FINAL FOUNDATION REPORT

Interstate 80; Missouri River to 13th Street

Omaha, NE

NH-80-9(889); CN 22132

April 10, 2009

PREPARED BY

NDOR GEOTECHNICAL SECTION
SOIL MECHANICS UNIT

NDOR
Nebraska
Department of Roads

April 10, 2009

REFERENCE: Final Foundation Report for I-80; Missouri River to 13th Street
NH-80-9(889), CN 22132

The NDOR Geotechnical Section has prepared the enclosed report that summarizes the findings of a soil and foundation engineering study and provides recommendations related to the design and construction of the foundation for the referenced project.

If any questions arise concerning this report or if additional information is needed about foundation conditions at this site, please contact the NDOR Geotechnical Section for assistance.

Sincerely,

NDOR Geotechnical Section
Materials & Research Division

Mark C. Lindemann
Soil Mechanics Unit Manager

Omar Qudus
Geotechnical Engineer

Enclosures
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I. INTRODUCTION

The Nebraska Department of Roads plans to expand Interstate 80 in Omaha from the Missouri River to 13th Street. The project consists of converting the current westbound lanes from two lanes to five lanes and the eastbound lanes converted from two lanes to four lanes. As part of this expansion several retaining walls, consisting of Soil Nail and MSE (Mechanically Stabilized Earth) Walls, are proposed to aid in the expansion and to limit acquisition of right-of-way. This report provides foundation soil recommendations for the design of the retaining wall structures.

Field and laboratory work consisted of: (a) making auger borings and Cone-Penetration Test (CPT) soundings to determine the depth, thickness, and composition of each soil formation encountered to the depths of the borings, (b) performing field tests to determine the approximate strength of the foundation soils, (c) performing a geologic study to determine the origin of the deposits underlying the site, and (d) performing standard tests to determine the engineering properties of the soil strata that would affect the performance of the structure.

An engineering evaluation has been made of subsurface conditions with respect to design and construction of the proposed expansion project. Recommendations are provided for the type of foundation, the foundation soil parameters for MSE and Soil Nail Walls, the types of soils to be used as fill and backfill, and the placement of fill and backfill.

II. SUBSURFACE EXPLORATION & FIELD TESTING

A program of electronic CPT soundings, test borings, and soil sampling was performed at the project site on November of 2005 and March of 2009.

Six (6) CPT soundings were made at the site. The results of the soundings were used to determine the depths for obtaining undisturbed soil samples from an exploratory boring made immediately adjacent to each sounding. Ten (10) exploratory borings were taken to depths of 15 to 40 feet below the existing grade to establish the general subsurface conditions of the area under consideration.

The CPT soundings were performed with a mechanical penetrometer in accordance with ASTM D 5778-07, Test Method for Electronic Friction Cone and Piezecone Cone Penetration Testing of Soils. The Electronic Friction Cone provides continuous point resistance and frictional resistance during penetration of a conical-shaped penetrometer and cylindrical sleeve as it is advanced into subsurface soils at a steady rate. The CPT transmits the components of penetration resistance (cone bearing and friction sleeve resistance) to the surface for measurement. The plot of the test data identifies the relative positions and thicknesses of hard and soft layers. The borings were made in accordance with AASHTO T 306-98, Standard Method of Test for Progressing Auger Borings for Geotechnical Explorations. A machine-driven, hollow-stem auger having an inside diameter of 4.5 inches was used to advance the holes for split-barrel and thin-walled tube sampling. The bore holes were stable and casing was not required.

Forty-six (46) relatively undisturbed soil samples were recovered for visual observation and laboratory testing. This sampling was performed in accordance with AAHTO T207-03, Standard Method for Thin-Walled Tube Sampling of Soil, utilizing an open-tube sampler having an outside diameter of 3.0 inches.

The penetration diagrams (see Appendix A) present the results of the CPT soundings. The boring logs (refer to Appendix B) present the data obtained in the subsurface exploration.

The logs include the surface elevations, the approximate depths and elevations of major changes in the character of the subsurface materials, visual descriptions of the materials, groundwater data, and the locations of undisturbed samples of soil. Water level readings were made in the auger borings at times and under conditions stated on the boring logs.

During exploration, a platform was excavated in the slope of the proposed 3-tiered wall location at boring location MR1 (Station 1424+00, 146' Left). As a result of the excavation, a vertical slope approximately 6 feet in height and decreasing to about 2 feet in height. A stand-up test was performed on this excavation. The stand-up test consisted of observation and photraphing the vertical cut immediately after excavation, approximately 24 hours after excavation, and 4 days after excavation. Immediately after excavation the vertical cut showed no signs of instability or sloughing. At 24 hours and 4 days the vertical cut showed no signs of instability, with minor sloughing at the surface due to drying of the surficial loess soils. The stand-up time test is for informational purposes only and NDOR does not take responsibility for any design based on this information.

III. LABORATORY ANALYSES

The moisture content and dry density of selected undisturbed soil samples are presented in the boring logs opposite the respective sample location. These data correlate with the strength and compressibility of the soil. High moisture content and low density usually indicates low strength and high compressibility.

Consolidated, undrained triaxial compression tests were performed on three samples of subsurface soils to provide data on the shearing strength of these materials. The triaxial compression tests were performed in accordance with AASHTO T 297-94 (reapproved 2007), Standard Test Method for Consolidated-Undrained Triaxial Compression Test on Cohesive Soils. Specimens were backpressure saturated prior to shearing. Pore pressure measurements were taken during shearing, thus permitting both total stress and effective

stress strength parameters to be determined. A summary of the test data is shown in Table 1.

TABLE 1
Triaxial Compression Test Data

Boring No.	Depth ft	Phi(ø) degrees	Cohesion lbf/ft^2
MS1	14.5 – 15.1	18.3	2044
MS2	8.5 – 9.3	29.8	0
MR1	14.9 – 15.6	30	0

The unconfined compressive strengths of forty (40) undisturbed samples of subsurface soils were determined in accordance with AASHTO T 208-05, Standard Test Method for Unconfined Compressive Strength of Cohesive Soil. These data are summarized in Table 2.

TABLE 2
Unconfined Compression Test Data

Boring No.	Depth ft	Moisture %	Dry Density lbf/ft^3	Unconfined Compressive Strength, psf
MS1	2.7 – 3.3	12.3	93.2	3600
MS1	7.7 – 8.3	20.1	98.7	2034
MS1	15.4 – 15.7	22.0	103.3	2678
MS1	24.5 – 25.1	22.3	102.8	2223
MS2	4.5 – 4.9	17.4	86.6	1070
MS2	7.5 – 8.1	17.0	82.1	1096
MS2	19.5 – 20.0	20.8	94.0	1445
MS2	29.5 – 30.1	21.2	104.8	1837
MS3	4.5 – 5.2	23.1	96.4	1732
MS3	8.1 – 8.7	25.5	93.1	565
MS3	14.8 – 15.4	28.1	73.3	543
MS3	20.0 – 20.6	27.6	75.4	826
MS3	25.0 – 25.6	21.8	80.5	632
MS3	29.5 – 30.2	21.1	81.7	444
MS4	3.1 – 3.7	19.3	109.2	4658
MS4	7.6 – 8.2	31.7	88.1	716
MS4	14.6 – 15.2	23.1	102.8	3005
MS4	19.7 – 20.3	27.0	78.5	1957
MS5	2.8 – 3.4	20.9	100.3	2126
MS5	4.9 – 5.5	23.7	90.2	1076
MS5	8.0 – 8.5	25.7	87.3	746
MS5	9.5 – 10.2	19.3	107.8	6577
MS5	14.5 – 15.2	16.5	82.7	1340

TABLE 2 (continued)
Unconfined Compression Test Data

Boring No.	Depth ft	Moisture %	Dry Density lbf/ft³	Unconfined Compressive Strength, psf
MS6	3.4 – 4.0	19	110	4677
MS6	4.5 – 5.1	23.6	99.5	1742
MS6	7.5 – 8.2	24.2	98.2	1550
MS6	9.5 – 10.1	25.2	92.2	1302
MS6	14.5 – 15.2	16.8	80	2484
MS7	5.2 – 5.8	18.6	83.3	1407
MS7	9.9 – 10.5	15.6	94.5	1361
MS7	14.7 – 15.3	14.9	84	478
MS7	19.5 – 20.2	18.7	86.5	1870
MS8	4.9 – 5.5	17.3	109.0	3525
MS8	9.5 – 10.0	25.0	83.9	1704
MS8	15.1 – 15.7	24.4	92.3	862
MS8	20.1 – 20.8	22.3	81.0	1096
MS8	24.8 – 25.4	21.8	84.9	876
MR1	14.6 – 14.9	18.4	100	3412
MR1	30.1 – 30.7	17.5	92.2	2413
MR2	29.7 – 30.1	16.3	87.4	2498

The plasticity characteristics of nineteen (19) air-dried samples of soil materials were determined in accordance with AASHTO Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils (T 89 and T 90). These limits of consistency (Atterberg limits) are used in the Unified Soil Classification System as a basis for laboratory differentiation between materials of appreciable plasticity (clays) and slightly plastic or nonplastic materials (silts). The test results are presented in the boring logs.

V. GEOLOGY AND SITE CONDITIONS

The city of Omaha lies in the Dissected Till Plains section of Nebraska, a part of the Central Lowland province of the Interior Plains physiographic division[1]. The project site is located west of the Missouri River and is situated on Peoria loess with intermittent areas containing artificial fill due to construction. The Peoria loess is typically a massive, calcareous or non-

[1] Physiographic Provinces of North America, Map by A. K. Lobeck, 1948; The Geographical Press; Columbia University, New York

calcareous, brown to light yellowish brown, wind-deposited clayey silt (silt loam). Peoria typically stands nearly vertically in road cuts and stream cuts. The grain size distribution for the project site typically contains a trace of sand (less than 5%), 72 to 83 percent silt, and 16 to 27 percent clay. Peoria loess is prone to slumping on steep slopes and disturbed and sparsely vegetated areas are susceptible to gullying and sheet erosion. Detailed descriptions of the subsurface materials encountered are provided in the boring logs, which are presented in Appendix B.

Groundwater was not encountered at any of the borings performed for this project at the time of drilling. The water table could be expected to fluctuate several feet depending on surface drainage, rainfall, lawn watering, irrigation, vegetation, temperature, and other factors.

V. DISCUSSION AND RECOMMENDATIONS

The following recommendations for design and construction of the foundation for the proposed Interstate expansion are based upon site conditions, the engineering properties of the subsurface materials, and the requirements of the proposed structure.

STATION 1414+60 – 1428+11 Left

Due to the 5-lane expansion of the westbound lanes at this location, a 3-Tiered Soil Nail Wall with a total height of 45 feet (two 15-foot walls and one 10-foot wall) is planned. Table 3 presents the slope-stability safety factor values that have been calculated for the Soil Nail Wall.

Table 3

Circumstance	Factor of Safety
Global Stability of the proposed Soil Nail Wall (short term)	1.38
Global Stability of the proposed Soil Nail Wall (long term)	1.68

The above listed slope stability safety factors are considered acceptable for all of the circumstances presented in Table 3. Table 4 presents the allowable values for the foundation soils that will support the Soil Nail Walls.

Table 4
Foundation Soil Characteristic Values for the 3-tier Soil Nail Wall
From Station 1414+60 to 1428+11 Left

Foundation Soil Description		Cohesion	Angle of Internal Friction,	Moist Unit Weight	Minimum Ultimate Grout Bond Capacity	Minimum Nail Length	Minimum Nail Diameter
Location	Soil Type	(psf)	(degrees)	(pcf)	(psf)	(ft)	(inch)
Sta. 1414+60 to 1428+11, Lt.	CL-Peoria	848	13.2	110	1,500	0.8 H	0.86

*H = Height of Individual Soil Nail Wall (each tier)

STATION 1404+01 – 1410+49 Left

Due to the expansion to 5-lanes for the westbound lanes at this location, an18-foot cut section will be required into the existing cut-slope adjacent to the existing westbound lanes. It should be noted that the existing north abutment Riverview Bridge will be constructed approximately 40 feet east of the existing bridge. A single Soil Nail Wall at this location would be have a maximum height of approximately 18 feet in height with a 3:1 slope behind the wall. Table 5 presents the slope-stability safety factor values that have been calculated for the Soil Nail Wall.

Table 5

Circumstance	Factor of Safety
Global Stability of the proposed Soil Nail Wall (short term)	2.31
Global Stability of the proposed Soil Nail Wall (long term)	1.56

The above listed slope stability safety factors are considered acceptable for all of the circumstances presented in Table 5. Table 6 presents the allowable values for the foundation soils that will support the Soil Nail Walls.

Table 6
Foundation Soil Characteristic Values for the Soil Nail Wall
From Station 1404+01 to 1410+49 Left

Foundation Soil Description		Cohesion	Angle of Internal Friction,	Moist Unit Weight	Minimum Ultimate Grout Bond Capacity	Minimum Nail Length	Minimum Nail Diameter
Location	Soil Type	(psf)	(degrees)	(pcf)	(psf)	(ft)	(inch)
Sta. 1404+01 to 1410+49, Lt.	CL-Peoria	0	29.8	116	1,500	0.8 H	0.86

*H = Height of Individual Soil Nail Wall

STATION 1401+69 – 1413+50 Right

Due to the expansion to 4-lanes for the eastbound lanes at this location, a 16-foot cut section will be required into the existing cut-slope adjacent to the existing eastbound lanes. It should be noted that the existing south abutment Riverview Bridge will be constructed approximately 40 feet east of the existing bridge. A single Soil Nail Wall at this location would be approximately 16 feet in height with a 3:1 slope behind the wall. Table 7 presents the slope-stability safety factor values that have been calculated for the Soil Nail Wall.

Table 7

Circumstance	Factor of Safety
Global Stability of the proposed Soil Nail Wall (short term)	1.5
Global Stability of the proposed Soil Nail Wall (long term)	1.96

The above listed slope stability safety factors are considered acceptable for all of the circumstances presented in Table 7. Table 8 presents the allowable values for the foundation soils that will support the Soil Nail Walls.

Table 8
Foundation Soil Characteristic Values for the Soil Nail Wall
From Station 1401+69 to 1413+50 Right

Foundation Soil Description		Cohesion	Angle of Internal Friction,	Moist Unit Weight	Minimum Ultimate Grout Bond Capacity	Minimum Nail Length	Minimum Nail Diameter
Location	Soil Type	(psf)	(degrees)	(pcf)	(psf)	(ft)	(inch)
Sta. 1401+69 to 1413+50, Rt.	CL-Peoria	0	29.8	116	1,500	0.8 H	0.86

*H = Height of Individual Soil Nail Wall (each tier)

STATION 107+31 – 112+75 Right

Due to the westbound expansion a single Soil Nail at the westbound off-ramp will be utilized. This Soil Nail Wall will begin east of 10th Street and proceed via the off-ramp to 13th Street. The maximum Soil Nail Wall height is estimated at 14 feet with a 3:1 slope behind the wall. Table 9 presents the slope-stability safety factor values that have been calculated for the Soil Nail Wall.

Table 9

Circumstance	Factor of Safety
Global Stability of the proposed Soil Nail Wall (short term)	2.41
Global Stability of the proposed Soil Nail Wall (long term)	3.23

The above listed slope stability safety factors are considered acceptable for all of the circumstances presented in Table 9. Table 10 presents the allowable values for the foundation soils that will support the Soil Nail Walls.

Table 10
Foundation Soil Characteristic Values for the Soil Nail Wall
From Station 107+31 to 112+75 Right

Foundation Soil Description		Cohesion	Angle of Internal Friction,	Moist Unit Weight	Minimum Ultimate Grout Bond Capacity	Minimum Nail Length	Minimum Nail Diameter
Location	Soil Type	(psf)	(degrees)	(pcf)	(psf)	(ft)	(inch)
Sta. 107+31 to 112+75, Rt.	CL-Fill	1704	0	115	1,700	0.93 H	0.86

*H = Height of Individual Soil Nail Wall

STATION 1393+86 – 1397+75 Right

Due to the expansion to 4-lanes for the eastbound lanes at this location, approximately 15 feet of driving lane (including the shoulder) will be added to the right of the existing eastbound lanes. At this location a Soil Nail Wall at the existing south abutment of the 10th Street Bridge over I-80 is being considered. The maximum Soil Nail Wall height is estimated at 5 feet with a 2:1 slope behind the wall. Table 11 presents the slope-stability safety factor values that have been calculated for the Soil Nail Wall.

Table 11

Circumstance	Factor of Safety
Global Stability of the proposed Soil Nail Wall (short term)	3.58
Global Stability of the proposed Soil Nail Wall (long term)	4.92

The above listed slope stability safety factors are considered acceptable for all of the circumstances presented in Table 11. Table 12 presents the allowable values for the foundation soils that will support the Soil Nail Walls.

Table 12
Foundation Soil Characteristic Values for the 3-tier Soil Nail Wall
From Station 107+31 to 112+75 Right

Foundation Soil Description		Cohesion	Angle of Internal Friction,	Moist Unit Weight	Minimum Ultimate Grout Bond Capacity	Minimum Nail Length	Minimum Nail Diameter
Location	Soil Type	(psf)	(degrees)	(pcf)	(psf)	(ft)	(inch)
Sta. 1393+86 to 1397+75, Rt.	CL-Fill	1704	0	115	1,700	0.93 H	0.86

*H = Height of Individual Soil Nail Wall

STATION 1414+00 – 1416+90 Right

Due to the expansion to 4-lanes for the eastbound lanes at this location, a 6-foot tall MSE Wall at this location will be constructed to the right of the shoulder in order to avoid encroaching on existing right of way. A typical MSE Wall design is suitable for this location. Table 13 presents the slope-stability safety factor values that have been calculated for the MSE Wall.

Table 13

Circumstance	Factor of Safety
Global Stability of the proposed MSE Wall (short term)	1.5
Global Stability of the proposed MSE Wall (long term)	1.96

The above listed slope stability safety factors are considered acceptable for all of the circumstances presented in Table 13. Table 14 presents the allowable bearing pressure ($q_{allowable}$) cohesion (C) and angle of internal friction (ϕ) values for the foundation soils that will support the MSE Walls.

Table 14
Foundation Soil Characteristic Values for the MSE Wall
From Station 1414+00 to 1416+90 Right

Foundation Soil Description			Cohesion (psf)	Angle of Internal Friction, (degrees)	Allowable Bearing Capacity* (psf)
Location	Soil Type	Depth			
Sta. 1414+00 to 1416+90	Peoria	Minimum Embedment of 3 feet	0	29.8	7,500

*Assumes MSE Wall foundation elevations at least 3 feet below finished grade.

The external stability (sliding, overturning and bearing capacity) of the MSE Wall is satisfactory based on an overall retained earth height of 6 feet and a minimum reinforced earth length of 8 feet.

STATION 1397+75 – 1401+69 Right

Due to the expansion to 4-lanes for the eastbound lanes at this location, approximately 30 feet of driving lane (including the shoulder) will be added to the right of the existing eastbound lanes. An 6-foot tall MSE Wall at this location will be constructed to the right of the shoulder in order to avoid encroaching on existing right of way. A typical MSE Wall design is suitable for this location. Table 13 presents the slope-stability safety factor values that have been calculated for the MSE Wall.

Table 13

Circumstance	Factor of Safety
Global Stability of the proposed MSE Wall (short term)	3.2
Global Stability of the proposed MSE Wall (long term)	3.47

The above listed slope stability safety factors are considered acceptable for all of the circumstances presented in Table 13. Table 14 presents the allowable bearing pressure ($q_{allowable}$) cohesion (C) and angle of internal friction (ϕ) values for the foundation soils that will support the MSE Walls.

Table 14
Foundation Soil Characteristic Values for the MSE Wall
From Station 1398+00 to 1402+00 Right

Foundation Soil Description			Cohesion (psf)	Angle of Internal Friction, (degrees)	Allowable Bearing Capacity* (psf)
Location	Soil Type	Depth			
Sta. 1397+75 to 1401+69, Rt.	Clay Fill	Above Elevation 1078.5 feet	750	0	1,600
Sta. 1397+75 to 1401+69, Rt	Clay Fill	Below Elevation 1078.5 feet	1,340	0	2,500

*Assumes MSE Wall foundation elevations at least 3 feet below finished grade.

The external stability (sliding, overturning and bearing capacity) of the MSE Wall is satisfactory based on an overall retained earth height of 6 feet and a minimum reinforced earth length of 8.0 feet.

STATION 113+00 – 117+50 Left

Due to the westbound expansion a MSE Wall at the westbound off-ramp will be utilized from Station 113+00 to Station 117+50, Left. The maximum MSE Wall height is estimated at 4.5 feet with. Table 15 presents the slope-stability safety factor values that have been calculated for the Soil Nail Wall.

Table 15

Circumstance	Factor of Safety
Global Stability of the proposed MSE Wall (short term)	2.64
Global Stability of the proposed MSE Wall (long term)	2.34

The above listed slope stability safety factors are considered acceptable for all of the circumstances presented in Table 15. Table 16 presents the allowable bearing pressure ($q_{allowable}$) cohesion (C) and angle of internal friction (ϕ) values for the foundation soils that will support the MSE Walls.

Table 16
Foundation Soil Characteristic Values for the MSE Wall
From Station 113+00 to 117+50 Left

Foundation Soil Description			Cohesion (psf)	Angle of Internal Friction, (degrees)	Allowable Bearing Capacity* (psf)
Location	Soil Type	Depth			
Sta. 113+00 to 117+50, Lt.	Clay Fill	Minimum Embedment of 3 feet	1704	0	3,500

*Assumes MSE Wall foundation elevations at least 3 feet below finished grade.

The external stability (sliding, overturning and bearing capacity) of the MSE Wall is satisfactory based on an overall retained earth height of 4.5 feet and a minimum reinforced earth length of 8 feet.

A. Settlement. Settlement of the proposed retaining wall structures is expected to be negligible if the fill materials are properly placed and the recommendations in this report are carried out.

B. Placement of Fill and Backfill. The suggested basis for controlling the placement of fill and backfill on the site, excluding free-draining granular materials, are the "optimum moisture content" and "maximum dry density" as determined by AASHTO T-99-01(reapproved 2004), Procedure A, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3) (600 kN-m/m^3). The recommended acceptable values of moisture content and degree of compaction are given in Table 17.

TABLE 17
Compaction Recommendations of Controlled Earth Fill and Backfill

Location	Soil Type	Minimum Moisture Content	Minimum Compaction
Embankment/Roadway grading, including driveways, to receive concrete pavement	Silts and Clays	-3% Opt +2%	98%
Upper 3.0 feet	Granular	**	100%

TABLE 17 (continued)
Compaction Recommendations of Controlled Earth Fill and Backfill

Location	Soil Type	Minimum Moisture Content	Minimum Compaction
Embankment/Roadway grading, including driveways, to receive concrete pavement	Silts and Clays	-3% Opt +2%	98%
All depths greater than 3.0 feet	Granular	**	100%
Embankment/Roadway grading, including detours, temporary roads, and driveways, to receive flexible pavement	Silts and Clays	-2% Opt +1%	98%
Upper 3.0 feet	Granular	**	100%
Embankment/Roadway grading, including detours, temporary roads, and driveways, to receive flexible pavement	Silts and Clays	-3% Opt +2%	95%
All depths greater than 3.0 feet	Granular	**	100%
Embankment/ Roadway Grading not to be surfaced	Silts and Clays	-3% Opt +2%	95%
	Silty and Clayey Sands	**	95%
Subgrade Preparation, Shoulder Subgrade Preparation (Concrete Pavement)	Silts and Clays	-3% Opt +2%	98%
(Upper 6 Inches)	Silty and Clayey Sands	**	100%
Subgrade Preparation, Shoulder Subgrade Preparation (Flexible Pavement)	Silts and Clays	-2% Opt +1%	100%
Upper 6 inches	Silty and Clayey Sands	**	100%
Disturbed Embankment Behind Soil Nail Walls	Silts and Clays	-3% Opt +2%	98%
Embankments of Driveways Not to be surfaced	All Materials	See NDOR Specifications	Class I

TABLE 17 (continued)
Compaction Recommendations of Controlled Earth Fill and Backfill

Location	Soil Type	Minimum Moisture Content	Minimum Compaction
Bituminous Pavement Patching	All Materials	See NDOR Specifications	100%
Foundation Course/ Subgrade Stabilization	_	See NDOR Specifications	100%
Stabilized Subgrade (ie Lime, Flyash, etc)	-	See NDOR Special Provisions	100%
Granular Structural Fill (MSE Walls, Granular Fill For bridges, culverts, etc)	Granular	-3% Opt +3%	100%

** Moisture as necessary to obtain density (near Optimum)
(A moisture target value at maximum density shall be established in the field by the Contractor during the compaction process. The acceptable moisture content shall be ± 2% of the target value)

C. Applicability of Recommendations. The recommendations presented in this report are based in part upon the analysis of the data from the CPT soundings and soil borings. The penetration diagrams, boring logs, and related information depict subsurface conditions only at the specific sounding and boring locations and at the time of the subsurface exploration. Soil conditions may differ between the soundings and exploratory borings and might change with the passage of time. The nature and extent of any variations between the sounding and boring locations or of any changes in soil conditions (e.g., drying of soil) might not become evident until grading operations and construction of the foundation for the referenced project have begun. If variations and changes in the soil conditions then appear, it will be necessary to re-evaluate the recommendations stated in this report.

VI. CONCLUSIONS

The NDOR Geotechnical Section, on the basis of the findings of the subsurface exploration at the project site and the evaluation of the engineering properties of samples of the foundation materials, that the proposed retaining wall structures can be safely constructed. Satisfactory performance of the retaining wall structures is to be expected if the foregoing recommendations are carried out.

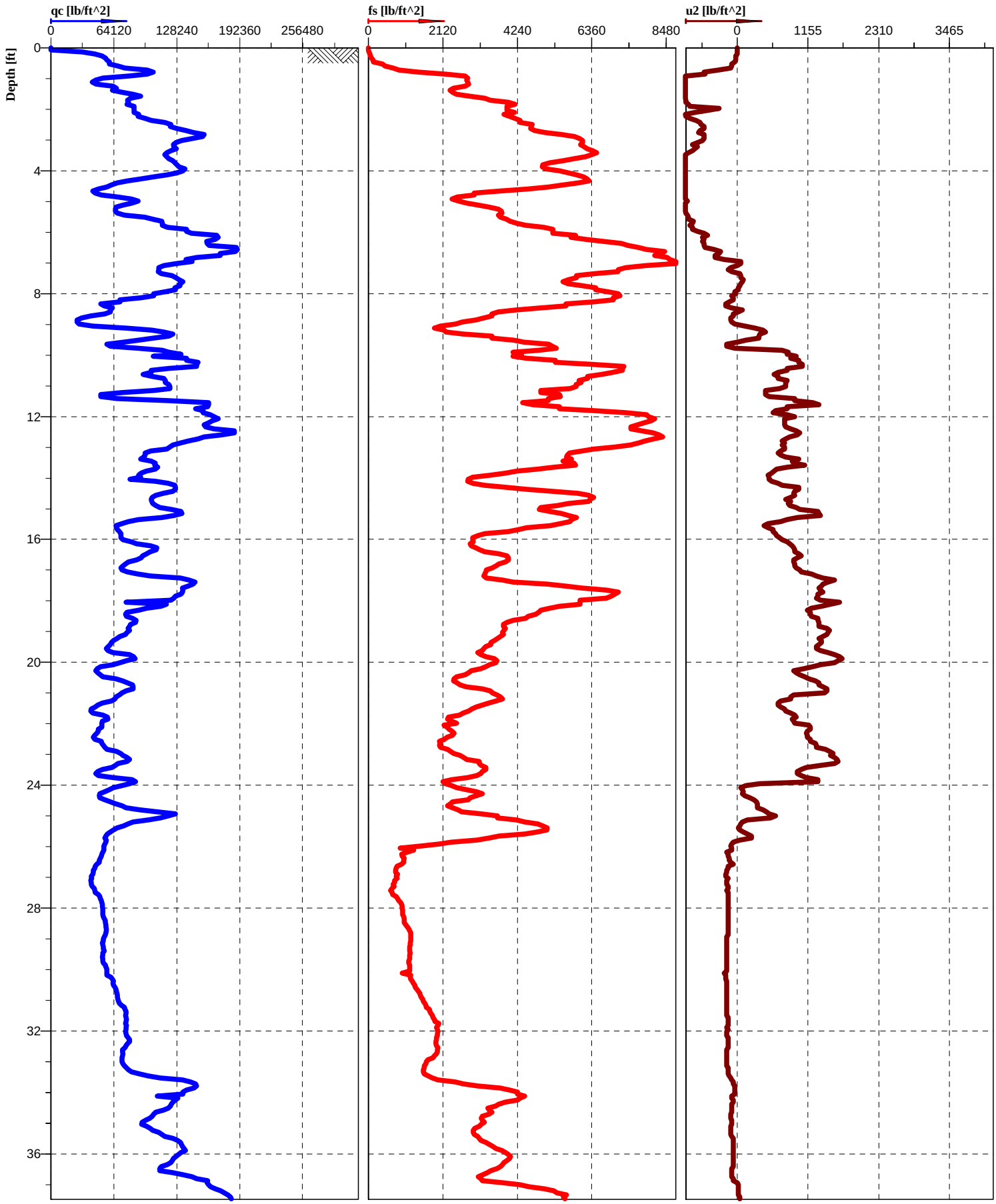
The NDOR Geotechnical Section should be contacted if any questions arise concerning this report or if changes in the nature, design, or location of the structures are planned. If any such changes are made, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed by the NDOR Geotechnical Section and the conclusions of this report are modified or verified in writing.

Submitted By

NDOR Geotechnical Section
Soil Mechanics Unit

Mark C. Lindemann

APPENDIX A.
CONE PENETRATION TEST DIAGRAMS



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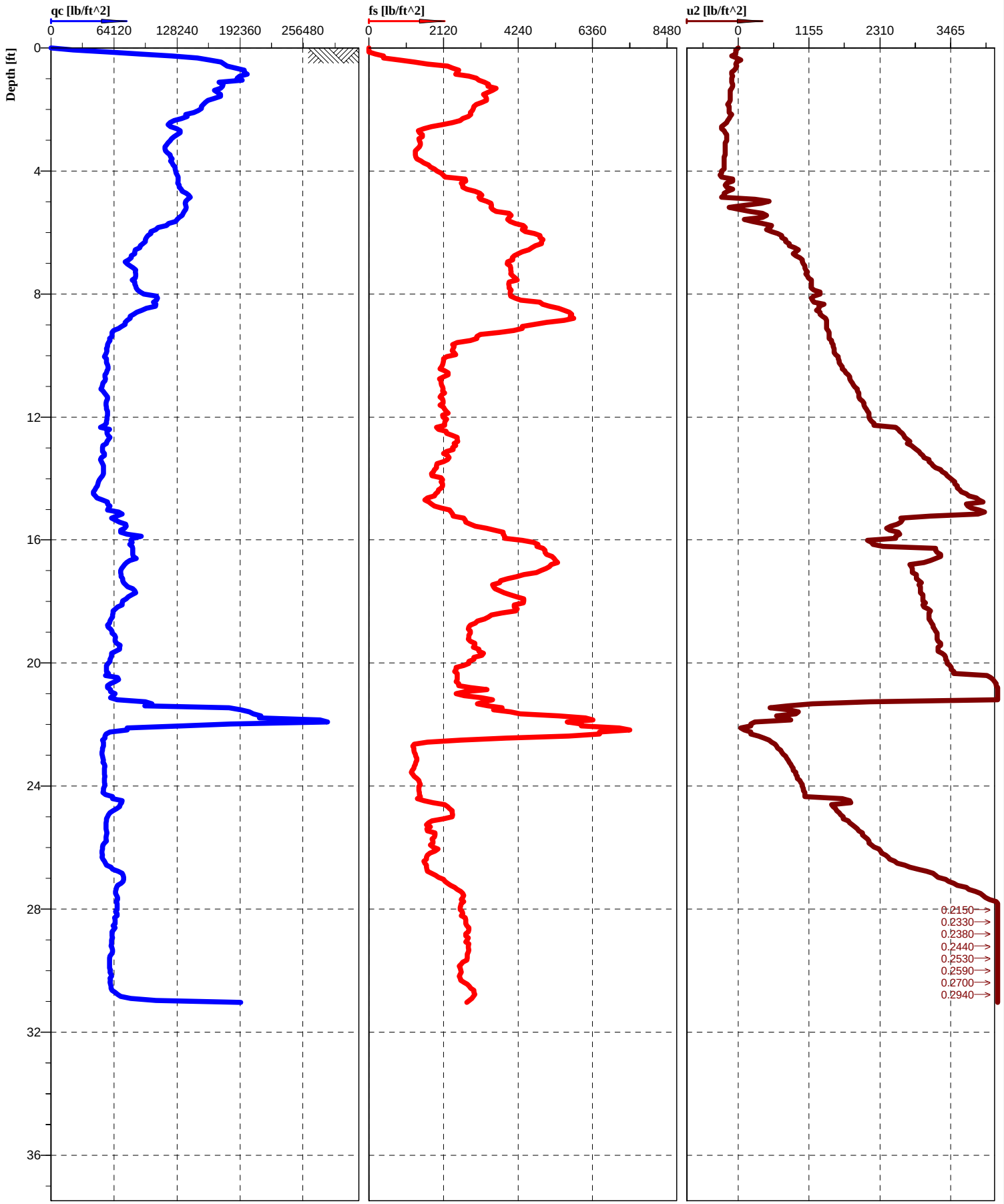
Cone No: 3646
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Station 1424+00, 146' Lt	Position: X: 0.00 m, Y: 0.00 m	Ground level: 1120.5	Test no: 1
Project ID: 80-9(889)	Client: NDOR	Date: 3/30/2009	Scale: 1 : 50
Project: I-80- Missouri River - 13th Street		Page: 1/2	Fig:
		File: MR-1.CPT	



NDOR
Nebraska Department of Roads

U2

Cone No: 3646
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Stat. 1423+50	Position: X: 0.00 m, Y: 0.00 m	Ground level: 1076	Test no: 1
Project ID: 80-9(889)	Client: NDOR	Date: 11/3/2005	Scale: 1 : 50
Project: I-80 Missouri River - 13th		Page: 1/1	Fig:
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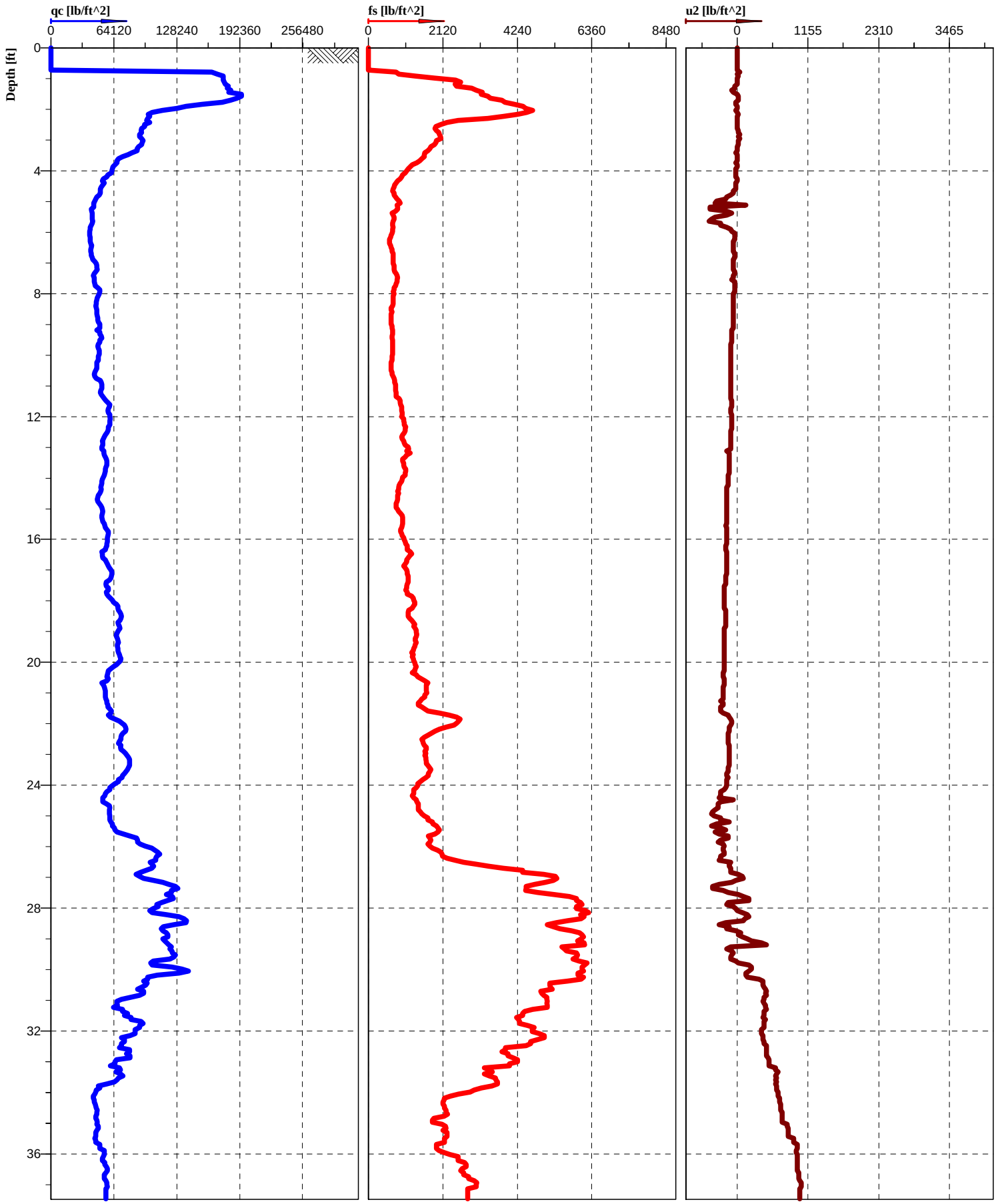

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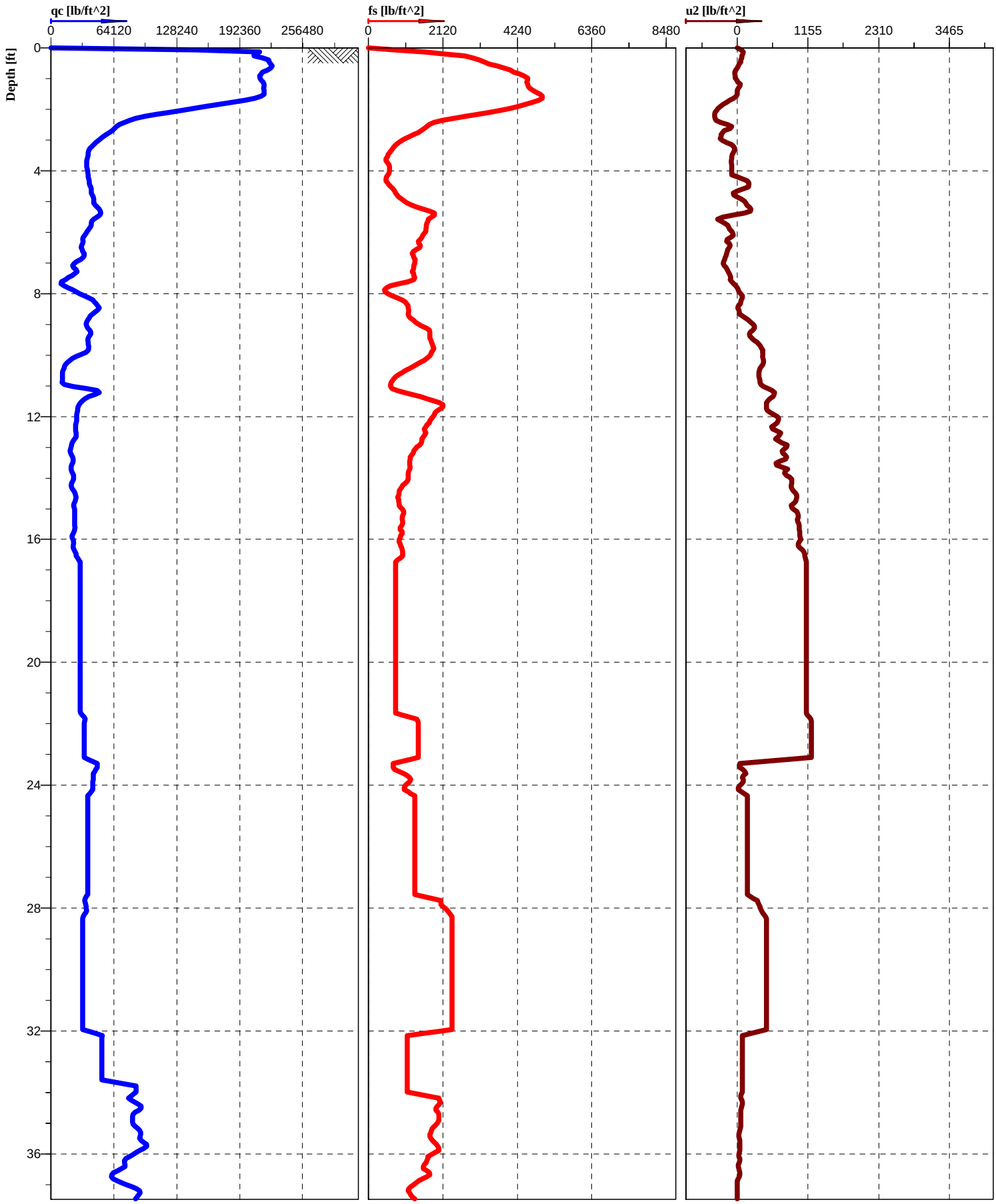
U2

Cone No: 3646
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Station 1418+80	Position: X: 0.00 m, Y: 0.00 m	Ground level: 1082	Test no: 2
Project ID: 80-9(889)	Client: NDOR	Date: 11/3/2005	Scale: 1 : 50
Project: I-80 Missouri River - 13th		Page: 1/2	Fig:
		File: ms2.cpd	



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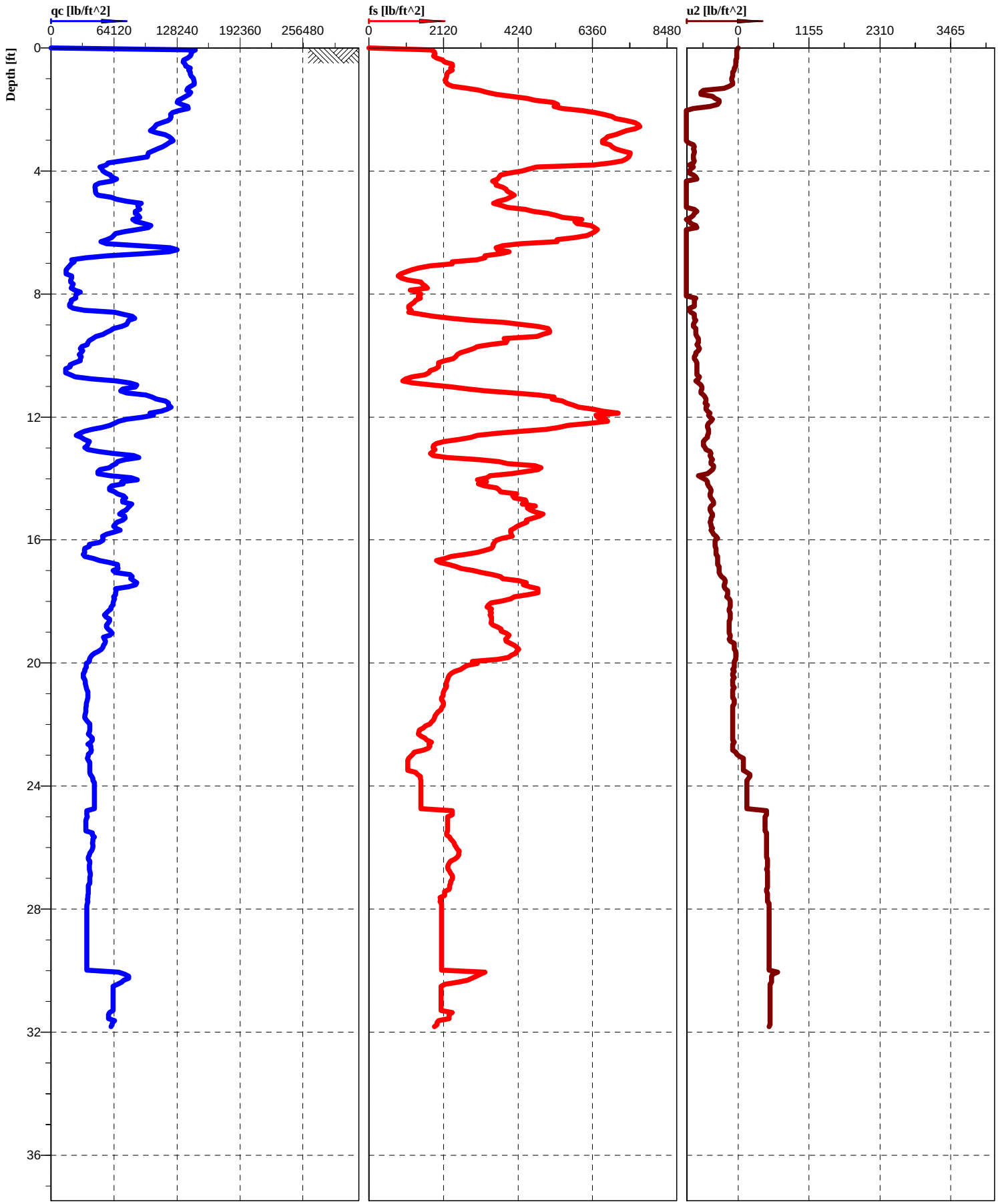
Cone No: 3646
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Stat. 1410+10	Position: X: 0.00 m, Y: 0.00 m	Ground level: 1088	Test no: 3
Project ID: 80-9(889)	Client: NDOR	Date: 11/7/2005	Scale: 1 : 50
Project: I-80 Missouri River - 13th		Page: 1/2	Fig:
		File: MS3.cpd	



Location: Station 1412+20	Position: X: 0.00 m, Y: 0.00 m	Ground level: 1088	Test no: 4
Project ID: 80-9(889)	Client: NDOR	Date: 11/7/2005	Scale: 1 : 50
Project: I-80 Missouri River - 13th		Page: 1/1	Fig:
		File: MS4.cpd	

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U2

Cone No: 3646
Tip area [cm2]: 10
Sleeve area [cm2]: 150

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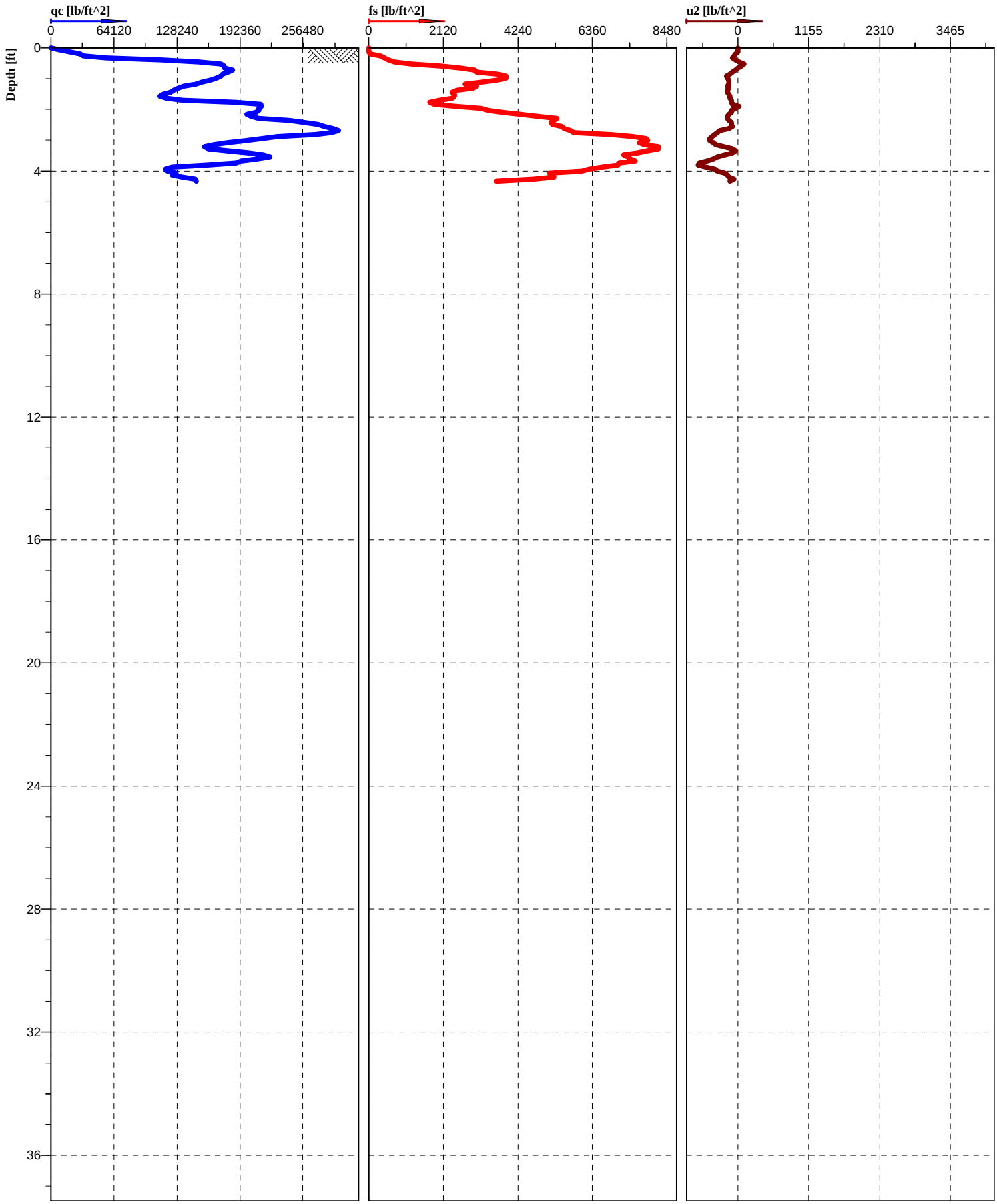
U2

Cone No: 3646
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Station 1409+00	Position: X: 0.00 m, Y: 0.00 m	Ground level: 1088	Test no: 7
Project ID: 80-9(889)	Client: NDOR	Date: 11/21/2005	Scale: 1 : 50
Project: I-80 Missouri River - 13th		Page: 1/1	Fig:
		File: MS7.cpd	



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Cone No: 3646
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Station 1396+40	Position: X: 0.00 m, Y: 0.00 m	Ground level: 1087	Test no: 8
Project ID: 80-9(889)	Client: NDOR	Date: 11/21/2005	Scale: 1 : 50
Project: I-80 Missouri River - 13th		Page: 1/1	Fig:
		File: MS8.cpd	

APPENDIX B. BORING LOGS

Boring Log

Hole No	MR1	**Tested By**	Josh Kalin
Station	1424+00 146 LT	**Logged By**	Mark Lindemann
Total Length	41 Ft	**Drilling Method**	Hollow Stem Auger
Elevation	1120.5 Ft	**Water Level**	
Date	3/30/2009	**Site Description**	

Depth (Ft)	Group Symbol	Geologic Description	Sample No	Sample Depth	M.C.	D.D.	W.D.	P.I.	L.L.	qu psf	Water
1	CL	Lean Clay; trace of fine sand; medium plastic brown; moist; very stiff (Peoria)									
2											
3											
4											
5											
6			MR1-1	5-6	19	90.5	107.70				
7											
8	8										
9	CL	Lean Clay; trace of fine sand; medium plastic; light brown mottled with yellowish brown; moist; very stiff (Peoria)									
10											
11											
12											
13											
14											
15			MR1-2	14.6-14.9	18.4	100	118.40			3412	
16											
17											
18											
19											
20	20										
21	CL	Lean Clay; trace of fine sand; medium plastic; dark brown mottled with brown; moist; very stiff (Peoria)									
22											
23											
24											
25											
26			MR1-3	25.1-25.6	21.3	88.54	107.40				
27											
28	28										
29	CL	Lean Clay; trace of fine sand; medium plastic; light brown mottled with yellowish brown; moist; very stiff (Peoria)									
30											

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Boring Log

Hole No	MR1	**Tested By**	Josh Kalin
Station	1424+00 146 LT	**Logged By**	Mark Lindemann
Total Length	41 Ft	**Drilling Method**	Hollow Stem Auger
Elevation	1120.5 Ft	**Water Level**	
Date	3/30/2009	**Site Description**	

Depth (Ft)	Group Symbol	Geologic Description	Sample No	Sample Depth	M.C.	D.D.	W.D.	P.I.	L.L.	qu psf	Water
31			MR1-4	30.1-30.7	17.5	92.17	108.30			2413	
32											
33											
34											
35											
36											
37											
38											
39											
40											
41	41										
42											
43											
44											
45											
46											
47											
48											
49											
50											
51											
52											
53											
54											
55											
56											
57											
58											
59											
60											

Boring Log

Hole No	MR2	**Tested By**	Josh Kalin
Station	1417+50 100 LT	**Logged By**	Mark Lindemann
Total Length	30.1 Ft	**Drilling Method**	Hollow Stem Auger
Elevation	1118 Ft	**Water Level**	
Date	3/30/2009	**Site Description**	

Depth (Ft)	Group Symbol	Geologic Description	Sample No	Sample Depth	M.C.	D.D.	W.D.	P.I.	L.L.	qu psf	Water
1	CL	Lean Clay; trace of ; medium plastic brown mottled with yellowish red; moist; stiff (Peoria)									
2											
3											
4											
5											
6											
7	7										
8	CL	Lean Clay; trace of fine sand; medium plastic; light brown; moist; very stiff (Peoria)									
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20	20										
21	CL	Lean Clay; trace of fine sand; medium plastic; light brown mottled with light grayish brown; moist; very stiff (Peoria)									
22											
23											
24											
25											
26			MR2-3	25-26	15						
27	27										
28	CL	Lean Clay; trace of fine sand; medium plastic; light brown mottled with black and light brown; moist; very stiff (Peoria)									
29											
30											

Boring Log

Hole No	MR2	**Tested By**	Josh Kalin
Station	1417+50 100 LT	**Logged By**	Mark Lindemann
Total Length	30.1 Ft	**Drilling Method**	Hollow Stem Auger
Elevation	1118 Ft	**Water Level**	
Date	3/30/2009	**Site Description**	

Depth (Ft)	Group Symbol	Geologic Description	Sample No	Sample Depth	M.C.	D.D.	W.D.	P.I.	L.L.	qu psf	Water
30.1											
31			MR2-4	29.7-30.1	16.3	87.36	101.60			2498	
32											
33											
34											
35											
36											
37											
38											
39											
40											
41											
42											
43											
44											
45											
46											
47											
48											
49											
50											
51											
52											
53											
54											
55											
56											
57											
58											
59											
60											

Boring Log

Hole No	MS1	**Tested By**	Doug Churchwell
Station	1423+40 20 LT	**Logged By**	Mark Lindemann
Total Length	36 Ft	**Drilling Method**	Hollow Stem Auger
Elevation	1076 Ft	**Water Level**	
Date	11/4/2005	**Site Description**	

Depth (Ft)	Group Symbol	Geologic Description	Sample No	Sample Depth	M.C.	D.D.	W.D.	P.I.	L.L.	qu psf	Water
1	CL	Lean Clay; trace of fine sand; medium plastic yellowish brown; moist; very stiff (Peoria)									
2											
3			MS1-1	2.7-3.3	12.3	93.23	104.70	13.00	34	3600	
4											
5											
6											
7											
8			MS1-2	7.7-8.3	20.1	98.67	118.50	11.00	34	2034	
9											
10											
11											
12											
13											
14	14										
15	CL	Lean Clay; trace of fine sand; medium plastic reddish brown; moist; very stiff (Peoria)									
16			MS1-3	15.4-15.7	22	103.28	126.00			2678	
17											
18											
19											
20											
21	21.5										
22	CH	Fat Clay; 5-15% fine to medium sand; high plastic brown mottled with black; moist; very stiff (Alluvium)									
23											
24											
25			MS1-4	24.5-25.1	22.3	102.78	125.70	34.00	51	2223	
26											
27											
28											
29											
30											

Boring Log

Hole No	MS1	**Tested By**	Doug Churchwell
Station	1423+40 20 LT	**Logged By**	Mark Lindemann
Total Length	36 Ft	**Drilling Method**	Hollow Stem Auger
Elevation	1076 Ft	**Water Level**	
Date	11/4/2005	**Site Description**	

Depth (Ft)	Group Symbol	Geologic Description	Sample No	Sample Depth	M.C.	D.D.	W.D.	P.I.	L.L.	qu psf	Water
	30.5										
31	SP	Poorly graded sand; 95-100% fine to medium sand; trace of (0-5%) silty fines; light brown; moist; loose (Alluvium)									
32											
33											
34											
35											
36	36										
37											
38											
39											
40											
41											
42											
43											
44											
45											
46											
47											
48											
49											
50											
51											
52											
53											
54											
55											
56											
57											
58											
59											
60											

Boring Log

Hole No	MS2	**Tested By**	Doug Churchwell
Station	1418+80 25 LT	**Logged By**	Mark Lindemann
Total Length	30.7 Ft	**Drilling Method**	Hollow Stem Auger
Elevation	1082 Ft	**Water Level**	
Date	11/4/2005	**Site Description**	

Depth (Ft)	Group Symbol	Geologic Description	Sample No	Sample Depth	M.C.	D.D.	W.D.	P.I.	L.L.	qu psf	Water
1	CL	Lean Clay; medium plastic brown; moist; stiff (Peoria)									
2											
3											
4											
5			MS2-1	4.5-4.9	17.4	86.63	101.70			1070	
6											
7											
8			MS2-2	7.5-8.1	17	82.05	96.00	12.00	34	1096	
9											
10											
11											
12											
13											
14											
15											
16	16										
17	CL	Lean Clay; trace of fine sand; medium plastic reddish brown; moist; stiff (Loveland)									
18											
19											
20			MS2-3	19.5-20	20.8	94.04	113.60			1445	
21											
22											
23											
24											
25											
26	26										
27	CL	Lean Clay; trace of fine sand; medium plastic brown mottled with yellowish brown; moist; stiff. (Alluvium)									
28											
29											
30											

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Boring Log

Hole No	MS2	**Tested By**	Doug Churchwell
Station	1418+80 25 LT	**Logged By**	Mark Lindemann
Total Length	30.7 Ft	**Drilling Method**	Hollow Stem Auger
Elevation	1082 Ft	**Water Level**	
Date	11/4/2005	**Site Description**	

Depth (Ft)	Group Symbol	Geologic Description	Sample No	Sample Depth	M.C.	D.D.	W.D.	P.I.	L.L.	qu psf	Water
31	30.7		MS2-4	29.5-30.1	21.2	104.79	127.00	17.00	35	1837	
32											
33											
34											
35											
36											
37											
38											
39											
40											
41											
42											
43											
44											
45											
46											
47											
48											
49											
50											
51											
52											
53											
54											
55											
56											
57											
58											
59											
60											

Boring Log

Hole No	MS3	**Tested By**	Doug Churchwell
Station	1410+10 55 RT	**Logged By**	Mark Lindemann
Total Length	30.8 Ft	**Drilling Method**	Hollow Stem Auger
Elevation	1087.5 Ft	**Water Level**	
Date	11/7/2005	**Site Description**	

Depth (Ft)	Group Symbol	Geologic Description	Sample No	Sample Depth	M.C.	D.D.	W.D.	P.I.	L.L.	qu psf	Water
1, 2, 3	CL	Lean Clay; medium plastic yellowish brown mottled with black; moist; stiff (Fill).									
3											
4	CL	Lean Clay; medium plastic yellowish brown mottled with black; moist; medium stiff (Fill)									
5			MS3-1	4.5-5.2	23.1	96.34	118.60			1732	
6, 7, 8											
9			MS3-2	8.1-8.7	25.5	93.07	116.80			565	
10, 11, 12											
12											
13	CL	Lean Clay; medium plastic; very dark grayish brown; moist; medium stiff (Topsoil)									
14, 15											
15			MS3-3	14.8-15.4	28.1	73.3	93.90	15.00	36	543	
16, 17											
17											
18	CL	Lean Clay; medium plastic brown mottled with light brown; moist; medium stiff. (Peoria)									
19, 20											
21			MS3-4	20-20.6	27.6	75.39	96.20	16.00	37	826	
22, 23, 24, 25											
26			MS3-5	25-25.6	21.8	80.46	98.00	11.00	33	632	
27, 28											
28											
29	CL	Lean Clay; medium plastic yellowish brown mottled with brown; moist; medium stiff. (Peoria)									
30											

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Boring Log

Hole No	MS3	**Tested By**	Doug Churchwell
Station	1410+10 55 RT	**Logged By**	Mark Lindemann
Total Length	30.8 Ft	**Drilling Method**	Hollow Stem Auger
Elevation	1087.5 Ft	**Water Level**	
Date	11/7/2005	**Site Description**	

Depth (Ft)	Group Symbol	Geologic Description	Sample No	Sample Depth	M.C.	D.D.	W.D.	P.I.	L.L.	qu psf	Water
31	30.8		MS3-6	29.5-30.2	21.1	81.67	98.90			444	
32											
33											
34											
35											
36											
37											
38											
39											
40											
41											
42											
43											
44											
45											
46											
47											
48											
49											
50											
51											
52											
53											
54											
55											
56											
57											
58											
59											
60											

Boring Log

Hole No	MS4	**Tested By**	Doug Churchwell
Station	1412+20 55 RT	**Logged By**	Mark Lindemann
Total Length	20.9 Ft	**Drilling Method**	Hollow Stem Auger
Elevation	1088 Ft	**Water Level**	
Date	11/7/2005	**Site Description**	

Depth (Ft)	Group Symbol	Geologic Description	Sample No	Sample Depth	M.C.	D.D.	W.D.	P.I.	L.L.	qu psf	Water
1, 2, 3	CL	Lean Clay; medium plastic grayish brown mottled with brown; moist; very stiff. (Fill)									
4			MS4-1	3.1-3.7	19.3	109.22	130.30			4658	
5	5										
6, 7	CL	Lean Clay; medium plastic yellowish brown mottled with brownish gray; moist; medium stiff (Fill)									
8			MS4-2	7.6-8.2	31.7	88.08	116.00	11.00	34	716	
9, 10											
11	11										
12, 13, 14	CL	Lean Clay; medium plastic; blueish gray mottled with brown; moist; very stiff. (Fill)									
15			MS4-3	14.6-15.2	23.1	102.76	126.50			3005	
16											
17	17										
18, 19	CL	Lean Clay; medium plastic; very dark grayish brown; moist; stiff (Topsoil)									
20			MS4-4	19.7-20.3	27	78.5	99.70	14.00	41	1957	
21	21.1										
22, 23, 24, 25, 26, 27, 28, 29, 30											

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Boring Log

Hole No	MS5	**Tested By**	Doug Churchwell
Station	1398+50 75 RT	**Logged By**	Mark Lindemann
Total Length	15.4 Ft	**Drilling Method**	Hollow Stem Auger
Elevation	1087 Ft	**Water Level**	
Date	11/8/2005	**Site Description**	

Depth (Ft)	Group Symbol	Geologic Description	Sample No	Sample Depth	M.C.	D.D.	W.D.	P.I.	L.L.	qu psf	Water
1	CL	Lean clay; trace of rock; medium plastic; yellowish brown mottled with black; moist; stiff. (Fill)									
2											
3			MS5-1	2.8-3.4	20.9	100.33	121.30			2126	
4	4										
5	CL	Lean Clay; medium plastic yellowish brown mottled with brown; moist; stiff. (Fill)	MS5-2	4.9-5.5	23.7	90.22	111.60	18.00	39	1076	
6											
7											
8			MS5-3	8-8.5	25.7	87.27	109.70			746	
9											
10	10		MS5-4	9.5-10.2	19.3	107.8	128.60			6577	
11	CL	Lean Clay; medium plastic yellowish brown mottled with brown; moist; very stiff. (Peoria)									
12											
13											
14											
15	15.4		MS5-5	14.5-15.2	16.5	82.66	96.30	16.00	37	1340	
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											
26											
27											
28											
29											
30											

Boring Log

Hole No	MS6	**Tested By**	Doug Churchwell
Station	1401+30 70 RT	**Logged By**	Mark Lindemann
Total Length	0.1 Ft	**Drilling Method**	Hollow Stem Auger
Elevation	1086 Ft	**Water Level**	
Date	11/8/2005	**Site Description**	

Depth (Ft)	Group Symbol	Geologic Description	Sample No	Sample Depth	M.C.	D.D.	W.D.	P.I.	L.L.	qu psf	Water
1, 2, 3	CL	Lean Clay; 5-15% fine to coarse sand; medium plastic brown mottled with dark brown; moist; stiff. (Fill)									
4	4		MS6-1	3.4-4	19	110	130.90			4677	
5	CL	Lean Clay; medium plastic brown mottled with grayish brown and black; moist; stiff (Fill)	MS6-2	4.5-5.1	23.6	99.51	123.00	15.00	36	1742	
6	6										
7	CL	Lean Clay; medium plastic yellowish brown mottled with black; moist; stiff (Fill)									
8			MS6-3	7.5-8.2	24.2	98.15	121.90			1550	
9	9										
10	CL	Lean Clay; medium plastic yellowish brown mottled with brown; moist; stiff. (Fill)	MS6-4	9.5-10.1	25.2	92.17	115.40			1302	
11, 12, 13	13										
14	CH	Fat Clay; high plastic; dark brown mottled with brown; moist; very stiff. (Subsoil)									
15			MS6-5	14.5-15.2	16.8	79.97	93.40	19.00	40	2484	
16	16.1										
17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30											

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Boring Log

Hole No	MS7	**Tested By**	Doug Churchwell
Station	1409+00 60 LT	**Logged By**	Mark Lindemann
Total Length	21.3 Ft	**Drilling Method**	Hollow Stem Auger
Elevation	1088 Ft	**Water Level**	
Date	11/21/2005	**Site Description**	

Depth (Ft)	Group Symbol	Geologic Description	Sample No	Sample Depth	M.C.	D.D.	W.D.	P.I.	L.L.	qu psf	Water
1	CL	Lean Clay; medium plastic; light brown mottled with yellowish brown; moist; stiff. (Peoria)									
2											
3											
4											
5											
6			MS7-1	5.2-5.8	18.6	83.31	98.80			1407	
7											
8											
9											
10											
11			MS7-2	9.9-10.5	15.6	94.46	109.20	25.00	35	1361	
12											
13											
14											
15			MS7-3	14.7-15.3	14.9	83.99	96.50			478	
16											
17											
18	18										
19	CL	Lean Clay; medium plastic reddish brown mottled with black; moist; stiff (Loveland)									
20			MS7-4	19.5-20.2	18.7	86.52	102.70	10.00	33	1870	
21	21.3										
22											
23											
24											
25											
26											
27											
28											
29											
30											

Boring Log

Hole No	MS8	**Tested By**	Doug Churchwell
Station	1396+40 105 LT	**Logged By**	Mark Lindemann
Total Length	26 Ft	**Drilling Method**	Hollow Stem Auger
Elevation	1087.0 Ft	**Water Level**	
Date	11/21/2005	**Site Description**	

Depth (Ft)	Group Symbol	Geologic Description	Sample No	Sample Depth	M.C.	D.D.	W.D.	P.I.	L.L.	qu psf	Water
1, 2, 3, 4	CL	Lean clay; trace of gravel; medium plasticity; brown mottled with black and dark brown; moist; very stiff. (Fill)									
4											
5	CL	Lean Clay; medium plastic; very dark grayish brown; moist; stiff (Alluvium)									
			MS8-1	4.9-5.5	17.3	109.04	127.90			3525	
6, 7, 8, 9											
10			MS8-2	9.5-10	25	83.92	104.90	19.00	42	1704	
11											
12											
13	CL	Lean Clay; medium plastic; dark brown; moist; medium stiff (Alluvium)									
14, 15											
16			MS8-3	15.1-15.7	24.4	92.28	114.80			862	
17											
18	CL	Lean Clay; medium plastic yellowish brown; moist; medium stiff (Peoria)									
19, 20											
21			MS8-4	20.1-20.8	22.3	81.03	99.10	15.00	37	1096	
22, 23, 24											
25											
26			MS8-5	24.8-25.4	21.8	84.89	103.40	12.00	33	876	
27, 28, 29, 30											

Nebraska Department of Roads
Material and Research Division
Geotechnical Section
Soil Mechanics Unit

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