Fuller
Mossbarger
Scott &
May
FMSM ENGINEERS

Report of Geotechnical Exploration

Ohio River Bridges Project
East End Approach - Section 4
Roadway Portion
Item No. 5-118.11
Jefferson County, Kentucky

Prepared for:
H.W. Lochner, Inc.
Lexington, Kentucky

FULLER, MOSSBARGER, SCOTT & MAY ENGINEERS, INC.

June 10, 2008

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June 10, 2008 O.1.1.LX2004110R01

Mr. Jerry Leslie, PE
H.W. Lochner, Inc.
1040 Monarch Street, Suite 300
Lexington, Kentucky 40513

Re: Report of Geotechnical Exploration
Ohio River Bridges Project
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Item No. 5-118.11
Jefferson County, Kentucky

Dear Jerry:

Fuller, Mossbarger, Scott, and May Engineers, Inc. (FMSM) is submitting the geotechnical engineering report for the above referenced project with this letter. The exploration generally followed guidelines presented in the KYTC Geotechnical Manual. Specific project dates were:

Exploration Plans	-	January 10, 2005
Field Explorations	-	Late January and February, 2005, Late November and December, 2005
Request for Preliminary Cut Stability Slopes Review	-	November 3, 2005
Cut Stability Slope Review Meetings	-	November 10, 2005; June 30, 2006; July 25, 2006; August 10, 2006; August 22, 2006; December 19, 2007
Draft Report and Geotechnical Notes Submitted to the Branch for Review	-	February 27, 2008
Comments from Geotechnical Branch on Draft Report	-	May 9, 2008
Final Soils Meeting – Not Scheduled	-	

This report includes results of field the exploration, laboratory testing program, and recommendations for design and construction of the roadway. In addition, data collected for the tunnel portion is included for informational purposes. A legend sheet, soil profile sheets, and cut and embankment stability sections are included as half-scale reproductions.

We have enjoyed working with you in support of your design process. If we can be of further assistance, please call our office.

Sincerely,

FULLER, MOSSBARGER, SCOTT AND MAY
ENGINEERS, INC.

Adam Crace, PE
Senior Project Engineer

Mark A. Litkenhus, PE
Senior Associate

/rws

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1. Introduction

The Bi-State Management Team, consisting of representatives from the Federal Highway Administration (FHWA), Kentucky Transportation Cabinet (KYTC) and Indiana Department of Transportation (INDOT), is planning and overseeing the design of the Ohio River Bridges Project which will address the cross-river transportation needs in Louisville, Kentucky and Southern Indiana. The Ohio River Bridges Project consists of six separate design sections.

- Section 1 Kennedy Interchange
- Section 2 Downtown Bridge
- Section 3 Downtown Indiana Approach
- Section 4 East End Kentucky Approach
- Section 5 East End Bridge
- Section 6 East End Indiana Approach

This report specifically addresses the geotechnical concerns relative to the roadway portion of the East End Kentucky Approach (Section 4), referred to herein as the East End Approach. Project plans provided to Fuller, Mossbarger, Scott and May Engineers, Inc. (FMSM) by H. W. Lochner, Inc. (Lochner), indicate the improvements will include approximately 3.3 miles of mainline roadway, beginning at about Station 11+33, just west of the I-265/I-71 interchange, and ending near Station 186+50 near Transylvania Beach Road. The plans also show an approximately 2000-foot long tunnel that will carry a portion of the roadway beneath US Highway 42 and the Drumanard Property from approximate Station 106+00 to approximate Station 127+20. Traditional open cuts with a maximum height of approximately 90 feet are projected just back-station of the tunnel entrance, and 60 feet ahead-station of the tunnel exit. About 900 feet northwest of the tunnel location, a bridge from approximate Stations 135+75 to 150+75 will carry the alignment over River Road and Harrods Creek. As the roadway traverses towards the Ohio River, it will be situated on a new embankment ranging in heights from 35 feet to 60 feet between approximate Station 150+50 and approximate Station 168+50. This section ends as an approach structure over the floodplain adjacent to the Ohio River that will connect with the proposed East End Bridge (Section 5). Appendix A contains a location map illustrating the proposed project alignment.

This geotechnical report addresses geotechnical recommendations for the roadway portion of this project. Specific recommendations related to the tunnel, Wolf Pen Branch Bridge, Springdale Road, Ramp A bridge over KY 841, bridge over Harrods Creek, approach structures to Ohio River, and any retaining walls will be provided by under a separate cover.

2. Topography and Drainage

The project is located in the northwestern portion of Central Kentucky within the Outer Bluegrass Physiographic Region. The topography of the project vicinity is characterized as moderately to deeply dissected upland area. A dendritic drainage pattern has developed within the project vicinity from natural stream erosion through the stratified sedimentary bedrock. The proposed improvements will traverse drainage swales and Harrods Creek which direct surface drainage to the Ohio River. The low-lying areas adjacent to major drainage features tend to become soft and wet during periods of precipitation. Ground water within these low lying areas is influenced by the Ohio River.

Topography along the project varies from rolling hills from the start of the project to the area near Harrods Creek. In the vicinity of Harrods Creek the topography begins to flatten and transitions to a relatively flat landscape along the flood plain of the Ohio River.

3. Geology

Available geologic mapping (Geologic Map of the Anchorage Quadrangle USGS, 1972, and Geologic Map of Parts of the Jeffersonville, New Albany, and Charlestown Quadrangles USGS, 1974) shows the beginning portion of the alignment underlain by bedrock belonging to the Sellersburg and Jeffersonville Limestone formations, the Louisville Limestone, Waldron Shale and the Laurel Dolomite formations, in descending order of lithology. The Sellersburg Limestone formation consists of olive-gray to greenish-gray limestone, crypto- to micrograined, laminated to cross laminated and fossiliferous with the lower portion being described as dolomitic.

The Jeffersonville Limestone consists of limestone described as olive- and brownish-gray to light-gray in color, fine to very coarse fossil fragments in matrix of silt- to clay-sized lime mud or crystalline calcite. The formation is locally dolomitic, pyritic and finely crystalline-grained. The unit weathers pale yellowish gray to light yellowish gray.

The Louisville Limestone is composed of dolomitic limestone and dolomite. The USGS mapping describes the formation as yellowish-gray to light-gray, finely crystalline-grained, argillaceous, pyritic and thin- to very thin-bedded in the upper part and thick-bedded near the base of the unit. Prominent bench-forming massive beds are noted to be located 35 to 60 feet above the base of the unit.

The Waldron Shale is described as dark-greenish-gray clay shale, silty, dolomitic, and pyritic and contains rare pod-like inclusions of dolomite. The formation weathers to gentle slopes on benches formed by the more resistant underlying unit.

The Laurel Dolomite, as described by the USGS mapping, consists of dolomite of two types. One type of dolomite, which occurs in the upper portion of the unit, consists of greenish-gray to light-olive-gray dolomite, micro- to very-finely crystalline-grained and weathers dark-yellowish-orange. The second type is described as being more massive and somewhat porous, mottled dolomite in two bedding sets separated by dark-gray to olive-gray dolomitic clay shale situated approximately five to eight feet above the base of the formation.

Near the end of the project, the alignment crosses alluvium, lacustrine and outwash soil deposits associated with the floodplain of the Ohio River. These deposits consist of intermixed sand, gravel, silt and clay, and can be in excess of 100 feet deep in some areas. These types of deposits are present from just ahead station of Harrods Creek to the Ohio River.

The limestone and dolomite at the site are known for the development of sinkholes and other karst activity. These formations commonly contain voids, clay seams, sinkholes and other solution features. Available topographic mapping of the project site does indicate the presence of some surface depressions near the roadway alignment indicative of sinkhole activity.

Structural contours, drawn on the top of the Waldron Shale, show the bedrock to be dipping towards the northwest at approximately 66 feet per mile. The Springdale Anticline is also mapped within the reference quadrangles approximately three miles southeast of the alignment. No faults or other detrimental geologic features are noted to be present by the referenced mapping within the immediate vicinity of the proposed roadway.

4. Field Exploration

The field exploration for this project was divided into a three phase approach. Phase I includes the cut intervals from approximate Stations 54+00 to 106+00 and from Stations 127+00 to 134+50 which are the entrance and exit cuts for the tunnel. Phase II is the tunnel portion of the project between approximate Stations 106+00 and 127+00. Phase III is the exploration for the embankments ahead-station of Station 134+50 which includes preliminary information for the Harrods Creek bridge and the overflow structure. A list of borings with latitude and longitude has been included in Appendix B.

4.1. Drilling and Sampling

4.1.1. General

FMSM personnel prepared boring plans for Phases I and III after a review of available plans, profiles, and cross-sections provided by Lochner. Hatch Mott MacDonald (HMM) developed boring plans for the Phase II area. Lochner and Community Transportation Solutions (CTS) approved the boring plans prior to mobilizing field crews and equipment. Others staked the boring locations. Copies of the final boring plans are located in Appendix C.

FMSM executed drilling and sampling operations in late January and February 2005, and late November and December 2005. These efforts included rock core borings, undisturbed soil sampling, rockline soundings and water pressure testing. Both truck-mounted and track-mounted drill rigs performed the drilling. A geotechnical engineer from FMSM observed field operations, and adjusted the boring program as subsurface conditions and physical constraints warranted. Personnel from HMM were on-site to observe the Phase I and II drilling and sampling program. Appendix D contains reduced-scale geotechnical drawings showing results of the drilling and sampling program that are applicable to the roadway design. In addition, preliminary drilling was performed in the Phase III area near the bridge locations. This information was also used to provide guidance on the embankments throughout the area.

4.1.2. Rock Core Borings

Selected critical cut sections along the Phase I roadway alignment contained rock core borings. FMSM utilized these borings to evaluate cut slopes leading in and out of the tunnel. Upon completion of the Phase I borings, the rock cores were transported to FMSM's office and logged by the project geologist. The geologist determined the depth of the rock disintegration zone (RDZ) for each boring, and also determined the percent recovery and rock quality designation (RQD) for each core run. As previously noted, the predominant rock types in the project area are limestone, dolomite and shale. Appendix D contains cut stability sections with detailed rock core descriptions.

In addition, the Phase II area (tunnel) contained rock coring. FMSM provided this information to HMM. Typed boring logs for the Phase II drilling within the tunnel are included in Appendix E.

4.1.3. Undisturbed Sample Borings

Several cut stability sections included sample borings where soil thicknesses at the rock core locations exceeded ten feet, and at selected locations near the centerline for the Phase III embankments and structures. Undisturbed thin-walled (Shelby) tube samples were generally collected at five-foot intervals of depth, or less, to provide specimens for subsequent shear-strength testing. Where granular soils were encountered, or where gravel and rock fragments resulted in poor Shelby tube recoveries, standard penetration tests (SPT) were performed in the sample borings. Selected Shelby tube specimens were subjected to consolidated-undrained triaxial strength, unconfined compressive strength, one-dimensional consolidation and engineering classification testing. Appendix D contains graphical results on the appropriate stability sections.

4.1.4. Rockline Soundings

Station 58+50, 80 feet right included the use of one rockline sounding. This was the only sounding performed and is shown on the appropriate section in Appendix D.

4.1.5. Water Pressure Testing

Selected Phase I and II borings included water pressure testing for use by HMM personnel to evaluate the permeability of the bedrock. The water pressure testing generally followed guidelines described in the "Louisville Southern Indiana Ohio River Bridges Project, Kentucky East End Approach Tunnel, Proposed Geotechnical, Geophysical and Vegetation Investigation Program" issued by HMM on October 31, 2005. FMSM performed water pressure testing with a setup that included a high pressure water pump, a water bypass system with a pressure gauge, a volume meter and an inflatable packer system. The high pressure water pump pumped water through the coring tools to the bedrock zone that was tested. The water bypass system was located inline between the pump and the coring tools to vary the water pressure of the pump and measure water flow volumes into the tested bedrock zone. An inflatable packer creates a seal with the bedrock and allows a zone to be isolated for testing. Two different inflatable packer systems were utilized on this project. A double packer system, which creates a seal above and below the testing zone, was used in Hole Nos. B-11, B-14, and B-15 after the rock coring operations were complete. A single packer system, which uses the bottom of the rock coring tools to seal the top of the zone and the bottom of the current coring run for the bottom of the hole, was used in Hole Nos. B-5, B-6, B-8, B-9 and B-10 during the rock coring process. HMM personnel selected and monitored the tested zones.

The water pressure testing system was setup so that water pressure could be varied in a given testing zone with water volume readings recorded per interval of time. In a typical testing zone, the pressures were cycled five times to represent a "step" method of pressure testing. The pressures were based on an initial pressure of one-quarter the overburden pressure with an increase to one-half and then to one times the overburden pressure. The interval was then "stepped" down with a decrease in pressure to one-half and then to one-quarter times the overburden pressure. Results of water pressure tests from the field have been included in Appendix E. Refer to the report being prepared by HMM for interpretations of the water pressure testing in relation to the design of the tunnel.

4.2. Observation Wells

Selected boring locations included observation wells to estimate the presence of ground water. FMSM installed traditional KYTC type observation wells where the overburden depths in the borings exceeded 10 feet as outlined in the KYTC Geotechnical Manual. Water level readings were obtained from the observation wells a minimum of seven days following the completion of the borings. Based on these observations, ground water was noted near the top of rock within the hillsides in several borings. Within the fill areas of the project, the ground water exists at approximately the same elevations as nearby Harrods Creek or the Ohio River. The observed water levels indicated on the embankment and cut stability sections in Appendix D are as recorded at the time of the exploration. These water levels may vary considerably, with time, according to the prevailing climate, rainfall or other factors. Table 1 includes a summary of ground water measurements.

Table 1. Observation Well Measurements

Station and Offset	Depth of Water from Top of Ground (feet)	Thickness of Soil Overburden (feet)
63+50, 105' Lt.	Dry	19.4
68+50, 95' Rt.	Dry	16.2
73+50, 85' Lt.	15.3	16.6
84+25, 85' Lt.	17.0	21.6
88+50, 60' Lt.	12.1	12.7
138+73.1, 3.5' Lt.	8.5	56.5
165+26.8, 6.2' Rt.	41.1	NR
174+50, CL	13.6	99.2
184+00, CL	13.8	98.0

NR – Boring terminated before bedrock was encountered.

In addition, select rock core borings near and within the limits of the tunnel contained special observation wells. HMM personnel specified the location, depths, and requirements for these wells. They were installed to evaluate potential ground water from various bedrock zones over a long period of time. In some borings, a nested well configuration was utilized to monitor multiple zones. In addition, four locations within the tunnel alignment included wells at the soil/bedrock interface to check for water at this boundary. The wells typically incorporated a 1-inch schedule 80 polyvinyl chloride (PVC) pipe with a 10-slot screen of varying length wrapped in a sand pack. A bentonite seal installed in the boring annulus created a seal above and below the monitored bedrock zone. A sand pack installed between the bentonite seals allowed a free exchange of water from the bedrock zone to the PVC screen. Because these wells were installed in rock core borings where water was introduced as part of the coring process, all of the water could not be removed from the core boring. As such, piezometer testing was performed on Borings B-12, B-14, B-15, and B-18. At these locations, piezometer lag/slug testing was performed to: (1) estimate if a "free" exchange of water/groundwater table was present, and (2) estimate a hydraulic conductivity (K), if applicable. The tests were performed by first recording a static water level in the piezometer. Then the piezometer was filled with water and allowed to dissipate over time. Water level observations along with the data and time of the observation were recorded over time. The water level was allowed to recover until approximately 95 percent of the head charge had decayed. At that time, water was removed from the piezometer and the water level allowed to recharge. Water level observations were obtained periodically while the recharge occurred. Based on the testing performed, it is FMSM's opinion that groundwater is present at the B-12 and B-14 locations. The water that "appears" to be present at B-15 and B-18 is most likely water left over from the rock coring process and not groundwater.

The field data from B-12 and B-14 was evaluated using the Single Well Solutions software package developed by Streamline. Hydraulic conductivity (K) values were calculated using the Bouwer Rice method, which is used to analyze unconfined aquifers. The results of the groundwater testing is presented in Table 2. Data recorded in the field during testing along with data curves and solutions, if applicable, are presented in Appendix E. Refer to Appendix E for detailed observation well installation logs and water level recordings. This information has been provided to HMM for further evaluation and incorporation into the tunnel design.

Table 2. Results of Groundwater Testing

Boring No.	Static Water Level and Date Recorded*			Hydraulic Conductivity (ft)
	Depth (ft)	Elevation (ft)	Date	
B-12	88.6	480.2	04/18/05	1.33×10^{-6}
B-14	33.6	494.9	04/18/05	2.99×10^{-6}

* Static water levels recorded from the rim of the protective cover/ground surface prior to aquifer testing.

As part of the Phase 2 exploration, additional observation wells were installed within the limits of the proposed tunnel. These wells were installed in Borings B-6, B-8, and B-10. In these wells FMSM utilized a down the hole pump in an effort to remove the water associated with the rock coring process before the observation wells were installed. However, the pump was not able to remove all of the water before the observation wells were installed. Based on the water level readings, it is FMSM's opinion that groundwater is present within the rock at the B-8b, B-8c and B-10c locations. Refer to Appendix E for detailed observation well installation logs and water level recordings.

4.3. Borehole Imaging and Downhole Geophysical Logging

Borehole imaging and downhole geophysical logging were performed by Layne Christensen Company – Colog Division (Colog) in Hole Nos. B-5, B-6, B-8, B-10 and B-11. Based upon guidelines provided by HMM, Colog used four different tools to further evaluate the bedrock within the tunnel limits. An acoustic televiewer scanned the hole from the bottom up to create a 360° image of the borehole wall showing fractures and other discontinuities. In addition, the televiewer was equipped with an instrument to record borehole deviation. A Gamma-Gamma survey checked the in-place densities of the various bedrock strata. A Neutron-Neutron tool determined in-place moisture content of the existing bedrock which can be correlated to rock porosity. Finally, a Caliper test evaluated the diameter of the borehole measuring diameter changes that may show cavities or weathered zones. Refer to the Colog report on CD included in Appendix E for specific results of the borehole imaging and downhole geophysical logging program. Refer to HMM's report for further interpretations and the use of this data in the tunnel design.

4.4. Surface Geophysical Program

A geophysical methodology study was performed at the portal areas of the planned tunnel to explore for anomalies that may indicate the presence of karst features. The intent of the study was to identify the technique most likely to produce the best results, should an expansion of the geophysical study through the tunnel area be considered necessary. HMM specified the desired techniques and guidelines for use in this study. Personnel from the University of Missouri – Rolla (UMR) performed the surface geophysical program. UMR utilized six geophysical techniques at these two areas. The area near the southern portal included three geophysical lines that were approximately parallel to the existing KY 841 exit ramp onto US 42. The northern portal area contained six geophysical lines that were approximately perpendicular to the proposed centerline of the roadway. The six geophysical techniques used were electrical resistivity, multichannel analysis of surface waves, conventional seismic refraction, ground-penetrating radar, self-potential, and gravity.

UMR prepared a report comparing the six methods and their respective results. In summary, UMR has recommended that future surface geophysical programs for this project utilize electrical resistivity and a form of conventional seismic refraction called refraction tomography for any follow-up geophysical work within the tunnel area. Due to the complexity of the bedrock surface in the area of the tunnel, UMR recommends two modifications to the recommended test methods. The electrode spacing for the electrical resistivity testing should be positioned no more than 5 feet apart, and refraction (surface) tomography data should be acquired instead of the conventional refraction information. The refraction (surface) tomography is different in that the sources are discharged off line so that a three-dimensional image is reproduced instead of a two-dimensional image. A full copy of the report is included on CD in Appendix E. In addition, HMM will be utilizing and interpreting the data for use in their tunnel design.

5. Laboratory Testing and Results

5.1. General

FMSM performed laboratory testing in accordance with applicable AASHTO or Kentucky Methods of soil and rock testing specifications. The results of the laboratory tests for Phases I and III are depicted graphically on the appropriate subsurface data sheets presented in Appendix D. The results for Phase II lab testing have been included in Appendix E.

5.2. Testing of Cohesive/Undisturbed (Shelby) Tube Samples

Selected critical cut and embankment stability locations included sampling techniques such as undisturbed (Shelby) tubes. Soil samples were extruded from the tubes, trimmed into six-inch specimens, and described visually. Unit weights (wet and dry) and natural moisture contents were determined for each six-inch specimen. Testing on selected specimens consisted of engineering classification, unconfined compressive strength, one-dimensional consolidation testing, and consolidated-undrained triaxial testing. The appropriate cross-sections in Appendix D present these test results. The following paragraphs further discuss the specific testing.

5.2.1. Engineering Classification Test Results for Cohesive Samples

Testing performed on selected six-inch specimens extruded from the Shelby tubes obtained at cut and embankment stability sections included classification testing. Table 3 summarizes the percentage types of soils resulting from laboratory classification testing of undisturbed (Shelby) tube specimens. Applicable cut and embankment stability sections in Appendix D show specific tube classifications.

Table 3. Summary of Engineering Classification Testing

USCS Classification	Percentage of Specimens Tested	AASHTO Classification	Percentage of Specimens Tested
CL	68	A-7-6	50
CH	23	A-6	37
CH/CL	3	A-4	10
CL/CH	3	A-7-5	3
SC	3		

5.2.2. Unconfined Compressive Strength Testing of Cohesive Samples

Unconfined compressive strength testing performed on Shelby tube specimens provided information for estimating soil strength parameters. The unconfined compressive strength values obtained from specimens taken from borings range from 880 psf to 5,120 psf. Appendix D presents the results of the unconfined compressive strength tests next to the sample borings. Table 4 summarizes the results.

Table 4. Summary of Unconfined Compressive Strength Tests

Station and Offset	Sample Interval (ft)	Unit Weights		Moisture Content %	Unconfined Compressive Strength (psf)	Cohesion (psf)
		Dry (pcf)	Wet (pcf)			
63+50, 105' Lt.	5.6 – 6.1	122.5	98.6	24	2,900	1,450
68+50, 95' Rt.	5.0 – 5.5	118.2	95.6	24	1,820	910
68+50, 95' Rt.	15.0 – 15.5	121.3	99.0	23	3,900	1,850
73+50, 85' Lt.	2.6 – 3.1	122.6	99.4	23	1,700	850
73+50, 85' Lt.	15.0 – 15.5	117.5	94.5	24	1,300	650
84+25, 85' Lt.	15.0 – 15.5	119.2	94.8	26	3,660	1,830
128+60, 85' Lt.	5.7 – 6.2	123.3	98.8	25	2,100	1,050
132+00, 80' Lt.	10.0 – 10.5	121.8	97.3	25	980	490
138+50, CL	2.6 – 3.1	128.5	107.3	20	4,780	2,390
138+50, CL	5.0 – 5.5	126.0	100.0	26	1,000	500
150+60, 20' Lt.	2.0 – 2.5	125.5	102.7	22	1,720	860
165+50, CL	2.0 – 2.5	124.1	102.0	22	2,600	1,300
165+50, CL	5.0 – 5.5	122.9	98.3	25	880	440
174+50, CL	2.6 – 3.1	126.4	103.4	22	5,120	2,560
174+50, CL	5.0 – 5.5	119.0	95.1	25	2,140	1,070
174+50, CL	10.0 – 10.5	126.1	102.3	23	2,000	1,000
184+00, CL	2.6 – 3.1	113.3	87.9	29	2,080	1,040
184+00, CL	5.0 – 5.5	111.9	84.3	33	1,120	560

The unconfined compressive strength can be used to estimate the bearing capacity and cohesion of a soil material. The value of cohesion in an engineering analysis is generally estimated to be one-half of the unconfined compressive strength for cohesive soils. Based on the above test results, the cohesion values derived from unconfined compression testing range from 440 psf to 2,560 psf.

5.2.3. Consolidated-Undrained Triaxial Results

Testing of selected 6-inch specimens extruded from Shelby tubes included consolidated-undrained (CU) triaxial testing with pore pressure measurements. CU testing provides effective-stress shear-strength parameters for utilization in short- and long-term stability analyses. The results of the CU triaxial tests are presented on the stability sections in Appendix D, and are summarized in Table 5. Appendix F contains the stress path envelope derived from CU triaxial testing.

Table 5. Summary of Consolidated – Undrained Triaxial Testing

Station and Offset	Sample Interval (ft)	USCS Classification	CU Triaxial Strength	
			$\bar{c}$ (psf)	$\bar{\phi}$ (degrees)
63+50, 105.0' Lt.	2.6 – 3.1	CL	280	33.4
73+50, 85.0' Lt.	2.0 – 2.5	CL		
73+50, 85.0' Lt.	5.0 – 5.5	CL		
84+25, 85.0' Lt.	5.9 – 6.4	CH/CL	340	28.4
84+25, 85.0' Lt.	10.0 – 10.5	CL		
88+50, 60.0' Lt.	10.0 – 10.5	CL		
138+50, CL	2.0 – 2.5	CL	340	28.6
138+50, CL	10.0 – 10.5	CL		
165+50, CL	5.6 – 6.1	CL		

5.2.4. One-Dimensional Consolidation Testing

One-dimensional consolidation testing was performed on selected samples extruded from the Shelby tubes to provide initial void ratio and consolidation parameters utilized in settlement analyses. Table 6 summarizes the consolidation results and Appendix F contains the actual lab data.

Table 6. Summary of One-Dimensional Consolidation Tests

Station and Offset	Test Interval (ft)	Initial Void Ratio (e_o)	Compression Index (C_c)	Recompression Index (C_r)	Preconsolidation Pressure (P_c) (psf)
138+50, CL	5.7' – 6.0'	0.623	0.180	0.052	3,800

5.3. Laboratory Testing of Non-Cohesive Soils/ Standard Penetration Test Samples

Laboratory testing of the SP samples included natural moisture content, silt plus clay, and standard engineering classification testing. Selected samples from SP testing were combined for engineering classification testing. Classification testing in conjunction with the N-values from SP testing were used to estimate soil strength and settlement parameters based on published correlations of such data. The non-cohesive soils tested primarily classify as SM and SW-SM with lesser occurrences of CL and SP-SM according to USCS, and primarily as A-1-b with lesser occurrences of A-4, A-6, and A-1-a based on the AASHTO classification system. Refer to Table 7 for a summary of the classification testing performed on non-cohesive soil samples recovered from SP testing.

Table 7. Summary of Non-Cohesive Soil Classification Testing

USCS		AASHTO	
Soil Type	**Percentage**	**Soil Type**	**Percentage**
SM	39	A-1-b	66
SW-SM	33	A-4	22
CL	17	A-6	6
SP-SM	11	A-1-a	6

5.4. Slake Durability Index (SDI) and Jar Slake (JS) Testing

The SDI and Jar Slake tests provide indications of the effects weathering will have on the bedrock when exposed in open cut faces. Shale recovered from the rock coring operations included these tests. The Kentucky Transportation Cabinet separates shale into four categories for design purposes, depending upon SDI and Jar Slake values, as follows:

Table 8. KYTC Shale Classifications

Classification	SDI (%)	Typical Jar Slake Category
Durable	≥ 95	6
Non-Durable, Class I	80 to 94	4 or 5
Non-Durable, Class II	50 to 79	3 or 4
Non-Durable, Class III	≤ 49	1 or 2

A review of SDI and Jar Slake results from Phase I indicates that approximately 33 percent of the samples tested classify as durable shale; 47 percent classify as non-durable, Class I; 10 percent classify as non-durable, Class II; and 10 percent classify as non-durable, Class III. Figure 1 presents graphical results of SDI testing. Specific sample locations with corresponding SDI and JS values are depicted on the graphical core logs in Appendix D. Results of the SDI and JS values from Phase II are included in Appendix E.

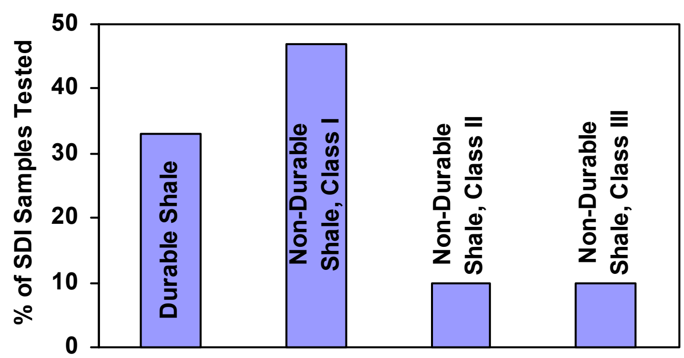


Figure 1. Slake Durability Index Test Results

5.5. Tunnel Rock Testing

HMM personnel selected rock samples from the rock core borings advanced near and within the tunnel alignment for specialized testing. FMSM performed unconfined compressive strength, axial and diametral point load and splitting tensile strength testing on selected specimens. In addition, Earth Mechanics Institute, Department of Engineering, Colorado School of Mines performed thin section petrographic analyses, Cerchar abrasivity index tests, punch-penetration index tests, porosity, void ratio, acoustic and dynamic elastic constants, axial swelling, laboratory shear box, ball peen hammer and saturation tests on selected samples. The results of these tests are included on CD in Appendix E. HMM will be utilizing and interpreting these results for use in tunnel design.

6. Engineering Analyses

6.1. Correction of Standard Penetration Test Data

As discussed in Section 4 of this report, a drill rig equipped with an automatic hammer performed SP testing. Standard correlations for SP testing are based upon blow counts using a safety hammer/rope/cat-head system, generally estimated to be 60 percent efficient. Thus correlations report values termed as N_{60} data. The efficiency of the automatic hammers used for this exploration was estimated to be on the order of 80 percent based on previous efficiency testing of FMSM drill rigs equipped with automatic hammers. The correction for hammer efficiency is a direct ratio of relative efficiencies as follows:

$$N_{60} = N_{80}\left(\frac{80}{60}\right) \qquad (6.1)$$

Standardized N_{60} values were corrected for the effect of overburden pressure prior to using the data in conjunction with correlations for non-cohesive soil parameters. N_{60} values were normalized to vertical effective overburden stresses of 2,000 pounds per-square foot. This calculation requires an effective unit weight for each soil horizon multiplied by the depth of the soil horizon. The relationship between the correction factor, C_N, and the effective overburden stress, σ', was based on a relationship proposed by Liao and Whitman as referenced in Seed and Harder [1990]:

$$C_N = \frac{1}{\sqrt{\sigma'}} \qquad (6.2)$$

Where:

C_N = correction factor for overburden stress

σ' = vertical effective overburden stress (tsf)

Consequently, the standardized corrected N-value, $(N')_{60}$ is equal to:

$$(N')_{60} = C_N N_{60} \qquad (6.3)$$

Where:

C_N = correction factor for overburden stress

$(N')_{60}$ = standardized N-value

Appendix G contains summaries of the SP data and corrections for the borings performed along the roadway alignment. The spreadsheets also include correlations of corrected SP data with published correlations for estimates of unit weight and shear strength parameters. The values of $(N')_{60}$ were utilized to obtain relative densities, D_r, based on relationships developed by Tokimatsu and Seed [1988]. NAVFAC [1982] presents a relationship using relative density of specific soil types to correlate angle of internal friction, unit weight and void ratio. Soil classifications for the correlations came from actual laboratory test results and visual observations, and were used to estimate an in situ unit weight of the material. Once the relationships for the angle of internal friction, unit weight and void ratio were established, an in situ unit weight was calculated based upon the natural moisture content.

6.2. Soil Parameter Selections

FMSM created a subsurface characterization for the foundation soils based upon the results of the drilling and sampling program discussed in Section 4, and the laboratory testing addressed in Section 5. Appendix G shows summaries of correlations of Standard Penetration Testing (SPT) data to unit weight and shear strength parameters. These correlations include results from all standard penetration testing and the applicable corrections to the N-values obtained using automatic hammers.

The estimated strength parameters took into account the corrected N-values in conjunction with soil classification and natural moisture content testing. Values of internal angles of friction (ϕ') for granular soils obtained from the correlations vary from 28.0 to 39.0 degrees for soils near the Ohio River. A review of these parameters indicate in general an increasing trend with depth which coincides with denser, coarse grained deposits typically found within the site's geological setting.

6.3. Cut Sections

6.3.1. Rock Cut Stability

Bedrock encountered in the rock core borings drilled along the project site correlates well with the referenced geologic mapping. The rock cores consist of limestones and shales. The limestones are described as microcrystalline- to fine-grained, medium- to thick-bedded, fossiliferous with zones argillaceous and zones dolomitic. The shales are reddish-brown to dark gray, silty to sandy with zones clay-like.

Cut slope recommendations were based upon review of the rock cores obtained at selected critical cut sections, soil thicknesses at these locations, associated laboratory testing, regional and local lithology, and FMSM's experiences gained from past design of cut slopes in similar rock formations. Preliminary cut slope configurations were submitted to Lochner, CTS and KYTC on November 3, 2005 and a rock core meeting was conducted on November 10, 2005.

During and subsequent to the rock core meeting, the Design Team presented the group with an interchange configuration joining mainline with US 42. Because right-of-way options are limited in this area, traditional cut slopes are not feasible. The Design Team evaluated different roadway templates that utilized cut slopes, retaining walls, and bridges for the entrance and exit ramps onto US 42. A combination of all of these options were agreed upon during a December 19, 2007 Design Team meeting. Because vertical rock walls will be utilized in many of the cut slopes, additional analyses will be required to determine what type of long term support is necessary such as rock bolts, tie-back walls, etc. These types of analyses were beyond the scope of this report. Appendix D presents final cut slope recommendations.

6.3.2. Soil Cut Stability

Slope recommendations for soil cuts took into account borings drilled at critical cut sections, soil thicknesses at these locations, associated laboratory testing and slope stability analyses. Selected critical soil cut sections were evaluated for intermediate-term and long-term slope stability. The REAME (Rotational Equilibrium Analyses of Multi-Layered Embankments) computer program, developed at the University of Kentucky, performed the calculations. The REAME computer program assumes a circular (rotational) failure surface and calculates the factor of safety based on the Simplified Bishop method of slices. Intermediate-term analyses, using effective-stress shear-strength parameters for residual materials, simulate conditions after excess pore pressures have dissipated and the ground water table is positioned at its maximum anticipated height within the cut. Long-term analyses, using effective-stress shear-strength parameters, simulate conditions that will exist long after the cut is constructed, excess pore pressures within the materials have dissipated, and the ground water table has been lowered due to the presence of the cut. For the long-term loading condition, the KYTC suggests that the effective cohesion of the materials be reduced by 80% to account for the potential for swelling of cohesive soils upon exposure in cuts.

The KYTC Geotechnical Manual presents target factors of safety for slope stability situations. Table 9 summarizes these values.

Table 9. Target Factors of Safety for Slope Stability Analysis

	Short-Term	Intermediate-Term	Long-Term	Rapid Drawdown
Roadway Embankments	1.1 - 1.3	---	1.4 - 1.6	1.0 - 1.2
Bridge Approach Slopes	1.2 - 1.4	---	1.6 - 1.8	1.0 - 1.2
Cut Slopes in Soil	1.2 - 1.4	1.2 - 1.4	1.4 - 1.6	---

Based on a review of the soil types and thicknesses encountered within cut intervals, it is apparent that the majority of cuts will be constructed in cohesive soils (clays of moderate to high plasticity). Shear-strength parameters for the residual materials were derived from soil classification data and consolidated-undrained triaxial shear-strength tests discussed in Section 5 of this report.

Appendix D presents results of slope stability analyses, including predicted minimum factors of safety, predicted failure surfaces, assigned soil shear-strength parameters, and modeled ground water table positions graphically on the appropriate cut stability sections. Table 10 provides a summary of the results of the cut stability analyses.

Table 10. Summary of Cut Stability Analyses

Station	Slope Geometry (H:V)	Factors of Safety		
		Short-Term	Intermediate-Term	Long-Term
100+00	2:1	---	2.8	1.6
132+00	2:1	--	3.0	1.7

From Table 10, it should be pointed out that the 2:1 (H:V) cut slopes analyzed meet or exceed the KYTC minimum target factors of safety.

6.3.3. Embankment Stability Analyses

FMSM performed slope stability analyses on selected embankment sections in the Phase III area. The slope stability of the embankments were evaluated for short-term, long-term and rapid drawdown loading conditions, where applicable, utilizing the REAME computer program. Short-term analyses, using total-stress shear-strength parameters for foundations and embankment materials, simulate conditions that will exist immediately following completion of the embankments. Long-term analyses, using effective-stress shear-strength parameters, simulate conditions that will exist long after the embankment is constructed and excess pore pressures within the foundation materials have dissipated. Rapid drawdown analyses, using effective-stress parameters and saturated soil conditions below a specified flood elevation, simulate conditions that will exist when water levels have receded following a flood event leaving embankment materials in a saturated state.

It is our understanding that the material from the tunnel and roadway excavation will be used for the construction of the roadway embankments. Therefore, it is anticipated that the embankments will be constructed from the available durable rock. In the event that the durable rock can not be used for fill the following minimum fill parameters were utilized for the stability analyses. If a borrow source is used for the embankments, the material strength properties should be tested and compared against the estimated properties summarized below. If the strength properties are less than what has been estimated, then the slope configurations should be reevaluated.

Embankment Shear-Strength Parameters

Total Stress	Effective Stress
Soil Fill Material	
c = 1,400 psf	$\bar{c}$ = 200 psf
ϕ = 0°	$\bar{\phi}$ = 23°
γ = 120 pcf	γ = 120 pcf

Appendix D presents the results of slope stability analyses, including predicted minimum factors of safety, predicted failure surfaces, and modeled ground water table positions graphically on the appropriate stability sections. Table 11 provides a summary of the results of the embankment stability analyses. Based on discussions with Lochner, FMSM understands the embankment side slopes ahead station of the Harrods Creek bridge will be constructed no steeper than a 3:1 (H:V), therefore, the stabilities were modeled with 3:1 (H:V) side slopes.

Table 11. Summary of Embankment Stability Analyses

Station	Slope Geometry (H:V)	Factors of Safety		
		Short-Term	Long-Term	Rapid* Drawdown
Mainline				
151+00	3:1	2.1	2.0	---
165+50	3:1	1.9	2.0	
Structures				
KY 841 over Harrods Creek and River Road Back-Station Spill Thru Slope (Not Shown)	2:1	1.5	1.6	1.3
KY 841 over Harrods Creek and River Road Back-Station Spill through Slope	Breastwall Abutment	1.5	1.8	1.6

* Based upon 100-year flood elevation.

The factors of safety presented in Table 11 meet or exceed the minimum target values outlined in the KYTC Geotechnical Manual and indicate the embankment configurations exhibit adequate stability as proposed for the majority of the embankment configurations.

It should be noted that if 2:1 (H:V) side slopes are used, then the upper portion of all embankments should be limited to a maximum soil height of 45 feet. Embankments greater than 45 feet in height should incorporate durable rock in the bottom portions of the embankment to maintain minimum factors of safety for stability. In areas where the embankment is near a structure location the maximum soil height should be limited to 35 feet to meet or exceed the minimum target values outlined in the KYTC Geotechnical Manual for bridge approach slopes. This height restriction should continue approximately 100 feet ahead-station or back-station of the structure.

6.4. Settlement Analyses

A selected end bent location for the Harrods Creek Bridge included settlement analyses as a part of the preliminary engineering conducted for the bridges. Once the structure locations have been finalized, settlement will need to be reevaluated based upon the exact locations of the foundation elements. The preliminary analyses were performed based on approach embankment height, foundation soil depths, soil classifications and laboratory testing obtained from selected borings. A preliminary settlement analyses was performed near the ahead-station end bent for the Harrods Creek and River Road Bridge at Station 151+00. This section includes an embankment that is approximately 38 feet in height. Foundation soils consisted of approximately 8 feet of clay and approximately 40 feet of sand and gravel. Estimates indicate that approximately 4.3 inches of settlement of the foundation soils could occur beneath the ahead-station approach embankment. Time rate of settlement calculations suggest that an estimated 3.5 months (105 days) may be required following completion of the embankment to achieve primary settlement (90% of the total settlement) at the position of the Harrods Creek and River Road ahead-station end bent.

It should be anticipated that settlements near the remaining Phase III structures will be of the same magnitude. However, the settlement estimates should be reevaluated once the bridges locations are finalized. Based upon the settlement estimates above, the approximate times required for primary consolidation of cohesive soils should be observed between the construction of the approach embankments to full height and installation of the pile foundations. Allowing settlement of the foundation soils to occur prior to bridge foundation construction will reduce the potential for down-drag and lateral squeeze on the foundation elements. Additional recommendations specific to foundation design and construction of the bridges will be provided under separate covers.

7. Preliminary Bridge Information

As a part of this report, FMSM performed a preliminary evaluation for the two bridges located within the Phase III limits. Based on information provided to FMSM by Lochner, it is our understanding that the Harrods Creek and River Road Bridge will begin at approximate Station 135+50 and end at approximate Station 150+50. The Ohio River Overflow structure will begin at approximate Station 168+20 and will connect to the East End Bridge over the Ohio River.

7.1. Harrods Creek and River Road Bridge

The preliminary exploration conducted for the proposed bridge consisted of advancing two sample borings to auger refusal. Based upon the results from the preliminary drilling, bedrock varies in depth from 56.5 feet near the back-station abutment to 52.6 feet near the ahead-station abutment. The foundation options for this structure should consist of steel H-piles or drilled shafts bearing on bedrock. In addition, the Designer will need to evaluate scour. Appendix D contains drawings with D_{50} and D_{95} values for use in the scour analyses. It is recommended that a complete geotechnical exploration be performed once the locations of the substructure elements have been finalized. Upon completion of a final geotechnical exploration, additional analyses will be required such as driving resistance, down-drag and lateral squeeze analyses.

7.2. Ohio River Overflow Structure

The preliminary exploration conducted at the overflow structure consisted of advancing two sample borings to auger refusal. Based upon the results, bedrock depth varies from 98.0 feet to 99.2 feet within the limits for the bridge. The foundation options for this structure should consist of steel H-piles or drilled shafts acting as friction elements or bearing on bedrock. Scour analyses will also be important at this structure. The results for the scour analyses will be required in conjunction with the other analyses to determine the embedment length of possible friction supported foundation elements. Appendix D contains drawings with the D_{50} and D_{95} values for use in the scour analyses. It is recommended that a complete geotechnical exploration be performed once the locations of the substructure elements have been finalized. Upon completion of a final geotechnical exploration, additional analyses will be required such as pile/shaft capacity, driving resistance, down-drag and lateral squeeze analyses

8. Special Considerations

As previously discussed, the project site is underlain by limestone bedrock that is susceptible to solutioning and karst activity. The solutioning process typically begins along fissures, joints or bedding planes and creates channel systems within the bedrock. Generally, ground water flows through these rock channels and removes soil located immediately above the rockline. As internal erosion continues, the upper portion of the soil overburden collapses to form sinkholes and regolith zones (zones of unconsolidated soil and rock fragments). Refer to Figure 2 (from United States Geological Survey, Geologic Map of the Somerset Quadrangle, Pulaski County, Kentucky, 1974) for a graphical depiction of karst activity typical of areas underlain by limestone bedrock.

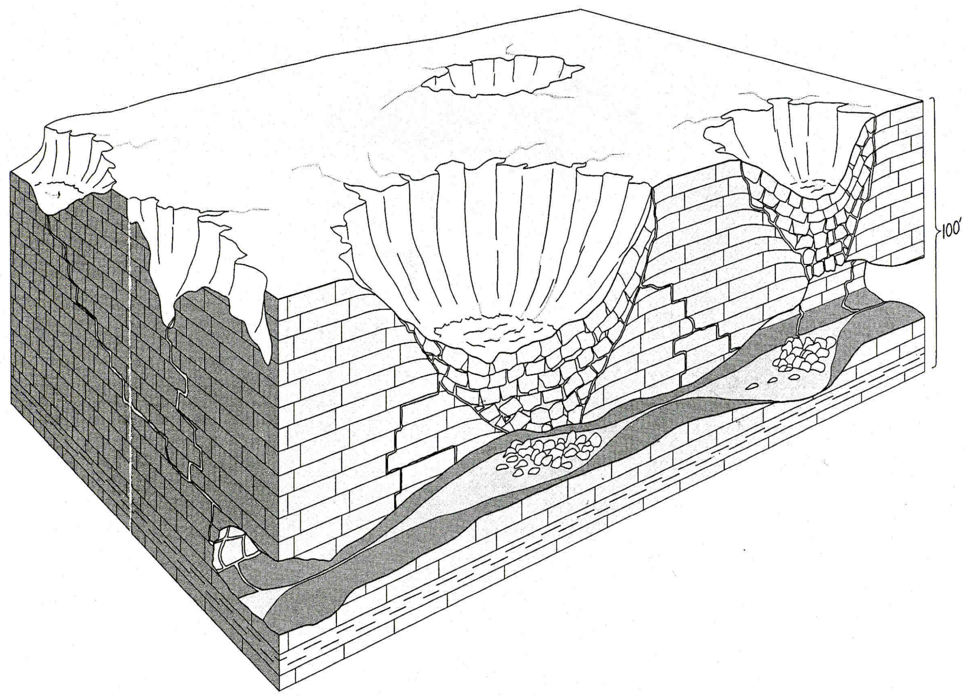


Figure 2. Areas Underlain by Limestone Bedrock

Several surface depressions/sinkholes and regolith zones are located near the project corridor, and are typical of this region of the state where karst bedrock is present. FMSM personnel performed visual observations of such areas to locate any surface openings (open throats) that could carry water and/or soil underground to larger karstic features. Table 12 contains a summary of the surface depressions/sinkholes identified near the project construction limits and information associated with each feature.

Table 12. Summary of Surface Depressions/Sinkholes

Approximate Center Station and Offset	Approximate Dimensions	Comments/General Description
Mainline		
113+35, 15' Lt.	20' X 15'	• Located within tunnel limits. • Open throats observed. • Refer to tunnel report by HMM for additional information.
123+00, 130' Rt.	50' X 40'	• Located outside the limits of the tunnel. • Open throat that accepts drainage. • Refer to tunnel report by HMM for additional information.
128+60, 40' Lt.	15' X 20'	• Located within cut ahead-station of tunnel. • No open throat observed.

The first two surface depressions/sinkholes are located within the tunnel area. The potential impacts these features have on the tunnel design will be addressed by HMM. The depression/sinkhole located at Station 128+60, 40 feet left is within a cut ahead-station of the tunnel. This cut will be approximately 70 feet deep and therefore there is a reduced potential that the depression/sinkhole would affect the cut slopes within this interval. Based on the information obtained during this exploration, surface depressions with open throats along the project alignment generally take drainage. However, such a determination cannot be concluded for the other surface depressions for which open throats were not observed. This would require extensive study of topography, ground water regimes, and rainfall events over an extended period of time, and was beyond the scope of work for this exploration.

It should be noted that the project area may be susceptible to future sinkhole developments from ground water removing soil particles via underground streams, and to ground subsidence from the collapses of rock above possible voids. While this potential is not considered to be a serious hindrance to roadway construction, there are no assurances that future problems related to karst activity will not occur.

9. Geotechnical Notes and Recommendations

The following geotechnical notes and recommendations are based upon reviews of available data, information obtained during the field exploration, results of laboratory testing, engineering analyses, and discussions with the Designer, CTS and KYTC personnel. The notes presented forthwith are intended only for the Phase I and Phase III roadway construction limits. In addition, some general structure notes are presented for the structures that will be constructed as part of Phase III. Separate reports will be submitted by HMM and K.S. Ware and Associates. HMM will address specific geotechnical design and concerns for the tunnel. In addition, KSW is performing the geotechnical exploration for Springdale Road and Wolf Pen Road Bridge.

9.1. Roadway Geotechnical Notes

9.1.1. Clearing and grubbing of embankment areas shall be completed in accordance with Section 202 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction.

9.1.2. Removal of existing structures and other obstructions shall, whether shown on the plans or not, shall be completed in accordance with Section 203 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction.

9.1.3. All water wells within the limits of construction, whether shown on the plans or not, shall be plugged in accordance with requirements of Section 708 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction.

9.1.4. All catch basins and manholes shall be filled and capped, and all septic tanks shall be cleaned and filled in accordance with Section 708 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction.

9.1.5. All channel changes and special ditches shall be constructed prior to placement of any embankment materials adjacent to them in accordance with Section 206 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction. At the direction of the Engineer, materials excavated from these areas may be utilized in construction of the embankments, but may require aeration to the proper moisture contents prior to compaction operations. No extra payment shall be permitted for rehandling, hauling, stockpiling and/or manipulating these materials. Only limestone and durable shales shall be utilized for Class IV channel lining. All non-durable shales shall be excluded from use as channel lining.

9.1.6. In accordance with Section 206 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction, the moisture content of embankment material shall not vary from the optimum moisture content, as determined by KM 64-511, by more than plus or minus two percent. This moisture content requirement shall have equal weight with the density requirement when determining the acceptability of embankment or subgrade construction. Refer to the Family of Curves for moisture-density relationships.

9.1.7. All soils, whether from roadway excavation or borrow, may require manipulation to obtain proper moisture content prior to compaction. Direct payment shall not be permitted for rehandling, hauling, stockpiling and/or manipulating soils.

9.1.8. The Contractor is responsible for conducting any operations necessary in order to excavate the cut areas to the required typical sections. These operations shall be incidental to the roadway excavation price.

9.1.9. Any saturated, soft and unstable areas encountered within embankment foundation limits and/or any other areas as specified by the Engineer shall be drained and stabilized with a minimum of three feet (vertical thickness) of durable limestone and shale from roadway excavation.

The following intervals are provided only to aid in establishing quantities for coarse aggregate and geotextile fabric for bidding purposes. Actual areas requiring such stabilization may differ significantly from those listed herein.

Approximate Station Limits

Mainline
134+50 to 135+50
158+50 to 160+00

9.1.10. As directed by the Engineer, a three-foot vertical thickness of durable limestone and shale from roadway excavation be utilized to fill and stabilize any existing drainage swales or stream channels located within the limits of the roadway embankments. The granular embankment material shall also be placed over all adjacent areas, which may be soft and saturated. Positive drainage of these abandoned stream channels shall be maintained to reduce the possibility of trapping water within the roadway embankments.

Approximate Station Limits

Mainline
153+50 to 154+50

9.1.11. Overhaul of excavated materials will not be considered on this project.

9.1.12. As directed by the Engineer, existing bituminous concrete that is positioned within the limits of new roadway embankments, and positioned at a distance greater than three feet below proposed subgrade elevation, shall be scarified or broken until all cleavage planes are destroyed, or the pavement shall be removed entirely as conditions demand, in accordance with Section 206 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction. Subgrade materials remaining after removal of pavements may need to be stabilized prior to placement of new pavement sections, as directed by the Engineer.

Approximate Station Limits

Mainline
150+00 to 152+00
163+70 to 167+00

9.13. A pond was observed at the following approximate location and is situated entirely or partially within embankment foundation limits. The pond shall be drained and any soft and saturated material (estimated to be 2 feet) shall be removed and/or stabilized as directed by the Engineer prior to placement of the roadway embankment. For stabilization purposes, a sufficient thickness (estimated to be 3 feet) of limestone shot rock from roadway excavation shall be used. Additional rock may be required to stabilize soft soils and to maintain positive drainage.

For quantity estimate purposes only, this shall include the following area. Actual thickness and locations of rock material will be determined by the Engineer during construction. The cost of placing these materials shall be incidental to the earthwork.

Approximate Station Limits

Mainline
137+00 to 138+00, Left

9.14. Conventional transverse benches shall be constructed and perforated pipe underdrains installed at the following approximate locations in accordance with Kentucky Department of Highways Standard Drawings RDP-005 and RDP-006, project cross-sections (as applicable), and as directed by the Engineer. Contrary to Standard Drawing RDP-006, transverse benches and perforated pipe underdrains shall be installed in both uphill and downhill transition areas between cuts and fills.

Approximate Station

Mainline
134+50

9.15. Perforated pipes for subgrade drainage shall be installed at vertical sags and at the upgrade ends of structures, in accordance with Kentucky Department of Highways Standard Drawing RDP-005 and/or as directed by the Engineer. Contrary to Standard Drawing RDP-005, such drains shall be installed even when a rock roadbed is being constructed. These drainage features shall be installed at the following approximate locations:

Approximate Station

Mainline
150+50

9.16. Because of high water concerns near Harrods Creek, Cyclopean Stone rip-rap conforming to Section 805 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction shall be utilized to construct the outer portions of the proposed roadway embankments within the following approximate station limits.

Approximate Station Limits

Mainline
135+00 to 137+20

The riprap shall be used to construct the outer portion of both the left and right side slopes of the mainline embankment and shall wrap around the face of the back-station approach slope for the mainline crossing over Harrods Creek. A minimum 3-foot layer of riprap shall be placed as an integral part of the embankment, and not as an additional thickness on the outside face of final embankment geometries. The riprap shall extend from the toes of the embankments upwardly to elevation 453.0 feet, approximately one foot above the 100-year high water elevation of 452.0 feet. The size and thicknesses of riprap shall be designed for applicable flood flow velocities. The riprap shall be placed in general accordance with Section 703 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction, and as directed by the Engineer.

Type I Geotextile Fabric in accordance with Sections 214 and 843 of the current Standard Specifications for Road and Bridge Construction shall be placed on the ground surface and along the faces of all embankment slopes prior to placing riprap. The fabric shall be overlapped across the top of the riprap at elevation 453.0 feet prior to placing additional embankment materials on and above the riprap.

9.17. Embankment stability analyses were conducted using estimated soil strength parameters for embankment materials. It is recommended that borrow material used for embankment construction meet the following minimum strength parameters.

Total Stress	**Effective Stress**
c = 1,400 psf	$\bar{c}$ = 200 psf
ϕ = 0 degrees	$\bar{\phi}$ = 23 degrees

9.18. As directed by the Engineer, the solid rock road bed shall be undercut a minimum of 5 feet below required grade to provide a transition between a non-yielding subgrade between the retained fill and the rock slope. The refill shall be constructed with the appropriate subgrade material between the following approximate locations.

Approximate Station Limits

Mainline
91+50 to 98+50

9.19. The embankments shall include "pile cores" at all applicable substructure element locations to facilitate installation of the foundation systems. The core material shall consist of "Granular Embankment" and shall be free of rock fragments larger than 3 inches maximum dimension, and any other obstruction which would interfere with the foundation installation. Construction of the pile cores shall be in accordance with KYTC Special Provision No. 69, Standard Drawing Nos. RGX-100 and RGX-105 and Section 206 of the current Kentucky Department of Highways Standard Specifications for Highway Road and Bridge Construction.

10. Design Recommendations

10.1. A rock swell factor of 15 percent is recommended for materials excavated below the RDZ.

10.2. An average soil shrinkage value of two percent is recommended for soils to be excavated on this project. This value is to be applied in calculating an "apparent" shrinkage value. This shrinkage value should be applied only to soil positioned above the top of rock. A shrink/swell value of zero should be applied to the weathered rock zone considered to be RDZ material.

10.3. FMSM understands that sufficient quantities of durable rock will be available to construct a rock subgrade for pavement sections. Therefore, a two-foot rock roadbed shall be constructed of durable limestone excavated from below the RDZ in accordance with Section 204 of the current edition of the Kentucky Department of Highways Standard

Specifications for Road and Bridge Construction for the entire length of the project. All shales shall be excluded from use in the rock roadbed construction. A CBR of 11 may be utilized in design of pavements.

10.4. At the time the exploration plan was created for Phase III (Station 134+50 to 186+50) the embankment and structure information was preliminary. Therefore, limited drilling was performed in an effort to assist with bridge foundation options. As the design process proceeds, additional geotechnical information will be needed for the design of the two bridges, multiple retaining walls and the Phase III embankments.

11. Closing

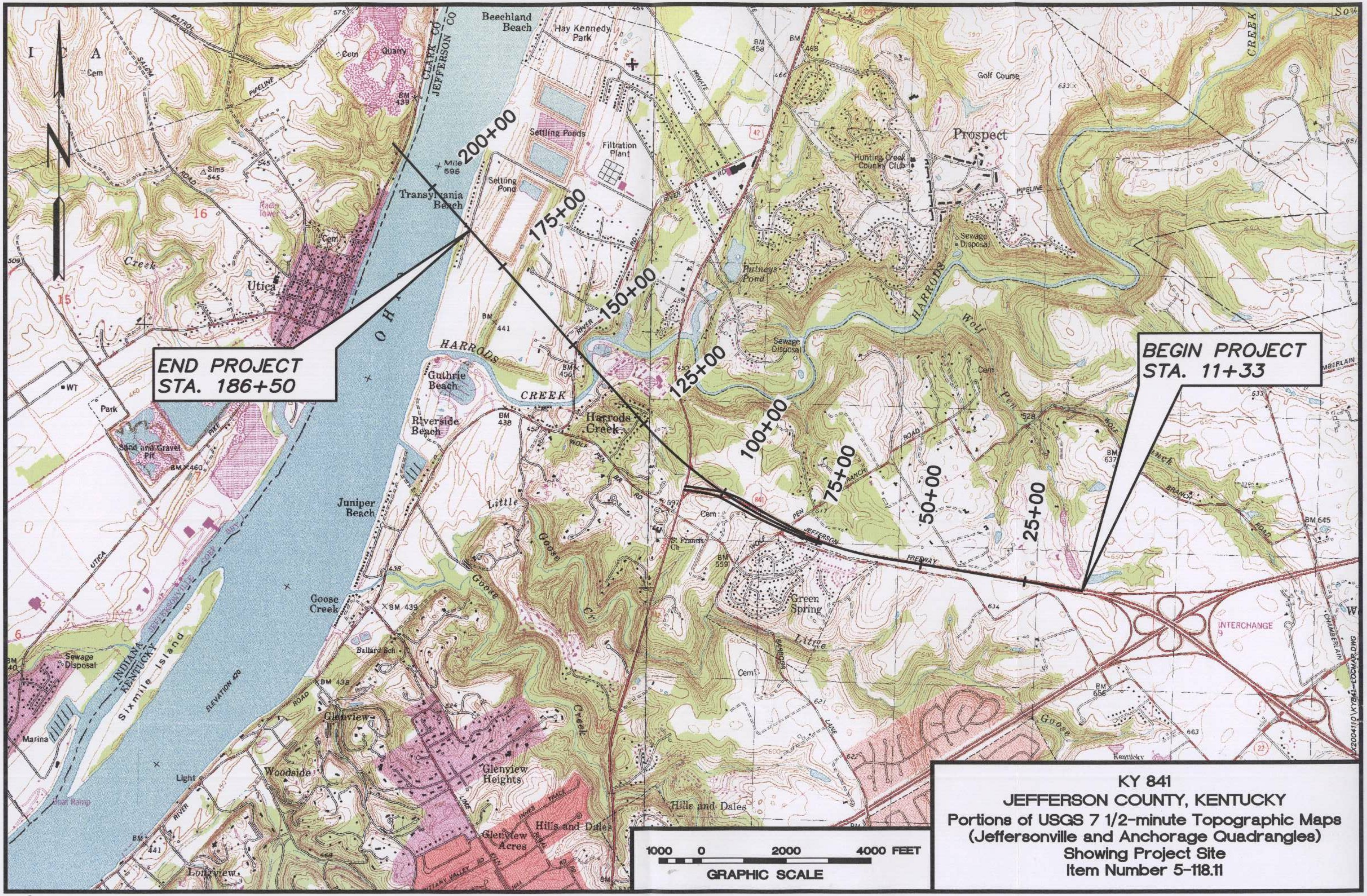
11.1. General soil and rock descriptions and indicated boundaries are based on an engineering interpretation of all available subsurface information and may not necessarily reflect the actual variation in subsurface conditions between borings and samples. Collected data and field interpretation of conditions encountered in individual borings are shown on the Subsurface Data Sheets.

11.2. The observed water levels and/or conditions indicated on the boring logs are as recorded at the time of exploration. These water levels and/or conditions may vary considerably, with time, according to the prevailing climate, rainfall or other factors and are otherwise dependent on the duration of and methods used in the exploration program.

11.3. Sound engineering judgment was exercised in preparing the subsurface information presented herein. This information was prepared and is intended for design and estimating purposes. Its presentation on the plans or elsewhere is for the purpose of providing intended users with access to the same information available to the KYTC. This subsurface information interpretation is presented in good faith and is not intended as a substitute for personal investigations, independent interpretations or judgments of the Contractor.

Appendix A

Location Map



KY 841
JEFFERSON COUNTY, KENTUCKY
Portions of USGS 7 1/2-minute Topographic Maps
(Jeffersonville and Anchorage Quadrangles)
Showing Project Site
Item Number 5-118.11

Appendix B

Coordinate Data Submission Form

COORDINATE DATA SUBMISSION FORM
KYTC DIVISION OF MATERIALS - GEOTECHNICAL BRANCH

County: Jefferson
Road Number: Ohio River Bridges - East End Approach
Survey Crew / Consultant: Hall-Harmon/ FMSM Engineers
Contact Person: Larry Harmon/ Adam Crace
Item No.: 5-118.11
Mars No.: C-04224166
Project No.: N/A

Date:

Notes:

(select one) **Elevation Datum** **Sea Level** **Assumed**

HOLE NUMBER	STATION	OFFSET	ELEVATION (ft)	LATITUDE	LONGITUDE
B-25	58+50	80.0' Rt.	628.6	38.319099	85.605389
B-24	63+50	80.0' Lt.	630.3	38.318913	85.607203
B-24A	63+50	105.0' Lt.	630	38.318846	85.607221
B-23	68+50	90.0' Rt.	621.5	38.319522	85.608755
B-23A	68+50	95.0' Rt.	621.4	38.319700	85.608754
B-22	73+50	70.0' Lt.	619.8	38.319658	85.610586
B-22A	73+50	85.0' Lt.	620.0	38.319618	85.310602
B-21	78+70	70.0' Lt.	613.3	38.320124	85.612239
B-20	84+00	70.0' Lt.	616.4	38.320718	85.614017
B-20A	84+25	85.0' Lt.	612.5	38.320709	85.614118
B-19	88+50	60.0' Rt.	625.8	38.621576	85.615233
B-19A	88+50	60.0' Lt.	602	38.321283	85.615423
B-18	93+50	35.0' Rt.	611.4	38.322165	85.616802
B-18A	93+50	130.0' Rt.	610.5	38.322391	85.616637
B-17	100+20	85.0' Lt.	593.9	38.322848	85.619015
B-16	103+30	10.0' Lt.	586.3	38.323498	85.619766
B-15	106+00	60.0' Rt.	578	38.324120	85.620355

COORDINATE DATA SUBMISSION FORM
KYTC DIVISION OF MATERIALS - GEOTECHNICAL BRANCH

County: Jefferson
Road Number: Ohio River Bridges - East End Approach
Survey Crew / Consultant: Hall-Harmon/ FMSM Engineers
Contact Person: Larry Harmon/ Adam Crace
Item No.: 5-118.11
Mars No.: C-04224166
Project No.: N/A

Date:

Notes:

(select one) **Elevation Datum** **Sea Level** **Assumed**

HOLE NUMBER	STATION	OFFSET	ELEVATION (ft)	LATITUDE	LONGITUDE
B-12	109+13	60.0' Lt.	568.8	38.324332	85.621485
B-11	113+35.5	20.7' Rt.	584.1	38.325253	85.622470
B-9	116+84.1	99.9' Rt.	568.0	38.326047	85.623195
B-9A	116+84.1	103.0' Rt.	568.1	38.326042	85.623198
B-10	116+68.7	14.1' Rt.	559.5	38.325843	85.623355
B-10A	116+69	17.1' Rt.	559.7	38.325848	85.623352
B-8	118+67.7	18.2' Rt.	539.9	38.326222	85.623853
B-8A	118+67.7	22.2' Rt.	540.1	38.326217	85.623856
B-5	121+91.2	66.0' Rt.	528.3	38.326856	85.624727
B-6	122+08.4	8.5' Rt.	526.1	38.326933	85.624543
B-6A	122+08.4	11.5' Rt.	526.1	38.326928	85.624546
B-7	124+40	CL	517.5	38.327295	85.625310
B-14	128+60	15.0' Rt.	528.5	38.328142	85.626305
B-13	132+00	80.0' Lt.	520.9	38.328643	85.627364
B-26	138+73.1	3.5' Lt.	429.2	38.330184	85.628704
B-27	150+15	25.0' Lt.	456.8	38.332453	85.631452
B-28	165+26.8	6.2' Rt.	461.7	38.335567	85.634939

COORDINATE DATA SUBMISSION FORM
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County: Jefferson
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Project No.: N/A

Date:

Notes:

(select one) **Elevation Datum** **Sea Level** **Assumed**

HOLE NUMBER	STATION	OFFSET	ELEVATION (ft)	LATITUDE	LONGITUDE
B-29	174+50	CL	432.1	38.337422	85.637133
B-30	184+00	CL	433.0	38.339343	85.639374

Appendix C

Project Correspondence

Boring Plan
January 10, 2005
Geotechnical Exploration
East End Approach – Phase I
Item No. 5-118
Jefferson County, Kentucky

I. Rock Core Borings

Rock cores are to be obtained at the following locations. Drill through the overburden to the top of bedded material and core to the specified elevation. All measurements in the following summation are expressed in English.

NOTE: If the overburden depth exceeds 10 feet, an undisturbed sample boring with an observation well is to be drilled at least 25 feet uphill from the core hole location (along the same stability section). If offset borings are necessary then such borings will be sampled on 5 foot intervals (split spoons and/or Shelby tubes, as applicable) to the top of bedded material or 20 feet below the proposed ditch line grade, whichever is less. Water table readings are to be obtained no sooner than seven (7) days after completion of well installation.

A. Mainline Cut Stability Borings

1. Cut limits from Station 55+00 to 106+10

						Ground Surface Elevation
a.	Station 63+50,	80 L	B-24	(Core to Elevation =	596)	630
b.	Station 68+50,	90 R	B-23	(Core to Elevation =	582)	628
c.	Station 73+50,	70 L	B-22	(Core to Elevation =	570)	620
d.	Station 78+50,	70 L	B-21	(Core to Elevation =	556)	615
e.	Station 84+00,	70 L	B-20	(Core to Elevation =	540)	619
f.	Station 88+50,	60 R	B-19	(Core to Elevation =	528)	627
g.	Station 93+50,	35 R	B-18[1,3]	(Core to Elevation =	489)	612
	[3] Install one observation well at the Limestone/Shale interface					
h.	Station 98+90,	10 L	B- 4	Previously Drilled		
i.	Station 100+20,	85 L	B-17[1,3]	(Core to Elevation =	471)	594
j.	Station 103+30,	10 L	B-16[1]	(Core to Elevation =	462)	585
k.	Station 106+00,	75 R	B-15[1,3,4]	(Core to Elevation =	452)	580
	[3] Install one observation well at the Limestone/Shale interface					
l.	Station 109+05,	60 L	B-12[1,3]	(Core to Elevation =	444)	570
	[3] Install one observation well in the lower Limestone					
m.	Station 110+30,	20 L	B- 3	Previously Drilled		

2. Cut limits from Station 125+26 to 135+20

a.	Station 124+40,	0 L	B- 7[1,2,3]	(Core to Elevation =	407)	518
	[3] Install one observation well in the lower Limestone					
b.	Station 126+35,	0 L	B- 2	Previously Drilled		
c.	Station 128+60,	0 L	B-14[1,2,3,4]	(Core to Elevation =	409)	528
	[3] Install one observation well at the soil/rock interface and one at the Limestone/Shale interface					
d.	Station 129+35,	75 R	B- 1	Previously Drilled		
e.	Station 132+00,	100 L	B-13[1,2]	(Core to Elevation =	416)	525

Notes:
[1] Borings that are proposed by HMM for the tunnel and will also need to be grouted.
[2] Sample and core holes because of limited movement and anticipated deep soils.
[3] Install observation well.
[4] Perform pressure testing of bedrock with a double packer system after the boring is complete.

II. Rock Line Soundings

The following rock line soundings are to be drilled to auger refusal or to the top of bedded material, whichever is encountered first.

	Station	Offset	Boring No.
a.	58+50	80 R	B-25

III. Open Face Logging of Rock Exposures

a. Open Face Log Highwall along US 42.

IV. Access to Borings

Borings will be accessed utilizing tracked drill rigs or drills mounted on 4x4 F-550 type trucks. Borings within the first cut interval are located in state R/W were existing topography is relatively level. Accesses will be made to and from KY 841. Borings within the second cut interval will be from Shadow Woods Subdivision. B-13 is positioned alongside/within the roadway. B-14 and B-7 are positioned on private property. Access will be worked out with each property owner in order to limit the amount of disturbance. However, it is not anticipated that any of the proposed Phase I borings will require a bulldozer for access.

Louisville Southern Indiana Ohio River Bridges Project

Kentucky East End Approach Tunnel: Proposed Highway Tunnels.

Table 1: Proposed Geotechnical Investigation Program

Item#										Remarks:
0.1	Introductory Note:									
	This schedule does not address the following design issues:									
0.1.1	Groundwater monitoring									Insufficient current information to gain complete understanding on nature of aquifer in which tunnel will be excavated; issue will be revisited on completion of current phase of surface investigation and geophysical program.
0.1.2	Structural stability and groundwater monitoring of the Exploratory Tunnel Access Shaft									Location of shaft will require confirmation of ground conditions assumed for shaft design.
0.1.3	Highway tunnel portal and portal face stability									Confirmation of topography and vertical jointing at portal locations required, when fixed.
0.1.4	Testing as part of the exploratory tunnel is not included.									
1	Boreholes Located within the Drumanard Estate to be drilled from Surface									Remarks
1.1	Boring Designation	Station (subject to revision following geologic mapping)	Inclination of hole	Offset (ft)	Ground Elevation (ft)	Construction Invert Elevation (ft)	Length in direction of Drilling (ft)	Primary Purpose	Planned in hole testing	
1.2	B-5	121+80	angle hole:inclined at 40 degrees from vertical directed towards south west	70 R	530	448	135	To investigate nature of horizontal bedding planes and vertical joints where present.	Packer Tests, Long term Ground Water Monitoring Wells, and Downhole Geophysics	BH-5 positioned on assumption that stream course may be aligned to vertical structural features.
1.3	B-6	122+02	vertical	4 L	523	447	90	To investigate nature of horizontal bedding planes	Packer Tests, Long term Ground Water Monitoring Wells, and Downhole Geophysics	
1.4	B-8	118+68	vertical	0	536	455	100	To investigate nature of horizontal bedding planes	Packer Tests, Long term Ground Water Monitoring Wells, and Downhole Geophysics	
1.5	B-9	117+02	vertical	107 R	567	459	130	To investigate nature of horizontal bedding planes	Packer Tests, Long term Ground Water Monitoring Wells, and Downhole Geophysics	
1.6	B-10	115+80	vertical	5	553	460	115	To investigate nature of horizontal bedding planes	Packer Tests, Long term Ground Water Monitoring Wells, and Downhole Geophysics	
1.7	B-11	113+55	angle hole:inclined at 15 degrees from vertical directed to south-west	29R	585	468	145	angle hole:inclined at 15 degrees from vertical to identify vertical joints	Packer Tests, Long term Ground Water Monitoring Wells, and Downhole Geophysics	BH-11 positioned to cross orientation of vertical joint system mapped in outcrop approximately 5 miles from the site.
1.8	Total (ft)						715			

Preliminary Boring Plan
Geotechnical Exploration
East End Approach – Phase III
Item No. 5-118
Jefferson County, Kentucky
April 20, 2005

I. Undisturbed Sample/Embankment Stability Borings

Undisturbed sample borings are to be performed at the following locations. Thin-walled tube samples are to be obtained in cohesive soils, and standard penetration tests are to be performed in granular type soils in accordance with the KYTC Geotechnical Manual. Soil sampling shall be performed on 5 foot intervals of depth to the cutoff depth specified below or the top of bedded material, whichever is encountered first. Sampling shall begin approximately 2 feet below the ground surface. If the overburden depth exceeds 5 feet, a cased observation well will be installed and seven (7) day water table readings will be obtained at the well locations.

1. Fill Limits from ±Station 134+25 to ±Station 189+11

				Cutoff Depth
a.	Station 138+50,	Centerline	B-26	Bedrock
b.	Station 150+60,	Centerline	B-27	Bedrock
c.	Station 165+50,	Centerline	B-28	75 feet
d.	Station 174+50,	Centerline	B-29	140 feet
e.	Station 184+00,	Centerline	B-30	160 feet

II. Access to Borings

Borings will be accessed utilizing tracked drill rigs or drills mounted on 4x4 F-550 type trucks. Three of the borings are situated within trees or brushy areas and may require a bulldozer to facilitate accessing the boring locations. Access will be worked out with each property owner in order to limit the amount of disturbance.

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Fuller Mossbarger Scott & May
FMSM
ENGINEERS

November 21, 2005

O.1.1.LX2004110L08

Mr. Jerry Leslie, PE
H.W. Lochner, Inc.
1040 Monarch Street, Suite 300
Lexington, Kentucky 40513

Re: Minutes/Rock Core Meeting
LSIORBP - SDC 4
Item No. 05-118.11
Mars No. 65541-05D
Jefferson County, Kentucky

Dear Jerry:

This letter is to confirm discussions of the Rock Core Meeting held November 10, 2005 at FMSM's Lexington office. The following people were in attendance:

- Mike Blevins – KYTC Division of Structural Design/Geotechnical Branch
- Christian Wallover – KYTC Division of Structural Design/Geotechnical Branch
- Debby Taylor – Lochner
- Jerry Leslie – Lochner
- John Beam - Fuller, Mossbarger, Scott, and May Engineers, Inc.
- Scott Murray - Fuller, Mossbarger, Scott, and May Engineers, Inc.
- Don Blanton - Fuller, Mossbarger, Scott, and May Engineers, Inc.
- Mark Litkenhus - Fuller, Mossbarger, Scott, and May Engineers, Inc.

The following items represent the primary topics of discussion during the meeting:

1. Rock core specimens, corresponding boring logs, results of jar slake and slake durability index tests, roadway cross-sections and the preliminary cut slope configurations proposed by FMSM were reviewed by the group. The following intervals were reviewed:

Mainline 54+00 to 106+00

127+00 to 134+50

2. A review of the geology indicates that the cuts will be within the Louisville Limestone, Waldron Shale and Laurel Dolomite, in descending order. Several borings also penetrated the Osgood Formation which lies below roadway grade 30 feet to 55 feet.

3. The group discussed the following cut slope options:

- Conventional cut slopes using 1/4(H):1(V) slopes and 20-foot intermediate benches.
- 20(H):1(V) cut slopes with 18 and 20-foot intermediate benches.
- Configurations with reduced intermediate benches.
- Slopes that are near vertical with a tall retaining wall in front of the cut face.

Because the current cross-sections do not depict ramp configurations that will also impact the cut slopes, as well as the poor performance of existing near vertical cut slopes in the area, the group agreed to utilize 1/4 (H):1(V) cut slopes at this time. The remaining configuration and details will be further discussed after the ramp alignments and grades are established.

4. The group discussed possible options such as eliminating the bench located on top of the shale layer near elevation 518 feet. This bench transitions out of the ditch and would be approximately 600 feet long including transitions at both ends. Under consideration is shotcreting the shale if the bench is removed. This will require periodic maintenance and will be further evaluated after the ramp configurations are identified and how they might be located in relation to this bench location.

5. The group discussed the possible use of a retaining wall and a safety wall located at the top of the cut between approximate stations 99+00 to 106+00. This wall may need to be a pile and lagging type structure to retain the soil. The purpose of the retaining wall would be to keep the cut within the proposed FEIS ROW. This will require further evaluation after the ramp alignments are established.

6. Any wall footings or bridge foundations located on benches need to be placed a minimum of 10 feet away from the open cut face.

7. Lochner will evaluate roadway grade and ramp configurations. Upon completion, plans, profiles and sections will be sent out to the remaining group for further evaluation of cut slopes. An additional meeting may be required to discuss the new information.

If you have any questions regarding these minutes, please feel free to contact us. If any of the attendees have revisions to the minutes, please forward them to FMSM within ten days of the receipt of this letter. Otherwise, the minutes will become the final record of the November meeting.

Respectfully submitted,

FULLER, MOSSBARGER, SCOTT AND MAY
ENGINEERS, INC.

Mark A. Litkenhus, PE
Associate

/dd

LOCHNER

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Technical Review Meeting Summary
Section 4 Project Team Meeting
December 19, 2007
Summary by: Debby Taylor, H. W. Lochner, Inc.

A meeting was held on December 19, 2007 at the KYTC offices in Frankfort, KY to discuss issues related to the proposed rock cut slopes for the mainline for Section 4 of the Louisville-Southern Indiana Ohio River Bridges Project (LSIORBP) with the design consultant project team members for Section 4.

The following were in attendance:

Bill Hanson	FHWA
Matt Bullock	KYTC
Jadie Tomlinson	KYTC
Bart Asher	KYTC
Michael Blevins	KYTC
Jim Hilton	CTS/GEC
Kevin Villier	CTS/GEC
Mark Litkenhus	FMSM
Adam Crace	FMSM
Jim Klein	LKA
Bryan Reid	H.W. Lochner, Inc.
Todd White	H.W. Lochner, Inc.
Jerry Leslie	H.W. Lochner, Inc.
Debby Taylor	H.W. Lochner, Inc.

1. The meeting began at approximately 10:05 a.m. The agenda follows:

- **Overview of the Project**
  - Status/Overview
  - Differences from last meeting on July 25, 2006

- **Concepts** (Constructability, Maintainability, Economics and Aesthetics)
  - Wolfpen Woods
  - Springdale
  - Allison Barrickman House
  - Bridgepointe
  - Northside of Tunnel

- **Review of FMSM's Geotechnical Cross Sections**
- **Discussions and Questions**
- **What is the next step?**

2. Hardcopies of Mid-level cross-sections and cut stability slope sections were distributed to the Project Team members.
3. Jerry presented an overview of the proposed rock cut slopes and wall configurations developed for the Mid-level Plans in the mainline area leading to the south portal.
4. The slopes and walls adjacent to Wolf Pen Woods subdivision were discussed in relation to the 60" waterline that runs parallel to KY 841. Hand excavation was performed on the waterline on November 16, 2007 to more accurately locate the line. Cross-sections have been revised based on the information obtained from the location excavation.
5. There is an existing utility easement for the 60" waterline. Various private fences, landscaping, decks, pools, etc. have been constructed within the easement area.
6. Lochner and CTS will continue coordination with LWC concerning blasting limits for construction adjacent to the waterline.
7. A noise wall that varies from 4' to 8' tall has been determined to be feasible for Wolf Pen Woods based on the results of the Noise Barrier Analysis performed and approved by BSMT in 2006. Constructability issues with the noise wall being too close to the 60" waterline present a problem with the present ditch, retaining wall, and noise wall combination. The Project Team agreed for Lochner to evaluate the revision to the typical section through the Wolf Pen Woods/waterline area including elimination of the rock ditch, addition of a crashworthy barrier at the edge of shoulder, addition of a 5' planting area behind the barrier, elimination of retaining walls if possible, and placement of the noise wall within existing right-of-way. Advantages for this scenario would include:
    a. The reduction and/or elimination of fee simple right-of-way acquisition for the Wolf Pen Woods property owners.
    b. Reduction of proximity impact to existing 60" waterline.
    c. Improves access to noise wall for maintenance.
    d. Leave maintenance access for 60" waterline as is currently.
    e. Narrowing of the roadway prior to the tunnel would possibly serve to slow drivers down in anticipation of the tunnel.
    f. Variable slope on the earth overburden could allow additional planting areas.
    g. Improve constructability for the roadway and necessary walls.
8. Discussion followed on making the typical consistent on the Springdale side of the mainline with the Wolf Pen Woods side. Due to the median barrier height and the fact that the southbound lanes are leaving the tunnel, allowing the southbound

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lanes to remain more open was the consensus of opinion. The typical section shall remain unchanged for this location.

9. The transmission line that runs parallel to Springdale Road was discussed. Lochner will evaluate options for minimizing the relocation of this line in the Springdale Road area. The addition of a soil retaining wall at top of rock will be investigated as a means to minimize transmission line relocation and any undercutting of Springdale Road.
10. Various wall types were discussed concerning their constructability adjacent to the Allison-Barrickman historic boundary. The concept as presented at Mid-level with the tall walls appears to be the most feasible option for preventing any impacts to the Allison-Barrickamn historic property.
11. Lochner will investigate eliminating some of the walls in the Bridgepointe area and utilizing rock cut slopes instead. 18' benches will work for lifts up to 30'. 20' benches will be necessary for lifts higher than 30'.
12. The north portal rock cut slopes were briefly discussed. These will remain as Mid-level Plan show.
13. After developing the revised rock cut slope and wall concepts, Lochner will submit the cross-sections to CTS for a meeting with BSMT for review and approval. This presentation to BSMT is tentatively scheduled for January 14, 2008. Jim Hilton will request addition of the presentation to the the BSMT agenda.
14. Upon review and approval of the BSMT, the Design Executive Summary will be revised based on the new concepts and resubmitted for BSMT review and approval.
15. Additional corings will be needed for wall design.
16. The meeting adjourned at approximately 1:00 p.m.

Mark Litkenhus

From: Mark Litkenhus
Sent: Thursday, May 29, 2008 1:49 PM
To: Slone, Chris (KYTC-WSC); Mark Litkenhus; jleslie@hwlochner.com
Cc: Adam Crace; Debby Taylor (dtaylor@hwlochner.com); White, Todd
Subject: RE: LSIORB Section 4 Comments from the Geotechnical Branch
Attachments: Summary of Rock Quantities.pdf; Revised Geotech Notes.pdf

Chris,

The following summarizes comments received from the Geotechnical Branch on May 9, 2008 regarding the roadway report. FMSM's responses are in italics and have been indented.

Written Report Portion

1) Page 16. Why are 3:1(H:V) slopes being used on the embankments?
   FMSM – Lochner has indicated that flatter slopes are being used to reduce the amount of waste on the project.

Drawings Portion

2) Geotechnical Note Sheet, Notes 2 and 5. A question mark is placed beside these two notes.
   FMSM – Based upon additional correspondence from the Geotechnical Branch on May 28, 2008, we will modify Note 2 to apply to existing structures that are not noted on the plans such as old building foundations, cellars, old bridge footings. Note 5 will be deleted.

3) Geotechnical Note Sheet, Notes 10 and 11. Why not specify shot rock?
   FMSM – Notes 10 and 11 will be edited to specify durable rock below the RDZ. Based upon additional correspondence with the KYTC Geotechnical Branch on May 28, 2008, an additional note should be added that states: Overhaul of excavated materials will not be considered on this project.

4) Geotechnical Note Sheet, Note 12. If rock roadbed is utilized, this note is not necessary.
   FMSM – Note 12 will be deleted.

5) General comment regarding note for vertical cuts on most of the cut stability sections; change note to read "Vertical cuts in rock will require long term support such as a retaining wall or other similar type measures."
   FMSM – Agreed.

6) Cut Stability Section 84+00. Add a bench transition note for the 20-foot IB at elevations 570 feet and 564 feet.
   FMSM – Agreed.

7) Cut Stability Section 93+50. Add a bench transition note for the 20-foot IB at elevation 540 feet left of centerline.
   FMSM – Agreed.

8) Cut Stability Section 100+00. Add a 10-foot OB at top of left cut.
   FMSM – Agreed.

9) Cut Stability Section 100+00. Noise/safety wall at top of right cut is beyond the "proposed R/W". What does this mean?
   FMSM – Adjustments to the R/W will need to be performed.

10) Cut Stability Section 103+50. Is Ramp A still on a bridge at this point?

FMSM – Yes, Ramp A is still a bridge at this location.

11) Cut Stability Section 106+00. Intermediate benches at elevations 570 feet and 565 feet will still be applicable for this section.
FMSM – Agreed.

12) KY 841 Spill Thru Slope Station 136+30 to 139+40. Is the Rapid Drawdown analyses based upon the 100 year or 500 year flood?
FMSM – 100-year flood.

13) KY 841 Embankment Stability Section Station 151+00. Why is the left slope a 3:1 (H:V) instead of 2:1 (H:V)?
FMSM – Lochner has indicated that 3:1 (H:V) slopes will be utilized.

14) Please submit rock quantity sheets for project.
FMSM – See attached Summary of Rock Quantities sheet submitted by Lochner.

15) *FMSM – Because sufficient quantities of shot rock are available for embankment construction, a new note will be added to include pile cores at the appropriate bridge abutments.*

We have attached a "marked" up geotechnical note sheet for additional review. We will proceed with making the above changes and issuing a Final Report by the end of next week unless otherwise directed.

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Mark Litkenhus

From: Mark Litkenhus
Sent: Monday, May 19, 2008 3:07 PM
To: jleslie@hwlochner.com; Adam Crace
Cc: White, Todd; Debby Taylor (dtaylor@hwlochner.com)
Subject: RE: Geotechnical Coordination.doc

Jerry,

Our responses to Mr. Kirby's comments are in red and italics beneath Mr. Kirby's comments below. If you have any questions, please let us know. Please forward these comments to anyone else on the Team that may require documentation.

Thanks.

Mark Litkenhus, PE
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From: Leslie, Jerry [mailto:jleslie@hwlochner.com]
Sent: Monday, April 28, 2008 11:31 AM
To: Mark Litkenhus; Adam Crace
Cc: White, Todd; Debby Taylor (dtaylor@hwlochner.com)
Subject: FW: Geotechnical Coordination.doc

FYI - Some comments from CTS on the Geotechnical Report.

From: Kevin Villier [mailto:kvillier@ctsgec.com]
Sent: Monday, April 28, 2008 11:21 AM
To: Leslie, Jerry; Taylor, Debby
Cc: Craycraft, Charles; Sacksteder, John
Subject: FW: Geotechnical Coordination.doc

Jerry, below are comments on the Draft Geotechnical Roadway Report from David Kirby. He did a brief review on items that could impact structures.

If you have any questions, please contact me.

Kevin V

From: Dave Kirby [mailto:dkirby@hmbconsultants.com]

Sent: Monday, April 28, 2008 11:15 AM
To: 'Kevin Villier'
Cc: jsacksteder@ctsgec.com; 'Hilton, Jim'
Subject: Geotechnical Coordination.doc

Louisville Bridges
Section 4
Geotechnical Coordination

1) The spill thru slope stability at station 136+50 is labeled "Ohio River bridge approach structure" when this is actually the south end of Harrods Creek bridge.
   FMSM - Agree. Label will be corrected.
2) The span arrangement study recommended breastwall abutments on both ends of the Harrods Creek bridge, but the geotechnical report appears to be checking a spill thru condition.
   FMSM – Bridge information to-date has been preliminary. Our concern is that "if" a spill-thru option is implemented, the Team would have information regarding slope conditions. This information can be removed if the Team decides it is not necessary.
3) The slope stability for a spill thru slope at station 168+50 is not addressed in the geotechnical report even though the embankment appears higher that the analysis performed at station 136+50 for the Harrods Creek bridge.
   FMSM – See recommendation 10.4. Additional information will be obtained during the structure exploration. The scope of work for this portion has been included in the recently submitted contract modification.
4) A settlement analysis needs performed at station 154+00 where the embankment height is the greatest (55 to 60 feet) and where a concrete arch culvert is planned for Middleton Branch. A stability analysis at this location would also seem to be prudent.
   FMSM - These type of analyses are generally performed as part of the structure exploration and report. Additional information will be obtained during the structure exploration. The scope of work for this portion has been included in the recently submitted contract modification.
5) The report shows a 3:1 slope at the Approach River Bridge endbent slope. The bridge SAS shows a 2:1. The bridge will need to be longer if a 3:1 is used.
   FMSM – Agree. FMSM has discussed slopes with Lochner and they indicate 3:1 (H:V) slopes will be utilized.
6) The roadway cross-section at 152+00 shows a 2:1 below the shared use path. The geotech apparently requires a 3:1. There is also a retaining wall for the shared use path that is not mentioned in the geotech report.
   FMSM – Lochner has indicated that wall scenarios are still preliminary. Further evaluation will be required during the structure exploration portion of this contract. The recently submitted contract modification includes scope for this wall.
7) The phased construction of the embankment at station 150+00 (end of the Harrods Creek bridge) should be addressed. Constructing one bridge, and partial embankment in order to build the remaining embankment.
   FMSM – We are not aware of phased construction requirements. Will need additional information to understand comment.
8) The uncertainty of slopes and walls in the rock cuts could have major cost implications. This needs to be addressed by the project team. Why was this "beyond the scope of this report"?
   FMSM – FMSM has always raised a cost concern regarding the retaining walls. Our understanding is that Lochner has allotted significant dollars to account for the walls. The original geotechnical scope of work was for traditional cut slopes, not massive rock tie-back type walls. Additional work is included in the recently submitted contract modification to further evaluate the vertical rock walls.

Appendix D

Geotechnical Drawings

COUNTY OF	ITEM NO.	SHEET NO.
JEFFERSON	5-118.11	

GEOTECHNICAL SYMBOL SHEET

AASHTO Classification of Soils and Soil-Aggregate Mixtures

General Classification	Granular Materials (35% or less passing 0.075 mm)							Silt-Clay Materials (More than 35% passing 0.075 mm)			
Group Classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6
Sieve Analyses, percent Passing 2.00 mm (No. 10) 0.425 mm (No. 40) 0.075 mm (No. 200)	50 max 30 max 15 max	--- 50 max 25 max	--- 51 min 10 max	--- --- 35 max	--- --- 35 max	--- --- 35 max	--- --- 35 max	--- --- 36 min	--- --- 36 min	--- --- 36 min	--- --- 36 min
Characteristics of Fraction Passing 0.425 mm (No. 40) Liquid Limit Plasticity Index	--- 6 max		--- N.P.	40 max 10 max	41 min 10 max	40 max 11 min	41 min 11 min	40 max 10 max	41 min 10 max	40 max 11 min	41 min 11 min

Unified Soil Classifications

MAJOR DIVISIONS		SYMBOL		NAME
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW		Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP		Poorly graded gravels or gravel-sand mixtures, little or no fines.
		GM		Silty gravels, gravel-sand-silt mixtures.
		GC		Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW		Well-graded sands or gravelly sands, little or no fines.
		SP		Poorly graded sands or gravelly sands, little or no fines.
		SM		Silty sands, sand-silt mixtures.
		SC		Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS LL IS LESS THAN 50	ML		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
	SILTS AND CLAYS LL IS GREATER THAN 50	MH		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH		Inorganic clays of high plasticity, fat clays.
UNCLASSIFIED MATERIAL		NONE		Non-classified material (i.e. overburden, pavement, slag, etc.) Include visual description.

AI	Activity Index
LI	Liquidity Index
S+C	Silt + Clay (% finer than No. 200 Sieve)
○	Rockline Soundings
	Disturbed Sample Boring
◎	Undisturbed Sample Boring
⊙	Undisturbed Sample Boring & Rock Core
●	Rock Core
□	Open Face Log
	Slope Inclinometer Installation typical applications:
OW	Observation Well
	Approximate Footing Elevation
▼ (Date)	Water Elevation
VS (psf)	Field Vane Shear Strength
■	Thin-walled Tube Sample
<	Standard Penetration Test Sample
N	Penetration Resistance
Qu (psf)	Unconfined Compressive Strength
UU (psf)	Unconsolidated Undrained Triaxial Strength
w(%)	Moisture Content
KY RQD	Rock Quality Designation (Kentucky Method)
STD RQD	Rock Quality Designation (Standard Method)
SDI (JS)	Slake Durability Index (Jar Slake Test)
REC	Core Recovery
ϕ	Angle of Internal Friction (Total Stress)
$\bar{\phi}$	Angle of Internal Friction (Effective Stress)
c (psf)	Cohesion (Total Stress)
$\bar{c}$ (psf)	Cohesion (Effective Stress)
γ (psf)	Total Unit Weight
RDZ	Rock Disintegration Zone
OB	Overburden Bench
IB	Intermediate Bench
R	Refusal
NR	Refusal Not Encountered

LIMESTONE

SANDSTONE

DURABLE SHALE (SDI $\geq$ 95)

NONDURABLE SHALE (SDI < 95)

COAL

TALUS, MINE WASTE, FILL MATERIAL, BOULDERS, & ETC.

GRANULAR EMBANKMENT

STRUCTURE GRANULAR BACKFILL

SLOPE PROTECTION

PREPARED BY FULLER, MOSSBARGER, SCOTT AND MAY ENGINEERS, INC DATE SEPT., 2001
CHECKED BY DATE
APPROVED BY DATE

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COUNTY OF	ITEM NO.	SHEET NO.
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Geotechnical Notes

Roadway Geotechnical Notes

1. Clearing and grubbing of embankment areas shall be completed in accordance with Section 202 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction.

2. Removal of existing structures and other obstructions, whether shown on the plans or not, shall be completed in accordance with Section 203 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction.

3. All water wells within the limits of construction, whether shown on the plans or not, shall be plugged in accordance with requirements of Section 708 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction.

4. All catch basins and manholes shall be filled and capped, and all septic tanks shall be cleaned and filled in accordance with Section 708 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction.

5. All channel changes and special ditches shall be constructed prior to placement of any embankment materials adjacent to them in accordance with Section 206 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction. At the direction of the Engineer, materials excavated from these areas may be utilized in construction of the embankments, but may require aeration to the proper moisture contents prior to compaction operations. No extra payment shall be permitted for rehandling, hauling, stockpiling and/or manipulating these materials. Only limestone and durable shales shall be utilized for Class IV channel lining. All non-durable shales shall be excluded from use as channel lining.

6. In accordance with Section 206 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction, the moisture content of embankment material shall not vary from the optimum moisture content, as determined by KM 64-511, by more than plus or minus two percent. This moisture content requirement shall have equal weight with the density requirement when determining the acceptability of embankment or subgrade construction. Refer to the Family of Curves for moisture-density relationships.

7. All soils, whether from roadway excavation or borrow, may require manipulation to obtain proper moisture content prior to compaction. Direct payment shall not be permitted for rehandling, hauling, stockpiling and/or manipulating soils.

8. The Contractor is responsible for conducting any operations necessary in order to excavate the cut areas to the required typical sections. These operations shall be incidental to the roadway excavation price.

9. Any saturated, soft and unstable areas encountered within embankment foundation limits and/or any other areas as specified by the Engineer shall be drained and stabilized with a minimum opf three feet (vertical thickness) of durable limestone and shale from roadway excavation. The following intervals are provided only to aid in establishing quantities for coarse aggregate and geotextile fabric for bidding purposes. Actual areas requiring such stabilization may differ significantly from those listed herein.

   Approximate Station Limits
   Mainline
   134+50 to 135+50
   158+50 to 160+00

10. As directed by the Engineer, a three-foot vertical thickness of durable limestone and shale from roadway excavation shall be utilized to fill and stabilize any existing drainage swales or stream channels located within the limits of the roadway embankments. The rock material shall also be placed over all adjacent areas, which may be soft and saturated. Positive drainage of these abandoned stream channels shall be maintained to reduce the possibility of trapping water within the roadway embankments.

    Approximate Station Limits
    Mainline
    153+50 to 154+50

11. Overhual of excavated materials will not be considered on this project.

12. As directed by the Engineer, existing bituminous concrete that is positioned within the limits of new roadway embankments, and positioned at a distance greater than three feet below proposed subgrade elevation, shall be scarified or broken until all cleavage planes are destroyed, or the pavement shall be removed entirely as conditions demand, in accordance with Section 206 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction. Subgrade materials remaining after removal of pavements may need to stabilized prior to placement of new pavement sections, as directed by the Engineer.

    Approximate Station Limits
    Mainline
    150+00 to 152+00
    163+70 to 167+00

13. A pond was observed at the following approximate location and is situated entirely or partially within embankment foundation limits. The pond shall be drained and any soft and saturated material (estimated to be 2 feet) shall be removed and/or stabilized as directed by the Engineer prior to placement of the roadway embankment. For stabilization purposes, a sufficient thickness (estimated to be 3 feet) of limestone shot rock from roadway excavation shall be used. Additional rock may be required to stabilize soft soils and to maintain positive drainage.
    For quantity estimate purposes only, this shall include the following area. Actual thickness and locations of rock material will be determined by the Engineer during construction. The cost of placing these materials shall be incidental to the earthwork.

    Approximate Station Limits
    Mainline
    137+00 to 138+00, Left

14. Conventional transverse benches shall be constructed and perforated pipe underdrains installed at the following approximate locations in accordance with Kentucky Department of Highways Standard Drawings RDP-005 and RDP-006, project cross-sections (as applicable), and as directed by the Engineer. Contrary to Standard Drawing RDP-006, transverse benches and perforated pipe underdrains shall be installed in both uphill and downhill transition areas between cuts and fills.

    Approximate Station
    Mainline
    134+50

15. Perforated pipes for subgrade drainage shall be installed at vertical sags and at the upgrade ends of structures, in accordance with Kentucky Department of Highways Standard Drawing RDP-005 and/or as directed by the Engineer. Contrary to Standard Drawing RDP-005, such drains shall be installed even when a rock roadbed is being constructed. These drainage features shall be installed at the following approximate locations:

    Approximate Station
    Mainline
    150+50

16. Because of high water concerns near Harrods Creek, Cyclopean Stone rip-rap conforming to Section 805 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction shall be utilized to construct the outer portions of the proposed roadway embankments within the following approximate station limits.

    Approximate Station Limits
    Mainline
    135+00 to 137+20

    The riprap shall used to construct the outer portion of both the left and right side slopes of the mainline embankment and shall wrap around the face of the back-station approach slope for the mainline crossing over Harrods Creek. A minimum 3-foot layer of riprap shall be placed as an integral part of the embankment, and not as an additional thickness on the outside face of final embankment geometries. The riprap shall extend from the toes of the embankments upwardly to elevation 453.0 feet, approximately one foot above the 100-year high water elevation of 452.0 feet. The size and thicknesses of riprap shall be designed for applicable flood flow velocities. The riprap shall be placed in general accordance with Section 703 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction, and as directed by the Engineer.

    Type I Geotextile Fabric in accordance with Sections 214 and 843 of the current Standard Specifications for Road and Bridge Construction shall be placed on the ground surface and along the faces of all embankment slopes prior to placing riprap. The fabric shall be overlapped across the top of the riprap at elevation 453.0 feet prior to placing additional embankment materials on and above the riprap.

PREPARED BY ____ DATE ____
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Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS
COUNTY OF
JEFFERSON

PROJECT NUMBERS: EAST END APPROACH

GEOTECHNICAL NOTES

Geotechnical Notes (Continued)

17. Embankment stability analyses were conducted using estimated soil strength parameters for embankment materials. It is recommended that material used for embankment construction meet the following minimum strength parameters.

Total Stress	Effective stress
c = 1,400 psf	$\bar{c}$ = 200 psf
ø = 0°	$\bar{ø}$ = 23°

18. As directed by the Engineer, the solid rock roadbed shall be undercut a minumum of 5 feet below required grade to provide a transition between a non-yeilding subgrade between the retained fill and the rock slope. The refill shall be constructed with the appropriate subgrade material between the following approximate location.

Approximate Station Limits
Mainline
91+50 to 98+50

19. The embankments shall include "pile cores" at all applicable substructure element locations to facilitate installation of the foundation systems. The core material shall consist of "granular embankment" and shall be free of rock fragments larger than 3 inches maximum dimension, and any other obstructions which would interfere with foundation installation. Construct the pile cores in accordance with KYTC Special Provision No. 69, Standard Drawing No.'s RGX-100 and RGK-105 and section 206 of the current Kentucky Department of Highways Standard Specifications for Road and Bridge Construction.

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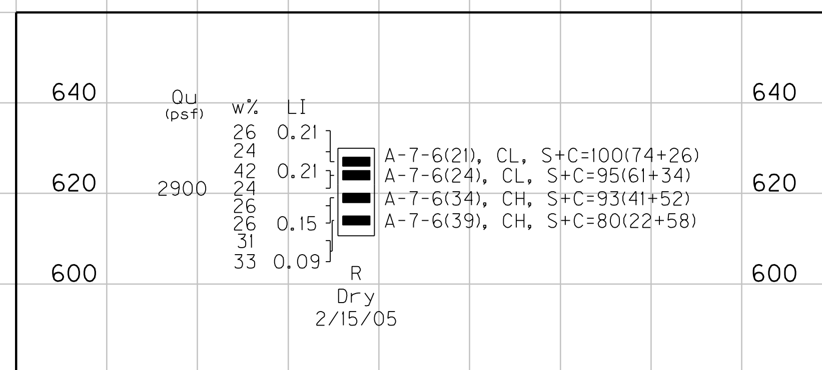
SUMMARY OF TRIAXIAL TEST DATA		
STATION	63+50	73+50
OFFSET	105' Lt.	85' Lt.
DEPTH	(2.6-3.1)	(2.0-2.5) (5.0-5.5)
c̄	280 psf	280 psf
ø̄	33.4°	33.4°

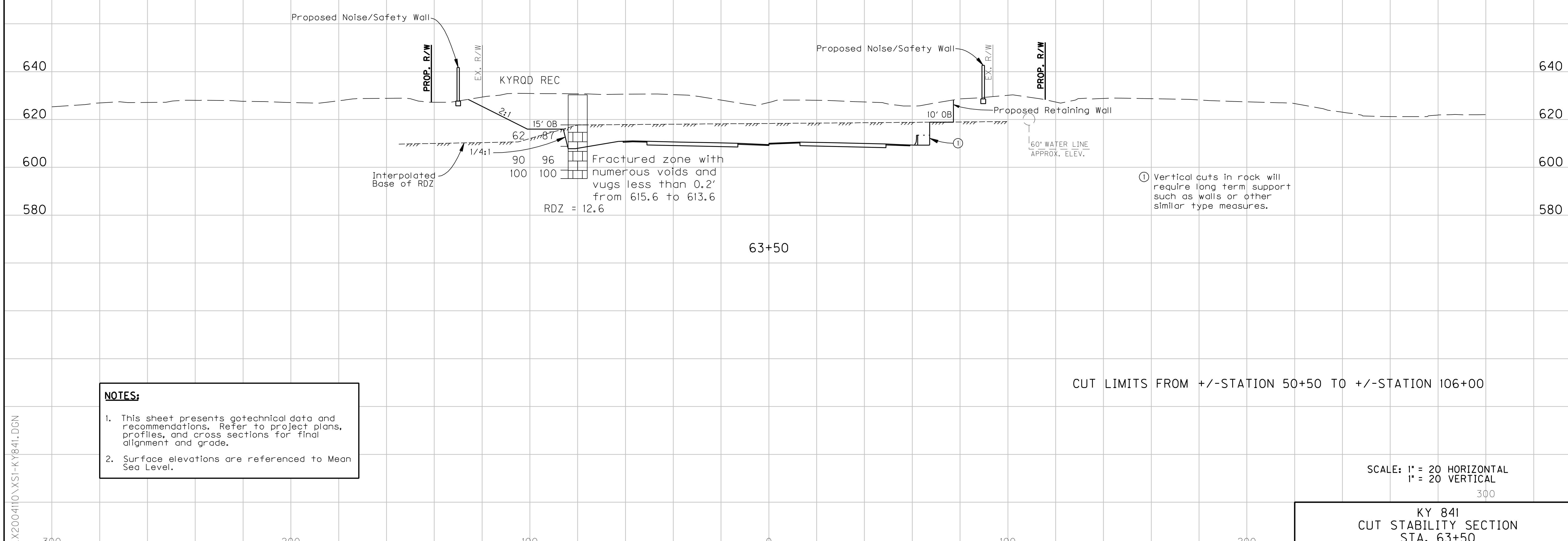
Core Log Station 63+50, 80' Lt.

Elev. 630.3 - 617.7	Overburden
617.7 - 595.3	Limestone, gray, mirco- to finely crystalline grained, medium to thick bedded, zones fossiliferous, argillaceous

Rockline Sounding Information

Station	Offset	Depth to Refusal
58+50	80' Rt.	15.1'





① Vertical cuts in rock will require long term support such as walls or other similar type measures.

CUT LIMITS FROM +/-STATION 50+50 TO +/-STATION 106+00

NOTES:

1. This sheet presents gotechnical data and recommendations. Refer to project plans, profiles, and cross sections for final alignment and grade.
2. Surface elevations are referenced to Mean Sea Level.

SCALE: 1" = 20 HORIZONTAL
1" = 20 VERTICAL

KY 841
CUT STABILITY SECTION
STA. 63+50

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APPROVED BY ____ DATE ____

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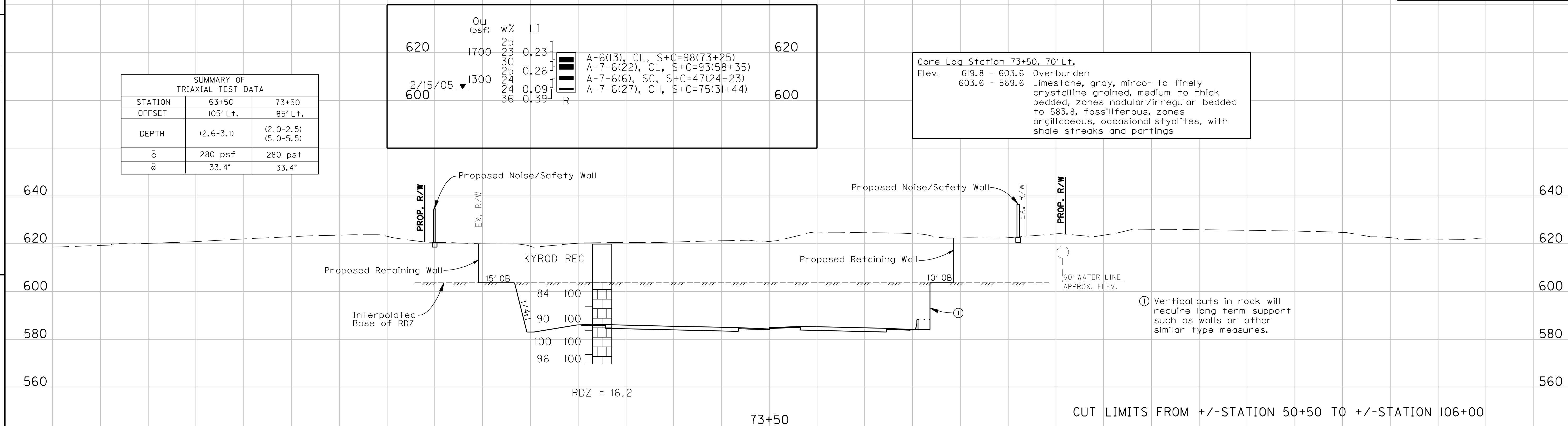
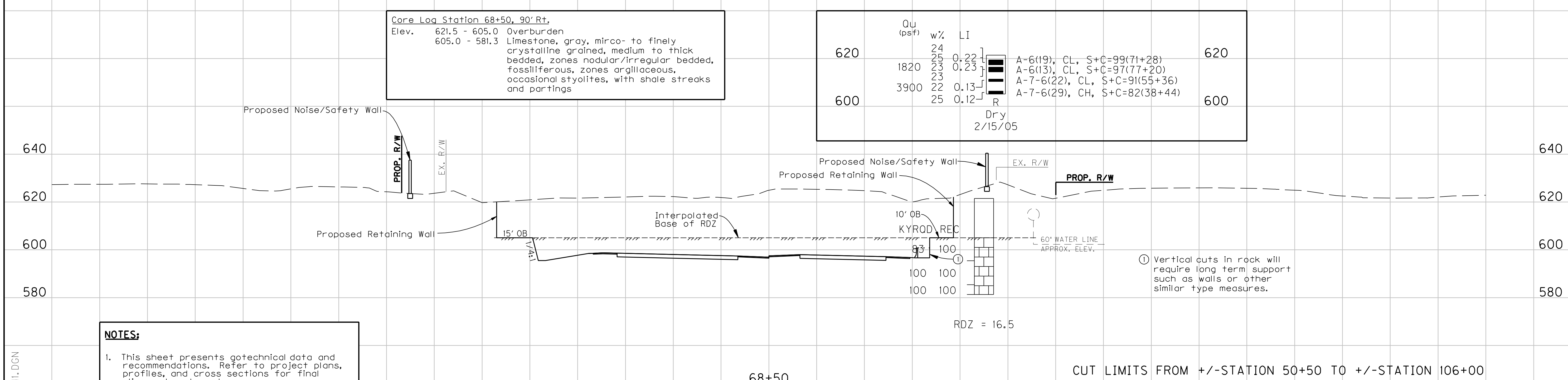
COUNTY OF	ITEM NO.	SHEET NO.
JEFFERSON	5-118.11	

SUMMARY OF TRIAXIAL TEST DATA		
STATION	63+50	73+50
OFFSET	105' Lt.	85' Lt.
DEPTH	(2.6-3.1)	(2.0-2.5) (5.0-5.5)
c̄	280 psf	280 psf
ø	33.4°	33.4°





NOTES:

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SCALE: 1" = 20 HORIZONTAL
1" = 20 VERTICAL

KY 841
CUT STABILITY SECTIONS
STA. 68+50 AND STA. 73+50

PREPARED BY ____ DATE ____
CHECKED BY ____ DATE ____
APPROVED BY ____ DATE ____

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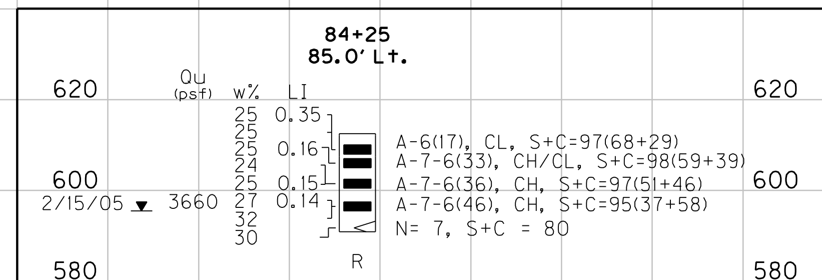
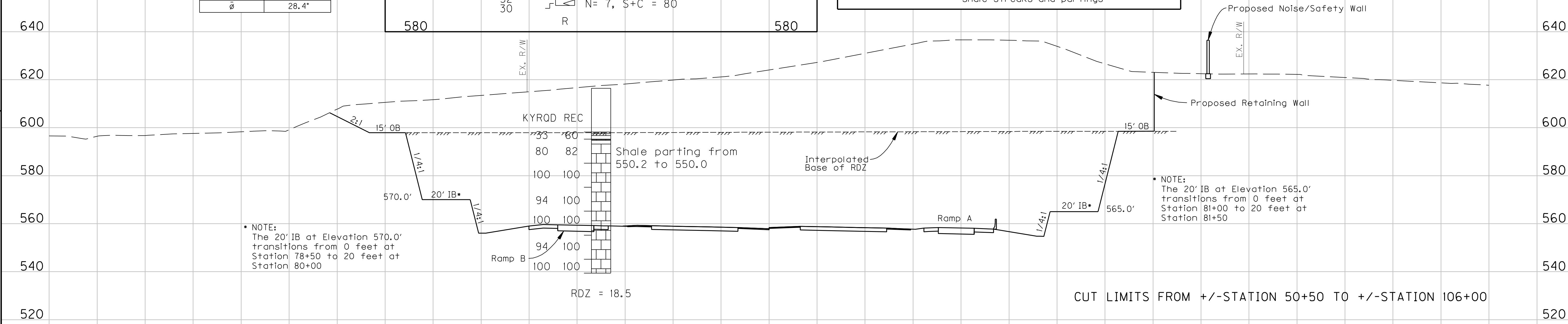
SUMMARY OF TRIAXIAL TEST DATA	
STATION	84+25
OFFSET	85' Lt.
DEPTH	(5.9'-6.4') (10.0'-10.5') (10.6'-11.1')
c̄	340 psf
ø̄	28.4°



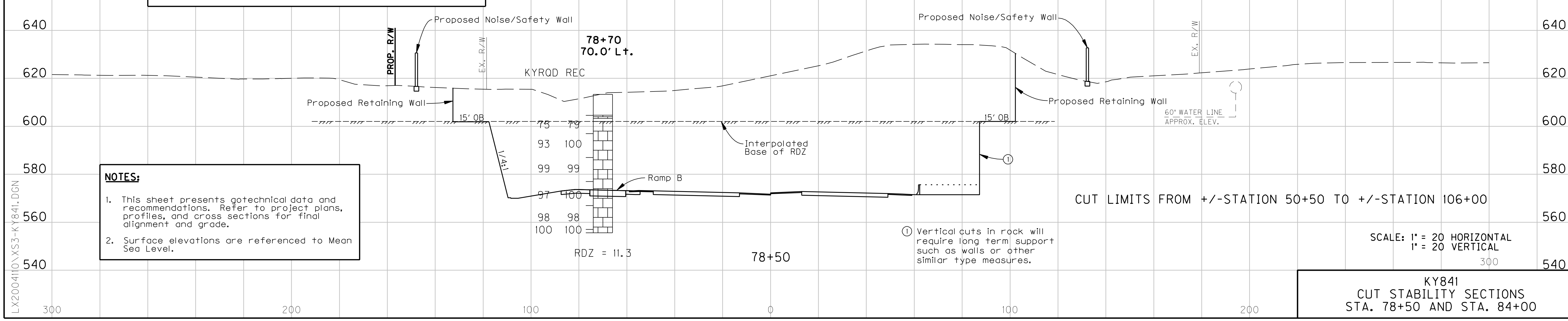
Core Log Station 84+00, 70' Lt.

Elev.
- 616.4 - 598.2 Overburden
- 598.2 - 596.7 Limestone, gray, mircograined to fine crystalline grained, thin to thick bedded, zones nodular/irregular bedded, fossiliferous, argillaceous zones, with shale streaks and partings
- 596.7 - 595.2 Void
- 595.2 - 594.7 Limestone, gray, mircograined to fine crystalline grained, thin to thick bedded, zones nodular/irregular bedded, fossiliferous, argillaceous zones, with shale streaks and partings
- 594.7 - 593.2 Void
- 593.2 - 539.4 Limestone, gray, mircograined to fine crystalline grained, thin to thick bedded, zones nodular/irregular bedded to 570.4, fossiliferous, argillaceous zones, with shale streaks and partings



Core Log Station 78+70, 70' Lt.

Elev.
- 613.3 - 604.6 Overburden
- 604.6 - 603.3 Limestone, gray, mirco- to finely crystalline grained, medium to thick bedded, argillaceous zones, occasional styolites, with shale stringers, and partings
- 603.3 - 602.0 Void
- 602.0 - 555.6 Limestone, gray, mirco- to finely crystalline grained, medium to thick bedded, augillaceous zones, occasional styolites, with shale stringers streaks and partings



NOTES:

1. This sheet presents gotechnical data and recommendations. Refer to project plans, profiles, and cross sections for final alignment and grade.
2. Surface elevations are referenced to Mean Sea Level.

(1) Vertical cuts in rock will require long term support such as walls or other similar type measures.

SCALE: 1" = 20 HORIZONTAL
1" = 20 VERTICAL

KY841
CUT STABILITY SECTIONS
STA. 78+50 AND STA. 84+00

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PREPARED BY ____ DATE ____
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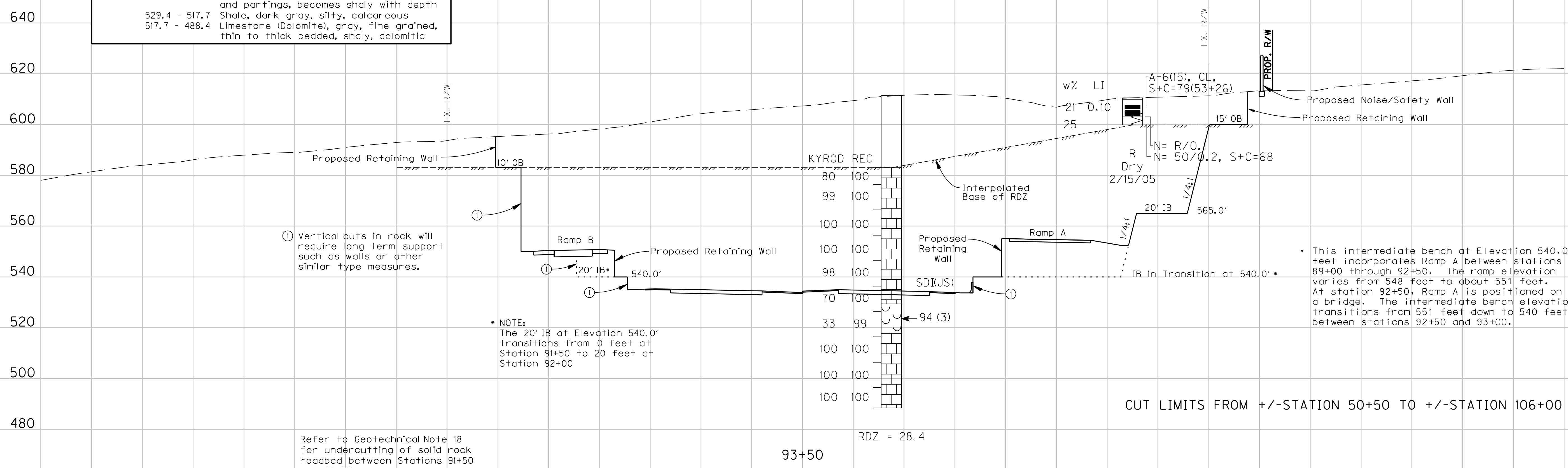
Core Log Station 93+50, 35' Rt.

Elev.
611.4 - 583.0 Overburden
583.0 - 529.4 Limestone, gray, mirco- to finely crystalline grained, thin to thick bedded, zones nodular/irregular bedded to 571.4, fossiliferous, argillaceous, occasional styolites, with shale streaks and partings, becomes shaly with depth
529.4 - 517.7 Shale, dark gray, silty, calcareous
517.7 - 488.4 Limestone (Dolomite), gray, fine grained, thin to thick bedded, shaly, dolomitic



① Vertical cuts in rock will require long term support such as walls or other similar type measures.

• NOTE:
The 20' IB at Elevation 540.0' transitions from 0 feet at Station 91+50 to 20 feet at Station 92+00

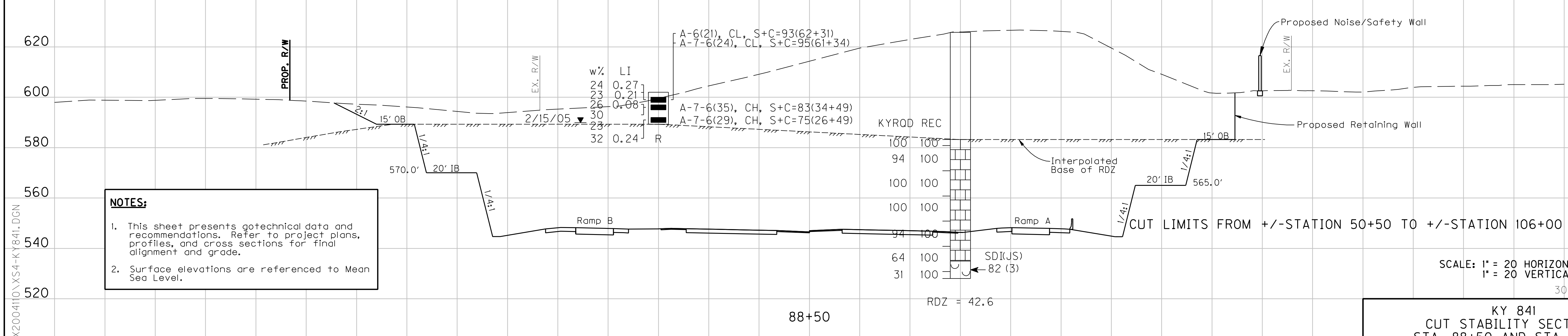
• This intermediate bench at Elevation 540.0 feet incorporates Ramp A between stations 89+00 through 92+50. The ramp elevation varies from 548 feet to about 551 feet. At station 92+50, Ramp A is positioned on a bridge. The intermediate bench elevation transitions from 551 feet down to 540 feet between stations 92+50 and 93+00.

CUT LIMITS FROM +/-STATION 50+50 TO +/-STATION 106+00

Refer to Geotechnical Note 18 for undercutting of solid rock roadbed between Stations 91+50 and 98+50.

Core Log Station 88+50, 60' Rt.

Elev.
625.8 - 583.2 Overburden
583.2 - 534.9 Limestone, gray, mirco- to finely crystalline grained, thin to medium bedded, fossiliferous, argillaceous zones, styolitic, with shale streaks and partings becomes shaly with depth
534.9 - 528.0 Shale, gray, silty, argillaceous



CUT LIMITS FROM +/-STATION 50+50 TO +/-STATION 106+00

NOTES:

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SCALE: 1" = 20 HORIZONTAL
1" = 20 VERTICAL

KY 841
CUT STABILITY SECTIONS
STA. 88+50 AND STA. 93+50

USER: $$$$USER$$$$
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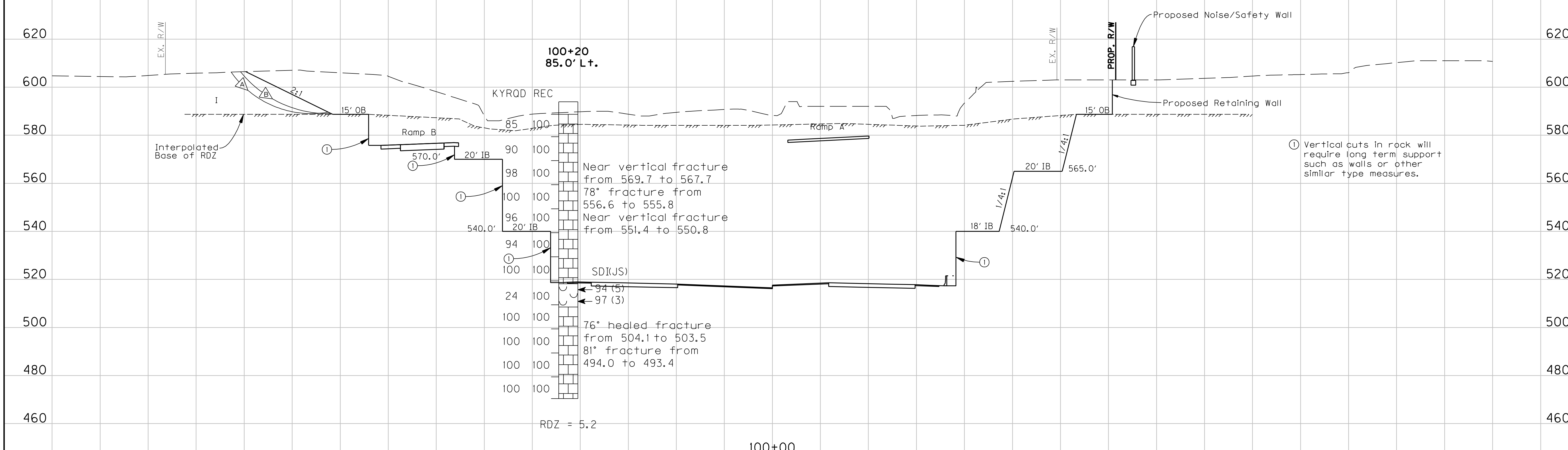
Core Log Station 100+20, 85' Lt.

Elev.		
	593.9 - 588.7	Overburden
	588.7 - 518.2	Limestone, gray, mirco- to finely crystalline grained, medium to thick bedded, zones nodular/irregular bedded, fossiliferous, zones argillaceous, with occasional shale streaks and partings
	518.2 - 508.5	Shale, gray, calcareous
	508.5 - 470.4	Limestone (Dolomite), gray, fine grained, medium to thick bedded, dolomitic, occasional styolites

FACTORS OF SAFETY		
INTERMEDIATE TERM	A	2.8
LONG TERM	B	1.6

ESTIMATED SOIL STRENGTH PARAMETERS	
SOIL	I
INTERMEDIATE TERM	γ = 120 pcf $\bar{c}$ = 340 psf $\bar{\phi}$ = 28°
LONG TERM	γ = 120 pcf $\bar{c}$ = 68 psf $\bar{\phi}$ = 28°



NOTES:

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2. Surface elevations are referenced to Mean Sea Level.

CUT LIMITS FROM +/-STATION 50+50 TO +/-STATION 106+00

SCALE: 1" = 20 HORIZONTAL
1" = 20 VERTICAL

300 200 100 0 100 200 300

KY 841
CUT STABILITY SECTION
STA. 100+00

USER: $$$$USER$$$$
DATE: $$$$DATE$$$$
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E-SHEET NAME:
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JEFFERSON	5-118.11	

PREPARED BY ______ DATE ______
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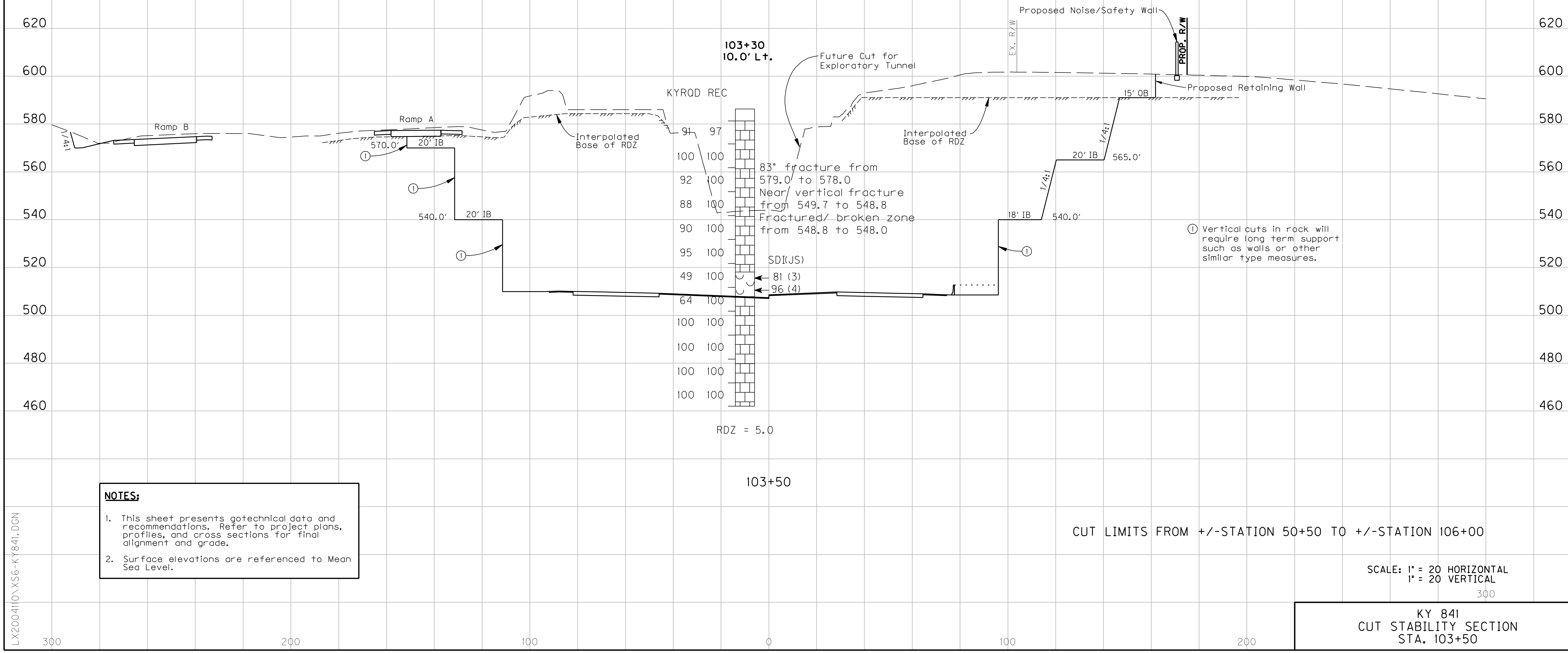
Core Log Station 103+30, 10' Lt.

Elev.		
	586.3 - 581.3	Overburden
	581.3 - 518.1	Limestone, gray, mirco- to finely crystalline grained, medium to thick bedded, zones nodular/irregular bedded, fossiliferous, zones argillaceous, with shale streaks and partings
	518.1 - 507.8	Shale, gray, calcareous
	507.8 - 462.0	Limestone (Dolomite), gray, fine grained, medium to thick bedded, dolomitic, occasional stylolites, with shale stringers, streaks and partings



NOTES:

1. This sheet presents gotechnical data and recommendations. Refer to project plans, profiles, and cross sections for final alignment and grade.
2. Surface elevations are referenced to Mean Sea Level.

CUT LIMITS FROM +/-STATION 50+50 TO +/-STATION 106+00

SCALE: 1" = 20 HORIZONTAL
1" = 20 VERTICAL

KY 841
CUT STABILITY SECTION
STA. 103+50

USER: $$$$USER$$$$
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JEFFERSON	5-118.11	

PREPARED BY ______ DATE ______
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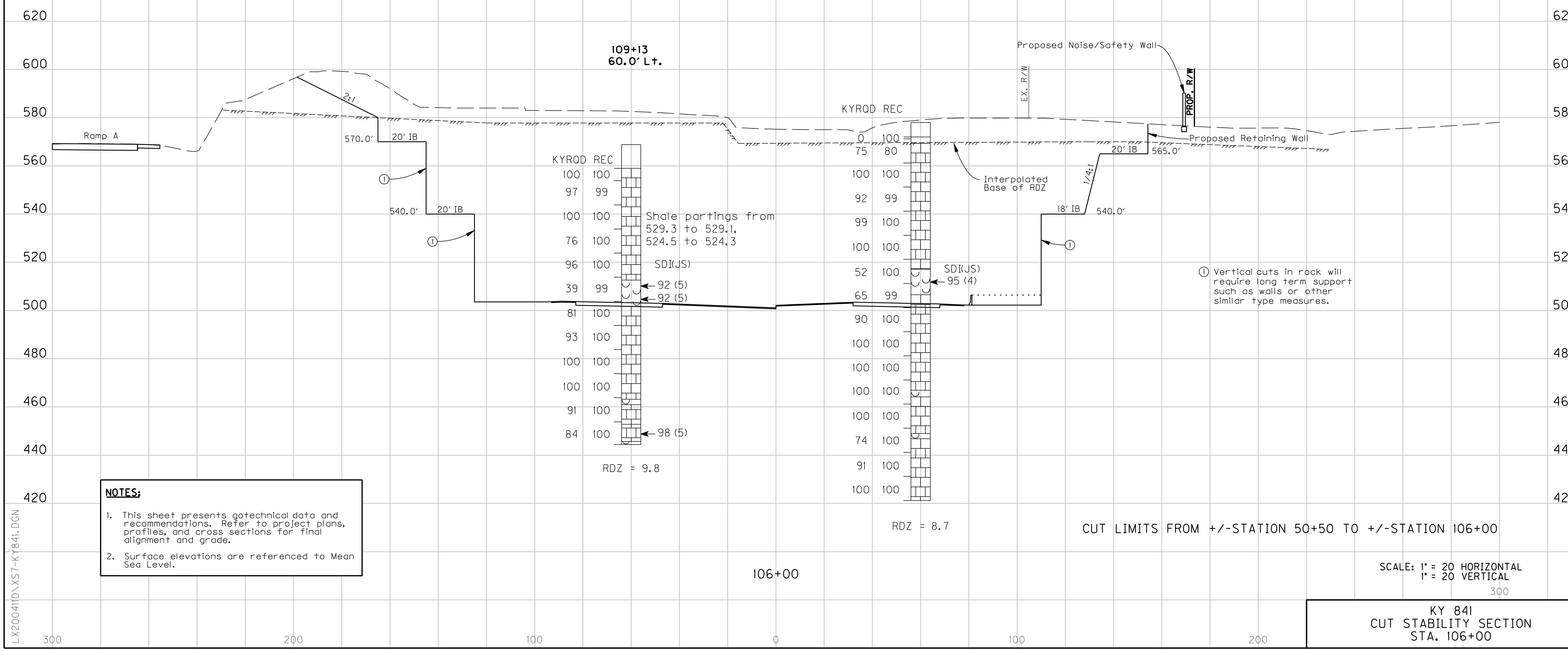
Core Log Station 109+13, 60' Lt.

Elev.		
	568.8 - 559.0	Overburden
	559.0 - 512.6	Limestone, gray, mirco- to finely crystalline grained, medium to thick bedded, zones nodular/irregular bedded, argillaceous zones, occasional styolites, fossiliferous, with shale stringers and partings
	512.6 - 501.7	Shale, gray, calcareous
	501.7 - 463.2	Limestone (Dolomite), gray, fine grained, medium to thick bedded, occasional styolites, dolomitic with occasional shale stringers, streaks and partings
	463.2 - 460.9	Shale, gray, silty, calcareous
	460.9 - 452.8	Limestone, gray, fine grained, medium to thick bedded, dolomitic with occasional shale stringers, streaks and partings
	452.8 - 445.4	Limestone (Dolomite), gray, micro-grained to fine grained, thin to medium bedded, silty, shaly, dolomitic
	445.4 - 444.4	Shale, gray to reddish-brown, silty to sandy, calcareous

Core Log Station 106+00, 60' Rt.

Elev.		
	578.0 - 572.0	Overburden
	572.0 - 569.3	Boulders and cobbles in a clay matrix
	569.3 - 517.1	Limestone, gray, micro- to finely crystalline grained, medium to thick bedded, zones nodular/irregular bedded to 533.5, fossiliferous, argillaceous zones, with shaly stringers and partings
	517.1 - 506.5	Shale, gray, calcareous
	506.5 - 466.9	Limestone (Dolomite), gray, fine grained, thin to thick bedded, dolomitic
	466.9 - 464.2	Shale, gray, calcareous
	464.2 - 449.0	Limestone, gray, fine grained medium to thick bedded, dolomitic
	449.0 - 446.8	Shale, red to gray, clay-like
	446.8 - 421.2	Limestone, gray, fine grained, medium to thick bedded, zones dolomitic, zone shaly, with shale streaks and partings



NOTES:

1. This sheet presents gotechnical data and recommendations. Refer to project plans, profiles, and cross sections for final alignment and grade.
2. Surface elevations are referenced to Mean Sea Level.

SCALE: 1" = 20 HORIZONTAL
1" = 20 VERTICAL

KY 841
CUT STABILITY SECTION
STA. 106+00

LX2004110\XS7-KY841.DGN

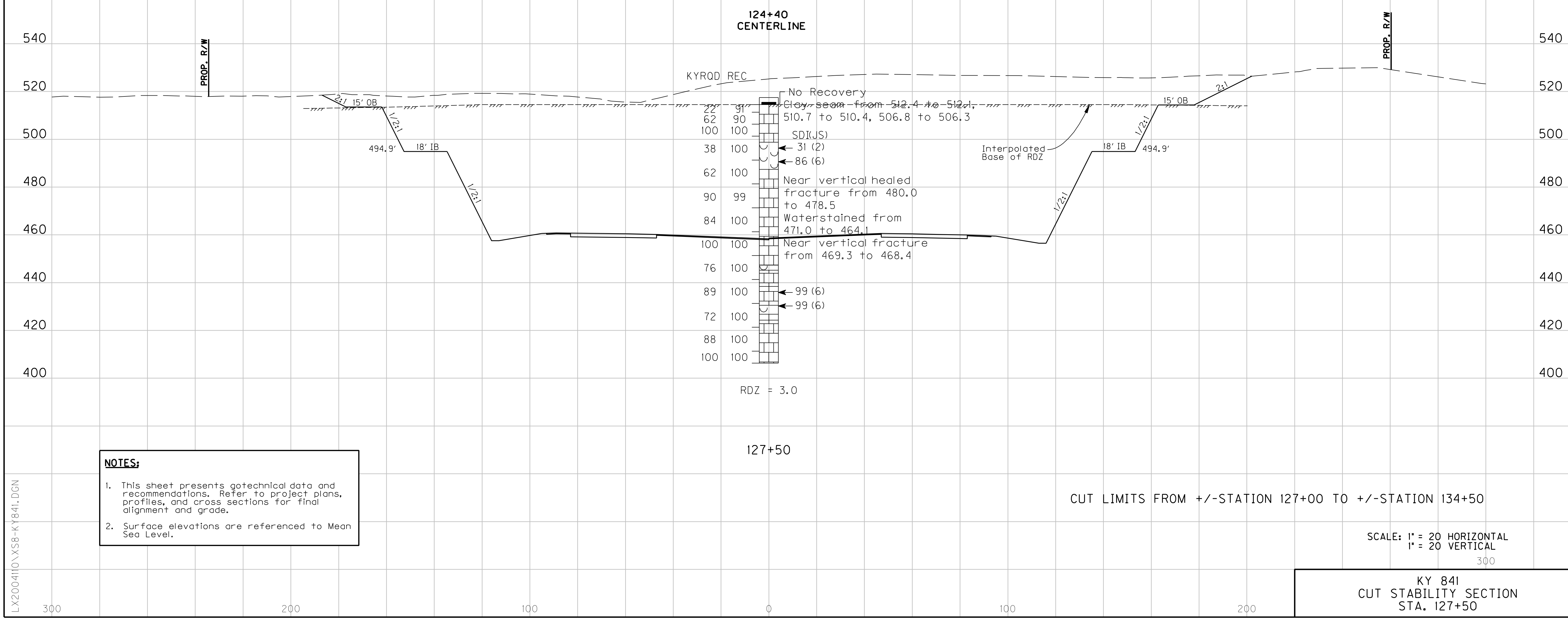
USER: $$$$USER$$$$
DATE: $$$$DATE$$$$
FILE NAME: $$$design$file$specification$$$$
E-SHEET NAME:

COUNTY OF	ITEM NO.	SHEET NO.
JEFFERSON	5-118.11	

PREPARED BY ____ DATE ____
CHECKED BY ____ DATE ____
APPROVED BY ____ DATE ____

Core Log Station 124+40, Centerline

Elev.		
	517.5 - 514.5	Overburden
	514.5 - 498.8	Limestone, gray, mirco- to finely crystalline grained, thin to thick bedded, fossiliferous, zones argillaceous, occasional weathered zones, with occasional shale stringers and partings
	498.8 - 487.4	Shale, gray, calcareous
	487.4 - 447.3	Limestone (Dolomite), gray, fine grained, medium to thick bedded, with shale stringers, streaks and partings, occasional styolites, zones waterstained
	447.3 - 445.2	Shale, gray, calcareous
	445.2 - 438.4	Limestone gray, fine grained, medium to thick bedded, dolomitic, with shale stringers, streaks and partings,
	438.4 - 430.5	Limestone (Dolomite), gray, micro-grained, to fine grained, thin to medium bedded, silty, shaly, dolomitic
	430.5 - 426.8	Shale, gray to reddish-brown, silty to sandy, calcareous
	426.8 - 406.3	Limestone, gray, fine grained, medium to thick bedded, dolomitic, with shale stringers, streaks and partings



NOTES:

1. This sheet presents gotechnical data and recommendations. Refer to project plans, profiles, and cross sections for final alignment and grade.
2. Surface elevations are referenced to Mean Sea Level.

CUT LIMITS FROM +/-STATION 127+00 TO +/-STATION 134+50

SCALE: 1" = 20 HORIZONTAL
1" = 20 VERTICAL

300

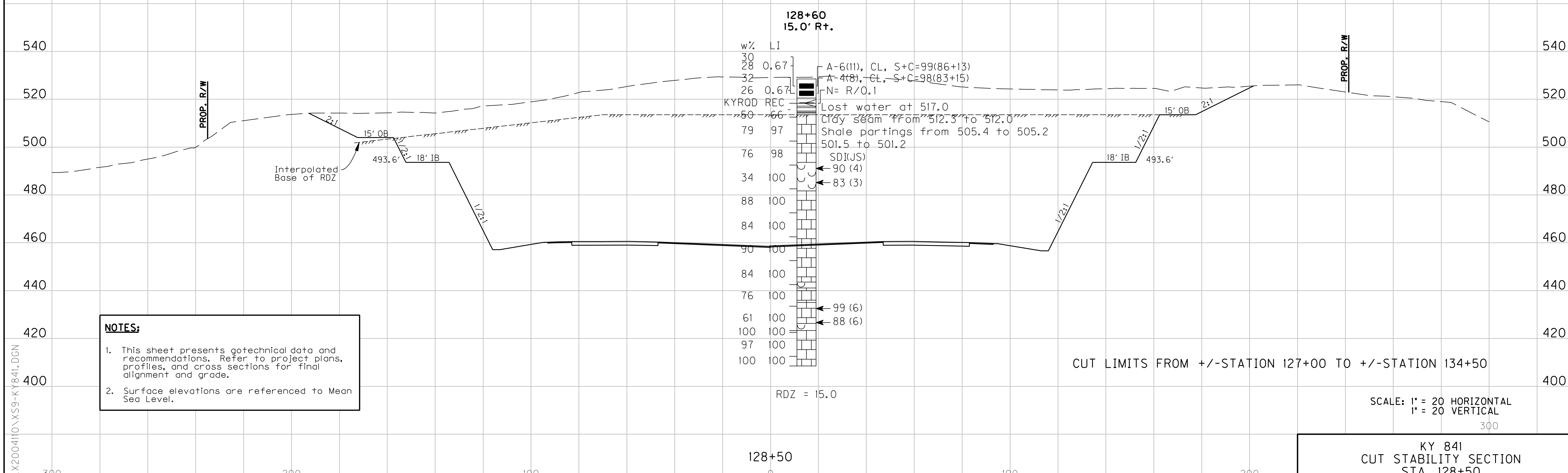
KY 841
CUT STABILITY SECTION
STA. 127+50

USER: $$$$USER$$$$
DATE: $$$$DATE$$$$
FILE NAME: $$$design$file$specification$$$$
E-SHEET NAME:
LX2004110\XS8-KY841.DGN

PREPARED BY ____ DATE ____
CHECKED BY ____ DATE ____
APPROVED BY ____ DATE ____

Core Log Station 128+60, 15' Rt.

Elev.		
	528.5 - 518.3	Overburden
	518.3 - 517.1	Limestone, gray, micro- to finely crystalline grained, medium to thick bedded, zones nodular/irregular bedded, argillaceous zones, occasional styolites, fossiliferous, with shale stringers, streaks and partings
	517.1 - 516.5	Void
	516.5 - 515.1	Limestone, gray, micro- to finely crystalline grained, medium to thick bedded, zones nodular/irregular bedded, argillaceous zones, occasional styolites, fossiliferous, with shale stringers, streaks and partings
	515.1 - 514.6	Void
	514.6 - 514.2	Limestone, gray, micro- to finely crystalline grained, medium to thick bedded, zones nodular/irregular bedded, argillaceous zones, occasional styolites, fossiliferous, with shale stringers, streaks and partings
	514.2 - 513.5	Void
	513.5 - 493.6	Limestone, gray, micro- to finely crystalline grained, medium to thick bedded, zones nodular/irregular bedded, argillaceous zones, occasional styolites, fossiliferous, with shale stringers, streaks and partings
	493.6 - 481.7	Shale, gray, calcareous
	481.7 - 443.6	Limestone (Dolomite), fine grained, medium to massive bedded, dolomitic, occasional styolites, zones waterstained
	443.6 - 441.1	Shale, gray, calcareous
	441.1 - 435.0	Limestone, fine grained, medium to massive bedded, dolomitic, zones waterstained
	435.0 - 426.3	Limestone (Dolomite), gray, micro-grained to fine grained, thin to medium bedded, zones very silty, shaly, dolomitic
	426.3 - 423.3	Shale, gray to reddish-brown, silty to sandy
	423.3 - 408.5	Limestone, gray, micro- to finely crystalline grained, medium to thick bedded, glauconitic, dolomitic, zones shaley, with shale stringers streaks and partings



CUT LIMITS FROM +/-STATION 127+00 TO +/-STATION 134+50

SCALE: 1" = 20 HORIZONTAL
1" = 20 VERTICAL

NOTES:

1. This sheet presents gotechnical data and recommendations. Refer to project plans, profiles, and cross sections for final alignment and grade.
2. Surface elevations are referenced to Mean Sea Level.

KY 841
CUT STABILITY SECTION
STA. 128+50

USER: $$$$USER$$$$
DATE: $$$$DATE$$$$
FILE NAME: $$$$design$file$specification$$$$
E-SHEET NAME:
LX2004110\XS9-KY841.DGN

COUNTY OF	ITEM NO.	SHEET NO.
JEFFERSON	5-118.11	

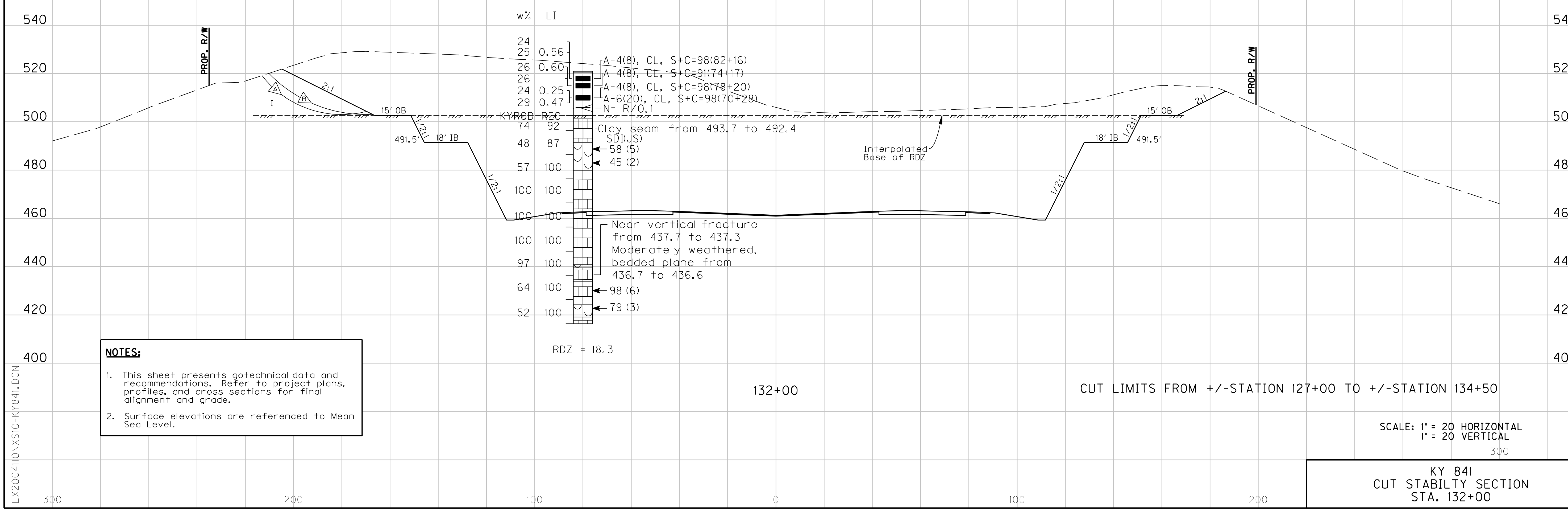
PREPARED BY ____ DATE ____
CHECKED BY ____ DATE ____
APPROVED BY ____ DATE ____

Core Log Station 132+00, 80' Lt.

Elev.		
	520.9 - 502.6	Overburden
	502.6 - 491.5	Limestone, gray, finely crystalline grained, thin to medium bedded, occasional styolites, fossiliferous, with shale streaks and partings
	491.5 - 479.9	Shale, gray, silty, calcareous
	479.9 - 440.8	Limestone (Dolomite), gray, fine grained, medium to massive bedded, zones argillaceous, occasional styolites, occasional shale streaks and partings
	440.8 - 439.5	Shale, gray, silty, calcareous
	439.5 - 433.7	Limestone gray, finely crystalline to micrograined, medium to thick bedded, with stringers and shale partings
	433.7 - 424.4	Limestone (Dolomite), gray, micro-grained to fine grained, zones very silty, thin to medium bedded, shaly, dolomitic
	424.4 - 419.1	Shale, gray to reddish-brown, silty calcareous
	419.1 - 416.4	Limestone, gray, fine grained, medium to thick bedded, dolomitic, with shale stringers, streaks and partings

FACTORS OF SAFETY		
INTERMEDIATE TERM	A	3.0
LONG TERM	B	1.7

ESTIMATED SOIL STRENGTH PARAMETERS	
SOIL	I
INTERMEDIATE TERM	γ = 120 pcf c̄ = 340 psf ø̄ = 28°
LONG TERM	γ = 120 pcf c̄ = 68 psf ø̄ = 28°



CUT LIMITS FROM +/-STATION 127+00 TO +/-STATION 134+50

NOTES:

1. This sheet presents gotechnical data and recommendations. Refer to project plans, profiles, and cross sections for final alignment and grade.
2. Surface elevations are referenced to Mean Sea Level.

SCALE: 1" = 20 HORIZONTAL
1" = 20 VERTICAL

KY 841
CUT STABILTY SECTION
STA. 132+00

USER: $$$$USER$$$$
DATE: $$$$DATE$$$$
FILE NAME: $$$design$file$specification$$$$
E-SHEET NAME:
LX2004110\XS10-KY841.DGN

COUNTY OF	ITEM NO.	SHEET NO.
JEFFERSON	5-118.11	

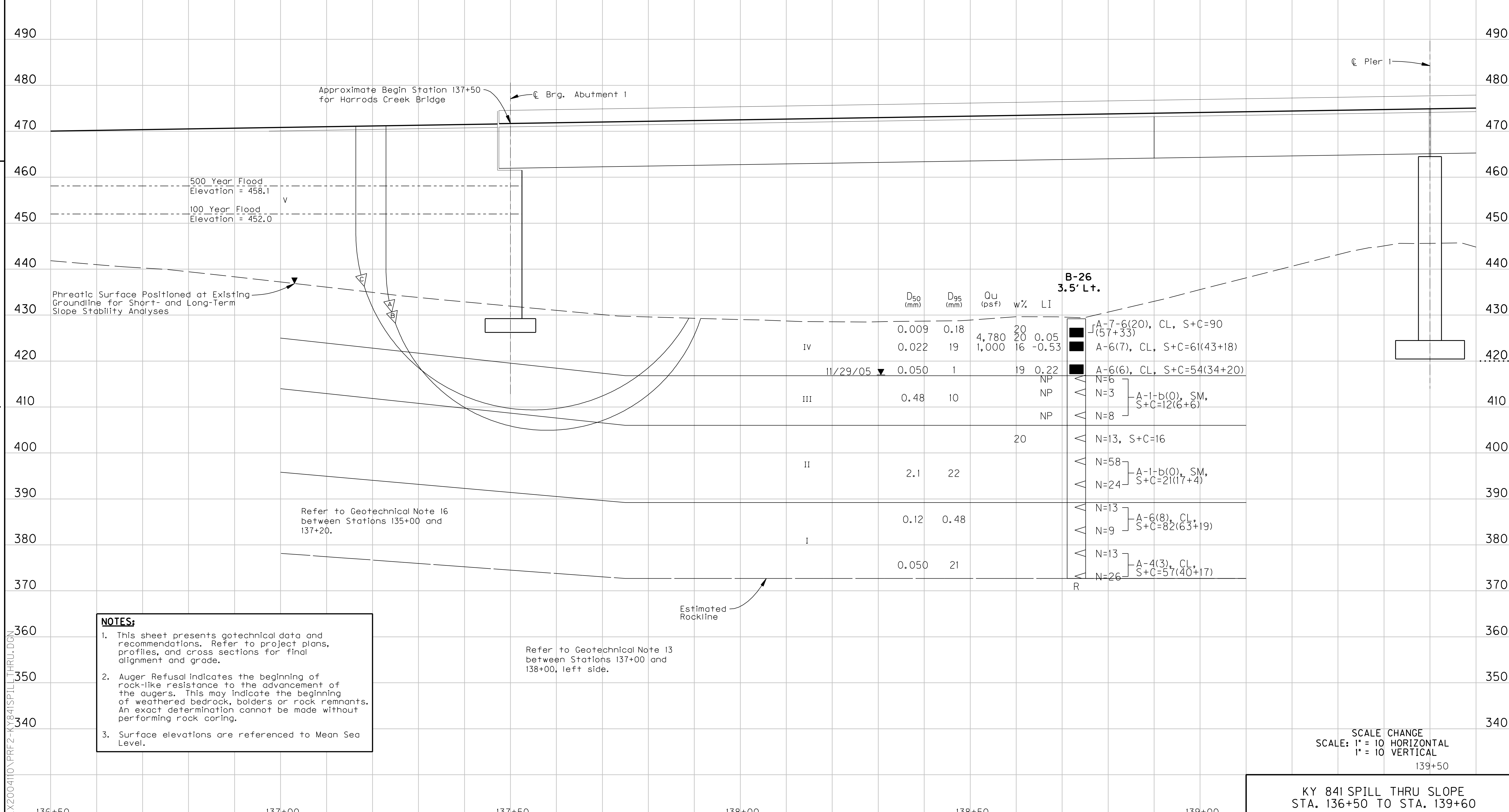
FACTORS OF SAFETY		
SHORT TERM	A	1.5
LONG TERM	B	1.8
RAPID DRAWDOWN (100-yr)	C	1.6

ESTIMATED SOIL STRENGTH PARAMETERS

SOIL	I	II	III	IV	V
SHORT TERM	γ = 120 pcf c = 1,900 psf ϕ = 0°	γ = 112 pcf c = 0 psf ϕ = 33°	γ = 124 pcf c = 0 psf ϕ = 29°	γ = 127 pcf c = 500 psf ϕ = 0°	γ = 120 pcf c = 1,400 psf ϕ = 0°
LONG TERM	γ = 120 pcf $\bar{c}$ = 270 psf $\bar{\phi}$ = 28°	γ = 112 pcf $\bar{c}$ = 0 psf $\bar{\phi}$ = 33°	γ = 124 pcf $\bar{c}$ = 0 psf $\bar{\phi}$ = 29°	γ = 127 pcf $\bar{c}$ = 340 psf $\bar{\phi}$ = 28°	γ = 120 pcf $\bar{c}$ = 200 psf $\bar{\phi}$ = 23°

SUMMARY OF TRIAXIAL TEST DATA

STATION	138+73.1	165+26.8
OFFSET	3.5' Lt.	6.2' Rt.
DEPTH	(2.0-2.5) (10.0-10.5)	(5.6-6.1)
$\bar{c}$	340 psf	
$\bar{\phi}$	28.6°	



NOTES:

1. This sheet presents gotechnical data and recommendations. Refer to project plans, profiles, and cross sections for final alignment and grade.
2. Auger Refusal indicates the beginning of rock-like resistance to the advancement of the augers. This may indicate the beginning of weathered bedrock, bolders or rock remnants. An exact determination cannot be made without performing rock coring.
3. Surface elevations are referenced to Mean Sea Level.

SCALE CHANGE
SCALE: 1" = 10 HORIZONTAL
1" = 10 VERTICAL

KY 841 SPILL THRU SLOPE
STA. 136+50 TO STA. 139+60

PREPARED BY ____ DATE ____
CHECKED BY ____ DATE ____
APPROVED BY ____ DATE ____

USER: $$$$USER$$$$
DATE: $$$$DATE$$$$
FILE NAME: $$$design$file$specification$$$$
E-SHEET NAME:
LX200411O\PRF2-KY841SPILL_THRU.DGN

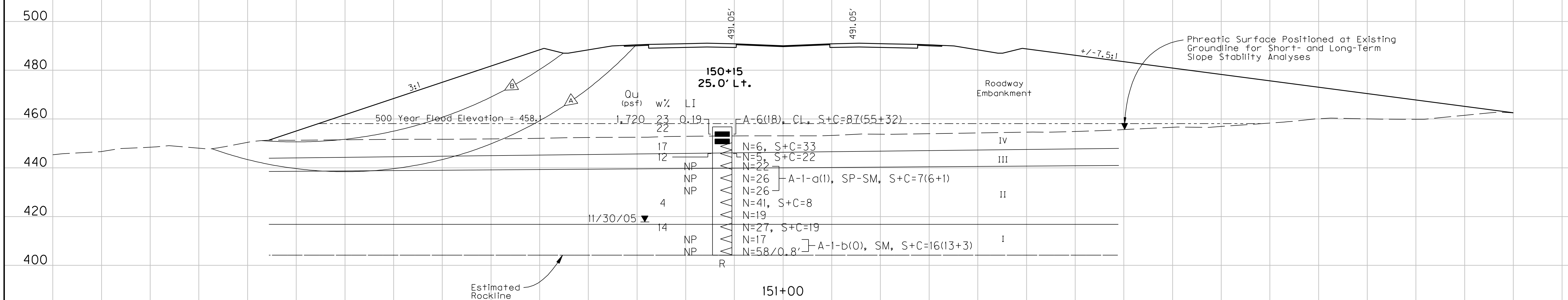
COUNTY OF	ITEM NO.	SHEET NO.
JEFFERSON	5-118.11	

PREPARED BY ____ DATE ____
CHECKED BY ____ DATE ____
APPROVED BY ____ DATE ____

SUMMARY OF ESTIMATED SETTLEMENT PARAMETERS	
SOIL LAYER	SETTLEMENT PARAMETERS
I	C' = 50 γ = 121 pcf
II	C' = 71 γ = 119 pcf
III	C' = 50 γ = 118 pcf
IV	e_o = 0.623 C_c = 0.180 C_r = 0.052 γ = 126 pcf

FACTORS OF SAFETY		
SHORT TERM	A	2.1
LONG TERM	B	2.0

ESTIMATED SOIL STRENGTH PARAMETERS					
SOIL	I	II	III	IV	Roadway Embankment
SHORT TERM	γ = 121 pcf c = 0 psf ø = 32°	γ = 119 pcf c = 0 psf ø = 32°	γ = 118 pcf c = 0 psf ø = 31°	γ = 126 pcf c = 800 psf ø = 0°	γ = 120 pcf c = 1,400 psf ø = 0°
LONG TERM	γ = 121 pcf $\bar{c}$ = 0 psf $\bar{ø}$ = 32°	γ = 119 pcf $\bar{c}$ = 0 psf $\bar{ø}$ = 32°	γ = 118 pcf $\bar{c}$ = 0 psf $\bar{ø}$ = 31°	γ = 126 pcf $\bar{c}$ = 340 psf $\bar{ø}$ = 28°	γ = 120 pcf $\bar{c}$ = 200 psf $\bar{ø}$ = 23°



Refer to Geotechnical Note 12 between Stations 150+00 and 152+00.

FILL LIMITS FROM +/-STATION 150+50 TO +/-STATION 168+50

NOTES:

1. This sheet presents gotechnical data and recommendations. Refer to project plans, profiles, and cross sections for final alignment and grade.
2. Auger Refusal indicates the beginning of rock-like resistance to the advancement of the augers. This may indicate the beginning of weathered bedrock, bolders or rock remnants. An exact determination cannot be made without performing rock coring.
3. Surface elevations are referenced to Mean Sea Level.

SCALE CHANGE
SCALE: 1" = 20 HORIZONTAL
1" = 20 VERTICAL

300 200 100 0 100 200 300

KY 841
EMBANKMENT STABILITY SECTION
STA. 151+00

USER: $$$$USER$$$$
DATE: $$$$DATE$$$$
FILE NAME: $$$$design$file$specification$$$$
E-SHEET NAME:
LX200411O\EMB1-KY841.DGN

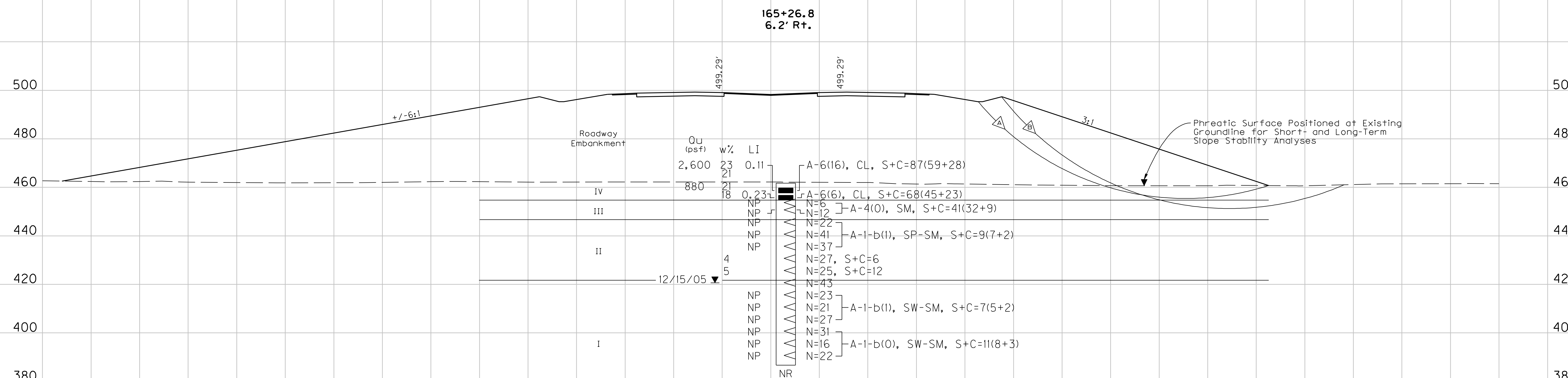
COUNTY OF	ITEM NO.	SHEET NO.
JEFFERSON	5-118.11	

PREPARED BY ______ DATE ______
CHECKED BY ______ DATE ______
APPROVED BY ______ DATE ______

SUMMARY OF TRIAXIAL TEST DATA		
STATION	138+73.1	165+26.8
OFFSET	3.5' Lt.	6.2' Rt.
DEPTH	(2.0-2.5) (10.0-10.5)	(5.6-6.1)
$\bar{c}$	340 psf	
$\bar{\phi}$	28.6°	

ESTIMATED SOIL STRENGTH PARAMETERS					
SOIL	I	II	III	IV	Roadway Embankment
SHORT TERM	γ = 113 pcf c = 0 psf ø = 33°	γ = 116 pcf c = 0 psf ø = 35°	γ = 101 pcf c = 0 psf ø = 30°	γ = 124 pcf c = 440 psf ø = 0°	γ = 120 pcf c = 1,400 psf ø = 0°
LONG TERM	γ = 113 pcf $\bar{c}$ = 0 psf $\bar{\phi}$ = 33°	γ = 116 pcf $\bar{c}$ = 0 psf $\bar{\phi}$ = 35°	γ = 101 pcf $\bar{c}$ = 0 psf $\bar{\phi}$ = 30°	γ = 124 pcf $\bar{c}$ = 340 psf $\bar{\phi}$ = 28°	γ = 120 pcf $\bar{c}$ = 200 psf $\bar{\phi}$ = 23°

FACTORS OF SAFETY		
SHORT TERM	A	1.9
LONG TERM	B	2.0



Refer to Geotechnical Note 12 between Stations 163+70 and 167+00.

165+50

FILL LIMITS FROM +/-STATION 150+50 TO +/-STATION 168+50

NOTES:

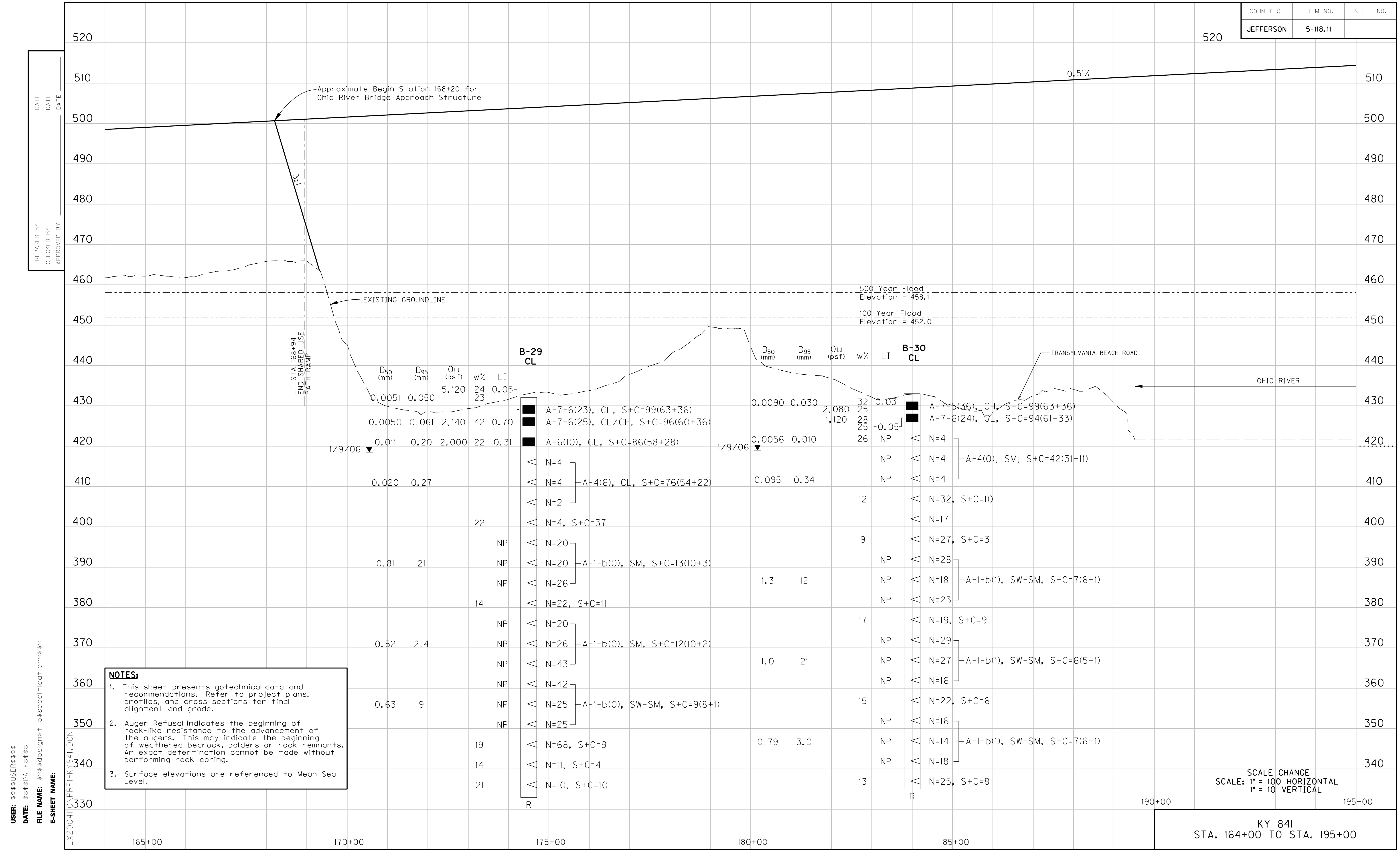
1. This sheet presents gotechnical data and recommendations. Refer to project plans, profiles, and cross sections for final alignment and grade.
2. Surface elevations are referenced to Mean Sea Level.

SCALE: 1" = 20 HORIZONTAL
1" = 20 VERTICAL

300 200 100 0 100 200 300

USER: $$$$USER$$$$
DATE: $$$$DATE$$$$
FILE NAME: $$$$design$file$specification$$$$
E-SHEET NAME:
LX200411O\EMB2-KY841.DGN

KY 841
EMBANKMENT STABILITY SECTION
STA. 165+50



COUNTY OF
JEFFERSON
ITEM NO.
5-118.11
SHEET NO.
PREPARED BY — DATE
CHECKED BY — DATE
APPROVED BY — DATE
Approximate Begin Station 168+20 for Ohio River Bridge Approach Structure
0.51%
3:1
EXISTING GROUNDLINE
LT STA 168+94 END SHARED USE PATH RAMP
500 Year Flood Elevation = 458.1
100 Year Flood Elevation = 452.0
TRANSYLVANIA BEACH ROAD
OHIO RIVER
B-29 CL
D50 (mm) D95 (mm) Qu (psf) w% LI
5,120 24 23 0.05
0.0051 0.050
A-7-6(23), CL, S+C=99(63+36)
0.0050 0.061 2,140 42 0.70 A-7-6(25), CL/CH, S+C=96(60+36)
0.011 0.20 2,000 22 0.31 A-6(10), CL, S+C=86(58+28)
1/9/06
N=4
N=4 A-4(6), CL, S+C=76(54+22)
0.020 0.27
N=2
22 N=4, S+C=37
NP N=20
0.81 21 NP N=20 A-1-b(0), SM, S+C=13(10+3)
NP N=26
14 N=22, S+C=11
NP N=20
0.52 2.4 NP N=26 A-1-b(0), SM, S+C=12(10+2)
NP N=43
NP N=42
0.63 9 NP N=25 A-1-b(0), SW-SM, S+C=9(8+1)
NP N=25
19 N=68, S+C=9
14 N=11, S+C=4
21 N=10, S+C=10
R
B-30 CL
D50 (mm) D95 (mm) Qu (psf) w% LI
0.0090 0.030 32 0.03 A-7-5(36), CH, S+C=99(63+36)
2,080 25
1,120 28 A-7-6(24), CL, S+C=94(61+33)
25 -0.05
0.0056 0.010 26 NP N=4
1/9/06
NP N=4 A-4(0), SM, S+C=42(31+11)
0.095 0.34 NP N=4
12 N=32, S+C=10
N=17
9 N=27, S+C=3
NP N=28
1.3 12 NP N=18 A-1-b(1), SW-SM, S+C=7(6+1)
NP N=23
17 N=19, S+C=9
NP N=29
1.0 21 NP N=27 A-1-b(1), SW-SM, S+C=6(5+1)
NP N=16
15 N=22, S+C=6
NP N=16
0.79 3.0 NP N=14 A-1-b(1), SW-SM, S+C=7(6+1)
NP N=18
13 N=25, S+C=8
R
520 510 500 490 480 470 460 450 440 430 420 410 400 390 380 370 360 350 340 330
165+00 170+00 175+00 180+00 185+00 190+00 195+00
NOTES:
1. This sheet presents gotechnical data and recommendations. Refer to project plans, profiles, and cross sections for final alignment and grade.
2. Auger Refusal indicates the beginning of rock-like resistance to the advancement of the augers. This may indicate the beginning of weathered bedrock, bolders or rock remnants. An exact determination cannot be made without performing rock coring.
3. Surface elevations are referenced to Mean Sea Level.
SCALE CHANGE
SCALE: 1" = 100 HORIZONTAL
1" = 10 VERTICAL
KY 841
STA. 164+00 TO STA. 195+00
USER: $$$$USER$$$$
DATE: $$$$DATE$$$$
FILE NAME: $$$$design$file$specification$$$$
E-SHEET NAME:
LX200411O\PRF1-KY841.DGN

Appendix E

Drilling and Laboratory Information for the Tunnel

- Boring Logs
- Water Pressure Testing Results
- Observation Well Installation Details
- Observation Well Readings
- Phase II Soil Testing Results
- CD with Rock Testing Results
- CD with "Borehole Geophysical Logging Results East End Approach Phase II, Prepared by Colog
- CD with "Geophysical Pilot Program in Test Areas Immediately Adjacent to the Drumanard Estates" Prepared by Department of Geological Sciences and Engineering University of Missouri - Rolla

Boring Logs

FMSM ENGINEERS

Anchorage Quadrangle
GQ #906
Louisville Limestone Formation

SUBSURFACE LOG

County	Jefferson	Item No.	5-118.11
State Project No.	Ohio River Bridges		
Fed. Project No.	Design Section No. 4		
MARS No.	65541-05D		
Structure ID	East End Approach		
Roadway ☐	Structure ☐	Driller	Merle Wethington
Supervisor	Adam Crace		
Logged By	Adam Crace		

Location	Station 113+35.5 20.7 ft rt		
Boring No.	B-11	Total Depth	144.9'
Latitude	38.325253	Longitude	85.622470
Surface Elevation	584.1'		
Date Started	12/1/05	Completed	12/5/05
Depth to Water	Dry	Date/Time	12/5/05
Depth to Water	N/A	Date/Time	N/A
Automatic Hammer ☒	Safety Hammer ☐	Other ☐	

Lithology Elevation	Lithology Depth	Description	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
584.1'	0.0'	Top of Hole						
		Overburden						Drilled at a 15 degree angle; 9 Boxes
566.9'	17.2'							
		Limestone, gray, microcrystalline to fine grained, medium bedded to thick bedded, zones nodular/irregular bedded, argillaceous zones, occasional styolites, fossiliferous, with shale stringers and partings	77/77	3.9'	3.2'	82	21.1'	Lost water at 17.2
			94/94	3.6'	3.6'	100	24.7'	
			100/100	10.1'	10.1'	100	34.8'	Water level after drilling at 27.0

FMSM_KYTC_STR LX2004110.GPJ KYTC COMPONENT.GDT 1/26/06

County	Jefferson	Item No.	5-118.11	Location	Station 113+35.5 20.7 ft rt		
State Project No.	Ohio River Bridges			Boring No.	B-11	Total Depth	144.9'

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
		Limestone, gray, microcrystalline to fine grained, medium bedded to thick bedded, zones nodular/irregular bedded, argillaceous zones, occasional styolites, fossiliferous, with shale stringers and partings *(Continued)*							
				100/100	10.0'	10.0'	100	44.8'	
				100/100	10.2'	10.2'	100	55.0'	
				99/99	10.0'	9.9'	99	65.0'	
				100/100	10.0'	10.0'	100	75.0'	
505.8'	78.3'								
		Shale, gray, silty, calcareous							Boring grouted with 7 bags of cement

FMSM ENGINEERS

SUBSURFACE LOG

County Jefferson Item No. 5-118.11 Location Station 113+35.5 20.7 ft rt

State Project No. Ohio River Bridges Boring No. **B-11** Total Depth 144.9'

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
		Shale, gray, silty, calcareous *(Continued)*		53/100	10.0'	10.0'	100	85.0'	
494.1'	90.0'								
		Limestone (dolomitic), gray, fine grained, medium bedded to thick bedded, occasional styolites, dolomitic with occasional shale stringers, streaks and partings		72/98	10.0'	9.8'	98	95.0'	
				100/100	10.0'	10.0'	100	105.0'	
				100/100	10.0'	10.0'	100	115.0'	
				100/100	10.0'	10.0'	100	125.0'	

FMSM_KYTC_STR LX2003110.GPJ KYTC COMPONENT.GDT 1/26/06

County Jefferson Item No. 5-118.11 Location Station 113+35.5 20.7 ft rt

State Project No. Ohio River Bridges Boring No. **B-11** Total Depth 144.9'

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
455.1'	129.0'								
453.1'	131.0'	Shale, gray, silty, calcareous							
		Limestone, gray, fine grained, medium bedded to thick bedded, zones dolomitic, with occasional shale stringers, streaks and partings		99/99	10.0'	9.9'	99	135.0'	
446.4'	137.7'								
439.2'	144.9'	Shale, gray, sandy		100/100	9.9'	9.9'	100	144.9'	

Bottom of Hole
Top of Rock = 17.2'
Elevation 566.9'

Base of Weathered Rock = 17.2'
Elevation 566.9'

at Elevation '

Scour Elevation '

FMSM ENGINEERS

Anchorage Quadrangle
GQ #906
Louisville Limestone Formation

SUBSURFACE LOG

County	Jefferson	Item No.	5-118.11
State Project No.	Ohio River Bridges		
Fed. Project No.	Design Section No. 4		
MARS No.	65541-05D		
Structure ID	East End Approach		
Roadway ☐	Structure ☐	Driller	Merle Wethington
Supervisor	Adam Crace		
Logged By	Adam Crace		

Location	Station 116+68.7 14.1 ft rt		
Boring No.	B-10	Total Depth	115.8'
Latitude	38.325843	Longitude	85.623355
Surface Elevation	559.5'		
Date Started	12/8/05	Completed	12/12/05
Depth to Water	Dry	Date/Time	12/12/05
Depth to Water	N/A	Date/Time	N/A
Automatic Hammer ☒	Safety Hammer ☐	Other ☐	

Lithology: Elevation	Lithology: Depth	Description	Overburden / Rock Core: Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
559.5'	0.0'	Top of Hole						
		Overburden						
554.0'	5.5'							8 Boxes
		Limestone, gray, microcrystalline to fine grained, medium bedded to thick bedded, zones nodular/irregular bedded, zones argillaceous, occasional styolites, fossiliferous, with shale stringers and partings	68/68	5.6'	4.4'	79	11.1'	
			98/98	4.9'	4.8'	98	16.0'	
			99/99	10.0'	10.0'	100	26.0'	
			100/100	10.0'	10.0'	100	36.0'	

FMSM_KYTC_STR LX2005110.GPJ KYTC COMPONENT.GDT 1/26/06

FMSM ENGINEERS

SUBSURFACE LOG

County Jefferson Item No. 5-118.11 Location Station 116+68.7 14.1 ft rt

State Project No. Ohio River Bridges Boring No. **B-10** Total Depth 115.8'

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
		Limestone, gray, microcrystalline to fine grained, medium bedded to thick bedded, zones nodular/irregular bedded, zones argillaceous, occasional styolites, fossiliferous, with shale stringers and partings- *(Continued)*		89/89	10.0'	9.8'	98	46.0'	
506.0'	53.5'								
		Shale, gray, silty, calcareous		72/95	10.0'	10.0'	100	56.0'	
495.8'	63.7'								
		Limestone (dolomite), gray, fine grained, medium bedded to thick bedded, occasional styolites, dolomitic, with shale stringers, streaks and partings		53/95	10.0'	10.0'	100	66.0'	
				99/99	10.0'	9.9'	99	76.0'	

FMSM_KYTC_STR L020034110.GPJ KYTC COMPONENT.GDT 1/26/06

FMSM ENGINEERS

SUBSURFACE LOG

County Jefferson Item No. 5-118.11 Location Station 116+68.7 14.1 ft rt

State Project No. Ohio River Bridges Boring No. **B-10** Total Depth 115.8'

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
		Limestone (dolomite), gray, fine grained, medium bedded to thick bedded, occasional styolites, dolomitic, with shale stringers, streaks and partings *(Continued)*		99/99	10.0'	10.0'	100	86.0'	
				100/100	10.0'	10.0'	100	96.0'	
457.2'	102.3'								
454.9'	104.6'	Shale, gray, silty, calcareous							
		Limestone, gray, fine grained, medium bedded to thick bedded, zones dolomitic, with occasional shale stringers, streaks and partings		68/96	10.0'	9.8'	98	106.0'	
449.2'	110.3'								
443.7'	115.8'	Shale, gray, zones sandy		64/100	9.8'	9.8'	100	115.8'	

Bottom of Hole
Top of Rock = 5.5'
Elevation 554.0'

Base of Weathered Rock = 5.5'
Elevation 554.0'

at Elevation '

Scour Elevation '

FMSM_KYTC_STR LX2004110.GPJ KYTC COMPONENT.GDT 1/26/06

1/26/06

ENGINEERS

Anchorage Quadrangle
GQ #906
Louisville Limestone Formation

SUBSURFACE LOG

County	Jefferson Item No. 5-118.11	Location	Station 116+69.0 17.1 ft rt
State Project No.	Ohio River Bridges	Boring No.	**B-10A** Total Depth 9.8'
Fed. Project No.	Design Section No. 4	Latitude	38.325848 Longitude 85.623352
MARS No.	65541-05D	Surface Elevation	559.6'
Structure ID	East End Approach	Date Started	12/8/05 Completed 12/8/05
Roadway ☐	Structure ☐ Driller Merle Wethington	Depth to Water	Dry Date/Time 12/8/05
Supervisor	Adam Crace	Depth to Water	N/A Date/Time N/A
Logged By	Adam Crace	Automatic Hammer ☒	Safety Hammer ☐ Other ☐

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
559.6'	0.0'	Top of Hole							
554.4'	5.2'	Overburden							
549.8'	9.8'	Limestone, gray, microcrystalline to fine grained, medium bedded to thick bedded							1 Box

NR(549.8) / Bottom of Hole
Top of Rock = 5.2'
Elevation 554.4'

Base of Weathered Rock = 5.2'
Elevation 554.4'

at Elevation '

Scour Elevation '

FMSM_KYTC_STR UC2004110.GPJ KYTC COMPONENT.GDT 2/15/06

FMSM ENGINEERS

Anchorage Quadrangle
GQ #906
Louisville Limestone Formation

SUBSURFACE LOG

County	Jefferson Item No. 5-118.11	Location	Station 116+84.0 100.0 ft rt
State Project No.	Ohio River Bridges	Boring No.	B-9 Total Depth 131.0'
Fed. Project No.	Design Section No. 4	Latitude	38.32604667 Longitude 85.62319500
MARS No.	65541-05D	Surface Elevation	568.0'
Structure ID	East End Approach	Date Started	12/7/05 Completed 12/8/05
Roadway ☐	Structure ☐ Driller Merle Wethington	Depth to Water	Dry Date/Time 12/8/05
Supervisor	Adam Crace	Depth to Water	N/A Date/Time N/A
Logged By	Adam Crace	Automatic Hammer ☒	Safety Hammer ☐ Other ☐

Lithology: Elevation	Depth	Description	Overburden / Rock Core	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
568.0'	0.0'	Top of Hole							
556.6'	11.4'	Overburden							9 Boxes
		Limestone, gray, microcrystalline to fine, medium bedded to thick bedded, zones nodular/irregular bedded, zones argillaceous, occasional styolites, fossiliferous, with shale stringers and partings		93/93	4.6'	4.6'	100	16.0'	
				98/98	10.0'	10.0'	100	26.0'	
				98/98	10.0'	10.0'	100	36.0'	

FMSM_KYTC_STR LX2004110.GPJ KYTC COMPONENT.GDT 1/26/06

1/26/06

FMSM ENGINEERS

SUBSURFACE LOG

County: Jefferson Item No. 5-118.11 Location: Station 116+84.0 100.0 ft rt

State Project No. Ohio River Bridges Boring No. **B-9** Total Depth 131.0'

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
		Limestone, gray, microcrystalline to fine, medium bedded to thick bedded, zones nodular/irregular bedded, zones argillaceous, occasional styolites, fossiliferous, with shale stringers and partings *(Continued)*		100/100	10.0'	10.0'	100	46.0'	
				91/91	10.0'	10.0'	100	56.0'	
507.9'	60.1'								
		Shale, gray, silty, calcareous		51/99	10.0'	9.9'	99	66.0'	
496.2'	71.8'								
		Limestone (dolomite), gray, fine grained, medium bedded to thick bedded, occasional styolites, dolomitic with shale stringers, streaks and partings		67/100	10.0'	10.0'	100	76.0'	

FMSM_KYTC_STR LX2009110.GPJ KYTC COMPONENT.GDT 1/26/06

1/26/06

County: Jefferson Item No. 5-118.11 Location: Station 116+84.0 100.0 ft rt

State Project No. Ohio River Bridges Boring No. B-9 Total Depth 131.0'

Lithology: Elevation	Lithology: Depth	Description	Overburden / Rock Core	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
		Limestone (dolomite), gray, fine grained, medium bedded to thick bedded, occasional styolites, dolomitic with shale stringers, streaks and partings *(Continued)*		100/100	10.0'	10.0'	100	86.0'	
				57/57	10.0'	10.0'	100	96.0'	Near vertical fracture from 90.4 to 95.7 (sl. wea, ws)
				88/88	10.0'	9.9'	99	106.0'	
457.9'	110.1'								
		Shale, gray, silty, calcareous							
455.3'	112.7'								
		Limestone, gray, fine grained, medium bedded to thick bedded, zones dolomitic, with occasional shale stringers, streaks and partings		72/100	10.0'	10.0'	100	116.0'	
449.8'	118.2'								
		Shale, gray to red brown, sandy, zones sandy to very sandy		100/100	10.0'	10.0'	100	126.0'	

FMSM_KYTC_STR LX2001110.GPJ KYTC COMPONENT.GDT 1/26/06

FMSM ENGINEERS

SUBSURFACE LOG

County	Jefferson	Item No.	5-118.11	Location	Station 116+84.0 100.0 ft rt
State Project No.	Ohio River Bridges			Boring No.	B-9	Total Depth	131.0'

Lithology		Description	Overburden	Sample #	Depth	Recovery	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core	RQD % KY/STD	Run Length	Recovery	Rec. %	Run Depth	
437.0'	131.0'	Shale, gray to red brown, sandy, zones sandy to very sandy *(Continued)*		44/100	5.0'	5.0'	100	131.0'	

Bottom of Hole
Top of Rock = 11.4'
Elevation 556.6'

Base of Weathered Rock = 11.4'
Elevation 556.6'

at Elevation '

Scour Elevation '

FMSM_KYTC_STR LX2004110.GPJ KYTC COMPONENT.GDT 1/26/06

FMSM ENGINEERS

Anchorage Quadrangle
GQ #906
Louisville Limestone Formation

SUBSURFACE LOG

County	Jefferson Item No. 5-118.11	Location	Station 116+84.1 103.0 ft rt
State Project No.	Ohio River Bridges	Boring No.	B-9A Total Depth 17.0'
Fed. Project No.	Design Section No. 4	Latitude	38.326042 Longitude 85.623198
MARS No.	65541-05D	Surface Elevation	568.1'
Structure ID	East End Approach	Date Started	12/14/05 Completed 12/14/05
Roadway ☐	Structure ☐ Driller Merle Wethington	Depth to Water	Dry Date/Time 12/14/05
Supervisor	Adam Crace	Depth to Water	N/A Date/Time N/A
Logged By	Adam Crace	Automatic Hammer ☒	Safety Hammer ☐ Other ☐

Lithology: Elevation	Lithology: Depth	Description	Overburden / Rock Core: Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
568.1'	0.0'	Top of Hole						
556.2'	11.9'	Overburden						1 Box
551.1'	17.0'	Limestone, gray, microcrystalline to fine grained, medium bedded to thick bedded	100/100	5.1'	5.1'	100	17.0'	

Bottom of Hole
Top of Rock = 11.9'
Elevation 556.2'

Base of Weathered Rock = 11.9'
Elevation 556.2'

at Elevation '

Scour Elevation '

FMSM_KYTC_STR LX2004110.GPJ KYTC COMPONENT.GDT 2/15/06

2/15/06

FMSM ENGINEERS

Anchorage Quadrangle
GQ #906
Louisville Limestone Formation

SUBSURFACE LOG

County	Jefferson Item No. 5-118.11	Location	Station 118+67.7 18.2 ft rt
State Project No.	Ohio River Bridges	Boring No.	**B-8** Total Depth 102.0'
Fed. Project No.	Design Section No. 4	Latitude	38.326222L Longitude 85.623853L
MARS No.	65541-05D	Surface Elevation	539.9'
Structure ID	East End Approach	Date Started	12/13/05 Completed 12/14/05
Roadway ☐ Structure ☐ Driller	Merle Wethington	Depth to Water	Dry Date/Time 12/14/05
Supervisor	Adam Crace	Depth to Water	N/A Date/Time N/A
Logged By	Adam Crace	Automatic Hammer ☒ Safety Hammer ☐ Other ☐	

Lithology			Overburden	Sample #	Depth	Recovery	Blows	Mois.Cont. %	
Elevation	Depth	Description	Rock Core	RQD % KY/STD	Run Length	Recovery	Rec. %	Run Depth	Remarks
539.9'	0.0'	Top of Hole							
		Overburden							
532.6'	7.3'								7 Boxes
		Limestone, gray, microcrystalline to fine grained, medium bedded to thick bedded, zones nodular/irregular bedded, zones argillaceous, occasional styolites, fossiliferous, with shale stringer and partings		90/90	10.0'	9.3'	93	17.3'	
				97/97	9.8'	9.8'	100	27.1'	
506.0'	33.9'								
		Shale, gray, silty, calcareous							

FMSM_KYTC_STR LX2004110.GPJ KYTC COMPONENT.GDT 1/26/06

County: Jefferson Item No. 5-118.11 Location: Station 118+67.7 18.2 ft rt

State Project No. Ohio River Bridges Boring No. B-8 Total Depth: 102.0'

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
		Shale, gray, silty, calcareous *(Continued)*		68/99	10.0'	9.9'	99	37.1'	
494.3'	45.6'								
		Limestone (dolomite), gray, fine grained, medium bedded to thick bedded, occasional styolites, dolomitic with shale stringers, streaks and partings		34/92	10.0'	10.0'	100	47.1'	
				100/100	10.0'	10.0'	100	57.1'	
				98/98	10.0'	9.8'	98	67.1'	
				97/97	10.0'	9.9'	99	77.1'	

FMSM_KYTC_STR LX2004110.GPJ KYTC COMPONENT.GDT 1/26/06

FMSM ENGINEERS

SUBSURFACE LOG

County: Jefferson   Item No. 5-118.11   Location: Station 118+67.7 18.2 ft rt

State Project No. Ohio River Bridges   Boring No. B-8   Total Depth: 102.0'

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
455.0'	84.9'								
452.9'	87.0'	Shale, gray, sandy, calcareous		99/99	9.1'	9.4'	103	86.2'	Zones dolomitic from 84.5 to 92.1
446.3'	93.6'	Limestone, gray, fine grained, medium bedded to thick bedded, zones dolomitic, with occasional shale stringers, streaks and partings							
		Shale, gray to red-brown, sandy, zones sandy		92/100	10.0'	10.0'	100	96.2'	
437.9'	102.0'			72/100	5.7'	5.7'	100	102.0'	

Bottom of Hole
Top of Rock = 7.3'
Elevation 532.6'

Base of Weathered Rock = 7.3'
Elevation 532.6'

at Elevation '

Scour Elevation '

FMSM_KYTC_STR LX2004110.GPJ KYTC COMPONENT.GDT 1/26/06

FMSM ENGINEERS

Anchorage Quadrangle
GQ #906
Louisville Limestone Formation

SUBSURFACE LOG

County	Jefferson Item No. 5-118.11	Location	Station 118+67.7 22.2 ft rt
State Project No.	Ohio River Bridges	Boring No.	B-8A Total Depth 14.5'
Fed. Project No.	Design Section No. 4	Latitude	38.326217 Longitude 85.623856
MARS No.	65541-05D	Surface Elevation	540.1'
Structure ID	East End Approach	Date Started	12/13/05 Completed 12/14/05
Roadway ☐	Structure ☐ Driller Merle Wethington	Depth to Water	Dry Date/Time 12/14/05
Supervisor	Adam.Crace	Depth to Water	N/A Date/Time N/A
Logged By	Adam Crace	Automatic Hammer ☒	Safety Hammer ☐ Other ☐

Lithology Elevation	Depth	Description (Overburden / Rock Core)	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
540.1'	0.0'	Top of Hole						
530.6'	9.5'	Overburden						1 Box
525.6'	14.5'	Limestone, gray, microcrystalline to fine grained, medium bedded to thick bedded	100/100	5.0'	5.0'	100	14.5'	

Bottom of Hole
Top of Rock = 9.5'
Elevation 530.6'

Base of Weathered Rock = 9.5'
Elevation 530.6'

at Elevation '

Scour Elevation '

FMSM_KYTC_STR LX200411.GPJ KYTC COMPONENT.GDT 2/15/06

2/15/06

County	Jefferson	Item No.	5-118.11
State Project No.	Ohio River Bridges		
Fed. Project No.	Design Section No. 4		
MARS No.	65541-05D		
Structure ID	East End Approach		
Roadway ☐	Structure ☐	Driller	Mike Muncy
Supervisor	Adam Crace		
Logged By	Adam Crace		

Location	Station 121+91.2 66.0 ft rt		
Boring No.	**B-5**	Total Depth	136.9'
Latitude	38.326933	Longitude	85.624543
Surface Elevation	528.3'		
Date Started	12/14/05	Completed	12/16/05
Depth to Water	Dry	Date/Time	12/16/05
Depth to Water	N/A	Date/Time	N/A
Automatic Hammer ☒	Safety Hammer ☐	Other ☐	

Lithology: Elevation	Lithology: Depth	Description	Overburden / Rock Core	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
528.3'	0.0'	Top of Hole							
515.4'	12.9'	Overburden							9 Boxes
		Limestone, gray, microcrystalline to fine grained, medium bedded to thick bedded, zones nodular/irregular bedded, zones argillaceous, occasional styolites, fossiliferous, with shale stringers and partings		82/82	9.1'	9.1'	100	22.0'	Boring drilled at 40 degree angle
				98/98	10.0'	10.0'	100	32.0'	Lost water at 25.0
493.5'	34.8'								
		Shale, gray, silty, calcareous							

FMSM_KYTC_STR LX2004110.GPJ KYTC COMPONENT.GDT 1/26/06

FMSM ENGINEERS

SUBSURFACE LOG

County: Jefferson Item No. 5-118.11 Location: Station 121+91.2 66.0 ft rt
State Project No. Ohio River Bridges Boring No. B-5 Total Depth 136.9'

Lithology: Elevation	Lithology: Depth	Description	Overburden / Rock Core	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
		Shale, gray, silty, calcareous *(Continued)*		54/94	5.0'	5.0'	100	37.0'	
				30/93	9.7'	9.7'	100	46.7'	
478.1'	50.2'								
		Limestone (dolomite), gray, fine, medium bedded to thick bedded, occasional styolites, dolomitic with shale stringers, streaks and partings		81/100	10.0'	10.0'	100	57.0'	
				100/100	10.0'	10.0'	100	67.0'	
				91/91	10.0'	10.0'	100	77.0'	Slightly water stained from 74.2 to 78.2

FMSM_KYTC_STR LX2004110.GPJ KYTC COMPONENT.GDT 1/26/06

County	Jefferson	Item No.	5-118.11	Location	Station 121+91.2 66.0 ft rt
State Project No.	Ohio River Bridges			Boring No.	B-5
				Total Depth	136.9'

Lithology: Elevation	Lithology: Depth	Description	Overburden / Rock Core	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
		Limestone (dolomite), gray, fine, medium bedded to thick bedded, occasional styolites, dolomitic with shale stringers, streaks and partings - *(Continued)*		97/97	10.0'	9.8'	98	87.0'	
				100/100	10.0'	10.0'	100	97.0'	
427.9'	100.4'	Shale, gray, silty, calcareous							
424.1'	104.2'	Limestone, gray, fine, medium bedded to thick bedded, zones dolomitic, with occasional stringers, streaks and partings		93/100	10.0'	10.0'	100	107.0'	
				99/99	9.8'	9.7'	99	116.8'	
411.9'	116.4'	Shale, reddish brown to gray, silty, zones sandy to very sandy							

FMSM_KYTC_STR LX2004110.GPJ KYTC COMPONENT.GDT 1/26/06

County	Jefferson	Item No.	5-118.11	Location	Station 121+91.2 66.0 ft rt
State Project No.	Ohio River Bridges			Boring No.	B-5
				Total Depth	136.9'

Lithology		Description	Overburden	Sample #	Depth	Recovery	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core	RQD % KY/STD	Run Length	Recovery	Rec. %	Run Depth	
401.4'	126.9'			74/93	10.0'	9.9'	99	127.0'	
		Limestone, gray, microcrystalline to fine grained, medium bedded to thick bedded, zones dolomitic, with occasional stringers, streaks and partings							
391.4'	136.9'			100/100	9.9'	9.9'	100	136.9'	

Bottom of Hole
Top of Rock = 12.9'
Elevation 515.4'

Base of Weathered Rock = 12.9'
Elevation 515.4'

at Elevation '

Scour Elevation '

FMSM ENGINEERS

Anchorage Quadrangle
GQ #906
Louisville Limestone Formation

SUBSURFACE LOG

County	Jefferson	Item No.	5-118.11
State Project No.	Ohio River Bridges		
Fed. Project No.	Design Section No. 4		
MARS No.	65541-05D		
Structure ID	East End Approach		
Roadway ☐	Structure ☐	Driller	Mike Muncy
Supervisor	Adam Crace		
Logged By	Adam Crace		

Location	Station 122+08.4 8.5 ft rt		
Boring No.	**B-6**	Total Depth	94.9'
Latitude	38.326856	Longitude	85.624727
Surface Elevation	526.1'		
Date Started	12/13/05	Completed	12/14/05
Depth to Water	Dry	Date/Time	12/14/05
Depth to Water	N/A	Date/Time	N/A
Automatic Hammer ☒	Safety Hammer ☐	Other ☐	

Lithology		Description	Overburden / Rock Core	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
Elevation	Depth								
526.1'	0.0'	Top of Hole							
525.8'	0.3'	Asphalt							
		Lean Clay, brown, moist to wet, soft to stiff		SPT-1	2.0' - 3.5'	1.2'	1-2-2	--	
				SPT-2	5.0' - 6.5'	1.2'	5-6-7	--	
				SPT-3	10.0' - 11.5'	1.3'	7-4-21	--	6 Boxes
513.8'	12.3'								
		Limestone, gray, microcrystalline to fine grained, medium bedded to thick bedded, zones nodular/irregular bedded, zones argillaceous, occasinoal styolites, fossiliferous, with shale stringers and partings		96/96	2.3'	2.3'	100	14.6'	
503.1'	23.0'								
502.5'	23.6'	Shale, gray, silty, calcareous							
501.5'	24.6'	Limestone (dolomite), gray, fine, medium bedded		91/91	10.0'	10.0'	100	24.6'	
		Shale, gray, calcareous							
490.9'	35.2'			51/98	10.0'	10.0'	100	34.6'	Lost water at 40.0

FMSM_KYTC_STR LX2004110.GPJ KYTC COMPONENT.GDT 1/26/06

1/26/06

County: Jefferson Item No. 5-118.11 Location: Station 122+08.4 8.5 ft rt

State Project No. Ohio River Bridges Boring No. B-6 Total Depth 94.9'

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD % KY/STD	Depth / Run Length	Recovery / Recovery	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
		Limestone (dolomite), gray, fine, medium bedded to thick bedded, zones dolomitic, with occasional shale stringers, streaks and partings - *(Continued)*							
				100/100	10.0'	10.0'	100	44.6'	
									70 degree fracture from 44.8 to 55.0 78 degree fracture from 46.0 to 46.7 Near vertical fracture from 48.0 to 50.7
				59/59	10.0'	10.0'	100	54.6'	
				99/99	10.0'	9.9'	99	64.6'	
451.6'	74.5'			100/100	10.0'	10.0'	100	74.6'	
		Shale, gray, sandy							
449.5'	76.6'								
		Limestone, gray, fine, medium bedded to thick bedded, zones dolomitic, with occasional shale stringers, streaks and partings							

FMSM_KYTC_STR LX2004110.GPJ KYTC COMPONENT.GDT 1/26/06

County Jefferson Item No. 5-118.11 Location Station 122+08.4 8.5 ft rt

State Project No. Ohio River Bridges Boring No. **B-6** Total Depth 94.9'

Lithology		Description	Overburden	Sample #	Depth	Recovery	Blows	Mois.Cont. %	
Elevation	Depth		Rock Core	RQD % KY/STD	Run Length	Recovery	Rec. %	Run Depth	Remarks
442.2'	83.9'			96/96	9.3'	9.3'	100	83.9'	
		Shale, gray to reddish brown, sandy, zones sandy to very sandy		62/100	10.0'	10.0'	100	93.9'	
431.2'	94.9'			80/100	1.0'	1.0'	100	94.9'	

Bottom of Hole
Top of Rock = 12.3'
Elevation 513.8'

Base of Weathered Rock = 12.3'
Elevation 513.8'

at Elevation '

Scour Elevation '

FMSM ENGINEERS

Anchorage Quadrangle
GQ #906
Louisville Limestone Formation

SUBSURFACE LOG

County	Jefferson	Item No.	5-118.11
State Project No.	Ohio River Bridges		
Fed. Project No.	Design Section No. 4		
MARS No.	65541-05D		
Structure ID	East End Approach		
Roadway ☐	Structure ☐	Driller	Mike Muncy
Supervisor	Adam Crace		
Logged By	Adam Crace		

Location	Station 122+08.4 11.5 ft rt		
Boring No.	B-6A	Total Depth	17.1'
Latitude	38.326928	Longitude	85.624546
Surface Elevation	526.1'		
Date Started	12/19/05	Completed	12/19/05
Depth to Water	Dry	Date/Time	12/19/05
Depth to Water	N/A	Date/Time	N/A

Automatic Hammer ☒ Safety Hammer ☐ Other ☐

Lithology		Description	Overburden	Sample #	Depth	Recovery	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core	RQD % KY/STD	Run Length	Recovery	Rec. %	Run Depth	
526.1'	0.0'	Top of Hole							
514.7'	11.4'	Overburden							1 Box
509.0'	17.1'	Limestone, gray, microcrystalline to fine grained, thin bedded to medium bedded		91/100	5.7'	5.7'	100	17.1'	

Bottom of Hole
Top of Rock = 11.4'
Elevation 514.7'

Base of Weathered Rock = 11.4'
Elevation 514.7'

at Elevation '

Scour Elevation '

FMSM_KYTC_STR LX2004110.GPJ KYTC COMPONENT.GDT 2/15/06

Water Pressure Testing Results

Boring:	B-15
Water Pressure Testing	
Date:	2/9/05-2/9/05

Depth: 43.0' - 53.0'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
24	12:06:00 PM	0	2.80	
24	12:07:00 PM	1	2.80	0.00
24	12:08:00 PM	2	2.80	0.00
24	12:09:00 PM	3	2.80	0.00
24	12:10:00 PM	4	2.80	0.00
24	12:11:00 PM	5	2.80	0.00
32	12:12:00 PM	0	2.90	
32	12:13:00 PM	1	2.90	0.00
32	12:14:00 PM	2	2.90	0.00
32	12:15:00 PM	3	2.90	0.00
32	12:16:00 PM	4	2.90	0.00
32	12:17:00 PM	5	2.90	0.00
*Ended Test				

Depth: 78.0' - 88.0'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
42	11:22:00 AM	0	0.60	
42	11:23:00 AM	1	0.80	0.20
42	11:24:00 AM	2	1.00	0.20
42	11:25:00 AM	3	1.10	0.10
42	11:26:00 AM	4	1.20	0.10
42	11:27:00 AM	5	1.30	0.10
42	11:28:00 AM	6	1.40	0.10
42	11:29:00 AM	7	1.50	0.10
52	11:35:00 AM	0	1.90	
52	11:36:00 AM	1	1.95	0.05
52	11:37:00 AM	2	1.95	0.00
52	11:38:00 AM	3	2.00	0.05
52	11:39:00 AM	4	2.05	0.05
52	11:40:00 AM	5	2.05	0.00
52	11:41:00 AM	6	2.10	0.05
*Ended Test				

Depth: 123.0' - 133.0'

P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
72	10:38:00 AM	0	8.00	
72	10:39:00 AM	1	8.20	0.20
72	10:40:00 AM	2	8.40	0.20
72	10:41:00 AM	3	8.60	0.20
72	10:42:00 AM	4	8.70	0.10
72	10:43:00 AM	5	8.90	0.20
72	10:44:00 AM	6	9.10	0.20
72	10:45:00 AM	7	9.20	0.10
64	10:46:00 AM	0	9.30	
64	10:47:00 AM	1	9.35	0.05
64	10:48:00 AM	2	9.40	0.05
64	10:49:00 AM	3	9.40	0.00
64	10:50:00 AM	4	9.40	0.00
64	10:51:00 AM	5	9.40	0.00
*Ended Test				

Boring:	B-11
Water Pressure Testing	
Date:	12/05/05-12/06/05

P_{max}= (Mid depth - soil) x cos (angle) + 0.4 x (soil) x cos(angle)

P_{max}= (Mid depth - 12.9') x cos 40 + 0.4 x 12.9' x cos 40

Depth: 21.3' - 31.3'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
4		0	3.00	
4		1	7.40	4.40
4		2	3.90	-3.50
4		3	4.10	0.20
4		4	4.40	0.30
4		5	4.60	0.20
8		0	4.70	
8		1	4.80	0.10
8		2	4.90	0.10
8		3	4.90	0.00
8		4	5.00	0.10
8		5	5.10	0.10
16		0	5.40	
16		1	5.60	0.20
16		2	5.90	0.30
16		3	6.10	0.20
16		4	6.50	0.40
16		5	6.70	0.20
*Ended Test				

Depth: 31.3' - 41.3'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
6	3:23:00 PM	0	4.00	
6	3:24:00 PM	1	4.00	0.00
6	3:25:00 PM	2	4.00	0.00
6	3:26:00 PM	3	4.00	0.00
6	3:27:00 PM	4	4.00	0.00
6	3:28:00 PM	5	4.00	0.00
12	3:29:00 PM	0	5.20	
12	3:30:00 PM	1	5.25	0.05
12	3:31:00 PM	2	5.25	0.00
12	3:32:00 PM	3	5.25	0.00
12	3:33:00 PM	4	5.25	0.00
12	3:34:00 PM	5	5.25	0.00
25	3:34:00 PM	0	6.15	

25	3:35:00 PM	1	6.15	0.00
25	3:36:00 PM	2	6.15	0.00
25	3:37:00 PM	3	6.20	0.05
25	3:38:00 PM	4	6.20	0.00
25	3:39:00 PM	5	6.20	0.00
*Ended Test				

Depth: 41.3' - 51.3'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
9	2:51:00 PM	0	6.10	
9	2:52:00 PM	1	6.30	0.20
9	2:53:00 PM	2	6.60	0.30
9	2:54:00 PM	3	6.70	0.10
9	2:55:00 PM	4	6.80	0.10
9	2:56:00 PM	5	6.80	0.00
17	2:57:00 PM	0	8.20	
17	2:58:00 PM	1	8.20	0.00
17	2:59:00 PM	2	8.20	0.00
17	3:00:00 PM	3	8.20	0.00
17	3:01:00 PM	4	8.40	0.20
17	3:02:00 PM	5	8.50	0.10
35	3:03:00 PM	0	9.60	
35	3:04:00 PM	1	9.80	0.20
35	3:05:00 PM	2	10.20	0.40
35	3:06:00 PM	3	10.40	0.20
35	3:07:00 PM	4	10.70	0.30
35	3:08:00 PM	5	10.90	0.20
17	3:09:00 PM	0	11.00	
17	3:10:00 PM	1	11.00	0.00
17	3:11:00 PM	2	11.00	0.00
17	3:12:00 PM	3	11.00	0.00
17	3:13:00 PM	4	11.00	0.00
17	3:14:00 PM	5	11.00	0.00
*Ended Test				

Depth: 51.3' - 61.3'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
11	2:27:00 PM	0	0.30	
11	2:28:00 PM	1	0.30	0.00
11	2:29:00 PM	2	0.30	0.00
11	2:30:00 PM	3	0.35	0.05
11	2:31:00 PM	4	0.35	0.00
11	2:32:00 PM	5	0.35	0.00
22	2:32:00 PM	0	1.25	

22	2:33:00 PM	1	1.25	0.00
22	2:34:00 PM	2	1.25	0.00
22	2:35:00 PM	3	1.25	0.00
22	2:36:00 PM	4	1.25	0.00
22	2:37:00 PM	5	1.25	0.00
44	2:38:00 PM	0	2.20	
44	2:39:00 PM	1	2.20	0.00
44	2:40:00 PM	2	2.40	0.20
44	2:41:00 PM	3	2.40	0.00
44	2:42:00 PM	4	2.55	0.15
44	2:43:00 PM	5	2.60	0.05
*Ended Test				

Depth: 61.3' - 71.3'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
13.5	1:39:00 PM	0	0.30	
13.5	1:40:00 PM	1	1.60	1.30
13.5	1:41:00 PM	2	2.40	0.80
13.5	1:42:00 PM	3	2.70	0.30
13.5	1:43:00 PM	4	2.90	0.20
13.5	1:44:00 PM	5	3.10	0.20
13.5	1:45:00 PM	6	3.30	0.20
27	1:46:00 PM	0	3.70	
27	1:47:00 PM	1	4.60	0.90
27	1:48:00 PM	2	5.60	1.00
27	1:49:00 PM	3	6.50	0.90
27	1:50:00 PM	4	7.60	1.10
27	1:51:00 PM	5	8.60	1.00
54	1:52:00 PM	0	10.10	
54	1:53:00 PM	1	13.90	3.80
54	1:54:00 PM	2	17.00	3.10
54	1:55:00 PM	3	20.60	3.60
54	1:56:00 PM	4	27.30	6.70
54	1:57:00 PM	5	30.60	3.30
27	1:59:00 PM	0	31.60	
27	2:00:00 PM	1	32.70	1.10
27	2:01:00 PM	2	33.70	1.00
27	2:02:00 PM	3	34.70	1.00
27	2:03:00 PM	4	35.70	1.00
27	2:04:00 PM	5	36.50	0.80
13.5	2:05:00 PM	0	36.80	
13.5	2:06:00 PM	1	37.00	0.20
13.5	2:07:00 PM	2	37.10	0.10
13.5	2:08:00 PM	3	37.30	0.20
13.5	2:09:00 PM	4	37.40	0.10
13.5	2:10:00 PM	5	37.50	0.10
*Ended Test				

Depth: 71.3' - 81.3'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
16	1:00:00 PM	0	8.60	
16	1:01:00 PM	1	8.70	0.10
16	1:02:00 PM	2	8.90	0.20
16	1:03:00 PM	3	9.00	0.10
16	1:04:00 PM	4	9.20	0.20
16	1:05:00 PM	5	9.40	0.20
32	1:06:00 PM	0	9.90	
32	1:07:00 PM	1	10.10	0.20
32	1:08:00 PM	2	10.20	0.10
32	1:09:00 PM	3	10.40	0.20
32	1:10:00 PM	4	10.50	0.10
32	1:11:00 PM	5	10.50	0.00
64	1:12:00 PM	0	11.20	
64	1:13:00 PM	1	14.00	2.80
64	1:14:00 PM	2	16.70	2.70
64	1:15:00 PM	3	19.30	2.60
64	1:16:00 PM	4	21.90	2.60
64	1:17:00 PM	5	24.20	2.30
32	1:18:00 PM	0	25.50	
32	1:19:00 PM	1	25.60	0.10
32	1:20:00 PM	2	25.70	0.10
32	1:21:00 PM	3	25.80	0.10
32	1:22:00 PM	4	25.90	0.10
32	1:23:00 PM	5	26.00	0.10
16	1:24:00 PM	0	26.10	
16	1:25:00 PM	1	26.10	0.00
16	1:26:00 PM	2	26.10	0.00
16	1:27:00 PM	3	26.20	0.10
16	1:28:00 PM	4	26.20	0.00
16	1:29:00 PM	5	26.20	0.00

Depth: 81.3' - 91.3'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
18	11:57:00 AM	0	2.60	
18	11:58:00 AM	1	3.10	0.50
18	11:59:00 AM	2	3.20	0.10
18	12:00:00 PM	3	3.20	0.00
18	12:01:00 PM	4	3.20	0.00
18	12:02:00 PM	5	3.20	0.00
37	12:03:00 PM	0	3.30	

37	12:04:00 PM	1	3.30	0.00
37	12:05:00 PM	2	3.40	0.10
37	12:06:00 PM	3	3.50	0.10
37	12:07:00 PM	4	3.50	0.00
37	12:08:00 PM	5	3.60	0.10
73	12:09:00 PM	0	3.70	
73	12:10:00 PM	1	3.80	0.10
73	12:11:00 PM	2	4.00	0.20
73	12:12:00 PM	3	4.10	0.10
73	12:13:00 PM	4	4.30	0.20
73	12:14:00 PM	5	4.40	0.10
37	12:15:00 PM	0	4.40	
37	12:16:00 PM	1	4.50	0.10
37	12:17:00 PM	2	4.60	0.10
37	12:18:00 PM	3	4.70	0.10
37	12:19:00 PM	4	4.70	0.00
37	12:20:00 PM	5	4.80	0.10

Depth: 91.3' - 101.3'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
21	11:08:00 AM	0	7.80	
21	11:09:00 AM	1	8.80	1.00
21	11:10:00 AM	2	9.60	0.80
21	11:11:00 AM	3	9.70	0.10
21	11:12:00 AM	4	9.70	0.00
21	11:13:00 AM	5	9.80	0.10
21	11:14:00 AM	6	9.80	0.00
21	11:15:00 AM	7	9.80	0.00
42	11:16:00 AM	0	9.90	
42	11:17:00 AM	1	10.00	0.10
42	11:18:00 AM	2	10.00	0.00
42	11:19:00 AM	3	10.10	0.10
42	11:20:00 AM	4	10.20	0.10
42	11:21:00 AM	5	10.30	0.10
83	11:22:00 AM	0	10.40	
83	11:23:00 AM	1	10.70	0.30
83	11:24:00 AM	2	10.90	0.20
83	11:25:00 AM	3	11.20	0.30
83	11:26:00 AM	4	11.50	0.30
83	11:27:00 AM	5	11.80	0.30
42	11:28:00 AM	0	11.90	
42	11:29:00 AM	1	12.00	0.10
42	11:30:00 AM	2	12.10	0.10
42	11:31:00 AM	3	12.20	0.10
42	11:32:00 AM	4	12.40	0.20
42	11:33:00 AM	5	12.50	0.10
21	11:33:00 AM	0	12.50	

21	11:34:00 AM	1	12.60	0.10
21	11:35:00 AM	2	12.60	0.00
21	11:36:00 AM	3	12.60	0.00
21	11:37:00 AM	4	12.70	0.10
21	11:38:00 AM	5	12.70	0.00

Depth: 101.3' - 111.3'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
23	10:16:00 AM	0	3.90	
23	10:17:00 AM	1	4.80	0.90
23	10:18:00 AM	2	5.10	0.30
23	10:19:00 AM	3	5.60	0.50
23	10:20:00 AM	4	6.10	0.50
23	10:21:00 AM	5	6.50	0.40
46	10:22:00 AM	0	7.30	
46	10:23:00 AM	1	9.90	2.60
46	10:24:00 AM	2	12.70	2.80
46	10:25:00 AM	3	15.50	2.80
46	10:26:00 AM	4	18.50	3.00
46	10:27:00 AM	5	21.40	2.90
93	10:37:00 AM	0	2.20	
93	10:38:00 AM	1	3.90	1.70
93	10:39:00 AM	2	5.80	1.90
93	10:40:00 AM	3	7.90	2.10
93	10:41:00 AM	4	9.90	2.00
93	10:42:00 AM	5	11.80	1.90
46	10:43:00 AM	0	12.30	
46	10:44:00 AM	1	12.40	0.10
46	10:45:00 AM	2	12.40	0.00
46	10:46:00 AM	3	12.40	0.00
46	10:47:00 AM	4	12.50	0.10
46	10:48:00 AM	5	12.50	0.00
23	10:49:00 AM	0	12.45	
23	10:50:00 AM	1	12.50	0.05
23	10:51:00 AM	2	12.50	0.00
23	10:52:00 AM	3	12.50	0.00
23	10:53:00 AM	4	12.55	0.05
23	10:54:00 AM	5	12.55	0.00

Depth: 111.3' - 121.3'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
26	9:36:00 AM	0	3.80	

26	9:37:00 AM	1	4.00	0.20
26	9:38:00 AM	2	4.25	0.25
26	9:39:00 AM	3	4.65	0.40
26	9:40:00 AM	4	4.95	0.30
26	9:41:00 AM	5	5.00	0.05
51	9:42:00 AM	0	5.00	
51	9:43:00 AM	1	5.00	0.00
51	9:44:00 AM	2	5.00	0.00
51	9:45:00 AM	3	5.00	0.00
51	9:46:00 AM	4	5.00	0.00
51	9:47:00 AM	5	5.00	0.00
102	9:48:00 AM	0	5.05	
102	9:49:00 AM	1	5.15	0.10
102	9:50:00 AM	2	5.20	0.05
102	9:51:00 AM	3	5.30	0.10
102	9:52:00 AM	4	5.40	0.10
102	9:53:00 AM	5	5.50	0.10
51	9:54:00 AM	0	5.50	
51	9:55:00 AM	1	5.55	0.05
51	9:56:00 AM	2	5.55	0.00
51	9:57:00 AM	3	5.60	0.05
51	9:58:00 AM	4	5.60	0.00
51	9:59:00 AM	5	5.60	0.00
26	10:00:00 AM	0	5.60	
26	10:01:00 AM	1	5.65	0.05
26	10:02:00 AM	2	5.70	0.05
26	10:03:00 AM	3	5.70	0.00
26	10:04:00 AM	4	5.70	0.00
26	10:05:00 AM	5	5.70	0.00

Depth: 121.3' - 131.3'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
28	8:55:00 AM	0	6.30	
28	8:56:00 AM	1	9.50	3.20
28	8:57:00 AM	2	9.90	0.40
28	8:58:00 AM	3	10.00	0.10
28	8:59:00 AM	4	10.15	0.15
28	9:00:00 AM	5	10.30	0.15
56	9:01:00 AM	0	10.45	
56	9:02:00 AM	1	10.80	0.35
56	9:03:00 AM	2	11.00	0.20
56	9:04:00 AM	3	11.20	0.20
56	9:05:00 AM	4	11.45	0.25
56	9:06:00 AM	5	11.70	0.25
112	9:07:00 AM	0	11.90	
112	9:08:00 AM	1	12.20	0.30
112	9:09:00 AM	2	12.50	0.30

112	9:10:00 AM	3	12.90	0.40
112	9:11:00 AM	4	13.25	0.35
112	9:12:00 AM	5	13.60	0.35
56	9:13:00 AM	0	13.70	
56	9:14:00 AM	1	14.00	0.30
56	9:15:00 AM	2	14.25	0.25
56	9:16:00 AM	3	14.50	0.25
56	9:17:00 AM	4	14.70	0.20
56	9:18:00 AM	5	14.95	0.25
28	9:19:00 AM	0	15.00	
28	9:20:00 AM	1	15.10	0.10
28	9:21:00 AM	2	15.20	0.10
28	9:22:00 AM	3	15.35	0.15
28	9:23:00 AM	4	15.50	0.15
28	9:24:00 AM	5	15.60	0.10

Depth: 131.3' - 141.3'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
34	5:10:00 PM	0	3.30	
34	5:11:00 PM	1	3.60	0.30
34	5:12:00 PM	2	3.90	0.30
34	5:13:00 PM	3	4.10	0.20
34	5:14:00 PM	4	4.40	0.30
34	5:15:00 PM	5	4.60	0.20
68	5:16:00 PM	0	4.70	
68	5:17:00 PM	1	4.80	0.10
68	5:18:00 PM	2	4.90	0.10
68	5:19:00 PM	3	4.90	0.00
68	5:20:00 PM	4	5.00	0.10
68	5:21:00 PM	5	5.10	0.10
134	5:22:00 PM	0	5.40	
134	5:23:00 PM	1	5.60	0.20
134	5:24:00 PM	2	5.90	0.30
134	5:25:00 PM	3	6.10	0.20
134	5:26:00 PM	4	6.50	0.40
134	5:27:00 PM	5	6.70	0.20
68	5:28:00 PM	0	6.80	
68	5:29:00 PM	1	6.80	0.00
68	5:30:00 PM	2	6.80	0.00
68	5:31:00 PM	3	6.80	0.00
68	5:32:00 PM	4	6.90	0.10
68	5:33:00 PM	5	6.90	0.00
34	5:34:00 PM	0	6.90	
34	5:35:00 PM	1	6.90	0.00
34	5:36:00 PM	2	7.00	0.10
34	5:37:00 PM	3	7.00	0.00
34	5:38:00 PM	4	7.00	0.00
34	5:39:00 PM	5	7.00	0.00

Boring:	B-8
Water Pressure Testing	
Date:	12/13/05-12/14/05

P_{max}= (Mid depth - soil) + 0.4 x (soil)

P_{max}= (Mid depth - 6.8') + 0.4 x 6.8'

Depth: 11.3' - 27.3'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
4	12:35:30 PM	0	4.85	
4	12:36:30 PM	1	4.85	0.00
4	12:37:30 PM	2	4.85	0.00
4	12:38:30 PM	3	4.85	0.00
4	12:39:30 PM	4	4.85	0.00
4	12:40:30 PM	5	4.85	0.00
8	**12:42:00 PM	0	4.80	
8	12:43:00 PM	1	4.85	0.05
8	12:44:00 PM	2	4.85	0.00
8	12:45:00 PM	3	4.85	0.00
8	12:46:00 PM	4	4.85	0.00
8	12:47:00 PM	5	4.85	0.00
15	12:48:00 PM	0	4.85	
15	12:49:00 PM	1	4.85	0.00
15	12:50:00 PM	2	4.85	0.00
15	12:51:00 PM	3	4.85	0.00
15	12:52:00 PM	4	4.85	0.00
15	12:53:00 PM	5	4.85	0.00
*Ended Test				

**Changed pressure gauges

Depth: 27.3' - 47.1'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
8	1:54:00 PM	0	6.85	
8	1:55:00 PM	1	6.85	0.00
8	1:56:00 PM	2	6.85	0.00
8	1:57:00 PM	3	6.85	0.00
8	1:58:00 PM	4	6.85	0.00
8	1:59:00 PM	5	6.85	0.00
17	2:00:00 PM	0	6.95	
17	2:01:00 PM	1	7.00	0.05
17	2:02:00 PM	2	7.00	0.00
17	2:03:00 PM	3	7.00	0.00
17	2:04:00 PM	4	7.00	0.00

17	2:05:00 PM	5	7.00	0.00
33	2:06:00 PM	0	7.40	
33	2:07:00 PM	1	7.45	0.05
33	2:08:00 PM	2	7.55	0.10
33	2:09:00 PM	3	7.55	0.00
33	2:10:00 PM	4	7.55	0.00
33	2:11:00 PM	5	7.60	0.05
*Ended Test				

Depth: 47.1' - 67.1'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
13	3:03:00 PM	0	8.90	
13	3:04:00 PM	1	8.90	0.00
13	3:05:00 PM	2	8.90	0.00
13	3:06:00 PM	3	8.95	0.05
13	3:07:00 PM	4	8.95	0.00
13	3:08:00 PM	5	8.95	0.00
27	3:09:00 PM	0	9.35	
27	3:10:00 PM	1	9.50	0.15
27	3:11:00 PM	2	9.60	0.10
27	3:12:00 PM	3	9.75	0.15
27	3:13:00 PM	4	9.80	0.05
27	3:14:00 PM	5	9.90	0.10
53	3:15:00 PM	0	10.15	
53	3:16:00 PM	1	10.20	0.05
53	3:17:00 PM	2	10.20	0.00
53	3:18:00 PM	3	10.20	0.00
53	3:19:00 PM	4	10.20	0.00
53	3:20:00 PM	5	10.20	0.00
*Ended Test				

Depth: 67.1' - 86.2'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
18	4:18:00 PM	0	9.75	
18	4:19:00 PM	1	9.75	0.00
18	4:20:00 PM	2	9.75	0.00
18	4:21:00 PM	3	9.75	0.00
18	4:22:00 PM	4	9.75	0.00
18	4:23:00 PM	5	9.75	0.00
36	4:24:00 PM	0	10.65	
36	4:25:00 PM	1	10.65	0.00
36	4:26:00 PM	2	10.70	0.05
36	4:27:00 PM	3	10.70	0.00
36	4:28:00 PM	4	10.75	0.05

36	4:29:00 PM	5	10.80	0.05
72	**4:32:00 PM	0	0.65	
72	4:33:00 PM	1	1.20	0.55
72	4:34:00 PM	2	1.40	0.20
72	4:35:00 PM	3	1.65	0.25
72	4:36:00 PM	4	2.00	0.35
72	4:37:00 PM	5	2.20	0.20
*Ended Test				

**Changed pressure gauges

Depth: 86.2' - 102'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
23	9:07:00 AM	0	6.75	
23	9:08:00 AM	1	6.75	0.00
23	9:09:00 AM	2	6.75	0.00
23	9:10:00 AM	3	6.75	0.00
23	9:11:00 AM	4	6.75	0.00
23	9:12:00 AM	5	6.75	0.00
45	9:13:00 AM	0	7.10	
45	9:14:00 AM	1	7.25	0.15
45	9:15:00 AM	2	7.30	0.05
45	9:16:00 AM	3	7.40	0.10
45	9:17:00 AM	4	7.45	0.05
45	9:18:00 AM	5	7.50	0.05
90	9:19:00 AM	0	7.55	
90	9:20:00 AM	1	7.85	0.30
90	9:21:00 AM	2	8.05	0.20
90	9:22:00 AM	3	8.30	0.25
90	9:23:00 AM	4	8.55	0.25
90	9:24:00 AM	5	8.75	0.20
45	9:25:00 AM	0	8.85	
45	9:26:00 AM	1	8.85	0.00
45	9:27:00 AM	2	8.90	0.05
45	9:28:00 AM	3	9.00	0.10
45	9:29:00 AM	4	9.00	0.00
45	9:30:00 AM	5	9.05	0.05
*Ended Test				

Boring:	B-10
Water Pressure Testing	
Date:	12/12/2005

P_{max}= (Mid depth - soil) + 0.4 x (soil)

P_{max}= (Mid depth - 6.8') + 0.4 x 5.0'

Depth: 16' - 36'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
6	3:40:30 PM	0	0.10	
6	3:41:30 PM	1	0.60	0.50
6	3:42:30 PM	2	1.30	0.70
6	3:43:30 PM	3	2.05	0.75
6	3:44:30 PM	4	2.80	0.75
6	3:45:30 PM	5	3.50	0.70
6	3:46:30 PM	6	4.20	0.70
12	3:47:00 PM	0	4.70	
12	3:48:00 PM	1	5.70	1.00
12	3:49:00 PM	2	6.80	1.10
12	3:50:00 PM	3	7.80	1.00
12	3:51:00 PM	4	8.75	0.95
12	3:52:00 PM	5	9.70	0.95
23	3:52:30 PM	0	10.60	
23	3:53:30 PM	1	12.30	1.70
23	3:54:30 PM	2	14.40	2.10
23	3:55:30 PM	3	16.60	2.20
23	3:56:30 PM	4	18.60	2.00
23	3:57:30 PM	5	20.80	2.20
23	3:58:30 PM	6	23.00	2.20
12	3:59:00 PM	0	23.90	
12	4:00:00 PM	1	25.70	1.80
12	4:01:00 PM	2	27.45	1.75
12	4:02:00 PM	3	29.10	1.65
12	4:03:00 PM	4	30.75	1.65
12	4:04:00 PM	5	32.40	1.65
6	4:05:00 PM	0	33.70	
6	4:06:00 PM	1	34.90	1.20
6	4:07:00 PM	2	36.10	1.20
6	4:08:00 PM	3	37.35	1.25
6	4:09:00 PM	4	38.55	1.20
6	4:10:00 PM	5	39.75	1.20
*Ended Test				

Depth: 36.1' - 56.1'

P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
**22	12:08:30 PM	0	4.50	
22	12:09:30 PM	1	4.50	0.00
22	12:10:30 PM	2	4.50	0.00
22	12:11:30 PM	3	4.50	0.00
22	12:12:30 PM	4	4.50	0.00
22	12:13:30 PM	5	4.50	0.00
43	12:14:30 PM	0	4.65	
43	12:15:30 PM	1	4.75	0.10
43	12:16:30 PM	2	4.85	0.10
43	12:17:30 PM	3	4.95	0.10
43	12:18:30 PM	4	5.05	0.10
43	12:19:30 PM	5	5.15	0.10
*Ended Test				

**Hole stabilizes at 20 psi, could not do 11psi

Depth: 56.1' - 76.0'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
32	1:29:30 PM	0	9.55	
32	1:30:30 PM	1	9.60	0.05
32	1:31:30 PM	2	9.80	0.20
32	1:32:30 PM	3	10.00	0.20
32	1:33:30 PM	4	10.20	0.20
32	1:34:30 PM	5	10.35	0.15
32	**1:35:30 PM	0	0.70	
63	1:36:30 PM	1	0.90	0.20
63	1:37:30 PM	2	1.10	0.20
63	1:38:30 PM	3	1.20	0.10
63	1:39:30 PM	4	1.35	0.15
63	1:40:30 PM	5	1.50	0.15
32	1:41:30 PM	0	1.55	
32	1:42:30 PM	1	1.65	0.10
32	1:43:30 PM	2	1.80	0.15
32	1:44:30 PM	3	1.90	0.10
32	1:45:30 PM	4	2.05	0.15
32	1:46:30 PM	5	2.15	0.10
*Ended Test				

**Hole stabilizes at 19 psi, could not do 16psi

**Changed pressure gauge

Depth: 76' - 96'

P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
21	2:48:30 PM	0	4.05	
21	2:49:30 PM	1	4.05	0.00
21	2:50:30 PM	2	4.05	0.00
21	2:51:30 PM	3	4.05	0.00
21	2:52:30 PM	4	4.05	0.00
21	2:53:30 PM	5	4.05	0.00
42	2:54:30 PM	0	4.20	
42	2:55:30 PM	1	4.20	0.00
42	2:56:30 PM	2	4.20	0.00
42	2:57:30 PM	3	4.20	0.00
42	2:58:30 PM	4	4.20	0.00
42	2:59:30 PM	5	4.20	0.00
83	3:00:30 PM	0	5.50	
83	3:01:30 PM	1	5.55	0.05
83	3:02:30 PM	2	5.60	0.05
83	3:03:30 PM	3	5.70	0.10
83	3:04:30 PM	4	5.70	0.00
83	3:05:30 PM	5	5.75	0.05
*Ended Test				

Depth: 96' - 116'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
26	4:42:00 PM	0	3.40	
26	4:43:00 PM	1	3.95	0.55
26	4:44:00 PM	2	4.55	0.60
26	4:45:00 PM	3	4.95	0.40
26	4:46:00 PM	4	5.25	0.30
26	4:47:00 PM	5	5.55	0.30
26	4:48:00 PM	6	5.75	0.20
26	4:49:00 PM	7	6.05	0.30
26	4:50:00 PM	8	6.25	0.20
52	4:51:00 PM	0	6.65	
52	4:52:00 PM	1	6.70	0.05
52	4:53:00 PM	2	7.15	0.45
52	4:54:00 PM	3	7.30	0.15
52	4:55:00 PM	4	7.50	0.20
52	4:56:00 PM	5	7.75	0.25
103	**4:59:00 PM	0	8.30	
103	5:00:00 PM	1	8.65	0.35
103	5:01:00 PM	2	8.90	0.25
103	5:02:00 PM	3	9.10	0.20

**Changed pressure gauge

103	5:03:00 PM	4	9.40	0.30
103	5:04:00 PM	5	9.60	0.20
52	5:05:00 PM	0	9.65	
52	5:06:00 PM	1	9.80	0.15
52	5:07:00 PM	2	9.95	0.15
52	5:08:00 PM	3	10.10	0.15
52	5:09:00 PM	4	10.20	0.10
52	5:10:00 PM	5	10.35	0.15
*Ended Test				

Boring:	B-9
Water Pressure Testing	
Date:	12/7/05-12/8/05

P_{max}= (Mid depth - soil) + 0.4 x (soil)

P_{max}= (Mid depth - 11.4') + 0.4 x 11.4'

Depth: 16' - 36'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
5	?10:00:00 AM	0	3.80	
5	10:01:00 AM	1	4.00	0.20
5	10:02:00 AM	2	4.25	0.25
5	10:03:00 AM	3	4.50	0.25
5	10:04:00 AM	4	4.50	0.00
5	10:05:00 AM	5	4.50	0.00
5	10:06:00 AM	6	4.50	0.00
10	10:06:30 AM	0	4.55	
10	10:07:30 AM	1	4.55	0.00
10	10:08:30 AM	2	4.55	0.00
10	10:09:30 AM	3	4.55	0.00
10	10:10:30 AM	4	4.55	0.00
10	10:11:30 AM	5	4.55	0.00
19	10:12:00 AM	0	4.65	
19	10:13:00 AM	1	4.65	0.00
19	10:14:00 AM	2	4.65	0.00
19	10:15:00 AM	3	4.65	0.00
19	10:16:00 AM	4	4.65	0.00
19	10:17:00 AM	5	4.65	0.00
*Ended Test				

**Used incorrect pressures accidently

**Depth: 36' - 56'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
7	12:29:00 PM	0	9.65	
7	12:30:00 PM	1	9.65	0.00
7	12:31:00 PM	2	9.65	0.00
7	12:32:00 PM	3	9.65	0.00
7	12:33:00 PM	4	9.65	0.00
7	12:34:00 PM	5	9.65	0.00
15	12:34:30 PM	0	9.70	
15	12:35:30 PM	1	9.75	0.05
15	12:36:30 PM	2	9.75	0.00

15	12:37:30 PM	3	9.75	0.00
15	12:38:30 PM	4	9.75	0.00
15	12:39:30 PM	5	9.75	0.00
29	12:40:00 PM	0	9.95	
29	12:41:00 PM	1	10.05	0.10
29	12:42:00 PM	2	10.25	0.20
29	12:43:00 PM	3	10.30	0.05
29	12:44:00 PM	4	10.40	0.10
29	12:45:00 PM	5	10.50	0.10
*Ended Test				

Depth: 56' - 76'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
15	3:04:30 PM	0	8.35	
15	3:05:30 PM	1	8.35	0.00
15	3:06:30 PM	2	8.40	0.05
15	3:07:30 PM	3	8.40	0.00
15	3:08:30 PM	4	8.40	0.00
15	3:09:30 PM	5	8.40	0.00
30	3:10:00 PM	0	8.40	
30	3:11:00 PM	1	8.40	0.00
30	3:12:00 PM	2	8.40	0.00
30	3:13:00 PM	3	8.40	0.00
30	3:14:00 PM	4	8.40	0.00
30	3:15:00 PM	5	8.40	0.00
59	3:15:30 PM	0	8.45	
59	3:16:30 PM	1	8.45	0.00
59	3:17:30 PM	2	8.45	0.00
59	3:18:30 PM	3	8.45	0.00
59	3:19:30 PM	4	8.45	0.00
59	3:20:30 PM	5	8.45	0.00
*Ended Test				

Depth: 76' - 96'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
20	4:08:00 PM	0	1.50	
20	4:09:00 PM	1	2.70	1.20
20	4:10:00 PM	2	3.50	0.80
20	4:11:00 PM	3	4.15	0.65
20	4:12:00 PM	4	4.65	0.50
20	4:13:00 PM	5	5.15	0.50
20	4:14:00 PM	6	5.60	0.45
20	4:15:00 PM	7	6.00	0.40
40	4:15:30 PM	0	6.50	

40	4:16:30 PM	1	7.25	0.75
40	4:17:30 PM	2	8.00	0.75
40	4:18:30 PM	3	8.70	0.70
40	4:19:30 PM	4	9.40	0.70
40	4:20:30 PM	5	10.10	0.70
79	4:21:30 PM	0	11.40	
79	4:22:30 PM	1	12.65	1.25
79	4:23:30 PM	2	13.90	1.25
79	4:24:30 PM	3	15.10	1.20
79	4:25:30 PM	4	16.30	1.20
79	4:26:30 PM	5	17.50	1.20
40	4:27:00 PM	0	17.80	
40	4:28:00 PM	1	18.35	0.55
40	4:29:00 PM	2	18.90	0.55
40	4:30:00 PM	3	19.45	0.55
40	4:31:00 PM	4	20.00	0.55
40	4:32:00 PM	5	20.55	0.55
20	4:32:30 PM	0	20.60	
20	4:33:30 PM	1	20.80	0.20
20	4:34:30 PM	2	21.05	0.25
20	4:35:30 PM	3	21.30	0.25
20	4:36:30 PM	4	21.55	0.25
20	4:37:30 PM	5	21.80	0.25
*Ended Test				

Depth: 96' - 116'					
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference	
25	9:13:00 AM	0	8.60		
25	9:14:00 AM	1	8.65	0.05	
25	9:15:00 AM	2	8.75	0.10	
25	9:16:00 AM	3	8.80	0.05	
25	9:17:00 AM	4	8.85	0.05	
25	9:18:00 AM	5	8.90	0.05	
50	9:18:30 AM	0	9.00		
50	9:19:30 AM	1	9.15	0.15	
50	9:20:30 AM	2	9.30	0.15	
50	9:21:30 AM	3	9.40	0.10	
50	9:22:30 AM	4	9.55	0.15	
50	9:23:30 AM	5	9.65	0.10	
99	**9:27:30 AM	0	6.75		**Changed pressure gauges
99	9:28:30 AM	1	6.80	0.05	
99	9:29:30 AM	2	6.95	0.15	
99	9:30:30 AM	3	7.10	0.15	
99	9:31:30 AM	4	7.20	0.10	
99	9:32:30 AM	5	7.30	0.10	
50	9:33:00 AM	0	7.35		

50	9:34:00 AM	1	7.35	0.00
50	9:35:00 AM	2	7.35	0.00
50	9:36:00 AM	3	7.35	0.00
50	9:37:00 AM	4	7.40	0.05
50	9:38:00 AM	5	7.40	0.00
*Ended Test				

Depth: 116' - 132'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
29	11:24:00 AM	0	9.80	
29	11:25:00 AM	1	9.80	0.00
29	11:26:00 AM	2	9.80	0.00
29	11:27:00 AM	3	9.80	0.00
29	11:28:00 AM	4	9.80	0.00
29	11:29:00 AM	5	9.80	0.00
59	11:30:00 AM	0	9.95	
59	11:31:00 AM	1	10.00	0.05
59	11:32:00 AM	2	10.05	0.05
59	11:33:00 AM	3	10.15	0.10
59	11:34:00 AM	4	10.15	0.00
59	11:35:00 AM	5	10.20	0.05
117	**11:37:00 AM	0	10.30	
117	11:38:00 AM	1	10.60	0.30
117	11:39:00 AM	2	10.75	0.15
117	11:40:00 AM	3	10.95	0.20
117	11:41:00 AM	4	11.10	0.15
117	11:42:00 AM	5	11.25	0.15
*Ended Test				

**Changed pressure gauges

Boring:	B-5
Water Pressure Testing	
Date:	12/14/05-12/16/05

P_{max}= (Mid depth - soil) x cos (angle) + 0.4 x (soil) x cos(angle)

P_{max}= (Mid depth - 12.9') x cos 40 + 0.4 x 12.9' x cos 40

Depth: 17' - 37'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
4	1:13:00 PM	0	9.70	
4	1:14:00 PM	1	9.80	0.10
4	1:15:00 PM	2	9.85	0.05
4	1:16:00 PM	3	9.85	0.00
4	1:17:00 PM	4	9.85	0.00
4	1:18:00 PM	5	9.85	0.00
7	1:19:00 PM	0	10.40	
7	1:20:00 PM	1	10.40	0.00
7	1:21:00 PM	2	10.40	0.00
7	1:22:00 PM	3	10.40	0.00
7	1:23:00 PM	4	10.40	0.00
6.5	1:24:00 PM	5	10.40	0.00
14	1:25:00 PM	0	14.40	
15	1:26:00 PM	1	17.00	2.60
15	1:27:00 PM	2	19.60	2.60
15	1:28:00 PM	3	22.30	2.70
15	1:29:00 PM	4	24.90	2.60
15	1:30:00 PM	5	27.70	2.80
7	1:31:00 PM	0	28.50	
7	1:32:00 PM	1	29.50	1.00
7	1:33:00 PM	2	30.75	1.25
7	1:34:00 PM	3	32.00	1.25
7	1:35:00 PM	4	32.95	0.95
7	1:36:00 PM	5	33.90	0.95
7	1:37:00 PM	6	34.80	0.90
4	1:38:00 PM	0	35.00	
4	1:39:00 PM	1	35.00	0.00
4	1:40:00 PM	2	35.00	0.00
*Ended Test				

Depth: 37' - 57'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
8	4:20:00 PM	0	6.40	
8	4:21:00 PM	1	6.65	0.25
8	4:22:00 PM	2	6.90	0.25

8	4:23:00 PM	3	7.15	0.25
8	4:24:00 PM	4	7.40	0.25
8	4:25:00 PM	5	7.70	0.30
15	4:26:00 PM	0	11.10	
15	4:27:00 PM	1	11.15	0.05
15	4:28:00 PM	2	12.00	0.85
15	4:29:00 PM	3	12.65	0.65
15	4:30:00 PM	4	13.20	0.55
15	4:31:00 PM	5	13.90	0.70
15	4:32:00 PM	6	14.60	0.70
15	4:33:00 PM	7	15.35	0.75
29	4:35:00 PM	0	20.10	
30	4:36:00 PM	1	22.00	1.90
30	4:37:00 PM	2	23.70	1.70
30	4:38:00 PM	3	25.60	1.90
30	4:39:00 PM	4	27.70	2.10
30	4:40:00 PM	5	29.80	2.10
14	4:41:00 PM	0	30.95	
15	4:42:00 PM	1	32.30	1.35
15	4:43:00 PM	2	33.75	1.45
15	4:44:00 PM	3	35.20	1.45
15	4:45:00 PM	4	36.90	1.70
15	4:46:00 PM	5	38.40	1.50
8	4:47:00 PM	0	39.70	
8	4:48:00 PM	1	41.00	1.30
8	4:49:00 PM	2	42.00	1.00
8	4:50:00 PM	3	43.05	1.05
8	4:51:00 PM	4	44.15	1.10
8	4:52:00 PM	5	45.40	1.25
*Ended Test				

Depth: 57' - 77'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
11	8:12:00 AM	0	6.25	
11	8:13:00 AM	1	6.40	0.15
11	8:14:00 AM	2	6.85	0.45
10	8:15:00 AM	3	7.75	0.90
11	8:16:00 AM	4	9.50	1.75
11	8:17:00 AM	5	10.30	0.80
11	8:18:00 AM	6	10.90	0.60
11	8:19:00 AM	7	11.60	0.70
11	8:20:00 AM	8	12.90	1.30
23	8:22:00 AM	0	1.80	
24	8:23:00 AM	1	3.80	2.00
22	8:24:00 AM	2	5.00	1.20
23	8:25:00 AM	3	6.75	1.75
23	8:26:00 AM	4	8.55	1.80
23	8:27:00 AM	5	10.85	2.30

22	8:28:00 AM	6	12.70	1.85
45	8:29:00 AM	0	18.20	
45	8:30:00 AM	1	21.30	3.10
46	8:31:00 AM	2	24.10	2.80
44	8:32:00 AM	3	26.90	2.80
46	8:33:00 AM	4	30.00	3.10
45	8:34:00 AM	5	33.00	3.00
25	8:35:00 AM	0	33.30	
22	8:36:00 AM	1	34.15	0.85
24	8:37:00 AM	2	36.95	2.80
22	8:38:00 AM	3	38.60	1.65
22	8:39:00 AM	4	41.20	2.60
23	8:40:00 AM	5	43.60	2.40
11	8:41:00 AM	0	43.60	
11	8:42:00 AM	1	43.80	0.20
11	8:43:00 AM	2	44.40	0.60
11	8:44:00 AM	3	46.35	1.95
11	8:45:00 AM	4	47.70	1.35
11	8:46:00 AM	5	49.35	1.65
*Ended Test				

Depth: 77' - 97'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
15	10:20:00 AM	0	8.00	
15	10:21:00 AM	1	8.00	0.00
15	10:22:00 AM	2	8.10	0.10
15	10:23:00 AM	3	8.10	0.00
15	10:24:00 AM	4	8.10	0.00
15	10:25:00 AM	5	8.20	0.10
30	10:26:00 AM	0	8.50	
30	10:27:00 AM	1	8.60	0.10
30	10:28:00 AM	2	8.65	0.05
30	10:29:00 AM	3	8.70	0.05
30	10:30:00 AM	4	8.80	0.10
30	10:31:00 AM	5	8.90	0.10
61	10:32:00 AM	0	9.35	
61	10:33:00 AM	1	9.50	0.15
61	10:34:00 AM	2	9.60	0.10
59	10:35:00 AM	3	9.70	0.10
60	10:36:00 AM	4	9.80	0.10
60	10:37:00 AM	5	9.90	0.10
*Ended Test				

Depth: 97' - 117'

P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
19	12:09:00 PM	0	5.75	
19	12:10:00 PM	1	5.75	0.00
20	12:11:00 PM	2	5.85	0.10
19	12:12:00 PM	3	6.05	0.20
19	12:13:00 PM	4	6.25	0.20
19	12:14:00 PM	5	6.30	0.05
38	12:15:00 PM	0	8.65	
38	12:16:00 PM	1	8.70	0.05
38	12:17:00 PM	2	8.70	0.00
38	12:18:00 PM	3	8.80	0.10
38	12:19:00 PM	4	8.90	0.10
38	12:20:00 PM	5	9.00	0.10
80	12:21:00 PM	0	10.90	
80	12:22:00 PM	1	11.00	0.10
75	12:23:00 PM	2	11.10	0.10
76	12:24:00 PM	3	11.20	0.10
76	12:25:00 PM	4	11.30	0.10
76	12:26:00 PM	5	11.40	0.10
*Ended Test				

Depth: 117' - 137'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
23	2:28:00 PM	0	6.70	
23	2:29:00 PM	1	6.70	0.00
23	2:30:00 PM	2	6.70	0.00
23	2:31:00 PM	3	6.70	0.00
23	2:32:00 PM	4	6.80	0.10
23	2:33:00 PM	5	6.85	0.05
46	2:34:00 PM	0	9.15	
46	2:35:00 PM	1	9.25	0.10
46	2:36:00 PM	2	9.35	0.10
46	2:37:00 PM	3	9.40	0.05
46	2:38:00 PM	4	9.50	0.10
46	2:39:00 PM	5	9.60	0.10
91	2:40:00 PM	0	11.50	
91	2:41:00 PM	1	11.60	0.10
91	2:42:00 PM	2	11.70	0.10
91	2:43:00 PM	3	11.80	0.10
91	2:44:00 PM	4	11.90	0.10
91	2:45:00 PM	5	12.00	0.10
*Ended Test				

Boring:	B-6
Water Pressure Testing	
Date:	12/13/05-12/14/05

P_{max}= (Mid depth - soil) + 0.4 x (soil)

P_{max}= (Mid depth - 6.8') + 0.4 x 6.8'

Depth: 14.6' - 34.6'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
5.5	11:46:00 AM	0	46.50	
5.5	11:47:00 AM	1	46.50	0.00
5.5	11:48:00 AM	2	46.80	0.30
5.5	11:49:00 AM	3	46.90	0.10
5.5	11:50:00 AM	4	47.00	0.10
5.5	11:51:00 AM	5	47.10	0.10
5.5	11:52:00 AM	6	47.20	0.10
5.5	11:53:00 AM	7	47.40	0.20
5.5	11:54:00 AM	8	47.50	0.10
9	11:56:00 AM	0	48.70	
9	11:57:00 AM	1	48.80	0.10
9	11:58:00 AM	2	48.90	0.10
9	11:59:00 AM	3	48.90	0.00
9	12:00:00 PM	4	48.90	0.00
9	12:01:00 PM	5	48.90	0.00
9	12:02:00 PM	6	48.90	0.00
17	12:03:00 PM	0	49.20	
17	12:04:00 PM	1	49.30	0.10
17	12:05:00 PM	2	49.40	0.10
17	12:06:00 PM	3	49.50	0.10
17	12:07:00 PM	4	49.60	0.10
17	12:08:00 PM	5	49.90	0.30
17	12:09:00 PM	6	50.00	0.10
17	12:10:00 PM	7	50.10	0.10
9	12:11:00 PM	0	50.20	
9	12:12:00 PM	1	50.30	0.10
9	12:13:00 PM	2	50.30	0.00
9	12:14:00 PM	3	50.30	0.00
9	12:15:00 PM	4	50.30	0.00
9	12:16:00 PM	5	50.30	0.00
*Ended Test				

Depth: 34.6' - 54.6'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
10	2:22:00 PM	0	774.50	

10	2:23:00 PM	1	784.20	9.70
9.5	2:24:00 PM	2	794.00	9.80
9	2:25:00 PM	3	804.00	10.00
11	2:26:00 PM	4	815.00	11.00
8	2:27:00 PM	5	825.50	10.50
19	2:29:00 PM	0	856.50	
16	2:30:00 PM	1	872.00	15.50
17	2:31:00 PM	2	888.90	16.90
16	2:32:00 PM	3	905.60	16.70
14	2:33:00 PM	4	923.00	17.40
18	2:34:00 PM	5	940.30	17.30
8	2:34:00 PM	0	957.00	
8.5	2:35:00 PM	1	972.50	15.50
8.5	2:36:00 PM	2	988.20	15.70
8	2:37:00 PM	3	1003.70	15.50
8	2:38:00 PM	4	1019.20	15.50
8	2:39:00 PM	5	1035.00	15.80
*Ended Test				

Depth: 54.6' - 74.6'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
15	3:46:00 PM	0	46.10	
15	3:47:00 PM	1	46.10	0.00
15	3:48:00 PM	2	46.30	0.20
15.5	3:49:00 PM	3	46.50	0.20
15.5	3:50:00 PM	4	46.50	0.00
13.5	3:51:00 PM	5	46.50	0.00
15	3:52:00 PM	6	46.60	0.10
14.5	3:53:00 PM	7	46.60	0.00
28.5	3:55:00 PM	0	50.10	
29.5	3:56:00 PM	1	50.20	0.10
27.5	3:57:00 PM	2	50.20	0.00
29	3:58:00 PM	3	50.30	0.10
28	3:59:00 PM	4	50.40	0.10
55	4:10:00 PM	0	53.10	
55	4:11:00 PM	1	53.20	0.10
56.5	4:12:00 PM	2	53.30	0.10
55	4:13:00 PM	3	53.40	0.10
55.5	4:14:00 PM	4	53.50	0.10
55.5	4:15:00 PM	5	53.50	0.00
28	4:17:00 PM	0	52.60	
29	4:18:00 PM	1	52.80	0.20
28	4:19:00 PM	2	52.80	0.00
27	4:20:00 PM	3	52.90	0.10
27.5	4:21:00 PM	4	53.00	0.10
27	4:22:00 PM	5	53.00	0.00
14.5	4:23:00 PM	0	52.40	
14.5	4:24:00 PM	1	52.60	0.20

15	4:25:00 PM	2	52.60	0.00
15	4:26:00 PM	3	52.60	0.00
14.5	4:27:00 PM	4	52.70	0.10
14.5	4:28:00 PM	5	52.70	0.00
*Ended Test				

Depth: 74.6' - 94.6'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
18	10:01:00 AM	0	68.80	
18	10:02:00 AM	1	70.60	1.80
21	10:03:00 AM	2	71.20	0.60
20	10:04:00 AM	3	71.50	0.30
20	10:05:00 AM	4	71.70	0.20
20	10:06:00 AM	5	72.00	0.30
20	10:10:00 AM	6	72.30	0.30
20	10:11:00 AM	7	72.50	0.20
38	10:12:00 AM	0	73.40	
38	10:13:00 AM	1	73.70	0.30
38	10:14:00 AM	2	74.10	0.40
38	10:15:00 AM	3	74.50	0.40
38	10:16:00 AM	4	74.80	0.30
38	10:17:00 AM	5	75.20	0.40
80	10:20:00 AM	0	77.60	
80	10:21:00 AM	1	78.10	0.50
80	10:22:00 AM	2	78.50	0.40
81	10:23:00 AM	3	78.90	0.40
78	10:24:00 AM	4	79.20	0.30
79	10:25:00 AM	5	79.60	0.40
39	10:27:00 AM	0	80.10	
39	10:28:00 AM	1	80.40	0.30
39	10:29:00 AM	2	80.60	0.20
39	10:30:00 AM	3	80.80	0.20
39	10:31:00 AM	4	80.90	0.10
39	10:32:00 AM	5	81.10	0.20
19	10:33:00 AM	0	81.20	
19	10:34:00 AM	1	81.20	0.00
19	10:35:00 AM	2	81.40	0.20
19	10:36:00 AM	3	81.50	0.10
19	10:37:00 AM	4	81.60	0.10
19	10:38:00 AM	5	81.70	0.10
*Ended Test				

Boring:	B-14
Water Pressure Testing	
Date:	2/11/05-2/11/05

Depth: 20.0' - 30.0'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
13	10:49:00 AM	0	5.60	
13	10:50:00 AM	1	5.60	0.00
13	10:51:00 AM	2	5.60	0.00
13	10:52:00 AM	3	5.60	0.00
13	10:53:00 AM	4	5.60	0.00
13	10:54:00 AM	5	5.60	0.00
23	10:55:00 AM	0	6.20	
23	10:56:00 AM	1	6.20	0.00
23	10:57:00 AM	2	6.20	0.00
23	10:58:00 AM	3	6.20	0.00
23	10:59:00 AM	4	6.20	0.00
23	11:00:00 AM	5	6.20	0.00
*Ended Test				

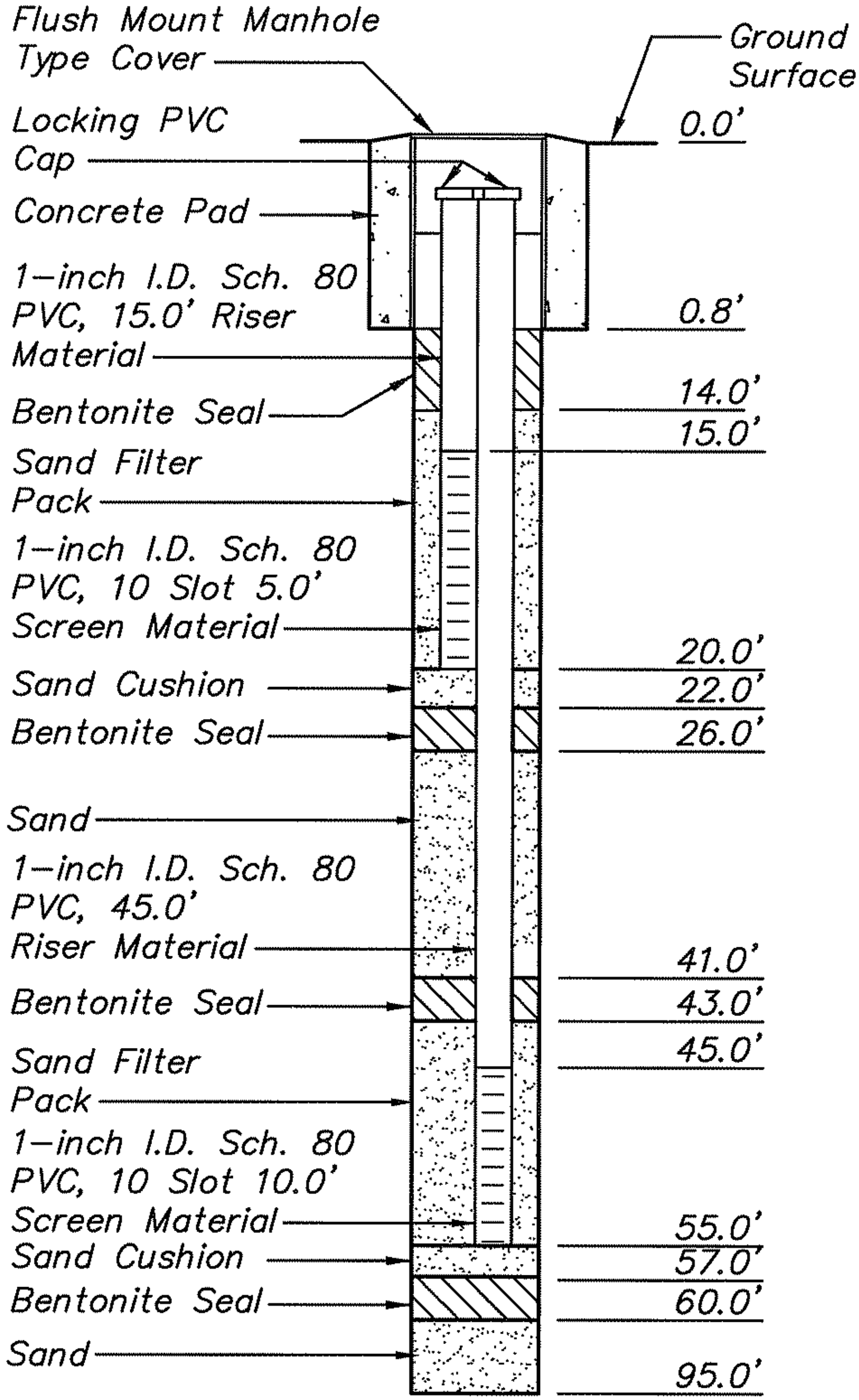
Depth: 35.0' - 45.0'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
20	10:17:00 AM	0	2.20	
20	12:00:00 AM	1	2.25	0.05
20	10:19:00 AM	2	2.30	0.05
20	10:20:00 AM	3	2.40	0.10
20	10:21:00 AM	4	2.45	0.05
20	10:22:00 AM	5	2.50	0.05
30	10:23:00 AM	0	2.60	
30	10:24:00 AM	1	2.60	0.00
30	10:25:00 AM	2	2.60	0.00
30	10:26:00 AM	3	2.60	0.00
30	10:27:00 AM	4	2.60	0.00
30	10:28:00 AM	5	2.60	0.00
*Ended Test				

Depth: 60.0' - 70.0'

P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
35	9:28:00 AM	0	4.10	
35	9:29:00 AM	1	4.30	0.20
35	9:30:00 AM	2	4.40	0.10
35	9:31:00 AM	3	4.60	0.20
35	9:32:00 AM	4	4.70	0.10
35	9:33:00 AM	5	4.90	0.20
35	9:34:00 AM	6	5.10	0.20
35	9:35:00 AM	7	5.30	0.20
42	9:36:00 AM	0	5.50	
42	9:37:00 AM	1	5.60	0.10
42	9:38:00 AM	2	5.70	0.10
42	9:39:00 AM	3	5.80	0.10
42	9:40:00 AM	4	5.90	0.10
42	9:41:00 AM	5	6.00	0.10
*Ended Test				

Depth: 110.0' - 120.0'				
P(Gauge pressure, psi)	Time	Time Passed (mins)	Water Meter Reading (Gallons)	Difference
54	8:31:00 AM	0	5.90	
54	8:32:00 AM	1	6.10	0.20
54	8:33:00 AM	2	6.30	0.20
54	8:34:00 AM	3	6.50	0.20
54	8:35:00 AM	4	6.70	0.20
54	8:36:00 AM	5	6.90	0.20
62	8:37:00 AM	0	6.90	
62	8:38:00 AM	1	7.00	0.10
62	8:39:00 AM	2	7.10	0.10
62	8:40:00 AM	3	7.20	0.10
62	8:41:00 AM	4	7.30	0.10
62	8:42:00 AM	5	7.40	0.10
62	8:43:00 AM	6	7.50	0.10
62	8:44:00 AM	7	7.60	0.10
62	8:45:00 AM	8	7.70	0.10
*Ended Test				

Observation Well Installation Details

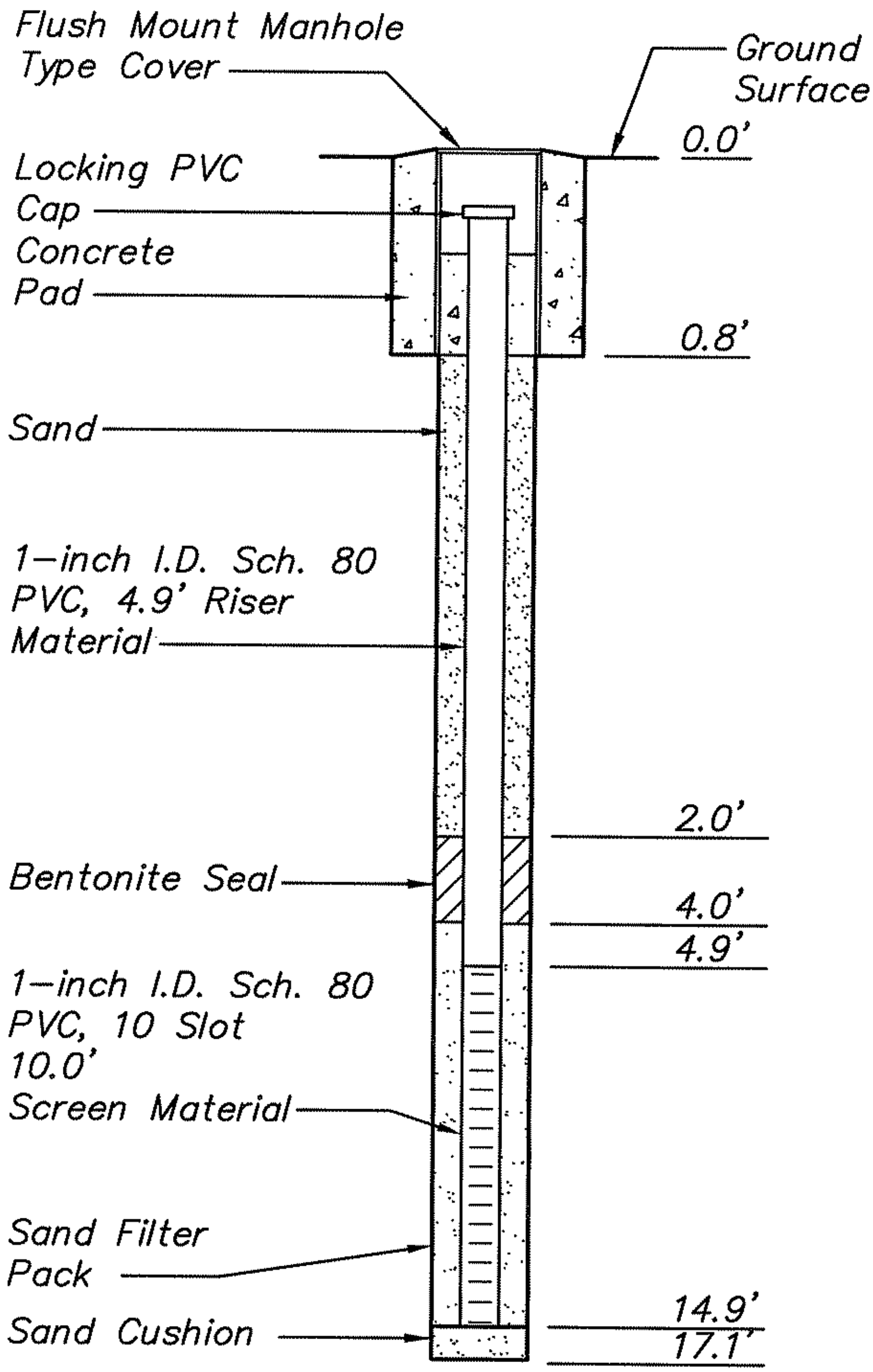


OBSERVATION WELL
INSTALLATION DETAIL B-6
Ohio River Bridge
Design Section No.4
Item No. 5-118.11
Jefferson County, Kentucky

FMSM ENGINEERS

NOT TO SCALE

LX2004110\MWELLB-6.DWG

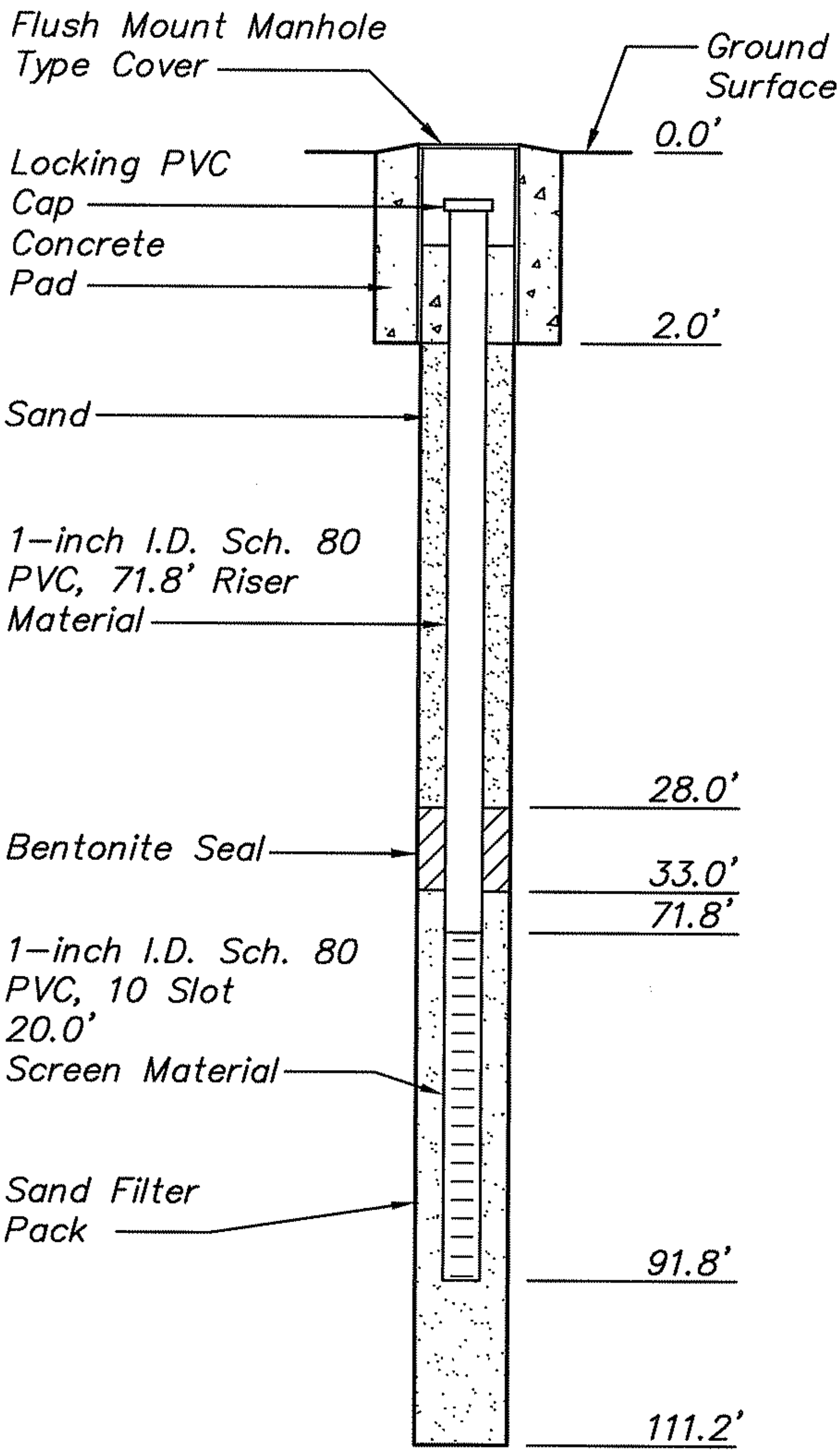


OBSERVATION WELL
INSTALLATION DETAIL B-6A
Ohio River Bridge
Design Section No.4
Item No. 5-118.11
Jefferson County, Kentucky

NOT TO SCALE

EMSM ENGINEERS

LX200411O\MWELLB-6A.DWG

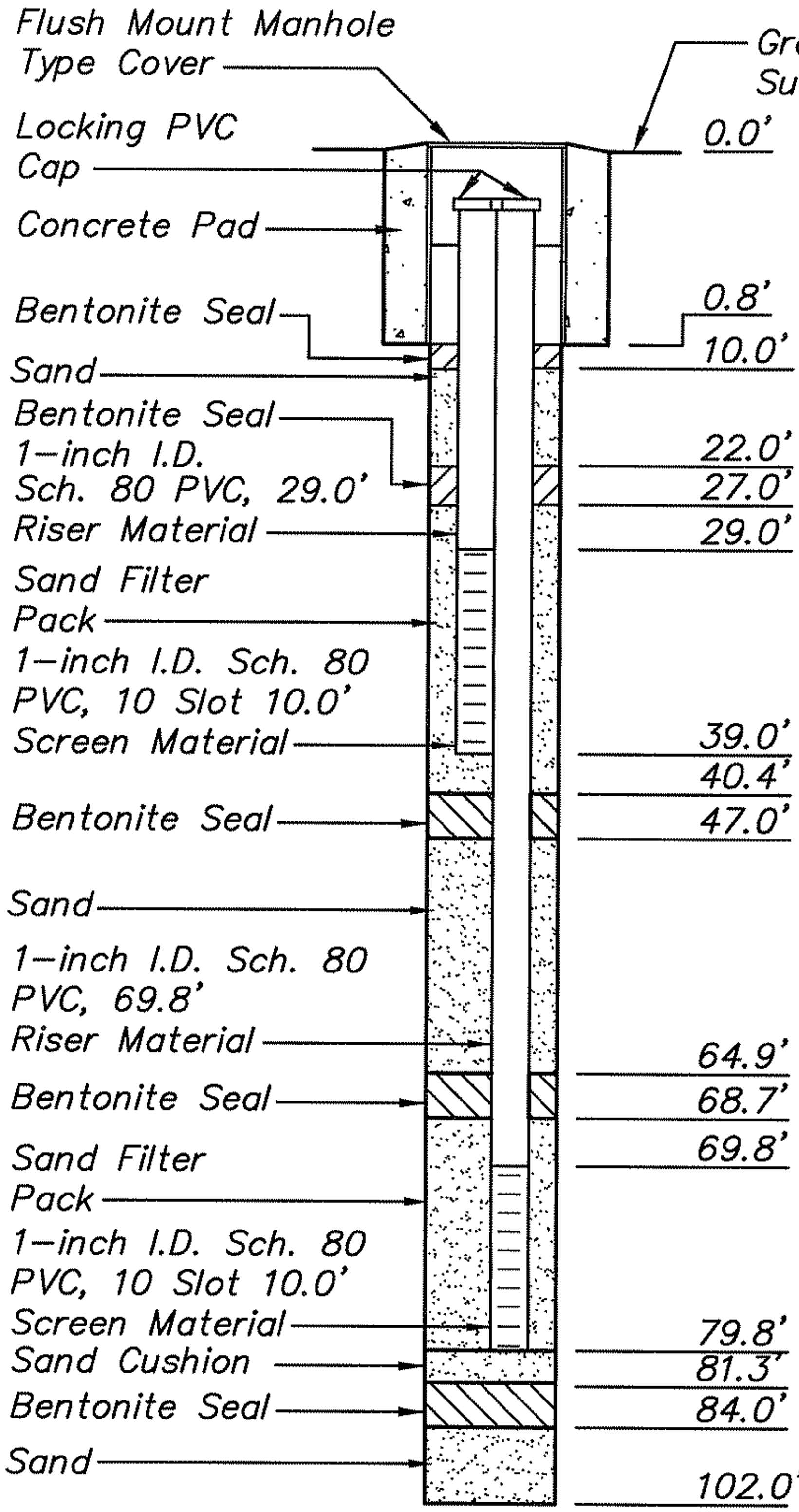


OBSERVATION WELL
INSTALLATION DETAIL B-7
Ohio River Bridge
Design Section No.4
Item No. 5-118.11
Jefferson County, Kentucky

NOT TO SCALE

EMSM ENGINEERS

LX200411O\WWELLB-7.DWG

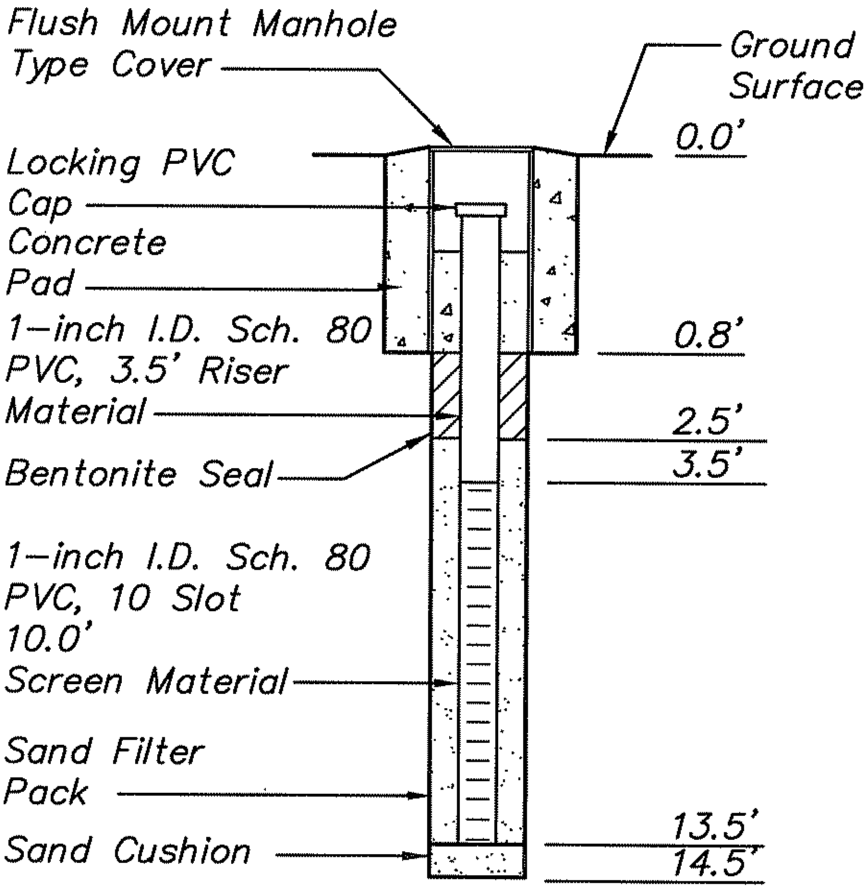


OBSERVATION WELL
INSTALLATION DETAIL B-8
Ohio River Bridge
Design Section No.4
Item No. 5-118.11
Jefferson County, Kentucky

EMSM ENGINEERS

NOT TO SCALE

LX2004110\MWELLB-8.DWG

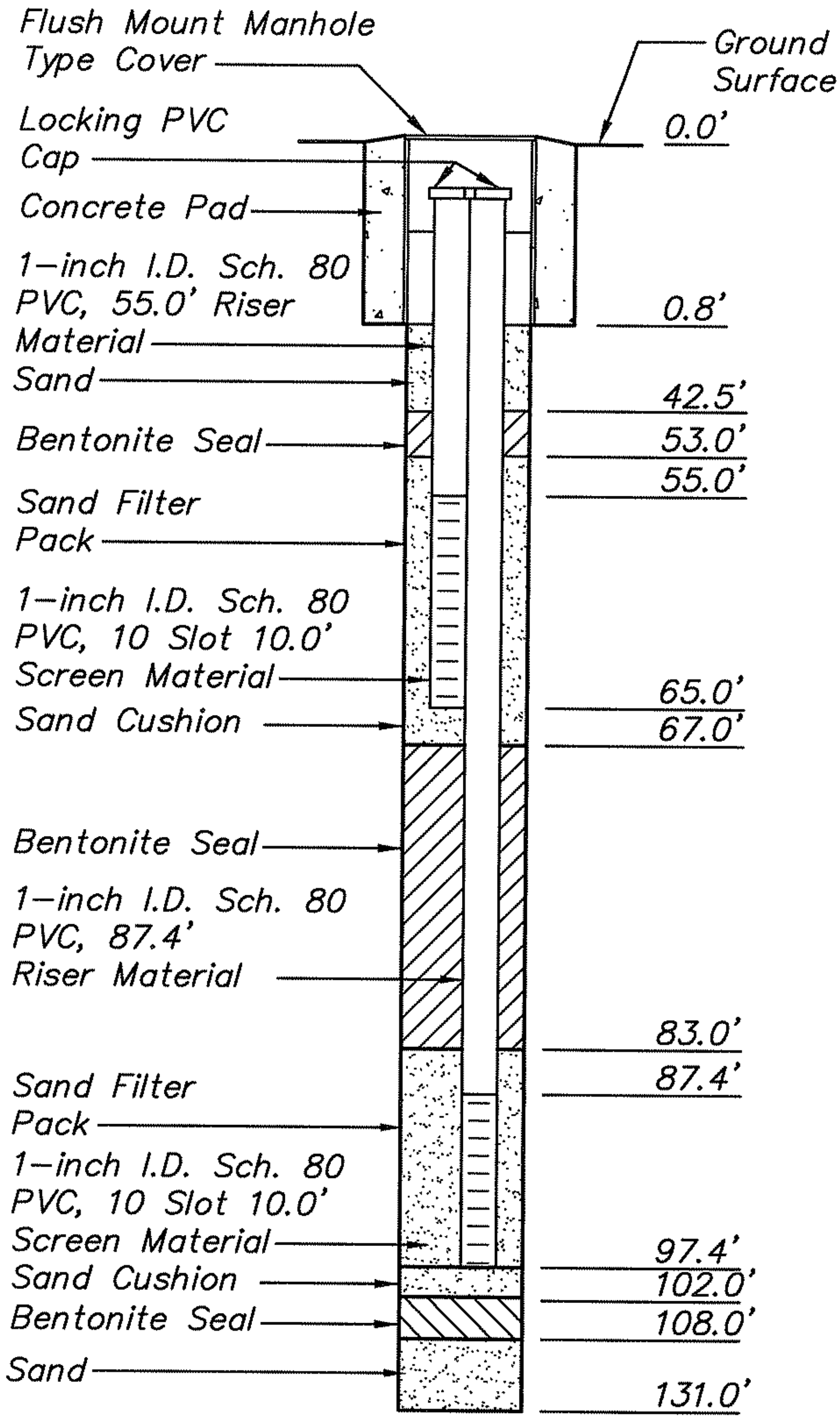


OBSERVATION WELL
INSTALLATION DETAIL B-8A
Ohio River Bridge
Design Section No.4
Item No. 5-118.11
Jefferson County, Kentucky

NOT TO SCALE

FMSM ENGINEERS

LX200411O\MWELLB-8A.DWG

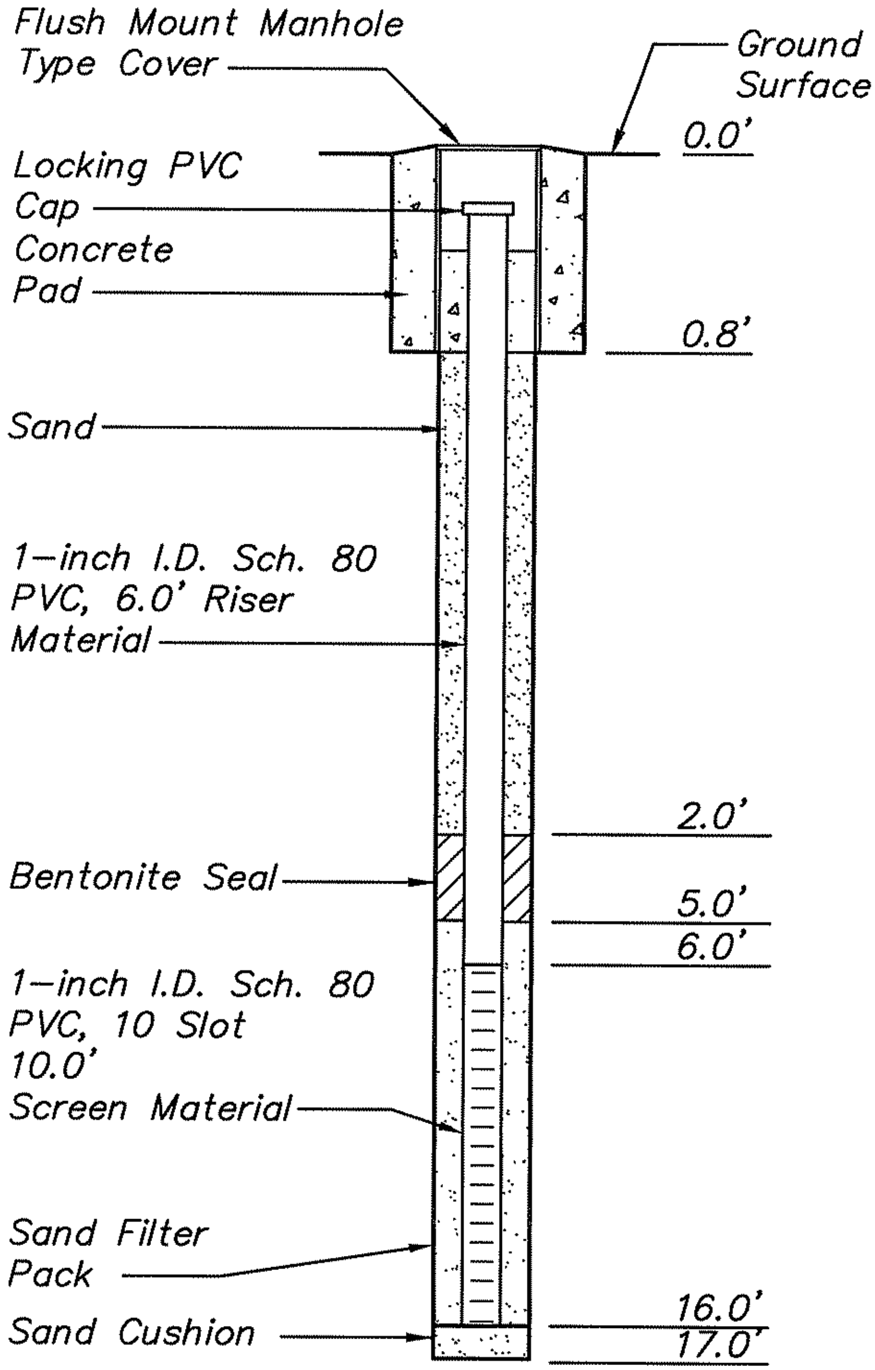


OBSERVATION WELL
INSTALLATION DETAIL B-9
Ohio River Bridge
Design Section No.4
Item No. 5-118.11
Jefferson County, Kentucky

FMSM ENGINEERS

NOT TO SCALE

LX200411O\MWELLB-9.DWG

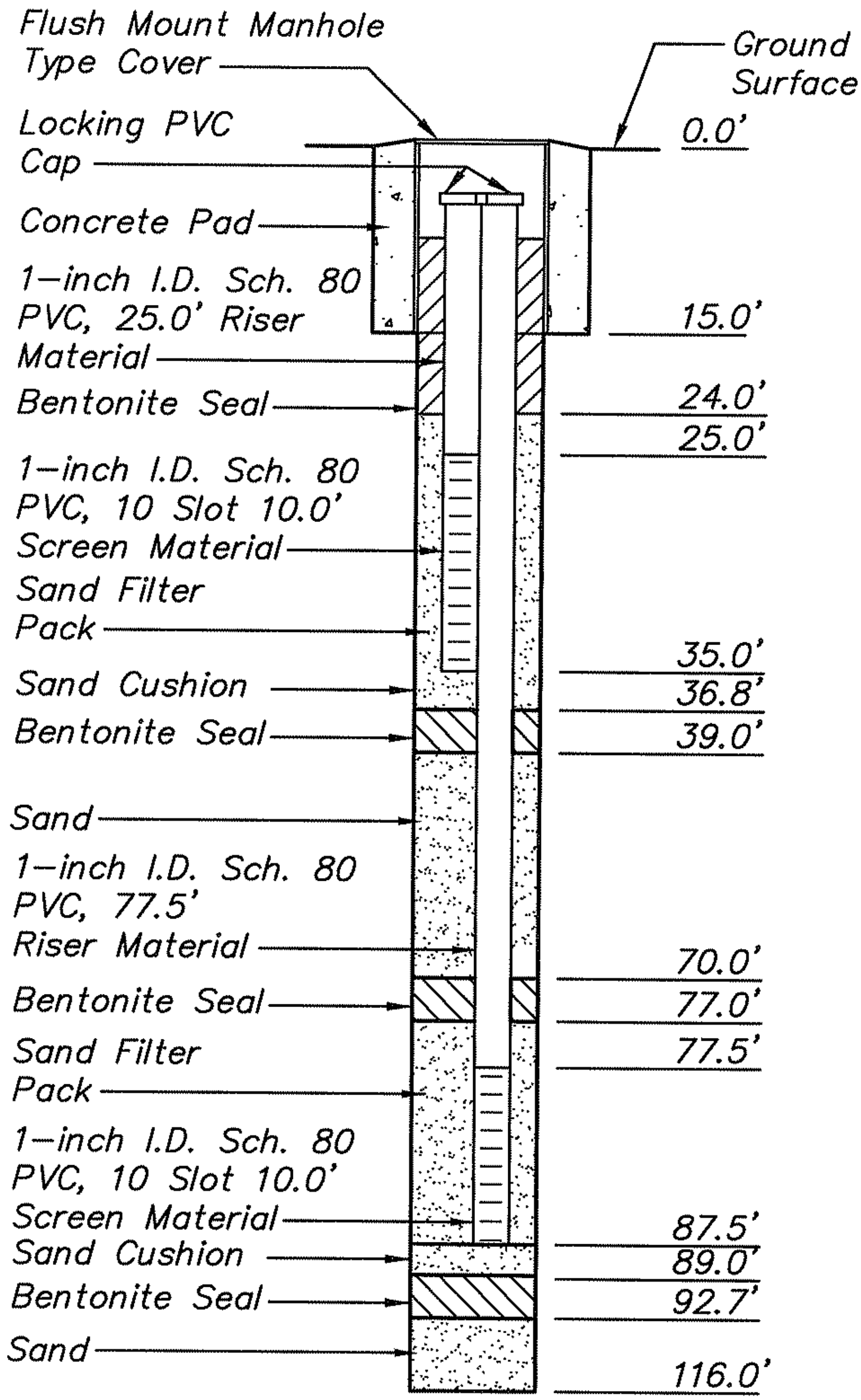


OBSERVATION WELL
INSTALLATION DETAIL B-9A
Ohio River Bridge
Design Section No.4
Item No. 5-118.11
Jefferson County, Kentucky

EMSM
ENGINEERS

NOT TO SCALE

LX203411O\WWELLB-9A.DWG

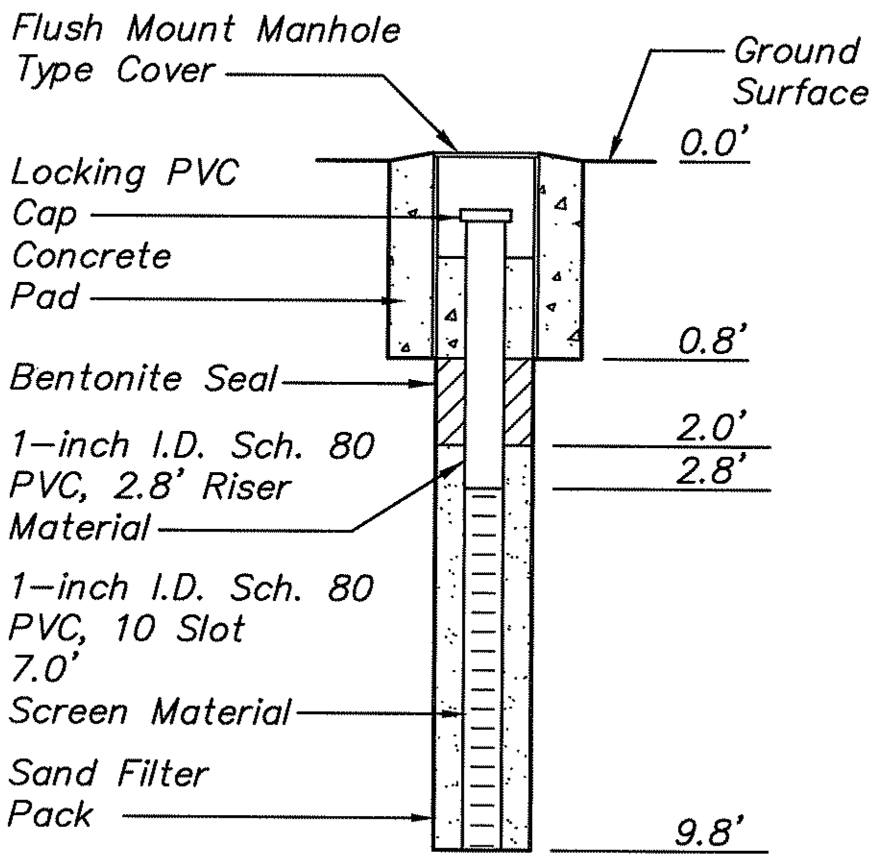


OBSERVATION WELL
INSTALLATION DETAIL B-10
Ohio River Bridge
Design Section No.4
Item No. 5-118.11
Jefferson County, Kentucky

NOT TO SCALE

EMSM ENGINEERS

LX200410\MWELLB-10.DWG

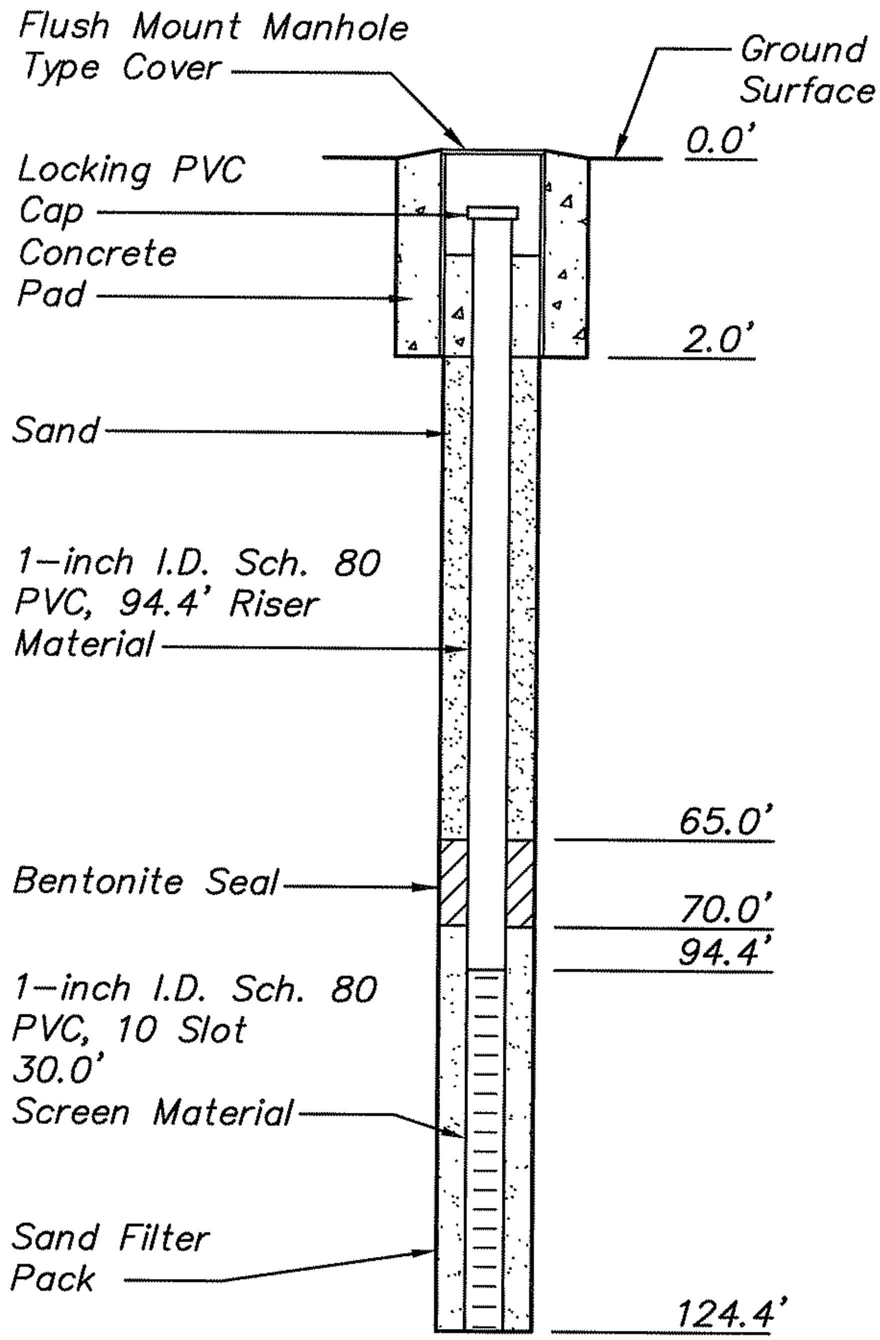


OBSERVATION WELL
INSTALLATION DETAIL B-10A
Ohio River Bridge
Design Section No.4
Item No. 5-118.11
Jefferson County, Kentucky

NOT TO SCALE

FMSM ENGINEERS

LX2004110\MWELLB-10A.DWG

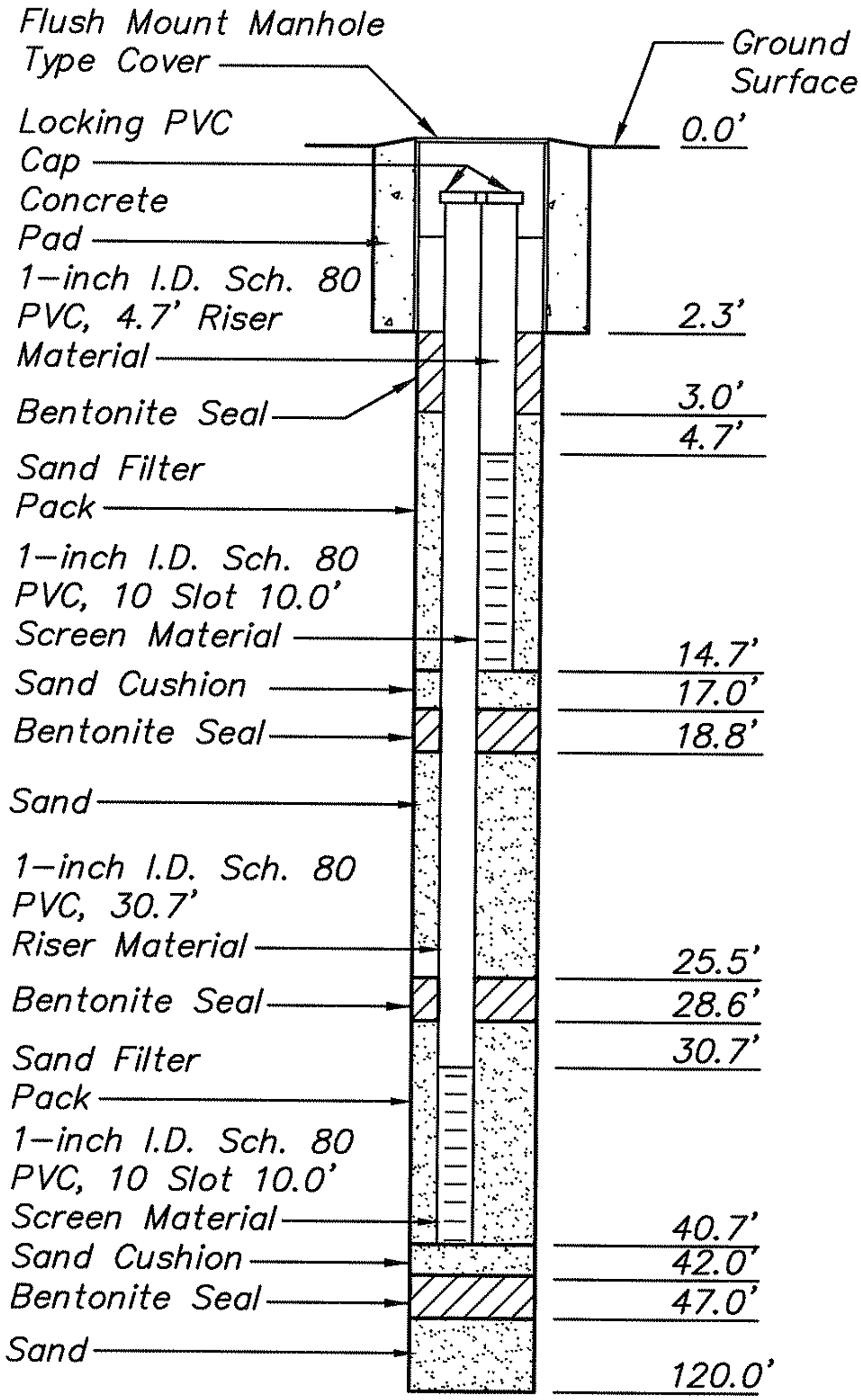


OBSERVATION WELL
INSTALLATION DETAIL B-12
Ohio River Bridge
Design Section No.4
Item No. 5-118.11
Jefferson County, Kentucky

NOT TO SCALE

EMSM ENGINEERS

LX2004110\WWELLB-12.DWG



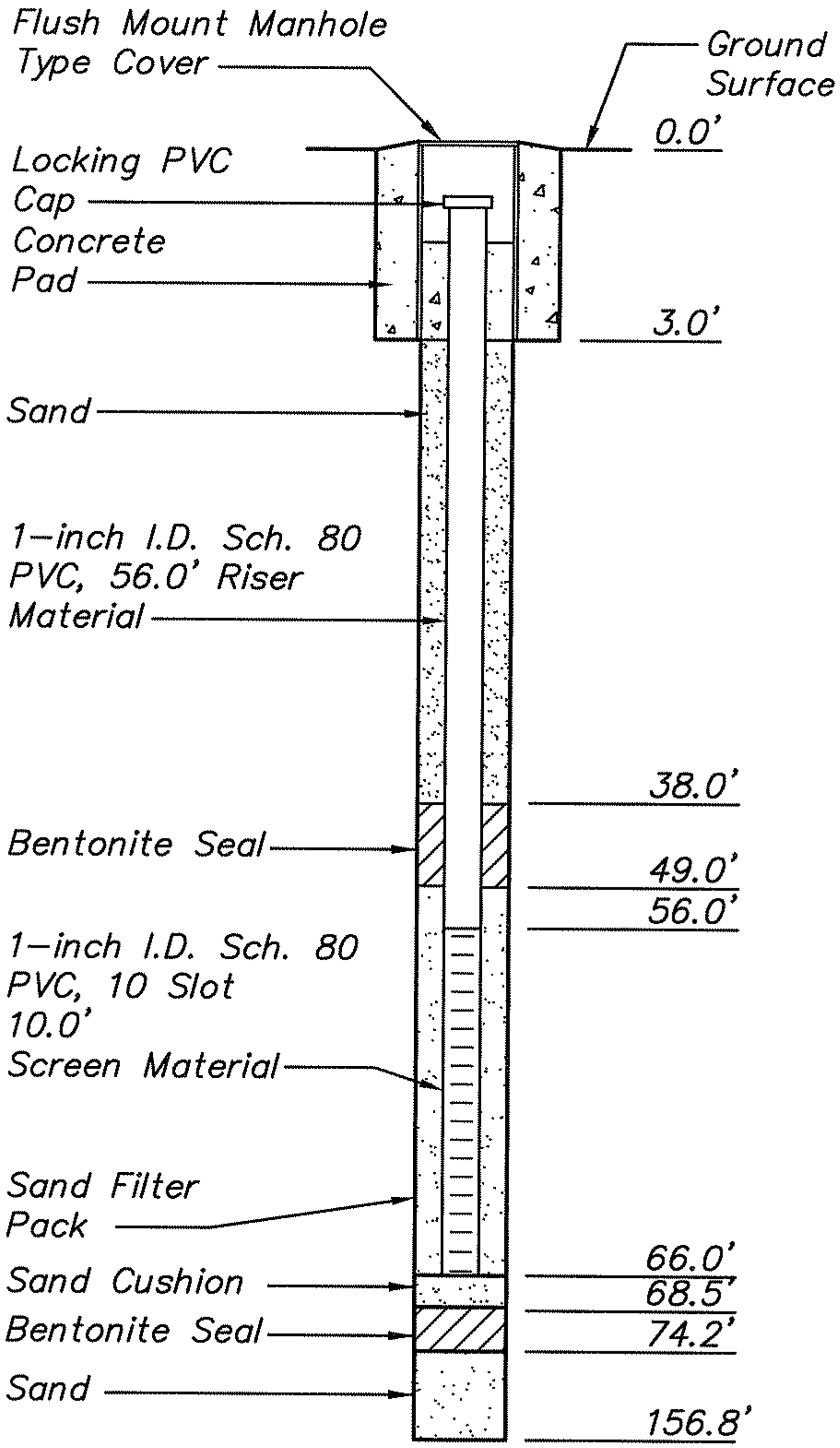
OBSERVATION WELL
INSTALLATION DETAIL B-14

Ohio River Bridge
Design Section No.4
Item No. 5-118.11
Jefferson County, Kentucky

FMSM ENGINEERS

NOT TO SCALE

LX2004110\MWELLB-14.DWG

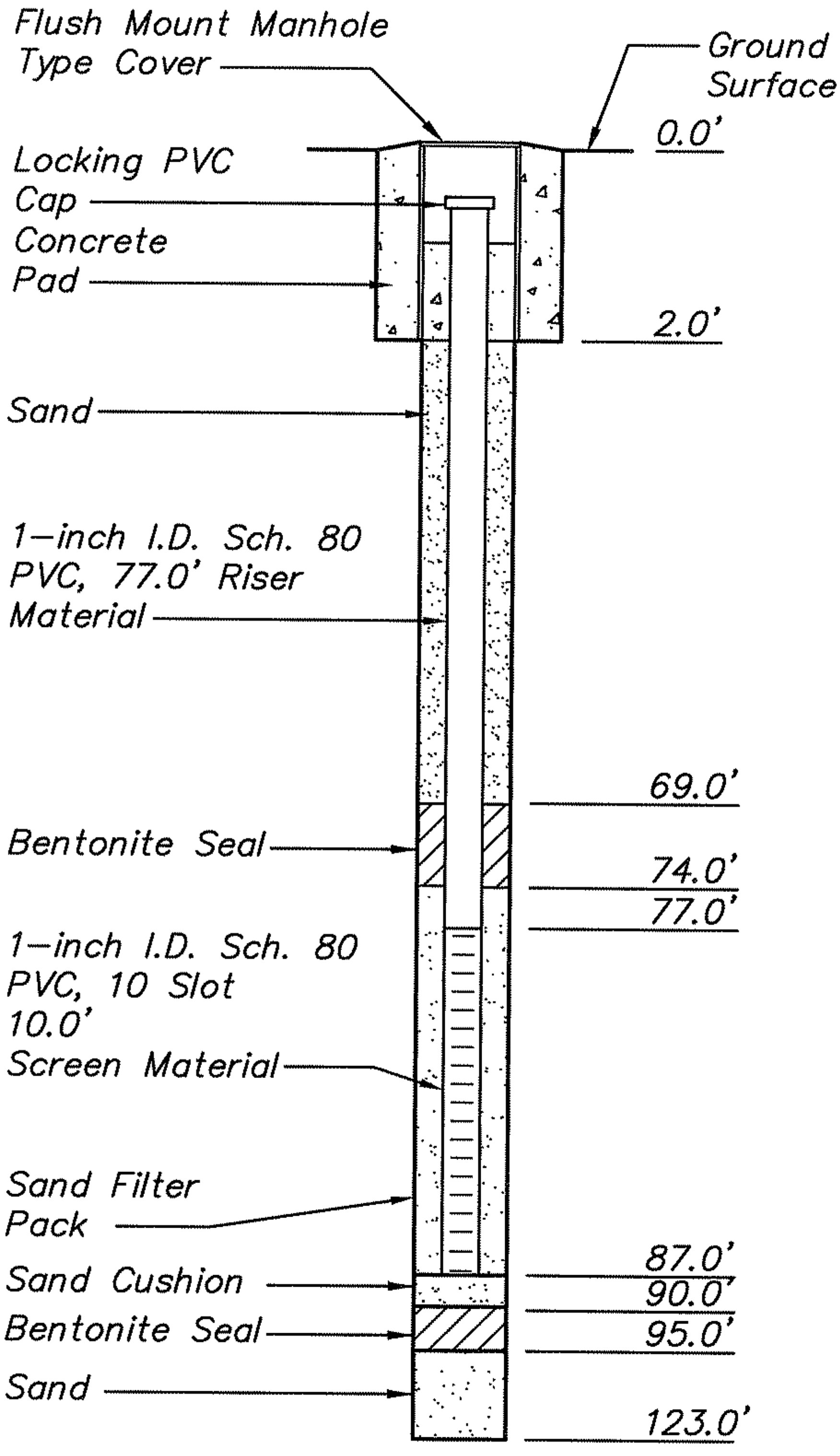


OBSERVATION WELL
INSTALLATION DETAIL B-15
Ohio River Bridge
Design Section No.4
Item No. 5-118.11
Jefferson County, Kentucky

NOT TO SCALE

FMSM ENGINEERS

LX2004110\MWELLB-15.DWG



OBSERVATION WELL
INSTALLATION DETAIL B-18
Ohio River Bridge
Design Section No.4
Item No. 5-118.11
Jefferson County, Kentucky

NOT TO SCALE

FMSM ENGINEERS

LX2004110\MWELLB-18.DWG

Observation Well Readings

East End Approach Phase II
Observation Well Readings LX2004110

Station and Offset	Hole Number		Boring Elevation (ft)	Tip Depth (ft)	Depth to Water 12/15/05	Depth to Water 12/16/05	Depth to Water 12/20/05	Depth to Water 12/27/05	Depth to Water 1/9/06	Depth to Water 1/23/06	Depth to Water 2/6/06	Depth to Water 3/6/06
					Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
Phase II												
122+08.4, 11.5' Rt.	B-6A		526.1	14.9			14.5	14.5	14.5	12.1	14.4	
122+08.4, 8.5' Rt.	B-6b		526.1	20.0			Dry	19.9	19.9	19.9	19.9	
122+08.4, 8.5' Rt.	B-6c		526.1	55.0			Dry	49.9	52.4	52.7	52.7	
118+67.7, 22.2' Rt.	B-8A		540.1	13.5	13.0	10.2	10.3	10.5	10.5	10.2	10.5	
118+67.7, 18.2' Rt.	B-8b		539.9	38.5			Dry	31.3	32.8	31.1	29.3	
118+67.7, 18.2' Rt.	B-8c		539.9	79.8			79.7	50.6	50.9	44.3	43.4	
116+84.1, 103.0' Rt.	B-9A		568.1	16.0	15.0	14.3	14.3	14.3	14.4	14.5	14.5	
116.84.1, 99.9' Rt.	B-9b		568.0	65.0			Dry	Dry	Dry	Dry	Dry	
116.84.1, 99.9' Rt.	B-9c		568.0	97.4			Dry	93.8	93.9	93.9	93.9	
116+68.7, 17.1' Rt.	B-10A		559.7	9.8	9.6	9.3	9.4	9.5	9.5	6.3	6.7	
116+68.7, 14.1' Rt.	B-10b		559.5	35.0			Dry	32.9	33.8	33.4	33.0	
116+68.7, 14.1' Rt.	B-10c		559.5	87.5			Dry	86.8	86.0	72.6	79.9	
Phase I												
93+50, 35' Rt.	B-18		611.4	87.0					83.0	82.8	82.8	
106+00, 60' Rt.	B-15		578.0	66.0					59.2	58.9	58.6	
109+13, 60' Lt.	B-12		568.8	124.4					88.0	87.9	87.9	
124+40, CL	B-7		517.5	91.8					Dry	Dry	Dry	
128+60, 15' Rt. (Soil/ Rock)	B-14		528.5	14.7					Dry	Dry	Dry	
128+60, 15' Rt. (Limestone/Shale)	B-14		528.5	40.7					33.5	33.5	33.5	

Note: All observation wells were installed in rock core holes where water was used during the coring process. FMSM was unable to completely remove the water from the core holes before the wells were installed. In addition, water was added to the boring annulus to ıtonite pellets which were installed to create a seal.

Added water to the system

PIEZOMETER TIME LAG TEST

PROJECT: East End Approach **Piezometer I.D.:** B-12

INSTRUMENT DATA

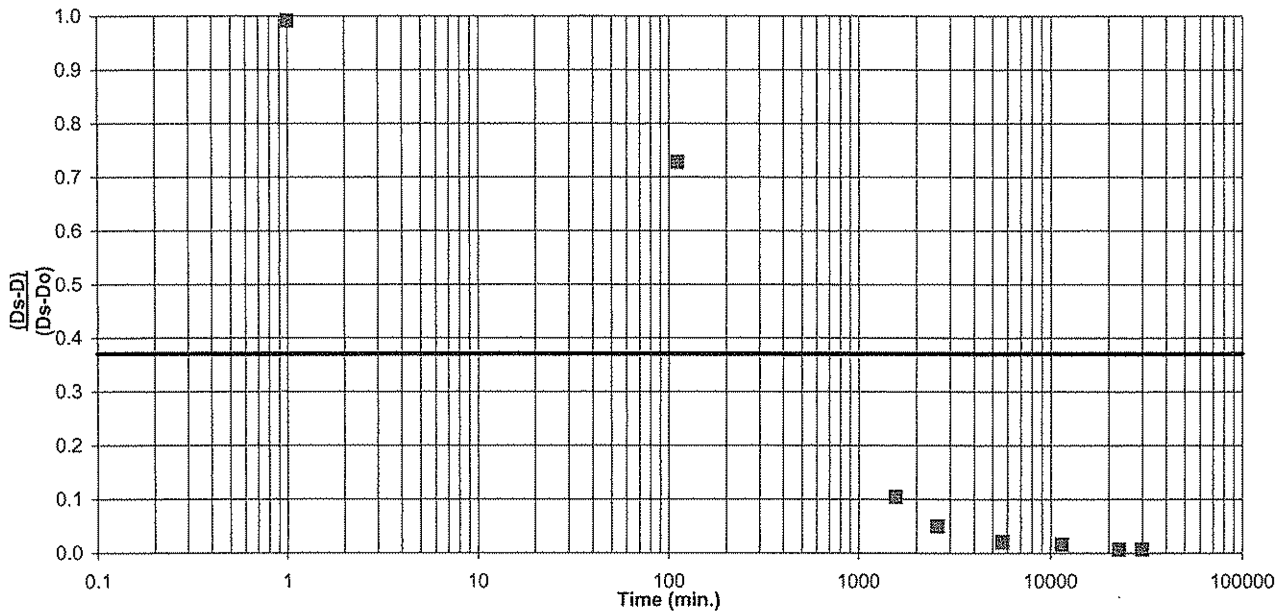
Ground Surface El., G.S.: 568.8
Top of Riser El., T.O.R.: 568.4
Bottom of Piezometer El.: 444.4
Depth from T.O.R.:
Station: 109+13
Offset: 60 FT Lt.

Observers: DB/TO
Date of Test: 4/18/05 -
Dia. of Well 1" Sch 80
Water Level Indicator #:
Water Level Indicator Adjustment: 0
Ambient Piezometer Level, Ds: 88.6
Amount of Water Used (Gal.): +/- 7.5

TEST DATA

Riser below MH rim = 0.37'

Reading Number	Time of Reading	Elapsed Time (min)	D	(Ds-D) / (Ds-Do)	Reading Number	Time of Reading	Elapsed Time (min)	D	(Ds-D) / (Ds-Do)
1	4/18/05 2:09 PM	0.0	0.4	1.000	16				
2	4/18/05 2:10 PM	1.0	1.2	0.991	17				
3	4/18/05 4:01 PM	111.3	24.4	0.728	18				
4	4/19/05 4:22 PM	1572.2	79.4	0.104	19				
5	4/20/05 9:22 AM	2592.2	84.2	0.050	20				
6	4/22/05 12:35 PM	5665.3	86.8	0.020	21				
7	4/26/05 12:45 PM	11435.3	87.2	0.016	22				
8	5/4/05 9:39 AM	22769.3	88.0	0.007	23				
9	5/9/05 11:08 AM	30058.2	88.0	0.007	24				
10				1.004	25				
11				1.004	26				
12				1.004	27				
13				1.004	28				
14				1.004	29				
15				1.004	30				



97270/brr/Brr.xls

Added water to the system

PIEZOMETER TIME LAG TEST

PROJECT: East End Approach **Piezometer I.D.:** B-14

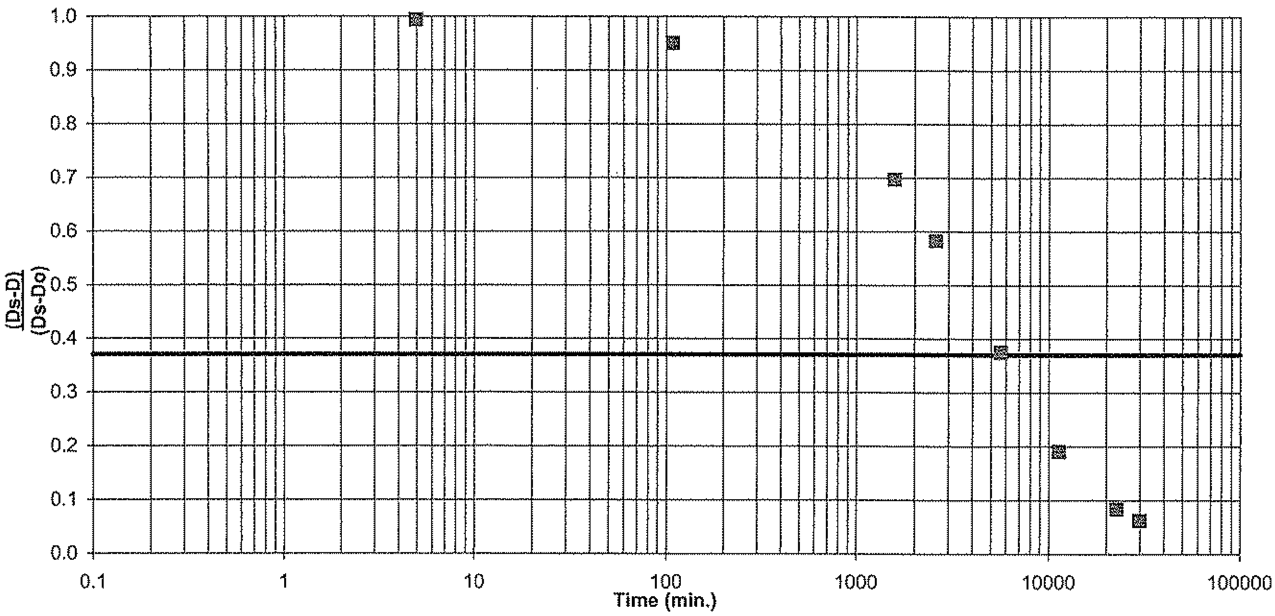
INSTRUMENT DATA

Ground Surface El., G.S.:	528.5	Observers:	DB/TO
Top of Riser El., T.O.R.:	528.2	Date of Test:	4/18/05 -
Bottom of Piezometer El.:	487.8	Dia. of Well	1" Sch 80
Depth from T.O.R.:		Water Level Indicator #:	
		Water Level Indicator Adjustment:	0
Station:	128+60	Ambient Piezometer Level, Ds:	33.6
Offset:	15 FT Rt.	Amount of Water Used (Gal.):	+/- 3.25

TEST DATA

Riser below MH rim = 0.34'

Reading Number	Time of Reading	Elapsed Time (min)	D	(Ds-D) / (Ds-Do)	Reading Number	Time of Reading	Elapsed Time (min)	D	(Ds-D) / (Ds-Do)
1	4/18/05 2:30 PM	0.0	0.3	1.000	16				
2	4/18/05 2:35 PM	5.0	0.6	0.994	17				
3	4/18/05 4:19 PM	108.7	2.0	0.950	18				
4	4/19/05 4:53 PM	1582.2	10.4	0.697	19				
5	4/20/05 9:47 AM	2596.2	14.2	0.583	20				
6	4/22/05 12:53 PM	5662.3	21.1	0.375	21				
7	4/26/05 1:06 PM	11435.2	27.3	0.190	22				
8	5/4/05 9:55 AM	22764.2	30.8	0.084	23				
9	5/9/05 11:15 AM	30044.2	31.5	0.063	24				
10				1.010	25				
11				1.010	26				
12				1.010	27				
13				1.010	28				
14				1.010	29				
15				1.010	30				



Added water to the system

PIEZOMETER TIME LAG TEST

PROJECT: East End Approach **Piezometer I.D.:** B-15

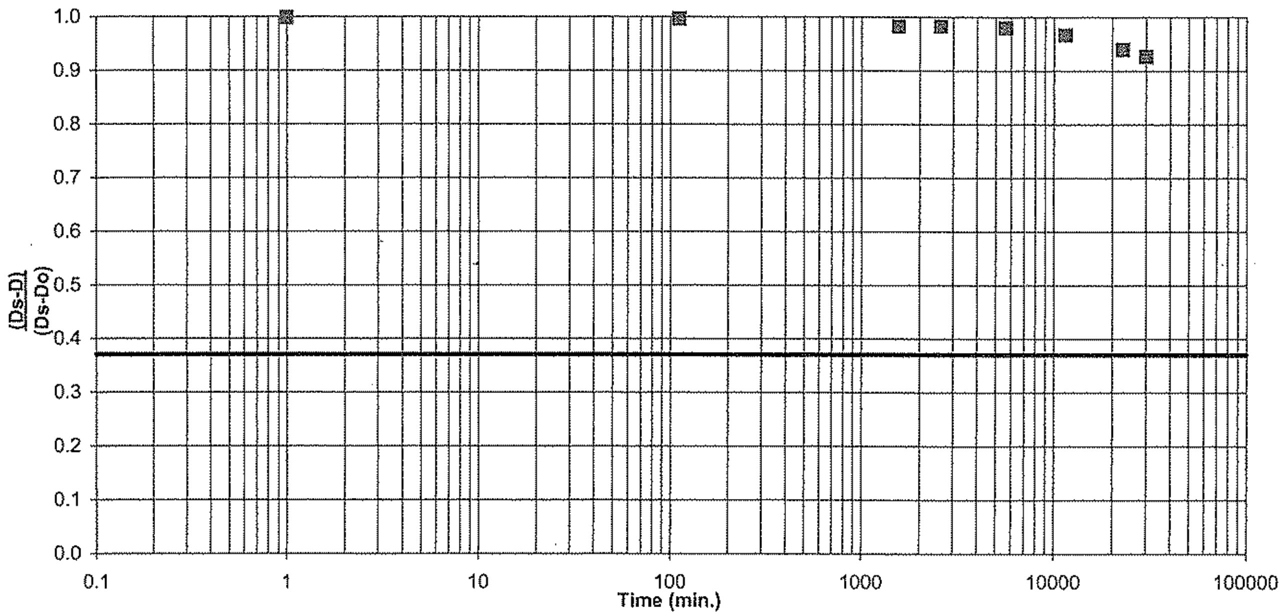
INSTRUMENT DATA

Ground Surface El., G.S.:	578	Observers:	DB/TO
Top of Riser El., T.O.R.:	577.8	Date of Test:	4/18/05 -
Bottom of Piezometer El.:	512	Dia. of Well	1" Sch 80
Depth from T.O.R.:		Water Level Indicator #:	
Station:	106+00	Water Level Indicator Adjustment:	0
Offset:	60 FT Rt.	Ambient Piezometer Level, Ds:	62.3
		Amount of Water Used (Gal.):	+/- 3.85

TEST DATA Riser below MH rim = 0.25'

Reading Number	Time of Reading	Elapsed Time (min)	D	(Ds-D) / (Ds-Do)	Reading Number	Time of Reading	Elapsed Time (min)	D	(Ds-D) / (Ds-Do)
1	4/18/05 2:16 PM	0.0	0.3	1.000	16				
2	4/18/05 2:17 PM	1.0	0.4	0.998	17				
3	4/18/05 4:07 PM	111.5	0.5	0.996	18				
4	4/19/05 4:15 PM	1559.0	1.3	0.983	19				
5	4/20/05 9:28 AM	2592.0	1.3	0.983	20				
6	4/22/05 12:29 PM	5653.0	1.5	0.980	21				
7	4/26/05 1:38 PM	11482.0	2.3	0.967	22				
8	5/4/05 9:33 AM	22757.0	4.0	0.939	23				
9	5/9/05 2:05 PM	30229.0	4.8	0.926	24				
10				1.004	25				
11				1.004	26				
12				1.004	27				
13				1.004	28				
14				1.004	29				
15				1.004	30				

* Water levels adjusted from 4/19/05 by subtracting 1.8 ft from the field reading.



Added water to the system

PIEZOMETER TIME LAG TEST

PROJECT: East End Approach **Piezometer I.D.:** B-18

INSTRUMENT DATA

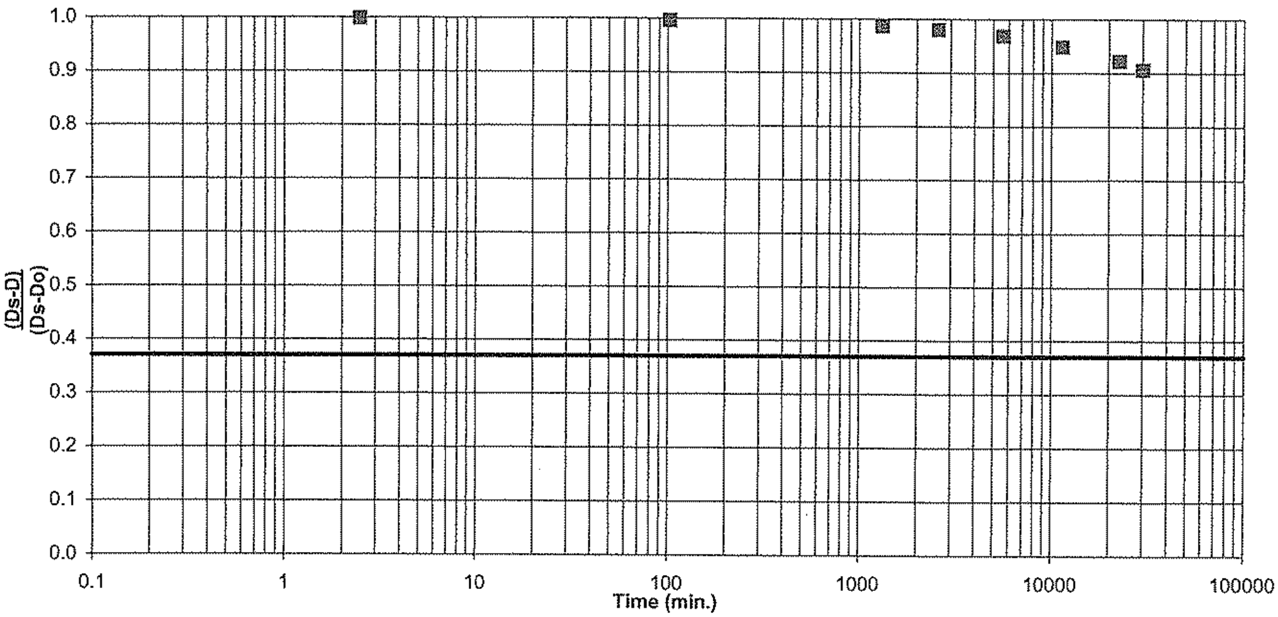
Ground Surface El., G.S.:	611.4	Observers:	DB/TO
Top of Riser El., T.O.R.:	611.2	Date of Test:	4/18/05 -
Bottom of Piezometer El.:	524.4	Dia. of Well	1" Sch 80
Depth from T.O.R.:		Water Level Indicator #:	
Station:	93+50	Water Level Indicator Adjustment:	0
Offset:	35 FT Rt.	Ambient Piezometer Level, Ds:	85.1
		Amount of Water Used (Gal.):	+/-4.5

TEST DATA

Riser below MH rim = 0.23'

Reading Number	Time of Reading	Elapsed Time (min)	D	(Ds-D)/(Ds-Do)	Reading Number	Time of Reading	Elapsed Time (min)	D	(Ds-D)/(Ds-Do)
1	4/18/05 2:47 PM	0.0	0.2	1.000	16				
2	4/18/05 2:50 PM	2.5	0.4	0.998	17				
3	4/18/05 4:30 PM	102.5	0.6	0.996	18				
4	4/19/05 12:44 PM	1316.5	1.4	0.986	19				
5	4/20/05 10:04 AM	2596.5	1.9	0.980	20				
6	4/22/05 1:06 PM	5658.5	2.9	0.969	21				
7	4/26/05 1:22 PM	11434.5	4.6	0.948	22				
8	5/4/05 10:13 AM	22765.5	6.8	0.922	23				
9	5/9/05 1:55 PM	30187.5	8.2	0.906	24				
10				1.003	25				
11				1.003	26				
12				1.003	27				
13				1.003	28				
14				1.003	29				
15				1.003	30				

* Water levels adjusted from 4/19/05 by subtracting 1.6 ft from the field reading.



Removed water from the system

PIEZOMETER SLUG TEST

PROJECT: East End Approach **Piezometer I.D.:** B-12

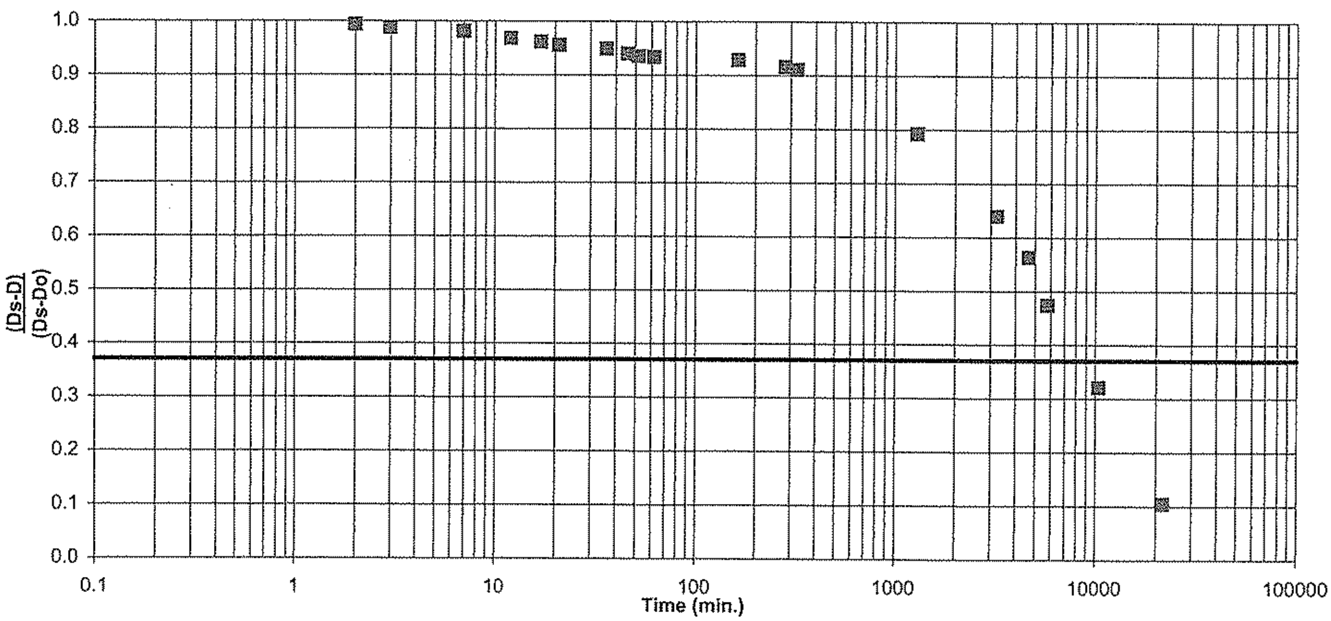
INSTRUMENT DATA

Ground Surface El., G.S.:	568.8	Observers:	DB/TO
Top of Riser El., T.O.R.:	568.4	Date of Test:	5/9/05
Bottom of Piezometer El.:	444.4	Dia. of Well	1" Sch 80
Depth from T.O.R.:		Water Level Indicator #:	
Station:	109+13	Water Level Indicator Adjustment:	0
Offset:	60 FT Lt.	Ambient Piezometer Level, Ds:	88.6
		Date of Ambient Level:	4/18/2005

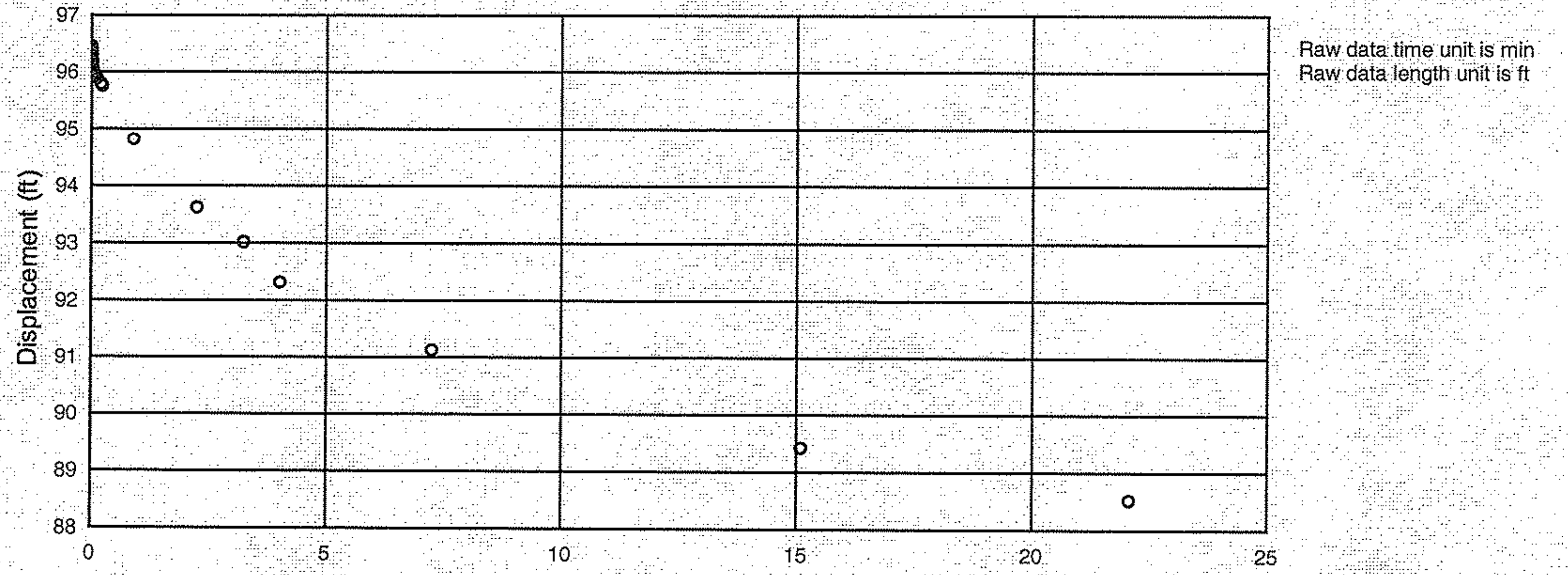
TEST DATA

Riser below MH rim = 0.37'
+/- 1.1 gallons removed

Reading Number	Time of Reading	Elapsed Time (min)	D	(Ds-D) / (Ds-Do)	Reading Number	Time of Reading	Elapsed Time (min)	D	(Ds-D) / (Ds-Do)
1	5/9/05 11:38 AM	0.0	96.45	1.000	16	5/11/05 5:31 PM	3233.0	93.62	0.639
2	5/9/05 11:40 AM	2.0	96.40	0.994	17	5/12/05 5:22 PM	4664.0	93.02	0.563
3	5/9/05 11:41 AM	3.0	96.35	0.987	18	5/13/05 12:05 PM	5787.0	92.32	0.474
4	5/9/05 11:45 AM	7.0	96.30	0.981	19	5/16/05 5:35 PM	10437.0	91.12	0.321
5	5/9/05 11:50 AM	12.0	96.20	0.968	20	5/24/05 2:00 PM	21742.0	89.42	0.104
6	5/9/05 11:55 AM	17.0	96.15	0.962	21	5/31/05 1:18 PM	31780.0	88.52	-0.010
7	5/9/05 11:59 AM	21.0	96.10	0.955	22				
8	5/9/05 12:14 PM	36.0	96.05	0.949	23				
9	5/9/05 12:24 PM	46.0	95.98	0.940	24				
10	5/9/05 12:30 PM	52.0	95.94	0.935	25				
11	5/9/05 12:40 PM	62.0	95.93	0.934	26				
12	5/9/05 2:22 PM	164.0	95.89	0.929	27				
13	5/9/05 4:20 PM	282.0	95.79	0.916	28				
14	5/9/05 5:02 PM	324.0	95.75	0.911	29				
15	5/10/05 9:13 AM	1295.0	94.82	0.792	30				

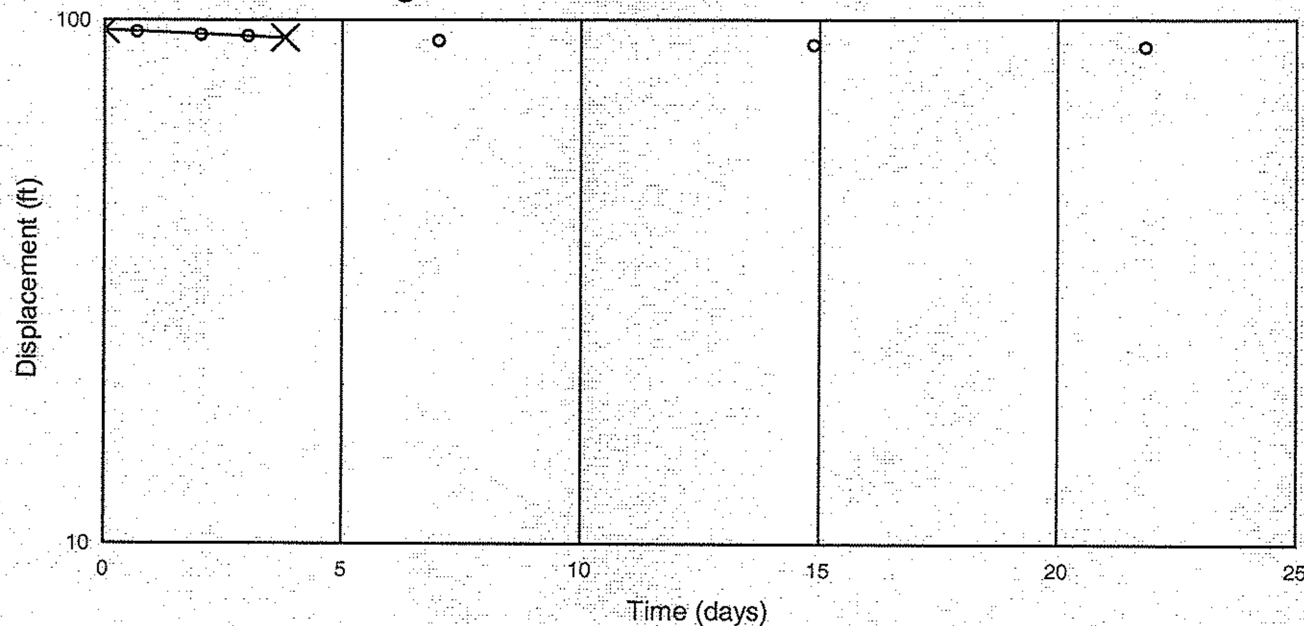


Rising Head Slug Test
Boring 12



(Bouwer & Rice, 1976)

Rising Head Slug Test
Boring 12



(Bouwer & Rice, 1976)

Rising head test

INPUT PARAMETERS
Raw data time unit is min
Raw data length unit is ft
b = 35.80 ft
H = 35.80 ft
L = 30.00 ft
rw = 0.08 ft
rc = 0.04 ft

CALCULATED PARAMETERS
Corr. coeff. = -9.94E-001
Yt = 94.97 ft
t = 9.71E+002 min

OUTPUT PARAMETERS
K = 1.33E-006 ft/day

Removed water from the system

PIEZOMETER SLUG TEST

PROJECT: East End Approach **Piezometer I.D.:** B-14

INSTRUMENT DATA

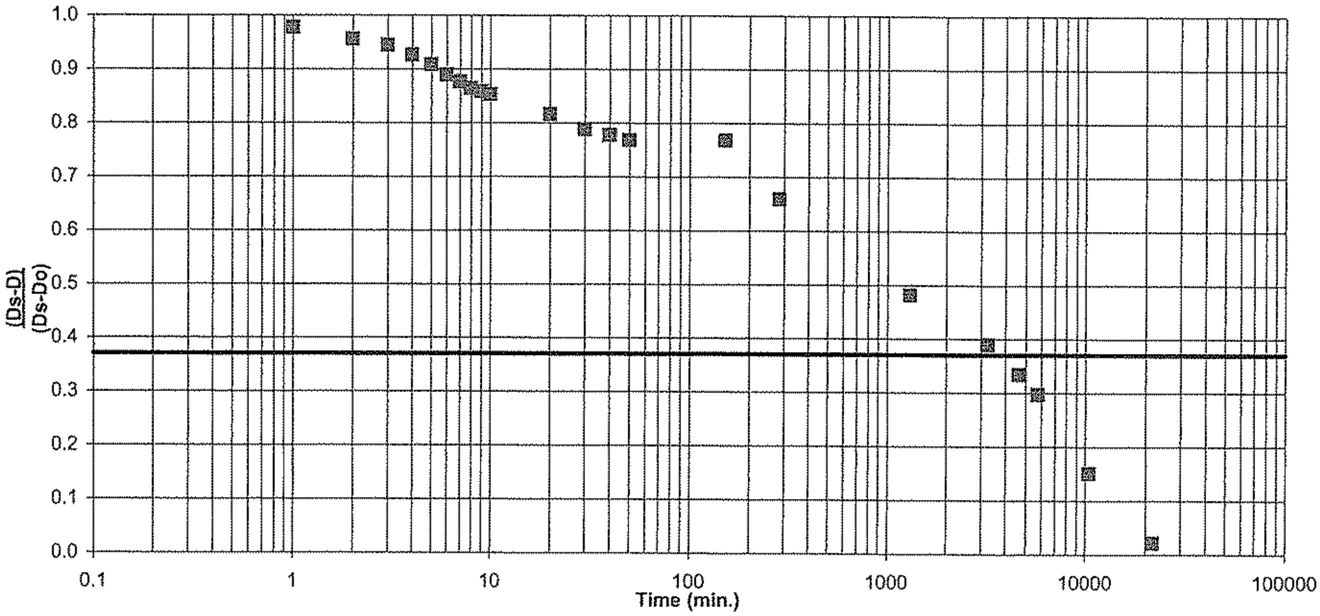
Ground Surface El., G.S.: 528.5
Top of Riser El., T.O.R.: 528.2
Bottom of Piezometer El.: 487.8
Depth from T.O.R.:
Station: 128+60
Offset: 15 FT Rt.

Observers: DB/TO
Date of Test: 5/9/05 -
Dia. of Well 1" Sch 80
Water Level Indicator #:
Water Level Indicator Adjustment: 0
Ambient Piezometer Level, Ds: 33.6
Date of Ambient Level: 4/18/2005

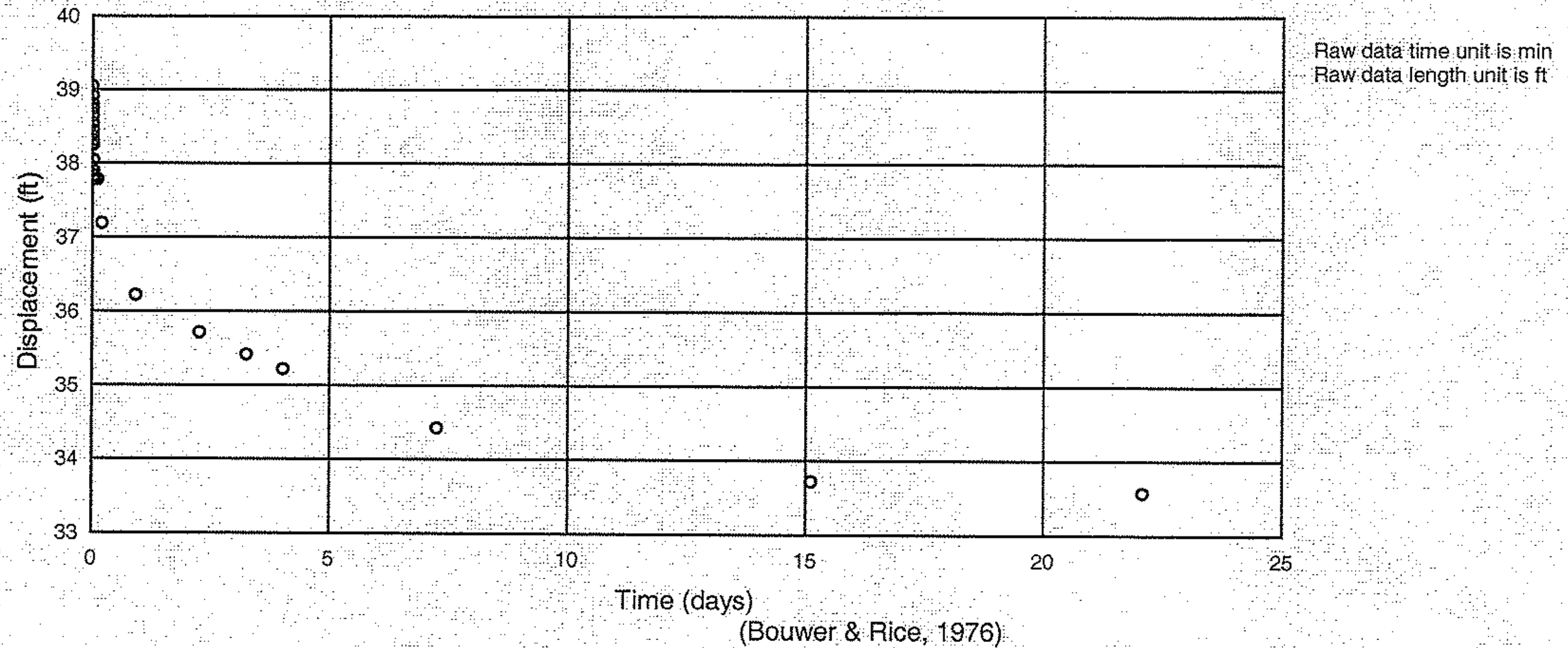
TEST DATA

Riser below MH rim = 0.34'
+/- 1.05 gallons removed

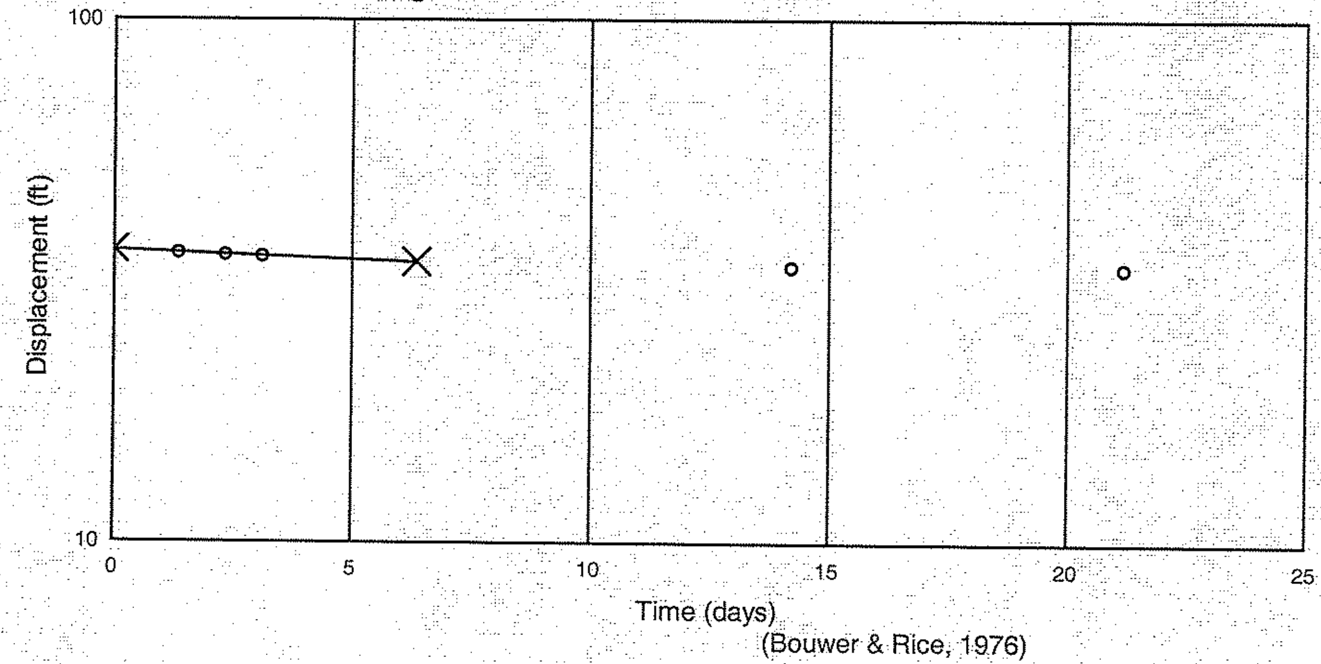
Reading Number	Time of Reading	Elapsed Time (min)	D	(Ds-D) (Ds-Do)	Reading Number	Time of Reading	Elapsed Time (min)	D	(Ds-D) (Ds-Do)
1	5/9/05 11:43 AM	0.0	39.04	1.000	16	5/9/05 2:14 PM	151.0	37.78	0.768
2	5/9/05 11:44 AM	1.0	38.92	0.978	17	5/9/05 4:28 PM	285.0	37.19	0.660
3	5/9/05 11:45 AM	2.0	38.80	0.956	18	5/10/05 9:30 AM	1307.0	36.22	0.482
4	5/9/05 11:46 AM	3.0	38.74	0.945	19	5/11/05 5:51 PM	3248.0	35.72	0.390
5	5/9/05 11:47 AM	4.0	38.64	0.926	20	5/12/05 5:40 PM	4677.0	35.42	0.335
6	5/9/05 11:48 AM	5.0	38.54	0.908	21	5/13/05 12:11 PM	5788.0	35.22	0.298
7	5/9/05 11:49 AM	6.0	38.44	0.890	22	5/16/05 5:48 PM	10445.0	34.42	0.151
8	5/9/05 11:50 AM	7.0	38.37	0.877	23	5/24/05 2:17 PM	21754.0	33.72	0.022
9	5/9/05 11:51 AM	8.0	38.30	0.864	24	5/31/05 1:37 PM	31794.0	33.57	-0.006
10	5/9/05 11:52 AM	9.0	38.27	0.858	25				
11	5/9/05 11:53 AM	10.0	38.24	0.853	26				
12	5/9/05 12:03 PM	20.0	38.04	0.816	27				
13	5/9/05 12:13 PM	30.0	37.89	0.789	28				
14	5/9/05 12:23 PM	40.0	37.83	0.778	29				
15	5/9/05 12:33 PM	50.0	37.78	0.768	30				



Rising Head Slug Test
Boring 14



Rising Head Slug Test
Boring 14



Rising head test

INPUT PARAMETERS
Raw data time unit is min
Raw data length unit is ft
b = 8.40 ft
H = 8.40 ft
L = 8.40 ft
rw = 0.08 ft
rc = 0.04 ft

CALCULATED PARAMETERS
Corr. coeff. = -9.96E-001
Yt = 35.75 ft
t = 1.94E+003 min

OUTPUT PARAMETERS
K = 2.99E-006 ft/day

Removed water from the system

PIEZOMETER SLUG TEST

PROJECT: East End Approach **Piezometer I.D.:** B-15

INSTRUMENT DATA

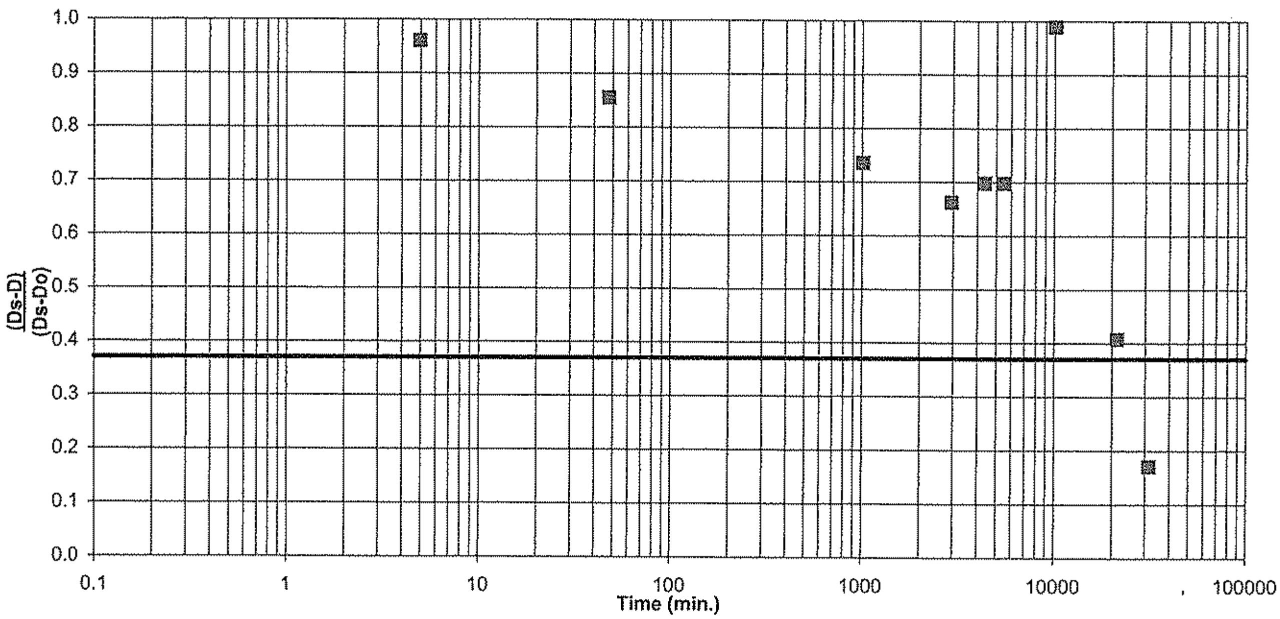
Ground Surface El., G.S.: 578
Top of Riser El., T.O.R.: 577.8
Bottom of Piezometer El.: 512
Depth from T.O.R.:
Station: 106+00
Offset: 60 FT Rt.

Observers: DB/TO
Date of Test: 5/9/2005
Dia. of Well 1" Sch 80
Water Level Indicator #:
Water Level Indicator Adjustment: 0
Ambient Piezometer Level, Ds: 62.3
Date of Ambient Level: 4/18/2005

TEST DATA

Riser below MH rim = 0.25'
+/- 3.25 gallons removed

Reading Number	Time of Reading	Elapsed Time (min)	D	(Ds-D) (Ds-Do)	Reading Number	Time of Reading	Elapsed Time (min)	D	(Ds-D) (Ds-Do)
1	5/9/05 4:11 PM	0.0	65.05	1.000	16				
2	5/9/05 4:16 PM	5.0	64.94	0.960	17				
3	5/9/05 4:59 PM	48.0	64.65	0.855	18				
4	5/10/05 9:06 AM	1015.0	64.32	0.735	19				
5	5/11/05 5:26 PM	2955.0	64.12	0.662	20				
6	5/12/05 5:17 PM	4386.0	64.22	0.698	21				
7	5/13/05 11:58 AM	5507.0	64.22	0.698	22				
8	5/16/05 5:28 PM	10157.0	65.02	0.989	23				
9	5/24/05 1:53 PM	21462.0	63.42	0.407	24				
10	5/31/05 1:13 PM	31502.0	62.77	0.171	25				
11				-22.655	26				
12				-22.655	27				
13				-22.655	28				
14				-22.655	29				
15				-22.655	30				



Removed water from the system

PIEZOMETER SLUG TEST

PROJECT: East End Approach **Piezometer I.D.:** B-18

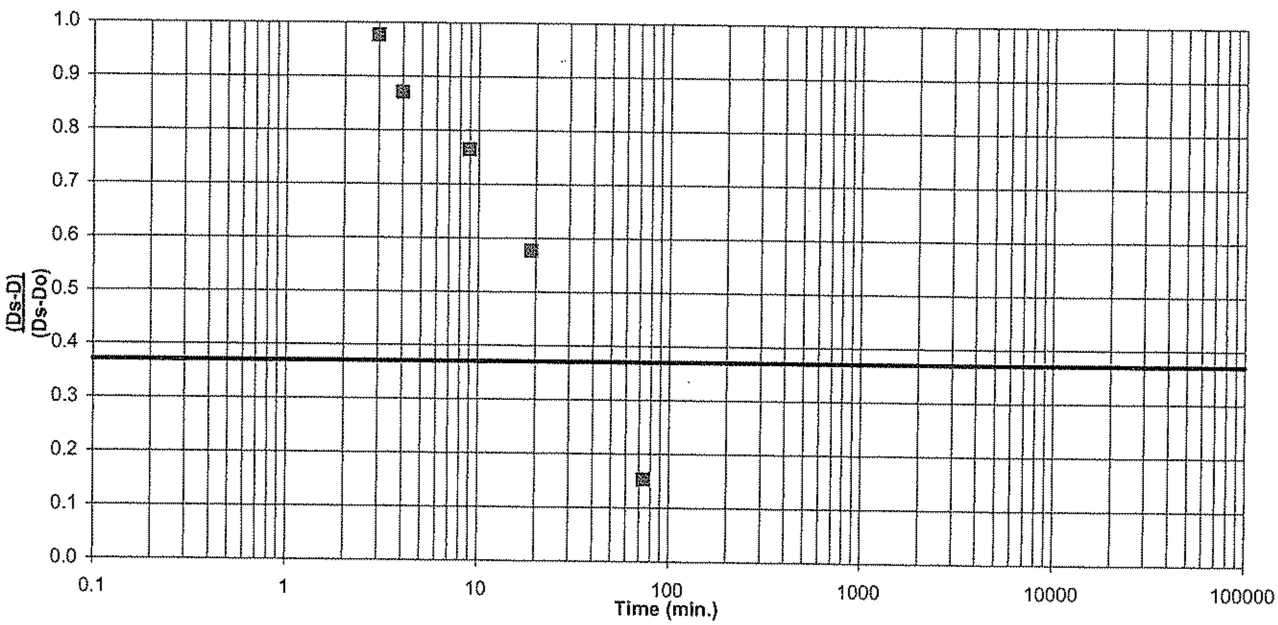
INSTRUMENT DATA

Ground Surface El., G.S.:	611.4	Observers:	DB/TO
Top of Riser El., T.O.R.:	611.2	Date of Test:	5/9/2005
Bottom of Piezometer El.:	524.4	Dia. of Well	1" Sch 80
Depth from T.O.R.:		Water Level Indicator #:	
Station:	93+50	Water Level Indicator Adjustment:	0
Offset:	35 FT Rt.	Ambient Piezometer Level, Ds:	85.1
		Date of Ambient Level:	4/18/2005

TEST DATA

Riser below MH rim = 0.23'
+/- 3.6 gallons removed

Reading Number	Time of Reading	Elapsed Time (min)	D	(Ds-D) (Ds-Do)	Reading Number	Time of Reading	Elapsed Time (min)	D	(Ds-D) (Ds-Do)
1	5/9/05 3:31 PM	0.0	85.95	1.000	16				
2	5/9/05 3:34 PM	3.0	85.93	0.976	17				
3	5/9/05 3:35 PM	4.0	85.84	0.871	18				
4	5/9/05 3:40 PM	9.0	85.75	0.765	19				
5	5/9/05 3:50 PM	19.0	85.59	0.576	20				
6	5/9/05 4:45 PM	74.0	85.23	0.153	21				
7	5/10/05 9:40 AM	1089.0	85.02	-0.094	22				
8	5/11/05 6:05 PM	3034.0	84.92	-0.212	23				
9	5/12/05 5:53 PM	4462.0	85.02	-0.094	24				
10	5/13/05 12:30 PM	5579.0	85.02	-0.094	25				
11	5/16/05 6:02 PM	10231.0	84.92	-0.212	26				
12	5/24/05 2:28 PM	21537.0	84.82	-0.329	27				
13	5/31/05 1:53 PM	31582.0	84.67	-0.506	28				
14				-100.118	29				
15				-100.118	30				



Phase II Soil Testing Results

Fuller Mossbarger Scott & May

FMSM ENGINEERS

Moisture Content of Soil

AASHTO T 265

Project Name East End Approach

Project Number LX2004110

Tested By MH

Test Method KM

Maximum Particle Size in Sample	No. 40	No. 4	1/2"	1"	2"	
Recommended Minimum Mass (g)	10	100	300	500	1,000	

Material Type: Stratified, Laminated, Lensed, Homogenious

Source	Lab ID	Date Tested	Material Type	Maximum Particle Size	Material Excluded Amount	Material Excluded Size	Pass Min. Mass? (Y/N)	Can Weight (g)	Wet Soil & Can Weight (g)	Dry Soil & CanWeight (g)	Moisture Content (%)
B-6 / 122+10, 5' Rt., 2.0'-3.5'	113	12/22/05	Hom	No. 4			No	18.80	64.50	54.97	26.3
B-6 / 122+10, 5' Rt., 5.0'-6.5'	114	12/22/05	Hom	1/2"	3	1/2"	No	19.32	68.99	59.88	22.5

FMSM ENGINEERS

Summary of Soil Tests

Project Name: East End Approach
Project Number: LX2004110
Source: B-6 / 122+10, 5' Rt., 2.0'-3.5', 5.0'-6.5'
Lab ID: 112

County: Jefferson
Date Received: 12-2-05
Sample Type: SPT Composite
Date Reported: 1-9-06

Test Results

Natural Moisture Content
Test Not Performed
Moisture Content (%): N/A

Particle Size Analysis
Preparation Method: AASHTO T 87
Gradation Method: AASHTO T 88
Hydrometer Method: AASHTO T 88

Particle Size		%
Sieve Size	(mm)	Passing
3"	75	
2"	50	
1 1/2"	37.5	
1"	25	
3/4"	19	100.0
3/8"	9.5	99.1
No. 4	4.75	97.1
No. 10	2	92.6
No. 40	0.425	86.8
No. 200	0.075	83.5
	0.02	49.4
	0.005	25.1
	0.002	19.8
estimated	0.001	19.0

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	2.9	7.4
Coarse Sand	4.5	5.8
Medium Sand	5.8	---
Fine Sand	3.3	3.3
Silt	58.4	63.7
Clay	25.1	19.8

Atterberg Limits
Test Method: AASHTO T 89 & T 90
Prepared: Dry
Liquid Limit: 34
Plastic Limit: 20
Plasticity Index: 14
Activity Index: 0.70

Moisture-Density Relationship
Test Not Performed
Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio
Test Not Performed
Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity
Test Method: AASHTO T 100
Prepared: Dry
Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.69

Classification
Unified Group Symbol: CL
Group Name: Lean clay with sand
AASHTO Classification: A-6 (11)

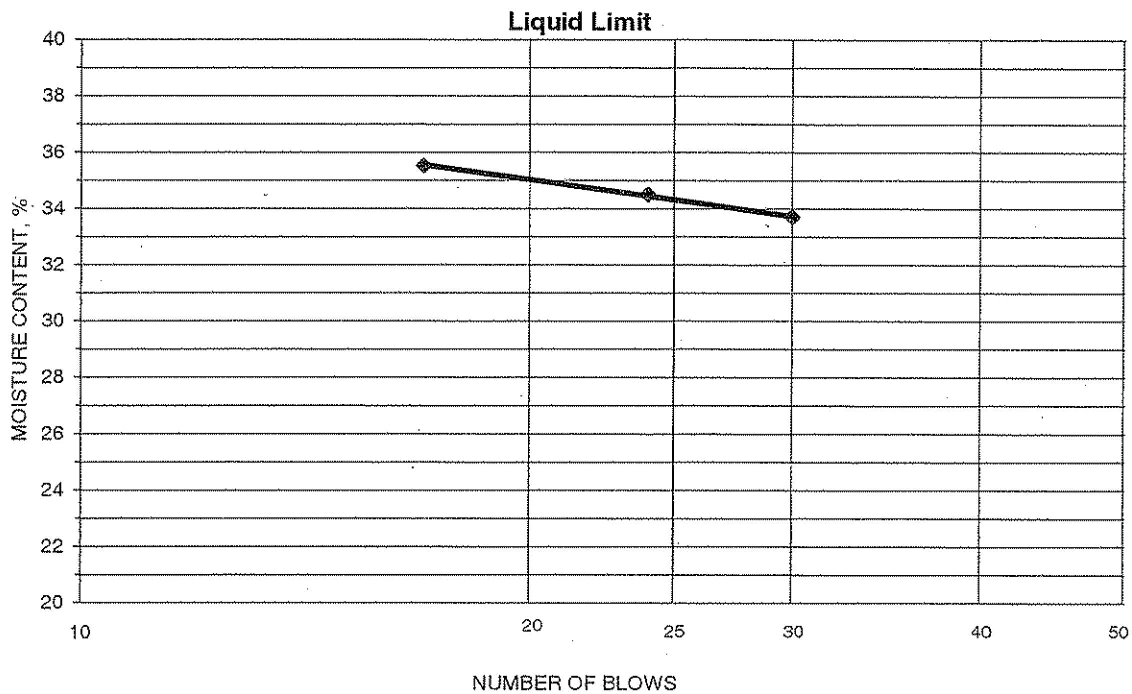
Comments:

Reviewed by:

ATTERBERG LIMITS

Project	East End Approach	Project No.	LX2004110
Source	B-6 / 122+10, 5' Rt., 2.0'-3.5', 5.0'-6.5'	Lab ID	112
		% + No. 40	13
Tested By	KWS	Test Method	AASHTO T 89 & T 90
Date Received	12-02-2005		
Test Date	01-04-2006	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
20.81	18.35	11.05	30	33.7	
20.70	18.23	11.07	24	34.5	
19.45	17.24	11.02	17	35.5	34



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
17.86	16.74	11.18	20.1	20	14
17.90	16.74	11.11	20.6		

Remarks:

Reviewed By

File: LX2004110_Sum-112.xls
Sheet: Limit-Report
Preparation Date: 1998
Revision Date: 05-2002

Fuller, Mossbarger, Scott and May Engineers, Inc.

Laboratory Document
Prepared By: MW
Approved BY: TLK

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Particle-Size Analysis of Soils

AASHTO T 88

Project Name	East End Approach	Project Number	LX2004110
Source	B-6 / 122+10, 5' Rt., 2.0'-3.5', 5.0'-6.5'	Lab ID	112

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: AASHTO T 88
Prepared using: AASHTO T 87

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: MH
Test Date: 12-29-2005
Date Received 12-02-2005

Maximum Particle size: 3/4" Sieve

Sieve Size	% Passing
3"	
2"	
1 1/2"	
1"	
3/4"	100.0
3/8"	99.1
No. 4	97.1
No. 10	92.6

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

Specific Gravity 2.69

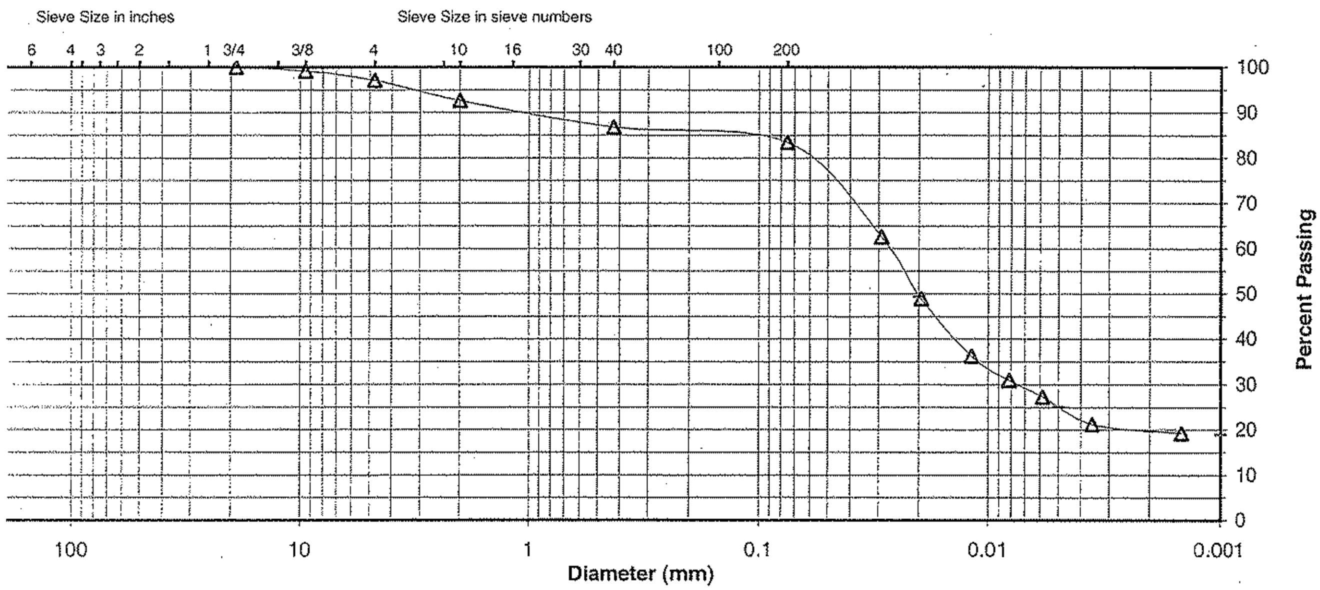
Dispersed using: Apparatus A - Mechanical, for 1 minute

Sieve Size	% Passing
No. 40	86.8
No. 200	83.5
0.02 mm	49.4
0.005 mm	25.1
0.002 mm	19.8
0.001 mm	19.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	2.9	4.5	5.8	3.3	58.4	25.1

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	7.4	5.8	3.3	63.7	19.8



Comments

Reviewed By

Gradation Analysis
AASHTO T 88

FMSM ENGINEERS

Project Name East End Approach — Project Number LX2004110
Source B-6 / 122+10, 5' Rt., 10.0'-11.5' — Lab ID 115

Particle Shape Angular — Particle Hardness Hard and Durable — Prepared AASHTO T 11 Method A

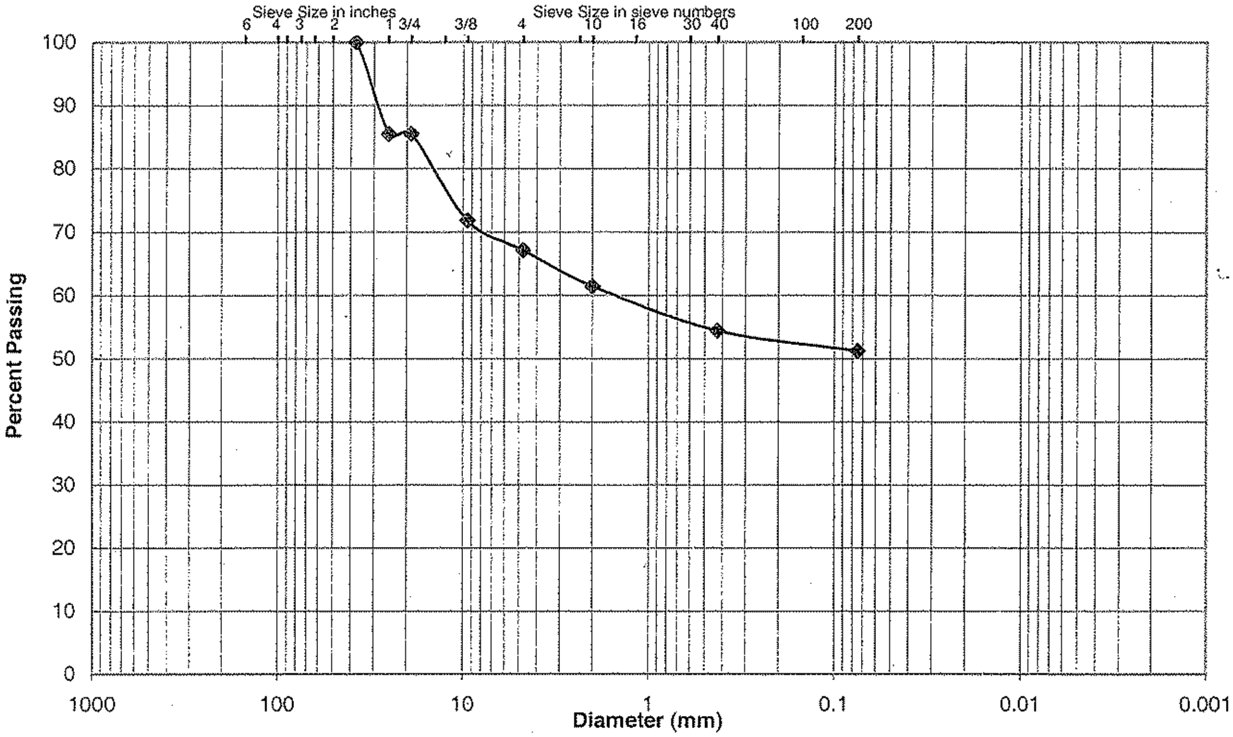
Tested by DC — Test Date 01-04-2006 — Date Received 12-02-2005

Sample Dry Mass (g) 319.51 — Analysis based on: Total Sample

Moisture Content (%) 20.6

Sieve Size	Grams Retained	% Retained	% Passing
6"			
3"			
1 1/2"	0	0.0	100.0
1"	46.49	14.6	85.4
3/4"	0	0.0	85.4
3/8"	43.53	13.6	71.8
No. 4	15.01	4.7	67.1
No. 10	18.13	5.6	61.5
No. 40	22.46	7.1	54.4
No. 200	10.11	3.1	51.3
Pan	164.93	51.7	---

Particle Size Distribution



Comments

Reviewed By

File: LX2004110_200-115.xls Sheet: Sieve-Report
Preparation Date: 5-98
Revision Date: 01-2001

Fuller, Mossbarger, Scott and May Engineers, Inc

Laboratory Document
Prepared By: MW
Approved By: TLK

Appendix E - CD

- CD with Rock Testing Results
- CD with “Borehole Geophysical Logging Results East End Approach Phase II, Prepared by Colog
- CD with “Geophysical Pilot Program in Test Areas Immediately Adjacent to the Drumanard Estates” Prepared by Department of Geological Sciences and Engineering University of Missouri - Rolla

Earth Mechanics Institute

Colorado School of Mines

Mining Engineering Department

Project Name : Ohio River Bridges

Location:

Client: Hatch Mott McDonald

Date: 3/30/2006	Rock Type	Average	Average	Density		Dynamic Velocity				Dynamic Elastic Constants		
Sample		Diameter	Length			P-wave		S-wave		Young's Modulus		Poisson's
ID		(in)	(in)	(lb/ft^3)	(g/cm^3)	(ft/sec)	(m/sec)	(ft/sec)	(m/sec)	(ksi)	(GPa)	Ratio
B-2-9a@17.82-18.09	Sedimentary	1.985	4.099	170	2.72	18,977	5,784	10,047	3,062	9,674	66.7	0.31
B-5-10@57.9-58.35	Sedimentary	1.768	3.945	164	2.63	17,770	5,416	9,669	2,947	8,540	58.9	0.29
B-10-1@47.2-47.6	Sedimentary	1.764	3.973	169	2.71	18,919	5,767	10,033	3,058	9,601	66.2	0.30
B-11-4@85.8-86.3	Sedimentary	1.748	4.007	166	2.65	9,821	2,993	5,757	1,755	2,936	20.2	0.24
B-12-13@45-45.5	Sedimentary	1.982	4.093	164	2.63	15,864	4,835	9,096	2,772	7,368	50.8	0.26
B-12-14@30.8-31.3	Sedimentary	1.983	4.024	168	2.69	19,162	5,841	9,863	3,006	9,292	64.1	0.32

Earth Mechanics Institute

Project Name : LSIORB Section 4

East End Approach Phase 1

Location: Lexington, KY

Client: FMSM

Colorado School of Mines

Mining Engineering Department

Date: 08/04/2005 Sample ID	Rock Name	Cerchar Abrasivity Index
B-7-6@39.0-39.6	Dolomite	1.0
B-7-12@15.1-15.6	Limestone	0.7
B-12-4@72.4-72.9	Dolomite	1.4
B-12-8@10.3-10.9	Limestone	1.0
B-12-9@34.0-34.5	Limestone	0.8
B-14-3@87.1-87.6	Limestone	0.8
B-15-3@122.5-123.1	Dolomite	0.5
B-15-5@66.8-69.5	Shale	0.6
B-15-6@75.6-76.2	Limestone	1.0
B-18-1@50.6-51.3	Limestone	0.9
B-18-4@36.5-37.0	Limestone	0.9

FMSM ENGINEERS
Fuller Mossbarger Scott & May

Point Load Strength Index of Rock

ASTM D 5731
ISRM, Point Load Test

Project Name LSIORB Section 4, East End Approach
Storage Environment Ambient laboratory conditions
Test Method ASTM

Project Number LX2004110
Testing Date 08-11-2005
Drilling Date Feb. 2004

Lab ID	Boring, Interval	Depth (ft)	Rock Type	Moisture Condition	Test Type	Aniso. Load	Foliation/ Joint Dip	W (in)	D (in)	D_e (in)	Load (lbf)	I_s (psi)	F	$I_{s(50)}$ (psi)	Failure Type
57	B-7-12, 15.6'-15.9'	15.8'	Limestone	As received, dry	D			N/A	1.99	1.99	2700	681.8	1.005	685.1	2
63	B-12-9, 33.6'-34.0'	33.8'	Limestone	As received, dry	D			N/A	1.98	1.98	2400	612.2	1.003	613.8	2
68	B-14-3, 86.8'-87.1'	86.9'	Limestone	As received, dry	D			N/A	1.99	1.99	2450	618.7	1.005	621.7	2
80	B-15-5, 70.0'-70.2'	70.1'	Shale	As received, dry	D			N/A	1.99	1.99	1020	257.6	1.005	258.8	2

Test Type: D = Diametral, A = Axial, B = Block and I = Irregular.
Anisotropic Load: ⊥ = Load applied perpendicular to anisotropic planes. // = Load applied parallel to anisotropic planes.
Foliation/Joint Dip: Angle measured from plane perpendicular to core axis. F = Foliation, J = Joint, B = Bedding, M = Massive (no apparent foliation of joints)
Failure Type: 1 = Along joint or foliation. 2 = Across core axis. 3 = Along core axis. 4 = Pop-out (invalid). 5 = Failure prior to loading (invalid).
Diameter correction factor, F, is calculated using $F = (D_e/50)^{0.45}$, where De is in millimeters.

Comments

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Point Load Strength Index of Rock

ASTM D 5731
ISRM, Point Load Test

Project Name LSIORB Section 4, East End Approach
Storage Environment Ambient laboratory conditions
Test Method ASTM

Project Number LX2004110
Testing Date 01-27-2006

Lab ID	Boring	Depth (ft)	Rock Type	Moisture Condition	Test Type	Aniso. Load	Foliation/ Joint Dip	W (in)	D (in)	D_e (in)	Load (lbf)	I_s (psi)	F	$I_{s(50)}$ (psi)	Failure Type
228	B-7-17, 12.0'-12.2'	12.1	Limestone	As received, moist	D		M	N/A	2.00	2.00	5400	1350.0	1.007	1359.7	2
228	B-7-17, 12.2'-12.3'		Limestone	As received, moist	A		M	2.00	1.09	1.67	4100	1470.1	0.929	1365.3	3
229	B-7-18, 13.0'-13.2'	13.1	Limestone	As received, moist	D		M	N/A	1.99	1.99	3000	757.6	1.005	761.3	2
229	B-7-18, 13.2'-13.3'		Limestone	As received, moist	A		M	2.00	1.04	1.63	4100	1543.2	0.919	1417.5	3
230	B-7-19, 14.55'-14.75'	14.65	Limestone	As received, moist	D		M	N/A	1.99	1.99	3250	820.7	1.005	824.7	2
230	B-7-19, 14.75'-14.85'		Limestone	As received, moist	A		M	1.99	1.08	1.65	2250	826.4	0.924	763.3	3
231	B-7-20, 16.2'-16.4'	16.3	Limestone	As received, moist	D		M	N/A	2.00	2.00	2850	712.5	1.007	717.6	2
231	B-7-20, 16.4'-16.5'		Limestone	As received, moist	A		M	2.00	1.06	1.64	2600	966.7	0.921	890.4	3
232	B-7-21, 17.0'-17.2'	17.1	Limestone	As received, moist	D		M	N/A	1.99	1.99	4450	1123.7	1.005	1129.2	2
232	B-7-21, 17.2'-17.3'		Limestone	As received, moist	A		M	1.99	0.98	1.58	2600	1041.5	0.906	943.4	3

Test Type: D = Diametral, A = Axial, B = Block and I = Irregular.
Anisotropic Load: ⊥ = Load applied perpendicular to anisotropic planes. // = Load applied parallel to anisotropic planes.
Foliation/Joint Dip: Angle measured from plane perpendicular to core axis. F = Foliation, J = Joint, B = Bedding, M = Massive (no apparent foliation of joints)
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Diameter correction factor, F, is calculated using $F = (D_e/50)^{0.45}$, where De is in millimeters.

Comments

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Point Load Strength Index of Rock

ASTM D 5731
ISRM, Point Load Test

Project Name LSIORB Section 4, East End Approach
Storage Environment Ambient laboratory conditions
Test Method ASTM

Project Number LX2004110
Testing Date 01-27-2006

Lab ID	Boring	Depth (ft)	Rock Type	Moisture Condition	Test Type	Aniso. Load	Foliation/ Joint Dip	W (in)	D (in)	D_e (in)	Load (lbf)	I_s (psi)	F	$I_{s(50)}$ (psi)	Failure Type
223	B-7-12a/6.45'-66.5'	6.55	Limestone	As received, moist	D		M	N/A	1.97	1.97	2750	708.6	1.000	708.8	2
223	B-7-12a/6.3'-6.4'		Limestone	As received, moist	A		M	1.97	0.93	1.53	1700	726.2	0.893	648.4	3
224	B-7-13/8.0'-8.2'	8.1	Limestone	As received, moist	D		M	N/A	1.99	1.99	4400	1111.1	1.005	1116.5	2
224	B-7-13/8.2'-8.3'		Limestone	As received, moist	A		M	2.00	1.12	1.69	2700	945.3	0.934	882.6	3
225	B-7-14/9.8'-10.0'	9.9	Limestone	As received, moist	D		M	N/A	1.99	1.99	5000	1262.6	1.005	1268.8	2
225	B-7-14/9.7'-9.8'		Limestone	As received, moist	A		M	1.99	1.06	1.64	2500	929.5	0.921	856.2	3
226	B-7-15/10.0'-10.2'	10.1	Limestone	As received, moist	D		M	N/A	1.99	1.99	3950	997.4	1.005	1002.3	2
226	B-7-15/10.3'-10.4'		Limestone	As received, moist	A		M	1.99	0.87	1.48	1800	821.8	0.880	722.8	3
227	B-7-16/11.3'-11.5'	11.4	Limestone	As received, moist	D		M	N/A	1.99	1.99	1950	492.4	1.005	494.8	2
227	B-7-16/11.2'-11.3'		Limestone	As received, moist	A		M	1.99	1.23	1.77	1090	347.9	0.953	331.7	3

Test Type: D = Diametral, A = Axial, B = Block and I = Irregular.
Anisotropic Load: ⊥ = Load applied perpendicular to anisotropic planes. // = Load applied parallel to anisotropic planes.
Foliation/Joint Dip: Angle measured from plane perpendicular to core axis. F = Foliation, J = Joint, B = Bedding, M = Massive (no apparent foliation of joints)
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Diameter correction factor, F, is calculated using $F = (D_e/50)^{0.45}$, where De is in millimeters.

Comments

ENGINEERS

Point Load Strength Index of Rock

ASTM D 5731
ISRM, Point Load Test

Project Name LSIORB Section 4, East End Approach
Storage Environment Ambient laboratory conditions
Test Method ASTM

Project Number LX2004110
Testing Date 01-24-2006

Lab ID	Boring	Depth (ft)	Rock Type	Moisture Condition	Test Type	Aniso. Load	Foliation/ Joint Dip	W (in)	D (in)	D_e (in)	Load (lbf)	I_s (psi)	F	$I_{s(50)}$ (psi)	Failure Type
219	B-15-12/46.1'-46.4'	46.25	Limestone	As received, moist	D	//	J = 0°	N/A	1.99	1.99	1130	285.3	1.005	286.7	1
219	B-15-12/46.25'-46.4'		Limestone	As received, moist	A	⊥	J = 0°	2.00	1.34	1.85	2900	847.3	0.972	824.0	3
208	B-12-16/51.7'-52.0'	51.85	Limestone	As received, moist	D		M	N/A	1.98	1.98	4850	1237.1	1.003	1240.4	2
208	B-12-16/52.0'-52.1'		Limestone	As received, moist	A		M	1.99	1.24	1.77	3300	1053.3	0.953	1004.1	3
209	B-12-17/61.55'-6.8'	61.7	Shale	As received, moist	D	//	B = 0°	N/A	1.98	1.98	300	76.5	1.003	76.7	1
209	B-12-17/6.7'-6.8'		Shale	As received, moist	A	⊥	B = 0°	2.00	1.25	1.78	1900	599.7	0.956	573.1	3
210	B-12-19/95.6'-95.8'	95.7	Dolomite	As received, moist	D		M	N/A	1.98	1.98	3850	982.0	1.003	984.6	2
210	B-12-19/95.6'-95.7'		Dolomite	As received, moist	A		M	1.98	1.04	1.62	3500	1333.6	0.916	1221.7	3
189	B-9-6/63.45'-63.75'	63.6	Shale	As received, moist	D	//	B = 0°	N/A	1.76	1.76	480	153.3	0.951	145.8	1
189	B-9-6/63.45'-63.6'		Shale	As received, moist	A	⊥	B = 0°	1.77	1.58	1.89	840	235.2	0.982	230.9	3

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Anisotropic Load: ⊥ = Load applied perpendicular to anisotropic planes. // = Load applied parallel to anisotropic planes.
Foliation/Joint Dip: Angle measured from plane perpendicular to core axis. F = Foliation, J = Joint, B = Bedding, M = Massive (no apparent foliation of joints)
Failure Type: 1 = Along joint or foliation. 2 = Across core axis. 3 = Along core axis. 4 = Pop-out (invalid). 5 = Failure prior to loading (invalid).
Diameter correction factor, F, is calculated using $F = (D_e/50)^{0.45}$, where De is in millimeters.

Comments

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Point Load Strength Index of Rock

ASTM D 5731
ISRM, Point Load Test

Project Name LSIORB Section 4, East End Approach
Storage Environment Ambient laboratory conditions
Test Method ASTM

Project Number LX2004110
Testing Date 01-24-2006

Lab ID	Boring	Depth (ft)	Rock Type	Moisture Condition	Test Type	Aniso. Load	Foliation/ Joint Dip	W (in)	D (in)	D_e (in)	Load (lbf)	I_s (psi)	F	$I_{s(50)}$ (psi)	Failure Type
211	B-3-1a/21.0'-21.3'	21.15'	Limestone	As received, moist	D		M	N/A	1.99	1.99	2200	555.5	1.005	558.3	2
211	B-3-1a/21.0'-21.15'		Limestone	As received, moist	A		M	1.99	1.76	2.11	2100	471.7	1.032	486.7	3
213	B-3-3a/45.6'-45.9	45.75	Limestone	As received, moist	D		M	N/A	1.99	1.99	1950	492.4	1.005	494.8	2
213	B-3-3a/45.6'-45.75'		Limestone	As received, moist	A		M	1.99	1.85	2.17	3250	690.2	1.045	721.1	3
214	B-3-4a/55.3'-55.6'	55.45	Limestone	As received, moist	D		M	N/A	1.99	1.99	3200	808.1	1.005	812.0	2
214	B-3-4a/55.6'-55.75'		Limestone	As received, moist	A		M	1.99	1.53	1.97	2850	734.4	1.000	734.6	3
217	B-15-9/21.7'-22.0'	21.85	Limestone	As received, moist	D		M	N/A	1.99	1.99	3800	959.6	1.005	964.3	2
217	B-15-9/22.0'-22.1'		Limestone	As received, moist	A		M	2.00	1.28	1.81	4050	1236.2	0.963	1190.4	3
218	B-15-11/38.9'-39.0'	38.95	Limestone	As received, moist	D		M	N/A	2.00	2.00	2700	675.0	1.007	679.8	2
218	B-15-11/38.9'-38.85'		Limestone	As received, moist	A		M	2.00	0.89	1.51	2050	899.1	0.888	798.0	3

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Anisotropic Load: ⊥ = Load applied perpendicular to anisotropic planes. // = Load applied parallel to anisotropic planes.
Foliation/Joint Dip: Angle measured from plane perpendicular to core axis. F = Foliation, J = Joint, B = Bedding, M = Massive (no apparent foliation of joints)
Failure Type: 1 = Along joint or foliation. 2 = Across core axis. 3 = Along core axis. 4 = Pop-out (invalid). 5 = Failure prior to loading (invalid).
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Comments

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Point Load Strength Index of Rock

ASTM D 5731
ISRM, Point Load Test

Project Name LSIORB Section 4, East End Approach
Storage Environment Ambient laboratory conditions
Test Method ASTM

Project Number LX2004110
Testing Date 01-31-2006

Lab ID	Boring	Depth (ft)	Rock Type	Moisture Condition	Test Type	Aniso. Load	Foliation/ Joint Dip	W (in)	D (in)	D_e (in)	Load (lbf)	I_s (psi)	F	$I_{s(50)}$ (psi)	Failure Type
205	B-11-9, 130.5'-130.7'	130.6	Shale	As received, moist	D	//	B = 10°	N/A	1.76	1.76	100	32.3	0.951	30.7	1
205	B-11-9, 129.9'-130.0'		Shale	As received, moist	A	⊥	B = 10°	1.75	1.07	1.54	940	396.4	0.895	354.9	1
204	B-11-8, 110.0'-110.2'	110.1	Dolomite	As received, moist	D		M	N/A	1.76	1.76	2900	936.2	0.951	890.2	2
204	B-11-8, 110.2'-110.3'		Dolomite	As received, moist	A		M	1.76	1.14	1.60	1700	664.1	0.911	604.9	3
202	B-11-3, 85.1'-85.3'	85.2	Shale	As received, moist	D	//	B = 10°	N/A	1.75	1.75	750	244.9	0.948	232.3	1
202	B-11-3, 85.3'-85.4'		Shale	As received, moist	A	⊥	B = 10°	1.75	1.07	1.54	1020	430.1	0.895	385.1	1

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Failure Type: 1 = Along joint or foliation. 2 = Across core axis. 3 = Along core axis. 4 = Pop-out (invalid). 5 = Failure prior to loading (invalid).
Diameter correction factor, F, is calculated using $F = (D_e/50)^{0.45}$, where De is in millimeters.

Comments

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Point Load Strength Index of Rock

ASTM D 5731
ISRM, Point Load Test

Project Name LSIORB Section 4, East End Approach
Storage Environment Ambient laboratory conditions
Test Method ASTM

Project Number LX2004110
Testing Date 01-25-2006

Lab ID	Boring	Depth (ft)	Rock Type	Moisture Condition	Test Type	Aniso. Load	Foliation/ Joint Dip	W (in)	D (in)	D_e (in)	Load (lbf)	I_s (psi)	F	$I_{s(50)}$ (psi)	Failure Type
191	B-9-10/76.2'-76.4'	76.3	Dolomite	As received, moist	D		M	N/A	1.76	1.76	2400	774.8	0.951	736.7	2
191	B-9-10/76.4'-76.5'		Dolomite	As received, moist	A		M	1.76	1.03	1.52	4650	2012.6	0.890	1791.6	3
192	B-9-11/90.2'-90.4'	90.3	Dolomite	As received, moist	D		M	N/A	1.77	1.77	3050	973.5	0.953	928.1	3
192	B-9-11/90.4'-90.5'		Dolomite	As received, moist	A		M	1.76	1.13	1.59	1110	437.1	0.908	397.0	3
184	B-8-14/74.3'-74.6'	74.45	Dolomite	As received, moist	D		M	N/A	1.76	1.76	2550	823.2	0.951	782.8	2
184	B-8-14/74.45'-74.6'		Dolomite	As received, moist	A		M	1.76	1.78	2.00	4100	1025.0	1.007	1032.3	3
183	B-8-13/65.35'-65.65'	65.5	Dolomite	As received, moist	D		M	N/A	1.77	1.77	4250	1356.6	0.953	1293.2	2
183	B-8-13/65.5'-65.65'		Dolomite	As received, moist	A		M	1.77	1.85	2.04	2700	648.8	1.016	659.3	3
182	B-8-12/54.3'-54.6'	54.45	Dolomite	As received, moist	D		M	N/A	1.77	1.77	4050	1292.7	0.953	1232.4	2
182	B-8-12/54.2'-54.3'		Dolomite	As received, moist	A		M	1.76	1.06	1.54	4700	1981.8	0.895	1774.5	3

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Failure Type: 1 = Along joint or foliation. 2 = Across core axis. 3 = Along core axis. 4 = Pop-out (invalid). 5 = Failure prior to loading (invalid).
Diameter correction factor, F, is calculated using $F = (D_e/50)^{0.45}$, where De is in millimeters.

Comments

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Point Load Strength Index of Rock

ASTM D 5731
ISRM, Point Load Test

Project Name LSIORB Section 4, East End Approach
Storage Environment Ambient laboratory conditions
Test Method ASTM

Project Number LX2004110
Testing Date 01-26-2006

Lab ID	Boring	Depth (ft)	Rock Type	Moisture Condition	Test Type	Aniso. Load	Foliation/ Joint Dip	W (in)	D (in)	D_e (in)	Load (lbf)	I_s (psi)	F	$I_{s(50)}$ (psi)	Failure Type
185	B-9-1/56.45'-56.65'	56.55	Limestone	As received, moist	D		M	N/A	1.77	1.77	2300	734.1	0.953	699.9	2
185	B-9-1/56.65'-56.75'		Limestone	As received, moist	A		M	1.77	1.01	1.51	1900	833.3	0.888	739.6	3
187	B-9-4/60.0'-60.2'	60.1	Limestone	As received, moist	D		M	N/A	1.77	1.77	2350	750.1	0.953	715.1	2
187	B-9-4/60.1'-60.2'		Limestone	As received, moist	A		M	1.77	1.40	1.78	3250	1025.8	0.956	980.3	3
220	B-7-9/3.55'-3.85'	3.7	Limestone	As received, moist	D		M	N/A	1.98	1.98	2250	573.9	1.003	575.4	2
220	B-7-9/3.7'-3.8'		Limestone	As received, moist	A		M	1.98	1.37	1.86	2300	664.8	0.975	648.1	3
221	B-7-10/4.5'-4.7'	4.6	Limestone	As received, moist	D	//	J = 0°	N/A	1.98	1.98	510	130.1	1.003	130.4	1
221	B-7-10/4.6'-4.7'		Limestone	As received, moist	A	⊥	J = 0°	1.99	0.93	1.54	1140	480.7	0.895	430.4	3
222	B-7-11a/5.4'-5.6'	5.5	Limestone	As received, moist	D		M	N/A	1.97	1.97	2200	566.9	1.000	567.1	2
222	B-7-11a/5.6'-5.7'		Limestone	As received, moist	A		M	1.97	1.05	1.62	1850	704.9	0.916	645.7	3

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Diameter correction factor, F, is calculated using $F = (D_e/50)^{0.45}$, where De is in millimeters.

Comments

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FMSM ENGINEERS

Point Load Strength Index of Rock

ASTM D 5731
ISRM, Point Load Test

Project Name LSIORB Section 4, East End Approach
Storage Environment Ambient laboratory conditions
Test Method ASTM

Project Number LX2004110
Testing Date 01-25-2006

Lab ID	Boring	Depth (ft)	Rock Type	Moisture Condition	Test Type	Aniso. Load	Foliation/ Joint Dip	W (in)	D (in)	D_e (in)	Load (lbf)	I_s (psi)	F	$I_{s(50)}$ (psi)	Failure Type
175	B-8-1/32.5'-32.7'	32.6	Limestone	As received, moist	D		M	N/A	1.76	1.76	2300	742.5	0.951	706.0	2
175	B-8-1/32.4'-32.5'		Limestone	As received, moist	A		M	1.77	1.21	1.65	3000	1101.9	0.924	1017.8	3
176	B-8-2/34.8'-35.1'	35	Shale	As received, moist	D	//	B = 10°	N/A	1.76	1.76	500	161.4	0.951	153.5	1
176	B-8-2/35.0'-35.1'		Shale	As received, moist	A	⊥	B = 10°	1.76	1.60	1.89	780	218.4	0.982	214.4	1
180	B-8-9/47.1'-47.3'	47.2	Dolomite	As received, moist	D		M	N/A	1.76	1.76	4450	1436.6	0.951	1366.0	2
180	B-8-9/47.3'-47.4'		Dolomite	As received, moist	A		M	1.77	1.24	1.67	2700	968.1	0.929	899.1	3
178	B-8-5/40.0'-40.65'	40.5	Shale	As received, moist	D	//	B = 0°	N/A	1.76	1.76	640	206.6	0.951	196.5	1
178	B-8-5/40.5'-40.65'		Shale	As received, moist	A	⊥	B = 0°	1.76	0.92	1.44	440	212.2	0.869	184.3	1
162	B-6-19/32.4'-32.7'	32.55	Shale	As received, moist	D	//	B = 0°	N/A	1.77	1.77	1100	351.1	0.953	334.7	1
162	B-6-19/32.55'-32.7'		Shale	As received, moist	A	⊥	B = 0°	1.76	1.62	1.91	560	153.5	0.987	151.4	1

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Diameter correction factor, F, is calculated using $F = (D_e/50)^{0.45}$, where De is in millimeters.

Comments

FMSM ENGINEERS

Point Load Strength Index of Rock

ASTM D 5731
ISRM, Point Load Test

Project Name LSIORB Section 4, East End Approach
Storage Environment Ambient laboratory conditions
Test Method ASTM

Project Number LX2004110
Testing Date 01-27-2006

Lab ID	Boring	Depth (ft)	Rock Type	Moisture Condition	Test Type	Aniso. Load	Foliation/ Joint Dip	W (in)	D (in)	D_e (in)	Load (lbf)	I_s (psi)	F	$I_{s(50)}$ (psi)	Failure Type
168	B-5-4, 42.9'-43.1'	43	Shale	As received, moist	D	//	B = 0°	N/A	1.76	1.76	400	129.1	0.951	122.8	1
168	B-5-4, 43.1'-43.2'		Shale	As received, moist	A	⊥	B = 0°	1.76	1.09	1.56	610	248.6	0.901	223.9	1
171	B-5-7, 51.8'-52.0'	51.9	Dolomite	As received, moist	D		M	N/A	1.77	1.77	4900	1564.0	0.953	1491.0	2,3
171	B-5-7, 52.0'-52.1'		Dolomite	As received, moist	A		M	1.77	1.05	1.54	3250	1370.4	0.895	1227.1	3
173	B-5-12, 66.45'-66.65'	66.55	Dolomite	As received, moist	D		M	N/A	1.77	1.77	4200	1340.6	0.953	1278.0	2,3
173	B-5-12, 66.35'-66.45'		Dolomite	As received, moist	A		M	1.78	1.11	1.59	4200	1661.3	0.908	1509.1	3
174	B-5-13, 101.7'-101.9'	101.8	Shale	As received, moist	D	//	B = 30°	N/A	1.76	1.76	940	303.5	0.951	288.6	1
174	B-5-13, 101.6'-101.7'		Shale	As received, moist	A	⊥	B = 30°	1.77	1.08	1.56	960	394.5	0.901	355.3	1
203	B-11-7, 98.35'-98.55'	98.45	Dolomite	As received, moist	D		M	N/A	1.76	1.76	4000	1291.3	0.951	1227.9	2
203	B-11-7, 98.25'-98.35'		Dolomite	As received, moist	A		M	1.76	0.97	1.47	3000	1388.3	0.877	1217.4	3

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Diameter correction factor, F, is calculated using $F = (D_e/50)^{0.45}$, where De is in millimeters.

Comments

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Point Load Strength Index of Rock

ASTM D 5731
ISRM, Point Load Test

Project Name LSIORB Section 4, East End Approach
Storage Environment Ambient laboratory conditions
Test Method ASTM

Project Number LX2004110
Testing Date 01-26-2005

Lab ID	Boring	Depth (ft)	Rock Type	Moisture Condition	Test Type	Aniso. Load	Foliation/ Joint Dip	W (in)	D (in)	D_e (in)	Load (lbf)	I_s (psi)	F	$I_{s(50)}$ (psi)	Failure Type
164	B-6-22/47.0'-47.2'	47.1	Dolomite	As received, moist	D		M	N/A	1.76	1.76	2800	903.9	0.951	859.5	2
164	B-6-22/47.2'-47.3'		Dolomite	As received, moist	A		M	1.77	1.11	1.58	2150	861.2	0.906	780.1	3
165	B-6-24/59.4'-59.6'	59.5	Dolomite	As received, moist	D		M	N/A	1.77	1.77	3900	1244.9	0.953	1186.7	3
165	B-6-24/59.6'-59.7'		Dolomite	As received, moist	A		M	1.77	1.06	1.55	4400	1831.4	0.898	1644.7	3
194	B-10-4/54.9'-55.1'	55	Shale	As received, moist	D	//	B = 0°	N/A	1.75	1.75	680	220.4	0.948	209.0	1
194	B-10-4/54.8'-54.9'		Shale	As received, moist	A	⊥	B = 0°	1.76	0.98	1.48	810	367.5	0.880	323.2	1
196	B-10-6/58.05'-58.35'	58.2	Shale	As received, moist	D	//	B = 0°	N/A	1.76	1.76	1100	355.1	0.951	337.7	1
196	B-10-6/58.2'-58.35'		Shale	As received, moist	A	⊥	B = 0°	1.76	1.80	2.01	1850	457.9	1.009	462.2	1
199	B-10-10/65.2'-65.4'	65.3	Dolomite	As received, moist	D		M	N/A	1.77	1.77	5150	1643.8	0.953	1567.1	2
199	B-10-10/65.4'-65.5'		Dolomite	As received, moist	A		M	1.77	1.11	1.58	4850	1942.8	0.906	1759.8	3

Test Type: D = Diametral, A = Axial, B = Block and I = Irregular.
Anisotropic Load: ⊥ = Load applied perpendicular to anisotropic planes. // = Load applied parallel to anisotropic planes.
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Diameter correction factor, F, is calculated using $F = (D_e/50)^{0.45}$, where De is in millimeters.

Comments

FMSM ENGINEERS

Point Load Strength Index of Rock

ASTM D 5731
ISRM, Point Load Test

Project Name LSIORB Section 4, East End Approach
Storage Environment Ambient laboratory conditions
Test Method ASTM

Project Number LX2004110
Testing Date 01-30-2006

Lab ID	Boring	Depth (ft)	Rock Type	Moisture Condition	Test Type	Aniso. Load	Foliation/ Joint Dip	W (in)	D (in)	D_e (in)	Load (lbf)	I_s (psi)	F	$I_{s(50)}$ (psi)	Failure Type
154	B-6-9, 21.0'-21.2'	21.1	Limestone	As received, moist	D		M	N/A	1.77	1.77	6150	1963.0	0.953	1871.4	2,3
154	B-6-9, 21.2'-21.3'		Limestone	As received, moist	A		M	1.77	1.03	1.52	3750	1623.1	0.890	1444.8	3
155	B-6-10, 22.0'-22.2'	22.1	Limestone	As received, moist	D		M	N/A	1.77	1.77	5700	1819.4	0.953	1734.4	2
155	B-6-10, 22.2'-22.3'		Limestone	As received, moist	A		M	1.77	1.10	1.57	2900	1176.5	0.903	1062.7	3
156	B-6-11, 24.3'-24.5'	24.4	Limestone	As received, moist	D		M	N/A	1.77	1.77	2900	925.7	0.953	882.4	2
156	B-6-11, 24.5'-24.6'		Limestone	As received, moist	A		M	1.77	1.07	1.55	2200	915.7	0.898	822.3	3
157	B-6-13, 26.4'-26.6'	26.5	Shale	As received, moist	D		M	N/A	1.74	1.74	630	208.1	0.946	196.8	1
157	B-6-13, 26.5'-26.6'		Shale	As received, moist	A		M	1.74	1.17	1.61	490	189.0	0.914	172.7	1
158	B-6-14, 27.7'-27.9'	27.8	Shale	As received, moist	D		M	N/A	1.75	1.75	400	130.6	0.948	123.9	1
158	B-6-14, 27.8'-27.9'		Shale	As received, moist	A		M	1.75	1.29	1.70	1400	484.4	0.936	453.5	1

Test Type: D = Diametral, A = Axial, B = Block and I = Irregular.
Anisotropic Load: $\perp$ = Load applied perpendicular to anisotropic planes. // = Load applied parallel to anisotropic planes.
Foliation/Joint Dip: Angle measured from plane perpendicular to core axis. F = Foliation, J = Joint, B = Bedding, M = Massive (no apparent foliation of joints)
Failure Type: 1 = Along joint or foliation. 2 = Across core axis. 3 = Along core axis. 4 = Pop-out (invalid). 5 = Failure prior to loading (invalid).
Diameter correction factor, F, is calculated using $F = (D_e/50)^{0.45}$, where De is in millimeters.

Comments

Point Load Strength Index of Rock

ASTM D 5731
ISRM, Point Load Test

Project Name LSIORB Section 4, East End Approach
Storage Environment Ambient laboratory conditions
Test Method ASTM

Project Number LX2004110
Testing Date 01-30-2006

Lab ID	Boring	Depth (ft)	Rock Type	Moisture Condition	Test Type	Aniso. Load	Foliation/ Joint Dip	W (in)	D (in)	D_e (in)	Load (lbf)	I_s (psi)	F	$I_{s(50)}$ (psi)	Failure Type
149	B-6-4, 16.0'-16.2'	16.1	Limestone	As received, moist	D		M	N/A	1.77	1.77	4150	1324.7	0.953	1262.8	2
149	B-6-4, 16.2'-16.3'		Limestone	As received, moist	A		M	1.77	1.03	1.52	2950	1276.8	0.890	1136.6	3
150	B-6-5, 17.0'-17.2'	17.1	Limestone	As received, moist	D		M	N/A	1.77	1.77	2150	686.3	0.953	654.2	2
150	B-6-5, 17.2'-17.3'		Limestone	As received, moist	A		M	1.77	1.06	1.55	2400	999.0	0.898	897.1	3
151	B-6-6, 18.8'-19.0'	18.9	Limestone	As received, moist	D		M	N/A	1.77	1.77	2700	861.8	0.953	821.6	2
151	B-6-6, 18.7'-18.8'		Limestone	As received, moist	A		M	1.78	1.02	1.52	2200	952.2	0.890	847.6	3
152	B-6-7, 19.6'-19.8'	19.7	Limestone	As received, moist	D		M	N/A	1.77	1.77	2600	829.9	0.953	791.1	2
152	B-6-7, 19.5'-19.6'		Limestone	As received, moist	A		M	1.77	1.30	1.71	2600	889.2	0.939	834.6	3
153	B-6-8, 20.4'-20.6'	20.5	Limestone	As received, moist	D		M	N/A	1.77	1.77	3100	989.5	0.953	943.3	2
153	B-6-8, 20.6'-20.7'		Limestone	As received, moist	A		M	1.77	1.05	1.54	3100	1307.1	0.895	1170.4	3

Test Type: D = Diametral, A = Axial, B = Block and I = Irregular.
Anisotropic Load: ⊥ = Load applied perpendicular to anisotropic planes. // = Load applied parallel to anisotropic planes.
Foliation/Joint Dip: Angle measured from plane perpendicular to core axis. F = Foliation, J = Joint, B = Bedding, M = Massive (no apparent foliation of joints)
Failure Type: 1 = Along joint or foliation. 2 = Across core axis. 3 = Along core axis. 4 = Pop-out (invalid). 5 = Failure prior to loading (invalid).
Diameter correction factor, F, is calculated using $F = (D_e/50)^{0.45}$, where De is in millimeters.

Comments

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Point Load Strength Index of Rock

ASTM D 5731
ISRM, Point Load Test

Project Name LSIORB Section 4, East End Approach
Storage Environment Ambient laboratory conditions
Test Method ASTM

Project Number LX2004110
Testing Date 01-24-2006

Lab ID	Boring	Depth (ft)	Rock Type	Moisture Condition	Test Type	Aniso. Load	Foliation/ Joint Dip	W (in)	D (in)	D_e (in)	Load (lbf)	I_s (psi)	F	$I_{s(50)}$ (psi)	Failure Type
140	B-2-1a, 26.75'-27.0'	26.9	Shale	As received, moist	D	//	J = 0°	N/A	1.99	1.99	1300	328.3	1.005	329.9	1
140	B-2-1a, 26.9'-27.0'		Shale	As received, moist	A	⊥	J = 0°	1.99	1.47	1.93	2700	724.9	0.991	718.4	3
142	B-2-4a, 39.3'-39.6'	39.45	Dolomite	As received, moist	D		M	N/A	1.99	1.99	3000	757.6	1.005	761.3	2
142	B-2-4a, 39.45'-39.6'		Dolomite	As received, moist	A		M	1.97	1.77	2.11	3100	696.3	1.032	718.4	3
143	B-2-6a, 44.3'-44.6'	44.45	Dolomite	As received, moist	D		M	N/A	1.99	1.99	5600	1414.1	1.005	1421.0	2
143	B-2-6a, 44.5'-44.6'		Dolomite	As received, moist	A		M	1.98	1.61	2.01	5200	1287.1	1.009	1299.2	3
144	B-2-7a, 56.2'-56.5'	56.35	Dolomite	As received, moist	D		M	N/A	1.99	1.99	1600	404.0	1.005	406.0	1
144	B-2-7a, 56.35'-56.5'		Dolomite	As received, moist	A		M	1.98	1.77	2.11	3000	673.8	1.032	695.2	3
215	B-3-5a, 67.1'-67.4'	67.25	Dolomite	As received, moist	D		M	N/A	2.00	2.00	2200	550.0	1.007	553.9	2
215	B-3-5a, 67.25'-67.4'		Dolomite	As received, moist	A		M	1.99	1.79	2.13	2800	617.2	1.036	639.5	3

Test Type: D = Diametral, A = Axial, B = Block and I = Irregular.
Anisotropic Load: ⊥ = Load applied perpendicular to anisotropic planes. // = Load applied parallel to anisotropic planes.
Foliation/Joint Dip: Angle measured from plane perpendicular to core axis. F = Foliation, J = Joint, B = Bedding, M = Massive (no apparent foliation of joints)
Failure Type: 1 = Along joint or foliation. 2 = Across core axis. 3 = Along core axis. 4 = Pop-out (invalid). 5 = Failure prior to loading (invalid).
Diameter correction factor, F, is calculated using $F = (D_e/50)^{0.45}$, where De is in millimeters.

Comments

File: LX2004110_PL-140-215.xls Sheet: Report
Preparation Date: 1993
Revision Date: 2-2005

Fuller, Mossbarger, Scott and May Engineers, Inc.

Laboratory Document
Prepared By: JW
Approved By: TLK

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Point Load Strength Index of Rock

ASTM D 5731
ISRM, Point Load Test

Project Name LSIORB Section 4, East End Approach
Storage Environment Ambient laboratory conditions
Test Method ASTM

Project Number LX2004110
Testing Date 01-27-2006

Lab ID	Boring	Depth (ft)	Rock Type	Moisture Condition	Test Type	Aniso. Load	Foliation/ Joint Dip	W (in)	D (in)	D_e (in)	Load (lbf)	I_s (psi)	F	$I_{s(50)}$ (psi)	Failure Type
233	B-7-22, 18.2'-18.4'	18.3	Limestone	As received, moist	D		M	N/A	1.99	1.99	4100	1035.3	1.005	1040.4	2
233	B-7-22, 18.4'-18.5'		Limestone	As received, moist	A		M	1.99	1.03	1.62	2500	952.6	0.916	872.6	3
234	B-7-23, 19.5'-19.7'	19.6	Shale	As received, moist	D	//	B = 0°	N/A	1.99	1.99	1400	353.5	1.005	355.3	1
234	B-7-23, 19.7'-19.8'		Shale	As received, moist	A	⊥	B = 0°	2.00	0.99	1.59	830	328.3	0.908	298.2	1
146	B-6-1, 13.0'-13.2'	13.1	Limestone	As received, moist	D		M	N/A	1.77	1.77	3800	1212.9	0.953	1156.3	2,3
146	B-6-1, 13.2'-13.3'		Limestone	As received, moist	A		M	1.77	1.07	1.55	3600	1498.4	0.898	1345.6	3
147	B-6-2, 14.0'-14.2'	14.1	Limestone	As received, moist	D		M	N/A	1.76	1.76	1650	532.7	0.951	506.5	2
147	B-6-2, 14.2'-14.3'		Limestone	As received, moist	A		M	1.77	1.08	1.56	1800	739.6	0.901	666.1	3
148	B-6-3, 15.4'-15.6'	15.5	Limestone	As received, moist	D		M	N/A	1.77	1.77	1900	606.5	0.953	578.1	2
148	B-6-3, 15.6'-15.7'		Limestone	As received, moist	A		M	1.77	1.06	1.55	2550	1061.4	0.898	953.2	3

Test Type: D = Diametral, A = Axial, B = Block and I = Irregular.
Anisotropic Load: ⊥ = Load applied perpendicular to anisotropic planes. // = Load applied parallel to anisotropic planes.
Foliation/Joint Dip: Angle measured from plane perpendicular to core axis. F = Foliation, J = Joint, B = Bedding, M = Massive (no apparent foliation of joints)
Failure Type: 1 = Along joint or foliation. 2 = Across core axis. 3 = Along core axis. 4 = Pop-out (invalid). 5 = Failure prior to loading (invalid).
Diameter correction factor, F, is calculated using $F = (D_e/50)^{0.45}$, where De is in millimeters.

Comments

Earth Mechanics Institute

Colorado School of Mines

Mining Engineering Department

Project Name : LSIORB Section 4

East End Approach Phase 1

Location: Lexington, KY

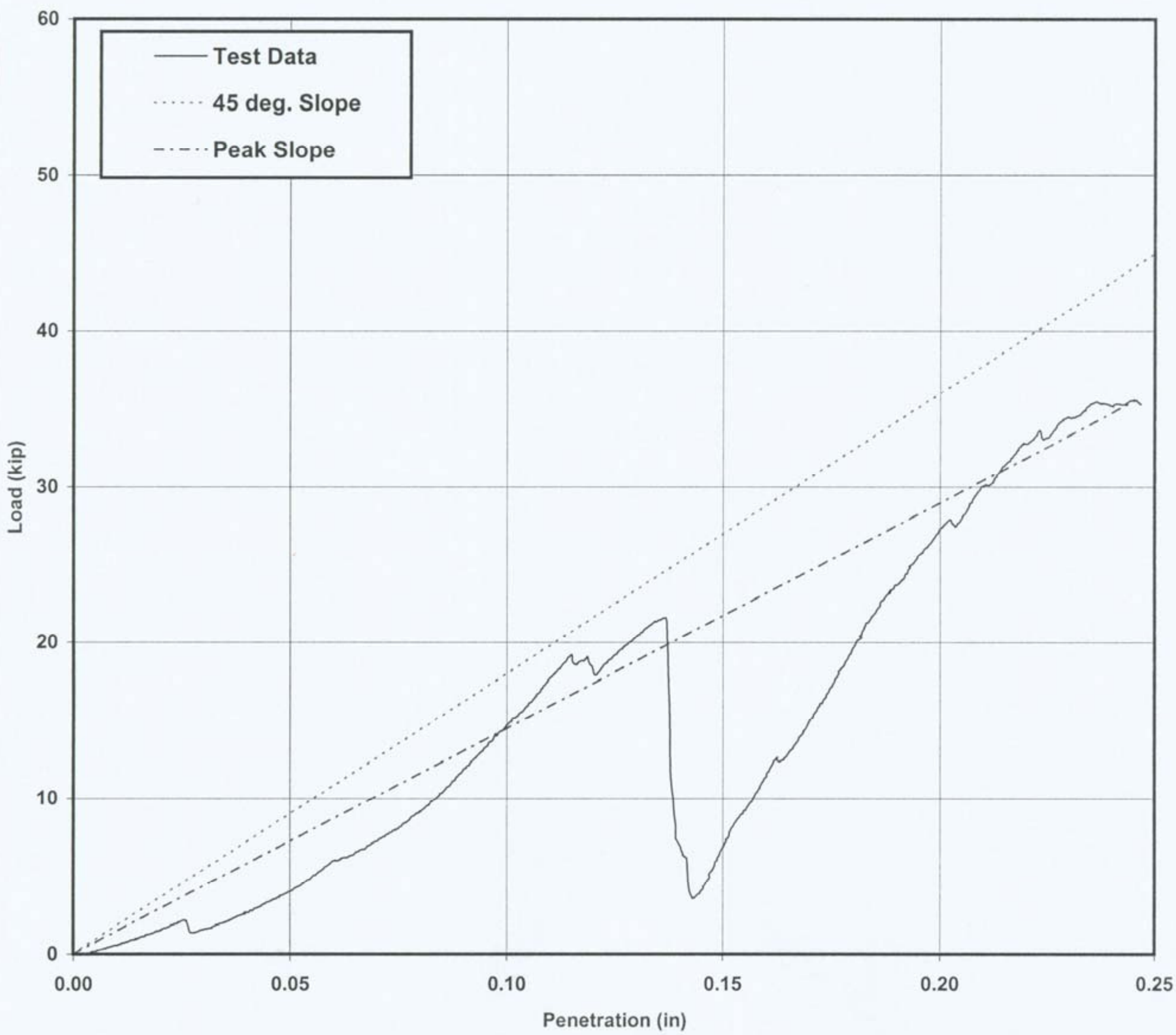
Client: FMSM

Date: 08/04/2005 Sample ID	Rock Type	Punch Penetration Test Peak Slope (kips/in)
B-7-6@39.0-39.6	Dolomite	145
B-7-12@15.1-15.6	Limestone	127
B-12-4@72.4-72.9	Dolomite	160
B-12-8@10.3-10.9	Limestone	121
B-12-9@34.0-34.5	Limestone	134
B-14-3@87.1-87.6	Limestone	108
B-15-3@122.5-123.1	Dolomite	96
B-15-5@66.8-69.5	Shale	61
B-15-6@75.6-76.2	Limestone	165
B-18-1@50.6-51.3	Limestone	129
B-18-4@36.5-37.0	Limestone	93

Earth Mechanics Institute
Mining Engineering Department, CSM

Punch Penetration Index Test (Ver. 3.0)

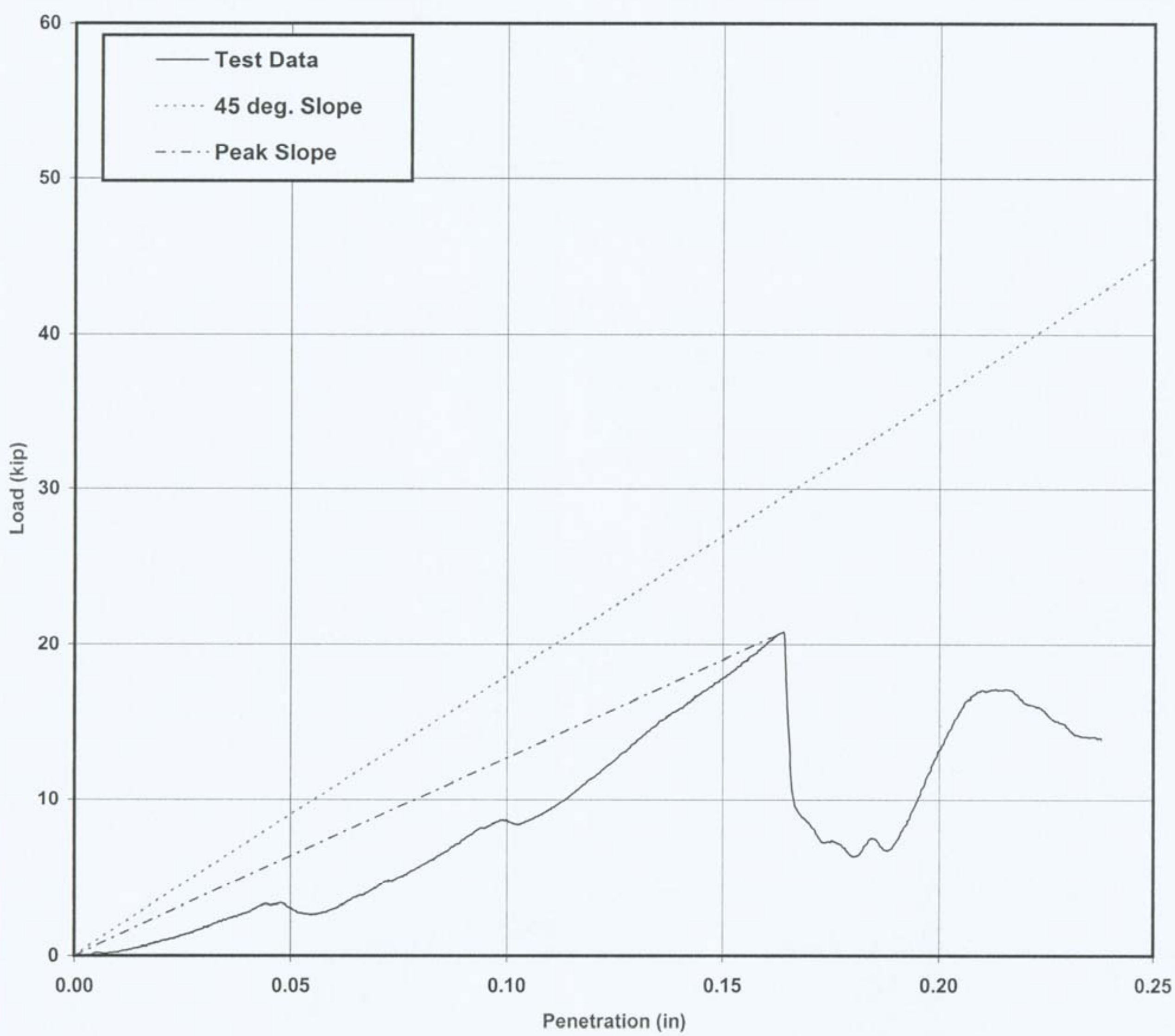
Project:	*FMSM Section 4*	**Moisture Condition:**	*Air Dried*	
Location:	*Lexington, KY*	**Penetration:**	*0.001*	**in/sec**
Rock Type:	*Sedimentary*	**Max. Load:**	35,555	**lbs**
Rock Name:	*Dolomite*			
Characteristics:	*Light Gray*			
Core ID:	*B-7-6@39.0-39.6*			
File Name:	*B-7-6@39.0-39.6*	**45 Degree (Standard) Index:**	***175***	
Test Performed by:	*Kevin*	**Peak Slope Index:**	***145***	
Date Tested:	*08/02/05*			
Data Reduced by:	*Kevin*			
Date Reduced:	*08/02/05*			



Earth Mechanics Institute
Mining Engineering Department, CSM

Punch Penetration Index Test (Ver. 3.0)

Project:	*FMSM Section 4*	**Moisture Condition:**	*Air Dried*	
Location:	*Lexington, KY*	**Penetration:**	*0.001*	**in/sec**
Rock Type:	*Sedimentary*	**Max. Load:**	20,840	**lbs**
Rock Name:	*Limestone*			
Characteristics:	*Light Gray*			
Core ID:	*B-7-12@15.1-15.6*			
File Name:	*B-7-12@15.1-15.6*	**45 Degree (Standard) Index:**	*175*	
Test Performed by:	*Kevin*	**Peak Slope Index:**	*127*	
Date Tested:	*08/04/05*			
Data Reduced by:	*Kevin*			
Date Reduced:	*08/04/05*			



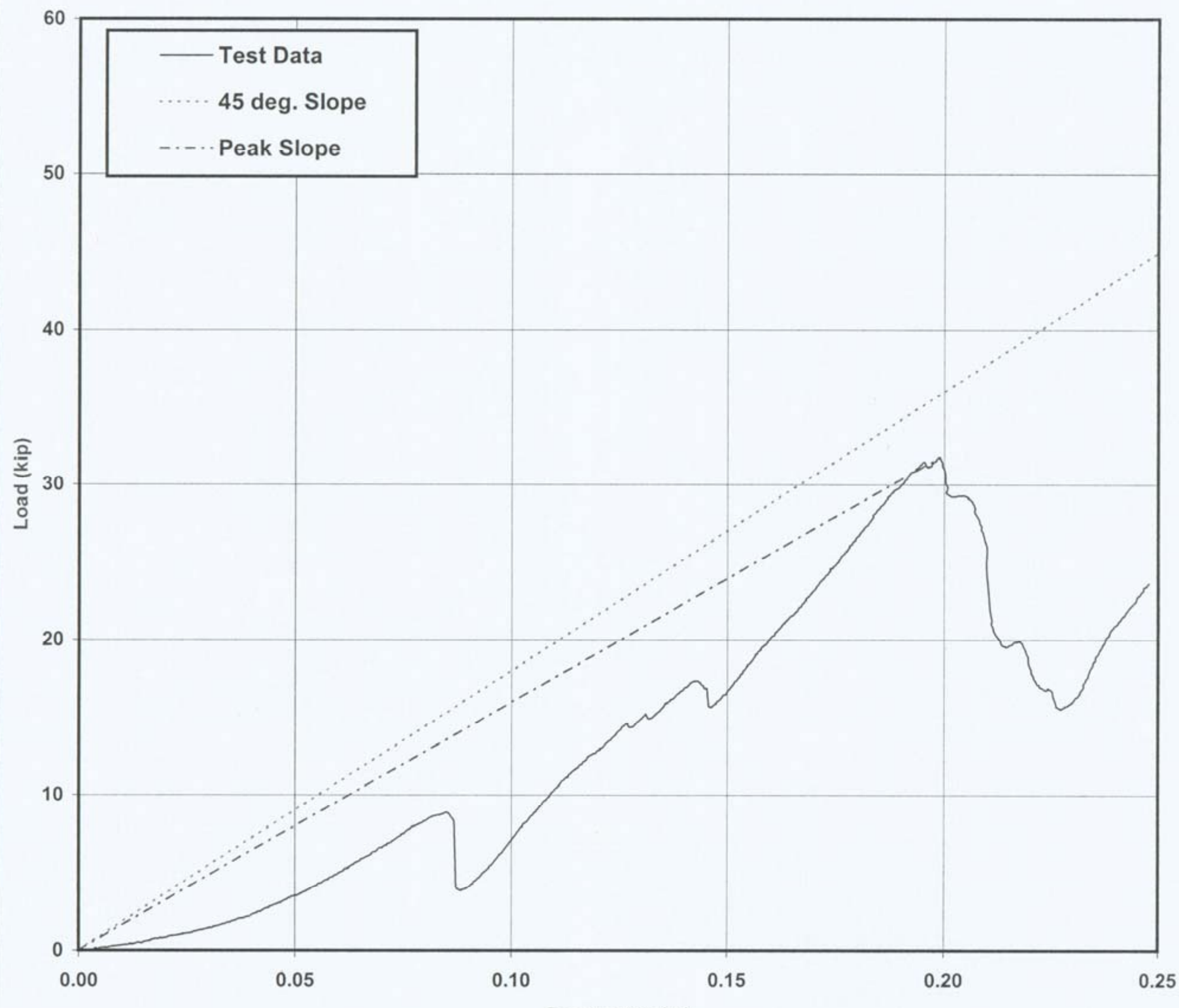
Earth Mechanics Institute
Mining Engineering Department, CSM

Punch Penetration Index Test (Ver. 3.0)

Project: *FMSM Section 4*
Location: *Lexington, KY*
Rock Type: *Sedimentary*
Rock Name: *Dolomite*
Characteristics: *Light Gray*
Core ID: *B-12-4@72.4-72.9*
File Name: *B-12-4@72.4-72.9*
Test Performed by: *Kevin*
Date Tested: *08/02/05*
Data Reduced by: *Kevin*
Date Reduced: *08/02/05*

Moisture Condition: *Air Dried*
Penetration: *0.001* **in/sec**
Max. Load: 31,747 **lbs**

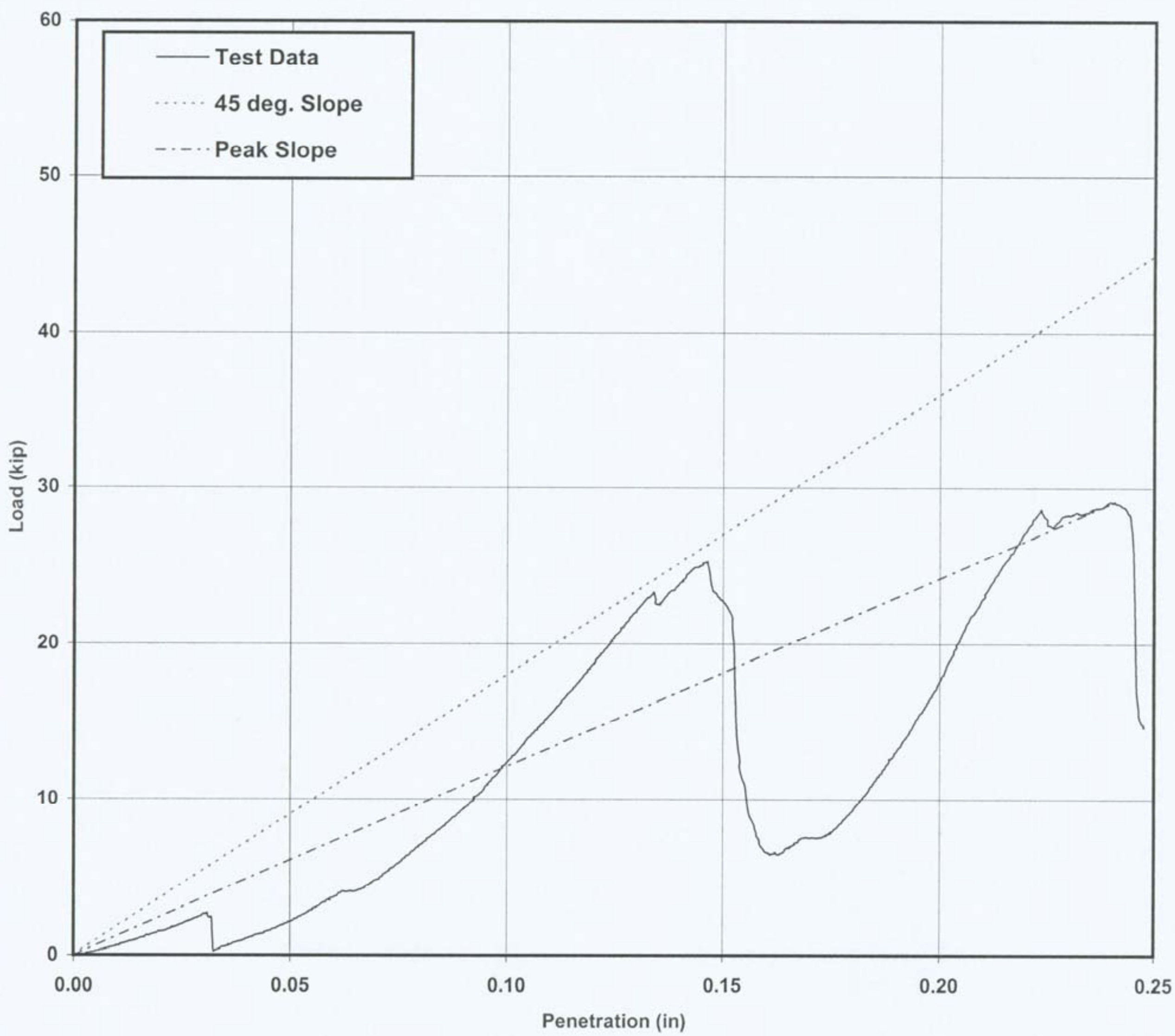
45 Degree (Standard) Index: *175*
Peak Slope Index: *160*



Earth Mechanics Institute
Mining Engineering Department, CSM

Punch Penetration Index Test (Ver. 3.0)

Project:	*FMSM Section 4*	**Moisture Condition:**	*Air Dried*	
Location:	*Lexington, KY*	**Penetration:**	*0.001*	**in/sec**
Rock Type:	*Sedimentary*	**Max. Load:**	29,119	**lbs**
Rock Name:	*Limestone*			
Characteristics:	*Light Gray*			
Core ID:	*B-12-8@10.3-10.9*			
File Name:	*B-12-8@10.3-10.9*	**45 Degree (Standard) Index:**	***175***	
Test Performed by:	*Kevin*	**Peak Slope Index:**	***121***	
Date Tested:	*08/02/05*			
Data Reduced by:	*Kevin*			
Date Reduced:	*08/02/05*			



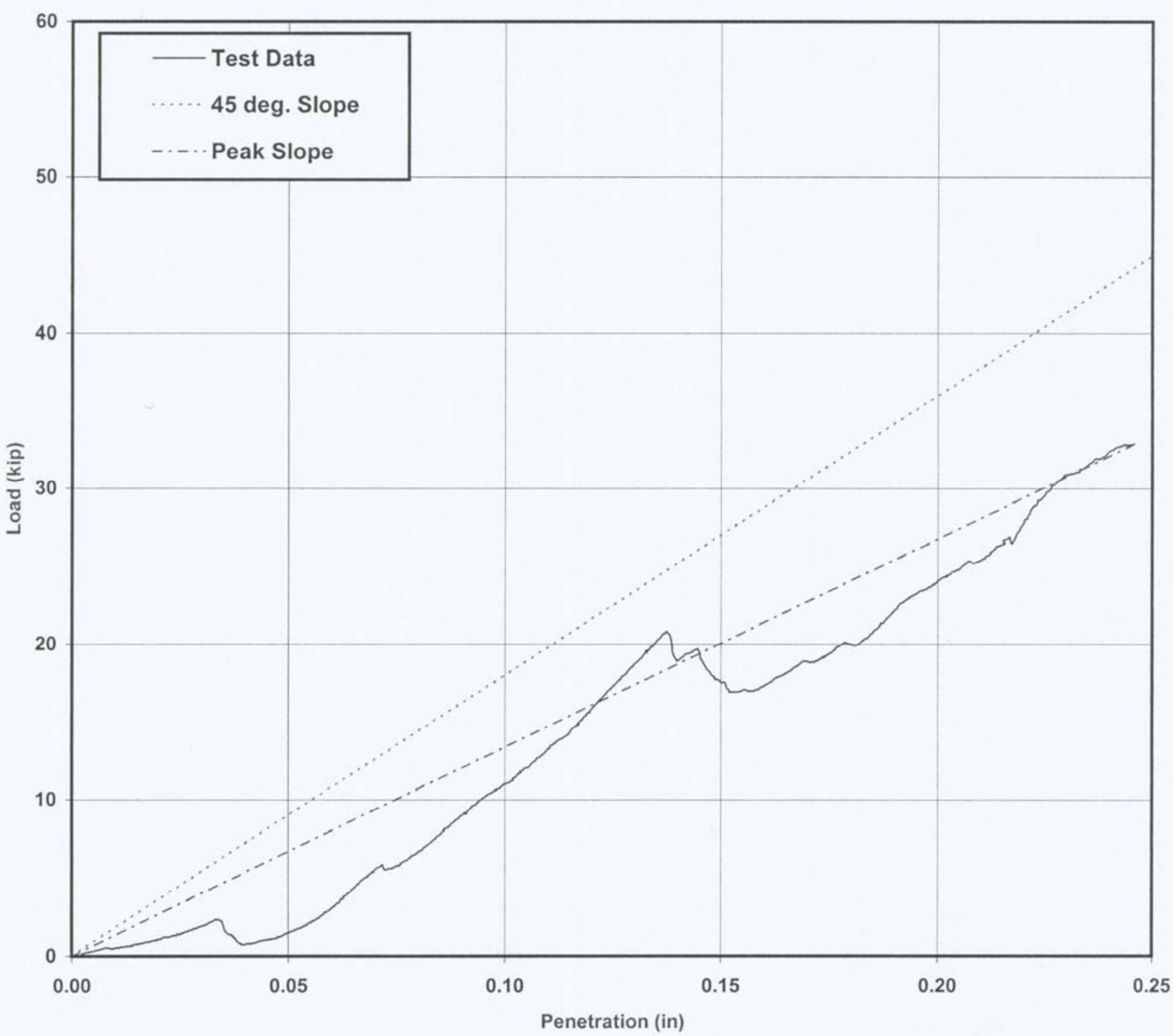
Earth Mechanics Institute
Mining Engineering Department, CSM

Punch Penetration Index Test (Ver. 3.0)

Project: *FMSM Section 4*
Location: *Lexington, KY*
Rock Type: *Sedimentary*
Rock Name: *Limestone*
Characteristics: *Light Gray*
Core ID: *B-12-9@34.0-34.5*
File Name: *B-12-9@34.0-34.5*
Test Performed by: *Kevin*
Date Tested: *08/02/05*
Data Reduced by: *Kevin*
Date Reduced: *08/02/05*

Moisture Condition: *Air Dried*
Penetration: *0.001* in/sec
Max. Load: 32,885 lbs

45 Degree (Standard) Index: *175*
Peak Slope Index: *134*



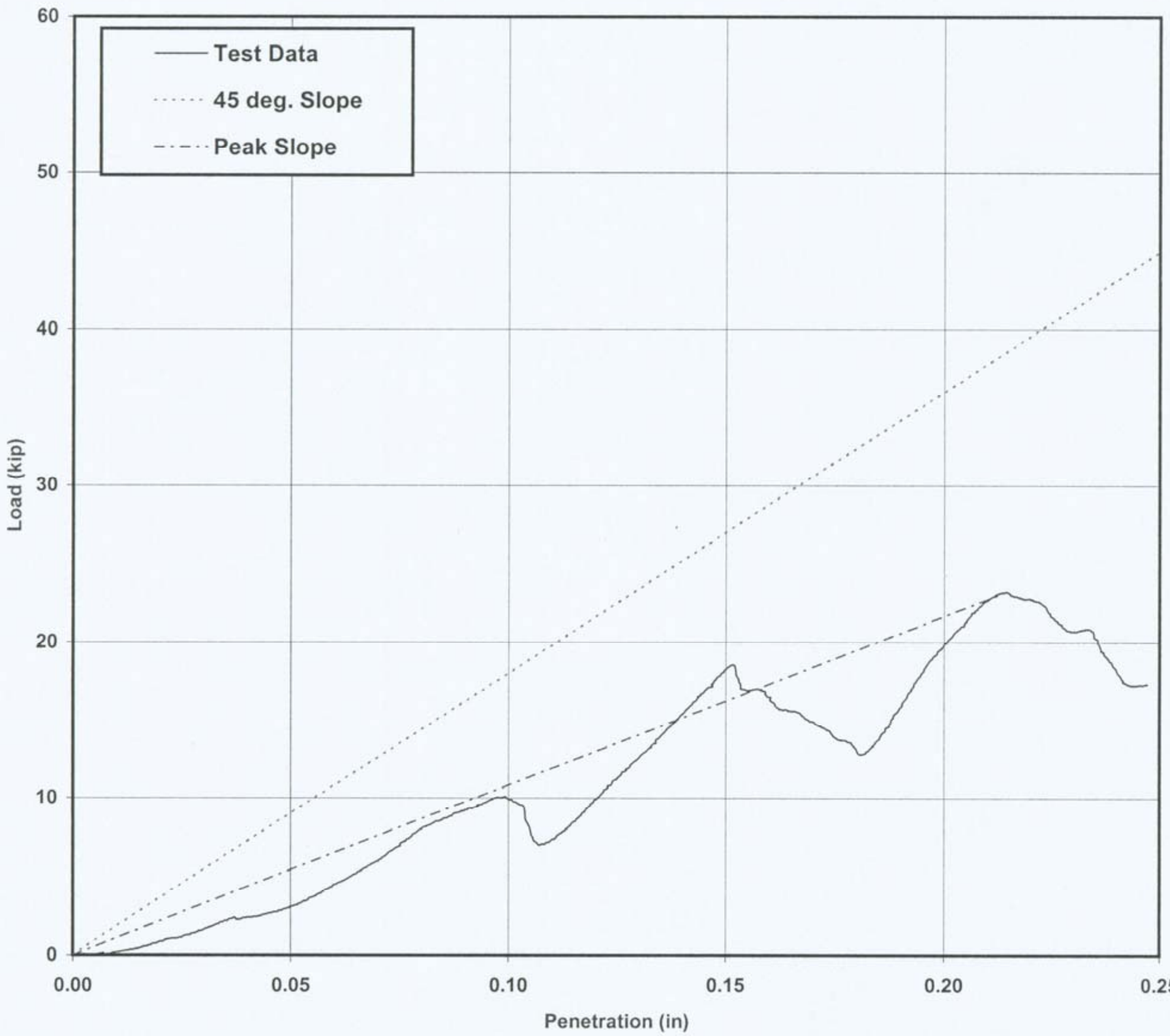
Earth Mechanics Institute
Mining Engineering Department, CSM

Punch Penetration Index Test (Ver. 3.0)

Project: *FMSM Section 4*
Location: *Lexington, KY*
Rock Type: *Sedimentary*
Rock Name: *Limestone*
Characteristics: *Light Gray*
Core ID: *B-14-3@87.1-87.6*
File Name: *B-14-3@87.1-87.6*
Test Performed by: *Kevin*
Date Tested: *08/02/05*
Data Reduced by: *Kevin*
Date Reduced: *08/02/05*

Moisture Condition: *Air Dried*
Penetration: *0.001* **in/sec**
Max. Load: 23,220 **lbs**

45 Degree (Standard) Index: ***175***
Peak Slope Index: ***108***



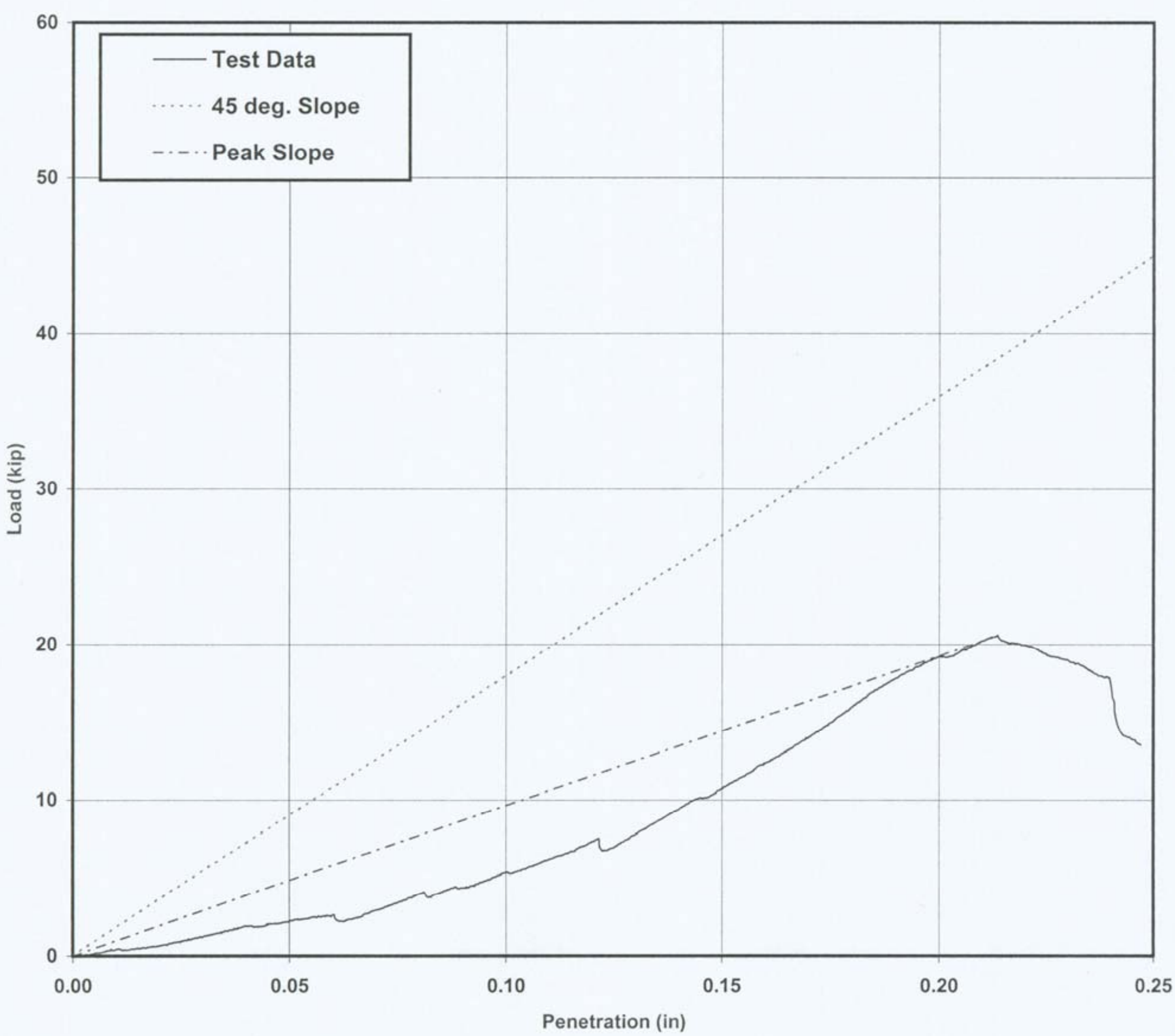
Earth Mechanics Institute
Mining Engineering Department, CSM

Punch Penetration Index Test (Ver. 3.0)

Project: *FMSM Section 4*
Location: *Lexington, KY*
Rock Type: *Sedimentary*
Rock Name: *Dolomite*
Characteristics: *Light Gray*
Core ID: *B-15-3@122.5-123.1*
File Name: *B-15-3@122.5-123.1*
Test Performed by: *Kevin*
Date Tested: *08/02/05*
Data Reduced by: *Kevin*
Date Reduced: *08/02/05*

Moisture Condition: *Air Dried*
Penetration: *0.001* **in/sec**
Max. Load: 20,592 **lbs**

45 Degree (Standard) Index: *175*
Peak Slope Index: *96*



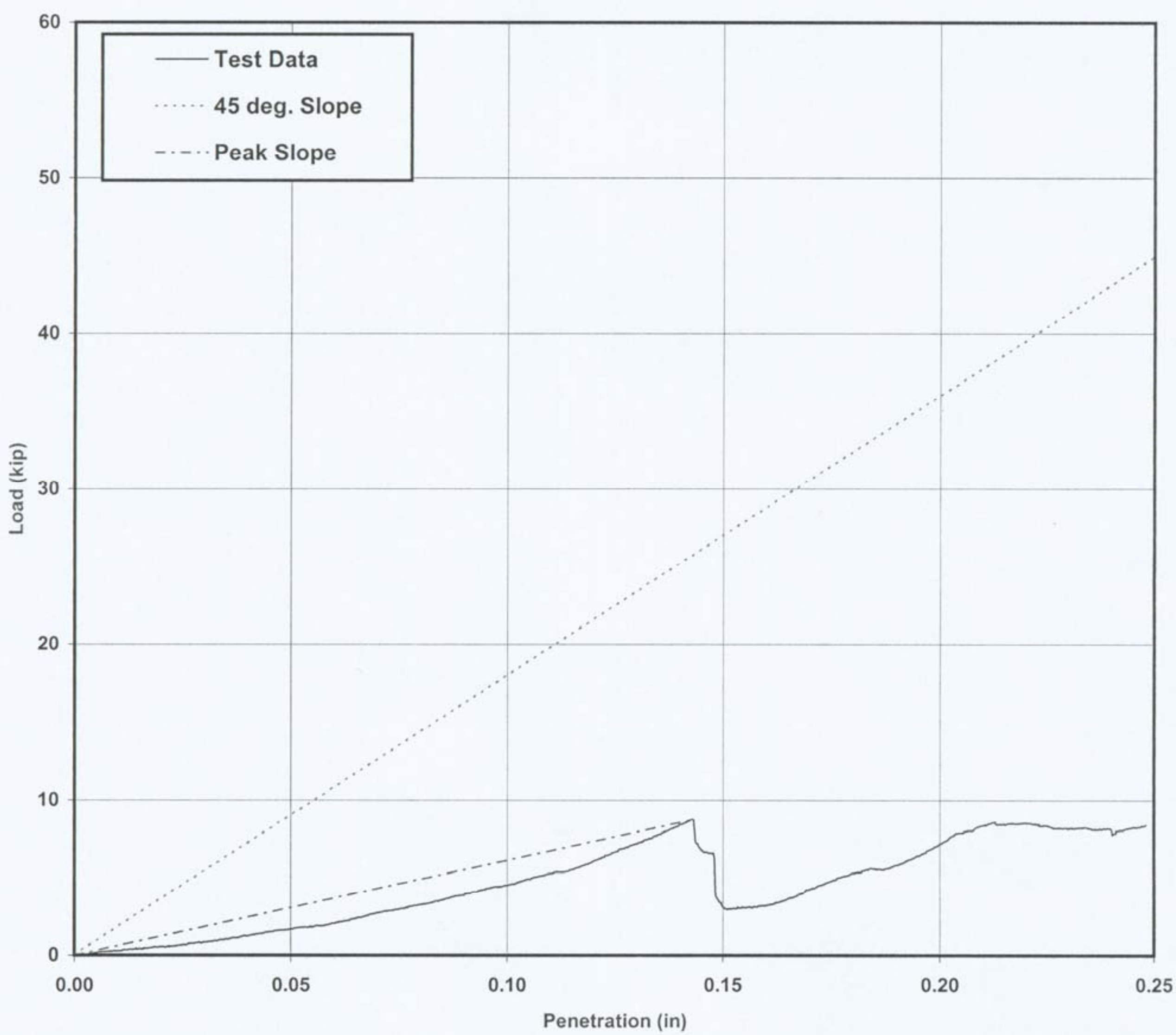
Earth Mechanics Institute
Mining Engineering Department, CSM

Punch Penetration Index Test (Ver. 3.0)

Project: *FMSM Section 4*
Location: *Lexington, KY*
Rock Type: *Sedimentary*
Rock Name: *Shale*
Characteristics: *Light Gray*
Core ID: *B-15-5@66.8-69.5*
File Name: *B-15-5@66.8-69.5*
Test Performed by: *Kevin*
Date Tested: *08/02/05*
Data Reduced by: *Kevin*
Date Reduced: *08/02/05*

Moisture Condition: *Air Dried*
Penetration: *0.001* in/sec
Max. Load: 8,734 lbs

45 Degree (Standard) Index: *175*
Peak Slope Index: *61*



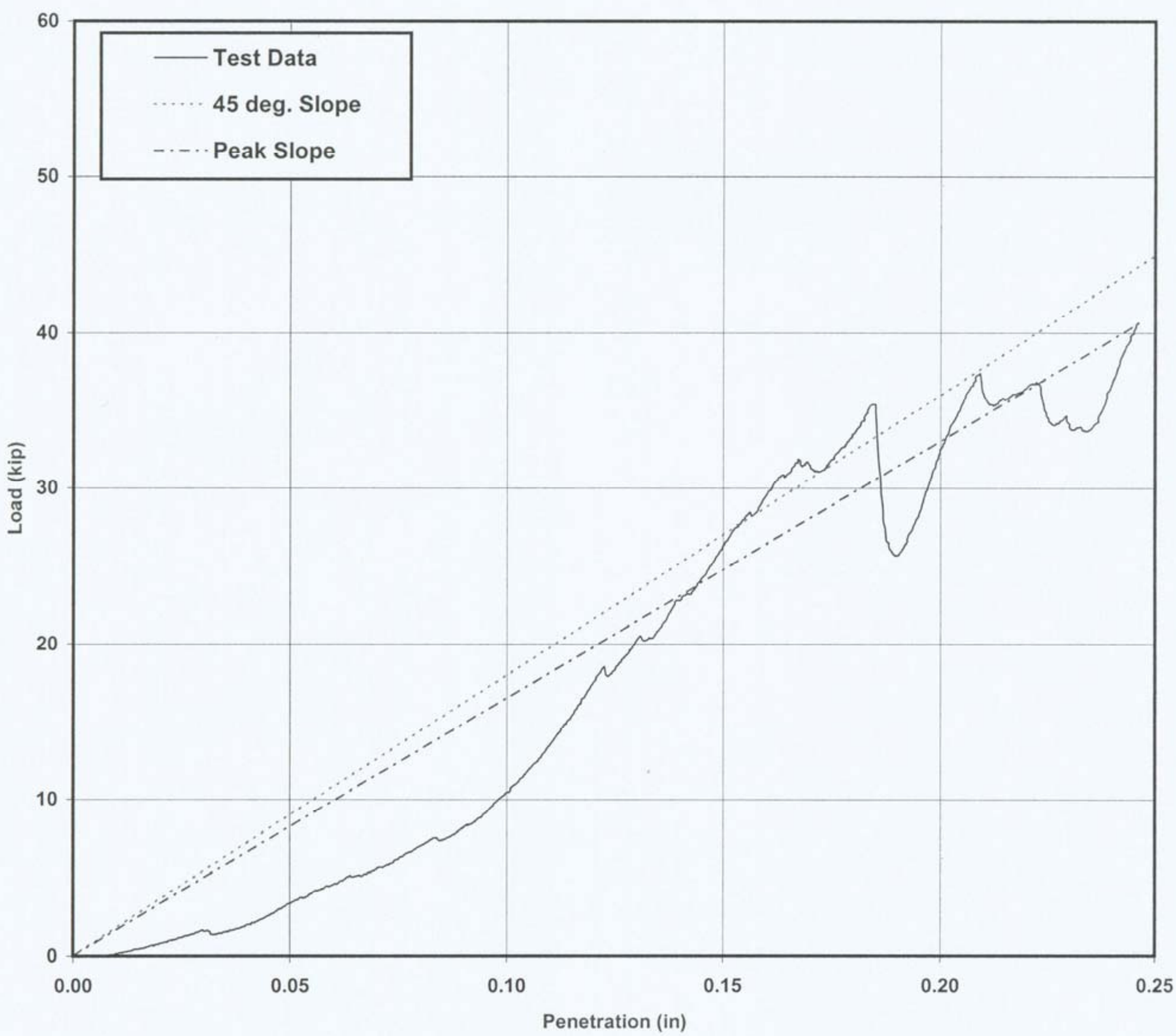
Earth Mechanics Institute
Mining Engineering Department, CSM

Punch Penetration Index Test (Ver. 3.0)

Project: *FMSM Section 4*
Location: *Lexington, KY*
Rock Type: *Sedimentary*
Rock Name: *Limestone*
Characteristics: *Light Gray*
Core ID: *B-15-6@75.6-76.2*
File Name: *B-15-6@75.6-76.2*
Test Performed by: *Kevin*
Date Tested: *08/04/05*
Data Reduced by: *Kevin*
Date Reduced: *08/04/05*

Moisture Condition: *Air Dried*
Penetration: *0.001* **in/sec**
Max. Load: 40,646 **lbs**

45 Degree (Standard) Index: *175*
Peak Slope Index: *165*



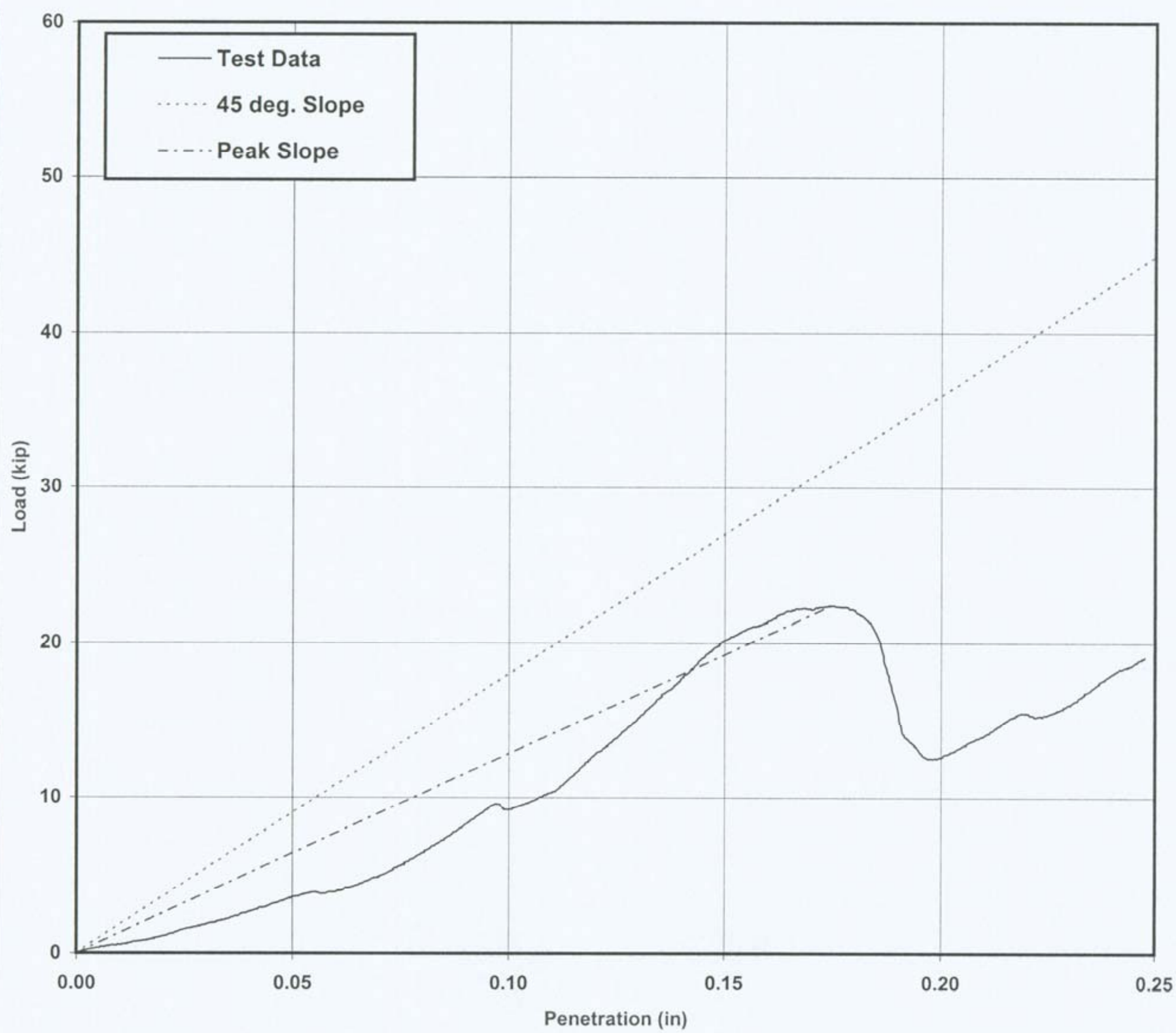
Earth Mechanics Institute
Mining Engineering Department, CSM

Punch Penetration Index Test (Ver. 3.0)

Project: *FMSM Section 4*
Location: *Lexington, KY*
Rock Type: *Sedimentary*
Rock Name: *Limestone*
Characteristics: *Light Gray*
Core ID: *B-18-1@50.6-51.3*
File Name: *B-18-1@50.6-51.3*
Test Performed by: *Kevin*
Date Tested: *08/02/05*
Data Reduced by: *Kevin*
Date Reduced: *08/02/05*

Moisture Condition: *Air Dried*
Penetration: *0.001* **in/sec**
Max. Load: 22,434 **lbs**

45 Degree (Standard) Index: *175*
Peak Slope Index: *129*



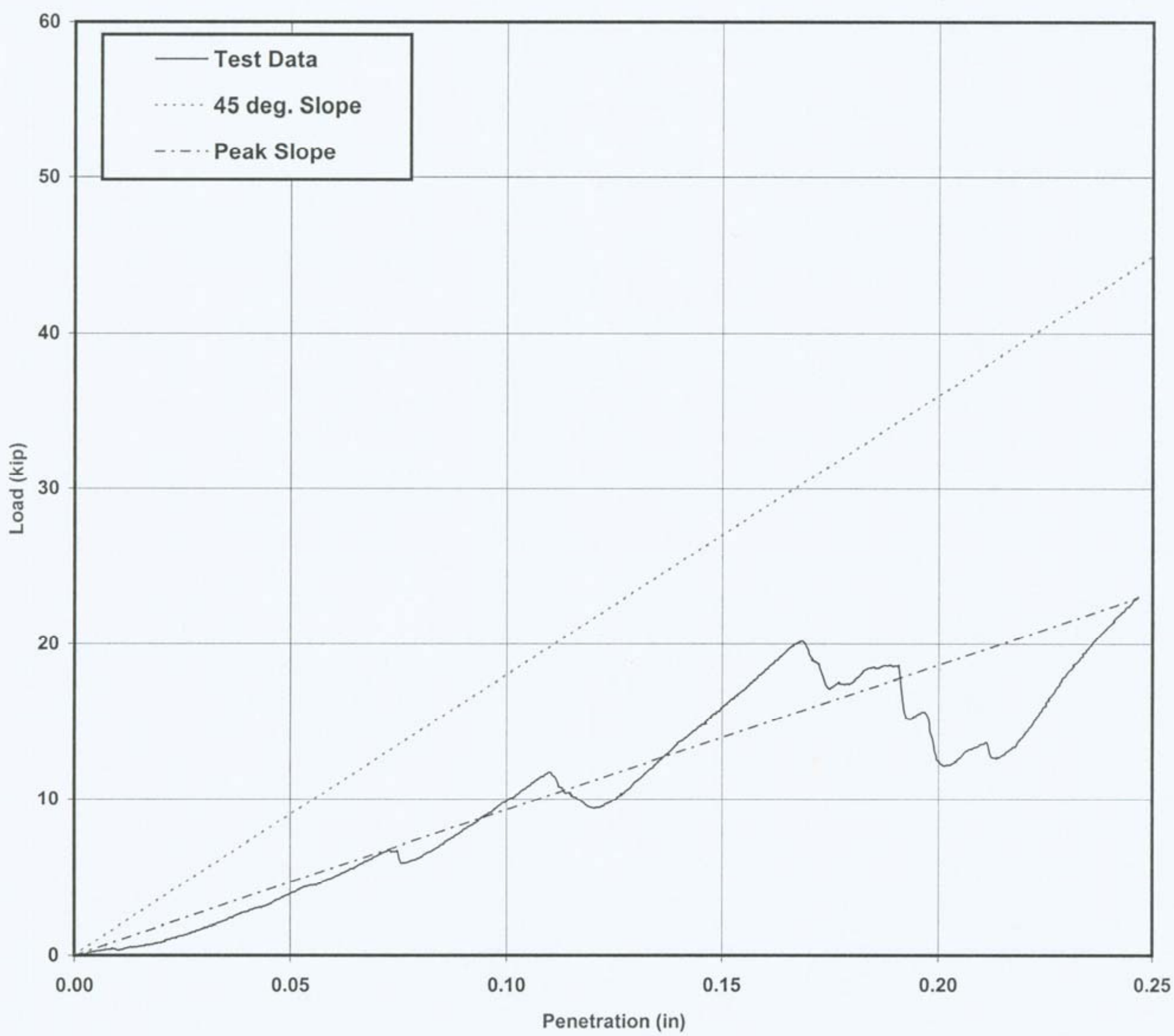
Earth Mechanics Institute
Mining Engineering Department, CSM

Punch Penetration Index Test (Ver. 3.0)

Project: *FMSM Section 4*
Location: *Lexington, KY*
Rock Type: *Sedimentary*
Rock Name: *Limestone*
Characteristics: *Light Gray*
Core ID: *B-18-4@36.5-37.0*
File Name: *B-18-4@36.5-37.0*
Test Performed by: *Kevin*
Date Tested: *08/02/05*
Data Reduced by: *Kevin*
Date Reduced: *08/02/05*

Moisture Condition: *Air Dried*
Penetration: *0.001* **in/sec**
Max. Load: 22,993 **lbs**

45 Degree (Standard) Index: *175*
Peak Slope Index: *93*



Earth Mechanics Institute **Colorado School of Mines**

Project Name : Ohio River Bridges **Mining Engineering Department**

Location:

Client: Hatch Mott McDonald

Date: 3/30/2006		Schmidt Hammer Rebound Hardness		
Sample ID	Rock Type	Calibration Factor	Schmidt Index (H_R)	Notes *(Spot hitted)*
B-2-3a@11.65-11.84	Sedimentary	0.95	37.3	Core sample side walls
B-2-5a@12.74-12.99	Sedimentary	0.95	43.7	Core sample side walls
B-5-8@53.15-53.9	Sedimentary	0.95	41.4	Core sample side walls
B-5-11@61-61.75	Sedimentary	0.95	43.9	Core sample side walls
B-6-21@41.05-41.7	Sedimentary	0.95	41.4	Core sample side walls
B-6-23@51.9-52.95	Sedimentary	0.95	45.2	Core sample side walls
B-8-6@40.65-41.1	Sedimentary	0.95	33.1	Core sample side walls
B-8-10@48.7-49.05	Sedimentary	0.95	42.8	Core sample side walls
B-9-2@58.25-58.65	Sedimentary	0.95	40.5	Core sample side walls
B-10-11@68.3-68.75	Sedimentary	0.95	42.2	Core sample side walls
B-10-2@49.35-49.9	Sedimentary	0.95	35.6	Core sample side walls
B-9-8@71.25-71.7	Sedimentary	0.95	24.6	Core sample side walls
B-11-2@73.1-73.8	Sedimentary	0.95	36.7	Core sample side walls
B-11-6@96-96.8	Sedimentary	0.95	43.3	Core sample side walls
B-12-12@42.7-43.1	Sedimentary	0.95	34.1	Core sample side walls

Fuller Mossbarger Scott & May ENGINEERS

Splitting Tensile Strength Of Intact Rock Core

ASTM D 3967

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, light gray, moderately hard	Lab ID	BT-53
Hole Number	B-7-6 Depth (ft/elev) 39.7' - 39.8'	Date Received	07-27-2005

Side Planeness	Pass	Height (in.)	1.221	Wet Unit Weight (pcf)	163.2
Perpendicularity	Pass	Diameter (in.)	1.994	Dry Unit Weight (pcf)	N/A
Height/Diameter	Pass	Wet Mass (g)	163.32	Moisture Content (%)	N/A

Test Date 08-08-2005

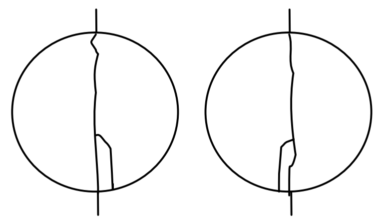
Moisture Condition As received, dry
Temperature (°F) 70

Loading Rate (lbf/sec) 10
Peak Load (lbf) 5640

Splitting Tensile Strength 1475 psi

Failure Type Split
Bearing Strip Cardboard

Failure Sketches

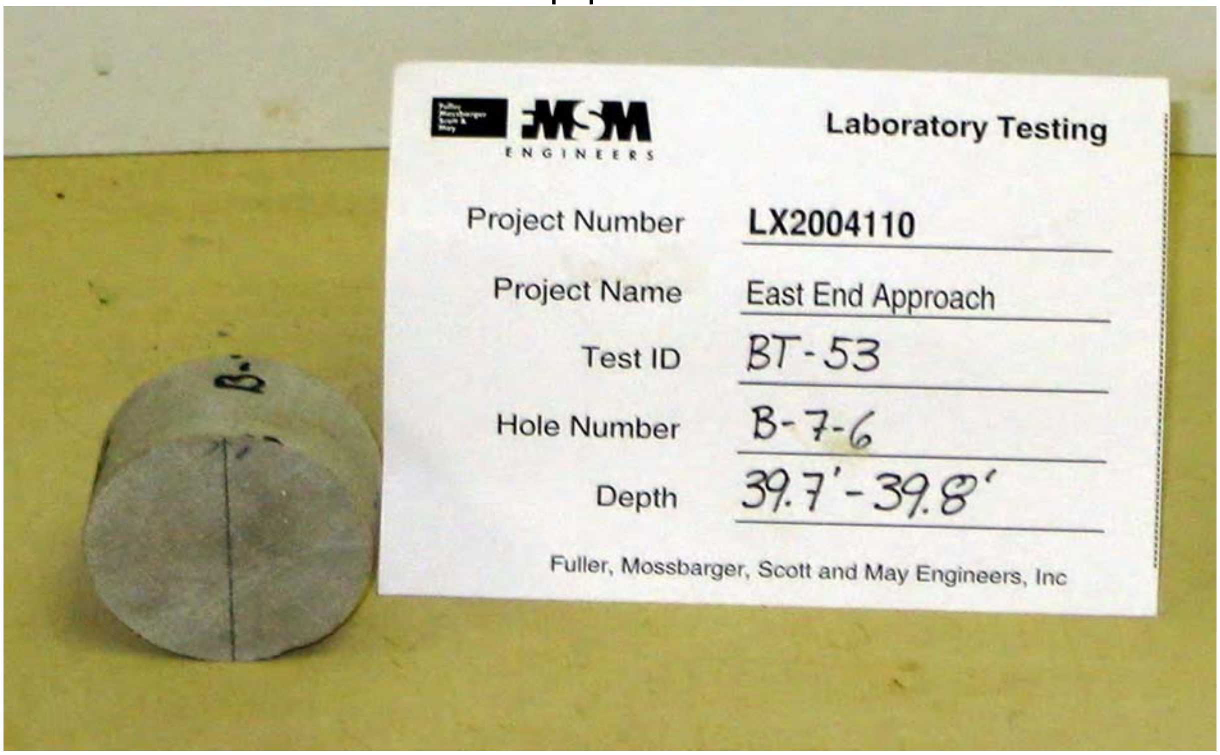


Comments

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, light gray, moderately hard	Lab ID	BT-53
Hole Number	B-7-6 Depth (ft) 39.6' - 40.0'		
Test Type	Splitting tensile strength of intact rock core		

Core preparation



Core preparation

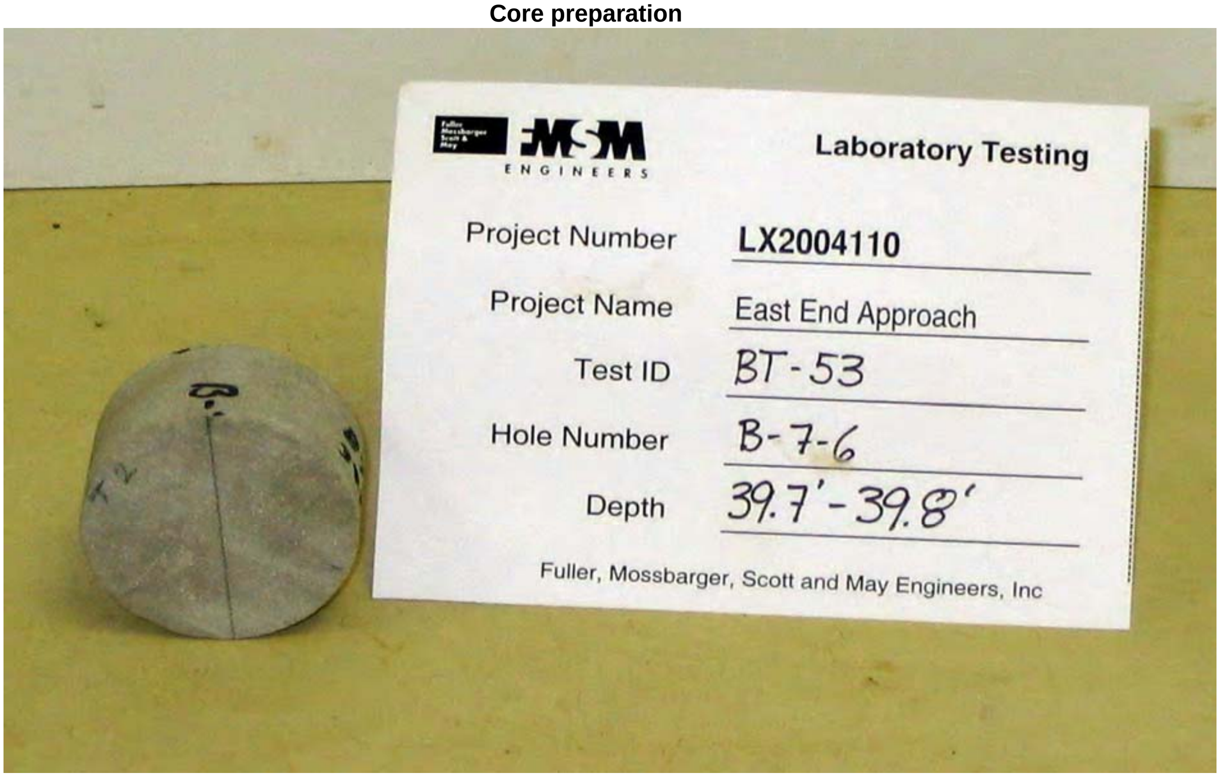


Photo Report

Project Name: LSIORB Section 4, East End Approach

Project Number: LX2004110

Lithology: Dolomite, light gray, moderately hard

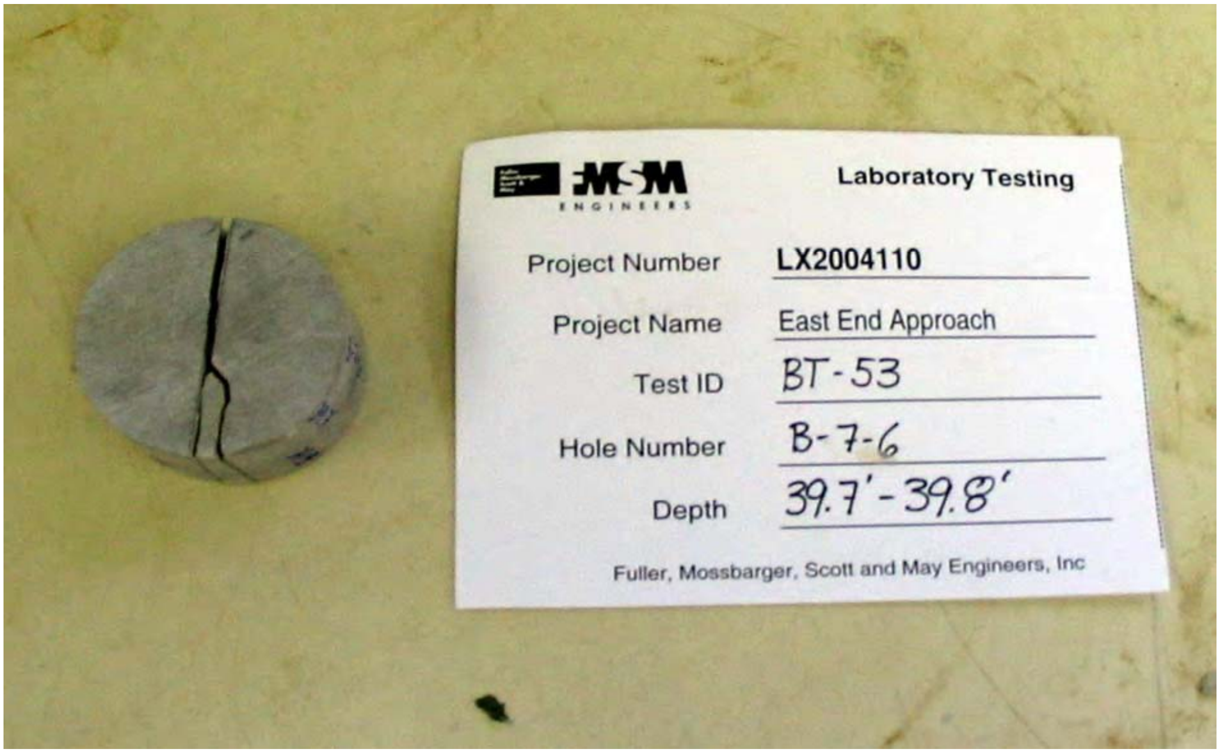
Lab ID: BT-53

Hole Number: B-7-6

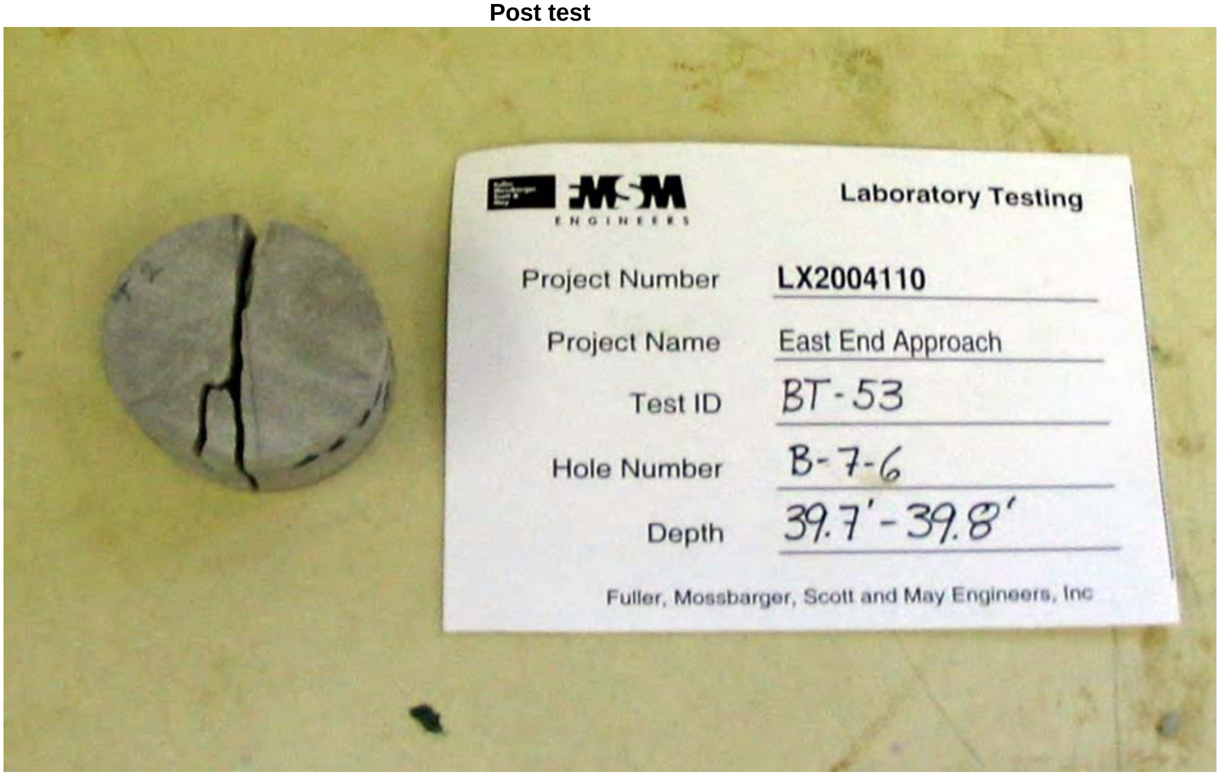
Depth (ft): 39.6' - 40.0'

Test Type: Splitting tensile strength of intact rock core

Post test



Post test



Fuller Mossbarger Scott & May
ENGINEERS

Splitting Tensile Strength Of Intact Rock Core
ASTM D 3967

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, light gray, moderately hard	Lab ID	BT-59
Hole Number	B-12-4 Depth (ft/elev) 73.1' - 73.2'	Date Received	07-27-2005

Side Planeness	Pass	Height (in.)	1.202	Wet Unit Weight (pcf)	166.4
Perpendicularity	Pass	Diameter (in.)	1.984	Dry Unit Weight (pcf)	N/A
Height/Diameter	Pass	Wet Mass (g)	162.29	Moisture Content (%)	N/A

Test Date 08-08-2005

Moisture Condition As received, dry
Temperature (°F) 70

Loading Rate (lbf/sec) 10
Peak Load (lbf) 4430

Splitting Tensile Strength 1183 psi

Failure Type Split
Bearing Strip Cardboard

Comments

Failure Sketches

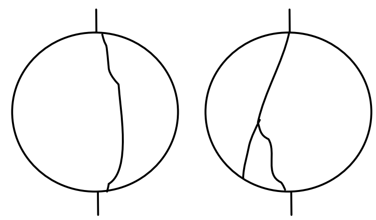


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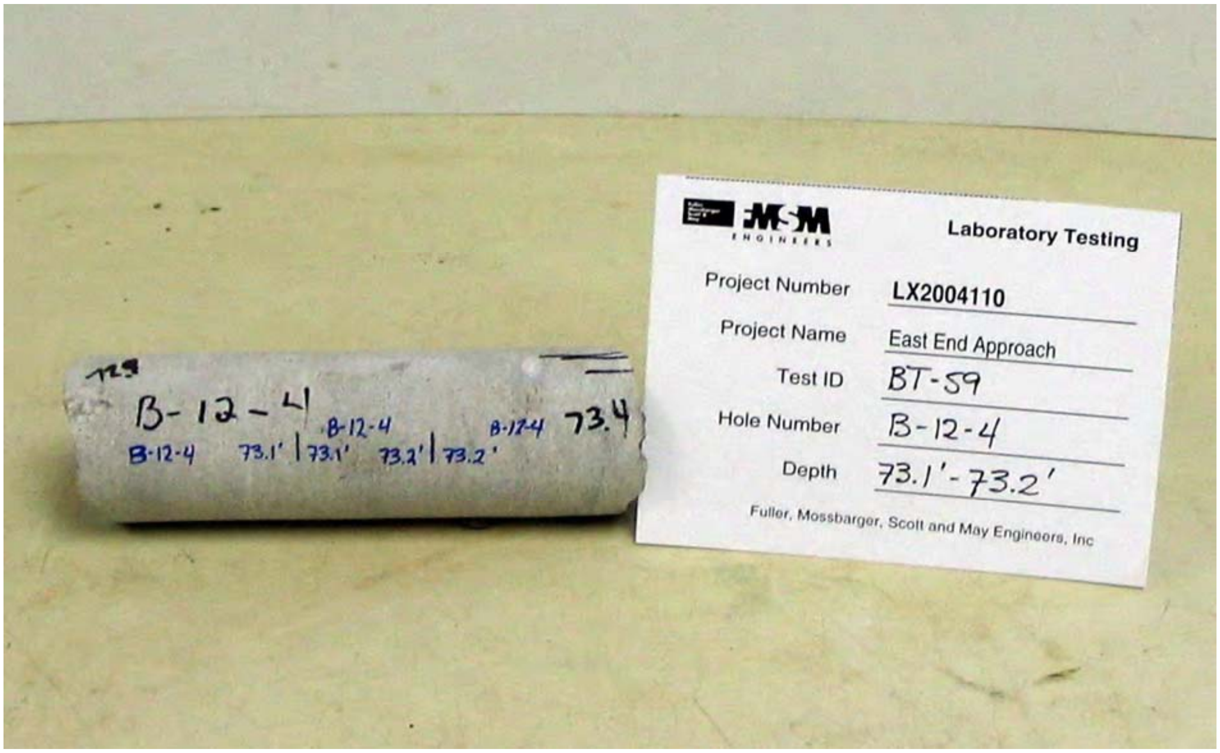
Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Dolomite, light gray, moderately hard
Hole Number B-12-4 Depth (ft) 73.1' - 73.2'
Test Type Splitting tensile strength of intact rock core

Project Number LX2004110
Lab ID BT-59

As received



Core preparation

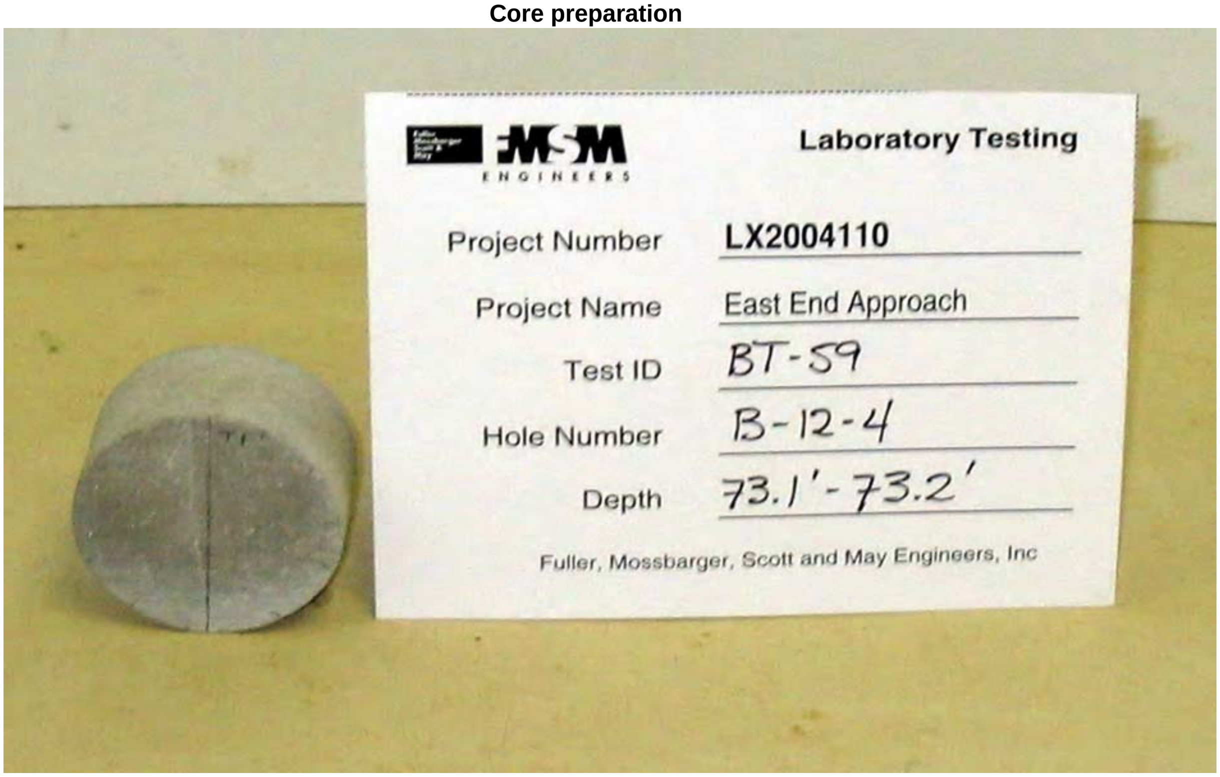


Photo Report

Project Name LSIORB Section 4, East End Approach

Project Number LX2004110

Lithology Dolomite, light gray, moderately hard

Lab ID BT-59

Hole Number B-12-4 Depth (ft) 73.1' - 73.2'

Test Type Splitting tensile strength of intact rock core

Core preparation

Post test

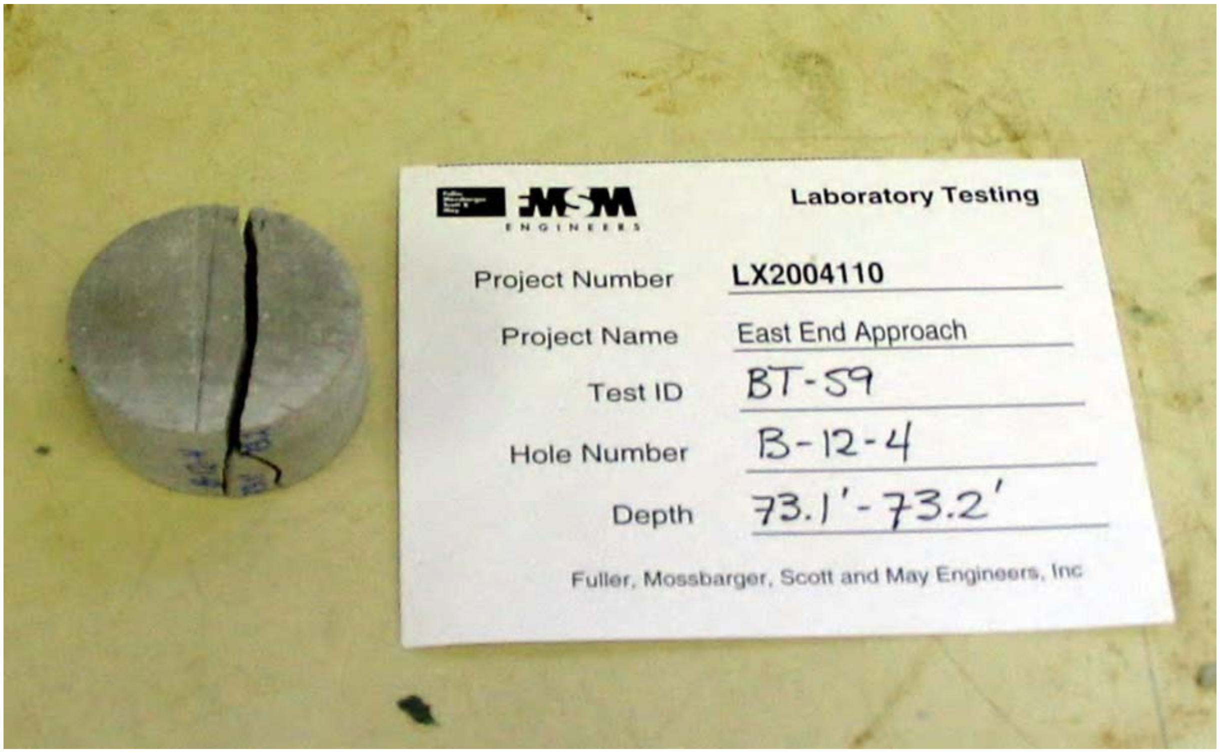


Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Dolomite, light gray, moderately hard
Hole Number B-12-4 Depth (ft) 73.1' - 73.2'
Test Type Splitting tensile strength of intact rock core

Project Number LX2004110
Lab ID BT-59

Post test

Splitting Tensile Strength
Of Intact Rock Core
ASTM D 3967

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, light gray, moderately hard
Hole Number B-12-8 Depth (ft/elev) 10.0' - 10.1'

Project Number LX2004110
Lab ID BT-62
Date Received 07-27-2005

Side Planeness Pass
Perpendicularity Pass
Height/Diameter Pass

Height (in.) 1.130
Diameter (in.) 1.981
Wet Mass (g) 150.75

Wet Unit Weight (pcf) 164.9
Dry Unit Weight (pcf) N/A
Moisture Content (%) N/A

Test Date 08-08-2005

Moisture Condition As received, dry
Temperature (°F) 70

Loading Rate (lbf/sec) 10
Peak Load (lbf) 4470

Splitting Tensile Strength 1271 psi

Failure Type Split
Bearing Strip Cardboard

Comments

Failure Sketches

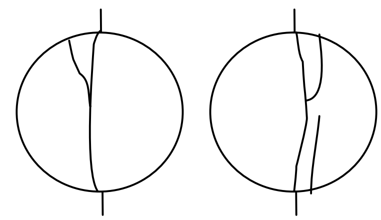
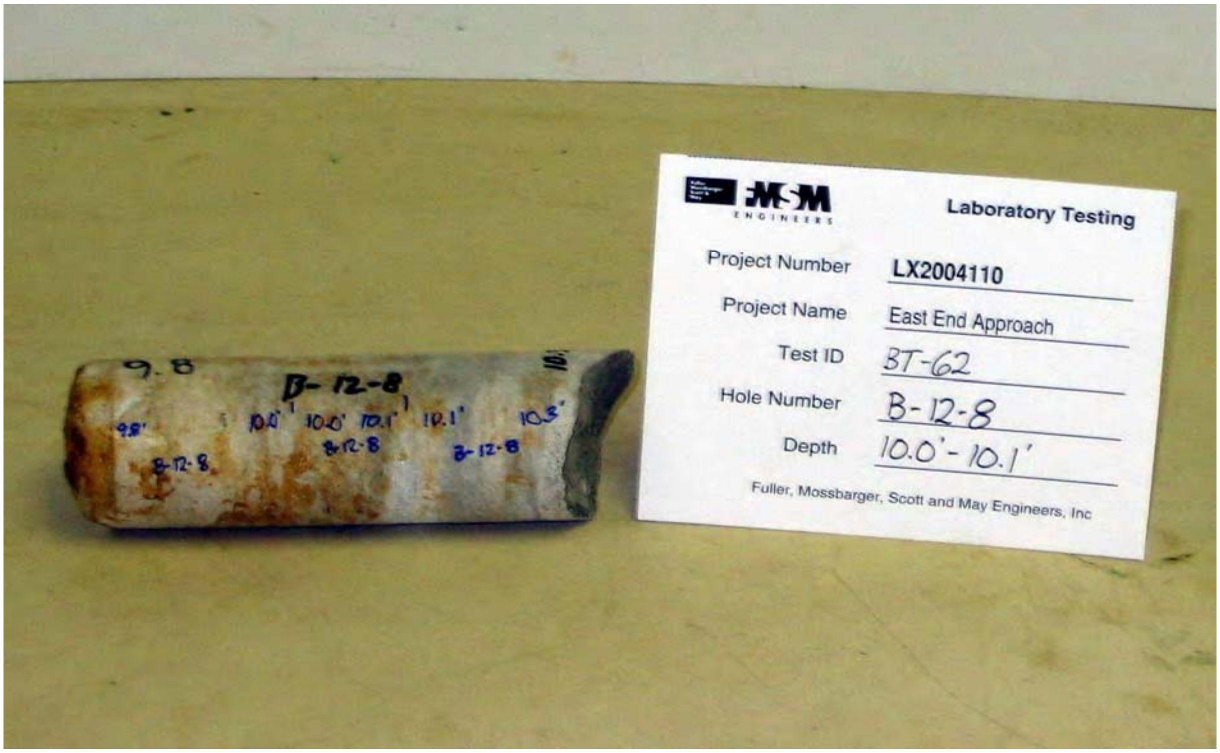


Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, light gray, moderately hard
Hole Number B-12-8 Depth (ft) 10.0' - 10.1'
Test Type Splitting tensile strength of intact rock core

Project Number LX2004110
Lab ID BT-62

As received



Core preparation

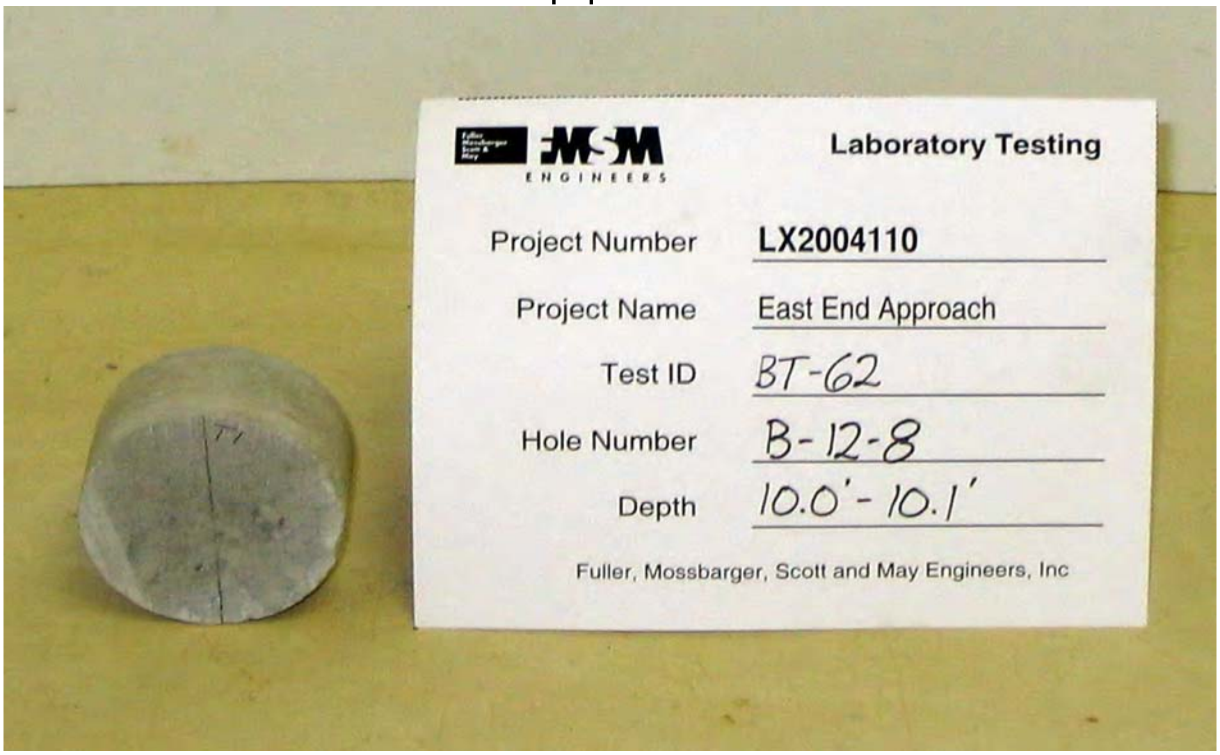
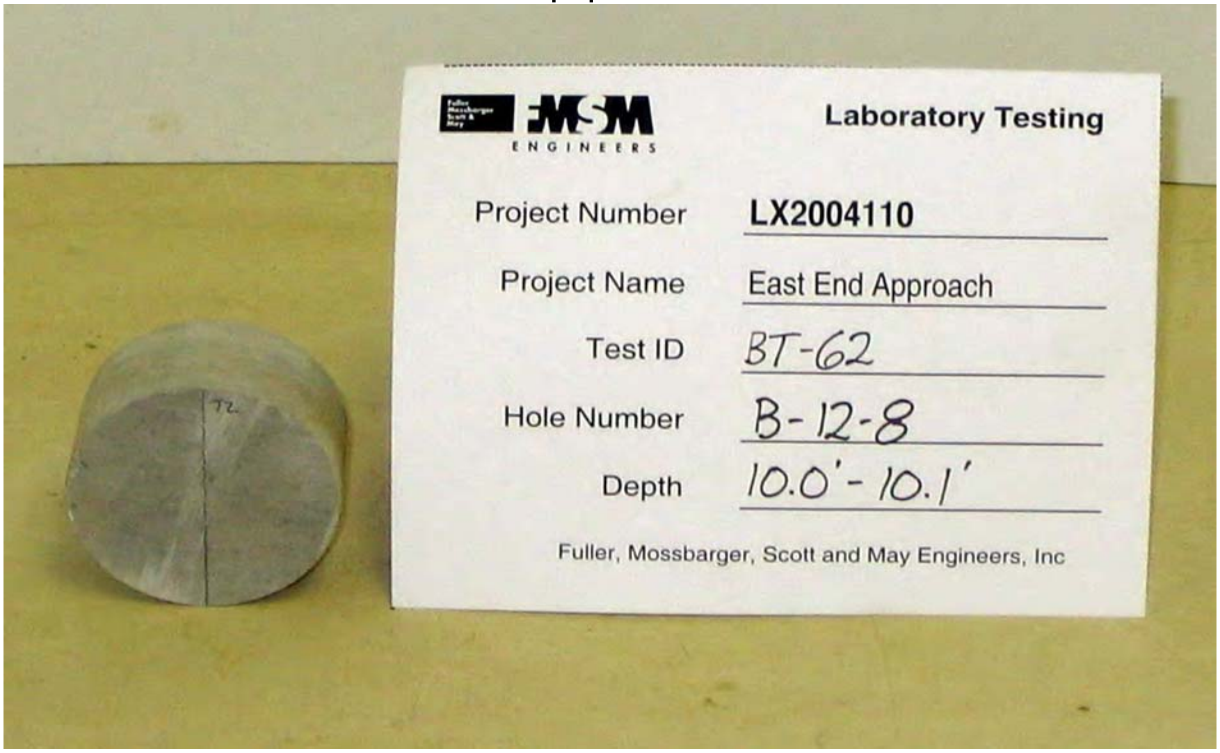


Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, light gray, moderately hard
Hole Number B-12-8 Depth (ft) 10.0' - 10.1'
Test Type Splitting tensile strength of intact rock core

Project Number LX2004110
Lab ID BT-62

Core preparation



Post test

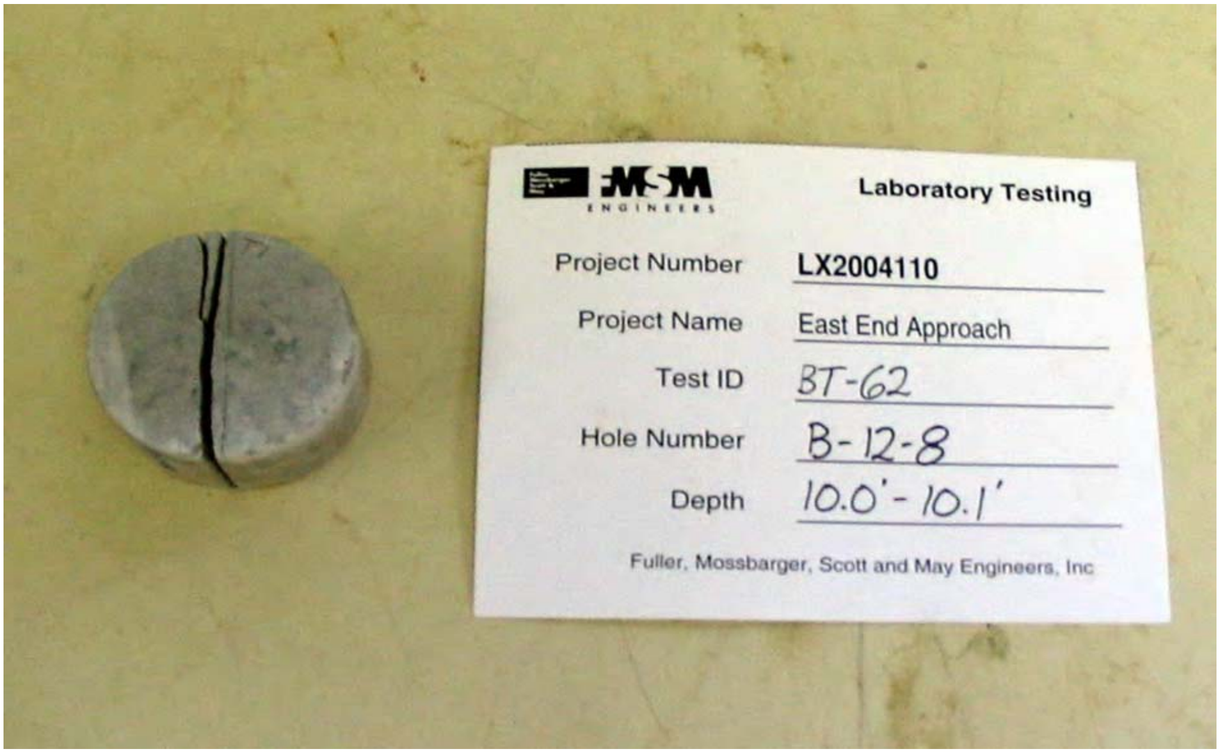
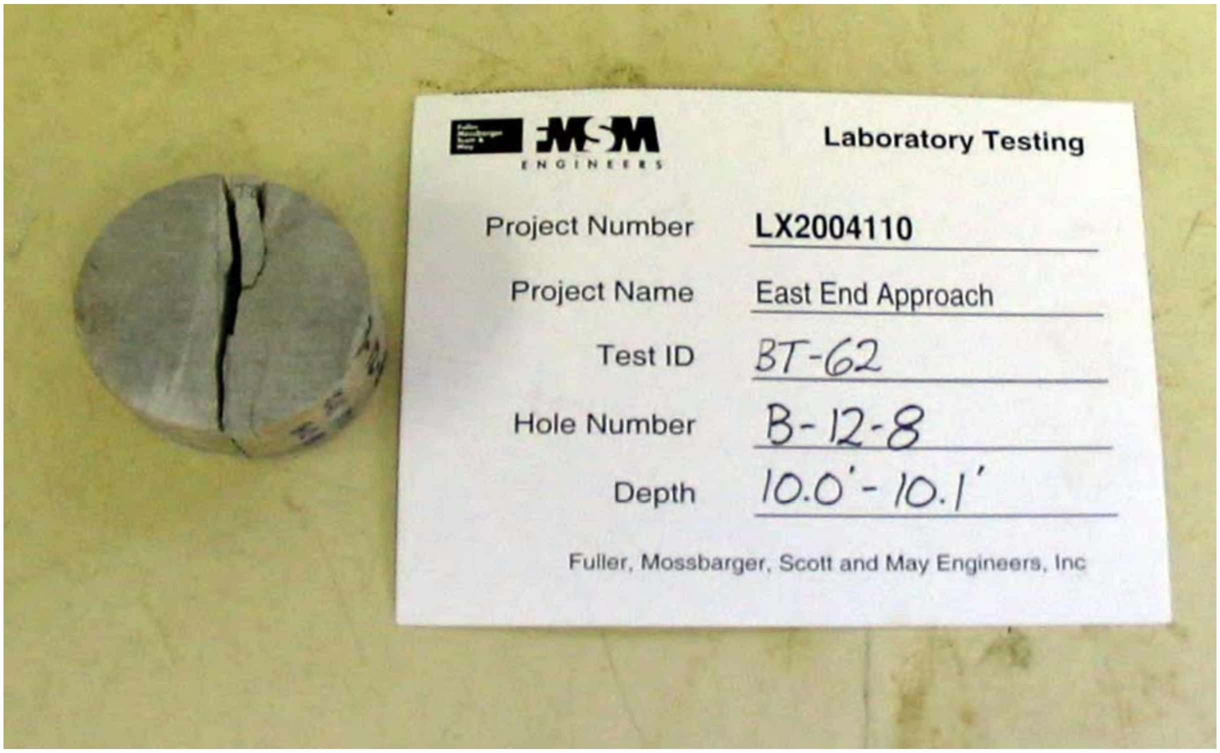


Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, light gray, moderately hard
Hole Number B-12-8 Depth (ft) 10.0' - 10.1'
Test Type Splitting tensile strength of intact rock core

Project Number LX2004110
Lab ID BT-62

Post test



Fuller Mossbarger Scott & May
FMSM ENGINEERS

Splitting Tensile Strength Of Intact Rock Core

ASTM D 3967

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Limestone, light gray, moderately hard
Lab ID: BT-63
Hole Number: B-12-9
Depth (ft/elev): 33.0' - 33.1'
Date Received: 07-27-2005

Side Planeness	Pass	Height (in.)	1.138	Wet Unit Weight (pcf)	165.3
Perpendicularity	Pass	Diameter (in.)	1.984	Dry Unit Weight (pcf)	N/A
Height/Diameter	Pass	Wet Mass (g)	152.70	Moisture Content (%)	N/A

Test Date: 08-08-2005

Moisture Condition: As received, dry
Temperature (°F): 70

Loading Rate (lbf/sec): 10
Peak Load (lbf): 3840

Splitting Tensile Strength: 1082 psi

Failure Type: Split
Bearing Strip: Cardboard

Comments:

Failure Sketches

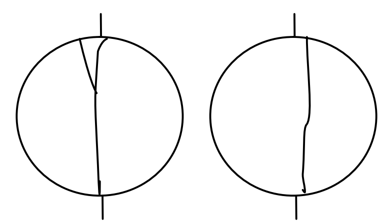


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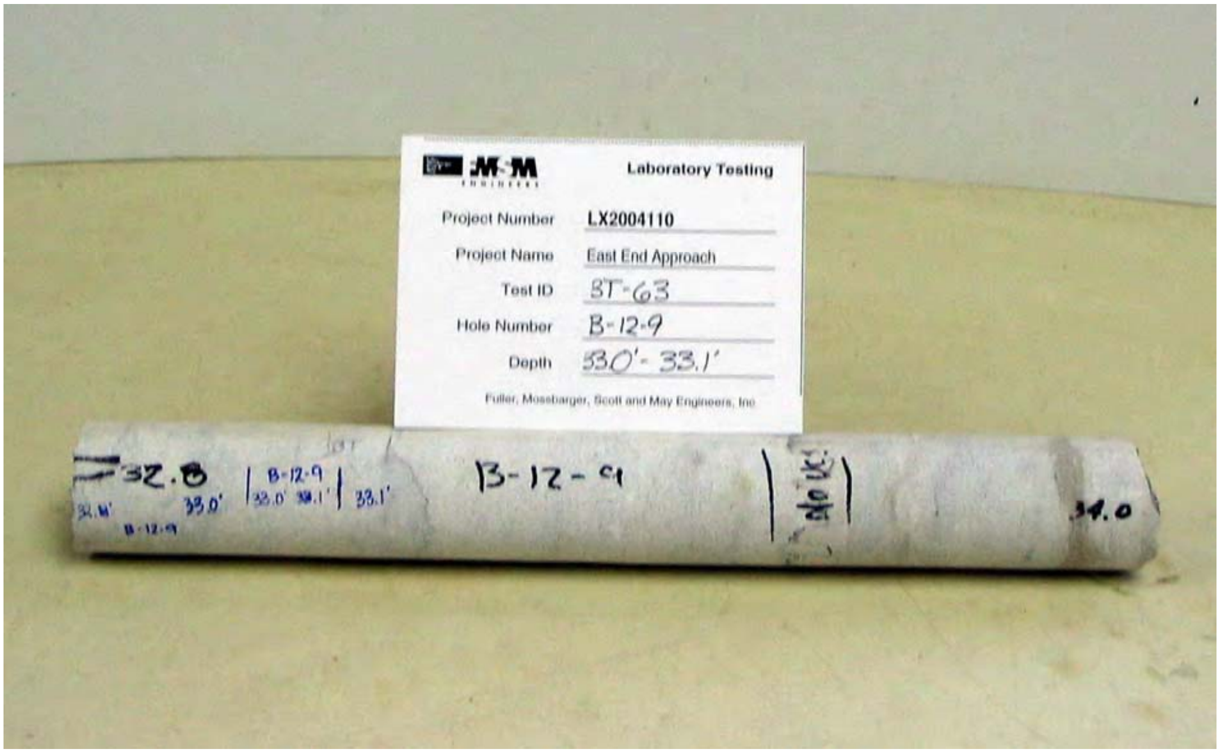
Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, light gray, moderately hard	Lab ID	BT-63
Hole Number	B-12-9	Depth (ft)	33.0' - 33.1'
Test Type	Splitting tensile strength of intact rock core		

As received



Core preparation

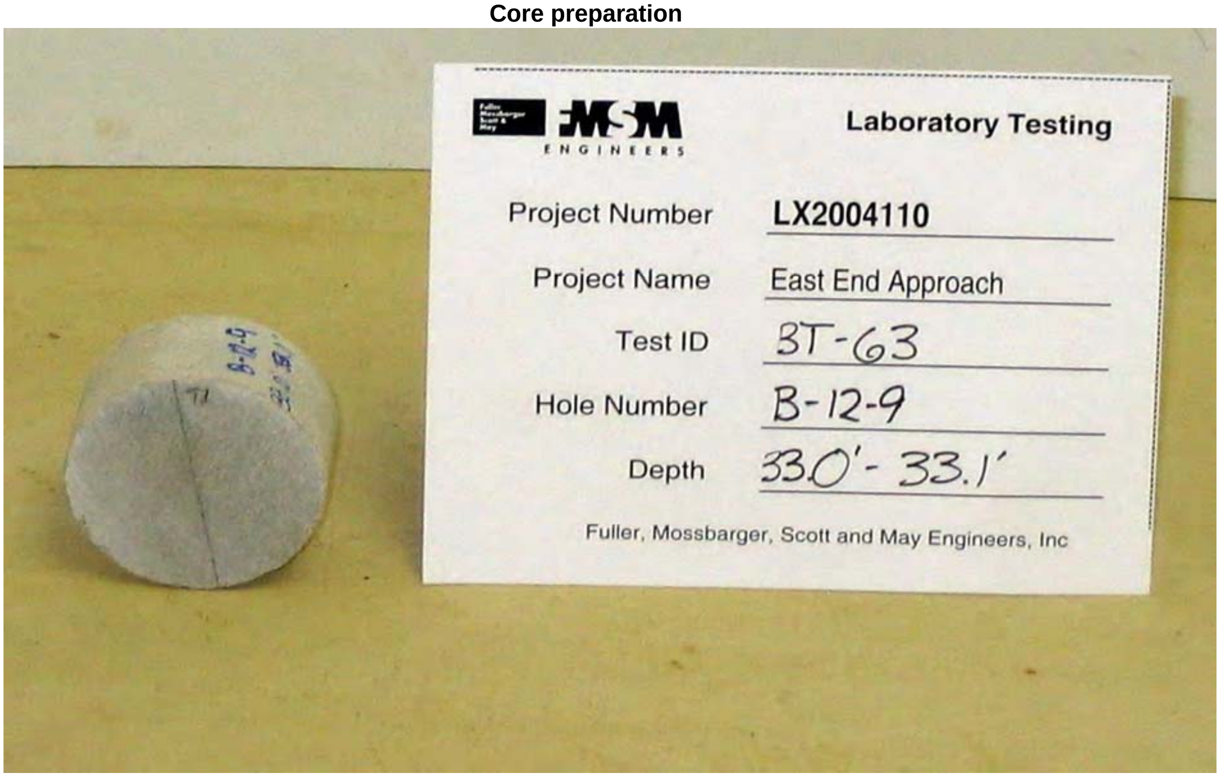
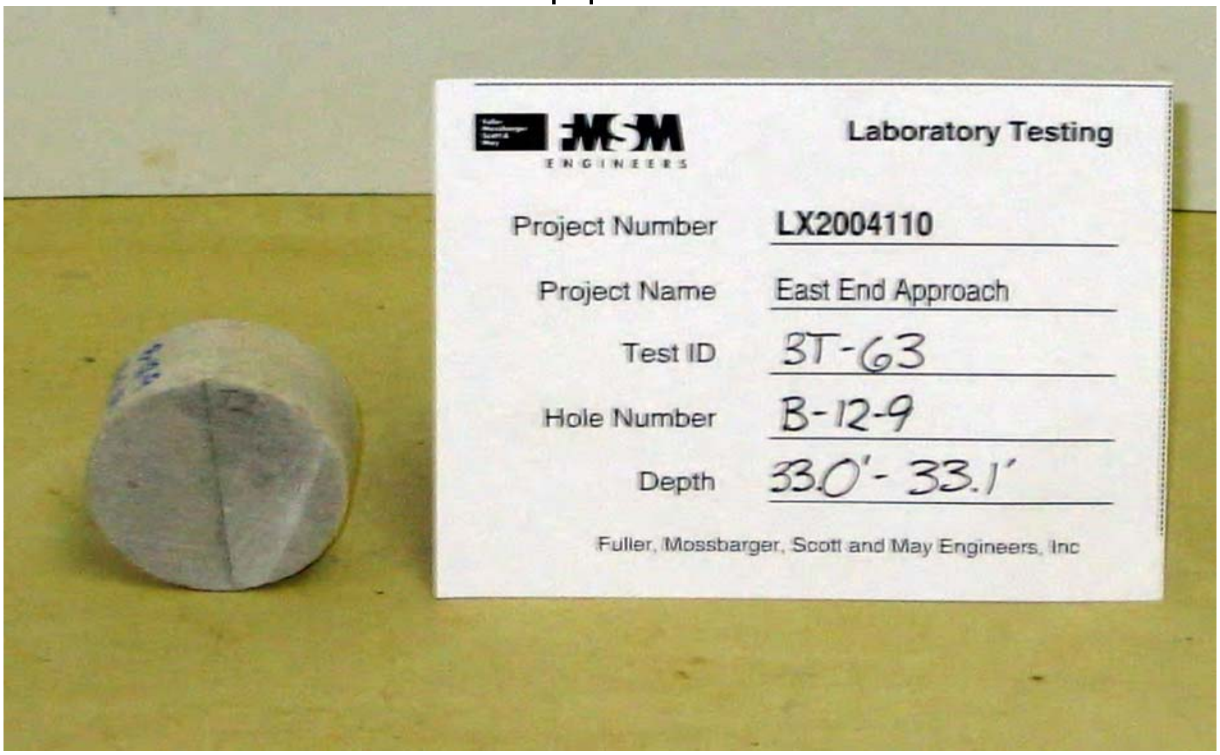


Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, light gray, moderately hard
Hole Number B-12-9 Depth (ft) 33.0' - 33.1'
Test Type Splitting tensile strength of intact rock core

Project Number LX2004110
Lab ID BT-63

Core preparation



Post test

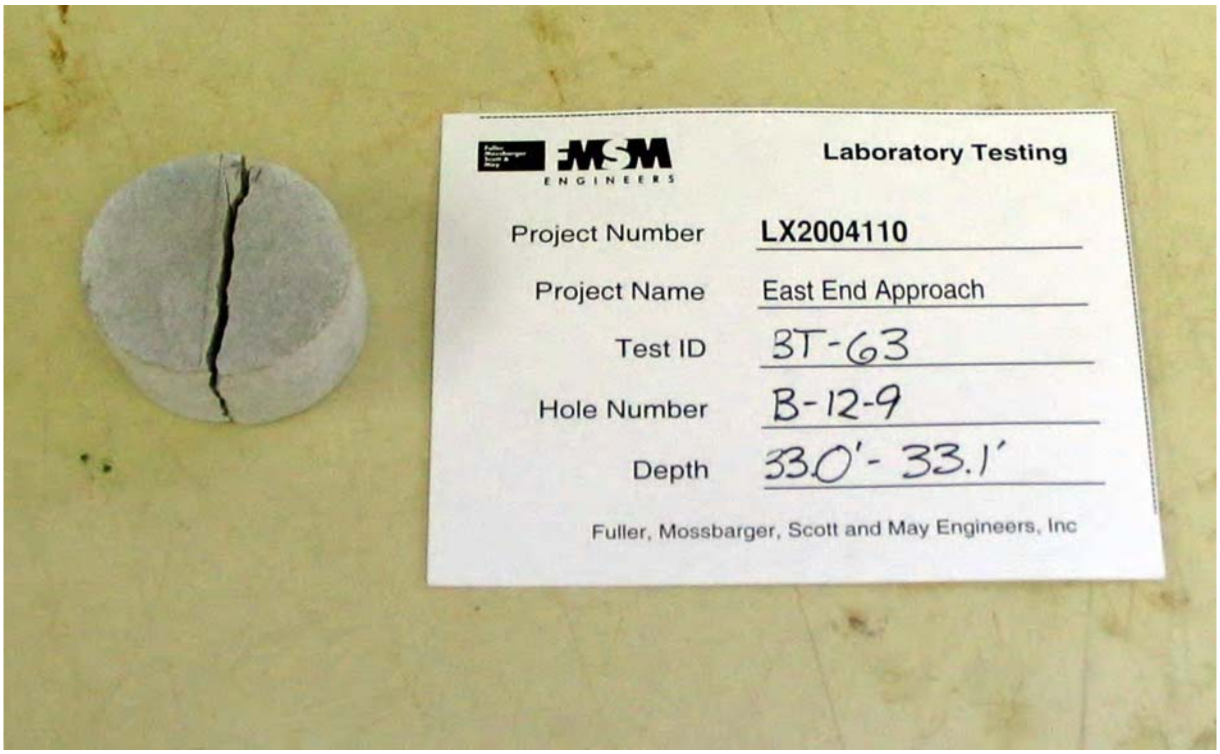
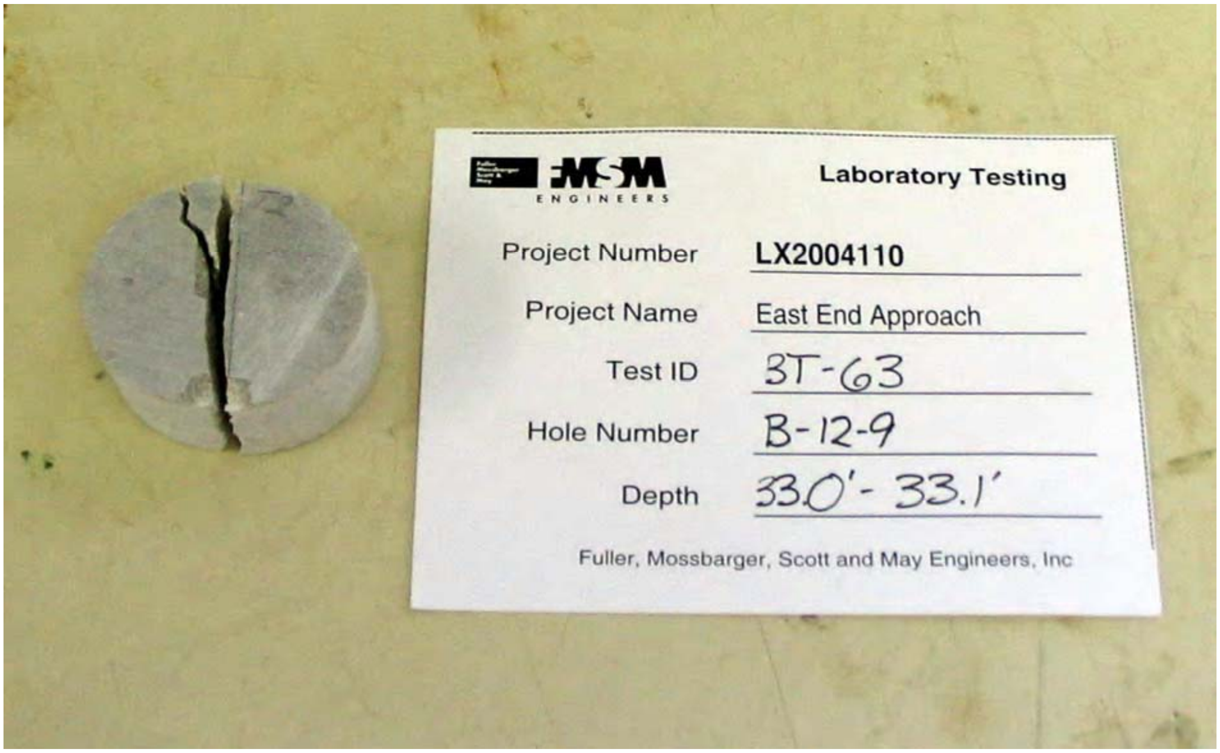


Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, light gray, moderately hard
Hole Number B-12-9 Depth (ft) 33.0' - 33.1'
Test Type Splitting tensile strength of intact rock core

Project Number LX2004110
Lab ID BT-63

Post test



Splitting Tensile Strength Of Intact Rock Core
ASTM D 3967

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Dolomite, gray, moderately hard
Lab ID: BT-79
Hole Number: B-15-3
Depth (ft/elev): 122.4' - 122.5'
Date Received: 07-27-2005

Side Planeness: Pass
Perpendicularity: Pass
Height/Diameter: Pass

Height (in.): 0.847
Diameter (in.): 1.983
Wet Mass (g): 112.13

Wet Unit Weight (pcf): 163.4
Dry Unit Weight (pcf): N/A
Moisture Content (%): N/A

Test Date: 08-08-2005

Moisture Condition: As received, moist
Temperature (°F): 70

Loading Rate (lbf/sec): 10
Peak Load (lbf): 2660

Splitting Tensile Strength: 1009 psi

Failure Type: Split
Bearing Strip: Cardboard

Comments:

Failure Sketches

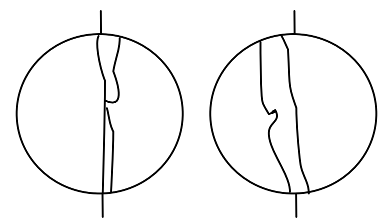
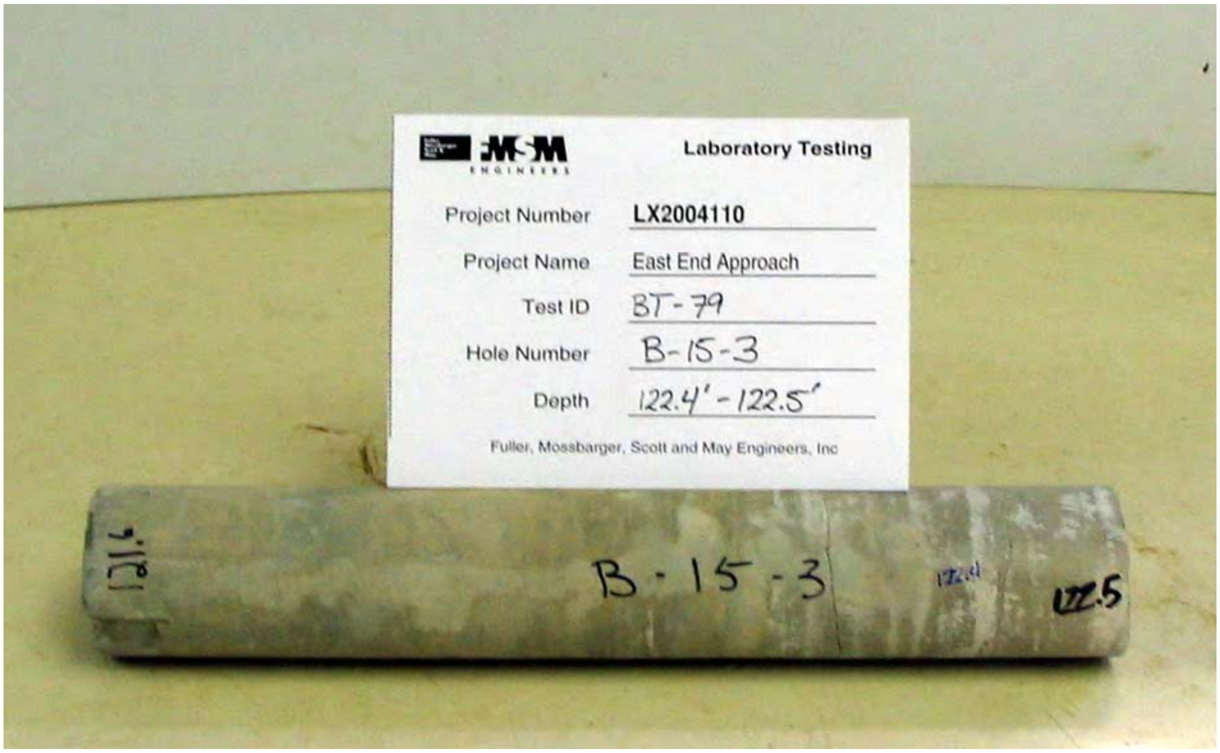


Photo Report

Project Name LSIORB Section 4, East End Approach | Project Number LX2004110
Lithology Dolomite, gray, moderately hard | Lab ID BT-79
Hole Number B-15-3 | Depth (ft) 122.4' - 122.5'
Test Type Splitting tensile strength of intact rock core

As received



Core preparation

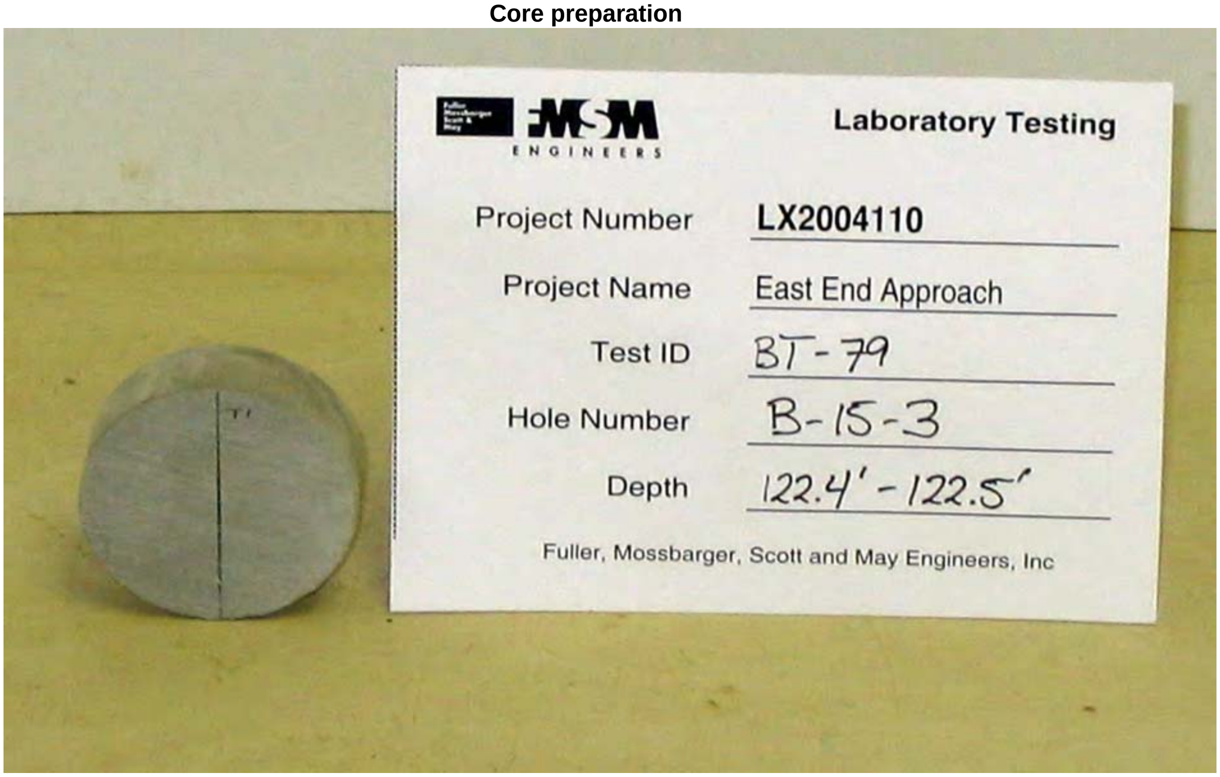
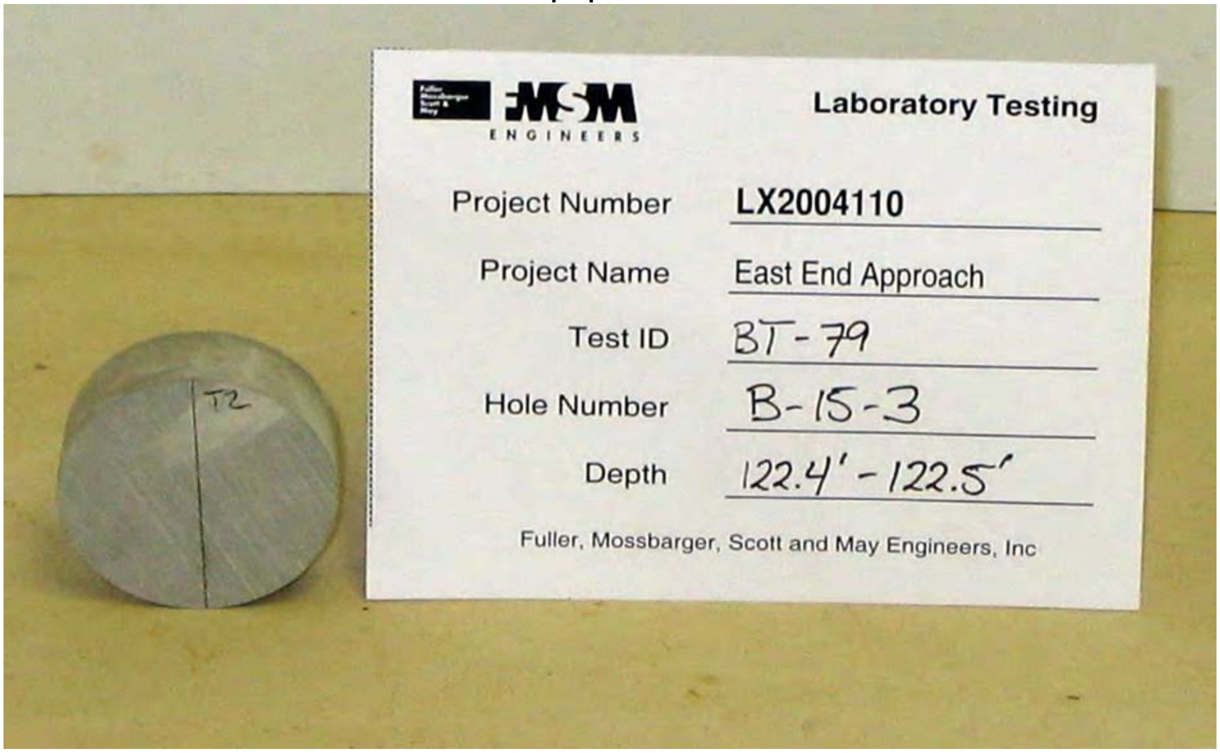


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, gray, moderately hard	Lab ID	BT-79
Hole Number	B-15-3	Depth (ft)	122.4' - 122.5'
Test Type	Splitting tensile strength of intact rock core		

Core preparation



Post test

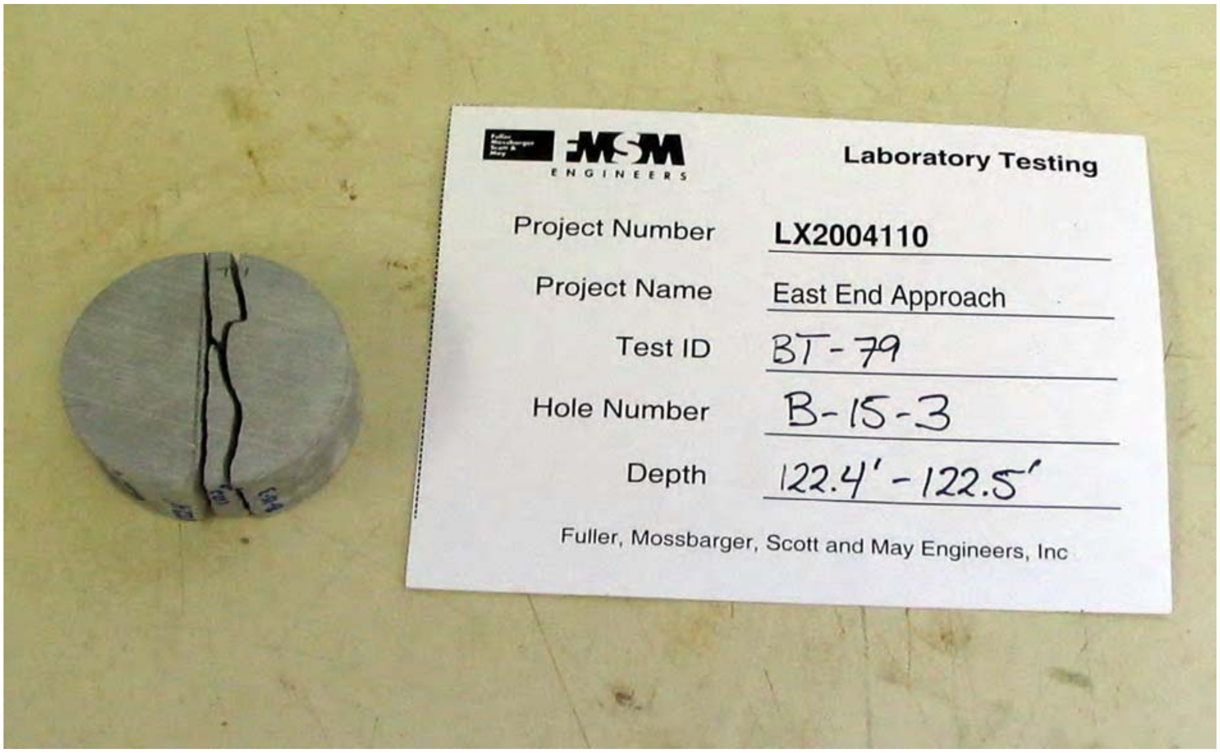


Photo Report

Project Name LSIORB Section 4, East End Approach

Lithology Dolomite, gray, moderately hard

Hole Number B-15-3 Depth (ft) 122.4' - 122.5'

Test Type Splitting tensile strength of intact rock core

Project Number LX2004110

Lab ID BT-79

Post test

Splitting Tensile Strength
Of Intact Rock Core
ASTM D 3967

FMSM ENGINEERS — Fuller Mossbarger Scott & May

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Shale, gray, soft	Lab ID	BT-80
Hole Number	B-15-5 Depth (ft/elev) 69.9' - 70.0'	Date Received	07-27-2005

Side Planeness	Pass	Height (in.)	1.089	Wet Unit Weight (pcf)	165.7
Perpendicularity	Pass	Diameter (in.)	1.983	Dry Unit Weight (pcf)	N/A
Height/Diameter	Pass	Wet Mass (g)	146.23	Moisture Content (%)	N/A

Test Date 08-08-2005

Moisture Condition As received, dry
Temperature (°F) 70

Loading Rate (lbf/sec) 10
Peak Load (lbf) 2570

Splitting Tensile Strength 758 psi

Failure Type Split
Bearing Strip Cardboard

Comments

Failure Sketches

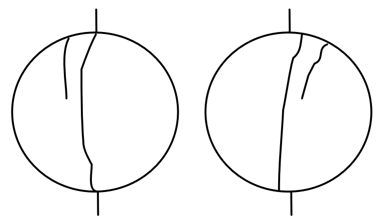


Photo Report

Project Name LSIORB Section 4, East End Approach

Project Number LX2004110

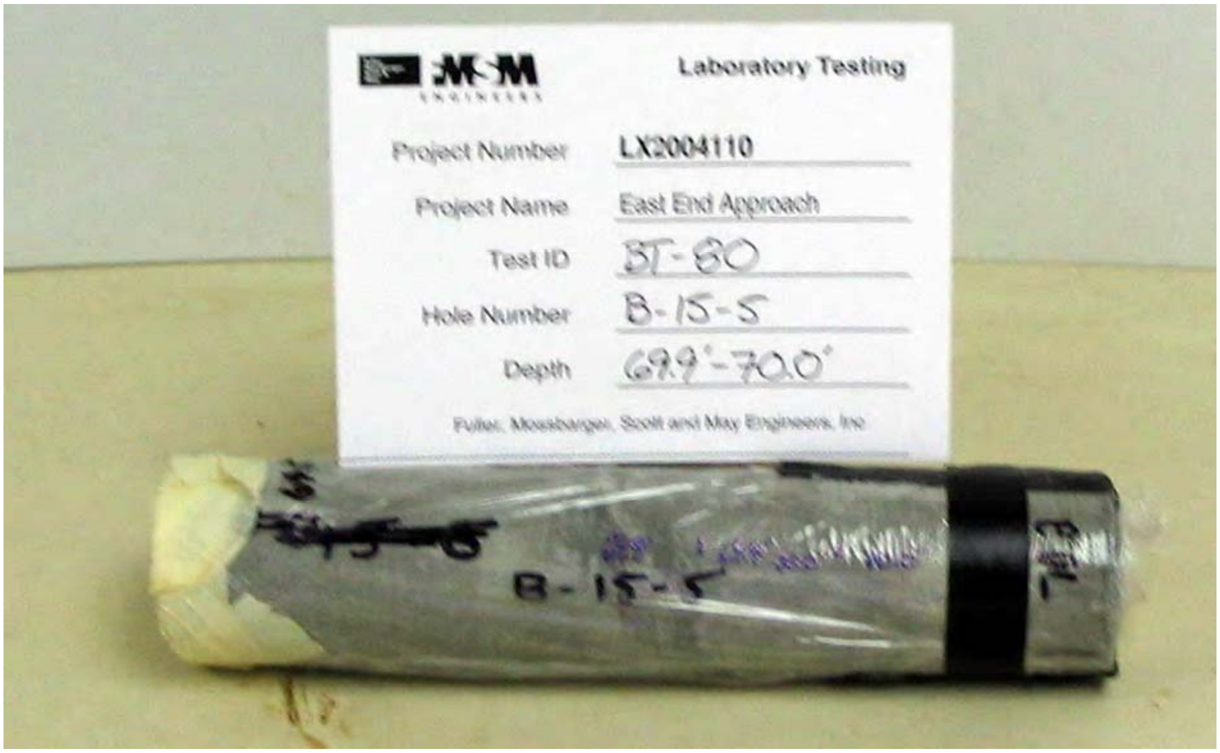
Lithology Shale, gray, soft

Lab ID BT-80

Hole Number B-15-5 Depth (ft) 69.6' - 70.0'

Test Type Splitting tensile strength of intact rock core

As received



Post test

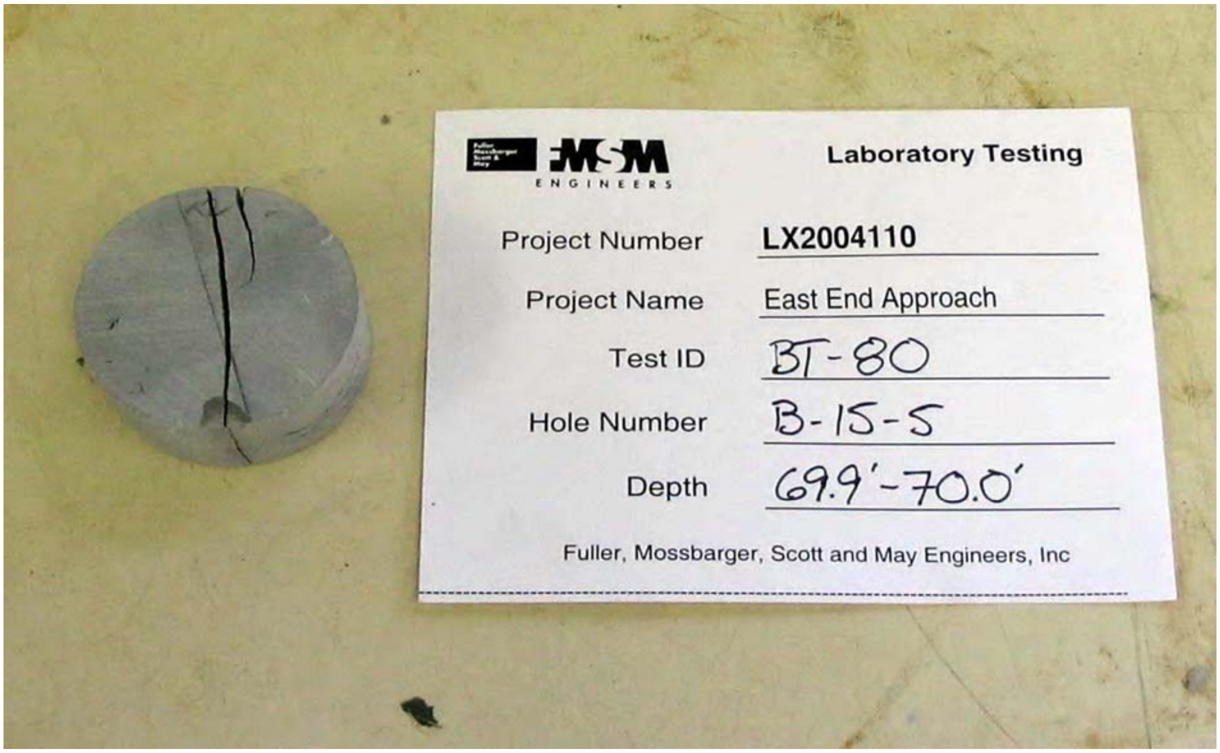
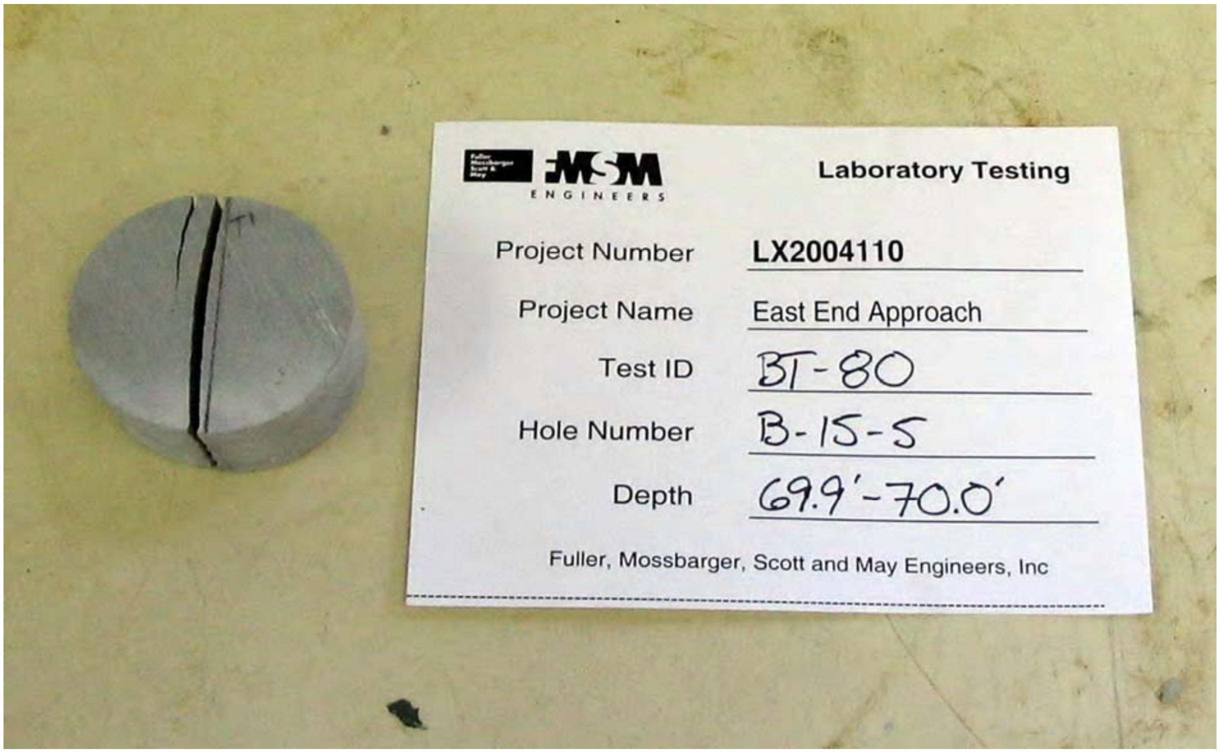


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Shale, gray, soft	Lab ID	BT-80
Hole Number	B-15-5	Depth (ft)	69.6' - 70.0'
Test Type	Splitting tensile strength of intact rock core		

Post test



ENGINEERS

Splitting Tensile Strength
Of Intact Rock Core
ASTM D 3967

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, gray, moderately hard	Lab ID	BT-81
Hole Number	B-15-6	Depth (ft/elev)	76.6' - 76.7'
Date Received	07-27-2005		

Side Planeness	Pass	Height (in.)	1.118	Wet Unit Weight (pcf)	166.8
Perpendicularity	Pass	Diameter (in.)	1.997	Dry Unit Weight (pcf)	N/A
Height/Diameter	Pass	Wet Mass (g)	153.33	Moisture Content (%)	N/A

Test Date 08-08-2005

Moisture Condition As received, dry
Temperature (°F) 70

Loading Rate (lbf/sec) 10
Peak Load (lbf) 5800

Splitting Tensile Strength 1654 psi

Failure Type Split
Bearing Strip Cardboard

Comments

Failure Sketches

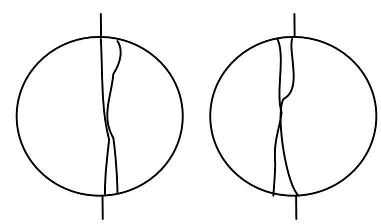
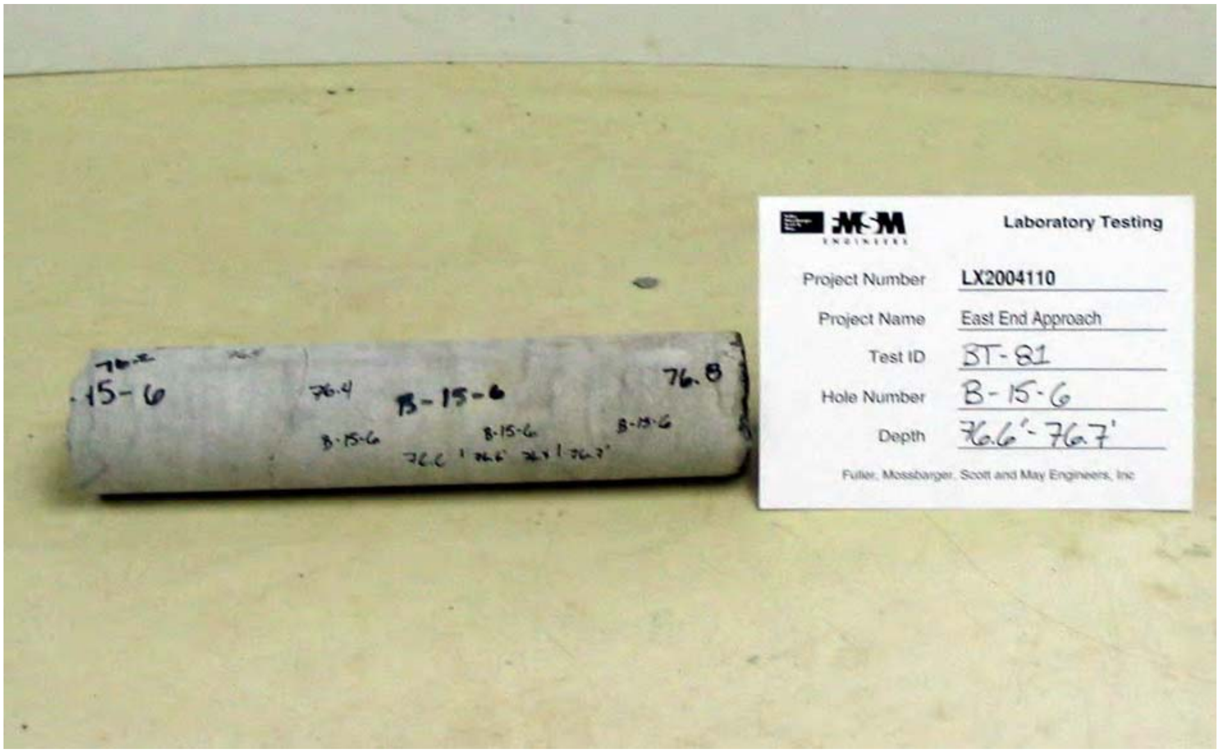


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, gray, moderately hard	Lab ID	BT-81
Hole Number	B-15-6	Depth (ft)	76.6' - 76.7'
Test Type	Splitting tensile strength of intact rock core		

As received



Core preparation

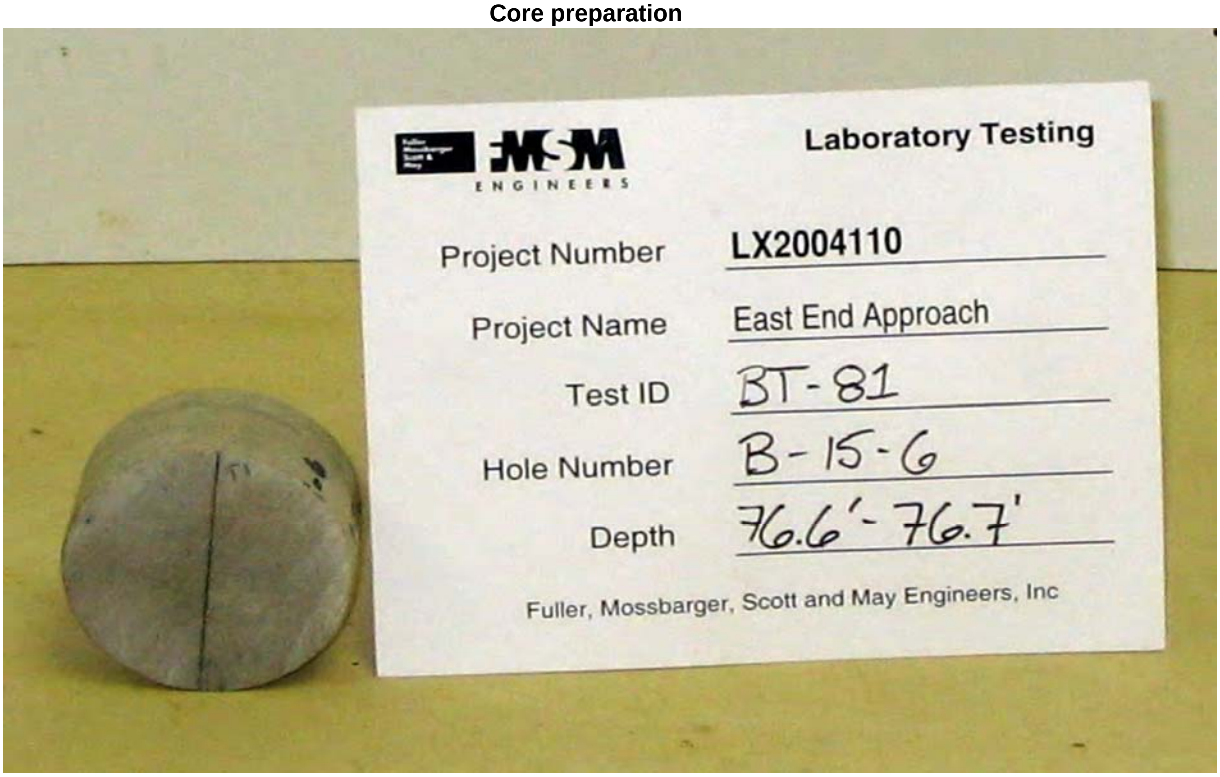
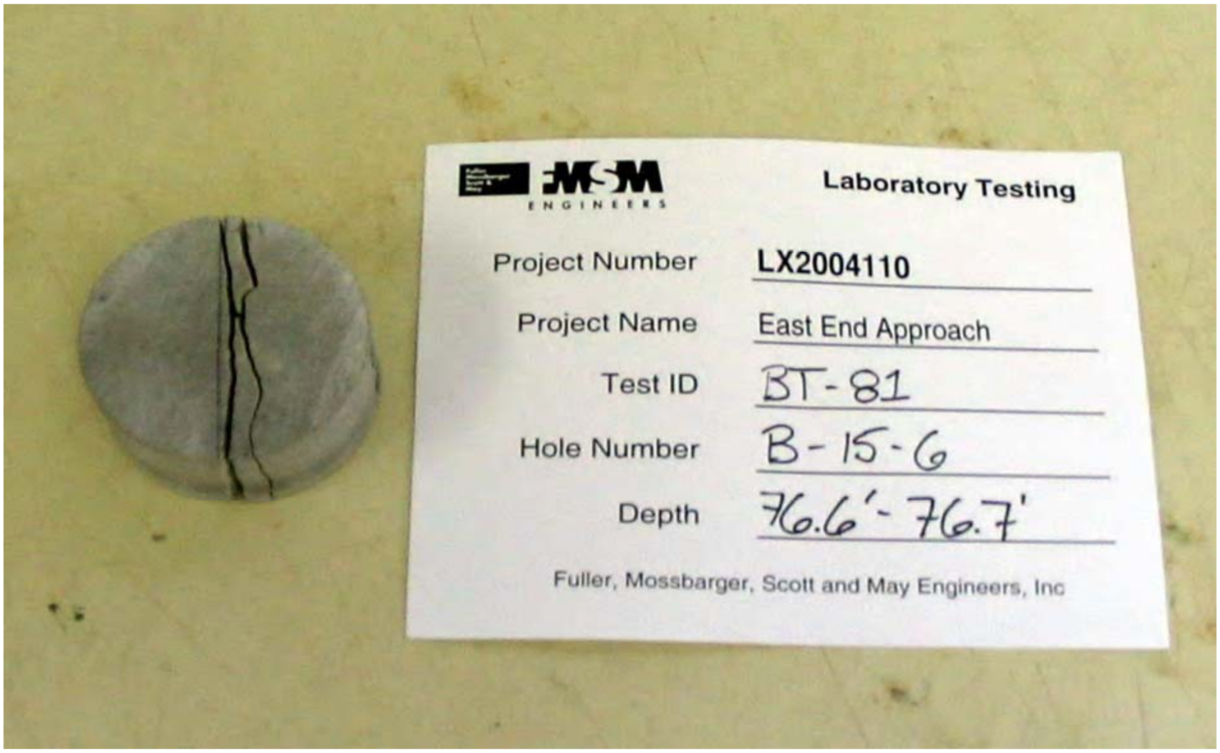


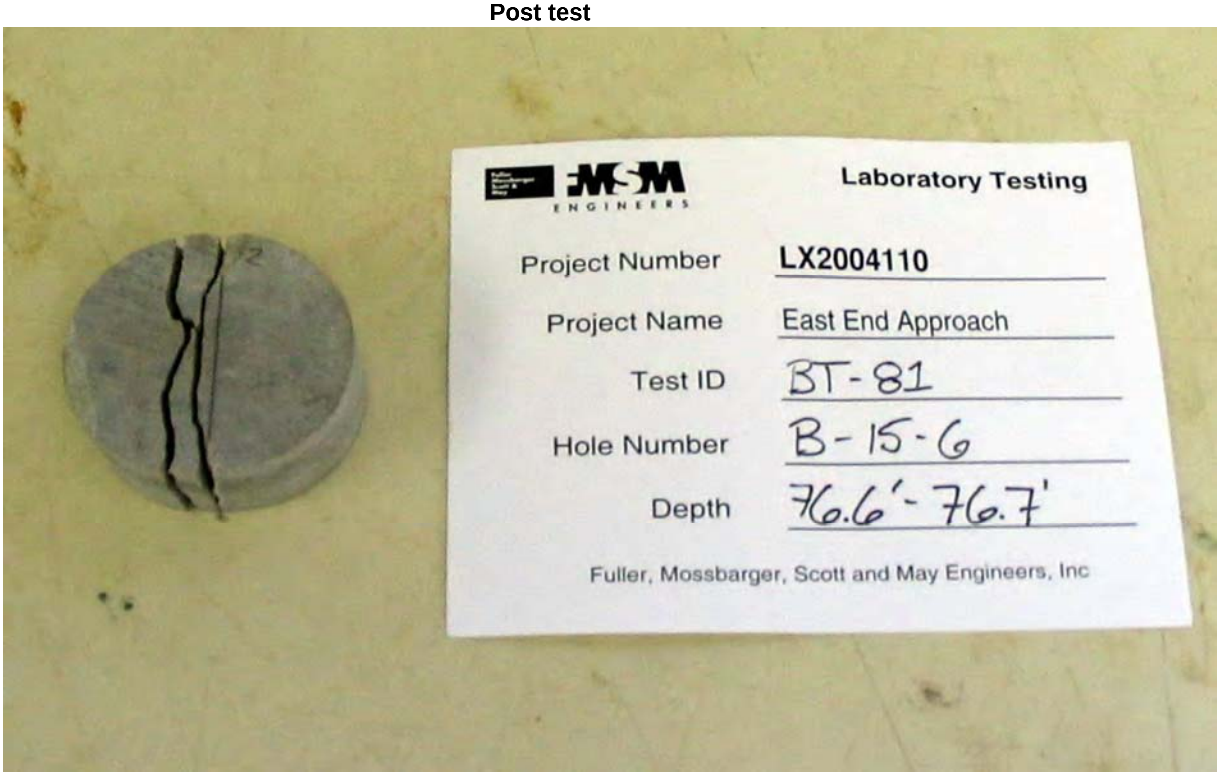
Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, gray, moderately hard	Lab ID	BT-81
Hole Number	B-15-6 Depth (ft) 76.6' - 76.7'		
Test Type	Splitting tensile strength of intact rock core		

Post test



Post test



Splitting Tensile Strength Of Intact Rock Core

ASTM D 3967

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Limestone, light gray, moderately hard
Lab ID: BT-85
Hole Number: B-18-1
Depth (ft/elev): 51.4' - 51.5'
Date Received: 07-27-2005

Side Planeness: Pass
Perpendicularity: Pass
Height/Diameter: Pass

Height (in.): 0.943
Diameter (in.): 1.982
Wet Mass (g): 126.99

Wet Unit Weight (pcf): 166.3
Dry Unit Weight (pcf): N/A
Moisture Content (%): N/A

Test Date: 08-08-2005

Moisture Condition: As received, dry
Temperature (°F): 70

Loading Rate (lbf/sec): 10
Peak Load (lbf): 4790

Splitting Tensile Strength: 1632 psi

Failure Type: Split
Bearing Strip: Cardboard

Comments:

Failure Sketches

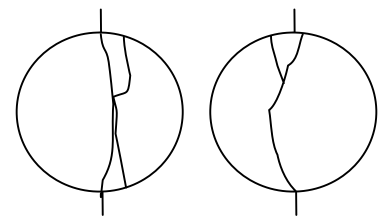
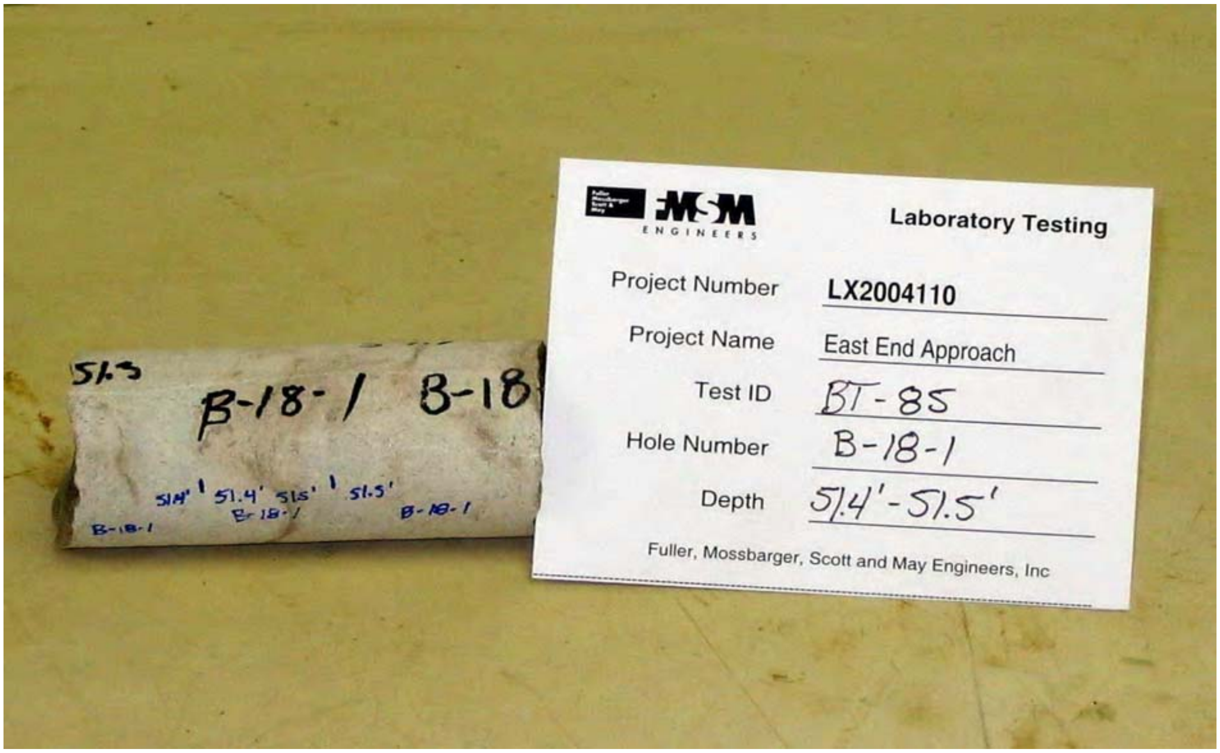


Photo Report

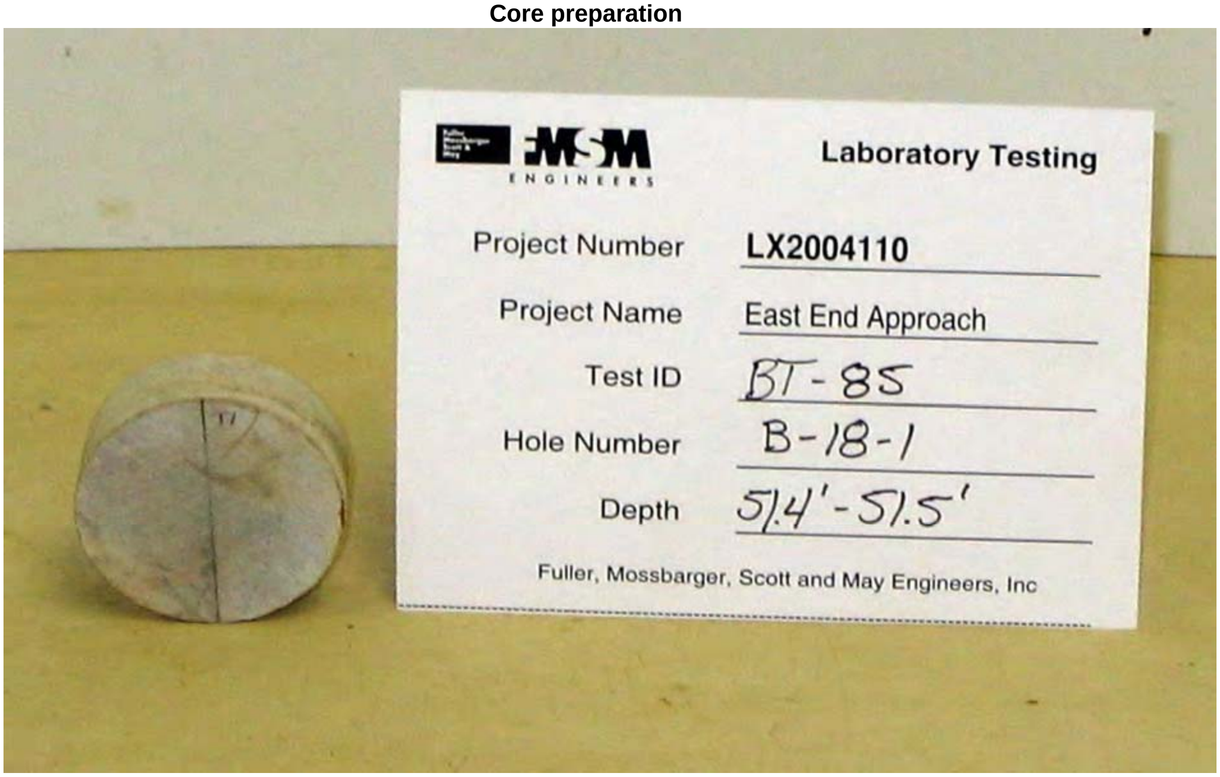
Project Name LSIORB Section 4, East End Approach
Lithology Limestone, light gray, moderately hard
Hole Number B-18-1 Depth (ft) 51.4' - 51.5'
Test Type Splitting tensile strength of intact rock core

Project Number LX2004110
Lab ID BT-85

As received



Core preparation

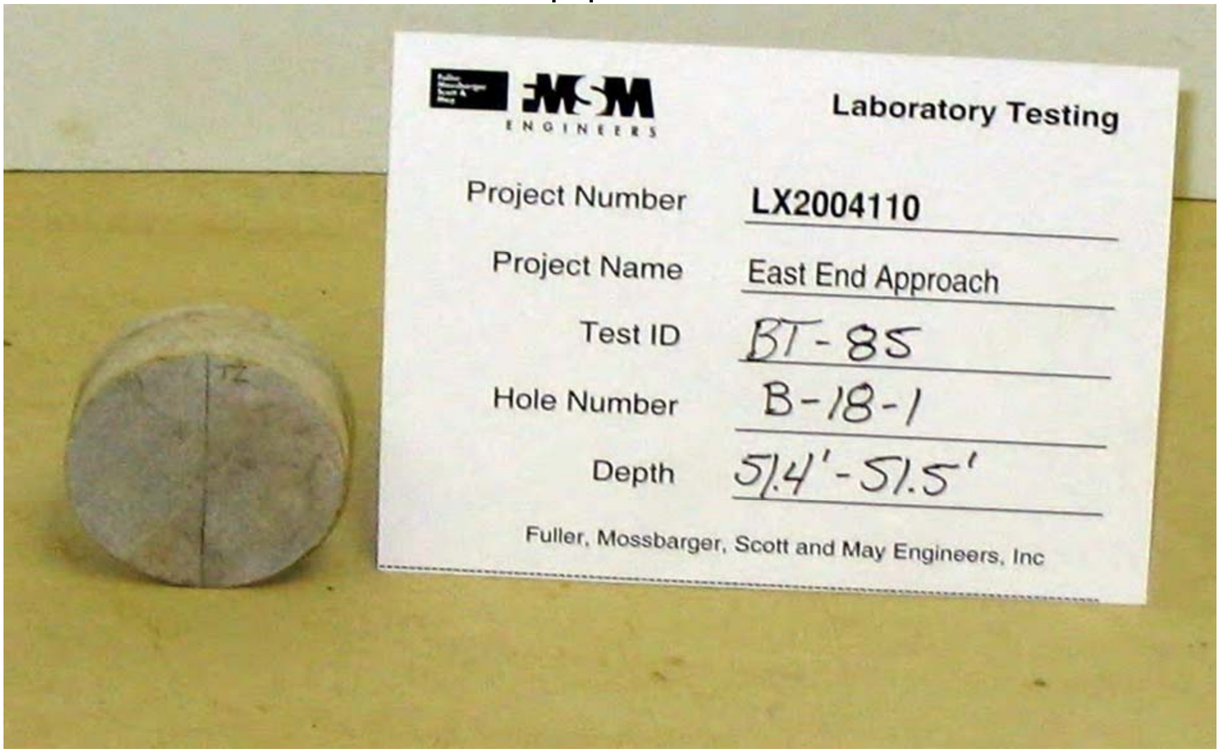


Fuller Mossbarger Scott & May ENGINEERS

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, light gray, moderately hard	Lab ID	BT-85
Hole Number	B-18-1 Depth (ft) 51.4' - 51.5'		
Test Type	Splitting tensile strength of intact rock core		

Core preparation



Post test

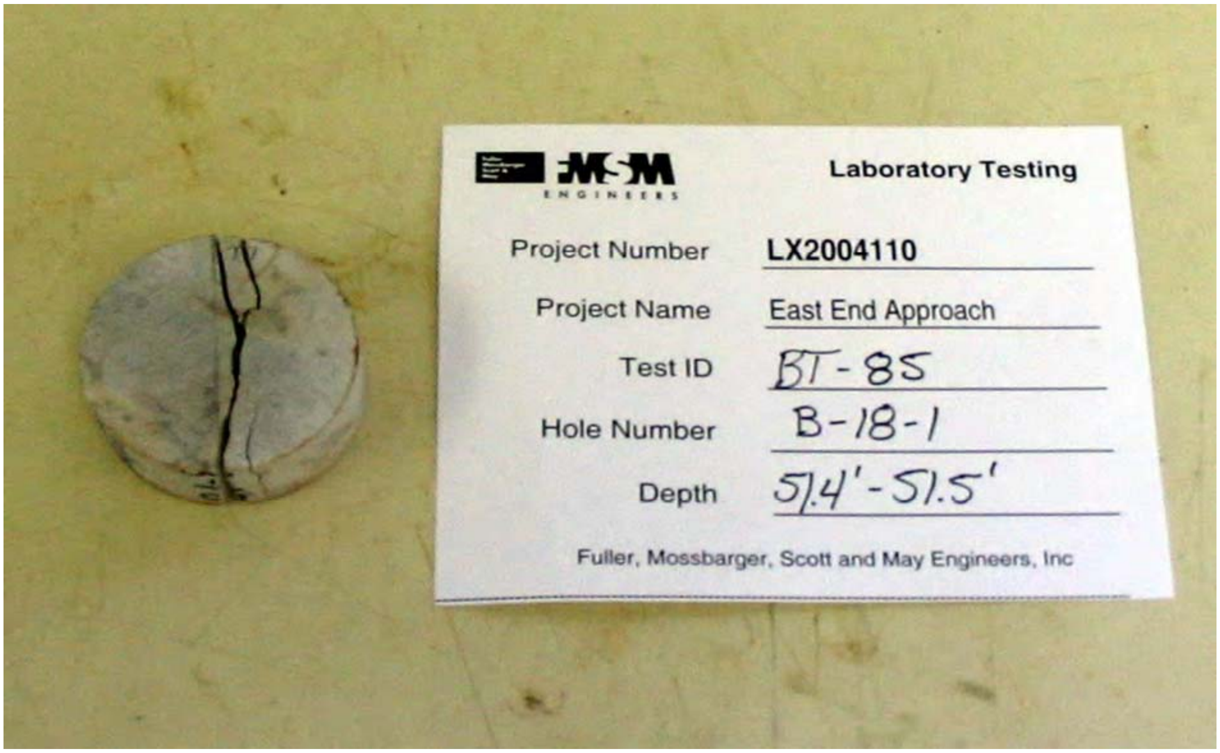
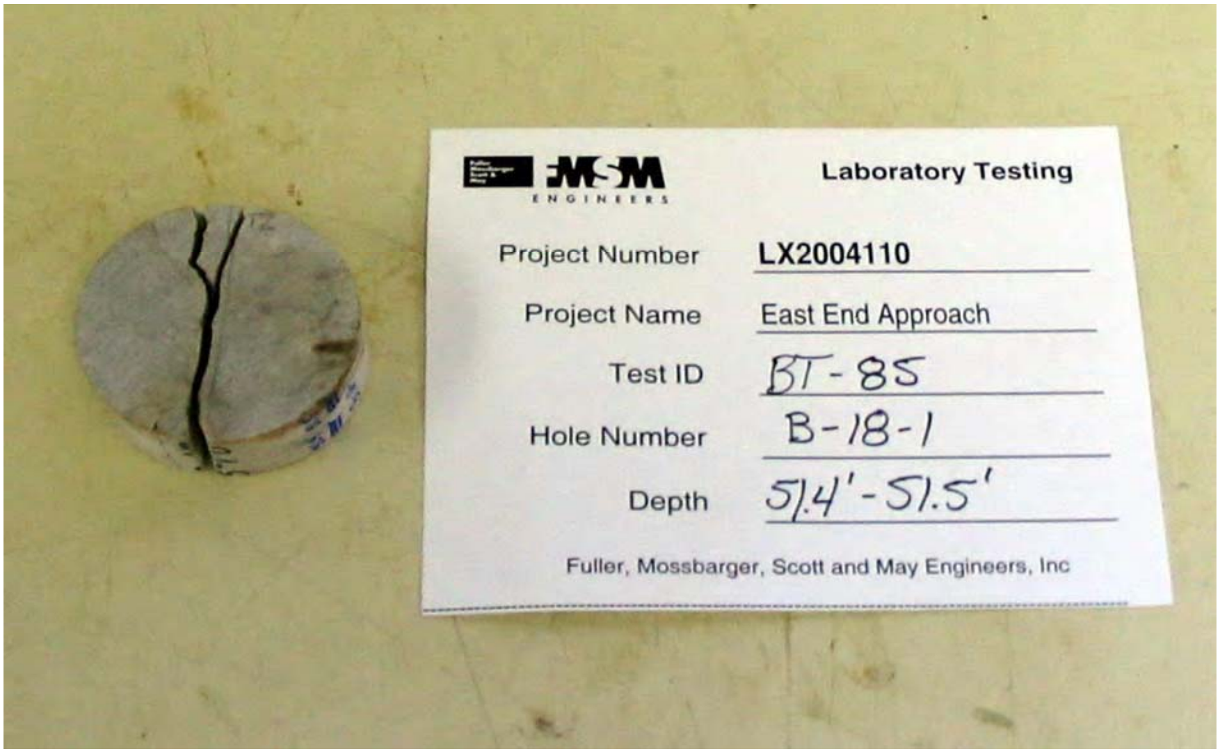


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, light gray, moderately hard	Lab ID	BT-85
Hole Number	B-18-1	Depth (ft)	51.4' - 51.5'
Test Type	Splitting tensile strength of intact rock core		

Post test



ENGINEERS

Splitting Tensile Strength Of Intact Rock Core

ASTM D 3967

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Limestone, light gray, moderately hard
Lab ID: BT-88
Hole Number: B-18-4
Depth (ft/elev): 36.1' - 36.2'
Date Received: 07-27-2005

Side Planeness: Pass
Perpendicularity: Pass
Height/Diameter: Pass

Height (in.): 1.264
Diameter (in.): 1.979
Wet Mass (g): 173.60

Wet Unit Weight (pcf): 170.1
Dry Unit Weight (pcf): N/A
Moisture Content (%): N/A

Test Date: 08-08-2005

Moisture Condition: As received, dry
Temperature (°F): 70

Loading Rate (lbf/sec): 10
Peak Load (lbf): 7250

Splitting Tensile Strength: 1845 psi

Failure Type: Split
Bearing Strip: Cardboard

Comments:

Failure Sketches

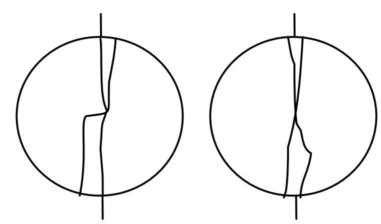


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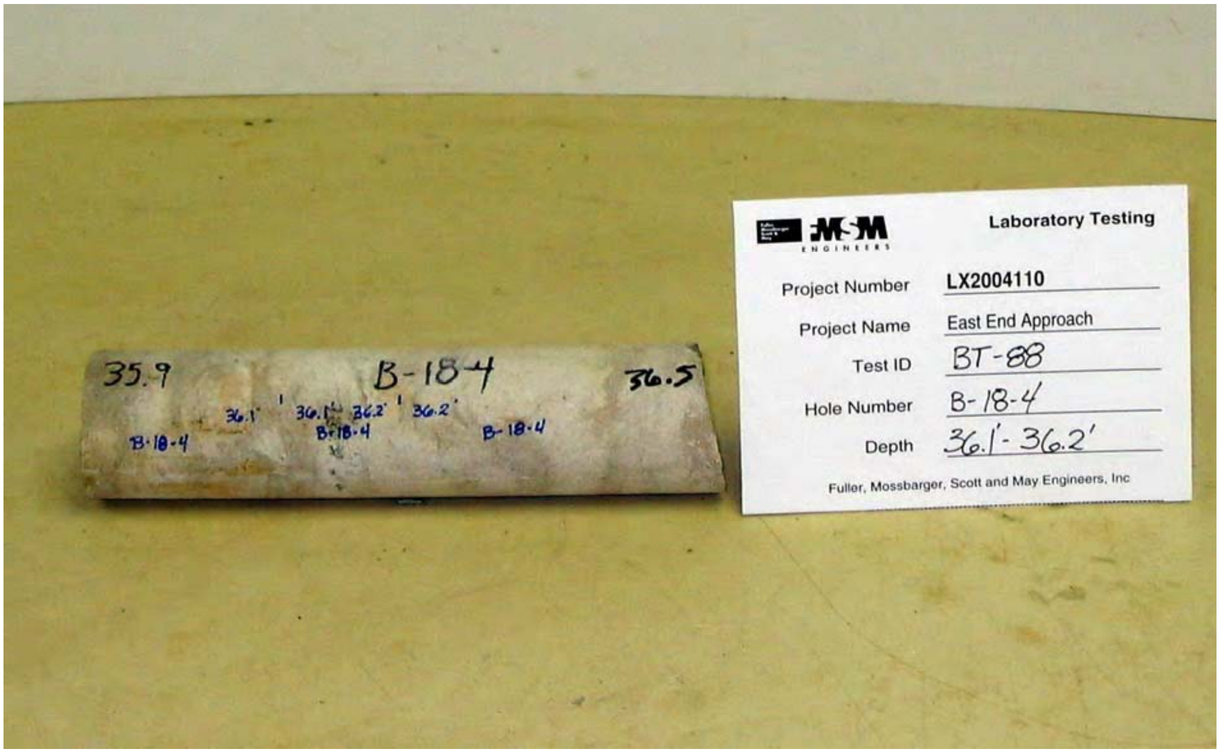
Photo Report

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Limestone, light gray, moderately hard
Lab ID BT-88
Hole Number B-18-4 Depth (ft) 36.1' - 36.2'
Test Type Splitting tensile strength of intact rock core

As received



Core preparation

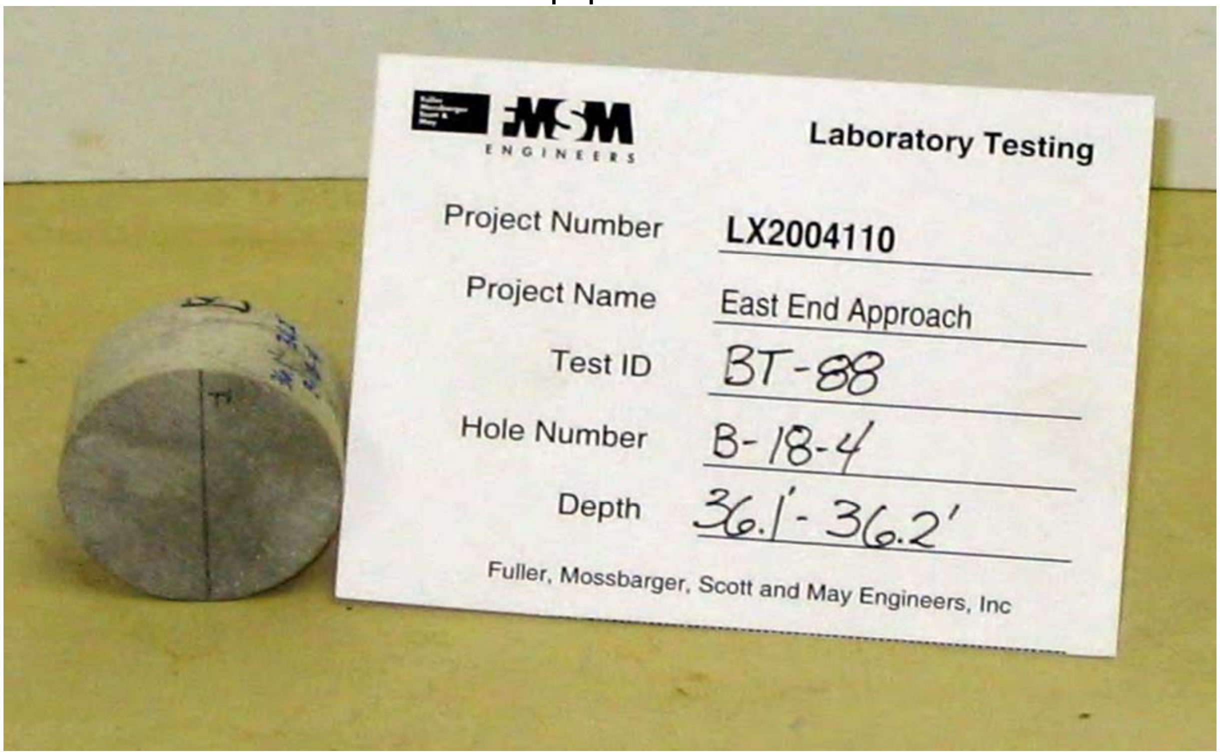
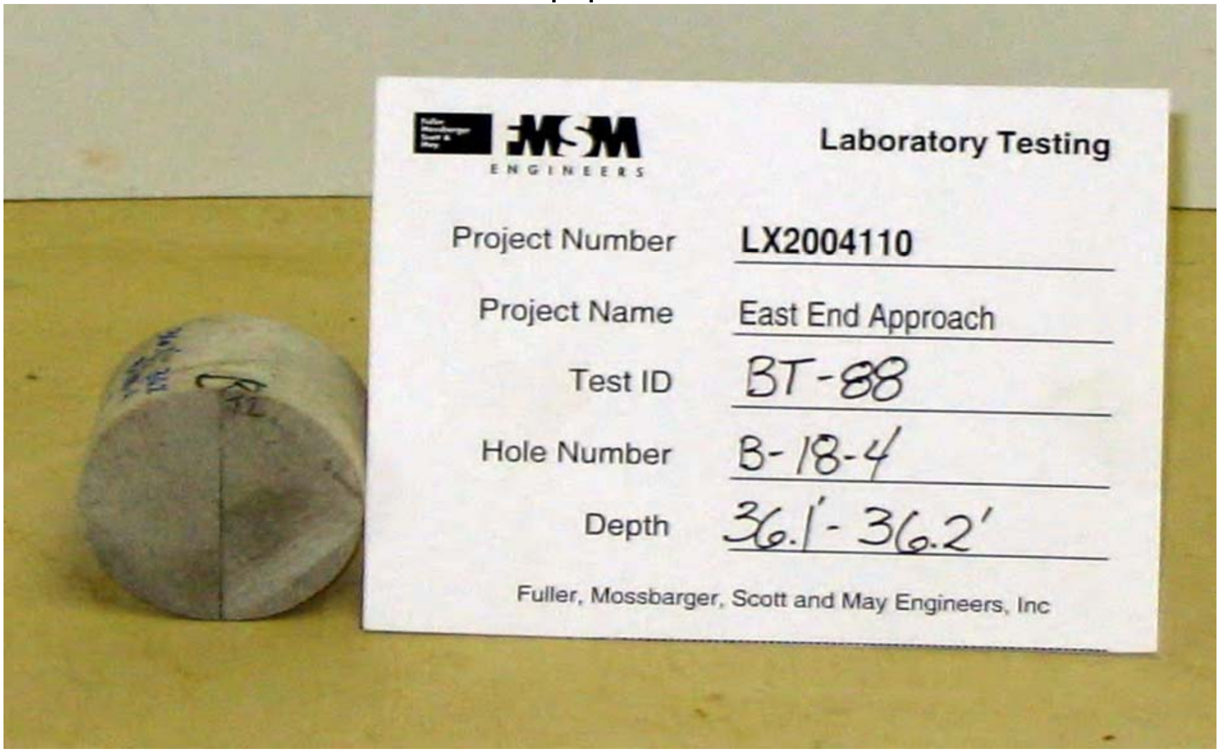


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, light gray, moderately hard	Lab ID	BT-88
Hole Number	B-18-4	Depth (ft)	36.1' - 36.2'
Test Type	Splitting tensile strength of intact rock core		

Core preparation



Post test

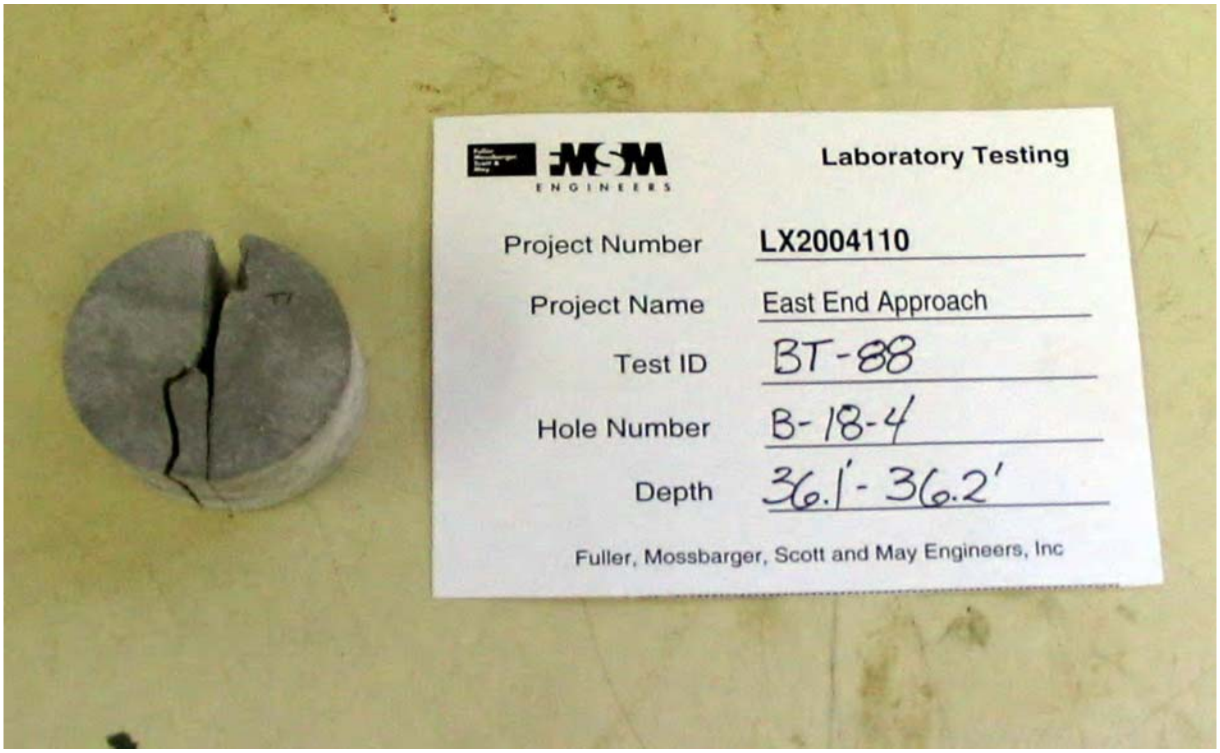
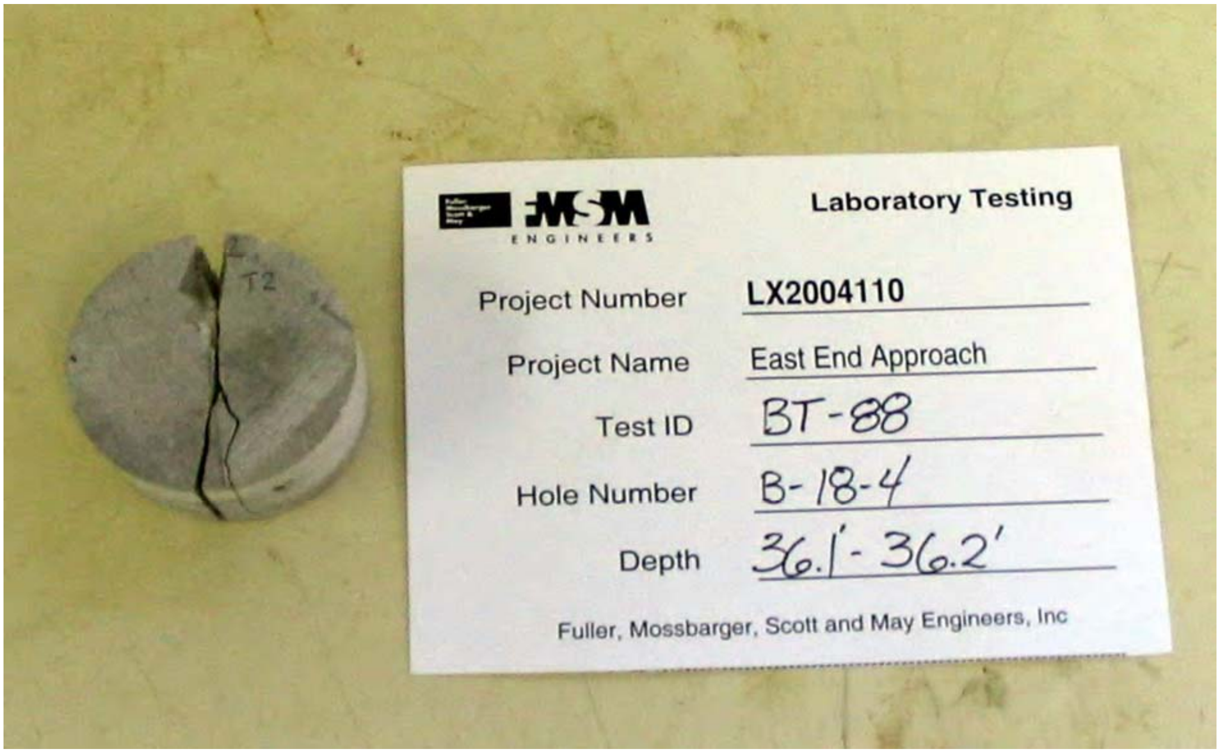


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, light gray, moderately hard	Lab ID	BT-88
Hole Number	B-18-4 Depth (ft) 36.1' - 36.2'		
Test Type	Splitting tensile strength of intact rock core		

Post test



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ENGINEERS

Splitting Tensile Strength Of Intact Rock Core
ASTM D 3967

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Shale, gray, moderately hard
Lab ID: BT-141
Hole Number: B-2-2a
Depth (ft/elev): 37.7'-37.8'
Date Received: 01-19-2006

Side Planeness	Pass	Height (in.)	1.217	Wet Unit Weight (pcf)	159.2
Perpendicularity	Pass	Diameter (in.)	1.993	Dry Unit Weight (pcf)	N/A
Height/Diameter	Pass	Wet Mass (g)	158.66	Moisture Content (%)	N/A

Test Date: 01-25-2006

Moisture Condition: As received, moist
Temperature (°F): 70

Loading Rate (lbf/sec): 10
Peak Load (lbf): 2480

Splitting Tensile Strength: 651 psi

Failure Type: Split
Bearing Strip: Cardboard

Comments:

Failure Sketches

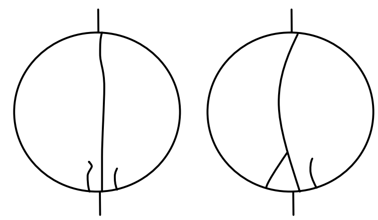
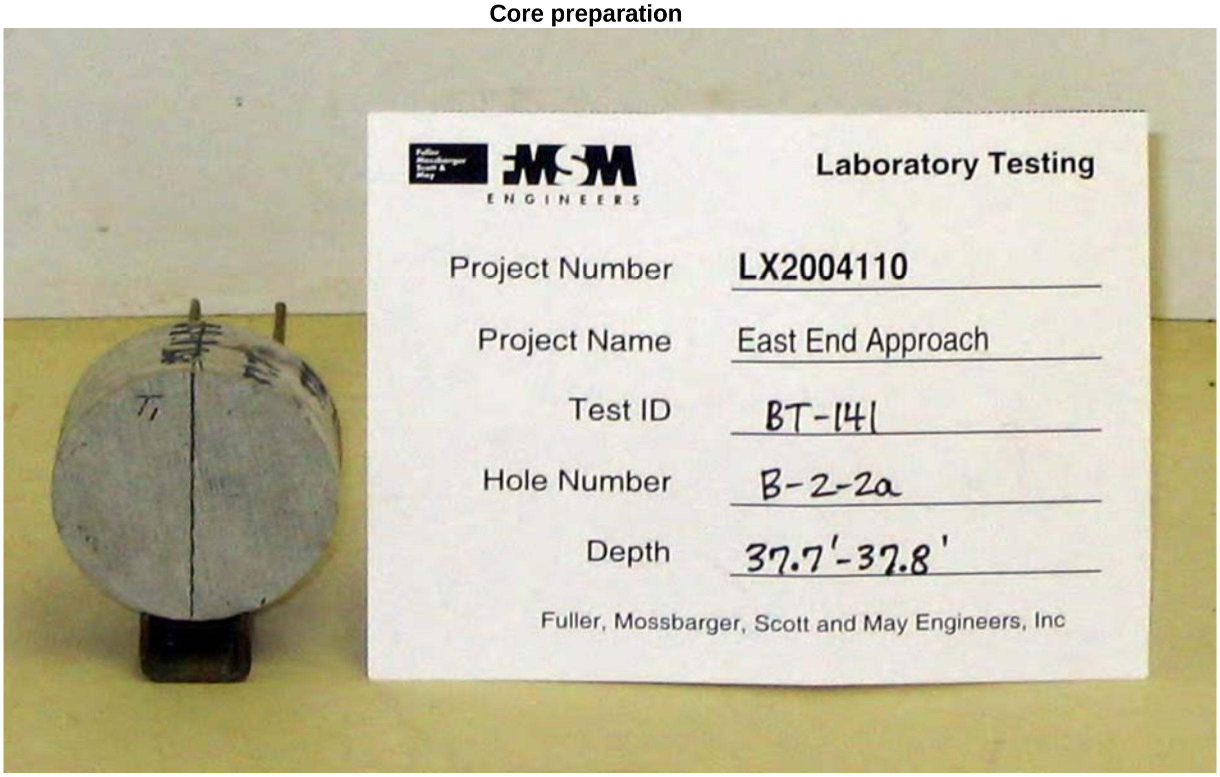


Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Shale, gray, moderately hard
Hole Number B-2-2a Depth (ft) 37.7'-37.8'
Test Type Splitting tensile strength of intact rock core

Project Number LX2004110
Lab ID BT-141

Core preparation



Core preparation

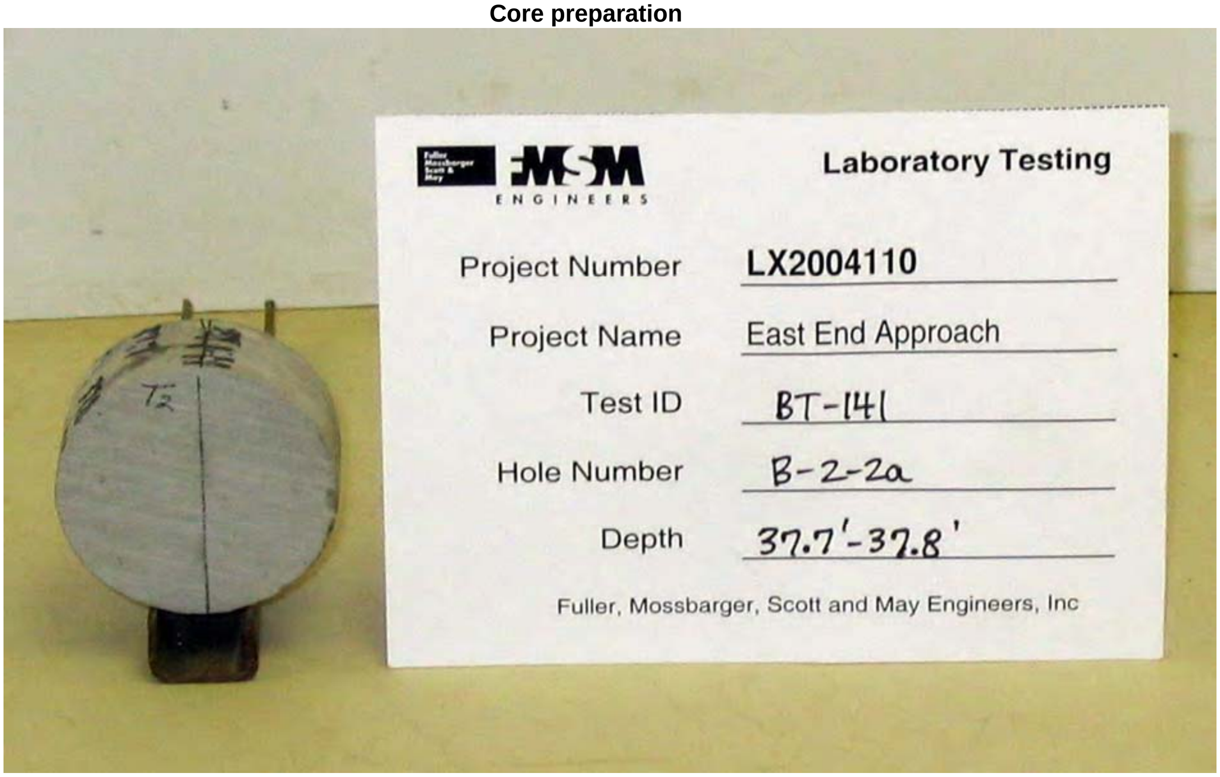
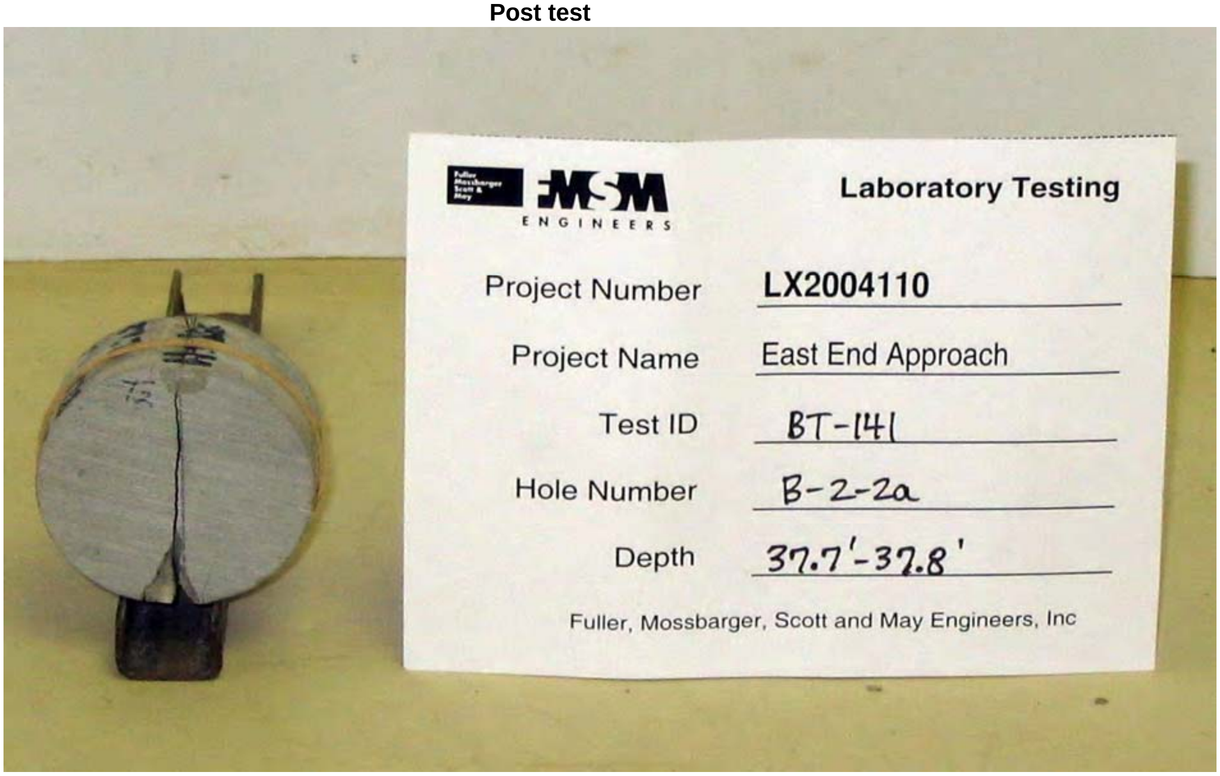


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Shale, gray, moderately hard	Lab ID	BT-141
Hole Number	B-2-2a	Depth (ft)	37.7'-37.8'
Test Type	Splitting tensile strength of intact rock core		

Post test

Post test



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Splitting Tensile Strength Of Intact Rock Core

ASTM D 3967

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Dolomite, light brown, hard
Lab ID: BT-145
Hole Number: B-2-8a
Depth (ft/elev): 58.0'-58.1'
Date Received: 01-19-2006

Side Planeness	Pass	Height (in.)	1.240	Wet Unit Weight (pcf)	155.3
Perpendicularity	Pass	Diameter (in.)	1.990	Dry Unit Weight (pcf)	N/A
Height/Diameter	Pass	Wet Mass (g)	157.14	Moisture Content (%)	N/A

Test Date: 01-25-2006

Moisture Condition: As received, moist
Temperature (°F): 70

Loading Rate (lbf/sec): 10
Peak Load (lbf): 3420

Splitting Tensile Strength: 883 psi

Failure Type: Split
Bearing Strip: Cardboard

Comments:

Failure Sketches

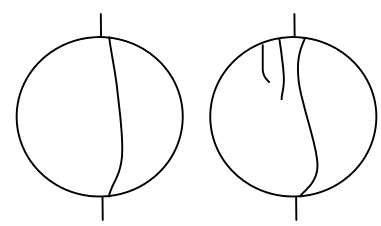
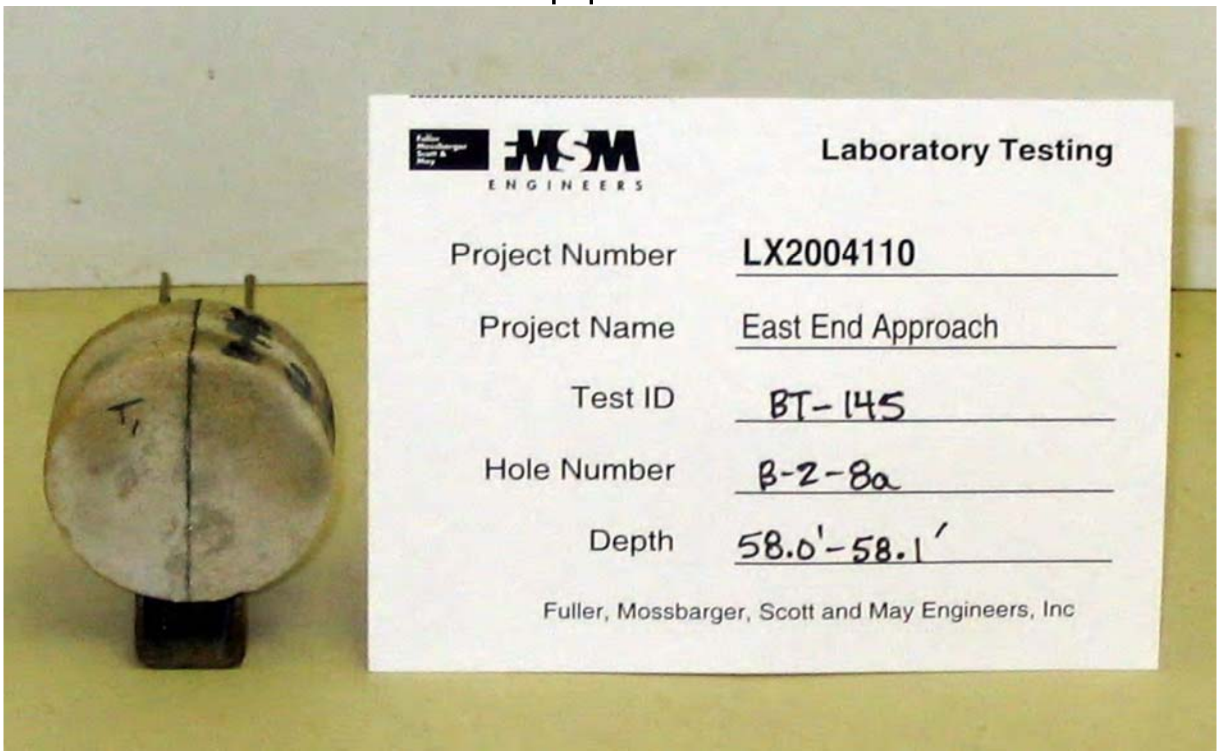


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, light brown, hard	Lab ID	BT-145
Hole Number	B-2-8a	Depth (ft)	58.0'-58.1'
Test Type	Splitting tensile strength of intact rock core		

Core preparation



Core preparation

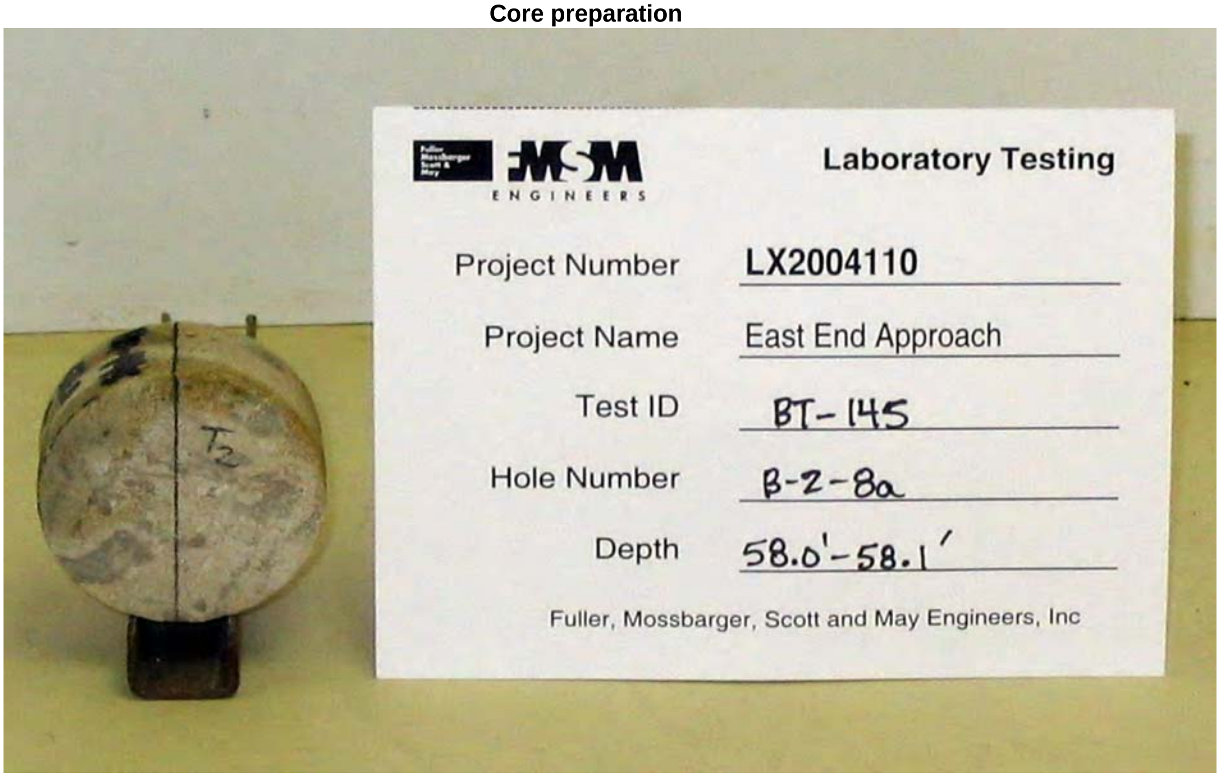
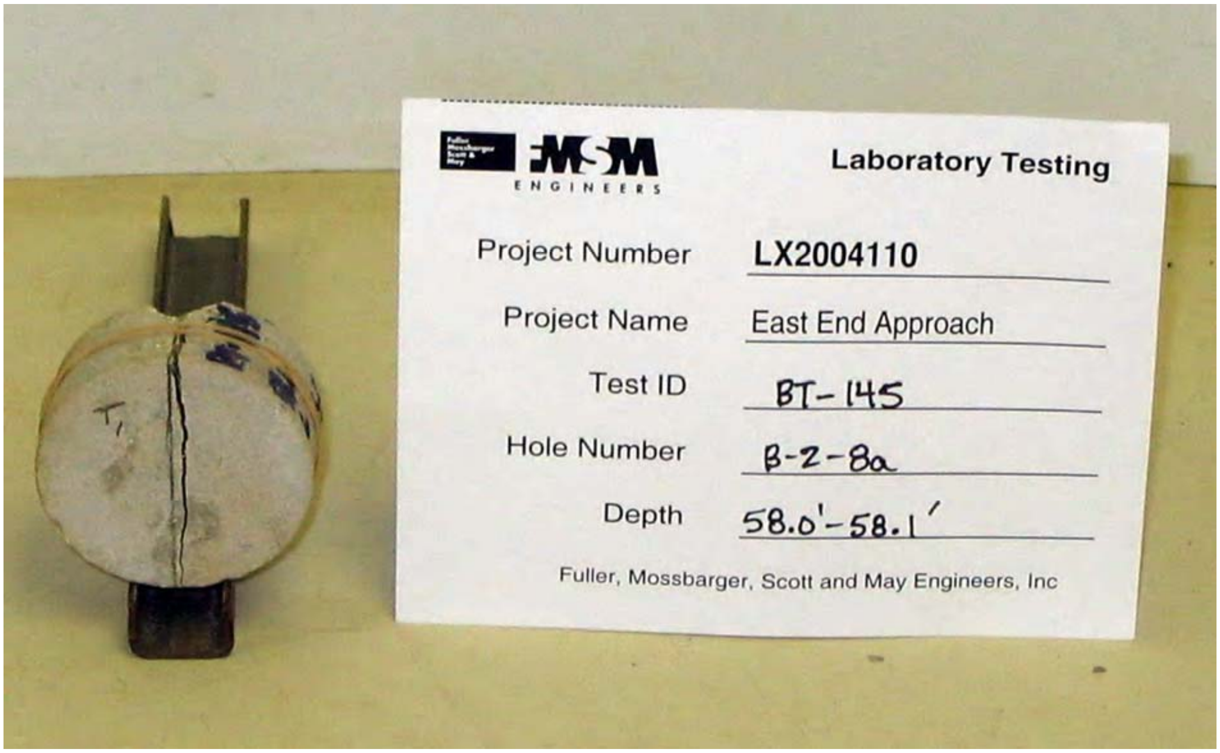


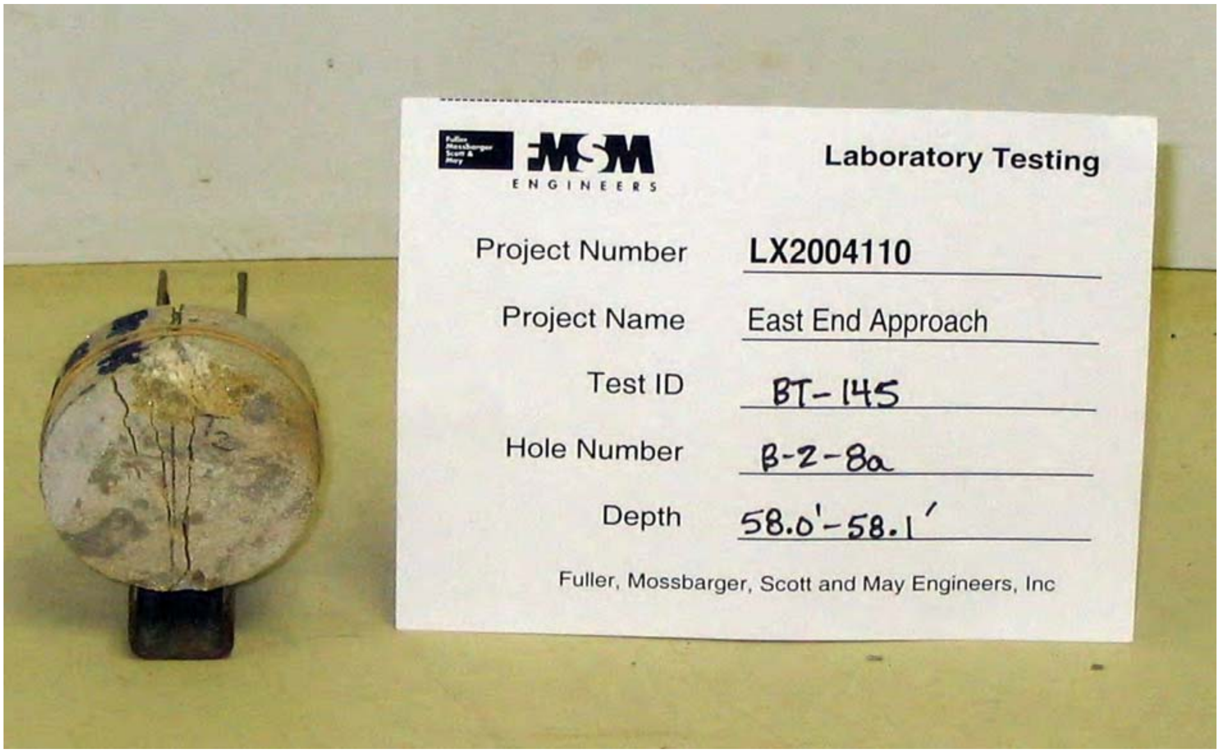
Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, light brown, hard	Lab ID	BT-145
Hole Number	B-2-8a Depth (ft) 58.0'-58.1'		
Test Type	Splitting tensile strength of intact rock core		

Post test



Post test



Splitting Tensile Strength Of Intact Rock Core
ASTM D 3967

Fuller Mossbarger Scott & May ENGINEERS

Project Name	LSIORB Section 4, East End Approach
Lithology	Shale, gray, moderately hard
Hole Number	B-6-15
Depth (ft/elev)	28.4'-28.5'
Project Number	LX2004110
Lab ID	BT-159
Date Received	01-19-2006

Side Planeness	Pass
Perpendicularity	Pass
Height/Diameter	Pass
Height (in.)	1.161
Diameter (in.)	1.759
Wet Mass (g)	121.94
Wet Unit Weight (pcf)	164.7
Dry Unit Weight (pcf)	N/A
Moisture Content (%)	N/A

Test Date 01-25-2006

Moisture Condition As received, moist
Temperature (°F) 70

Loading Rate (lbf/sec) 10
Peak Load (lbf) 2200

Splitting Tensile Strength 686 psi

Failure Type Split
Bearing Strip Cardboard

Comments

Failure Sketches

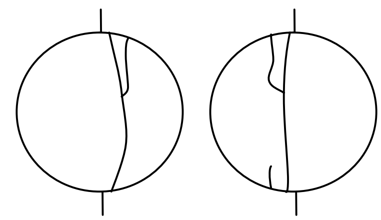
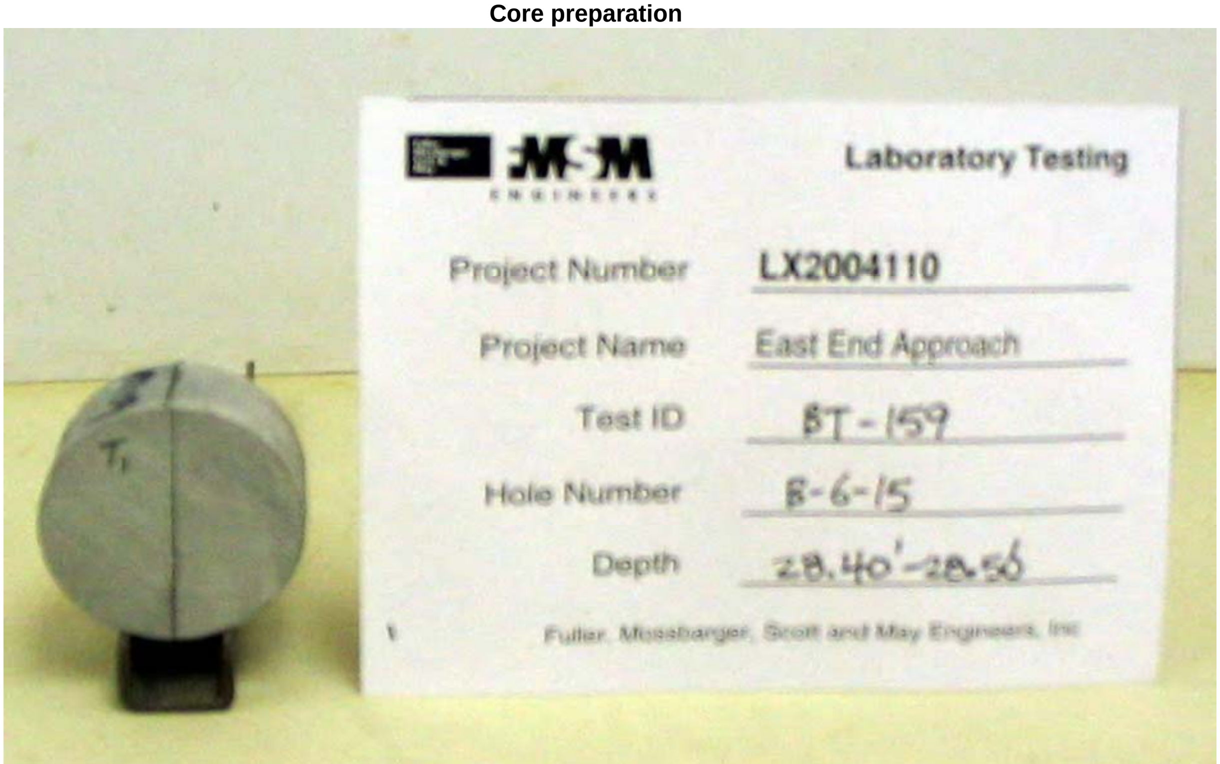


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Shale, gray, moderately hard	Lab ID	BT-159
Hole Number	B-6-15	Depth (ft)	28.4'-28.5'
Test Type	Splitting tensile strength of intact rock core		

Core preparation



Core preparation

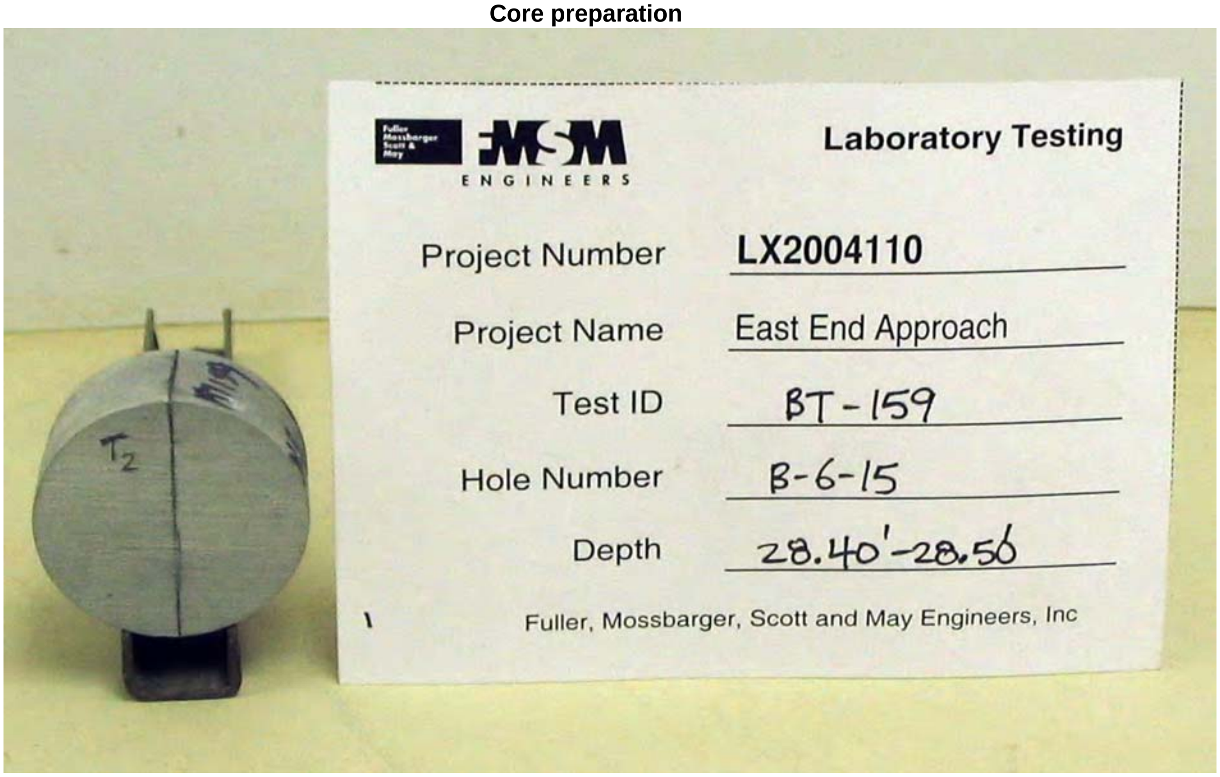
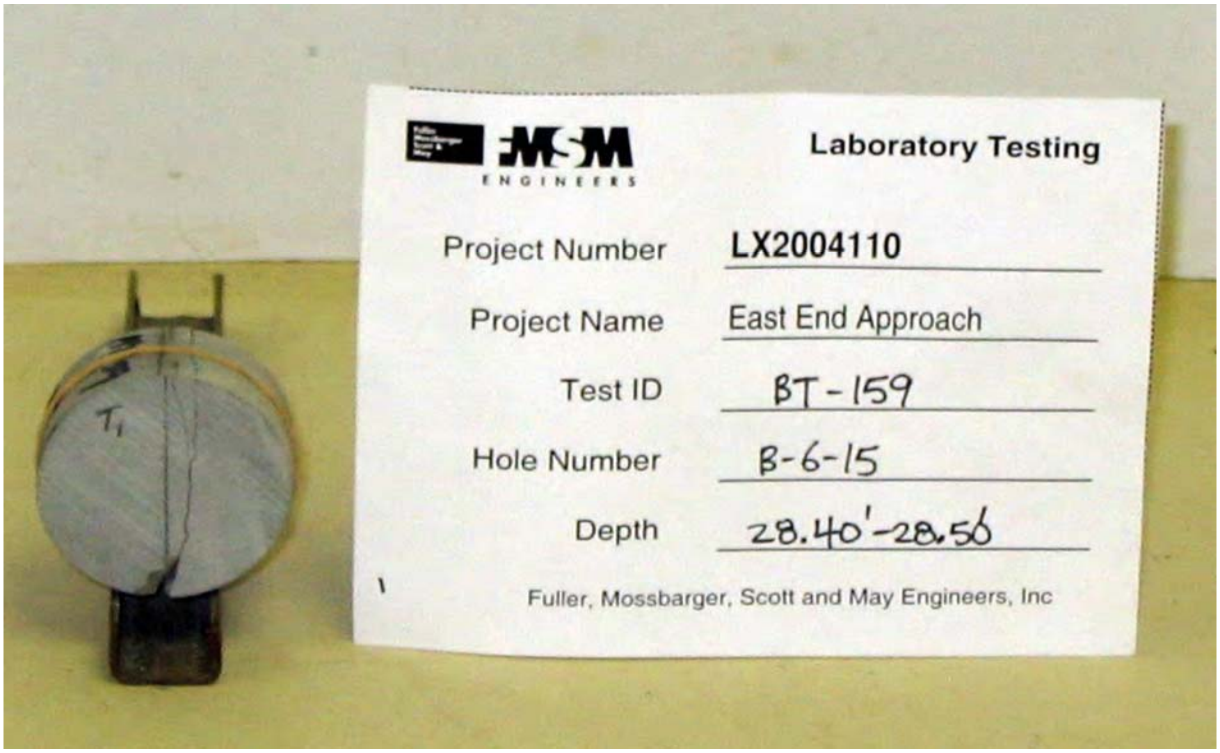


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Shale, gray, moderately hard	Lab ID	BT-159
Hole Number	B-6-15	Depth (ft)	28.4'-28.5'
Test Type	Splitting tensile strength of intact rock core		

Post test



Post test

Splitting Tensile Strength Of Intact Rock Core

ASTM D 3967

FMSM ENGINEERS — Fuller Mossbarger Scott & May

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Shale, gray, moderately hard	Lab ID	BT-163
Hole Number	B-6-20	Depth (ft/elev)	35.6'-35.7'
Date Received	01-19-2006		

Side Planeness	Pass	Height (in.)	1.320	Wet Unit Weight (pcf)	162.4
Perpendicularity	Pass	Diameter (in.)	1.761	Dry Unit Weight (pcf)	N/A
Height/Diameter	Pass	Wet Mass (g)	136.98	Moisture Content (%)	N/A

Test Date 01-25-2006

Moisture Condition As received, moist

Temperature (°F) 70

Loading Rate (lbf/sec) 10

Peak Load (lbf) 3560

Splitting Tensile Strength 975 psi

Failure Type Split

Bearing Strip Cardboard

Comments

Failure Sketches

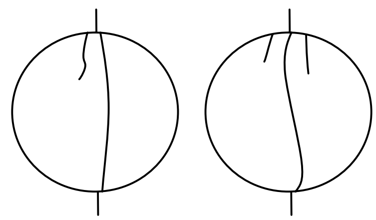
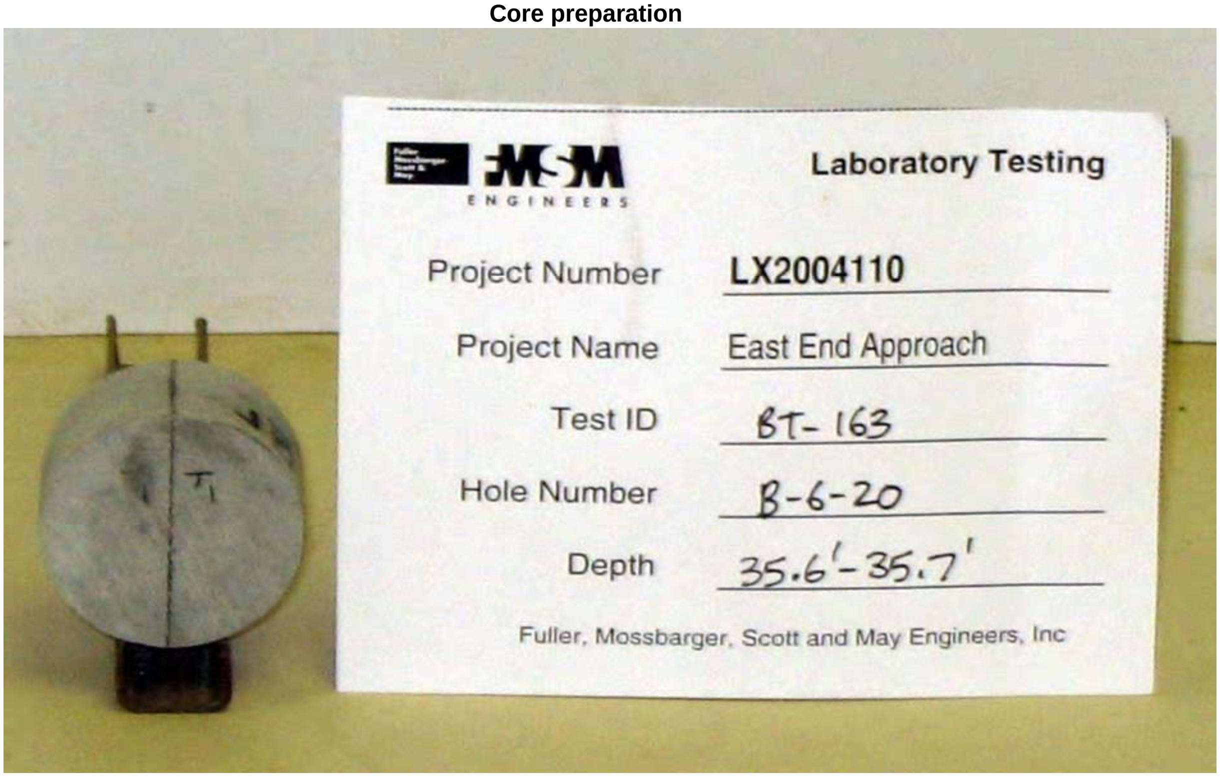


Photo Report

Project Name LSIORB Section 4, East End Approach | Project Number LX2004110
Lithology Shale, gray, moderately hard | Lab ID BT-163
Hole Number B-6-20 | Depth (ft) 35.6'-35.7'
Test Type Splitting tensile strength of intact rock core

Core preparation



Core preparation

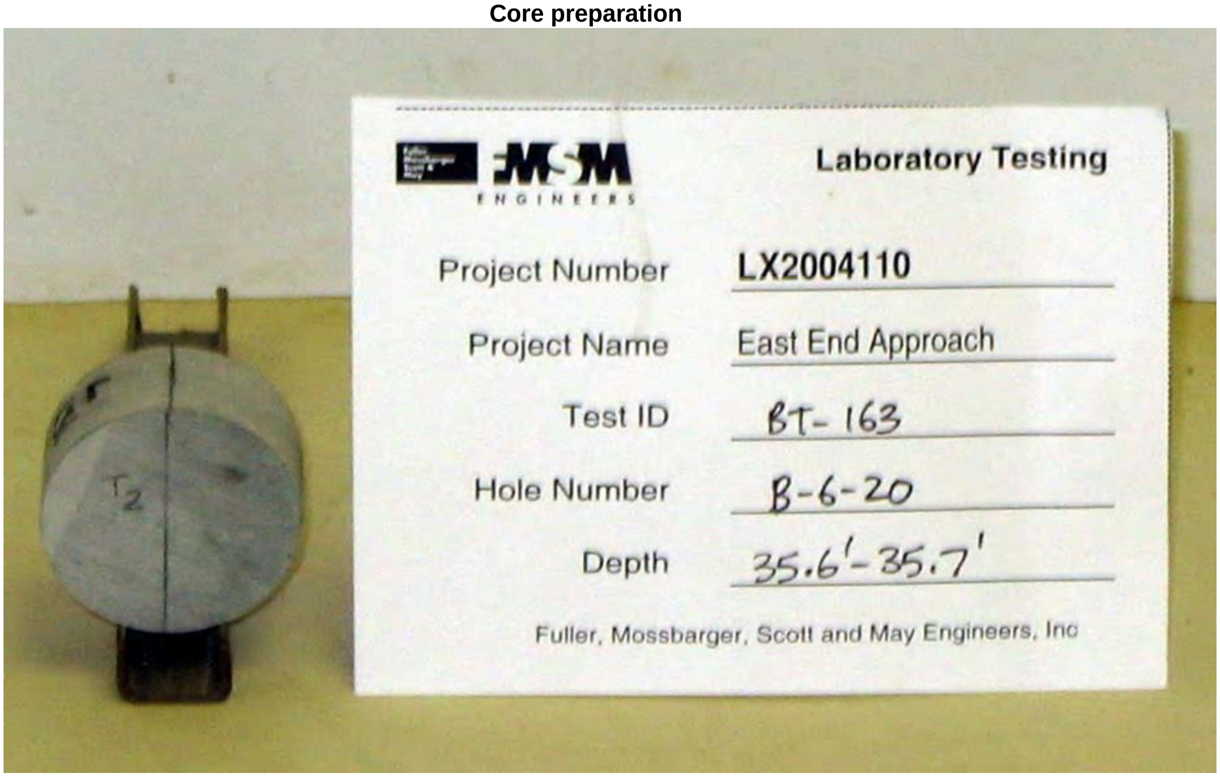


Photo Report

Project Name LSIORB Section 4, East End Approach

Lithology Shale, gray, moderately hard

Hole Number B-6-20 Depth (ft) 35.6'-35.7'

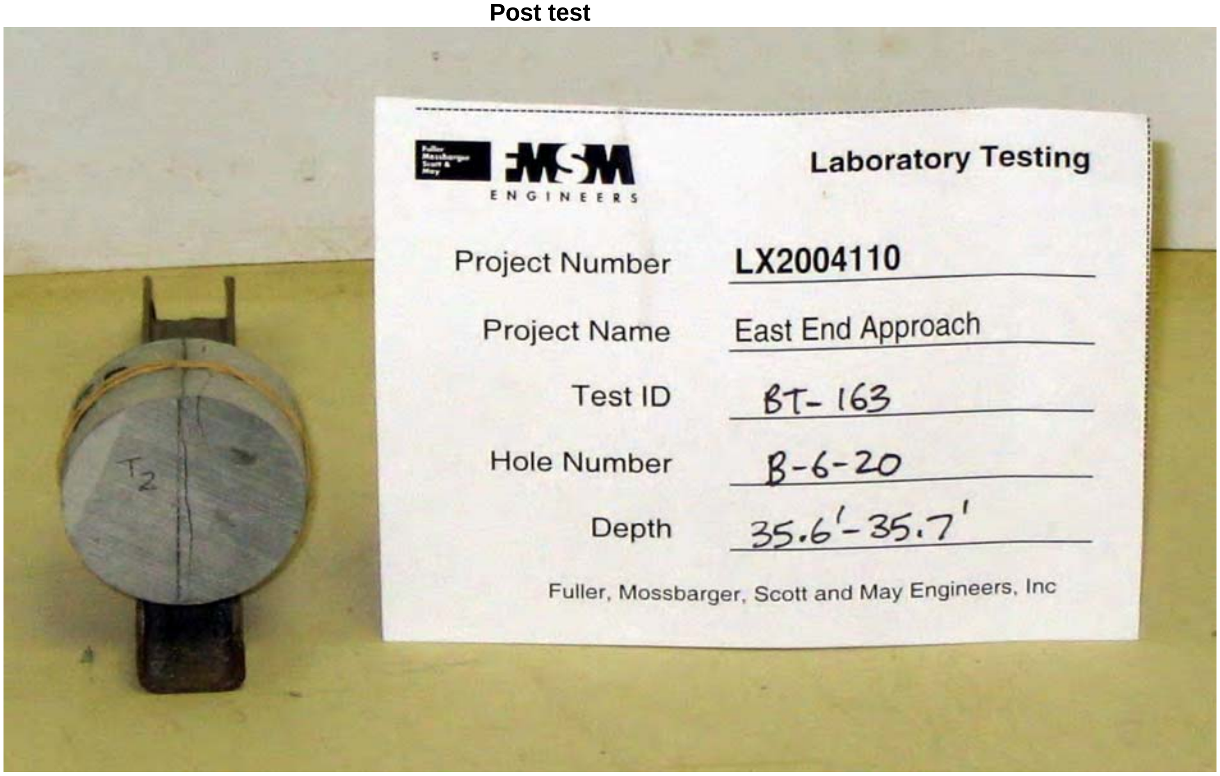
Test Type Splitting tensile strength of intact rock core

Project Number LX2004110

Lab ID BT-163

Post test

Post test



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Splitting Tensile Strength Of Intact Rock Core
ASTM D 3967

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, gray, hard	Lab ID	BT-166
Hole Number	B-6-25	Depth (ft/elev)	69.55'-69.65'
Date Received	01-19-2006		

Side Planeness	Pass	Height (in.)	1.277	Wet Unit Weight (pcf)	167.4
Perpendicularity	Pass	Diameter (in.)	1.772	Dry Unit Weight (pcf)	N/A
Height/Diameter	Pass	Wet Mass (g)	138.44	Moisture Content (%)	N/A

Test Date 01-25-2006

Moisture Condition As received, moist
Temperature (°F) 70

Loading Rate (lbf/sec) 10
Peak Load (lbf) 3020

Splitting Tensile Strength 850 psi

Failure Type Split
Bearing Strip Cardboard

Comments

Failure Sketches

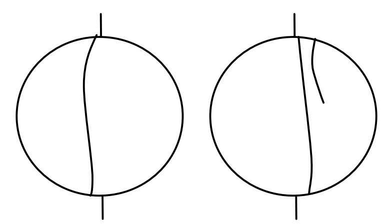
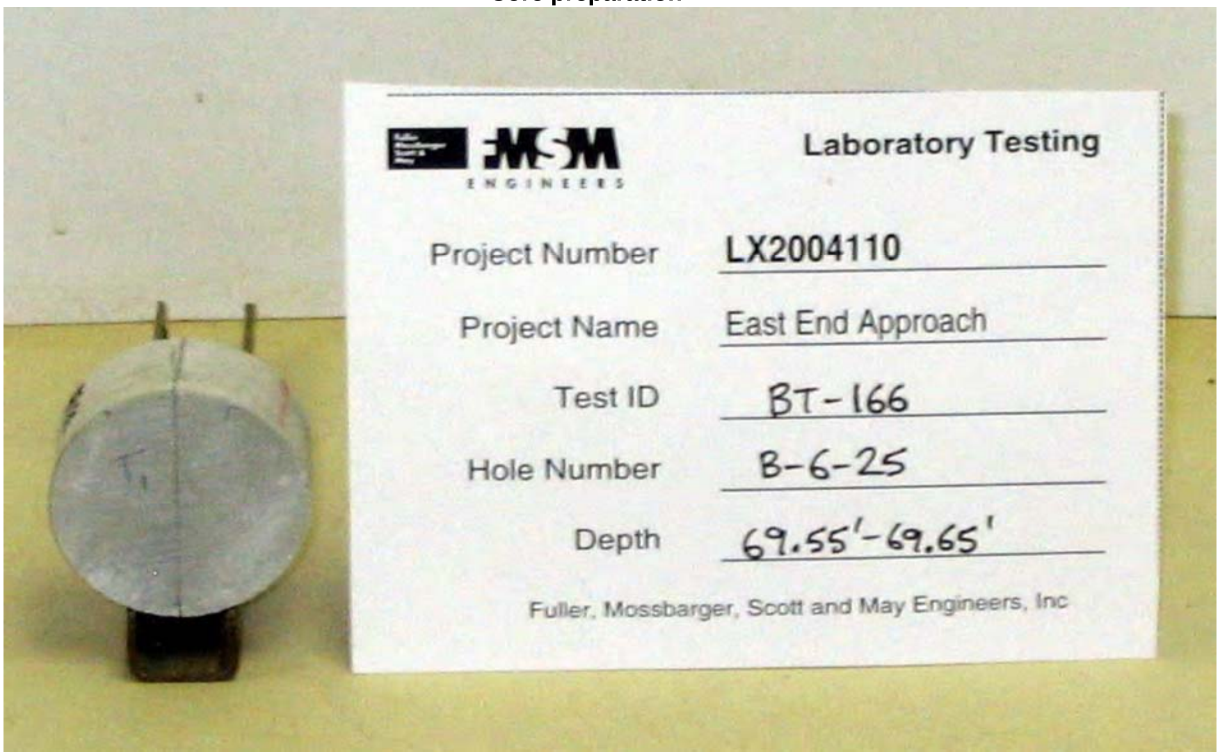


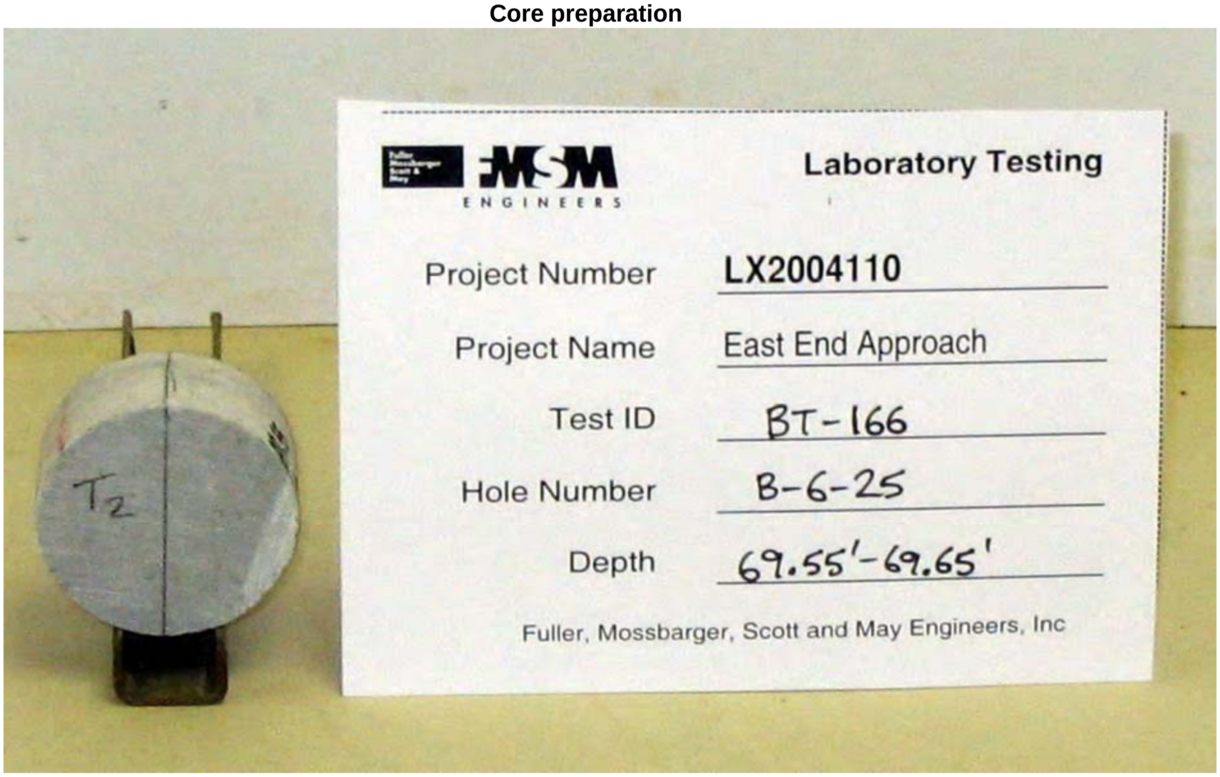
Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, gray, hard	Lab ID	BT-166
Hole Number	B-6-25	Depth (ft)	69.55'-69.65'
Test Type	Splitting tensile strength of intact rock core		

Core preparation



Core preparation

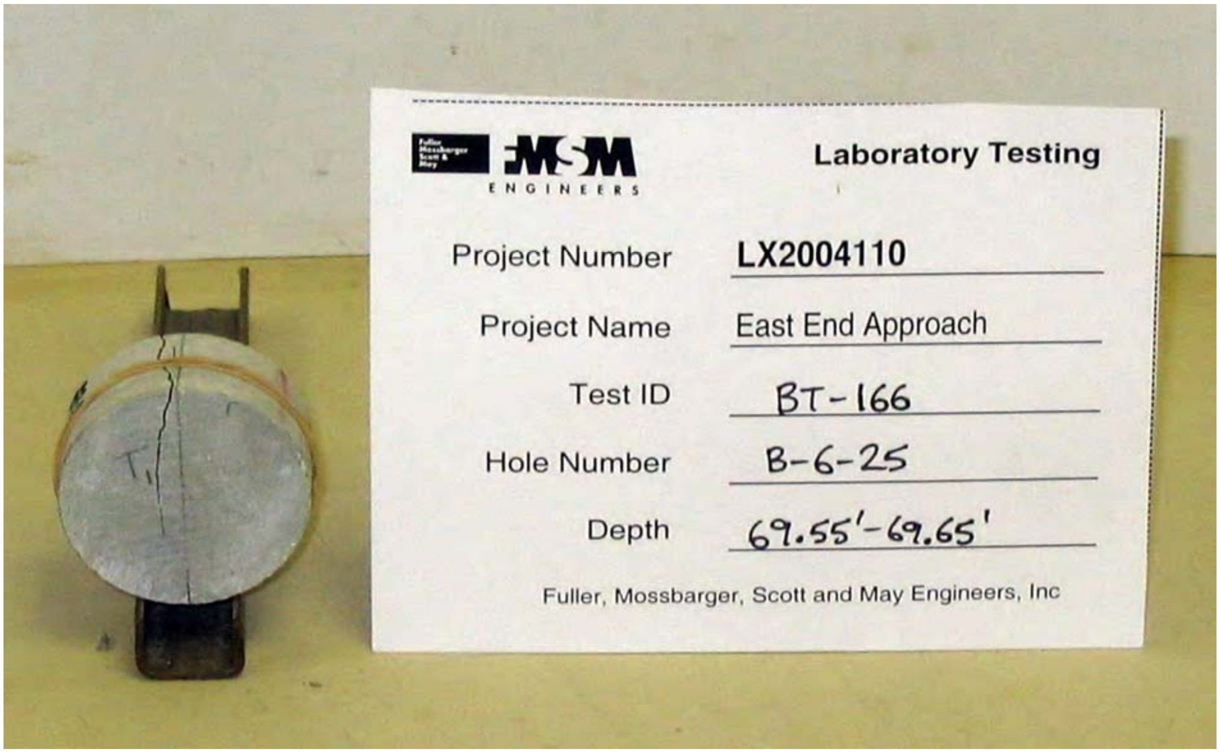


Fuller Mossbarger Scott & May ENGINEERS

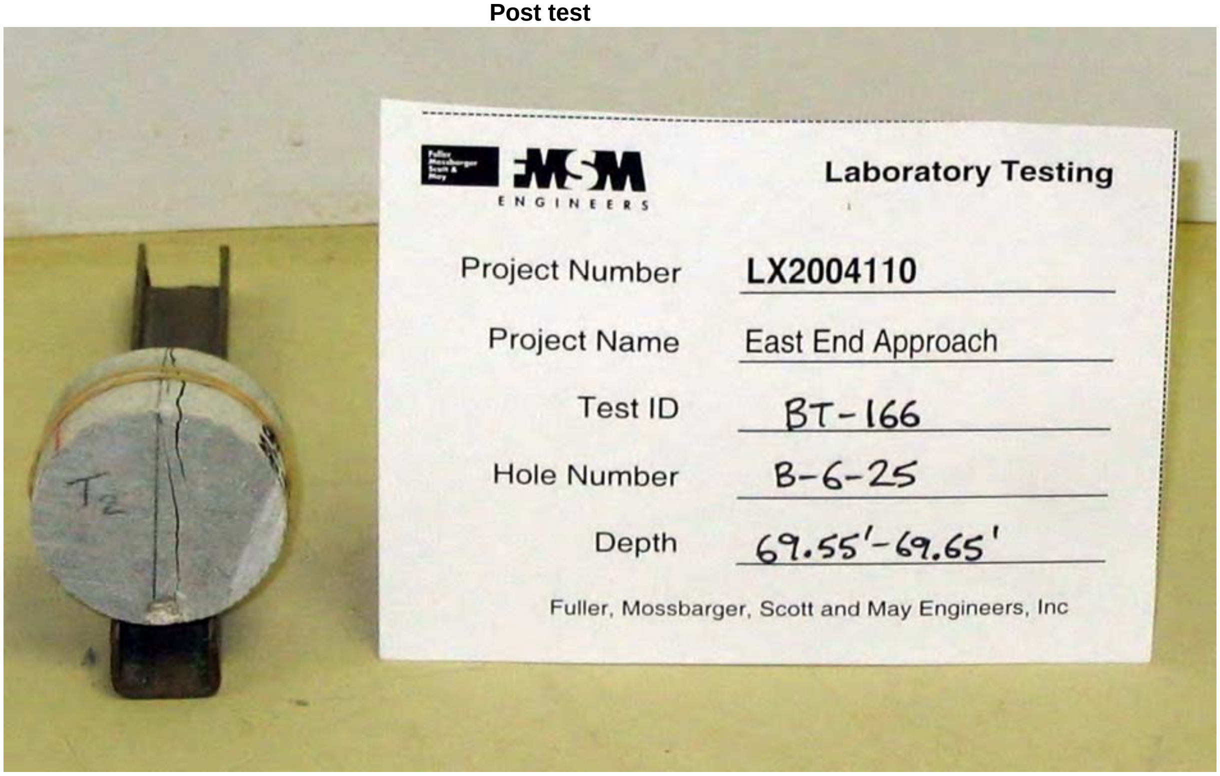
Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, gray, hard	Lab ID	BT-166
Hole Number	B-6-25	Depth (ft)	69.55'-69.65'
Test Type	Splitting tensile strength of intact rock core		

Post test



Post test



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Splitting Tensile Strength Of Intact Rock Core
ASTM D 3967

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, gray, hard	Lab ID	BT-172
Hole Number	B-5-9	Depth (ft/elev)	57.7'-57.8'
		Date Received	01-19-2006

Side Planeness	Pass	Height (in.)	1.219	Wet Unit Weight (pcf)	166.7
Perpendicularity	Pass	Diameter (in.)	1.771	Dry Unit Weight (pcf)	N/A
Height/Diameter	Pass	Wet Mass (g)	131.42	Moisture Content (%)	N/A

Test Date 02-01-2006

Moisture Condition As received, moist
Temperature (°F) 70

Loading Rate (lbf/sec) 10
Peak Load (lbf) 3130

Splitting Tensile Strength 923 psi

Failure Type Split
Bearing Strip Cardboard

Comments

Failure Sketches

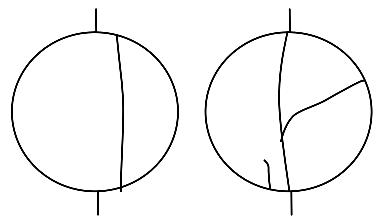


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, gray, hard	Lab ID	BT-172
Hole Number	B-5-9 Depth (ft) 57.7'-57.8'		
Test Type	Splitting tensile strength of intact rock core		

Core preparation

Core preparation

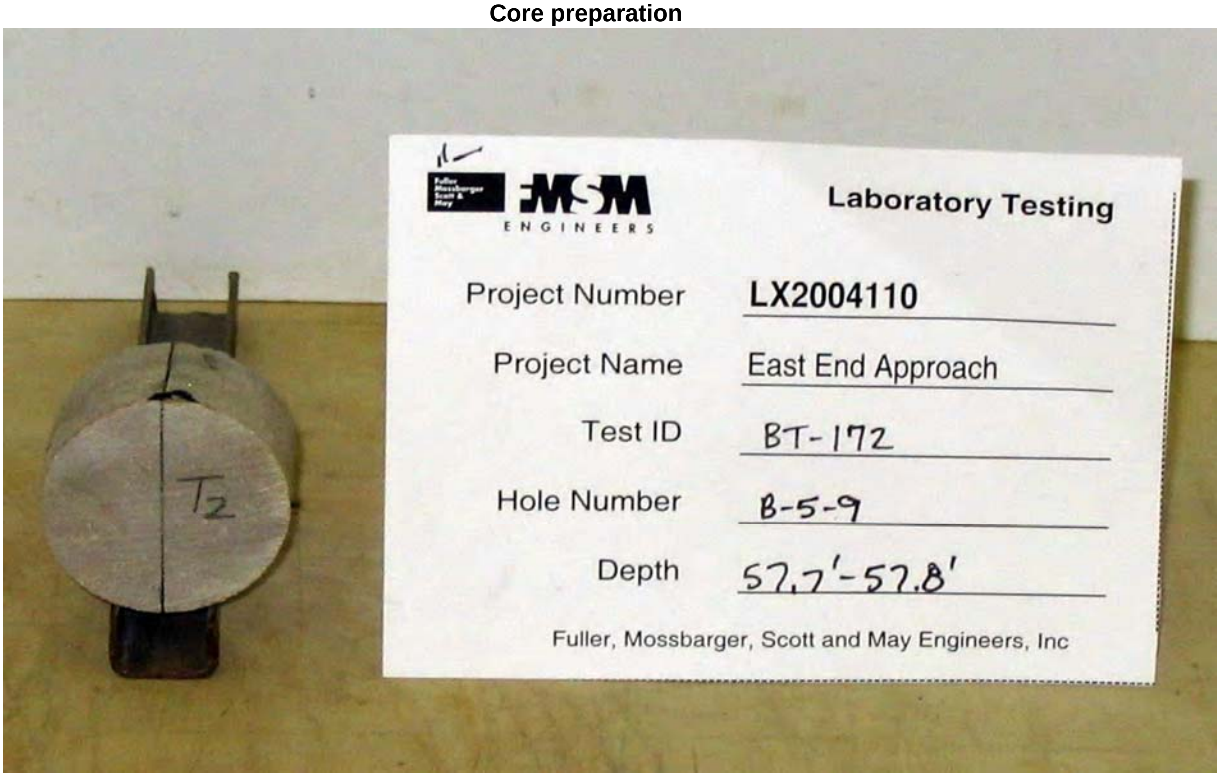
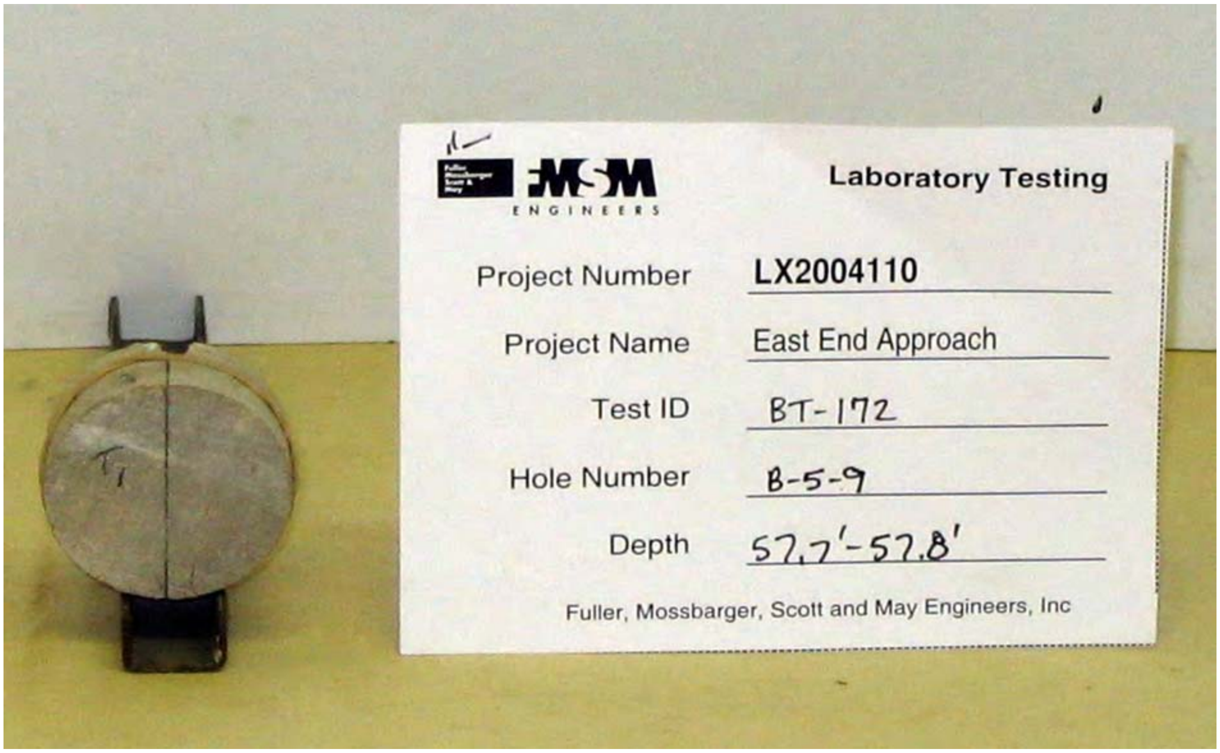


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, gray, hard	Lab ID	BT-172
Hole Number	B-5-9	Depth (ft)	57.7'-57.8'
Test Type	Splitting tensile strength of intact rock core		

Post test



Post test

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Splitting Tensile Strength Of Intact Rock Core
ASTM D 3967

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Dolomite, gray, hard
Lab ID BT-181
Hole Number B-8-11
Depth (ft/elev) 51.35'-51.45'
Date Received 01-19-2006

Side Planeness	Pass	Height (in.)	1.260	Wet Unit Weight (pcf)	166.0
Perpendicularity	Pass	Diameter (in.)	1.735	Dry Unit Weight (pcf)	N/A
Height/Diameter	Pass	Wet Mass (g)	129.88	Moisture Content (%)	N/A

Test Date 01-25-2006

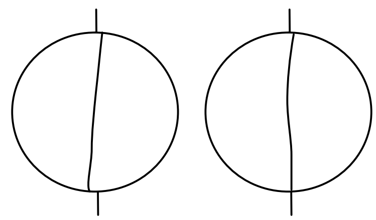
Moisture Condition As received, moist
Temperature (°F) 70

Loading Rate (lbf/sec) 10
Peak Load (lbf) 3090

Splitting Tensile Strength 900 psi

Failure Type Split
Bearing Strip Cardboard

Failure Sketches

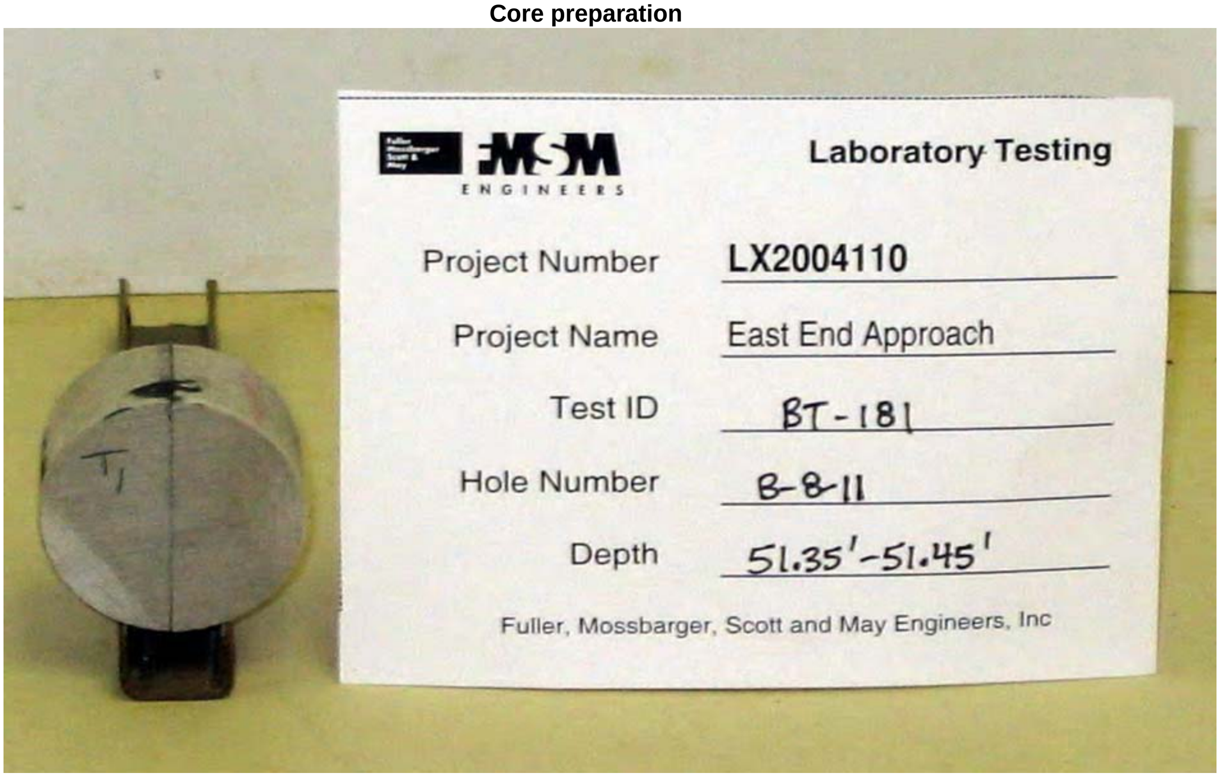


Comments

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, gray, hard	Lab ID	BT-181
Hole Number	B-8-11 Depth (ft) 51.35'-51.45'		
Test Type	Splitting tensile strength of intact rock core		

Core preparation



Core preparation

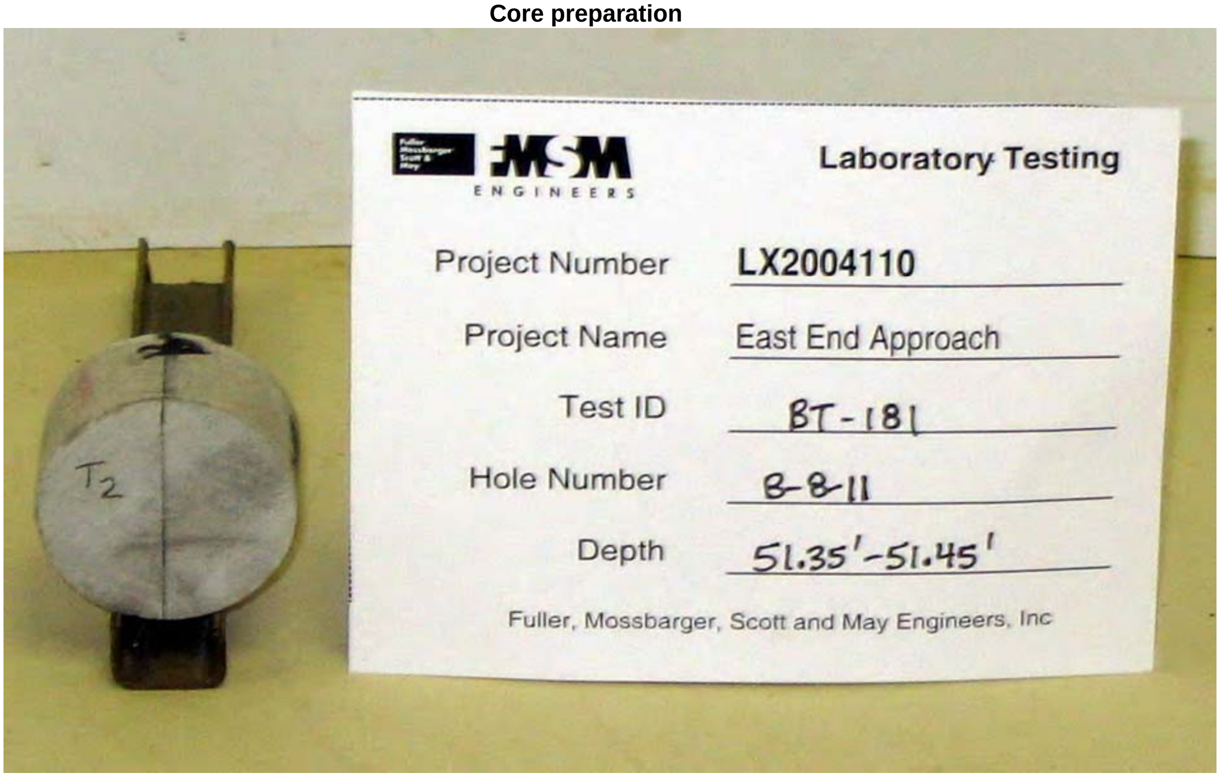
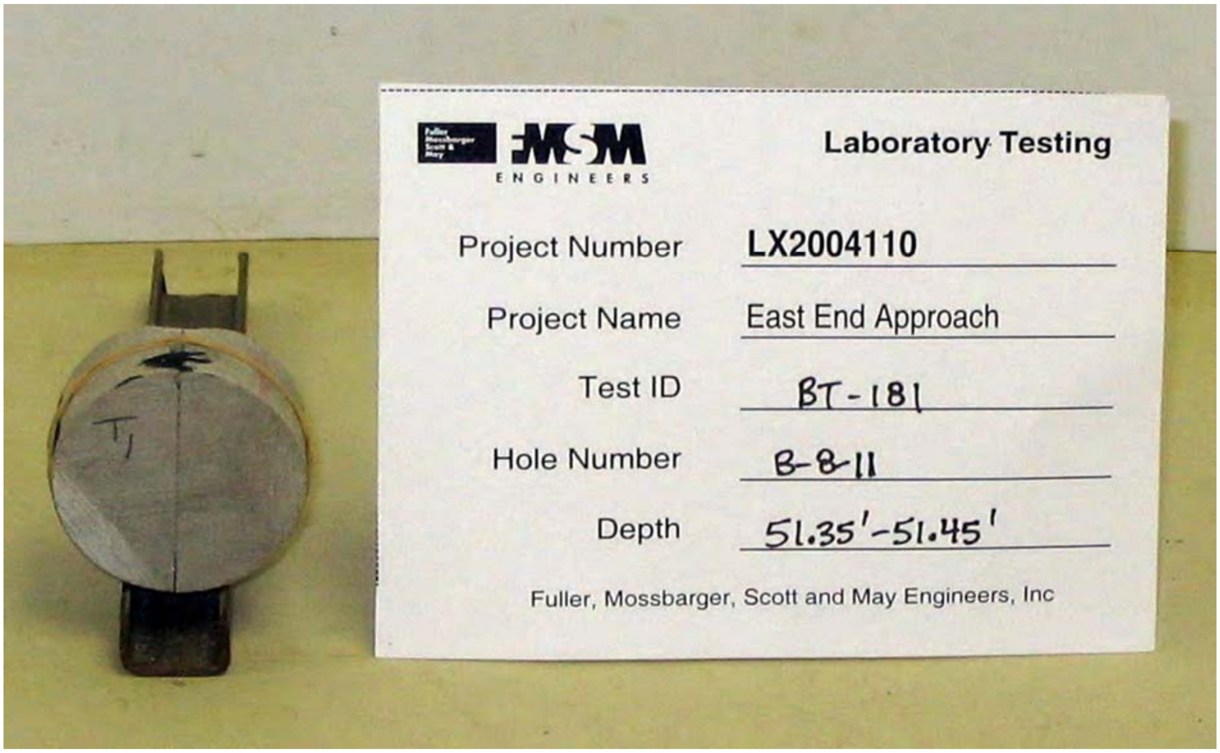


Photo Report

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Dolomite, gray, hard
Lab ID BT-181
Hole Number B-8-11
Depth (ft) 51.35'-51.45'
Test Type Splitting tensile strength of intact rock core

Post test



Post test

Splitting Tensile Strength Of Intact Rock Core

ASTM D 3967

ENGINEERS

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, gray, moderately hard	Lab ID	BT-186
Hole Number	B-9-3 Depth (ft/elev) 58.95'-59.05'	Date Received	01-19-2006

Side Planeness	Pass	Height (in.)	1.293	Wet Unit Weight (pcf)	168.5
Perpendicularity	Pass	Diameter (in.)	1.769	Dry Unit Weight (pcf)	N/A
Height/Diameter	Pass	Wet Mass (g)	140.58	Moisture Content (%)	N/A

Test Date 01-25-2006

Moisture Condition As received, moist
Temperature (°F) 70

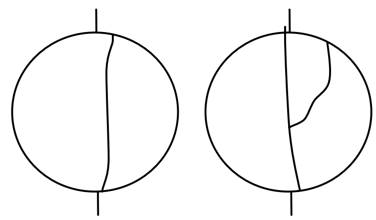
Loading Rate (lbf/sec) 10
Peak Load (lbf) 1930

Splitting Tensile Strength 537 psi

Failure Type Split
Bearing Strip Cardboard

Comments

Failure Sketches



Fuller Mossbarger Scott & May
FMSM ENGINEERS

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, gray, moderately hard	Lab ID	BT-186
Hole Number	B-9-3	Depth (ft)	58.95'-59.05'
Test Type	Splitting tensile strength of intact rock core		

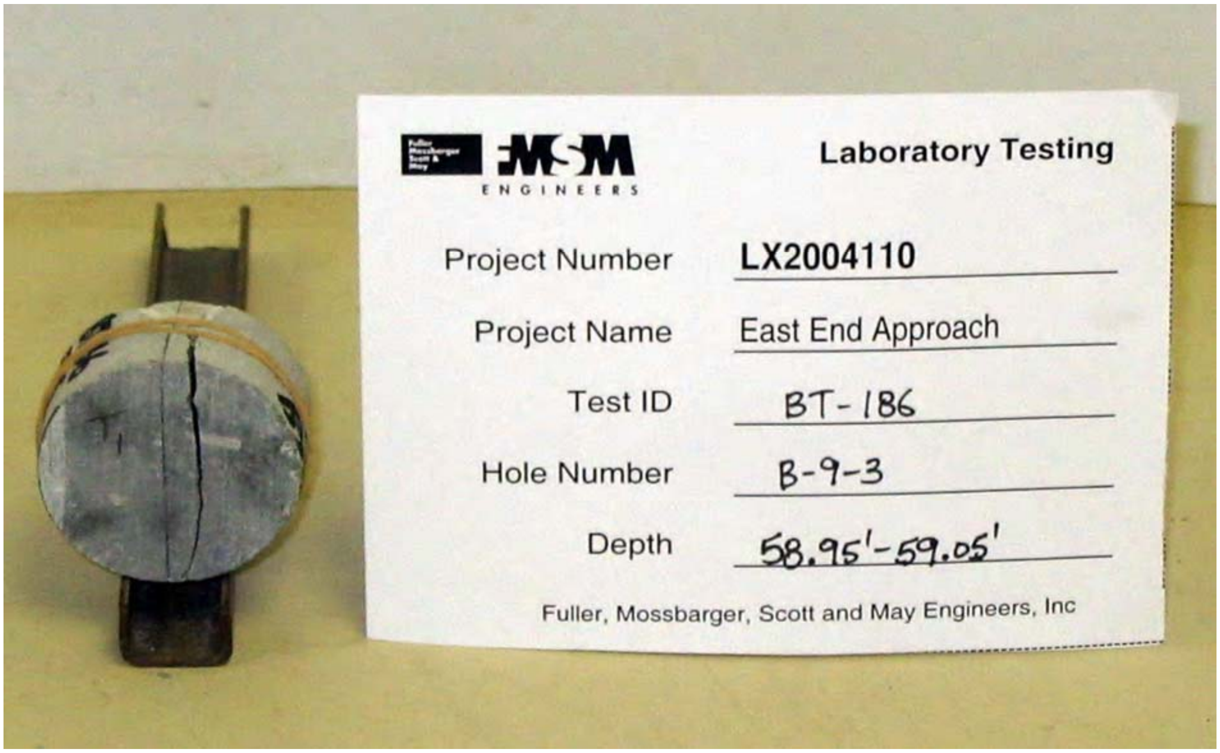
Core preparation

Core preparation

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, gray, moderately hard	Lab ID	BT-186
Hole Number	B-9-3 Depth (ft) 58.95'-59.05'		
Test Type	Splitting tensile strength of intact rock core		

Post test



Post test

ENGINEERS

Splitting Tensile Strength Of Intact Rock Core

ASTM D 3967

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Dolomite, gray, hard
Lab ID BT-190
Hole Number B-9-9
Depth (ft/elev) 72.8'-72.9'
Date Received 01-19-2006

Side Planeness Pass
Perpendicularity Pass
Height/Diameter Pass

Height (in.) 1.326
Diameter (in.) 1.768
Wet Mass (g) 142.31

Wet Unit Weight (pcf) 166.6
Dry Unit Weight (pcf) N/A
Moisture Content (%) N/A

Test Date 01-25-2006

Moisture Condition As received, moist
Temperature (°F) 70

Loading Rate (lbf/sec) 10
Peak Load (lbf) 3180

Splitting Tensile Strength 864 psi

Failure Type Split
Bearing Strip Cardboard

Comments

Failure Sketches

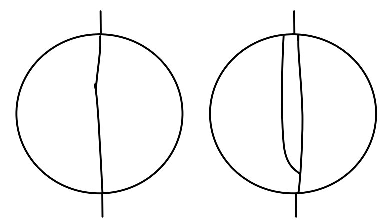
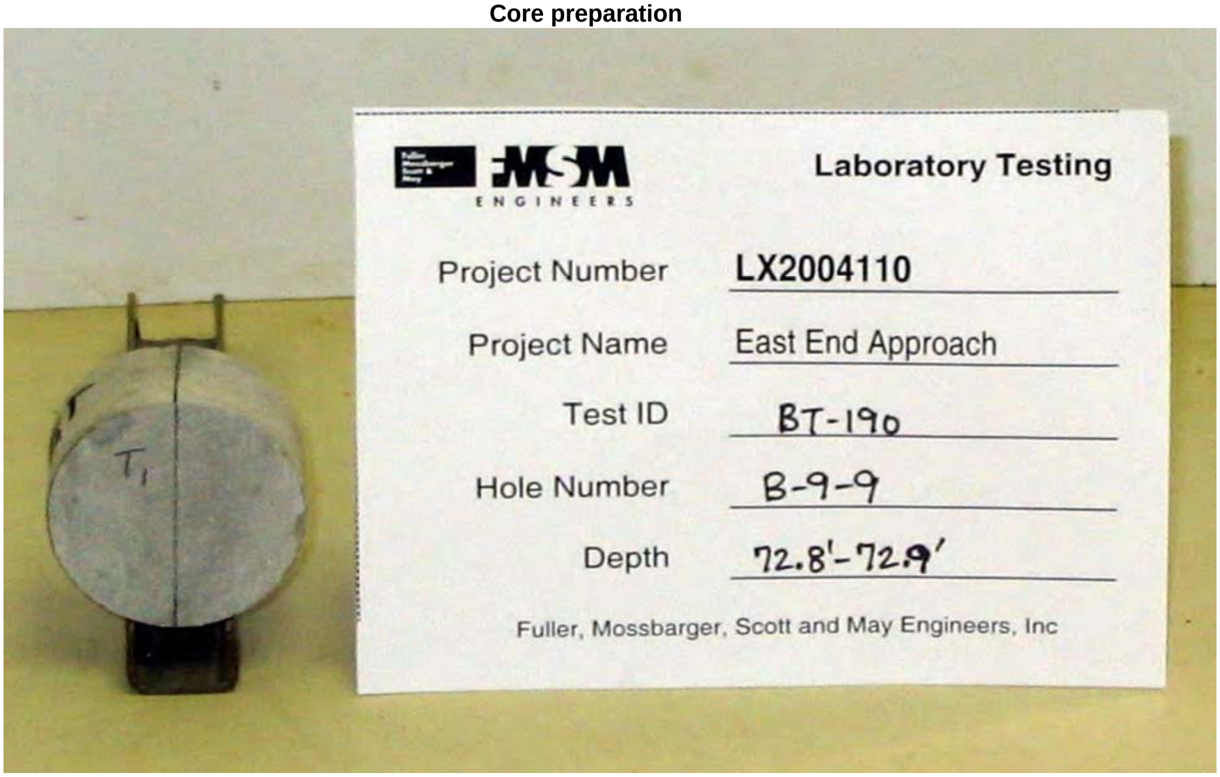


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, gray, hard	Lab ID	BT-190
Hole Number	B-9-9 Depth (ft) 72.8'-72.9'		
Test Type	Splitting tensile strength of intact rock core		

Core preparation



Core preparation

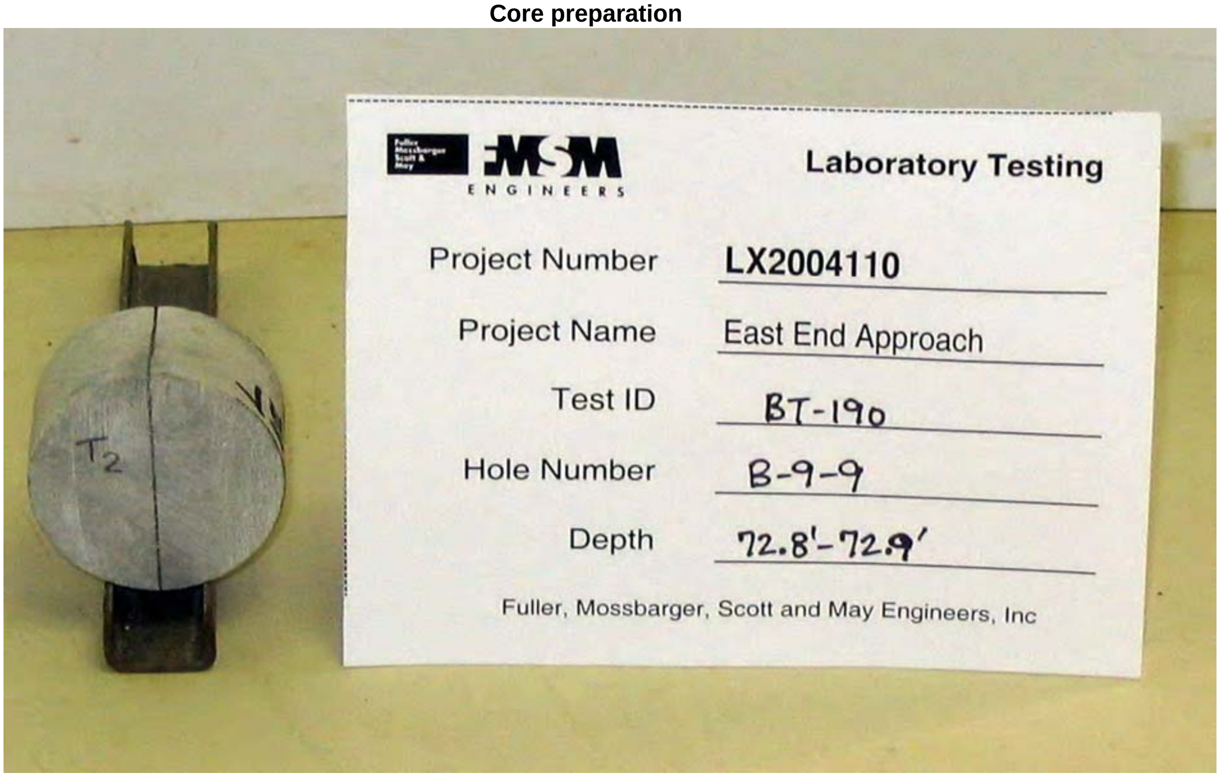
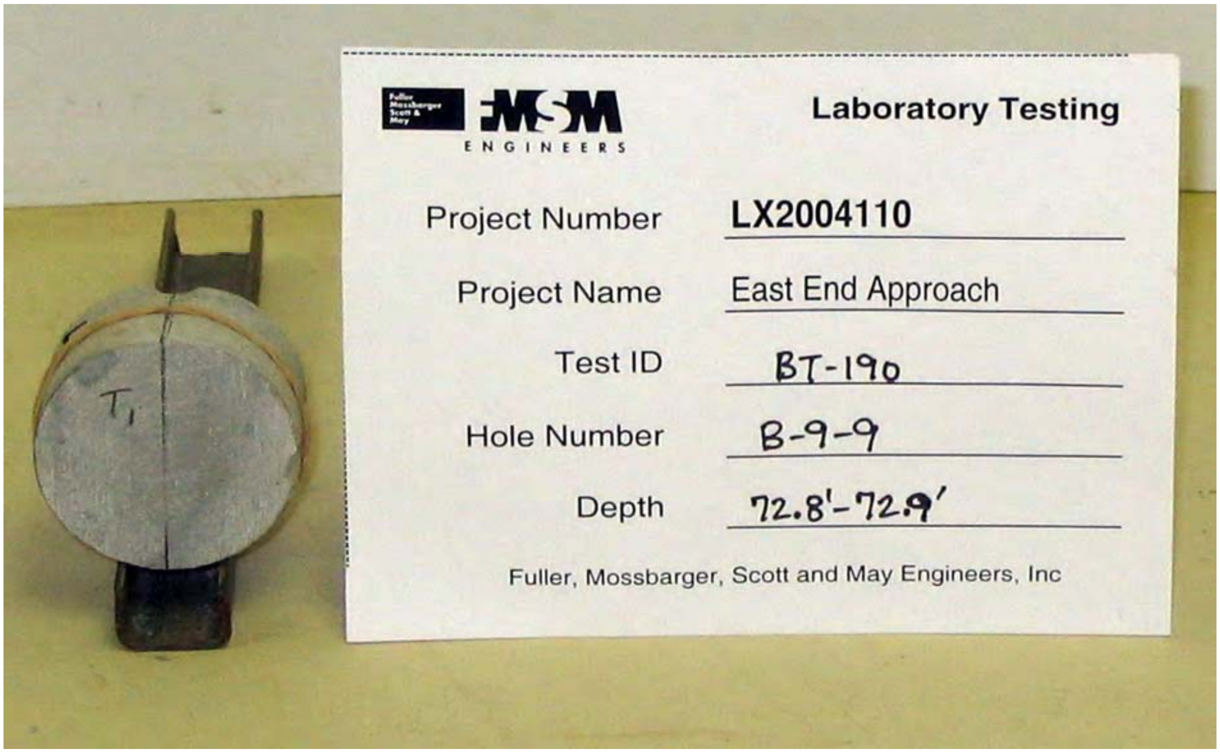


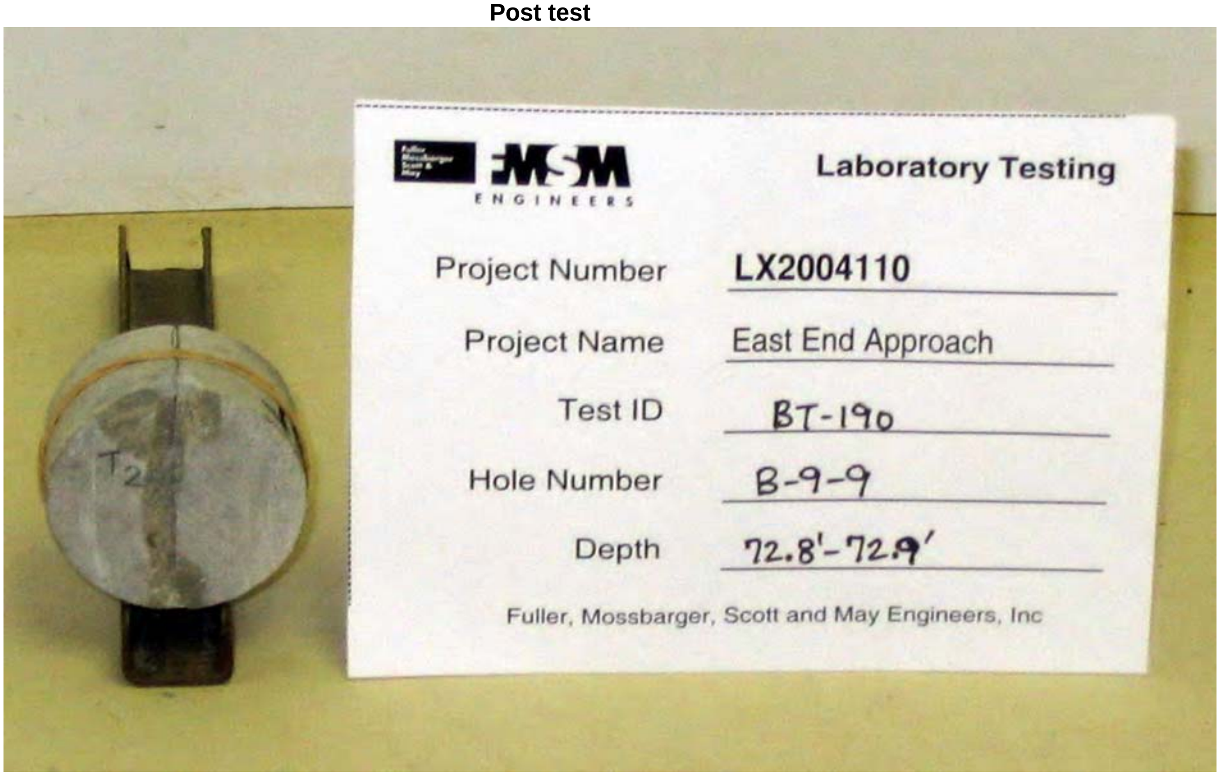
Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, gray, hard	Lab ID	BT-190
Hole Number	B-9-9	Depth (ft)	72.8'-72.9'
Test Type	Splitting tensile strength of intact rock core		

Post test



Post test



Fuller Mossbarger Scott & May
FMSM ENGINEERS

Splitting Tensile Strength Of Intact Rock Core

ASTM D 3967

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Limestone, gray, hard
Lab ID: BT-193
Hole Number: B-10-3
Depth (ft/elev): 52.4'-52.5'
Date Received: 01-19-2006

Side Planeness: Pass
Perpendicularity: Pass
Height/Diameter: Pass

Height (in.): 1.290
Diameter (in.): 1.766
Wet Mass (g): 139.86

Wet Unit Weight (pcf): 168.6
Dry Unit Weight (pcf): N/A
Moisture Content (%): N/A

Test Date: 01-25-2006

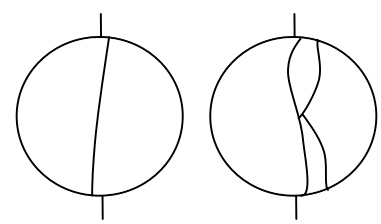
Moisture Condition: As received, moist
Temperature (°F): 70

Loading Rate (lbf/sec): 10
Peak Load (lbf): 2980

Splitting Tensile Strength: 833 psi

Failure Type: Split
Bearing Strip: Cardboard

Failure Sketches



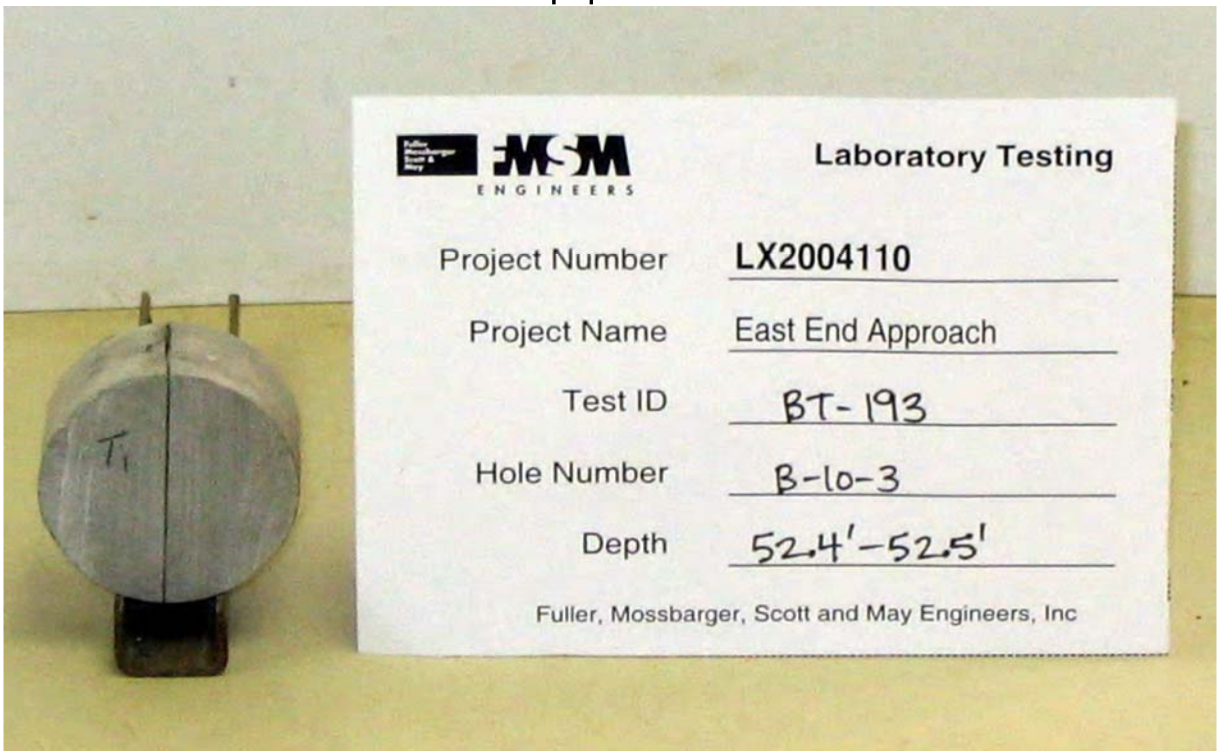
Comments:

Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, gray, hard
Hole Number B-10-3 Depth (ft) 52.4'-52.5'
Test Type Splitting tensile strength of intact rock core

Project Number LX2004110
Lab ID BT-193

Core preparation



Core preparation

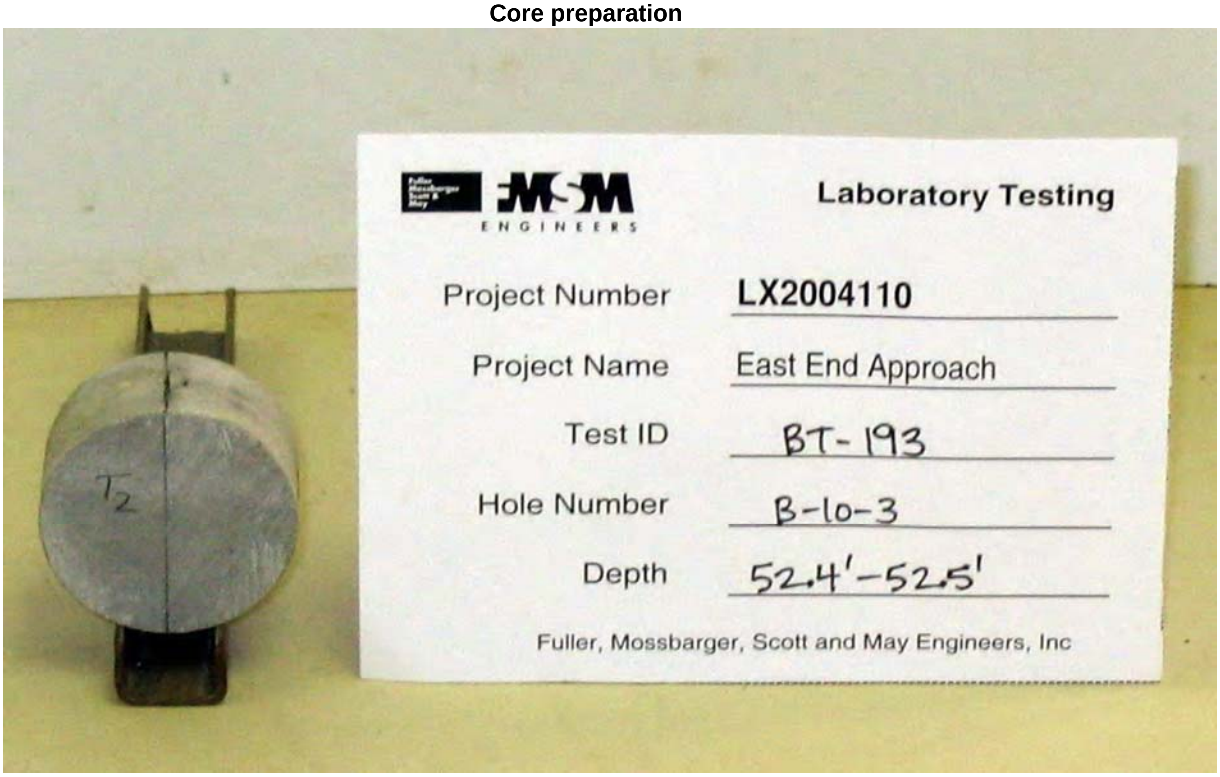
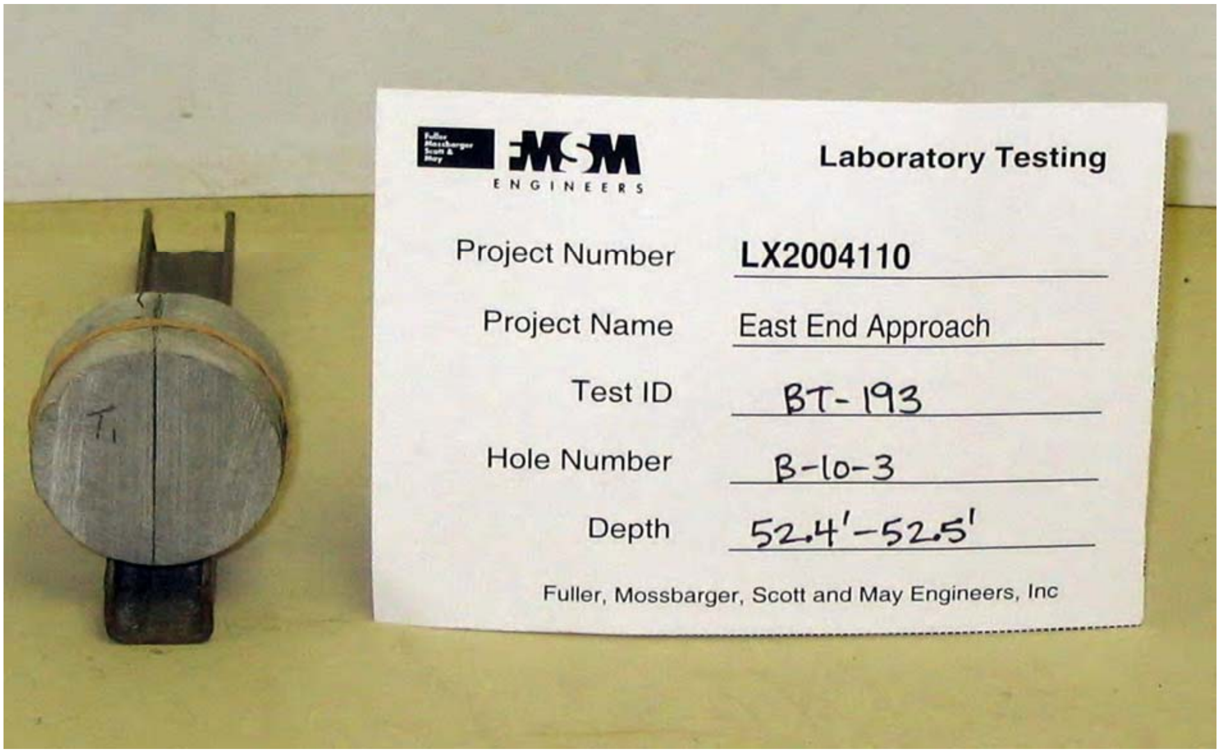


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, gray, hard	Lab ID	BT-193
Hole Number	B-10-3	Depth (ft)	52.4'-52.5'
Test Type	Splitting tensile strength of intact rock core		

Post test



Post test

ENGINEERS

Splitting Tensile Strength Of Intact Rock Core

ASTM D 3967

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Shale, gray, moderately hard
Lab ID: BT-198
Hole Number: B-10-8
Depth (ft/elev): 61.5'-61.6'
Date Received: 01-19-2006

Side Planeness: Pass
Perpendicularity: Pass
Height/Diameter: Pass

Height (in.): 1.233
Diameter (in.): 1.762
Wet Mass (g): 129.68

Wet Unit Weight (pcf): 164.3
Dry Unit Weight (pcf): N/A
Moisture Content (%): N/A

Test Date: 01-25-2006

Moisture Condition: As received, moist
Temperature (°F): 70

Loading Rate (lbf/sec): 10
Peak Load (lbf): 1450

Splitting Tensile Strength: 425 psi

Failure Type: Split
Bearing Strip: Cardboard

Comments:

Failure Sketches

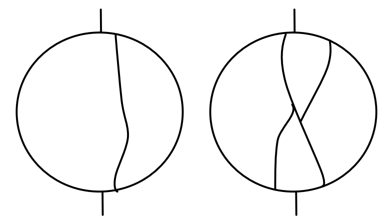
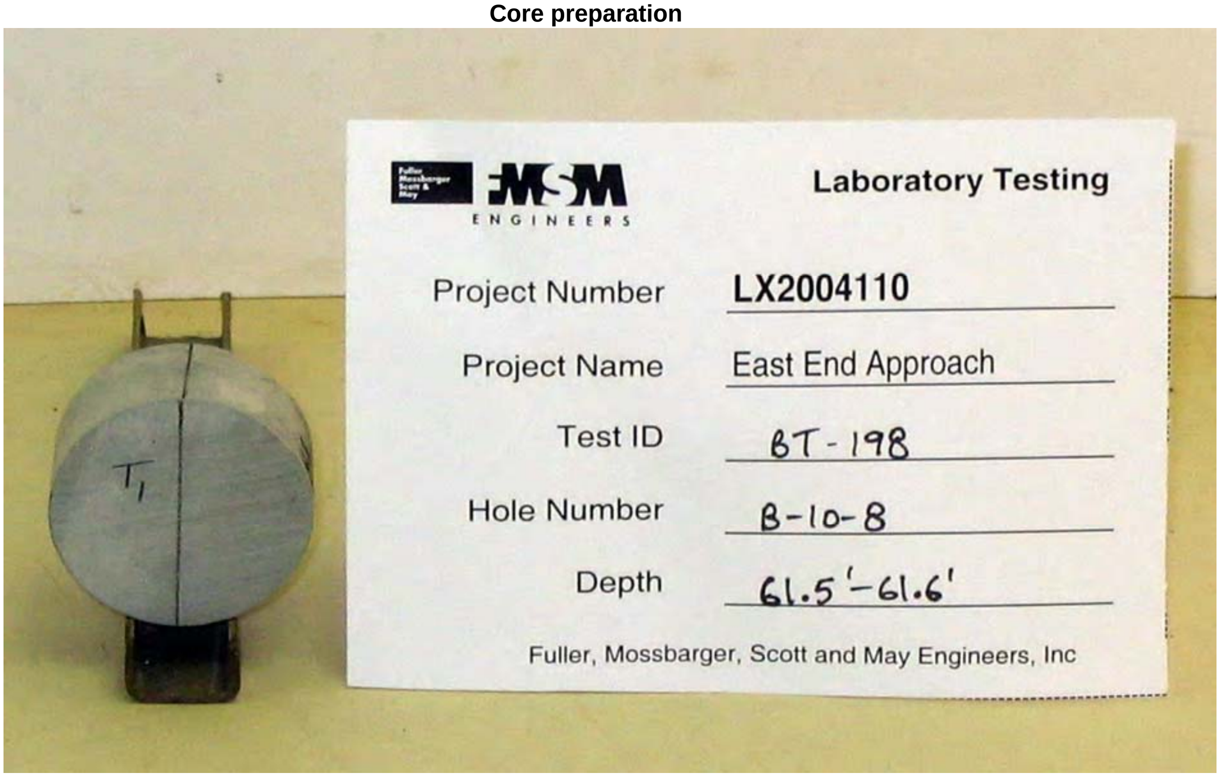


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Shale, gray, moderately hard	Lab ID	BT-198
Hole Number	B-10-8 Depth (ft) 61.5'-61.6'		
Test Type	Splitting tensile strength of intact rock core		

Core preparation



Core preparation

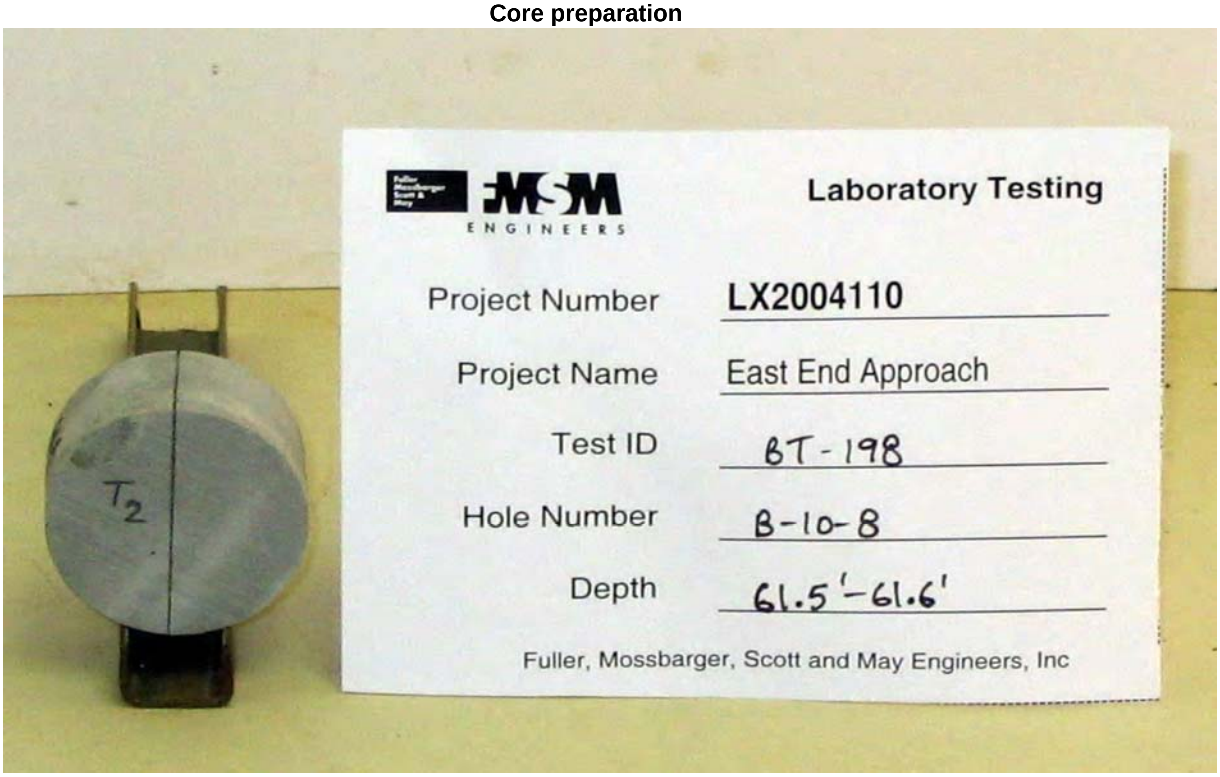
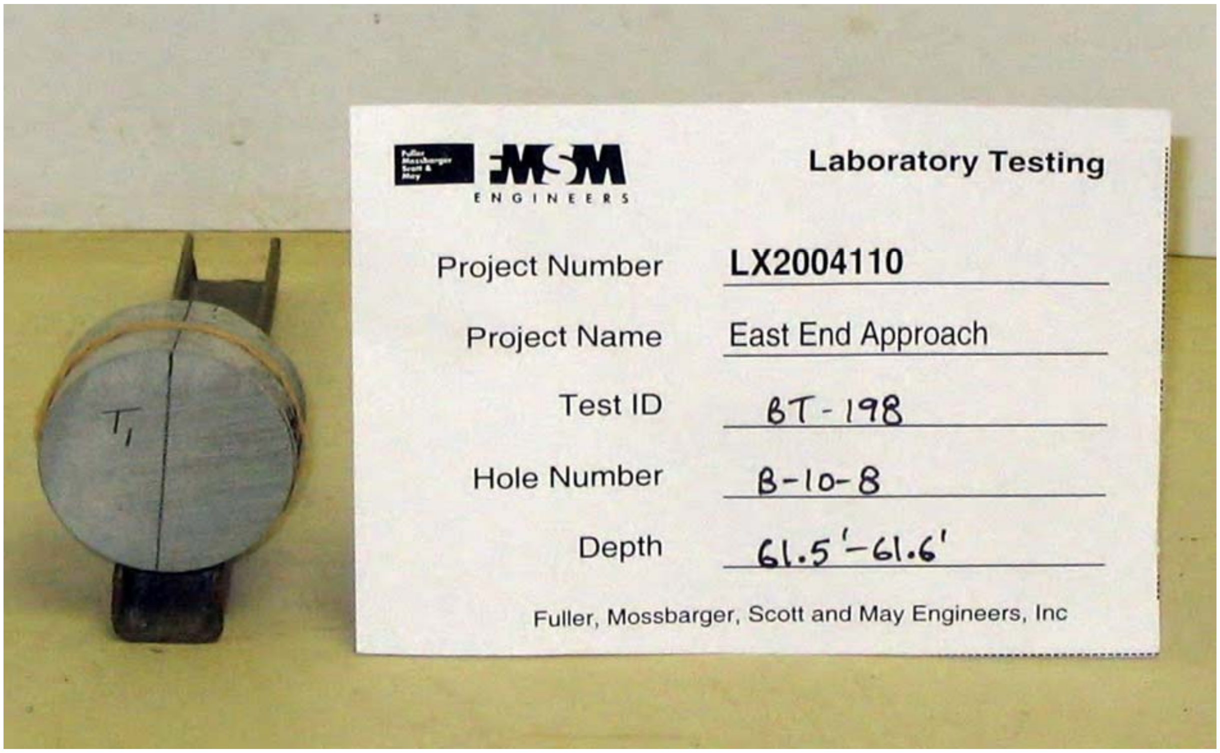


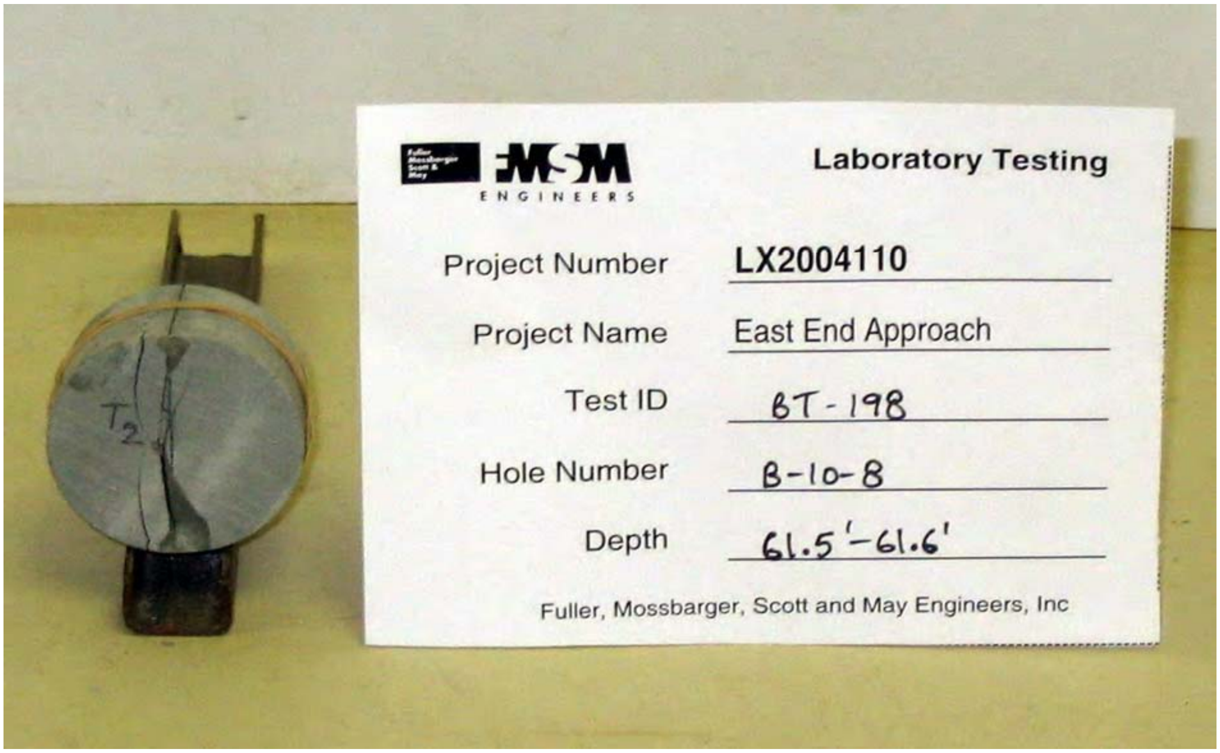
Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Shale, gray, moderately hard	Lab ID	BT-198
Hole Number	B-10-8	Depth (ft)	61.5'-61.6'
Test Type	Splitting tensile strength of intact rock core		

Post test



Post test



Splitting Tensile Strength Of Intact Rock Core
ASTM D 3967

Fuller Mossbarger Scott & May ENGINEERS

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, gray, hard	Lab ID	BT-200
Hole Number	B-10-12 Depth (ft/elev) 71.25'-71.35'	Date Received	01-19-2006

Side Planeness	Pass	Height (in.)	1.323	Wet Unit Weight (pcf)	171.9
Perpendicularity	Pass	Diameter (in.)	1.769	Dry Unit Weight (pcf)	N/A
Height/Diameter	Pass	Wet Mass (g)	146.73	Moisture Content (%)	N/A

Test Date 01-26-2006

Moisture Condition As received, moist
Temperature (°F) 70

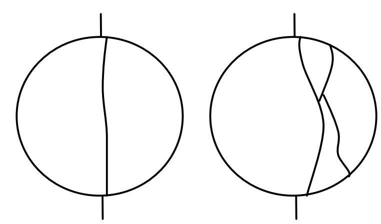
Loading Rate (lbf/sec) 10
Peak Load (lbf) 3690

Splitting Tensile Strength 1004 psi

Failure Type Split
Bearing Strip Cardboard

Comments

Failure Sketches

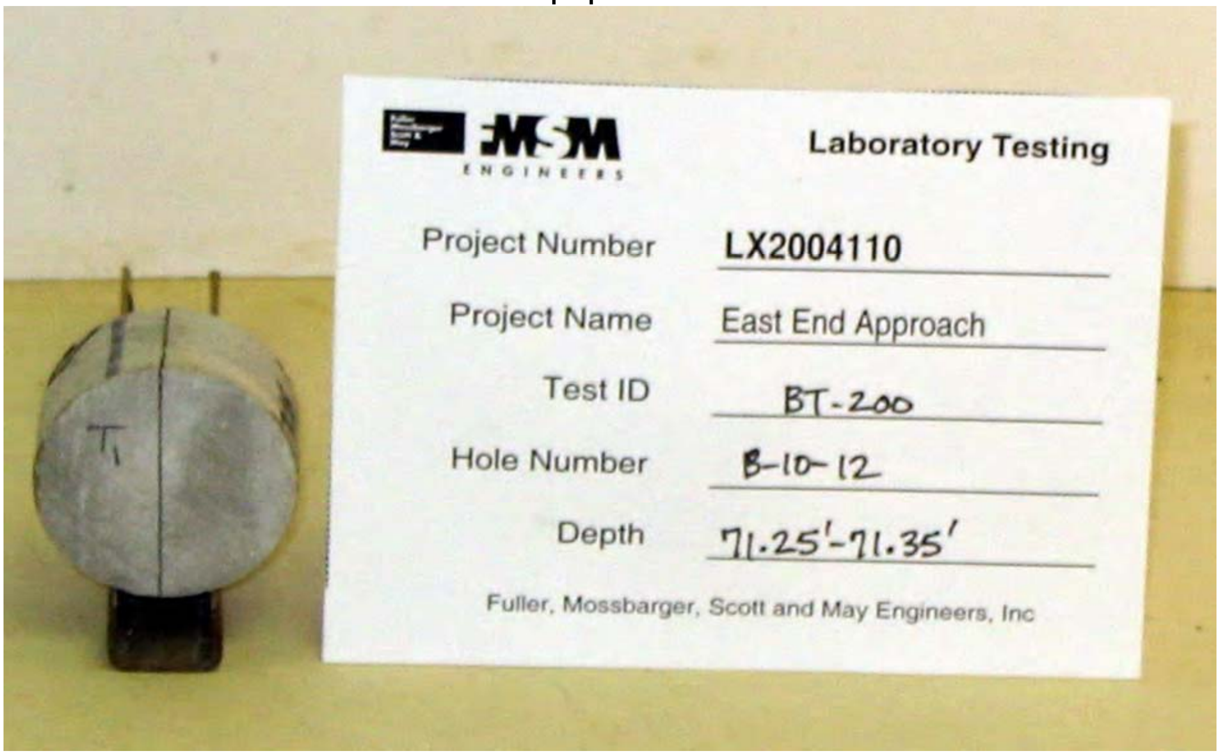


Fuller Mossbarger Scott & May
FMSM ENGINEERS

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, gray, hard	Lab ID	BT-200
Hole Number	B-10-12	Depth (ft)	71.25'-71.35'
Test Type	Splitting tensile strength of intact rock core		

Core preparation



Core preparation

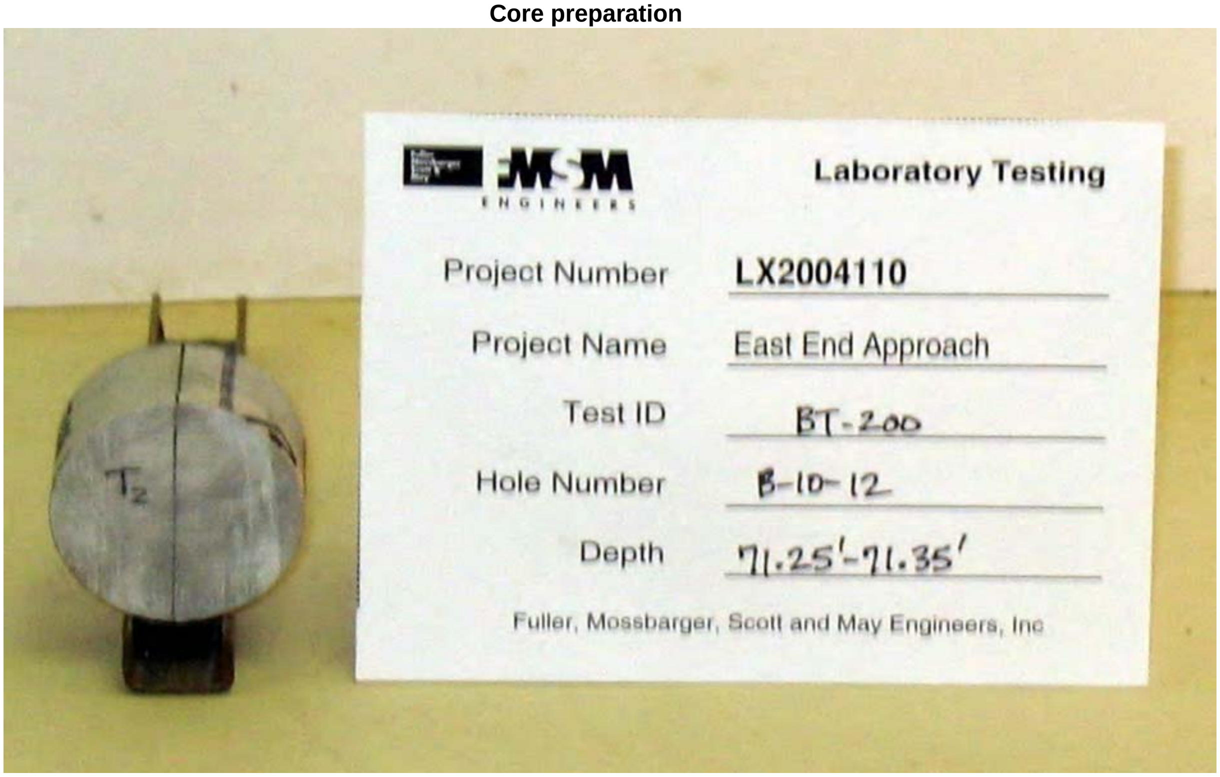


Photo Report

Project Name LSIORB Section 4, East End Approach

Project Number LX2004110

Lithology Dolomite, gray, hard

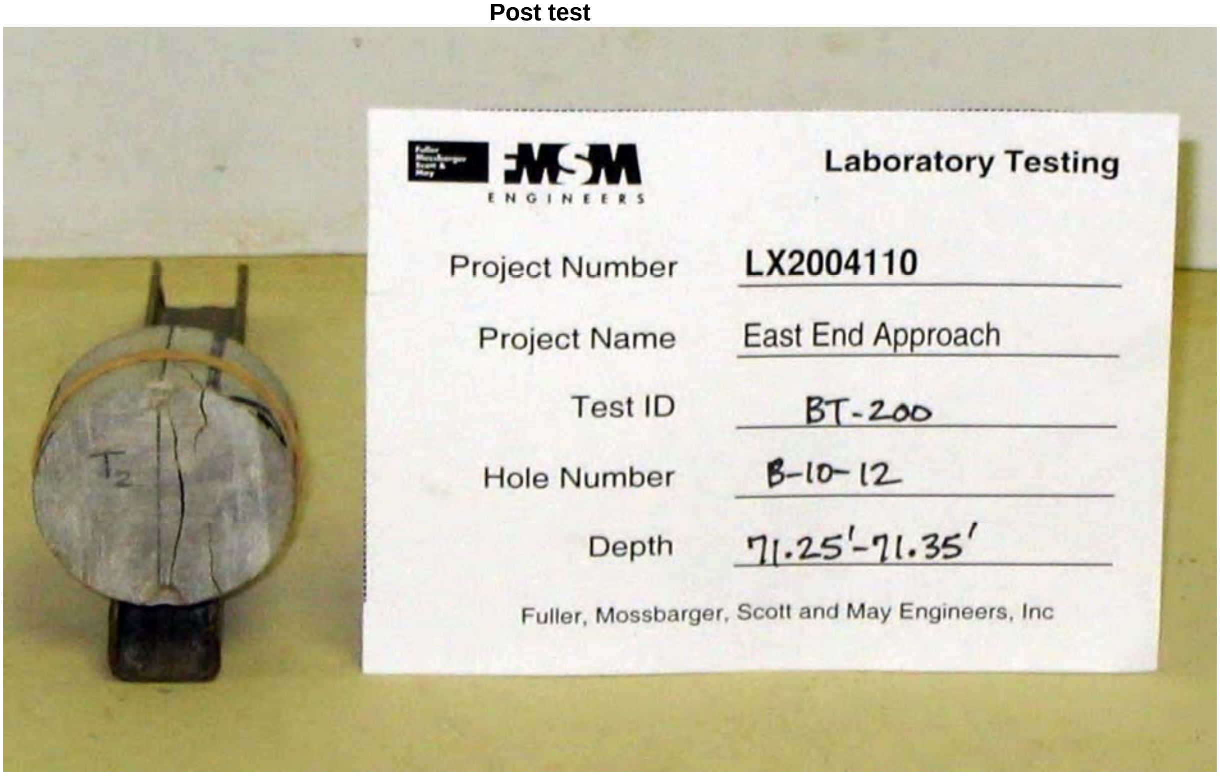
Lab ID BT-200

Hole Number B-10-12 Depth (ft) 71.25'-71.35'

Test Type Splitting tensile strength of intact rock core

Post test

Post test



ENGINEERS

Splitting Tensile Strength Of Intact Rock Core
ASTM D 3967

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Limestone, gray, moderately hard
Lab ID: BT-201
Hole Number: B-11-1
Depth (ft/elev): 66.8'-66.9
Date Received: 01-19-2006

Side Planeness	Pass	Height (in.)	1.151	Wet Unit Weight (pcf)	157.8
Perpendicularity	Pass	Diameter (in.)	1.764	Dry Unit Weight (pcf)	N/A
Height/Diameter	Pass	Wet Mass (g)	116.43	Moisture Content (%)	N/A

Test Date: 02-01-2006

Moisture Condition: As received, moist
Temperature (°F): 70

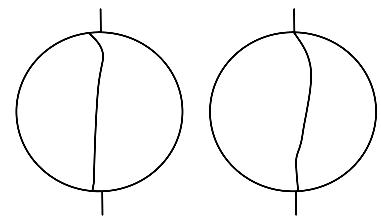
Loading Rate (lbf/sec): 10
Peak Load (lbf): 1320

Splitting Tensile Strength: 414 psi

Failure Type: Split
Bearing Strip: Cardboard

Comments:

Failure Sketches



File: LX2004110_BT-201.xls Sheet: Report
Preparation Date: 2-2002
Revision Date: 7-2002

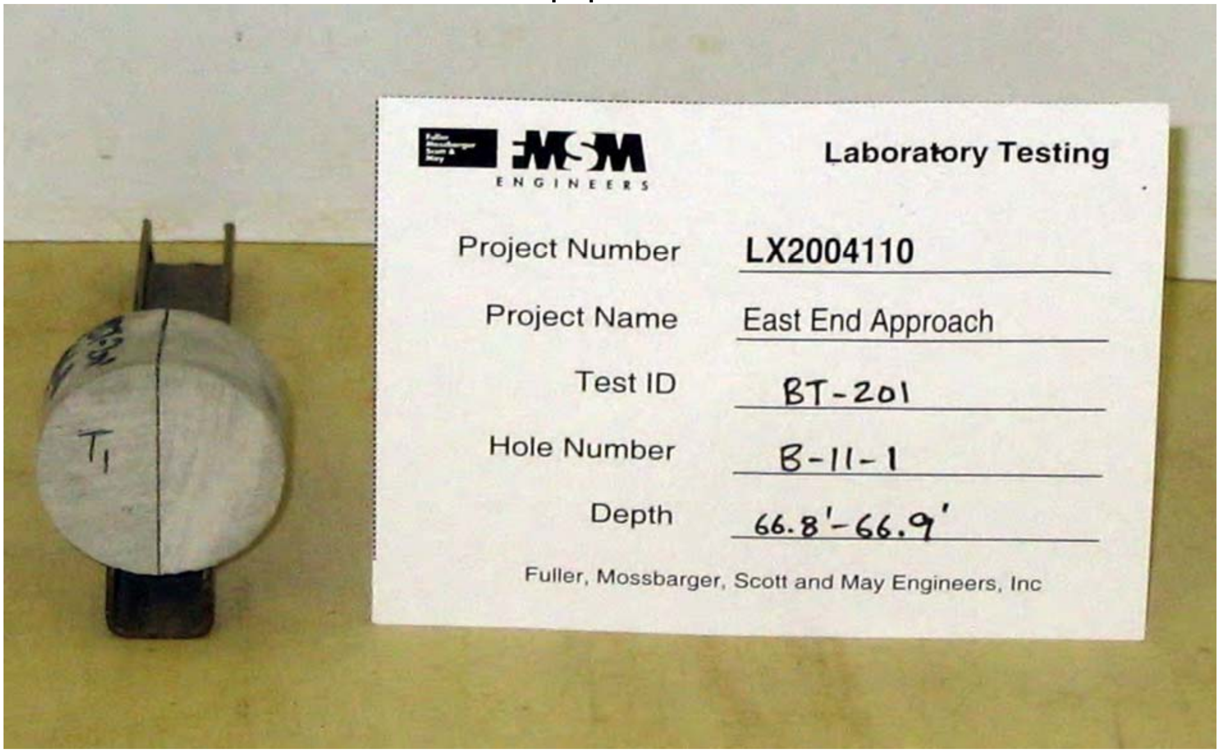
Fuller, Mossbarger, Scott and May Engineers, Inc.

Laboratory Document
Prepared By: JW
Approved By: TLK

Photo Report

Project Name LSIORB Section 4, East End Approach | Project Number LX2004110
Lithology Limestone, gray, moderately hard | Lab ID BT-201
Hole Number B-11-1 Depth (ft) 66.8'-66.9
Test Type Splitting tensile strength of intact rock core

Core preparation



Core preparation

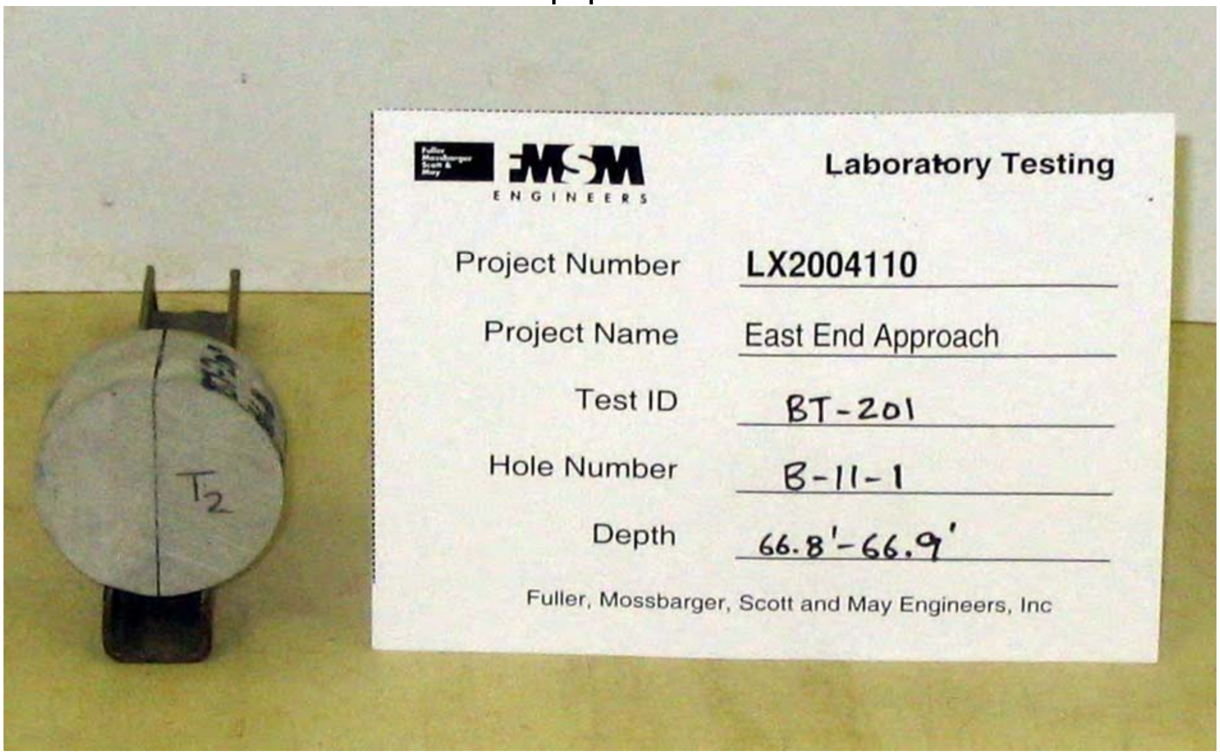
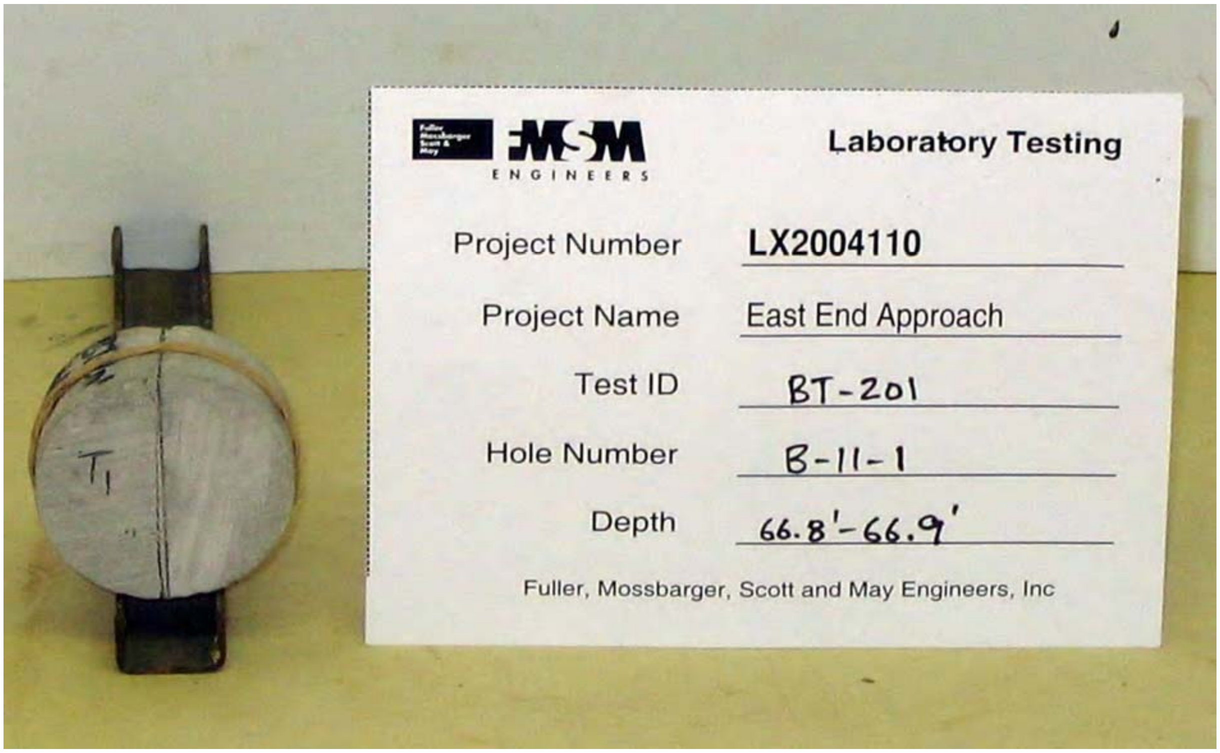


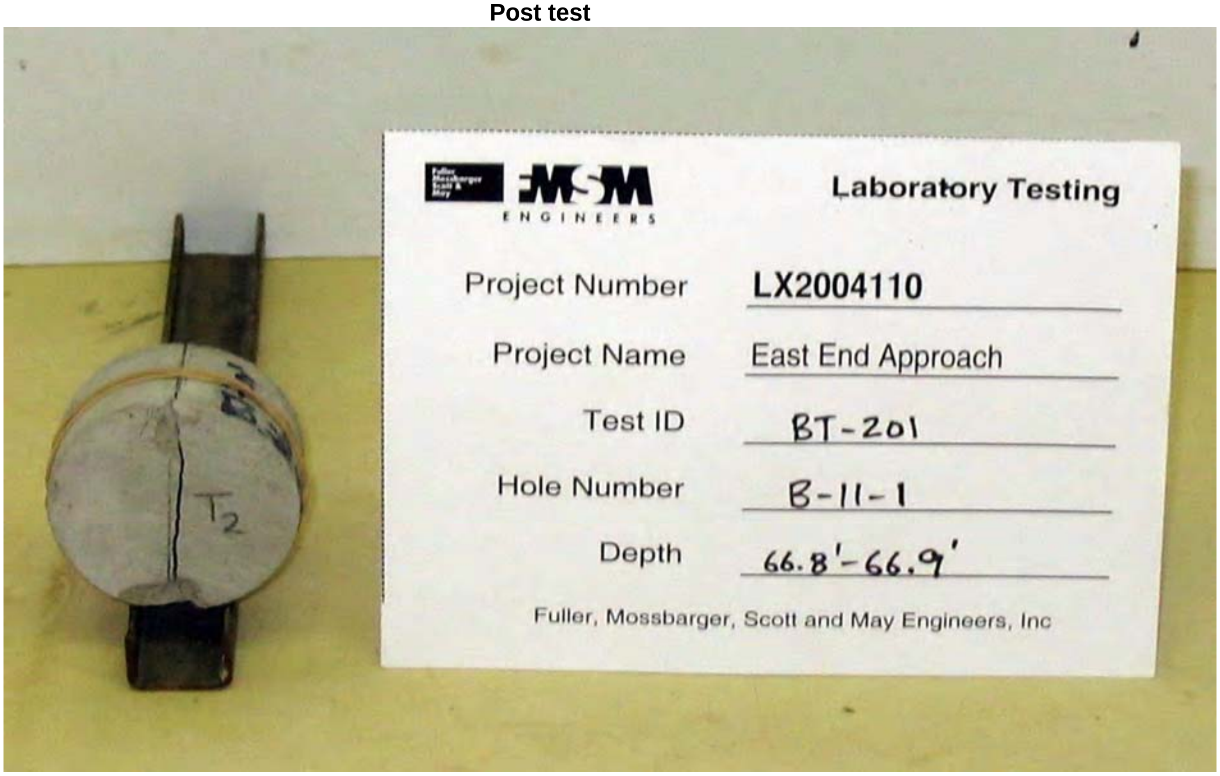
Photo Report

Project Name LSIORB Section 4, East End Approach | Project Number LX2004110
Lithology Limestone, gray, moderately hard | Lab ID BT-201
Hole Number B-11-1 | Depth (ft) 66.8'-66.9
Test Type Splitting tensile strength of intact rock core

Post test



Post test



Splitting Tensile Strength Of Intact Rock Core

ASTM D 3967

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Limestone, gray, hard
Lab ID BT-206
Hole Number B-12-11 Depth (ft/elev) 40.55'-40.65'
Date Received 01-19-2006

Side Planeness	Pass	Height (in.)	1.371	Wet Unit Weight (pcf)	166.9
Perpendicularity	Pass	Diameter (in.)	1.986	Dry Unit Weight (pcf)	N/A
Height/Diameter	Pass	Wet Mass (g)	185.98	Moisture Content (%)	N/A

Test Date 01-26-2006

Moisture Condition As received, moist
Temperature (°F) 70

Loading Rate (lbf/sec) 10
Peak Load (lbf) 2790

Splitting Tensile Strength 653 psi

Failure Type Split
Bearing Strip Cardboard

Comments

Failure Sketches

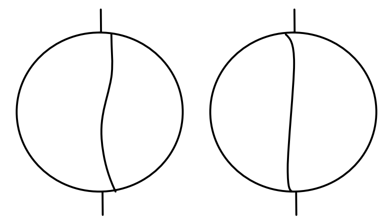


Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, gray, hard
Hole Number B-12-11 Depth (ft) 40.55'-40.65'
Test Type Splitting tensile strength of intact rock core

Project Number LX2004110
Lab ID BT-206

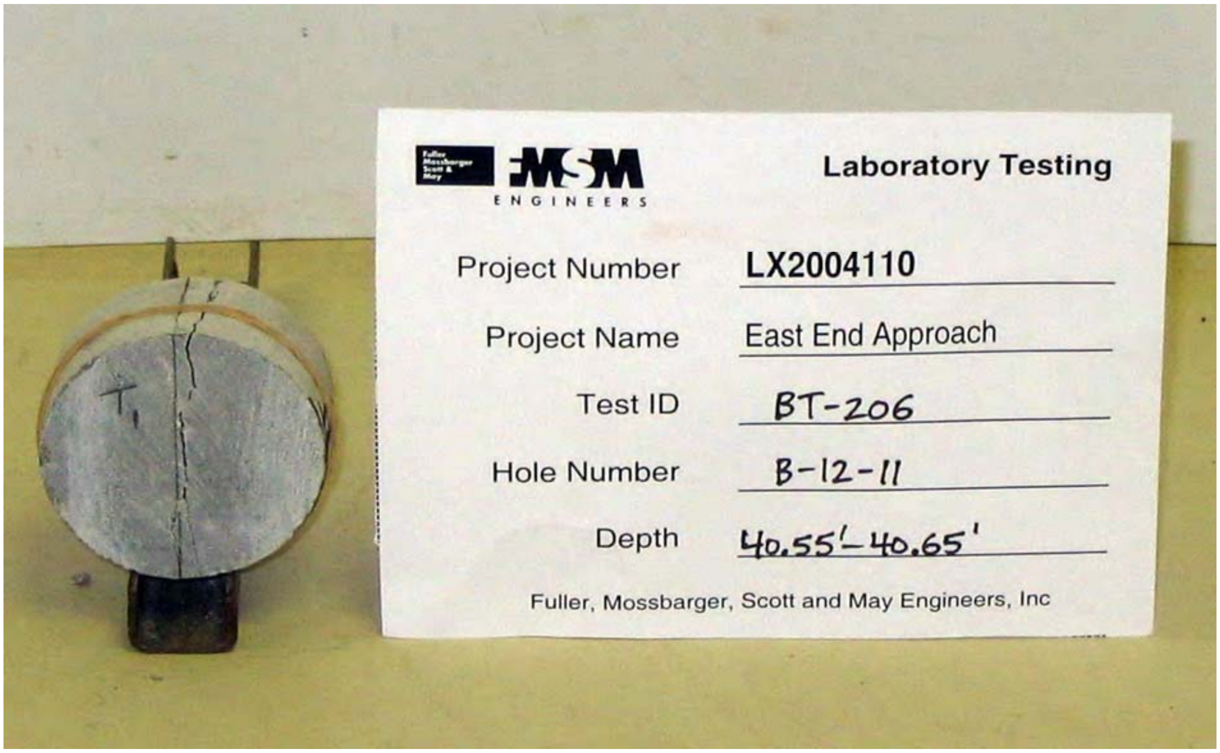
Core preparation

Core preparation

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, gray, hard	Lab ID	BT-206
Hole Number	B-12-11	Depth (ft)	40.55'-40.65'
Test Type	Splitting tensile strength of intact rock core		

Post test



Post test

ENGINEERS

Splitting Tensile Strength Of Intact Rock Core

ASTM D 3967

Project Name LSIORB Section 4, East End Approach

Project Number LX2004110

Lithology Limestone, gray, hard

Lab ID BT-207

Hole Number B-12-15

Depth (ft/elev) 48.95'-49.05'

Date Received 01-19-2006

Side Planeness Pass

Perpendicularity Pass

Height/Diameter Pass

Height (in.) 1.307

Diameter (in.) 1.988

Wet Mass (g) 177.48

Wet Unit Weight (pcf) 166.6

Dry Unit Weight (pcf) N/A

Moisture Content (%) N/A

Test Date 01-26-2006

Moisture Condition As received, moist

Temperature (°F) 70

Loading Rate (lbf/sec) 10

Peak Load (lbf) 6020

Splitting Tensile Strength 1475 psi

Failure Type Split

Bearing Strip Cardboard

Comments

Failure Sketches

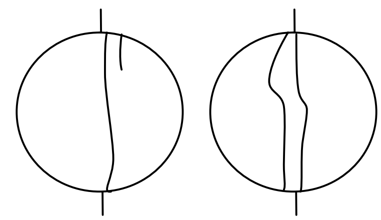


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, gray, hard	Lab ID	BT-207
Hole Number	B-12-15	Depth (ft)	48.95'-49.05'
Test Type	Splitting tensile strength of intact rock core		

Core preparation

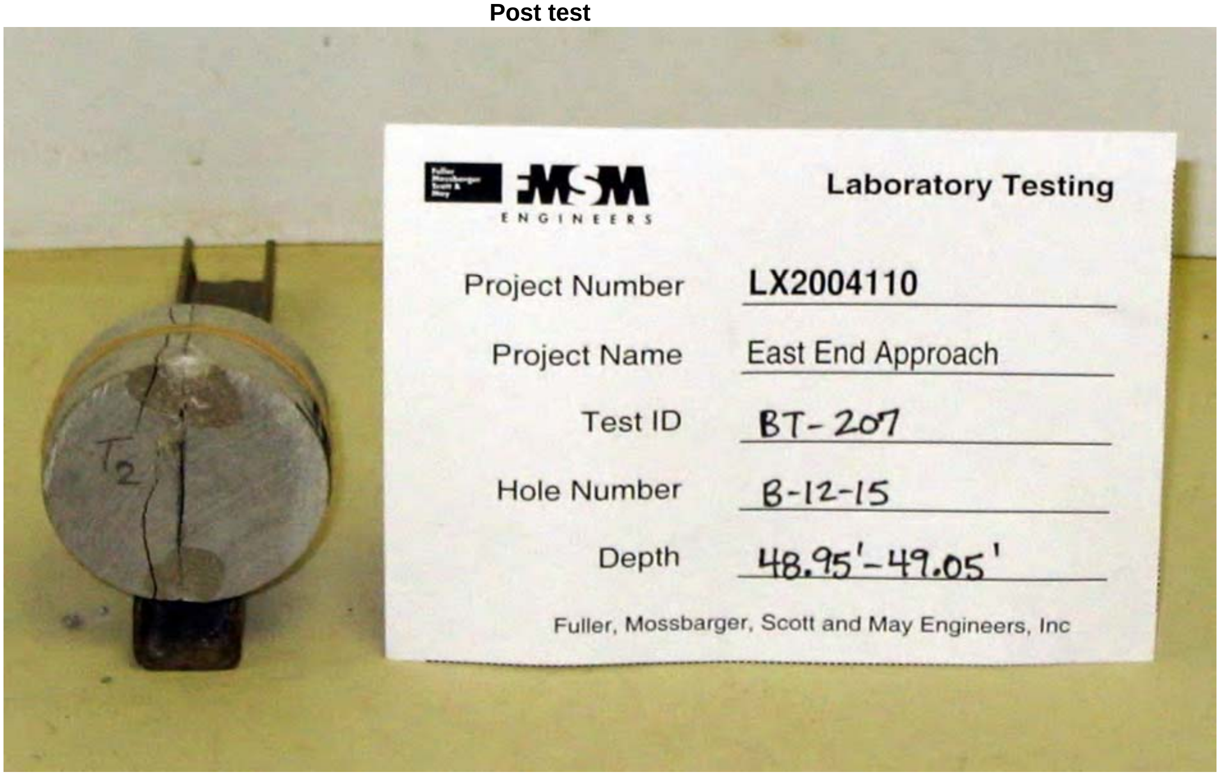
Core preparation

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, gray, hard	Lab ID	BT-207
Hole Number	B-12-15	Depth (ft)	48.95'-49.05'
Test Type	Splitting tensile strength of intact rock core		

Post test

Post test



Splitting Tensile Strength Of Intact Rock Core

ASTM D 3967

Fuller Mossbarger Scott & May ENGINEERS

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Limestone, gray, moderately hard
Lab ID BT-212
Hole Number B-3-2a
Depth (ft/elev) 40.8'-40.9'
Date Received 01-19-2006

Side Planeness	Pass	Height (in.)	1.289	Wet Unit Weight (pcf)	164.8
Perpendicularity	Pass	Diameter (in.)	1.997	Dry Unit Weight (pcf)	N/A
Height/Diameter	Pass	Wet Mass (g)	174.64	Moisture Content (%)	N/A

Test Date 01-26-2006

Moisture Condition As received, moist
Temperature (°F) 70

Loading Rate (lbf/sec) 10
Peak Load (lbf) 2530

Splitting Tensile Strength 626 psi

Failure Type Split
Bearing Strip Cardboard

Comments

Failure Sketches

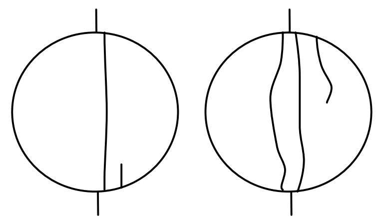
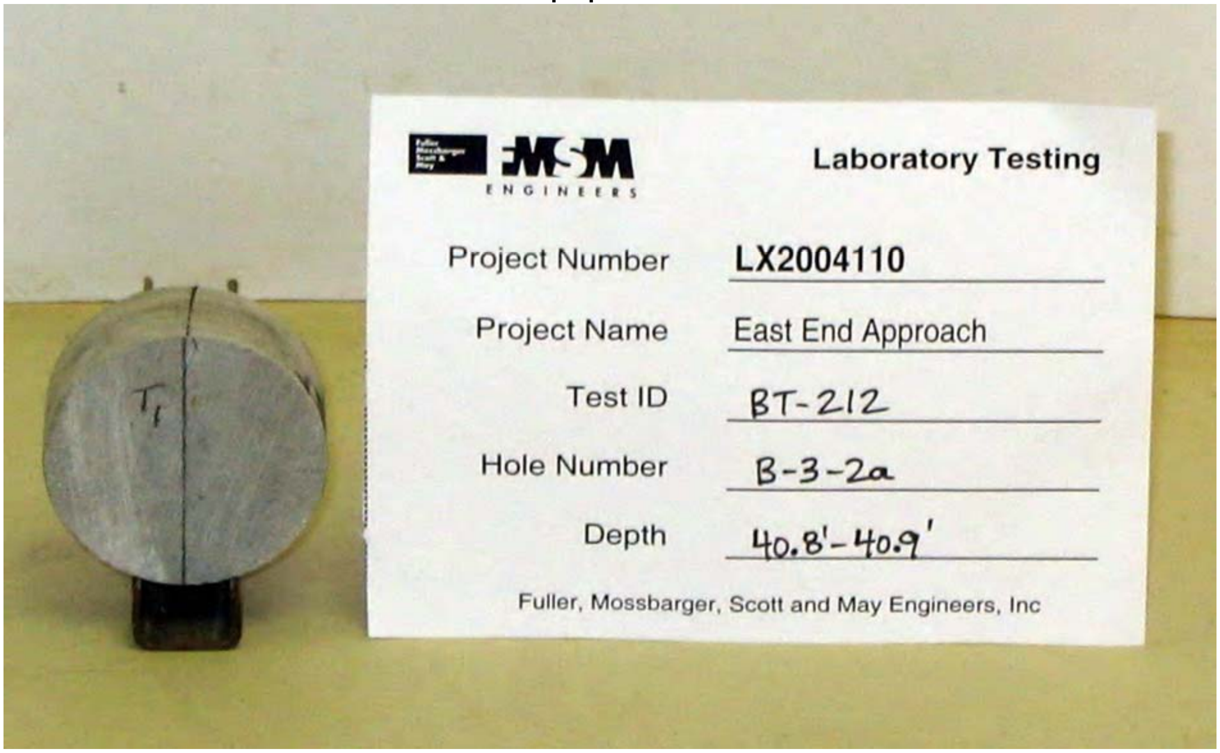


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, gray, moderately hard	Lab ID	BT-212
Hole Number	B-3-2a	Depth (ft)	40.8'-40.9'
Test Type	Splitting tensile strength of intact rock core		

Core preparation

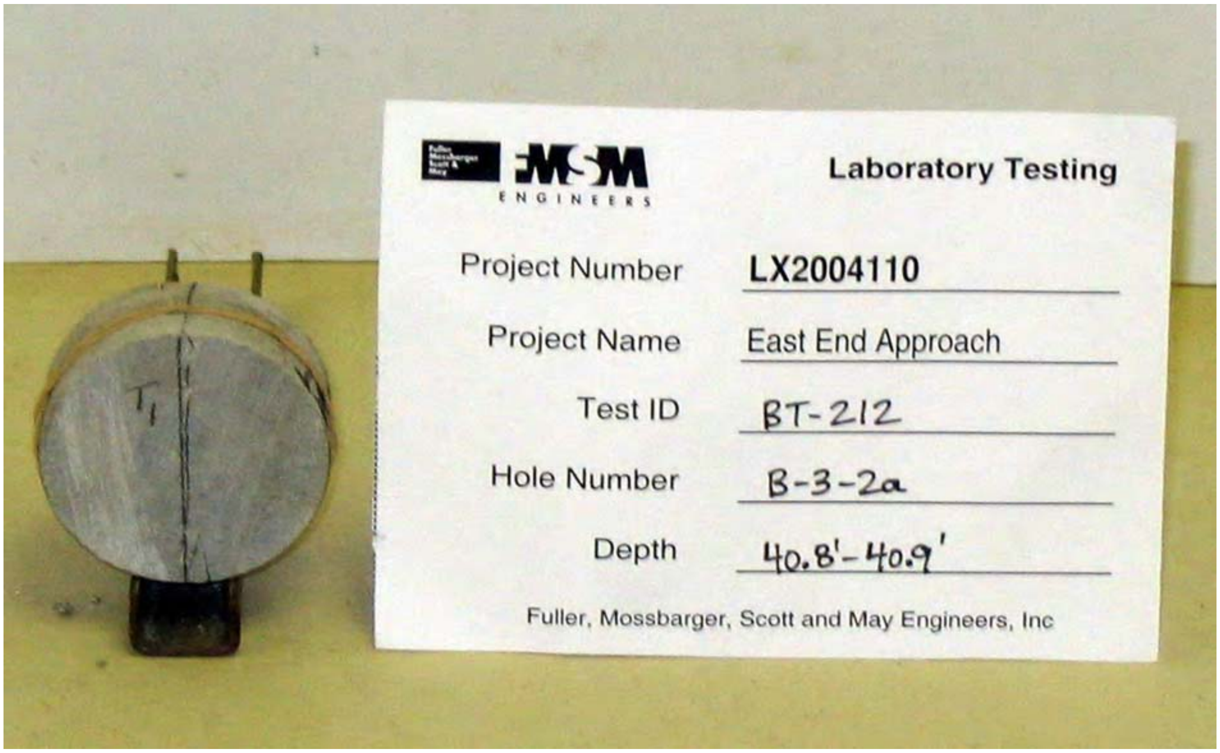


Core preparation

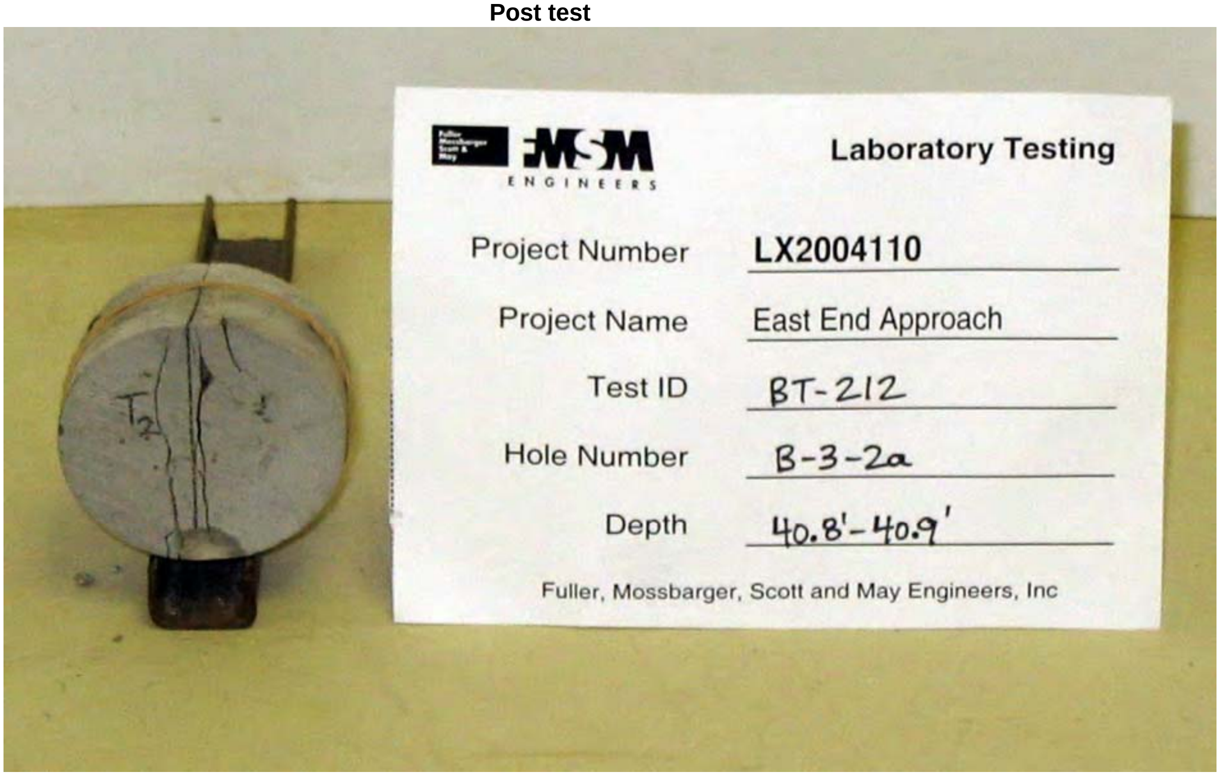
Photo Report

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Limestone, gray, moderately hard
Lab ID BT-212
Hole Number B-3-2a Depth (ft) 40.8'-40.9'
Test Type Splitting tensile strength of intact rock core

Post test



Post test



Splitting Tensile Strength Of Intact Rock Core

ASTM D 3967

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, gray, hard	Lab ID	BT-216
Hole Number	B-3-6a	Depth (ft/elev)	81.3'-81.4'
		Date Received	01-19-2006

Side Planeness	Pass	Height (in.)	1.252	Wet Unit Weight (pcf)	159.6
Perpendicularity	Pass	Diameter (in.)	1.993	Dry Unit Weight (pcf)	N/A
Height/Diameter	Pass	Wet Mass (g)	163.62	Moisture Content (%)	N/A

Test Date 01-26-2006

Moisture Condition As received, moist

Temperature (°F) 70

Loading Rate (lbf/sec) 10

Peak Load (lbf) 3490

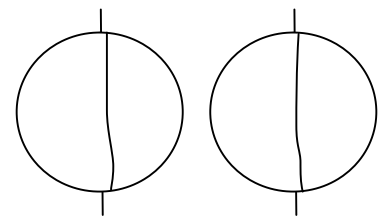
Splitting Tensile Strength 890 psi

Failure Type Split

Bearing Strip Cardboard

Comments

Failure Sketches



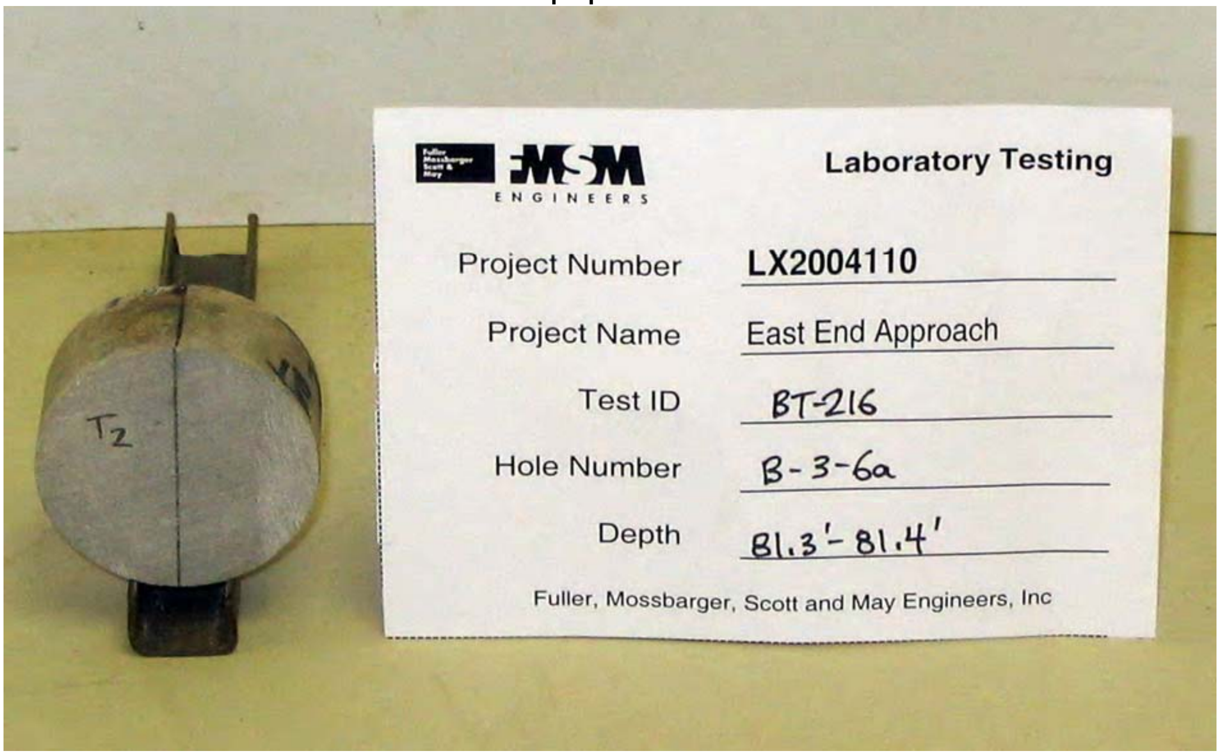
Fuller Mossbarger Scott & May ENGINEERS

Photo Report

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Dolomite, gray, hard
Lab ID BT-216
Hole Number B-3-6a
Depth (ft) 81.3'-81.4'
Test Type Splitting tensile strength of intact rock core

Core preparation

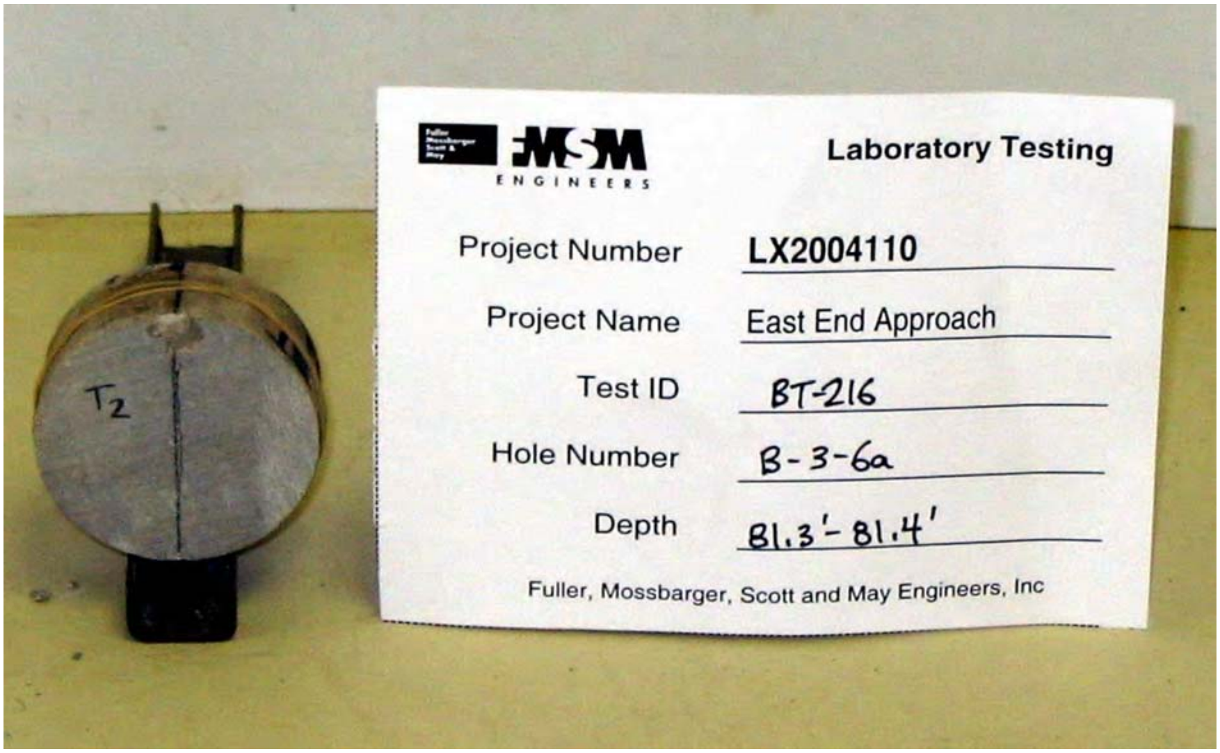
Core preparation



Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Dolomite, gray, hard	Lab ID	BT-216
Hole Number	B-3-6a	Depth (ft)	81.3'-81.4'
Test Type	Splitting tensile strength of intact rock core		

Post test

Post test



EARTH MECHANICS INSTITUTE
Department of Mining Engineering
Colorado School of Mines
Thin Section Petrographic Analysis

Project: LSIORB Section 4, East End Approach   Studied by: Sandin E. Phillipson

Client: FMSM   Date: August 27, 2005

The samples in this suite can be broadly divided into limestone and fossiliferous limestone. Most of the limestone samples, which are generally characterized by a matrix of very fine-grained carbonate mud, can be classified as grainstone or mudstone according to the classification scheme for carbonate rocks developed by Dunham (1962); they can be classified as sparite or micrite according to the classification scheme for carbonate rocks developed by Folk (1962). Most of the fossiliferous limestone samples can be classified as wackestone or biomicrite, according to the respective schemes. Although almost all of the samples were originally characterized by a matrix of very fine-grained carbonate mud, all samples exhibit the presence of secondary dolomite, indicating the process of dolomitization. The original matrix of several samples has been nearly obliterated by the growth of diamond-shaped dolomite crystals, which have commonly replaced the original mud-supported texture with a grain-supported texture in which larger, angular dolomite crystals touch each other along corners and straight boundaries. Dolomite alteration preferentially affects the fine-grained matrix in all samples, but does not extend into fossil fragments. Most samples exhibit dolomite contents of less than 15%, although several samples exhibit dolomite content of nearly 30%, and two samples (B-7-1 @ 105.3-105.4 and B-18-1 @ 50.6-51.3) exhibit dolomite contents of 40-45%. These latter two samples might be referred to as dolomite, given the extensive replacement of the original matrix in each rock.

Due to the dominance by calcite with generally subordinate dolomite, most of the average Mohs Hardness values range between H = 3.12 and 3.27. Higher calcite content (B-7-12 @ 15.1-15.6) results in a lower H = 3.08 whereas higher dolomite content (B-7-1 @ 105.3-105.4 and B-18-1 @ 50.6-51.3) results in higher H = 3.45-3.54. Although quartz grains occur in nearly all samples, the low content ($\leq 1\%$) does not significantly influence the average Mohs Hardness value. Grain interlocking is generally poor, except in B-18-4 @ 36.5-37.0 where extensive dolomitization results in interlocking between fossil fragments and surrounding necklaces of diamond-shaped dolomite crystals. Sample B-7-12 @ 15.1-15.6 also exhibits moderate interlocking between coarse-grained fossil fragments, with very little interstitial matrix.

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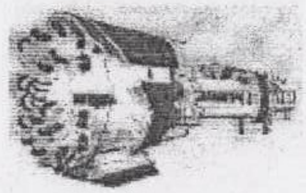
Thin Section Petrographic Analysis



Project: LSIORB Section 4, East End Approach

Location: Lexington, KY | **Client:** FMSM

Formation: not given | **Core ID:** B-7-1 @ 105.3-105.4

Date Studied: August 21, 2005 | **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary | **Alteration:** dolomitization

Texture: equigranular | **Rock Name:** grainstone / sparite

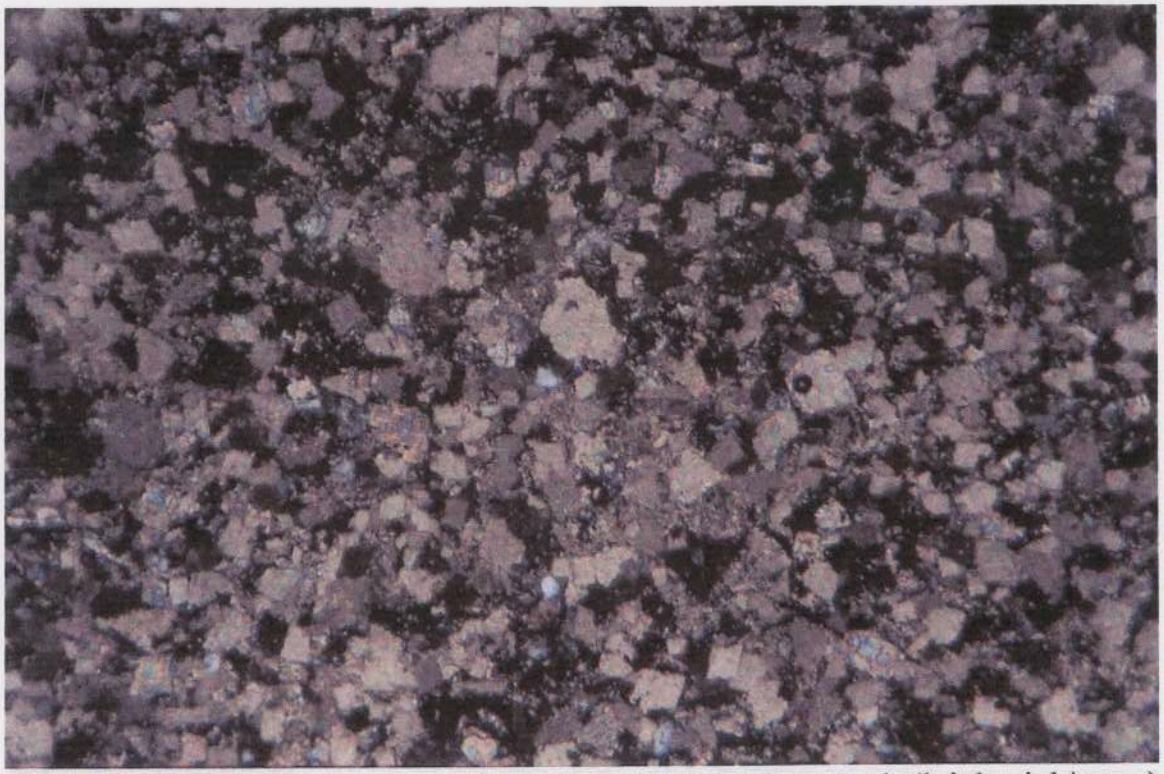
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	53	3	<.01-0.2	Angular, commonly irregularly shaped grains touch each other and dolomite along corners and straight boundaries.
Dolomite	40	3.5-4	.03-0.1	Diamond-shaped crystals are abundantly distributed, and touch each other and calcite along corners and straight boundaries.
Voids	4	-	.05-0.1	Some areas of the dolomitized matrix exhibit angular void spaces bounded by calcite and dolomite grains; some void spaces may represent plucking during sample preparation.
Quartz	3	7	.02-0.1	Angular to very angular grains are sparsely distributed throughout the rock, isolated by surrounding, angular calcite and dolomite grains.

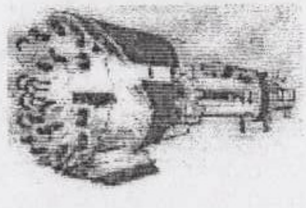
Weighted Average: 3.54

Remarks: The texture of this rock is characterized by similarly sized grains of calcite and dolomite that touch along straight boundaries. Angular quartz grains are sporadically distributed throughout the rock, isolated and tightly held by surrounding calcite and dolomite grains.

Principal Investigator: Sandin Phillipson **Date:** August 21, 2005



B-7-1 @ 105.3-105.4. Abundant, diamond-shaped dolomite crystals (bright pink/green) mask much of the original calcite mud matrix (dark, speckled background). Angular grains of quartz (light gray) are isolated and moderately held along tangential boundaries by surrounding dolomite crystals. Field of view 2.4 mm at 40X, taken under crossed polars.



EARTH MECHANICS INSTITUTE
Department of Mining Engineering
Colorado School of Mines
Thin Section Petrographic Analysis

Project: LSIORB Section 4, East End Approach

Location: Lexington, KY **Client:** FMSM

Formation: not given **Core ID:** B-7-4 @ 87.1-87.3

Date Studied: August 21, 2005 **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary **Alteration:** dolomitization

Texture: mud supported **Rock Name:** mudstone / micrite

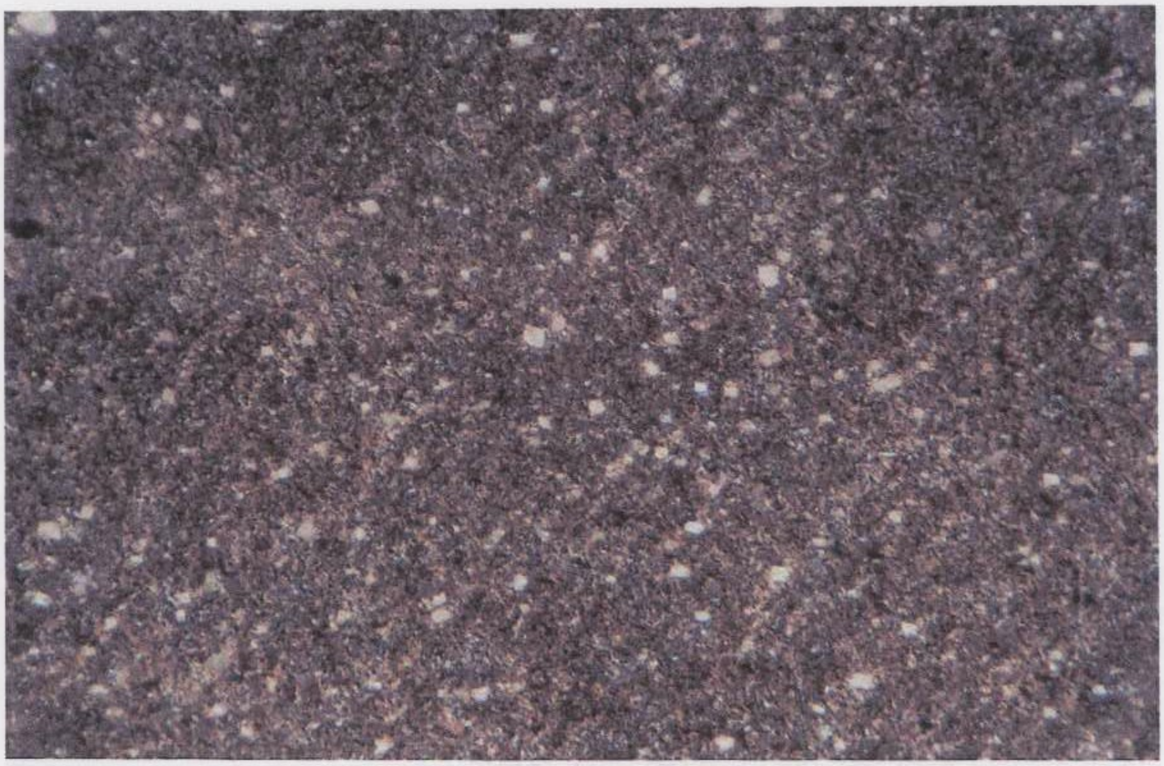
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	89	3	<.01	Fine- and very fine-grained calcite represents a muddy carbonate matrix that hosts angular grains of dolomite and quartz.
Dolomite	10	3.5-4	.01-.07	Diamond-shaped crystals are sporadically distributed, isolated and surrounded by the very fine-grained calcite mud matrix.
Quartz	1	7	.01-.03	Angular grains are very sparsely distributed throughout the rock, enclosed by the surrounding calcite mud matrix.

Weighted Average: 3.14

Remarks: The texture of this rock is characterized by a very fine-grained calcite mud matrix that encloses angular grains of dolomite and quartz.

Principal Investigator: Sandin Phillipson **Date:** August 21, 2005



B-7-4 @ 87.1-87.3. Matrix of fine-grained calcite mud (brown, speckled) hosts secondary dolomite crystals (bright, diamond-shaped), and encloses or isolates them from contact with each other. Field of view 2.4 mm at 40X, taken under crossed polars.

EARTH MECHANICS INSTITUTE
Department of Mining Engineering
Colorado School of Mines
Thin Section Petrographic Analysis

Project: LSIORB Section 4, East End Approach

Location: Lexington, KY **Client:** FMSM

Formation: not given **Core ID:** B-7-6 @ 39.0-39.6

Date Studied: August 25, 2005 **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary **Alteration:** dolomitization

Texture: equigranular **Rock Name:** grainstone / sparite

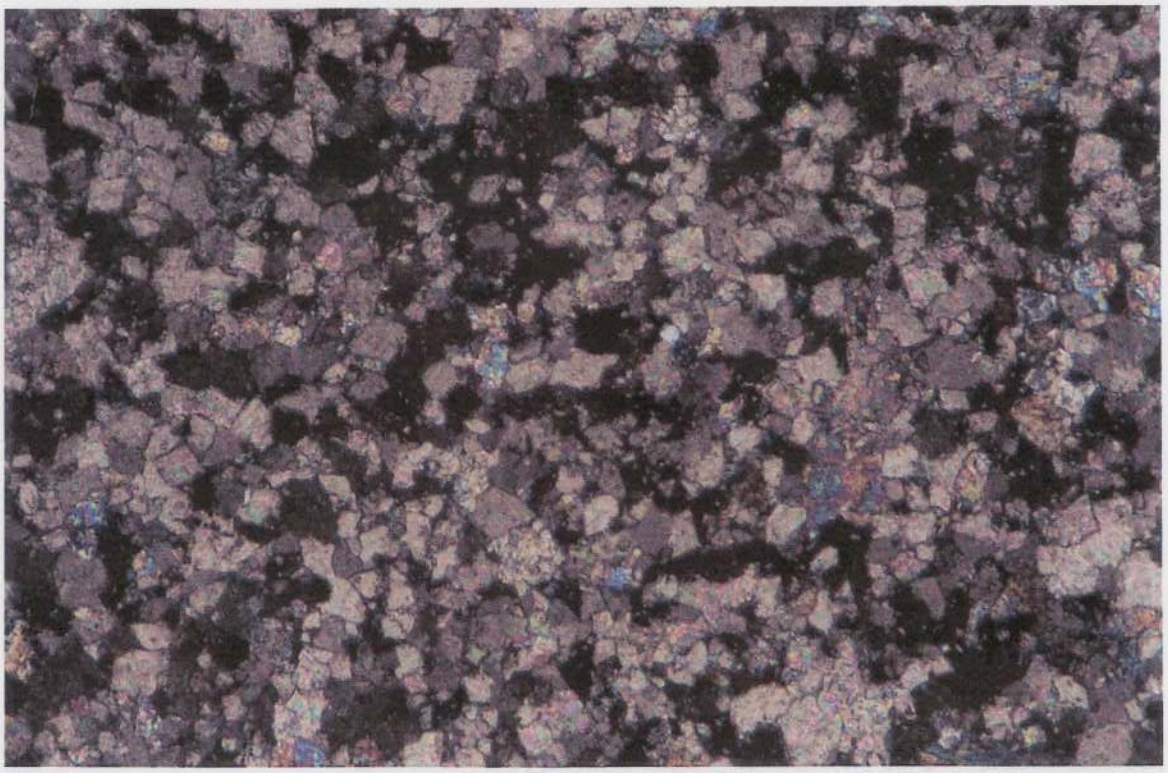
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	79	3	.03-0.5	Angular, commonly irregularly shaped grains touch each other and dolomite along angular boundaries; large, intergrown crystals define in-filled fossils that are surrounded by the equigranular calcite/dolomite matrix.
Dolomite	12	3.5-4	.02-0.1	Diamond-shaped crystals are sporadically distributed throughout the calcite matrix, where they share straight boundaries or touch along corners.
Voids	8	-	.02-0.3	Angular void spaces conform to the shape of surrounding dolomite crystals and are highlighted by blue epoxy.
Quartz	1	7	.04-.05	Angular grains are sparsely distributed, isolated by poorly interlocking calcite and dolomite grains, and held along straight boundaries.

Weighted Average: 3.17

Remarks: The texture of this rock is characterized by a matrix of nearly equigranular calcite and dolomite grains that touch along straight and angular boundaries. Angular void spaces are bounded by straight boundaries of surrounding dolomite crystals.

Principal Investigator: Sandin Phillipson **Date:** August 25, 2005



B-7-6 @ 39.0-39.6. Dolomite crystals (diamond-shaped, bright pink/green) touch along corners and straight boundaries within a matrix of fine-grained calcite grains (irregularly shaped, brightly speckled pink/green). Field of view 2.4 mm at 40X, taken under crossed polars.

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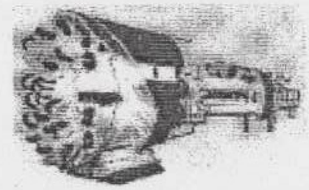
Colorado School of Mines
Thin Section Petrographic Analysis



Project: LSIORB Section 4, East End Approach

Location: Lexington, KY **Client:** FMSM

Formation: not given **Core ID:** B-7-8 @ 26.2-26.3

Date Studied: August 25, 2005 **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary **Alteration:** dolomitization; dissolution

Texture: equigranular **Rock Name:** grainstone / sparite

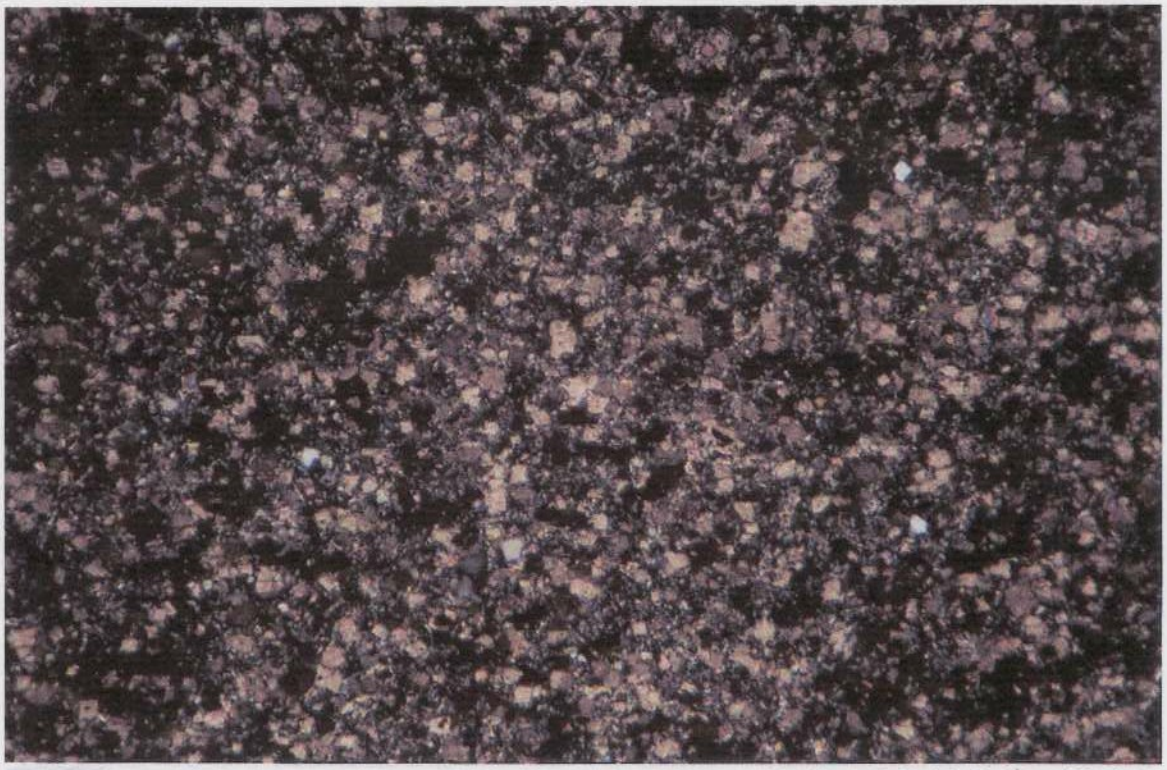
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	78	3	.01-0.1	Very fine grains represent a matrix that surrounds dolomite and quartz grains; larger grains interlock moderately to poorly along touching, angular boundaries.
Dolomite	21	3.5-4	.01-.09	Diamond-shaped crystals are abundantly distributed, surrounded by the fine-grained calcite matrix.
Quartz	1	7	.03-.08	Angular to subangular grains are sparsely distributed throughout the rock, isolated and moderately held along straight or tangential boundaries by surrounding, poorly interlocking calcite and dolomite.

Weighted Average: 3.25

Remarks: The texture of this rock is characterized by a matrix of fine- to very fine-grained calcite that surrounds diamond-shaped crystals of dolomite that are abundantly scattered throughout the rock. Fine-grained, subangular quartz grains are isolated and moderately held along tangential boundaries by surrounding, poorly interlocking calcite.

Principal Investigator: Sandin Phillipson **Date:** August 25, 2005



B-7-8 @ 26.2-26.3. Abundant dolomite crystals (diamond-shaped, brightly speckled pink/green) are distributed within the very fine-grained calcite matrix (dark, speckled) and commonly touch along corners. Rare quartz grains (white/light gray) moderately to poorly interlock with surrounding dolomite along tangential boundaries. Field of view 2.4 mm at 40X, taken under crossed polars.

EARTH MECHANICS INSTITUTE
Department of Mining Engineering
Colorado School of Mines
Thin Section Petrographic Analysis

Project: LSIORB Section 4, East End Approach

Location: Lexington, KY **Client:** FMSM

Formation: not given **Core ID:** B-12-4 @ 72.4-72.9

Date Studied: August 25, 2005 **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary **Alteration:** dolomitization

Texture: equigranular; voids **Rock Name:** grainstone / sparite

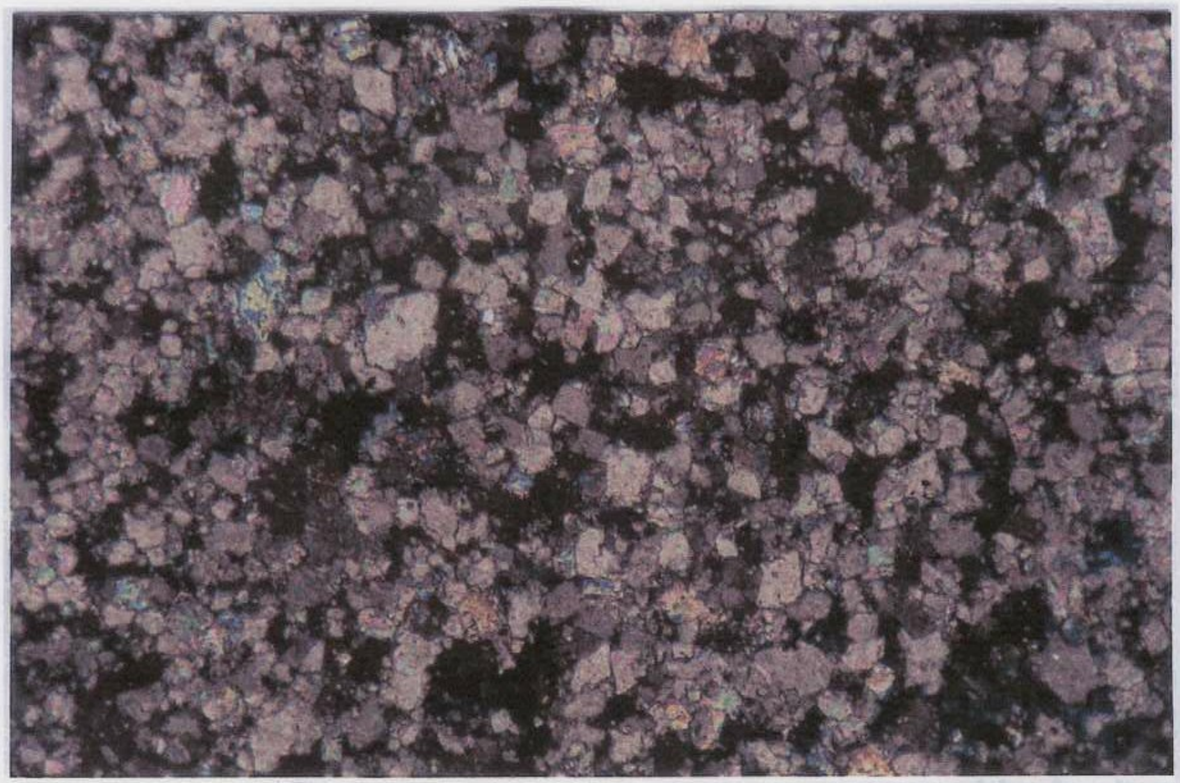
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	77	3	.02-0.5	Subangular grains interlock moderately with each other and dolomite along angular boundaries; large, angular, intergrown crystals may represent in-filling of fossils.
Dolomite	12	3.5-4	.04-0.2	Diamond-shaped crystals are scattered sporadically throughout the rock, isolated and surrounded by angular to subangular grains of calcite.
Voids	10	-	.02-0.2	Angular spaces are bounded by the straight edges of surrounding dolomite crystals; angular pore spaces are generally isolated from each other and do not connect.
Quartz	1	7	.02-.04	Angular grain fragments are sparsely distributed throughout the rock, isolated and held along angular and tangential boundaries by surrounding, moderately interlocking calcite and dolomite.

Weighted Average: 3.17

Remarks: The texture of this rock is characterized by a matrix of similarly sized calcite and dolomite grains that interlock moderately along angular and tangential boundaries. Angular quartz grains are held along angular and tangential boundaries by surrounding, moderately interlocking calcite and dolomite grains.

Principal Investigator: Sandin Phillipson **Date:** August 25, 2005



B-12-4 @ 72.4-72.9. Large fossil fragments are surrounded by a finer-grained matrix in which secondary dolomite (diamond-shaped, brightly speckled pink/green) obscures some of the original calcite mud matrix (brown, speckled). Field of view 2.4 mm at 40X, taken under crossed polars.

EARTH MECHANICS INSTITUTE

Department of Mining Engineering
Colorado School of Mines

Thin Section Petrographic Analysis

Project: LSIORB Section 4, East End Approach

Location: Lexington, KY — **Client:** FMSM

Formation: not given — **Core ID:** B-12-8 @ 10.3-10.9

Date Studied: August 25, 2005 — **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary — **Alteration:** dolomitization

Texture: fossiliferous; mud supported — **Rock Name:** wackestone / biomicrite

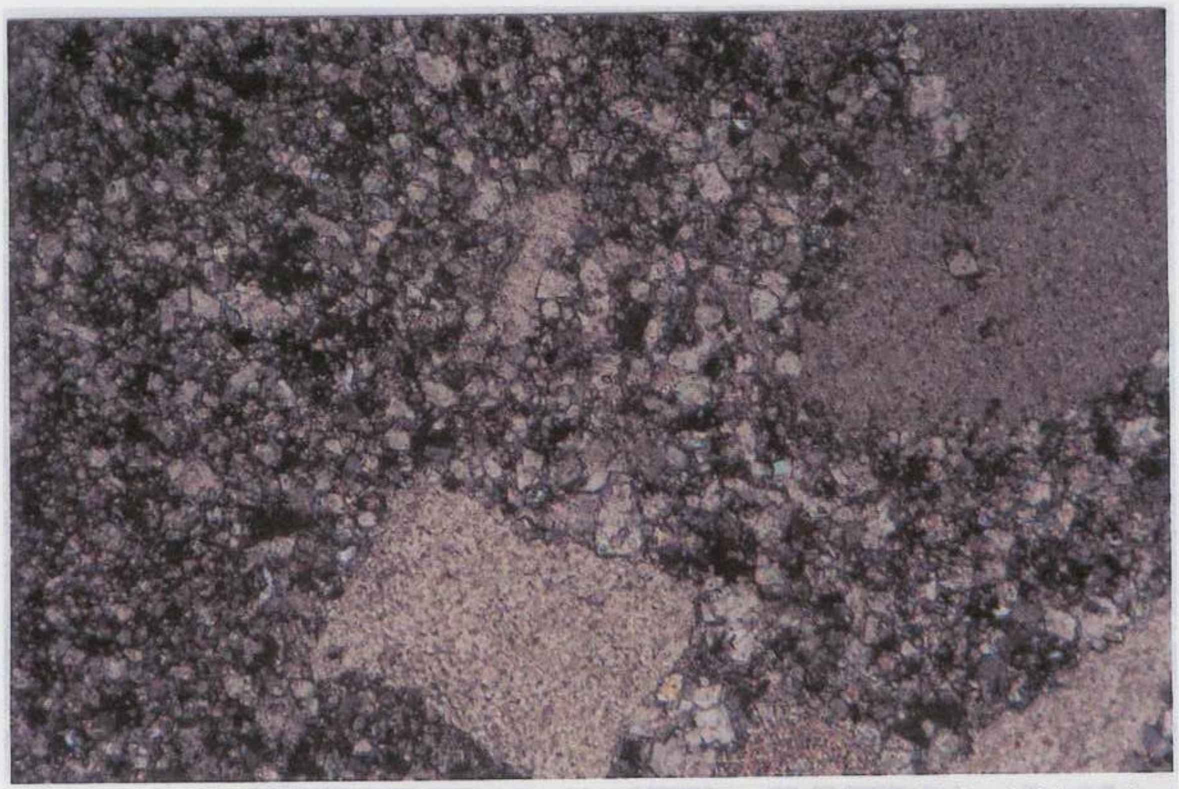
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	80	3	<.01-3.6	Matrix (60%): subangular to angular grains interlock moderately with each other along angular and tangential boundaries; Fossils (40%): represent jagged fragments of bryozoans and sponges, and round fragments of crinoid stems.
Dolomite	19	3.5-4	.01-0.1	Diamond-shaped crystals are sporadically distributed throughout the calcite grainstone matrix.
Quartz	1	7	.01-.06	Angular grains are sparsely distributed, isolated and moderately held along straight and tangential boundaries by surrounding, moderately interlocking calcite grains.

Weighted Average: 3.23

Remarks: The texture of this rock is characterized by a matrix of very fine-grained to muddy calcite that has been moderately dolomitized, exhibiting abundant diamond-shaped dolomite crystals. The matrix encloses abundant angular and round fossil fragments that are composed of intergrown calcite.

Principal Investigator: Sandin Phillipson — **Date:** August 25, 2005



B-12-8 @ 10.3-10.9. Abundant dolomite crystals (diamond-shaped, bright pink/green) touch each other along straight boundaries and corners, and mask much of the original very fine-grained calcite mud matrix (brown, speckled). Rare quartz grains (light gray) are tightly held along straight boundaries by surrounding dolomite crystals. Field of view 2.4 mm at 40X, taken under crossed polars.

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Thin Section Petrographic Analysis

Project: LSIORB Section 4, East End Approach	
Location: Lexington, KY	**Client:** FMSM
Formation: not given	**Core ID:** B-12-9 @ 34.0-34.5
Date Studied: August 25, 2005	**Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary	**Alteration:** dolomitization
Texture: fossiliferous; grain supported	**Rock Name:** wackestone / biomicrite

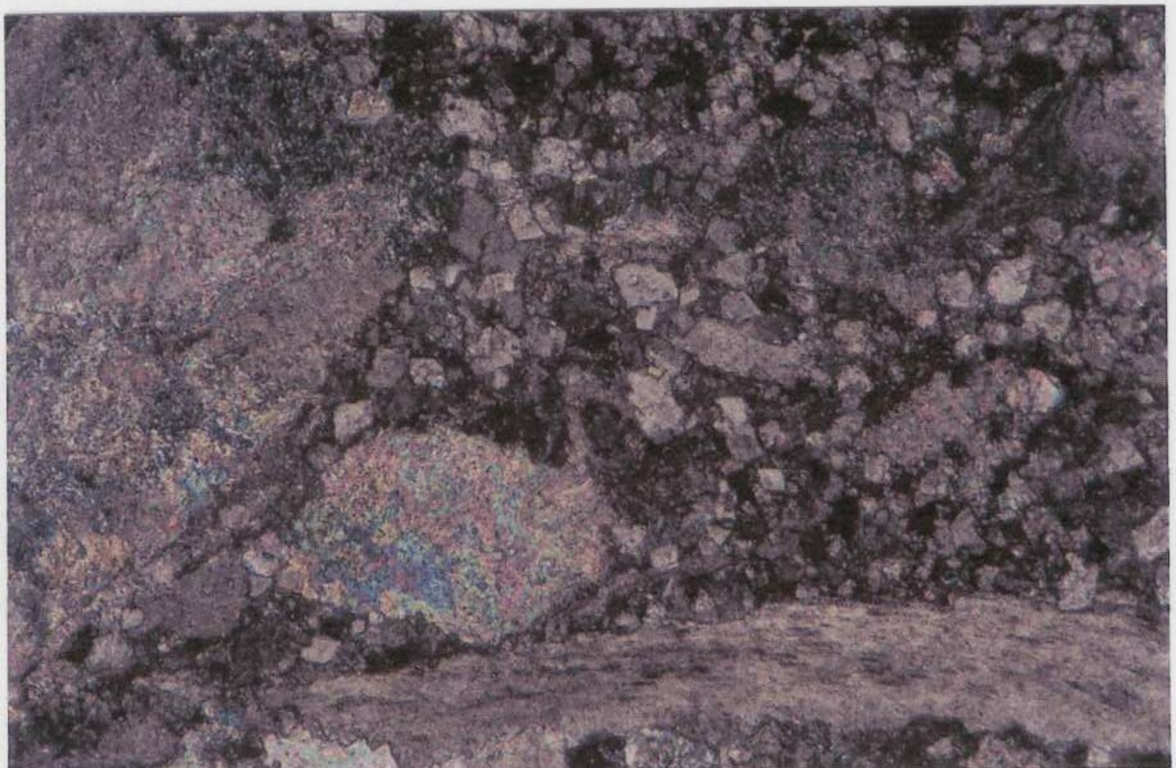
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	69	3	<.01-9.6	Matrix (35%): very fine-grained, muddy carbonate represents the original matrix, which was subsequently dolomitized; matrix partially surrounds large fossil fragments; Fossils (65%): abundant fossil fragments represent bivalves, crinoid stems, and bryozoans; jagged fragments are tightly held by the dolomitized matrix; some fossils host minor aragonite.
Dolomite	30	3.5-4	.01-0.2	Diamond-shaped crystals are abundantly distributed throughout the muddy calcite matrix, and commonly touch each other along corners.
Quartz	1	7	.01-.06	Angular to subangular grains are sparsely distributed, isolated and held along straight and tangential boundaries with surrounding calcite grains.

Weighted Average: 3.34

Remarks: The texture of this rock is characterized by an original matrix of very fine-grained to muddy carbonate that was subsequently dolomitized. The matrix partially surrounds and encloses large, commonly jagged fossil fragments that commonly touch each other along tangential boundaries.

Principal Investigator: Sandin Phillipson **Date:** August 25, 2005



B-12-9 @ 34.0-34.5. Large, angular and jagged-edged fossil fragments are enclosed in a fine-grained calcite mud matrix (brown, speckled) that hosts secondary dolomite crystals (diamond-shaped, speckled bright pink/green). Field of view 2.4 mm at 40X, taken under crossed polars.

EARTH MECHANICS INSTITUTE
Department of Mining Engineering
Colorado School of Mines
Thin Section Petrographic Analysis

Project: LSIORB Section 4, East End Approach

Location: Lexington, KY **Client:** FMSM

Formation: not given **Core ID:** B-14-2 @ 84.9-85.0

Date Studied: August 26, 2005 **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary **Alteration:** dolomitization

Texture: mud supported **Rock Name:** wackestone / sparite

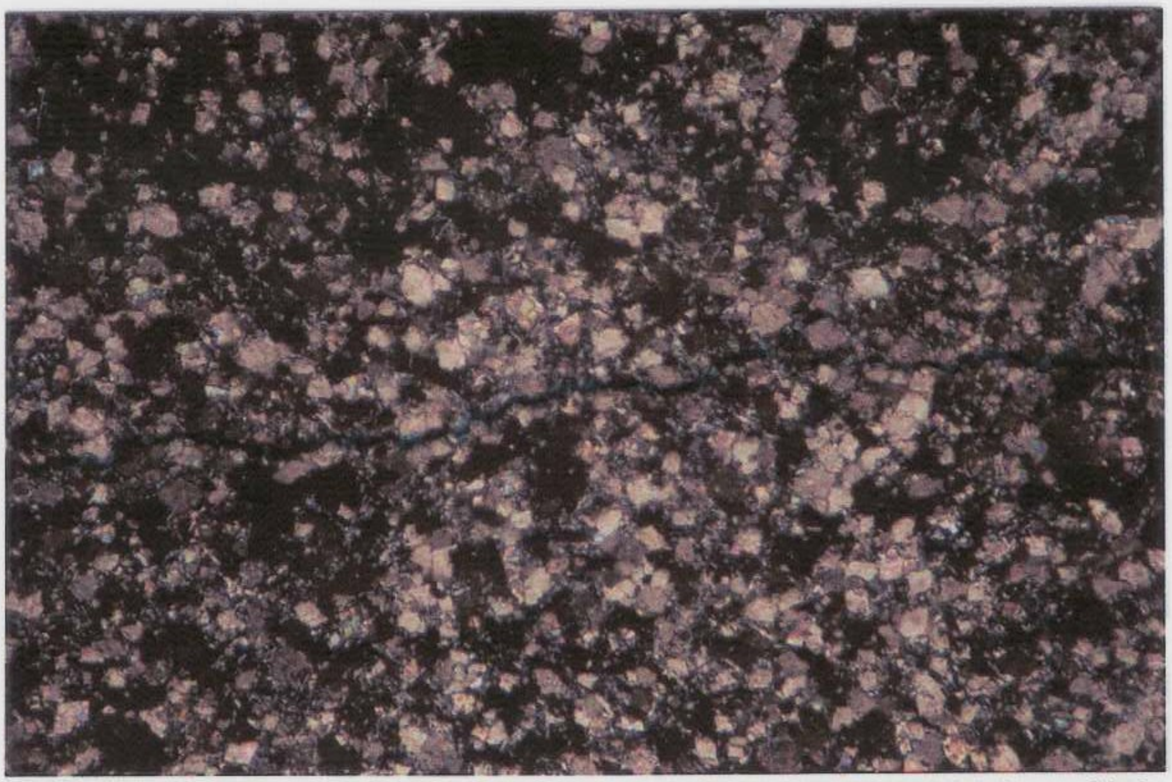
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	71	3	.01-0.5	Very fine-grained calcite represents a very fine-grained matrix that hosts abundant crystals of secondary dolomite.
Dolomite	20	3.5-4	.02-.09	Diamond-shaped crystals are abundantly distributed throughout the fine-grained calcite matrix, and are enclosed by the matrix.
Voids	8	-	.06-0.8	Irregularly shaped, ragged edged void spaces are isolated within the fine-grained calcite matrix; because blue epoxy staining does not fill the voids, they may represent plucking of grains during sample preparation.
Quartz	1	7	.02-.05	Fine-grained angular grains are sporadically distributed, isolated by surrounding, moderately to poorly interlocking grains of calcite.

Weighted Average: 3.26

Remarks: The texture of this rock is characterized by a matrix of very fine-grained calcite that is composed of ragged, irregularly shaped grains. The matrix has been extensively dolomitized, and hosts abundant, diamond-shaped dolomite crystals.

Principal Investigator: Sandin Phillipson **Date:** August 26, 2005



B-14-20 @ 84.9-85.0. Abundant dolomite crystals (diamond-shaped, brightly speckled pink/green) touch along straight boundaries and corners in a matrix of very fine-grained calcite mud (brown, speckled). Micro fracture cuts across the photo. Field of view 2.4 mm at 40X, taken under crossed polars.

EARTH MECHANICS INSTITUTE
Department of Mining Engineering
Colorado School of Mines
Thin Section Petrographic Analysis

Project: LSIORB Section 4, East End Approach	
Location: Lexington, KY	**Client:** FMSM
Formation: not given	**Core ID:** B-14-3 @ 87.1-87.6
Date Studied: August 26, 2005	**Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary	**Alteration:** dolomitization
Texture: fossiliferous; grain supported	**Rock Name:** grainstone / packed biomicrite

Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	89	3	<.01-6	Matrix (15%): consists of fine-grained calcite mud that occurs in discontinuous interstices between large fossil fragments; the matrix has been preferentially dolomitized; Fossils (85%): large, abundant fragments of crinoid plates and bivalve shells interlock moderately along long, straight and angular boundaries.
Dolomite	10	3.5-4	.03-.07	Diamond-shaped crystals are abundantly distributed throughout the interstitial muddy carbonate matrix.
Quartz	1	7	.02-.04	Angular grains are sparsely distributed, but preferentially located in the dolomitized calcite mud matrix, which occupies interstices between large fossils.

Weighted Average: 3.14

Remarks: The texture of this rock is characterized by large, abundant fossil fragments that interlock poorly along long, straight and tangential boundaries. Irregular interstices between fossils host a muddy carbonate matrix that preferentially hosts abundant dolomite crystals.

Principal Investigator: Sandin Phillipson **Date:** August 26, 2005

B-14-3 @ 87.1-87.6. Large fossil fragments interlock along long, straight boundaries and angular boundaries. Field of view 2.4 mm at 40X, taken under crossed polars.

EARTH MECHANICS INSTITUTE
Department of Mining Engineering
Colorado School of Mines
Thin Section Petrographic Analysis

Project: LSIORB Section 4, East End Approach

Location: Lexington, KY | **Client:** FMSM

Formation: not given | **Core ID:** B-14-6 @ 102.1-102.2

Date Studied: August 26, 2005 | **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary | **Alteration:** dolomitization

Texture: mud supported | **Rock Name:** mudstone / intraclast bearing micrite

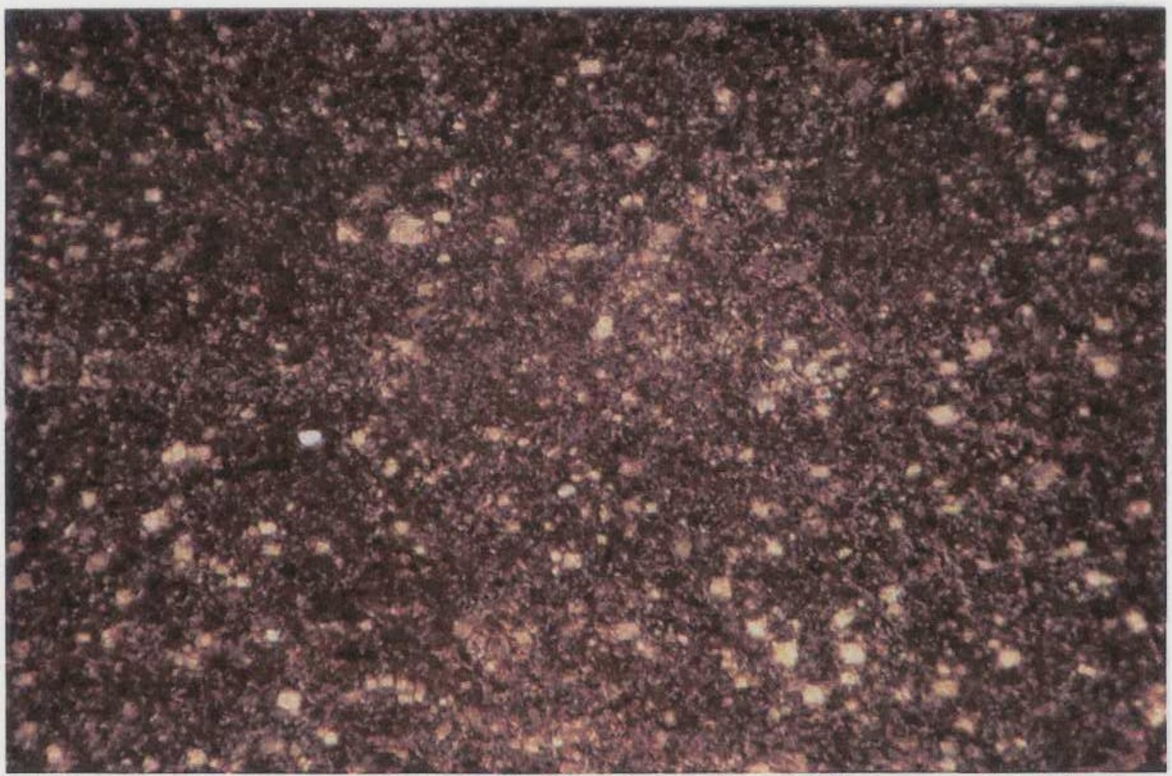
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	91	3	<.01-.07	Very fine-grained carbonate mud represents a matrix that hosts very fine bedding laminations; some laminations are coarse-grained and host greater dolomitization; other larger subangular grains of calcite are sporadically distributed throughout the muddy matrix and may represent intraclasts.
Dolomite	8	3.5-4	.02-.07	Diamond-shaped crystals are abundantly distributed throughout the rock, enclosed by the muddy matrix; crystals uncommonly touch along angular boundaries.
Quartz	1	7	.01-.06	Subangular to subrounded grains are sporadically distributed throughout the rock, and are enclosed by the surrounding carbonate mud matrix.

Weighted Average: 3.12

Remarks: The texture of this rock is characterized by a matrix of carbonate mud that hosts very fine bedding laminations. The mud matrix hosts abundant dolomite crystals, and very sparsely distributed quartz grains.

Principal Investigator: Sandin Phillipson **Date:** August 26, 2005



B-14-6 @ 102.1-102.2. Very fine-grained calcite mud matrix (brown, speckled) hosts sporadically distributed dolomite crystals (diamond-shaped, bright) and rare quartz grains (white), which are enclosed and isolated from each other. Field of view 2.4 mm at 40X, taken under crossed polars.

EARTH MECHANICS INSTITUTE
Department of Mining Engineering
Colorado School of Mines
Thin Section Petrographic Analysis

Project: LSIORB Section 4, East End Approach

Location: Lexington, KY **Client:** FMSM

Formation: not given **Core ID:** B-15-3 @ 122.5-123.1

Date Studied: August 26, 2005 **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary **Alteration:** dolomitization

Texture: equigranular; grain supported **Rock Name:** grainstone / dismicrite

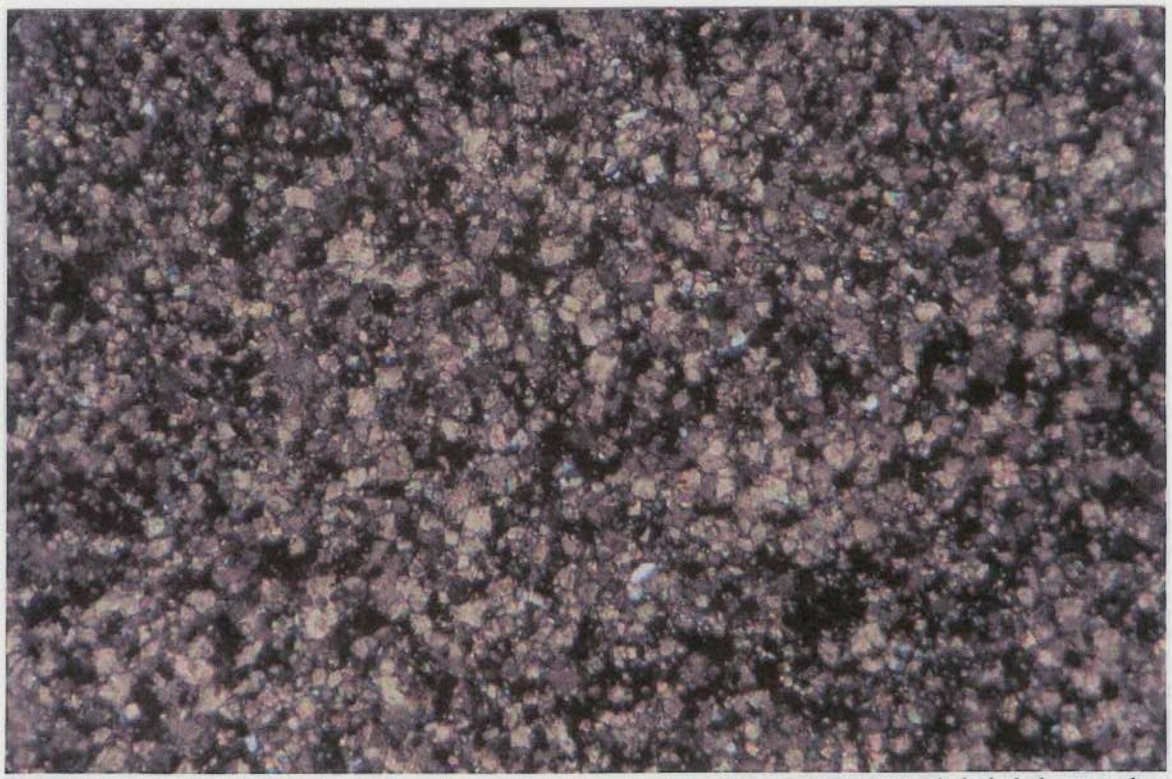
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	43	3	.03-0.3	Fine- and very fine-grained calcite represents a matrix of grains that touch along straight and tangential boundaries; other grains are intergrown with secondary dolomite crystals.
Dolomite	40	3.5-4	.01-.06	Diamond-shaped crystals are abundantly distributed throughout the muddy carbonate matrix, and commonly touch each other along corners.
Voids	15	-	.04-0.7	Roughly circular, jagged-edged voids are bounded by angular dolomite crystal faces; other diffuse void spaces pervade the matrix.
Quartz	2	7	.03-.05	Angular and subangular grains are sporadically distributed, isolated and poorly held along tangential boundaries by the surrounding calcite matrix.

Weighted Average: 3.55

Remarks: The texture of this rock is characterized by a matrix of fine-grained calcite grains that touch along straight and tangential boundaries. Calcite grains are intergrown with abundant dolomite crystals, and diffuse void spaces pervade the matrix.

Principal Investigator: Sandin Phillipson **Date:** August 26, 2005



B-15-30 @ 122.5-123.1. Abundant dolomite crystals (diamond-shaped, brightly speckled pink/green) are intergrown with fine-grained calcite (irregularly shaped, brightly speckled pink/green) in a fine-grained calcite matrix (dark, speckled). Rare angular quartz grains (white/light gray) interlock poorly with surrounding dolomite along tangential boundaries. Field of view 2.4 mm at 40X, taken under crossed polars.

EARTH MECHANICS INSTITUTE
Department of Mining Engineering
Colorado School of Mines
Thin Section Petrographic Analysis

Project: LSIORB Section 4, East End Approach

Location: Lexington, KY **Client:** FMSM

Formation: not given **Core ID:** B-15-5 @ 66.8-69.5

Date Studied: August 26, 2005 **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary **Alteration:** dolomitization

Texture: equigranular; dissolution **Rock Name:** grainstone / sparite

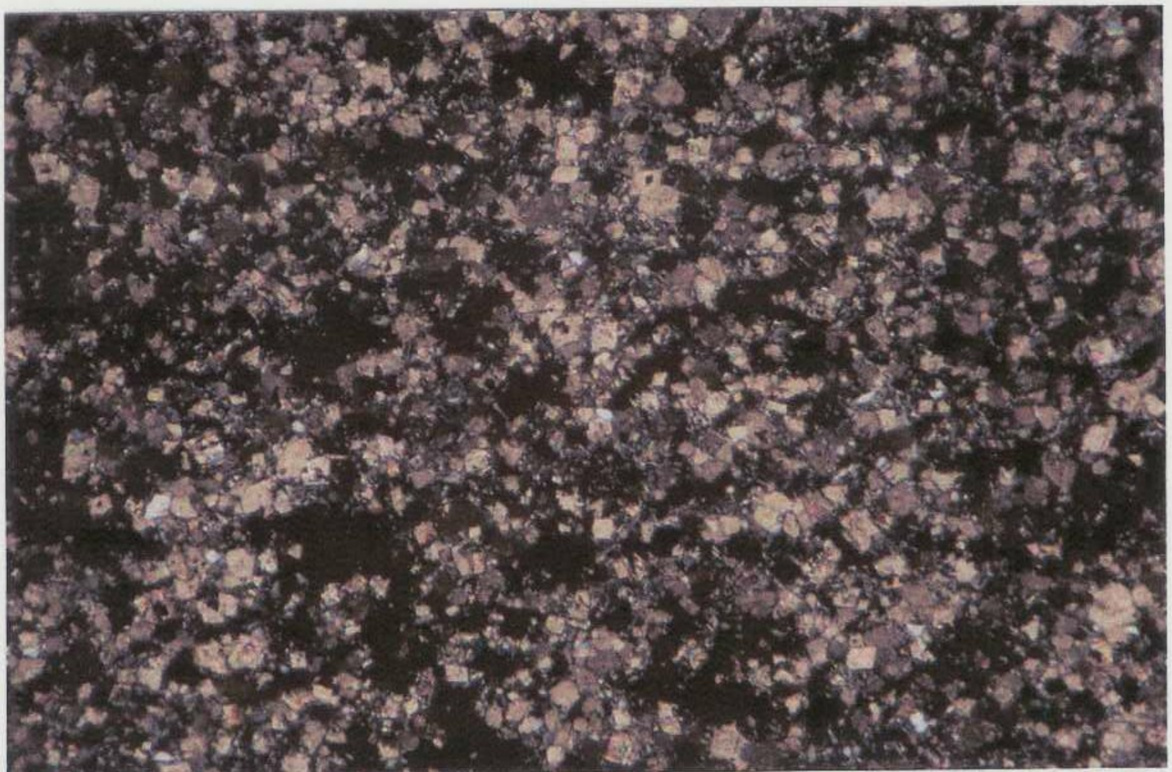
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	78	3	<.01-0.7	Fine-grained crypto-crystalline calcite represents a matrix that has been extensively dolomitized; larger grains are intergrown in what may be roughly oval, ragged-edged, remnant fossils.
Dolomite	20	3.5-4	.02-0.1	Diamond-shaped crystals are abundantly distributed throughout the calcite matrix; crystals commonly interlock poorly with surrounding calcite grains along tangential boundaries.
Quartz	2	7	.03-0.1	Subangular and subrounded grains are sporadically distributed, poorly to moderately held along tangential boundaries by surrounding calcite grains.

Weighted Average: 3.28

Remarks: The texture of this rock is characterized by a matrix of fine-grained calcite that has been extensively dolomitized. Although there are some void spaces, they were not penetrated by blue epoxy and may have formed during sample preparation.

Principal Investigator: Sandin Phillipson **Date:** August 26, 2005



B-15-5 @ 66.8-69.5. Abundant dolomite crystals (diamond-shaped, speckled pink/green) interlock moderately along straight boundaries within a matrix of very fine-grained calcite mud (brown, speckled). Black areas represent voids that probably formed during sample preparation as they are not penetrated by blue epoxy. Field of view 2.4 mm at 40X, taken under crossed polars.

EARTH MECHANICS INSTITUTE
Department of Mining Engineering
Colorado School of Mines
Thin Section Petrographic Analysis

Project: LSIORB Section 4, East End Approach

Location: Lexington, KY — **Client:** FMSM

Formation: not given — **Core ID:** B-15-6 @ 75.6-76.2

Date Studied: August 26, 2005 — **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary — **Alteration:** dolomitization

Texture: inequigranular; grain supported — **Rock Name:** packstone / biosparite

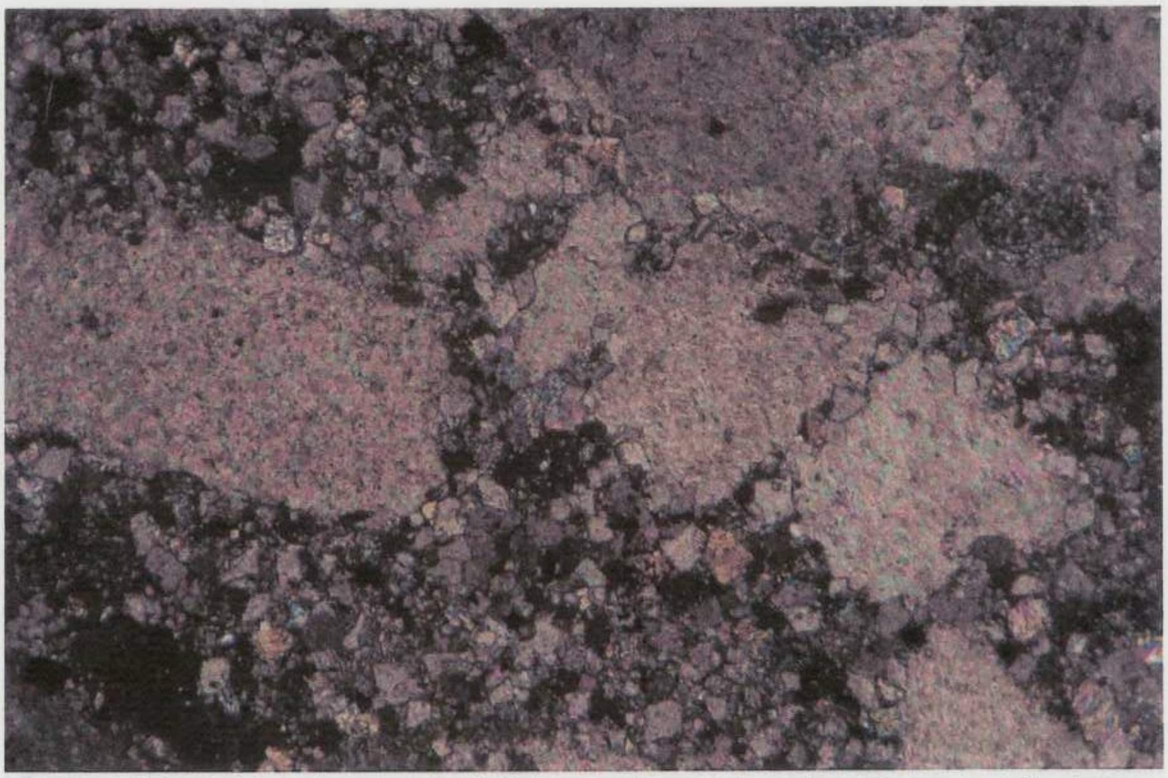
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	62	3	<.01-1.1	Large, subangular fossil fragments interlock moderately along angular and long, straight boundaries; interstices between plates host a muddy calcite matrix that has been extensively dolomitized, such that abundant diamond-shaped dolomite crystals commonly obscure the original muddy matrix; larger jagged-edged fossil fragments interlock along angular boundaries with surrounding, small, angular dolomite crystals.
Dolomite	37	3.5-4	.02-0.2	Diamond-shaped crystals are abundantly distributed throughout the fine-grained matrix; crystals have commonly grown to interfere with neighboring boundaries to form a grain-supported texture.
Quartz	1	7	.03-.08	Angular to subangular grains are very sparsely distributed, isolated and surrounded by moderately interlocking calcite and dolomite; quartz grains are tightly held along straight-segmented boundaries by the surrounding, intergrown calcite/dolomite matrix.

Weighted Average: 3.41

Remarks: The texture of this rock is characterized by large, angular and subangular fossil fragments that may represent crinoid plates. The interstices between the large fragments are filled with fine-grained carbonate mud that has been extensively dolomitized to form a secondary grain supported texture.

Principal Investigator: Sandin Phillipson **Date:** August 26, 2005



B-15-6 @ 75.6-76.2. Angular fossil fragments interlock moderately to strongly along angular, locally jagged-edged boundaries with surrounding, fine-grained dolomite crystals (diamond-shaped, brightly speckled pink/green). Dolomite obscures much of the original matrix of very fine-grained calcite mud (brown, speckled). Field of view 2.4 mm at 40X, taken under crossed polars.

EARTH MECHANICS INSTITUTE
Department of Mining Engineering
Colorado School of Mines
Thin Section Petrographic Analysis

Project: LSIORB Section 4, East End Approach

Location: Lexington, KY **Client:** FMSM

Formation: not given **Core ID:** B-15-7 @ 153.6-153.7

Date Studied: August 27, 2005 **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary **Alteration:** dolomitization

Texture: inequigranular **Rock Name:** packstone / pelsparite

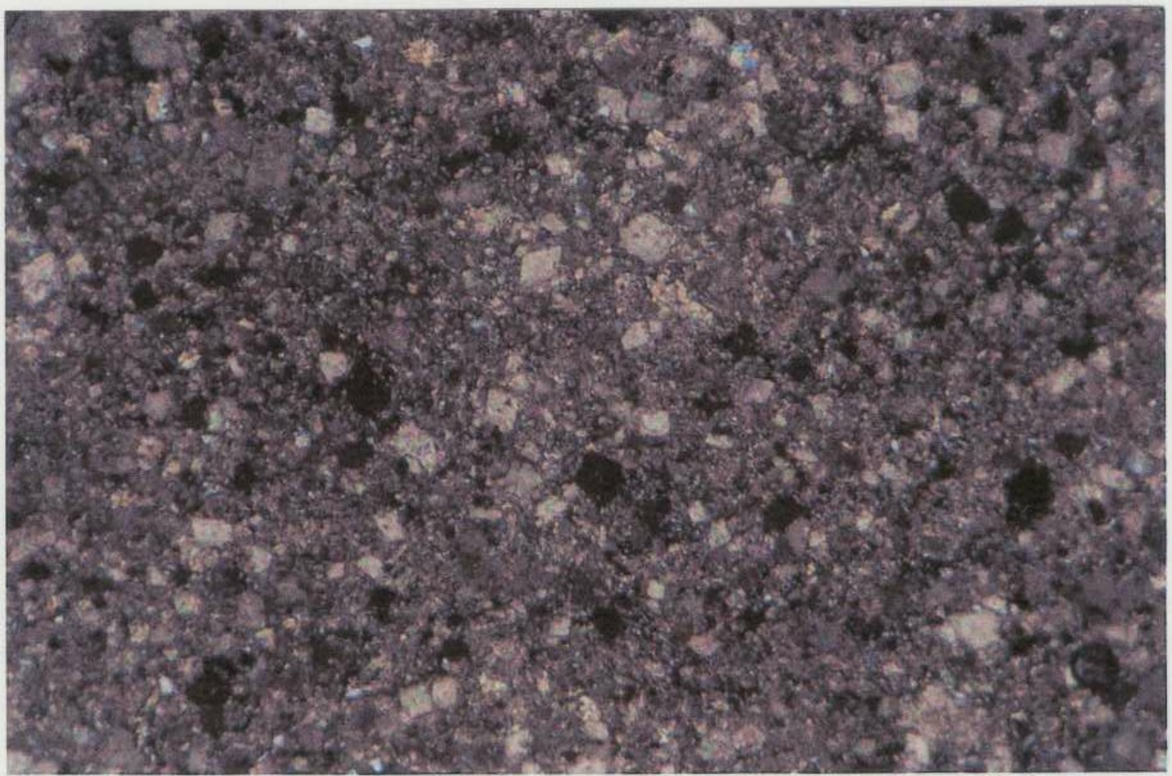
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	83	3	<.01-0.3	Patches of fine-grained carbonate mud are sporadically distributed throughout the fine- to medium-grained calcite matrix; much of the matrix is partially obscured by secondary dolomite crystals; coarse-grained portion of the matrix is characterized by angular grains of calcite that interlock moderately along angular boundaries.
Dolomite	15	3.5-4	.02-0.1	Diamond-shaped crystals are abundantly distributed throughout the calcite matrix; crystal corners are tightly held by the surrounding calcite matrix.
Quartz	2	7	.02-0.1	Angular to subangular grains are sporadically distributed, isolated by surrounding, moderately interlocking calcite and dolomite; grains are tightly held by calcite along long, straight boundaries.

Weighted Average: 3.23

Remarks: The texture of this rock is characterized by a matrix of fine-grained, angular calcite grains that interlock moderately along angular boundaries. Patchy areas of carbonate mud pervade the matrix. Dolomite crystals are abundantly distributed throughout the matrix, tightly held on corners by the matrix.

Principal Investigator: Sandin Phillipson **Date:** August 27, 2005



B-15-7 @ 153.6-153.7. Dolomite crystals (diamond-shaped, brightly speckled pink/green) are isolated by a very fine-grained matrix of calcite mud (brown, speckled) or less commonly touch along corners. Rare angular grains of quartz (white/light gray) are enclosed within the calcite mud matrix. Field of view 2.4 mm at 40X, taken under crossed polars.

EARTH MECHANICS INSTITUTE
Department of Mining Engineering
Colorado School of Mines
Thin Section Petrographic Analysis

Project: LSIORB Section 4, East End Approach

Location: Lexington, KY | **Client:** FMSM

Formation: not given | **Core ID:** B-18-1 @ 50.6-51.3

Date Studied: August 27, 2005 | **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary | **Alteration:** dolomitization

Texture: fossiliferous; mud supported | **Rock Name:** wackestone / biomicrite

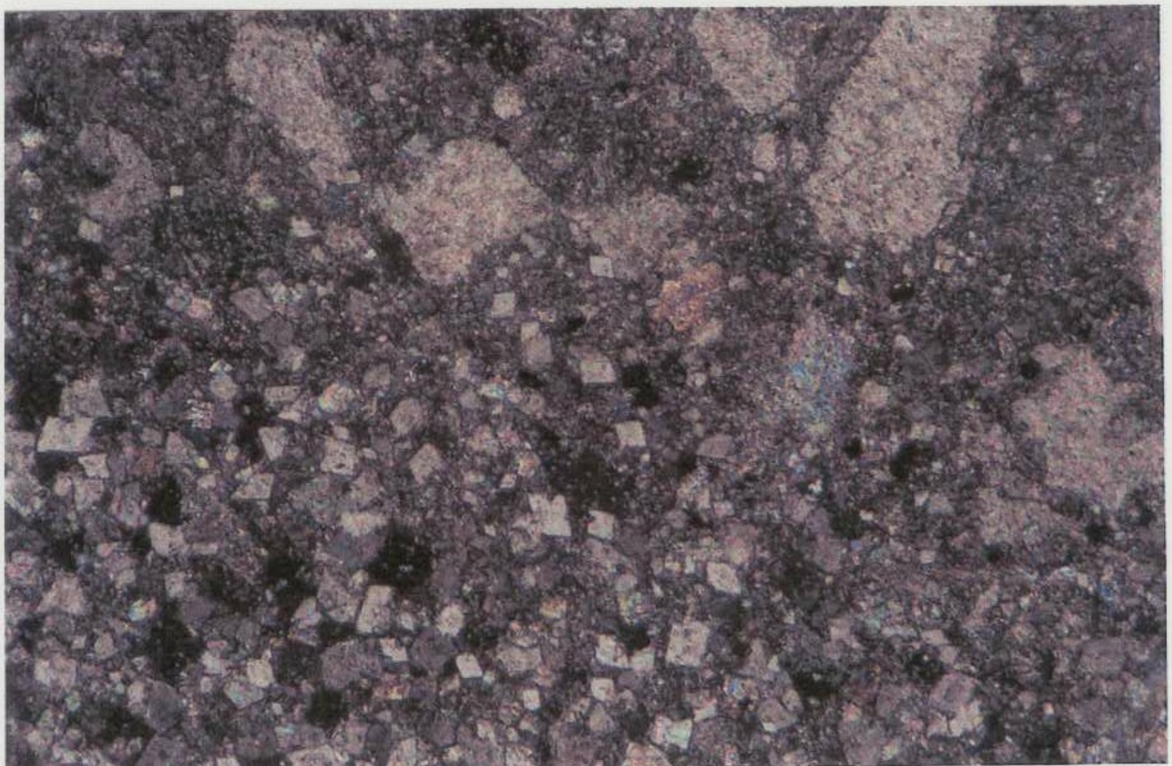
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	55	3	<.01-1.0	Matrix (65%): the original matrix is represented by very fine-grained carbonate mud that hosts angular fossil fragments; much of the original micrite matrix has been obliterated by secondary dolomite growth. Fossils (35%): angular, blocky, and irregularly shaped fossil fragments are sporadically distributed throughout parts of the rock, surrounded and enclosed by the muddy carbonate matrix.
Dolomite	45	3.5-4	.01-0.1	Diamond-shaped crystals are abundantly distributed, obliterated much of the original micritic matrix; crystals locally form a grain-supported texture in which dolomite crystals touch along corners and straight boundaries.

Weighted Average: 3.45

Remarks: The texture of this rock is characterized by an original matrix of very fine-grained carbonate mud that encloses angular irregularly shaped fossil fragments. Parts of the matrix were subsequently altered by secondary dolomite growth, resulting in a local grain-supported texture that obscures much of the original matrix. Although the original rock was mud supported, dolomitization has resulted in a grain-supported texture.

Principal Investigator: *Sandin Phillipson* (signature) **Date:** *August 27, 2005*



B-18-1 @ 50.6-51.3. Angular fossil fragments are enclosed by a very fine-grained matrix of calcite mud (brown, speckled). Other portions of the matrix have been extensively dolomitized, hosting abundant dolomite crystals (diamond-shaped, brightly speckled pink/green) that interlock moderately along straight boundaries. Field of view 2.4 mm at 40X, taken under crossed polars.

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Department of Mining Engineering
Colorado School of Mines

Thin Section Petrographic Analysis

Project: LSIORB Section 4, East End Approach

Location: Lexington, KY **Client:** FMSM

Formation: not given **Core ID:** B-18-3 @ 84.5-84.7

Date Studied: August 27, 2005 **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary **Alteration:** dolomitization

Texture: mud supported **Rock Name:** mudstone / micrite

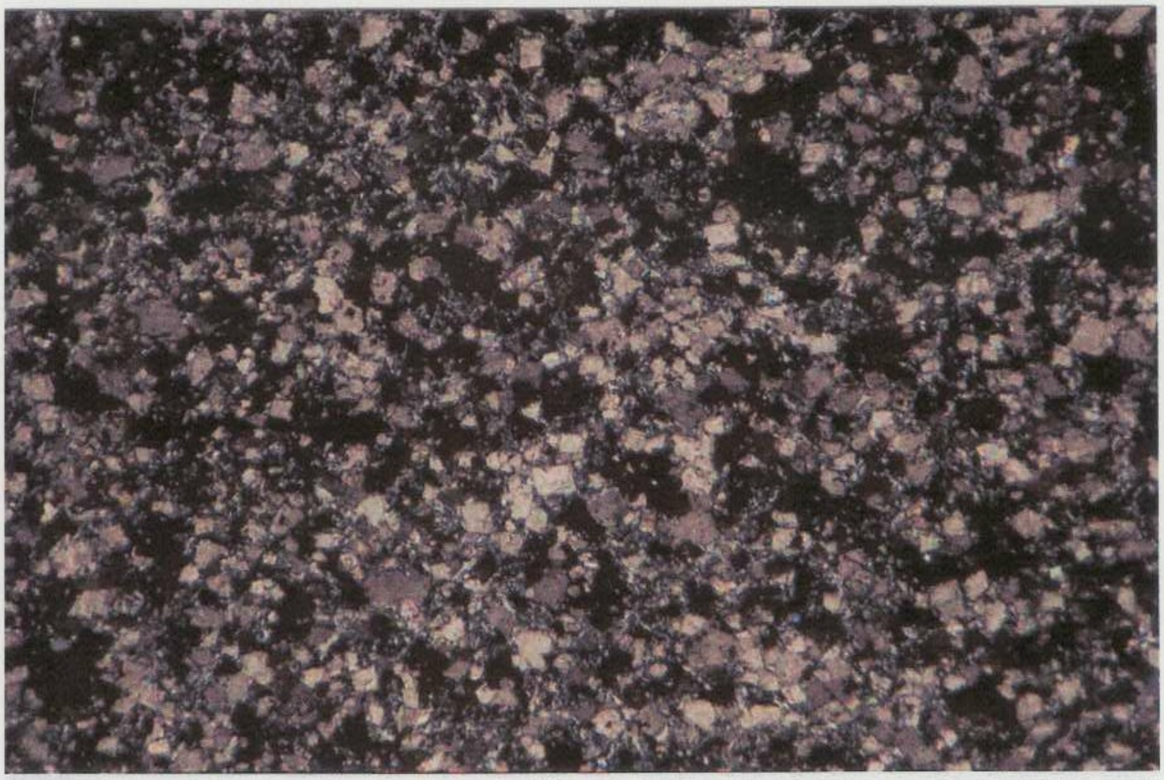
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	73	3	<.01	Occurs as carbonate mud that represents the original matrix of the rock; secondary dolomite has obscure some of the original texture; patches of the original mud matrix appear to have been stripped away during sample preparation.
Dolomite	27	3.5-4	.02-0.1	Diamond-shaped crystals are abundantly distributed throughout the carbonate mud matrix; crystals commonly touch each other along corners and straight boundaries.

Weighted Average: 3.27

Remarks: The texture of this rock is characterized by an original matrix composed of carbonate mud. Secondary dolomite crystal growth has obliterated parts of the original texture, and touching dolomite crystals have resulted in a locally grain-supported texture instead of the original mud-supported texture.

Principal Investigator: Sandin Phillipson **Date:** August 27, 2005



B-18-3 @ 84.5-84.7. Dolomite crystals (diamond-shaped, brightly speckled pink/green) interlock moderately to poorly with each other along straight boundaries and touch along corners. Matrix is represented by very fine-grained calcite mud (brown, speckled). Black areas represent voids that probably formed during sample preparation, and are not penetrated by blue epoxy. Field of view 2.4 mm at 40X, taken under crossed polars.

EARTH MECHANICS INSTITUTE
Department of Mining Engineering
Colorado School of Mines
Thin Section Petrographic Analysis

Project: LSIORB Section 4, East End Approach

Location: Lexington, KY | **Client:** FMSM

Formation: not given | **Core ID:** B-18-4 @ 36.5-37.0

Date Studied: August 27, 2005 | **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary | **Alteration:** dolomitization

Texture: fossiliferous; grain supported | **Rock Name:** wackestone / biomicrite

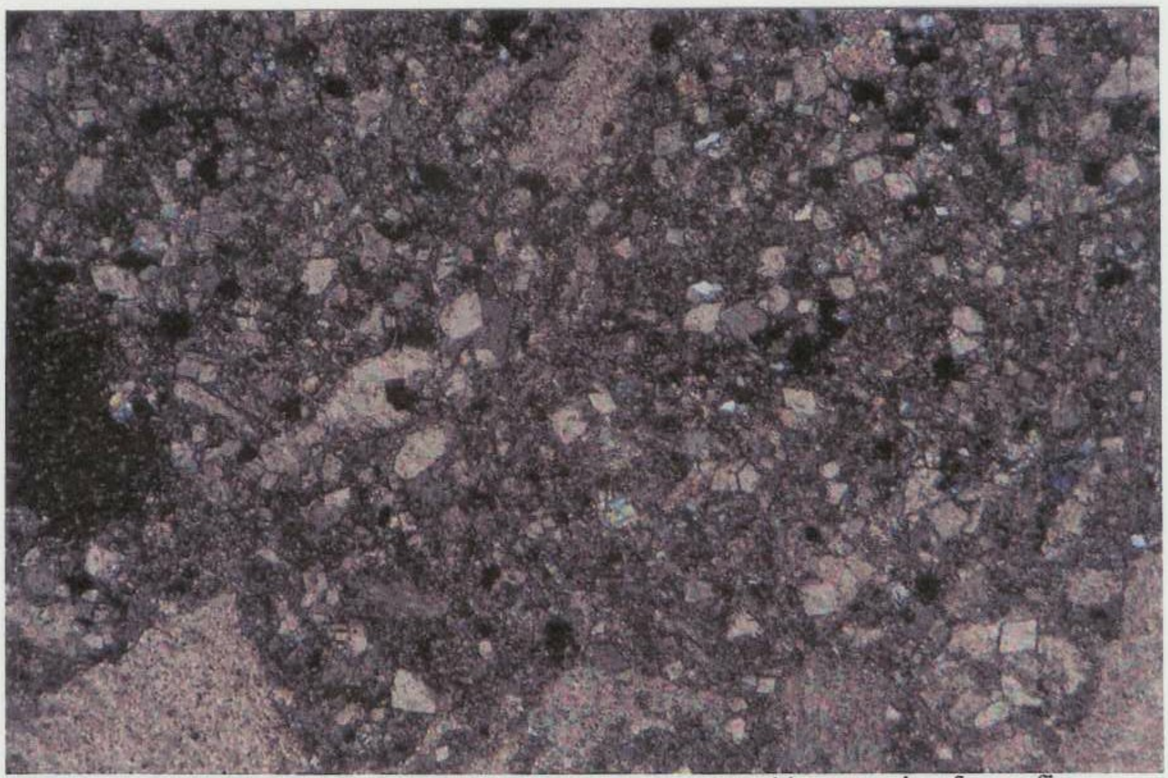
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	68	3	<.01-1.6	Matrix (60%): the original matrix is composed of fine-grained carbonate mud and encloses large, angular fossil fragments; the matrix has been preferentially dolomitized, resulting in formation of a grain supported texture; Fossils (40%): large, angular and jagged bryozoan fragments and blocky crinoid plates are enclosed by the carbonate matrix, and commonly interlock along angular boundaries with surrounding dolomite crystals; some fragments exhibit in-filling by aragonite.
Dolomite	30	3.5-4	.02-0.2	Diamond-shaped crystals are abundantly distributed throughout the original matrix, forming a grain-supported texture that masks the original mud-supported texture; crystals touch along straight boundaries and corners.
Quartz	2	7	.03-.07	Angular and very angular grains are sporadically distributed throughout the dolomitized matrix; grains are isolated and tightly held along straight boundaries by surrounding dolomite crystals.

Weighted Average: 3.38

Remarks: The texture of this rock is characterized by a muddy matrix that has been extensively dolomitized, replacing the original mud-supported texture with a grain-supported texture. The dolomitized matrix encloses irregularly shaped fossil fragments, with which they interlock along angular boundaries.

Principal Investigator: Sandin Phillipson **Date:** August 27, 2005



B-18-4 @ 36.5-37.0. Angular fossil fragments are enclosed in a matrix of very fine-grained calcite mud (brown, speckled), which also hosts abundant, secondary dolomite crystals (diamond-shaped, speckled bright pink/green). Some dolomite crystals touch along straight boundaries or corners, but most are isolated by the matrix. Field of view 2.4 mm at 40X, taken under crossed polars.

EARTH MECHANICS INSTITUTE
Department of Mining Engineering
Colorado School of Mines
Thin Section Petrographic Analysis

Project: LSIORB Section 4, East End Approach	
Location: Lexington, KY	**Client:** FMSM
Formation: not given	**Core ID:** B-7-12 @ 15.1-15.6
Date Studied: August 27, 2005	**Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary	**Alteration:** dolomitization
Texture: fossiliferous; grain supported	**Rock Name:** packstone / packed biomicrite

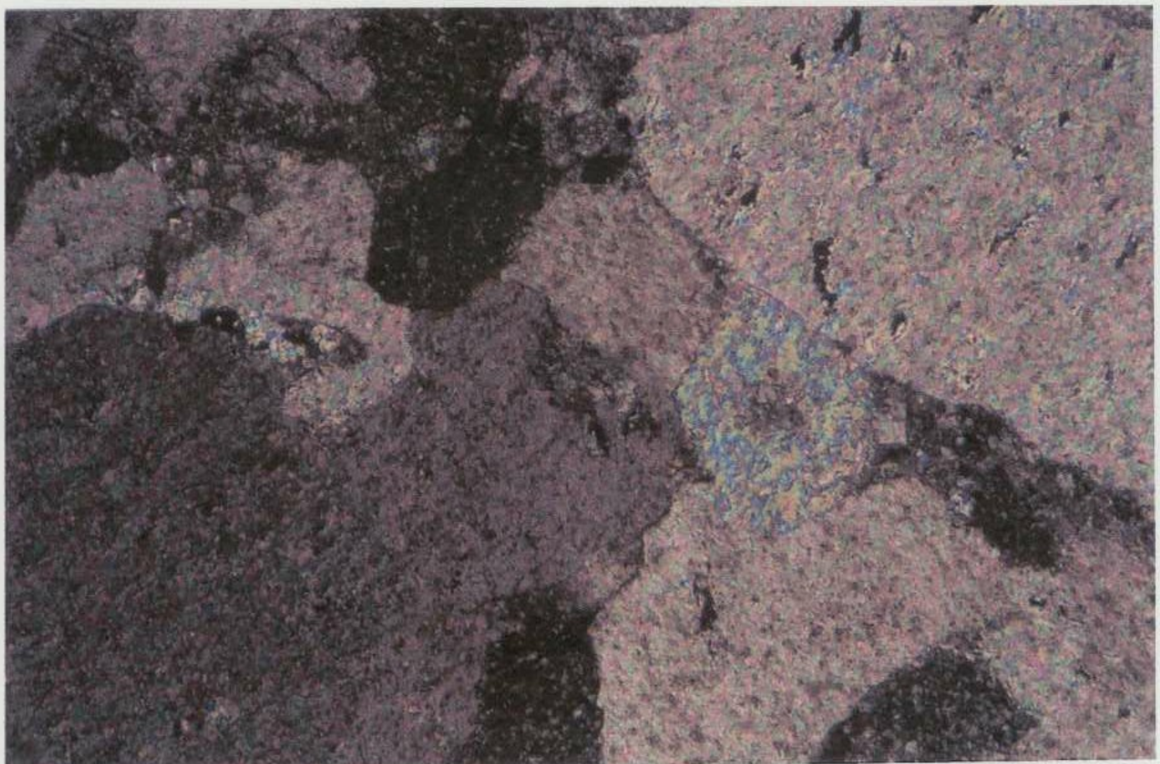
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Calcite	92	3	<.01-1.8	Matrix (10%): carbonate mud occurs in interstices between large fossil fragments; the matrix has been preferentially dolomitized, with dolomite crystals that commonly interlock with fossil boundaries; Fossils (90%): large, angular crinoid plates interlock moderately with each other along angular and long, straight boundaries.
Dolomite	8	3.5-4	.01-.09	Diamond-shaped crystals are preferentially concentrated in the matrix, which is restricted to interstices between large fossil fragments.

Weighted Average: 3.08

Remarks: The texture of this rock is characterized by large, angular fossil fragments that interlock moderately with each other along angular and long, straight boundaries. Interstices between fossils host a dolomitized carbonate mud matrix. Dolomite crystals commonly interlock along angular boundaries with fossils.

Principal Investigator: Sandin Phillipson **Date:** August 27, 2005



B-7-12 @ 15.1-15.6. Large fossil fragments interlock moderately to poorly along angular and long, straight boundaries. Rare dolomite crystals (diamond-shaped, brightly speckled pink/green) are restricted to the rare calcite mud matrix (brown, speckled) that occurs in small interstices between large fossils. Field of view 2.4 mm at 40X, taken under crossed polars.

EARTH MECHANICS INSTITUTE
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Colorado School of Mines
Thin Section Petrographic Analysis

Project: KYTC Client: Hatch Mott MacDonald

Date: March 5, 2006 Studied by: Sandin E. Phillipson

The three samples in this suite are all very similar in texture and mineral content. The samples were originally characterized by very fine-grained calcite mud that hosted rare, angular to subangular quartz grains. The original rock can be classified as mudstone according to the classification scheme developed for carbonate rocks by Dunham (1962), or as micrite according to the classification scheme developed for carbonate rocks by Folk (1962). Due to extensive growth of dolomite crystals in the original calcite mud, they could be all referred to currently as dolomite. The degree of dolomite growth varies somewhat, ranging from 92% in Sample B-2-3a,11.65-11.84 where the calcite mud matrix is nearly obliterated, to 77% in Sample B-6-16,28.95-29.64 in which much of the original calcite mud matrix remains intact.

The growth of dolomite affects the rock texture, as well as the average Mohs Hardness value. Rocks with greater dolomite growth have effectively replaced the original calcite mud matrix, forming a rigid framework of diamond-shaped crystals that touch along straight boundaries and point contacts. The greater dolomite (H = 4) content also increases the average Mohs Hardness value compared to the original calcite mud (H = 3). Although all the samples contain 2-3% quartz, the isolated grains contribute little to the average Mohs Hardness. Instead, due to dolomite content, the average Mohs Hardness of the rocks range from H = 3.89-4.

Porosity appears to be very low, limited to approximately less than 2-3% in all samples. Porosity occurs as isolated, angular to rounded void spaces that are surrounded by diamond-shaped dolomite crystals and are not interconnected.

EARTH MECHANICS INSTITUTE
Department of Mining Engineering
Colorado School of Mines
Thin Section Petrographic Analysis

Project: KYTC

Location: Lexington, Kentucky **Client:** Hatch Mott MacDonald

Formation: not given **Core ID:** B-2-3a,11.65-11.84

Date Studied: March 5, 2006 **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary **Alteration:** dolomitization

Texture: grain supported **Rock Name:** mudstone/micrite (dolomite)

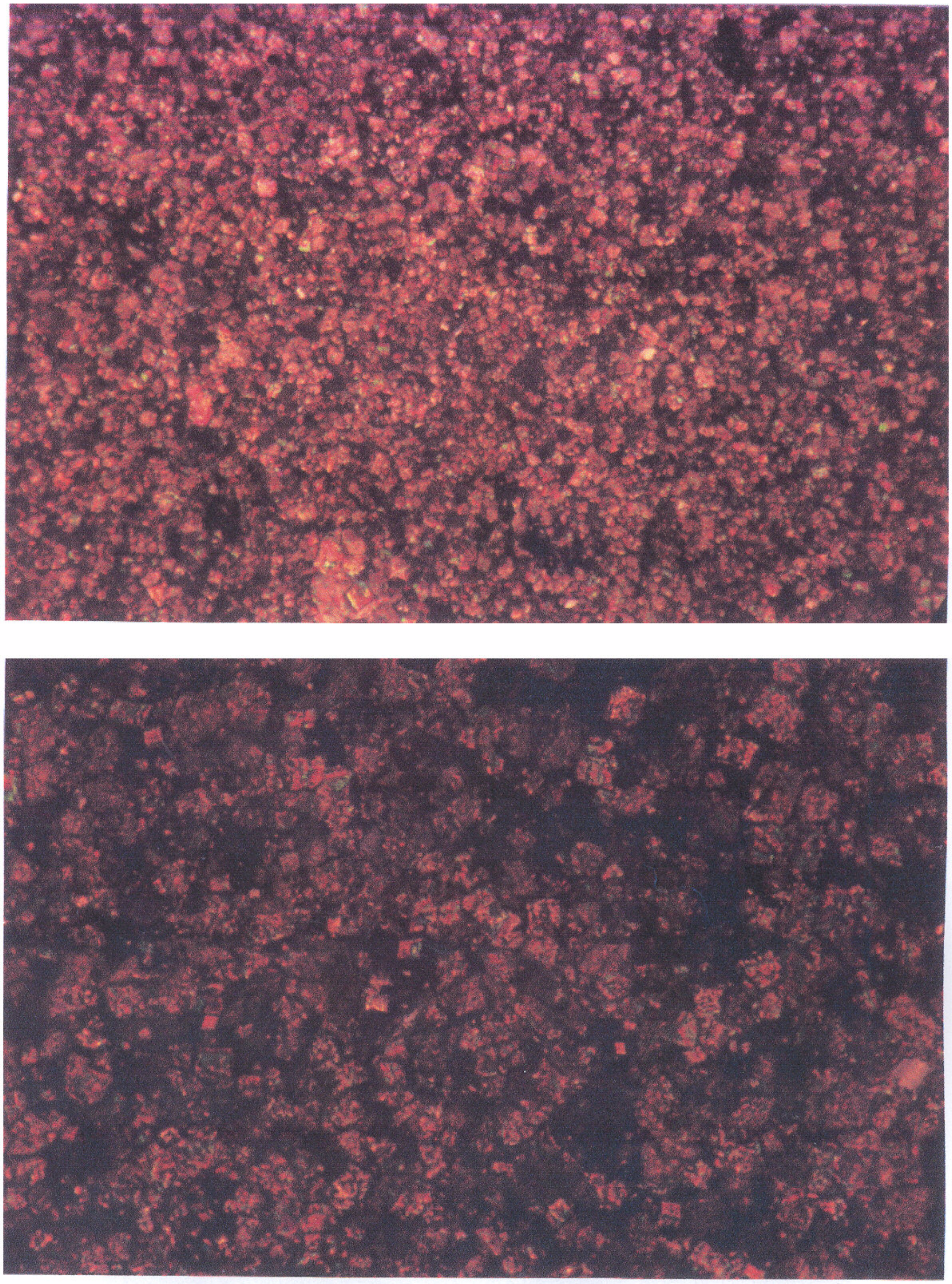
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Dolomite	92	3.5-4	.01-0.2	Angular, diamond-shaped crystals dominate the rock and interlock along straight boundaries and point contacts; crystals define a rigid framework.
Calcite	6	3	<.01	Very fine-grained mud represents the original matrix, but has been nearly completely obliterated by extensive dolomitization; calcite mud remains as rare patches in interstices between angular dolomite crystals.
Quartz	2	7	.02-.05	Angular grains are sparsely distributed throughout the rock, with individual grains isolated by surrounding, diamond-shaped dolomite crystals.

Weighted Average: 4

Remarks: The texture of this rock is characterized by a framework of diamond-shaped dolomite crystals that touch along straight boundaries and point contacts. Interstitial calcite mud is very rarely distributed between the diamond-shaped dolomite crystals.

Principal Investigator: Sandin Phillipson **Date:** March 7, 2006



B-2-3a, 11.65-11.84. Diamond-shaped dolomite crystals touch along straight boundaries, obscuring the original dark, limey mud matrix. Field of view 2.4 mm at 40X (top) and 1 mm at 100X (bottom), taken under crossed polars.

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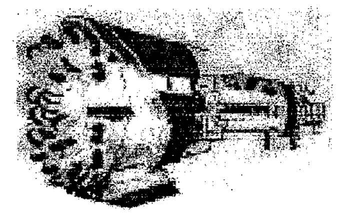
Thin Section Petrographic Analysis



Project: KYTC

Location: Lexington, Kentucky **Client:** Hatch Mott MacDonald

Formation: not given **Core ID:** B-6-16,28.95-29.64

Date Studied: March 5, 2006 **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary **Alteration:** dolomitization

Texture: grain supported **Rock Name:** mudstone/micrite (dolomite)

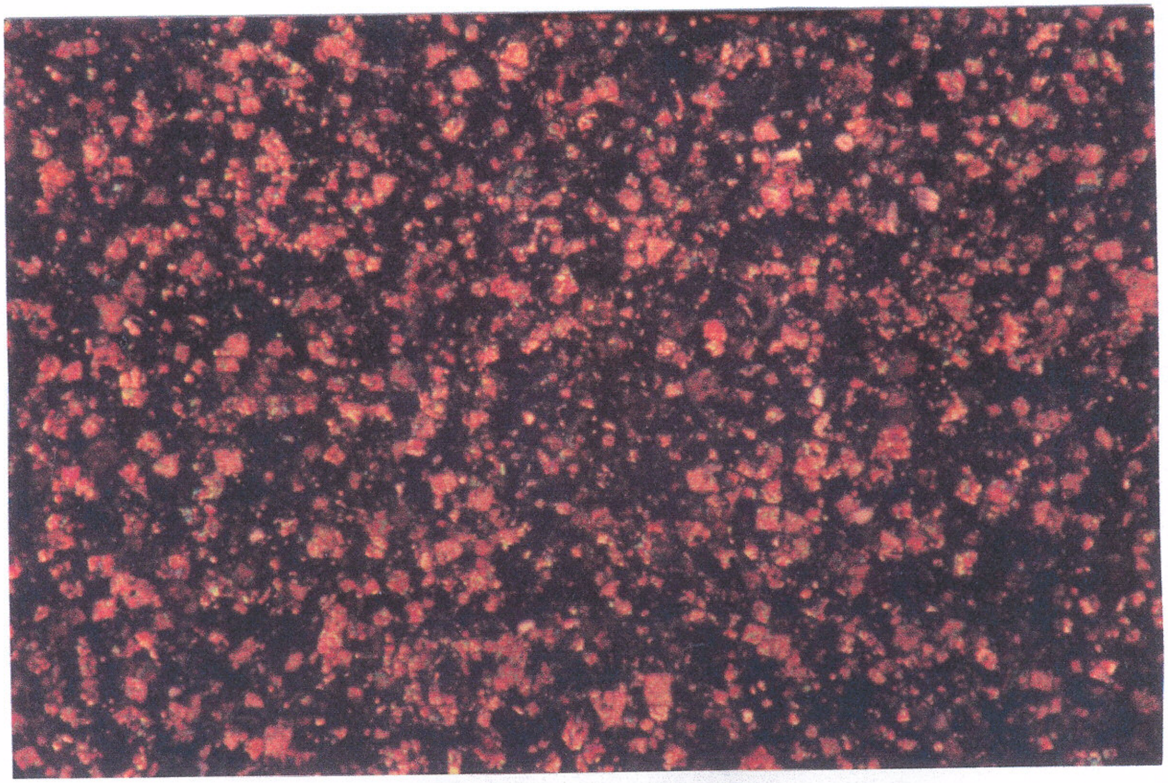
Description of Individual Minerals

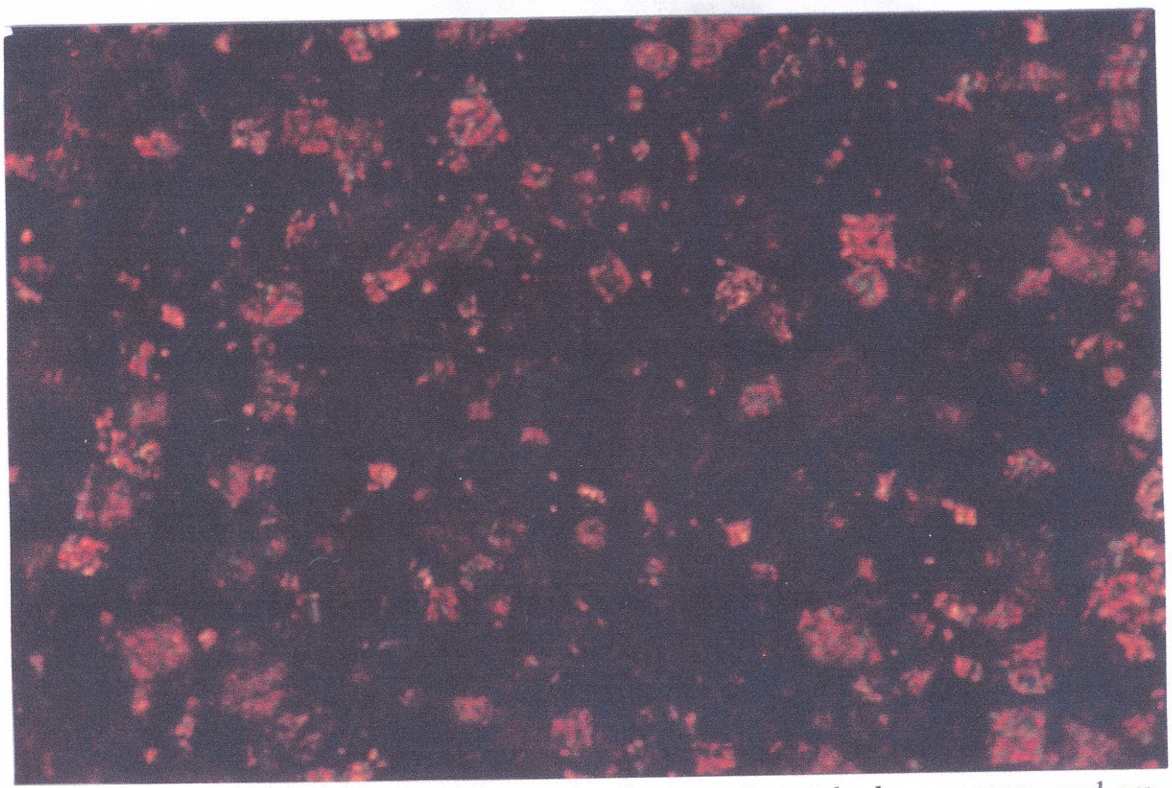
Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Dolomite	77	3.5-4	.02-0.2	Diamond-shaped crystals are abundantly distributed throughout the calcite mud matrix; crystals are commonly isolated but generally occur in areas where they touch along straight boundaries and point contacts.
Calcite	20	3	<.01	Very fine-grained calcite mud represents the original matrix, which isolates some dolomite crystals or occurs in interstices between other dolomite crystals.
Quartz	3	7	.02-.07	Angular to subangular grains are sparsely distributed throughout the rock, with individual grains isolated by surrounding diamond-shaped dolomite crystals.

Weighted Average: 3.89

Remarks: The texture of this rock is characterized by a matrix of very fine-grained calcite mud, which hosts rare quartz grains and abundant, diamond-shaped dolomite crystals. Dolomite crystals touch along straight boundaries and point contacts, forming a skeletal, grain-supported framework.

Principal Investigator: [illegible] **Date:** March 7, 2006





B-6-16, 28.95-29.64. Diamond-shaped dolomite crystals touch along corners, and are partially to completely surrounded by very fine-grained, limey mud that represents the original matrix. Field of view 2.4 mm at 40X (top) and 1 mm at 100X (bottom), taken under crossed polars.

EARTH MECHANICS INSTITUTE

Department of Mining Engineering

Colorado School of Mines

Thin Section Petrographic Analysis

Project: KYTC

Location: Lexington, Kentucky **Client:** Hatch Mott MacDonald

Formation: not given **Core ID:** B-8-6,40.65-41.1

Date Studied: March 5, 2006 **Studied by:** Sandin E. Phillipson

Classification

Rock type: sedimentary **Alteration:** dolomitization

Texture: grain supported **Rock Name:** mudstone/micrite (dolomite)

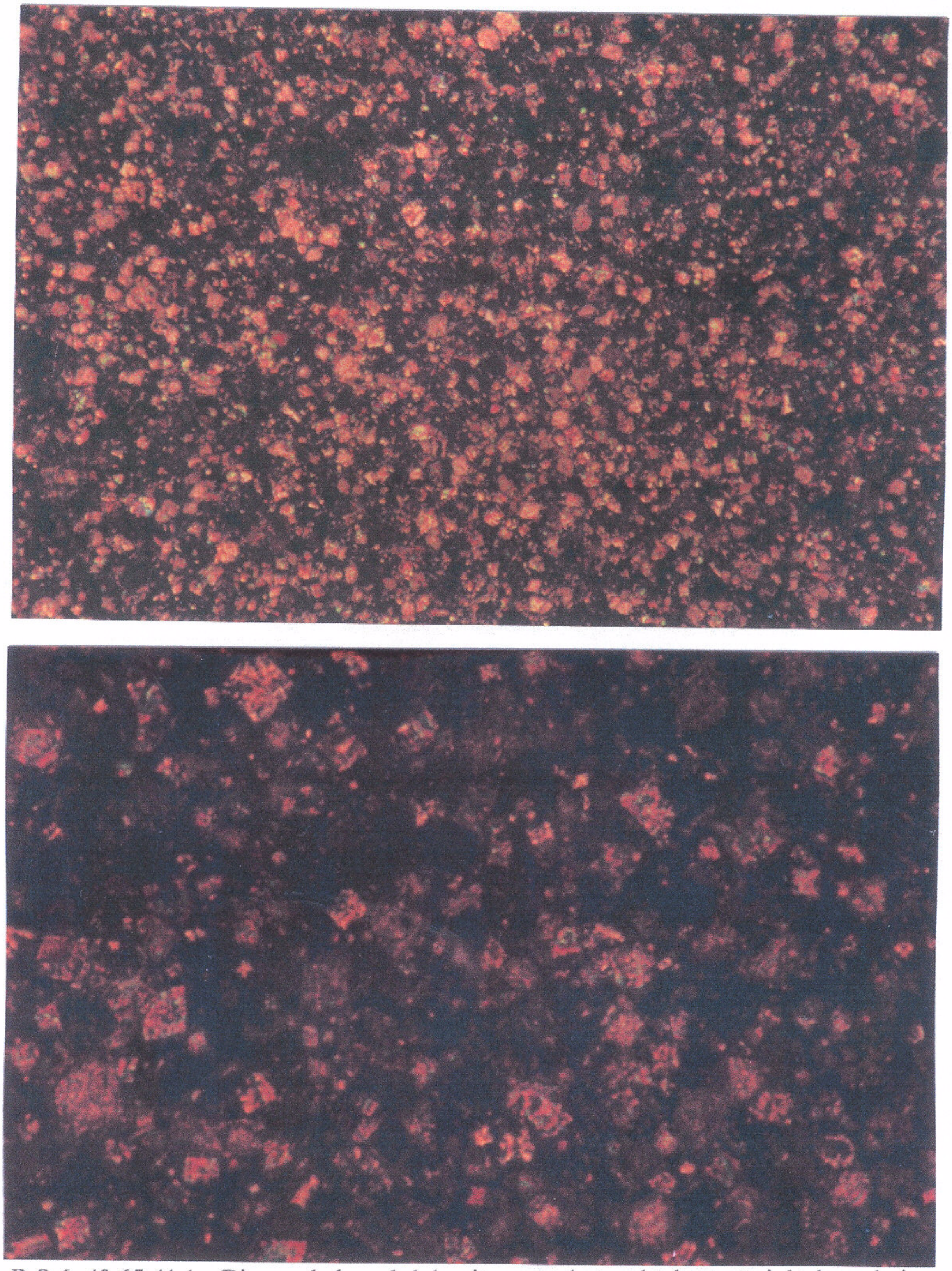
Description of Individual Minerals

Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Dolomite	85	3.5-4	.01-1.0	Diamond-shaped crystals are abundantly distributed throughout the fine-grained, calcite mud matrix; dolomite crystals partially obscure the original matrix, and touch each other along straight boundaries and point contacts.
Calcite	12	3	<.01	Very fine-grained calcite mud represents the original matrix; calcite mud occurs in interstices between fine-grained, diamond-shaped dolomite crystals.
Quartz	3	7	.03-.06	Angular to subangular grains are sparsely distributed throughout the rock, isolated by surrounding, diamond-shaped dolomite crystals that touch along straight edges or point contacts.

Weighted Average: 3.97

Remarks: The texture of this rock is characterized by an original matrix of calcite mud, which hosts abundant dolomite crystals and rare quartz grains. Abundant dolomite crystals touch along straight edges and point contacts, forming a framework. Possible rare trace fossils are outlined by concentrations of opaque minerals, probably hematite.

Principal Investigator: Sandin Phillipson **Date:** March 7, 2006



B-8-6, 40.65-41.1. Diamond-shaped dolomite crystals touch along straight boundaries and corners, with very fine-grained, dark, limey mud in interstices. Field of view 2.4 mm at 40X (top) and 1 mm at 100X (bottom), taken under crossed polars.

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

Fuller Mossbarger Scott & May ENGINEERS

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Limestone, gray, moderately hard
Lab ID: UCSS-50
Hole Number: B-7-1
Depth (ft/elev): 104.4' - 104.8'
Date Received: 07-27-2005

Temperature (^oC): 22
Moisture Condition: As received, dry
Date Tested: 08-08-2005

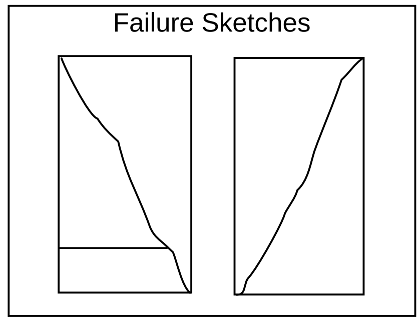
Side Planeness: Pass
Height (in): 4.862
Wet Unit Weight (pcf): 165.7
Perpendicularity: Pass
Diameter (in): 1.993
Dry Unit Weight (pcf): 164.5
End Planeness: Pass
Area (in^2): 3.121
Moisture Content (%): 0.7

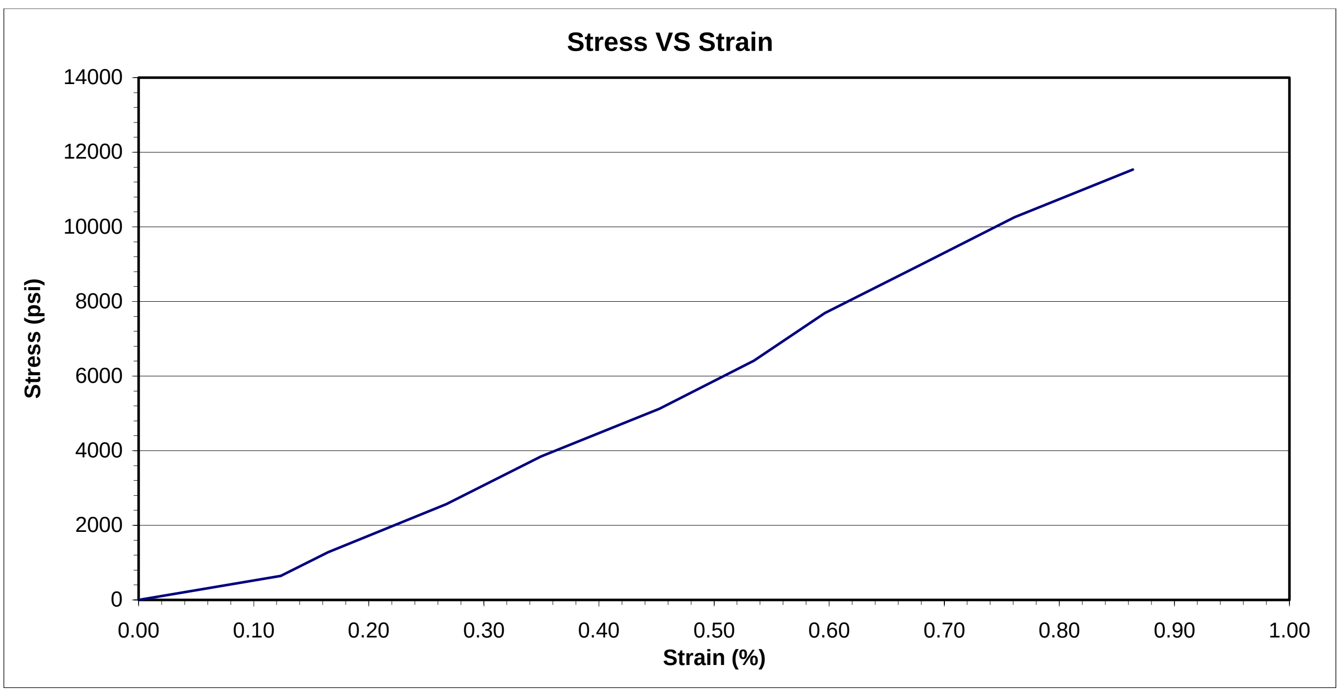
Loading Rate (lbf/sec): 86
Peak Load (lbf): 37330

Failure Type: Shear

Compressive Strength (psi): 11960

Compressive Strength (tsf): 861





Comments

Reviewed By

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

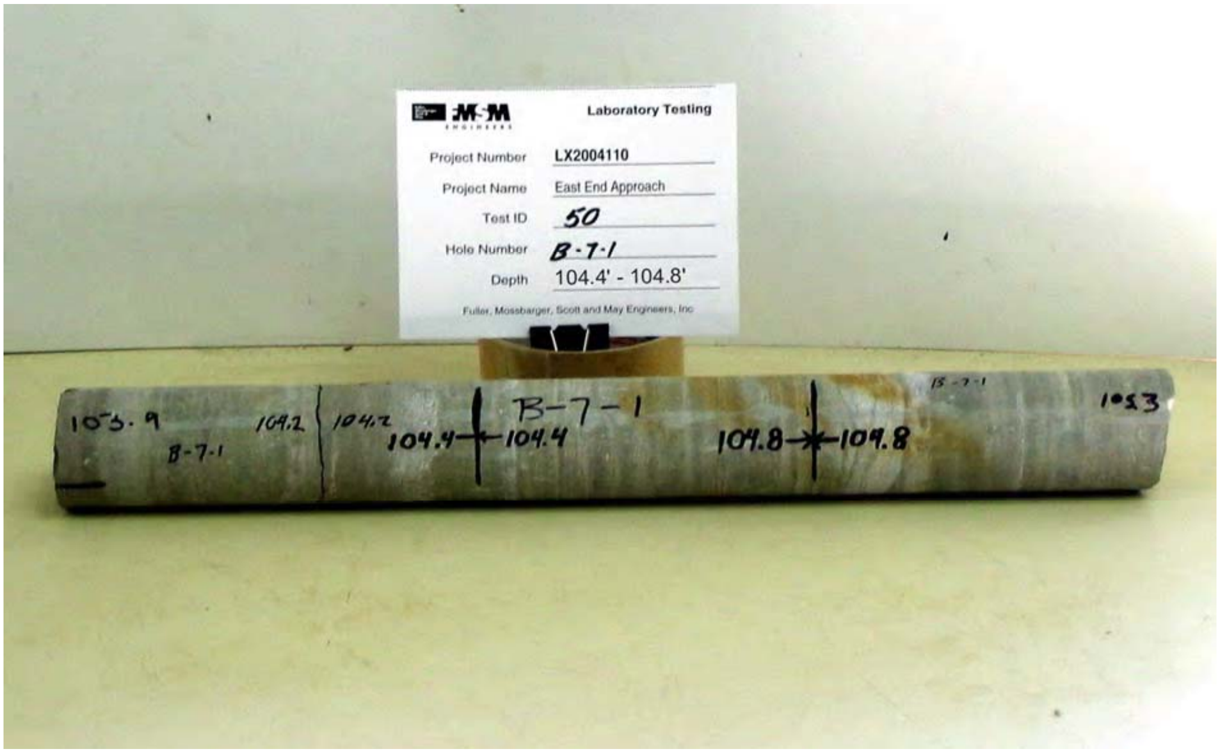
Fuller Mossbarger Scott & May

FMSM ENGINEERS

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, gray, moderately hard	Lab ID	UCSS-50
Hole Number	B-7-1 Depth (ft) 104.4' - 104.8'		
Test Type	Unconfined compressive strength of intact rock core		

As received



Core preparation

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, gray, moderately hard	Lab ID	UCSS-50
Hole Number	B-7-1 Depth (ft) 104.4' - 104.8'		
Test Type	Unconfined compressive strength of intact rock core		

Core preparation

Post test

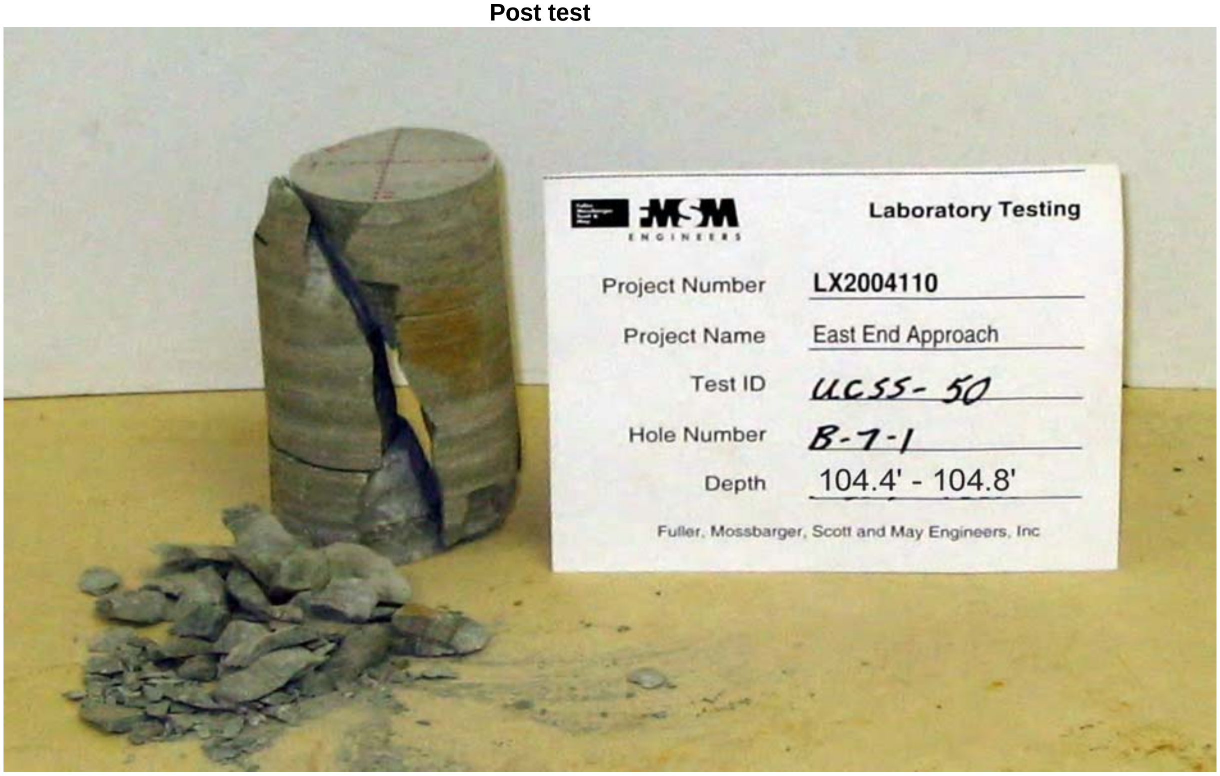
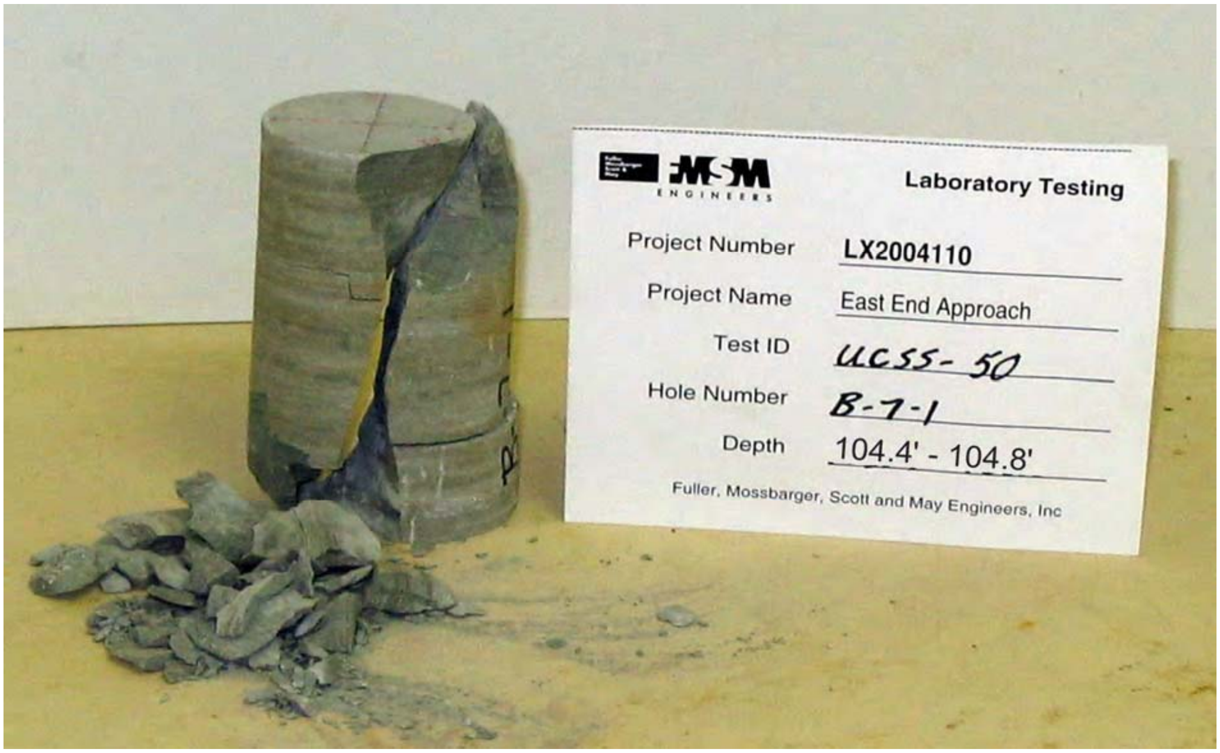


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, gray, moderately hard	Lab ID	UCSS-50
Hole Number	B-7-1 Depth (ft) 104.4' - 104.8'		
Test Type	Unconfined compressive strength of intact rock core		

Post test



Fuller Mossbarger Scott & May
FMSM ENGINEERS

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Dolomite, gray to gray-brown, hard
Lab ID UCSS-51
Hole Number B-7-2
Depth (ft/elev) 79.2' - 79.6'
Date Received 07-27-2005

Temperature (^oC) 22
Moisture Condition As received, dry
Date Tested 08-08-2005

Side Planeness Pass
Perpendicularity Pass
End Planeness Pass

Height (in) 4.797
Diameter (in) 1.994
Area (in^2) 3.122

Wet Unit Weight (pcf) 163.5
Dry Unit Weight (pcf) 162.4
Moisture Content (%) 0.7

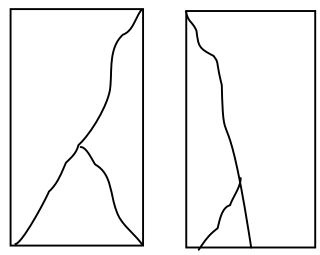
Loading Rate (lbf/sec) 104
Peak Load (lbf) 32580

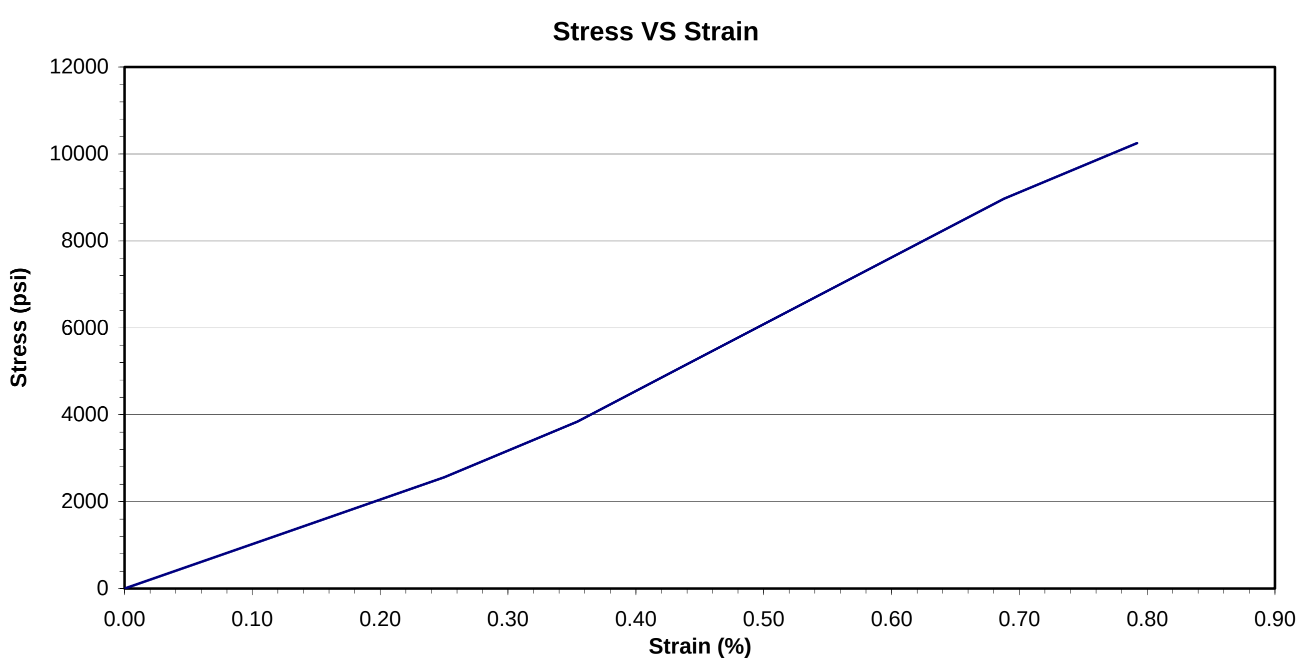
Failure Type Cone and Shear

Compressive Strength (psi) 10440

Compressive Strength (tsf) 751

Failure Sketches





Comments

Reviewed By

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Dolomite, gray to gray-brown, hard
Hole Number B-7-2 Depth (ft) 79.2' - 79.6'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-51

As received

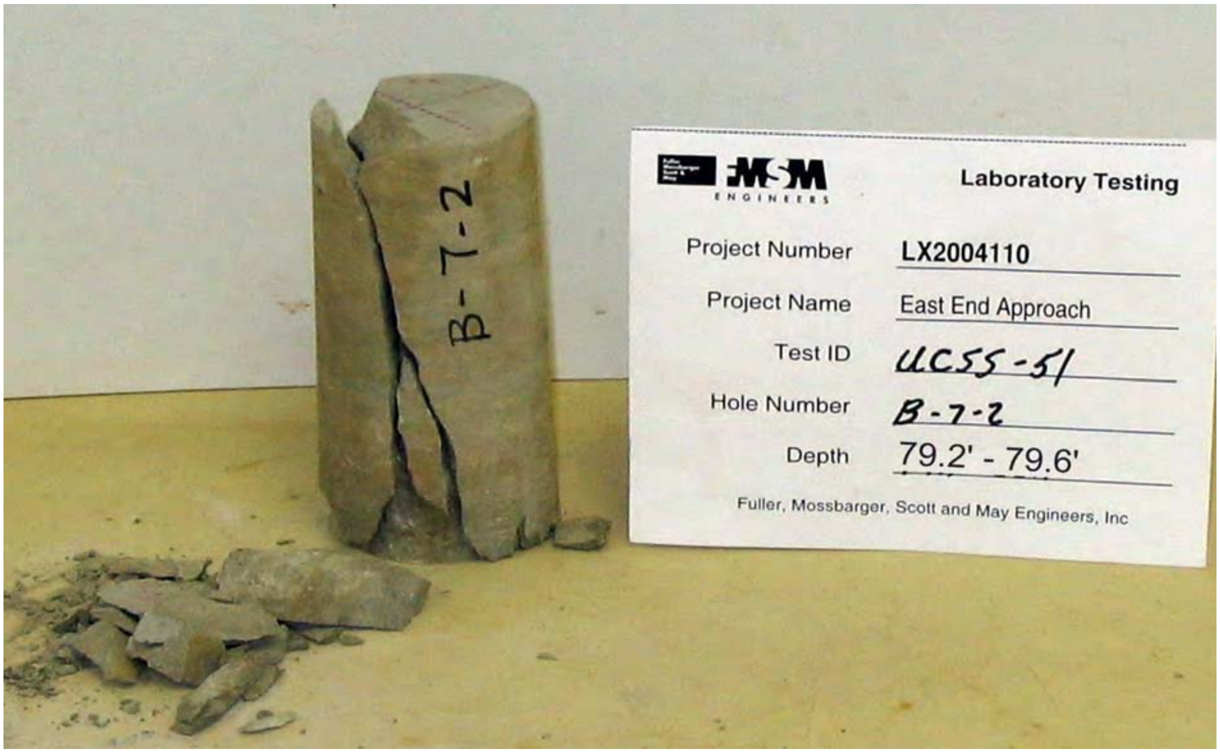
Core preparation

Photo Report

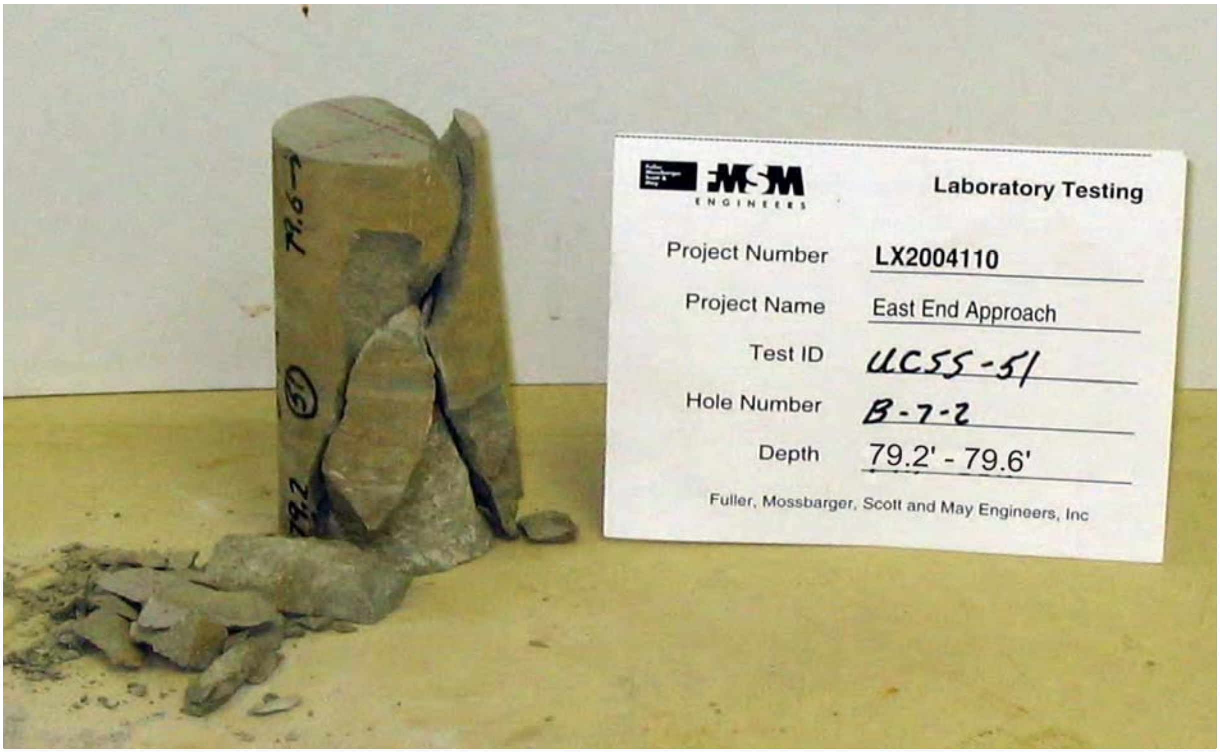
Project Name LSIORB Section 4, East End Approach
Lithology Dolomite, gray to gray-brown, hard
Hole Number B-7-2 Depth (ft) 79.2' - 79.6'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-51

Post test



Post test



Fuller Mossbarger Scott & May
FMSM ENGINEERS

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Red Shale, redish brown, moderately hard
Lab ID: UCSS-52
Hole Number: B-7-4
Depth (ft/elev): 87.4' - 87.8'
Date Received: 07-27-2005

Temperature (^{o}C): 22
Moisture Condition: As received, dry
Date Tested: 08-08-2005

Side Planeness: Pass
Height (in): 4.846
Wet Unit Weight (pcf): 165.1
Perpendicularity: Pass
Diameter (in): 1.995
Dry Unit Weight (pcf): 162.3
End Planeness: Pass
Area (in^2): 3.125
Moisture Content (%): 1.7

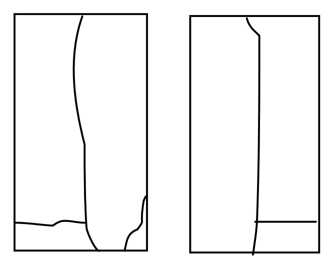
Loading Rate (lbf/sec): 127
Peak Load (lbf): 21290

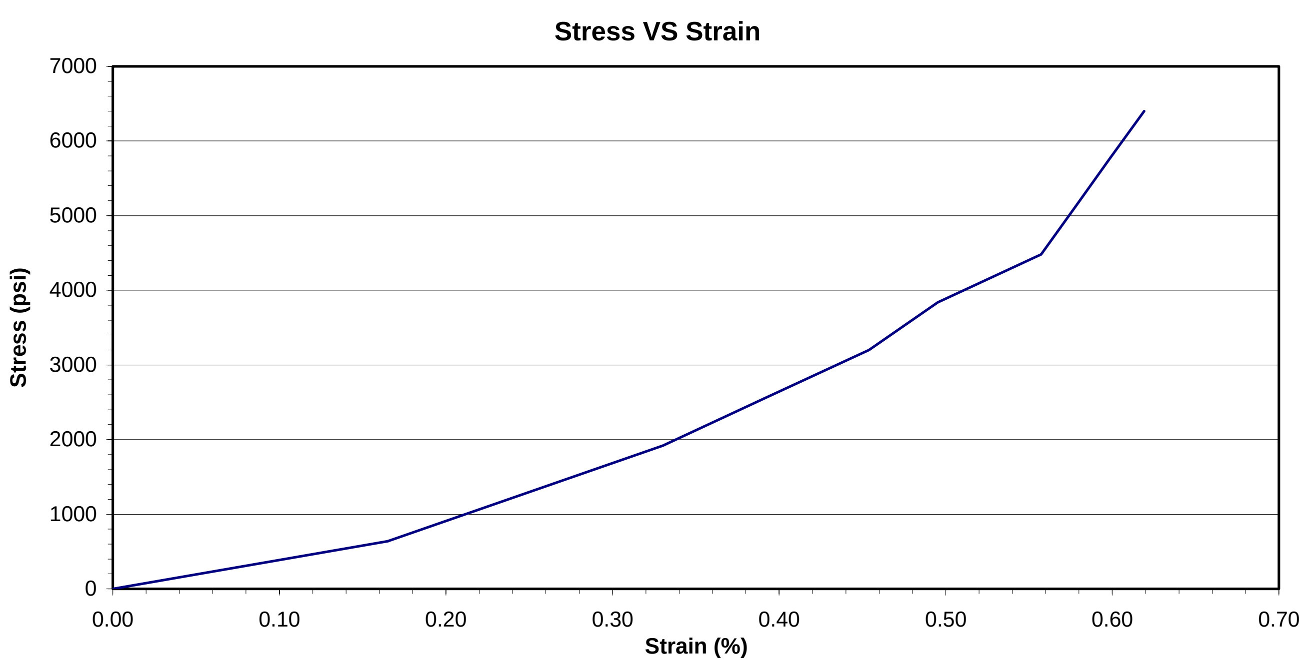
Failure Type: Columnar

Compressive Strength (psi): 6810

Compressive Strength (tsf): 491

Failure Sketches





Comments ______

Reviewed By ______

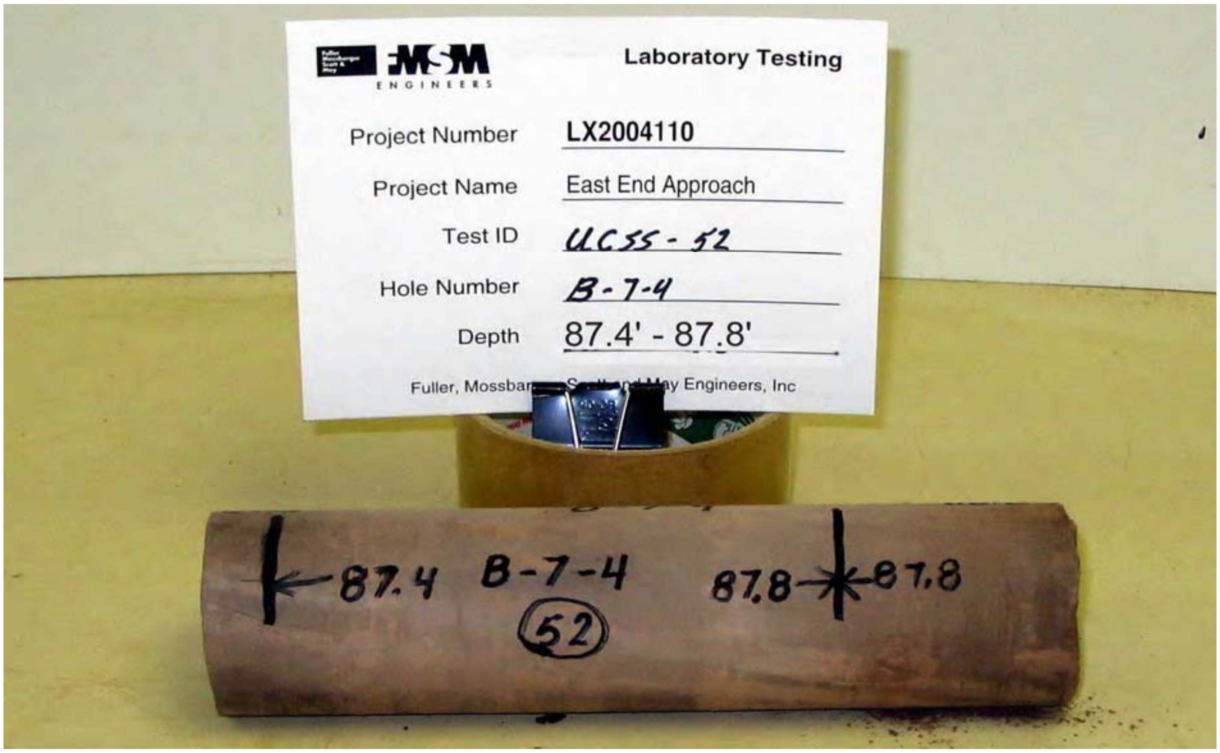
* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Fuller Mossbarger Scott & May
ENGINEERS

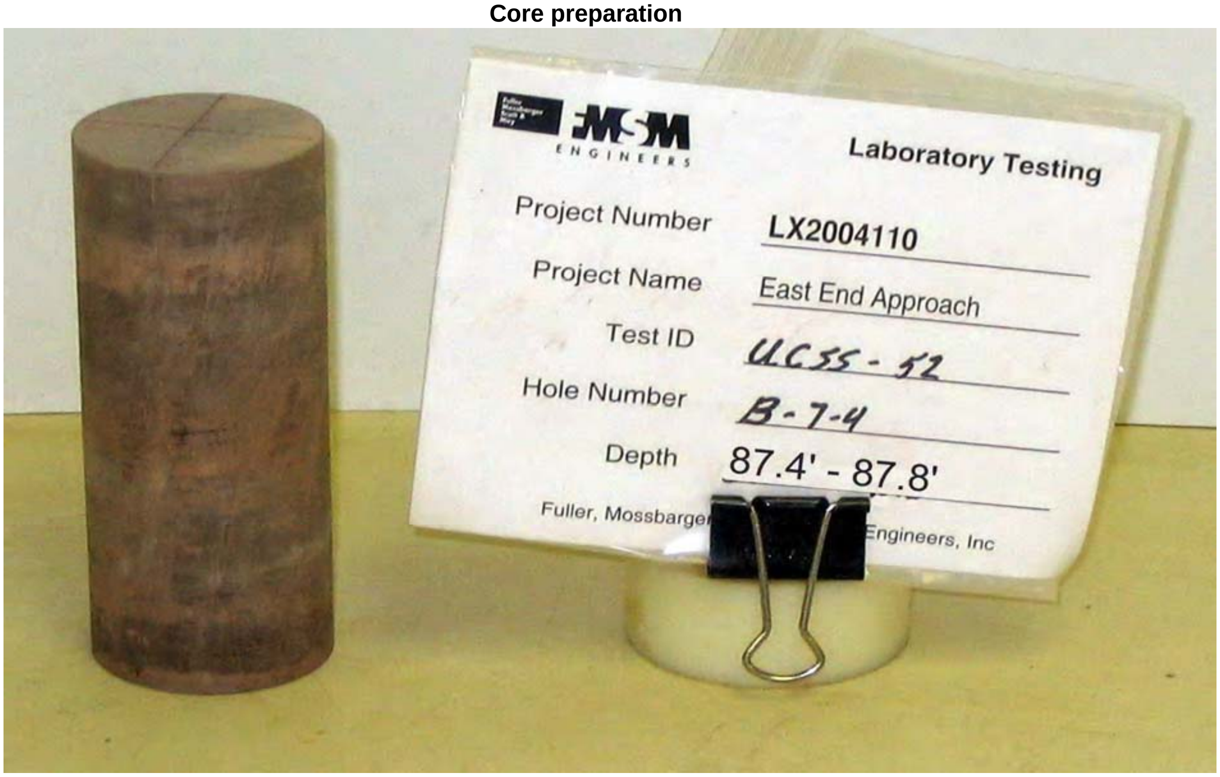
Photo Report

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Red Shale, redish brown, moderately hard
Lab ID: UCSS-52
Hole Number: B-7-4
Depth (ft): 87.4' - 87.8'
Test Type: Unconfined compressive strength of intact rock core

As received



Core preparation



Fuller Mossbarger Scott & May
FMSM ENGINEERS

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Red Shale, redish brown, moderately hard	Lab ID	UCSS-52
Hole Number	B-7-4	Depth (ft)	87.4' - 87.8'
Test Type	Unconfined compressive strength of intact rock core		

Post test

Post test

ENGINEERS

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Shale, gray, soft	Lab ID	UCSS-54
Hole Number	B-7-8	Depth (ft/elev)	26.4' - 26.8'
Date Received	07-27-2005		
Temperature (^{o}C)	23	Moisture Condition	As received, dry
Date Tested	08-10-2005		

Side Planeness	Pass	Height (in)	4.617	Wet Unit Weight (pcf)	165.4
Perpendicularity	Pass	Diameter (in)	1.986	Dry Unit Weight (pcf)	161.5
End Planeness	Pass	Area (in^2)	3.099	Moisture Content (%)	2.4

Loading Rate (lbf/sec) 72

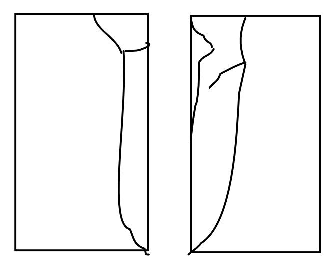
Peak Load (lbf) 16390

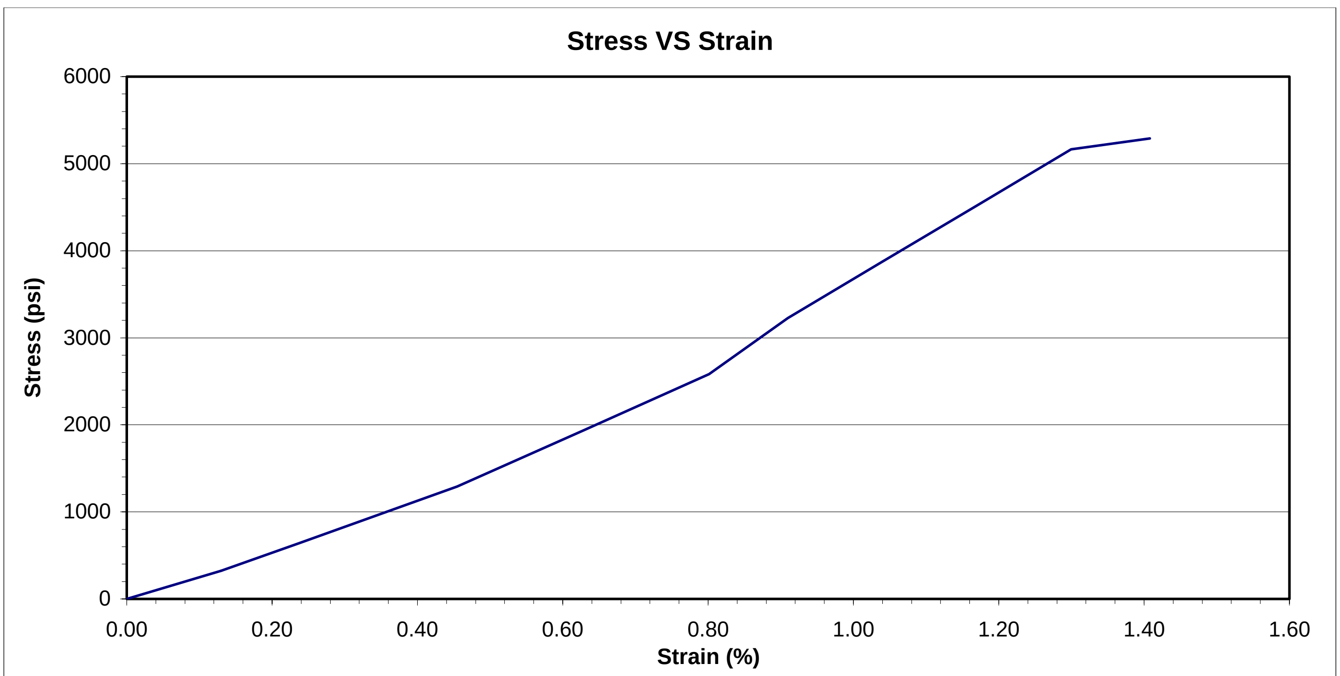
Failure Type Columnar

Compressive Strength (psi) 5290

Compressive Strength (tsf) 381

Failure Sketches





Comments

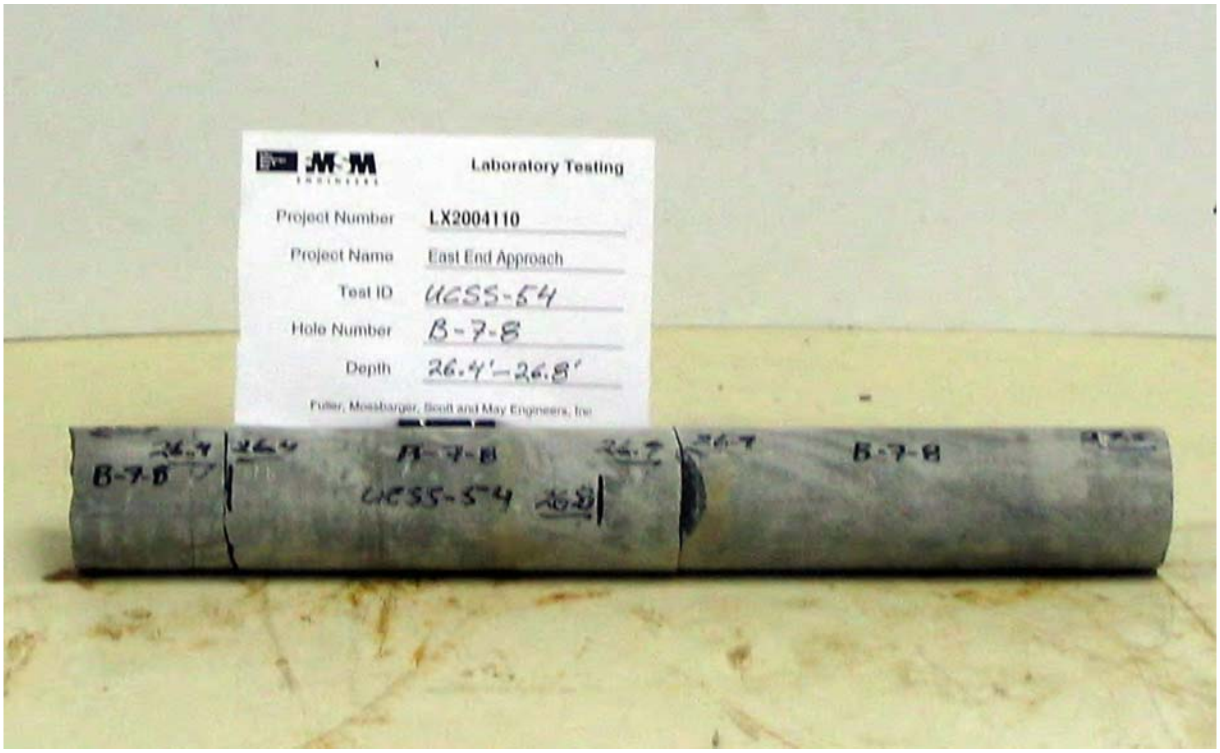
Reviewed By

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Shale, gray, soft	Lab ID	UCSS-54
Hole Number	B-7-8	Depth (ft)	26.4' - 26.8'
Test Type	Unconfined compressive strength of intact rock core		

As received



Core preparation

Photo Report

Project Name LSIORB Section 4, East End Approach

Project Number LX2004110

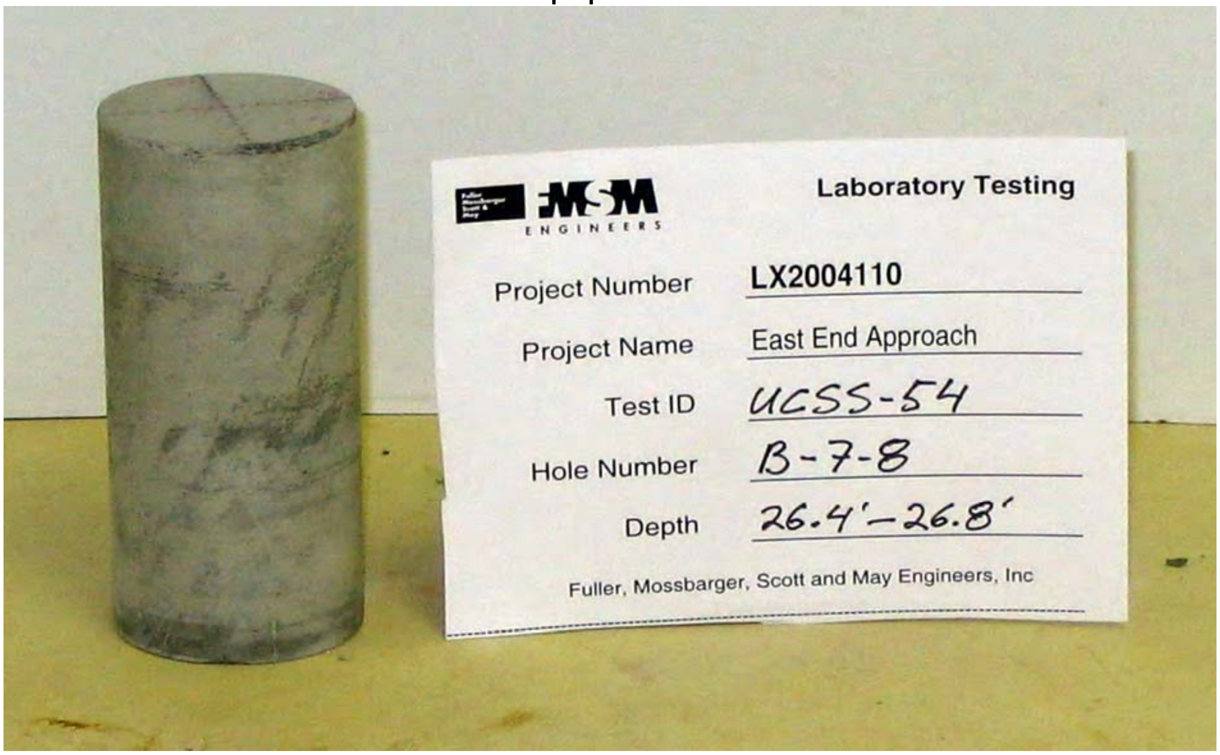
Lithology Shale, gray, soft

Lab ID UCSS-54

Hole Number B-7-8 Depth (ft) 26.4' - 26.8'

Test Type Unconfined compressive strength of intact rock core

Core preparation



Post test

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Shale, gray, soft	Lab ID	UCSS-54
Hole Number	B-7-8 Depth (ft) 26.4' - 26.8'		
Test Type	Unconfined compressive strength of intact rock core		

Post test

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*
ASTM D 2938

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Limestone, gray, moderately hard
Lab ID UCSS-55
Hole Number B-7-10
Depth (ft/elev) 66.2' - 66.8'
Date Received 07-27-2005

Temperature (^{o}C) 22
Moisture Condition As received, dry
Date Tested 08-08-2005

Side Planeness Pass
Perpendicularity Pass
End Planeness Pass

Height (in) 4.775
Diameter (in) 1.994
Area (in^2) 3.124

Wet Unit Weight (pcf) 166.7
Dry Unit Weight (pcf) 166.4
Moisture Content (%) 0.2

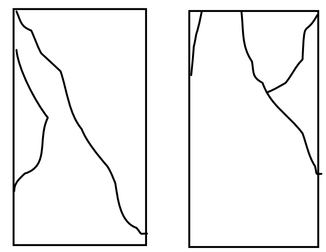
Loading Rate (lbf/sec) 125
Peak Load (lbf) 58540

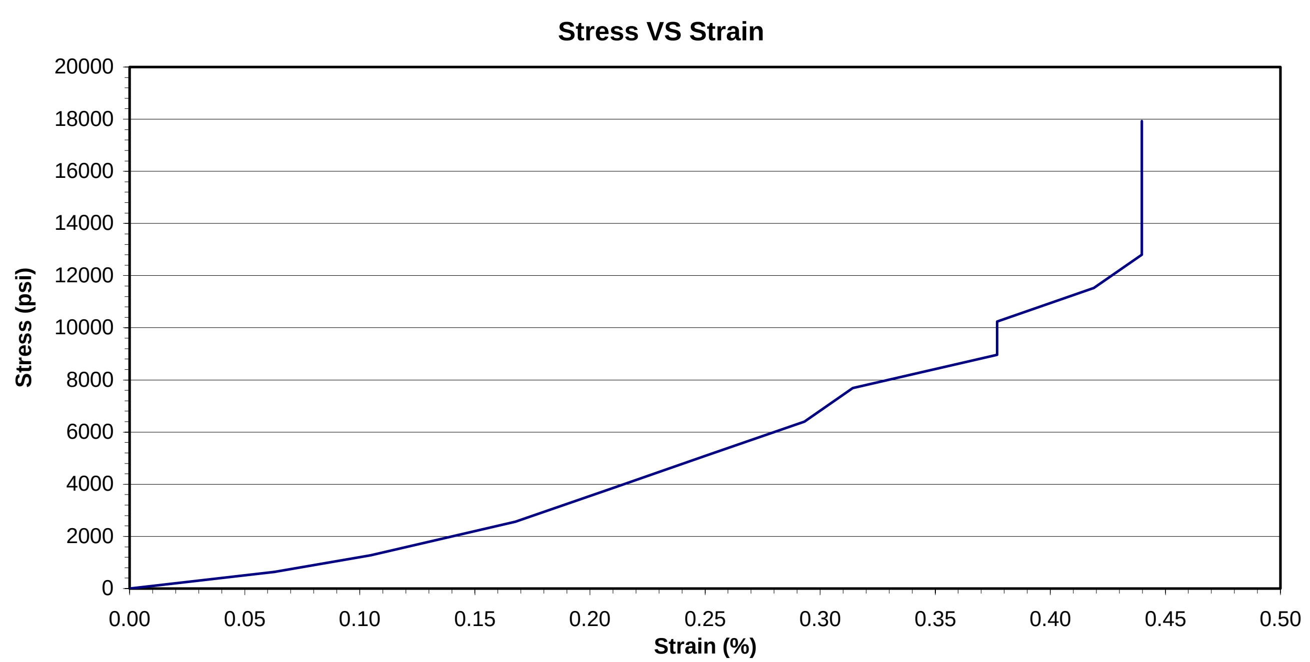
Failure Type Cone and Shear

Compressive Strength (psi) 18740

Compressive Strength (tsf) 1349

Failure Sketches





Comments

Reviewed By

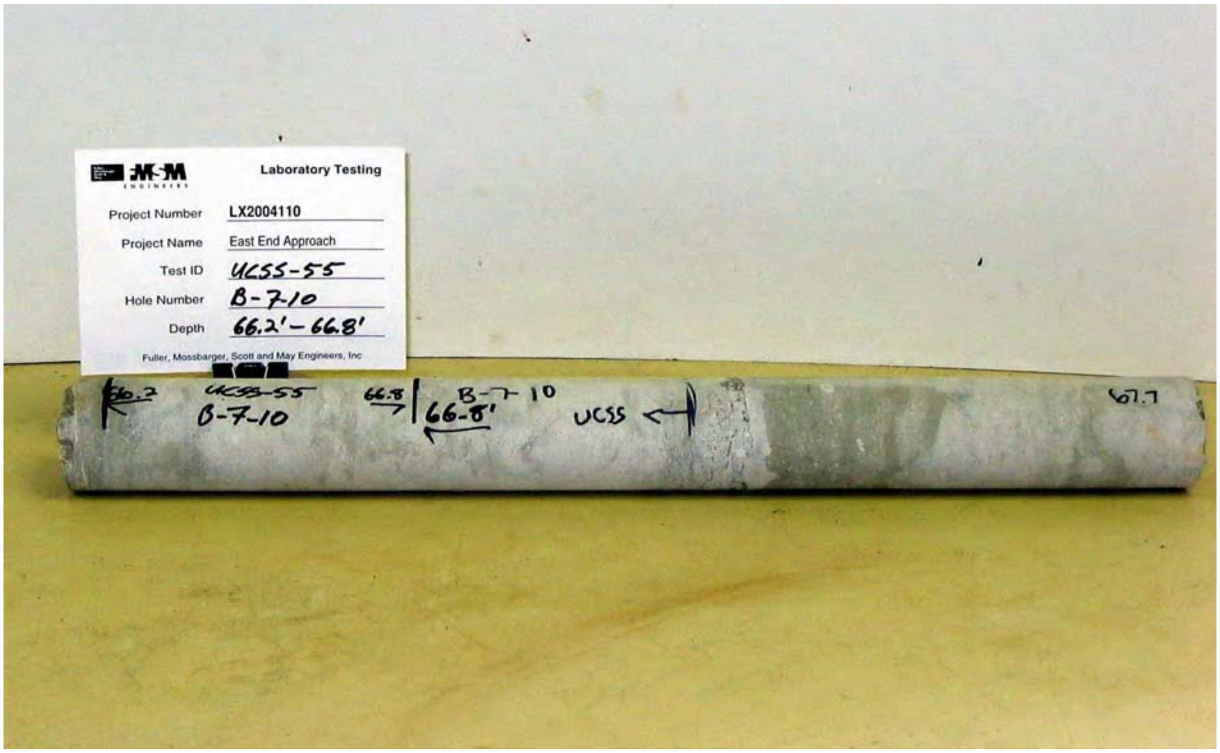
* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

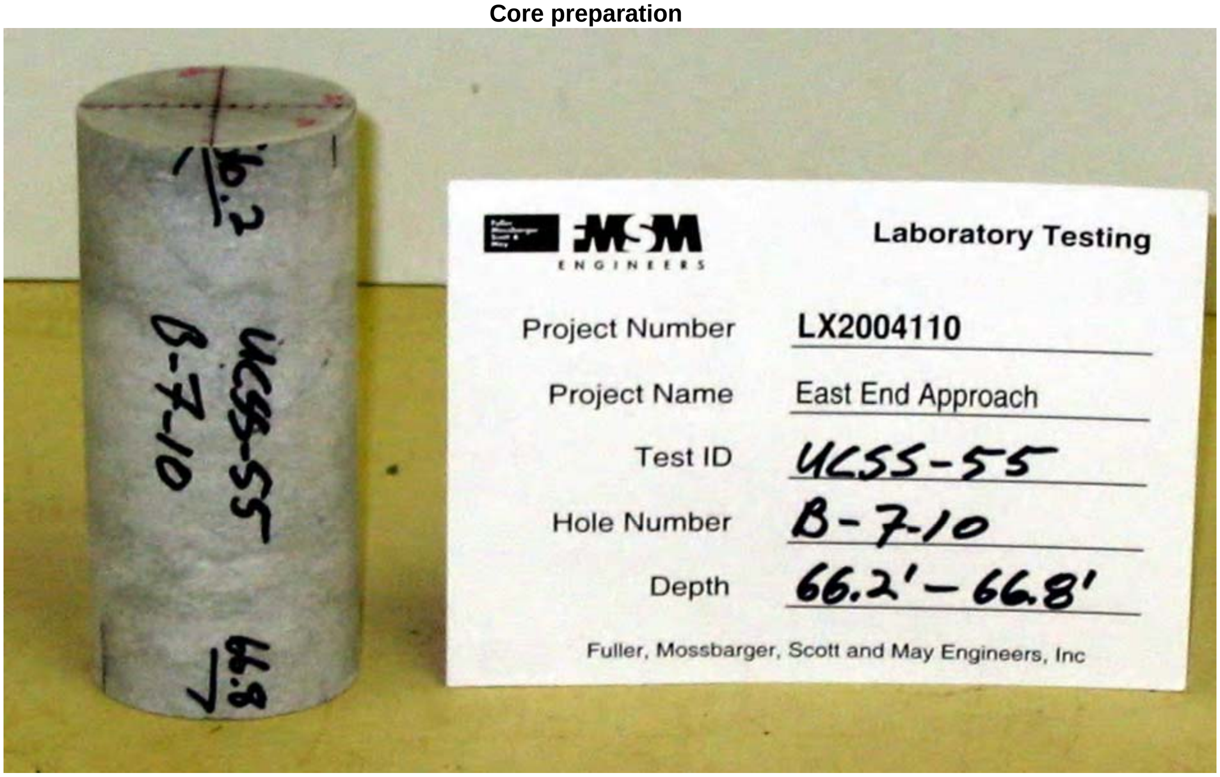
Project Name LSIORB Section 4, East End Approach
Lithology Limestone, gray, moderately hard
Hole Number B-7-10 Depth (ft) 66.2' - 66.8'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-55

As received



Core preparation

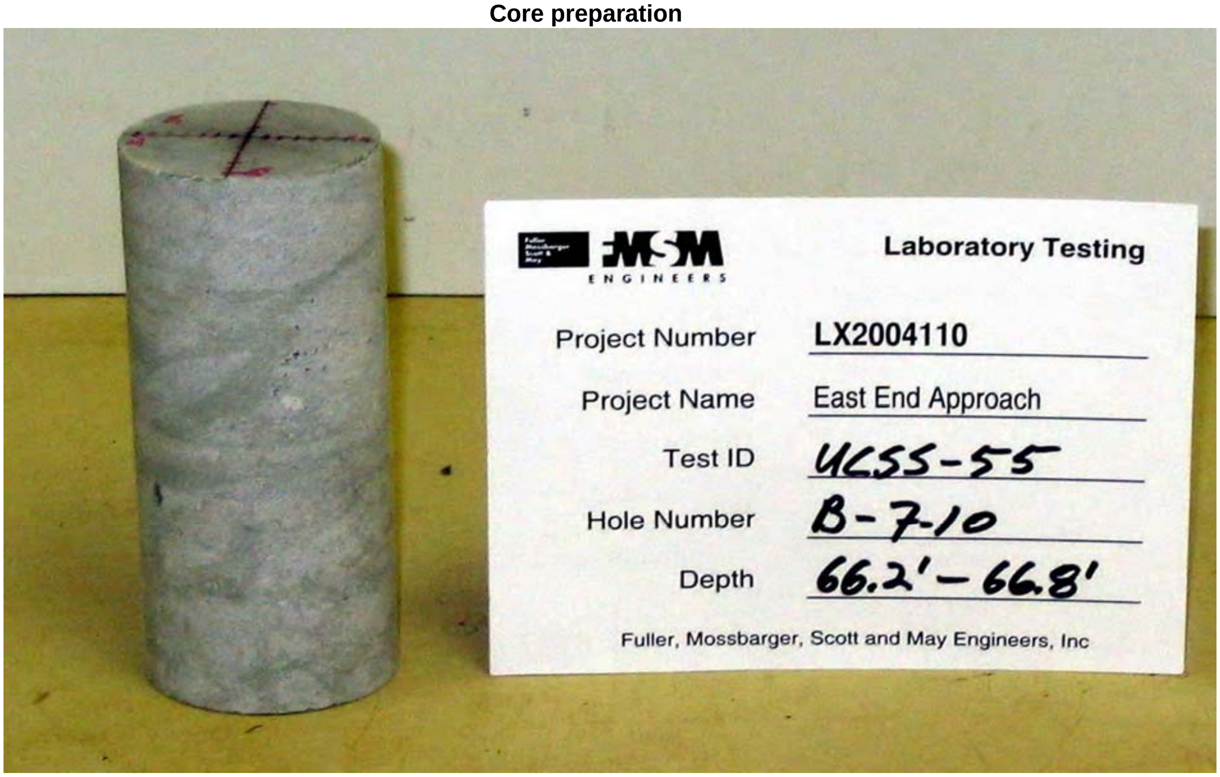


Fuller Mossbarger Scott & May
ENGINEERS

Photo Report

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Limestone, gray, moderately hard
Lab ID UCSS-55
Hole Number B-7-10 Depth (ft) 66.2' - 66.8'
Test Type Unconfined compressive strength of intact rock core

Core preparation



Post test

Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, gray, moderately hard
Hole Number B-7-10 Depth (ft) 66.2' - 66.8'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-55

Post test

Fuller Mossbarger Scott & May ENGINEERS

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Limestone/Dolomite, gray, moderately hard
Lab ID UCSS-56
Hole Number B-7-11
Depth (ft/elev) 7.0' - 7.4'
Date Received 07-27-2005

Temperature (^oC) 23
Moisture Condition As received, dry
Date Tested 08-09-2005

Side Planeness Pass
Height (in) 4.702
Wet Unit Weight (pcf) 158.3
Perpendicularity Pass
Diameter (in) 1.991
Dry Unit Weight (pcf) 157.7
End Planeness Pass
Area (in^2) 3.114
Moisture Content (%) 0.4

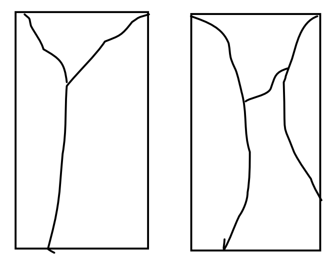
Loading Rate (lbf/sec) 143
Peak Load (lbf) 26170

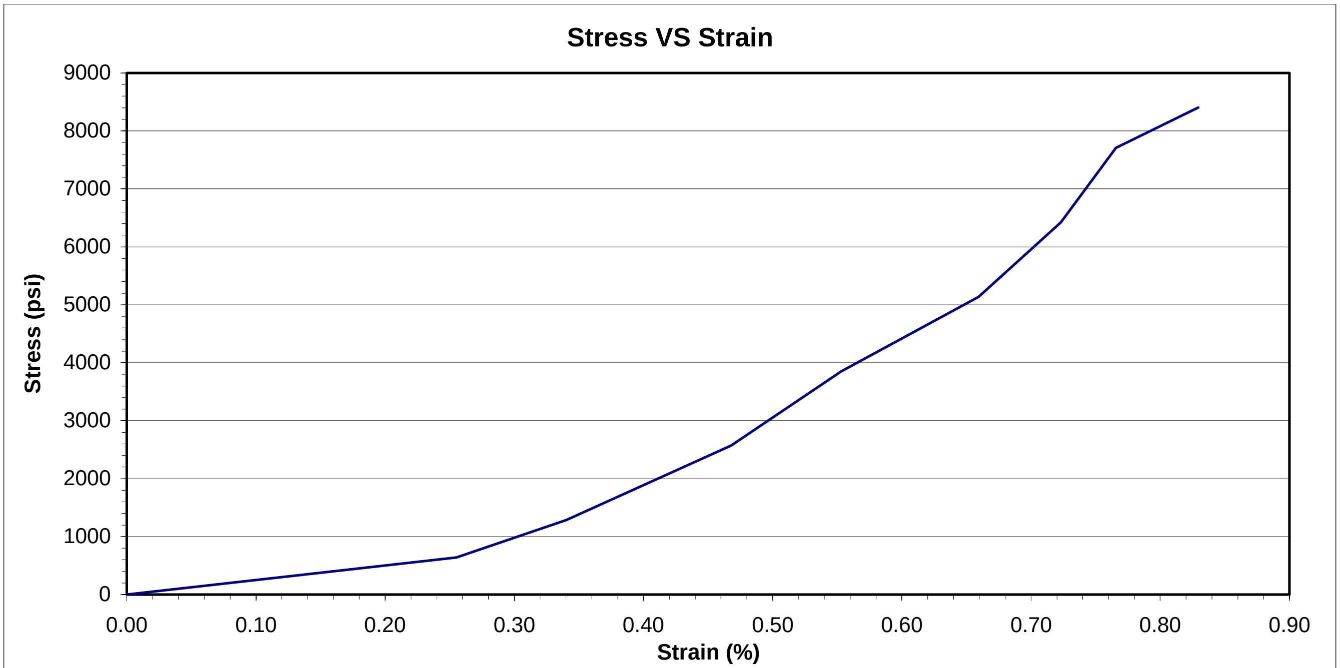
Failure Type Cone and Split

Compressive Strength (psi) 8400

Compressive Strength (tsf) 605

Failure Sketches





Comments ______

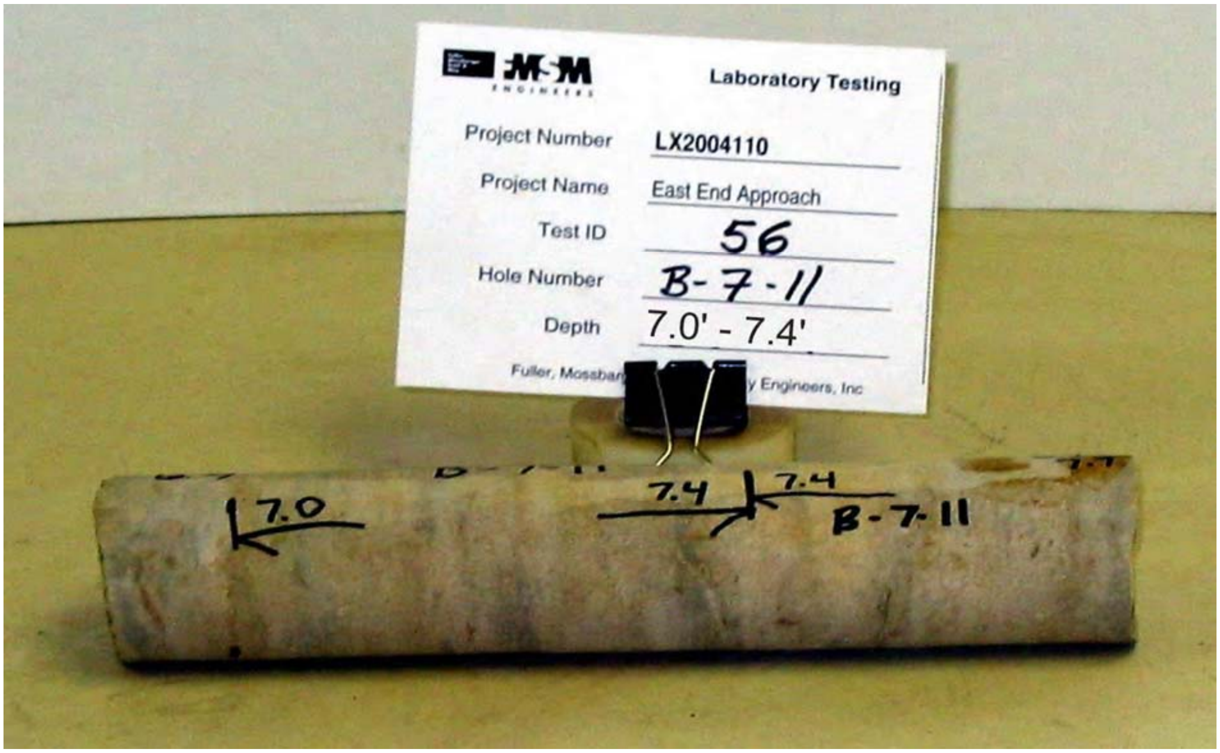
Reviewed By ______

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone/Dolomite, gray, moderately hard	Lab ID	UCSS-56
Hole Number	B-7-11 Depth (ft) 7.0' - 7.4'		
Test Type	Unconfined compressive strength of intact rock core		

As received



Core preparation

Photo Report

Project Name LSIORB Section 4, East End Approach

Lithology Limestone/Dolomite, gray, moderately hard

Hole Number B-7-11 Depth (ft) 7.0' - 7.4'

Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110

Lab ID UCSS-56

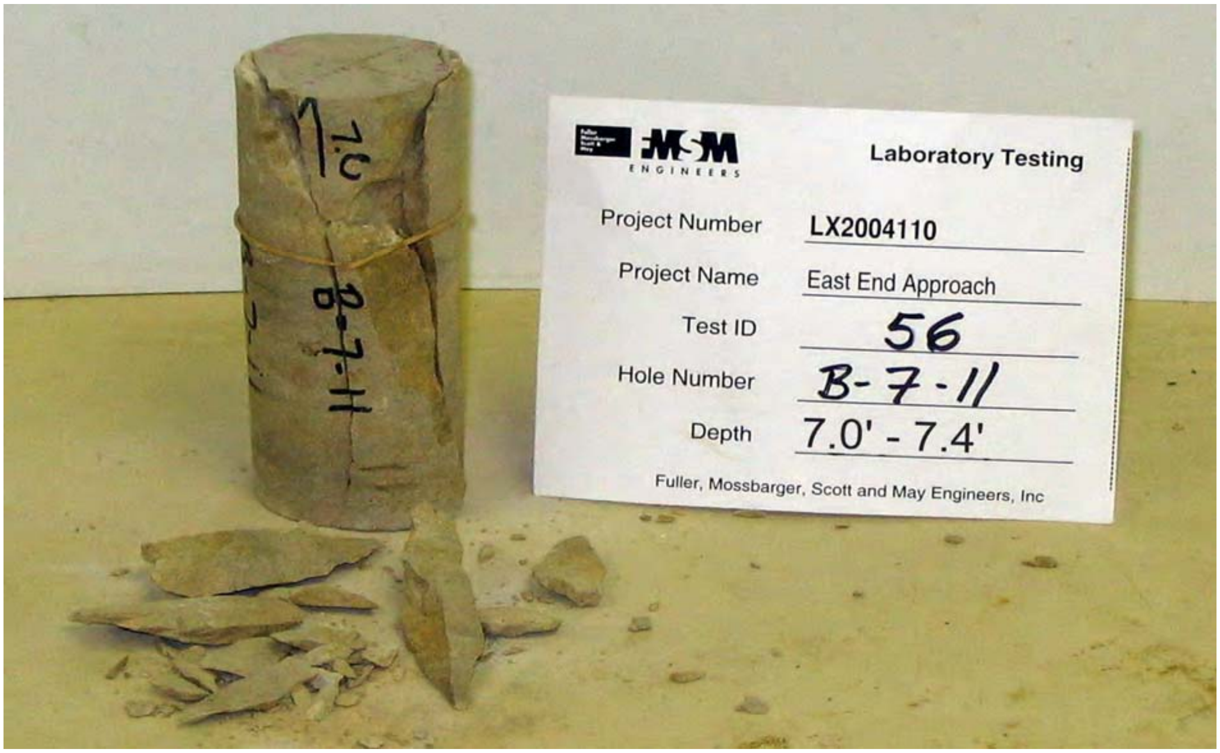
Core preparation

Post test

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone/Dolomite, gray, moderately hard	Lab ID	UCSS-56
Hole Number	B-7-11 Depth (ft) 7.0' - 7.4'		
Test Type	Unconfined compressive strength of intact rock core		

Post test



ENGINEERS

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Shale, dark gray, soft
Lab ID UCSS-58
Hole Number B-12-3
Depth (ft/elev) 66.5' - 66.9'
Date Received 07-27-2005

Temperature (^{o}C) 22
Moisture Condition As received, dry
Date Tested 08-09-2005

Side Planeness	Fail	Height (in)	4.948	Wet Unit Weight (pcf)	163.6
Perpendicularity	Pass	Diameter (in)	1.978	Dry Unit Weight (pcf)	161.0
End Planeness	3 of 4 Pass	Area (in^2)	3.073	Moisture Content (%)	1.6

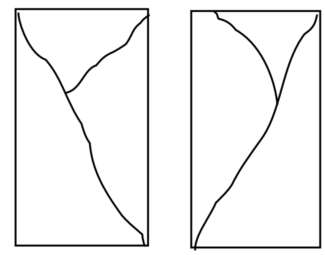
Loading Rate (lbf/sec) 104
Peak Load (lbf) 28840

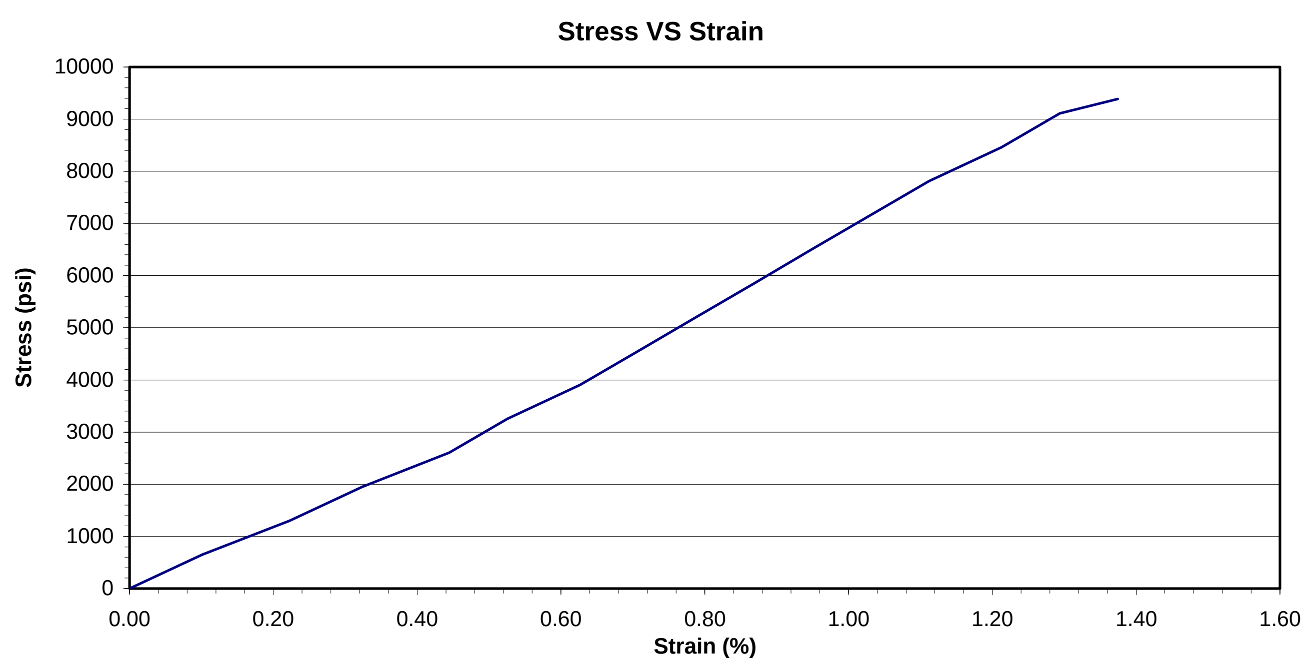
Failure Type Cone and Shear

Compressive Strength (psi) 9390

Compressive Strength (tsf) 676

Failure Sketches





Comments Fragile nature of specimen inhibited preparation.

Reviewed By

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Shale, dark gray, soft
Hole Number B-12-3 Depth (ft) 66.5' - 66.9'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-58

As received

Core preparation

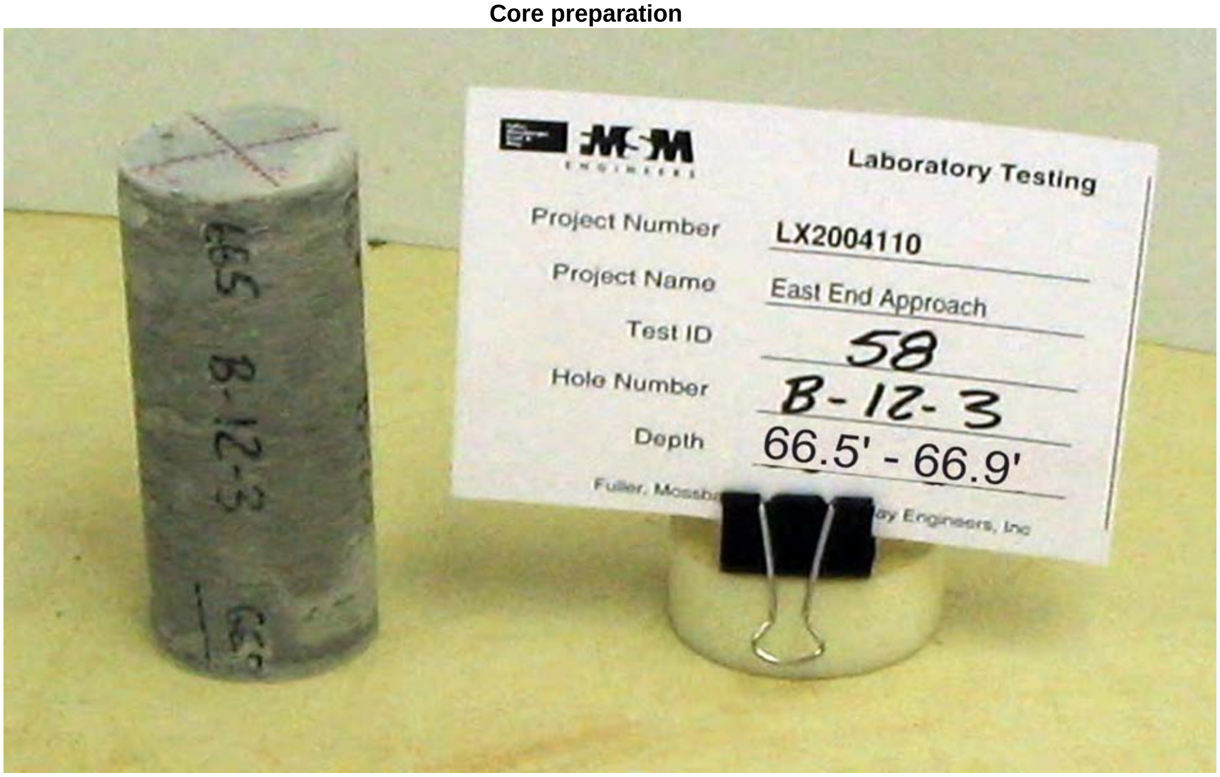


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Shale, dark gray, soft	Lab ID	UCSS-58
Hole Number	B-12-3 Depth (ft) 66.5' - 66.9'		
Test Type	Unconfined compressive strength of intact rock core		

Core preparation

Post test

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

FMSM Engineers — Fuller Mossbarger Scott & May

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Limestone, light gray, hard
Lab ID UCSS-60
Hole Number B-12-5
Depth (ft/elev) 96.3' - 96.7'
Date Received 07-27-2005

Temperature (°C) 22
Moisture Condition As received, dry
Date Tested 08-09-2005

Side Planeness	Pass	Height (in)	4.777	Wet Unit Weight (pcf)	168.0
Perpendicularity	Pass	Diameter (in)	1.986	Dry Unit Weight (pcf)	167.9
End Planeness	Pass	Area (in^2)	3.097	Moisture Content (%)	0.1

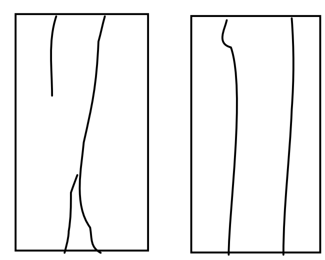
Loading Rate (lbf/sec) 242
Peak Load (lbf) 72400

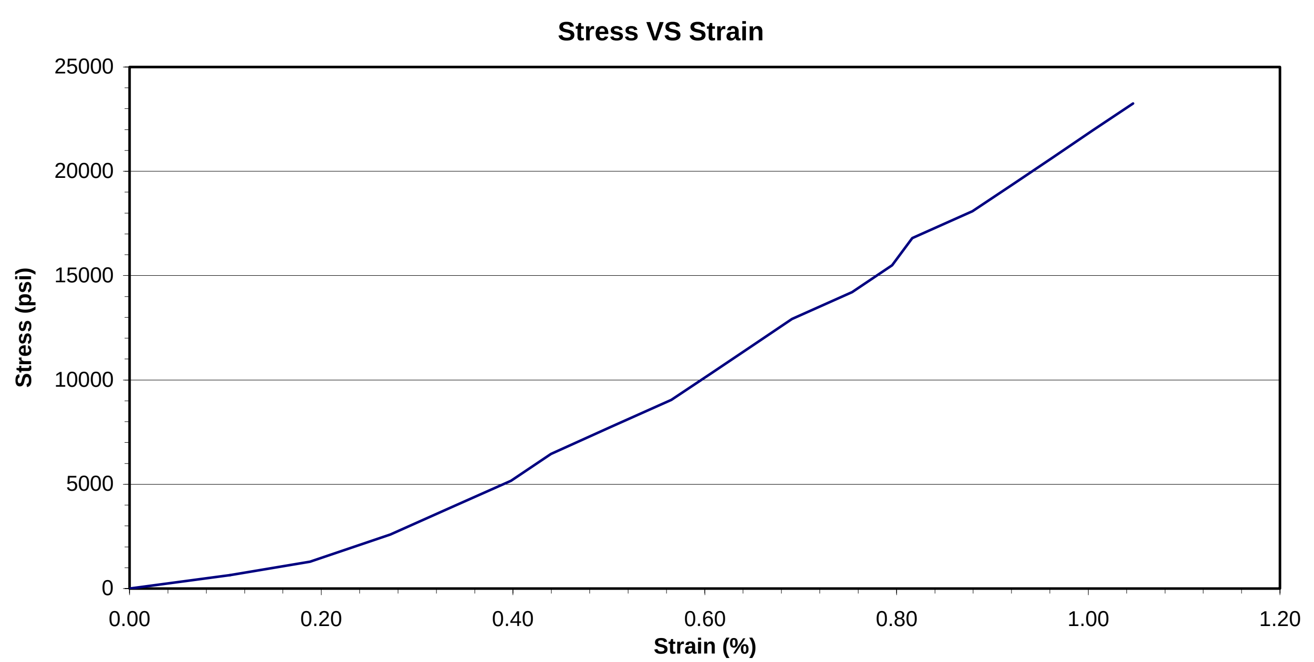
Failure Type Columnar

Compressive Strength (psi) 23380

Compressive Strength (tsf) 1683

Failure Sketches





Comments

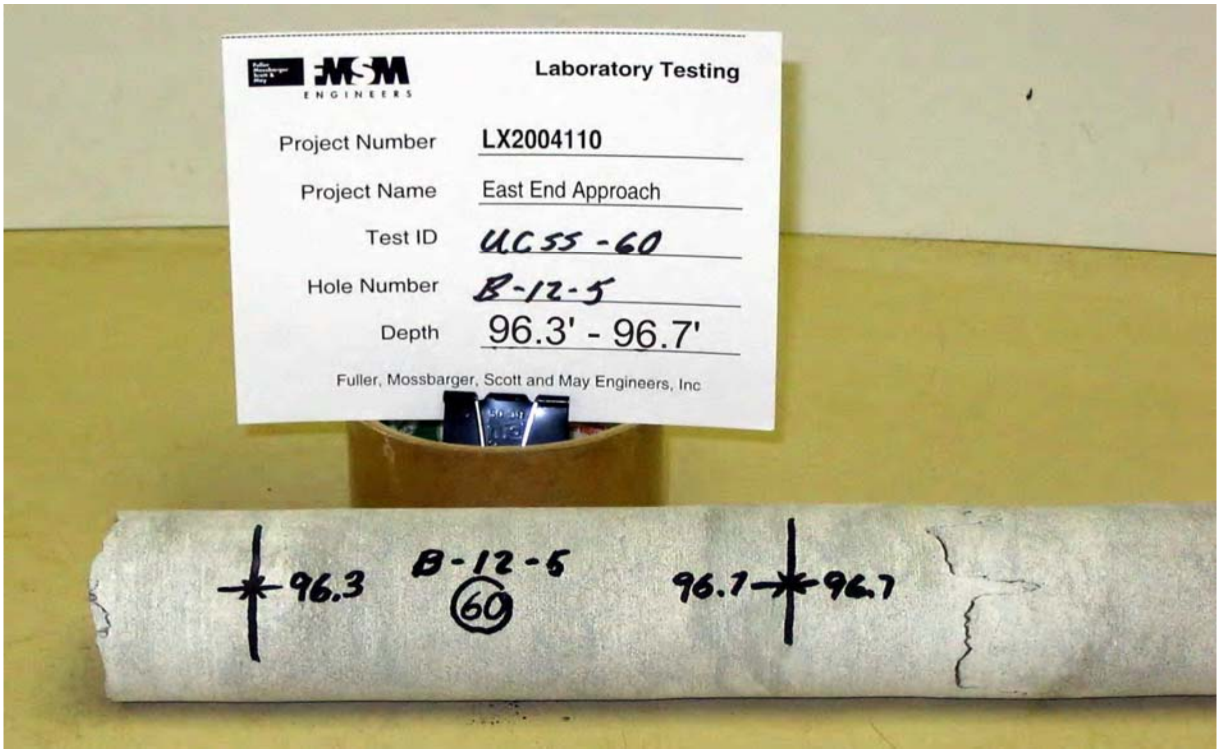
Reviewed By

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, light gray, hard	Lab ID	UCSS-60
Hole Number	B-12-5 Depth (ft) 96.3' - 96.7'		
Test Type	Unconfined compressive strength of intact rock core		

As received



Core preparation

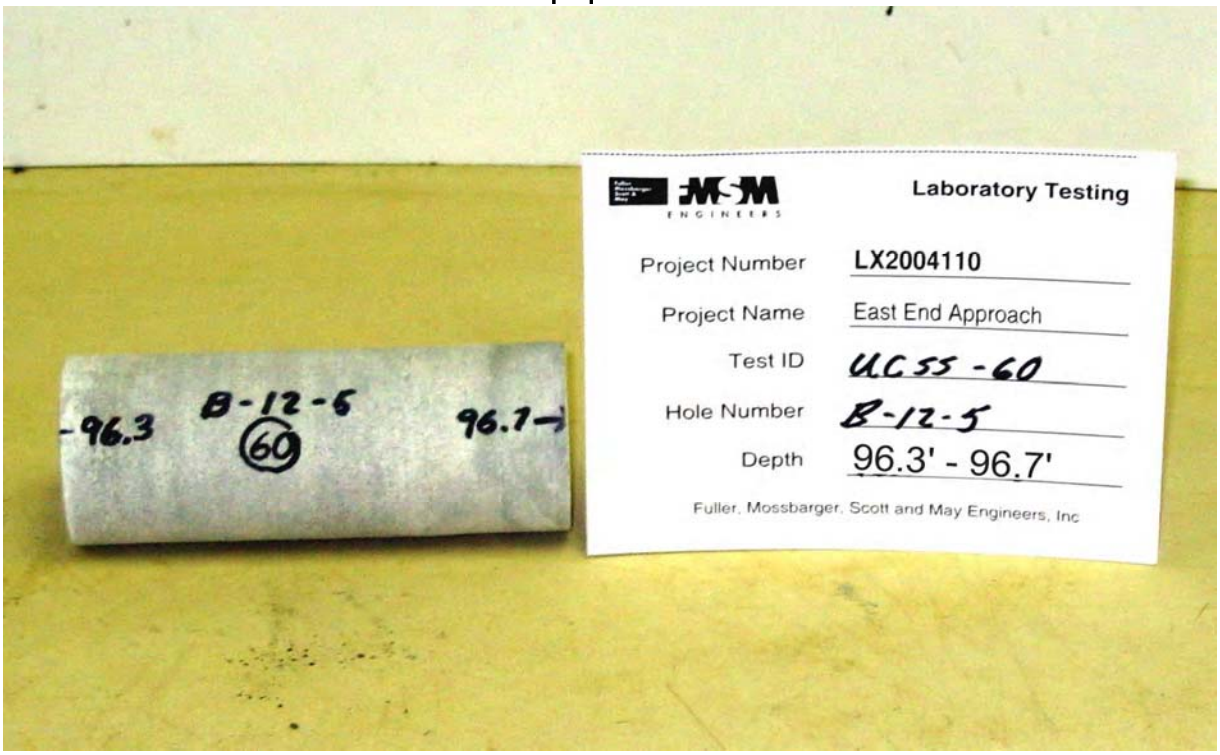
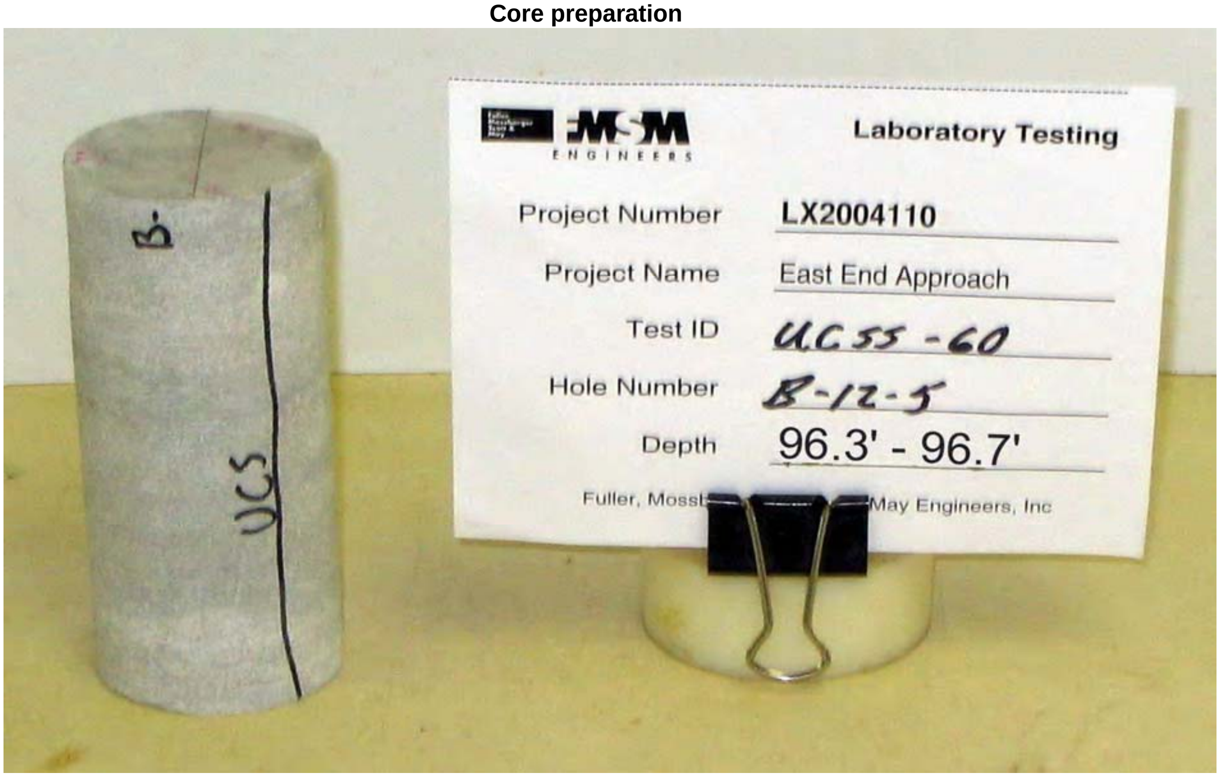


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, light gray, hard	Lab ID	UCSS-60
Hole Number	B-12-5 Depth (ft) 96.3' - 96.7'		
Test Type	Unconfined compressive strength of intact rock core		

Core preparation



Post test

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

Fuller Mossbarger Scott & May ENGINEERS

Project Name	LSIORB Section 4, East End Approach			Project Number	LX2004110
Lithology	Red Shale, redish brown, soft			Lab ID	UCSS-61
Hole Number	B-12-6	Depth (ft/elev)	123.7' - 124.1'	Date Received	07-27-2005
Temperature (^{o}C)	22	Moisture Condition	As received, dry	Date Tested	08-09-2005
Side Planeness	Fail	Height (in)	4.916	Wet Unit Weight (pcf)	158.0
Perpendicularity	Pass	Diameter (in)	1.983	Dry Unit Weight (pcf)	155.3
End Planeness	Pass	Area (in^2)	3.088	Moisture Content (%)	1.7

Loading Rate (lbf/sec) 39

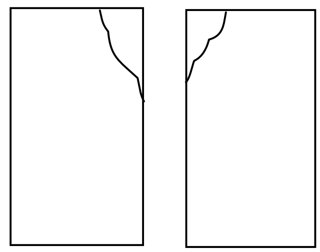
Peak Load (lbf) 5870

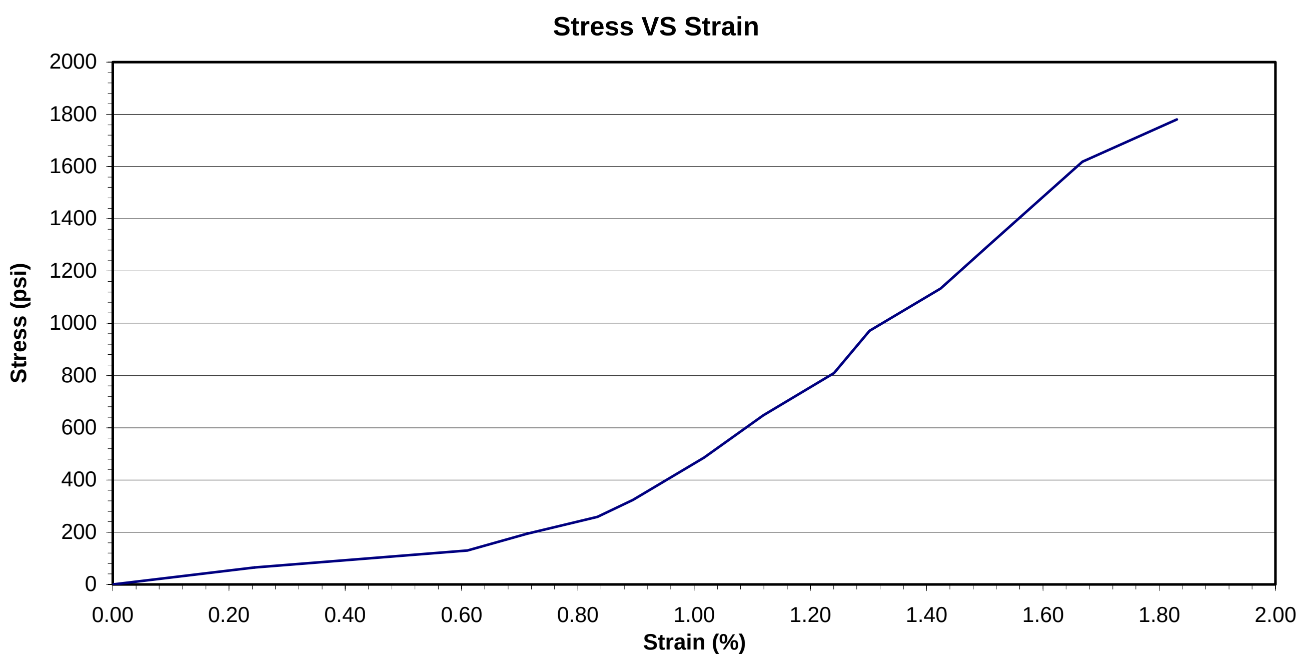
Failure Type Shear

Compressive Strength (psi) 1900

Compressive Strength (tsf) 137

Failure Sketches





Comments ______

Reviewed By ______

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

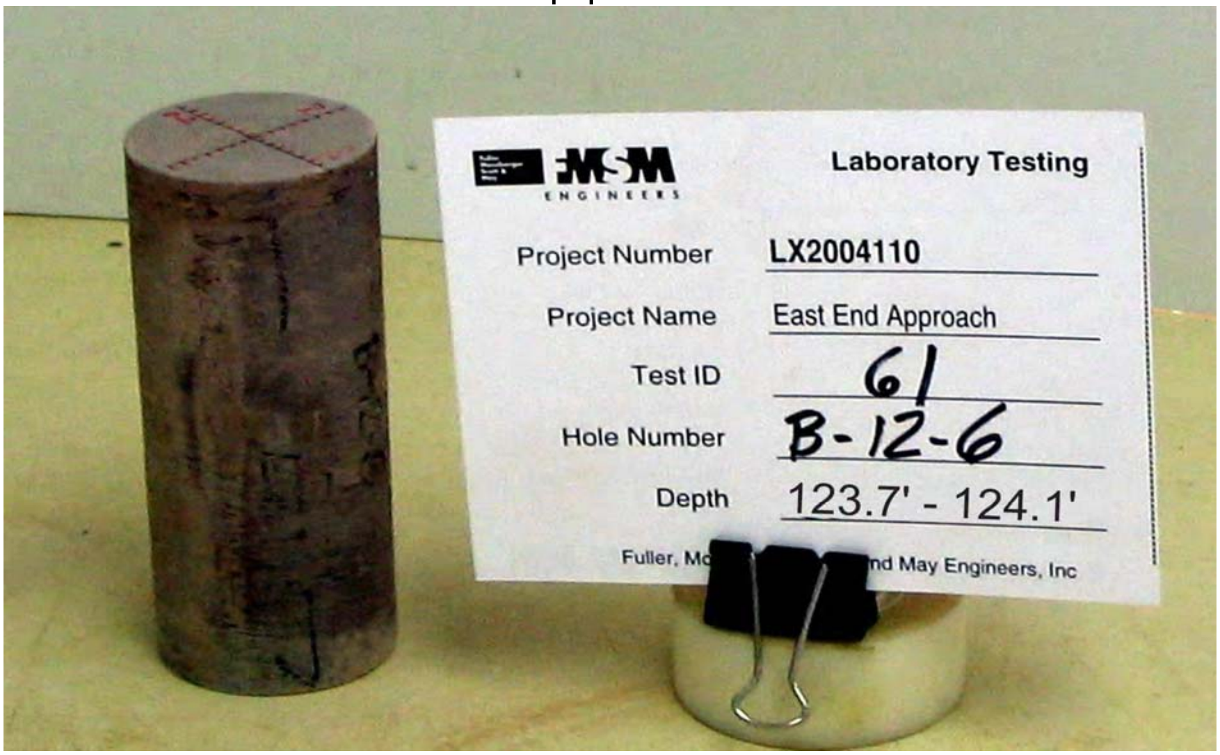
Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Red Shale, redish brown, soft
Hole Number B-12-6 Depth (ft) 123.7' - 124.1'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-61

As received

Core preparation



Fuller Mossbarger Scott & May
FMSM ENGINEERS

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Red Shale, redish brown, soft	Lab ID	UCSS-61
Hole Number	B-12-6 Depth (ft) 123.7' - 124.1'		
Test Type	Unconfined compressive strength of intact rock core		

Core preparation

Post test

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Red Shale, redish brown, soft	Lab ID	UCSS-61
Hole Number	B-12-6 Depth (ft) 123.7' - 124.1'		
Test Type	Unconfined compressive strength of intact rock core		

Post test

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*
ASTM D 2938

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Limestone, gray, moderately hard
Lab ID UCSS-63
Hole Number B-12-9
Depth (ft/elev) 33.2' - 33.6'
Date Received 07-27-2005

Temperature (^oC) 23
Moisture Condition As received, dry
Date Tested 08-10-2005

Side Planeness Pass
Perpendicularity Pass
End Planeness Pass

Height (in) 4.521
Diameter (in) 1.985
Area (in^2) 3.095

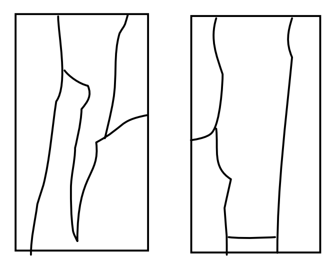
Wet Unit Weight (pcf) 166.2
Dry Unit Weight (pcf) 166.0
Moisture Content (%) 0.1

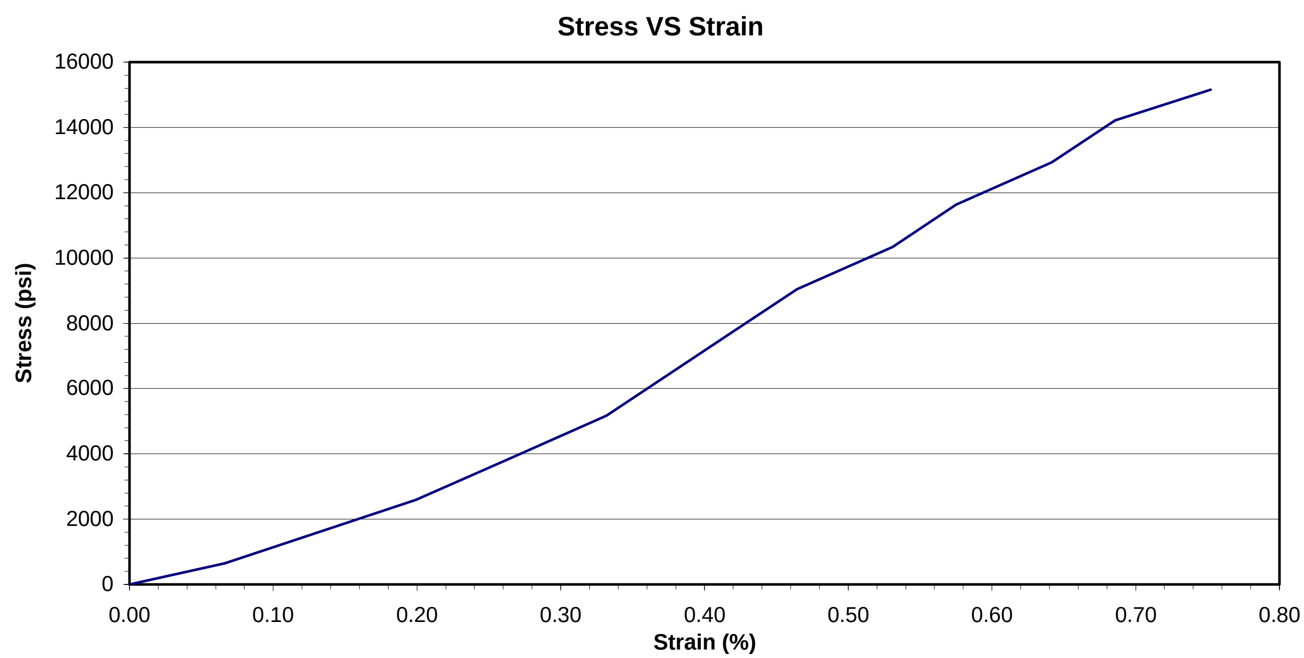
Loading Rate (lbf/sec) 194
Peak Load (lbf) 46900

Failure Type Columnar

Compressive Strength (psi) 15160

Compressive Strength (tsf) 1091

Failure Sketches




Comments

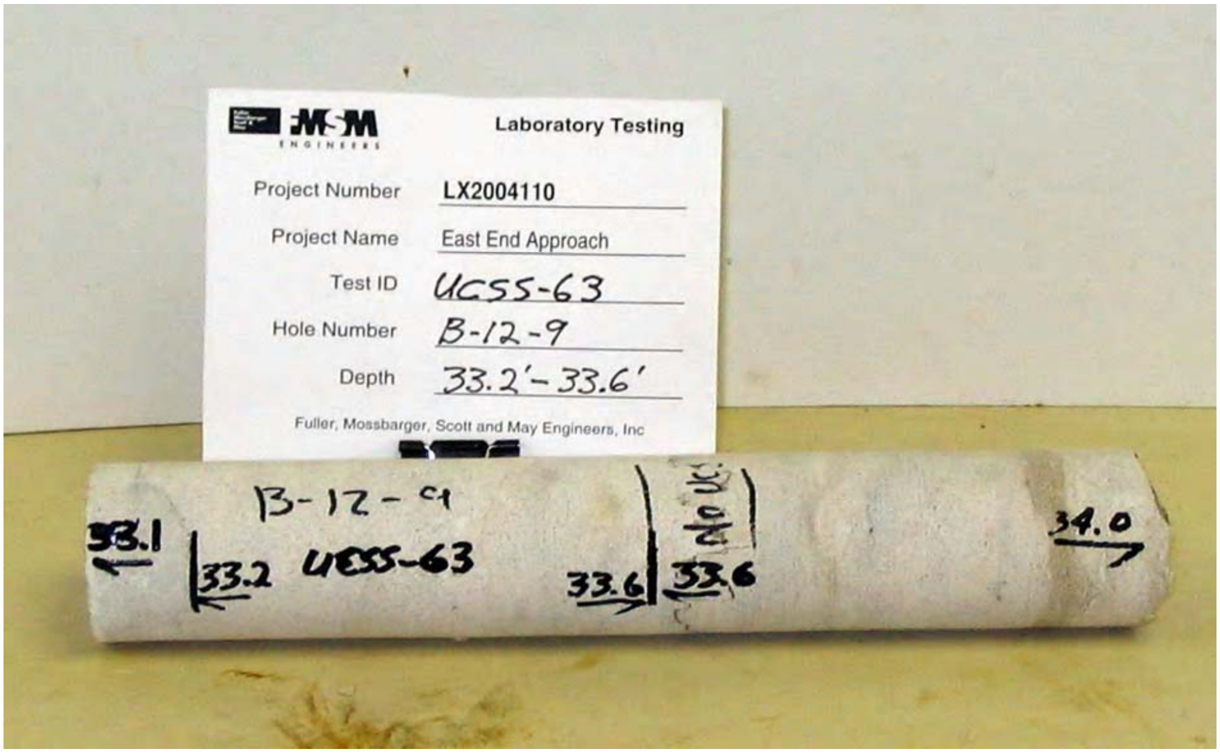
Reviewed By

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

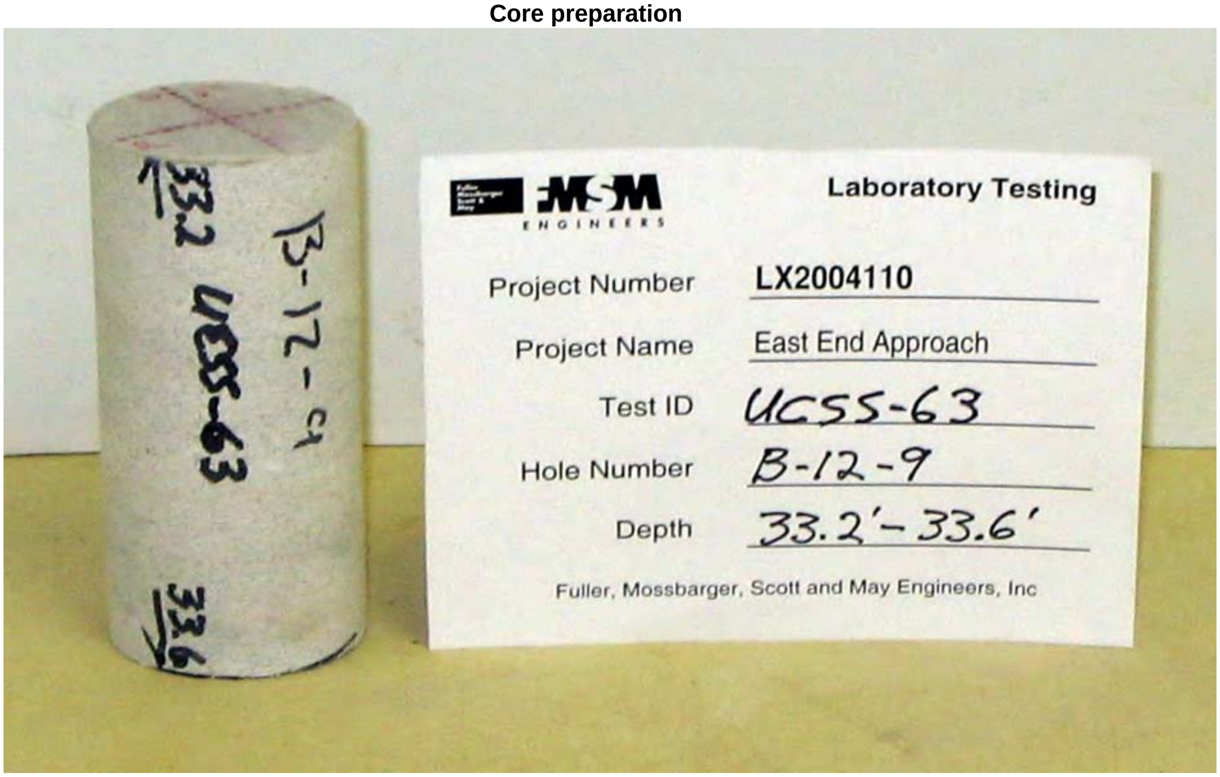
Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, gray, moderately hard	Lab ID	UCSS-63
Hole Number	B-12-9 Depth (ft) 33.2' - 33.6'		
Test Type	Unconfined compressive strength of intact rock core		

As received



Core preparation



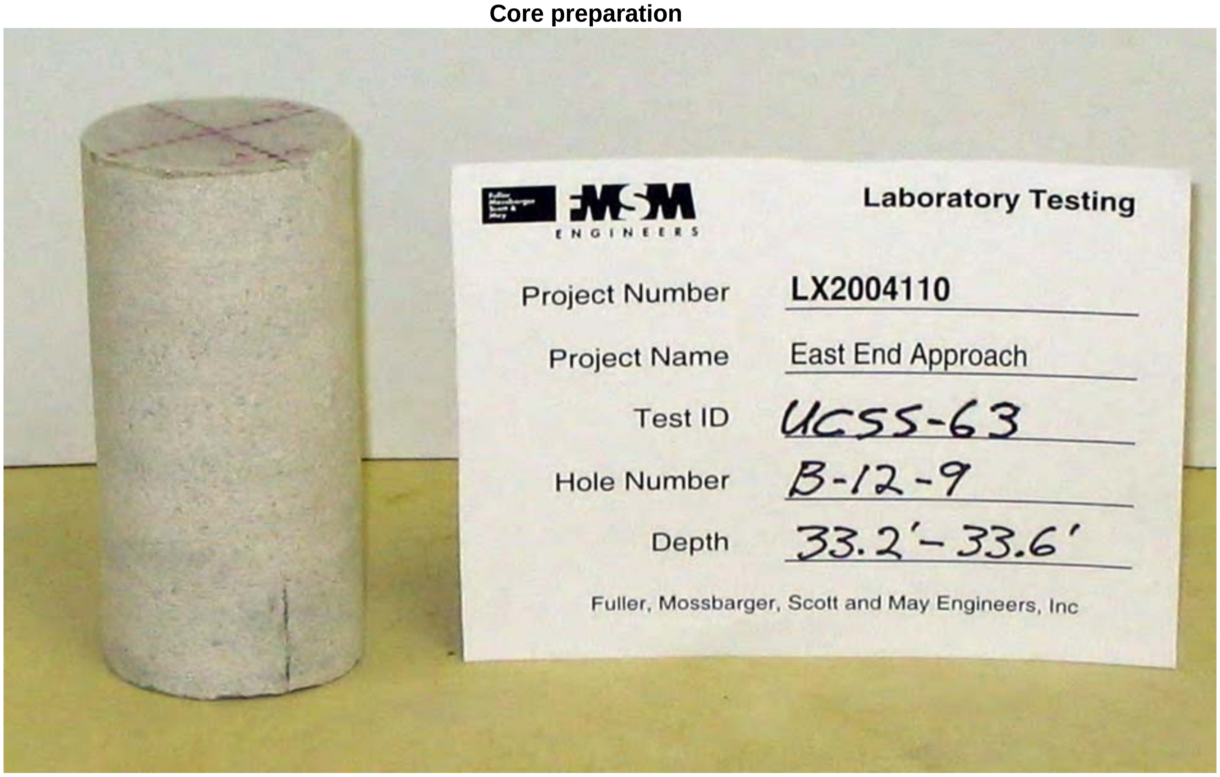
Fuller Mossbarger Scott & May
FMSM
ENGINEERS

Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, gray, moderately hard
Hole Number B-12-9 Depth (ft) 33.2' - 33.6'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-63

Core preparation



Post test

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

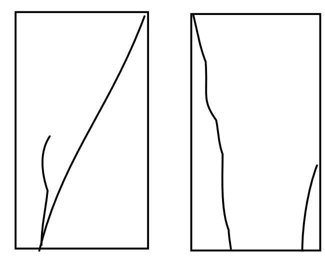
ASTM D 2938

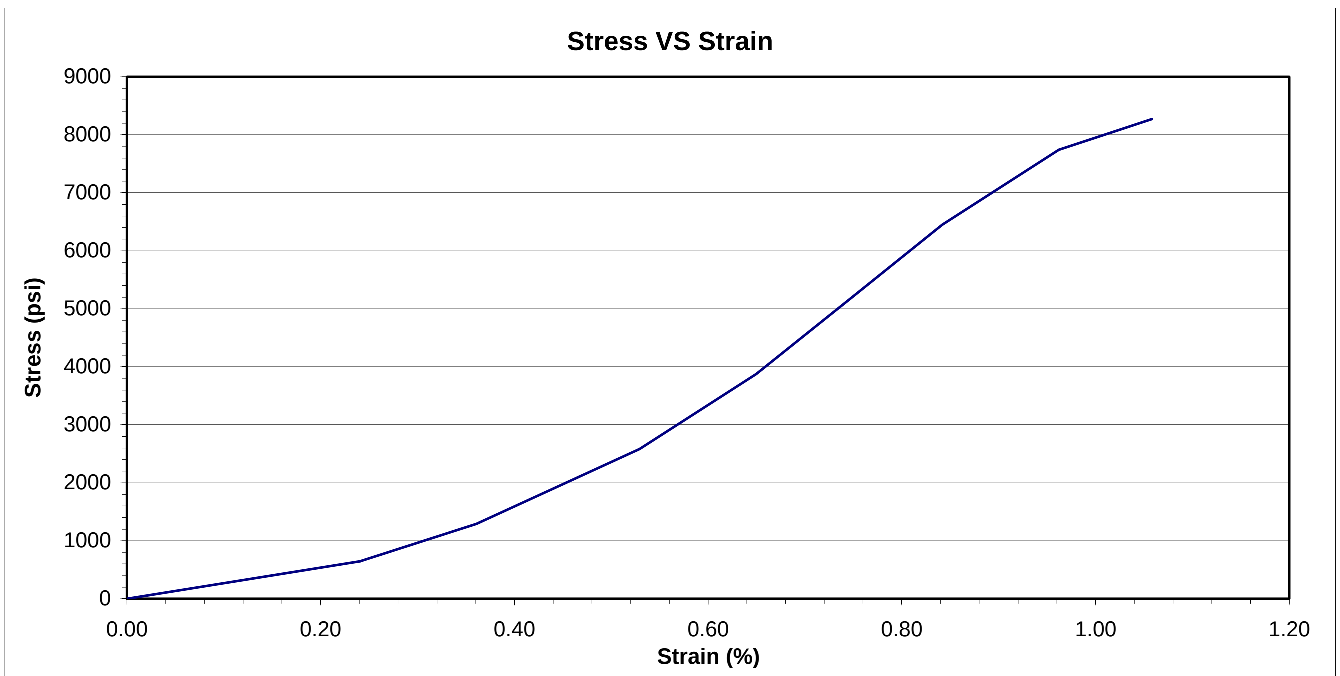
FMSM ENGINEERS (Fuller Mossbarger Scott & May)

Project Name	LSIORB Section 4, East End Approach			Project Number	LX2004110
Lithology	Limestone, gray, moderately hard			Lab ID	UCSS-64
Hole Number	B-12-10	Depth (ft/elev)	52.6' - 53.0'	Date Received	07-27-2005
Temperature (^oC)	22	Moisture Condition	As received, dry	Date Tested	08-09-2005
Side Planeness	Pass	Height (in)	4.157	Wet Unit Weight (pcf)	166.2
Perpendicularity	Pass	Diameter (in)	1.987	Dry Unit Weight (pcf)	166.1
End Planeness	Pass	Area (in^2)	3.100	Moisture Content (%)	0.1

Loading Rate (lbf/sec)	110
Peak Load (lbf)	25640
Failure Type	Shear
Compressive Strength (psi)	8270
Compressive Strength (tsf)	596

Failure Sketches





Comments ______________________

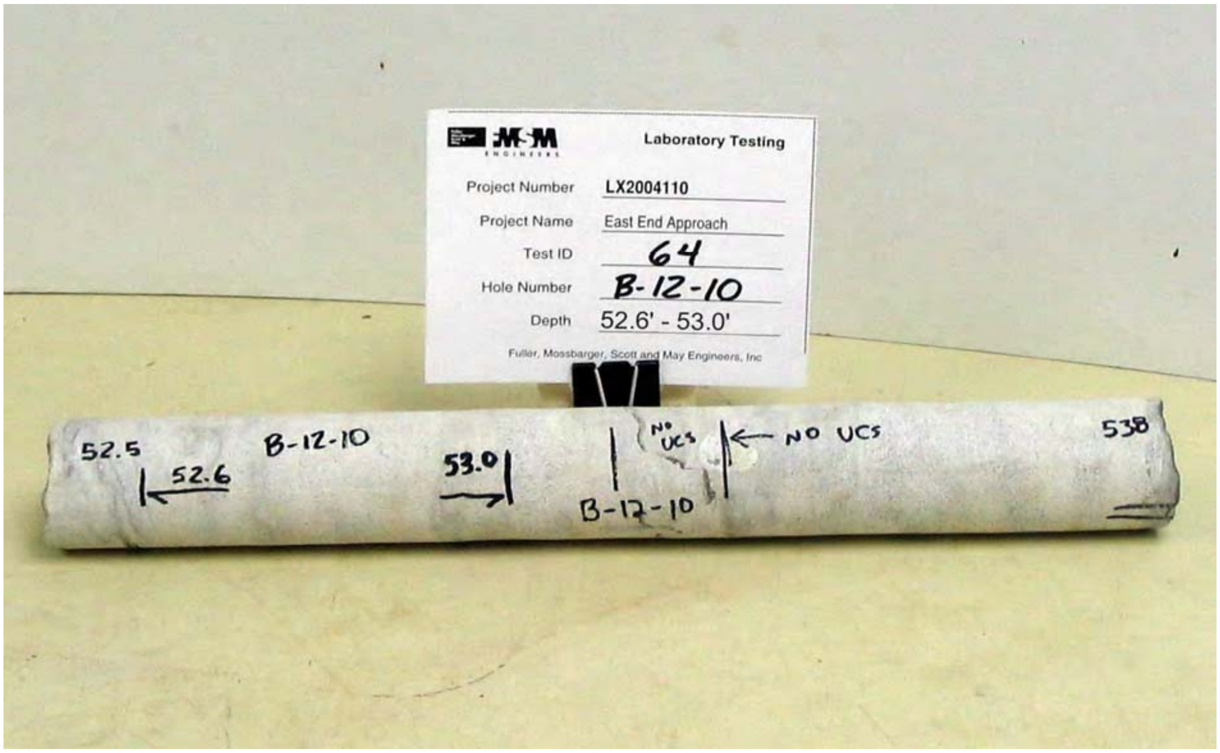
Reviewed By ___________

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Limestone, gray, moderately hard
Lab ID UCSS-64
Hole Number B-12-10 Depth (ft) 52.6' - 53.0'
Test Type Unconfined compressive strength of intact rock core

As received



Core preparation

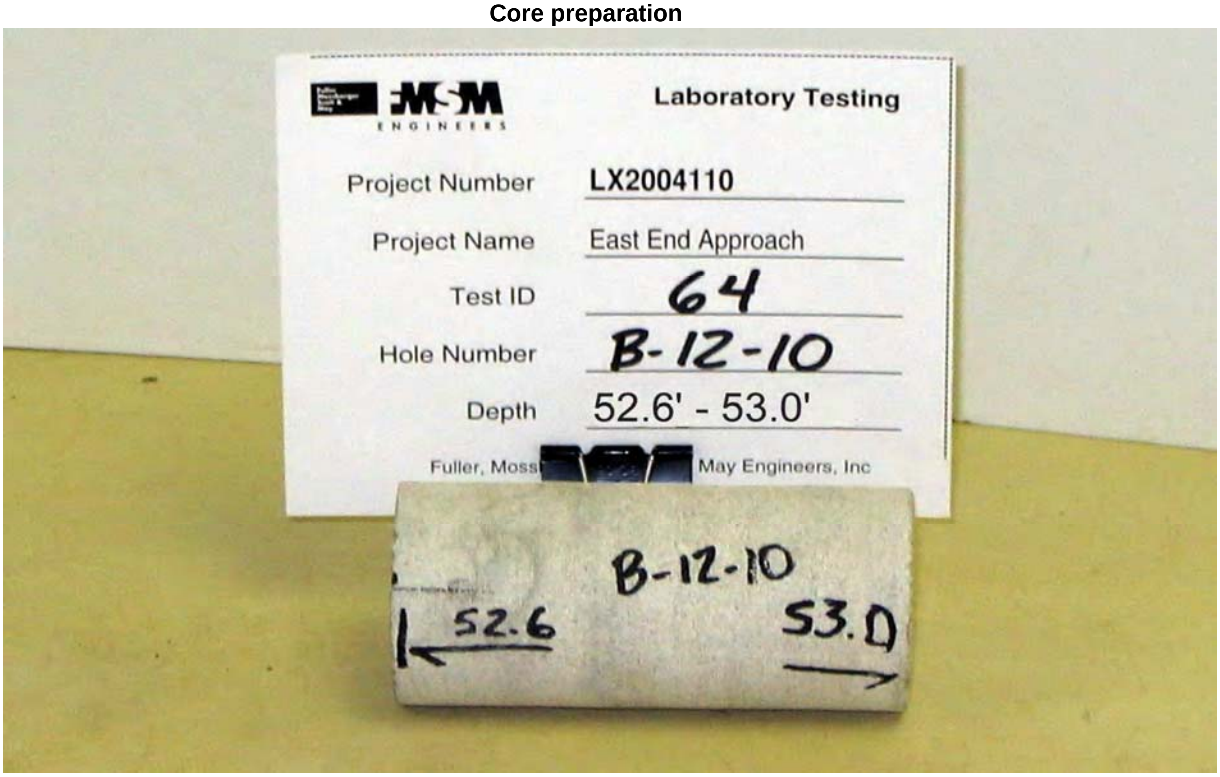
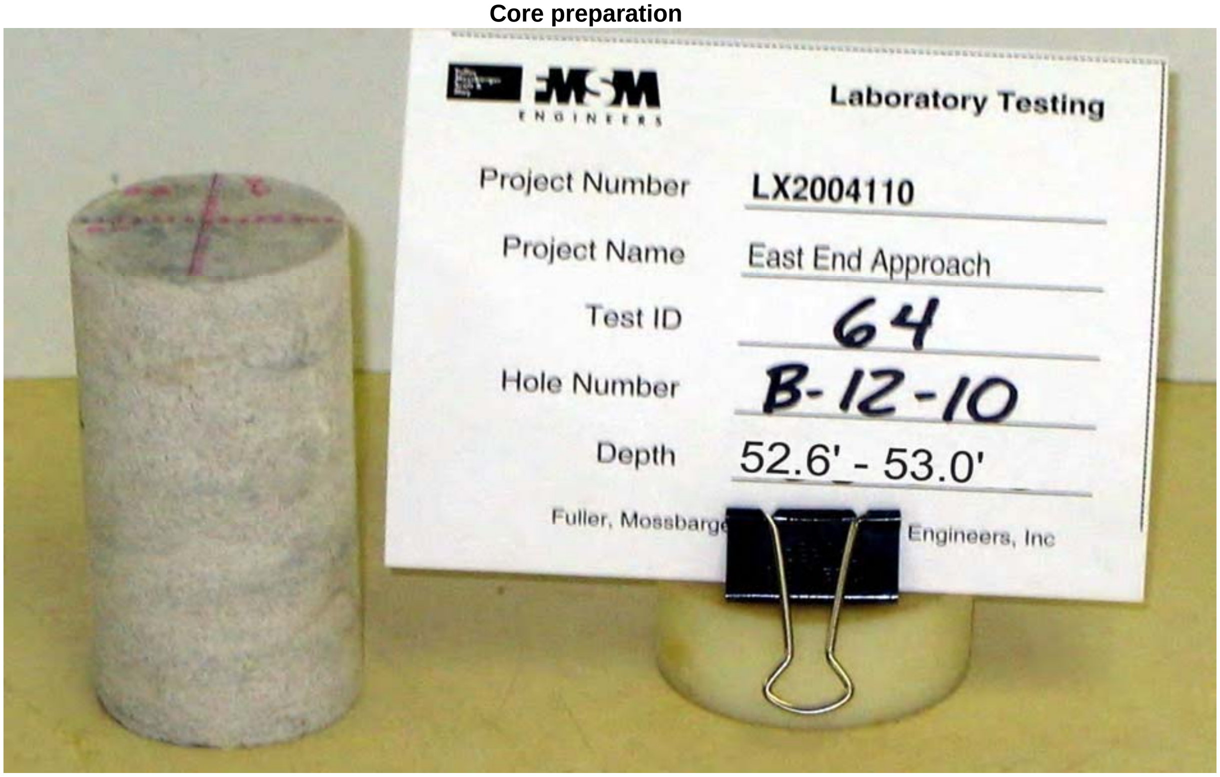


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, gray, moderately hard	Lab ID	UCSS-64
Hole Number	B-12-10	Depth (ft)	52.6' - 53.0'
Test Type	Unconfined compressive strength of intact rock core		

Core preparation



Post test

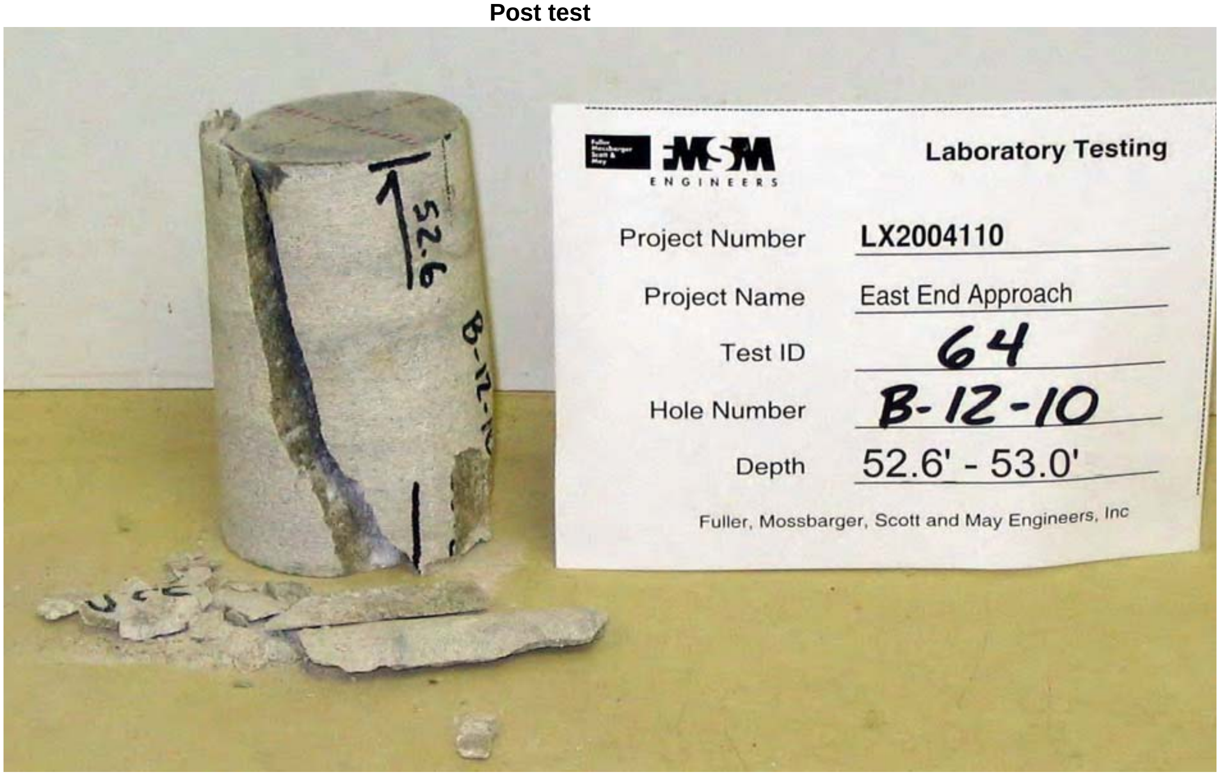


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, gray, moderately hard	Lab ID	UCSS-64
Hole Number	B-12-10	Depth (ft)	52.6' - 53.0'
Test Type	Unconfined compressive strength of intact rock core		

Post test

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Limestone, gray, moderately hard
Lab ID UCSS-65
Hole Number B-13-2
Depth (ft/elev) 43.0' - 43.4'
Date Received 07-27-2005

Temperature (^oC) 22
Moisture Condition As received, dry
Date Tested 08-09-2005

Side Planeness Pass
Perpendicularity Pass
End Planeness Pass

Height (in) 4.649
Diameter (in) 1.991
Area (in^2) 3.112

Wet Unit Weight (pcf) 168.6
Dry Unit Weight (pcf) 168.5
Moisture Content (%) 0.1

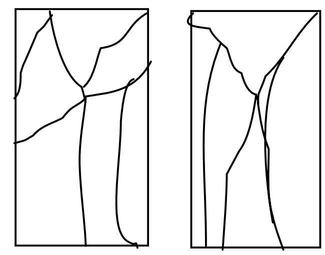
Loading Rate (lbf/sec) 236
Peak Load (lbf) 65650

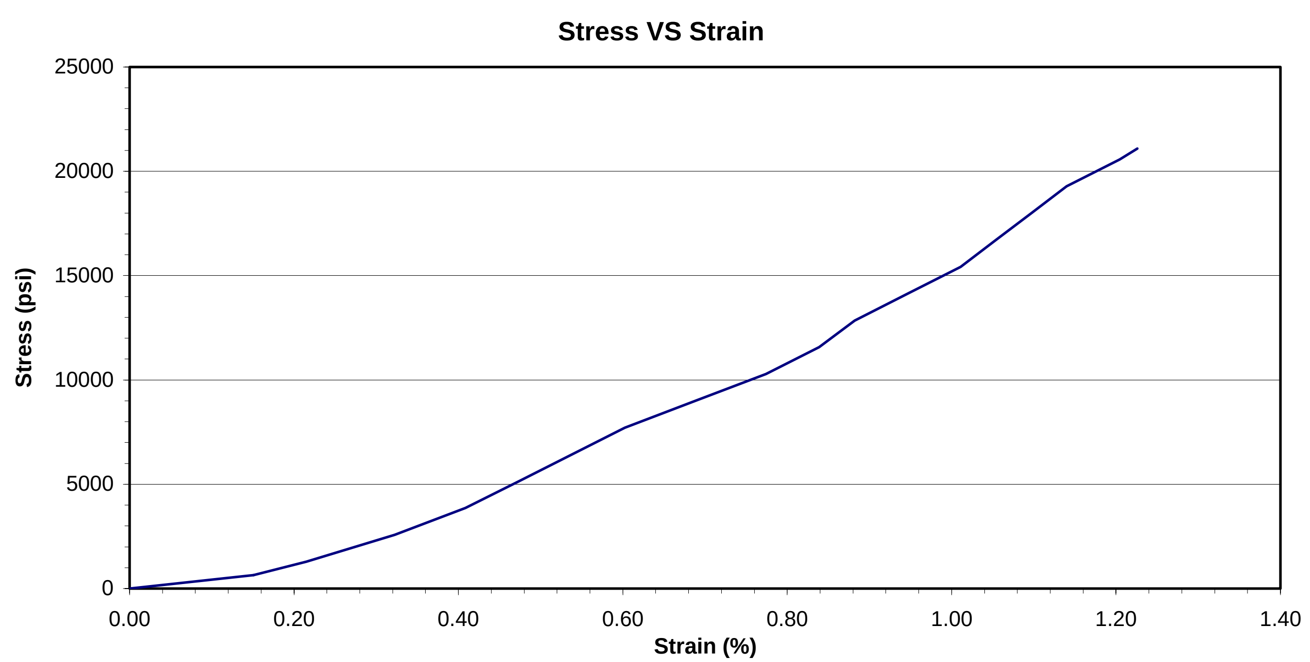
Failure Type Cone and Split

Compressive Strength (psi) 21090

Compressive Strength (tsf) 1519

Failure Sketches





Comments

Reviewed By

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name LSIORB Section 4, East End Approach

Project Number LX2004110

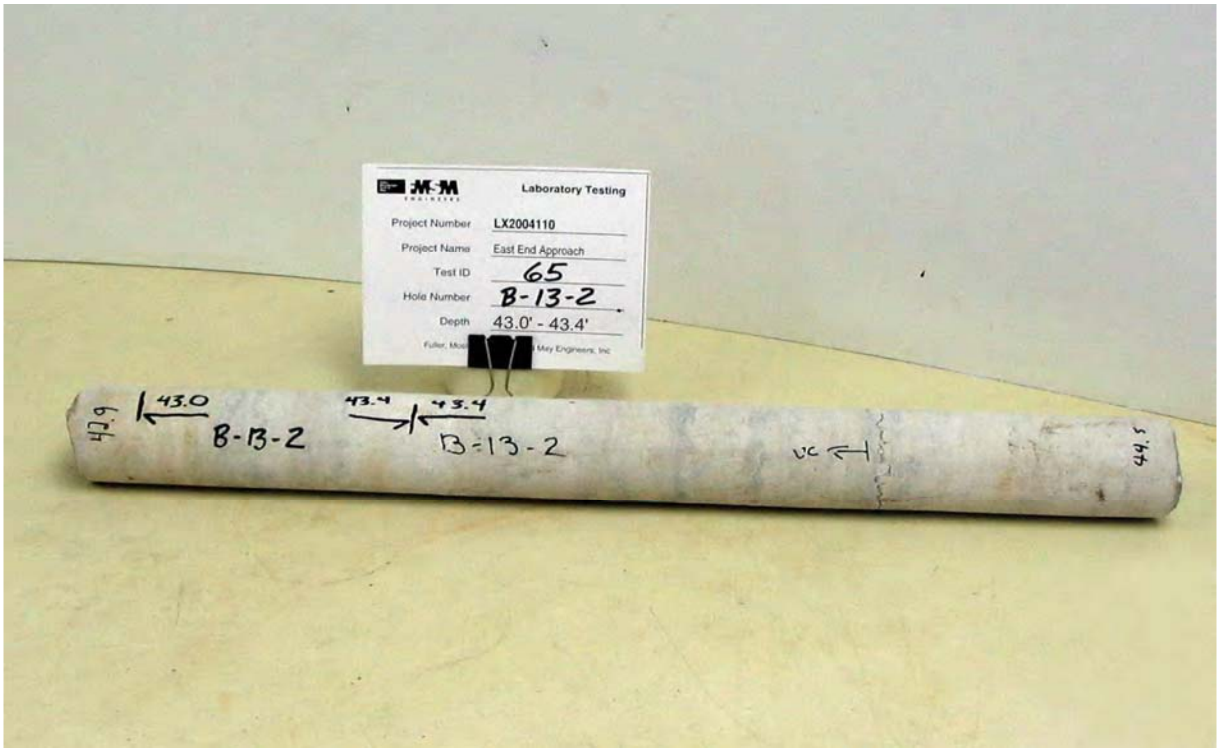
Lithology Limestone, gray, moderately hard

Lab ID UCSS-65

Hole Number B-13-2 Depth (ft) 43.0' - 43.4'

Test Type Unconfined compressive strength of intact rock core

As received



Core preparation

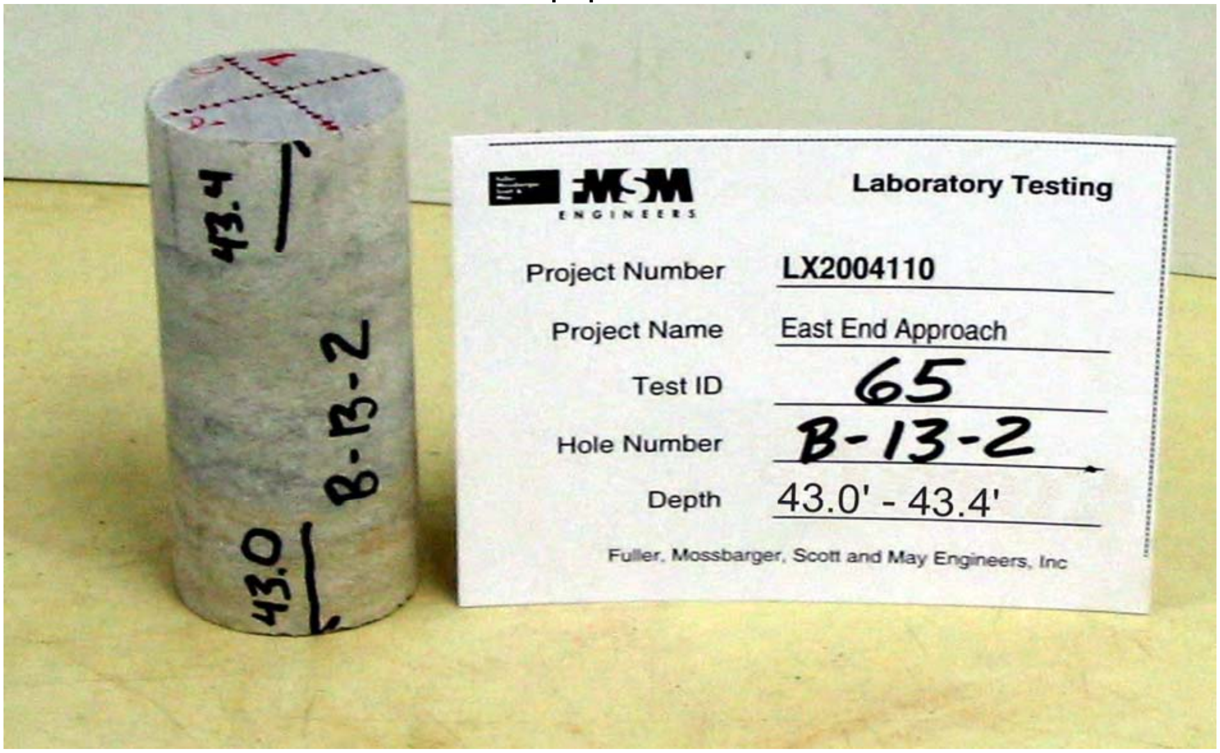


Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, gray, moderately hard
Hole Number B-13-2 Depth (ft) 43.0' - 43.4'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-65

Core preparation

Post test

Fuller Mossbarger Scott & May

FMSM ENGINEERS

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Limestone, gray, moderately hard
Lab ID UCSS-66
Hole Number B-13-4
Depth (ft/elev) 23.4' - 23.8'
Date Received 07-27-2005

Temperature (^oC) 22
Moisture Condition As received, dry
Date Tested 08-09-2005

Side Planeness Pass
Height (in) 4.703
Wet Unit Weight (pcf) 170.4
Perpendicularity Pass
Diameter (in) 1.994
Dry Unit Weight (pcf) 170.2
End Planeness Pass
Area (in^2) 3.124
Moisture Content (%) 0.1

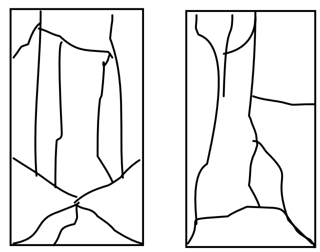
Loading Rate (lbf/sec) 241
Peak Load (lbf) 81070

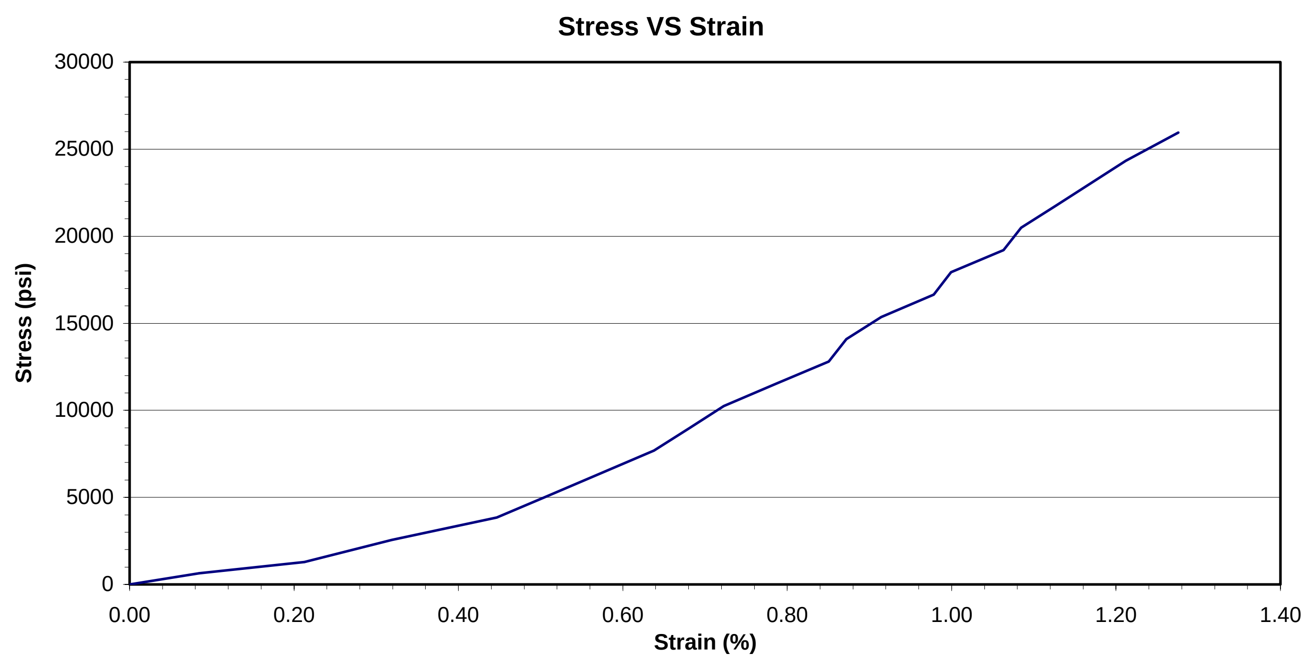
Failure Type Columnar

Compressive Strength (psi) 25950

Compressive Strength (tsf) 1869

Failure Sketches





Comments

Reviewed By

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name LSIORB Section 4, East End Approach

Project Number LX2004110

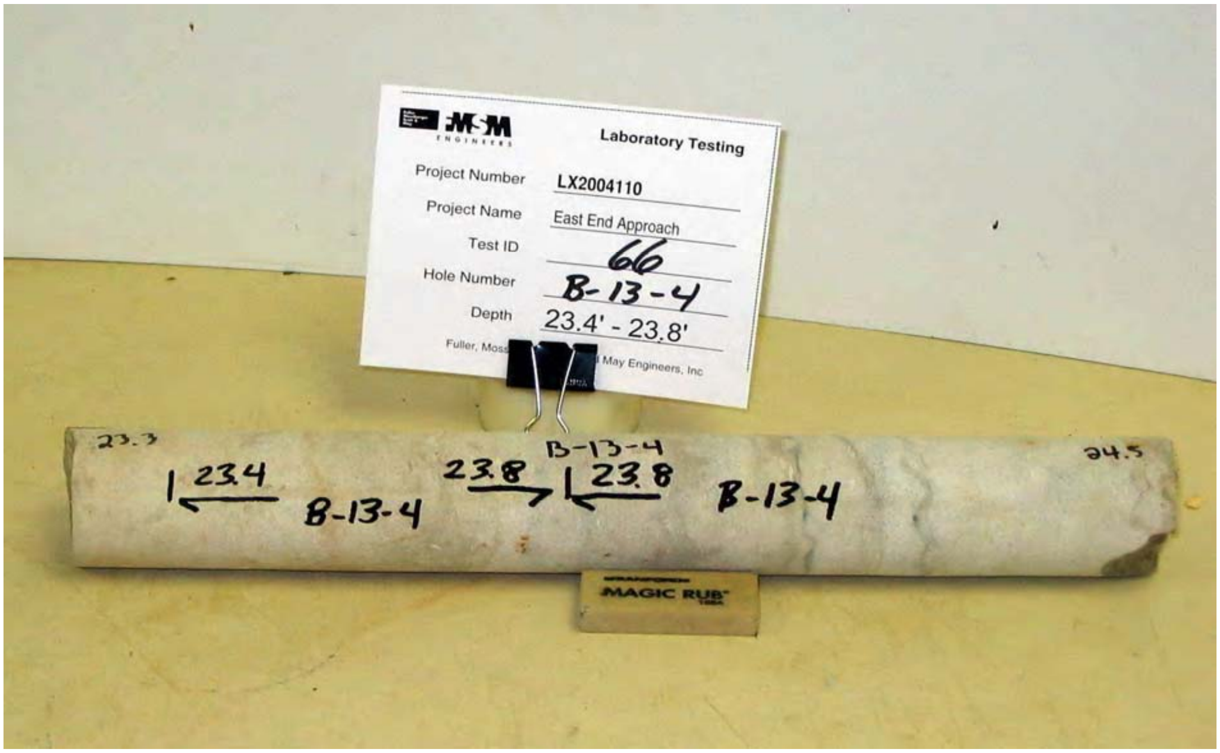
Lithology Limestone, gray, moderately hard

Lab ID UCSS-66

Hole Number B-13-4 Depth (ft) 23.4' - 23.8'

Test Type Unconfined compressive strength of intact rock core

As received



Core preparation

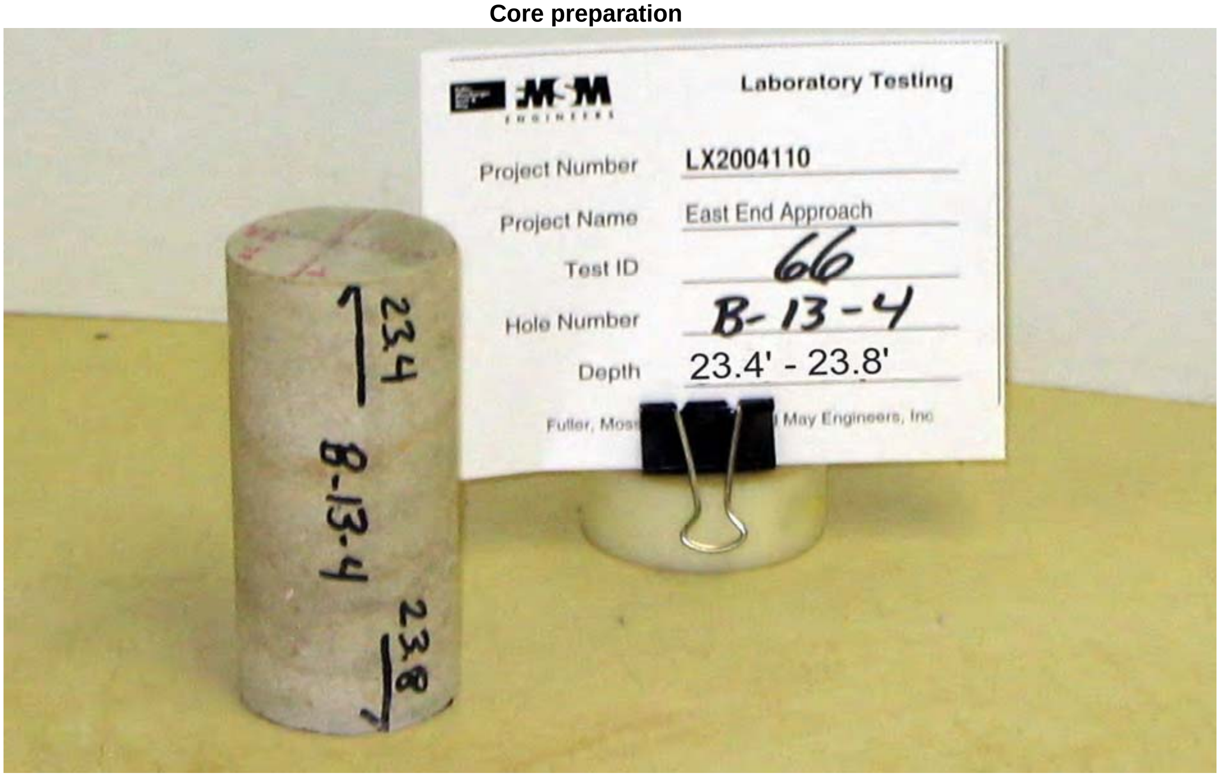


Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, gray, moderately hard
Hole Number B-13-4 Depth (ft) 23.4' - 23.8'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-66

Post test

Fuller Mossbarger Scott & May ENGINEERS

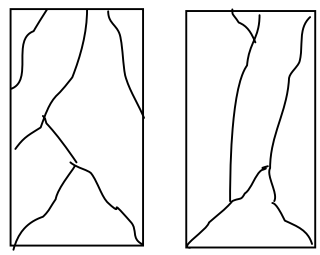
Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

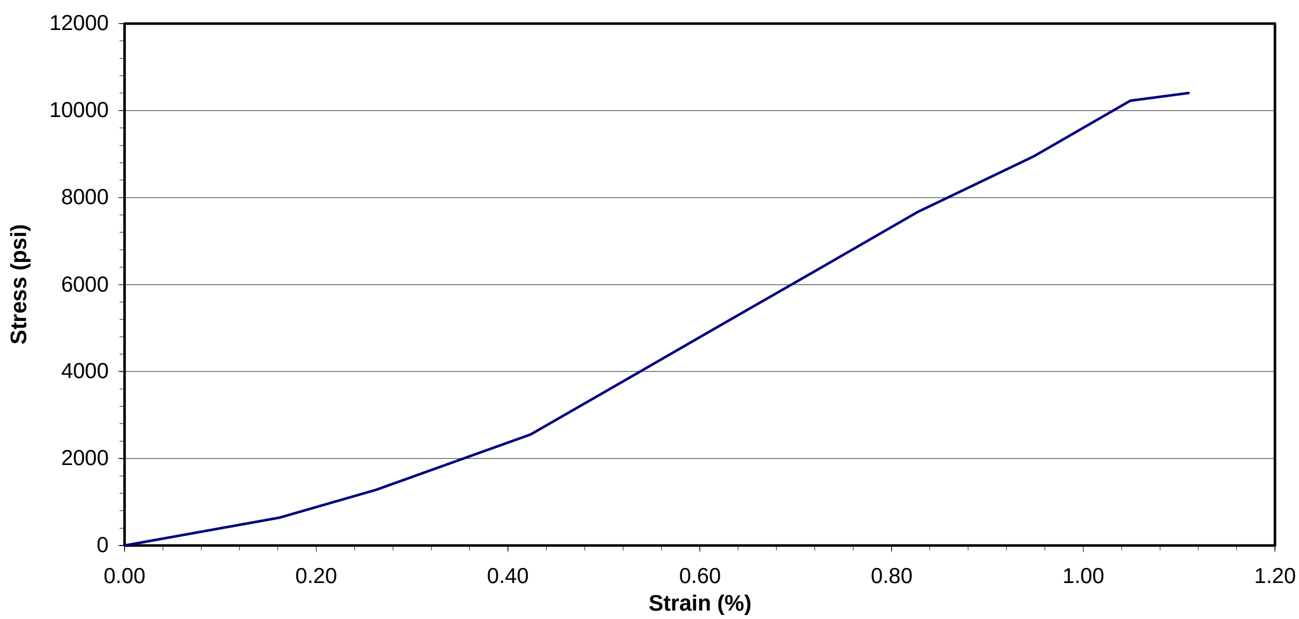
ASTM D 2938

Project Name	LSIORB Section 4, East End Approach			Project Number	LX2004110
Lithology	Shale, gray, soft			Lab ID	UCSS-67
Hole Number	B-14-2	Depth (ft/elev)	85.3' - 85.7'	Date Received	07-27-2005
Temperature (°C)	23	Moisture Condition	As received, dry	Date Tested	08-09-2005
Side Planeness	Fail	Height (in)	4.956	Wet Unit Weight (pcf)	165.7
Perpendicularity	Pass	Diameter (in)	1.996	Dry Unit Weight (pcf)	164.1
End Planeness	Pass	Area (in^2)	3.130	Moisture Content (%)	1.0

Loading Rate (lbf/sec)	109
Peak Load (lbf)	32570
Failure Type	Cone and Split
Compressive Strength (psi)	10410
Compressive Strength (tsf)	749

Failure Sketches





Comments ______________________

Reviewed By ____________

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Shale, gray, soft	Lab ID	UCSS-67
Hole Number	B-14-2	Depth (ft)	85.3' - 85.7'
Test Type	Unconfined compressive strength of intact rock core		

As received

Core preparation

Project Name LSIORB Section 4, East End Approach
Lithology Shale, gray, soft
Hole Number B-14-2 Depth (ft) 85.3' - 85.7'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-67

Post test

Post test

Fuller Mossbarger Scott & May FMSM ENGINEERS

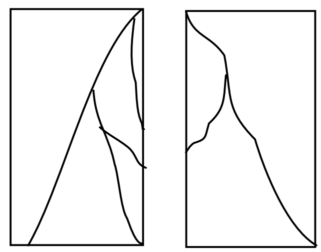
Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

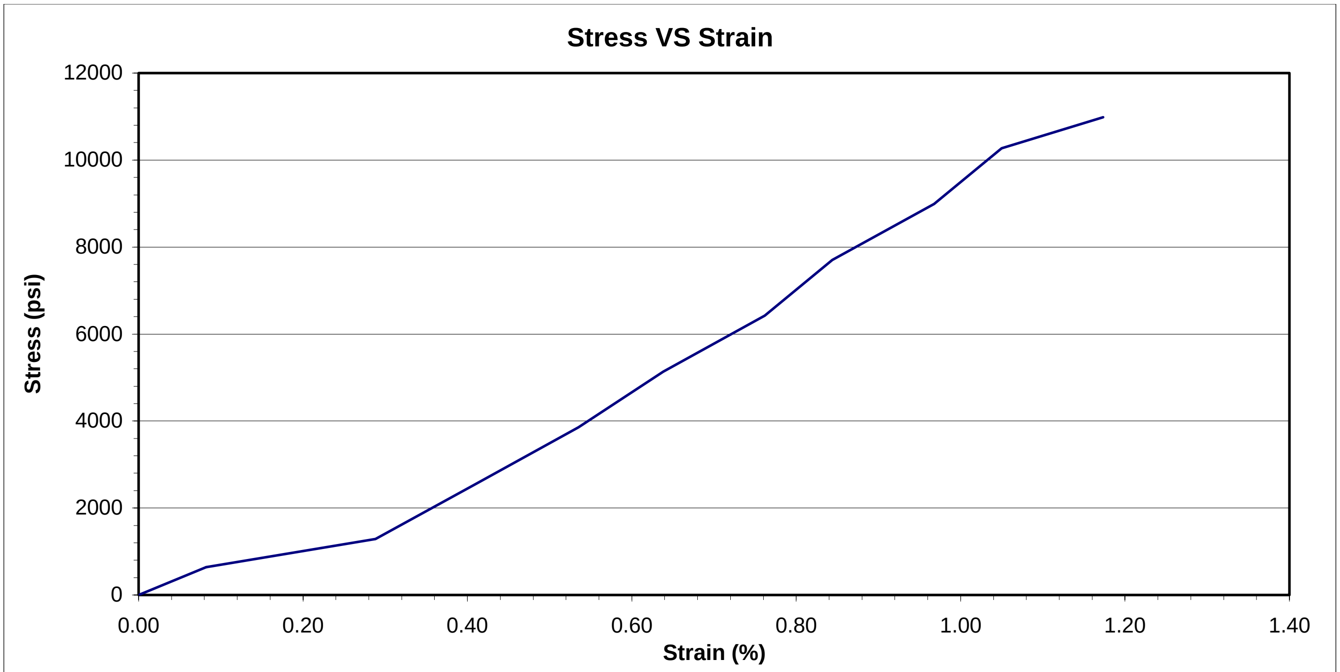
ASTM D 2938

Project Name	LSIORB Section 4, East End Approach			Project Number	LX2004110
Lithology	Limestone/Dolomite, gray, moderately hard			Lab ID	UCSS-69
Hole Number	B-14-4	Depth (ft/elev)	94.0' - 94.4'	Date Received	07-27-2005
Temperature (^oC)	23	Moisture Condition	As received, dry	Date Tested	08-09-2005
Side Planeness	Pass	Height (in)	4.858	Wet Unit Weight (pcf)	164.5
Perpendicularity	Pass	Diameter (in)	1.992	Dry Unit Weight (pcf)	163.3
End Planeness	Pass	Area (in^2)	3.115	Moisture Content (%)	0.7

Loading Rate (lbf/sec)	164
Peak Load (lbf)	34230
Failure Type	Cone and Shear
Compressive Strength (psi)	10990
Compressive Strength (tsf)	791

Failure Sketches





Comments ______________________

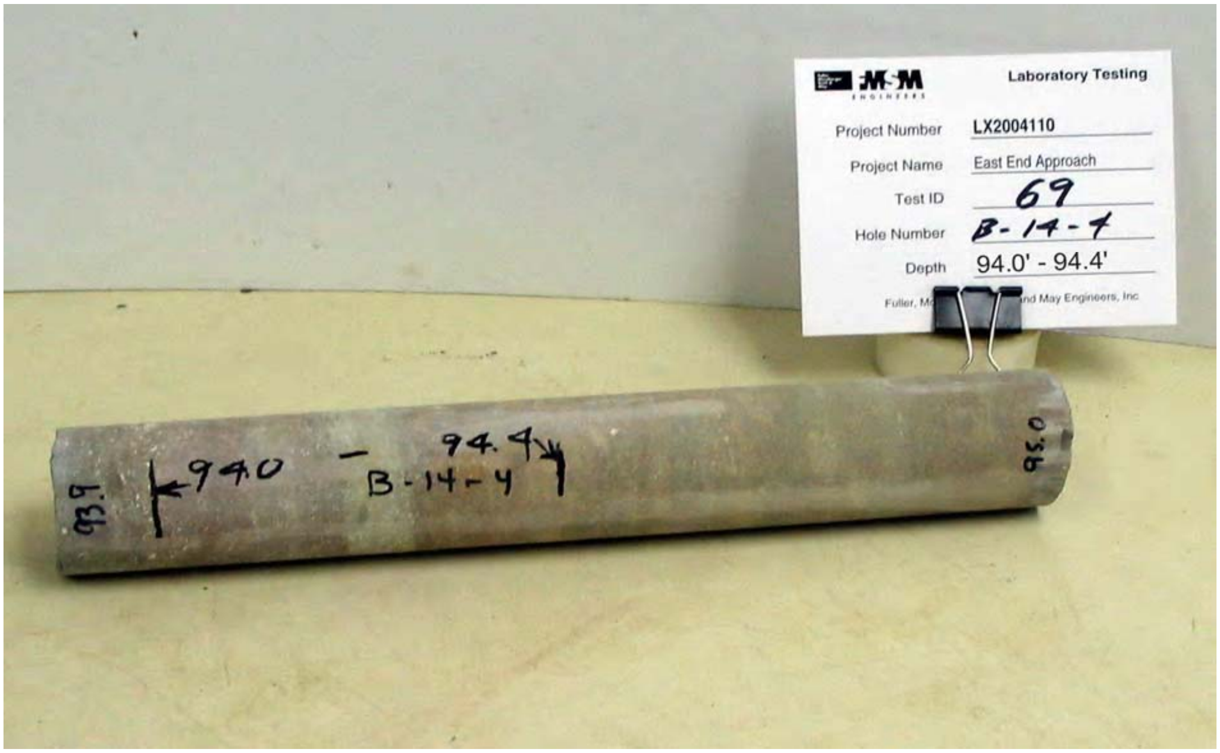
Reviewed By ___________

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Limestone/Dolomite, gray, moderately hard
Lab ID UCSS-69
Hole Number B-14-4 Depth (ft) 94.0' - 94.4'
Test Type Unconfined compressive strength of intact rock core

As received



Post test

Fuller Mossbarger Scott & May ENGINEERS

Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone/Dolomite, gray, moderately hard
Hole Number B-14-4 Depth (ft) 94.0' - 94.4'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-69

Post test

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*
ASTM D 2938

FMSM ENGINEERS — Fuller Mossbarger Scott & May

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Red Shale, redish brown, soft
Lab ID: UCSS-70
Hole Number: B-14-6
Depth (ft/elev): 102.2' - 102.8'
Date Received: 07-27-2005

Temperature (^oC): 23
Moisture Condition: As received, dry
Date Tested: 08-09-2005

Side Planeness	Fail	Height (in)	4.817	Wet Unit Weight (pcf)	162.4
Perpendicularity	Pass	Diameter (in)	1.996	Dry Unit Weight (pcf)	160.2
End Planeness	Pass	Area (in^2)	3.130	Moisture Content (%)	1.4

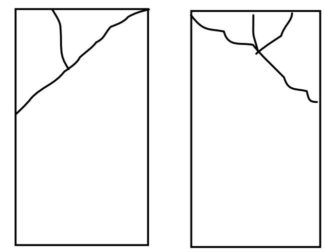
Loading Rate (lbf/sec): 92
Peak Load (lbf): 25640

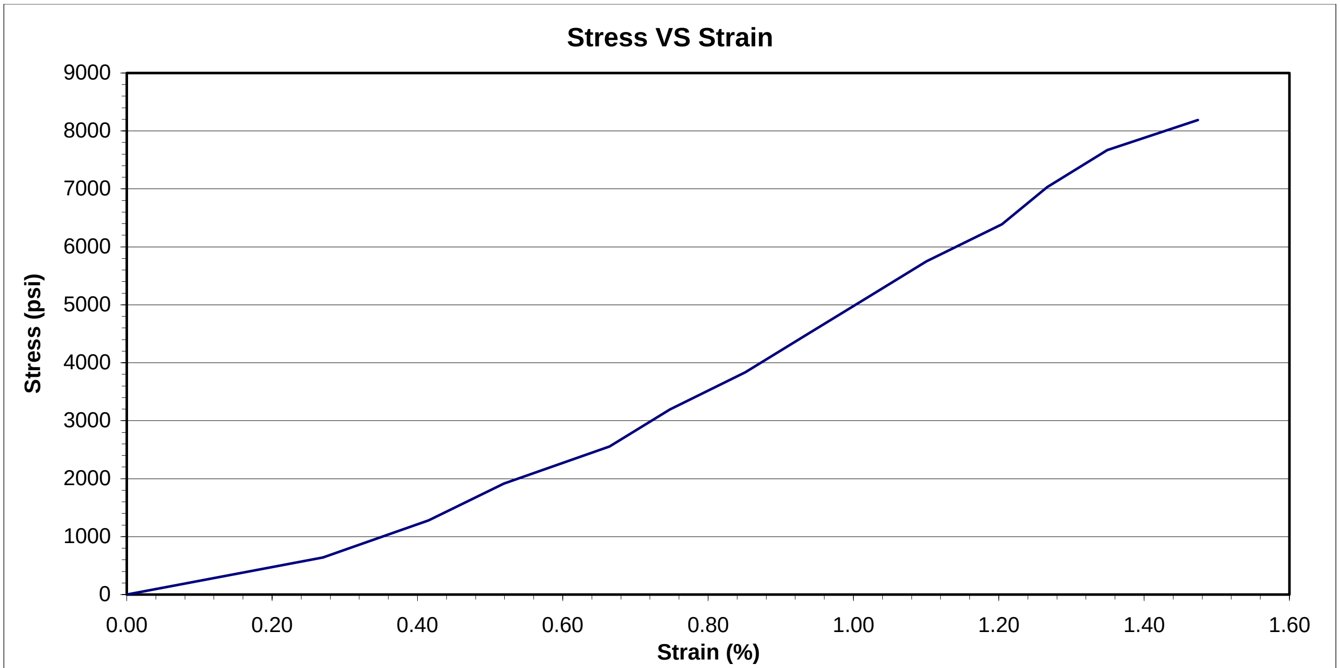
Failure Type: Shear

Compressive Strength (psi): 8190

Compressive Strength (tsf): 590

Failure Sketches





Comments ______________________

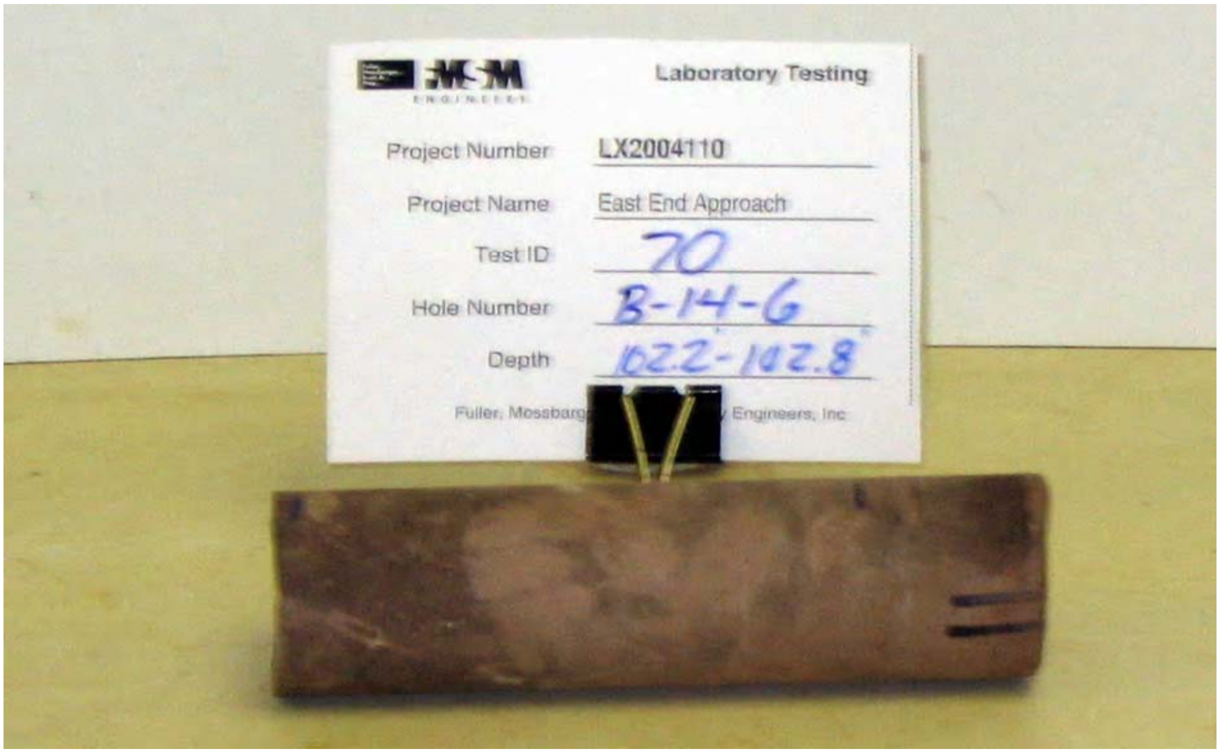
Reviewed By ____________

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Red Shale, redish brown, soft	Lab ID	UCSS-70
Hole Number	B-14-6 Depth (ft) 102.2' - 102.8'		
Test Type	Unconfined compressive strength of intact rock core		

As received



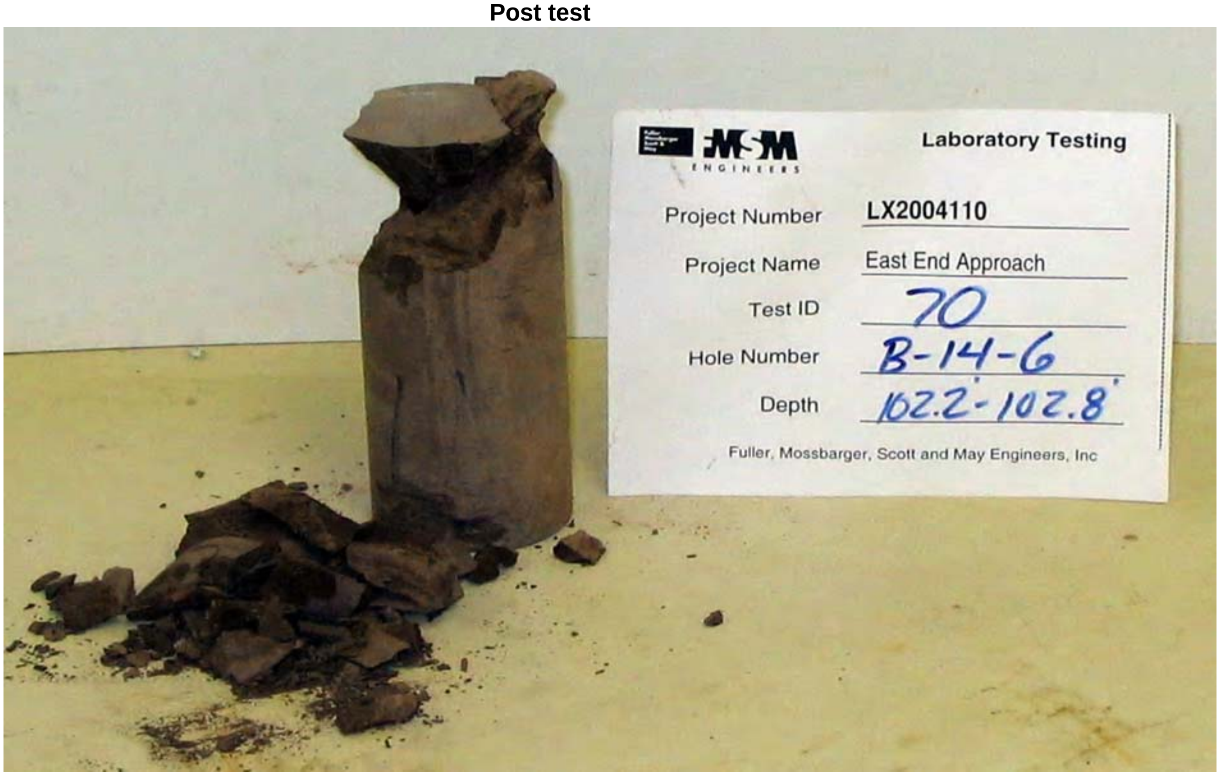
Core preparation

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Red Shale, redish brown, soft	Lab ID	UCSS-70
Hole Number	B-14-6	Depth (ft)	102.2' - 102.8'
Test Type	Unconfined compressive strength of intact rock core		

Post test

Post test



Fuller Mossbarger Scott & May
FMSM ENGINEERS

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Limestone, light gray, moderately hard
Lab ID: UCSS-71
Hole Number: B-14-7
Depth (ft/elev): 112.2' - 112.6'
Date Received: 07-27-2005

Temperature (^{o}C): 23
Moisture Condition: As received, dry
Date Tested: 08-09-2005

Side Planeness	Fail	Height (in)	4.824	Wet Unit Weight (pcf)	165.9
Perpendicularity	Pass	Diameter (in)	1.995	Dry Unit Weight (pcf)	165.1
End Planeness	Pass	Area (in^2)	3.125	Moisture Content (%)	0.5

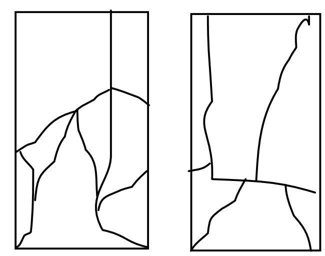
Loading Rate (lbf/sec): 173
Peak Load (lbf): 39320

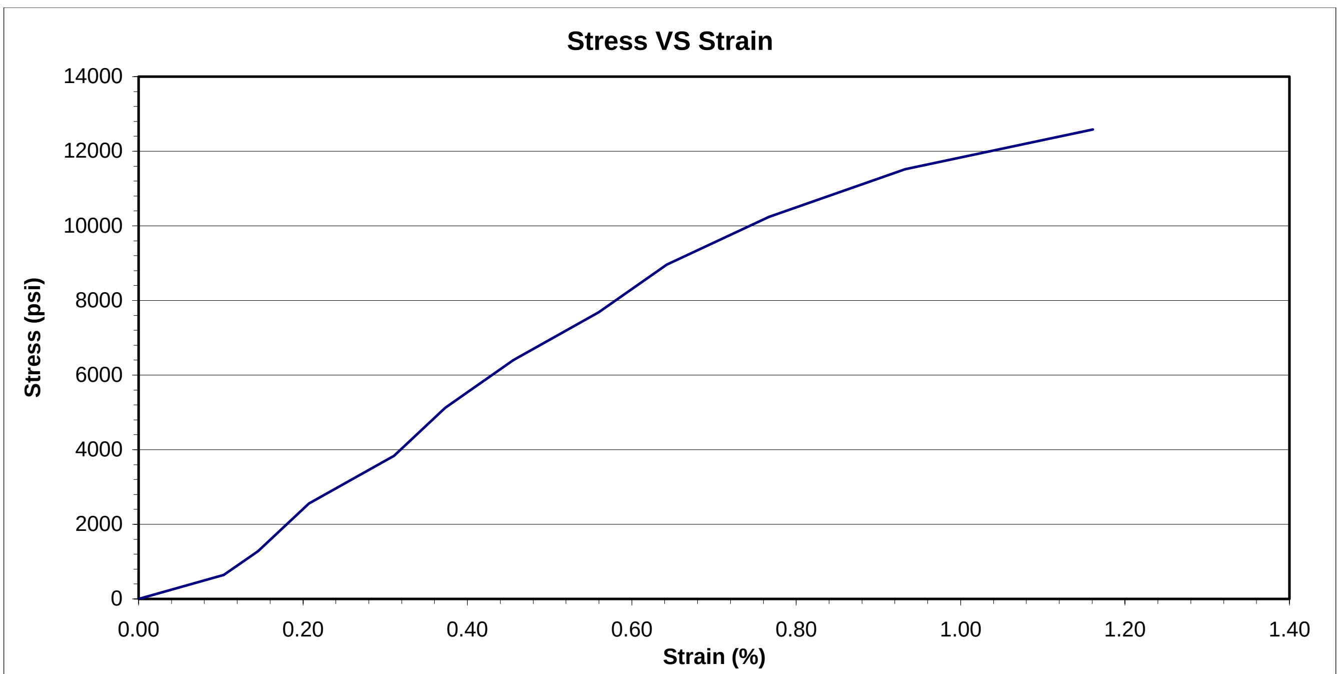
Failure Type: Cone and Shear

Compressive Strength (psi): 12580

Compressive Strength (tsf): 906

Failure Sketches





Comments

Reviewed By

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name LSIORB Section 4, East End Approach

Project Number LX2004110

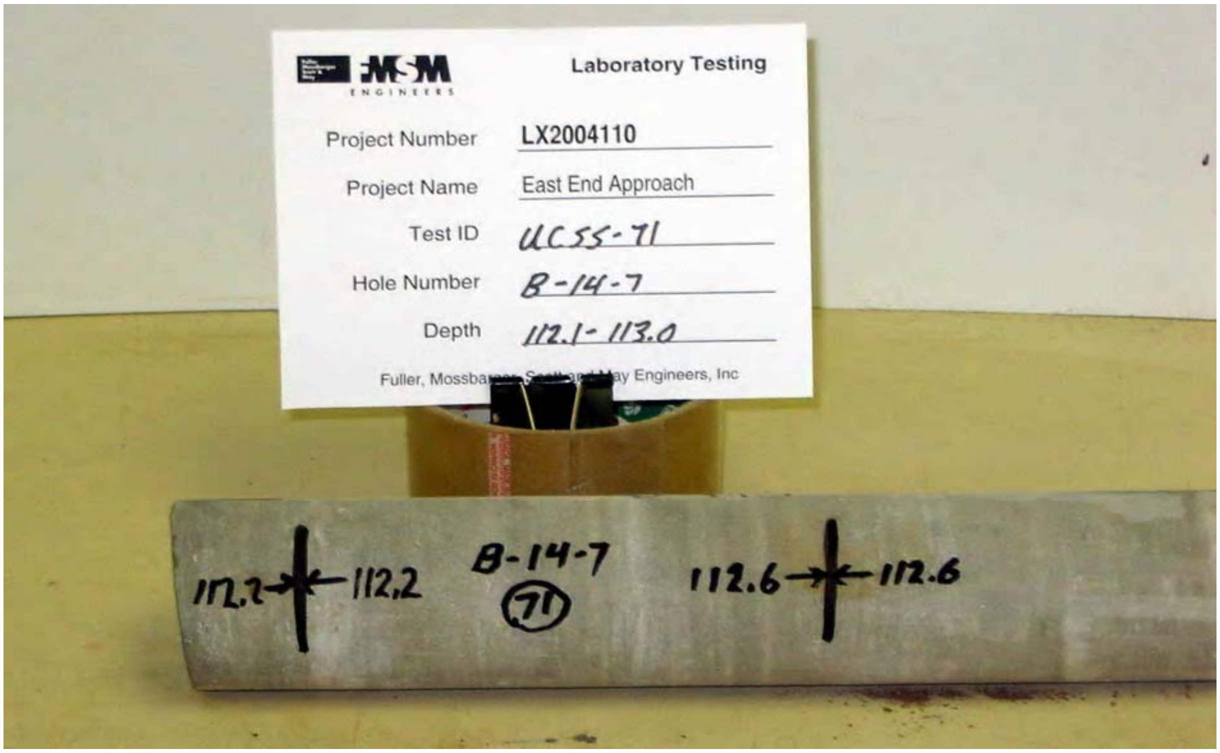
Lithology Limestone, light gray, moderately hard

Lab ID UCSS-71

Hole Number B-14-7 Depth (ft) 112.2' - 112.6'

Test Type Unconfined compressive strength of intact rock core

As received

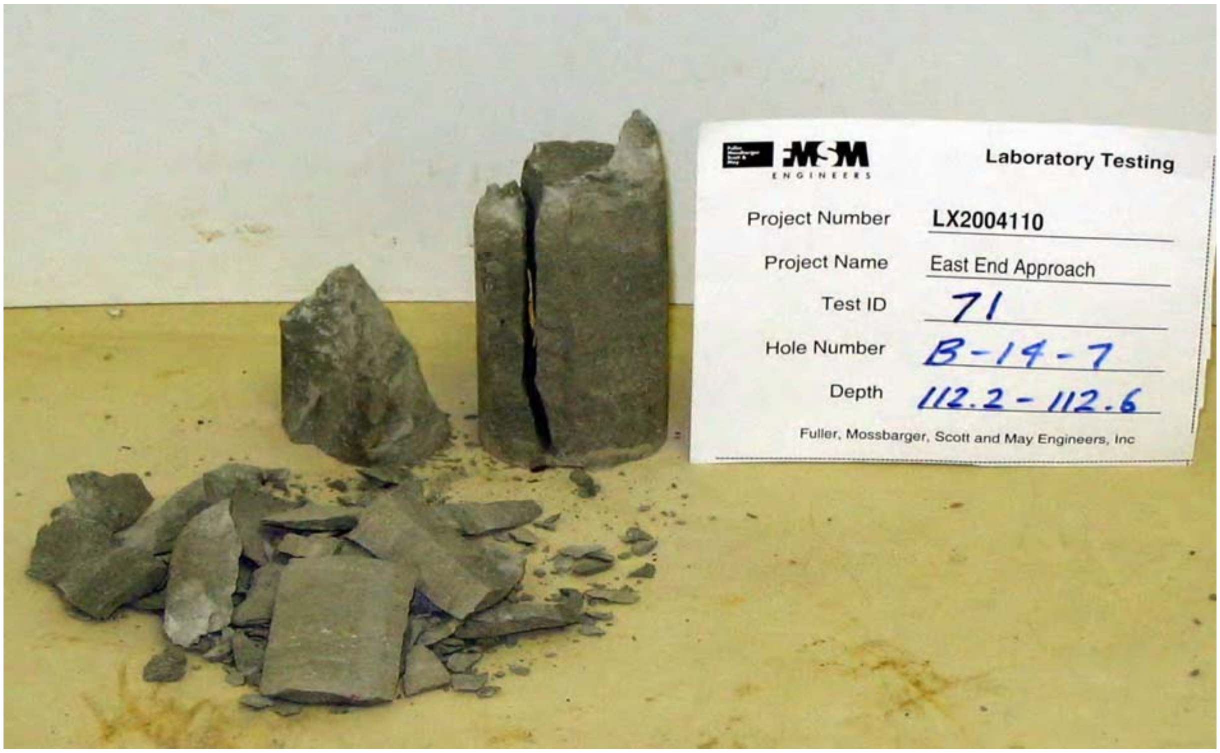


Core preparation

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, light gray, moderately hard	Lab ID	UCSS-71
Hole Number	B-14-7	Depth (ft)	112.2' - 112.6'
Test Type	Unconfined compressive strength of intact rock core		

Post test



Post test

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

Fuller Mossbarger Scott & May ENGINEERS

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Dolomite, gray, moderately hard
Lab ID: UCSS-72
Hole Number: B-14-8
Depth (ft/elev): 69.3' - 69.7'
Date Received: 07-27-2005

Temperature (°C): 23
Moisture Condition: As received, dry
Date Tested: 08-09-2005

Side Planeness: Fail
Height (in): 4.898
Wet Unit Weight (pcf): 162.4
Perpendicularity: Pass
Diameter (in): 1.995
Dry Unit Weight (pcf): 162.3
End Planeness: Pass
Area (in^2): 3.125
Moisture Content (%): 0.1

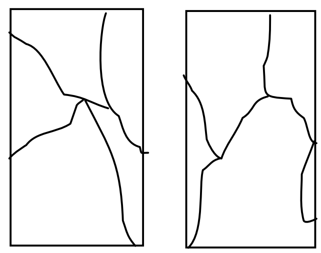
Loading Rate (lbf/sec): 255
Peak Load (lbf): 42380

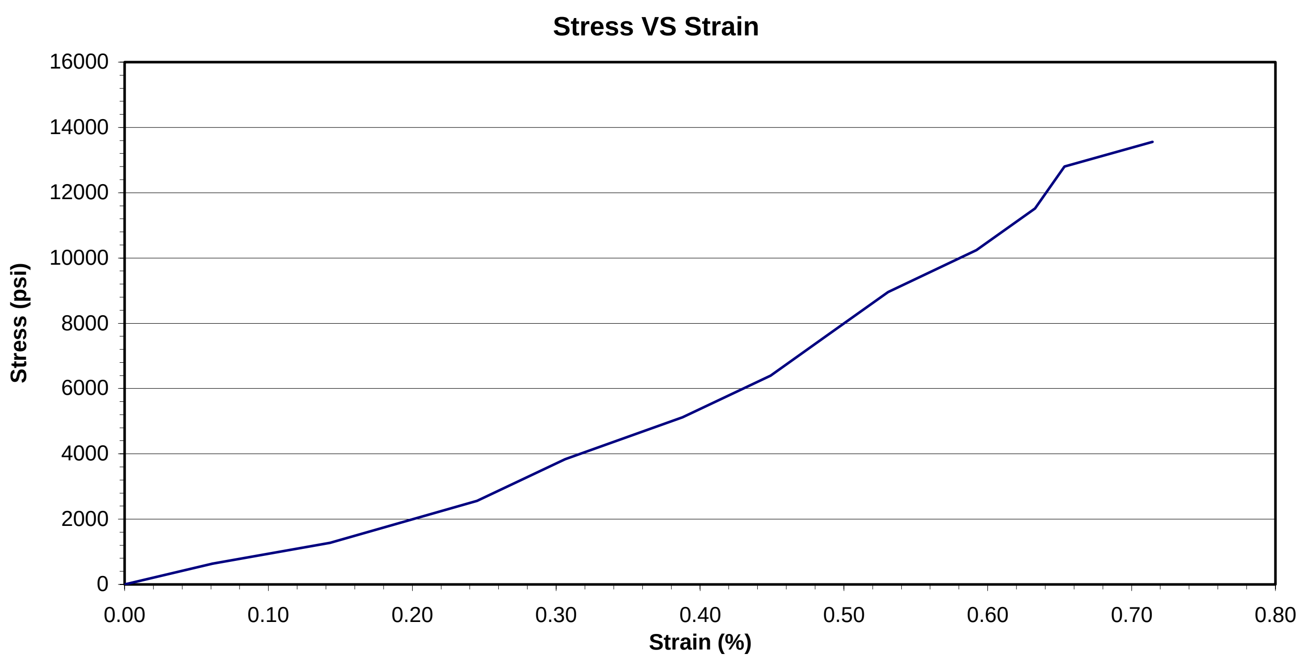
Failure Type: Cone and Shear

Compressive Strength (psi): 13560

Compressive Strength (tsf): 976

Failure Sketches





Comments ______

Reviewed By ______

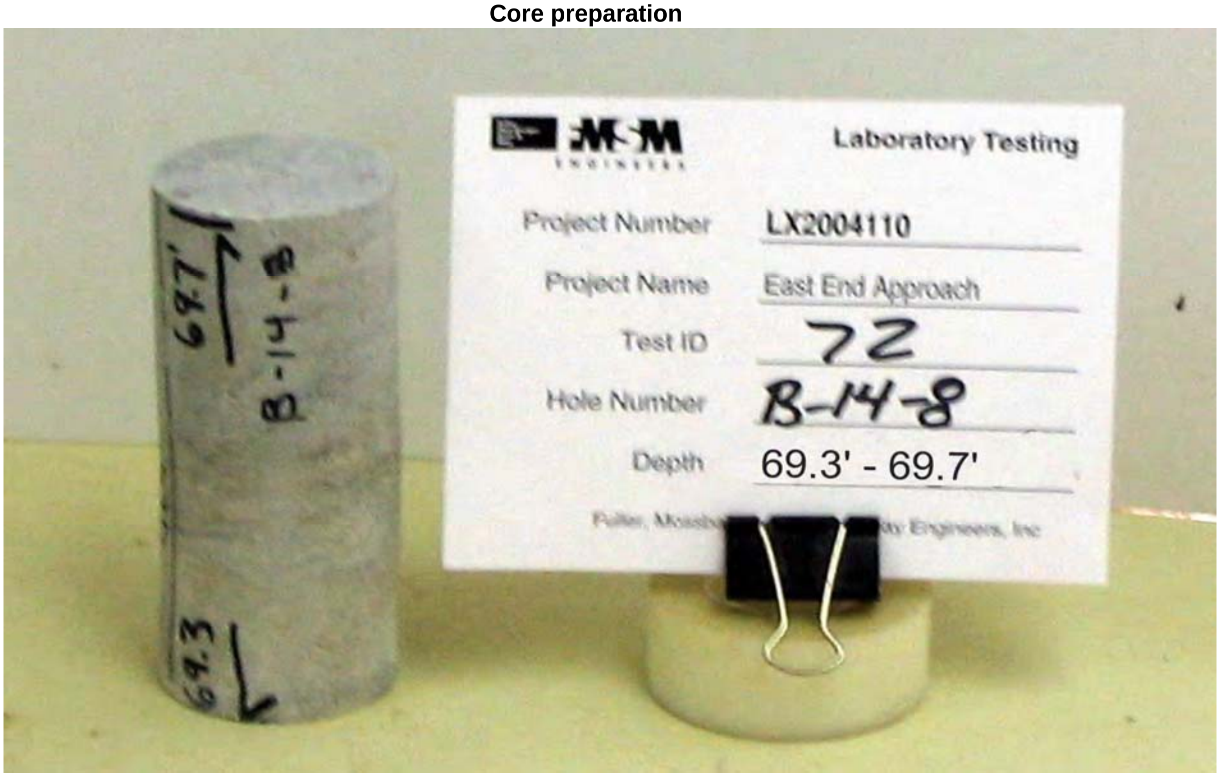
* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Photo Report

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Dolomite, gray, moderately hard
Lab ID UCSS-72
Hole Number B-14-8 Depth (ft) 69.3' - 69.7'
Test Type Unconfined compressive strength of intact rock core

Core preparation



Post test

Photo Report

Project Name LSIORB Section 4, East End Approach

Project Number LX2004110

Lithology Dolomite, gray, moderately hard

Lab ID UCSS-72

Hole Number B-14-8 Depth (ft) 69.3' - 69.7'

Test Type Unconfined compressive strength of intact rock core

Post test

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Limestone/Dolomite, light gray, moderately hard
Lab ID UCSS-73
Hole Number B-14-10
Depth (ft/elev) 52.5' - 52.9'
Date Received 07-27-2005

Temperature (^{o}C) 23
Moisture Condition As received, dry
Date Tested 08-09-2005

Side Planeness	Fail	Height (in)	4.767	Wet Unit Weight (pcf)	165.2
Perpendicularity	Fail	Diameter (in)	1.992	Dry Unit Weight (pcf)	165.0
End Planeness	Pass	Area (in^2)	3.115	Moisture Content (%)	0.1

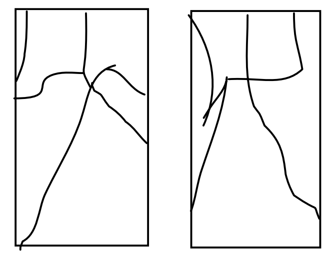
Loading Rate (lbf/sec) 270
Peak Load (lbf) 76040

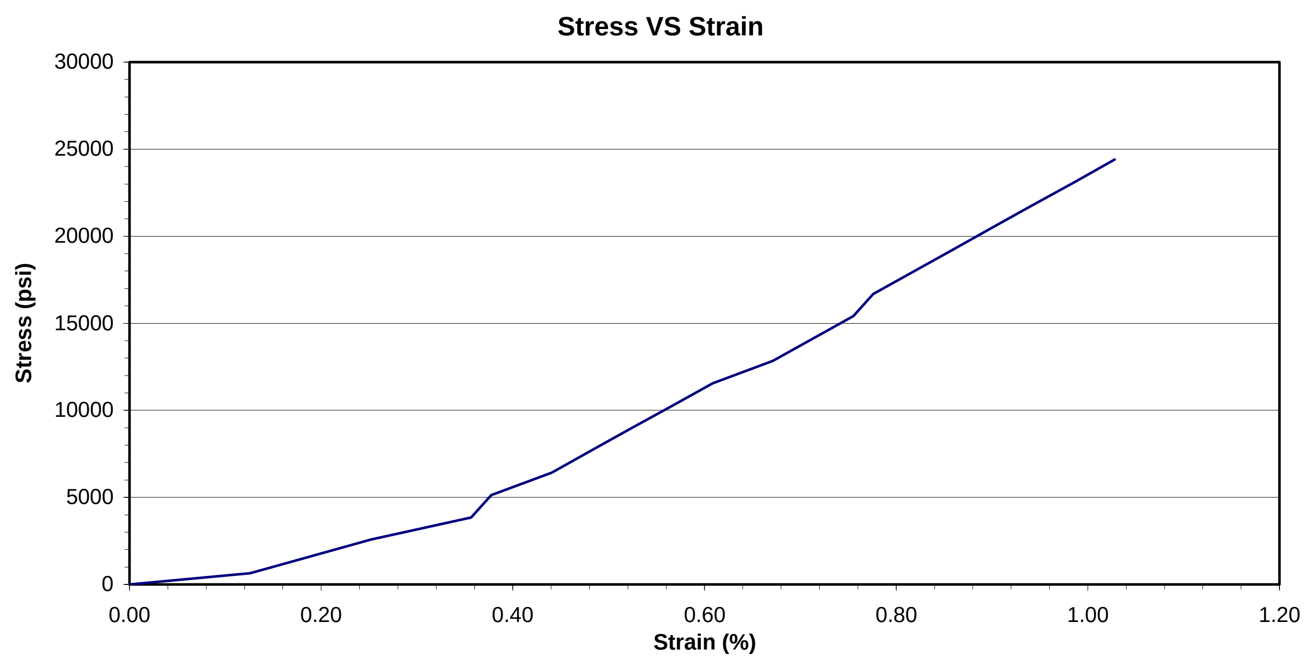
Failure Type Cone and Shear

Compressive Strength (psi) 24410

Compressive Strength (tsf) 1757

Failure Sketches





Comments

Reviewed By

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone/Dolomite, light gray, moderately hard	Lab ID	UCSS-73
Hole Number	B-14-10 Depth (ft) 52.5' - 52.9'		
Test Type	Unconfined compressive strength of intact rock core		

As received

Core preparation

Photo Report

Project Name LSIORB Section 4, East End Approach

Lithology Limestone/Dolomite, light gray, moderately hard

Hole Number B-14-10 Depth (ft) 52.5' - 52.9'

Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110

Lab ID UCSS-73

Post test

Post test

Fuller Mossbarger Scott & May

FMSM ENGINEERS

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

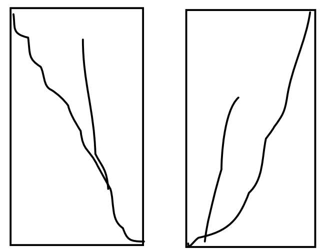
ASTM D 2938

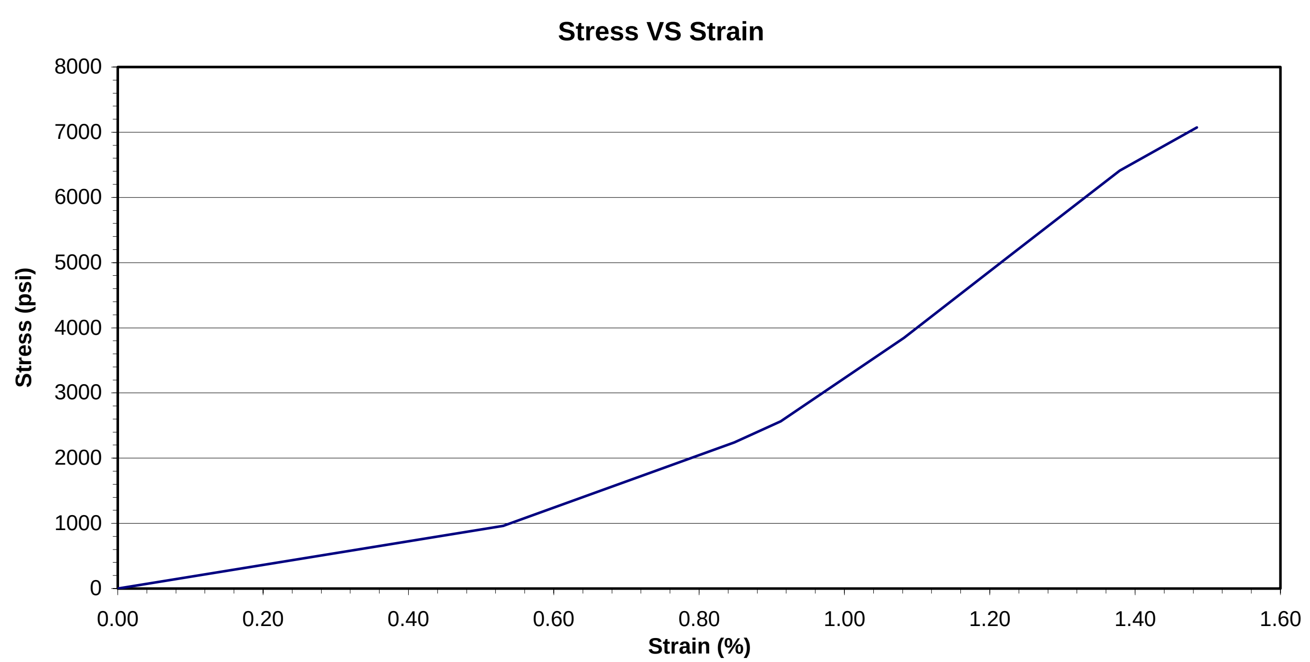
Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, light gray, moderately hard	Lab ID	UCSS-74
Hole Number	B-14-11	Depth (ft/elev)	19.7' - 20.1'
Date Received	07-27-2005		

Temperature (^oC)	23	Moisture Condition	As received, dry	Date Tested	08-10-2005
Side Planeness	Pass	Height (in)	4.714	Wet Unit Weight (pcf)	165.9
Perpendicularity	Pass	Diameter (in)	1.993	Dry Unit Weight (pcf)	165.4
End Planeness	Pass	Area (in^2)	3.120	Moisture Content (%)	0.3

Loading Rate (lbf/sec)	131
Peak Load (lbf)	22070
Failure Type	Shear
Compressive Strength (psi)	7070
Compressive Strength (tsf)	509

Failure Sketches





Comments ______

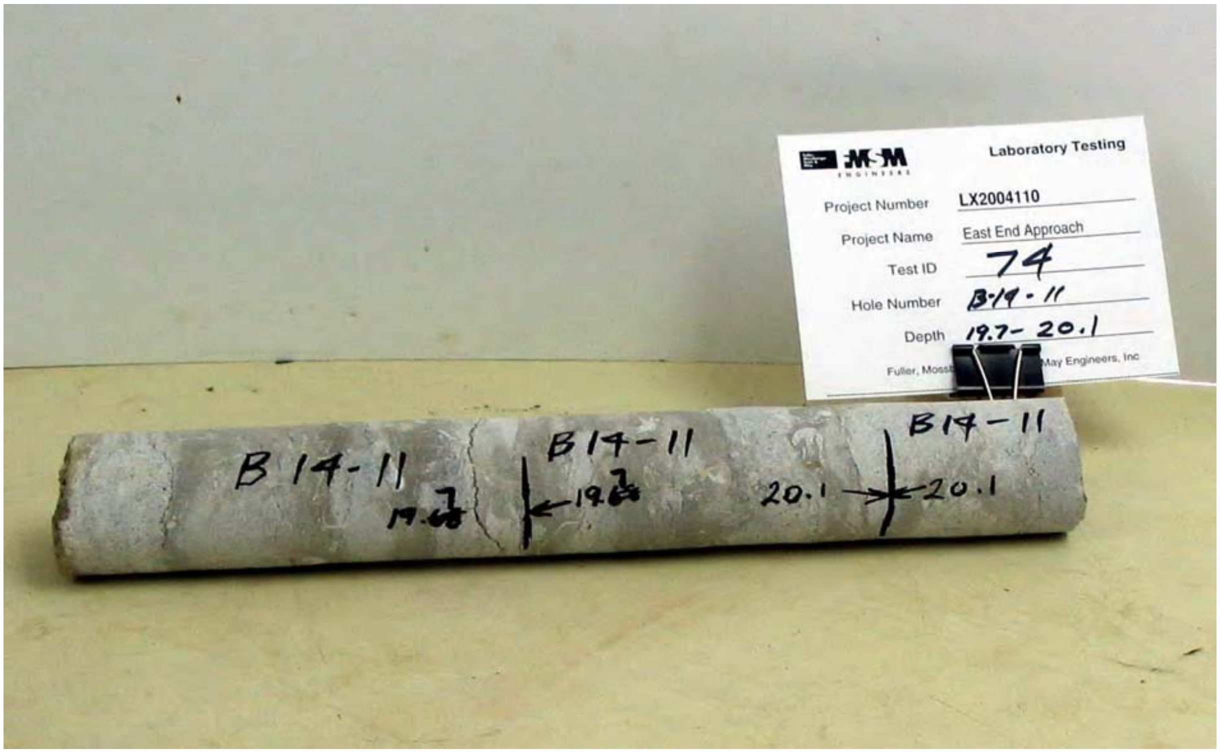
Reviewed By ______

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, light gray, moderately hard	Lab ID	UCSS-74
Hole Number	B-14-11 Depth (ft) 19.7' - 20.1'		
Test Type	Unconfined compressive strength of intact rock core		

As received



Core preparation

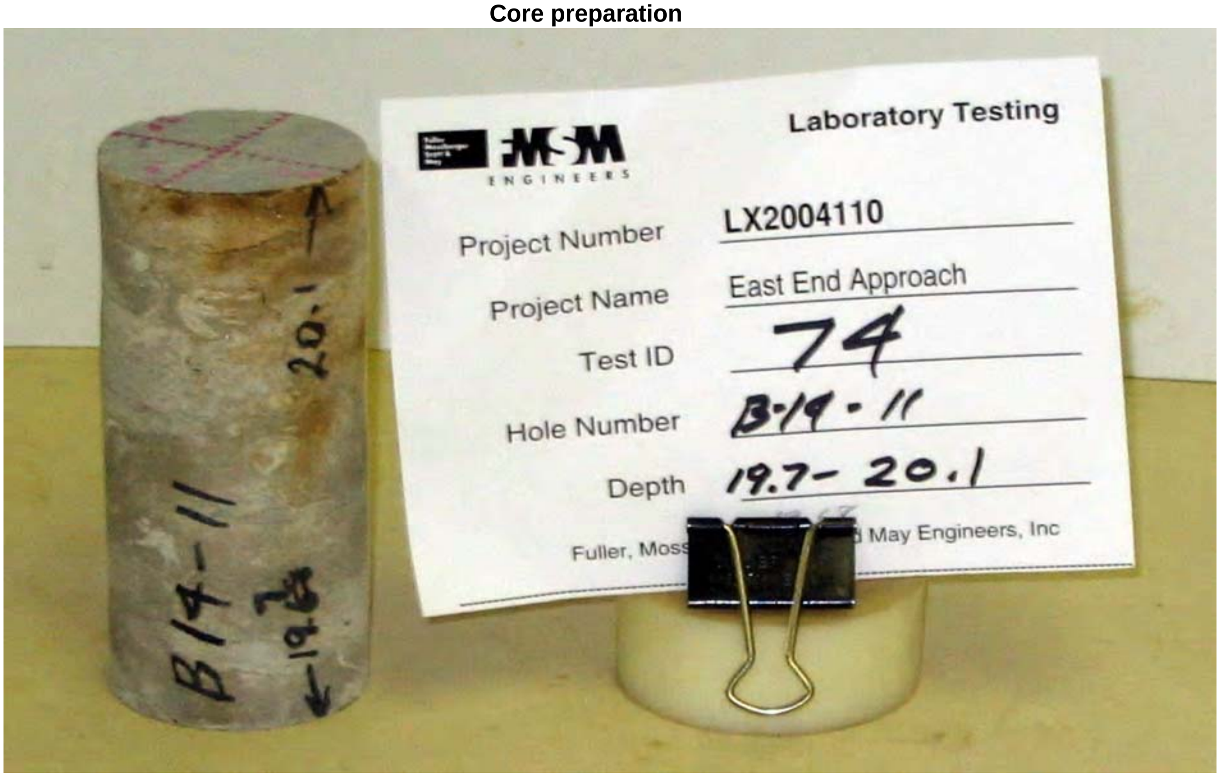


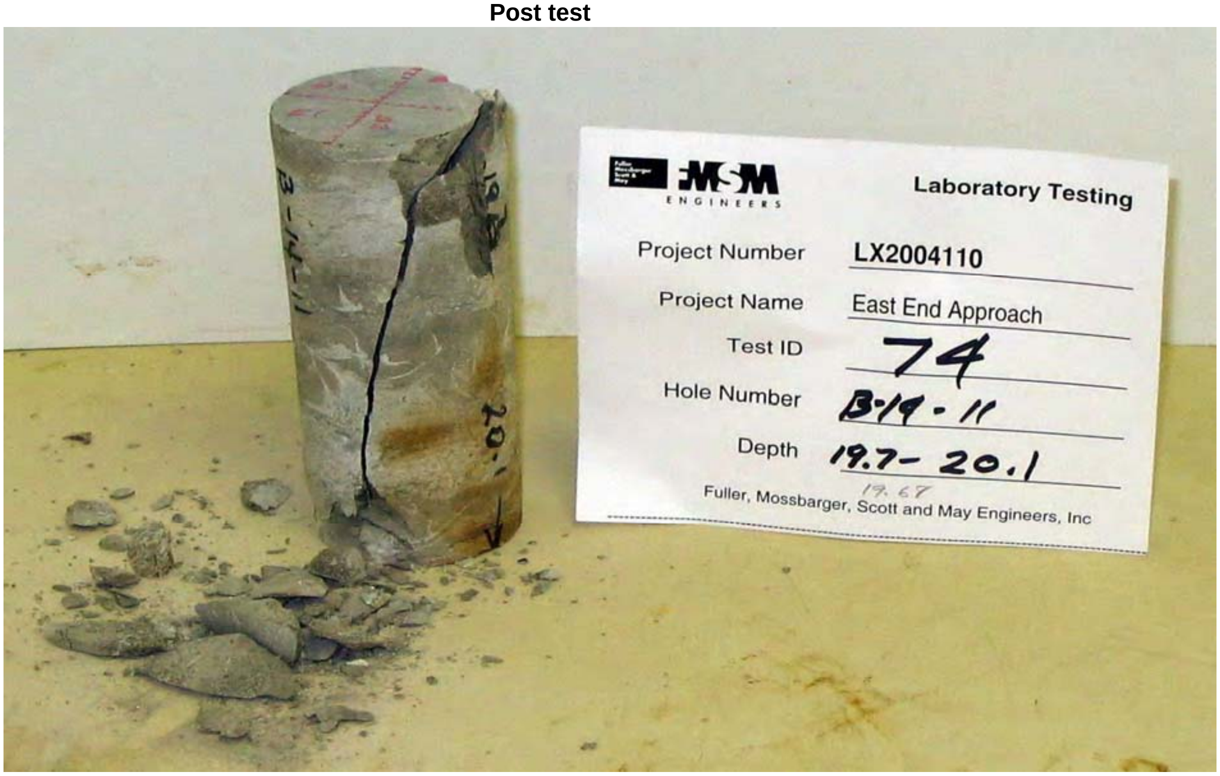
Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, light gray, moderately hard
Hole Number B-14-11 Depth (ft) 19.7' - 20.1'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-74

Post test

Post test



Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Shale, gray, soft
Lab ID UCSS-75
Hole Number B-14-12
Depth (ft/elev) 41.9' - 42.3'
Date Received 07-27-2005

Temperature (^oC) 23
Moisture Condition As received, dry
Date Tested 08-10-2005

Side Planeness	N/A	Height (in)	4.666	Wet Unit Weight (pcf)	164.1
Perpendicularity	N/A	Diameter (in)	1.996	Dry Unit Weight (pcf)	160.6
End Planeness	N/A	Area (in^2)	3.129	Moisture Content (%)	2.2

Dimensions were not confirmed.

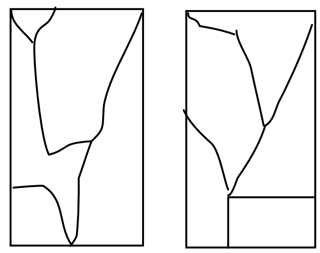
Loading Rate (lbf/sec) 104
Peak Load (lbf) 23150

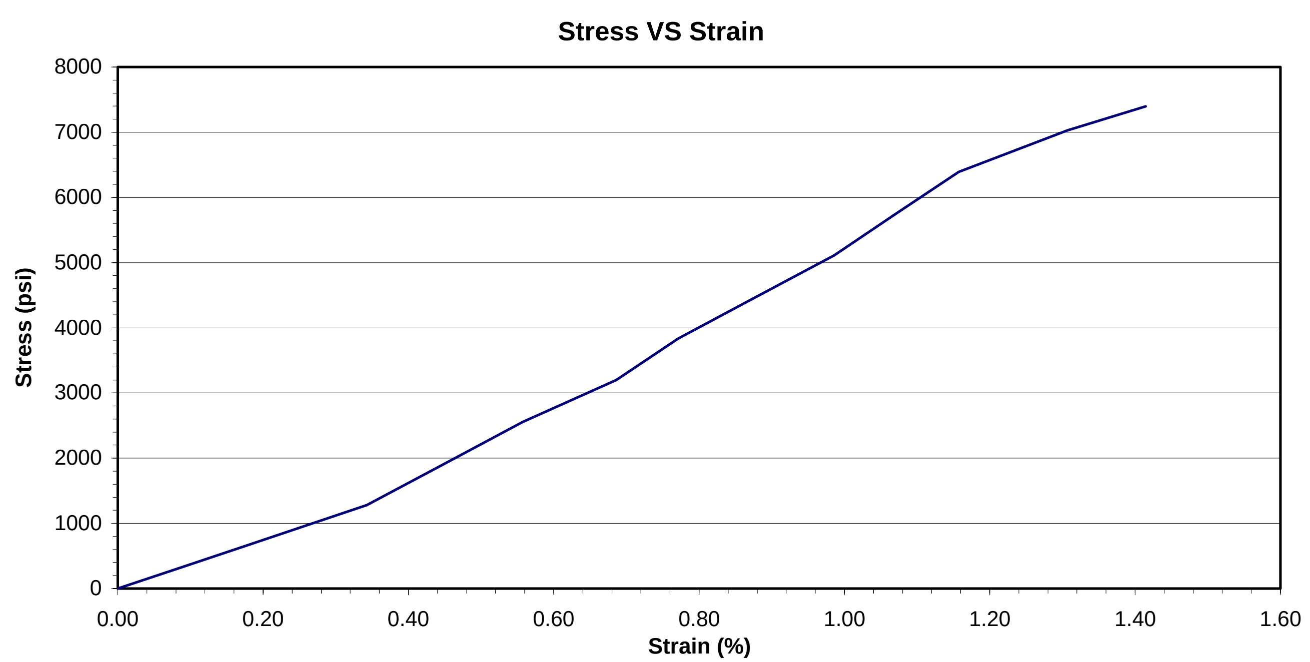
Failure Type Cone and Shear

Compressive Strength (psi) 7400

Compressive Strength (tsf) 533

Failure Sketches





Comments Fragile nature of specimen inhibited preparation.

Reviewed By ____________

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name LSIORB Section 4, East End Approach

Project Number LX2004110

Lithology Shale, gray, soft

Lab ID UCSS-75

Hole Number B-14-12 Depth (ft) 41.9' - 42.3'

Test Type Unconfined compressive strength of intact rock core

As received

Core preparation

Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Shale, gray, soft
Hole Number B-14-12 Depth (ft) 41.9' - 42.3'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-75

Post test

Post test

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*
ASTM D 2938

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Limestone, light gray, moderately hard
Lab ID UCSS-76
Hole Number B-14-14
Depth (ft/elev) 30.2' - 30.6'
Date Received 07-27-2005

Temperature (^oC) 23
Moisture Condition As received, dry
Date Tested 08-10-2005

Side Planeness	Pass	Height (in)	4.597	Wet Unit Weight (pcf)	167.6
Perpendicularity	Pass	Diameter (in)	1.997	Dry Unit Weight (pcf)	167.4
End Planeness	Pass	Area (in^2)	3.131	Moisture Content (%)	0.1

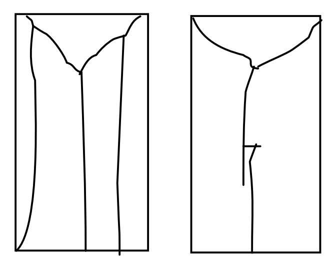
Loading Rate (lbf/sec) 191
Peak Load (lbf) 62380

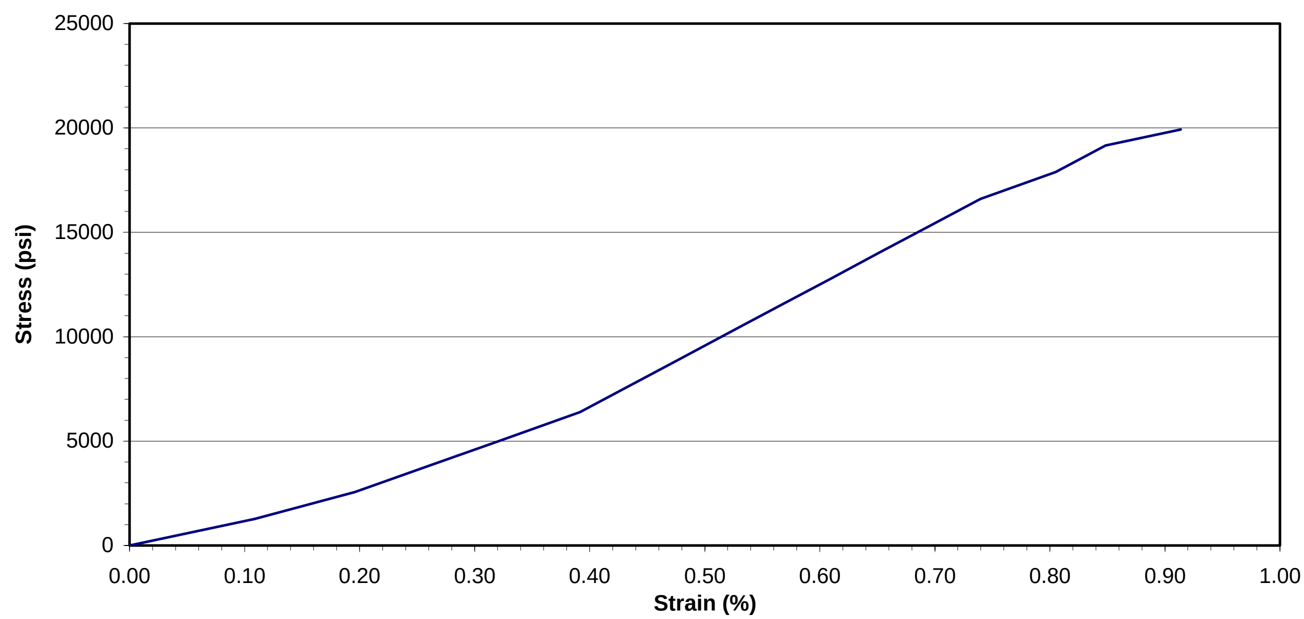
Failure Type Cone and Split

Compressive Strength (psi) 19920

Compressive Strength (tsf) 1434

Failure Sketches





Comments

Reviewed By

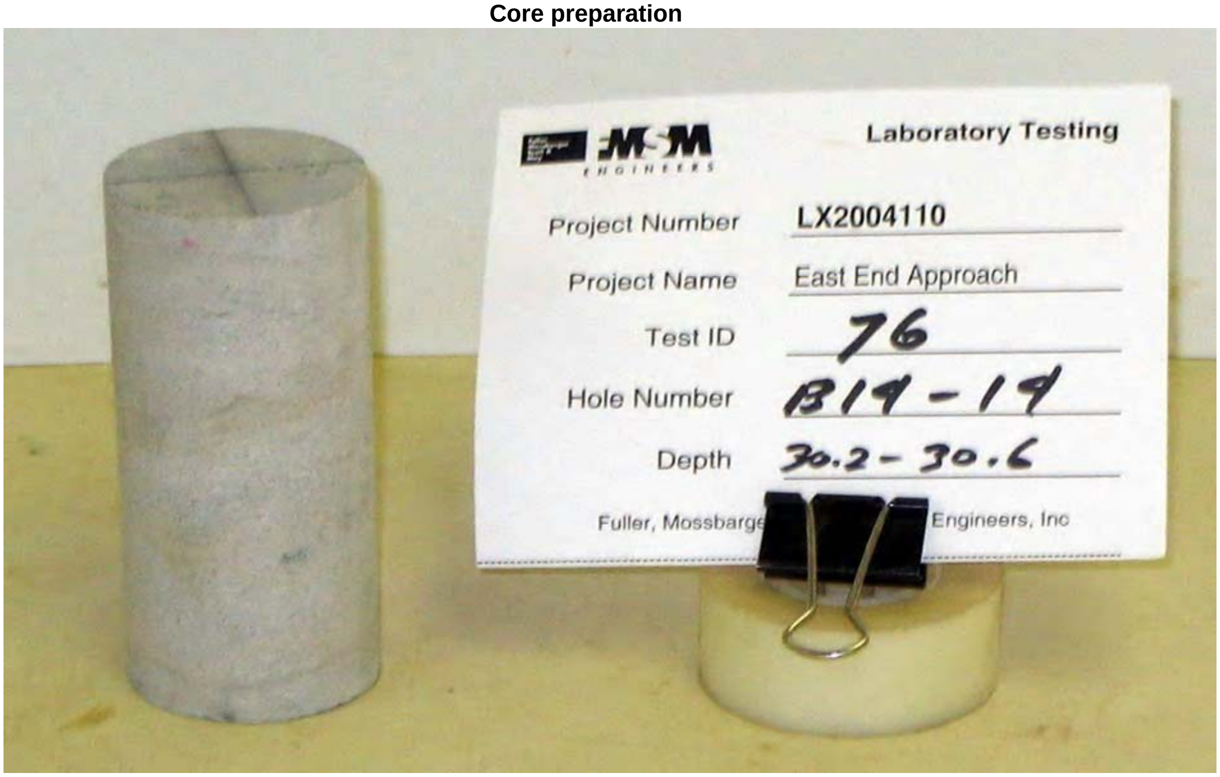
* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

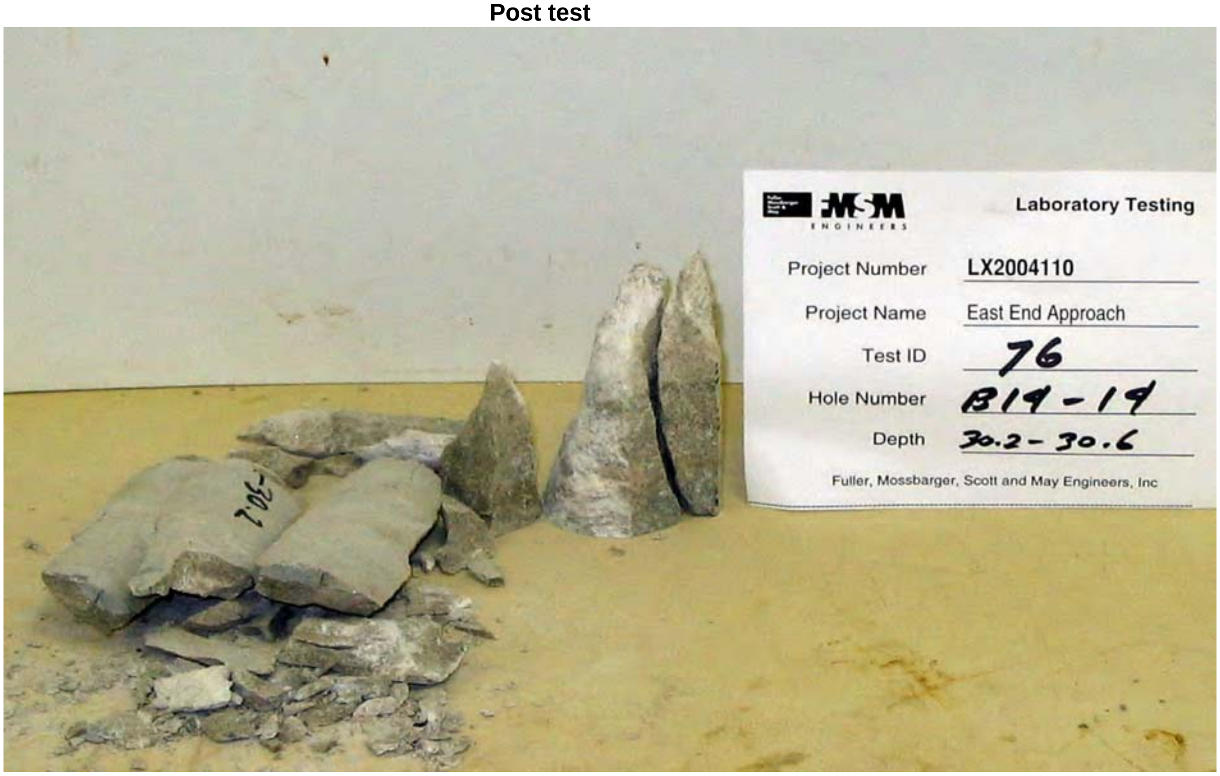
Project Name LSIORB Section 4, East End Approach
Lithology Limestone, light gray, moderately hard
Hole Number B-14-14 Depth (ft) 30.2' - 30.6'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-76

Core preparation



Post test



Fuller Mossbarger Scott & May ENGINEERS

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, light gray, moderately hard	Lab ID	UCSS-76
Hole Number	B-14-14 Depth (ft) 30.2' - 30.6'		
Test Type	Unconfined compressive strength of intact rock core		

Post test

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Limestone, light gray, moderately hard
Lab ID: UCSS-77
Hole Number: B-15-1
Depth (ft/elev): 100.7' - 101.1'
Date Received: 07-27-2005

Temperature (^oC): 23
Moisture Condition: As received, dry
Date Tested: 08-10-2005

Side Planeness	Pass	Height (in)	4.728	Wet Unit Weight (pcf)	167.7
Perpendicularity	Pass	Diameter (in)	1.995	Dry Unit Weight (pcf)	167.6
End Planeness	Pass	Area (in^2)	3.125	Moisture Content (%)	0.1

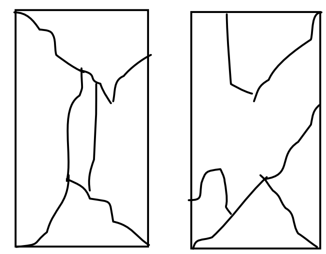
Loading Rate (lbf/sec): 202
Peak Load (lbf): 66920

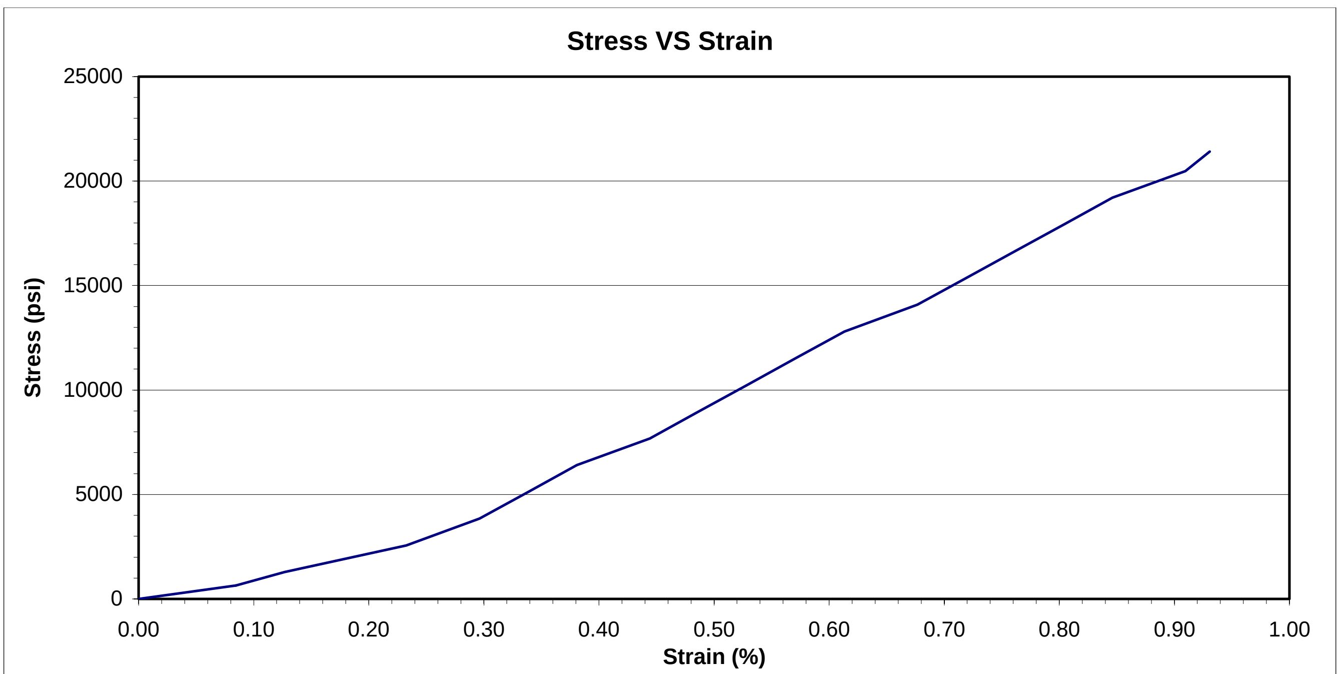
Failure Type: Cone

Compressive Strength (psi): 21420

Compressive Strength (tsf): 1542

Failure Sketches





Comments ________________________________

Reviewed By __________

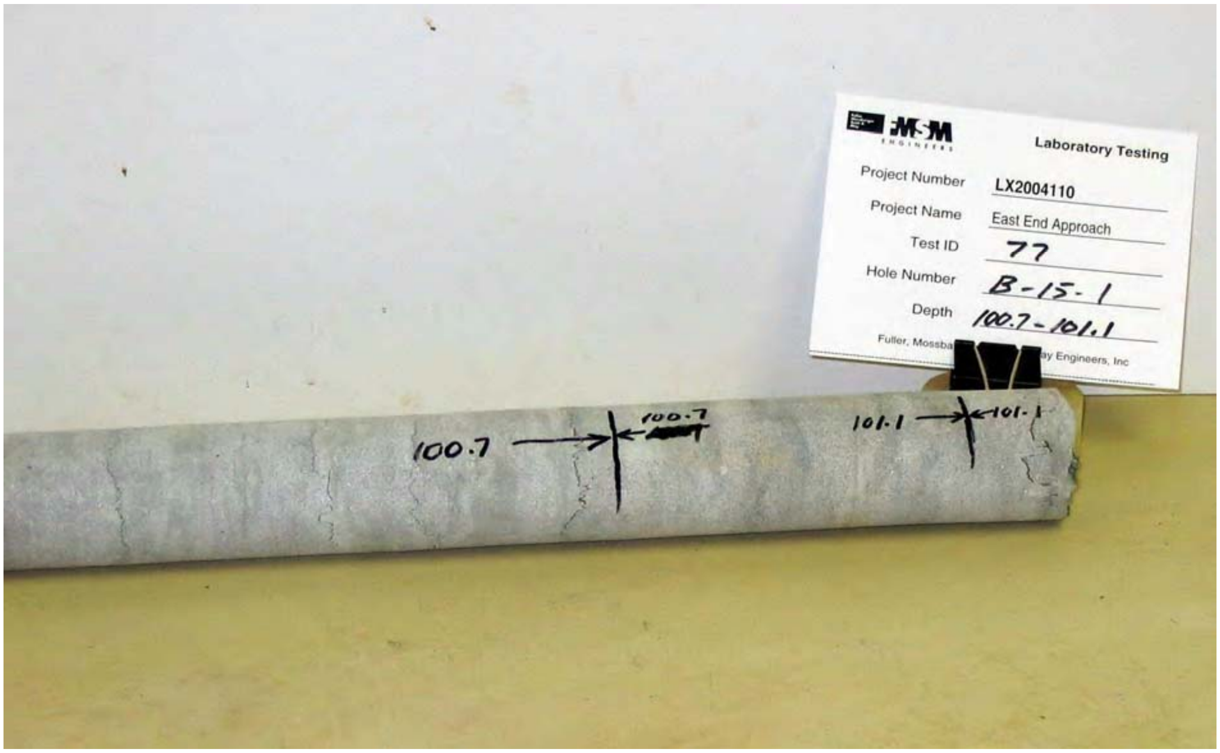
* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, light gray, moderately hard
Hole Number B-15-1 Depth (ft) 100.7' - 101.1'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-77

As received



Core preparation

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, light gray, moderately hard	Lab ID	UCSS-77
Hole Number	B-15-1 Depth (ft) 100.7' - 101.1'		
Test Type	Unconfined compressive strength of intact rock core		

Post test

Post test

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

FMSM ENGINEERS (Fuller Mossbarger Scott & May)

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Shale, gray, soft
Lab ID: UCSS-78
Hole Number: B-15-2
Depth (ft/elev): 112.5' - 112.9'
Date Received: 07-27-2005

Temperature (°C): 23
Moisture Condition: As received,dry
Date Tested: 08-10-2005

Side Planeness	Pass	Height (in)	4.626	Wet Unit Weight (pcf)	167.3
Perpendicularity	Pass	Diameter (in)	1.991	Dry Unit Weight (pcf)	165.2
End Planeness	Pass	Area (in^2)	3.113	Moisture Content (%)	1.3

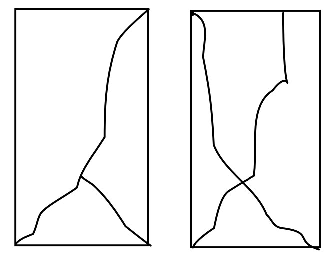
Loading Rate (lbf/sec): 118
Peak Load (lbf): 29140

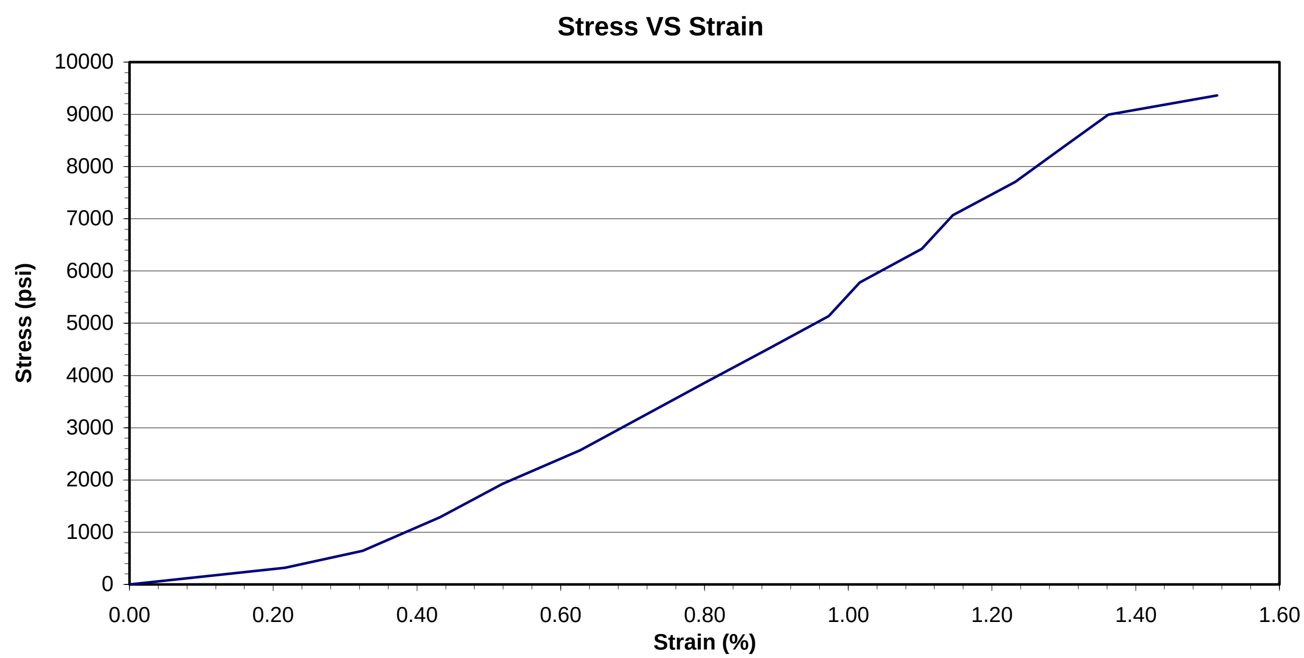
Failure Type: Cone and Shear

Compressive Strength (psi): 9360

Compressive Strength (tsf): 674

Failure Sketches





Comments ____________________

Reviewed By ____________

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name LSIORB Section 4, East End Approach

Lithology Shale, gray, soft

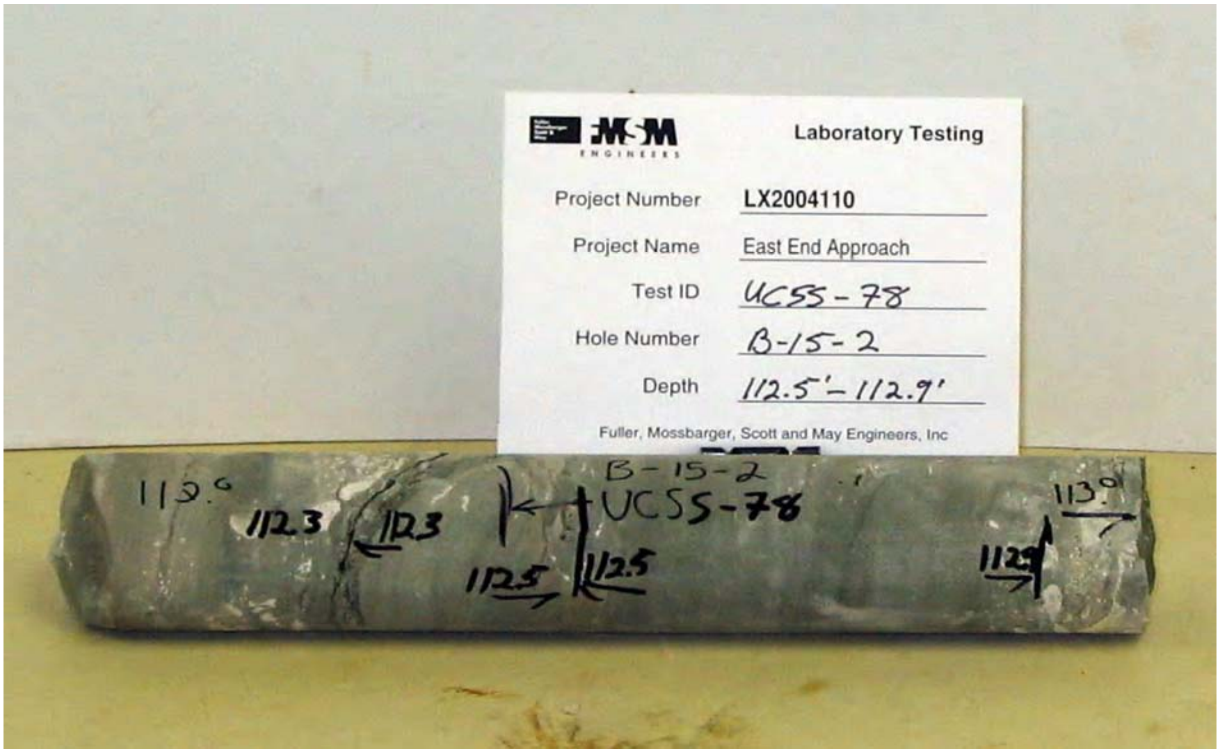
Hole Number B-15-2 Depth (ft) 112.5' - 112.9'

Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110

Lab ID UCSS-78

As received



Core preparation

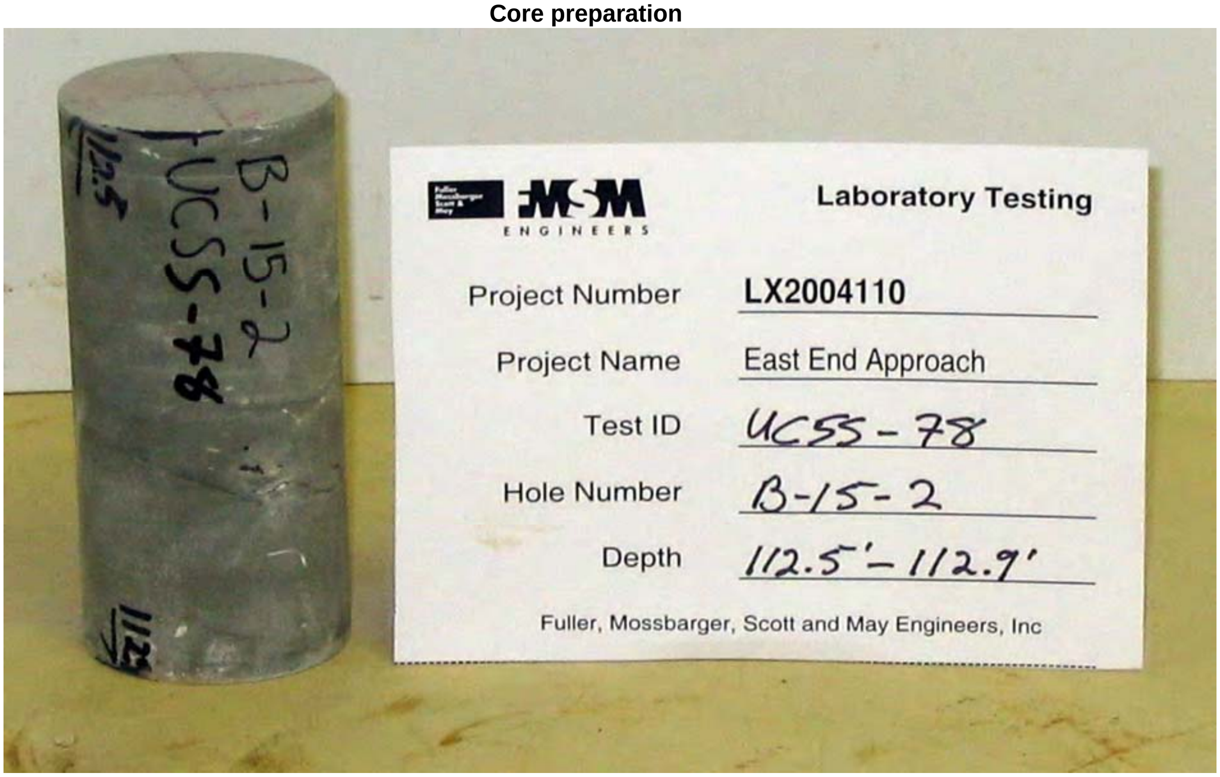
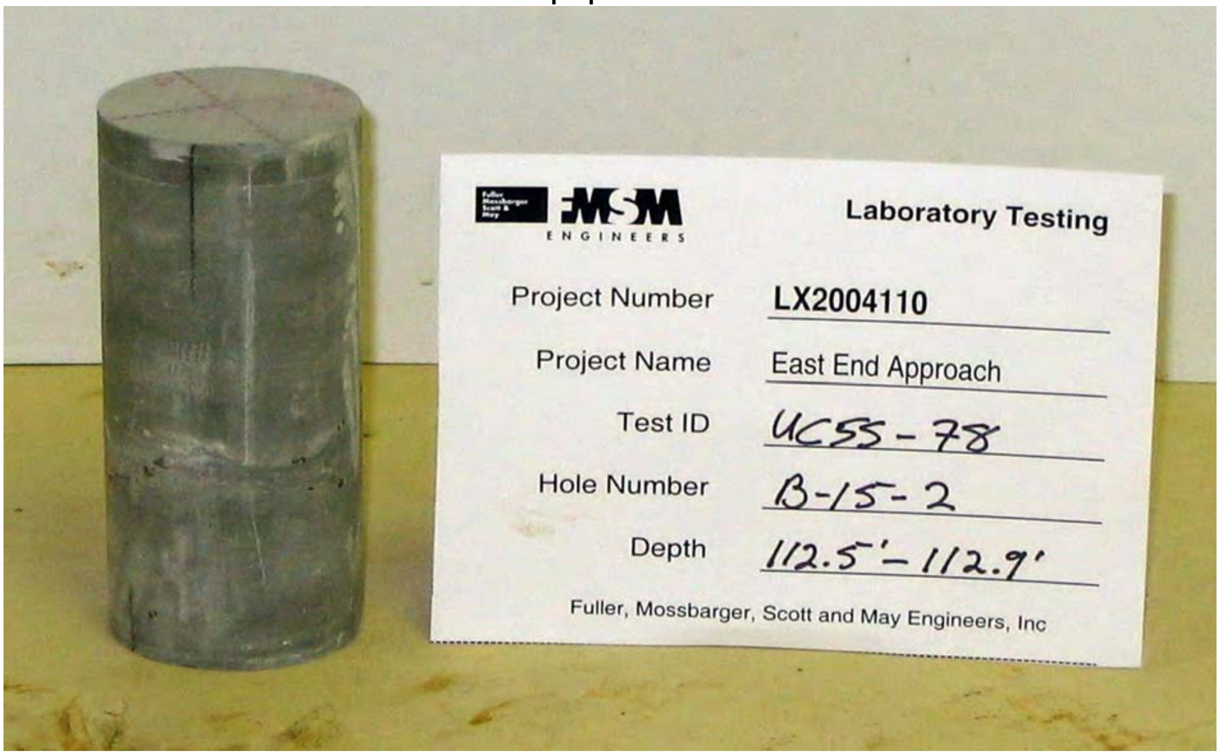


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Shale, gray, soft	Lab ID	UCSS-78
Hole Number	B-15-2	Depth (ft)	112.5' - 112.9'
Test Type	Unconfined compressive strength of intact rock core		

Core preparation



Post test

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Shale, gray, soft	Lab ID	UCSS-78
Hole Number	B-15-2	Depth (ft)	112.5' - 112.9'
Test Type	Unconfined compressive strength of intact rock core		

Post test

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*
ASTM D 2938

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Limestone, gray, moderately hard
Lab ID UCSS-82
Hole Number B-15-7
Depth (ft/elev) 153.2' - 153.6'
Date Received 07-27-2005

Temperature (^oC) 23
Moisture Condition As received, dry
Date Tested 08-10-2005

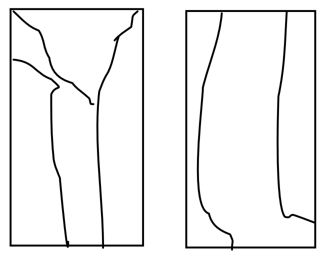
Side Planeness Pass
Height (in) 4.240
Wet Unit Weight (pcf) 165.7
Perpendicularity Pass
Diameter (in) 1.997
Dry Unit Weight (pcf) 165.1
End Planeness Pass
Area (in^2) 3.132
Moisture Content (%) 0.4

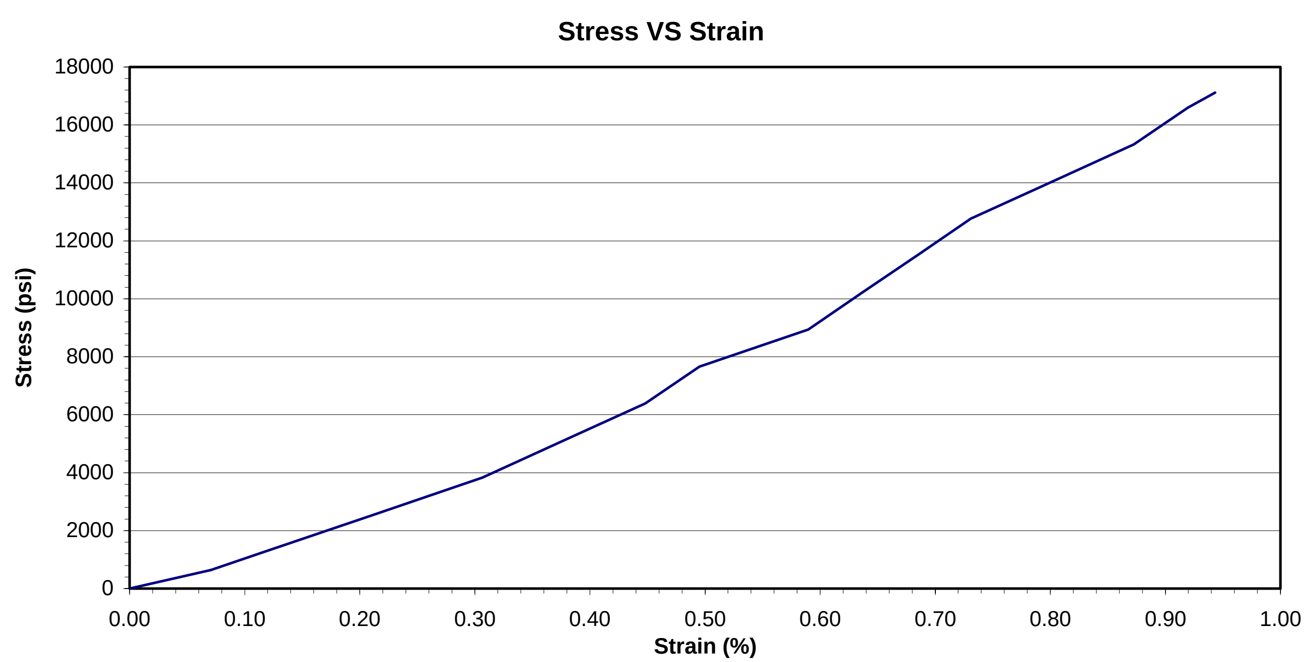
Loading Rate (lbf/sec) 244
Peak Load (lbf) 53600

Failure Type Cone and Split

Compressive Strength (psi) 17110

Compressive Strength (tsf) 1232

Failure Sketches




Comments

Reviewed By

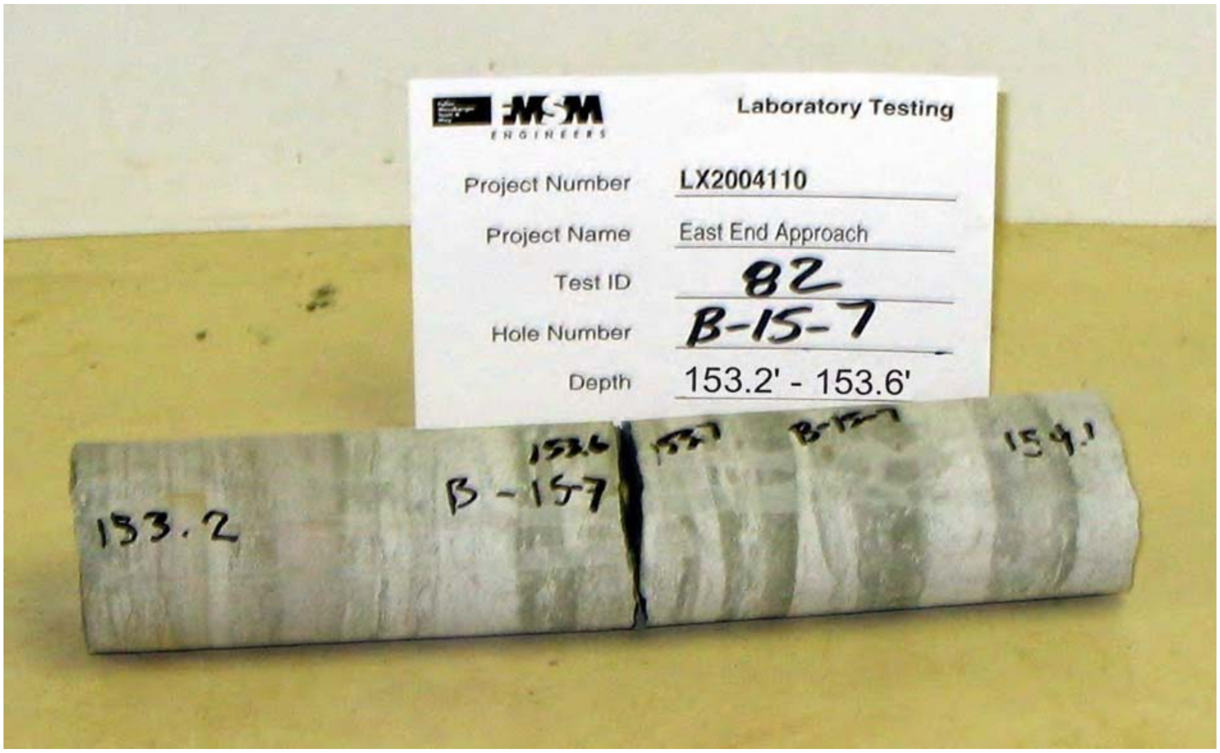
* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, gray, moderately hard
Hole Number B-15-7 Depth (ft) 153.2' - 153.6'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-82

As received



Core preparation

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, gray, moderately hard
Hole Number B-15-7 Depth (ft) 153.2' - 153.6'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-82

Core preparation

Post test

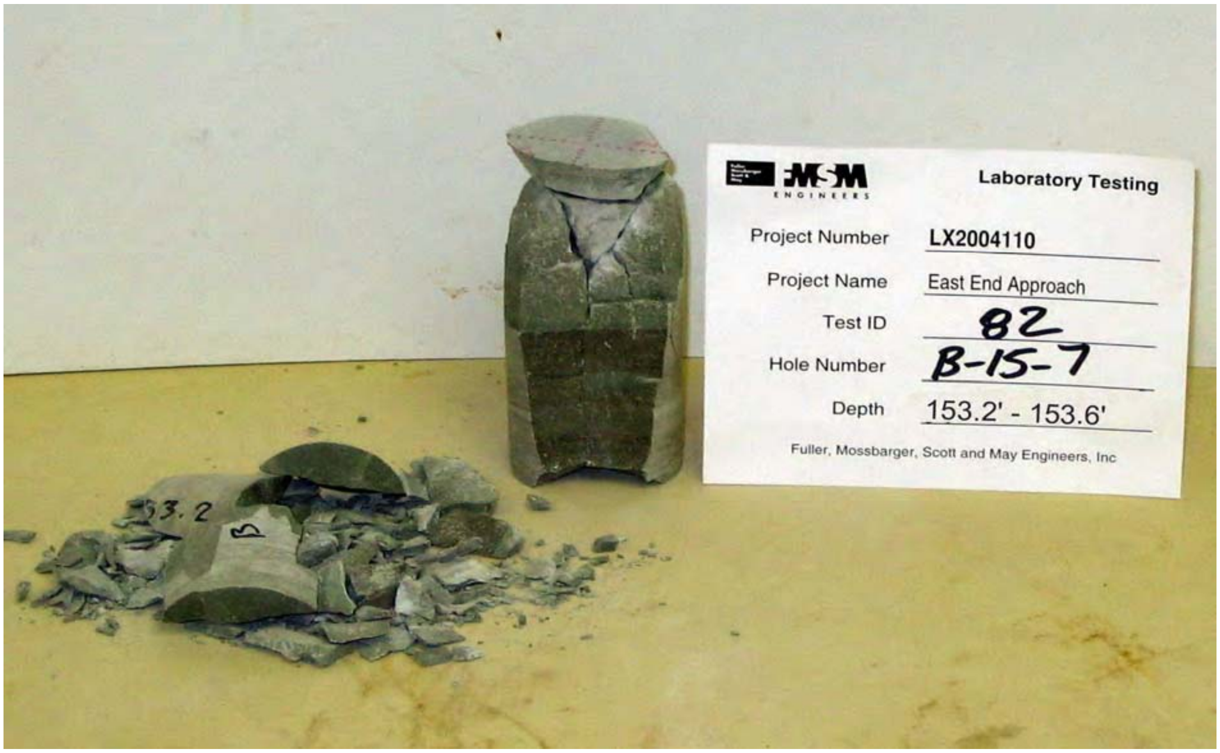


Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, gray, moderately hard
Hole Number B-15-7 Depth (ft) 153.2' - 153.6'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-82

Post test

Fuller Mossbarger Scott & May

FMSM ENGINEERS

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Limestone, light gray, moderately hard
Lab ID UCSS-83
Hole Number B-15-8
Depth (ft/elev) 37.1' - 37.5'
Date Received 07-27-2005

Temperature (^oC) 23
Moisture Condition As received, dry
Date Tested 08-10-2005

Side Planeness	Pass	Height (in)	4.759	Wet Unit Weight (pcf)	162.9
Perpendicularity	Pass	Diameter (in)	1.998	Dry Unit Weight (pcf)	162.7
End Planeness	Pass	Area (in^2)	3.136	Moisture Content (%)	0.1

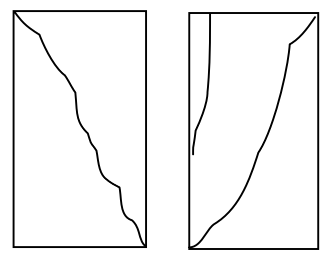
Loading Rate (lbf/sec) 237
Peak Load (lbf) 42600

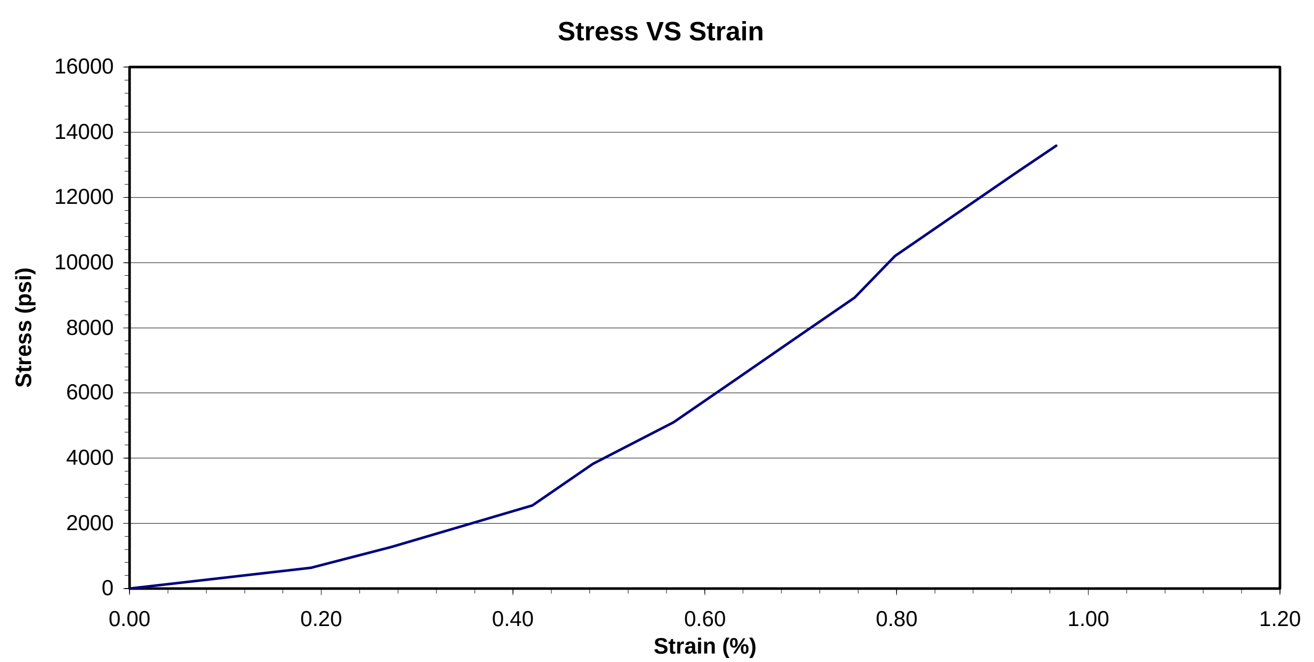
Failure Type Shear

Compressive Strength (psi) 13580

Compressive Strength (tsf) 978

Failure Sketches





Comments ______________________

Reviewed By ___________

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

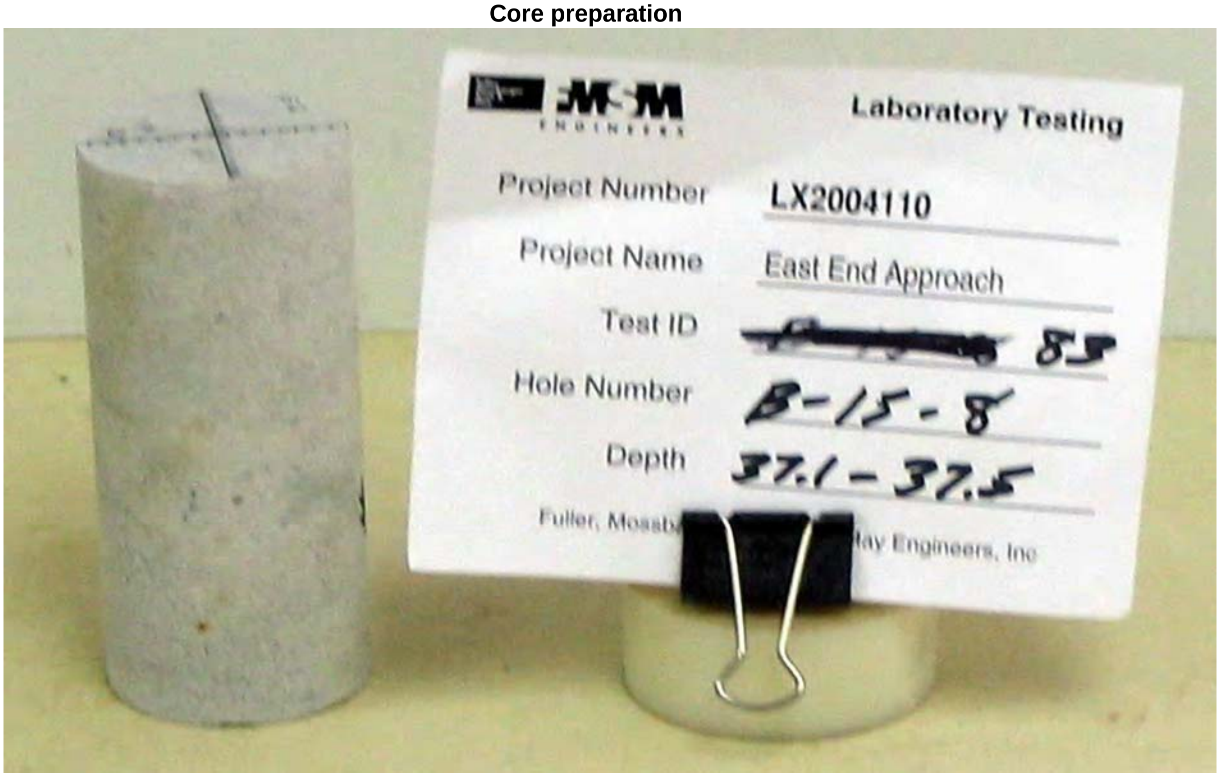
Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, light gray, moderately hard
Hole Number B-15-8 Depth (ft) 37.1' - 37.5'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-83

As received

Core preparation



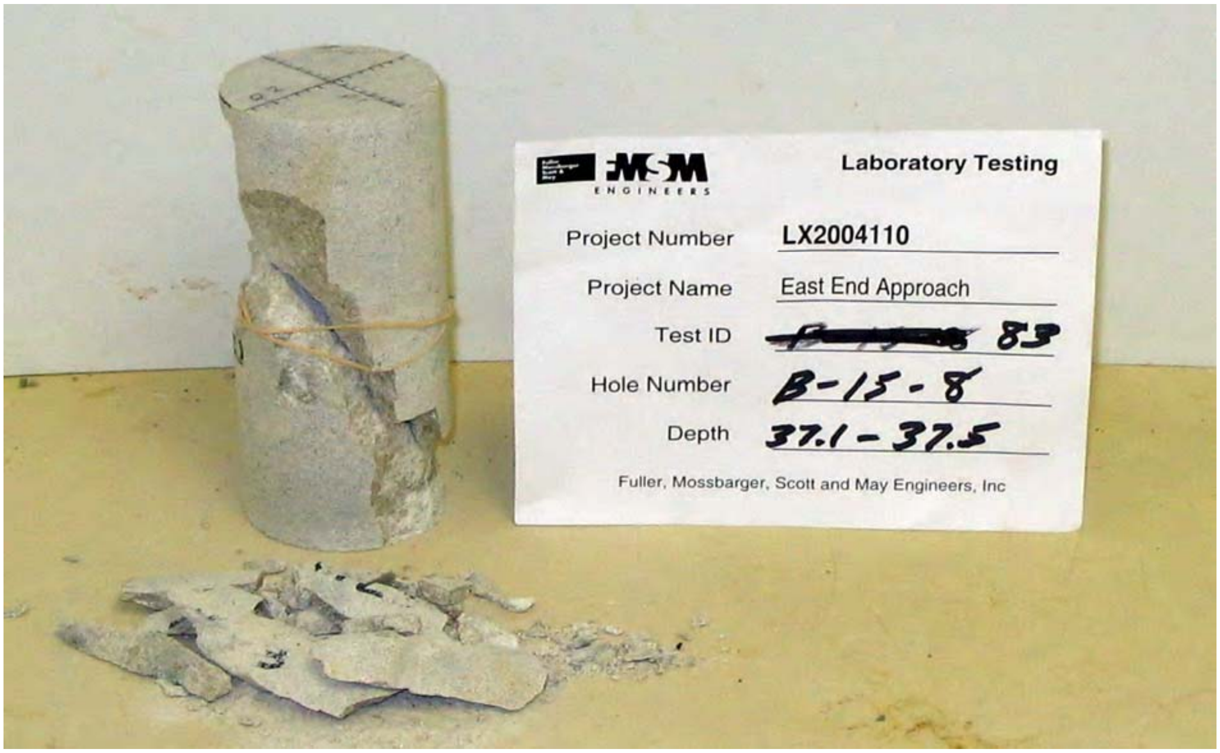
Fuller Mossbarger Scott & May
FMSM ENGINEERS

Photo Report

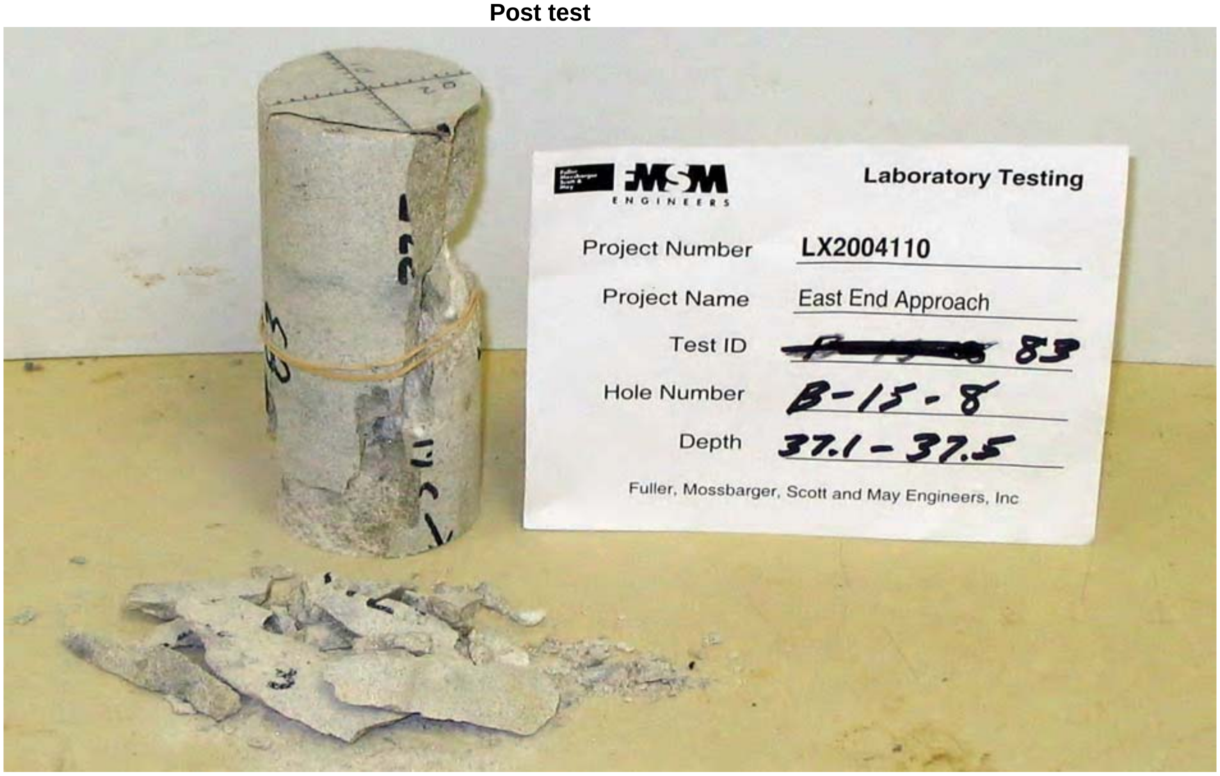
Project Name LSIORB Section 4, East End Approach
Lithology Limestone, light gray, moderately hard
Hole Number B-15-8 Depth (ft) 37.1' - 37.5'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-83

Post test



Post test



Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

FMSM ENGINEERS — Fuller Mossbarger Scott & May

Project Name: LSIORB Section 4, East End Approach
Project Number: LX2004110
Lithology: Limestone, gray, moderately hard
Lab ID: UCSS-84
Hole Number: B-15-10
Depth (ft/elev): 22.6' - 23.0'
Date Received: 07-27-2005

Temperature (°C): 23
Moisture Condition: As received, dry
Date Tested: 08-10-2005

Side Planeness	Pass	Height (in)	4.742	Wet Unit Weight (pcf)	167.0
Perpendicularity	Pass	Diameter (in)	1.997	Dry Unit Weight (pcf)	166.7
End Planeness	Pass	Area (in^2)	3.133	Moisture Content (%)	0.2

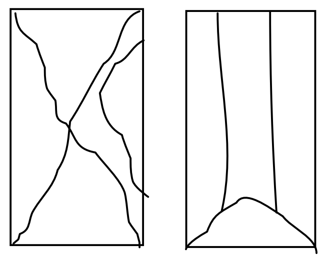
Loading Rate (lbf/sec): 290
Peak Load (lbf): 75090

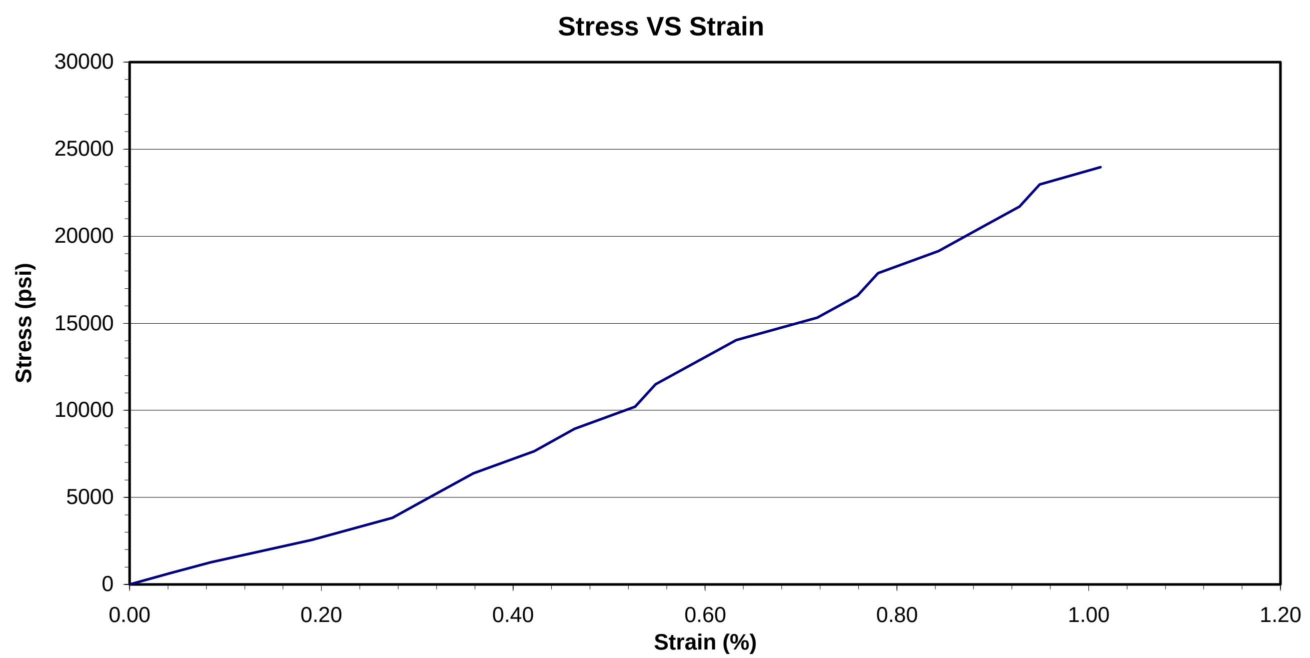
Failure Type: Columnar

Compressive Strength (psi): 23970

Compressive Strength (tsf): 1726

Failure Sketches





Comments ______________________

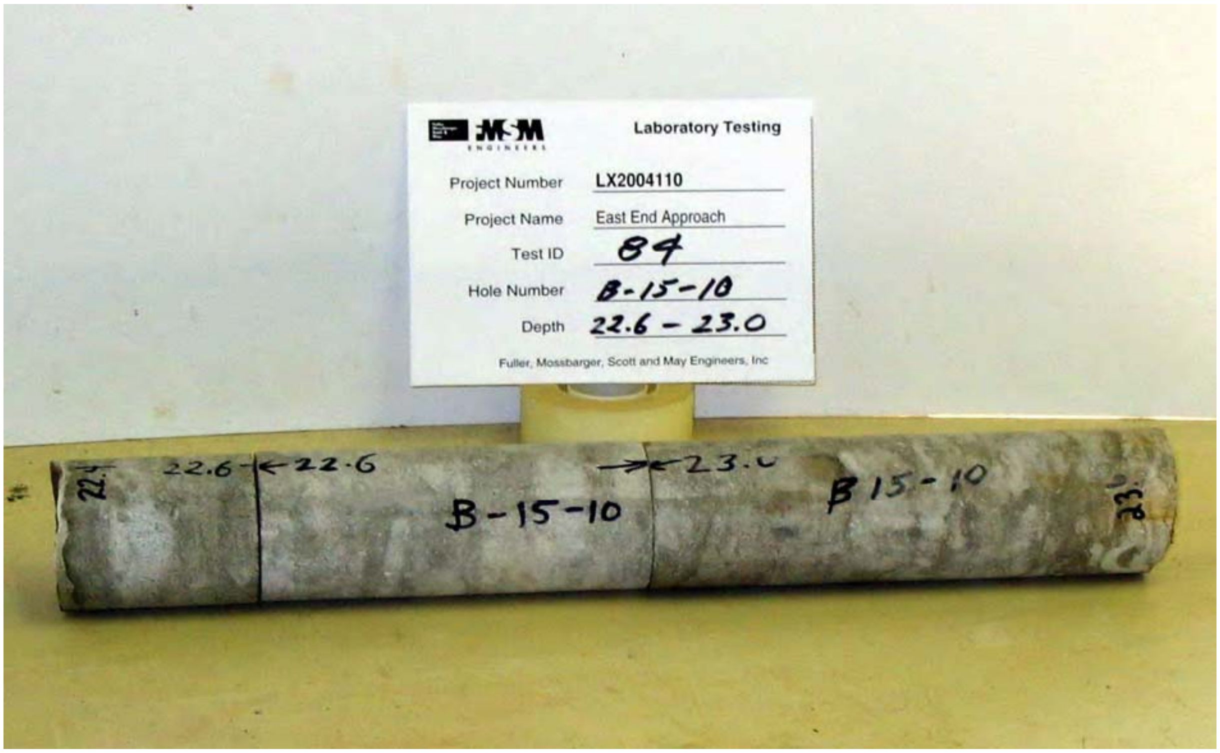
Reviewed By ___________

* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, gray, moderately hard
Hole Number B-15-10 Depth (ft) 22.6' - 23.0'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-84

As received



Core preparation

Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, gray, moderately hard
Hole Number B-15-10 Depth (ft) 22.6' - 23.0'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-84

Post test

Post test

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

Fuller Mossbarger Scott & May ENGINEERS

Project Name	LSIORB Section 4, East End Approach			Project Number	LX2004110
Lithology	Limestone, light gray, moderately hard			Lab ID	UCSS-85
Hole Number	B-18-1	Depth (ft/elev)	51.7' - 52.1'	Date Received	07-27-2005
Temperature (^{o}C)	21	Moisture Condition	As received, dry	Date Tested	08-11-2005
Side Planeness	Pass	Height (in)	4.678	Wet Unit Weight (pcf)	164.7
Perpendicularity	Pass	Diameter (in)	1.992	Dry Unit Weight (pcf)	164.5
End Planeness	Pass	Area (in^2)	3.117	Moisture Content (%)	0.1

Loading Rate (lbf/sec) 250

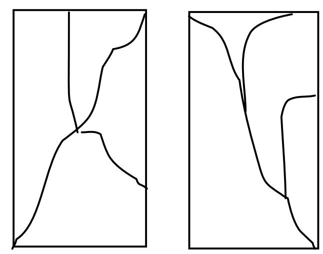
Peak Load (lbf) 35240

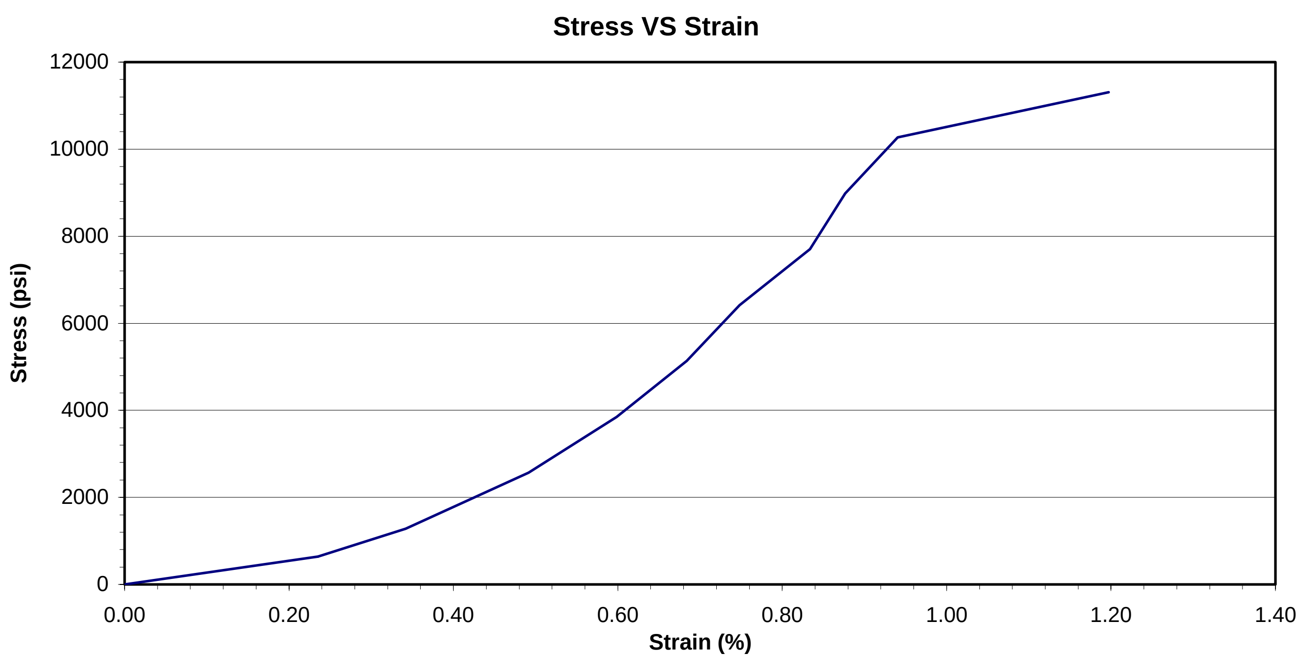
Failure Type Cone and Split

Compressive Strength (psi) 11310

Compressive Strength (tsf) 814

Failure Sketches





Comments

Reviewed By

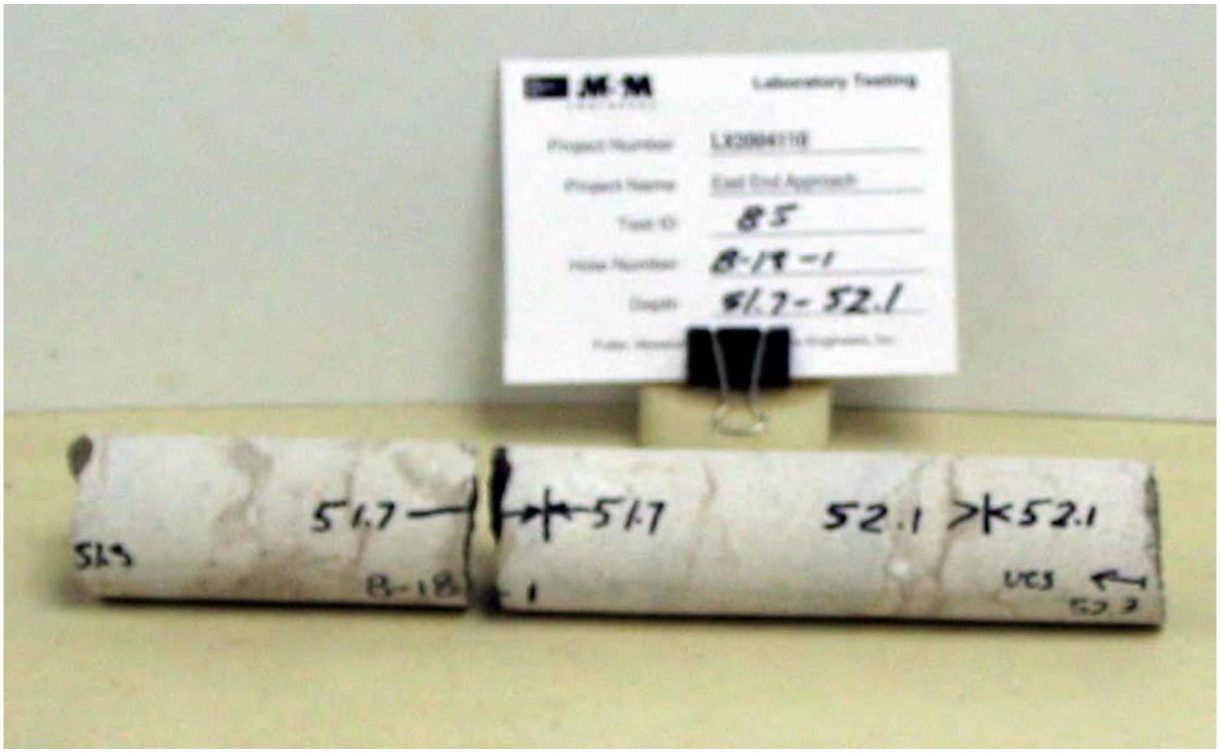
* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Fuller Mossbarger Scott & May
ENGINEERS

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, light gray, moderately hard	Lab ID	UCSS-85
Hole Number	B-18-1 Depth (ft) 51.7' - 52.1'		
Test Type	Unconfined compressive strength of intact rock core		

As received



Core preparation

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, light gray, moderately hard	Lab ID	UCSS-85
Hole Number	B-18-1	Depth (ft)	51.7' - 52.1'
Test Type	Unconfined compressive strength of intact rock core		

Post test

Post test

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

FMSM ENGINEERS — Fuller Mossbarger Scott & May

Project Name LSIORB Section 4, East End Approach

Project Number LX2004110

Lithology Limestone, light gray, moderately hard

Lab ID UCSS-86

Hole Number B-18-2

Depth (ft/elev) 78.4' - 78.8'

Date Received 07-27-2005

Temperature (^{o}C) 21

Moisture Condition As received, dry

Date Tested 08-11-2005

Side Planeness Fail

Perpendicularity Fail

End Planeness Pass

Height (in) 4.717

Diameter (in) 1.990

Area (in^2) 3.111

Wet Unit Weight (pcf) 166.3

Dry Unit Weight (pcf) 166.1

Moisture Content (%) 0.1

Loading Rate (lbf/sec) 157

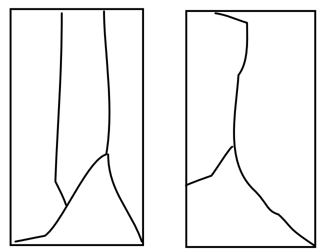
Peak Load (lbf) 36650

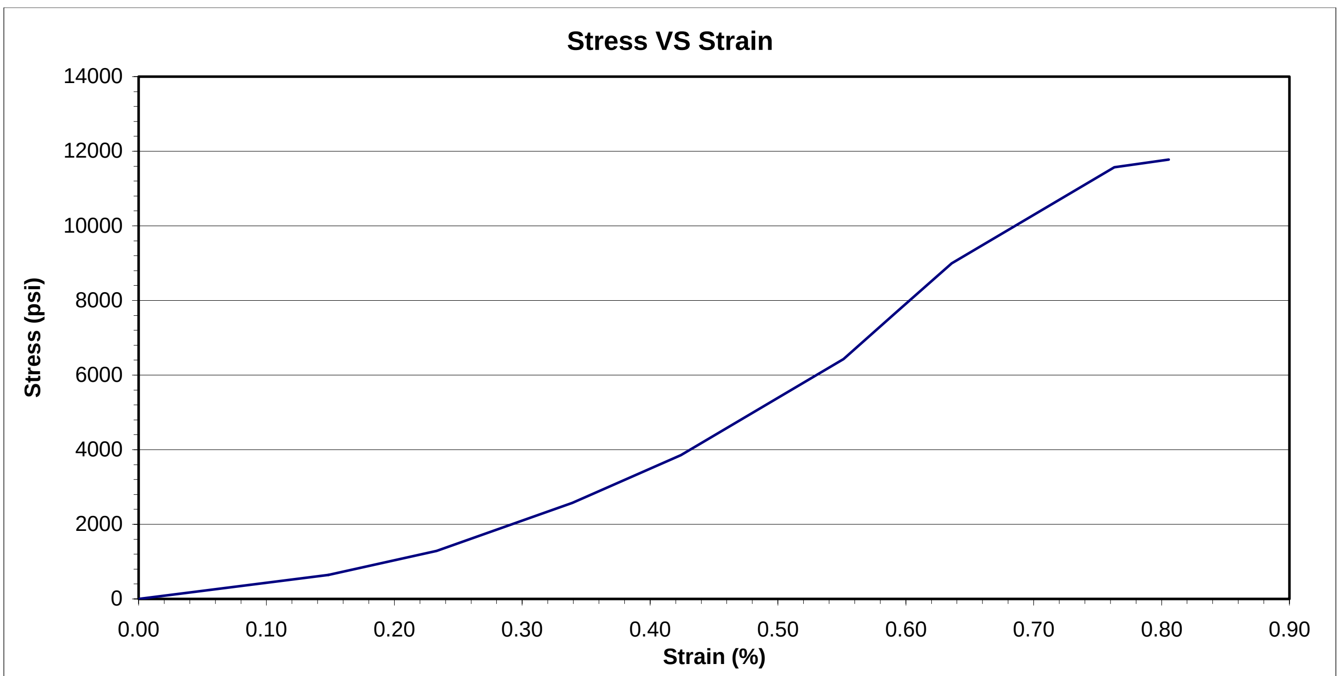
Failure Type Cone and Split

Compressive Strength (psi) 11780

Compressive Strength (tsf) 848

Failure Sketches





Comments

Reviewed By

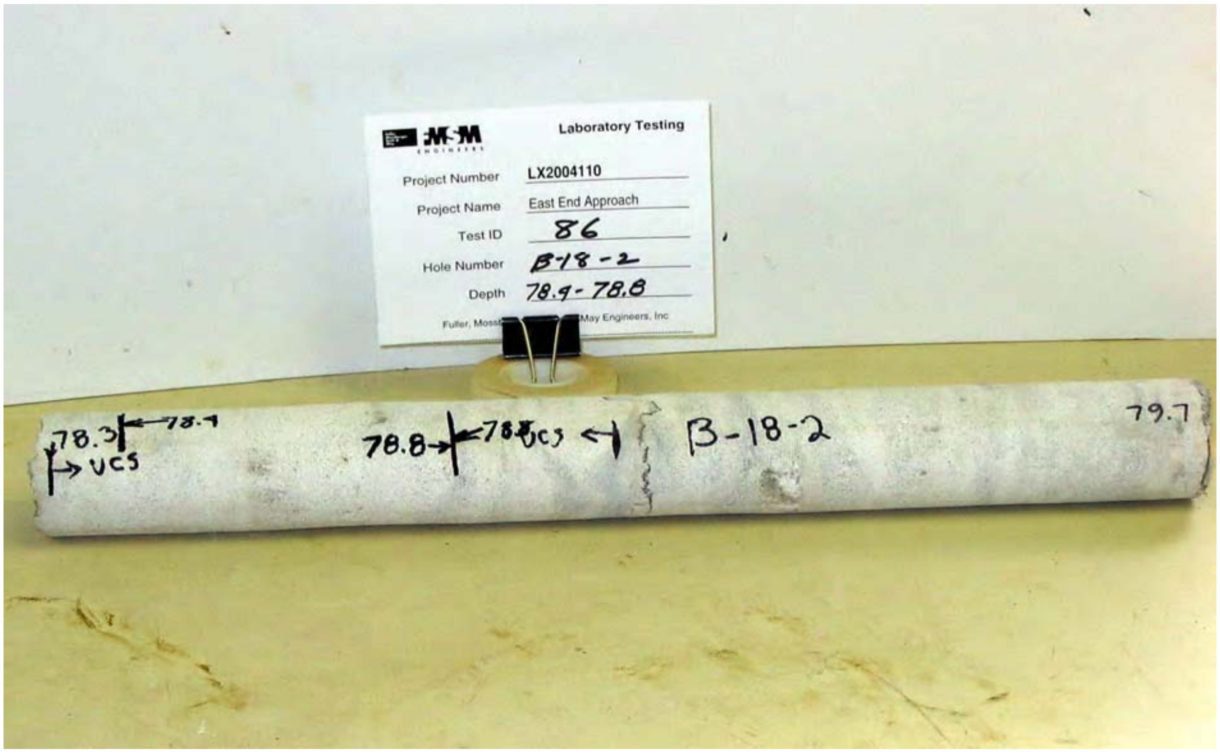
* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

Project Name LSIORB Section 4, East End Approach
Lithology Limestone, light gray, moderately hard
Hole Number B-18-2 Depth (ft) 78.4' - 78.8'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-86

As received



Core preparation

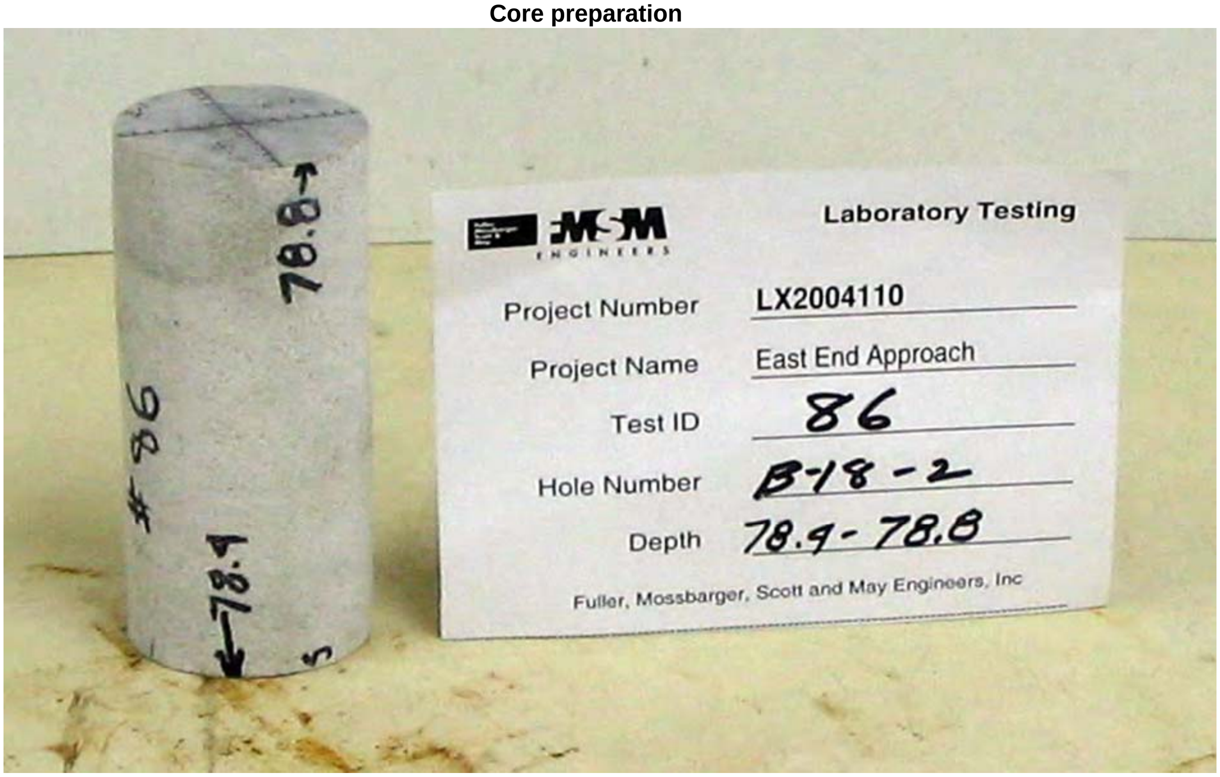


Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, light gray, moderately hard	Lab ID	UCSS-86
Hole Number	B-18-2 Depth (ft) 78.4' - 78.8'		
Test Type	Unconfined compressive strength of intact rock core		

Core preparation

Post test

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Limestone, light gray, moderately hard	Lab ID	UCSS-86
Hole Number	B-18-2	Depth (ft)	78.4' - 78.8'
Test Type	Unconfined compressive strength of intact rock core		

Post test

Fuller Mossbarger Scott & May
FMSM ENGINEERS

Unconfined Compressive Strength of Intact Rock Core with Stress-Strain*

ASTM D 2938

Project Name LSIORB Section 4, East End Approach
Project Number LX2004110
Lithology Shale, gray, soft
Lab ID UCSS-87
Hole Number B-18-3
Depth (ft/elev) 83.9' - 84.3'
Date Received 07-27-2005

Temperature (°C) 21
Moisture Condition As received, dry
Date Tested 08-11-2005

Side Planeness Pass
Perpendicularity Fail
End Planeness 3 of 4 Pass

Height (in) 4.069
Diameter (in) 1.983
Area (in^2) 3.089

Wet Unit Weight (pcf) 161.5
Dry Unit Weight (pcf) 158.8
Moisture Content (%) 1.7

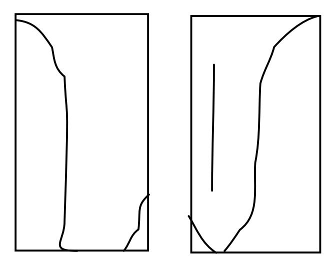
Loading Rate (lbf/sec) 88
Peak Load (lbf) 17960

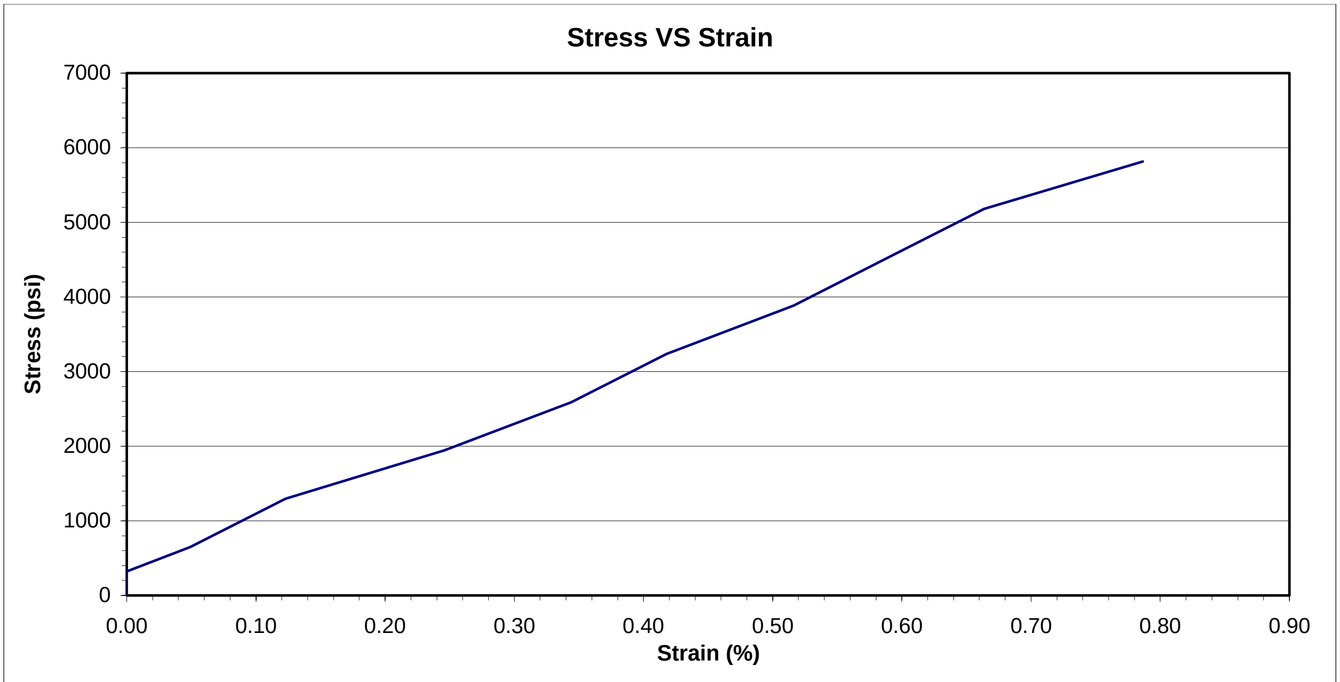
Failure Type Columnar

Compressive Strength (psi) 5810

Compressive Strength (tsf) 419

Failure Sketches





Comments Fragile nature of specimen inhibited preparation.

Reviewed By ___________

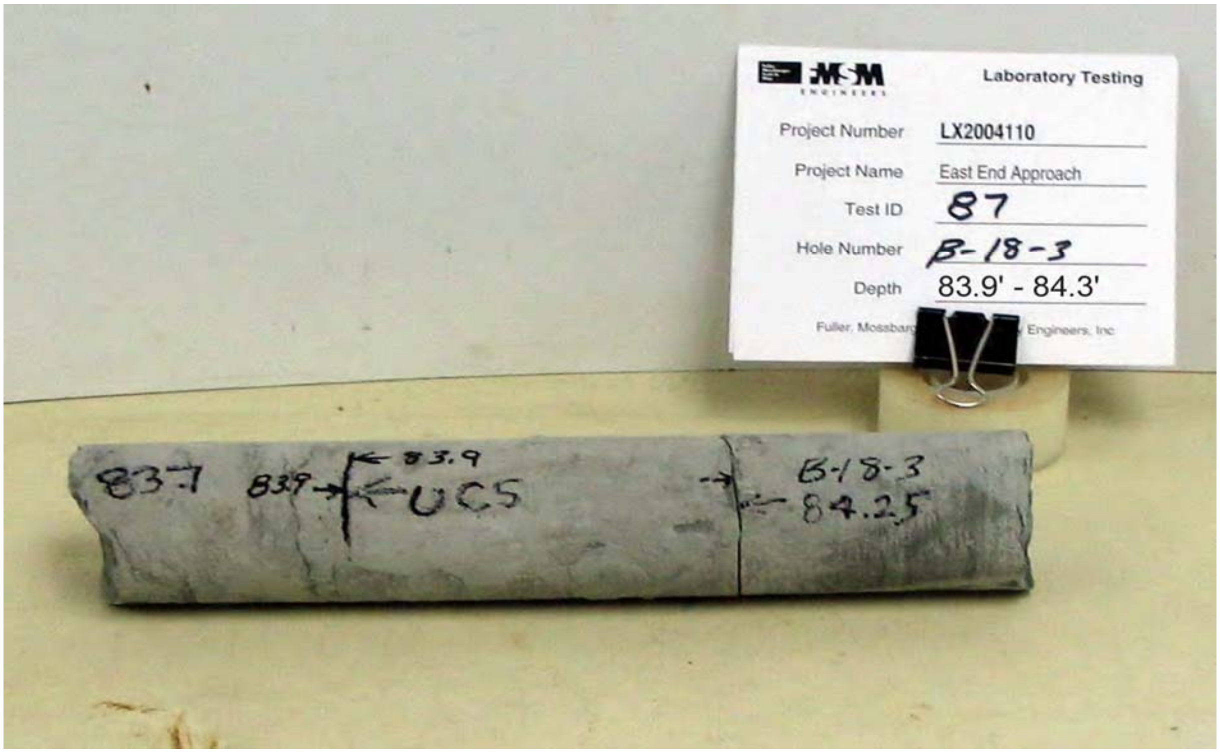
* Stress-strain data was obtained and presented as per FMSM custom testing procedures.

Photo Report

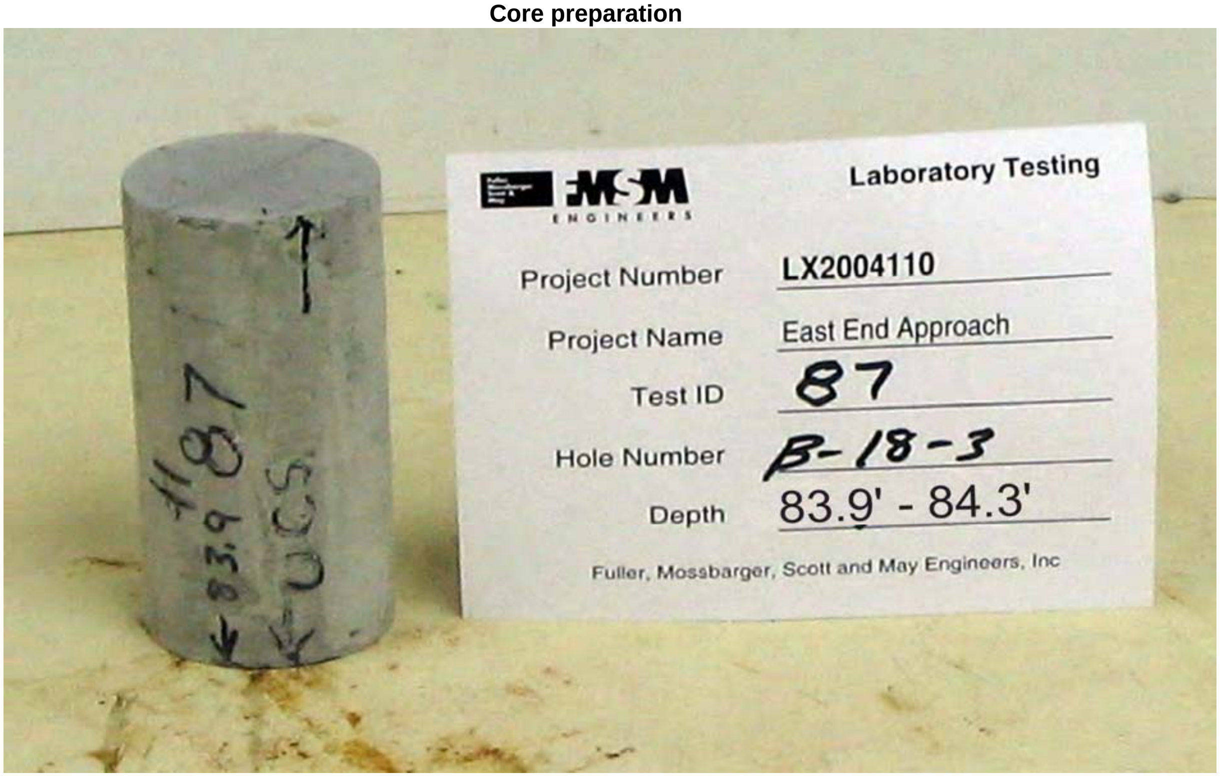
Project Name LSIORB Section 4, East End Approach
Lithology Shale, gray, soft
Hole Number B-18-3 Depth (ft) 83.9' - 84.3'
Test Type Unconfined compressive strength of intact rock core

Project Number LX2004110
Lab ID UCSS-87

As received



Core preparation



Fuller Mossbarger Scott & May
FMSM ENGINEERS

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Shale, gray, soft	Lab ID	UCSS-87
Hole Number	B-18-3	Depth (ft)	83.9' - 84.3'
Test Type	Unconfined compressive strength of intact rock core		

Core preparation

Post test

Photo Report

Project Name	LSIORB Section 4, East End Approach	Project Number	LX2004110
Lithology	Shale, gray, soft	Lab ID	UCSS-87
Hole Number	B-18-3	Depth (ft)	83.9' - 84.3'
Test Type	Unconfined compressive strength of intact rock core		

Post test

Borehole Geophysical Logging Results
East End Approach, Phase 2
Louisville, Kentucky

Prepared for
FMSM
February 3, 2006

Prepared by
COLOG Division of Layne Christensen Company
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Prepared By:

Summer Montgomery
Geophysical Engineer

Reviewed By:

Nathan O. Davis
Geophysical Engineer

Table of Contents

Geophysical Logging Results,
East End Approach, Phase 2, Louisville, Kentucky

Geophysical Logging Results
East End Approach, Phase 2, Louisville, Kentucky

I. Introduction

This document is prepared for FMSM Engineers to report on the borehole geophysical data collected for the East End Approach, Phase 2, project in Louisville, Kentucky.

In accordance with COLOG's proposal, dated November 9, 2005, COLOG has logged five boreholes with optical televiewer, 4-pi density, neutron, and 3-arm caliper tools. Also according to COLOG's proposal, stereonet and rose plots of fracture/bedding orientation, fracture/bedding orientation tables, and original generation of color optical televiewer logs are provided in the appendices of this report.

The boreholes tested are: B-5, B-6, B-8, B-10, and B-11.

COLOG's logging of the five subject wellbores was performed over the period of December 18th through December 19th, 2005.

II. Methodology

A. 3-Arm Caliper

The caliper log represents the average borehole diameter determined by the extension of 1 or 3 spring-loaded arms. The measurement of the borehole diameter is determined by the change in the variable pot resistors in the probe, which are internally connected to the caliper arms.

Caliper logs may show diameter increases in cavities and, depending on drilling techniques used, in weathered zones. An apparent decrease in borehole diameter may result from mud or drill-cutting accumulation along the sides of the borehole (mudcake), a swelled clay horizon or a planned change in drill bit size. The bottom of the boring can also induce a small diameter reading from the caliper due to the caliper leaning up against on side of the borehole. The caliper log is often a useful indicator of fracturing. The log anomalies do not directly represent the true in-situ fracture size or geometry. Rather, they represent areas of borehole wall breakage associated with the mechanical weakening at the borehole-fracture intersection. Caliper anomalies may represent fractures, bedding planes, lithologic changes or solution openings. Generally, in solid bedrock caliper log anomalies indicate the intervals where fractures intersect boreholes.

COLOG records the caliper log with either a single-arm caliper measurement using the decentralization arm of the density probe or a separate stand-alone three-arm caliper. Calibrations of the probe are done routinely on the bench and in the field directly before the tool is placed into the borehole. Calibration standards consist of rings of known diameters that are placed over the extended arms as the tool response at these diameters is recorded. Additionally, as with other geophysical measurements, a repeat section may be collected and compared with original logs for consistency and accuracy.

Fundamental assumptions and limitations inherent in these procedures are as follows:

- Excessive borehole diameters (greater than 36 inches) may limit the range of borehole caliper measurements. Holes greater than 12 inches must be logged with extended arms for hole diameters up to 36 inches.

- Since the caliper probe is an electro-mechanical device, a certain amount of error is inherent in the measurement. These errors are due to: 1) averaging hole diameter using three arms, 2) non-linearity of the measurement resistor, 3) tolerance in the mechanical movement of the caliper arms (mechanical hysteresis).Caliper Measurement

B. Optical Televiewer (BIPS or OBI)

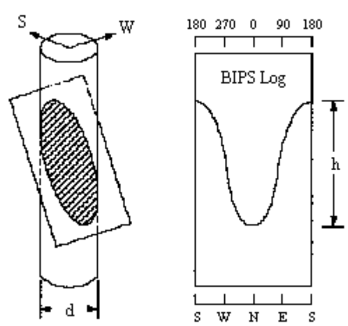
The optical televiewer provides the highest resolution available for fracture and feature analysis in boreholes. This technology is based on direct optical observation of the borehole wall face. Precise measurements of dip angle and direction of bedding and joint planes, along with other geological analyses, are possible in both air and clear fluid filled boreholes.

Theory of Operation

A small light ring illuminates the borehole wall allowing a camera to directly image the borehole wall face. A conical mirror housed in a clear cylindrical window focuses a 360° optical "slice" of the borehole wall into the camera's lens. As the optical televiewer tool is lowered down the hole, the video signal from this camera is transmitted uphole via the wireline to the optical televiewer surface instrumentation.

The signal is digitized in real time by capturing 360 pixels around a 0.5 mm ring from the conical image. The rings are stacked and unwrapped to a 2-D image of the borehole wall. A digital fluxgate magnetometer is used to determine the orientation of the digital image. A secondary mechanical compass is imaged along with the analog signal to insure proper orientation of the digital image.

The optical televiewer image is an oriented, 2-D picture of the borehole wall unwrapped from south to south or north to north depending on the software used (Figure 1). Planar features that intersect the borehole appear to be sinusoids on the unwrapped image. To calculate the dip angle of a fracture or bedding feature the amplitude of the sinusoid (h) and the borehole diameter (d) are required. The angle of dip is equal to the arc tangent of h/d, and the dip direction is picked at the trough of the sinusoid (Figure 1).



Dip Direction = Orientation of Sinusoid Minimum
Dip Angle = ArcTan h/d
where: h = height of sinusoid
d = borehole diameter

Figure 1: Geometric representation of a north dipping fracture plane and corresponding log.

Sinusoidal features were picked throughout wells by visual inspection of the digital optical televiewer images using interactive software. The software performed the orientation calculations and assigned depths to the fractures or bedding features at the inflection points (middles) of the sinusoids. Features were subjectively ranked for flow potential using COLOG's

Ranking System for optical televiewer features included in this report. The features picked along with their assigned ranks, orientations and depths are presented in tables for each well. Orientations are based on magnetic north and are corrected for declination. The Stereonet plots and Rose Diagrams provide useful information concerning the statistical distribution and possible patterns or trends that may exist from the optical televiewer feature orientations.

Interpreting Optical Televiewer Data

Data acquired from the optical televiewer is typically in the form of dip direction/dip angle, i.e. 230/45. When plotted in 2-D color, the fractures and features intersecting the borehole appear as sinusoids as discussed above. Using the software program WellCAD version 3.2, the user identifies the features/fractures and has the software assign and record a dip angle and direction based on the above algorithm as described in the “Theory” section. The data can easily be converted into table format for display in Excel or any tabular editing program. From the data table, rose diagrams and/or stereonets can be generated if requested.

Rose Diagrams

A rose diagram is a polar diagram in which radial length of the petals indicates the relative frequency (percentage) of observation of a particular angle or fracture dip direction or range of angles or dip directions. Rose diagrams are used to identify patterns (if any) in the frequency of dip angles or directions for a particular data set. Figures 3 and 4 are example rose diagrams from an optical televiewer data set of fractures and features.

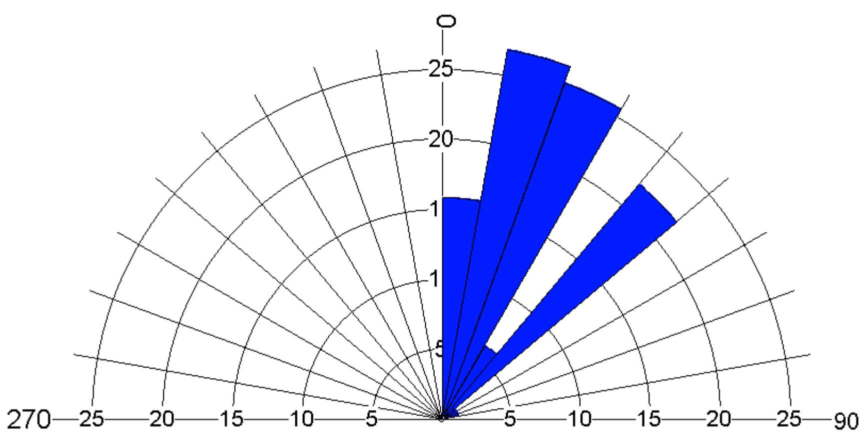
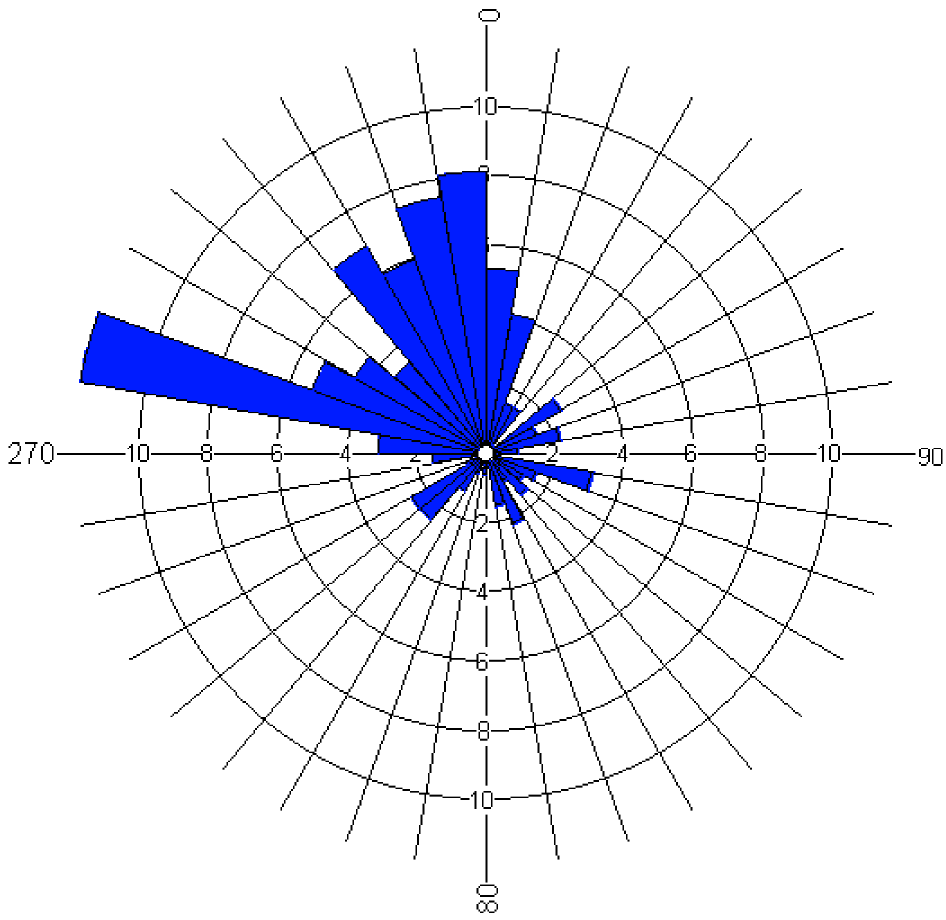


Figure 3: Example rose diagram from an optical televiewer data set illustrating the frequency (%) of dip angles.

Figure 3 above indicates, from an example data set, that approximately 16 percent of the fractures/features have a dip angle between 0 and 10 degrees, approximately 27 percent of the fractures/features have a dip angle between 11 and 20 degrees, approximately 25.5 percent between 21 and 30 degrees, approximately 6 percent between 31 and 40 degrees and 22 percent between 41 and 50 degrees. A quick glance at Figure 3 identifies a pattern of dip angle where greater than 50 percent of the fracture/features identified have a dip angle between 11 and 30 degrees. Additionally, no high-angle (greater than 50 degrees) fractures/features were identified



from this data set.

Figure 4: Example rose diagram from an optical televiewer data set illustrating the frequency (%) of dip direction.

Figure 4 (example data set) above indicates, with a quick glance, that the majority of the fractures/features dip in the direction of northwest. Specifically, approximately 62 percent of the identified fractures/features have a dip direction of 280 degrees (west) to 20 degrees (north).

Stereonets

For stereonets, COLOG utilizes a Schmidt net, an equal-area plot of longitude and latitude used in plotting geologic data such as the direction of structural features. Here, the angle indicates dip direction and the distance from the center indicates the dip magnitude. The further from the center the shallower the dip angle. Figure 5 below is an example stereonet diagram from an acoustic televiewer data set of fractures and features.

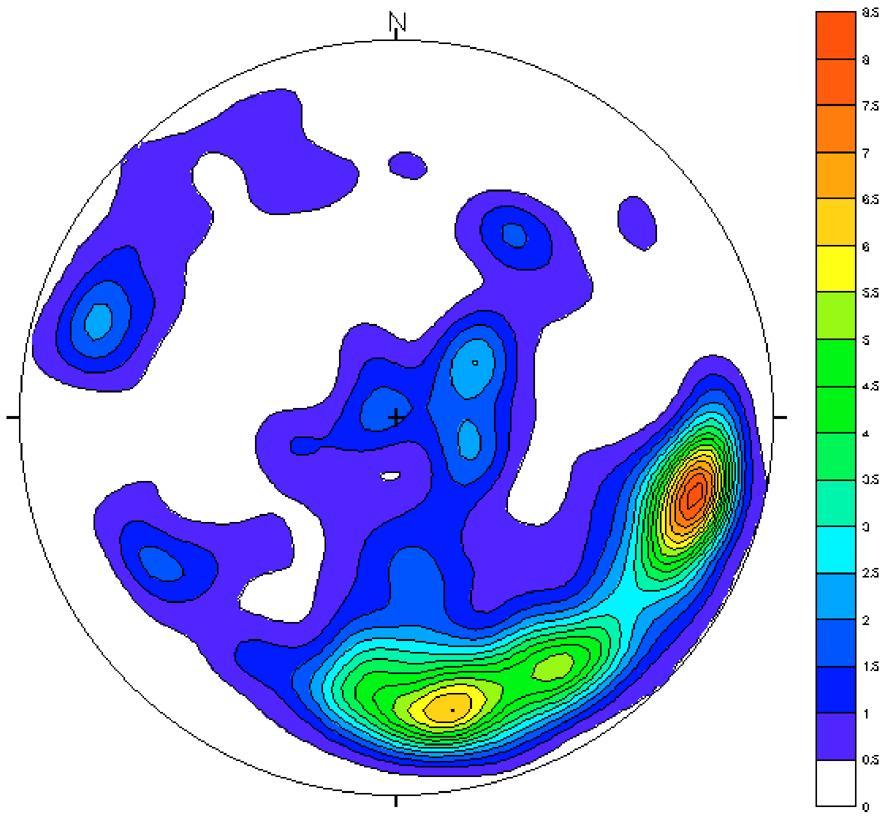


Figure 5: Example stereonet from an optical televiewer data set illustrating the frequency (%) of dip direction and dip angle in 2-D space.

Figure 5 above indicates, with a quick glance, that two distinct patterns exist in the example data set. A cluster of fractures/features with similar dip direction of approximately 110 degrees and similar shallow dip angles is apparent. A second cluster, slightly less dense, is apparent with similar dip directions of approximately 170 degrees (almost due south) and similarly shallow dip angles.

Please refer to the following Ranking System for Optical Televiewer Features for an explanation of the qualitative ranks assigned each optical televiewer feature identified.

C. Neutron Logs

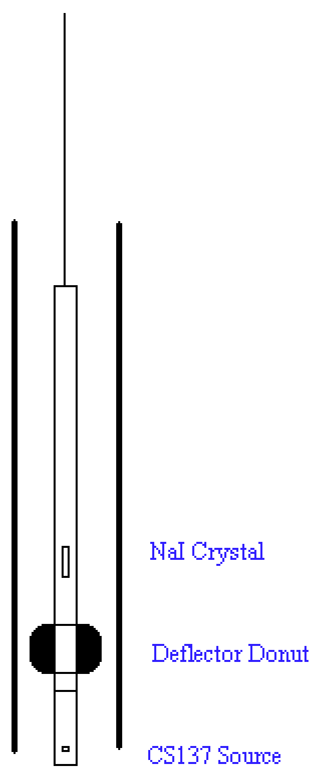
High energy neutrons are generated by a 3 curie Am^{241}-Be radioactive source, housed in the probe. These neutrons interact with the media that surrounds the probe, including the borehole fluid and formation. The significant aspects of that interaction are the loss of energy due to collisions with hydrogen atoms and the subsequent capture of the neutrons by various nuclei (including hydrogen). The detector in the neutron tool is spaced 14" from source and counts only the low energy (thermal) neutrons that have not been captured. Within a certain (unspecified) range the thermal neutron count rate is inversely proportional to the population of hydrogen atoms surrounding the tool. Therefore, for a constant borehole size, the neutron count rate can be related to total water content surrounding the tool, registering higher counts for lower water content. The inverse counts vs. water content relationship can be explained in terms of the degree of neutron capture that occurs. For example, lower water content captures fewer low energy neutrons and results in a higher neutron count rate at the detector.

Total water content in a saturated formation is affected by the clay content, because clay minerals contain a significant volume of bound water. In view of the inverse relationship described above, this means that lower neutron count rates are also associated with higher clay content.

D. Spherical (4-pi) Density

The 4-Pi Density measurement is often utilized for evaluating the integrity of a well completion, particularly with respect to the grout occupying the annular space between the well casing and the formation. It is also used extensively in non-destructive integrity testing of concrete piers. Like most density probes, the 4-Pi is configured with a gamma radiation source, and a gamma detector spaced at some distance from the source. The count rate measured at the detector is inversely proportional to the density of the medium between the source and detector. The depth of investigation can be changed by varying the distance between the source and detector. However, this spacing is generally short for well completions, so as to identify any anomalies (voids) directly behind the casing. Generally, the output shows variations in count rate at the detector, and thus relative density. However, in certain situations, models can be constructed to calibrate the output to actual engineering units (lb/cu.ft or gm/cc).

The 4-Pi density averages the response resulting from all of the media between the source and detector. As a result, small cracks or voids may be difficult to identify. Therefore, a focused density measurement such as the compensated or high-resolution density should also be run for a more thorough investigation.



- The spherical density log, as with all nuclear or radiation logs, have a fundamental advantage over most other logs in that they may be recorded in either cased or open holes that are fluid or air filled. Borehole fluid and casing may attenuate the gamma values.

- Excessive borehole rugosity, often caused by air drilling, may degrade natural gamma ray log results.

- Accuracy of the spherical density data is affected by the distance of the source from the detector(s).

III. Geophysical Logging Results

BOREHOLE GEOPHYSICS & HYDROPHYSICS
COLOG
A DIVISION OF LAYNE CHRISTENSEN COMPANY

Geophysical Summary Plot

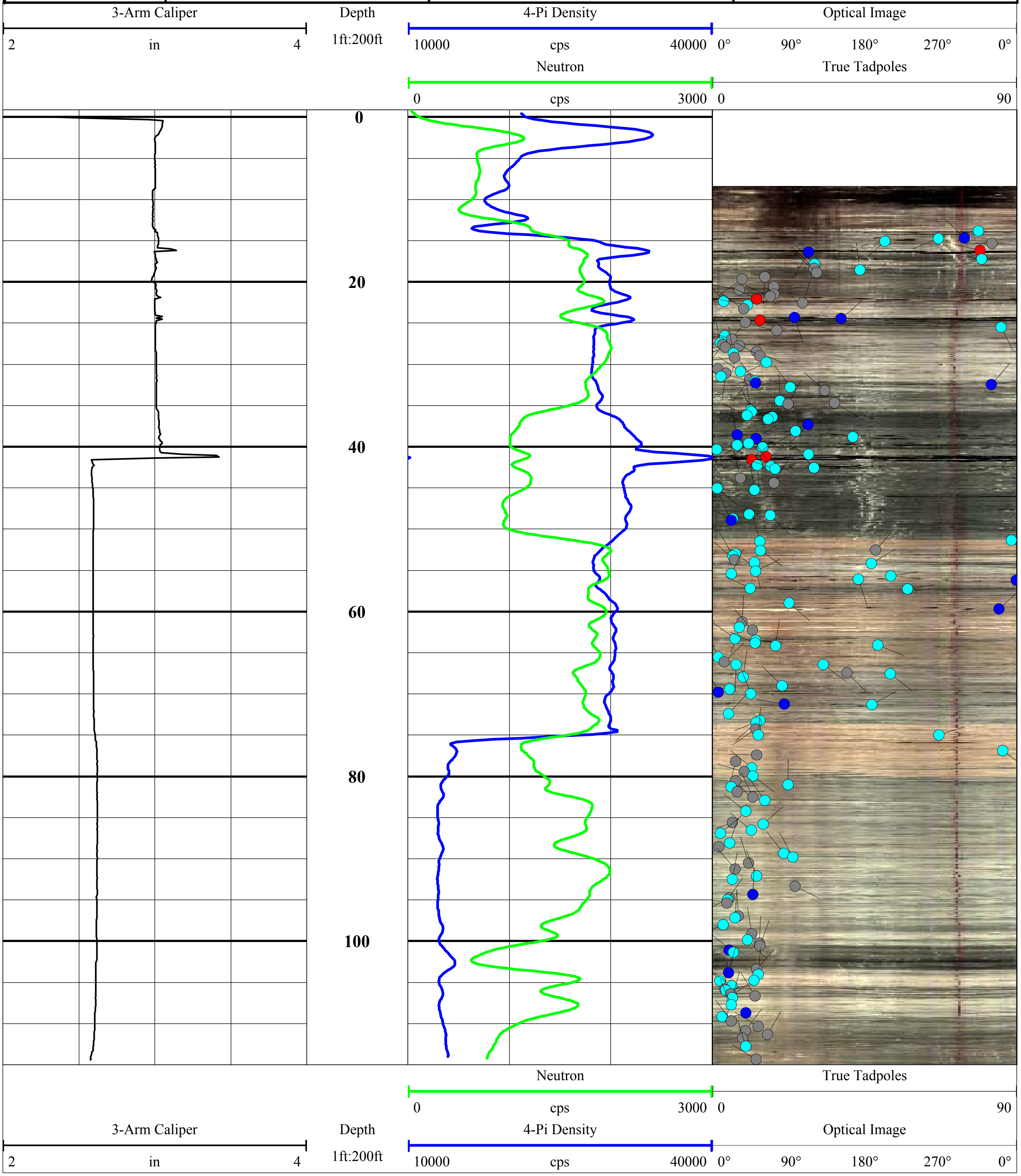
COMPANY: FMSM

PROJECT: East End Approach, Phase 2

DATE LOGGED: 18 December 2005

WELL: B-5

COLOG Main Office
810 Quail Street, Suite E, Lakewood, CO 80215
Phone: (303) 279-0171, Fax: (303) 278-0135
www.colog.com



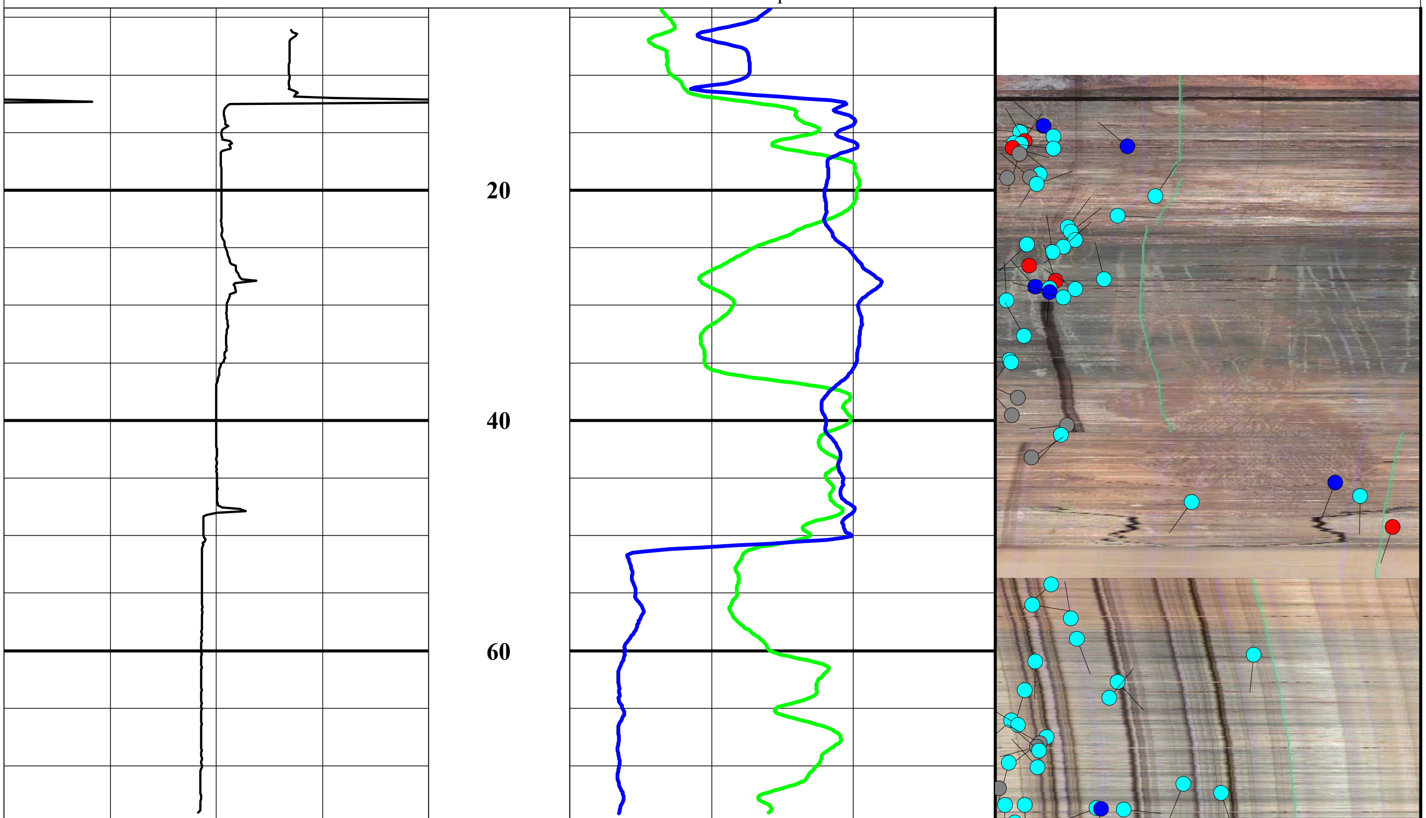
Geophysical Summary Plot

COLOG — Borehole Geophysics & Hydrophysics — A Division of Layne Christensen Company

COMPANY: FMSM	PROJECT: East End Approach, Phase 2
DATE LOGGED: 18 December 2005	WELL: B-6

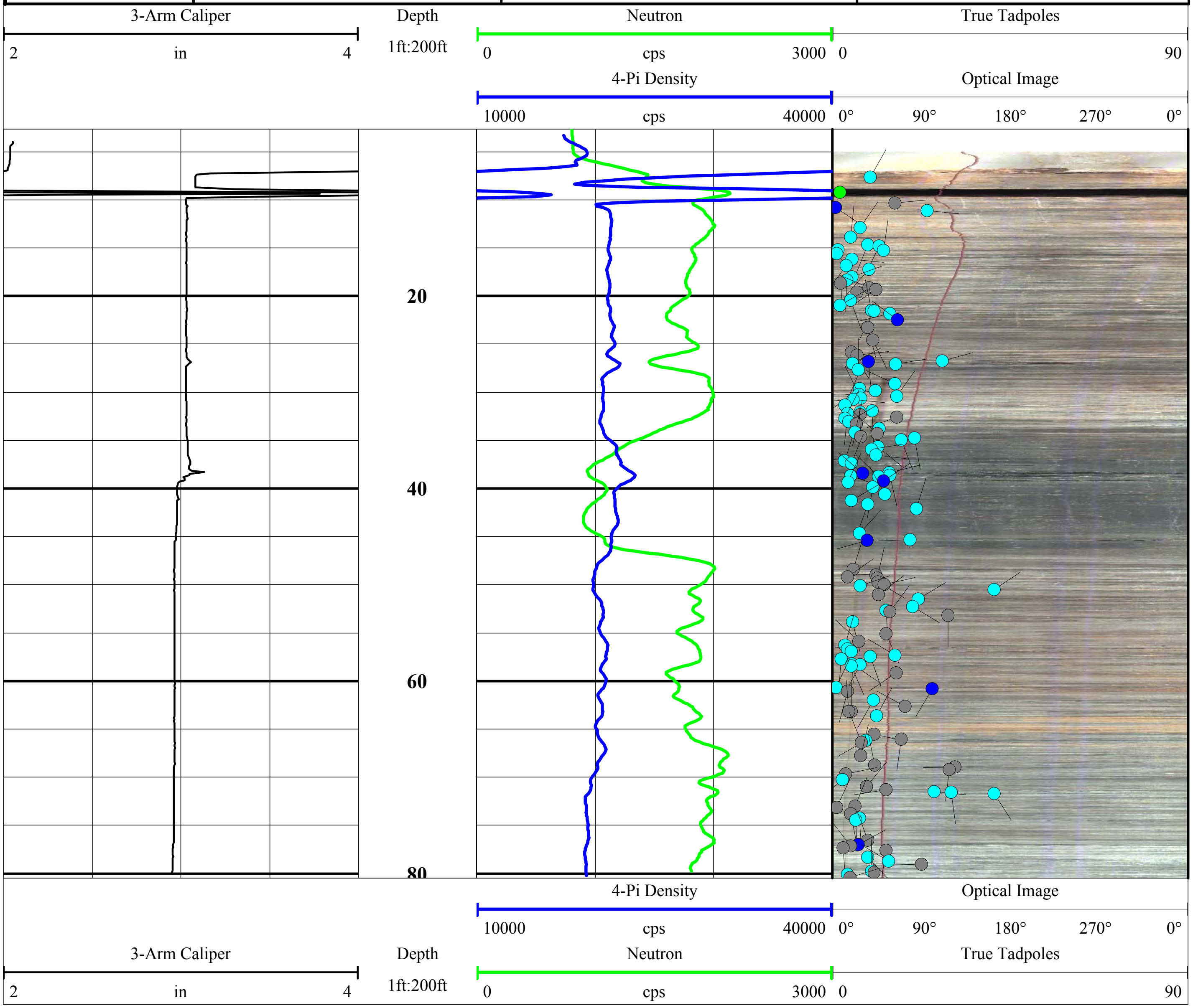
COLOG Main Office
810 Quail Street, Suite E, Lakewood, CO 80215
Phone: (303) 279-0171, Fax: (303) 278-0135
www.colog.com

3-Arm Caliper	Depth	Neutron / 4-Pi Density	Optical Image / True Tadpoles
2 in 4	1ft:200ft	Neutron: 0 cps 3000	Optical Image: 0° 90° 180° 270° 0°
		4-Pi Density: 10000 cps 40000	True Tadpoles: 0 90



3-Arm Caliper	Depth	4-Pi Density / Neutron	True Tadpoles / Optical Image
		4-Pi Density: 10000 cps 40000	True Tadpoles: 0 90
2 in 4	1ft:200ft	Neutron: 0 cps 3000	Optical Image: 0° 90° 180° 270° 0°

	Geophysical Summary Plot		COLOG Main Office
	COMPANY: FMSM	PROJECT: East End Approach, Phase 2	810 Quail Street, Suite E, Lakewood, CO 80215
	DATE LOGGED: 18 December 2005	WELL: B-8	Phone: (303) 279-0171, Fax: (303) 278-0135
			www.colog.com

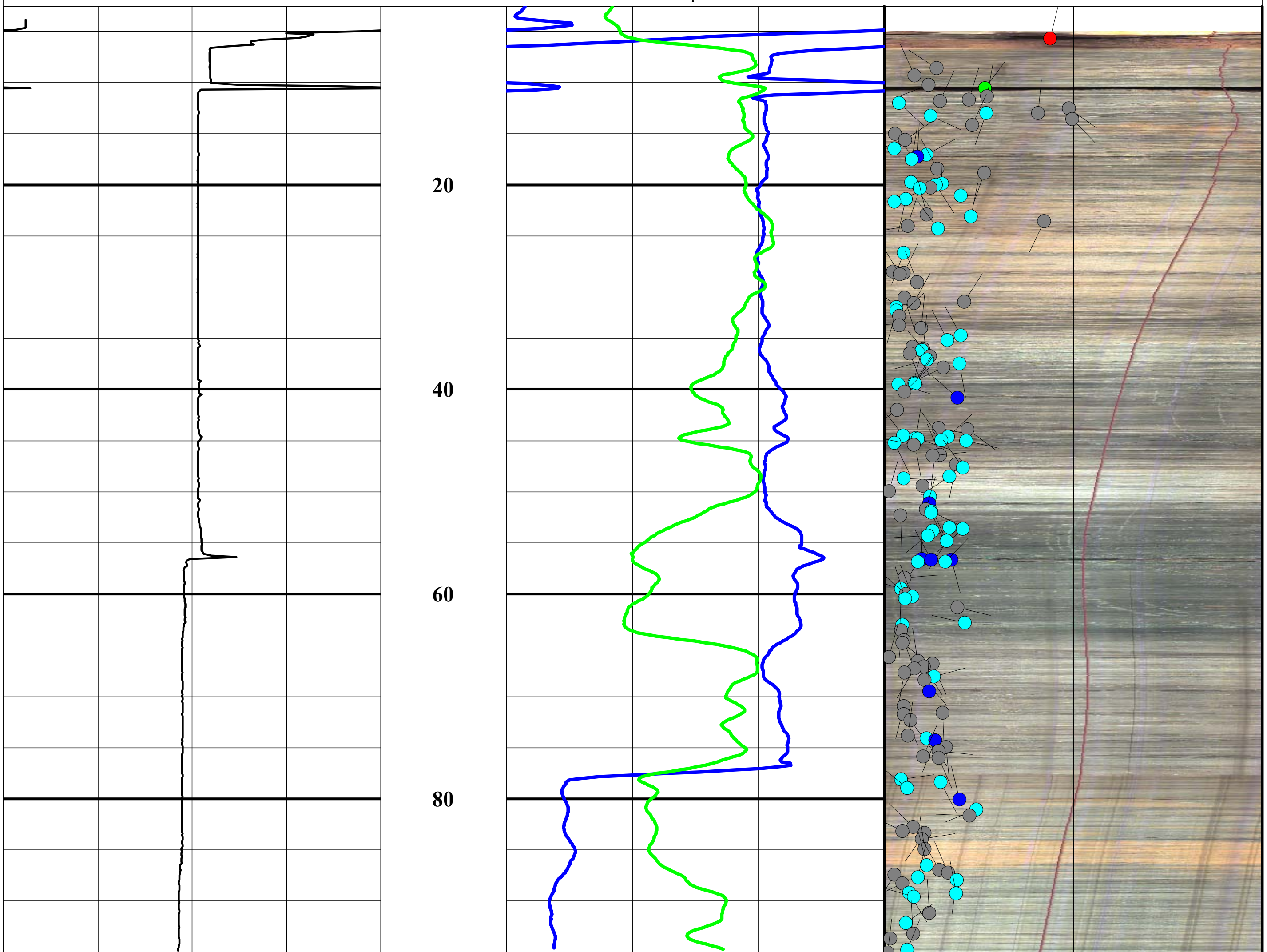


Geophysical Summary Plot

COMPANY: FMSM	PROJECT: East End Approach, Phase 2	
DATE LOGGED: 19 December 2005	WELL: B-10	

COLOG Main Office
810 Quail Street, Suite E, Lakewood, CO 80215
Phone: (303) 279-0171, Fax: (303) 278-0135
www.colog.com

3-Arm Caliper	Depth	4-Pi Density	Optical Image
2 in 4	1ft:200ft	10000 cps 40000	0° 90° 180° 270° 0°
		Neutron	True Tadpoles
		0 cps 3000	0 90



3-Arm Caliper	Depth	4-Pi Density	Optical Image
		Neutron	True Tadpoles
		0 cps 3000	0 90
2 in 4	1ft:200ft	10000 cps 40000	0° 90° 180° 270° 0°

Geophysical Summary Plot

COLOG
BOREHOLE GEOPHYSICS & HYDROPHYSICS
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COMPANY: FMSM	PROJECT: East End Approach, Phase 2
DATE LOGGED: 19 December 2005	WELL: B-11

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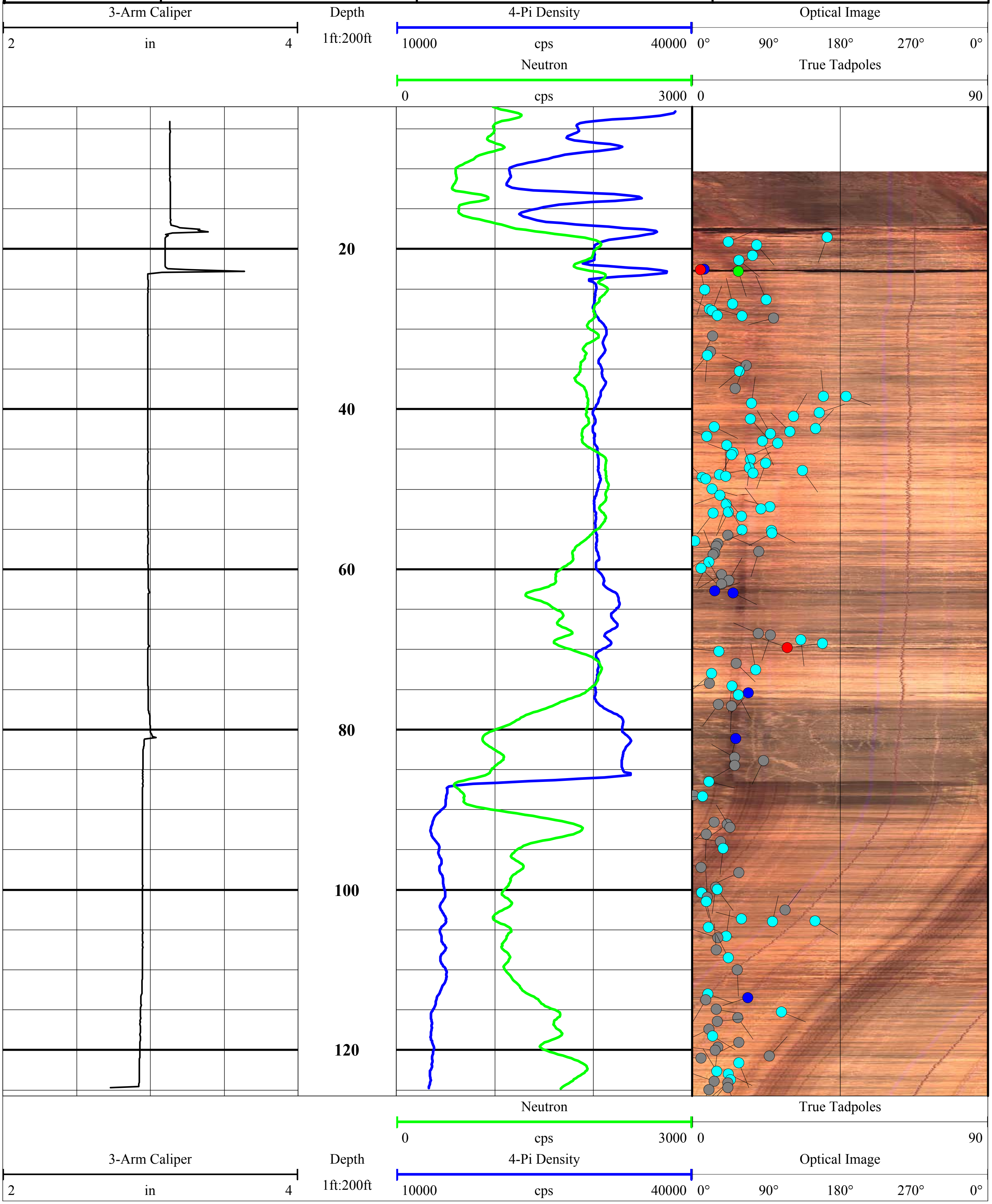

APPENDIX A

OPTICAL TELEVIEWER LOGS

Optical Borehole Image Plot

COMPANY: FMSM	PROJECT: East End Approach, Phase 2	COLOG Main Office 810 Quail Street, Suite E, Lakewood, CO 80215 Phone: (303) 279-0171, Fax: (303) 278-0135 www.colog.com
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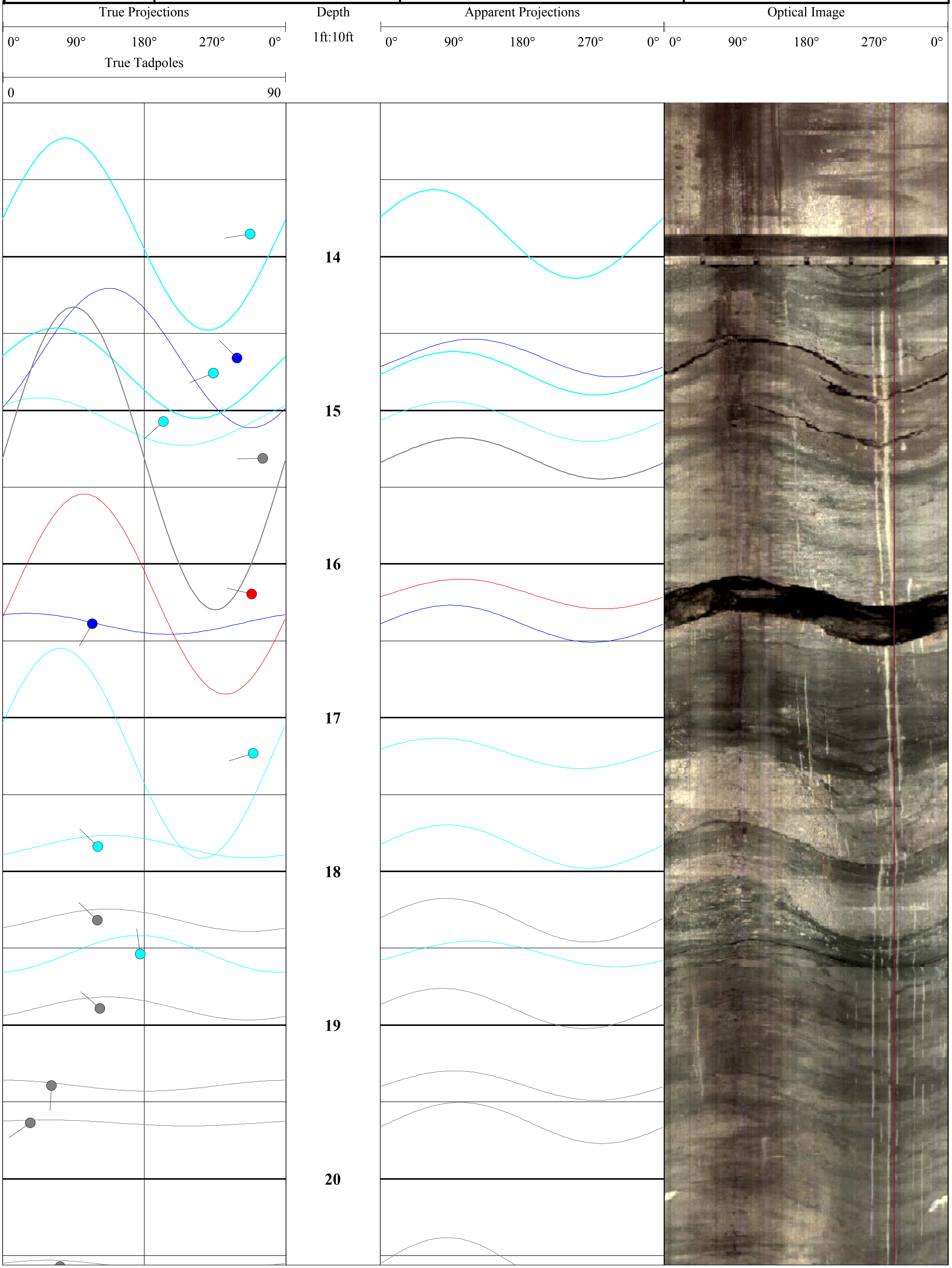

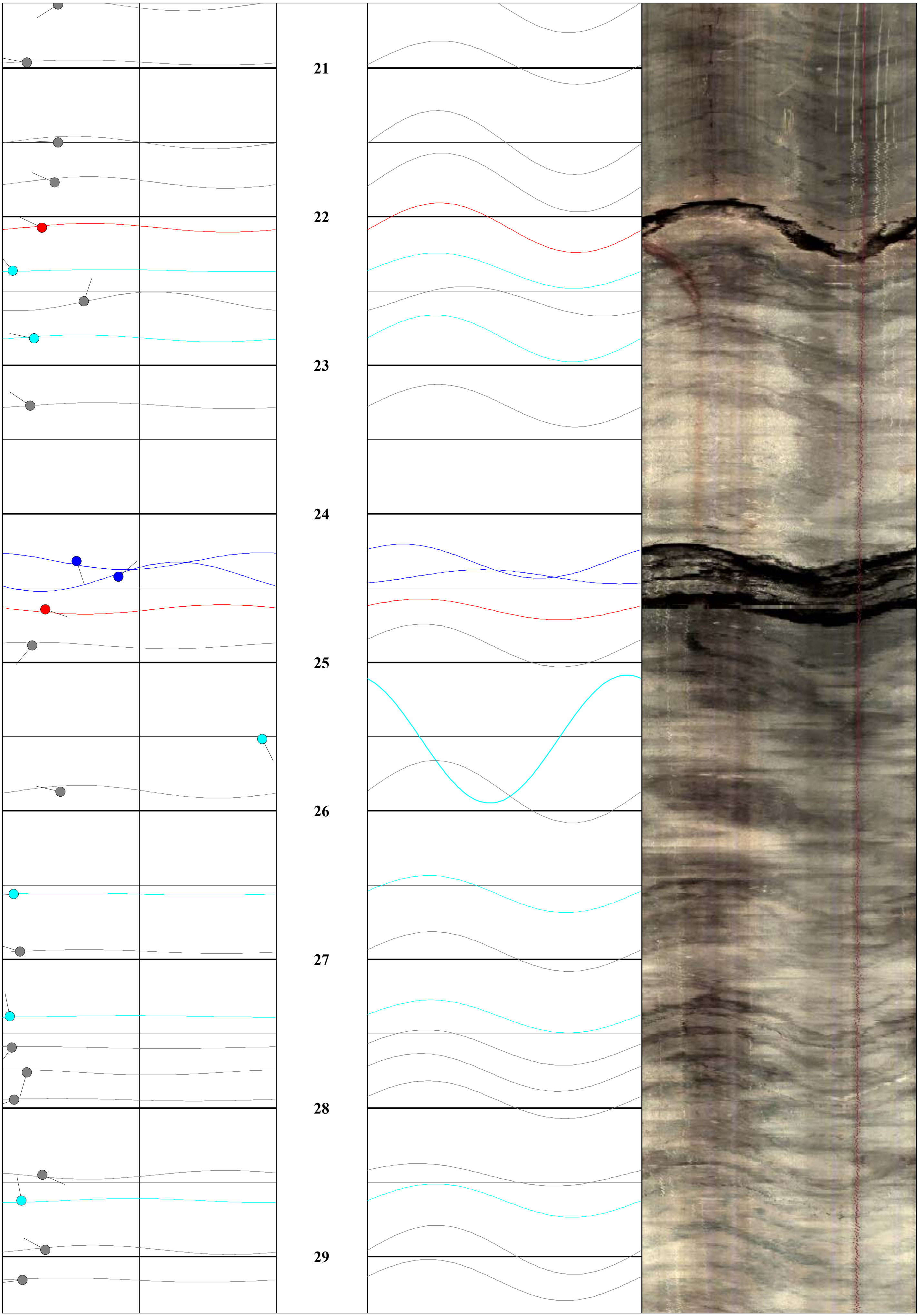
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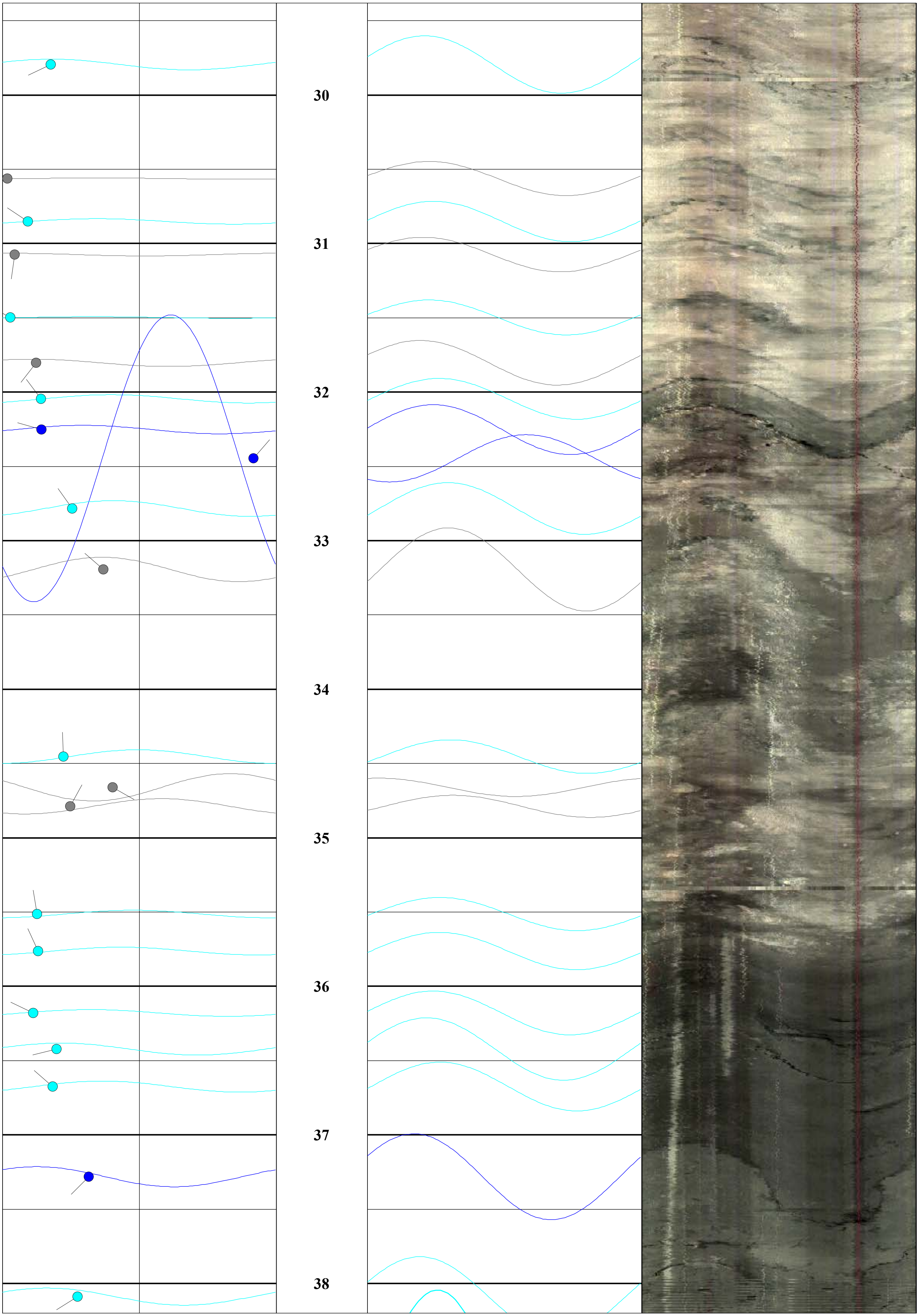
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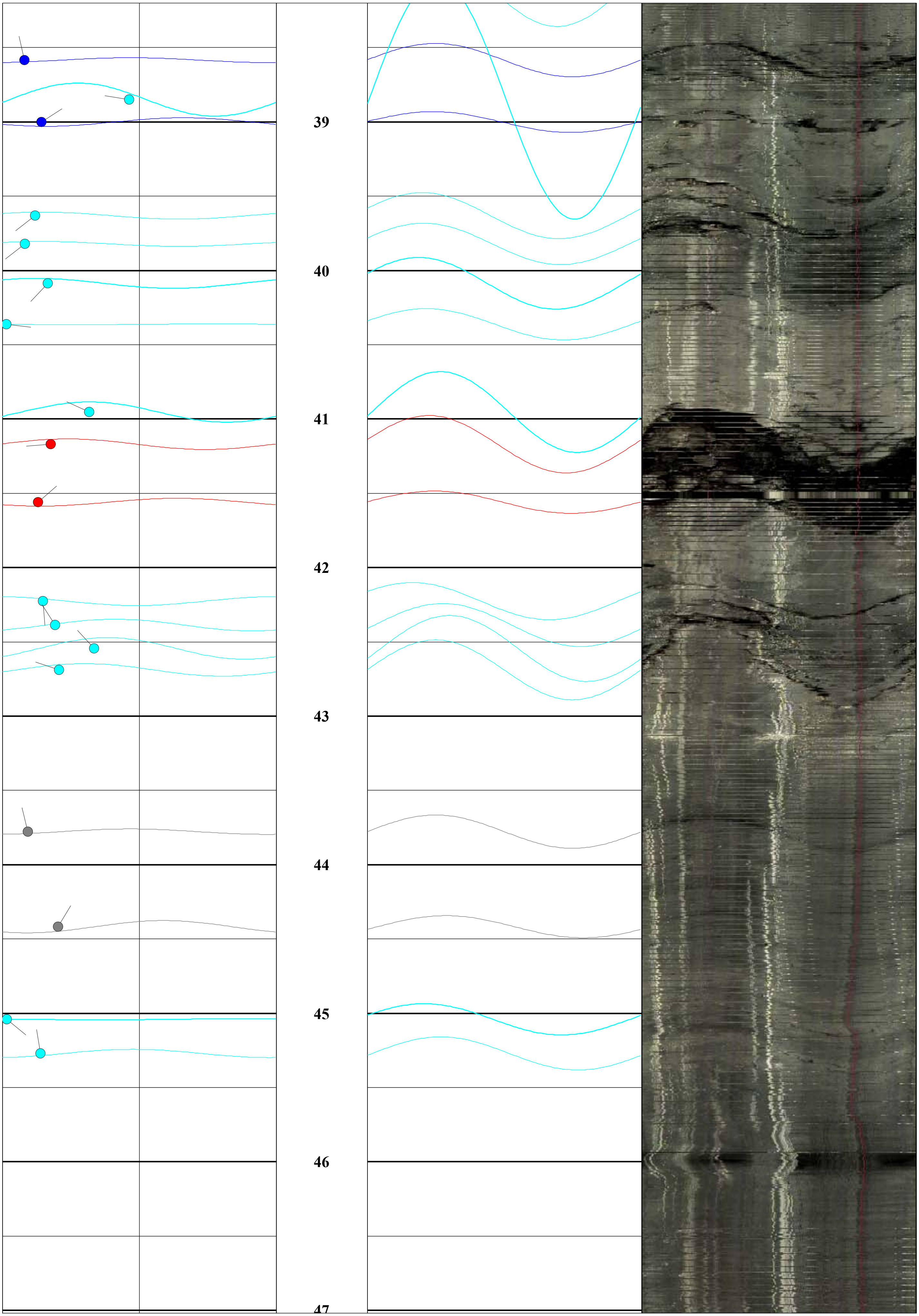
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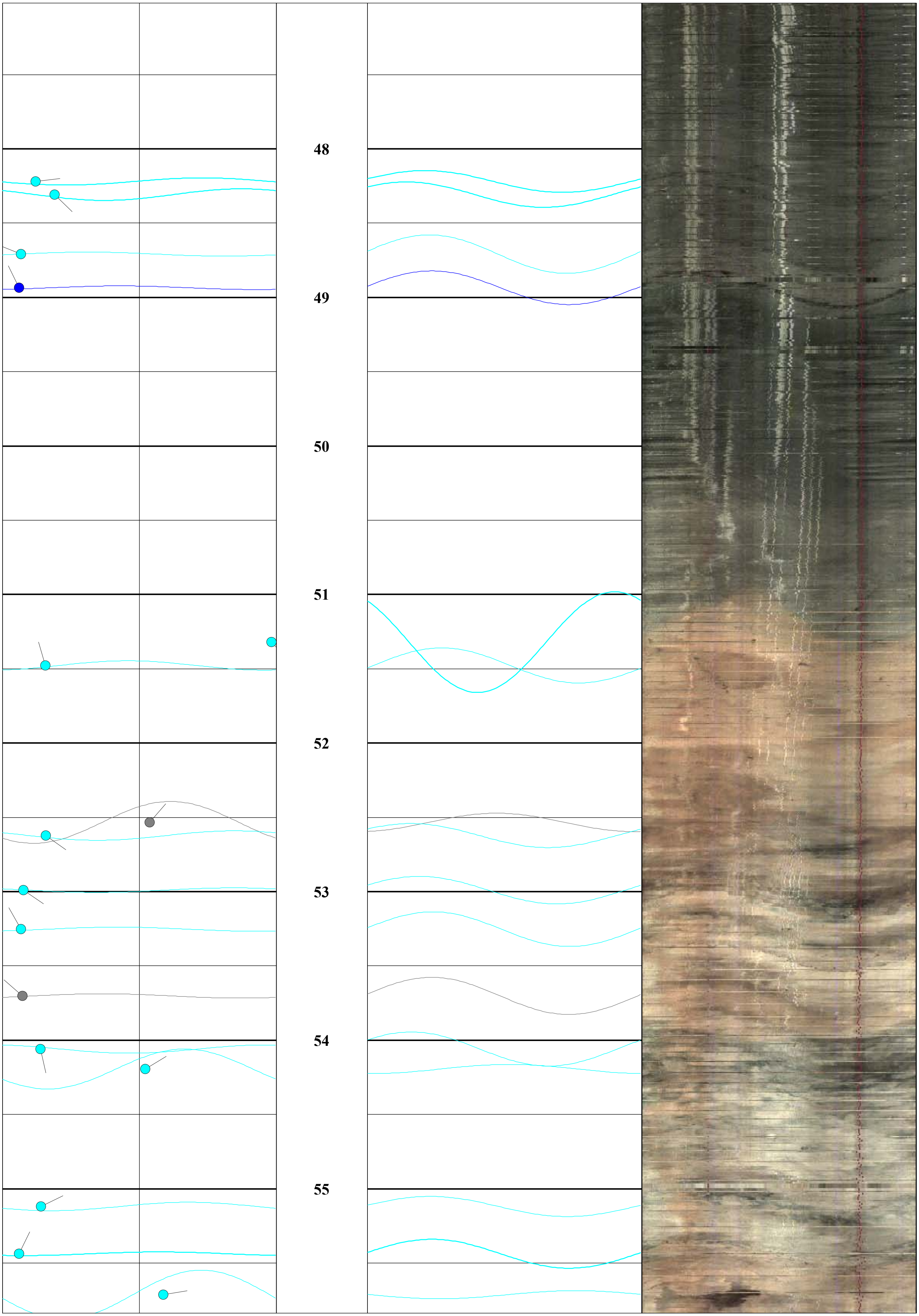
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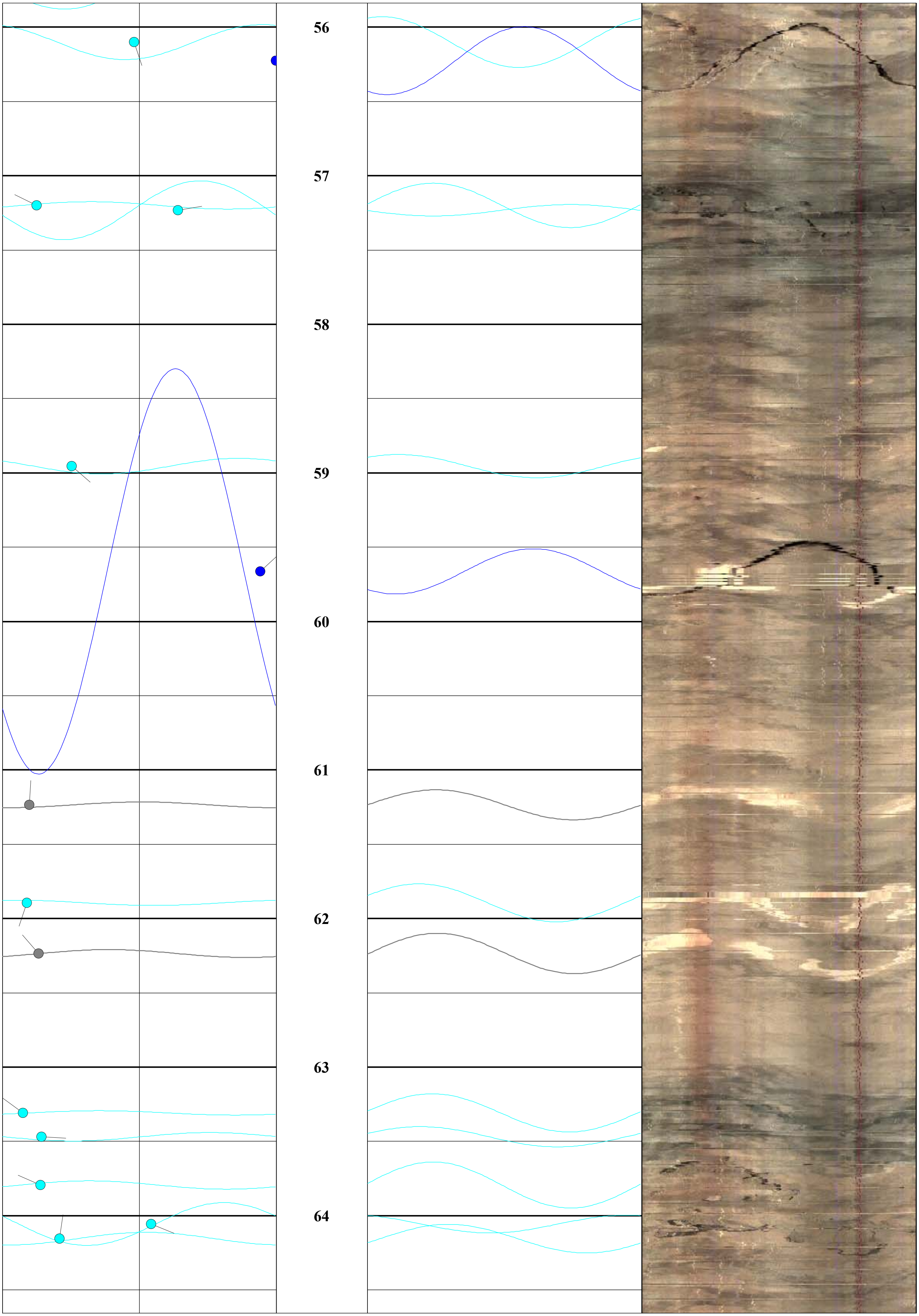
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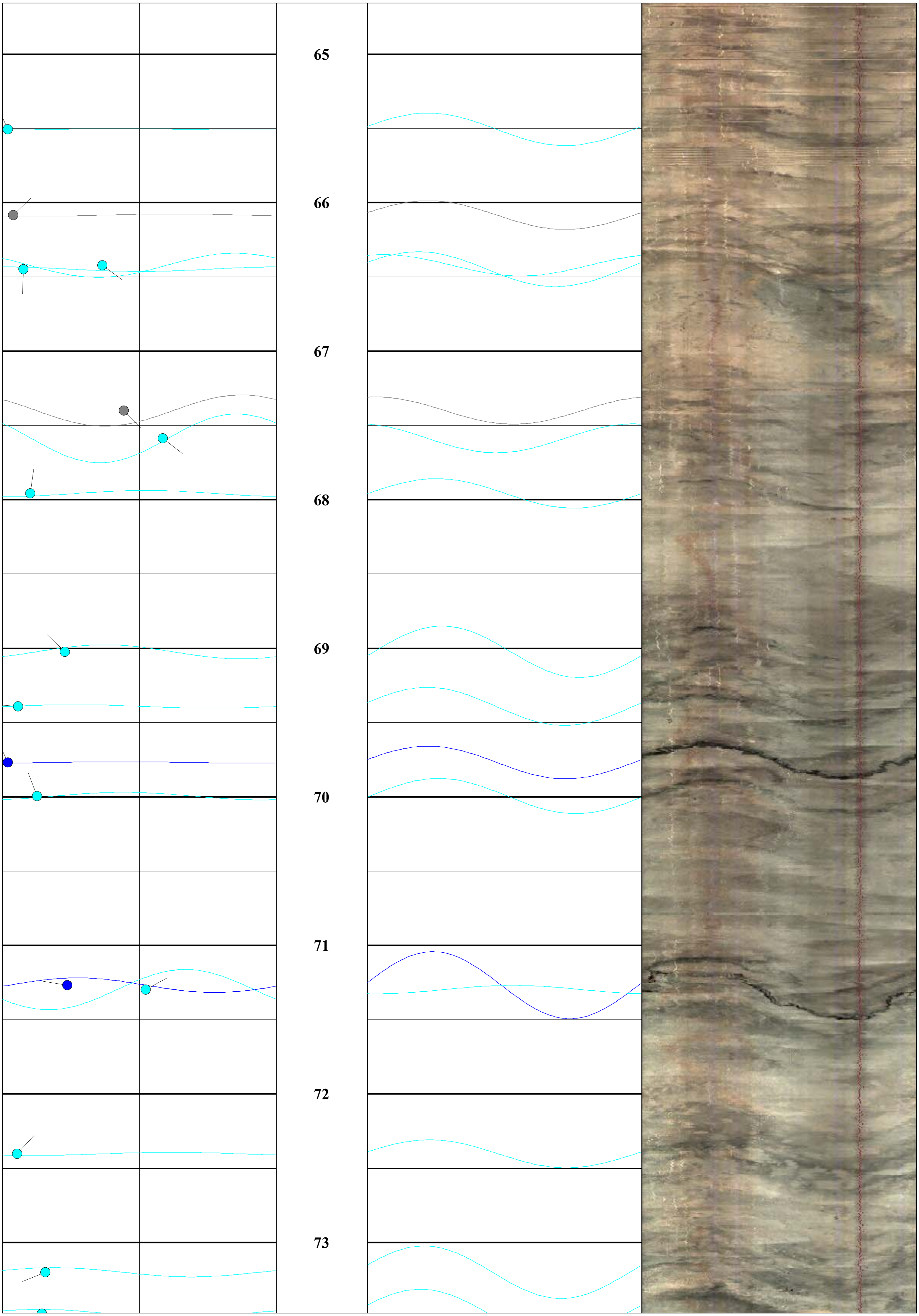
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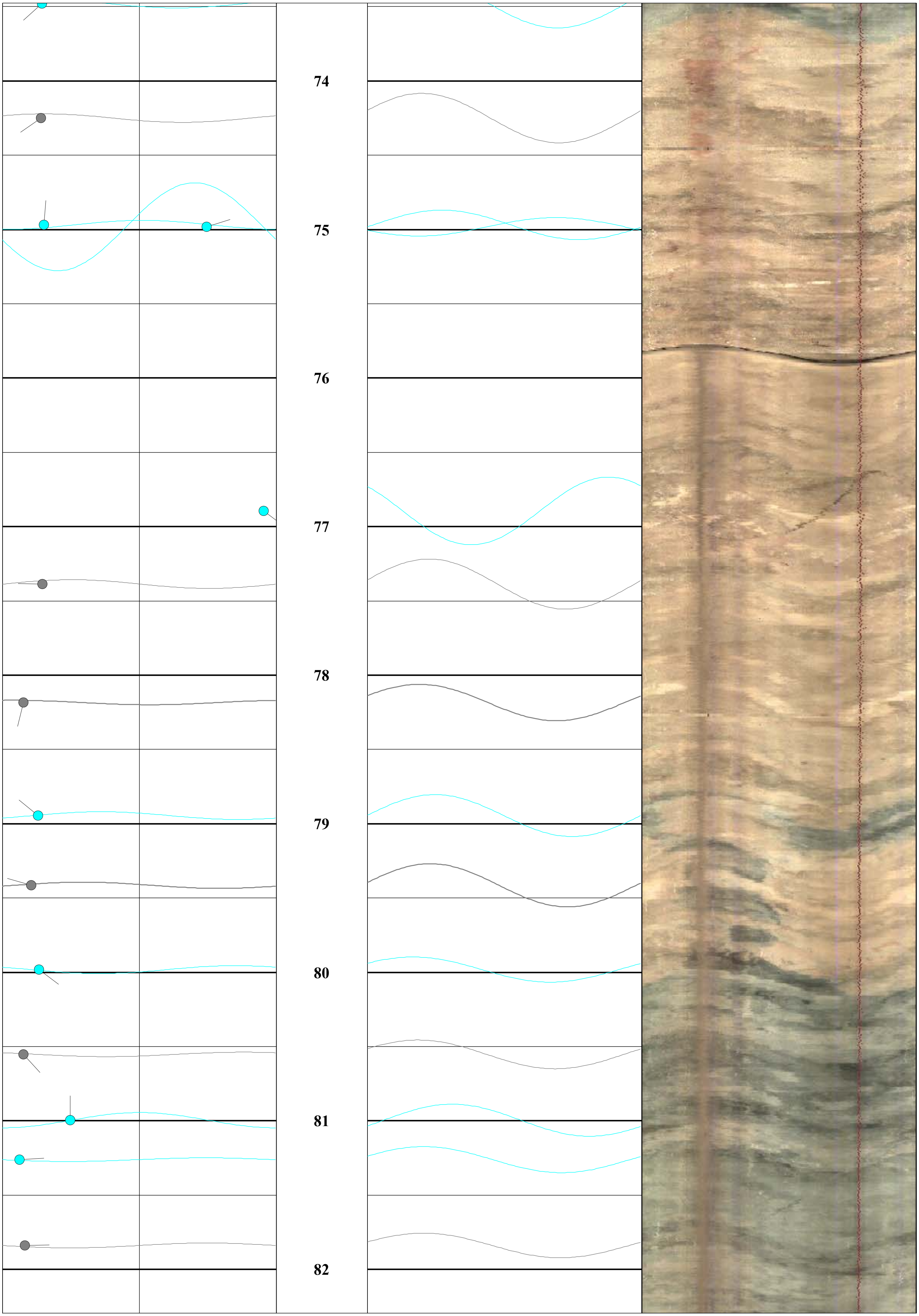
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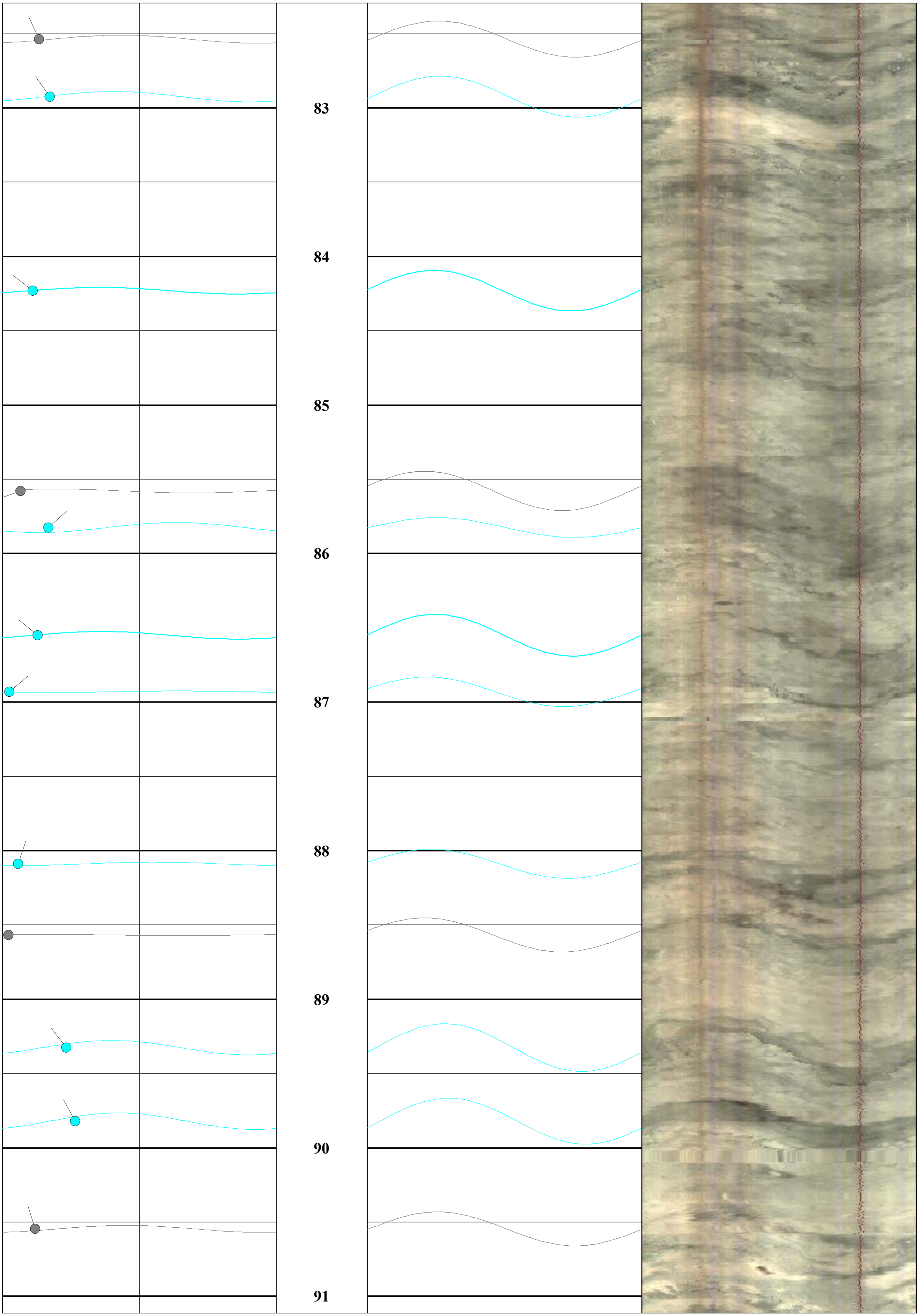
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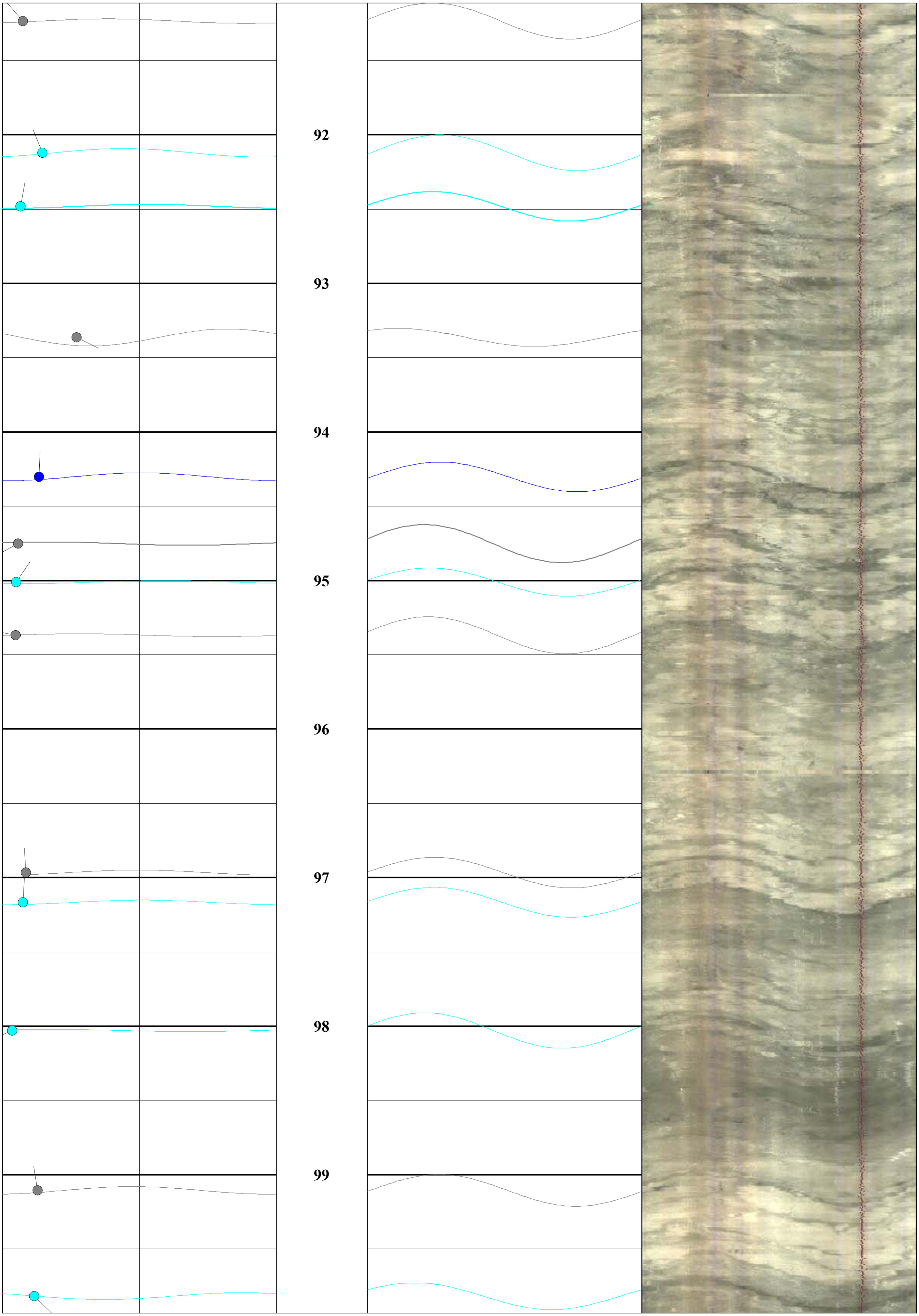
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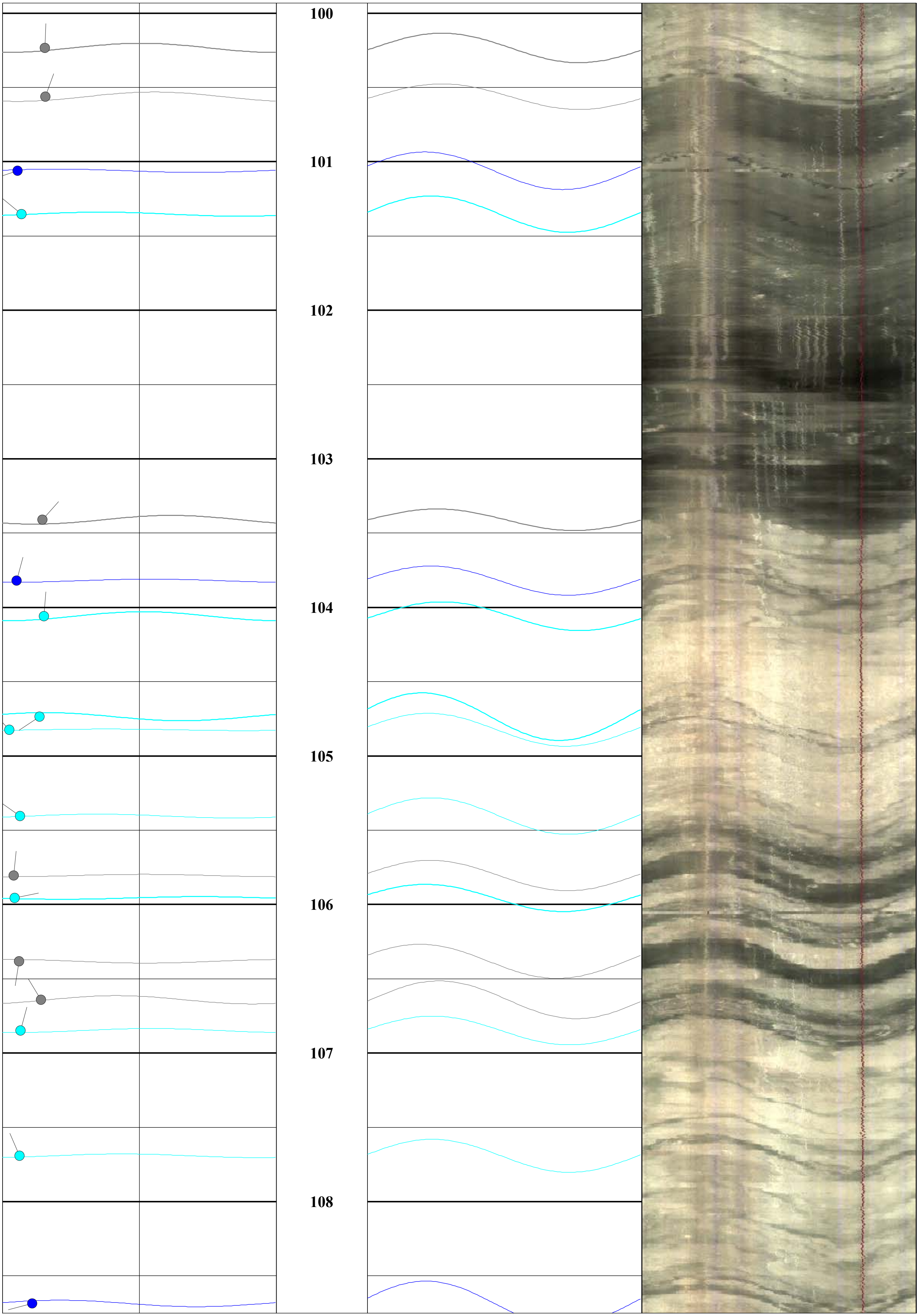
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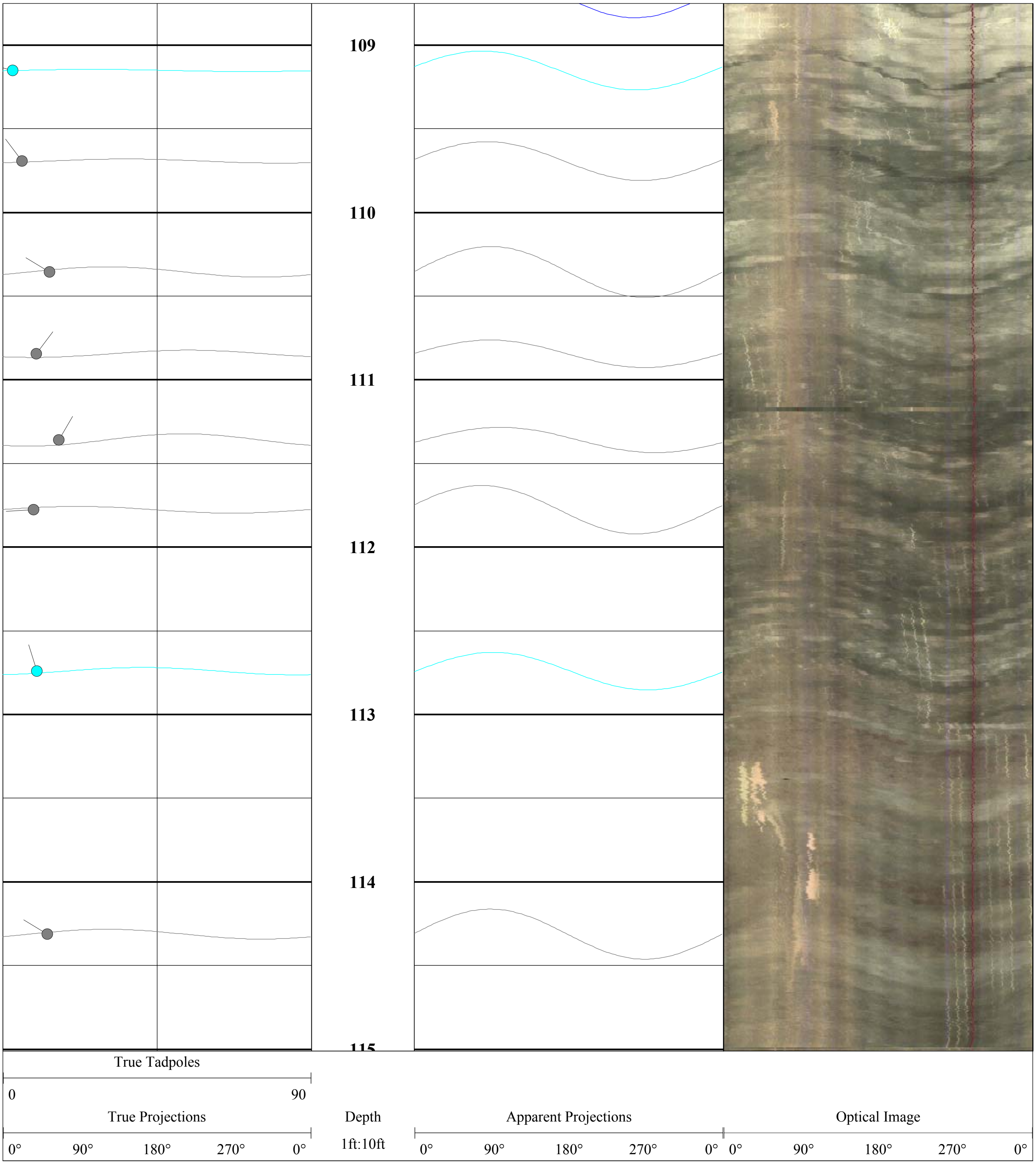
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True Tadpoles
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True Projections
0° 90° 180° 270° 0°
Depth
1ft:10ft
Apparent Projections
0° 90° 180° 270° 0°
Optical Image
0° 90° 180° 270° 0°

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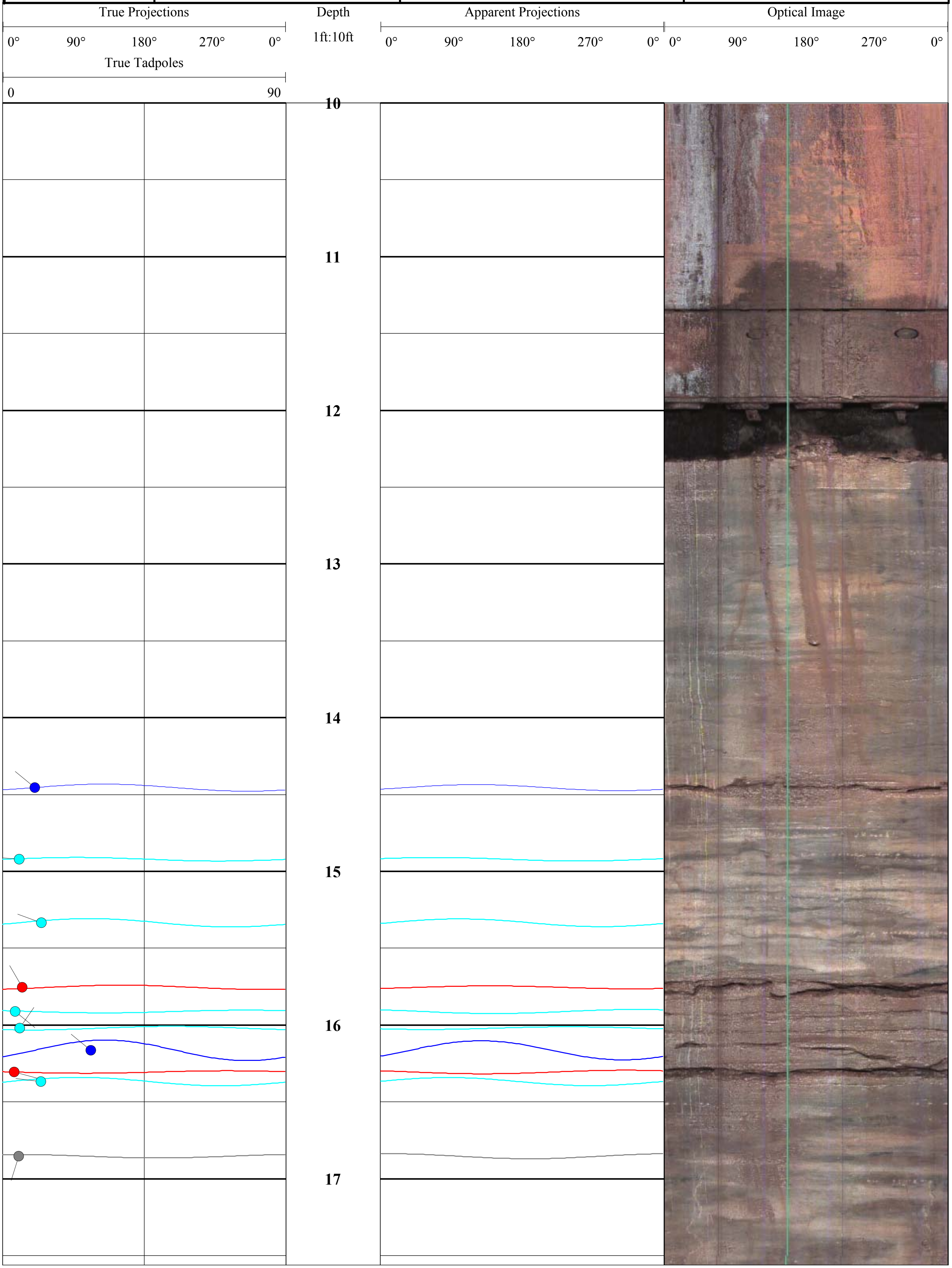

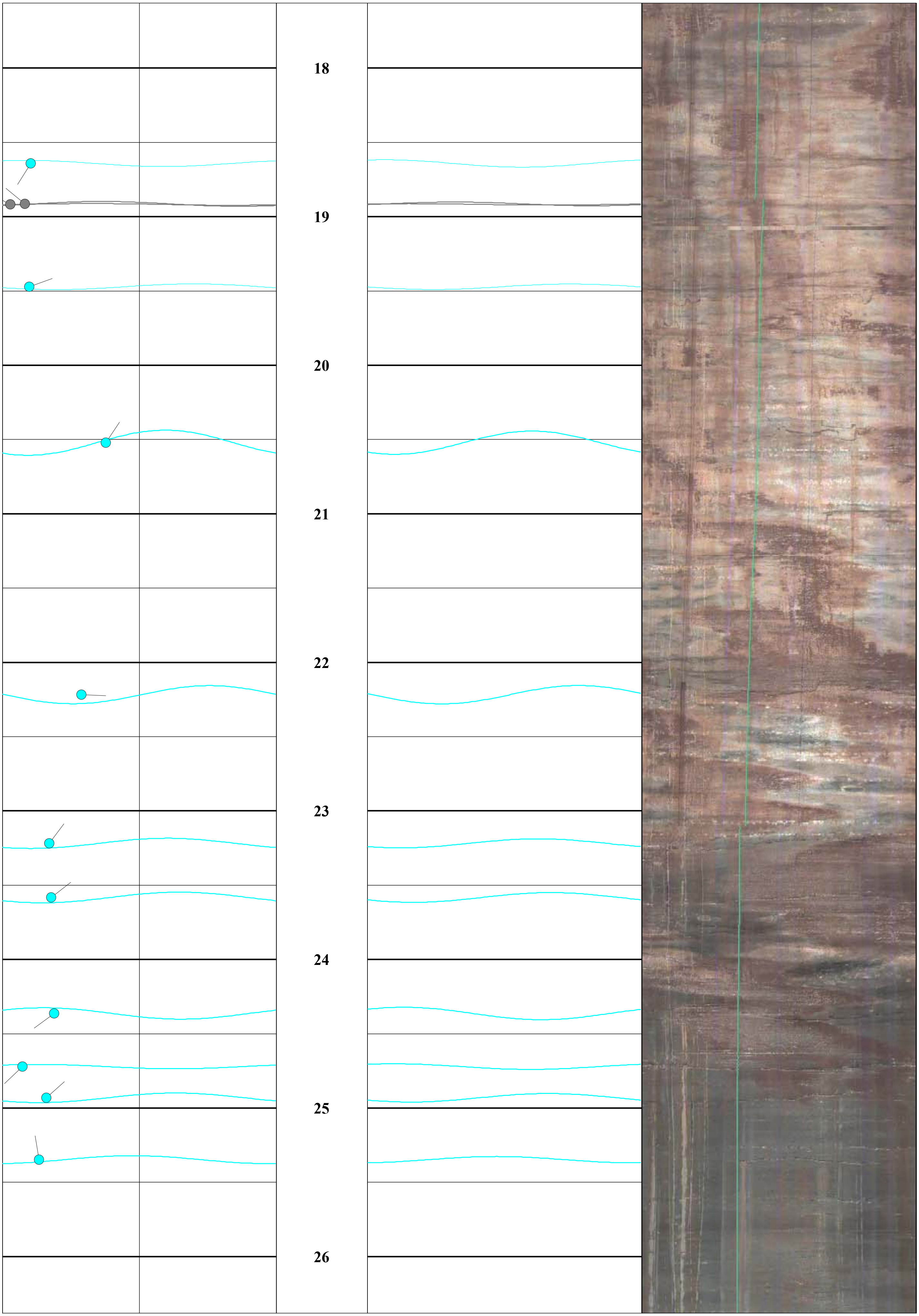
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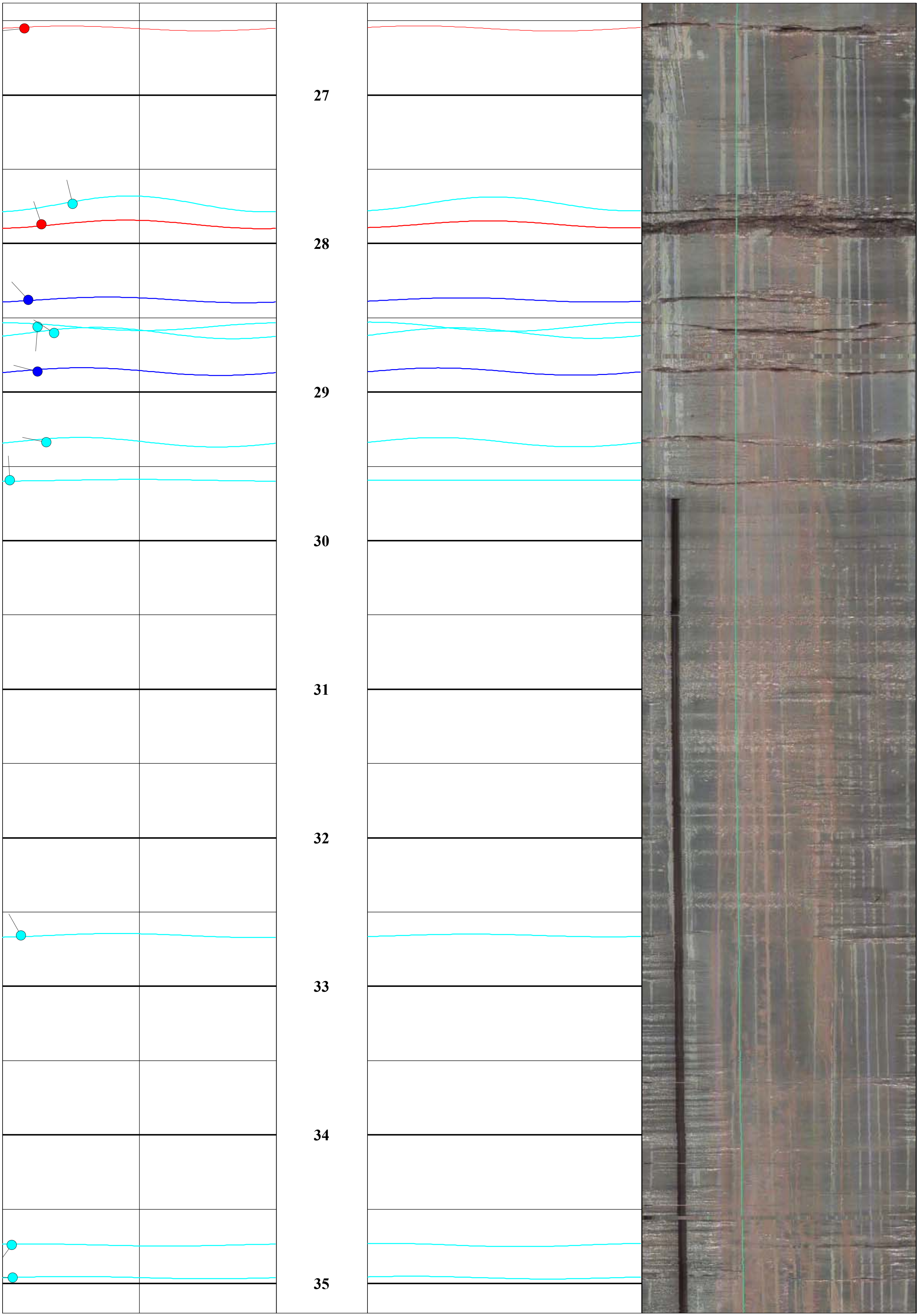
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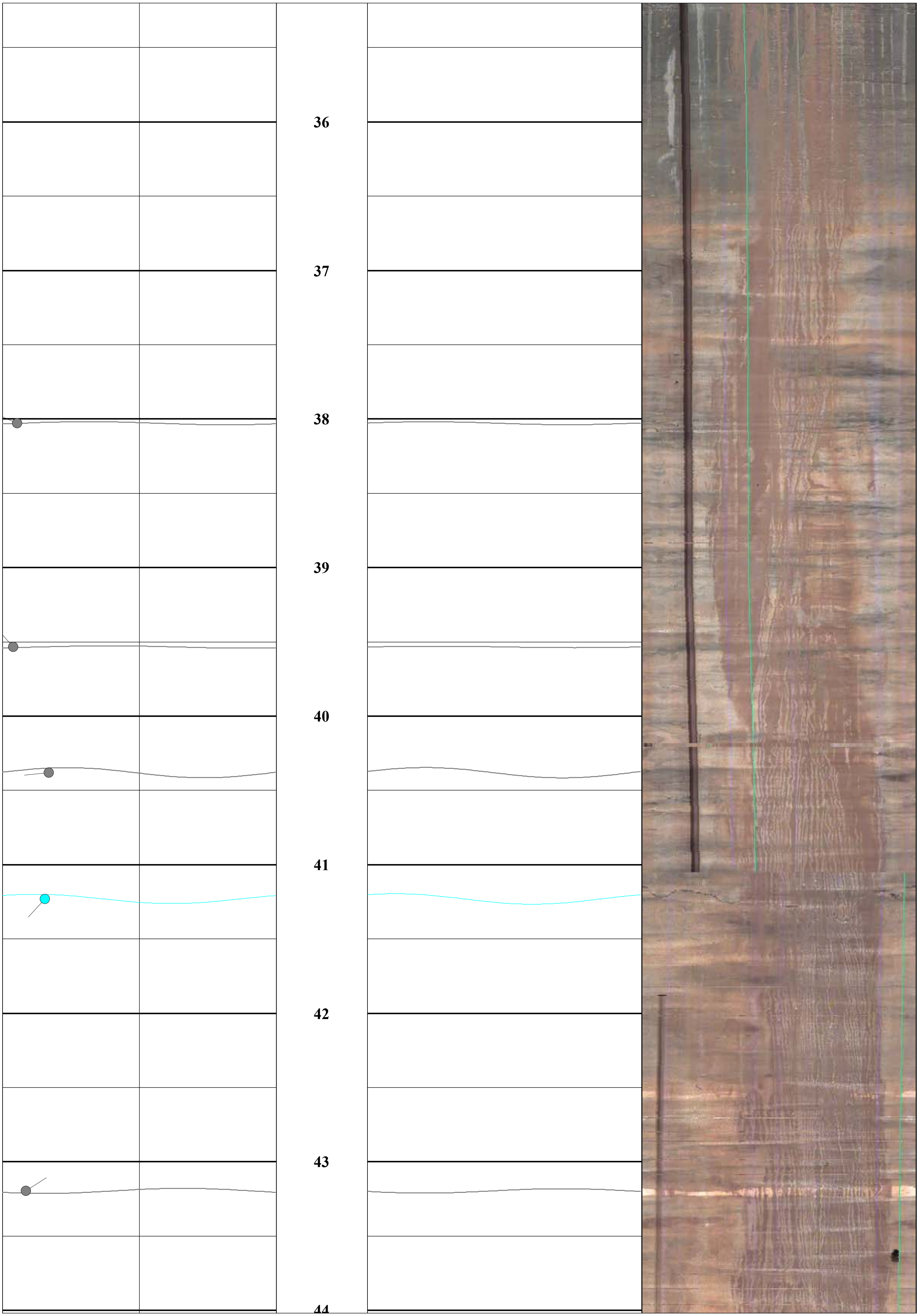
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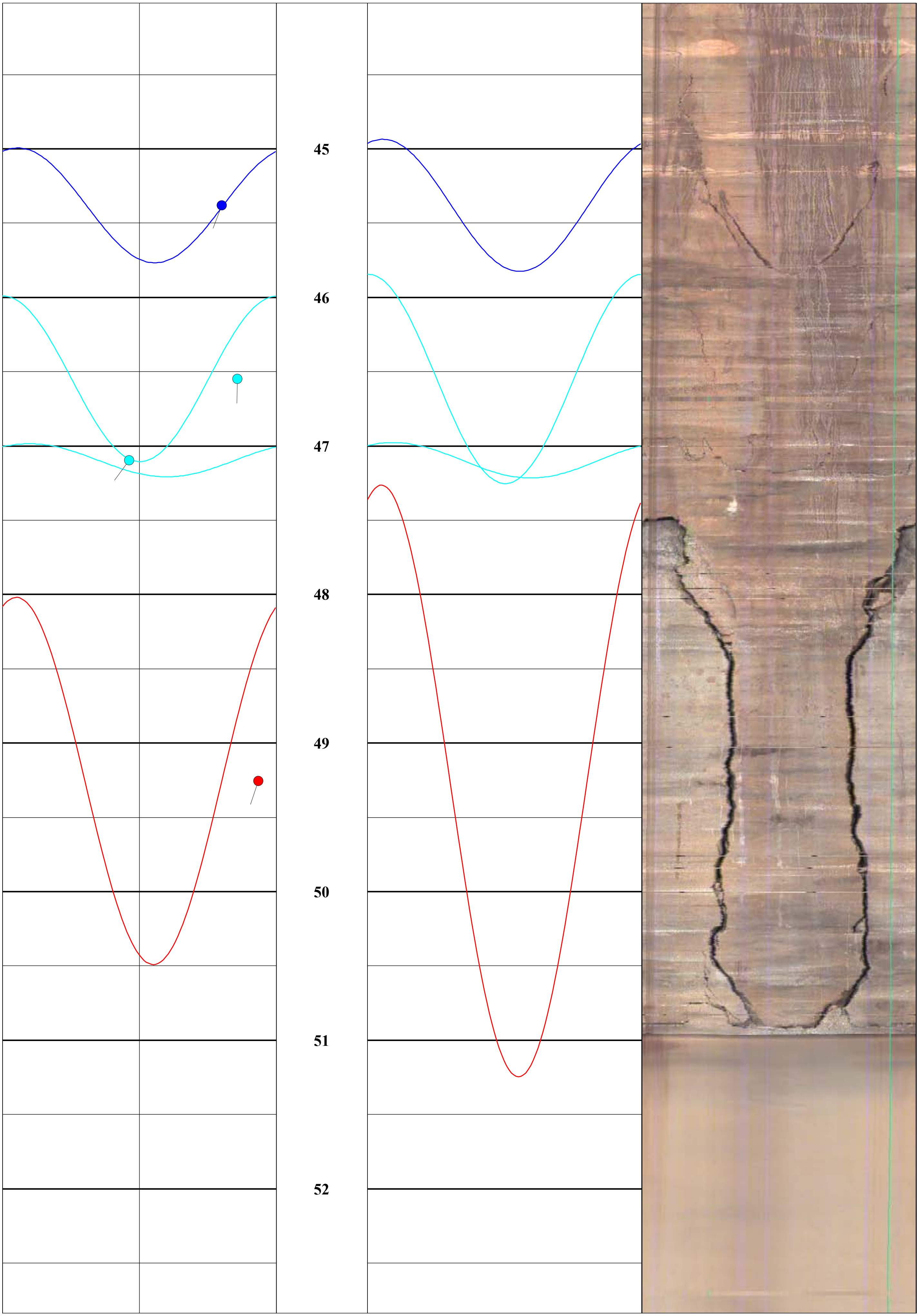
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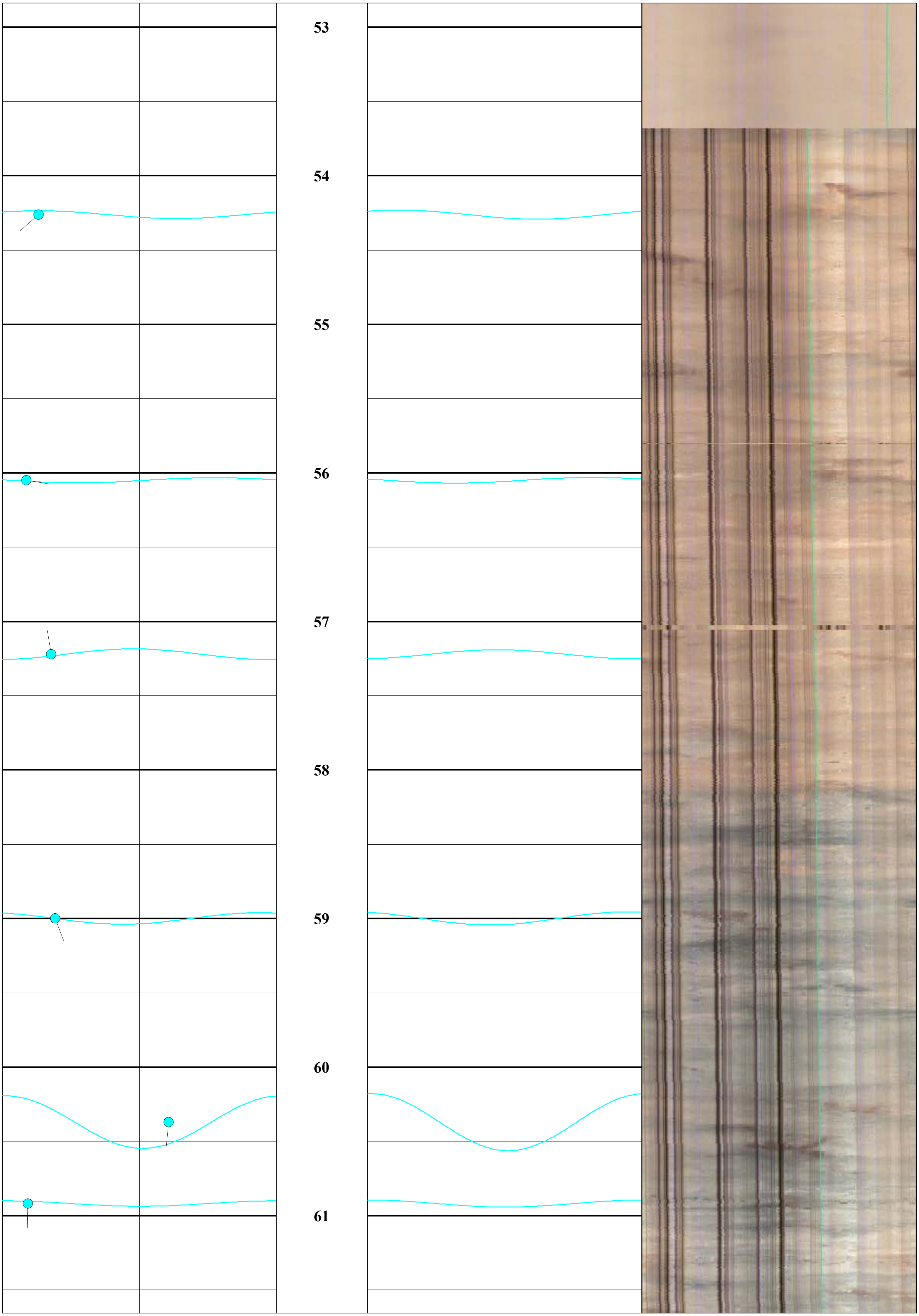
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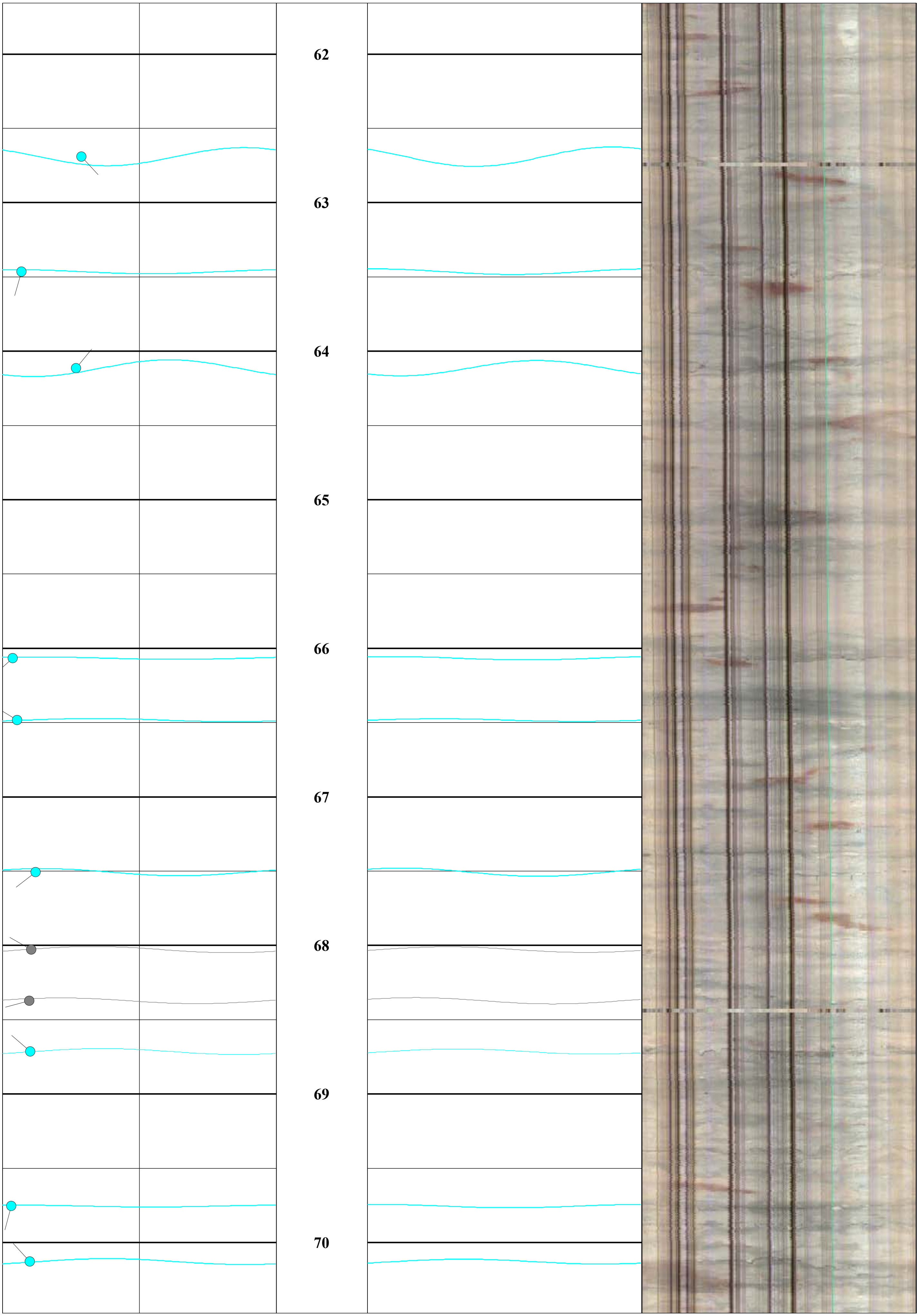
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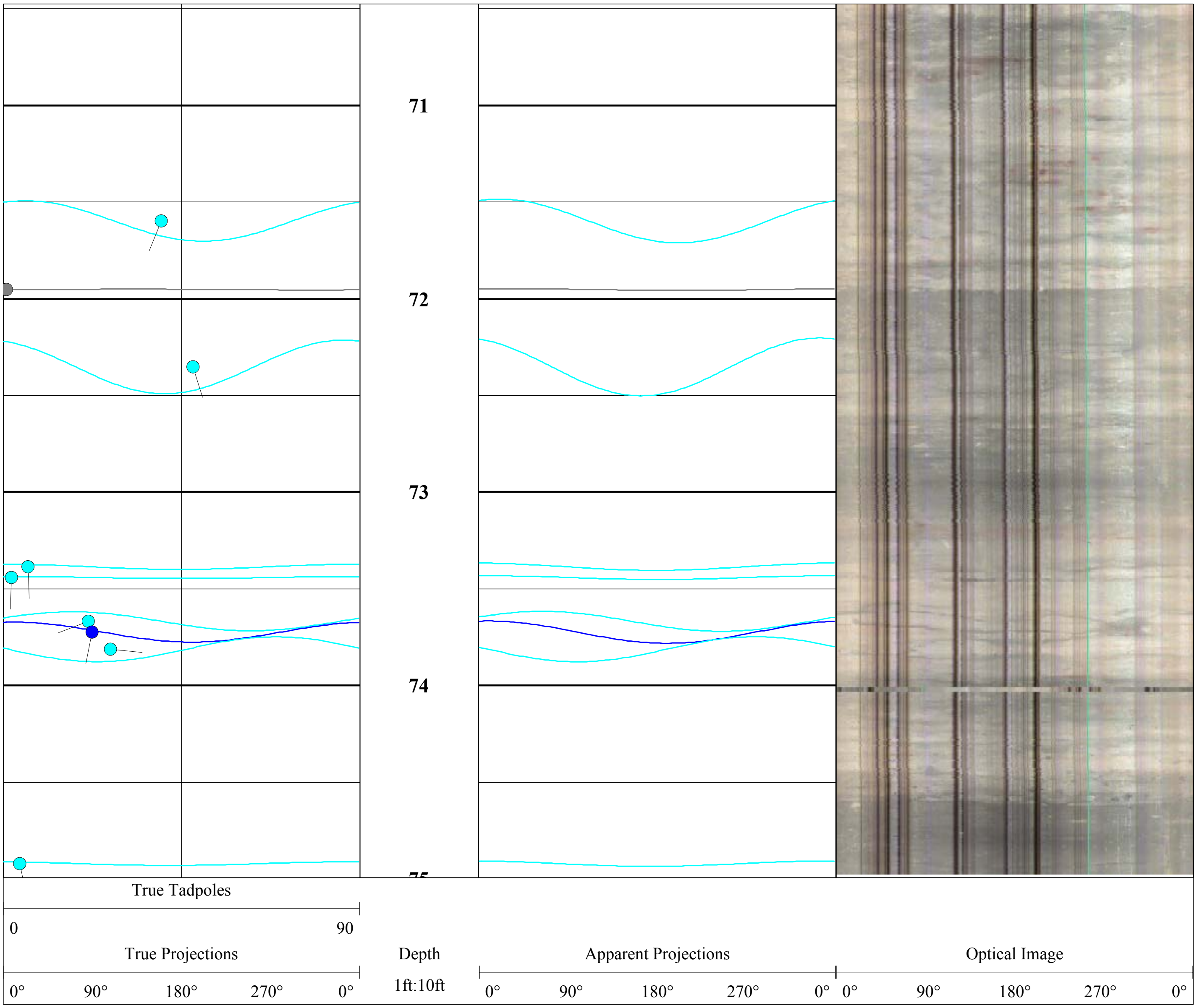
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True Tadpoles
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True Projections
0° 90° 180° 270° 0°
Depth
1ft:10ft
Apparent Projections
0° 90° 180° 270° 0°
Optical Image
0° 90° 180° 270° 0°

	Optical Borehole Image Plot		COLOG Main Office
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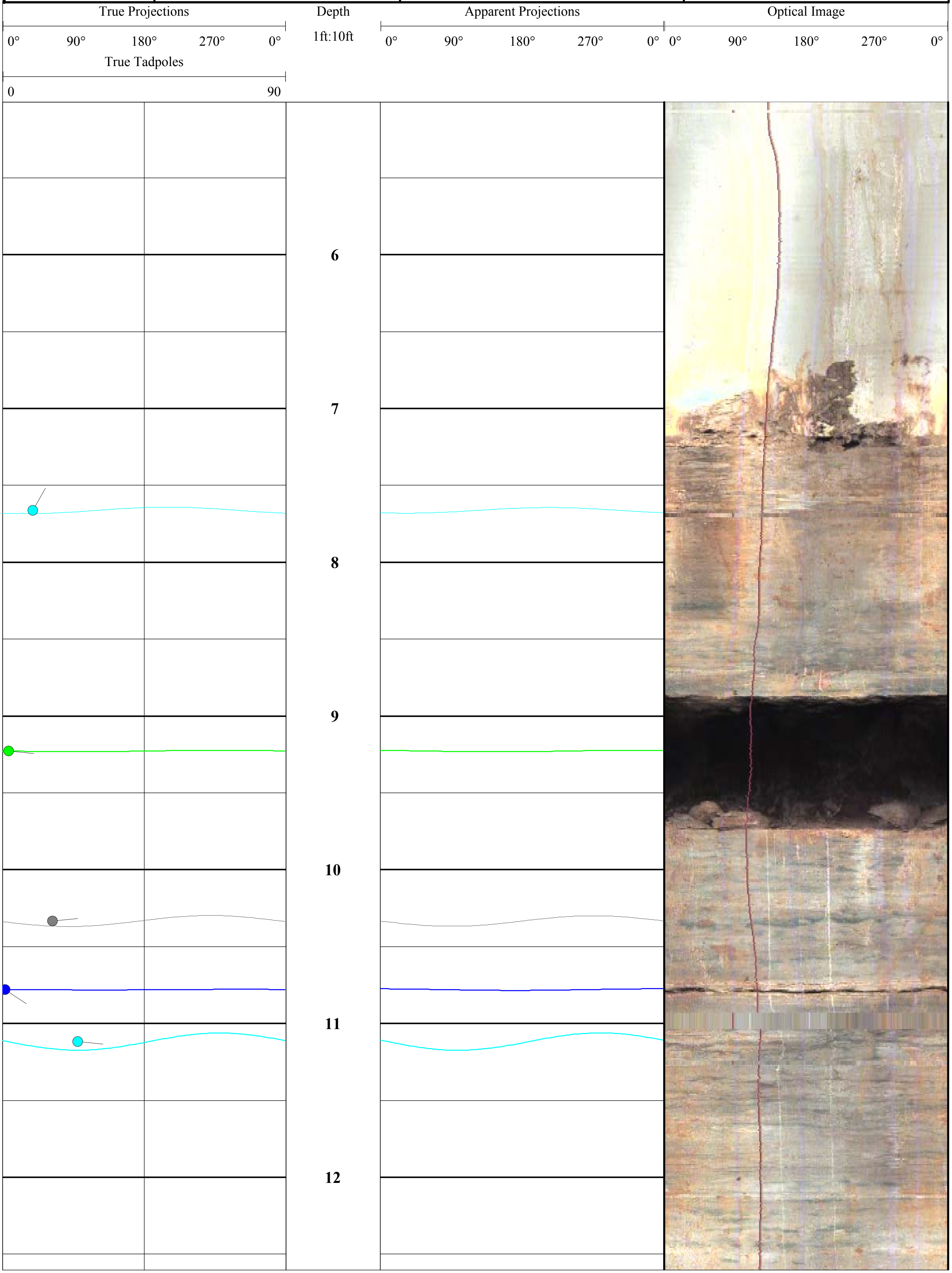

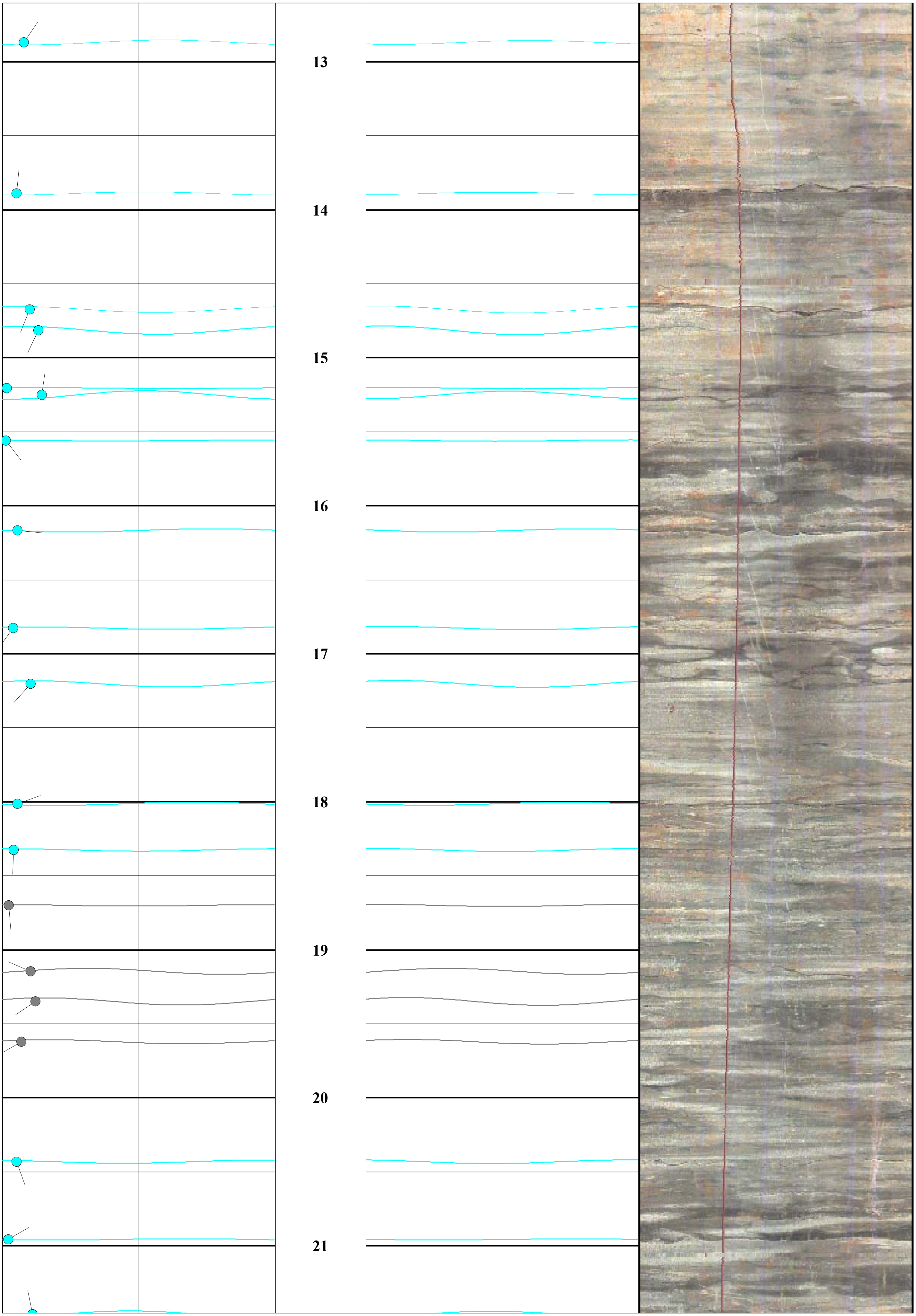
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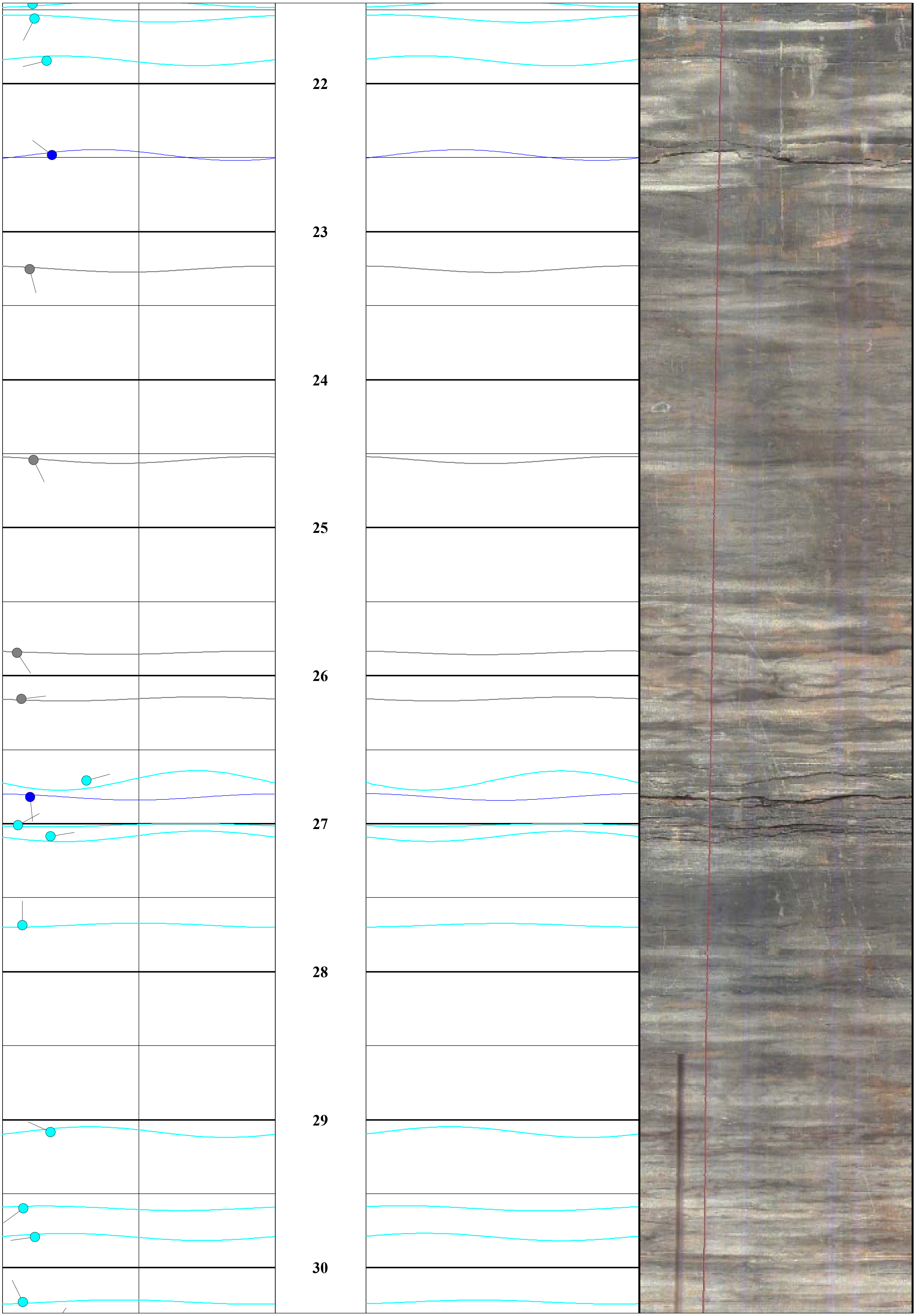
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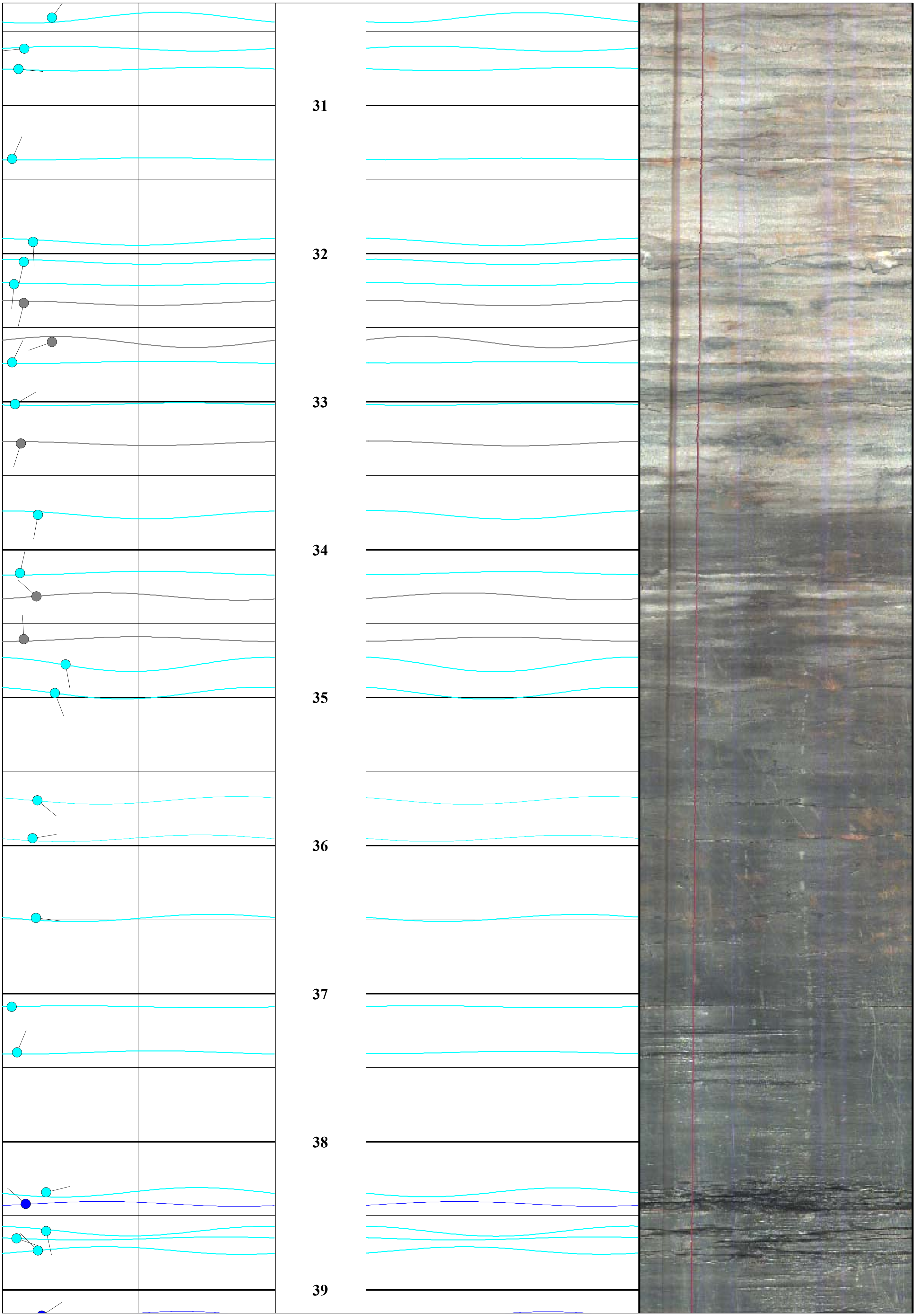
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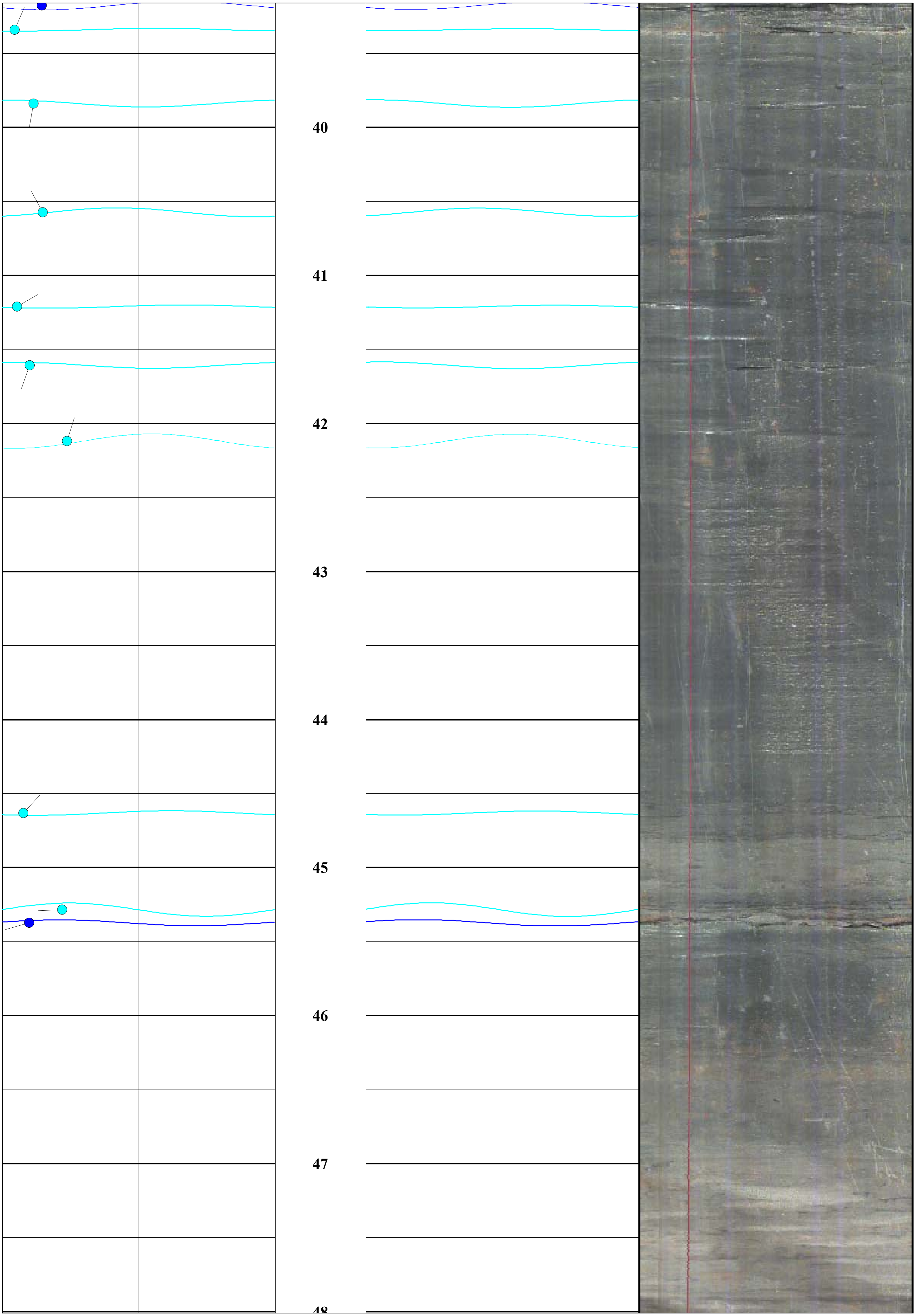
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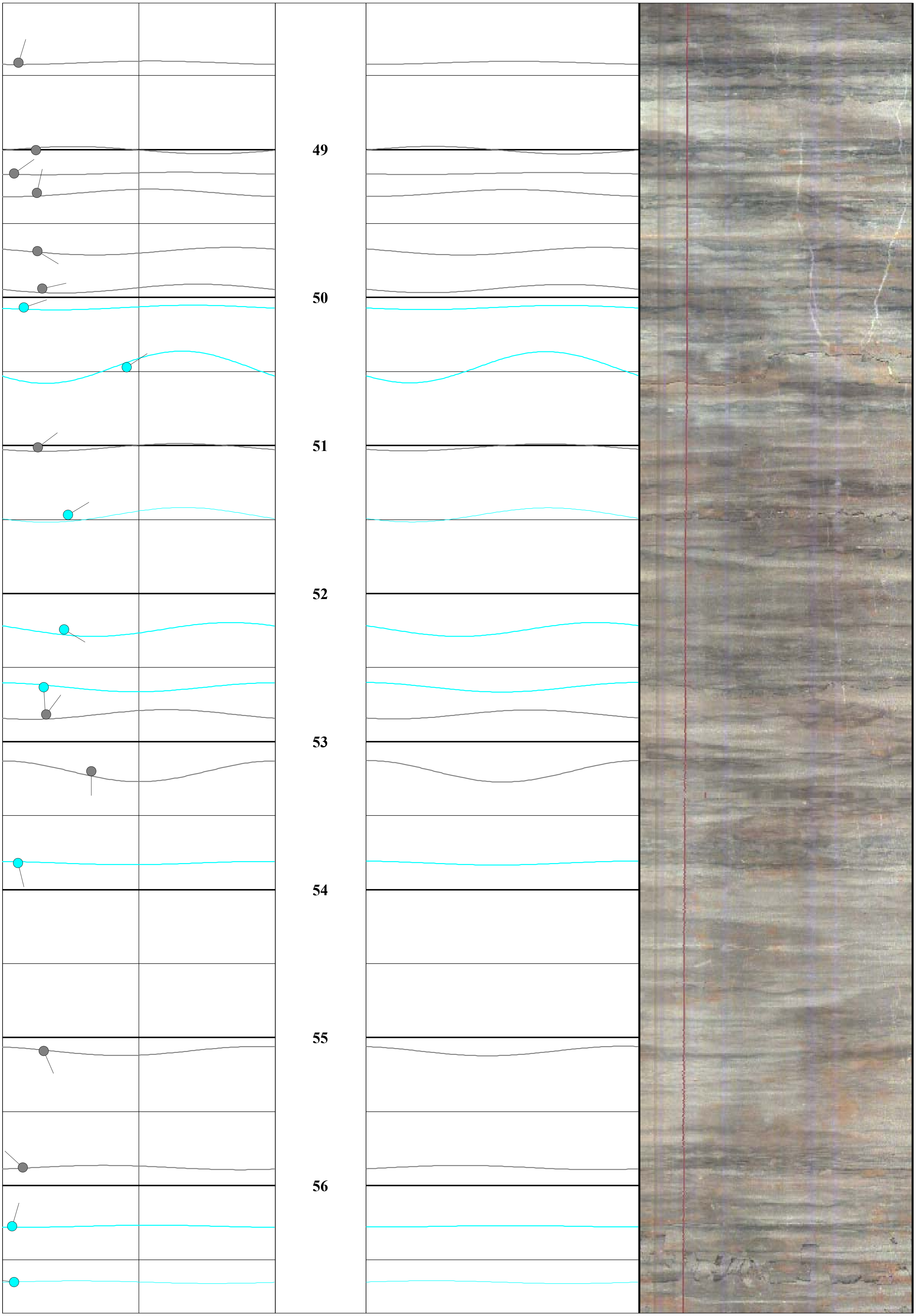
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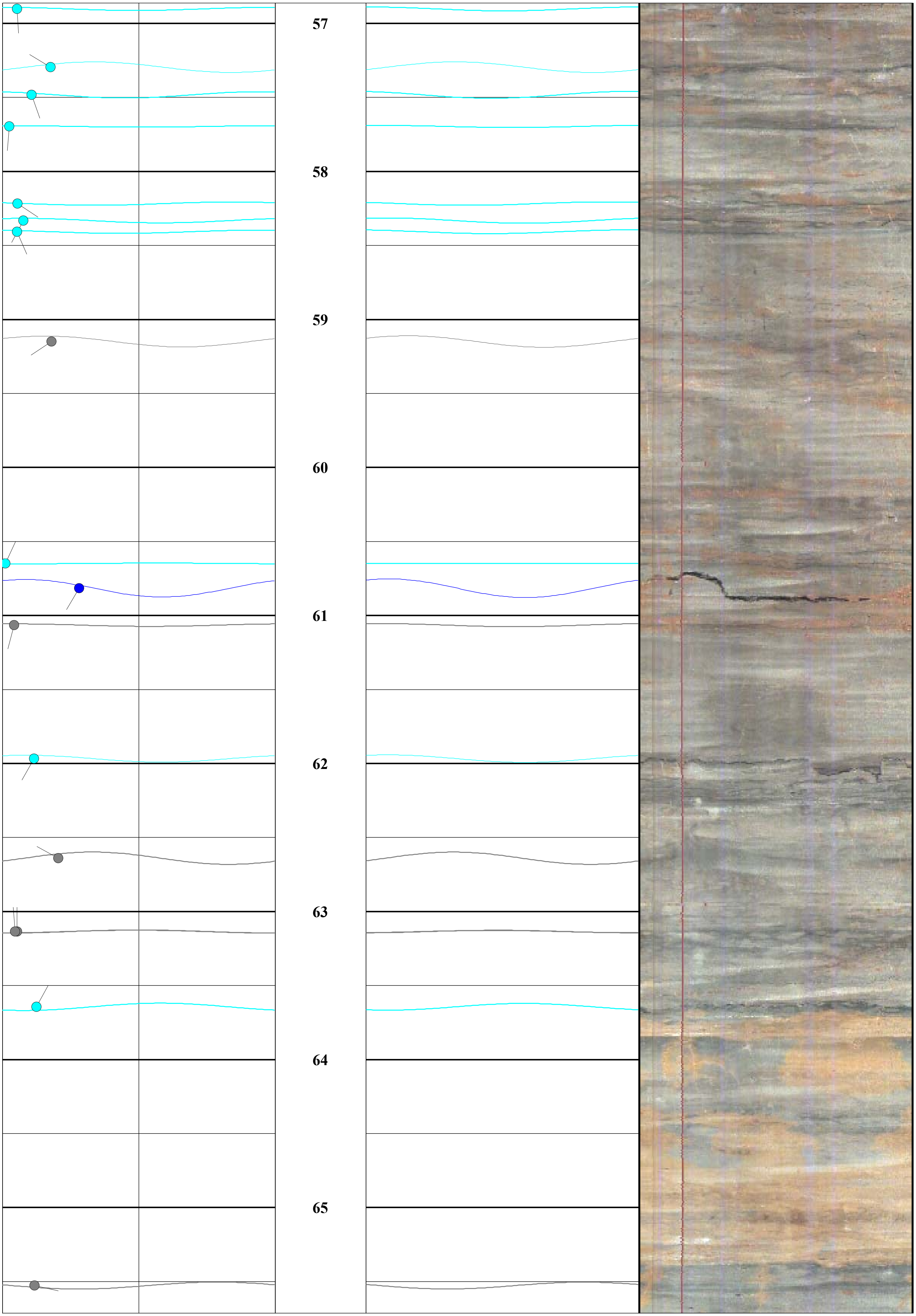
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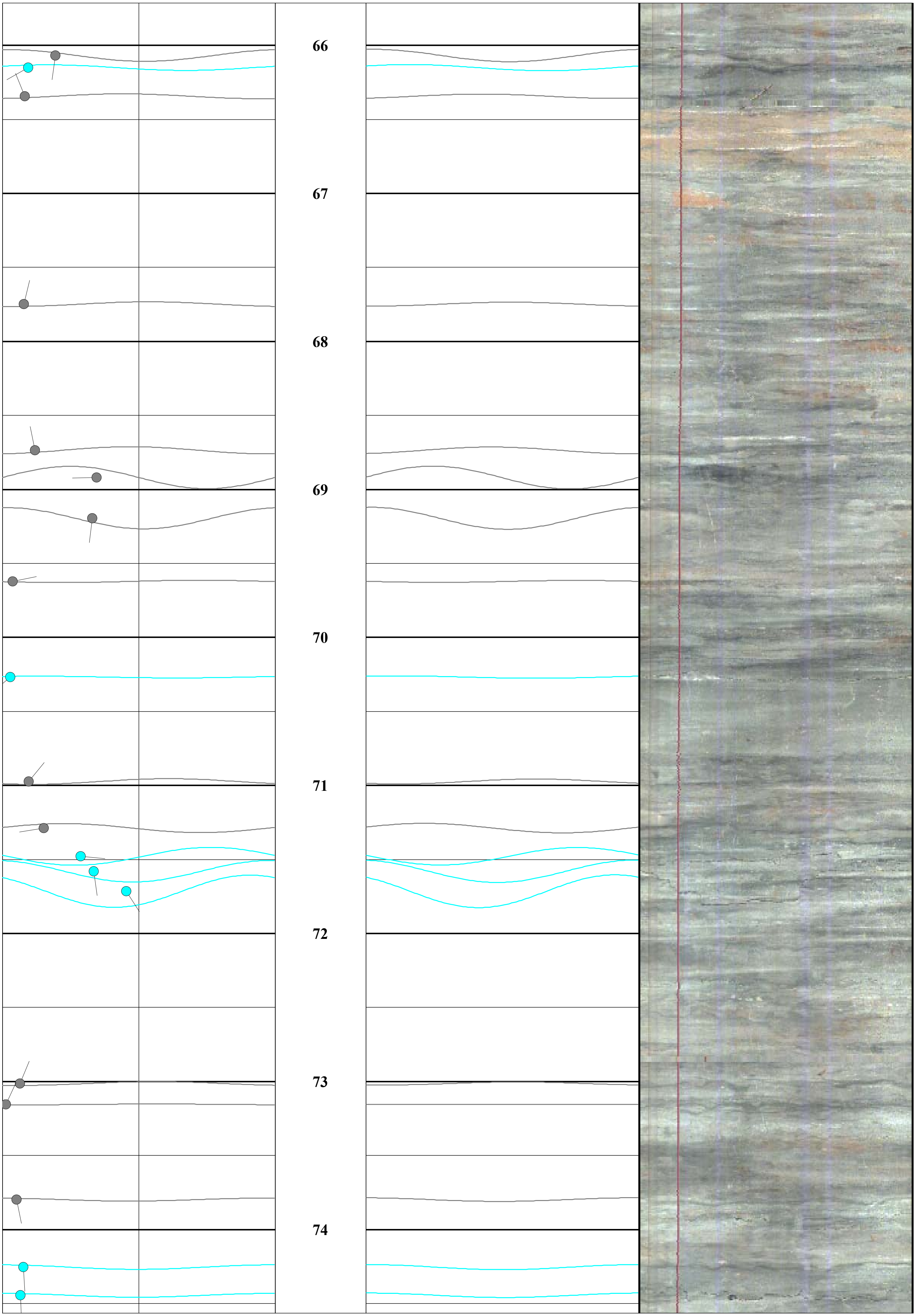
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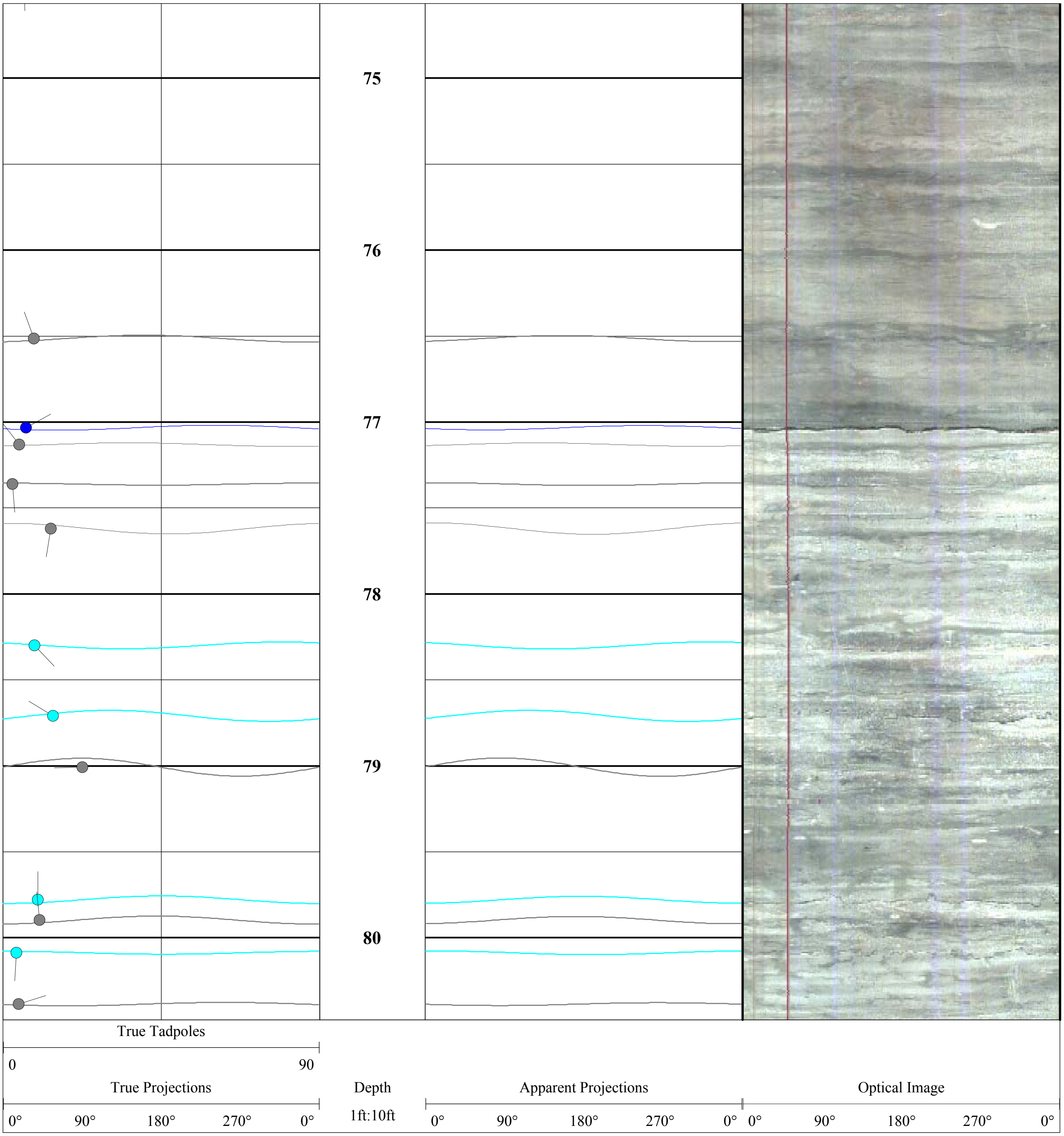
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True Tadpoles
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True Projections
0° 90° 180° 270° 0°
Depth
1ft:10ft
Apparent Projections
0° 90° 180° 270° 0°
Optical Image
0° 90° 180° 270° 0°

Optical Borehole Image Plot

COMPANY: FMSM	PROJECT: East End Approach, Phase 2	COLOG Main Office
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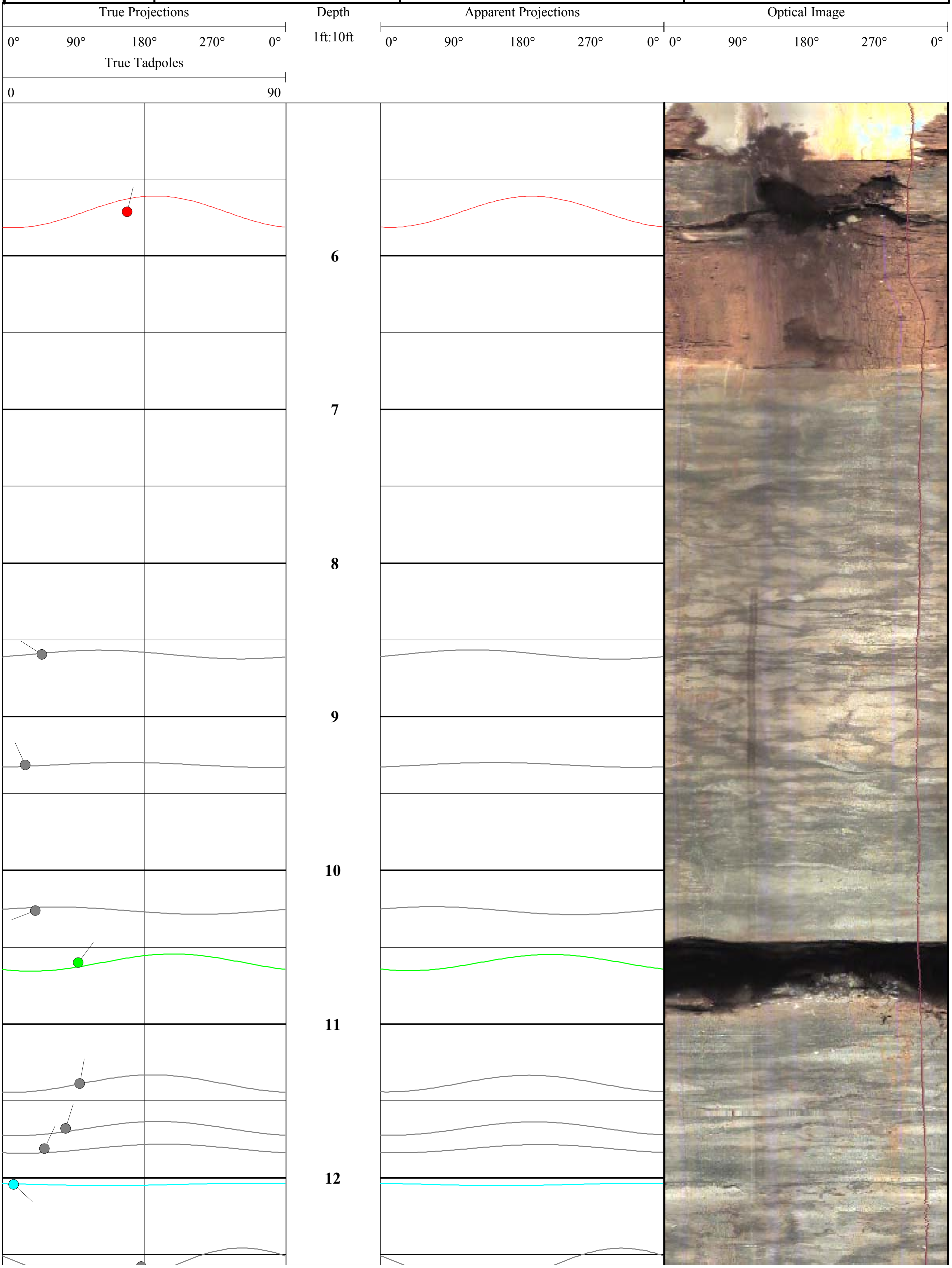

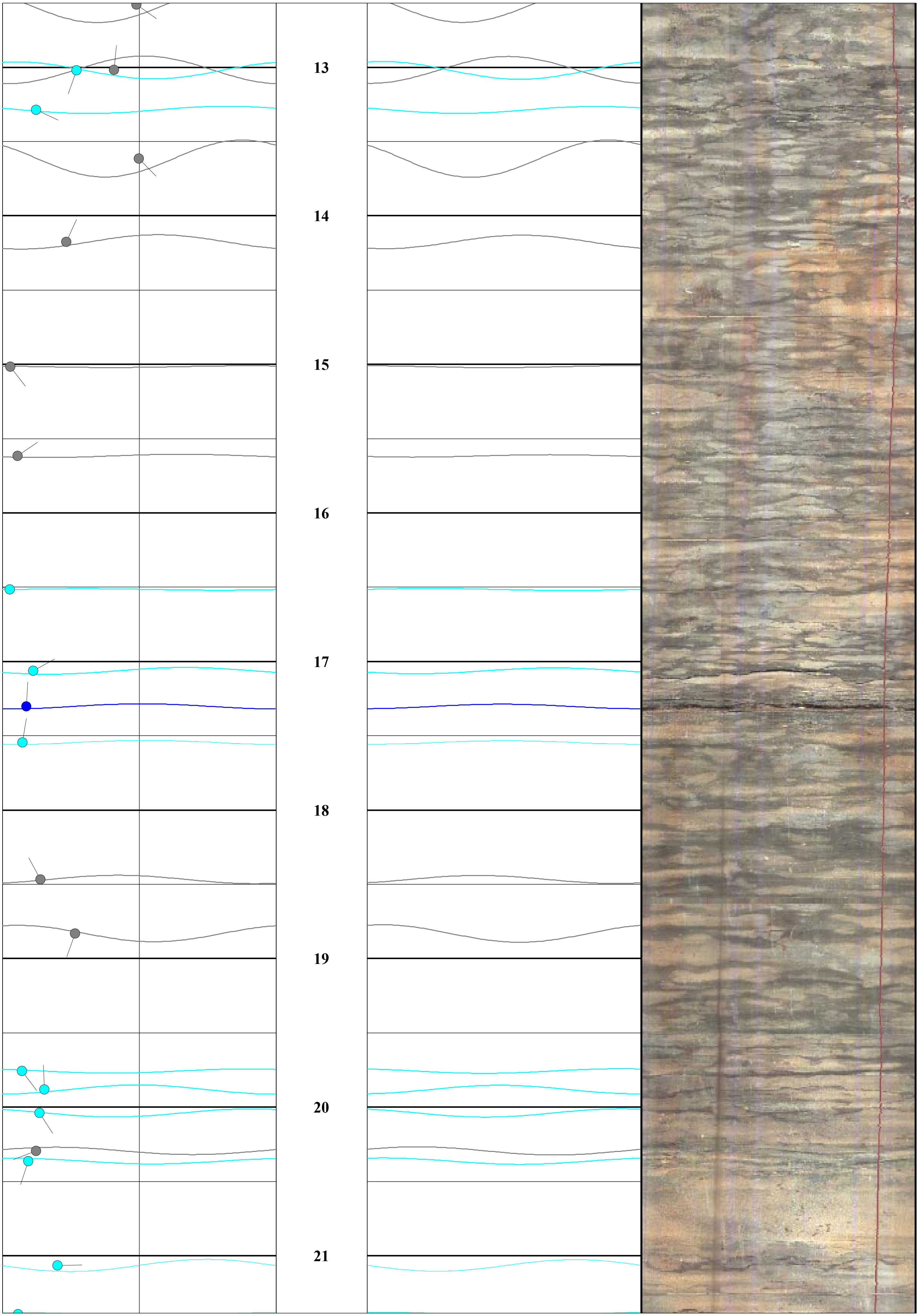
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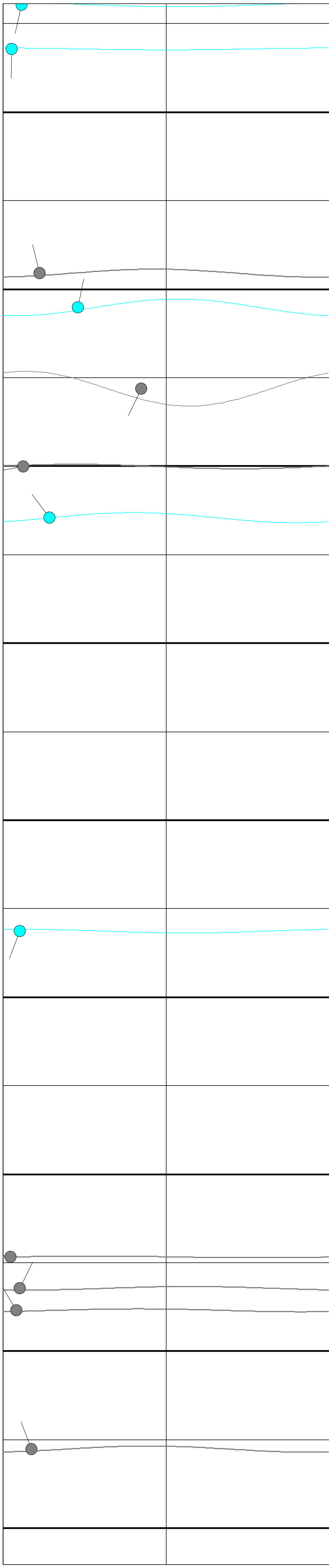

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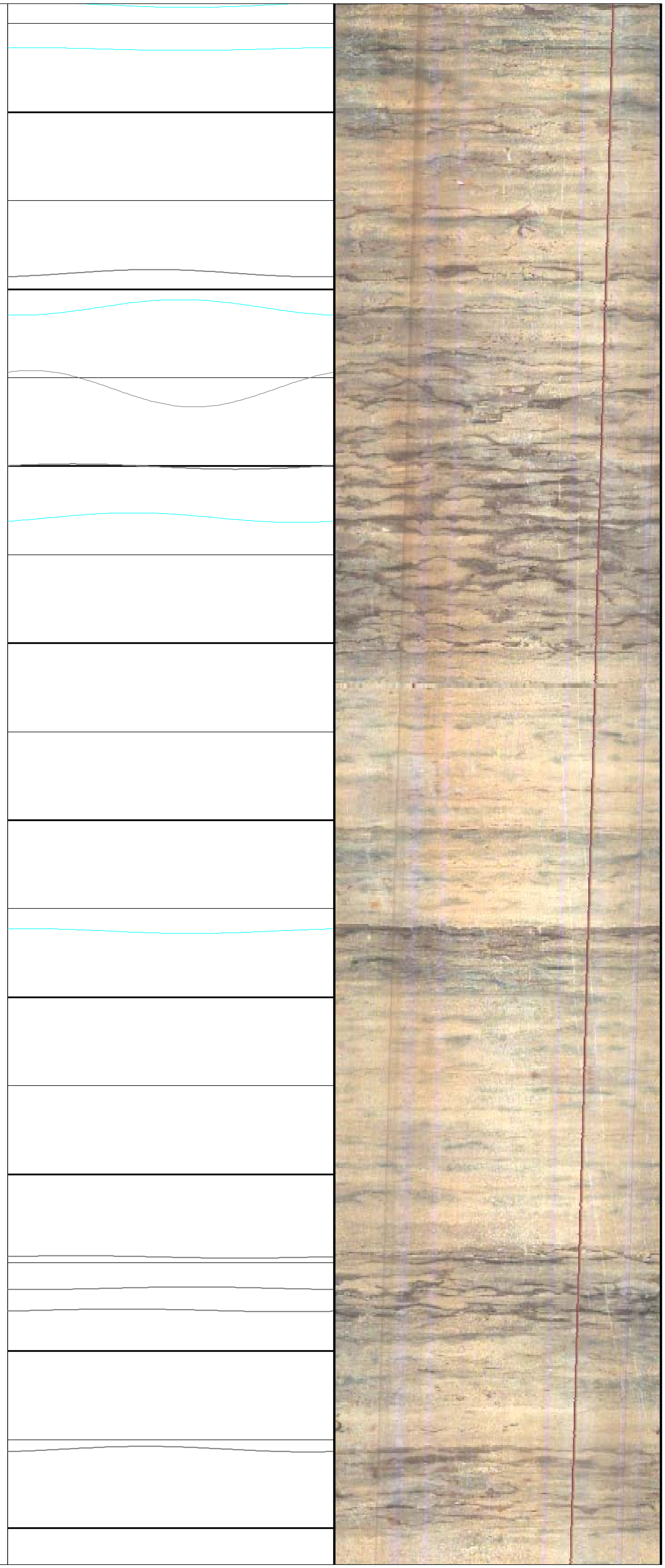

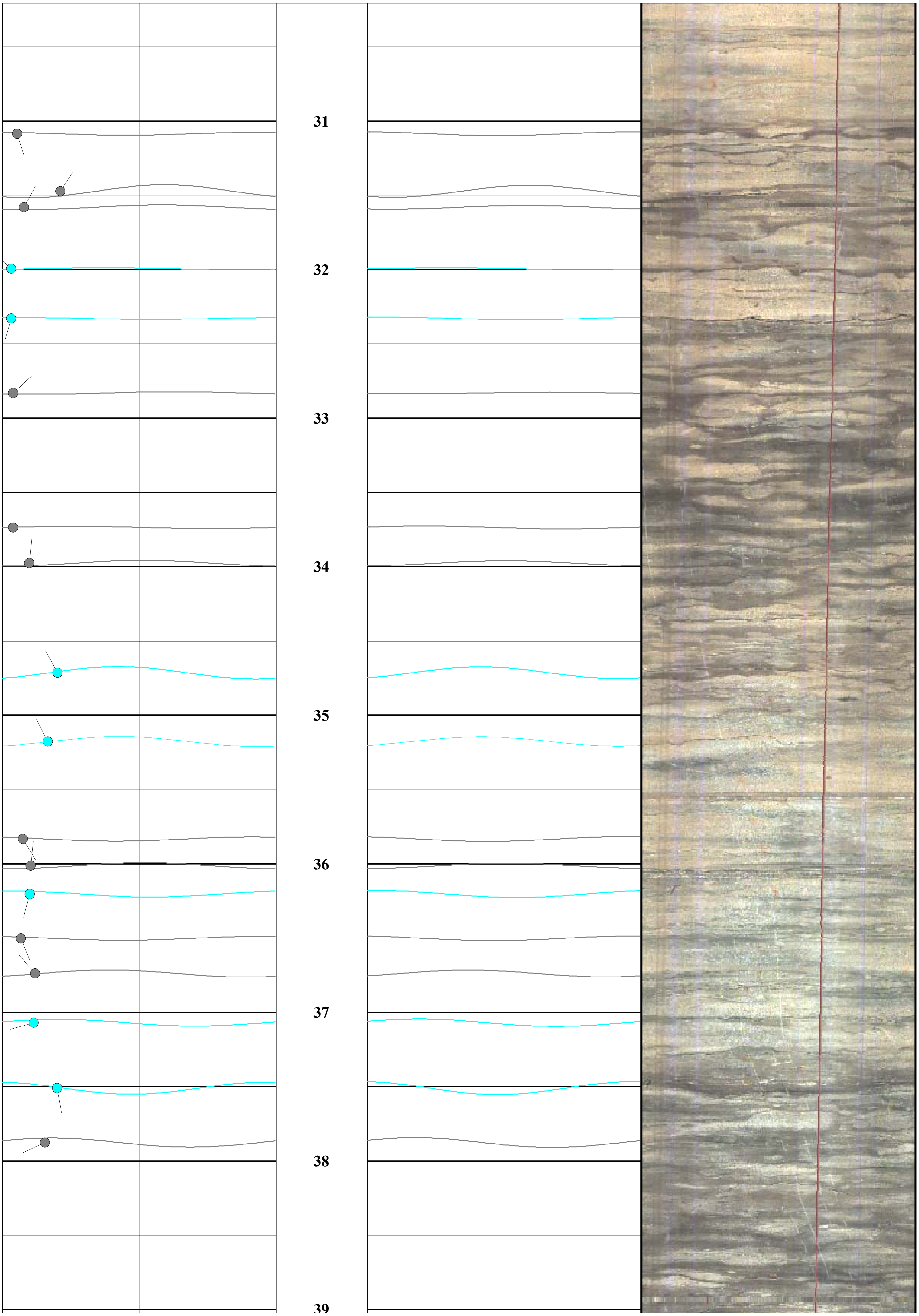
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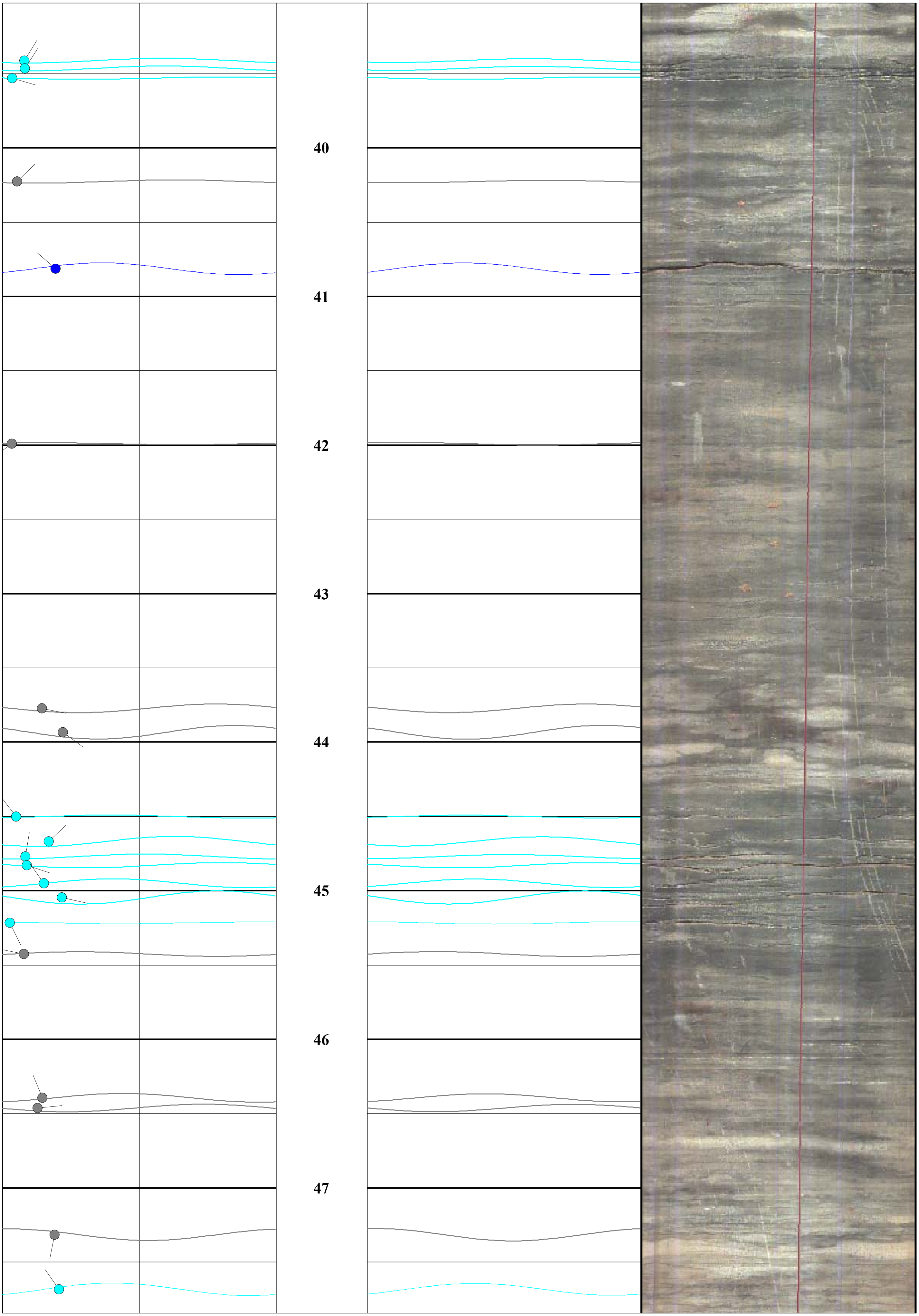
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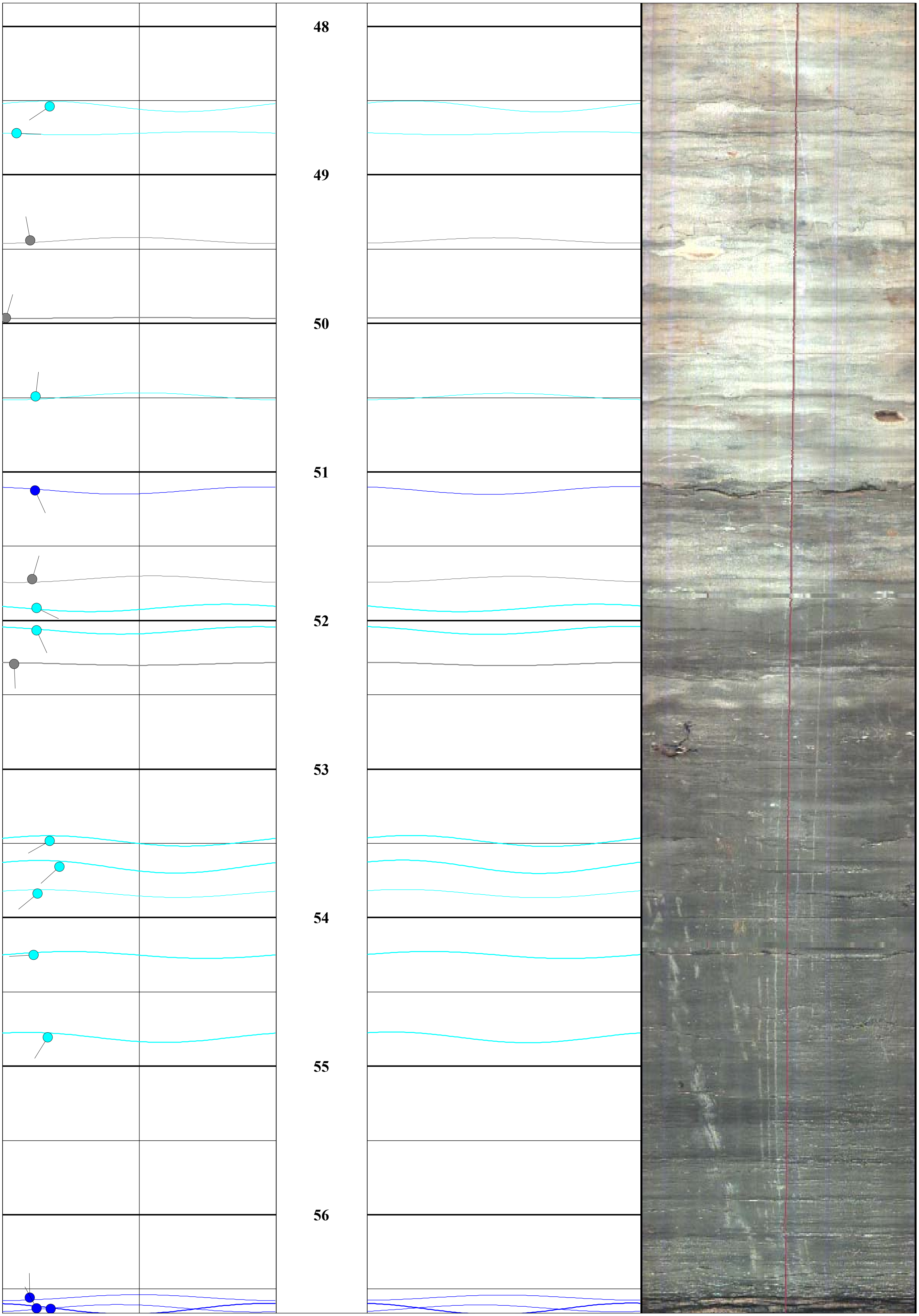
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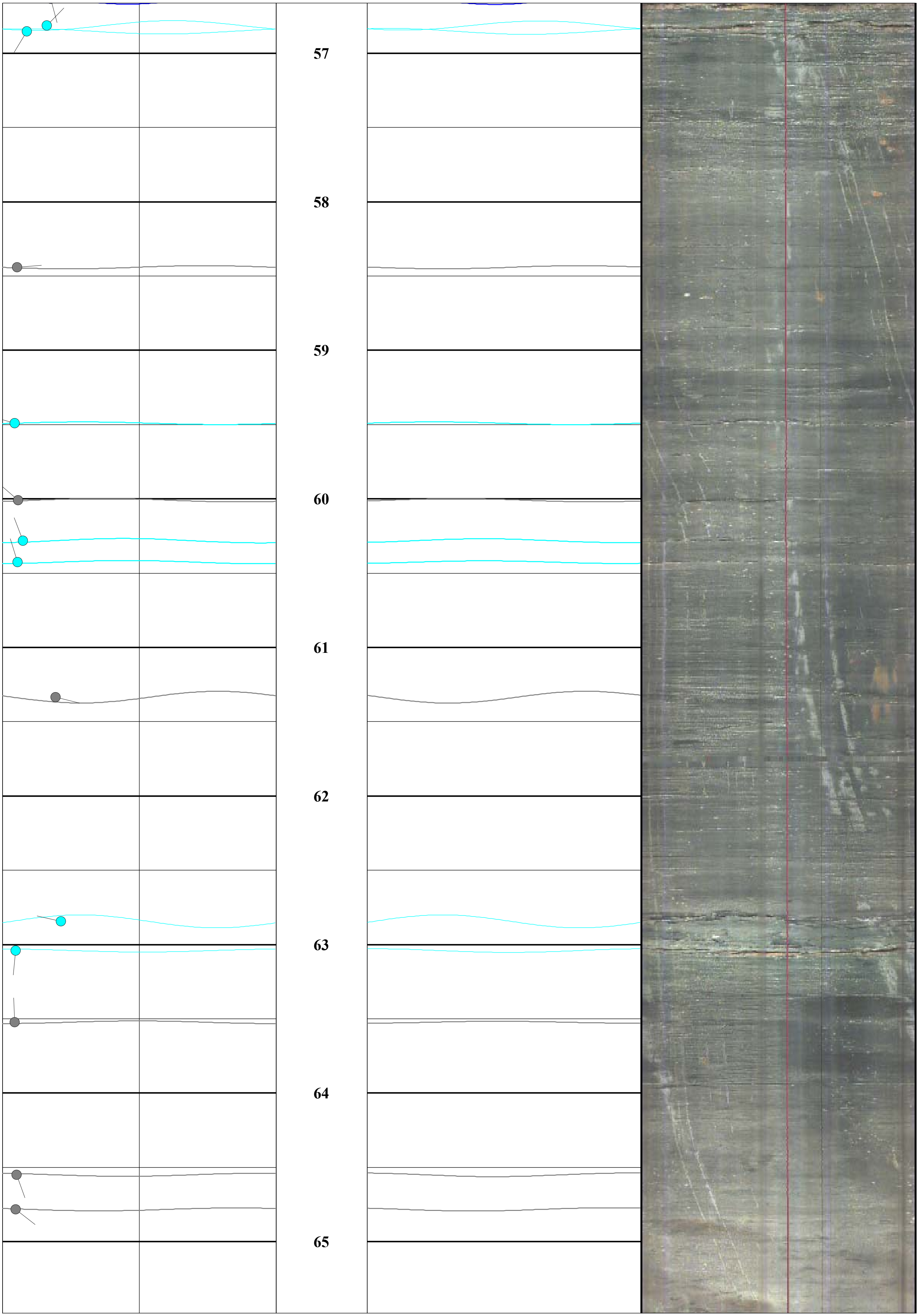
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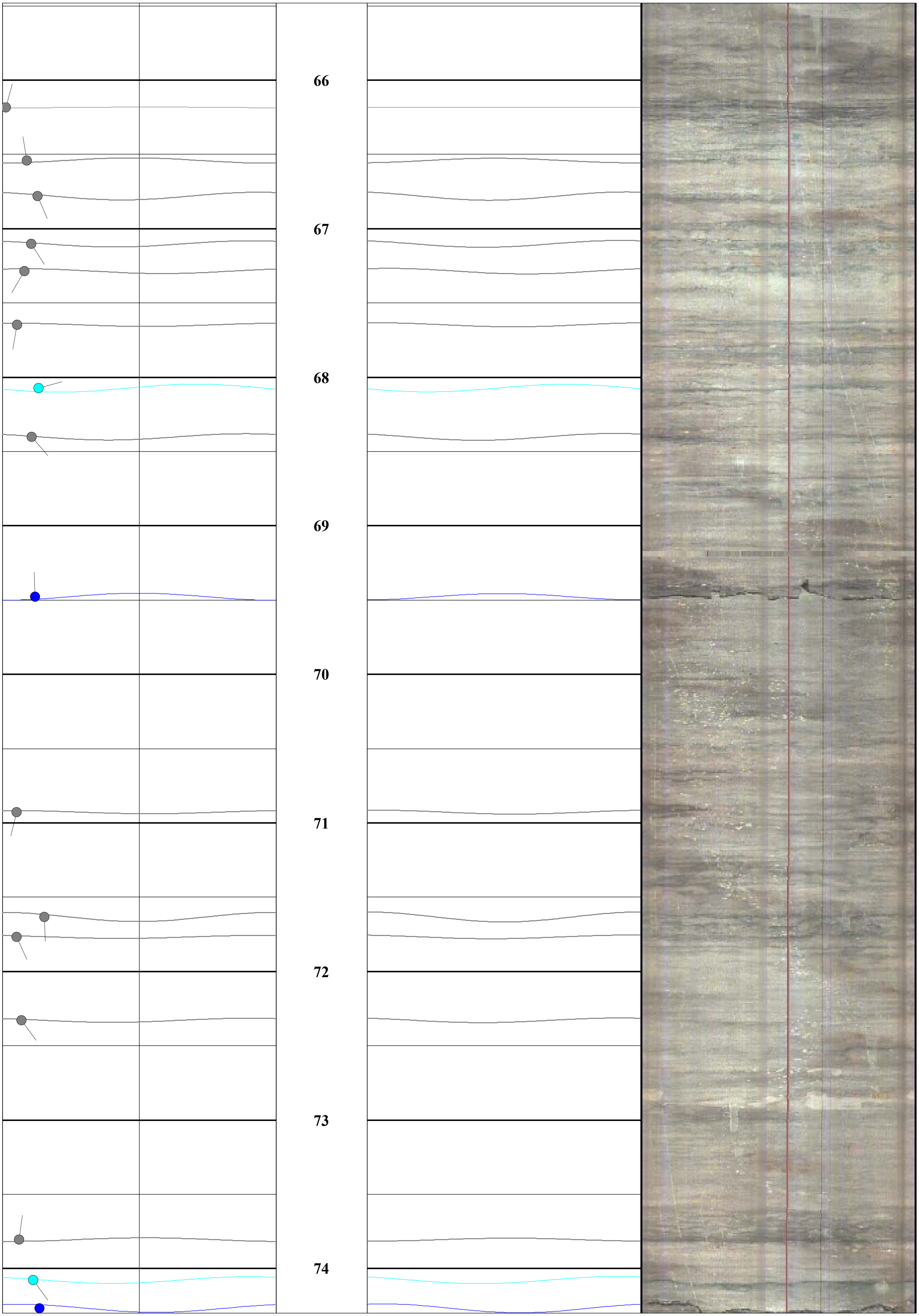
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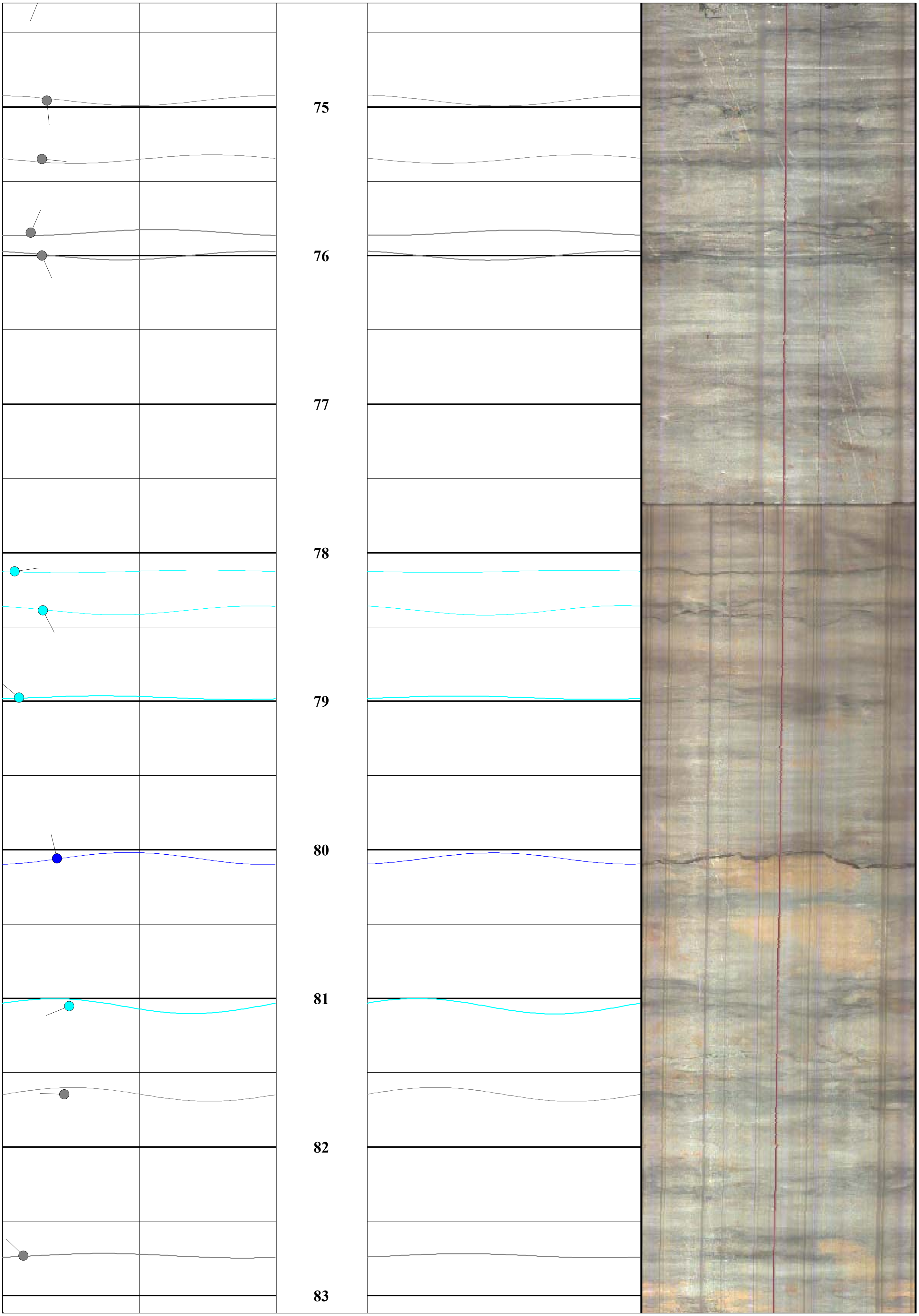
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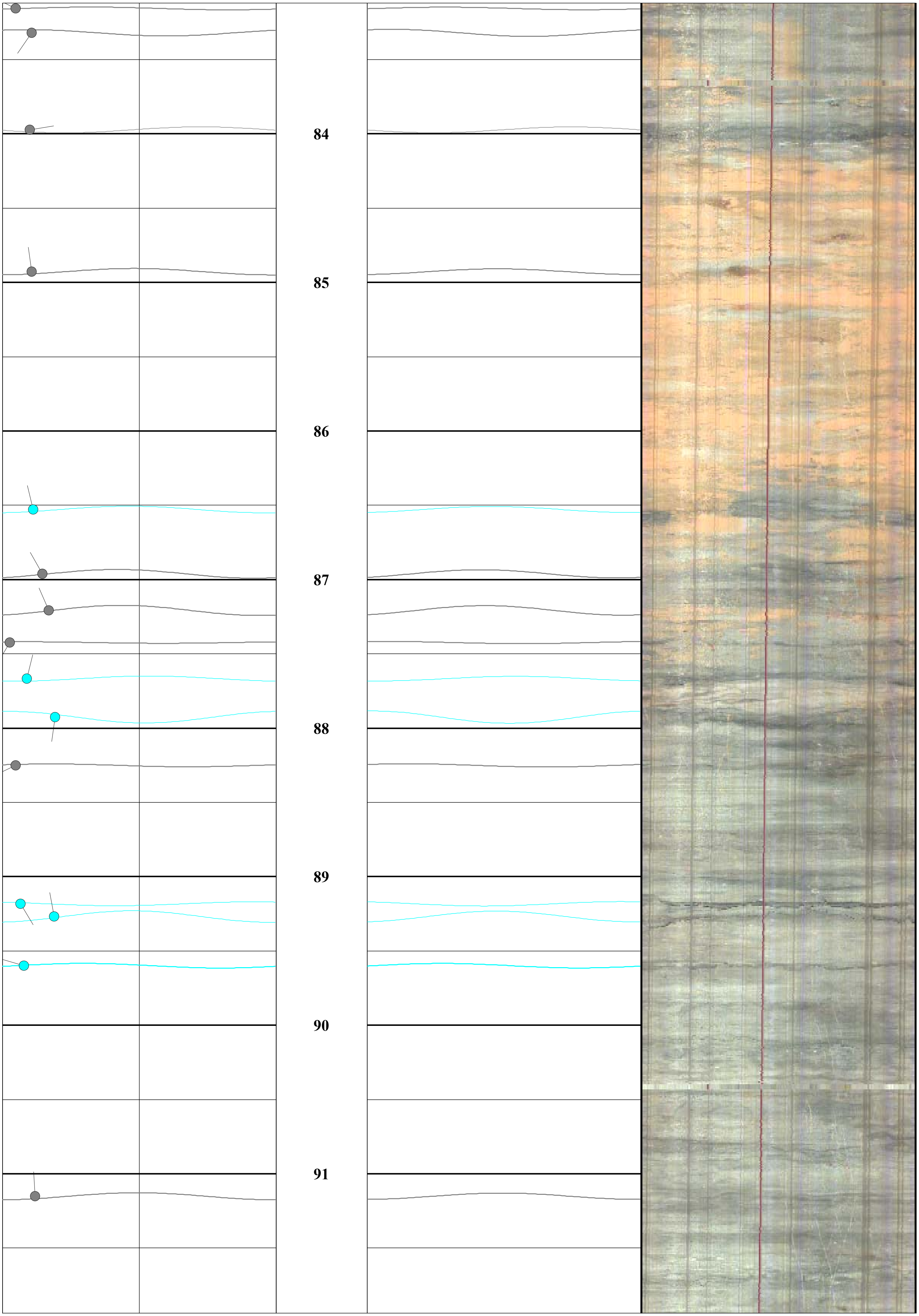
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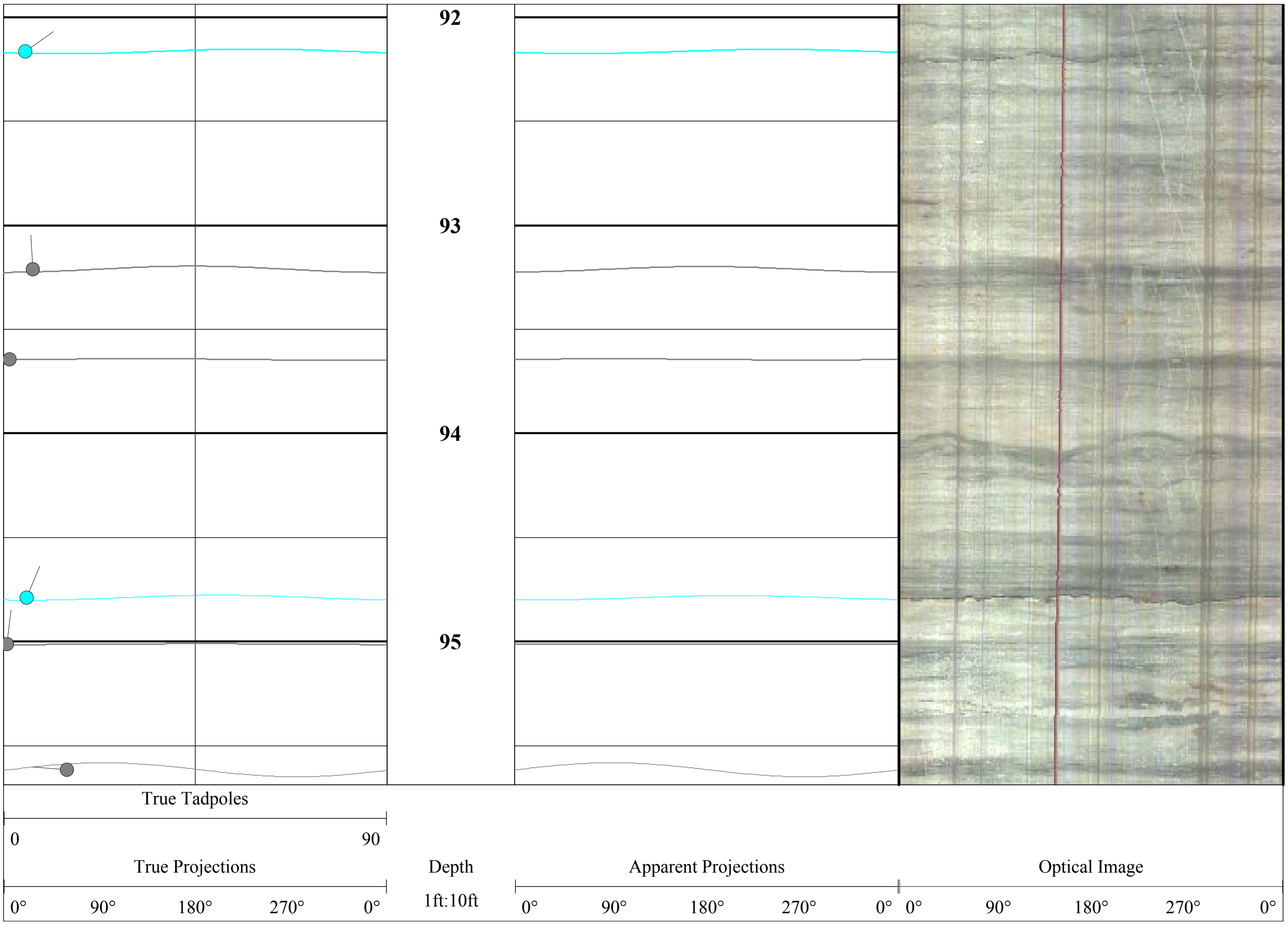
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True Tadpoles
0
90
True Projections
0° 90° 180° 270° 0°
Depth
1ft:10ft
Apparent Projections
0° 90° 180° 270° 0°
Optical Image
0° 90° 180° 270° 0°

COLOG
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A DIVISION OF LAYNE CHRISTENSEN COMPANY

Optical Borehole Image Plot

COMPANY: FMSM	PROJECT: East End Approach, Phase 2
DATE LOGGED: 19 December 2005	WELL: B-11

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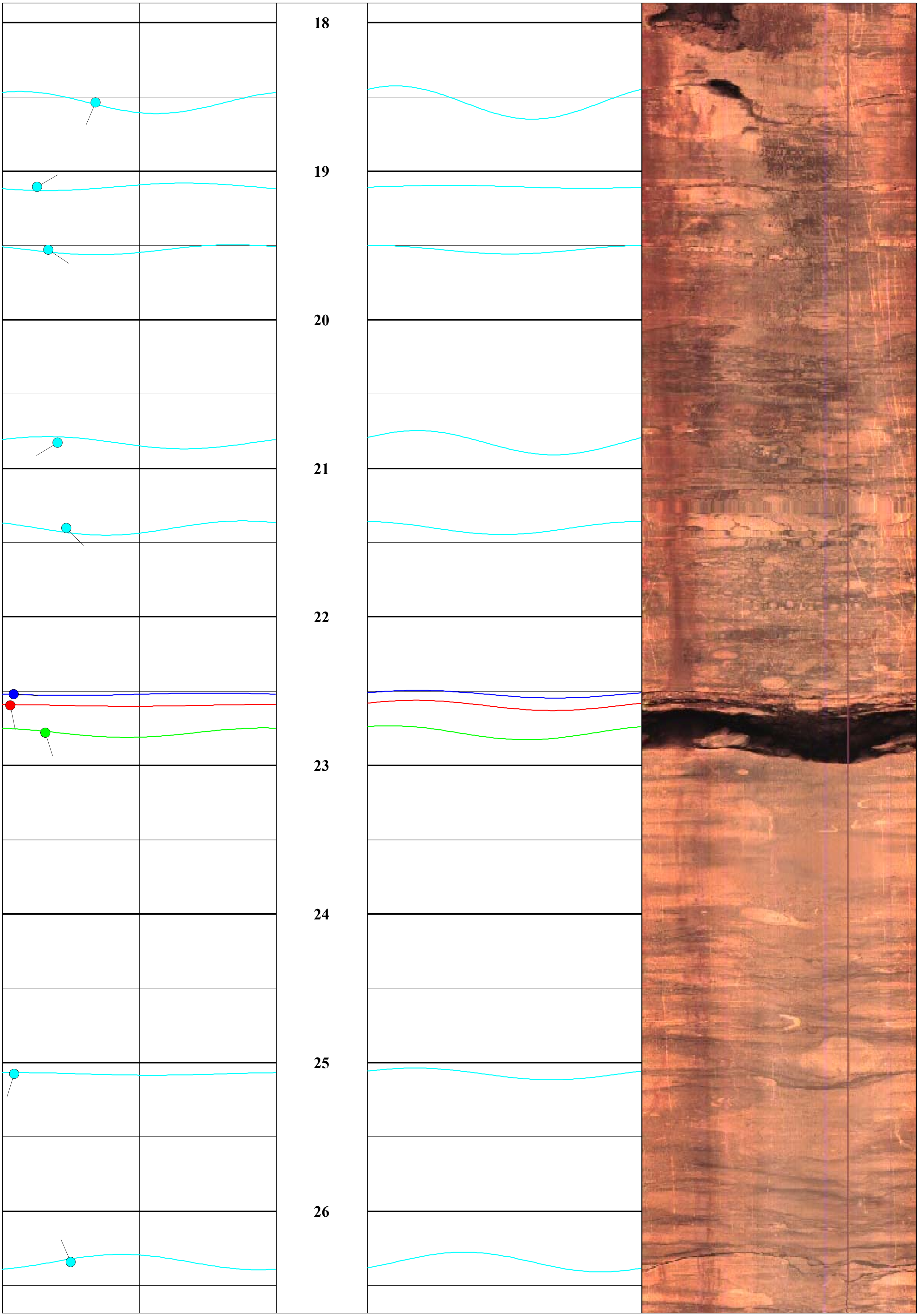
True Projections	Depth	Apparent Projections	Optical Image
0° 90° 180° 270° 0°	1ft:10ft	0° 90° 180° 270° 0°	0° 90° 180° 270° 0°
True Tadpoles			
0 90			

Depth: **11** **12** **13** **14** **15** **16** **17**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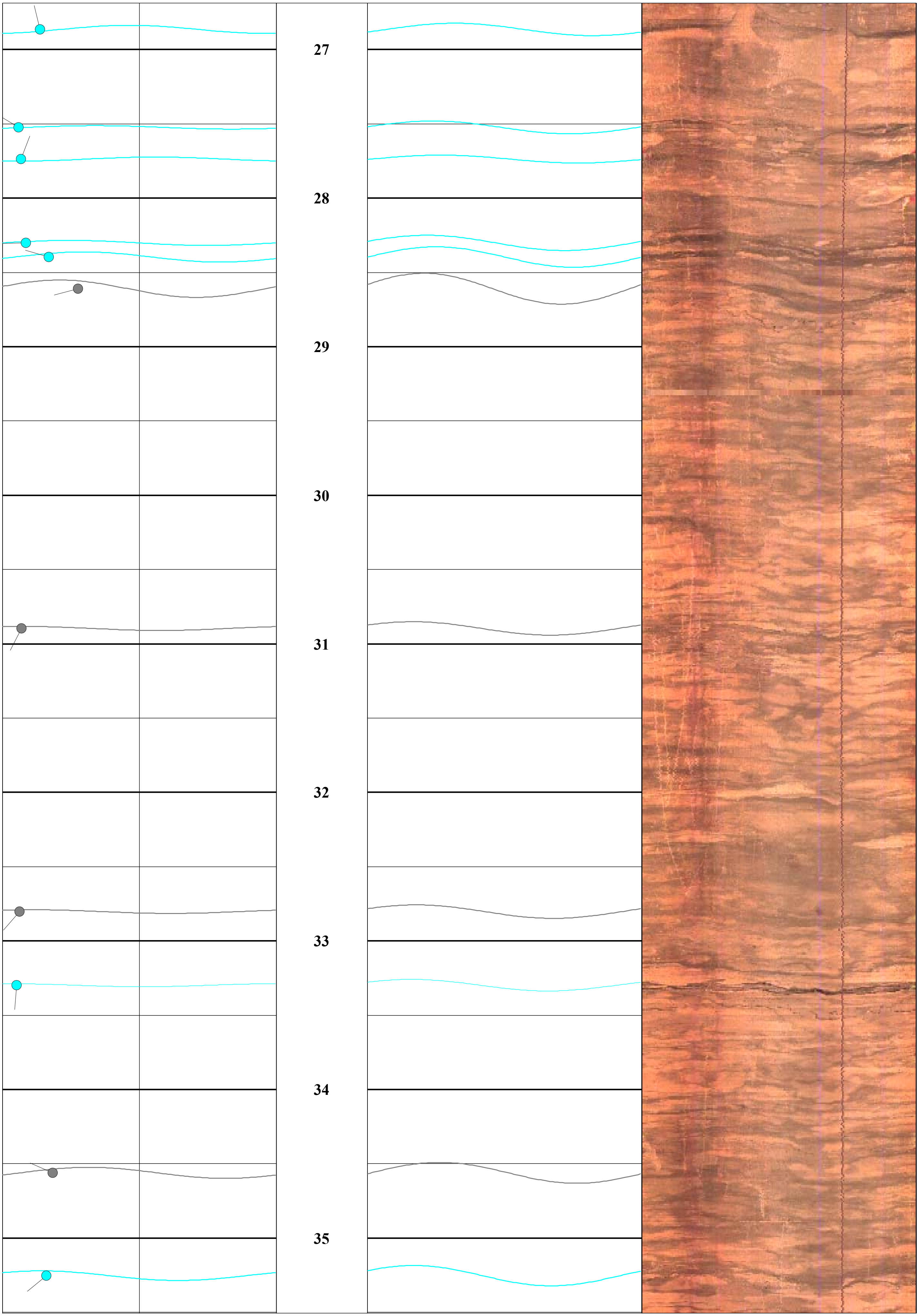
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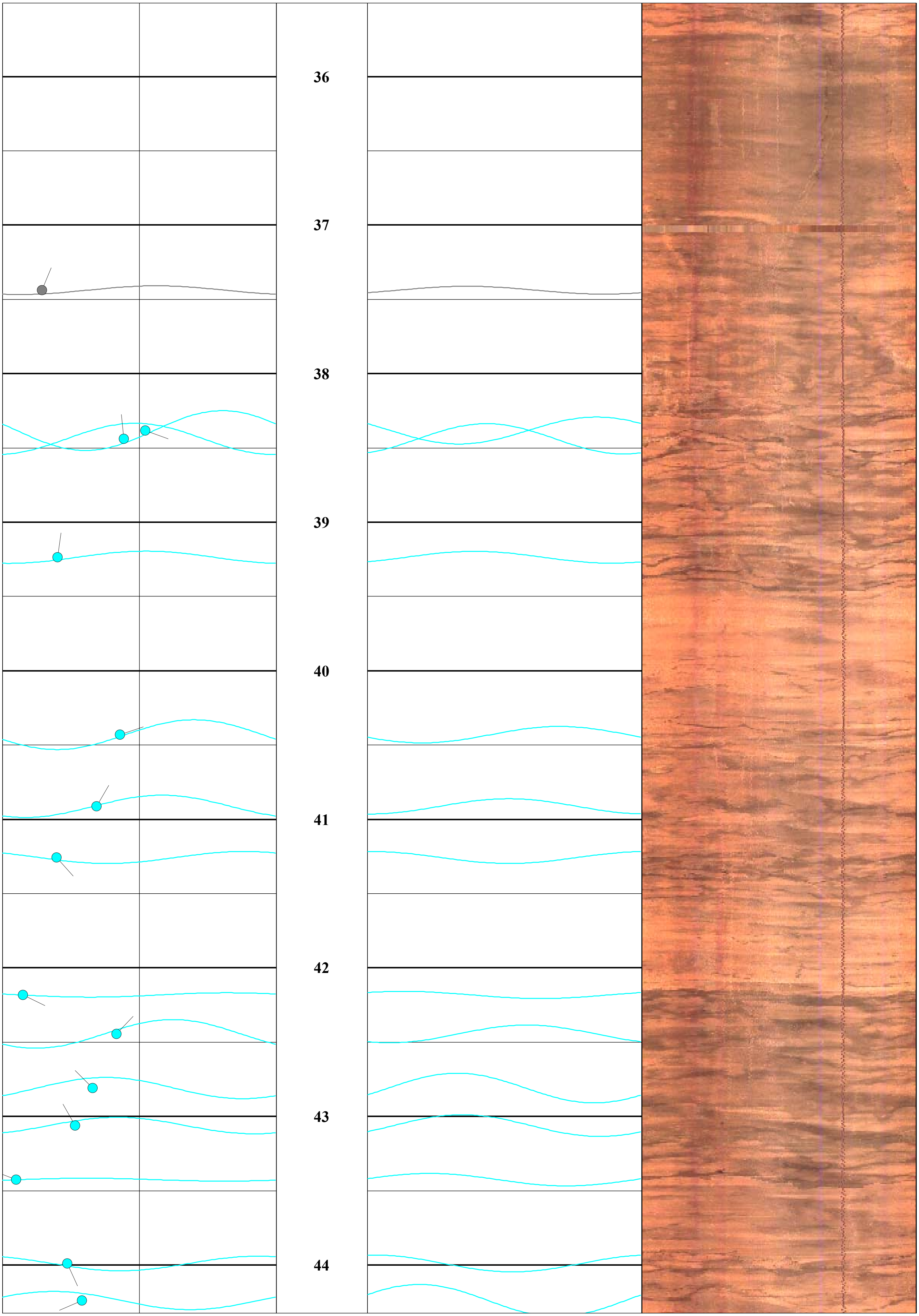
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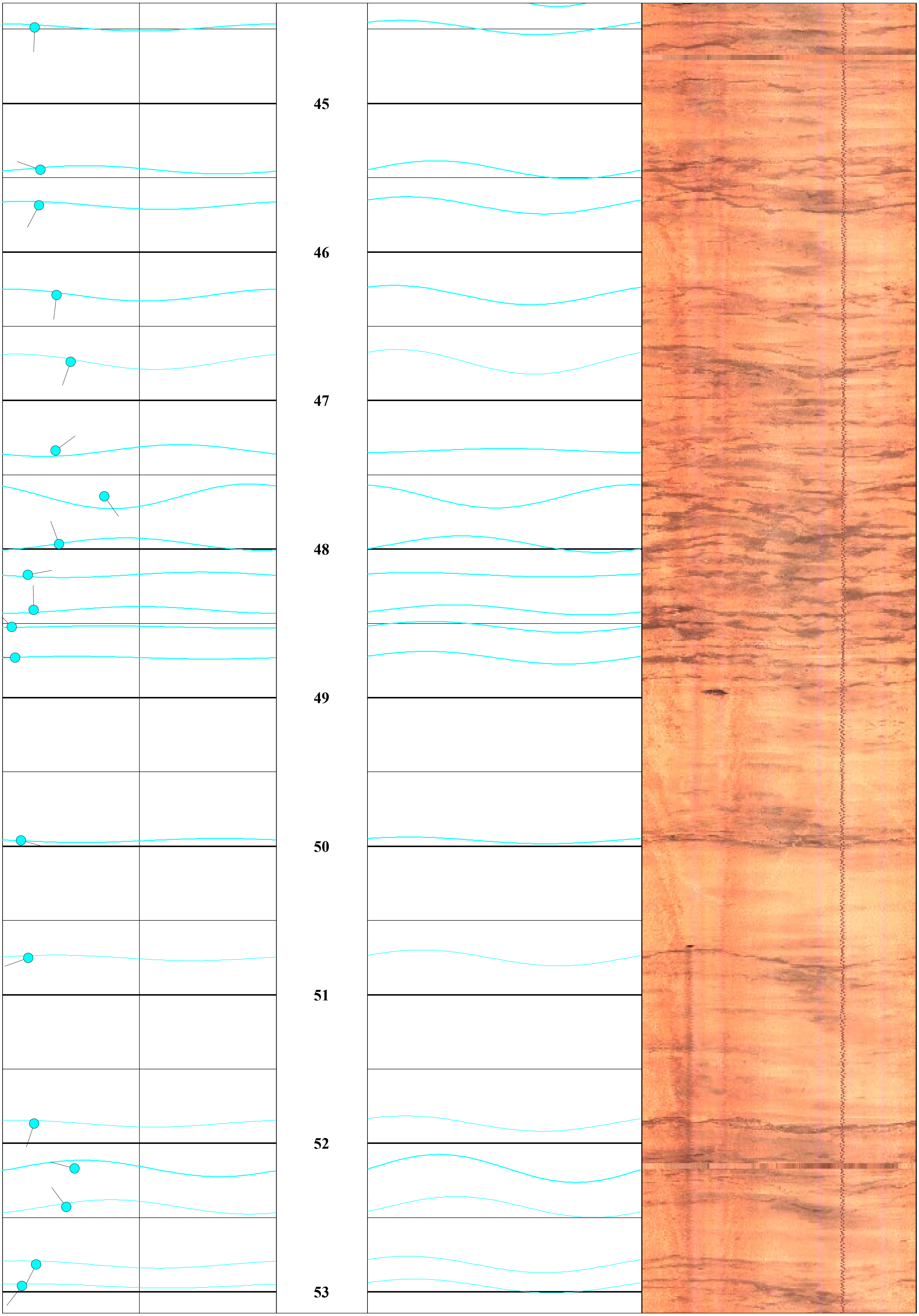
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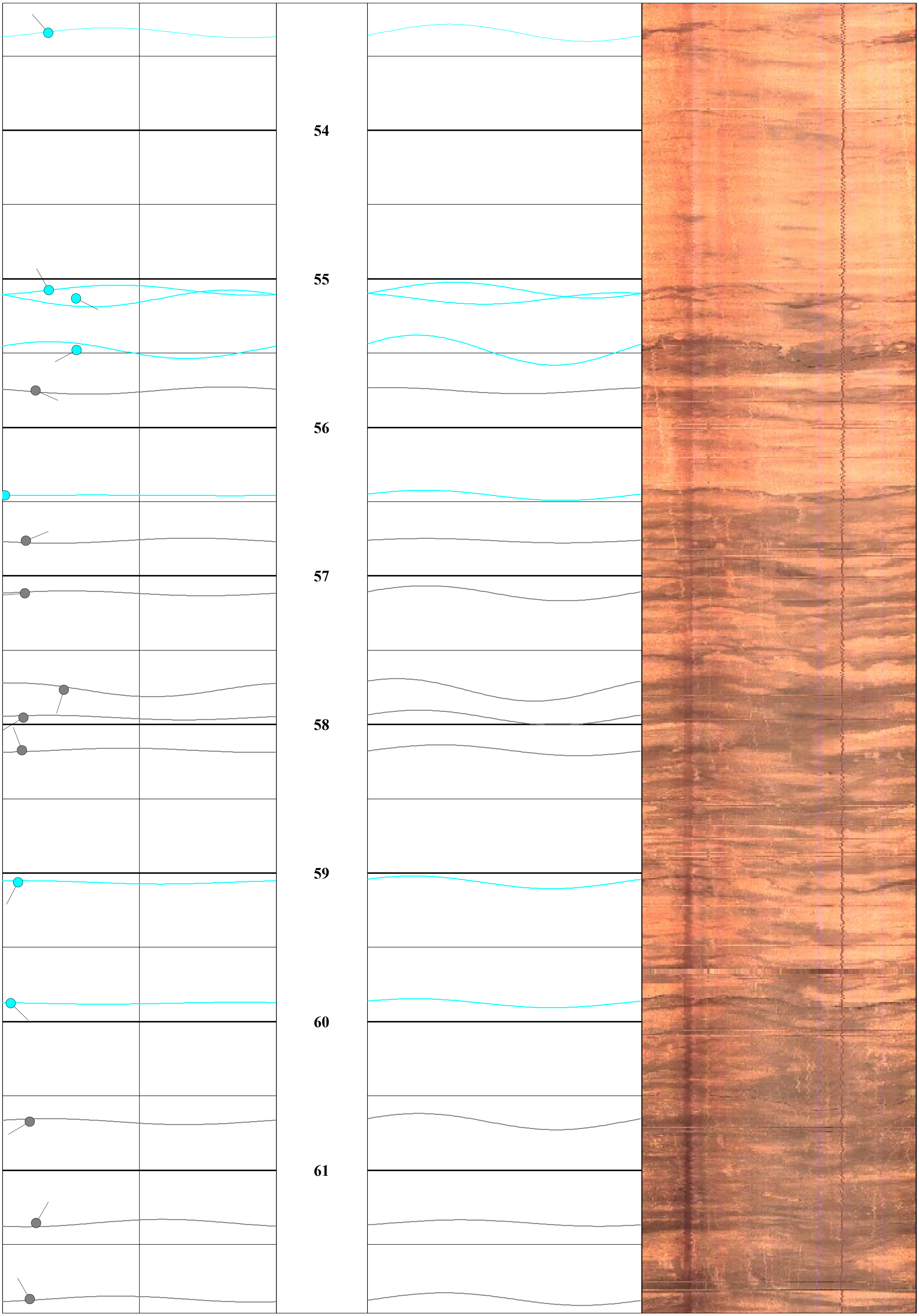
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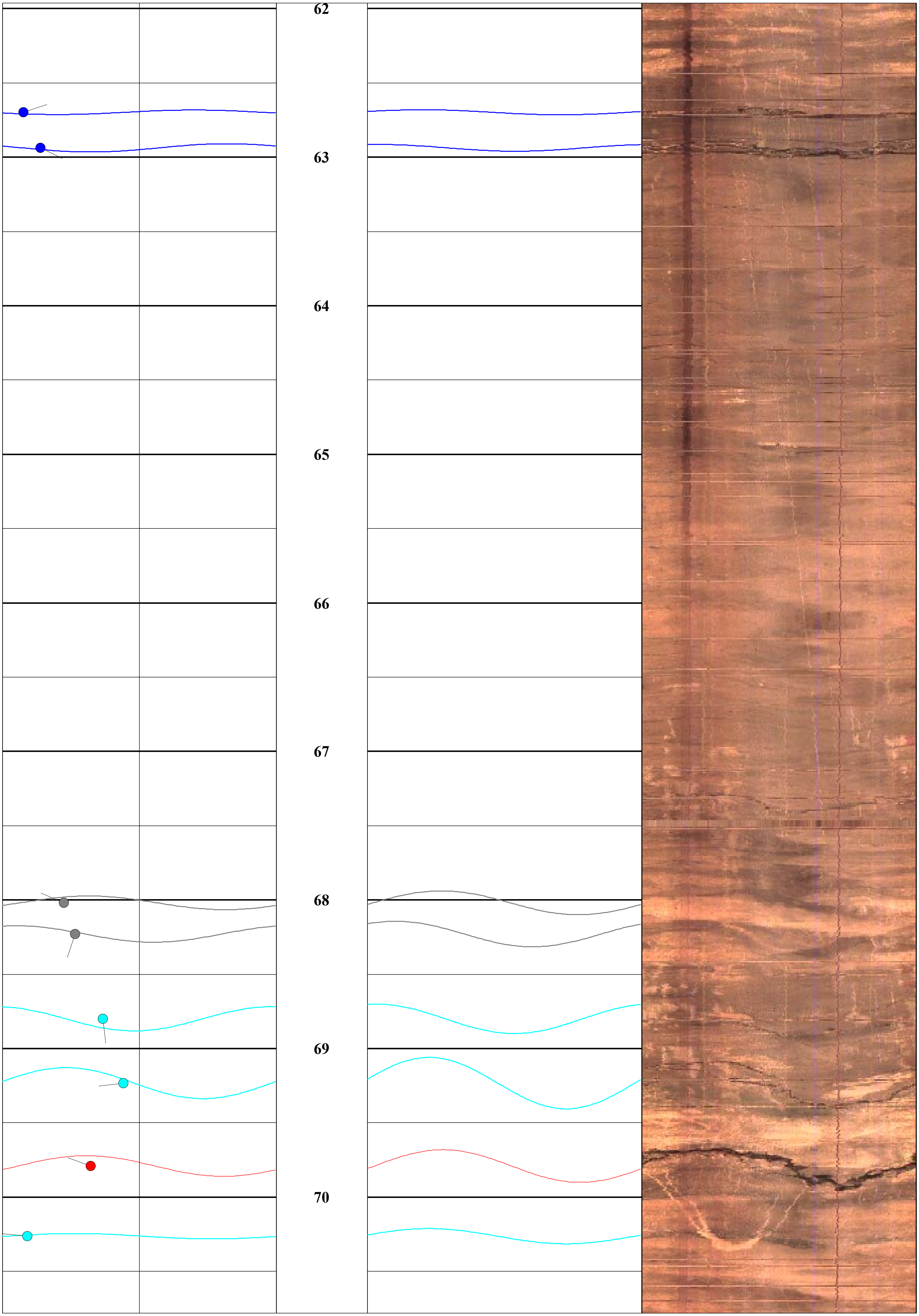
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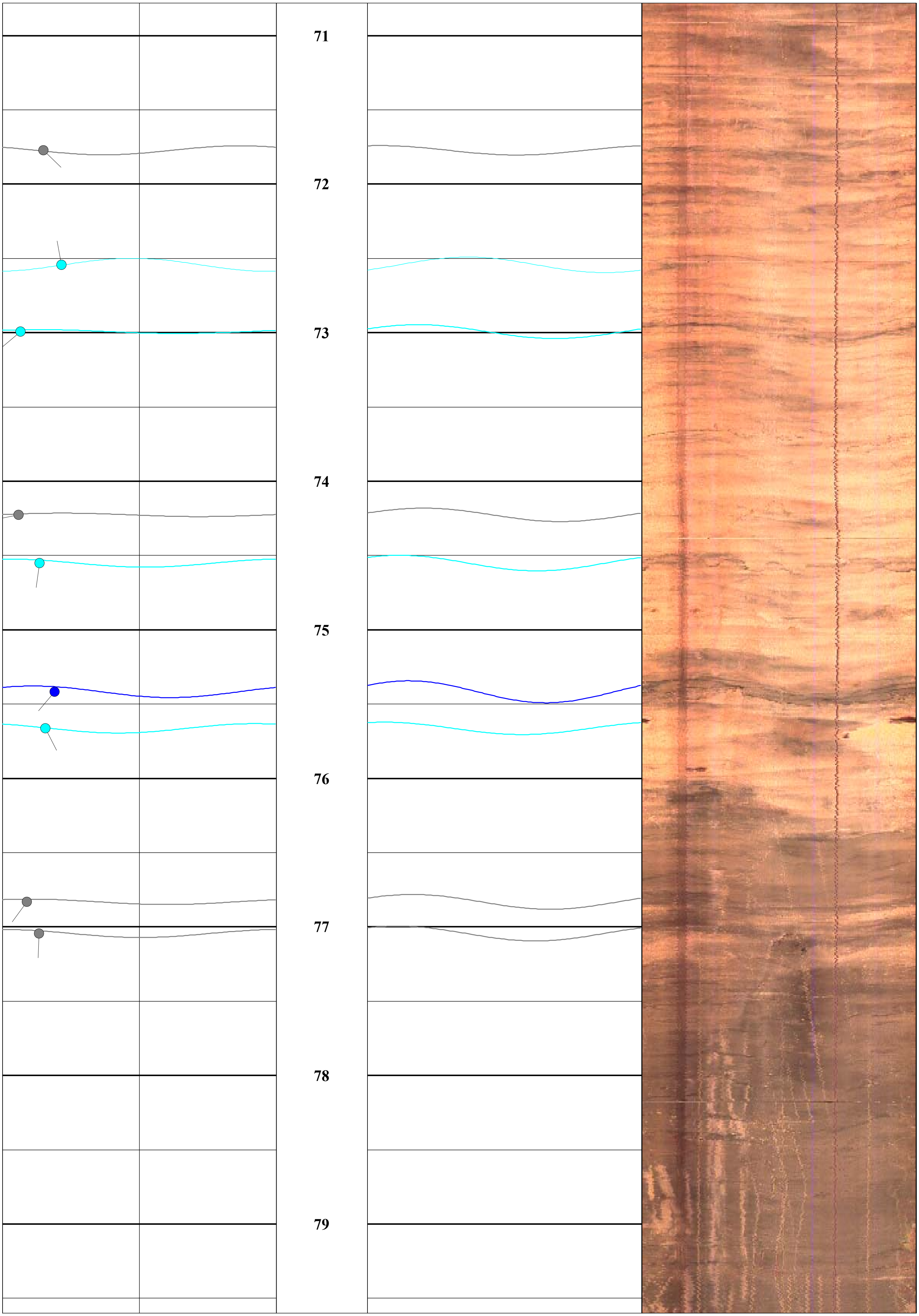
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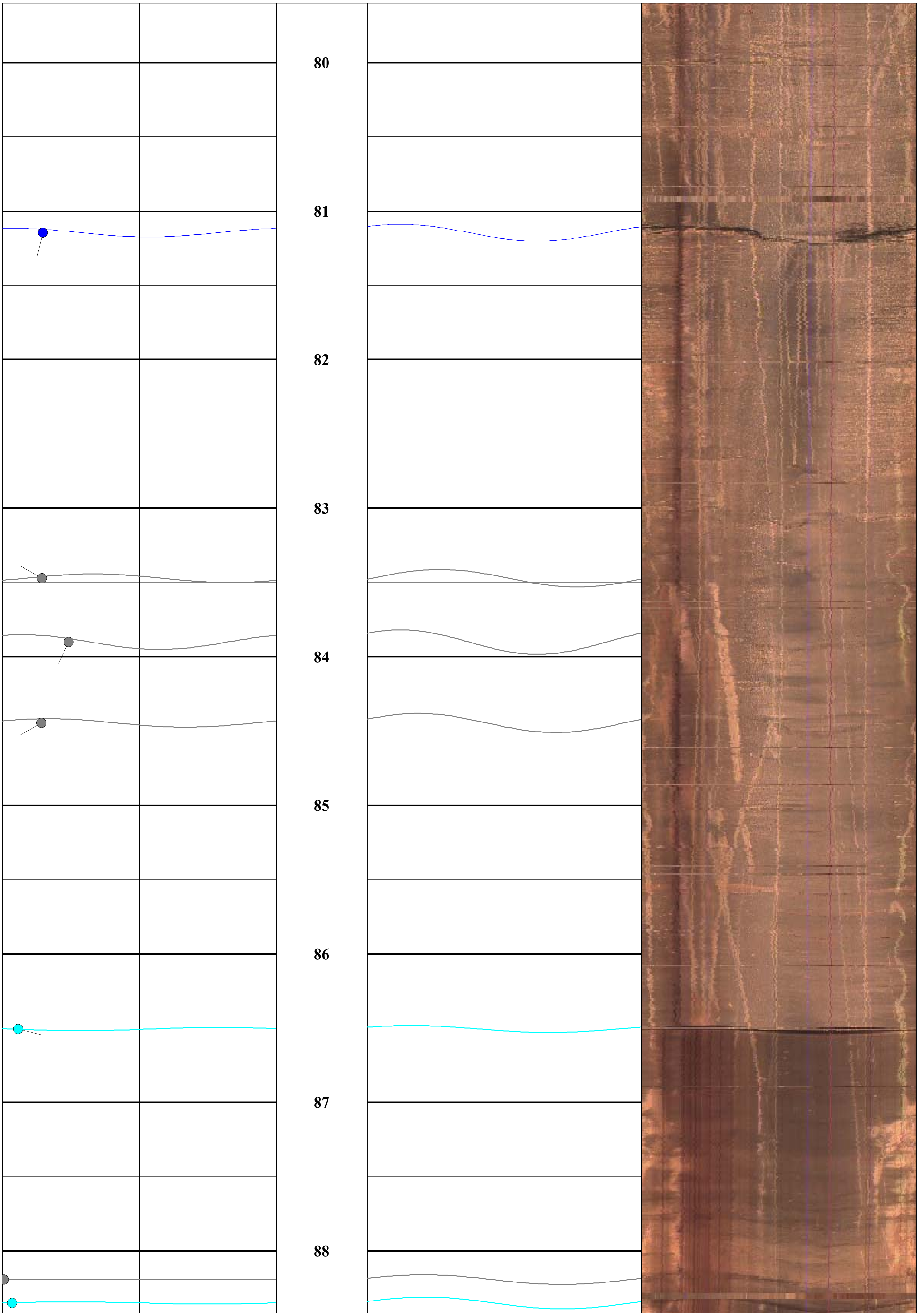
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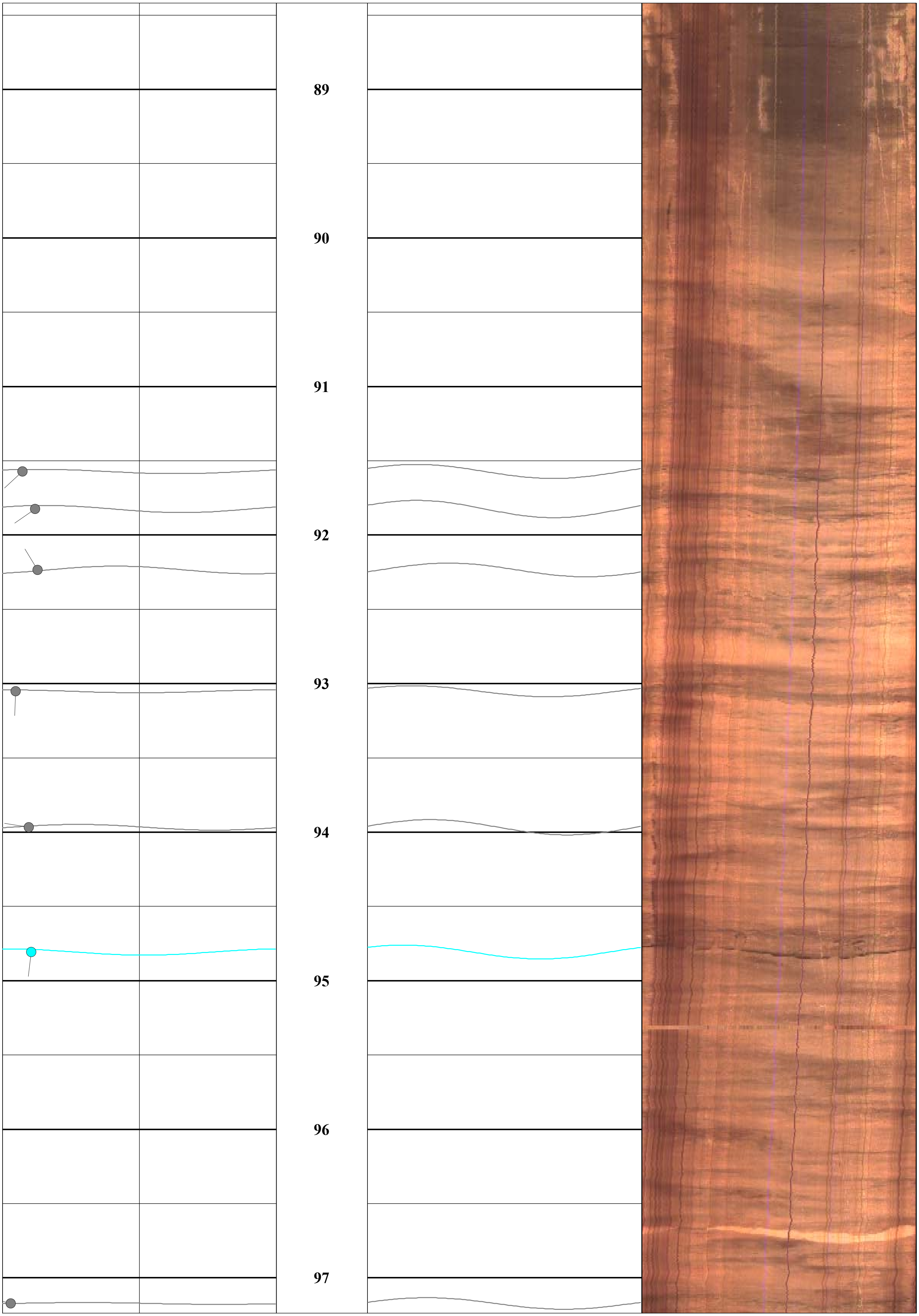
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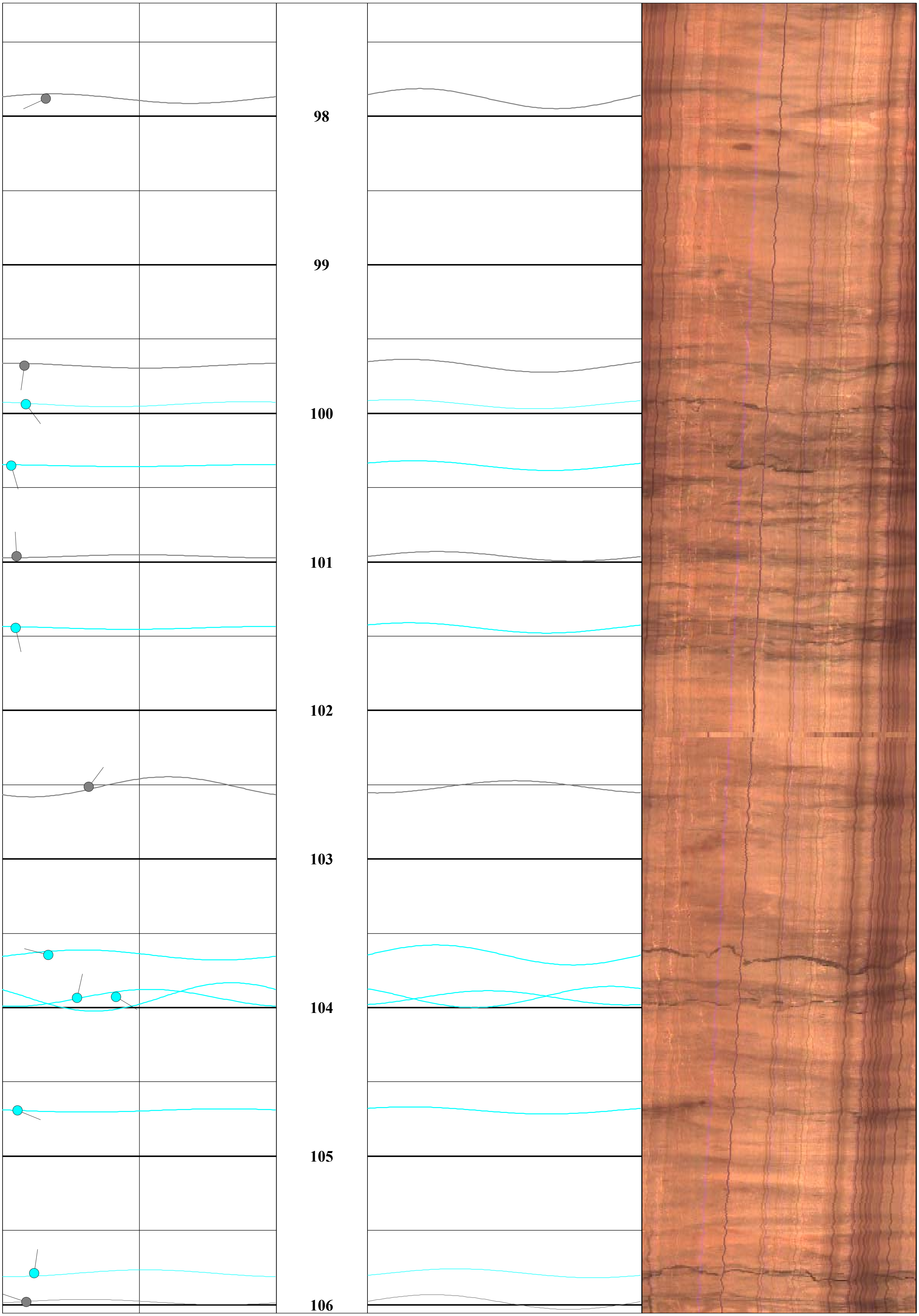
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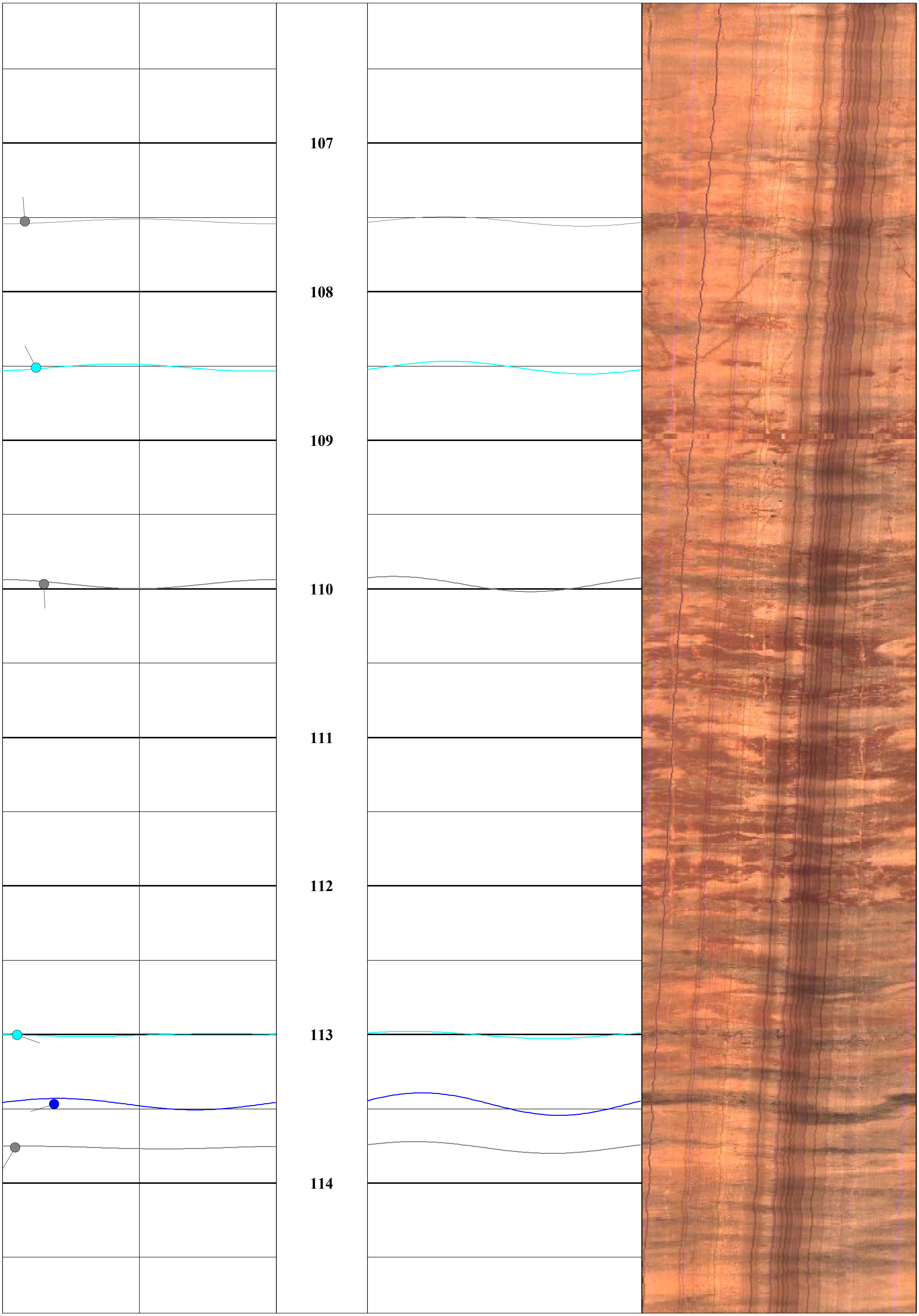
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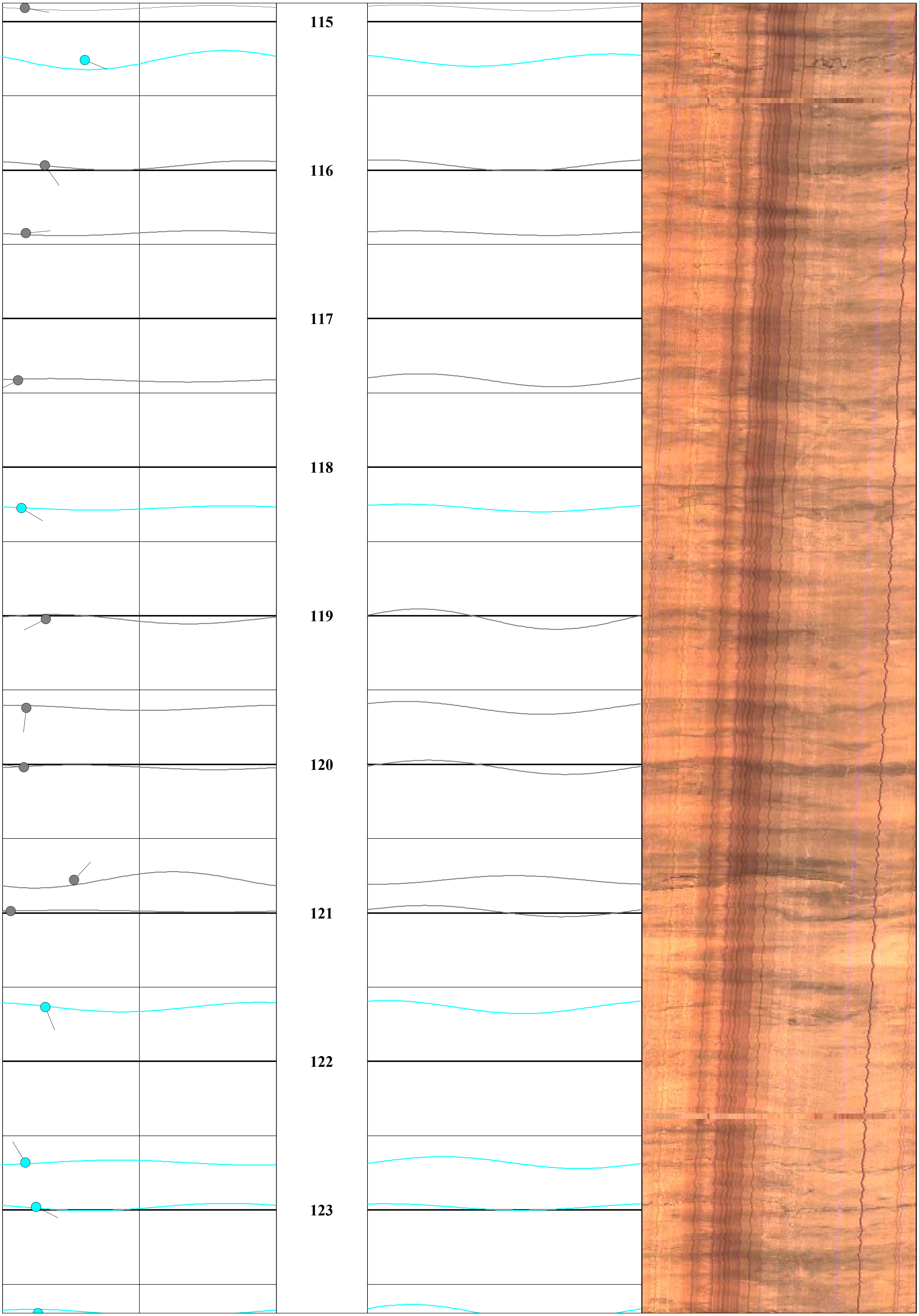
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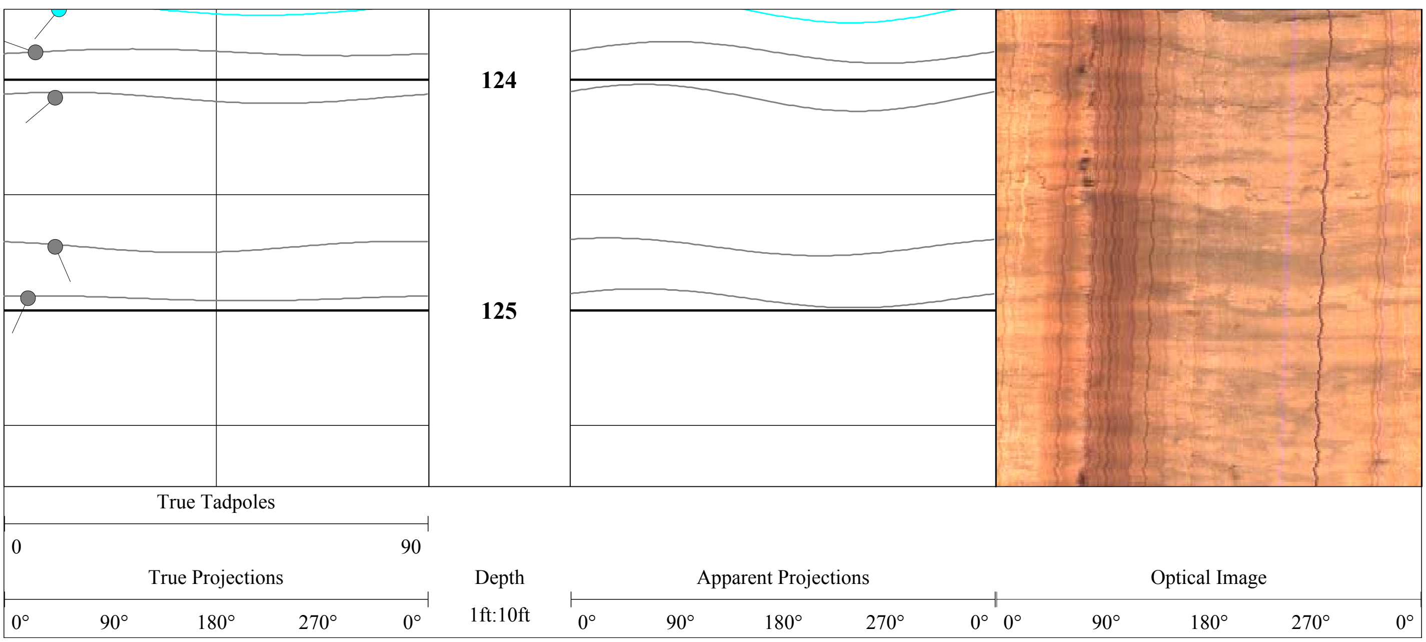

124
125
True Tadpoles
0
90
True Projections
0°
90°
180°
270°
0°
Depth
1ft:10ft
Apparent Projections
0°
90°
180°
270°
0°
Optical Image
0°
90°
180°
270°
0°

APPENDIX B

ORIENTATION SUMMARY TABLES

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B5
F.M.S.M.
18 December 2005

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
1	4.22	13.9	261	79	1
2	4.47	14.7	315	75	2
3	4.50	14.8	248	67	1
4	4.59	15.1	228	51	1
5	4.67	15.3	270	83	0
6	4.93	16.2	283	79	3
7	5.00	16.4	211	29	2
8	5.25	17.2	253	80	1
9	5.44	17.8	315	30	1
10	5.58	18.3	314	30	0
11	5.65	18.5	353	44	1
12	5.76	18.9	312	31	0
13	5.91	19.4	183	16	0
14	5.99	19.6	235	9	0
15	6.27	20.6	238	18	0
16	6.39	21.0	281	8	0
17	6.55	21.5	274	18	0
18	6.64	21.8	293	17	0
19	6.73	22.1	296	13	3
20	6.82	22.4	320	3	1
21	6.88	22.6	19	27	0
22	6.96	22.8	281	10	1
23	7.09	23.3	305	9	0
24	7.41	24.3	161	24	2
25	7.44	24.4	50	38	2
26	7.51	24.6	108	14	3
27	7.59	24.9	220	10	0
28	7.78	25.5	153	85	1
29	7.89	25.9	283	19	0
30	8.10	26.6	266	4	1
31	8.21	27.0	287	6	0
32	8.35	27.4	348	2	1
33	8.41	27.6	216	3	0
34	8.46	27.8	195	8	0
35	8.52	28.0	251	4	0
36	8.67	28.5	113	13	0
37	8.72	28.6	351	6	1
38	8.82	29.0	299	14	0
39	8.89	29.2	264	7	0
40	9.08	29.8	245	16	1
41	9.31	30.6	304	2	0
42	9.40	30.9	304	8	1
43	9.47	31.1	188	4	0
44	9.60	31.5	299	3	1

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B5
F.M.S.M.
18 December 2005

45	9.69	31.8	218	11	0
46	9.77	32.1	324	13	1
47	9.83	32.3	286	13	2
48	9.89	32.5	41	83	2
49	9.99	32.8	326	23	1
50	10.12	33.2	311	33	0
51	10.50	34.5	358	20	1
52	10.56	34.7	119	36	0
53	10.60	34.8	29	22	0
54	10.82	35.5	352	11	1
55	10.90	35.8	336	12	1
56	11.03	36.2	296	10	1
57	11.10	36.4	257	18	1
58	11.18	36.7	312	17	1
59	11.36	37.3	225	28	2
60	11.61	38.1	239	25	1
61	11.76	38.6	348	7	2
62	11.84	38.9	279	42	1
63	11.89	39.0	57	13	2
64	12.08	39.6	232	11	1
65	12.14	39.8	232	7	1
66	12.22	40.1	224	15	1
67	12.30	40.4	96	1	1
68	12.48	41.0	295	29	1
69	12.55	41.2	266	16	3
70	12.67	41.6	49	12	3
71	12.87	42.2	176	13	1
72	12.92	42.4	328	17	1
73	12.97	42.6	318	30	1
74	13.01	42.7	288	19	1
75	13.34	43.8	347	8	0
76	13.54	44.4	32	18	0
77	13.73	45.0	128	2	1
78	13.80	45.3	351	13	1
79	14.70	48.2	83	11	1
80	14.72	48.3	134	17	1
81	14.85	48.7	292	6	1
82	14.91	48.9	335	6	2
83	15.64	51.3	137	89	1
84	15.69	51.5	344	14	1
85	16.01	52.5	41	48	0
86	16.04	52.6	125	14	1
87	16.15	53.0	124	7	1
88	16.23	53.3	331	6	1
89	16.37	53.7	311	7	0
90	16.48	54.1	167	13	1
91	16.52	54.2	59	47	1

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B5
F.M.S.M.
18 December 2005

92	16.80	55.1	64	13	1
93	16.90	55.4	26	6	1
94	16.98	55.7	81	53	1
95	17.10	56.1	161	43	1
96	17.14	56.2	33	90	2
97	17.43	57.2	296	11	1
98	17.44	57.2	80	58	1
99	17.97	59.0	130	23	1
100	18.18	59.7	47	85	2
101	18.67	61.2	3	9	0
102	18.87	61.9	198	8	1
103	18.97	62.2	320	12	0
104	19.30	63.3	306	7	1
105	19.35	63.5	92	13	1
106	19.44	63.8	294	13	1
107	19.53	64.1	111	49	1
108	19.55	64.2	9	19	1
109	19.97	65.5	336	2	1
110	20.14	66.1	46	4	0
111	20.24	66.4	126	33	1
112	20.25	66.5	182	7	1
113	20.54	67.4	134	40	0
114	20.60	67.6	128	53	1
115	20.71	68.0	8	9	1
116	21.04	69.0	314	21	1
117	21.15	69.4	275	5	1
118	21.27	69.8	335	2	2
119	21.33	70.0	339	11	1
120	21.72	71.3	279	21	2
121	21.73	71.3	61	47	1
122	22.07	72.4	43	5	1
123	22.31	73.2	248	14	1
124	22.40	73.5	228	13	1
125	22.63	74.3	236	13	0
126	22.85	75.0	4	14	1
127	22.85	75.0	72	67	1
128	23.44	76.9	126	86	1
129	23.59	77.4	271	13	0
130	23.83	78.2	194	7	0
131	24.06	79.0	310	12	1
132	24.20	79.4	286	10	0
133	24.38	80.0	127	12	1
134	24.55	80.6	137	7	0
135	24.69	81.0	0	22	1
136	24.77	81.3	87	6	1
137	24.94	81.8	89	7	0
138	25.16	82.5	335	12	0

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B5
F.M.S.M.
18 December 2005

139	25.28	82.9	325	16	1
140	25.67	84.2	308	10	1
141	26.08	85.6	250	6	0
142	26.16	85.8	48	15	1
143	26.38	86.6	310	12	1
144	26.50	86.9	50	2	1
145	26.85	88.1	18	5	1
146	27.00	88.6	231	2	0
147	27.23	89.3	323	21	1
148	27.38	89.8	332	24	1
149	27.60	90.5	343	11	0
150	27.81	91.2	319	7	0
151	28.08	92.1	339	13	1
152	28.19	92.5	10	6	1
153	28.46	93.4	115	24	0
154	28.74	94.3	3	12	2
155	28.88	94.8	243	5	0
156	28.96	95.0	34	5	1
157	29.07	95.4	281	4	0
158	29.56	97.0	357	8	0
159	29.62	97.2	4	7	1
160	29.88	98.0	247	3	1
161	30.21	99.1	351	12	0
162	30.43	99.8	134	11	1
163	30.55	100.2	2	14	0
164	30.65	100.6	20	14	0
165	30.80	101.1	253	5	2
166	30.89	101.4	310	6	1
167	31.52	103.4	42	13	0
168	31.64	103.8	15	5	2
169	31.72	104.1	5	14	1
170	31.92	104.7	236	12	1
171	31.95	104.8	317	2	1
172	32.13	105.4	305	6	1
173	32.25	105.8	6	4	0
174	32.30	106.0	79	4	1
175	32.42	106.4	188	5	0
176	32.50	106.6	330	13	0
177	32.57	106.9	15	6	1
178	32.82	107.7	337	6	1
179	33.13	108.7	255	10	2
180	33.27	109.2	285	3	1
181	33.43	109.7	324	6	0
182	33.64	110.4	302	14	0
183	33.78	110.8	36	10	0
184	33.94	111.4	30	16	0
185	34.07	111.8	267	9	0

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B5
F.M.S.M.
18 December 2005

186	34.36	112.7	343	10	1
187	34.84	114.3	301	13	0

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B6
F.M.S.M.
18 December 2005

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
1	4.40	14.5	309	10	2
2	4.55	14.9	275	5	1
3	4.67	15.3	290	12	1
4	4.80	15.8	330	6	3
5	4.85	15.9	129	4	1
6	4.88	16.0	34	6	1
7	4.93	16.2	310	28	2
8	4.97	16.3	104	4	3
9	4.99	16.4	277	12	1
10	5.14	16.9	197	5	0
11	5.68	18.6	211	9	1
12	5.77	18.9	310	7	0
13	5.77	18.9	297	3	0
14	5.93	19.5	71	9	1
15	6.25	20.5	34	34	1
16	6.77	22.2	92	26	1
17	7.08	23.2	37	15	1
18	7.19	23.6	52	16	1
19	7.42	24.4	234	17	1
20	7.53	24.7	226	7	1
21	7.60	24.9	48	14	1
22	7.73	25.4	351	12	1
23	8.09	26.6	265	7	3
24	8.45	27.7	346	23	1
25	8.49	27.9	342	13	3
26	8.65	28.4	318	9	2
27	8.71	28.6	184	12	1
28	8.72	28.6	303	17	1
29	8.80	28.9	285	12	2
30	8.94	29.3	282	14	1
31	9.02	29.6	357	3	1
32	9.95	32.7	331	6	1
33	10.59	34.7	216	3	1
34	10.66	35.0	273	3	1
35	11.59	38.0	293	5	0
36	12.05	39.5	319	4	0
37	12.31	40.4	265	15	0
38	12.57	41.2	223	14	1
39	13.17	43.2	57	8	0
40	13.83	45.4	200	72	2
41	14.19	46.6	181	77	1
42	14.36	47.1	216	42	1
43	15.01	49.3	198	84	3
44	16.54	54.3	229	12	1

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B6
F.M.S.M.
18 December 2005

45	17.08	56.1	99	8	1
46	17.44	57.2	352	16	1
47	17.98	59.0	158	17	1
48	18.40	60.4	185	55	1
49	18.57	60.9	180	8	1
50	19.11	62.7	138	26	1
51	19.35	63.5	195	6	1
52	19.54	64.1	39	24	1
53	20.14	66.1	228	3	1
54	20.26	66.5	302	5	1
55	20.58	67.5	232	11	1
56	20.74	68.0	300	10	0
57	20.84	68.4	256	9	0
58	20.94	68.7	311	9	1
59	21.26	69.8	195	3	1
60	21.38	70.1	318	9	1
61	21.82	71.6	202	40	1
62	21.93	72.0	311	1	0
63	22.05	72.4	163	48	1
64	22.37	73.4	178	6	1
65	22.38	73.4	182	2	1
66	22.45	73.7	250	21	1
67	22.47	73.7	190	22	2
68	22.50	73.8	95	27	1
69	22.84	74.9	168	4	1

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B8
F.M.S.M.
19 December 2005

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
1	2.33	7.7	29	10	1
2	2.81	9.2	95	2	5
3	3.15	10.3	84	16	0
4	3.29	10.8	123	1	2
5	3.39	11.1	96	24	1
6	3.92	12.9	34	7	1
7	4.23	13.9	6	5	1
8	4.47	14.7	201	9	1
9	4.52	14.8	205	12	1
10	4.64	15.2	223	1	1
11	4.65	15.3	9	13	1
12	4.74	15.6	142	1	1
13	4.93	16.2	95	5	1
14	5.13	16.8	216	4	1
15	5.24	17.2	222	9	1
16	5.49	18.0	70	5	1
17	5.58	18.3	182	4	1
18	5.70	18.7	175	2	0
19	5.84	19.2	293	9	0
20	5.90	19.4	237	11	0
21	5.98	19.6	241	6	0
22	6.23	20.4	160	5	1
23	6.39	21.0	60	2	1
24	6.54	21.5	349	10	1
25	6.57	21.6	207	11	1
26	6.66	21.9	256	15	1
27	6.85	22.5	307	16	2
28	7.09	23.3	164	9	0
29	7.48	24.5	154	10	0
30	7.88	25.9	146	5	0
31	7.97	26.2	83	6	0
32	8.14	26.7	75	28	1
33	8.17	26.8	175	9	2
34	8.23	27.0	62	5	1
35	8.25	27.1	81	16	1
36	8.44	27.7	0	7	1
37	8.86	29.1	295	16	1
38	9.02	29.6	234	7	1
39	9.08	29.8	263	11	1
40	9.21	30.2	334	7	1
41	9.27	30.4	35	16	1
42	9.33	30.6	264	7	1
43	9.37	30.8	95	5	1
44	9.56	31.4	23	3	1

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B8
F.M.S.M.
19 December 2005

45	9.73	31.9	178	10	1
46	9.77	32.1	192	7	1
47	9.82	32.2	185	4	1
48	9.85	32.3	193	7	0
49	9.94	32.6	251	16	0
50	9.98	32.7	26	3	1
51	10.06	33.0	60	4	1
52	10.14	33.3	197	6	0
53	10.29	33.8	190	12	1
54	10.41	34.2	13	6	1
55	10.46	34.3	312	11	0
56	10.55	34.6	357	7	0
57	10.60	34.8	169	21	1
58	10.66	35.0	159	17	1
59	10.88	35.7	130	12	1
60	10.96	36.0	81	10	1
61	11.12	36.5	96	11	1
62	11.31	37.1	275	3	1
63	11.40	37.4	22	5	1
64	11.69	38.3	76	14	1
65	11.71	38.4	311	8	2
66	11.77	38.6	168	15	1
67	11.78	38.7	108	5	1
68	11.81	38.7	315	12	1
69	11.94	39.2	57	13	2
70	11.99	39.3	23	4	1
71	12.14	39.8	190	10	1
72	12.37	40.6	332	13	1
73	12.56	41.2	60	5	1
74	12.68	41.6	199	9	1
75	12.84	42.1	17	21	1
76	13.60	44.6	42	7	1
77	13.80	45.3	269	20	1
78	13.83	45.4	254	9	2
79	14.76	48.4	17	5	0
80	14.94	49.0	272	11	0
81	14.98	49.2	55	4	0
82	15.02	49.3	13	11	0
83	15.15	49.7	121	12	0
84	15.22	49.9	78	13	0
85	15.26	50.1	71	7	1
86	15.38	50.5	56	41	1
87	15.55	51.0	54	12	0
88	15.69	51.5	59	22	1
89	15.92	52.2	120	20	1
90	16.04	52.6	176	14	1
91	16.10	52.8	37	15	0

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B8
F.M.S.M.
19 December 2005

92	16.22	53.2	180	29	0
93	16.40	53.8	167	5	1
94	16.79	55.1	157	14	0
95	17.03	55.9	313	7	0
96	17.15	56.3	17	3	1
97	17.27	56.7	278	4	1
98	17.34	56.9	177	5	1
99	17.46	57.3	301	16	1
100	17.52	57.5	160	10	1
101	17.59	57.7	184	2	1
102	17.75	58.2	123	5	1
103	17.78	58.3	208	7	1
104	17.80	58.4	156	5	1
105	18.03	59.2	237	16	0
106	18.49	60.7	25	1	1
107	18.54	60.8	210	25	2
108	18.61	61.1	194	4	0
109	18.89	62.0	210	11	1
110	19.09	62.6	299	18	0
111	19.25	63.1	0	5	0
112	19.25	63.1	356	4	0
113	19.40	63.7	28	11	1
114	19.97	65.5	102	11	0
115	20.14	66.1	188	18	0
116	20.16	66.2	241	9	1
117	20.22	66.3	339	7	0
118	20.65	67.8	14	7	0
119	20.95	68.7	349	11	0
120	21.01	68.9	270	31	0
121	21.09	69.2	186	30	0
122	21.22	69.6	79	3	0
123	21.42	70.3	230	3	1
124	21.63	71.0	39	9	0
125	21.73	71.3	261	14	0
126	21.79	71.5	95	26	1
127	21.82	71.6	172	30	1
128	21.86	71.7	147	41	1
129	22.25	73.0	22	6	0
130	22.30	73.2	25	1	0
131	22.49	73.8	168	5	0
132	22.63	74.3	177	7	1
133	22.69	74.4	178	6	1
134	23.32	76.5	341	9	0
135	23.48	77.0	62	7	2
136	23.51	77.1	323	5	0
137	23.58	77.4	175	3	0
138	23.66	77.6	188	14	0

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B8
F.M.S.M.
19 December 2005

139	23.87	78.3	136	9	1
140	23.99	78.7	302	14	1
141	24.08	79.0	269	23	0
142	24.32	79.8	0	10	1
143	24.35	79.9	355	11	0
144	24.41	80.1	183	4	1
145	24.50	80.4	73	5	0

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B10
F.M.S.M.
19 December 2005

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
1	1.74	5.7	14	40	3
2	2.62	8.6	303	13	0
3	2.84	9.3	336	7	0
4	3.13	10.3	249	11	0
5	3.23	10.6	36	24	5
6	3.47	11.4	10	25	0
7	3.56	11.7	17	20	0
8	3.60	11.8	25	13	0
9	3.67	12.0	133	4	1
10	3.83	12.6	124	44	0
11	3.97	13.0	6	37	0
12	3.97	13.0	199	24	1
13	4.05	13.3	115	11	1
14	4.15	13.6	135	45	0
15	4.32	14.2	24	21	0
16	4.58	15.0	142	3	0
17	4.76	15.6	55	5	0
18	5.03	16.5	286	2	1
19	5.20	17.1	61	10	1
20	5.27	17.3	3	8	2
21	5.35	17.6	9	7	1
22	5.63	18.5	332	13	0
23	5.74	18.8	199	24	0
24	6.02	19.8	143	6	1
25	6.06	19.9	358	14	1
26	6.11	20.0	147	12	1
27	6.18	20.3	249	11	0
28	6.21	20.4	198	9	1
29	6.42	21.1	89	18	1
30	6.52	21.4	193	5	1
31	6.60	21.6	180	2	1
32	6.98	22.9	347	10	0
33	7.04	23.1	12	21	1
34	7.18	23.6	205	38	0
35	7.32	24.0	260	6	0
36	7.40	24.3	324	13	1
37	8.12	26.6	200	5	1
38	8.68	28.5	280	2	0
39	8.73	28.7	26	5	0
40	8.77	28.8	329	4	0
41	9.01	29.6	340	8	0
42	9.48	31.1	162	5	0
43	9.59	31.5	33	19	0
44	9.63	31.6	29	7	0

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B10
F.M.S.M.
19 December 2005

45	9.75	32.0	312	3	1
46	9.85	32.3	195	3	1
47	10.01	32.8	47	4	0
48	10.28	33.7	273	4	0
49	10.36	34.0	5	9	0
50	10.58	34.7	332	18	1
51	10.72	35.2	334	15	1
52	10.92	35.8	148	7	0
53	10.98	36.0	6	9	0
54	11.03	36.2	195	9	1
55	11.13	36.5	158	6	0
56	11.20	36.7	320	11	0
57	11.30	37.1	254	10	1
58	11.43	37.5	169	18	1
59	11.55	37.9	246	14	0
60	12.01	39.4	32	7	1
61	12.03	39.5	32	7	1
62	12.05	39.5	106	3	1
63	12.26	40.2	46	5	0
64	12.44	40.8	311	18	2
65	12.80	42.0	234	3	0
66	13.34	43.8	101	13	0
67	13.39	43.9	126	20	0
68	13.56	44.5	323	5	1
69	13.62	44.7	47	15	1
70	13.65	44.8	9	8	1
71	13.66	44.8	108	8	1
72	13.70	45.0	325	14	1
73	13.73	45.1	103	20	1
74	13.78	45.2	153	3	1
75	13.85	45.4	281	7	0
76	14.14	46.4	338	13	0
77	14.16	46.5	84	12	0
78	14.42	47.3	191	17	0
79	14.53	47.7	325	19	1
80	14.79	48.5	237	16	1
81	14.85	48.7	92	5	1
82	15.07	49.4	350	9	0
83	15.23	50.0	16	1	0
84	15.39	50.5	7	11	1
85	15.58	51.1	155	11	2
86	15.76	51.7	17	10	0
87	15.83	51.9	115	11	1
88	15.87	52.1	155	11	1
89	15.94	52.3	178	4	0
90	16.30	53.5	240	16	1
91	16.36	53.7	228	19	1

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B10
F.M.S.M.
19 December 2005

92	16.41	53.8	231	12	1
93	16.54	54.3	267	10	1
94	16.70	54.8	212	15	1
95	17.24	56.6	359	9	2
96	17.26	56.6	332	11	2
97	17.26	56.6	165	16	2
98	17.32	56.8	44	15	1
99	17.33	56.9	211	8	1
100	17.81	58.4	86	5	0
101	18.13	59.5	286	4	1
102	18.29	60.0	312	5	0
103	18.37	60.3	339	7	1
104	18.42	60.4	343	5	1
105	18.70	61.3	103	17	0
106	19.15	62.8	282	19	1
107	19.21	63.0	185	4	1
108	19.36	63.5	358	4	0
109	19.67	64.6	160	5	0
110	19.74	64.8	127	4	0
111	20.17	66.2	15	1	0
112	20.28	66.5	351	8	0
113	20.35	66.8	157	12	0
114	20.45	67.1	147	10	0
115	20.51	67.3	210	7	0
116	20.62	67.7	190	5	0
117	20.75	68.1	75	12	1
118	20.85	68.4	139	10	0
119	21.18	69.5	358	11	2
120	21.62	70.9	194	5	0
121	21.83	71.6	178	14	0
122	21.88	71.8	155	5	0
123	22.05	72.3	144	6	0
124	22.50	73.8	8	6	0
125	22.58	74.1	144	10	1
126	22.64	74.3	201	12	2
127	22.85	75.0	174	15	0
128	22.97	75.4	96	13	0
129	23.12	75.8	24	9	0
130	23.16	76.0	156	13	0
131	23.81	78.1	82	4	1
132	23.89	78.4	152	13	1
133	24.07	79.0	310	5	1
134	24.40	80.1	347	18	2
135	24.70	81.1	248	22	1
136	24.89	81.7	272	20	0
137	25.22	82.7	314	7	0
138	25.35	83.2	296	4	0

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B10
F.M.S.M.
19 December 2005

139	25.40	83.3	215	10	0
140	25.59	84.0	81	9	0
141	25.89	84.9	353	10	0
142	26.37	86.5	346	10	1
143	26.51	87.0	331	13	0
144	26.58	87.2	337	15	0
145	26.65	87.4	211	2	0
146	26.72	87.7	13	8	1
147	26.80	87.9	187	17	1
148	26.90	88.3	244	4	0
149	27.18	89.2	148	6	1
150	27.21	89.3	351	17	1
151	27.31	89.6	287	7	1
152	27.78	91.2	357	11	0
153	28.09	92.2	55	5	1
154	28.41	93.2	357	7	0
155	28.54	93.6	310	1	0
156	28.89	94.8	23	6	1
157	28.96	95.0	7	1	0
158	29.14	95.6	275	15	0

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B11
F.M.S.M.
19 December 2005

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
1	5.65	18.5	203	31	1
2	5.82	19.1	60	11	1
3	5.95	19.5	124	15	1
4	6.35	20.8	239	18	1
5	6.52	21.4	135	21	1
6	6.86	22.5	93	4	2
7	6.89	22.6	169	3	3
8	6.94	22.8	163	14	5
9	7.64	25.1	197	4	1
10	8.03	26.3	337	23	1
11	8.19	26.9	347	12	1
12	8.39	27.5	301	5	1
13	8.46	27.7	21	6	1
14	8.63	28.3	269	8	1
15	8.66	28.4	286	15	1
16	8.72	28.6	255	25	0
17	9.42	30.9	207	6	0
18	10.00	32.8	221	6	0
19	10.15	33.3	184	5	1
20	10.53	34.6	293	17	0
21	10.74	35.3	230	14	1
22	11.41	37.4	22	13	0
23	11.70	38.4	109	47	1
24	11.72	38.4	354	40	1
25	11.96	39.2	8	18	1
26	12.32	40.4	72	39	1
27	12.47	40.9	30	31	1
28	12.58	41.3	138	18	1
29	12.86	42.2	115	7	1
30	12.94	42.4	44	38	1
31	13.05	42.8	315	30	1
32	13.12	43.1	331	24	1
33	13.23	43.4	292	5	1
34	13.41	44.0	155	21	1
35	13.48	44.2	247	26	1
36	13.56	44.5	182	11	1
37	13.85	45.5	289	13	1
38	13.93	45.7	208	12	1
39	14.11	46.3	186	18	1
40	14.25	46.7	200	22	1
41	14.43	47.3	53	17	1
42	14.52	47.6	144	34	1
43	14.62	48.0	340	19	1
44	14.68	48.2	80	8	1

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B11
F.M.S.M.
19 December 2005

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
45	14.76	48.4	359	10	1
46	14.79	48.5	316	3	1
47	14.85	48.7	272	4	1
48	15.23	50.0	104	6	1
49	15.47	50.8	250	9	1
50	15.81	51.9	198	10	1
51	15.90	52.2	285	24	1
52	15.98	52.4	323	21	1
53	16.10	52.8	206	11	1
54	16.14	53.0	217	6	1
55	16.26	53.3	320	15	1
56	16.79	55.1	331	15	1
57	16.80	55.1	117	24	1
58	16.91	55.5	241	24	1
59	16.99	55.8	113	11	0
60	17.21	56.5	299	1	1
61	17.30	56.8	68	8	0
62	17.41	57.1	266	7	0
63	17.61	57.8	197	20	0
64	17.66	58.0	239	7	0
65	17.73	58.2	340	6	0
66	18.00	59.1	208	5	1
67	18.25	59.9	133	3	1
68	18.49	60.7	240	9	0
69	18.70	61.4	31	11	0
70	18.86	61.9	330	9	0
71	19.11	62.7	72	7	2
72	19.18	62.9	116	13	2
73	20.73	68.0	293	20	0
74	20.80	68.2	198	24	0
75	20.97	68.8	173	33	1
76	21.10	69.2	263	40	1
77	21.27	69.8	290	29	3
78	21.42	70.3	275	8	1
79	21.88	71.8	133	14	0
80	22.11	72.5	350	19	1
81	22.25	73.0	230	6	1
82	22.63	74.2	259	5	0
83	22.72	74.6	187	12	1
84	22.99	75.4	220	17	2
85	23.06	75.7	152	14	1
86	23.42	76.8	216	8	0
87	23.48	77.0	182	12	0
88	24.73	81.2	193	13	2

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B11
F.M.S.M.
19 December 2005

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
89	25.44	83.5	300	13	0
90	25.57	83.9	206	22	0
91	25.74	84.5	240	13	0
92	26.37	86.5	103	5	1
93	26.88	88.2	328	1	0
94	26.93	88.4	270	3	1
95	27.91	91.6	228	7	0
96	27.99	91.8	235	11	0
97	28.11	92.2	330	12	0
98	28.36	93.1	181	4	0
99	28.64	94.0	279	9	0
100	28.90	94.8	186	10	1
101	29.62	97.2	285	3	0
102	29.83	97.9	246	14	0
103	30.38	99.7	187	7	0
104	30.46	99.9	143	8	1
105	30.59	100.4	164	3	1
106	30.77	101.0	357	5	0
107	30.92	101.4	167	4	1
108	31.25	102.5	37	28	0
109	31.59	103.7	285	15	1
110	31.68	103.9	121	37	1
111	31.68	103.9	13	25	1
112	31.91	104.7	111	5	1
113	32.24	105.8	8	10	1
114	32.30	106.0	288	8	0
115	32.78	107.5	357	7	0
116	33.07	108.5	333	11	1
117	33.52	110.0	178	14	0
118	34.44	113.0	109	5	1
119	34.59	113.5	253	17	2
120	34.67	113.8	210	4	0
121	35.02	114.9	100	7	0
122	35.13	115.3	112	27	1
123	35.35	116.0	145	14	0
124	35.49	116.4	84	8	0
125	35.79	117.4	244	5	0
126	36.05	118.3	121	6	1
127	36.28	119.0	244	14	0
128	36.46	119.6	187	8	0
129	36.58	120.0	277	7	0
130	36.81	120.8	43	24	0
131	36.88	121.0	273	3	0
132	37.08	121.6	158	14	1

All directions are with respect to magnetic north.

Orientation Summary Table
Image Features
East End Approach, Phase 2, Well: B11
F.M.S.M.
19 December 2005

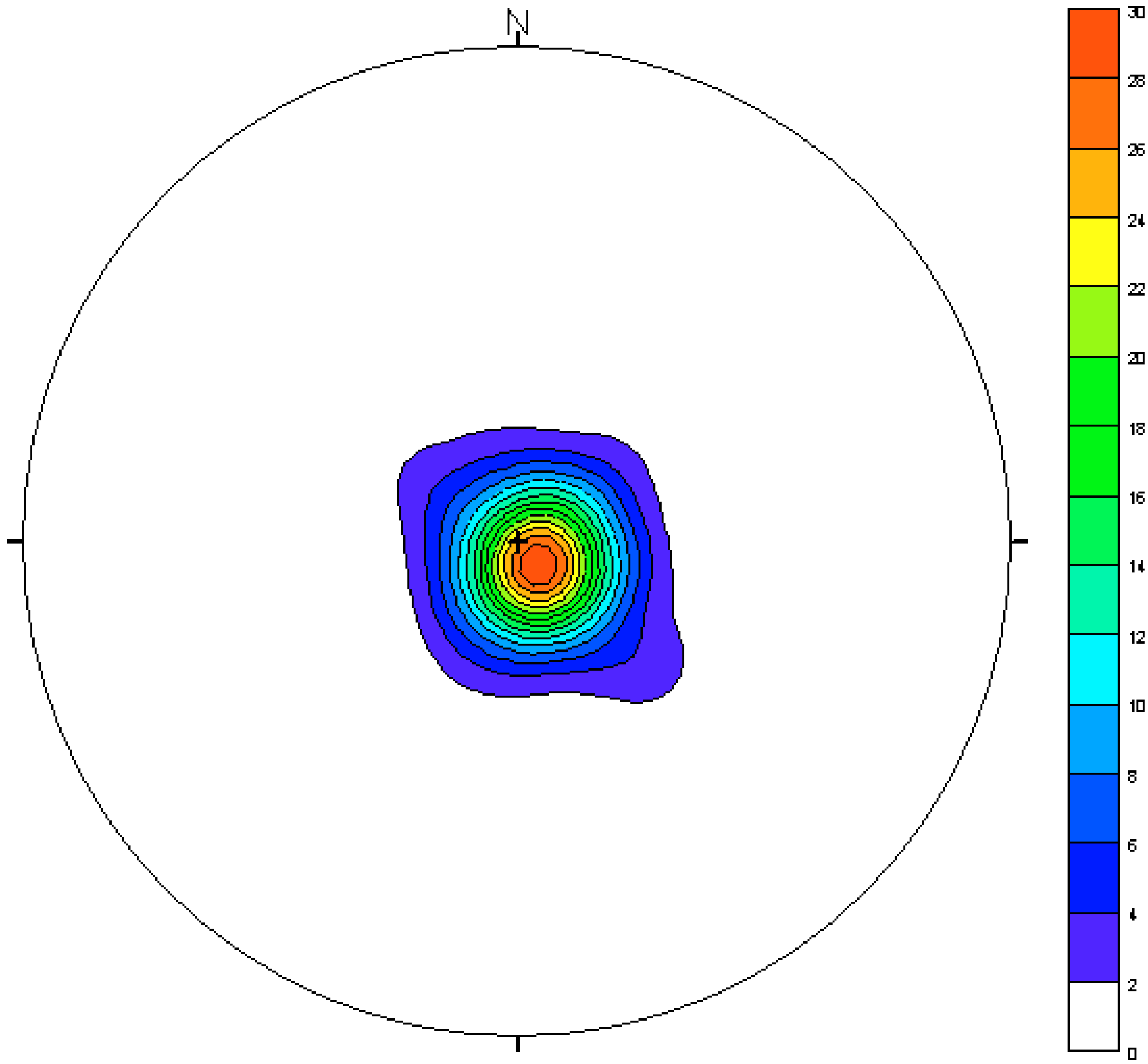
Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
133	37.39	122.7	330	8	1
134	37.48	123.0	115	11	1
135	37.70	123.7	220	12	1
136	37.76	123.9	289	7	0
137	37.82	124.1	230	11	0
138	38.02	124.7	157	11	0
139	38.08	125.0	204	5	0

All directions are with respect to magnetic north.

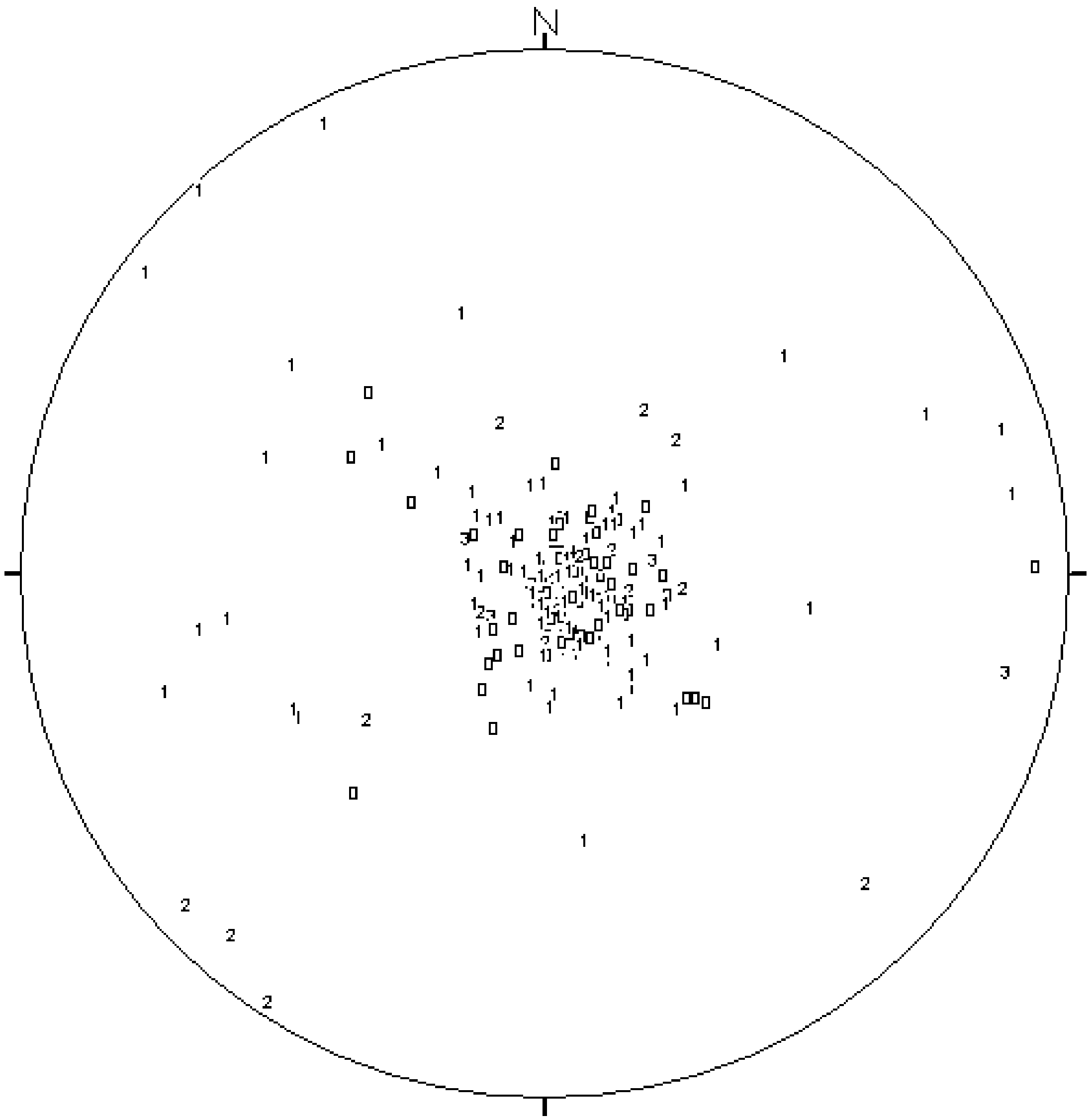
APPENDIX C

STEREONET AND ROSE DIAGRAMS

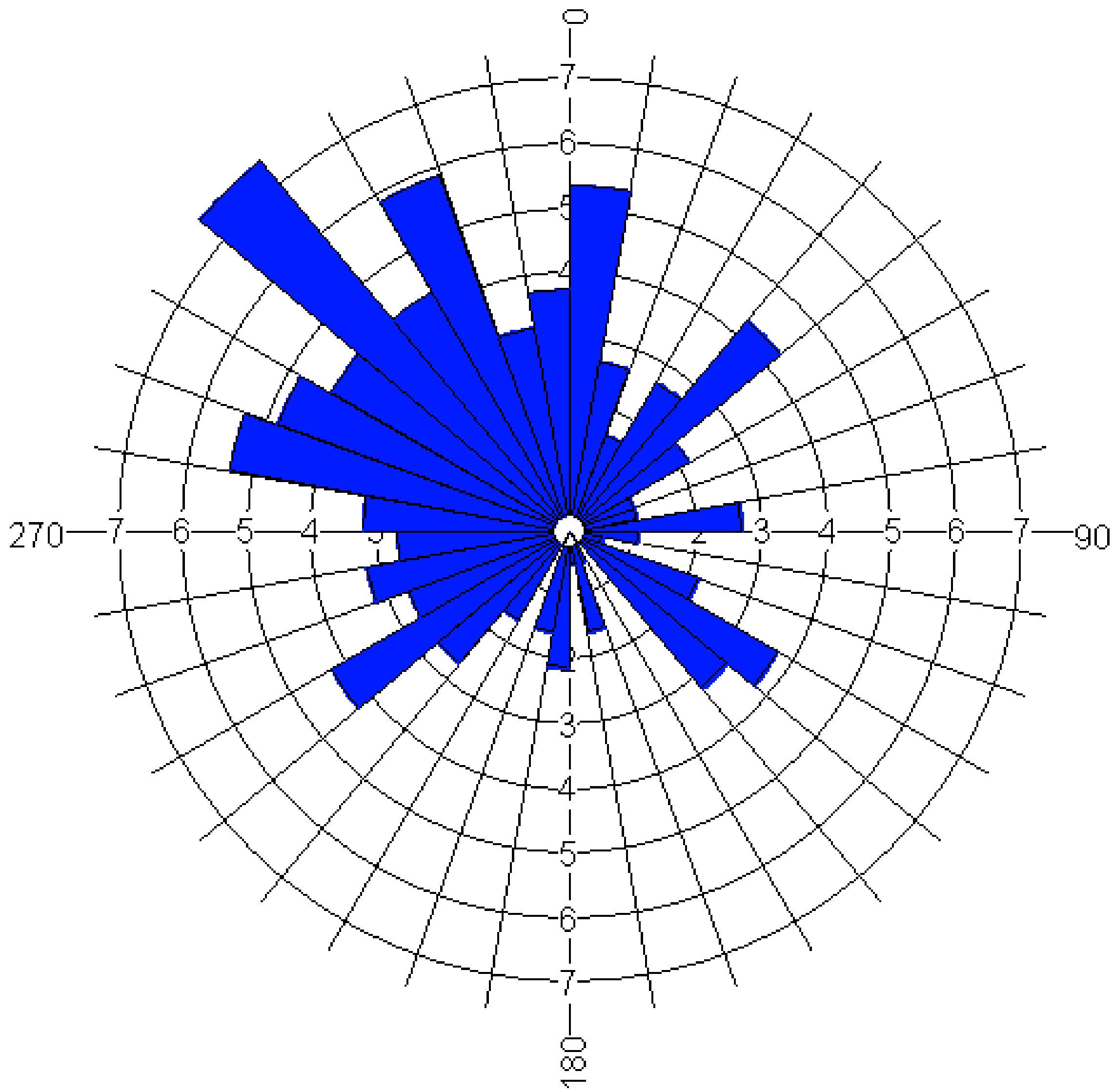
Stereonet Diagram – Schmidt Projection
Optical Features
East End Approach, Phase 2, Well: B5
F.M.S.M.
18 December 2005



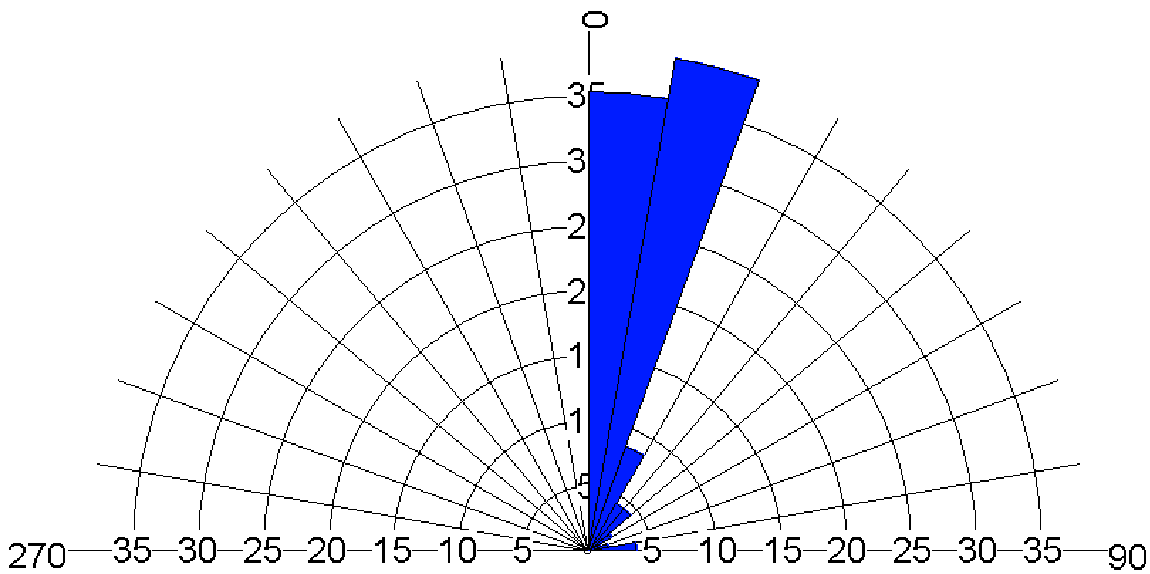
Stereonet Diagram – Schmidt Projection
Optical Features
East End Approach, Phase 2, Well: B5
F.M.S.M.
18 December 2005



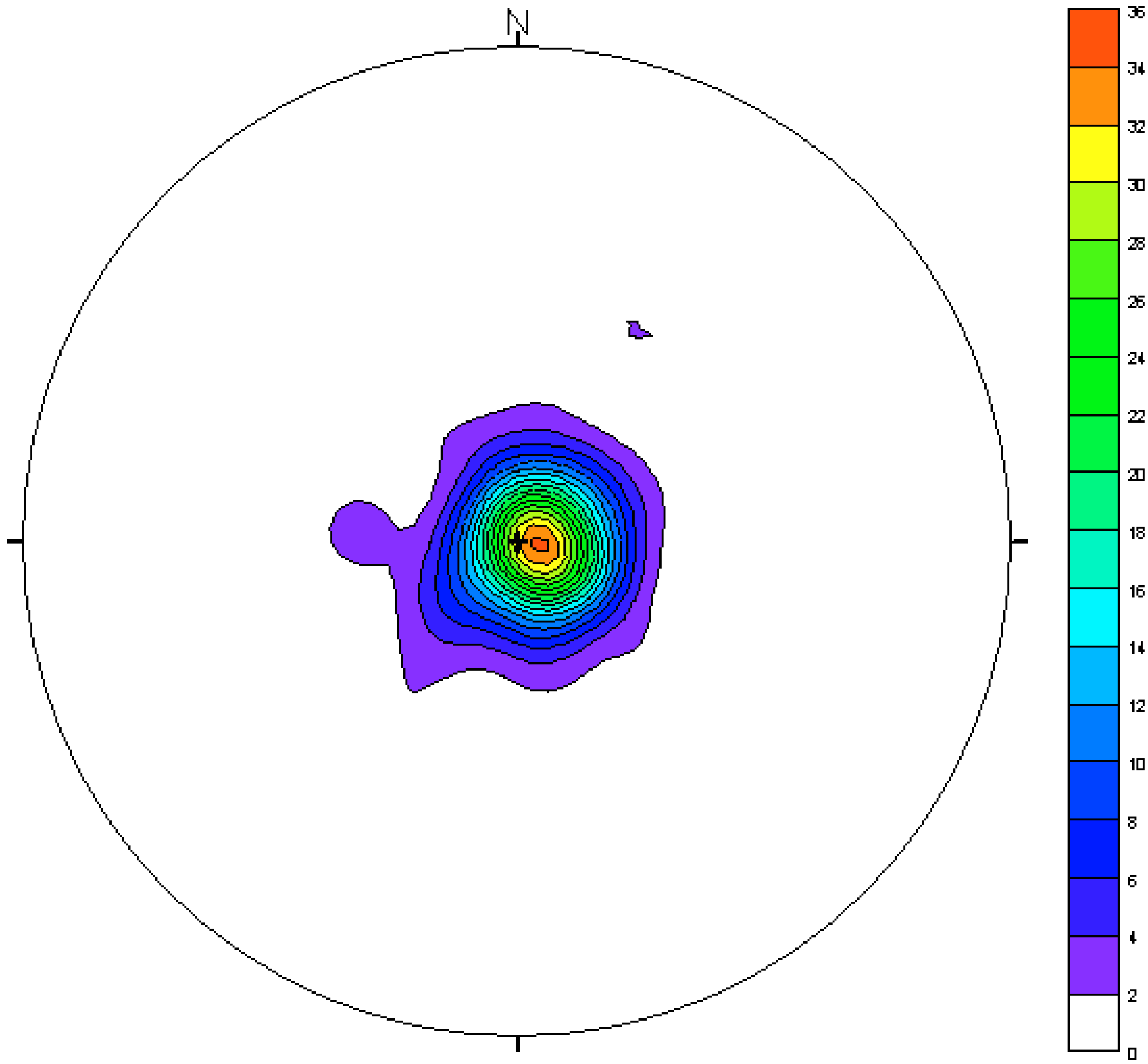
Rose Diagram – Dip Directions
Optical Features
East End Approach, Phase 2, Well: B5
F.M.S.M.
18 December 2005



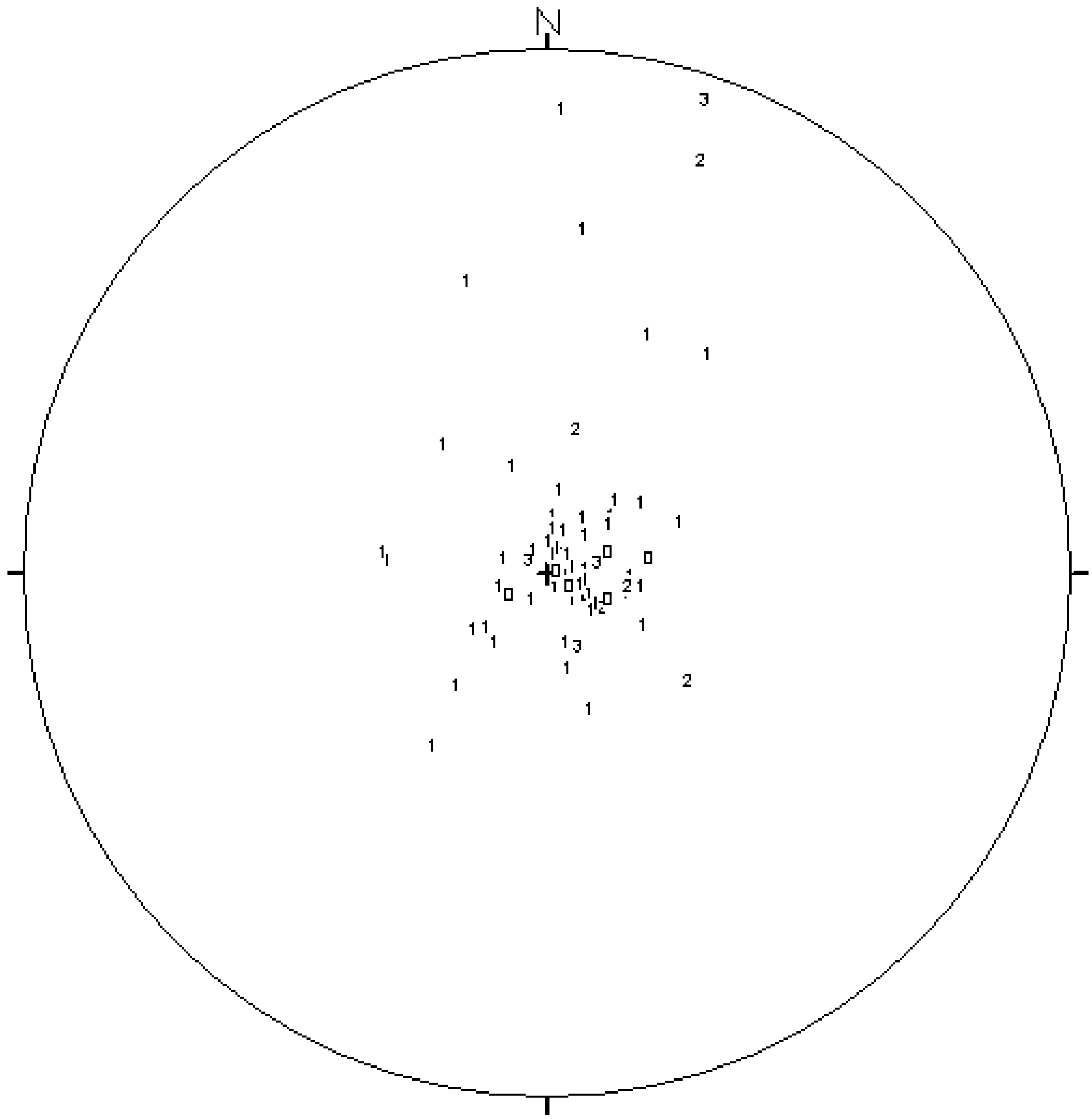
Rose Diagram – Dip Angles
Optical Features
East End Approach, Phase 2, Well: B5
F.M.S.M.
18 December 2005



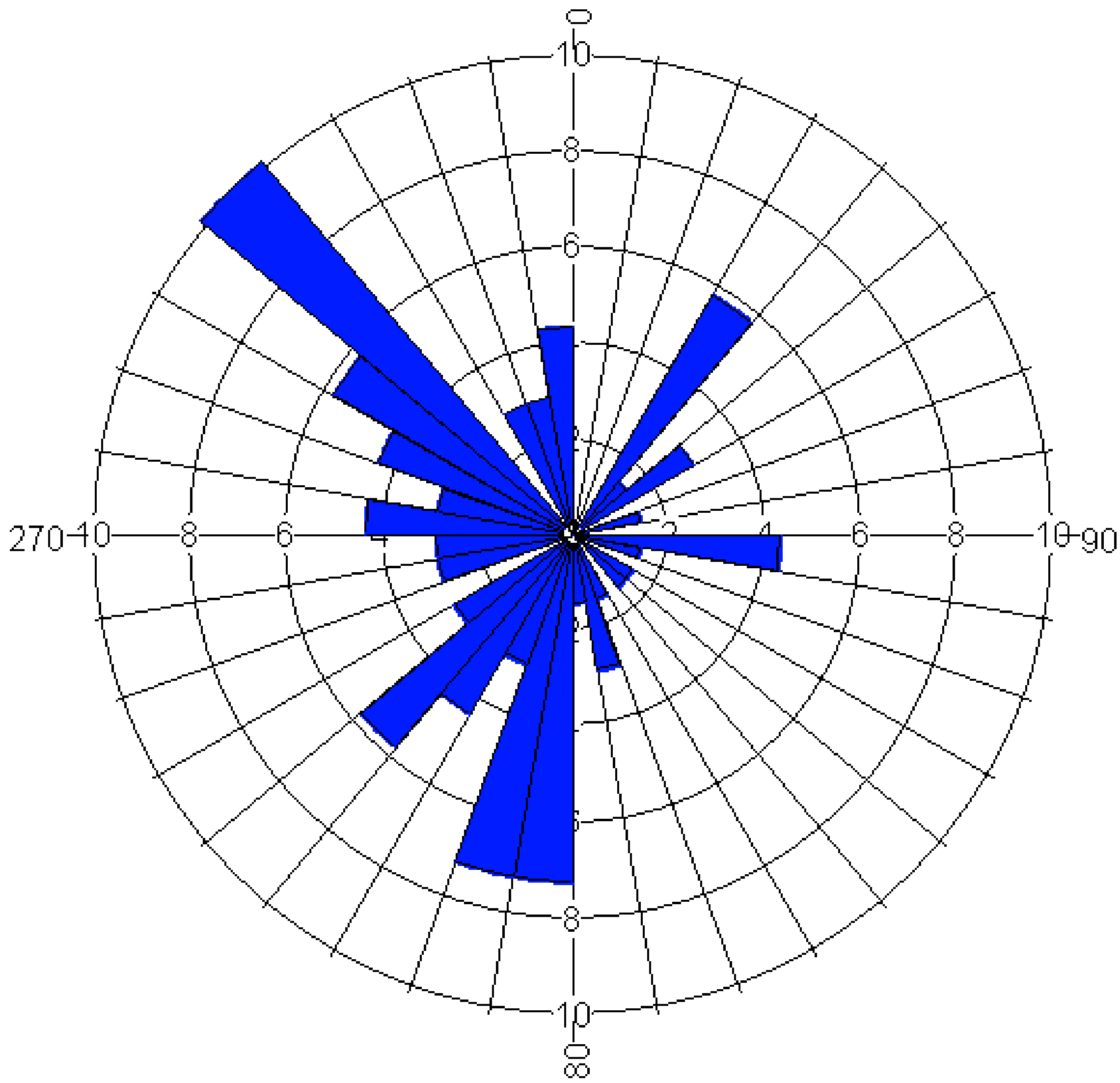
Stereonet Diagram – Schmidt Projection
Optical Features
East End Approach, Phase 2, Well: B6
F.M.S.M.
18 December 2005



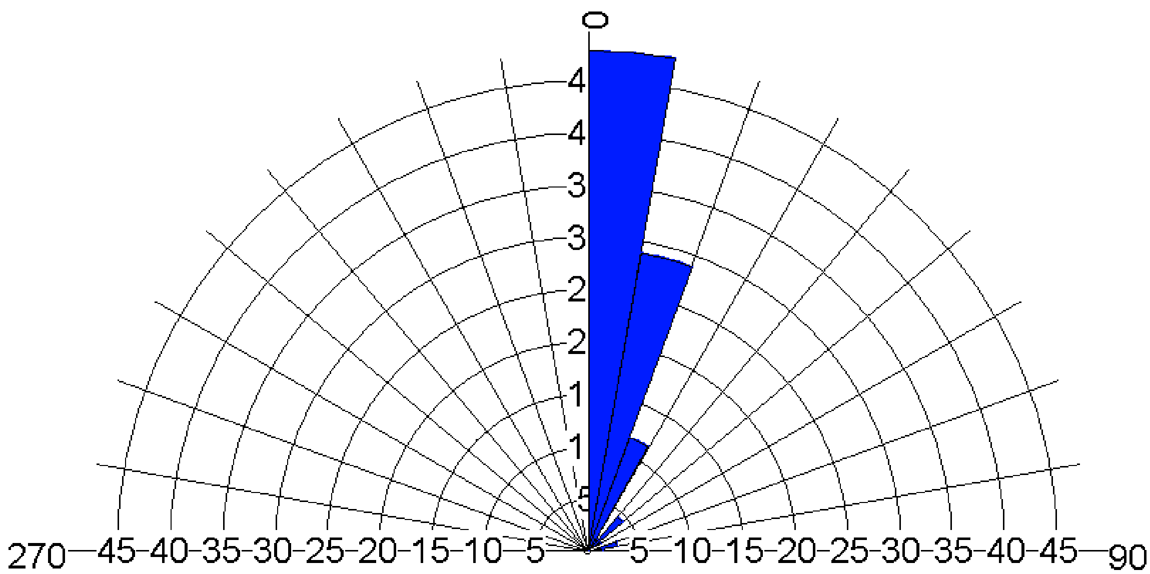
Stereonet Diagram – Schmidt Projection
Optical Features
East End Approach, Phase 2, Well: B6
F.M.S.M.
18 December 2005



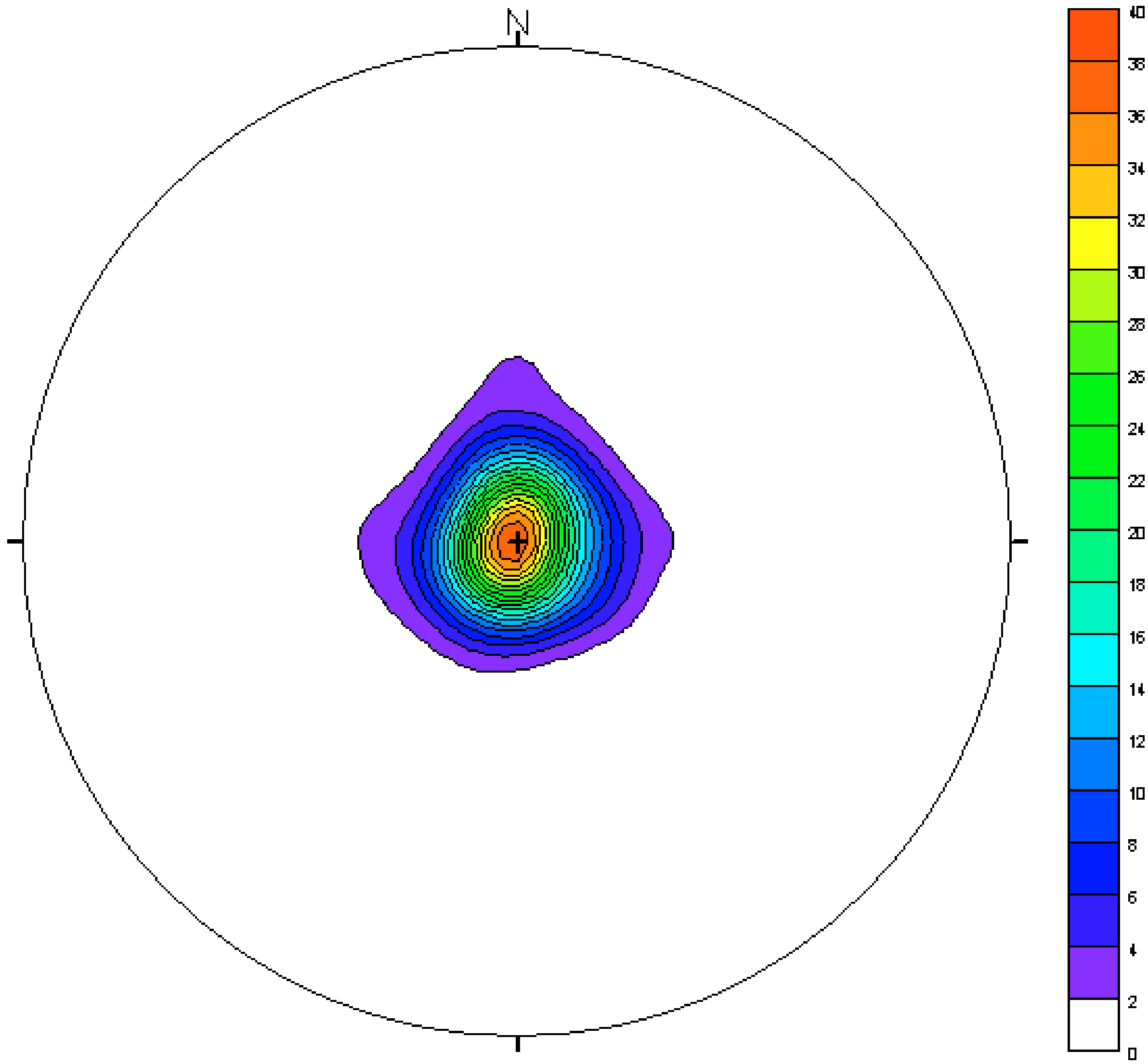
Rose Diagram – Dip Directions
Optical Features
East End Approach, Phase 2, Well: B6
F.M.S.M.
18 December 2005



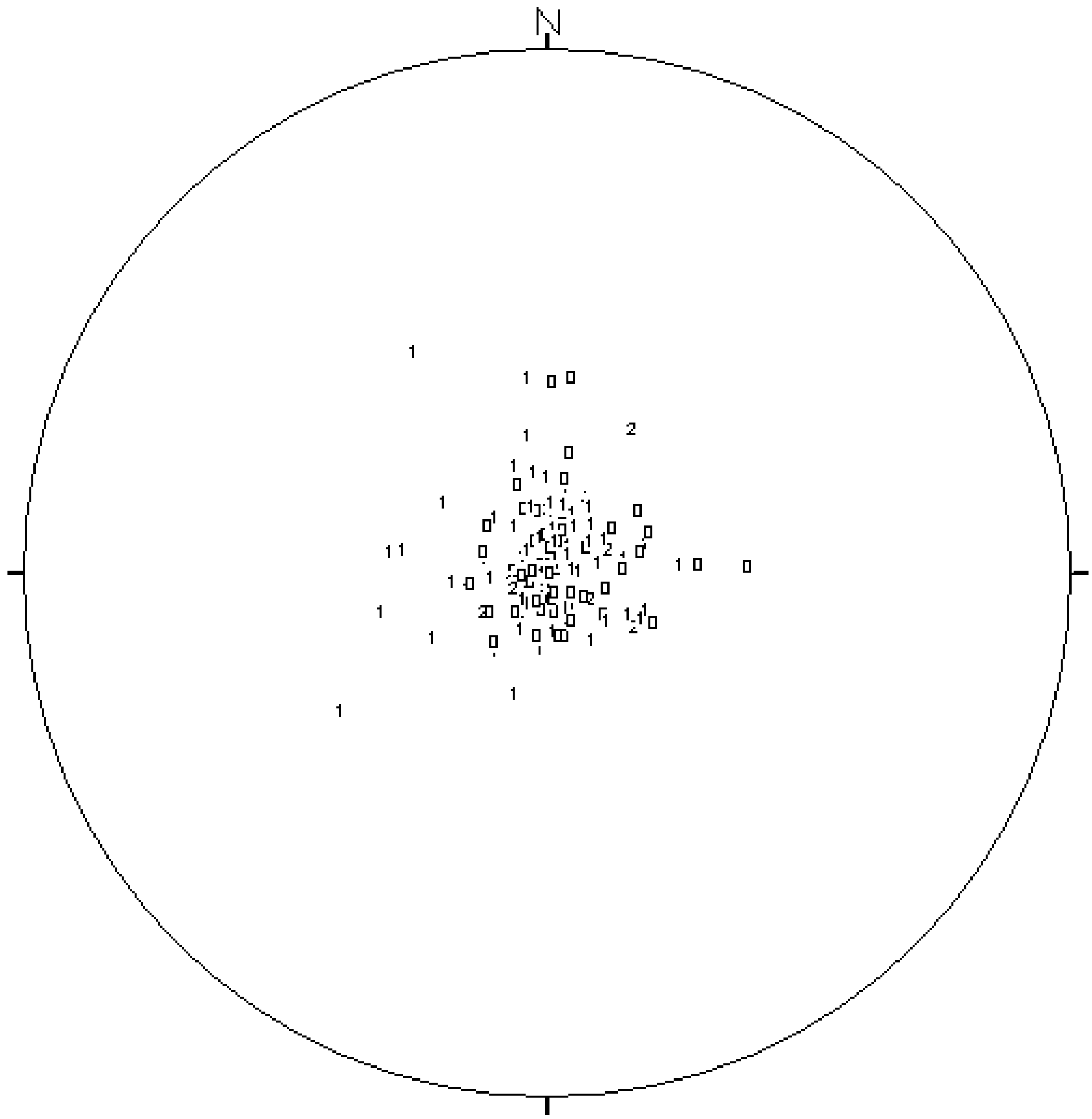
Rose Diagram – Dip Angles
Optical Features
East End Approach, Phase 2, Well: B6
F.M.S.M.
18 December 2005



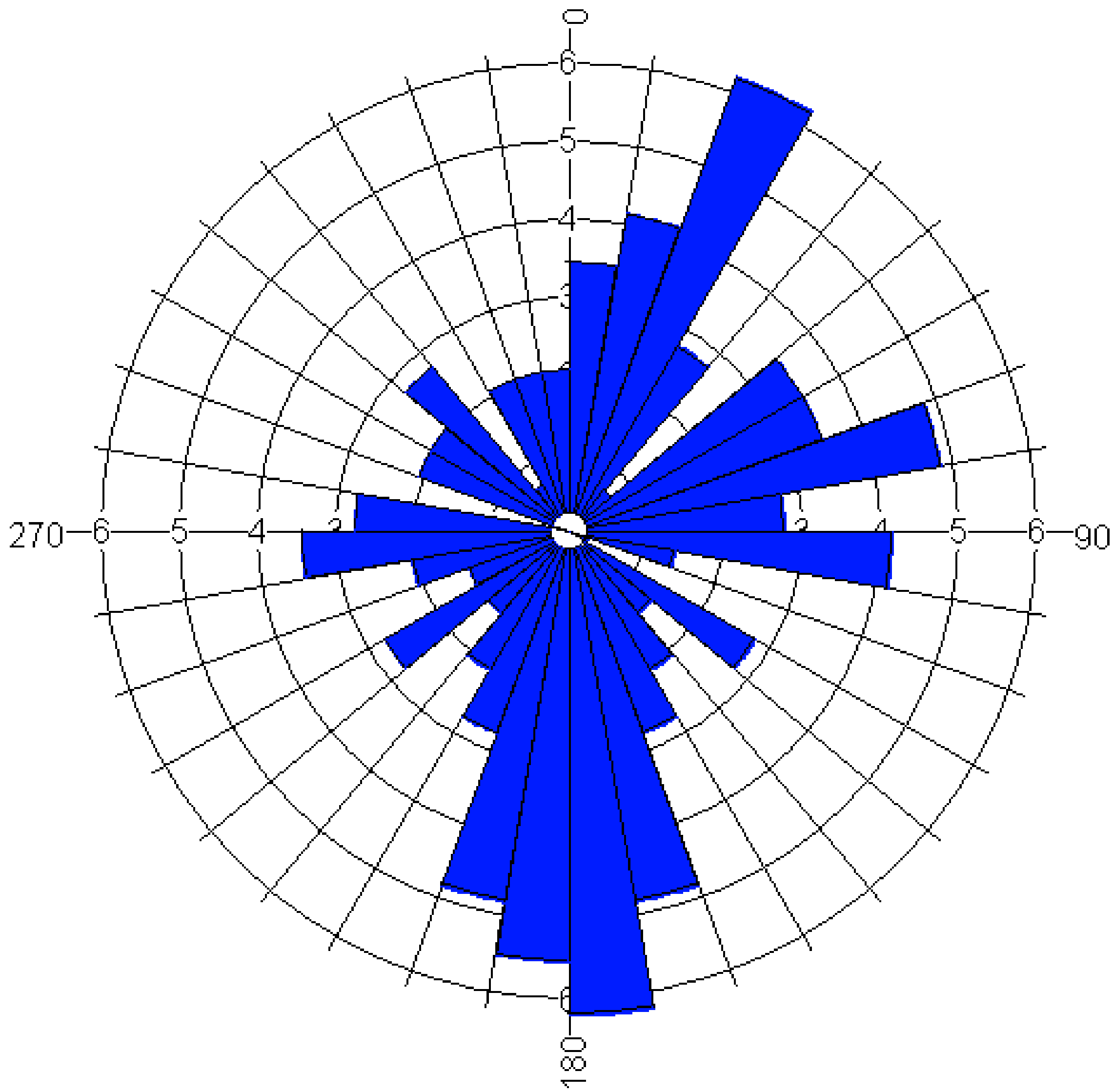
Stereonet Diagram – Schmidt Projection
Optical Features
East End Approach, Phase 2, Well: B8
F.M.S.M.
19 December 2005



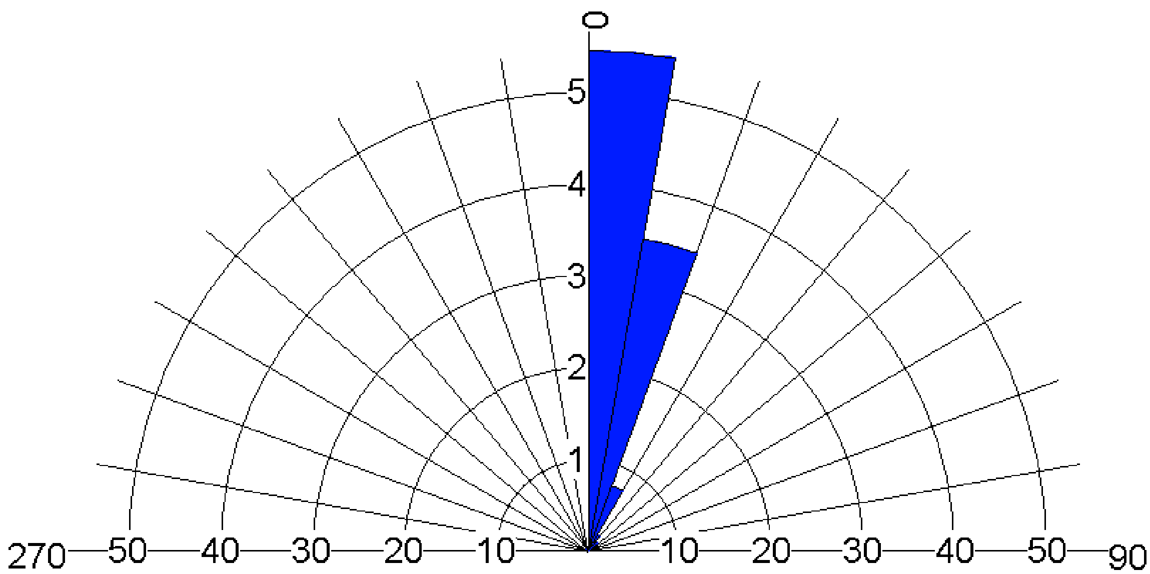
Stereonet Diagram – Schmidt Projection
Optical Features
East End Approach, Phase 2, Well: B8
F.M.S.M.
19 December 2005



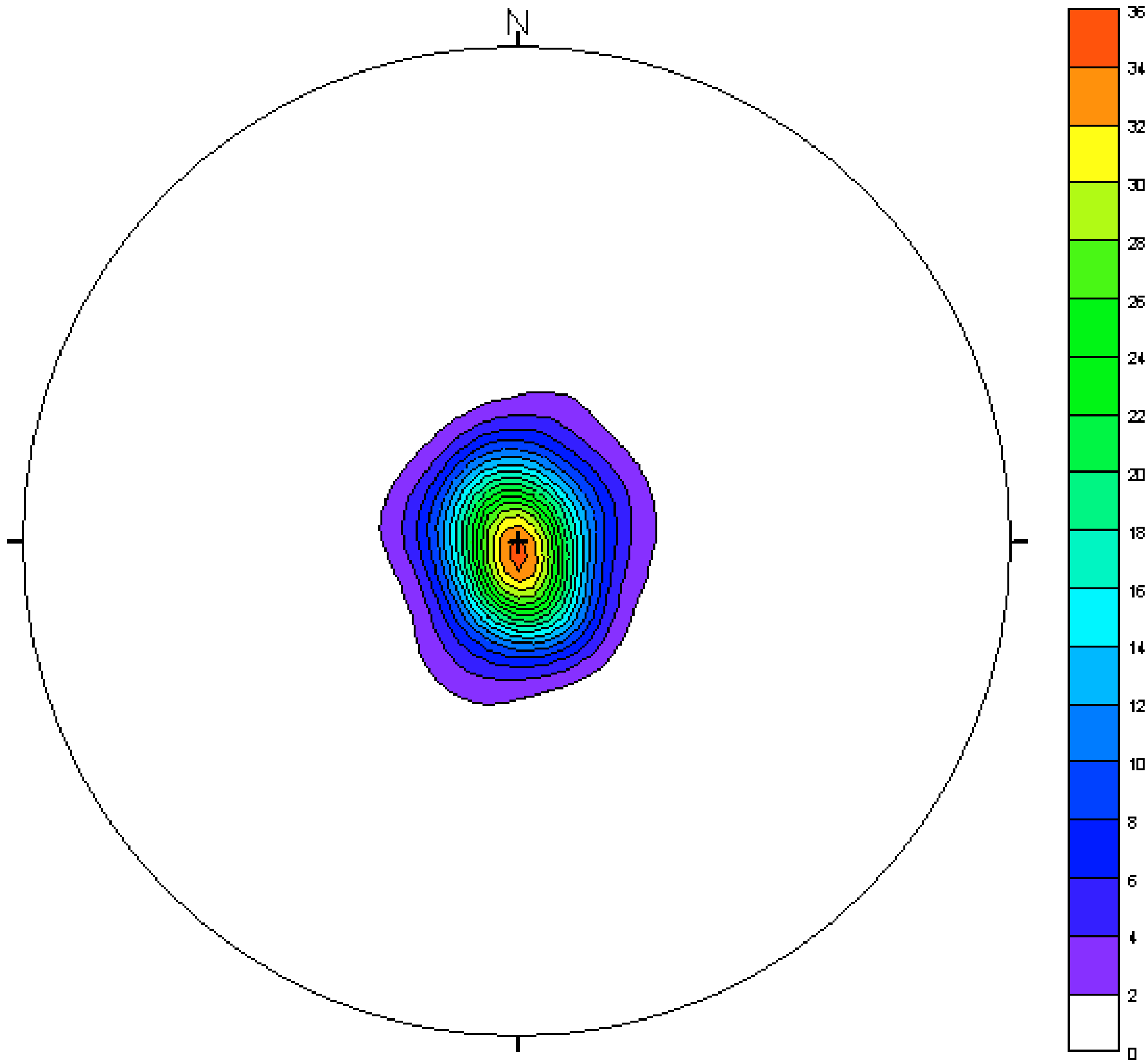
Rose Diagram – Dip Directions
Optical Features
East End Approach, Phase 2, Well: B8
F.M.S.M.
19 December 2005



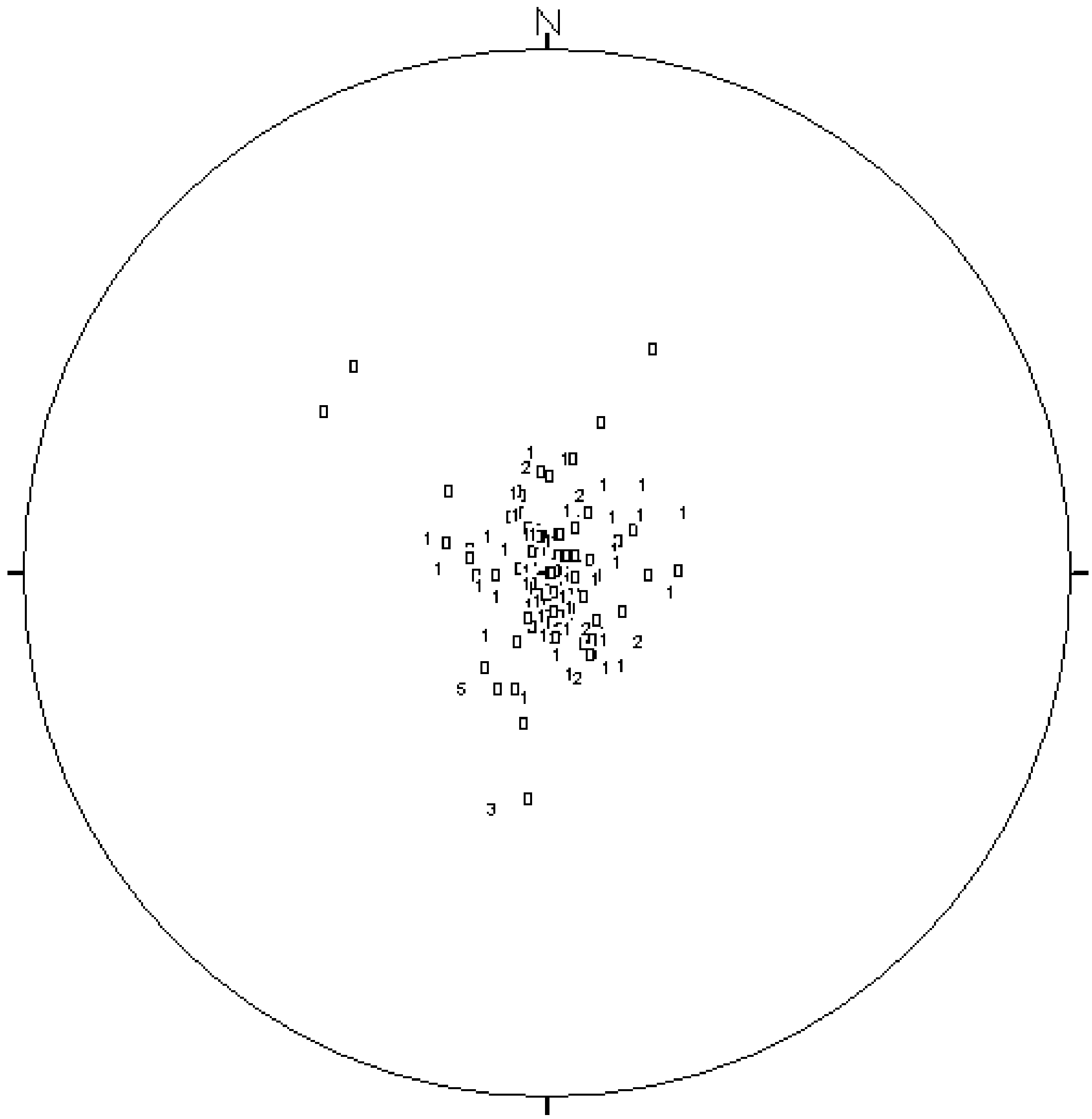
Rose Diagram – Dip Angles
Optical Features
East End Approach, Phase 2, Well: B8
F.M.S.M.
19 December 2005



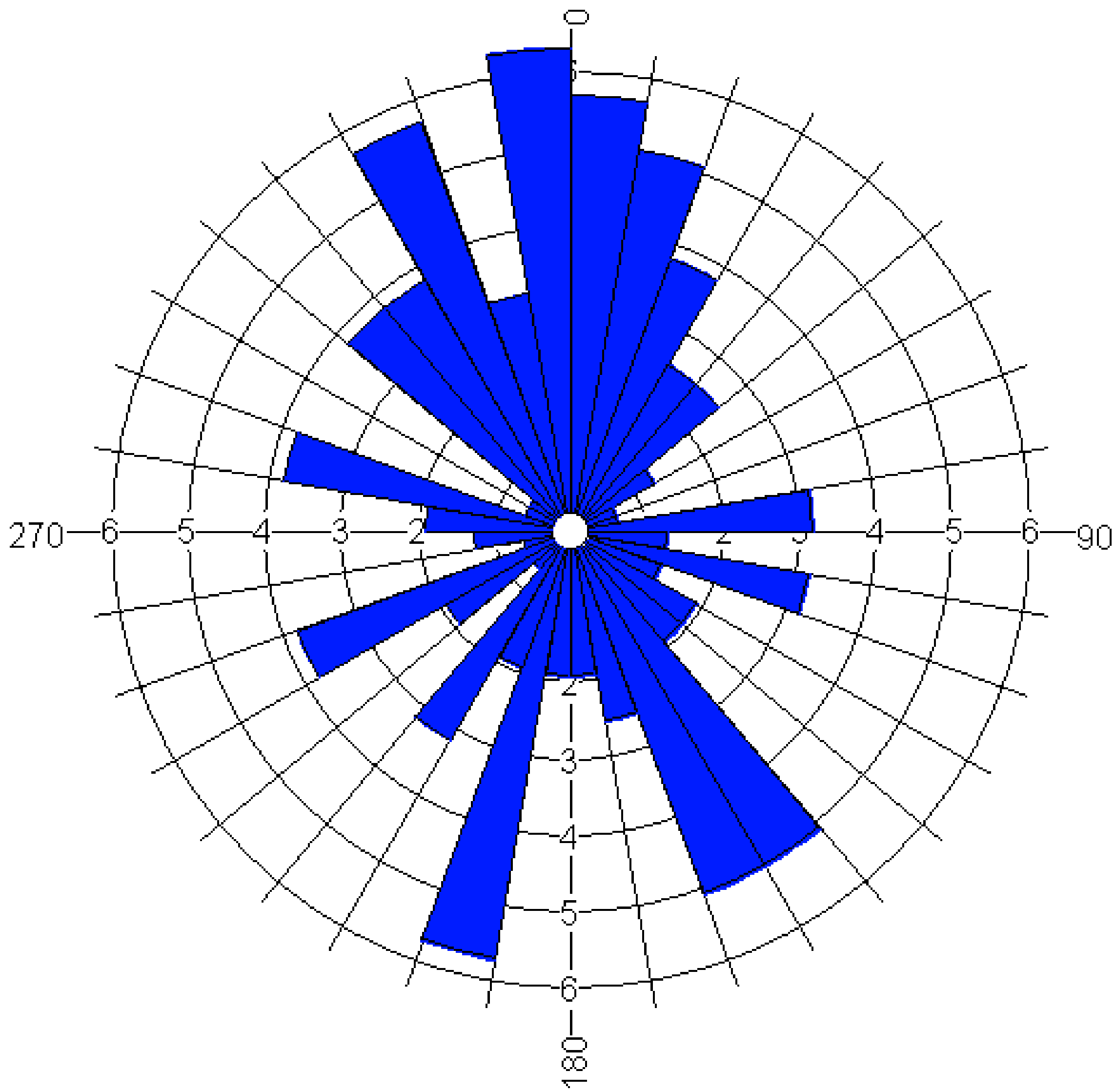
Stereonet Diagram – Schmidt Projection
Optical Features
East End Approach, Phase 2, Well: B10
F.M.S.M.
19 December 2005



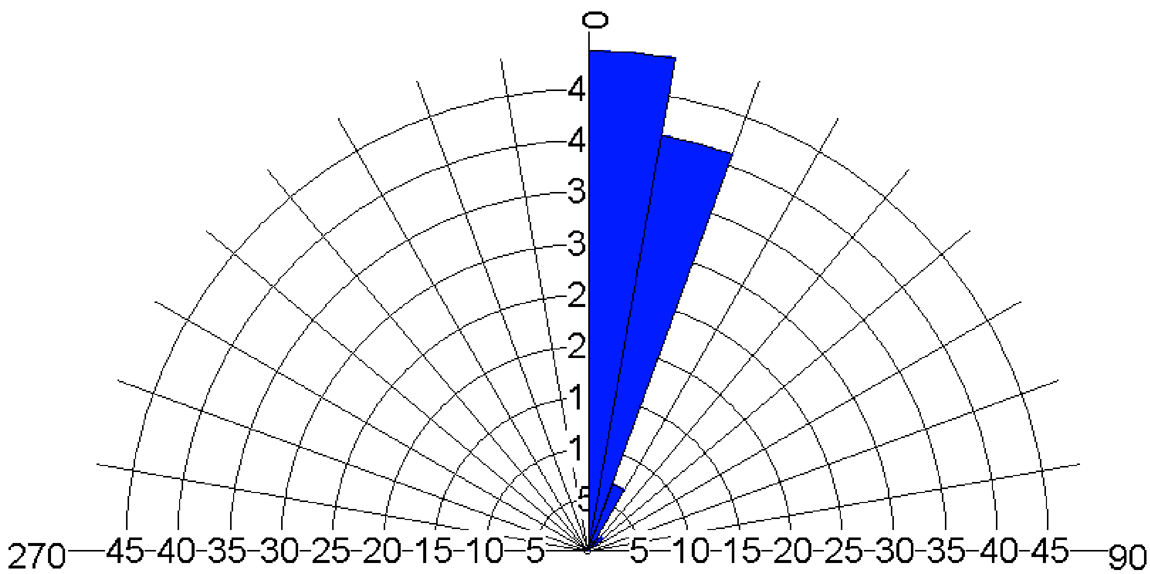
Stereonet Diagram – Schmidt Projection
Optical Features
East End Approach, Phase 2, Well: B10
F.M.S.M.
19 December 2005



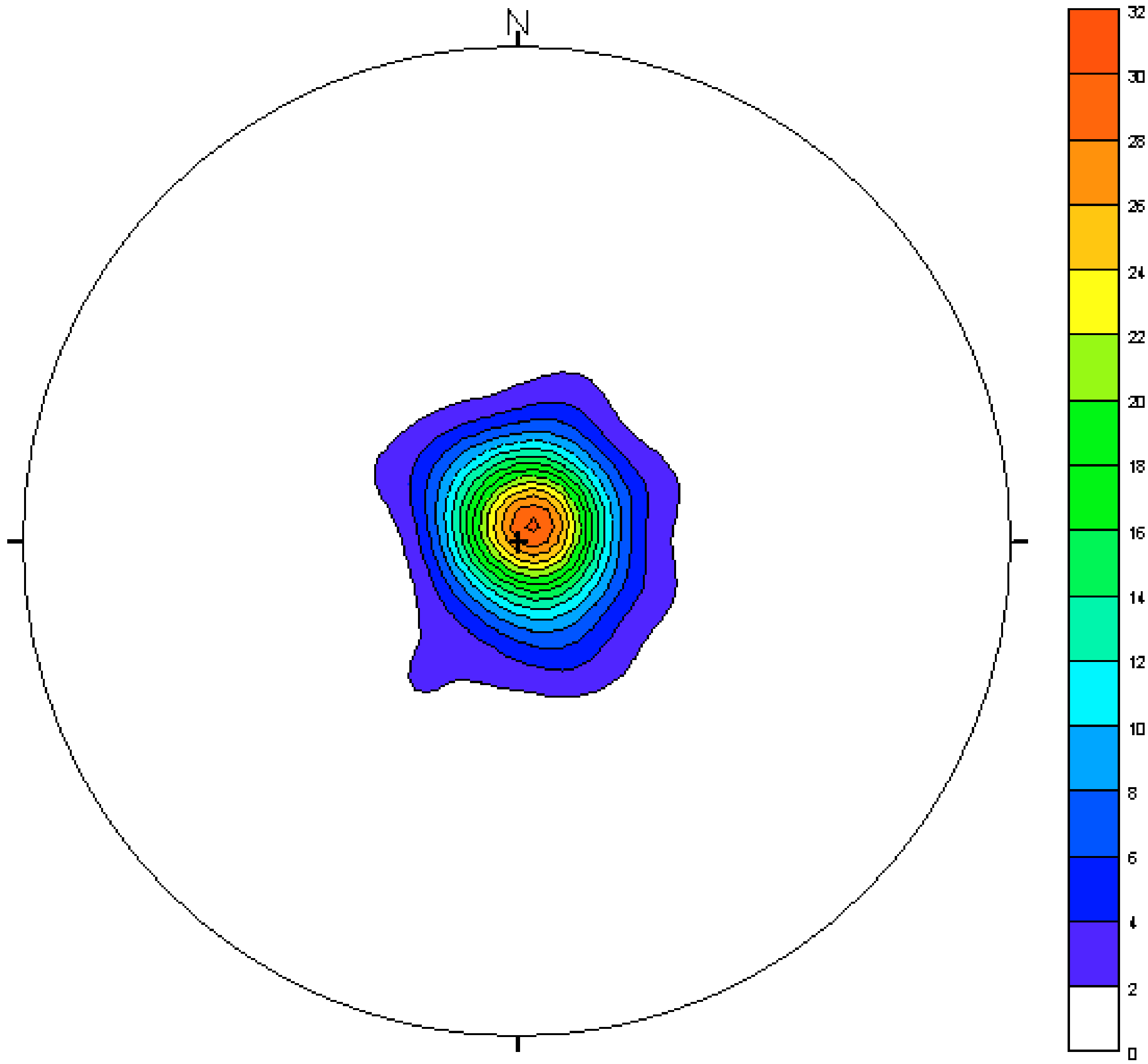
Rose Diagram – Dip Directions
Optical Features
East End Approach, Phase 2, Well: B10
F.M.S.M.
19 December 2005



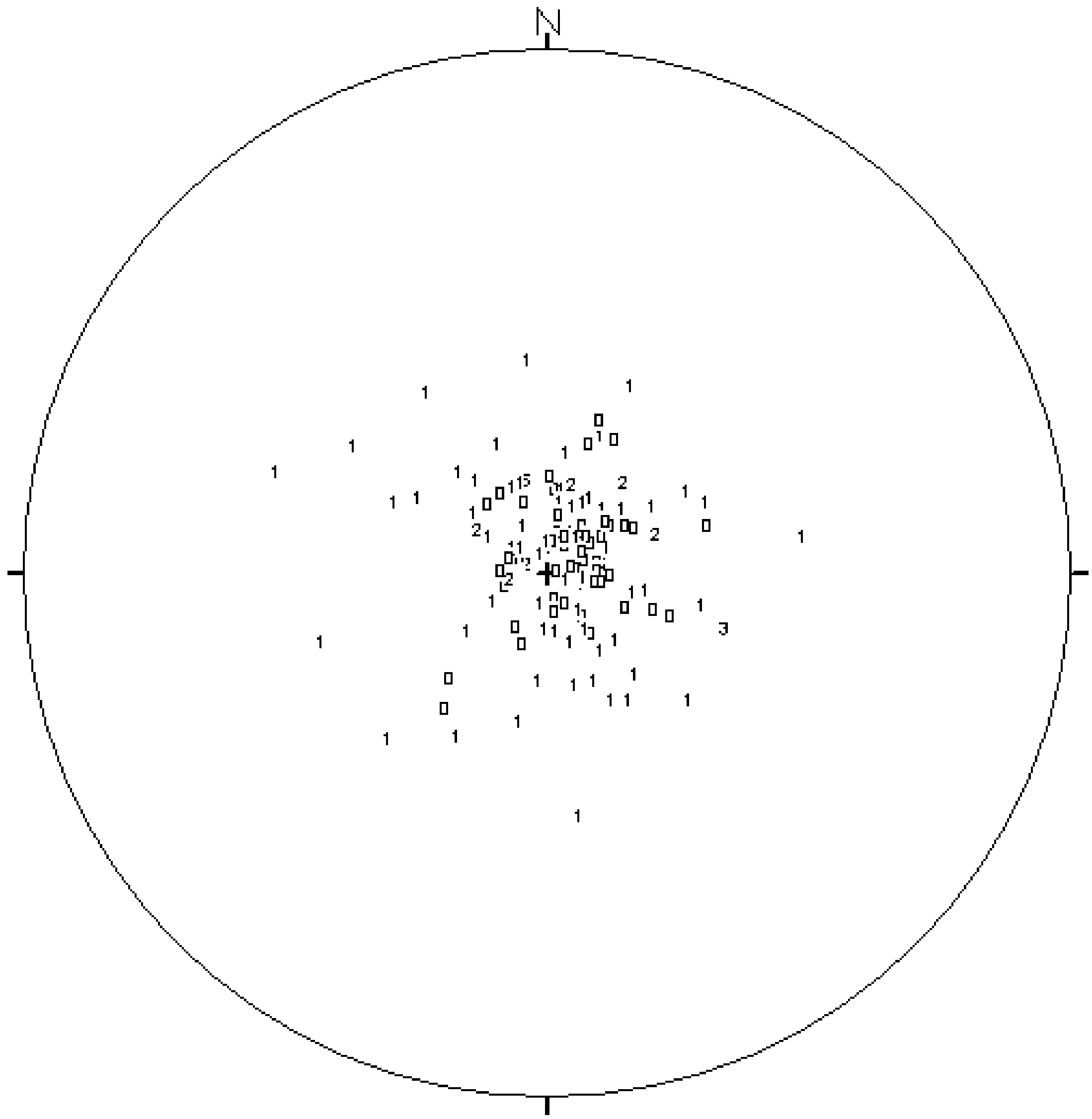
Rose Diagram – Dip Angles
Optical Features
East End Approach, Phase 2, Well: B10
F.M.S.M.
19 December 2005



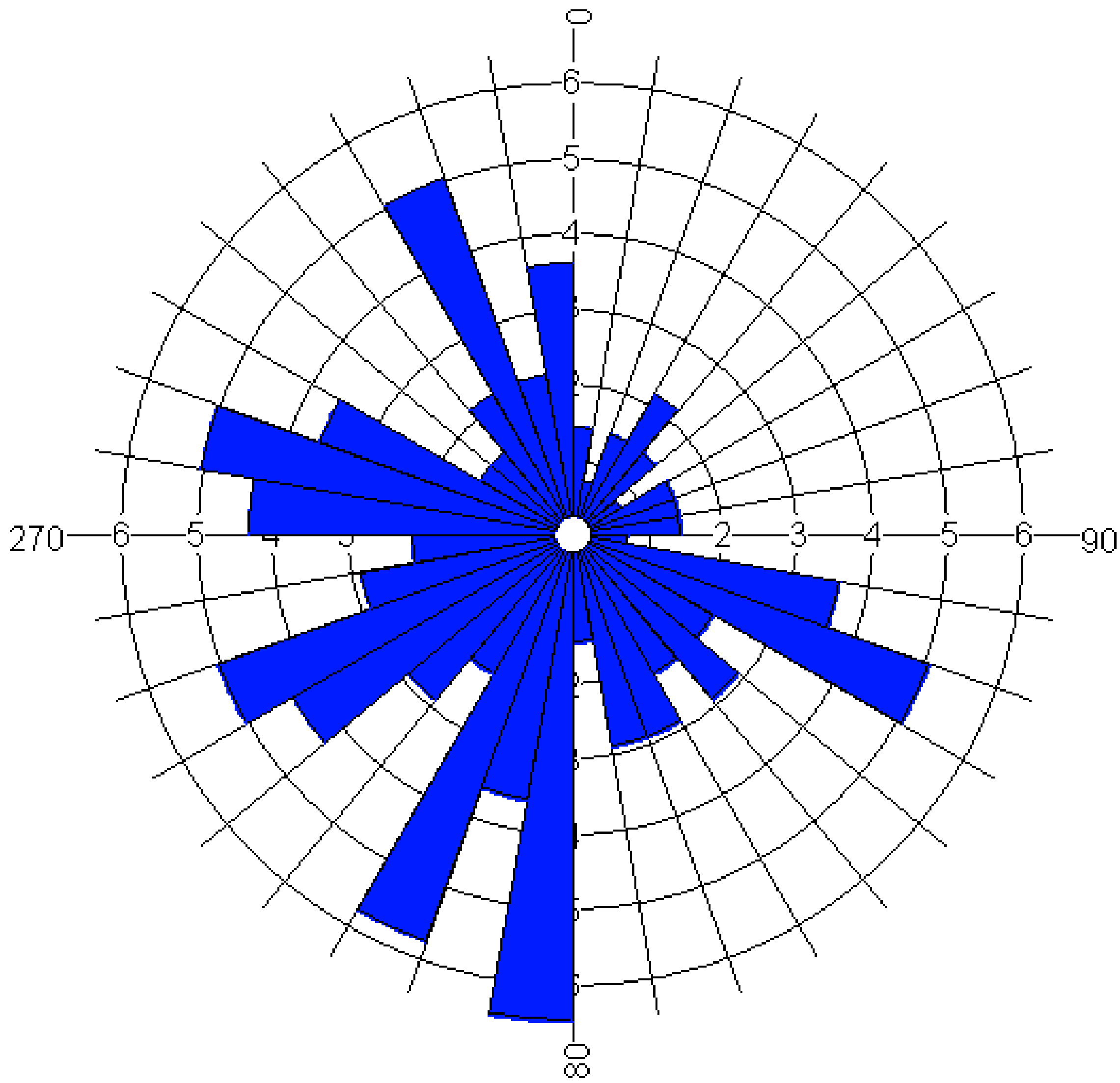
Stereonet Diagram – Schmidt Projection
Optical Features
East End Approach, Phase 2, Well: B11
F.M.S.M.
19 December 2005



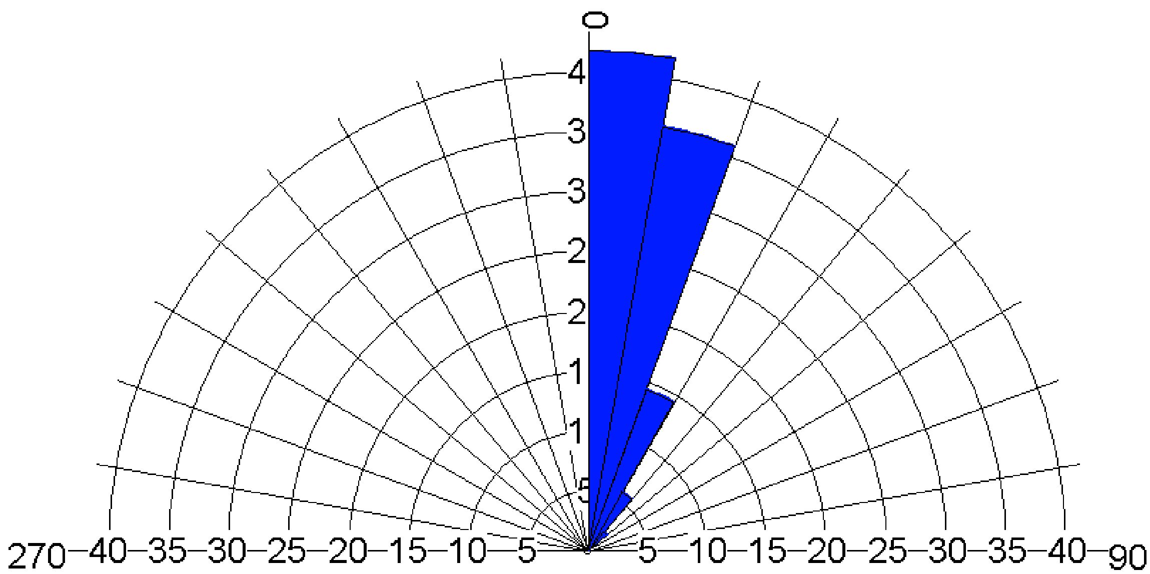
Stereonet Diagram – Schmidt Projection
Optical Features
East End Approach, Phase 2, Well: B11
F.M.S.M.
19 December 2005



Rose Diagram – Dip Directions
Optical Features
East End Approach, Phase 2, Well: B11
F.M.S.M.
19 December 2005



Rose Diagram – Dip Angles
Optical Features
East End Approach, Phase 2, Well: B11
F.M.S.M.
19 December 2005



APPENDIX D

LIMITATIONS

LIMITATIONS

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GEOPHYSICAL PILOT PROGRAM IN TEST AREAS IMMEDIATELY ADJACENT TO THE DRUMANARD ESTATE, LOUISVILLE, KENTUCKY

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EXECUTIVE SUMMARY

Six independent geophysical data sets were acquired along nine predetermined traverses on two test sites immediately adjacent to the Drumanard Estate, Louisville, Kentucky. The following imaging technologies were employed.

- conventional seismic refraction
- gravity
- self-potential
- ground-penetrating radar
- electrical resistivity
- multi-channel surface wave

Based on our analyses of the acquired test geophysical data, we conclude:

- Seismic refraction (or refraction tomography) and electrical resistivity control will provide reliable and useful information about the depth to bedrock and the presence of karstic solutioning/indentation, including information about the depth/base to which the indentations extend and the nature of the in-fill sediment.
- Electrical resistivity control should provide information about the presence and location of any substantive air-filled voids in the subsurface.
- Self-potential data will provide qualitative information about the location of active water channels.

On the basis of the evaluation of the acquired geophysical data, we recommend that electrical resistivity data, seismic refraction (or refraction tomography) and self-potential data be acquired as part of any subsequent geophysical investigation of the Drumanard Estate. Electrical resistivity and seismic refraction (or refraction tomography) imaging technologies will provide cost-effective and useful information about soil lithology and thickness, and the nature of bedrock including the presence of solution-widened joints, karst-related fractures, infill clays and air-filled voids. Self-potential data will useful provide information about seepage pathways within shallow karsted bedrock.

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1. SCOPE OF WORK

Six independent geophysical data sets were acquired along a total of nine traverses on two test sites immediately adjacent to the Drumanard Estate, Louisville, Kentucky (Figures 1 and 2) as part of a pilot program designed to field-test subsurface imaging technologies. The following six geophysical methods were employed and evaluated:

- electrical resistivity
- multi-channel surface wave (MASW)
- conventional seismic refraction
- ground-penetrating radar (GPR)
- self-potential (SP)
- gravity

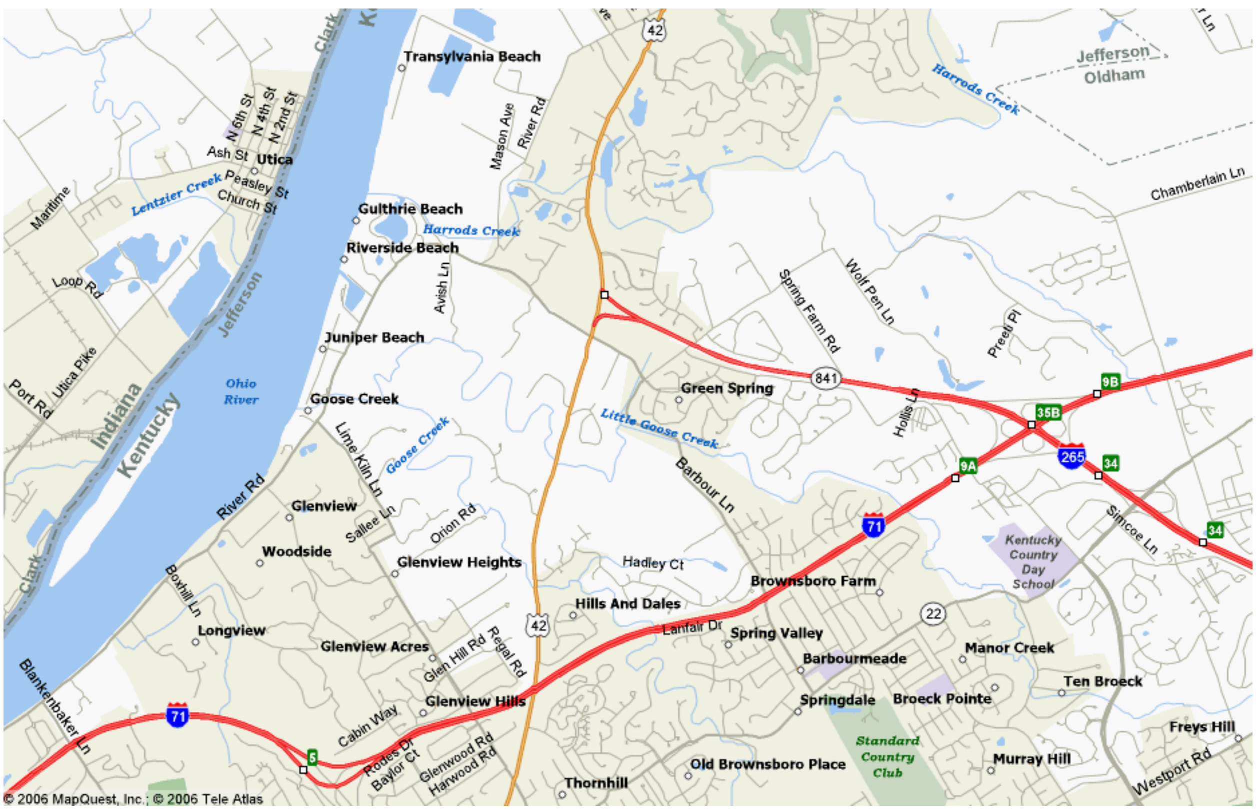


Figure 1: The Drumanard Estate is located at the intersection of Highway 841 and Route 42.

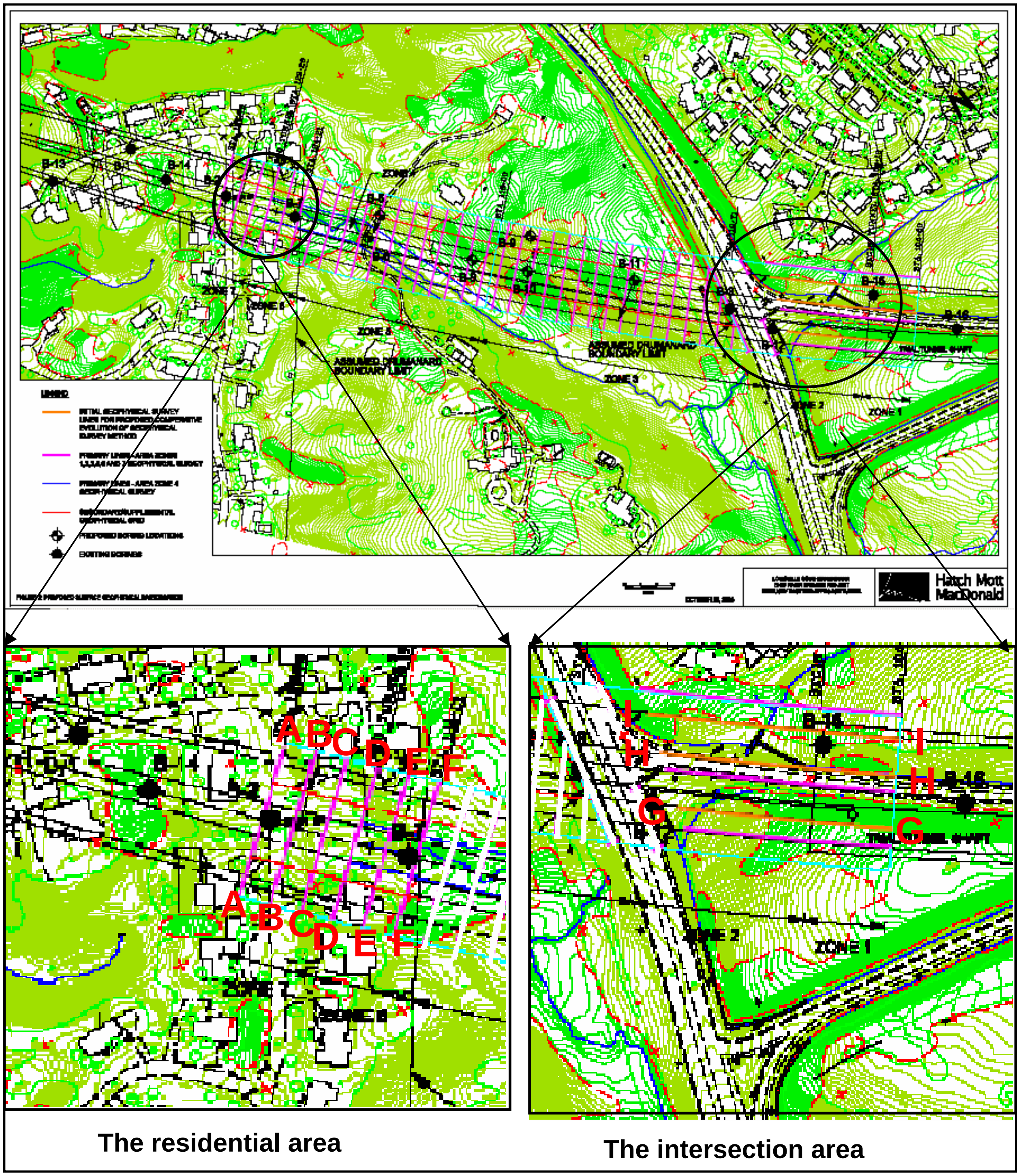


Figure 2: Six independent geophysical data sets were acquired on two test sites (residential area and intersection area) immediately adjacent to the Drumanard Estate as part of a pilot program designed to evaluate the utility of available geophysical technologies. The nine geophysical traverses are designated by the letters A-I, inclusive.

The primary objective of this pilot study was to evaluate each of these six imaging methods and to recommend which, if any, should be used in any follow-up geophysical investigation of the Drumanard Estate (Figure 2). The recommendations were to be based on the following criterion:

1. Did the geophysical method provide reliable and useful information about the depth to bedrock?
2. Did the geophysical method provide reliable and useful information about the presence of karstic solutioning/indentation?
3. Did the geophysical method provide reliable and useful information about the depth/base to which the indentations extend?
4. Did the geophysical method provide reliable and useful information about karstic indentation in-fill? Are they in-filled with clay or other sediment? Are air-filled voids present?
5. Did the geophysical method provide reliable and useful supplemental information about kartsic caves, the depth to the standing water table or the location of active water channels?

2. EVALUATIONS OF GEOPHYSICAL METHODS TESTED ON STUDY SITES IMMEDIATELY ADJACENT TO THE DRUMANARD ESTATE

Six independent geophysical data sets were acquired along nine flagged traverses (A-I, inclusive) in two test areas immediately adjacent to the Drumanard Estate, Louisville, Kentucky (Figures 1 and 2) as part of a pilot program designed to evaluate the utility of geophysical imaging technologies. The following methods were field-tested using acquisition parameters either specified in the FMSM-provided document entitled “Proposed Mapping Program” or otherwise authorized by FMSM personnel:

- electrical resistivity
- multi-channel surface wave (MASW)
- conventional seismic refraction
- ground-penetrating radar (GPR)
- self-potential (SP)
- gravity

The acquired geophysical data were processed, interpreted and evaluated. Evaluations of each of the field-tested technologies are presented sequentially in this section (Section 2) of the Report. The processed data themselves are presented in Appendix A. Brief descriptions of each geophysical method are presented herein. For more in-depth overviews, the reader is referred to: FHWA, 2005, Application of Geophysical Methods to Highway Related Problems: http://www.cflhd.gov/agm/index.htm.

Electrical Resistivity Data: The electrical resistivity data were acquired using a SuperSting R8 resistivity unit equipped with 40 electrodes (Figure 3). As per the “Mapping Program Document”, a dipole-dipole array with an electrode spacing of 10 feet was used to acquire all resistivity data (Figures A1–A9), with the exception of the resistivity data acquired along traverse I. For comparative purposes, two resistivity profiles were acquired along traverse I; electrical resistivity profile I was acquired using a 12 ft electrode spacing, whereas electrical profile I-2 was acquired using a 5 ft electrode spacing (Figure 4).

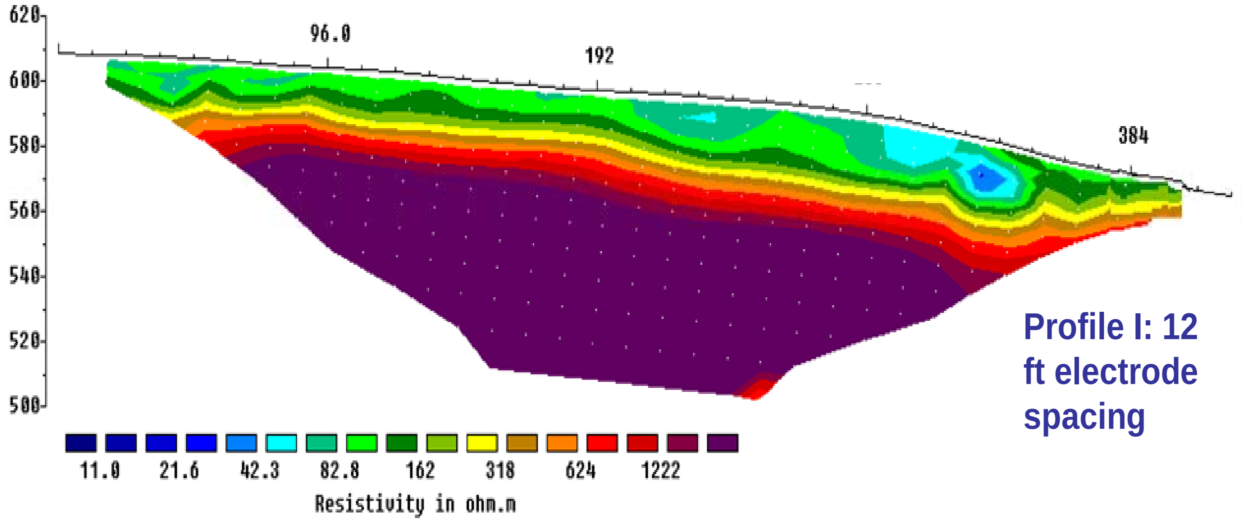
The acquired resistivity data were processed using the commercially available software package RES2DINV. During processing, the subsurface along the length of each resistivity traverse was subdivided into 2-D pixels, each of which was assigned a specific value of resistivity. The dimensions of each pixel are functions of the electrode spacing employed and the depth of investigation. More specifically, the pixels on the resistivity profiles acquired using a 10 ft electrode spacing are 10 ft x ~4 ft (width x height) at the shallowest depths of investigation and 10 ft x ~7 ft at depths of investigation on the order of 35 ft. The pixels on the on the resistivity profile acquired using a 5 ft electrode spacing are 5 ft x ~2 ft (width x height) at the shallowest depths of investigation and 5 ft x ~4 ft at depths of investigation on the order of 35 ft. The lateral and vertical resolution of the resistivity data acquired using the 5 ft electrode spacing is therefore essentially twice that of the resistivity data acquired using a10 ft electrode spacing.

Figure 3: Electrical resistivity data were acquired using a SuperSting R8 resistivity unit equipped with 40 electrodes.

Two example resistivity profiles are presented in Figure 4. Resistivity profile I was acquired along the entire length of traverse I using a 12 ft electrode spacing; resistivity profile 1-2 was acquired along a segment of traverse I, using a 5 ft electrode spacing. The bedrock surface is characterized by higher resistivity values than the overlying soil and is readily mapped across both profiles. The top of bedrock on resistivity profiles I and I-2 is believed to coincide (approximately) with the 162 ohm-m contour. This resistivity contrast between soil (<162 ohm-m) and limestone (>162 ohm-m) is consistent with published literature (Figure 5).

In an effort to assess the reasonableness of this interpretation, the processed, interpreted resistivity profiles were compared to available boring control.

Boring 15 is located approximately 25 ft to the south of station 144 on resistivity profile I (Figure 2). The estimated depth to bedrock at station 144 on resistivity profile I (based on the 162 ohm-m criteria) is ~11 ft. This is consistent with proximal boring B-15 which encountered bedrock at a depth of 8.7 ft (Figure 2). The upper 50+ ft of bedrock at boring B-15 is described as "*limestone, gray, micro- to finely-crystalline grained, thin to medium bedded, fossiliferous, argillaceous with shaley zones*", so it is not surprising that bedrock on resistivity profile I is characterized by uniformly high resistivities. (Air-filled voids typically characterized by resistivity values in excess of 7500 ohm-m as shown in Figure 5, are not imaged on resistivity profile I or on any of the other acquired resistivity profiles.)



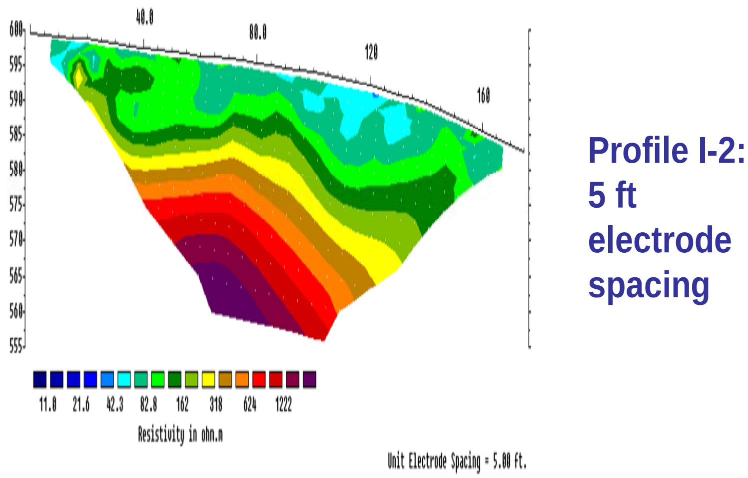


Figure 4: Electrical resistivity profile I was acquired using a12 ft electrode spacing; electrical resistivity profile I-2 was acquired using a 5 ft electrode spacing.

Boring B-15 is also located about 40 ft to the north of resistivity profile H. The estimated depth to bedrock at station 180 on resistivity profile H (based on the 162 ohm-m criteria) is ~12 ft. This is consistent with proximal boring B-15 which encountered bedrock at a depth of 8.7 ft (Figure 2). Despite this close apparent correlation, the resistivity profile H is “suspect” as far as interpretability is concerned. This is because resistivity profile H was acquired along the outer edge of the drainage ditch paralleling the roadway, in an area presumed to have been excavated and then in-filled with road construction material. Resistivity profile H has also almost certainly been subject to lateral averaging (smoothing effects) due to 3-D current flow, particularly in areas where the traverse H parallels the road cut. Additionally, the drainage ditch is a conduit for run-off, and the underlying soils and rock may be anomalously wet. As a result, the 162 ohm-m criteria may not apply to bedrock along segments of this profile.

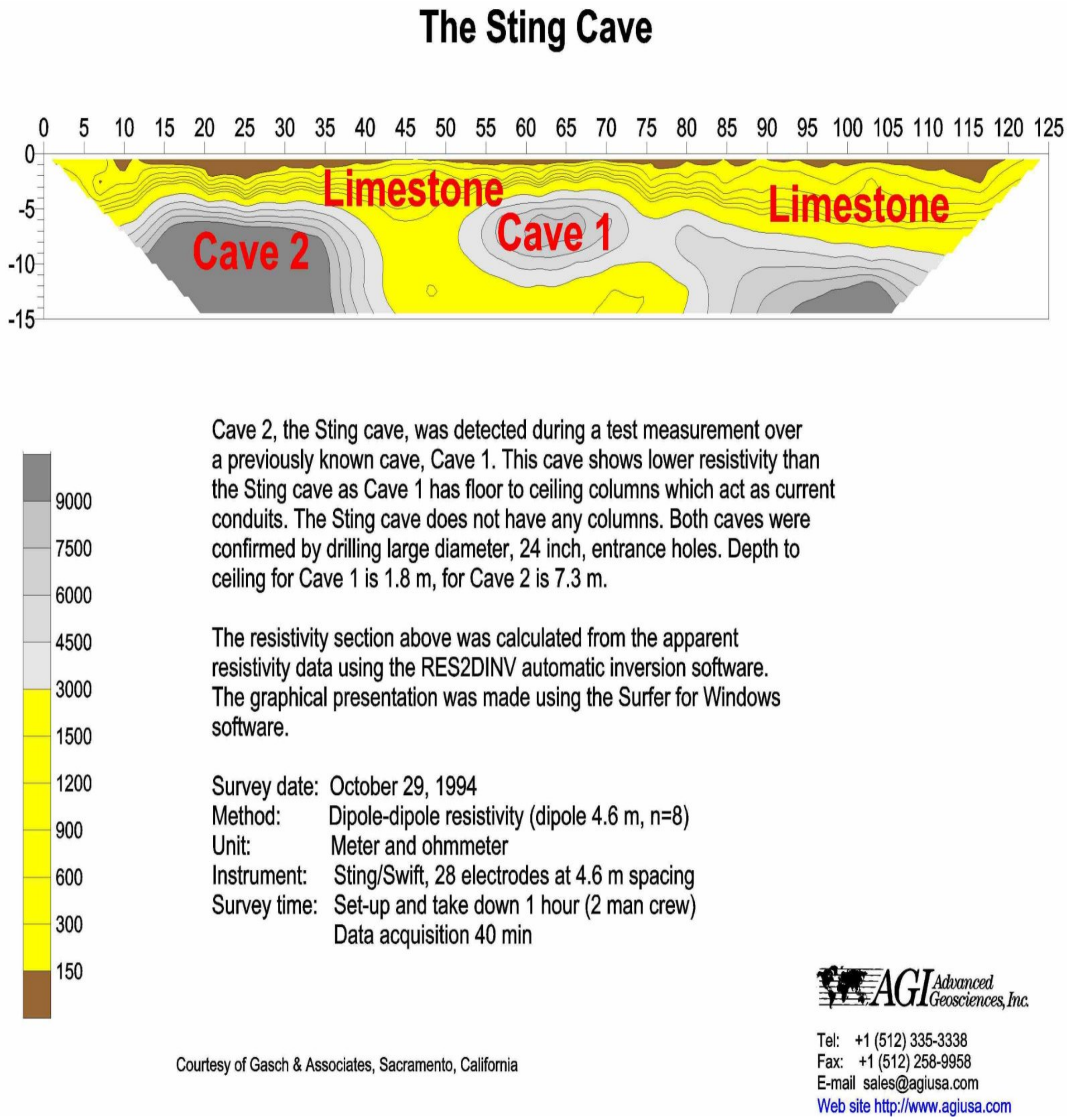


Figure 5: Example electrical resistivity profile across known caves. The electrode spacing was 2.5 ft.

Two other borings in the study area effectively “tie’ the acquired resistivity profiles. These are borings B-2 and B-7.

The depth to bedrock at boring B-2 is approximately 12 ft (Figure 2). The upper 15 ft of bedrock at boring B-2 is described as “*limestone with shale stringers and partings. Partings up to 0.3 ft thick. Limestone is gray, hard, fine-to medium-crystalline, very thin to thin bedded. Clay seam from 5.5 ft to 7.5 ft*”. This upper limestone unit is underlain by 11 ft of shale described as “*gray, clayey, soft, silty, very thin- to thin-bedded*”. The shale is underlain by dolomite.

Boring B-2 ties resistivity profile A near station 140 (Figures 2 and 6). The depth to bedrock at resistivity station 140 cannot be accurately estimated using the 162 ohm-m contour criteria (suitable for resistivity profile I; Figure 4) because resistivity values of 162 ohm-m are not observed at depths of less than 70 ft at station 140! However, depths to bedrock at resistivity stations 110 (est. 15 ft) and 180 (est. 5 ft) can be estimated using the 162 ohm-m criteria. The thickness of the upper limestone unit encountered at boring B-2 (15 ft) can also be estimated at resistivity stations 110 (est. 15 ft) and stations 180 (est. 20 ft) using this same 162 ohm-m criteria.

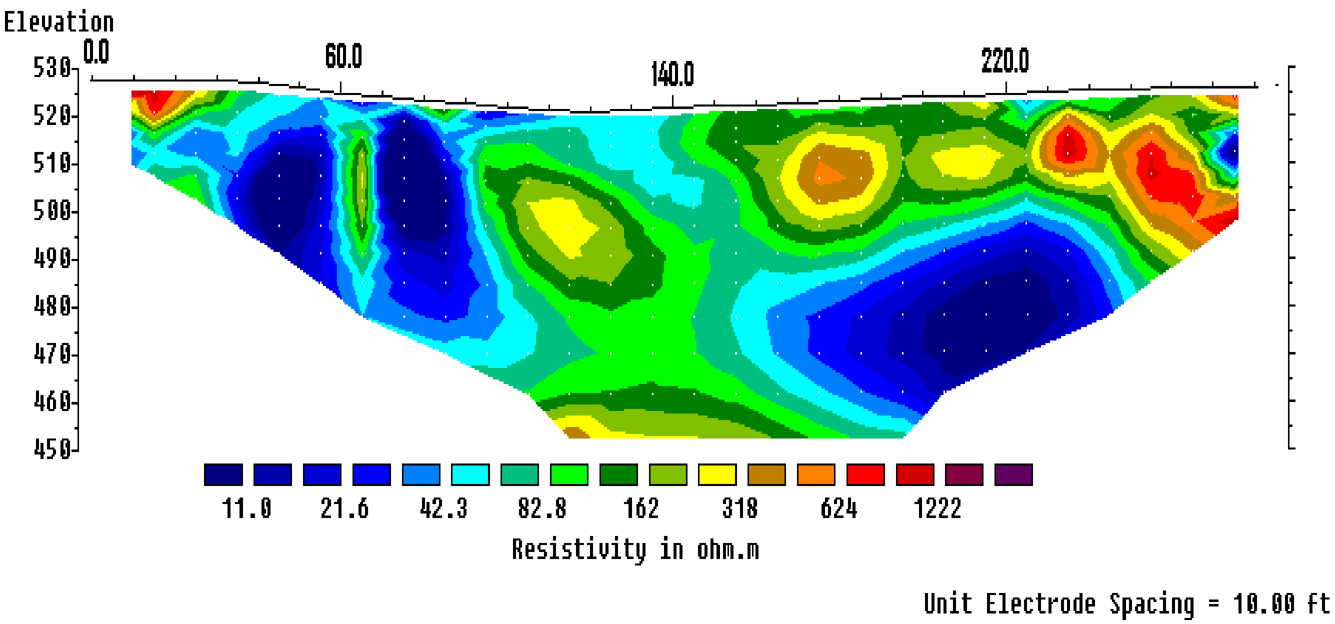


Figure 6: Electrical resistivity profile A.

There are two plausible explanations for the absence of resistivity values on the order of 162 ohm-m at shallow depths at station 140 on electrical resistivity profile A (Figure 6):

1. One plausible explanation is that the upper limestone unit at station 140 is either absent or too thin to be accurately imaged using an electrode spacing of 10 ft, because of the pixel size and vertical/lateral smoothing therein. Pixels at depths of 15 ft at station 140 have dimensions of 10 ft x ~5 ft. The resistivity value assigned to each pixel represents the "average" resistivity within that pixel. Hence vertical and lateral averaging could "mask" the top and base of a thin, highly-resistive limestone encased in thicker, much-less resistive soils, clays and shales.

2. A second, equally plausible explanation, is that the upper limestone unit in proximity to station 140 is extensively fractured (and in-filled with moist clay) and therefore characterized by anomalously low resistivities (<162 ohm-m).

We note that the upper limestone unit also appears to be thin, absent or extensively fractured between stations 30 and 90 on resistivity profile A. It is very possible that this section of resistivity profile A images an in-filled karst feature that developed along a linear solution-widened fracture/joint zone. The fracture hypothesis is supported by the observation that similar, though slightly-less anomalous features, are observed on parallel resistivity profiles B, C and D (see Appendix). We note that this interpreted "fracture" zone is not imaged on resistivity profiles E or F (see Appendix).

The depth to bedrock at boring B-7 is approximately 3 ft (Figure 2). The upper ~16 ft of bedrock at boring B-7 is described as "*limestone, gray, micro- to finely-crystalline grained, thin to thick bedded, fossiliferous, occasional weathered zones*". This limestone unit is underlain by 12 ft of shale described as "gray". The shale is underlain by "limestone (dolomite)".

Boring B-7 is located about 20 ft to the east of station 130 on resistivity profile E near (Figure 7). The depth to bedrock at resistivity station 130, based on the 162 ohm-m contour criteria, is approximately 3 ft. While this estimate of depth to bedrock is consistent with B-7 boring control, a closer analysis of profile E elucidates the limitations of the acquired resistivity data with respect to resolution. More specifically, bedrock depths cannot be estimated at stations immediately to the south of station 130 (station 110 for example) using the 162 ohm-m criteria because the shallowest resistivity values at this station are greater than 270 ohm-m. Presumably, the absence of a low resistivity zone in the shallowest subsurface is the result of vertical and lateral averaging within the shallowest pixel. In all probability, depth to bedrock at station 130 on profile F would have been more accurately imaged on a resistivity profile employing an electrode spacing 5 ft.

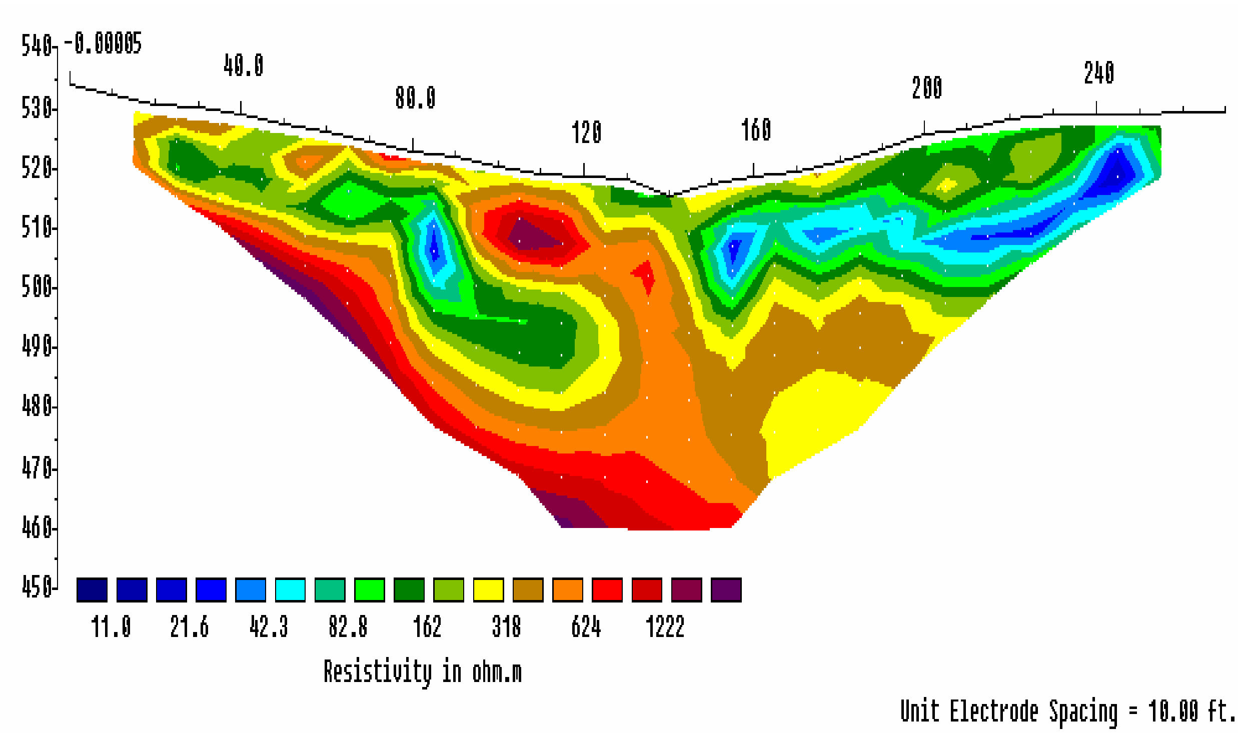


Figure 7: Electrical resistivity profile E.

Based on the apparent agreement between boring control (B-16, B-2 and B-7) and the interpreted electrical resistivity profiles, we recommend that electrical resistivity data be acquired during any follow-up geophysical investigation of the Drumanard Estate. However, because of the apparent complexity of the bedrock surface, we recommend that data be acquired using an electrode spacing of 5 ft and an array length that provides penetration depths on the order of 50 ft. We do not recommend the re-acquisition of resistivity data with a shorter (5 ft) electrode spacing along traverses A-I (Figure 2) at this time, because existing control (utilizing a 10 ft electrode spacing) might suffice particularly when constrained by supplemental geophysical data and boring control.

Multi-channel Surface Wave Data (MASW): As per the "Mapping Program Document", MASW (Rayleigh wave) field records were acquired using an RAS 24-channel engineering seismograph, 4.5 Hz geophones spaced at 5 ft intervals, and a sledge hammer (acoustic) source impacted on an aluminum plate placed at a near-offset distance of 20 to 30 ft (Figures 8 and 9). Individual MASW field records (consisting of 6 to 12 seismic traces, depending on data quality) were acquired at 20 ft intervals along each traverse (Figure 8).

Each MASW field record was transformed into a 1-D shear-wave profile using the commercially available software package SurfSeis (Figure 8). (It is important to recall that each field record consisted of between 6 and 12 traces, meaning that each 1-D shear-wave curve was generated using seismic data acquired over lateral subsurface distances of between 25 and 55 ft. Hence lateral smoothing occurred.)

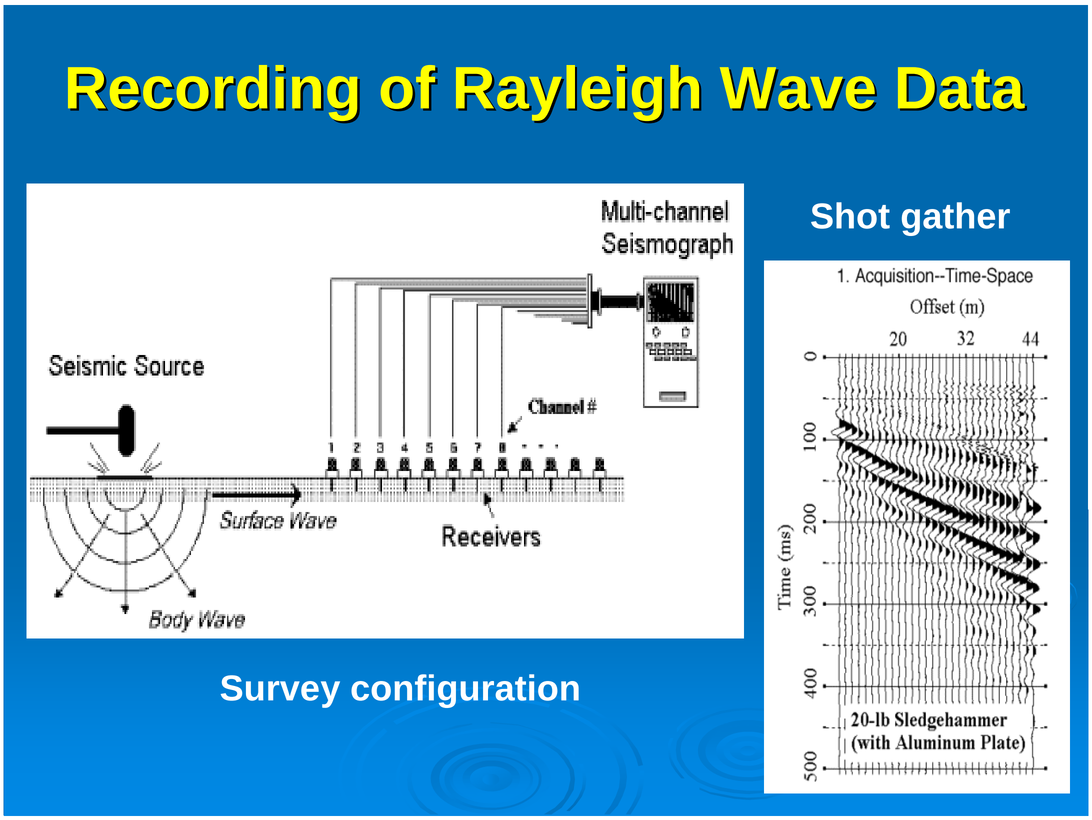


Figure 8: The MASW data were acquired using a 24-channel reflection seismograph, 4.5 Hz geophones and a near-offset of 20 to 30 ft. The example field record consists of 44 traces.

The 1-D shear-wave curves, generated for each traverse, were used to generate 2-D shear-wave velocity profile for that traverse (Figure 10). MASW profile E is presented as Figure 10 in order to illustrate the strengths and limitations of the MASW subsurface imaging technique.

In a general sense, MASW profile E, and the other MASW profiles, correlate reasonably well with the corresponding resistivity profiles. More specifically, shear-wave velocities values on MASW profiles are higher where the subsurface is more resistive (bedrock) and lower where the subsurface is more conductive (soils and clays). However, MASW profile lacks the lateral and vertical resolution provided by the corresponding resistivity profile. In terms of lateral and vertical resolution, the resistivity profile is far superior.

Figure 9: A 20 pound sledge hammer was used as an acoustic source.

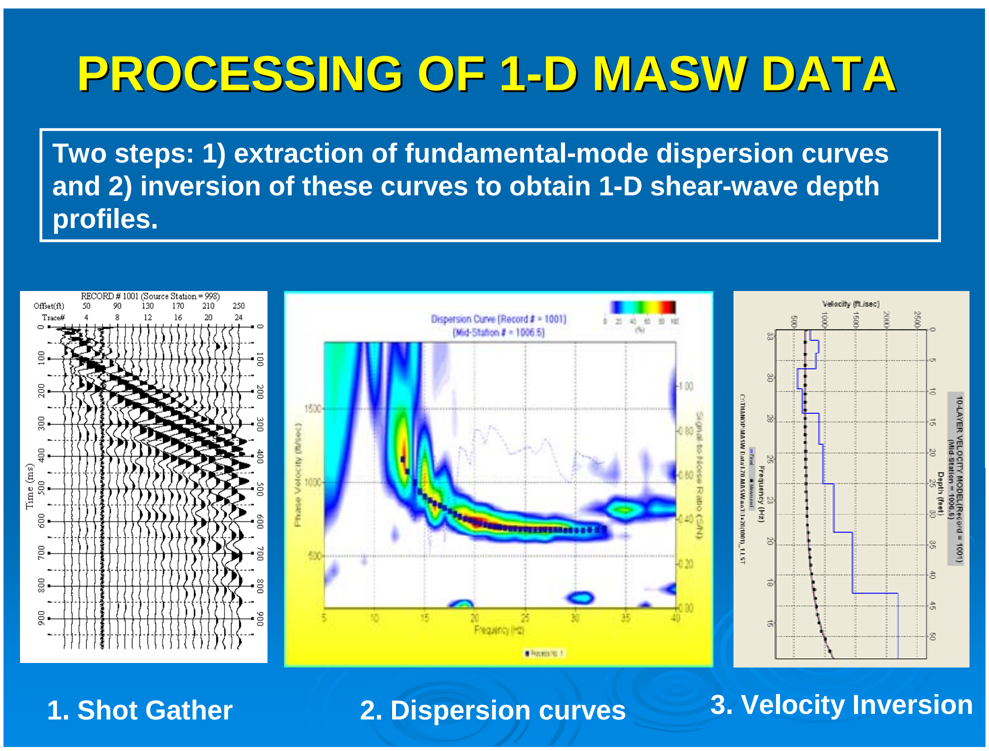


Figure 10: A 1-D shear-wave velocity curve was generated for each MASW field record.

Unfortunately, the resolution provided by the MASW tool cannot be significantly increased by simply acquiring more closely spaced 1-D profiles, as the output 1-D velocities would still be averaged over lateral distances of between 25 and 55 ft. Lateral resolution could be increased by decreasing the geophone spacing however this would result in less depth penetration.

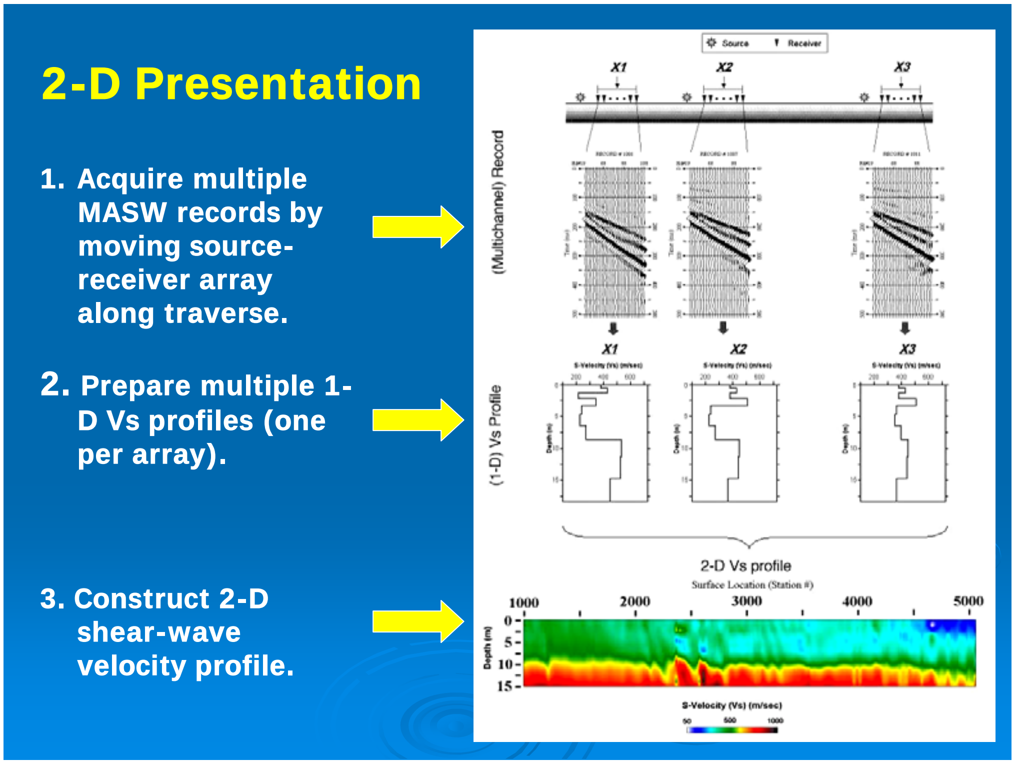


Figure 11: The 1-D shear-wave velocity curves acquired along each traverse were used to generate a 2-D shear-wave profile for that traverse.

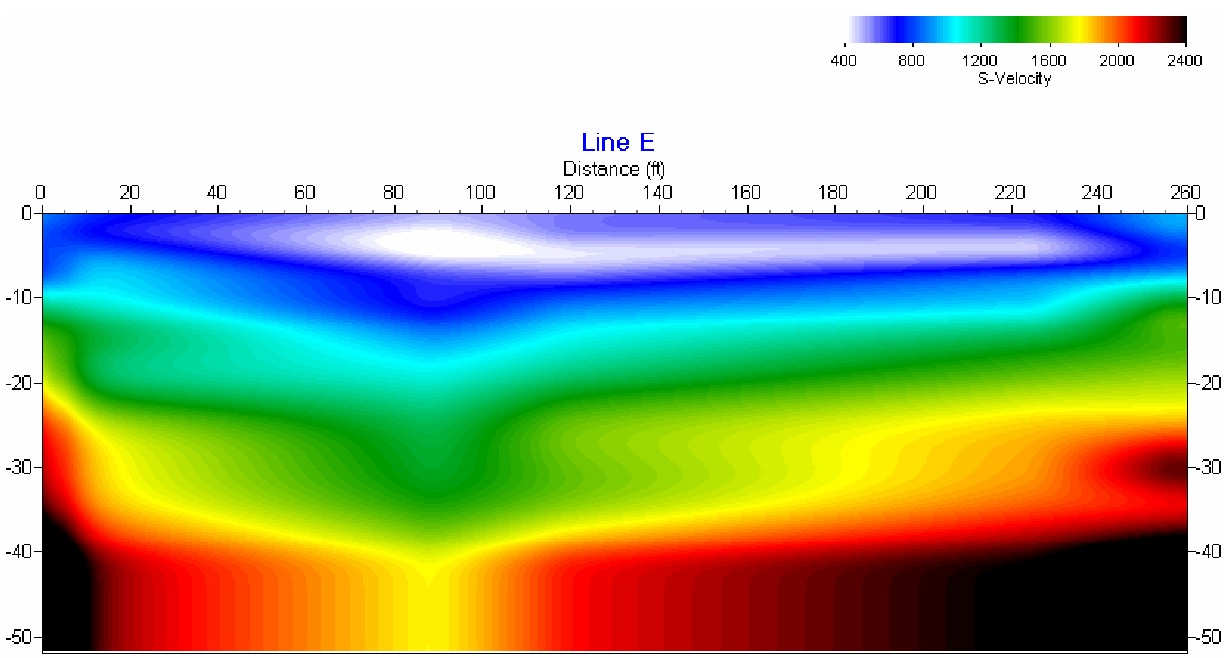


Figure 12: MASW profile E (vertical scale is in ft).

The bottom line is that electrical resistivity is a better tool for mapping depth to bedrock and differentiating rock from clay in the study area. Additionally, relative to resistivity data, MASW data are more expensive to acquire, process and interpret. Unless the determination of average shear-wave velocity profiles is critical, we do not recommend the acquisition of additional MASW control.

Conventional Seismic Refraction Data: As per verbal authorization from FMSM personnel, conventional seismic refraction field data were acquired using an RAS 24-channel engineering seismograph, 14 Hz geophones spaced at 5 ft intervals, and a sledge hammer (acoustic) source impacted on an aluminum plate placed at five station locations along each geophone array (Figure 13). The five field records acquired for each 24-geophone array were processed using commercially available SIP software. The output, in each case, was a simple, 2-layered, 2-D velocity/depth profile of the subsurface. For example, refraction profile I is shown as Figure 14.

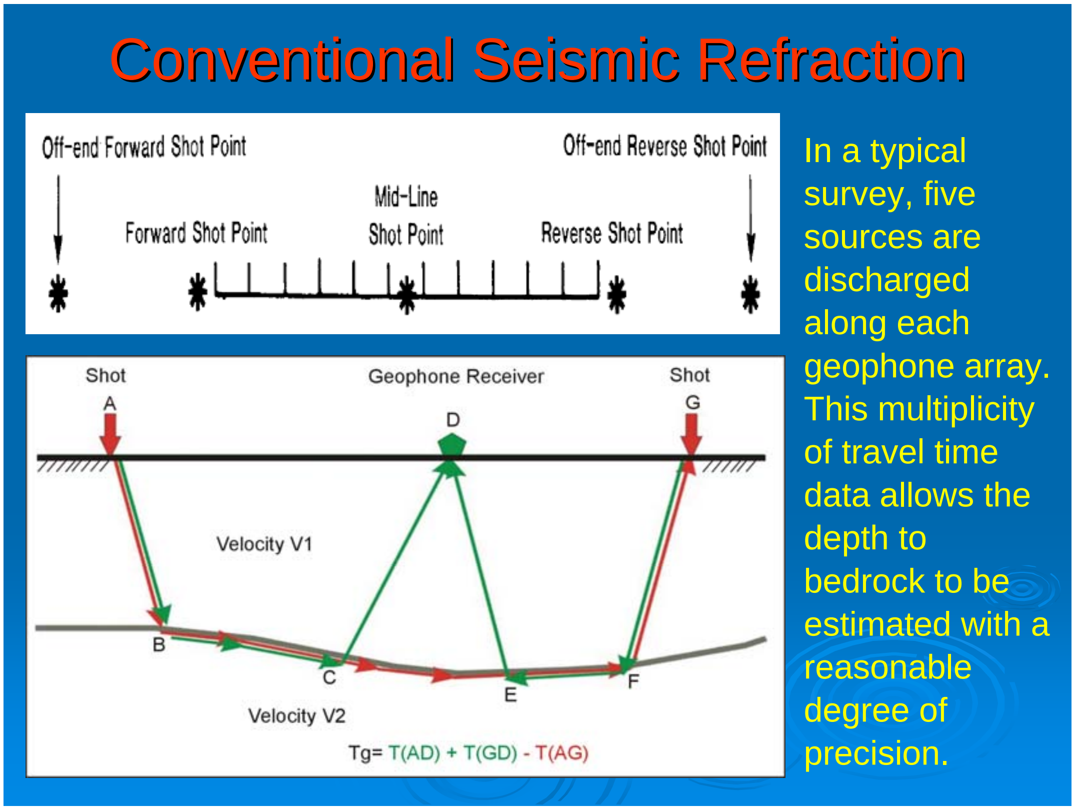


Figure 13: Typically, acoustic sources are discharged at five locations along each geophone array.

In an effort to assess the accuracy of the acquired conventional seismic refraction control, these data were compared to available boring control.

Boring 15 is located approximately 25 ft to the south of station 140 on refraction profile I (Figure 14). The estimated depth to bedrock at station 140 on refraction profile I is ~10 ft. This is consistent with both the proximal boring B-15 which encountered bedrock at a depth of 8.7 ft (Figure 2) and the corresponding resistivity control.

Boring B-15 is also located about 40 ft to the north of station 180 on refraction profile H. The estimated depth to bedrock at station 180 on refraction profile H is ~12 ft. This depth estimate is consistent with proximal boring B-15 which encountered bedrock at a depth of 8.7 ft (Figure 2), and the corresponding resistivity control. We note that depth to bedrock on refraction profile H is suspect in places because refracted events may have been generated from the rock face of road cut in places (as opposed to having been generated from bedrock vertically beneath traverse H).

Boring B-2 ties refraction profile A near station 140 (Figures 2 and 15). Depth to bedrock at station 140 on refraction profile A is approximately 9 ft. This depth estimate is consistent with proximal boring B-15 which encountered bedrock at a depth of 8.7 ft (Figure 2). We note that bedrock on refraction profile H is anomalously low between stations 40 and 100, and that bedrock along this segment of refraction profile H was assigned an anomalously low velocity (~4500 ft/s). This suggests that the upper limestone unit between stations 40 and 100 is absent, thin or extensively fractured. (This interpretation is consistent with the interpretation of electrical resistivity profile A.)

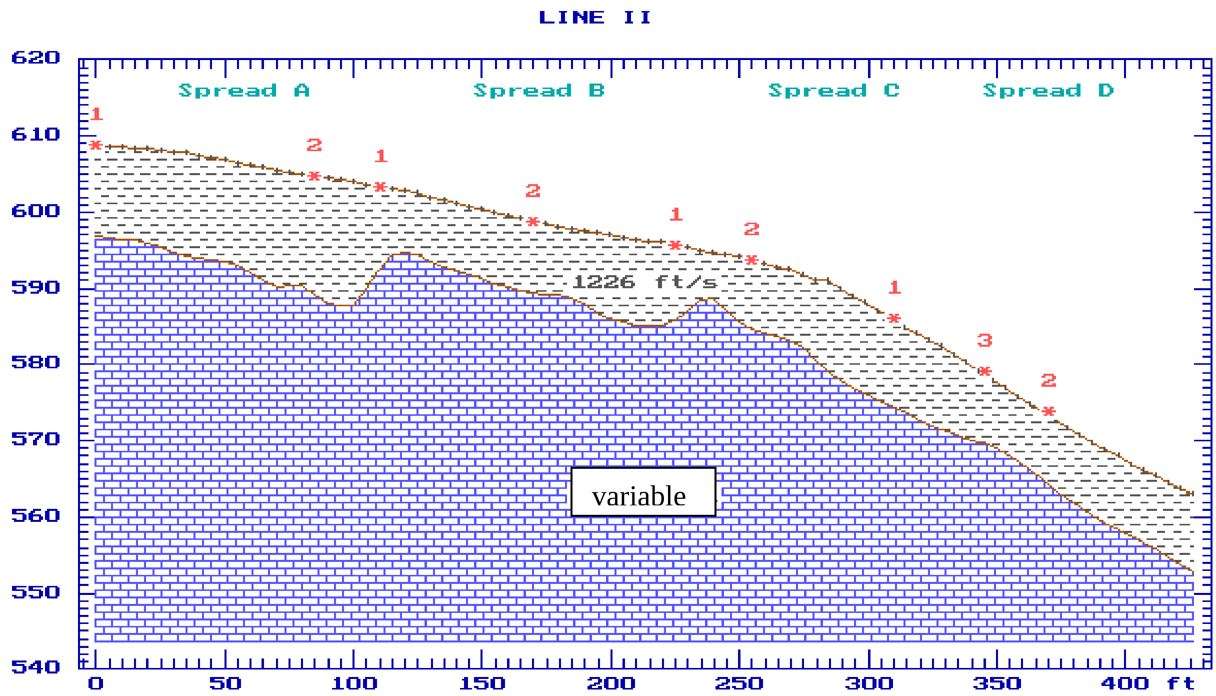


Figure 14: Refraction profile I. Velocity of bedrock varied from spread to spread.

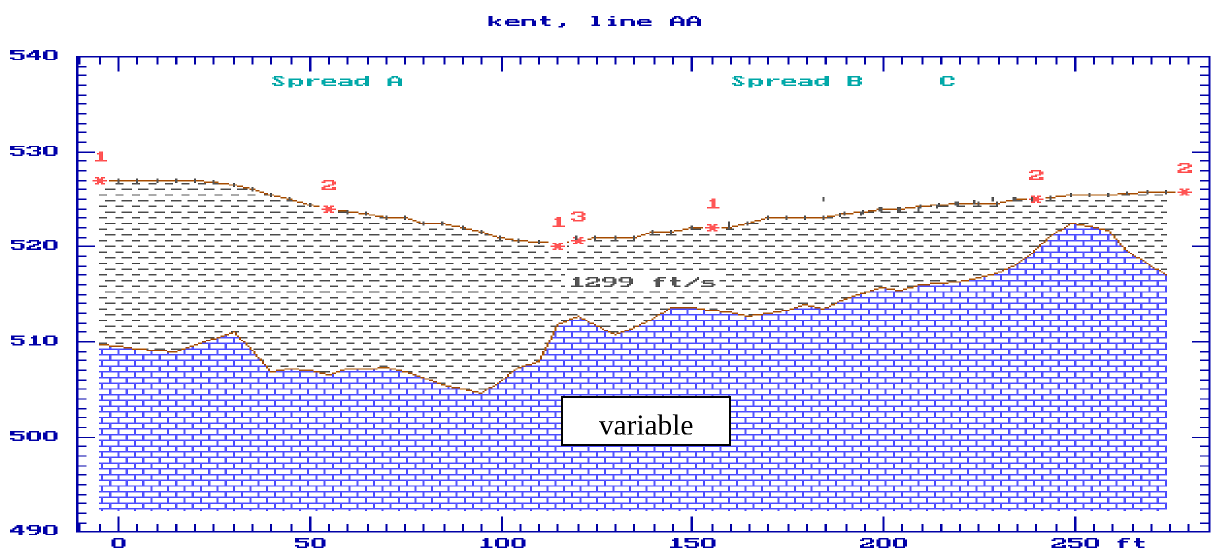


Figure 15: Refraction profile B. Velocity of bedrock varied from spread to spread.

Boring B-7 is also located about 20 ft to the east of station 130 on refraction profile E. The estimated depth to bedrock at station 130 on refraction profile E is ~5 ft. This is consistent with both proximal boring B-7 which encountered bedrock at a depth of 3 ft (Figure 2) and the corresponding resistivity control.

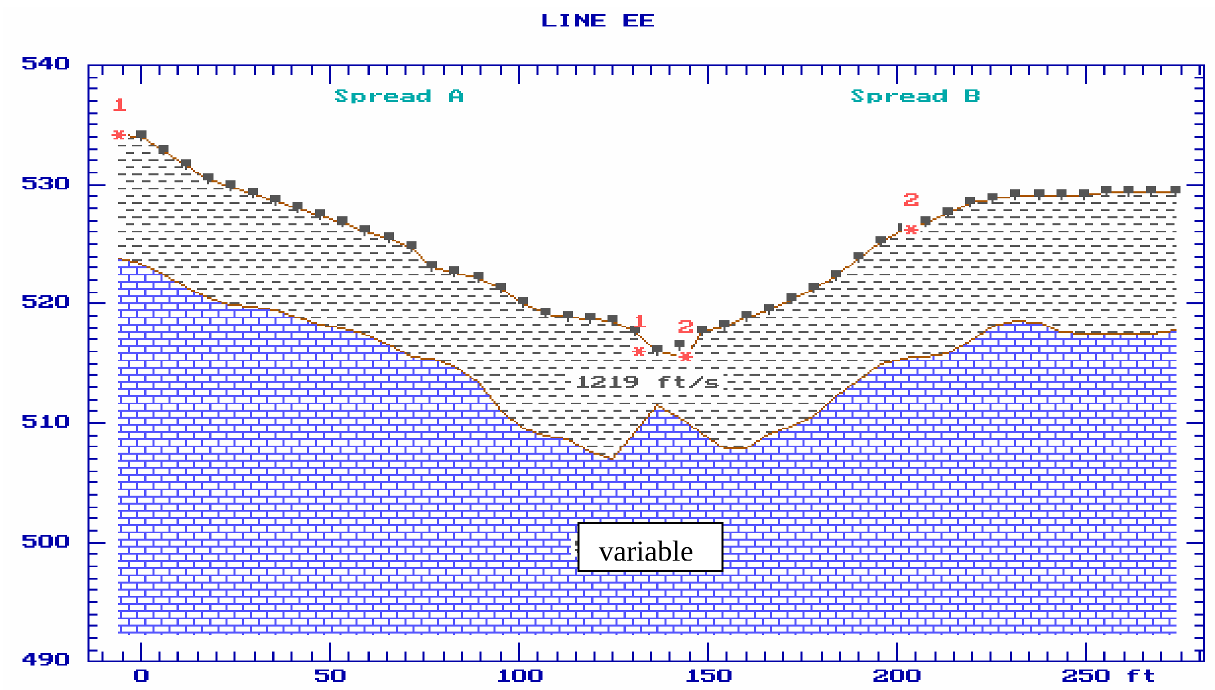


Figure 16: Refraction profile E. Velocity of bedrock varied from spread to spread.

The estimated depths to bedrock on refraction profiles A, E, H and I correlate reasonably well with both proximal boring control and corresponding resistivity control. In our opinion, the most significant difference between the two refraction and resistivity profiles is that the later more accurately image heterogeneities within bedrock and the soil. Indeed, because of the limited number of source locations employed during acquisition, the bedrock and soil on each segment of each refraction profile were assigned uniform acoustic velocities, even though we know the velocities of the rock and soil vary both vertically and laterally because of changes in lithology, moisture, compaction and the presence of joints, fractures, clay seams and weathering.

As evidenced by the degree of correlation between boring and refraction control, the conventional refraction tool is capable of providing reasonable depths to bedrock in the study area, and hence is very useful. However, the utility of the refraction method could be significantly increased if a greater number of sources were discharged along the length of each geophone array and if these data were processed using tomographic imaging software instead on conventional refraction software. The output subsurface models would show lateral and vertical velocity variations, and even velocity inversions (Figure 17).

The pilot study demonstrated that quality refraction data can be acquired in the study area. We recommend the acquisition of additional refraction control during any subsequent study. However, because of the complexity of bedrock, we recommend the acquisition of refraction (surface) tomography data (as opposed to conventional refraction control). Additionally, we recommend that sources be discharged off-line so that 3-D swath images of the subsurface can be generated (Figure 18).

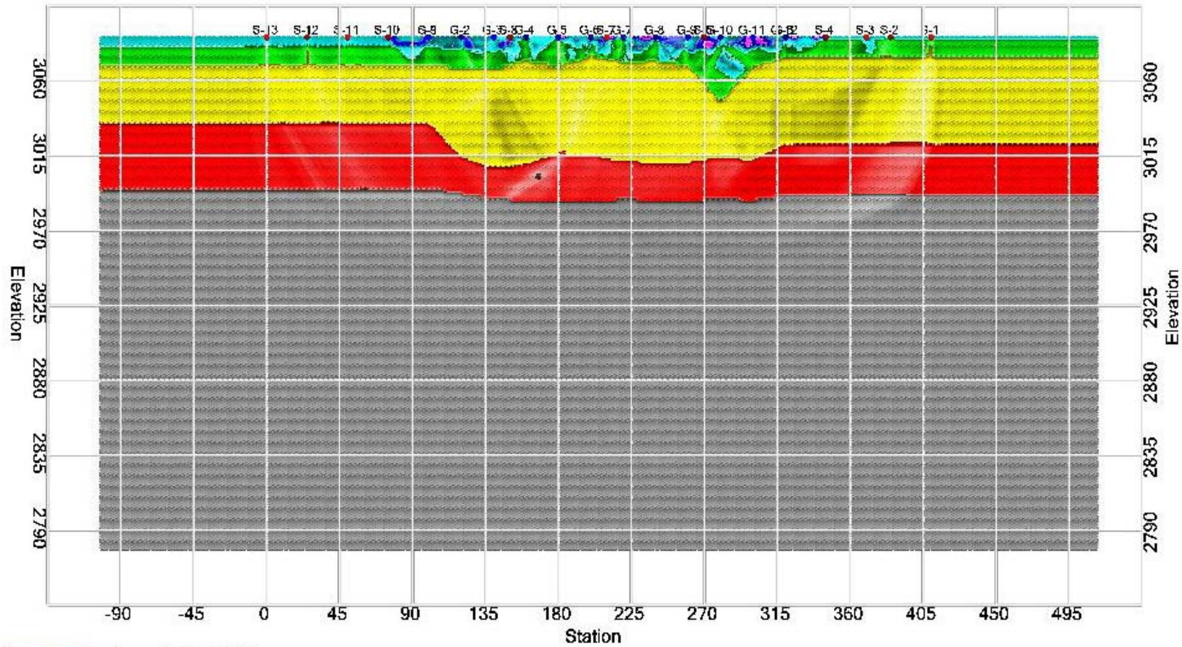


Figure 17: Example refraction tomography profile. Lateral and vertical velocity variations and velocity inversion are incorporated into this basic model.

The result is not simply an image. It's calibrated ground simulation.

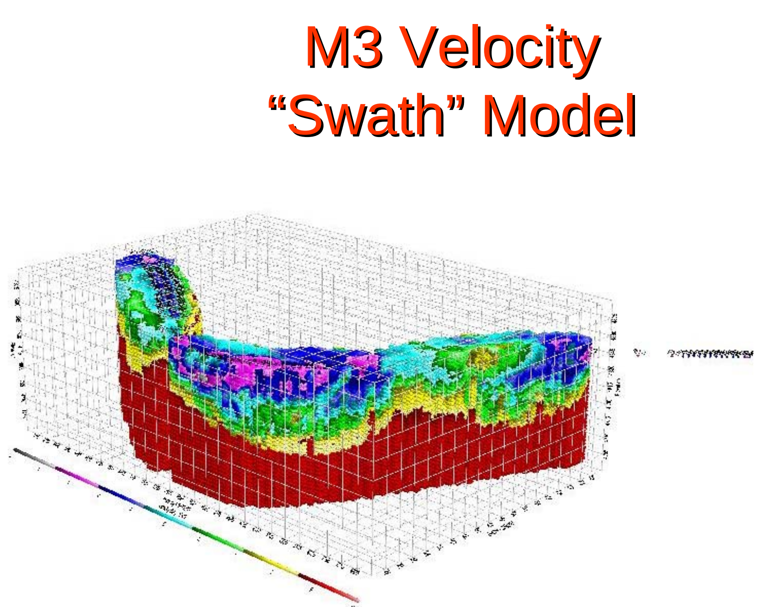


Figure 18: Example 3-D (swath) refraction tomography profile. Lateral and vertical velocity variations, and velocity inversions, are incorporated into this basic model.

Sources can be discharged off-line, allowing 3-D (swath) images of the subsurface to be generated.

Ground Penetrating Radar Data (GPR): As per the "Mapping Program Document", GPR data were acquired along each of the traverses using a GSSI SIR 10-B system equipped with a 200 MHz antenna (Figure 19). A spatial sampling rate of two radar traces per inch was employed. The GPR data were processed using the commercially available software package Reflex. Every effort was made to acquire quality data in the field and to enhance any continuous reflections during data processing. For example, GPR profile B is presented as Figure 15.

Unfortunately, probably because conductive clay in the soil absorbed the electromagnetic signal emitted by the 200 MHz antenna, bedrock could not be confidently identified and/or mapped on the GPR profiles. Given the extensiveness of signal attenuation, it is highly doubtful that superior results would be obtained using a lower frequency source antenna. Therefore we do not recommend that GPR data be acquired on the Drumanard Estate during any subsequent geophysical investigations.

Figure 19: GPR data were acquired using a GSSI SIR 10B system equipped with a 200 MHz antenna.

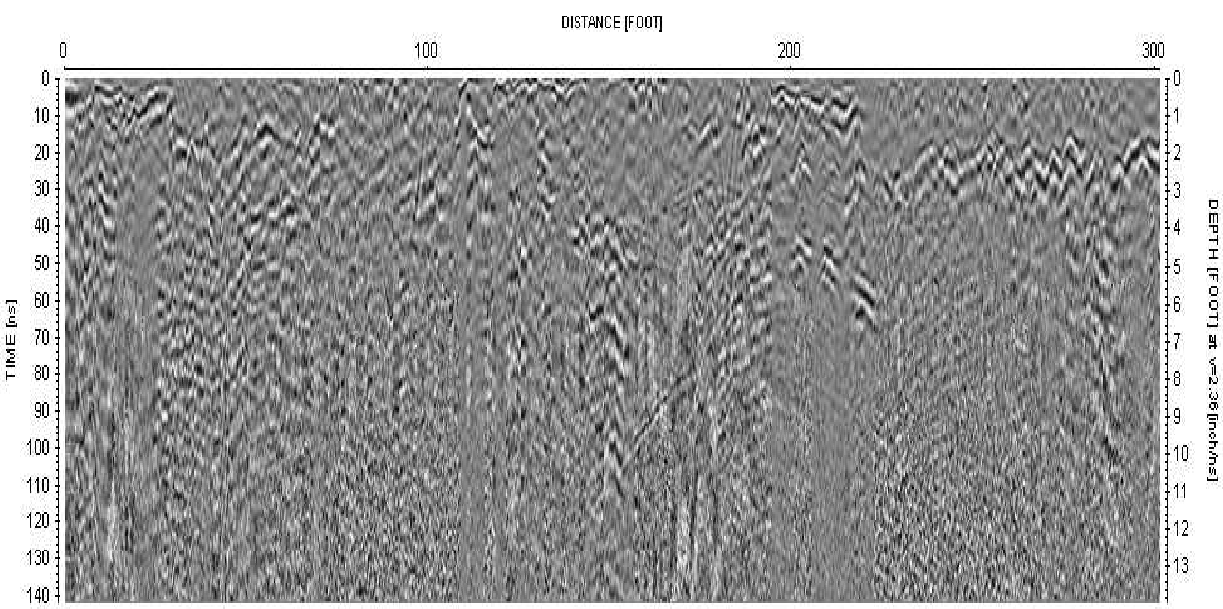


Figure 20: GPR profile B. Bedrock could not be confidently identified on the GPR profiles, probably because of the presence of overlying clay which absorbed the pulsed electromagnetic radiation emitted by the 200 MHz antenna.

Self-Potential Data (SP): As per the "Mapping Program Document" and personnel directives from FMSM personnel, two sets of SP data were acquired along each of the traverses using Model #920 023 non-polarizable electrodes and a voltmeter (Figure 21). One set of SP data were acquired along each traverse; a second set was acquired at stations located 5 ft off the traverse (Figure 22). The trailing electrode was coupled to the base station; the lead electrode was moved along the length of the traverses at 10 ft intervals.

Figure 21: Non-polarizable Model #920 023 electrodes.

The SP tool is unique because it is the only geophysical method that responds directly to the presence of flowing/seeping water (into the subsurface). Locations where water is flowing/seeping into the ground are typically characterized by prominent negative anomalies; locations where water is flowing/seeping out of the ground are normally characterized by prominent positive anomalies.

The SP data acquired along traverse B decreases in value gradually from right to left (Figure 22). The absence of any prominent positive or negative anomalies across this profile probably indicates that water is neither flowing into or out of bedrock anywhere along this profile. In contrast, a prominent negative anomaly is observed on SP profile D (Figure 23). This prominent anomaly on SP profile D is located above a topographic low which appears to be a natural surface drainage pathway. It is also located above a prominent resistivity anomaly which is interpreted as a solution-widened "fracture/joint zone" (see section on resistivity). Similar prominent negative SP anomalies are also observed on SP profiles D-1, D-2, C-1 and C-2 (Figure 2), and are interpreted as indicative of water flowing/seeping vertically into bedrock. We note that a prominent SP anomaly is not observed on SP profiles E-1, E-2, F-1 or F-2 (Figure 2). Initially, this was somewhat surprising inasmuch as traverses B, C, D, E and F are parallel and closely spaced.

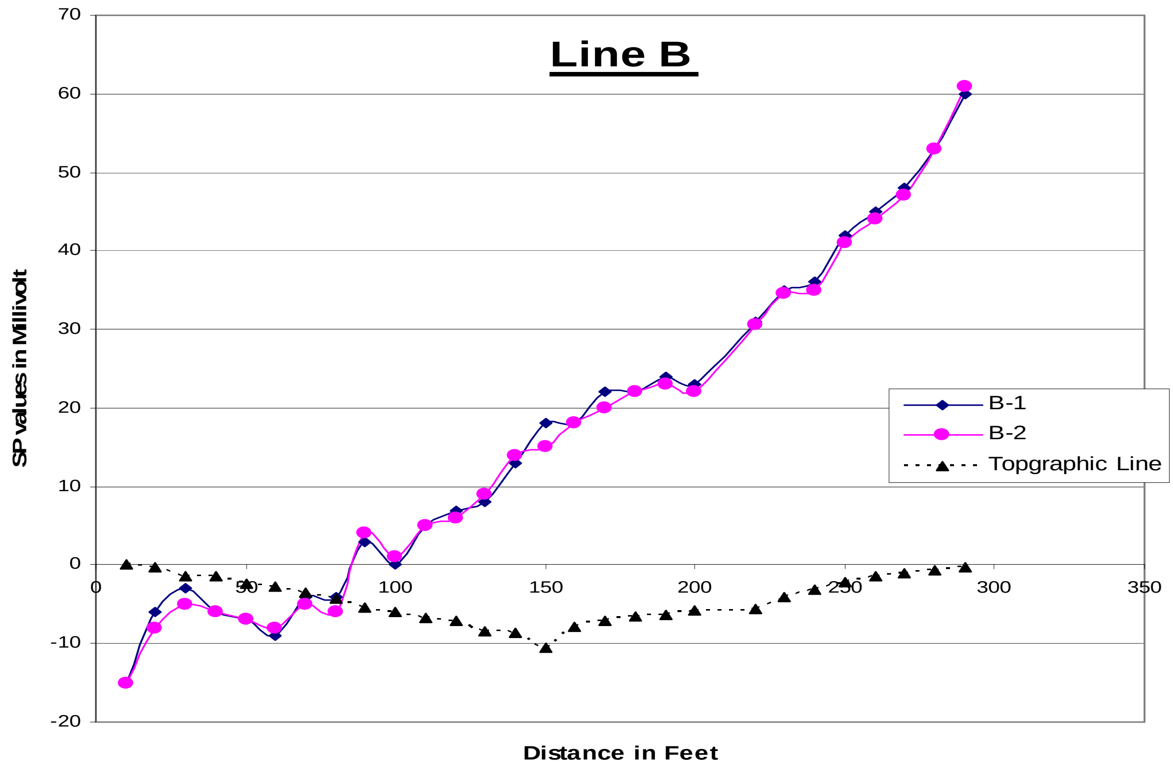


Figure 22: Two sets of SP data were acquired along each of the traverses. One set of SP data (set 1) were acquired along each traverse; a second set (set 2) was acquired at stations located 5 ft off the traverse. Topographic data has been superposed on the profile for reference purposes.

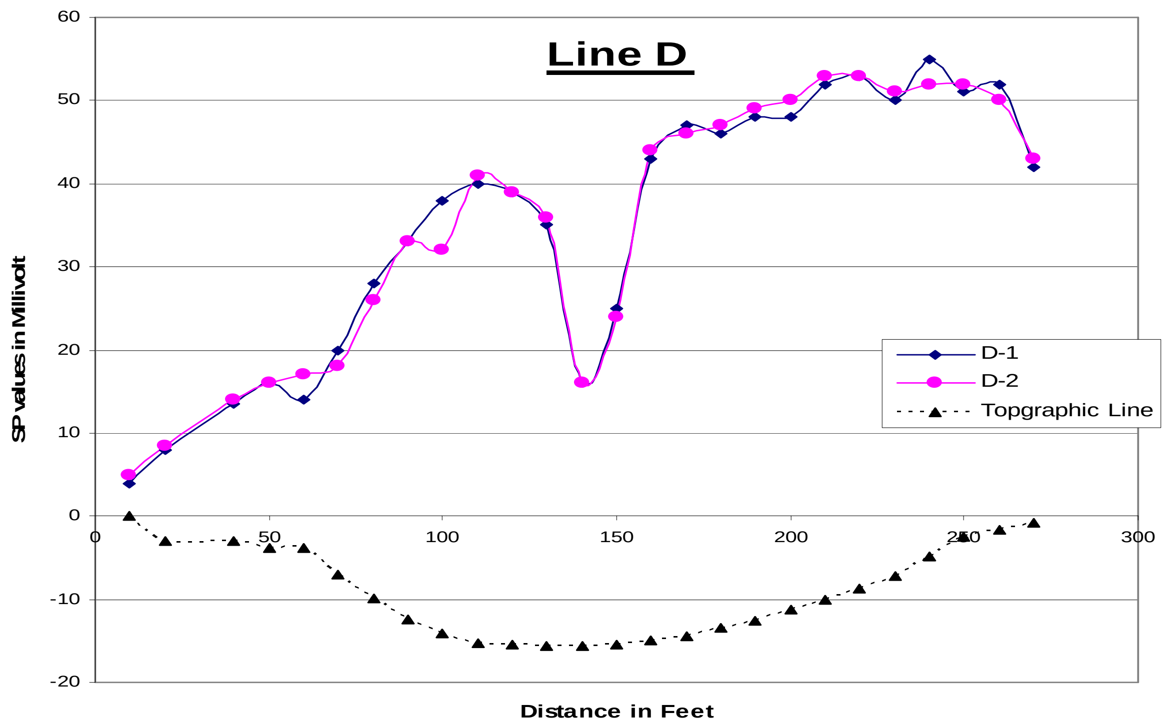


Figure 23: A prominent negative anomaly is observed on SP profiles D-1 and D-2. These anomalies are attributed to the flow of water into bedrock at these locations.

Our explanation for the absence of a prominent SP anomaly of SP profiles E-1, E-2, F-1 and F-2 is as follows. As noted in the discussion of the acquired resistivity data, resistivity profiles A, B, C and D image what is interpreted as a linear solution-widened "fracture/joint" zone. The prominent electrical resistivity anomaly associated with this interpreted "fracture zone" does not extend onto either resistivity profile E or F. A plausible explanation for the presence/absence of a pronounced SP anomaly on adjacent traverses, is that water is flowing/seeping into bedrock beneath traverses B and C along a fractured fluid conduit, but that this conduit is not present (or not as hydraulically conductive) beneath traverses E and F (or was not as active when the SP survey was conducted).

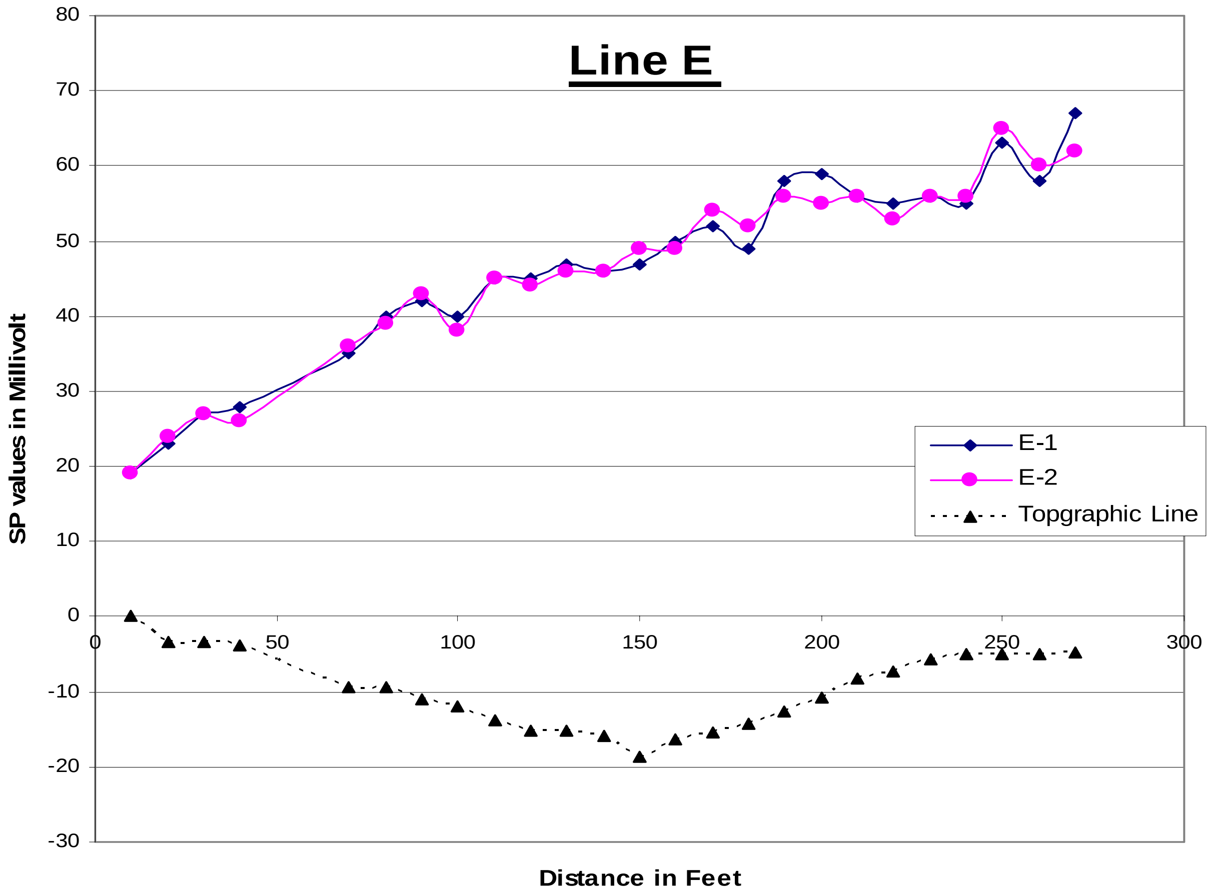


Figure 24: A prominent negative anomaly is observed on SP profiles E-1 and E-2. These anomalies are attributed to the flow of water into bedrock at these locations.

In summary, SP data are relatively inexpensive to acquire and process, and can be used to locate zones where near-surface waters (within the soil) flow/seep into bedrock (presumably through fractures within karsted bedrock). If information about the location of fractured conduits is critical, we recommend the acquisition of SP data on the Drumanard Estate.

As indicated on SP profiles B-1 and B-2, the SP anomalies can be relatively narrow. SP data should therefore be acquired at station spacings of no less than 10 ft, along traverses spaced at intervals of no more than 20 ft.

Gravity Data: As per the "Mapping Program Document", gravity data were collected using a Lacoste and Romberg model G gravity meter, at station spacings of 10 or 20 ft. (The "Mapping Program Document" specified a 20 ft station spacing, however gravity data were acquired along several traverses using a 10 ft station intervals for comparison purposes.) At each station, the meter was leveled and at least two readings were recorded to an accuracy of 0.005 gravity meter units. The first station on each profile was used as a base station, where a reading was taken every one hour in order to determine the instrumental drift of the meter which varied between 0.02 and 0.005 gravity units.

The field data were processed into complete Bouguer gravity anomaly values. This process included removing from the field data instrumental drift variations, earth tide changes, and elevation and latitude variations using values supplied by surveying engineers. Bouguer gravity anomaly values were determined using a 2.67 gm/cm reduction density. Terrain corrections were applied using the method of Hammer for the zones A and B.

In an attempt to quantitatively estimate variable depth to bedrock along each traverse, a two and one-half dimensional gravity model was constructed for each profile. The elevations of each data point were used in the modeling. The density difference between the soil and limestone was estimated from density tables of average values for common rock types, but was varied slightly from traverse to traverse in an effort to obtain an optimum fit between the acquired gravity data and the output model (variable depth to bedrock only). Additionally, to determine the gravity effect due to the soil layer only, a constant gravity value along each profile was subtracted.

For evaluation purposes, the gravity profiles were compared to available boring control.

Boring 15 is located approximately 10 ft to the south of station 140 on gravity profile I (Figure 25). The estimated depth to bedrock at station 140 on gravity profile I is ~10 ft. This depth value is consistent with both proximal boring B-15 which encountered bedrock at a depth of 8.7 ft (Figure 2) and the corresponding resistivity and refraction control.

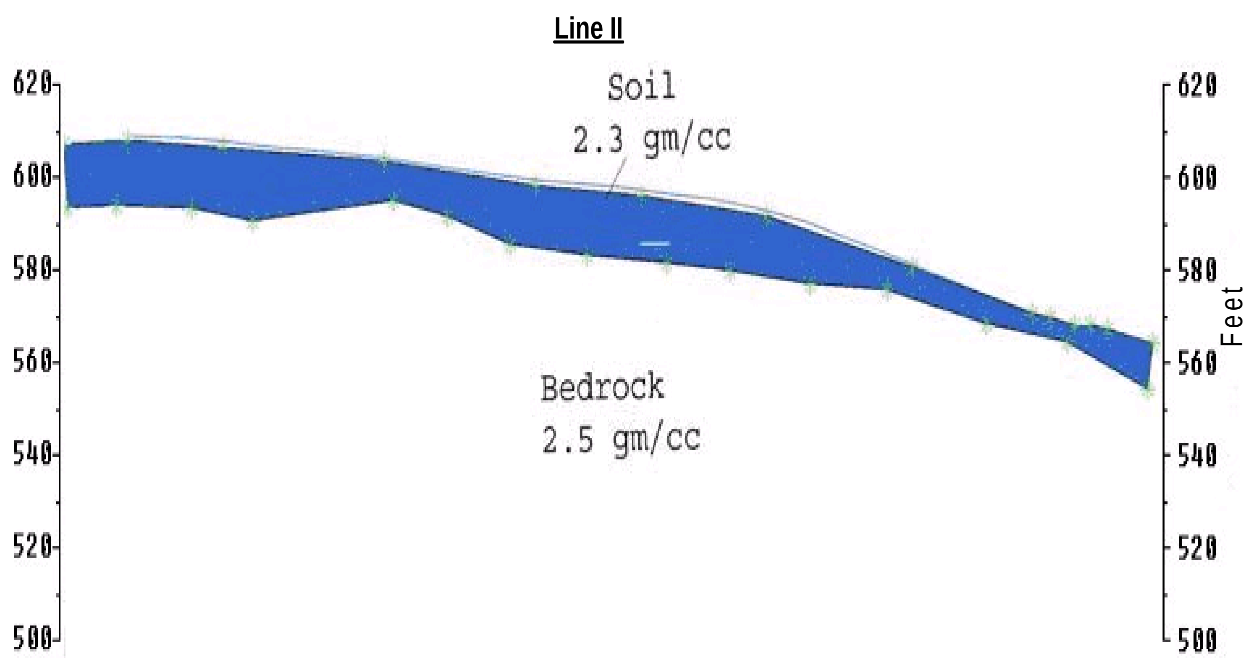


Figure 25: Gravity profile I.

Boring B-15 is also located about 40 ft to the north of station 180 on gravity profile H. The estimated depth to bedrock at station 180 on gravity profile H is ~15 ft. This depth estimate is greater than the depth to bedrock at proximal boring B-15 which encountered bedrock at a depth of 8.7 ft (Figure 2), but reasonably consistent with the corresponding resistivity (est. 12 ft) and refraction (est. 12 ft) control.

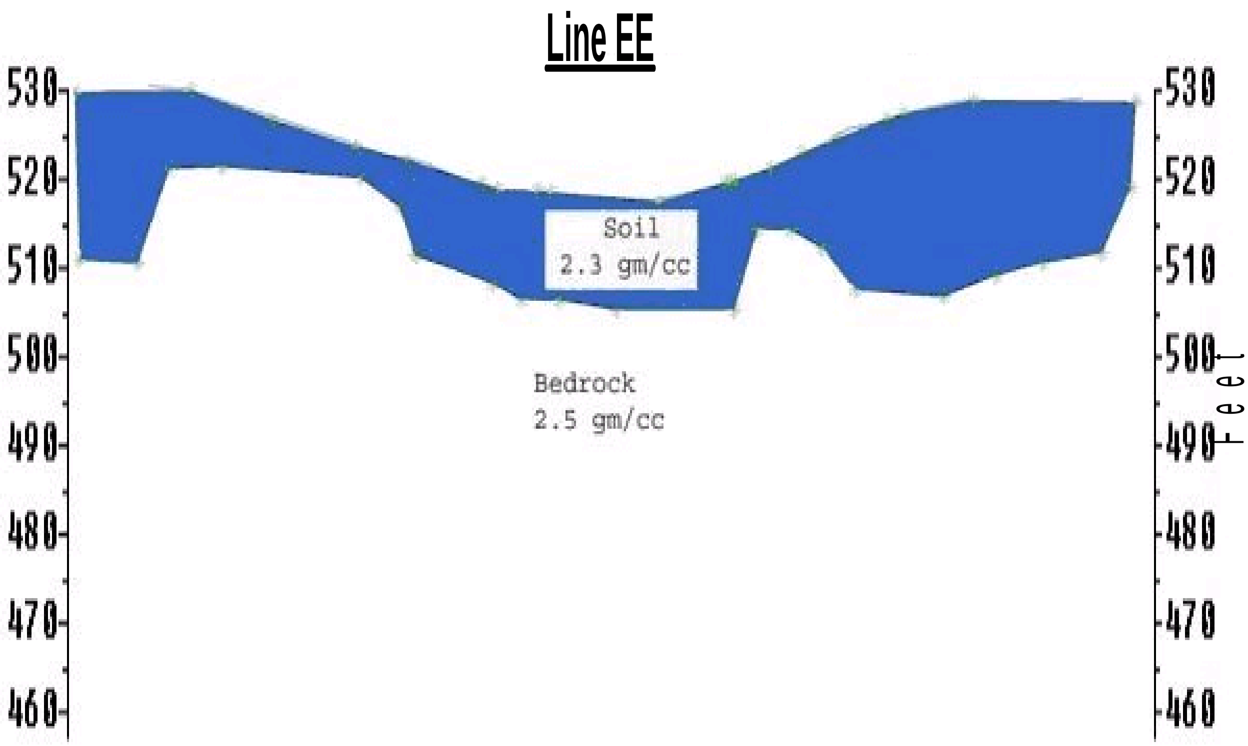


Figure 25: Gravity profile E.

Boring B-7 is located about 20 ft to the east of station 130 on refraction profile E. The estimated depth to bedrock at station 130 on gravity profile E is ~13 ft. This is inconsistent with proximal boring B-7 which encountered bedrock at a depth of 3 ft (Figure 2) and inconsistent with the corresponding resistivity and refraction control.

This inconsistencies between the gravity interpretations (re: depth to bedrock) and interpretations based on other control (boring data and resistivity and refraction data) is attributed to the fact that depth to bedrock was the only variable considered when the gravity data were interpreted. If the depth to bedrock along each traverse was not a variable (i.e. it was constrained by refraction or electrical resistivity control), the gravity data could be reinterpreted and used to estimate the shape, size, orientation and depth of density variations within the subsurface (due to voids, in-filled karst features, etc.).

In our opinion, gravity is of less utility as a reconnaissance tool than either electrical resistivity or seismic refraction because of the complex nature of the bedrock surface and bedrock. However, the gravity tool could be of significant utility, if constrained by resistivity and refraction control, and used to characterize any subsurface anomalies identified on reconnaissance-type geophysical data. We do not recommend the acquisition of reconnaissance-type gravity data. However we recommend that gravity control be acquired as necessary in an effort to delineate anomalies observed on other geophysical data sets.

3. SUMMARY AND RECOMMENDATIONS

Six independent geophysical data sets were acquired along a total of nine traverses on two test sites immediately adjacent to the Drumanard Estate, Louisville, Kentucky (Figures 1 and 2) as part of a pilot program designed to field-test subsurface imaging technologies. The following six geophysical methods were employed and evaluated:

- electrical resistivity
- multi-channel surface wave (MASW)
- conventional seismic refraction
- ground-penetrating radar (GPR)
- self-potential (SP)
- gravity

The acquired geophysical data were processed, interpreted and evaluated in terms of their utility (with a view to characterizing soil and bedrock). A summary of the evaluation is presented in tabular form as Table 1. A summary of recommendations are presented as Table 2.

Geophysical Method	Reliability of estimated depth to bedrock	Horizontal and vertical resolution	Ability to detect and map fractures	Ability to differentiate rock and clay	Ability to locate flowing water	Ability to detect and map air-filled cavities
Electrical resistivity	**2**	**1**	**1**	**1**	**NA**	**1**
Conventional seismic refraction	**1**	**2**	**2**	**2**	**NA**	**4**
Self-potential (SP)	**NA**	**NA**	**NA**	**NA**	**1**	**NA**
Gravity	**3**	**3**	**3**	**3**	**NA**	**2**
Multi-channel surface wave (MASW)	**4**	**4**	**4**	**4**	**NA**	**3**
Ground-penetrating radar (GPR)	∞	∞	∞	∞	**NA**	∞

Table 1: Summary of comparative evaluations.

Based on our analyses of the acquired test geophysical data, we conclude:

- Seismic refraction (or refraction tomography) and electrical resistivity control will provide reliable and useful information about the depth to bedrock and the presence of karstic solutioning/indentation, including information about the depth/base to which the indentations extend and the nature of the in-fill sediment.
- Electrical resistivity control will provide information about the presence and location of any substantive air-filled voids.
- The self-potential data will provide qualitative information about the location of active water channels.

On the basis of the evaluation of the acquired geophysical data, we recommend that electrical resistivity data, seismic refraction (or refraction tomography) and self-potential data be acquired as part of any subsequent geophysical investigation of the Drumanard Estate. The electrical resistivity and seismic refraction (or refraction tomography) imaging technologies will provide cost-effective and useful information about soil lithology and thickness, and the nature of bedrock including the presence of joints, fractures, infill clays and air-filled voids. Self-potential data will provide information about seepage pathways within the shallow karsted bedrock.

Geophysical Method	Recommendations
Electrical resistivity	Electrical resistivity data should be acquired during any follow-up geophysical investigation of the Drumanard Estate. Because of the apparent complexity of the bedrock surface, electrical resistivity data should be acquired using an electrode spacing of 5 ft, with array lengths that allow for penetration depths on the order of 50 ft.
Conventional seismic refraction	The pilot study demonstrated that quality refraction data can be acquired in the study area. We recommend the acquisition of refraction control in any follow-up geophysical investigation of the Drumanard Estate. However, because of the complexity of the bedrock surface, we recommend the acquisition of refraction tomography data (as opposed to conventional refraction control). Additionally, sources could be discharged off-line as well, so that 3-D swath images of the subsurface could be generated.
Self-potential (SP)	SP data are relatively inexpensive to acquire and process, and can be used to locate zones where near-surface waters flow into bedrock (presumably through fractures within karsted bedrock). Because information about the location of fractured conduits is critical, we recommend the acquisition of SP data on the Drumanard Estate at station spacings of no less than 10 ft, along traverses spaced at intervals of no more than 20 ft.
Gravity	In our opinion, gravity is of less utility as a reconnaissance tool than either electrical resistivity or refraction tomography, primarily because of the complex nature of the bedrock surface and bedrock itself. However, the gravity tool could be of significant utility if used to constrain the interpretation of anomalies identified on other reconnaissance-type geophysical data. We recommend that gravity be acquired as necessary in an effort to elucidate anomalies observed on other geophysical data sets.
Multi-channel surface wave (MASW)	Electrical resistivity and seismic tomography provide better resolution than MASW. Unless the determination of "smoothed" subsurface shear-wave velocities is critical for design or construction purposes, we do not recommend the acquisition of additional MASW control.
Ground-penetrating radar (GPR)	Unfortunately, because conductive clay in the soil absorbed the electromagnetic signal emitted by the 200 MHz antenna, the bedrock surface could not be confidently identified and/or mapped on the GPR profiles. Given the extensiveness of signal attenuation, it is highly doubtful that superior results would be obtained using a lower frequency source antenna. Therefore we do not recommend that GPR data be acquired on the Drumanard Estate during any subsequent geophysical investigations.

Table 2: Summary of recommendations.

4. REFERENCES

FHWA, 2005, Application of Geophysical Methods to Highway Related Problems: http://www.cflhd.gov/agm/index.htm

5. INTRODUCTION TO APPENDIX A

Six independent geophysical data sets were acquired along a total of nine traverses in two test areas immediately adjacent to the Drumanard Estate, Louisville, Kentucky (Figures 1 and 2) as part of a pilot program designed to field-test subsurface imaging technologies. The following six geophysical methods were employed and evaluated:

- electrical resistivity
- multi-channel surface wave (MASW)
- conventional seismic refraction
- ground-penetrating radar (GPR)
- self-potential (SP)
- gravity

The complete geophysical data set is presented as Figures A1-A54 (pages A1-A54, respectively).

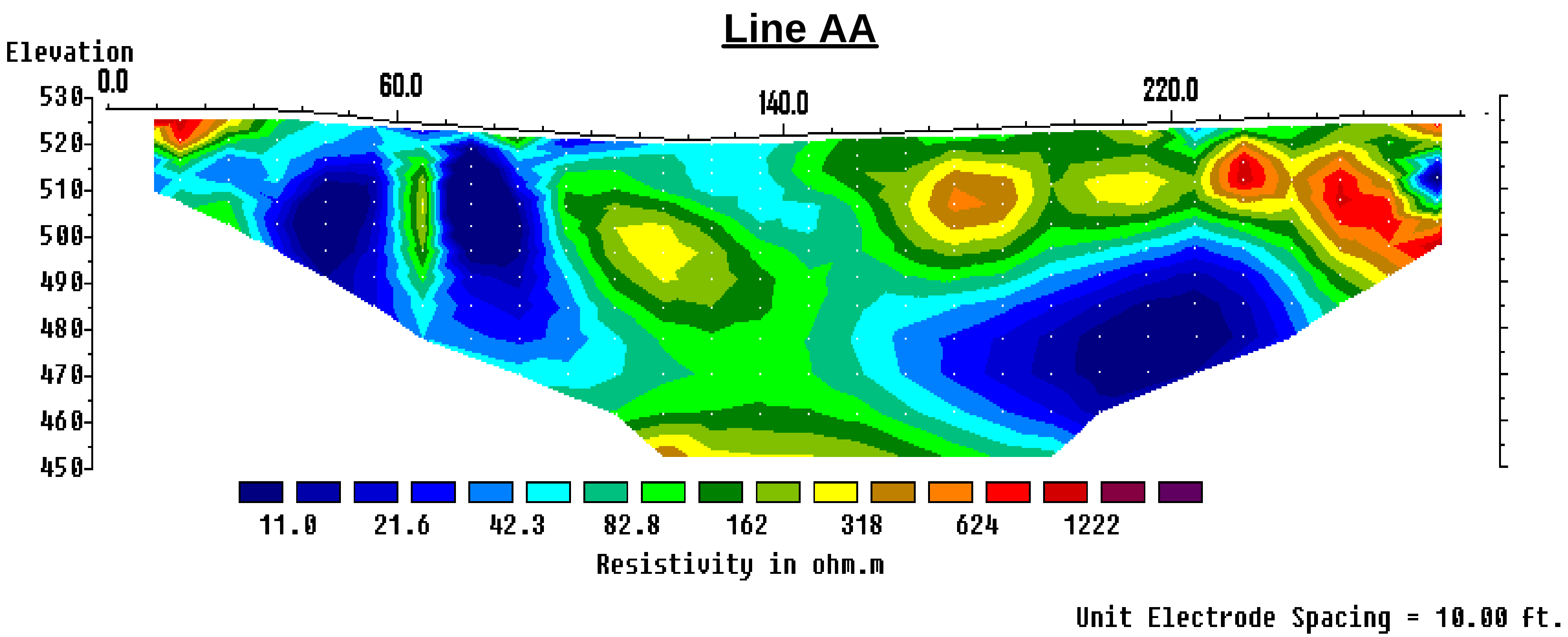


Figure A1: Electrical resistivty profile A. All distance/depth units are in feet.

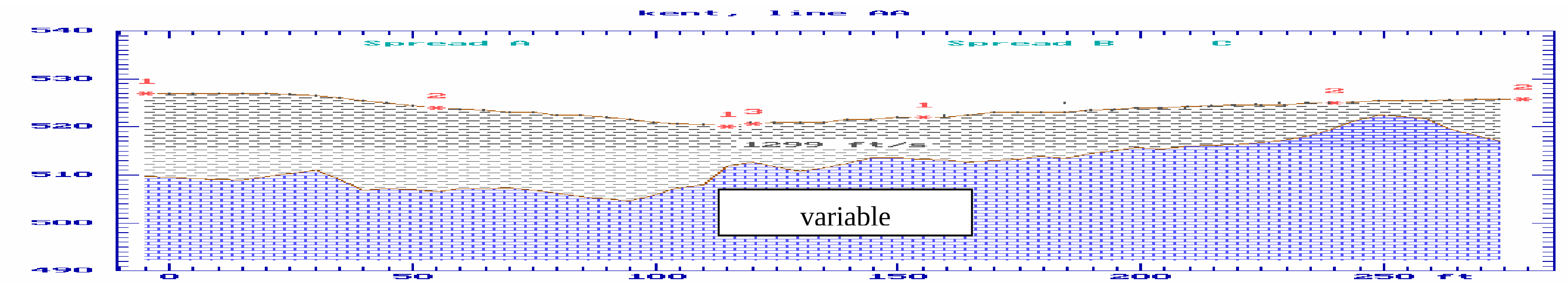


Figure A2: Seismic refraction profile A. All distance/depth units are in feet.

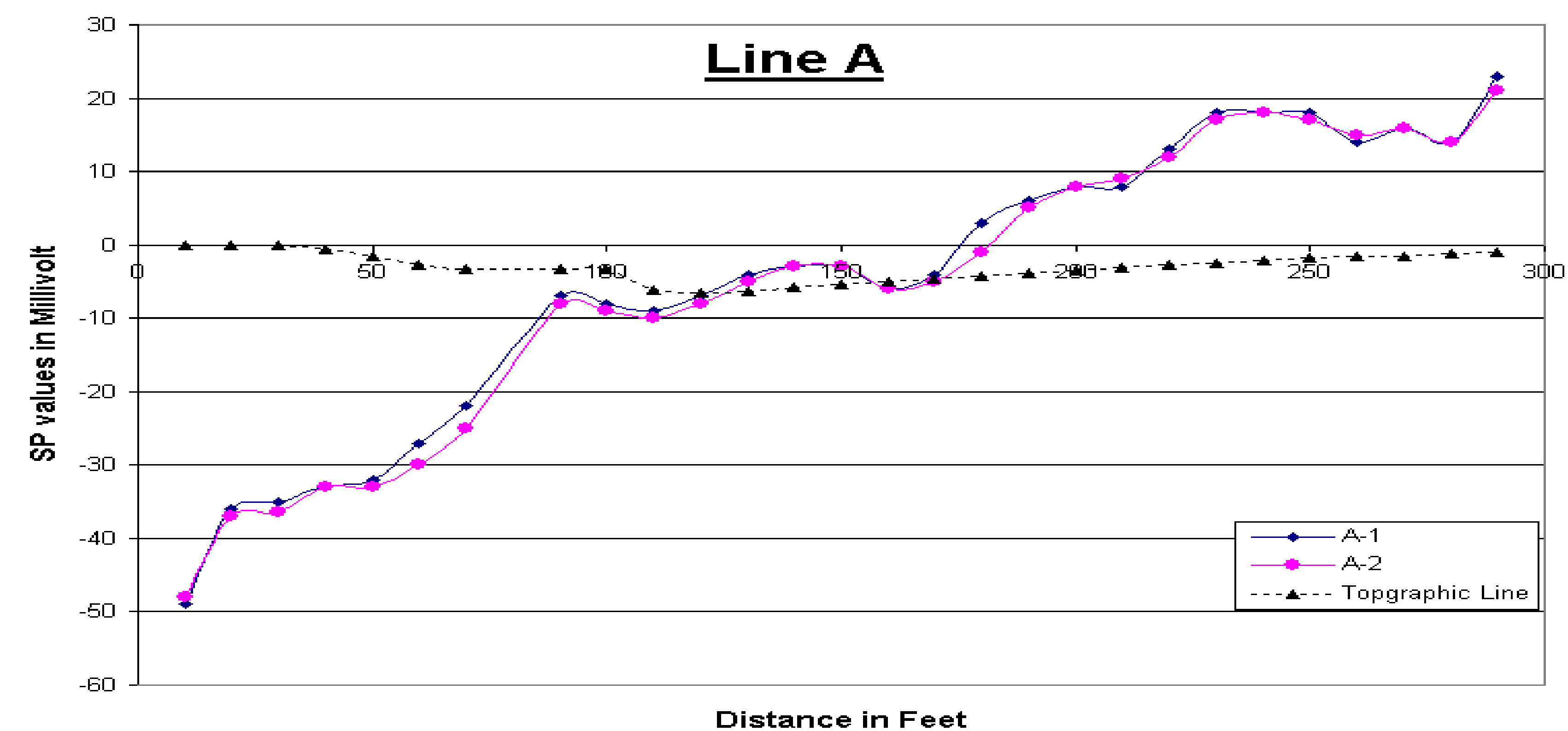


Figure A3: Self potential profile A. All distance/depth units are in feet.

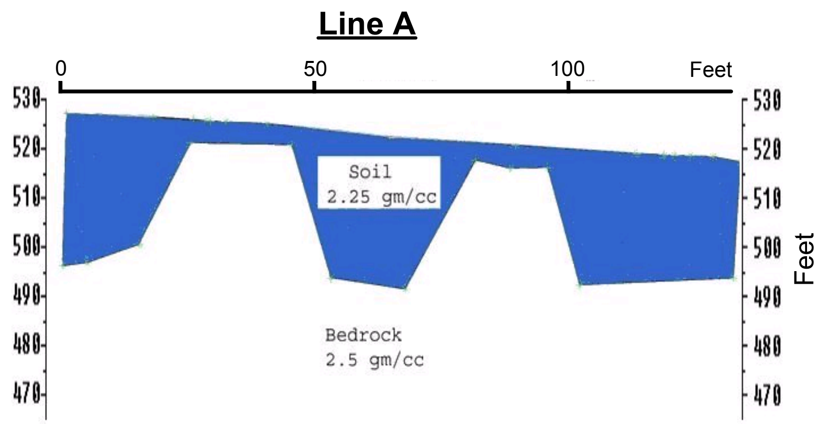


Figure A4: Gravity profile A. All distance/depth units are in feet. (Gravity profile A was truncated because many of the flags were removed from the traverse by the property owner.)

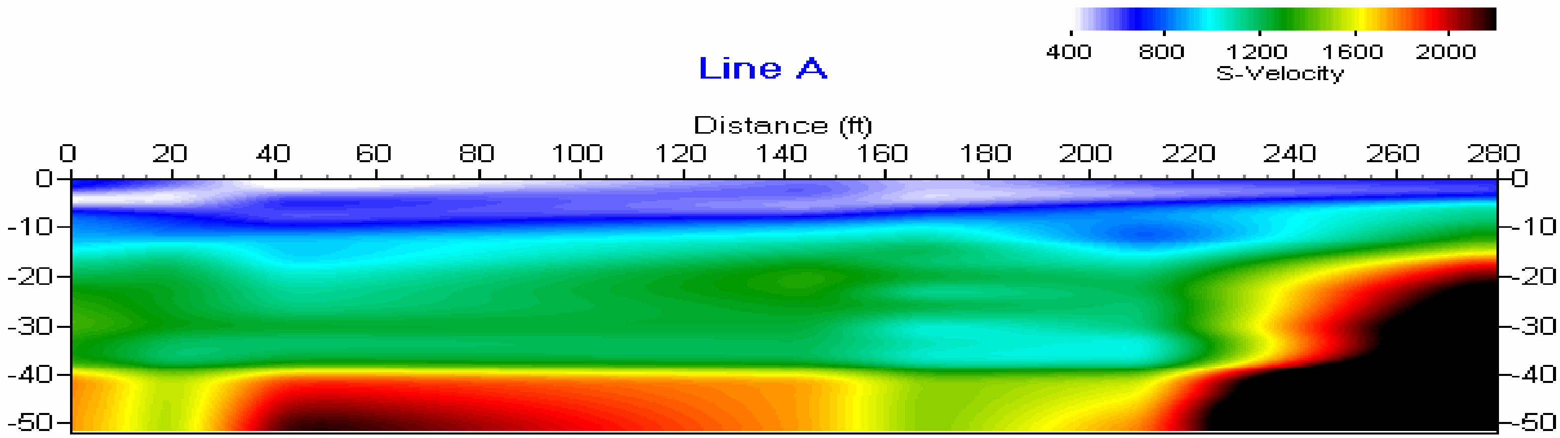


Figure A5: MASW profile A. All distance/depth units are in feet.

Line AA

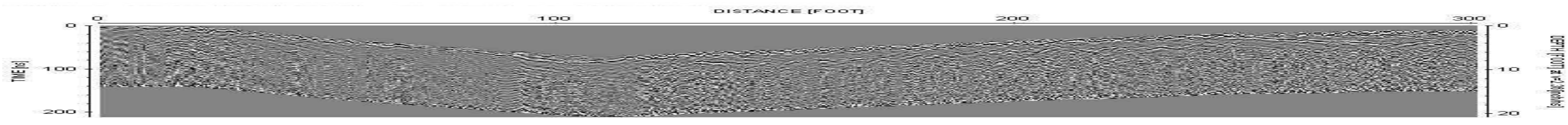


Figure A6: Ground penetrating radar profile A. All distance/depth units are in feet.

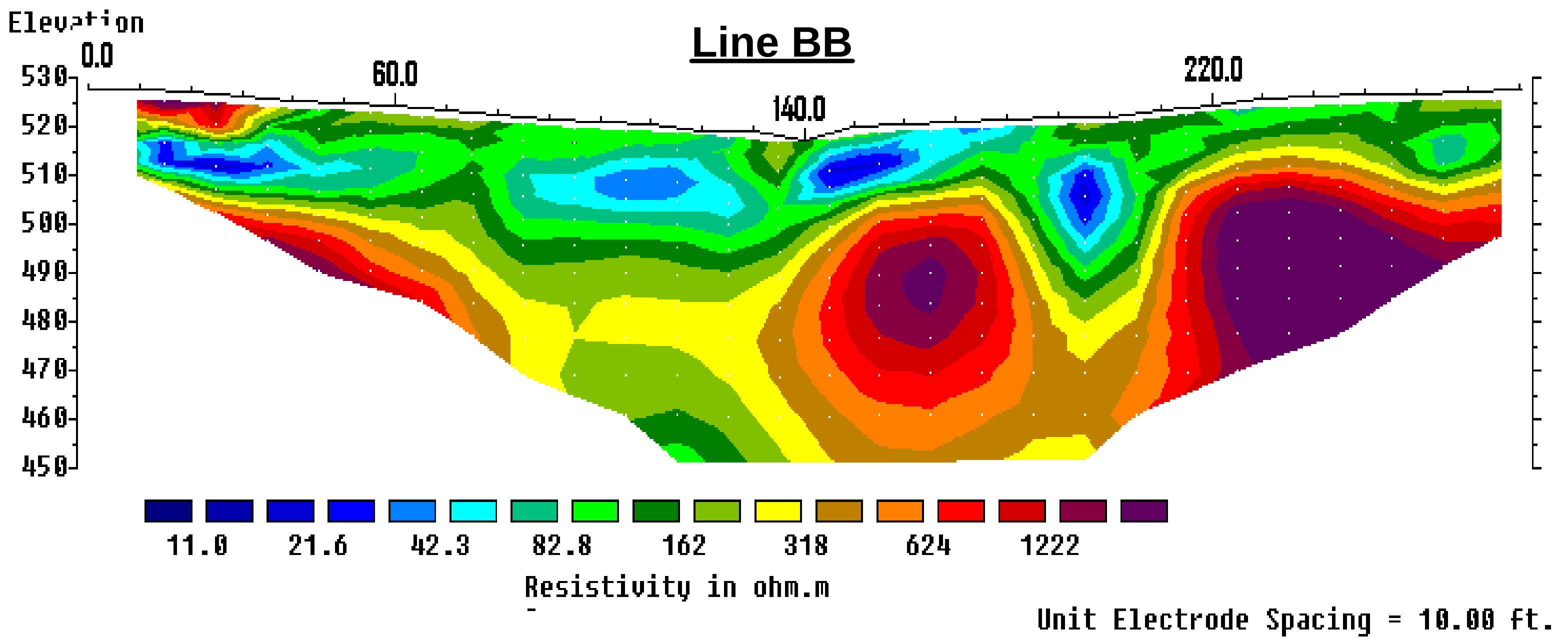


Figure A7: Electrical resistivty profile B. All distance/depth units are in feet.

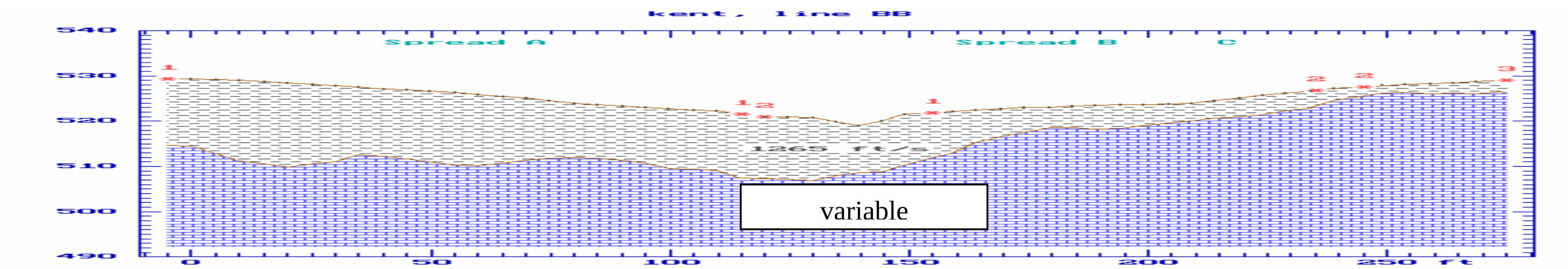


Figure A8: Seismic refraction profile B. All distance/depth units are in feet.

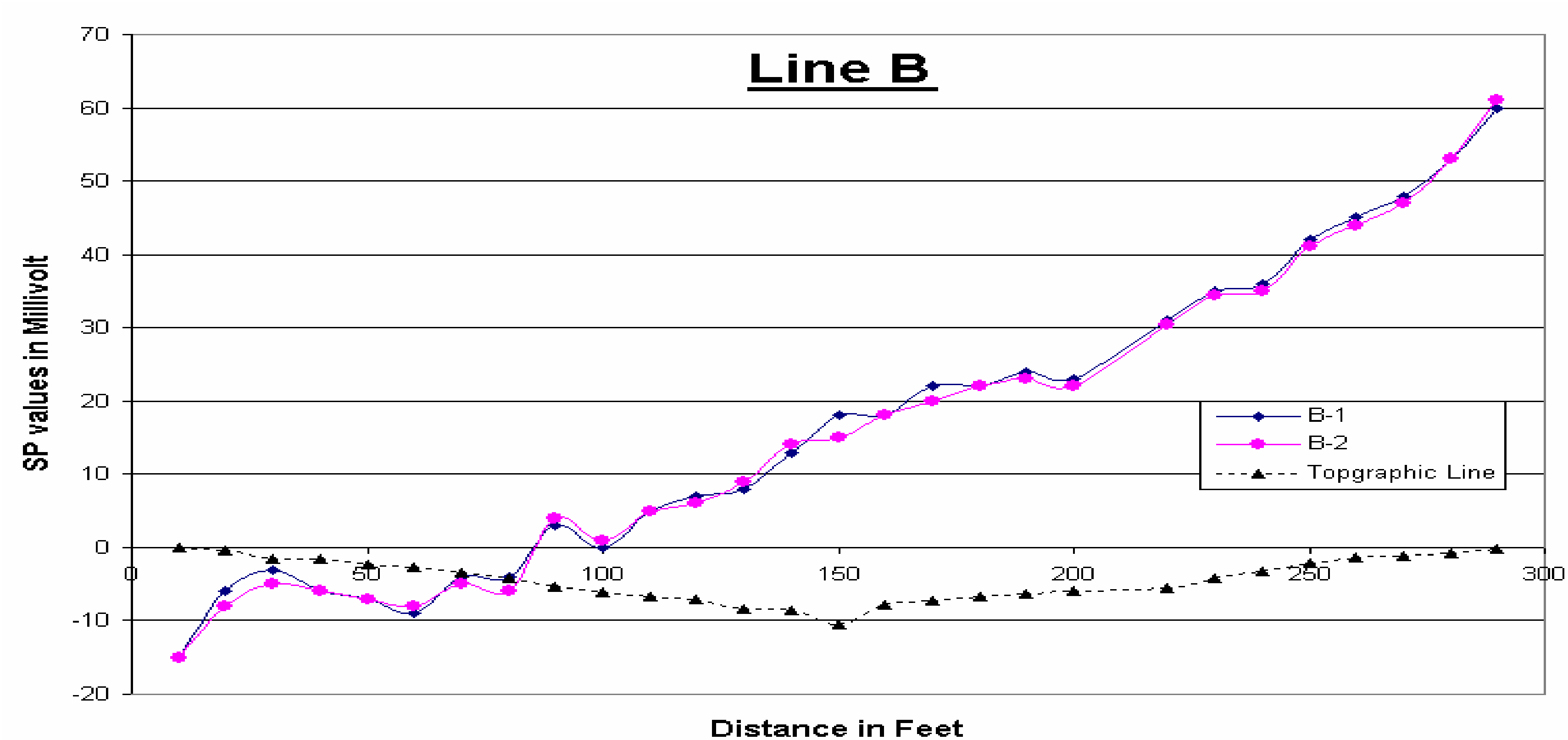


Figure A9: Self potential profile B. All distance/depth units are in feet.

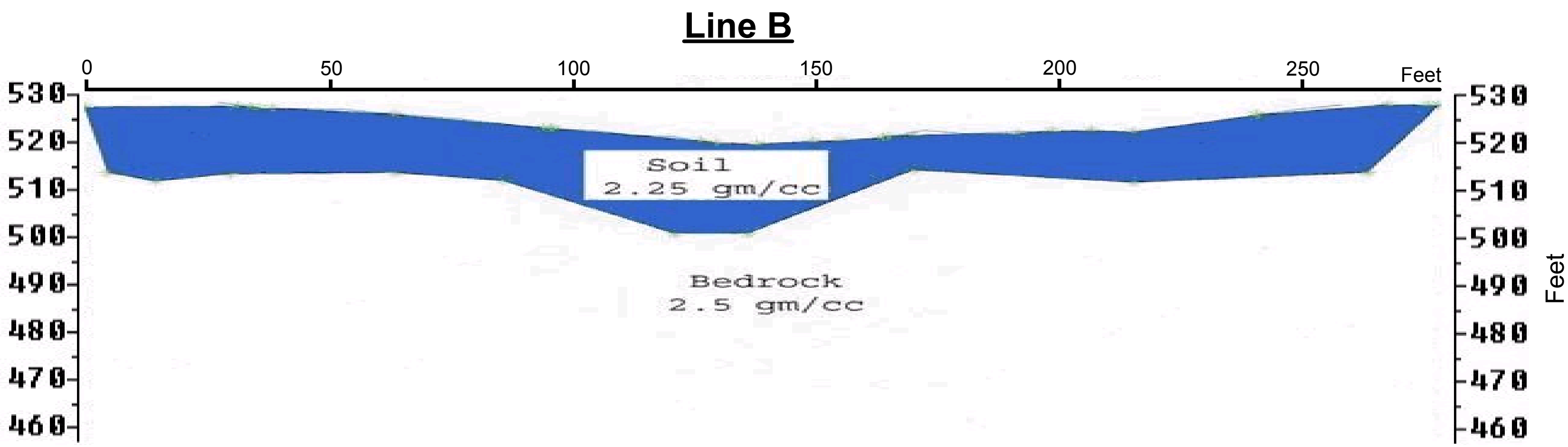


Figure A10: Gravity profile B. All distance/depth units are in feet.

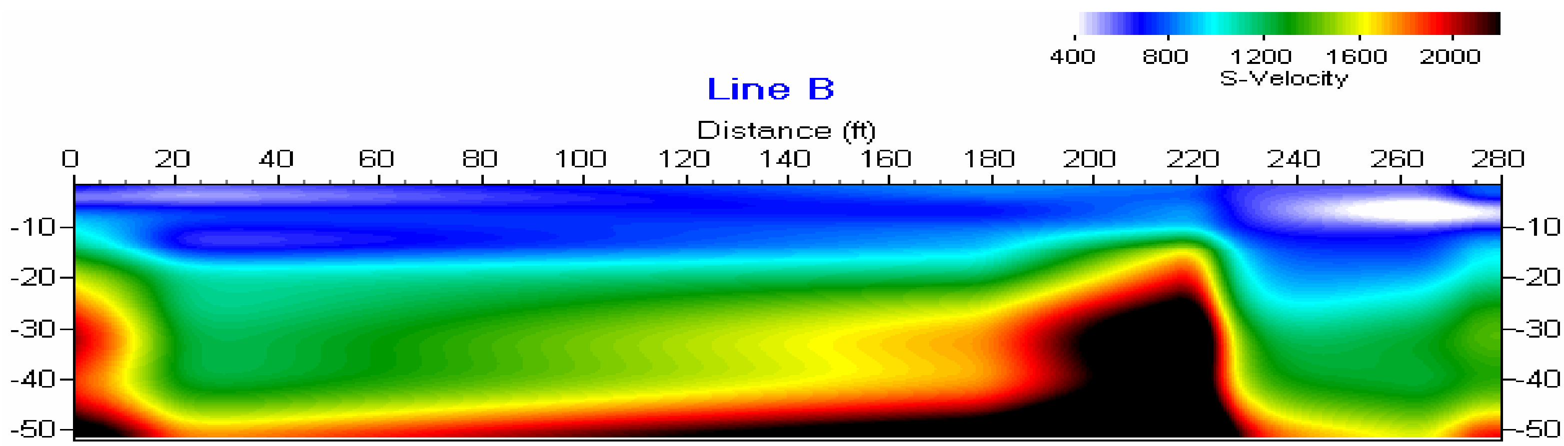


Figure A11: MASW profile B. All distance/depth units are in feet.

Line BB

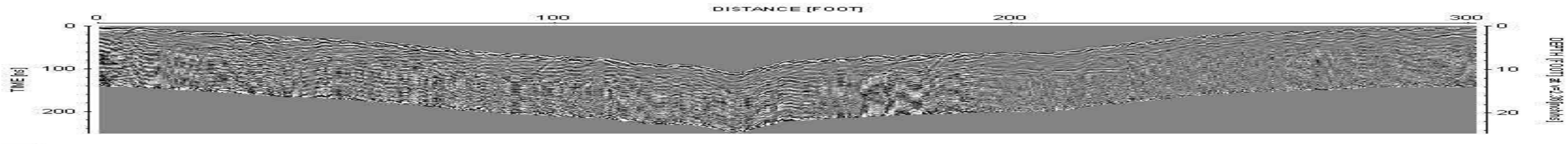


Figure A12: Ground penetrating radar profile B. All distance/depth units are in feet.

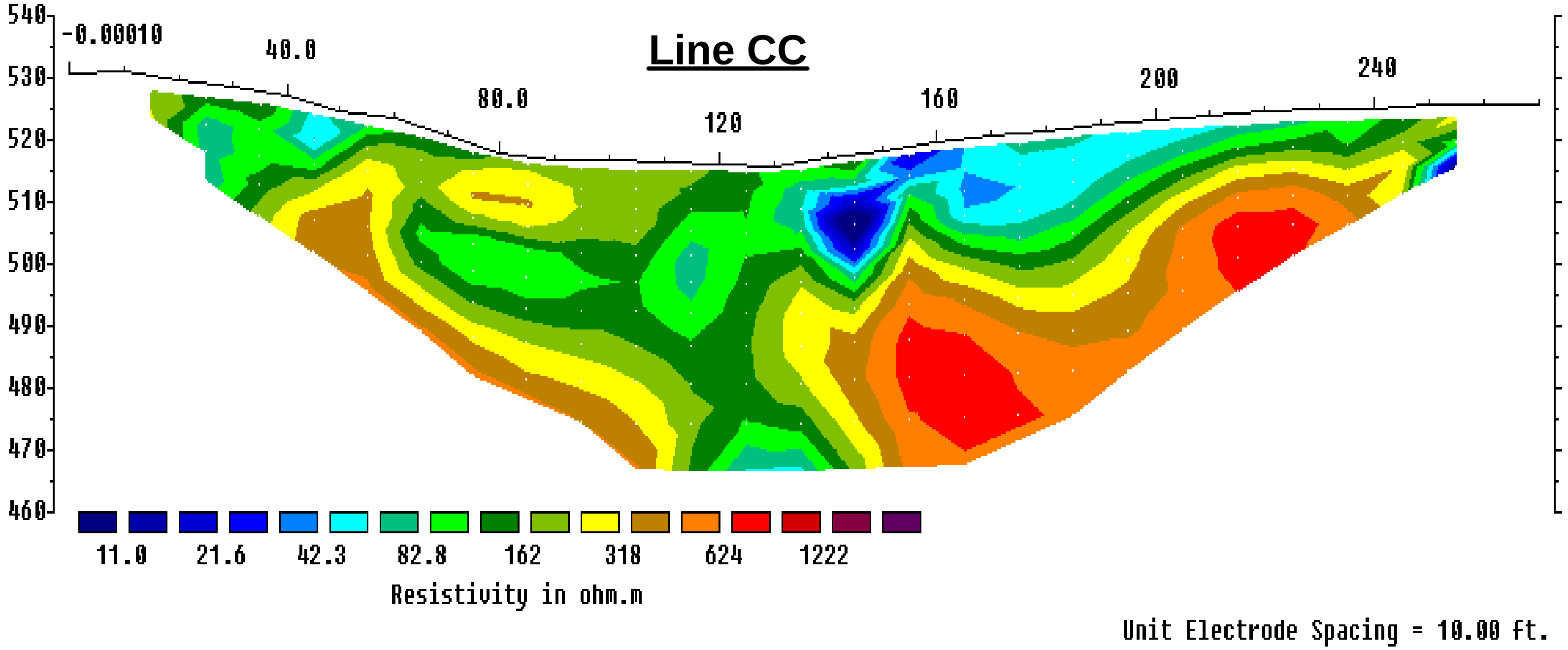


Figure A13: Electrical resistivty profile C. All distance/depth units are in feet.

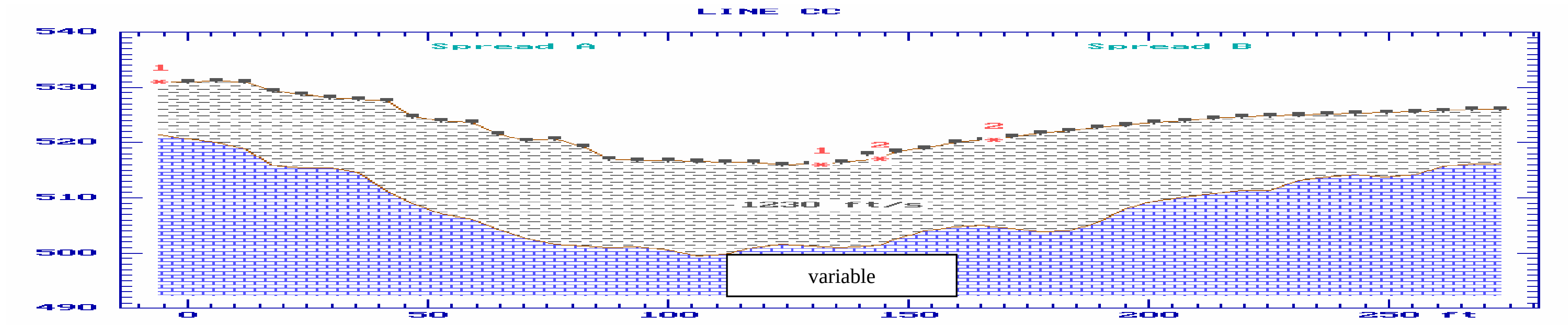


Figure A14: Seismic refraction profile C. All distance/depth units are in feet.

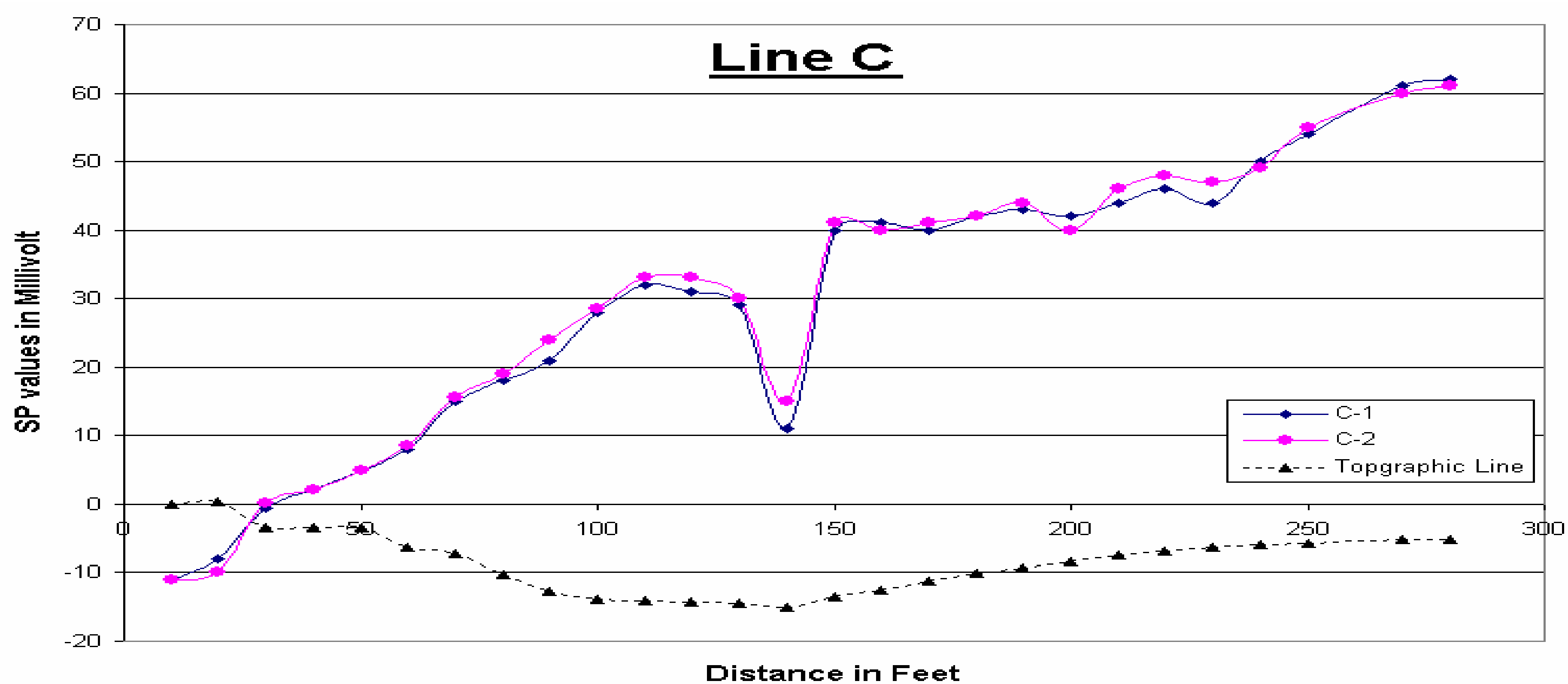


Figure A15: Self potential profile C. All distance/depth units are in feet.

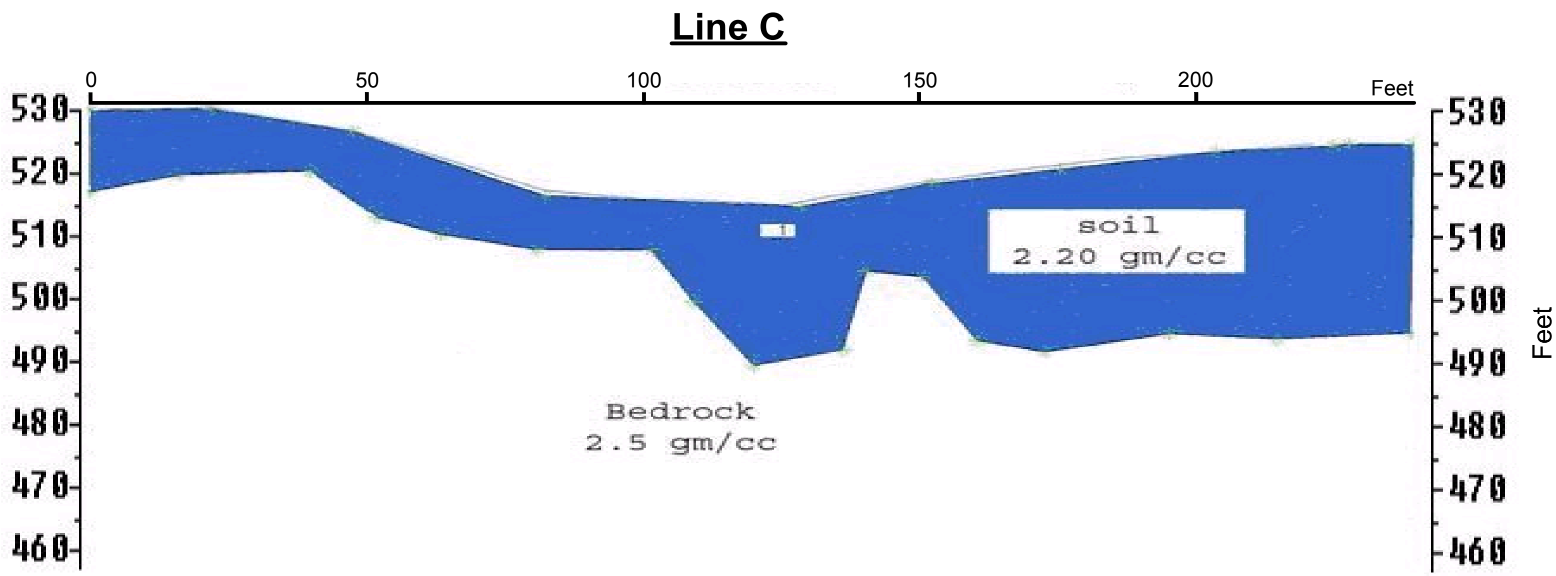


Figure A16: Gravity profile C. All distance/depth units are in feet.

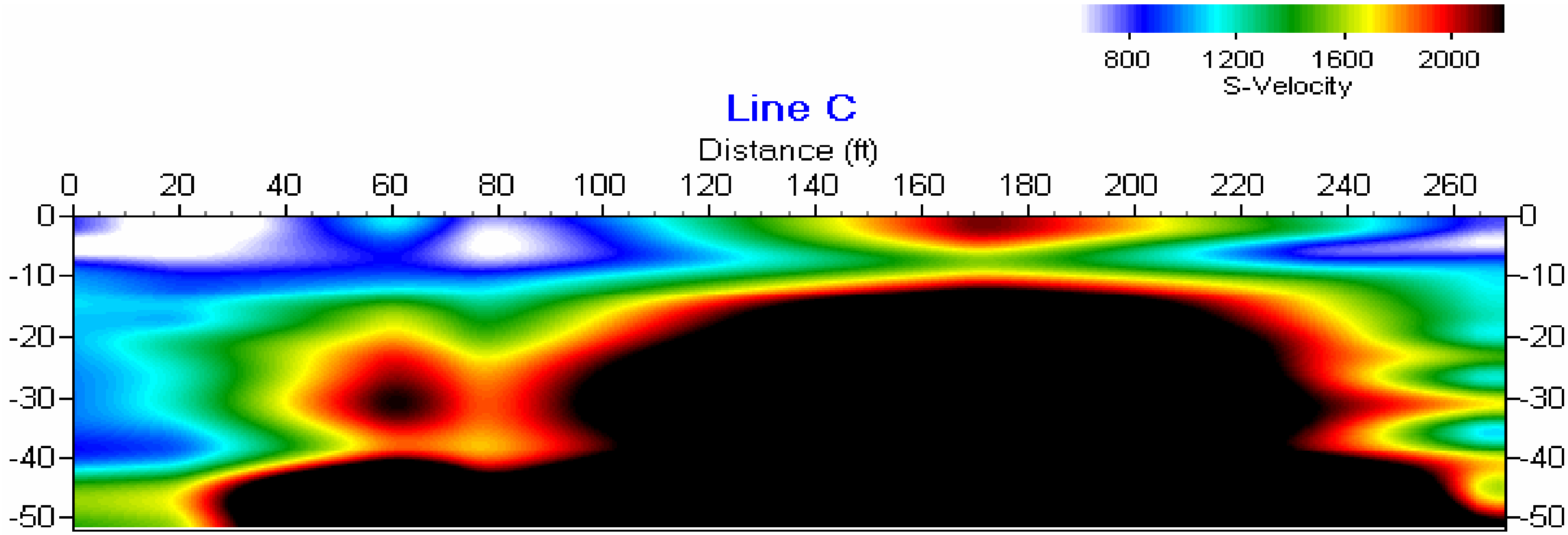


Figure A17: MASW profile C. All distance/depth units are in feet.

Line CC

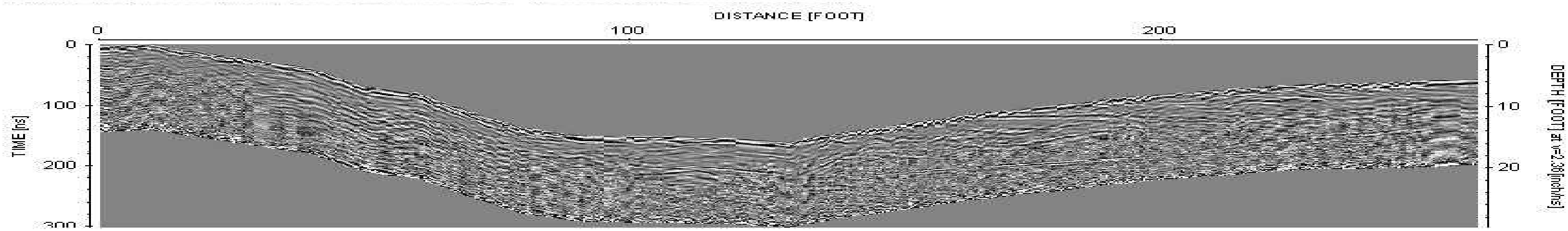


Figure A18: Ground penetrating radar profile C. All distance/depth units are in feet

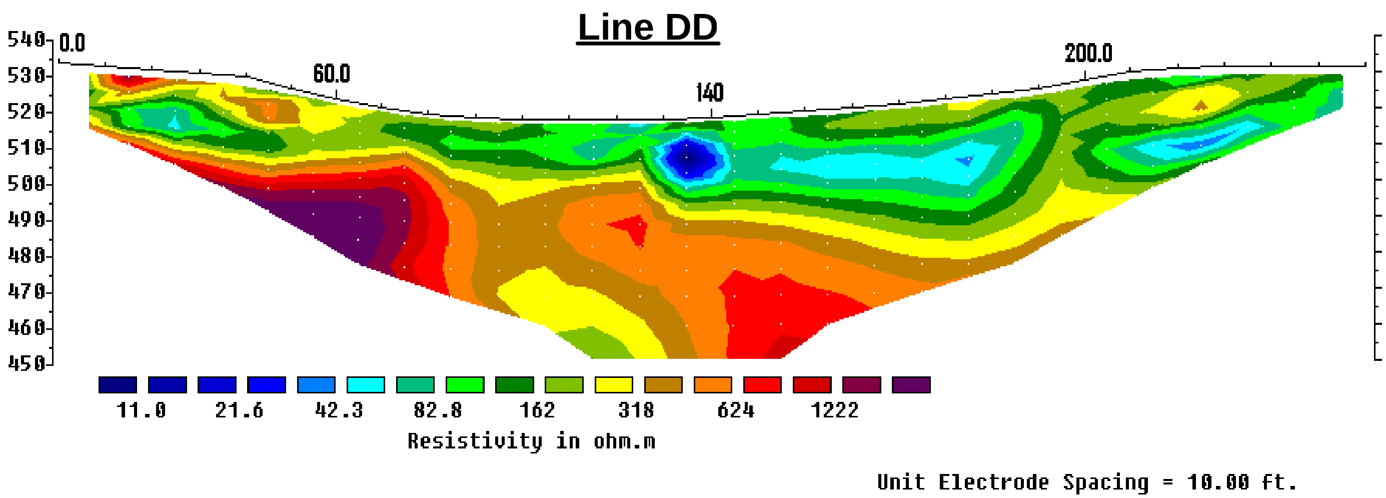


Figure A19: Electrical resistivty profile D. All distance/depth units are in feet.

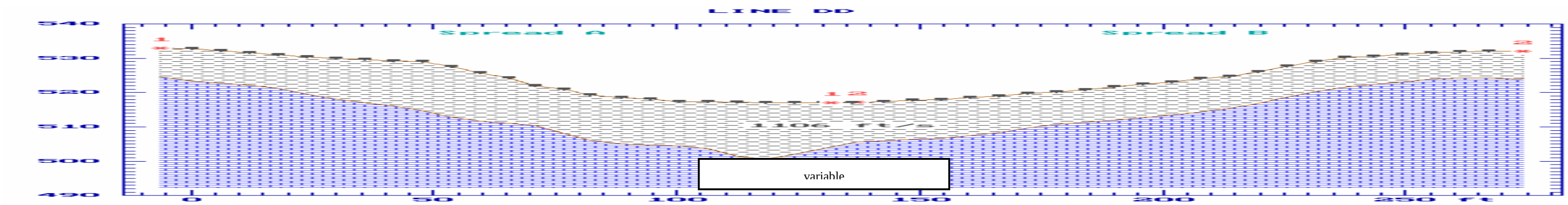


Figure A20: Seismic refraction profile D. All distance/depth units are in feet.

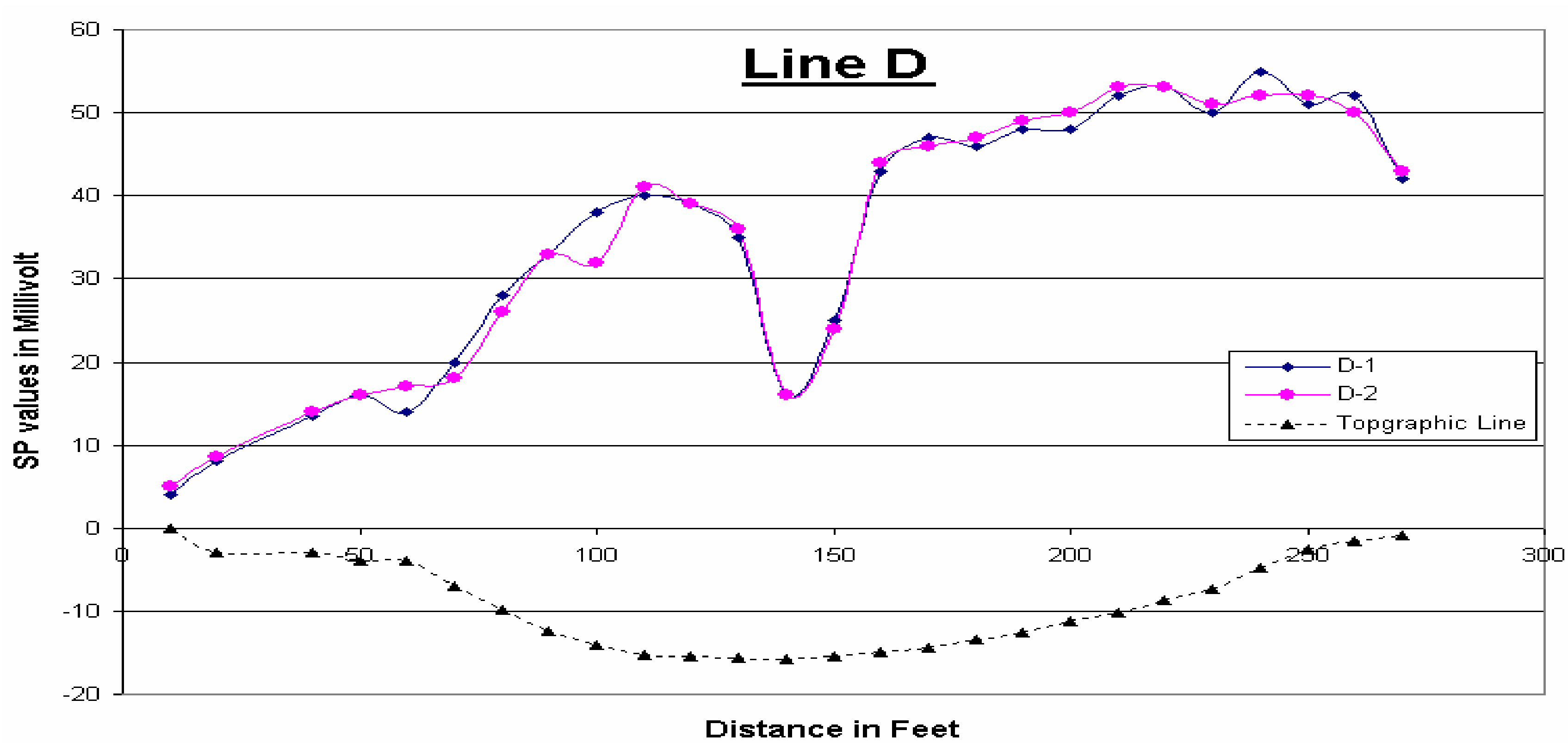


Figure A21: Self potential profile D. All distance/depth units are in feet

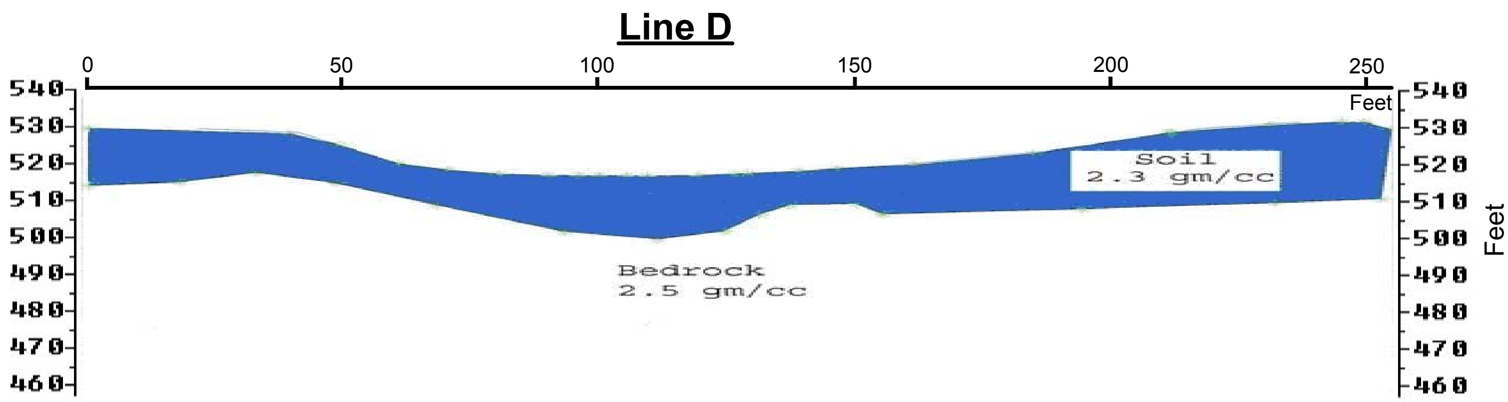


Figure A22: Gravity profile D. All distance/depth units are in feet.

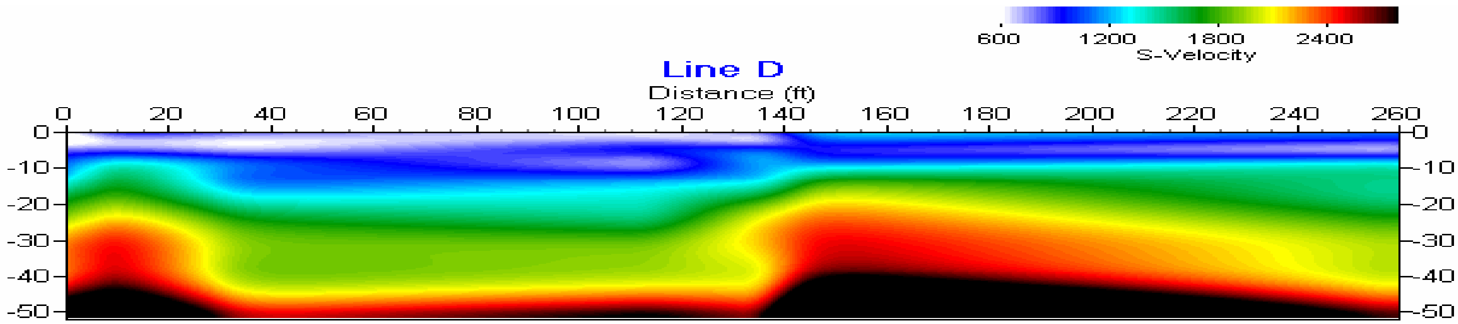


Figure A23: MASW profile D. All distance/depth units are in feet.

Line DD

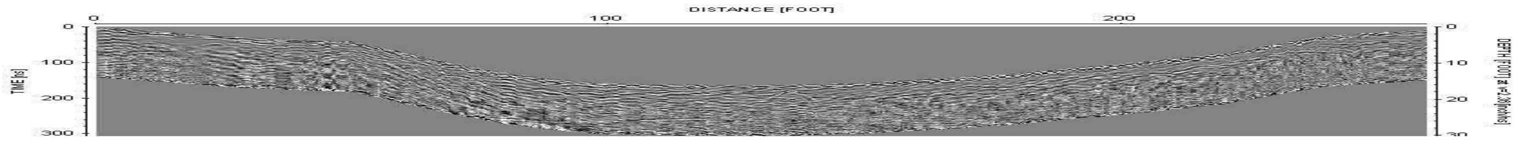


Figure A24: Ground penetrating radar profile D. All distance/depth units are in feet.

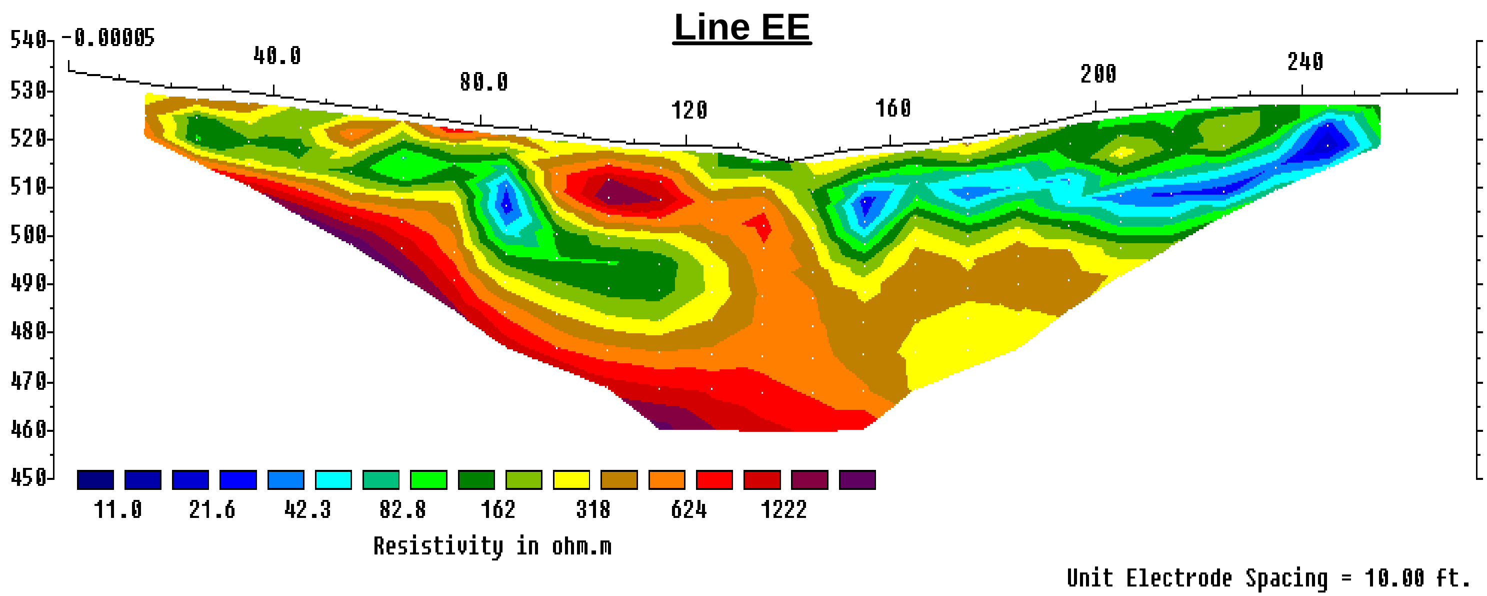


Figure A25: Electrical resistivty profile E. All distance/depth units are in feet.

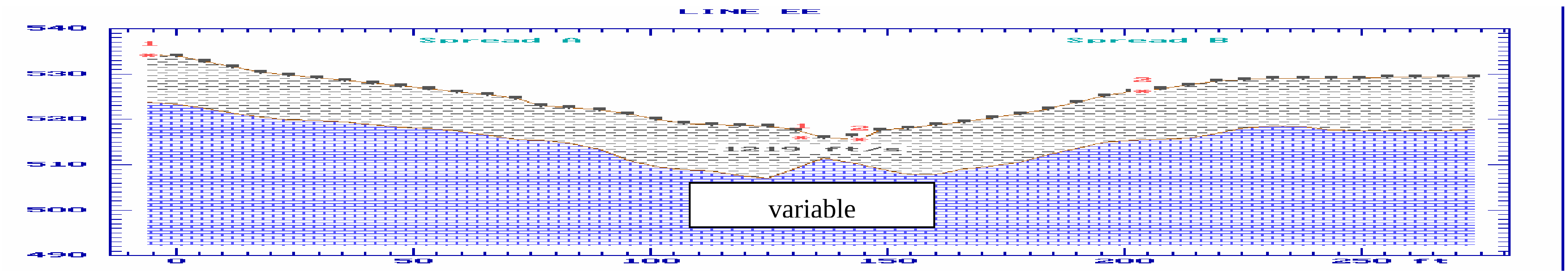


Figure A26: Seismic refraction profile E. All distance/depth units are in feet.

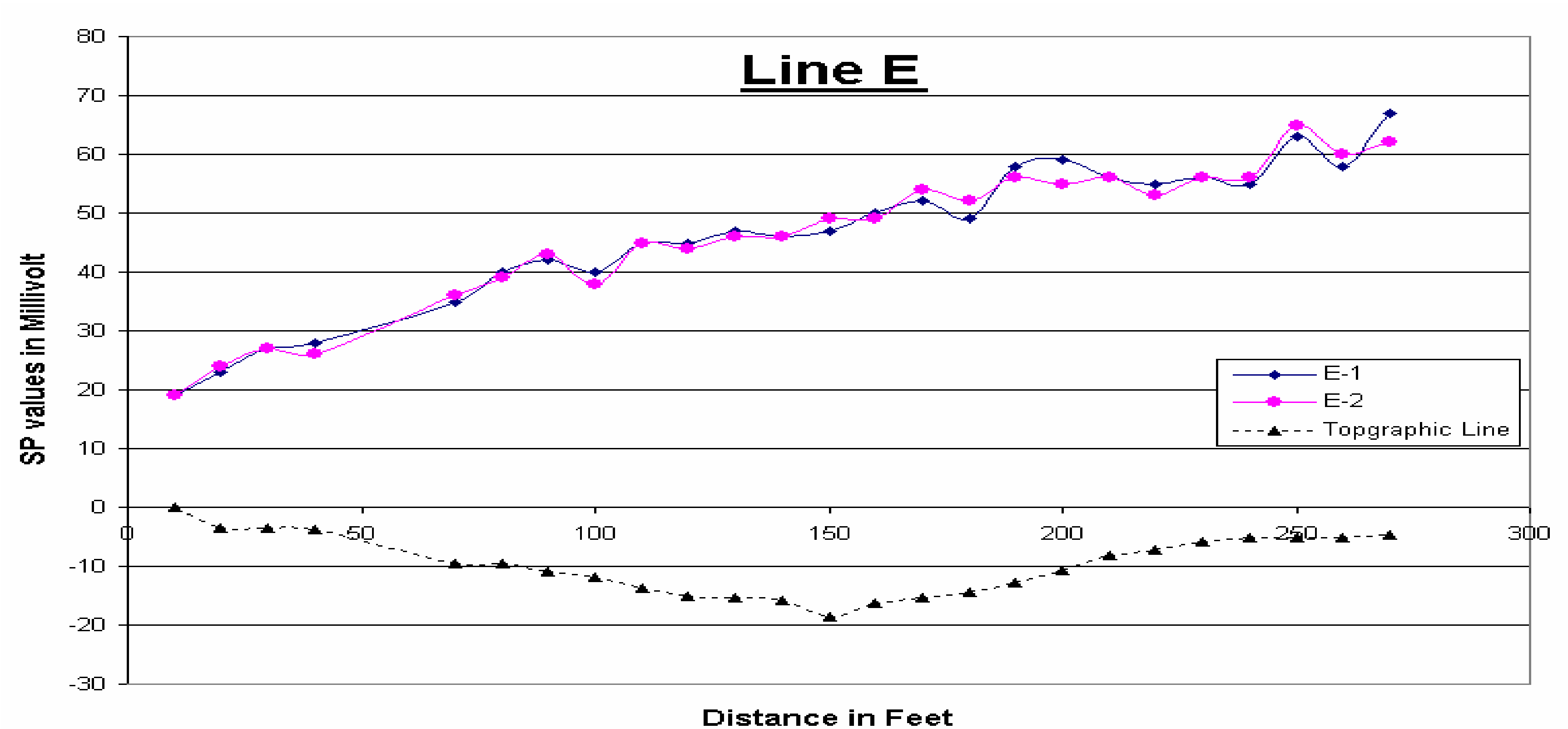


Figure A27: Self potential profile E. All distance/depth units are in feet.

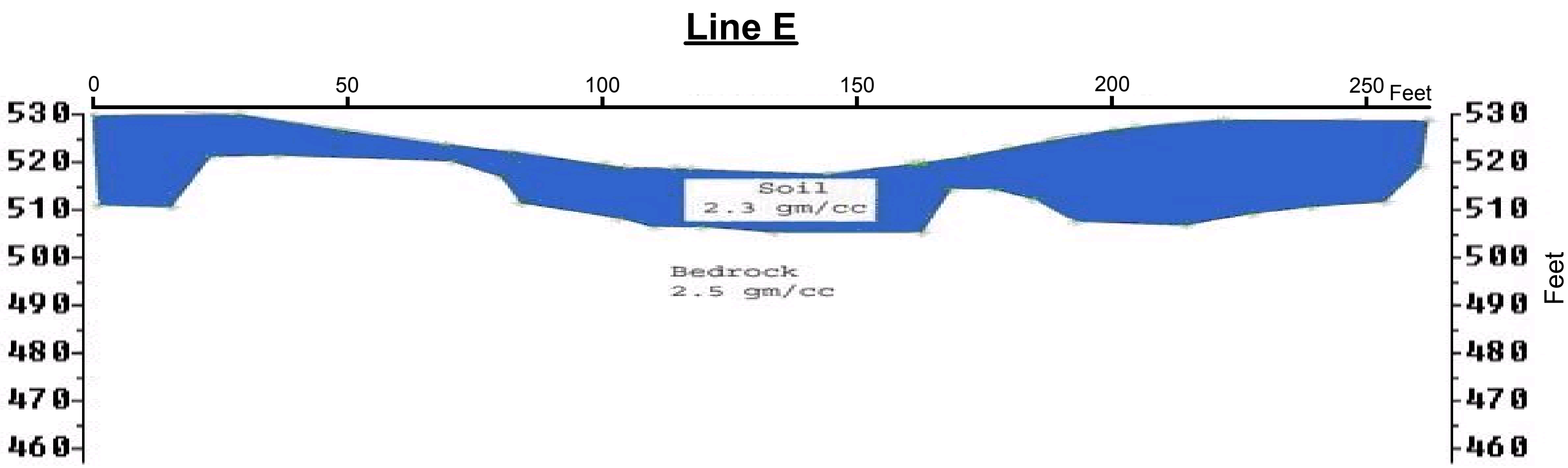


Figure A28: Gravity profile E. All distance/depth units are in feet.

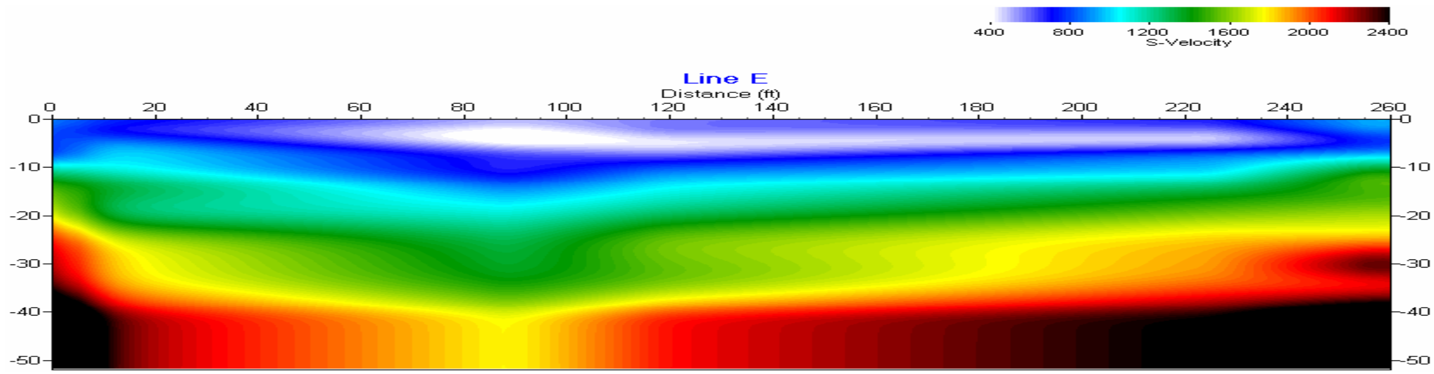


Figure A29: MASW profile E. All distance/depth units are in feet.

Line EE

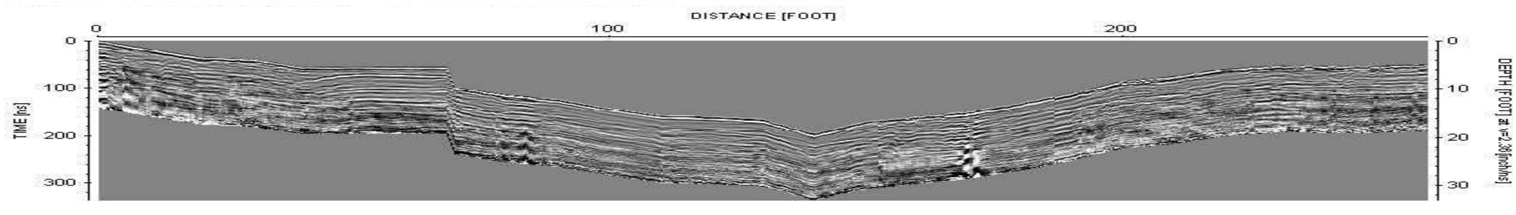


Figure A30: Ground penetrating radar profile E. All distance/depth units are in feet.

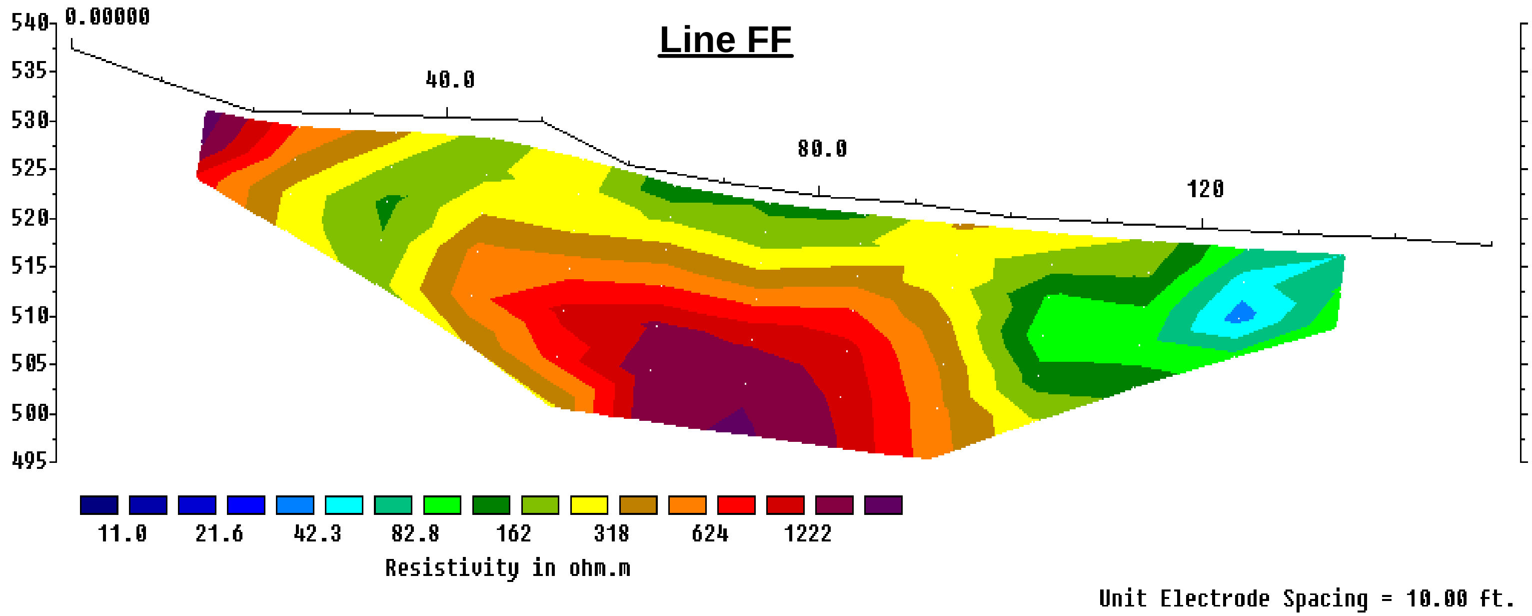


Figure A31: Electrical resistivty profile F. All distance/depth units are in feet.

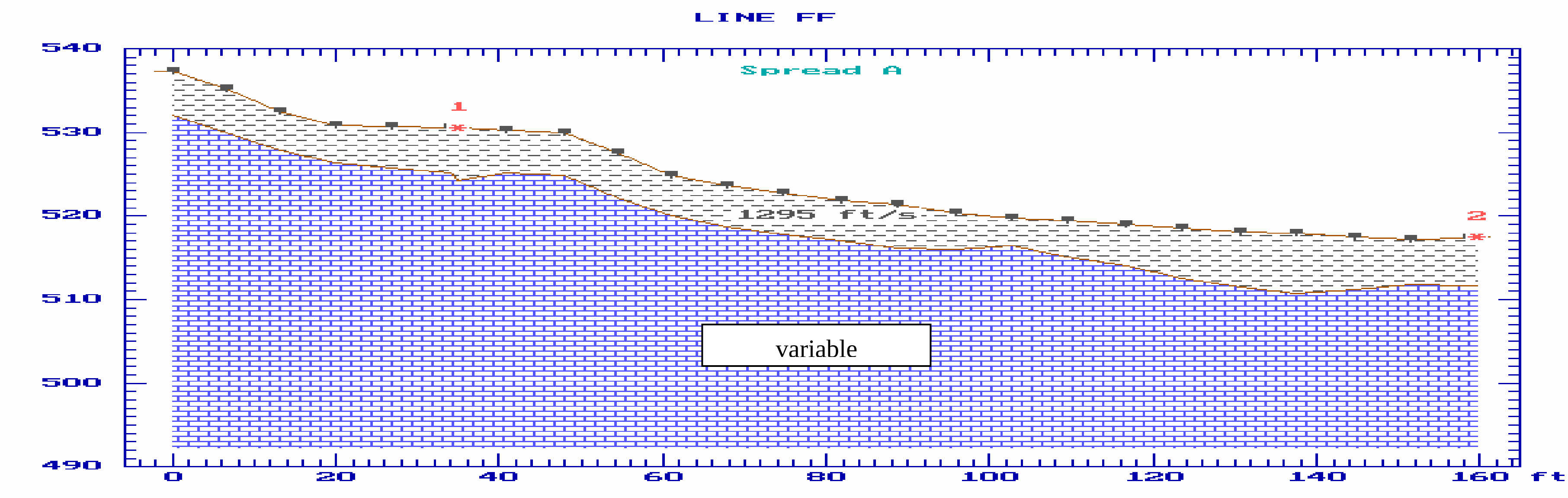


Figure A32: Seismic refraction profile F. All distance/depth units are in feet.

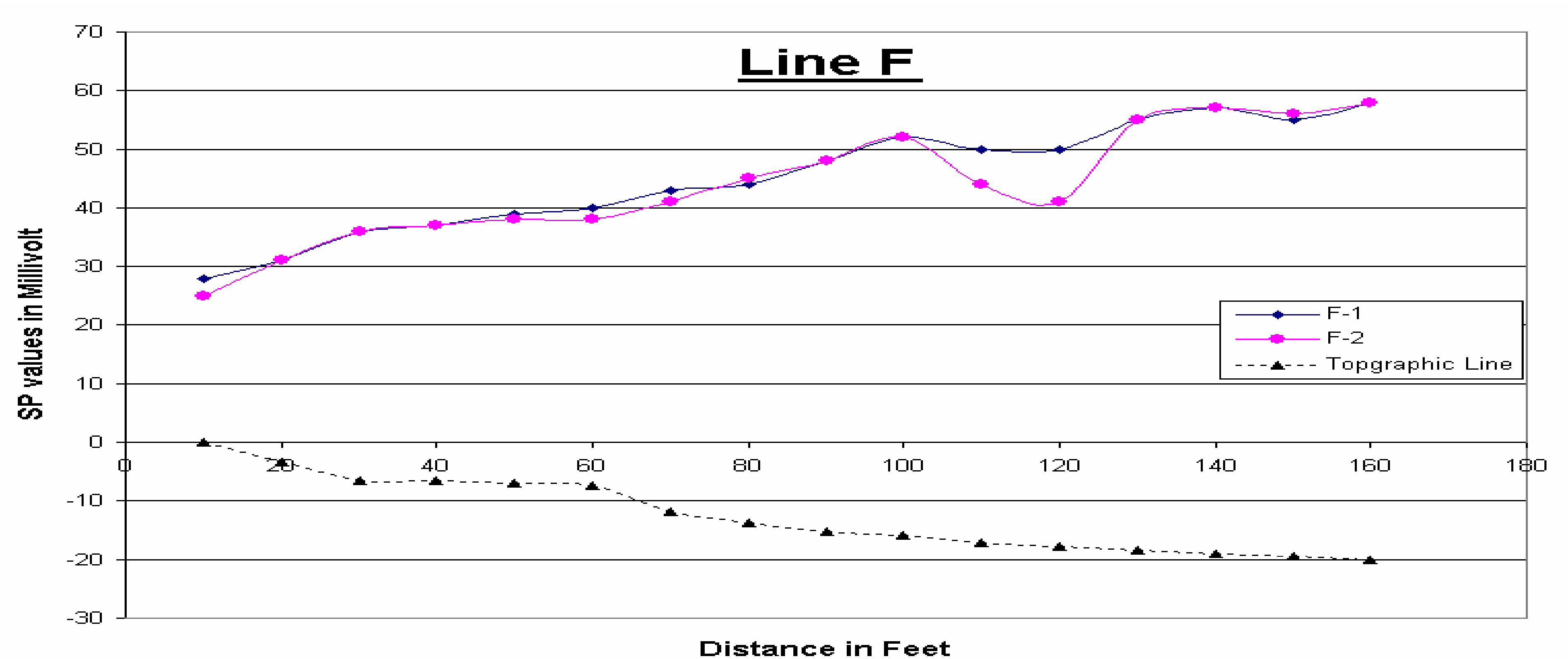


Figure A33: Self potential profile F. All distance/depth units are in feet.

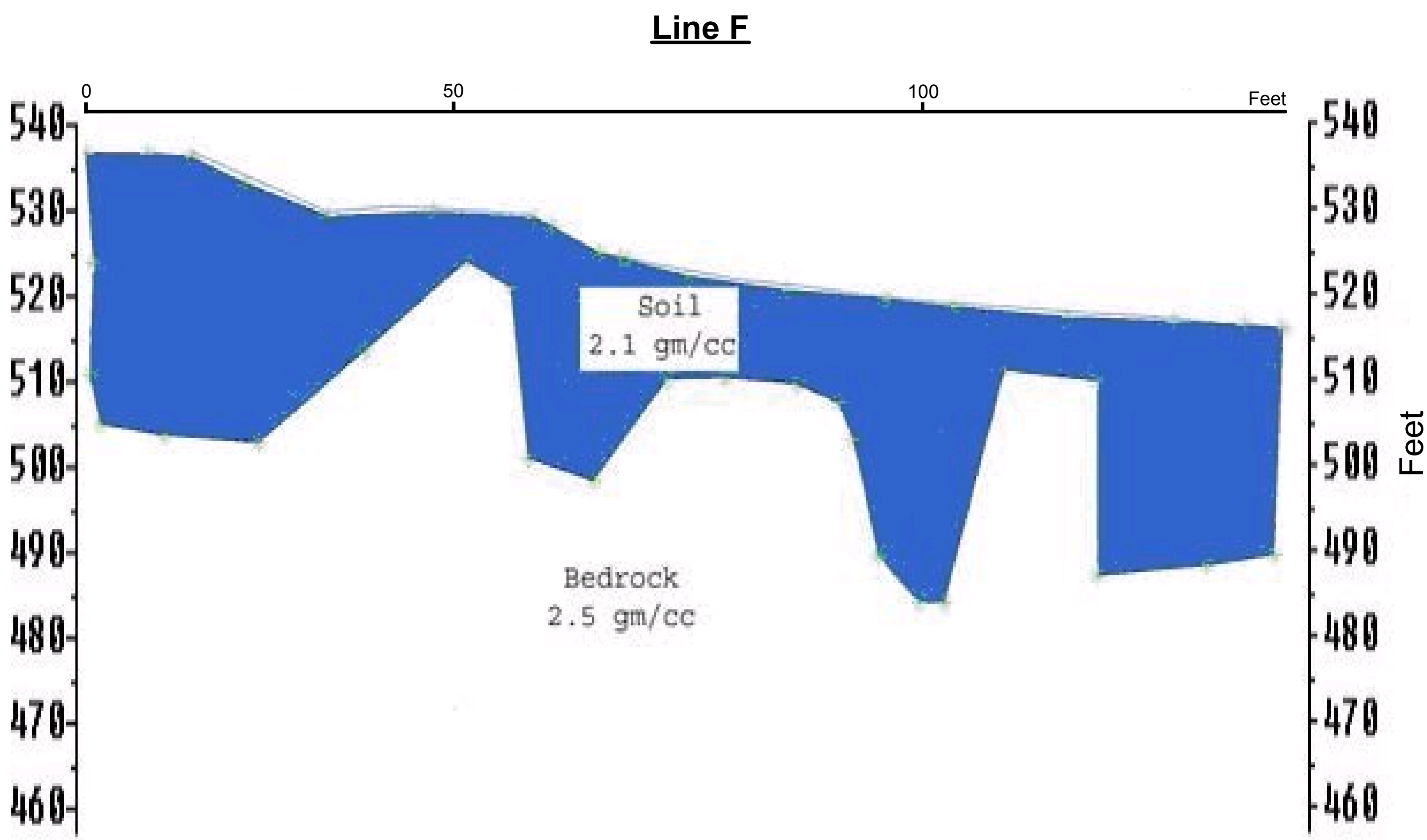


Figure A34: Gravity profile F. All distance/depth units are in feet.

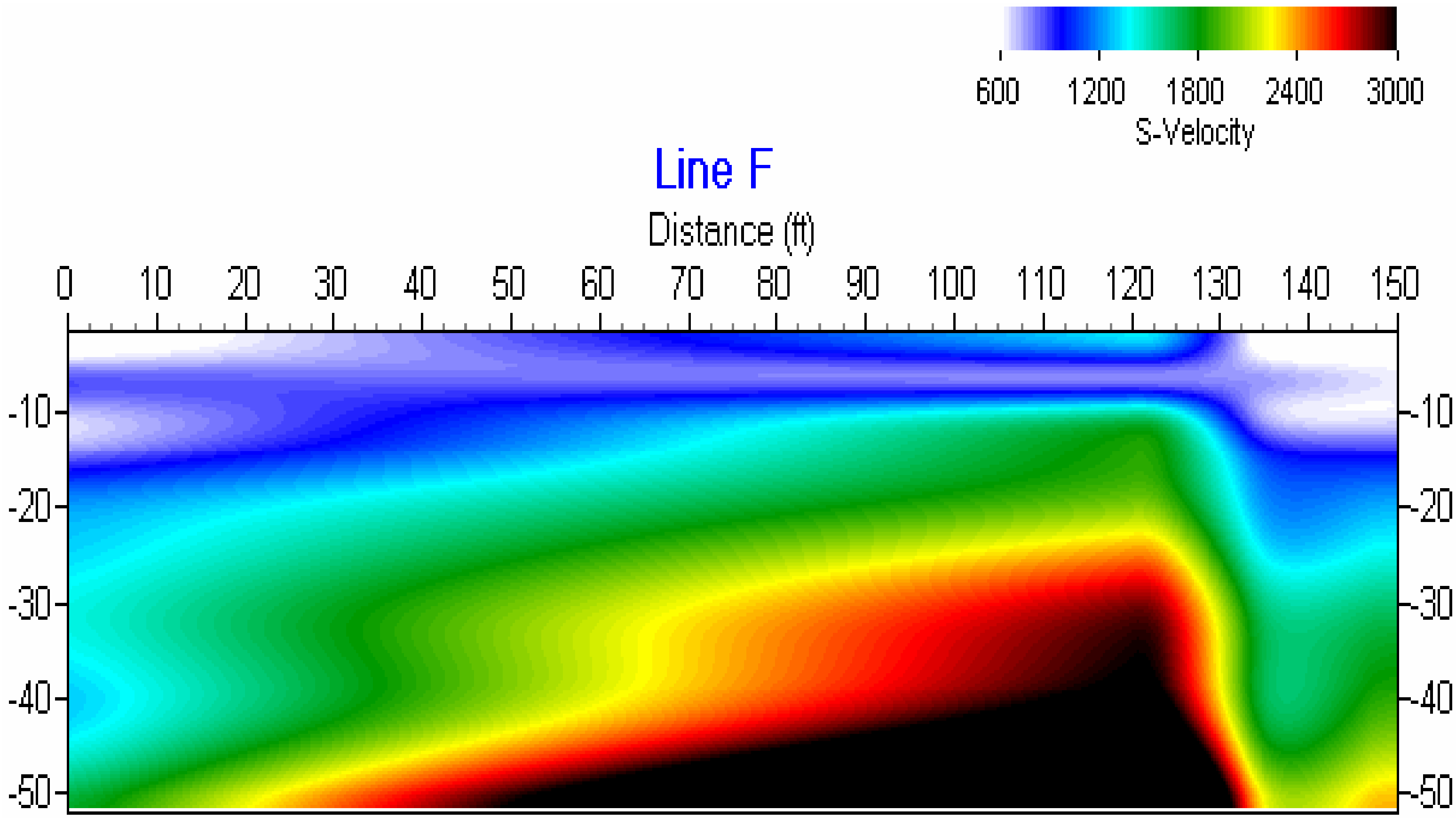


Figure A35: MASW profile F. All distance/depth units are in feet.

Line FF

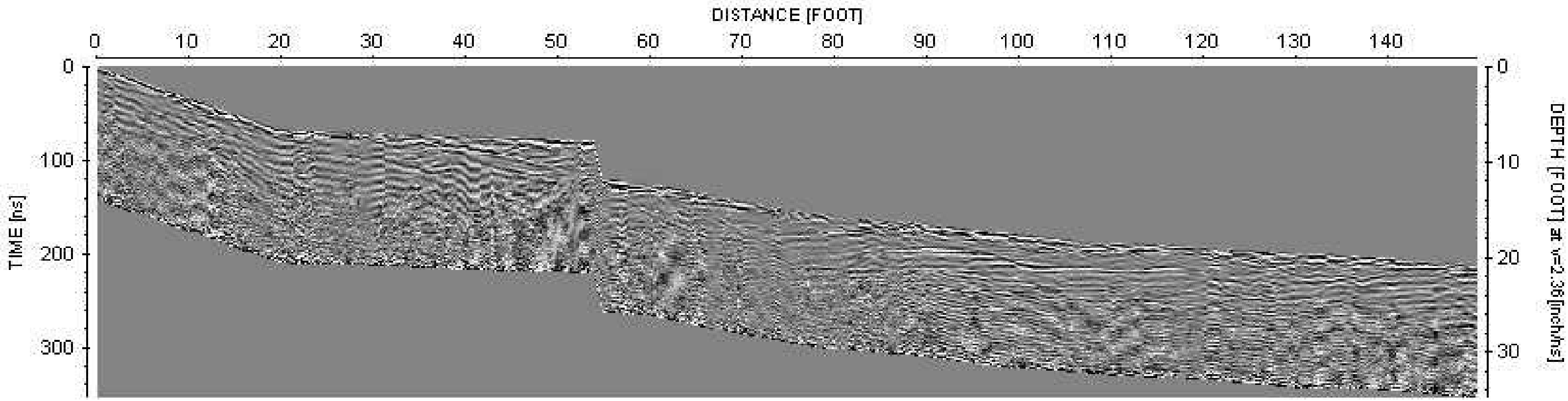


Figure A36: Ground penetrating radar profile F. All distance/depth units are in feet.

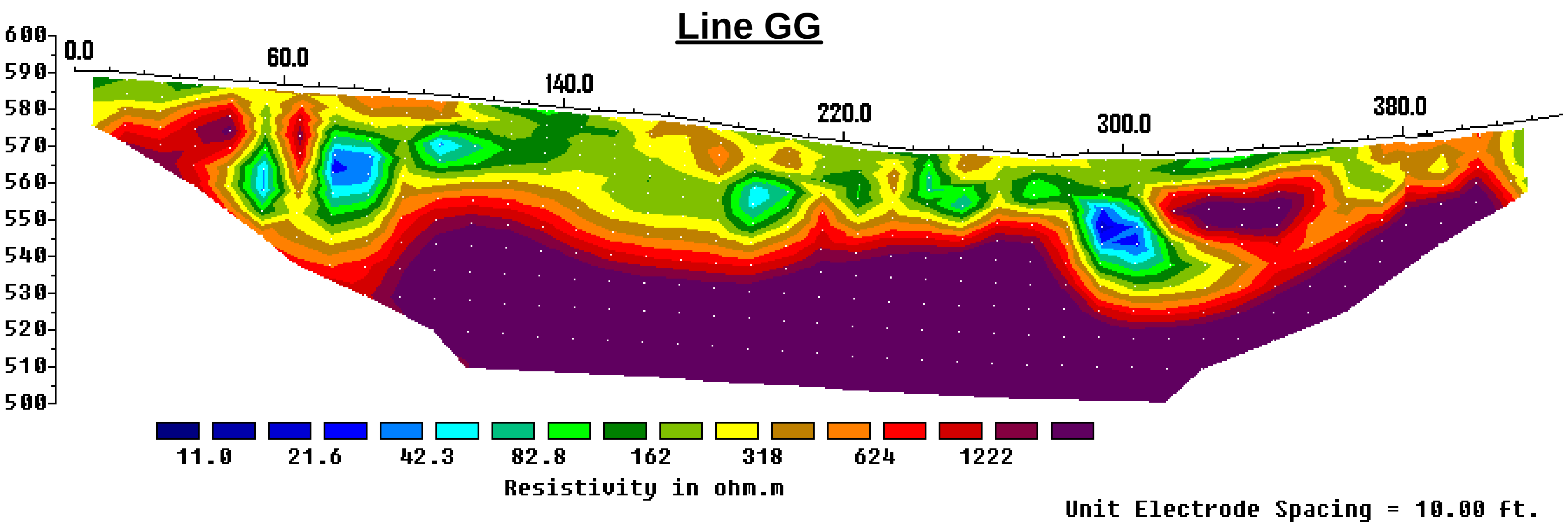


Figure A37: Electrical resistivty profile G. All distance/depth units are in feet.

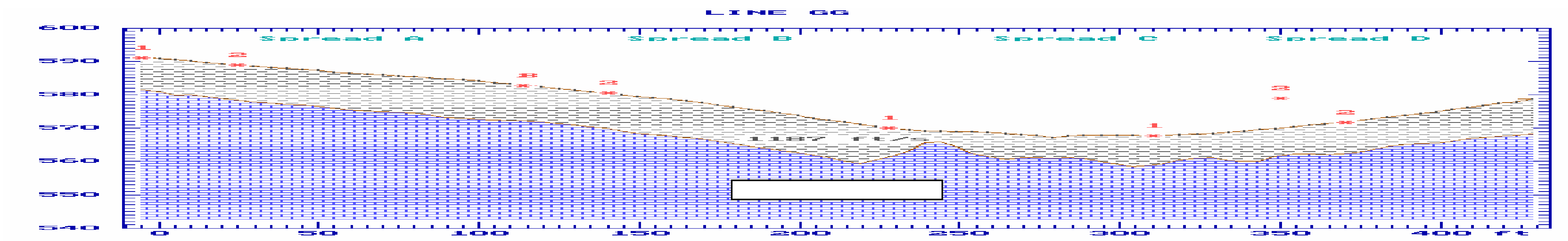


Figure A38: Seismic refraction profile G. All distance/depth units are in feet.

Figure A39: Self potential profile G. All distance/depth units are in feet.

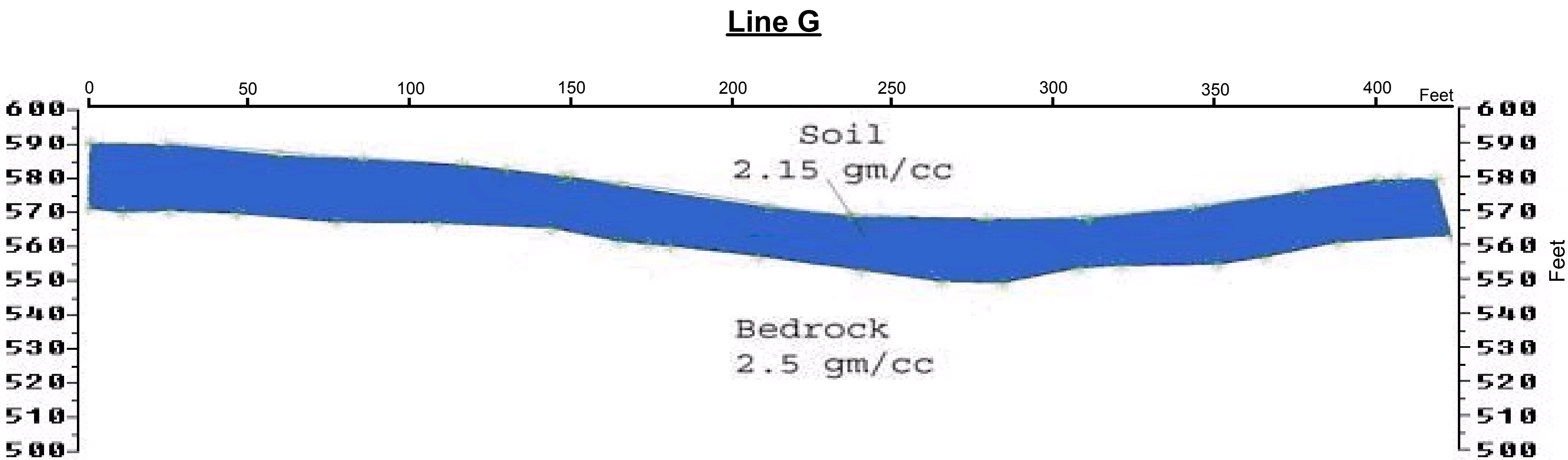


Figure A40: Gravity profile G. All distance/depth units are in feet.

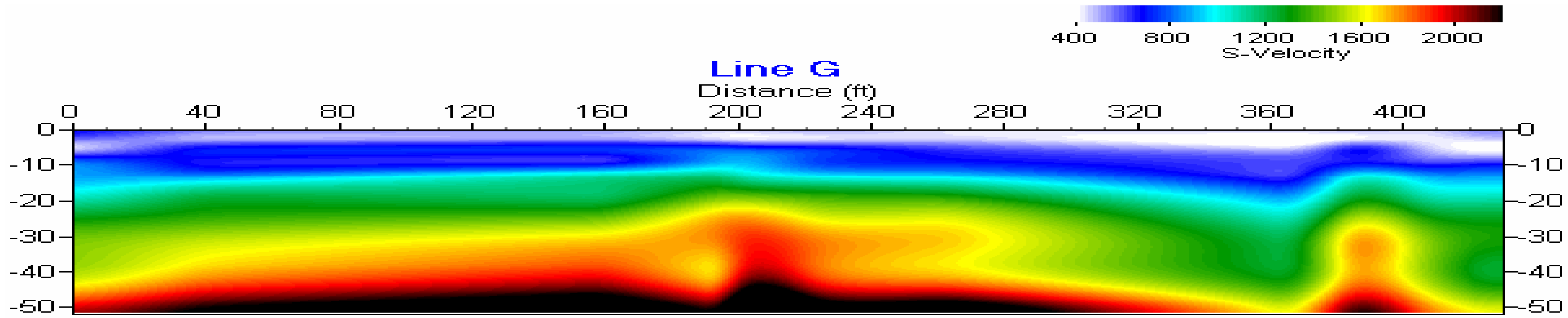


Figure A41: MASW profile G. All distance/depth units are in feet.

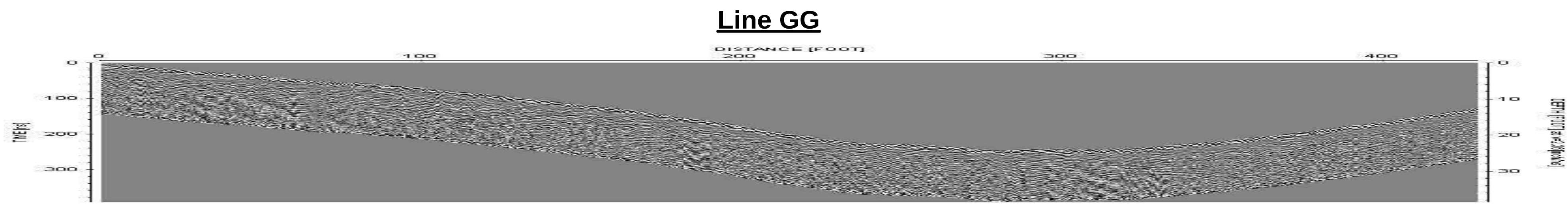


Figure A42: Ground penetrating radar profile G. All distance/depth units are in feet.

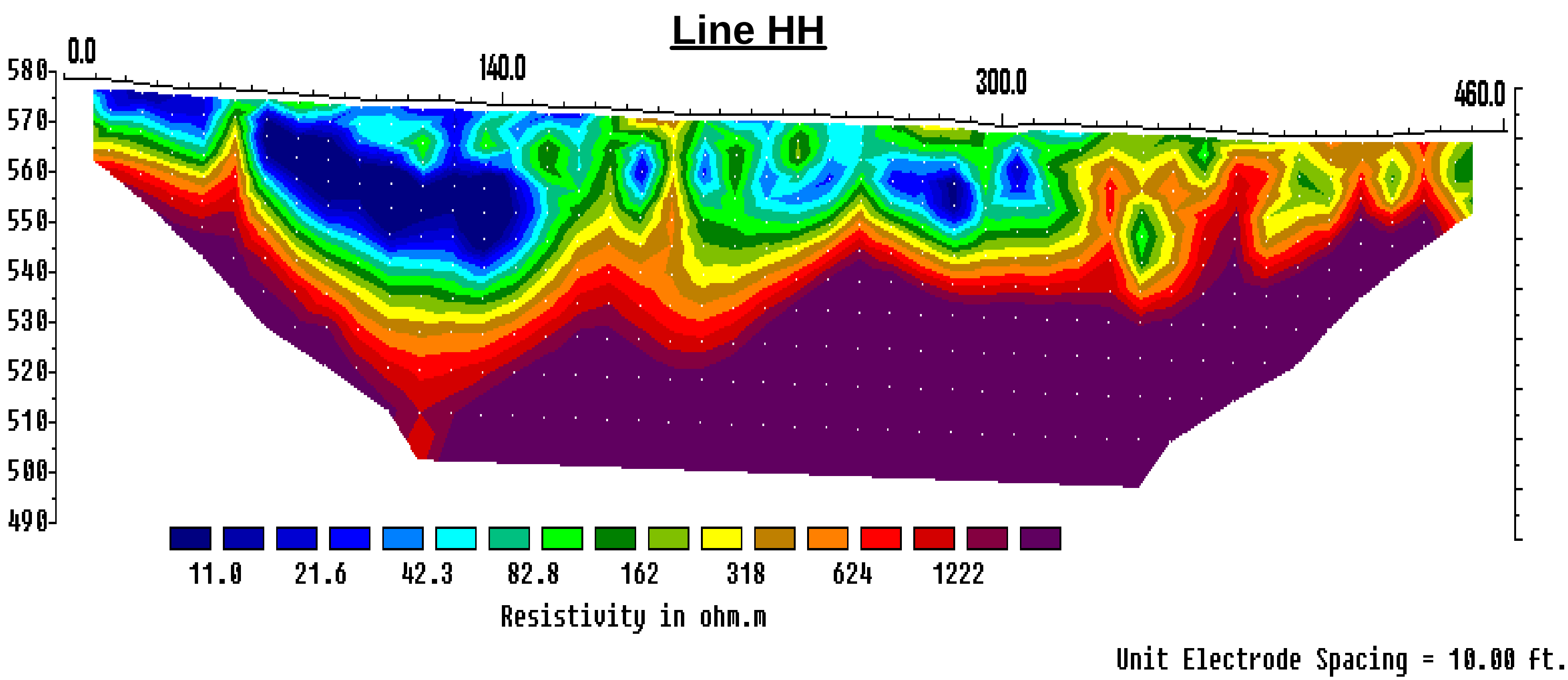


Figure A43: Electrical resistivty profile H. All distance/depth units are in feet

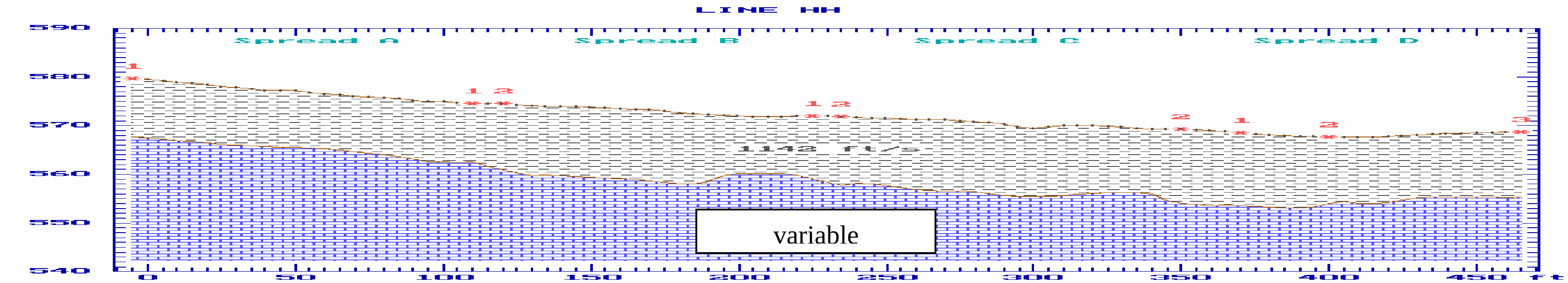


Figure A44: Seismic refraction profile H. All distance/depth units are in feet.

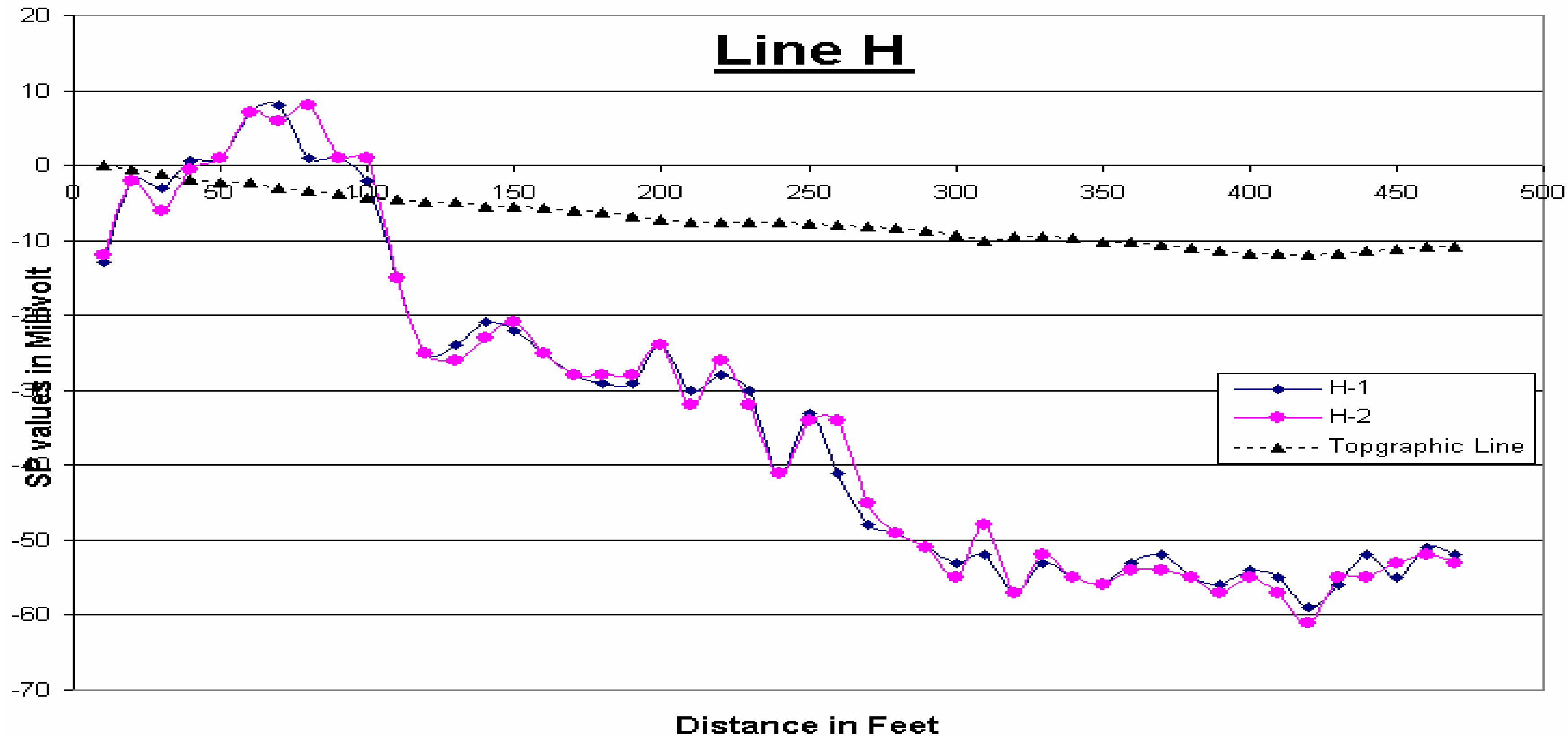


Figure A45: Self potential profile H. All distance/depth units are in feet.

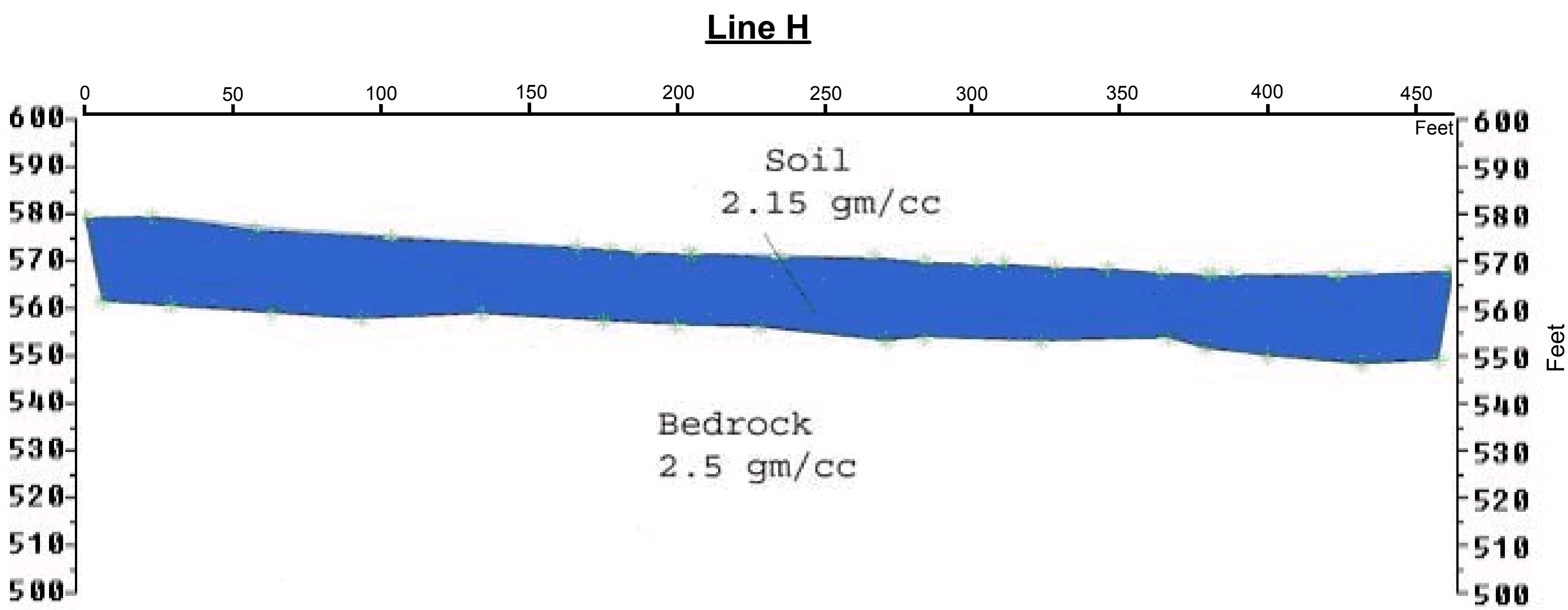


Figure A46: Gravity profile H. All distance/depth units are in feet.

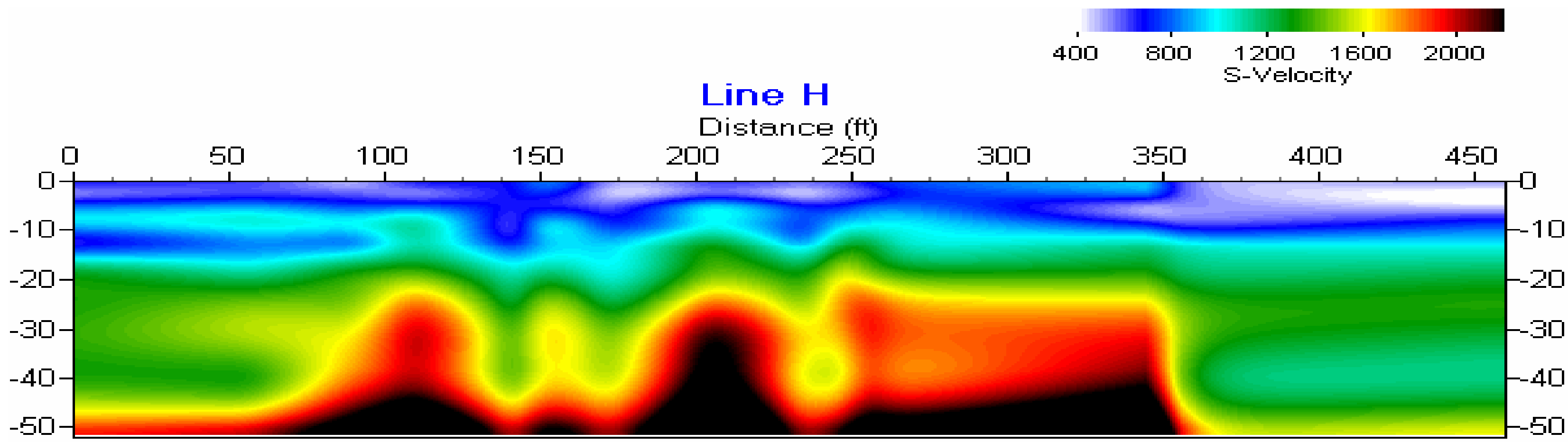


Figure A47: MASW profile H. All distance/depth units are in feet.

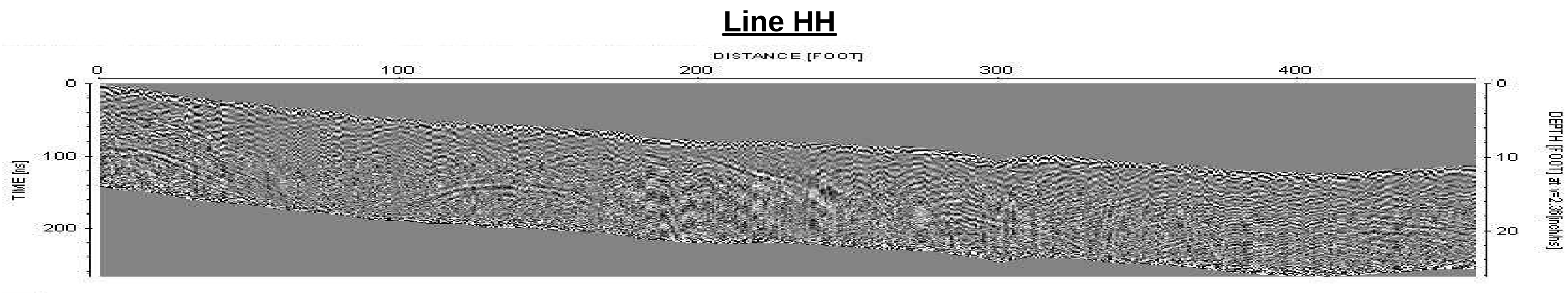


Figure A48: Ground penetrating radar profile H. All distance/depth units are in feet.

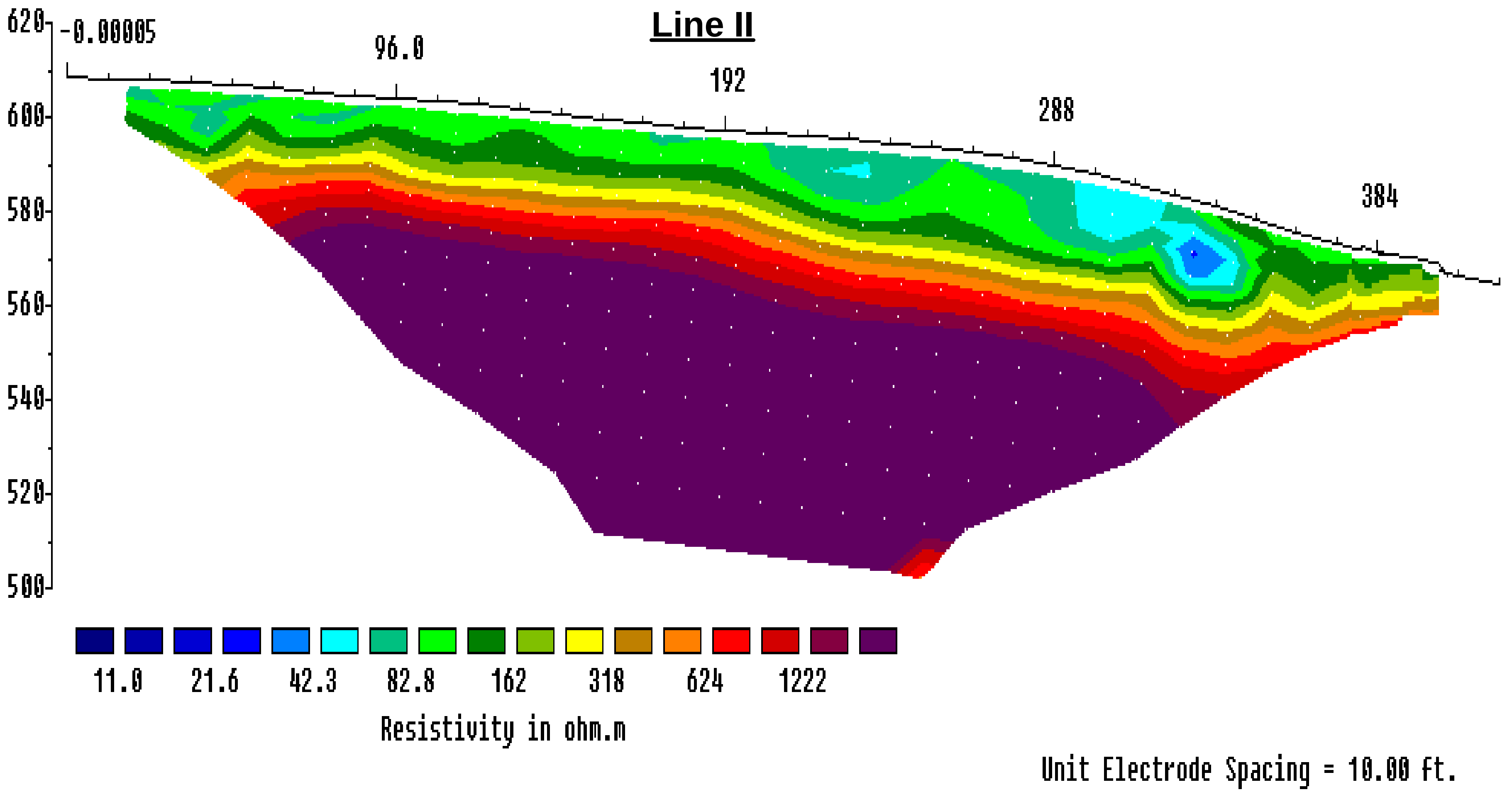


Figure A49: Electrical resistivty profile I. All distance/depth units are in feet.

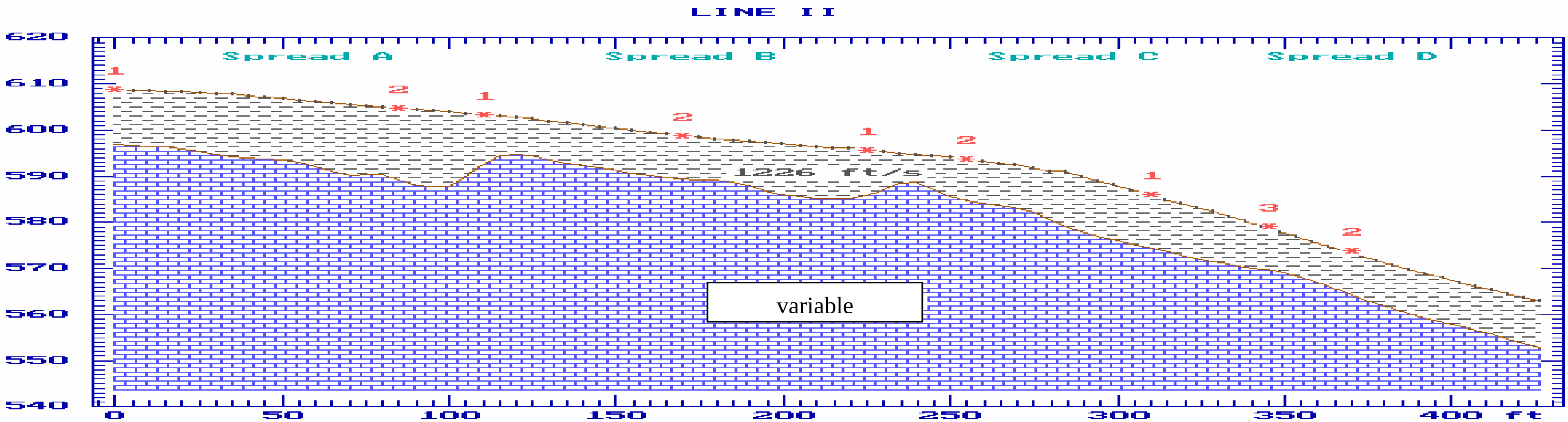


Figure A50: Seismic refraction profile I. All distance/depth units are in feet.

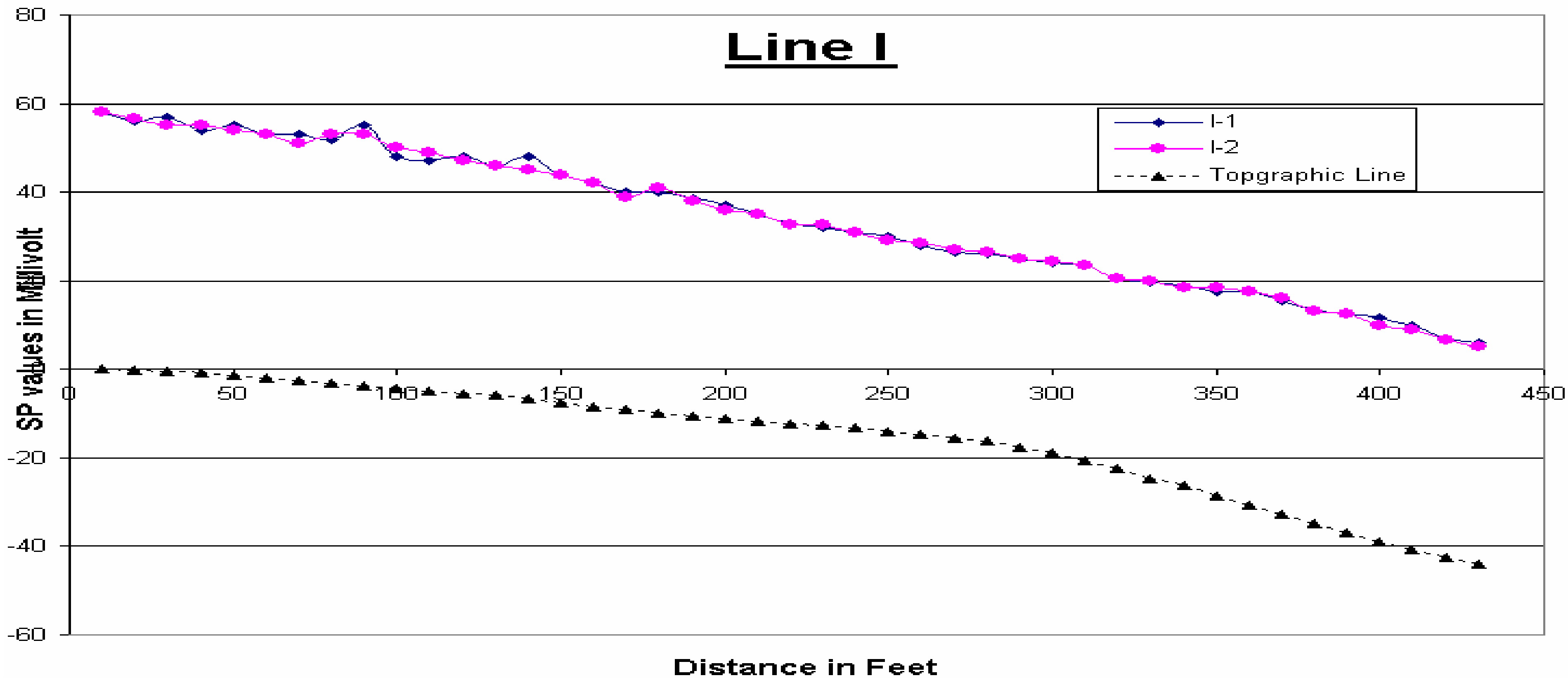


Figure A51: Self potential profile I. All distance/depth units are in feet.

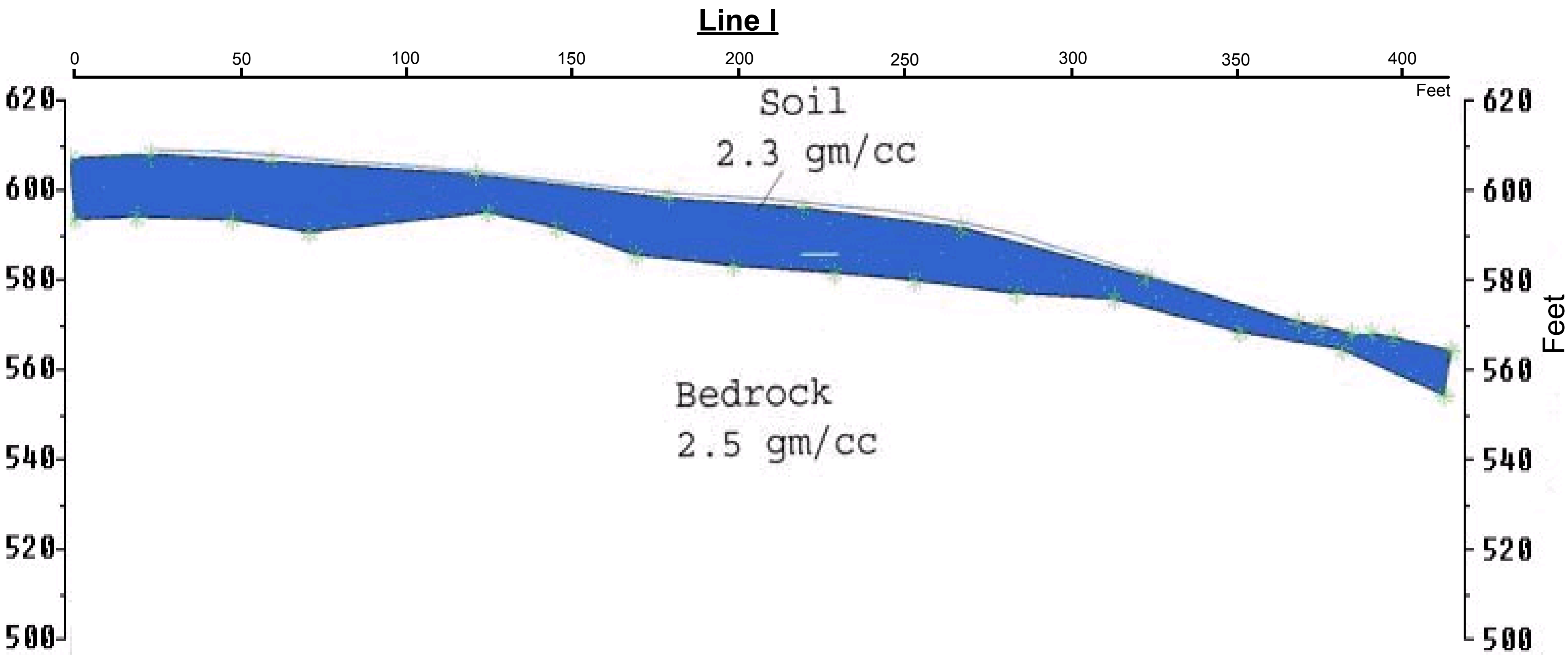


Figure A52: Gravity profile I. All distance/depth units are in feet.

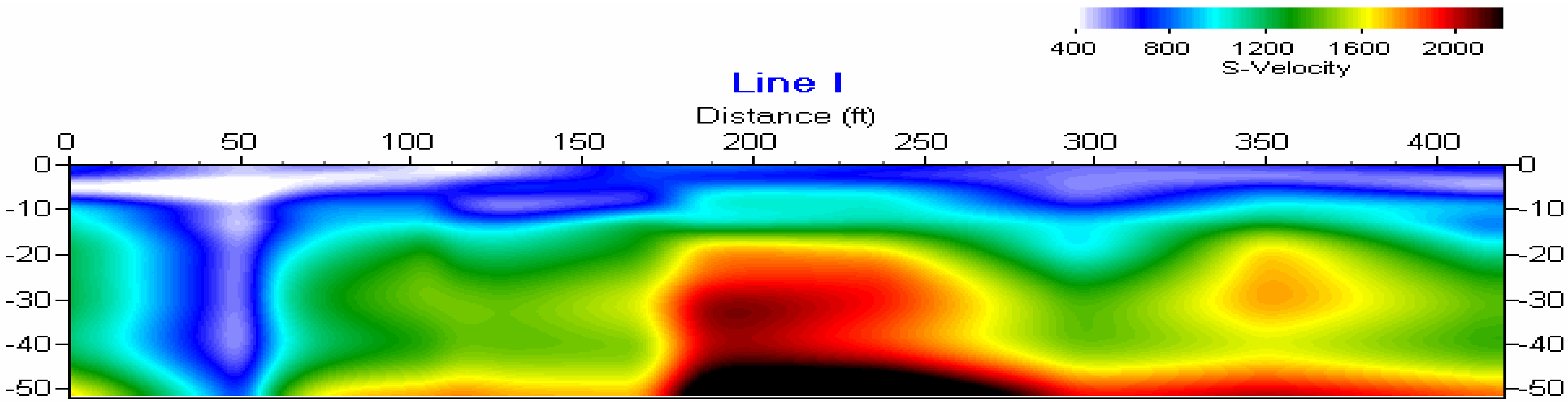


Figure A53: MASW profile I. All distance/depth units are in feet.

<u>**Line II**</u>

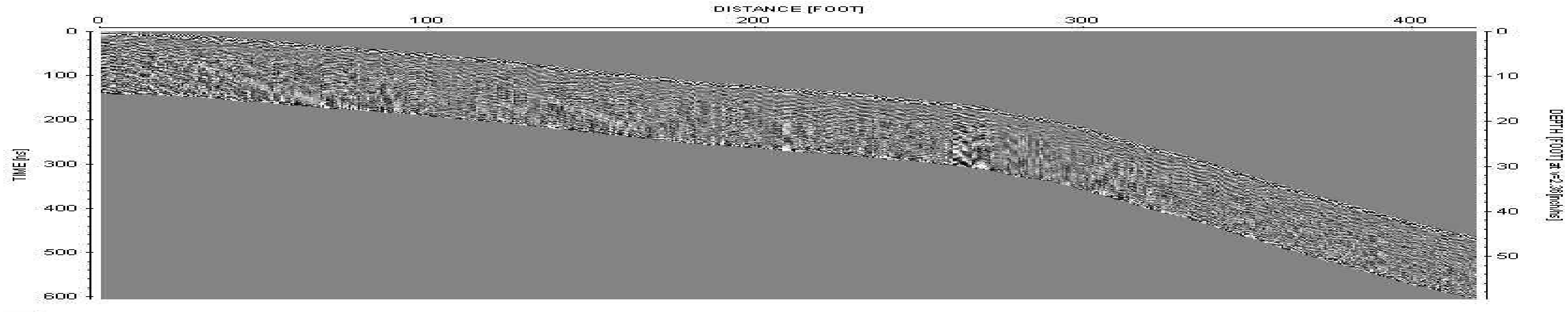


Figure A54: Ground penetrating radar profile I. All distance/depth units are in feet.

Appendix F

Lab Results

- One Dimensional Consolidation Curves
- CU Stress Paths

FMSM ENGINEERS

One-Dimensional Consolidation of Soils

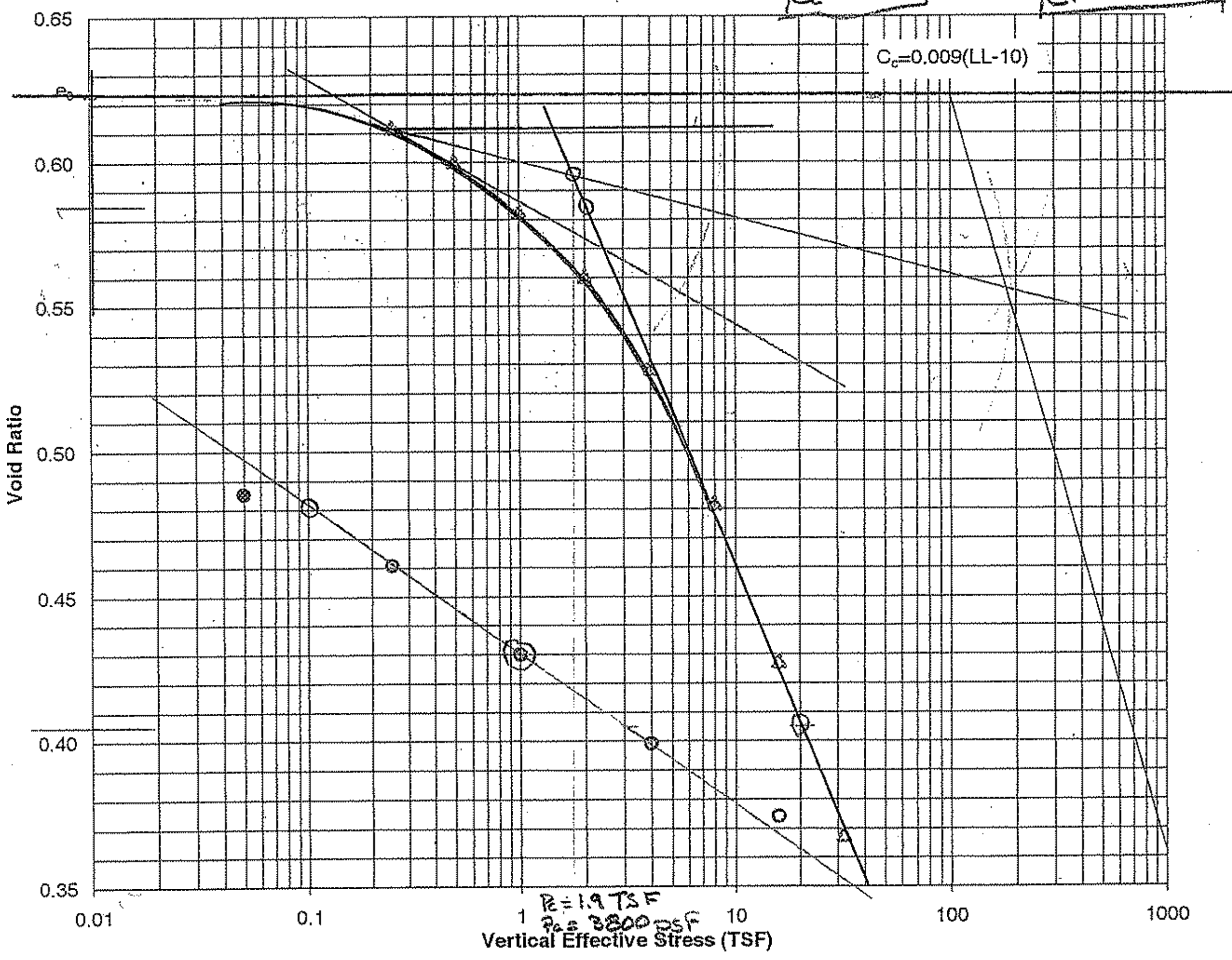
ASTM D 2435

Project Name	East End Approach	Project No.	LX2004110
Source	B-26/138+50, CL, 5.75' - 6.0'	Sample ID	90
Cv computation Method: Square Root of Time		Initial Void Ratio	0.623
Swell Pressure (tsf) - 7.59 E-02		Preconsolidation Pressure (tsf)	

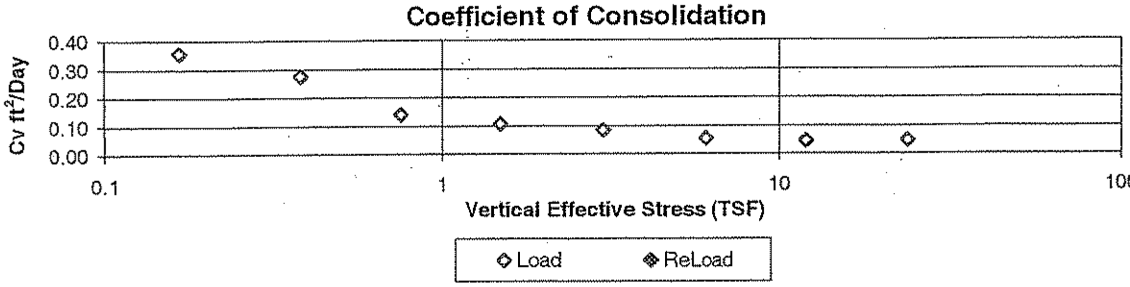
$C_c = \frac{0.585 - 0.405}{\log(20/0.2)}$ $C_r = \frac{0.482 - 0.430}{\log(1/0.1)}$

$C_c = 0.18$ $C_r = 0.052$

Void Ratio at d_{100} vs. Stress



Coefficient of Consolidation



LX2004110_Con-90.xls e d100
Prepared: 02-1998
Revised: 2-2003

Fuller, Mossbarger, Scott and May Engineers, Inc.

Laboratory Document
Prepared By: MW
Approved By: TLK

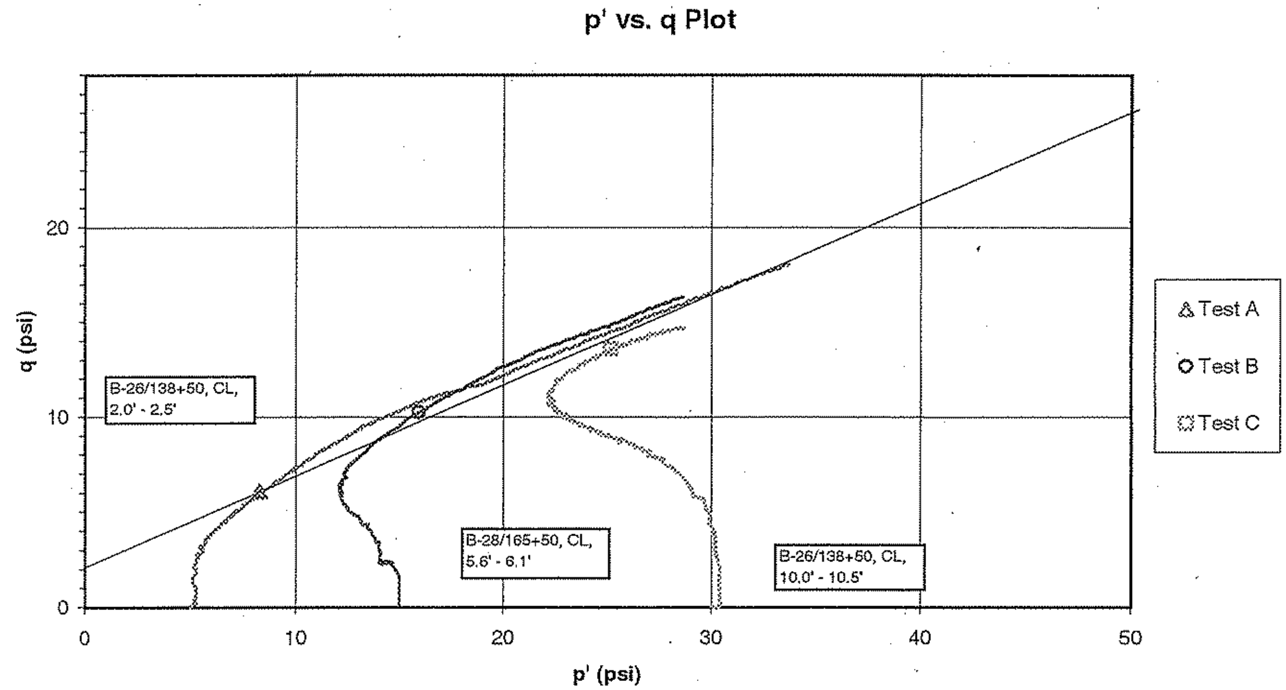
Fuller Mossbarger Scott & May
FMSM ENGINEERS

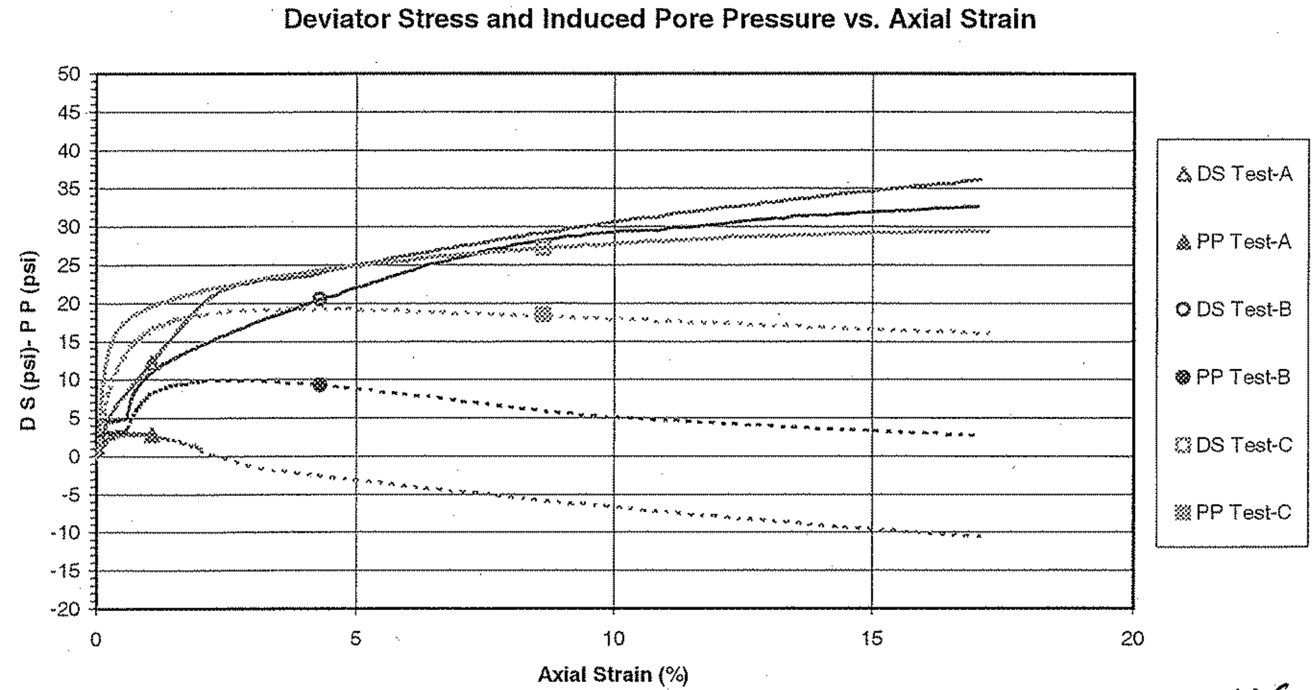
Consolidated Undrained Triaxial Test
ASTM D4767-95

Project	East End Approach	Project No.	LX2004110
Sample ID	B-26/138+50, CL, 2.0' - 2.5', 10.0' - 10.5'; B-28/165+50, CL, 5.6' - 6.1'	Test Number	3

$\phi' =$ 28.6 deg. c' = 340 psf

Failure Criterion: Maximum Effective Principal Stress Ratio





KDG

LX2004110_CU-3.xls Plots
Preparation Date: 1998
Revision Date: 11-2000

Fuller, Mossbarger, Scott and May Engineers

Laboratory Document
Prepared By: MW
Approved By: TLK

Fuller Mossbarger Scott & May FMSM ENGINEERS

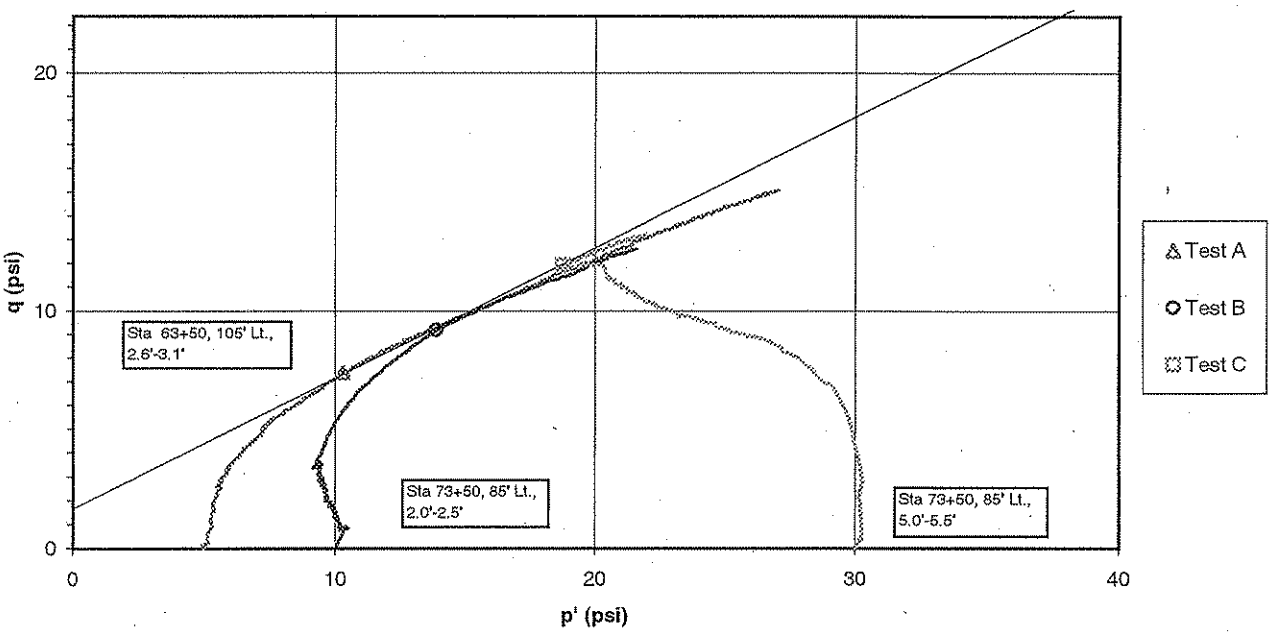
Consolidated Undrained Triaxial Test
ASTM D4767-95

Project	East End Approach	Project No.	LX2004110
Sample ID	Sta 63+50, 105' Lt., 2.6'-3.1', Sta 73+50, 85' lt., 2.0'-2.5', 5.0'-5.5'	Test Number	CU-2

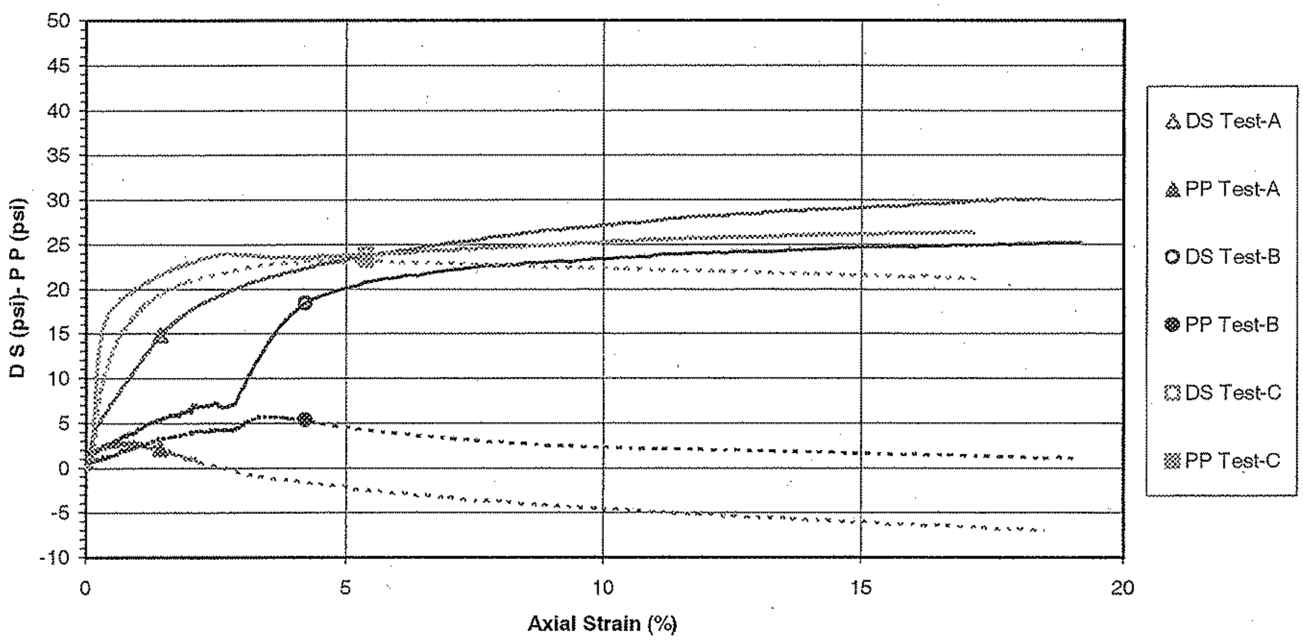
ϕ' = 33.4 deg.   c' = 280 psf

Failure Criterion: Maximum Effective Principal Stress Ratio

p' vs. q Plot



Deviator Stress and Induced Pore Pressure vs. Axial Strain



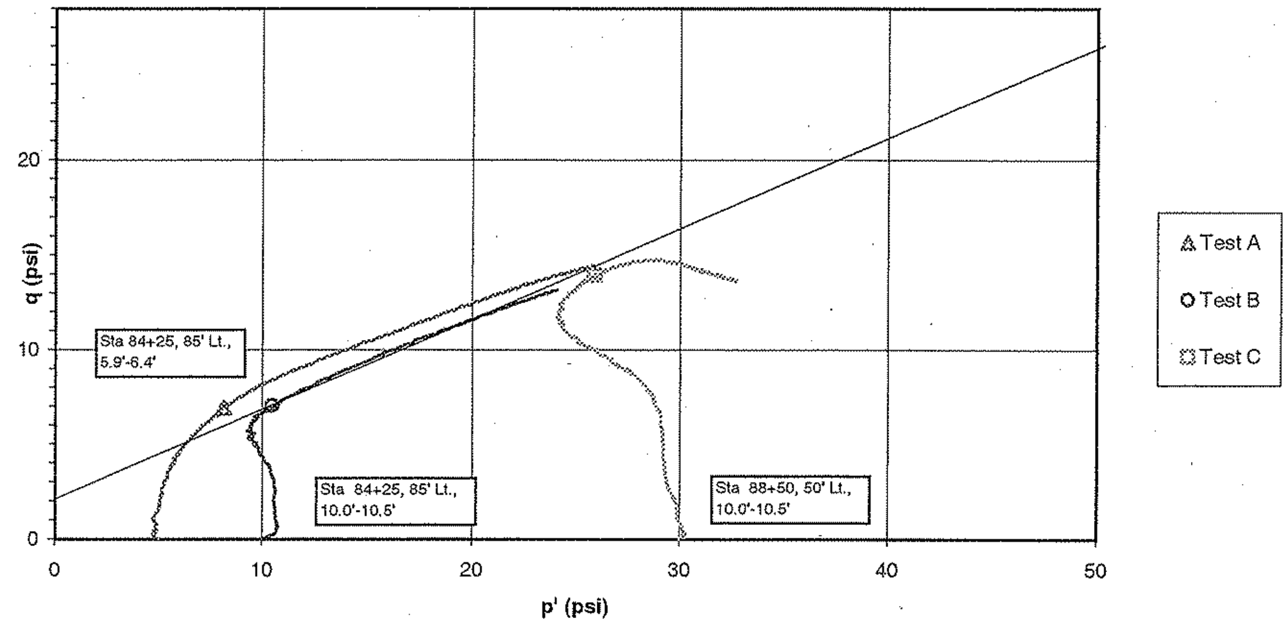
Fuller Mossbarger Scott & May
FMSM ENGINEERS

Consolidated Undrained Triaxial Test
ASTM D4767-95

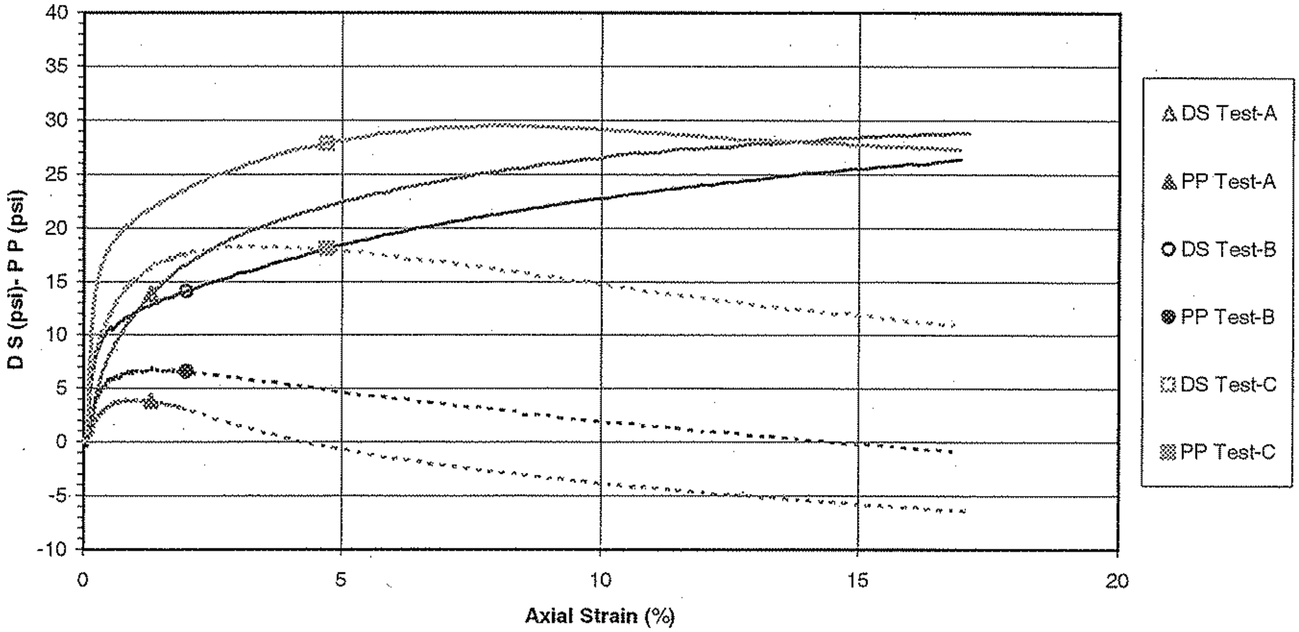
Project	East End Approach	Project No.	LX2004110
Sample ID	Sta 84+25, 85' Lt., 5.9'-6.4', 10.0'-10.5', Sta 88+50, 60' Lt., 10.0'-10.5'	Test Number	CU-1
	ϕ' = 28.4 deg.	c' =	340 psf

Failure Criterion: Maximum Effective Principal Stress Ratio

p' vs. q Plot



Deviator Stress and Induced Pore Pressure vs. Axial Strain



Appendix G

Correction of SPT Data

KENNEDY INTERCHANGE
CORRELATION OF SPT DATA TO UNIT WEIGHTS AND SHEAR STRENGTHS
FOR COARSE GRAINED SOILS

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Soil No.	Depth of Mid. Pt. of Sample (ft.)	Assumed Estimated Unit Weight (pcf)	Vertical Effective Stress (tsf)	SPT N Value	SPT N Value	Correction Factor	Corrected N-Value	Relative Density (%)	Unified Soil Classification	Internal Angle of Friction (degrees)	Unit Weight Dry (pcf)	Moisture Content (%)	Revised In-situ Unit Weight (pcf)	Void Ratio
		γ_w	σ'	N_{80}	N_{60}	C_N	$(N_1)_{60}$	D_r		ϕ'	γ_d	m	γ_w	e

NOTES:

C.	This spreadsheet has been designed such that an initial "Assumed Estimated Unit Weight" is placed into Column C.
E.	N_{80} is the blow count per foot as determined in the field using a automatic hammer.
F.	$N_{60} = (E_{AH}/60)\ N_{AH}$, where: E_{AH} = autohammer efficiency (80%): N_{AH} = blowcount from the autohammer, as referenced in (1)
	The autohammer efficiency is based on typical values of efficiencies (85 - 95) and actual testing preformed on FMSM hammers. SPT Analyzer equipment from
	Pile Dynamics Inc. was used to conduct the testing. An autohammer is more enegry efficient than a standard hammer.
	Hammer efficiency is a means of comparing the energy transferred from the hammer to the drill string during sampling.
G.	Correction Factor Based on 1/(square root of vertical effective stress). (Liao, S.C. and Whitman, R.V. 1985.
	"Overburden Correction Factors for SPT in Sand", JGED, ASCE, Vol. 112, No. 3, pp. 373-377; as referenced in (2).
	This correction factor is limited to vertical effective stresses greater than 0.25 tsf.
I.	Relative Density based on Tokimatsu, K. and Seed, H.B. 1988. "Evaluation of Settlements in Sands Due to Earthquake Shaking",
	JGED, ASCE, Vol. 113, No. 8, pp. 861-878; as referenced in (2).
J.	Classification based on field and laboratory data by FMSM.
K, L and O	Angle of Internal Friction (phi), Unit Weight Dry and Void Ratio based on NAVFAC 7.1 "Soil Mechanics", May 1982, page 7.1-149.
M.	Moisture content based on laboratory testing of SPT samples by FMSM.
N.	In-situ unit weight is based on dry unit weight (L) times (1 + moisture content).
(1)	Goble, George, GRL Newsletter, December 1995 "SPT Improvements"
(2)	Seed and Harder, Volume 2 Memorial Symposium Proceedings, May 1990. "SPT Based Analysis of
	Cyclic Pore Pressure Generation and Undrained Residual Strength", pp. 361-362.

KENNEDY INTERCHANGE
CORRELATION OF SPT DATA TO UNIT WEIGHTS AND SHEAR STRENGTHS
FOR COARSE GRAINED SOILS

Sample Interval			Depth of Mid. Pt. of Sample (ft.)	Assumed Estimated Unit Weight (pcf) γ_w	Vertical Effective Stress (tsf) σ'	SPT N Value N_{80}	SPT N Value N_{60}	Correction Factor C_N	Corrected N-Value $(N_1)_{60}$	Relative Density (%) D_r	Unified Soil Classification	Internal Angle of Friction (degrees) ϕ'	Unit Weight Dry (pcf) γ_d	Moisture Content (%) m	Revised In-situ Unit Weight (pcf) γ_w	Void Ratio e
						Input Required										
B-26				water =	8.5	12/15/2005										
2.0	-	4.0	3	115	0.17	ST	NA	1.00	NA	#N/A	CL	NA	NA	20.0	NA	NA
5.0	-	7.0	6	115	0.35	ST	NA	1.00	NA	#N/A	CL	NA	NA	16.0	NA	NA
10.0	-	12.0	11	115	0.48	ST	NA	1.00	NA	#N/A	CL	NA	NA	19.0	NA	NA
12.0	-	13.5	12.75	115	0.52	6	8	1.00	8	41	SM	30.5	95	20.0	114	0.76
15.0	-	16.5	15.75	115	0.60	3	4	1.00	4	27	SM	29	92	20.0	110	0.82
20.0	-	21.5	20.75	115	0.73	8	11	1.00	11	47	SM	31	96	20.0	115	0.74
25.0	-	26.5	25.75	115	0.86	13	17	1.00	17	60	SM	33	99	20.0	119	0.69
30.0	-	31.5	30.75	115	1.00	58	77	1.00	77	100	SM	38	108	20.0	130	0.55
35.0	-	36.5	35.75	115	1.13	24	32	0.94	30	79	SM	34.5	102	20.0	122	0.63
40.0	-	41.5	40.75	115	1.26	13	17	0.89	15	58	CL	NA	NA	20.0	NA	NA
45.0	-	46.5	45.75	115	1.39	9	12	0.85	10	47	CL	NA	NA	20.0	NA	NA
50.0	-	51.5	50.75	115	1.52	13	17	0.81	14	56	CL	NA	NA	20.0	NA	NA
55.0	-	56.5	55.75	115	1.65	26	35	0.78	27	77	CL	NA	NA	20.0	NA	NA

KENNEDY INTERCHANGE
CORRELATION OF SPT DATA TO UNIT WEIGHTS AND SHEAR STRENGTHS
FOR COARSE GRAINED SOILS

Sample Interval		Depth of Mid. Pt. of Sample (ft.)	Assumed Estimated Unit Weight (pcf) γ_w	Vertical Effective Stress (tsf) σ'	SPT N Value N_{80}	SPT N Value N_{60}	Correction Factor C_N	Corrected N-Value $(N_1)_{60}$	Relative Density (%) D_r	Unified Soil Classification	Internal Angle of Friction (degrees) ϕ'	Unit Weight Dry (pcf) γ_d	Moisture Content (%) m	Revised In-situ Unit Weight (pcf) γ_w	Void Ratio e
					Input Required										
B-27			water =	39.0	11/30/2005										
2.0 -	4.0	3	115	0.17	ST	NA	1.00	NA	#N/A	CL	NA	NA	22.5	NA	NA
5.0 -	7.0	6	115	0.35	ST	NA	1.00	NA	#N/A	CL	NA	NA	0.0	NA	NA
7.0 -	8.5	7.75	115	0.45	6	8	1.00	8	41	SP-SM	31.5	103	17.0	120.5	0.62
10.0 -	11.5	10.75	115	0.62	5	7	1.00	7	35	SP-SM	31	102	12.0	114.2	0.64
15.0 -	16.5	15.75	115	0.91	22	29	1.00	29	79	SP-SM	36	110	12.0	123.2	0.52
20.0 -	21.5	20.75	115	1.19	26	35	0.92	32	81	SP-SM	36.5	111.5	4.0	116.0	0.5
25.0 -	26.5	25.75	115	1.48	26	35	0.82	29	77	SP-SM	36	110	4.0	114.4	0.52
30.0 -	31.5	30.75	115	1.77	41	55	0.75	41	91	SP-SM	38	114	4.0	118.6	0.47
35.0 -	36.5	35.75	115	2.06	19	25	0.70	18	60	SP-SM	34	107	19.0	127.3	0.56
40.0 -	41.5	40.75	115	2.19	27	36	0.68	24	73	SM	34	101	19.0	120.2	0.65
45.0 -	46.5	45.75	115	2.32	17	23	0.66	15	56	SM	32.5	98	19.0	116.6	0.7
50.0 -	51.5	50.75	115	2.45	58	77	0.64	49	97	SM	37	107	19.0	127.3	0.56

KENNEDY INTERCHANGE
CORRELATION OF SPT DATA TO UNIT WEIGHTS AND SHEAR STRENGTHS
FOR COARSE GRAINED SOILS

Sample Interval			Depth of Mid. Pt. of Sample (ft.)	Assumed Estimated Unit Weight (pcf) γ_w	Vertical Effective Stress (tsf) σ'	SPT N Value N_{80}	SPT N Value N_{60}	Correction Factor C_N	Corrected N-Value $(N_1)_{60}$	Relative Density (%) D_r	Unified Soil Classification	Internal Angle of Friction (degrees) ϕ'	Unit Weight Dry (pcf) γ_d	Moisture Content (%) m	Revised In-situ Unit Weight (pcf) γ_w	Void Ratio e
						Input Required										
1B-352				water =	41.1	12/15/2005										
2.0	-	4.0	3	115	0.17	ST	NA	1.00	NA	#N/A	CL	NA	NA	22.0	NA	NA
5.0	-	7.0	6	115	0.35	ST	NA	1.00	NA	#N/A	CL	NA	NA	19.5	NA	NA
7.0	-	8.5	7.75	115	0.45	6	8	1.00	8	41	SM	30.5	95	4.0	99	0.76
10.0	-	11.5	10.75	115	0.62	12	16	1.00	16	60	SM	33	99	4.0	103	0.69
15.0	-	16.5	15.75	115	0.91	22	29	1.00	29	79	SP-SM	36	110	4.0	114	0.52
20.0	-	21.5	20.75	115	1.19	41	55	0.92	50	98	SP-SM	38.5	115	4.0	120	0.45
25.0	-	26.5	25.75	115	1.48	37	49	0.82	41	89	SP-SM	37	113	4.0	118	0.48
30.0	-	31.5	30.75	115	1.77	27	36	0.75	27	77	SP-SM	36	110	4.0	114	0.52
35.0	-	36.5	35.75	115	2.06	25	33	0.70	23	71	SP-SM	35	109	4.0	113	0.54
40.0	-	41.5	40.75	115	2.34	43	57	0.65	38	87	SW-SM	37	113	5.0	119	0.48
45.0	-	46.5	45.75	115	2.47	23	31	0.64	20	65	SW-SM	34.5	108	5.0	113	0.55
50.0	-	51.5	50.75	115	2.61	21	28	0.62	17	60	SW-SM	34	107	5.0	112	0.56
55.0	-	56.5	55.75	115	2.74	27	36	0.60	22	68	SW-SM	34.5	108	5.0	113	0.55
60.0	-	61.5	60.75	115	2.87	31	41	0.59	24	73	SW-SM	35	109	5.0	114	0.54
65.0	-	66.5	65.75	115	3.00	16	21	0.58	12	52	SW-SM	33	105	5.0	110	0.59
70.0	-	71.5	70.75	115	3.13	22	29	0.57	17	60	SW-SM	34	107	5.0	112	0.56

KENNEDY INTERCHANGE
CORRELATION OF SPT DATA TO UNIT WEIGHTS AND SHEAR STRENGTHS
FOR COARSE GRAINED SOILS

Sample Interval		Depth of Mid. Pt. of Sample (ft.)	Assumed Estimated Unit Weight (pcf) γ_w	Vertical Effective Stress (tsf) σ'	SPT N Value N_{80}	SPT N Value N_{60}	Correction Factor C_N	Corrected N-Value $(N_1)_{60}$	Relative Density (%) D_r	Unified Soil Classification	Internal Angle of Friction (degrees) ϕ'	Unit Weight Dry (pcf) γ_d	Moisture Content (%) m	Revised In-situ Unit Weight (pcf) γ_w	Void Ratio e
					Input Required										
B-29			water =	13.6	1/9/2006										
2.0 -	4.0	3	115	0.17	ST	NA	1.00	NA	#N/A	CL	NA	NA	23.5	NA	NA
5.0 -	7.0	6	115	0.35	ST	NA	1.00	NA	#N/A	CL/CH	NA	NA	42.0	NA	NA
10.0 -	12.0	11	115	0.63	ST	NA	1.00	NA	#N/A	CL	NA	NA	22.0	NA	NA
15.0 -	16.5	15.75	115	0.76	4	5	1.00	5	32	CL	NA	NA	22.0	NA	NA
20.0 -	21.5	20.75	115	0.89	4	5	1.00	5	32	CL	NA	NA	22.0	NA	NA
25.0 -	26.5	25.75	115	1.02	2	3	0.99	3	18	CL	NA	NA	22.0	NA	NA
30.0 -	31.5	30.75	115	1.15	4	5	0.93	5	32	SM	29.5	93	22.0	113	0.8
35.0 -	36.5	35.75	115	1.28	20	27	0.88	24	71	SM	34	101	22.0	123	0.65
40.0 -	41.5	40.75	115	1.41	20	27	0.84	22	70	SM	34	101	14.0	115	0.65
45.0 -	46.5	45.75	115	1.55	26	35	0.80	28	77	SM	34.5	102	14.0	116	0.63
50.0 -	51.5	50.75	115	1.68	22	29	0.77	23	70	SM	34	101	14.0	115	0.65
55.0 -	56.5	55.75	115	1.81	20	27	0.74	20	65	SM	33.5	100	14.0	114	0.67
60.0 -	61.5	60.75	115	1.94	26	35	0.72	25	73	SM	34	101	14.0	115	0.65
65.0 -	66.5	65.75	115	2.07	43	57	0.69	40	89	SM	36	105	14.0	120	0.6
70.0 -	71.5	70.75	115	2.20	42	56	0.67	38	87	SW-SM	37	113	14.0	129	0.48
75.0 -	76.5	75.75	115	2.34	25	33	0.65	22	68	SW-SM	34.5	108	14.0	123	0.55
80.0 -	81.5	80.75	115	2.47	25	33	0.64	21	68	SW-SM	34.5	108	14.0	123	0.55
85.0 -	86.5	85.75	115	2.60	68	91	0.62	56	100	SW-SM	39	116	19.0	138	0.44
90.0 -	91.5	90.75	115	2.73	11	15	0.61	9	41	SW-SM	31.5	103	14.0	117	0.62
95.0 -	96.5	95.75	115	2.86	10	13	0.59	8	41	SW-SM	31.5	103	13.0	116	0.62

KENNEDY INTERCHANGE
CORRELATION OF SPT DATA TO UNIT WEIGHTS AND SHEAR STRENGTHS
FOR COARSE GRAINED SOILS

Sample Interval			Depth of Mid. Pt. of Sample (ft.)	Assumed Estimated Unit Weight (pcf) γ_w	Vertical Effective Stress (tsf) σ'	SPT N Value N_{80}	SPT N Value N_{60}	Correction Factor C_N	Corrected N-Value $(N_1)_{60}$	Relative Density (%) D_r	Unified Soil Classification	Internal Angle of Friction (degrees) ϕ'	Unit Weight Dry (pcf) γ_d	Moisture Content (%) m	Revised In-situ Unit Weight (pcf) γ_w	Void Ratio e
						Input Required										
B-30				water =	13.8	1/9/2006										
2.0	-	4.0	3	115	0.17	ST	NA	1.00	NA	#N/A	CH	NA	NA	28.5	NA	NA
5.0	-	7.0	6	115	0.35	ST	NA	1.00	NA	#N/A	CL	NA	NA	26.5	NA	NA
10.0	-	11.5	10.75	115	0.62	4	5	1.00	5	32	SM	29.5	93	26.0	117	0.8
15.0	-	16.5	15.75	115	0.75	4	5	1.00	5	32	SM	29.5	93	26.0	117	0.8
20.0	-	21.5	20.75	115	0.88	4	5	1.00	5	32	SM	29.5	93	12.0	104	0.8
25.0	-	26.5	25.75	115	1.01	32	43	0.99	42	91	SM	36.5	106	12.0	119	0.58
30.0	-	31.5	30.75	115	1.14	17	23	0.93	21	68	SM	33.5	100	12.0	112	0.67
35.0	-	36.5	35.75	115	1.28	27	36	0.89	32	81	SW-SM	36.5	111.5	9.0	122	0.5
40.0	-	41.5	40.75	115	1.41	28	37	0.84	32	81	SW-SM	36.5	111.5	9.0	122	0.5
45.0	-	46.5	45.75	115	1.54	18	24	0.81	19	65	SW-SM	34.5	108	9.0	118	0.55
50.0	-	51.5	50.75	115	1.67	23	31	0.77	24	71	SW-SM	35	109	17.0	128	0.54
55.0	-	56.5	55.75	115	1.80	19	25	0.75	19	63	SW-SM	34	107	17.0	125	0.56
60.0	-	61.5	60.75	115	1.93	29	39	0.72	28	77	SW-SM	36	110	17.0	129	0.52
65.0	-	66.5	65.75	115	2.06	27	36	0.70	25	74	SW-SM	35	109	17.0	128	0.54
70.0	-	71.5	70.75	115	2.20	16	21	0.67	14	56	SW-SM	33.5	106	17.0	124	0.57
75.0	-	76.5	75.75	115	2.33	22	29	0.66	19	65	SW-SM	34.5	108	15.0	124	0.55
80.0	-	81.5	80.75	115	2.46	16	21	0.64	14	53	SW-SM	33	105	15.0	121	0.59
85.0	-	86.5	85.75	115	2.59	14	19	0.62	12	47	SW-SM	32	104	15.0	120	0.61
90.0	-	91.5	90.75	115	2.72	18	24	0.61	15	56	SW-SM	33.5	106	21.0	128	0.57
95.0	-	96.5	95.75	115	2.85	25	33	0.59	20	65	SW-SM	34.5	108	21.0	131	0.55