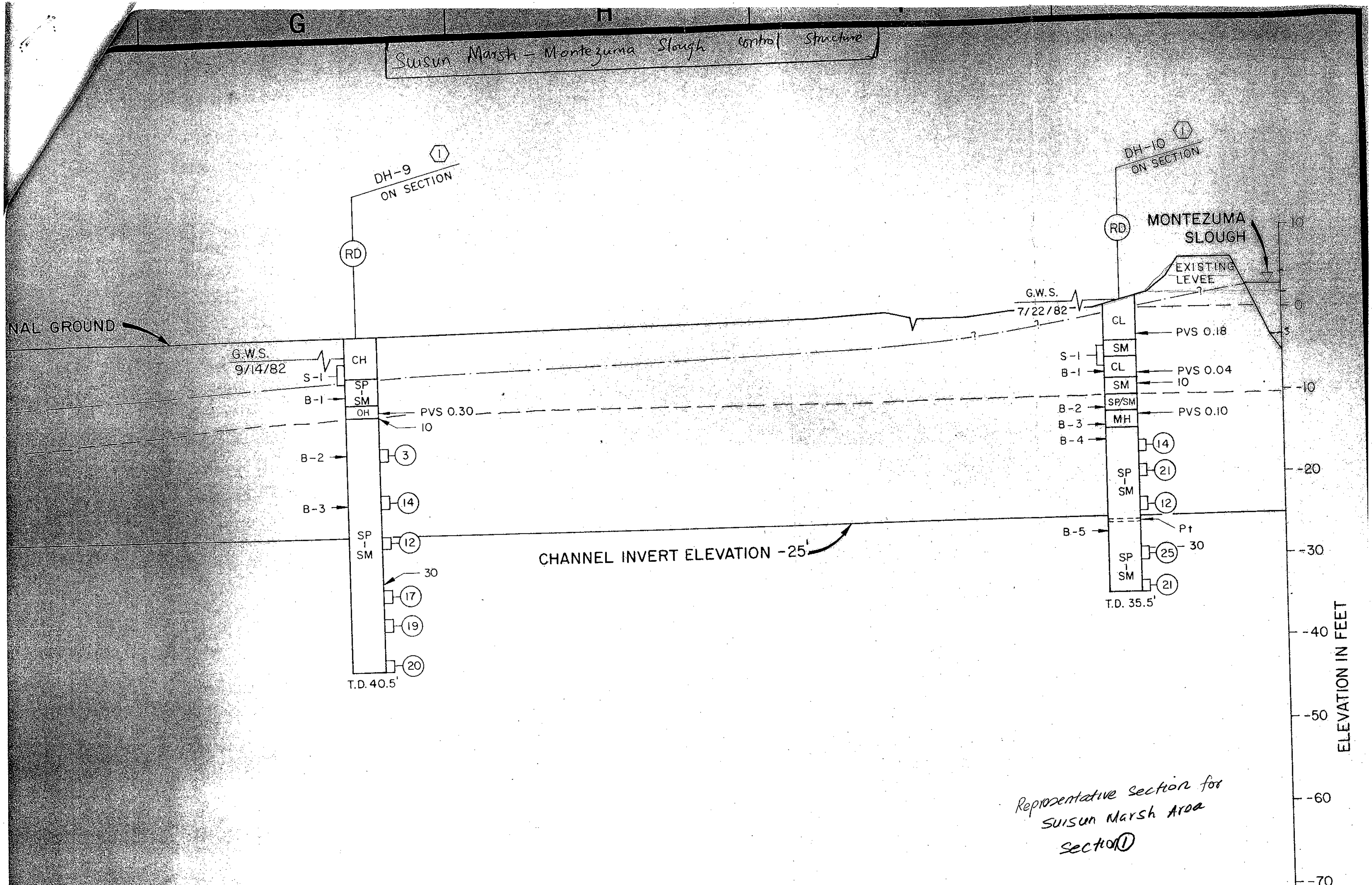
Appendix A
Available Cross Sections

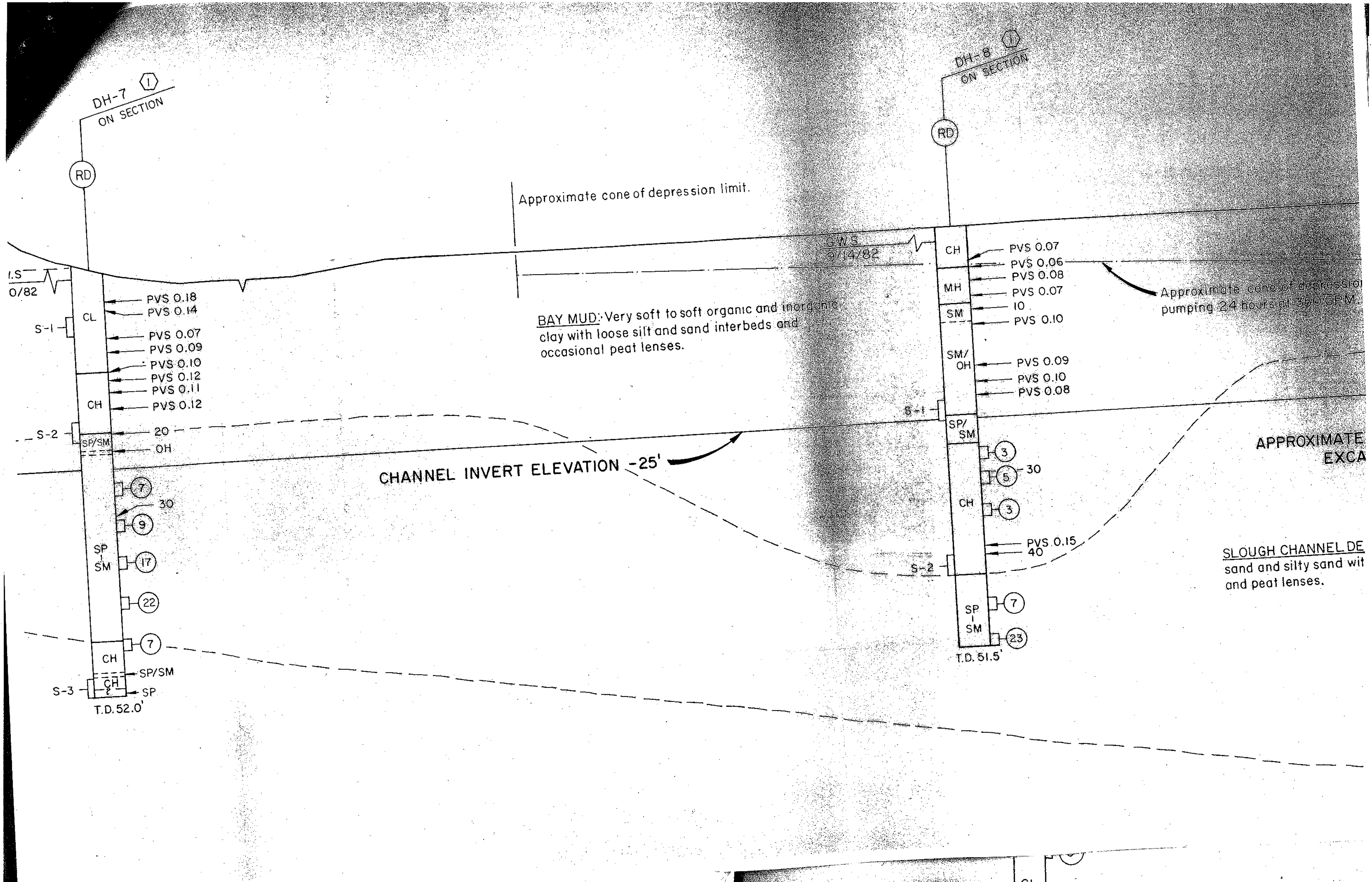
Index

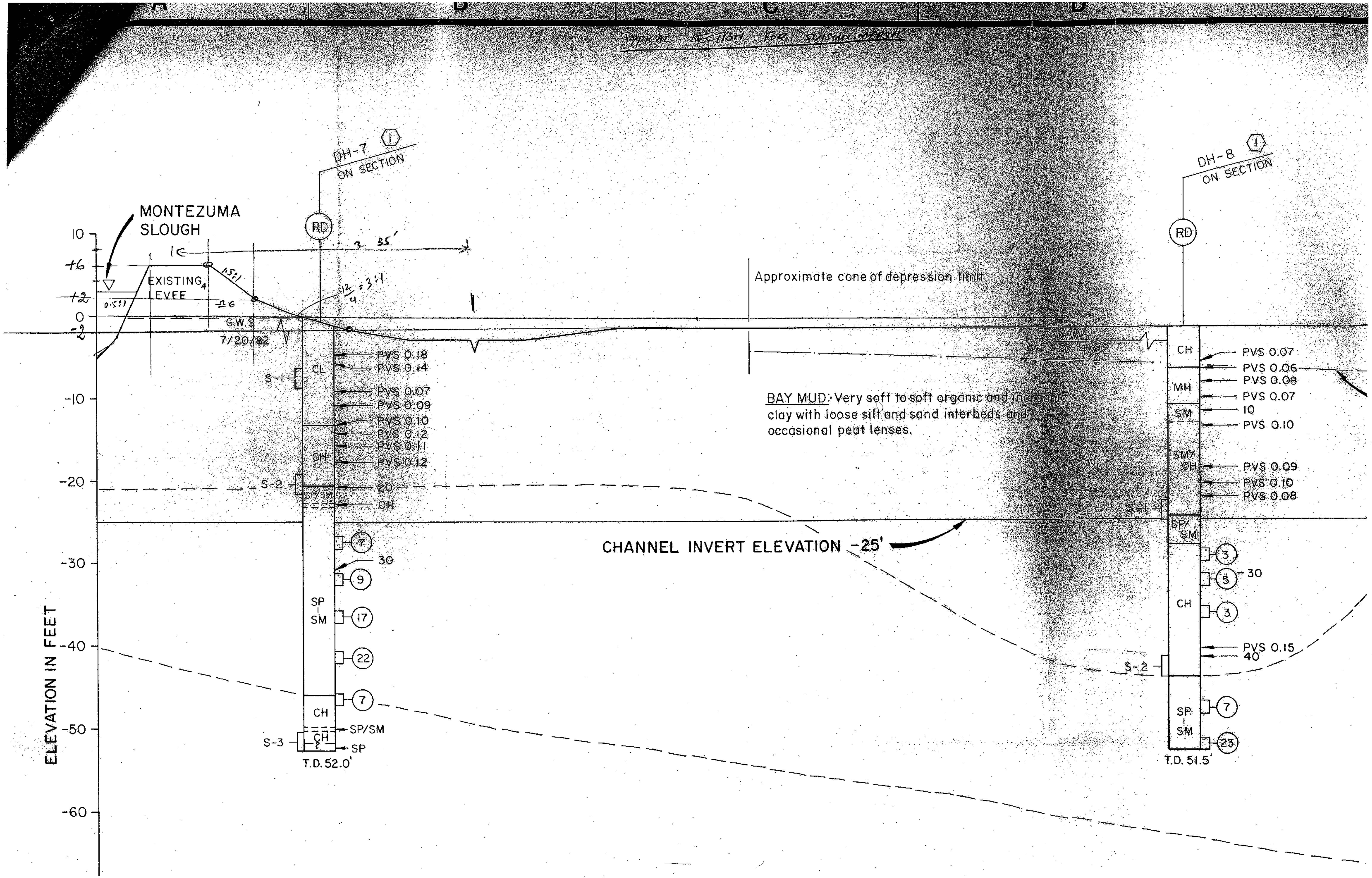
1. **Section discussed in Section 4.0**
2. **Other available cross sections**

Suisun Marsh - Montezuma Slough Control Structure



Representative Section for Suisun Marsh Area Section 1


DH-7 ON SECTION 1
RD
W.S 0/82
S-1
CL
PVS 0.18
PVS 0.14
PVS 0.07
PVS 0.09
PVS 0.10
PVS 0.12
PVS 0.11
CH
PVS 0.12
S-2
20
SP/SM
OH
30
SP SM
CH
SP/SM
S-3
CH
SP
T.D. 52.0'
Approximate cone of depression limit.
BAY MUD: Very soft to soft organic and inorganic clay with loose silt and sand interbeds and occasional peat lenses.
CHANNEL INVERT ELEVATION -25'
DH-8 ON SECTION 1
RD
G.W.S. 9/14/82
CH
PVS 0.07
PVS 0.06
MH
PVS 0.08
PVS 0.07
SM
10
PVS 0.10
SM/OH
PVS 0.09
PVS 0.10
PVS 0.08
S-1
SP/SM
30
CH
PVS 0.15
40
S-2
SP SM
T.D. 51.5'
Approximate cone of depressio pumping 24 hours at 350 GPM.
APPROXIMATE EXCA
SLOUGH CHANNEL DE
sand and silty sand wit
and peat lenses.
CL

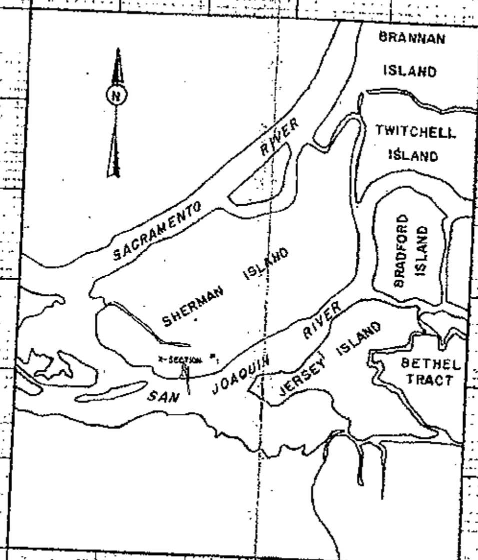


TYPICAL SECTION FOR SUISUN MARSH
DH-7
ON SECTION
DH-8
ON SECTION
RD
MONTEZUMA SLOUGH
EXISTING LEVEE
G.W.S. 7/20/82
G.W.S. 9/14/82
Approximate cone of depression limit
BAY MUD: Very soft to soft organic and inorganic clay with loose silt and sand interbeds and occasional peat lenses.
CHANNEL INVERT ELEVATION -25'
PVS 0.18
PVS 0.14
PVS 0.07
PVS 0.09
PVS 0.10
PVS 0.12
PVS 0.11
PVS 0.12
CL
CH
SP/SM
OH
SP SM
T.D. 52.0'
T.D. 51.5'
MH
SM
SM/OH
PVS 0.07
PVS 0.06
PVS 0.08
PVS 0.15
ELEVATION IN FEET
10
0
-10
-20
-30
-40
-50
-60

NOTES:

GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION
ALL BORINGS ARE ONE INCH DIAMETER EXCEPT WHERE NOTED
HAMMER WEIGHT: 140 LBS.
DRILLING DATES: 1" HOLES - JULY 1, 1957 TO JULY 10, 1957
2" HOLES - AUGUST 9, 1957 TO SEPTEMBER 3, 1957

20
10
0 Mean Sea Level
10
20
30
40
50
60
70
80
90
100
110
120
130
140



LOCATION MAP

LEGEND

BLOWS PER FOOT (P INDICATES PUSH, W INDICATES WASH)

DRY (WET) DENSITY IN POUNDS PER CUBIC FOOT

UNCONFINED COMPRESSIVE STRENGTH K_c Kg/cm²

UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, S_{10} Kg/cm²

LOSS ON IGNITION IN PERCENT

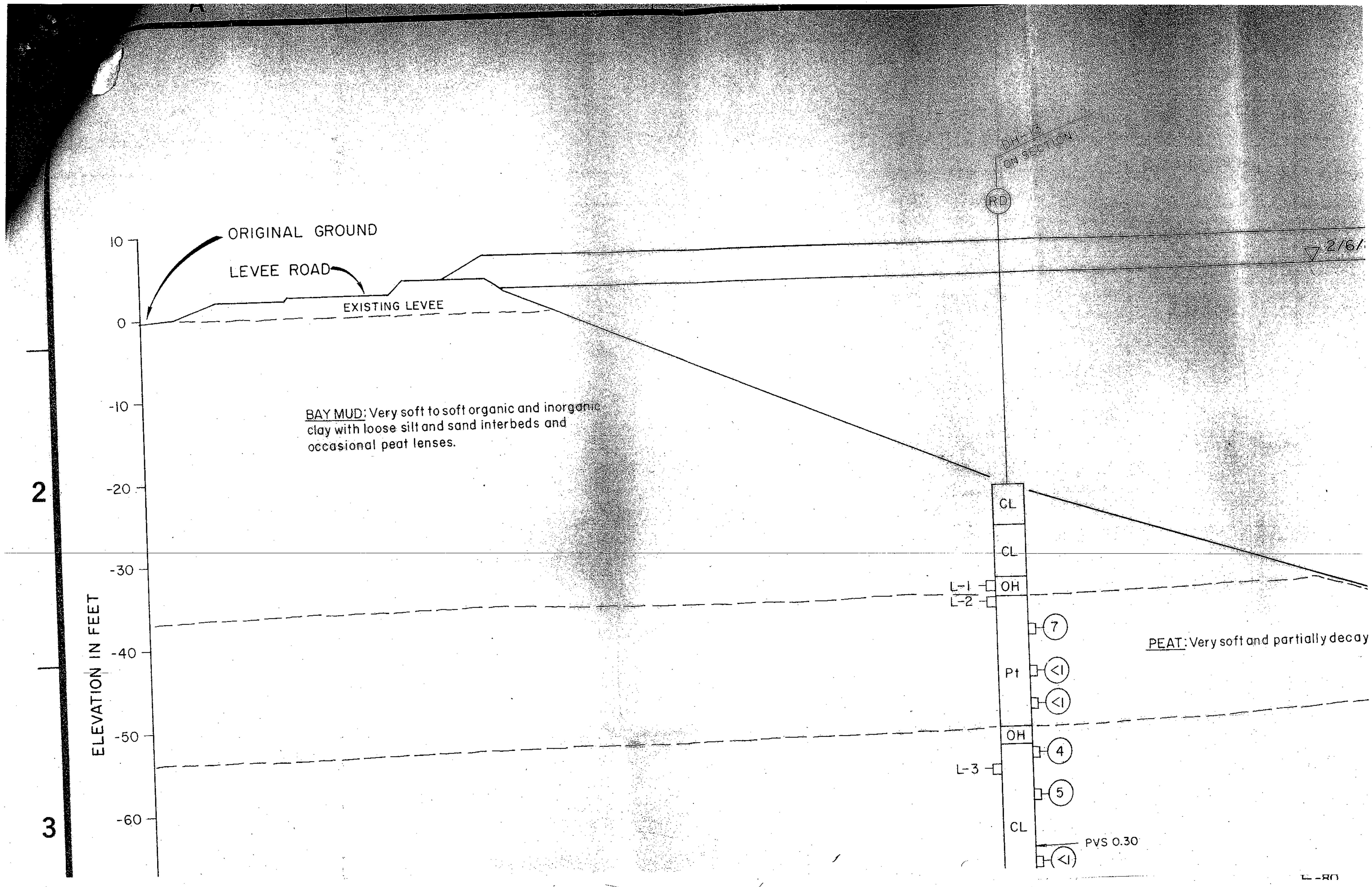
MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D_{50}

SPECIFIC GRAVITY

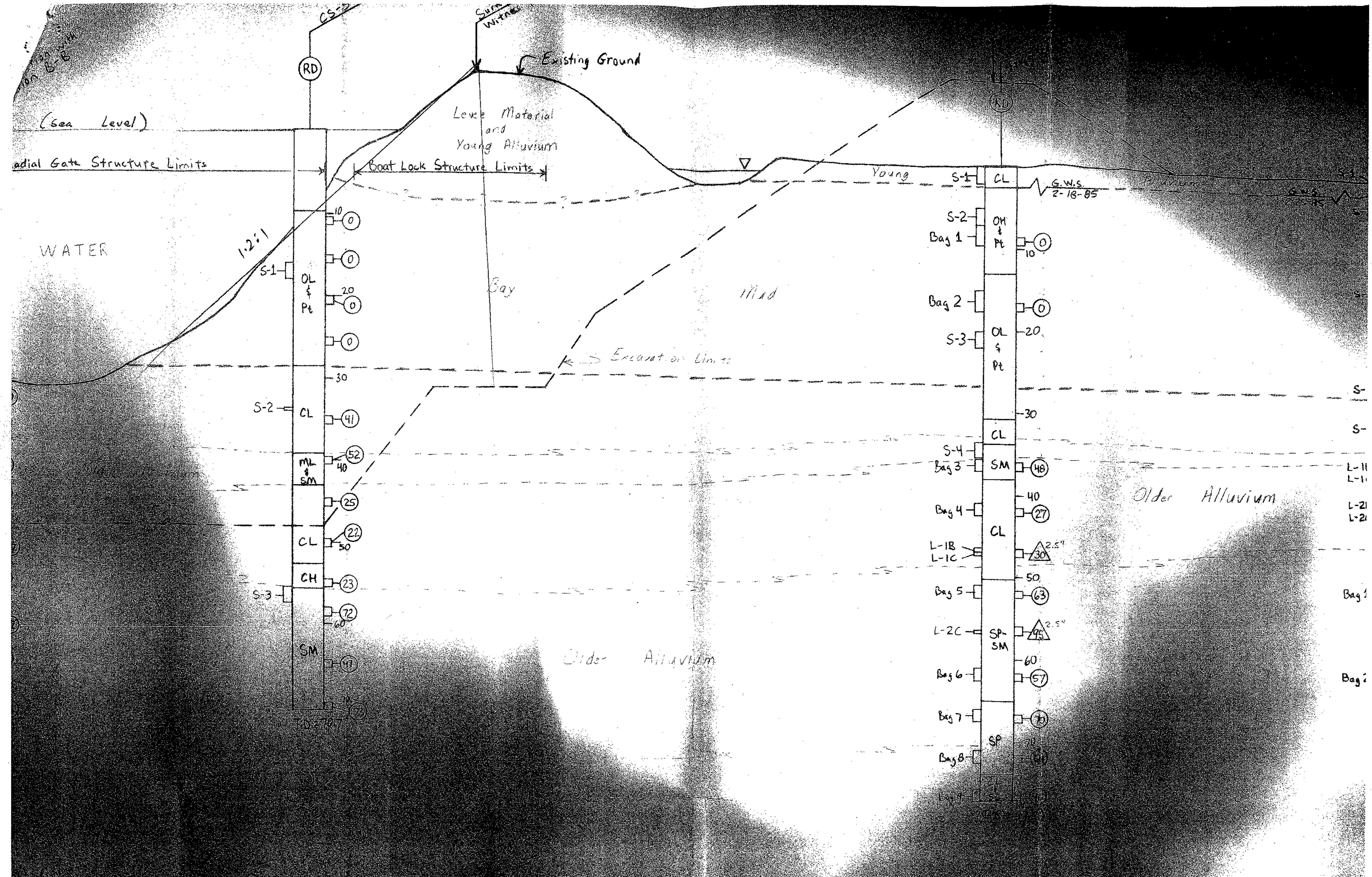
SILT
PEAT
CLAY
SAND
ORGANIC SILT
ORGANIC CLAY
SILTY PEAT
SILTY CLAY
SILTY SAND
SAND WITH SILT LENSES

SHERMAN ISLAND CROSS SECTION NO. 1

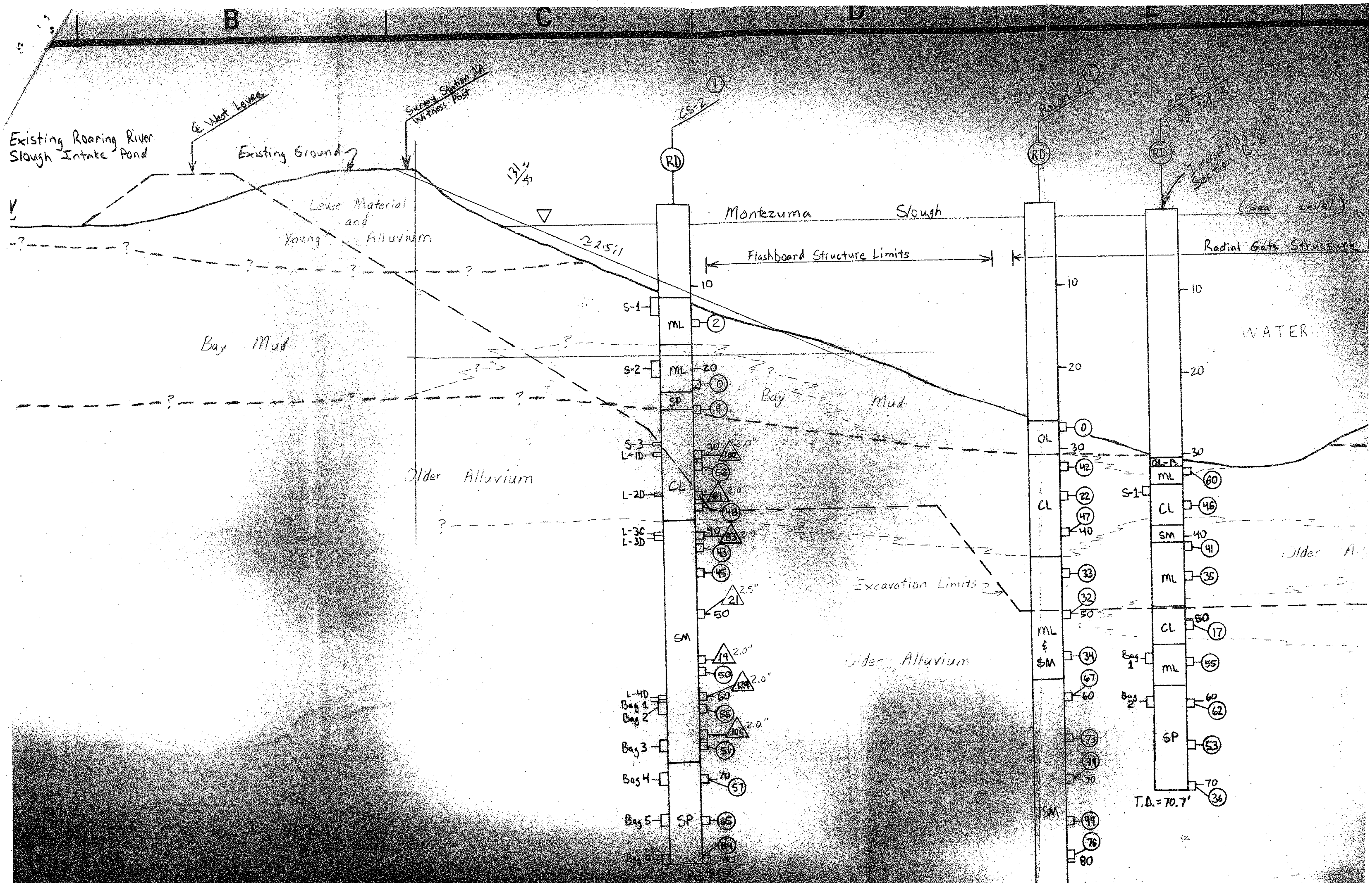
SECTION (2)



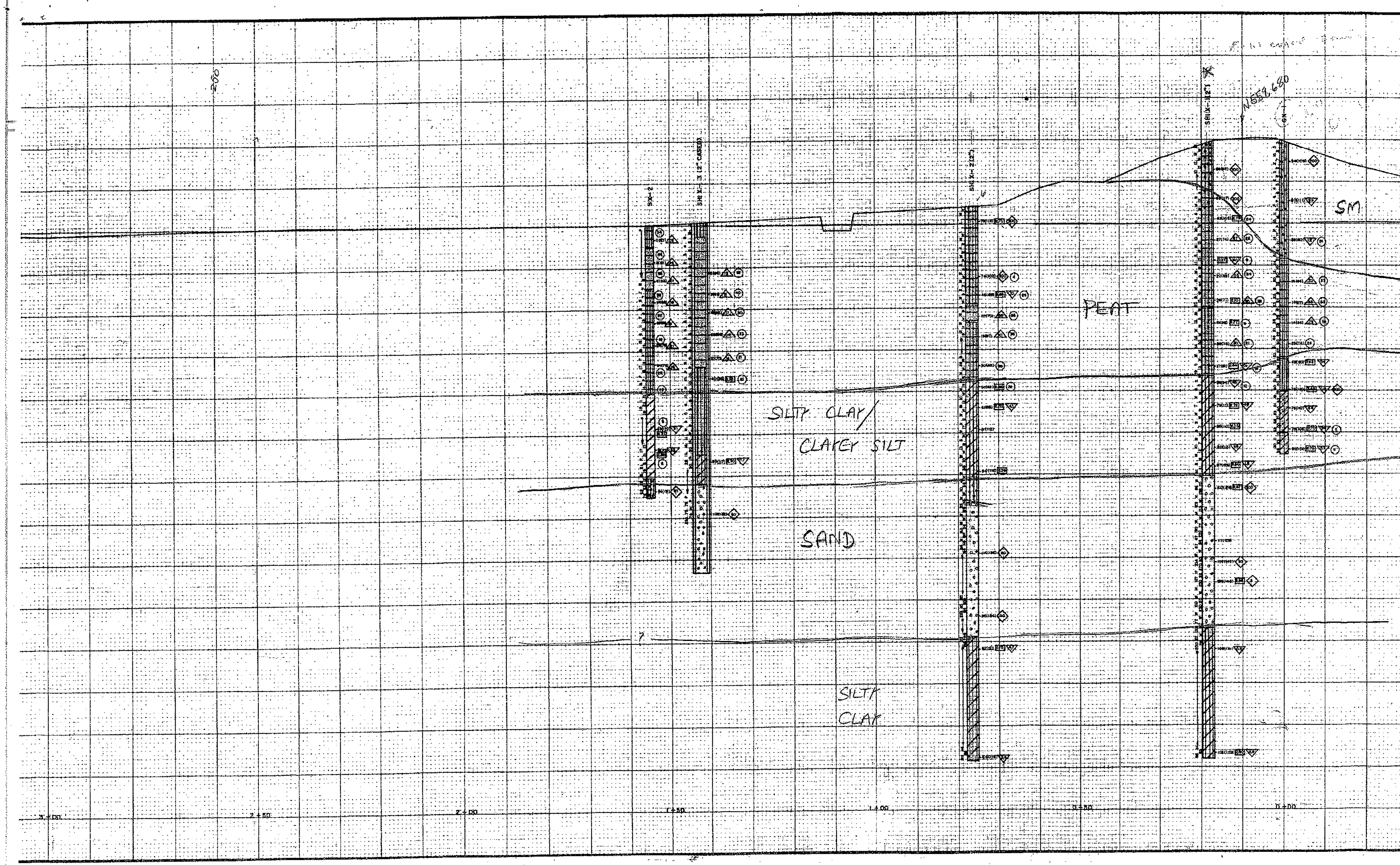
DH-13
ON SECTION
RD
ORIGINAL GROUND
LEVEE ROAD
EXISTING LEVEE
2/6/
10
0
-10
-20
-30
-40
-50
-60
ELEVATION IN FEET
BAY MUD: Very soft to soft organic and inorganic clay with loose silt and sand interbeds and occasional peat lenses.
CL
CL
L-1
OH
L-2
7
Pt
<1
<1
OH
4
L-3
5
CL
PVS 0.30
<1
PEAT: Very soft and partially decay
2
3



Existing Ground
RD
(Sea Level)
Radial Gate Structure Limits
Boat Lock Structure Limits
Levee Material and Young Alluvium
WATER
1.2:1
Bay
Mud
Young
Excavation Limits
G.W.S. 2-18-85
S-1
OL & Pt
S-2
CL
ML & SM
CH
S-3
SM
TD=70
OH & Pt
Bag 1
Bag 2
OL & Pt
S-4
Bag 3
SM
Bag 4
L-1B
L-1C
Bag 5
L-2C
SP-SM
Bag 6
Bag 7
SP
Bag 8
Older Alluvium

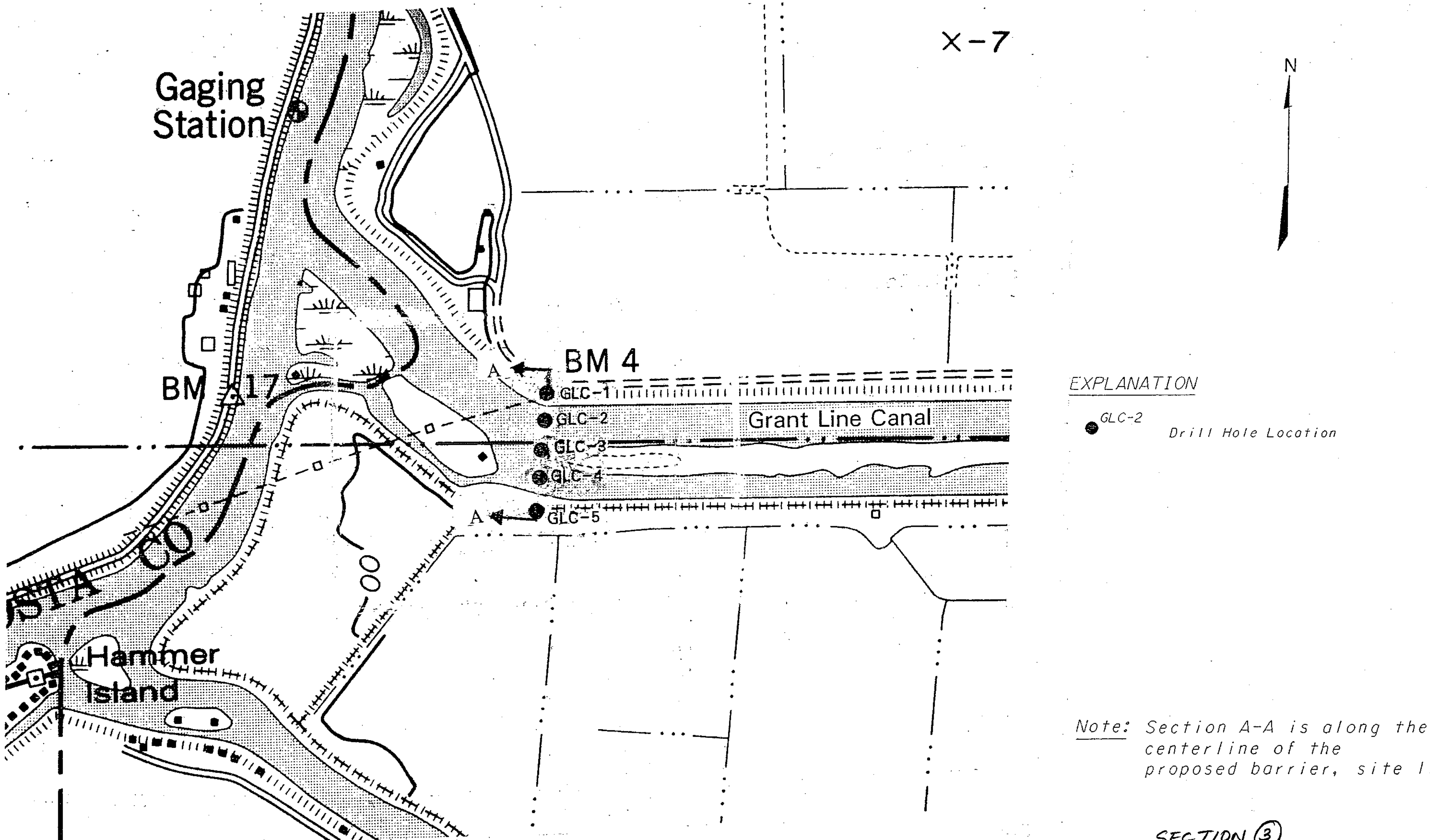


B
C
D
E
Existing Roaring River Slough Intake Pond
℄ West Levee
Existing Ground
Survey Station 1A Witness Post
Levee Material and Young Alluvium
CS-2
RD
Recon. 1
CS-3 Projected 35'
Intersection with Section B-B
Montezuma Slough
(Sea Level)
Flashboard Structure Limits
Radial Gate Structure
WATER
Bay Mud
Older Alluvium
Excavation Limits
S-1
S-2
S-3
L-1D
L-2D
L-3C
L-3D
L-4D
Bag 1
Bag 2
Bag 3
Bag 4
Bag 5
Bag 6
ML
SP
CL
SM
OL
ML & SM
T.D.=70.7'



N558,680
SM
PEAT
SILTY CLAY/
CLAYEY SILT
SAND
SILTY
CLAY
+20
0
-20
-80
-100
-120
2+50
2+00
1+50
1+00
0+50
0+00

X-7



SECTION ③

REV.	DATE	DESCRIPTION

DRAWING SCALES

1" = 500' — 250 0 250 500 750 1000 — SCALE OF FEET

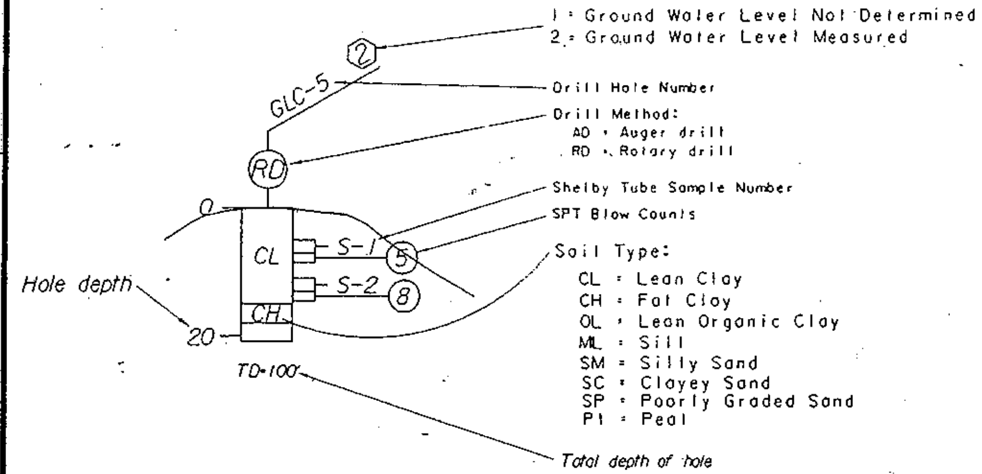
GEOLOGY REPORT No. 80-10-04	GEOLOGIC MAPPING AND/OR LOGGING BY: [1] T. Peltier; [2] I. Waters
CONSTRUCTION SPEC. No.	
GEOLOGY DRAWING No. PG-D2-03	DRAWING PREPARED BY: I. Waters DATE: 2/3/94

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF DESIGN AND CONSTRUCTION
PROJECT GEOLOGY BRANCH
STATE WATER FACILITIES

GRANT LINE CANAL BARRIER – SITE 1
DRILL HOLE LOCATION MAP

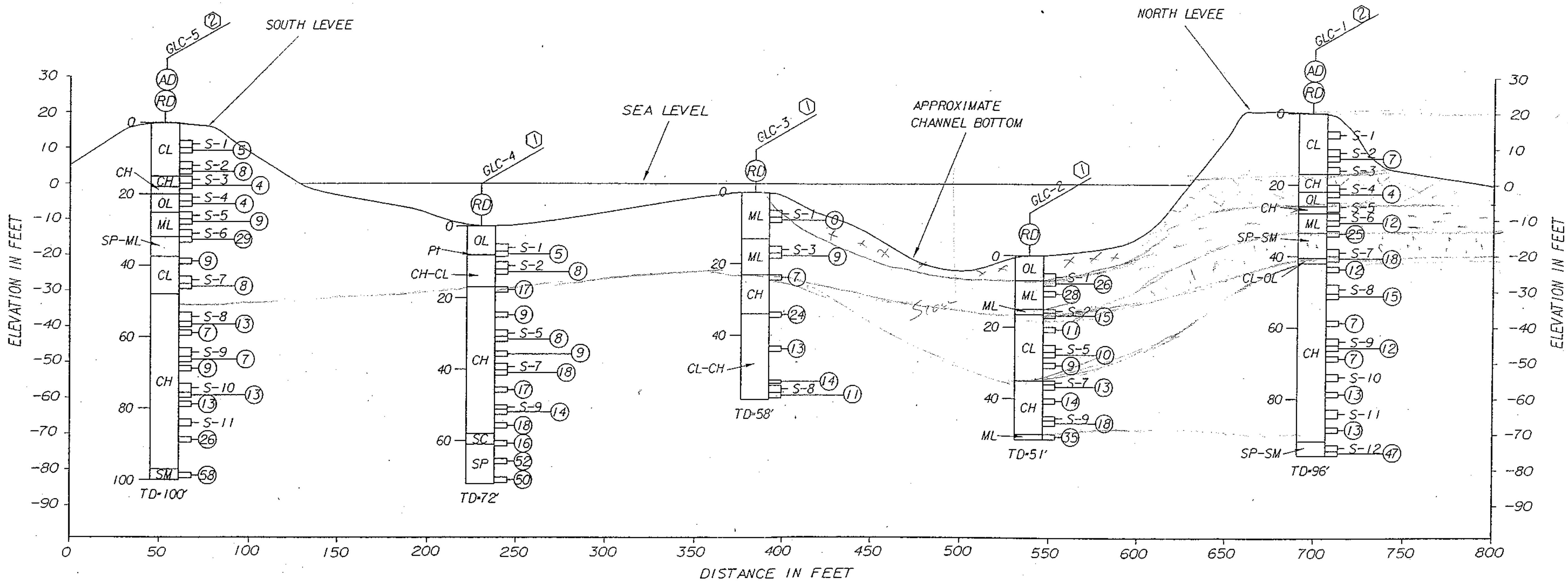
RELEASE DATE: 10-6-94
SHEET No. 1 of 1
PLATE 1

6-OCT-1994 /usr2/projects/delta/drn



NOTES

1. See Plate 1 for location of section.
2. Section is along the centerline of the proposed barrier.
3. Observation wells installed in GLC-1 and GLC-5.
4. See drill hole logs for additional drill hole information.



SECTION A-A

REV.	DATE	DESCRIPTION	

DRAWING SCALES

1" = 60' — HORIZONTAL SCALE OF FEET (30, 0, 30, 60, 90, 120)

1" = 30' — VERTICAL SCALE OF FEET (15, 0, 15, 30, 45, 60)

GEOLOGY REPORT No. 80-10-04

CONSTRUCTION SPEC. No.

GEOLOGY DRAWING No. PG-D2-02

GEOLOGIC MAPPING AND/OR LOGGING BY: 1 T. Peltier; 2 R. Bartlett

DRAWING PREPARED BY: I. Waters DATE: 2/3/94

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF DESIGN AND CONSTRUCTION
PROJECT GEOLOGY BRANCH
STATE WATER FACILITIES

GRANT LINE CANAL BARRIER - SITE 1

GEOLOGIC SECTION

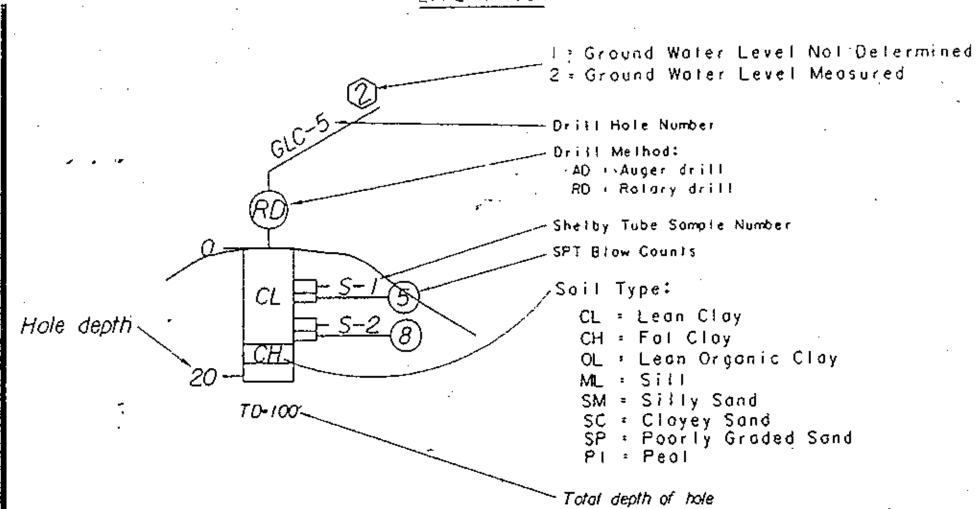
RELEASE DATE: 10-6-94

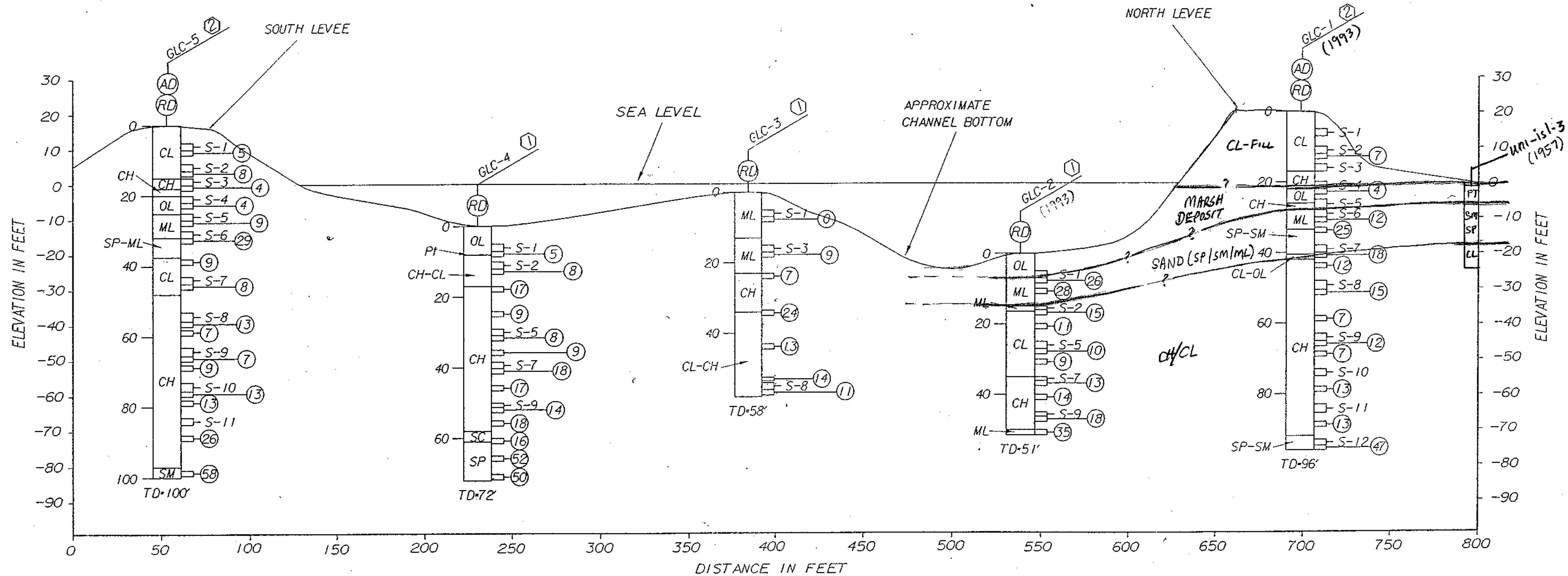
SHEET No. 1 of 1

PLATE 2

NOTES

1. See Plate 1 for location of section.
2. Section is along the centerline of the proposed barrier.
3. Observation wells installed in GLC-1 and GLC-5.
4. See drill hole logs for additional drill hole information.





SECTION A–A

NOTE:
uni-isl-3 (Boring 1958, DWR) was added to the profile.

DRAWING SCALES	
1" = 60'	HORIZONTAL SCALE OF FEET (30, 0, 30, 60, 90, 120)
1" = 30'	VERTICAL SCALE OF FEET (15, 0, 15, 30, 45, 60)

GEOLOGY REPORT No. 80-10-04
CONSTRUCTION SPEC. No.
GEOLOGY DRAWING No. PG-D2-02

GEOLOGIC MAPPING AND/OR LOGGING BY: 1 T. Peltier; 2 R. Bartlett
DRAWING PREPARED BY: J. Waters DATE: 2/3/94

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF DESIGN AND CONSTRUCTION
PROJECT GEOLOGY BRANCH
STATE WATER FACILITIES

GRANT LINE CANAL BARRIER – SITE 1
GEOLOGIC SECTION

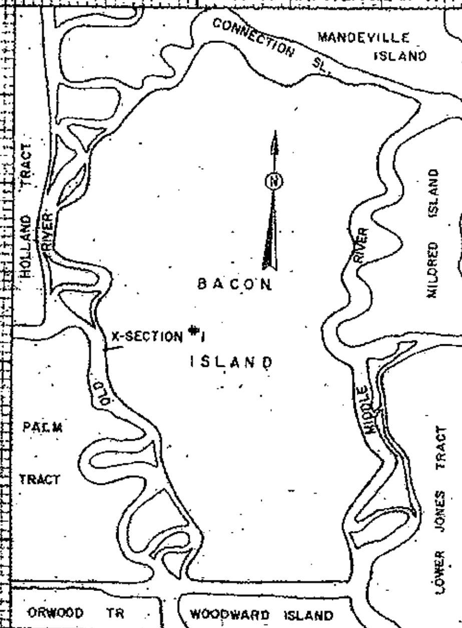
RELEASE DATE: 10-6-94
SHEET No. 1 of 1
PLATE 2

REV. | DATE | DESCRIPTION

NOTES:

GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION.
ALL BORINGS ARE ONE INCH DIAMETER EXCEPT WHERE NOTED
HAMMER WEIGHT: 1"-2 8 LBS.
2"-140 & 175 LBS.

DRILLING DATES:
1" HOLES-NOV. 11, 1957 TO NOV. 18, 1957
2" HOLES-NOV. 18, 1957 TO DEC. 5, 1957
BARGE HOLE-APRIL 9, 1958



LOCATION MAP

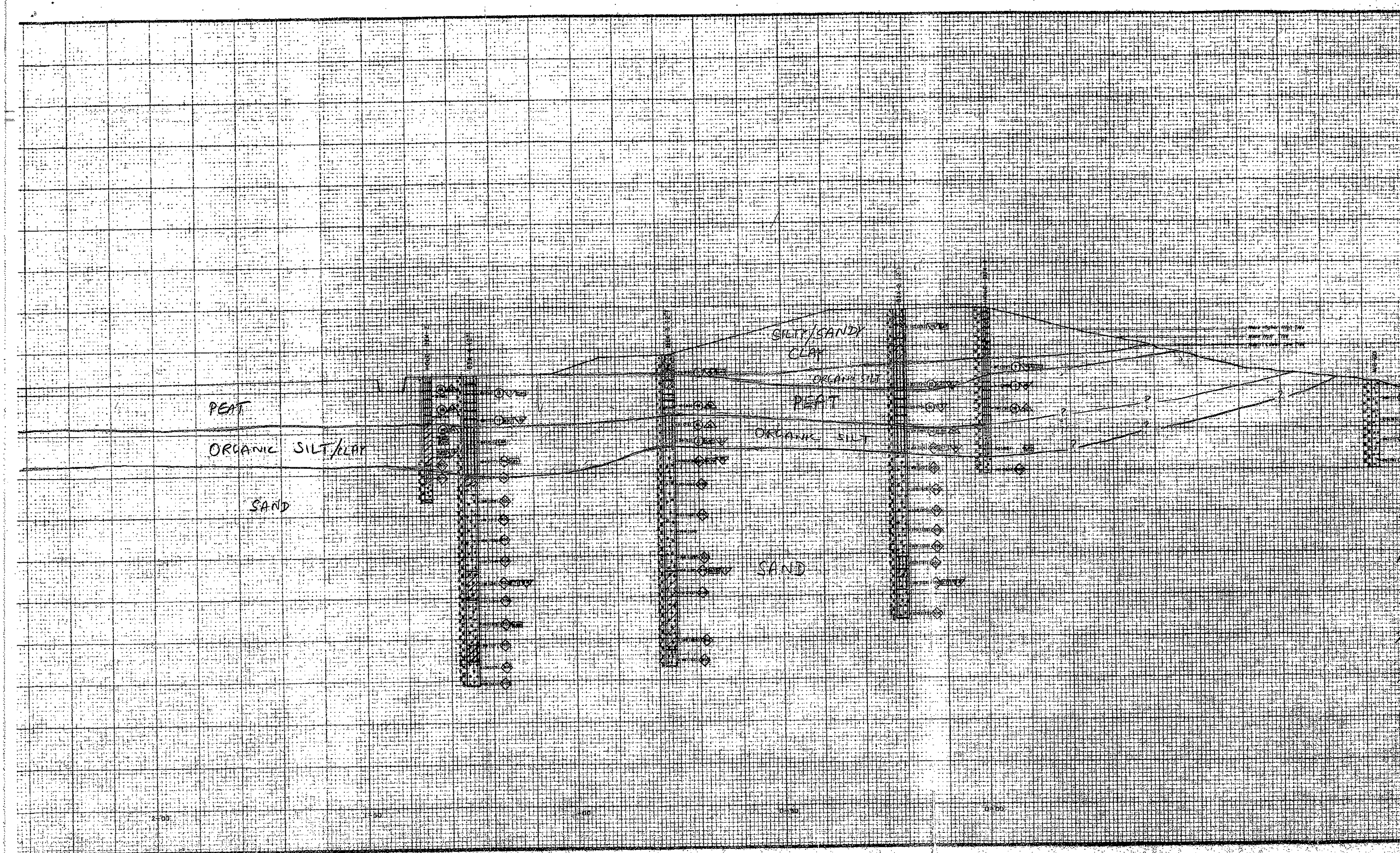
LEGEND

BLOWS PER FOOT (P INDICATES PUSH, W INDICATES WASH)
DRY (WET) DENSITY IN POUNDS PER CUBIC FOOT
UNCONFINED COMPRESSIVE STRENGTH, K_c Kg/cm^2
UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, K_{10} Kg/cm^2
LOSS ON IGNITION IN PERCENT
MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D_{50}
SPECIFIC GRAVITY

SILT	ORGANIC CLAY
PEAT	SILTY PEAT
CLAY	SILTY CLAY
SAND	SILTY SAND
ORGANIC SILT	SAND WITH SILT LENSES

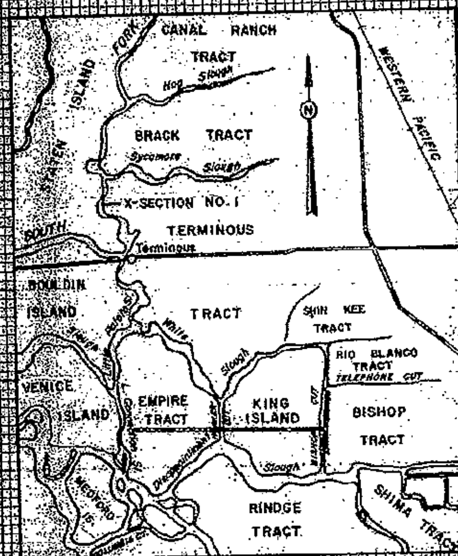
BACON ISLAND CROSS SECTION NO. 1

SECTION (4)


PEAT
ORGANIC SILT/CLAY
SAND
SILTY/SANDY
CLAY
ORGANIC SILT
PEAT
ORGANIC SILT
SAND

NOTES:
GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION
ALL BORINGS ARE TWO INCH DIAMETER EXCEPT WHERE NOTED
[illegible] HOLES [illegible] BARGE HOLES [illegible]
[illegible] DATES
[illegible] JUNE 20, 1966 TO JUNE 24, 1966
BARGE HOLES: FEBRUARY 24, 1969

20
10
0 Mean Sea Level
10
20
30
40
50
60
70



LOCATION MAP

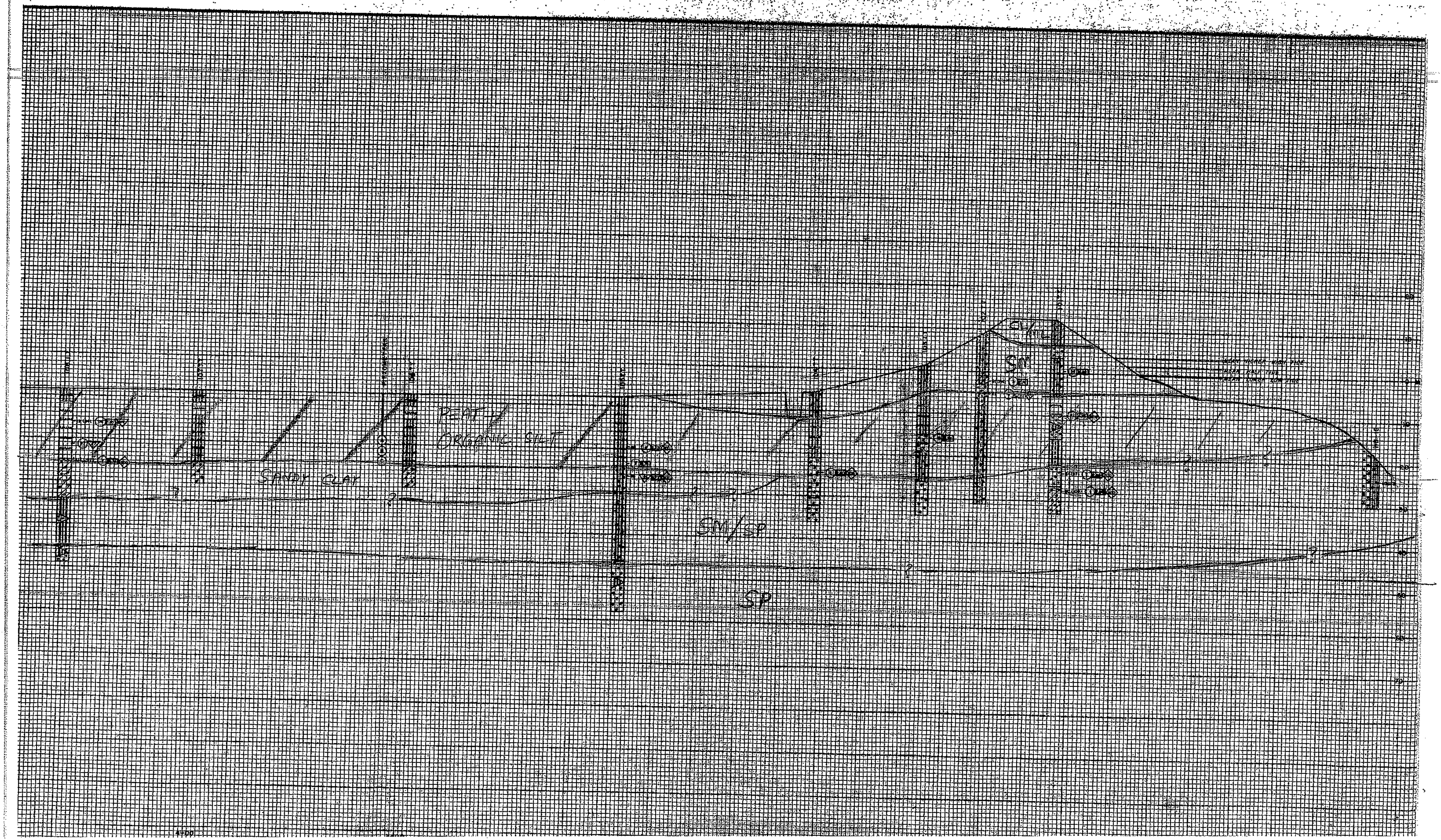
LEGEND

BLOWS PER FOOT (P INDICATES PUSH, W INDICATES WASH)
DRY UNIT DENSITY IN POUNDS PER CUBIC FOOT
UNCONFINED COMPRESSIVE STRENGTH, K_f Kg/cm²
UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, S_{10} Kg/cm²
LOSS ON IGNITION IN PERCENT
MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D_{50}
SPECIFIC GRAVITY

SILT
PEAT
CLAY
SAND
ORGANIC SILT
ORGANIC CLAY
SILTY PEAT
SILTY CLAY
SILTY SAND
SAND WITH SILT LENSES

TERMINOUS TRACT CROSS SECTION NO. I

SECTION 5



PEAT /
ORGANIC SILT
SANDY CLAY
SM/SP
SP
SM

NOTES:

GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION

HAMMER WEIGHT:

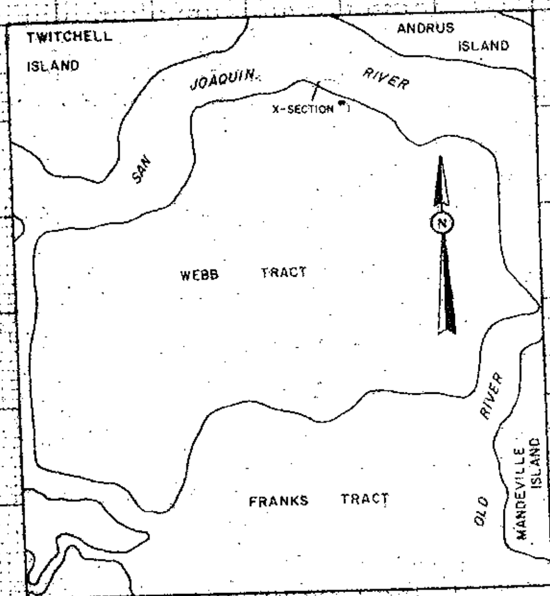
1" - 116 LBS.

2" - 175 LBS.

DRILLING DATES:

1" HOLES - DECEMBER 17, 1957 TO DECEMBER 19, 1957

2" HOLES - DECEMBER 19, 1957 TO JANUARY 22, 1958



LOCATION MAP

LEGEND

BLOWS PER FOOT (P INDICATES PUSH, W INDICATES WASH)

DRY (WET) DENSITY IN POUNDS PER CUBIC FOOT

UNCONFINED COMPRESSIVE STRENGTH, K_c Kg/cm^2

UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, S_{10} Kg/cm^2

LOSS ON IGNITION IN PERCENT

MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D_{50}

SPECIFIC GRAVITY

SILT

PEAT

CLAY

SAND

ORGANIC SILT

ORGANIC CLAY

SILTY PEAT

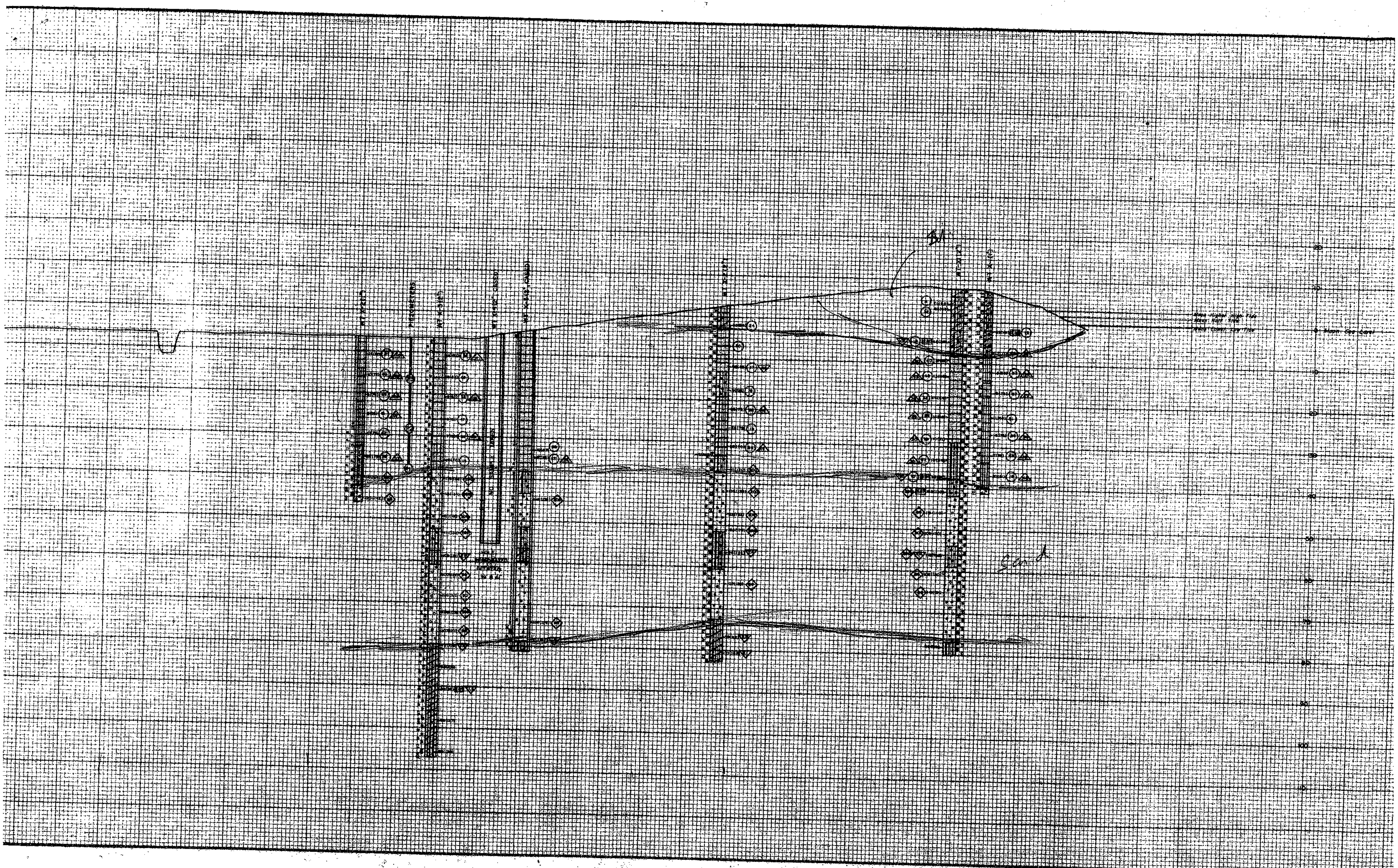
SILTY CLAY

SILTY SAND

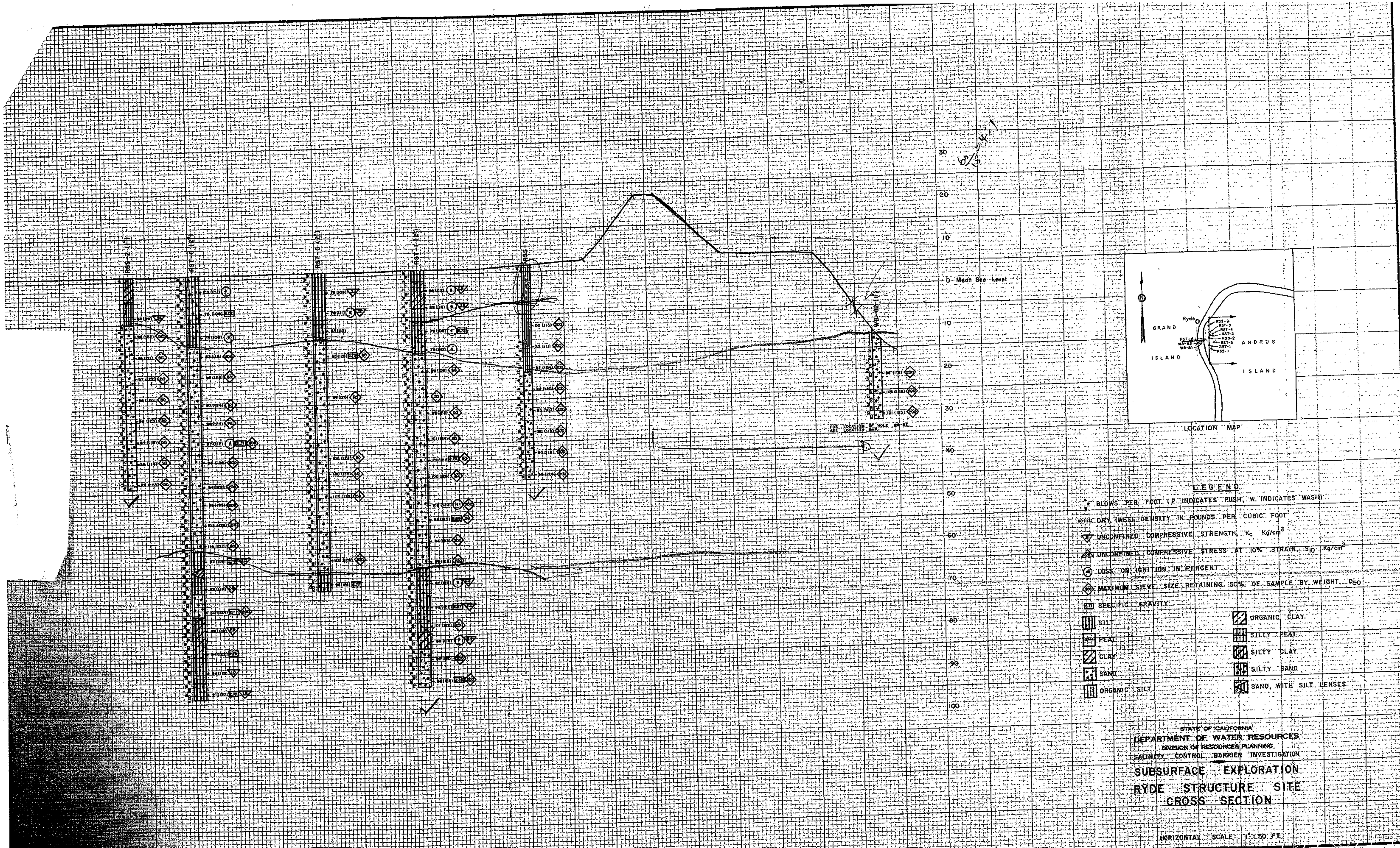
SAND, WITH SILT LENSES

WEBB TRACT CROSS SECTION NO. 1

SECTION 6



Mean Higher High Tide
Mean Half Tide
Mean Lower Low Tide
Mean Sea Level
Sand



0 Mean Sea Level
LOCATION MAP
GRAND ISLAND
ANDRUS ISLAND
Ryde
LEGEND
BLOWS PER FOOT (P INDICATES PUSH, W INDICATES WASH)
DRY (WET) DENSITY IN POUNDS PER CUBIC FOOT
UNCONFINED COMPRESSIVE STRENGTH, Kc Kg/cm2
UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, S10 Kg/cm2
LOSS ON IGNITION IN PERCENT
MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D50
SPECIFIC GRAVITY
SILT
PEAT
CLAY
SAND
ORGANIC SILT
ORGANIC CLAY
SILTY PEAT
SILTY CLAY
SILTY SAND
SAND, WITH SILT LENSES
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
SALINITY CONTROL BARRIER INVESTIGATION
SUBSURFACE EXPLORATION
RYDE STRUCTURE SITE
CROSS SECTION
HORIZONTAL SCALE: 1" = 50 FT.

SECTION 7

SECTION 8

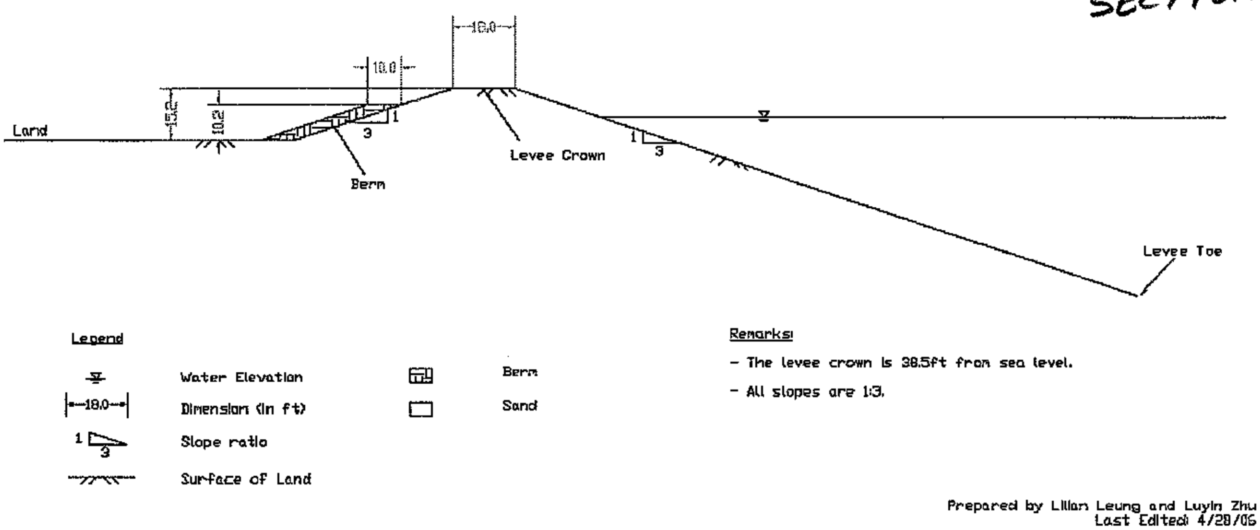


Fig. 3. Cross section of existing levee

together. However, earthquake loading against low, normal, high, and 100-year return period flood water levels are reasonable combinations of earthquake and flood loads and are the bases for evaluation in this study.

An earthquake scale of 475-year return period is equivalent to probability of occurrence of 10% within 50 years. The peak ground acceleration (PGA) for such scale of earthquake can be found from the USGS website "Earthquake Probability Earthquake" (USGS, 2006) by inputting longitude and latitude of the location. For our study levee location (121.35W, 38.38N), it is found to be 0.14g.

Study Cases for Analyses

Five particular study cases are chosen for analyses to achieve better understanding of levee stability. Water level in the Sacramento River plays a role in determining the strength of sand layers as it affects their effective strength. Lower water level means stronger soil while higher water level makes the soil weaker. On the other hand, high water level acts as a counteractive force that pushes against the failure on water side even if the soil liquefies. Five cases with variance in water level describe the overall effects of these two factors.

Water level data are acquired from three sources. One data source is Water Data Library at the website of California Department of Water Resources (DWR, 2006). According to the website, the mean lowest water level in the past 10 years (1996-2005) at our location of investigation is 20 feet above sea level, while mean highest water level is 25 feet above sea level. Another source is the draft report by Northwest Hydraulics Consultants (NHC, 2006). It indicates that average water level in fall, which is the lowest average water level among four seasons, is 8 feet above sea level. The highest average water level is 18 feet above sea level in winter. Since there is discrepancy in collected data, it is decided that the study levee should be analyzed with respect to water levels of 8, 20 and 25 feet to evaluate all conditions throughout four seasons. Water level of 100-year return-period flood event is acquired from reports by MBK Engineers (2005). It is found to be 35.5 feet above sea level.

With such information, five study cases are conducted as follows:

Case 1: Low Water Level and Earthquake of 475-year Return Period Condition

The Sacramento River's water level reaches its lowest in summer and fall, the dry season. This can be seen as the best scenario as soil is strongest and failure of levees would not immediately cause flooding. This value is taken to be 8 feet above sea level.

Case 2: Normal Water Level and Earthquake of 475-year Return Period Condition

A normal water level is taken into consideration. This value is taken to be 20 feet above sea level.

Case 3: High Water Level and Earthquake of 475-year Return Period Condition

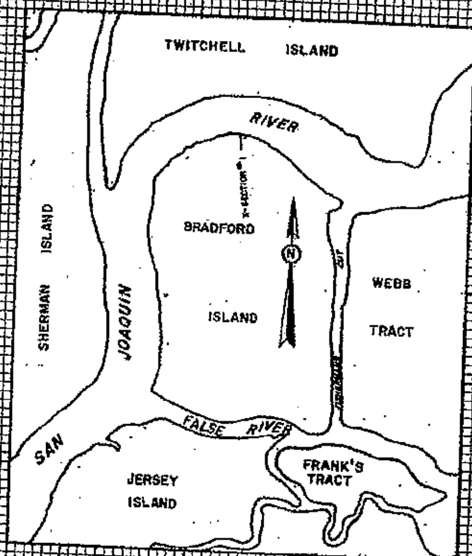
The Sacramento River's water level reaches its highest in winter due to heavy raining and snow-melting. This value is taken to be 25 feet above sea level.

Case 4: Flood Water Level of 100-year Return Period and Earthquake of 475-year Return Period Condition

The worst scenario is designed to study the combined effect of flooding and earthquake simultaneously. This value is taken to be 35.5 feet above sea level.

APPENDIX - A

NOTES:
GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION
ALL BORINGS ARE ONE INCH DIAMETER EXCEPT WHERE NOTED
HAMMER WEIGHT: 1" HOLES - 16 LBS., 2" HOLES - 76 LBS.
DRILLING DATES:
1" HOLES= NOV. 19, 1957 TO NOV. 20, 1957
2" HOLES= DEC. 5, 1957 TO DEC. 17, 1957



LOCATION MAP

LEGEND

DRY (WET) DENSITY IN POUNDS PER CUBIC FOOT

UNCONFINED COMPRESSIVE STRENGTH, q_u KG/CM^2

UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, S_{10} KG/CM^2

LOSS ON IGNITION IN PERCENT

MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D_{50}

SPECIFIC GRAVITY

SILT

PEAT

CLAY

SAND

ORGANIC SILT

ORGANIC CLAY

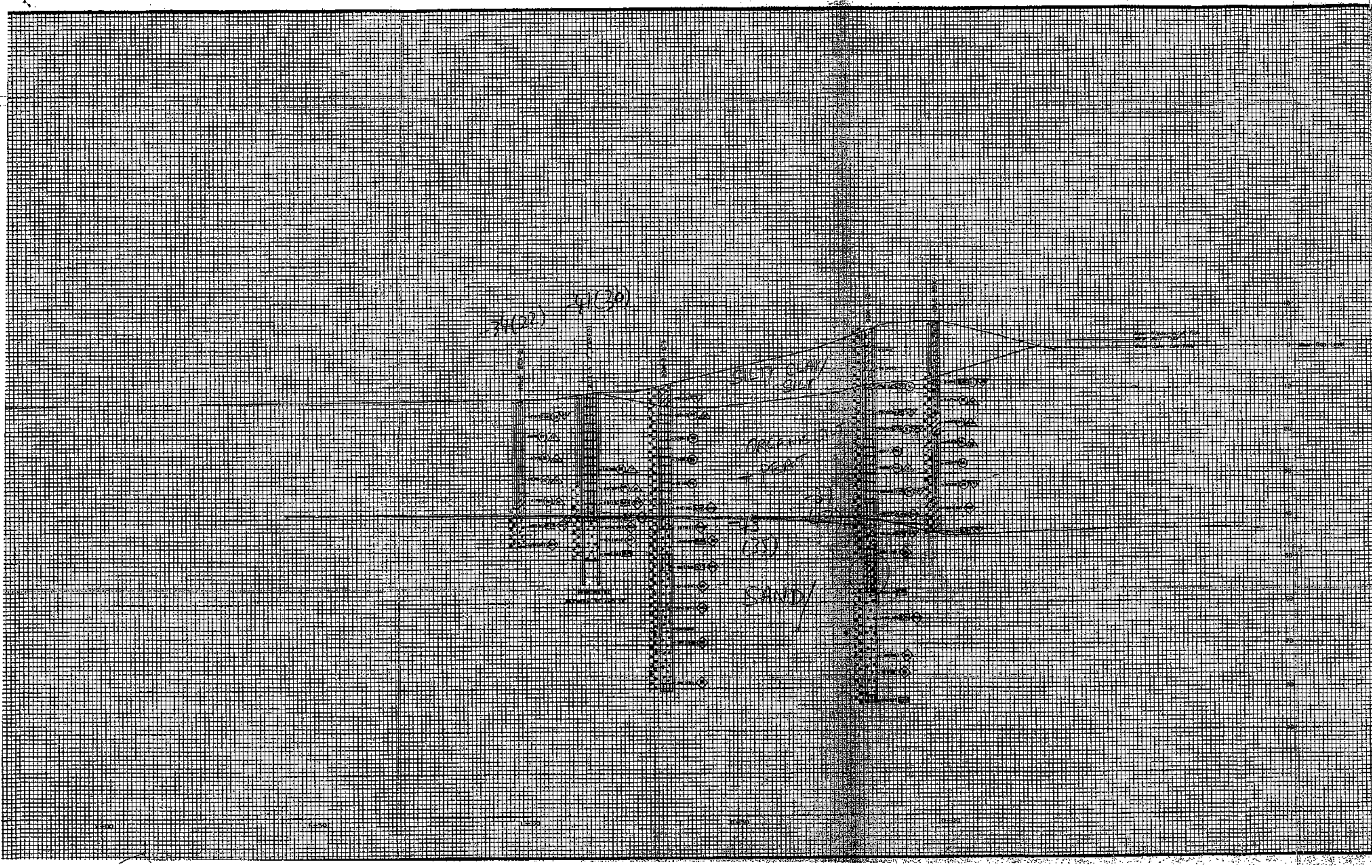
SILTY PEAT

SILTY CLAY

SILTY SAND

SAND, WITH SILT LENSES

BRADFORD ISLAND CROSS SECTION NO. 1



34(27)
24(30)
SILTY CLAY/
SILT
ORGANIC
+ PEAT
(23)
SAND/

20

10

0 Mean Sea Level

10

20

30

40

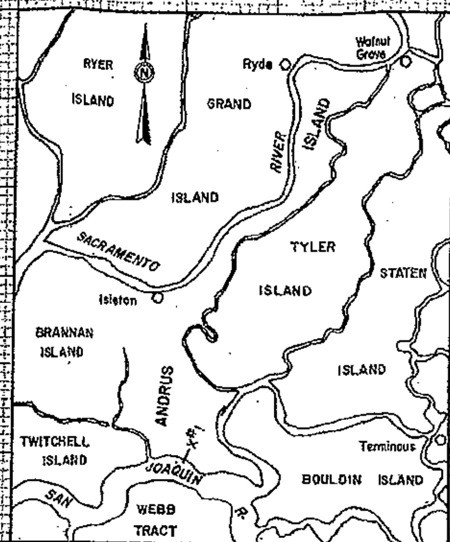
50

60

70

80

NOTES:
GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION
ALL BORINGS ARE ONE INCH DIAMETER EXCEPT WHERE NOTED
HAMMER WEIGHT: 1" HOLES - 140 LBS.
2" HOLES - 350 LBS.
DRILLING DATES: 1" HOLES - APRIL 25, 1957
2" HOLES - APRIL 19, 1957 TO APRIL 24, 1956



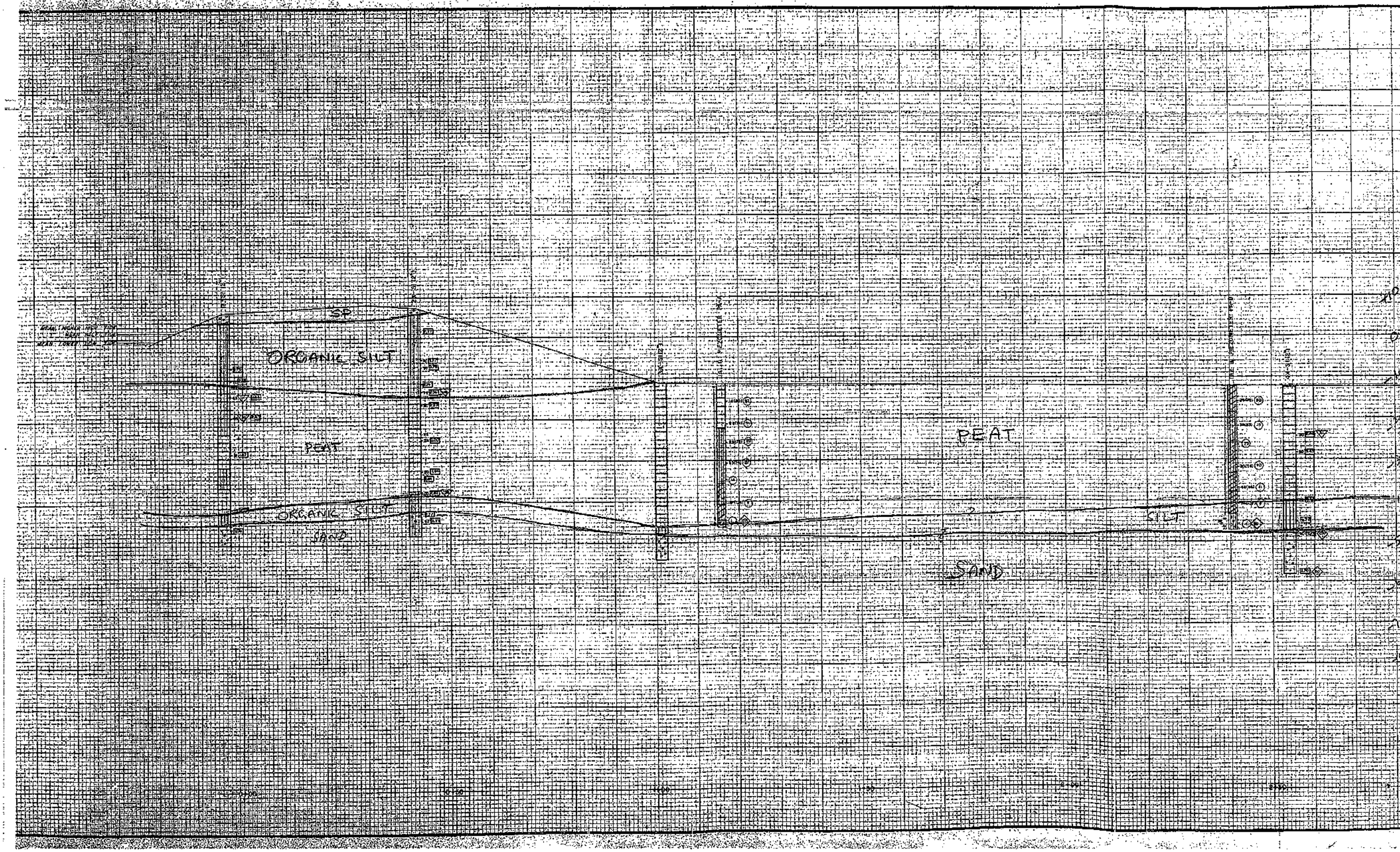
LOCATION MAP

LEGEND

BLOWS PER FOOT (P INDICATES PUSH, W INDICATES WASH)
DRY (WET) DENSITY IN POUNDS PER CUBIC FOOT
UNCONFINED COMPRESSIVE STRENGTH, K_c Kg/cm²
UNCONFINED COMPRESSIVE STRESS AT 0% STRAIN S_{10} Kg/cm²
LOSS ON IGNITION IN PERCENT
MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT D_{50}
SPECIFIC GRAVITY

SILT
PEAT
CLAY
SAND
ORGANIC SILT
ORGANIC CLAY
SILTY PEAT
SILTY CLAY
SILTY SAND
SAND, WITH SILT LENSES

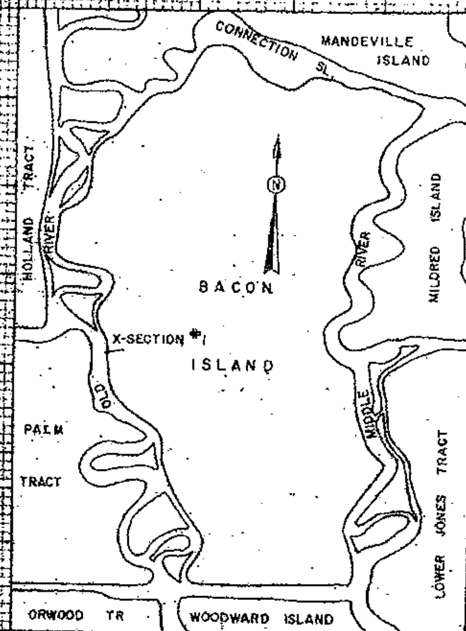
ANDRUS ISLAND CROSS SECTION NO. 1


SP
ORGANIC SILT
PEAT
ORGANIC SILT
SAND
PEAT
SILT
SAND

NOTES:

GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION
ALL BORINGS ARE ONE INCH DIAMETER EXCEPT WHERE NOTED
HAMMER WEIGHT: 1"-18 LBS.
2"-140 & 175 LBS.

DRILLING DATES:
1" HOLES: NOV. 6, 1957 TO NOV. 18, 1957
2" HOLES: NOV. 18, 1957 TO DEC. 5, 1957
BARGE HOLE: APRIL 9, 1958



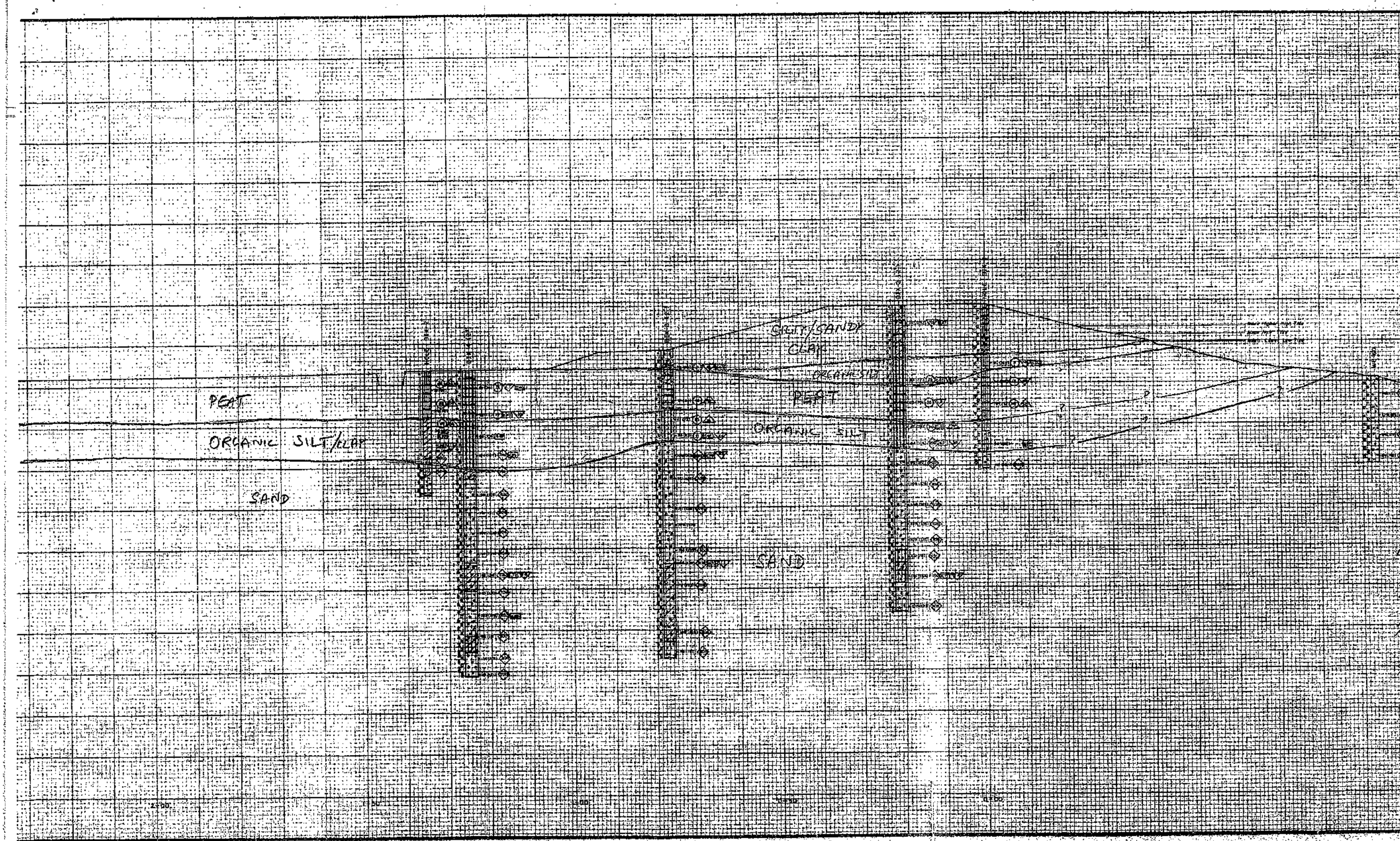
LOCATION MAP

LEGEND

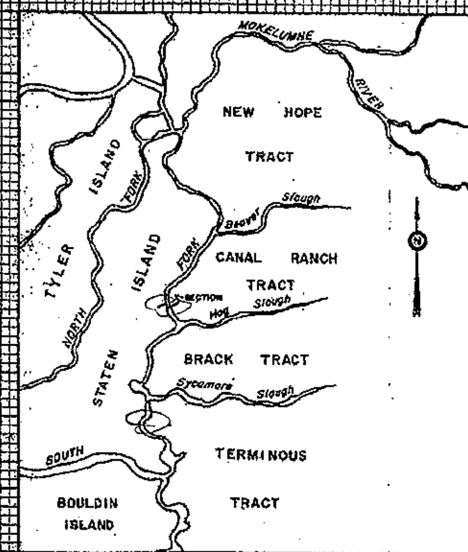
BLOWS PER FOOT (P INDICATES PUSH, W INDICATES WASH)
DRY (WET) DENSITY IN POUNDS PER CUBIC FOOT
UNCONFINED COMPRESSIVE STRENGTH, K_u Kg/cm^2
UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, S_{10} Kg/cm^2
LOSS ON IGNITION IN PERCENT
MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D_{50}
SPECIFIC GRAVITY

SILT	ORGANIC CLAY
PEAT	SILTY PEAT
CLAY	SILTY CLAY
SAND	SILTY SAND
ORGANIC SILT	SAND WITH SILT LENSES

BACON ISLAND CROSS SECTION NO. 1


SILTY/SANDY CLAY
ORGANIC SILT
PEAT
ORGANIC SILT
SAND
PEAT
ORGANIC SILT/CLAY
SAND

NOTES:
GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION
ALL BORINGS ARE ONE INCH DIAMETER EXCEPT WHERE NOTED
HAMMER WEIGHT: 140 LBS.
DRILLING DATES:
1" HOLES – MAY 24, 1957 TO MAY 27, 1957
2" HOLES – JUL 17, 1957 TO JUL 24, 1957
BARGE HOLE – FEB 20, 1958



LOCATION MAP

LEGEND

BLOWS PER FOOT (P INDICATES PUSH, W INDICATES WASH)

DRY WELL DENSITY IN POUNDS PER CUBIC FOOT

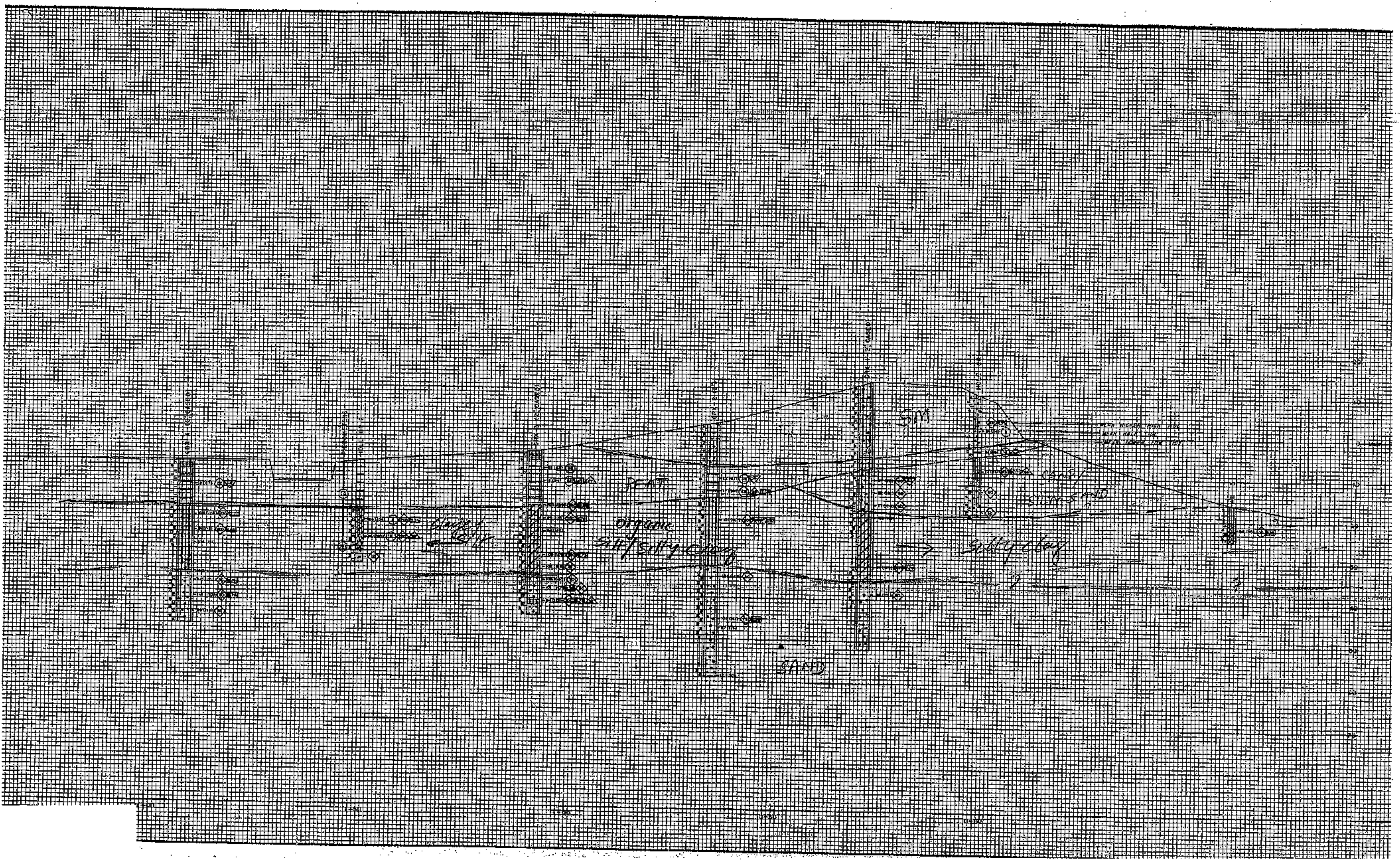
UNCONFINED COMPRESSIVE STRENGTH S_u Kg/cm^2

UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, S_{10} Kg/cm^2

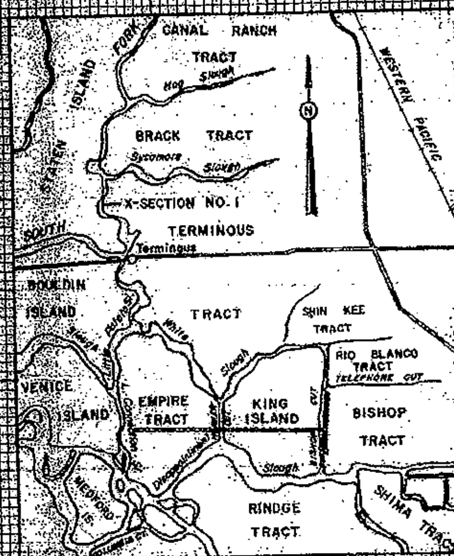
LOSS ON IGNITION IN PERCENT

MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT D_{50}

SPECIFIC GRAVITY


SM
PEAT
organic
silt/silty clay
silty clay
SAND

NOTES:
GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION.
ALL BORINGS ARE TWO INCH DIAMETER EXCEPT WHERE NOTED.
[illegible]
[illegible]
[illegible] JUNE 24,1986
[illegible] FEBRUARY 26,1988



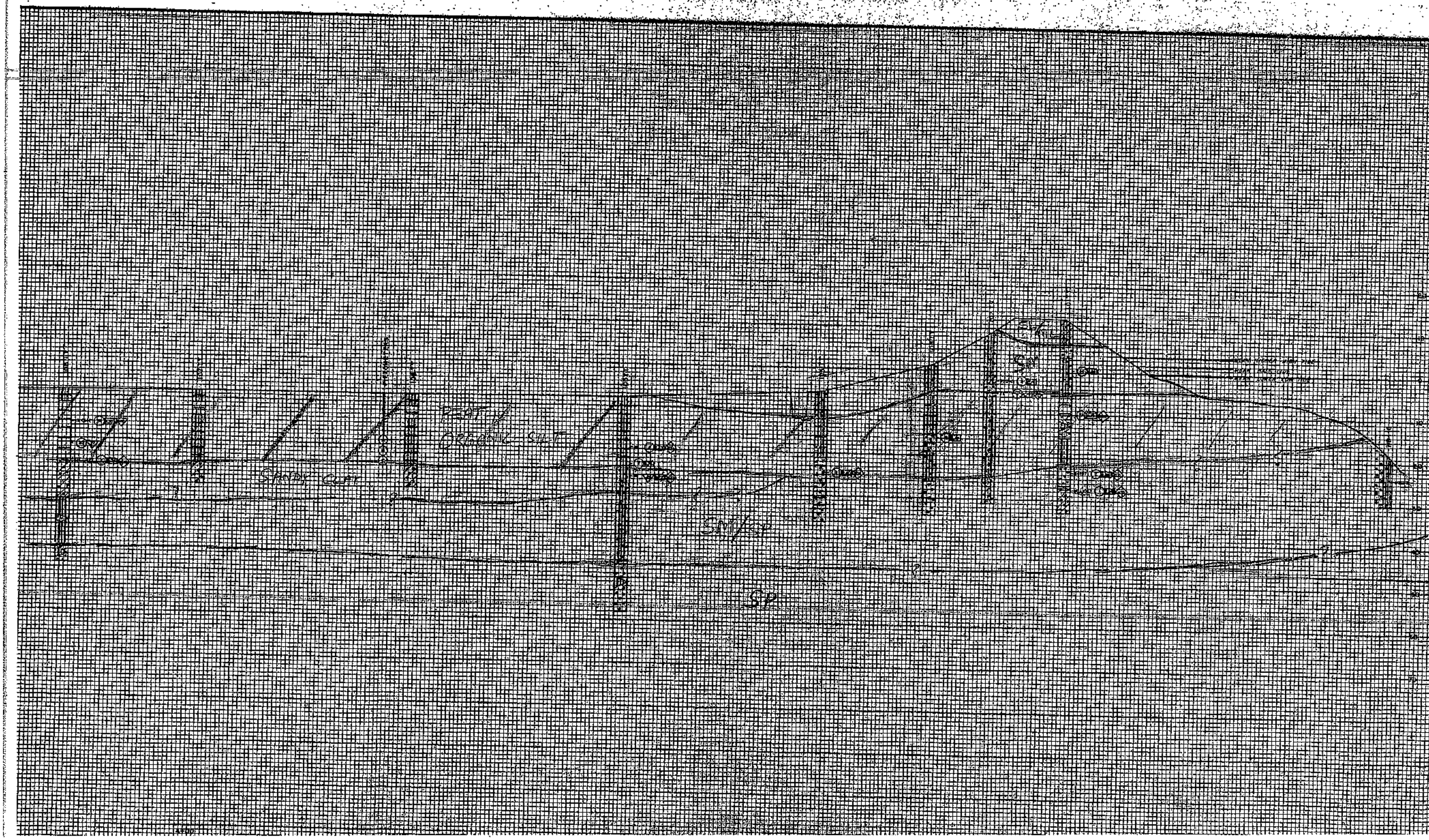
LOCATION MAP

LEGEND

BLOWS PER FOOT (P INDICATES PUSH, W INDICATES WASH)
DRY UNIT DENSITY IN POUNDS PER CUBIC FOOT
UNCONFINED COMPRESSIVE STRENGTH, K_u Kg/cm^2
UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, S_{10} Kg/cm^2
LOSS ON IGNITION IN PERCENT
MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D_{50}
SPECIFIC GRAVITY

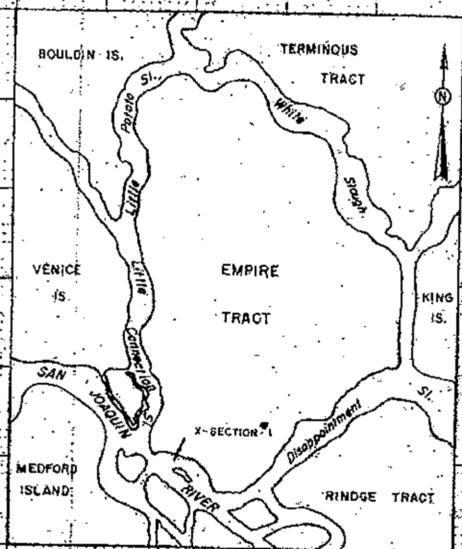
SILT
PEAT
CLAY
SAND
ORGANIC SILT
ORGANIC CLAY
SILTY PEAT
SILTY CLAY
SILTY SAND
SAND WITH SILT LENSES

TERMINOUS TRACT CROSS SECTION NO. I



FILL
SM
PEAT / ORGANIC SILT
SANDY CLAY
SM/SP
SP

NOTES:
GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION
HAMMER WEIGHT: 1" HOLES - 140 LBS., 2" HOLES - 270 LBS.
DRILLING DATES:
1" HOLES = APRIL 10, 1957
2" HOLES = OCTOBER 8, 1957 TO OCTOBER 23, 1957



LOCATION MAP

LEGEND

BLOWS PER FOOT (P INDICATES PUSH, W INDICATES WASH)

DRY (WET) DENSITY IN POUNDS PER CUBIC FOOT

UNCONFINED COMPRESSIVE STRENGTH, K_c Kg/cm^2

UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, S_{10} Kg/cm^2

LOSS ON IGNITION IN PERCENT

MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D_{50}

SPECIFIC GRAVITY

SILT

PEAT

CLAY

SAND

ORGANIC SILT

ORGANIC CLAY

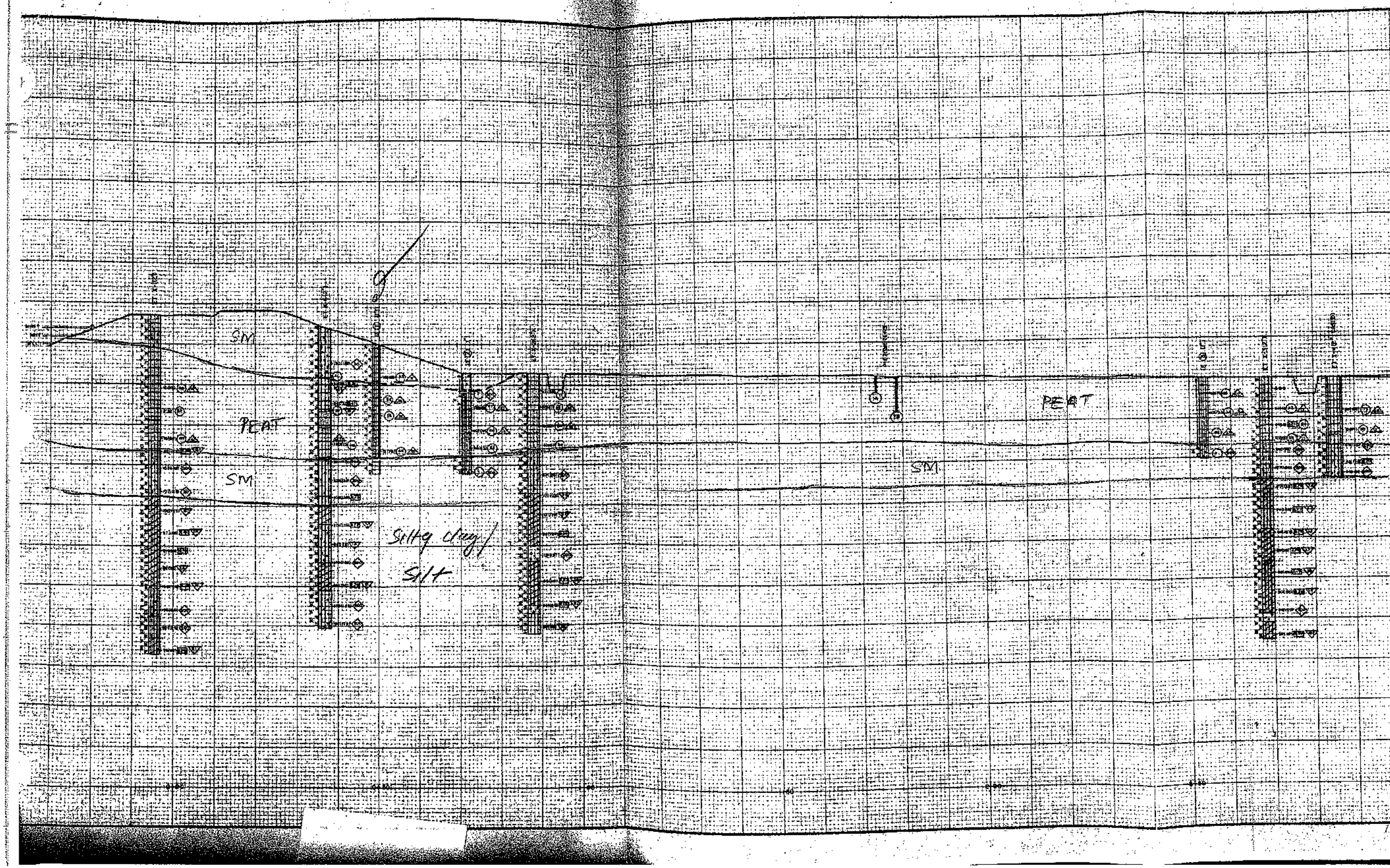
SILTY PEAT

SILTY CLAY

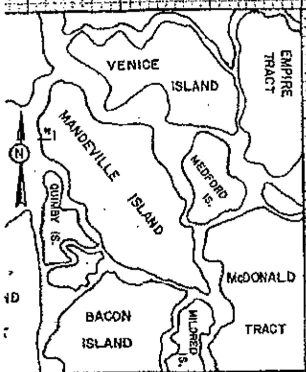
SILTY SAND

SAND, WITH SILT LENSES

EMPIRE TRACT CROSS SECTION NO. 1


SM
PEAT
SM
Silty clay/
Silt
PEAT
SM

NOTES:
GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION.
ALL BORINGS ARE ONE INCH DIAMETER EXCEPT WHERE NOTED.
HAMMER WEIGHT: 1" HOLES=140 LBS. 2" HOLES=140 LBS.
DRILLING DATES:
1" HOLES= SEPTEMBER 18, 1957 TO SEPTEMBER 19, 1957
2" HOLES= OCTOBER 24, 1957 TO NOVEMBER 5, 1957



LOCATION MAP

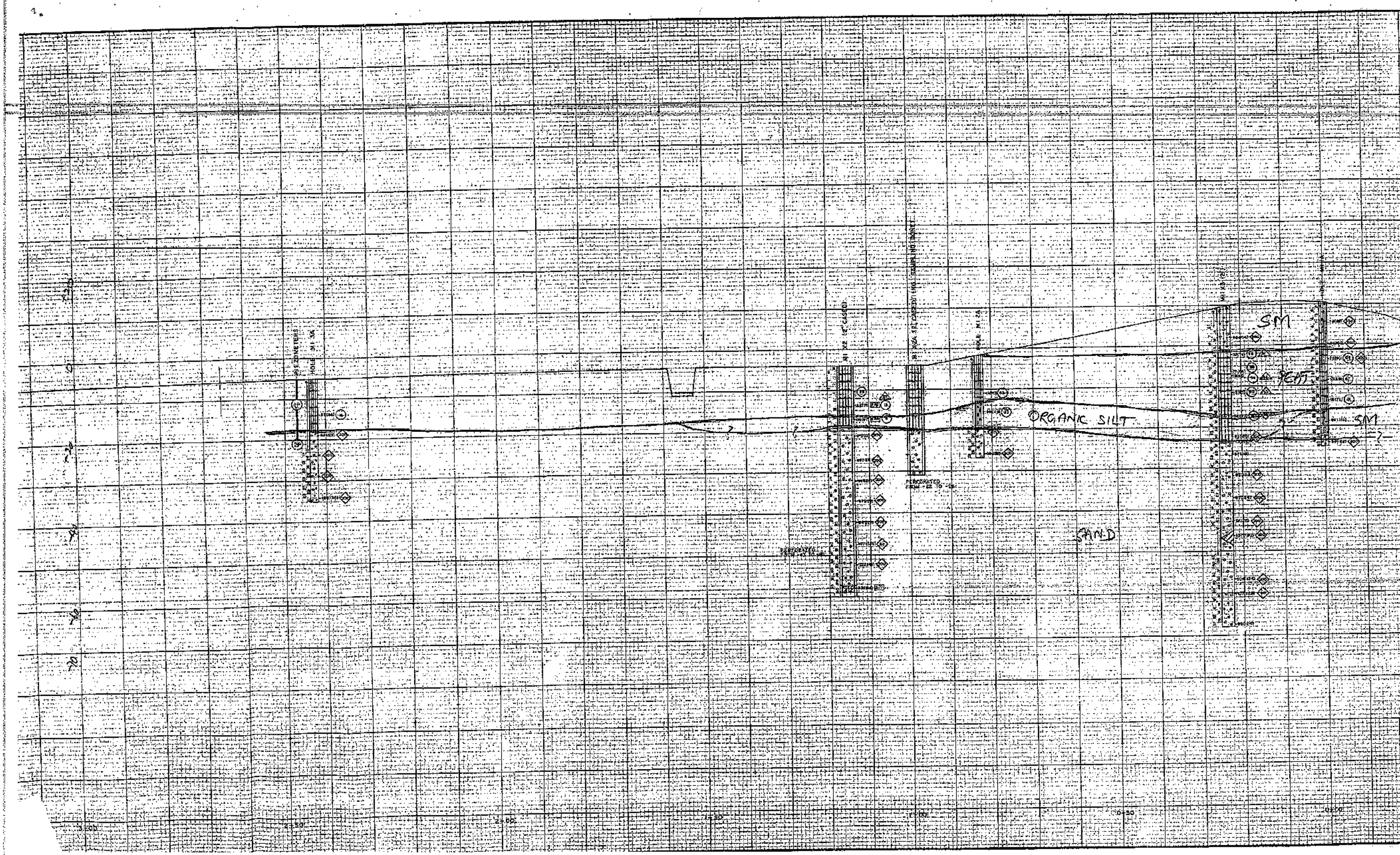
20
10
Mean Higher High Tide
Mean Half Tide
Mean Lower Low Tide
0 Mean Sea Level
10
20
30
40
50
60
70

LEGEND

FOOT (P INDICATES PUSH, W INDICATES WASH)
DENSITY IN POUNDS PER CUBIC FOOT
COMPRESSIVE STRENGTH, K_c Kg/cm^2
COMPRESSIVE STRESS AT 10% STRAIN, S_{10} Kg/cm^2
IGNITION IN PERCENT
SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D_{50}
GRAVITY

ORGANIC CLAY
SILTY PEAT
SILTY CLAY
SILTY SAND
SILT
SAND WITH SILT LENSES

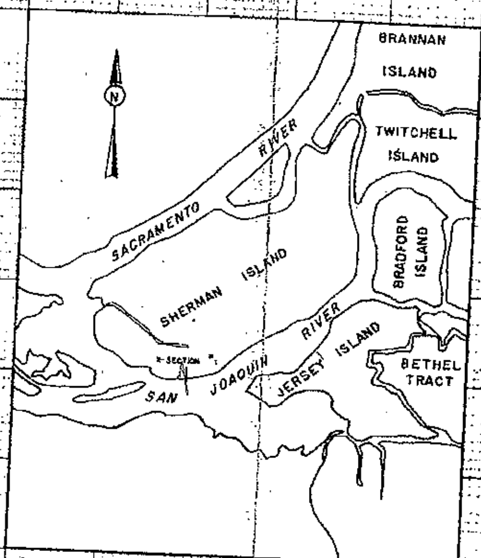
E ISLAND CROSS SECTION NO. I


SM
PEAT
ORGANIC SILT
SM
SAND
PIEZOMETERS
HOLE M1 3A
M1 X2 (12" CASED)
HOLE M1 2A
PERFORATED FROM -22 TO -26
0
-20
-40
3+00
2+50
2+00
1+50
1+00
0+50
0+00

NOTES:

GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION
ALL BORINGS ARE ONE INCH DIAMETER EXCEPT WHERE NOTED
HAMMER WEIGHT: 140 LBS.
DRILLING DATES: 1" HOLES - JULY 1, 1957 TO JULY 10, 1957
2" HOLES - AUGUST 9, 1957 TO SEPTEMBER 3, 1957

20' 10' 0' Mean Sea Level 10' 20' 30' 40' 50' 60' 70' 80' 90' 100' 110' 120' 130' 140'



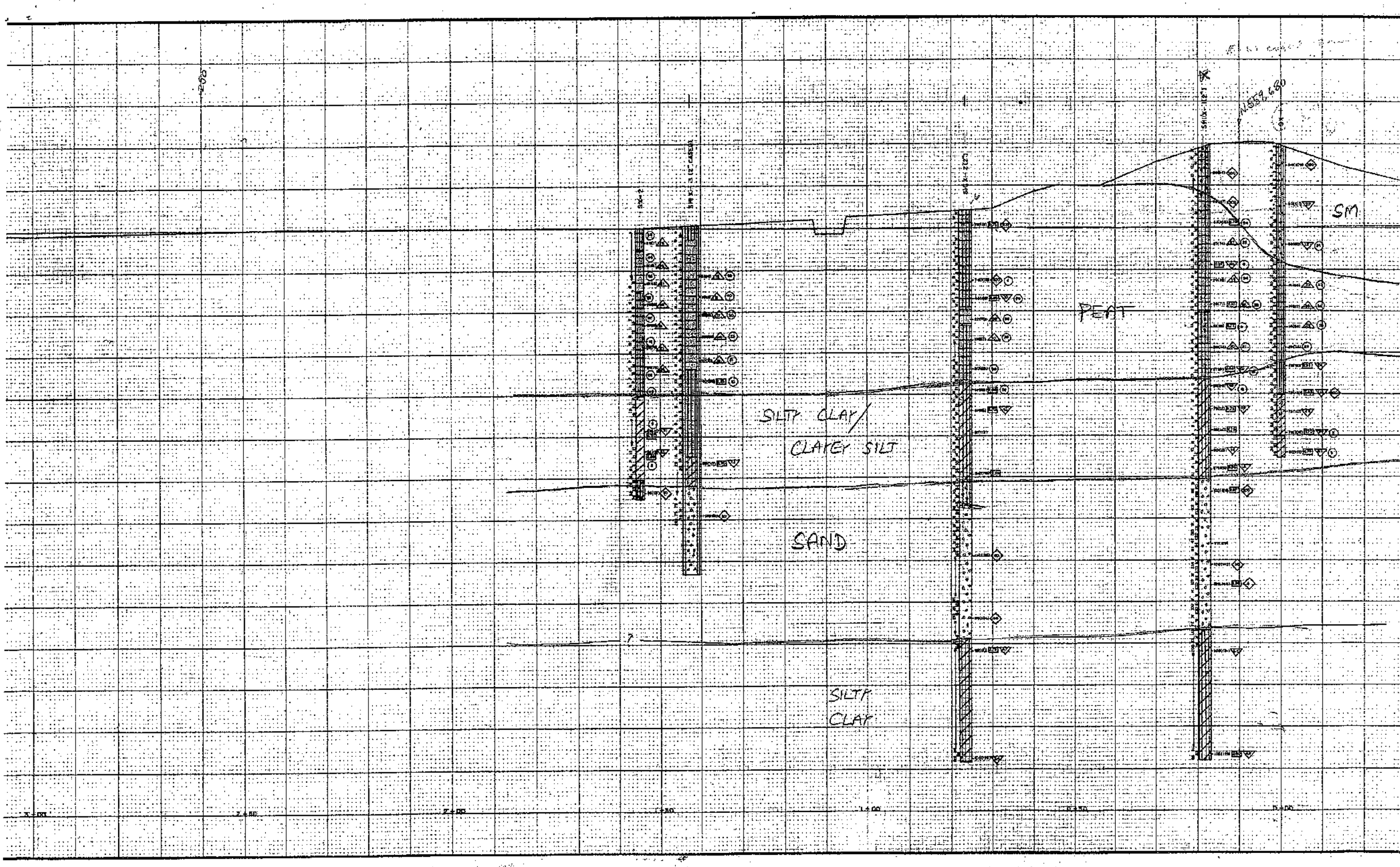
LOCATION MAP

LEGEND

BLOWS PER FOOT (P INDICATES PUSH, W INDICATES WASH)
DRY (WET) DENSITY IN POUNDS PER CUBIC FOOT
UNCONFINED COMPRESSIVE STRENGTH K_c Kg/cm²
UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, S_{10} Kg/cm²
LOSS ON IGNITION IN PERCENT
MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D_{50}
SPECIFIC GRAVITY

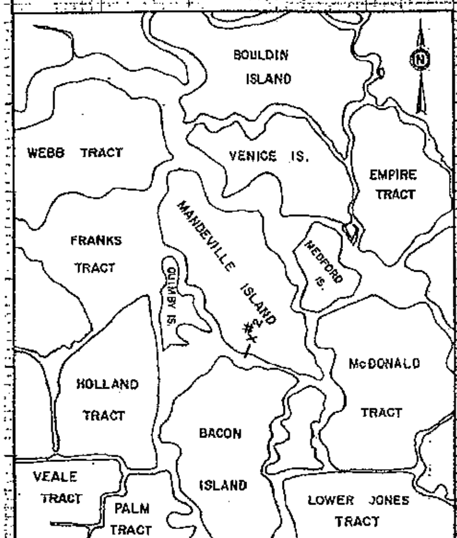
SILT
PEAT
CLAY
SAND
ORGANIC SILT
ORGANIC CLAY
SILTY PEAT
SILTY CLAY
SILTY SAND
SAND WITH SILT LENSES

SHERMAN ISLAND CROSS SECTION NO. 1



SM
PEAT
SILTY CLAY/
CLAYEY SILT
SAND
SILTY
CLAY
N559,680
+20
0
-20
-40
-60
-80
-100
-120

NOTES:
GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION
ALL BORINGS ARE ONE INCH DIAMETER, EXCEPT WHERE NOTED
HAMMER WEIGHT 140 LBS
DRILLING DATES: 1" HOLES - OCT. 1, 1957 TO OCT. 2, 1957
2" HOLES - NOV. 6, 1957 TO NOV. 14, 1957



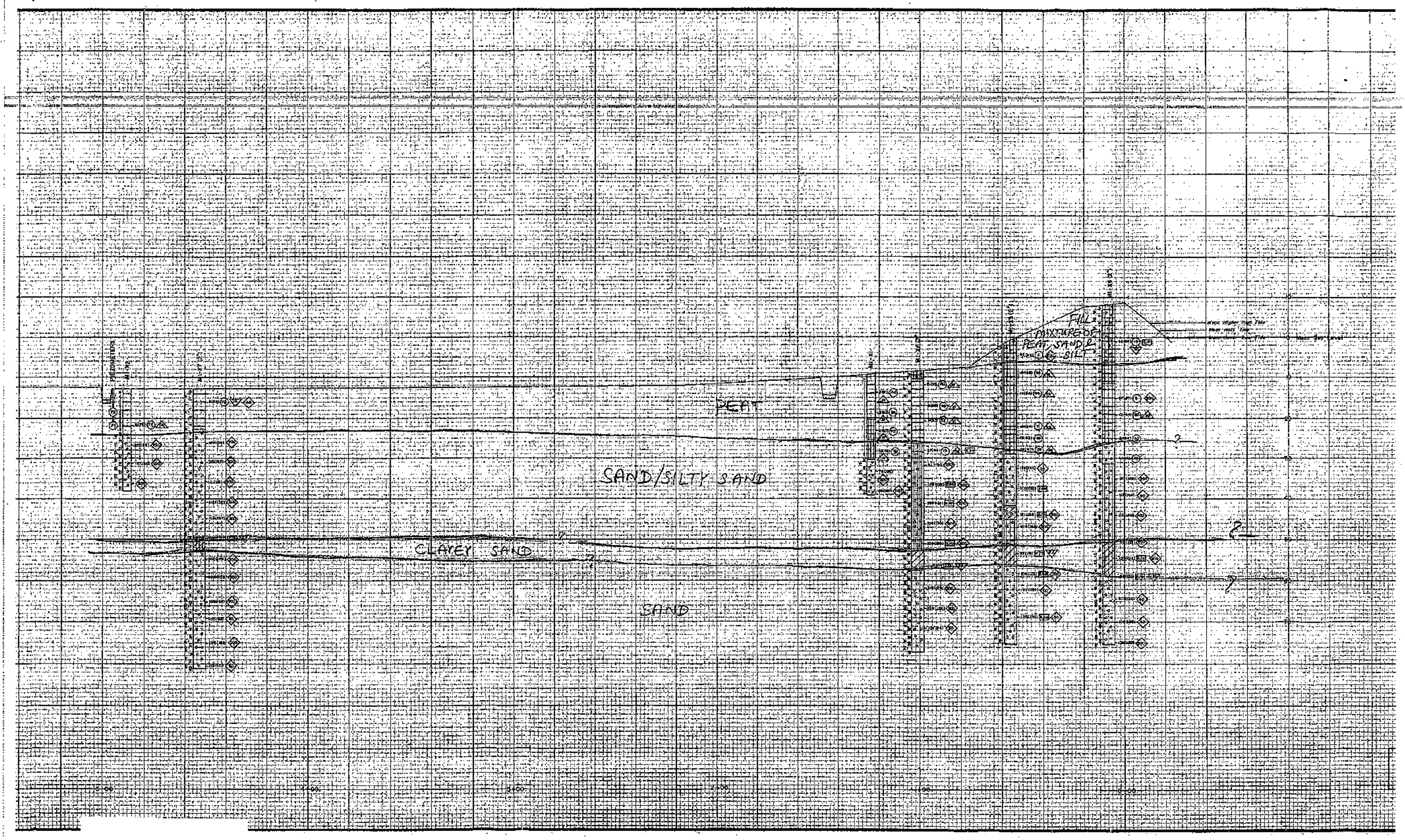
LOCATION MAP

LEGEND

DWS PER FOOT (P INDICATES PUSH, W INDICATES WASH)
Y (WET) DENSITY IN POUNDS PER CUBIC FOOT
CONFINED COMPRESSIVE STRENGTH, K_c Kg/cm^2
CONFINED COMPRESSIVE STRESS AT 10% STRAIN S_{10} Kg/cm^2
SS ON IGNITION IN PERCENT
DIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D_{50}
ECIFIC GRAVITY

T	ORGANIC CLAY
AT	SILTY PEAT
AY	SILTY CLAY
ND	SILTY SAND
GANIC SILT	SAND WITH SILT LENSES

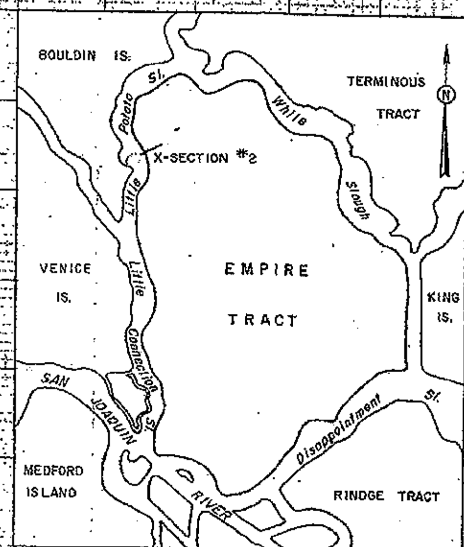
VILLE ISLAND CROSS SECTION NO. 2



FILL
MIXTURE OF PEAT, SAND & SILT
PEAT
SAND/SILTY SAND
CLAYEY SAND
SAND
PIEZOMETERS

NOTES:

GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION
ALL BORINGS ARE ONE INCH DIAMETER EXCEPT WHERE NOTED
HAMMER WEIGHT: 1" HOLES-140 LBS, 2" HOLE-270 LBS.
DRILLING DATES:
1" HOLES-APR. 24, 1957 TO APR. 25, 1957
2" HOLES-JUN. 27, 1957 TO JUL. 10, 1957



LOCATION MAP

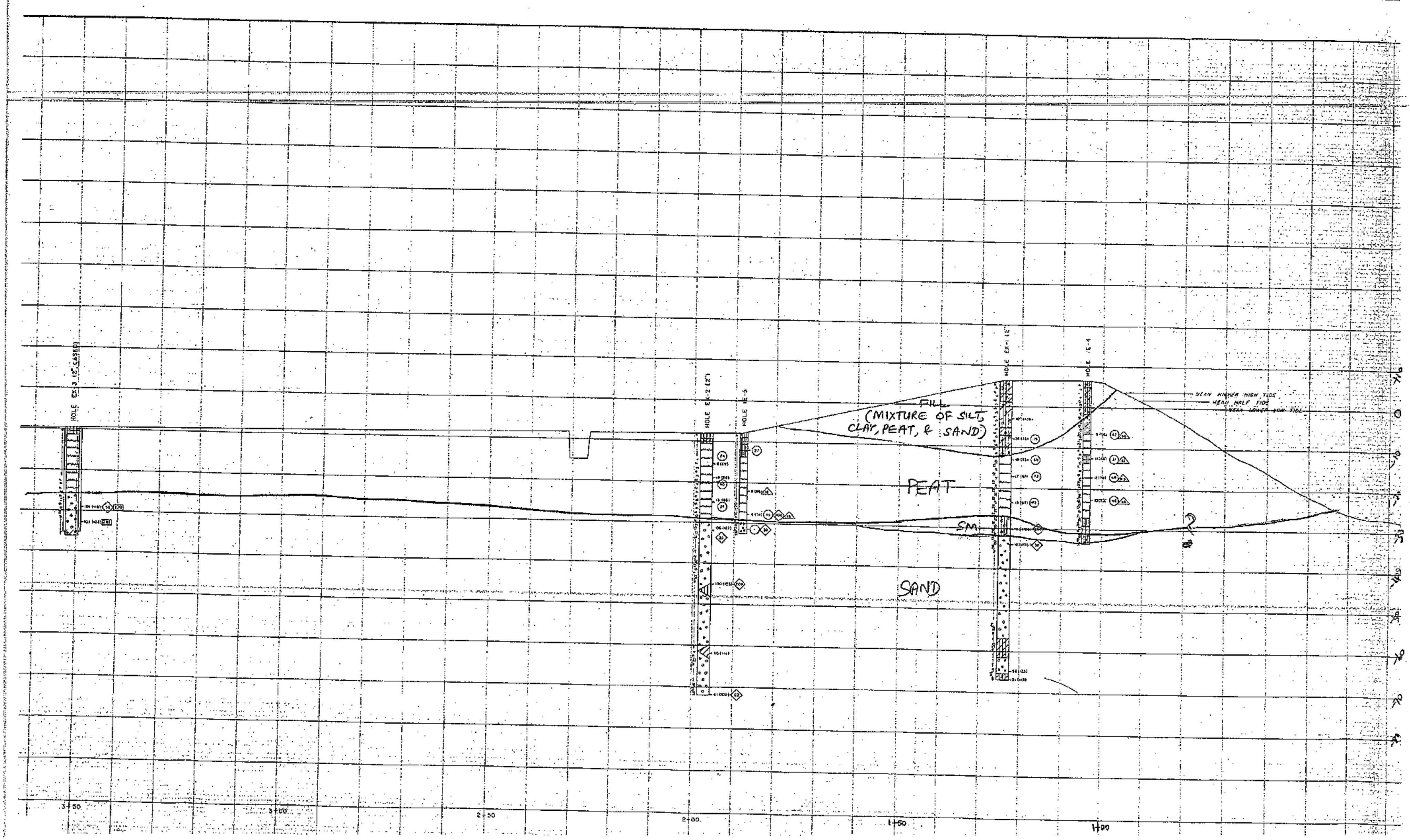
10
0 Mean Sea Level
10
20
30
40
50
60
70
80

LEGEND

BLOWS PER FOOT (P INDICATES PUSH, W INDICATES WASH)
DRY (WET) DENSITY IN POUNDS PER CUBIC FOOT
UNCONFINED COMPRESSIVE STRENGTH, X_c, Kg/cm^2
UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, S_{10}, Kg/cm^2
LOSS ON IGNITION IN PERCENT
MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, #60
SPECIFIC GRAVITY

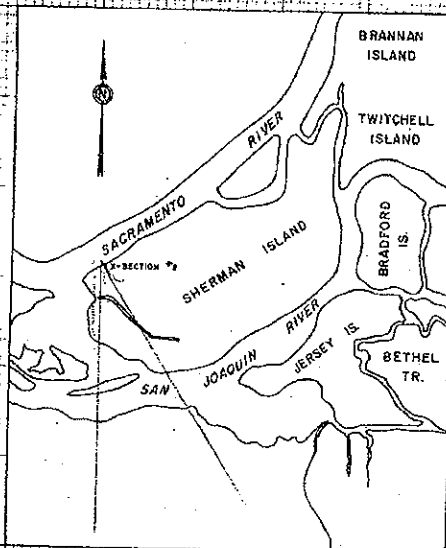
SILT
PEAT
CLAY
SAND
ORGANIC SILT
ORGANIC CLAY
SILTY PEAT
SILTY CLAY
SILTY SAND
SAND, WITH SILT LENSES

EMPIRE TRACT CROSS SECTION NO. 2


HOLE EX-3 (12" CASED)
HOLE EX-2 (2")
HOLE IE-5
HOLE EX-1 (2")
HOLE IE-4
MEAN HIGHER HIGH TIDE
MEAN HALF TIDE
MEAN LOWER LOW TIDE
FILL
(MIXTURE OF SILT, CLAY, PEAT, & SAND)
PEAT
SM
SAND
3+50
3+00
2+50
2+00
1+50
1+00

NOTES:

GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION
ALL BORINGS ARE ONE INCH DIAMETER EXCEPT WHERE NOTED
HAMMER WEIGHT: 140 LBS.
DRILLING DATES: 1" HOLES - JULY 11, 1957 TO JULY 17, 1957,
2" HOLES - SEPT. 4, 1957 TO SEPT. 19, 1957.



LOCATION MAP

LEGEND

BLOWS PER FOOT (P INDICATES PUSH, W INDICATES WASH)

DRY (WET) DENSITY IN POUNDS PER CUBIC FOOT

UNCONFINED COMPRESSIVE STRENGTH, K_c Kg/cm²

UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, D_{10} Kg/cm²

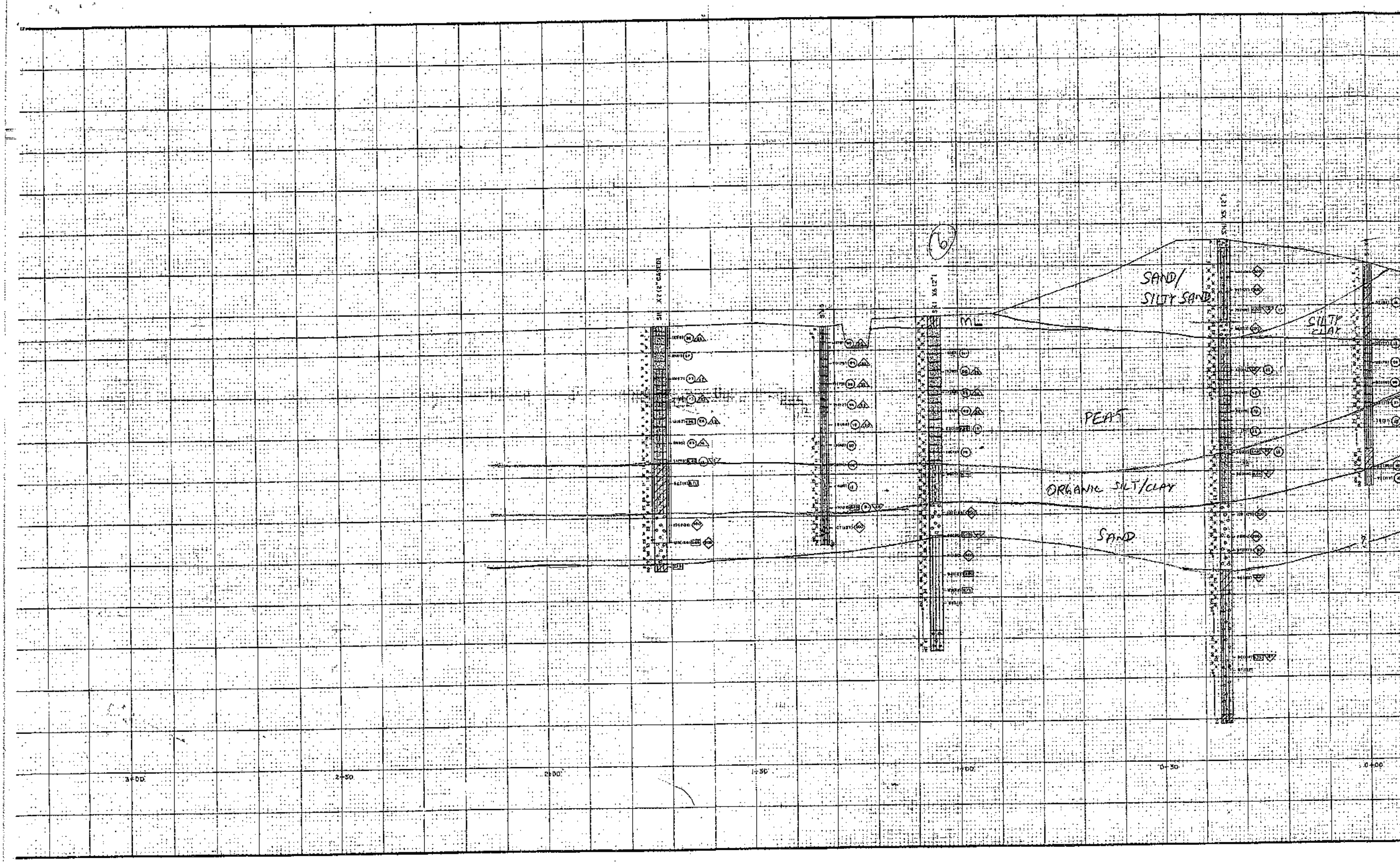
LOSS ON IGNITION IN PERCENT

MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D_{50}

SPECIFIC GRAVITY

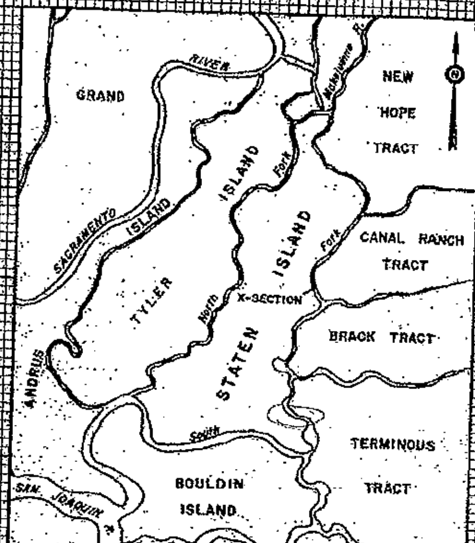
SILT — ORGANIC CLAY
PEAT — SILTY PEAT
CLAY — SILTY CLAY
SAND — SILTY SAND
ORGANIC SILT — SAND WITH SILT LENSES

SHERMAN ISLAND CROSS SECTION NO. 2


SAND/
SILTY SAND
SILTY CLAY
ML
PEAT
ORGANIC SILT/CLAY
SAND
3+00
2+50
2+00
1+50
1+00
0+50
0+00

NOTES:

GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION
ALL BORINGS ARE ONE INCH DIAMETER EXCEPT WHERE NOTED
HAMMER WEIGHT 140 LBS
DRILLING DATES:
11 HOLES : MAY 27 1957 TO MAY 28 1957
[illegible] HOLES : JUL 9 1957 TO JUL 16 1957
BARGE HOLE : FEB 17 1958



LOCATION MAP

LEGEND

BLOWS PER FOOT OR INDICATES PUSH, W INDICATES WASH

DRY (WET) DENSITY IN POUNDS PER CUBIC FOOT

UNCONFINED COMPRESSIVE STRENGTH, q_u Kg/cm^2

UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, S_{10} Kg/cm^2

LOSS ON IGNITION IN PERCENT

MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D_{50}

SPECIFIC GRAVITY

SILT

PEAT

CLAY

SAND

ORGANIC SILT

ORGANIC CLAY

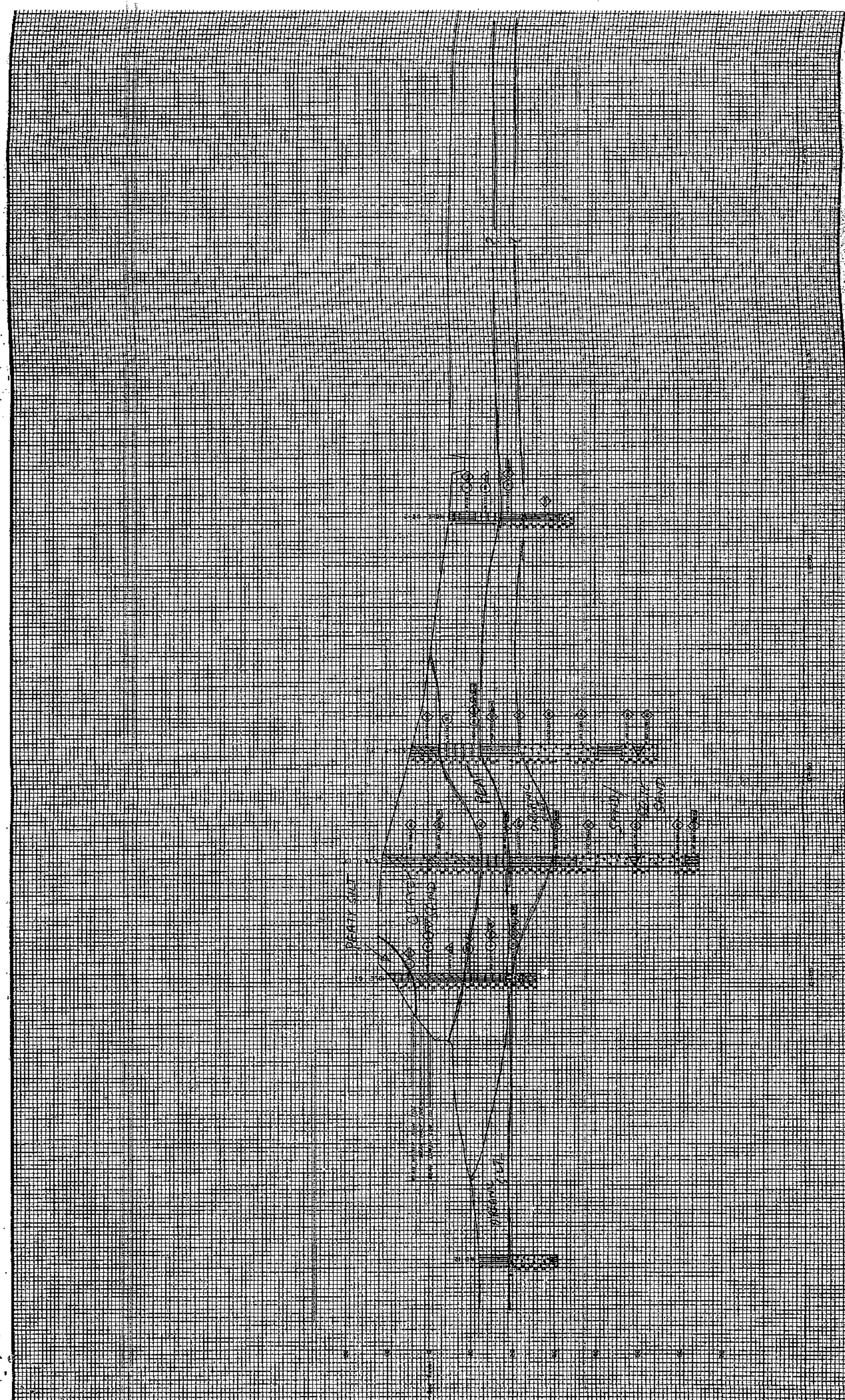
SILTY PEAT

SILTY CLAY

SILTY SAND

SAND, WITH SILT LENSES

STATEN ISLAND CROSS SECTION NO. 1


PEATY SILT
PEAT
SAND
ORGANIC SILT

NOTES:

GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION.

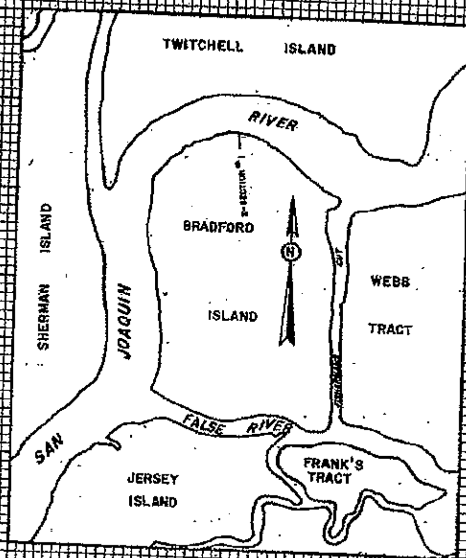
ALL BORINGS ARE ONE INCH DIAMETER EXCEPT WHERE NOTED.

HAMMER WEIGHT: 1" HOLES: 16 LBS., 2" HOLES: 70 LBS.

DRILLING DATES:

1" HOLES= NOV 19, 1957 TO NOV 20, 1957

2" HOLES= DEC 5, 1957 TO DEC 17, 1957



LOCATION MAP

LEGEND

DRY (WET) DENSITY IN POUNDS PER CUBIC FOOT

UNCONFINED COMPRESSIVE STRENGTH, q_u Kg/cm²

UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, S_{10} Kg/cm²

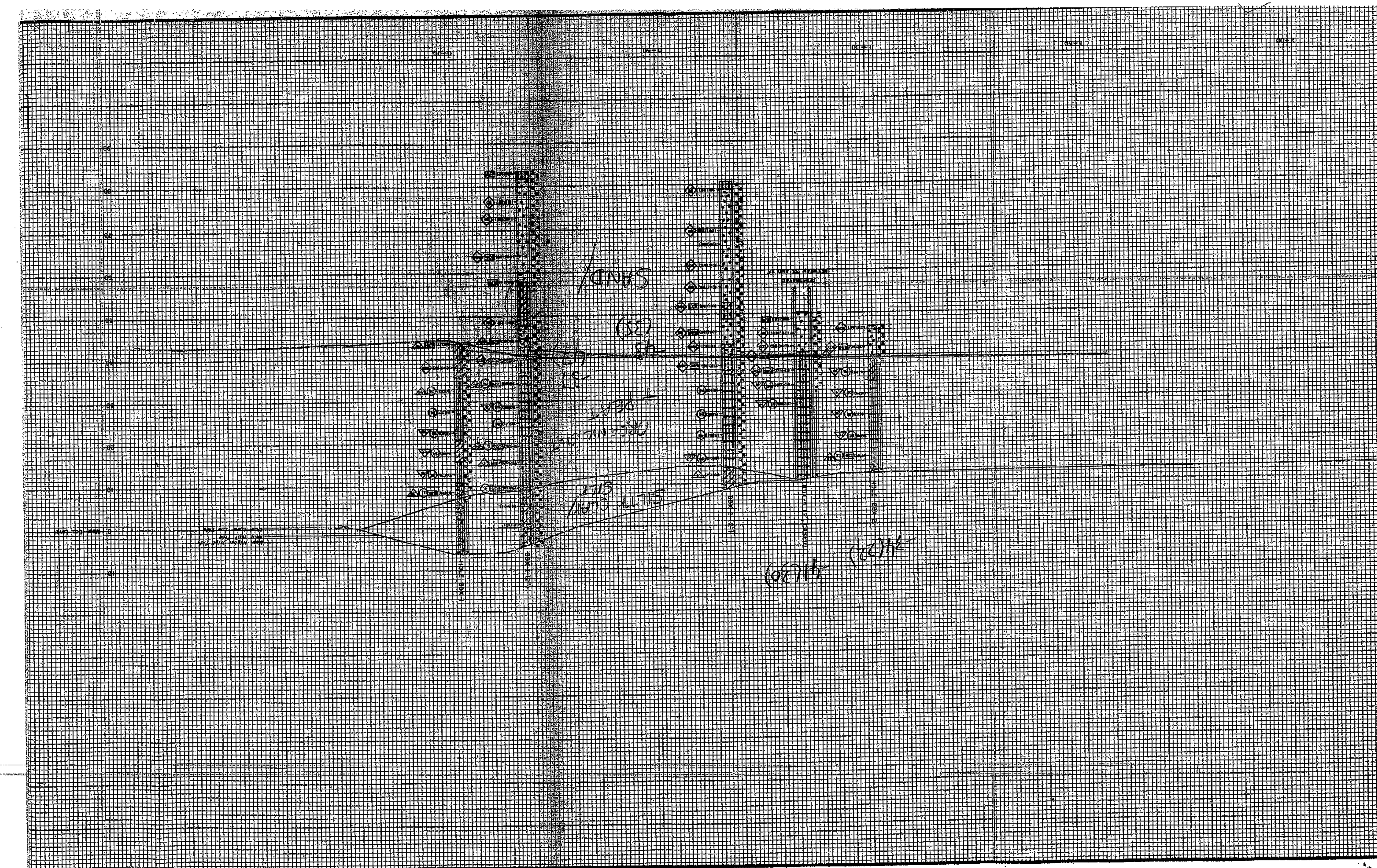
LOSS ON IGNITION IN PERCENT

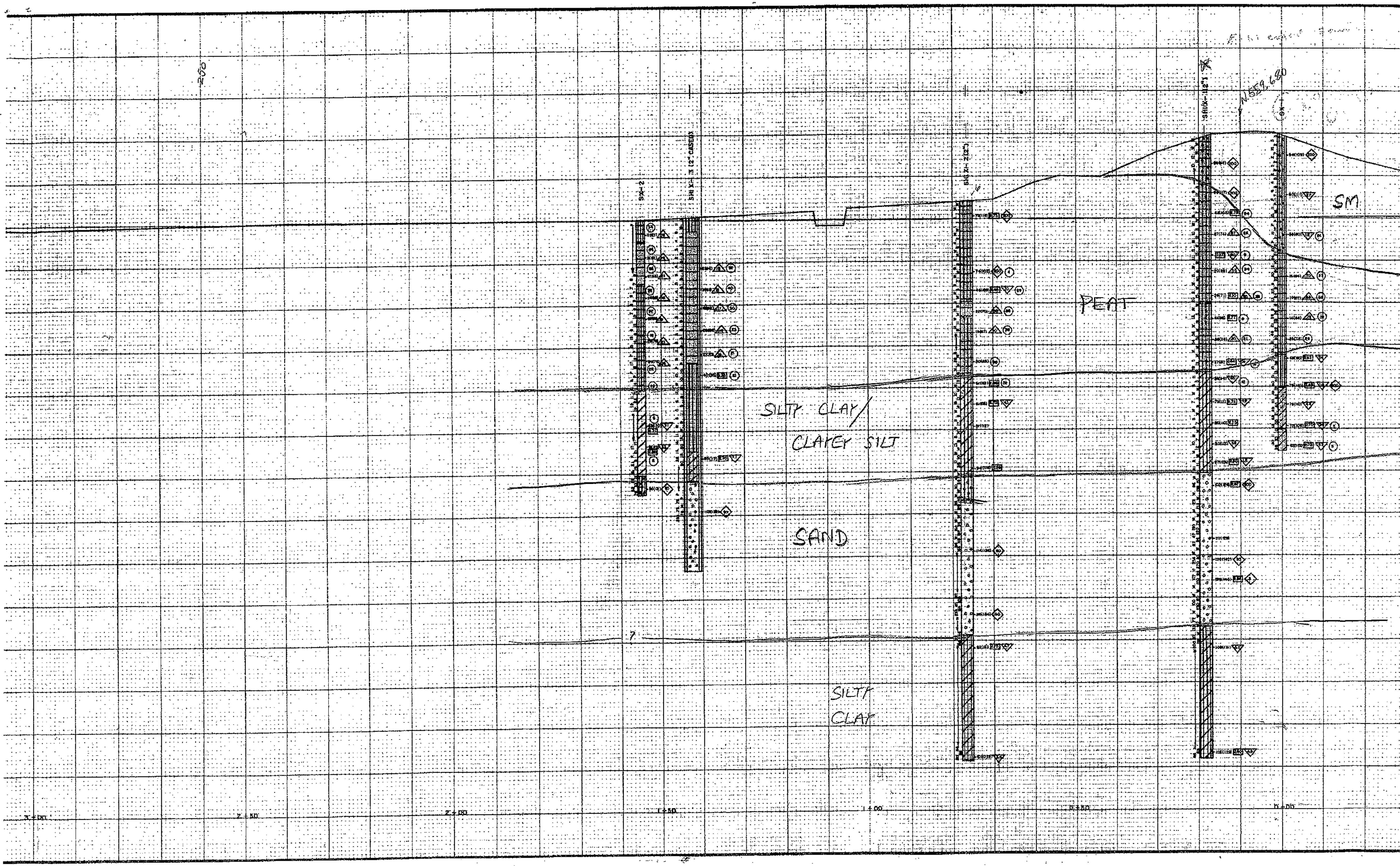
MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D_{50}

SPECIFIC GRAVITY

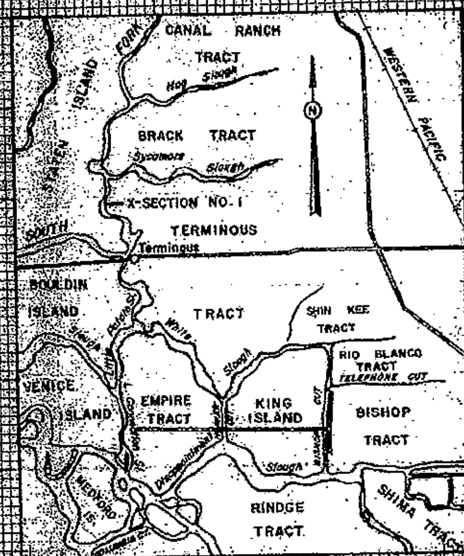
SILT	ORGANIC CLAY
PEAT	SILTY PEAT
CLAY	SILTY CLAY
SAND	SILTY SAND
ORGANIC SILT	SAND WITH SILT LENSES

BRADFORD ISLAND CROSS SECTION NO. 1




SM
PEAT
SILTY CLAY/
CLAYEY SILT
SAND
SILTY
CLAY
+20
0
-20
-60
-80
-100
-120

NOTES:
GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION.
ALL BORINGS ARE TWO INCH DIAMETER EXCEPT WHERE NOTED.
[illegible] RANGE HOLES [illegible]
[illegible] DATES:
STATIONS JUNE 20, 1956 TO JUNE 24, 1956
RANGE HOLES - FEBRUARY 24, 1958



LOCATION MAP

LEGEND

BLOWS PER FOOT (P INDICATES PUSH, W INDICATES WASH)

DRY (WET) DENSITY IN POUNDS PER CUBIC FOOT

UNCONFINED COMPRESSIVE STRENGTH, K_c Kg/cm^2

UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, S_{10} Kg/cm^2

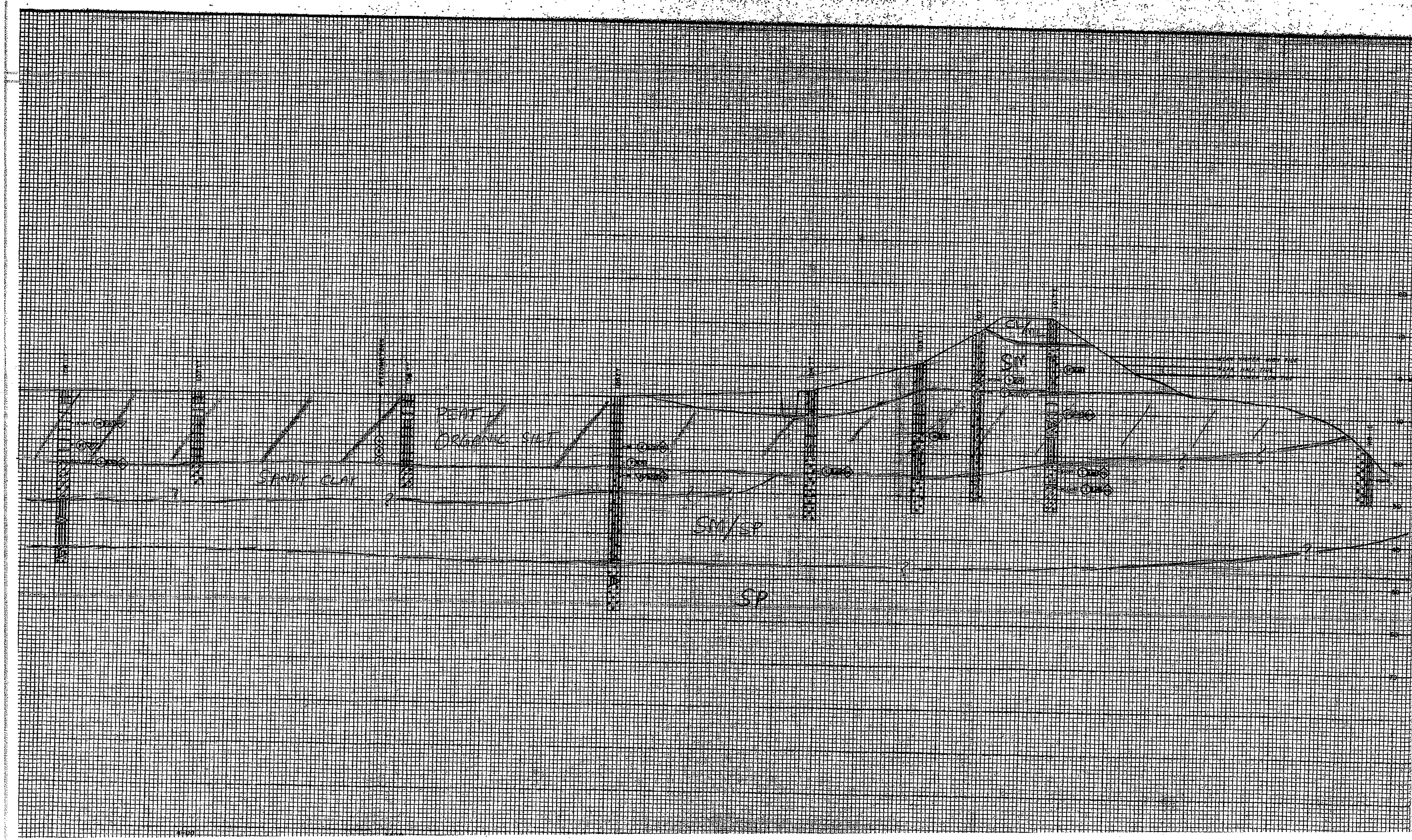
LOSS ON IGNITION IN PERCENT

MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D_{50}

SPECIFIC GRAVITY

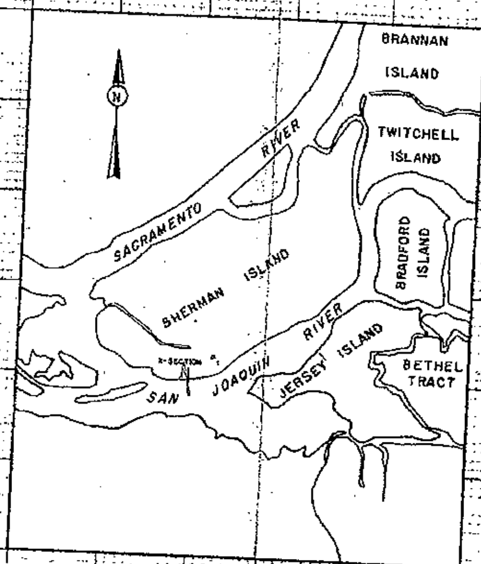
SILT	ORGANIC CLAY
PEAT	SILTY PEAT
CLAY	SILTY CLAY
SAND	SILTY SAND
ORGANIC SILT	SAND WITH SILT LENSES

TERMINOUS TRACT CROSS SECTION NO. 1


PEAT &
ORGANIC SILT
SANDY CLAY
SM/SP
SP
SM

NOTES:
GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION
ALL BORINGS ARE ONE INCH DIAMETER EXCEPT WHERE NOTED
HAMMER WEIGHT: 140 LBS.
DRILLING DATES: 1" HOLES - JULY 1, 1957 TO JULY 10, 1957
2" HOLES - AUGUST 9, 1957 TO SEPTEMBER 3, 1957

20
10
0' Mean Sea Level
10
20
30
40
50
60



LOCATION MAP

70

LEGEND

BLOWS PER FOOT (P INDICATES PUSH, W INDICATES WASH)

DRY (WET) DENSITY IN POUNDS PER CUBIC FOOT

UNCONFINED COMPRESSIVE STRENGTH K_c Kg/cm^2

UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, S_{10} Kg/cm^2

LOSS ON IGNITION IN PERCENT

MAXIMUM SIEVE SIZE RETAINING 30% OF SAMPLE BY WEIGHT, D_{30}

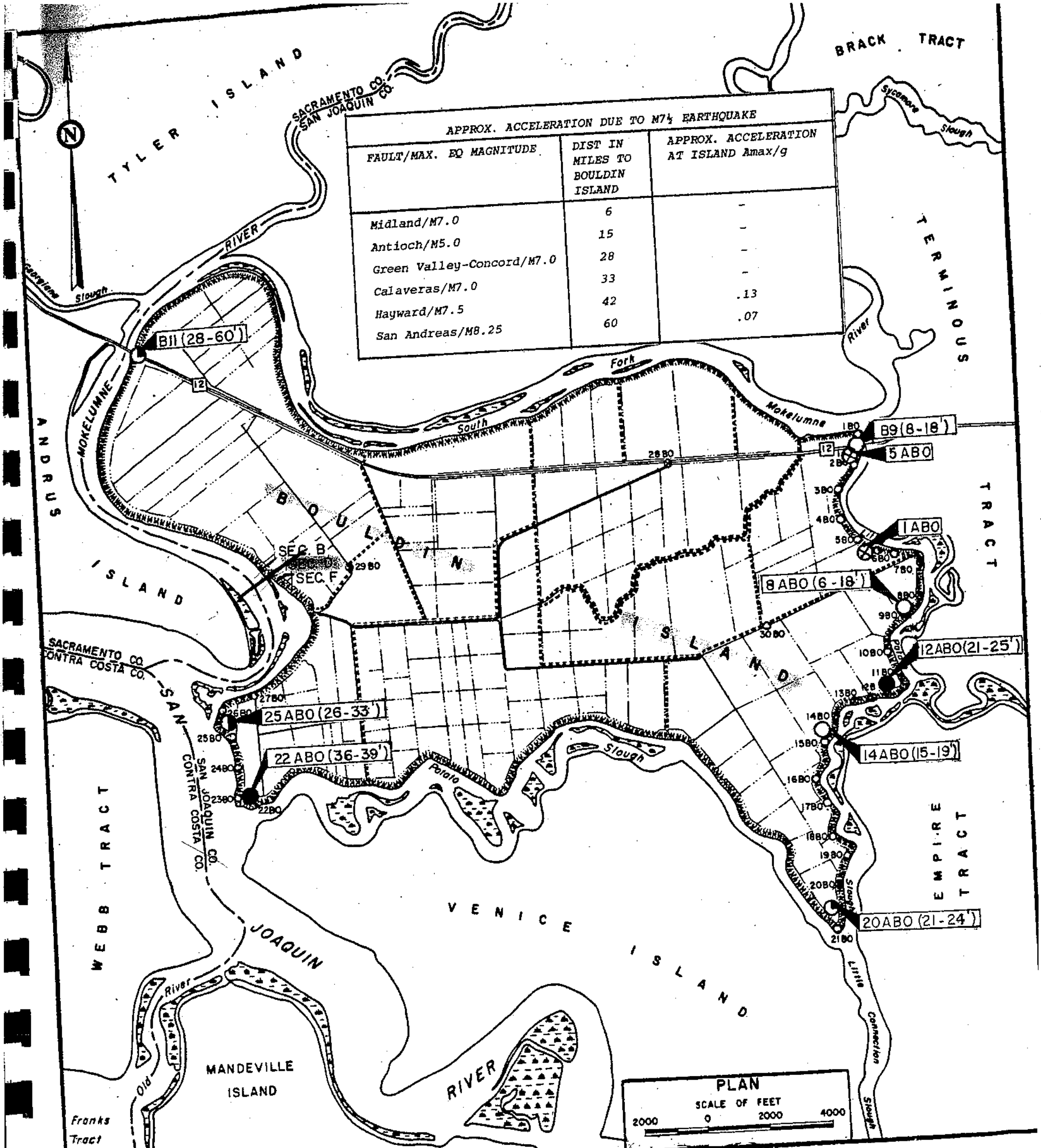
SPECIFIC GRAVITY

SILT	ORGANIC CLAY
PEAT	SILTY PEAT
CLAY	SILTY CLAY
SAND	SILTY SAND
ORGANIC SILT	SAND WITH SILT LENSES

80
90
100
110
120
130

SHERMAN ISLAND CROSS SECTION NO. 1

140



APPROX. ACCELERATION DUE TO M7½ EARTHQUAKE		
FAULT/MAX. EQ MAGNITUDE	DIST IN MILES TO BOULDIN ISLAND	APPROX. ACCELERATION AT ISLAND Amax/g
Midland/M7.0	6	-
Antioch/M5.0	15	-
Green Valley-Concord/M7.0	28	-
Calaveras/M7.0	33	-
Hayward/M7.5	42	.13
San Andreas/M8.25	60	.07

LEGEND

- ○ *Liquefiable Strata for acceleration .05g*
- ◔ *Liquefiable Strata for acceleration .10g*
- ◑ *Liquefiable Strata for acceleration .20g*
- ● *Acceleration greater than .20g required for liquefaction*
- ⊗ *Non-liquefiable soil types i.e., clayey and organic soils*
- ( ) *Depth interval (Feet) of liquefiable strata below levee foundation*

Figure 1

SPT BORING LOCATIONS
AND LIQUEFACTION POTENTI
M=7½
BOULDIN ISLAND

FIGURE

Bouldin Island

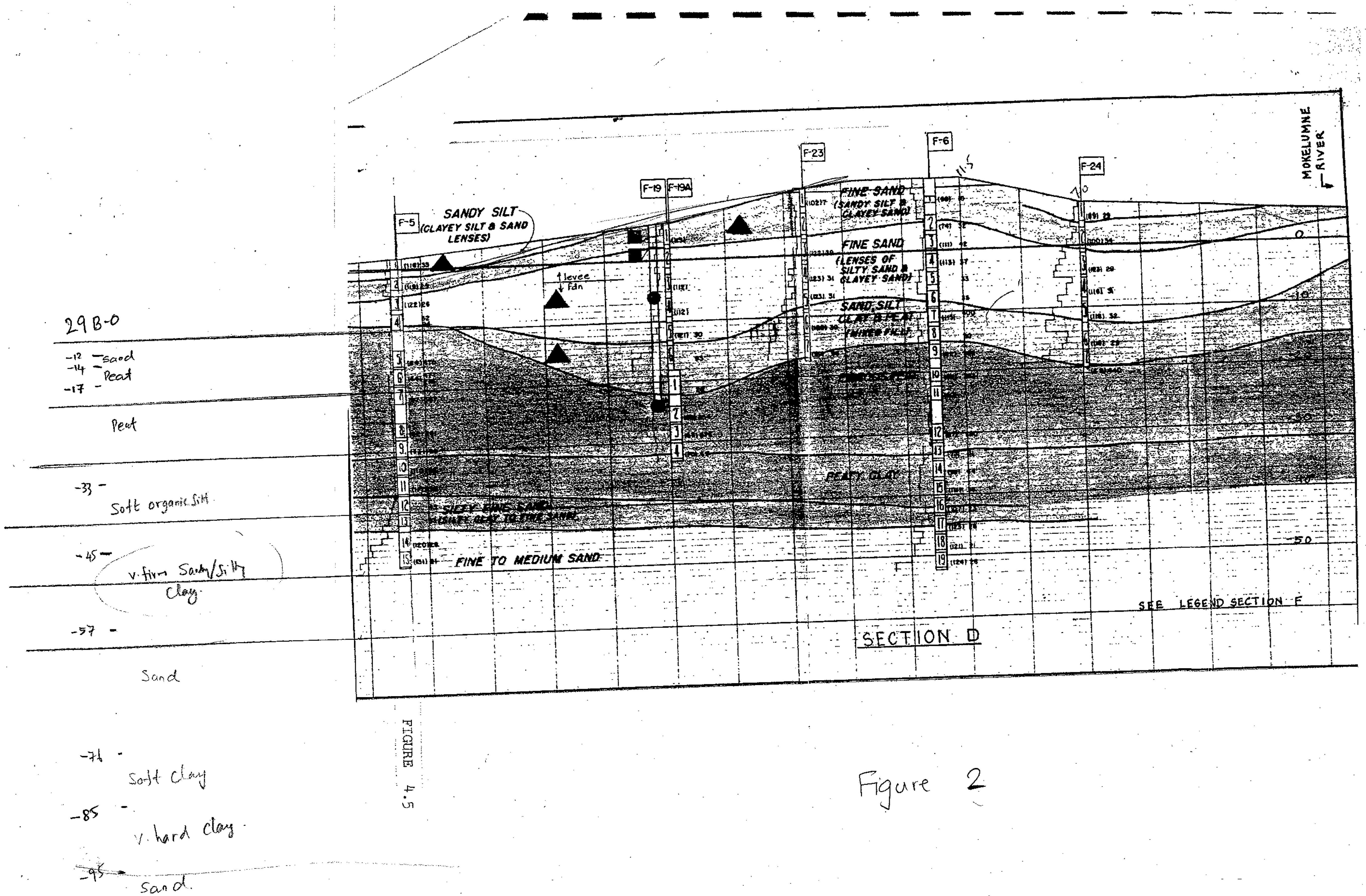
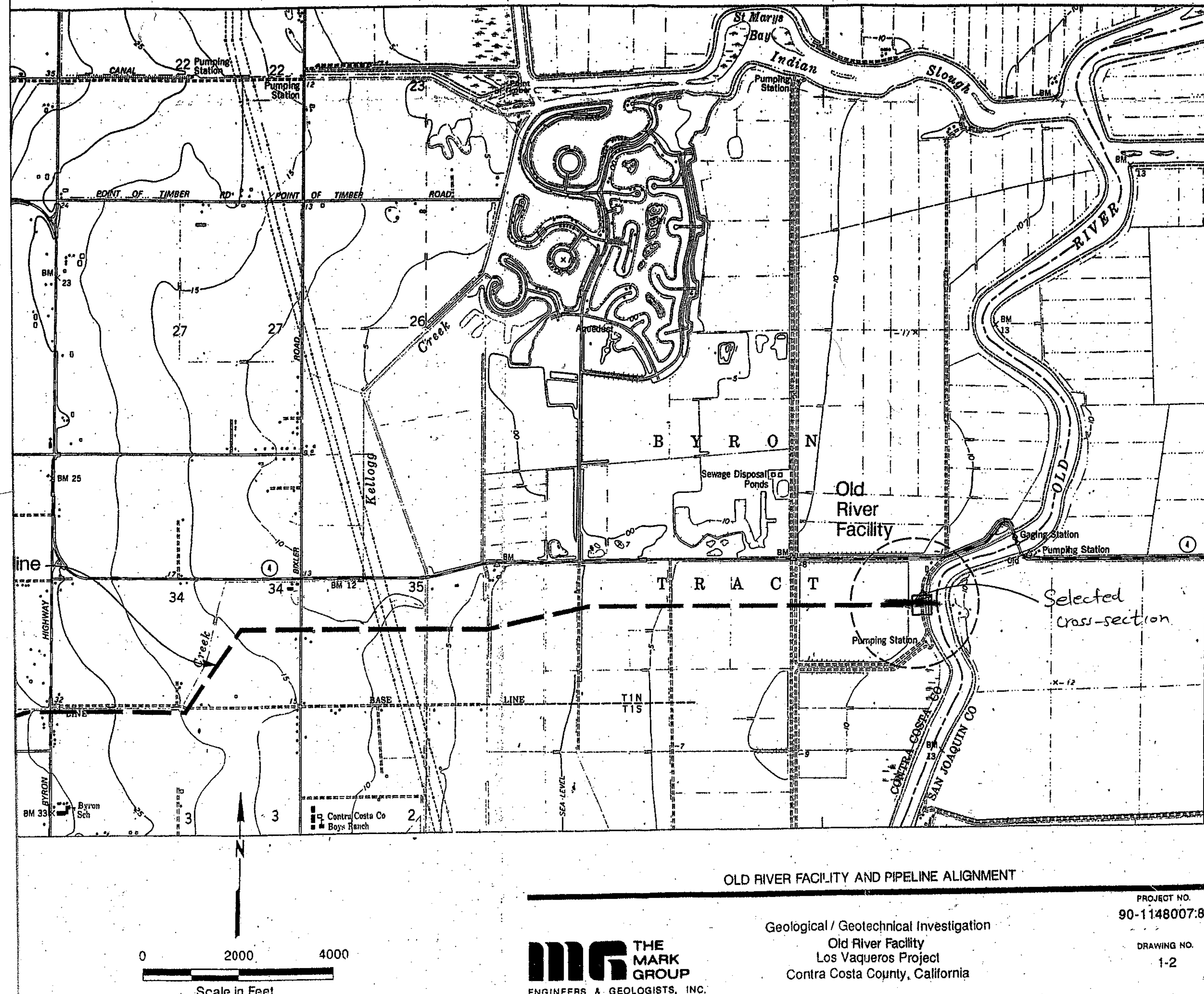


FIGURE 4.5

Figure 2

BYRON TRACT



OLD RIVER FACILITY AND PIPELINE ALIGNMENT

PROJECT NO.
90-1148007:80

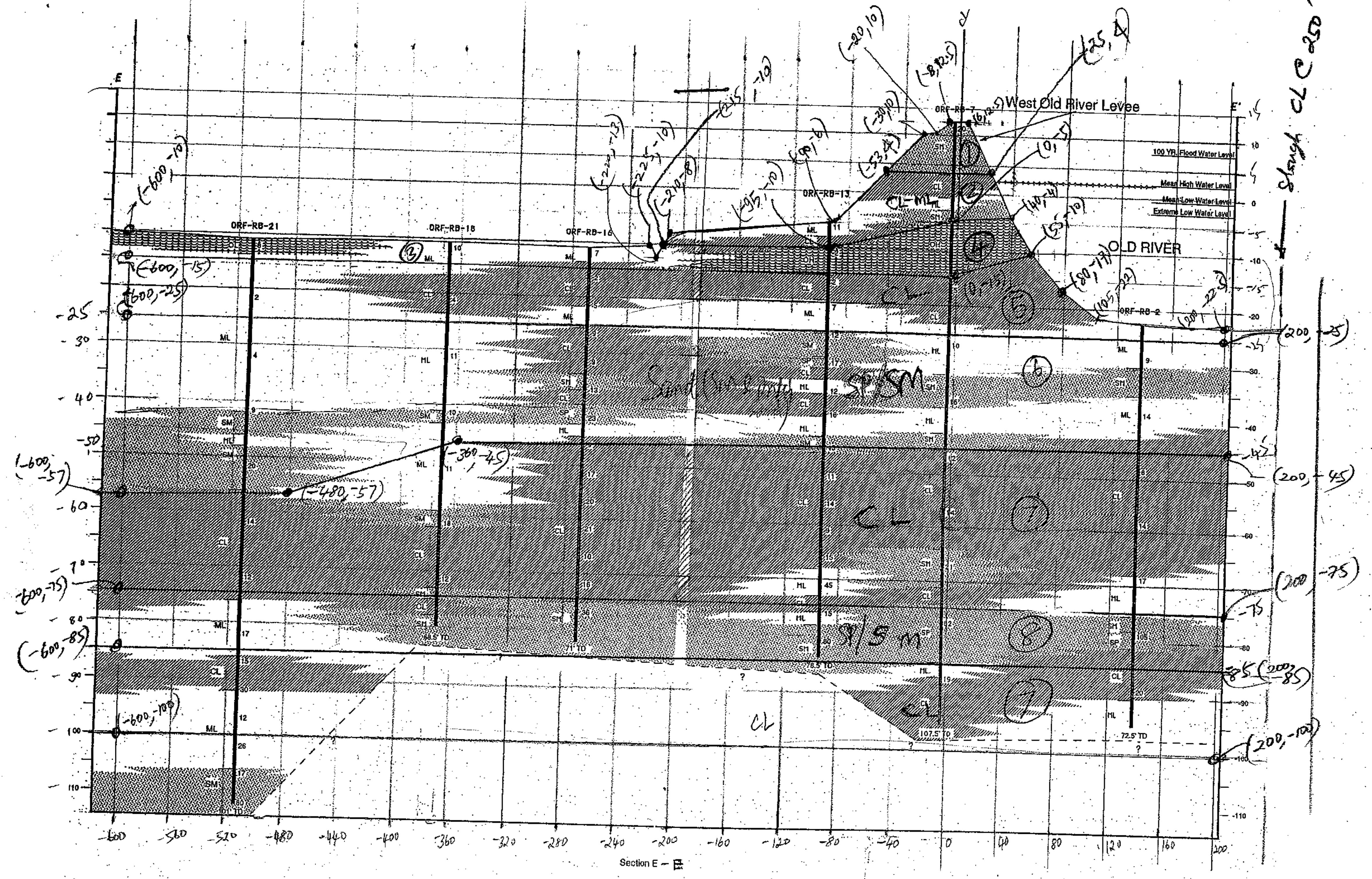
Geological / Geotechnical Investigation
Old River Facility
Los Vaqueros Project
Contra Costa County, California

DRAWING NO.
1-2

THE MARK GROUP
ENGINEERS & GEOLOGISTS, INC.

GENERALIZED CROSS-SECTION

* Drilling 1991, Pitcher Drilling



Section I

Scale: 1" = 10'
1" = 40'

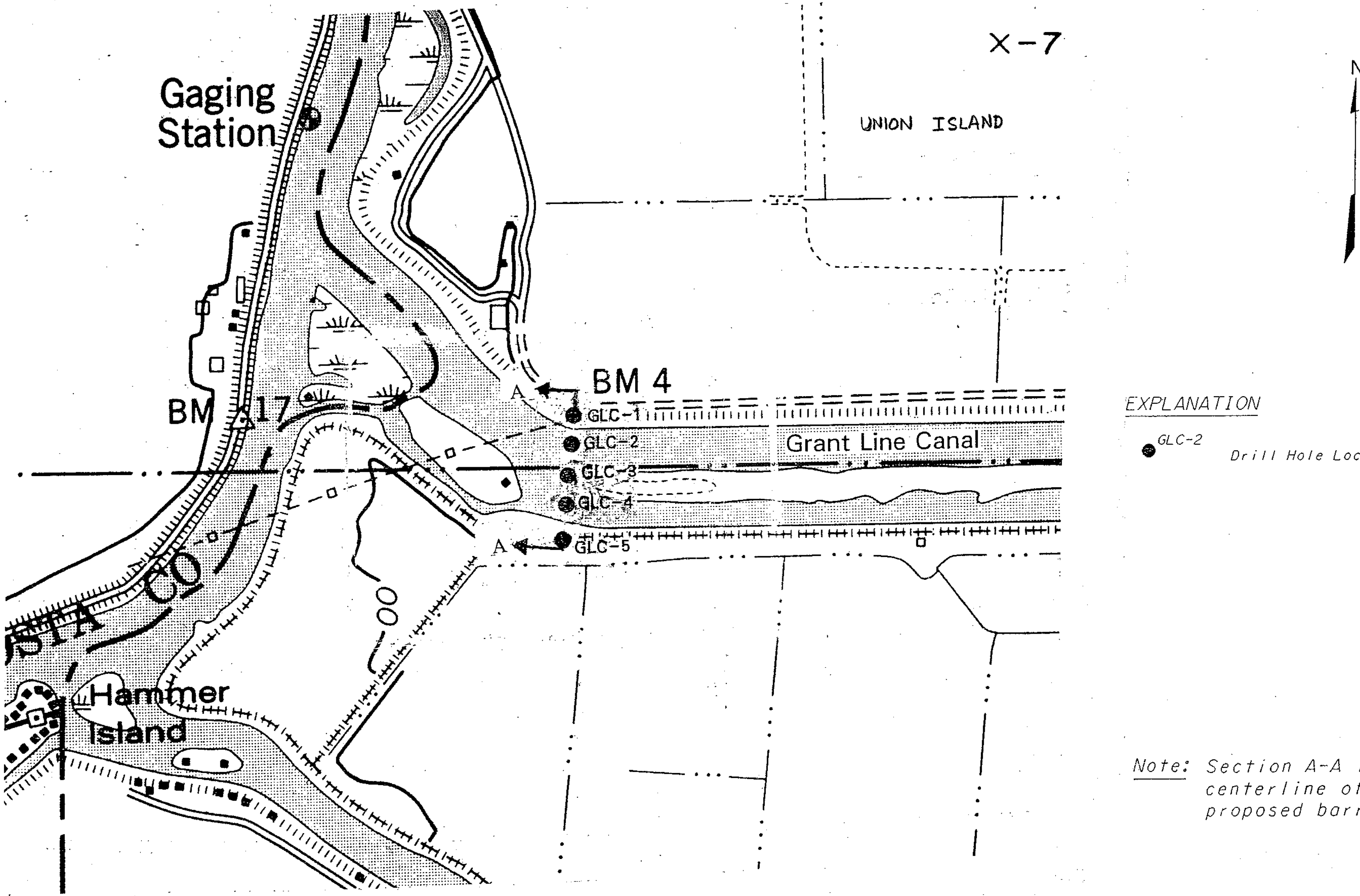
LEGEND:

- CL/CH: Inorganic clays of low to high plasticity, sandy clays and silty clays
- SW/SP/SM/SC: Well-graded to poorly graded sands, gravelly sands, silty sands, and clayey sands
- Pt/OL: Peat, organic silts and organic silt-clay
- ML/MH: Inorganic silts, sand silts, and clayey silts of low to high plasticity
- ? Unkown contact
- Geotechnical boring indicating location, lithologic contact and Unified Soils Classification, and SPT-N value (drive sampler)

NOTE: The patterns designating the interface between subsurface materia on this geologic section are interpretive in nature and are therefore approximations. The transition between materials may be sharp or gradual. Only at the bore hole locations should profile be considered to be reasonably accurate, and then only to the degree implied by the notes on the bore hole logs. Refer to the Unified Soil Classification System for soil designation explanation.

① – SM – medium dense fill
② – CL-ML fill
③ – MD – free field
④ – ~~MD~~ – Under levee
⑦ & ⑤ – CL
⑥ – SM
⑧ SP/SM – dense

X-7



EXPLANATION

● *GLC-2* *Drill Hole Location*

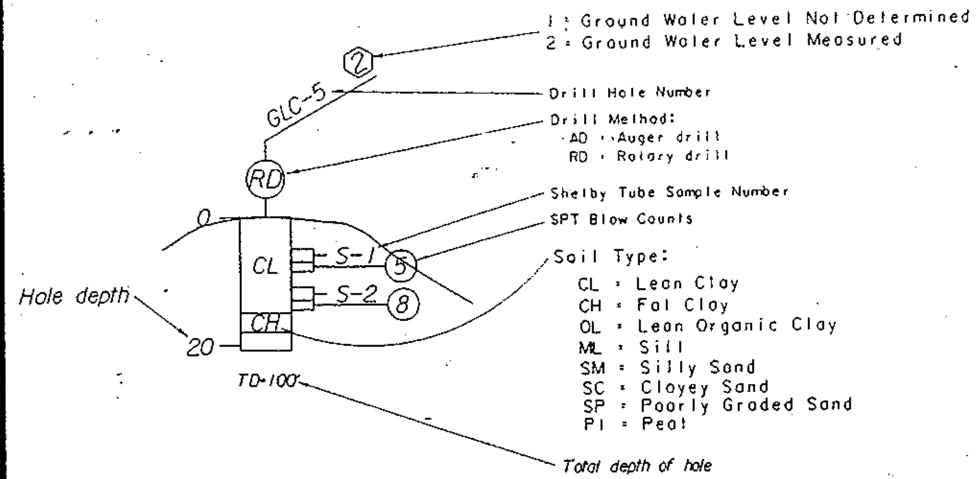
Note: Section A-A is along the centerline of the proposed barrier, site 1.

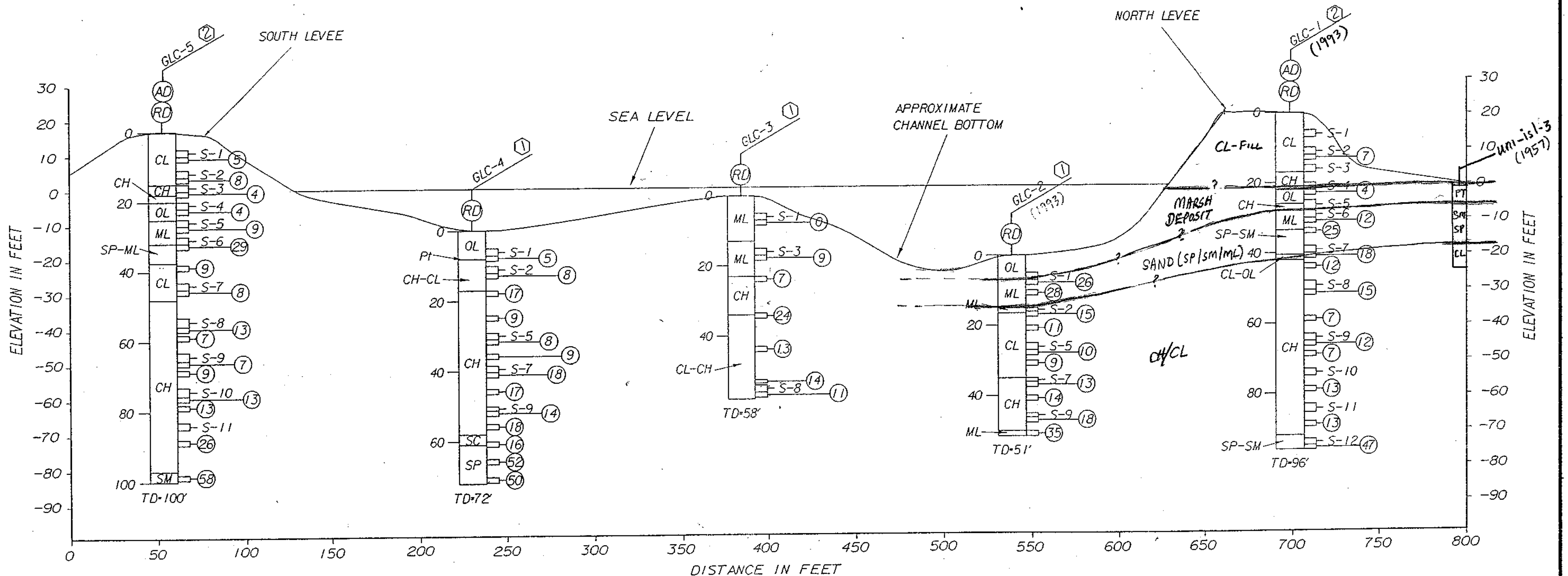
DRAWING SCALES	1" = 500' — 250 0 250 500 750 1000 SCALE OF FEET
GEOLOGY REPORT No.	80-10-04
CONSTRUCTION SPEC. No.	
GEOLOGY DRAWING No.	PG-D2-03
GEOLOGIC MAPPING AND/OR LOGGING BY:	1 T. Peltier; 2 I. Waters
DRAWING PREPARED BY:	I. Waters — DATE: 2/3/94
	STATE OF CALIFORNIA THE RESOURCES AGENCY DEPARTMENT OF WATER RESOURCES DIVISION OF DESIGN AND CONSTRUCTION PROJECT GEOLOGY BRANCH STATE WATER FACILITIES
	GRANT LINE CANAL BARRIER - SITE 1 DRILL HOLE LOCATION MAP
RELEASE DATE:	10-6-94
SHEET No.	1 of 1
PLATE	1
REV. / DATE / DESCRIPTION	

6-OCT-1994 /usr2/projects/delta/grnt

NOTES

1. See Plate 1 for location of section.
2. Section is along the centerline of the proposed barrier.
3. Observation wells installed in GLC-1 and GLC-5.
4. See drill hole logs for additional drill hole information.





SECTION A-A

NOTE: uni-isl-3 (Boring 1958, DWR) was added to the profile.

REV.	DATE	DESCRIPTION

DRAWING SCALES
1" = 60' HORIZONTAL SCALE OF FEET (30 0 30 60 90 120)
1" = 30' VERTICAL SCALE OF FEET (15 0 15 30 45 60)

GEOLOGY REPORT No.	80-10-04
CONSTRUCTION SPEC. No.	
GEOLOGY DRAWING No.	PG-D2-02
GEOLOGIC MAPPING AND/OR LOGGING BY:	1 T. Peltier; 2 R. Bartlett
DRAWING PREPARED BY:	I. Waters
DATE:	2/3/94

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
DIVISION OF DESIGN AND CONSTRUCTION
PROJECT GEOLOGY BRANCH
STATE WATER FACILITIES

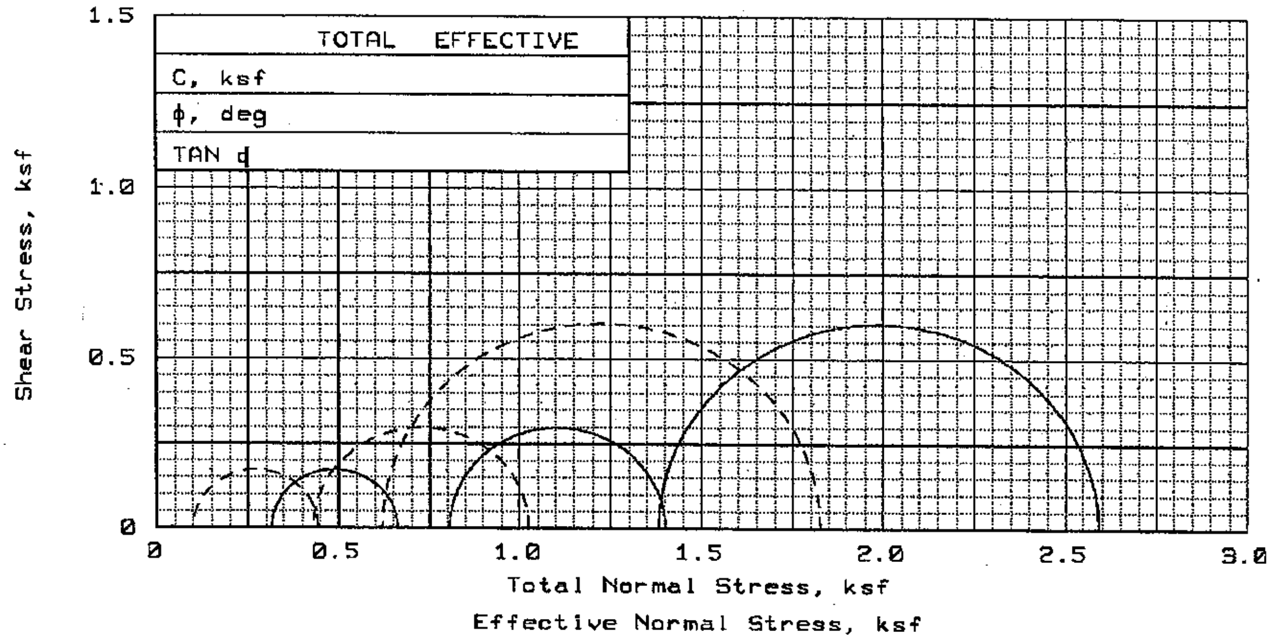
GRANT LINE CANAL BARRIER - SITE 1
GEOLOGIC SECTION

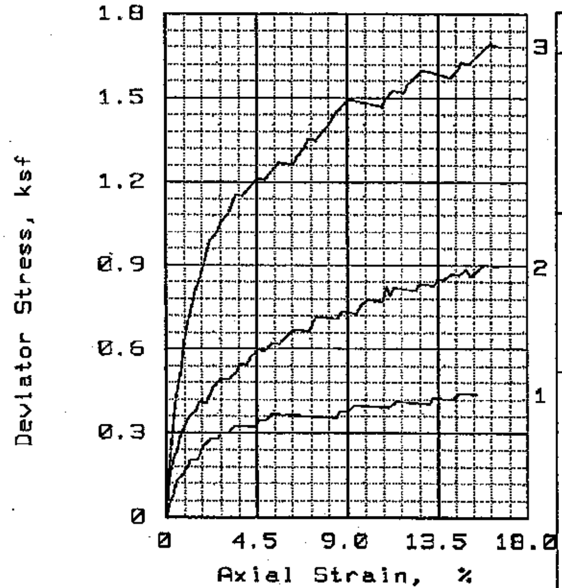
RELEASE DATE:	10-6-94
SHEET No.	1 of 1
PLATE	2

6-OCT-1994 /usr2/projects/delta/grn

Appendix B
Available Laboratory Test Results

1. **Shear Strength Data**
2. **Consolidation Data**
3. **Gradation Data**
4. **Permeability Data**
5. **Measured Shear Wave and P-Wave Data**
6. **Measured Dynamic Properties- UC Davis Research paper**





SAMPLE NO.:		1	2	3
INITIAL	WATER CONTENT, %	308.2	410.2	578.1
	DRY DENSITY, pcf	16.7	13.2	9.1
	SATURATION, %			
	VOID RATIO			
	DIAMETER, in	2.87	2.87	2.87
	HEIGHT, in	6.00	6.00	6.00
AT TEST	WATER CONTENT, %	277.5	285.1	334.2
	DRY DENSITY, pcf	19.8	19.3	16.8
	SATURATION, %			
	VOID RATIO			
	DIAMETER, in	2.66	2.48	2.21
	HEIGHT, in	5.89	5.50	5.50
Strain rate, %/min		0.03	0.03	0.03
EFF CELL PRESSURE, ksf		0.32	0.81	1.38
Deviator Stress, ksf		0.34	0.59	1.21
EXCESS PORE PR., ksf		0.22	0.37	0.76
STRAIN, %		4.9	4.9	4.9
Ultimate Stress, ksf				
EXCESS PORE PR., ksf				
STRAIN, %				
$\bar{\sigma}_1$ FAILURE, ksf		0.44	1.03	1.83
$\bar{\sigma}_3$ FAILURE, ksf		0.10	0.43	0.62

TYPE OF TEST:
CU with Pore Pressures

SAMPLE TYPE: Undisturbed

DESCRIPTION: dark brown PEAT

ASSUMED SPECIFIC GRAVITY=

REMARKS:

Fig. No.: ______

CLIENT: Hultgren

PROJECT: 541.01

SAMPLE LOCATION: B28 @ 21.5-22'

PROJ. NO.: 212-055 DATE: 6/9/03

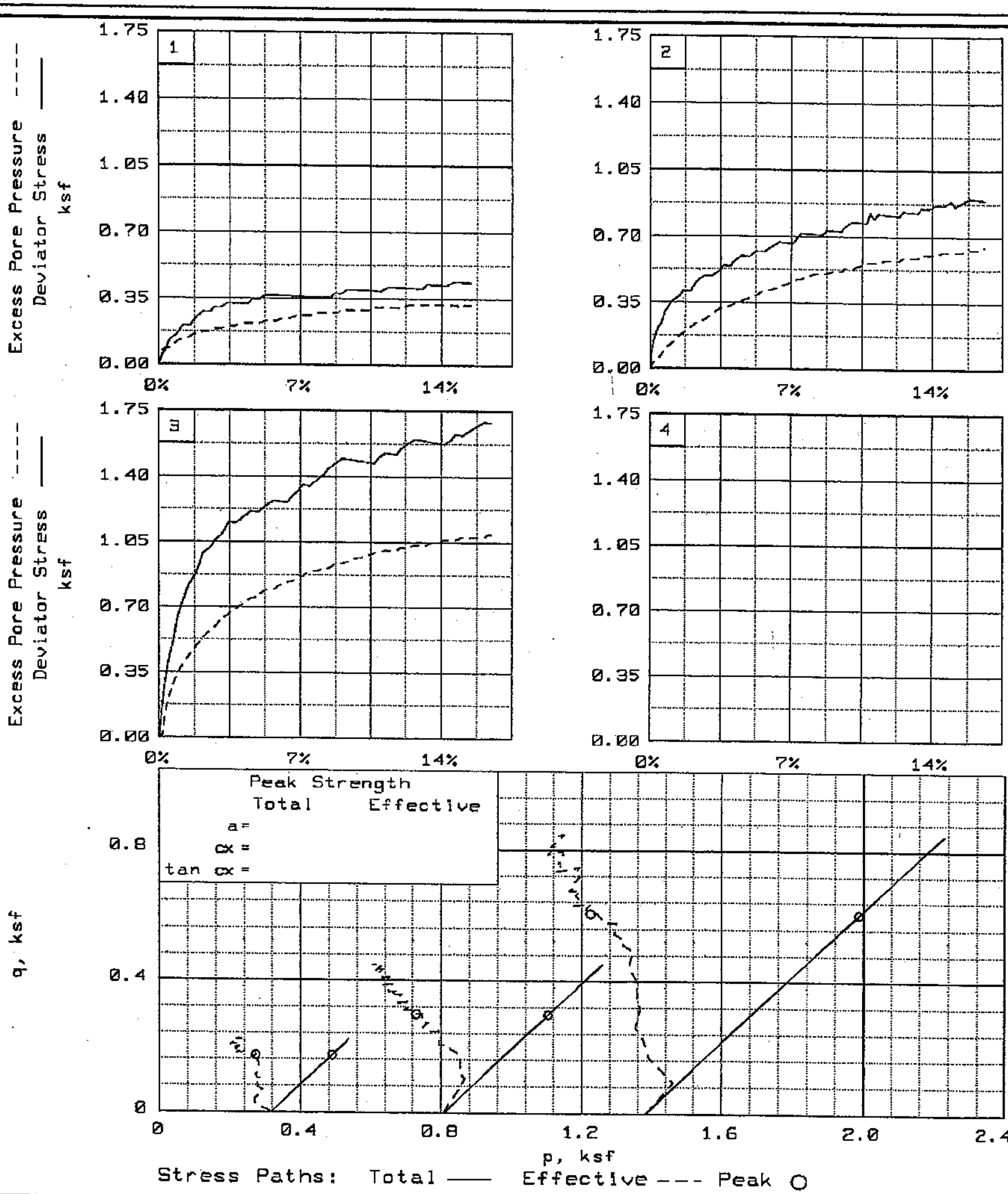
TRIAXIAL SHEAR TEST REPORT

COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

CU Triaxial Test Results

Hultgren - Tillis Engineers | Project No. 541.01 | Plate No. 49

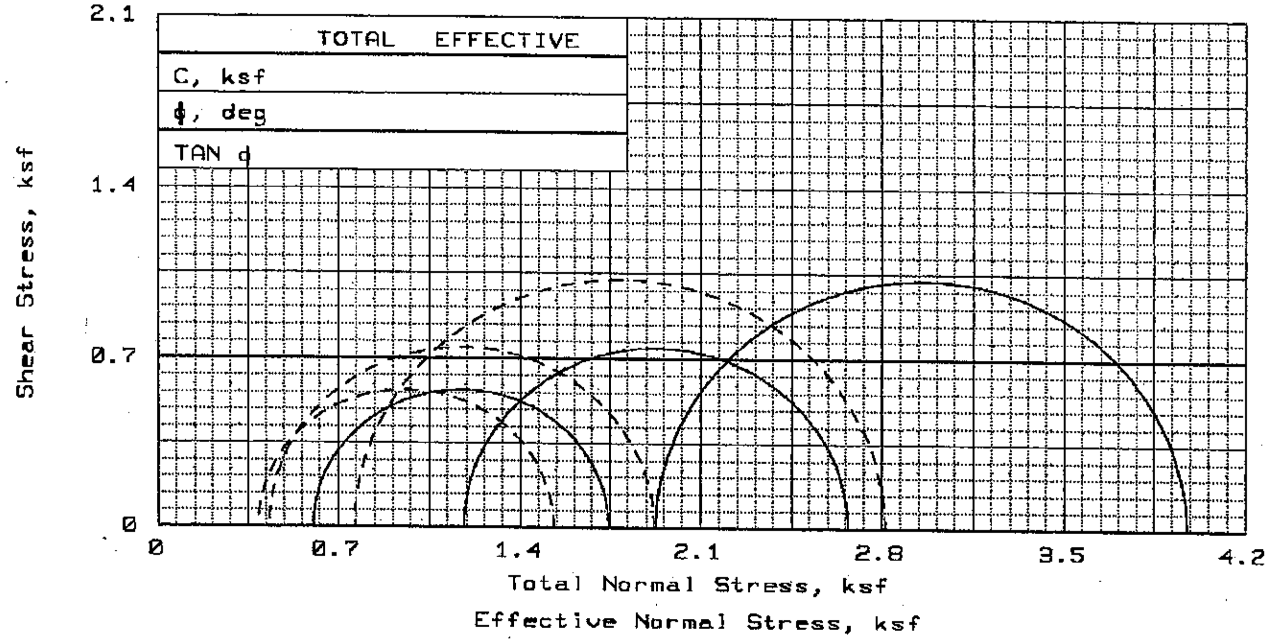


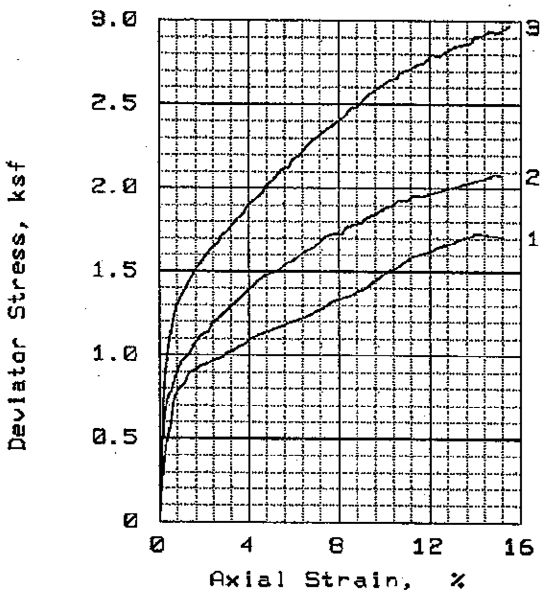
Client: Hultgren
Project: 541.01
Location: B28 @ 21.5-22'
File: 212-055 Project No.: 212-055 Fig. No.: ____

Triple Decker Project
Van Sickle Island
Solano County, California

CU Triaxial Test Results

Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 50





	SAMPLE NO.:	1	2	3
INITIAL	WATER CONTENT, %	45.8	45.5	44.1
	DRY DENSITY, pcf	75.6	75.2	77.7
	SATURATION, %			
	VOID RATIO			
	DIAMETER, in	2.87	2.87	2.87
	HEIGHT, in	6.20	6.00	6.00
AT TEST	WATER CONTENT, %	41.5	41.4	38.0
	DRY DENSITY, pcf	80.2	80.3	84.7
	SATURATION, %			
	VOID RATIO			
	DIAMETER, in	2.85	2.78	2.78
	HEIGHT, in	5.95	6.00	5.87
	Strain rate, %/min	0.03	0.03	0.03
	EFF CELL PRESSURE, ksf	0.60	1.18	1.93
	Deviator Stress, ksf	1.14	1.49	2.05
	EXCESS PORE PR., ksf	0.22	0.75	1.17
	STRAIN, %	4.8	5.0	5.1
	Ultimate Stress, ksf			
	EXCESS PORE PR., ksf			
	STRAIN, %			
	$\bar{\sigma}_1$ FAILURE, ksf	1.53	1.92	2.81
	$\bar{\sigma}_3$ FAILURE, ksf	0.39	0.43	0.76

TYPE OF TEST:
CU with Pore Pressures
SAMPLE TYPE: Undisturbed
DESCRIPTION: Gray CLAY (very Silty)

ASSUMED SPECIFIC GRAVITY=
REMARKS:

Fig. No.: ______

CLIENT: Hultgren-Tillis

PROJECT: Van Sickle Island - 541.01

SAMPLE LOCATION: B28 @ 28-29.5'

PROJ. NO.: 212-055a DATE: 6/17/03

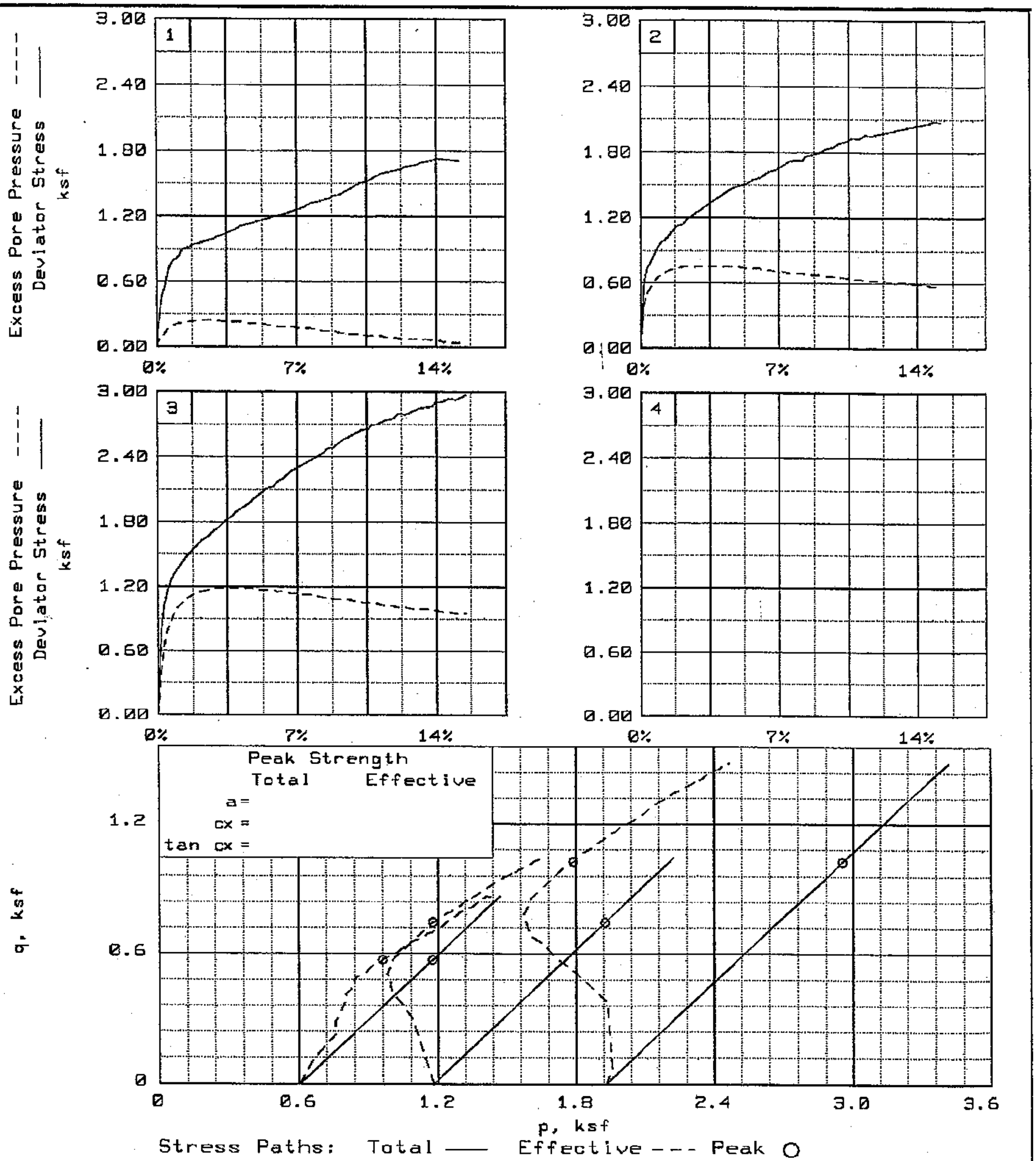
TRIAXIAL SHEAR TEST REPORT

COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

CU Triaxial Test Results

Hultgren - Tillis Engineers | Project No. 541.01 | Plate No. 51

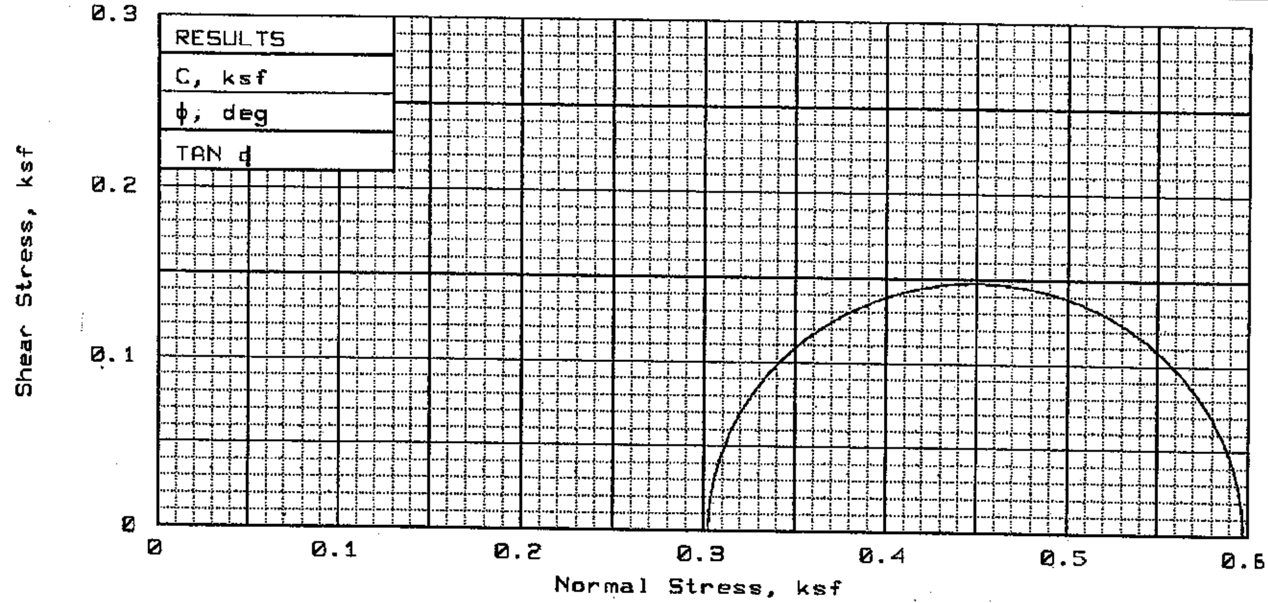


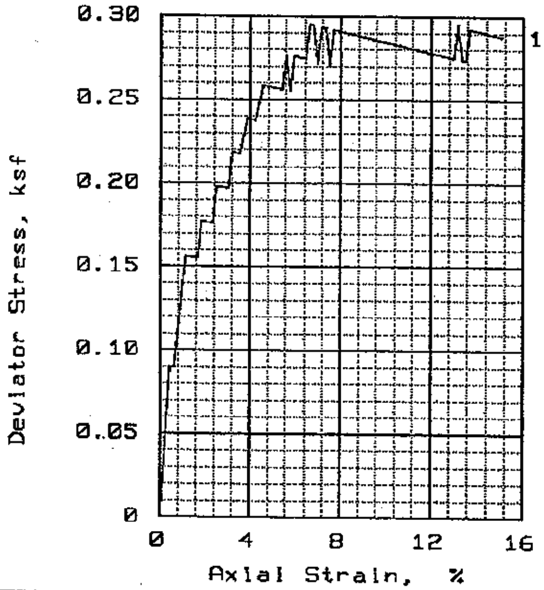
Client: Hultgren-Tillis
Project: Van Sickle Island - 541.01
Location: B28 @ 28-29.5'
File: 212-055A Project No.: 212-055a Fig. No.: _____

Triple Decker Project
Van Sickle Island
Solano County, California

CU Triaxial Test Results

Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 52





SAMPLE NO.:		1
INITIAL	WATER CONTENT, %	224.3
	DRY DENSITY, pcf	21.6
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.85
	HEIGHT, in	6.00
AT TEST	WATER CONTENT, %	224.3
	DRY DENSITY, pcf	21.6
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.85
	HEIGHT, in	6.00
Strain rate, %/min		1.00
BACK PRESSURE, ksf		0.00
CELL PRESSURE, ksf		0.30
FAIL. STRESS, ksf		0.30
ULT. STRESS, ksf		
σ_1 FAILURE, ksf		0.60
σ_3 FAILURE, ksf		0.30

TYPE OF TEST:
Unconsolidated Undrained
SAMPLE TYPE: Undisturbed
DESCRIPTION: Dark Brown PEAT

SPECIFIC GRAVITY=
REMARKS:

Fig. No.: ______

CLIENT: Hultgren-Tillis

PROJECT: Van Sickle Island - 541.01

SAMPLE LOCATION: B28 @ 9-9.5'

PROJ. NO.: 212-055k DATE: 6/17/03

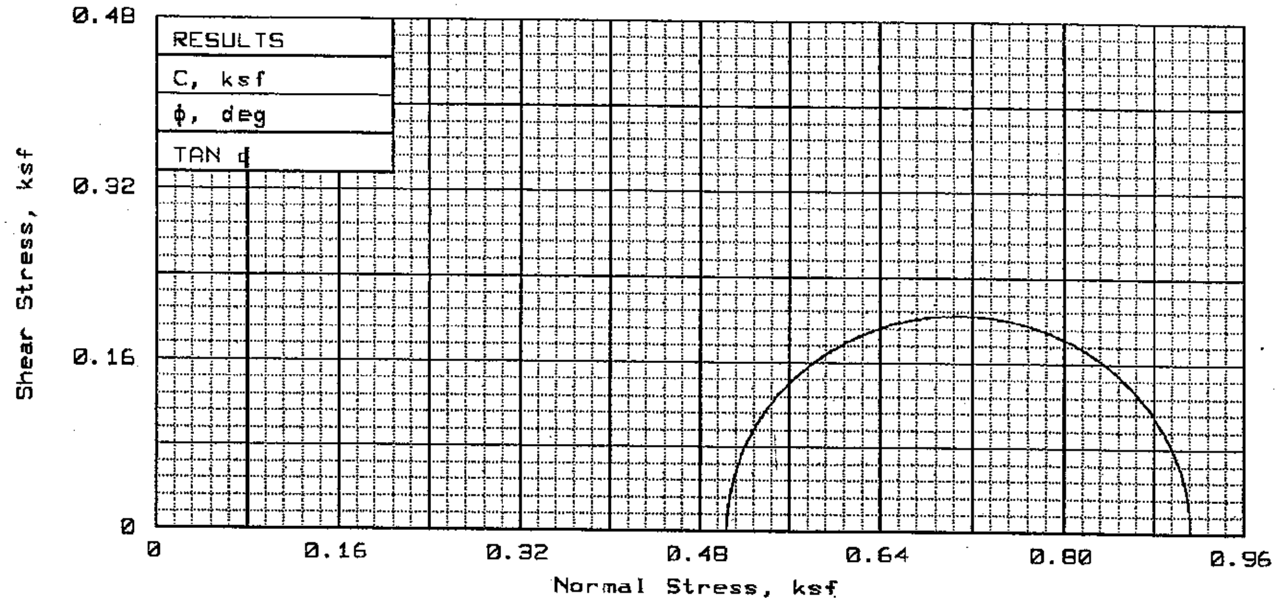
TRIAXIAL SHEAR TEST REPORT

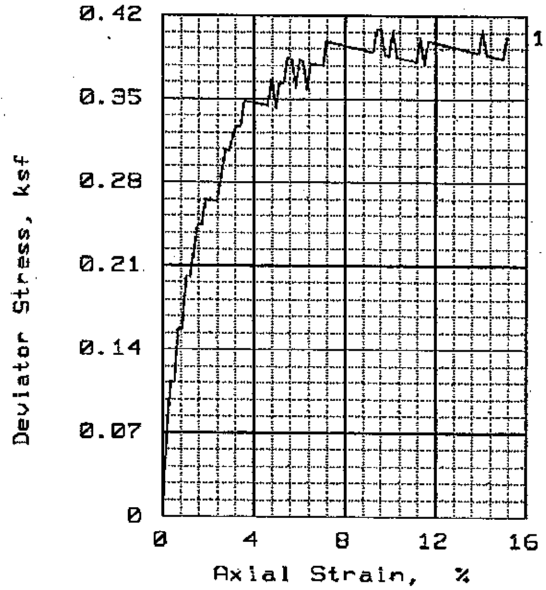
COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

UU Triaxial Test Results

Hultgren - Tillis Engineers | Project No. 541.01 | Plate No. 53





SAMPLE NO.:		1
INITIAL	WATER CONTENT, %	285.3
	DRY DENSITY, pcf	16.8
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.85
	HEIGHT, in	6.00
AT TEST	WATER CONTENT, %	285.3
	DRY DENSITY, pcf	16.8
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.85
	HEIGHT, in	6.00
Strain rate, %/min		1.00
BACK PRESSURE, ksf		0.00
CELL PRESSURE, ksf		0.50
FAIL. STRESS, ksf		0.41
ULT. STRESS, ksf		
σ_1 FAILURE, ksf		0.91
σ_3 FAILURE, ksf		0.50

TYPE OF TEST:
Unconsolidated Undrained
SAMPLE TYPE: Undisturbed
DESCRIPTION: Dark Brown PEAT

SPECIFIC GRAVITY=
REMARKS:

Fig. No.: ______

CLIENT: Hultgren_Tillis

PROJECT: Van Sickle Island - 541.01

SAMPLE LOCATION: B28 @ 21-21.5'

PROJ. NO.: 212-0551 DATE: 6/17/03

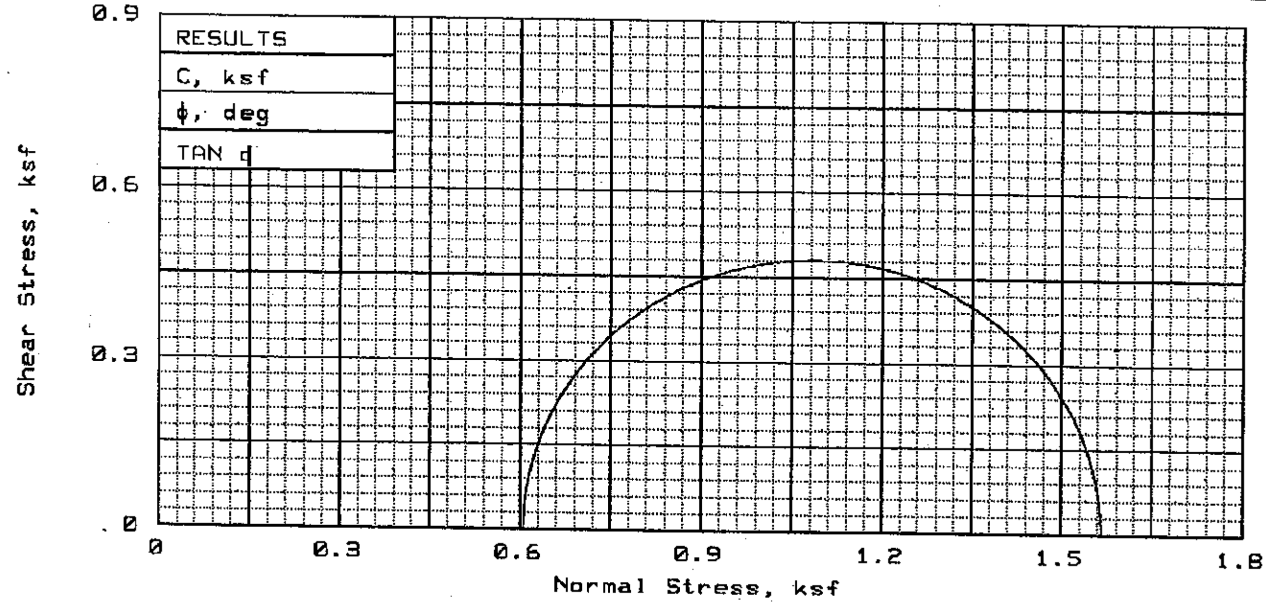
TRIAXIAL SHEAR TEST REPORT

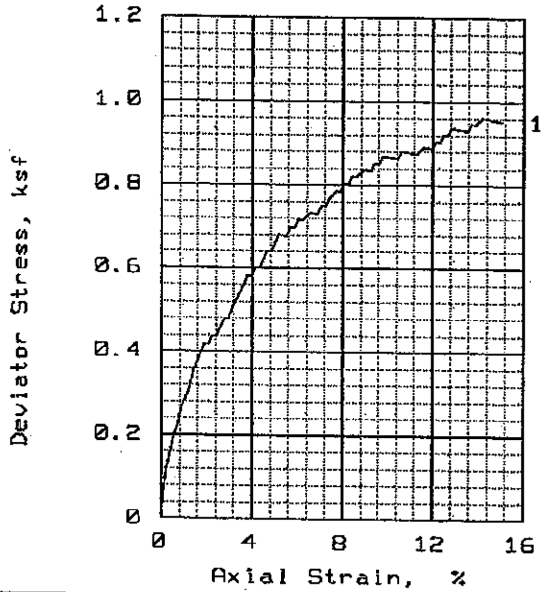
COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

UU Triaxial Test Results

Hultgren - Tillis Engineers | Project No. 541.01 | Plate No. 54





SAMPLE NO.:		1
INITIAL	WATER CONTENT, %	48.1
	DRY DENSITY, pcf	72.6
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.86
	HEIGHT, in	6.00
AT TEST	WATER CONTENT, %	48.1
	DRY DENSITY, pcf	72.6
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.86
	HEIGHT, in	6.00
Strain rate, %/min		1.00
BACK PRESSURE, ksf		0.00
CELL PRESSURE, ksf		0.60
FAIL. STRESS, ksf		0.96
ULT. STRESS, ksf		
σ_1 FAILURE, ksf		1.57
σ_3 FAILURE, ksf		0.60

TYPE OF TEST:
Unconsolidated Undrained
SAMPLE TYPE: Undisturbed
DESCRIPTION: Gray CLAY (very Silty)

SPECIFIC GRAVITY=
REMARKS:

Fig. No.: ______

CLIENT: Hultgren-Tillis

PROJECT: Van Sickle Island - 541.01

SAMPLE LOCATION: B2Bb @ 30.25-30.75'

PROJ. NO.: 212-055p DATE: 6/17/03

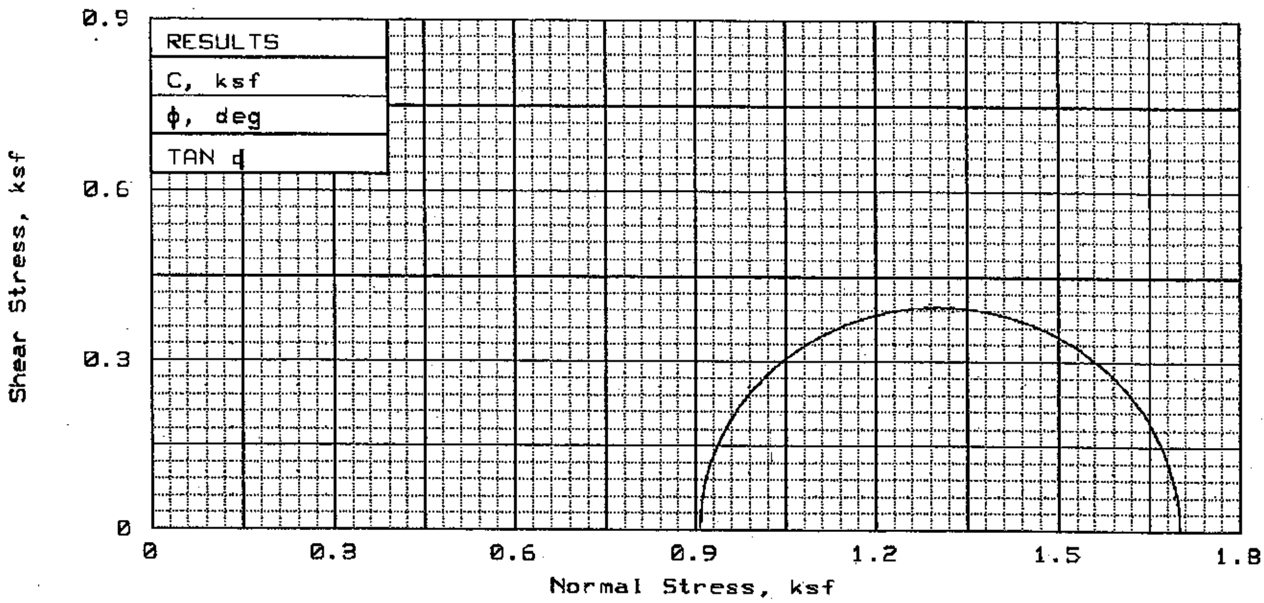
TRIAXIAL SHEAR TEST REPORT

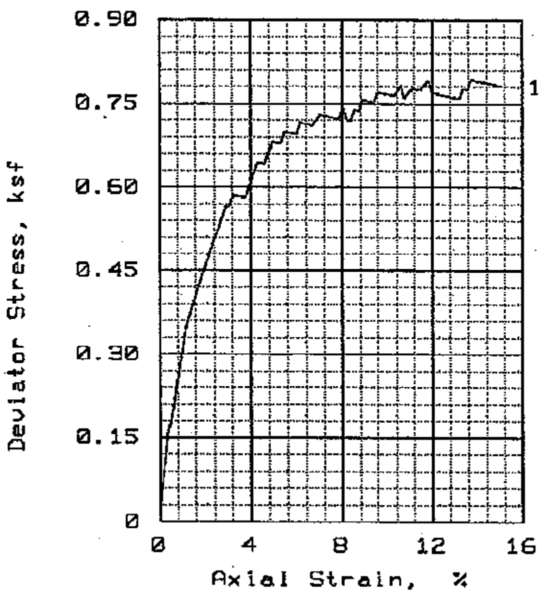
COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

UU Triaxial Test Results

Hultgren - Tillis Engineers | Project No. 541.01 | Plate No. 55





SAMPLE NO.:		1
INITIAL	WATER CONTENT, %	51.3
	DRY DENSITY, pcf	70.0
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.86
	HEIGHT, in	6.00
AT TEST	WATER CONTENT, %	51.3
	DRY DENSITY, pcf	70.0
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.86
	HEIGHT, in	6.00
Strain rate, %/min		1.00
BACK PRESSURE, ksf		0.00
CELL PRESSURE, ksf		0.91
FAIL. STRESS, ksf		0.79
ULT. STRESS, ksf		
σ_1 FAILURE, ksf		1.70
σ_3 FAILURE, ksf		0.91

TYPE OF TEST:
Unconsolidated Undrained
SAMPLE TYPE: Undisturbed
DESCRIPTION: Gray CLAY
(very Silty)

SPECIFIC GRAVITY=
REMARKS:

Fig. No.: ______

CLIENT: Hultgren-Tillis

PROJECT: Van Sickle Island - 541.01

SAMPLE LOCATION: B28 @ 37.5-38'

PROJ. NO.: 212-055q DATE: 6/17/03

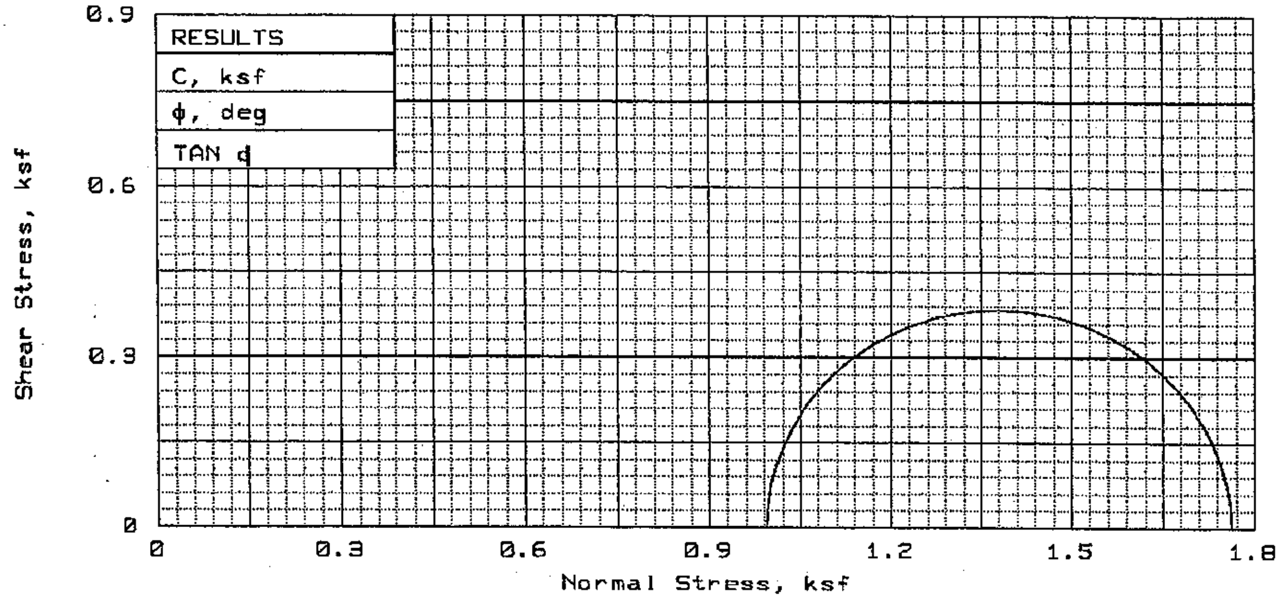
TRIAXIAL SHEAR TEST REPORT

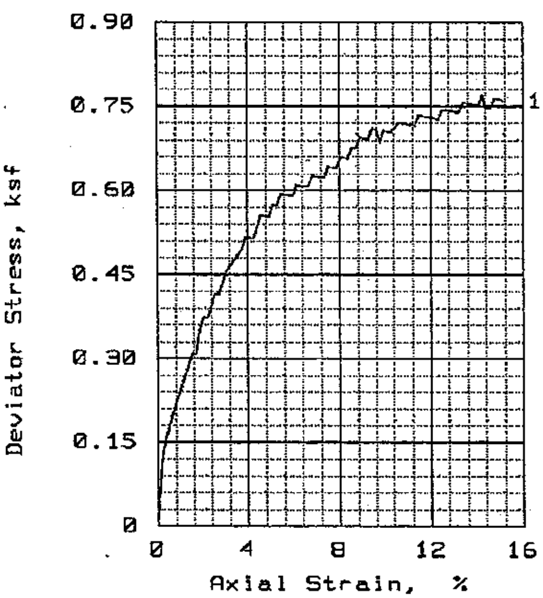
COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

UU Triaxial Test Results

Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 56





SAMPLE NO.:		1
INITIAL	WATER CONTENT, %	56.5
	DRY DENSITY, pcf	66.8
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.86
	HEIGHT, in	6.00
AT TEST	WATER CONTENT, %	56.5
	DRY DENSITY, pcf	66.8
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.86
	HEIGHT, in	6.00
Strain rate, %/min		1.00
BACK PRESSURE, ksf		0.00
CELL PRESSURE, ksf		0.99
FAIL. STRESS, ksf		0.77
ULT. STRESS, ksf		
σ_1 FAILURE, ksf		1.76
σ_3 FAILURE, ksf		0.99

TYPE OF TEST:
Unconsolidated Undrained
SAMPLE TYPE: Undisturbed
DESCRIPTION: Olive-Brown SILT with Sand (slightly plastic)

SPECIFIC GRAVITY=
REMARKS:

Fig. No.: ______

CLIENT: Hultgren-Tillis

PROJECT: Van Sickle Island - 541.01

SAMPLE LOCATION: B-30 @ 17-17.5'

PROJ. NO.: 212-056b DATE: 6/26/03

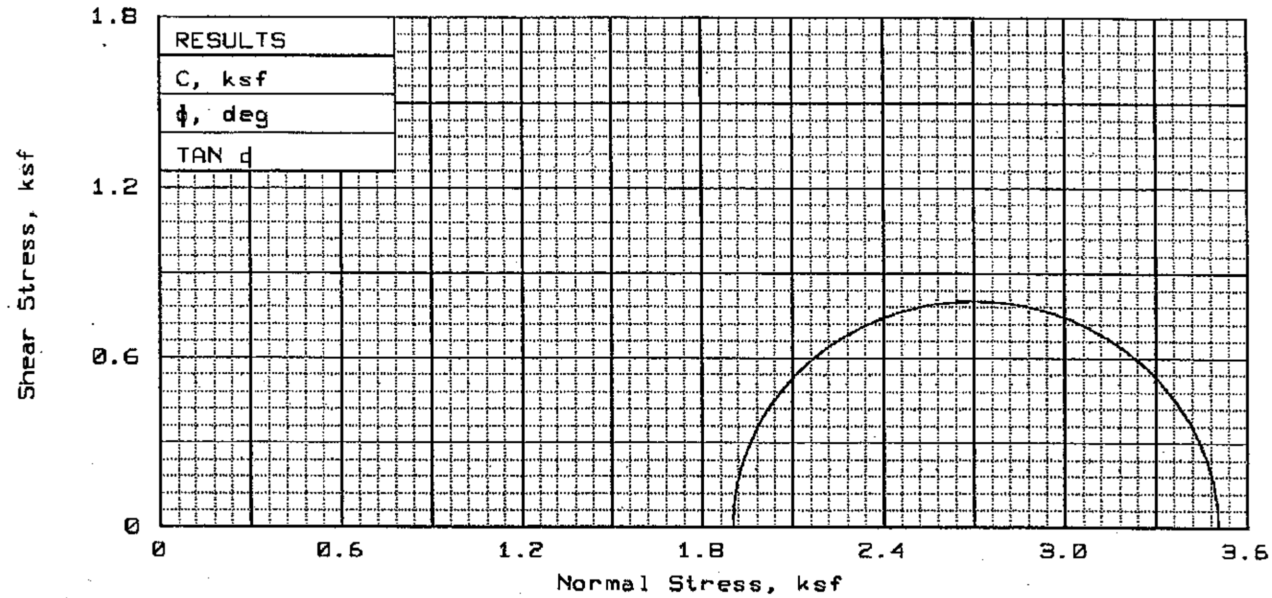
TRIAXIAL SHEAR TEST REPORT

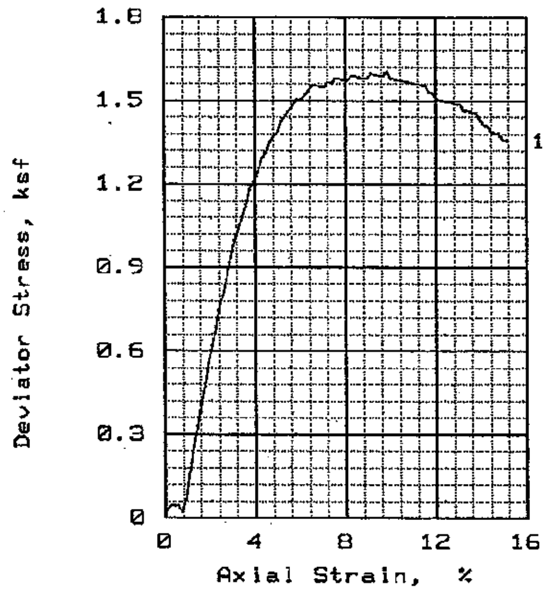
COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

UU Triaxial Test Results

Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 61





SAMPLE NO.:		1
INITIAL	WATER CONTENT, %	190.1
	DRY DENSITY, pcf	23.6
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.85
	HEIGHT, in	6.00
AT TEST	WATER CONTENT, %	190.1
	DRY DENSITY, pcf	23.6
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.85
	HEIGHT, in	6.00
Strain rate, %/min		1.00
BACK PRESSURE, ksf		0.00
CELL PRESSURE, ksf		1.90
FAIL. STRESS, ksf		1.60
ULT. STRESS, ksf		
σ_1 FAILURE, ksf		3.50
σ_3 FAILURE, ksf		1.90

TYPE OF TEST:
Unconsolidated Undrained
SAMPLE TYPE: Undisturbed
DESCRIPTION: Dark Brown Peat

SPECIFIC GRAVITY=
REMARKS:

Fig. No.: ______

CLIENT: Hultgren-Tillis

PROJECT: Van Sickle Island - 541.01

SAMPLE LOCATION: B31 @ 37-37.5'

PROJ. NO.: 212-056D DATE: 6/26/03

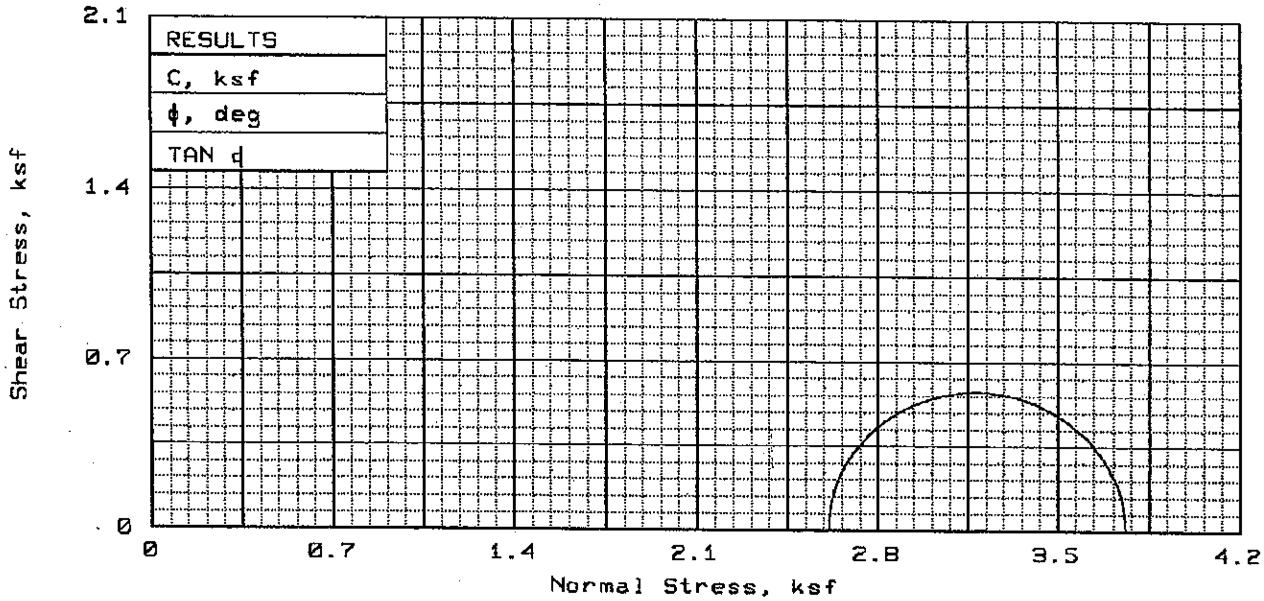
TRIAXIAL SHEAR TEST REPORT

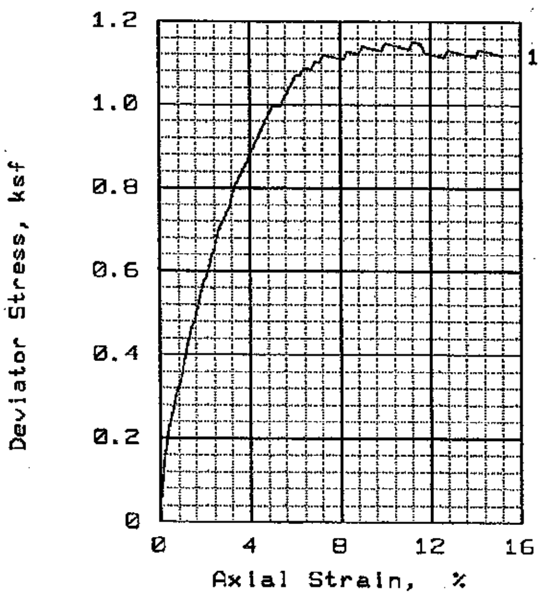
COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

UU Triaxial Test Results

Hultgren - Tillis Engineers | Project No. 541.01 | Plate No. 63





SAMPLE NO.:		1
INITIAL	WATER CONTENT, %	63.9
	DRY DENSITY, pcf	59.6
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.86
	HEIGHT, in	5.98
AT TEST	WATER CONTENT, %	63.9
	DRY DENSITY, pcf	59.6
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.86
	HEIGHT, in	5.98
Strain rate, %/min		1.00
BACK PRESSURE, ksf		0.00
CELL PRESSURE, ksf		2.61
FAIL. STRESS, ksf		1.15
ULT. STRESS, ksf		
σ_1 FAILURE, ksf		3.76
σ_3 FAILURE, ksf		2.61

TYPE OF TEST:
Unconsolidated Undrained
SAMPLE TYPE: Undisturbed
DESCRIPTION: Gray SILT with trace peat

SPECIFIC GRAVITY=
REMARKS:

Fig. No.: ______

CLIENT: Hultgren_Tillis

PROJECT: Van Sickle Island - 541.01

SAMPLE LOCATION: B31 @ 65-65.5'

PROJ. NO.: 212-056E DATE: 4/26/03

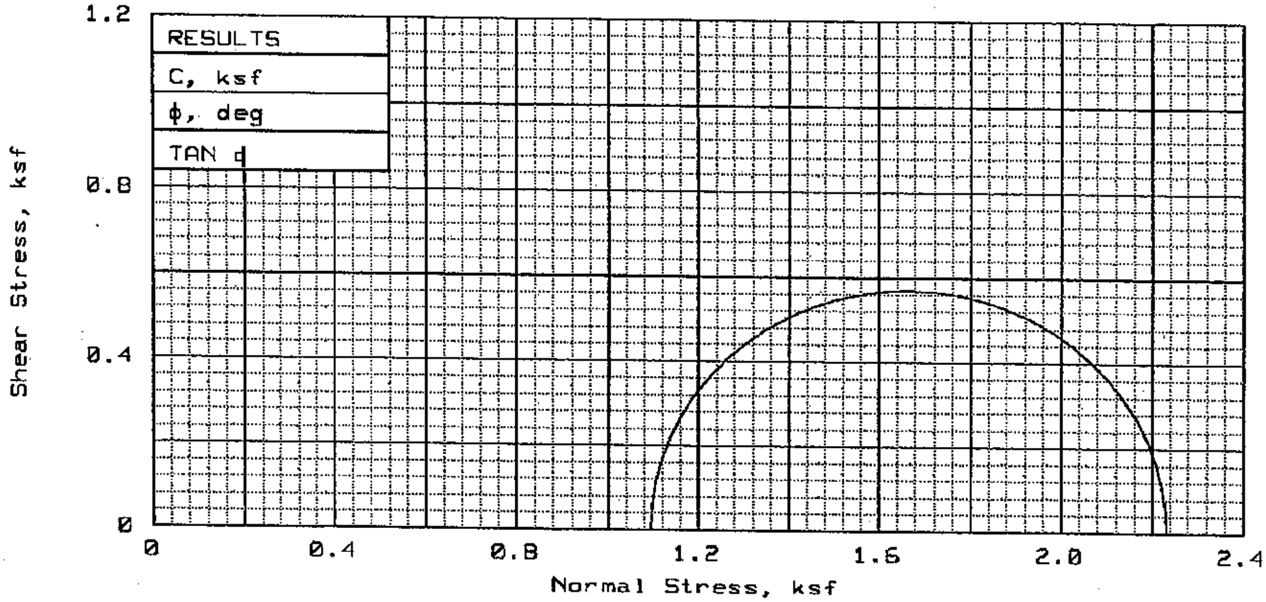
TRIAXIAL SHEAR TEST REPORT

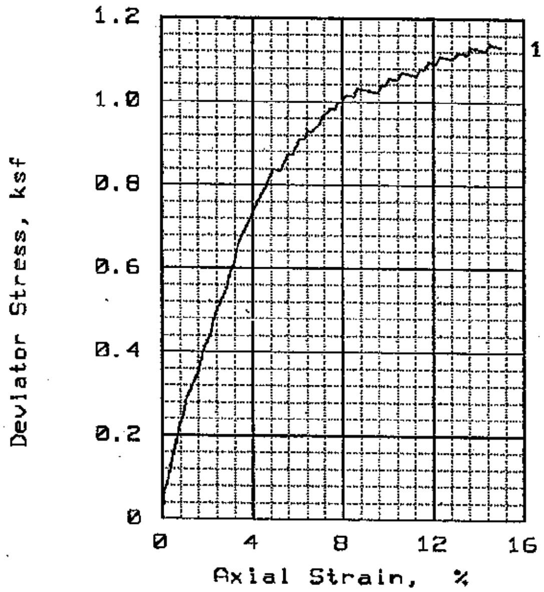
COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

UU Triaxial Test Results

Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 64





SAMPLE NO.:		1
INITIAL	WATER CONTENT, %	365.1
	DRY DENSITY, pcf	13.3
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.85
	HEIGHT, in	6.00
AT TEST	WATER CONTENT, %	365.1
	DRY DENSITY, pcf	13.3
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.85
	HEIGHT, in	6.00
Strain rate, %/min		1.00
BACK PRESSURE, ksf		0.00
CELL PRESSURE, ksf		1.09
FAIL. STRESS, ksf		1.14
ULT. STRESS, ksf		
σ_1 FAILURE, ksf		2.23
σ_3 FAILURE, ksf		1.09

TYPE OF TEST:
Unconsolidated Undrained
SAMPLE TYPE: Undisturbed
DESCRIPTION: Dark Brown PEAT

SPECIFIC GRAVITY=
REMARKS:

Fig. No.: ______

CLIENT: Hultgren-Tillis

PROJECT: Van Sickle Island - 541.01

SAMPLE LOCATION: B32 @ 31.25-31.75'

PROJ. NO.: 212-055b DATE: 6/17/03

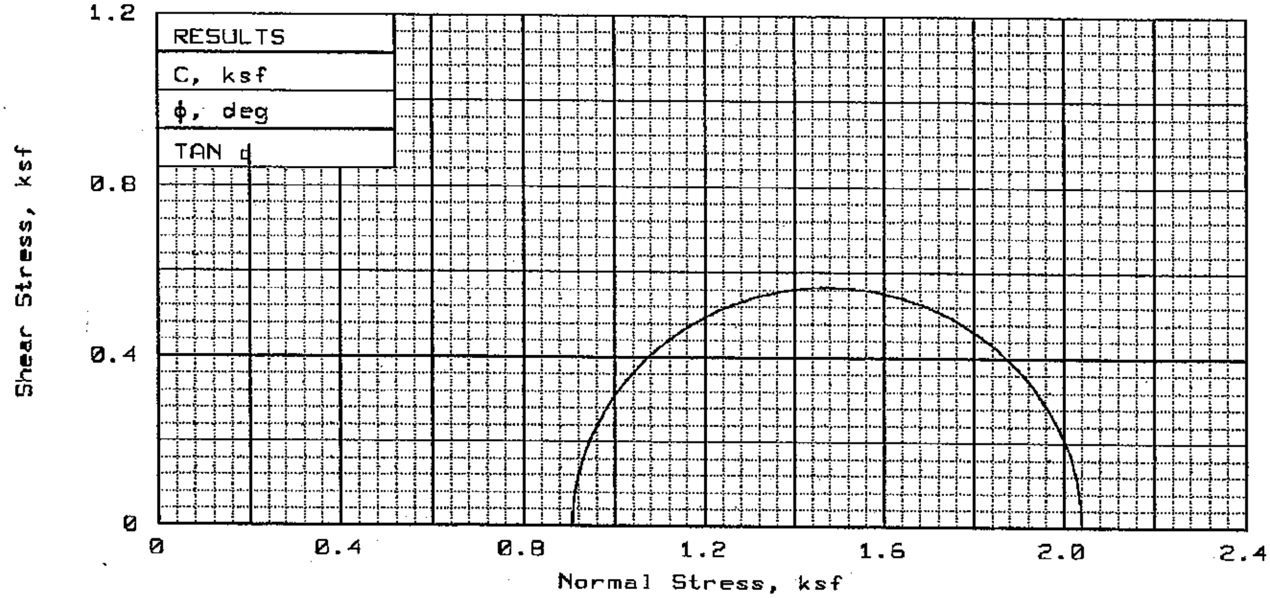
TRIAXIAL SHEAR TEST REPORT

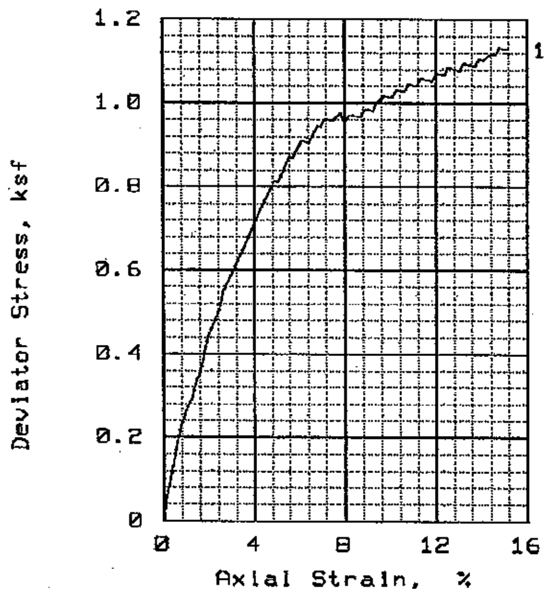
COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

UU Triaxial Test Results

Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 65





SAMPLE NO.:		1
INITIAL	WATER CONTENT, %	57.5
	DRY DENSITY, pcf	65.3
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.85
	HEIGHT, in	5.97
AT TEST	WATER CONTENT, %	57.5
	DRY DENSITY, pcf	65.3
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.85
	HEIGHT, in	5.97
Strain rate, %/min		1.00
BACK PRESSURE, ksf		0.00
CELL PRESSURE, ksf		0.91
FAIL. STRESS, ksf		1.13
ULT. STRESS, ksf		
σ_1 FAILURE, ksf		2.04
σ_3 FAILURE, ksf		0.91

TYPE OF TEST:
Unconsolidated Undrained
SAMPLE TYPE: Undisturbed
DESCRIPTION: Gray SILT

SPECIFIC GRAVITY=
REMARKS:

Fig. No.: ______

CLIENT: Hultgren-Tillis

PROJECT: Van Sickle Island - 541.01

SAMPLE LOCATION: B36 @ 14-14.5'

PROJ. NO.: 212-056G DATE: 6/26/03

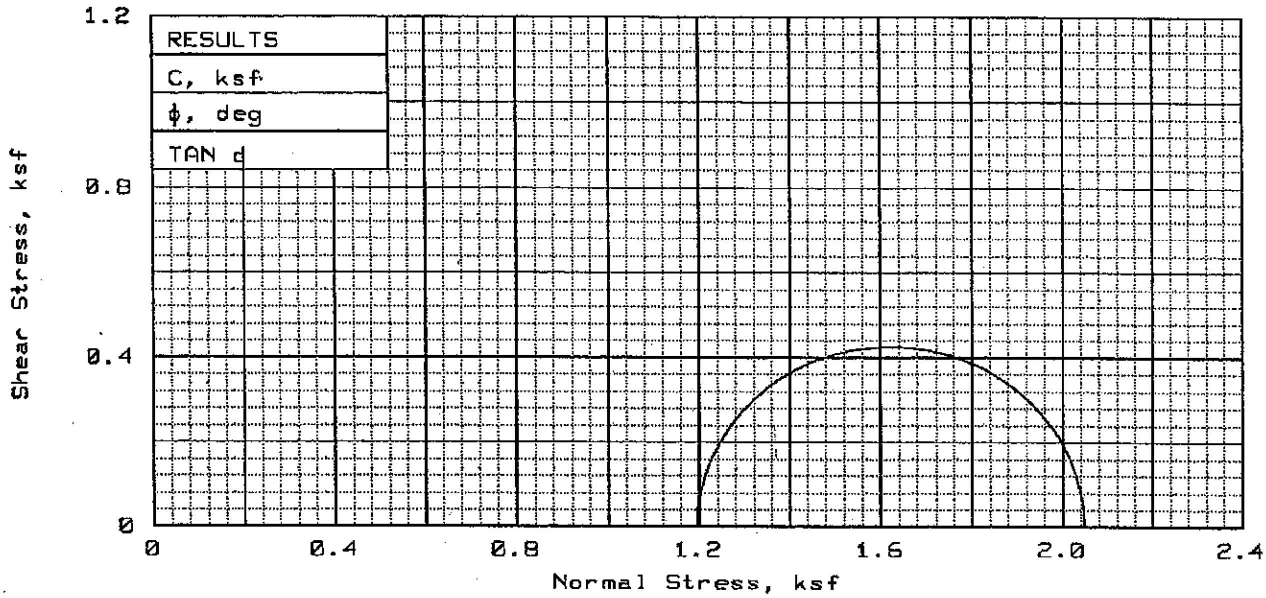
TRIAXIAL SHEAR TEST REPORT

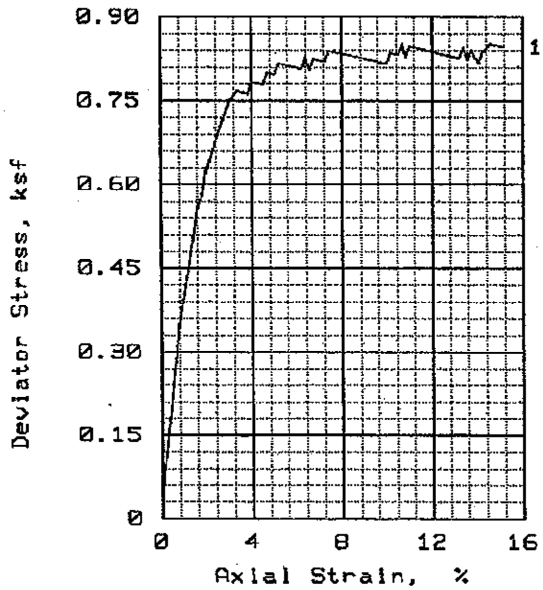
COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

UU Triaxial Test Results

Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 67





SAMPLE NO.:		1
INITIAL	WATER CONTENT, %	55.4
	DRY DENSITY, pcf	67.3
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.84
	HEIGHT, in	5.98
AT TEST	WATER CONTENT, %	55.4
	DRY DENSITY, pcf	67.3
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.84
	HEIGHT, in	5.98
Strain rate, %/min		1.00
BACK PRESSURE, ksf		0.00
CELL PRESSURE, ksf		1.20
FAIL. STRESS, ksf		0.85
ULT. STRESS, ksf		
σ_1 FAILURE, ksf		2.05
σ_3 FAILURE, ksf		1.20

TYPE OF TEST:
Unconsolidated Undrained
SAMPLE TYPE: Undisturbed
DESCRIPTION: Gray SILT

SPECIFIC GRAVITY=
REMARKS:

Fig. No.: ______

CLIENT: Hulgren-Tillis

PROJECT: Van Sickle Island - 541.01

SAMPLE LOCATION: B36 @ 24-24.5'

PROJ. NO.: 212-056H DATE: 6/26/03

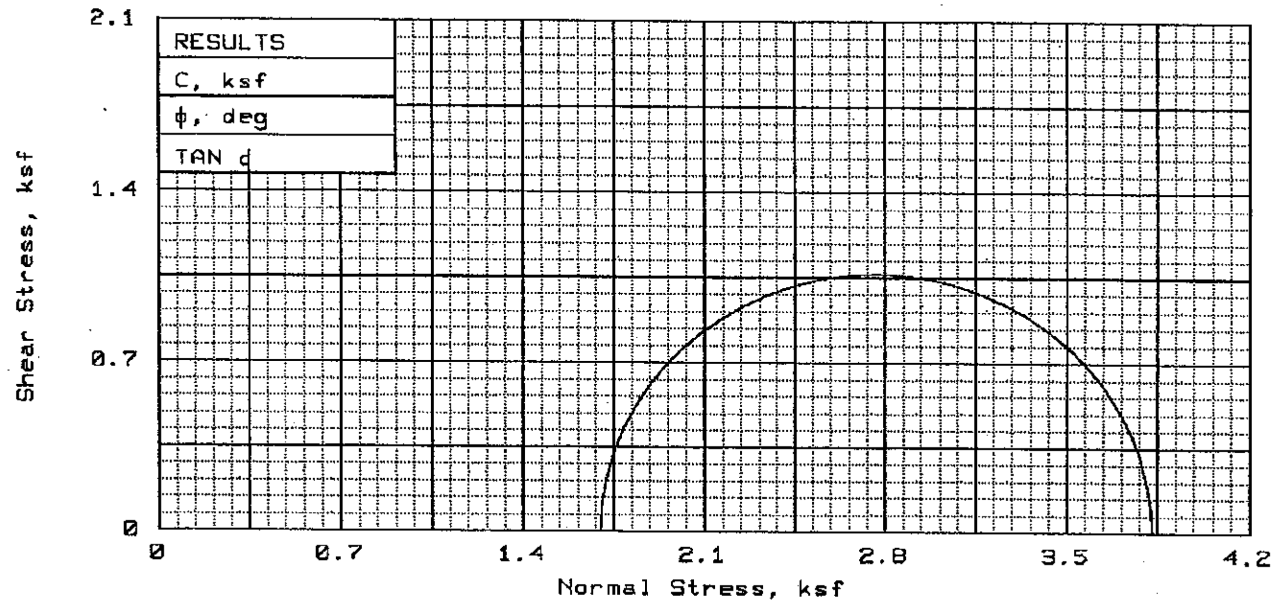
TRIAXIAL SHEAR TEST REPORT

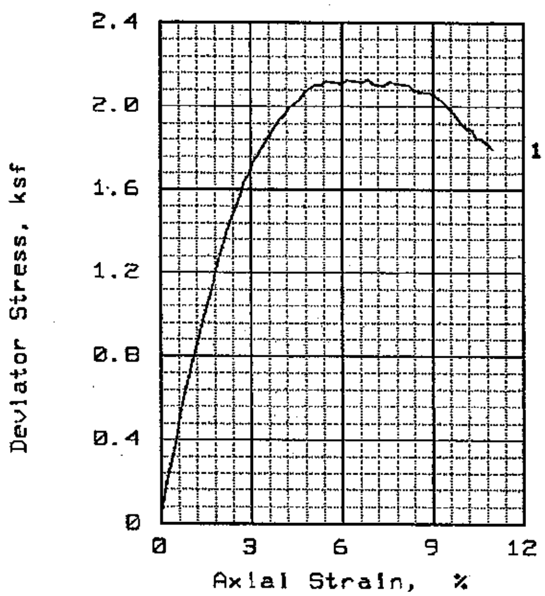
COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

UU Triaxial Test Results

Hultgren - Tillis Engineers | Project No. 541.01 | Plate No. 68





SAMPLE NO.:		1
INITIAL	WATER CONTENT, %	230.3
	DRY DENSITY, pcf	19.8
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.86
	HEIGHT, in	6.00
AT TEST	WATER CONTENT, %	230.3
	DRY DENSITY, pcf	19.8
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.86
	HEIGHT, in	6.00
Strain rate, %/min		1.00
BACK PRESSURE, ksf		0.00
CELL PRESSURE, ksf		1.70
FAIL. STRESS, ksf		2.13
ULT. STRESS, ksf		
σ_1 FAILURE, ksf		3.83
σ_3 FAILURE, ksf		1.70

TYPE OF TEST:
Unconsolidated Undrained
SAMPLE TYPE: Undisturbed
DESCRIPTION: Dark Brown PEAT

SPECIFIC GRAVITY=
REMARKS:

Fig. No.: ______

CLIENT: Hultgren-Tillis

PROJECT: Van Sickle Island - 541.01

SAMPLE LOCATION: B36 @ 39-39.5'

PROJ. NO.: 212-056I DATE: 6/26/03

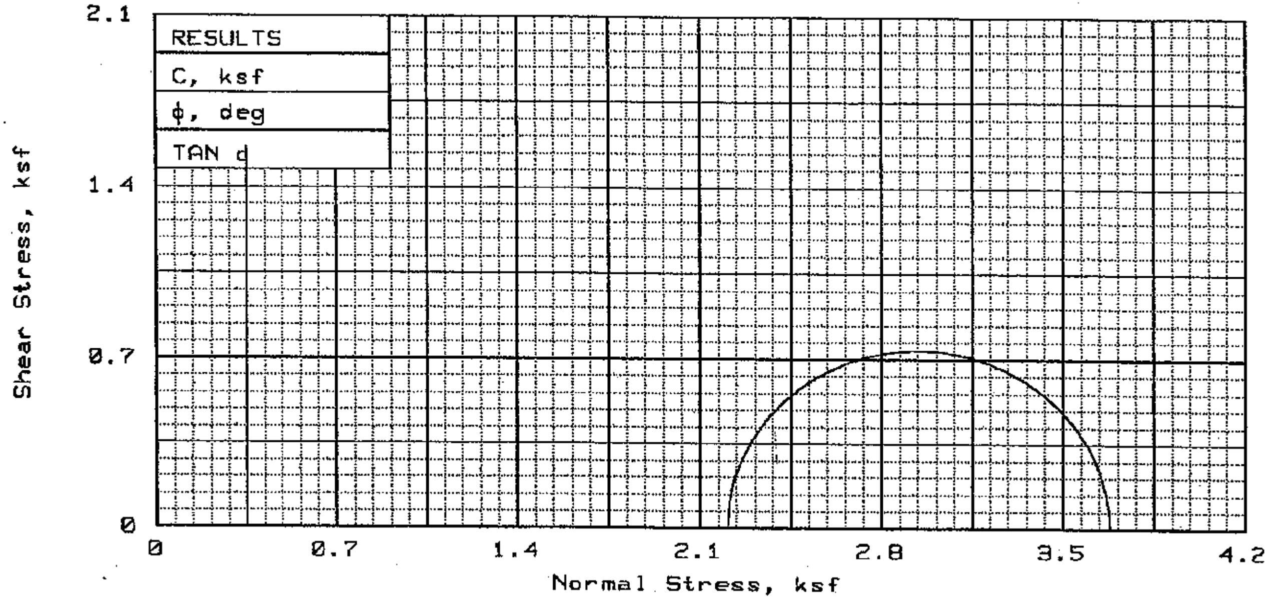
TRIAXIAL SHEAR TEST REPORT

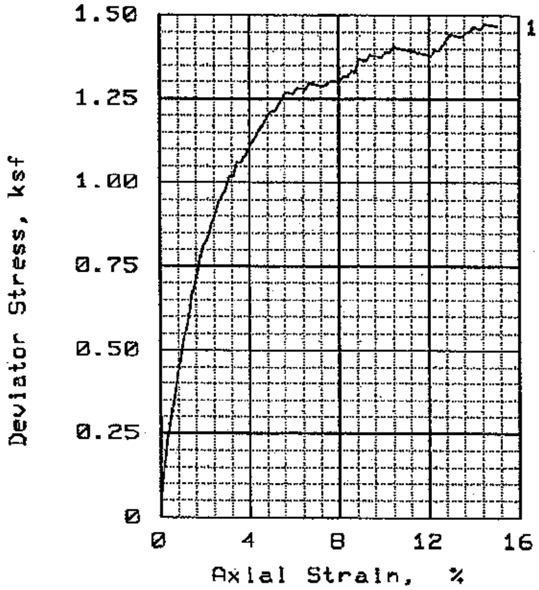
COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

UU Triaxial Test Results

Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 69





SAMPLE NO.:		1
INITIAL	WATER CONTENT, %	39.6
	DRY DENSITY, pcf	78.7
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.86
	HEIGHT, in	6.00
AT TEST	WATER CONTENT, %	39.6
	DRY DENSITY, pcf	78.7
	SATURATION, %	
	VOID RATIO	
	DIAMETER, in	2.86
	HEIGHT, in	6.00
Strain rate, %/min		1.00
BACK PRESSURE, ksf		0.00
CELL PRESSURE, ksf		2.20
FAIL. STRESS, ksf		1.48
ULT. STRESS, ksf		
σ_1 FAILURE, ksf		3.68
σ_3 FAILURE, ksf		2.20

TYPE OF TEST:
Unconsolidated Undrained
SAMPLE TYPE: Undisturbed
DESCRIPTION: Gray SILT

SPECIFIC GRAVITY=
REMARKS:

Fig. No.: ______

CLIENT: Hultgren-Tillis

PROJECT: Van Sickle Island - 541.01

SAMPLE LOCATION: B-36 @ 59-59.5'

PROJ. NO.: 212-056j   DATE: 6/26/03

TRIAXIAL SHEAR TEST REPORT

COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

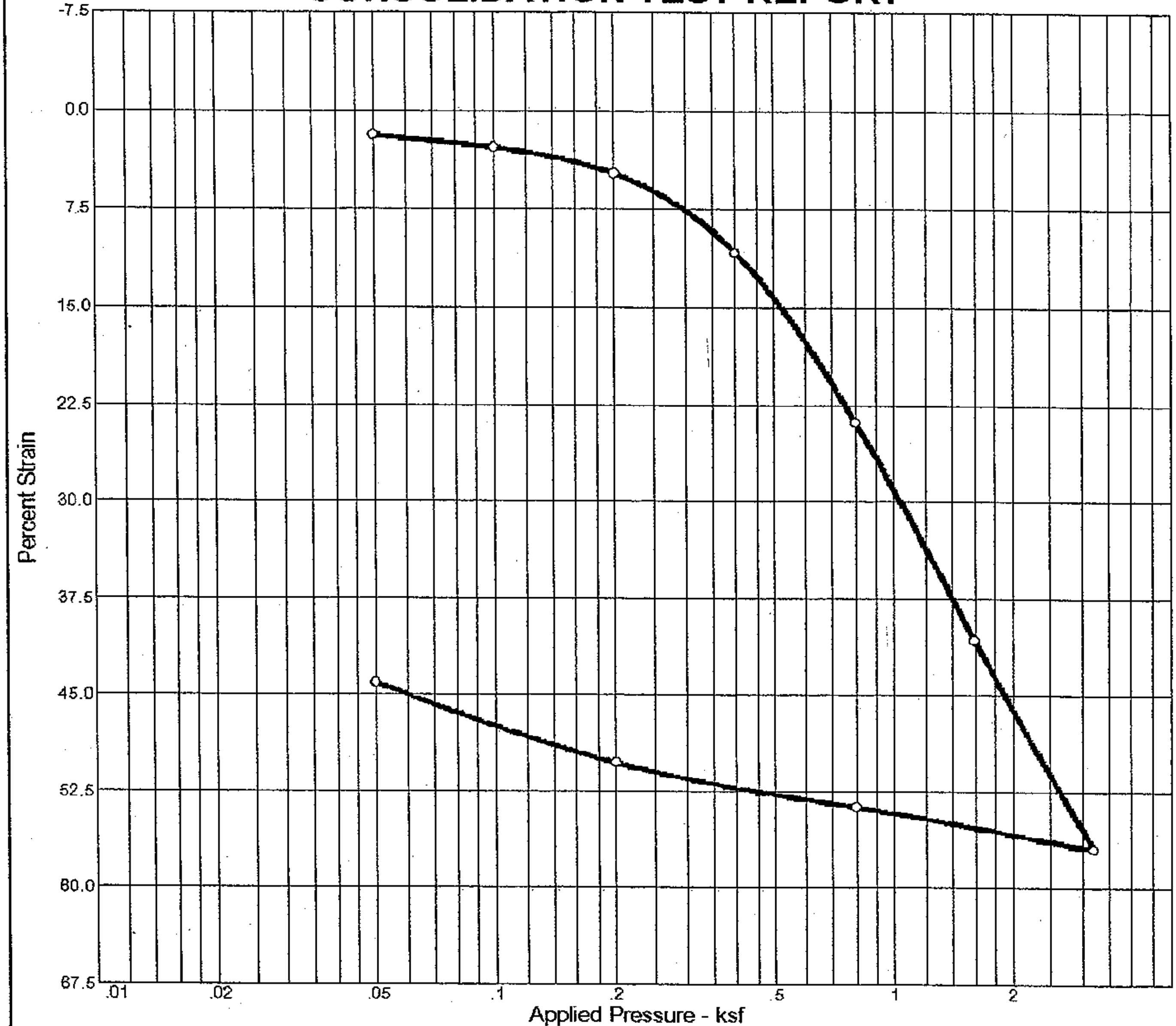
UU Triaxial Test Results

Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 70

NOTE FOR CONSOLIDATION TEST RESULTS (PLATES 71 TO 85)

The commercial software used to present the time-rate data from the consolidation tests does not allow suppression of the computer drawn curve fitting lines. For many cases, we believe the algorithm used for the curve fitting does not provide a suitable basis for computing the coefficient of consolidation, c_v. We recommend that users of this data ignore the computer generated interpretation and that they make their own assessments of best fit lines for estimating c_v.

CONSOLIDATION TEST REPORT



Sample Depth:	Boring 28 @ 14.75-15'

Natural		Dry Density (pcf)	Specific Gravity	Initial Void Ratio
Saturation	Moisture			
98%	617%	9.1	1.8 (assumed)	11.3

Testing performed by Cooper Testing Laboratory

Triple Decker Project
Van Sickle Island
Solano County, California

Consolidation Test Results

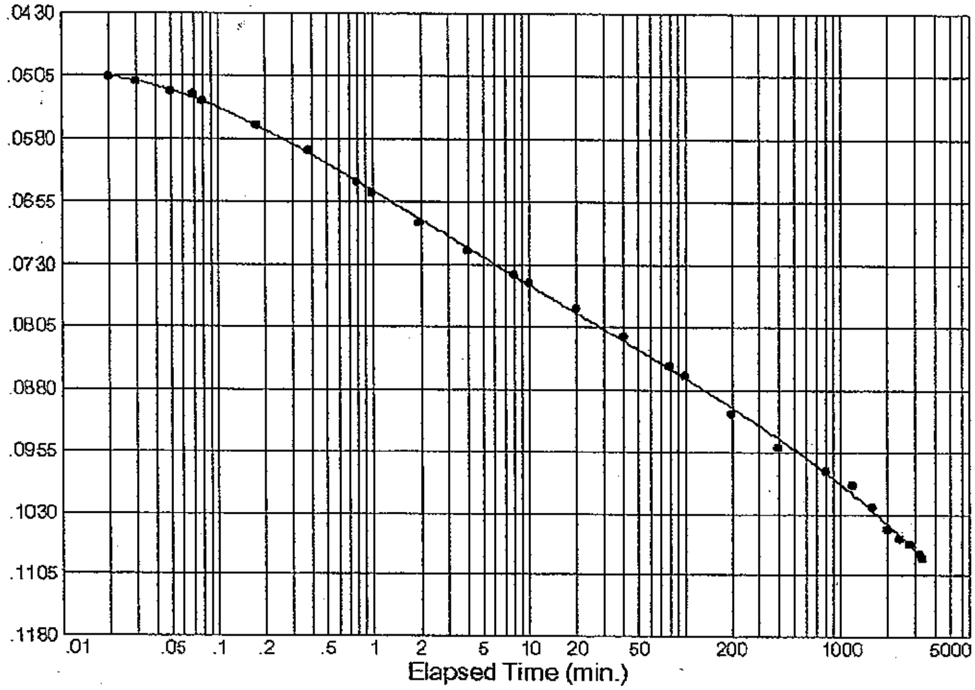
Hultgren - Tillis Engineers | Project No. 541.01 | Plate No. 71

Dial Reading vs. Time

Project No.: 541.01
Project: Hultgren-Tillis

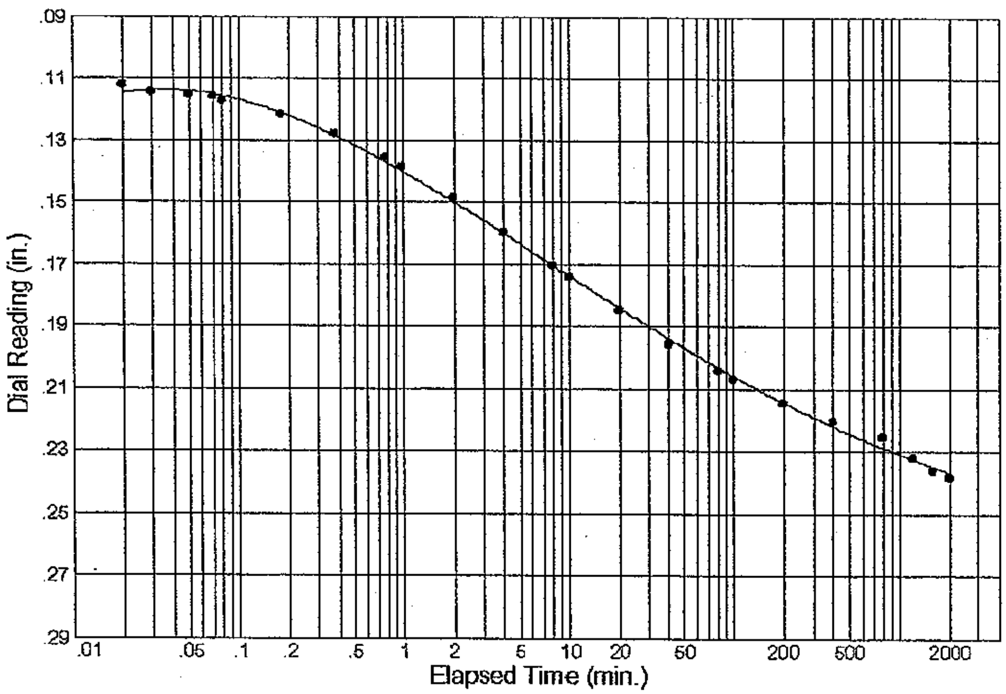
Source: B-28

Elev./Depth: 14.75-15



Load No.= 4
Load= 0.40 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_v @ T_{50}



Load No.= 5
Load= 0.80 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_v @ T_{50}

COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

Consolidation Test Results

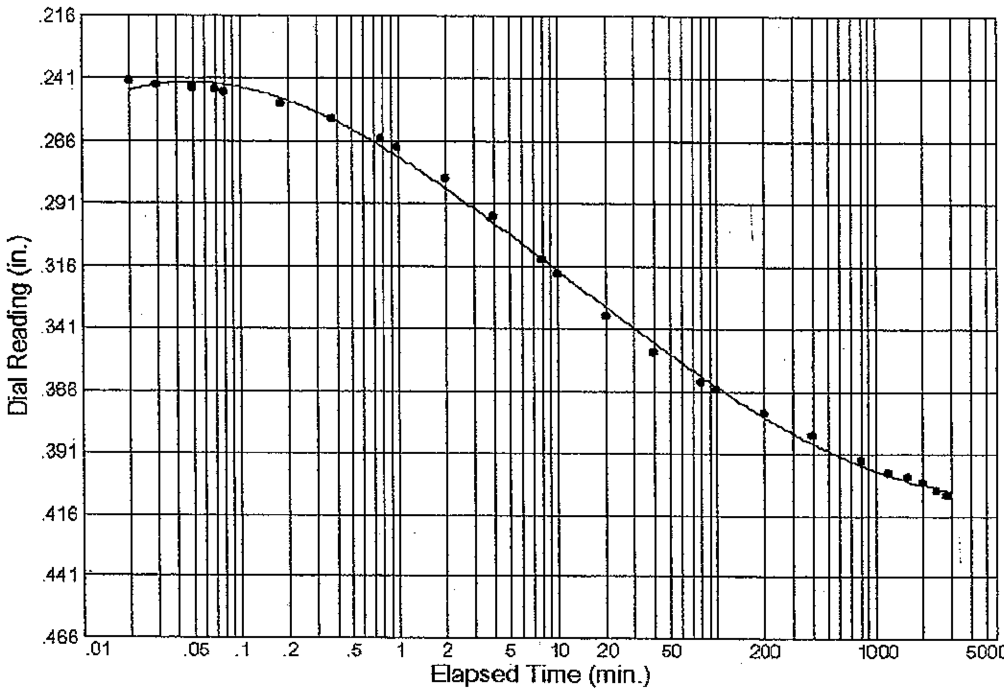
Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 72

Dial Reading vs. Time

Project No.: 541.01
Project: Hultgren-Tillis

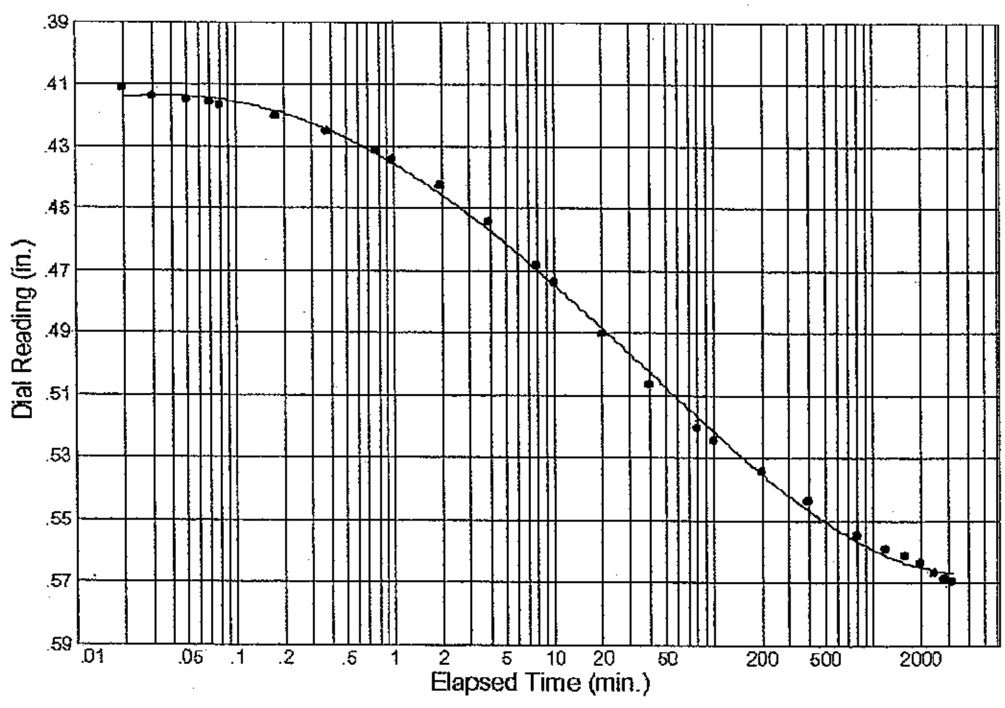
Source: B-28

Elev./Depth: 14.75-15



Load No.= 6
Load= 1.60 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_V @ T_{50}



Load No.= 7
Load= 3.20 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_V @ T_{50}

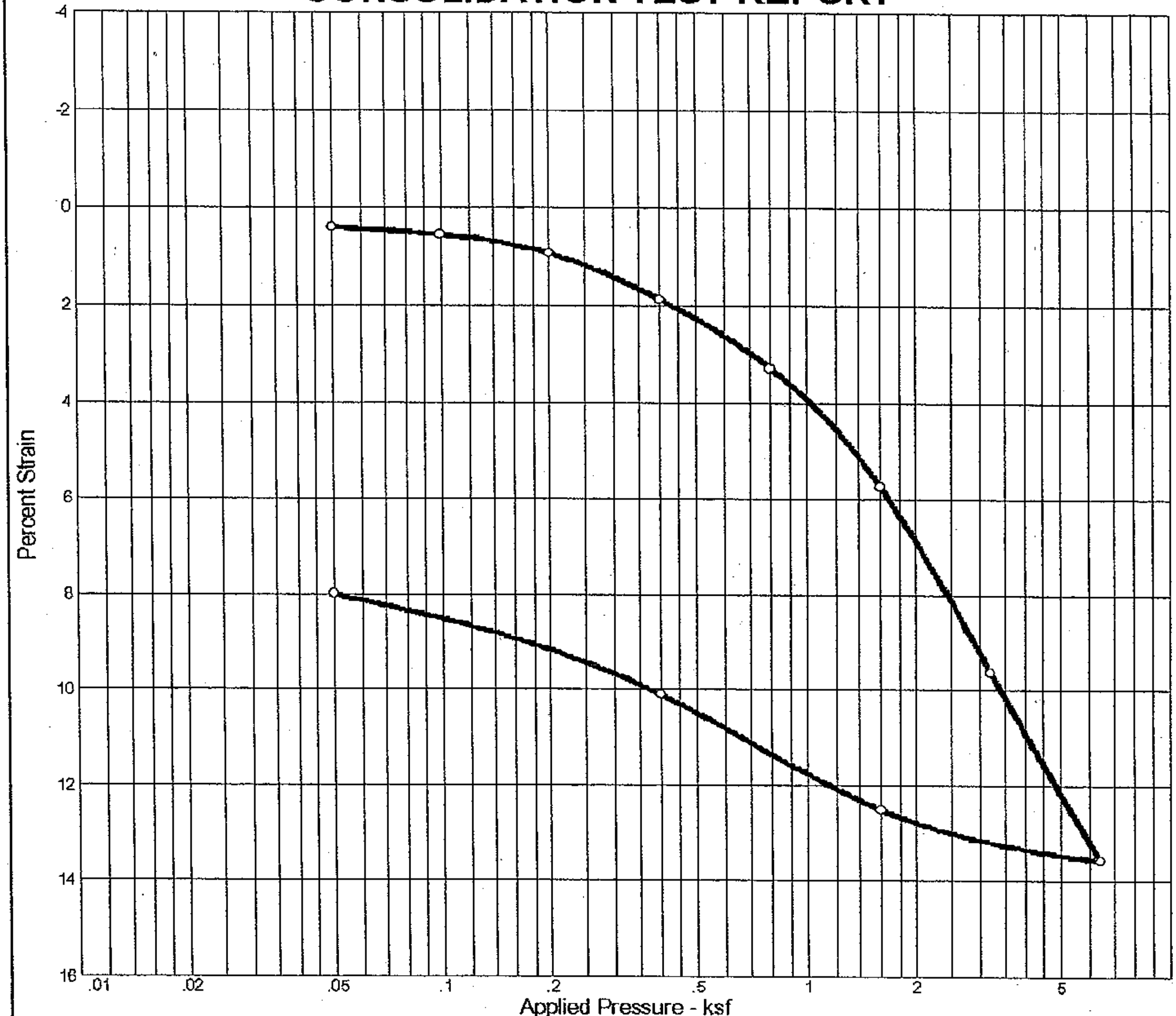
COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

Consolidation Test Results

Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 73

CONSOLIDATION TEST REPORT



Sample Depth:	Boring 28 @ 30.75-31'

Natural		Dry Density (pcf)	Specific Gravity	Initial Void Ratio
Saturation	Moisture			
100%	49%	72	2.6 (assumed)	1.3

Testing performed by Cooper Testing Laboratory

Triple Decker Project
Van Sickle Island
Solano County, California

Consolidation Test Results

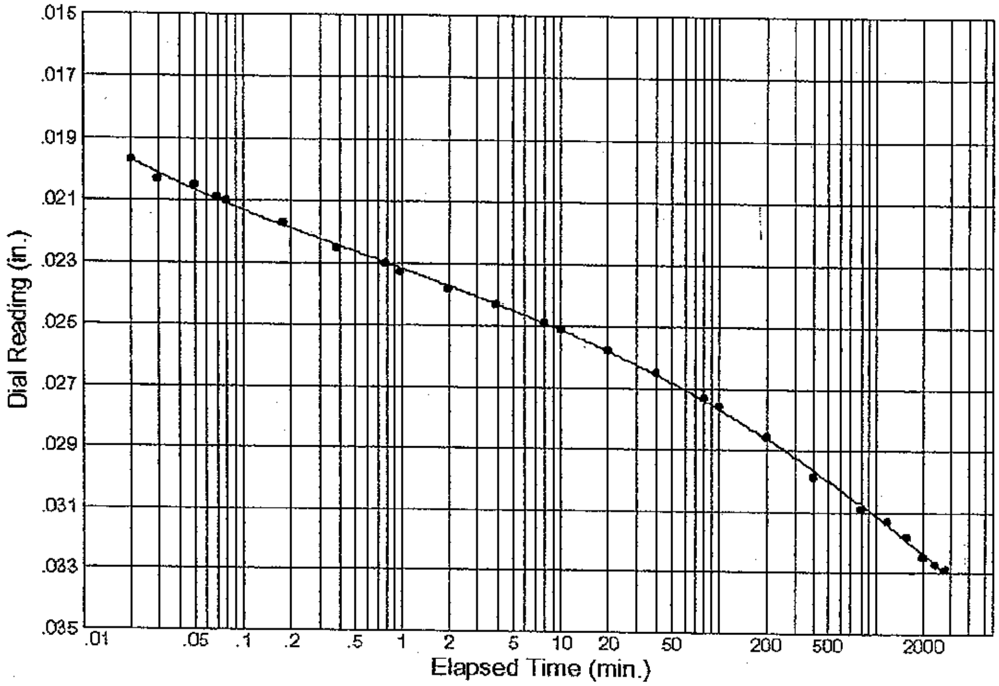
Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 74

Dial Reading vs. Time

Project No.: 541.01
Project: Hultgren-Tillis

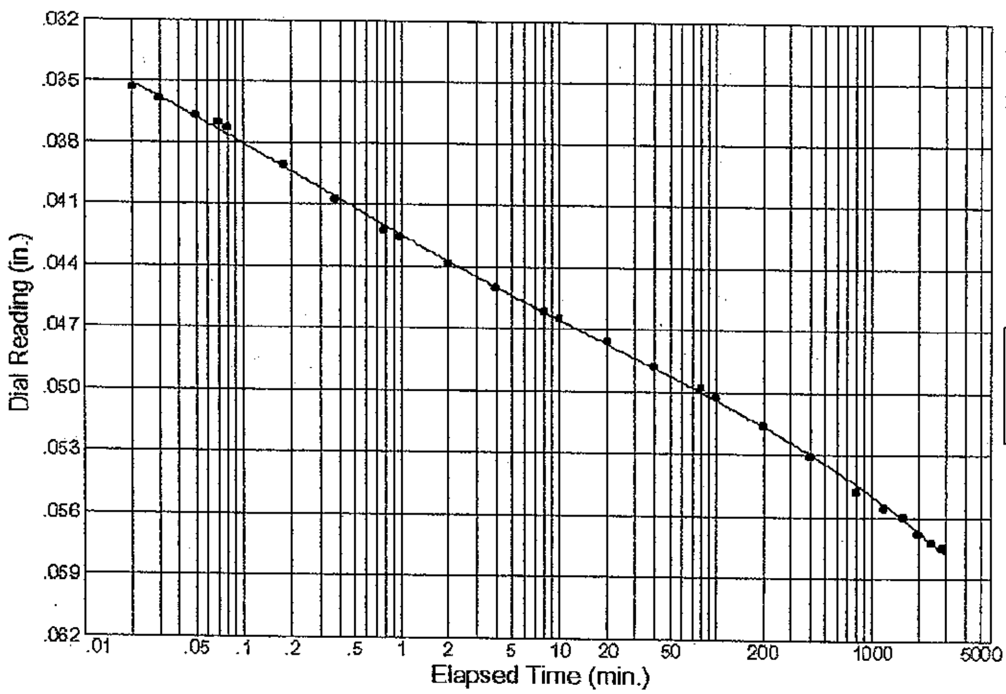
Source: B-28

Elev./Depth: 30.75-31



Load No.= 5
Load= 0.80 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_v @ T_{50}



Load No.= 6
Load= 1.60 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_v @ T_{50}

COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

Consolidation Test Results

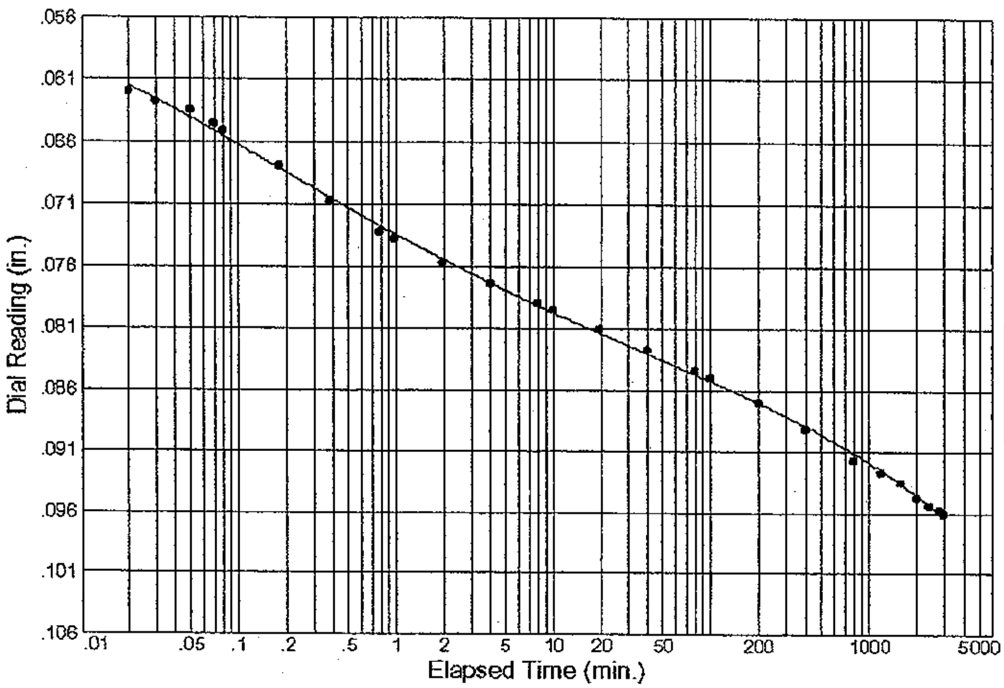
Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 75

Dial Reading vs. Time

Project No.: 541.01
Project: Hultgren-Tillis

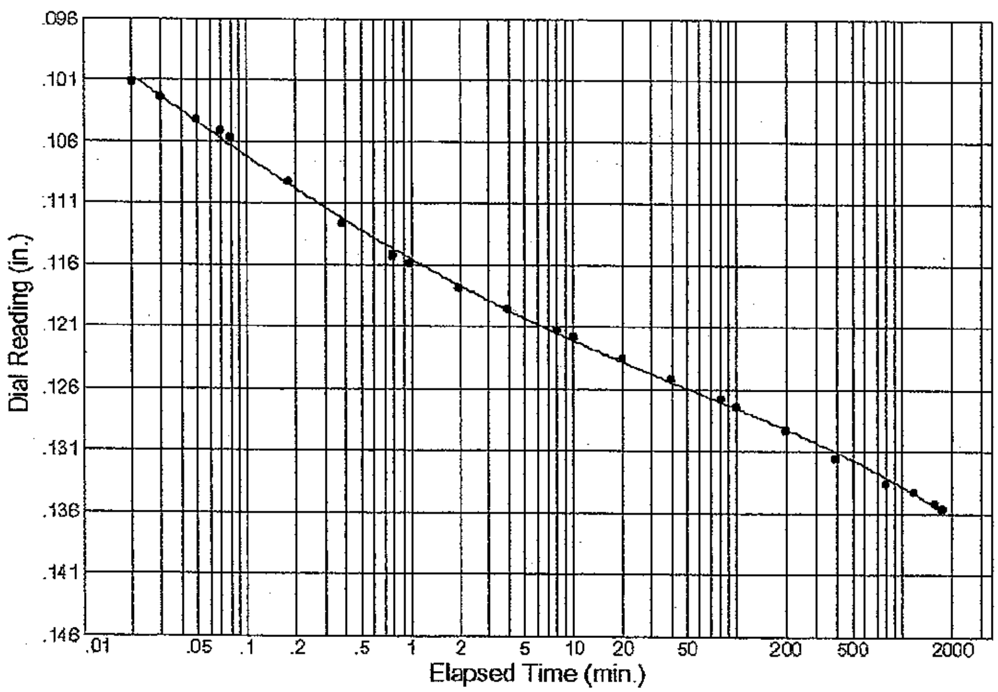
Source: B-28

Elev./Depth: 30.75-31



Load No.= 7
Load= 3.20 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_v @ T_{50}



Load No.= 8
Load= 6.40 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_v @ T_{50}

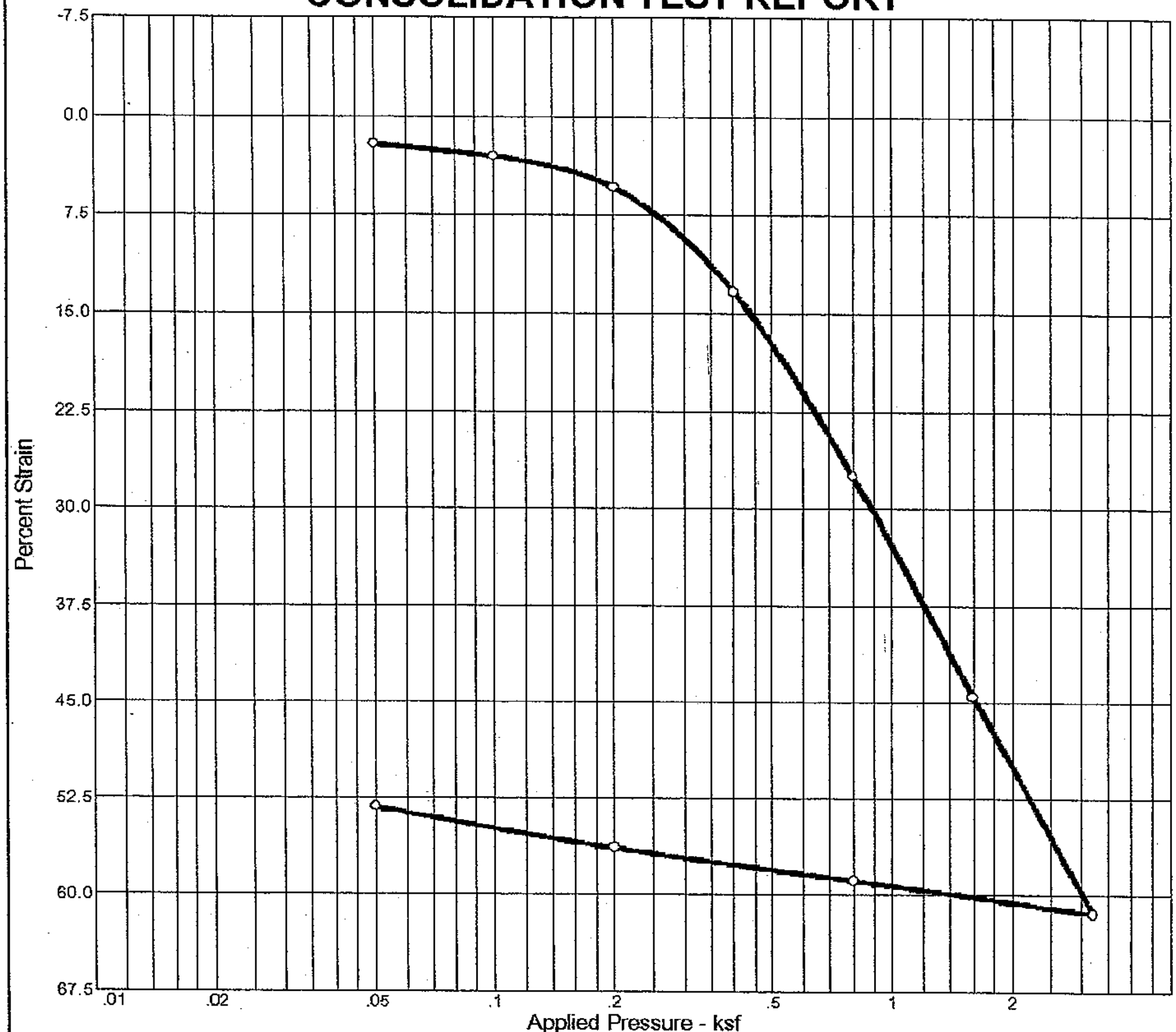
COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

Consolidation Test Results

Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 76

CONSOLIDATION TEST REPORT



Sample Depth:	Boring 29 @ 10.75-11'

Natural		Dry Density (pcf)	Specific Gravity	Initial Void Ratio
Saturation	Moisture			
98%	545%	10	1.8 (assumed)	10.0

Testing performed by Cooper Testing Laboratory

Triple Decker Project
Van Sickle Island
Solano County, California

Consolidation Test Results

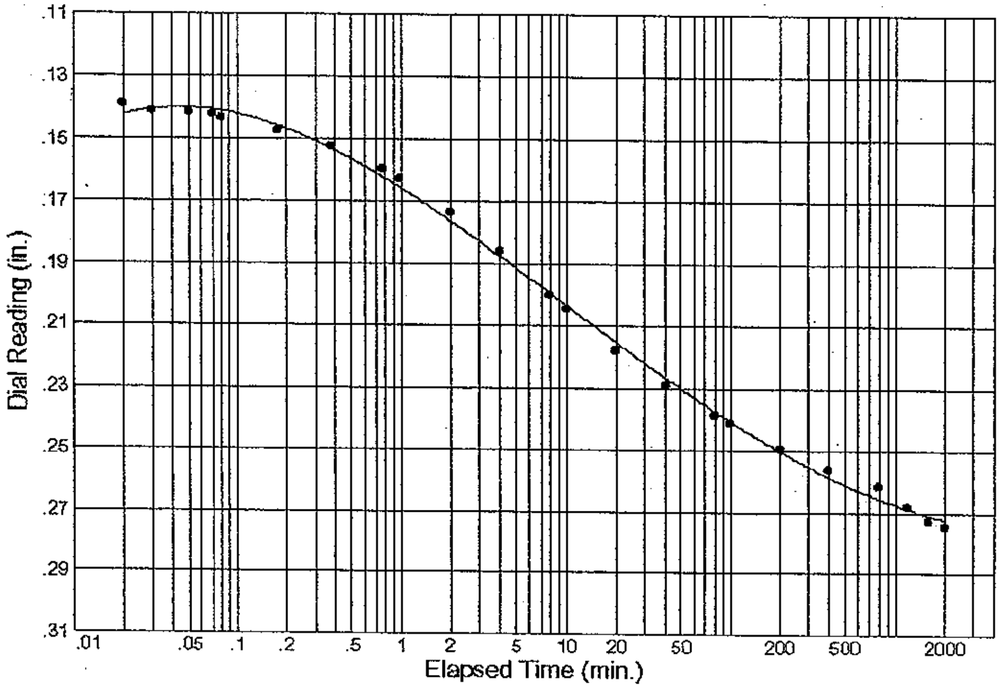
Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 77

Dial Reading vs. Time

Project No.: 541.01
Project: Hultgren-Tillis

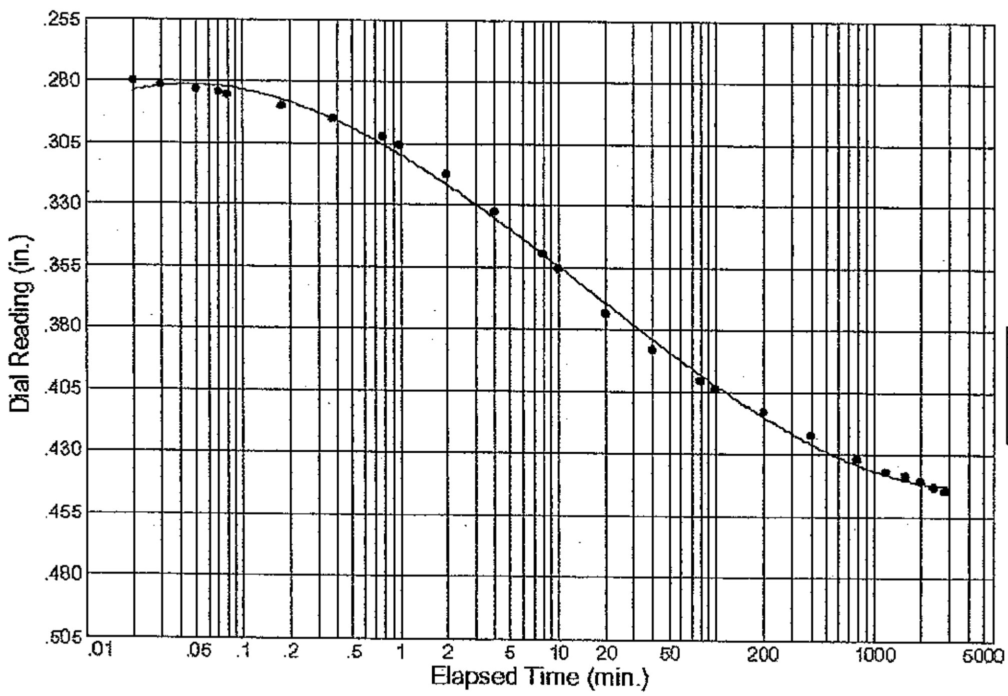
Source: B-29

Elev./Depth: 10.75-11



Load No.= 5
Load= 0.80 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_V @ T_{50}



Load No.= 6
Load= 1.60 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_V @ T_{50}

COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

Consolidation Test Results

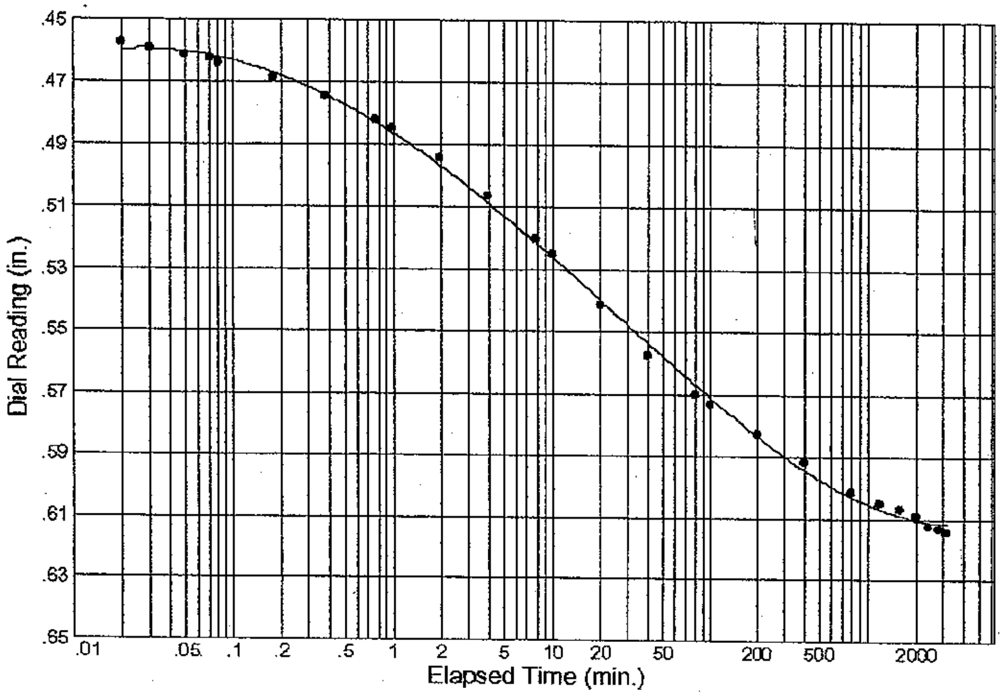
Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 78

Dial Reading vs. Time

Project No.: 541.01
Project: Hultgren-Tillis

Source: B-29

Elev./Depth: 10.75-11



Load No.= 7
Load= 3.20 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_V @ T_{50}

COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

Consolidation Test Results

Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 79

CONSOLIDATION TEST REPORT

Sample Depth:	Boring 29 @ 26.75-27'

Natural		Dry Density (pcf)	Specific Gravity	Initial Void Ratio
Saturation	Moisture			
95%	631%	8.7	1.8	11.9
			(assumed)	

Testing performed by Cooper Testing Laboratory

Triple Decker Project
Van Sickle Island
Solano County, California

Consolidation Test Results

Hultgren - Tillis Engineers

Project No. 541.01

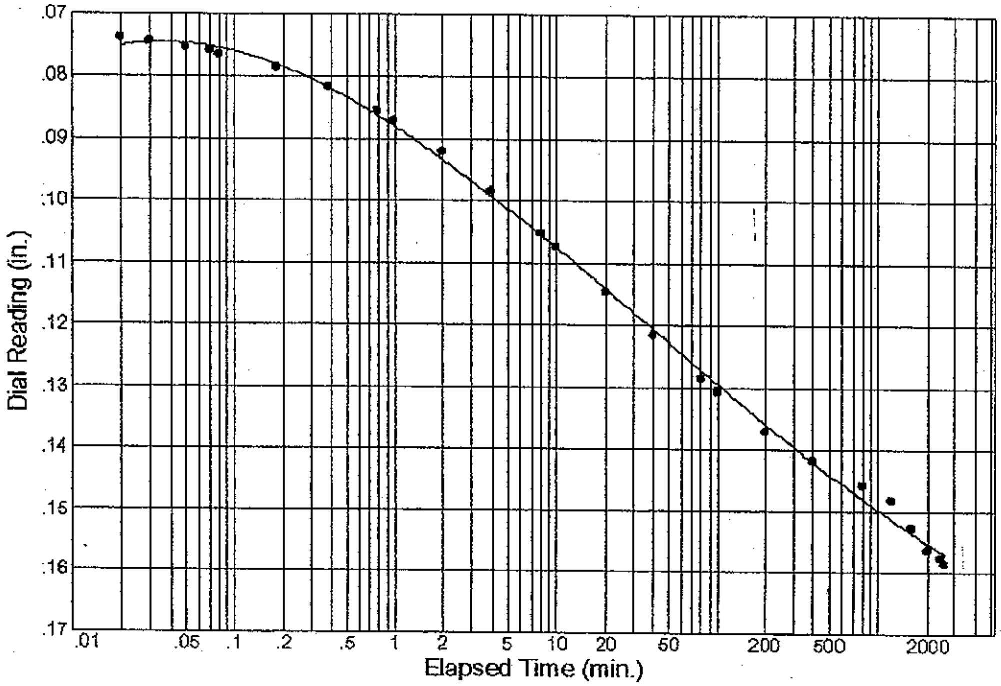
Plate No. 80

Dial Reading vs. Time

Project No.: 541.01
Project: Hultgren-Tillis

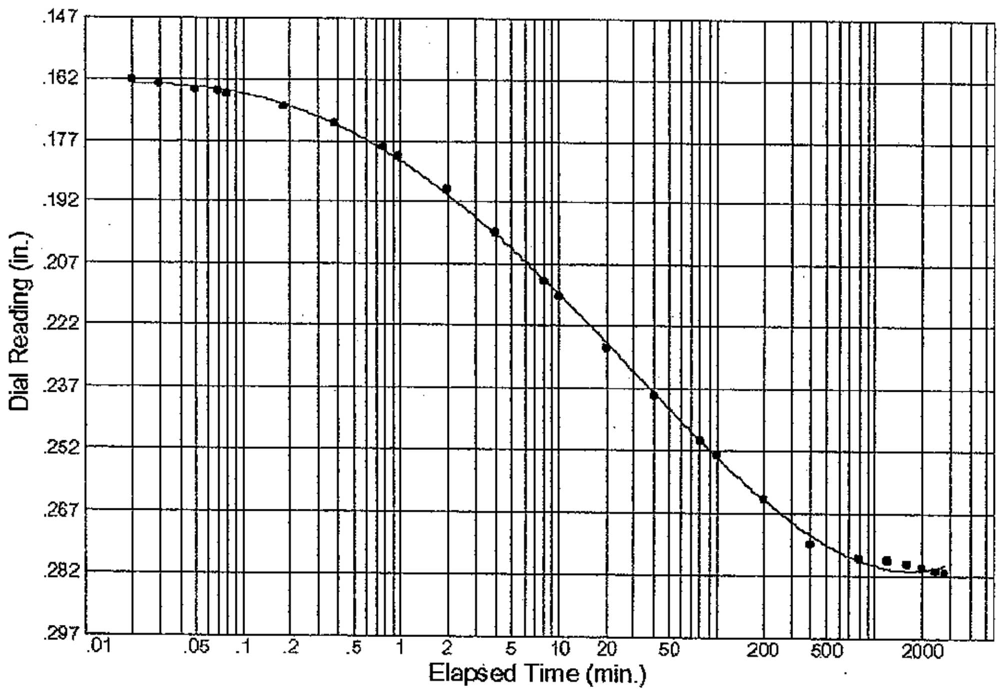
Source: B-29

Elev./Depth: 26.75-27



Load No.= 4
Load= 0.40 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_v @ T_{50}



Load No.= 5
Load= 0.80 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_v @ T_{50}

COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

Consolidation Test Results

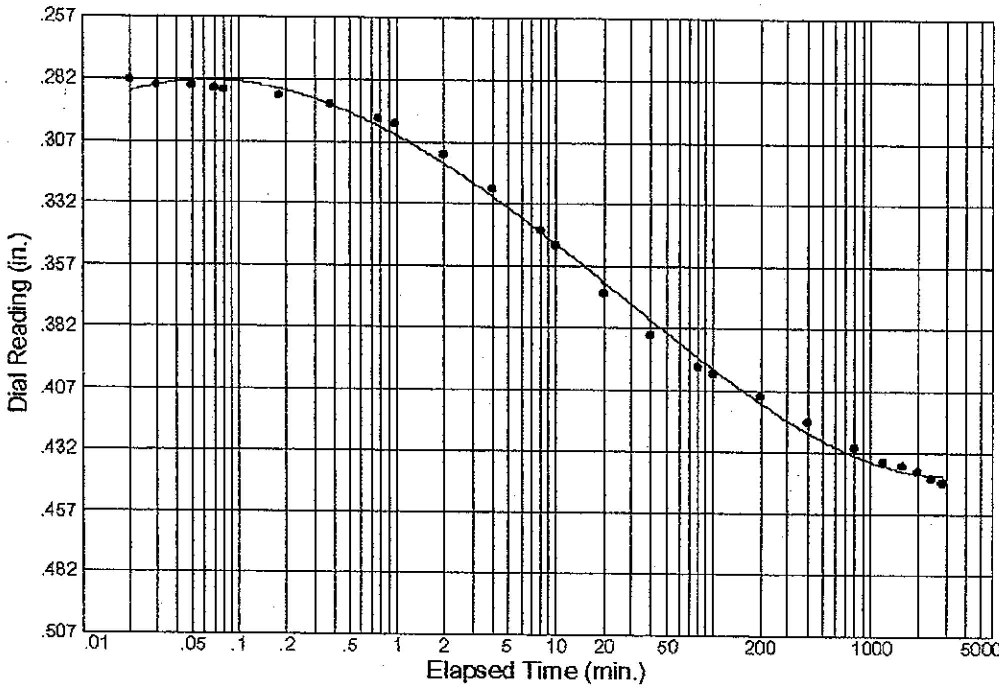
Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 81

Dial Reading vs. Time

Project No.: 541.01
Project: Hultgren-Tillis

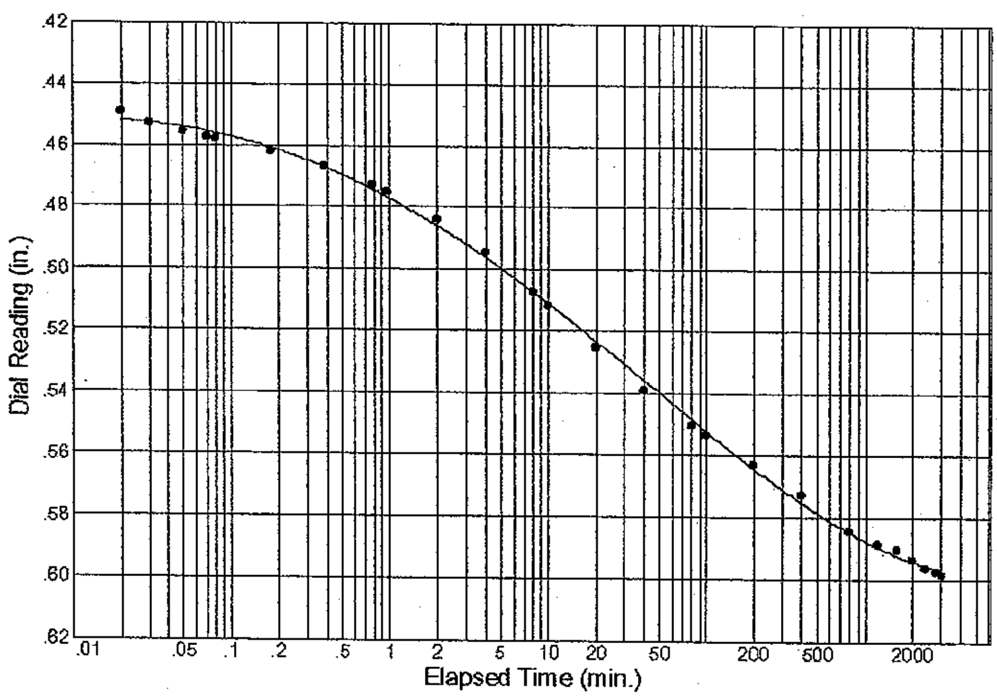
Source: B-29

Elev./Depth: 26.75-27



Load No.= 6
Load= 1.60 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_v @ T_{50}



Load No.= 7
Load= 3.20 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_v @ T_{50}

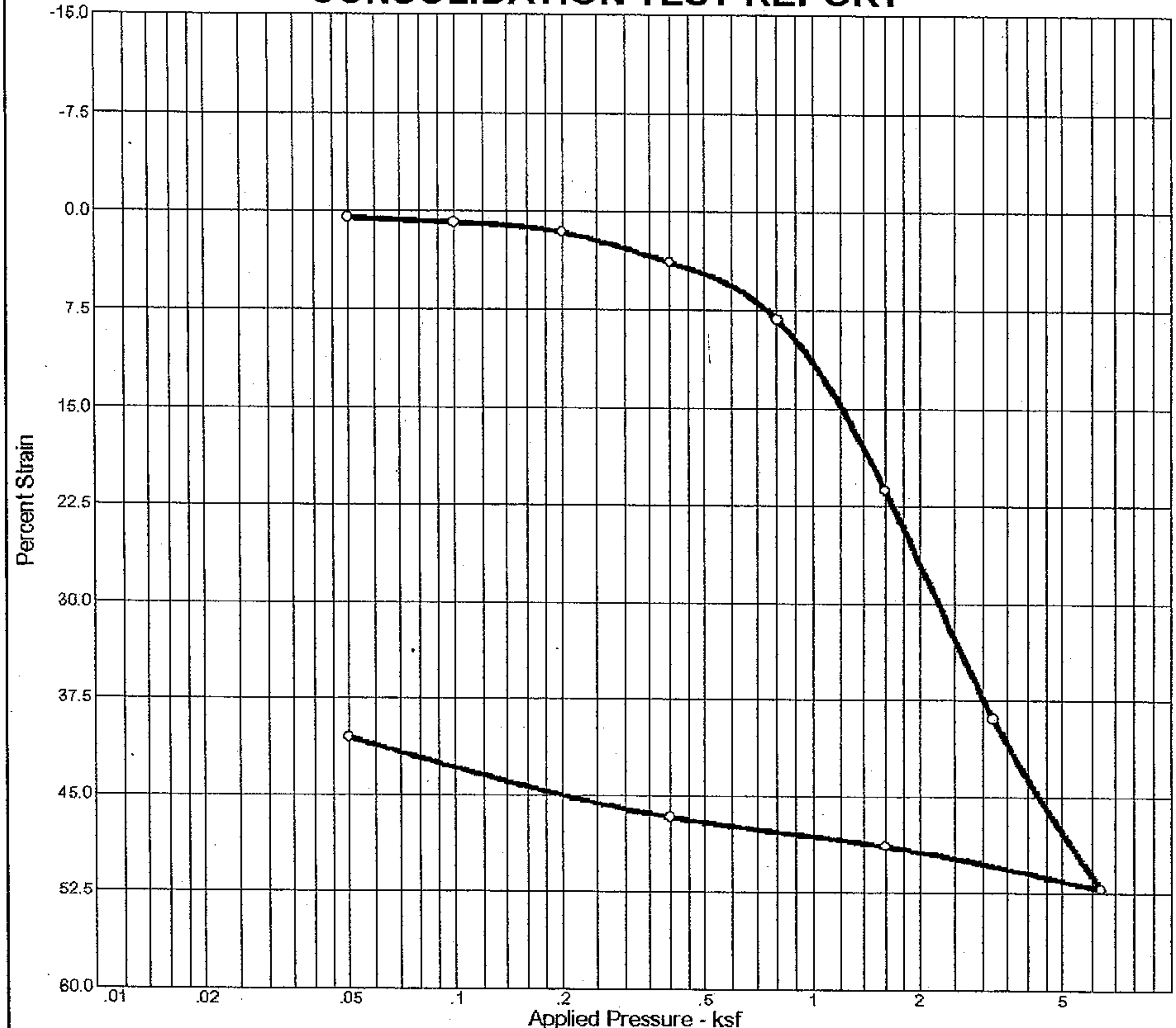
COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

Consolidation Test Results

Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 82

CONSOLIDATION TEST REPORT



Sample Depth:	Boring 32 @ 31.75-32'

Natural		Dry Density (pcf)	Specific Gravity	Initial Void Ratio
Saturation	Moisture			
92%	485%	11	1.8 (assumed)	9.5

Testing performed by Cooper Testing Laboratory

Triple Decker Project
Van Sickle Island
Solano County, California

Consolidation Test Results

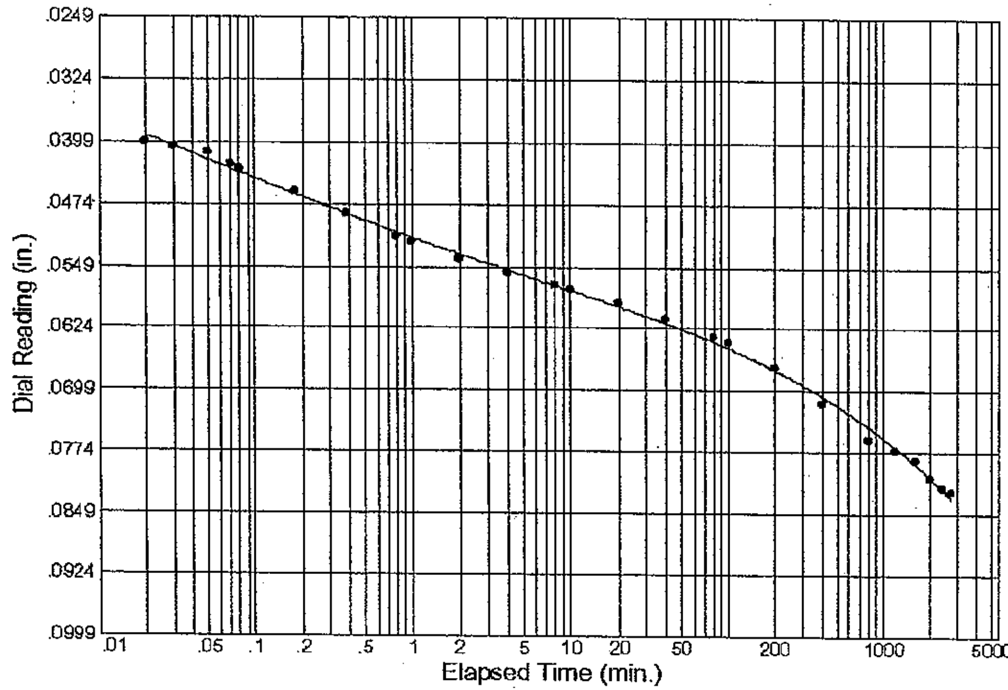
Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 83

Dial Reading vs. Time

Project No.: 541.01
Project: Hultgren-Tillis

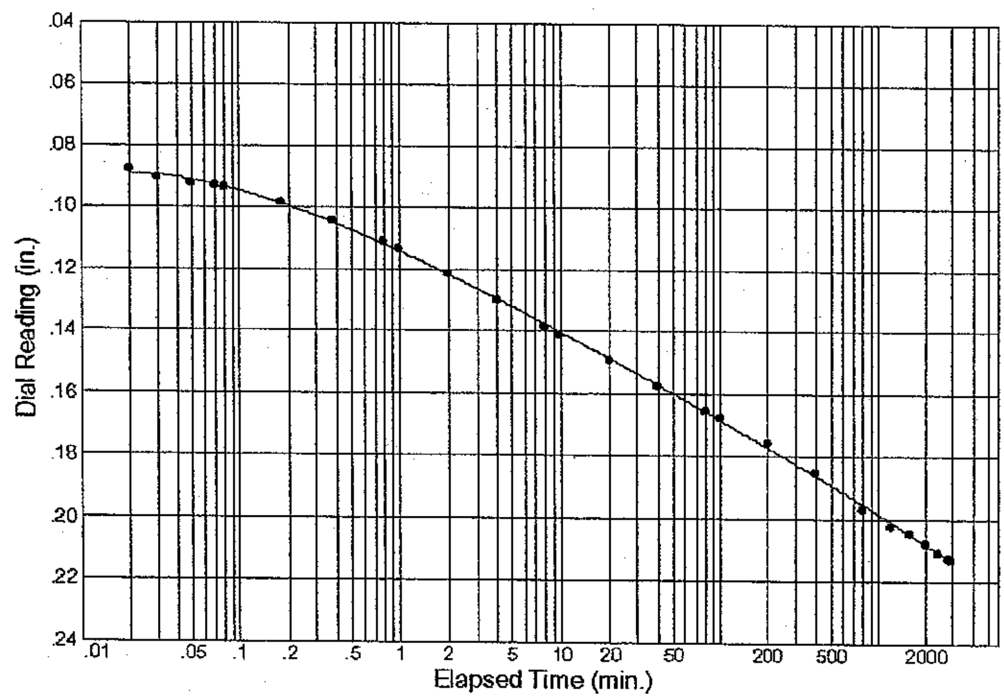
Source: B-32

Elev./Depth: 31.75-32



Load No.= 5
Load= 0.80 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_v @ T_{50}



Load No.= 6
Load= 1.60 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_v @ T_{50}

COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

Consolidation Test Results

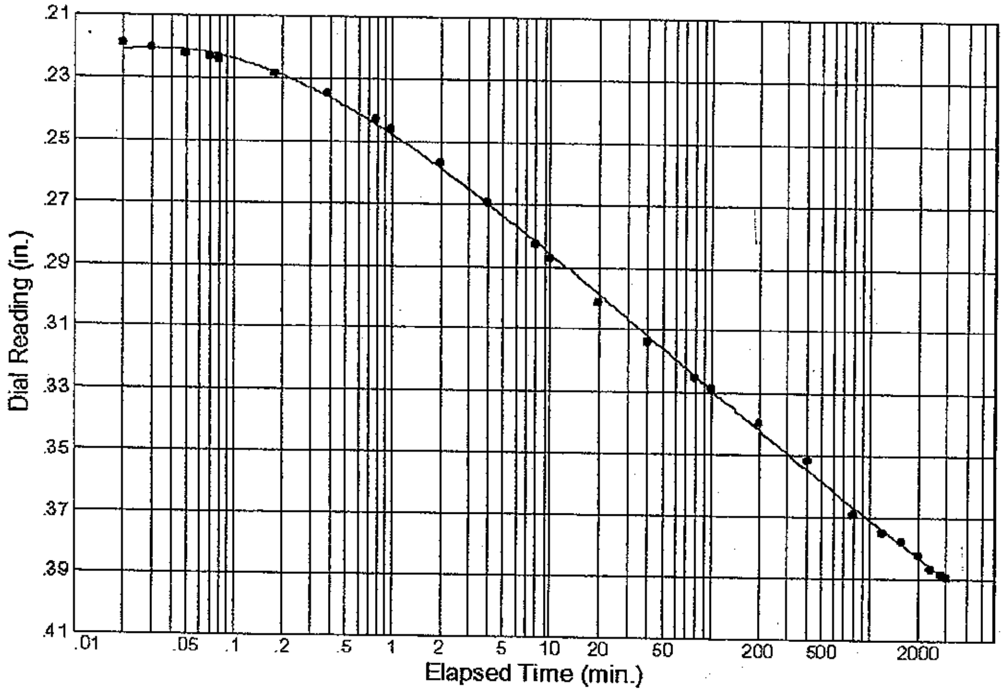
Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 84

Dial Reading vs. Time

Project No.: 541.01
Project: Hultgren-Tillis

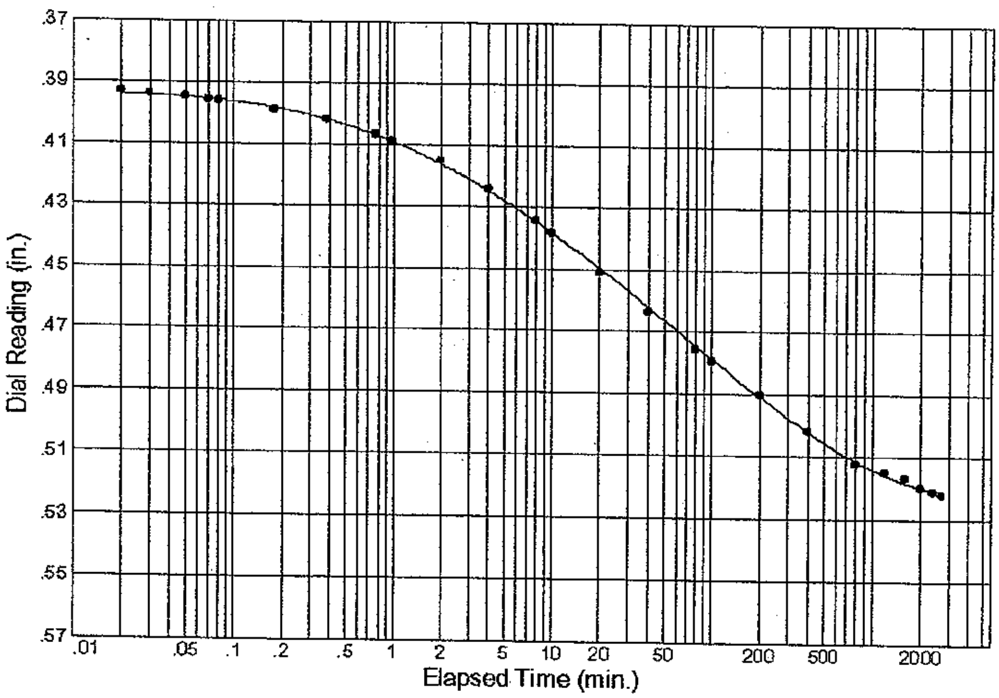
Source: B-32

Elev./Depth: 31.75-32



Load No.= 7
Load= 3.20 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

C_v @ T_{50}



Load No.= 8
Load= 6.40 ksf
D_0 =
D_{50} =
D_{100} =
T_{50} =

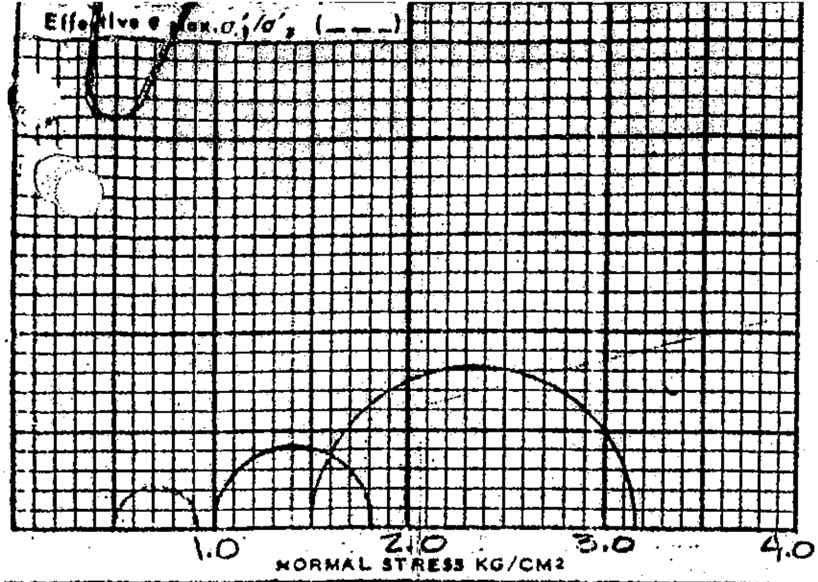
C_v @ T_{50}

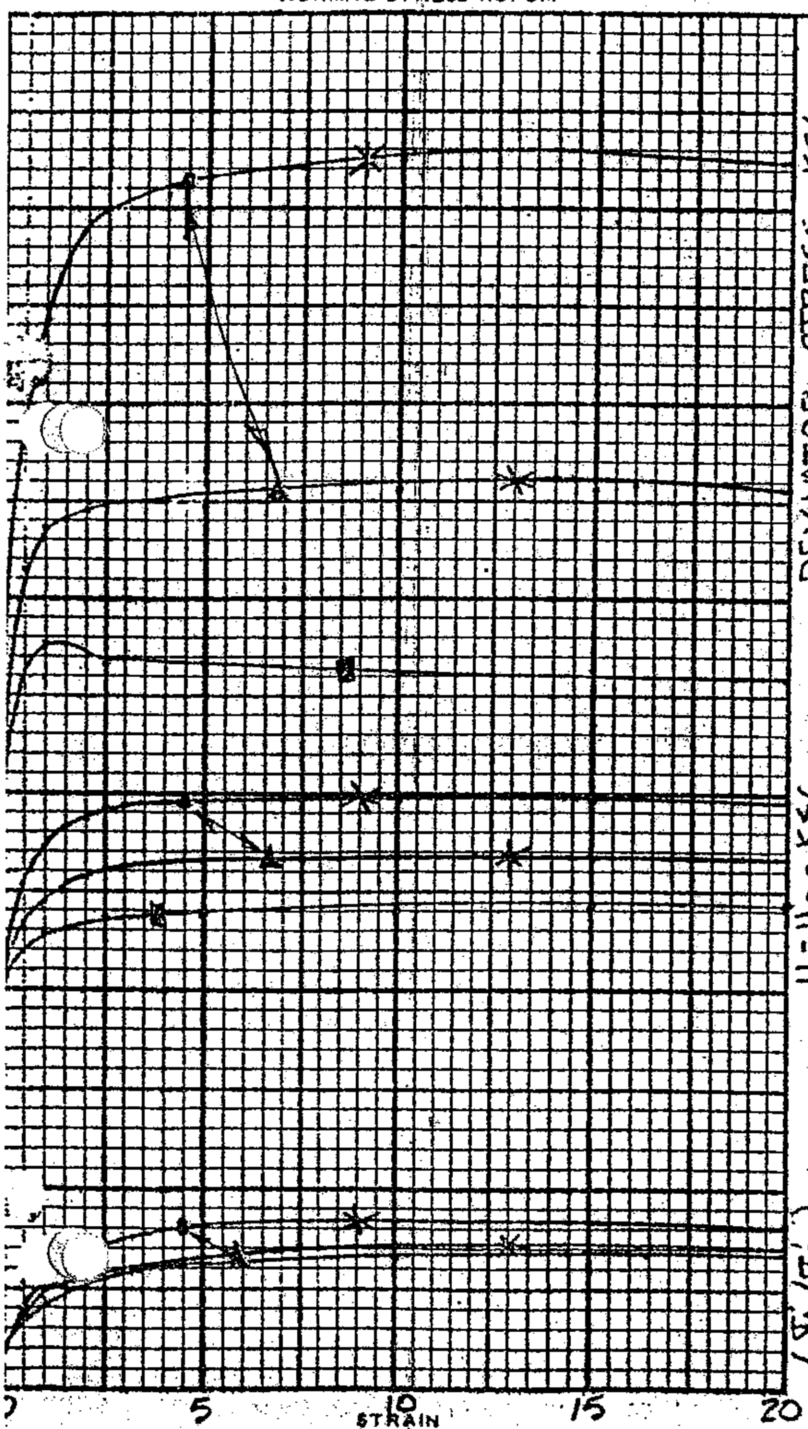
COOPER TESTING LABORATORY

Triple Decker Project
Van Sickle Island
Solano County, California

Consolidation Test Results

Hultgren - Tillis Engineers	Project No. 541.01	Plate No. 85





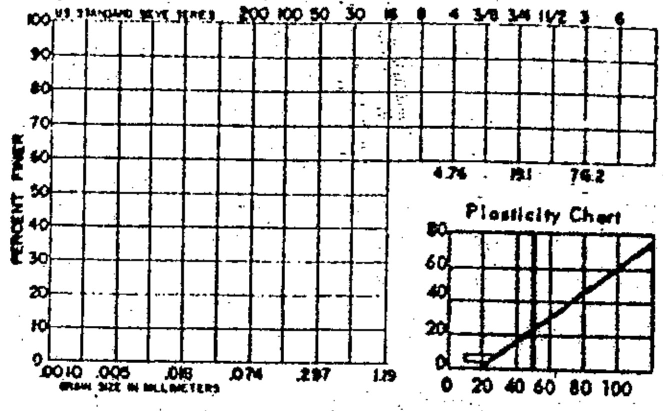
SHEARING STRENGTH SUMMARY SHEET

TYPE OF TEST CUE

Saturated
Consolidated
Undrained

Strain Controlled .003 in/min.
Stress

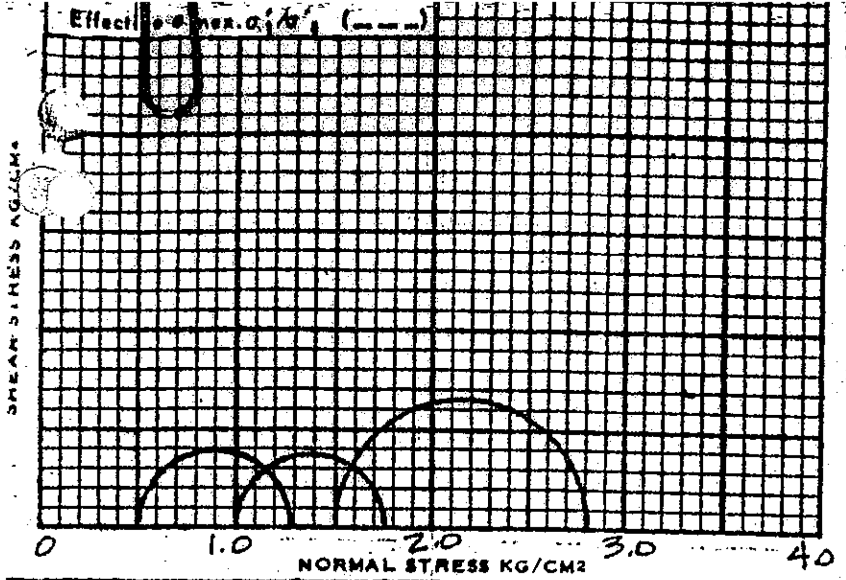
Remarks

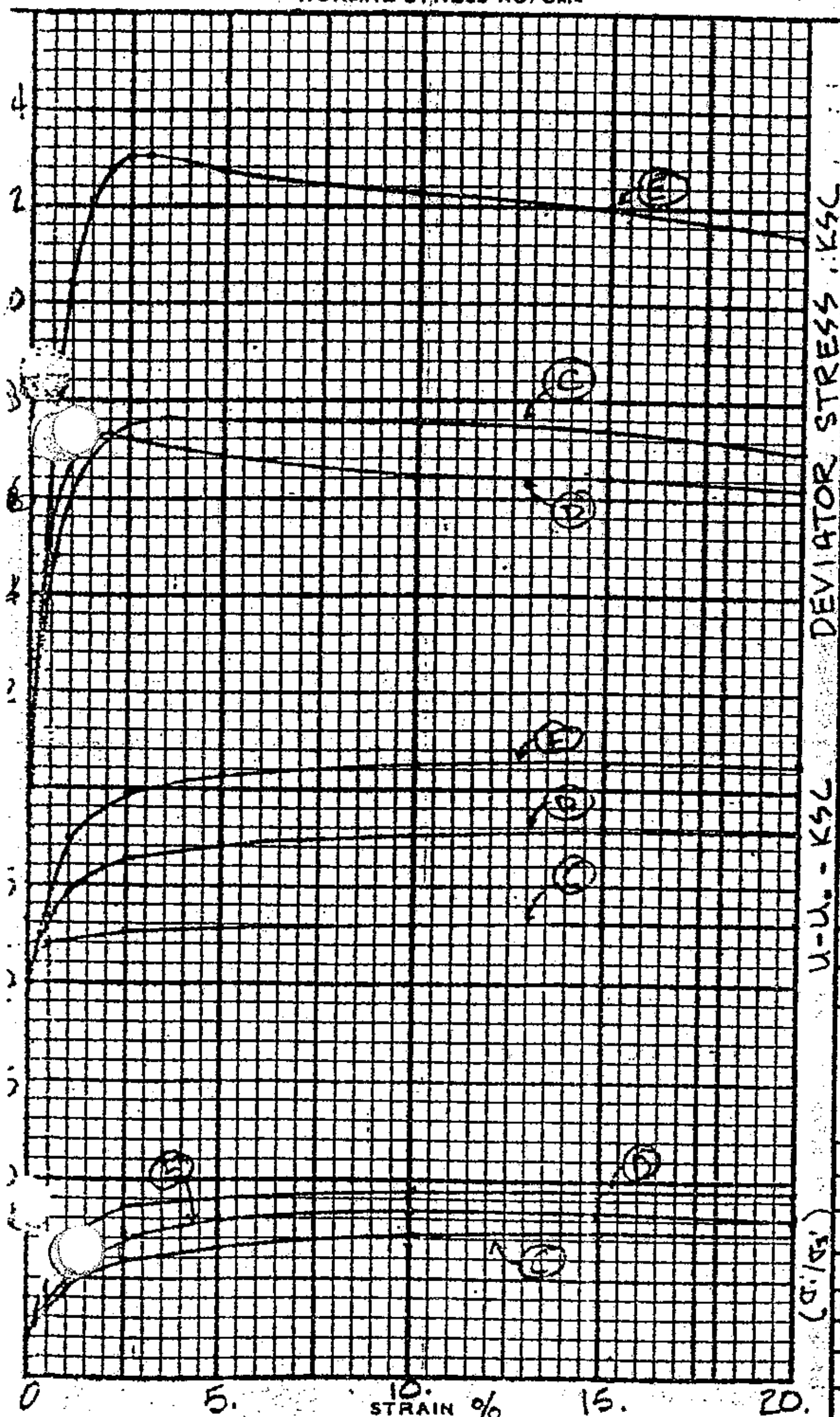


Mechanical Analysis Diagram

Classification				Ga	
Specimen		●	▲	■	♦
Laboratory No. 85-345		D	E	C	
Initial	Water Content, W_o %	47.3	65.0	42.5	
	Dry Density, p.c.f.	56.3	55.3	53.7	
	Void Ratio, e_o				
	Saturation, S_o, %				
	Specimen Diameter, cm.	7.31	7.33	7.30	
	Specimen Height, cm.	15.80	15.70	15.85	
Normal Pressure, kg/cm2		1.0	1.5	.5	
Before Test	Time, days	14	14	15	
	Change in Volume, %	5.4	4.1	4.5	
	Dry Density, p.c.f.	59.5	57.6	56.2	
	Void Ratio, e				
	Saturation, $B = \frac{\Delta u}{\Delta \sigma_3}$	.95	.97	.94	
	Back Pressure, kg/cm2	5.5	4.5	7.0	
Failure	Void Ratio, ef				
	Saturation, Sf, %				
Time to Max. dev., min.		282	281		
Time to Max. (σ'_1/σ'_3)		263	183		
TESTED SPECIMEN			PEAT		

Project MONTEZUMA SLOUGH			
Feature CONTROL STRUCTURE			
Hole No. CS-10		Field Sample No. S-1	
Type of sample 3" SHELBY		Depth 0' - 2'	
φ'	tan φ'	c	kg/cm²
φs	tan φ	cs	kg/cm²
Date of Report 6-7-85		Drawn R.T.	Checked
Request No. 85-17		Lab. Sample No. 85-345 D, E	





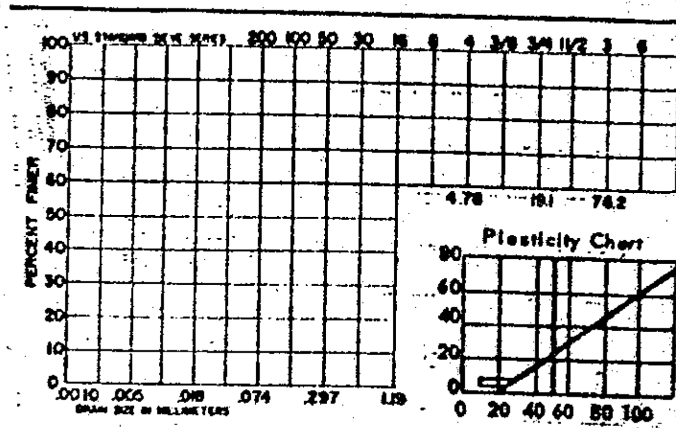
DEPARTMENT OF WATER RESOURCES — SOILS LABORATORY

SHEARING STRENGTH SUMMARY SHEET

TYPE OF TEST CUB

Saturated Consolidated Undrained — Strain Controlled .003 in/min. Stress

Remarks

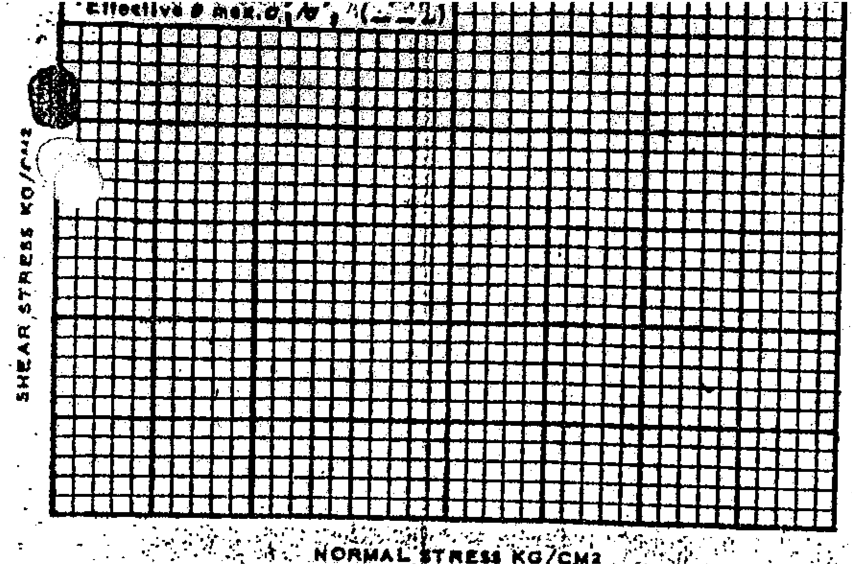


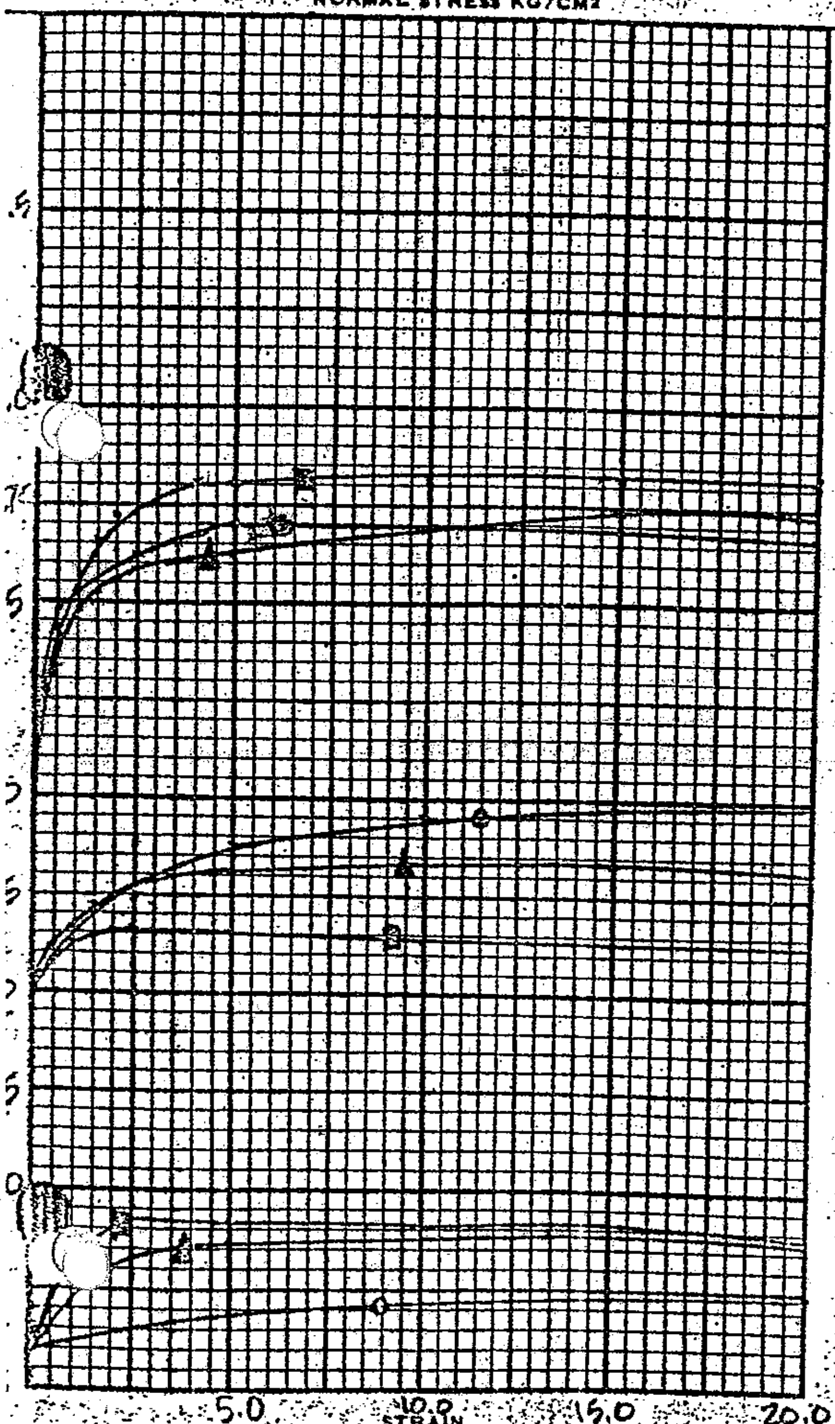
Mechanical Analysis Diagram

Classification				Gs	
Specimen		●	▲	■	♦
Laboratory No. 85-320		C	D	E	
Initial	Water Content, W_o %	50.7	52.2	55.0	
	Dry Density, p.c.f.	59.4	56.4	60.2	
	Void Ratio, e_o				
	Saturation, S_o, %				
	Specimen Diameter, cm.	7.35	7.34	7.33	
	Specimen Height, cm.	15.95	15.70	15.90	
Normal Pressure, kg/cm²		.5	1.0	1.5	
Before Test	Time, days	12	12	13	
	Change in Volume, %	2.9	4.9	4.8	
	Dry Density, p.c.f.	61.1	59.4	63.2	
	Void Ratio, e				
	Saturation, $B = \frac{\Delta u}{\Delta \sigma_3}$	.96	.95	.95	
	Back Pressure, kg/cm²	5.5	6.0	4.5	
Failure	Void Ratio, ef				
	Saturation, Sf, %				
Time to Max. dev., min.		64	41	51	
Time to Max. (σ'_1/σ'_3)		368	282	226	
TESTED SPECIMEN					

Project MONTEZUMA SLOUGH			
Feature CONTROL STRUCTURE			
Hole No. CS-7		Field Sample No. S-1	
Type of sample UNDISTURBED		Depth 0-2'	
ϕ'	tan ϕ'	c	kg/cm²
ϕ_a	tan ϕ	ca	kg/cm²
Date of Report 7-2-85		Drawn R.T.	Checked
Request No. 85-17		Lab. Sample No. 85-320 C, D, E	

Effective ϕ max. σ_1'/σ_3', (— — —)





R 726 (REV. 6/65)

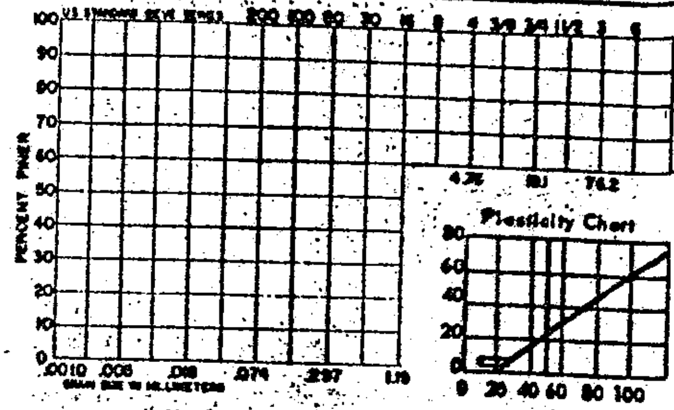
DEPARTMENT OF WATER RESOURCES — SOILS LABORATORY

SHEARING STRENGTH SUMMARY SHEET

TYPE OF TEST CUE

Saturated / Consolidated / Undrained — Strain / Stress Controlled .003 in/min.

Remarks



Mechanical Analysis Diagram

Classification				Go	
Specimen		●	▲	■	◆
Laboratory No. 85-262		C	D	E	
Initial	Water Content, W_o %	70.5	38.9	35.1	
	Dry Density, p.c.f.	56.5	81.6	86.5	
	Void Ratio, e_o				
	Saturation, S_o, %				
	Specimen Diameter, cm.	7.32	7.33	7.33	
	Specimen Height, cm.	15.3	15.20	16.0	
Normal Pressure, kg/cm²		1.5	1.0	.50	
Before Test	Time, days	10	10	10	
	Change in Volume, %	+25.3	7.35	1.62	
	Dry Density, p.c.f.	42.2	88.1	87.9	
	Void Ratio, e				
	Saturation, $B = \frac{\Delta u}{\Delta \sigma_3}$	.97	.95	.97	
	Back Pressure, kg/cm²	4.5	4.5	4.5	
Failure	Void Ratio, ef				
	Saturation, Sf, %				
Time to Max. dev., min.					
Time to Max. (σ_1'/σ_3')					
TESTED SPECIMEN					

Project MONTEZUMA Slough			
Feature CONTROL Structure			
Hole No. CS-1		Field Sample No. S-4	
Type of sample 3" SHELBY		Depth 27½-29½	
ϕ'	tan ϕ'	c'	kg/cm²
ϕ	tan ϕ	c	kg/cm²
Date of Report 4/2/85		Drawn R.T.	Checked
Request No. 85-7		Lab. Sample No. 85-262 C,D,E	

THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

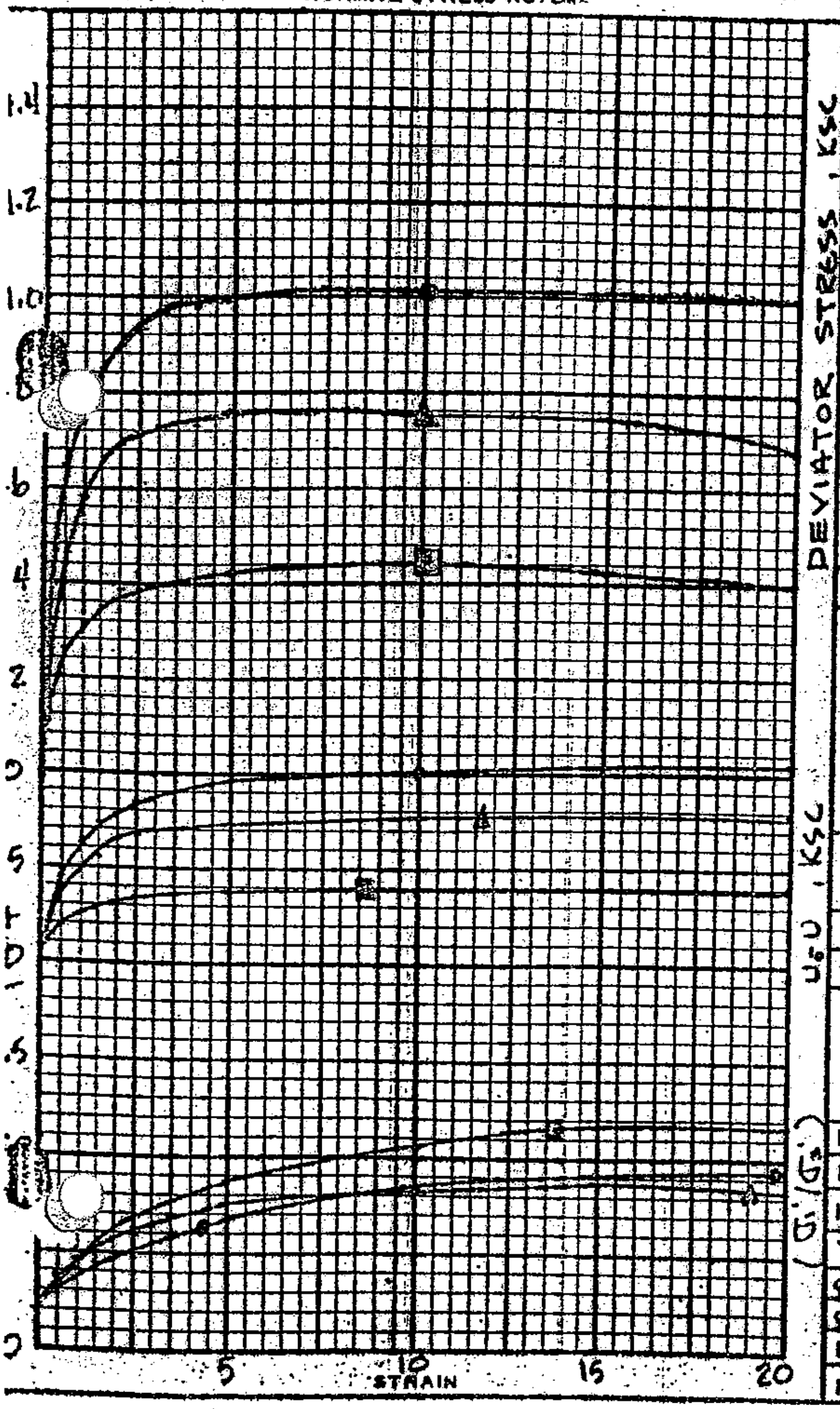
LABORATORIES BRANCH
SOILS LABORATORY

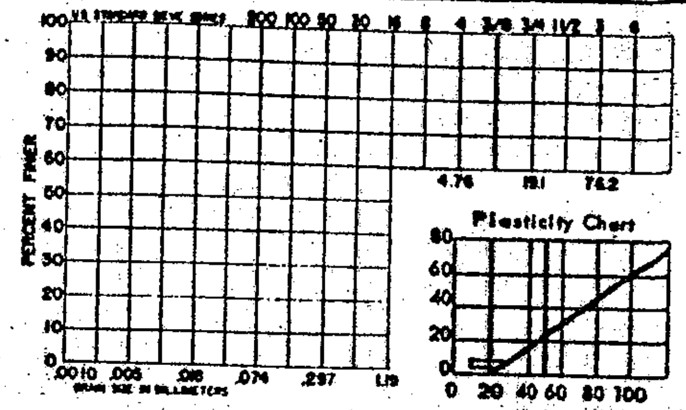
SHEARING STRENGTH SUMMARY SHEET

TYPE OF TEST CUE

Saturated Consolidated Undrained — Strain Controlled .003 in/min.

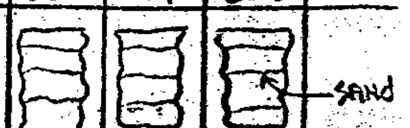
Remarks organic clay with Evenly spaced thin horizontal sand layers.





Mechanical Analysis Diagram

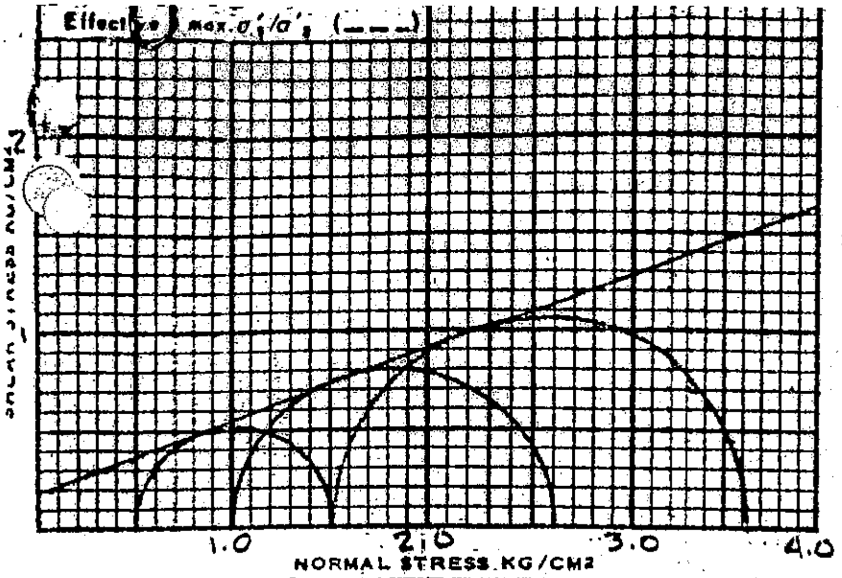
Classification				Gs	
Specimen		●	▲	■	♦
Laboratory No. 85-264		C	D	E	
Initial	Water Content, W_o %	83.2	79.1	76.6	
	Dry Density, p.c.f.	50.8	52.5	53.7	
	Void Ratio, e_o				
	Saturation, S_o, %				
	Specimen Diameter, cm.	7.28	7.28	7.29	
	Specimen Height, cm.	16.1	14.6	14.8	
Normal Pressure, kg/cm²		1.5	1.0	0.5	
Before Test	Time, days	13	13	13	
	Change in Volume, %	23.37	15.83	5.00	
	Dry Density, p.c.f.	66.3	62.4	56.6	
	Void Ratio, e				
	Saturation, $B = \frac{\Delta u}{\Delta \sigma_3}$	.99	.94	1.00	
	Back Pressure, kg/cm²				
Failure	Void Ratio, ef				
	Saturation, Sf, %				
Time to Max. dev., min.		193	90	191	
Time to Max. (σ'_1/σ'_3)		387	271	286	
TESTED SPECIMEN					

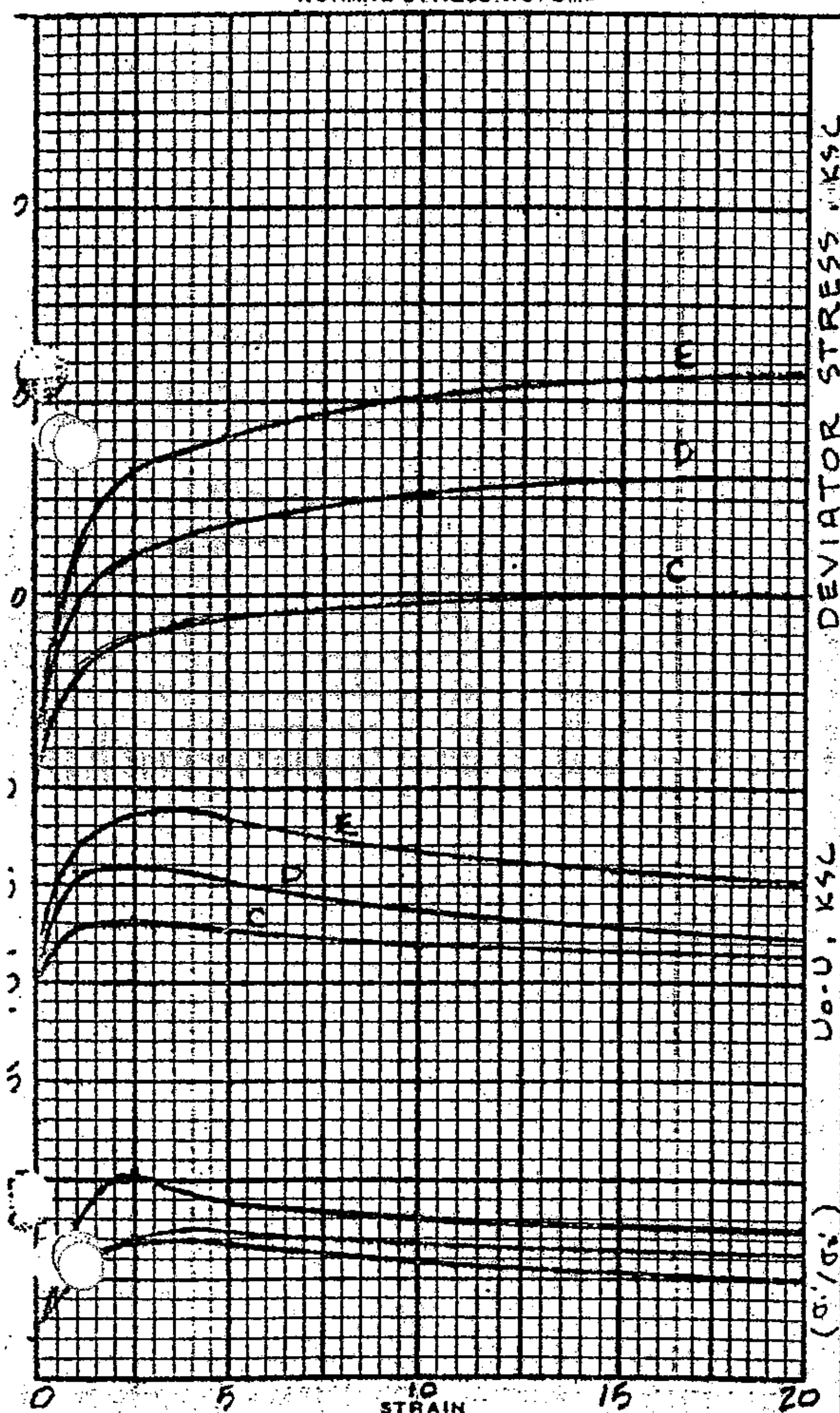


Project MONTEZUMA SLOUGH
Feature CONTROL STRUCTURE
Hole No. CS-2 — Field Sample No. S-2
Type of sample 3" SHELBY — Depth 19°-21°

ø'	tan ø'	c	kg/cm²
øu 8°	tan ø	cu .125	kg/cm²

Date of Report 4-22-85 — Drawn R.T. — Checked
Request No. 85-7 — Lab. Sample No. 85-264 C, D, E





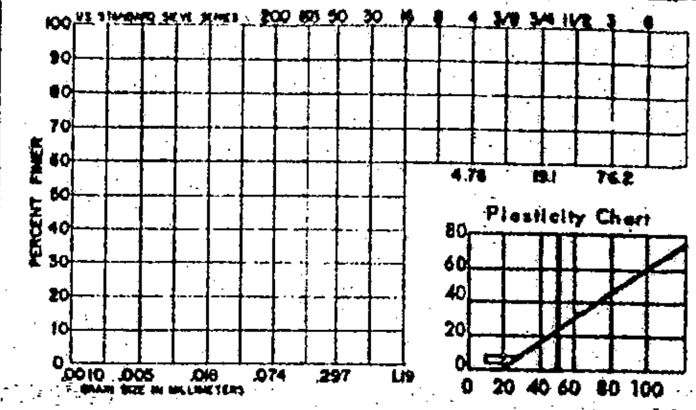
IR 728 (REV. 6/68)

SHEARING STRENGTH SUMMARY SHEET

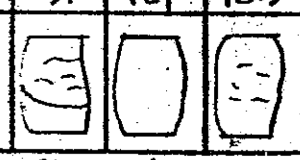
TYPE OF TEST CUE

Saturated Consolidated Undrained — Strain Controlled .004-C in/min. .003-D .003-E — Stress

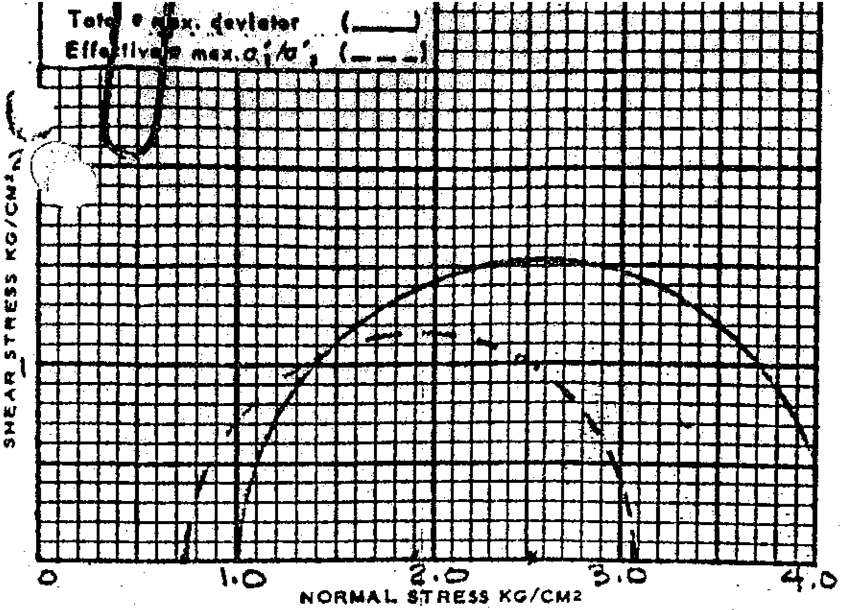
Remarks

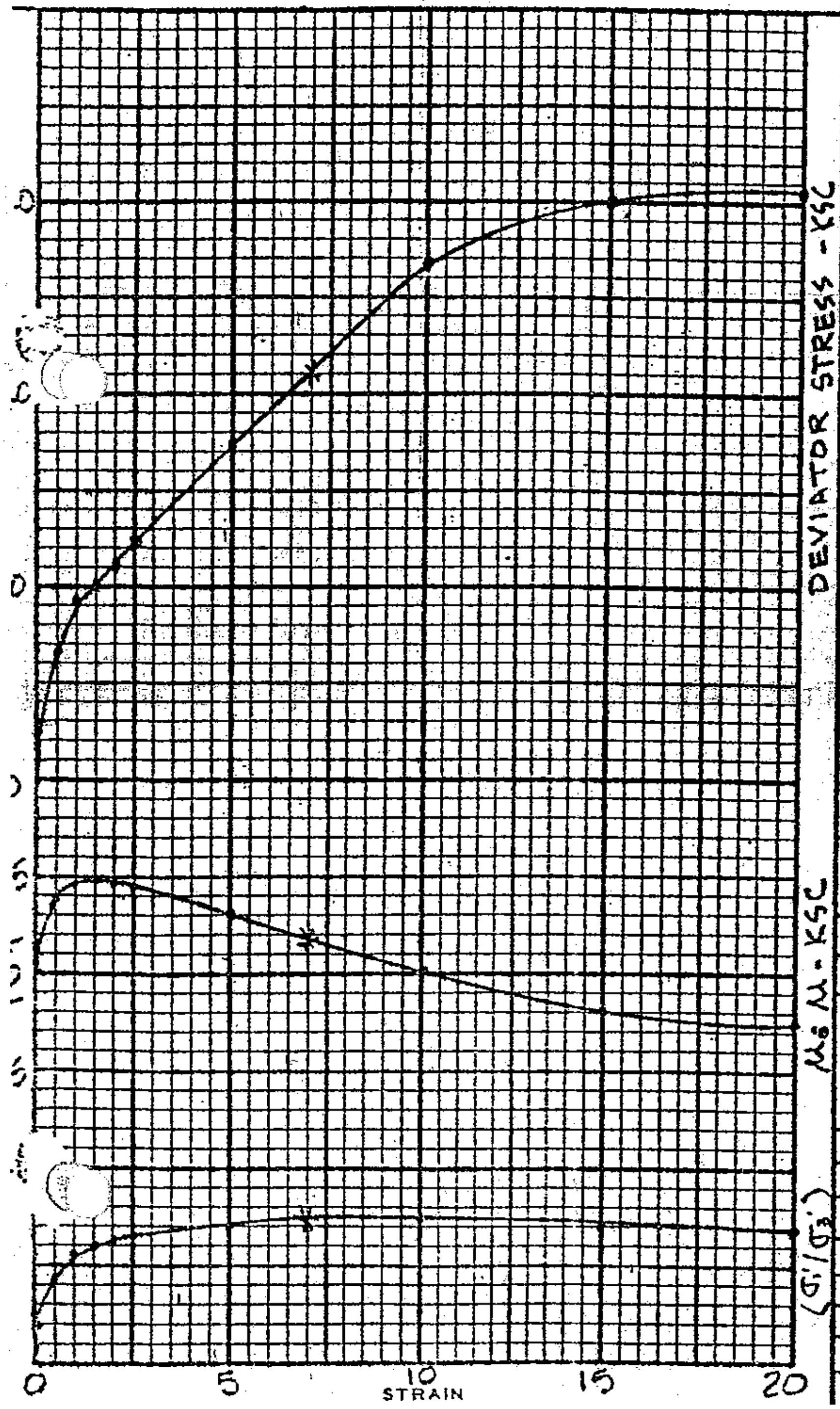


Mechanical Analysis Diagram

Classification					Gs
Specimen		●	▲	■	◆
Laboratory No. 85-347		C	D	E	
Initial	Water Content, W_o %	26.2	24.8	24.5	
	Dry Density, p.c.f.	96.1	100.5	100.9	
	Void Ratio, e_o				
	Saturation, S_o, %				
	Specimen Diameter, cm.	7.36	7.34	7.33	
	Specimen Height, cm.	15.6	16.2	16.3	
Normal Pressure, kg/cm²		.5	1.0	1.5	
Before Test	Time, days	14	14	14	
	Change in Volume, %	3.5	3.2	4.6	
	Dry Density, p.c.f.	99.6	103.8	105.7	
	Void Ratio, e				
	Saturation, $B = \frac{\Delta u}{\Delta \sigma_3}$	.97	.93	.95	
	Back Pressure, kg/cm²	4.5	6.0	4.0	
Failure	Void Ratio, ef				
	Saturation, Sf, %				
Time to Max. dev., min.		346	402	407	
Time to Max. (σ'_1/σ'_3)		51	121	105	
TESTED SPECIMEN					

Project MONTEZUMA SLOUGH			
Feature CONTROL STRUCTURE			
Hole No. CS-10	Field Sample No. S-3		
Type of sample UNDISTURBED	Depth 31' - 32'		
ϕ'	tan ϕ'	c	kg/cm²
ϕ_a	tan ϕ	ca	kg/cm²
Date of Report 6-20-85	Drawn R.T.	Checked	
Request No. 85-17	Lab. Sample No. 85-347 C,D,E		





THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

LABORATORIES BRANCH
SOILS LABORATORY

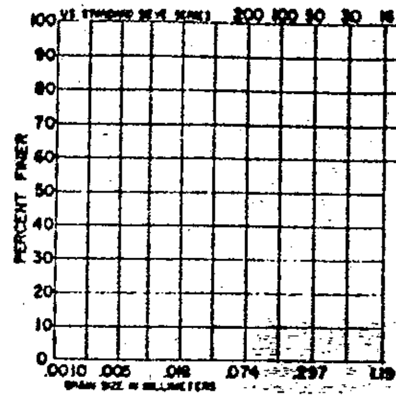
SHEARING STRENGTH SUMMARY SHEET

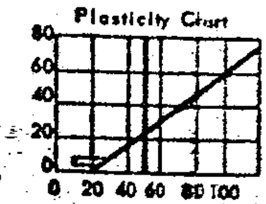
TYPE OF TEST CUE

Saturated
Consolidated
Undrained

Strain
Stress
Controlled .003 in/min.

Remarks





Mechanical Analysis Diagram

Classification				Gs	
Specimen		●	▲	■	♦
Laboratory No. 85-324				D	
Initial	Water Content, W_o %			26.8	
	Dry Density, p.c.f.			96.5	
	Void Ratio, e_o				
	Saturation, S_o, %				
	Specimen Diameter, cm.			7.32	
	Specimen Height, cm.			15.9	
Normal Pressure, kg/cm²				1.0	
Before Test	Time, days			20	
	Change in Volume, %			1.7	
	Dry Density, p.c.f.			98.2	
	Void Ratio, e				
	Saturation, $B = \frac{\Delta u}{\Delta \sigma_3}$			.95	
	Back Pressure, kg/cm²			5.0	
Failure	Void Ratio, ef				
	Saturation, Sf, %				
Time to Max. dev., min.				346	
Time to Max. σ'_1/σ'_3)				144	
TESTED SPECIMEN					

Project MONTEZUMA SLOUGH

Feature CONTROL STRUCTURE

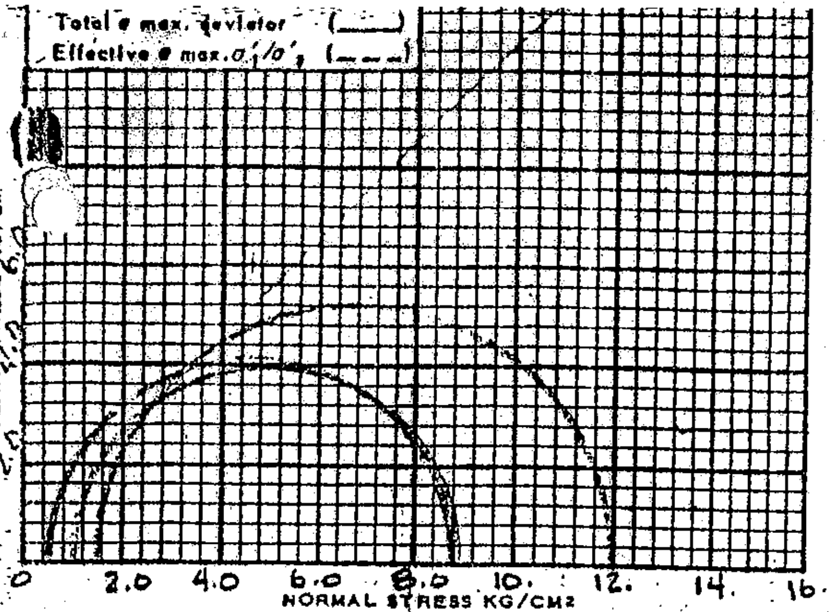
Hole No. CS-7	Field Sample No. S-4		
Type of sample UNDISTURB		Depth 33² - 35²	
ϕ'	tan ϕ'	c	kg/cm²
ϕ_m	tan ϕ	cm	kg/cm²
Date of Report 8-12-85	Drawn R.T.	Checked	

Request No. 85-17 Lab. Sample No. 85-324 D

THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

LABORATORIES BRANCH
SOILS LABORATORY

SHEARING STRENGTH SUMMARY SHEET

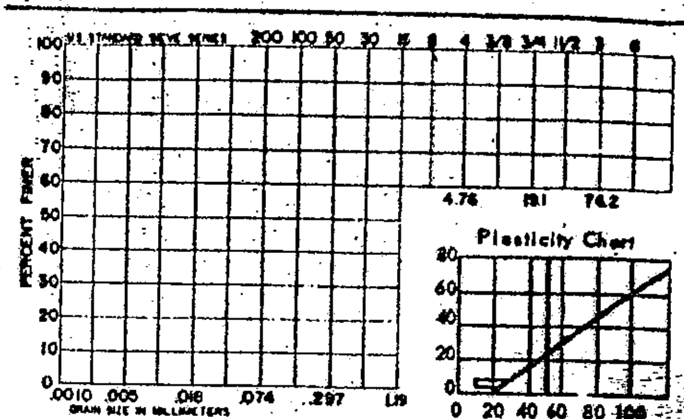


TYPE OF TEST CUE

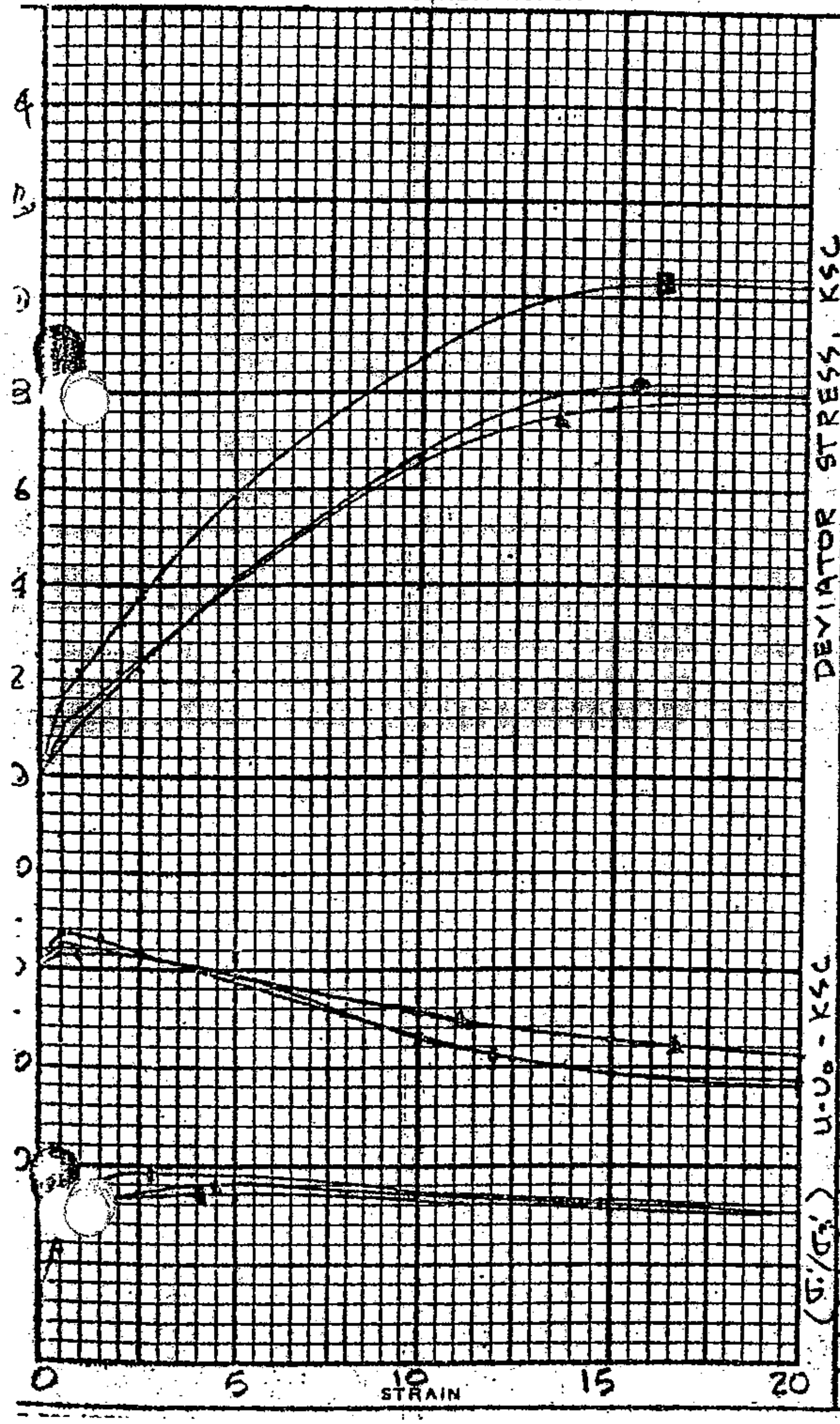
Saturated
Consolidated
Undrained

Strain Controlled .003 in/min.
Stress

Remarks SAND
Possible loss of chamber fluid



Mechanical Analysis Diagram

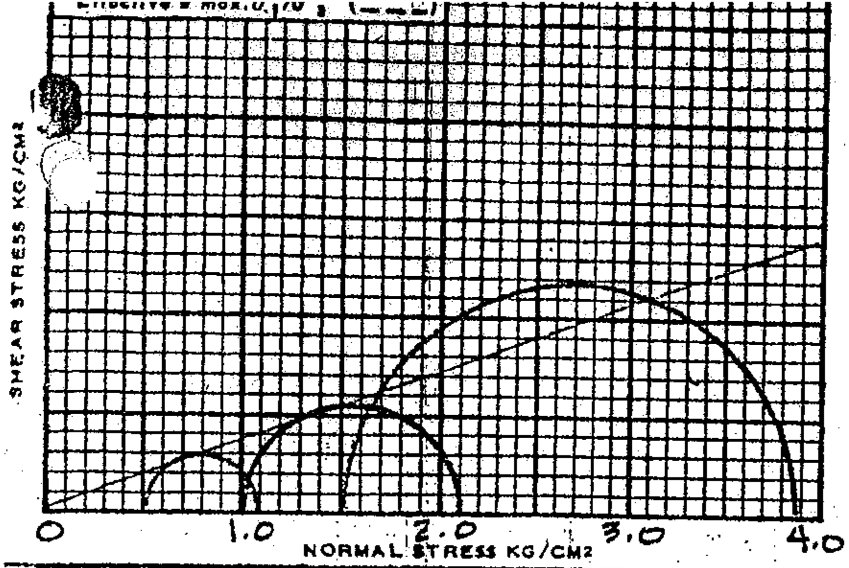


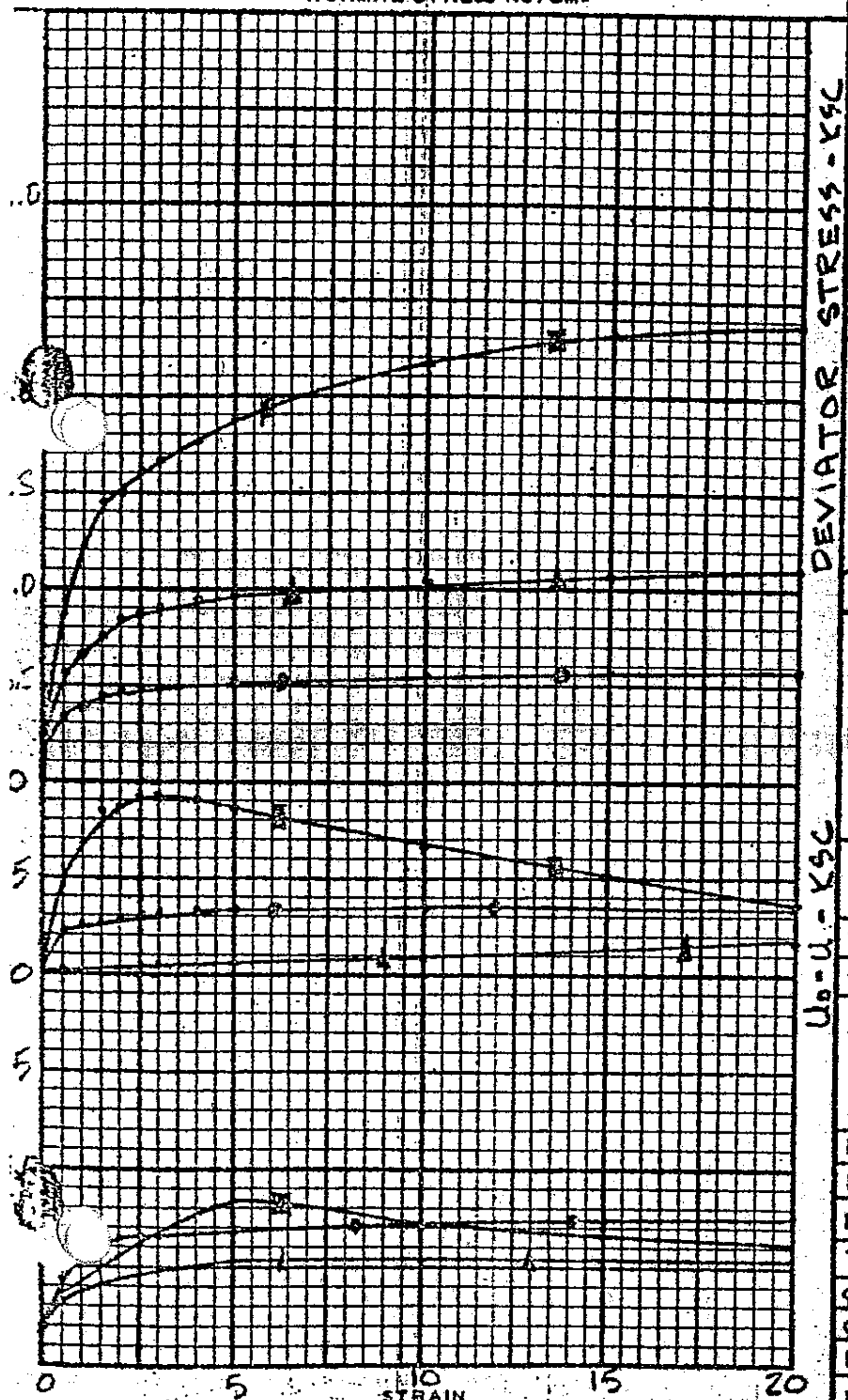
Classification				Gs	
Specimen		●	▲	■	◆
Laboratory No. 85-202		C	D	E	
Initial	Water Content, W_o %	32.5	29.1	32.7	
	Dry Density, p.c.f.	88.0	82.7	88.2	
	Void Ratio, e_o				
	Saturation, S_o, %				
	Specimen Diameter, cm.	7.30	7.32	7.32	
	Specimen Height, cm.	15.45	15.55	16.20	
Normal Pressure, kg/cm²		0.5	1.0	1.5	
Before Test	Time, days	13	13	13	
	Change in Volume, %	.81	1.10	1.90	
	Dry Density, p.c.f.	88.7	83.6	89.9	
	Void Ratio, e				
	Saturation, $B = \frac{\Delta u}{\Delta \sigma_3}$	.96	.95	.94	
	Back Pressure, kg/cm²	4.0	4.0	5.5	
Failure	Void Ratio, ef				
	Saturation, Sf, %				
Time to Max. dev., min.		400	395	390	
Time to Max. (σ'_1/σ'_3)		53	101	79	
TESTED SPECIMEN					

Project MONTEZUMA SLOUGH

Feature CONTROL STRUCTURE

Hole No. CS-5		Field Sample No. S-3	
Type of sample 3" SHELBY		Depth 55²-57²	
φ'	tan φ'	c	kg/cm²
φu	tan φ	cu	kg/cm²
Date of Report 5/23/85		Drawn R.T.	Checked
Request No. 85-7		Lab. Sample No. 85-202 D	



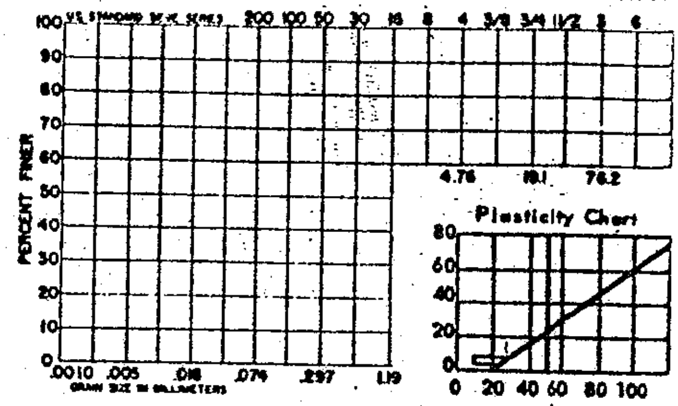


SHEARING STRENGTH SUMMARY SHEET

TYPE OF TEST CUE

Saturated Consolidated Undrained — Strain Controlled .003 in/min.

Remarks

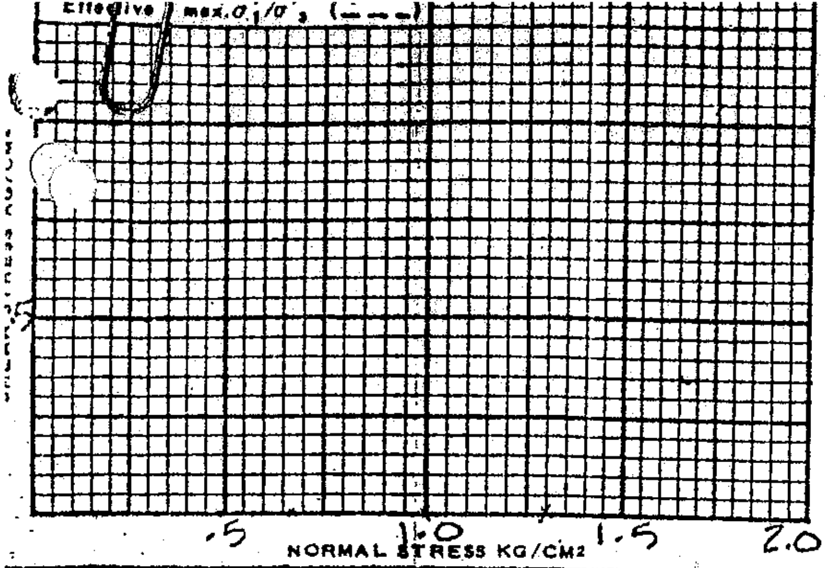


Mechanical Analysis Diagram

Classification					Gs	
Specimen		●	▲	■	♦
Laboratory No. 85-198		C	D	E	
Initial	Water Content, W_o %	32.1	27.4	25.2	
	Dry Density, p.c.f.	89.9	97.8	100.5	
	Void Ratio, e_o				
	Saturation, S_o, %				
	Specimen Diameter, cm.	7.35	7.35	7.35	
	Specimen Height, cm.	14.95	15.15	15.15	
Normal Pressure, kg/cm²		.5	1.0	1.5	
Before Test	Time, days	13	13	13	
	Change in Volume, %	5.55	1.99	4.80	
	Dry Density, p.c.f.	95.2	99.8	105.6	
	Void Ratio, e				
	Saturation, $B = \frac{\Delta u}{\Delta \sigma}$	.95	.96	.97	
	Back Pressure, kg/cm²	6.0	6.5	5.0	
Failure	Void Ratio, ef				
	Saturation, Sf, %				
Time to Max. dev., min.		397	365	386	
Time to Max. (σ'_1/σ'_3)					
TESTED SPECIMEN					

Project MONTEZUMA SLOUGH			
Feature CONTROL STRUCTURE			
Hole No. CS-4		Field Sample No. S-3	
Type of sample 3" SHELBY		Depth 31½-33½	
ϕ'	tan ϕ'	c	kg/cm²
ϕ= 20°	tan ϕ .364	c= 0	kg/cm²
Date of Report 5-7-85	Drawn R.T.	Checked	
Request No. 85-7	Lab. Sample No. 85-198 C, D, E		

VR 728 (REV. 6/68)

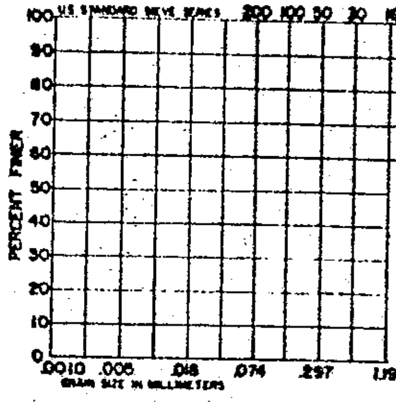


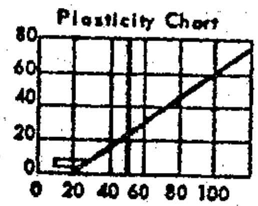
SHEARING STRENGTH SUMMARY SHEET

TYPE OF TEST CUE

Saturated Consolidated Undrained — Strain Controlled .003 in/min.

Remarks MEMBRANE AND PISTON FRICTION correction NOT INCLUDED, Sample 85-350 B, possible crack before test, some shrinkage

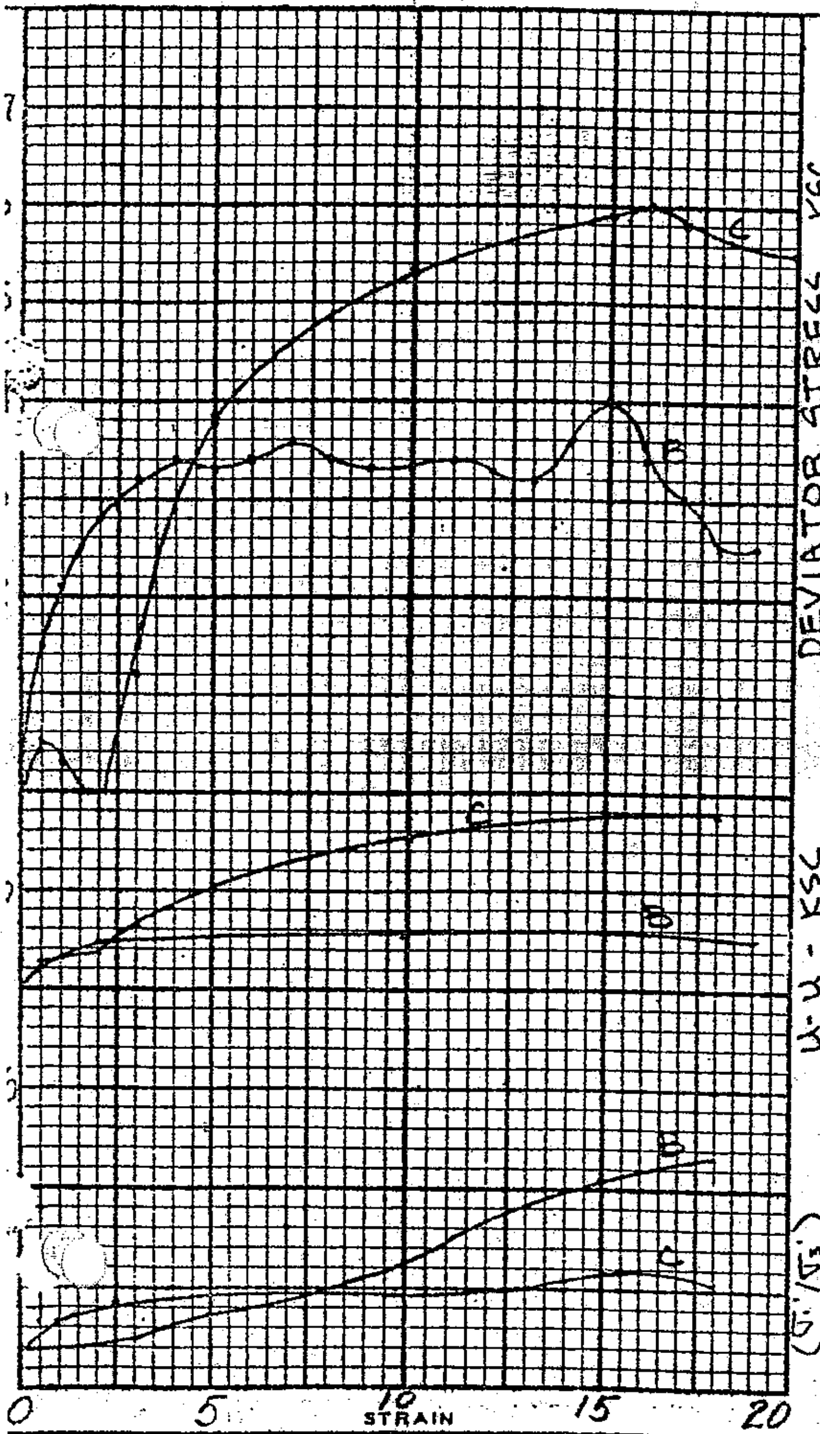




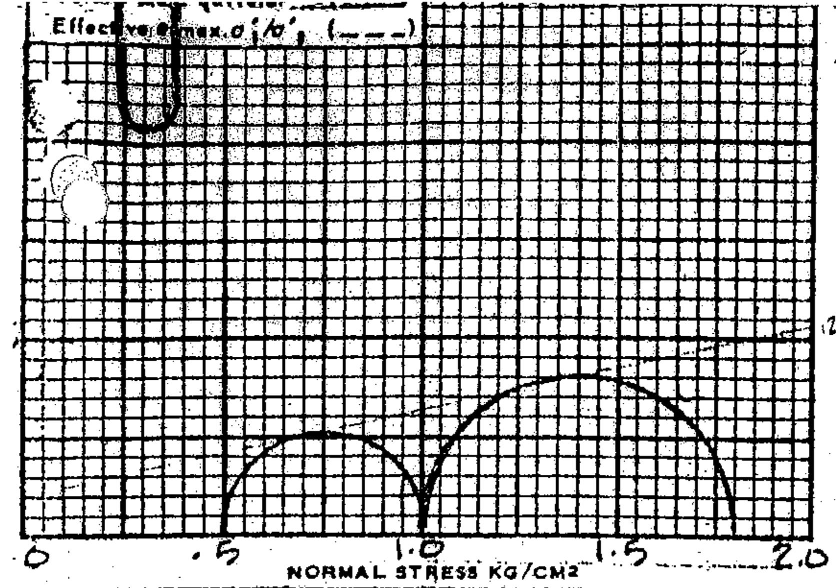
Mechanical Analysis Diagram

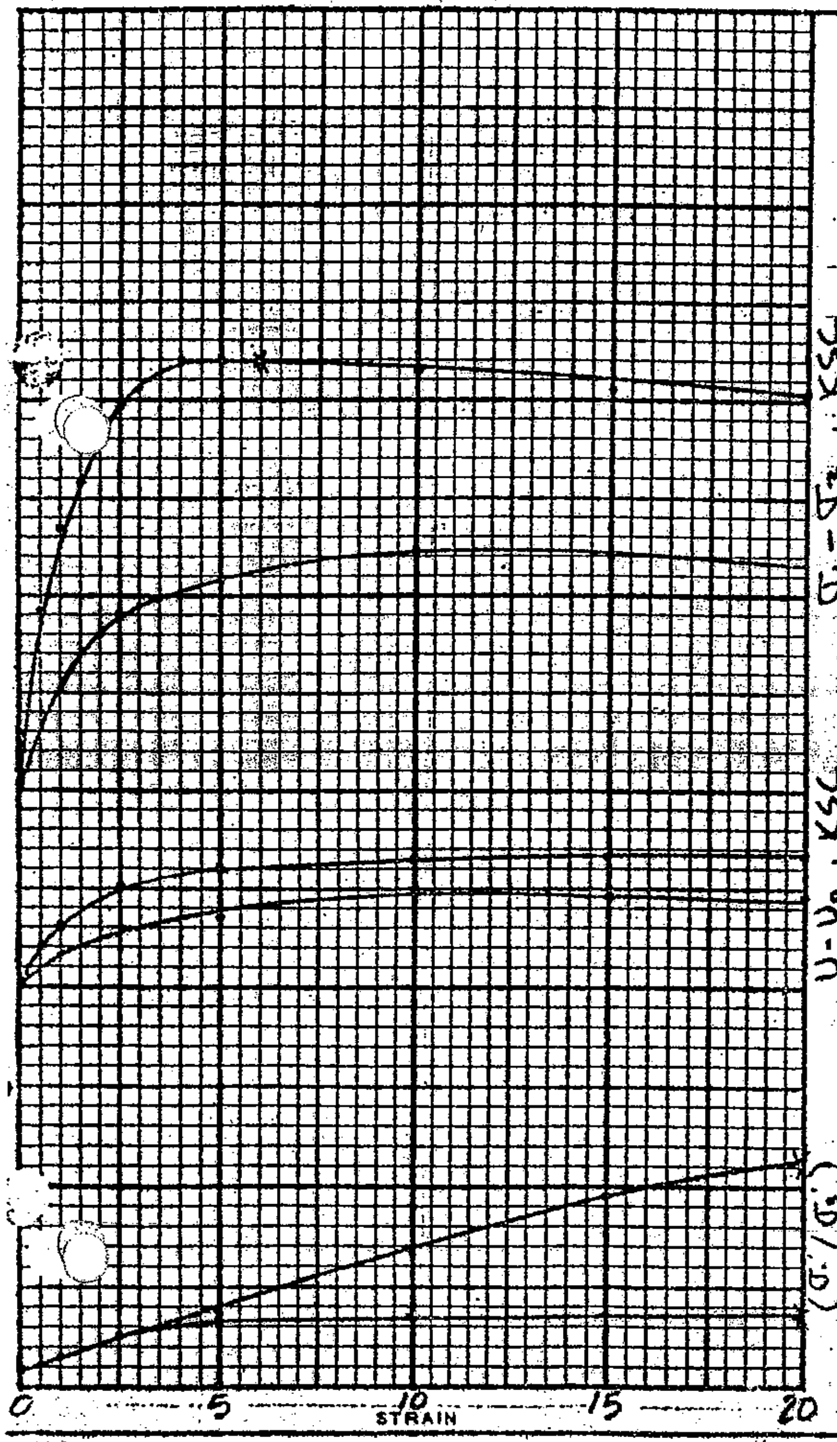
Classification					Gs
Specimen					
Laboratory No. 85-350		B	C	D	
Initial	Water Content, W_o %	318.2	314.4	EQUIPMENT MALFUNCTION	
	Dry Density, p.c.f.	16.5	16.6		
	Void Ratio, e_o				
	Saturation, S_o, %				
	Specimen Diameter, cm.	7.26	7.30		
	Specimen Height, cm.	16.1	16.2		
Normal Pressure, kg/cm2		.5	1.0		
Before Test	Time, days	20	20		
	Change in Volume, %	6.3	29.6		
	Dry Density, p.c.f.	15.5	23.5		
	Void Ratio, e				
	Saturation, $B = \frac{\Delta u}{\Delta \sigma_3}$	.96	.97		
	Back Pressure, kg/cm2	5.5	5.0		
Failure	Void Ratio, ef				
	Saturation, Sf, %				
Time to Max. dev., min.		93	332		
Time to Max. (σ'_1/σ'_3)		151	372		
TESTED SPECIMEN		70°	70°		

Project MONTEZUMA SLOUGH			
Feature CONTROL STRUCTURE			
Hole No. CS-11		Field Sample No. S-3	
Type of sample UNDISTURB		Depth 16.0 - 18.0	
φ'	tan φ'	c	kg/cm2
φx	tan φ	cx	kg/cm2
Date of Report 8/9/85	Drawn R.T.	Checked	
Request No. 85-17	Lab. Sample No. 85-350 B,C,D		



1726 (REV. 6/68)



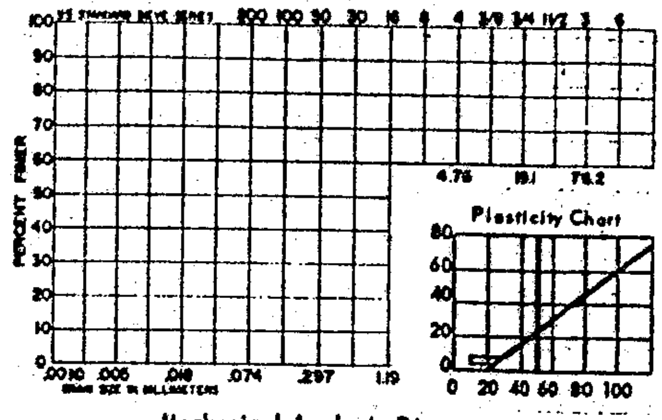


SHEARING STRENGTH SUMMARY SHEET

TYPE OF TEST CUE

Saturated Consolidated Undrained — Strain Controlled .003 in/min.; Stress

Remarks: SAMPLE D - Bottom 1/2 of sample considerable drier and more brittle. No membrane correction used in calcs.



Mechanical Analysis Diagram

Classification			Gs	
Specimen				
Laboratory No. 85-384		C	D	
Initial — Water Content, W_o %		220.1	83.9	
Initial — Dry Density, p.c.f.		23.6	51.6	
Initial — Void Ratio, e_o				
Initial — Saturation, S_o, %				
Initial — Specimen Diameter, cm.		7.25	7.31	
Initial — Specimen Height, cm.		16.85	16.50	
Normal Pressure, kg/cm²		.5	1.0	
Before Test — Time, days		30	30	
Before Test — Change in Volume, %		22.0	20.8	
Before Test — Dry Density, p.c.f.				
Before Test — Void Ratio, e				
Before Test — Saturation, $B = \frac{\Delta u}{\Delta \sigma_3}$		.96	.95	
Before Test — Back Pressure, kg/cm²		4.0	4.0	
Failure — Void Ratio, ef				
Failure — Saturation, Sf, %				
Time to Max. dev., min.		224	130	
Time to Max. (σ'_1/σ'_3)		425	422	
TESTED SPECIMEN				

Project MONTEZUMA SLOUGH

Feature CONTROL STRUCTURE

Hole No. MSR-18 — Field Sample No. S-2

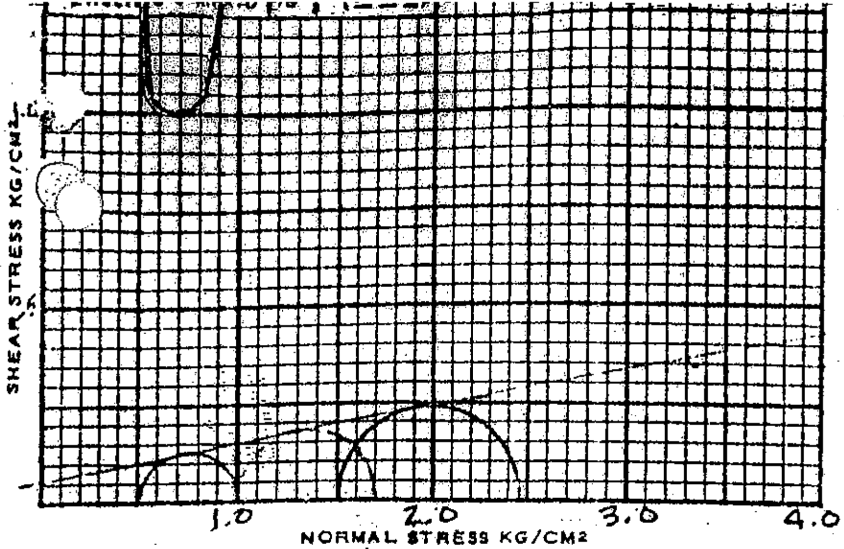
Type of sample UNDISTURBED — Depth 10' - 12'

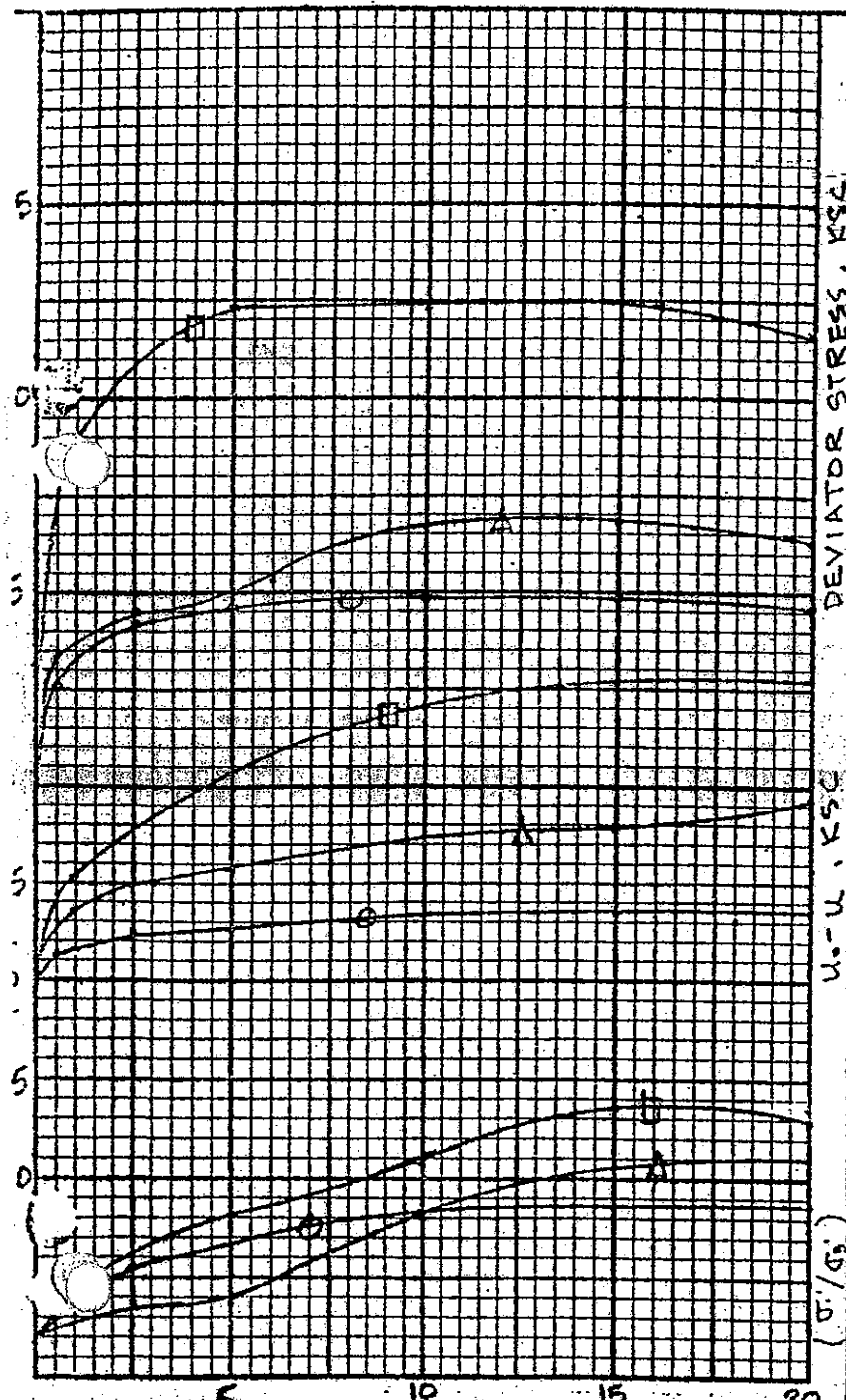
φ'	tan φ'	c	kg/cm²
φu	tan φ	cu	kg/cm²

Date of Report 8-17-85 — Drawn R.T. — Checked

Request No. 85-17 — Lab. Sample No. 85-384 C,D

7-226 (REV. 6/68)



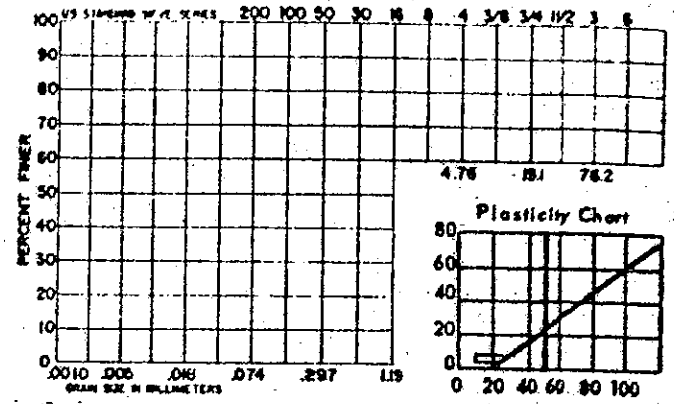


SHEARING STRENGTH SUMMARY SHEET

TYPE OF TEST CUE

Saturated Consolidated Undrained — Strain Stress Controlled .003 in/min.

Remarks CLAYEY PEAT



Mechanical Analysis Diagram

Classification			Gs	
Specimen	●	▲	■	♦
Laboratory No. 85-346	B	C	D	
Initial — Water Content, W_o %	103.7	96.4	92.0	
Initial — Dry Density, p.c.f.	42.4	44.9	46.7	
Initial — Void Ratio, e_o				
Initial — Saturation, S_o, %				
Initial — Specimen Diameter, cm.	7.26	7.29	7.29	
Initial — Specimen Height, cm.	15.25	15.70	15.90	
Normal Pressure, kg/cm2	.5	1.0	1.50	
Before Test — Time, days				
Before Test — Change in Volume, %	15.59	31.54	20.5	
Before Test — Dry Density, p.c.f.	50.2	65.6	58.8	
Before Test — Void Ratio, e				
Before Test — Saturation, B = $\frac{\Delta u}{\Delta \sigma}$	.96	.99	.99	
Before Test — Back Pressure, kg/cm2	4.00	4.00	4.5	
Failure — Void Ratio, ef				
Failure — Saturation, Sf, %				
Time to Max. dev., min.				
Time to Max. (σ'_1/σ'_3)				
TESTED SPECIMEN				

Project MONTEZUMA SLOUGH

Feature CONTROL STRUCTURE

Hole No. CS-10 | Field Sample No. S-2

Type of sample UNDISTURBED | Depth 10°-12°

ϕ'	tan ϕ'	c	kg/cm²
ϕ	tan ϕ	c	kg/cm²

Date of Report 6-17-85 | Drawn R.T. | Checked

Request No. 85-17 | Lab. Sample No. 85-346 B,C,D

R 724 (REV. 6/66)

DEPARTMENT OF WATER RESOURCES — LABORATORIES BRANCH — SOILS LABORATORY

SHEARING STRENGTH SUMMARY SHEET

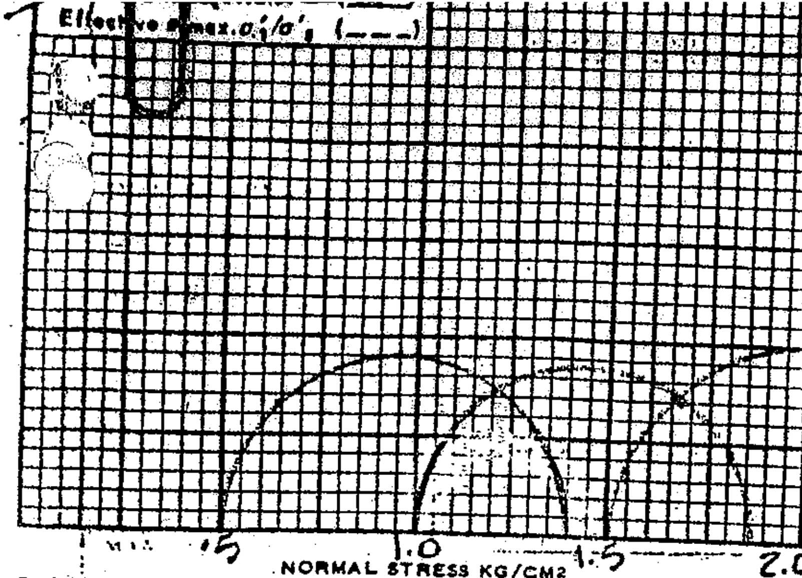
TYPE OF TEST CUE

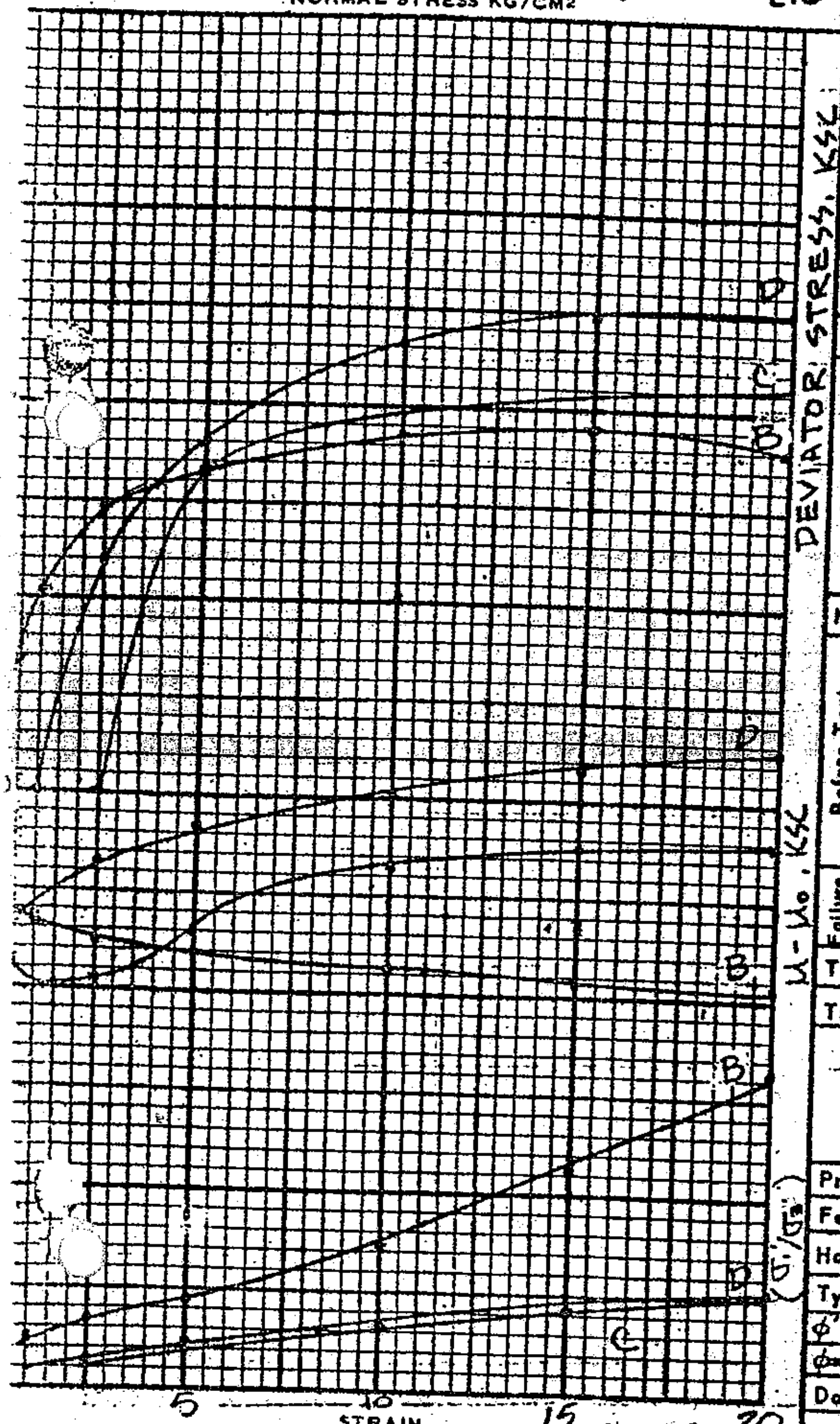
Saturated Consolidated Undrained — Strain / Stress Controlled .003 in/min.

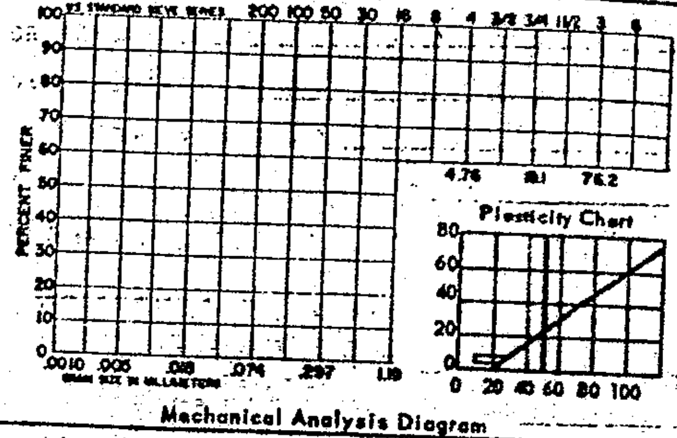
Remarks HIGHLY ORGANIC

TESTED BY

SPECIFIC GRAVITY







Classification				
Specimen	●	▲	■	♦
Laboratory No. 85-321	B	C	D	
Initial — Water Content, Wo %	250.2	261.4	213.2	
Dry Density, p.c.f.	20.6	19.8	23.8	
Void Ratio, eo				
Saturation, So, %				
Specimen Diameter, cm.	7.31	7.29	7.29	
Specimen Height, cm.	14.50	16.20	16.15	
Normal Pressure, kg/cm²	.5	1.0	1.5	
Before Test — Time, days	20	11	11	
Change in Volume, %	26.5	23.1	21.6	
Dry Density, p.c.f.	28.0	25.8	30.4	
Void Ratio, e				
Saturation, B = Δu/Δσ₃	.98	.99	.97	
Back Pressure, kg/cm²	4.0	4.0	4.0	
Failure — Void Ratio, ef				
Saturation, Sf, %				
Time to Max. dev., min.	355	411	395	
Time to Max. (σ'₁/σ'₃)	355	411	395	
TESTED SPECIMEN				

Project MONTEZUMA SLOUGH

Feature CONTROL STRUCTURE

Hole No. CS-7 — Field Sample No. S-2

Type of sample UNDIST. — Depth 5'-7'

ϕ' — tan ϕ' — c' — kg/cm²

ϕ — tan ϕ — c — kg/cm²

Date of Report 8-21-85 — Drawn R.T. — Checked

Request No. 85-17 — Lab. Sample No. 85-321 B.C

NO. OF SAMPLES	SAMPLE AVERAGE	ST. DEV. OF SAMPLE	VARIANCE OF SAMPLE
[illegible]	9.833	8.183	66.97

Hole No.	Sample	Cons.	CUE	Kc	s3	MA	Gs	PI	Area
CS-4	S-2	1	2	1,1	.5,1.	2	3	2	1
CS-7	S-2	1	3	1,1,1	.5,1,1.5	3	3	1	1
CS-10	S-2	1	3	1,1,1	.5,1,1.5	3	2	3	1
CS-11	S-3	1	2	1,1	.5,1.	3	1	3	1
MSR-18	S-2	1	2	1,1	.5,1.	4	1	2	1
		5	12			15	10	11	
CS-4	S-3	0	3	1,1,1	.5,1,1.5	3	3	1	2
CS-5	S-3	0	3	1,1,1	.5,1,1.5	3	3	1	2
CS-3	S-1	1	0	---	---	1	1	0	2
CS-7	S-4	0	1	1	1.0	3	2	2	2
CS-10	S-3	0	3	1,1,1	.5,1,1.5	3	3	0	2
		1	10			13	12	4	
CS-1	S-4	0	3	1,1,1	.5,1,1.5	4	3	4	3
CS-2	S-2	0	3	1,1,1	.5,1,1.5	3	2	3	3
		0	6			7	5	7	
CS-10	S-1	0	3	1,1,1	.5,1,1.5	3	3	3	4
CS-7	S-1	0	3	1,1,1	.5,1,1.5	3	3	3	4
		0	6			6	6	6	

1 -- Organic Layer - East Levee
2 -- Older Alluvium - Underlying East and West Levees
3 -- "Bay Mud" Layer - West Levee/Roaring River Intake
4 -- Young Alluvium - Underlying East and West Levees

Triaxial Compression Test Summary

			Total[a]					Effective[b]					
Lab. No.	Hole No.	F.S. No.	S_3 kg/cm²	S_d kg/cm²	S_1 kg/cm²	P kg/cm²	Q kg/cm²	S_3 kg/cm²	S_d kg/cm²	S_1 kg/cm²	P' kg/cm²	Q kg/cm²	
7C	CS-4	S-2	0.50	0.75	1.25	0.88	0.38	0.10	0.62	0.72	0.41	0.31	1
D			1.00	0.94	1.94	1.47	0.47	0.45	0.74	1.19	0.82	0.37	
321B	CS-7	S-2	0.50	0.70	1.20	0.85	0.35	0.30	0.64	0.94	0.62	0.32	
C			1.00	0.77	1.77	1.39	0.39	0.70	0.64	1.34	1.02	0.32	
D			1.50	0.94	2.44	1.97	0.47	0.70	0.70	1.40	1.05	0.35	
346B	CS-10	S-2	0.50	0.45	0.95	0.73	0.23	0.22	0.44	0.66	0.44	0.22	
C			1.00	0.65	1.65	1.33	0.33	0.41	0.49	0.90	0.66	0.25	
D			1.50	1.21	2.71	2.11	0.61	0.42	1.21	1.63	1.03	0.61	
350B	CS-11	S-3	0.50	0.36	0.86	0.68	0.18	0.25	0.31	0.56	0.41	0.16	
C			1.00	0.53	1.53	1.27	0.27	0.49	0.36	0.85	0.67	0.18	
384C	MSR-18	S-2	0.50	0.45	0.95	0.73	0.23	0.14	0.41	0.55	0.35	0.21	
D			1.00	0.86	1.86	1.43	0.43	0.40	0.86	1.26	0.83	0.43	
198C	CS-4	S-3	0.50	0.51	1.01	0.78	0.26	0.17	0.48	0.65	0.41	0.24	2
D			1.00	1.01	2.01	1.51	0.51	0.93	0.95	1.88	1.41	0.48	
E			1.50	2.24	3.74	2.62	1.12	0.63	1.85	2.48	1.56	0.93	
202C	CS-5	S-3	0.50	8.04	8.54	4.52	4.02	0.20	2.37	2.57	1.39	1.19	
D			1.00	7.64	8.64	4.82	3.82	1.20	4.00	5.20	3.20	2.00	
E			1.50	10.0	11.5	6.50	5.00	1.70	5.90	7.60	4.65	2.95	
324D	CS-7	S-4	1.00	2.94	3.94	2.47	1.47	0.70	1.70	2.40	1.55	0.85	
347C	CS-10	S-3	0.50	0.94	1.44	0.97	0.47	0.20	0.78	0.98	0.59	0.39	
D			1.00	1.54	2.54	1.77	0.77	0.41	1.19	1.60	1.01	0.60	
E			1.50	2.04	3.54	2.52	1.02	0.64	1.62	2.26	1.45	0.81	
262C	CS-1	S-4	1.50	0.73	2.23	1.87	0.37	0.78	0.68	1.46	1.12	0.34	3
D			1.00	0.68	1.68	1.34	0.34	0.39	0.61	1.00	0.70	0.31	
E			0.50	0.79	1.29	0.90	0.40	0.20	0.73	0.93	0.57	0.37	
264C	CS-2	S-2	1.50	0.98	2.48	1.99	0.49	0.52	0.98	1.50	1.01	0.49	
D			1.00	0.72	1.72	1.36	0.36	0.28	0.74	1.02	0.65	0.37	
E			0.50	0.40	0.90	0.70	0.20	0.11	0.42	0.53	0.32	0.21	
345C	CS-10	S-1	0.50	0.37	0.87	0.69	0.49	0.10	0.32	0.42	0.26	0.16	4
D			1.00	0.74	1.74	1.37	0.37	0.33	0.75	1.08	0.71	0.38	
E			1.50	1.60	3.10	2.30	0.80	0.53	1.56	2.09	1.31	0.78	
320C	CS-7	S-1	0.50	0.74	1.24	0.87	0.37	0.21	0.74	0.95	0.58	0.37	
D			1.00	0.71	1.71	1.36	0.36	0.30	0.67	0.97	0.64	0.34	
E			1.50	1.28	2.78	2.14	0.64	0.44	1.25	1.69	1.07	0.63	

a -- Failure Criterion: Higher of peak strength or 15%

b -- Failure Criterion: deviator stress taken at max. obliquity ratio or 5%

Area 1 -- Organic Layer
Area 2 -- Older Alluvium
Area 3 -- Bay Mud
Area 4 -- Young Alluvium

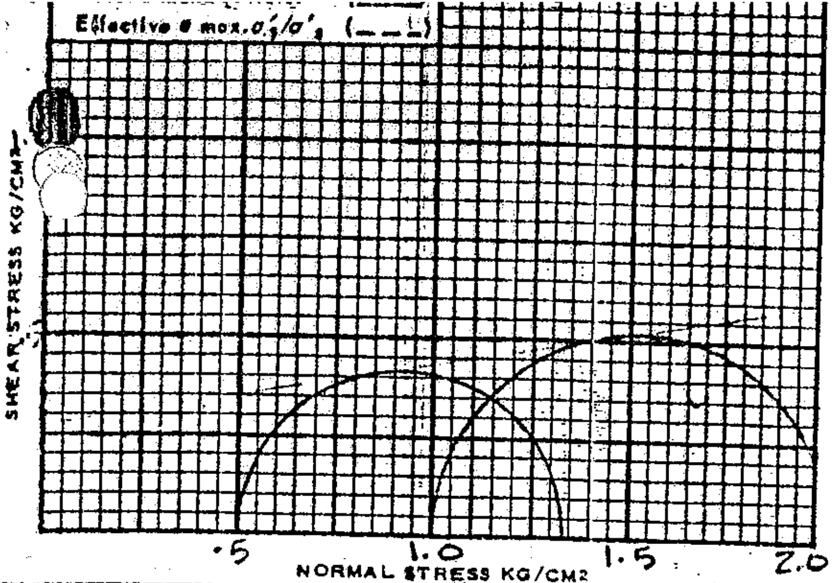
DEPARTMENT OF WATER RESOURCES — LABORATORIES BRANCH, SOILS LABORATORY

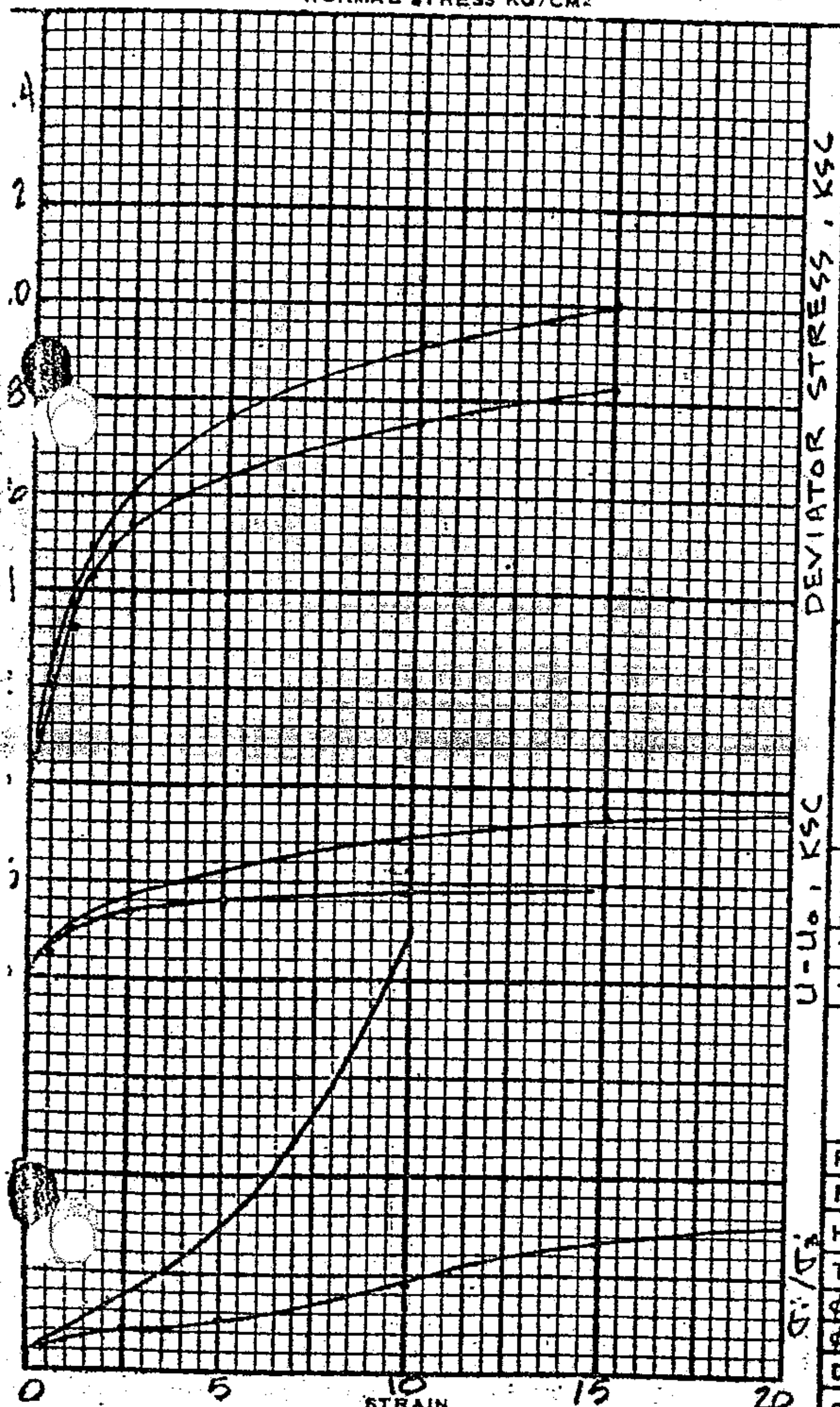
SHEARING STRENGTH SUMMARY SHEET

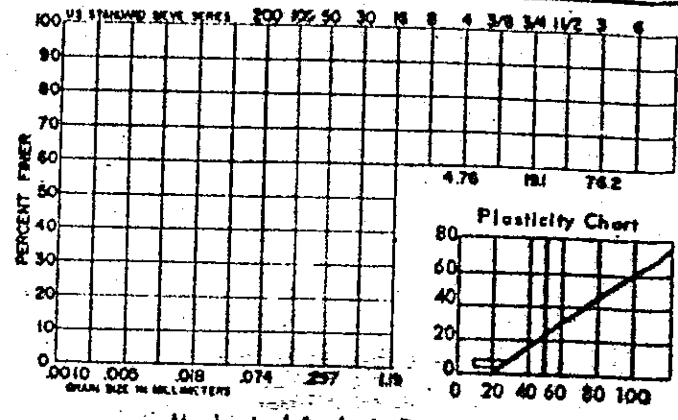
TYPE OF TEST CUB

Saturated Consolidated Undrained — Strain Controlled .063 in/min.

Remarks HIGHLY ORGANIC POSSIBLY PEAT







Classification				Gs	
Specimen		●	▲	■	◆
Laboratory No. 85-197		C	D		
Initial	Water Content, W_o %	34.1	59.6		
	Dry Density, p.c.f.	51.9	44.2		
	Void Ratio, e_o				
	Saturation, S_o, %				
	Specimen Diameter, cm.	7.28	7.28		
	Specimen Height, cm.	15.30	15.60		
Normal Pressure, kg/cm²		0.5	1.0		
Before Test	Time, days	12	12		
	Change in Volume, %	17.49	24.45		
	Dry Density, p.c.f.	62.9	58.4		
	Void Ratio, e				
	Saturation, $B = \frac{\Delta u}{\Delta \sigma}$	.896	.949		
	Back Pressure, kg/cm²	3.5	3.5		
Failure	Void Ratio, ef				
	Saturation, Sf, %				
Time to Max. dev., min.		511	301		
Time to Max. (σ'_1/σ'_3)					
TESTED SPECIMEN					

Project MONTEZUMA SLOUGH

Feature CONTROL STRUCTURE

Hole No. CS-4 — Field Sample No. S-2

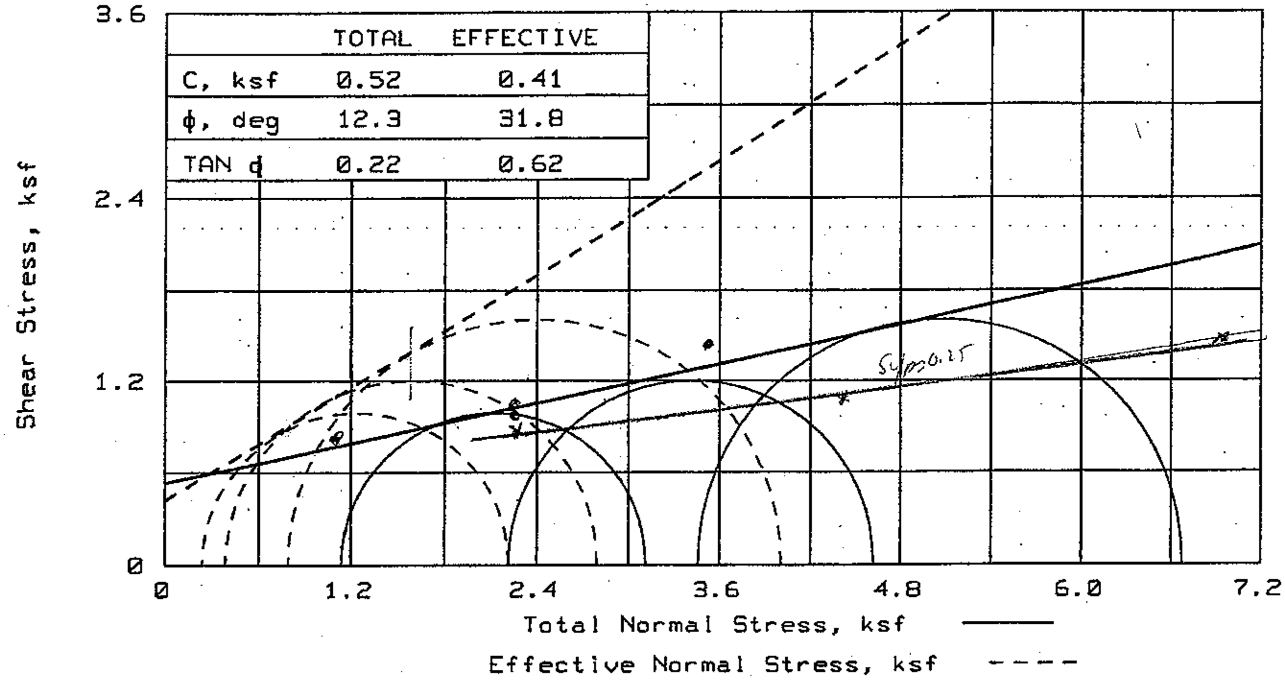
Type of sample 3" SHELBY — Depth 25⁰-27⁰

ø'	tan ø'	c	kg/cm²
øu	tan ø	cu	kg/cm²

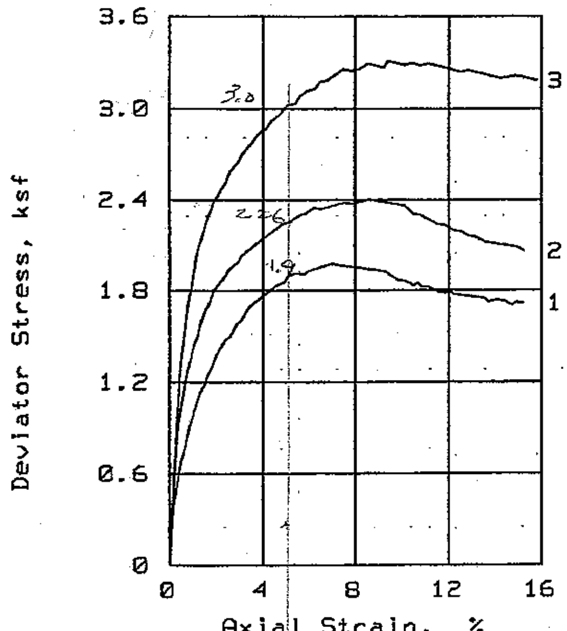
Date of Report 6-4-85 — Drawn R.T. — Checked

Request No. 85-7 — Lab. Sample No. 85-197 C, D

R 738 (REV. 6/68)



	TOTAL	EFFECTIVE
C, ksf	0.52	0.41
φ, deg	12.3	31.8
TAN φ	0.22	0.62



	SAMPLE NO.:	1	2	3
INITIAL	WATER CONTENT, %	87.1	99.8	83.7
	DRY DENSITY, pcf	47.2	44.3	50.8
	SATURATION, %	91.4	96.0	97.9
	VOID RATIO	2.572	2.807	2.310
	DIAMETER, in	2.85	2.85	2.85
	HEIGHT, in	6.00	6.00	6.00
AT TEST	WATER CONTENT, %	82.5	85.7	65.0
	DRY DENSITY, pcf	52.2	50.8	61.2
	SATURATION, %	100.0	100.0	100.0
	VOID RATIO	2.228	2.314	1.754
	DIAMETER, in	2.73	2.69	2.65
	HEIGHT, in	5.91	5.83	5.75
	Strain rate, %/min	0.02	0.02	0.02
	EFF CELL PRESSURE, ksf	1.14	2.22	3.46
	Deviator Stress, ksf	1.97	2.40	3.22
	EXCESS PORE PR., ksf	0.89	1.83	2.66
	STRAIN, %	7.0	8.6	15.0
	, ksf			
	EXCESS PORE PR., ksf			
	STRAIN, %			
	$\bar{\sigma}_1$ FAILURE, ksf	2.22	2.79	4.01
	$\bar{\sigma}_3$ FAILURE, ksf	0.24	0.39	0.79

TYPE OF TEST:
CU with Pore Pressures

SAMPLE TYPE: undisturbed

DESCRIPTION: Drk-Brn Silty CLAY

ASSUMED SPECIFIC GRAVITY= 2.7

REMARKS:

Fig. No.: ______

CLIENT: Hultgren-Tillis

PROJECT: 494.04

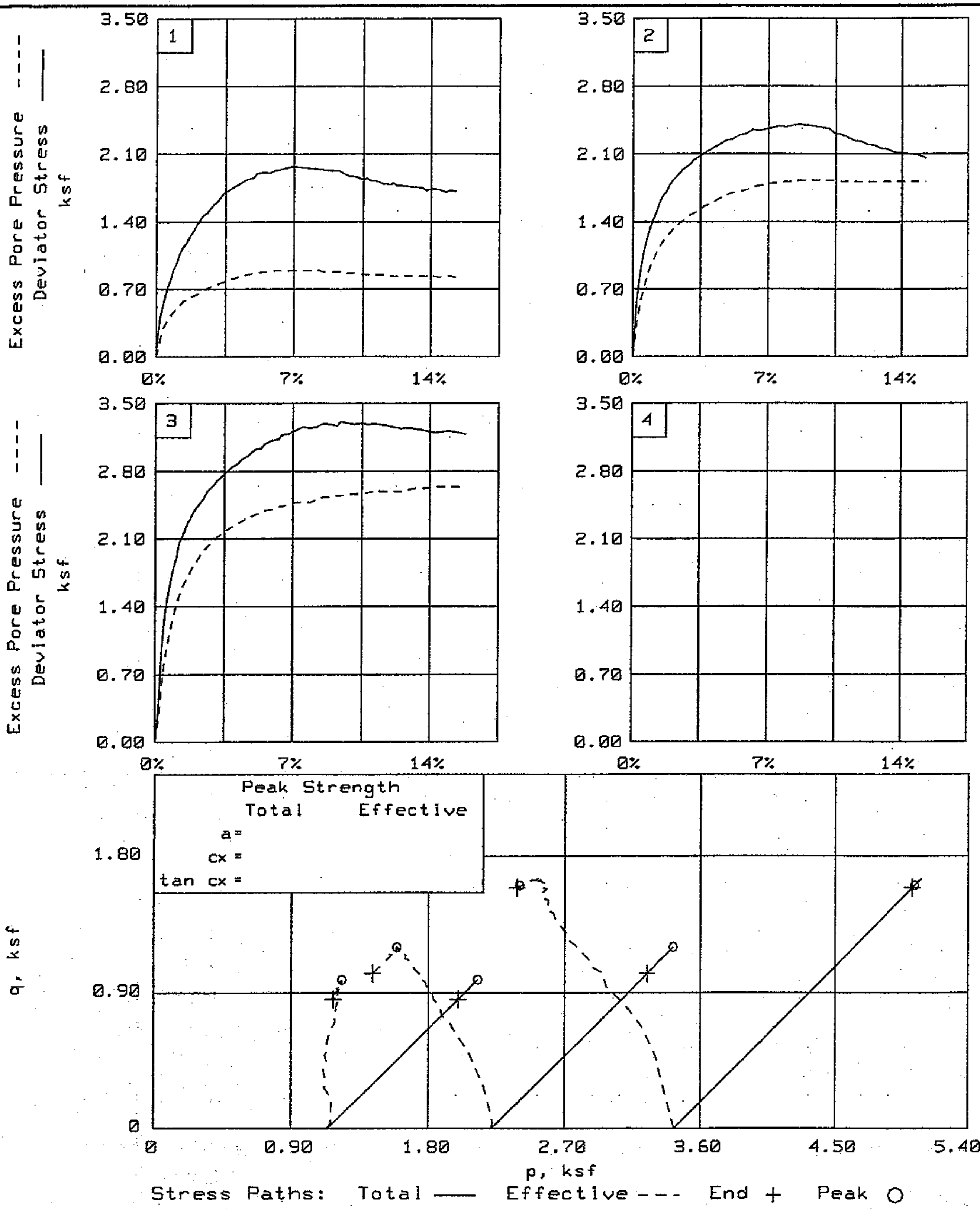
SAMPLE LOCATION: B2 @ 18'

Silt

PROJ. NO.: 212-012d DATE: 4/10/02

TRIAXIAL SHEAR TEST REPORT

COOPER TESTING LABORATORY

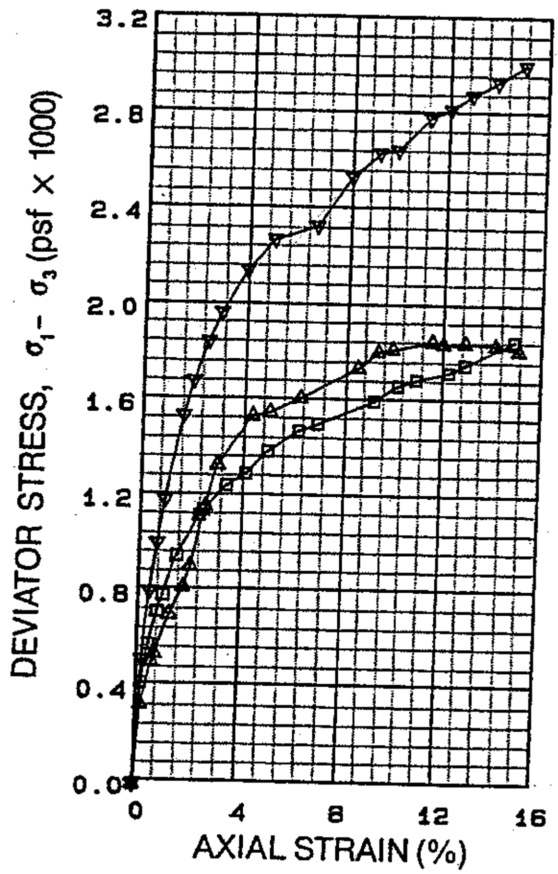


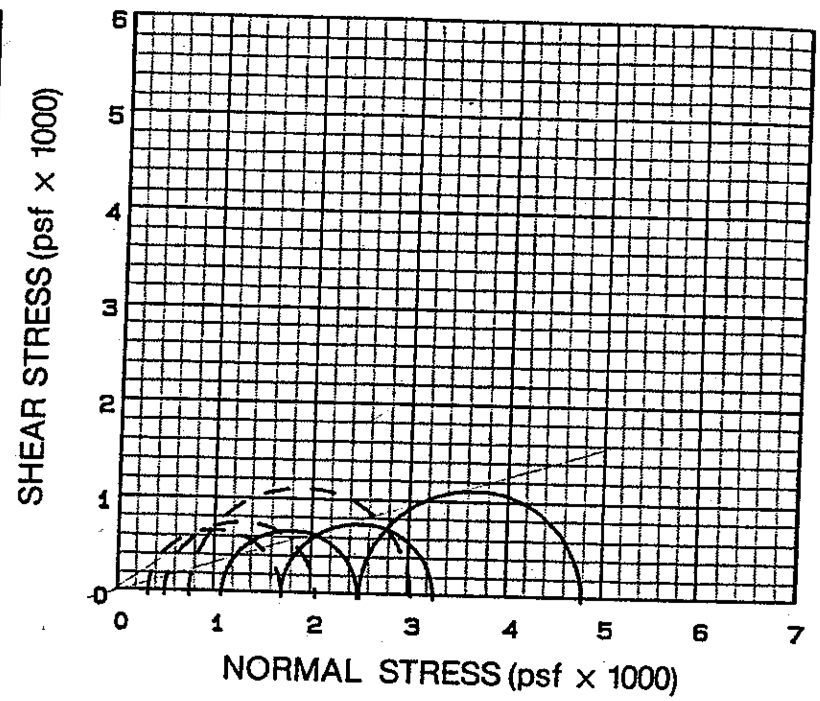
Client: Hultgren-Tillis

Project: 494.04

Location: B2 @ 18'

File: 212-012D Project No.: 212-012d Fig. No.: ____





TEST TYPE: CONSOLIDATED UNDRAINED

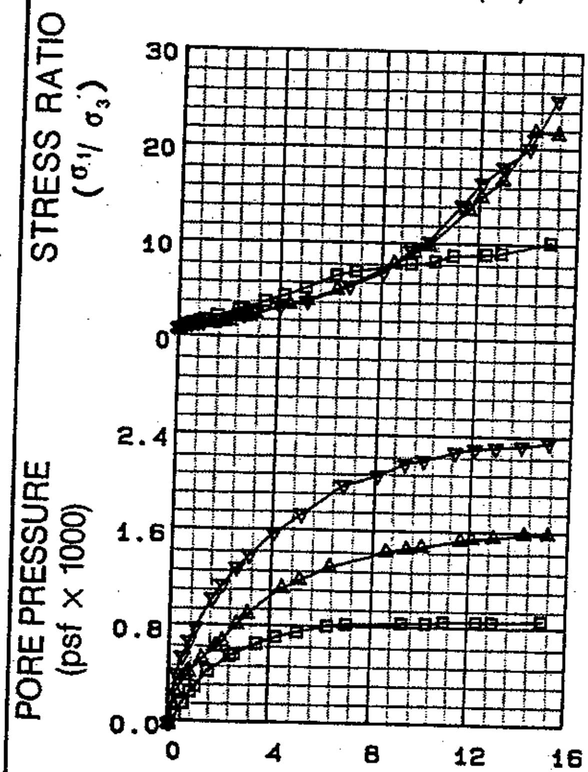
Controlled STRAIN

PHYSICAL CONDITIONS		TEST NO. A ▫	B ▲	C ▼
INITIAL	Diameter (in.)	2.87	2.87	2.87
	Height (in.)	6.50	6.50	6.50
	Water Content (%)	199.0	196.4	348.1
	Void Ratio	3.402	3.359	6.383
	Saturation (%)	100.0	100.0	93.2
	Dry Density (pcf)	24.2	24.5	14.5
BEFORE	Consolidation Pressure (psf)	1090	1701	2500
	Backpressure (psf)	9360	9360	9360
	Water Content (%)	202.7	202.1	357.8
	Void Ratio	3.467	3.455	6.119
FINAL	Water Content (%)	185.9	168.3	255.1
	Dry Density (pcf)	25.5	27.5	19.9
	Void Ratio	3.179	2.877	4.362
	Saturation (%)	100.0	100.0	100.0
FAILURE	σ_1 Major Principal Stress (psf)	1707	2051	3025
	σ_3 Minor Principal Stress (psf)	312	491	743
	Pore Pressure (psf)	778	1210	1757
	Axial Strain at Failure (%)	5.0	5.1	5.1
	Time to Failure (min.)	522	694	600

Sample Source: BA-5-6 @ 25.0

Classification:

1.71



Harding Lawson Associates
Engineers, Geologists
& Geophysicists

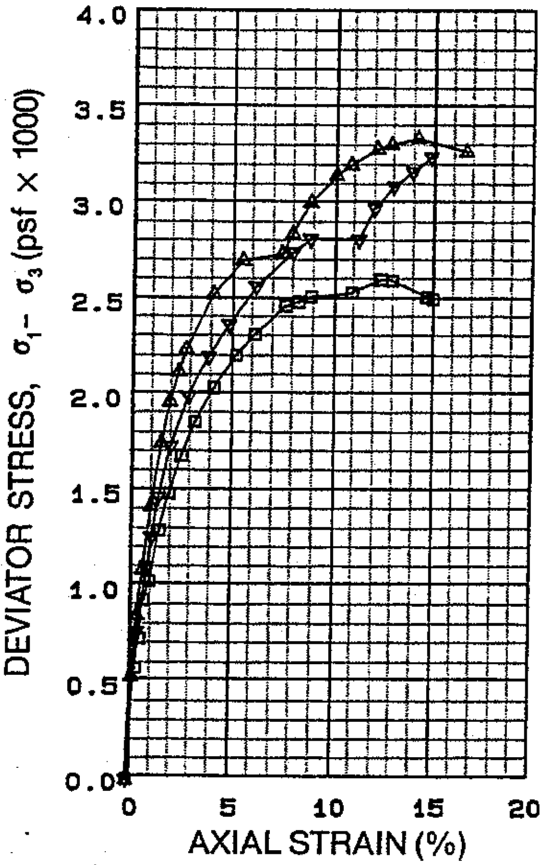
Triaxial Compression Test

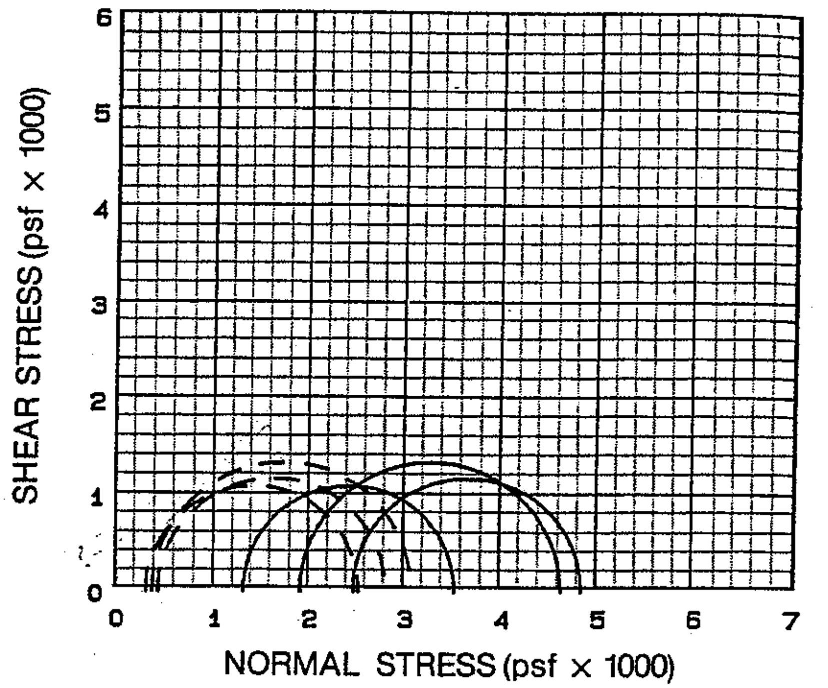
Bacon Island
San Joaquin County, California

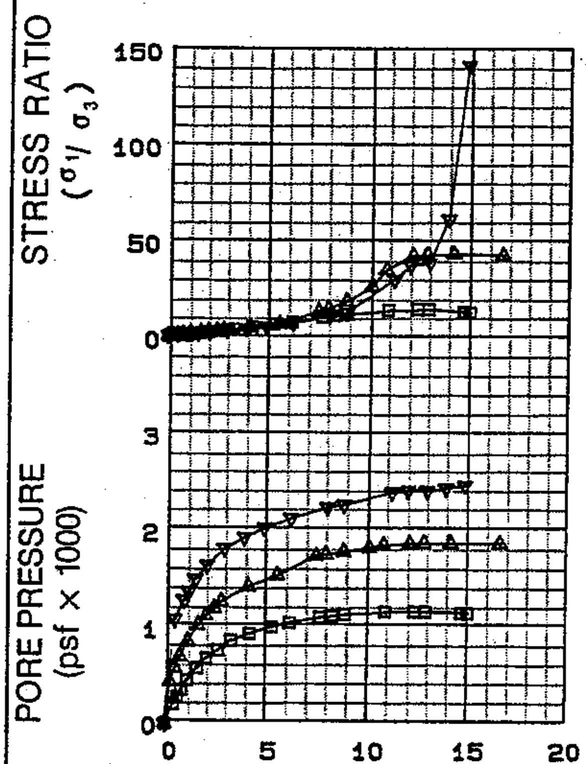
PLATE

B-102

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
	18749.001.03	SWH	08-08-1988		







TEST TYPE: CONSOLIDATED UNDRAINED   Controlled STRAIN

	PHYSICAL CONDITIONS	TEST NO. A ⊡	TEST NO. B ▲	TEST NO. C ▼
INITIAL	Diameter (in.)	2.87	2.87	2.87
	Height (in.)	6.50	6.50	6.50
	Water Content (%)	395.3	306.2	415.1
	Void Ratio	8.128	6.364	8.134
	Saturation (%)	88.5	87.6	92.9
	Dry Density (pcf)	12.4	15.4	12.4
BEFORE	Consolidation Pressure (psf)	1351	1950	2500
	Backpressure (psf)	7920	7920	7920
	Water Content (%)	443.4	336.5	433.9
	Void Ratio	8.071	6.124	7.898
FINAL	Water Content (%)	369.2	265.4	286.1
	Dry Density (pcf)	14.7	19.5	18.3
	Void Ratio	6.720	4.831	5.207
	Saturation (%)	100.0	100.0	100.0
FAILURE	σ_1 Major Principal Stress (psf)	2559	3117	2845
	σ_3 Minor Principal Stress (psf)	343	409	469
	Pore Pressure (psf)	1008	1541	2030
	Axial Strain at Failure (%)	5.4	5.7	5.0
	Time to Failure (min.)	677	725	7163

Sample Source: WE-2 @ 20.0

Classification:

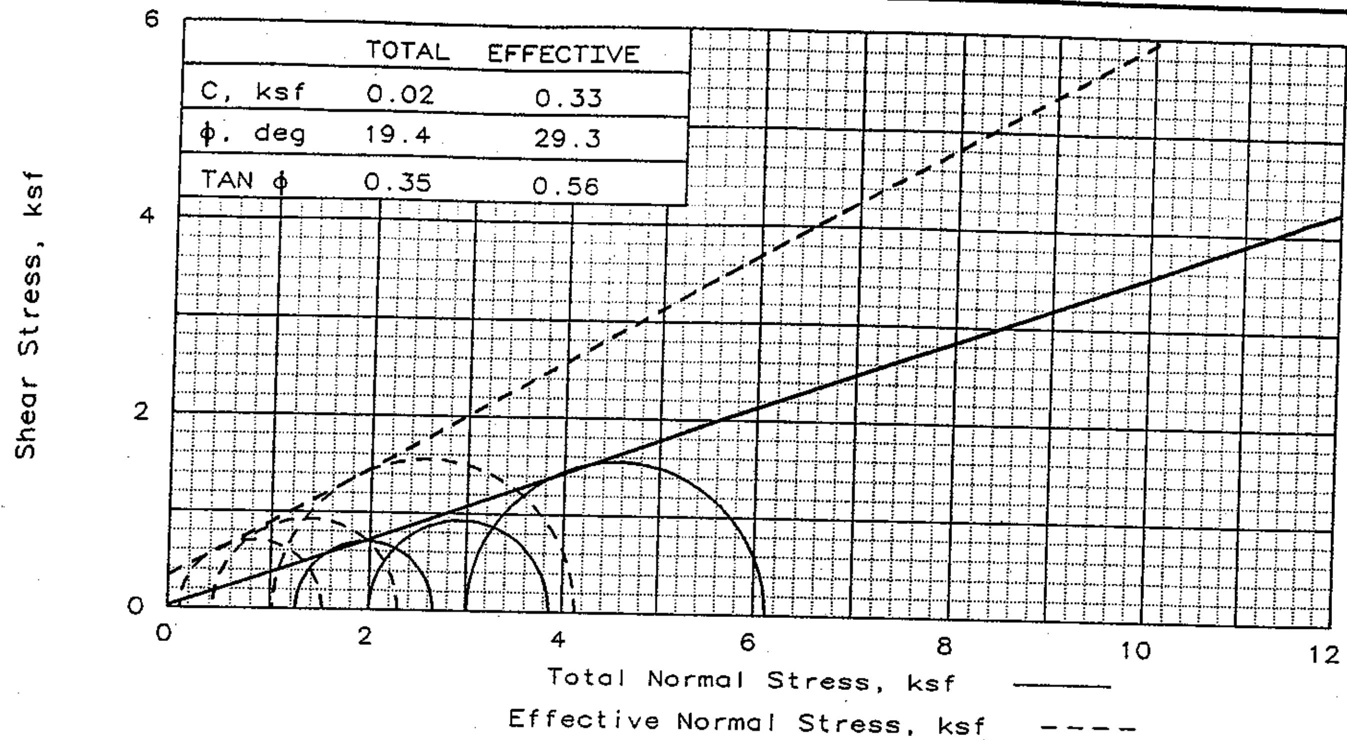
1.82

Harding Lawson Associates
Engineers, Geologists
& Geophysicists

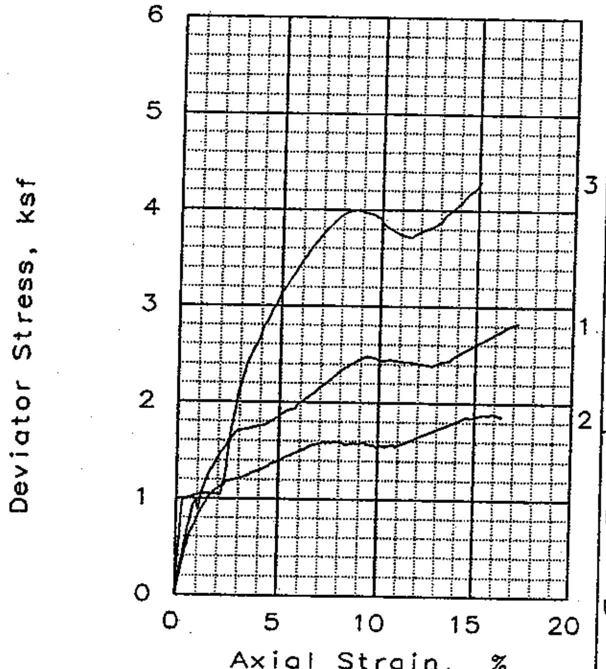
Triaxial Compression Test
Webb Tract
Contra Costa County, California

PLATE
B–108

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
	18149.001.03	SWH	09-01-1988		



	TOTAL	EFFECTIVE
C, ksf	0.02	0.33
ϕ, deg	19.4	29.3
TAN ϕ	0.35	0.56



SAMPLE NO.:		1	2	3
INITIAL	WATER CONTENT, %	277.1	291.1	304.9
	DRY DENSITY, pcf	17.3	16.4	16.0
	SATURATION, %	86.0	85.2	86.9
	VOID RATIO	8.379	8.887	9.125
	DIAMETER, in	2.86	2.86	2.86
	HEIGHT, in	6.00	6.00	6.00
AT TEST	WATER CONTENT, %	199.2	248.5	172.6
	DRY DENSITY, pcf	26.3	21.8	29.6
	SATURATION, %	100.0	100.0	100.0
	VOID RATIO	5.179	6.462	4.488
	DIAMETER, in	2.48	2.58	2.31
	HEIGHT, in	5.24	5.55	4.99
Strain rate, %/min			0.01	0.01
EFF CELL PRESSURE, ksf		2.00	1.25	3.01
Deviator Stress, ksf		1.86	1.41	3.11
EXCESS PORE PR., ksf		1.57	1.14	1.99
STRAIN, %		5.0	5.1	4.9
ULT. STRESS, ksf				
EXCESS PORE PR., ksf				
STRAIN, %				
$\bar{\sigma}_1$ FAILURE, ksf		2.29	1.52	4.13
$\bar{\sigma}_3$ FAILURE, ksf		0.43	0.12	1.02

TYPE OF TEST:
CU with Pore Pressures

SAMPLE TYPE: undisturbed

DESCRIPTION: Dark Grey, mottled Brown CLAY w/peat

ASSUMED SPECIFIC GRAVITY= 2.6

REMARKS: Strengths picked at 5% strain.

Fig. No.: ______

CLIENT: Hultgren-Tillis

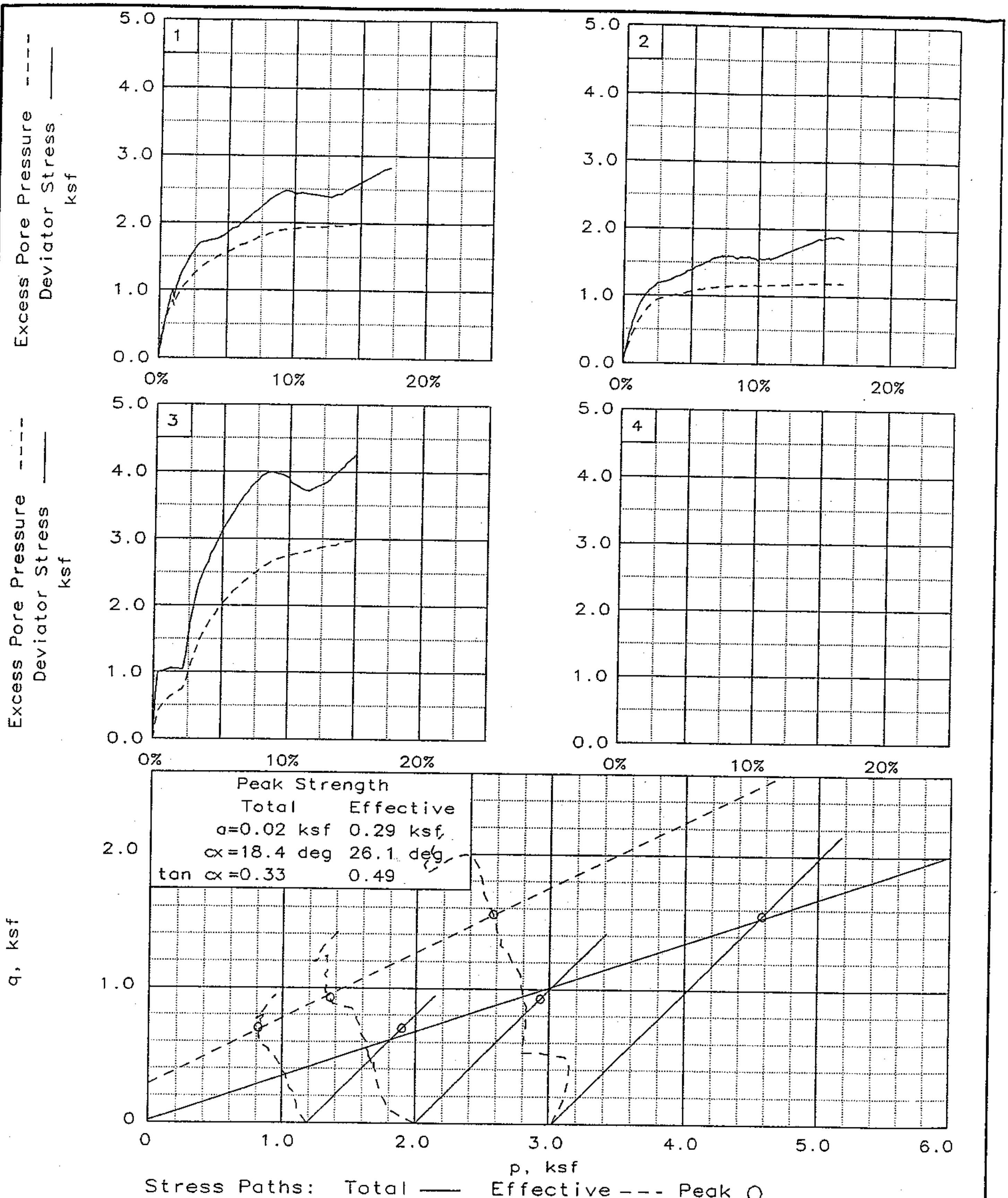
PROJECT: 113.07/Webb Tract

SAMPLE LOCATION: B-5 @ 16-19'

PROJ. NO.: 212-031   DATE: 8/16/00

TRIAXIAL SHEAR TEST REPORT

COOPER TESTING LABORATORY

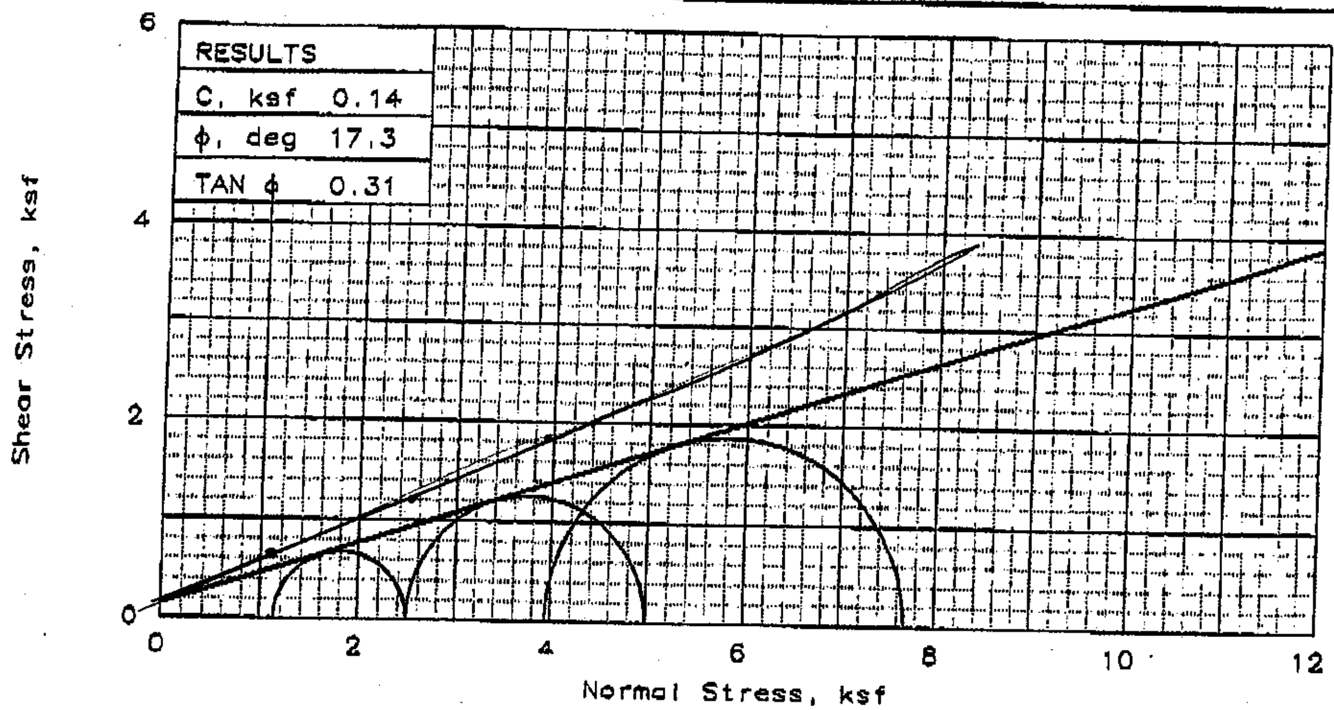


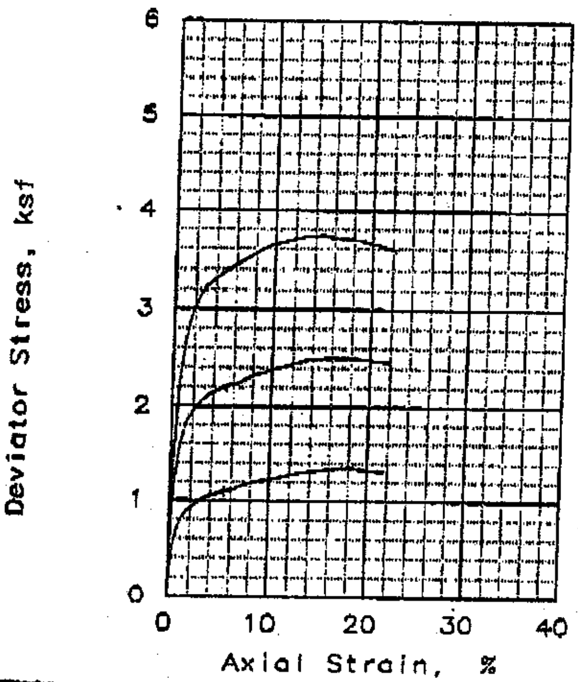
Client: Hultgren-Tillis

Project: 113.07/Webb Tract

Location: B-5 @ 16-19'

File: 212-031 Project No.: 212-031 Fig. No.: ____





	SAMPLE NO.:	1	2	3
INITIAL	WATER CONTENT, %	121.8	98.1	98.7
	DRY DENSITY, pcf	38.9	45.9	45.3
	SATURATION, %	99.8	99.8	99.4
	VOID RATIO	3.172	2.603	2.582
	DIAMETER, in	2.86	2.86	2.86
	HEIGHT, in	6.01	6.01	6.06
AT TEST	WATER CONTENT, %	75.9	63.4	59.0
	DRY DENSITY, pcf	54.6	61.7	64.0
	SATURATION, %	100.0	100.0	100.0
	VOID RATIO	1.973	1.680	1.534
	DIAMETER, in	2.52	2.59	2.56
	HEIGHT, in	5.54	5.44	5.35
	Strain rate, %/min	0.50	0.50	0.50
	BACK PRESSURE, ksf	4.90	5.05	5.10
	CELL PRESSURE, ksf	6.03	7.55	9.04
	Deviator Stress, ksf	1.35	2.50	3.74
	p. stress ratio, ksf			
	σ_1 FAILURE, ksf	2.49	4.99	7.68
	σ_3 FAILURE, ksf	1.14	2.49	3.95

TYPE OF TEST:
Consolidated Undrained

SAMPLE TYPE: undisturbed

DESCRIPTION: gray organic SILT

ASSUMED SPECIFIC GRAVITY= 2.6

REMARKS: Strengths taken at peak deviator stress.

CLIENT: Hultgren Geotechnical

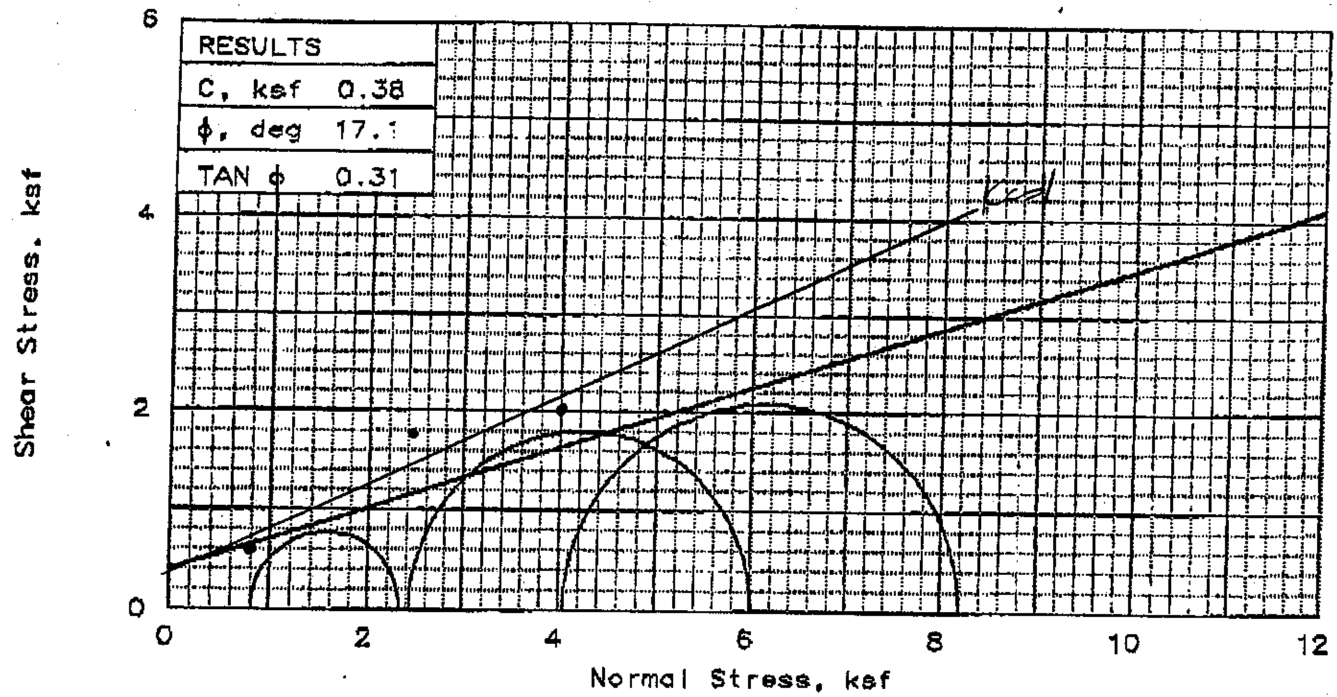
PROJECT: 156.05 Silt

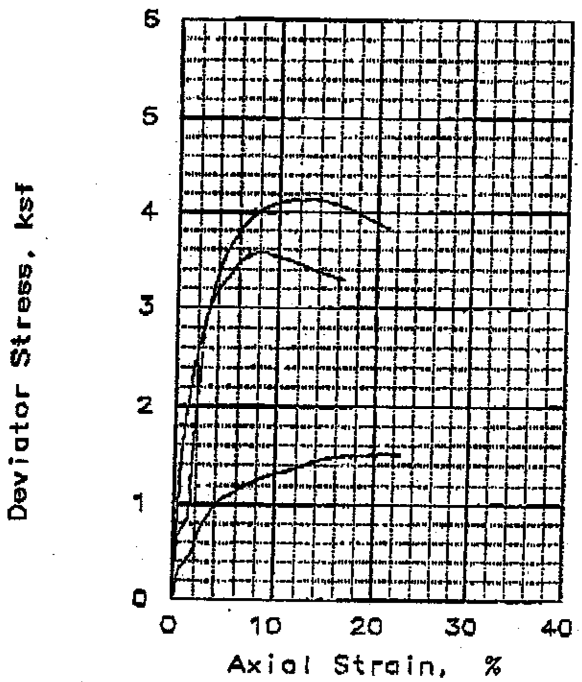
SAMPLE LOCATION: B-3 @ 8-10.5'

PROJ. NO.: 212-016c DATE: 7/8/96

TRIAXIAL SHEAR TEST REPORT

COOPER TESTING LABORATORY





SAMPLE NO.:		1	2	3
INITIAL	WATER CONTENT, %	590.4	160.7	121.9
	DRY DENSITY, pcf	8.8	27.4	35.0
	SATURATION, %	96.7	99.8	99.2
	VOID RATIO	6.167	2.415	2.212
	DIAMETER, in	2.86	2.86	2.86
	HEIGHT, in	6.06	6.06	6.06
AT TEST	WATER CONTENT, %	460.0	144.3	91.8
	DRY DENSITY, pcf	11.2	29.6	42.4
	SATURATION, %	100.0	100.0	100.0
	VOID RATIO	4.646	2.165	1.653
	DIAMETER, in	2.72	2.84	2.69
	HEIGHT, in	5.26	5.71	5.66
Strain rate, %/min		0.50	0.50	0.50
BACK PRESSURE, ksf		5.21	5.10	4.98
CELL PRESSURE, ksf		6.03	7.55	9.04
Deviator Stress, ksf		1.52	3.57	4.15
ASSUMED SPECIFIC GRAVITY		1.01	1.50	1.80
p. stress ratio, ksf				
σ_1 FAILURE, ksf		2.34	6.02	8.21
σ_3 FAILURE, ksf		0.82	2.45	4.06

TYPE OF TEST:
Consolidated Undrained

SAMPLE TYPE: undisturbed

DESCRIPTION: black PEAT

ASSUMED SPECIFIC GRAVITY

REMARKS: Strengths taken at the peak deviator stress.

CLIENT: Hultgren Geotechnical

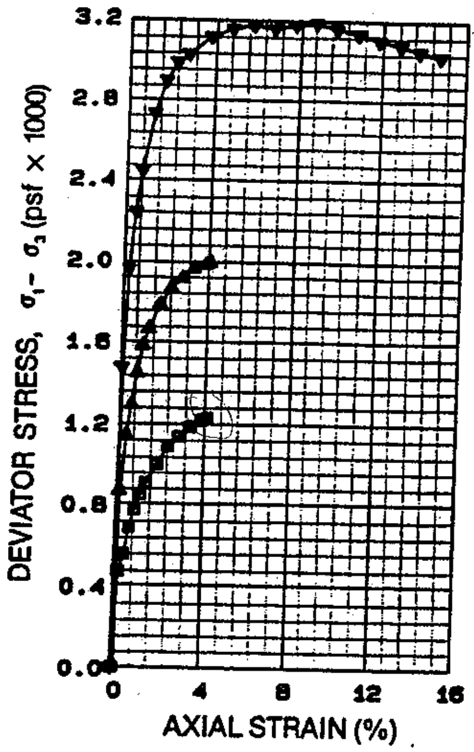
PROJECT: 156.05

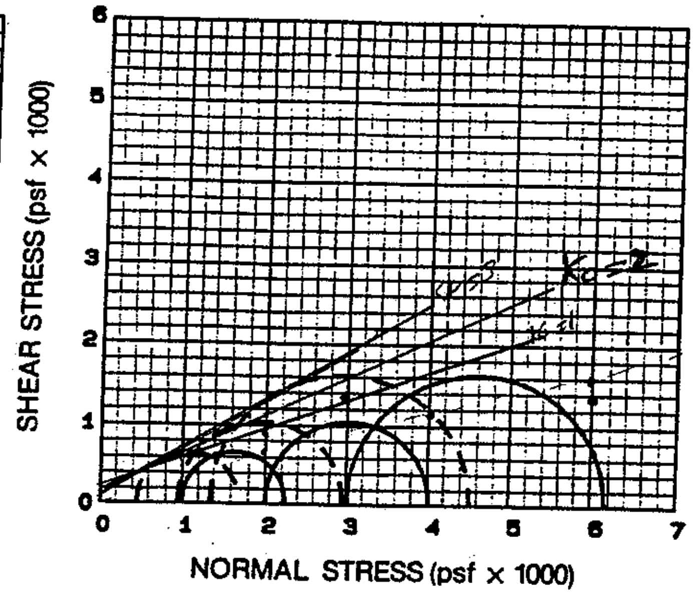
SAMPLE LOCATION: 1: B-5 @ 4-5.5'
2 & 3: B-4 @ 4-6'

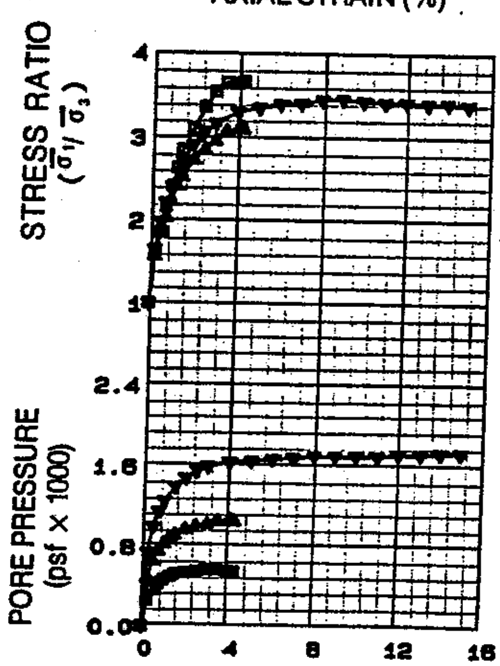
PROJ. NO.: 212-016b DATE: 7/1/96

TRIAXIAL SHEAR TEST REPORT

COOPER TESTING LABORATORY







TEST TYPE: CONSOLIDATED UNDRAINED   Controlled STRAIN

	PHYSICAL CONDITIONS	TEST NO. A ■	B ▲	C ▼
INITIAL	Diameter (in.)	2.87	2.79	2.78
	Height (in.)	6.44	6.36	6.15
	Water Content (%)	51.4	47.5	44.5
	Void Ratio	1.454	1.289	1.198
	Saturation (%)	95.4	99.5	100.2
	Dry Density (pcf)	69	74	77
BEFORE	Consolidation Pressure (psf)	1008	2002	2995
	Backpressure (psf)	7488	7488	7488
	Water Content (%)	41.2	41.4	38.8
	Void Ratio	1.112	1.118	1.049
FINAL	Water Content (%)	47.5	44.5	41.6
	Dry Density (pcf)	74	77	79
	Void Ratio	1.283	1.200	1.124
	Saturation (%)	100.0	100.0	100.0
FAILURE	$\bar{\sigma}_1$ Major Principal Stress (psf)	1684	2935	4481
	$\bar{\sigma}_3$ Minor Principal Stress (psf)	461	950	1339
	Pore Pressure (psf)	547	1051	1656
	Axial Strain at Failure (%)	4.3	4.3	5.0
	Time to Failure (min.)	280	244	270

Sample Source: BORING 4 AT 17 FEET

Classification: GREY ELASTIC SILT (MH)   2.70

TESTING LAB: HARDING LAWSON ASSOCIATES

ENGEO INCORPORATED
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

TRIAXIAL COMPRESSION TEST

SUBDIVISION 7434, BETHEL ISLAND

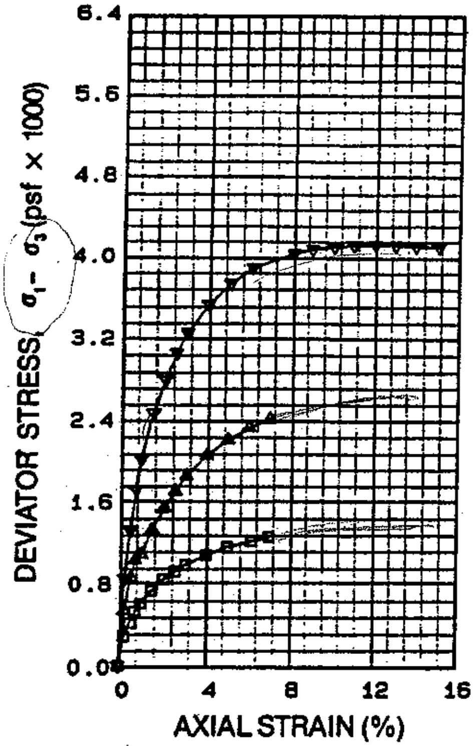
CONTRA COSTA COUNTY, CALIFORNIA

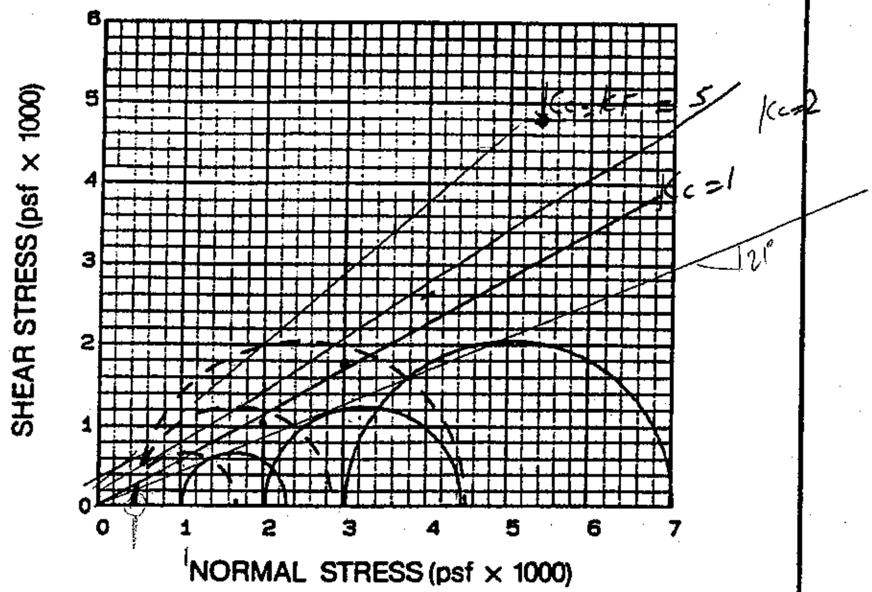
FIGURE NO. A27

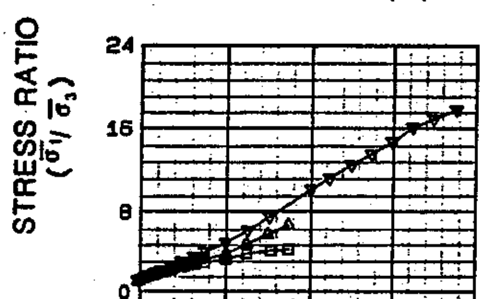
SCALE: ----

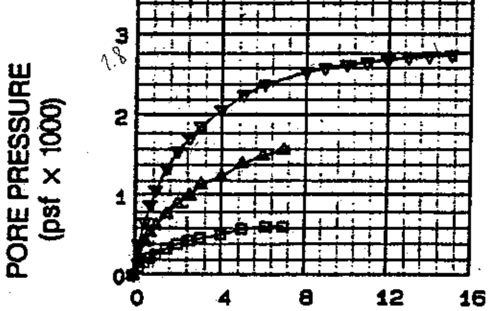
DATE: JUNE 1990

JOB NO. N90-2925-E2









TEST TYPE: CONSOLIDATED UNDRAINED Controlled STRAIN

PHYSICAL CONDITIONS		TEST NO. A ▫	TEST NO. B ▲	TEST NO. C ▼
INITIAL	Diameter (in.)	2.43	2.21	2.13
	Height (in.)	5.97	5.20	4.68
	Water Content (%)	365.4	285.2	232.3
	Void Ratio	10.668	7.417	6.040
	Saturation (%)	89.0	100.0	100.0
	Dry Density (pcf)	14	19	23
BEFORE	Consolidation Pressure (psf)	1008	2002	2995
	Backpressure (psf)	7488	7488	7488
	Water Content (%)	160.0	179.5	182.9
	Void Ratio	4.161	4.668	4.755
FINAL	Water Content (%)	285.2	232.3	207.6
	Dry Density (pcf)	19	23	25
	Void Ratio	7.414	6.041	5.398
	Saturation (%)	100.0	100.0	100.0
FAILURE	$\bar{\sigma}_1$ Major Principal Stress (psf)	1650	2829	4455
	$\bar{\sigma}_3$ Minor Principal Stress (psf)	403	432	446
	Pore Pressure (psf)	605	1570	2549
	Axial Strain at Failure (%)	7.0	7.0	8.1
	Time to Failure (min.)	386	305	216

Sample Source: BORING 7 AT 11 FEET

Classification:
BLACK PEAT (PT) 2.60

TESTING LAB: HARDING LAWSON ASSOCIATES

ENGEO INCORPORATED
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

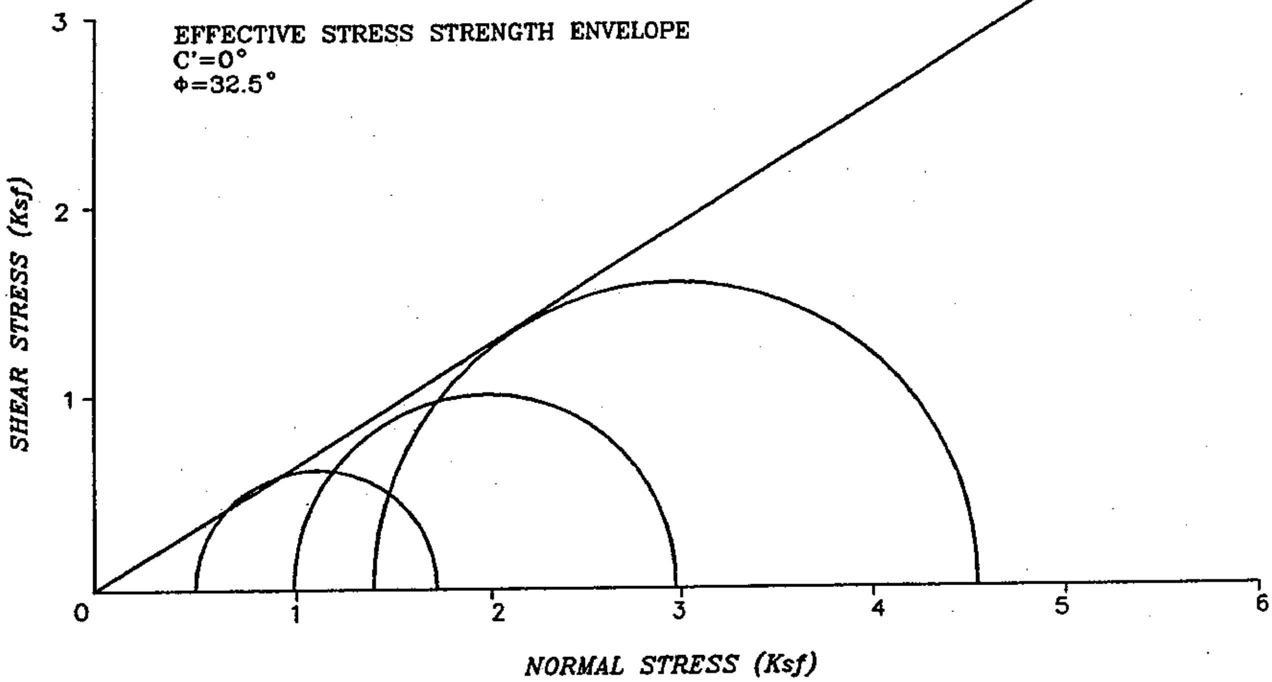
TRIAXIAL COMPRESSION TEST
SUBDIVISION 7434, BETHEL ISLAND
CONTRA COSTA COUNTY, CALIFORNIA

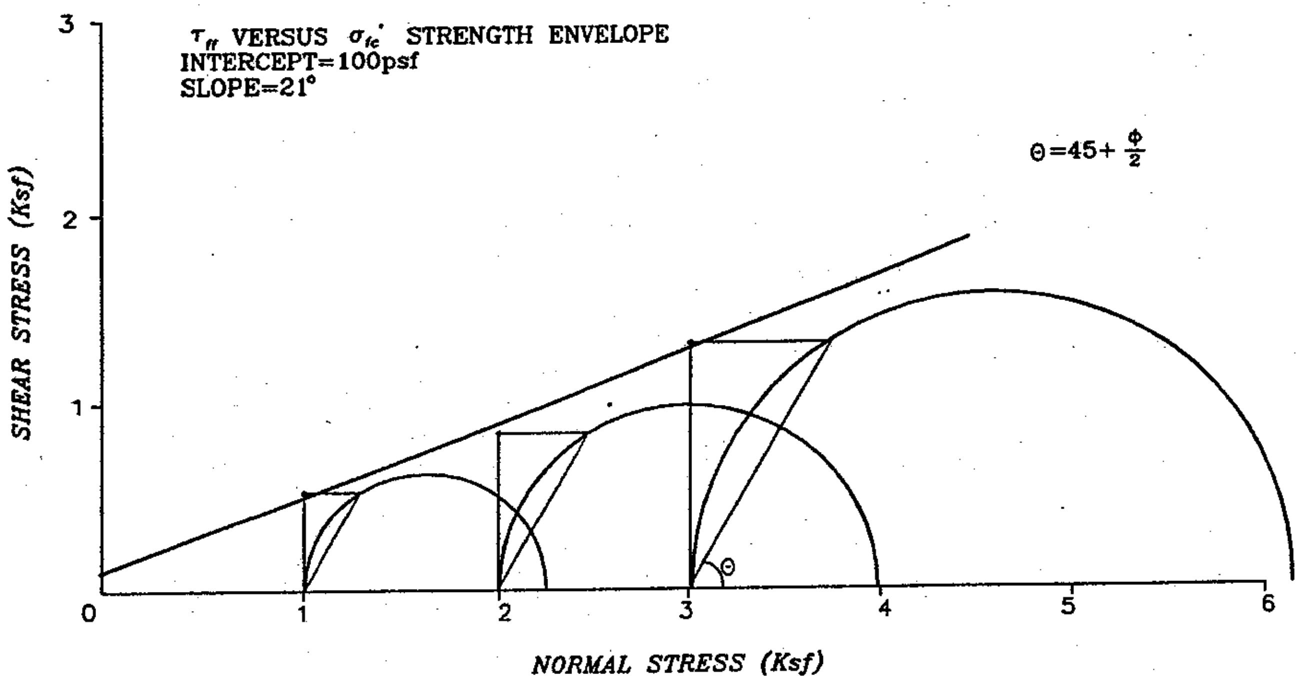
FIGURE NO. A28

SCALE: ----
DATE: JUNE 1990
JOB NO. N90-2925-E2

SAMPLE 6-4

Soft Silt/Clay





ENGEO INCORPORATED
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

STRENGTH ENVELOPES

SUBDIVISION 7434, BETHEL ISLAND PROJECT

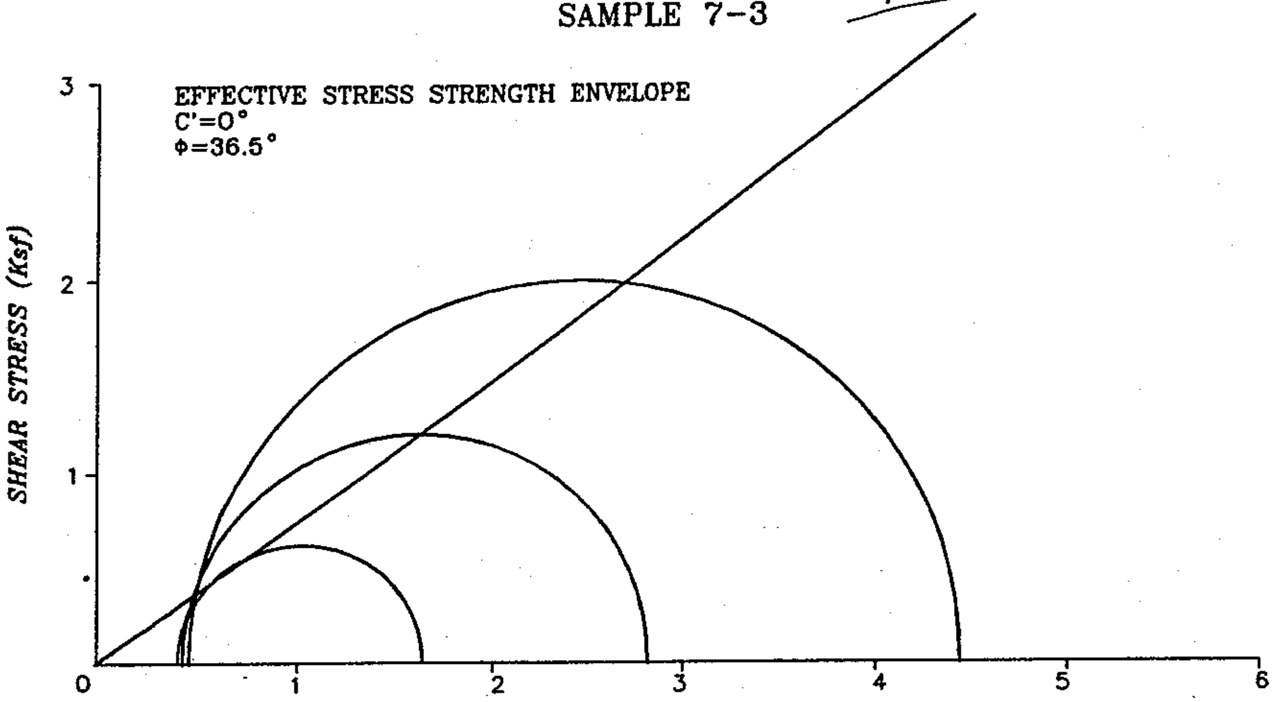
CONTRA COSTA COUNTY, CALIFORNIA

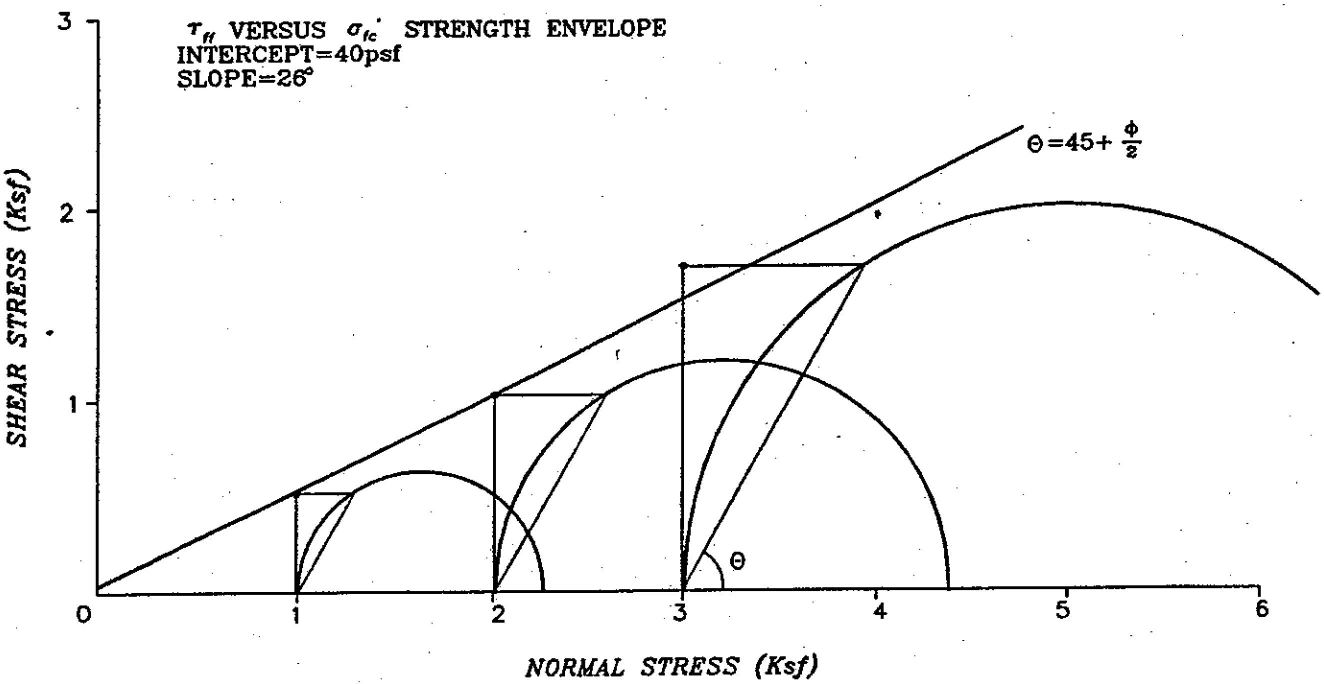
SCALE: AS SHOWN	JOB NO. N90-2925-E2
DATE: JUNE 1990	

FIGURE NO. 9

SAMPLE 7-3

Peat



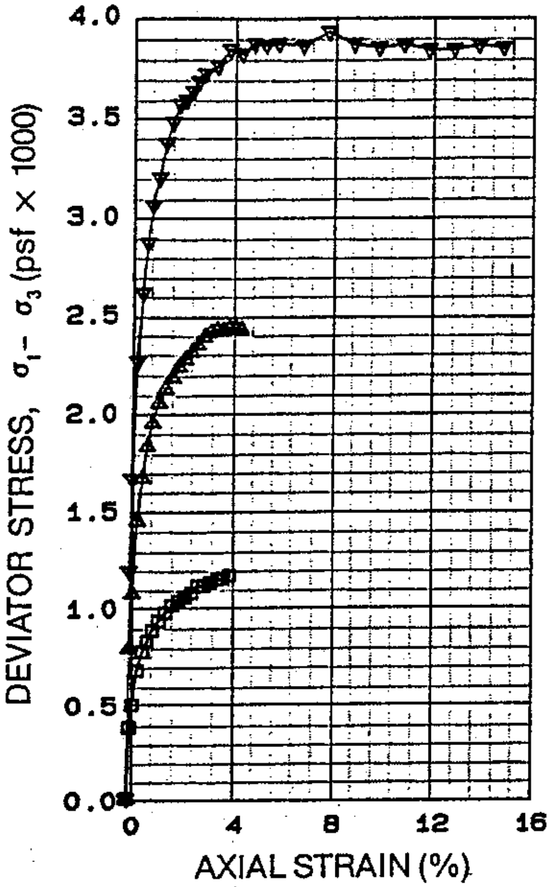


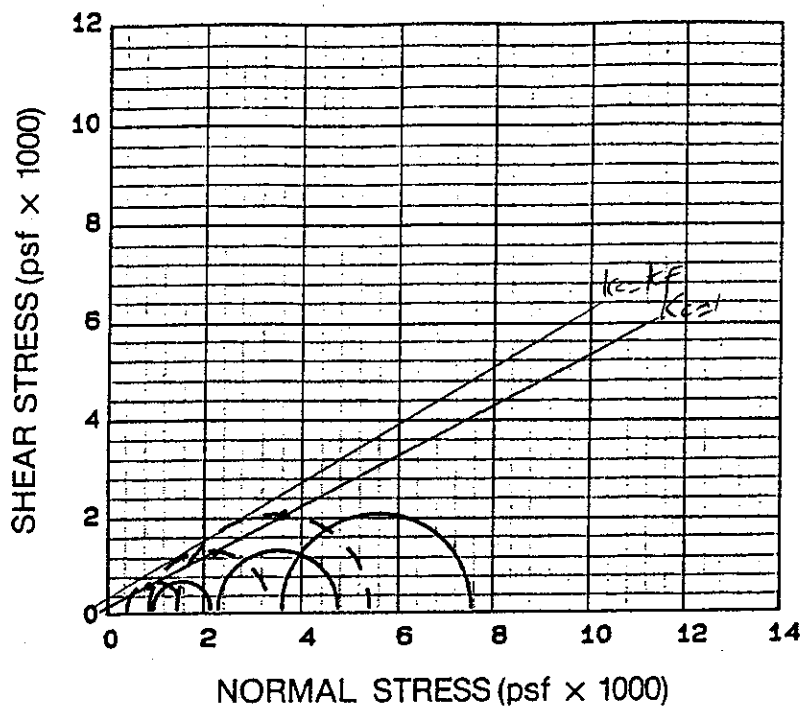
ENGEO INCORPORATED
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

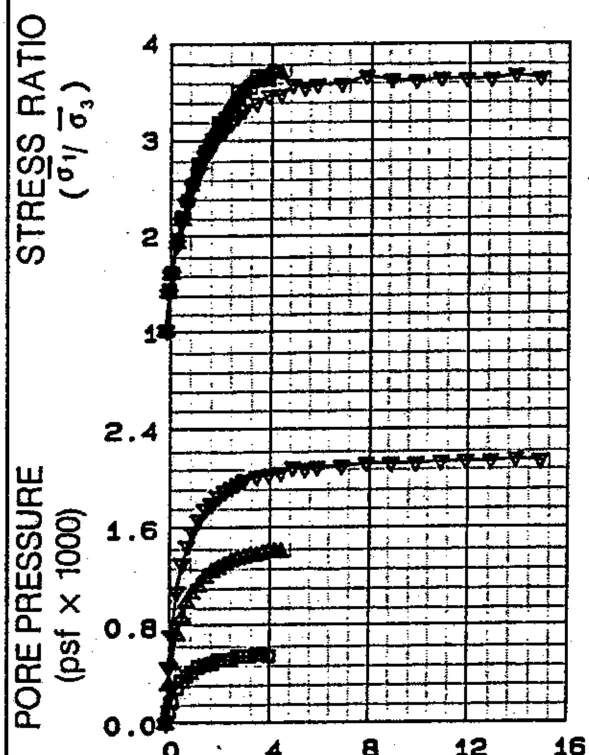
STRENGTH ENVELOPES
SUBDIVISION 7434, BETHEL ISLAND PROJECT
CONTRA COSTA COUNTY, CALIFORNIA

SCALE: AS SHOWN
DATE: JUNE 1990
JOB NO. N90-2925-E2

FIGURE NO. 10







TEST TYPE: CONSOLIDATED UNDRAINED   Controlled STRAIN

	PHYSICAL CONDITIONS	TEST NO. A ◘	TEST NO. B ▲	TEST NO. C ▼
INITIAL	Diameter (in.)	2.87	2.93	2.99
	Height (in.)	6.38	6.24	6.00
	Water Content (%)	81.3	72.5	66.1
	Void Ratio	2.246	2.306	2.311
	Saturation (%)	93.4	81.1	73.7
	Dry Density (pcf)	50	49	49
BEFORE	Consolidation Pressure (psf)	994	2304	3600
	Backpressure (psf)	6048	6048	6048
	Water Content (%)	N.A.	N.A.	N.A.
	Void Ratio	1.708	1.540	1.412
FINAL	Water Content (%)	N.A.	N.A.	N.A.
	Dry Density (pcf)	56	60	63
	Void Ratio	1.870	1.704	1.558
	Saturation (%)	100.0	100.0	100.0
FAILURE	$\bar{\sigma}_1$ Major Principal Stress (psf)	1602	3325	5383
	$\bar{\sigma}_3$ Minor Principal Stress (psf)	446	907	1483
	Pore Pressure (psf)	547	1397	2117
	Axial Strain at Failure (%)	4.0	4.0	8.0
	Time to Failure (min.)	79	83	164

Sample Source: B-1 @ 5.0 FT

Classification: BLACK ELASTIC SILT WITH PEAT (MH)   2.58

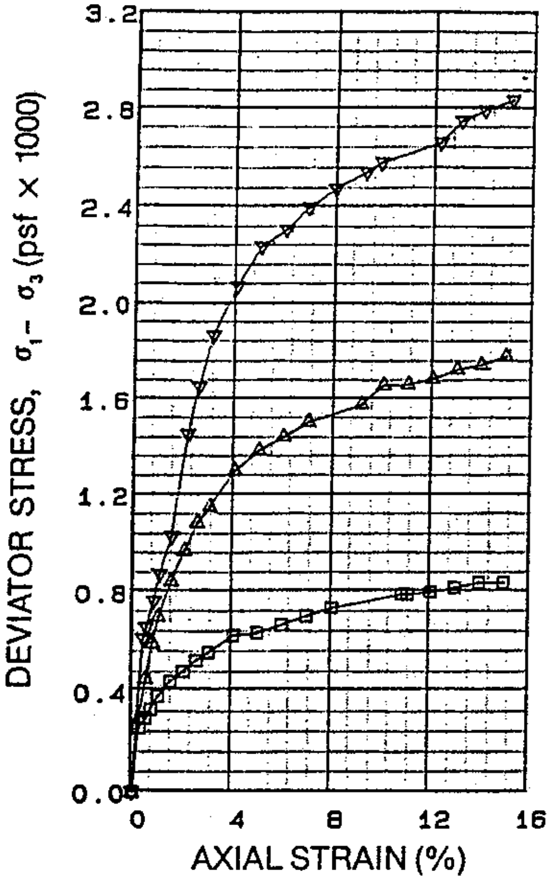
Harding Lawson Associates
Engineers, Geologists
& Geophysicists

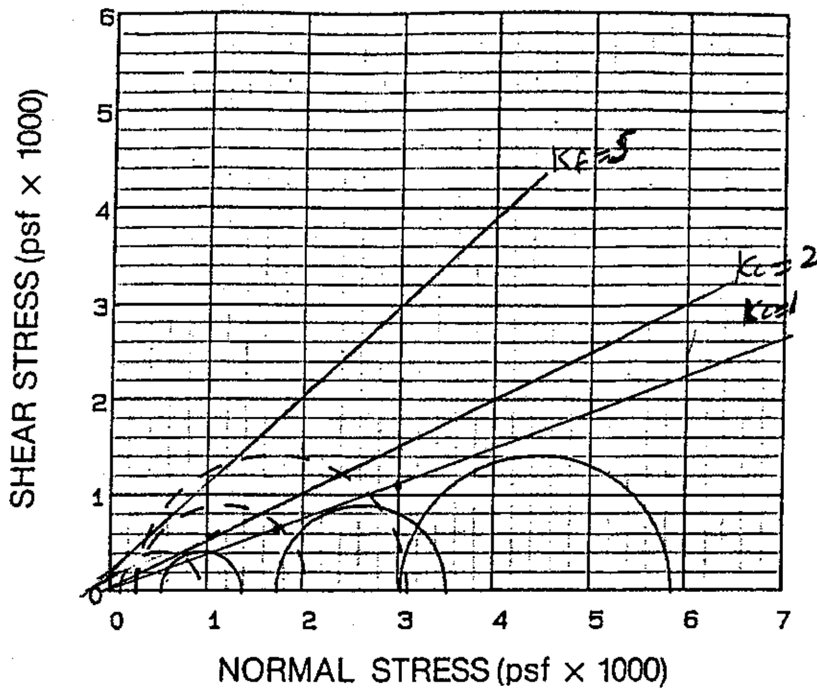
Triaxial Compression Test
Wilkerson Dam
San Joaquin County, California

PLATE **B.2.3.1**

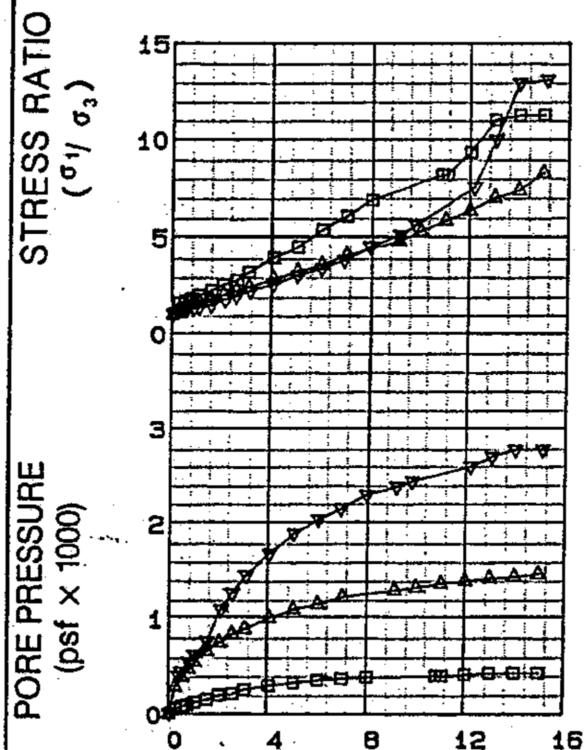
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
	18749.010.03	TJD	11-04-1990		

plotted values – conservative in Wilkerson





TEST TYPE: CONSOLIDATED UNDRAINED — Controlled STRAIN



PHYSICAL CONDITIONS		TEST NO. A ▣	B ▲	C ▼
INITIAL	Diameter (in.)	2.87	2.87	2.87
	Height (in.)	6.50	6.50	6.50
	Water Content (%)	734.1	584.5	470.5
	Void Ratio	8.943	7.103	5.587
	Saturation (%)	94.4	94.6	96.8
	Dry Density (pcf)	7	9	11
BEFORE	Consolidation Pressure (psf)	500	1701	3000
	Backpressure (psf)	7488	7488	7486
	Water Content (%)	679.5	544.6	471.3
	Void Ratio	7.815	6.263	5.420
FINAL	Water Content (%)	599.0	317.6	225.3
	Dry Density (pcf)	9	15	20
	Void Ratio	6.888	3.652	2.591
	Saturation (%)	100.0	100.0	100.0
FAILURE	$\bar{\sigma}_1$ Major Principal Stress (psf)	922	2029	3072
	$\bar{\sigma}_3$ Minor Principal Stress (psf)	82	246	235
	Pore Pressure (psf)	418	1454	2765
	Axial Strain at Failure (%)	15.0	15.0	15.1
	Time to Failure (min.)	1446	1474	1549

Sample Source: B-10 @ 4.0

Classification: BLACK PEAT (pt) (Pe. H) 1.15

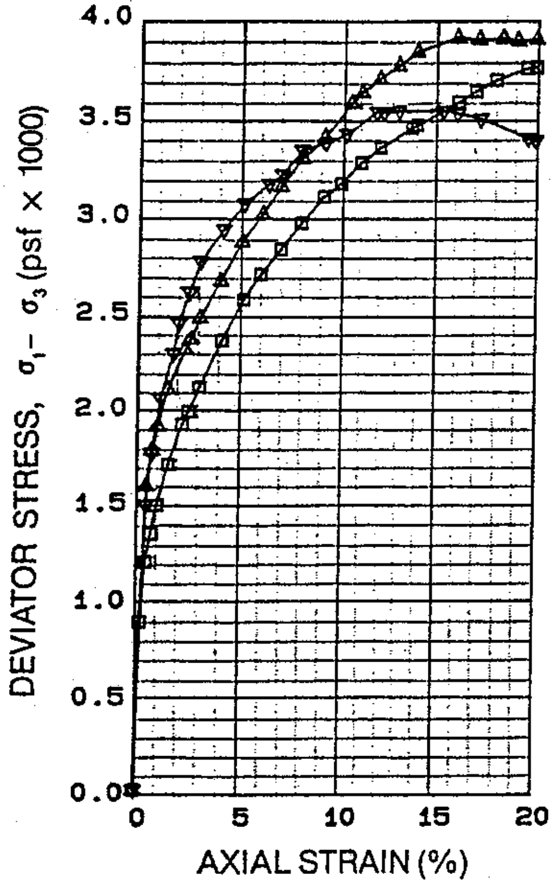
Harding Lawson Associates
Engineers, Geologists
& Geophysicists

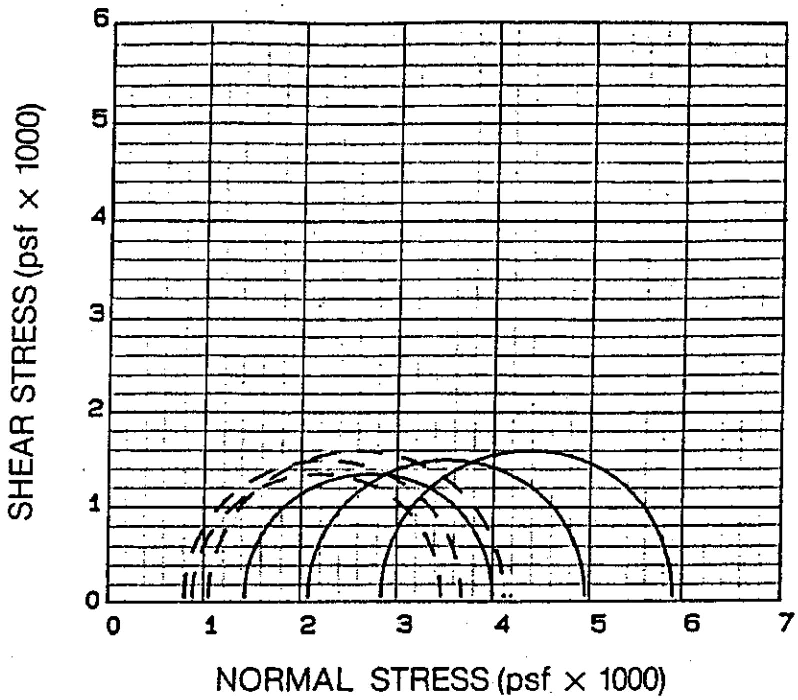
Triaxial Compression Test

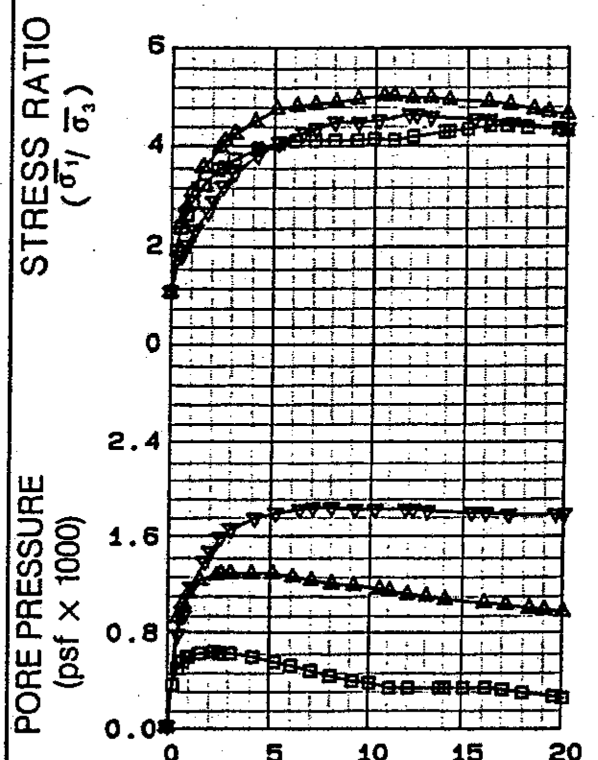
Wilkerson Dam
San Joaquin County, California

PLATE **B.2.1.1**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
	18749.011.03	TJD	06-17-1989		







TEST TYPE: CONSOLIDATED UNDRAINED Controlled STRAIN

	PHYSICAL CONDITIONS	TEST NO. A ▫	TEST NO. B ▲	TEST NO. C ▼
INITIAL	Diameter (in.)	2.87	2.87	2.87
	Height (in.)	6.50	6.50	6.50
	Water Content (%)	41.7	41.4	46.8
	Void Ratio	1.285	1.189	1.318
	Saturation (%)	88.9	95.5	97.4
	Dry Density (pcf)	75	78	74
BEFORE	Consolidation Pressure (psf)	1400	2051	2799
	Backpressure (psf)	7488	7488	7488
	Water Content (%)	40.2	39.2	45.3
	Void Ratio	1.102	1.074	1.240
FINAL	Water Content (%)	38.5	35.7	40.0
	Dry Density (pcf)	83	86	82
	Void Ratio	1.055	0.979	1.096
	Saturation (%)	100.0	100.0	100.0
FAILURE	$\bar{\sigma}_1$ Major Principal Stress (psf)	3418	3631	4071
	$\bar{\sigma}_3$ Minor Principal Stress (psf)	867	783	1028
	Pore Pressure (psf)	533	1267	1771
	Axial Strain at Failure (%)	5.2	5.1	5.2
	Time to Failure (min.)	91	89	102

Sample Source: B-53 @ 25.0 FT

Classification:
GREY SANDY SILT (ML) — West End 2.74

Harding Lawson Associates
Engineers, Geologists
& Geophysicists

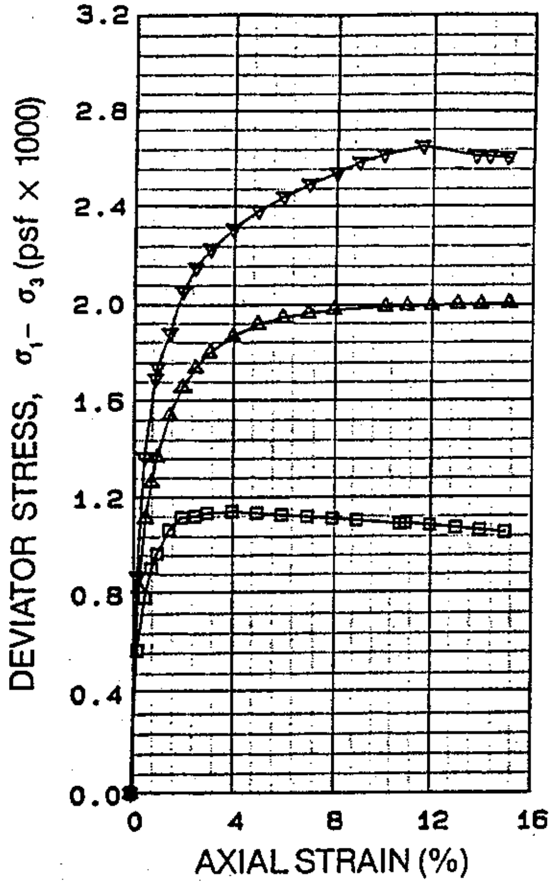
Triaxial Compression Test

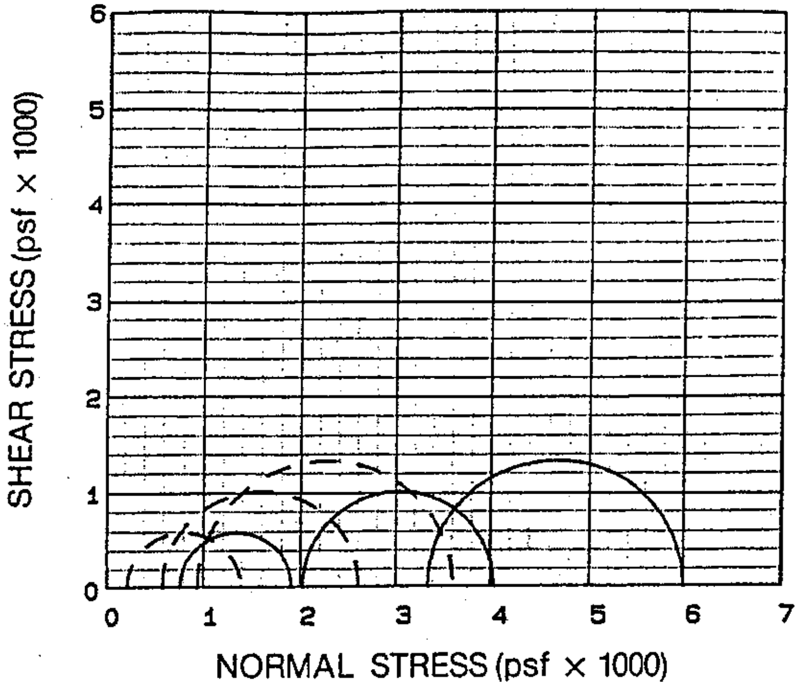
Wilkerson Dam
San Joaquin County, California

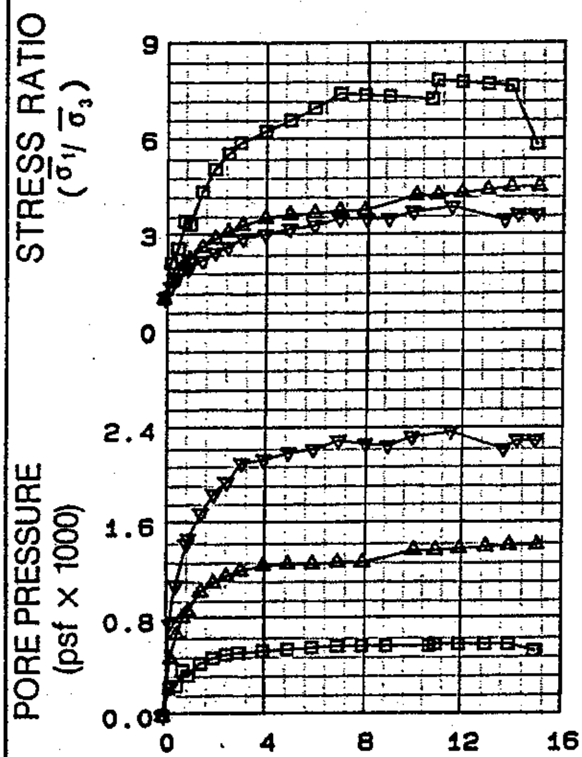
PLATE B.2.2.5

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
	18749.011.03	KCC	09-20-1989		

8, ·, · ·,







TEST TYPE: CONSOLIDATED UNDRAINED   Controlled STRAIN

	PHYSICAL CONDITIONS	TEST NO. A ▫	TEST NO. B ▵	TEST NO. C ▿
INITIAL	Diameter (in.)	2.87	2.87	2.87
	Height (in.)	6.50	6.50	6.00
	Water Content (%)	58.1	49.7	48.6
	Void Ratio	1.716	1.392	1.351
	Saturation (%)	92.1	97.2	97.9
	Dry Density (pcf)	62	71	72
BEFORE	Consolidation Pressure (psf)	750	1999	3300
	Backpressure (psf)	7488	7488	7488
	Water Content (%)	56.1	47.8	48.2
	Void Ratio	1.526	1.300	1.310
FINAL	Water Content (%)	54.5	42.1	40.1
	Dry Density (pcf)	68	79	81
	Void Ratio	1.482	1.146	1.090
	Saturation (%)	100.0	100.0	100.0
FAILURE	$\bar{\sigma}_1$ Major Principal Stress (psf)	1353	2568	3566
	$\bar{\sigma}_3$ Minor Principal Stress (psf)	217	573	924
	Pore Pressure (psf)	533	1426	2376
	Axial Strain at Failure (%)	4.0	15.1	11.6
	Time to Failure (min.)	1485	1591	1434

Sample Source: B-33 @ 15.0 FT

Classification:
GREY ELASTIC SILT (MH) West End   2.72

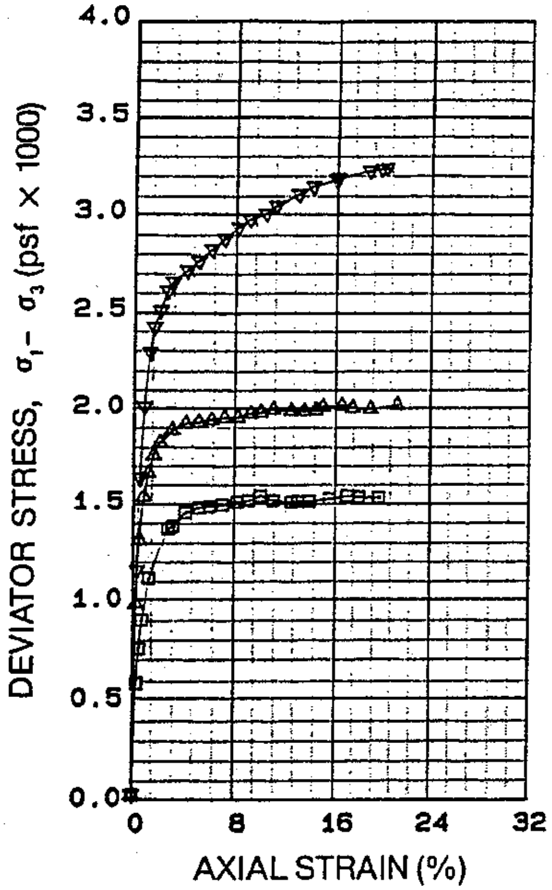
Harding Lawson Associates
Engineers, Geologists & Geophysicists

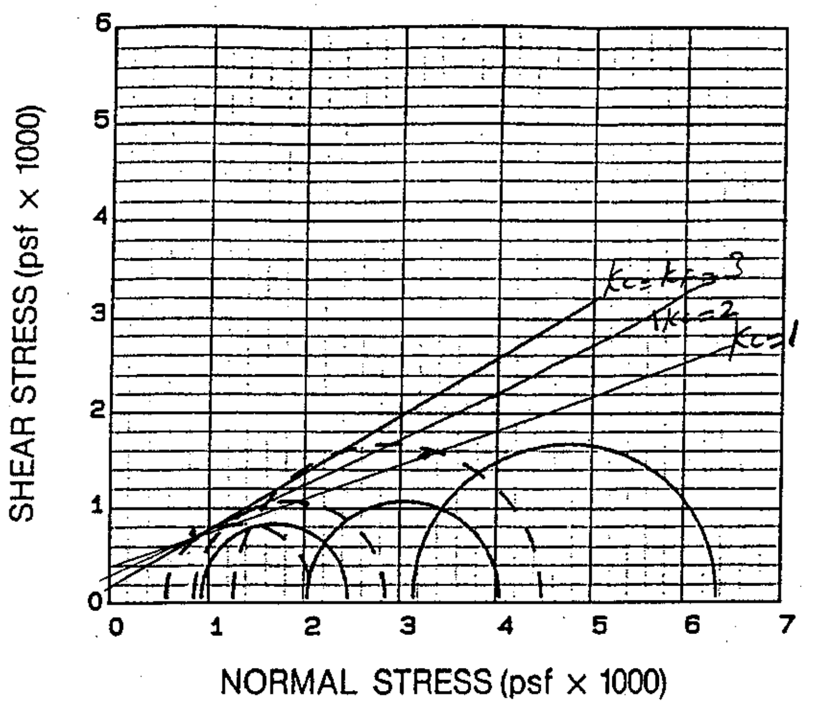
Triaxial Compression Test

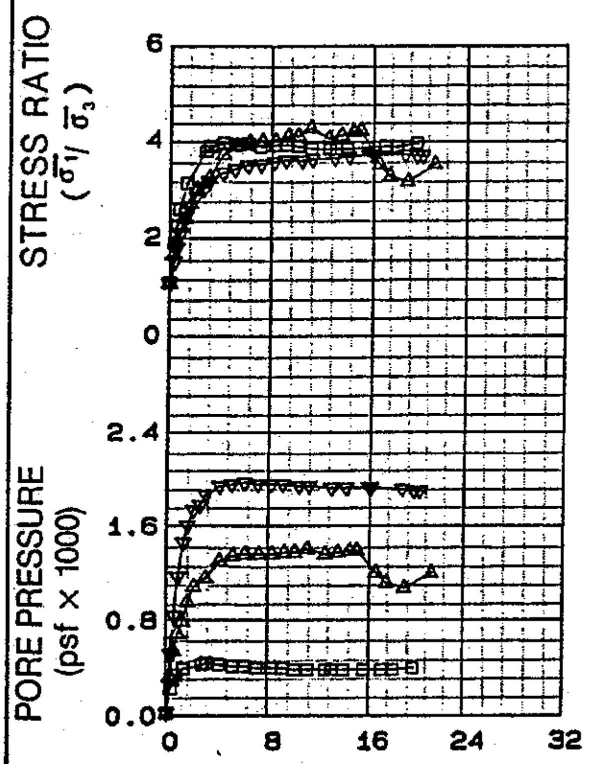
Wilkerson Dam
San Joaquin County, California

PLATE
B.2.2.1

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
	18749.011.03	KCC	07-12-1989		







TEST TYPE: CONSOLIDATED UNDRAINED Controlled STRAIN

	PHYSICAL CONDITIONS	TEST NO. A ◻	B ▲	C ▼
INITIAL	Diameter (in.)	2.87	2.87	2.87
	Height (in.)	6.50	6.50	6.50
	Water Content (%)	43.5	38.9	33.4
	Void Ratio	1.266	1.067	0.925
	Saturation (%)	94.1	100.0	99.0
	Dry Density (pcf)	75	83	89
BEFORE	Consolidation Pressure (psf)	900	2000	3100
	Backpressure (psf)	7488	7488	7488
	Water Content (%)	43.2	36.0	32.1
	Void Ratio	1.185	0.987	0.880
FINAL	Water Content (%)	41.3	32.8	28.2
	Dry Density (pcf)	80	90	96
	Void Ratio	1.132	0.899	0.774
	Saturation (%)	100.0	100.0	100.0
FAILURE	$\overline{\sigma_1}$ Major Principal Stress (psf)	2050	2804	4426
	$\overline{\sigma_3}$ Minor Principal Stress (psf)	540	819	1228
	Pore Pressure (psf)	360	1181	1872
	Axial Strain at Failure (%)	10.0	21.2	20.1
	Time to Failure (min.)	408	318	287

Sample Source: B-49 @ 25.0 FT

Classification: GREY SANDY SILT (ML) – West End 2.74

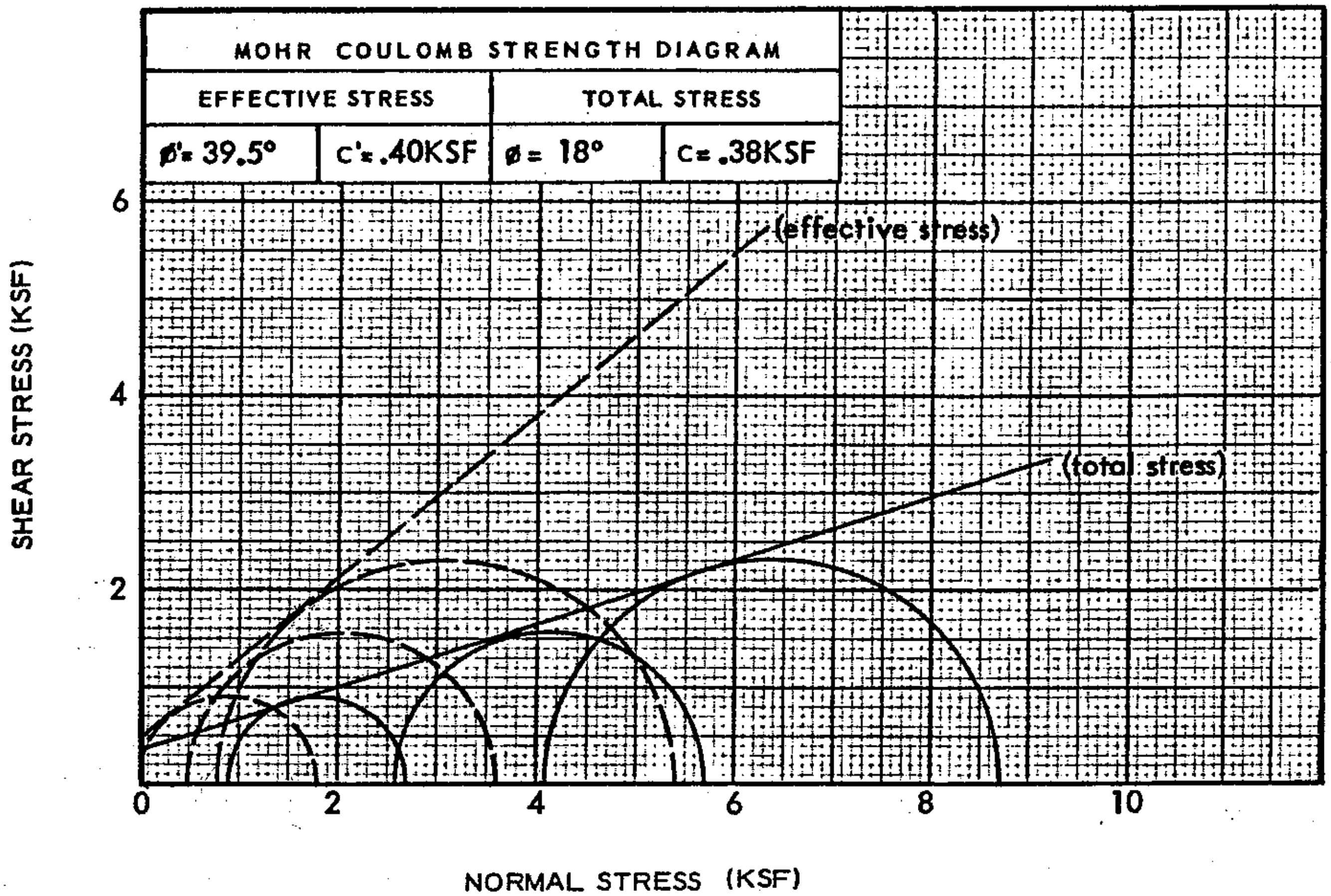
Harding Lawson Associates
Engineers, Geologists & Geophysicists

Triaxial Compression Test

Wilkerson Dam
San Joaquin County, California

PLATE B.2.2.3

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
	18749.011.03	KRC	09-13-1989		



SYMBOL	STAGE	BORING	SAMPLE	DEPTH (FT)	INITIAL DRY DENS (PCF)	INITIAL WAT CONT (%)	FINAL DRY DENS (PCF)	FINAL WAT CONT (%)	TEST VALUES AT FAILURE (1) APPL LAT PRESS (KSF)	DEV STRESS (KSF)	PORE PRESS (KSF)	EFF LAT PRESS (KSF)	EFF VERT STRESS (KSF)	INIT BACK PRESS USED (KSF)	DESCRIPTION
--	1	9	--	21	24	186	--	--	0.9	1.8	0.9	0	1.8	4.3	Multistage
	2	"		"		(69)			2.6	3.1	2.1	0.5	3.6	4.3	
	3	"		"					4.1	4.6	3.3	0.8	5.4	4.3	

NOTES: (1) FAILURE DEFINED BY 5% Strain

Horizon 3
Description: PEAT/GRAY CLAY (Pt-CL)

TRIAXIAL COMPRESSION TESTS (CUE)

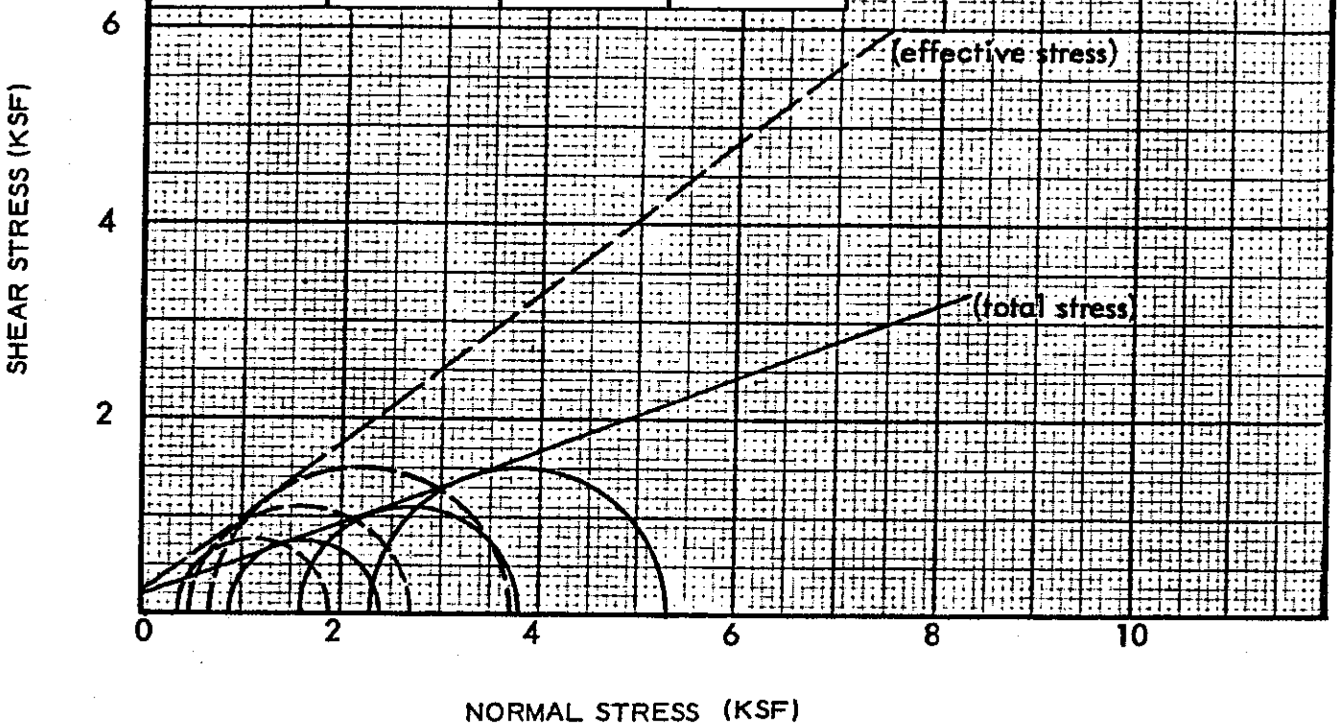
WOODWARD ISLAND ENGINEERING STUDIES
for East Bay Municipal Utility District

Project No.
78-4109-01

ConverseWardDavisDixon Geotechnical Consultants

Drawing No.
B-10

MOHR COULOMB STRENGTH DIAGRAM			
EFFECTIVE STRESS		TOTAL STRESS	
ø'= 38°	c'=.15KSF	ø = 20°	c=.15KSF



SYMBOL	STAGE	BORING	SAMPLE	DEPTH (FT)	INITIAL		FINAL		TEST VALUES AT FAILURE (1)					INIT BACK PRESS USED (KSF)	DESCRIPTION
					DRY DENS (PCF)	WAT CONT (%)	DRY DENS (PCF)	WAT CONT (%)	APPL LAT PRESS (KSF)	DEV STRESS (KSF)	PORE PRESS (KSF)	EFF LAT PRESS (KSF)	EFF VERT STRESS (KSF)		
--	1	9	--	14.5	51	64.6	--	--	0.9	1.5	0.5	0.4	1.9	4.3	Multistage
	2	"		"		(84)			1.6	2.2	1.1	0.5	2.7	4.3	
	3	"		"					2.3	3.0	1.6	0.7	3.7	4.3	

NOTES: (1) FAILURE DEFINED BY $(\sigma_1'/\sigma_3')_{max}$ Assume 5%

Horizon 2
Description: DARK GRAY DECAYED PEATY SILT (OL)

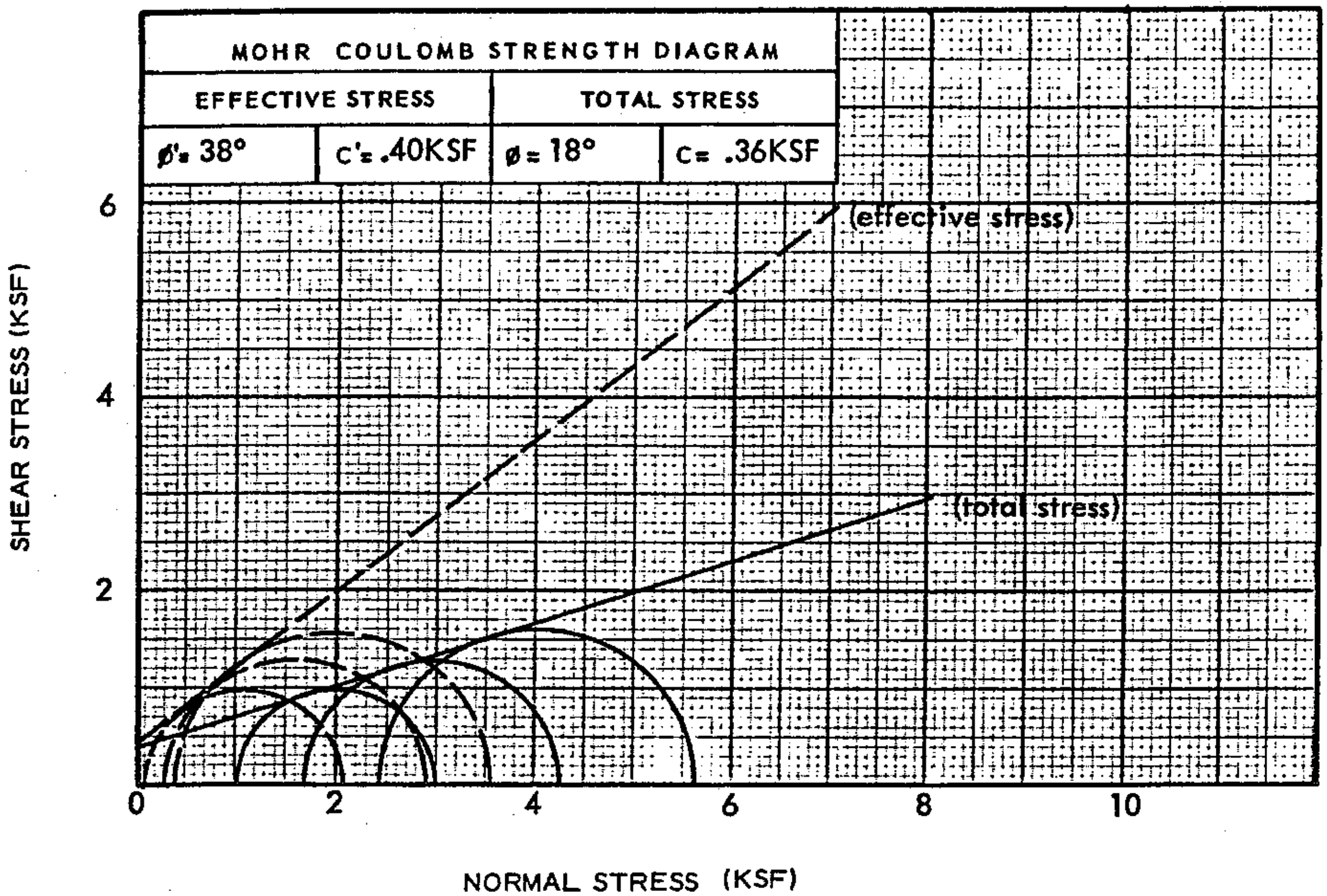
TRIAXIAL COMPRESSION TESTS (CUE)

WOODWARD ISLAND ENGINEERING STUDIES
for East Bay Municipal Utility District

Project No. 78-4109-01

ConverseWardDavisDixon Geotechnical Consultants

Drawing No. B-7



SYMBOL	STAGE	BORING	SAMPLE	DEPTH (FT)	INITIAL DRY DENS (PCF)	INITIAL WAT CONT (%)	FINAL DRY DENS (PCF)	FINAL WAT CONT (%)	TEST VALUES AT FAILURE (1) APPL LAT PRESS (KSF)	DEV STRESS (KSF)	PORE PRESS (KSF)	EFF LAT PRESS (KSF)	EFF VERT STRESS (KSF)	INIT BACK PRESS USED (KSF)	DESCRIPTION
--	1	11	--	23.4	50	68.4	--	--	1.0	2.0	0.9	0.1	2.1	4.3	Multistage
	2	"		"		(84)			1.7	2.6	1.4	0.3	2.9	4.3	
	3	"		"					2.45	3.2	2.0	0.45	3.6	4.3	

NOTES: (1) FAILURE DEFINED BY 5% Strain

Horizon 2
Description: LIGHT GRAY CLAYEY SILT w/ PEAT LENSES (ML)

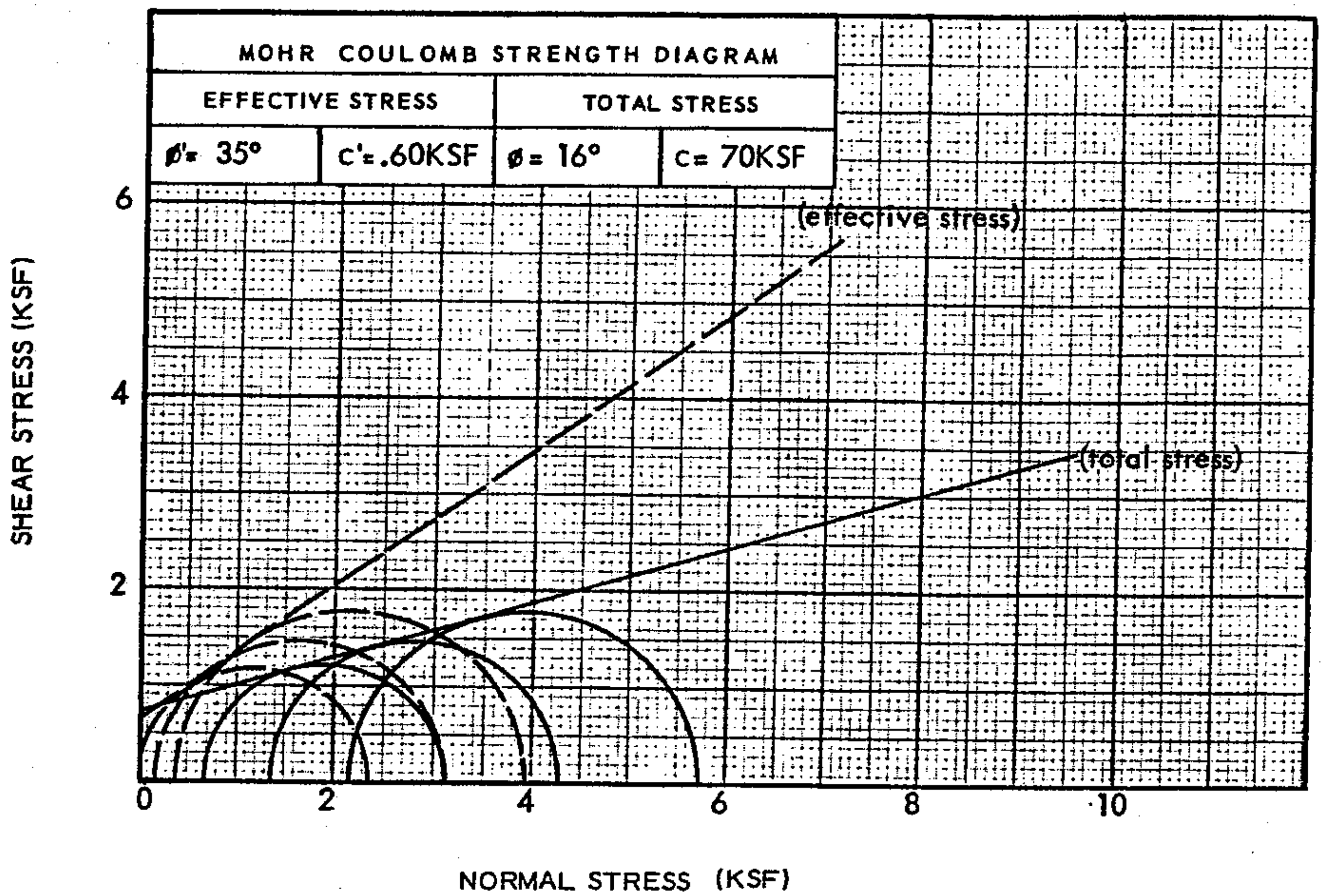
TRIAXIAL COMPRESSION TESTS (CUE)

WOODWARD ISLAND ENGINEERING STUDIES
for East Bay Municipal Utility District

Project No.
78-4109-01

ConverseWardDavisDixon Geotechnical Consultants

Drawing No.
B-8



SYMBOL	STAGE	BORING	SAMPLE	DEPTH (FT)	INITIAL DRY DENS (PCF)	INITIAL WAT CONT (%)	FINAL DRY DENS (PCF)	FINAL WAT CONT (%)	TEST VALUES AT FAILURE (1) APPL LAT PRESS (KSF)	DEV STRESS (KSF)	PORE PRESS (KSF)	EFF LAT PRESS (KSF)	EFF VERT STRESS (KSF)	INIT BACK PRESS USED (KSF)	DESCRIPTION
--	1	12	--	12.5	38	114	--	--	0.7	2.4	0.7	0	2.4	4.3	Multistage
	2	"		"		91			1.4	2.9	1.2	0.2	3.1	4.3	
	3	"		"					2.2	3.5	1.8	0.4	3.9	4.3	

NOTES: (1) FAILURE DEFINED BY 5% Strain

Horizon 2
Description: GRAY CLAY w/ PEAT LENSES (CL)

TRIAXIAL COMPRESSION TESTS (CUE)

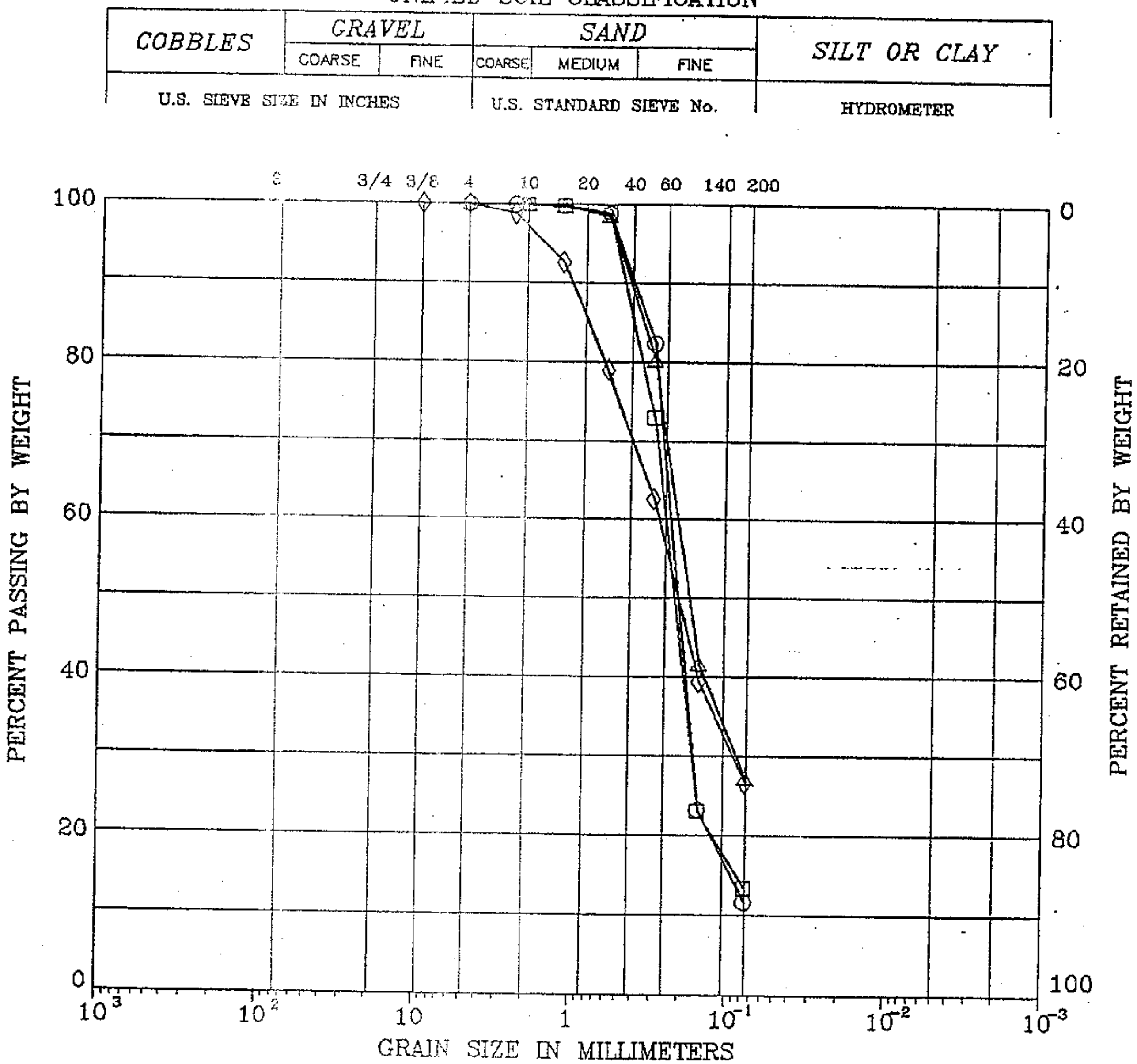
WOODWARD ISLAND ENGINEERING STUDIES
for East Bay Municipal Utiity District

Project No.
78-4109-01

ConverseWardDavisDixon Geotechnical Consultants

Drawing No.
B-9

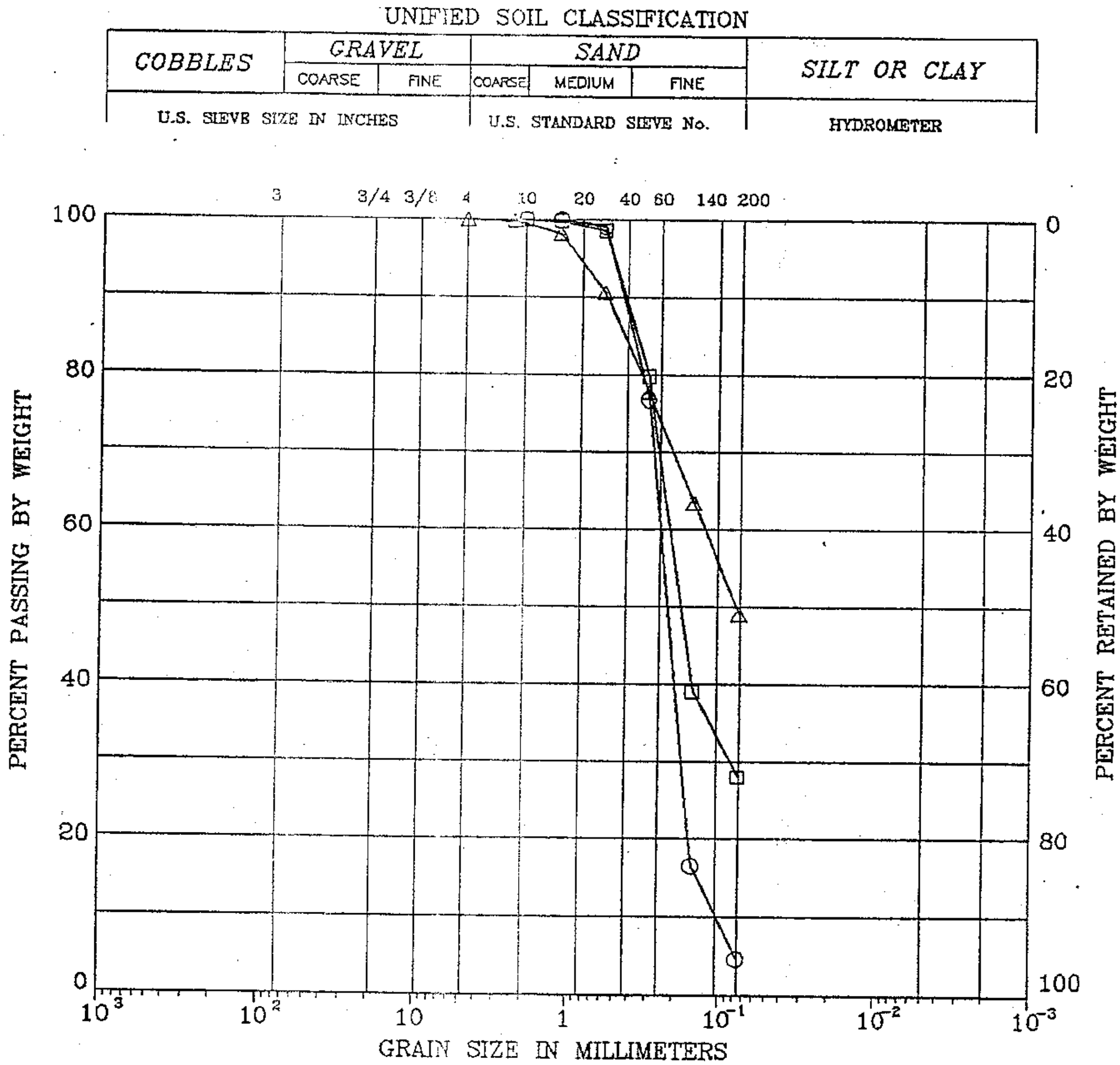
UNIFIED SOIL CLASSIFICATION



SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION
○	B-1, S-1	2.5-5			silty SAND, yellow brown (SP-SM)
□	B-1, S-10	27.5-30			silty SAND, gray (SM)
△	B-1, S-11	30-32.5			silty SAND, blue gray (SM)
◇	B-1, S-14	38-39.2			clayey SAND, yellow brown (SC)

Remark : March 1991

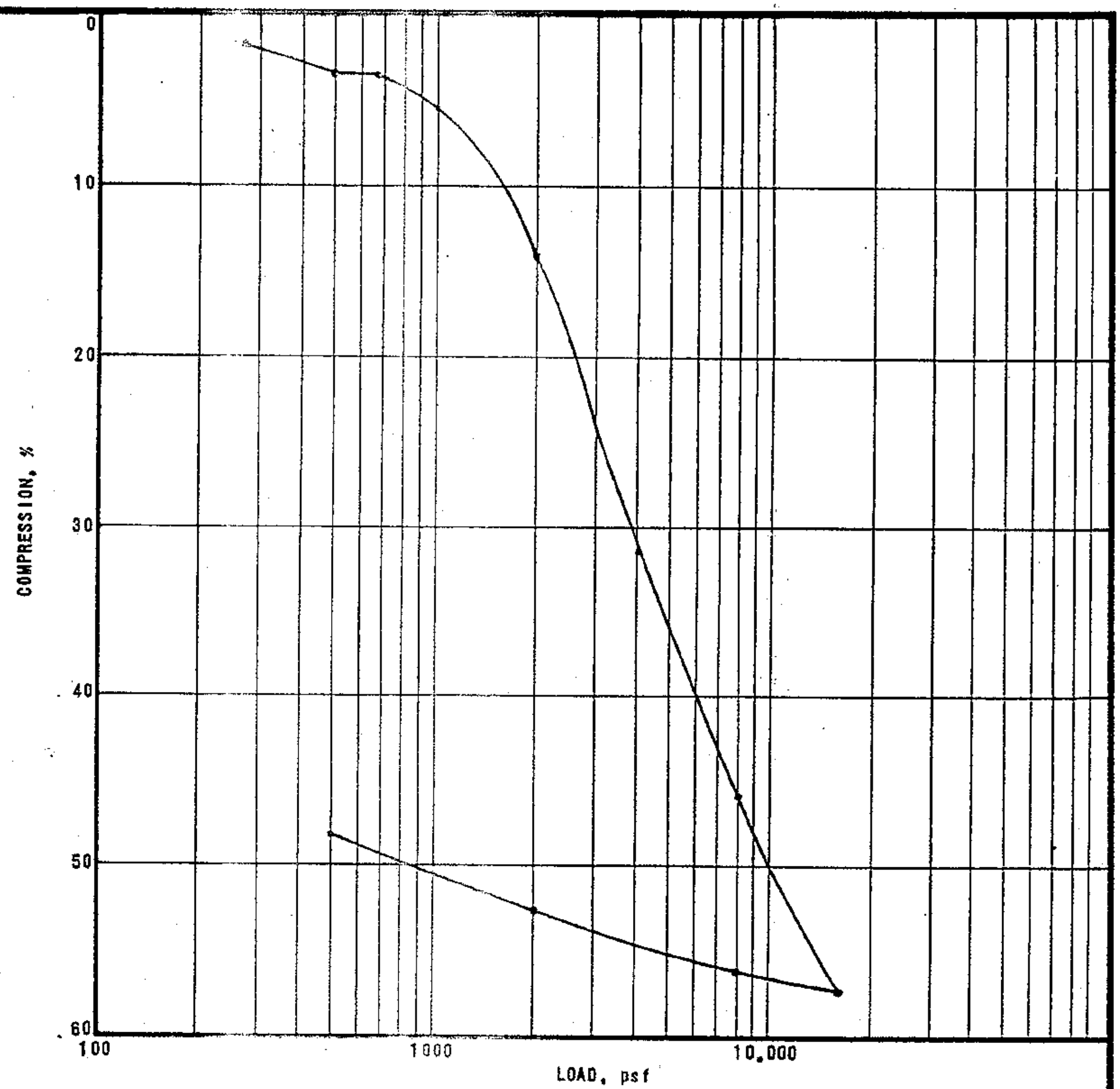
Project MBK-214A	King Island Levees
Wahler Associates	GRAIN SIZE DISTRIBUTION Figure No. B-1



SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION
○	B-2, S-1	2.5-5			slightly silty SAND, yellow brown (SP)
□	B-2, C-10	30.5-32			silty SAND, gray (SM)
△	B-2, C-11	35-36.5			silty SAND/sandy SILT, gray (SM/ML)

Remark : March 1991

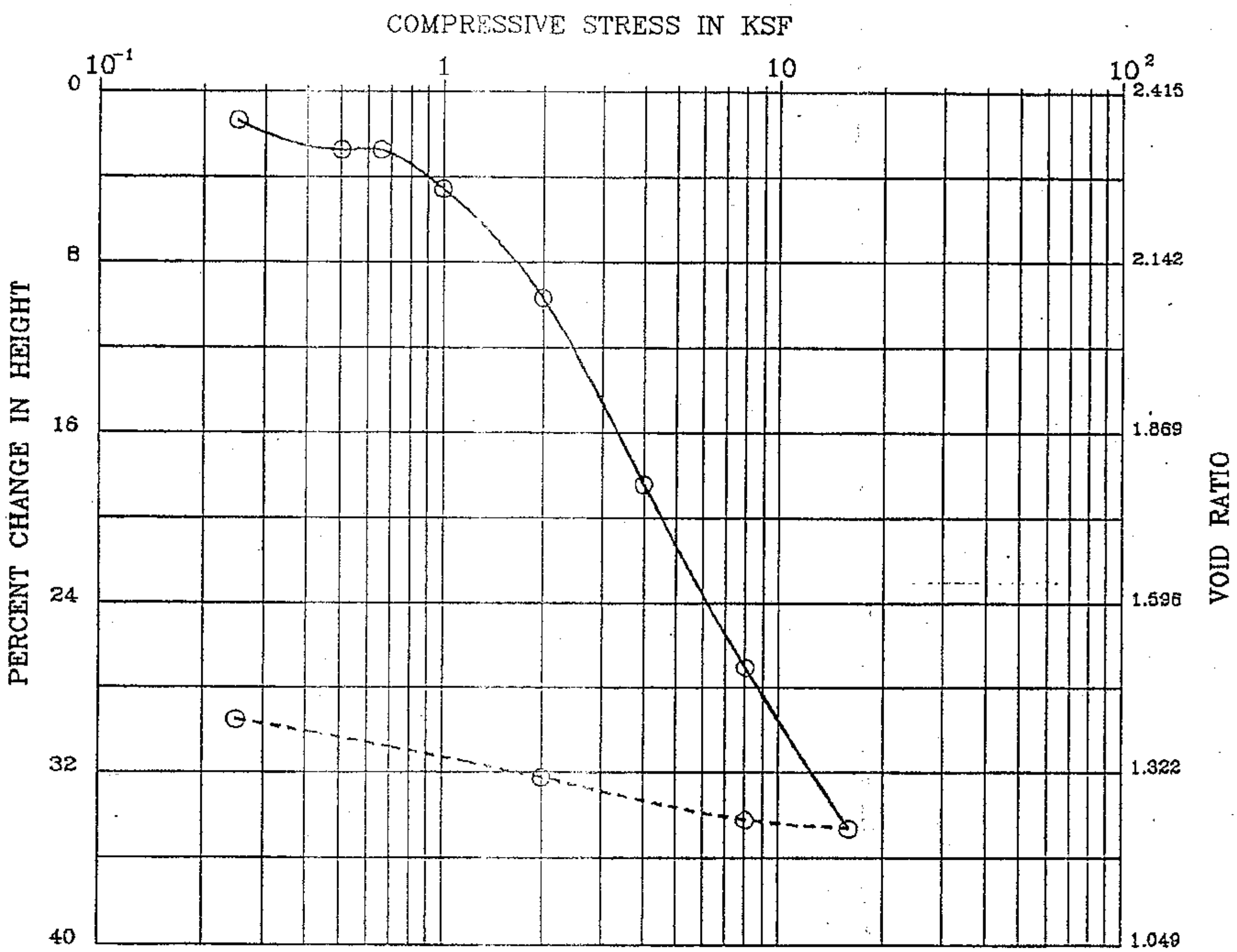
Project MBK-214A	King Island Levees
Wahler Associates	GRAIN SIZE DISTRIBUTION Figure No. B-2



Sample description: PEAT, black, fibrous (Pt)

HOLE NO.	SAMPLE NO.	DEPTH (ft)	INITIAL SPECIMEN DATA			FINAL SPECIMEN DATA		
			DRY DENSITY (pcf)	WATER CONTENT (%)	VOID RATIO	DRY DENSITY (pcf)	WATER CONTENT (%)	DEGREE OF SATURATION (%)
B-2	S-5	14.7-15	13.1	394.2	8.241	25.2	196.0	100

Wahler Associates	KING ISLAND LEVEES	CONSOLIDATION TEST		
	PALO ALTO • CALIFORNIA	PROJECT NO.	DATE	FIGURE NO.
		MBK-214A	MARCH 1991	B-3



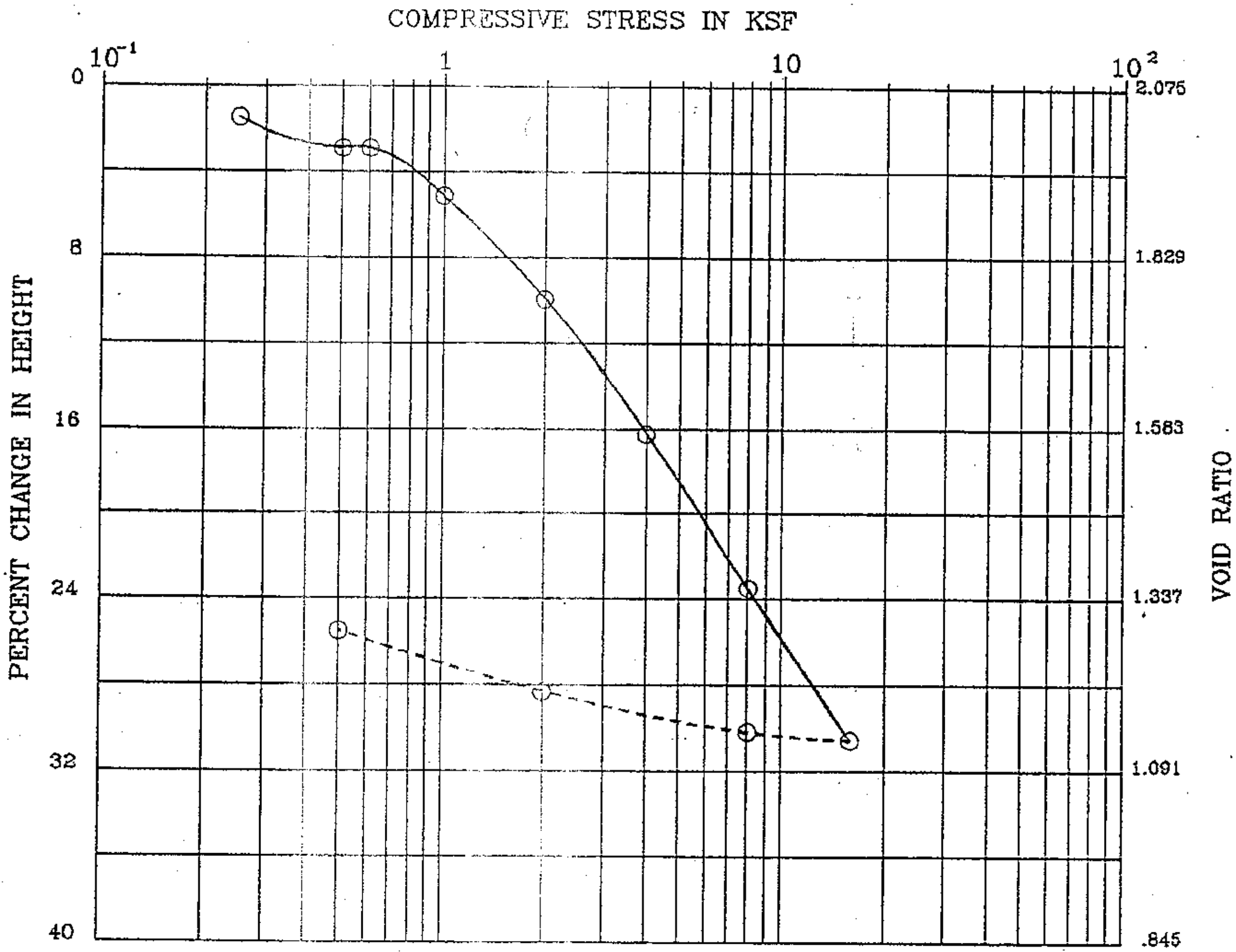
BORING : B-2, S-9
DEPTH (ft) : 22.5–25
SPEC. GRAVITY : 2.79

DESCRIPTION : clayey SILT, gray (MH)
LIQUID LIMIT :
PLASTIC LIMIT :

	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	PERCENT SATURATION	VOID RATIO
INITIAL	82.7	51.1	96	2.415
FINAL	50.3	72.5	100	1.408

Remark : March 1991

Project MBK-214A	King Island Levees
Wahler Associates	CONSOLIDATION TEST Figure No. B-4



BORING : B-3, S-9

DEPTH (ft) : 25-27.5

SPEC. GRAVITY : 2.79

DESCRIPTION : clayey SILT, gray (MH)

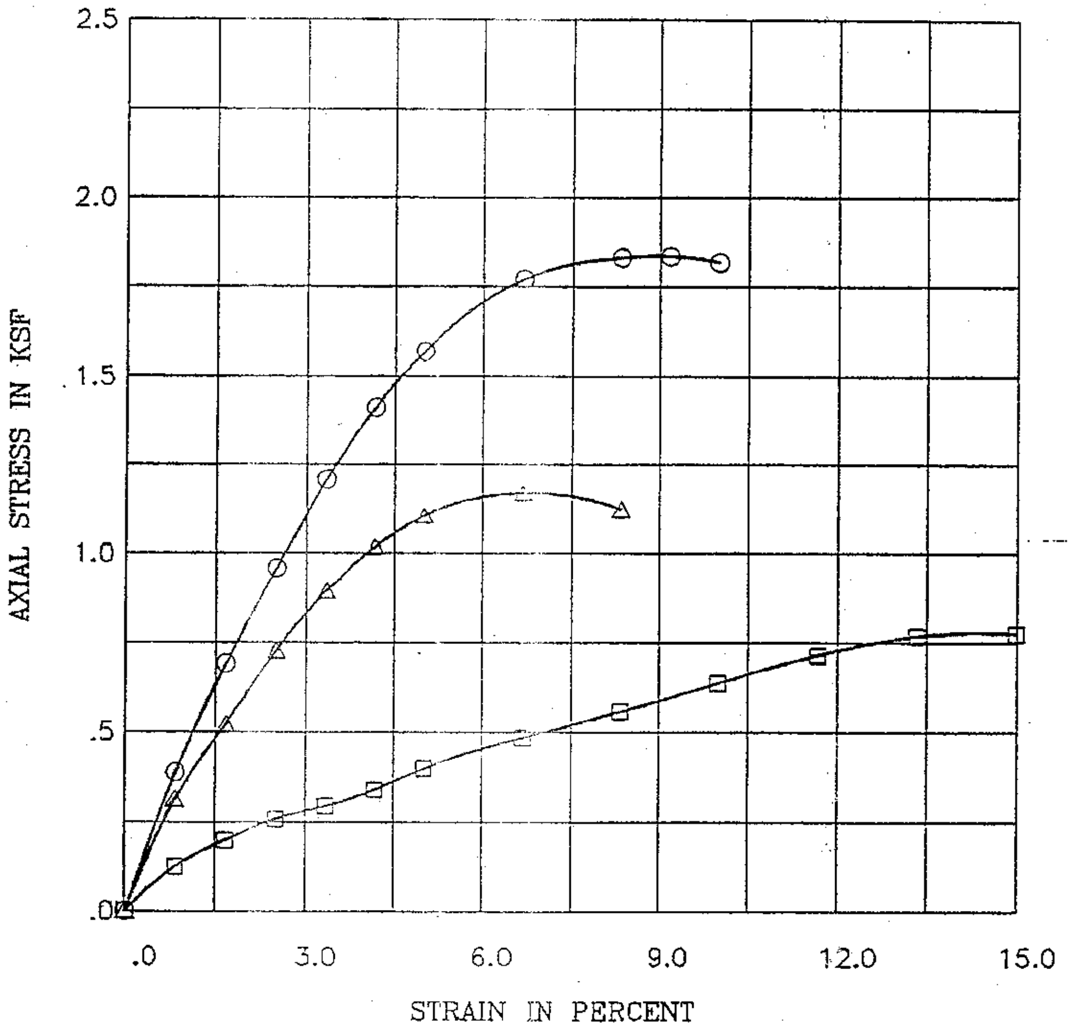
LIQUID LIMIT :

PLASTIC LIMIT :

	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	PERCENT SATURATION	VOID RATIO
INITIAL	71.6	56.7	96	2.075
FINAL	46.1	76.2	100	1.291

Remark : March 1991

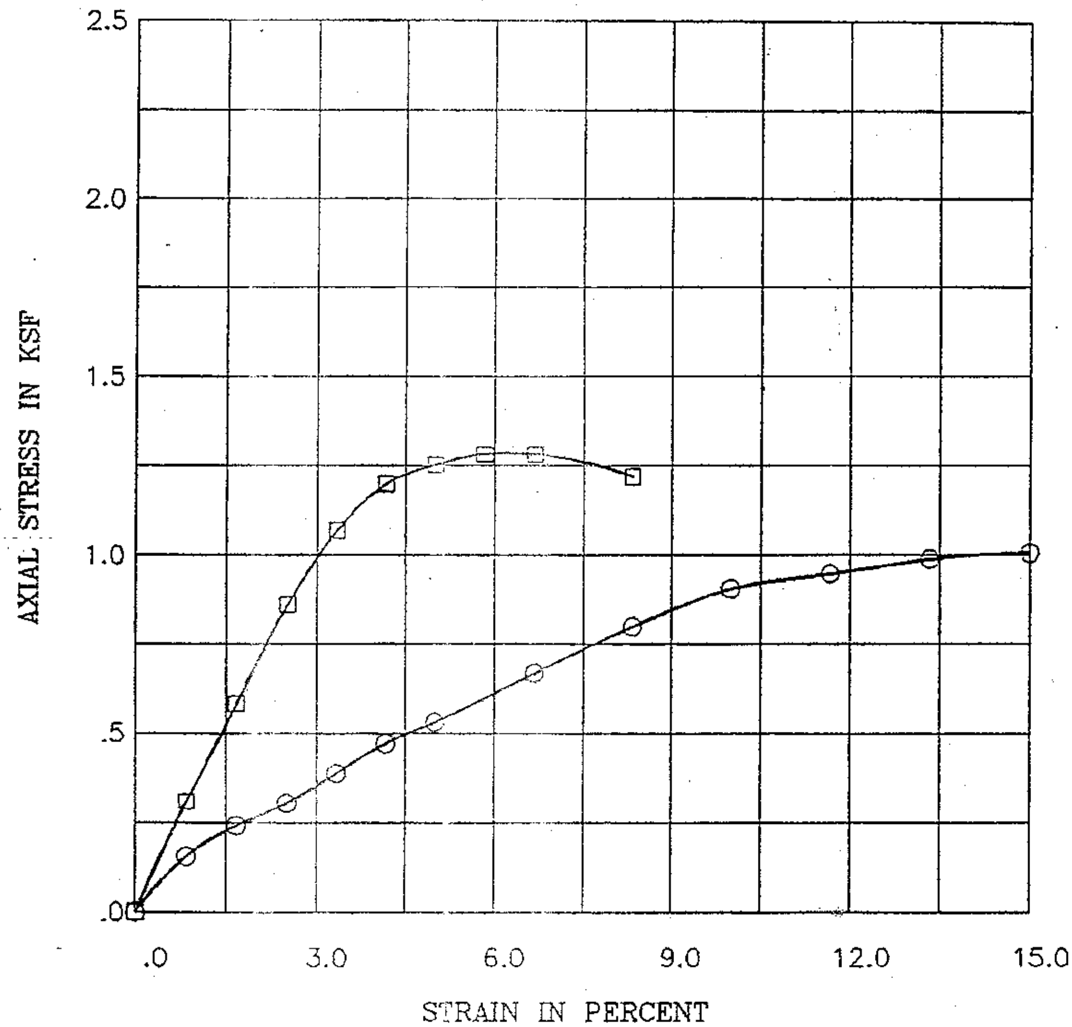
Project MBK-214A	King Island Levees	
Wahler Associates	CONSOLIDATION TEST	Figure No. B-5



SYMBOL	SAMPLE LOCATION	DEPTH (ft)	DESCRIPTION	PEAK STRESS (ksf)	AXIAL STRAIN (%)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)
○	B-1, S-5	13-15	clayey SILT, gray (MH)	1.8	9.0	53.6	66.2
□	B-1, S-8	20-22.5	clayey SILY, gray (MH)	.8	14.3	70.4	55.3
△	B-1, S-9	22.5-25	clayey SILT, gray (MH)	1.2	6.7	88.3	48.0

Remark : March 1991

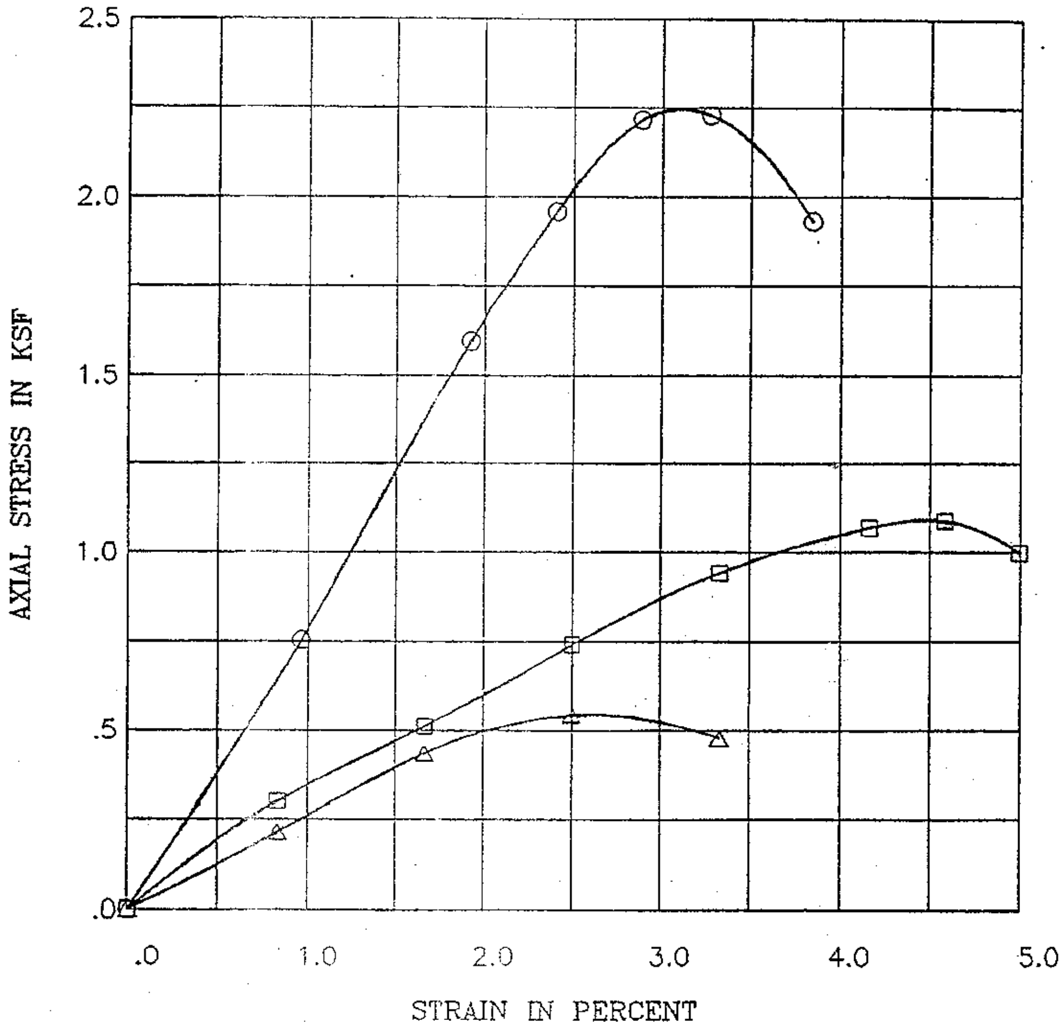
Project MBK-214A	King Island Levees
Wahler Associates	UNCONFINED COMPRESSION TEST **Figure No. B-6**



SYMBOL	SAMPLE LOCATION	DEPTH (ft)	DESCRIPTION	PEAK STRESS (ksf)	AXIAL STRAIN (%)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)
○	B-2, S-8	20-22.5	clayey SILT, gray (MH)	1.0	15.0	77.6	53.5
□	B-2, S-9	22.5-25	clayey SILT, gray (MH)	1.3	6.2	71.7	56.1

Remark : March 1991

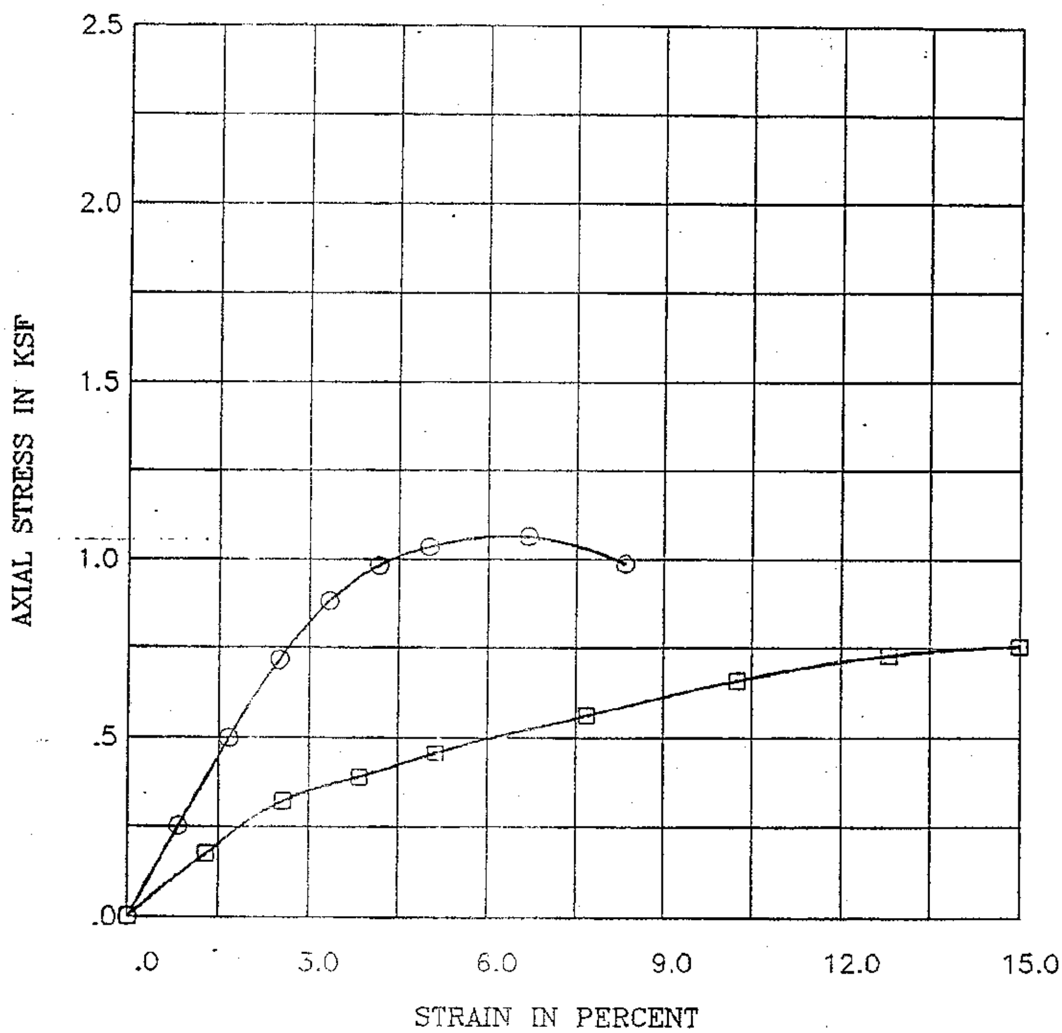
Project MBK-214A	King Island Levees
Wahler Associates	UNCONFINED COMPRESSION TEST **Figure No. B-7**



SYMBOL	SAMPLE LOCATION	DEPTH (ft)	DESCRIPTION	PEAK STRESS (ksf)	AXIAL STRAIN (%)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)
○	B-3, S-1	2.5-5	silty CLAY, yel brn (CL)	2.2	3.1	36.6	67.7
□	B-3, S-2	5-7.5	silty CLAY, yel brn (CL)	1.1	4.5	41.2	63.1
△	B-3, S-3	7.5-10	silty CLAY, yel brn (CL)	.5	2.7	55.0	65.3

Remark : March 1991

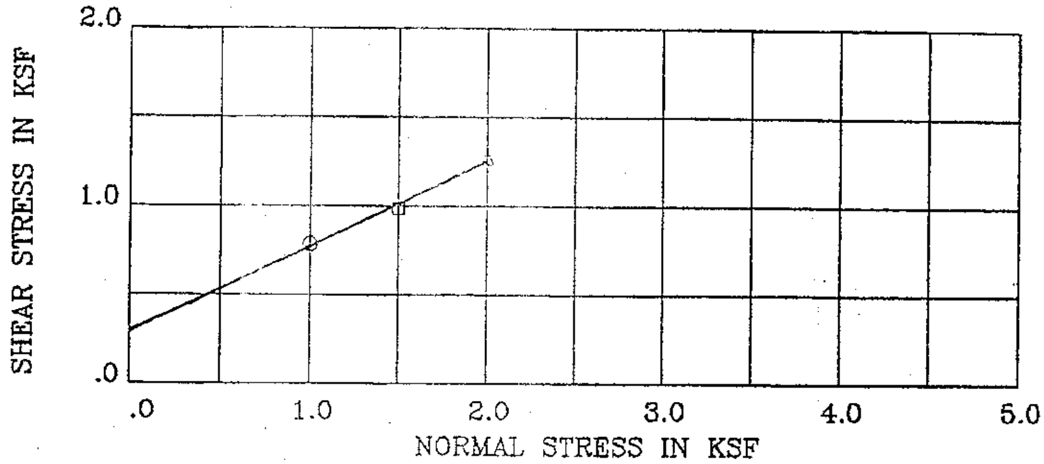
Project MBK-214A	King Island Levees
Wahler Associates	UNCONFINED COMPRESSION TEST **Figure No. B-8**

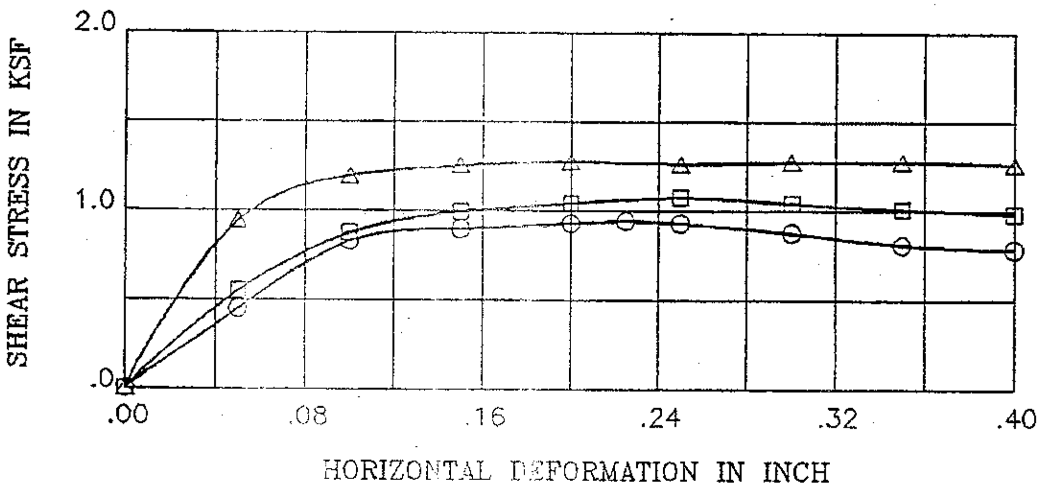


SYMBOL	SAMPLE LOCATION	DEPTH (ft)	DESCRIPTION	PEAK STRESS (ksf)	AXIAL STRAIN (%)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)
○	B-3, S-8	22.5-25	clayey SILT, gray (MH)	1.1	6.3	68.9	57.8
□	B-3, S-9	25-27.5	clayey SILT, gray (MH)	.8	15.0	74.4	56.2

Remark : March 1991

Project MBK-214A	King Island Levees
Wahler Associates	UNCONFINED COMPRESSION TEST **Figure No. B-9**





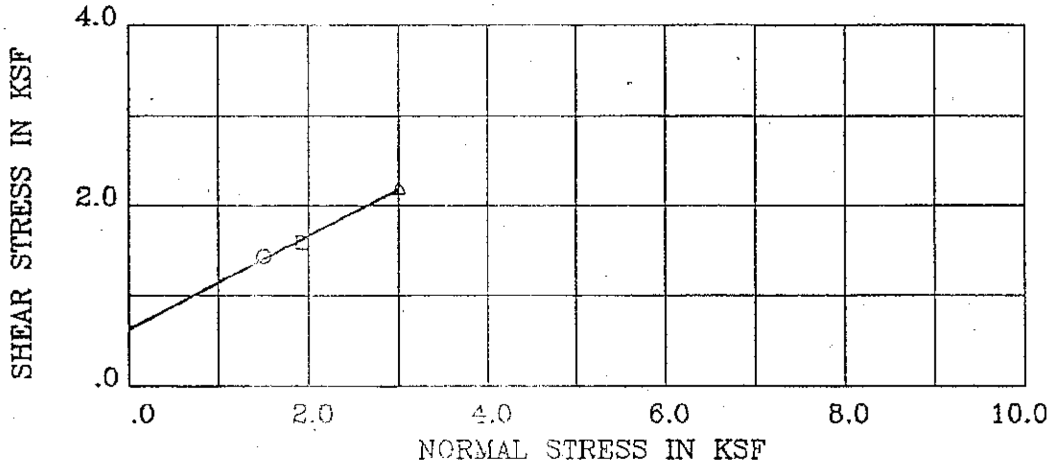
BORING/SAMPLE : B-1, S-4 DEPTH (ft) : 10-12.5
DESCRIPTION : sandy clayey SILT, yellow brown (ML)
STRENGTH INTERCEPT (C) : .289 KSF
FRICTION ANGLE (PHI) : 25.7 DEG

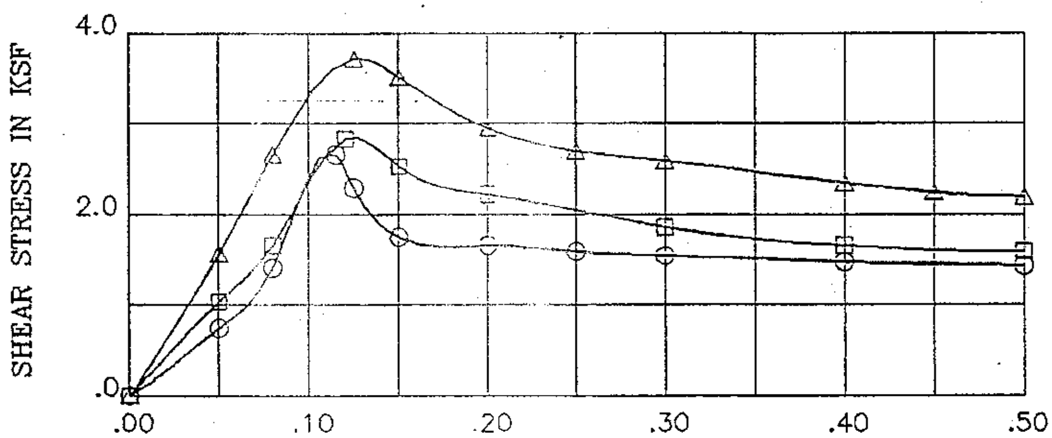
(RESIDUAL STRENGTH)

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	VOID RATIO	NORMAL STRESS (ksf)	PEAK SHEAR (ksf)	RESIDUAL SHEAR (ksf)
○	35.4	72.5	1.409	1.00	.94	.78
□	34.7	72.9	1.395	1.50	1.08	.99
△	31.8	76.6	1.260	2.00	1.28	1.27

Remark : March 1991

Project MBK-214A	King Island Levees
Wahler Associates	DIRECT SHEAR TEST Figure No. B-10



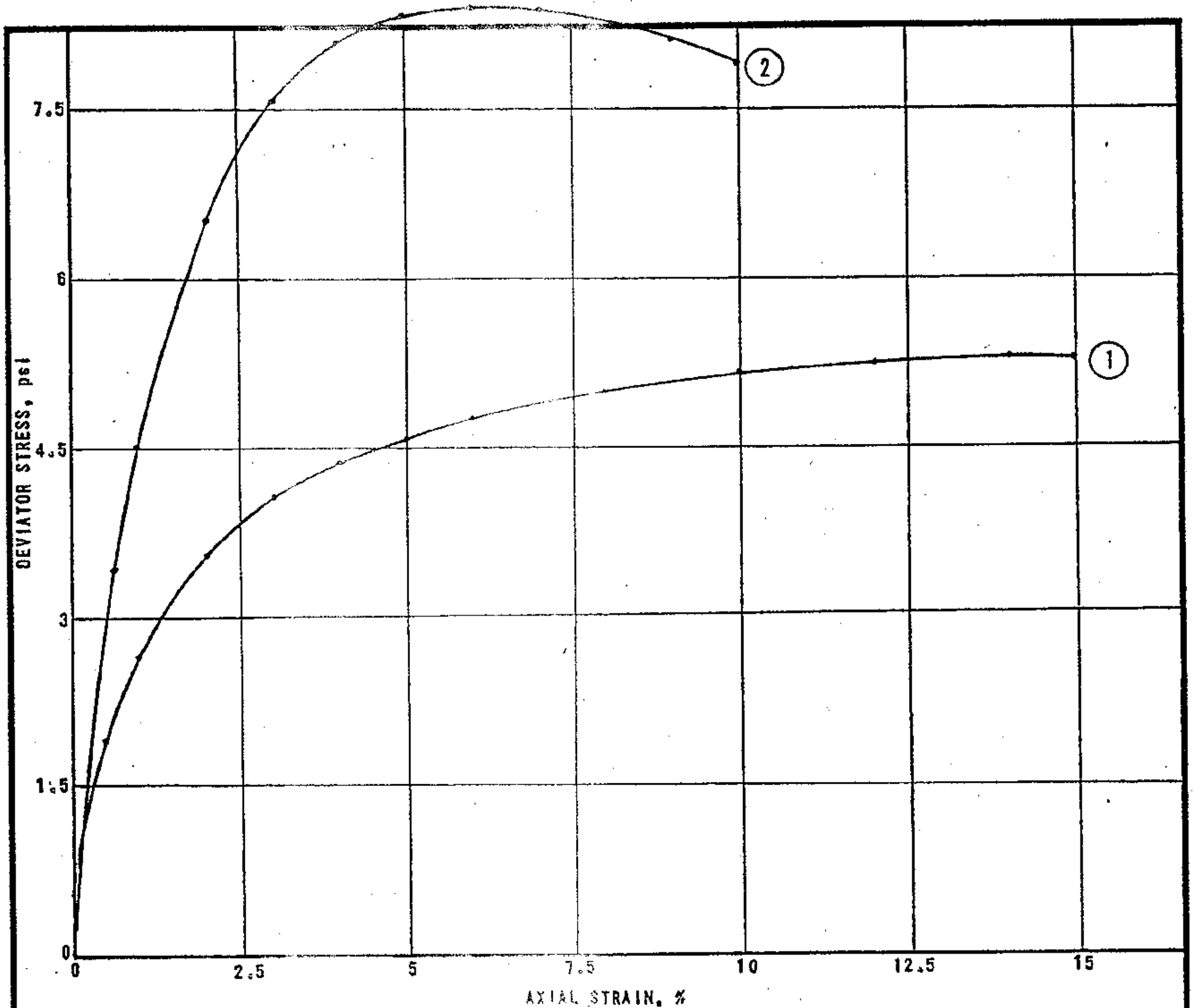


BORING/SAMPLE : B-1, S-11 DEPTH (ft) : 30-32.5
DESCRIPTION : silty SAND, blue gray (SM)
STRENGTH INTERCEPT (C) : .627 KSF
FRICTION ANGLE (PHI) : 27.4 DEG
(RESIDUAL STRENGTH)

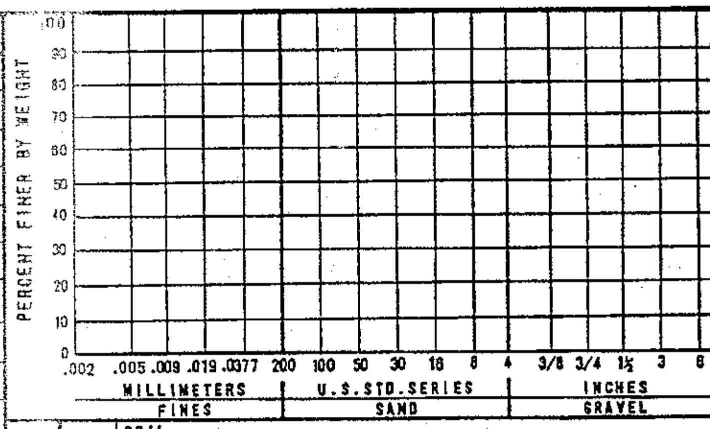
SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	VOID RATIO	NORMAL STRESS (ksf)	PEAK SHEAR (ksf)	RESIDUAL SHEAR (ksf)
○	18.7	109.3	.541	1.50	2.64	1.43
□	20.4	107.3	.570	1.93	2.83	1.59
△	19.0	109.2	.543	3.00	3.72	2.20

Remark : March 1991

Project MBK-214A	King Island Levees
Wahler Associates	DIRECT SHEAR TEST **Figure No. B-11**



SPECIMEN NO.		(1)	(2)	
INITIAL CONDITION	Water Content,%	72.6	75.1	
	Opt.Water Content,%	---	---	
	Dry Density,pcf	55.5	54.0	
	Max.Dry Density,pcf	---	---	
	Void Ratio	2.146	2.233	
	Saturation,%	95	95	
FINAL CONDITION	Consol.Pressure,psi	18.3	20.0	
	Water Content,%	---	---	
	Dry Density, pcf	---	---	
	Void Ratio	---	---	
	"B" Parameter	0.71	0.73	
GENERAL	Specimen Diameter,in	2.875	2.875	
	Back Pressure,psi	0	0	
	Test Time,hr	1.43	0.95	
	Rate of Strain,%/hr	10.5	10.5	



SYMB	MH	SOIL CLASSIFICATION CLAYEY SILT, GRAY
LL	---	
PL	---	SAMPLE LOCATION SPEC. #1: B-2, S-8, 20-22.5 FEET
PI	---	SPEC. #2: B-2, S-9, 22.5-25 FEET
SG	2.8 (est.)	NOTE: UNDISTURBED TUBE SPECIMENS

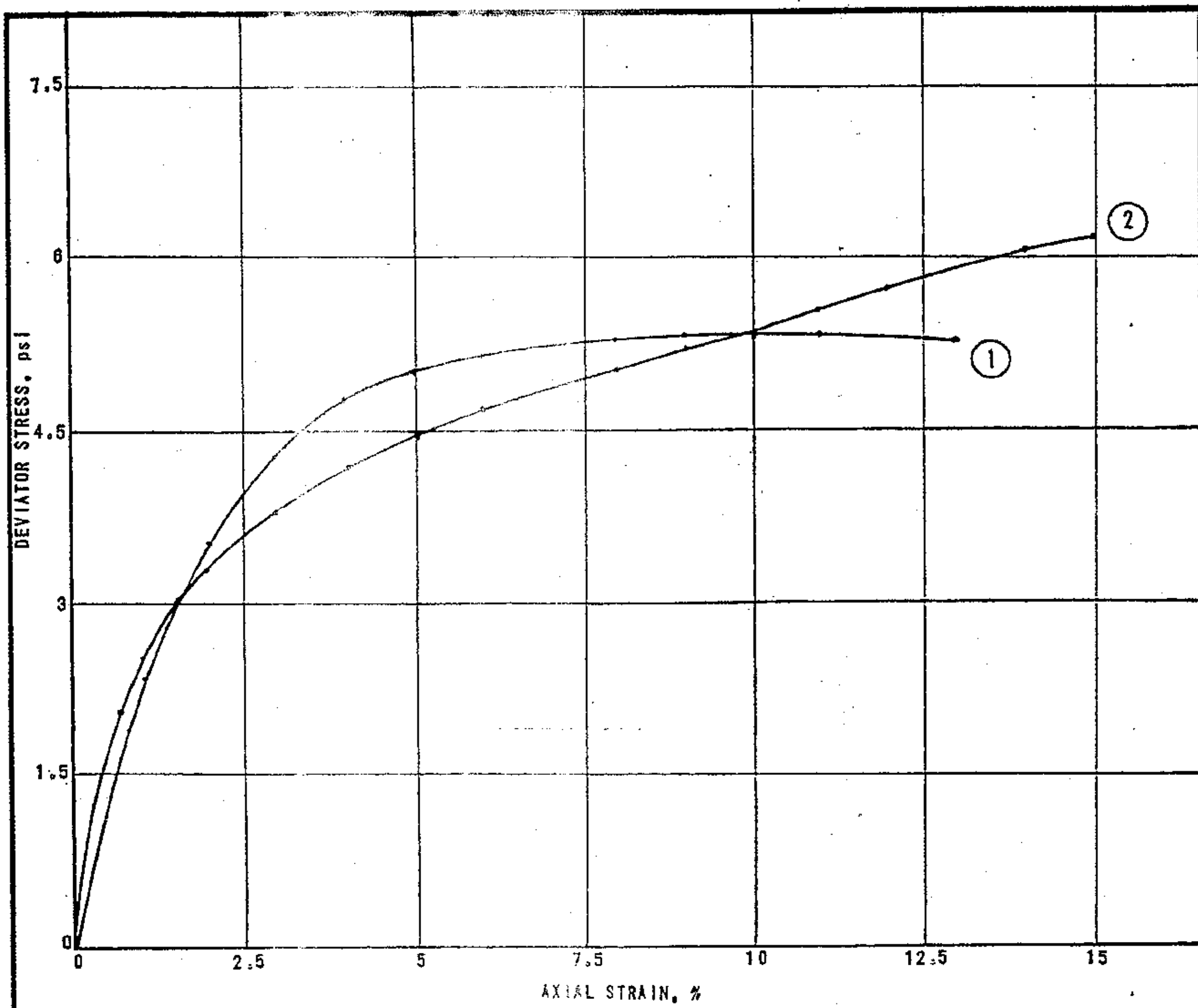
Wahler Associates

KING ISLAND LEVEES

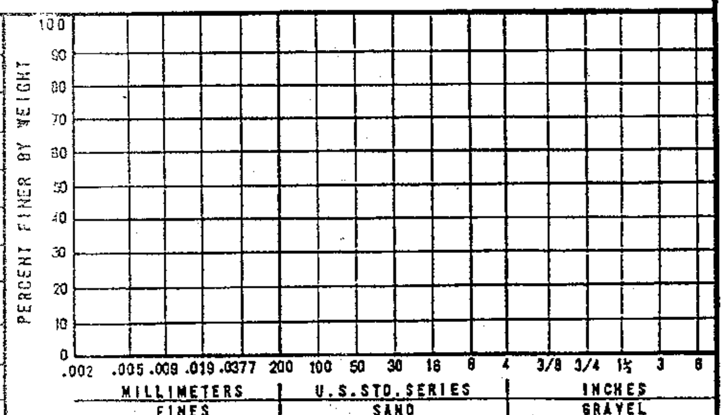
PALO ALTO • CALIFORNIA

TRIAXIAL TEST RESULTS
UNCONSOLIDATED UNDRAINED

PROJECT NO.	DATE	FIGURE NO.	HOLE NO., SAMPLE NO.
WBK-214A	MARCH 1991	B-12	B-2, S-8 & S-9



SPECIMEN NO.		1	2	
INITIAL CONDITION	Water Content,%	69.3	71.4	
	Opt.Water Content,%	---	---	
	Dry Density,pcf	57.2	57.9	
	Max.Dry Density,pcf	---	---	
	Void Ratio	2.055	2.016	
	Saturation,%	94	99	
FINAL CONDITION	Consol.Pressure,psi	20.0	21.7	
	Water Content,%	---	---	
	Dry Density, pcf	---	---	
	Void Ratio	---	---	
	"B" Parameter	0.91	0.52	
GENERAL	Specimen Diameter,in	2.875	2.875	
	Back Pressure,psi	0	0	
	Test Time,hr	1.25	1.43	
	Rate of Strain,%/hr	10.4	10.5	



SYMB	MH	SOIL CLASSIFICATION CLAYEY SILT, GRAY
LL	---	
PL	---	SAMPLE LOCATION SPEC. #1: B-3, S-8, 22.5-25 FEET
PI	---	SPEC. #2: B-3, S-9, 25-27.5 FEET
SG	2.8 (est.)	NOTE: UNDISTURBED TUBE SPECIMENS

Wahler Associates	KING ISLAND LEVEES	TRIAXIAL TEST RESULTS UNCONSOLIDATED UNDRAINED		HOLE NO., SAMPLE NO.
	PALO ALTO • CALIFORNIA	PROJECT NO.	DATE	FIGURE NO.
		MBK-214A	MARCH 1991	B-13

HOLE NO., SAMPLE NO. B-3, S-8 & S-9

Table B-19. Permeability:

Soil Type	Boring	Depth (ft)	Dry Density (pcf)	Water Content (%)		Permeability (cm/sec.)
Peat Vertical	B-26 V	4	31	150.8		2.13×10^{-6}
	B-36	5	10	546.4		7.54×10^{-7}
	B-37 V	11	9	657.8		9.66×10^{-7}
	B-44 V	10	13	413.1		1.83×10^{-7}
	B-48 V	5	16	326.3		1.52×10^{-6}
					AVG	1.11×10^{-6}
Peat Horizontal	B-26 H	4	11	533.8		1.51×10^{-6}
	B-37 H	11	11	531.3		1.86×10^{-6}
	B-44 H	10	8	770.7		2.59×10^{-6}
	B-48 H	20	13	420.8		8.84×10^{-7}
					AVG	1.71×10^{-6}
Organic Silt Vertical	B-36	15	23	221.7		5.73×10^{-7}
Soft Silt and Clay Vertical	B-48 V	20	80	41.6		3.11×10^{-6}
Soft Silt and Clay Horizontal	B-48 H	20	76	44.7		3.75×10^{-6}
Soft Silt and Clay Under Abutments Vertical	B-52	25	65	58.3		3.87×10^{-7}

Free field

Free field

State of California The Resources Agency

Memorandum

Date : February 16, 1994

Project Geology Branch
Report Number 80-10-05

To : Les Harder

From : Mark McQuilkin
Department of Water Resources

Subject: Delta Seismic Stability Study, Deep Hole Drilling Program; Completion of Phase I Geologic Exploration

Introduction

Phase I of the Delta Seismic Stability Study - Deep Hole Drilling Program has been completed. Work included drilling, sampling, and geophysical logging to depths of 300 feet at two sites (Bacon Island and Webb Tract) in the Delta (see Plate 1). This work was performed in response to your verbal request, and was defined in the following Memoranda from me to you:

May 19, 1993 Delta Seismic Stability Study, Deep Hole Program; Updated Information Regarding the Proposed Phase I Exploration Program

February 26, 1993 Delta Seismic Stability Study, Deep Hole Program; Proposed Phase I Exploration Program

April 21, 1992 Delta Seismicity, Proposal for Drilling Two Deep Exploration Holes to Determine the Depth to "Stiff" materials

Five progress reports were provided to you from Frank Glick with preliminary information regarding this work. The information in those reports (dated: July 9, 1993, July 16, 1993, August 4, 1993, August 6, 1993, and August 26, 1993) remain valid.

Field Investigations

The work was started on June 28, 1993, and was completed on August 18, 1993. The first exploration hole (DHP-1a) was drilled on the levee of Bacon Island (see Plates 1 and 2). The upper 35 feet of the hole was drilled with hollow stem augers. At a depth of 35 feet the augers were pulled and five-inch diameter PVC conductor casing was cemented in the hole. The remainder of the hole was drilled with standard mud rotary drilling equipment using bentonite drilling fluid. Standard Penetration Tests were performed and Shelby tube samples were taken every five to ten feet. This hole was abandoned at a

SURNAME | Peltier by Glick | [signature] | [illegible] depth of 150 feet due to excessive leakage of drilling fluid around the seal of the conductor casing.

A second (supplementary) hole (DHP-1b) was drilled at the Bacon Island site approximately 80 feet inland from the first hole. It was completed to the design depth of 300 feet. Both of these holes were surveyed with the OYO P-S Suspension Logging System prior to backfilling them with cement/bentonite grout.

Materials encountered in both holes at the Bacon Island location were primarily organic silts and clays to a depth of approximately 35 feet (excluding the levee materials in hole DHP-1a). Below the organic soils poorly graded sand was encountered to a depth of approximately 80 feet. From 80 feet to approximately 144 feet lean clay and silt was encountered. At approximately 144 feet a coarse-grained sand unit was encountered in hole DHP-1a and the drilling fluid circulation was lost. Repeated attempts were made to reestablish circulation. However, these efforts apparently contributed to the degradation of the surface seal and ultimately required abandonment of the hole. The supplementary hole (DHP-1b) also encountered a coarse material at approximately the same depth, however, there was no loss of circulation. Interbedded lean clay and poorly graded sand was encountered for the remainder of hole DHP-1b. Detailed logs of the drill holes are attached in Appendix A. The results of the downhole geophysical logging are attached in Appendix B.

The second deep hole site was located on a levee on Webb Tract (see Plate 1 only). This site was only accessible by ferry boat which operated on Mondays, Tuesdays and Fridays. The hole (DHP-2) was drilled with hollow stem augers to a depth of 70 feet. At 70 feet the augers were removed and a six-inch diameter PVC conductor casing was cemented in the hole to a depth of 66 feet. The remainder of the hole was drilled with mud rotary drilling equipment using bentonite drilling fluid to the design depth of 300 feet. Standard Penetration Tests were performed and Shelby tube samples were taken every five to ten feet. After completion, the hole was surveyed with the OYO apparatus and then backfilled with cement/bentonite grout.

Materials encountered in DHP-2 began with 14 feet of embankment material. Peat was then encountered to a depth of 36 feet. Below the peat, the drill hole encountered a succession of poorly graded sands, silts, and silty sands to a depth of 90 feet. Lean clay was encountered from 90 to 160 feet. The remainder of the hole was dominated by silt with lesser amounts of poorly graded sand, silty sand, and clay. A detailed log of the drill hole is attached in Appendix A. The results of the downhole geophysical logging are attached in Appendix B.

Organic soils were logged in the field according to the Project Geology Branch standards.

All Shelby tube samples from both sites were delivered to the Department's Bryte Soils Laboratory. Testing, if any, was requested by Civil Design personnel.

Geophysical Logging

Geophysical logging was conducted with the OYO Suspension P-S Logging System. Details regarding this equipment and the results of the geophysical logging at both sites are included in the report and letters by Agbabian Associates in Appendix B.

Please call Frank Glick at 653-9624 if you have any questions.

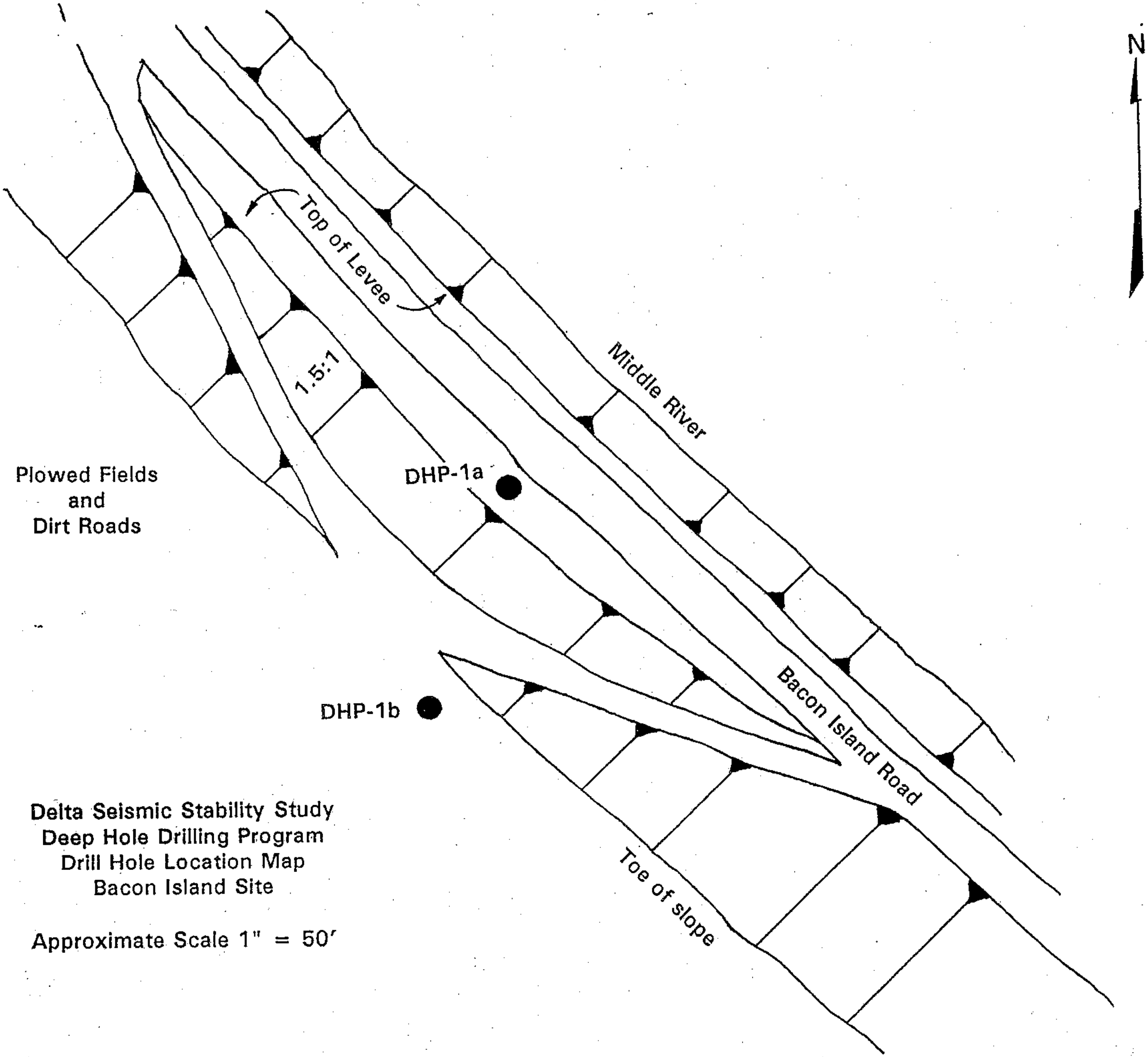
Attachments

c:\wpwin\delta\deep1.rpt

PLATES

APPENDIX A

DRILL HOLE LOGS



Delta Seismic Stability Study
Deep Hole Drilling Program
Drill Hole Location Map
Bacon Island Site

Approximate Scale 1" = 50′

Plate 2

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 1 of 9
HOLE NO. DHP-1a
ELEV. 8' (topo) FEET
DEPTH 159.0' FEET

PROJECT Delta Seismic Stability Study
DATE DRILLED 6/24-7/7/93
FEATURE Deep Hole Program
ATTITUDE Vertical
LOCATION Bacon Island; 800 ft. N. of the Middle River Bridge
LOGGED BY T. Peltier
CONTR. P.C. Exploration, Inc. DRILL RIG Mobile B-53
DEPTH TO WATER 20.3'

AD = Auger drilling, 8" hollow stem
P = Push Shelby Tube (3" diameter)
DR = Drive Standard Penetration Test Sampler w/sandline and downhole hammer 1.5" ID SPT barrel 1-3/8" tip
HQ = Drilling with HQ size rods and bentonite drilling fluid

Note: 0.0-35.0' SPT was driven with sandline and down-hole hammer from 35.0-300', S was attached to "A" rods driven from above.

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0		"LEVEE EMBANKMENT" (FILL) 0.0 - 2.0' Silty Sand With Gravel: Dark brown, nonplastic, 20% fines, 50% sand, 30% gravel to 1/2" size.			Begin drilling with 8" hollow stem auger w/center bit.
2.0	SM	2.0 - 13.0' Poorly Graded Sand: Light brown, nonplastic, moist, 95% fine to very fine sand, 5% fines, micaceous.		AD	
4.0		As above, loose, with minor organics in pods and lenses.			
			S-1	P 2.0/2.0	Push Shelby tube, 5.0-7.0'.
6.0	SP	Note regarding sampling numbering: The first interval sampled has the number "1", regardless of the method of sampling (S = sample is in a Shelby tube; B = sample is in a Bag), and so on.			
			B-1	DR 1.0/1.5	Drive SPT 7.0-8.5' 1/.5, 2/.5, 2/.5.
8.0					
				AD	
10.0			S-2	P 0.25/2.5	Push Shelby Tube 10.0-12.5'.
12.0		As above with rust mottling and some lamination.			
		13.0 - 21.0' Organic Soil: Dark gray, slight plasticity, very moist to wet, very soft, micaceous, 90% organic fines, 10% fine sand and silt. Rapid dilatancy, low dry strength.	B-2 B-2a	DR 1.5/1.5	Drive SPT 12.5-14.0' 1/.5, 1/.5, 1/.5.
14.0	OL				
				AD	
			S-3	P 2.5	Push Shelby Tube 15.0-17.5'

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 2 OF 9

HOLE NO. DHP-1a

PROJECT & FEATURE Delta Seismic Stability Stucy; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0		13.0 - 21.0' Organic Soil: (Cont'd) As above, with minor peat, some plant fragments identifiable, wet.	S-3	P 2.5/2.5	Push Shelby tube (Cont'd)
18.0			B-3	DR 1.5/1.5	Drive SPT 17.5-19.0'. 2/.5, 3/.5, 4/.5.
	OL			AD	
20.0		"QUATERNARY ALLUVIUM"			
		21.0 - 28.5' Peat: Dark brown fibrous organic matter, wet. Many large plant fragments. Large plant fragments up to 60%.	S-4	P 2.5/2.5	Push Shelby tube, 20.0-22.5'. Soil type changes somewhere in this Shelby tube.
22.0					
	PT		B-4	DR 1.5/1.5	Drive SPT 22.5-24.0'. 2/.5, 2/.5, 4/.5.
24.0					
				AD	
26.0			S-5	P 2.5/2.5	Push Shelby tube, 25.0-27.5'.
		As above, becoming finer textured, black.			
28.0		28.5 - 35.0' Organic Silt: Dark gray to black, slight plasticity, wet. Abundant mica, trace of fine sand. Moderate dilatancy; medium dry strength.	B-5	DR 1.2/1.5	Drive SPT 27.5-29.0', 2/.5, 3/.5, 2/.5.
				AD	
30.0	OL		S-6	P 2.0/2.5	Push Shelby Tube, 30.0-32.5'. 6" of slough in Shelby tube.
32.0		As above, becoming slightly higher in fine sand. < 5%.			
			B-6	DR 1.5/1.5	Drive SPT 32.5-34.0', 1/.5, 1/.5, 1/.5.
34.0					
				AD	
		35.0 - 80.5' Poorly Graded Sand: Dark gray, loose, nonplastic. 5% fines, 95% fine sand.	S-7	P 1.5	At 35.0' augers fell 1.5', Water standing in hole.
36.0	SP				

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

HOLE NO. DHP-1a

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
36.0	SP	35.0 - 80.5' <u>Poorly Graded Sand:</u> (Cont'd)	S-7	P 1.5/1.5	Continue pushing Shelby tube. Could not push more than 1.5'. Could not run SPT due to running sand. At 35' pulled augers. Set 6" ID PVC casing to 37', cemented annular space. End shift. 6-30-93 Water level 20.3' begin rotary drilling with HQ rods "Scotty Bit" and bentonite drilling fluid.
38.0				HQ	
40.0		As above, found 1.5" long piece of steel bar in sample? Very rusty and weathered, not from our drilling activities.	B-8	P 0.0/1.0 DR 0.7/2.5	Push Shelby tube 40.0-41.0'. No recovery-sand. Drive SPT 40.0-41.5', 13/.5, 26/.5, 30/.5. These blow counts are suspect due to sand in the hammer. Had driller clean out hammer.
42.0	SP			HQ	
44.0		As above, dark gray with abundant mica.			
46.0			B-9	DR 0.8/1.5	Drive SPT 45.0-46.5', 5/.5, 9/.5, 11/.5.
48.0	SP			HQ	
50.0		As above, becoming medium grained, locally has thin (<1/4") stringers of light gray clay.	B-9	P 0.0/2.0 DR 0.9/1.5	Push Shelby tube 50.0-52.0', no recovery. Drive SPT 50.0-51.5', 3/.5, 3/.5, 5/.5.
52.0				HQ	
54.0					
56.0	PT OL	As above, becoming coarse grained. Two peat and organic clay layers at 55.2 and 55.6'. Layers are 1" and 2" thi	B-10	DR 1.5/1.5	Drive SPT 55.0-56.5', 8/.5, 15/.5, 16/.5

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

SHEET 4 OF 9

HOLE NO. DHP-1a

PROJECT & FEATURE Delta Seismic Stability Stucy; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
56.0		35.0 - 80.5' Poorly Graded Sand: (Cont'd)	B-10	DR/1.5	Drive SPT (Cont'd)
				HQ	
58.0	SP				
60.0		As above, medium to coarse grained.		P 0.0/2.0	Attempted shelby tube 60.0-62.0'. No recovery. Drove SPT 60.0-61.5', 7/.5, 11/.5, 13/.5.
			B-11	DR 1.0/1.5	
62.0					
64.0				HQ	
		As above, fine grained. 1" thick fine gravel bed at 65.2'.			
	GP		B-12	DR 1.0/1.5	Drive SPT 65.0-66.5', 12/.5, 16/.5, 17/.5.
66.0					
68.0				HQ	
	SP				
70.0				P 0.0/1.5	Attempted Shelby sample. Pushed 1.0' to refusal. No recovery. Drilled to 71.0', Drive SPT 71.0-72.5', 10/.5, 23/.5, 18/.5.
		As above, locally coarse grained.	B-13	DR 1.0/2.5	
72.0					
74.0				HQ	
			B-14	DR 1.2/1.5	Drive SPT 75.0-76.5', 17/.5, 24/.5, 25/.5
76.0					

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 5 OF 9

HOLE NO. DHP-1a

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
76.0	SP	35.0 - 80.5' Poorly Graded Sand: (Cont'd)	B-14	DR 1.2/1.5	Drive SPT (Cont'd)
78.0				HQ	
80.0	CL	80.5 - 110.0' Lean Clay: Light gray, stiff, medium plasticity, wet, micaceous. Slow dilatancy, high dry strength.		DR 0.0/1.5	Drive SPT 80.0-81.5', 4/.5, 1/1.0. No recovery, traces of sand in SPT.
82.0				HQ	Driller reports change in drilling after sample. Change in soil type probably was at 80.5' where sampler sunk 1.0 ft. with 1 blow.
84.0					
86.0	CL		B-15	DR 1.0/1.5	Drive SPT 85.0-86.5', 3/.5, 5/.5, 9/.5.
88.0				HQ	Slower drilling.
90.0		As above, blue-gray, slow dilatancy, high dry strength.	S-16	P 1.7/2.0	Push Shelby tube, 90.0-92.0'.
92.0		As above, moist, very stiff. Root at 92.5 partially replaced with pyrite.	B-16	DR 1.5/1.5	Drive SPT 92.0-93.5'. 6/.5, 10/.5, 15/.5.
94.0				HQ	
		As above, becoming slightly sandy, locally grades to silty sand. Trace of peat in drive shoe	B-17	DR 1.2/1.5	Drive SPT 95.0-96.5'.

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

HOLE NO. DHP-1a

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
96.0		80.5 - 110.0' Lean Clay: (Cont'd)	B-17	DR	Continue driving SPT.
98.0				HQ	
100.0	CL			P 0.0/2.0	Push Shelby Tube 100.0-102.0'. No recovery.
102.0					
104.0					
106.0				HQ	
108.0					
110.0			B-18	DR 1.4/1.5	Drive SPT 110-111.5'. 8/.5, 8/.5, 8/.5.
112.0	ML	110.1 - 120.0' Silt: Gray green low plasticity, firm, moist. Quick dilatancy, medium dry strength, micaceous, 95% fines, 5% fine sand. Locally grades to sandy silt.			
114.0				HQ	
116.0					

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 7 OF 9

HOLE NO. DHP-1a

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
116.0		110.0 - 120.0' Silt: (Cont'd)			Continue rotary drilling with HQ size rods and bentonite drilling fluid.
				HQ	
118.0	ML				
120.0		120.0 - 140.0' Lean Clay: Similar to CL at 80.5-110.0'.	S-19	P 2.0/2.0	Push Shelby tube, 120.0-122.0'.
122.0			B-19	DR 1.5/1.5	Drive SPT 122.0-123.5'. 5/.5, 5/.5, 7/.5 End shift.
124.0					
126.0				HQ	
	CL				
128.0					
130.0		As above, locally grades to Silt.	B-20	DR 1.5/1.5	Drive SPT 130.0-131.5'. 5/.5, 6/.5, 6/.5.
132.0					
134.0				HQ	

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

SHEET 8 OF 9

HOLE NO: DHP-1a

PROJECT & FEATURE Delta Seismic Stability Study, Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
136.0	CL	120.0 - 140.0 Lean Clay: (Cont'd)		HQ	Continue rotary drilling with HQ size rods and bentonite drilling fluid.
138.0					
140.0	CH	140.0 - 144.0' Fat Clay: Dark greenish gray, high plasticity, stiff. No dilatancy, high dry strength. No Mica.	S-21	P 2.0/2.0	Push Shelby tube, 140.0-142.0'.
142.0			B-21	DR 1.5/1.5	Drive SPT 142.0-143.5'. 5/.5, 6/.5, 8/.5.
144.0	SP	144.0 - 148.0' Poorly Graded Sand: No sample obtained, logged from cuttings, coarse grained.		HQ	At 144' The hole started taking water. Driller says this may be due to a "collar" of clay forcing fluid into formation. Pulled rods, few grains of coarse sand on inside of bit. Mixed thick bentonite. Drilled to 145', lost circulation. End Shift.
146.0					
148.0	CH	148.0 - 153.0' Fat Clay: Similar to CH at 140-144'. Trace of peat at top of sample.			
150.0			B-22	DR 1.5/1.5	Drive SPT 150.0-151.5', 4/.5, 6/.5, 8/.5.
152.0					
153.0	SP	153.0 - 159.0' Poorly Graded Sand: Similar to sand at 144.0-148.0'.		HQ	At 153.0' hole starts taking water. When pump stops, fluid drains down hole, indicating this is not due to a "collar". Hole took approx. 900 gals. of fluid. At 155' added paper pulp to improve circulation.
154.0					

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 9 OF 9

HOLE NO. DHP-1a

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
156.0		153.0 - 159.0' Poorly Graded Sand: (Cont'd)			Continue HQ drilling.
				HQ	
158.0	SP				
159.0					
		T.D. - 159.0' on 7/6/93			Hole terminated at 159.0' because drilling mud surfaced around casing and in small crack in ground surface. Hole was geophysically logged with OYO PS suspension logger and then backfilled by tremie method with cement-bentonite grout on 7/7/93.

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

HOLE NO. DHP-1b

ELEV. -10' (topo); 17.5' lower than DHP-1a

DEPTH 301.5 FEET

PROJECT Delta Seismic Stability Study

DATE DRILLED 8/3-13/93

FEATURE Deep Hole Program

ATTITUDE Vertical

LOCATION Bacon Island, Approx. 800' N. of drawbridge, 100' W. of / Centerline

LOGGED BY T. Peltier/S. Killingsworth

CONTR. P.C. Exploration, Inc. DRILL RIG Mobile B-53

DEPTH TO WATER 5.7'(static) 8/16/93

AD = Auger drilling with 8" hollow stem auger.
HQ = Rotary drilling with HQ size rods and "Scotty bit" with bentonite drilling fluid.
DR = Hole advanced by drilling Standard Penetration sampler on AW rods.
P = Hole advanced by pushing 3" diameter Shelby Tube.

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0		"QUATERNARY ALLUVIUM" 0.0 - 11.0' Peat: Dark brown, decomposed plant matter. Logged from cuttings.		AD	Begin by Auger drilling with 8" hollow stem auger. No samples taken for first 130'. At 130.0' began SPT sampling with split-tube barrel w/inside diameter of 1-3/8"; shoe has I.D. of 1-3/8". CME automatic 140-lb. hammer used w/drop of 30 inches.
2.0					
4.0	PT				
6.0				AD	
		Becoming wet at 7.0'.			
8.0					
10.0					
		11.0 - 17.5' Organic Silt: Gray, slight plasticity, micaceous, 90% fines, 10% fine sand. Lithology from log for DHP-1a.		AD	
12.0					
14.0	OL				

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

SHEET 2 OF 11
HOLE NO. DHP-1b

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0	OL	11.0 - 17.5' Organic Silt: (Cont'd)		AD	Continue auger drilling with 8" hollow stem augers.
18.0	SP	17.5 - 63.0' Poorly Graded Sand: Lithology from log for DHP-1a. (See log for DHP-1a for lithology between 20' and 130').			
20.0				HQ	At 20.0' pulled augers and set 20' of 5" PVC casing. Switched to rotary drilling with HQ size rods and Scotty bit using bentonite drilling gluid.
22.0					
24.0					Slow drilling from 100' to 115'. End shift at 115.0'.
26.0					8/5/93. Continue rotary drilling to 130'.
28.0	SP				At 130.0' sent down SPT. SPT would only go to 120'. SPT had 1' of dense silt inside. Pulled drill rods, rods came up empty. Redrilled to 130.0'.
130.0		Note break in scale.			
	CH	130.0 - 150.0' Fat Clay: Greenish gray, high plasticity, stiff, moist. No dilatancy. Minor partings of peat.	B-1	DR 1.0/1.5	Drive SPT 130.0-131.5' 3/.5, 6/.5, 10/.5.
132.0				HQ	Coarse sand appeared in cuttings while drilling between 130.0 and 135.0'.
134.0					

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

HOLE NO. DHP-1b

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
136.0	CH	130.0 - 150.0' Fat Clay: (Cont'd)		HQ	Continue rotary drilling with HQ rods and "Scotty" bit using bentonite drilling fluid.
138.0			S-2	P 2.0/2.0	Push Shelby tube 138.0-140.0'.
140.0		As above, locally grades to lean clay. Approximately 5% fine sand.	B-2	DR 1.5/1.5	Drive SPT 140.0-141.5'. 14/.5, 19/.5, 19/.5.
142.0				HQ	Drilling rate varies slow to fast from 142-150'.
144.0		Possible gravel zone 145.0-145.5'.			Drilling chatter 145.0 to 145.5' (possible gravel).
146.0	CH				
148.0		Possible gravel zone 148.0-148.5'.			Drill rig chatter 148.0 to 148.5'.
150.0	CL	150.0 - 161.0' Lean Clay: Mottled gray and light brown, medium plasticity, stiff, moist. Slow dilatancy, medium to high dry strength.	B-3	DR 1.5/1.5	Drive SPT 150.0-151.5', 7/.5, 16/.5, 17/.5.
152.0				HQ	
154.0					
156.0					

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

HOLE NO. DHP-1b

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
156.0		150.0 - 161.0' Lean Clay: (Cont'd)			Continue rotary drilling with HQ size rods using bentonite drilling fluid.
158.0	CL			HQ	
160.0			S-4	P 1.8/2.0	Push Shelby tube 160.0-162.0'. Material changes in Shelby tube.
		161.0 - 181.0' Poorly Graded Sand: Gray, nonplastic, dense to very dense, wet. 90 to 100% fine sand, 0 to 10% fines. Locally grades to poorly graded sand with silt.			
162.0	SP		B-4	DR 1.0/1.5	End shift. 8/6/93 Drive SPT 162.0-163.5', 17/.5, 32/.5, 50/.5. Fast drilling from 160' to 164'.
164.0		Possible clay zone 164-166'.			Slows down at 164'. Faster drilling at 166'.
166.0				HQ	
168.0					
170.0		As above, becoming coarse grained with fewer fines.	B-5	DR 0.5/1.0	Drive SPT 170.0-171.0', 18/.5, 50/.5, (Refusal).
172.0	SP				
174.0				HQ	
176.0					

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 5 OF 11

HOLE NO. DHP-1b

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
176.0	SP	161.0 - 181.0' Poorly Graded Sand: (Cont'd)			Continue rotary drilling with HQ size rods and "Scotty" bit with bentonite drilling fluid.
178.0				HQ	Fast drilling from 170' to 180'. Did not run Shelby Tube at this sample interval because we have not been getting recovery in sand.
180.0			B-6	DR 1.4/1.5	Drive SPT 180.0-181.5', 21/.5, 23/.5, 16/.5.
	CL	181.0 - 220.0' Lean Clay: Similar to lean clay at 150.0-161.0', color is greenish gray.			Change of material in sampler. End of Shift.
182.0	CL				8/9/93: Back pressure in hole. No circulation. Hole "blows out" at surface, leaking fluid from several boils. Rods pulled.
184.0				HQ	20' PVC 5" casing pulled. 20' added; hole then cased to 38.6' (40' PVC w/1.4' s/u). Resumed drilling at 180.0'. Much med. to coarse sand (from higher in hole) in cuttings. End shift. 184.5'.
186.0					
188.0					8/10/93 - 95% drill fluid return. Med. sand in cuttings. Drilling slow through clay.
190.0	CL	Stiff to very stiff, contains trace of fine sand.	B-7	DR 1.5/1.5	Drive SPT 190.0-191.5' 8/.5, 13/.5, 16/.5.
192.0					70% drill fluid return. Fluid leaked out into formation and onto ground surface near hole through small boils; hole then sealed itself.
194.0				HQ	

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 6 OF 11

HOLE NO. DHP-1b

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
196.0		181.0 - 220.0' Lean Clay: (Cont'd)			
198.0	CL			HQ	198.0' Drill fluid leaks again at surface boils. Drilled to 200.0' to sample. Back pressure forces fluid out through opened rod for several minutes.
200.0		200.0-202.0' Becomes slightly more plastic, to medium-to-high, then returns to medium.	S-5 (S-8)	P 1.8/2.0	Push Shelby tube 200-202'. Tube difficult to pull up; sticks at bottom of hole.
202.0		Contains trace of mica.	B-8	DR 1.5/1.5	Drive SPT 202.0-203.5', 9/.5, 12/.5, 15/.5. 202.0' about 70% drill fluid return. No leaks at surface. Drilling slow.
204.0					
206.0	CL			HQ	
208.0					About 75-80% drill fluid return.
210.0		Same as above, but with high dry strength.	B-9	DR 1.5/1.5	Drive SPT 210.0-211.5', 7/.5, 15/.5, 20/.5.
212.0	CL			HQ	Drilling slow. 80-90% drill water return.
214.0					
216.0					

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 7 OF 11

HOLE NO. DHP-1b

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
216.0	CL	181.0 - 220.0' Lean Clay: (Cont'd)		HQ	220.0' End of Shift. 8/11/93 Poor circulation in hole (Driller says "collar" of material around rod). Rods pulled to 20' and put back down. Fluid leaks through fracture at ground surface, then stops. 80% drill fluid return.
218.0					
220.0	CH	220.0 - 221.0' Fat Clay: Olive, moist, stiff, high plasticity, no dilatancy, low toughness, high dry strength.	S-6 (S-10)	P 1.8/2.0	Push Shelby Tube 220.0-222.0'.
	CL	221.0 - 222.0' Sandy Clay: Gray, wet, stiff, medium plasticity, slow dilatancy, low toughness, contains 20% fine to medium sand, medium dry strength.			
222.0	SP-SM	222.0 - 222.5' Sand With Silt: Olive, fine to medium grained, noncohesive, approximate 10% nonplastic fines (silt), slow dilatancy, loose, wet, angular to subround.	B-10	DR 1.3/1.5	Drive SPT 222.0-223.5'. 6/.5, 7/.5, 17/.5. Change of material in sampler.
224.0	CL	222.5 - 230.0' Lean Clay: Similar to lean clay from 181.0 to 220.0'; gray, moderate plasticity, medium toughness, stiff, moist, no dilatancy; contains 5% fine sand; medium dry strength.		HQ	Fluid leaks at ground surface then stops. 90% fluid return.
226.0					Drilling slow.
228.0	CL				
230.0	SP	230.0 - 260.0' Poorly Graded Sand: Gray, wet, slow dilatancy, medium grained, angular to subround, very dense, noncohesive, contains 5% nonplastic fines.	B-11	DR 0.5/1.0	Drive SPT 230.0-231.0', 41/.5, 50 for 5" (refusal).
232.0				HQ	Drilling slow. 90% drill fluid return.
234.0					

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 8 OF 11

HOLE NO. DHP-1b

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
236.0		230.0 - 260.0' Poorly Graded Sand: (Cont'd)			
				HQ	Drilling slow.
238.0					
240.0	SP	240.0' Fine grained sand, otherwise same as above. Micaceous.			
				P	Attempted to push Shelby Tube at 240.0'. Would not push. Only 1" of sample recovered.
			B-12	DR	Attempted to drive SPT at at 240.2. 6 for 4", then sampler slid down hole due to heaving sand. Sampler pulled; 0.2' recovered.
242.0				HQ	Drilling slow. 90% fluid return. 243.0', end of shift.
244.0					8/12/93 Rods 20' off the bottom. Back pressure forces much fluid out top of opened rod. Rods pulled up 80'. Poor circulation. Back on bottom, poor circulation. Fracture at ground surface lengthens to 15', 15-20 gal. fluid leaks out. Rods pulled. Rods back down to drill ahead with lower mud pressure and sample SPT's only at 260', 280', and 300'. Circulation improves as rods go back down; surface leakage stops. Mud hose at top of Kelly rod blows out when about 20' off the bottom; replaced. Fluid seeps intermittently from small boils at ground surface, then stops. Drilling slow. About 80% drill fluid return.
246.0					
248.0	SP				
250.0					
252.0					
254.0				HQ	

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 9 OF 11

HOLE NO. DHP-1b

PROJECT & FEATURE Delta Seismic Stability Stucy; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
256.0		230.0 - 260.0' Poorly Graded Sand: (Cont'd)			
258.0	CL			HQ	
260.0	?	*260.0? - 270.0? Lean Clay: Olive, moist, stiff to very stiff, low plasticity, low to moderate thoughness, no dilatancy, high to very high dry strength.	B-13	DR 1.4/1.5	SPT driven 260.0-261.5', 9/.5, 13/.5, 19/.5. *Entire sample is in clay. Depth of contact w/overlying sand unknown due to fast drilling.
262.0					Fluid leaks from boils along fractured ground surface. Drilling moderate to fast.
264.0	CL				Fluid leaks intermittently at surface. Drilling moderate to fast.
266.0					
268.0					
270.0		*270.0? - 280.1' Sandy Clay: Blue-gray, moist, medium stiff, no dilatancy, low to moderate toughness; contains 35% medium sand; medium plasticity, medium dry strength.		HQ	
272.0	CL				
274.0					*Actual depth of contact with overlying unit is unknown due to 20' interval between samples.
276.0					

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

HOLE NO. DHP-1b

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
276.0	CL	*270.0? - 280.1' Sandy Clay: (Cont'd)		HQ	
280.0	SP	281.0? - 290.0? Poorly Graded Sand: Gray, moist, fine-grained, very dense, partially cemented ?; contains 5% nonplastic fines.	B-14	DR 1.0/1.0	SPT driven 280.0-281.0', 19/.5, 50/.5 (refusal). Material changes in top of sampler; sandy clay to sand. Actual depth of contact w/overlying unit from last sample (at 260.0') unknown.
284.0	SP			HQ	Fast drilling.
290.0	? CL/CH	*290.0 - 301.5' Lean to Fat Clay: Moist, very stiff, no dilatancy, medium plasticity, low to medium toughness, high dry strength.			*Actual depth of contact with overlying unit unknown due to 20' interval between samples.

Depth scale: 276.0, 278.0, 280.0, 282.0, 284.0, 286.0, 288.0, 290.0, 292.0, 294.0, 296.0

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

HOLE NO. DHP-1b

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
296.0		*290.0 - 301.5' Lean to Fat Clay: (Cont'd)			
298.0	CL/CH			HQ	
300.0			B-15	DR 1.4/1.5	SPT driven 300.0-301.5, 7/.5, 13/.5, 12/.5. End of shift.
301.0					
		T.D. = 301.5'.			*Actual depth of contact w/overlying unit unknown due to 20' interval between samples. 8/13/93 Hole OYO PS logged. 8/16/93 Hole cleaned out (sands caved) then backfill grouted to the surface by tremie method on 8/17/93.

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 1 of 16
HOLE NO. DHP-2
ELEV. 15 (topo) FEET
DEPTH 300.9 FEET

PROJECT Delta Seismic Stability Study
DATE DRILLED 7/9-30/93
FEATURE Deep Hole Program
ATTITUDE Vertical
LOCATION Webb Tract - 800' W. of Pumping Plant
LOGGED BY T.Peltier/F.Nasirian
CONTR. P.C. Exploration, Inc. DRILL RIG Mobile B-58
DEPTH TO WATER 10.0'

AD = Auger drilling-8" hollow stem augers.
P = Push Shelby Tube
DR = Drive Standard Penetration Sampler-from 0' to 12' driven with down hole hammer on sand line. From 12' to 300' driven with above-hole hammer on WE rods. Hammer is 140 lb.
HQ = Rotary drilling w/HQ rods and 4-1/4" casing bit. Weighed on bathroom scale.

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0	SM	"LEVEE EMBANKMENT" (FILL) 0.0 - 3.0' Silty Sand With Gravel: Gray, non-plastic, firm, dry.		AD	Begin drilling with 8" hollow stem augers.
2.0		Becoming sandier at 2.0', less than 10% gravel.			
	SP-SM	3.0 - 13.5' Poorly Graded Sand With Silt: Gray, nonplastic, firm, moist. 90% fine sand, 10% fines micaceous.			
4.0		As above, color changes locally to light brown, trace of organic material.			
6.0			B-1	DR 1.5/1.5	Drive SPT 5.0-6.5' 1/.5, 1/.5, 2/.5
8.0				AD	
10.0				P 0.0/2.0	Push Shelby Tube 10.0-12.0', No recovery.
12.0		Material appeared wet at 12.0'.			
	PT	"QUATERNARY ALLUVIUM" 13.5 - 35.8' Peat: Dark brown, fibrous, wet, 80% fine peat particles, 20% coarse peat fragments up to 1' long.		AD	Cuttings becoming dark brown and organic at 13.5'.
14.0					
			B-2	DR 1.5/1.5	Drive SPT 15.0-16.5', 1/.5, 1/.5, 4/.5

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

HOLE NO. DHP-2

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0		13.5 - 35.8' Peat: (Cont'd)	B-2	DR	Drive SPT (Cont'd)
18.0	PT			AD	
20.0		As above, locally silty.	S-3	P 2.0/2.0	Push Shelby tube, 20.0-22.0'.
22.0			B-3	DR 1.5/1.5	Drive SPT 22.0-23.5', 3/.5, 2/.5, 3/.5.
24.0				AD	
26.0		As above, becoming more fibrous, 40% coarse fibers, with seeds.	B-4	DR 0.8/1.5	Drive SPT 25.0-26.5', 3/.5, 3/.5, 4/.5.
28.0				AD	
30.0		As above.	S-5	P 2.0/2.0	Push Shelby tube, 30.0-32.0'.
32.0			B-5	DR 1.5/1.5	Drive SPT 32.0-33.5'. 3/.5, 2/.5, 1/.5
34.0				AD	End shift.
36.0		35.8 - 80.0' Poorly Graded Sand With Silt: Gray, loose to dense, nonplastic, wet. 90% fine sand, 10% fines, micaceous.	B-6A B-6B	DR 1.5/1.5	Begin shift, water at 10'. Drive SPT 35.0-36.5', 1/.5, 3/.5, 6/.5

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

HOLE NO. DHP-2

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
36.0		35.8 - 80.0' Poorly Graded Sand With Silt: (Cont'd)	B-6	DR	Continue Driving SPT
38.0	SP-SM			AD	
40.0		40.0-41.4' Peat interbed similar to peat in previous interval.			Push Shelby tube, 40.0-42.0'.
	PT		S-7	P 1.2/2.0	
42.0					Drive SPT 42.0-43.5'.
			B-7	DR 1.0/1.5	
44.0	SP-SM			AD	11/.5, 18/.5, 15/.5.
		As above, becoming greenish gray, fewer fines.			
46.0			B-8	DR 1.5/1.5	Drive SPT 45.0-46.5'. 8/.5, 8/.5, 7/.5.
48.0				AD	
50.0				P 0.0/1.0	Push Shelby 50.0-51.0'. Refusal at 51.0', apparently. Material too dense to push further. No recovery.
52.0				AD	
54.0		As above.			Sand ran up inside augers when center bit was pulled, clean-out by driving SPT but did not record blow counts.

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

HOLE NO. DHP-2

PROJECT & FEATURE Delta Seismic Stability Stucy; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
56.0		35.8 - 80.0' Poorly Graded Sand With Silt: (Cont'd)			Continue drilling with 8" hollow stem aguers.
58.0	SP-SM			AD	Drilled to 60.0', Used 3" sampler to remove sand from inside augers.
60.0					Sand still running in when sampler is pulled out. Drilled to 70.0'. 7-14-93 Pulled augers. Hole caved to 35'. Pushed 5" casing to 66'. Placed cement grout by tremie. Had to "wash in" cement to get tremie to 60'. End shift.
62.0					
64.0					
66.0				AD	
68.0					7-14-93 Set up for rotary drilling. Changed hammers. Drilled to 70', pushed Shelby tube.
70.0			S-9	P 0.5/0.8	70.0-70.8' (bottom of Shelby tube became crimped).
	SP		B-9	DR 1.0/1.5	7-15-93 Drive SPT 70.8-72.3' 0/.5, 3/.5, 6/.5. Sampler sunk first 6".
72.0				HQ	
74.0		74.0' Sand below this depth is much denser than above. 75.4-75.5' Interval of lean clay.			
	CL		B-10	DR	Drive SPT 75.0-76.5',

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

HOLE NO. DHP-2

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
76.0	SP-SM	38.5 - 80.0' Poorly Graded Sand With Silt: (Cont'd)	B-10	DR	Continue driving SPT.
78.0		As above, becoming dense, locally grades to sandy clay.		HQ	
80.0	ML	80.0 - 81.0' Silt: Gray green, firm, slight plasticity, moist.	S-11	P 1.3/2.0	Push Shelby tube 80.0-82.0'.
	SP-SM	81.0 - 83.4' Poorly Graded Sand With Silt: Light brown, dense, nonplastic, wet; contains about 90% fine to medium grained sand and 10% fines.			
82.0			B-11	DR 1.5/1.5	Drive SPT 82.0-83.5', 8/.5, 11/.5, 16/.5.
	ML	83.4 - 90.0' Silt: Gray with orange mottling, firm, slight plasticity, moist, slow dilatancy.			
84.0				HQ	
86.0			B-12	DR 1.0/1.5	Drive SPT 85.0-86.5', 11/.5, 6/.5, 7/.5.
88.0				HQ	
90.0	CL	90.0 - 160.0' Lean Clay: Greenish gray, moderate plasticity, stiff, moist.	S-13	P 2.0/2.0	Push Shelby tube 90.0-92.0'.
92.0			B-13	DR 1.5/1.5	Drive SPT 92.0-93.5', 4/.5, 7/.5, 7/.5.
		As above, locally grades to silt.			
94.0				HQ	
96.0			B-14	DR 1.5	Drive SPT 95.0-96.5', 3/.5, 6/.5, 12/.5.

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

HOLE NO. DHP-2

PROJECT & FEATURE Delta Seismic Stability Stury; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
96.0		90.0 - 160.0' Lean Clay: (Cont'd)	B-14	DR	Continue driving SPT.
98.0	CL			HQ	End Shift at 100.0'. 7-16-93
100.0				P 0.0/2.0	Pushed Shelby tube, 100.0-102.0'. No recovery.
102.0					
104.0					
106.0				HQ	
108.0					
110.0		As above, locally grades to silty sand, such as interval from 111.0 to 111.5'.	B-15	DR 1.5/1.5	Drive SPT 110.0-111.5', 3/.5, 8/.5, 32/.5, (Sampler is packed full)
	SM				
112.0					
114.0	CL			HQ	

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

SHEET 7 OF 16
HOLE NO. DHP-2

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
116.0		90.0 - 160.0' Lean Clay: Cont'd			Continue rotary drilling with HQ size rods and 4-1/4" casing bit.
118.0				HQ	
120.0				P 0.0/2.0	Push Shelby tube 120.0-122.0', Pushed hard but no recovery.
122.0	CL				
124.0				HQ	
126.0					Slower drilling, some thin hard zones.
128.0					
130.0		As above, becoming light brown with occasional sand stringers and iron oxide stain, few caliche nodules. Stiff to very stiff, moist. Up to 20% fine sand. Slow dilatancy, medium dry strength.	B-16	DR 1.5/1.5	Drive SPT 130.0-131.5', 11/.5, 16/.5, 28/.5, End shift.
132.0				HQ	7-19-93 resume drilling from 130.0'.
134.0					
136.0					

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 8 OF 16

HOLE NO. DHP-2

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
136.0		90.0 - 160.0' Lean Clay: (Cont'd)			Continue rotary drilling with HQ size rods and casing bit.
				HQ	
138.0					
	CL				
140.0		As above, becoming gray green colored, thinly bedded, locally grades to silty sand, micaceous. 141.8-142.2' Silty sand interval.	S-17	P 2.0/2.0	Push Shelby tube 140.0-142.0'.
142.0	SM		B-17	DR 1.4/1.5	Drive SPT 142.0-143.5', 6/.5, 15/.5, 16/.5
144.0					
	CL				Slower drilling at 145.0', driller reports stiff clay.
146.0				HQ	
148.0					
150.0		As above, becoming light brown.	B-18	DR 1.5/1.5	Drive SPT 150.0-151.5', 5/.5, 12/.5, 19/.5
152.0				HQ	
154.0					

DRILL HOLE LOG

PROJECT & FEATURE Delta Seismic Stability Stucy; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
156.0	CL	90.0 - 160.0' Lean Clay: (Cont'd)		HQ	Continue rotary drilling with HQ size rods and casing bit with bentonite drilling mud.
158.0					
160.0	SM	160.0 - 190.2' Silty Sand: Gray, nonplastic, firm to very firm, moist. 60% fine to medium sand, 40% fines.	S-19	P 2.0/2.0	Push Shelby tube, 160.0-162.0'.
162.0	SP	As above becoming higher in fines approximately 50%. Locally grades to poorly graded sand, such as interval 162.0-162.4'.	B-19	DR 1.4/1.5	Drive SPT 162.0-163.5' 7/.5, 15/.5, 19/.5.
164.0	SM			HQ	Hole starts taking water, about 10 gpm.
166.0					
168.0					
170.0	ML	As above, locally grades to sandy silt, such as interval 170.6-171.0'.	B-20	DR 1.5/1.5	Drive SPT 170.0-171.5', 5/.5, 6/.5, 8/.5.
172.0	SM			HQ	
174.0					
176.0					

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

HOLE NO. DHP-2

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
176.0		160.0 - 190.2' Silty Sand: (Cont'd)		HQ	Continue rotary drilling with HQ size rods and casing bit with bentonite drilling mud.
178.0	SM				
180.0		Becoming denser with depth.		P 0.0/0.5	End shift at 180.0'. 7-20-93 Hole sanded up overnight. Had to pull 40' of rods to get circulation going. Push Shelby tube 180.0-180.5' (Refusal). No recovery.
182.0					
184.0				HQ	
186.0					
188.0		Grades locally to Sandy Clay, such as interval 190.0-190.2'.			
190.0	SC	190.2 - 210.0' Poorly Graded Sand With Silt: Brown, nonplastic, very dense, wet. 90% fine to medium sand, 10% fines, little or no mica.	B-21	DR 0.7/0.7	Drive SPT 190.0-190.7', 40/.5, 50/.2, refusal.
	SP-SM				
192.0				HQ	
194.0					
196.0					

DRILL HOLE LOG

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
196.0		190.2 - 210.0' Poorly Graded Sand With Silt: (Cont'd)			Casing bit 3-3/4", continue rotary drilling with HQ size rods and casing bit with bentonite drilling fluid.
198.0	SP-SM			HQ	
200.0				P 0.0/1.0	Push Shelby tube, 200.0-201.0', no recovery.
202.0					
204.0				HQ	
206.0					
208.0					
210.0	ML	210.0 - 215.0' Silt: Dark greenish gray, slight plasticity, stiff to very stiff, moist to wet. Moderate to slow dilatancy, low dry strength.	B-22	DR 1.5/1.5	Drive SPT 210.0-211.5', 6/.5, 15/.5, 16/.5, sampler is full.
212.0				HQ	Pulled rods. Bit is worn out. Changed to Scotty bit, 4-7/8". Note: The HQ rods seem to partially cut core in this type of fine grained material. The SPT sampler becomes partially or completely filled when it is lowered to the bottom of the hole. Therefore, the above blow counts may not be valid. This lean clay seems to be only soft to stiff in the sampler. Other clay zones
214.0					
216.0	SP	215.0 - 222.0' Poorly Graded Sand: Dark gray green, nonplastic, dense, 95% fine to medium grained sand, 5% fines, fines increase locally to 15%.			

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

HOLE NO. DHP-2

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
216.0		215.0 - 222.0' Poorly Graded Sand: (Cont'd)		HQ	7-22-93 Resumed drilling at 215' Continue rotary drilling with HQ size rods and "Scotty Bit" with bentonite drilling fluid.
218.0	SP	Hole is taking fluid at about 10 gpm.			Driller reports we are in sand (based on drilling rate and return).
220.0		Driller reports change in material based on increase in drilling rate. See description on previous page.	B-23	DR 1.0/1.0	Substitute SPT for Shelby tube due to poor recovery of Shelby tubes in sand. Drive SPT 220.0-221.0' sampler did not reach bottom. Drove sampler 18", cleared coating on inside of rods. Blow counts not useful. 12/.5, 15/.5, 6/1.0. Drove sampler 1.0' more 8/.5, 22/.5.
222.0		222.0 - 229.0' Lean Clay: No samples obtained. Lithology based on drilling conditions. Slower drilling at 222.0', driller reports we are in clay-adding pressure to rods cuts off circulation.			
224.0	CL?			HQ	Sampler contained 0.3' of very dense Silt and lean clay, underlain by 1.0' of poorly graded sand.
226.0					The silt and lean clay are apparently material from between 210' and 220' which got inside the rods while reaming the hole.
228.0					
		229.0 - 299.8' Silt: Similar to ML at 210.00-215.0' locally grades to Silty Sand.			Drilling rate increases at 229.0'.
230.0	ML				Drive SPT 230.0-231.5', 4/.5, 7/.5, 11/.5.
	SM		B-24	DR 1.3/1.5	
232.0	ML				
234.0				HQ	Drilling rate highly variable through this zone 230-240'.
236.0					

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

HOLE NO. DHP-2

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
236		229.0 - 299.8' <u>Silt</u> (Cont'd)		HQ	Continue rotary drilling with HQ size rods and "Scotty Bit"' circulating bentonite drill fluid.
238					Drilling core variable from 230 to 240'.
240	ML	As above; becoming lighter green color and very dense.	S-25	P 1.5/1.5	Push Shelby tube 240.0-241.5' (refusal).
242			B-25	DR 1.5/1.5	Drive SPT 141.5'143.0', 9/.5, 15/.5, 19/.5 Start the shift 7/26; begin logging by F. Nasirian; smooth drilling, lost about 500 gallon of mud in the hole.
244				HQ	
246					
248					
250	SP	250.0-250.5' Sand, medium to fine grained. 250.5-251.5' Silt, medium plasticity, low dilatancy.	B-26 B-27	DR 1.5/1.5	250.0-251.5' 22/.5, 20/.5, 23/.5, N = 43.
252	ML			HQ	251.5-260.0' Smooth drilling about 350 gallon mud lost.
254					
256					

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 14 OF 16

HOLE NO. DHP-2

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
256		229.0 - 299.8' Silt: (Cont'd)			
258	ML			HQ	
260	CL	260.0-260.4' Clay; dark greenish-black, high plasticity, stiff.	B-28	P 4/1.5	260.0-260.4' Refusal. Lost 250 gal. mud, smooth drilling.
262					
264	ML			HQ	
266					
268					
270	CL	270.0-271.5' Clay: Dark greenish-black, medium to high plasticity.	B-29	DR 1.5/1.5	270.0-271.5' 41/.5, 6/.5, 8/.5' N=14. End of shift 7/26/93.
272					
274	ML			HQ	
276					

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

HOLE NO. DHP-2

PROJECT & FEATURE Delta Seismic Stability Study; Deep Hole Program

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
276		229.0 - 299.8' Silt: (Cont'd)		HQ	Smooth drilling, lost about 350 gallon of mud.
278					
280	ML	280.0' In top of sampler "Silt".	S-26	P 2.3/2.3	280.0-282.3'
282		282.8' Tip of sampler "clay", low to medium plasticity.			End of shift. About 40' of sand was sucked in the HQ rod due to very little clearance between the samplers HQ rod.
284				HQ	7-28-93 Bit was plugged, had to remove the HQ rods and redrill the rod to 290'.
286					Smooth drilling, lost about 1200 gal. of mud as redrilled 80' to 280'. Lost 250 gallon 280-290'.
288					
290	SP	290.0-290.7' Sand, poorly graded, fine to medium grained.	B-30	DR 1.5/1.5	End of shift, 290-291.5', 7-30-93. 9:00 a.m. water level at 21.0' SPT 9/16/27, Tip silt. N=33.
	ML	290.7-291.5' Silt as above.	B-31		
292	ML			HQ	
294					
296					

DWR 885 (2) (Rev. 9-84)

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 16 OF 16

HOLE NO. DHP-2

PROJECT & FEATURE

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
296		229.0-299.8' <u>Silt</u>: (Cont'd)			Smooth drilling 290-300', lost 150 gallon of mud.
298	ML			HQ	
		299.8 0 300.9' <u>Sandy Gravel</u>: Grayish-green, gravelly to 1" in diameter, rounded to sub-rounded, about 15-20% fine to medium grained sand, sample mostly poorly cemented.			299.8-300.5' Some vibration, possibly gravelly.
300	GP				300.5-300.9'
300.9			B-32	DR 50/.4	Refusal.
		Hole bottomed at 300.9', 7/30/93			Hole logged with OYO PS Suspension logging system; casing pulled; hole back-filled by tremie method with cement-bentonite grout.

SUSPENSION P- AND SH-WAVE VELOCITY MEASUREMENTS

ON THE

BACON ISLAND LEVEE, BOREHOLE DHP-1a

July 13, 1993
Report 9329-6441

Prepared for
P. C. Exploration
1780 Vernon Street, Suite 3
Roseville, California 95678
DWR Technical Liaison, Thomas Peltier

Prepared by
Agbabian Associates (Rob Steller)
1111 South Arroyo Parkway, Suite 405
Pasadena, California 91105
(818) 441-1060

APPENDIX B

RESULTS OF GEOPHYSICAL LOGGING

AGBABIAN ASSOCIATES
engineers and consultants

SUSPENSION P- AND SH-WAVE VELOCITY MEASUREMENTS

ON THE

BACON ISLAND LEVEE, BOREHOLE DHP-1a

July 13, 1993

Introduction

Suspension P- and S_h-velocity measurements were performed in test boring DHP-14, located on the Bacon Island levee near Stockton, California. The work was conducted for the Department of Water Resources under subcontract with P. C. Exploration, Inc. Data acquisition was performed on July 7, 1993. Mr. Thomas Peltier acted as Technical Liaison for the Department of Water Resources.

Scope of Work

This report presents the results of borehole velocity measurements performed on the east levee of Bacon Island, near the confluence of Middle River and Empire Cut on July 7, 1993. The borehole investigated, designated DHP-14, was an uncased nominal 4 3/4-inch diameter, 160 foot deep test boring, filled with drilling mud. The upper 37 feet of the borehole was cased with 6-inch I.D. PVC casing to prevent collapse of the borehole. The purpose of these tests was to acquire shear and compressional wave velocities as a function of depth which, in turn, will be used to characterize ground response to earthquake motion.

The OYO Suspension P-S Logging system was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 3.3 foot (1 meter) intervals. Additional data was collected at 7.9 inch (20 cm.) intervals from 49.2 to 59.1 feet, and from 72.2 to 82.0 feet. The acquired data was analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

Instrumentation

In-situ soil velocity measurements were performed using the Model 170 Suspension P-S Logging system, manufactured by OYO Corporation. This system directly determines the average velocity of a one meter high segment of the soil column surrounding the borehole of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The geophones that detect the wave, and the source that generates the wave, are moved as a unit in the borehole, producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave generator (S_h) and compressional-wave generator (P), joined to two biaxial geophones by a flexible isolation cylinder, as shown in Figure 1. The separation of the two geophones is one meter, allowing average wave velocity in the region between the geophones to be determined by inversion of the wave travel time between the two geophones. The total length of the probe is approximately 19 feet; the center point of the geophones is approximately 13 feet above the bottom end of the probe. The probe receives control signals from, and sends the amplified geophone signals to, instrumentation on the surface via an armored 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data.

The entire probe is suspended by the cable and centered in the borehole by nylon "whiskers", therefore, source motion is not coupled directly to the borehole walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the borehole and surrounding the source. This pressure wave is converted to P and S_h-waves in the surrounding soil and rock as it impinges upon the borehole wall. These waves propagate through the soil and rock surrounding the borehole, in turn causing a pressure wave to be generated in the fluid surrounding the geophones as the soil waves pass their location.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows: 1) the source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal geophones situated parallel to the axis of motion of the source are recorded; 2) the source is fired again in the opposite direction and the horizontal geophone signals are recorded; and 3) the source is fired again and the vertical geophone signals are recorded. The repeated source pattern facilitates the picking of the P and S_h-wave arrivals; reversal of the source changes the polarity of the S_h-wave pattern but not the P-wave pattern.

The data from each geophone during each source activation is recorded as a different channel on the recording system. The Model 170 has six channels (two simultaneous recording channels), each with a 12 bit 1024 sample record. The recorded data is displayed on a CRT display and on paper tape output as six channels with a common time scale. Data is stored on 3.5 inch floppy diskettes for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the CRT or paper tape allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number in order to optimize the quality of the data before recording.

Procedure

The suspension velocity surveys were performed the morning following completion of the borehole. The borehole was well circulated with drilling mud prior to the measurement procedure. The suspension probe was lowered to the bottom of the borehole, then returned to the surface, stopping at 3.3 foot intervals to collect data. Upon completion of this primary run, the probe was returned to a depth of 82.0 feet, and additional measurements recorded at 7.9 inch intervals. The deepest measurement was taken with the probe depth reference point located at 147.6 feet, placing the tip of the probe at approximately 160 feet. This depth indicates that measurements were taken to the total depth of the drilled borehole.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth was printed on paper tape, checked, and recorded on diskette before moving to the next depth.

Analysis

The digital records were analyzed to locate the first minima on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between these arrivals was used to calculate the P-wave velocity for that 1 meter interval. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. In addition, the soil velocity calculated from the travel time from source to first receiver was compared to the velocity derived from the travel time between receivers.

The digital records were studied to establish the presence of clear S_h-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_h-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering was used to remove the higher frequency P-wave signal from the S_h-wave signal. Different filter cutoffs were used to separate P- and S_h-waves at different depths, ranging from 500 Hz in the slowest zones to 1000 Hz in the regions of highest velocity.

Generally, the first maxima was picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by borehole inclination. This variation does not affect the velocity determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

In Figure 2, the time difference over the 1 meter interval of 5.50 millisecond is equivalent to a S_h-wave velocity of 597 ft/sec. Whenever possible, time differences were determined from several phase points on the S_h-waveform records to verify the data obtained from the first arrival of the S_h-wave pulse. In addition, the soil velocity calculated from the travel time from source to first receiver was compared to the velocity derived from the travel time between receivers.

Results

Figure 2 shows an example of these measurements on the filtered record for a depth of 49.2 feet. Figure 3 displays the same record before filtering with a 1000 Hz FFT - IFFT digital lowpass filter.

P- and S_h-wave velocity data is plotted in Figures 4 and 5. There is little correspondence between the shape of the P- and S_h-wave velocity curves, as the P-wave velocity of almost the entire borehole is dominated by the velocity of pressure waves in water. In may be noted that a thin lower velocity formation may be seen at a depth of approximately 55 feet. A thin high velocity layer is seen at approximately 72 feet. Additionally, the depth sequential records indicate a substantial increase in velocity at the bottom of the borehole, below the region measured with the Suspension Logger.

Depths and velocities for borehole DHP-1a are tabulated in Table 1. Depth sequential records of the horizontal geophone nearest the source are displayed in Figure 6.

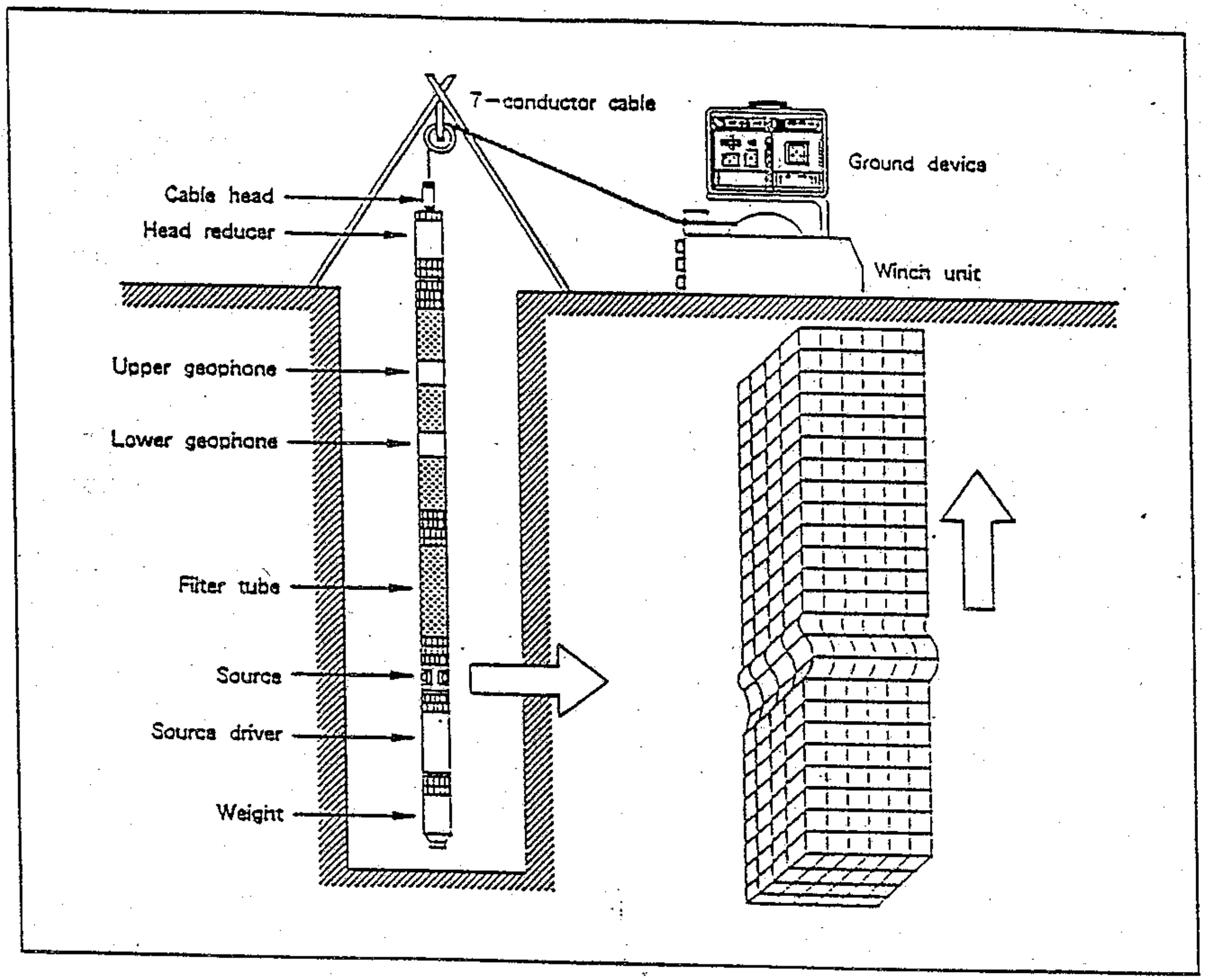


Figure 1. Concept Illustration of P-S Logging System

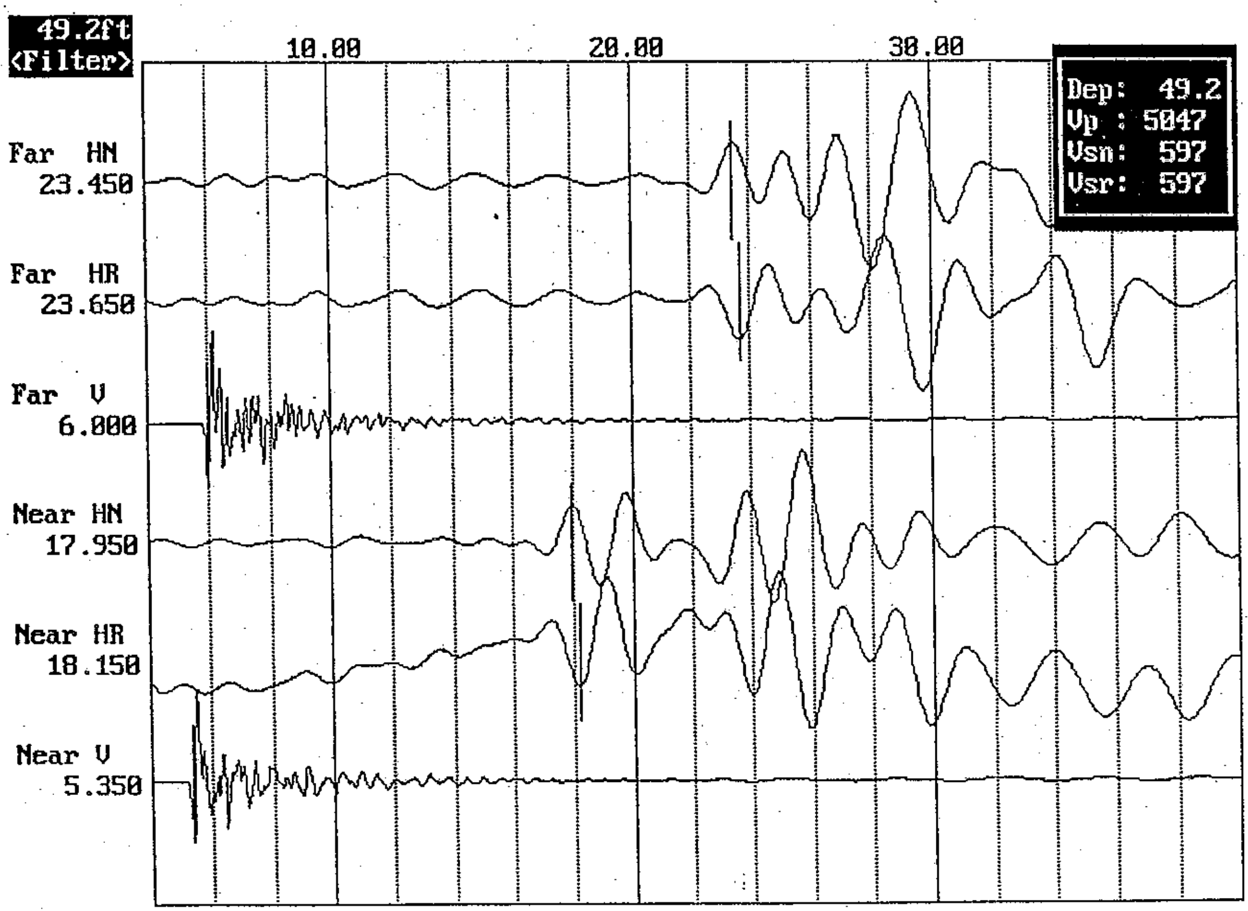


Figure 2. Filtered (1000 Hz lowpass) 49.2 ft. record from DHP-1a

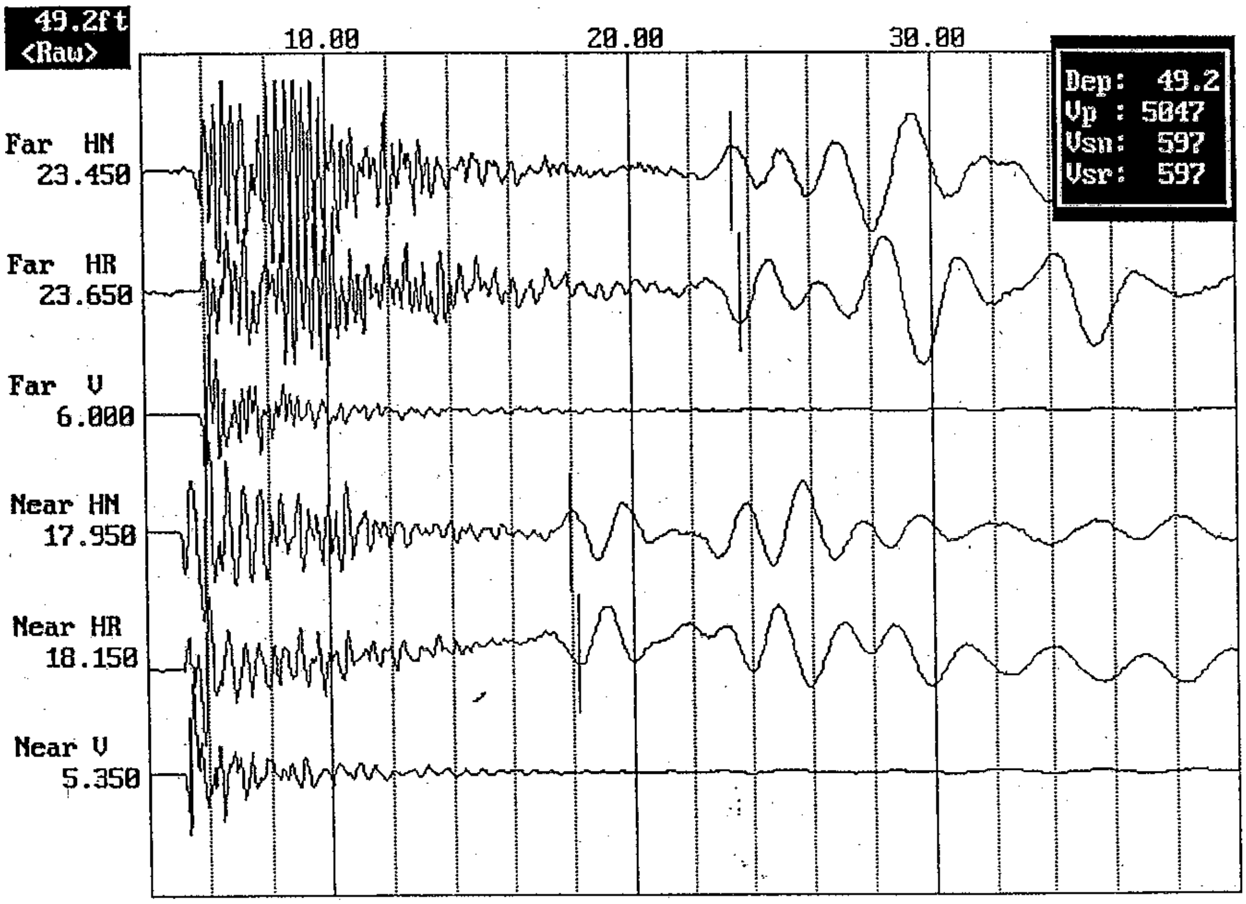


Figure 3. Unfiltered 49.2 ft. record from DHP-1a

BACON ISLAND BOREHOLE DHP-1a SUSPENSION LOGGING

P- AND S- WAVE VELOCITIES; DATA COLLECTED JULY 7, 1993

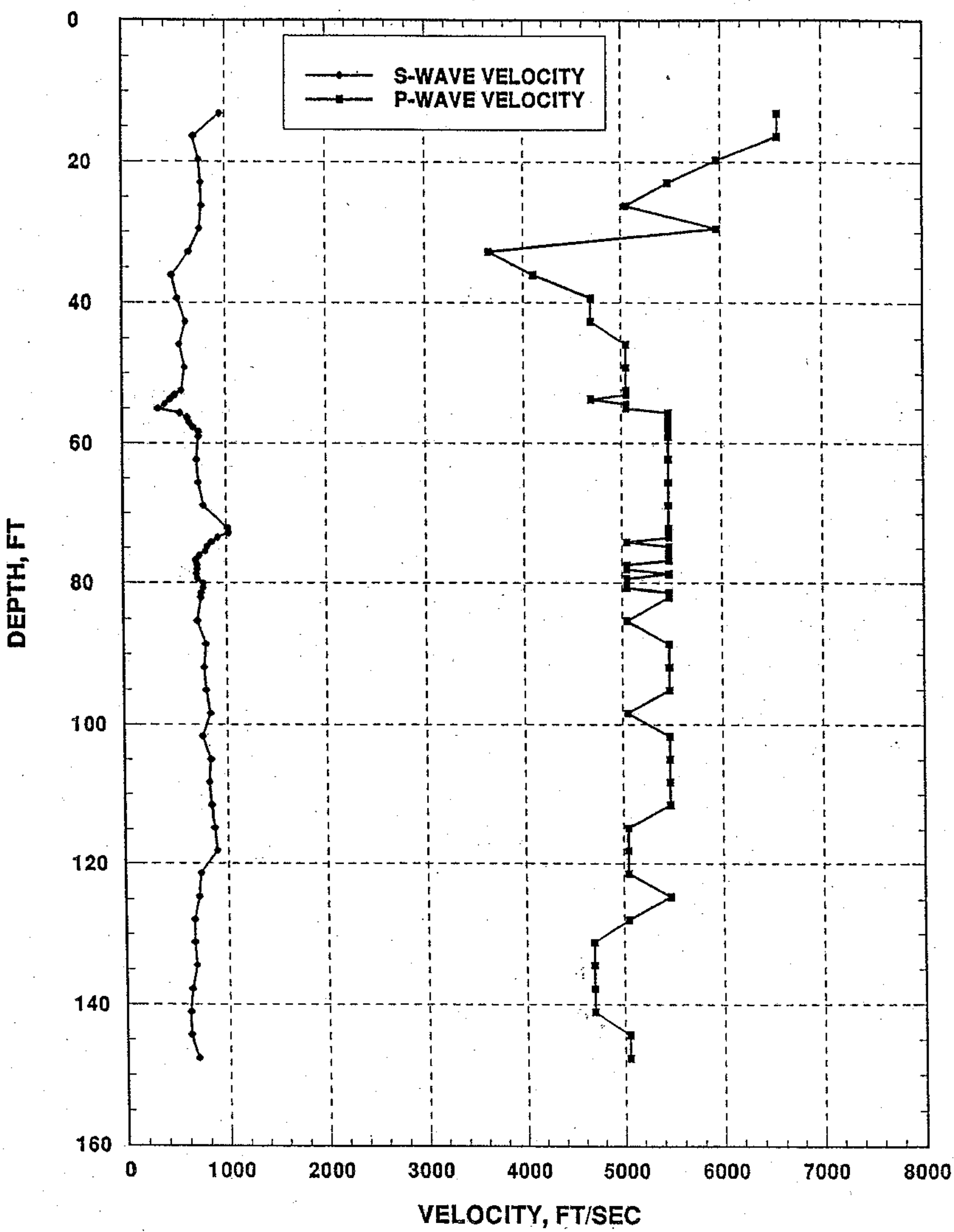
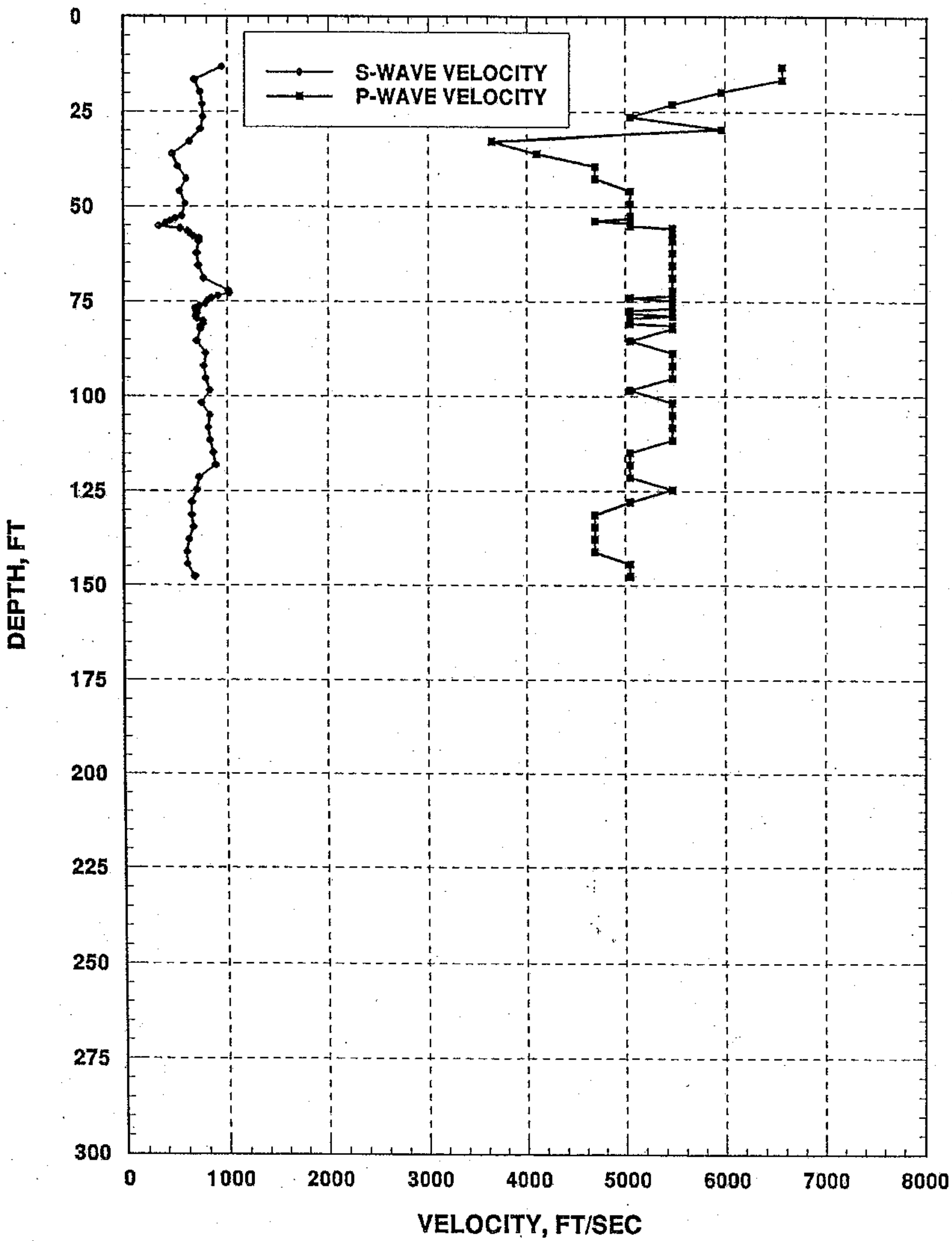


Figure 4. P- and S_h-wave Velocities for borehole DHP-1a

BACON ISLAND BOREHOLE DHP-1A SUSPENSION LOGGING

P- AND S- WAVE VELOCITIES; DATA COLLECTED JULY 7, 1993



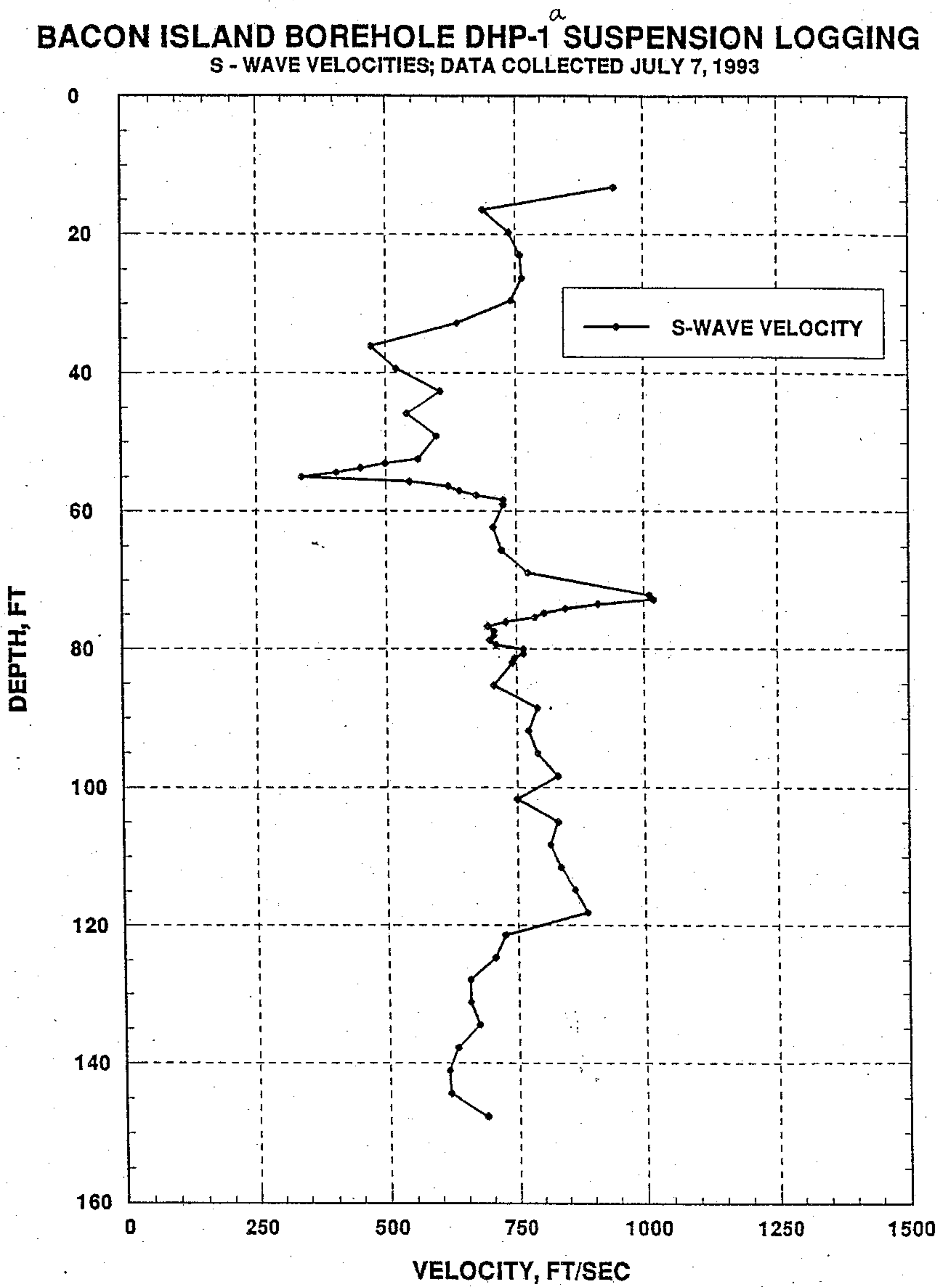
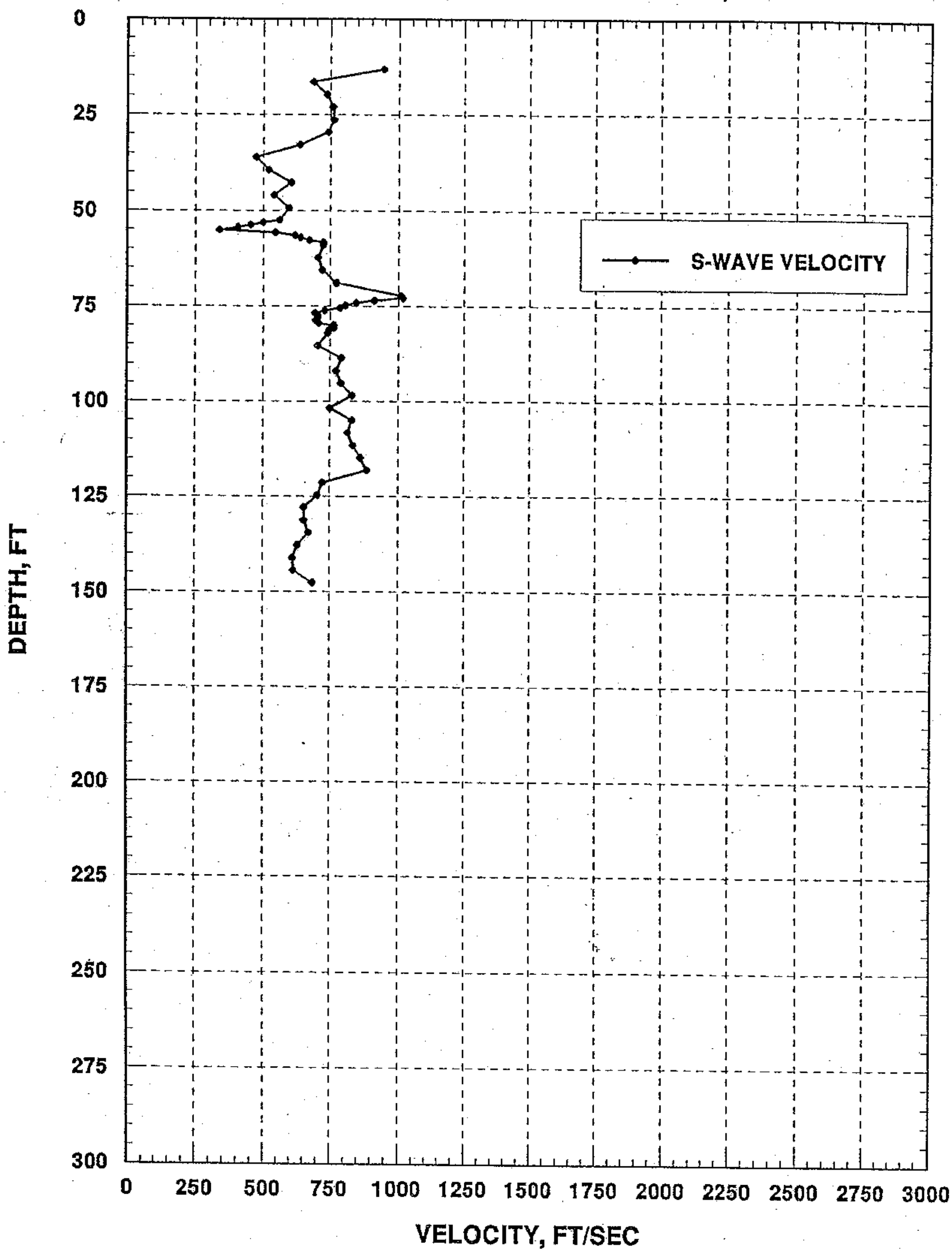


Figure 5. S_h-wave Velocities for borehole DHP-1a

BACON ISLAND BOREHOLE DHP-1A SUSPENSION LOGGING

S - WAVE VELOCITIES; DATA COLLECTED JULY 7, 1993



Depth (ft)	Vs (ft/s)	Vp (ft/s)
13.1	944	6562
16.4	687	6562
19.7	737	5965
23.0	759	5468
26.3	763	5047
29.5	741	5965
32.8	637	3645
36.1	474	4101
39.4	521	4687
42.7	605	4687
45.9	540	5047
49.2	597	5047
52.5	561	5047
53.2	499	5047
53.8	453	4687
54.5	405	5047
55.1	339	5047
55.8	545	5468
56.4	619	5468
57.1	640	5468
57.7	673	5468
58.4	725	5468
59.1	725	5468
62.3	706	5468
65.6	721	5468
68.9	772	5468
72.2	1009	5468
72.8	1017	5468
73.5	911	5468
74.2	847	5047
74.8	805	5468
75.5	786	5468
76.1	729	5468
76.8	694	5468
77.4	706	5047
78.1	706	5047
78.7	698	5468
79.4	709	5047
80.1	763	5047
80.7	763	5047
81.4	746	5468
82.0	741	5468
85.3	706	5047
88.6	791	5468
91.9	772	5468
95.1	791	5468
98.4	831	5047
101.7	750	5468
105.0	831	5468
108.3	815	5468
111.6	836	5468
114.8	863	5047
118.1	887	5047
121.4	725	5047
124.7	706	5468
128.0	656	5047
131.2	656	4687
134.5	673	4687
137.8	631	4687
141.1	613	4687
144.4	616	5047
147.6	687	5047

Table 1. Depth and velocity data for borehole DHP-1a

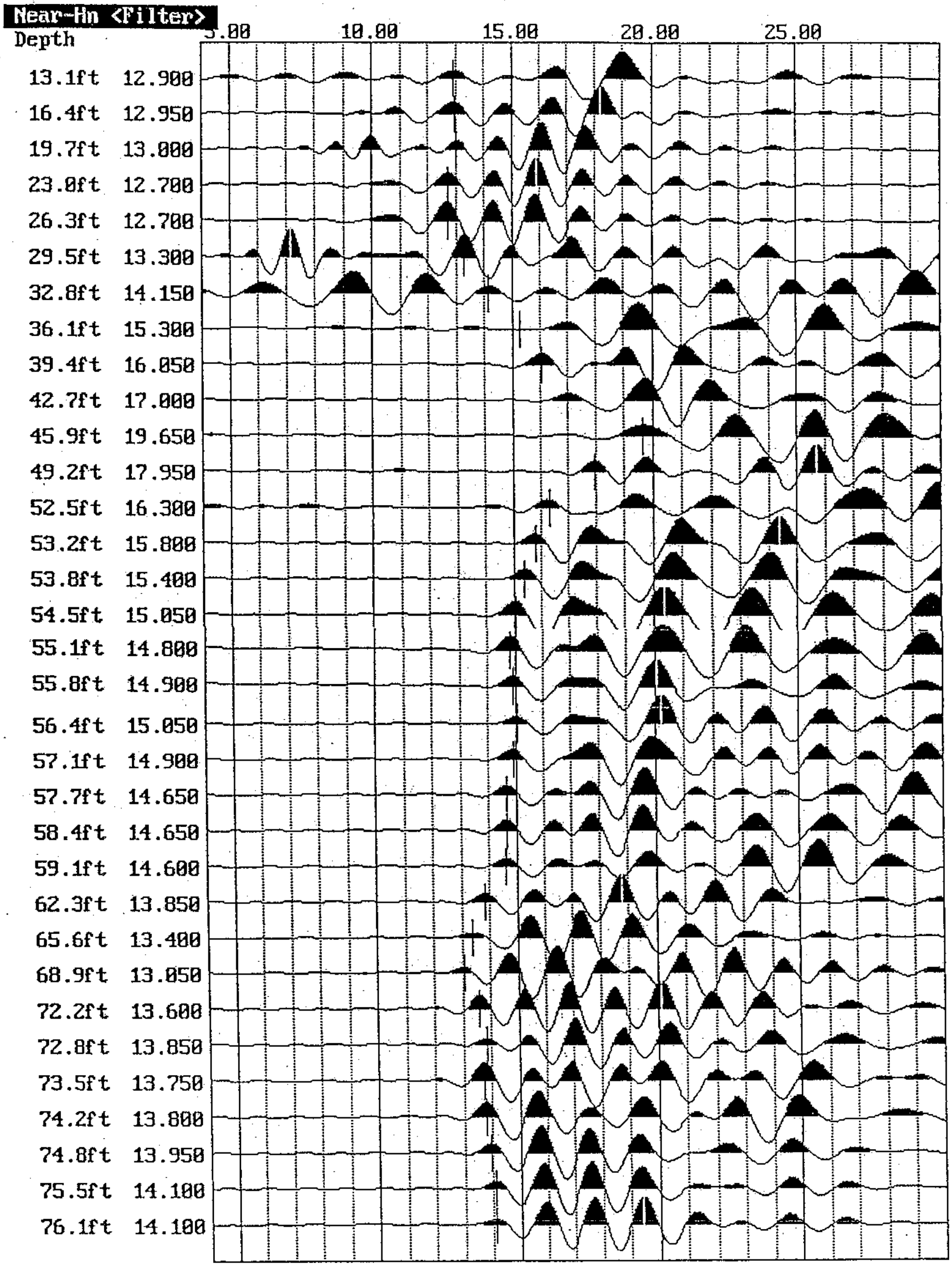


Figure 6.
Composite records for filtered near horizontal normal geophone at Borehole DHP-1a

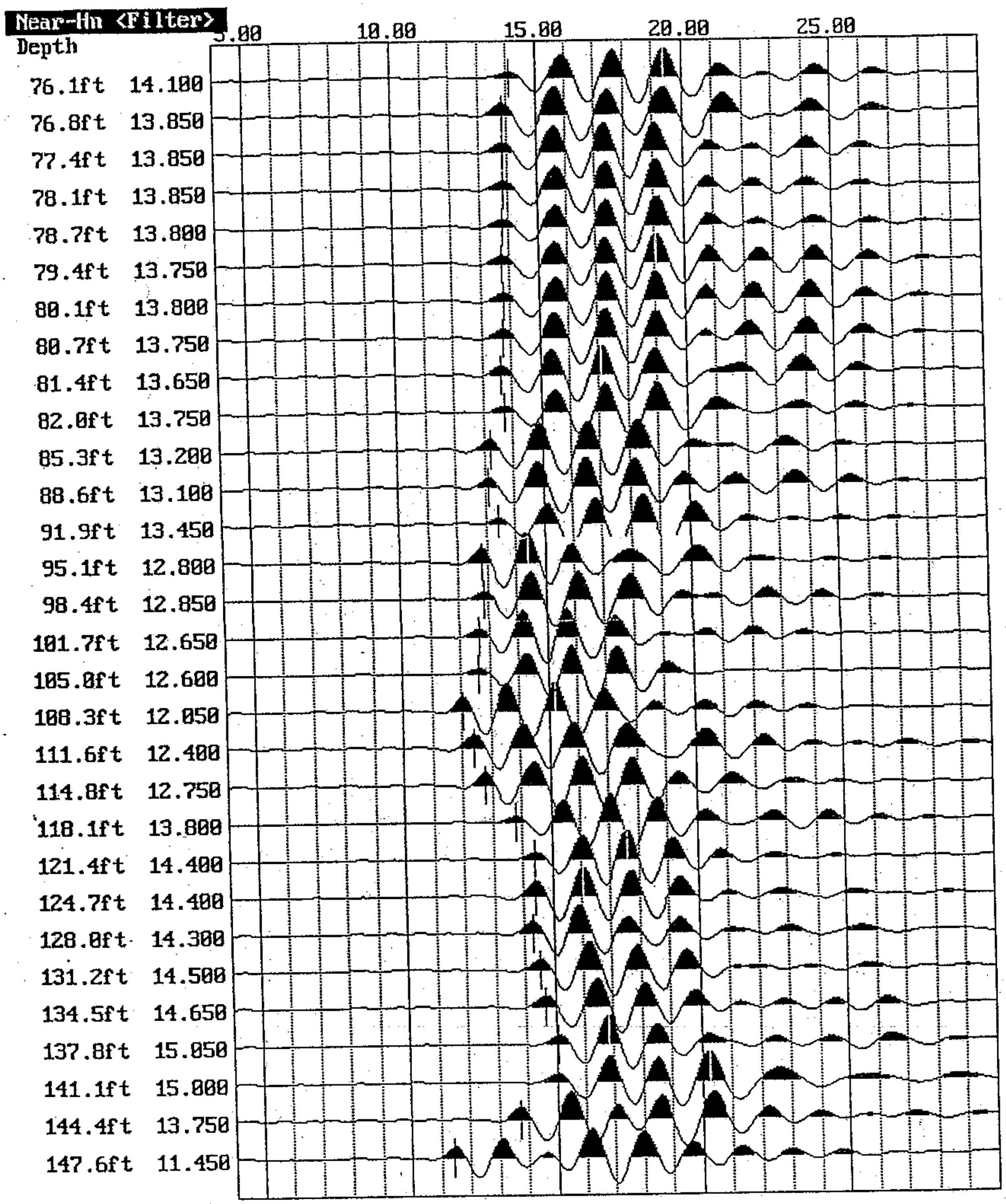


Figure 6. continued
Composite record for filtered near horizontal
normal geophone at Borehole DHP-1a

AGBABIAN ASSOCIATES
engineers and consultants

1111 South Arroyo Parkway, Suite 405, Pasadena, CA 91105 • (818) 441-1060 • FAX: (818) 441-0757

August 4, 1993

Tom Peltier
Department of Water Resources
Division of Design and Construction
1416 Ninth Street, Room 550
Sacramento, California 94236-001

Dear Mr. Peltier,

Enclosed please find our graphs and tables displaying suspension and downhole velocity data collected on August 2, 1993 at borehole DHP-2, located on Webb Tract, 800 feet west of the pumping plant. Due to the rapidly changing layers present at this site, we have collected data at 0.5 meter intervals, rather than the specified 1 meter intervals. I am very pleased with the results from this site in the region below the casing.

Below 60 feet, the plots show very good agreement in trends between P- and S-wave data; this is characteristic of soil sites of this sort. There is also good correlation between the velocity transitions and the layers indicated in the drill log.

The quality of suspension logging data in the cased region ranged from fair to useless. We collected additional downhole data at one meter intervals to supplement the suspension data from the cased region. The plots reflect standard suspension receiver 1 to receiver 2 measurements, and source to receiver (S-R1) data where available. In addition I have superimposed the best fit layer velocities derived from the downhole data over the suspension data. In the P-wave data set there is excellent agreement between the suspension and downhole data. The drop of P-wave velocity to approximately 2200 ft/sec between 35 and 42 feet is a new phenomena for me, as I expected this region to be below water table. There may be some drainage to the island, allowing this region to be less than saturated.

Even the downhole data was of poor quality, a condition generally caused by poor coupling of the casing to the borehole. Based upon the description of the drilling and casing of the top 66 feet of this hole, I expect that there are large regions of unconsolidated soil, water, and/or grout distributed along the entire length of the casing. We were unable to obtain any usable S-wave records between water table at 16 feet and the top of the caved region at 35 feet. The presence of voids created by the collapse of the hole, and the subsequent grouting may have had profound effects upon the measured velocities in the cased region.

AGBABIAN ASSOCIATES
engineers and consultants

1111 South Arroyo Parkway, Suite 405, Pasadena, CA 91105 • (818) 441-1060 • FAX: (818) 441-0757

For future work desiring to obtain velocity data from this site I would recommend drilling with rotary mud from the surface, or auger through the levee only, and use a casing advance technique (perhaps just driving the casing in without first drilling) in order to avoid the disturbances created in this hole. All other boreholes we have logged have been drilled using rotary mud from the surface or at most 8 feet down.

I will be out of our office until August 18. If borehole DHP-1B is completed before that date, please contact Ed at my Northern California office (510-831-0797), and he will manage the logging of the borehole.

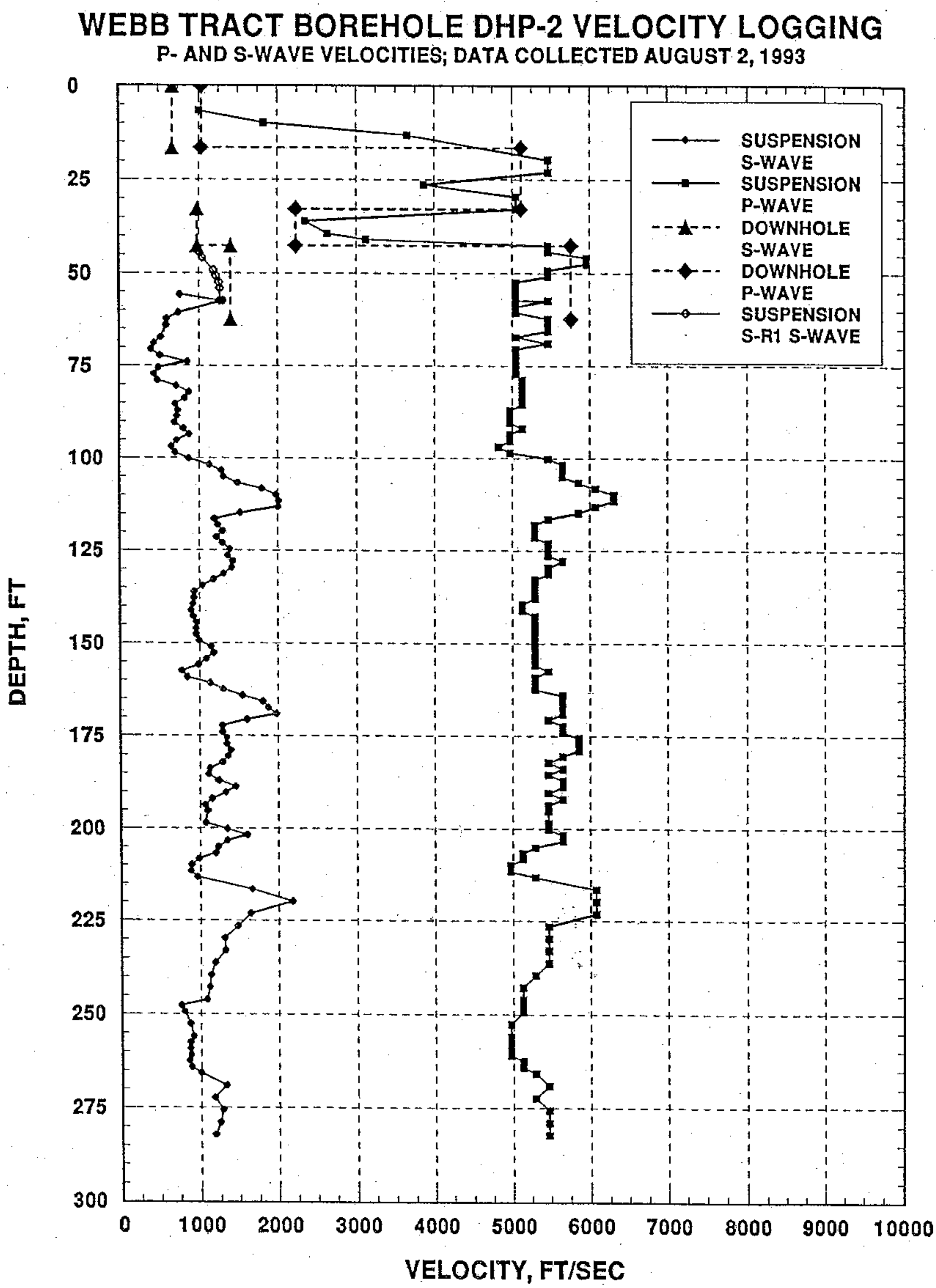
Regards,

Robert Steller
Manager of Geophysical Services

enclosure

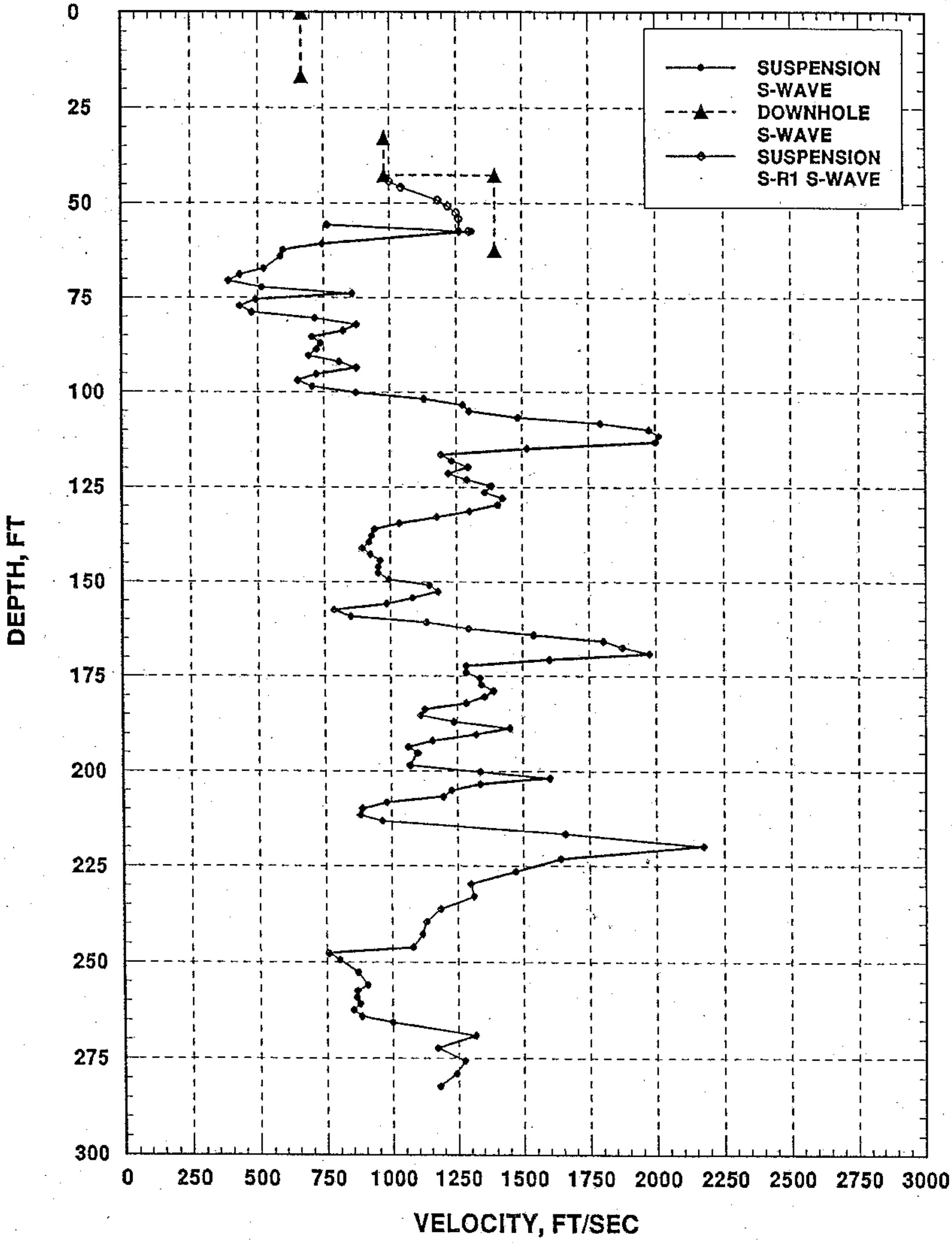
cc: Perris Baker, P. C. Exploration

Ref: 9329-15335


WEBB TRACT BOREHOLE DHP-2 VELOCITY LOGGING
P- AND S-WAVE VELOCITIES; DATA COLLECTED AUGUST 2, 1993
DEPTH, FT
VELOCITY, FT/SEC
0
25
50
75
100
125
150
175
200
225
250
275
300
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
SUSPENSION S-WAVE
SUSPENSION P-WAVE
DOWNHOLE S-WAVE
DOWNHOLE P-WAVE
SUSPENSION S-R1 S-WAVE

WEBB TRACT BOREHOLE DHP-2 VELOCITY LOGGING

S-WAVE VELOCITIES; DATA COLLECTED AUGUST 2, 1993



WEBB TRACT BOREHOLE DHP-2 VELOCITY LOGGING

Depth (ft)	Suspension R1-R2 Vs (ft/s)	Suspension S-R1 Vs (ft/s)	Downhole Layer Vs (ft/s)	Suspension R1-R2 Vp (ft/s)	Downhole Layer Vp (ft/s)
6.6			667	1009	1030
9.8			667	1823	1030
13.1			667	3645	1030
16.4			667		1030
19.7				5468	5111
23.0				5468	5111
26.3				3860	5111
29.5				5047	5111
32.8			980	5047	5111
36.1			980	2343	2129
39.4			980	2625	2129
41.0			980	3125	2129
42.7			980	5468	2129
44.3		1000	1400	5468	5765
45.9		1044	1400	5965	5765
47.6			1400	5965	5765
49.2		1183	1400	5468	5765
50.9		1220	1400	5468	5765
52.5		1252	1400	5047	5765
54.1		1263	1400	5047	5765
55.8	763		1400	5047	5765
57.4	1262	1263	1400	5047	5765
57.4	1312	1300	1400	5468	5765
59.1			1400	5047	5765
60.7	746		1400	5047	5765
62.3	597		1400	5468	5765
64.0	586			5468	
65.6				5468	
67.3	523			5047	
68.9	433			5468	
70.5	391			5047	
72.2	515			5047	
73.8	858			5047	
75.5	493			5047	
77.1	433			5047	
78.7	479			5126	
80.4	716			5126	
82.0	873			5126	
83.7	820			5126	
85.3	706			5126	
86.9	737			4971	
88.6	723			4971	
90.2	692			4971	
91.9	806			5126	
93.5	873			4971	
95.1	721			4971	
96.8	651			4825	
98.4	706			4971	

WEBB TRACT BOREHOLE DHP-2 VELOCITY LOGGING

Depth (ft)	Suspension R1-R2 Vs (ft/s)	Suspension S-R1 Vs (ft/s)	Downhole Layer Vs (ft/s)	Suspension R1-R2 Vp (ft/s)	Downhole Layer Vp (ft/s)
100.1	870			5468	
101.7	1127			5657	
103.4	1277			5657	
105.0	1302			5657	
106.6	1485			5859	
108.3	1793			6076	
109.9	1976			6309	
111.6	2013			6309	
113.2	2001			6076	
114.8	1519			5859	
116.5	1193			5468	
118.1	1233			5292	
119.8	1297			5292	
121.4	1220			5292	
123.0	1292			5468	
124.7	1384			5468	
126.3	1361			5468	
128.0	1426			5657	
129.6	1408			5468	
131.2	1302			5468	
132.9	1176			5292	
134.5	1035			5292	
136.2	940			5292	
137.8	929			5292	
139.4	919			5126	
141.1	894			5126	
142.7	924			5292	
144.4	962			5292	
146.0	954			5292	
147.6	954			5292	
149.3	994			5292	
150.9	1147			5292	
152.6	1180			5292	
154.2	1083			5292	
155.8	985			5292	
157.5	783			5468	
159.1	848			5292	
160.8	1135			5292	
162.4	1297			5292	
164.0	1540			5657	
165.7	1803			5657	
167.3	1875			5657	
169.0	1976			5657	
170.6	1600			5468	
172.2	1287			5657	
173.9	1287			5657	
175.5	1339			5859	

Depth (ft)	Suspension R1-R2 Vs (ft/s)	Suspension S-R1 Vs (ft/s)	Downhole Layer Vs (ft/s)	Suspension R1-R2 Vp (ft/s)	Downhole Layer Vp (ft/s)
177.2	1345			5859	
178.8	1390			5859	
180.5	1356			5657	
182.1	1287			5468	
183.7	1127			5657	
185.4	1112			5468	
187.0	1238			5657	
188.7	1452			5657	
190.3	1323			5468	
191.9	1155			5657	
193.6	1065			5468	
195.2	1101			5468	
195.2	1097			5468	
198.5	1072			5468	
200.1	1339			5468	
201.8	1600			5657	
203.4	1339			5657	
205.1	1229			5292	
206.7	1197			5126	
208.3	982			5126	
210.0	889			4971	
211.6	882			4971	
213.3	965			5292	
216.5	1657			6076	
219.8	2173			6076	
223.1	1640			6076	
226.4	1471			5468	
229.7	1302			5468	
232.9	1312			5468	
236.2	1184			5468	
239.5	1131			5292	
242.8	1116			5126	
246.1	1079			5126	
247.7	756			5126	
249.3	798			5126	
252.6	868			4971	
255.9	906			4971	
257.6	866			4971	
259.2	863			4971	
260.8	875			4971	
262.5	850			5126	
264.1	882			5126	
265.8	1000			5292	
269.0	1318			5468	
272.3	1172			5292	
275.6	1277			5468	
278.9	1243			5468	
282.2	1180			5468	

AGBABIAN ASSOCIATES
engineers and consultants

1111 South Arroyo Parkway, Suite 405, Pasadena, CA 91105 • (818) 441-1060 • FAX: (818) 441-0757

August 24, 1993

Tom Peltier
Department of Water Resources
Division of Design and Construction
1416 Ninth Street, Room 550
Sacramento, California 94236-001

Dear Mr. Peltier,

Enclosed please find our graphs and tables displaying suspension and downhole velocity data collected on August 13, 1993 at borehole DHP-1B, located on Bacon Island. Also enclosed are ASCII files of the depth and velocity values as well as ASCII waveform records for all three boreholes, as requested by Frank Glick.

Due to our experience with the rapidly changing layers present at the Webb Island site, and with borehole DHP-1A, we have collected data at 0.5 meter intervals, rather than the specified 1 meter intervals. I am very pleased with the results from this site in the region below the casing.

Comparison of the data from boreholes DHP-1A and DHP-1B show very close agreement of the S-wave velocities if the data from DHP-1B is shifted 15 or 16 feet up to correct for the difference in borehole collar elevation, i.e., the height of the levee. There are variations between the two data sets in the minimum and maximum velocities of several thin layers in the top 75 feet; this apparent lateral variation may be influenced by the additional overburden of the levee, or may represent natural variation due to ancient drainage courses.

The quality of suspension logging data in the cased region of DHP-1B ranged from fair to poor. We did not make additional efforts to collect data in the cased region due to the close agreement of the data with the plots of DHP-1A velocities, which characterize this region rather well.

Below 135 feet, the plots show very good agreement in trends between P- and S-wave data; this is characteristic of soil sites with S-wave velocities above 1000 ft/sec.

AGBABIAN ASSOCIATES
engineers and consultants

1111 South Arroyo Parkway, Suite 405, Pasadena, CA 91105 • (818) 441-1060 • FAX: (818) 441-0757

As I mentioned in my previous letter dated August 4, 1993, in future work desiring to obtain velocity data from this kind of site I would recommend drilling with rotary mud from the surface, or use a casing advance technique (perhaps just driving the casing in without first drilling) in order to avoid the disturbances created in the borehole. All other boreholes we have logged have been drilled using rotary mud from the surface, or at most 8 feet down.

We are pleased to have worked with you on this project, and hope that we will be able to assist you in future projects of this nature. Please let us know if you have any questions or comments regarding the results of this project.

Regards,

Robert Steller
Manager of Geophysical Services

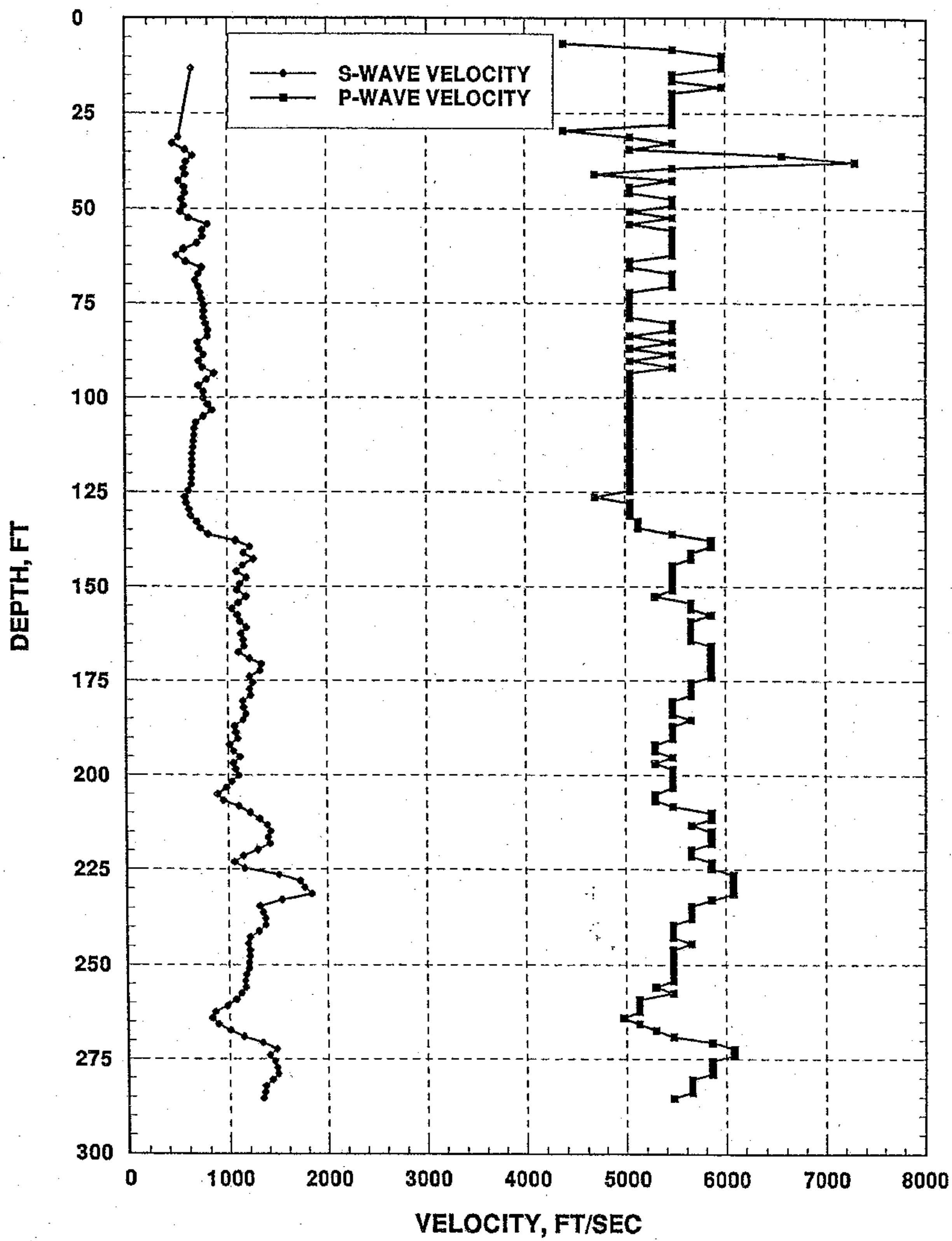
enclosure

cc: Perris Baker, P. C. Exploration

Ref: 9329-15353

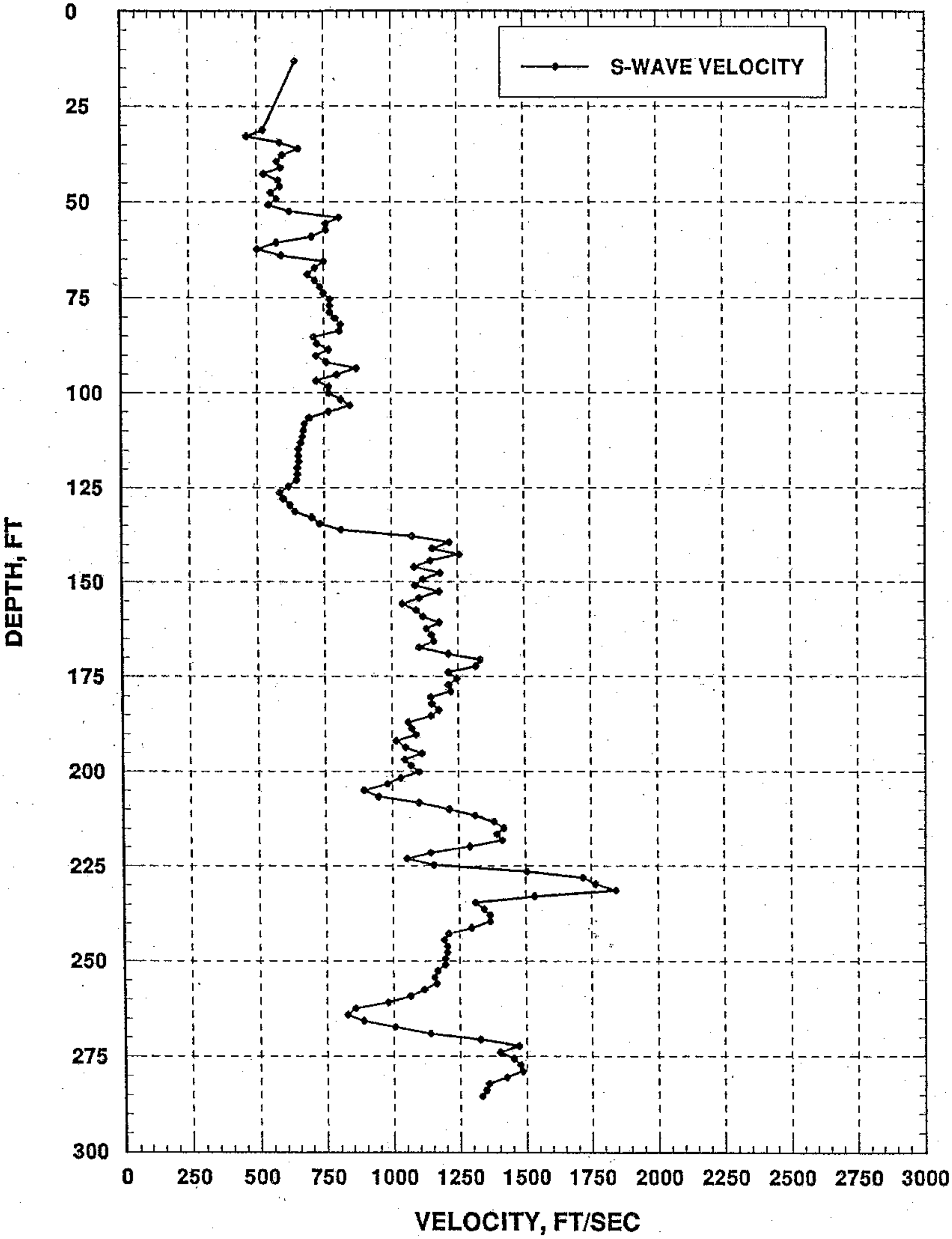
BACON ISLAND BOREHOLE DHP-1B SUSPENSION LOGGING

P- AND S- WAVE VELOCITIES; DATA COLLECTED AUGUST 13, 1993



BACON ISLAND BOREHOLE DHP-1B SUSPENSION LOGGING

S - WAVE VELOCITIES; DATA COLLECTED AUGUST 13, 1993



BACON ISLAND BOREHOLE DHP-1B VELOCITY LOGGING

Depth (ft)	Suspension Vs (ft/s)	Suspension Vp (ft/s)
160.8	1180	5657
162.4	1131	5657
164.0	1151	5657
165.7	1159	5859
167.3	1105	5859
169.0	1215	5859
170.6	1334	5859
172.2	1318	5859
173.9	1215	5859
175.5	1247	5657
177.2	1215	5657
178.8	1224	5657
180.5	1147	5468
182.1	1151	5468
183.7	1176	5468
185.4	1147	5657
187.0	1062	5468
188.7	1076	5468
190.3	1090	5468
191.9	1016	5292
193.6	1052	5292
195.2	1112	5468
196.9	1048	5292
198.5	1072	5468
200.1	1101	5468
201.8	1032	5468
203.4	982	5468
205.1	894	5292
206.7	948	5292
208.3	1101	5468
210.0	1215	5859
211.6	1312	5859
213.3	1384	5657
214.9	1420	5859
216.5	1396	5859
218.2	1414	5859
219.8	1292	5657
221.5	1143	5657
223.1	1055	5859
224.7	1155	5859
226.4	1505	6076
228.0	1718	6076
229.7	1764	6076
231.3	1843	6076
232.9	1533	5859
234.6	1312	5657
236.2	1345	5657

Depth (ft)	Suspension Vs (ft/s)	Suspension Vp (ft/s)
237.9	1367	5657
239.5	1367	5468
241.1	1297	5468
242.8	1211	5468
244.4	1193	5657
246.1	1206	5468
247.7	1206	5468
249.3	1197	5468
251.0	1197	5468
252.6	1168	5468
254.3	1155	5468
255.9	1163	5292
257.6	1116	5468
259.2	1065	5126
260.8	979	5126
262.5	857	5126
264.1	828	4971
265.8	887	5126
267.4	1006	5292
269.0	1139	5468
270.7	1328	5859
272.3	1471	6076
274.0	1402	6076
275.6	1452	5859
277.2	1478	5859
278.9	1485	5859
280.5	1426	5657
282.2	1361	5657
283.8	1350	5657
285.4	1334	5468

BACON ISLAND BOREHOLE DHP-1B VELOCITY LOGGING

Depth (ft)	Suspension Vs (ft/s)	Suspension Vp (ft/s)
3.3		
4.9		
6.6		4374
8.2		5468
9.8		5965
11.5		5965
13.1	643	5965
14.8		5468
16.4		5468
18.0		5965
19.7		5468
21.3		5468
23.0		5468
24.6		5468
26.3		5468
27.9		5468
29.5		4374
31.2	523	5047
32.8	464	5468
34.5	586	5047
36.1	656	6562
37.7	597	7291
39.4	576	5468
41.0	588	4687
42.7	527	5468
44.3	581	5047
45.9	586	5047
47.6	554	5468
49.2	573	5468
50.9	545	5047
52.5	622	5468
54.1	805	5047
55.8	759	5468
57.4	759	5468
59.1	706	5468
60.7	573	5468
62.3	503	5468
64.0	591	5047
65.6	750	5047
67.3	717	5468
68.9	691	5468
70.5	717	5468
72.2	737	5047
73.8	750	5047
75.5	772	5047
77.1	772	5047
78.7	772	5047
80.4	791	5468

Depth (ft)	Suspension Vs (ft/s)	Suspension Vp (ft/s)
82.0	810	5468
83.7	805	5047
85.3	713	5468
86.9	725	5047
88.6	767	5468
90.2	721	5047
91.9	759	5468
93.5	869	5047
95.1	795	5047
96.8	721	5047
98.4	767	5047
100.1	767	5047
101.7	810	5047
103.4	847	5047
105.0	767	5047
106.6	694	5047
108.3	676	5047
109.9	673	5047
111.6	670	5047
113.2	663	5047
114.8	653	5047
116.5	653	5047
118.1	656	5047
119.8	650	5047
121.4	650	5047
123.0	646	5047
124.7	616	5047
126.3	583	4687
128.0	597	5047
129.6	622	5047
131.2	640	5047
132.9	703	5126
134.5	734	5126
136.2	810	5468
137.8	1079	5859
139.4	1220	5859
141.1	1155	5657
142.7	1257	5657
144.4	1147	5468
146.0	1086	5468
147.6	1184	5468
149.3	1120	5468
150.9	1090	5468
152.6	1180	5292
154.2	1105	5657
155.8	1042	5657
157.5	1094	5859
159.1	1120	5657

ESTIMATION OF SEISMIC WAVE AMPLIFICATION IN SACRAMENTO-SAN JOAQUIN DELTA

Tadahiro KISHIDA[1], Ross W. BOULANGER[1], Norman A. ABRAHAMSON[2] Timothy M. WEHLING[3], and Michael W. DRILLER[3]

ABSTRACT

This paper describes the estimation of seismic wave amplification for the Sacramento-San Joaquin Delta where the subsurface soils include thick deposits of organic soil and peat. Sources of uncertainty that contribute to the variation of seismic wave amplification are evaluated, including variability in the input motions, soil profiles, and dynamic soil properties. These uncertainties are propagated through Monte Carlo simulations of one-dimensional, equivalent-linear, site response analyses, and are evaluated in terms of their impacts on the variation of site amplification factors.

INTRODUCTION

The Sacramento-San Joaquin Delta consists of about 1700 km of levees along various rivers and sloughs that direct water to San Francisco Bay, and provides water that serves about two-thirds of the population in California. The levees organize a complicated channel system that surrounds over 60 islands with ground surface levels below the adjacent waterway levels. Levee failures during an earthquake are a major concern because rapid inundation of the inner islands has the potential to significantly reduce the freshwater supply for California, in addition to damaging the natural habitat, crops and civil infrastructure. The California Department of Water Resources performed preliminary seismic stability evaluations of the levee system and concluded that the seismic wave amplification at sites underlain by peat and organic soil was a major source of uncertainty in seismic hazard evaluations for the delta (CDWR 1992).

The seismic wave amplification at soft soil sites depends on the input motions, the soil profile, and the nonlinearity of the subsurface soils. Intensity measures of input motions such as peak ground acceleration (*PGA*) or spectral acceleration (S_a) can be used as an estimator of nonlinearity in the site amplification. Idriss (1991) presented the nonlinear seismic wave amplification at soft soil sites against the *PGA* on rock based on earthquake observations. Fiegel (1995) obtained similar nonlinear seismic wave amplification relations using dynamic centrifuge models of soft soil profiles. Arulnathan et al. (2001) presented the nonlinear seismic wave amplification through thick peat deposits based on dynamic centrifuge model tests. Fiegel (1995) and Arulnathan (2000) showed that equivalent-linear site response analyses were capable of approximating the nonlinear seismic wave amplification observed in these centrifuge models of soft clay and peat profiles.

This paper presents results from a study of nonlinear seismic wave amplification in the Sacramento-San Joaquin Delta where the subsurface soils include thick deposits of soft clay and

[1] Department of Civil and Environmental Engineering, University of California, Davis, USA
[2] Pacific Gas and Electric, San Francisco, California, USA
[3] California Department of Water Resources, Sacramento, California, USA

silt, organic soil, and peat. One-dimensional equivalent-linear site response analyses were performed using a broad range of input motions, soil profiles, and realizations of dynamic soil properties. The dynamic properties of organic soil and peat were based on a new regression model developed against a database of laboratory test data. The resulting site amplification factors were checked for dependence on various characteristics of the input motions and dynamic soil profiles, and the sources of uncertainty in the site amplification factor were evaluated.

SEISMIC WAVE AMPLIFICATION

Variation of Input Motions

The NGA ground motion database organized by Pacific Earthquake Engineering Research Center (http://peer.berkeley.edu/nga/) was used in selecting the input motions for site response analysis. The ground acceleration records from sites classified as *NEHRP* (1994) site D (180 m/s < V_{s30} < 360 m/s) were used as input motions. This database includes more than 1,800 events obtained from 150 earthquakes. Figure 1 shows the variation of distance, moment magnitude, and *PGA* for site D recordings in the ground motion database. Distance, magnitude, and *PGA* vary from 0.4 km to 400 km, 4.3 to 7.9, and 0.002 g to 1.6 g, respectively. It can be seen that a broad range of magnitude and *PGA* combinations are represented in the database. The full set of site D recordings were used for site response calculations for select soil profiles, after which a subset of 70 recordings were selected that maintained the same distribution of site amplification factor (median value and variance) for those few sites.

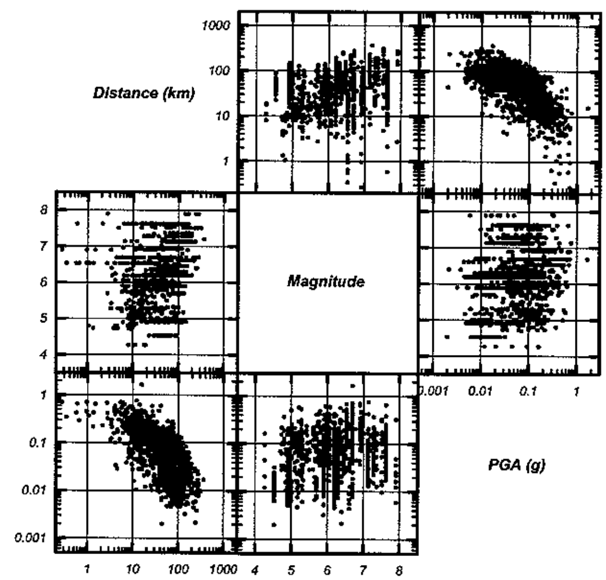


Figure 1. Scatter plots of motion characteristics

Variation of Dynamic Soil Properties

For predominantly sand or clay layers, dynamic soil properties were estimated as follows. Small strain stiffness (G_{max}) was obtained from the density (ρ) and shear wave velocity (V_s) with $G_{max} = \rho V_s^2$ when V_s and ρ were available. When V_s was not available, regression equations were used to estimate G_{max}. Normalized modulus reduction (G/G_{max}) and damping ratio (ξ) curves were based on EPRI (1993) for sandy layers and on Vucetic and Dobry (1991) for clayey layers.

For peat and organic soil layers, G, ξ, ρ were estimated by regression models when V_s and ρ were not available. Those equations were derived based on a database compiled from previous research by Stokoe et al. (1996), Boulanger et al. (1998), Kramer (2000), Wehling et al. (2003a, 2003b, 2003c), and Stokoe et al. (2003, personal communication). The following equations show the regression models for G_{lab}, ξ_{lab}, and ρ_{lab}. Parameters are shown in Table 1. A regression model between in situ V_s and laboratory V_s [computed as $\sqrt{(G_{max,lab}/\rho_{lab})}$] (updated from Kishida et al. 2006) was used to approximately adjust G_{lab} to estimated $G_{in\ situ}$ values; i.e., to account for factors such as sampling disturbance, load path, loading frequency, state of stress, etc. Note that the adjustment to G does not affect the ratio of G/G_{max}.

Laboratory relations:

$$\ln G_{lab} = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5\left(X_1-\overline{X_1}\right)\left(X_2-\overline{X_2}\right) + b_6\left(X_1-\overline{X_1}\right)\left(X_3-\overline{X_3}\right)$$
$$+b_7\left(X_2-\overline{X_2}\right)\left(X_3-\overline{X_3}\right) + b_8\left(X_1-\overline{X_1}\right)\left(X_2-\overline{X_2}\right)\left(X_3-\overline{X_3}\right)$$
$$\ln \xi_{lab} = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4\left(X_1-\overline{X_1}\right)\left(X_2-\overline{X_2}\right) + b_5\left(X_2-\overline{X_2}\right)\left(X_3-\overline{X_3}\right)$$
$$\ln \rho_{lab} = b_0 + b_1X_1 + b_2X_2$$

In situ relations:

$$\xi_{in\ situ} = \xi_{lab}$$
$$\rho_{in\ situ} = \rho_{lab}$$
$$G_{in\ situ} = 1.56\hat{G}_{lab}$$

where ^ denotes the expected values from the laboratory based model. Parameters are shown in Tables 1-3. Figures 2 and 3 show typical G/G_{max} and ξ curves obtained from the regression models. G/G_{max} tends to locate higher with increase of consolidation stress for low organic content (OC) soil, and does not vary with different consolidation stress for highly organic soil. ξ decreases with increase of consolidation stress for low organic soil, and does not vary with different consolidation stress for highly organic soil. Figures 4-7 show the residual plots of $\ln G$, $\ln\xi$, $\ln\rho$, and in situ $\ln V_s$ against predictor variables. The standard deviation (σ) of the in situ $\ln V_s$ was 0.357 which was larger than what was expected from the standard deviations in G and ρ from laboratory tests because the in situ variance includes the effects of spatial variability.

Table 1. Coefficient of $\ln G_{lab}$ model

Variables	Model Constrains	Reference strain
$X_1 = \ln(\gamma_c + \gamma_r)$	$b_2 = 1 - 0.37\overline{X_3}\left[1 + \frac{\ln(\gamma_r) - \ln(\gamma_c+\gamma_r)}{\ln(\gamma_l/\gamma_r + \gamma_c/\gamma_r)}\right]$	$\gamma_r = \exp\left[b_9 + b_{10}\left(X_3 - \overline{X_3}\right)\right]$
$X_2 = \ln\sigma'_{vo}$	$b_4 = 0.8 - 0.4X_3$	$\gamma_l = 1$
$X_3 = 2/[1+\exp(OC/23)]$	$b_5 = \frac{0.37\overline{X_3}}{\ln(\gamma_l/\gamma_r + \gamma_c/\gamma_r)}$	**Parameters**
$X_4 = \ln OCR$	$b_6 = 0$	$b_0 = 5.00$
Constant	$b_7 = -0.37\left[1 + \frac{\ln(\gamma_r) - \ln(\gamma_c+\gamma_r)}{\ln(\gamma_l/\gamma_r + \gamma_c/\gamma_r)}\right]$	$b_1 = -0.729$
$\overline{X_1} = -2.5$	$b_8 = \frac{0.37}{\ln(\gamma_l/\gamma_r + \gamma_c/\gamma_r)}$	$b_3 = -0.693$
$\overline{X_2} = 4.0$	**Standard deviation**	$b_9 = -1.41$
$\overline{X_3} = 0.5$	$\sigma = 0.348$	$b_{10} = -0.950$

Table 2. Coefficient of $\ln\xi$ model

Variables	Parameters
$X_1 = \ln\left[\ln\left(\hat{G}_{max}/\hat{G}\right)+b\right]$	$b_0 = 2.86$
$X_2 = \ln\sigma'_{vo}$	$b_1 = 0.571$
$X_3 = 2/\left[1+\exp(OC/23)\right]$	$b_2 = -0.103$
Constant	$b_3 = -0.141$
$\overline{X_1} = -1.0$	$b_4 = 0.0419$
$\overline{X_2} = 4.0$	$b_5 = -0.240$
$\overline{X_3} = 0.5$	$b = 0.103$
	Std.
	$\sigma = 0.235$

Table 3. Coefficient of $\ln\rho$ model

Variables	Parameters	Std.
$X_1 = \ln(\sigma'_{vo}/p_a)$	$b_0 = 0.063$	$\sigma = 0.038$
$X_2 = 2/\left[1+\exp(OC/23)\right]$	$b_1 = 0.038$	
	$b_2 = 0.36$	

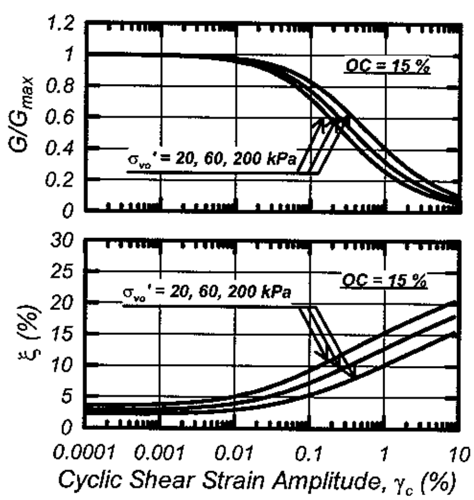


Figure 2. G/G_{max} and ξ for low organic soil

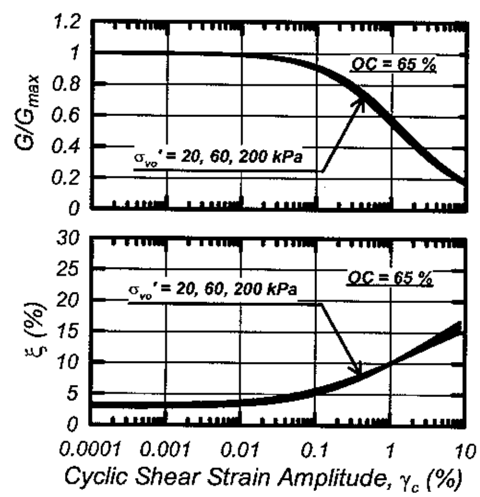


Figure 3. G/G_{max} and ξ for high organic soil

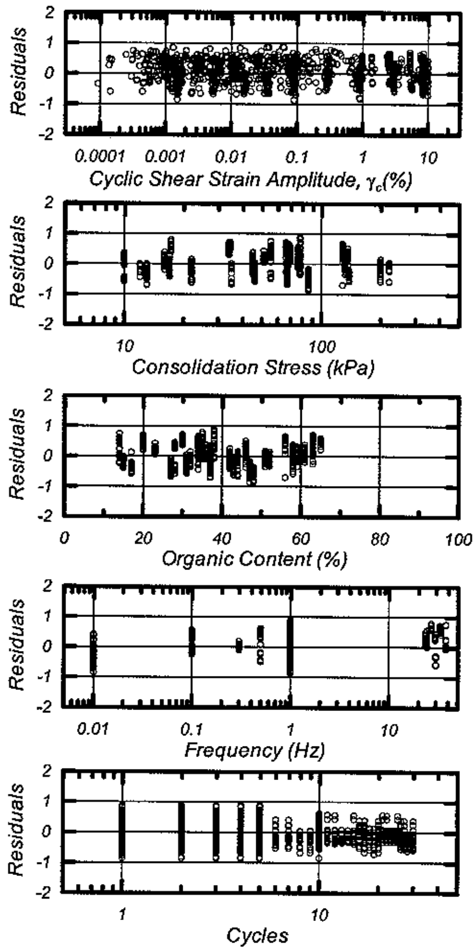


Figure 4. Residuals of $\ln G$

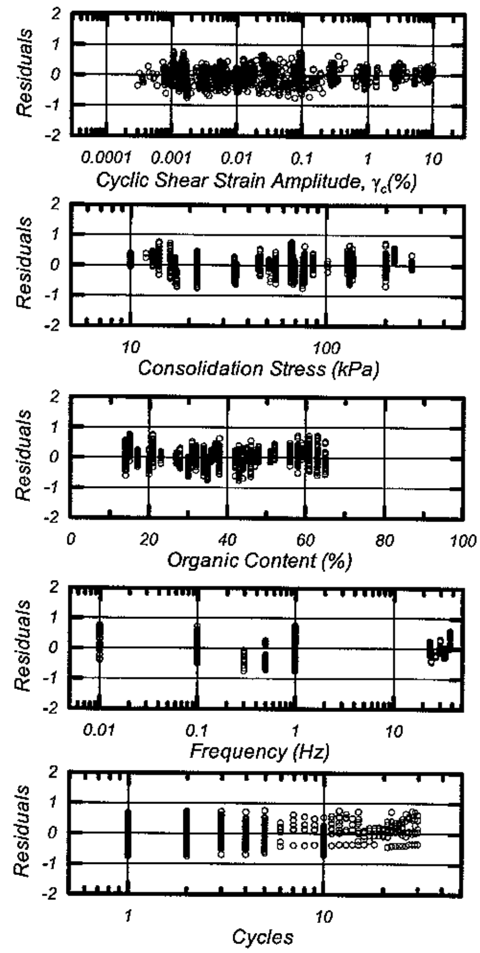


Figure 5. Residuals of $\ln \xi$

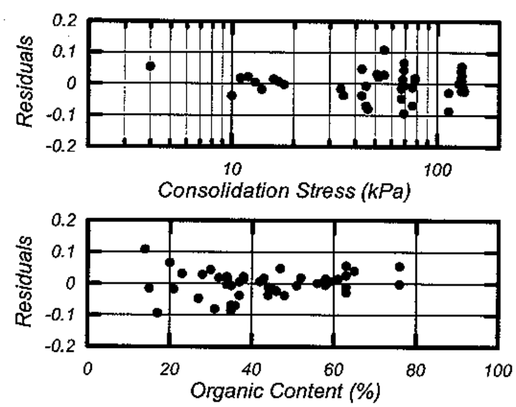


Figure 6. Residual plots of $\ln \rho$

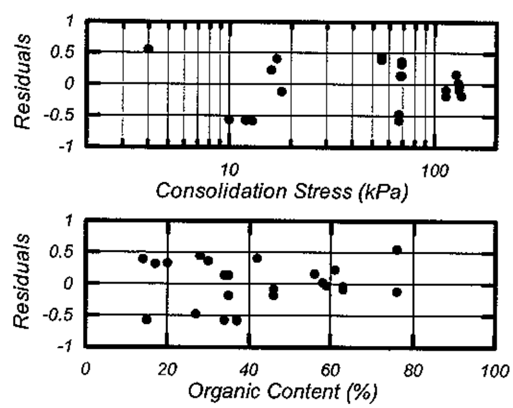


Figure 7. Residual plots of in situ $\ln V_s$

Variation of Soil Profiles

Twenty two soil profiles were selected from 14 different levees in the delta, at the approximate locations shown in Figure 8. All the profiles were obtained from crests of levees. Figure 9 shows a typical cross-section, illustrating the very gentle slopes on either side of the levee crest.

All profiles have a stiff sand deposit below approximately 20 to 30 m depth that has V_s values corresponding to *NEHRP* site D. Peat and organic soil layers ranged from 0 m to 13.5 m thick at the various soil profiles.

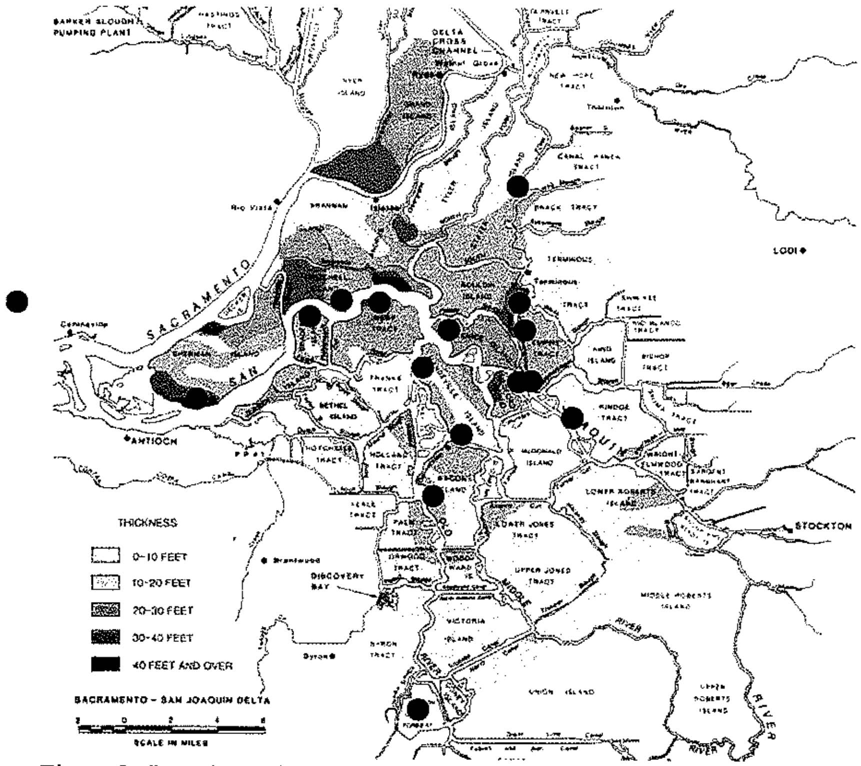


Figure 8. Locations of soil profiles used in site response analyses (base map from DWR).

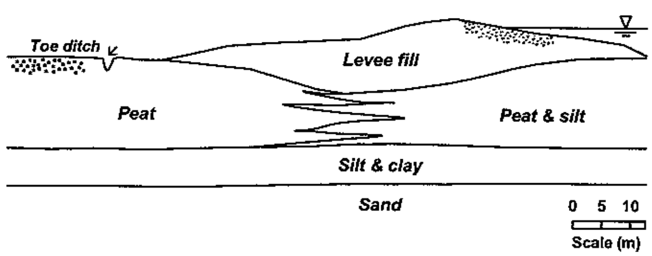


Figure 9. Typical cross section in Sacramento-San Joaquin delta (Sherman Island)

Realization of Dynamic Soil Profiles

Uncertainty in dynamic soil properties was modeled in Monte Carlo simulations using different soil profile realizations. In general, five different realizations were used for each soil profile. For select cases, up to twenty realizations were used. The covariance matrix of dynamic soil properties was obtained by combining a covariance matrix based on the covariance between residuals of dynamic soil properties as measured in the laboratory, and a covariance matrix for spatial correlation of soil properties. Spatial correlation was applied within the same geological layer and assumed to have a 2.0-m scale of fluctuation with exponential decay. Profiles of dynamic soil properties were generated using 0.1 m intervals. The site response analyses were performed using 1-m thick sub-layers with properties taken as the arithmetic mean of the dynamic soil properties within the sub-layer. Figure 10 shows two examples of soil profile realizations for two sites: one where V_s measurements are available for estimating dynamic properties, and another where dynamic properties must be estimated without V_s measurements.

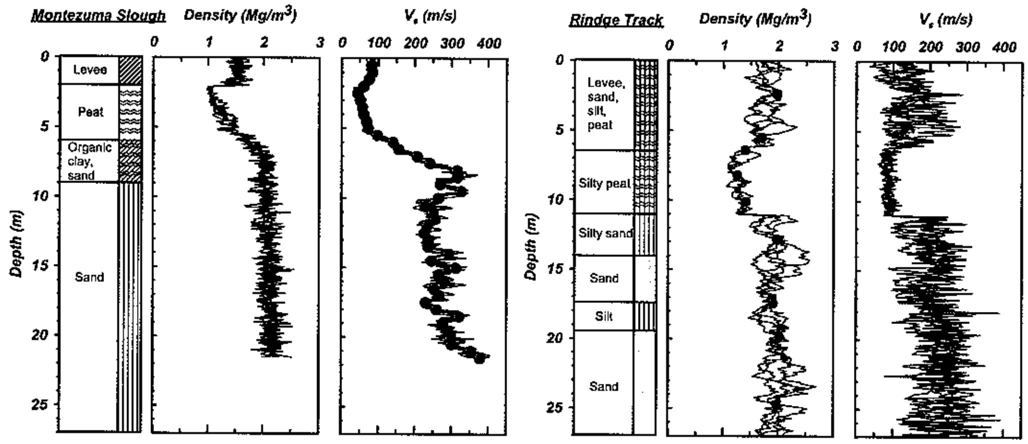


Figure 10. V_s realizations for two levees: (a) with V_s measurements, and (b) without V_s measurements.

Local Site Effects

Role of Interval

Dynamic soil properties were generated for every 0.1 m interval, and then averaged over 1.0-m thick sub-layers for the site response analyses. The effect of using different sub-layer thicknesses in the site response analyses was studied for select sites by repeating the analyses using 0.5, 1.0, 2.0, and 4.0 m thick sub-layers (with averaging of dynamic soil properties over the sub-layer). For example, Figure 11 shows results for one soil profile with twenty realizations, four input motions, and the four sub-layer thicknesses. For each motion, the geometric mean response was obtained and the residuals plotted versus the sub-layer thickness.

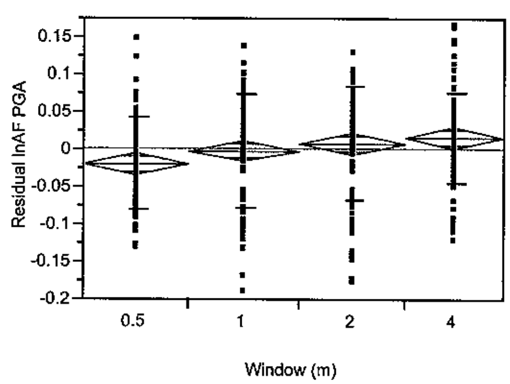


Figure 11. Residuals of PGA amplification factors against sub-layer thickness

The results in Figure 11 indicate that mean amplification factor increased slightly with increasing sub-layer thickness (or "window" in Figure 11), while the standard deviation was relatively independent of sub-layer thickness. Mean ANOVA and unequal variance test shows that the F values were about 4.0 indicating that the effect of sub-layer thickness on the mean values and standard deviations were vary small compared to the total variation of data. Therefore, the effects of sub-layer thickness on amplification factor and its variance is believed to be very small, and the use of a 1.0 m thick sub-layers for the majority of the analyses is considered reasonable.

Regression of Site Amplification Factor

The computed site amplification factors of *PGA* from *NEHRP* site D outcrop to levee crest at Delta are plotted in Figure 12. These results were first modeled by the following equation,

$$\ln AF = b_0 + b_1 \ln(PGA + b_2) + b_3 M_W$$

from which the parameter b_2 was estimated as 0.245. The regression model was subsequently expanded, keeping the parameter b_2 as 0.245, to,

$$\ln AF = b_0 + b_1 \ln(PGA + b_2) + b_3 M_W + \tau_{profiles} + \tau_{realization}$$

where τ is the random effect between the 22 soil profiles and between each realization respectively. Table 4 shows the coefficients obtained from the regression analysis. Regression results show that *PGA* site amplification factor tends to increase with increase of earthquake magnitude. This trend is similar to those presented by Idriss (1991) and observed by Fiegel (1995) for soft clay sites. The site amplification model is compared to the site response analysis results in Figure 12.

Table 4. Coefficient of site amplification factor model

b_0	b_1	b_2	b_3
-0.731	-0.522	0.245	0.0816

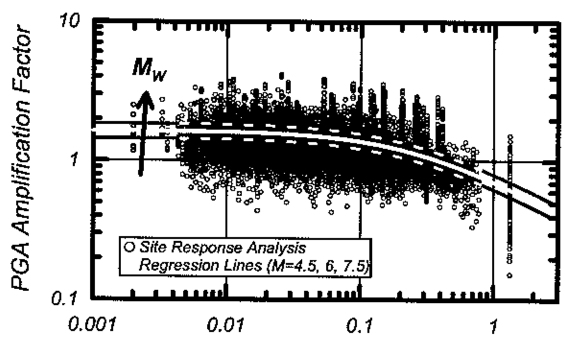


Figure 12. One-dimensional site amplification factor for the delta.

Regression results indicate that 65-75%, 4-10%, and 20-30% of the total variance (σ_{total}=0.36) come from the variation in soil profiles, the unpredictable randomness of dynamic soil properties, and the variation of input motions which is not explained by *PGA* and M_W, respectively. If the site profile is known, the contribution of input motion variability to the variance of site amplification factor is about 3 to 6 times larger than the contribution of dynamic property variability.

CONCLUDING REMARKS

A site amplification factor of *PGA* from *NEHRP* site D outcrop to levee crest was developed for the Sacramento-San Joaquin Delta. The subsurface soils include thick deposits of soft clay and silt, organic soil, and peat. A model for the dynamic properties of organic soil and peat was developed. Uncertainties in dynamic properties, soil profiles, and input motions were included in the one-dimensional equivalent-linear site response analyses. The variance in soil profiles across the delta had the greatest contribution to the total variance in site amplification factor, while the variance in input ground motions had the second greatest contribution. The variance in dynamic soil properties had a relatively small contribution to the total variance in site amplification factor.

This study is still in progress. The effects of two-dimensional versus one-dimensional response analyses for estimating the site amplification factor of these gently-sloped levees still need to be addressed. Additional details on soil profiles and appropriate site indices for predicting site amplification factor are being studied. The results are being prepared for use in probabilistic seismic hazard analyses and risk studies for the delta.

ACKNOWLEDGMENTS

This research was supported by the California Department of Water Resources (CDWR), State of California. The views and conclusions contained in this paper are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the State of California. Travel by the second author to this workshop was supported by the New Energy and Industrial Technology Development Organization (NEDO) of Japan. The above support is greatly appreciated.

REFERENCES

Arulnathan, R. (2000). Dynamic Properties and Site Response of Organic Soils, Doctoral thesis, Department of Civil and Environmental Engineering, University of California, Davis, CA.

Arulnathan, R., Boulanger, R. W., and Idriss, I. M. (2001). "Site response of organic soils." *Proceedings, Fourth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics*, S. Prakash, ed., University of Missouri-Rolla, Rolla, Missouri, Paper 1.07.

Arulnathan, R., Boulanger, R. W., and Riemer, M. F. (1998). Analysis of bender element tests, *Geotechnical Testing Journal, GTJODJ*, 21(2): 120-131.

ASTM (1999). D 2974 – 87 (Reapproved 1995): Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils, *American Society of Testing and Materials*, 4.08: 288-290.

Boulanger, R. W., Arulnathan, R., Harder, Jr., L. F., Torres, R. A., and Driller, M. W. (1998). Dynamic properties of Sherman Island peat, *Journal of Geotechnical and Geoenvironmental Engineering*, ASCE, 124(1): 12-20.

California (1992). Seismic stability evaluation of the Sacramento-San Joaquin Delta levees, Phase I Report: Preliminary Evaluations and Review of Previous Studies, Division of Design and Construction, California Department of Water Resources, August, 203 pages.

Electric Power Research Institute (1993). Guidelines for site specific ground motions, *Rept. TR-102293*, 1-5, Pala Alto, California.

Fiegel, G. L. (1995). "Centrifugal and analytical modeling of soft soil sites subjected to seismic shaking." Doctoral thesis, Department of Civil and Environmental Engineering, University of California, Davis, CA.

Idriss, I. M. (1991). Earthquake ground motions at soft soil sites, *Proceedings: Second International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics*, 2265-2272.

Kishida, T., Boulanger, R. W., Wehling, T. M., and Driller, M. W. (2006). "Variation of small strain stiffness for peat and organic soil." *8th U.S. National Conference on Earthquake Engineering*, Earthquake Engineering Research Institute, Paper no. 1057.

Kramer, S. L. (2000). Dynamic response of Mercer Slough Peat, *Journal of Geotechnical and Geoenvironmental Engineering,* ASCE, 126(6): 504-510.

Seed, H. B., and Idriss, I. M. (1970). Analyses of ground motions at Union Bay, Seattle during earthquakes and distant nuclear blasts, *Bulletin Seismological Society of America*, 60(1): 125-136.

Stokoe, II, K. H., Bay, J. A., Rosenbald, B. L., Hwang, S. K., and Twede, M. R. (1996). In situ seismic and dynamic laboratory measurements of geotechnical materials at Queensboro Bridge and Roosevelt Island, *Geotechnical Engineering Report GR94-5*, Civil Engineering Dept., University of Texas at Austin, June.

Vucetic, M., and Dobry, R. (1991). Effect of soil plasticity on cyclic response. *Journal of Geotechnical Engineering*, ASCE, 117(1): 89-107.

Wehling, T. M., Boulanger, R., Arulnathan, R., Harder, L. F., and Driller, M. W. (2003a). Nonlinear dynamic properties of a fibrous organic soil. *Journal of Geotechnical and Geoenvironmental Engineering,* ASCE, 129(10): 929-939.

Wehling, T. M., Driller, M. W., Harder, Jr., L. F. (2003b). Delta seismicity study: dynamic properties of organic soils at Montezuma Slough: laboratory testing summary. State of California, The Resources Agency, Department of Water Resources, Division of Engineering.

Wehling, T. M., Driller, M. W., Harder, Jr., L. F. (2003c). Delta seismicity study: dynamic properties of organic soils at Clifton Court: laboratory testing summary. State of California, The Resources Agency, Department of Water Resources, Division of Engineering.

Wehling, T. M., Boulanger, R. W., Harder, Jr., L. F., Driller, M. W. (2001). Dynamic properties of Sherman Island peat: Phase II study, *Report UCD/CGM-01/01*, Center for Geotechnical Modeling, University of California, Davis, CA.

APPENDIX C

NONLINEAR FINITE DIFFERENCE (FLAC) DYNAMIC ANALYSIS FOR SHERMAN ISLAND LEVEE

NONLINEAR FINITE DIFFERENCE (FLAC) DYNAMIC ANALYSIS FOR SHERMAN ISLAND LEVEE

1. SITE CONDITIONS AND LEVEE SECTION AT SHERMAN ISLAND

Sherman Island is located in the river delta area, north of Antioch. Figure 1 shows the map with sampling location on the Sherman Island levee site. The levee surrounding the island protects the land from flooding during rainy seasons. A typical levee section near station 650+00 was selected for the dynamic analysis. The selected section is presented in Figure 2.

At this Levee section, it is noted that the ground surface at the slough side is at elevation -25 feet, while the Island-side ground surface is at elevation -11.5 feet. The levee crest is at elevation 8 feet, such that the Levee is about 33 feet high. The embankment is composed of fill material. Below the fill, there is a thick soft peat layer ranging from about 25 feet (at the slough side) to 38.5 feet (at the Island side). A thin loose sand layer and a thick dense sand layer underlie the peat layer. The high tide water table (at elevation +3 feet) on the slough side was considered in the dynamic analysis.

2 DYNAMIC ANALYSIS PROCEDURE

Fragility analysis of earthquake induced deformations at Sherman Island was performed for selected ground motion records using the finite difference computer program FLAC (Itasca, 2005) with a user defined non-linear soil constitutive model through the program's CPPUDM option.

2.1 Input Motions

Input motions developed for the site are described in the section 6. Time histories for three earthquake magnitudes: 5.5, 6.5 and 7.5, were developed and are presented in Figures 6-17 through 6-22.

For the fragility analysis, each of the three earthquake records (6 components) was scaled to three different peak ground acceleration (PGA) levels. For the magnitude 5.5 earthquake, the scaled PGA values are 0.05g, 0.1g, and 0.2g. For the magnitude 6.5 earthquake, the scaled PGAs are 0.05g 0.2g, and 0.3g. For the magnitude 7.5 earthquake, the scaled peak ground accelerations are 0.05g 0.2g and 0.4g.

2.2 Program FLAC and Boundary Conditions

Nonlinear dynamic analyses of the Sherman Island levee were performed using the program FLAC incorporating a nonlinear bounding surface plasticity soil model. Prior to the dynamic analysis, a static gravity load analysis was first performed to compute the static stresses in the levee and its foundation soils using a Mohr-Coulomb model and effective stress strength. These initial static stresses were used in the FLAC program (during the dynamic analysis) to determine the shear strength for each material zone using the nonlinear model. The initial displacements were set to zero before proceeding with the dynamic analysis.

One-dimensional site response analyses using the program SHAKE were performed for a representative soil column of the island site foundation to develop input motions for the two-dimensional analysis (i.e. an interface motion at the base of the FLAC model). These one-dimensional analyses were performed using each of the time histories scaled to a specified PGA level as input (stiff site outcropping) motions with half-space wave velocity of 1100 fps. In such case, a rigid base was used at the bottom of the FLAC grid. On both sides of the grid, free-field boundary conditions are usually specified in the analysis. But at this Sherman island profile, the soft peat layer caused large lateral movement at the grid's side boundaries. In this case, we used fixed side boundaries for the FLAC analyses for the Sherman Island levee, however the two side boundaries were kept at a significant distance from the toes of the levee.

3 SOIL PROPERTIES AND MODEL PARAMETERS

3.1 Soil Properties

Based on laboratory consolidated undrained triaxial test results, and the results and back analyses from field performance case histories, effective stress shear strength parameters (c' and ϕ') and total stress strength parameters (c and ϕ) were estimated for the levee fill, foundation peat, and underlying sands as shown in Table 1 below.

Table 1. Soil Properties Used in Analyses

Sherman Island Levee

Description	Soil Type	γ_t pcf	c' psf	ϕ' deg	c psf	ϕ deg	K_{2max}	V_s fps
Fill	1	115	50	32			25	
Peat: Free Field	2	70	120	28	140	18		100
Peat: under Levee	3	70	120	28	140	18		300
Silt/Clay	4	125	0	25	1200	0		570
Dense Sand	5	125	0	38			65	

The shear modulus of peat was estimated based on field measured shear wave velocities using the following relationship:

$$V_s = \sqrt{\frac{gG_{\max}}{\gamma}} \qquad (1)$$

where, G_{max} = shear modulus at low strain
γ = unit weight of material
g = acceleration due to gravity
V_s = shear wave velocity

Figures 3 and 4 show the measured shear wave velocities for the peat under the levee crest and the peat in the free-field beyond the levee toe, respectively. From these data and other information for peat, the shear wave velocity for peat under the levee crest was estimated at 300 fps, and for peat in the free-field at 100fps. For the levee fill and sand layer in the foundation, K_{2max} values, as listed in Table 1, were be used to compute the shear modulus using the following equation:

$$G_{\max} = 1000\, K_{2\max} \sqrt{\sigma'_m}\, , in\ psf \qquad (2)$$

where, K_{2max} = parameter relating G_{max} and σ'_m, and is a function of density or void ratio.
σ'_m = mean effective confining pressure in pounds per square foot (psf)

This study utilized published modulus reduction curves (Seed-Idriss, 1970 mean relationship for sand) for the fill within the levee embankment, and the sand layer below the peat layer. For the modulus reduction curve of peat, the Wehling et al., 2001 relationship (for confining pressure 12 kPa) was used in the free-field. For the peat under levee, modulus reduction curve by Wehling et al., 2001 relationship for confining pressure greater that 40 kPa was used. The nonlinear model utilizes these relationships between the modulus reduction factor, G/G_{max} ,and shear strain, to determine the model parameters for each of the material zones as described in the following section.

3.2 Model Parameters

The model implemented in FLAC is a simplified 2D version of the bounding surface plasticity model for sand (Wang, 1990). This model has the ability to capture the complex behavior of sand including liquefaction under monotonic and dynamic loading.

An essential feature distinguishing bounding surface plasticity from classical elasto-plasticity formulations (such as the Mohr-Coulomb-Finn model) is its ability to simulate nonlinear stress-strain behavior, pore water pressure generation and liquefaction under both unloading and reloading conditions. The model was further simplified for total stress analysis purposes. The code is written in C++ language and operates under FLAC's CPPUDM option. In such situation, the shear strength is not affected by mean stress changes and is kept constant for any given material zone under dynamic loading (such that it is named as a S_u model). In such a simplified version only four model parameters (S_u, G_{max}, ν and h_s) are needed in a total stress analysis.

The model parameter S_u is the undrained shear strength for the material zone. For the dynamic analysis, total stress strength parameter (c and ϕ from Table 1) were used. S_u was estimated using $S_u = c + \sigma_v' \tan\phi$, and σ_v' was estimated from the static (layer by layer) construction to the levee crest using the FLAC's static stress analysis and the effective stress strength parameters and the Mohr-coulomb model. G_{max} is the maximum shear modulus as described in the previous section. The parameter ν is Poisson's ratio. For the dynamic undrained analysis, $\nu = 0.47$ was used. The only new model parameter is h_s which is used to fit a given modulus reduction curve.

The analytical expression of the model generated modulus reduction curve is

$$G/G_{\max} = \left[1 - \frac{2\tau_m}{h_s\tau}\left(\ln(1-\frac{\tau}{\tau_m}) + \frac{\tau}{\tau_m})\right)\right]^{-1} \quad (3)$$

$$\gamma = \tau / G$$

where G is the secant modulus, h_s is a model parameter, and τ_m is the shear strength, S_u. The modulus reduction curve, G/G_{max}, for this model is shown by the first relationship in Eq. (3).

For a given soil strength, τ_m, and shear modulus, G_{max}, the modulus reduction curve (Eq. (3)) is a function of shear stress (or shear strain, through the second equation of (3)), and the function varies with model parameter h_r. This parameter can be calibrated against a given soil modulus reduction curve to obtain the best fitt. Figures 5 and 6 present the model fitting to the specified modulus reduction curves for peat under the crest and in the free-field, respectively. Figures 7 and 8 present the model fitting to the specified modulus reduction curves for the fill in the levee and sand underlay the peat, respectively. The selected model parameter h_s for the peat are 1.5 and 0.1, for the fill is 0.2, and for the sand is 0.3.

4. EARTHQUAKE INDUCED DEFORMATION FOR A TYPICAL INPUT MOTION

Pre-earthquake static effective stresses were first calculated in the levee as described above. Then, a specified earthquake input motion was applied as an interface motion at the base of the levee sections grid model.

4.1 Static Stress Analysis

The FLAC numerical grid and material zones are presented in Figure 9. In the static analysis, the side boundaries were fixed with no horizontal movement allowed. The levee section at Sherman Island was first built up to get stress distributions in the fill and foundation soils using effective stress strength parameters in Table 1. In the next step, a water surface was assigned with an upstream elevation of +3 feet, and a downstream water surface at 1.5 feet below ground surface at the Island side. The pore water pressure was determined using the specified water table. The computed static vertical stresses and pore water pressure are presented in Figures 10 and 11. In the third step, the undrained strength parameters were input for each zone for the dynamic FLAC analysis using the non-linear model. The displacements computed during the static analyses were set back to zero, before performing the dynamic analyses.

4.2 Dynamic Deformation for a Typical Input Motion

A typical input motion of magnitude 6.5 earthquake with peak ground acceleration of 0.2g was used as outcrop motion. We used a rigid base in the FLAC analysis, and an interface motion that was first developed using the one dimensional SHAKE analysis. This interface motion is presented in Figure 12. As described earlier, the two lateral boundaries were set a distance away from the levee toes, such that a fixed boundary condition could be used. The computed crest displacement time histories, both horizontal and vertical, are presented in Figure 13. The final crest horizontal displacement is about 1 foot, while the final settlement of the crest is about 0.8 feet. The contours of horizontal and vertical displacements are presented in Figures 14 and 15, respectively. Figure 16 demonstrates the computed shear stress versus shear strain relations during earthquake shaking in a typical zone in the peat layer. Because we used a non-linear soil model in the FLAC analysis, the stress-strain relations show the permanent shear strain accumulation during the shaking and the non-linear nature of the soil.

5 DEFORMATION FRAGILITY CURVES

The FLAC dynamic analyses for Sherman Island Levee were performed for three magnitude earthquakes (each scaled for three levels of peak ground acceleration) and for each of two horizontal components. Earthquake induced deformations were computed for the entire duration of the input motions. The critical information from the above dynamic analyses is the crest horizontal and vertical displacements, because excessive crest displacement will cause the potential for loss of free board (possible over topping), cracking, erosion, and consequently, levee failure. Table 2 summarizes the crest horizontal and vertical displacement for above specified input motions. Note that, for the same level of peak ground acceleration, larger magnitude earthquakes, as expected, resulted in greater induced deformations. This is because larger magnitude earthquakes have longer duration of strong shaking.

The earthquake induced horizontal crest displacements for the magnitude 5.5, 6.5, and 7.5 earthquakes are presented in Figure 17. Positive values indicate horizontal movement to the island direction. The earthquake induced vertical crest displacements for the magnitude 5.5, 6.5, and 7.5 earthquakes are presented in Figure 18. Negative values indicate soil settlement.

Table 2. Computed Crest Deformation at Sherman Island Levee

Magnitude	7.5				6.5				5.5			
component	H1		H2		H1		H2		H1		H2	
PGA	x-disp	y-disp	x-disp	y-disp	x-disp	y-disp	x-disp	y-disp	x-disp	y-disp	x-disp	y-disp
(g)	(ft)		(ft)		(ft)		(ft)		(ft)		(ft)	
0.05	0.214	-0.238	0.191	-0.185	0.170	-0.119	0.058	-0.085	0.039	-0.040	0.029	-0.049
0.1									0.089	-0.089	0.070	-0.108
0.2	1.691	-1.506	1.632	-1.375	0.970	-0.802	0.506	-0.606	0.220	-0.221	0.165	-0.259
0.3					1.608	-1.288	0.841	-1.071				
0.4	5.071	-4.194	3.569	-3.167								

6. REFERENCES

Itasca Consulting Group, Inc., 2005. “FLAC – Fast Lagrangian Analysis of Continua, Version 5.0 User’s Manual,” Minneapolis, Minnesota: Itasca.

Wang, Z.L., 1990, “Bounding Surface Hypoplasticity Model for Granular Soils and its Applications,” Ph.D. Dissertation, University of California Davis, U.M.I., Dissertation Information Service, Order No. 9110679, Ann Arbor, MI 48106.

Wang, Z.L. and F.I. Makdisi, 1999. Implementing a Bounding Surface Hypoplasticity Model for Sand into FLAC Program,” Proceedings of the FLAC Symposium on Numerical Modeling in Geomechanics, Minneapolis, Minnesota, September 1-3.

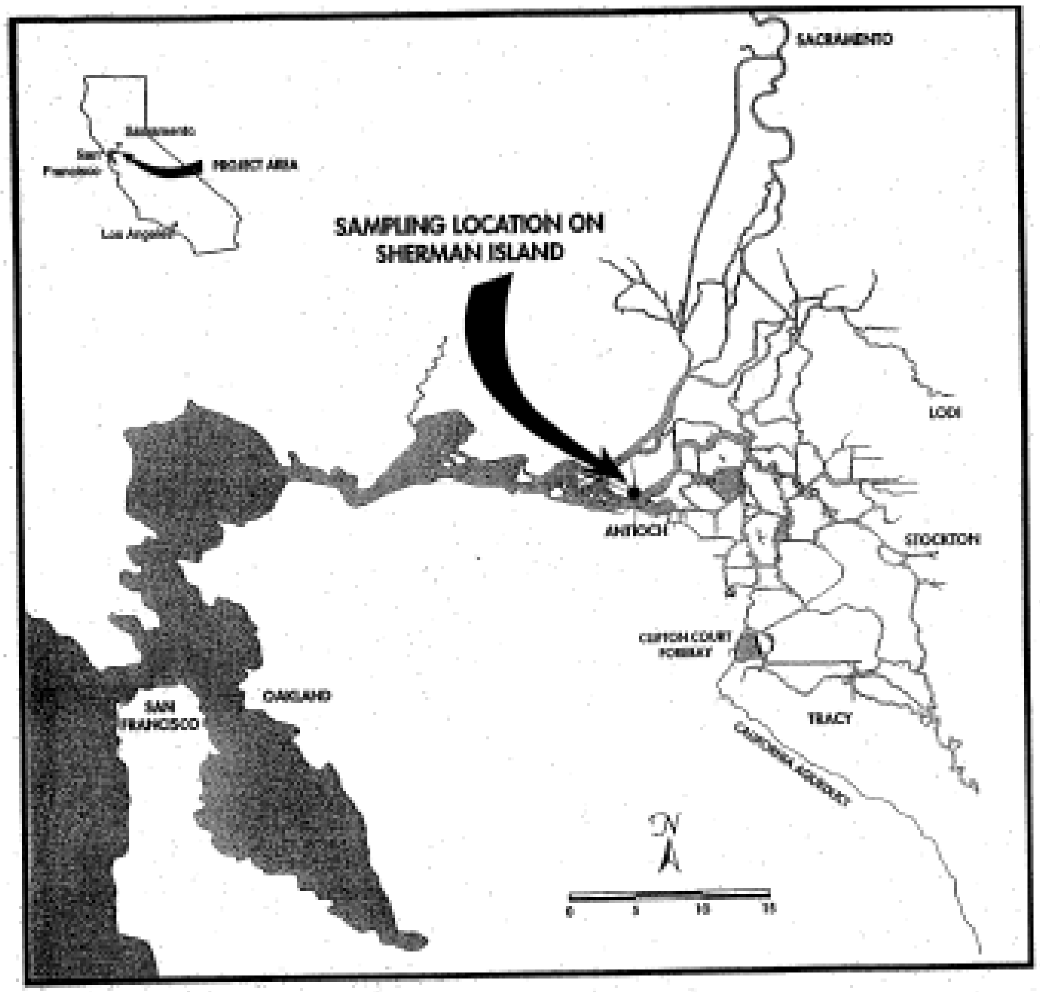


Figure 1. Location of Sherman Island

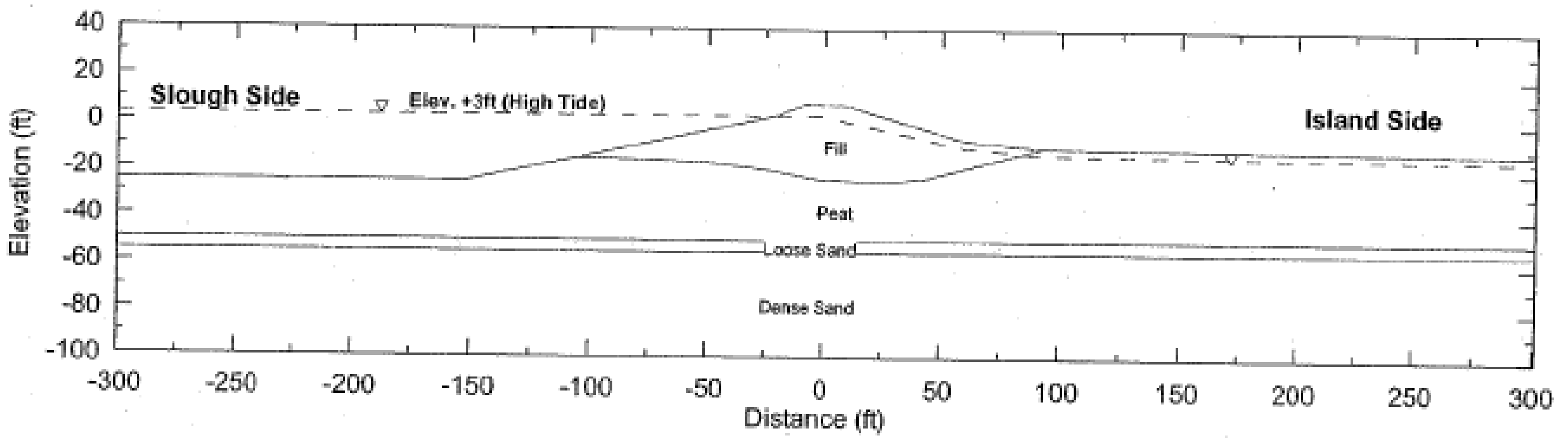


Figure 2. Analyzed Levee Cross Section at Sherman Island

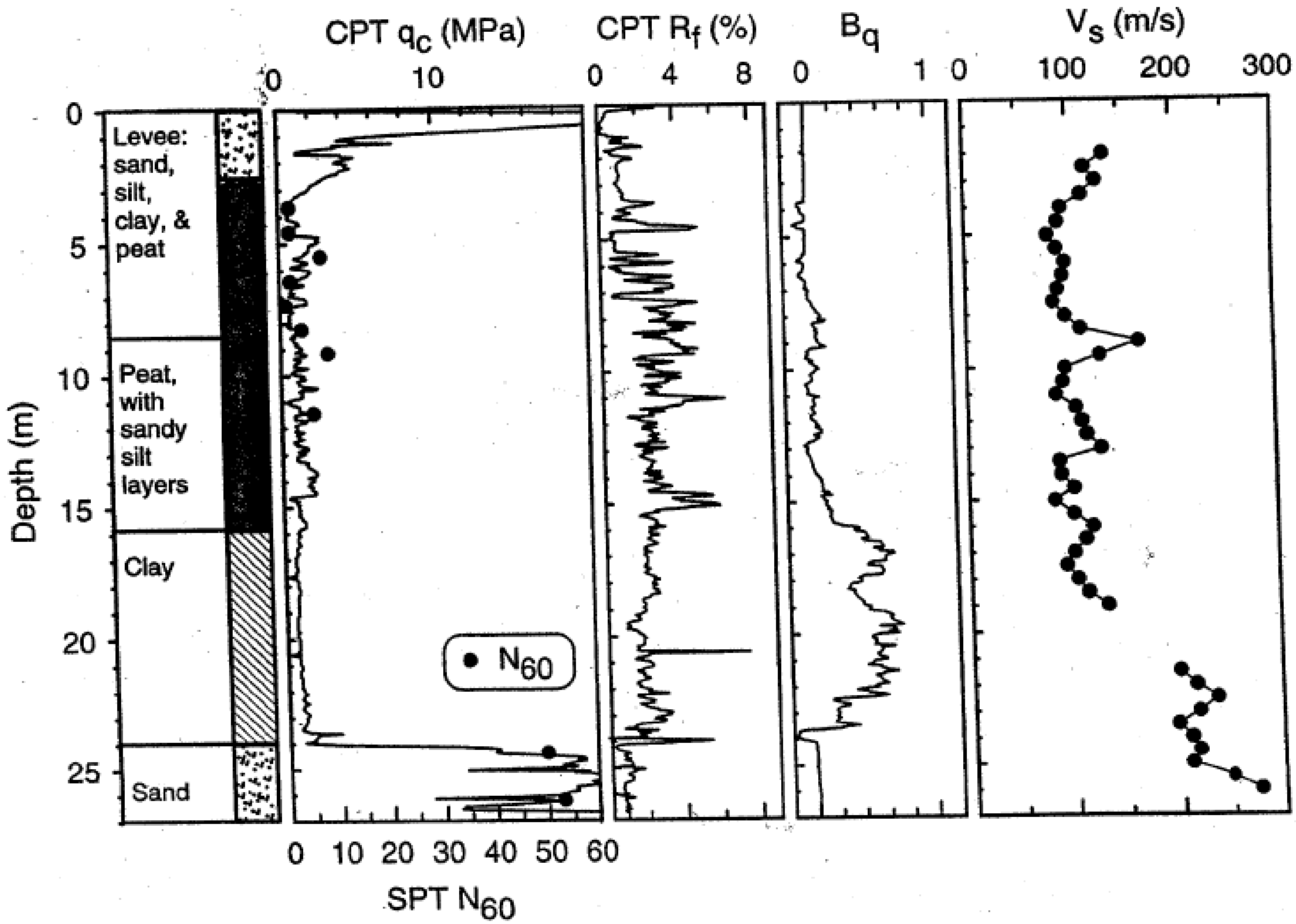


Figure 3. CPT and Shear Wave Velocity Data Beneath the Levee Crest at Sherman Island (Boulanger et al., 1998)

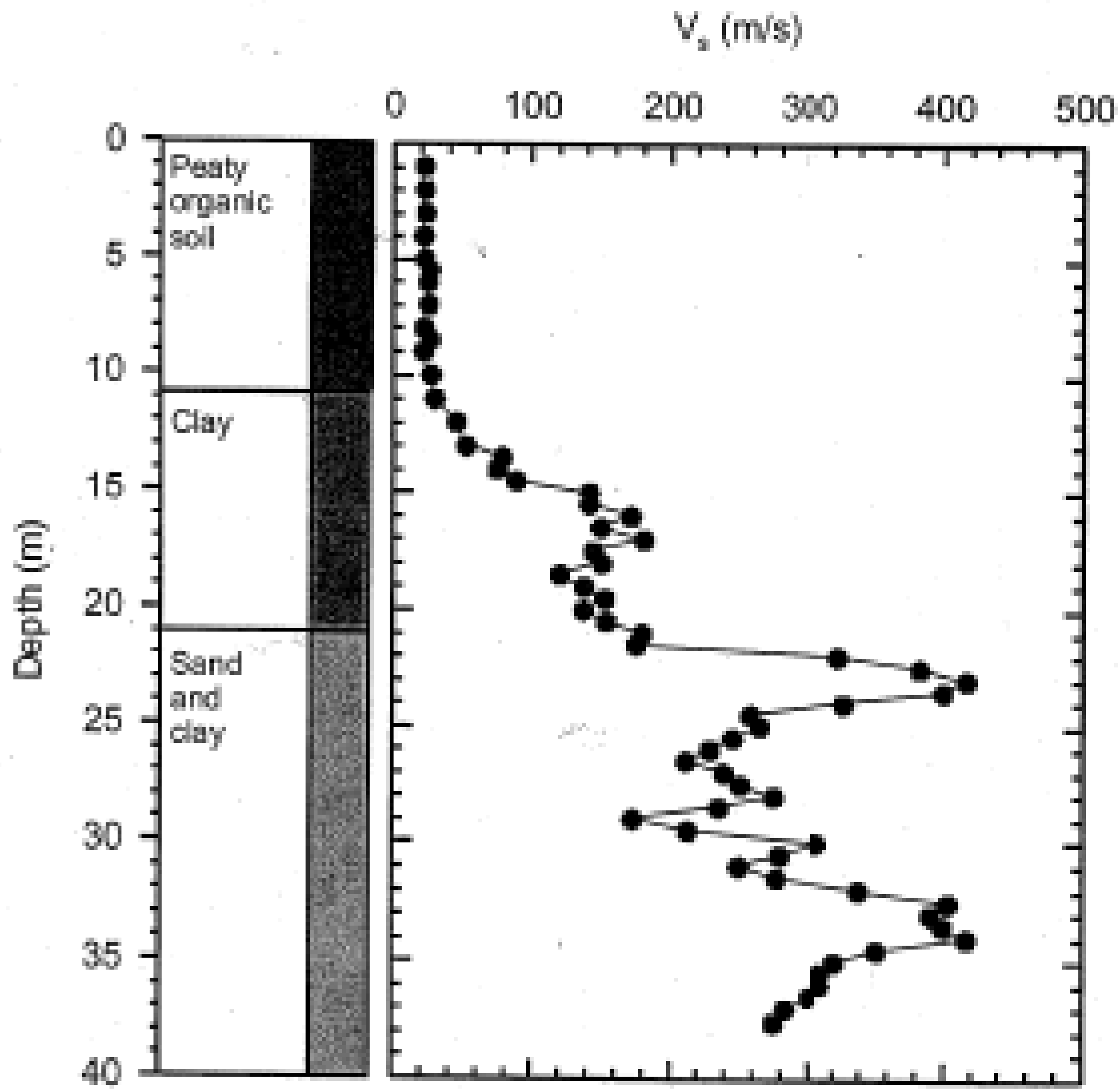
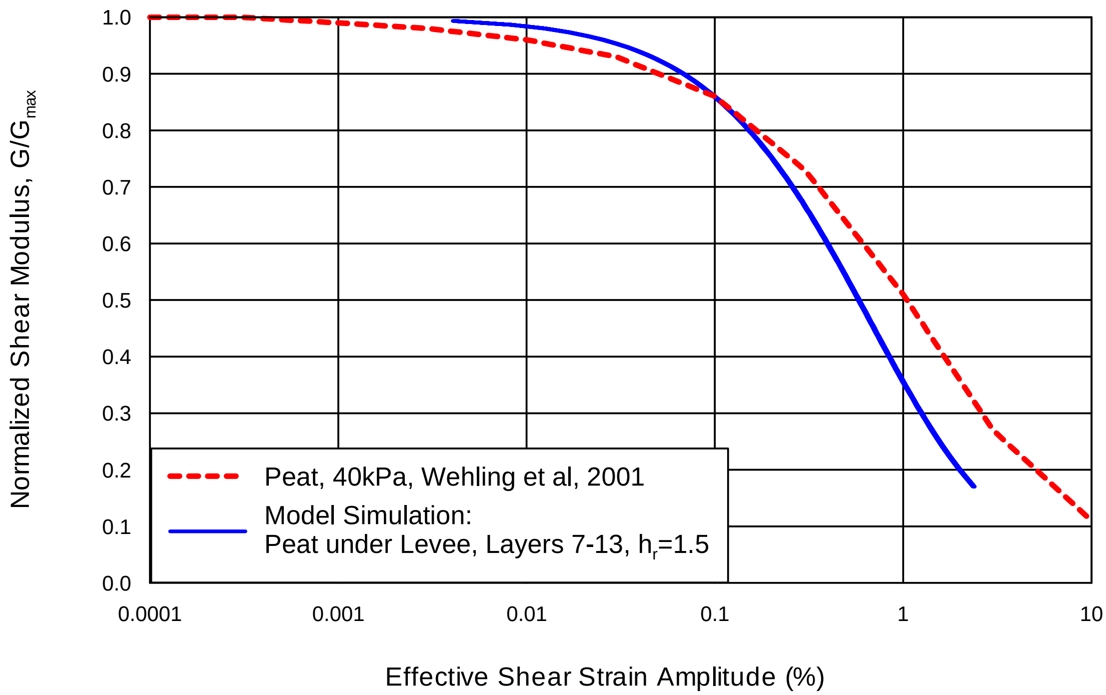


Figure 4. Shear Wave Velocity Data from the Free-Field at Sherman Island (Wehling et al., 2001)



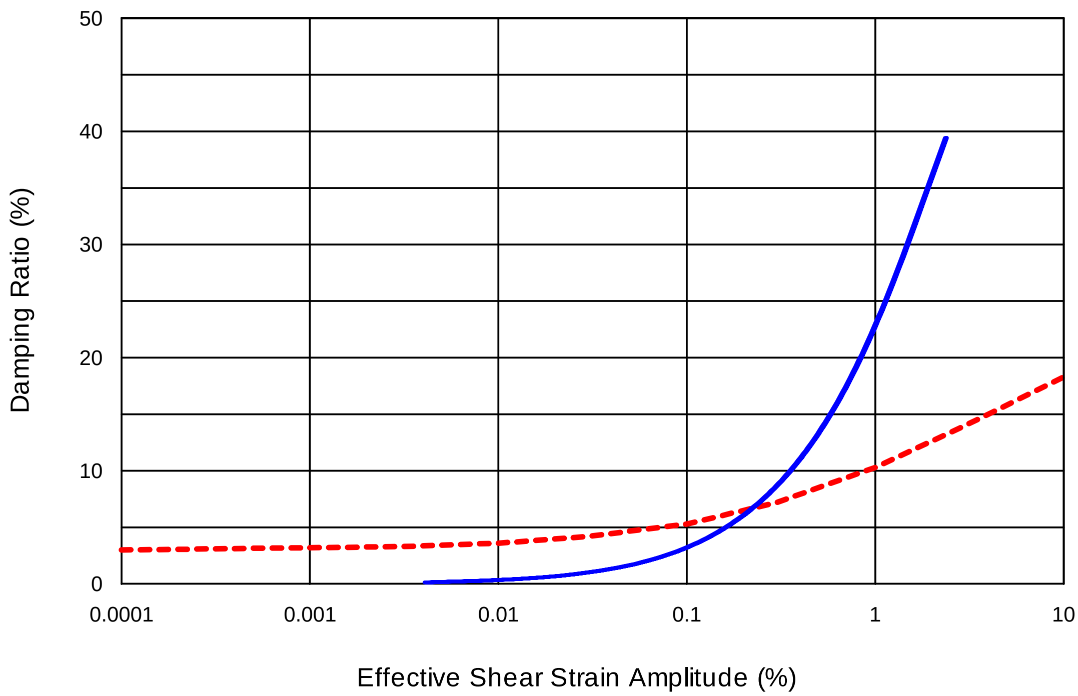


Figure 5. Modulus Reduction and Damping Ratio Relationship for Peat under Levee

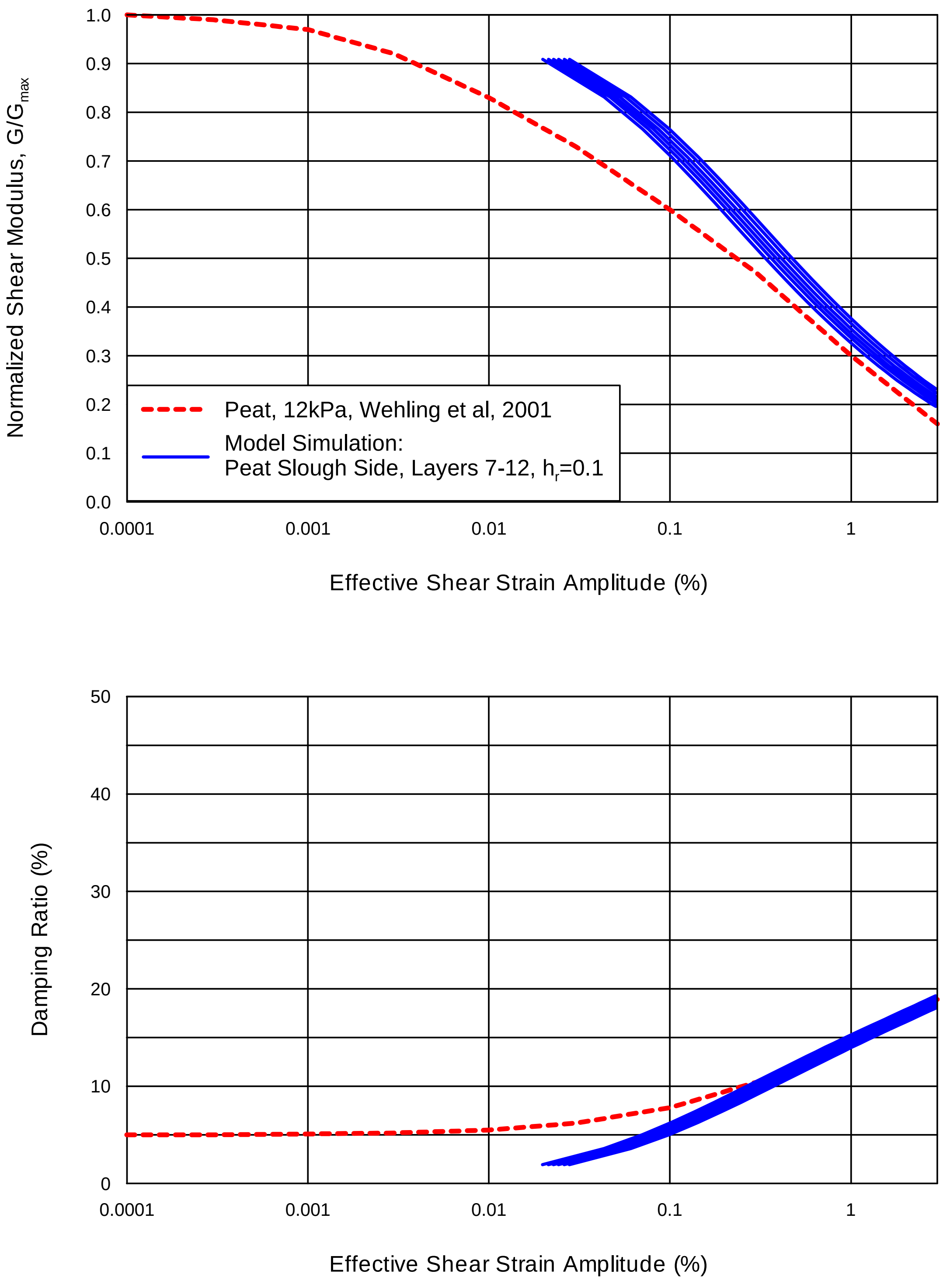


Figure 6. Modulus Reduction and Damping Ratio Relationship for Peat in Free-Field

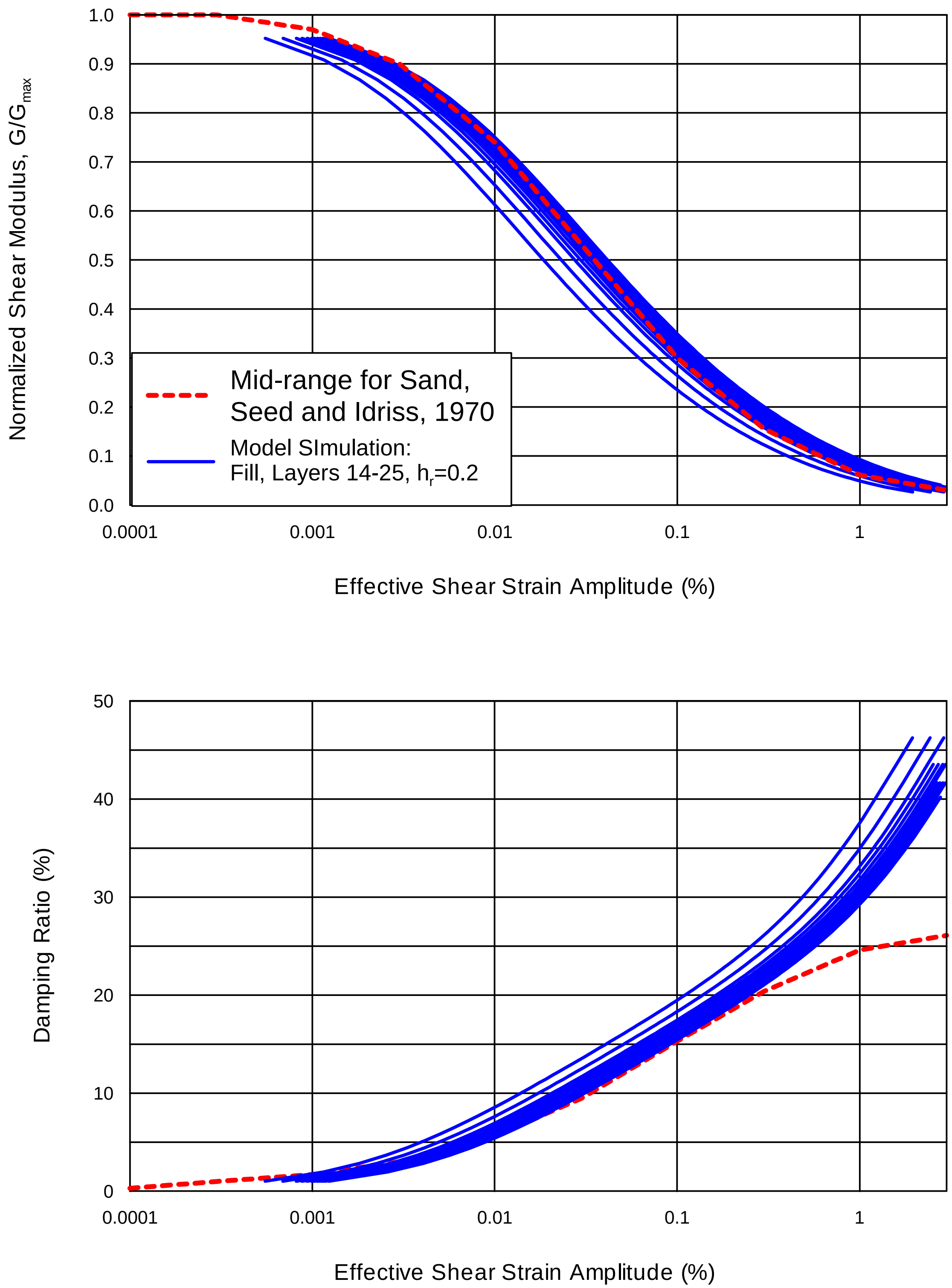
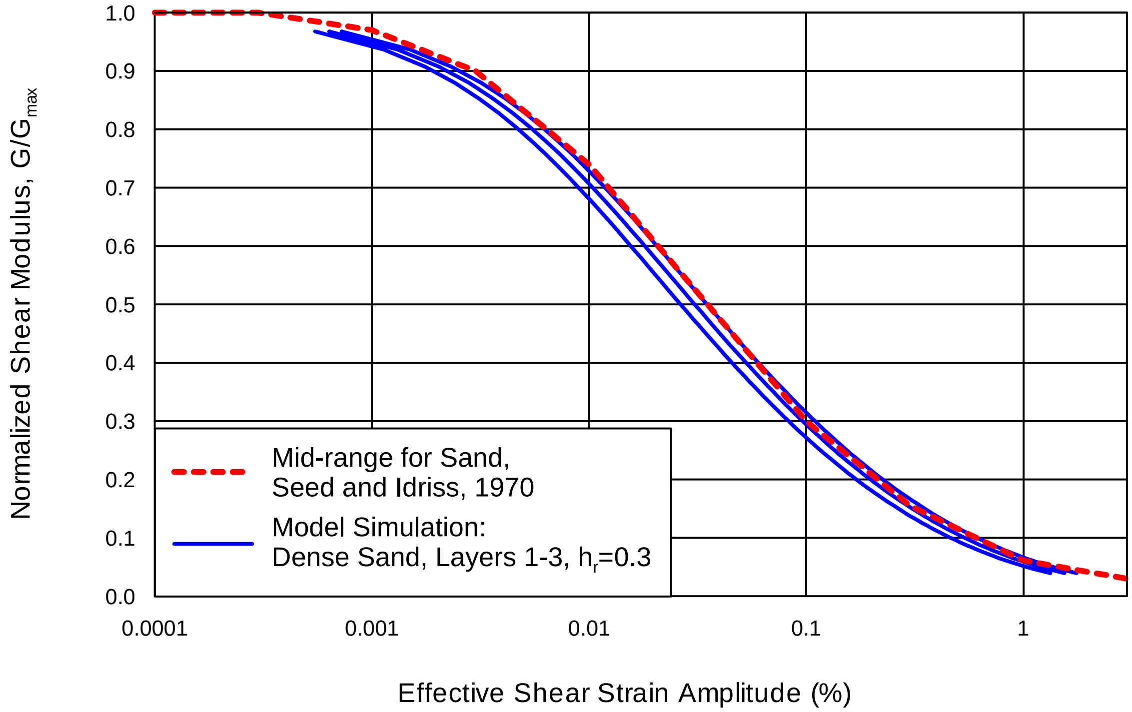


Figure 7. Modulus Reduction and Damping Ratio Relationship for Fill



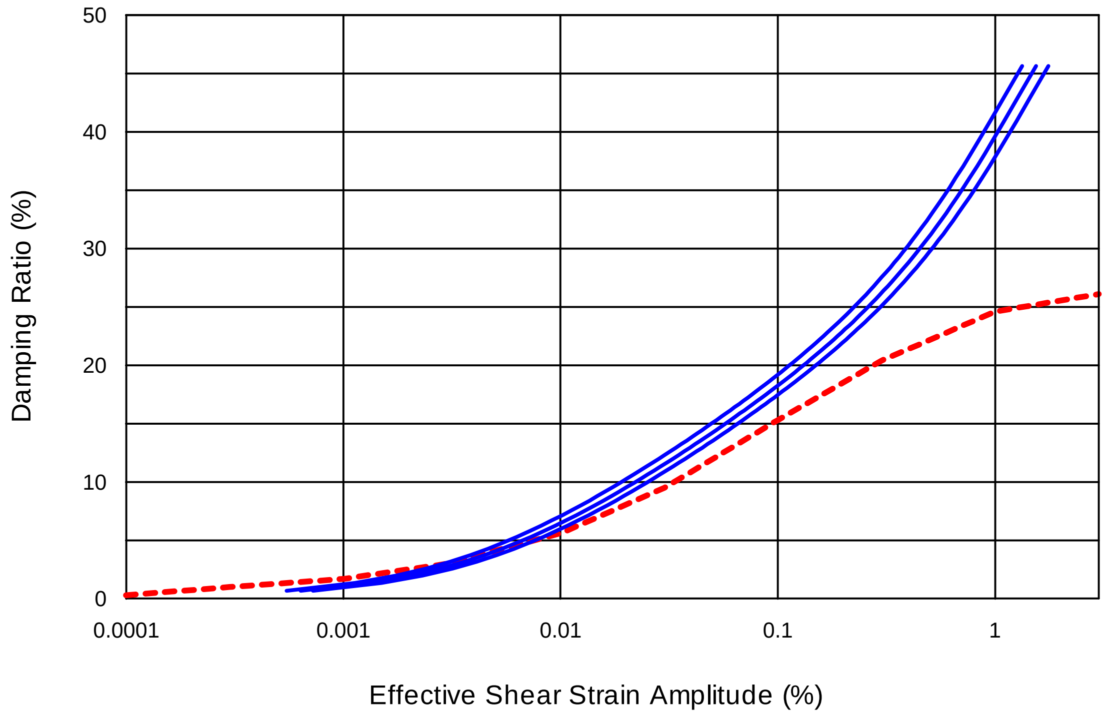


Figure 8. Modulus Reduction and Damping Ratio Relationship for Sand

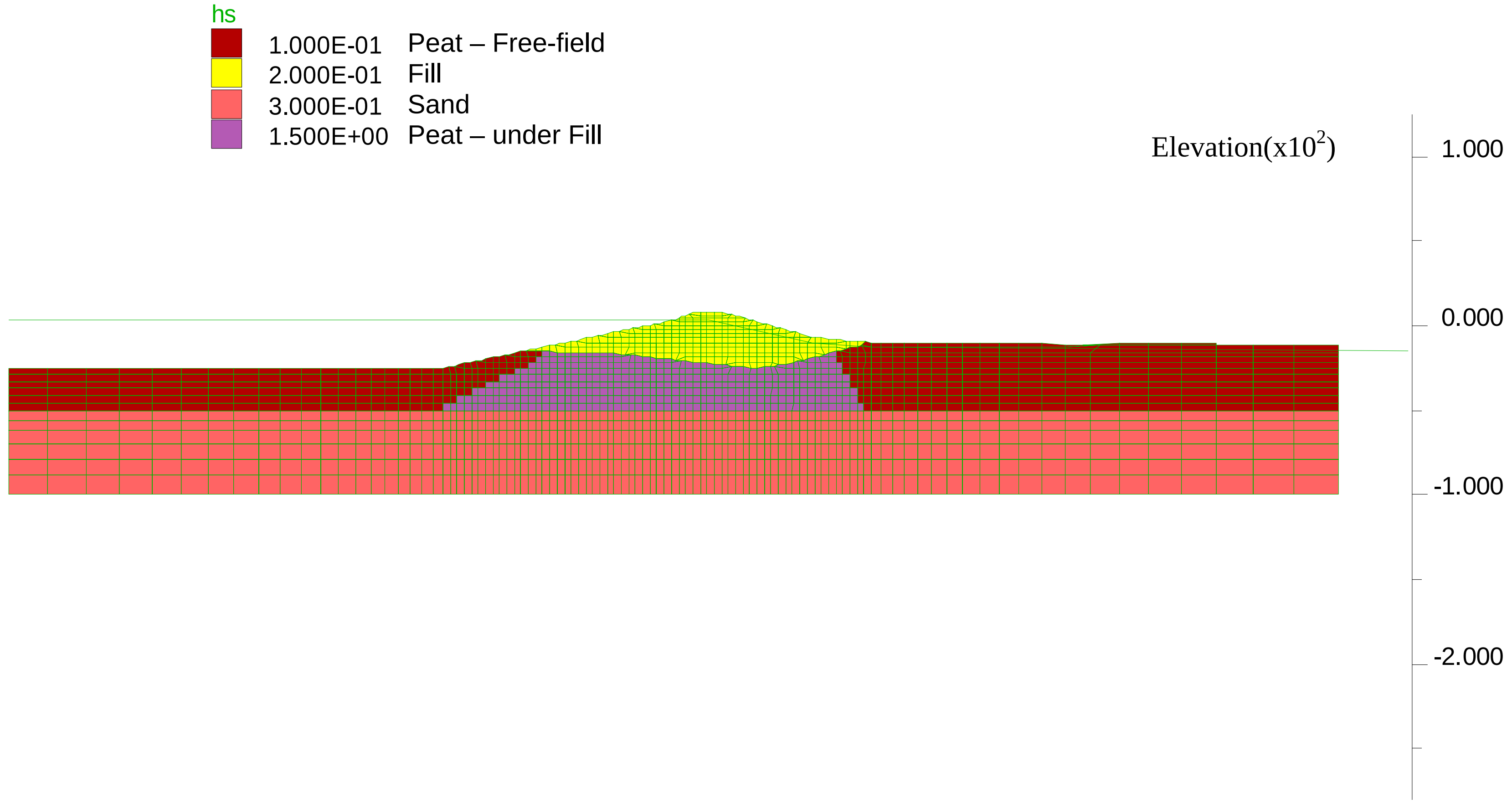


Figure 9. FLAC Numerical Grid Model and Material Zones, Sherman Island Levee Section

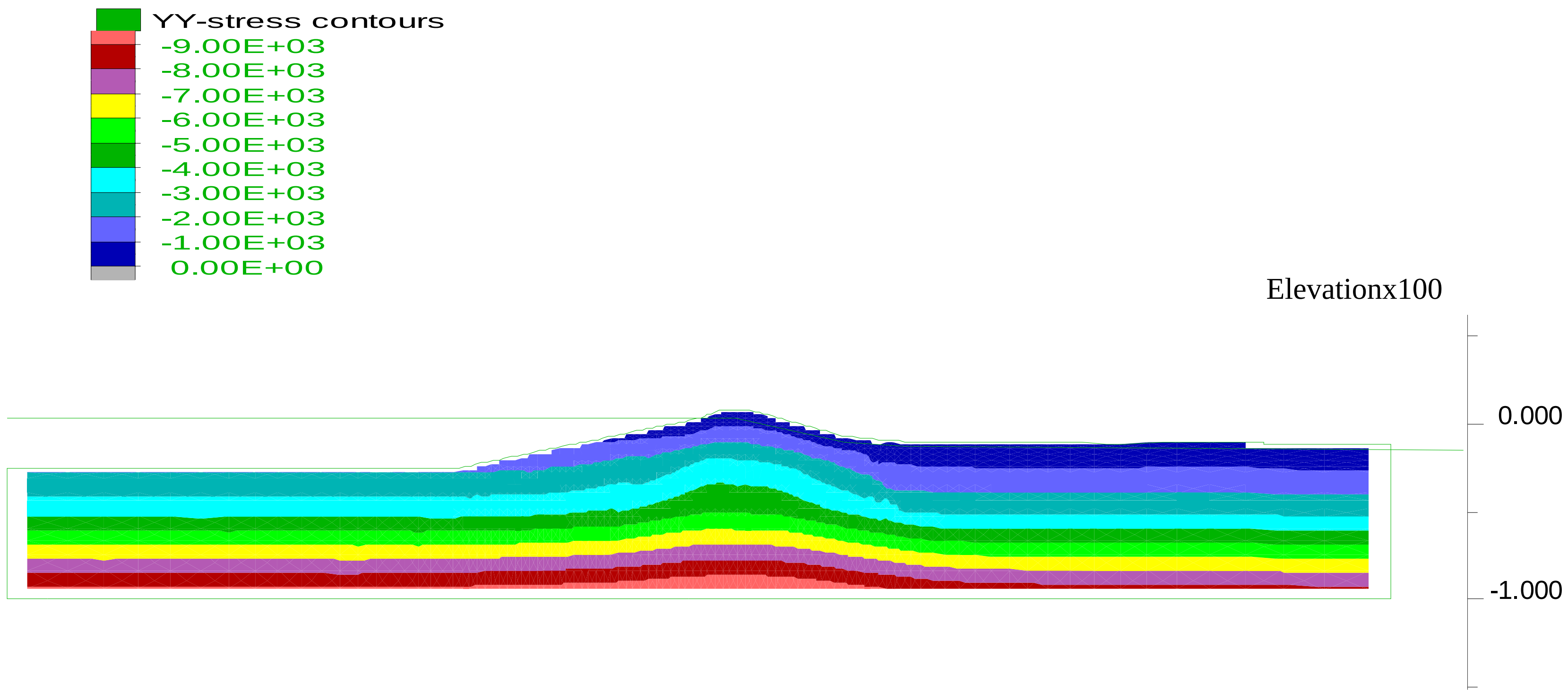


Figure 10. Computed Static Total Vertical Stresses (in psf), Sherman Island Levee Section

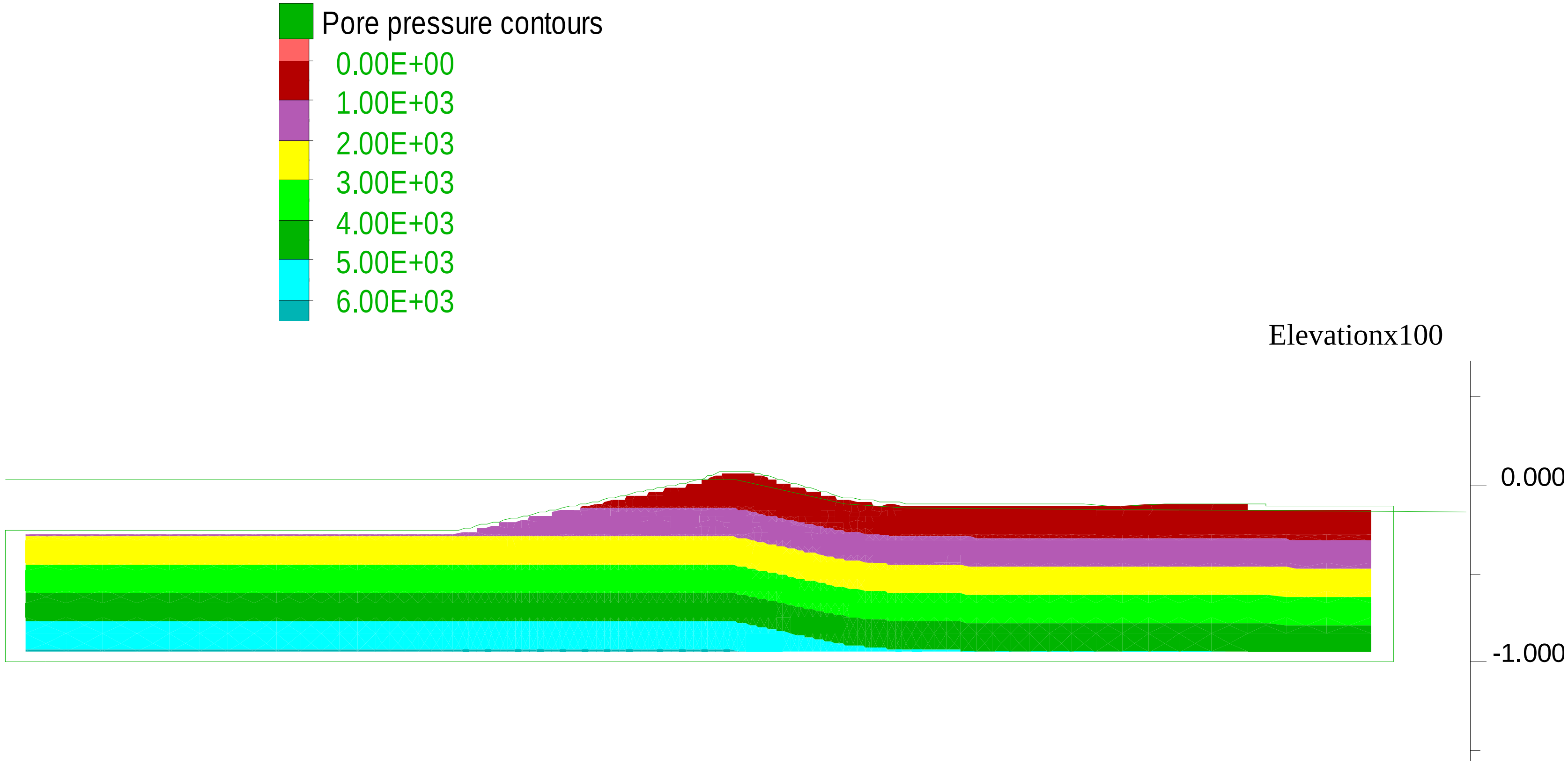


Figure 11. Computed Static Pore Water Pressure (in psf), Sherman Island Levee Section

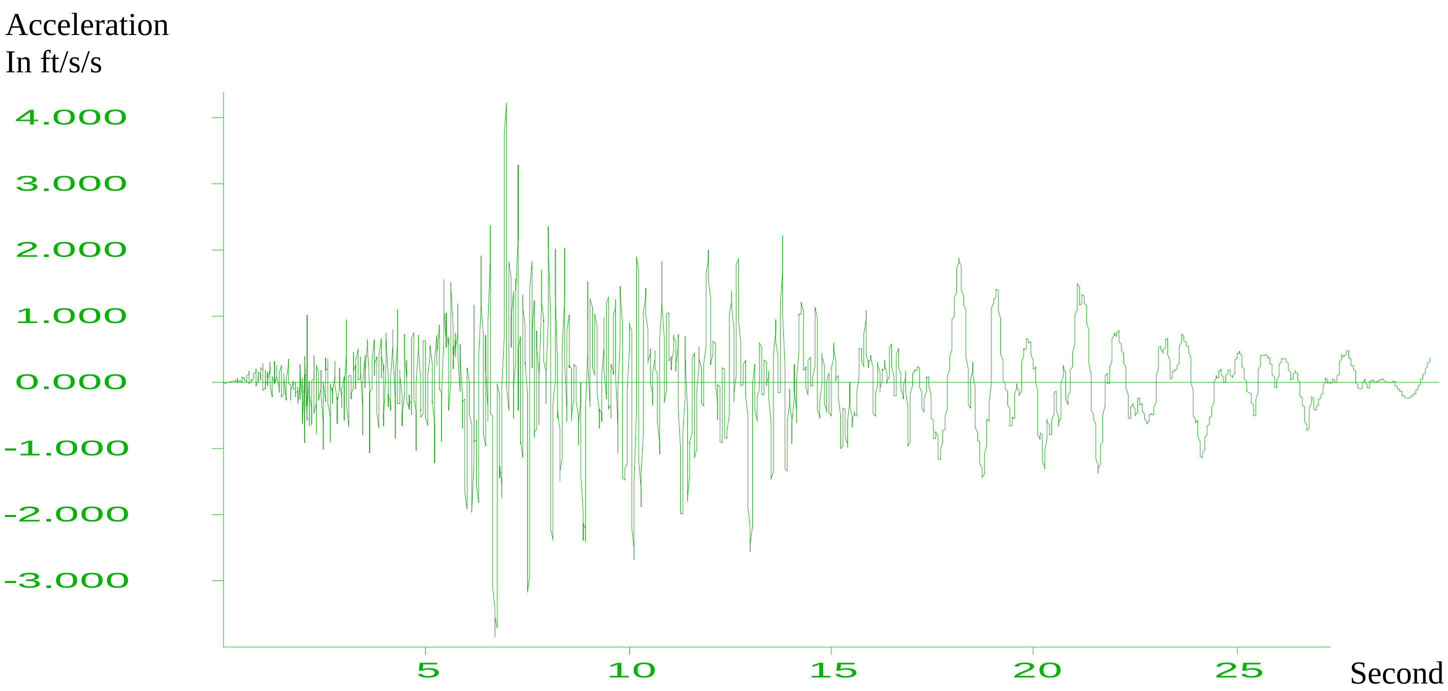


Figure 12. Interface Input Motion from M 6.5 Earthquake, H1 Component for FLAC (from Outcrop Motion with PGA=0.2g)

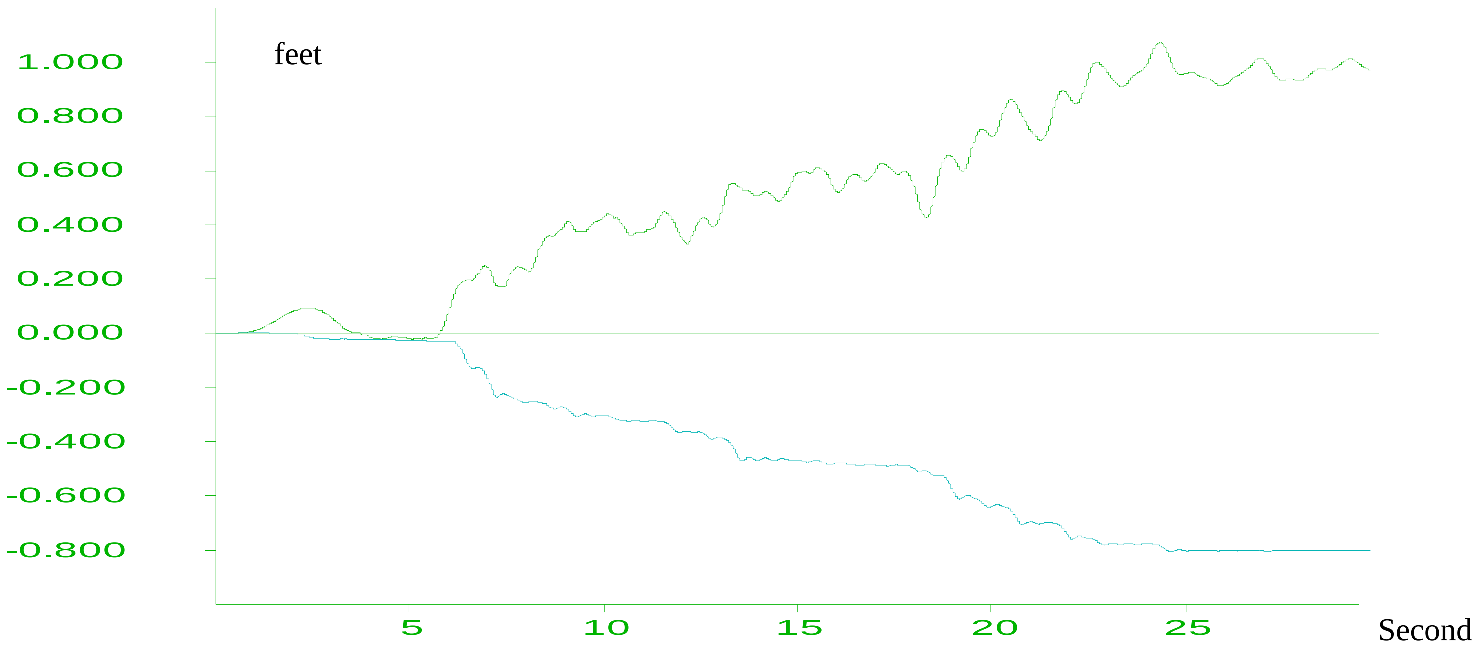


Figure 13. Computed Horizontal Crest Displacement (Upper Curve) and Vertical Displacement (Lower Curve) Time Histories from M 6.5, H1 Component Outcrop Motion with PGA=0.2g.

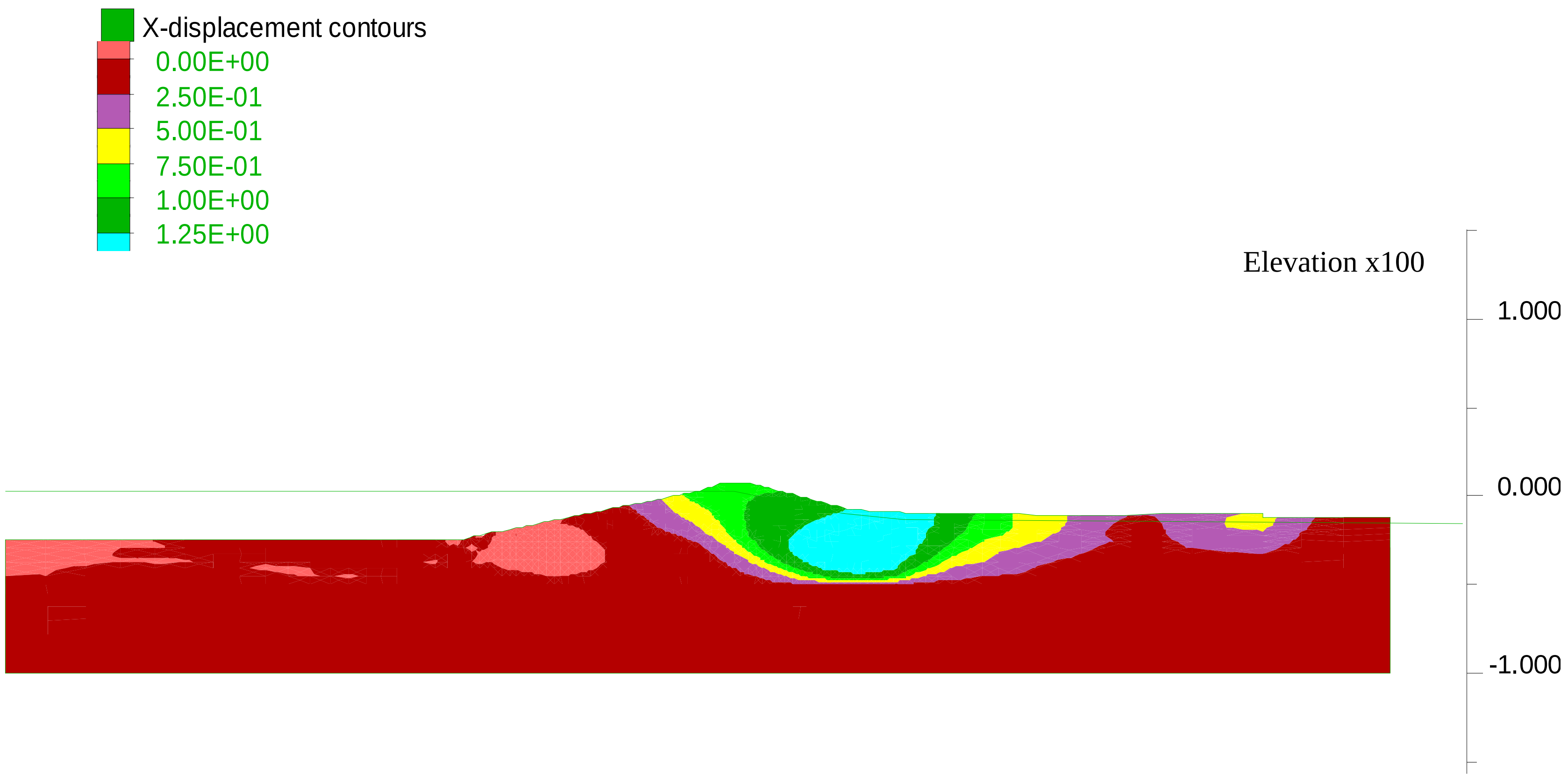


Figure 14. Computed Contours of Horizontal Displacement in feet (M 6.5, PGA=0.2g)

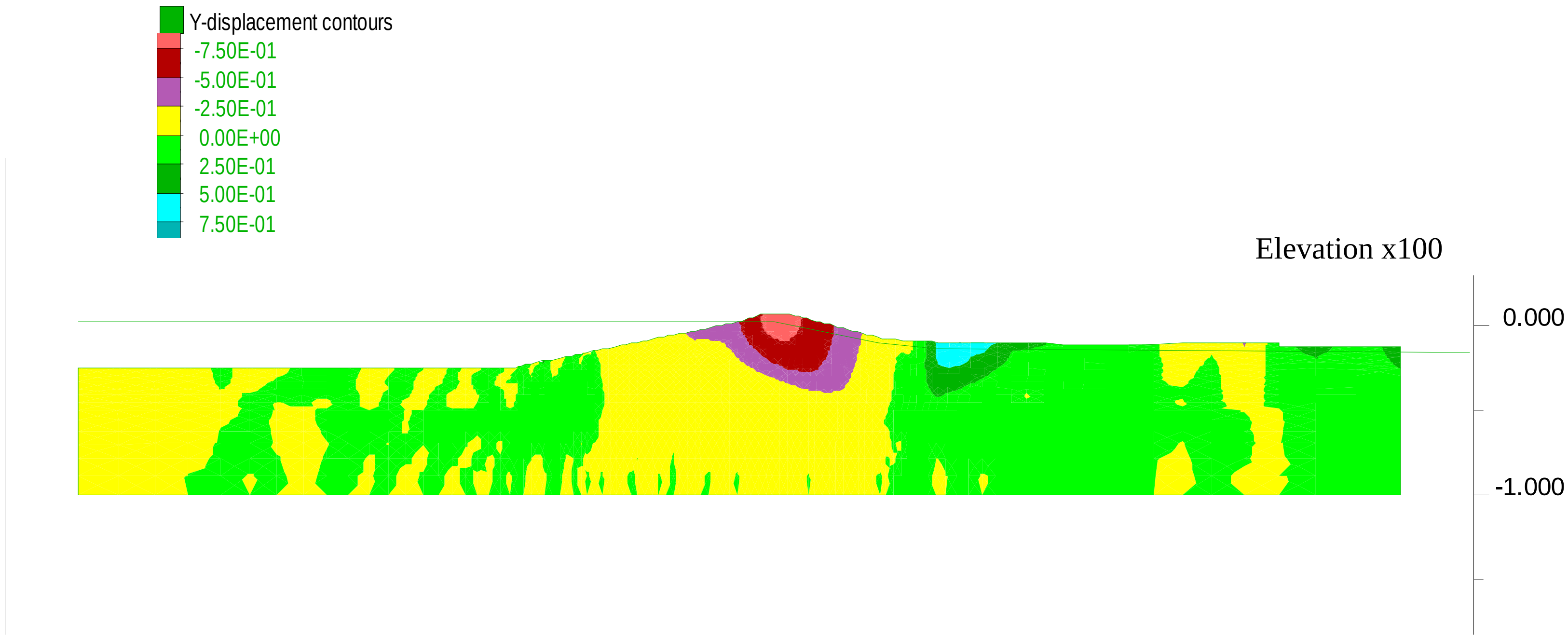


Figure 15. Computed Contours of Vertical Displacement in feet (M 6.5, PGA=0.2g)

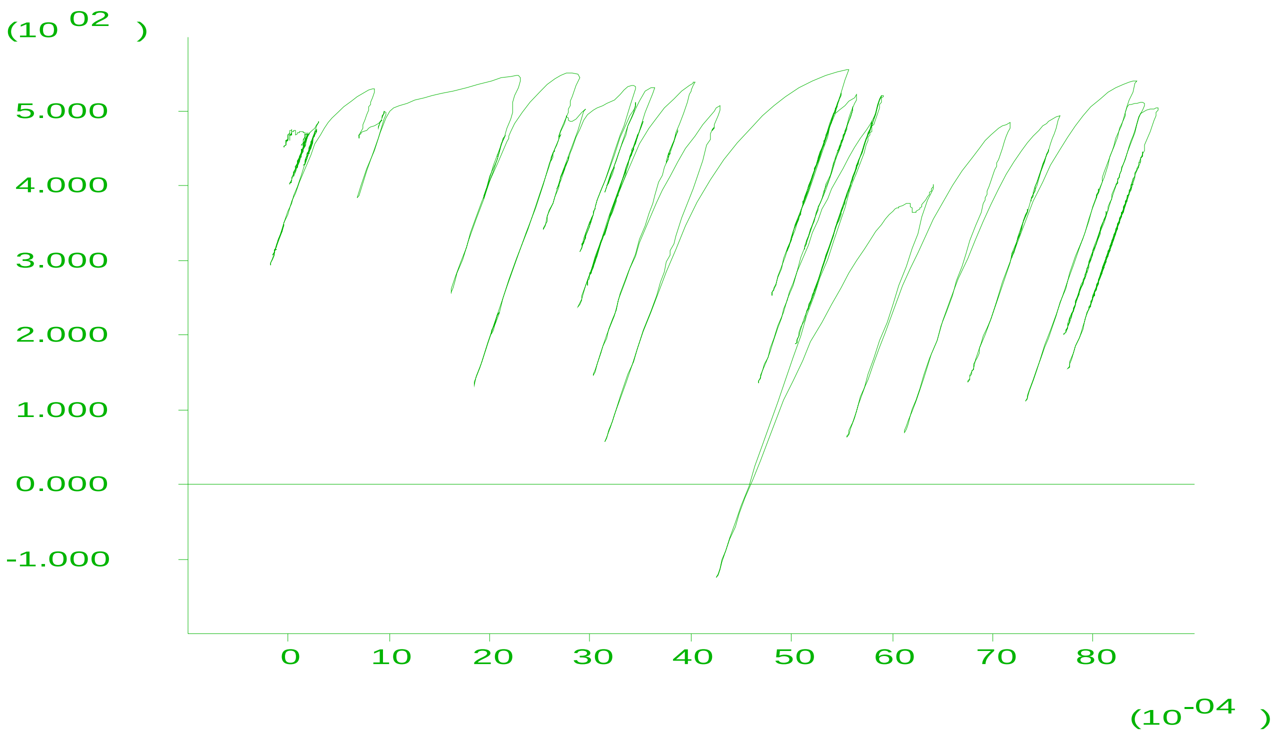


Figure 16. Computed Shear Stress (in psf) versus Shear Strain in a Peat Zone (M 6.5, PGA=0.2g)

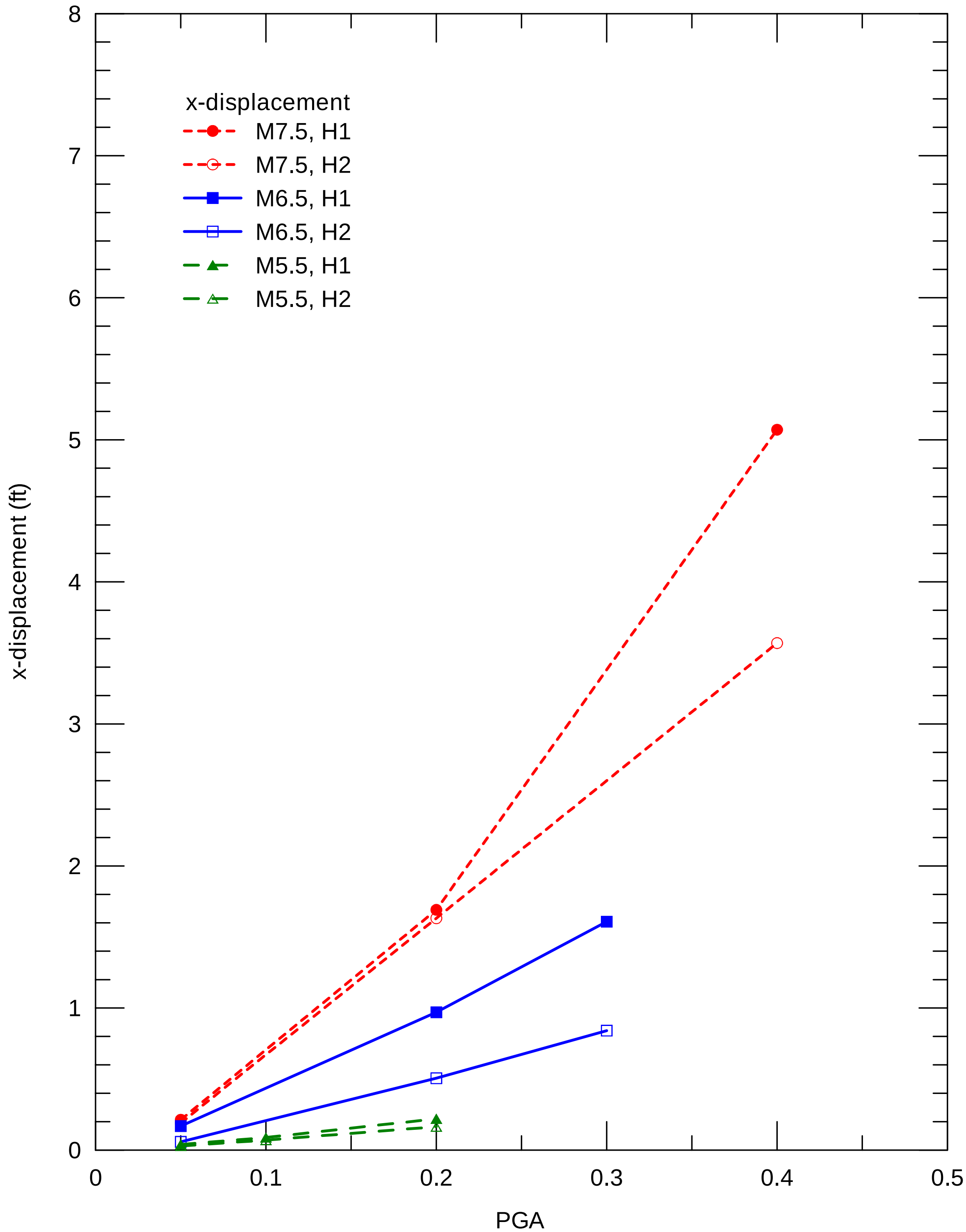


Figure 17. Computed Crest Horizontal Displacements versus PGA

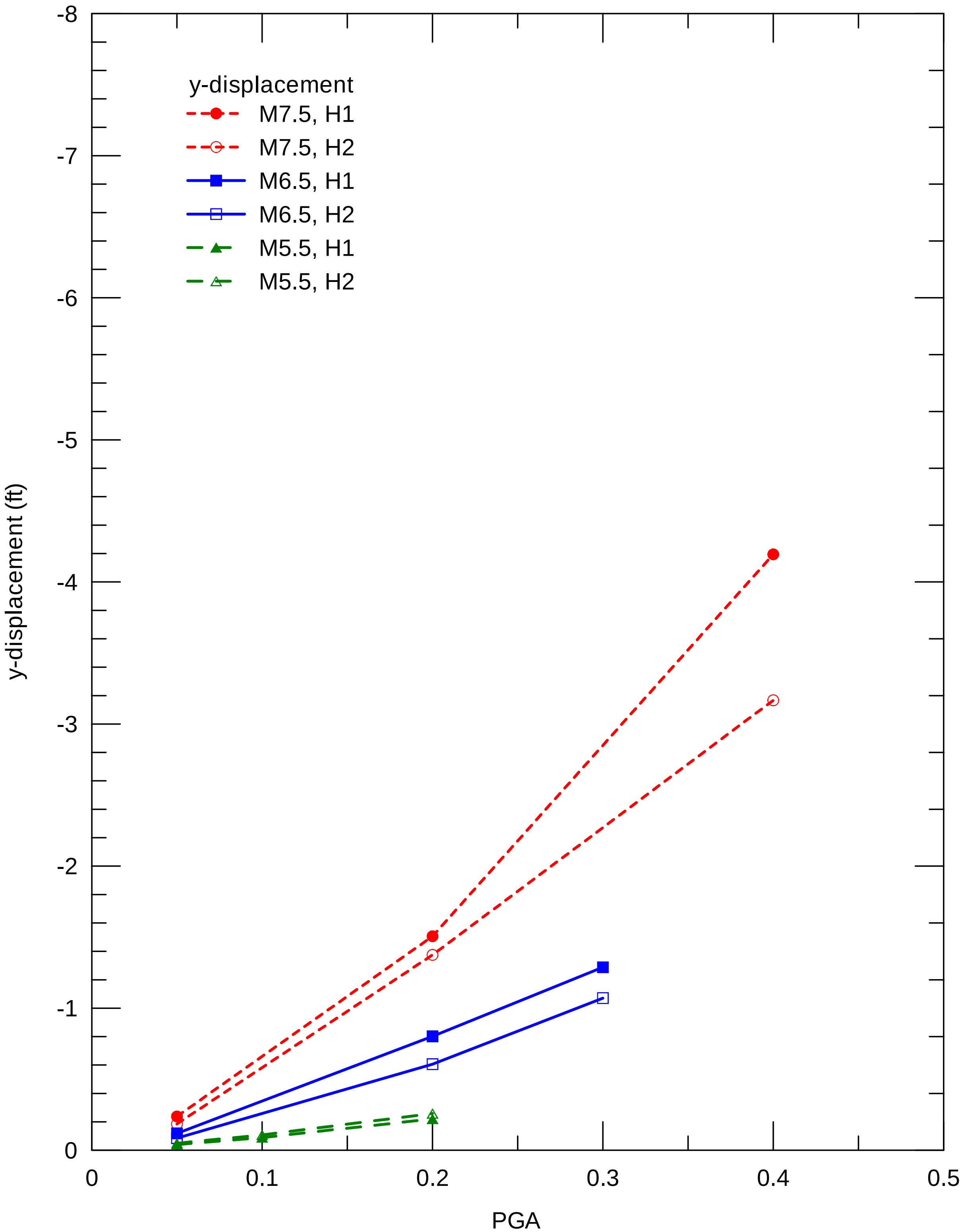


Figure 18. Computed Crest Vertical Displacements versus PGA