Appendix D

U.S. Department of Energy—Grand Junction, Colorado
Calculation Cover Sheet

Calc. No.: MOA-02-02-2006-1-10-00
Discipline: Geologic and Geophysical Properties
No. of Sheets: 4

Project: Moab UMTRA Project

Site: Crescent Junction, Utah

Feature: Test Pit Logs

Sources of Data:

Test pit logs

Sources of Formulae and References:

DOE 2005. *Work Plan for Characterization of Crescent Junction Disposal Site*, Revision No. 0, August 12, 2005, DOE-EM/GJ912-2005.

Preliminary Calc. ☐ **Final Calc.** ☑ **Supersedes Calc. No.**

Author: K. Karp for R. Heydenburg 3-15-06
Name Date

Checked by: 3-10-06
Name Date

3-15-06
Name Date

Craig Goodknight 3/15/06
Name Date

8/23/06
Name Date

Approved by: Ken Karp 3-15-06
Name Date

Problem Statement:

Preliminary site selection performed jointly by the U.S. Department of Energy (DOE) and the Contractor has identified a 2,300 acre withdrawal area in the Crescent Flat area just northeast of Crescent Junction, Utah, as a possible site for a final disposal cell for the Moab uranium mill tailings. The proposed disposal cell would cover approximately 300 acres. Based on the preliminary site-selection process, the suitability of the Crescent Junction disposal site is being evaluated from several technical aspects, including geomorphic, geologic, hydrologic, seismic, geochemical, and geotechnical. The objective of this calculation set is to present the test pit logs generated during the program to investigate subsurface geologic conditions at the Crescent Junction disposal site.

This calculation will be incorporated into Attachment 2 (Geology) of the Remedial Action Plan (RAP) and Site Design for Stabilization of Moab Title I Uranium Mill Tailings at the Crescent Junction, Utah, Disposal Site, and summarized in the appropriate sections of the Remedial Action Selection (RAS) report for the Moab site.

Method of Solution:

Five test pits were dug at the site to investigate subsurface conditions to depths ranging from 15 to 23 feet (ft)as shown in Figure 1 and Table 1. The pits were dug by trackhoe. Pit walls and samples were observed and logged in the field using visual soil-classification procedures described in DOE (2005; p.4-6). Field test pit logs were digitized and standardized using the gINT computer software program (gINT Software USA 2005). Appendix A contains the test pit logs for the Crescent Junction site. These data are also available in the SEEPro database at the DOE Grand Junction office.

Assumptions:

N/A

Calculation:

N/A

Discussion:

Results and evaluation of the test pit activities at the Crescent Junction disposal site during 2005 are discussed in detail in Attachment 2 (Geology) of the RAP and summarized in relevant sections of the RAS.

Conclusion and Recommendations:

N/A

Computer Source:

gINT computer software was used to digitize and standardize the test pit logs.

References:

DOE 2005. *Work Plan for Characterization of Crescent Junction Disposal Site,* Revision No. 0, August 12, 2005, DOE-EM/GJ912-2005.

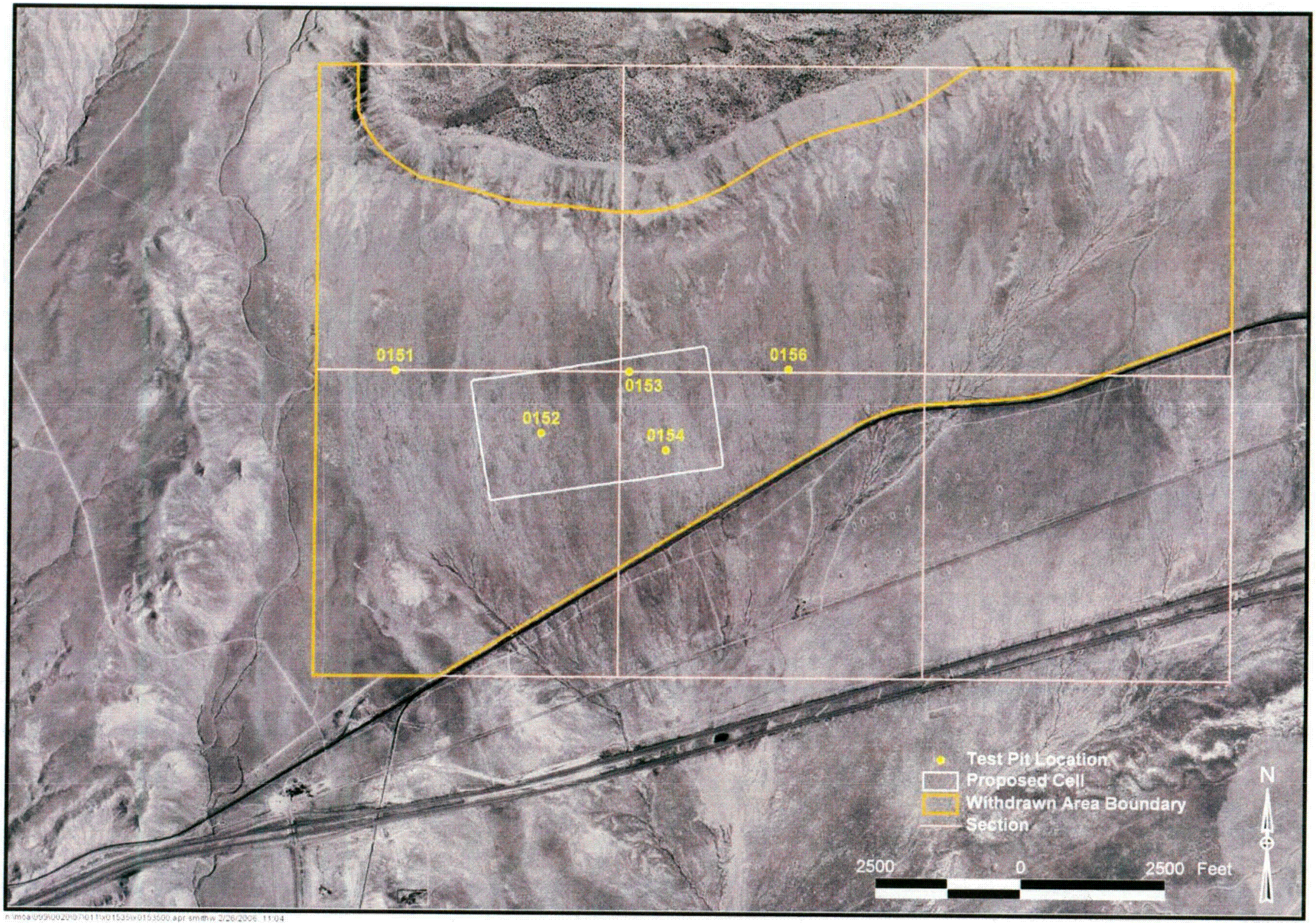

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Figure 1. Location of Test Pits at the Crescent Junction Site

Table 1. Test Pit Specifications at the Crescent Junction Site

Test Pit No.	N Coordinate[a]	E Coordinate[a]	Ground Elevation (ft ngvd)[b]	Total Depth (ft)	Date Completed	Geophysical Logs	Hole Size (in)	Casing (ft)	Sample Type	Drilling Method[c]
CRJ01-0151	6796084.42	2120861.99	4991.20	15.90	16-Aug-05	no	n/a	n/a	Bucket	Trackhoe
CRJ01-0152	6795018.03	2123400.06	4965.00	23.40	1-Nov-05	no	n/a	n/a	Bucket	Trackhoe
CRJ01-0153	6796083.25	2124922.48	4983.50	15.75	10-Nov-05	no	n/a	n/a	Bucket	Trackhoe
CRJ01-0154	6794730.87	2125565.10	4950.00	21.50	31-Oct-05	no	n/a	n/a	Bucket	Trackhoe
CRJ01-0156	6796137.16	2127679.48	4974.00	22.50	28-Oct-05	no	n/a	n/a	Bucket	Trackhoe

[a] Local coordinate system based on modified state plane coordinate system NAD 83 Utah Central Zone.
[b] ngvd = National Geodetic Vertical Datum
[c] HSA = hollow stem auger

Appendix A

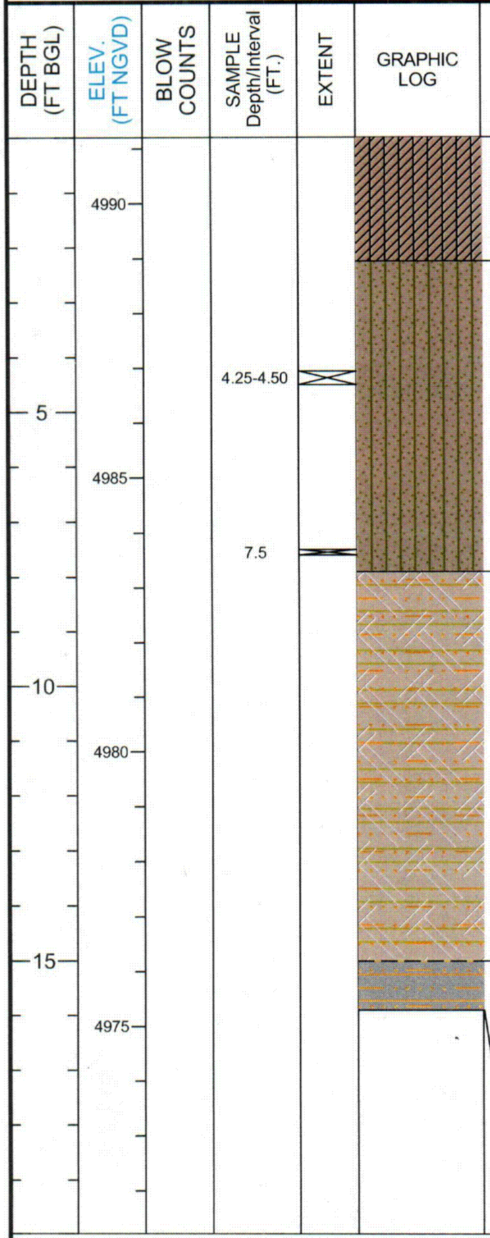
Test Pit Logs

TEST PIT LOG CRJ01-0151

PROJECT MOAB
LOCATION Crescent Junction, UT.
SITE Crescent Junction
WELL NUMBER CRJ01-0151
NORTH COORD. (FT) 6796084.42
EAST COORD. (FT) 2120861.99
SURFACE ELEV. (FT NGVD) 4991.20
HOLE DEPTH (FT) 15.90

DATE DRILLED 08/16/2005
DRILLING COMPANY Ksue Corporation
DRILLING METHOD Trackhoe
SAMPLING METHOD
DRILL OPERATOR Carter, C.
REMARKS Samples collected in 5.0 gallon buckets.

BIT SIZE(S) (IN)
CORE SIZE(S) (IN)
LOGGED BY Goodknight, C.
WL (FT BGS)



LITHOLOGIC DESCRIPTION

0-2.5 SILTY CLAY LOAM (ML/CL); some mottling, abundant roots, especially top I.0 ft., highly calcareous, porous from worm burrowing, looks like adobe brick, brown (10YR 5/3).

2.25-7.9 ft. SILTY SAND (SM); moderately calcareous, mottled throughout, mostly grayish brown (10YR 5/2), mixture of silt (~20%) and sand (80%) up to medium-coarse grained. Some rooting down to ~4.0 ft. Several layers of sheet wash material consisting of sandstone slabs and fragments up to 0.4-0.5 ft. in diameter. Two obvious sheet wash layers are at ~2.25-2.5 ft., and 3.5-4.0 ft. These sandstone fragments are generally very pale brown (10YR 7/4).

7.9-12.9 ft. WEATHERED MANCOS SHALE BEDROCK; highly weathered, soft, porous, shale and siltstone fragments, moderately calcareous, clear and white gypsum and calcite crystals fill small cavities. Mostly light brownish gray (2.5Y 6/2). Fluvial channel approximately 6.0-8.0 ft., wide cuts down into weathered Mancos Shale to depth of ~9.75 ft (1.8 ft., or nearly 2.0 ft.). Fluvial fill material consists of medium to coarse grained sand (SW) and trace small limonitic siltstone and shale rock fragments up to 0.025 ft. diameter and mottled, porous, silt (ML). Sand material is grayish brown (10YR 5/2) and silt is light brownish gray (10YR 6/2); all are highly calcareous.

12.9-14.0 ft. Mancos Shale is moderately weathered down to ~14.0 ft. and becomes increasingly competent.

14.0-15.0 ft. Mancos Shale is slightly weathered, fractured, hard, layered.

15.0-15.9 ft. MANCOS SHALE: slightly weathered to nonweathered sandy siltstone, hard, mostly planar bedding, highly calcareous, light gray (N7) to yellowish gray (5Y 7/2), trace fine black material which is framboidal pyrite replacing fossil fragments. Trace grayish orange (10YR 7/4) color along fractures and bedding planes. Rare flattened cephalopod fossil impression colored (light brown, 5YR 5/6) after limonite. Stopped test pit at 15.9 ft., unable to excavate further with trackhoe.

Total Depth 15.9 ft.

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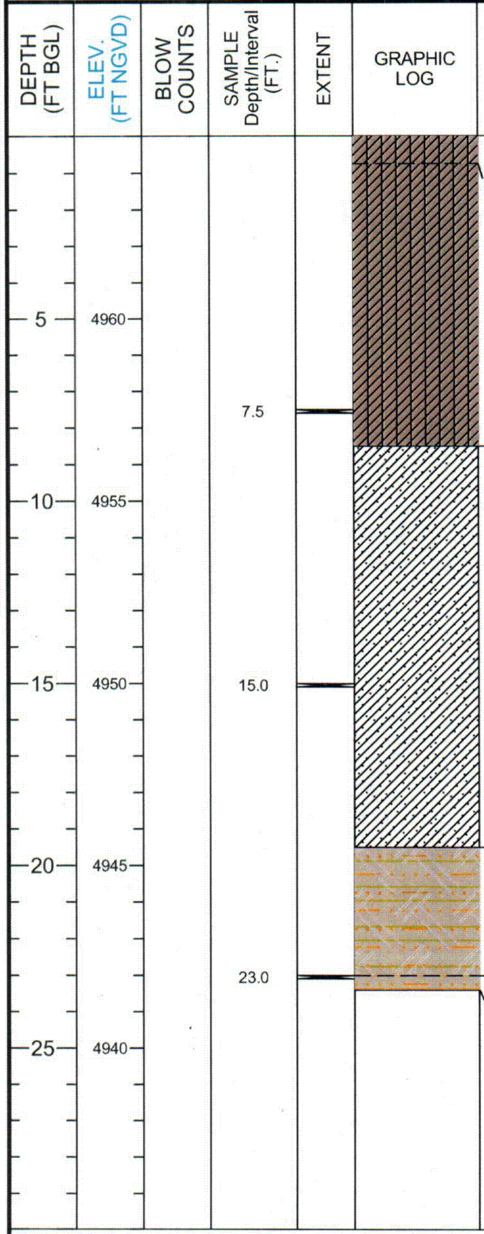
TEST PIT LOG CRJ01-0152

PROJECT MOAB
LOCATION Crescent Junction, UT.
SITE Crescent Junction
WELL NUMBER CRJ01-0152
NORTH COORD. (FT) 6795018.03
EAST COORD. (FT) 2123400.06
SURFACE ELEV. (FT NGVD) 4965.00
HOLE DEPTH (FT) 23.40

DATE DRILLED 10/31/2005 to 11/01/2005
DRILLING COMPANY Ksue Corporation
DRILLING METHOD Trackhoe
SAMPLING METHOD
DRILL OPERATOR Carter, C.
REMARKS Samples collected in 5.0 gallon buckets.

BIT SIZE(S) (IN)
CORE SIZE(S) (IN)
LOGGED BY Smith, G.
WL (FT BGS)



LITHOLOGIC DESCRIPTION

0-0.75 ft. SILTY CLAY (CL-ML); abundant roots, calcic (stage I carbonate development), some fine grained sand, blocky structure, sticky, moderately plastic, grayish brown (10YR 5/2). Represents A horizon.

0.75-8.5 ft. CLAY/SILTY CLAY WITH SAND (CL-ML); low to medium plasticity, sticky, fine grained sand, grayish brown (2.5Y 5/2), interbedded with channel deposits, sandstone fragments to cobble size, sub-rounded to sub-angular, medium to coarse grained sand, interbeds to 2.0 ft. thick. Represents sheet wash deposits.

8.5-19.5 ft. SILTY SANDY CLAY (CL); low plasticity, slightly sticky (75-100%); fine grained sand (0-25%); fine to medium grained sand, angular, calcareous (10%). Some channel deposits (2.0-3.0 ft deep), imbricated shale and sandstone fragments to 0.25 ft. in diameter, platy. Represents eolian and fluvial deposits.

19.5-23.0 ft. WEATHERED MANCOS SHALE BEDROCK: moderately plastic, platy, calcareous, some sandstone fragments, gypsum crystals, light brownish gray (2.5Y 6/2). Note: A fluvial channel deposit that is 2.0 ft. deep and 3.0 ft. wide is in east side wall that contains medium to coarse grained sand, shale fragments, and silt, and is calcareous, light yellowish brown (10YR 6/4).

23.0-23.4 ft. MANCOS SHALE: Stopped test pit at 23.4 ft., unable to excavate further with trackhoe.

Total Depth 23.4 ft

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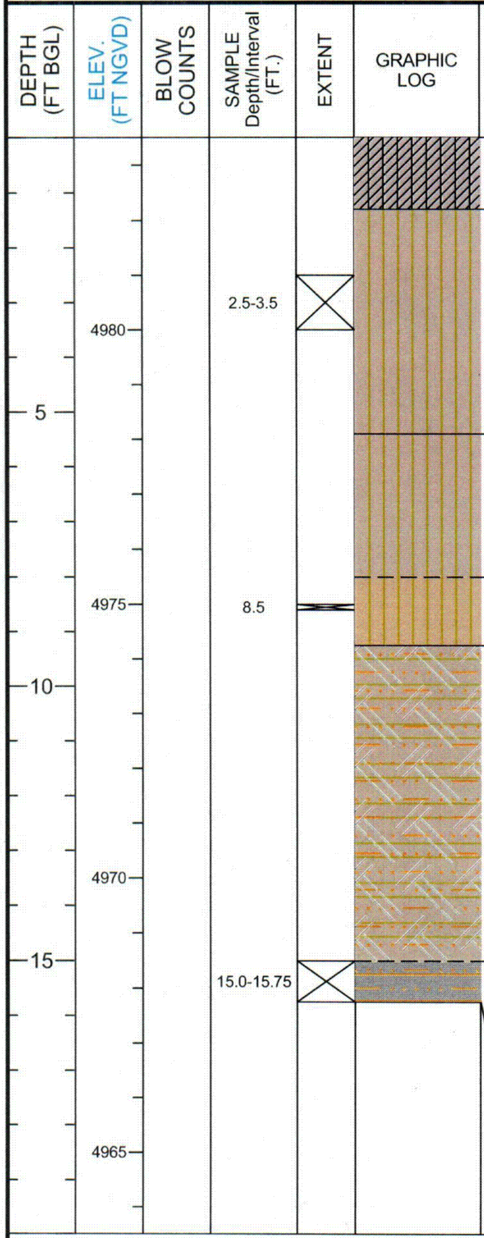
TEST PIT LOG CRJ01-0153

PROJECT MOAB
LOCATION Crescent Junction, UT.
SITE Crescent Junction
WELL NUMBER CRJ01-0153
NORTH COORD. (FT) 6796083.25
EAST COORD. (FT) 2124922.48
SURFACE ELEV. (FT NGVD) 4983.50
HOLE DEPTH (FT) 15.75

DATE DRILLED 11/10/2005
DRILLING COMPANY Ksue Corporation
DRILLING METHOD Trackhoe
SAMPLING METHOD
DRILL OPERATOR Carter, C.
REMARKS Samples collected in 5.0 gallon buckets.

BIT SIZE(S) (IN)
CORE SIZE(S) (IN)
LOGGED BY Goodknight, C.
WL (FT BGS)



LITHOLOGIC DESCRIPTION

0-1.3 ft. SILT/CLAY LOAM (CL-ML); some mottling, abundant roots especially top 0.75 ft., moderately calcareous, gray (2.5Y 6/1) to light brownish gray (2.5Y 6/2), looks like adobe brick, some small rock fragments (up to 0.1 ft. in diameter).

1.3-5.4 ft. SILT (SM); trace very fine grained sand, highly mottled (white), with abundant root filaments, moderately to highly calcareous, mostly light brownish gray (10YR 6/2). Several thin layers of sandstone rock fragments up to 0.3 ft. in diameter and some yellowish brown/orange limonitic siltstone fragments.

4.25-4.75 ft. slightly darker colored layer, light brownish gray (10YR 6/2), than the other 1.3 to 5.4 ft. layer, possibly because of higher moisture content (this interval seemed slightly damp during excavation).

5.4-8.0 ft. SILT (ML); trace very fine grained sand, light brownish gray (10YR 6/2), soft, crumbly, moderately to highly calcareous, some mottling, trace roots in upper part. Several thin fluvial layers of up to coarse grained sand size.

8.0-9.25 ft. SANDY SILT (ML); silt and very fine grained sand, light yellowish brown (10YR 6/4), highly calcareous, powdery, trace mottling, probable eolian origin. @9.25 ft., thin layer of limonitic siltstone fragments that appear to have been emplaced by sheet wash.

9.25-15.0 ft. WEATHERED MANCOS SHALE BEDROCK; highly weathered, soft, moderately calcareous, crumbly, porous, some platy shale and siltstone fragments, mottled (white) is calcareous material and gypsum. Mostly light brownish gray (2.5Y 6/2) and minor light yellowish brown (10YR 6/4), limonitic - colored fragments.

11.75-14.0 ft. moderately weathered, fractured, soft to moderately hard, layered.

14.0-15.0 ft. slightly weathered, fractured, hard, layered.

15.0-15.75 MANCOS SHALE; slightly weathered to non weathered siltstone, hard, planar to slightly wavy bedding, moderately to highly calcareous, light gray (N7) to yellowish gray (5Y 7/2), trace fine black material that is framboidal pyrite replacing fine fossil fragments. Some grayish orange (10YR 7/4) color along fractures and some bedding planes. Stopped test pit at 15.75 ft; unable to excavate further with trackhoe.

Total Depth 15.75 ft.

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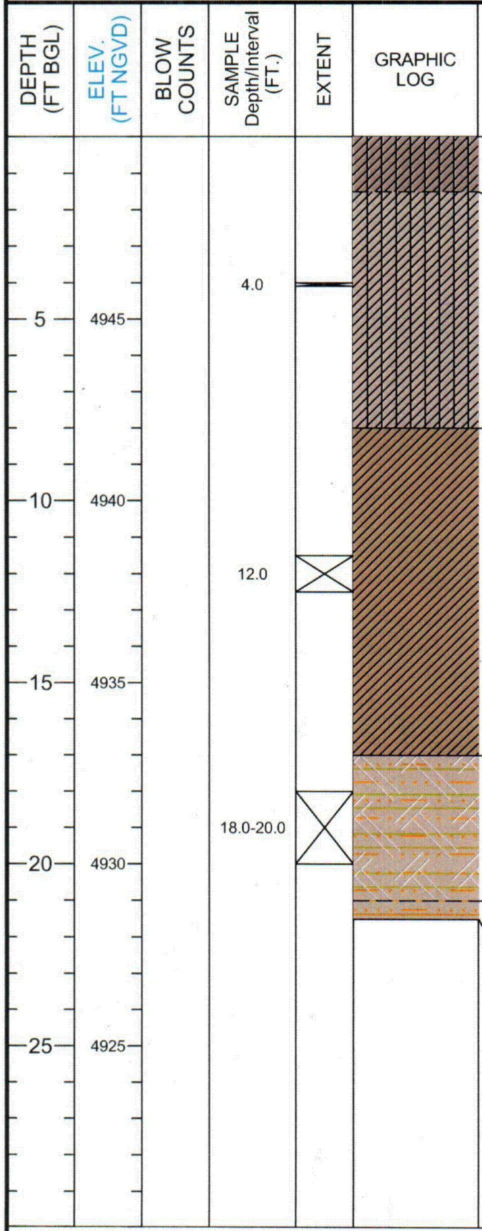
TEST PIT LOG CRJ01-0154

PROJECT MOAB
LOCATION Crescent Junction, UT.
SITE Crescent Junction
WELL NUMBER CRJ01-0154
NORTH COORD. (FT) 6794730.87
EAST COORD. (FT) 2125565.10
SURFACE ELEV. (FT NGVD) 4950.00
HOLE DEPTH (FT) 21.50

DATE DRILLED 10/28/2005 to 10/31/2005
DRILLING COMPANY Ksue Corporation
DRILLING METHOD Trackhoe
SAMPLING METHOD
DRILL OPERATOR Carter, C.
REMARKS Samples collected in 5.0 gallon buckets.

BIT SIZE(S) (IN)
CORE SIZE(S) (IN)
LOGGED BY Smith, G.
WL (FT BGS)



LITHOLOGIC DESCRIPTION

0-1.5 ft. SILTY CLAY (CL-ML); abundant roots, calcic, some fine grained sand, blocky structure, sticky, low to medium plasticity, grayish brown (10YR 5/2). Represents A horizon.

1.5-8.0 ft. SILTY CLAY (CL-ML); with some sand, sub-angular, moderately plastic, sticky, calcic, (Stage I carbonate development), grainy to blocky structure, medium to fine grained sand, light brownish gray (2.5Y 6/2). Represents sheet wash deposits.

8.0-17.0 ft. SILTY CLAY (CL); some fine grained sand, sub-angular, low plasticity, slightly sticky, yellowish brown (10YR 5/4), calcareous. Some fluvial channel intermixing, medium to coarse grained sands, silty, yellowish. Represents eolian deposits.

17.0-21.0 ft. WEATHERED MANCOS SHALE BEDROCK: beds of silty claystone (about 0.05 ft. thick), calcareous, weak, pale yellowish brown (10YR 6/2). Some sandstone fragments, abundant gypsum crystals, some limonitic coloration, dark yellowish orange (10YR 6/6).

21.0-21.5 ft. MANCOS SHALE: becoming hard and competent. Stopped test pit at 21.5 ft; unable to excavate further with trackhoe.

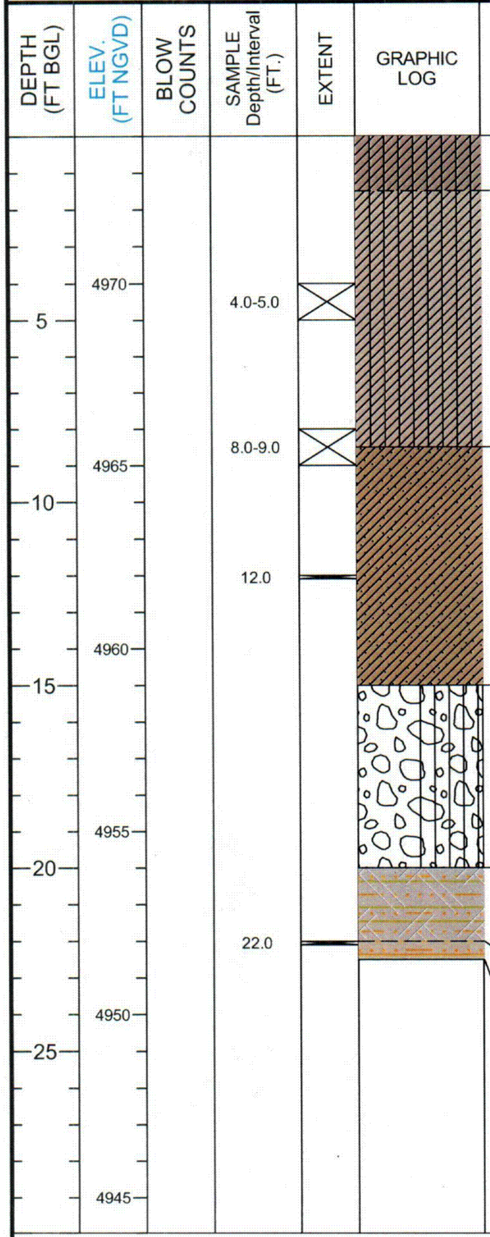
Total Depth 21.5 ft

TEST PIT LOG CRJ01-0156

PROJECT MOAB
LOCATION Crescent Junction, UT.
SITE Crescent Junction
WELL NUMBER CRJ01-0156
NORTH COORD. (FT) 6796137.16
EAST COORD. (FT) 2127679.48
SURFACE ELEV. (FT NGVD) 4974.00
HOLE DEPTH (FT) 22.50

DATE DRILLED 10/27/2005 to 10/28/2005
DRILLING COMPANY Ksue Corporation
DRILLING METHOD Trackhoe
SAMPLING METHOD
DRILL OPERATOR Carter, C.
REMARKS Samples collected in 5.0 gallon buckets.

BIT SIZE(S) (IN)
CORE SIZE(S) (IN)
LOGGED BY Smith, G., Goodknight, C.
WL (FT BGS)



LITHOLOGIC DESCRIPTION

0-1.5 ft. SILTY CLAY (CL-ML); abundant roots, some grained sand, angular blocky, low plasticity, grayish brown (10YR 5/2), highly calcareous. Represents A horizon.

1.5-8.5 ft. SILTY CLAY WITH SAND (CL-ML); fine grained sand (10-20%) subangular, moderate plasticity, sticky, calcic (stage I carbonate development), blocky structure, light brownish gray (2.5Y 6/2). Represents sheet wash deposits.

8.5-15.0 ft. CLAY/SILTY SAND CLAY; fine grained sand (30%), silty clay (70%), low plasticity, slightly sticky, diffuse calcium carbonate, yellowish brown (10YR 5/4). Pit sidewalls have salt coating, and the east sidewall is white. Represents eolian deposits.

15.0-20.0 ft. SILTY CLAYEY SAND AND GRAVEL (SM-GM); silty, clayey, sand and gravel. Sandstone boulders up to 2.0 ft. in diameter. Sub-rounded, platy sandstone fragments (up to 0.3-0.4 ft. long), medium to coarse grained sand. 10% boulders, 20-30% sands/gravels, and 50-60% sands/silts/clays. Represents a channel-fill deposit.

20.0-22.0 ft. WEATHERED MANCOS SHALE BEDROCK: Beds of silty claystone, light olive gray (5Y 6/1) and siltstone, yellowish gray (5Y 7/2) that are 0.05 to 0.3 ft. thick, moderately calcareous, break along bedding planes easily, trace carbonaceous material, gypsum, and pelecypod impressions along bedding.

22.0-22.5 ft. MANCOS SHALE: Becoming hard and competent. Stopped test pit at 22.5 ft; unable to excavate further with trackhoe.

Total Depth 22.5 ft.

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GRAND JUNCTION, COLORADO

02/28/2006

Appendix E

U.S. Department of Energy—Grand Junction, Colorado

Calculation Cover Sheet

Calc. No.: MOA-02-03-2006-4-01-00 **Discipline:** i.e., Geotechnical **No. of Sheets:** 5

Project: Moab UMTRA Project

Site: Crescent Junction Disposal Site

Feature:
Geotechnical Properties of Native Materials

Sources of Data:

Lab-Test Results from Geotechnical Engineering Group, Inc.

Sources of Formulae and References:

Geotechnical Engineering Group, Inc. December 22, 2005. *Geotechnical Testing Services* Letter Report to S.M. Stoller Corporation, GEG Job Number 2165.

Geotechnical Engineering Group, Inc. February 23, 2006. *Geotechnical Testing Services* Letter Report to S.M. Stoller Corporation, GEG Job Number 2165.

Preliminary Calc. ☐ **Final Calc.** ☑ **Supersedes Calc. No.**

Author: Name 3-16-06 Date

Checked by: Craig Goodknight Name 3/16/06 Date

Name K. Kemp for 3/16/06 Date

R. Heydenburg Name 3-16-06 Date

Name Date

Approved by: Name 3-16-06 Date

Problem Statement:

Preliminary site selection performed jointly by the U.S. Department of Energy (DOE) and the Contractor has identified a 2,300 acre withdrawal area in the Crescent Flat area just northeast of Crescent Junction, Utah, as a possible site for a final disposal cell for the Moab uranium mill tailings. The proposed disposal cell would cover approximately 300 acres. Based on the preliminary site-selection process, the suitability of the Crescent Junction disposal site is being evaluated from several technical aspects, including geomorphic, geologic, hydrologic, seismic, geochemical, and geotechnical. The objective of this calculation is to bring to light the geotechnical properties of native materials that were sampled from boreholes and test pits samples collected at the Crescent Junction site.

This calculation will be incorporated into Attachment 2 (Geology) of the Remedial Action Plan (RAP), and Site Design for Stabilization of Moab Title I Uranium Mill Tailings at the Crescent Junction, Utah, Disposal Site, and summarized in the appropriate sections of the Remedial Action Selection (RAS) report for the Moab site.

Method of Solution:

The geotechnical characterization of the Crescent Junction site was undertaken by drilling one hundred geotechnical boreholes with truck-mounted hollow-stem auger equipment and excavating five test pits with trackhoe equipment. Undisturbed drive samples were collected using the *Modified California* sampler with brass sleeves that were capped and labeled in the field. The boreholes were advanced to top of bedrock (refusal). Two samples were collected from the upper 5 feet and every 5 feet thereafter. Representative bulk samples from the soil and weathered-bedrock horizons were collected from test pits that were excavated to the top of bedrock.

The samples were stored temporarily in a *Connex* shipping container at the Crescent Junction site and transported twice weekly to Geotechnical Engineering Group (GEG) laboratory in Grand Junction, Colorado. GEG analyzed the geotechnical samples in accordance with the Statement of Work (S.M. Stoller 2005; Document X0114900). The Statement of Work required the subcontracted laboratory to follow ASTM procedures in carrying out the laboratory testing. In addition, S.M. Stoller Corporation completed a Quality Assurance (QA) audit of the testing laboratory and no findings were issued as a result of the surveillance. A copy of the QA Surveillance Report is attached in Appendix A.

Assumptions:

N/A

Calculation:

Laboratory results from the testing are contained in Appendices B and C. A summary of the index properties of the natural materials from the Crescent Junction site are contained in Table 1.

Discussion:

N/A

Conclusion and Recommendations:

N/A

Table 1. Summary of Geotechnical Index Properties for Natural Soil Materials at the Crescent Junction Site

Sample	Field Description	Tested Depth (ft)	Natural Moisture (%)	Dry Density (pcf)	Liquid Limit (%)	Plasticity Index (%)	Passing No. 200 (%)	Specific Gravity	$\square_{max}$ (Modified Proctor) (pcf)	W_{opt} (Modified Proctor) (%)	Sieve			Hydrometer		
											% Gravel	% Sand	% Fines	% silt	% clay	Double Hydrometer
Boreholes	**sandy silt**															
	Max	**17**	**13.4**	**113.4**	**34**	**19**	**94**									
	Min	**1.5**	**2.8**	**77**	**18**	**3**	**36**									
	Avg.	**6.3**	**6.7**	**92.4**	**23.6**	**7.3**	**64.8**									
	Count	37	37	31	36	36	36									
Test Pits	**fluvial/eolian**															
	Max	**15**			**21**	**3**	**84**	**2.65**	**127.5**	**12**	**49**	**35**	**67**	**52**	**27**	**83**
	Min	**8.5**			**19**	**2**	**63**	**2.63**	**118**	**10**	**0**	**22**	**29**	**15**	**14**	**62**
	Avg.	**11.9**			**20.0**	**2.7**	**69.5**	**2.6**	**123.0**	**11.0**	**12.5**	**30.5**	**57.0**	**36.5**	**20.5**	**72.5**
	Count	4			3	3	4	4	4	4	4	4	4	4	4	2
	sheet wash															
	Max	**7.5**			**26**	**9**	**83**	**2.82**	**123**	**13**	**4**	**30**	**84**	**62**	**22**	**79**
	Min	**3.5**			**22**	**4**	**66**	**2.64**	**118.5**	**11.5**	**0**	**16**	**66**	**54**	**13**	**61**
	Avg.	**4.9**			**23.8**	**6.0**	**72.8**	**2.7**	**120.5**	**12.4**	**1.0**	**25.4**	**73.6**	**58.8**	**16.8**	**70.0**
	Count	**5**			5	5	5	3	5	5	5	5	5	4	4	2
Boreholes	**weathered shale**															
	Max	**27**	**12.3**	**118**	**34**	**19**	**93**									
	Min	**3.5**	**2.6**	**71**	**21**	**4**	**19**									
	Avg.	**12.7**	**7.3**	**104.4**	**27.5**	**9.9**	**70.3**									
	Count	11	11	10	11	11	11									
Test Pits	**weathered shale**															
	Max	**23**			**38**	**20**	**97**	**2.73**	**127.5**	**13**	**2**	**14**	**97**	**55**	**42**	**86**
	Min	**20**			**25**	**7**	**84**	**2.56**	**120.5**	**11**	**0**	**3**	**84**	**53**	**31**	**62**
	Avg.	**21.7**			**32**	**13**	**92**	**2.6**	**123.0**	**12.0**	**0.7**	**7.3**	**92.0**	**54.3**	**37.7**	**74.0**
	Count	3			3	3	3	2	3	3	3	3	3	3	3	2

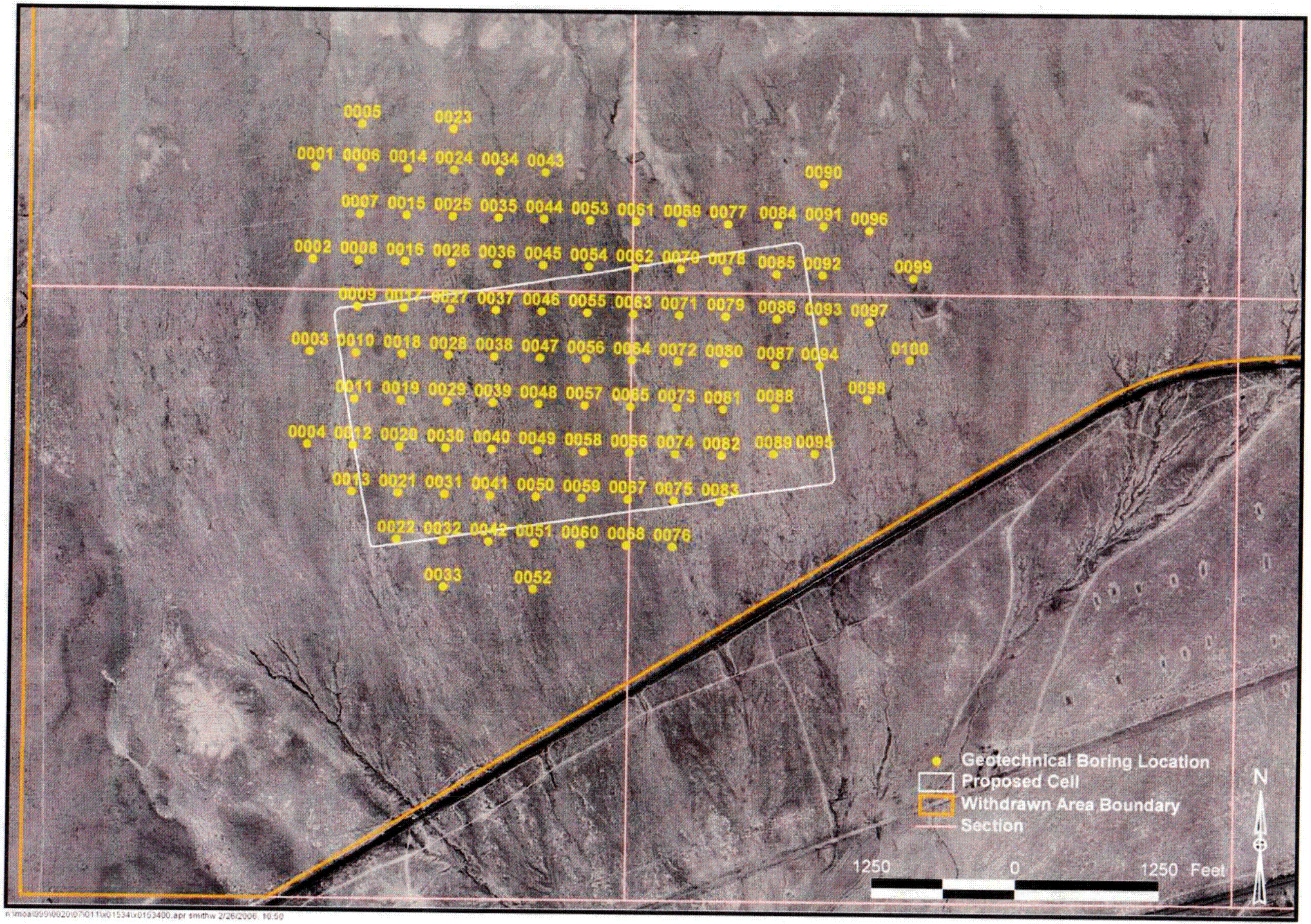

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Figure 1. Map Depicting the Locations of the 100 Geotechnical Boreholes at the Crescent Junction Site

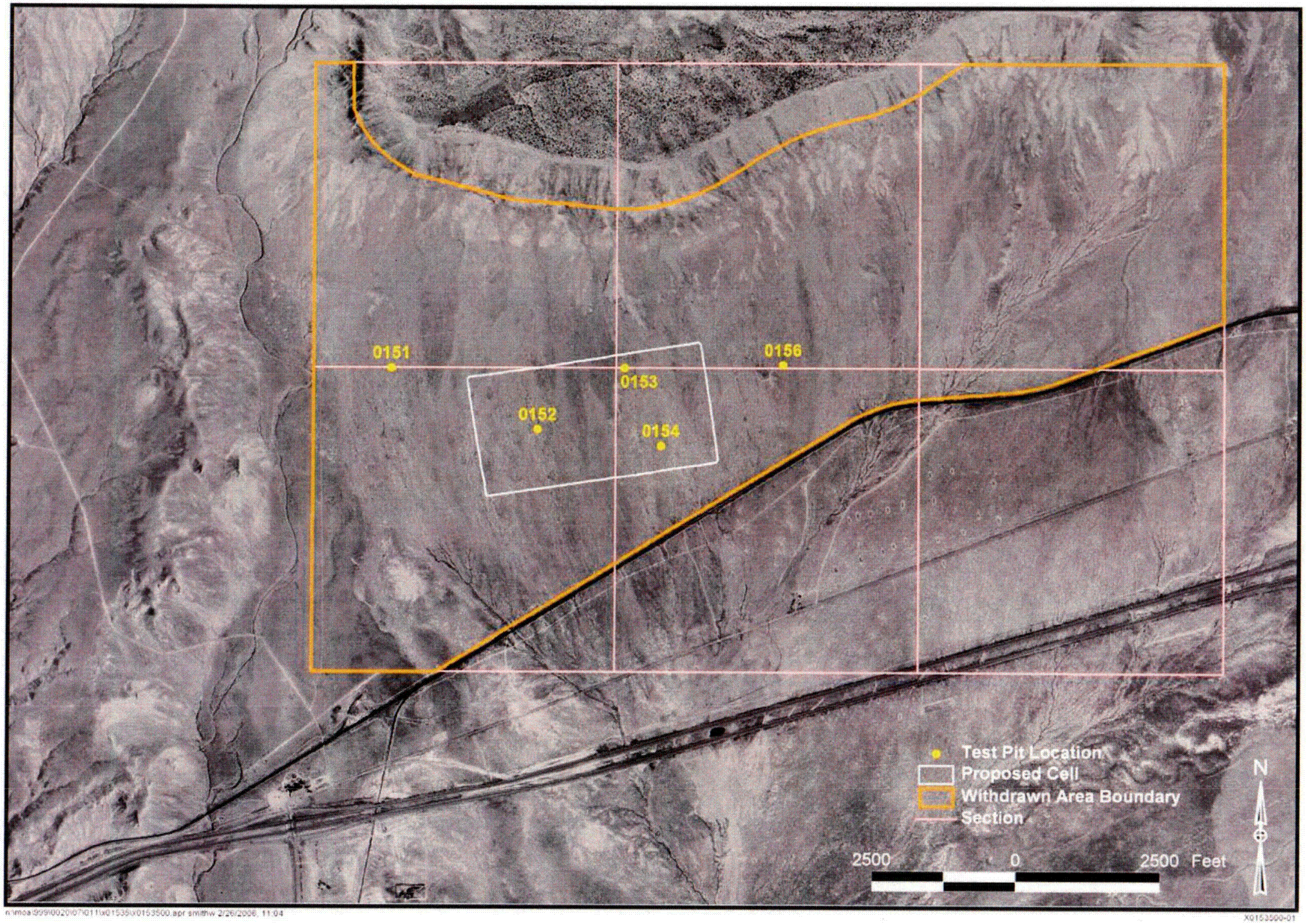

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Figure 2. Map Depicting the Location of the Five Test Pits at the Crescent Junction Site

Appendix A

Quality Assurance Surveillance Report

Stoller

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QA Surveillance Report

To: Mr. John Withers
Geotechnical Engineering Group, Inc.

Surveillance No. and Title: S-05-09, Geotechnical Engineering Group, Inc. laboratory

Project and Task: Moab Project, Crescent Junction Site
Analysis of soil samples obtained during geotechnical drilling.

Date(s) Performed: November 21 through 30, 2005 – review of procurement data
November 28, 2005 and December 15, 2005 – laboratory visit

Purpose and Scope: Evaluate subcontractor adherence to site-specific Statement of Work (SOW) for geotechnical testing of Crescent Junction soil samples.

Results: Sample transfer, receipt, and storage were being performed as directed in the SOW. Required personnel qualifications stipulated in American Society for Testing and Materials (ASTM) D 3740-01 were met. Discrepancies in samples, such as inadequate soil matrix or no sample at the specified depth, were resolved by discussion and mutual agreement between the laboratory and Stoller representatives. No findings are being issued as a result of this surveillance. One observation concerning documentation of instrument calibration is being submitted for your consideration.

Activities Observed: The contractor SOW was reviewed and subcontractor documents compared to the requirements specified in the SOW. Quality Assurance (QA) made an on-site visit November 28, 2005 at the Geotechnical Engineering Group, Inc. laboratory. During this visit QA interviewed you with regard to employee training, certification, laboratory procedures, accreditation, and performance of sample receipt, storage, and analysis, and instrument calibration.

Qualification requirements for this subcontract are equivalent to those stipulated in ASTM D 3740-01 *Standard Proactive for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil sand Rock as Used in Engineering Design and Construction* which requires that the supervising laboratory technician shall have at least 5 years experience performing tests on soil and rock and possess a current, valid NICET Level III Certification in Construction Materials Testing– Subfield Soils or Geotechnical Engineering Technology or Transportation Engineering, or equivalent. Submitted certification documentation for the laboratory technician has an expiration date of September 2004. When this was brought to your attention you assured me that you could provide Stoller with a current certificate for this employee. A copy of the current certification was received and is valid until September 1, 2007. Other personnel qualifications submitted for this SOW are compliant with ASTM D 3740-01.

It was my understanding from our discussion, subcontractor employees receive training provided in-house from experienced personnel, and they also participate in vendor provided certification training opportunities. The analytical procedures followed in the laboratory consist of a combination of in-house, process- or regional-specific procedures, as well as recognized industry standard published procedures (i.e., ASTM and American Association of State Highway and Transportation Officials (AASHTO) Standards). Copies of industry standards were available in the laboratory for employee reference. The Geotechnical Engineering Group, Inc. is accredited to AASHTO R18 specifications although none of the analysis provided for this SOW is applicable to this accreditation. Soil testing is being performed to ASTM industry standards in accordance with this SOW.

I observed the designated sample receiving area where shipment accountability and condition are reviewed, and samples are entered into the laboratory tracking system maintaining customer-issued identification numbers. Stoller samples were shipped, received, and tracked by hole/box number on the Chain-of-Custody documentation. Example: Hole 30, box 1 of 2 and 2 of 2. Each box contained differing amounts of sample tubes filled at various depths during drilling. Neither the Stoller representative offering the samples for analysis, or the laboratory, verified the samples by individual sample tubes/depths. Stoller samples were segregated and stored in an area that was removed from other customer samples. Stoller representatives directed the laboratory on which samples to analyze. Analytical requests are documented on analysis sheets and processed in order received. You explained to me there is a designated area where requests are staged and if any analysis is requested that is not a normal routine procedure, internal procedures dictate that an engineer is required to review and approve the request before analysis is performed. When there was a discrepancy in the sample, such as inadequate soil matrix or no sample at the specified depth, the laboratory informed Stoller and worked to resolve the issue.

During our tour of the laboratory, although Stoller samples were not being analyzed at the time, I was able to observe work practices of subcontractor employees performing analysis and view instrument calibration documentation posted on equipment. You explained that the laboratory instrument calibration program consists of procedures performed by trained employees as well as vendor-performed on-site equipment calibrations. From my observation, there appears to be two types of calibration stickers placed on equipment, in-house calibrations and vendor-performed calibrations. I noticed a mixture of current and out-of-date calibration stickers on laboratory equipment. The particular piece of equipment we discussed as out-of-calibration was for concrete measurements, not soils, however it would be advisable that the laboratory review all instrument calibration stickers and correct as applicable.

A second on-site visit was conducted on December 15, 2005. Rex Sellers, Contract Administrator and Greg Lord, S.M. Stoller Engineer accompanied QA on this visit. A Geotechnical Engineering Group representative conducted a tour of the laboratory and explained the processes and equipment used for performing geotechnical analysis. The employee conducting the tour was informative and knowledgeable of the type of work that was of interest to the contractor.

Findings: None

Observations: There is a mixture of current and out-of-date calibration stickers on laboratory equipment. It is advisable that the laboratory reviews all instrument calibration stickers and correct as applicable.

Surveillance of Compliance With: Geotechnical Testing Laboratory Statement of Work; Doc. No. X0114900, September 2005.

Persons Contacted: QA would like to thank the following individuals for their time and information provided during the performance of this surveillance: John Withers, Geotechnical Engineering Group Engineer, Terry Brown, Geotechnical Engineering Group Laboratory Manger, Robert Anderson, Geotechnical Engineering Group Laboratory Technician, Greg Lord, S.M. Stoller Engineer, Rex Sellers, Stoller Contract Administrator, Mark Kautsky, Stoller Technical Monitor

Action Required: None

Reviewed By: signature on file copy **Date:** 12/21/2005
Donna Riddle, RAB EMS-LA E051671
Stoller QA Manager

Issued By: signature on file copy **Date:** 12/21/2005
Linda Tegelman, ASQ CQA 28173
Stoller Lead Auditor

cc: QA File S-05-09

Email: K. E. Karp
M. Kautsky
G. G. Lord
J. O. Neff
R. D. Sellers

Appendix B

Geotechnical Testing Results

December 22, 2005

**Geotechnical
Engineering
Group, Inc.**

December 22, 2005

S.M Stoller Corporation
2597 B ¾ Road
Grand Junction, CO 81503

Attention: Mr. Rex Sellers
Senior Contract Adviser

Subject: Geotechnical Testing Services
Cresent Junction
Utah Disposal Site
GEG Job No. 2,165

Dear Mr. Sellers,

As requested, Geotechnical Engineering Group, Inc. (GEG) has performed laboratory testing for the subject project. The laboratory tests were performed on samples obtained by others. Laboratory tests performed were determined by S.M Stoller Corporation and include: moisture content tests, dry density tests, sieve analysis tests, percent passing No. 200 sieve tests, hydrometer tests, double hydrometer tests, Atterberg limits tests, moisture content-dry density relationship (Proctor) test and specific gravity tests.

Moisture Content and Dry Density

Moisture content and dry density were determined for each sample tested. The moisture content was determined according to ASTM Test Method D2216. The dry density of the sample was determined by using the wet weight of the entire sample tested. The results of the moisture and dry density determinations are presented on Table 1, Pages 1 through 4.

Sieve Analysis Tests and Hydrometer Tests

Sieve analysis tests and hydrometer tests were conducted on selected samples. The sieve analysis tests were conducted in general accordance with ASTM Test Method D422. The results of the sieve analysis tests are presented on Gradation Test Results (Figs. 1 through 6).

Percent Passing No. 200 Sieve

Percent passing No. 200 sieve was determined on select samples in general accordance with ASTM Test Method C117. Percent passing No. 200 sieve are presented in Table 1, Pages 1 through 4.

Double Hydrometer Tests

Double hydrometer tests were performed on select samples in general accordance with ASTM Test Method D4221. Double hydrometer tests results are presented in Table I, Pages 1 through 4.

Atterberg Limits Tests

Atterberg limits tests were conducted on select samples. Atterberg limits tests were conducted in general accordance with ASTM Test Method D4318. The results of the Atterberg limits tests are presented in Table 1, Pages 1 through 4.

Moisture Content-Dry Density Relationship Tests

Moisture content-dry density relationship (Proctor) tests were conducted on select samples. The moisture-density relationship tests were conducted in accordance with ASTM Test Method D1557. The results of the moisture-density relationship tests are presented on Figs. 1 through 12.

Specific Gravity Tests

Specific gravity tests were conducted on select samples. The specific gravity tests were conducted in general accordance with ASTM Test Method D854. The results of the specific gravity tests are presented on Table 1

We believe the laboratory study was performed and this letter was prepared in a manner consistent with that level of care and skill ordinarily used by geotechnical engineers practicing in this area at this time. No other warranty, either express or implied, is made. When we may be of further service or answer any questions from a geotechnical or construction materials point of view, please call.

Sincerely,
GEOTECHNICAL ENGINEERING GROUP, INC.

Robert W. Anderson
Laboratory Supervisor

RWA:cb
(3 copies sent)

TABLE I

Geotechnical
Engineering
Group, Inc.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

HOLE	DEPTH (FEET)	NATURAL MOISTURE (%)	DRY DENSITY (PCF)	Atterberg Limits LIQUID LIMIT (%)	PLASTICITY INDEX (%)	Double Hydrometer DISPERSION AT 5 MICRON (%)	PASSING NO. 200 SIEVE (%)	SPECIFIC GRAVITY	SOIL TYPE
TH-5	2	4.2	91	21	4	--	69	--	Clay, silty, sandy (CL)
	11	6	118	25	10	--	79	--	Shale
TH-7	10.5	4.5	100	21	9	--	62	--	Clay, silty, sandy (CL)
TH-9	4	6.6	83	24	9	--	74	--	Clay, silty, sandy (CL)
	6.5	6.6	107.2	28	9	--	84	--	Shale
TH-11	2	6.1	83	22	9	--	78	--	Clay, silty, sandy (CL)
	16	7.9	119.4	37	20	--	96	--	Shale
TH-13	7	8.3	113.4	NL*	NP*	--	43	--	Sand, clayey, silty (SC/SM)
TH-25	16.5	7.3	106	21	6	--	66	--	Clay, silty, sandy (CL)
TH-27	16.5	8.4	108	24	11	--	87	--	Clay, silty, sandy (CL)
TH-29	7	13.4	77	23	6	--	77	--	Clay, silty, sandy (CL)
	27	6.4	81	29	10	--	81	--	Shale
TH-31	12	8.2	96	24	4	--	50	--	Clay, sand, silty (CL/SC)
				* NL – Indicates sample did not exhibit liquid characteristics.					
				* NP – Indicates sample did not exhibit plastic characteristics.					
				** Assumed 2.65 for specific gravity, program sheet didn't indicate specific gravity tests.					

Geotechnical
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Group, Inc.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

HOLE	DEPTH (FEET)	NATURAL MOISTURE (%)	DRY DENSITY (PCF)	Atterberg Limits		Double Hydrometer	PASSING NO. 200 SIEVE (%)	SPECIFIC GRAVITY	SOIL TYPE
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)	DISPERSION AT 5 MICRON (%)			
TH-33	10.75	6.7	117	34	18	--	82	--	Shale
TH-43	3.5	6.1	90	25	8	--	53	--	Clay, silty, sandy (CL)
TH-45	1.5	4.6	84	19	7	--	57	--	Clay, silty, sandy (CL)
TH-49	6.5	6	83	20	6	--	62	--	Clay, silty, sandy (CL)
	12	5.4	102	19	5	--	80	--	Clay, silty, sandy (CL)
TH-51	3.5	3.8	85	20	6	--	57	--	Clay, silty, sandy (CL)
TH-64	2	12.4	95	34	5	--	74	--	Clay, silty, sandy (CL)
TH-66	3.5	4.7	90	21	5	--	53	--	Clay, silty, sandy (CL)
	7	12.3	112	31	10	--	90	--	Shale
TH-68	2	4.2	94	21	6	--	36	--	Clay, silty, sandy (CL)
TH-78	7	5.7	85	23	7	--	70	--	Clay, silty, sandy (CL)
TH-80	3	2.8	95	19	5	--	53	--	Clay, silty, sandy (CL)

* NL – Indicates sample did not exhibit liquid characteristics.

* NP – Indicates sample did not exhibit plastic characteristics.

** Assumed 2.65 for specific gravity, program sheet didn't indicate specific gravity tests.

JOB NO. 2,105

Geotechnical
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TABLE I

SUMMARY OF LABORATORY TEST RESULTS

HOLE	DEPTH (FEET)	NATURAL MOISTURE (%)	DRY DENSITY (PCF)	Atterberg Limits		Double Hydrometer	PASSING NO. 200 SIEVE (%)	SPECIFIC GRAVITY	SOIL TYPE
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)	DISPERSION AT 5 MICRON (%)			
TH-80	7	6	89	24	7	--	65	--	Clay, silty, sandy (CL)
TH-82	12	4.7	91	21	8	--	79	--	Clay, silty, sandy (CL)
	17	7.1	118	34	14	--	93	--	Shale
TH-90	12	8.2	99	22	5	--	55	--	Clay, silty, sandy (CL)
TH-92	2	5.7	87	22	9	--	63	--	Clay, silty, sandy (CL)
	12	7.7	71	26	6	--	71	--	Clay, silty, sandy (CL)
TH-94	4	12.2	89	31	10	--	61	--	Clay, silty, sandy (CL)
	17	7.1	102	20	5	--	37	--	Clay, silty, sandy (CL)
	21.5	6.8	112	21	4	--	33	--	Shale
TH-95	7	6.5	85	23	7	--	46	--	Clay, silty, sandy (CL)
TH-99	2.5	4.8	87	18	3	--	47	--	Sand, clayey, silty (SC/SM)
TP-151	4'3"-4'6"	5.6	--	24	5	--	66	**	Clay, silty, sandy (CL)
TP-152	7.5	4.3	--	26	9		74	2.64	Clay, silty, sandy (CL)

* NL – Indicates sample did not exhibit liquid characteristics.

* NP – Indicates sample did not exhibit plastic characteristics.

** Assumed 2.65 for specific gravity, program sheet didn't indicate specific gravity tests.

JOB NO. 2.165

Geotechnical
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Group, Inc.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

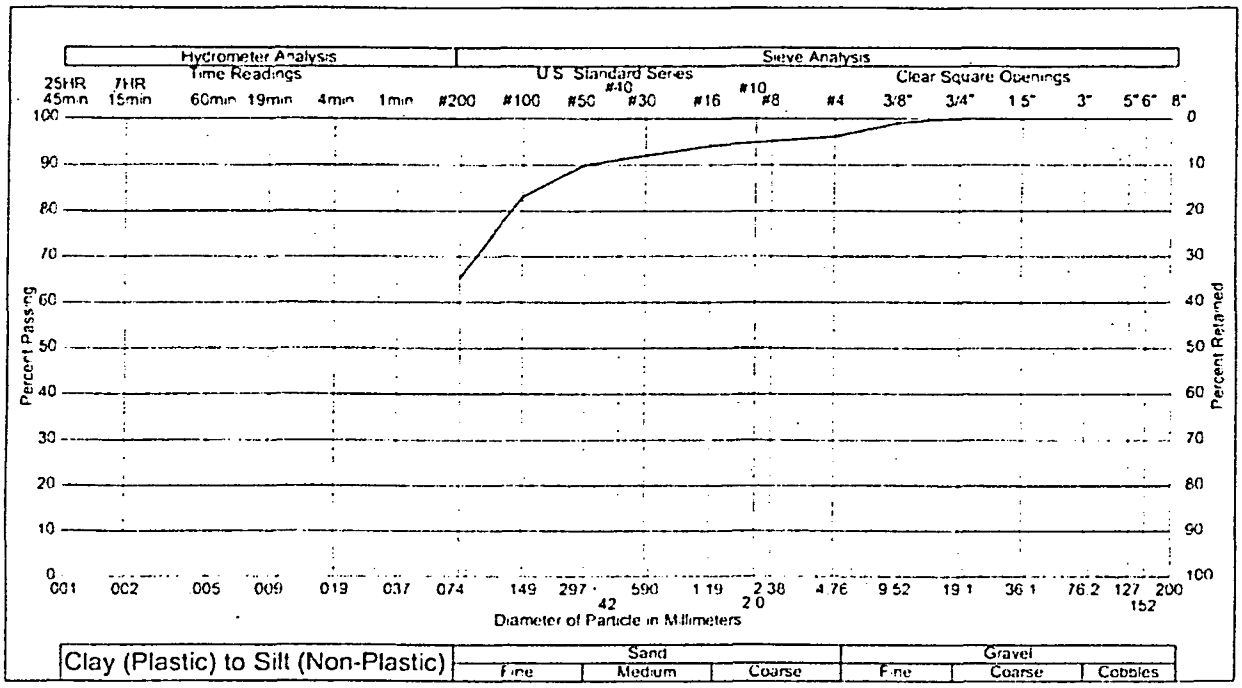
HOLE	DEPTH (FEET)	NATURAL MOISTURE (%)	DRY DENSITY (PCF)	Atterberg Limits		Double Hydrometer	PASSING NO. 200 SIEVE (%)	SPECIFIC GRAVITY	SOIL TYPE
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)	DISPERSION AT 5 MICRON (%)			
TP-152	15	2.9	--	21	3		84	2.63	Clay, silty, sandy (CL)
	23	5.5	--	33	12	--	97	**	Clay, silty, sandy (CL)
TP-153	2.5-3.5	5.7	--	23	5	--	72	2.68	Clay, silty, sandy (CL)
	8.5	4.4	--	NL*	NP*	--	67	2.65	Silt, sandy, clayey (ML)
TP-154	4	7.6	--	22	4	79	83	**	Clay, silty, sandy (CL)
	12	2.7	--	20	3	62	63	2.65	Clay, silty, sandy (CL)
	18-20	5.5	--	38	20	62	95	2.73	Shale
TP-15~~5~~6	4-5	7.2	--	24	7	61	69	2.82	Clay, silty, sandy (CL)
TP-156	12	2.7	--	19	2	83	64	2.64	Clay, silty, sandy (CL)
	22	5.5	--	25	7	86	84	2.56	Clay, silty, sandy (CL)

* NL – Indicates sample did not exhibit liquid characteristics.

* NP – Indicates sample did not exhibit plastic characteristics.

** Assumed 2.65 for specific gravity, program sheet didn't indicate specific gravity tests.

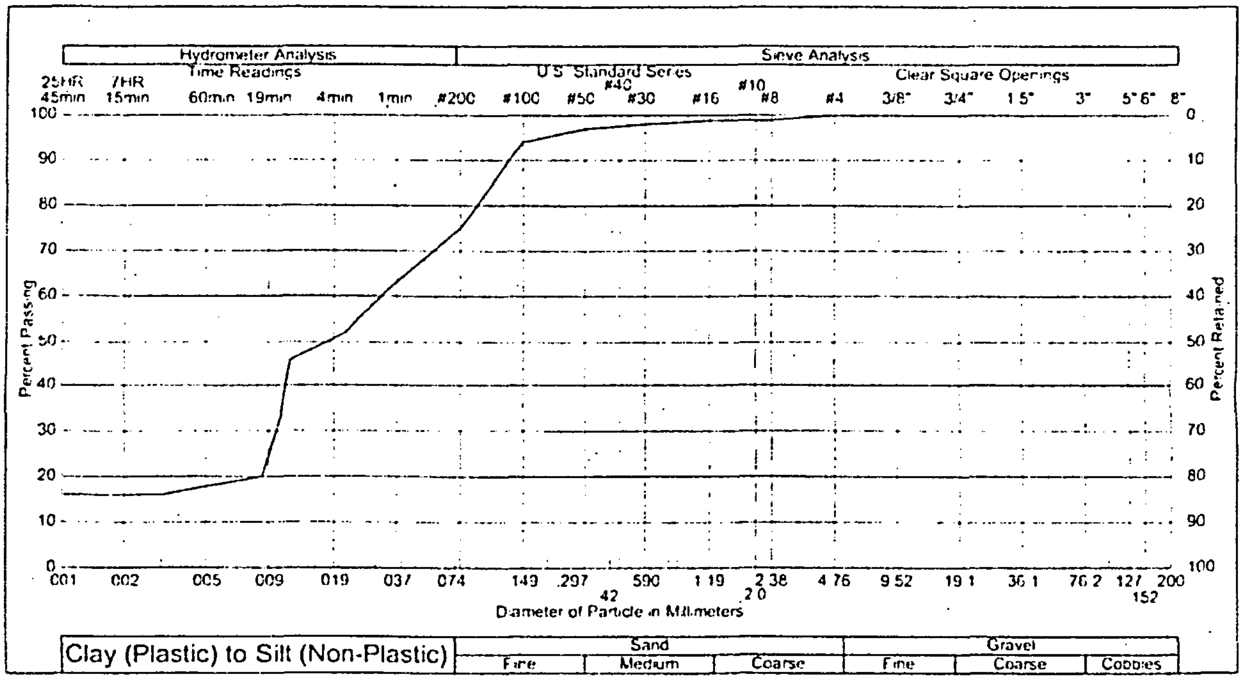
GRADATION TEST RESULTS



Sample of: 05-197
From: TH-0151 @ 4'3" - 4'6" foot depth
Moisture Content: 5.6 %

Gravel: 4 %
Sand: 30 %
Silt & Clay: 66 %

Liquid Limit: 24
Plastic Limit: 19
Plasticity Index: 5
Specific Gravity:



Sample of: Claly, silty, sandy, moist 05-186
From: TP-152 @ 7.5 foot depth
Moisture Content: 4.3 %

Gravel: 0 %
Sand: 25 %
Silt & Clay: 75 %

Liquid Limit: 26
Plastic Limit: 17
Plasticity Index: 9
Specific Gravity: 2.64

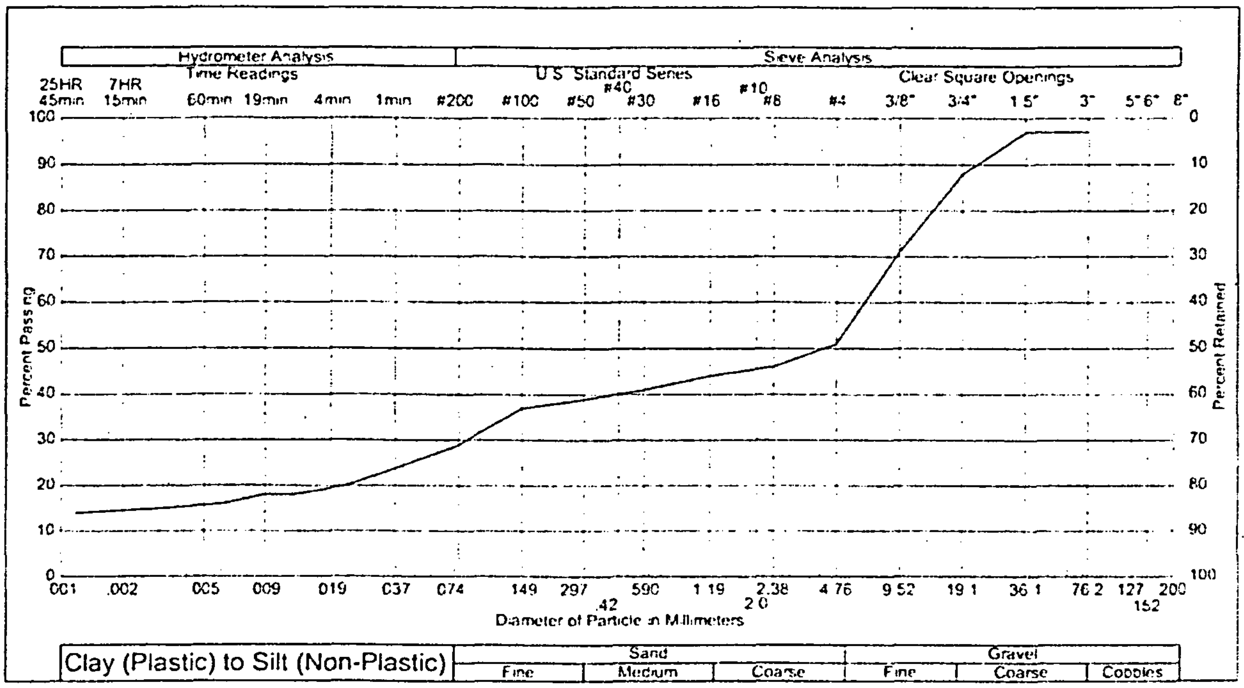
Gradation Test Results

Job No. 2,165

Geotechnical Engineering Group, Inc.

Date: December, 2005

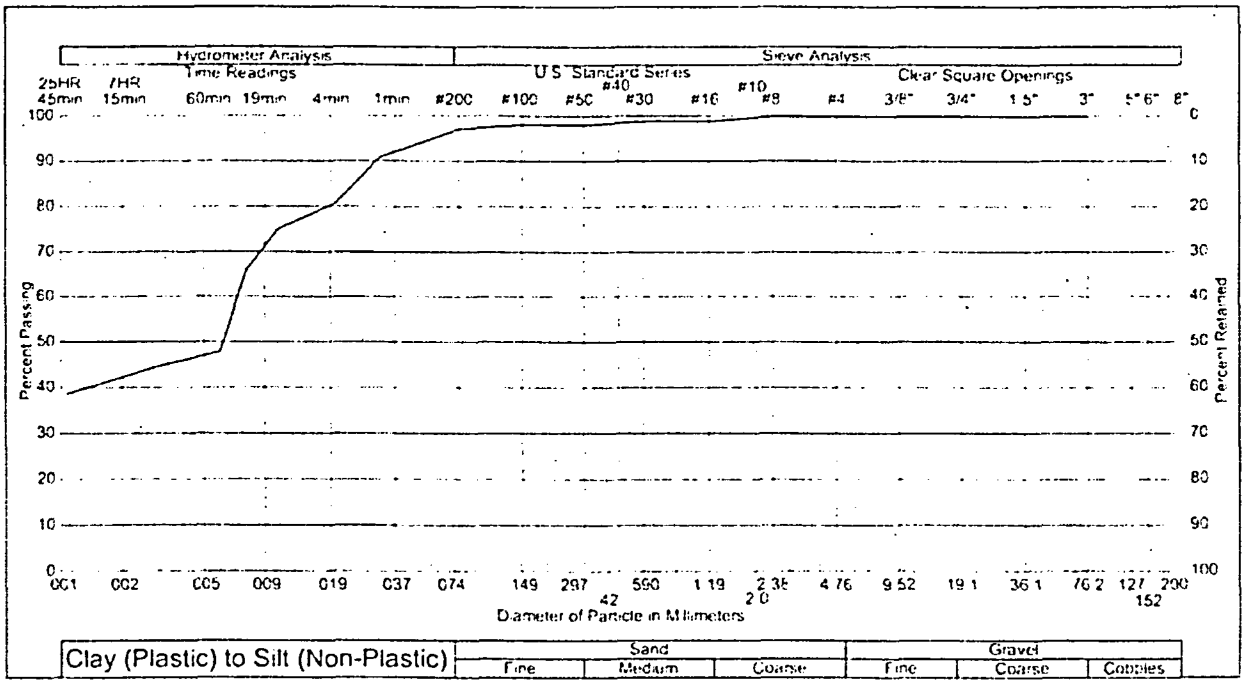
Fig. 1



Sample of: Clay, silty, sandy, sandstone 05-188
From: TH-152 @ 15 foot depth
Moisture Content: 2.9 %

Gravel: 49 %
Sand: 22 %
Silt & Clay: 29 %

Liquid Limit: 21
Plastic Limit: 18
Plasticity Index: 3
Specific Gravity: 2.63



Sample of: 05-198
From: TH-152 @ 23 foot depth
Moisture Content: 5.5 %

Gravel: 0 %
Sand: 3 %
Silt & Clay: 97 %

Liquid Limit: 33
Plastic Limit: 21
Plasticity Index: 12
Assumed Specific Gravity: 2.65

Gradation Test Results

Job No. 2,165

**Geotechnical
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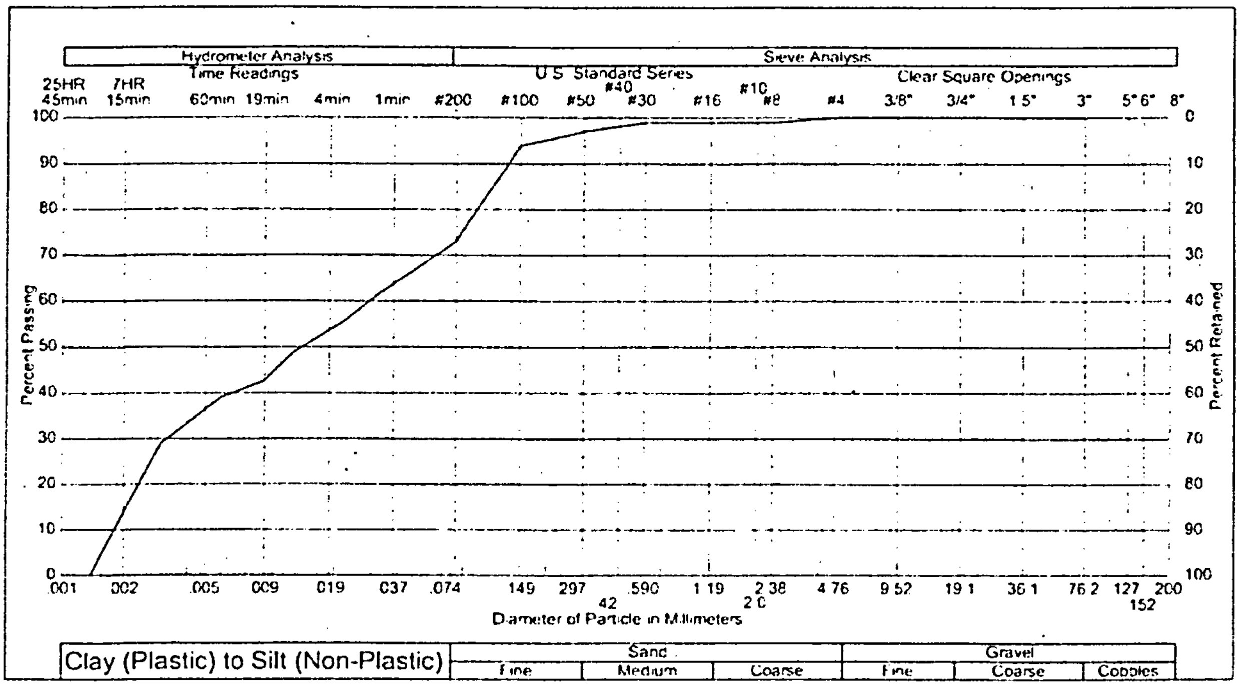
Group, Inc.**

Date: December, 2005

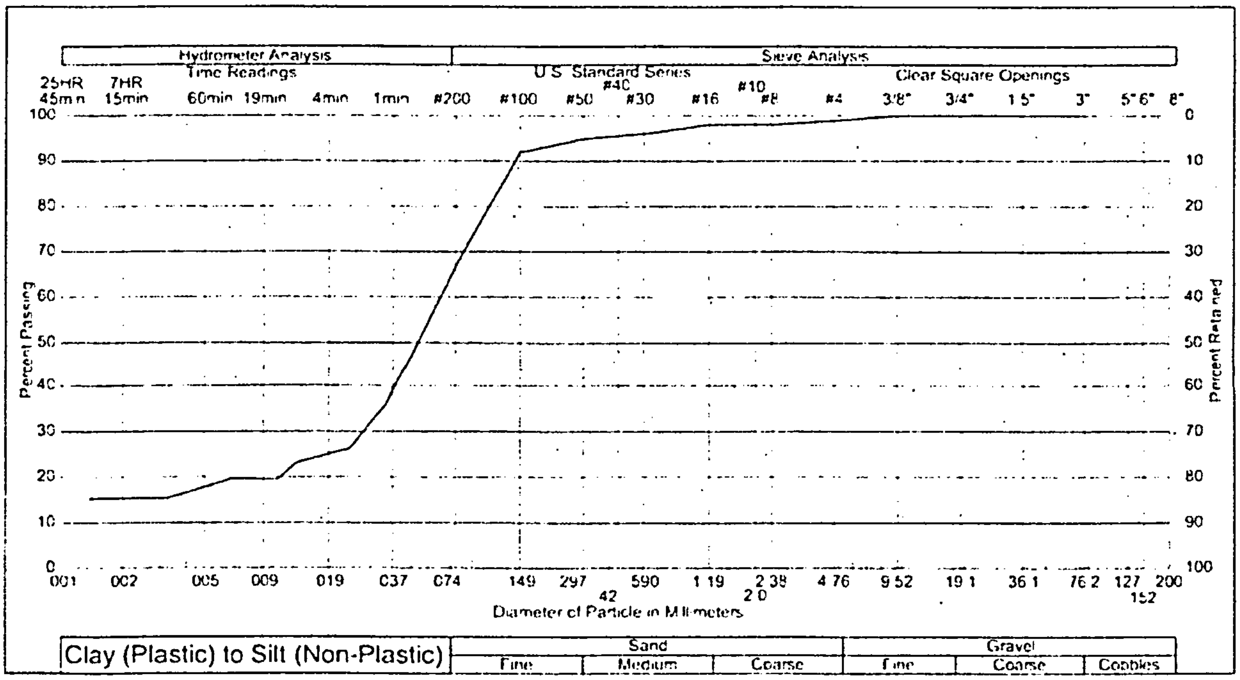
Fig. 2



Sample of: Silty, clay, sandy, moist, brown 05-189
From: TH-153 @ 2.5 to 3.5 foot depth
Moisture Content: 5.7 %

Gravel: 0 %
Sand: 27 %
Silt & Clay: 73 %

Liquid Limit: 23
Plastic Limit: 18
Plasticity Index: 5
Specific Gravity: 2.68



Sample of: Clay, sandy, dry, moist, brown 05-190
From: TH-153 @ 8.5 foot depth
Moisture Content: 4.4 %

Gravel: 1 %
Sand: 32 %
Silt & Clay: 67 %

Liquid Limit: NL
Plastic Limit:
Plasticity Index: NP
Specific Gravity: 2.65

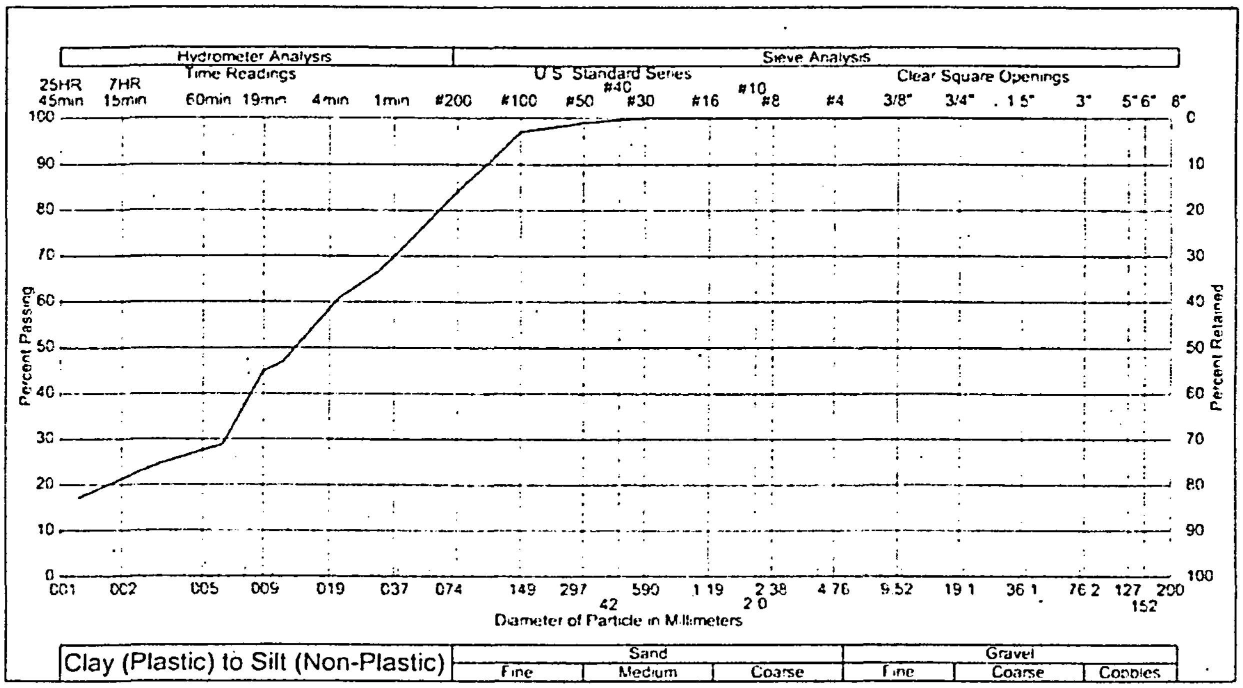
Gradation Test Results

Job No. 2,165

Geotechnical Engineering Group, Inc.

Date: December, 2005

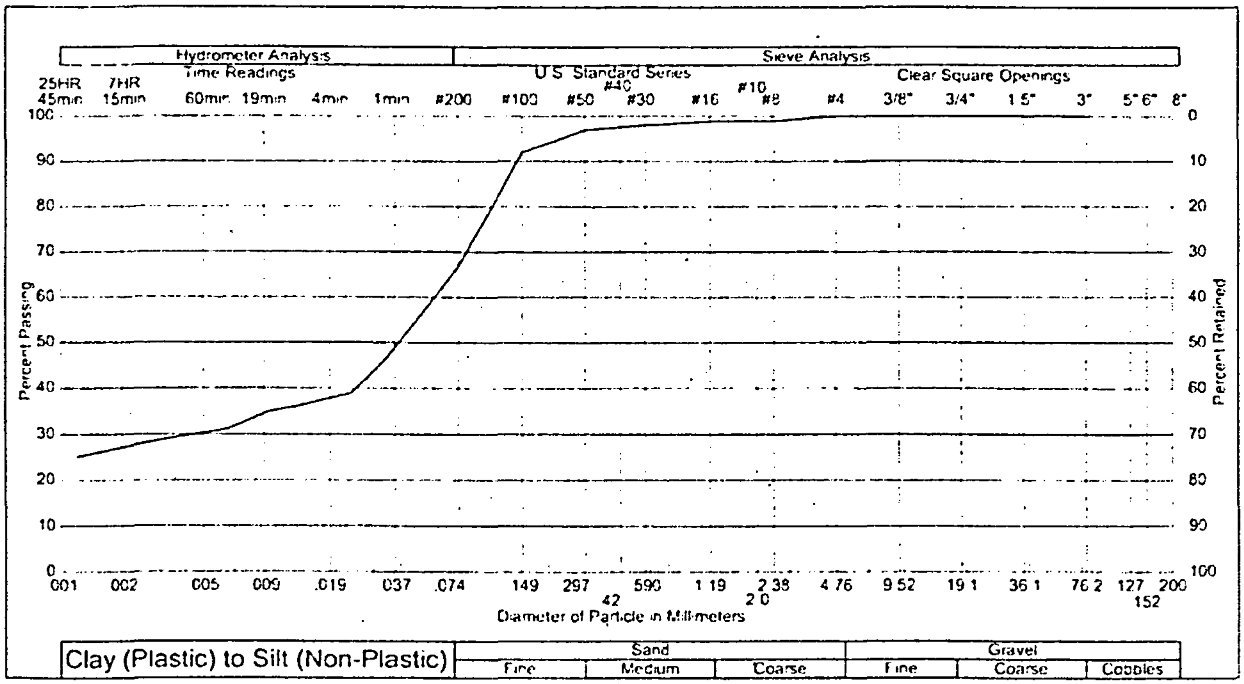
Fig. 3



Sample of: Clay, silty, sandy 05-187
From: TH-154 @ 4 foot depth
Moisture Content: 7.6 %

Gravel: 0 %
Sand: 16 %
Silt & Clay: 84 %

Liquid Limit: 22
Plastic Limit: 18
Plasticity Index: 4
Assumed Specific Gravity: 2.65



Sample of: Silty, clay,sandy, dry, tan 05-191
From: TH-154 @ 12 foot depth
Moisture Content: 2.7 %

Gravel: 0 %
Sand: 33 %
Silt & Clay: 67 %

Liquid Limit: 20
Plastic Limit: 17
Plasticity Index: 3
Assumed Specific Gravity: 2.65

Gradation Test Results

Job No. 2,165

**Geotechnical
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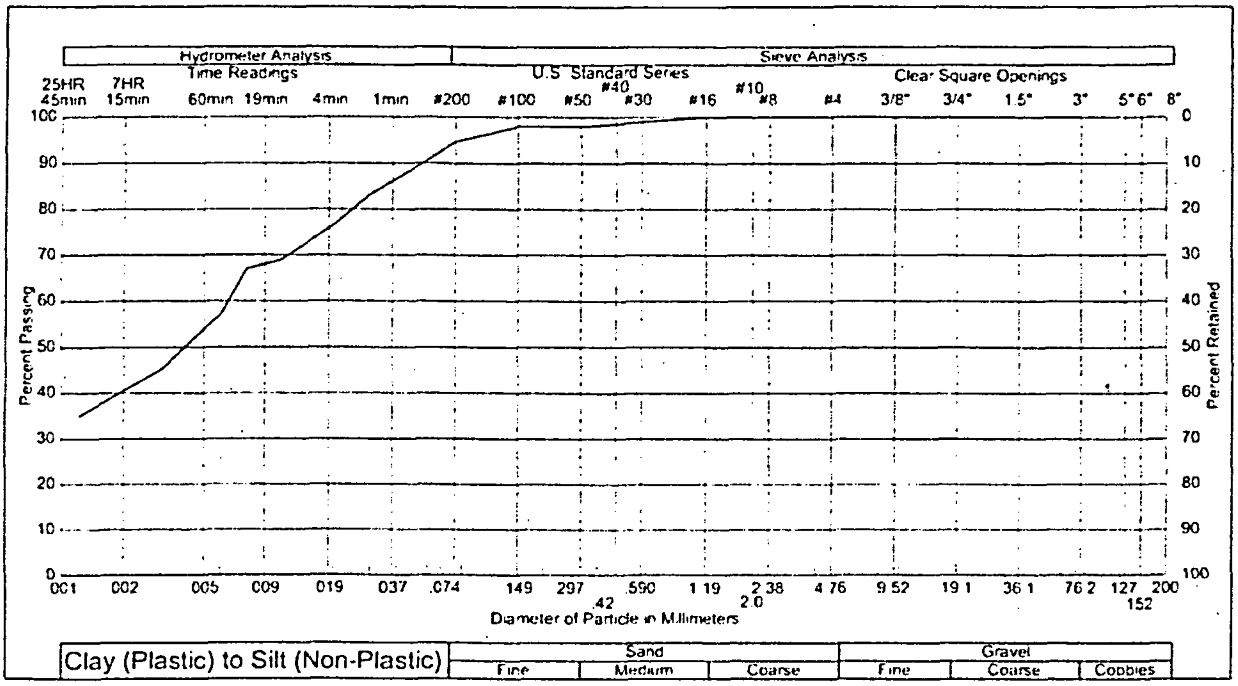
Date: December, 2005

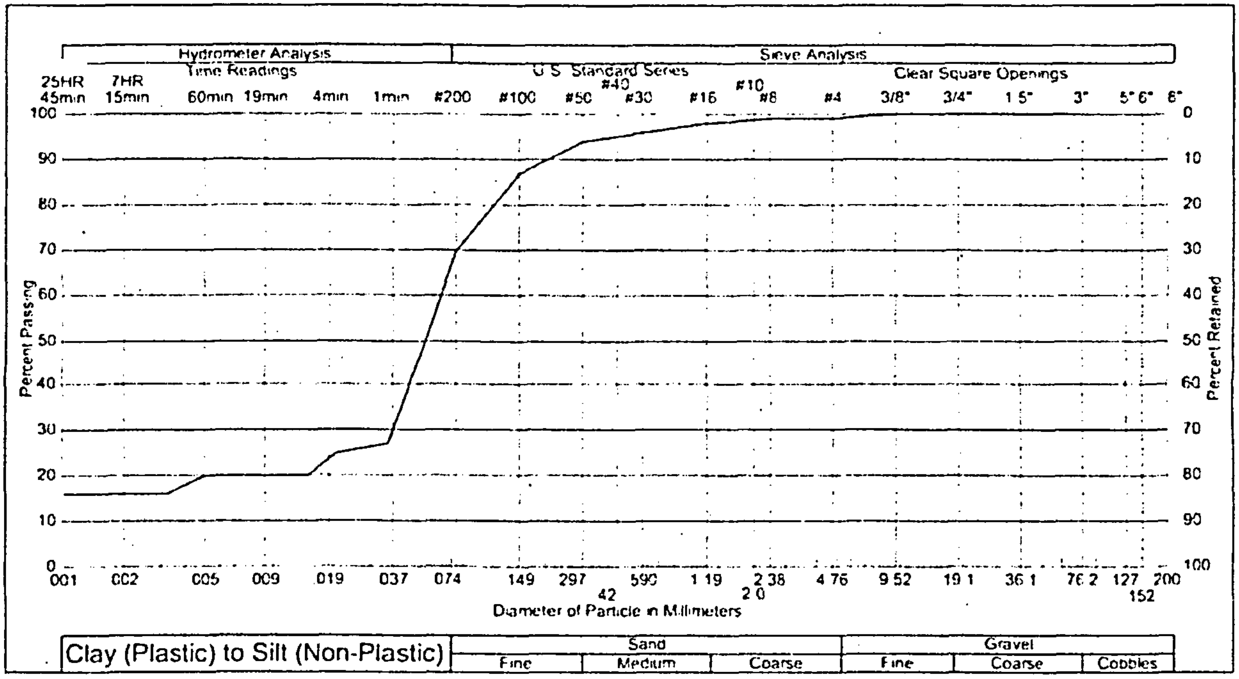
Fig. 4



Sample of: Shale, silty, sandy, dry, light tan 05-192
From: TH-154 @ 18 to 20 foot depth
Moisture Content: 5.5 %

Gravel: 0%
Sand: 5 %
Silt & Clay: 95 %

Liquid Limit: 38
Plastic Limit: 20
Plasticity Index: 20
Specific Gravity: 2.73



Sample of: Silty, clay, sandy, moist, brown 05-193
From: TH-15~~5~~16 @ 4 to 5 foot depth
Moisture Content: 7.2 %

Gravel: 1 %
Sand: 29 %
Silt & Clay: 70 %

Liquid Limit: 24
Plastic Limit: 17
Plasticity Index: 7
Specific Gravity: 2.82

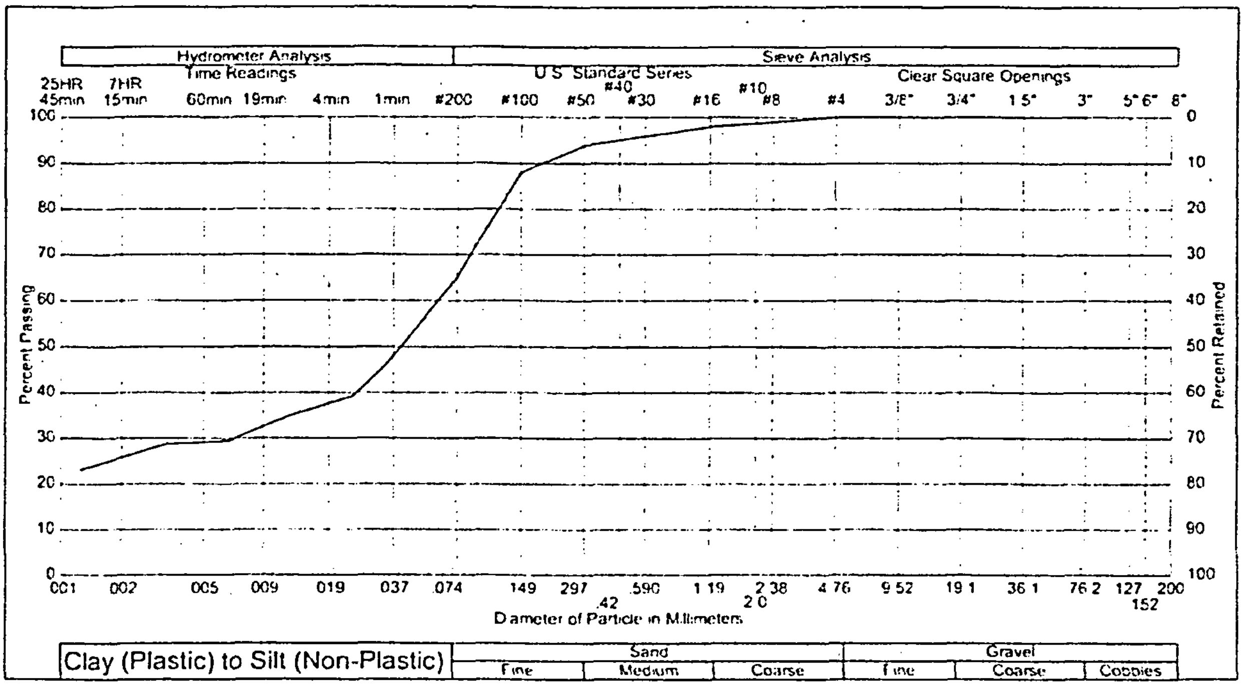
Gradation Test Results

Job No. 2,165

Geotechnical Engineering Group, Inc.

Date: December, 2005

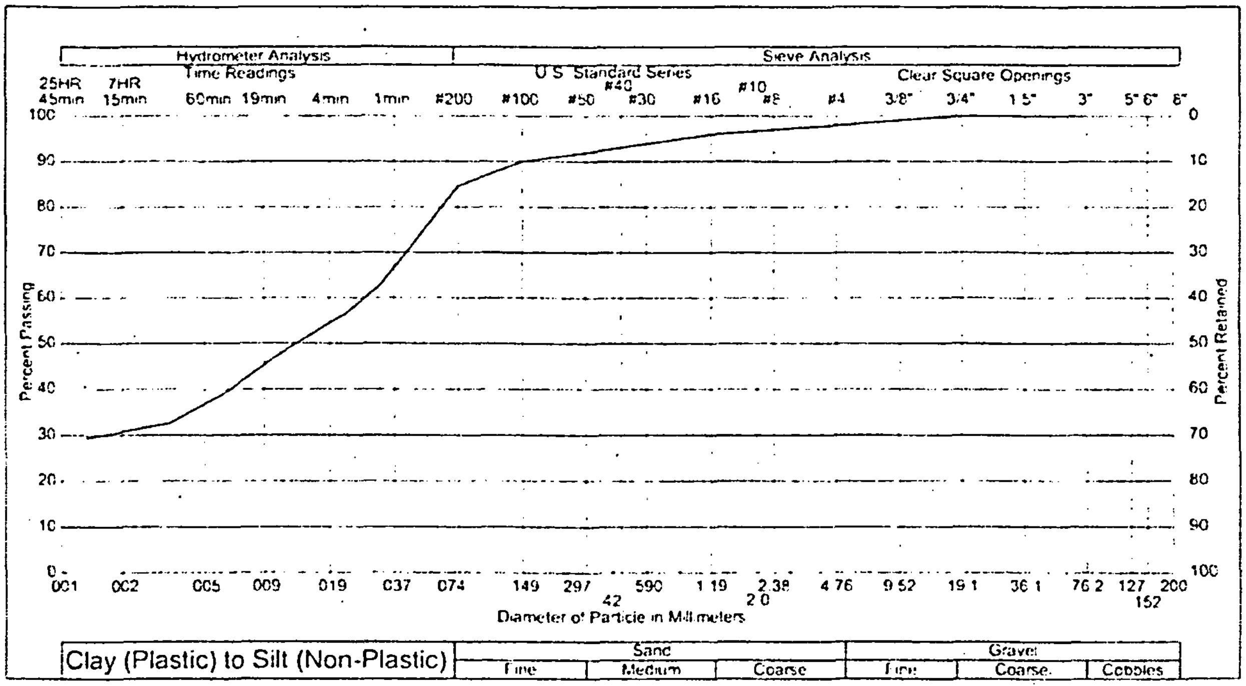
Fig. 5



Sample of: Silty, clay, sandy, moist, tan 05-194
From: TH-156 @ 12 foot depth
Moisture Content: 2.7 %

Gravel: 0 %
Sand: 35 %
Silt & Clay: 65 %

Liquid Limit: 19
Plastic Limit: 17
Plasticity Index: 2
Specific Gravity: 2.64



Sample of: 05-195
From: TH-156 @ 22 foot depth
Moisture Content: 5.5 %

Gravel: 2 %
Sand: 14 %
Silt & Clay: 84 %

Liquid Limit: 25
Plastic Limit: 18
Plasticity Index: 7
Specific Gravity: 2.56

Gradation Test Results

Job No. 2,165

**Geotechnical
Engineering
Group, Inc.**

Date: December, 2005

Fig. 6

PROCTOR AND CLASSIFICATION TEST RESULTS

Geotechnical Engineering Group, Inc.
Moisture- Density Relationship

Project Name: Crescent Junction

Sample Location: TP-151 @ 4'3" to 4'6"

Sample Description: 05-197

Test Method: 1557 method A

Maximum Dry Density: 118.5 pcf

Optimum Moisture: 13.0 %

<u>Rock Corrected</u>

Maximum Dry Density: N/A

Optimum Moisture: N/A

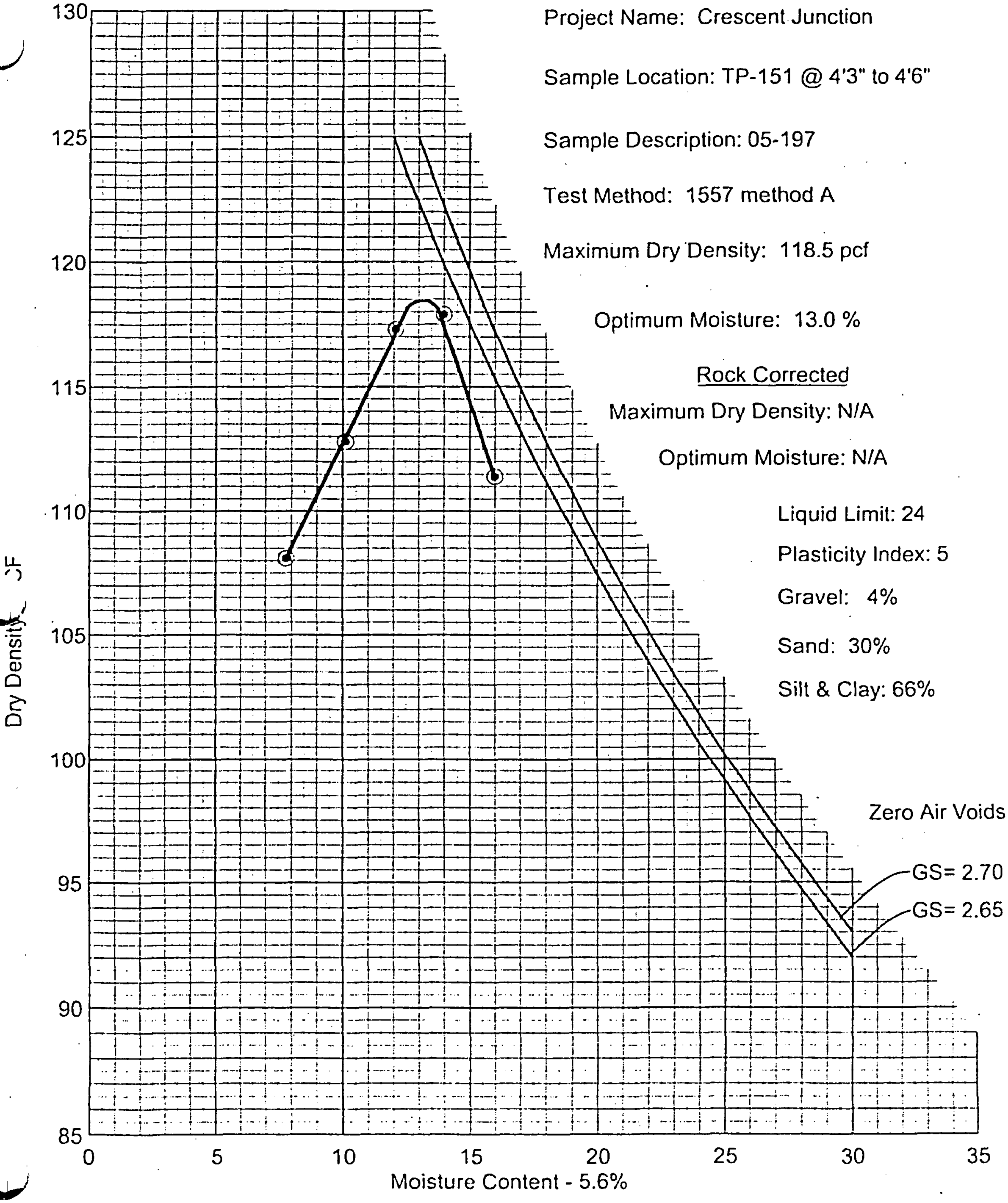
Liquid Limit: 24

Plasticity Index: 5

Gravel: 4%

Sand: 30%

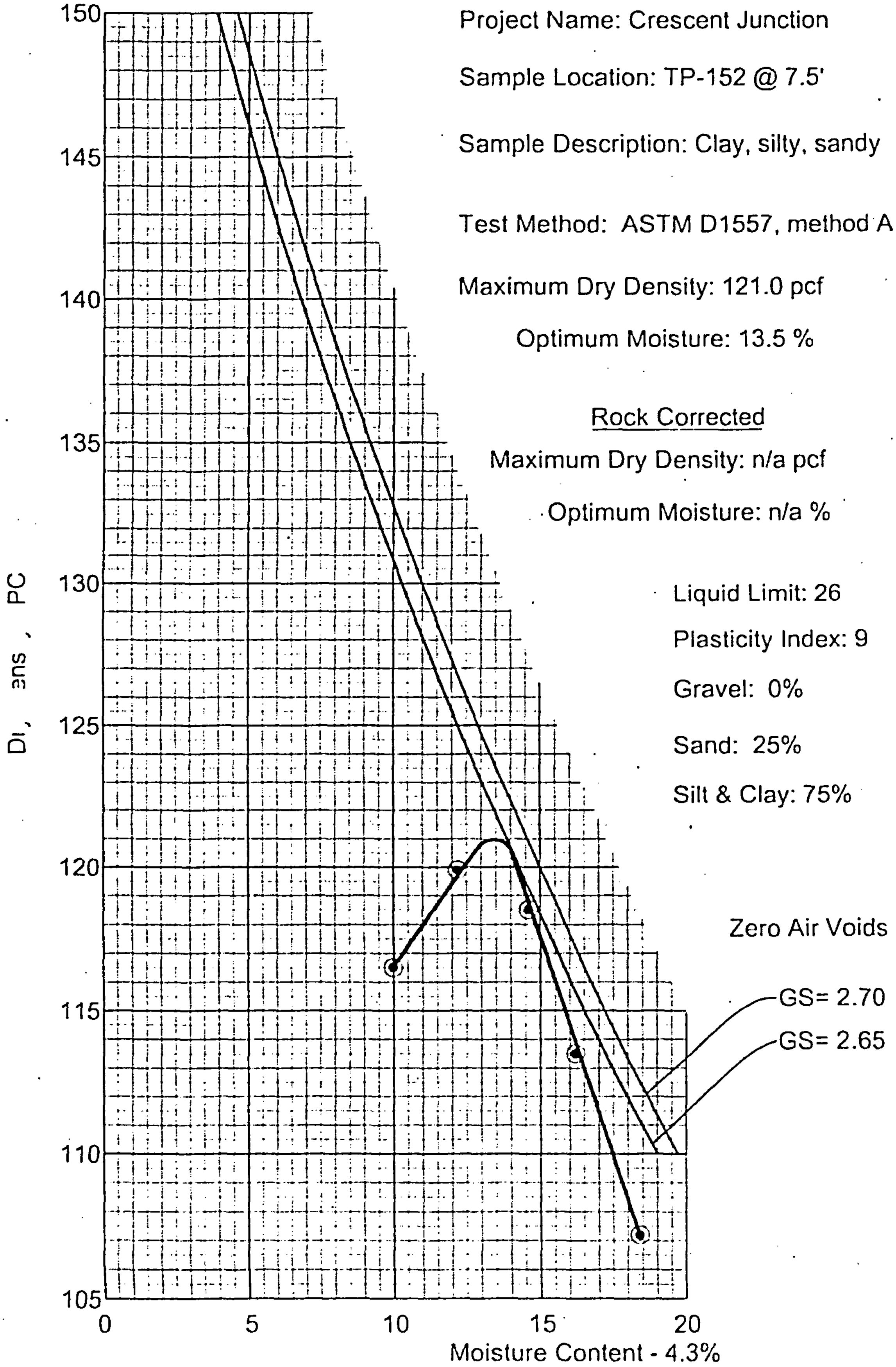
Silt & Clay: 66%



Job No. 2,165

Fig. 1

Geotechnical Engineering Group, Inc.
Moisture- Density Relationship



Project Name: Crescent Junction

Sample Location: TP-152 @ 7.5'

Sample Description: Clay, silty, sandy

Test Method: ASTM D1557, method A

Maximum Dry Density: 121.0 pcf

Optimum Moisture: 13.5 %

Rock Corrected

Maximum Dry Density: n/a pcf

Optimum Moisture: n/a %

Liquid Limit: 26

Plasticity Index: 9

Gravel: 0%

Sand: 25%

Silt & Clay: 75%

Job No. 2,165

Fig. 2

Geotechnical Engineering Group, Inc.
Moisture- Density Relationship

Project Name: Crescent Junction

Sample Location: TP-152 @ 15

Sample Description: Clay, silty, sandy, sandstone

Test Method: ASTM D1557, method A

Maximum Dry Density: 128.0 pcf

Optimum Moisture: 10.5 %

<u>Rock Corrected</u>

Maximum Dry Density: n/a pcf

Optimum Moisture: n/a %

Liquid Limit:

Plasticity Index:

Gravel: 49%

Sand: 22%

Silt & Clay: 29%

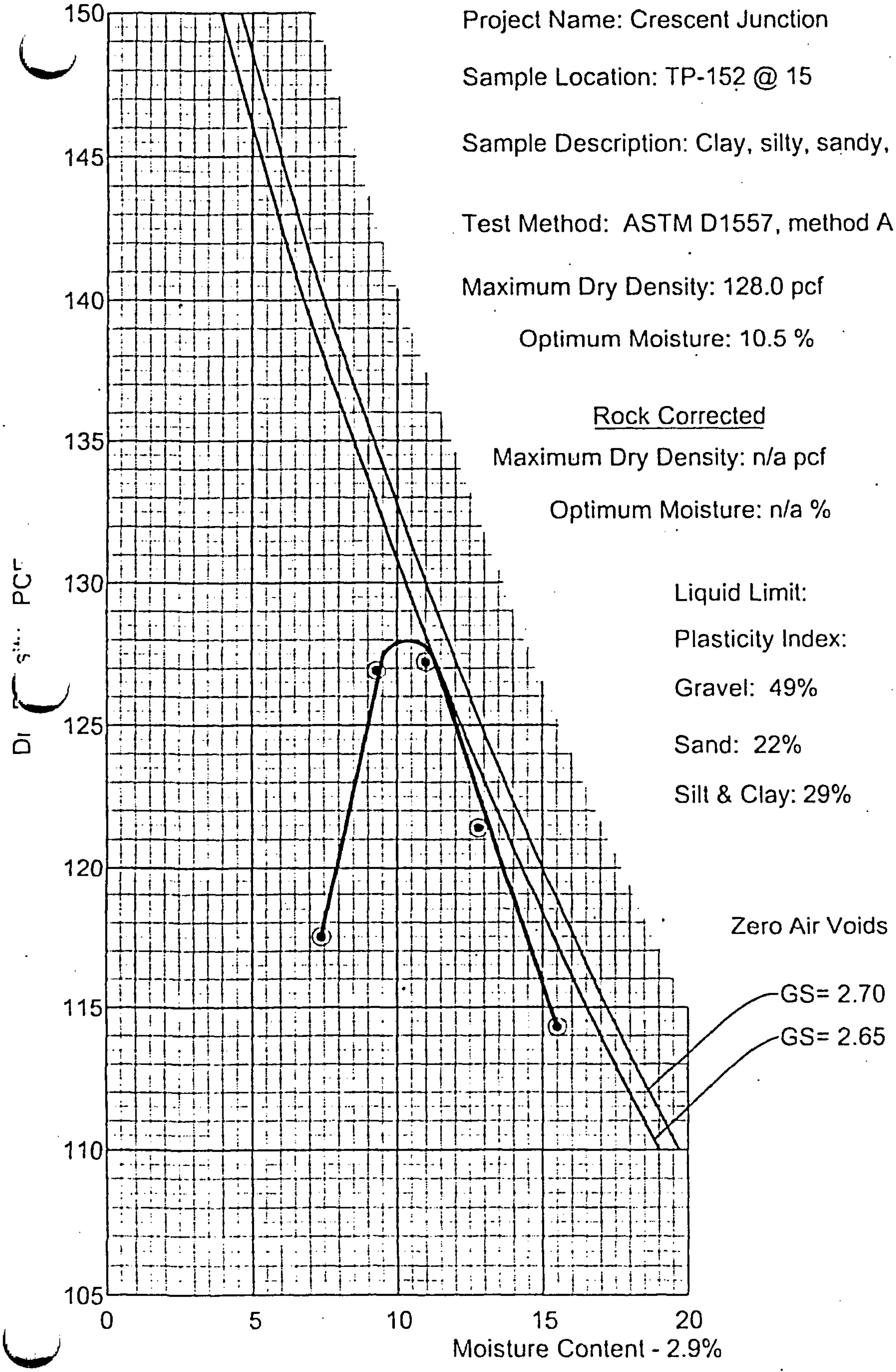


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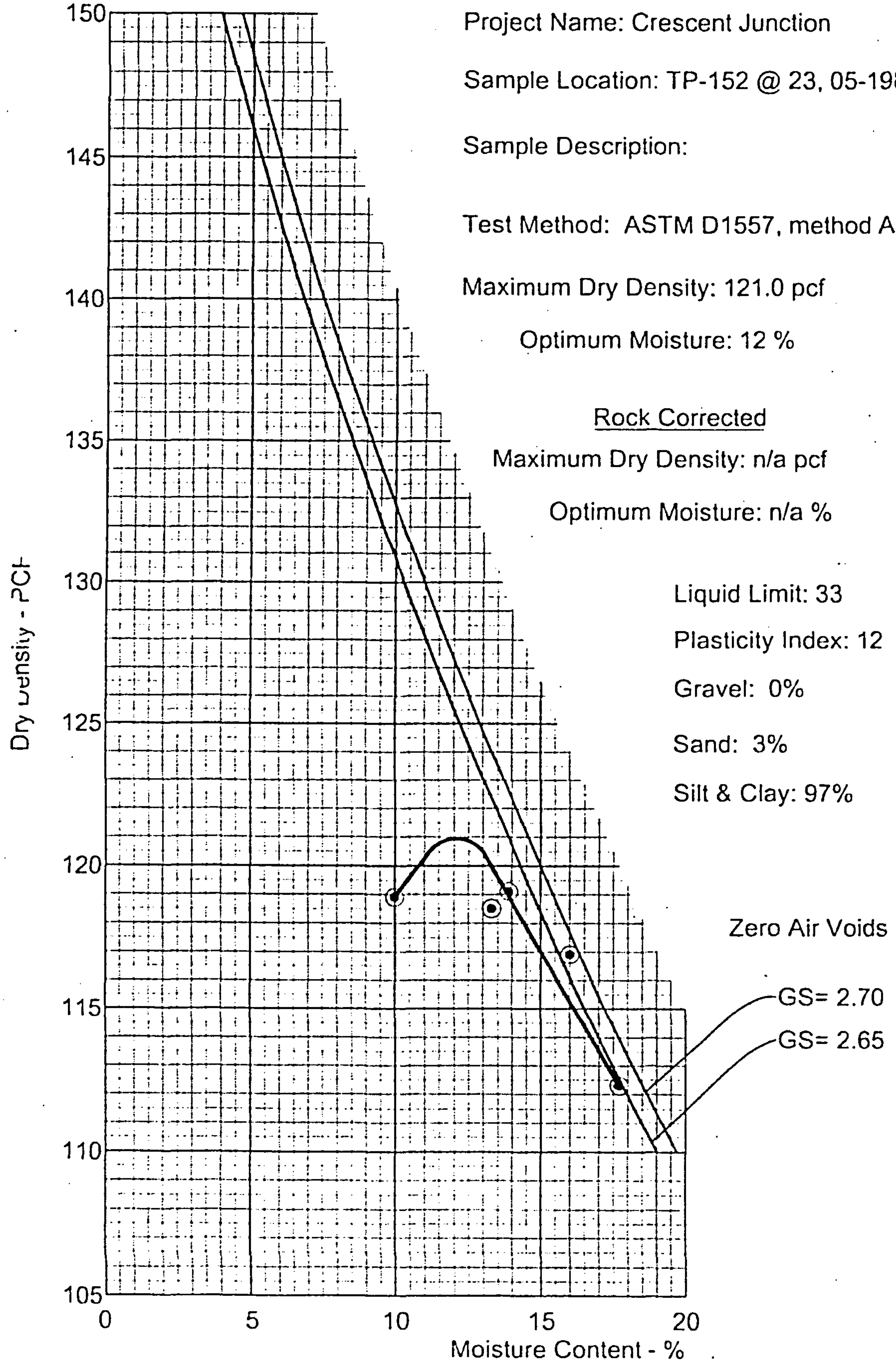
Fig. 3

Geotechnical Engineering Group, Inc.
Moisture- Density Relationship



Project Name: Crescent Junction

Sample Location: TP-152 @ 23, 05-198

Sample Description:

Test Method: ASTM D1557, method A

Maximum Dry Density: 121.0 pcf

Optimum Moisture: 12 %

Rock Corrected

Maximum Dry Density: n/a pcf

Optimum Moisture: n/a %

Liquid Limit: 33

Plasticity Index: 12

Gravel: 0%

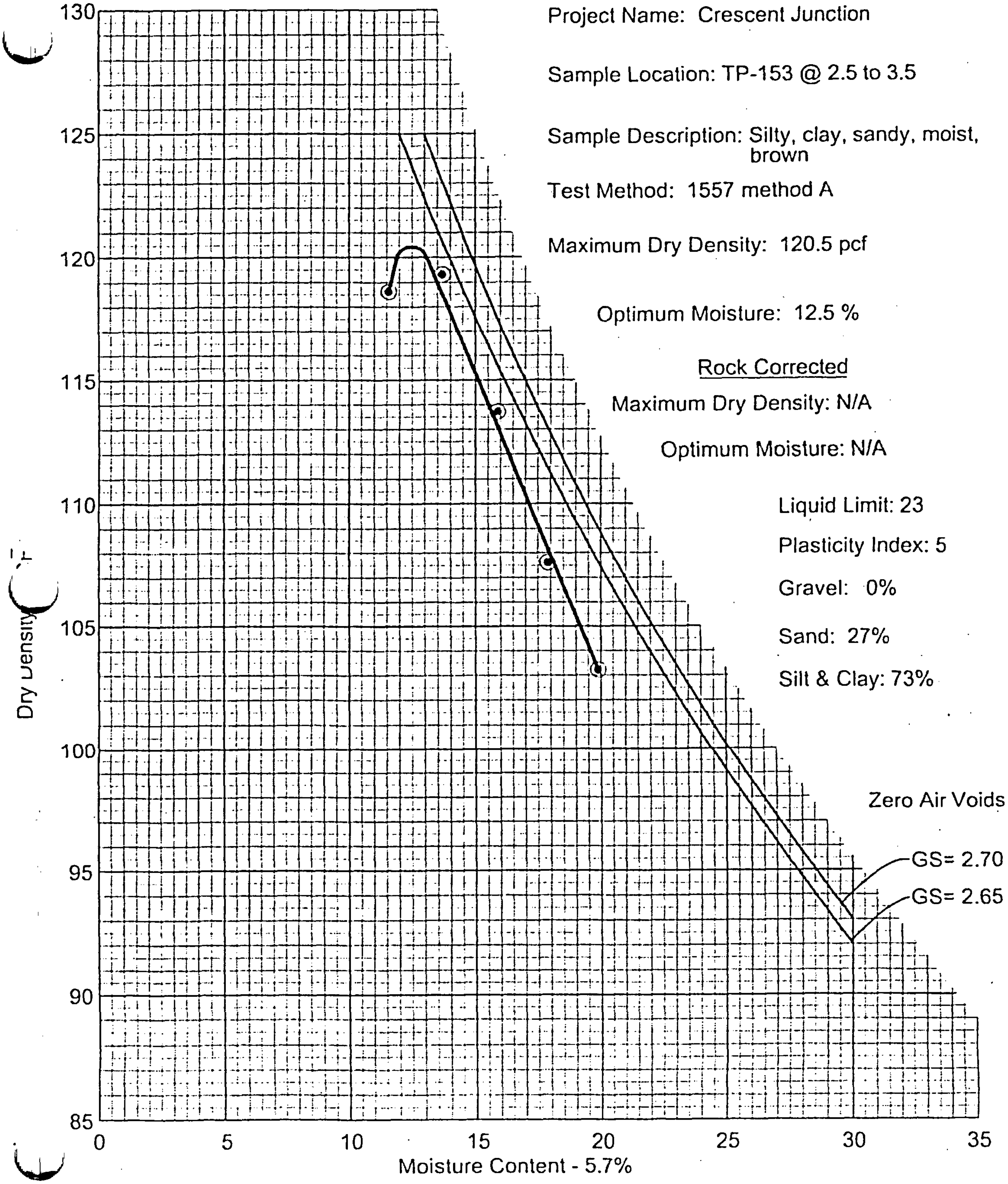
Sand: 3%

Silt & Clay: 97%

Job No. 2,165

Fig. 4

Geotechnical Engineering Group, Inc.
Moisture- Density Relationship



Project Name: Crescent Junction

Sample Location: TP-153 @ 2.5 to 3.5

Sample Description: Silty, clay, sandy, moist, brown

Test Method: 1557 method A

Maximum Dry Density: 120.5 pcf

Optimum Moisture: 12.5 %

Rock Corrected

Maximum Dry Density: N/A

Optimum Moisture: N/A

Liquid Limit: 23

Plasticity Index: 5

Gravel: 0%

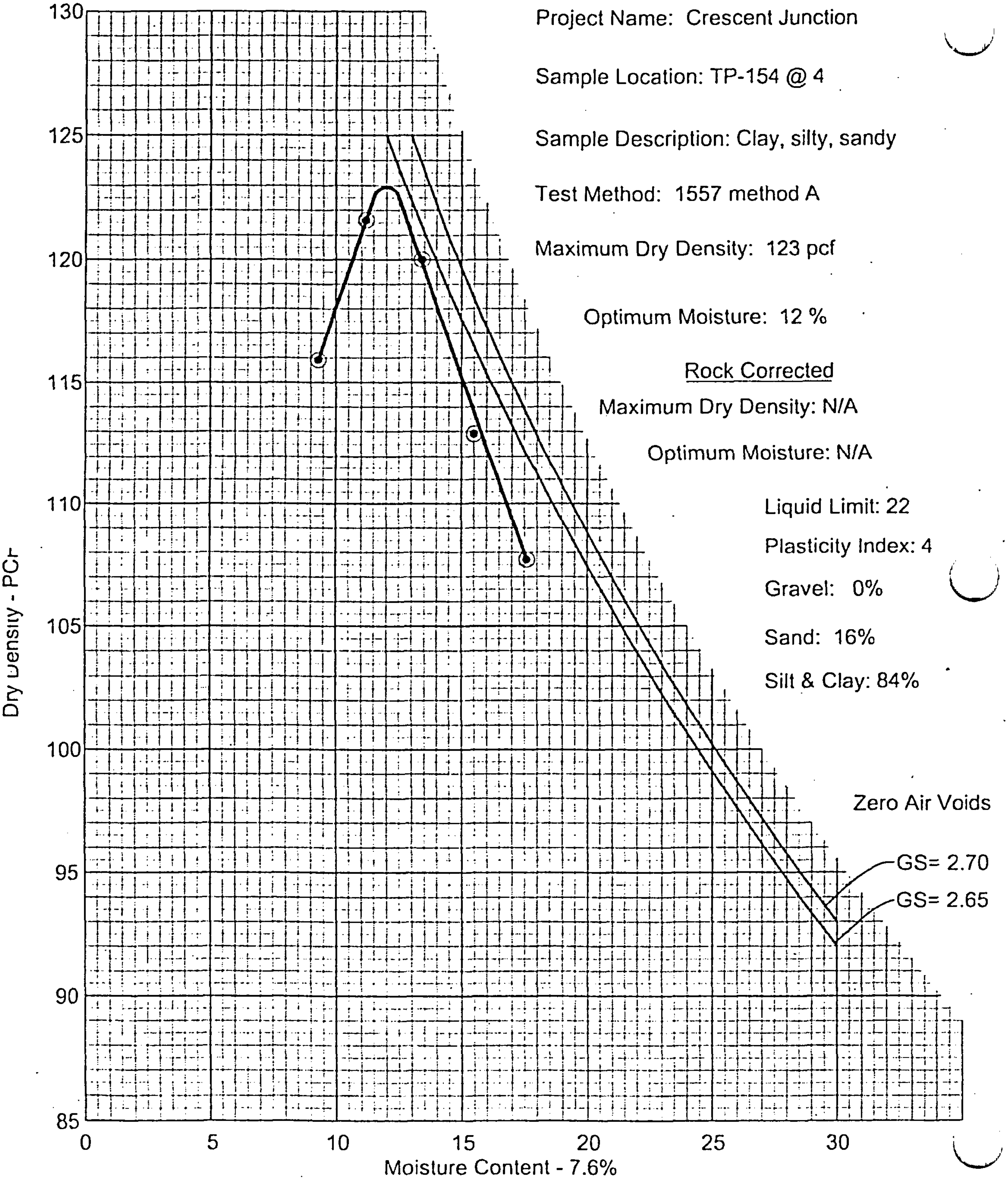
Sand: 27%

Silt & Clay: 73%

Job No. 2,165

Fig. 5

Geotechnical Engineering Group, Inc.
Moisture- Density Relationship



Project Name: Crescent Junction

Sample Location: TP-154 @ 4

Sample Description: Clay, silty, sandy

Test Method: 1557 method A

Maximum Dry Density: 123 pcf

Optimum Moisture: 12 %

Rock Corrected

Maximum Dry Density: N/A

Optimum Moisture: N/A

Liquid Limit: 22

Plasticity Index: 4

Gravel: 0%

Sand: 16%

Silt & Clay: 84%

Job No. 2,165

Fig. 7

Geotechnical Engineering Group, Inc.
Moisture- Density Relationship

Project Name: Crescent Junction

Sample Location: TP-154 @ 12

Sample Description: Silty, clay, sandy, dry, tan

Test Method: ASTM D1557, method A

Maximum Dry Density: 122.5 pcf

Optimum Moisture: 12 %

<u>Rock Corrected</u>

Maximum Dry Density: n/a pcf

Optimum Moisture: n/a %

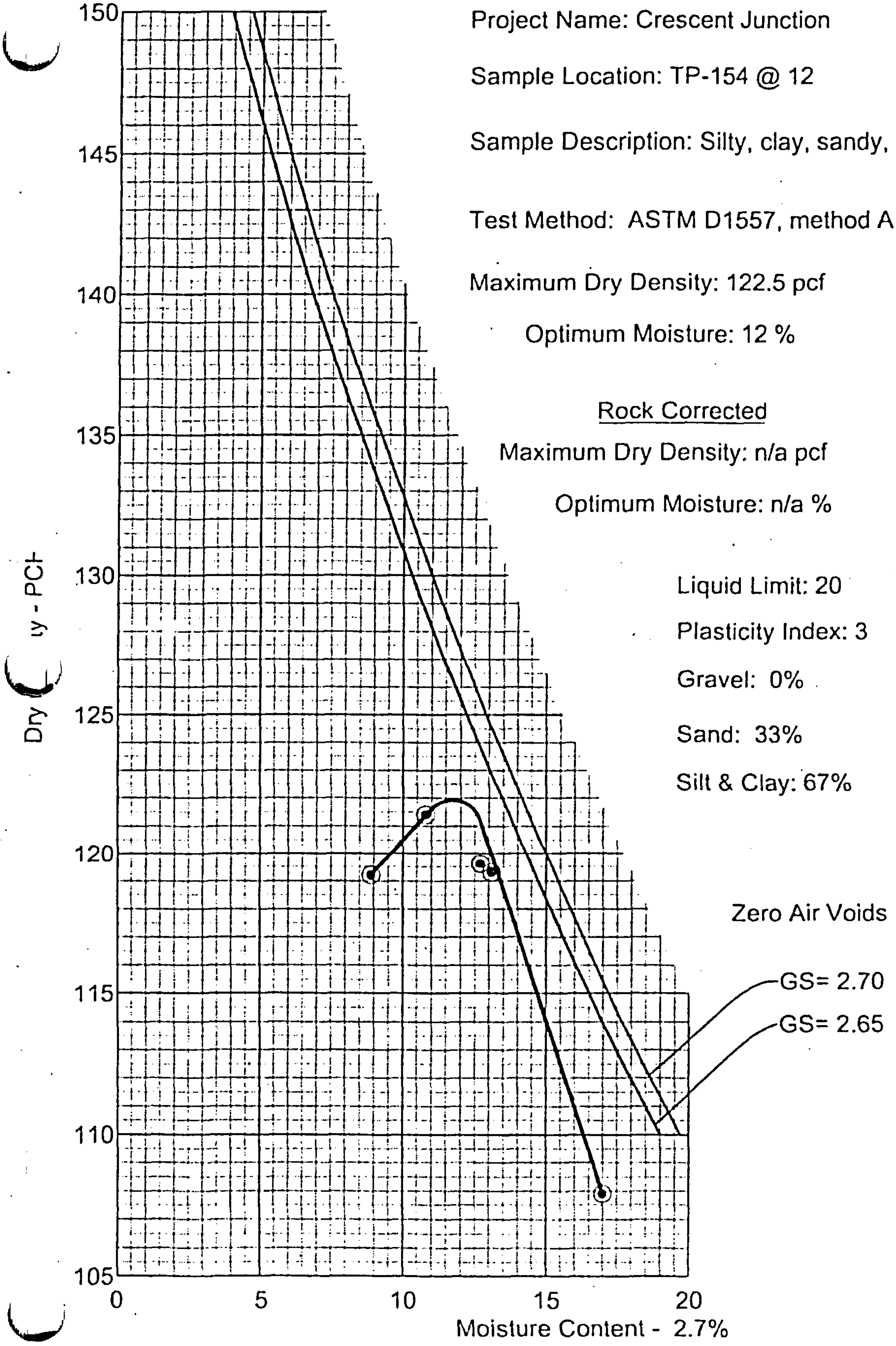
Liquid Limit: 20

Plasticity Index: 3

Gravel: 0%

Sand: 33%

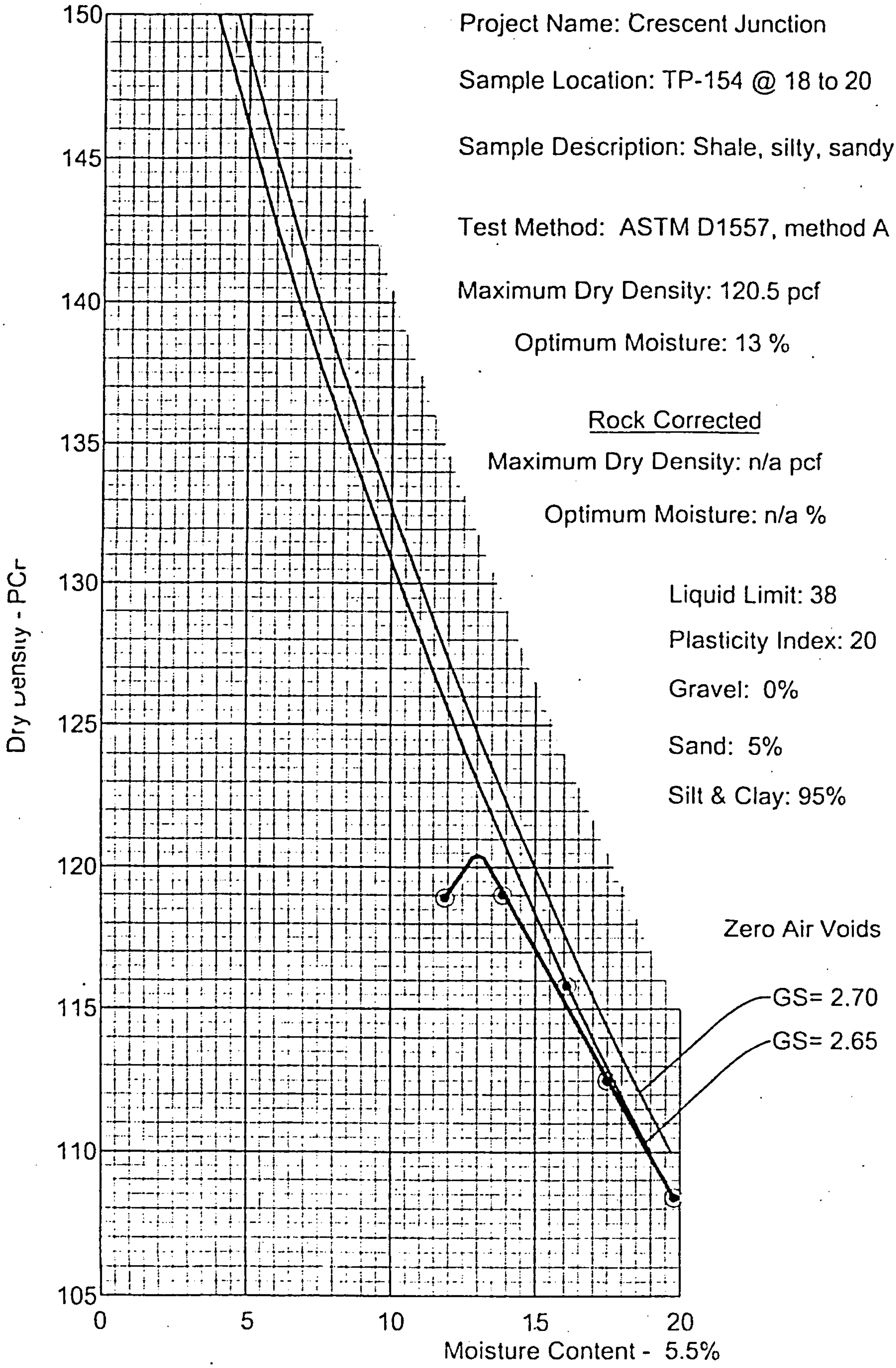
Silt & Clay: 67%



Job No. 2,165

Fig. 8

Geotechnical Engineering Group, Inc.
Moisture- Density Relationship



Project Name: Crescent Junction

Sample Location: TP-154 @ 18 to 20

Sample Description: Shale, silty, sandy, dry, light, tan

Test Method: ASTM D1557, method A

Maximum Dry Density: 120.5 pcf

Optimum Moisture: 13 %

Rock Corrected

Maximum Dry Density: n/a pcf

Optimum Moisture: n/a %

Liquid Limit: 38

Plasticity Index: 20

Gravel: 0%

Sand: 5%

Silt & Clay: 95%

Job No. 2,165

Fig. 9

Geotechnical Engineering Group, Inc.
Moisture- Density Relationship

Project Name: Crescent Junction

Sample Location: TP-15~~5~~6 @ 4 to 5

Sample Description: Silty, clay, sandy, moist, brown

Test Method: ASTM D1557, method A

Maximum Dry Density: 120 pcf

Optimum Moisture: 11.5 %

Rock Corrected

Maximum Dry Density: n/a pcf

Optimum Moisture: n/a %

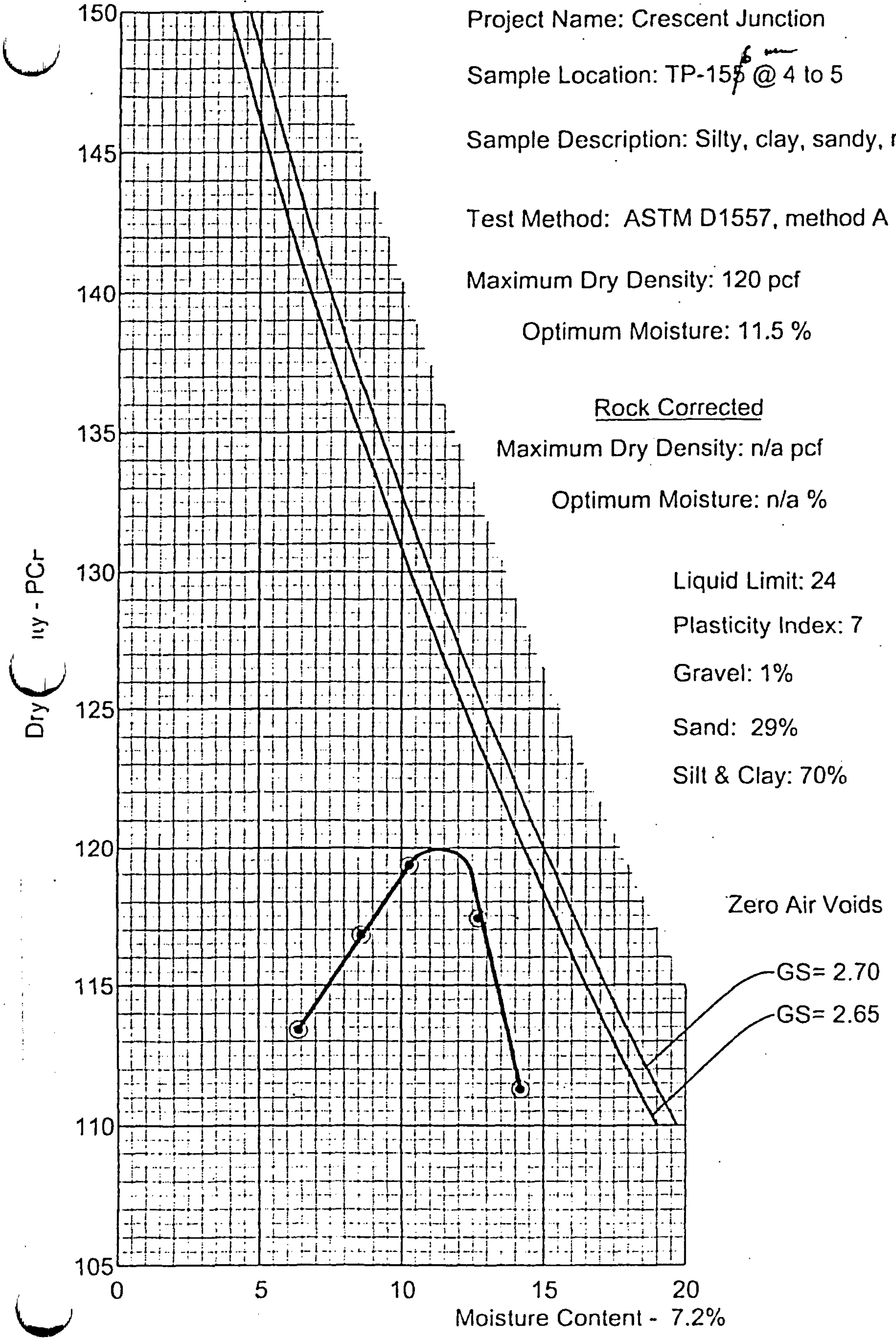
Liquid Limit: 24

Plasticity Index: 7

Gravel: 1%

Sand: 29%

Silt & Clay: 70%



Job No. 2,165

Fig. 10

Geotechnical Engineering Group, Inc.
Moisture- Density Relationship

Project Name: Crescent Junction

Sample Location: TP-156 @ 12

Sample Description: Silty, clay, sandy, moist, tan

Test Method: ASTM D1557, method A

Maximum Dry Density: 124.5 pcf

Optimum Moisture: 11 %

Rock Corrected

Maximum Dry Density: n/a pcf

Optimum Moisture: n/a %

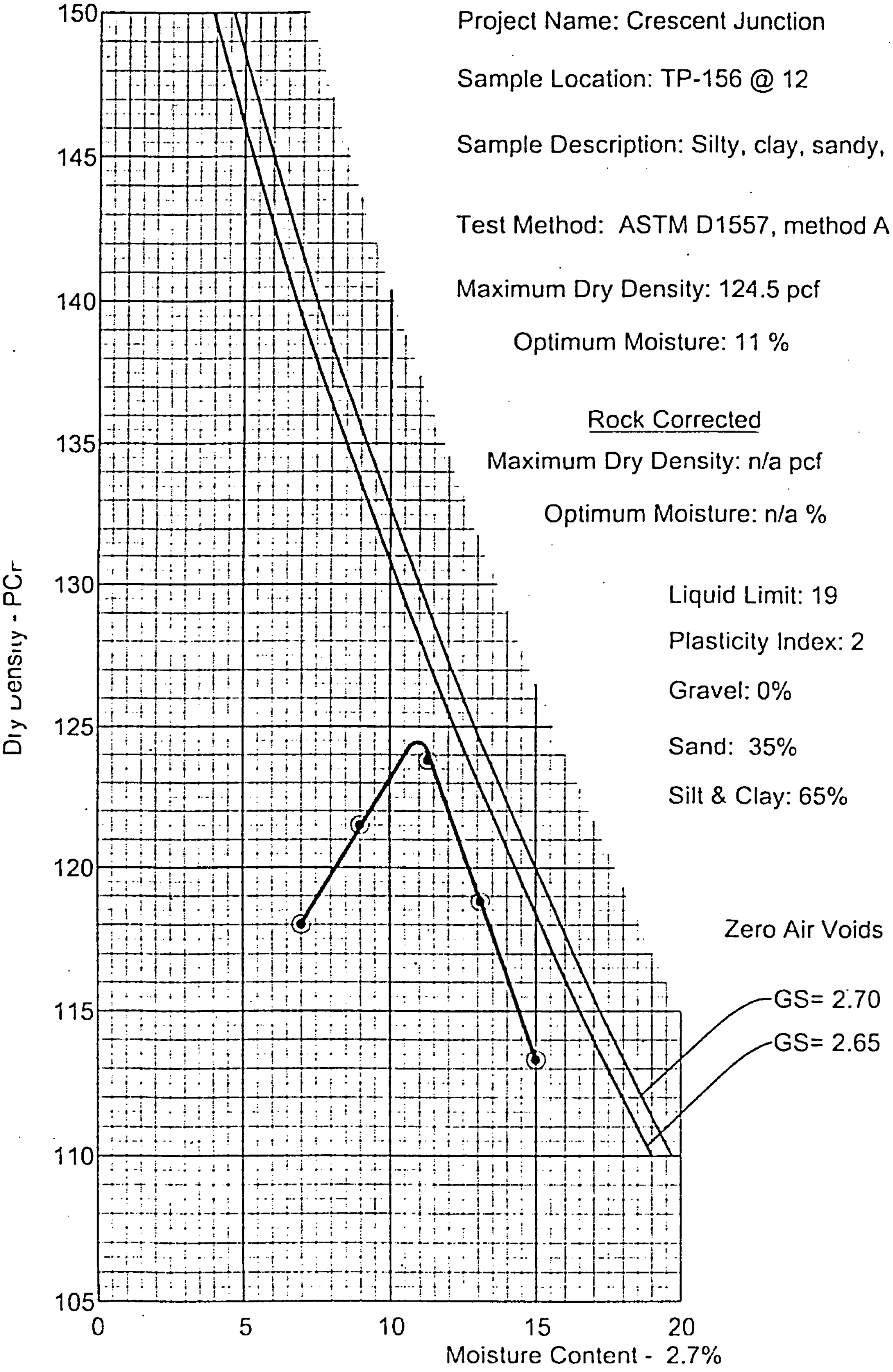
Liquid Limit: 19

Plasticity Index: 2

Gravel: 0%

Sand: 35%

Silt & Clay: 65%



Job No. 2,165

Fig. 11

Geotechnical Engineering Group, Inc.
Moisture- Density Relationship

Project Name: Crescent Junction

Sample Location: TP-156 @ 22

Sample Description:

Test Method: ASTM D1557, method A

Maximum Dry Density: 127.5 pcf

Optimum Moisture: 11 %

Rock Corrected

Maximum Dry Density: n/a pcf

Optimum Moisture: n/a %

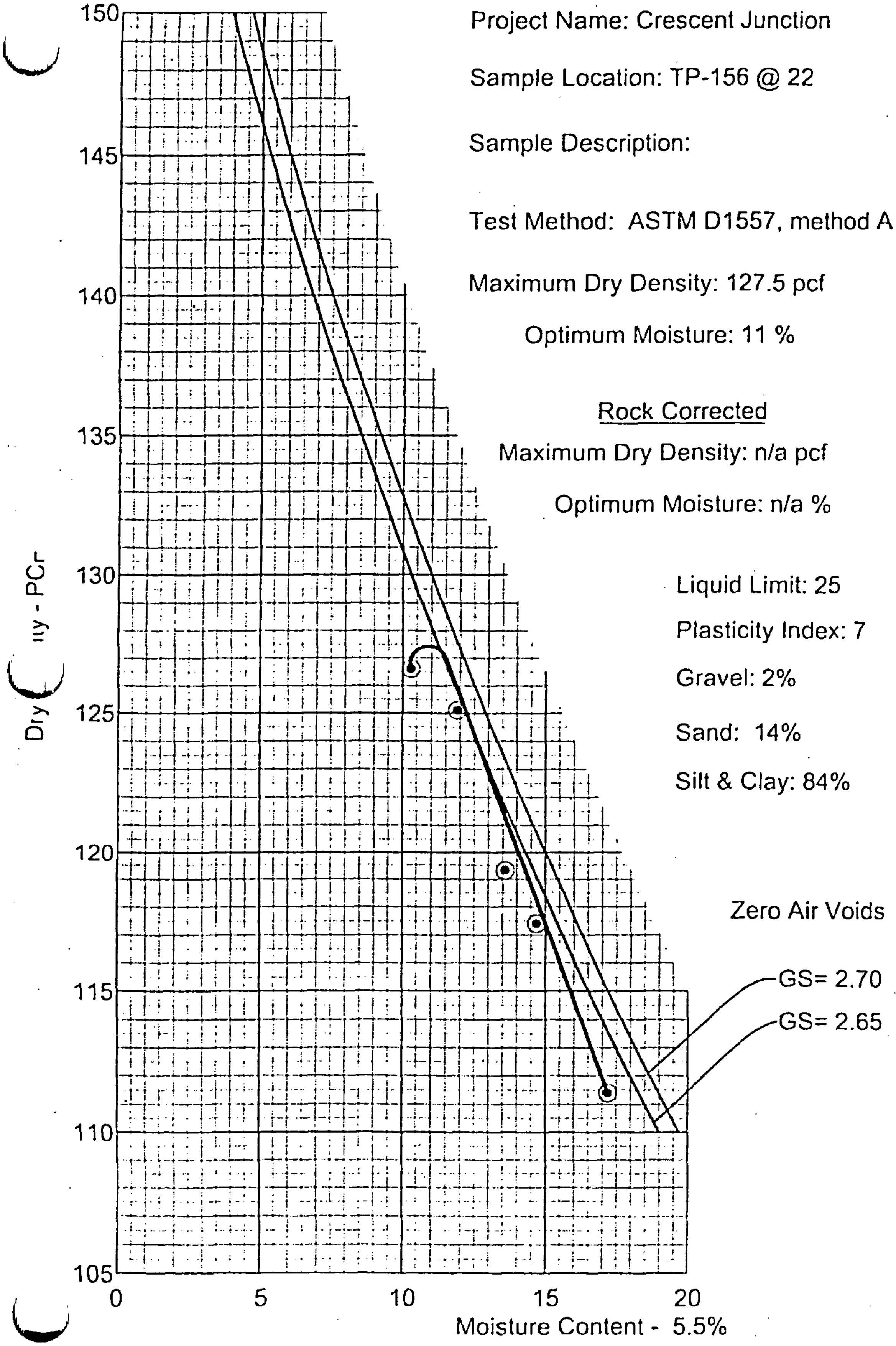
Liquid Limit: 25

Plasticity Index: 7

Gravel: 2%

Sand: 14%

Silt & Clay: 84%



Job No. 2,165

Fig. 12

Appendix C

Geotechnical Testing Results

February 23, 2006

Geotechnical Engineering Group, Inc.

February 23, 2006

S.M Stoller Corporation
2597 B ¾ Road
Grand Junction, CO 81503

Attention: Mr. Rex Sellers
Senior Contract Adviser

Subject: Geotechnical Testing Services
Cresent Junction
Utah Disposal Site
GEG Job No. 2,165

Dear Mr. Sellers,

As requested, Geotechnical Engineering Group, Inc. (GEG) has performed laboratory testing for the subject project. The laboratory tests were performed on samples obtained by others. Laboratory tests performed include moisture content tests, dry density tests, percent passing No. 200 sieve tests and Atterberg limits tests, presented on Table I. Routine Agronomic Analysis laboratory tests performed were determined by Enviro-Chem, presented on Table II.

Moisture Content and Dry Density

Moisture content and dry density were determined for each sample tested. The moisture content was determined according to ASTM Test Method D2216. The dry density of the sample was determined by using the wet weight of the entire sample tested. The results of the moisture and dry density determinations are presented on Table 1.

Percent Passing No. 200 Sieve

Percent passing No. 200 sieve was determined on select samples in general accordance with ASTM Test Method C117. Percent passing No. 200 sieve are presented in Table 1.

Atterberg Limits Tests

Atterberg limits tests were conducted on select samples. Atterberg limits tests were conducted in general accordance with ASTM Test Method D4318. The results of the Atterberg limits tests are presented in Table 1.

We believe the laboratory study was performed and this letter was prepared in a manner consistent with that level of care and skill ordinarily used by geotechnical engineers practicing in this area at this time. No other warranty, either express or implied, is made. When we may be of further service or answer any questions from a geotechnical or construction materials point of view, please call.

Sincerely,
GEOTECHNICAL ENGINEERING GROUP, INC.

Robert W. Anderson
Laboratory Supervisor

RWA:cb
(3 copies sent)

JOB NO. 2,165

Geotechnical Engineering Group, Inc.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

HOLE	DEPTH (FEET)	NATURAL MOISTURE (%)	DRY DENSITY (PCF)	Atterberg Limits		Swell / Consolidation		PASSING NO. 200 SIEVE (%)	WATER SOLUBLE SULFATES (ppm)	SOIL TYPE
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)	SWELL (%)	CONFINING PRESSURE (PSF)			
TH- 7	6.5	6.5	*	23	5					Clay, silty, sandy (CL)
TH- 7	7	4.9	*	23	8			94		Clay, silty, sandy (CL)
TH- 11	11.5	2.6	*	21	4			19		Sand, clayey, gravely
TH- 13	2.5	5.8	89	24	9			70		Clay, silty, sandy (CL)
TH- 23	3.5	6.0	*	25	8			72		Clay, silty, sandy (CL)
TH- 25	6	4.9	89	24	9			59		Clay, silty, sandy (CL)
TH- 26	15.5	5.7	*	24	10			71		Clay, silty, sandy (CL)
TH- 27	4	5.9	*	24	3			44		Sand, clayey, silty (SC)
TH- 31	5.5	7.0	87	25	9			85		Clay, silty, sandy (CL)
TH- 43	6	5.0	93	24	16			47		Sand, clayey, silty (SC)
TH- 45	6.5	8.6	98	32	9			78		Clay, silty, sandy (CL)
TH- 62	4	7.6	103	29	10			69		Clay, silty, sandy (CL)
TH- 64	3.5	10.0	109	31	19			86		Clay, silty sandy (CL)
TH- 79	10.5	4.4	*	25	10			78		Clay, silty, sandy (CL)
TH- 100	4	8.0	*	25	5			69		Clay, silty, sandy (CL)

*- Indicates sample disturbed.

Appendix F

U.S. Department of Energy—Grand Junction, Colorado

Calculation Cover Sheet

Calc. No. MOA-01-05-2006-5-22-00 **Discipline:** Engineering Design **No. of Sheets:** ~~3~~ 4
U.P.

Project: Moab UMTRA Project

Site: Moab, Utah

Feature: Cone Penetration Tests

Sources of Data:

ConeTec, Inc., 2006. *Cone Penetration Test Data – Former Atlas Mill Tailings Impoundment – Moab, Utah, December 14–19, 2005,* prepared by ConeTec, Inc., Salt Lake City, Utah, January.

Sources of Formulae and References:

N/A

Preliminary Calc. ☐ **Final Calc.** ☑ **Supersedes Calc. No.**

Author: Kent. Karp for R. Heydenburg 6-14-06
Name Date

Checked by: Mark Kautz for Greg Lord 6-15-0
Name Date

Gregory M. Smith 6-15-06
Name Date

R H Bird 6/15/06
Name Date

Mark Kautz 6-15-06
Name Date

Approved by: Tom E Elmer 6-15-06
Name Date

Problem Statement:

Preliminary site selection performed jointly by the U.S. Department of Energy (DOE) and the Contractor has identified a 2,300 acre withdrawal area in the Crescent Flat area just northeast of Crescent Junction, Utah, as a possible site for final disposal of the Moab uranium mill tailings. The proposed disposal cell would cover approximately 300 acres. Based on the preliminary site-selection process, the suitability of the Crescent Junction Disposal Site is being evaluated from several technical aspects, including geomorphic, geologic, hydrologic, seismic, geochemical, and geotechnical. The objective of this calculation set is to present the cone penetration test data from the Moab tailings site to provide information relevant to the design of the disposal cell at the Crescent Junction Site.

Findings and conclusions from these data will be incorporated into Attachment 1 of the *Remedial Action Plan and Site Design for Stabilization of Moab Title I Uranium Mill Tailings at the Crescent Junction, Utah, Disposal Site* (RAP), and summarized in appropriate sections of the Remedial Action Selection (RAS) Report for the Moab Site.

Method of Solution:

Cone penetration tests were performed at the Moab Processing Site from December 14–19, 2005, under the direction of Golder Associates personnel. The investigation consisted of 17 soundings at 15 locations with resistivity (except in 0382, 0383, 0386, and 0394) and pore-pressure dissipation measurements (Figure 1). Two soundings at location 0395 met shallow refusal, and the location was adjusted. The pore-pressure dissipation tests were conducted at all locations. All cone penetration testing was carried out in accordance with ASTM D-5778-95. Data were analyzed by ConeTec, Inc. of Salt Lake City, Utah. Data are included in the ConeTec report (Appendix A).

Assumptions:

N/A

Calculation:

N/A

Discussion:

Conclusion and Recommendations:

The cone penetration data collected by ConeTec will be used by Golder Associates Inc. for the following:

- Assisting in development of cross-sections through the existing tailings impoundment providing interpretation between various tailings types (i.e., sands, slimes and transitional tailings) for use in volume calculations.
- Interpreting depth to ground water or perched water layers within the tailings deposits based on porewater pressure measurements.
- Interpreting the undrained shear strength (S_u) of the tailings using measured cone resistance. This will be done by developing a site-specific correlation for CPT data to laboratory measurements of S_u from adjacent tailings samples. The values of S_u will be used in the geotechnical model being developed by Golder.
- Interpreting the over-consolidation ratio and sensitivity of the tailings using CPT data to assist in evaluation of material behavior.

Computer Source:

N/A

References:

See Cover Sheet.

N:\Moa\999\0020\07\011\X01732\X0173200.mxd smithw 5/5/2006 1:27:56 PM

Figure 1. Location of Cone Penetration Tests at the Moab, Utah, Site

Appendix A

Cone Penetration Test Data

Stoller established 1959
Grand Junction Office

Memorandum

Control Number 1000-T06-N/A

DATE: January 26, 2006

TO: Distribution

FROM: M. Kautsky

SUBJECT: Cone Penetration Test Data

Enclosed for your use is a copy of the Cone Penetration Test Data for the Moab UMTRA site, performed under the direction of Golder Associates personnel on December 14-19, 2005. The report contains one set of standard CPT plots, PPD plots, and a data CD. The CD contains the CPT data files (*.cor files) and the PPD data files (*.ppd files). The "cor" and "ppd" files are text files that can be viewed with any text editor or imported into various programs, such as a spreadsheet.

MK/dko

Enclosure

Distribution:
J. Johnson, Golder Assoc.
T. Wright, MFG
G. Lord, Stoller Corp.
Project File - MOA 043.07 (A)

H:\Moab\Transmittal Letters\Kautsky\ConePenetrationTestData.doc

CONE PENETRATION TEST DATA

Former Atlas Mill Tailings Impoundment
Moab, Utah

December 14 - 19, 2005

Prepared for:

S.M. Stoller Corporation
2597 B ¾ Road
Grand Junction, CO 81503

Prepared by:

ConeTec, Inc.
Salt Lake City, Utah

January 23, 2006

CONETEC

CONETEC
ConeTec, Inc.
Geotechnical and Environmental Site Investigation Contractors
3589 West 500 South, Suite 3, Salt Lake City, UT 84104 • PO Box 22082, Salt Lake City, UT 84122
Tel: (801) 973-3801 • Fax: (801) 973-3802 • Web: www.conetec.com • Email: saltlakecity@conetec.com

January 23, 2006

Job No.: 05-432

Mr. Mark Kautsky
S.M. Stoller Corporation
2597 B ¾ Road
Grand Junction, CO 81503

Tel: (970) 248-6556
Fax: (970) 248-7628

Re: CPT Results
Former Atlas Mill Tailings Impoundment
Moab, Utah

Dear Mr. Kautsky,

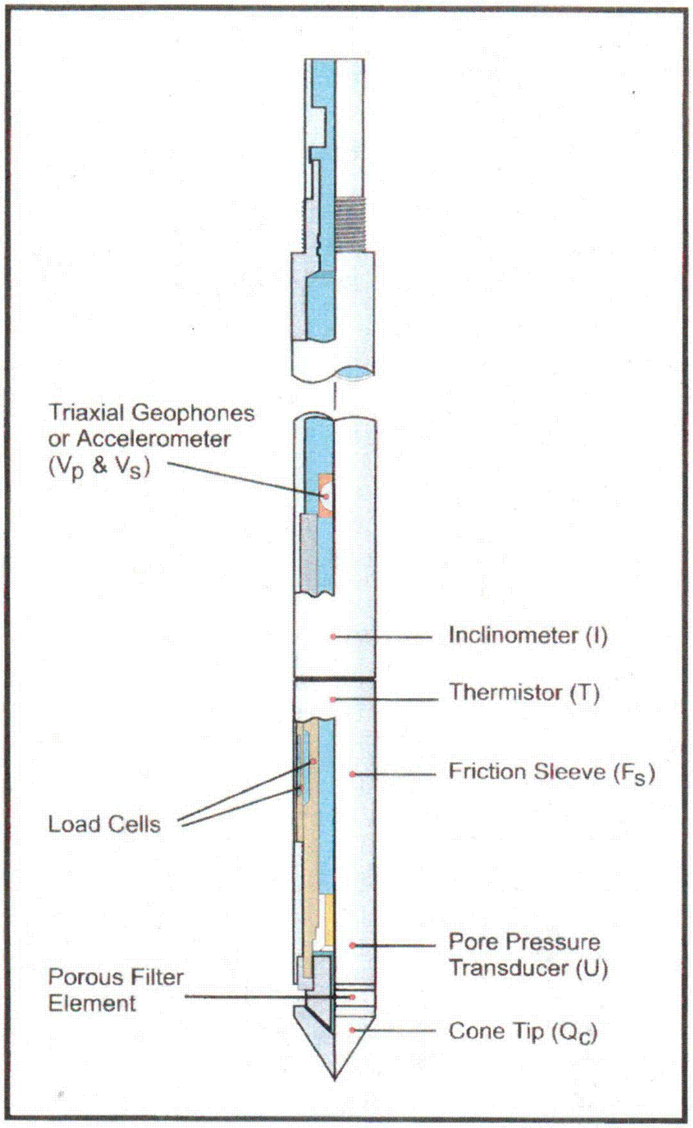
Per your request, we have completed the CPT investigation for the above referenced project. The scope of work consisted of performing fifteen soundings with resistivity and pore pressure measurements. This investigation was conducted as a follow-up to an original investigation completed in the spring of 2000 for SRK Consulting, Inc. The results of that investigation are contained in a report to SRK dated May 12, 2000. This follow-up investigation was performed from December 14-19, 2005, under the direction of Golder Associates personnel.

Enclosed within this report is one set of standard CPT plots, PPD plots and a data CD. The CD contains the CPT data files (*.cor files) and the PPD data files (*.ppd files). The "cor" and "ppd" files are text files that can be viewed with any text editor or imported into various programs, such as a spreadsheet. In addition to the data files, we have included digital copies of the CPT plots and PPD plots in PDF format. The enclosed summary table outlines the work performed at the site.

CONE PENETRATION TESTING

The cone penetration tests (CPTU) with pore pressure measurement were carried out by ConeTec using an integrated electronic cone system. A 20 ton compression type cone, as shown in the following figure, was used for all of the soundings. This cone has a tip area of 15 sq. cm. and a friction sleeve area of 225 sq. cm. The compression cone is designed with an equal end area friction sleeve and a tip end area ratio of 0.85. A porewater pressure filter was located directly behind the cone tip. The filter was made of porous plastic and was 5.0 mm thick. Each of the porewater pressure filters was saturated under vacuum pressure prior to penetration.

CONE PENETRATION TESTING, Continued



The cone was capable of recording the following parameters at varying depth intervals:

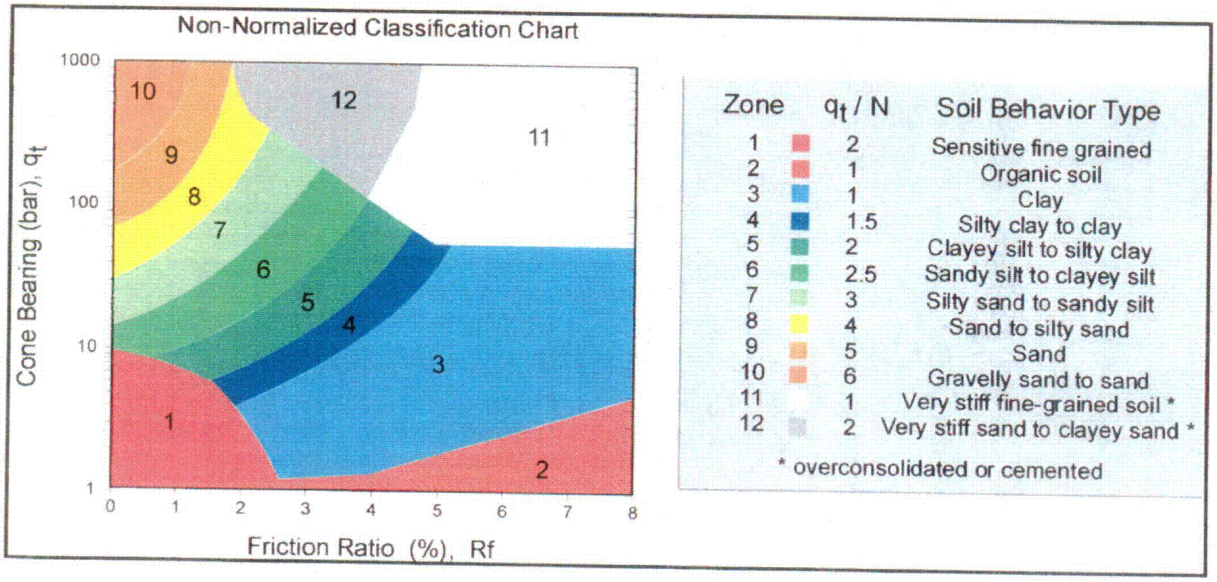
- Tip Resistance (q_c)
- Sleeve Friction (f_s)
- Dynamic Pore Pressure (u)
- Temperature (T)
- Cone Inclination (I)

During advancement of the cone penetrometer, selected parameters were printed simultaneously on a printer and stored on the data acquisition computer for future analysis and reference. All cone penetration testing was carried out in accordance with ASTM D-5778-95.

CONE PENETRATION TESTING, Continued

A complete set of baseline readings was taken prior to and at the completion of each sounding to determine temperature shifts and any zero load offsets. Corrections for temperature shifts and zero load offsets can be extremely important, especially when the recorded loads are relatively small. In sandy soils, however, these corrections are generally negligible.

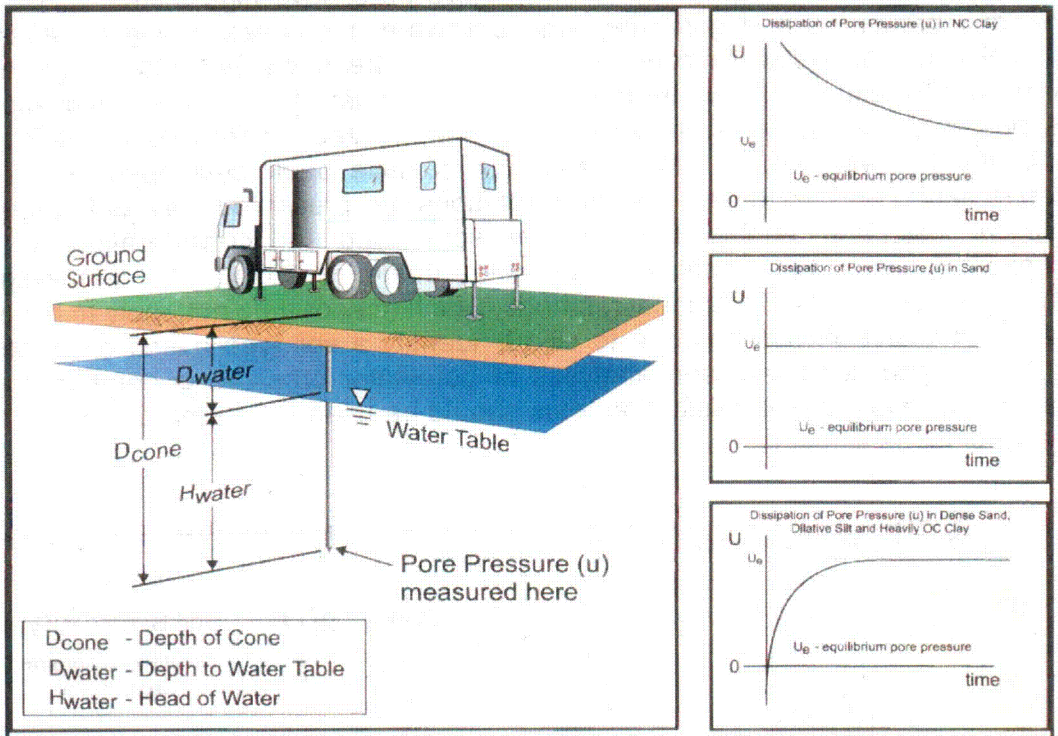
The inferred stratigraphic profile at each CPT test location is included with this report. The stratigraphic interpretations are based on relationships between cone bearing, q_t, sleeve friction, f_s, and dynamic pore pressure, u. The friction ratio, R_f (100 x f_s/q_t), is a calculated parameter which is used to identify the type of soil and hence gives an indication of its behavior. Generally, soft cohesive soils have high friction ratios, low cone bearing pressures and generate large porewater pressures during penetration. Cohesionless soils have lower friction ratios, high cone bearing pressures and generate little in the way of excess porewater pressure during penetration. The classification of soils is based on non-normalized correlations summarized by Robertson (1990), as shown in the following figure. Many correlations have been developed for design parameters based on CPT data. The interpretations are presented only as a guide for geotechnical use and should be carefully scrutinized for consideration in any geotechnical design. Assumptions have been made regarding soil unit weights, groundwater level and interpretational methods, which may or may not apply to this site. Additionally, it is not always possible to clearly identify a soil type based on q_t and f_s alone. Experience, judgment and analyses of porewater pressure generation during penetration and subsequent dissipation tests should be used in arriving at the soil type in these ambiguous situations.



PORE PRESSURE DISSIPATION TESTING

The pore pressure dissipation tests were performed at depths as directed by Golder personnel. Pore pressure dissipation data is automatically recorded during pauses in penetration and is recorded at 5-second intervals. Plots of pore pressure dissipation tests are presented in the appendices. Additionally, the summary table describes the location, depth, equilibrium pore pressure and the duration of each of the dissipation test.

Additionally, static pore pressure measurements were determined by simply pausing during penetration, releasing the load from the push rods and allowing the dynamic pore pressures to come to an equilibrium value, as shown in the following figure.



Water Table Calculation

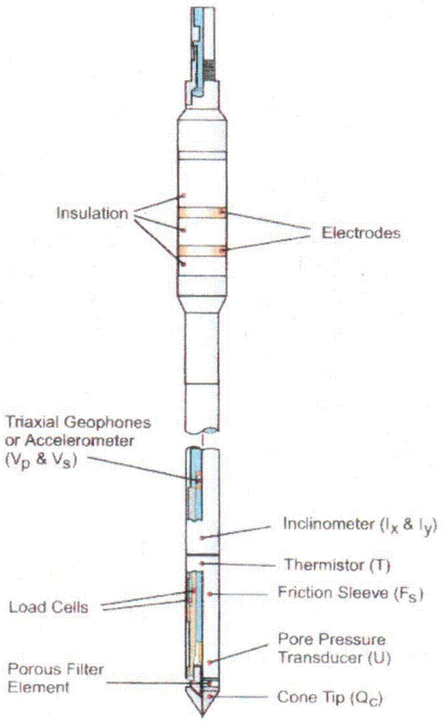
$$D_{water} = D_{cone} - H_{water}$$

where $H_{water} = U_e$ (depth units)

Useful Conversion Factors:
1psi = 0.704m = 2.31 feet (water)
1tsf = 0.958 bar = 13.9 psi
1m = 3.28 feet

RESISTIVITY CONE PENETRATION TEST

The resistivity cone used for this study combines a piezo cone with a resitivity module, as shown in the following figure. The resistivity cone penetration test works on the principle that the measured voltage drop across the electrodes in the soil, at a given excitation current, is proportional to the electrical resistivity of the soil. The stainless steel resistivity electrode is 6 mm in diameter. It is designed to be reasonably wear resistant and have high electrical conductivity. This small electrode provides excellent vertical resolution of resistivity changes. The insulator separating the electrode from the cone is made of Delrin plastic. The probe operates by applying a sinusoidal 1000 Hz current across the electrodes. From the resultant potential difference between the electrodes a resistance is determined. The current is regulated by a downhole microprocessor that adjusts the current when the resistivity changes appreciably to ensure a linear response to the soil. This enables resistivity measurements between 0 and 15,000 ohm-m to be made with an accuracy of +/- 0.2% of full scale. A 1000 Hz source is used to avoid polarization of the electrode. Polarization is the process where ions accumulate at the electrodes thus increasing the measured resistance. This frequency also falls within the range (25 – 3000 Hz) suggested by the ASTM (D1125-82) standard for water conductivity measurements.



RESISTIVITY CONE PENETRATION TEST, Continued

Resistance is not a material property but a function of the electrode spacing and size. To convert from resistance to resistivity, which is a material property, a lab calibration is necessary. The resistivity module was calibrated in a water tank. Solutions of known resistivity were prepared in the tank and the resistance across the electrodes was measured. On the basis of the calibration it was found that resistivity was linearly related to resistance. It is necessary to assume that the calibration factor when the cone is advanced through soil will not vary considerably from that determined in a homogeneous isotropic medium. The resistivity of the soil is for the most part influenced by the resistivity of the pore fluid, which in turn is a measure of the groundwater chemical composition. Electrical conduction in saturated soils is largely by electrolytic conduction in the pore fluid although ion exchange within the soil skeleton contributes significantly in clayey soils. The resistivity cone testing procedures used in this study were no different than for a standard piezocone test. No special preparation of the module was necessary and no manual adjustments are needed during the sounding. The resistivity measurements were carried out and recorded on a continuous basis at the same time as the tip, friction and pore pressure measurements.

CLOSURE

We appreciate the opportunity of providing these services to you. If you have any questions regarding the enclosed material or if, we can be of additional assistance, please contact us.

Sincerely,

ConeTec, Inc.

Shawn D. Steiner, P.E.
Manager

Enclosures

ConeTec, Inc. • Salt Lake City
Job No: 05-432
Client: S.M. Stoller
Project: Former Atlas Mill Tailings Impoundment

CPT Sounding and Pore Pressure Dissipation Summary

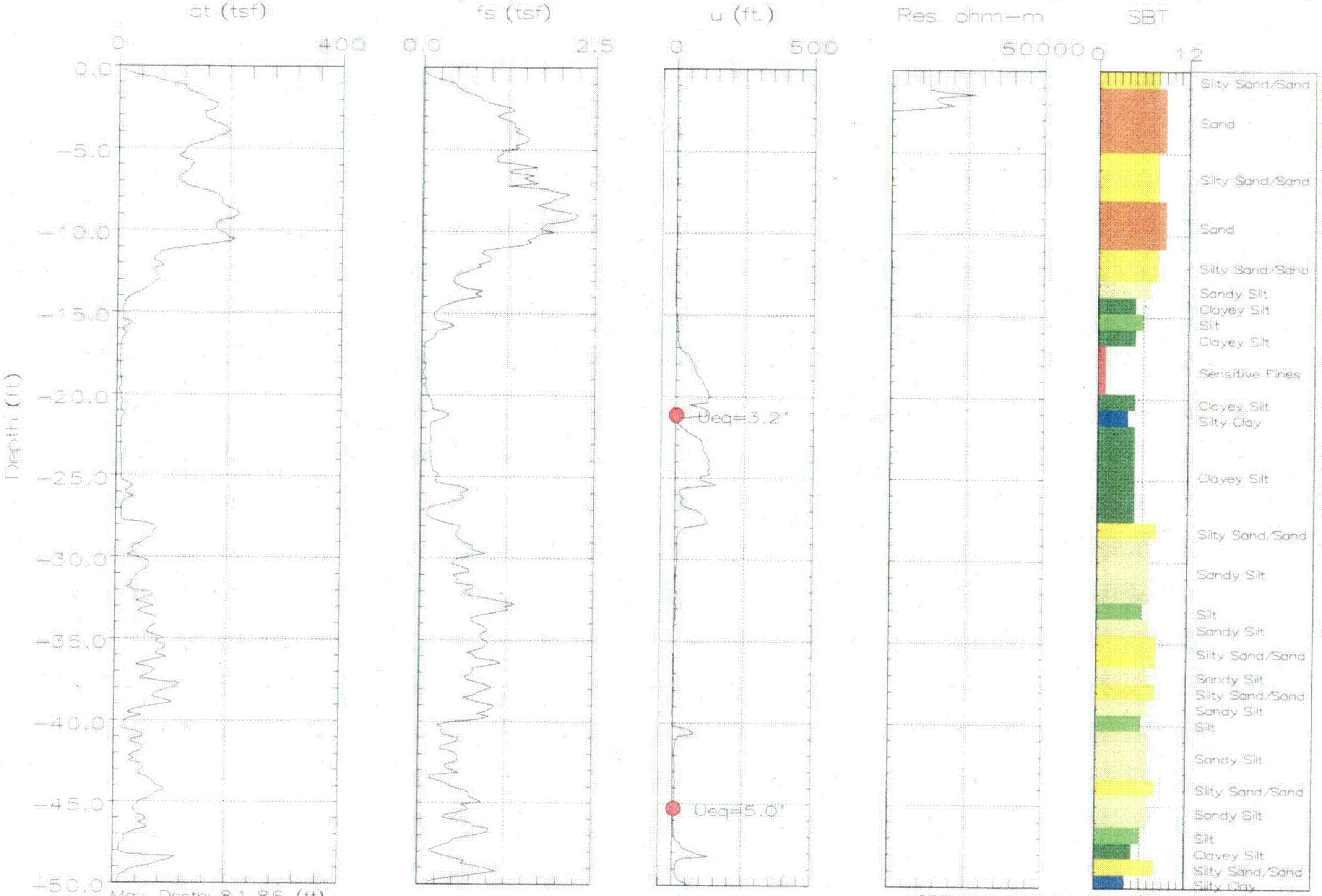
CPT Date	Hole No.	Filename	Sounding Depth (ft)	Dissipation Depth (ft)	Dissipation Time (sec)	Ueq (ft)	Comments
12/15/05	CPT-0381	432CP81	81.86	21.16	300	3.2	Refusal
				45.28	400	5.0	
				66.44	3000	12.5	
12/14/05	CPT-0382	432CP82	80.22	30.51	600	5.0	
				56.43	12000	~14.5	
				72.34	2000	41.0	
12/14/05	CPT-0383	432CP83	76.61	15.58	600	1.1	
				36.25	500	8.5	
				56.76	300	14.6	
12/17/05	CPT-0384	432CP84	66.60	10.17	405	~0.0	Refusal
				18.37	750	0.0	
				41.01	1805	17.5	
12/17/05	CPT-0385	432CP85	61.02	9.35	1500	3.6	
				54.46	4500	6.1	
				59.71	325	~0.0	
12/14/05	CPT-0386	432CP86	65.62	16.08	250	0.0	Refusal
				34.94	200	9.0	
				65.29	500	6.6	
12/16/05	CPT-0387	432CP87	61.35	58.40	9000	46.0	Refusal
12/17/05	CPT-0388	432CP88	54.63	10.33	400	7.4	
				52.99	300	7.7	
12/17/05	CPT-0389	432CP89	61.19	11.81	805	~0.0	Refusal
				54.63	6000	16.5	
				59.55	750	9.0	
12/18/05	CPT-0390	432CP90	59.87	13.12	1010	4.8	
				31.81	5600	15.0	
				50.36	1500	0.5	
12/15/05	CPT-0391	432CP91	69.55	19.85	2000	~0.0	
				52.66	2000	0.8	
				60.04	300	~0.0	
12/15/05	CPT-0392	432CP92	36.58	10.01	305	~0.0	
				20.51	3915	5.2	
				30.02	400	~0.0	
12/15/05	CPT-0393	432CP93	37.24	9.51	1800	3.3	Refusal
				20.01	1200	~0.0	
				30.02	800	~0.0	
12/16/05	CPT-0394	432CP94	42.81	10.01	1000	0.5	
				19.85	1205	0.4	
				30.02	1305	1.1	
12/16/05	CPT-0395A	432CP95A	10.99				Refusal
12/16/05	CPT-0395B	432CP95B	10.66				Refusal
12/16/05	CPT-0395 Toe	432CP95C	50.03	20.67	300	9.3	
				30.02	1000	1.3	
				40.03	1200	1.3	

CPT Plots

S.M. Stoller

Hole No.:CPT-0381
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 08:12



Max. Depth: 81.86 (ft)
Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

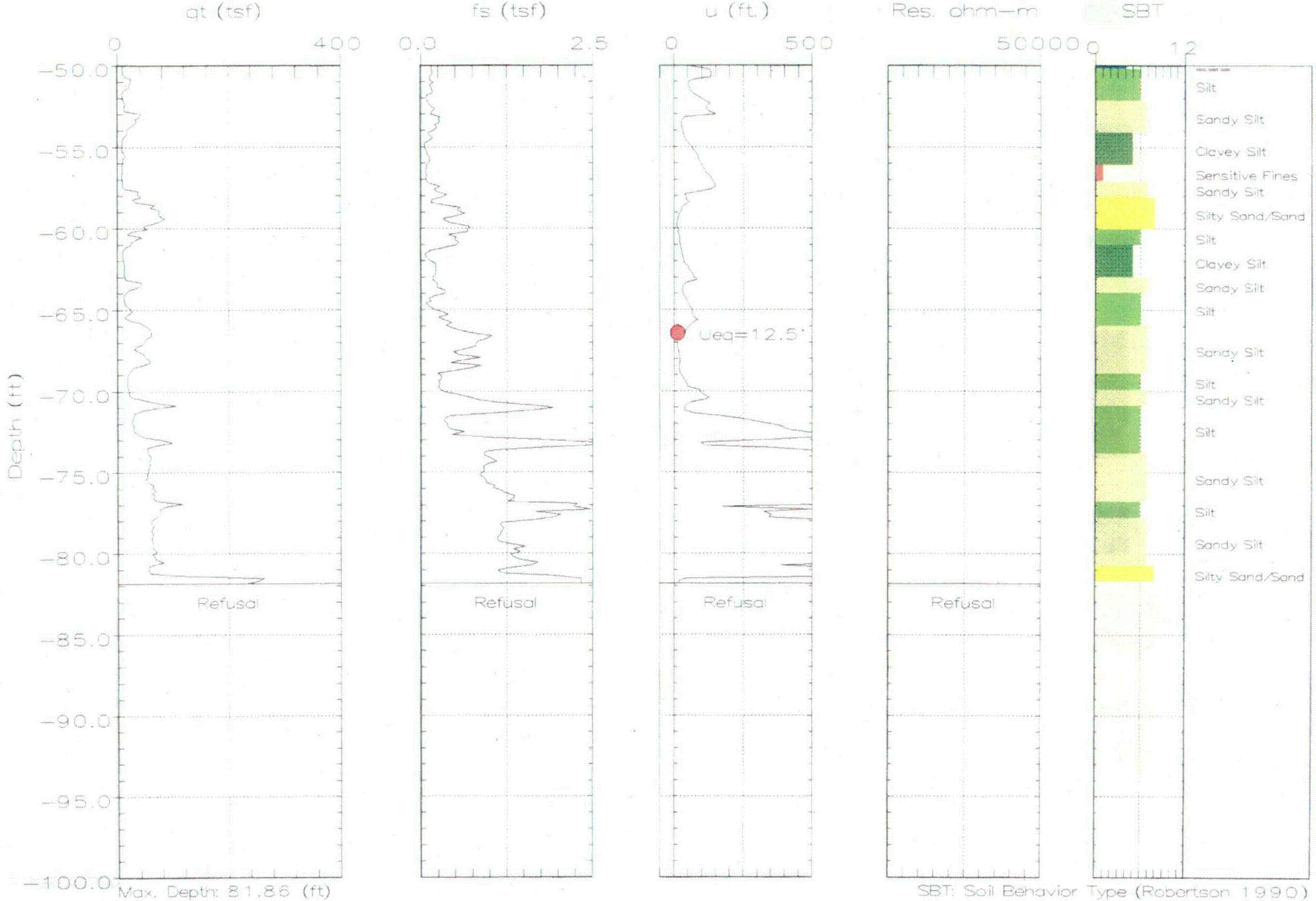
● Equilibrium Pore Pressure from Dissipation

CONETEC

S.M. Stoller

Hole No.:CPT-0381
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 08:12



Max. Depth: 81.86 (ft)

Depth Inc.: 0.164 (ft)

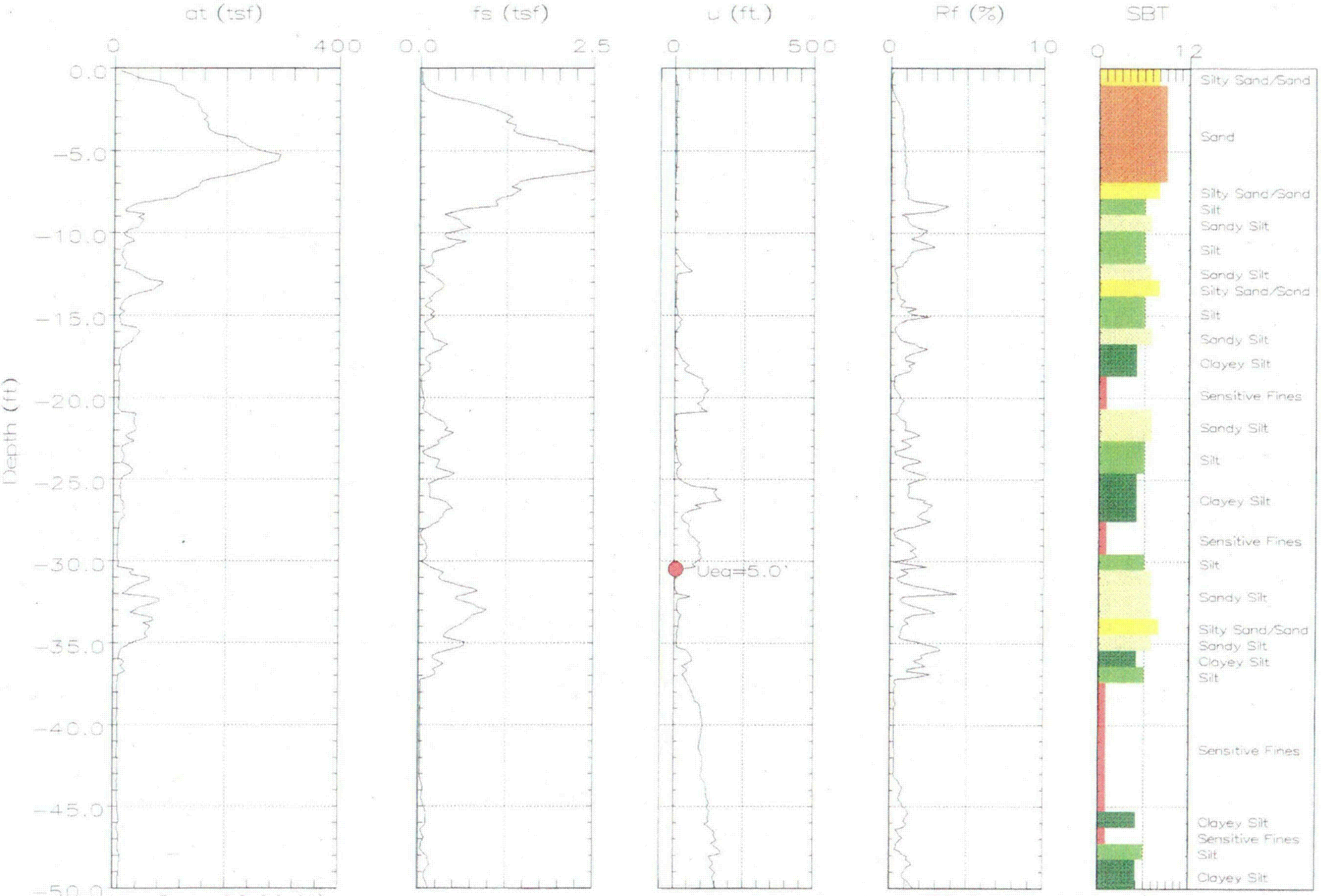
SBT: Soil Behavior Type (Robertson 1990)

● Equilibrium Pore Pressure from Dissipation

S.M. Stoller

Hole No.:CPT-0382
Location:ATLAS

Cone: 20 Ton St 183
Date:12:14:05 09:43



Max. Depth: 80.22 (ft)
Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

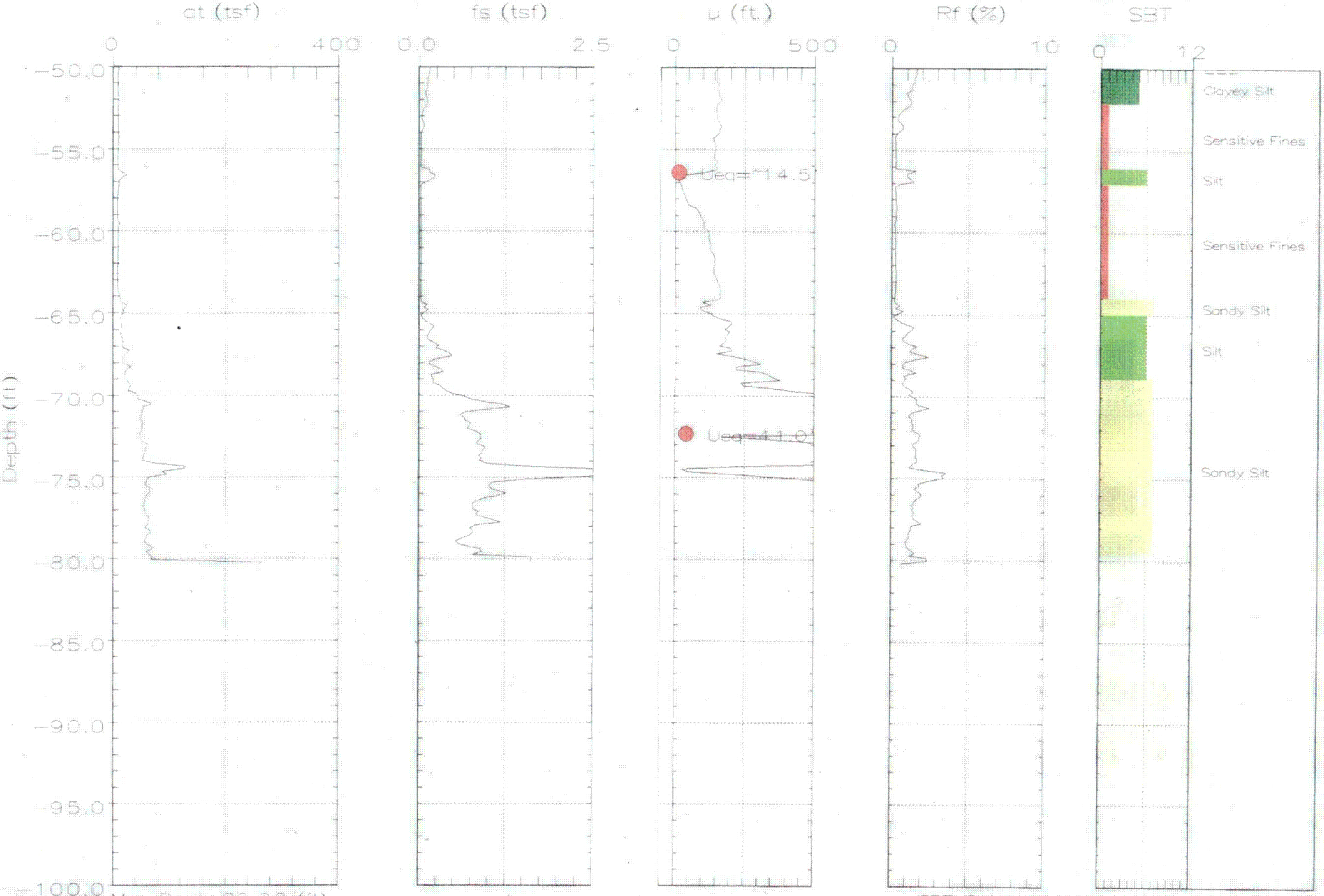
● Equilibrium Pore Pressure from Dissipation

CONETEC

S.M. Stoller

Hole No.:CPT-0382
Location:ATLAS

Cone: 20 Ton St 183
Date:12:14:05 09:43



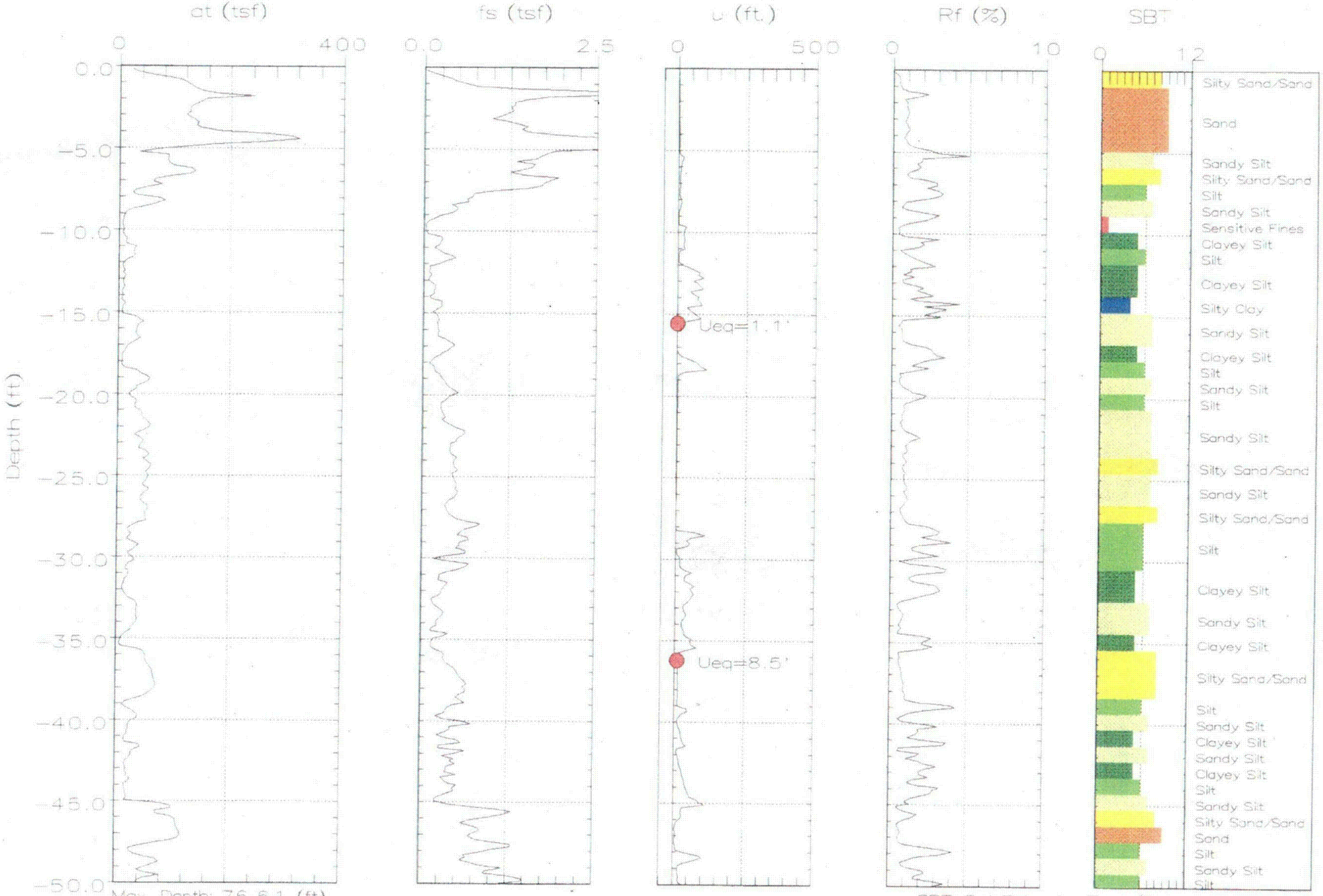
Max. Depth: 80.22 (ft)
Depth inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)
● Equilibrium Pore Pressure from Dissipation

S.M. Stoller

Hole No.:CPT-0383
Location:ATLAS

Cone: 20 Ton St 183
Date:12:14:05 08:16



Max. Depth: 76.61 (ft)

Depth Inc.: 0.164 (ft)

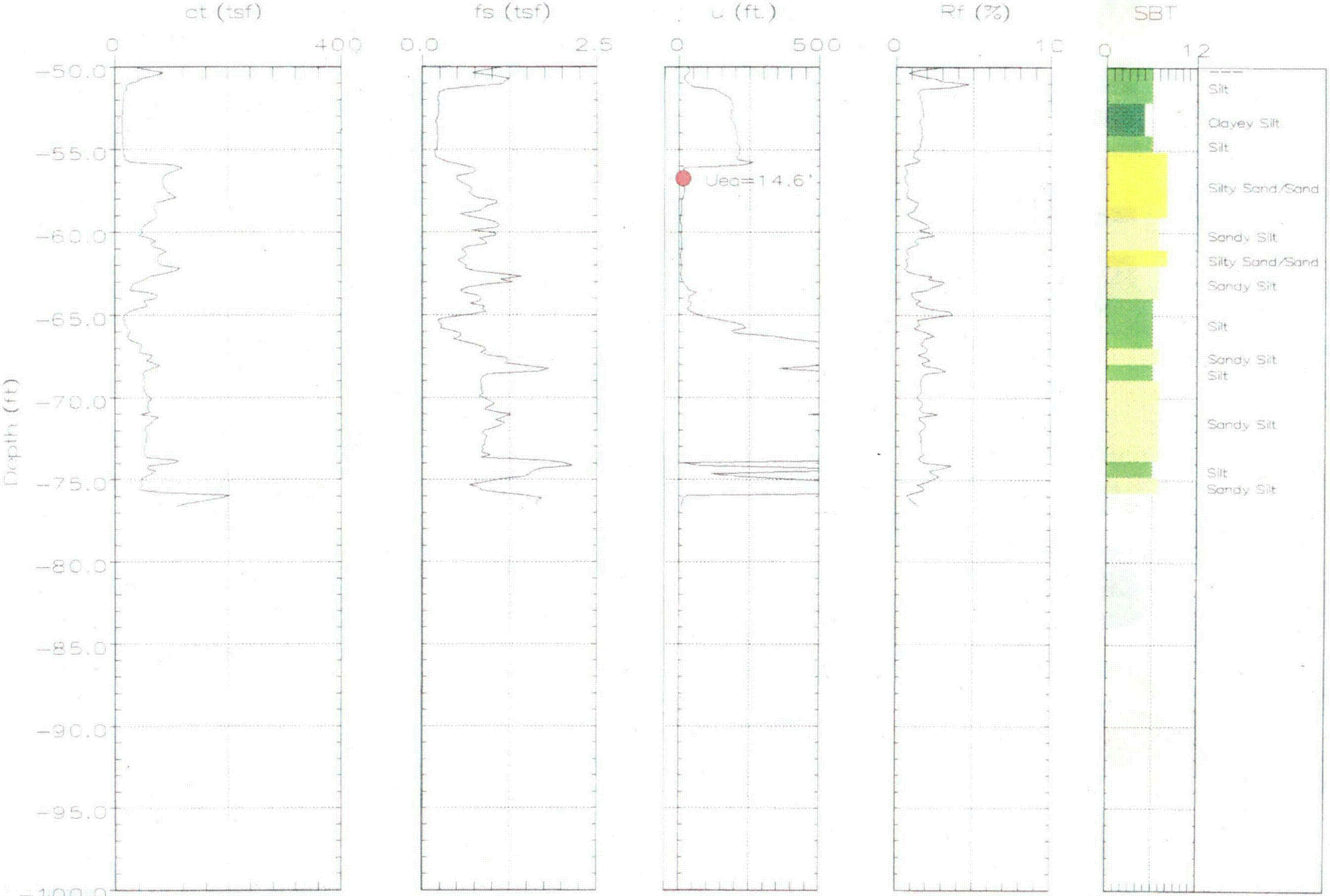
SBT: Soil Behavior Type (Robertson 1990)

● Equilibrium Pore Pressure from Dissipation

S.M. Stoller

Hole No.:CPT-0383
Location:ATLAS

Cone: 20 Ton St 183
Date:12:14:05 08:16



Max. Depth: 76.61 (ft)
Depth Inc.: 0.164 (ft)

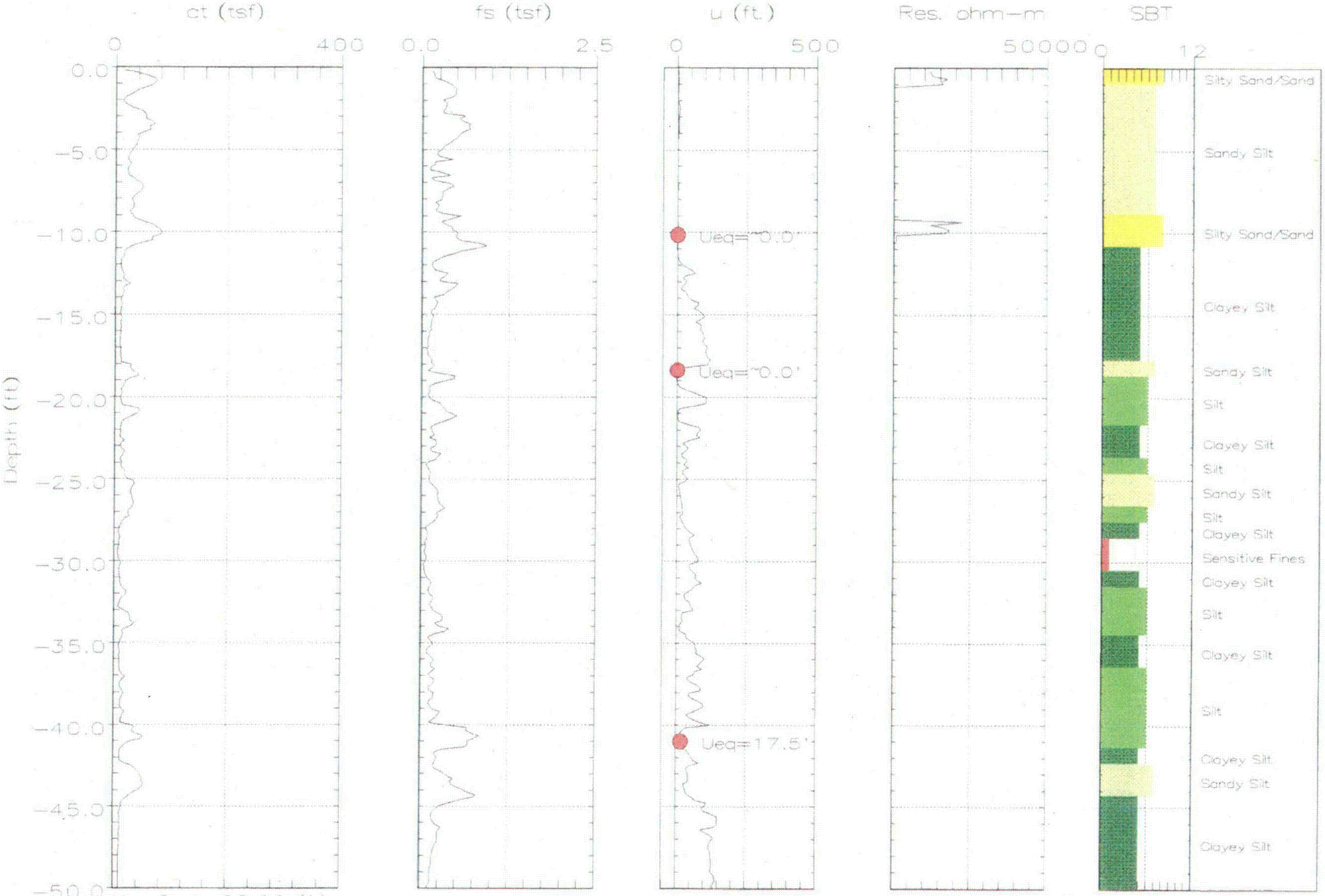
SBT: Soil Behavior Type (Robertson 1990)
● Equilibrium Pore Pressure from Dissipation

CONETEC

S.M. Stoller

Hole No.:CPT-0384
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 08:55



Max. Depth: 66.60 (ft)

Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

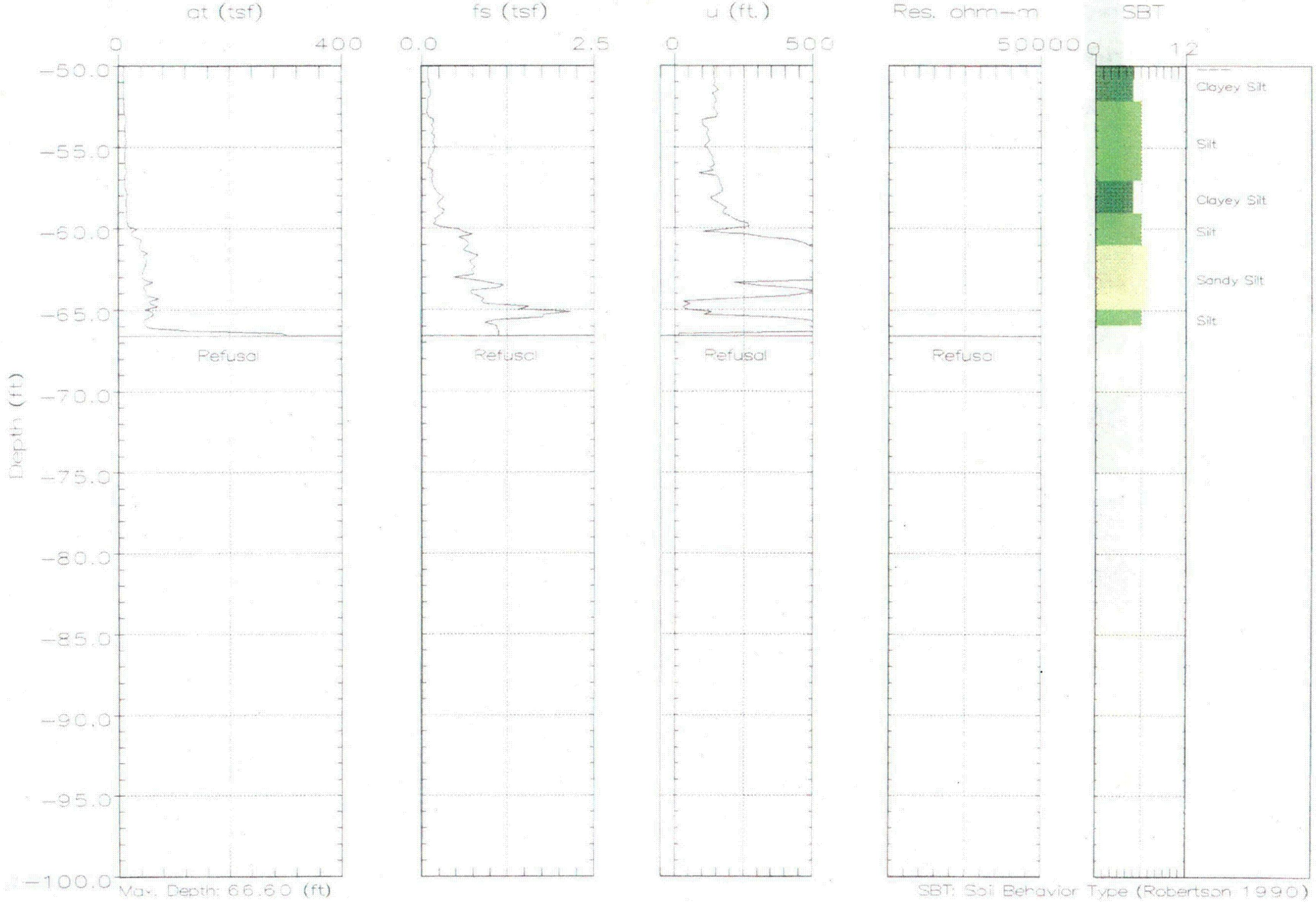
● Equilibrium Pore Pressure from Dissipation

CONETEC

S.M. Stoller

Hole No.:CPT-0384
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 08:55



Max. Depth: 66.60 (ft)

Depth inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

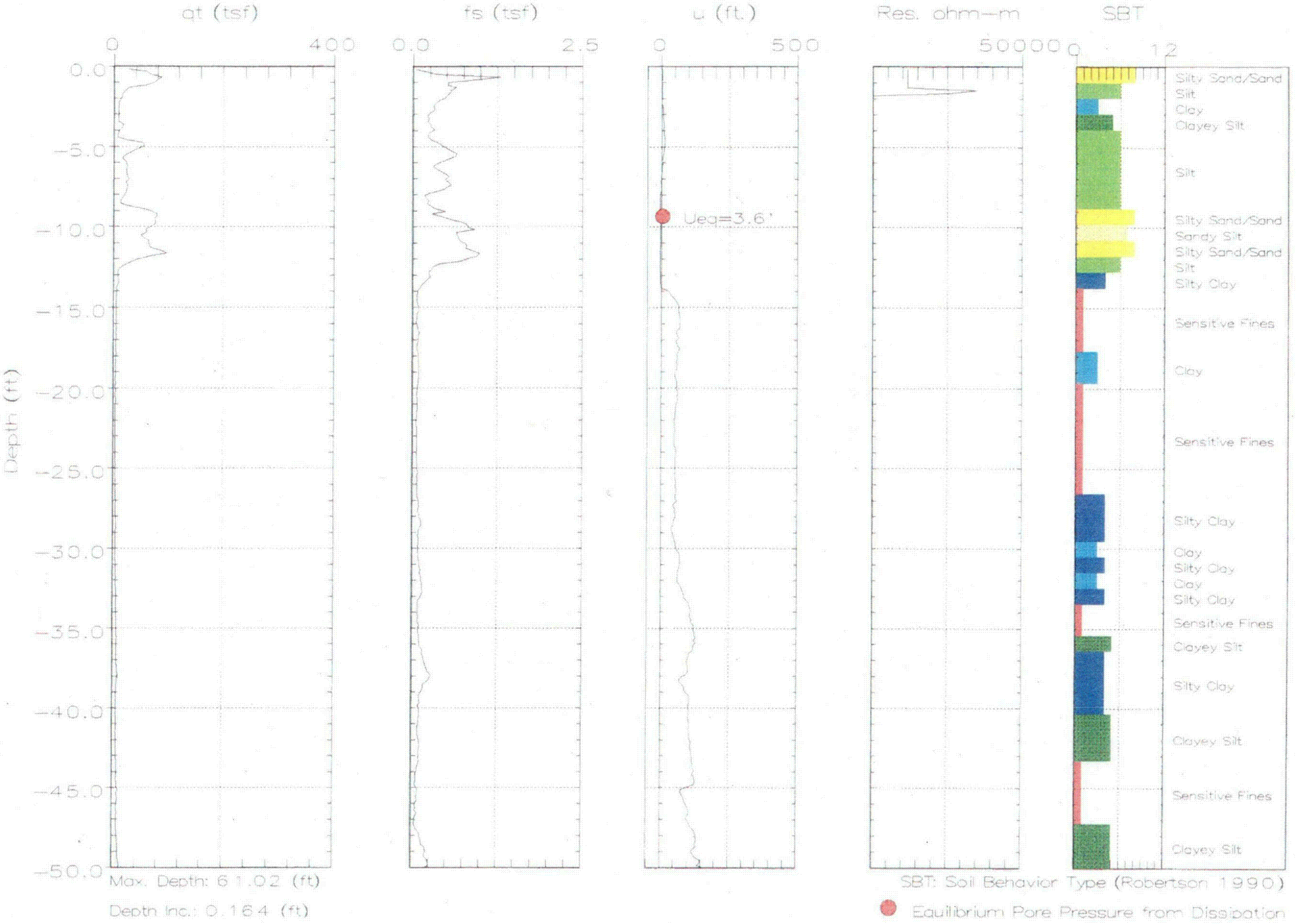
● Equilibrium Pore Pressure from Dissipation

ConeTec

S.M. Stoller

Hole No.:CPT-0385
Location:ATLAS

Cone: 20 Ton St: 183
Date:12:17:05 10:37



Max. Depth: 61.02 (ft)

Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

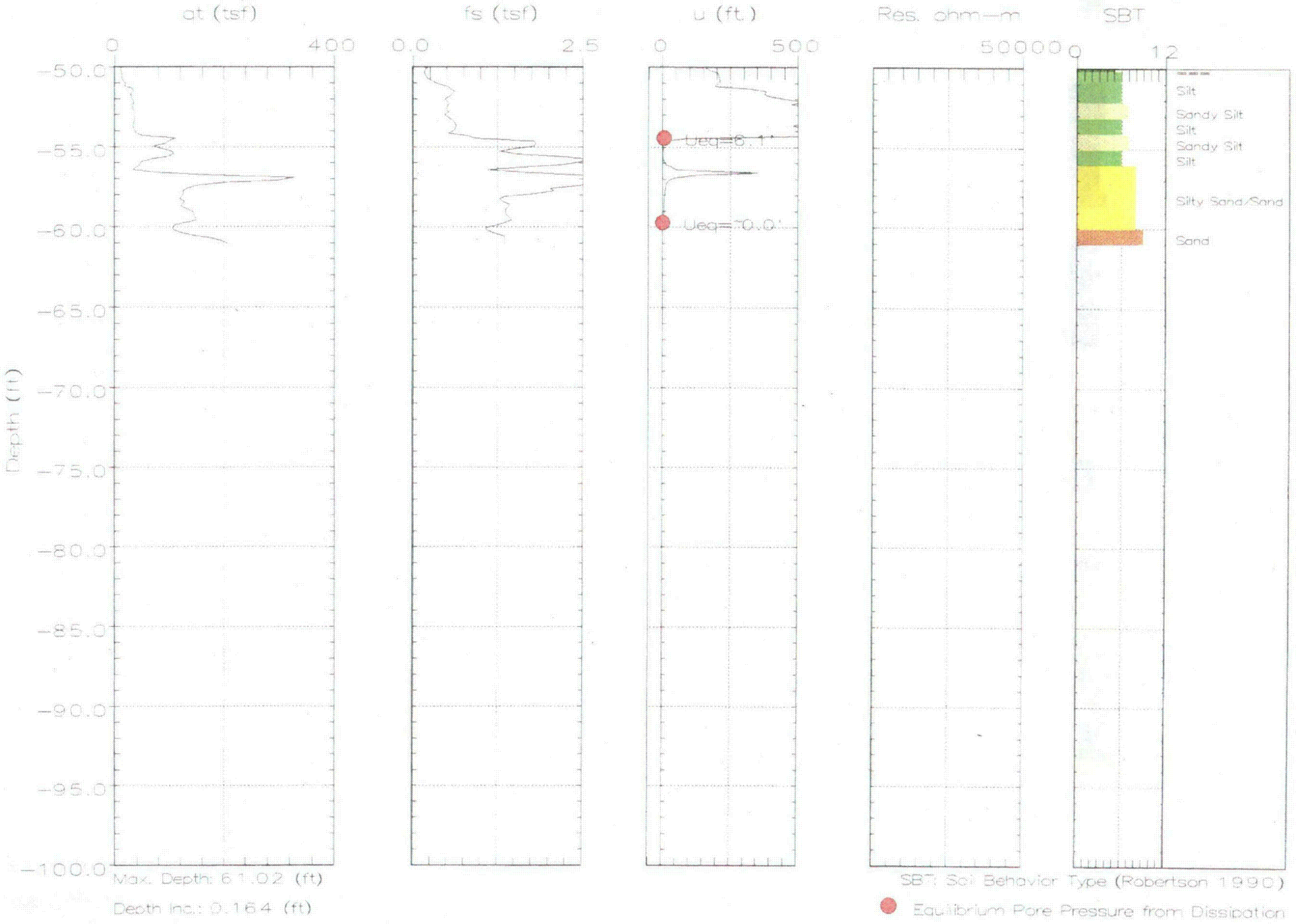
● Equilibrium Pore Pressure from Dissipation

CONETEC

S.M. Stoller

Hole No.:CPT-0385
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 10:37



Max. Depth: 61.02 (ft)
Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

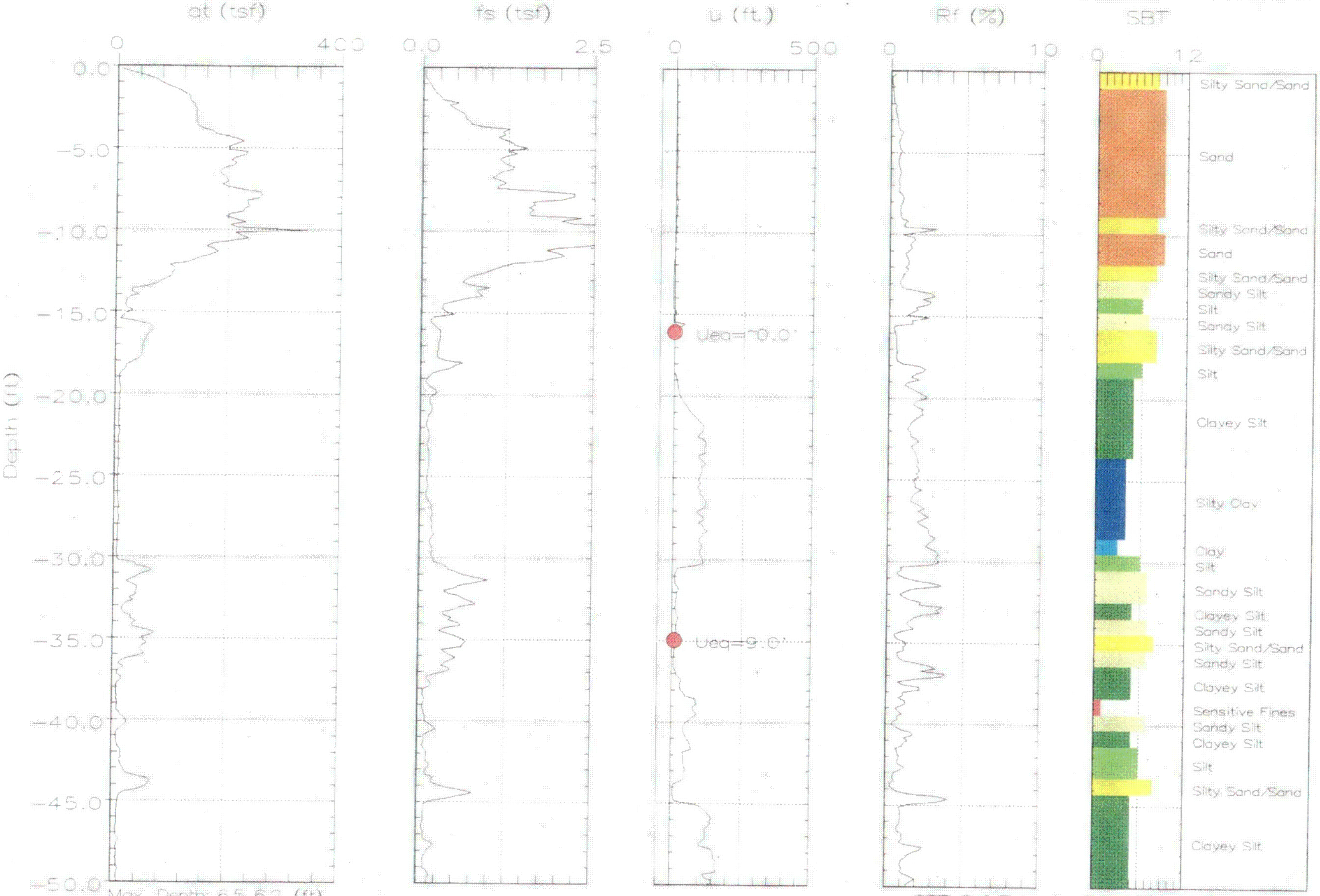
● Equilibrium Pore Pressure from Dissipation

CONETEC

S.M. Stoller

Hole No.:CPT-0386
Location:ATLAS

Cone: 20 Ton St 183
Date:12:14:05 14:53



Max. Depth: 65.62 (ft)

Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

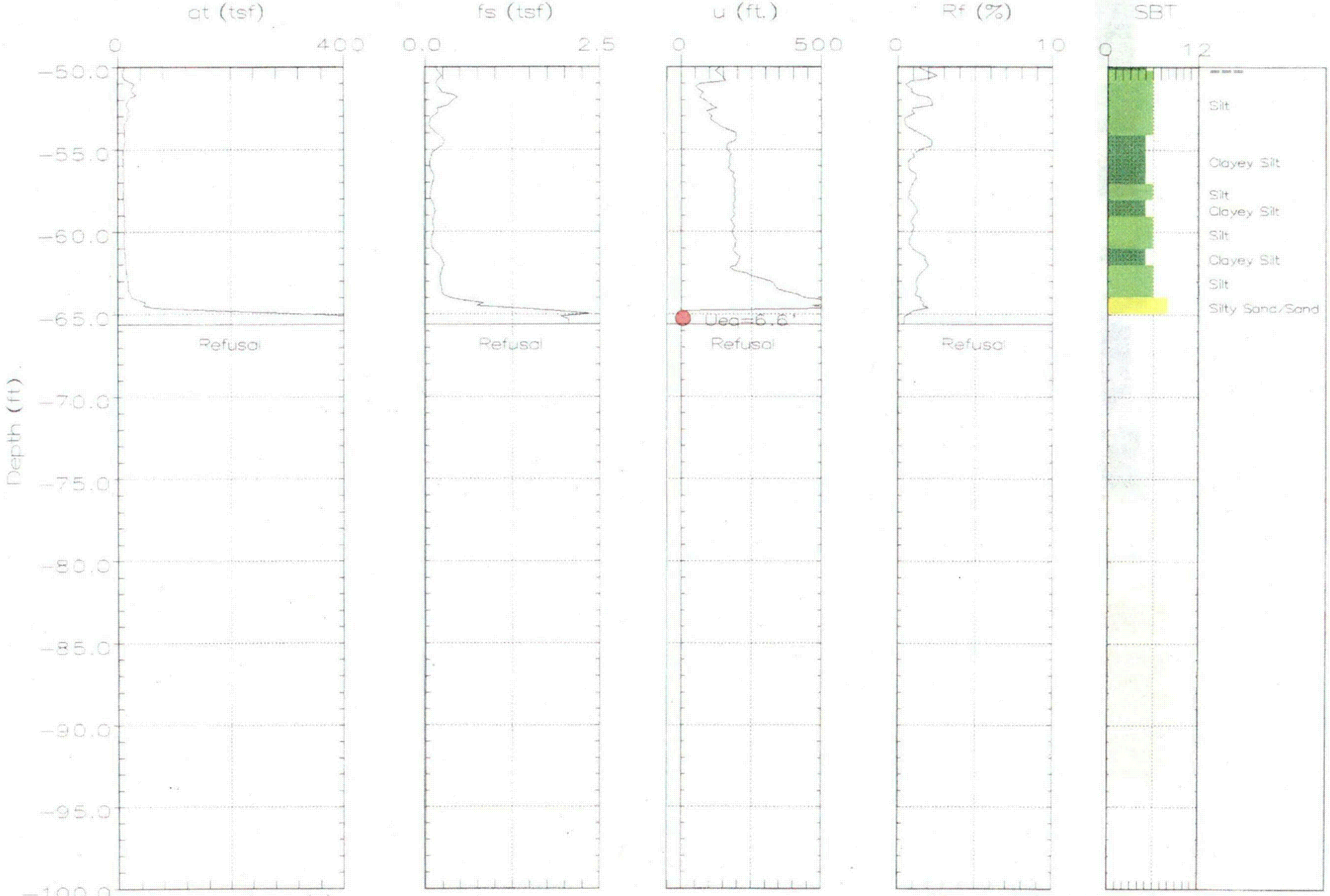
● Equilibrium Pore Pressure from Dissipation

CONETEC

S.M. Stoller

Hole No.:CPT-0386
Location:ATLAS

Cone: 20 Ton St 183
Date:12:14:05 14:53



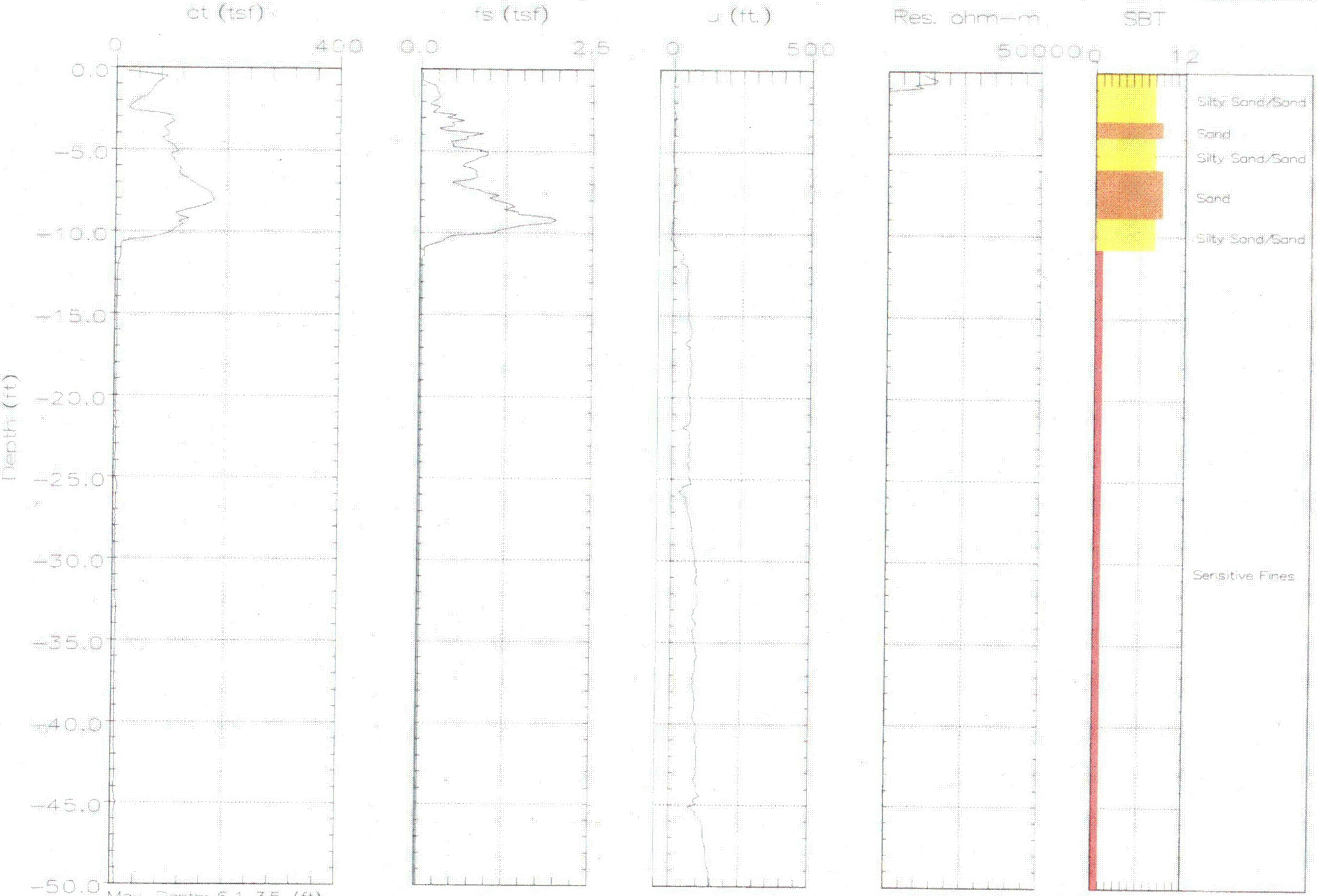
Max. Depth: 65.62 (ft)
Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)
● Equilibrium Pore Pressure from Dissipation

S.M. Stoller

Hole No.:CPT-0387
Location:ATLAS

Cone: 20 Ton St 183
Date:12:16:05 13:40



Max. Depth: 61.35 (ft)

Depth Inc.: 0.164 (ft)

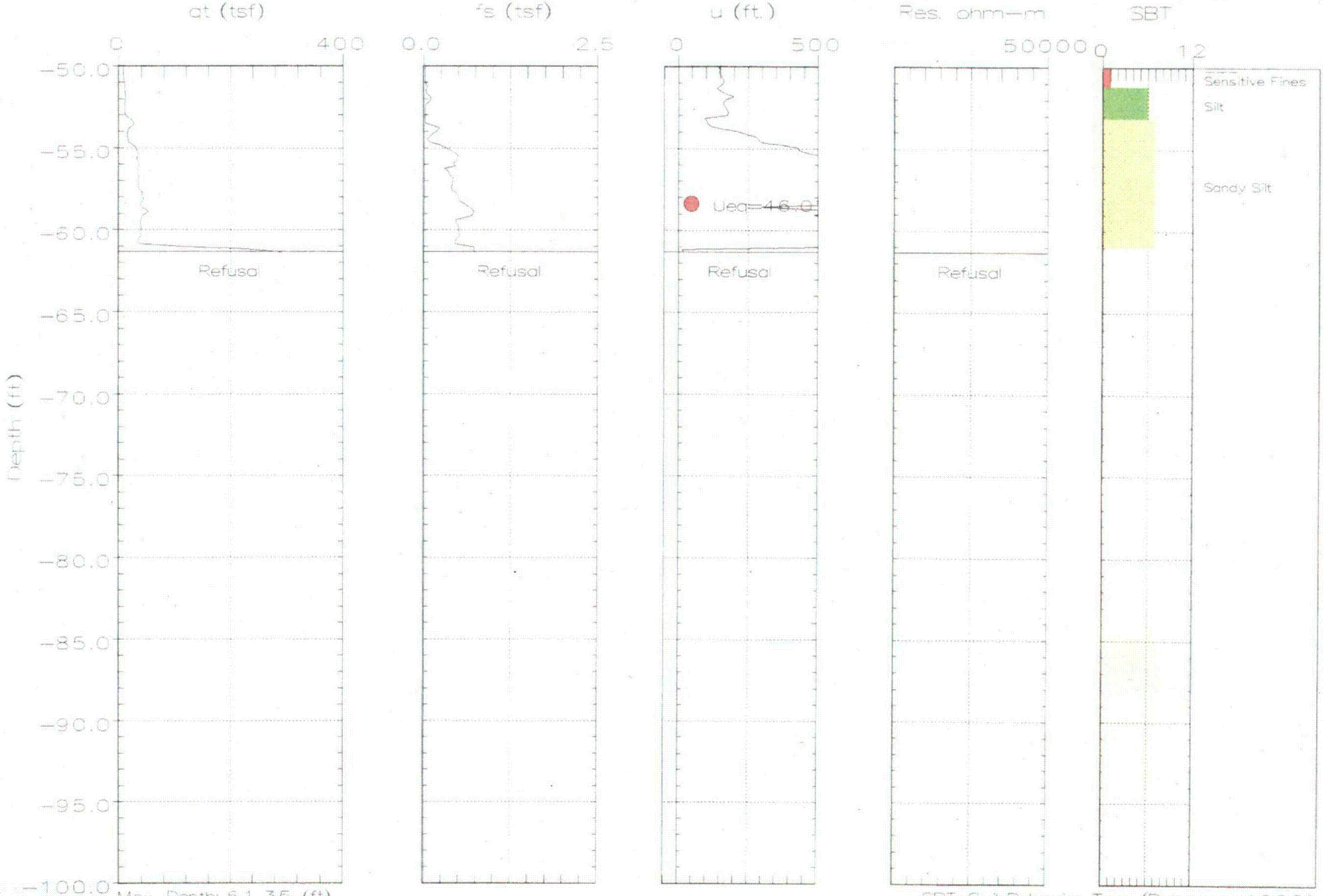
SBT: Soil Behavior Type (Robertson 1990)

● Equilibrium Pore Pressure from Dissipation

S.M. Stoller

Hole No.:CPT-0387
Location:ATLAS

Cone: 20 Ton St 183
Date:12:16:05 13:40



Max. Depth: 61.35 (ft)

Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

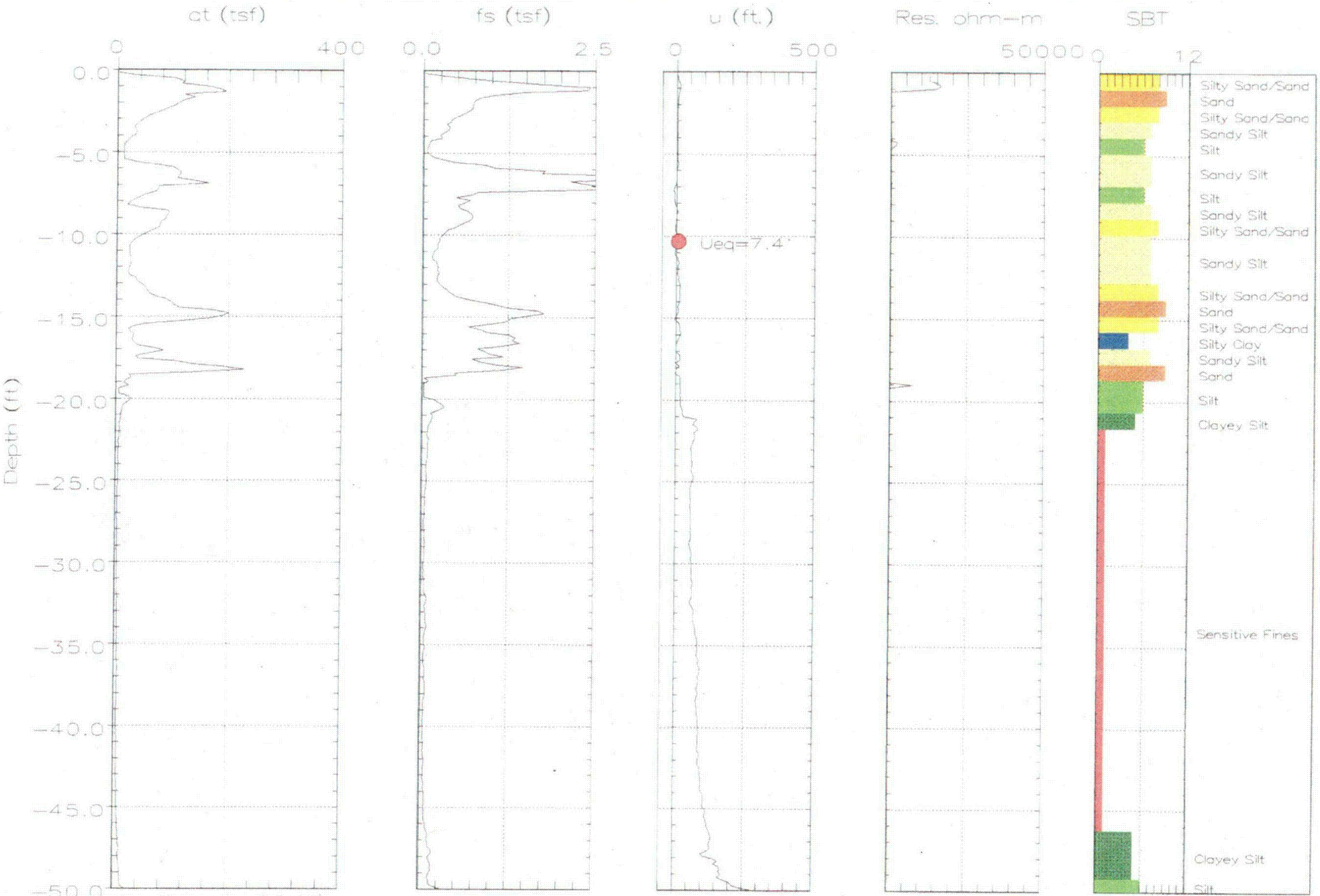
● Equilibrium Pore Pressure from Dissipation

CONETEC

S.M. Stoller

Hole No.:CPT-0388
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 07:45



Max. Depth: 54.63 (ft)

Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

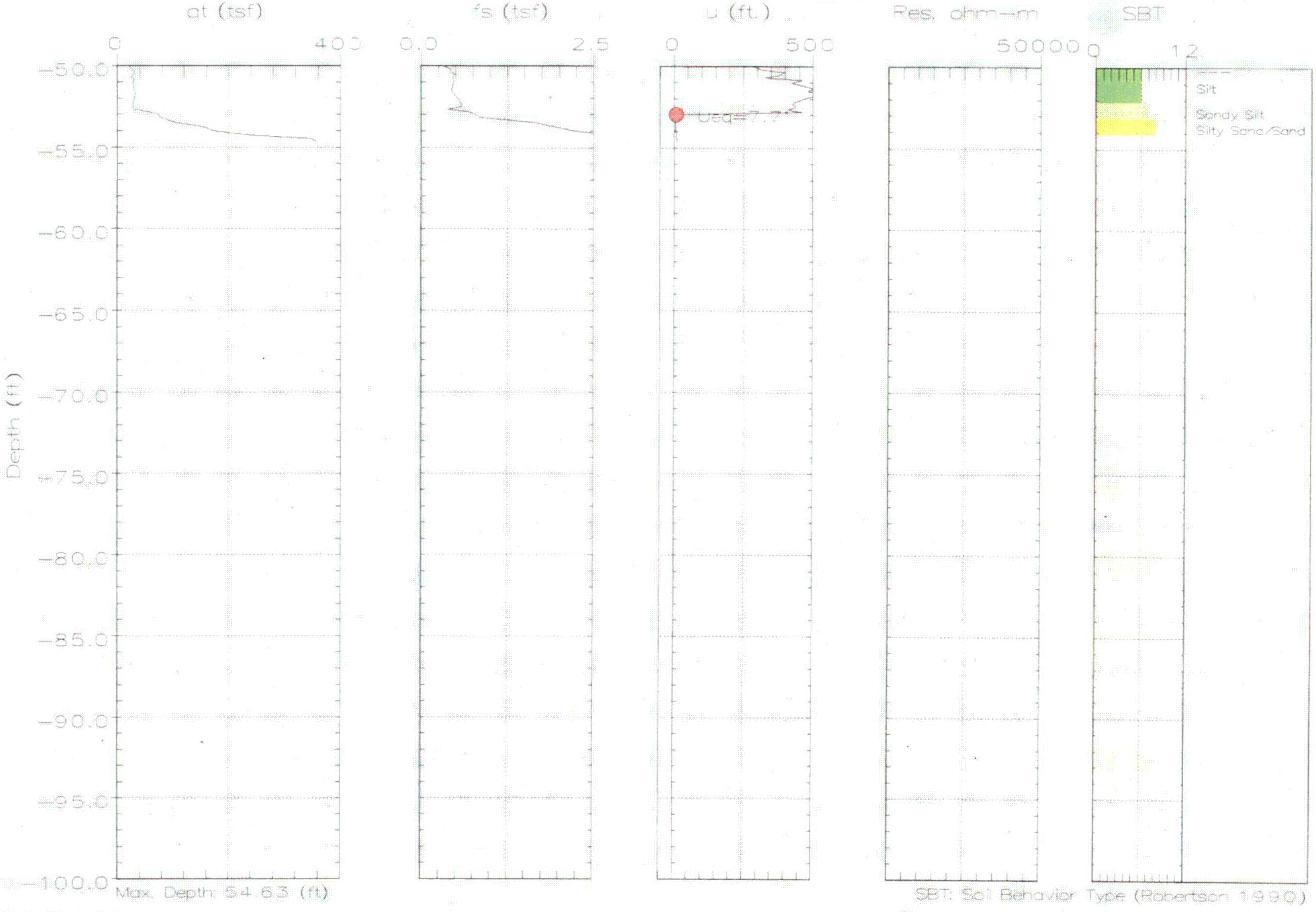
● Equilibrium Pore Pressure from Dissipation

CONETEC

S.M. Stoller

Hole No.:CPT-0388
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 07:45



Max. Depth: 54.63 (ft)
Depth Inc.: 0.164 (ft)

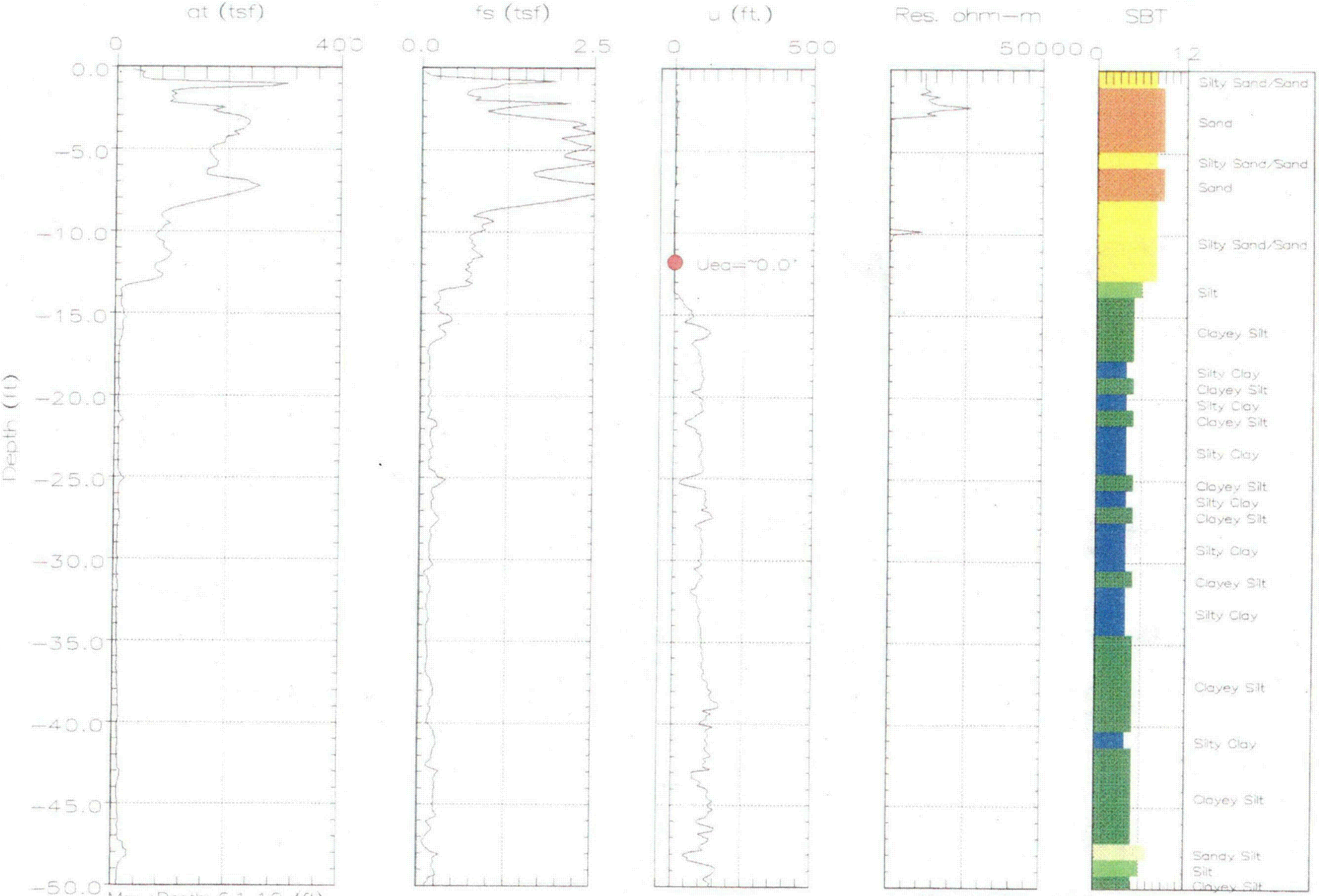
SBT: Soil Behavior Type (Robertson 1990)

● Equilibrium Pore Pressure from Dissipation

S.M. Stoller

Hole No.:CPT-0389
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 13:19



Max. Depth: 61.19 (ft)

Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

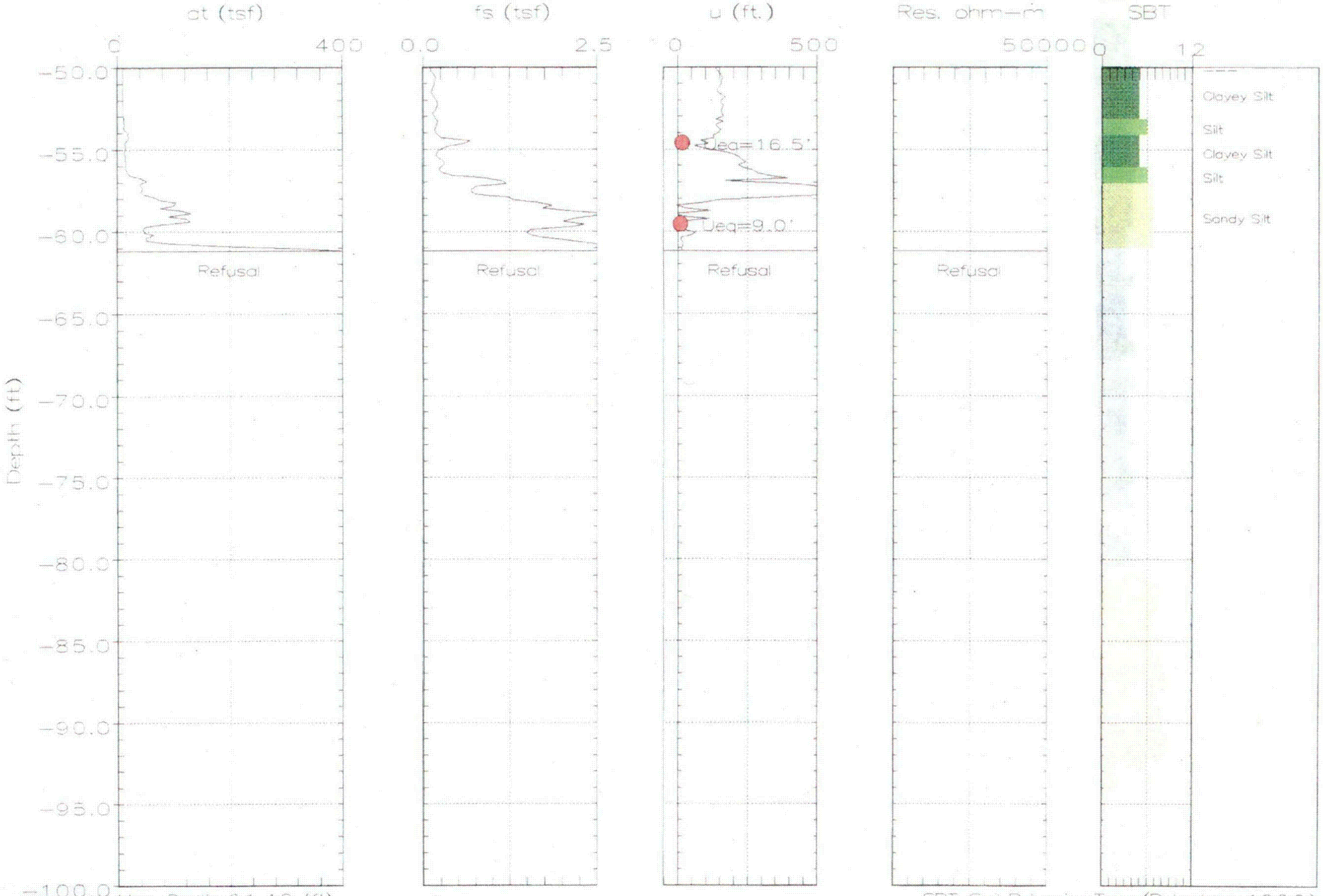
● Equilibrium Pore Pressure from Dissipation

CONETEC

S.M. Stoller

Hole No.:CPT-0389
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 13:19



Max. Depth: 61.19 (ft)
Depth Inc.: 0.164 (ft)

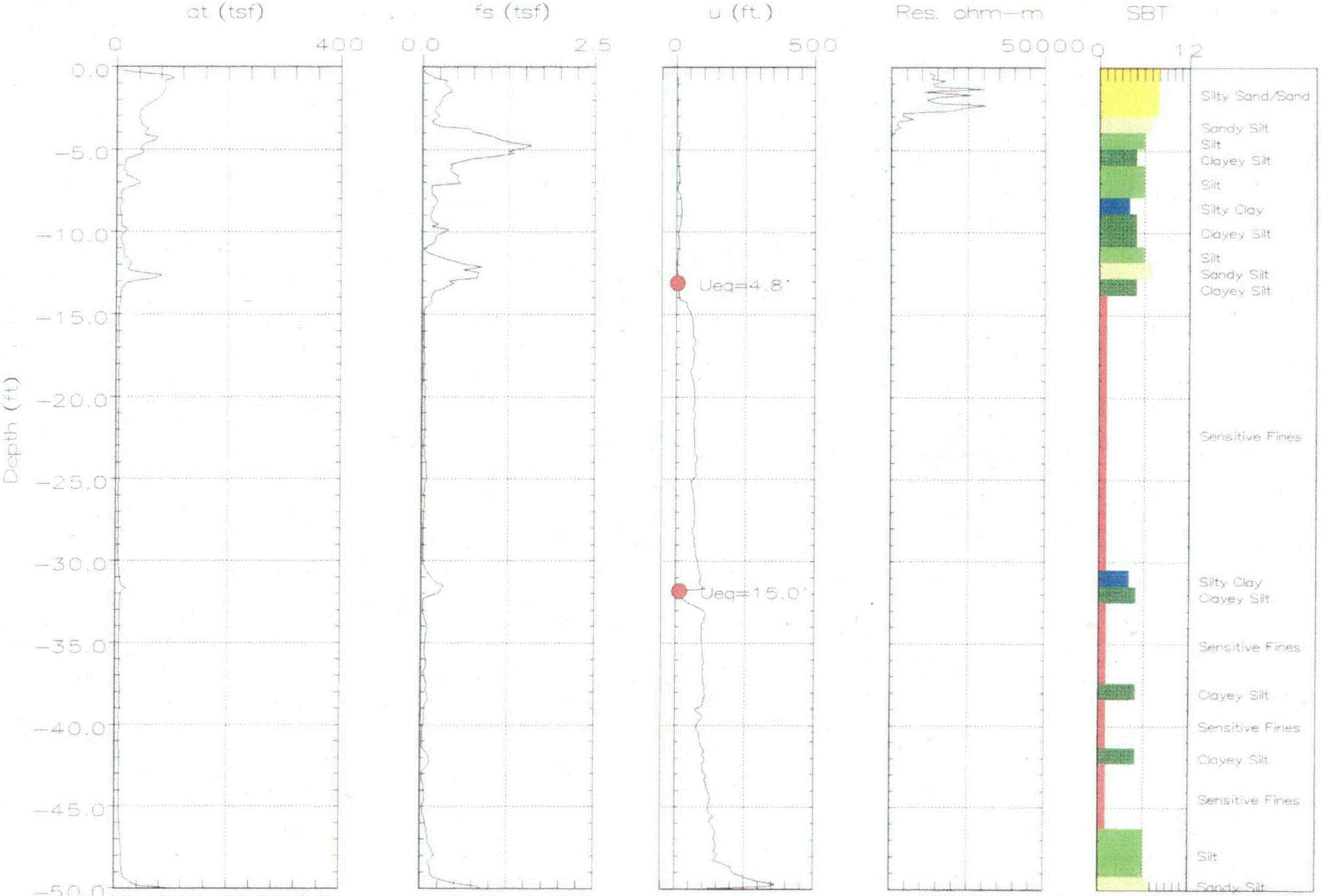
SBT: Soil Behavior Type (Robertson 1990)
● Equilibrium Pore Pressure from Dissipation

CONETEC

S.M. Stoller

Hole No.:CPT-0390
Location:ATLAS

Cone: 20 Ton St 183
Date:12:18:05 08:29



Max. Depth: 59.87 (ft)

Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

● Equilibrium Pore Pressure from Dissipation

ConeTec

S.M. Stoller

Hole No.:CPT-0390
Location:ATLAS

Cone: 20 Ton St 183
Date:12:18:05 08:29

Max. Depth: 59.87 (ft)

Depth inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

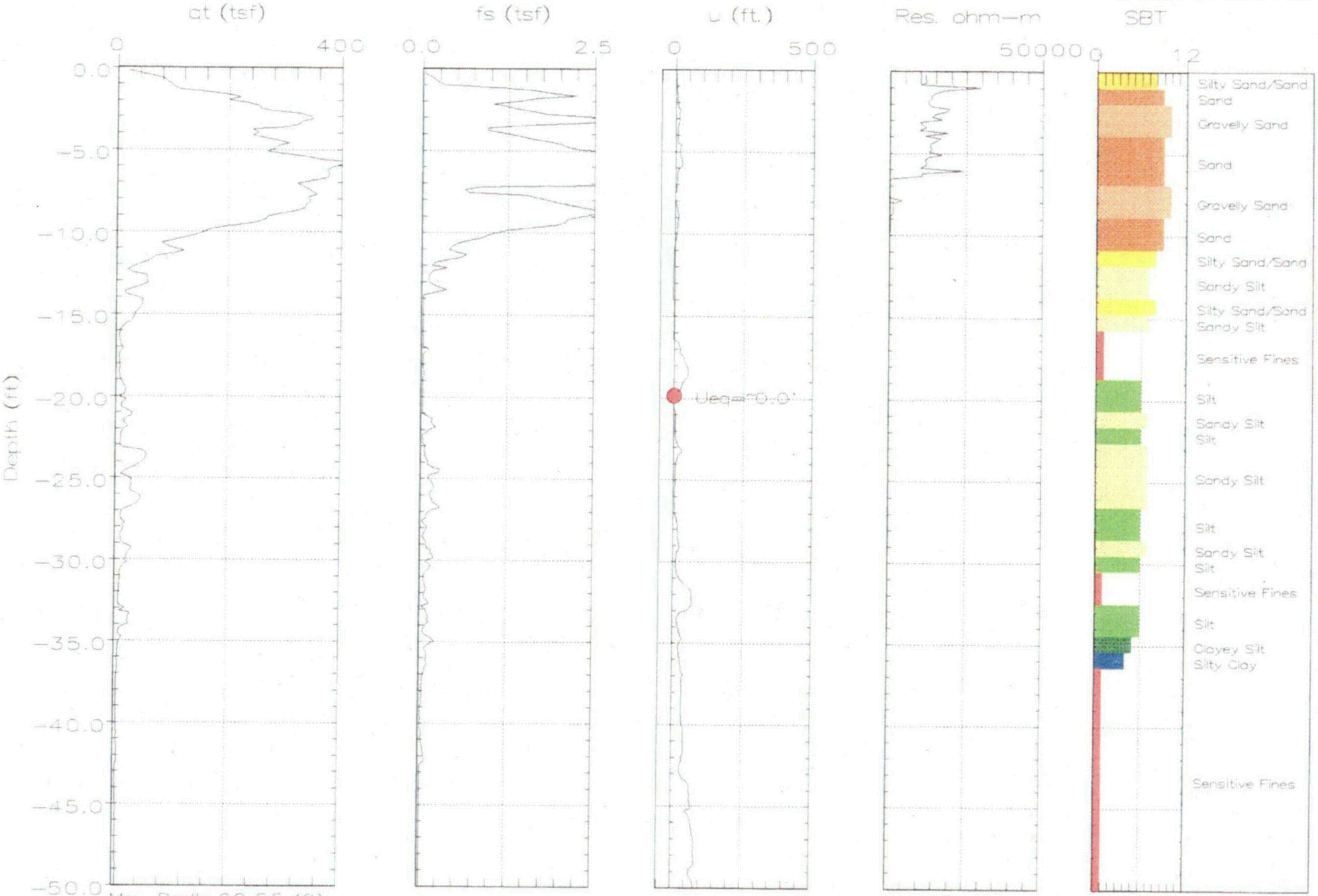
● Equilibrium Pore Pressure from Dissipation

CONETEC

S.M. Stoller

Hole No.:CPT-0391
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 10:21



Max. Depth: 69.55 (ft)

Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

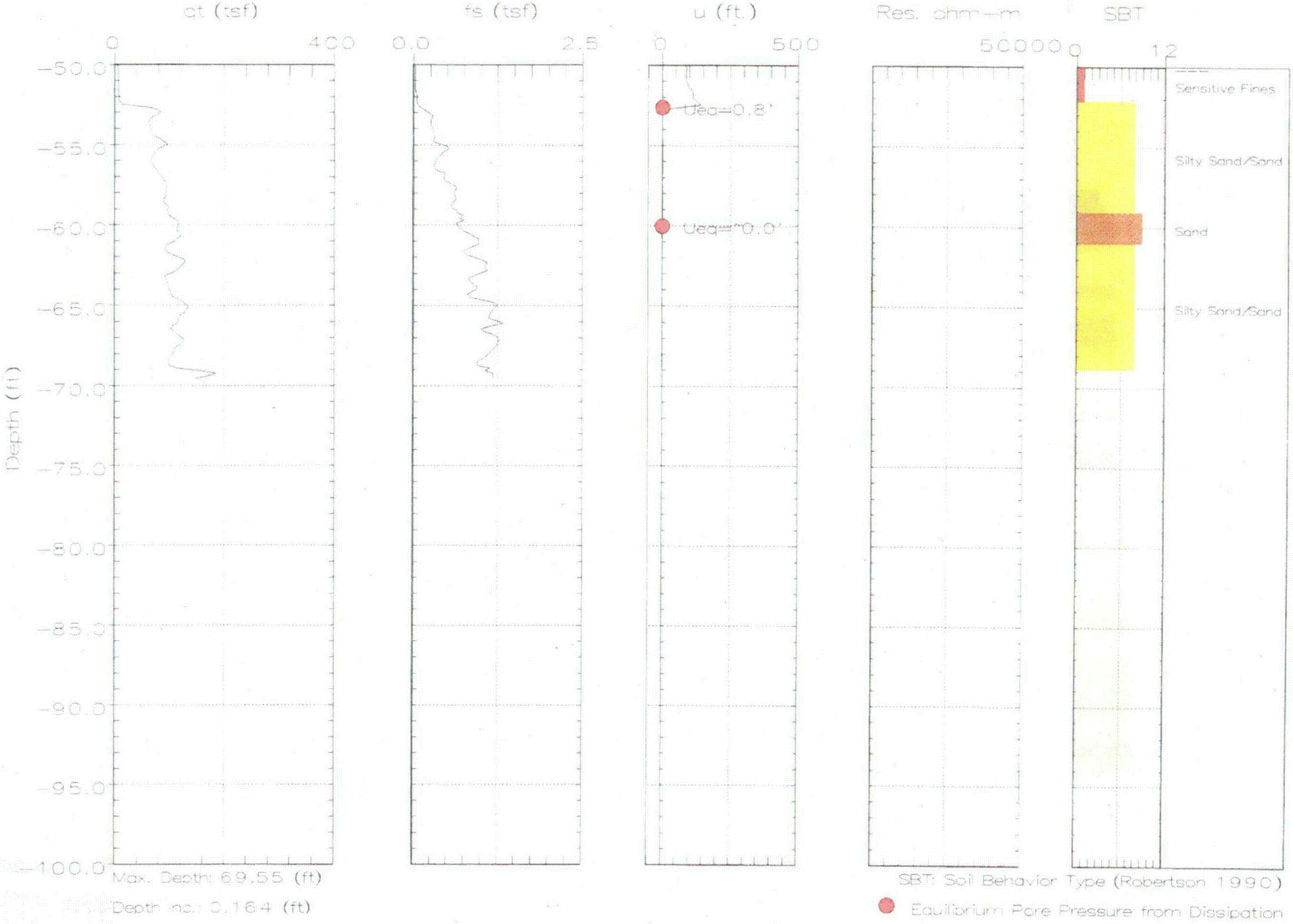
● Equilibrium Pore Pressure from Dissipation

CONETEC

S.M. Stoller

Hole No.:CPT-0391
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 10:21



Max. Depth: 69.55 (ft)
Depth Inc.: 0.164 (ft)

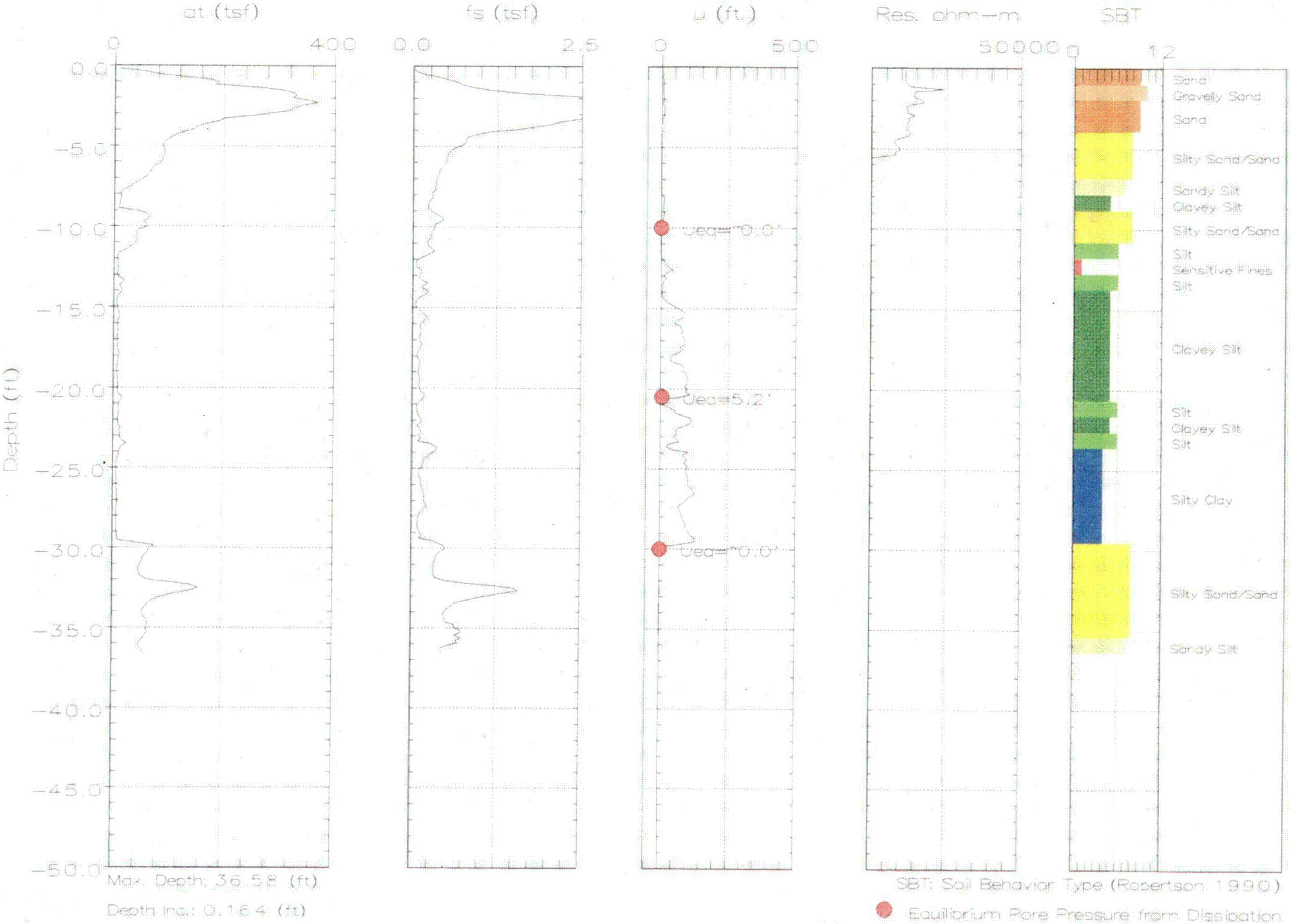
SBT: Soil Behavior Type (Robertson 1990)
● Equilibrium Pore Pressure from Dissipation

CONETEC

S.M. Stoller

Hole No.:CPT-0392
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 12:38

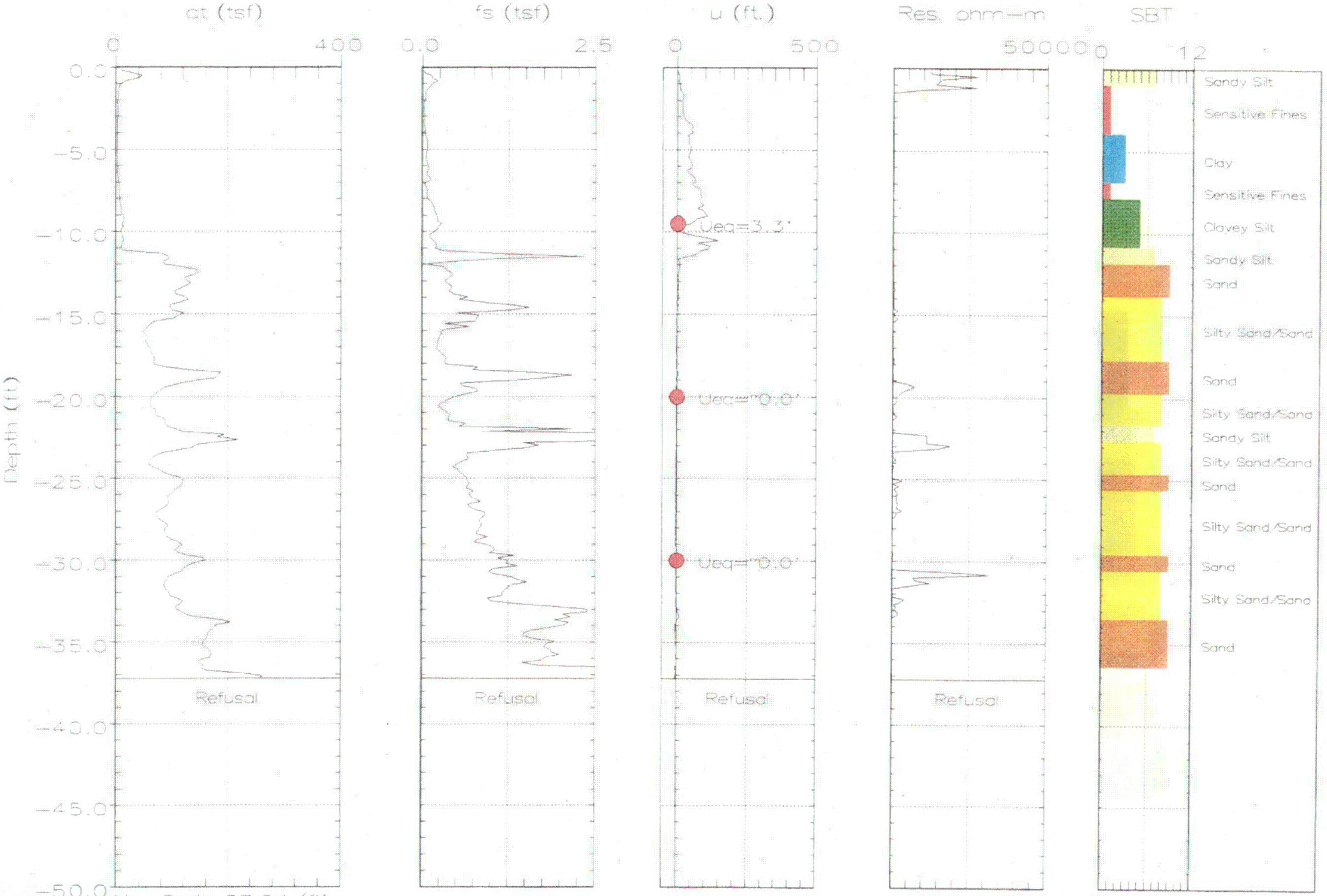


CONETEC

S.M. Stoller

Hole No.:CPT-0393
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 14:40



Max. Depth: 37.24 (ft)
Depth Inc.: 0.164 (ft)

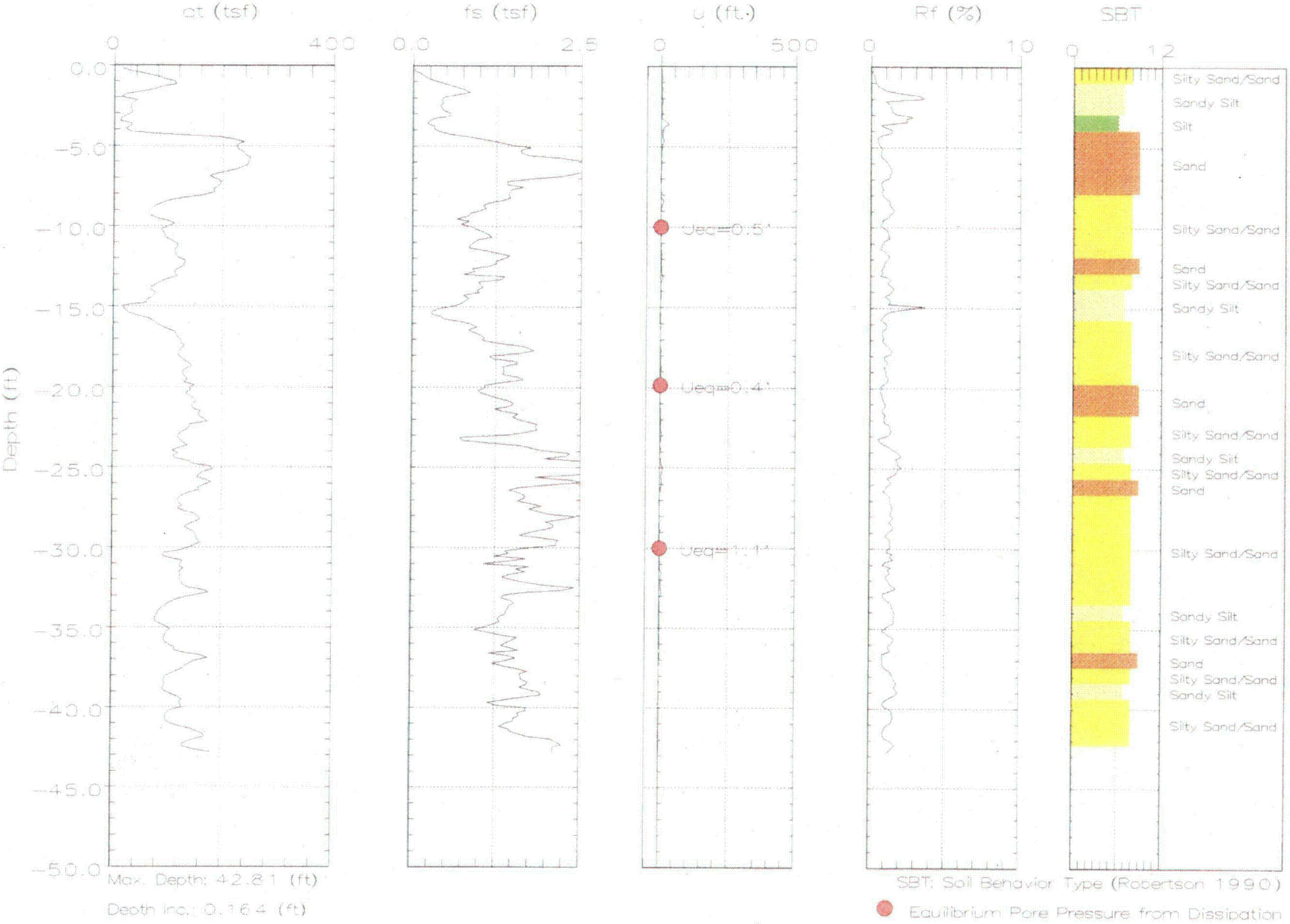
SBT: Soil Behavior Type (Robertson 1990)

● Equilibrium Pore Pressure from Dissipation

S.M. Stoller

Hole No.:CPT-0394
Location:ATLAS

Cone: 20 Ton St 183
Date:12:16:05 07:50



Max. Depth: 42.81 (ft)

Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

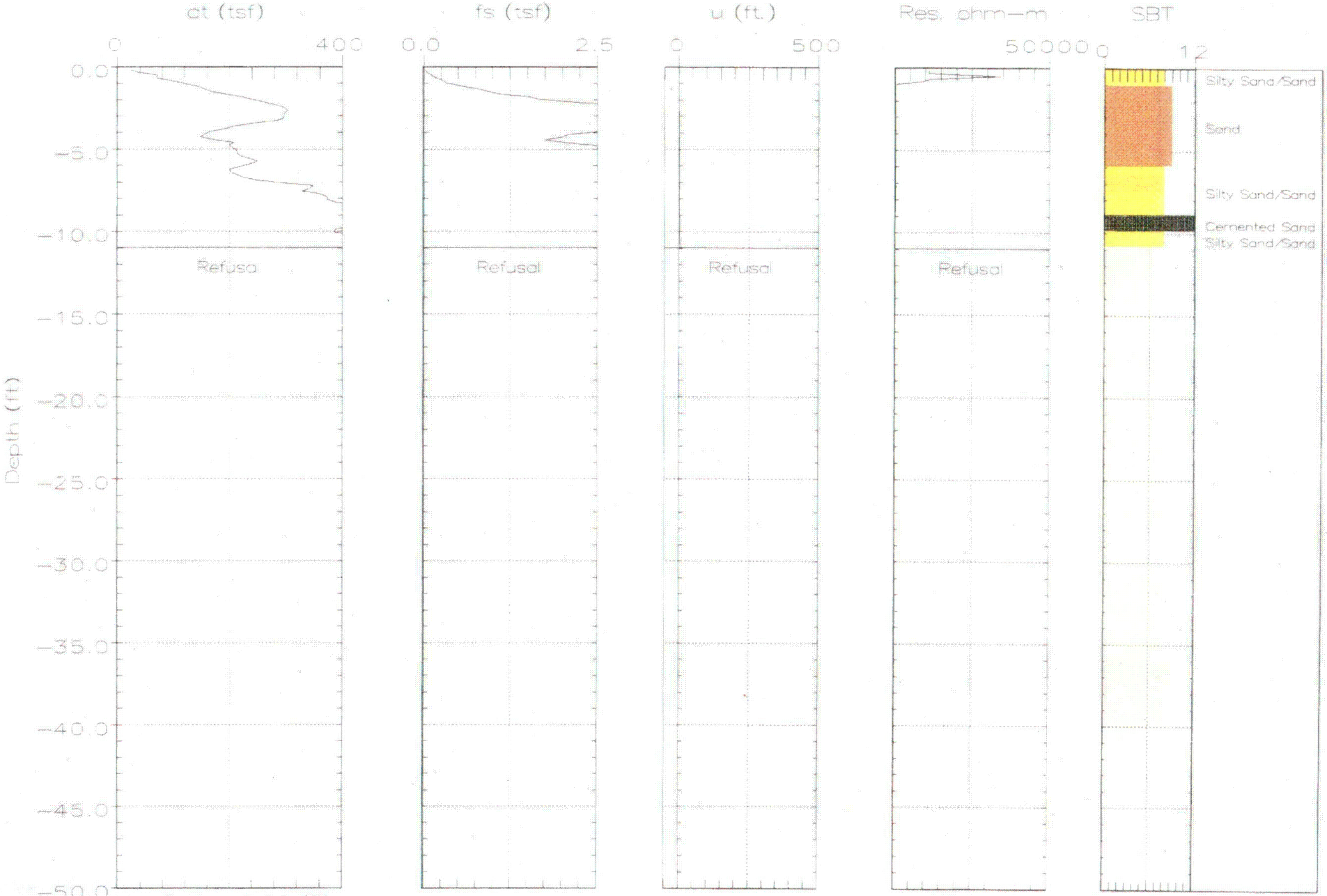
● Equilibrium Pore Pressure from Dissipation

CONETEC

S.M. Stoller

Hole No.:CPT-0395
Location:ATLAS

Cone: 20 Ton St 183
Date: 12:16:05 10:20



Max. Depth: 10.99 (ft)
Depth inc.: 0.164 (ft)

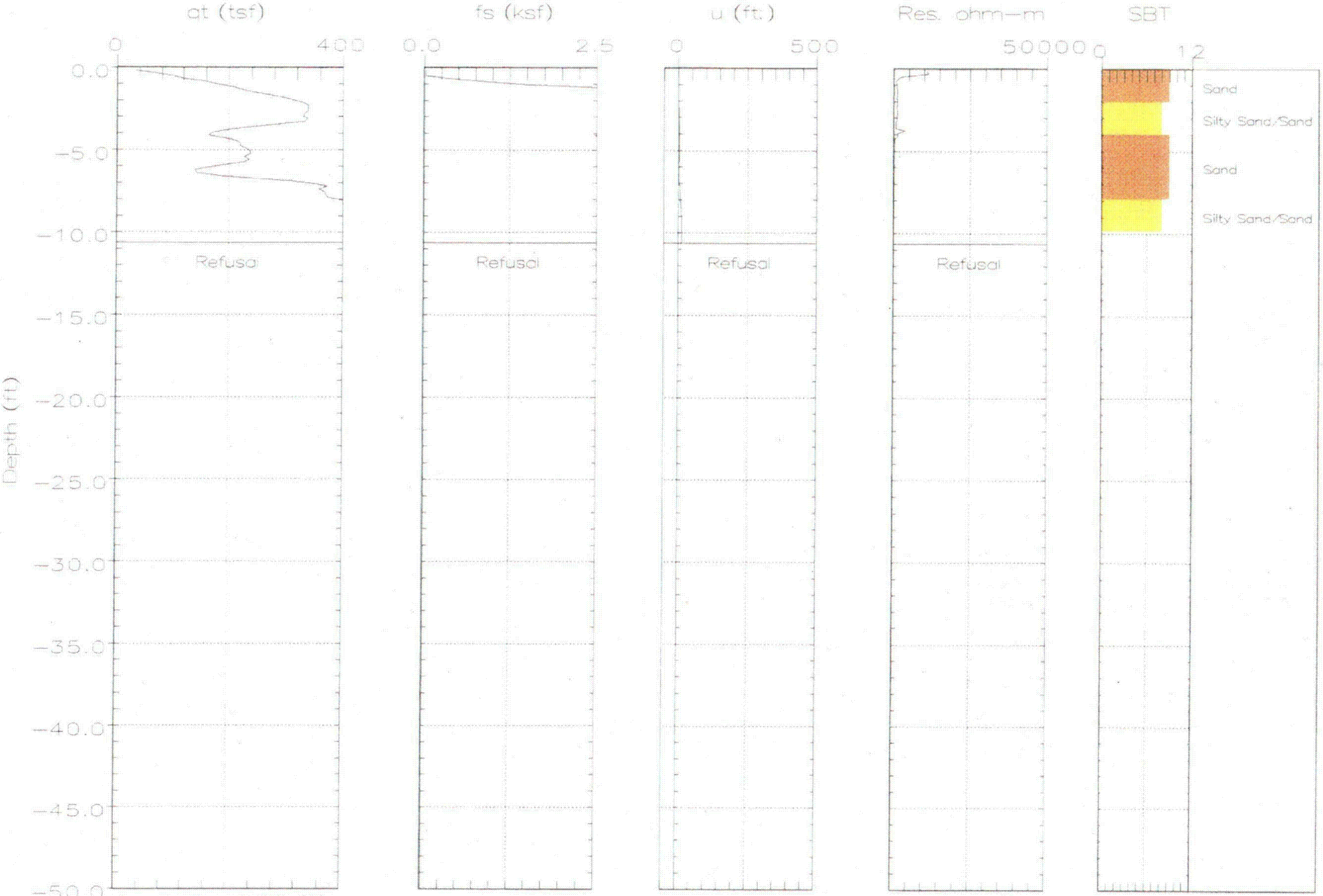
SBT: Soil Behavior Type (Robertson 1990)

● Equilibrium Pore Pressure from Dissipation

S.M. Stoller

Hole No.:CPT-0395
Location:ATLAS

Cone: 20 Ton St 183
Date:12:16:05 10:37



Max. Depth: 10.66 (ft)

Depth inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

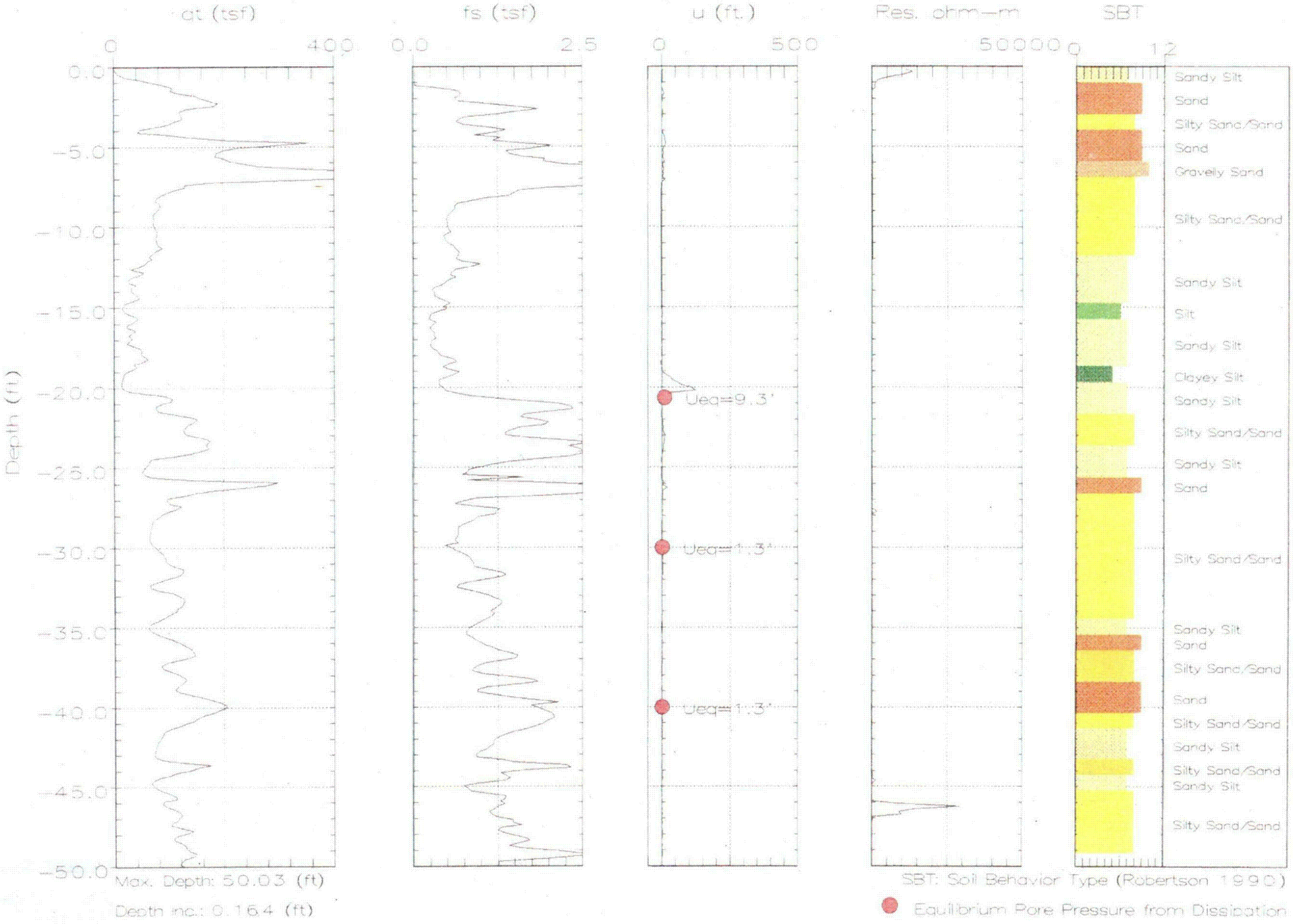
● Equilibrium Pore Pressure from Dissipation

CONETEC

S.M. Stoller

Hole No.:CPT-0395 TOE
Location:ATLAS

Cone: 20 Ton St 183
Date:12:16:05 11:05

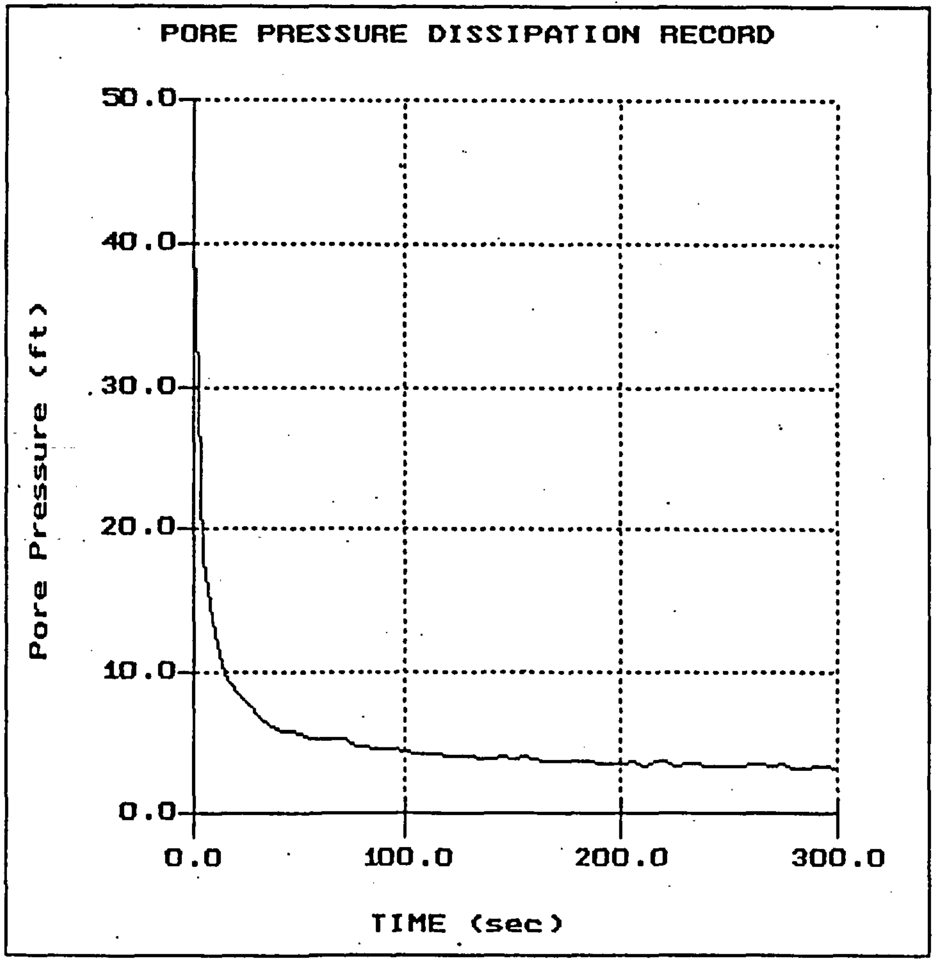


PPD Plots

S.M. Stoller

Hole No.:CPT-0381
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 08:12



PORE PRESSURE DISSIPATION RECORD

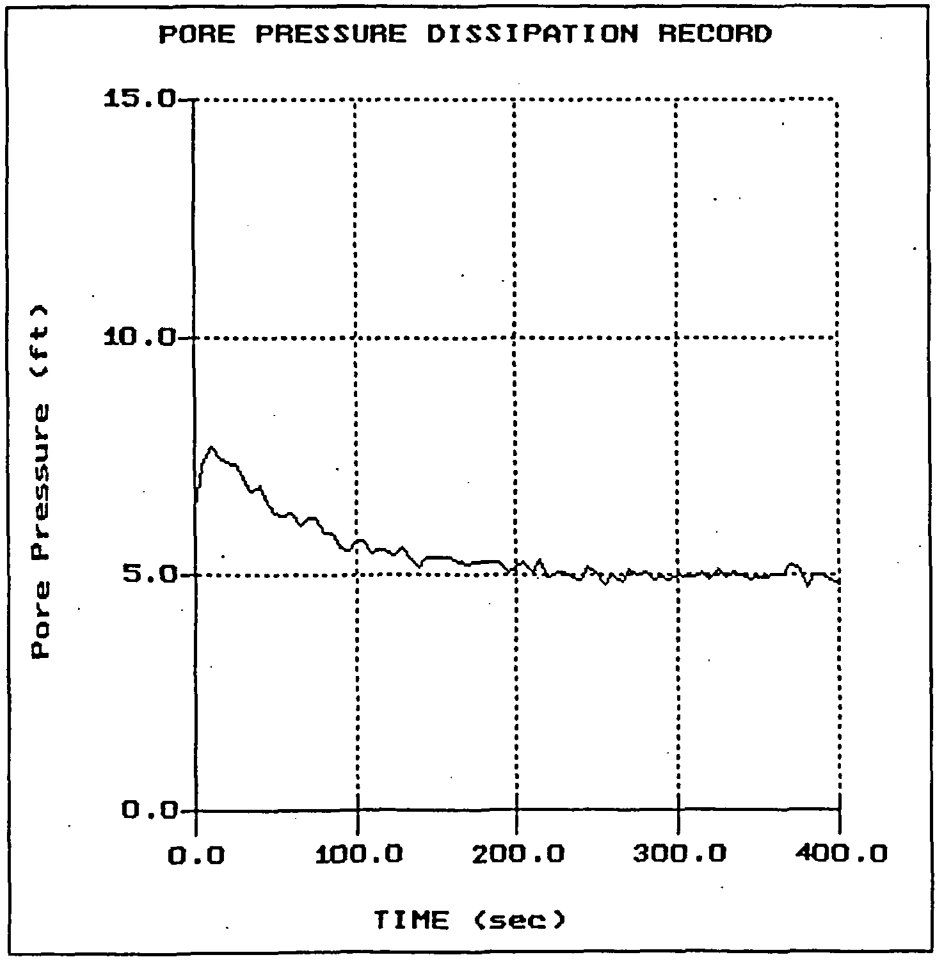
File: 432CP81.PPD
Depth (m): 6.45
(ft): 21.16
Duration : 300.0s
U-min: 3.13 285.0s
U-max: 41.10 0.0s

S.M. Stoller

Hole No.:CPT-0381
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 08:12

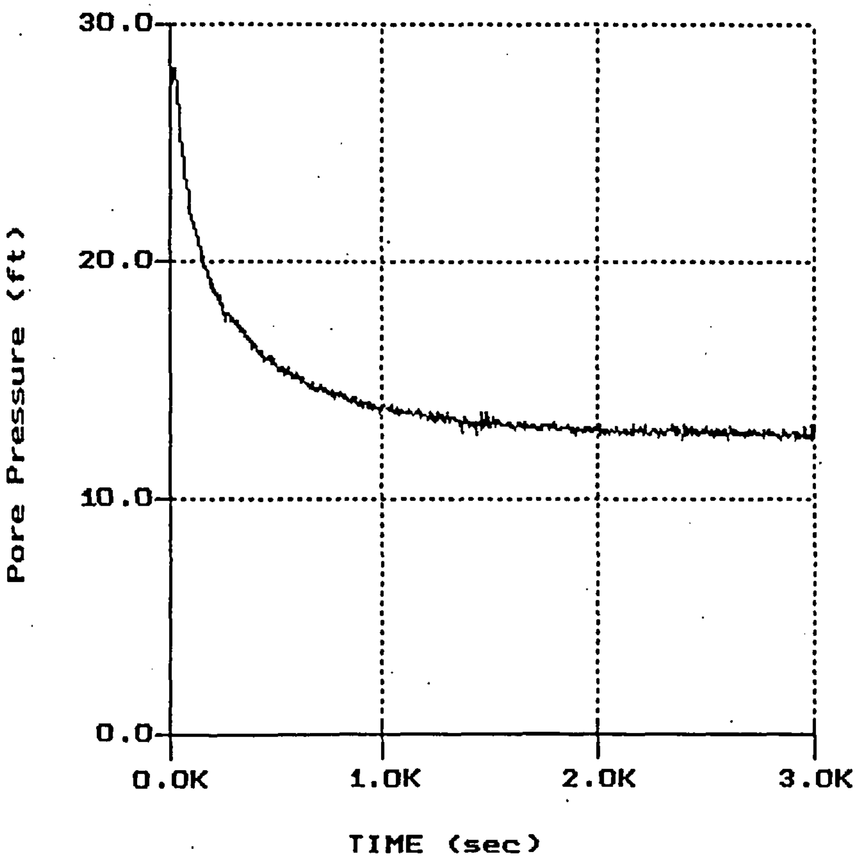
File: 432CP81.PPD
Depth (m): 13.80
(ft): 45.28
Duration : 400.0s
U-min: 4.73 380.0s
U-max: 7.73 10.0s



S.M. Stoller

Hole No.:CPT-0381
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 08:12



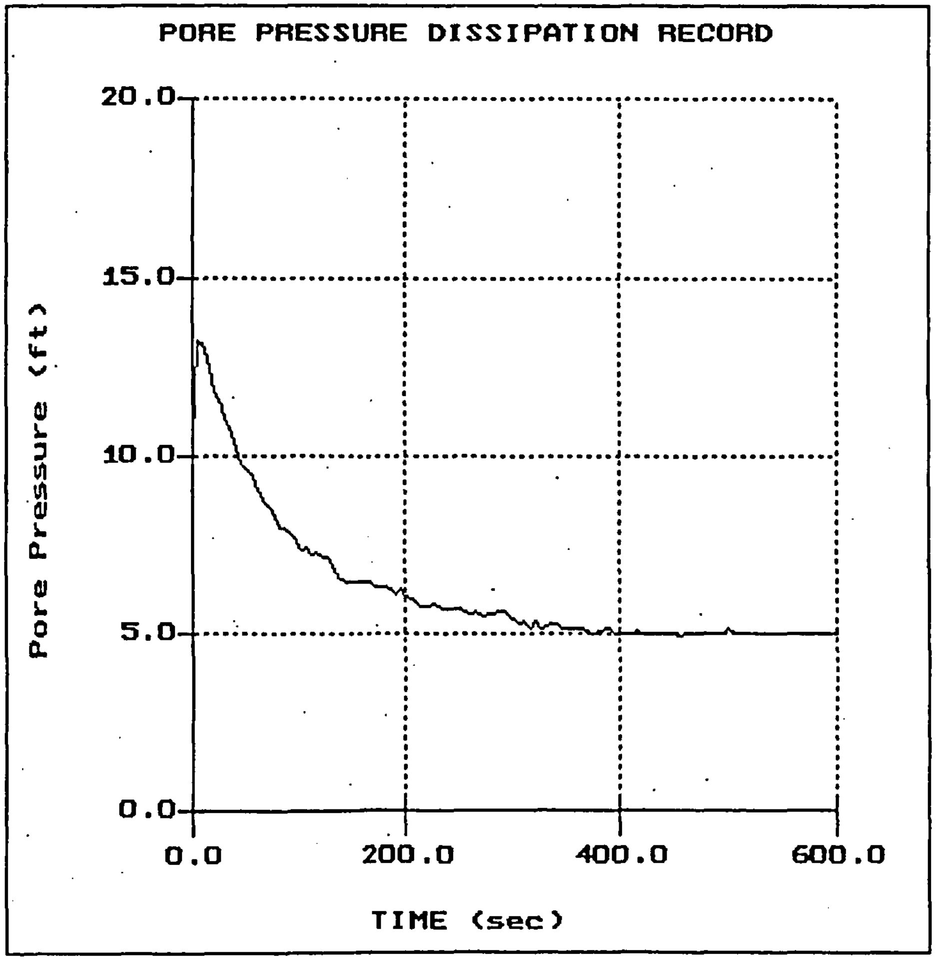
PORE PRESSURE DISSIPATION RECORD

File: 432CP81.PPD
Depth (m): 20.25
(ft): 66.44
Duration : 3000.0s
U-min: 12.47 2840.0s
U-max: 28.90 0.0s

S.M. Stoller

Hole No.:CPT-0382
Location:ATLAS

Cone: 20 Ton St 183
Date:12:14:05 09:43

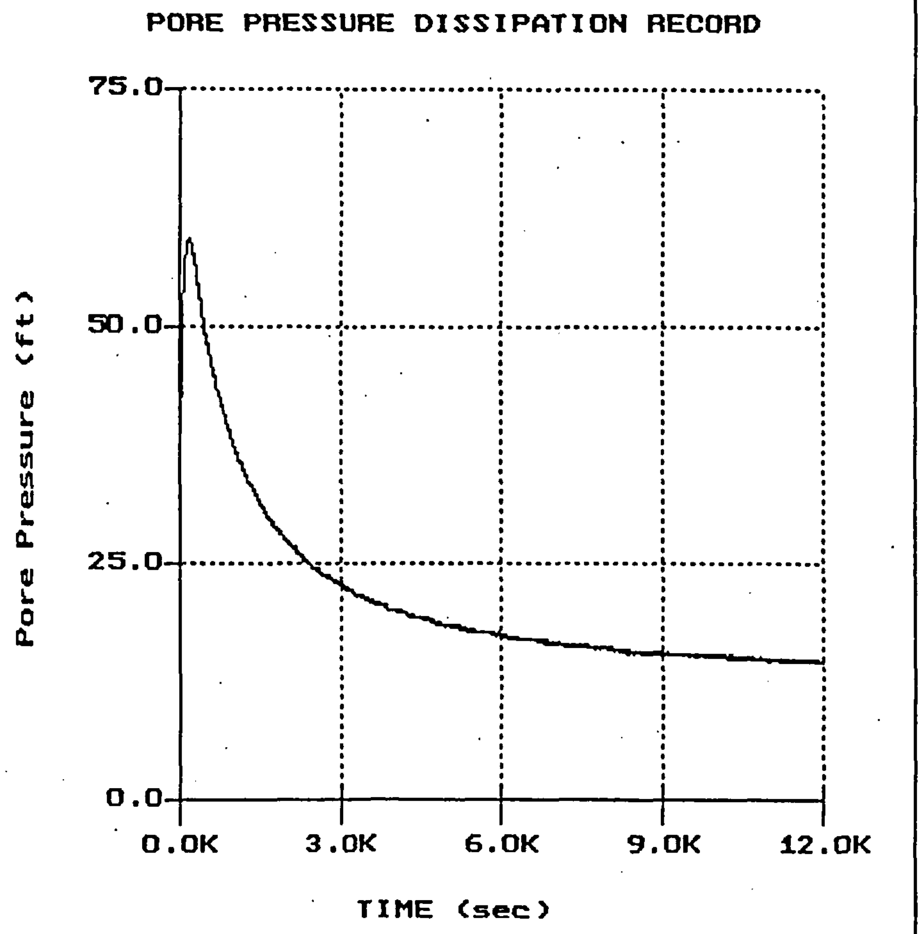


File: 432CP82.PPD
Depth (m): 9.30
(ft): 30.51
Duration : 600.0s
U-min: 4.93 455.0s
U-max: 13.23 5.0s

S.M. Stoller

Hole No.:CPT-0382
Location:ATLAS

Cone: 20 Ton St 183
Date:12:14:05 09:43

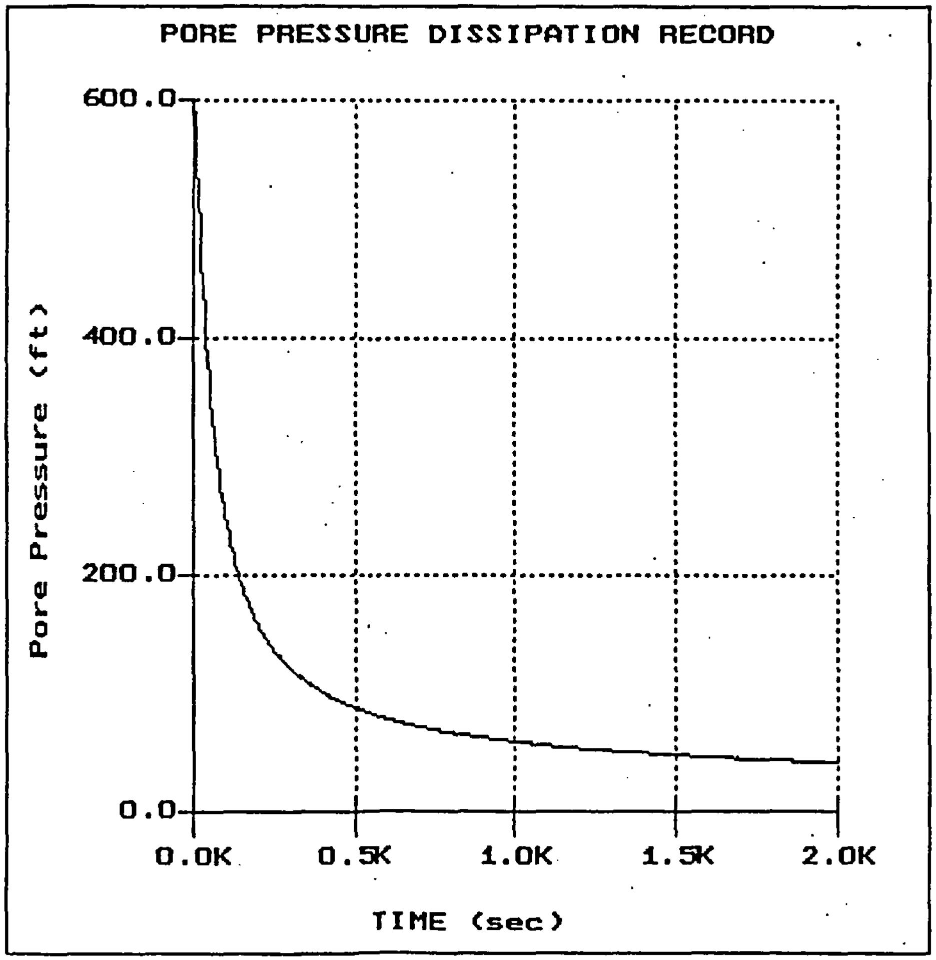


File: 432CP82.PPD
Depth (m): 17.20
(ft): 56.43
Duration : 12000.0s
U-min: 14.50 11795.0s
U-max: 59.08 185.0s

S.M. Stoller

Hole No.:CPT-0382
Location:ATLAS

Cone: 20 Ton St 183
Date:12:14:05 09:43



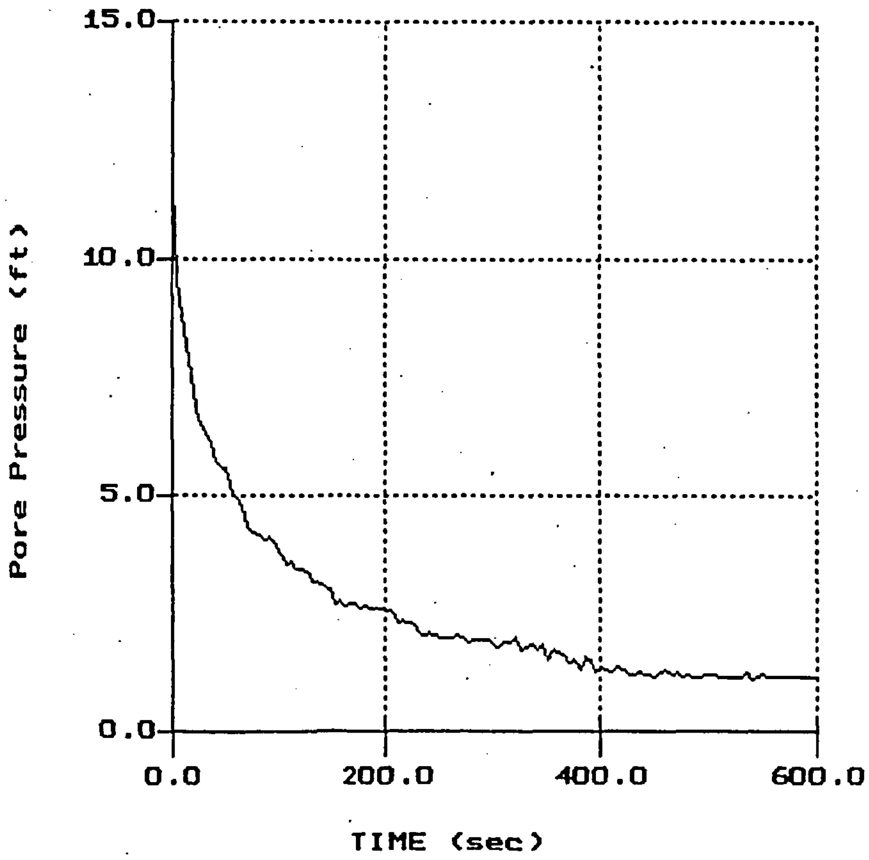
File: 432CP82.PPD
Depth (m): 22.05
(ft): 72.34
Duration : 2000.0s
U-min: 41.02 2000.0s
U-max: 689.52 0.0s

S.M. Stoller

Hole No.:CPT-0383
Location:ATLAS

Cone: 20 Ton St 183
Date:12:14:05 08:16

PORE PRESSURE DISSIPATION RECORD

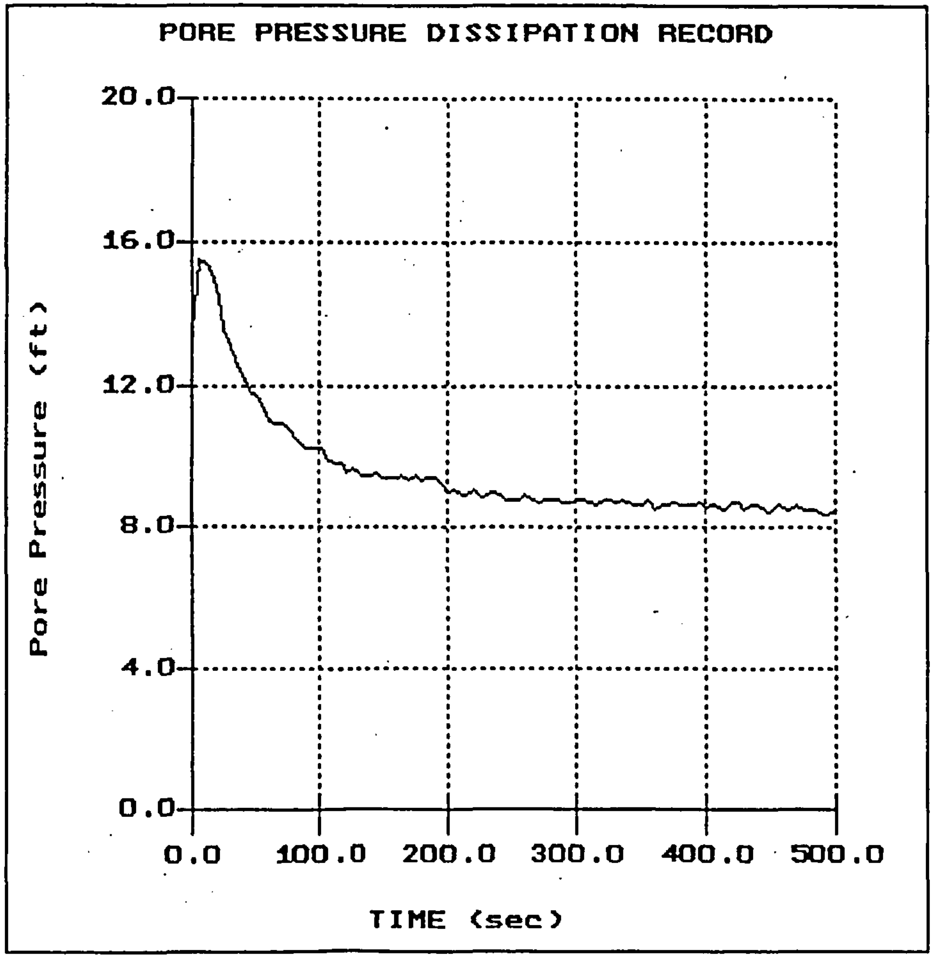


File: 432CP83.PPD
Depth (m): 4.75
(ft): 15.58
Duration : 600.0s
U-min: 1.08 540.0s
U-max: 11.64 0.0s

S.M. Stoller

Hole No.:CPT-0383
Location:ATLAS

Cone: 20 Ton St 183
Date:12:14:05 08:16

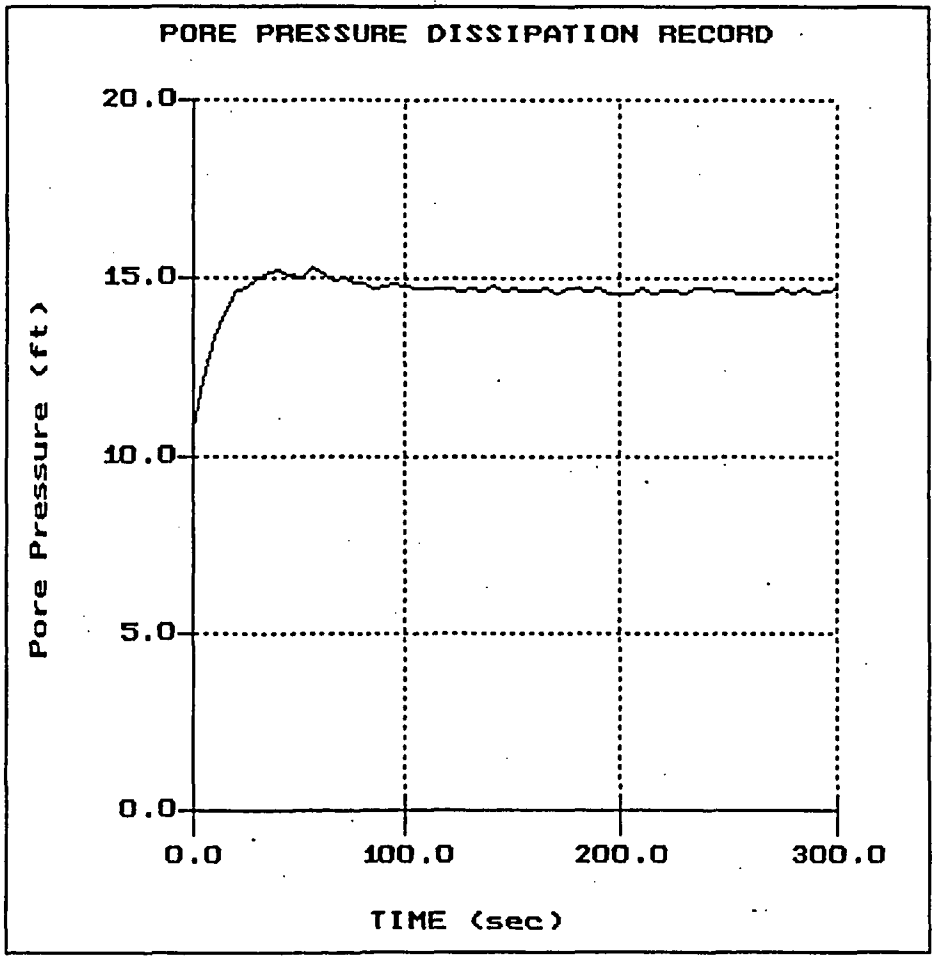

PORE PRESSURE DISSIPATION RECORD

File: 432CP83.PPD
Depth (m): 11.05
(ft): 36.25
Duration : 500.0s
U-min: 8.35 495.0s
U-max: 15.49 5.0s

S.M. Stoller

Hole No.:CPT-0383
Location:ATLAS

Cone: 20 Ton St 183
Date:12:14:05 08:16

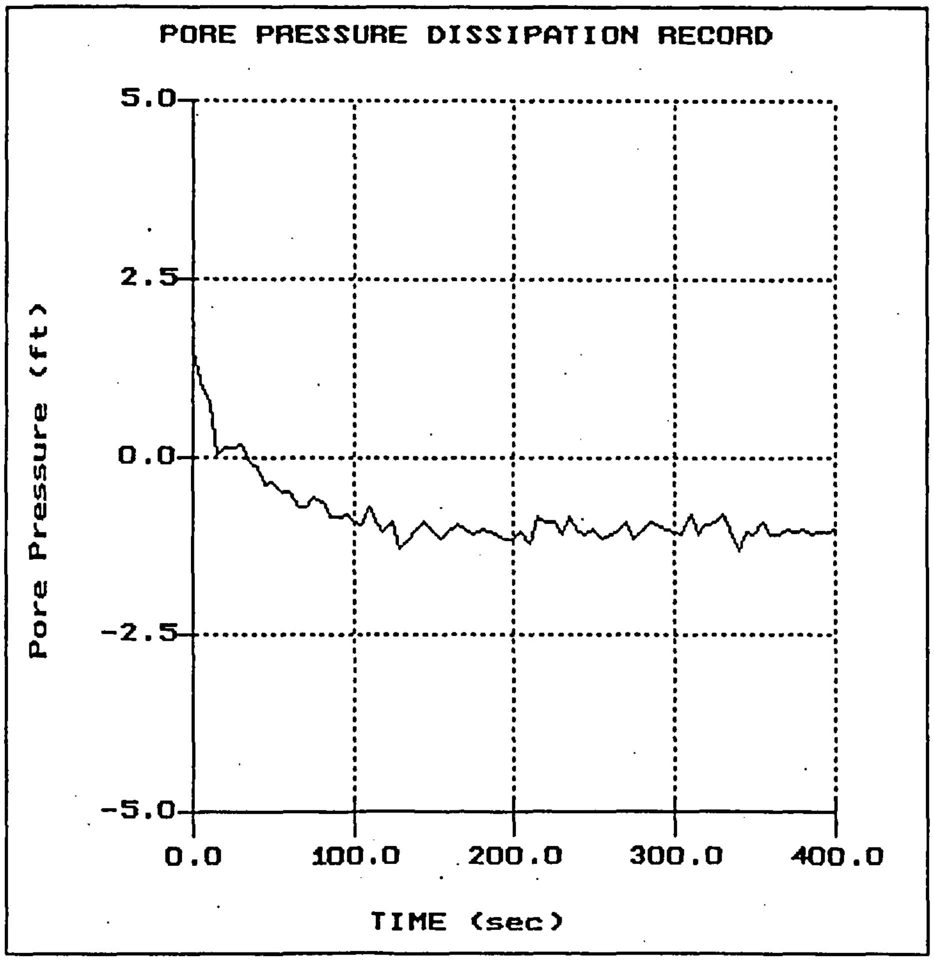


File: 432CP83.PPD
Depth (m): 17.30
(ft): 56.76
Duration : 300.0s
U-min: 10.75 0.0s
U-max: 15.25 55.0s

S.M. Stoller

Hole No.:CPT-0384
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 08:55



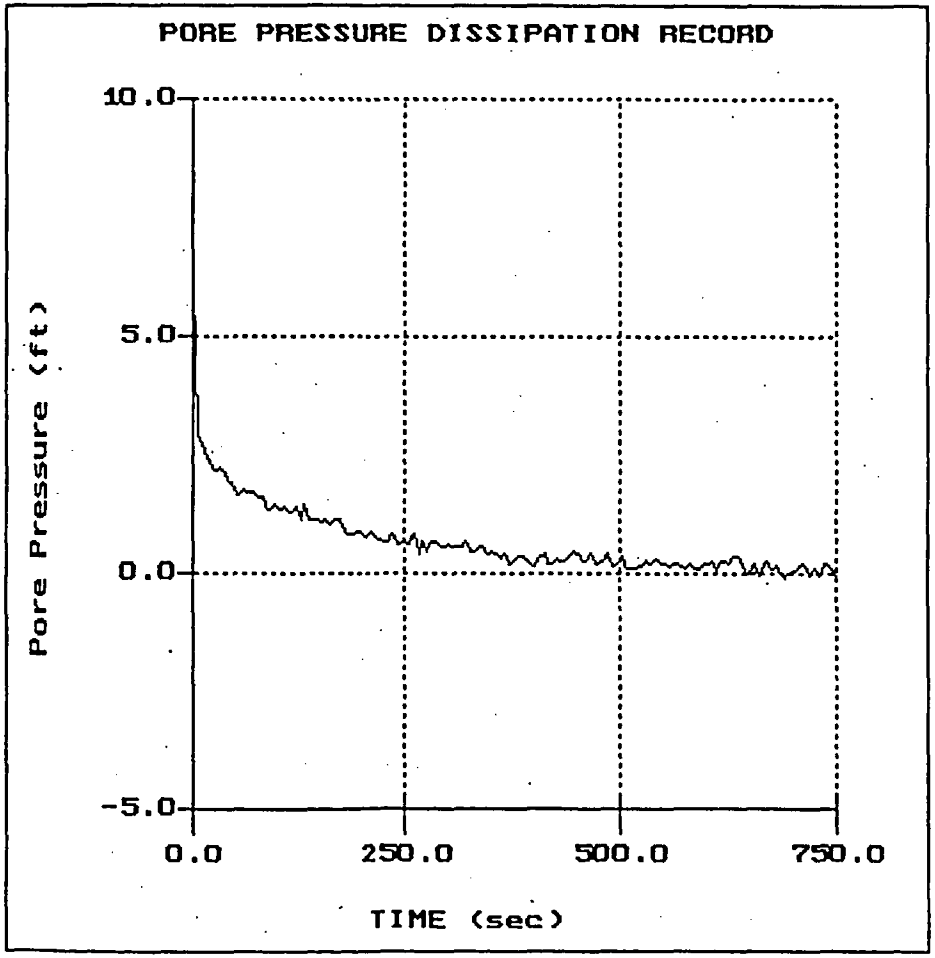
File: 432CP84.PPD
Depth (m): 3.10
(ft): 10.17
Duration : 405.0s
U-min: -1.31 340.0s
U-max: 1.50 0.0s

S.M. Stoller

Hole No.:CPT-0384
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 08:55

File: 432CP84.PPD
Depth (m): 5.60
(ft): 18.37
Duration : 750.0s
U-min: -0.09 750.0s
U-max: 6.24 0.0s



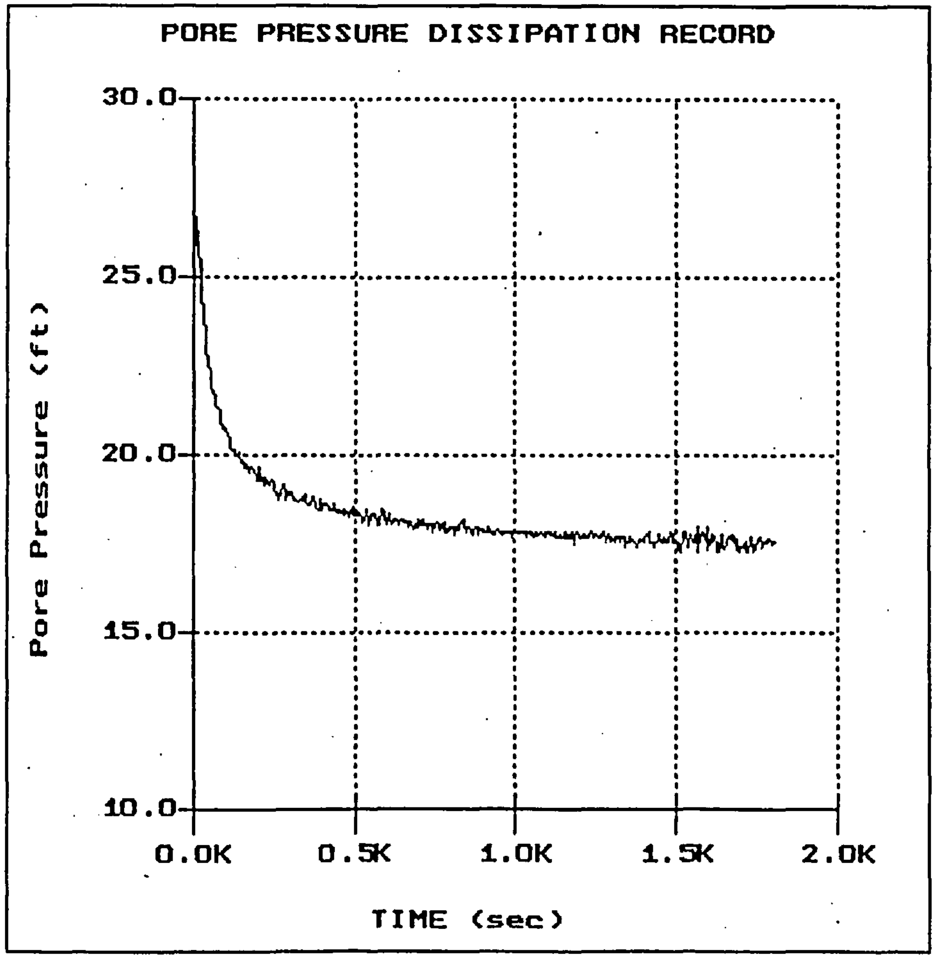
PORE PRESSURE DISSIPATION RECORD

S.M. Stoller

Hole No.:CPT-0384
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 08:55

File: 432CP84.PPD
Depth (m): 12.50
(ft): 41.01
Duration : 1805.0s
U-min: 17.27 1630.0s
U-max: 26.66 10.0s



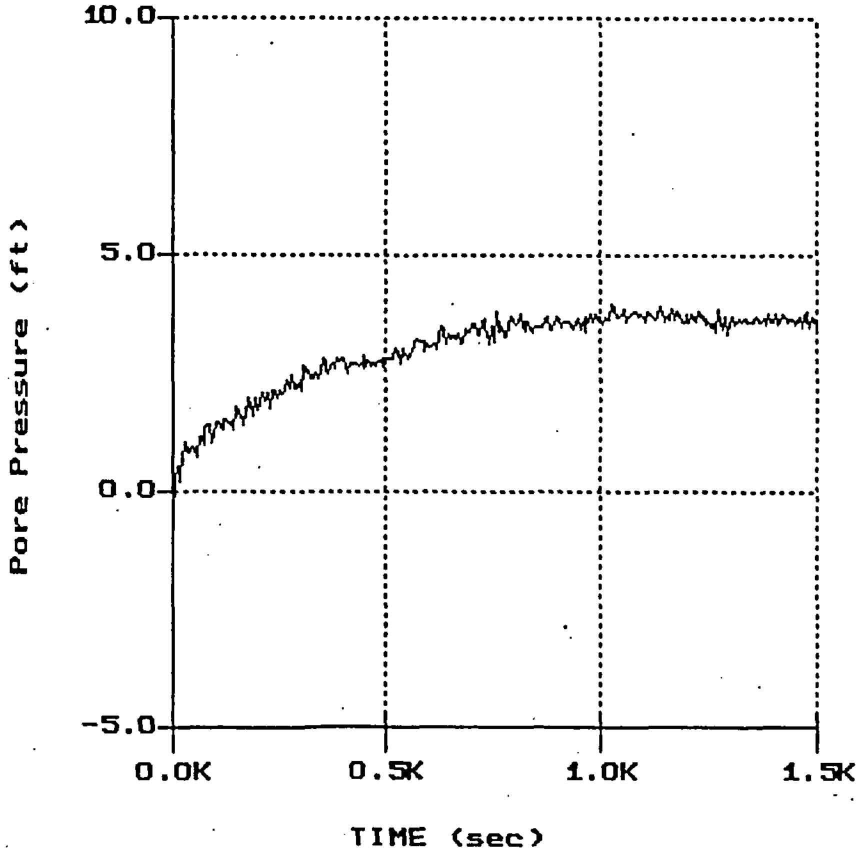
S.M. Stoller

Hole No.:CPT-0385
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 10:37

File: 432CP85.PPD
Depth (m): 2.85
(ft): 9.35
Duration : 1500.0s
U-min: -0.52 0.0s
U-max: 3.94 1025.0s

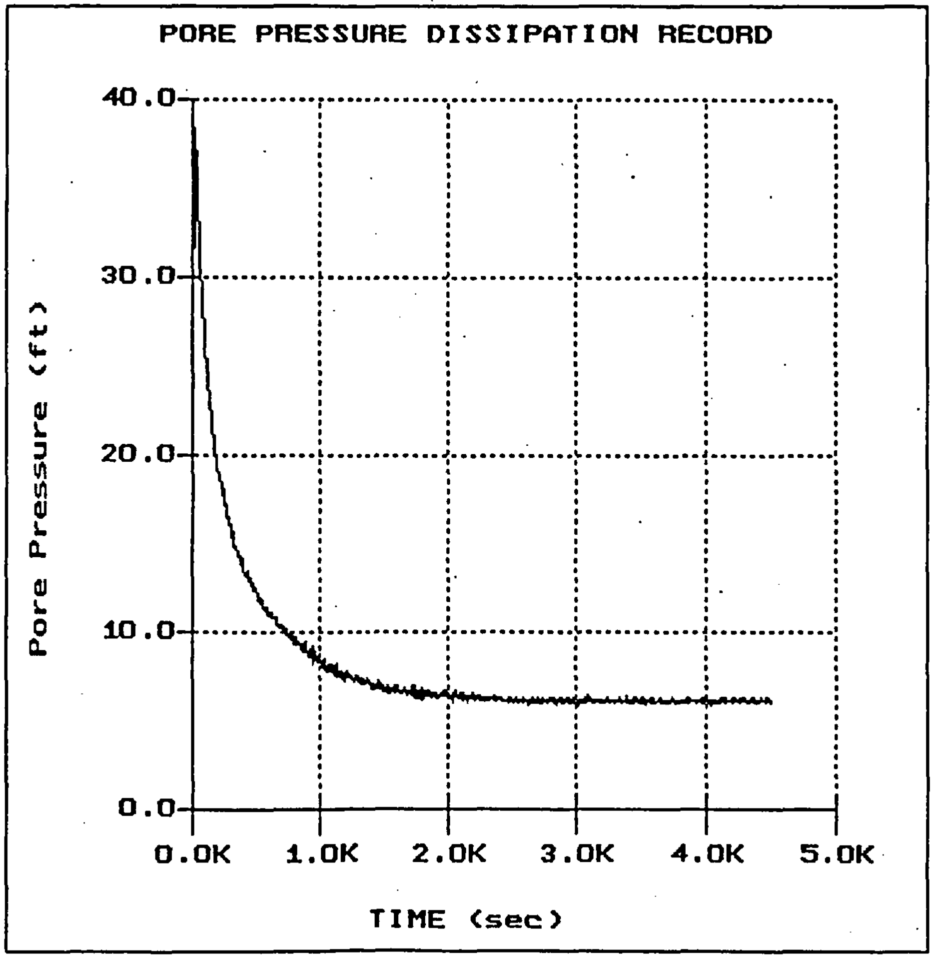
PORE PRESSURE DISSIPATION RECORD



S.M. Stoller

Hole No.:CPT-0385
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 10:37

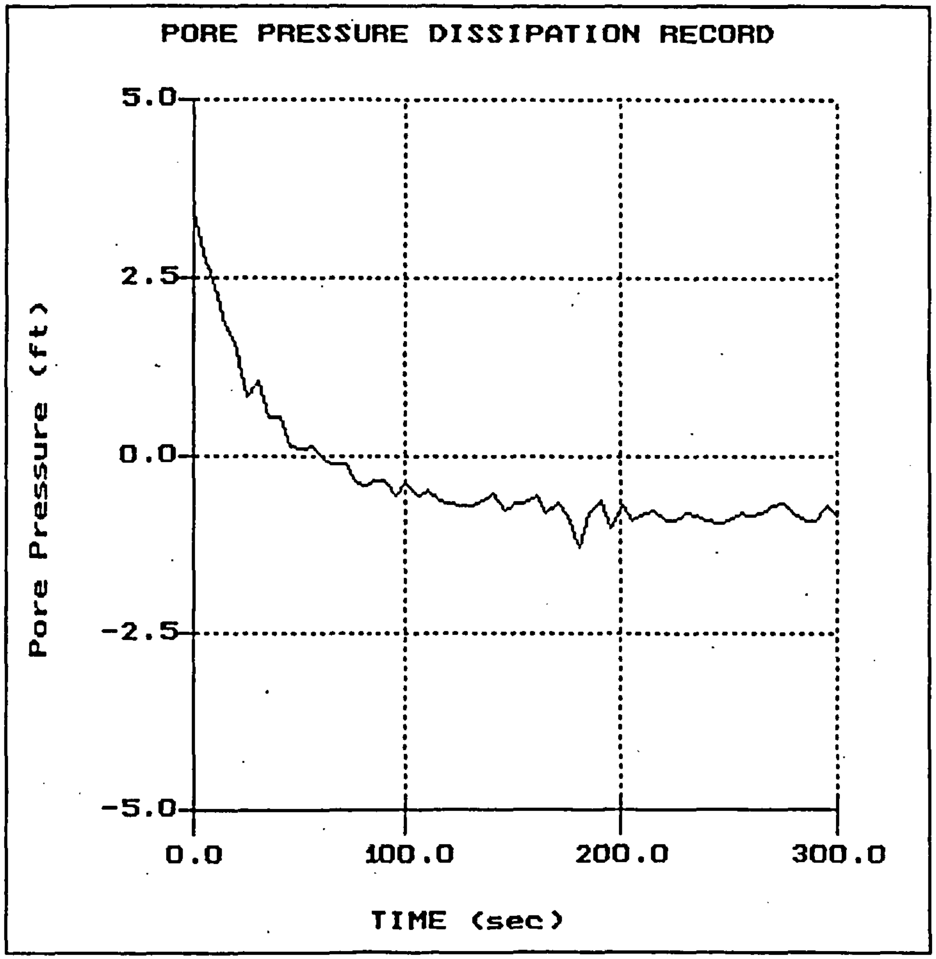


File: 432CP85.PPD
Depth (m): 16.60
(ft): 54.46
Duration : 4500.0s
U-min: 5.82 2845.0s
U-max: 38.39 20.0s

S.M. Stoller

Hole No.:CPT-0385
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 10:37

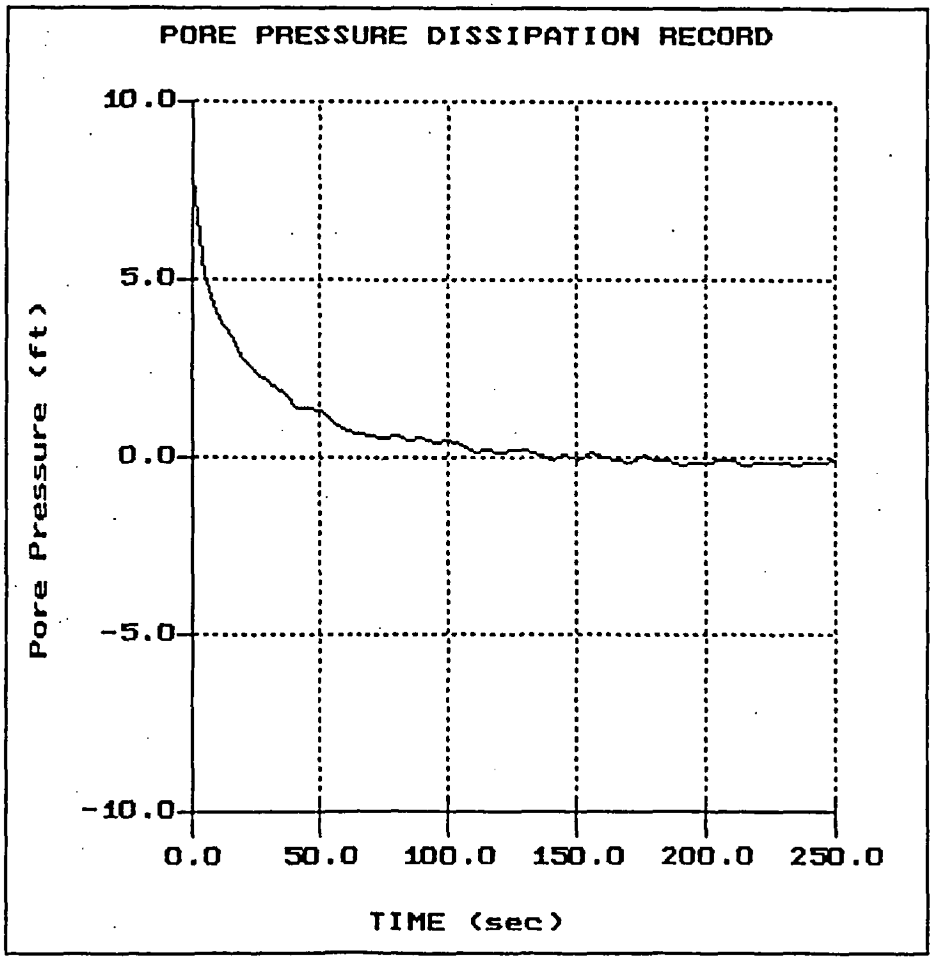


File: 432CP85.PPD
Depth (m): 18.20
(ft): 59.71
Duration : 325.0s
U-min: -1.27 180.0s
U-max: 3.43 0.0s

S.M. Stoller

Hole No.:CPT-0386
Location:ATLAS

Cone: 20 Ton St 183
Date:12:14:05 14:53



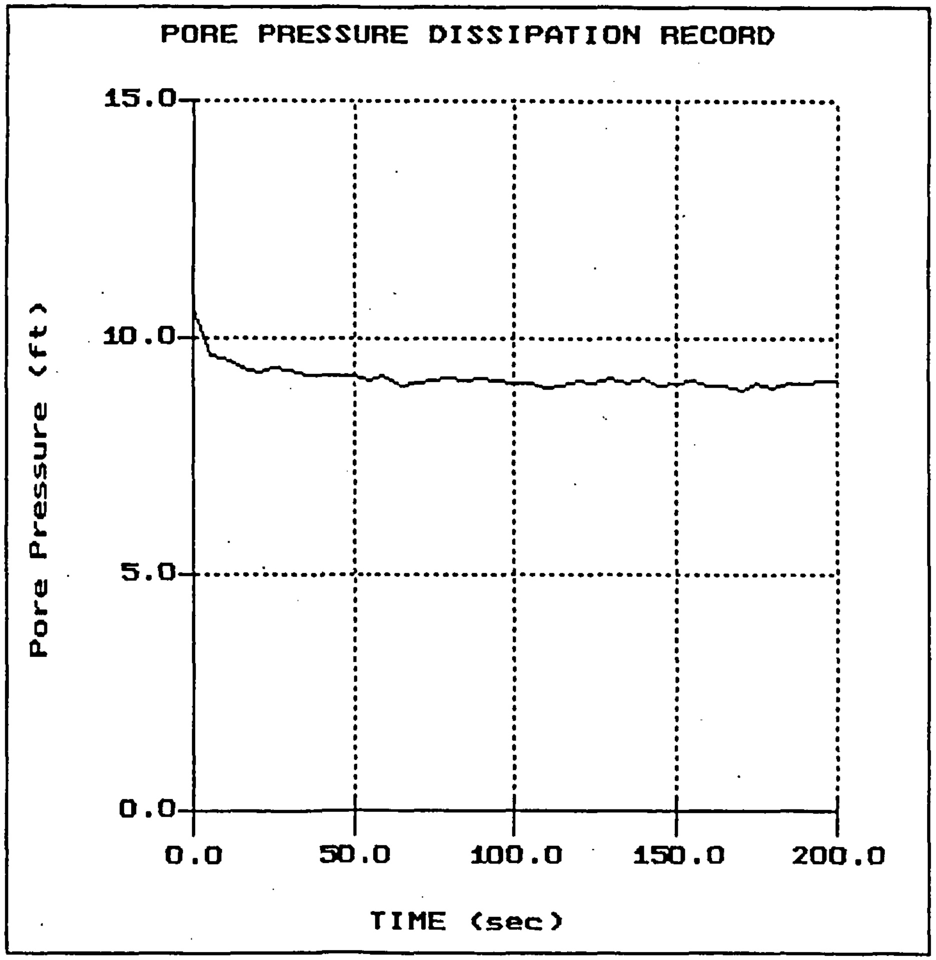
PORE PRESSURE DISSIPATION RECORD

File: 432CP86.PPD
Depth (m): 4.90
(ft): 16.08
Duration : 250.0s
U-min: -0.23 235.0s
U-max: 7.84 0.0s

S.M. Stoller

Hole No.:CPT-0386
Location:ATLAS

Cone: 20 Ton St 183
Date:12:14:05 14:53

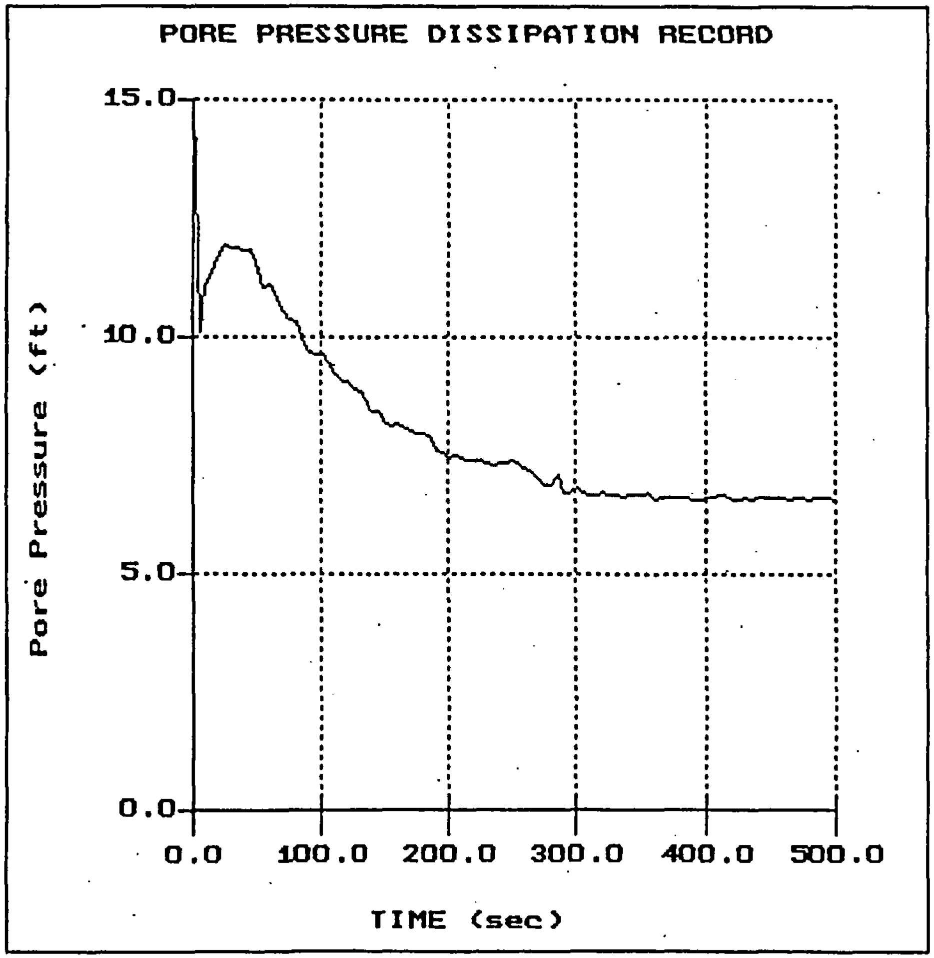


File: 432CP86.PPD
Depth (m): 10.65
(ft): 34.94
Duration : 200.0s
U-min: 8.92 170.0s
U-max: 10.61 0.0s

S.M. Stoller

Hole No.:CPT-0386
Location:ATLAS

Cone: 20 Ton St 183
Date:12:14:05 14:53



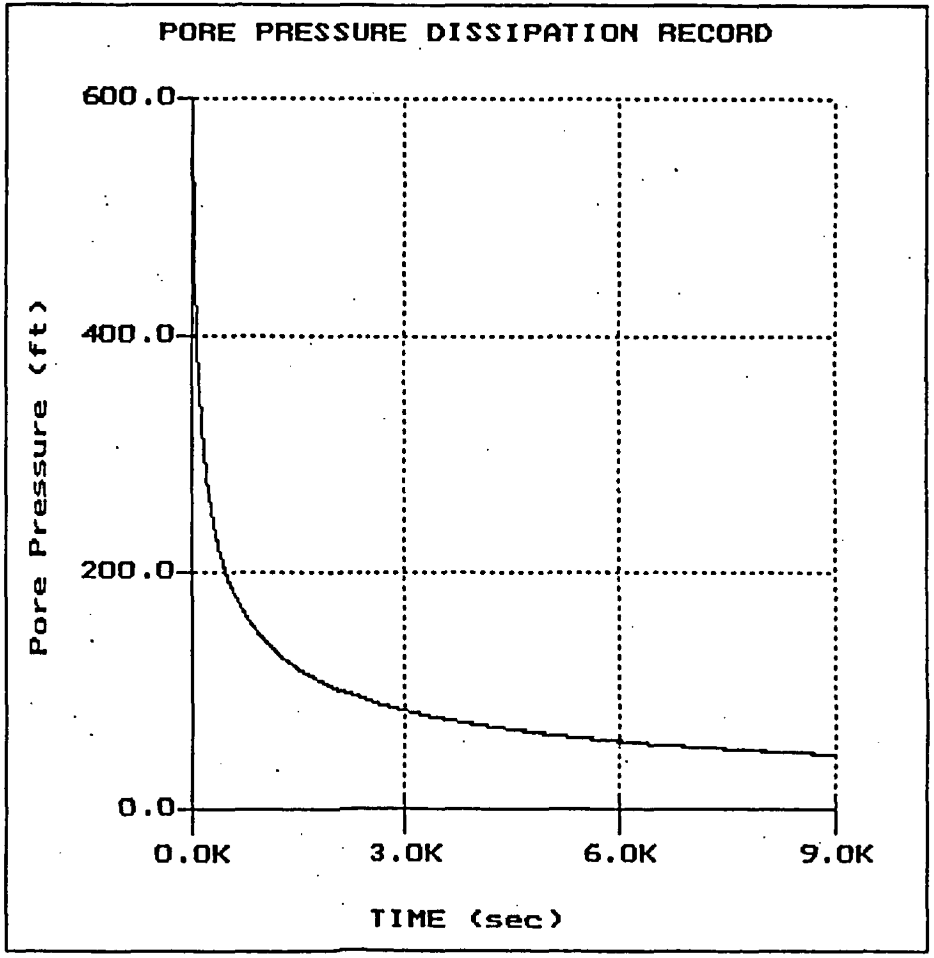
File: 432CP86.PPD
Depth (m): 19.90
(ft): 65.29
Duration : 500.0s
U-min: 6.57 500.0s
U-max: 16.38 0.0s

S.M. Stoller

Hole No.:CPT-0387
Location:ATLAS

Cone: 20 Ton St 183
Date:12:16:05 13:40

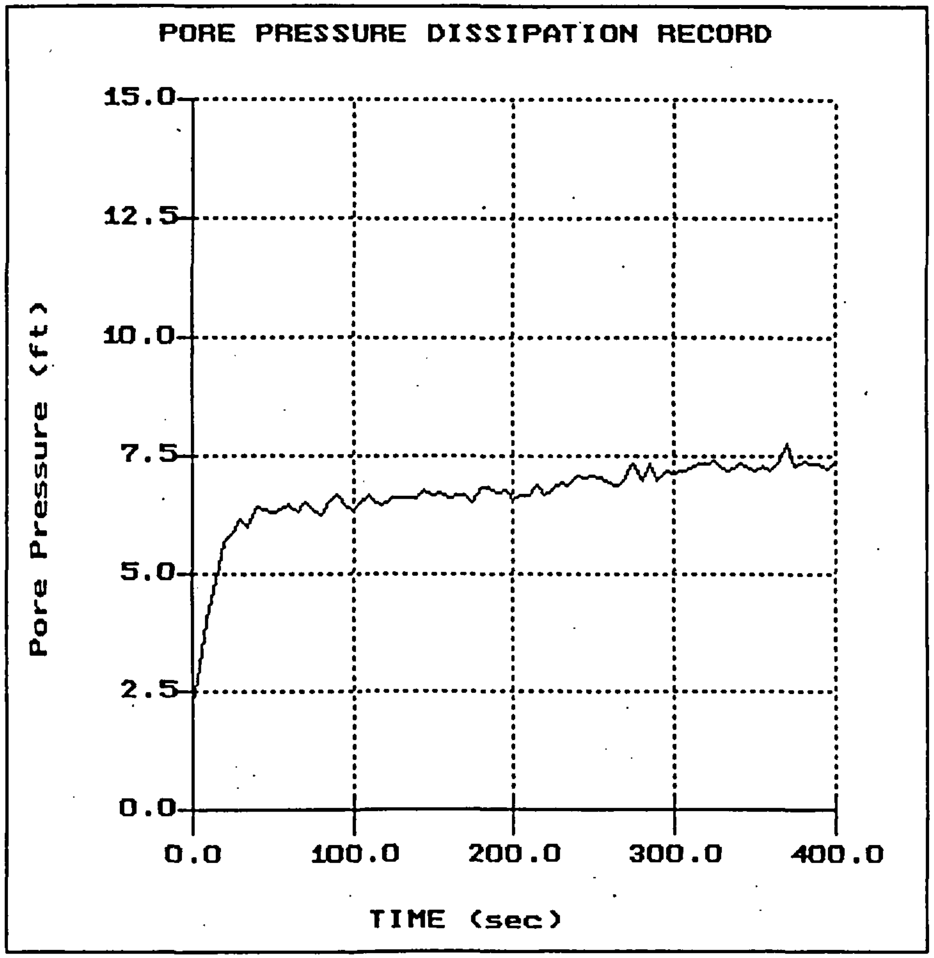
File: 432CP87.PPD
Depth (m): 17.80
(ft): 58.40
Duration : 9000.0s
U-min: 45.90 8995.0s
U-max: 632.93 0.0s



S.M. Stoller

Hole No.:CPT-0388
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 07:45

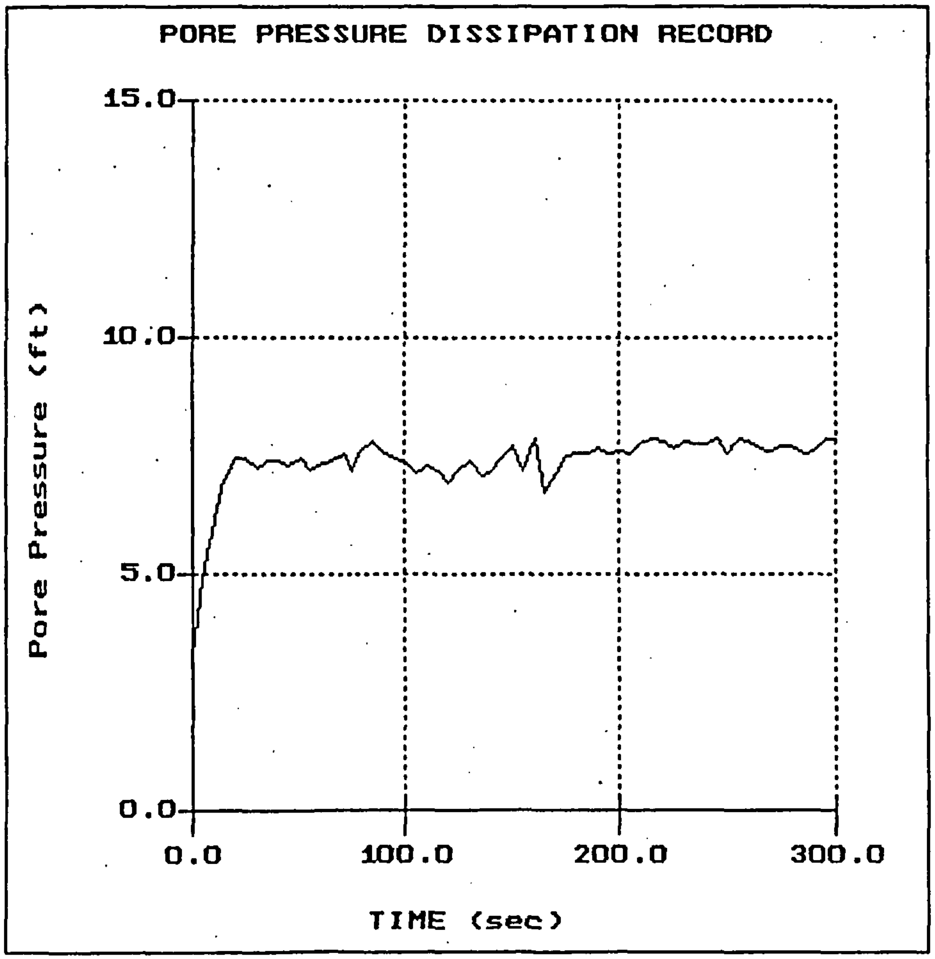


File: 432CP88.PPD
Depth (m): 3.15
(ft): 10.33
Duration : 400.0s
U-min: 2.25 0.0s
U-max: 7.74 370.0s

S.M. Stoller

Hole No.:CPT-0388
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 07:45

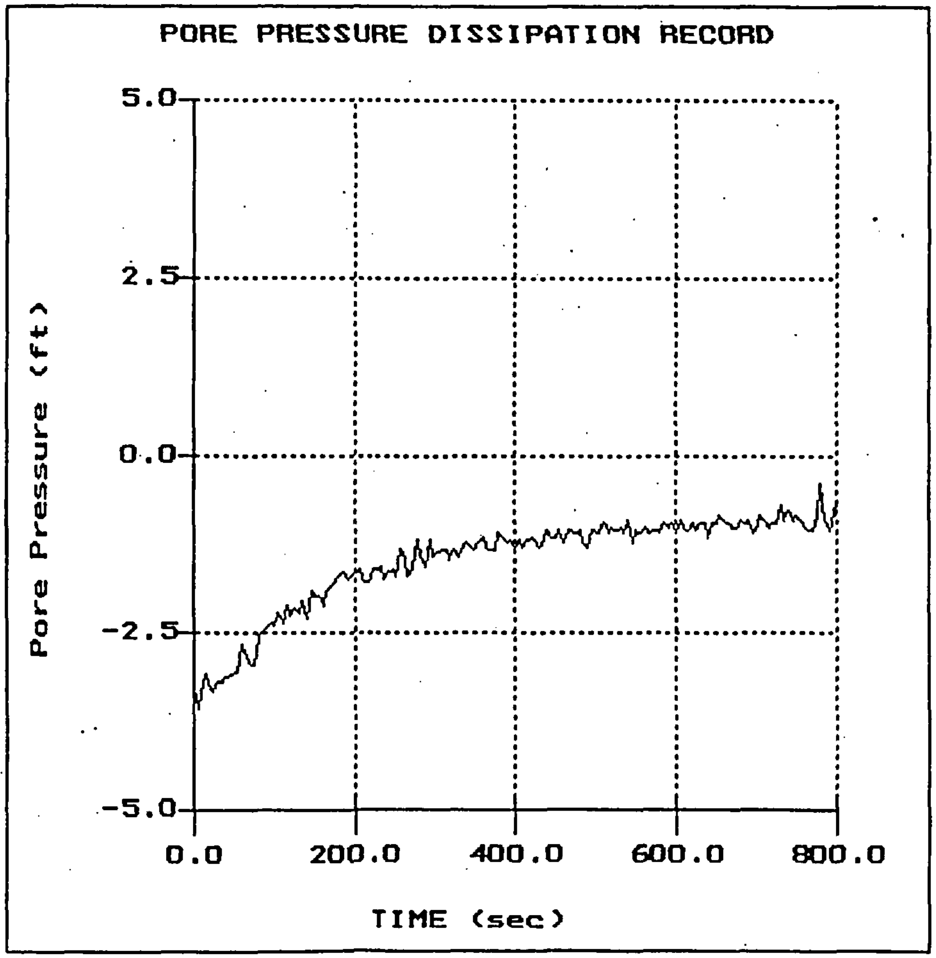


File: 432CP88.PPD
Depth (m): 16.15
(ft): 52.99
Duration : 300.0s
U-min: 3.24 0.0s
U-max: 7.88 295.0s

S.M. Stoller

Hole No.:CPT-0389
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 13:19

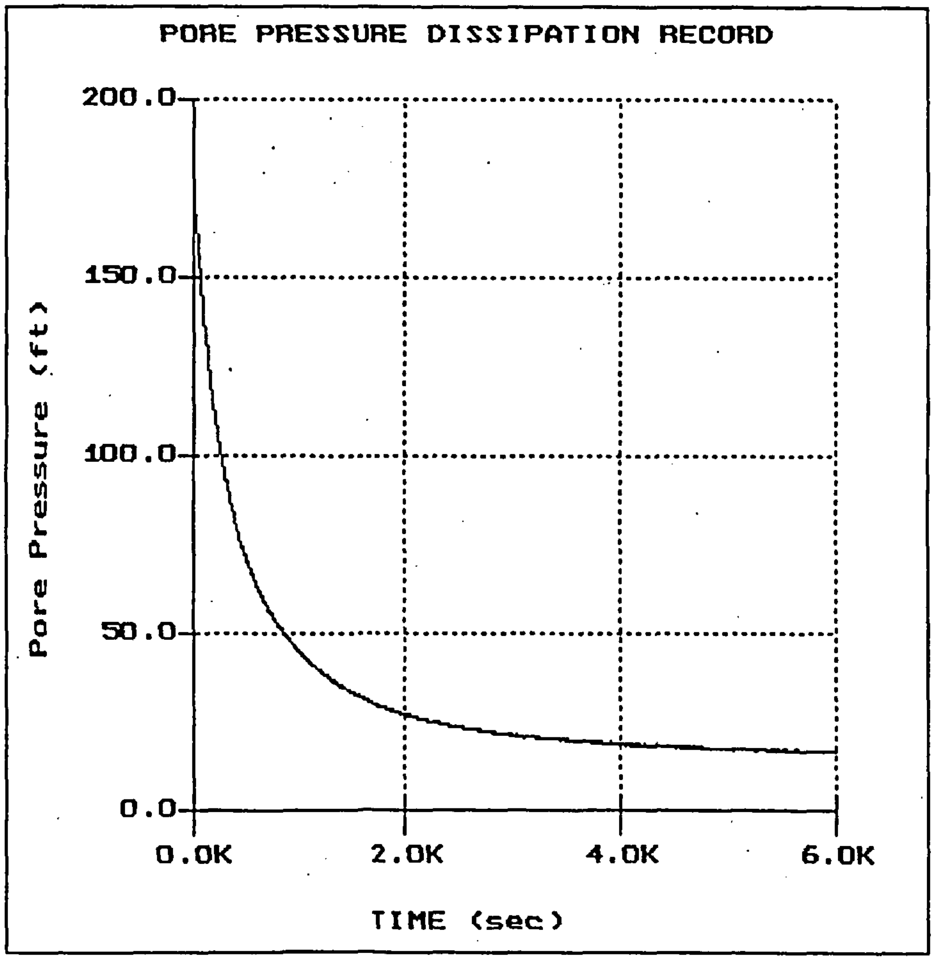


File: 432CP89.PPD
Depth (m): 3.60
(ft): 11.81
Duration : 805.0s
U-min: -3.57 5.0s
U-max: -0.38 780.0s

S.M. Stoller

Hole No.:CPT-0389
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 13:19

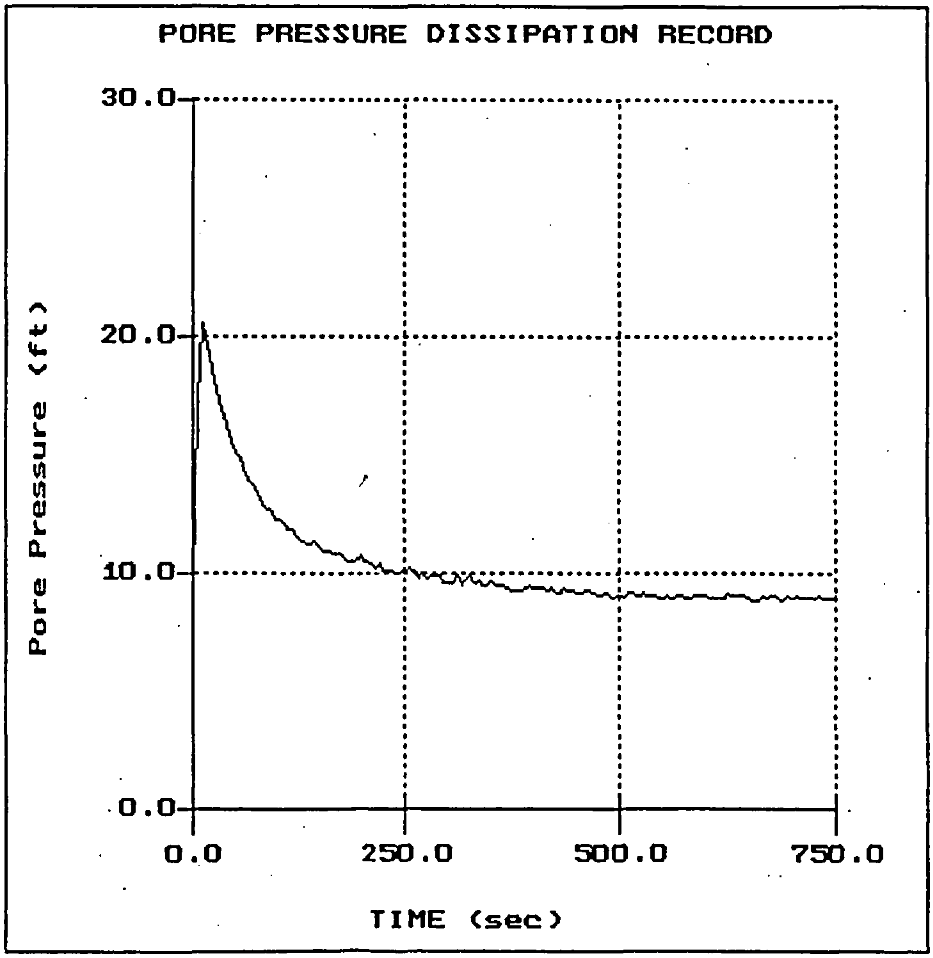


File: 432CP89.PPD
Depth (m): 16.65
(ft): 54.63
Duration : 6000.0s
U-min: 16.43 5880.0s
U-max: 167.07 15.0s

S.M. Stoller

Hole No.:CPT-0389
Location:ATLAS

Cone: 20 Ton St 183
Date:12:17:05 13:19

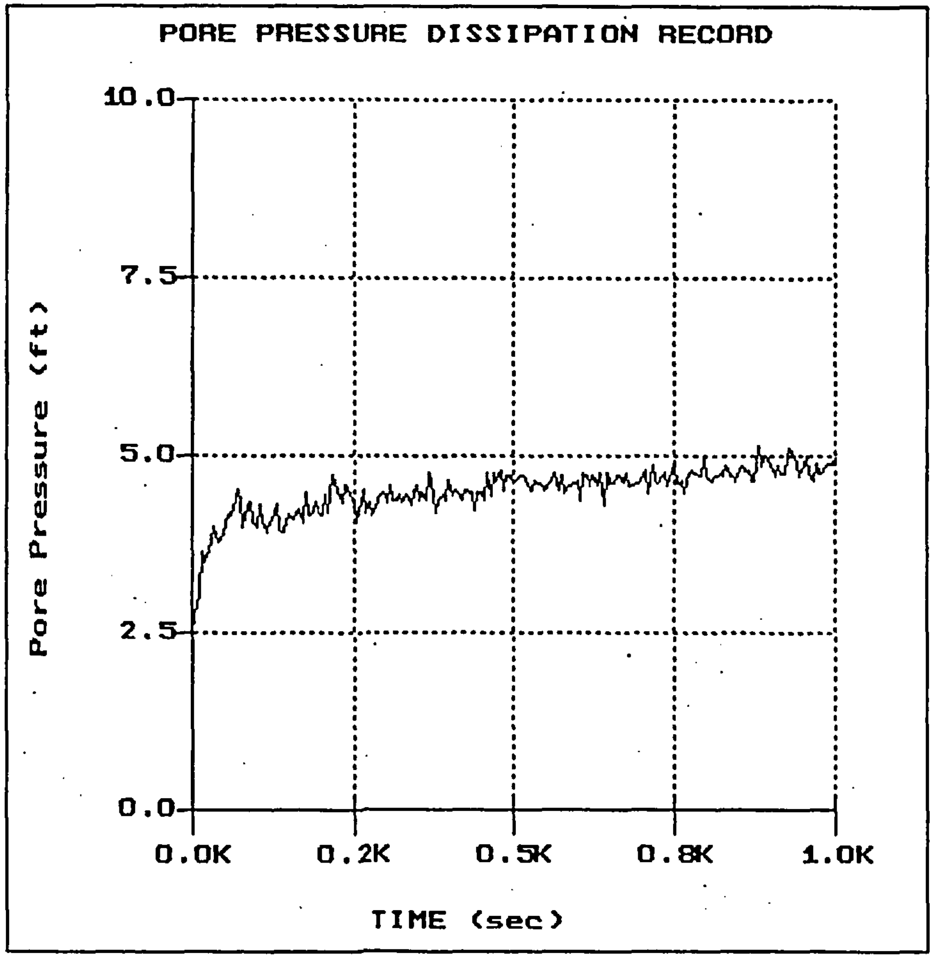


File: 432CP89.PPD
Depth (m): 18.15
(ft): 59.55
Duration : 750.0s
U-min: 8.82 660.0s
U-max: 20.51 10.0s

S.M. Stoller

Hole No.:CPT-0390
Location:ATLAS

Cone: 20 Ton St 183
Date:12:18:05 08:29

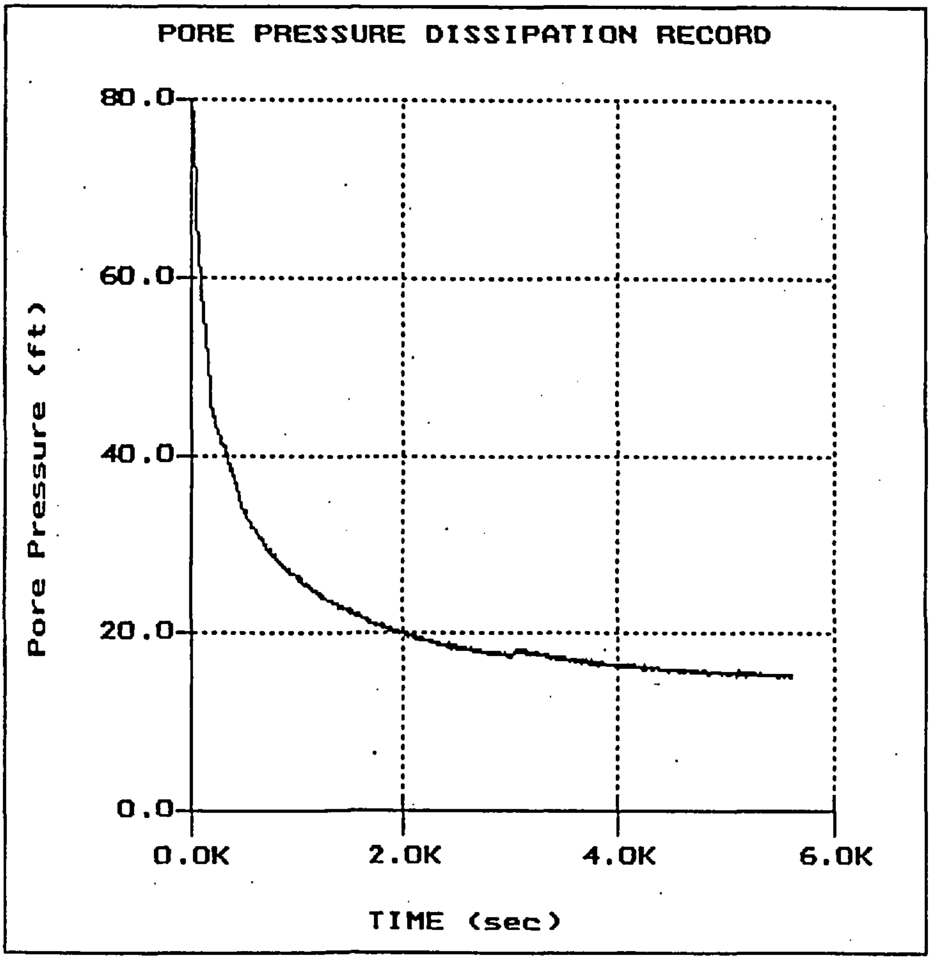


File: 432CP90.PPD
Depth (m): 4.00
(ft): 13.12
Duration : 1010.0s
U-min: 2.51 0.0s
U-max: 5.13 880.0s

S.M. Stoller

Hole No.:CPT-0390
Location:ATLAS

Cone: 20 Ton St 183
Date:12:18:05 08:29

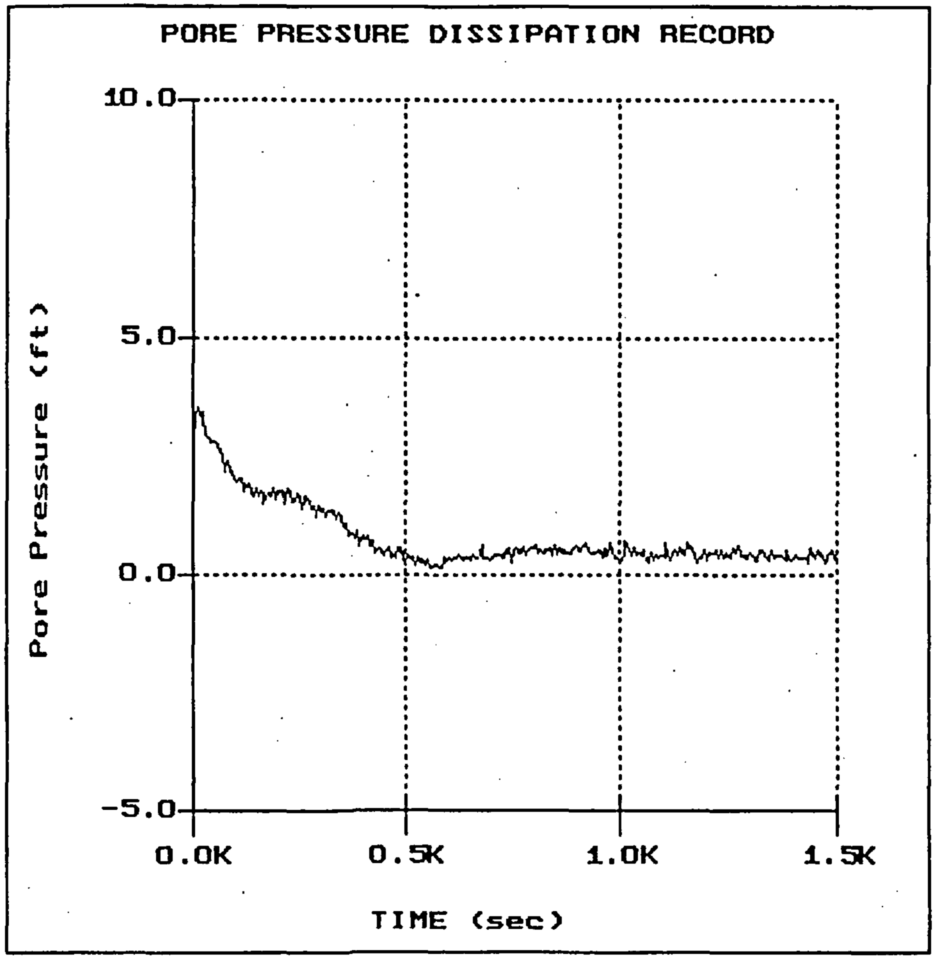

PORE PRESSURE DISSIPATION RECORD

File: 432CP90.PPD
Depth (m): 9.70
(ft): 31.82
Duration : 5600.0s
U-min: 15.08 5600.0s
U-max: 78.53 15.0s

S.M. Stoller

Hole No.:CPT-0390
Location:ATLAS

Cone: 20 Ton St 183
Date:12:18:05 08:29

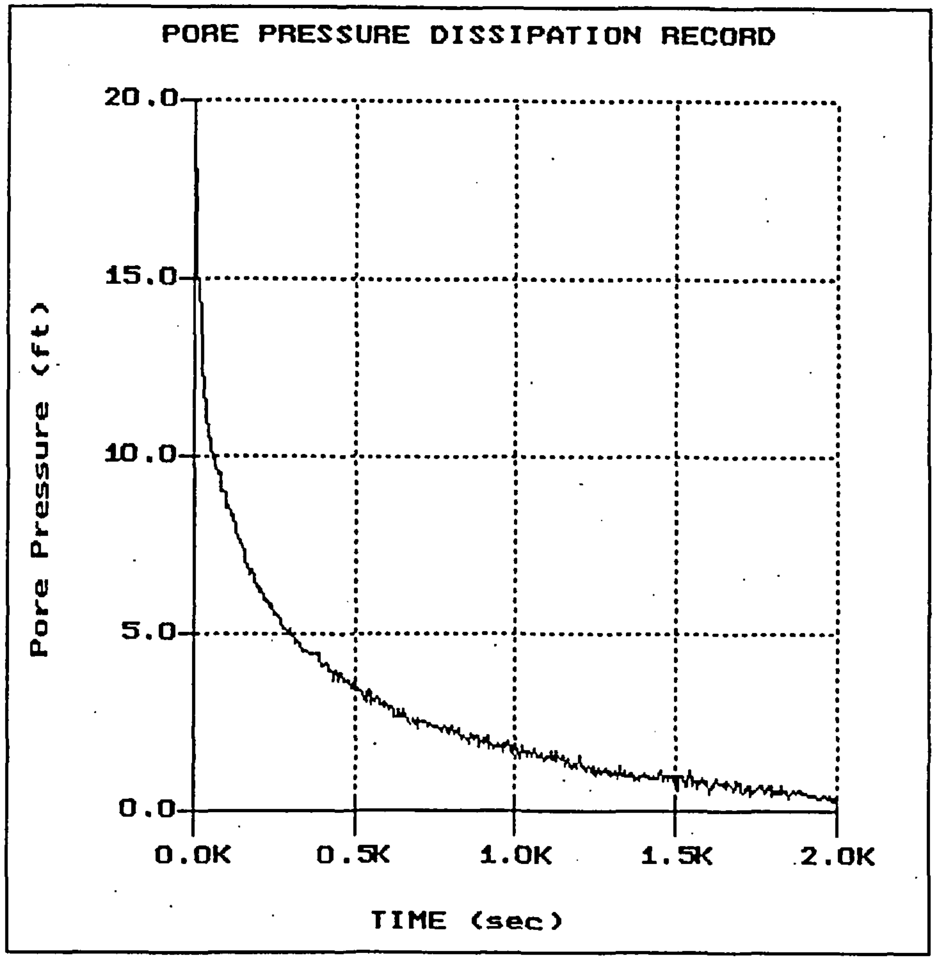


File: 432CP90.PPD
Depth (m): 15.35
(ft): 50.36
Duration : 1500.0s
U-min: 0.16 580.0s
U-max: 3.54 10.0s

S.M. Stoller

Hole No.:oCPT-0391
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 10:21

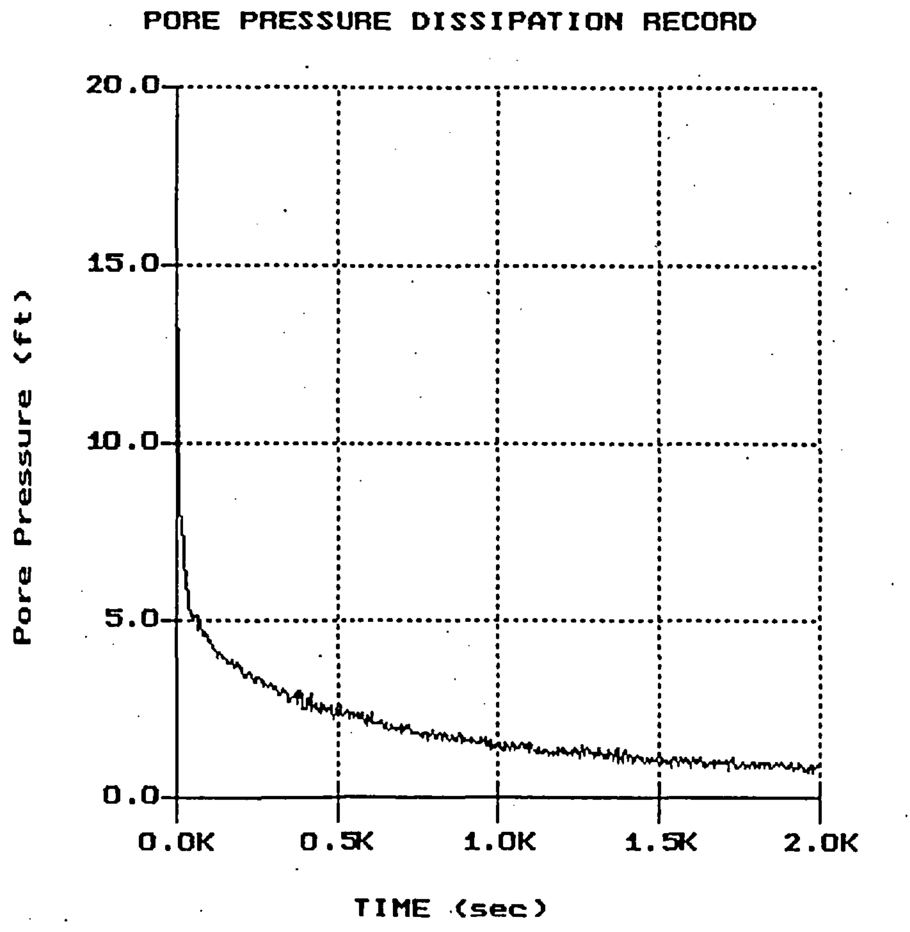


File: 432CP91.PPD
Depth (m): 6.05
(ft): 19.85
Duration : 2000.0s
U-min: 0.30 1995.0s
U-max: 18.72 0.0s

S.M. Stoller

Hole No.:oCPT-0391
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 10:21



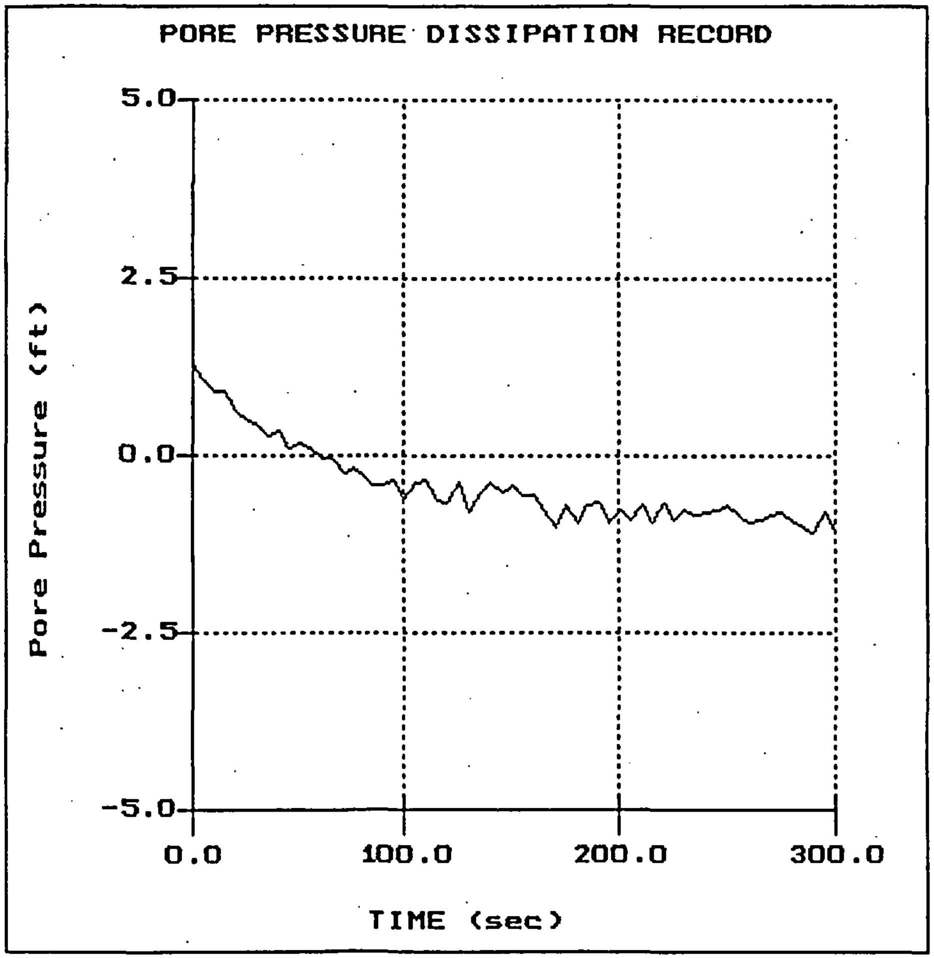
PORE PRESSURE DISSIPATION RECORD

File: 432CP91.PPD
Depth (m): 16.05
(ft): 52.66
Duration : 2000.0s
U-min: 0.66 1975.0s
U-max: 17.88 0.0s

S.M. Stoller

Hole No.:oCPT-0391
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 10:21



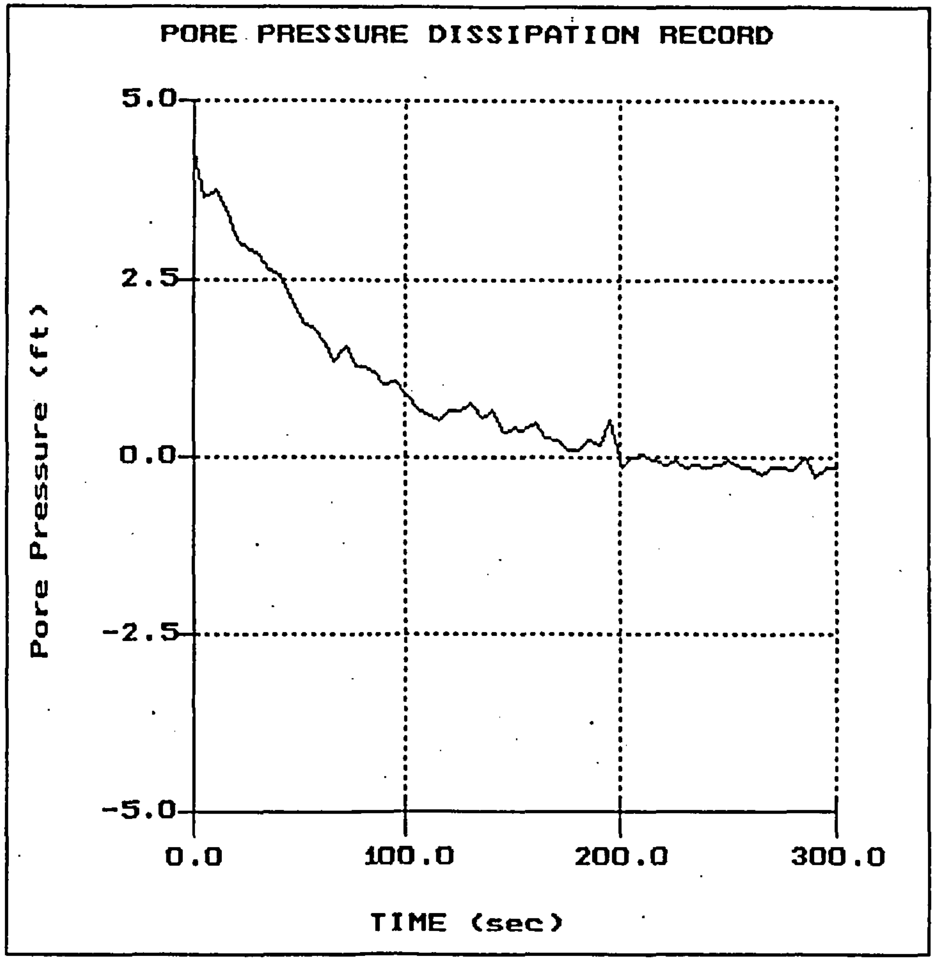
PORE PRESSURE DISSIPATION RECORD

File: 432CP91.PPD
Depth (m): 18.30
(ft): 60.04
Duration : 300.0s
U-min: -1.08 290.0s
U-max: 1.27 0.0s

S.M. Stoller

Hole No.:CPT-0392
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 12:38

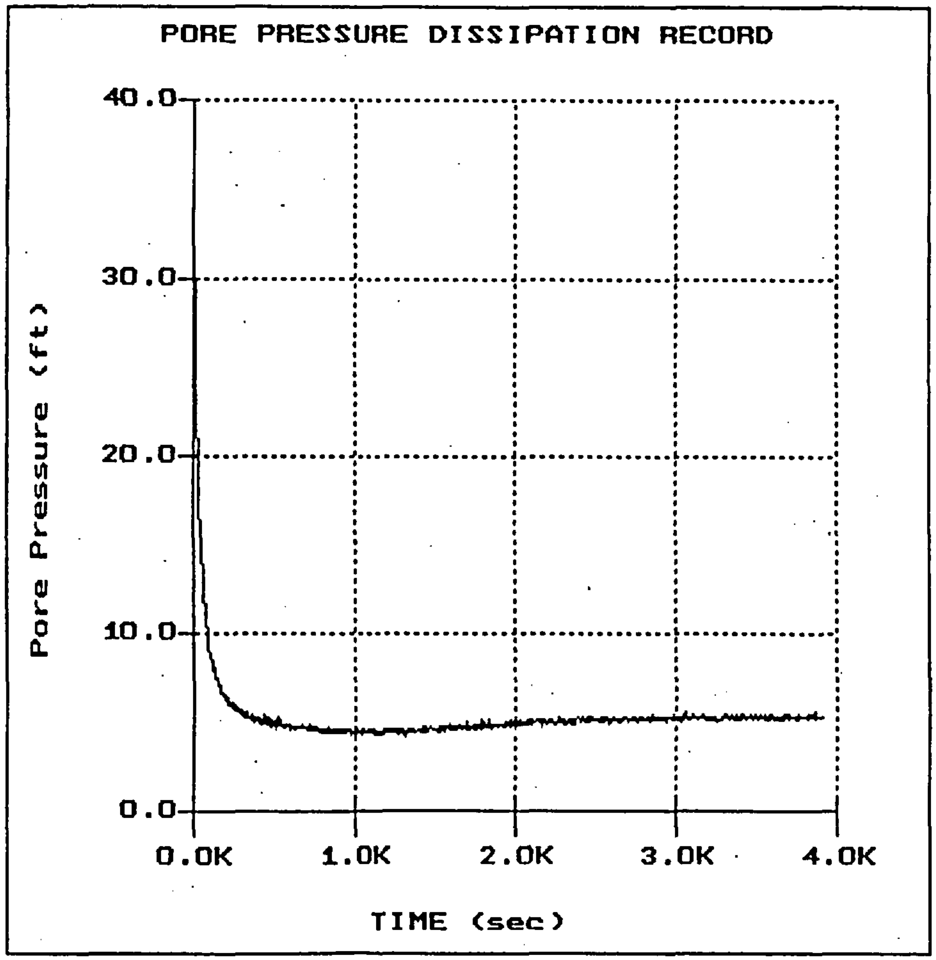


File: 432CP92.PPD
Depth (m): 3.05
(ft): 10.01
Duration : 305.0s
U-min: -0.28 290.0s
U-max: 4.32 0.0s

S.M. Stoller

Hole No.:CPT-0392
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 12:38



File: 432CP92.PPD
Depth (m): 6.25
(ft): 20.51
Duration : 3915.0s
U-min: 4.22 1330.0s
U-max: 30.74 5.0s

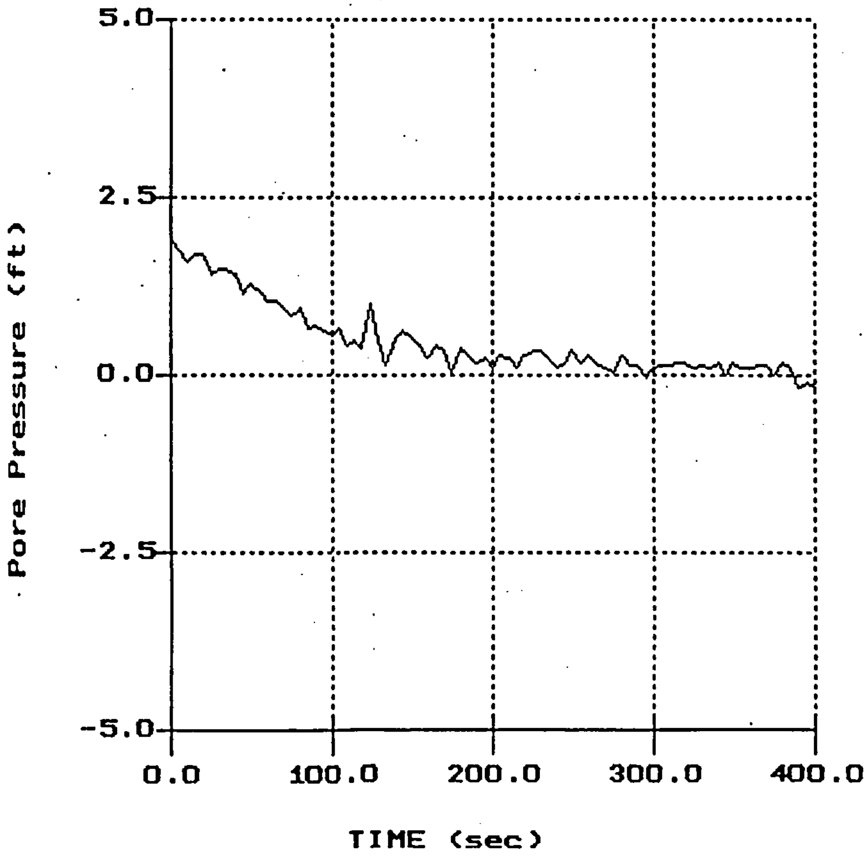
S.M. Stoller

Hole No.:CPT-0392
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 12:38

File: 432CP92.PPD
Depth (m): 9.15
(ft): 30.02
Duration : 400.0s
U-min: -0.19 400.0s
U-max: 1.92 0.0s

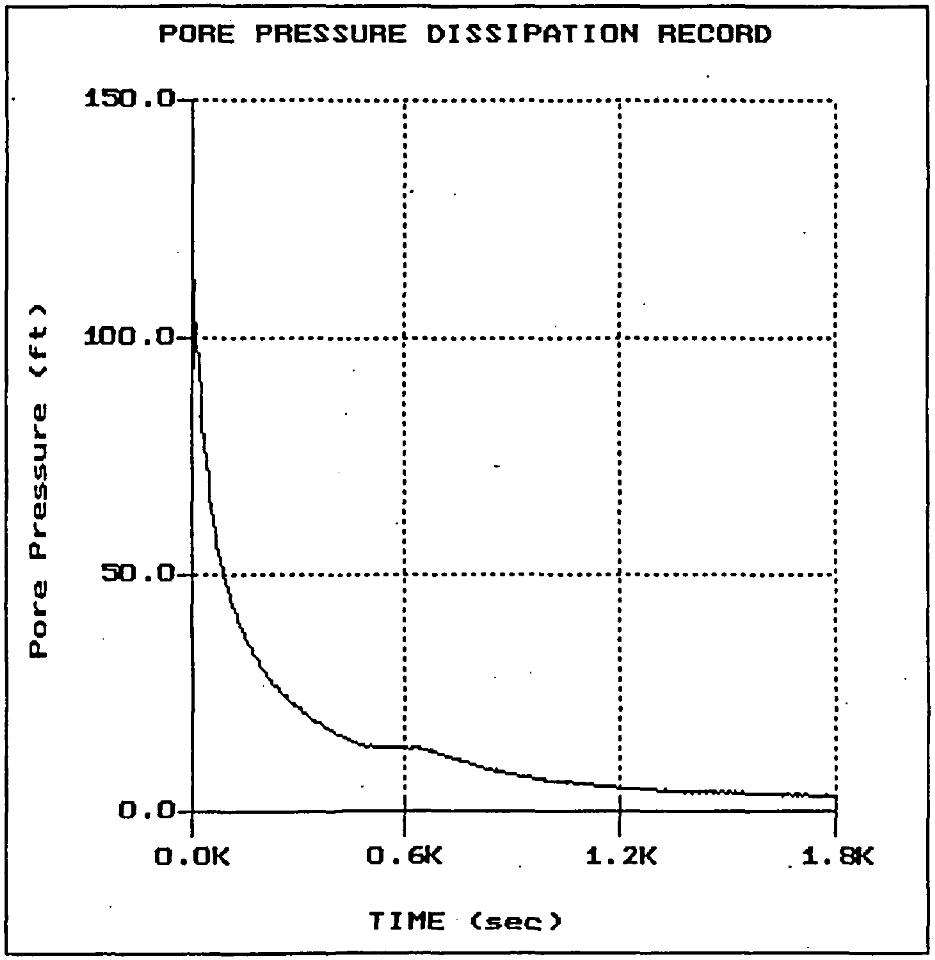
PORE PRESSURE DISSIPATION RECORD



S.M. Stoller

Hole No.:CPT-0393
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 14:40



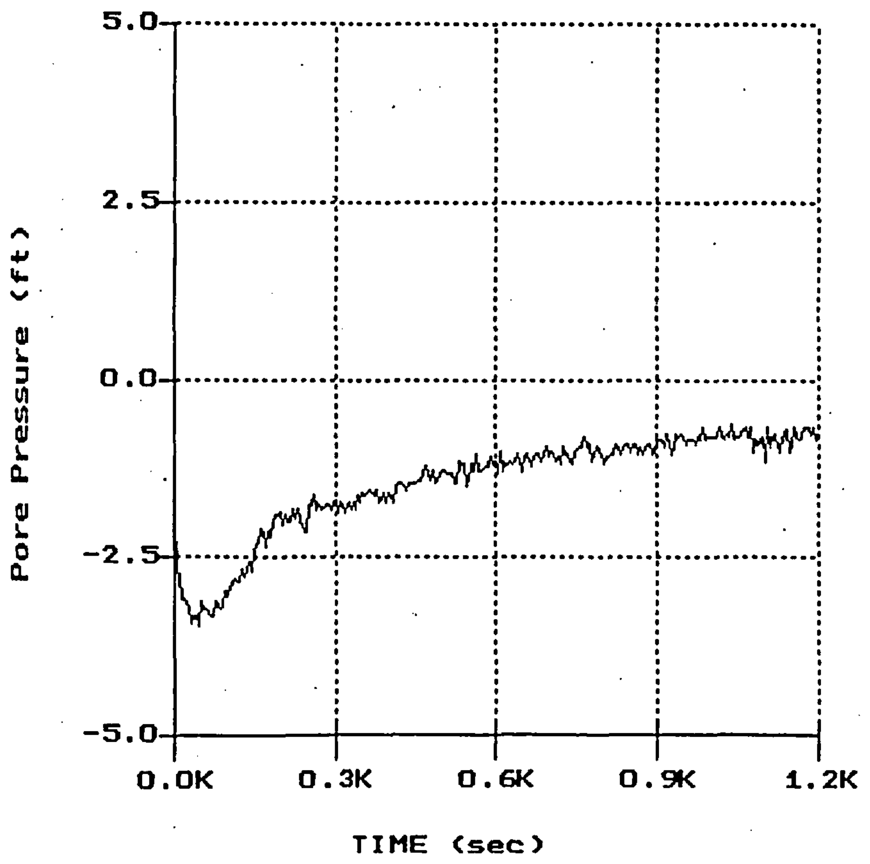
File: 432CP93.PPD
Depth (m): 2.90
(ft): 9.51
Duration : 1800.0s
U-min: 3.19 1735.0s
U-max: 112.11 5.0s

S.M. Stoller

Hole No.:CPT-0393
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 14:40

PORE PRESSURE DISSIPATION RECORD



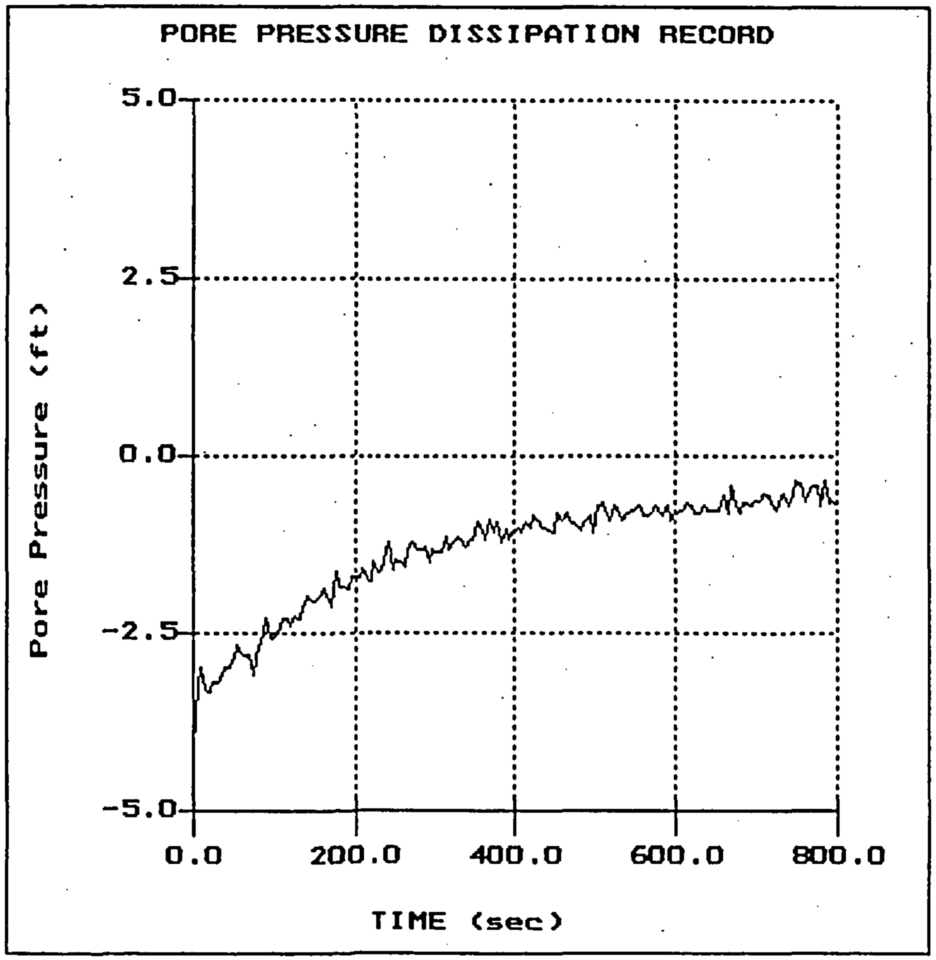
File: 432CP93.PPD
Depth (m): 6.10
(ft): 20.01
Duration : 1200.0s
U-min: -3.47 45.0s
U-max: -0.61 1040.0s

S.M. Stoller

Hole No.:CPT-0393
Location:ATLAS

Cone: 20 Ton St 183
Date:12:15:05 14:40

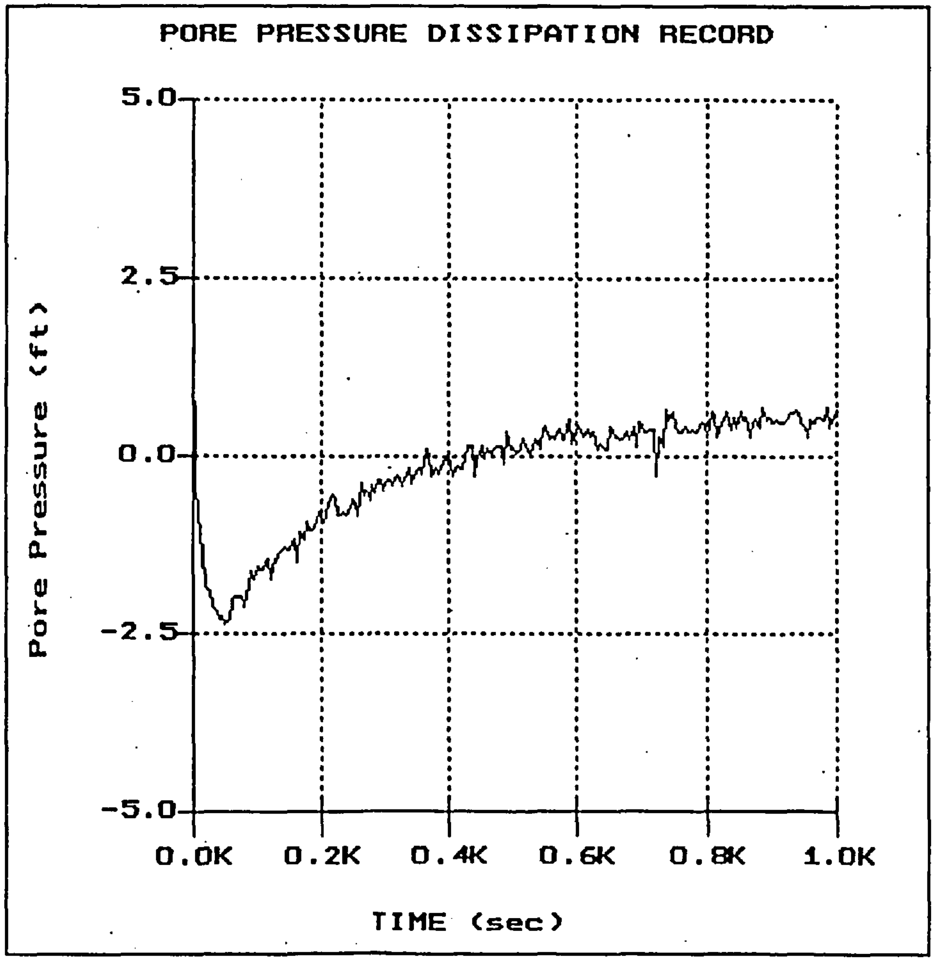
File: 432CP93.PPD
Depth (m): 9.15
(ft): 30.02
Duration : 800.0s
U-min: -4.13 0.0s
U-max: -0.33 785.0s



S.M. Stoller

Hole No.:CPT-0394
Location:ATLAS

Cone: 20 Ton St 183
Date:12:16:05 07:50

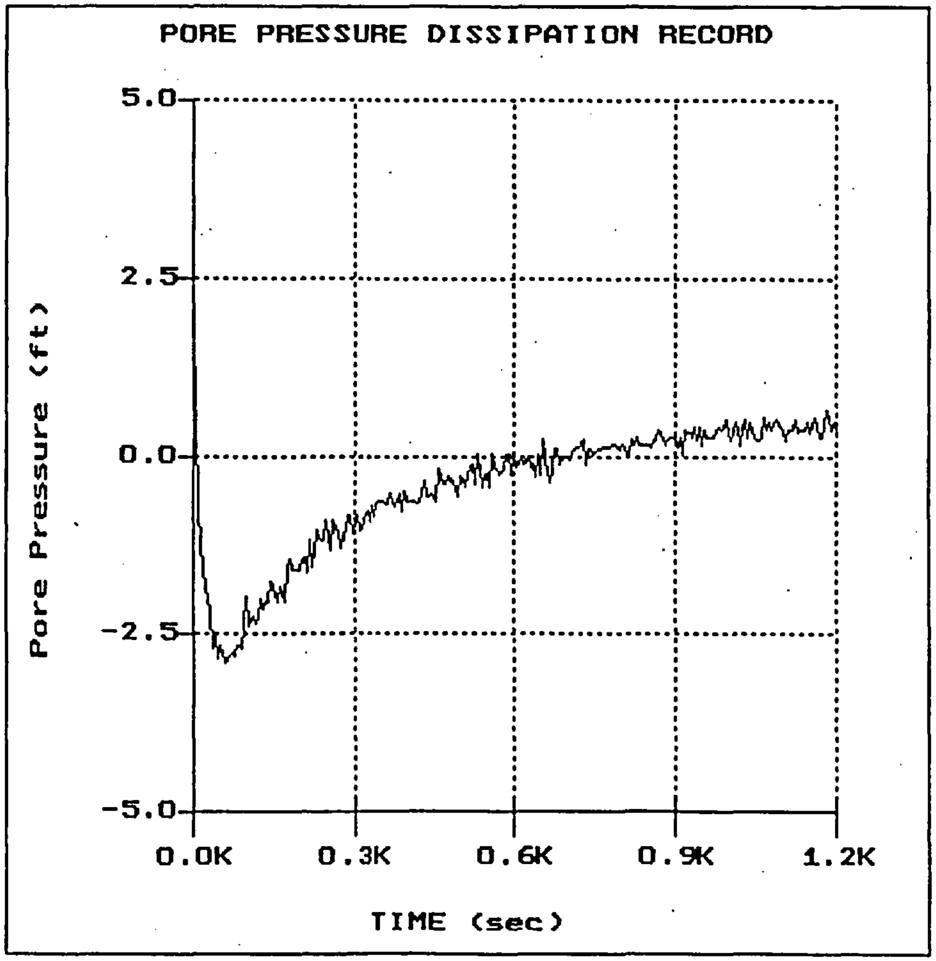


File: 432CP94.PPD
Depth (m): 3.05
(ft): 10.01
Duration : 1000.0s
U-min: -2.35 50.0s
U-max: 1.97 0.0s

S.M. Stoller

Hole No.:CPT-0394
Location:ATLAS

Cone: 20 Ton St 183
Date:12:16:05 07:50

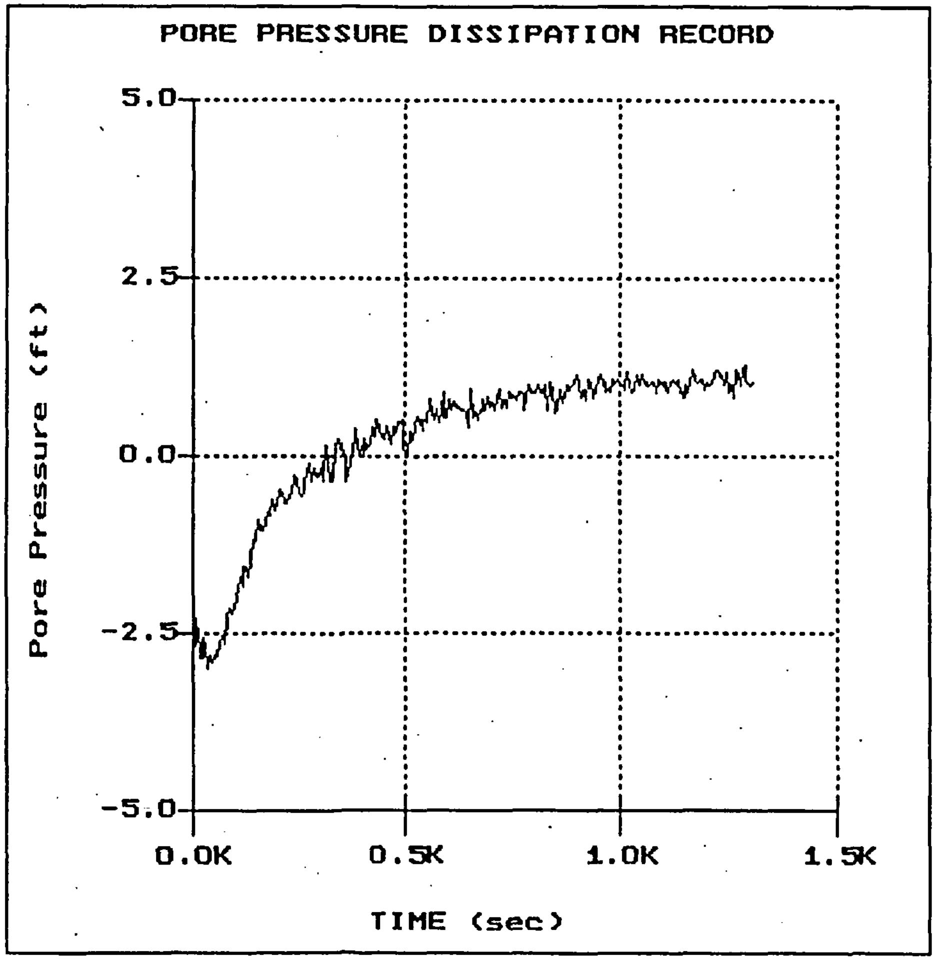


File: 432CP94.PPD
Depth (m): 6.05
(ft): 19.85
Duration : 1205.0s
U-min: -2.91 60.0s
U-max: 1.97 0.0s

S.M. Stoller

Hole No.:CPT-0394
Location:ATLAS

Cone: 20 Ton St 183
Date:12:16:05 07:50

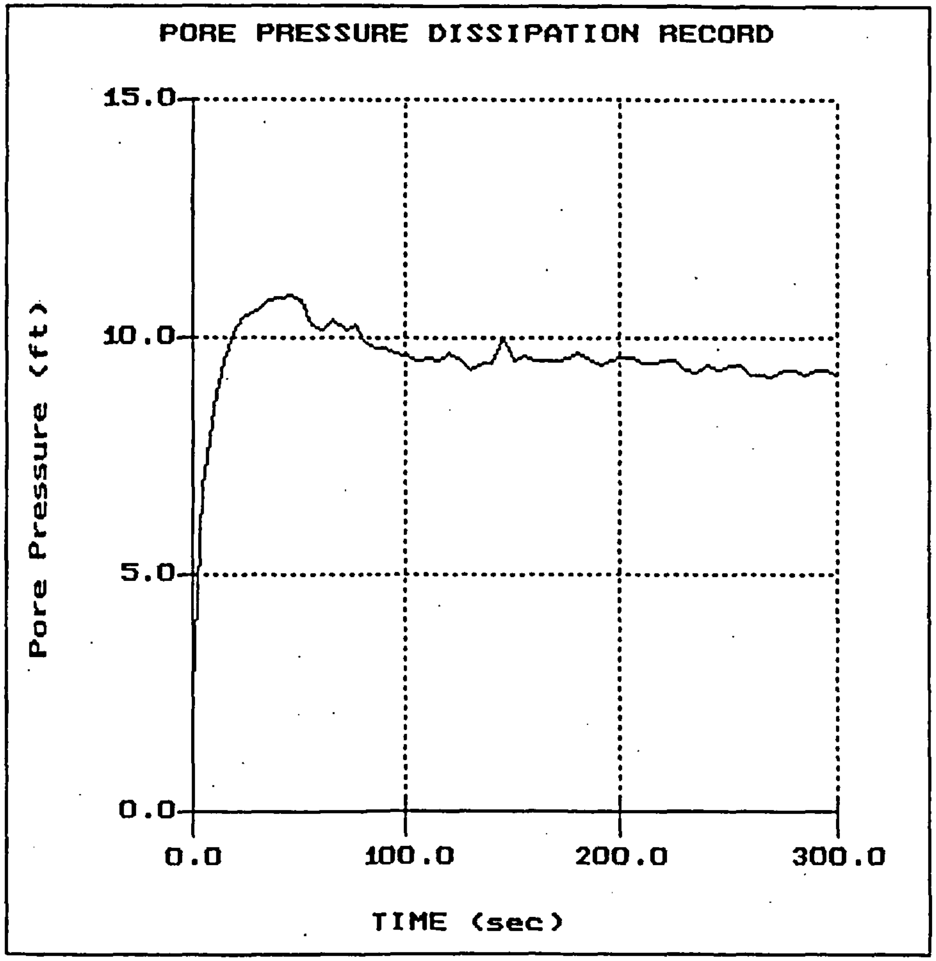


File: 432CP94.PPD
Depth (m): 9.15
(ft): 30.02
Duration : 1305.0s
U-min: -3.00 35.0s
U-max: 1.27 1285.0s

S.M. Stoller

Hole No.:CPT-0395 TOE
Location:ATLAS

Cone: 20 Ton St 183
Date:12:16:05 11:05



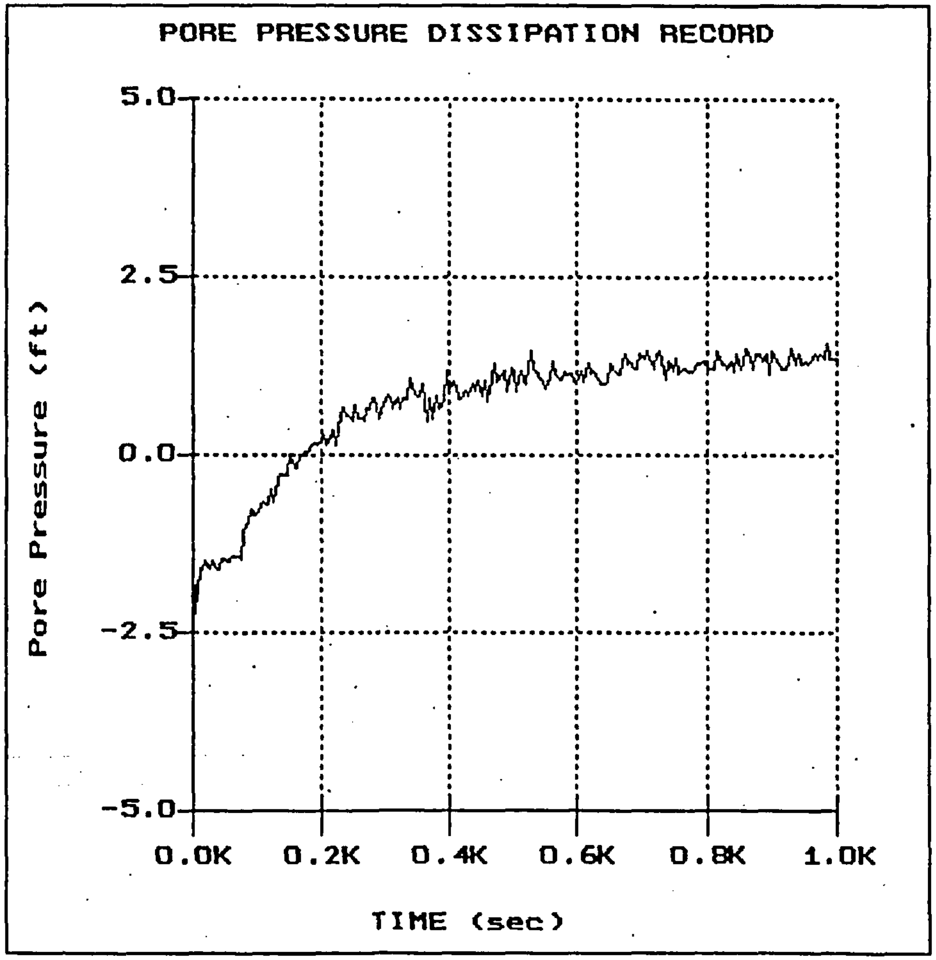
File: 432CP95C.PPD
Depth (m): 6.30
(ft): 20.67
Duration : 300.0s
U-min: 2.39 0.0s
U-max: 10.89 45.0s

S.M. Stoller

Hole No.:CPT-0395 TOE
Location:ATLAS

Cone: 20 Ton St 183
Date:12:16:05 11:05

File: 432CP95C.PPD
Depth (m): 9.15
(ft): 30.02
Duration : 1000.0s
U-min: -2.21 5.0s
U-max: 1.55 985.0s

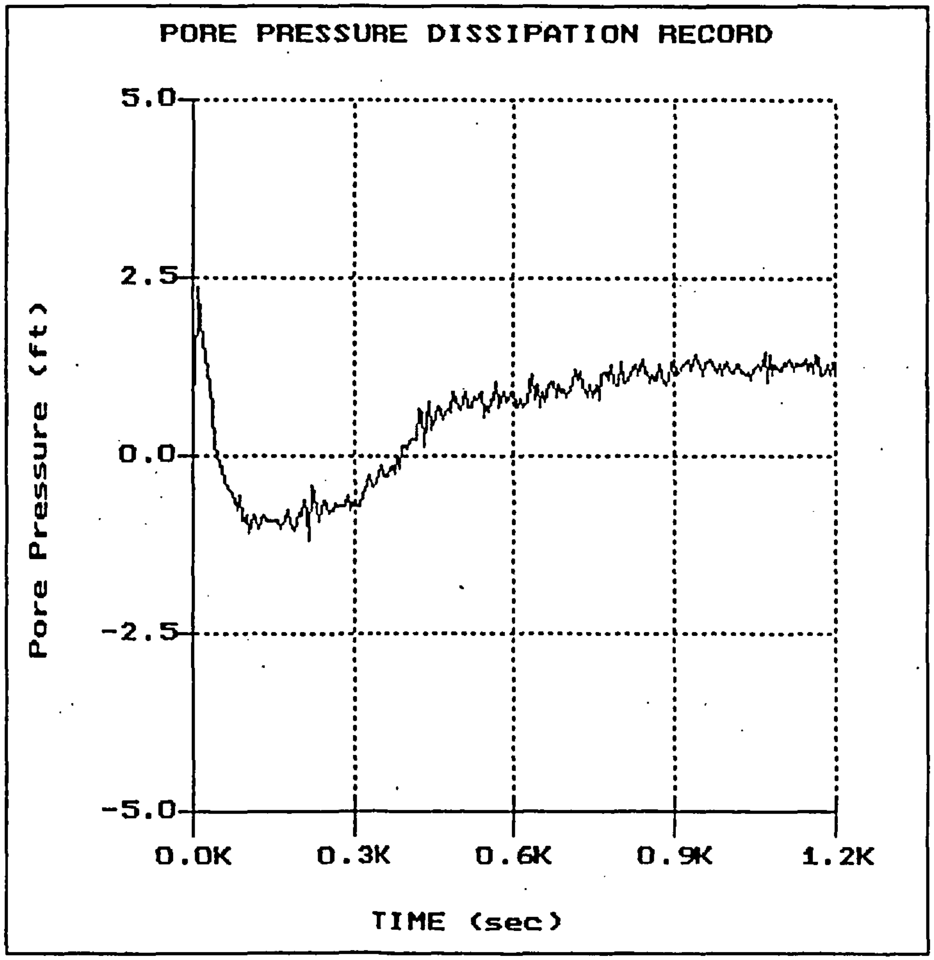


S.M. Stoller

Hole No.:CPT-0395 TOE
Location:ATLAS

Cone: 20 Ton St 183
Date:12:16:05 11:05

File: 432CP95C.PPD
Depth (m): 12.20
(ft): 40.03
Duration : 1200.0s
U-min: -1.17 215.0s
U-max: 2.35 10.0s



Appendix G

U.S. Department of Energy—Grand Junction, Colorado

Calculation Cover Sheet

Calc. No. MOA-02-03-2006-4-07-00 **Discipline:** Geotechnical Properties **No. of Sheets:** 2

Project: Moab UMTRA Project

Site: Crescent Junction, Utah

Feature: Seismic Rippability Investigation

Sources of Data:

Sources of Formulae and References:

Hasbrouck Geophysics, Inc., 2005. *Crescent Junction Disposal Site Seismic Rippability Investigation*, Final Report, November.

Mac Lean, H. D., 2005. "Review of Seismic Rippability Investigation Report", November.

Preliminary Calc. ☐ **Final Calc.** ☑ **Supersedes Calc. No.**

Author: R. Heydenburg
Name Date

Checked by: 6-9-06
Name Date

for Greg Lord 6-9-06
Name Date

6/12/06
Name Date

R. H. 6/13/06
Name Date

Approved by: 6-13-06
Name Date

Problem Statement:

Preliminary site selection performed jointly by the U.S. Department of Energy (DOE) and the Contractor has identified a 2,300 acre withdrawal area in the Crescent Flat area just northeast of Crescent Junction, Utah, as a possible site for a final disposal cell for the Moab uranium mill tailings. The proposed disposal cell would cover approximately 300 acres. Based on the preliminary site-selection process, the suitability of the Crescent Junction Disposal Site is being evaluated from several technical aspects, including geomorphic, geologic, hydrologic, seismic, geochemical, and geotechnical. The objective of this calculation set is to present results of the rippability investigation based on seismic refraction activities at the Crescent Junction Disposal Site.

This calculation will be used in the *Site Design for Stabilization of Moab Title I Uranium Mill Tailings at the Crescent Junction, Utah, Disposal Site*, and summarized in the appropriate sections of the Remedial Action Selection (RAS) report for the Moab site.

Method of Solution:

A refraction seismic survey was conducted along 10 seismic lines centered on existing boreholes at the Crescent Junction Site to assist in evaluation of suitability of the site for disposal of the Moab tailings. The purposes of the seismic surveys were to determine the seismic velocities of weathered and unweathered Mancos Shale deposits that underlie the site and relate those velocities to the rippability of the subsurface materials. The refraction seismic method is routinely used for rippability investigations. Data collection and analysis methods for this project were performed in accordance with the *Standard Guide for Using the Seismic Refraction Method for Subsurface Investigation* ASTM Designation: D 5777-00.

Data are included in the report of the investigation and in a review of the report in Appendix A.

Assumptions:

N/A

Calculation:

N/A

Discussion:

Results and evaluation of the seismic rippability investigation at the Crescent Junction Disposal Site during 2005 are used to evaluate construction equipment requirements for the project.

Conclusion and Recommendations:

N/A

Computer Source:

N/A

References:

Hasbrouck Geophysics, Inc., 2005. *Crescent Junction Disposal Site Seismic Rippability Investigation*, November.

Mac Lean, H. D., 2005. "Review of Seismic Refraction Report", November.

Appendix A

Seismic Rippability Investigation Report

Hasbrouck Geophysics, Inc.
Groundwater, Engineering, Environmental & Mining

Final Report

Crescent Junction Disposal Site
Seismic Rippability Investigation

for

S. M. Stoller Corporation
Grand Junction, Colorado

REGISTERED GEOPHYSICIST
JAMES C. HASBROUCK
No. GP 1026
STATE OF CALIFORNIA

11/21/05

November 21, 2005

2473 North Leah Lane
Prescott, Arizona 86301 USA
928-778-6320 (Telephone and Fax)
jim@hasgeo.com (E-Mail)
http://www.hasgeo.com (Homepage)

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INTRODUCTION

Refraction seismic surveys were conducted for S. M. Stoller Corporation along ten seismic lines centered on existing boreholes at the proposed Crescent Junction Disposal Site to assist in the evaluation of the suitability of the site as a final repository for the Moab uranium mill tailings. The purposes of the seismic surveys were to determine the seismic velocities of weathered and unweathered Mancos Shale deposits that underlie the site and relate those velocities to the rippability of the subsurface materials.

The refraction seismic method is routinely used for rippability investigations. Caterpillar Inc. has prepared charts that relate seismic velocities to different sized rippers. For typical refraction seismic rippability investigations a seismic velocity versus depth or elevation profile is generated along each survey line and then the velocities are related to the Caterpillar charts so that a proper ripper can be selected by the construction contractor. Two types of refraction seismic surveys may be conducted to ascertain the rippability estimates of the subsurface: two-dimensional (2D) tomography and delay-time. The 2D tomography method offers a more detailed and gradational section of the subsurface seismic velocity, but takes a little more time in the field and thus is slightly more expensive. The delay-time method offers only a layered and averaged velocity section, but may be more familiar to construction contractors since it has been in use for a much longer time than 2D tomography. Stoller selected the delay-time method for this project.

This seismic survey was a joint effort between Bird Seismic Service, Inc. of Globe, Arizona and Hasbrouck Geophysics, Inc. of Prescott, Arizona. Bird Seismic acquired the seismic data using the survey design prepared by Hasbrouck Geophysics, while Hasbrouck Geophysics processed and interpreted all the data and prepared the final report. This final report will be reviewed by Mr. H. David MacLean of Grand Junction, Colorado. Ken Bernstein is president of Bird Seismic Services, Inc. and may be reached at ken@bridseismic.com or 928-719-1848. Jim Hasbrouck is president of Hasbrouck Geophysics, Inc. and may be contacted at jim@hasgeo.com or 928-778-6320. Dave MacLean is available at 107770.3066@compuserve.com or 970-242-1649.

DATA ACQUISITION

Seismic surveys essentially consist of recording seismic waves that have been generated by artificial sources, observing the arrival times of these waves, and producing cross-sections of variations in subsurface seismic wave velocities that can then be related to geology. The source of seismic energy for surface surveys is primarily dependent upon the target depths and local geology, and for relatively shallow surveys is generally either a sledgehammer or weight-drop system. The seismic waves are detected by geophones in surface surveys. A geophone consists of a coil suspended by springs with magnets build into the case. A seismic wave moves the case and the magnets while the coil remains relatively stationary because of its inertia. The relative movement of the magnetic field with respect to the coil generates a voltage across the coil that is proportional to the velocity of the seismic wave. The electrical voltages produced by the geophones are transmitted back to a recording instrument (seismograph) via cables. In refraction seismic surveys it is necessary, according to Snell's Law, that velocities increase with depth so that the refracted seismic waves can be detected on the surface. For refraction seismic surveys in most sedimentary environments it is typical that velocities increase with depth (i.e., there are no velocity reversals) and it is assumed that this is the case for the Crescent Junction Disposal Site.

According to Stoller, the depth to weathered bedrock in the project area is assumed to vary from two to approximately 25 feet. Unweathered bedrock may be deeper than 50 feet thus the refraction seismic survey is designed to investigate to depths somewhat greater than 50 feet using the standard rule-of-thumb for refraction seismic surveys that the first geophone to "see" a refraction from a layer will be at a distance of three to five times the expected depth. For example, if an investigation depth of 60 feet is desired then the first geophone to see a refraction, if present, from that depth will be at 180 to 300 feet along the line of geophones, or spread, with the larger distance applicable to areas with generally slower velocities. In order to accurately map the deeper horizons, several geophones must be beyond the initial geophone that records the deeper refraction thus a geophone interval of 10 feet with 30 feet far offsets (resulting in a total spread of 500 feet) is used for this project.

The refraction seismic data for this project were acquired with a 48-channel Bison *9048* seismograph with 21-bits of dynamic range, 250 milliseconds (ms) record lengths, and 0.25 ms sample intervals with Mark Products 10-Hz geophones implanted approximately three inches into the ground at intervals of 10 feet along each line. The seismic source was an Elastic Wave Generator (EWG) accelerated weight-drop mounted on the back of a 4x4 pickup and consisted of a 207-pound weight that was lifted hydraulically against large springs and then released resulting in a force much greater than the weight itself. For each seismic line data from a minimum of eleven source points were acquired (seven within the spread nominally between geophones 6 and 7, 12 and 13, 18 and 19, 24 and 25, 30 and 31, 36 and 37, and 42 and 43, and off each end at distances of 10 and 30 feet). The geophone distances were initially measured with either a tape or takeout intervals on the geophone spread cable and after completion of data acquisition every fourth geophone and each offset source point was surveyed to at least centimeter accuracy by a contractor to Stoller. Because the surface topography change was minor and the seismic lines were relatively straight it was only necessary to survey the coordinates and elevations of every fourth geophone and then interpolate values for the intermediate geophones.

The seismic data were stacked nominally four to six times (depending upon offset and noise) at each source point to increase the signal-to-noise ratio. Stacking, or signal enhancement, involved repeated source impacts at the same point into the same set of geophones. For each source point, the stacked data were recorded into the same seismic data file and theoretically the seismic signal arrived at the same time from each impact and thus was enhanced, while noise was random and tended to be reduced or canceled. After recording the data on the hard disk of the seismograph, the seismic records were copied to a personal computer at the end of each field day. These data were e-mailed nightly from the field to Mr. Hasbrouck and copies of the Observer Reports (field notes) were faxed at the same time. The quality of the seismic data ranged from very good to excellent depending primarily upon offset, and identifiable first breaks (first arrivals of seismic energy) were present along all the lines.

DATA PROCESSING

The refraction seismic data were processed using the *SIPwin* (version 2.77) set of computer programs from Rimrock Geophysics Inc., Lakewood, Colorado. The general processing flow consisted of the initial selection, or "picking", of the seismic first breaks (first arrival of seismic energy) with the *SIPIK* program, creation of data files for input into the interpretation program with the *SIPIN* program, and interpretation of the data using modeling and iterative ray-tracing techniques with the *SIPT2* program. A first break was selected as the initial downward variation of the seismic signal from a horizontal line and was generally accurate to a time between 0.5 and 1 ms. To enhance the accuracy of first break picks, the seismic record was zoomed to a time that only encompassed the breaks themselves (i.e., only the portion of the seismic record where the first breaks were visible) The *SIPT2* program uses the delay-time method to obtain a first-approximation depth model, which is then trimmed by a series of ray-tracing and model adjustment iterations to minimize any discrepancies between the picked arrival times and corresponding times traced through a 2½-dimensional model. Arrival times at two geophones, separated by some variable XY-distance, are used in refractor velocity analyses and time-depth calculations. Using the principle of migration and iterative ray-tracing within the *SIPT2* program, forward and reverse seismic rays emerge from essentially the same point on the reflector, thus requiring the reflector to be plane over only a very small distance. The ray-tracing procedure tests and corrects the estimated migrated position of points representing the locations of ray entry and emergence from the refracting horizon and takes into account the dip of the refracting horizon at those emergence points, therefore enabling accurate representation of steeply dipping horizons.

For any refraction seismic data analysis, it is important to determine accurate velocities. The *SIPT2* program employs several routines for selection of the proper velocities. For the direct arrivals through the first layer, the velocity is computed by dividing the distances from each source point to each geophone by the corresponding arrival times. These individual velocities are averaged for each source point and a weighted average is computed. For layers beneath the first layer, velocities are computed by two methods: 1) Regression, in which a straight line is fit by least squares to the arrival times representing the velocity layer and average velocities are computed by taking the reciprocals of the weighted average of the slopes of the regression lines, and 2) the Hobson-Overton method wherein velocities are computed if there are reciprocal arrivals from two opposing source points at two or more geophones. Final velocities used in the *SIPT2* inversion process are computed by taking an average of the two methods. As quality control measures, time versus distance (T-D) plots (which represent velocities) are inspected along each seismic line relative to reciprocal times, irregularity and parallelism as per ASTM D5777. The refraction seismic data for this project adequately met the requirements of each of these tests.

Included within this report are a borehole and seismic line location map, and elevation and depth versus distance refraction seismic sections for each line with annotated average velocities for each layer. Also included is a CD with output from the *SIPT2* program that includes velocity analysis tables, T-D plots indicating the picked arrival times, and modeled elevations and depths beneath each source point and geophone. Note that the distances in the modeled results have been corrected for horizontal foreshortening (i.e., corrections are made to obtain true horizontal positions). The modeled results are used to construct the elevation and depth sections, and are in Microsoft Excel format for future client use if desired.

RESULTS

According to Stoller, the geology of the project area consists of essentially three layers. The near surface is alluvial overburden composed of unconsolidated silt, clay, and sandstone fragments. Beneath the alluvium is weathered bedrock, or weathered Mancos Shale, composed of fractured, chemically weathered, siltstone, silty sandstone or clayey siltstone of variable thickness. The weathered layer is often highly fractured with calcite and gypsum fracture coatings. The Mancos Shale is present beneath the weathered layer and is increasingly competent with depth. Although the Mancos Shale appears to be a great shale mass, it is not one homogeneous unit. According to available lithologic logs for the boreholes within the project area, the Mancos Shale seems to be described as consisting not only of shale but also some sandstone layers and what has been termed a silty claystone. The lithologic logs generally indicate variations in the composition of the unweathered Mancos Shale near its top with increasing shale constituents with depth.

Interpretation of the refraction seismic data indicates three layers, representing alluvial overburden, weathered Mancos Shale and competent Mancos Shale. Table 1 indicates the range in velocities and depths for each line. The first layer velocities range from about 1160 to 1330 feet per second and are consistent with typical unsaturated alluvial overburden values. The second layer velocities range from about 4060 to 5220 feet per second and represent typical values for weathered material such as the Mancos Shale. The variation in velocity values for the interpreted weathered Mancos Shale is probably related to the degree of fracturing and the amount of calcite and/or gypsum coating of the fractures. The higher velocities may have less fracturing or the fractures may be coated with an increased amount of calcite and/or gypsum. It is not possible from the seismic results to determine which scenario exists. The third layer, or competent Mancos Shale bedrock, velocities range from about 9000 to as high as 10000 feet per second with the majority of the velocity values in a range from about 9000 to 9400 feet per second. Velocity variations of the interpreted Mancos Shale bedrock are considered relatively minor and probably related to slight changes in composition of the bedrock or some amount of fracturing. Velocity variations are present along the intersecting seismic lines at each borehole, but generally than about 5% which is reasonable given that the velocity values are averages and the subsurface geology is variable (as evidenced by changes in the lithologic logs between boreholes).

The thickness of the overburden layer (or the depth to the top of layer 2 which is interpreted as weathered Mancos Shale) ranges from about 4½ to 18 feet, while the depth to the top of layer 3 (or interpreted unweathered Mancos Shale bedrock) varies from about 24 to 60 feet. The tie point depths between intersecting lines at each borehole are generally less than about 5% which is considered reasonable and quite acceptable for seismic surveys. Depth values at intersecting points from lines oriented in different directions often vary because of anisotropy within the subsurface geological formations. Anisotropy is defined as a variation of a physical property (e.g., velocity) depending upon the direction in which it is measured. In general, surface refraction seismic data have shown a 10% to 15% variation between the actual depths to velocity layer anomalies, as verified primarily by geophysical borehole logging, and the depth predicted by the models.

Table 1: Summary of interpreted velocities and depths

Line	Layer 1 velocity (ft/s)	Layer 2 velocity (ft/s)	Layer 3 velocity (ft/s)	Depth to top of layer 2 (ft)	Depth to top of layer 3 (ft)
202NW-SE	1230	4218	10005	4.5 - 15.1	34.3 - 58.7
202SW-NE	1305	4305	9353	11.3 - 17.1	31.5 - 53.0
204NW-SE	1334	4674	9035	8.0 - 14.9	40.4 - 61.1
204SW-NE	1206	4705	9399	10.1 - 18.1	40.5 - 59.3
206NW-SE	1305	5221	9380	9.9 - 16.0	29.5 - 46.8
206SW-NE	1281	5169	9479	7.7 - 15.2	25.4 - 47.5
207NW-SE	1159	4195	9011	7.1 - 14.3	26.7 - 49.1
207SW-NE	1228	4061	9021	5.9 - 15.0	28.9 - 45.9
208NW-SE	1260	4430	9676	11.0 - 14.5	33.3 - 48.8
208SW-NE	1191	4633	9805	9.0 - 13.6	23.4 - 48.4

Inspection of either the elevation or depth sections indicates that the subsurface is far from planar, with some areas showing signs of possible incised bedrock channels (e.g., particularly possibly both lines at borehole 208). Because both the first and last approximately 30 to 50 feet, or more, of the sections have less forward and reverse raypath coverage (refer to the T-D plots), results in those areas should be viewed with some caution. Nevertheless, subsurface depth variations are present along each of the seismic lines.

According to Caterpillar's ripping charts, shale is considered rippable at seismic velocities ranging up to about 6000 to 10200 feet per second for tractor models D8 to D11, respectively. Rippable velocities are slightly different if the subsurface material is composed more of a siltstone (up to about 6500 to 9900 for a D8 to D11 tractor, respectively). Referencing the ripping charts from Caterpillar, it is reasonable to assume that all of the interpreted layer 2 or weathered Mancos Shale can be ripped with a tractor as small as a D8 (note that the Caterpillar ripping charts are not available for tractors smaller than a D8). If it is necessary to rip the interpreted competent Mancos Shale bedrock, with velocities interpreted to be greater than 9000 feet per second, it will be necessary to employ a D11 tractor.

Although the seismic survey covered only a very small portion of the proposed Crescent Junction Disposal Site it is reasonable to assume that excavation in the proposed site will be impacted by the variable weathered and unweathered bedrock depths. Although the author of this report is not aware of the design depth of the proposed disposal site excavation, if it is say 40 feet then there will be areas encountered with much higher velocity material at depth which will require either larger rippers or other means of excavation. For example, if material is ripped along the borehole 207 SW to NE seismic line to a depth of 40 feet materials with average velocities of around 4000 and 9000 feet per second will both be encountered. Obviously, a D8 tractor would not be able to rip to a depth of 40 feet along the entire length of this line.

LIMITATIONS OF INVESTIGATION

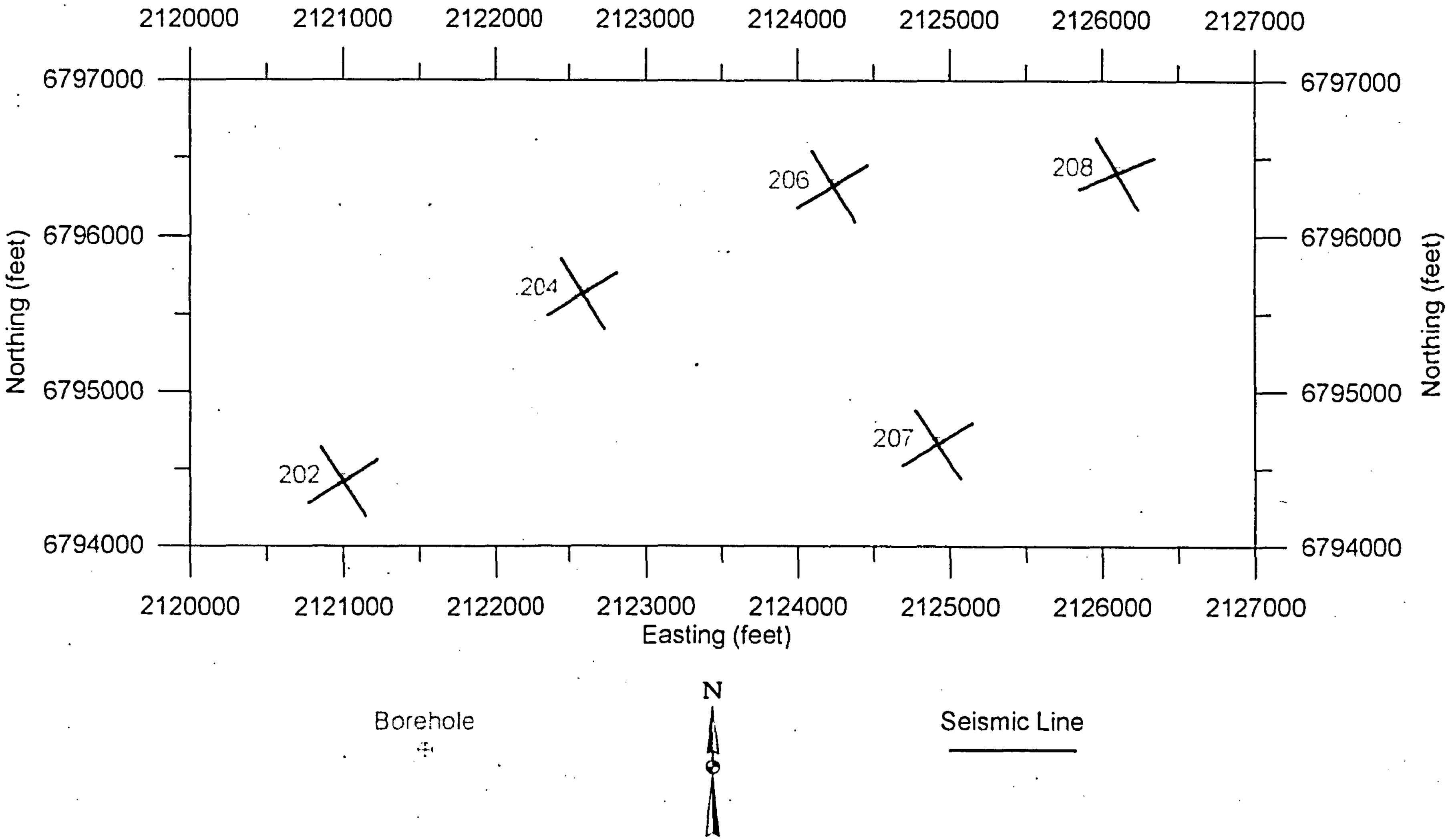
Although a refraction seismic investigation is the most cost-effective way to determine rippability of material in a project area (versus sporadic boreholes that offer only localized information), it must be realized that according to Caterpillar ripping is still more art than science, and much will depend upon operator skill and experience. Caterpillar states in their Handbook that tooth penetration is often the key to ripping success, regardless of seismic velocity. Low seismic velocities in sedimentary rocks can indicate probable rippability. However, if the fractures and bedding joints do not allow tooth penetration then the material may not be ripped effectively. Pre-blasting or "popping" may induce sufficient fracturing to permit tooth entry.

This survey was conducted with state-of-the-art instrumentation operated by experienced geophysicists, the data were processed by an experienced and licensed geophysicist with a commercial software package utilized on projects with similar objectives, and the results were interpreted by an experienced and licensed geophysicist. However, no warranty, either expressed or implied, is made as to the usability of the results of this survey. Additionally, the ripper performance charts developed by Caterpillar are intended for estimating purposes only and neither Caterpillar Inc. nor Hasbrouck Geophysics, Inc. warrant that the tractors will perform as estimated.

REFERENCE

Caterpillar Performance Handbook, Edition 30, October 1999, *Use of Seismic Velocity Charts*, pp. 1-71 to 1-78.

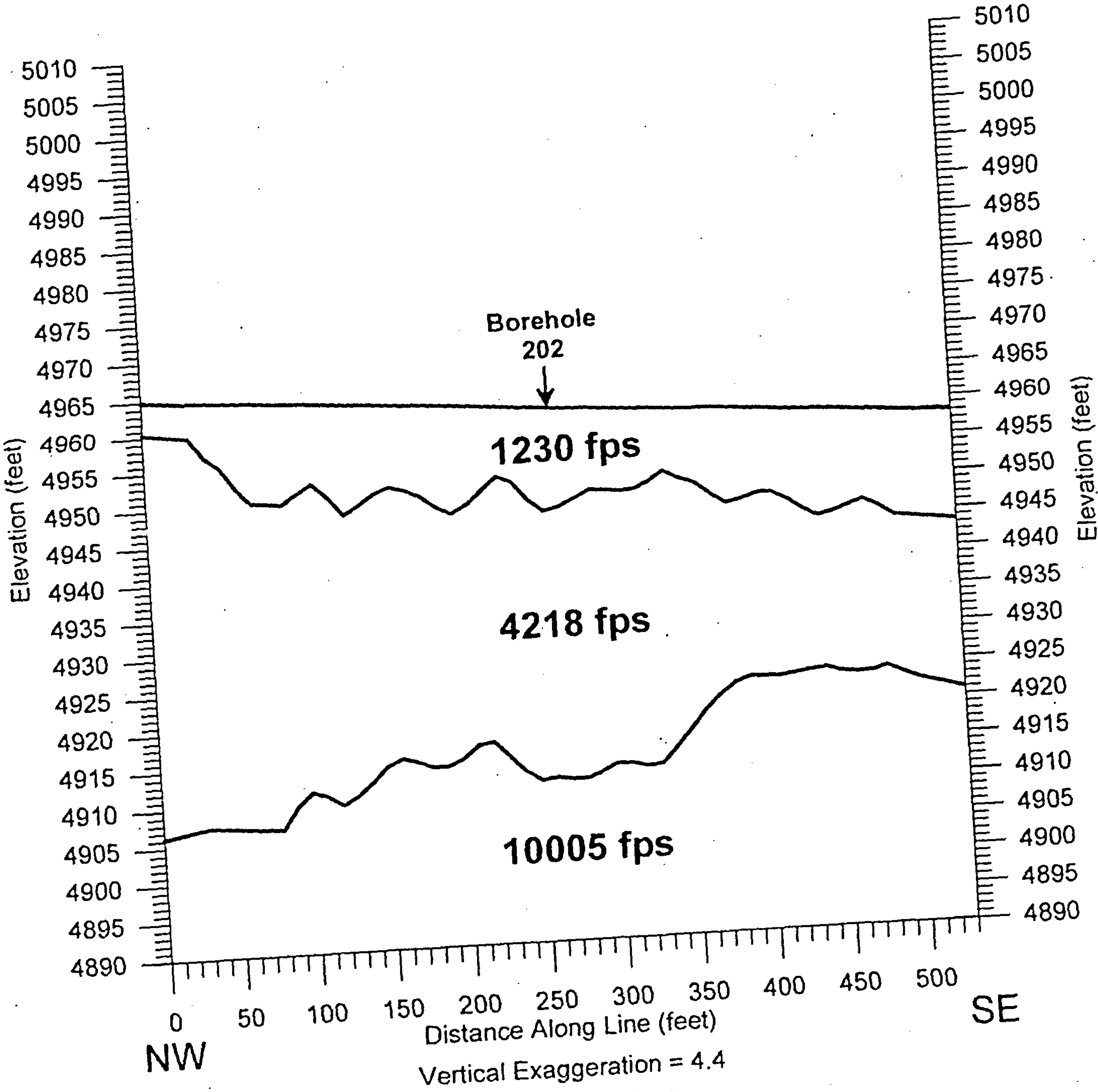
Seismic Rippability Investigation
Crescent Junction Disposal Site
Borehole and Seismic Line Locations



Hasbrouck Geophysics, Inc.

Borehole&LineLocations.grf

Seismic Rippability Investigation
Crescent Junction Disposal Site
Borehole 202 NW to SE Seismic Line
Elevation Section



Vertical Exaggeration = 4.4

Velocities in feet per second (fps)

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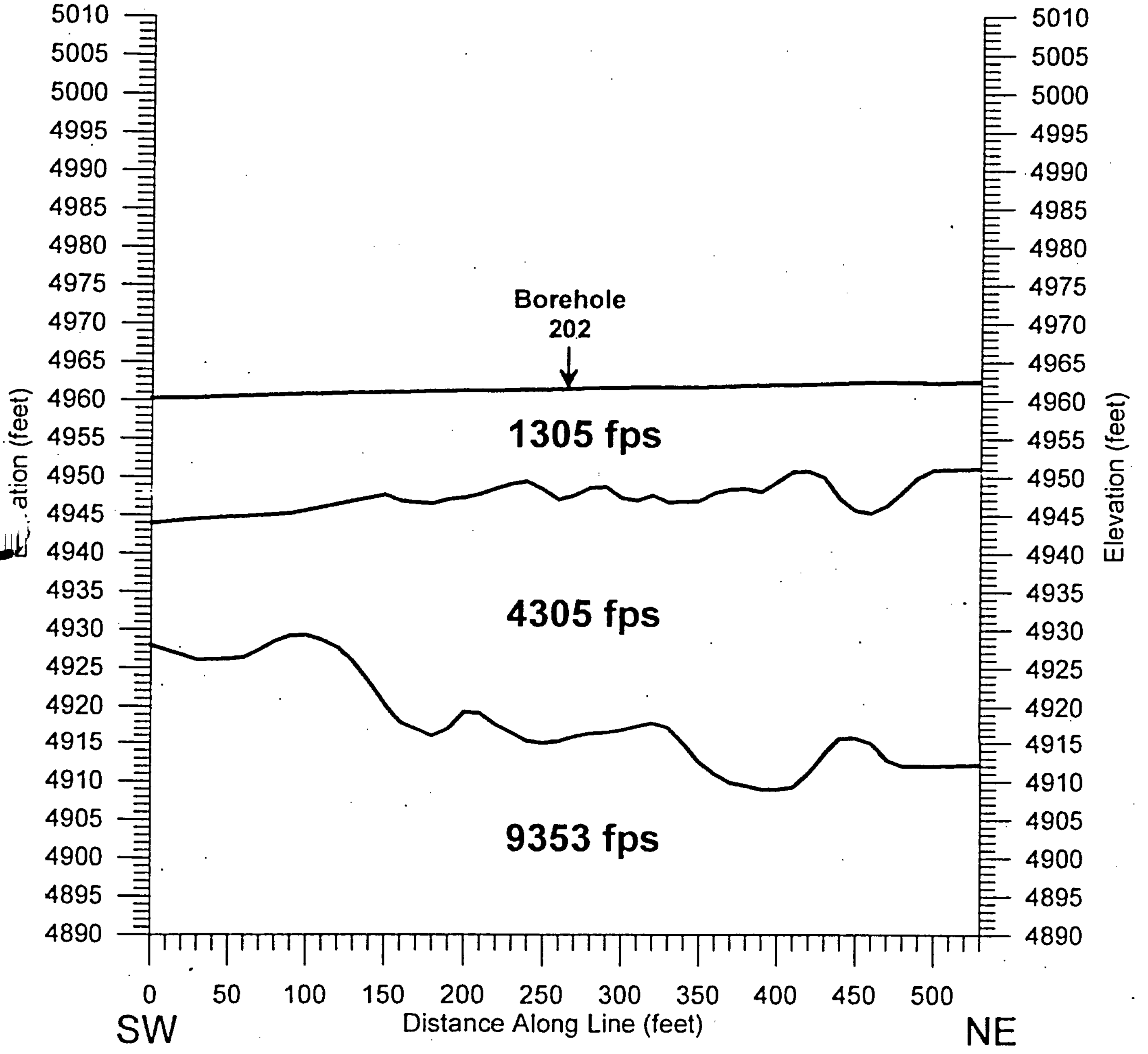
Hasbrouck Geophysics, Inc.

Seismic Rippability Investigation
Crescent Junction Disposal Site
Borehole 202 SW to NE Seismic Line
Elevation Section



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Velocities in feet per second (fps)

asbrouck Geophysics, Inc.

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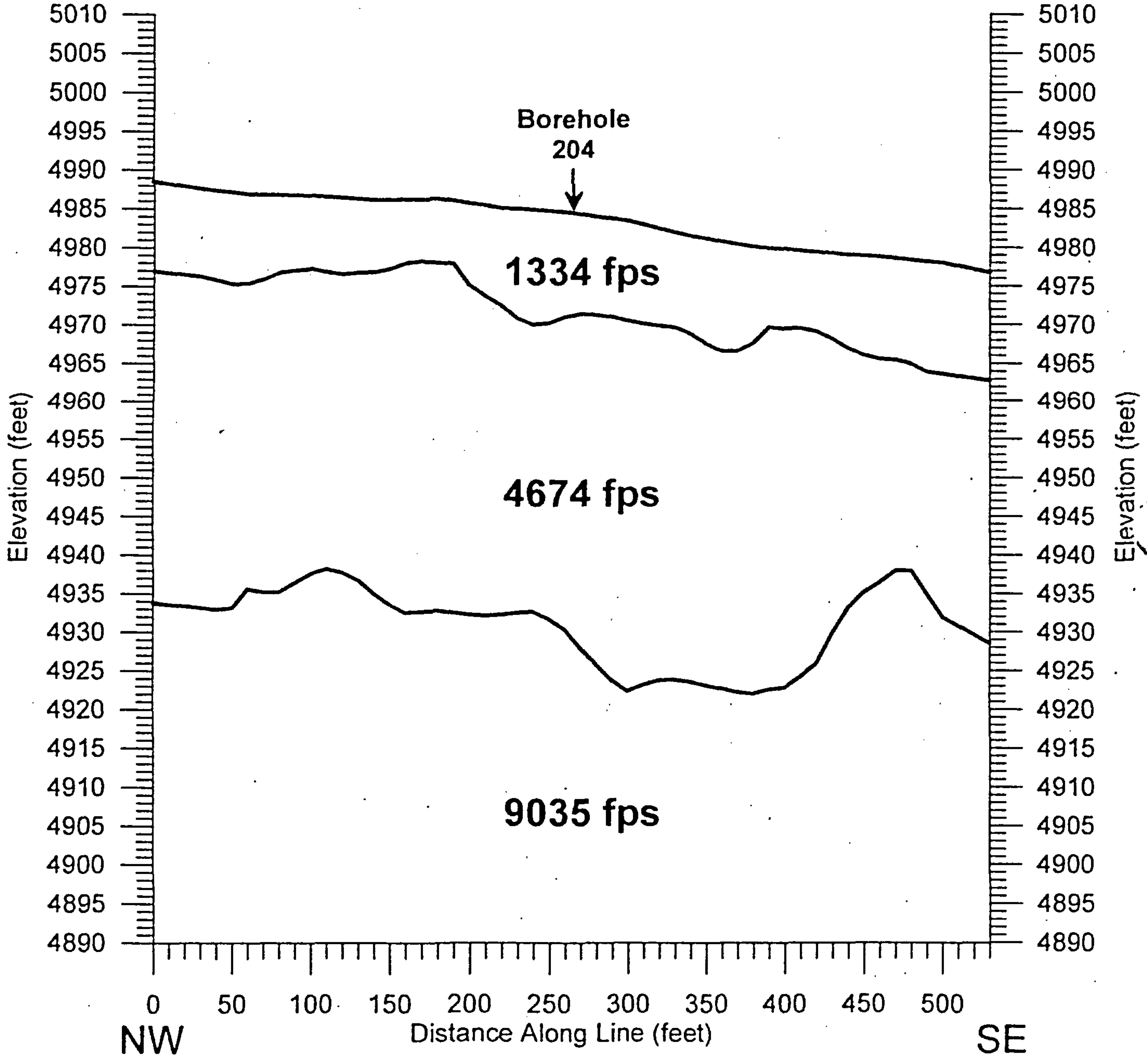
Crescent Junction Disposal Site
Borehole 204 NW to SE Seismic Line
Elevation Section



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Velocities in feet per second (fps)

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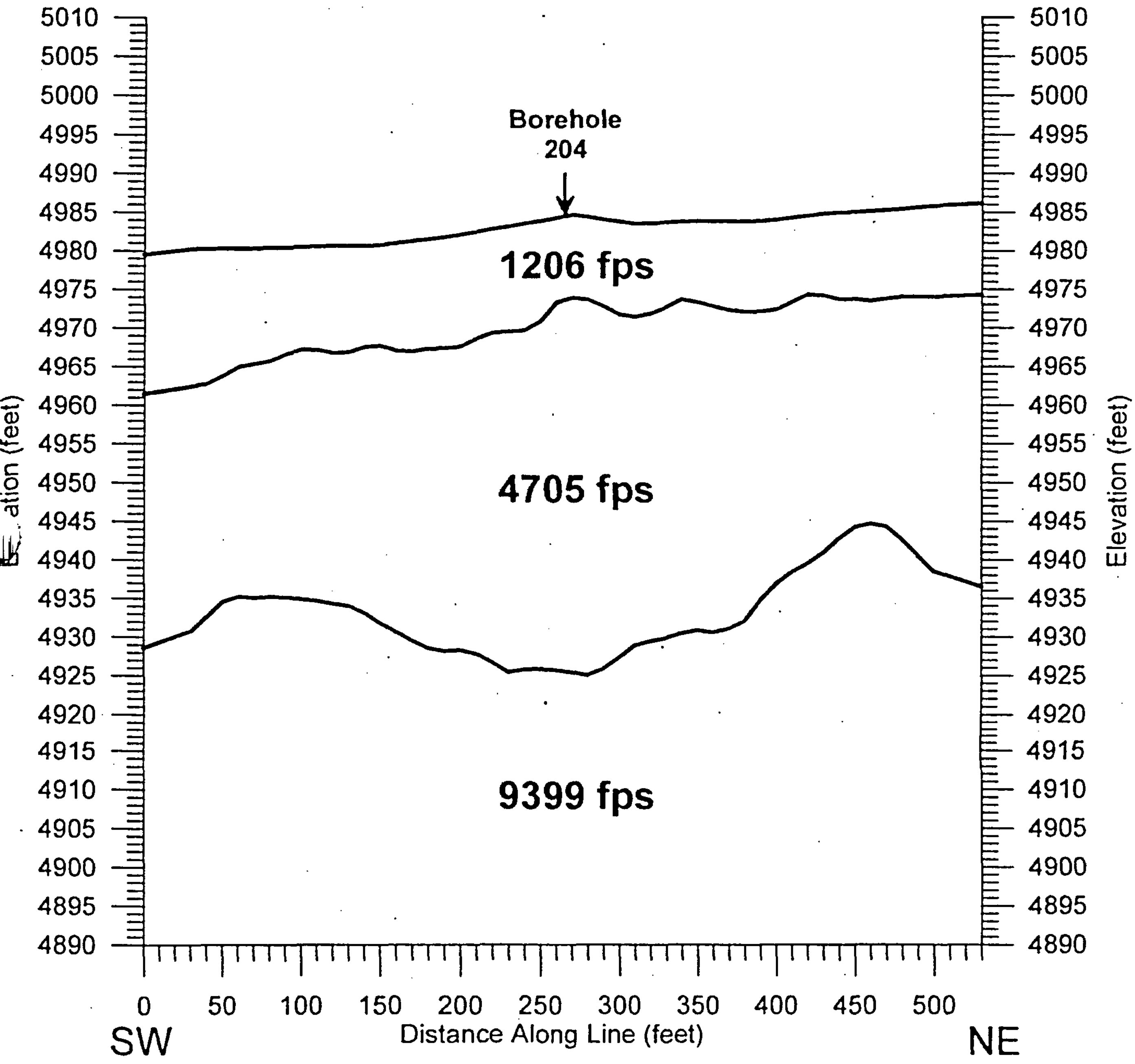
Crescent Junction Disposal Site
Borehole 204 SW to NE Seismic Line
Elevation Section



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**Velocities in feet
per second (fps)**

asbrouck Geophysics, Inc.

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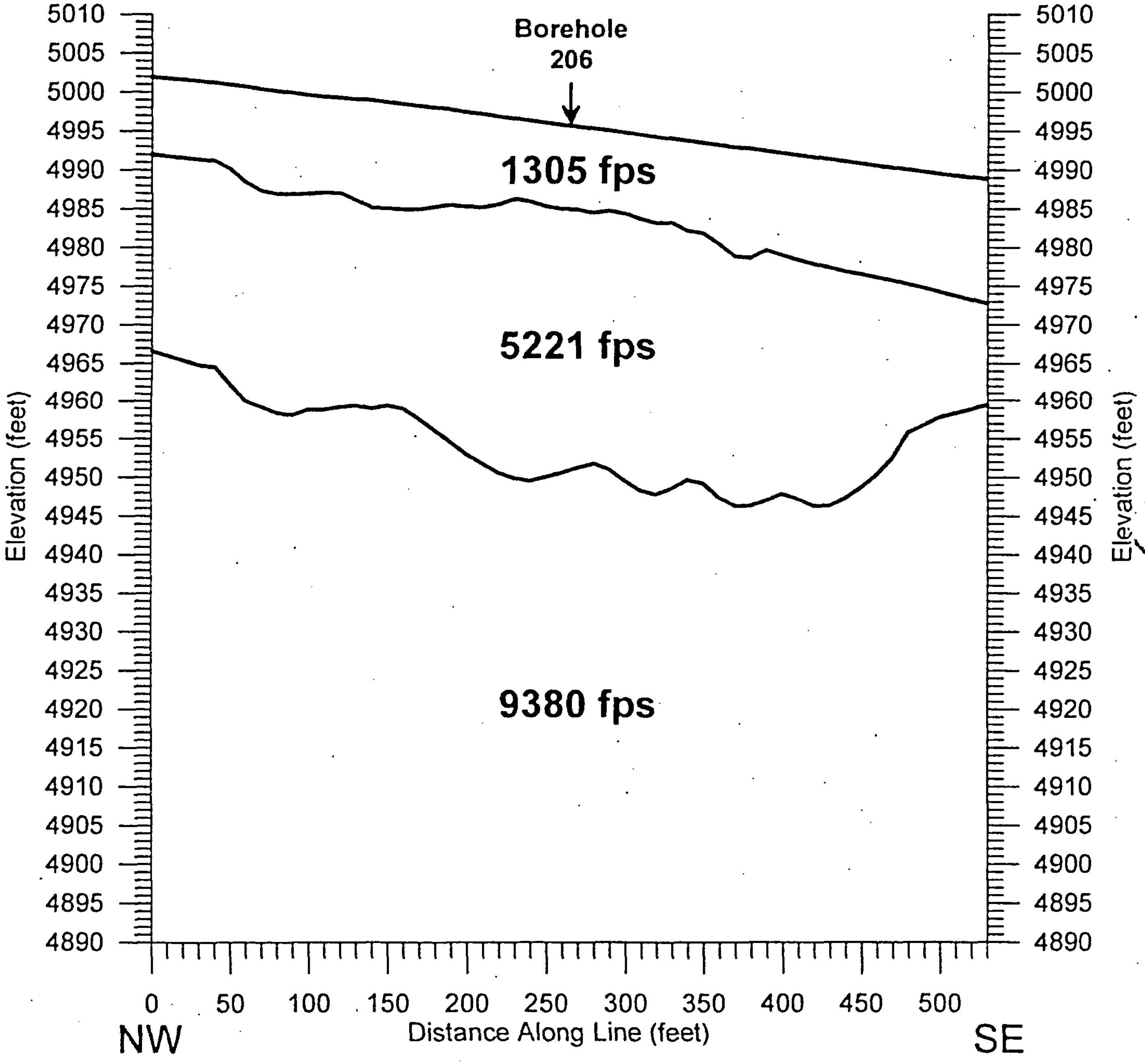
Crescent Junction Disposal Site
Borehole 206 NW to SE Seismic Line
Elevation Section



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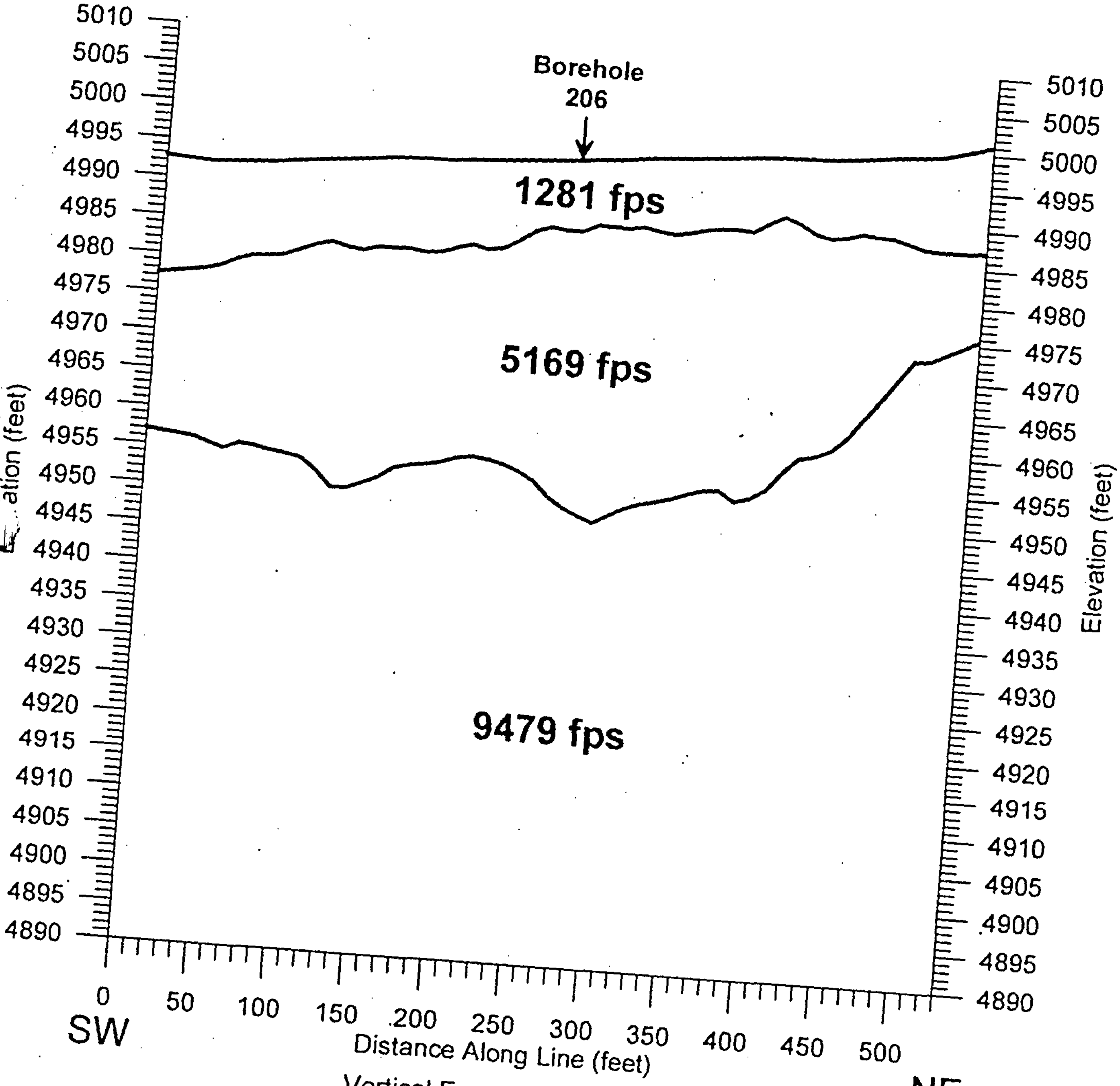
Velocities in feet per second (fps)

Seismic Rippability Investigation
Crescent Junction Disposal Site
Borehole 206 SW to NE Seismic Line
Elevation Section



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Velocities in feet per second (fps)

asbrouck Geophysics, Inc.

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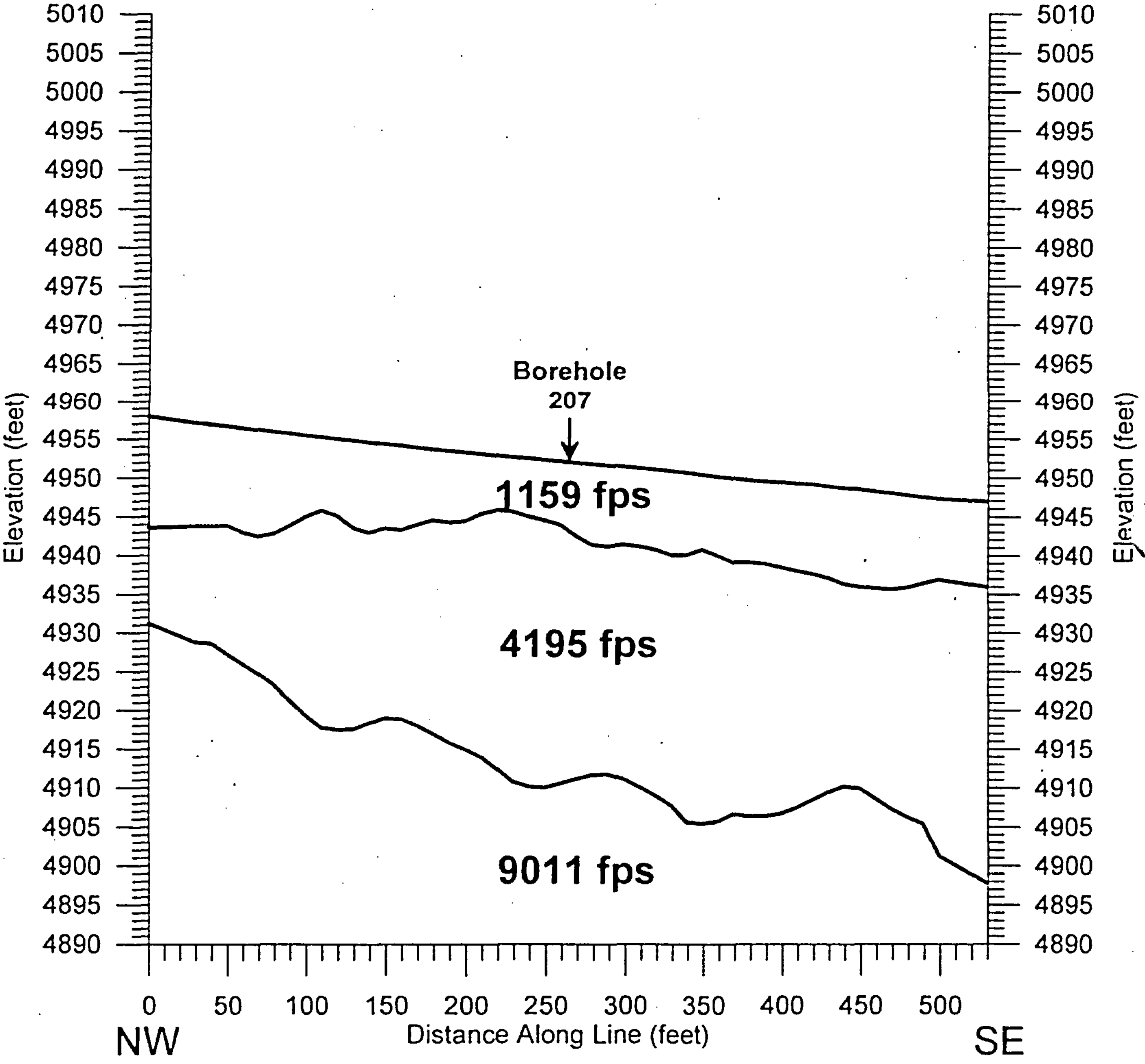
Crescent Junction Disposal Site
Borehole 207 NW to SE Seismic Line
Elevation Section



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Velocities in feet per second (fps)

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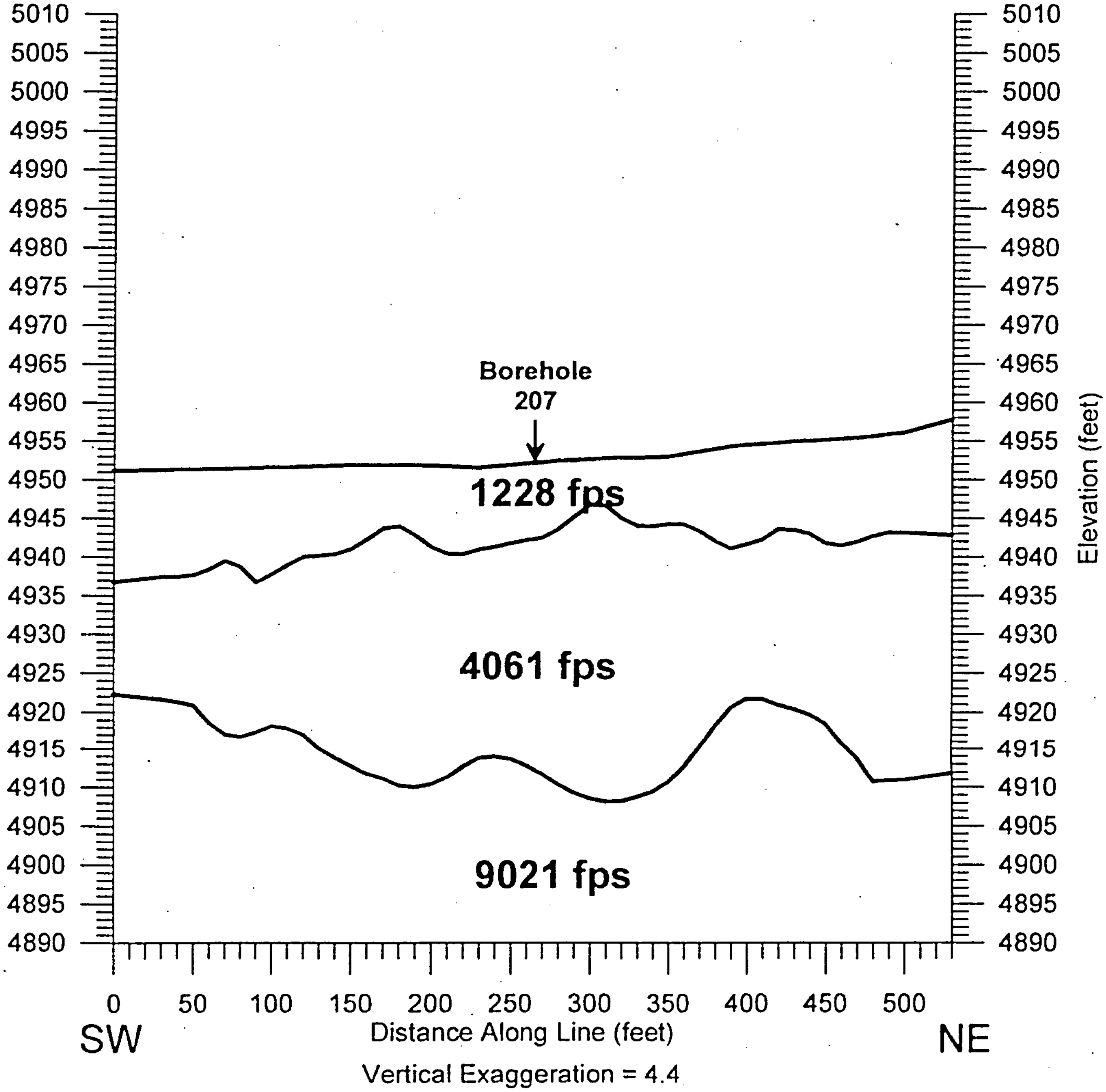
Crescent Junction Disposal Site
Borehole 207 SW to NE Seismic Line
Elevation Section



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Velocities in feet per second (fps)

asbrouck Geophysics, Inc.

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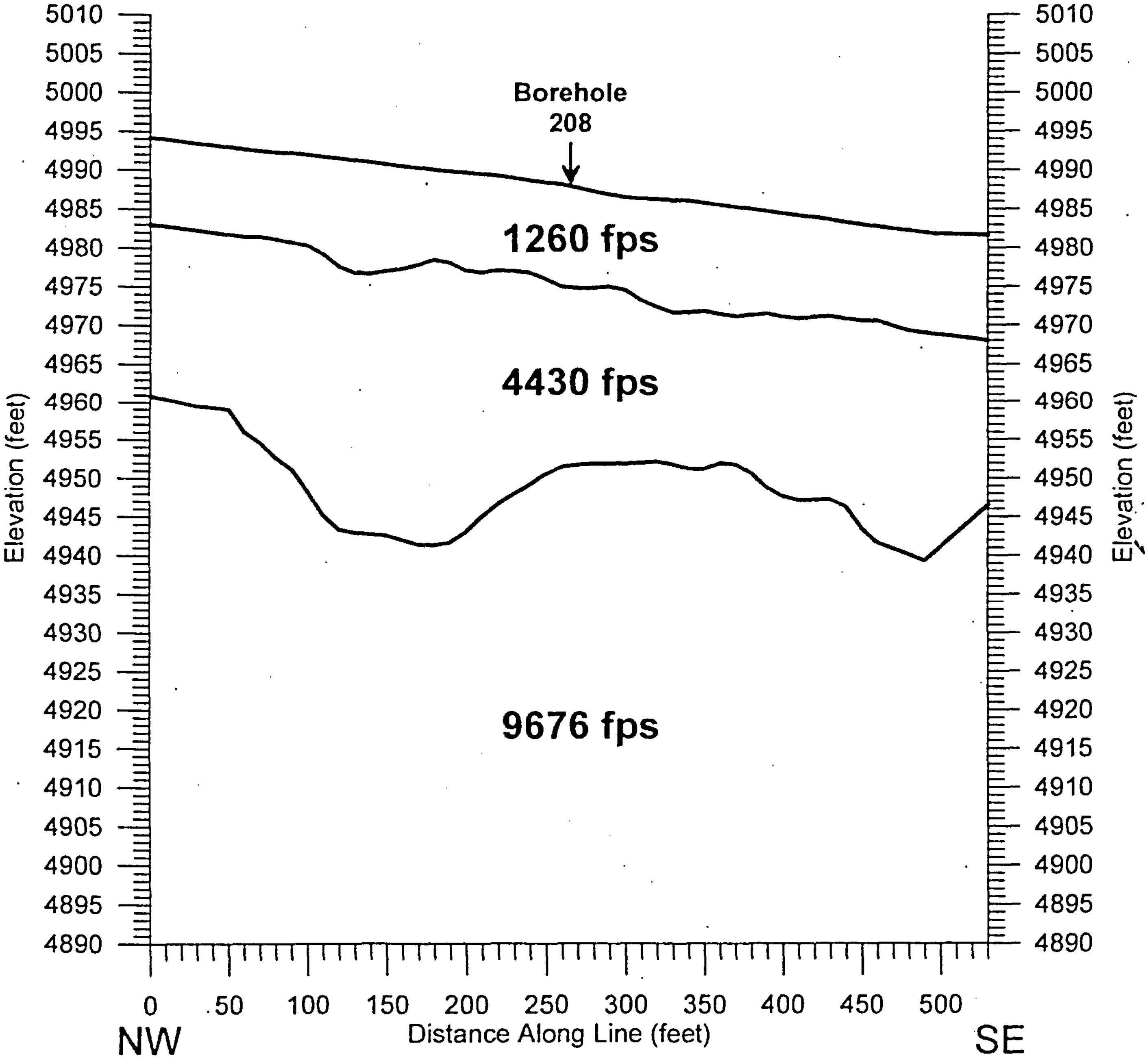
Crescent Junction Disposal Site
Borehole 208 NW to SE Seismic Line
Elevation Section



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Velocities in feet per second (fps)

Hasbrouck Geophysics, Inc.

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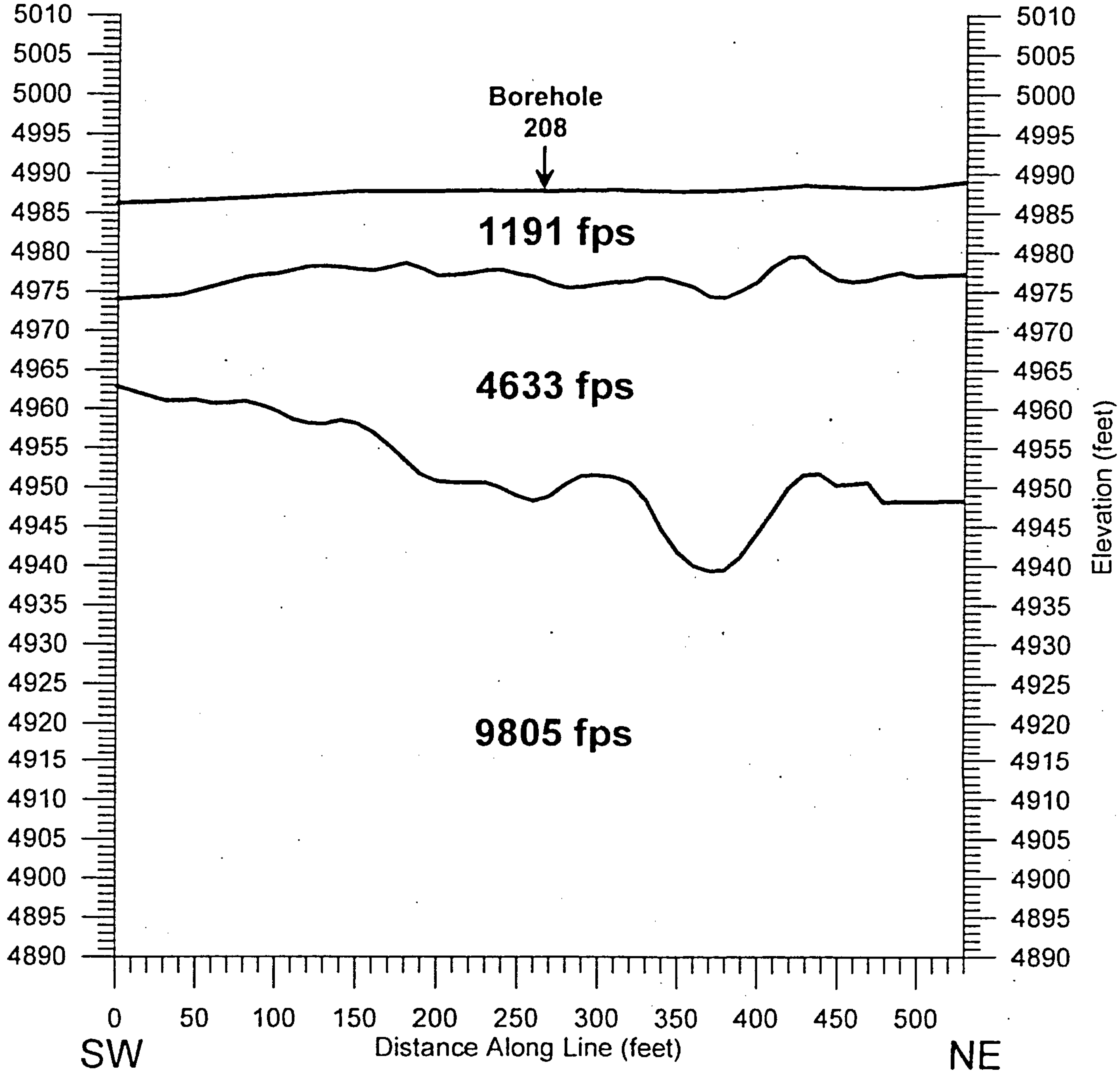
Seismic Rippability Investigation
Crescent Junction Disposal Site
Borehole 208 SW to NE Seismic Line
Elevation Section



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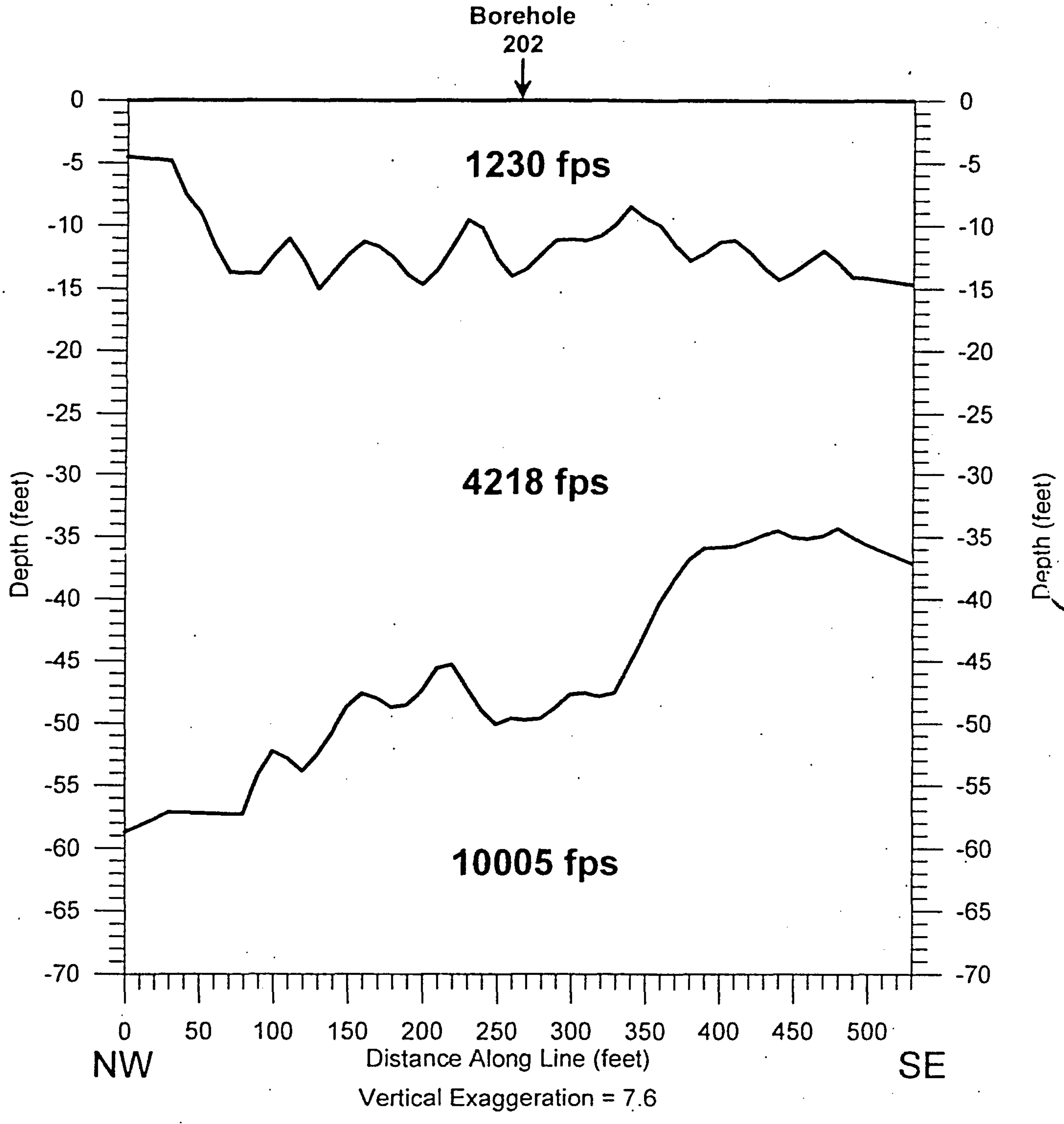
Velocities in feet per second (fps)

Seismic Rippability Investigation
Crescent Junction Disposal Site
Borehole 202 NW to SE Seismic Line
Depth Section



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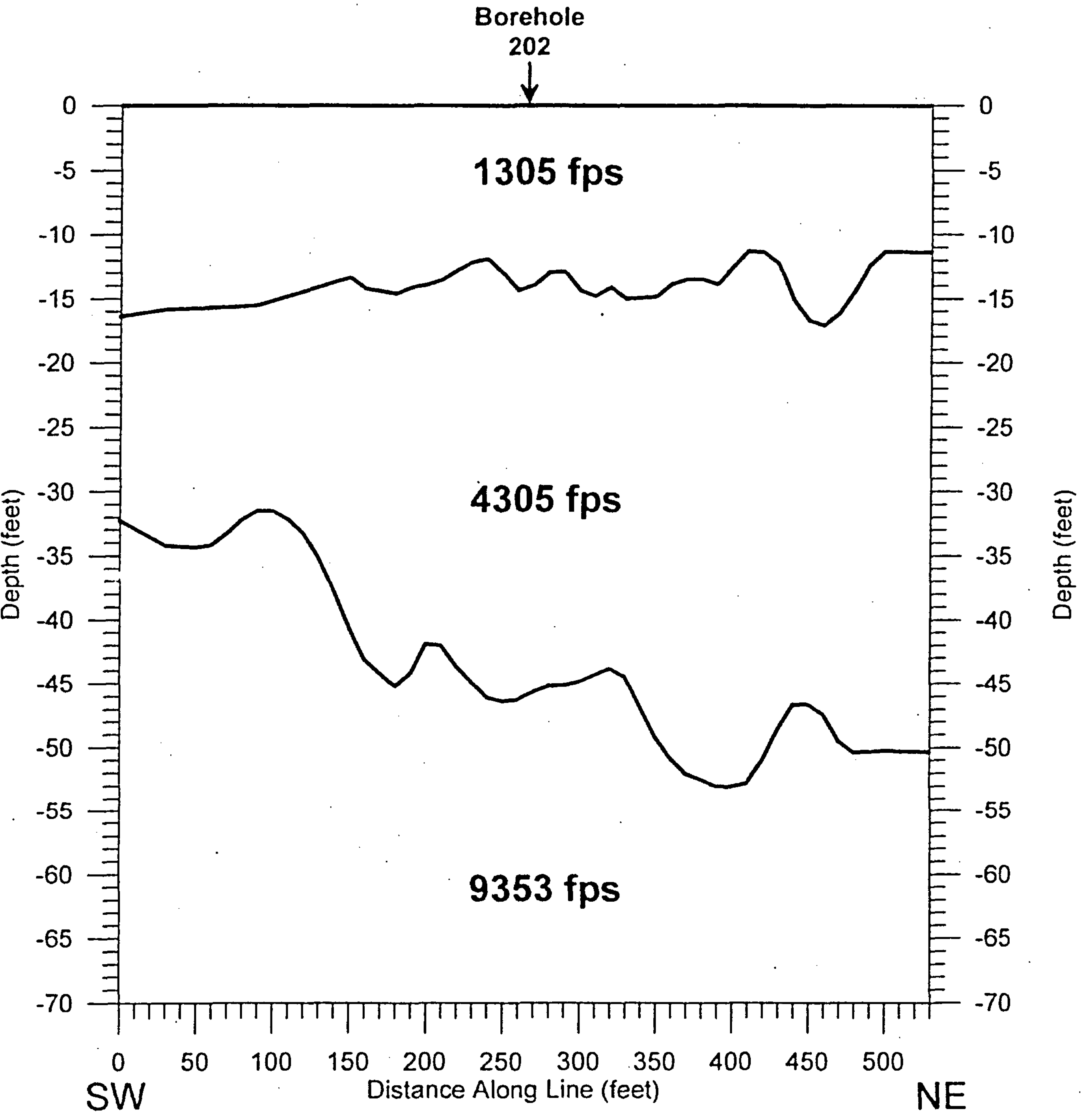
Velocities in feet per second (fps)

Hasbrouck Geophysics, Inc.

Borehole202NSDepth2D

Seismic Rippability Investigation
Crescent Junction Disposal Site
Borehole 202 SW to NE Seismic Line
Depth Section



Vertical Exaggeration = 7.6

Velocities in feet per second (fps)

asbrouck Geophysics, Inc.

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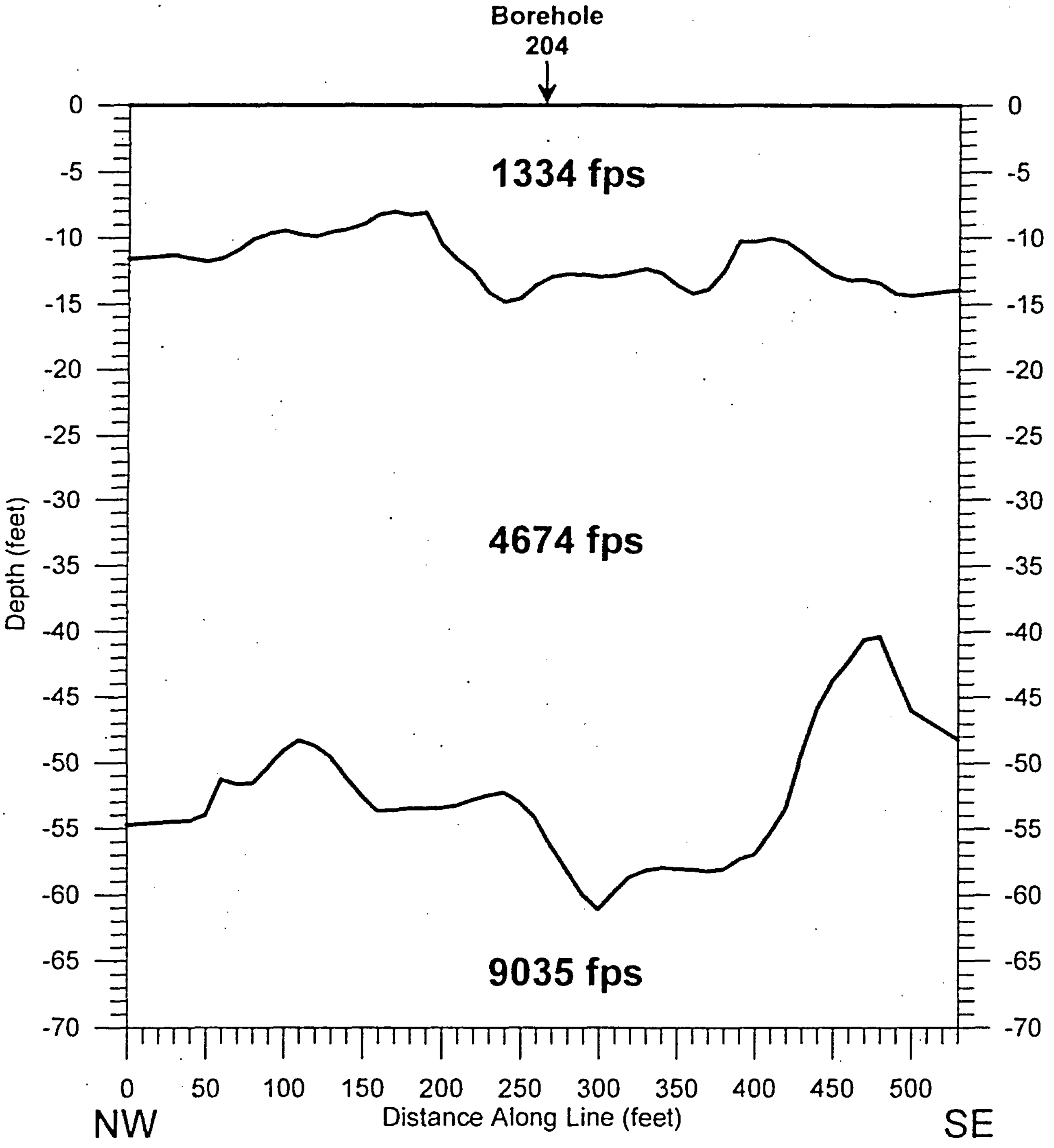
Seismic Rippability Investigation
Crescent Junction Disposal Site
Borehole 204 NW to SE Seismic Line
Depth Section



Vertical Exaggeration = 7.6

Velocities in feet per second (fps)

Hasbrouck Geophysics, Inc.

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Seismic Rippability Investigation
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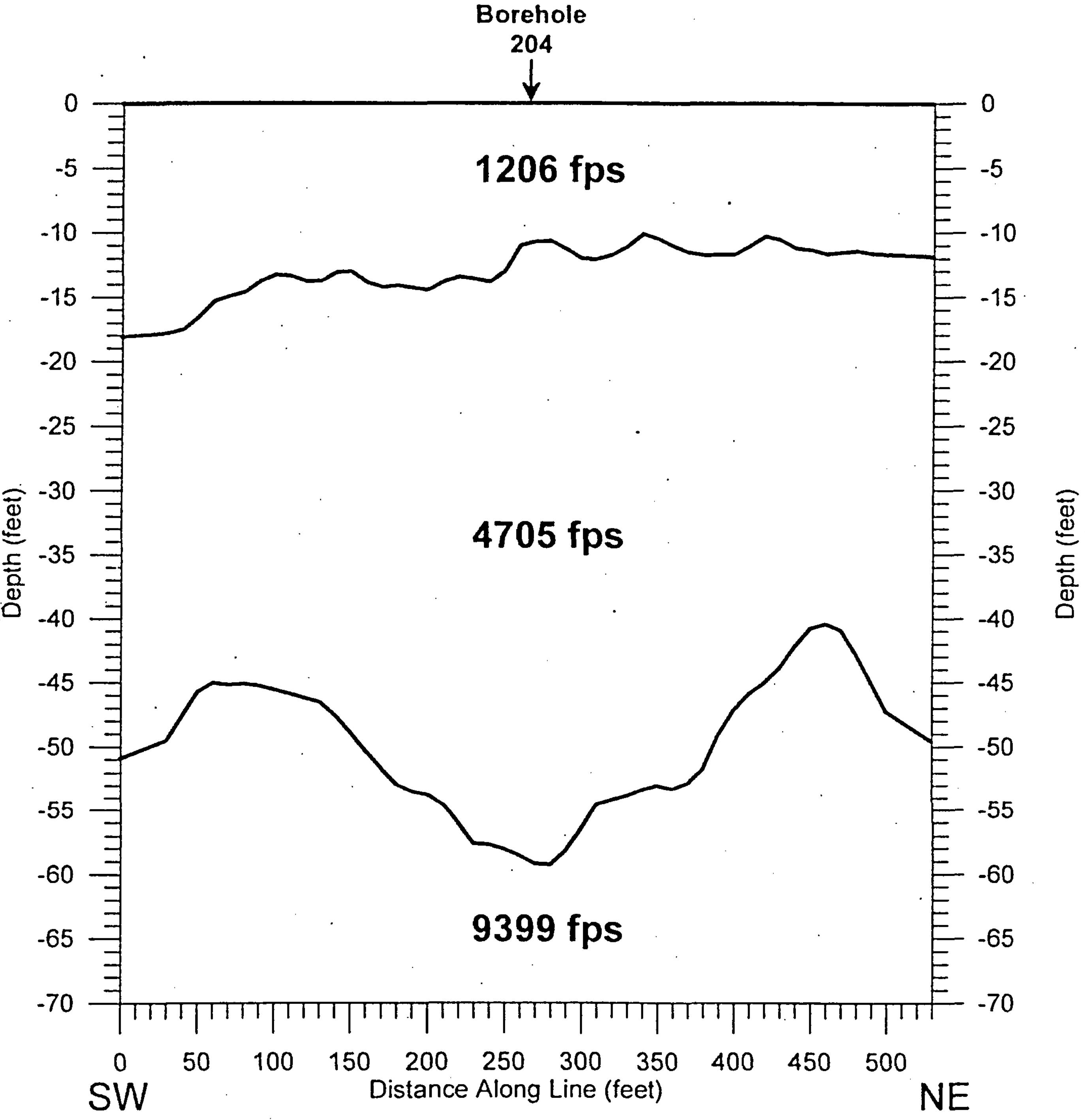
Borehole 204 SW to NE Seismic Line
Depth Section



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Velocities in feet per second (fps)

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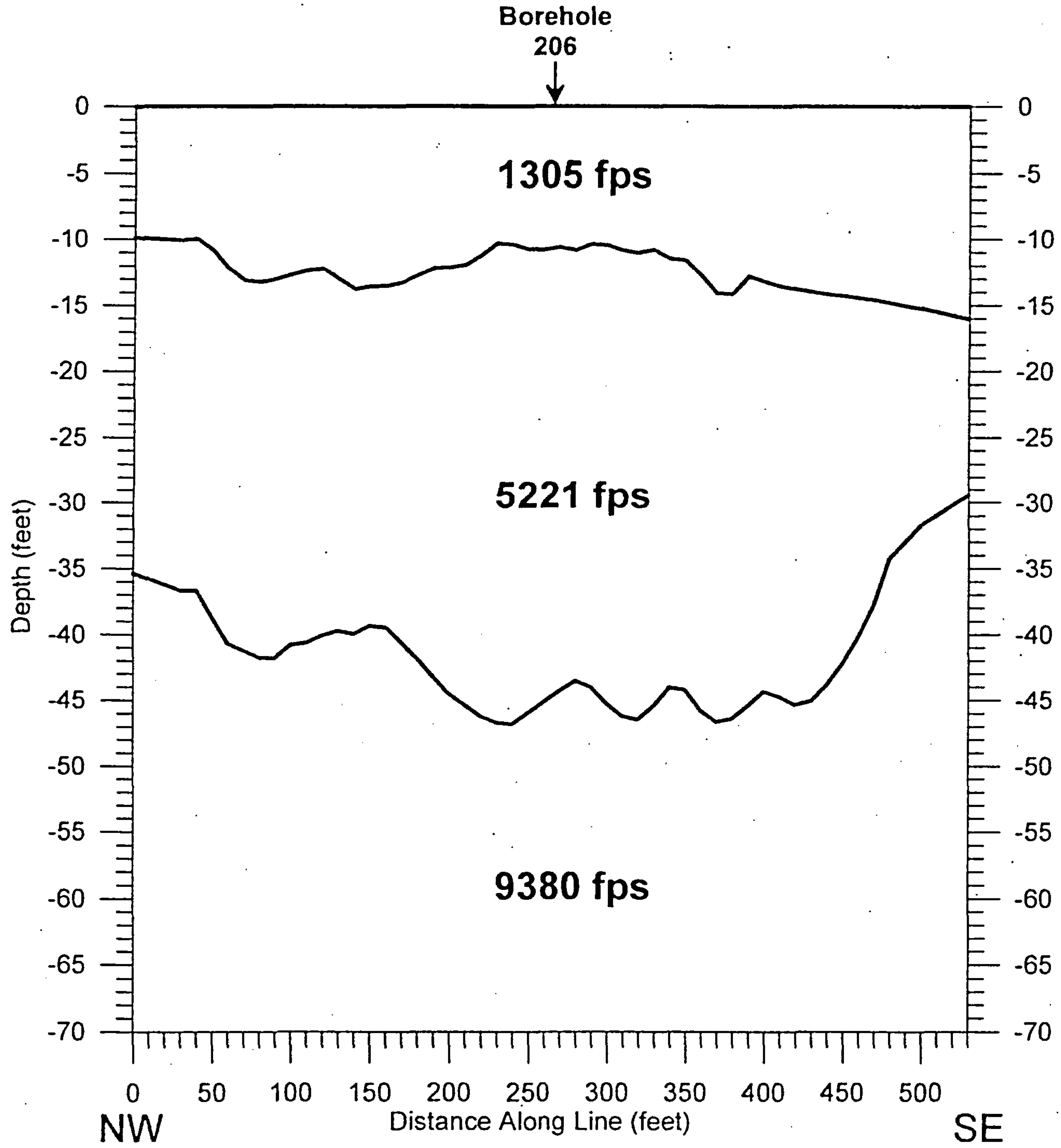
Seismic Rippability Investigation
Crescent Junction Disposal Site
Borehole 206 NW to SE Seismic Line
Depth Section



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Velocities in feet per second (fps)

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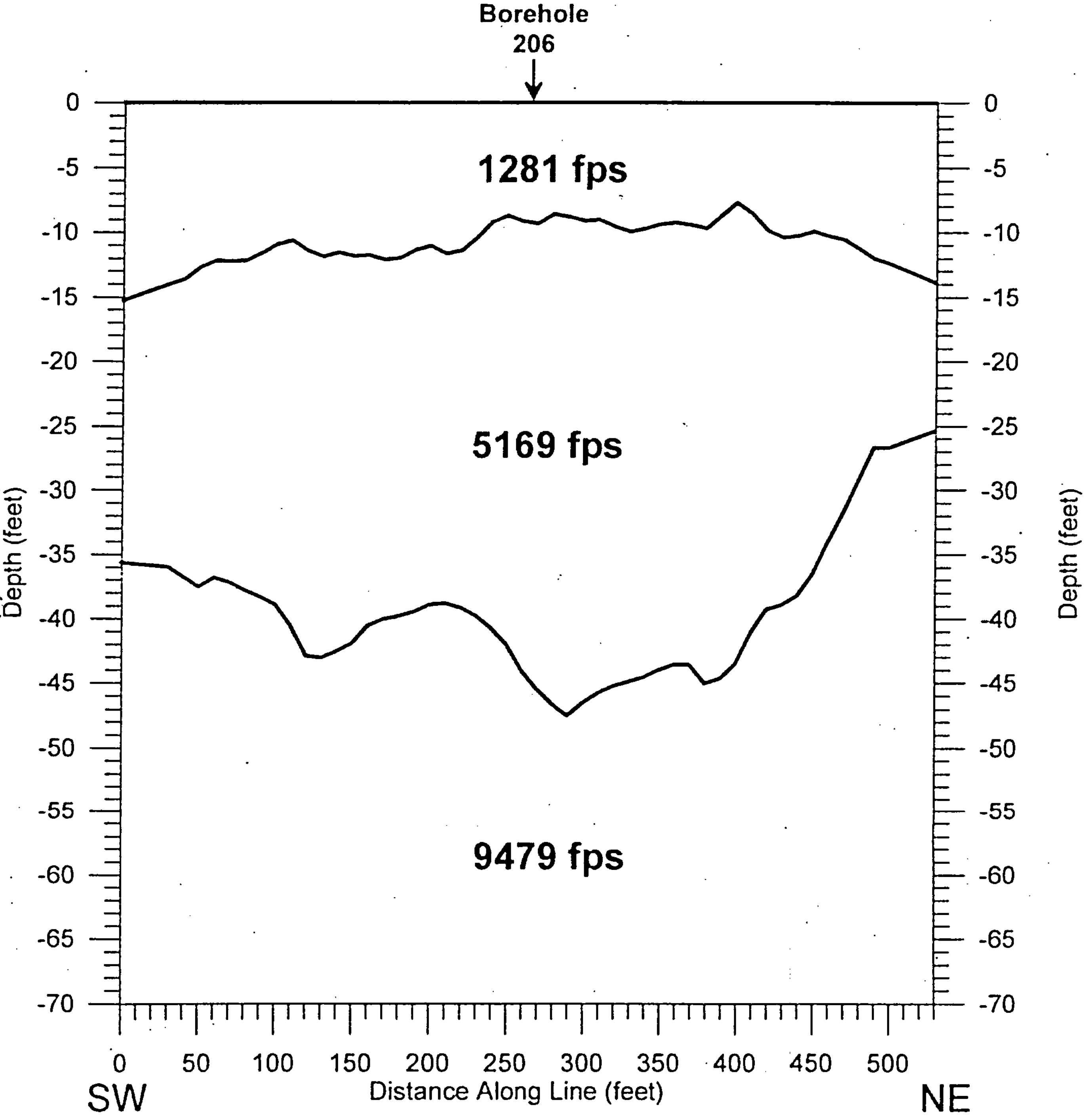
Depth Section



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Velocities in feet per second (fps)

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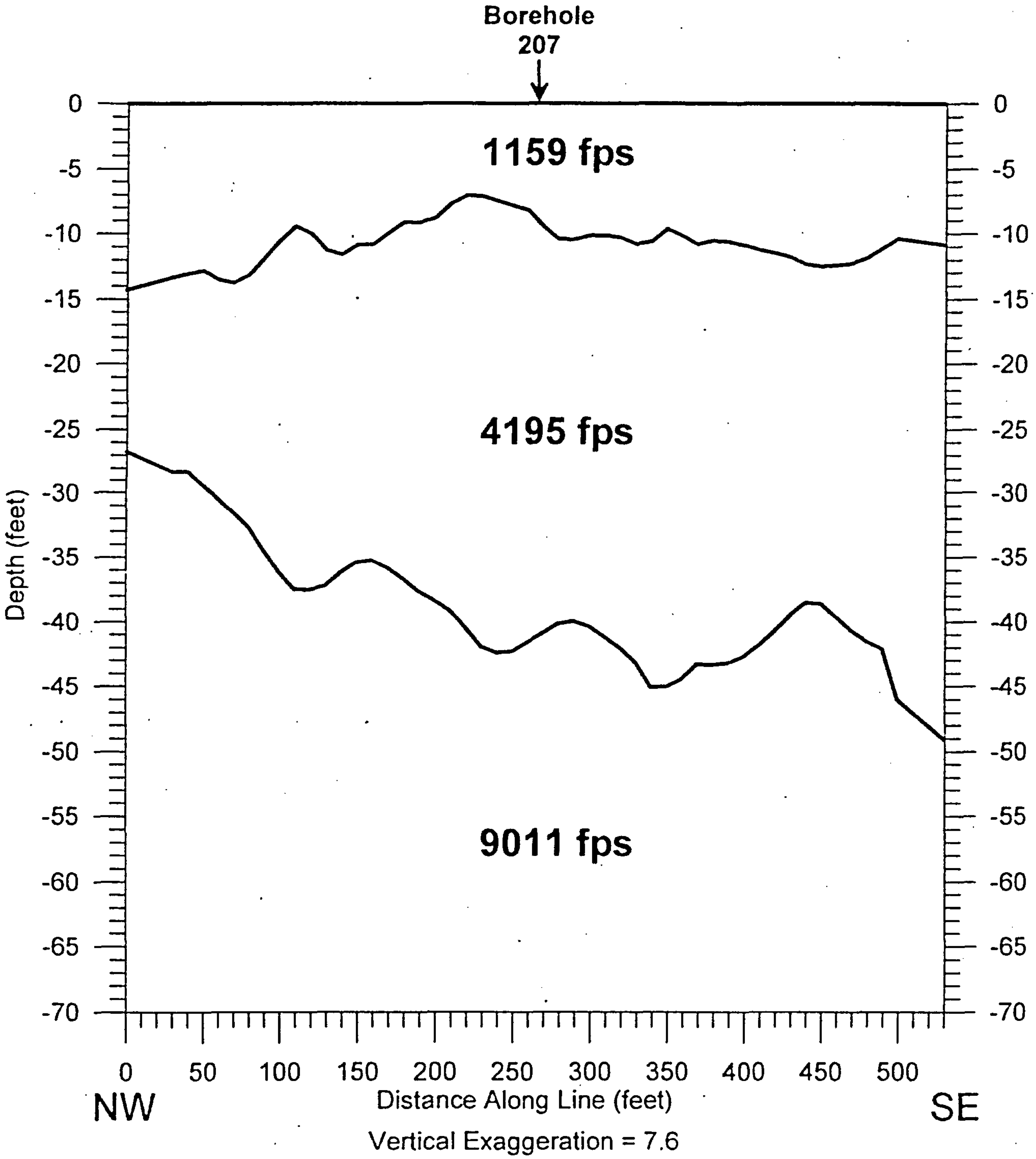
Crescent Junction Disposal Site
Borehole 207 NW to SE Seismic Line
Depth Section



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Velocities in feet per second (fps)

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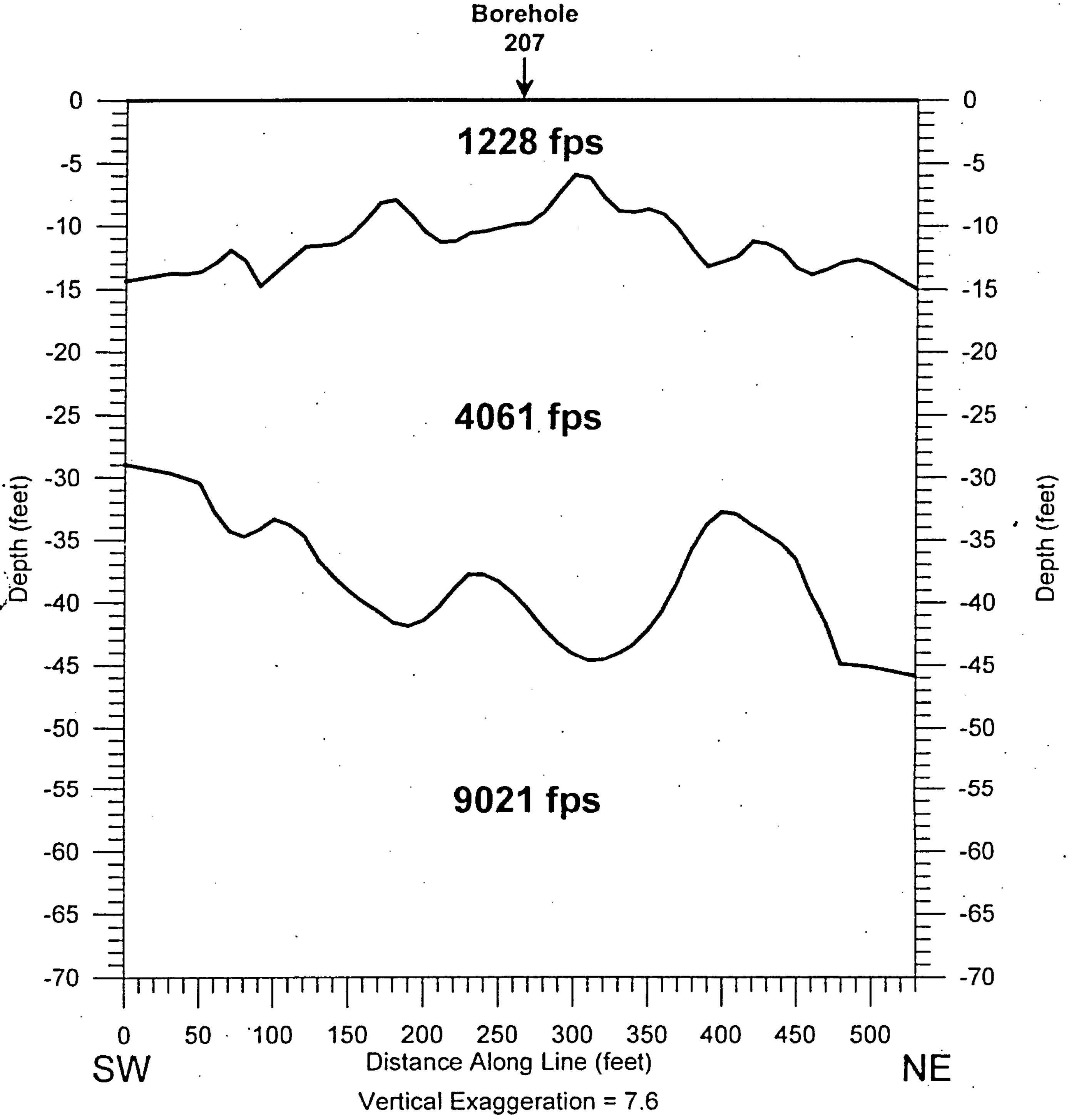
Crescent Junction Disposal Site
Borehole 207 SW to NE Seismic Line
Depth Section



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Velocities in feet per second (fps)

Hasbrouck Geophysics, Inc.

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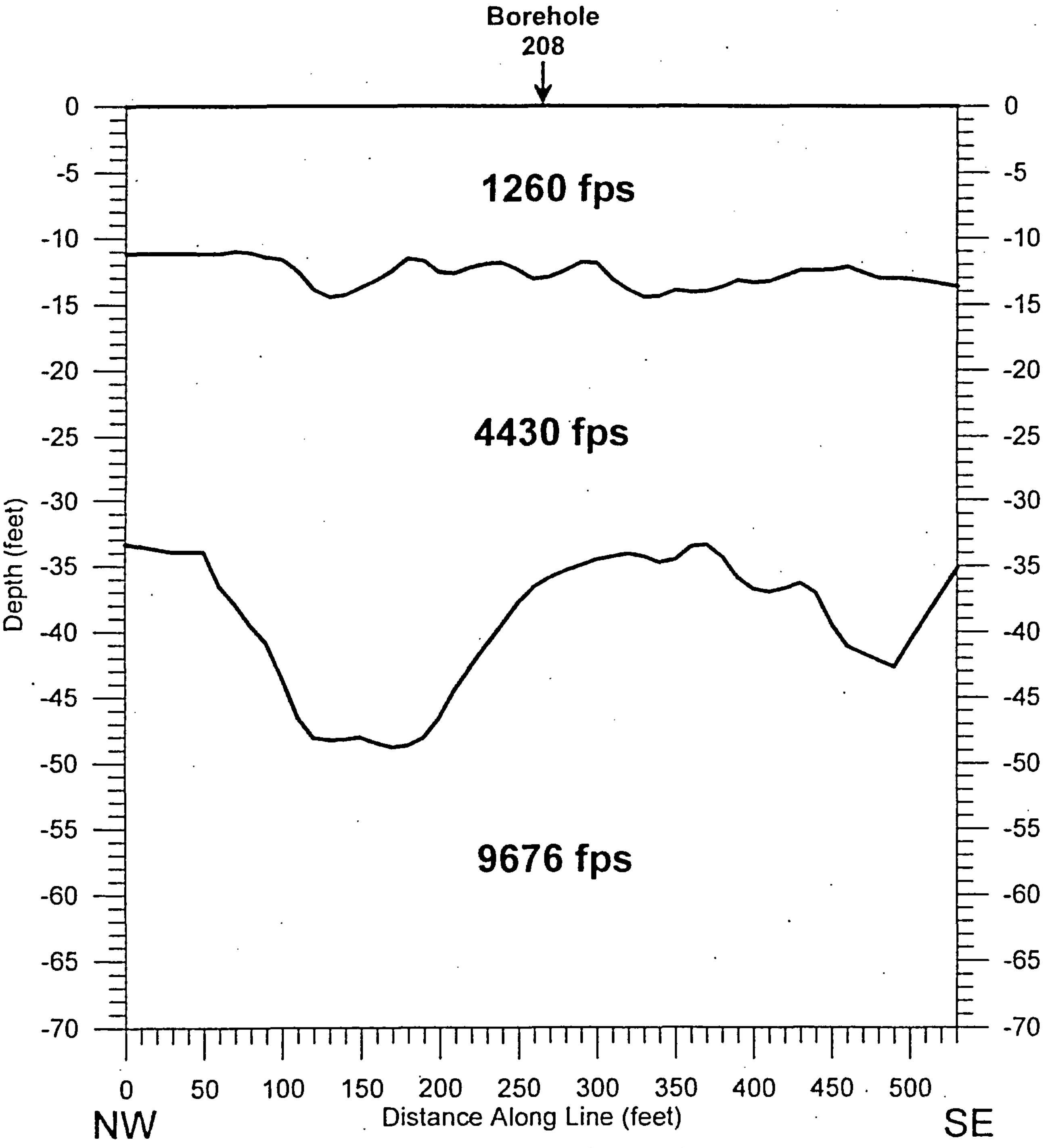
Crescent Junction Disposal Site
Borehole 208 NW to SE Seismic Line
Depth Section



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Seismic Rippability Investigation
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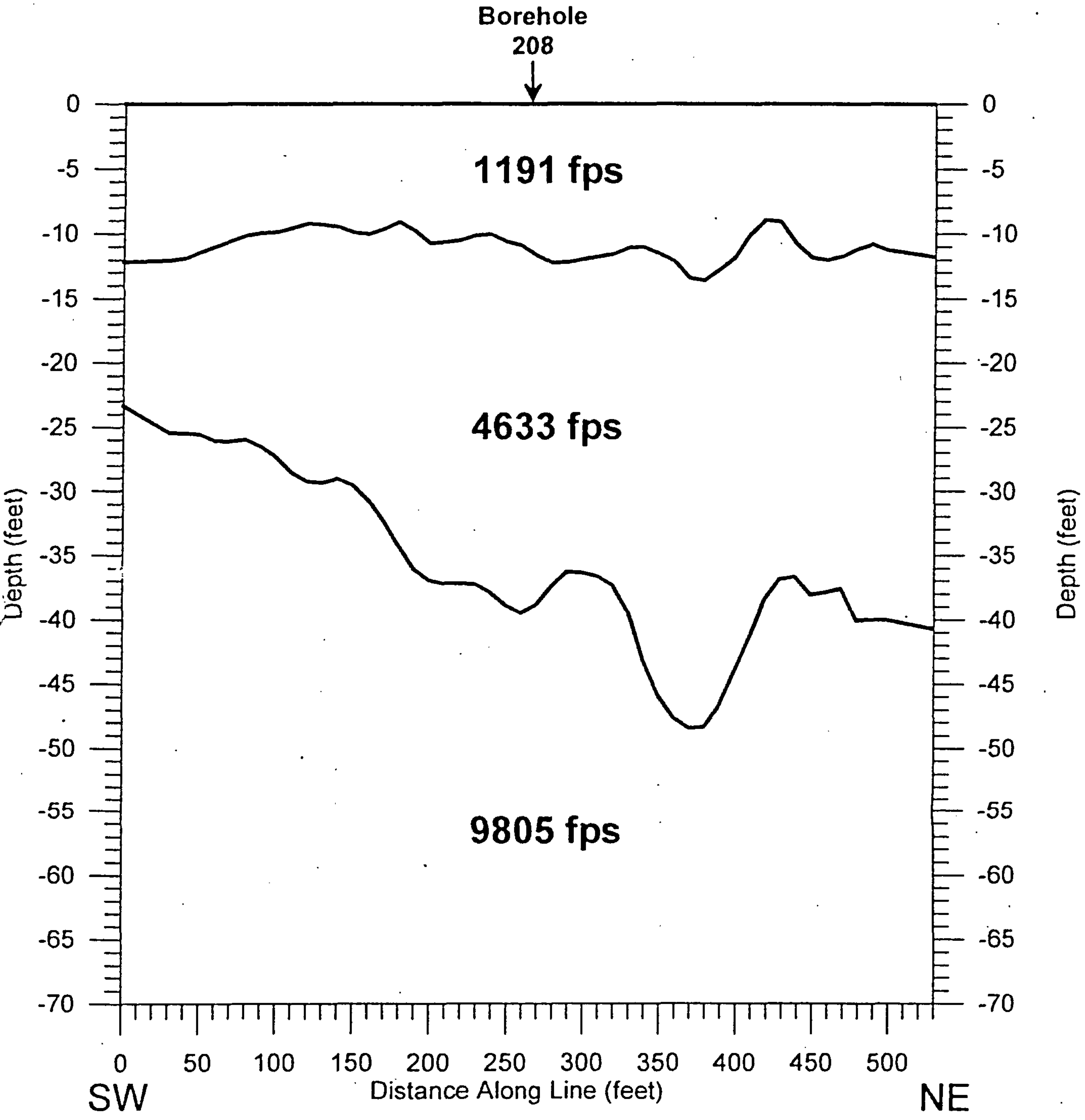
Borehole 208 SW to NE Seismic Line
Depth Section



Vertical Exaggeration = 7.6

Velocities in feet per second (fps)

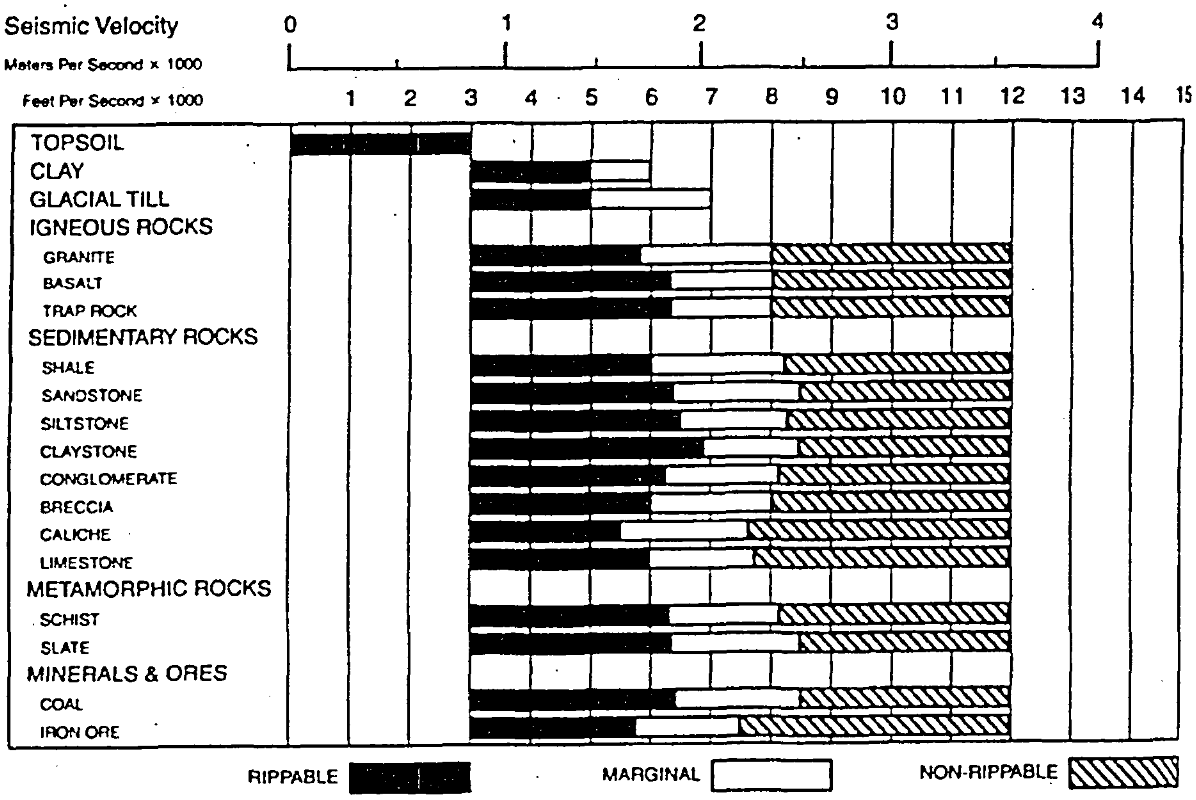
asbrouck Geophysics, Inc.

Borehole208EWDepth2D.grf

Caterpillar D8 Ripping Chart

D8R

- **Multi or Single Shank No. 8 Ripper**
- **Estimated by Seismic Wave Velocities**



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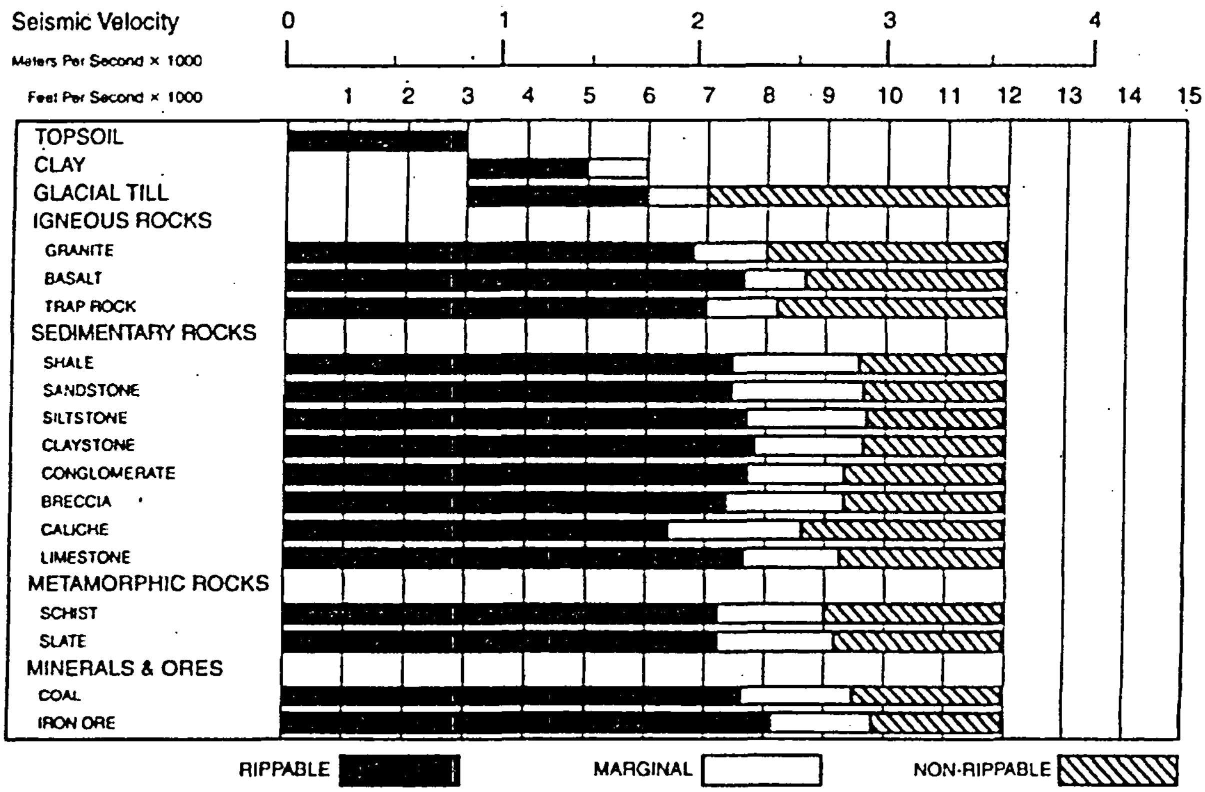
Caterpillar D9 Ripping Chart

D9R
- **Multi or Single Shank No. 9 Ripper**
- **Estimated by Seismic Wave Velocities**

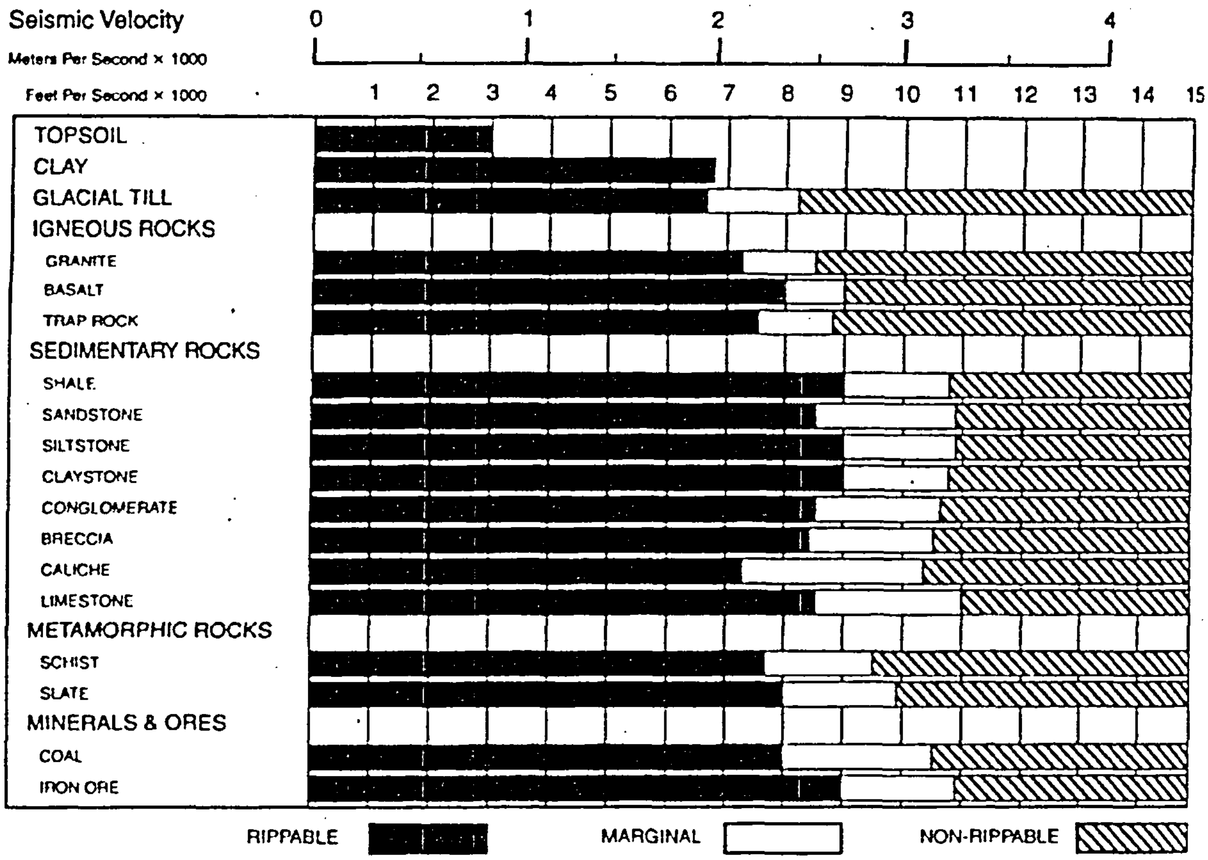


Hasbrouck Geophysics, Inc.

Caterpillar D10 Ripping Chart

D10R

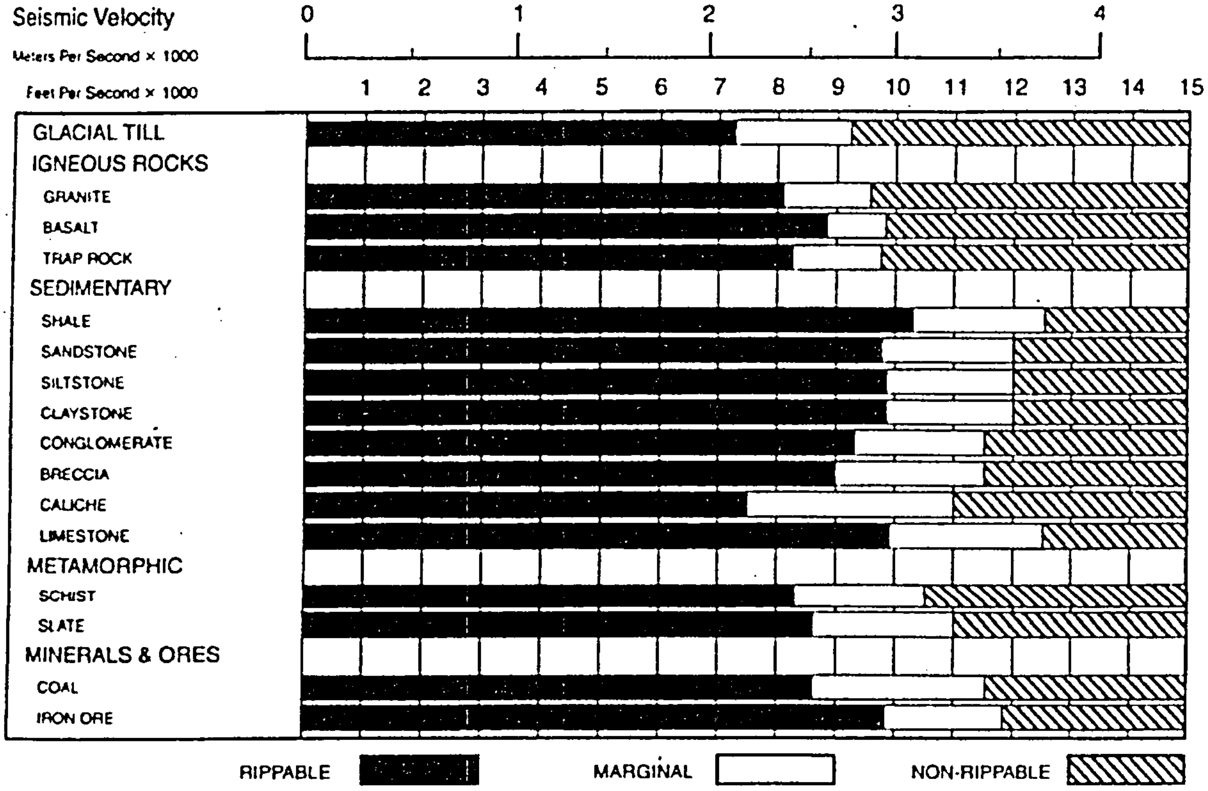
- **Multi or Single Shank No. 10 Ripper**
- **Estimated by Seismic Wave Velocities**



Hasbrouck Geophysics, Inc.

Caterpillar D11 Ripping Chart

D11R
- **Multi or Single Shank No. 11 Ripper**
- **Estimated by Seismic Wave Velocities**



Hasbrouck Geophysics, Inc.

Appendix B

Review of Seismic Report

The Word Works Inc., dba

H. David Mac Lean, P. Geoph

November 23, 2005

Mr. Mark Kautsky
S.M. Stoller Corp.
2597 B ¾ Road
Grand Junction CO 81503

Subject: Review of Report; *Seismic Rippability Investigations*
at the Crescent Junction Disposal Site.
for S.M. Stoller Corp. Grand Junction CO
by Hasbrouck Geophysics.

202 North Ave., PMB 252
Grand Junction Co 81501 Phone/fax : 970-242-1649

In its simplest form, the delay time method involves measurement of the time of arrival of a seismic wave at two geophone locations separated by a distance D. The description of the method and the procedures employed to accomplish the measurements as set forth in the above reference report are in accordance with standard industry practice. It is a limitation of the method that in order to measure the seismic velocity of successively deeper units, the seismic velocity must increase sequentially with depth, as stated in the report. This is usually the case in the most frequently encountered field situations, but low velocity, or reversal situations are encountered on occasion. Low velocity reversals do not appear to occur at the Crescent Junction site.

The lithologic section and the depth of investigation were specified by Stoller. The near surface section was determined by careful logging of core and cuttings from boreholes located throughout the planned repository. Selected boreholes formed the centers of the seismic refraction spreads as shown in the Borehole and Seismic Line Location Map included with the subject report. The refraction surveys were intended to extend the layer thickness information for approximately 250 ft in four orthogonal directions from the borehole.

Field Data Acquisition

The equipment referenced in the subject report was inspected during a visit to the field operations on October 29. The equipment was found to be as specified, and to be in good working order. Field conditions were less than optimal. Heavy rains had turned the area into a quagmire; nevertheless, the field crew was able to bring equipment into the area and proceeded with the survey with only minimal interruption caused by the adverse road and access conditions.

Field work for the survey was conducted October 29 and 30, 2005. It was observed that all field activities were conducted in a professional and workmanlike manner. Prior to commencement of operations, the field crew was briefed on health and safety issues by a Stoller representative, and a Health and Safety Plan was provided to the crew. The briefing was attended by this reviewer. Requirements of the plan, including clothing specifications were carefully observed by all field personnel.. In accordance with plan requirements, any soil that became even slightly contaminated in the course of the field activities was removed from the site and disposed of in accordance with applicable procedures and regulations.

This reviewer participated in one day of the field operations and noted that they were conducted as described in the report. Field work was conduct by a crew provided by Bird Geophysics in accordance with survey design specifications developed by Hasbrouck Geophysics. The crew was obviously well trained and performed all assigned tasks with competence and in a professional manner.

Upon locating the center of the refraction spreads referenced in an expanded version of the "Borehole and Seismic Line Location Map" included in the report, two orthogonal survey lines were extended in a NE-SW direction and a NW-SE direction. The lines were run by chain and compass; markers were placed at 10 foot intervals for a distance of 270 ft in the four directions from the center point. Every fourth marker from the center was identified so that its position could be surveyed later to the required accuracy. Since the terrain was open and unencumbered by vegetation, the entire line could be viewed from vantage points along the line. Lines were visually determined to be straight along the length of the chained interval.

Geophones were placed at each 10 foot marker. All geophones in a linear string were connected to the Bison 48 channel seismograph with Mark Products geophone cables.

Seismic signals were generated by the accelerated weight drop hammer mentioned in the report. A 200 lb metal bar is raised against compressing springs, and is thus accelerated downward to strike an aluminum plate placed on the ground at the shot point. The hammering operation started at one end of the line, and continued at various points along the spread as stated in the report. This is standard "shooting" procedure for seismic refraction surveys. The multiple shot points allow numerous depth and velocity determinations at various points along the spreads, and permit averaging and compensation for anisotropy and dip, since the seismic ray path can be observed in opposite directions. This procedure enables production of a much more detailed and representative velocity-depth section than would be possible if only a single shot point was employed.

Several (up to six) "shots" or hammer blows were taken at each shot point, allowing the seismic signals at each geophone location to be stacked. This procedure increases the signal to noise ratio. As pointed out in the report, seismic waves that arrive at a geophone at the same time following a hammer blow are additive to the signal; random noise or seismic signals for which the strike instant is incorrect are destructive and will not augment or enhance the initial seismic signal. On completion of the stacking activity, a seismogram was printed in the field for inspection and quality assurance purposes.

On the completion of the field survey day, digital data sets were forwarded to Hasbrouck Geophysics for processing and analysis. The data were processed by Hasbrouck Geophysics using the SIPwin software from Rimrock Geophysics. This processing software is state-of-the-technology for Refraction Seismic Data Processing. Given the software capabilities and the field procedures employed, Hasbrouck Geophysics was able to calculate seismic velocities over very short refractor distances. Velocities were calculated using both the regression and Hobson-Overton methods. This processing combination adequately deals with the effects anisotropy, and the distortions introduced by dipping layers. The resulting depth and velocity calculations were then employed to produce the very detailed velocity/depth sections included with the subject report.

Analysis

The velocities for the 3 layers discussed in the report, i.e., alluvium (layer 1) weathered Mancos Shale (layer 2) and Mancos Shale (layer 3) are well within the range expected for these materials. In unconsolidated material such as Layer 1, seismic velocities are often close to acoustic velocities in air (approximately 1100fps). Considerable variation in the measured velocity of Layer 2, (the weathered shale or regolith) can be expected depending on the amount of sand or silt inclusioning and the degree of consolidation within local areas. As pointed out in the report, weathering will not be complete through the entire geologic section and the lithologic material is not uniform. As expected, the seismic velocities increase as a function of depth.

The velocity function for all three layers underlying the planned repository is well illustrated by the time-distance (T-D) plot for one of the survey lines at borehole 204. A copy of the T-D plot is attached hereto. The figure provides a visual indication of the seismic velocity for the various layers. Generally, the flatter the curve on the T-D plot, the higher the velocity. A segment of the T-D plot that is continuous over a measurable interval indicates an identifiable layer. A simple estimate of the velocity associated with this interval can be made by dividing the distance interval D by the difference in arrival time (T) on the T-D plot. Of course the actual final determination of the depth associated with this interval involves a considerably more complex calculation, as has been discussed peripherally in the report.

Limitations

The purpose of measuring the seismic velocities of the layers underlying the proposed mill tailings repository was to estimate the rippability of the underlying lithologic units. Hasbrouck Geophysics has developed depth and velocity sections for all of the surveyed lines that show the lithologic layers to depths of 50 to 60 feet and the measured seismic velocities within these layers to the accuracy that is achievable with the equipment and methodology employed. However, the relationship of these measured seismic velocities to rippability of a particular unit is empirical, not an engineering certainty. Caterpillar Inc. and others involved with heavy equipment operations have observed an apparent relationship and have published charts and graphs showing the ripping capabilities of certain tractor models for various geologic material with a range of seismic velocities. However, there are many other factors that contribute to rippability, such as the degree and orientation of fracturing. Although the rippability charts published by Caterpillar Inc. represent that material with a seismic velocity in a certain range is usually within the ripping capability of certain tractor types, it is not an engineering certainty that this is the case.

Accordingly, any decision to employ a certain type of equipment based on the velocities provided in the subject report must be taken on the basis of the excavation contractor's own knowledge, and not on statements or implied statements in the report. The velocities and layer thicknesses provided in the report are valid within the accuracy of the seismic refraction method, and are reproducible by similar surveys. Nevertheless, the relationship of these in-situ measured velocities and the suitability of a specific tractor model for ripping a geologic unit with these velocities is strictly empirical and may vary from that presented in the rippability charts provided by Caterpillar Inc.

Conclusions

The subject report provides seismic velocities and the thickness of layers underlying the proposed tailings repository to a depth of about 60 ft or more. The sections showing these depths and velocities provided in the report were produced by means of a refraction seismic survey that was conducted in a professional and workmanlike manner, employing equipment that was suitable to the task. The measured interval velocities, unit thicknesses and variations to be expected are accurate to within the limitations of the current state of refraction seismic technology. The statement in the report that measured velocities are accurate to within 10 per cent is probably overly pessimistic; the accuracy of the measurements is probably much closer to 5% or less. General experience suggests that the unit thicknesses stated in the report are accurate to within 10% or better.

As stated in the report, the suitability of selecting equipment based on the reported velocities is based entirely on the experience of Caterpillar Inc. Nothing in the subject report should be construed as an endorsement of the suitability of a particular tractor model for ripping and excavating applications at the Crescent Junction repository. This decision must be taken on the basis of the excavator's own experience with ripping machinery in applications where seismic velocities are known.

Respectfully Submitted,

H. David Mac Lean, P. Geoph.

HDM/hdm

Enclosures:

Borehole 204 NW to SE Time-Distance plot

References:

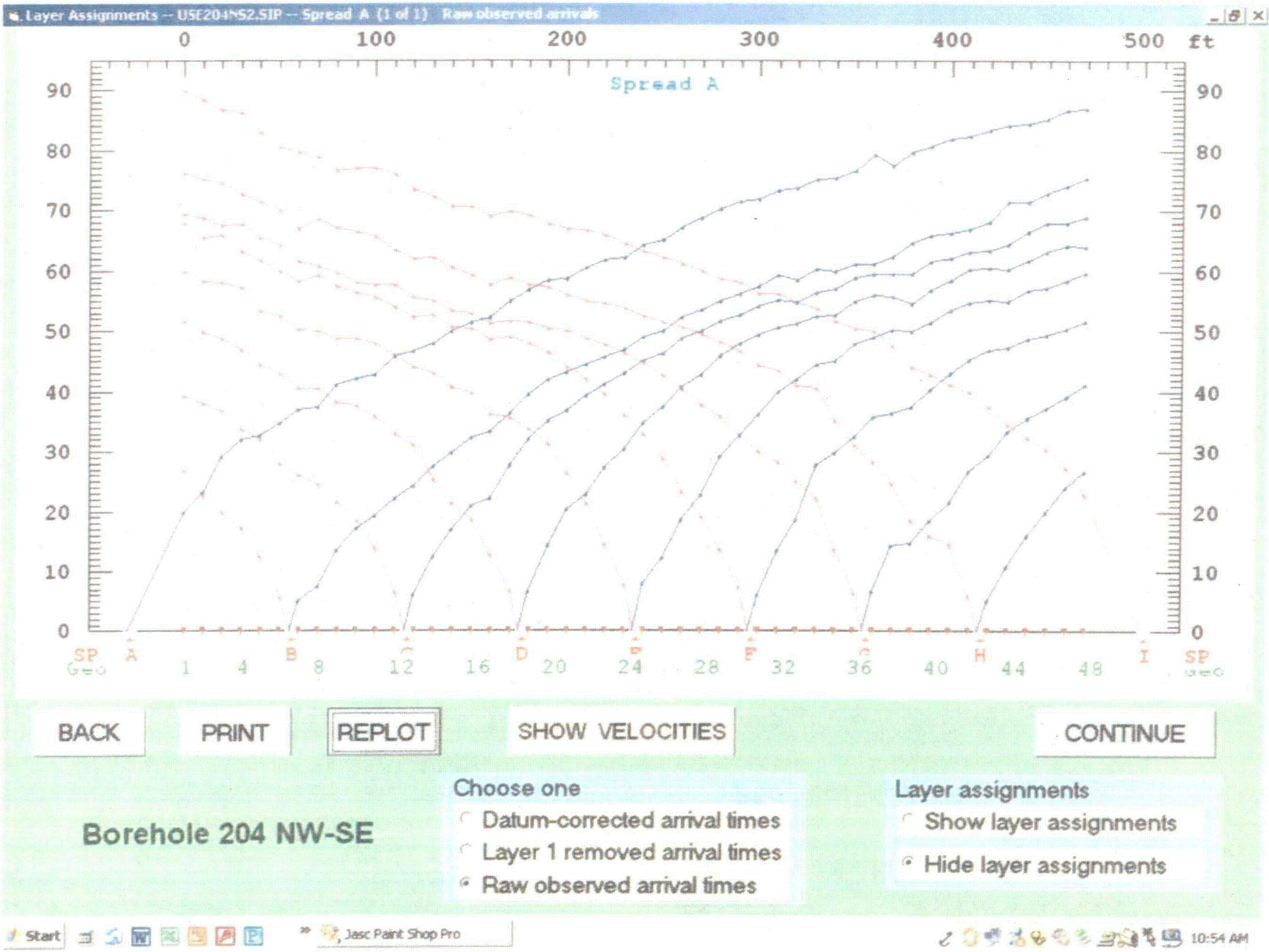
________________. Caterpillar Performance Handbook, Ed 30, October 1999, *Use of Seismic Velocity Charts* pp 1-71-1-78

Statement of Qualifications

H. David Mac Lean is a Registered Professional Geophysicist in the State of Californa, Registration No. 440 and in the Province of Alberta, Canada, Registration no.M15724. Mr. Mac Lean has been a practicing geophysicist for over 35 years.

Mr. Mac Lean has gained experience with the seismic refraction method while engaged in aggregate mapping activities in the Beaufort Sea, and in laying out seismic surveys for oil exploration in Alberta, Canada.

Mr. Mac Lean is an emeritus member of the Society of Exploration Geophysicists, the Canadian Exploration Geophysical Society, The Australian Society of Exploration Geophsicist, the Society for Mining and Metallurgy of the American Institute Mining Engineering and other technical and professional societies dedicated to the advancement of geophysics. Mr. MacLean is a frequent attendee at conventions, trade shows and seminars dedicated to geophysical technologies.



Borehole 204 NW-SE

Choose one

○ Datum-corrected arrival times

○ Layer 1 removed arrival times

● Raw observed arrival times

Layer assignments

○ Show layer assignments

● Hide layer assignments

Appendix H

U.S. Department of Energy—Grand Junction, Colorado

Calculation Cover Sheet

Calc. No.: MOA-02-03-2006-3-04-00 **Discipline:** Geochemical Properties **No. of Sheets:** 6

Project: Moab UMTRA Project

Site: Crescent Junction, Utah

Feature: Background Ground Water Quality

Sources of Data:

Chemistry results from the Crescent Junction Disposal Site ground water sampling events of November 7 and December 27, 2005, are available in the SEEPro database.

Sources of Formulae and References:

Hem, J.D. 1970. *Study and Interpretation of the Chemical Characteristics of Natural Water, Second Edition.* U.S. Geological Survey Water—Supply Paper 1473.

U.S. Department of Energy (DOE), 2005. *Ground Water and Surface Water Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites*, Revision 7, DOE-LM/GJ863-2005, prepared by the U.S. Department of Energy, Grand Junction, Colorado, April.

Van Voast, Wayne, A. 2003. *Geochemical Signature of Formation Waters Associated With Coalbed Methane*, AAPG Bulletin, v. 87, No. 4, pp. 667 – 676.

Preliminary Calc. ☐ **Final Calc.** ☑ **Supersedes Calc. No.**

Author: Name 5-12-06 Date

Checked by: Dave Peterson Name 5/15/06 Date

R. H. Bird Name 5/16/06 Date

Name 17 May 06 Date

Name 24 May 06 Date

Approved by: Name 5-22-06 Date

Problem Statement:

Preliminary site selection performed jointly by the U.S. Department of Energy (DOE) and the Contractor has identified a 2,300-acre withdrawal area in the Crescent Flat area just northeast of Crescent Junction, Utah, as a possible site for a final disposal cell for the Moab uranium mill tailings. The proposed disposal cell would cover approximately 300 acres. Based on the preliminary site-selection process, the suitability of the Crescent Junction Disposal Site is being evaluated from several technical aspects including geomorphic, geologic, hydrologic, seismic, geochemical, and geotechnical. The objective of this calculation set is to evaluate background ground water quality data from the Crescent Junction Disposal Site.

Conclusions from these data will be incorporated into Attachment 3 (Ground Water Hydrology) and Attachment 4 (Water Resources Protection) of the Remedial Action Plan and Site Design for Stabilization of Moab Title I Uranium Mill Tailings at the Crescent Junction, Utah, Disposal Site, and summarized in the Remedial Action Selection Report for the Moab Site.

Method of Solution:

Ten coreholes were advanced to depths of approximately 300 feet (ft) in the study area for the Crescent Junction Disposal Site (Figure 1 and Appendix A). Ground water was observed immediately after completion of drilling in coreholes 0201, 0202, 0203, 0204, and 0208. Ground water seeped into coreholes 0205 and 0210 over the course of several weeks after completion of drilling. Coreholes 0206, 0207, and 0209 remained dry as of March 31, 2006.

Background ground water samples were collected during two sampling events. The first event (November 7, 2005) included sampling of ground water at coreholes 0208 and 0210 to determine total dissolved solids (TDS) concentrations and major cations and anions. The second sampling event (December 27, 2005) included collection of ground water from coreholes 0201, 0202, 0203, 0204, and 0208. A more comprehensive list of constituents was analyzed during the December 2005 sampling event. Coreholes 0205 and 0210 were not sampled during the second round because in comparison to the other coreholes they had much deeper water levels and longer water-level recovery rates; therefore, they were considered less significant. Ground water was sampled according to procedures and protocols in the Sampling and Analysis Plan (SAP) (DOE 2005). The Paragon Analytics laboratory, located in Fort Collins, Colorado, analyzed the ground water samples (analytical results are provided in Appendix B). Data were validated according to the SAP (Appendix C) and then loaded into the SEEPro database located at DOE in Grand Junction, Colorado.

Assumptions:

N/A

Calculation:

N/A

Discussion:

Background ground water quality data from coreholes 0201, 0202, 0203, 0204, 0208, and 0210 are available in the SEEPro database and are presented in Appendix B (see Table 1 for summary of indicator constituents analyzed during the December 2005 sampling event). The ground water analyses indicated that TDS concentrations were significantly elevated, ranging from 23,000 to 42,000 milligrams per liter (mg/L). Uranium concentrations in ground water were typically very low (generally less than 0.002 mg/L) with the exception of the level in corehole 0208, where the measured background concentration of 0.031 mg/L was approaching the maximum concentration limit (MCL) of 0.044 mg/L (Table 1 to Subpart A of 40 CFR 192). Dissolved levels of other constituents with MCLs were consistently low and significantly below their respective MCLs.

Table 1. Background Concentrations[1] of Indicator Constituents in Ground Water

Constituent	**0201**	**0202**	**0203**	**0204**	**0208**	**0210**
Ammonia as N	13	15	13	15	4	N/A*
Alkalinity, Bicarbonate (as $CaCO_3$)	740	430	1,300	830	1,700	N/A
Alkalinity, Total (as $CaCO_3$)	740	430	1,300	830	1,700	634
Calcium	190	200	160	240	89	180
Chloride	26,000	24,000	19,000	27,000	8,000	23,000
Magnesium	140	94	110	130	78	140
Molybdenum	0.0018	0.0056	0.0021	0.0077	0.0068	N/A
Nitrate	0.027	0.022	0.026	0.032	11	N/A
ORP[2]	442	246	234	248	248	15
pH	6.88	7.26	6.93	7.22	7.02	7.23
Selenium	0.00048	0.0079	0.00076	0.0076	0.0021	N/A
Sodium	13,000	12,000	11,000	12,000	7,100	12,000
Sulfate	1,300	*25U**	4,200	*25U**	7,800	1,700
TDS	42,000	38,000	37,000	42,000	23,000	23,000
Uranium	0.0023	0.00041	0.00018	0.00042	0.031	N/A

[1] Concentrations in mg/L.

[2] ORP = oxidation—reduction potential.

*N/A = Not Analyzed

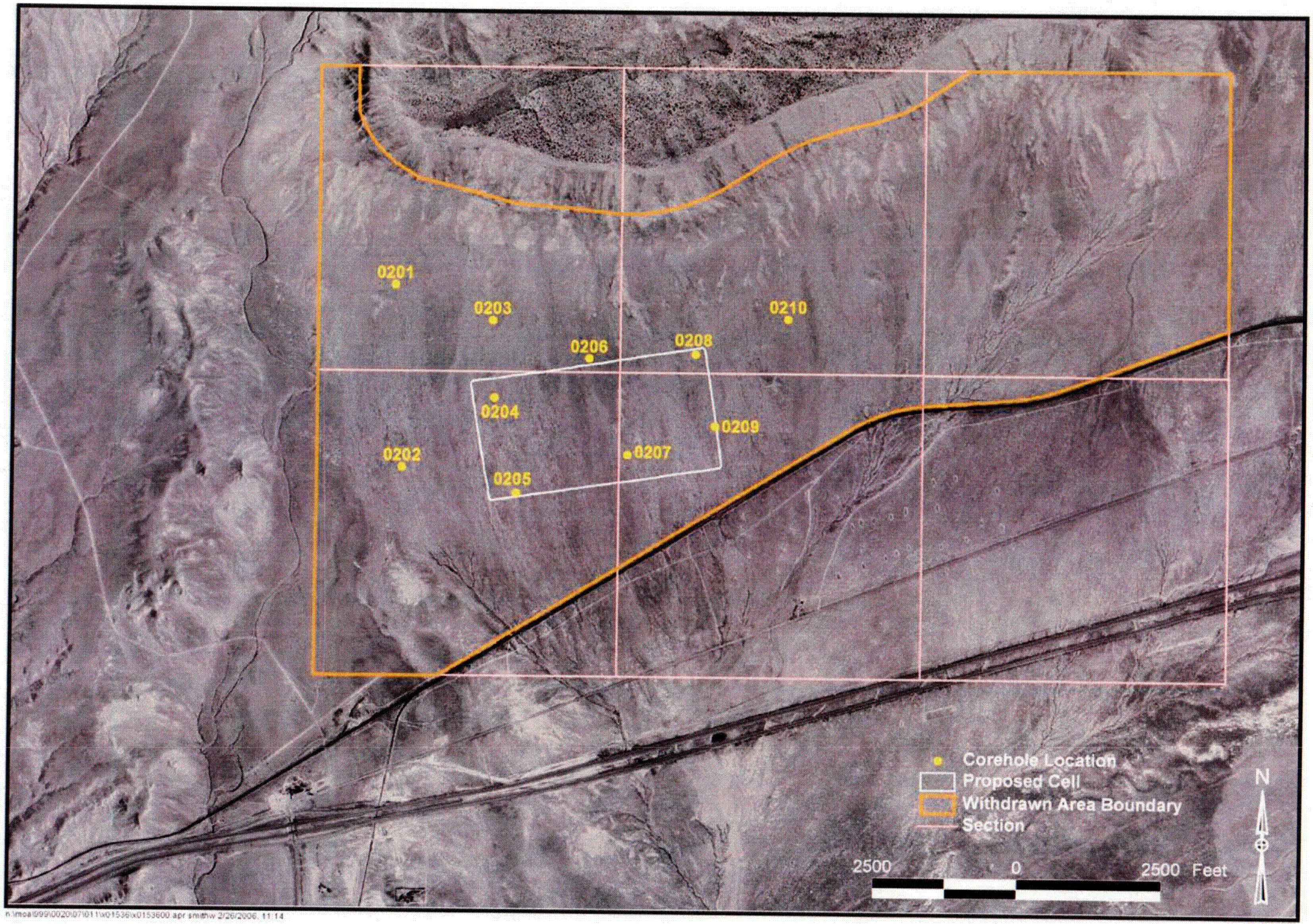
*U** = Data qualifier signifying that the parameter was analyzed for but not detected.

Because the TDS concentration in the ground water is particularly high, an examination of the dominant chemical species contributing to the TDS is warranted. Table 2 presents the ratios of the foremost chemical constituents to the TDS. The ratios of sodium to TDS are consistently about 0.3 in each sample. Ratios of chloride to TDS are approximately 0.6 in ground water at coreholes 0201, 0202, 0204, and 0210; consequently, sodium and chloride alone account for 93 to 95 percent of the chemical mass that makes up the TDS at these coreholes. Accordingly, the ratios of sulfate and bicarbonate to TDS are correspondingly low in coreholes 0201, 0202, 0204, and 0210. However, because the ratio of chloride to TDS is approximately 0.3 at corehole 0208, the deficit is made up through relative enrichment of primarily sulfate and some bicarbonate at corehole 0208. These results show that the briny ground water (TDS>35,000 mg/L) at the Crescent Junction Disposal Site is typified by a sodium-chloride-dominated composition. Ground water at corehole 0208, which was very saline (10,000 mg/L<TDS<35,000 mg/L), had an anion chemistry composed mostly of chloride and sulfate. Figure 2 shows the Piper diagram for these ground water samples.

Table 2. Ratios of Leading Chemical Concentrations in Ground Water to the TDS Concentrations

Corehole	Date	Na/TDS	Cl/TDS	SO_4/TDS	HCO_3/TDS	($Na+Cl+SO_4+HCO_3$) /TDS
0201	12/27/2005	0.31	0.62	0.03	0.02	0.98
0202	12/27/2005	0.32	0.63	0.00	0.01	0.96
0203	12/27/2005	0.30	0.51	0.11	0.04	0.96
0204	12/27/2005	0.29	0.64	0.00	0.02	0.95
0208	11/7/2005	0.28	0.32	0.31	N/A	N/A
0208	12/27/2005	0.27	0.29	0.34	0.07	0.97
0210	11/7/2005	0.32	0.62	0.05	N/A	N/A

N/A indicates that the analysis of bicarbonate was not available for that sample date.



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X0153600-01

Figure 1. Corehole Locations at the Crescent Junction Site

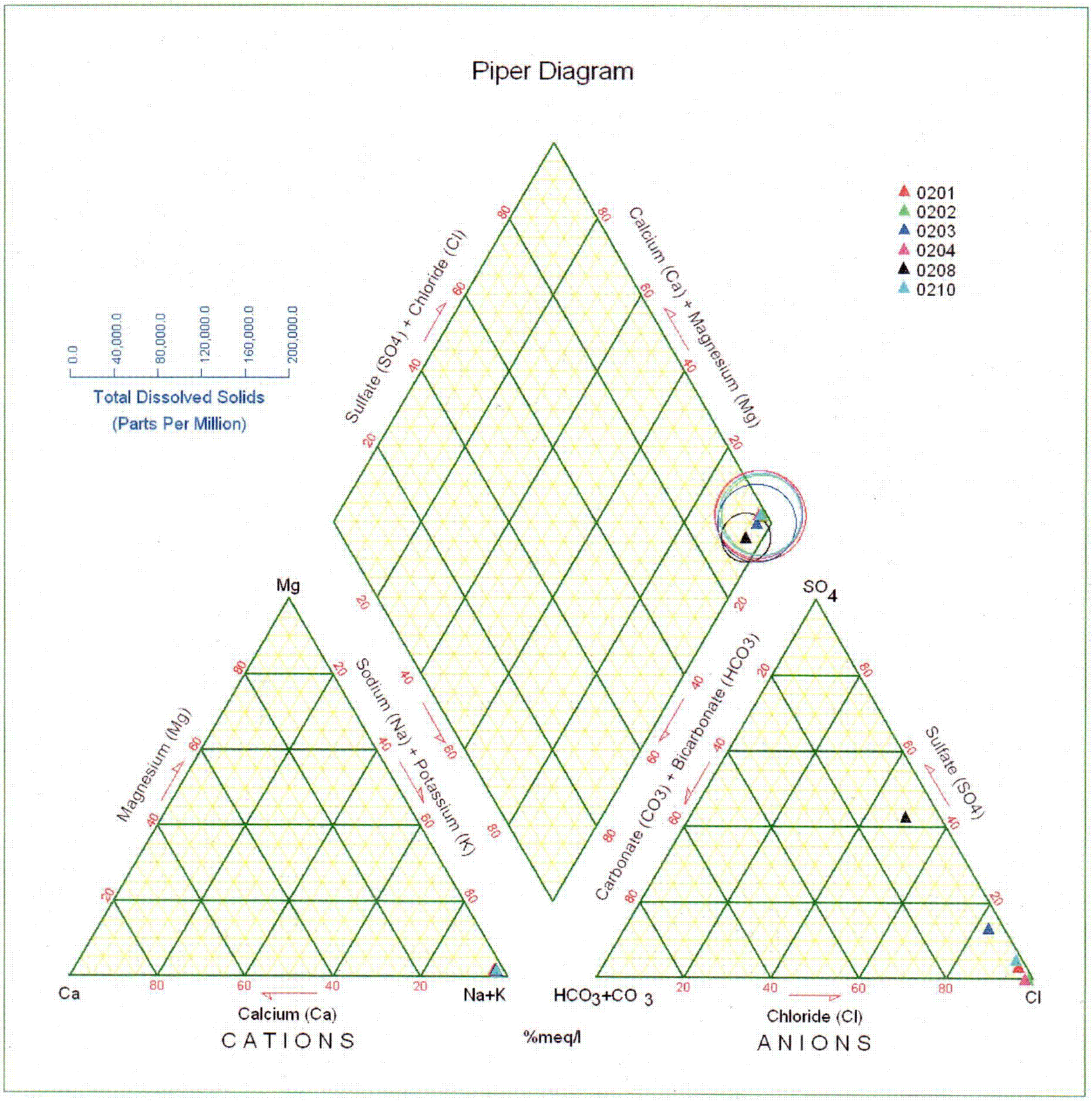

Figure 2. Piper Diagram for the Ground Water at the Crescent Junction Site

Conclusion and Recommendations:

Ground water encountered in the coreholes drilled into the shallow Mancos Shale was highly saline and often exceeded the minimum salinity levels characteristic of brine (TDS>35,000 mg/L) (Hem 1970; p. 219). Based on its occurrence and composition, the ground water intersected by these coreholes is likely to be connate water, or water that has been trapped in the pores of the rock since the rock was formed in a marine environment. This suggests that ground water in the shallowest zones of the Mancos Shale at the site does not necessarily occur in interconnected aquifers capable of producing significant amounts of water to wells. The significant variability of TDS levels in ground water in the coreholes infers lack of interconnected zones of saturation. These observations, along with other information collected during the field investigations and presented in other calculation sets, suggest that ground water found locally in the shallow Mancos Shale occurs in isolated pockets that are unaffected by, or disconnected from, a more regional, dynamic aquifer system.

Another aspect of the shallow ground water chemistry of the Mancos Shale is that there appears to be a modest enrichment of bicarbonate alkalinity accompanied by highly variable sulfate concentrations. The bicarbonate enrichment is noteworthy because it alone makes up the total alkalinity of the water. The pH grid in Hem (1970; p. 154–155) suggests that bicarbonate would make up about 80 percent of the total alkalinity. In addition, there is significant variability in the sulfate concentrations, which range from below detection in coreholes 0202 and 0204 to 7,800 mg/L at corehole 0208.

The combination of enriched bicarbonate and depleted sulfate, in coexistence with depleted calcium and magnesium concentrations, was proposed by Van Voast (2003; p. 673) to be an indication of a ground water system associated with hydrocarbon-rich environments where sulfate is unstable. A comparison of the calcium and magnesium concentrations shown in Table 1 and Appendix B to the average chemical composition of seawater (Hem 1970; p. 11) would show that they too are modestly depleted with respect to modern seawater. Evidence of sulfate depletion in the ground water is found in the occurrence of framboidal pyrite in all the coreholes drilled into the Mancos Shale for this project (Attachment 5, Appendix A, Corehole Logs). Perhaps the minor gas shows encountered in the Mancos Shale during drilling provide locally reducing conditions necessary to biochemically reduce sulfate, enrich bicarbonate, and precipitate calcium and magnesium.

Two additional confirmatory sampling events will be undertaken for this characterization project to evaluate if temporal changes have occurred since the coreholes were first advanced. Samples will be collected at coreholes 0201, 0202, 0203, 0204, 0205, 0208, and 0210. A more comprehensive analyte list will be developed that includes potential contaminants of concern from the Moab Processing Site, constituents listed in Table 1 to Subpart A of 40 CFR 192, and other diagnostic constituents for geochemical properties of the Mancos Shale at the disposal site. These sampling results will also verify the potentially anomalous analytical results reported for sulfate and uranium mentioned above. Because of the timing for sample analysis and data validation, results from these sampling events will be reported in the next revision to this calculation set.

Computer Source:

N/A