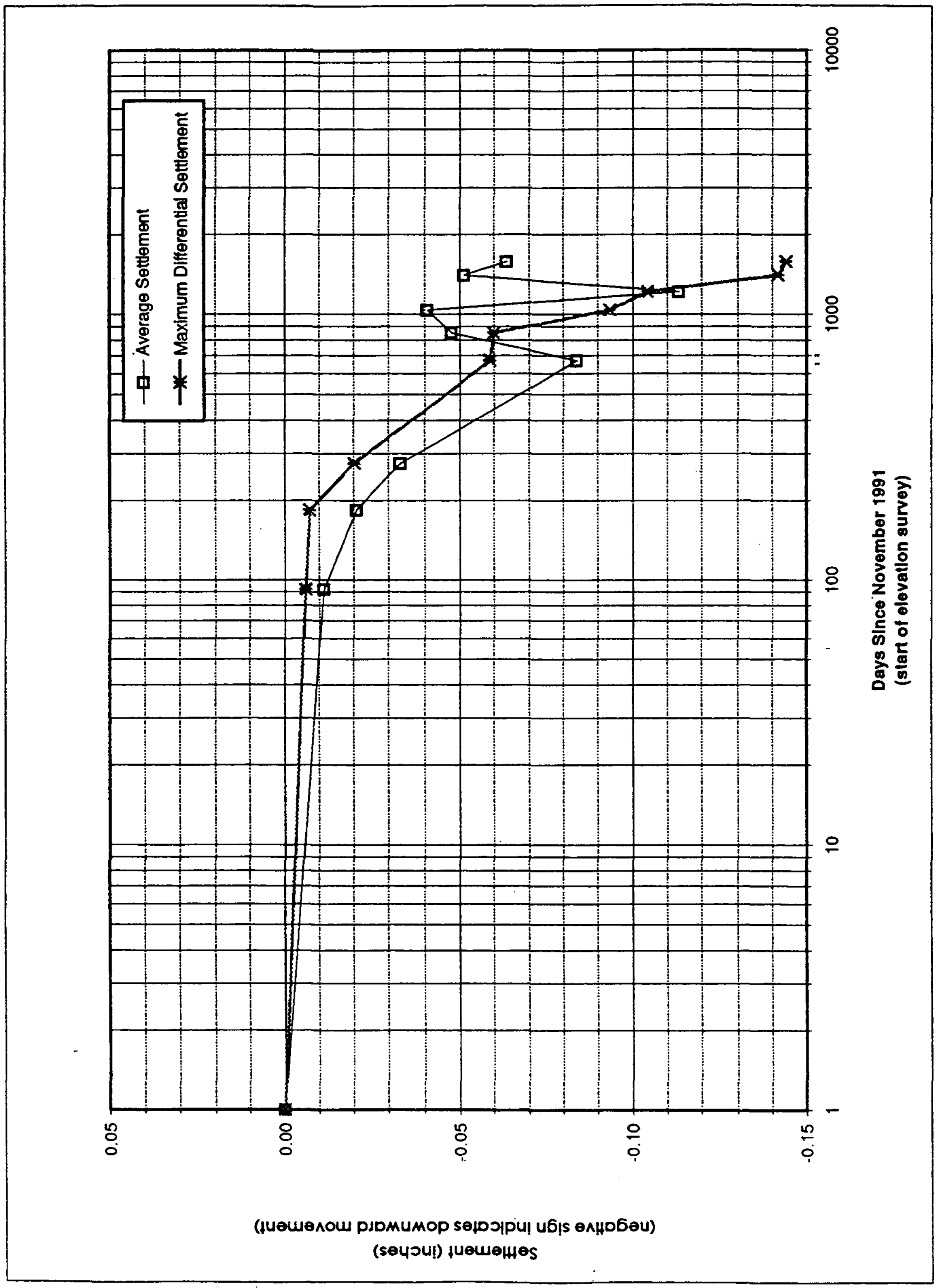


Figure 4.3-3 Log Time Versus Settlement Plot for Tank 1F

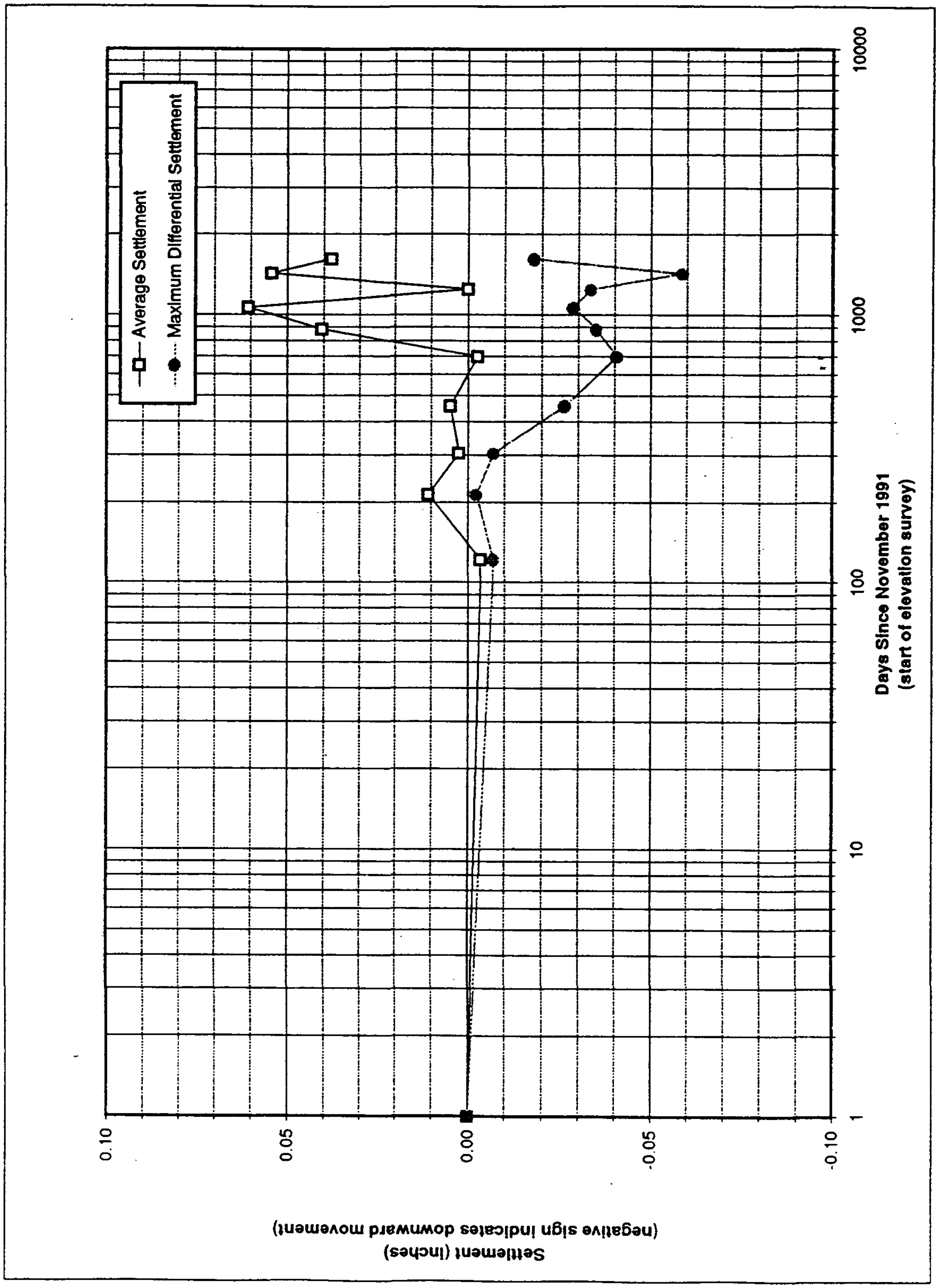


Figure 4.3-4 Log Time Versus Settlement Plot for FDB6 Structure

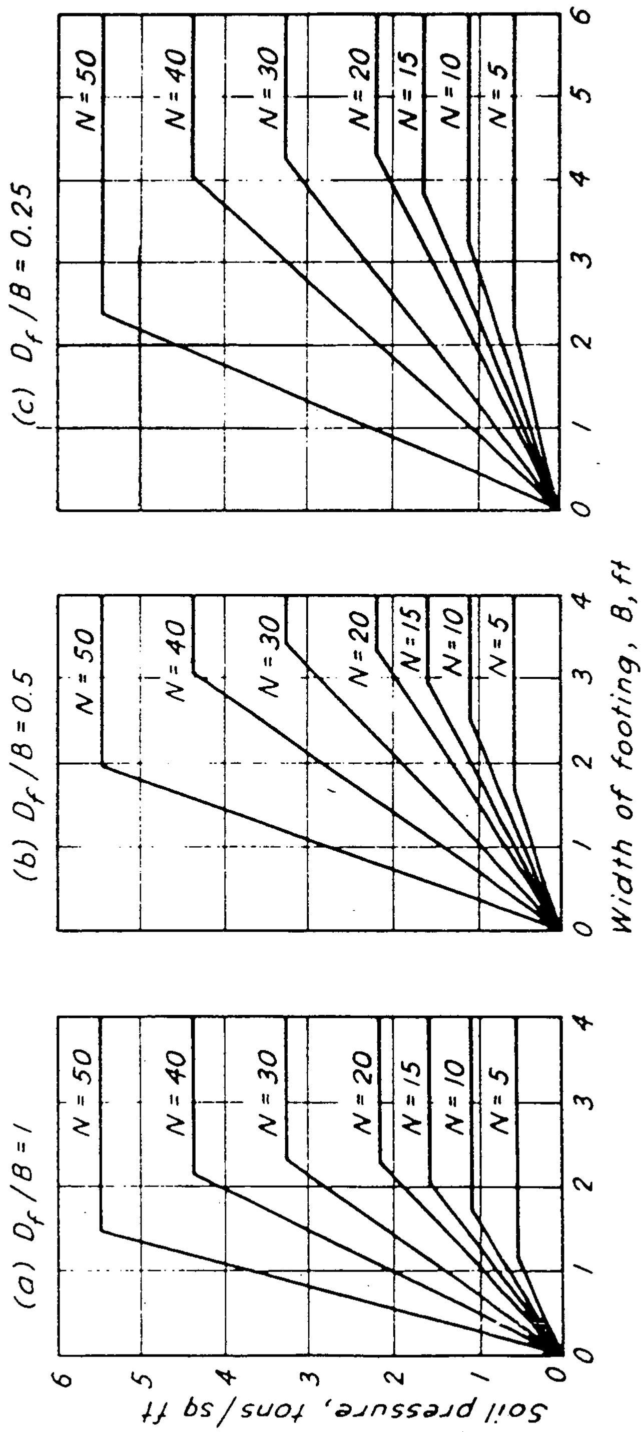


Figure 4.4-1 Design Chart for Proportioning Shallow Footings on Sand

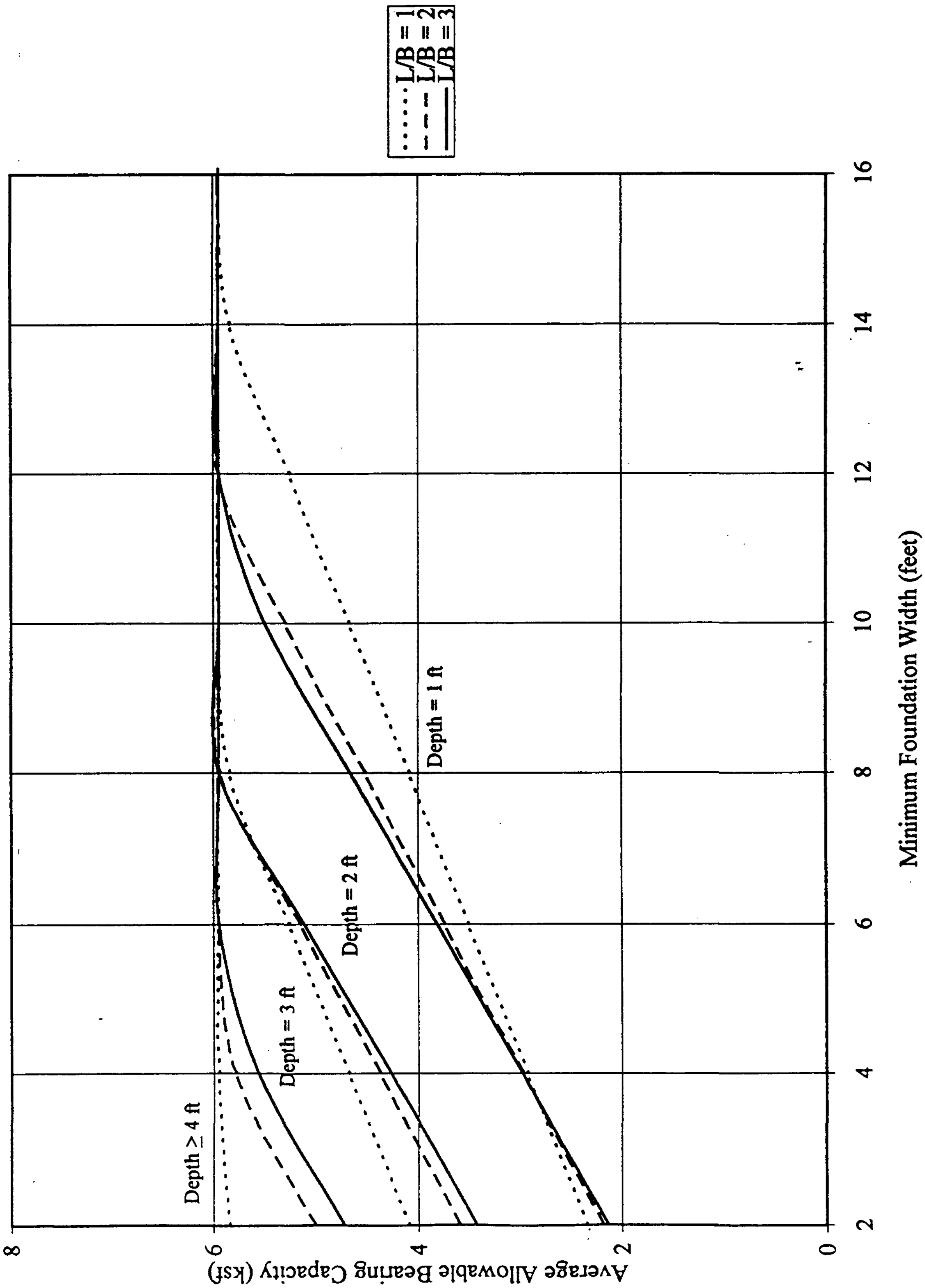


Figure 4.4-2 Average Bearing Capacities for Rectangular Foundations in F-Separations

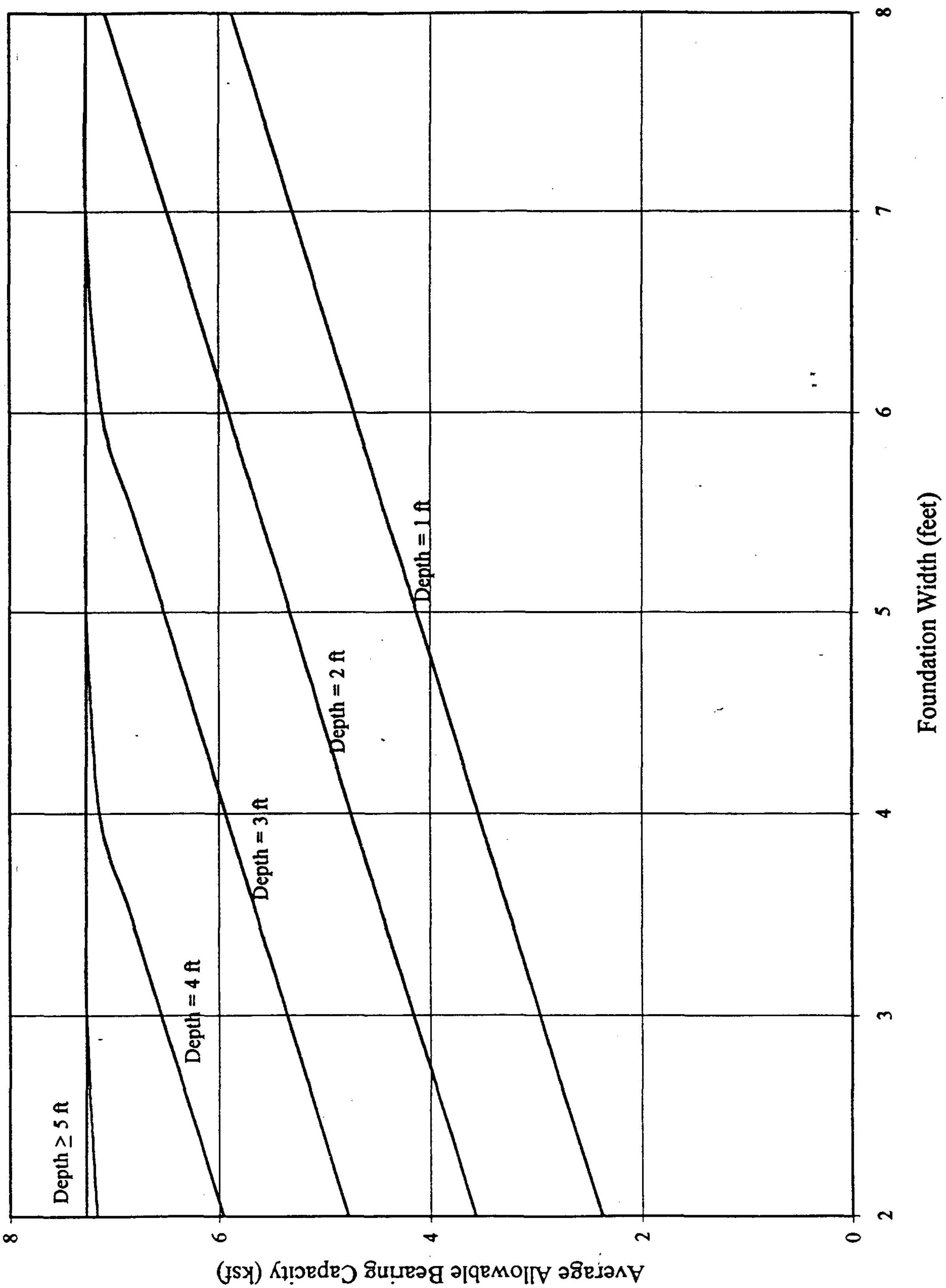


Figure 4.4-3 Average Bearing Capacities for Strip Foundations in F-Separations

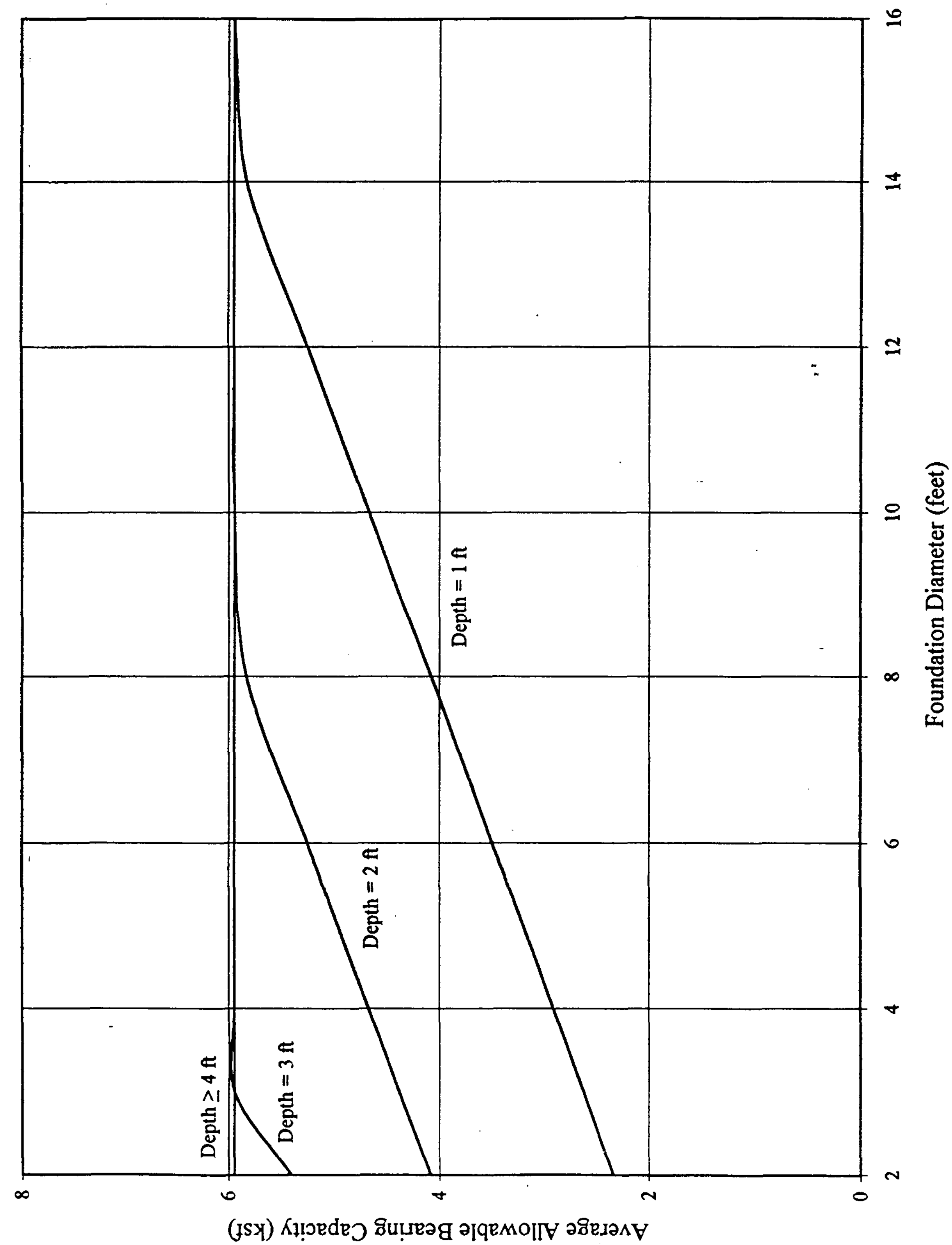


Figure 4.4-4 Average Bearing Capacities for Circular Foundations in F-Separations

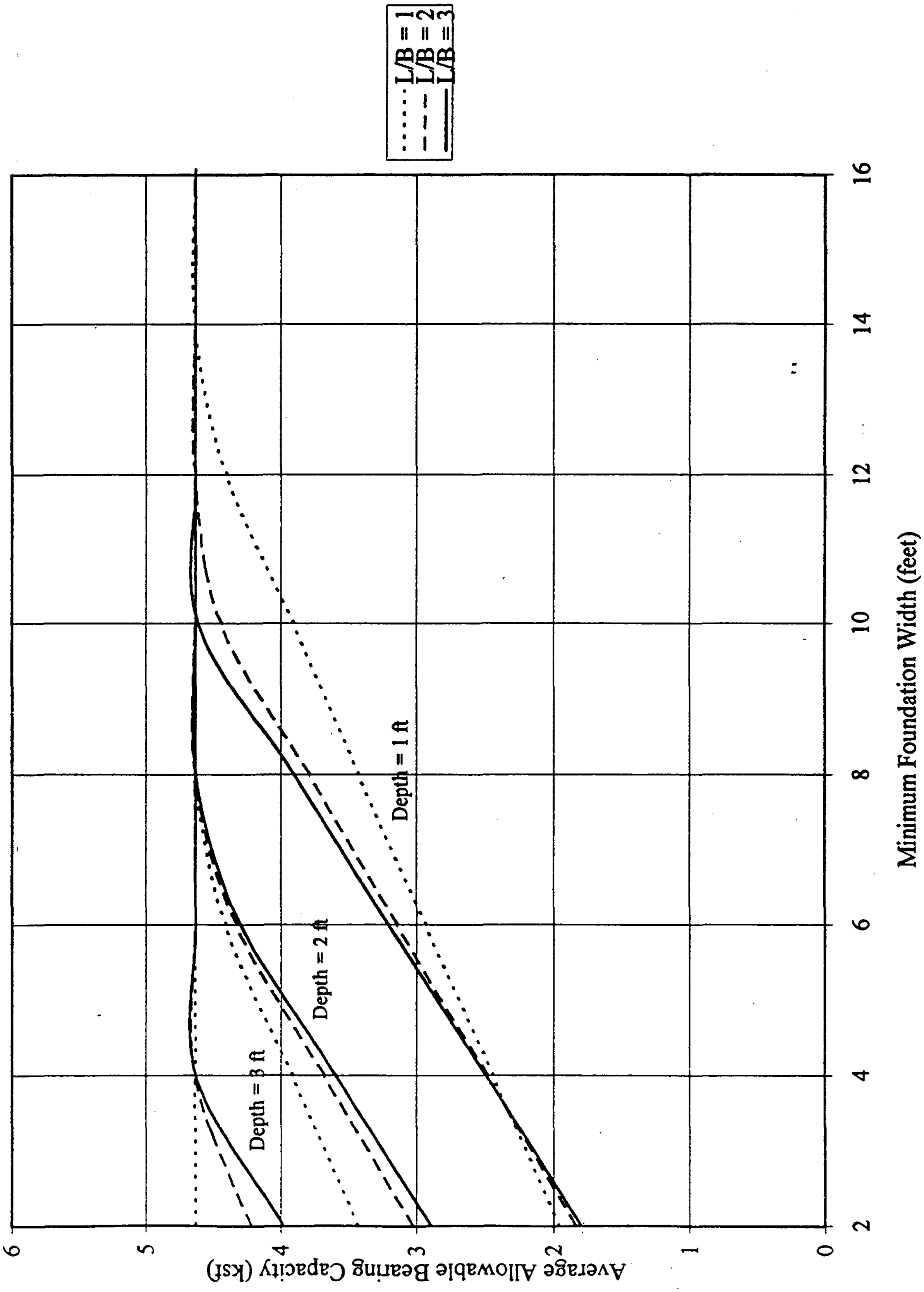


Figure 4.4-5 Average Bearing Capacities for Rectangular Foundations in F-Tank Farm

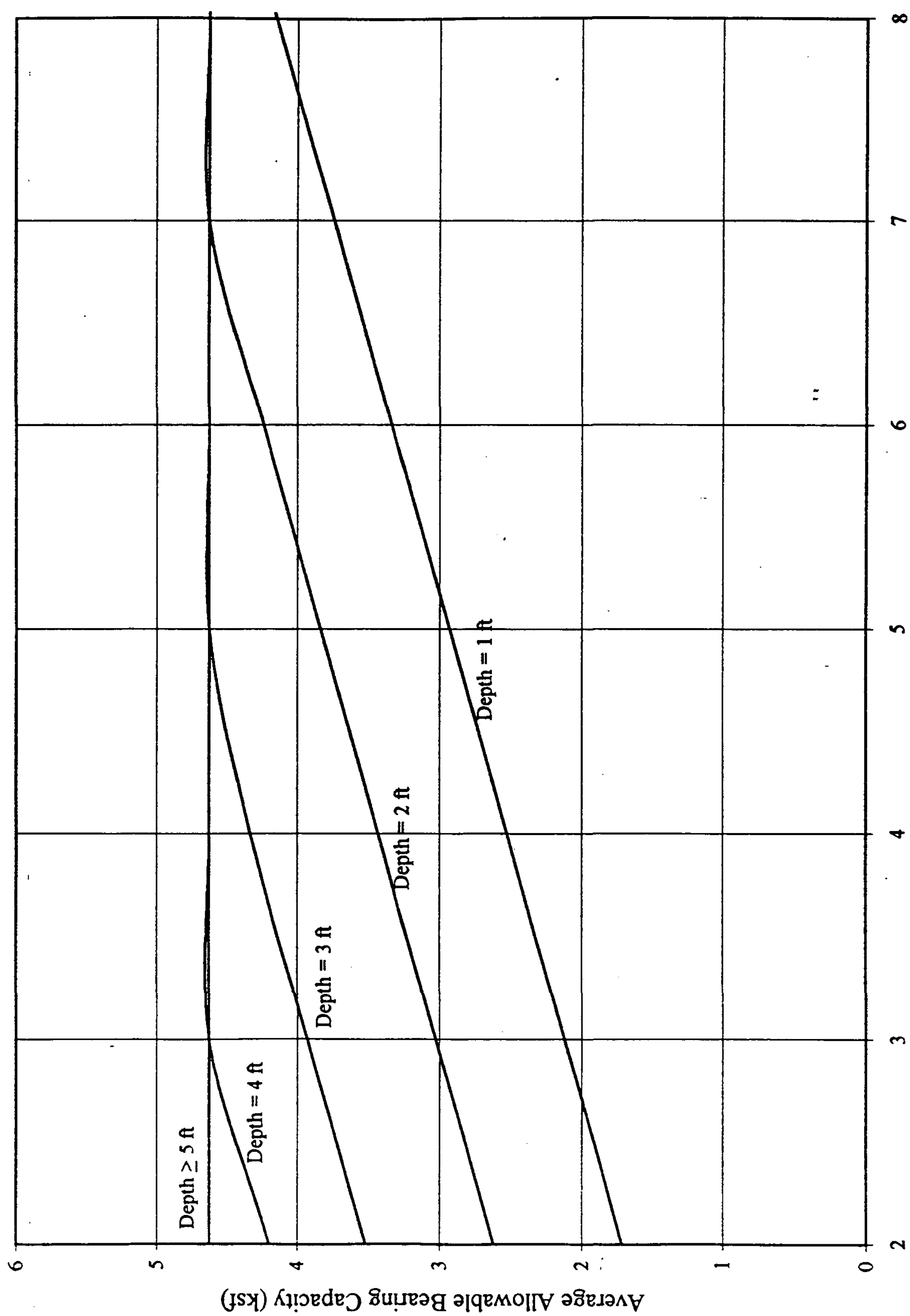


Figure 4.4-6 Average Bearing Capacities for Strip Foundations in F-Tank Farm

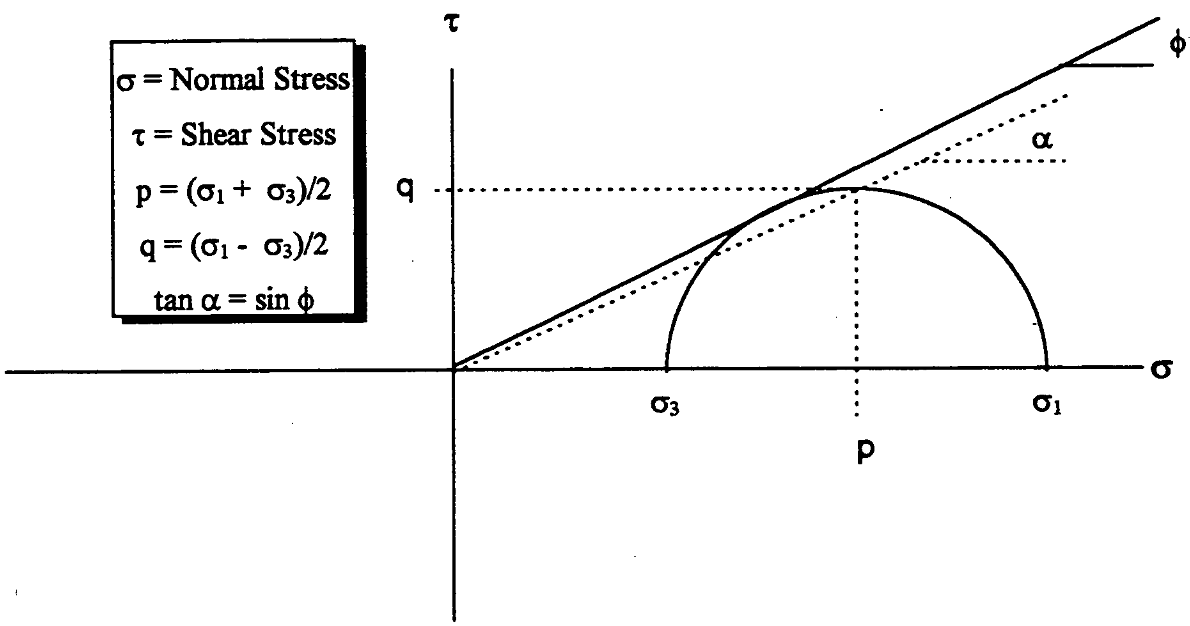


Figure 4.6-1 Mohr's Cycle at Soil Failure

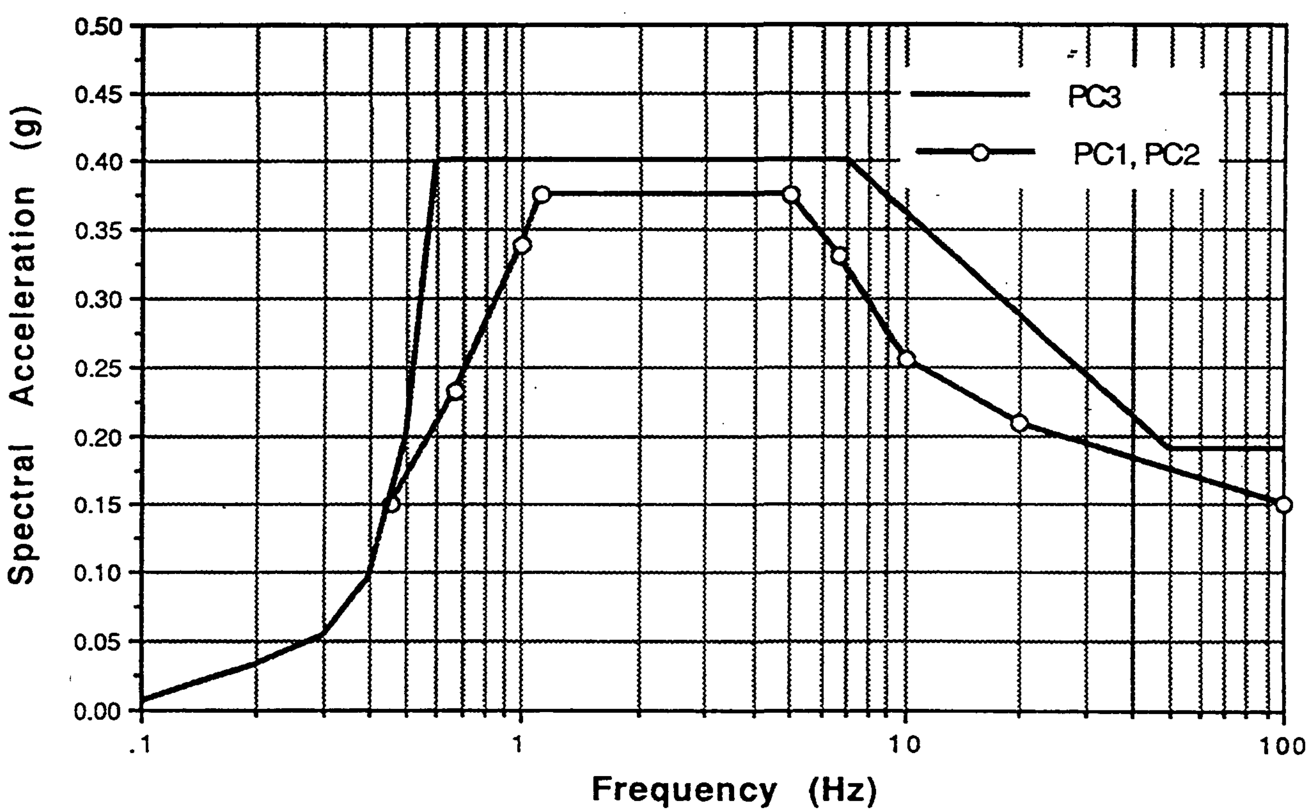


Figure B-1 Interim Site Spectra, Horizontal 5% Damping

AGE			UNIT	LITHOLOGY
TERTIARY	Miocene(?)		"upland unit"	Clayey, silty sands, conglomerates, pebbly sands, and clays; clay clasts common.
	—36.6mya			
TERTIARY	Late Eocene	Barnwell Group	Tobacco Road Sand	Red, purple, and orange, poorly to well-sorted sand and clayey sand with abundant clay laminae.
TERTIARY	Late Eocene	Barnwell Group	Dry Branch Formation	Tan, yellow, and orange, poorly to well-sorted sand with tan and gray clay layers near base; calcareous sands and clays and limestone in lower part downdip.
TERTIARY	Late Eocene	Barnwell Group	Clinchfield Formation	Biomoldic limestone, calcareous sand and clay, and tan and yellow sand.
TERTIARY	Middle Eocene		Santee Limestone Tinker/McBean/ Blue Bluff	Micritic, calcarenitic, shelly limestone, and calcareous sands; interbedded yellow and tan sands and clays; green clay and glauconitic sand near base.
TERTIARY	Middle Eocene		Warley Hill Formation	Muddy quartz sand, fines upwards to a clay. Dark grn and glauc. in places. Also brn,tan,yellow.
TERTIARY	Early Eocene		Congaree Formation	Yellow, orange, tan, and greenish-gray, fine to coarse, well-sorted sand; thin clay laminae common.
TERTIARY	Early Eocene		Fishburne/Fourmile Br	
	—57.8mya			
TERTIARY	Paleocene		Williamsburg Fm.	Light gray, silty sand interbedded with gray clay.
TERTIARY	Paleocene		Ellenton (Lang Syne) Formation (Sawdust Landing)	Black and gray, lignitic, pyritic sand and interbedded clays with silt and sand laminae.
	— 66.4mya			
LATE CRETACEOUS	Maestrichtian	Lumbee Group	Steel Creek Formation (Peedee)	Gray and tan, slightly to moderately clayey sand; gray, red, purple, and orange clays common in upper part.
LATE CRETACEOUS	Campanian	Lumbee Group	Black Creek Formation	Tan and light to dark gray sand; dark clays common in middle and oxidized clays at top.
LATE CRETACEOUS	Santonian	Lumbee Group	Middendorf Formation	Tan and gray, slightly to moderately clayey sand; gray, red, and purple clays near top.
LATE CRETACEOUS	Santonian		Cape Fear Formation	Gray, clayey sand with some conglomerates, and sandy clay; moderately to well indurated.
LATE TRIASSIC			Newark Supergroup	Boulder conglomerate, red, arkosic, poorly sorted sandstone and red shale.
PALEOZOIC and CRYPTOZOIC (?)			"crystallines"	Biotite gneiss, mica schist, amphibolite, chlorite schist, and granitoid rocks.

Lithology and ages of the stratigraphic units recognized in 1989 at SRS.
Currently in revision from Fallaw and Price (1992, 1995).

Figure C-1 Stratigraphic Column for Savannah River Site