HDR

S3 Submittal

US 218/US 30 Interchange

Benton County, Iowa

Iowa DOT Project No.
NHSX-030-6(231)—3H-06

October 2017

Prepared for:

IOWA DOT

HDR

October 5, 2017

Mr. Stephen Megivern, P.E.
Iowa Department of Transportation
Office of Design - Soils Design
800 Lincoln Way
Ames, Iowa 50010

RE: Final Geotechnical Design S3 Submittal
US 218/US 30 Interchange
Benton County, Iowa

Dear Mr. Megivern,

HDR, Inc. is pleased to provide the accompanying Final Geotechnical Design S3 submittal for the proposed new US 218/US 30 Interchange in Benton County, Iowa. This report presents our findings, conclusions and final recommendations for the geotechnical aspects of the project, as well as the results of our field exploration and laboratory testing.

Please contact us if you have any questions or comments concerning this information.

Sincerely,
HDR ENGINEERING, INC.

John Christiansen, P.E.
Senior Geotechnical Engineer

Patrick H. Poepsel, P.E
Geotechnical Section Manager

Enclosure

PROFESSIONAL ENGINEER JOHN A. CHRISTIANSEN 12644 LICENSED * IOWA *	**I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Iowa.** 10/5/17 **John Christiansen, P.E. Date** **My license renewal date is December 31, 2018.** **Pages covered by this seal: Pages 1 through 12, Figures 1 and 2, and Appendices A through G.**

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Final Geotechnical Design S3 Submittal
US 218/US 30 Interchange
Benton County, Iowa
Iowa DOT Project No. NHSX-030-6(231)—3H-06

1.0 Introduction

This report presents the results of the Final Geotechnical Design S3 Submittal performed for the proposed US 218/US 30 Interchange in Benton County, Iowa. The purpose of the S3 study is to perform final geotechnical investigations and engineering analyses so that the contract documents for the project can be prepared and finalized.

This report presents final S3 phase findings, conclusions and recommendations regarding:

- Geologic setting;
- Subsurface soil and groundwater conditions;
- Evaluation of the engineering characteristics of the foundation and embankment soils;
- Evaluation of stability of embankments and foundation soils;
- Evaluation of external stability of Mechanically Stabilized Earth (MSE) walls;
- Estimation of settlements of the embankments, culverts and the MSE walls; and
- Recommendations for construction.

This report has been prepared in combination with the following items for the (231) construction package:

- Van Dyke Report;
- Q Sheets showing the subsurface information in plan and profile;
- CS Sheets with tabulations for shrinkage, compaction with moisture control, sub-drains, plowing and shaping, topsoil; and
- W, X and Y Sheets showing the subsurface stratigraphy in cross sections spaced at 25-foot intervals.

The documents listed above were submitted under separate cover.

This report was prepared by a licensed professional civil engineer specializing in geotechnical engineering and licensed in the State of Iowa. The recommendations presented herein are based on the applicable standards of the profession at the time of this report within this geographic area. This report has been prepared for the exclusive use of the Iowa Department of Transportation (Iowa DOT) for specific application to the proposed project, in accordance with generally accepted soil and foundation engineering practices.

2.0 Project Description

A supplemental geotechnical study was requested and authorized by Iowa DOT for the US 218 interchange. The work originally covered by this supplemental study included construction of a new interchange where US 218 meets US 30 including a new US 218 bridge over US 30, approach embankments for the new bridge; construction of Loops A and B; construction of Ramps C and D; and construction of a mechanically stabilized earth (MSE) retaining wall which will support the approach embankments at the south bridge abutment. Additional work, outside the scope of the supplemental agreement, was subsequently added to the project. The additional out of scope work includes construction of a replacement reinforced concrete box (RCB) culvert under US 30 at Station 1400+94, construction of portions of 23rd Avenue north and south of US 30, and construction of portions of US 30 both east and west of the US 218 interchange. This work is being performed under Iowa DOT No. NHSX-030-6(231)—3H-06.

The proposed roadway sections and lengths of each section to be constructed under (231) are described as follows:

- US 218 (north of US 30) and 24th Avenue (south of US 30) (Stations 241450+05 to 241503+00, 5,295 lineal feet)
- 23rd Avenue (Stations 231416+75 to 231427+00, 1,100 lineal feet)
- Youngville Café Access (Stations 0+00 to 12+75, 1,275 lineal feet)
- US 30 Westbound (Stations 1389+00 to 1516+70, 12,770 lineal feet)
- US 30 Eastbound (Stations 1380+00 to 1516+70, 13,670 lineal feet)
- Loop A (Stations 11479+15 to 11486+64.72, 750 lineal feet)
- Loop B (Stations 21472+25 to 21479+75.06, 750 lineal feet)
- Ramp C (Stations 31440+41.75 to 31456+46.34, 1,605 lineal feet)
- Ramp D (Stations 41474+26.45 to 41489+96.32, 1,570 lineal feet)

A total of 33,490 lineal feet of roadway is included in this grading package. Cuts of up to 17 feet and fills of up to 28 feet in depth are anticipated to develop the proposed roadways.

3.0 Geotechnical Investigations

3.1 Historical Information

The available geotechnical information for the project consists of the following:

- *Grading Information for US 30 west of west junction US 218 east to west of Junction IA 201, Iowa DOT No. NHS-30-6(62)—19-06, dated January 12, 1998.* This information was limited to sheets A.01, C.11, and Q.01 through Q.05. No Standard Penetration (SPT) testing was reported on the Q sheets.

This information is presented in Appendix G.

3.2 Drilling, Sampling and In-Situ Testing

Seventy-nine exploratory test borings were evaluated and used for this S3 submittal. These borings were drilled for the original US 30 S2 study, and for the supplemental US 218 Interchange S2 and S3 studies. Three borings were also drilled for the US 218 over US 30 bridge, but are not included in this S3 submittal. The borings were completed between November 2013 and December 2015. The approximate locations of the borings are shown on Figures 2-1 through 2-4. Station and offset or coordinates, drilling depth, ground surface elevation, and estimated groundwater depth are indicated on the Boring Logs in Appendix A.

The borings were advanced with truck-mounted and ATV (rubber tire) mounted CME and Diedrich rotary drill rigs using 6-inch OD continuous flight augers and 3.25-inch ID hollow-stem augers. The depths of the borings ranged from 15 to 40.5 feet below the existing ground surface.

The sample numbers, types, recovery lengths, and sampling intervals are shown on the Boring Logs.

3.3 Laboratory Materials Testing

Following completion of the borings, the field logs were reviewed to estimate the approximate depths, thicknesses, and lateral extent of the various soil strata. A laboratory testing program was developed to evaluate the engineering properties of selected samples and to substantiate the soil classifications made in the field. All tests were conducted in general accordance with current ASTM or state-of-the-practice test procedures.

The foundation soils were tested to determine moisture content, dry density, gradation, plasticity indices, Standard Proctor, unconfined compressive strength, triaxial compressive strength (Unconsolidated-Undrained [UU]), and consolidation properties. Laboratory test results are presented in Appendix B.

4.0 Site Conditions

4.1 Geologic Setting

This project is located in an area of Iowa that formed by extensive glacial activity including erosion, reworking, and deposition followed by deposition of wind-blown loess. The glacial drift is Kansan age and has been weathered prior to deposition of the loess. The present topography has been dissected by the sequence of erosion and deposition of surficial material. Bedrock formations encountered beneath the Kansan drift include the Lime Creek Formation and the Cedar Valley Group of Devonian Age. These formations include shale, dolomite and limestone. Review of well records from the IDNR database (GEOSAM) suggests that bedrock is encountered at depths of 150 to 300 feet along the project alignment.

The U.S. Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) describes the soil in this area of Benton County using the following associations or units:

- *Dinsdale-Kenyon-Tama association*. These soils were formed in loess, glacial till, and loamy material or loess overlying glacial till. They are located on wide, gently sloping convex ridgetops and moderately sloping to strongly sloping side slopes. A well-developed network of drainageways is typical.
- *Muscatine-Garwin-Tama association*. These soils were formed in loess and are located on broad upland flats, long gentle slopes, slightly rounded hills and a well-developed network of drainageways.
- *Colo soils*. These soils were formed in alluvium and are located on bottom lands and in narrow drainageways in uplands.
- *Ely soils*. These soils were formed in alluvium and are located on foot slopes and alluvial fans.
- *Downs soils*. These soils were formed in loess and are located on gently sloping and moderately sloping ridgetops and on moderately sloping to very steep side slopes.
- *Dickinson soils*. These soils were formed in wind deposited or wind reworked alluvial sand, loamy sand, or sandy loam. They are located on gently sloping ridgetops to very steep side slopes dissected by many waterways.

4.2 Subsurface Conditions

The primary geologic strata encountered in this investigation include the following:

- Topsoil
- Existing fill soils
- Alluvium
- Wisconsinan Loess
- Kansan Glacial Till
- Kansan Glacial Outwash

A brief description of these units and their engineering characteristics is presented below.

4.2.1 Topsoil

Topsoil was encountered in some of the borings from the ground surface and extending to depths which typically ranged from 6 to 24 inches along the project alignment, with many locations measuring approximately 12 inches.

4.2.2 Existing Fill

Existing fill soils were encountered at various locations and at variable depths along the project alignment. The existing fill soils, where encountered in this study, generally consisted of dark brown to gray, firm to very hard, lean clay (CL). Thickness of the existing fills varied from 1 to 10 feet at the boring locations.

Pocket penetrometer measurements in the fill were typically 1 to more than 4 tons per square foot (tsf). Water contents from tested samples ranged from 14 to 29 percent and dry unit weights from tested samples ranged from 104 to 106 pounds per cubic foot (pcf). An unconfined compressive strength was approximately 0.8 tons per square foot (tsf).

4.2.3 Alluvium

Alluvial soils exist along the project alignment at various locations (typically at creeks and local drainageways), including cohesive alluvium and granular alluvium.

The cohesive alluvium was found to consist of gray and brown, soft to very stiff, lean clay (CL) and fat clay (CH). SPT blowcounts (uncorrected for overburden pressure) in this material ranged from approximately 4 to 12 blows per foot (bpf). Where encountered, the cohesive alluvium was up to 23 feet thick. Water contents from tested samples ranged from 19 to 29 percent and dry unit weights from tested samples ranged from 95 to 110 pounds per cubic foot (pcf). Liquid limits and plasticity indices ranged from approximately 30 to 54 and 18 to 36, respectively. Unconfined compressive strengths ranged from approximately 0.3 to 1.3 tons per square foot (tsf).

The granular alluvium was found to consist of brown and gray, loose to dense, poorly graded sand (SP). SPT blowcounts (uncorrected for overburden pressure) in this material ranged from approximately 0 (WOH) to 16 blows per foot (bpf). Where encountered, the granular alluvium was up to 23 feet thick.

4.2.4 Wisconsinan Loess

The Wisconsinan Loess was encountered throughout the alignment to depths up to 13 feet below existing grade. The loess was found to consist of brown and gray, firm to very stiff, lean clay (CL) and silty clay (ML-CL). SPT blowcounts (uncorrected for overburden pressure) in this material ranged from approximately 3 to 15 blows per foot (bpf). Dry unit weights from tested samples ranged from approximately 82 to 98 pounds per cubic foot (pcf). Liquid limits and plasticity indices ranged from approximately 45 to 51 and 21 to 24, respectively. Eight unconfined compressive strength tests ranged from approximately 0.4 to 2.2 tons per square foot (tsf).

4.2.5 Kansan Glacial Till and Outwash

The Kansan Glacial Till was found to consist of brown and gray, medium stiff to hard, sandy lean clay (CL) and was typically located beneath existing fill, Wisconsinan Loess or alluvium. SPT blowcounts (uncorrected for overburden pressure) in this material ranged from approximately 35 to 43 blows per foot (bpf). Dry unit weights from tested samples ranged from approximately 106 to 119 pounds per cubic foot (pcf). Liquid limits and plasticity indices ranged from approximately 30 to 37 and 17 to 23, respectively. Twenty-eight unconfined compressive strength tests ranged from 0.6 to 4 tons per square foot (tsf). Some of the unconfined compressive strength test results are lower than expected based on engineering judgment, likely resulting from the presence of sand and gravel within the clay matrix of the sample.

Coarse-grained glacial outwash was identified intermittently within the glacial drift at various locations and depths. The glacial outwash was found to consist of medium dense to very dense, gray and brown, poorly-graded sand (SP). SPT blowcounts (uncorrected for overburden pressure) in this material ranged from approximately 8 to 29 blows per foot (bpf). The thickness of glacial outwash ranged from 2.5 to 11 feet at the boring locations.

4.2.6 Bedrock

Bedrock was not encountered during our field investigation. However, we reviewed nearby well records that are published on-line on GEOSAM (Iowa Geological Survey's (IGS) geologic site and sample tracking program). Shale, dolomite and limestone bedrock are expected to underlie the glacial outwash at a depth of 150 to 300 feet below existing grades.

4.2.7 Groundwater

Based on field measurements made at boring locations at the time of this investigation, groundwater was encountered at depths ranging from 3 to 25 feet below existing grade. Groundwater measurements were taken at the times shown on the Boring Logs. Groundwater depth measurements and dates of the groundwater measurements are shown on the boring logs in Appendix A.

Fluctuations in groundwater levels should be expected with variations in the local and regional precipitation.

5.0 Engineering Analyses and Recommendations

5.1 General

Slope stability and settlement analyses were performed for the new embankments. Critical sections that were selected for analyses were based on:

- Areas with high fills for embankments; and
- Areas with poor subsurface conditions (weak, compressible soils).

5.2 Slope Stability

5.2.1 Method of Analysis

Slope stability analyses of potential deep-seated failures were performed using the computer program SLOPE/W (Geo-Slope International, 2012). The SLOPE/W program uses limit equilibrium techniques to search for the location of the critical failure surface that produces the minimum factor of safety (FS). The factor of safety is simply defined as the sum of the resisting forces divided by the sum of the driving forces. Specifically, the Spencer analysis method was used to evaluate both circular and non-circular (optimized) failure surfaces.

The minimum required factors of safety based on Iowa DOT and FHWA guidelines are provided in Table 1 below.

Table 1 – Minimum Required Factors of Safety

Case	Loading Case	Minimum FS
1	Short Term (end of construction)	1.3
2	Long Term	1.5
3	Seismic w/ a_h = 0.02g (Case II)	1.1

The design horizontal peak ground accelerations used in Case 3 are based upon the accelerations provided in AASHTO guidelines (AASHTO-LRFD 3.10.4.2) referenced in the Iowa DOT LRFD Bridge Design Manual.

5.2.2 Adopted Design Soil Strengths

The adopted design strengths used in the stability analyses were developed based on the results of laboratory strength testing, SPT, CPT and pocket penetrometer data completed for this project. A summary of the design strength parameters is presented in Table 2 below.

Table 2 – Adopted Design Shear Strengths

Material	Unit Weight	Short-Term Strengths		Long-term Strengths	
	γ_{total}	C	Φ	c'	Φ'
	(pcf)	(psf)	(degr.)	(psf)	(degr.)
New embankment fill – CL	125	600(1)	12(1)	150	28
Existing embankment fill - CL	125	600(1)	12(1)	150	28
Alluvium (fine) - CL	115	500 to 750	0	50	28
Alluvium (coarse) – SP, SM	120	0	30	0	30
Loess - CL	115	700	0	50	28
Glacial till (fine) - CL	125	2500	0	100	28
Glacial till (coarse) - SP	115	0	34	0	34
Iowa DOT Special Backfill	125	0	32	0	32
MSE Wall – granular backfill	120	0	34	0	34

where: C, C' = total and effective cohesion or undrained shear strength, and
Φ, Φ' = total and effective angle of internal friction.
(1)Based on Iowa DOT guidance, CU strengths were used for the fill in the short term cases.

The design strengths presented in the above table represent a reasonable and conservative assessment of the in-situ strength of the various materials present at the project site.

5.2.3 Results of Stability Analyses

A total of seven design sections were selected for the numerical analysis of slope stability. The sections were selected based on areas with the maximum fill heights and the area where the MSE wall will be constructed.

Side slopes of the roadway embankments were generally set at an inclination of 3.5H (horizontal):1V (vertical). A live load surcharge of 240 psf was applied as an external load to model the traffic acting on the crest of the roadway embankments, except for Case 3 (seismic loading scenario).

The results of the slope stability analyses are presented in Table 3 below. The graphical output from these analyses is provided in Appendix C.

Table 3 – Summary of Slope Stability Analyses

Roadway	Station	Borings	H_{fill} (feet)[2]	Case 1 F.S. Short Term (1.3 min.)	Case 2 F.S. Long Term (1.5 min.)	Case 3 F.S. Seismic (1.1 min.)	Notes
US 30	1361+00 R[1] foreslope	RB30-323	24	1.6	1.8	1.5	OK
US 30	1425+00 R[1] foreslope	RB30-352, RB30-353	16	1.7	1.8	1.5	OK
US 218	241474+00 L[1] MSE wall	RB24A-1, B-12	22	1.1	1.7	1.8	NG - Case 1
US 218	241474+00 L[1] MSE wall	RB24A-1, B-12	22	1.8	1.8	1.9	OK after coreout and replace
US 218	241474+00 R[1] foreslope	RB24A-1, B-12	22	2.1	2.4	2.2	OK
US 218	241478+00 L[1] foreslope	RB218-1, B-6	24	1.7	2.1	2.0	OK
US 218	241477+04 N abutment foreslope	B-16	24	1.3	1.7	1.7	OK
US 218	241474+47 S abutment MSE wall	B-18	22	1.1	1.6	1.6	NG - Case 1
US 218	241474+47 S abutment MSE wall	B-18	22	1.7	1.8	1.8	OK after coreout and replace

Notes:

[1] L=left side of roadway; R=right side of roadway.

[2] "H_{fill}" is the height of fill slope or MSE wall analyzed (or height of fill for embankments with MSE walls), which Includes embankment height and ditch cuts or roadway cuts. Embankment fill material for our evaluation was generally presumed to be low plasticity clay. Granular backfill was presumed for MSE walls and Iowa DOT Special Backfill was presumed for refill of coreout.

Groundwater levels were estimated from the soil boring logs or assumed to be at the bottom of the adjacent roadway ditches.

Global stability of existing conditions at the south approach and abutment MSE wall location was found to be insufficient based on evaluation of the proposed loading and end of construction (undrained) soil conditions. As a result, the global stability at the south approach and abutment MSE wall was evaluated for an alternative where the fine-grained alluvium beneath the south abutment area is cored out and replaced with Iowa DOT Special Backfill prior to construction of the embankment and MSE wall system. This alternative improves the estimated factor of safety to exceed the minimum requirements as shown in Table 1.

Except for the south abutment/approach MSE wall, results of the stability analyses demonstrated that slopes meet or exceed the minimum required factors of safety. Except for the coreout at the south approach embankment MSE wall, no additional remediation is required to support the proposed embankment fills.

5.3 Settlement

Settlement analyses have been performed to estimate the magnitude of post-construction settlement of the embankments due to compression of the foundation soils under the weight of the new embankment fills. One-dimensional consolidation theory and the results of the lab consolidation testing provided the basis for estimates of the magnitude and the time-rate of settlement. The borings were used to estimate thicknesses of compressible layers, to define the drainage conditions and to determine the length of each flow path. The foundation pressures from the new fill were estimated using the Boussinesq pressure distribution with depth and Terzaghi's one-dimensional consolidation theory.

The estimated settlements for 11 critical settlement areas are presented in Table 4. Calculations for the settlement analyses are provided in Appendix D.

Table 4 – Summary of Settlement Analyses (Post-Construction)

Station	Roadway	Height of New Fill (feet)	Thickness of Compressible Layer (feet)	Estimated Settlement (inches)	Estimated t_{90} (1) (days)
1388+10	US 30 EB & WB	20	15	6.1	75
1400+94	US 30 EB	18	8	2.1	45
1425+50	US 30 EB	15	23	6.1	45
1425+50	US 30 WB	16	15.5	5.3	45
1454+00	US 30 EB & WB	13	10	2.2	50
1460+75	US 30 EB	10	13	1.9	75
1493+85	US 30 EB	5.5	12	1.4	65
41476+17	Ramp D	20	12	5.2	65
41482+00	Ramp D	14.5	10.5	4.8	55
241478+10	US 218	23	8	4.1	60
241473+20	US 218	24	8	3.1	60

(1) Time required for 90 percent of the primary consolidation settlement to occur.

The estimated magnitudes of settlement under the proposed roadway embankments at the locations shown above are considered reasonable and acceptable for performance of the planned pavements. Settlement plates should be installed at the locations shown on the Q Sheets and listed in Tab 103-5 on CS sheet CS.1.

Various existing and proposed stormwater culverts cross the existing roadway alignments, based on a review of information shown in the D5 plans. Descriptions of the culverts, and our evaluation of the settlement at the locations of planned culverts are presented in the Summary of Structures Settlement Form included in Appendix E.

5.4 MSE Wall – External Stability Evaluation

The proposed MSE Wall supporting the embankment at the south end of the bridge was evaluated for several potential failure modes (direct sliding, bearing capacity and overturning) using the LRFD Methodology described in AASHTO (2014) and was found to exceed the minimum design requirements. Assumptions regarding the MSE wall components are as follows:

- Wall Facing
    - Precast concrete panels
    - Panel depth of 0.66 feet
    - Panel unit weight of 153 pcf
- Wall Reinforcement
    - Metal strips (ribbed) at South Abutment – 22.5 feet long

  - Metal strips (ribbed) at South Abutment Sidewall – 20 feet long
  - Strap length is 0.8 H, where H is the total height of the wall above and below ground
  - Yield strength of 65 ksi
  - Cross sectional area of 0.46 in^2
- Reinforced Soil
  - Friction angle of 34 degrees
  - Unit weight of 120 pcf
- Retained Soil at South Abutment
  - Friction angle of 34 degrees
  - Unit weight of 120 pcf
- Retained Soil at South Abutment Sidewall
  - Friction angle of 28 degrees
  - Unit weight of 125 pcf
- Foundation Soil
  - Friction angle of 32 degrees and unit weight of 125 pcf
- Effective wall height of 28 feet (20.5 feet reinforced zone with embedment of 4 feet, and 7.5 foot non-reinforced surcharge) at South Abutment
- Wall height of 25 feet with embedment of 4 feet at South Abutment Sidewall
- Traffic live load surcharge of 240 psf for non-seismic scenario
- Seismic design horizontal peak ground acceleration of 0.02g

The potential failure modes were evaluated using MSEW (2013) and the AASHTO LRFD design guidelines were followed. The following load (γ) and resistance (φ) factors were applied in this evaluation:

Table 5 – Summary of Load and Resistance Factors for MSE Walls (AASHTO 2014 LRFD)

Design Condition	External Stability Load Factors (γ)	
	Static	**Static and Seismic**
Vertical Earth Pressure for Sliding/Eccentricity	1	1
Vertical Earth Pressure for Bearing Capacity	1.35	1.35
Active Lateral Earth Pressure or Active Lateral Earth Pressure during Earthquake	1.5	1.5
Earthquake Loads	1	1
Live Load Surcharge	1.75	1.75
Dead Load Surcharge	1.5	1.5
	External Stability Resistance Factors (φ)	
	Static	**Static and Seismic**
Sliding at Reinforced Soil/Foundation Soil Interface	1	1
Bearing Capacity	0.65	0.65

The results of our evaluation are shown in Appendix F and are summarized in the following table:

Table 6 – Summary of MSE Wall External Stability – South Approach Embank. (AASHTO 2014 LRFD)

External Failure Mode	Embankment/Wall	Static	Seismic
		Calculated Minimum CDR(1)	
Direct Sliding at Foundation	South Abutment	2.3 (OK)	2.1 (OK)
Bearing Capacity	South Abutment	2.0 (OK)	2.0 (OK)
Overturning	South Abutment	4.8 (OK)	4.3 (OK)
Direct Sliding at Foundation	South Abutment Sidewall	1.5 (OK)	1.4 (OK)
Bearing Capacity	South Abutment Sidewall	1.6 (OK)	1.4 (OK)
Overturning	South Abutment Sidewall	2.7 (OK)	2.3 (OK)

(1) Capacity Demand Ratio; minimum required CDR is 1.0

The results of the MSEW analyses indicate that the proposed walls are stable with respect to sliding, bearing capacity and overturning, based on the coreout of approximately 8 feet of existing soil and replacement with special backfill beneath the retaining wall. The coreout details are shown on Sheet Q.22. The final MSE wall designs should include a minimum strap length of 0.8 times the total wall height above and below grade. Global stability analyses for the MSE walls are presented in Section 5.2.3.

The estimated settlement of the MSE wall is expected to be on the order of 1 to 2 inches based on the coreout of approximately 8 feet of existing soil and replacement with special backfill beneath the retaining wall. Differential settlements along the wall length (longitudinal) in this area could be 2 inches over a length of 50 feet, resulting in a predicted distortion of about 1/300.

Based on review of Table C11.10.4.1-1 in the AASHTO LRFD Bridge Design Specifications, the MSE walls with precast concrete panels at the south approach embankments should be able to accommodate the predicted distortion of 1/300 based on use of a 1/4-inch joint width and a precast concrete panel size less than 30 square feet.

5.5 Bridge Foundations

Findings and recommendations for the US 218 over US 30 Bridge are presented in the report entitled “Bridge Geotechnical Design S4 Submittal, US 218 over US 30, Benton County, Iowa” prepared by HDR, Inc., dated November 3, 2016.

5.6 Topsoil Stripping

After a review of the topsoil depths noted on the boring logs, topsoil stripping depths of 6, 9 and 12-inches were selected for the project, as depicted on the cross sections and listed in Tab 103-10 on Sheet CS.3.

5.7 Granular or Working Blankets

The need for granular or working blankets at this site was evaluated. Working blankets are recommended in five areas of existing surface water drainage as these areas may be saturated and may become unstable under construction traffic. Three of the working blankets are located on US 30, and two are located on Ramp C. Working blankets are shown on the Q Sheets and are listed in Tab 1.4-5C on Sheet CS.3.

5.8 Sliver Fills and Foreslope Benching

Based on review of the proposed cross sections, sliver fills are planned at various locations throughout the interchange site. Foreslope benching is desirable to provide interlocking of the new and existing embankment fills and is noted on Sheet Q.2.

5.9 Plowing and Shaping

The planned pavements would be partially supported on existing fill and partially supported on new fill where the proposed alignments taper away from the existing alignment. As a result, plowing and shaping would be required to provide a uniform layer of new fill for pavement support in this situation.

Plowing and shaping typically extends across the width of the pavement bearing zone defined by 1H:1V lines projecting downward and outward from the edges of the new pavement lanes (not including the shoulders) and to a depth of 2 to 5 feet below the pavement section base elevation as shown on Sheet CS.1. Stationing for the plowing and shaping zones is presented in Tab 107-31 on Sheet CS.2.

5.10 Backslope Subdrains

Based on evaluation of the soil layering and the proposed grading cuts, backslope subdrains are not required for the areas which are included in this submittal.

5.11 Coreouts

As discussed in Section 5.2.3, a coreout is planned at the south approach embankment MSE wall for the US 218 over US 30 bridge. The shallow alluvial clays should be overexcavated to expose the glacial till at approximately elevation 910. Based on information provided by Iowa DOT, excavation for the retaining wall will extend down to approximately elevation 918. Therefore, overexcavation for the coreout is assumed to extend between elevations 918 and 910. Our estimate of the coreout quantity presented on Sheet Q.22 is based on an 8-foot deep coreout extending between elevations 918 and 910. This overexcavation/coreout should be refilled with Iowa DOT Special Backfill to the base of the MSE wall. The nominal extent of this overexcavation is shown on Sheet Q.22.

Where the Special Backfill extends beyond the outside perimeter of the retaining wall, the backfill above the base of the MSE wall adjacent to the MSE wall face should consist of Class 10 (clay). The surface of the Class 10 clay should be sloped at least 2 percent away from the retaining wall.

5.12 Select Treatment Materials

The D5 plans indicate that the typical pavement section for US 30 will consist of 10 inches of Portland Cement concrete (PCC) over a 6 inch granular subbase. The typical pavement section for US 218 and the ramps and loops will consist of 10 inches of PCC over a 12 inch Modified Subbase drainage layer. The intent is for the paving contractor to install the subbase drainage layer immediately prior to paving.

We expect that the soils excavated from the existing roadway embankments and ditches at this site are soils of alluvial and glacial origin. We understand that these excavated soils will be reused as roadway fill where practical. Based on laboratory tests, the excavated soils will not meet the requirements of Select Treatment Materials (Cohesive Soils), so imported Select Treatment Materials will be needed. The subgrade treatment layer should be at least 2.5 feet thick in the portions of the project that are graded during one construction season and paved during the next construction season. For portions of the project that are graded and paved during the same construction season, the subgrade treatment layer should be at least 2 feet thick. In addition, the contractor will have the option to substitute 1 foot of imported Special Backfill for support of the pavement section in lieu of Select Treatment Materials.

5.13 Culverts

New culverts and culvert extensions are planned. Descriptions of the culverts, and our evaluation of the settlement at the locations of planned culverts are presented in the Summary of Structures Settlement Form shown in Appendix E.

6.0 Limitations

This S3 report presents the findings, conclusions and final recommendations for the geotechnical aspects of the interchange improvements and related features. It has been prepared in accordance with generally accepted engineering practice and in a manner consistent with the level of care and skill for this type of project within this geographical area. No warranty, expressed or implied, is made.

The conclusions and recommendations presented herein are based on field reconnaissance, research and available literature, the results of field exploration and laboratory materials testing, and the results of preliminary engineering analyses.

Geotechnical engineering and the geologic sciences are characterized by uncertainty. Professional judgments presented herein are based partly on our understanding of the proposed construction, partly on our general experience and the state-of-the-practice at the time of this evaluation.

7.0 References

Adama Engineering, Inc. (www.geoprograms.com), MSEW (2013), Version 3.0, Update #14.93.

AASHTO LRFD Bridge Design Specifications, Customary U.S. Units, 7th Edition, 2014.

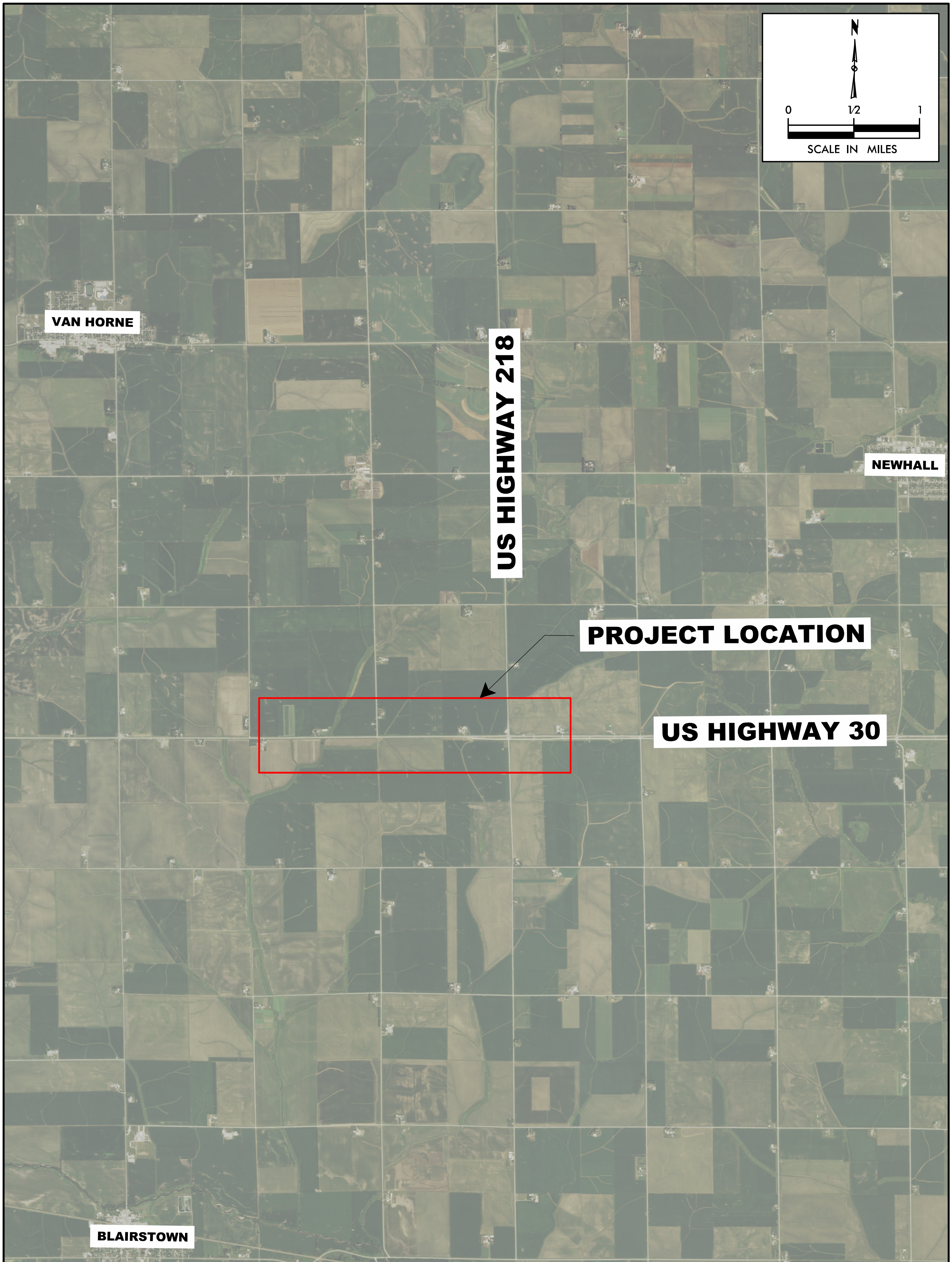
Iowa Department of Natural Resources (2015), Geological and Water Survey Bureau, GEOSAM (Geologic Site and Sample Tracking Program), Published on-line.

Iowa DOT Design Manual, Chapter 200E, Appendix A “Engineering Properties of Soil and Rock”, dated May 19, 2015.

Iowa DOT (2015), Standard Specifications for Highway and Bridge Construction, Iowa Department of Transportation.

SLOPE/W (2012), GeoStudio 2012, August 2015 Release, Version 8.15.4.11512, created by Geo-Slope International (www.geo-slope.com).

NRCS (1980), Soil Survey of Benton County, Iowa, U.S. Department of Agriculture, Natural Resources Conservation Service, 1980.



HDR

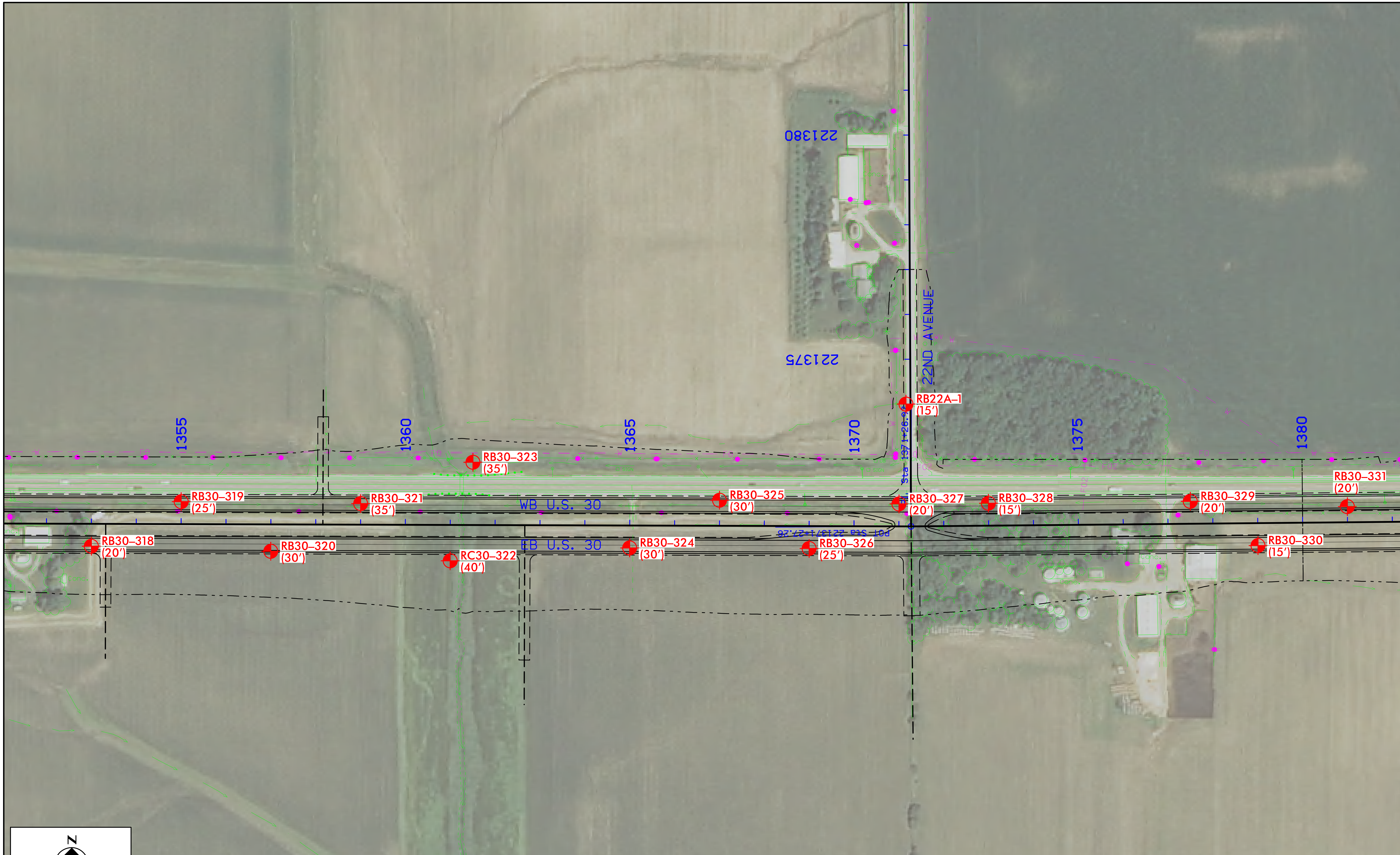
IOWADOT

SITE LOCATION PLAN

S3 Submittal – US218 Interchange
US 30 – Benton County NHSX–030–6(231)—3H–06

Date
December 2016

Figure
1



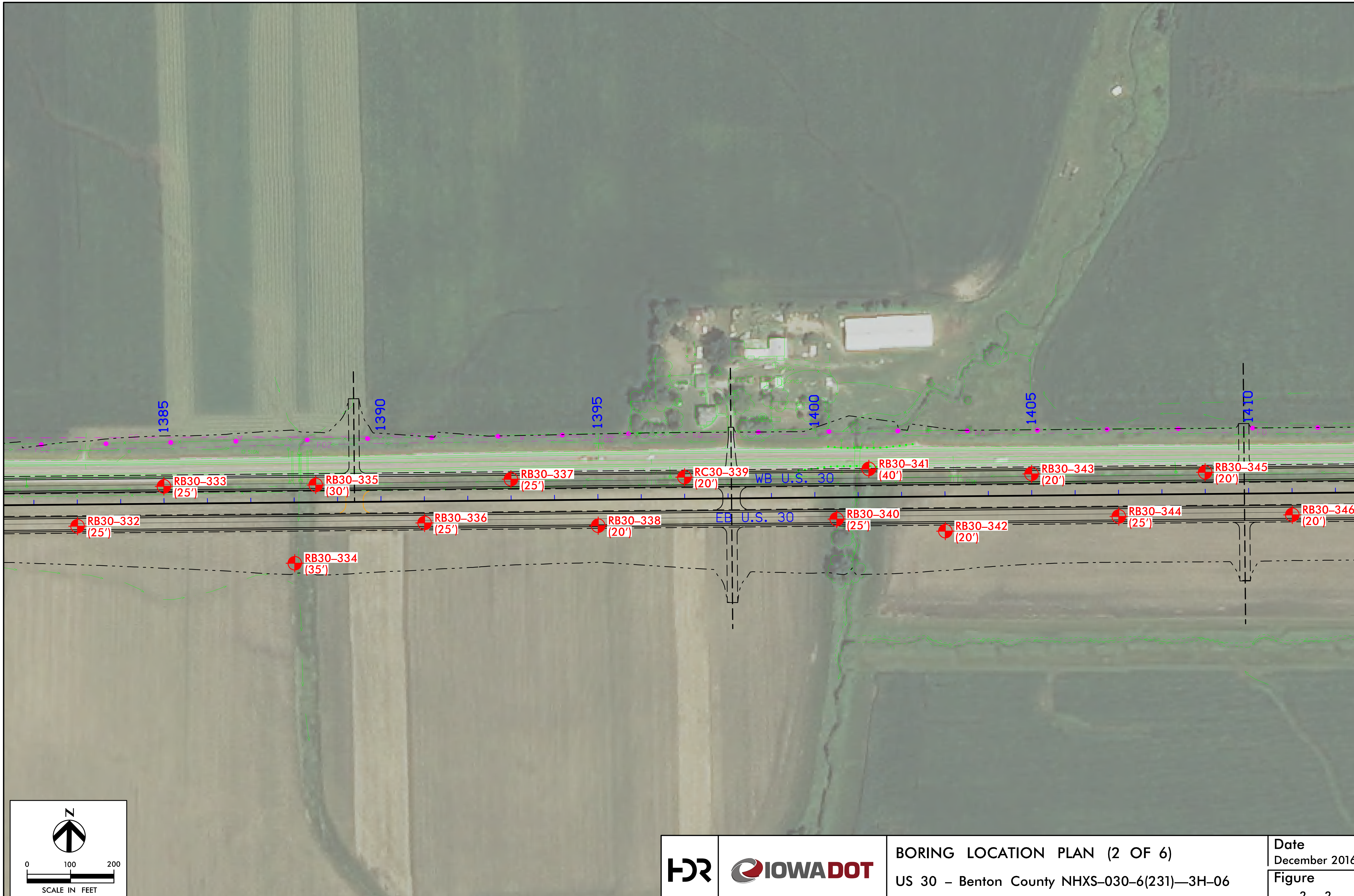
HDR | IOWADOT

BORING LOCATION PLAN (1 OF 6)

US 30 – Benton County NHXS–030–6(231)—3H–06

Date
December 2016

Figure
2 – 1



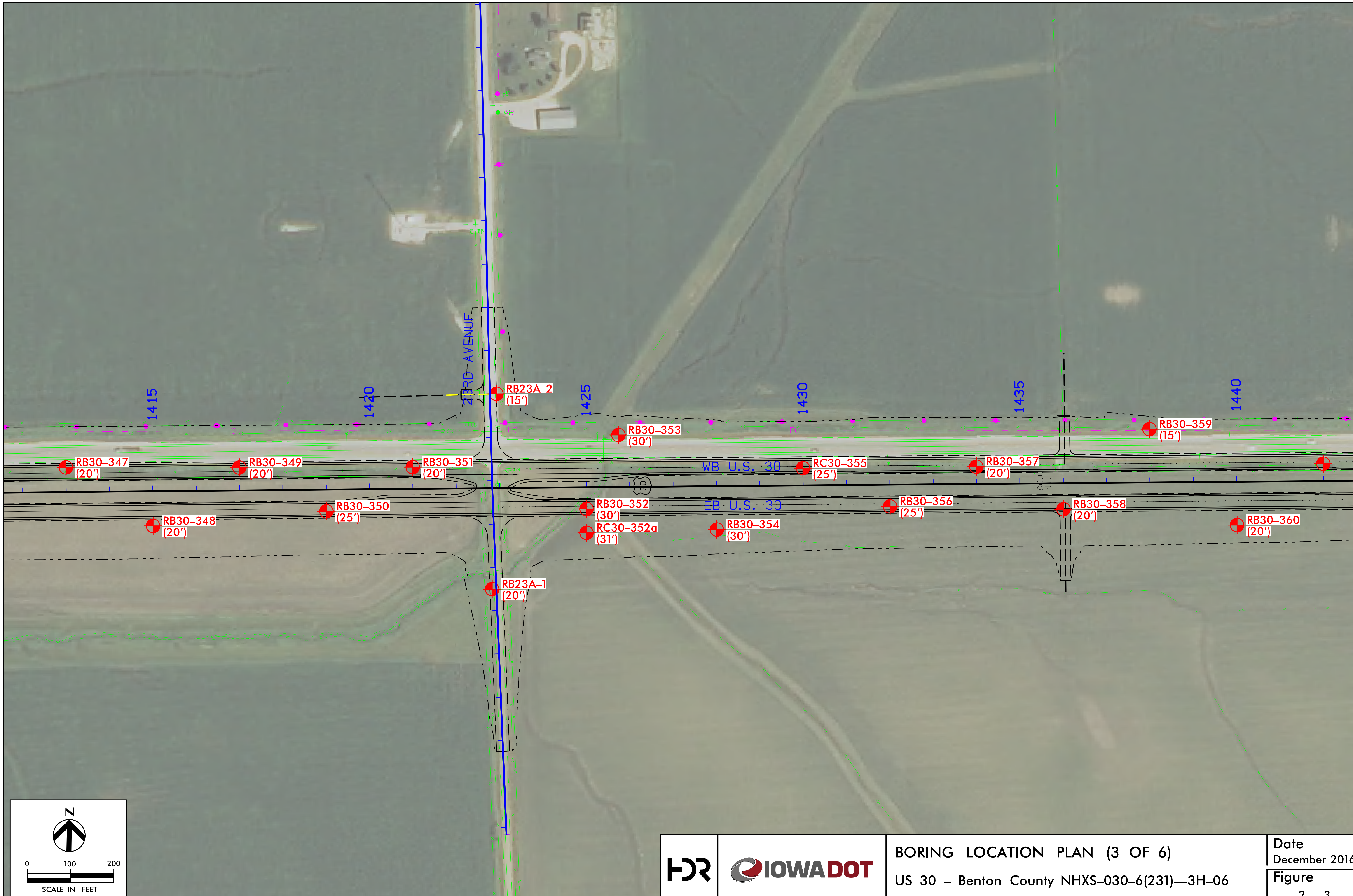
HDR IOWADOT

BORING LOCATION PLAN (2 OF 6)

US 30 – Benton County NHXS–030–6(231)—3H–06

Date
December 2016

Figure
2 – 2



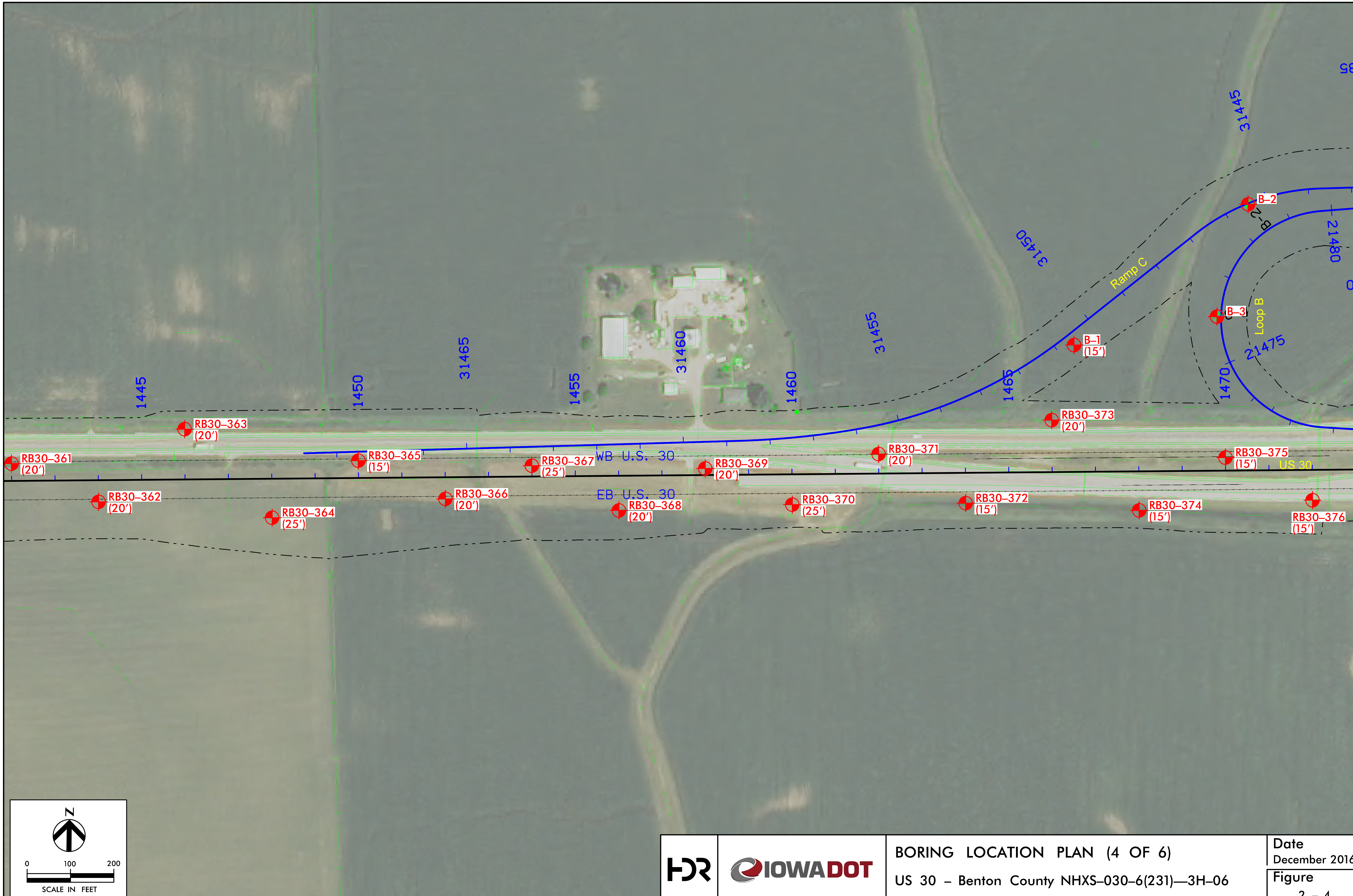
HDR | IOWADOT

BORING LOCATION PLAN (3 OF 6)

US 30 – Benton County NHXS–030–6(231)—3H–06

Date
December 2016

Figure
2 – 3



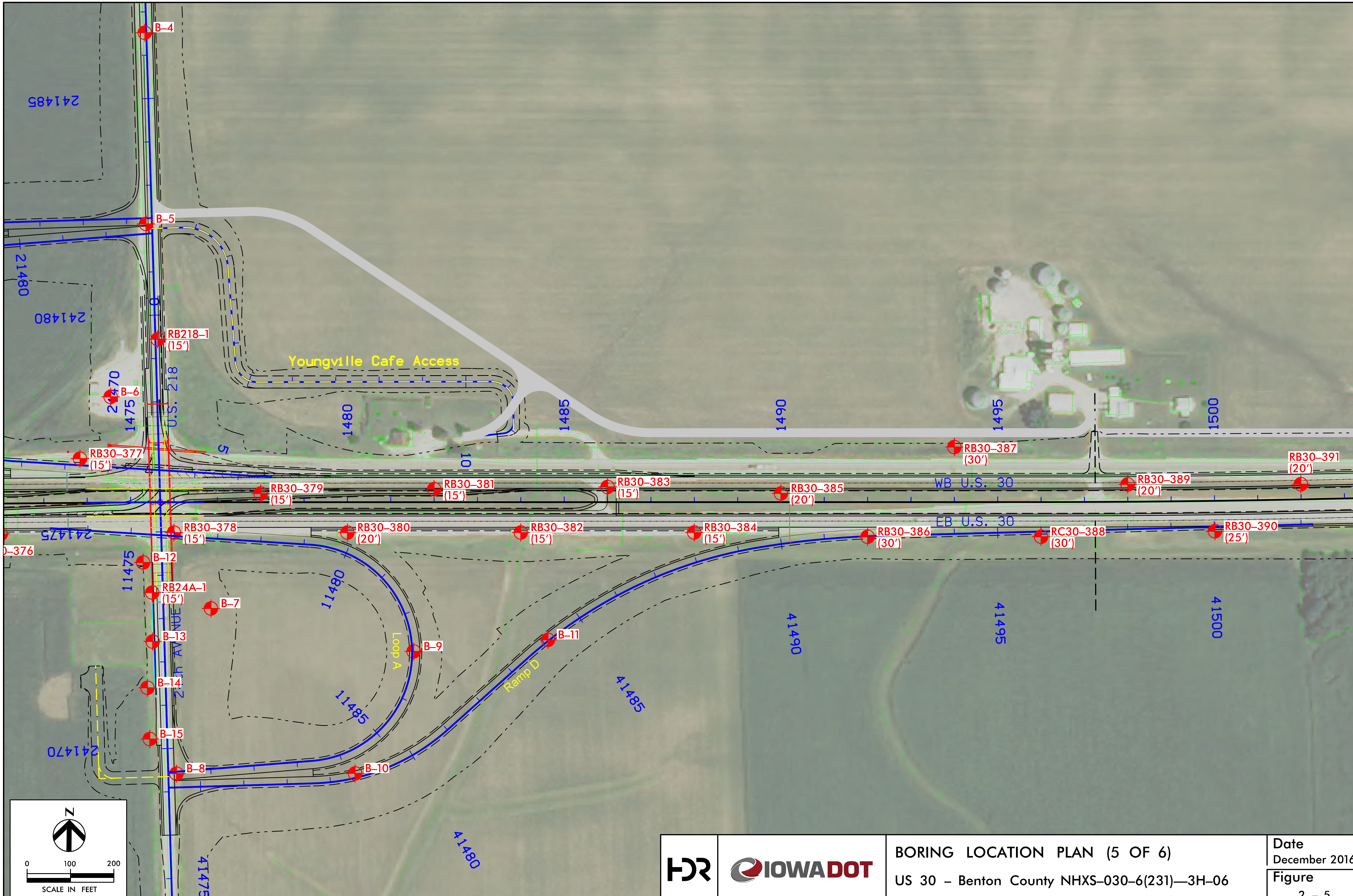
HDR | IOWADOT

BORING LOCATION PLAN (4 OF 6)

US 30 – Benton County NHXS–030–6(231)—3H–06

Date December 2016

Figure 2 – 4



HDR | IOWA DOT

BORING LOCATION PLAN (5 OF 6)

US 30 – Benton County NHXS–030–6(231)—3H–06

Date
December 2016

Figure
2 – 5

HDR | IOWA DOT

BORING LOCATION PLAN (6 OF 6)

US 30 – Benton County NHXS–030–6(231)—3H–06

Date
December 2016

Figure
2 – 6

APPENDIX A: Logs of Test Borings

8408 Indian Hills Drive
Omaha, NE 68114

Phone (402) 399-1000
Fax (402) 399-4979
www.hdrinc.com

BORING LOG NO. B-1

PROJECT: US Highway 30 / US Highway 218 Interchange

CLIENT: HDR Engineering, Inc. Omaha, Nebraska

SITE: S2 Borings Benton County, Iowa

OWNER: Iowa Department of Transportation IDOT Project No. NHS-030-6(87)--19-06

LOCATION WB on-ramp

Latitude: 41.964282° Longitude: -92.031035°

911.0

GRAPHIC LOG / DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" Topsoil**												
	LEAN CLAY (CL), trace sand, gray and brown mottled, very stiff Composite sample from 0.5 to 5 feet classifies as sandy lean clay.				5		2.5 (HP)				22 24	95	30-12-18
4.0	**SANDY LEAN CLAY (CL)**, trace gravel, occasional sand seams, brown	5	▽										
15.0		10 15											

Boring Terminated at 15 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

No water observed while drilling/sampling.

▽ *4' after boring*

Terracon
2640 12th St SW
Cedar Rapids, IA

Boring Started: 12/10/2015	Boring Completed: 12/10/2015
Drill Rig: CME-550	Driller: DL
Project No.: D1154514	Exhibit: A-1

BORING LOG NO. B-2

PROJECT: US Highway 30 / US Highway 218 Interchange

CLIENT: HDR Engineering, Inc. Omaha, Nebraska

SITE: S2 Borings Benton County, Iowa

OWNER: Iowa Department of Transportation IDOT Project No. NHS-030-6(87)--19-06

LOCATION WB on-ramp

Latitude: 41.965167° Longitude: -92.029552°

919.7

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		2-ft. Topsoil												
	2.0	**LEAN CLAY (CL)**, trace sand, brown												
	6.0	**SAND (SP)**, trace silt, fine to medium, brown	5											
	12.0	**SANDY LEAN CLAY (CL)**, trace gravel, occasional sand seams, brown	10											
	15.0	***Boring Terminated at 15 Feet***	15											

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method: Power Auger	Notes:
Abandonment Method:	

WATER LEVEL OBSERVATIONS

6' while drilling/sampling.

4' after boring

Wet cave-in at 5.5' after boring.

Terracon
2640 12th St SW
Cedar Rapids, IA

Boring Started: 12/10/2015	Boring Completed: 12/10/2015
Drill Rig: CME-550	Driller: DL
Project No.: D1154514	Exhibit: A-2

BORING LOG NO. B-3

PROJECT: US Highway 30 / US Highway 218 Interchange

CLIENT: HDR Engineering, Inc. Omaha, Nebraska

SITE: S2 Borings Benton County, Iowa

OWNER: Iowa Department of Transportation IDOT Project No. NHS-030-6(87)--19-06

LOCATION WB on-ramp

Latitude: 41.964457° Longitude: -92.02982°

Elevation (Ft.): 915.8

GRAPHIC LOG	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	2.0	**2-ft. Topsoil**			Hand									
	4.0	**LEAN CLAY (CL)**, trace sand, brown			Hand									
	15.0	**SANDY LEAN CLAY (CL)**, trace gravel, occasional sand seams, brown	5, 10, 15	∇ (13')	Hand									
		Boring Terminated at 15 Feet												

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

No water observed while drilling/sampling.

∇ *13' after boring*

Terracon
2640 12th St SW
Cedar Rapids, IA

Boring Started: 12/10/2015	Boring Completed: 12/10/2015
Drill Rig: CME-550	Driller: DL
Project No.: D1154514	Exhibit: A-3

BORING LOG NO. B-4

PROJECT: US Highway 30 / US Highway 218 Interchange

CLIENT: HDR Engineering, Inc. Omaha, Nebraska

SITE: S2 Borings, Benton County, Iowa

OWNER: Iowa Department of Transportation, IDOT Project No. NHS-030-6(87)--19-06

LOCATION U.S. 218

Latitude: 41.966461° Longitude: -92.027778°

937.7

DEPTH	Material Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" Asphaltic Cement Concrete**												
1.0	**6" Reinforced Portland Cement Concrete**												
2.0	**FILL - SANDY LEAN CLAY**, trace gravel, dark brown and brown												
8.0	**LEAN CLAY WITH SAND (CL)**, brown, very stiff	5			8		3.0 (HP)				29	97	37-15-22
15.0	**SANDY LEAN CLAY (CL)**, trace gravel, occasional sand seams, brown	10	▽										
	Boring Terminated at 15 Feet	15											

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

No water observed while drilling/sampling.

▽ *12.5' after boring*

Terracon
2640 12th St SW
Cedar Rapids, IA

Boring Started: 12/10/2015	Boring Completed: 12/10/2015
Drill Rig: CME-550	Driller: DL
Project No.: D1154514	Exhibit: A-4

BORING LOG NO. B-5

PROJECT: US Highway 30 / US Highway 218 Interchange	**CLIENT: HDR Engineering, Inc. Omaha, Nebraska**
SITE: S2 Borings Benton County, Iowa	**OWNER: Iowa Department of Transportation IDOT Project No. NHS-030-6(87)--19-06**

LOCATION U.S. 218

Latitude: 41.965252° Longitude: -92.027744°

927.3

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.7	**9" Asphaltic Cement Concrete**												
1.5	**FILL - SAND**, trace silt, brown												
2.3	**9½" Reinforced Portland Cement Concrete (Possible Rubble)**												
5.0	**LEAN CLAY (CL)**, trace sand and organics, dark brown	5											
8.0	**LEAN CLAY (CL)**, trace sand, brown												
15.0	**SANDY LEAN CLAY (CL)**, trace gravel, occasional sand seams, brown	10, 15	∇										

Boring Terminated at 15 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Power Auger

Abandonment Method:

Notes:

WATER LEVEL OBSERVATIONS

No water observed while drilling/sampling.

∇ *12' after boring*

Terracon
2640 12th St SW
Cedar Rapids, IA

Boring Started: 12/10/2015	Boring Completed: 12/10/2015
Drill Rig: CME-550	Driller: DL
Project No.: D1154514	Exhibit: A-5

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL D1154514 - US HIGHWAY 30 - US HIGHWAY 218 INTERCHANGE.GPJ TERRACON2015.GDT 1/30/17

BORING LOG NO. B-6

PROJECT: US Highway 30 / US Highway 218 Interchange

CLIENT: HDR Engineering, Inc.
Omaha, Nebraska

SITE: S2 Borings
Benton County, Iowa

OWNER: Iowa Department of Transportation
IDOT Project No. NHS-030-6(87)--19-06

LOCATION U.S. 218

Latitude: 41.964157° Longitude: -92.02808°

917.8

DEPTH	Material Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	STRENGTH TEST: CONFINING PRESSURE (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1.0	**12" Crushed Limestone**													
3.0	**<u>FILL - LEAN CLAY</u>**, trace sand and organics, dark brown and brown			Auger										
	<u>SANDY LEAN CLAY (CL)</u>, trace gravel, occasional sand seams, brown, medium stiff to very stiff	5			13		1.25 (HP)	UU	0.58	14.8	4	18	106	37-15-22
13.0		10			18		3.0 (HP)	UU	2.55	14.6	8	15	118	33-13-20
	<u>SANDY LEAN CLAY (CL)</u>, trace gravel, occasional sand seams, gray	15			0									
25.0		20		Auger										
	Boring Terminated at 25 Feet	25												

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Power Auger

Abandonment Method:

Notes:

WATER LEVEL OBSERVATIONS

No water observed while drilling/sampling.

No water observed after boring.

Terracon
2640 12th St SW
Cedar Rapids, IA

Boring Started: 12/10/2015	Boring Completed: 12/10/2015
Drill Rig: CME-550	Driller: DL
Project No.: D1154514	Exhibit: A-6

BORING LOG NO. B-7

PROJECT: US Highway 30 / US Highway 218 Interchange

CLIENT: HDR Engineering, Inc. Omaha, Nebraska

SITE: S2 Borings Benton County, Iowa

OWNER: Iowa Department of Transportation IDOT Project No. NHS-030-6(87)--19-06

LOCATION U.S. 218

Latitude: 41.962815° Longitude: -92.027237°

926.6

DEPTH	Description	ELEVATION (Ft.)
1.0	**1-ft. Topsoil**	
18.0	**SANDY LEAN CLAY (CL)**, trace gravel, occasional sand seams, gray and brown, very stiff to hard	
25.0	**SANDY LEAN CLAY (CL)**, trace gravel, occasional sand seams, gray	
	Boring Terminated at 25 Feet	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	STRENGTH TEST: CONFINING PRESSURE (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
5			13		3.25 (HP)							35-13-22
10			19		4.5+ (HP)	UU	3.10	14.6	8	15	119	34-14-20
15			21		4.5+ (HP)	UU	3.30	9.6	12	15	119	35-12-23
20												
25												

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

No water observed while drilling/sampling.

No water observed after boring.

Terracon
2640 12th St SW
Cedar Rapids, IA

Boring Started: 12/10/2015	Boring Completed: 12/10/2015
Drill Rig: CME-550	Driller: DL
Project No.: D1154514	Exhibit: A-7

BORING LOG NO. B-8

PROJECT: US Highway 30 / US Highway 218 Interchange

CLIENT: HDR Engineering, Inc. Omaha, Nebraska

SITE: S2 Borings Benton County, Iowa

OWNER: Iowa Department of Transportation IDOT Project No. NHS-030-6(87)--19-06

LOCATION U.S. 218

Latitude: 41.961772° Longitude: -92.027535°

917.1

DEPTH	GRAPHIC LOG / DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1.0	**1-ft. Topsoil Fill**												
3.0	**FILL - LEAN CLAY WITH SAND** , trace gravel and cinders, brown				12		4.0 (HP)				16 31	104	54-18-36
6.0	**FAT CLAY (CH)**, trace sand and organics, dark brown and brown	5											
12.0	**LEAN CLAY (CL)**, trace sand, brown	10											
15.0	**SANDY LEAN CLAY (CL)**, trace gravel, occasional sand seams, brown	15											
	Boring Terminated at 15 Feet												

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

No water observed while drilling/sampling.

No water observed after boring.

Terracon
2640 12th St SW
Cedar Rapids, IA

Boring Started: 12/10/2015	Boring Completed: 12/10/2015
Drill Rig: CME-550	Driller: DL
Project No.: D1154514	Exhibit: A-8

BORING LOG NO. B-9

PROJECT: US Highway 30 / US Highway 218 Interchange

CLIENT: HDR Engineering, Inc. Omaha, Nebraska

SITE: S2 Borings Benton County, Iowa

OWNER: Iowa Department of Transportation IDOT Project No. NHS-030-6(87)--19-06

LOCATION EB off-ramp

Latitude: 41.962538° Longitude: -92.025519°

917.2

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	1.5	**1.5-ft. Topsoil**													
	15.0	**SANDY LEAN CLAY (CL)**, trace gravel, occasional sand seams, brown		5, 10, 15											
		Boring Terminated at 15 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Power Auger

Abandonment Method:

Notes:

WATER LEVEL OBSERVATIONS

7' while drilling

7' after boring

Wet cave-in at 7' after boring.

Terracon
2640 12th St SW
Cedar Rapids, IA

Boring Started: 12/10/2015	Boring Completed: 12/10/2015
Drill Rig: CME-550	Driller: DL
Project No.: D1154514	Exhibit: A-9

BORING LOG NO. B-10

PROJECT: US Highway 30 / US Highway 218 Interchange	**CLIENT: HDR Engineering, Inc. Omaha, Nebraska**
SITE: S2 Borings Benton County, Iowa	**OWNER: Iowa Department of Transportation IDOT Project No. NHS-030-6(87)--19-06**

LOCATION EB off-ramp

Latitude: 41.961769° Longitude: -92.02602°

911.8

GRAPHIC LOG	DEPTH / DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	0.4 **5" Topsoil**													
	SANDY LEAN CLAY (CL), trace gravel, occasional sand seams, brown			▽ (3')										
			5											
					✋									
			10											
				▽ (13')										
	15.0		15											
	Boring Terminated at 15 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method: Power Auger		Notes:
Abandonment Method:		

WATER LEVEL OBSERVATIONS

- ▽ *3' while drilling*
- ▽ *13' after boring*

Terracon
2640 12th St SW
Cedar Rapids, IA

Boring Started: 12/10/2015	Boring Completed: 12/10/2015
Drill Rig: CME-550	Driller: DL
Project No.: D1154514	Exhibit: A-10

BORING LOG NO. B-11

PROJECT: US Highway 30 / US Highway 218 Interchange	**CLIENT:** HDR Engineering, Inc. Omaha, Nebraska
SITE: S2 Borings Benton County, Iowa	**OWNER:** Iowa Department of Transportation IDOT Project No. NHS-030-6(87)--19-06

LOCATION EB off-ramp

Latitude: 41.962608° Longitude: -92.024379°

916.3

GRAPHIC LOG	DEPTH / DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	1.0 **1-ft. Topsoil**												
	SANDY LEAN CLAY (CL), trace gravel, occasional sand seams, brown, very stiff				6		3.25 (HP)				23 18	87	32-14-18
		5											
		10											
	13.0 **SANDY LEAN CLAY (CL)**, trace gravel, occasional sand seams, gray												
	15.0 ***Boring Terminated at 15 Feet***	15											

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method: Power Auger		Notes:
Abandonment Method: Boring backfilled with auger cuttings upon completion.		

WATER LEVEL OBSERVATIONS
No water observed while drilling/sampling.
No water observed after boring.

Terracon
2640 12th St SW
Cedar Rapids, IA

Boring Started: 12/10/2015	Boring Completed: 12/10/2015
Drill Rig: CME-550	Driller: DL
Project No.: D1154514	Exhibit: A-11

BORING LOG NO. B-12

PROJECT: US Highway 30 / US Highway 218 Interchange

CLIENT: HDR Engineering, Inc. Omaha, Nebraska

SITE: S2 Borings Benton County, Iowa

OWNER: Iowa Department of Transportation IDOT Project No. NHS-030-6(87)--19-06

LOCATION Retaining wall

Latitude: 41.963108° Longitude: -92.02781°

918.4

GRAPHIC LOG	DEPTH / DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	STRENGTH TEST: CONFINING PRESSURE (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	SANDY SILTY CLAY (CL-ML), trace gravel, occasional sand seams, brown, soft to stiff		▽ (2')											
			▽ (3.5')		24		2.0 (HP)	UU	0.44	7.1	4	17	110	19-13-6
	6.5	5												
	SANDY SILT (ML), trace gravel, occasional sand seams, brown, stiff to very stiff				22		3.5 (HP)	UU	1.22	3.4	4	18	108	NP
	15.0	10												
	SANDY LEAN CLAY (CL), trace gravel, occasional sand seams, gray, very stiff	15												
	20.0	20												
	Boring Terminated at 20 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

▽ *2' while drilling*

▽ *3.5' after boring*

Terracon
2640 12th St SW
Cedar Rapids, IA

Boring Started: 12/10/2015	Boring Completed: 12/10/2015
Drill Rig: CME-550	Driller: DL
Project No.: D1154514	Exhibit: A-12

BORING LOG NO. B-13

PROJECT: US Highway 30 / US Highway 218 Interchange

CLIENT: HDR Engineering, Inc. Omaha, Nebraska

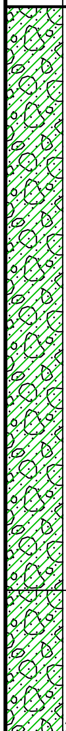
SITE: S2 Borings Benton County, Iowa

OWNER: Iowa Department of Transportation IDOT Project No. NHS-030-6(87)--19-06

LOCATION Retaining wall

Latitude: 41.962609° Longitude: -92.027732°

920.9



DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)	CONFINING PRESSURE (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
SANDY LEAN CLAY (CL), trace gravel, occasional sand seams, brown and gray, stiff to very stiff		5			15		2.0 (HP)	UU	1.73	14.9	4	16	113	30-13-17
		10			16		3.0 (HP)	UU	3.01	14.8	8	14	118	33-14-19
16.0		15												
SANDY LEAN CLAY (CL), trace gravel, occasional sand seams, gray														
20.0		20												
Boring Terminated at 20 Feet														

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Power Auger

Abandonment Method:

Notes:

WATER LEVEL OBSERVATIONS

No water observed while drilling/sampling.

No water observed after boring.

Terracon
2640 12th St SW
Cedar Rapids, IA

Boring Started: 12/10/2015	Boring Completed: 12/10/2015
Drill Rig: CME-550	Driller: DL
Project No.: D1154514	Exhibit: A-13

BORING LOG NO. B-14

PROJECT: US Highway 30 / US Highway 218 Interchange

CLIENT: HDR Engineering, Inc. Omaha, Nebraska

SITE: S2 Borings Benton County, Iowa

OWNER: Iowa Department of Transportation IDOT Project No. NHS-030-6(87)--19-06

LOCATION Retaining wall

Latitude: 41.962316° Longitude: -92.027777°

923.2

DEPTH (Ft.)	Description	ELEVATION (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	STRENGTH TEST: CONFINING PRESSURE (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.0–2.0	**LEAN CLAY (CL)**, trace sand, brown													
2.0–3.0	**SANDY LEAN CLAY (CL)**, trace gravel, occasional sand seams, brown and gray													
3.0–16.0	**SANDY LEAN CLAY (CL)**, trace gravel, occasional sand seams, brown, stiff to very stiff				20		3.0 (HP)	UU	1.37	14.8	4	17	115	35-13-22
					16		3.0 (HP)	UU	2.17	13.6	8	15	114	33-14-19
16.0–17.0	**SAND (SP)**, trace silt		▽ (16')											
17.0–20.0	**SANDY LEAN CLAY (CL)**, trace gravel, occasional sand seams, gray		▽ (18')											

Boring Terminated at 20 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Power Auger

Abandonment Method:

Notes:

WATER LEVEL OBSERVATIONS

16' while drilling

18' after boring

Terracon
2640 12th St SW
Cedar Rapids, IA

Boring Started: 12/10/2015	Boring Completed: 12/10/2015
Drill Rig: CME-550	Driler: DL
Project No.: D1154514	Exhibit: A-14

BORING LOG NO. B-15

PROJECT: US Highway 30 / US Highway 218 Interchange

CLIENT: HDR Engineering, Inc. Omaha, Nebraska

SITE: S2 Borings Benton County, Iowa

OWNER: Iowa Department of Transportation IDOT Project No. NHS-030-6(87)--19-06

LOCATION Retaining wall

Latitude: 41.961992° Longitude: -92.02776°

920.2

DEPTH	Material Description	ELEVATION (Ft.) / DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)	CONFINING PRESSURE (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	LEAN CLAY (CL), trace sand and organics, dark brown			Hand auger										
3.0	**FAT CLAY (CH)**, trace sand, brown, stiff	5		Sample	10		2.0 (HP)	UU	1.32	14.6	4	19	95	53-25-28
7.0	**SILTY SAND (SM)**, fine to medium, brown	10	▽ 7', cave-in 8'	Sample	24									NP
20.0	*Boring Terminated at 20 Feet*	15, 20												

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Power Auger

Abandonment Method:

WATER LEVEL OBSERVATIONS

▽ *7' while drilling*

▽ *8' after boring*

Wet cave-in at 8' after boring.

Terracon
2640 12th St SW
Cedar Rapids, IA

Notes:

Boring Started: 12/10/2015	Boring Completed: 12/10/2015
Drill Rig: CME-550	Driller: DL
Project No.: D1154514	Exhibit: A-15

BORING LOG NO. RB30-330

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1379+00
Offset: 50 R

Surface Elev.: 892.7 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" Topsoil (Harvested Soybean Field)**	892												
3.5	**LEAN CLAY (CL)** trace sand dark brown	889												
7.0	**SOFT TO STIFF SILTY CLAY (CL-ML)** brown	885.5	5		X	18	2-1-1 N=2	1.5 (HP)						
				▽ (7')										
13.0	**MEDIUM STIFF SANDY LEAN CLAY (CL)** trace gravel brown gray	879.5	10		X	18	0-2-2 N=4	1.0 (HP)						
15.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel, gray	877.5	15		X	18	5-6-8 N=14	4.0 (HP)						

Boring Terminated at 15 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

▽ *7' (12/16/13)*

Cave in @ 11' (12/16/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/12/2013	Boring Completed: 12/12/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-331

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1381+00
Offset: 35 L

Surface Elev.: 883.2 (Ft.)

DEPTH	DESCRIPTION	ELEVATION (Ft.)
0.5	**4 to 5" Root Zone / 6" Topsoil (Tall Grassy Ditch)**	882.5
9.0	**SOFT SANDY LEAN CLAY (CL)** trace gravel brown	874
10.0	**STIFF SANDY LEAN CLAY (CL)** trace gravel, gray brown	873
20.5	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel gray	862.5

Boring Terminated at 20.5 Feet

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
5	▽ ▽	X	18	1-1-2 N=3	0.25 (HP)				21		
10		X	18	4-7-8 N=15	4.0 (HP)						
15		X	15	3-6-7 N=13	2.0 (HP)				13		
20		X	18	4-9-8 N=17	3.5 (HP)						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *5' while sampling*

▽ *5½' (11/15/13)*

Cave in @ 16' (11/15/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/14/2013	Boring Completed: 11/14/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-332

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1383+00
Offset: 50 R

Surface Elev.: 879.7 (Ft.)

DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" Topsoil (Harvested Soybean Field)**	879												
3.5	**LEAN CLAY (CL)** trace sand dark brown	876												
4.5	**MEDIUM STIFF SILTY CLAY (CL-ML)**, trace organics, brown	875			X	15	0-2-2 N=4	2.0 (HP)						
			5											
8.0	**SAND (SP)** fine, brown	871.5												
	VERY SOFT TO SOFT SILTY CLAY (CL-ML) brown gray				X	18	0-0-1 N=1	0.5 (HP)						
12.0		867.5	10											
	MEDIUM STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel gray				X	18	0-3-3 N=6	2.5 (HP)						
			15	▽										
					X	18	4-7-8 N=15	3.5 (HP)						
			20											
25.0		854.5	25		X	18	5-7-9 N=16	4.0 (HP)						

Boring Terminated at 25 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *17' while drilling*

No water encountered (12/16/13)

Cave in @ 7' (12/16/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/12/2013	Boring Completed: 12/12/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-333

PROJECT: US Hwy 30

**CLIENT: HDR Engineering, Inc.
Omaha, NE**

**SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa**

LOCATION Station: 1385+00
Offset: 40 L

Surface Elev.: 876.1 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1.0	**4 to 5" Root Zone / 12" Topsoil (Tall Grassy Ditch)**	875												
4.0	**SANDY LEAN CLAY (CL)** brown	872												
6.0	**SOFT LEAN CLAY (CL)** trace sand, brown gray Oxidation present @ about 5 to 5½ feet.	870	5	▽	X	18	2-1-2 N=3	0.25 (HP)				35		
9.2	**LEAN CLAY (CL)** trace sand brown	867												
12.0	**STIFF SANDY LEAN CLAY (CL)** trace gravel brown gray	864	10		X	18	3-4-6 N=10	2.0 (HP)						
25.5	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel gray	850.5	15		X	13	3-4-7 N=11	3.75 (HP)				13		
			20		X	17	5-8-10 N=18	4.25 (HP)						
			25		X	18	4-8-11 N=19	2.75 (HP)				15		

Boring Terminated at 25.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *4½' while sampling*

▽ *5' (11/15/13)*

Cave in @ 13' (11/15/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/14/2013	Boring Completed: 11/14/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-334

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1388+00
Offset: 140 R

Surface Elev.: 869.3 (Ft.)

DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	Grassy Waterway **LEAN CLAY (CL)** trace sand dark brown													
3.5		866												
4.0	**VERY SOFT TO SOFT SILTY CLAY (CL-ML)**, brown	865.5			X	16	1-0-1 N=1	0.5 (HP)				23		
	SILTY CLAY (CL-ML) light gray		5	▽ (7')										
8.5		861												
	STIFF SILTY CLAY (CL-ML) brown gray				X	18	3-3-5 N=8	1.25 (HP)						
			10											
13.0		856.5												
	MEDIUM STIFF TO HARD SANDY LEAN CLAY (CL) trace gravel gray				X	18	2-2-3 N=5	2.5 (HP)						
			15											
					X	18	3-5-5 N=10	3.5 (HP)				16		
			20											
					X	18	4-5-8 N=13	3.25 (HP)						
			25											
					X	18	4-6-9 N=15	4.0 (HP)				13		
			30											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

▽ *7' (12/16/13)*

Cave in @ 13' (12/16/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/12/2013	Boring Completed: 12/12/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-334

PROJECT: US Hwy 30

**CLIENT: HDR Engineering, Inc.
Omaha, NE**

**SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa**

LOCATION Station: 1388+00
Offset: 140 R

Surface Elev.: 869.3 (Ft.)

GRAPHIC LOG	DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	MEDIUM STIFF TO HARD *(continued)* **SANDY LEAN CLAY (CL)** trace gravel, gray			X	18	5-7-15 N=22	4.5 (HP)						
	35.0 / 834.5	35											
	Boring Terminated at 35 Feet												

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

7' (12/16/13)

Cave in @ 13' (12/16/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/12/2013	Boring Completed: 12/12/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-335

PROJECT: US Hwy 30

**CLIENT: HDR Engineering, Inc.
Omaha, NE**

**SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa**

LOCATION Station: 1388+50 Offset: 40 L

Surface Elev.: 872.6 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
3.0	**4 to 5" Root Zone (Tall Grassy Ditch)** **Topsoil / Alluvium (Lean Clay, dark brown)**	869.5												
	SOFT TO MEDIUM STIFF SANDY LEAN CLAY (CL) with occasional sand seams brown gray		5	▽	X	18	2-1-2 N=3	0.75 (HP)						
9.0		863.5												
	STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel gray		10		■	21			UC	1.72	13.3	15	113	
			15		X	15	3-5-7 N=12	2.5 (HP)						
			20	▽	X	17	3-6-7 N=13	2.5 (HP)						
			25		X	18	2-5-6 N=11	2.0 (HP)						
30.5		842	30		X	18	3-6-8 N=14	2.75 (HP)						
	Boring Terminated at 30.5 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *21' while drilling*

▽ *6' (11/15/13)*

Cave in @ 12' (11/15/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/14/2013	Boring Completed: 11/14/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-336

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc. Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06 Benton County, Iowa

LOCATION Station: 1391+00 Offset: 50 R

Surface Elev.: 872.0 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" Topsoil (Harvested Soybean Field)**	871.5												
3.5	**LEAN CLAY (CL)** trace sand dark brown	868.5												
8.5	**MEDIUM STIFF TO VERY STIFF SILTY CLAY (CL-ML)** trace organics brown	863.5	3.5–5		X	18	2-3-2 N=5	2.75 (HP)						
13.0	**MEDIUM STIFF SILTY CLAY (CL-ML)** trace organics, brownish orange	859	8.5–10	▽ (9')	X	18	0-2-3 N=5	1.0 (HP)						
25.0	**MEDIUM STIFF TO HARD SANDY LEAN CLAY (CL)** trace gravel gray	847	13.5–15		X	18	3-3-4 N=7	3.5 (HP)						
			18.5–20	▽ (19')	X	18	3-5-4 N=9	4.0 (HP)						
			23.5–25		X	18	5-10-9 N=19	4.5 (HP)						
	Boring Terminated at 25 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *19' while sampling*

▽ *9' (12/16/13)*

Cave in @ 13' (12/16/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/12/2013	Boring Completed: 12/12/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-337

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1393+00
Offset: 49 L

Surface Elev.: 873.9 (Ft.)

DEPTH	Description	ELEVATION (Ft.)
0.0–2.0	**4 to 5" Root Zone / 24" Topsoil (Tall Grassy Ditch)**	872
2.0–9.5	**SOFT TO MEDIUM STIFF SANDY LEAN CLAY (CL)** trace gravel brown	864.5
9.5–12.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel, brown gray	862
12.0–18.0	**VERY STIFF SANDY LEAN CLAY (CL)** trace gravel gray	856
18.0–25.5	**VERY STIFF TO HARD SANDY LEAN CLAY (CL)** trace gravel with occasional sand seams gray	848.5

Boring Terminated at 25.5 Feet

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
5		X	12	2-2-2 N=4	0.25 (HP)				18		
7	▽ (7')										
9	▽ (9')										
10		X	17	2-4-6 N=10	3.25 (HP)						
15		X	11	4-11-12 N=23	3.5 (HP)				14		
20		X	17	8-10-14 N=24	4.5 (HP)						
25		X	18	5-9-12 N=21	4.0 (HP)				13		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *9' while sampling*

▽ *7' (11/15/13)*

Cave in @ 18' (11/15/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/14/2013

Boring Completed: 11/14/2013

Drill Rig: CME-550

Driller: DL

Project No.: 06135064

BORING LOG NO. RB30-338

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: **IDOT Project No. NHS-030-6(87)--19-06**
Benton County, Iowa

LOCATION Station: 1395+00
Offset: 60 R

Surface Elev.: 874.9 (Ft.)

DEPTH	Description	ELEVATION (Ft.)
0.5	**6" Topsoil (Harvested Soybean Field)**	874.5
3.5	**LEAN CLAY (CL)** trace sand dark brown	871.5
4.5	**MEDIUM STIFF SILTY CLAY (CL-ML)**, trace organics, brown	870.5
9.0	**SILTY SAND (SM)** brown	866
13.0	**SOFT TO MEDIUM STIFF SILTY CLAY (CL-ML)** brownish orange	862
20.0	**MEDIUM STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel gray	855
	Boring Terminated at 20 Feet	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
3.5–5		X	14	3-4-3 N=7	3.5 (HP)						
8.5	▽										
8.5–10		X	18	2-1-1 N=2	0.75 (HP)						
13.5–15		X	18	3-3-4 N=7	3.0 (HP)						
18.5–20		X	18	3-4-5 N=9	3.0 (HP)						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

▽ *8½' (12/16/13)*

Cave in @ 8½' (12/16/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/12/2013	Boring Completed: 12/12/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-340

PROJECT: US Hwy 30

**CLIENT: HDR Engineering, Inc.
Omaha, NE**

**SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa**

LOCATION Station: 1400+50
Offset: 50 R

Surface Elev.: 868.6 (Ft.)

DEPTH	Description	ELEVATION (Ft.)
0.5	**6" Topsoil (Harvested Soybean Field)**	868
4.0	**STIFF LEAN CLAY (CL)** with sand, trace organics, dark gray	864.5
8.0	**MEDIUM STIFF SILTY CLAY (CL-ML)** trace organics, brown gray	860.5
13.0	**VERY STIFF SANDY LEAN CLAY (CL)** trace gravel, gray	855.5
25.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel, gray	843.5
	Boring Terminated at 25 Feet	

RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
13		2.0 (HP)	UC	1.25	8.7	35	81	
18	2-2-2 N=4	3.0 (HP)						
24		3.25 (HP)	UC	2.39	8.2	13	118	
18	3-5-8 N=13	4.5 (HP)						
20		2.5 (HP)	UC	2.36	15	14	119	
18	5-8-9 N=17	3.0 (HP)						

Depth (Ft.): 5, 10, 15, 20, 25

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

18½' (12/16/13)

Cave in @ 20½' (12/16/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/12/2013	Boring Completed: 12/12/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-341

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1401+25 Offset: 53 L

Surface Elev.: 868.4 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	4 to 5" Root Zone (Tall Grassy Ditch) **Topsoil /Alluvium (Lean Clay, dark brown)**													
3.0		865.5												
	MEDIUM DENSE POORLY GRADED SAND (SP) trace gravel brown			∇										
			5		X	8	5-5-8 N=13					21		
9.0		859.5												
	STIFF SANDY LEAN CLAY (CL) trace gravel with cobbles gray		10		X	15	2-4-6 N=10	2.0 (HP)						
13.0		855.5												
	MEDIUM DENSE POORLY GRADED SAND (SP) gray		15		X	12	9-15-14 N=29					15		
19.0		849.5												
	STIFF TO HARD SANDY LEAN CLAY (CL) trace gravel gray		20		X	15	3-5-7 N=12	3.5 (HP)						
			25		X	16	4-6-9 N=15	3.25 (HP)				15		
			30		X	18	5-9-13 N=22	4.5+ (HP)						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

∇ *4' while sampling*

∇ *4' (11/15/13)*

Cave in @ 5½' (11/15/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/14/2013	Boring Completed: 11/14/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-341

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1401+25
Offset: 53 L

Surface Elev.: 868.4 (Ft.)

GRAPHIC LOG	DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	STIFF TO HARD *(continued)* **SANDY LEAN CLAY (CL)** trace gravel gray	35		X	18	5-9-11 N=20	4.5+ (HP)				13		
	38.0 — 830.5												
	HARD SANDY LEAN CLAY (CL) trace gravel gray brown	40		X	18	11-18-25 N=43	4.5+ (HP)						
	40.5 — 828												
	Boring Terminated at 40.5 Feet												

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

4' while sampling

4' (11/15/13)

Cave in @ 5½' (11/15/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/14/2013	Boring Completed: 11/14/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-342

PROJECT: US Hwy 30

**CLIENT: HDR Engineering, Inc.
Omaha, NE**

**SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa**

LOCATION Station: 1403+00
Offset: 80 R

Surface Elev.: 871.5 (Ft.)

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" Topsoil (Harvested Soybean Field)**	871												
3.5	**LEAN CLAY (CL)** trace sand dark brown	868												
4.0	**MEDIUM STIFF SILTY CLAY (CL-ML)**, brown gray	867.5	5		X	16	6-3-2 N=5	4.5 (HP)						
7.0	**LOOSE SILTY SAND (SM)** brownish orange	864.5		▽										
18.0	**MEDIUM DENSE SAND (SP)**, medium brownish orange	853.5	10		X	18	4-5-6 N=11							
			15		X	18	3-5-9 N=14							
20.0	**MEDIUM DENSE SAND (SP)**, medium brown	851.5	20		X	18	4-7-15 N=22							

Boring Terminated at 20 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *7' while drilling*

No water encountered (12/16/13)

Cave in @ 7' (12/16/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/12/2013	Boring Completed: 12/12/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-343

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1405+00
Offset: 50 L

Surface Elev.: 871.1 (Ft.)

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	**4 to 5" Root Zone / 3" Topsoil (Tall Grassy Ditch)**	871												
3.5	**SANDY LEAN CLAY (CL)** trace gravel gray brown	867.5												
	LOOSE TO MEDIUM DENSE POORLY GRADED SAND (SP) trace gravel brown		5		X	11	3-5-4 N=9							
				∇ ∇										
			10		X	16	3-7-7 N=14							
16.0		855	15		X	14	3-8-8 N=16							
19.0	**POORLY GRADED SAND (SP)** with occasional clay seams brown	852												
20.5	**VERY LOOSE TO LOOSE CLAYEY SAND (SC)** gray	850.5	20		X	10	4-2-1 N=3	0.5 (HP)						
	Boring Terminated at 20.5 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

∇ *6' while drilling*

∇ *6½' (11/15/13)*

Cave in @ 6½' (11/15/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/14/2013	Boring Completed: 11/14/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-344

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1407+00
Offset: 50 R

Surface Elev.: 871.9 (Ft.)

DEPTH	Material Description	ELEVATION (Ft.)	Water Level Observations	Sample Depth (Ft.)	Recovery (In.)	Field Test Results	Laboratory Torvane/HP (tsf)	Test Type	Compressive Strength (tsf)	Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
0.5	**6" Topsoil (Harvested Soybean Field)**	871.5											
3.5	**LEAN CLAY (CL)** trace sand dark brown	868.5											
8.0	**MEDIUM STIFF SILTY CLAY (CL-ML)** brown gray	864	▽ (7')	3.5–5	11	3-4-3 N=7	3.0 (HP)						
14.0	**MEDIUM DENSE SAND (SP)**, medium with gravel, brown	858		8.5–10	16	3-7-9 N=16							
18.0	**LOOSE SILTY SAND (SM)** brownish orange	854		13.5–15	18	2-2-1 N=3	0.75 (HP)						
23.0	**SOFT TO MEDIUM STIFF SILTY CLAY (CL-ML)** gray	849		18.5–20	11	0-0-0 N=0	0.5 (HP)						
25.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel, gray	847		23.5–25	18	4-5-7 N=12	2.5 (HP)						

Boring Terminated at 25 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *7' while drilling*

No water encountered (12/16/13)

Cave in @ 6' (12/16/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/12/2013	Boring Completed: 12/12/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-345

PROJECT: US Hwy 30

**CLIENT: HDR Engineering, Inc.
Omaha, NE**

**SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa**

LOCATION Station: 1409+00
Offset: 50 L

Surface Elev.: 873.8 (Ft.)

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	1.0	**4 to 5" Root Zone / 12" Topsoil (Tall Grassy Ditch)**	873												
	3.5	**SANDY LEAN CLAY (CL)** gray brown	870.5												
		LOOSE POORLY GRADED SAND (SP) trace gravel brown		5	▽ ▽	X	12	3-4-5 N=9					11		
	8.0		866												
		STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel with sand layers gray		10		X	15	5-5-3 N=8	1.25 (HP)						
				15		X	12	3-5-6 N=11	3.75 (HP)				14		
	20.5		853.5	20		X	18	3-5-9 N=14	3.0 (HP)						
		Boring Terminated at 20.5 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *7' while drilling*

▽ *6' (11/15/13)*

Cave in @ 6' (11/15/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/14/2013	Boring Completed: 11/14/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-346

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1411+00
Offset: 50 R

Surface Elev.: 876.7 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" Topsoil (Harvested Soybean Field)**	876												
3.5	**LEAN CLAY (CL)** trace sand dark brown	873												
5.0	**MEDIUM STIFF SILTY CLAY (CL-ML)** brown gray	871.5	5			11	2-3-4 N=7	4.5 (HP)						
8.0	**SAND (SP)**, fine to medium fine to medium with gravel brown	868.5		▽										
13.0	**SOFT TO STIFF SILTY CLAY (CL-ML)** brown gray	863.5	10	▽		16	0-0-3 N=3	1.5 (HP)						
20.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel gray	856.5	15			18	4-6-9 N=15	3.5 (HP)						
			20			11	4-7-9 N=16	3.5 (HP)						

Boring Terminated at 20 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *13' while drilling*

▽ *7' (12/16/13)*

Cave in @ 12' (12/16/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/12/2013	Boring Completed: 12/12/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-347

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1413+00
Offset: 57 L

Surface Elev.: 880.3 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**4 to 5" Root Zone / 6" Topsoil (Tall Grassy Ditch)**	880												
	MEDIUM STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel gray brown		5			16	2-2-2 N=4	0.75 (HP)						
				▽										
10.0		870.5	10			23		2.75 (HP)	UC	3.57	15	13	124	
	STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel gray		15			17	4-6-8 N=14	3.5 (HP)						
18.0		862.5												
	VERY STIFF TO HARD SANDY LEAN CLAY (CL) trace gravel with occasional sand seams gray		20			18	6-7-10 N=17	4.5 (HP)				13		
20.5		860												
	Boring Terminated at 20.5 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *9' while sampling*

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/15/2013	Boring Completed: 11/15/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-348

PROJECT: US Hwy 30

**CLIENT: HDR Engineering, Inc.
Omaha, NE**

**SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa**

LOCATION Station: 1415+00
Offset: 80 R

Surface Elev.: 879.5 (Ft.)

DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" Topsoil (Harvested Soybean Field)**	879												
3.5	**LEAN CLAY (CL)** trace sand dark brown	876												
4.5	**MEDIUM STIFF SILTY CLAY (CL-ML)**, brown	875				18	2-3-3 N=6	4.5 (HP)						
6.5	**LOOSE SAND (SP)**, fine, brown	873	5											
13.0	**STIFF SILTY CLAY (CL-ML)** brown gray	866.5	10			18	2-3-5 N=8	2.0 (HP)						
20.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel gray	859.5	15	▽		18	2-4-7 N=11	4.0 (HP)						
			20			18	3-5-8 N=13	3.5 (HP)						

Boring Terminated at 20 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *14' while sampling*

No water encountered (12/16/13)

Cave in @ 9' (12/16/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/12/2013	Boring Completed: 12/12/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-349

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1417+00
Offset: 53 L

Surface Elev.: 883.7 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1.0	**4 to 5" Root Zone / 12" Topsoil (Tall Grassy Ditch)**	882.5												
	MEDIUM STIFF TO STIFF SANDY LEAN CLAY (CL) with occasional sand seams gray brown		5		X	13	2-2-2 N=4	0.75 (HP)						
10.0		873.5	10		X	18	2-4-5 N=9	2.0 (HP)						
	STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel gray			▽ (12)										
			15		X	15	5-6-7 N=13	4.25 (HP)						
	Cobble encountered @ about 18 to 18½ feet.													
20.5		863	20		X	18	4-6-8 N=14	3.5 (HP)						

Boring Terminated at 20.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *12' while drilling*

Cave in @ 6' (11/18/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/15/2013	Boring Completed: 11/15/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-350

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1419+00
Offset: 50 R

Surface Elev.: 882.1 (Ft.)

DEPTH	DESCRIPTION	ELEVATION (Ft.)
0.5	**6" Topsoil (Harvested Soybean Field)**	881.5
3.5	**LEAN CLAY (CL)** trace sand dark brown	878.5
4.5	**MEDIUM STIFF SILTY CLAY (CL-ML)**, brown	877.5
8.5	**SAND (SP)**, fine to medium brownish orange	873.5
13.0	**SOFT TO MEDIUM STIFF SILTY CLAY (CL-ML)** brownish orange	869
25.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel gray	857
	Boring Terminated at 25 Feet	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
3.5–5		X	17	2-2-2 N=4	4.0 (HP)						
7	▽										
8.5–10	▽	X	18	0-0-2 N=2	2.0 (HP)						
13.5–15		X	18	4-6-9 N=15	3.0 (HP)						
18.5–20		X	18	4-6-9 N=15	4.0 (HP)						
23.5–25		X	18	5-7-8 N=15	4.0 (HP)						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

7' while drilling

8½' (12/16/13)

Cave in @ 8½' (12/16/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/12/2013	Boring Completed: 12/12/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-351

PROJECT: US Hwy 30

**CLIENT: HDR Engineering, Inc.
Omaha, NE**

**SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa**

LOCATION Station: 1421+00
Offset: 50 L

Surface Elev.: 883.8 (Ft.)

DEPTH	DESCRIPTION	ELEVATION (Ft.)
0.5	**4 to 5" Root Zone / 6" Topsoil (Tall Grassy Ditch)**	883.5
10.2	**SOFT TO STIFF SANDY LEAN CLAY (CL)** trace gravel, gray brown	873.5
20.5	**VERY STIFF TO HARD SANDY LEAN CLAY (CL)** trace gravel, gray	863.5
	Boring Terminated at 20.5 Feet	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
5	∇ (6')	X	14	2-1-2 N=3	0.75 (HP)				21		
10		X	18	3-6-7 N=13	4.0 (HP)						
15	∇ (14')	X	18	5-7-9 N=16	3.5 (HP)				12		
20		X	18	4-7-9 N=16	4.5 (HP)						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

∇ *14' while sampling*

∇ *6' (11/18/13)*

Cave in @ 12' (11/18/13)

2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/15/2013	Boring Completed: 11/15/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-352

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1425+00
Offset: 50 R

Surface Elev.: 881.0 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**(Grassy Right of Way)**	880.5												
3.5	**STIFF LEAN CLAY (CL)** trace sand and organics dark brown	877.5			Shelby	10		1.25 (HP)	UC	1.05	4	27	80	
4.5	**SOFT TO MEDIUM STIFF LEAN CLAY (CL)**, brown gray	876.5	5		SPT	18	1-1-1 N=2	1.0 (HP)						
8.5	**LEAN TO FAT CLAY (CL/CH)** trace sand gray	872.5		▽ ▽										
13.5	**VERY LOOSE SAND**, fine gray	867.5	10		SPT	18	0-0-0 N=0					16		
18.0	**MEDIUM STIFF TO STIFF SILTY CLAY (CL-ML)** gray	863	15		SPT	18	1-2-2 N=4	1.5 (HP)						
23.0	**SOFT LEAN CLAY (CL)** trace sand and gravel dark gray	858	20		Shelby	14		<0.25	UC	0.34	14.5	21	97	
30.0	**STIFF TO HARD SANDY LEAN CLAY (CL)** trace gravel gray	851	25		SPT	18	4-6-12 N=18	4.5 (HP)						
			30		SPT	8	3-3-5 N=8	1.5 (HP)				18		

Boring Terminated at 30 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS
- ▽ *8' while drilling*
- ▽ *6' (12/12/13)*
- *Cave in @ 7½' (12/12/13)*

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/11/2013	Boring Completed: 12/11/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-353

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1425+75
Offset: 120 L

Surface Elev.: 885.3 (Ft.)

DEPTH	Material Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	**2 to 3" Root Zone (Grassy Road Shoulder)**	885												
	FILL - SANDY LEAN CLAY with gravel dark brown to gray brown		5	▽ (4½')		4	1-3-3 N=6	1.0 (HP)						
10.0		875.5	10	▽ (11')		11			UC	0.84	11.2	14	106	
	VERY LOOSE POORLY GRADED SAND (SP) trace gravel gray													
15.5		870	15			6	0-0-1 N=1							
	MEDIUM DENSE FINE TO COARSE SAND (SP) trace gravel brown													
20.0		865.5	20			17	9-11-11 N=22					13		
	MEDIUM DENSE POORLY GRADED SAND (SP) trace gravel gray													
24.5		861	25			16	6-8-9 N=17							
	MEDIUM DENSE FINE TO COARSE SAND (SP) brown gray													
29.0		856.5												
	VERY STIFF SANDY LEAN CLAY (CL) trace gravel, gray		30			18	4-6-11 N=17	3.5 (HP)				13		
30.5	*Boring Terminated at 30.5 Feet*	855												

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *11' while drilling*

▽ *4½' (11/15/13)*

Cave in @ 4½' (11/15/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/14/2013

Boring Completed: 11/14/2013

Drill Rig: CME-550

Driller: DL

Project No.: 06135064

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 06135064.US HWY 30 - FINAL.GPJ TERRACON2012.GDT 2/26/14

BORING LOG NO. RB30-354

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1428+00
Offset: 100 R

Surface Elev.: 884.1 (Ft.)

DEPTH	Description	ELEVATION (Ft.)
0.5	**6" Topsoil (Plowed Soybean Field)**	883.5
3.5	**LEAN CLAY (CL)**, trace sand, brown	880.5
4.5	**MEDIUM STIFF SANDY LEAN CLAY (CL)**, brown gray	879.5
9.0	**VERY LOOSE SAND (SP)**, fine, brown	875
14.0	**VERY LOOSE SAND (SP)**, fine, brownish orange	870
18.5	**LOOSE SILTY SAND (SM)**, brown gray	865.5
30.0	**STIFF TO HARD SANDY LEAN CLAY (CL)**, trace gravel, gray	854

Boring Terminated at 30 Feet

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
3.5–5			16	3-3-3 N=6	4.5 (HP)						
8	▽										
9	▽										
8.5–10			17	2-0-1 N=1							
13.5–15			18	3-2-4 N=6							
18.5–20			18	3-4-7 N=11	2.5 (HP)						
23.5–25			18	4-5-8 N=13	3.75 (HP)						
28.5–30			11	10-10-7 N=17	4.5 (HP)						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *9' while sampling*
▽ *8' (12/12/13)*
Cave in @ 8' (12/12/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/11/2013	Boring Completed: 12/11/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-356

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1432+00
Offset: 50 R

Surface Elev.: 890.1 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" Topsoil (Plowed Soybean Field)**	889.5												
3.5	**LEAN CLAY (CL)** trace sand brown	886.5												
			4.5		X	18	2-2-2 N=4	3.5 (HP)						
8.0	**MEDIUM STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** brown gray	882	7.5	▽										
			9	▽	X	15	7-7-6 N=13	0.5 (HP)						
13.0	**STIFF SILT (ML)** brownish orange	877												
			14		X	18	4-5-7 N=12	2.5 (HP)						
19.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel gray; Sand seam @ about 18½ to 19 feet.	871	19		X	15	3-5-6 N=11	4.0 (HP)						
25.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel gray	865	24		X	18	3-7-8 N=15	4.0 (HP)						
	Boring Terminated at 25 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

- ▽ *9' while sampling*
- ▽ *7½' (12/12/13)*
- *Cave in @ 7½' (12/12/13)*

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/11/2013	Boring Completed: 12/11/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-357

PROJECT: US Hwy 30

**CLIENT: HDR Engineering, Inc.
Omaha, NE**

**SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa**

LOCATION Station: 1434+00
Offset: 40 L

Surface Elev.: 893.9 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1.0	**4 to 5" Root Zone / 12" Topsoil (Tall Grassy Ditch)**	893												
	MEDIUM STIFF TO STIFF SANDY LEAN CLAY (CL) trace gravel and organics gray brown		5			16	1-2-3 N=5	1.25 (HP)						
6.0		888		▽										
	VERY STIFF SANDY LEAN CLAY (CL) trace gravel gray brown		10			19			UC	3.97	9.4	13	115	
13.0		881												
	STIFF TO HARD SANDY LEAN CLAY (CL) trace gravel gray		15			16	4-6-9 N=15	4.0 (HP)						
				▽										
20.5		873.5	20			18	5-8-12 N=20	4.5 (HP)				13		

Boring Terminated at 20.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *19' while sampling*

▽ *6' (11/18/13)*

Cave in @ 11' (11/18/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/15/2013	Boring Completed: 11/15/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-358

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1436+00
Offset: 60 R

Surface Elev.: 895.4 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" Topsoil (Plowed Soybean Field)**	895												
3.5	**LEAN CLAY (CL)** trace sand, brown	892												
	MEDIUM STIFF TO VERY STIFF SANDY LEAN CLAY (CL) brown gray		5		X	18	3-3-4 N=7	3.75 (HP)						
			8	▽										
13.0		882.5	10		X	18	2-3-5 N=8	1.5 (HP)						
	STIFF TO HARD SANDY LEAN CLAY (CL) trace gravel, gray		15		X	18	3-4-7 N=11	4.5 (HP)						
20.0		875.5	20		X	18	4-5-7 N=12	4.5 (HP)						
	Boring Terminated at 20 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

▽ *8' (12/12/13)*

Cave in @ 12' (12/12/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/11/2013	Boring Completed: 12/11/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-359

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1438+00
Offset: 123 L

Surface Elev.: 903.3 (Ft.)

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	1.0	**4 to 5" Root Zone / 12" Topsoil (Tall Grassy Ditch)**	902.5												
		STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel gray brown													
				5		X	16	3-4-5 N=9	2.5 (HP)						
					∇										
				10		X	18	3-6-7 N=13	3.25 (HP)				14		
	15.5		888	15		X	18	7-10-11 N=21	3.0 (HP)						

Boring Terminated at 15.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS
∇ *8' while drilling*
∇ *8' (11/14/13)*
Cave in @ 11' (11/14/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/13/2013	Boring Completed: 11/13/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-360

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1440+00
Offset: 100 R

Surface Elev.: 900.2 (Ft.)

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	0.5	**6" Topsoil (Plowed Soybean Field)**	899.5												
	3.5	**LEAN CLAY (CL)** trace sand brown	896.5												
						X	18	0-0-2 N=2	0.5 (HP)						
				5											
					▽										
						X	18	0-3-4 N=7	1.0 (HP)				19		
				10											
	13.0	**SOFT TO MEDIUM STIFF SANDY LEAN CLAY (CL)** trace organics brown	887												
						X	18	3-5-7 N=12	3.0 (HP)						
				15											
					▽										
						X	18	6-10-9 N=19	4.5 (HP)				15		
	20.0	**STIFF TO HARD SANDY LEAN CLAY (CL)** trace gravel gray	880	20											

Boring Terminated at 20 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *18' while drilling*

▽ *7' (12/11/13)*

Cave in @ 14' (12/11/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/10/2013	Boring Completed: 12/10/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-361

PROJECT: US Hwy 30

**CLIENT: HDR Engineering, Inc.
Omaha, NE**

**SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa**

LOCATION Station: 1442+00
Offset: 40 L

Surface Elev.: 906.6 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
2.0	**4 to 5" Root Zone / 24" Topsoil (Tall Grassy Ditch)**	904.5												
5.0	**MEDIUM STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel and organics gray brown	901.5	5		X	11	2-3-2 N=5	2.5 (HP)				16		
13.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel gray brown	893.5	10	▽ (7'), ▽ (13')	X	17	3-5-6 N=11	4.0 (HP)						
19.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel gray	887.5	15		X	16	3-6-8 N=14	3.25 (HP)				12		
20.5	**VERY STIFF TO HARD SANDY LEAN CLAY (CL)** trace gravel, brown gray	886	20		X	18	5-8-12 N=20	4.5 (HP)						

Boring Terminated at 20.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

13' while drilling

7' (11/18/13)

Cave in @ 11½' (11/18/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/15/2013	Boring Completed: 11/15/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-362

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1444+00
Offset: 50 R

Surface Elev.: 906.2 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" Topsoil (Plowed Soybean Field)**	905.5												
3.5	**VERY STIFF LEAN TO FAT CLAY (CL/CH)** trace sand brown	902.5				13			UC	3.31	11.3	30	91	45-24-21
8.0	**MEDIUM STIFF TO HARD SANDY LEAN CLAY (CL)** trace gravel brown gray	898	5			18	4-4-3 N=7	4.5 (HP)						
14.0	**STIFF TO VERY STIFF SILTY CLAY (CL-ML)** trace sand brown	892	10	▽		18	3-5-5 N=10	2.5 (HP)				17		
20.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel gray	886	15			18	5-5-6 N=11	3.5 (HP)						
			20			18	4-7-6 N=13	4.0 (HP)				12		
	Boring Terminated at 20 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

▽ *8½' (12/11/13)*

Cave in @ 10' (12/11/13)

2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/10/2013	Boring Completed: 12/10/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-363

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1446+00
Offset: 116 L

Surface Elev.: 912.0 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.2	**4 to 5" Root Zone / 2" Topsoil (Grassy Ditch)**	912												
1.0	**SANDY LEAN CLAY (CL)** trace gravel, gray	911												
	MEDIUM STIFF TO STIFF SANDY LEAN CLAY (CL) trace gravel gray brown		5		X	14	2-3-3 N=6	1.0 (HP)						
			10		X	18	3-6-8 N=14	4.0 (HP)				15		
				▽ (12')										
14.2		898												
15.0	**STIFF SANDY LEAN CLAY (CL)** trace gravel, gray	897	15		X	18	4-5-8 N=13	2.5 (HP)						
	VERY STIFF SANDY LEAN CLAY (CL) trace gravel brown													
19.5		892.5												
20.5	**VERY STIFF SANDY LEAN CLAY (CL)** trace gravel, gray	891.5	20		X	18	3-5-7 N=12	2.75 (HP)				13		
	Boring Terminated at 20.5 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

▽ *12' (11/14/13)*

Cave in @ 16' (11/14/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/13/2013	Boring Completed: 11/13/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-364

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1448+00
Offset: 90 R

Surface Elev.: 916.6 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" Topsoil (Plowed Soybean Field)**	916												
3.5	**LEAN CLAY (CL)** trace sand brown	913												
	STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel brown		5		X	11	3-4-4 N=8	4.5 (HP)						
			10		X	18	3-5-5 N=10	4.25 (HP)						
18.5		898	15		X	18	4-6-6 N=12	2.5 (HP)						
	VERY STIFF TO HARD SANDY LEAN CLAY (CL) trace gravel brown gray		20		X	18	3-4-7 N=11	4.5 (HP)						
25.0		891.5	25		X	18	5-8-10 N=18	4.0 (HP)						
	Boring Terminated at 25 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.
No water encountered (12/11/13)
Cave in @ 24' (12/11/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/10/2013	Boring Completed: 12/10/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-365

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1450+00
Offset: 40 L

Surface Elev.: 906.3 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1.5	**4 to 5" Root Zone / 18" Topsoil (Tall Grassy Ditch)**	905												
	SOFT TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel, gray brown		5	▽		16	1-1-2 N=3	0.5 (HP)						
			10			23			UC	2.23	3.7	15	116	
14.0		892.5												
15.5	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel, gray	891	15			17	3-6-7 N=13	3.0 (HP)						

Boring Terminated at 15.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.
▽ *4' (11/18/13)*
Cave in @ 8' (11/18/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/15/2013	Boring Completed: 11/15/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-366

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1452+00
Offset: 50 R

Surface Elev.: 904.1 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**(Grassy Right of Way)**	903.5												
3.5	**LEAN CLAY (CL)** trace sand brown	900.5												
	SOFT TO STIFF SANDY LEAN CLAY (CL) trace organics brown		3.5–5		Split spoon	13	2-1-1 N=2	1.5 (HP)						
			7	▽										
			8–10		Shelby tube									
13.0		891												
	STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel gray		13.5–15		Split spoon	18	3-5-8 N=13	4.0 (HP)						
			18.5–20	▽ (19)	Split spoon	18	4-6-9 N=15	3.75 (HP)						
20.0	*Boring Terminated at 20 Feet*	884	20											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *19' while sampling*

▽ *7' (12/11/13)*

Cave in @ 13' (12/11/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/10/2013	Boring Completed: 12/10/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-367

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1454+00
Offset: 25 L
Surface Elev.: 903.4 (Ft.)

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		4 to 5" Root Zone / 24" Topsoil (Grassy Ditch)													
	2.0		901.5												
		MEDIUM STIFF TO STIFF SANDY LEAN CLAY (CL) trace gravel with occasional sand seams gray brown													
				5		X	5	2-2-2 N=4	1.0 (HP)						
					▽										
				10		X	18	2-4-4 N=8	1.5 (HP)						
	13.0		890.5												
		STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel gray			▽										
				15		X	18	3-6-8 N=14	2.75 (HP)						
				20		X	18	4-7-10 N=17	3.75 (HP)						
				25		X	18	4-8-10 N=18	1.5 (HP)						
	25.5		878												
		Boring Terminated at 25.5 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *14' while sampling*

▽ *6' (11/18/13)*

Cave in @ 19' (11/18/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/15/2013

Boring Completed: 11/15/2013

Drill Rig: CME-550

Driller: DL

Project No.: 06135064

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 06135064.US HWY 30 - FINAL.GPJ TERRACON2012.GDT 2/26/14

BORING LOG NO. RB30-368

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1456+00
Offset: 80 R

Surface Elev.: 903.5 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**(Grassy Right of Way)**	903												
3.5	**LEAN CLAY (CL)** trace sand brown	900												
7.0	**MEDIUM STIFF TO STIFF SANDY LEAN CLAY (CL)** brown	896.5	5		X	8	3-2-3 N=5	1.5 (HP)						
13.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel brown gray	890.5	10		X	16	4-5-7 N=12	4.0 (HP)						
20.0	**STIFF TO HARD SANDY LEAN CLAY (CL)** trace gravel gray	883.5	15		X	18	4-6-8 N=14	4.0 (HP)						
			20	∇	X	18	4-6-8 N=14	4.5 (HP)						

Boring Terminated at 20 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

∇ *18½' (12/11/13)*

Cave in @ 20' (12/11/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/10/2013 | Boring Completed: 12/10/2013

Drill Rig: Diedrich D-50 | Driller: MR

Project No.: 06135064

BORING LOG NO. RB30-369

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1458+00
Offset: 15 L

Surface Elev.: 907.1 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	**4 to 5" Root Zone (Grassy Ditch)**	907												
2.0	**FILL - SANDY LEAN CLAY** trace gravel, brown	905												
4.0	**SANDY LEAN CLAY (CL)** dark brown	903												
	MEDIUM STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel gray brown		5		X	15	2-4-3 N=7	1.5 (HP)				18		
			10	▽ (approx. 11 ft)	X	18	3-3-4 N=7	2.5 (HP)						
14.5		892.5												
	VERY STIFF TO HARD SANDY LEAN CLAY (CL) trace gravel gray		15		X	18	4-6-8 N=14	2.75 (HP)				14		
20.5		886.5	20		X	17	5-8-10 N=18	4.5 (HP)						

Boring Terminated at 20.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

▽ *11' (11/18/13)*

Cave in @ 11' (11/18/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/15/2013	Boring Completed: 11/15/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-370

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1460+00
Offset: 70 R

Surface Elev.: 901.7 (Ft.)

DEPTH	Material Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**(Grassy Right of Way)**	901												
3.5	**LEAN CLAY (CL)** trace sand brown	898												
4.0	**SOFT TO STIFF SANDY LEAN CLAY (CL)**, brown gray	897.5				18	1-1-1 N=2	1.5 (HP)						
			5	▽										
8.5	**CLAYEY SAND (SC)** brown	893												
14.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel gray brown	887.5	10	▽		18	3-3-5 N=8	1.75 (HP)						
						18	3-5-7 N=12	4.0 (HP)						
20.0	**VERY STIFF SANDY LEAN CLAY (CL)** trace gravel gray	881.5	15			18	4-6-12 N=18	3.75 (HP)						
20.5	**SAND (SP)** fine, gray	881	20											
25.0	**STIFF SANDY LEAN CLAY (CL)** trace gravel gray	876.5				15	3-4-5 N=9	0.5 (HP)						
	Boring Terminated at 25 Feet		25											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

- ▽ *13' while drilling*
- ▽ *5' (12/11/13)*
- *Cave in @ 6' (12/11/13)*

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/10/2013	Boring Completed: 12/10/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-371

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1462+00
Offset: 45 L

Surface Elev.: 908.0 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.2	**2 to 3" Root Zone (Grassy Median)**	908												
	STIFF TO VERY STIFF LEAN CLAY (Topsoil) trace sand, dark brown													
			5			16	4-4-5 N=9	2.5 (HP)						
5.5		902.5												
	MEDIUM STIFF TO STIFF SANDY LEAN CLAY (CL) trace gravel with occasional sand seams, brown													
			10			14		1.0 (HP)	UC	0.67	15	21	107	
			15			0	3-5-10 N=15							
17.0		891												
	STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel, gray													
20.5		887.5	20			16	4-6-9 N=15	2.5 (HP)						
	Boring Terminated at 20.5 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

7' while drilling

6½' (11/14/13)

Cave in @ 9' (11/14/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/13/2013	Boring Completed: 11/13/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-372

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1464+00
Offset: 70 R
Surface Elev.: 903.6 (Ft.)

DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**(Grassy Right of Way)**	903												
3.5	**LEAN CLAY (CL)** trace sand brown	900												
	SOFT TO MEDIUM STIFF SANDY LEAN CLAY (CL) brown gray				X	16	0-0-2 N=2	0.75 (HP)						
8.5		895	5											
	MEDIUM STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel gray		10		X	18	3-3-4 N=7	3.0 (HP)						
15.0		888.5	15		X	18	4-5-6 N=11	3.5 (HP)						
	Boring Terminated at 15 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS
No water while drilling and sampling.
No water encountered (12/11/13)
Cave in @ 3' (12/11/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/10/2013	Boring Completed: 12/10/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-373

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1466+00
Offset: 120 L

Surface Elev.: 906.4 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.2	**2 to 3" Root Zone (Grassy Road Shoulder)**	906												
4.0	**FILL - LEAN CLAY** with gravel, trace sand, dark brown	902.5												
7.0	**MEDIUM STIFF LEAN CLAY (CL)** gray	899.5	5	▽ (5')	X	3	2-2-2 N=4	1.0 (HP)						
				▽ (7')										
10.2	**MEDIUM STIFF TO STIFF SANDY LEAN CLAY (CL)** trace gravel, brown gray	896	10		X	15	2-2-4 N=6	1.5 (HP)				16		
11.0	**SAND (SP)** fine to coarse, trace gravel, brown	895.5												
	STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel with occasional sand seams, gray brown		15		X	11	3-3-5 N=8	2.5 (HP)						
20.0		886.5												
20.5	**VERY STIFF SANDY LEAN CLAY (CL)** trace gravel, gray	886	20		X	13	3-5-7 N=12	2.5 (HP)				20		

Boring Terminated at 20.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

▽ *7' while drilling*

▽ *5' (11/14/13)*

Cave in @ 8' (11/14/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/13/2013	Boring Completed: 11/13/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 06135064.US HWY 30 - FINAL.GPJ TERRACON2012.GDT 2/26/14

BORING LOG NO. RB30-374

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1468+00
Offset: 90 R

Surface Elev.: 906.9 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" Topsoil (Plowed Cornfield)**	906.5												
3.5	**LEAN CLAY (CL)** trace sand, brown	903.5												
8.0	**MEDIUM STIFF TO HARD SANDY LEAN CLAY (CL)** trace organics, brown	899	5		Split spoon	18	3-2-2 N=4	4.5+ (HP)				19		
15.0	**MEDIUM STIFF TO STIFF SANDY LEAN CLAY (CL)** trace gravel, brown gray	892	10		Split spoon	18	3-3-4 N=7	2.0 (HP)						
			15	▽	Shelby tube	24			UC	1.87	7.3	16	116	

Boring Terminated at 15 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS
No water while drilling and sampling.
▽ *13' (12/11/13)*
Cave in @ 14' (12/11/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/10/2013	Boring Completed: 12/10/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB30-375

PROJECT: US Hwy 30

**CLIENT: HDR Engineering, Inc.
Omaha, NE**

**SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa**

LOCATION Station: 1470+00
Offset: 30 L

Surface Elev.: 909.4 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.2	**2 to 3" Root Zone (Grassy Median)**	909												
2.0	**SILTY CLAY (Topsoil)** dark brown	907.5												
4.0	**SILTY CLAY (CL-ML)** gray	905.5		▽										
9.0	**MEDIUM STIFF SANDY LEAN CLAY (CL)** trace gravel with occasional sand seams gray brown	900.5	5	▽	X	18	1-2-2 N=4	1.0 (HP)						
14.0	**MEDIUM STIFF TO STIFF SANDY LEAN CLAY (CL)** trace gravel with occasional sand seams brown	895.5	10		X	16	2-4-5 N=9	0.75 (HP)						
15.5	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)**, trace gravel, gray	894	15		X	15	4-6-7 N=13	2.25 (HP)						

Boring Terminated at 15.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

▽ *9' while sampling*

▽ *3½' (11/14/13)*

Cave in @ 9' (11/14/13)

2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/13/2013	Boring Completed: 11/13/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-376

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1472+00
Offset: 70 R

Surface Elev.: 916.3 (Ft.)

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**6" Topsoil (Plowed Cornfield)**	916												
	LEAN CLAY (CL) trace sand brown													
3.5		913												
	STIFF TO HARD SANDY LEAN CLAY (CL) trace gravel brown gray					15	3-3-5 N=8	4.5+ (HP)						
			5											
						17	4-4-6 N=10	3.5 (HP)						
			10											
						18	3-5-7 N=12	4.5 (HP)						
15.0		901.5	15											
	Boring Terminated at 15 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

No water encountered (12/11/13)

Cave in @ 14' (12/11/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/10/2013

Boring Completed: 12/10/2013

Drill Rig: Diedrich D-50

Driller: MR

Project No.: 06135064

BORING LOG NO. RB30-377

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1473+84
Offset: 102 L

Surface Elev.: 918.1 (Ft.)

DEPTH	Material Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.2	**2 to 3" Root Zone (Grassy Road Shoulder)**	918												
4.0	**FILL - SANDY LEAN CLAY** trace gravel brown to dark brown	914		∇ (3')										
6.0	**SOFT LEAN CLAY (CL)** trace sand gray brown	912	5		X	12	2-1-2 N=3	0.25 (HP)				32		
12.0	**MEDIUM STIFF SANDY LEAN CLAY (CL)** trace gravel gray brown	906	10		X	18	2-2-3 N=5	0.5 (HP)						
14.3	**STIFF SANDY LEAN CLAY (CL)** trace gravel brown	904												
14.6	**STIFF SANDY LEAN CLAY (CL)** trace gravel, light gray	903.5												
15.5	**STIFF SANDY LEAN CLAY (CL)** trace gravel, gray	902.5	15		X	18	4-6-7 N=13	1.25 (HP)				15		

Boring Terminated at 15.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

∇ *3' (11/14/13)*

Cave in @ 8½' (11/14/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/13/2013	Boring Completed: 11/13/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-378

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1476+00
Offset: 70 R

Surface Elev.: 922.5 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	**3" Limestone Gravel (Gravel Shoulder)**	922.5												
	FILL - SANDY LEAN CLAY trace gravel brown, dark brown and brown gray													
			5			10	2-2-3 N=5	1.75 (HP)				29		
6.0		916.5												
	STIFF SANDY LEAN CLAY (CL) trace gravel brown													
			10			14		1.75 (HP)	UC	1.36	15	17	112	
15.0		907.5				18	3-5-7 N=12	2.0 (HP)						
15.5	**STIFF SANDY LEAN CLAY (CL)** trace gravel, gray brown	907	15											
	Boring Terminated at 15.5 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with bentonite after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

- *9' while sampling*
- *7' (11/13/13)*
- *Cave in @ 12½' (11/13/13)*

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/12/2013	Boring Completed: 11/12/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-379

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1478+00
Offset: 20 L

Surface Elev.: 920.3 (Ft.)

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	0.5	**2 to 3" Root Zone / 6" Topsoil (Grassy Median)**	920												
	1.5	**SILTY CLAY (CL-ML)** trace sand, brown to dark brown	919												
		MEDIUM STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel gray brown			▽										
				5			18	2-3-4 N=7	1.5 (HP)						
				10			20		3.5 (HP)	UC	3.87	6.8	15	118	
					▽										
	15.5		905	15			18	5-6-8 N=14	1.5 (HP)						

Boring Terminated at 15.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

▽ *14' while sampling*
▽ *3½' (11/14/13)*
Cave in @ 10' (11/14/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/13/2013	Boring Completed: 11/13/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-380

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1480+00
Offset: 70 R

Surface Elev.: 925.9 (Ft.)

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	**2 to 3" Root Zone (Grassy Shoulder)**	925.5												
2.0	**SANDY LEAN CLAY (CL)** dark brown	924												
5.5	**MEDIUM STIFF TO STIFF SILTY CLAY (CL-ML)** gray brown. Oxidation spots from about 4 to 4½ feet.	920.5	5		X	16	2-3-2 N=5	1.5 (HP)						
13.0	**STIFF SANDY LEAN CLAY (CL)** trace gravel brown	913	10		X	18	3-4-5 N=9	1.5 (HP)						
20.5	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel gray brown	905.5	15		X	18	3-6-7 N=13	3.0 (HP)						
			20		X	18	5-9-11 N=20	3.5 (HP)						

Boring Terminated at 20.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/12/2013	Boring Completed: 11/12/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 06135064.US HWY 30 - FINAL.GPJ TERRACON2012.GDT 2/26/14

BORING LOG NO. RB30-381

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1482+00
Offset: 30 L

Surface Elev.: 924.6 (Ft.)

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1.0	**2 to 3" Root Zone / 12" Topsoil (Grassy Median)**	923.5												
4.0	**SANDY LEAN CLAY (CL)** trace gravel brown	920.5												
	STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel gray brown		5		X	13	3-3-5 N=8	2.5 (HP)						
14.0		910.5	10		X	18	4-6-7 N=13	2.25 (HP)						
15.5	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel, brown gray	909	15		X	17	4-7-8 N=15	3.5 (HP)						
	Boring Terminated at 15.5 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/13/2013	Boring Completed: 11/13/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-382

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1484+00
Offset: 70 R

Surface Elev.: 927.7 (Ft.)

DEPTH	DESCRIPTION	ELEVATION (Ft.)
0.3	**2 to 3" Root Zone (Grassy Shoulder)**	927.5
3.5	**FILL - SANDY LEAN CLAY**, trace gravel, brown to dark brown	924
4.0	**SILTY CLAY (CL-ML)**	923.5
5.3	trace sand, gray	922.5
6.0	**STIFF TO VERY STIFF SILTY CLAY (CL-ML)**, trace organics, dark brown	921.5
	SANDY LEAN CLAY (CL), trace gravel, gray brown	
12.0	**STIFF TO VERY STIFF LEAN TO FAT CLAY (CL/CH)**, trace gravel and organics, dark gray / black	915.5
14.5	**MEDIUM STIFF SILT (ML)**, gray	913
15.5	**SILTY CLAY (CL-ML)**, trace gravel, brown	912
	Boring Terminated at 15.5 Feet	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
5		X	13	2-4-5 N=9	2.5 (HP)				24		
10		X	14	4-6-6 N=12	4.0 (HP)						
15		X	18	2-2-3 N=5	1.0 (HP)				31		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/12/2013	Boring Completed: 11/12/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-383

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1486+00
Offset: 35 L

Surface Elev.: 928.6 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1.0	**2 to 3" Root Zone / 12" Topsoil (Grassy Median)**	927.5												
4.0	**LEAN CLAY (CL)** trace sand brown to dark brown	924.5												
9.0	**STIFF SILTY CLAY (CL-ML)** trace sand dark brown	919.5	5		X	9	2-3-5 N=8	1.75 (HP)						
14.5	**MEDIUM STIFF TO STIFF SANDY LEAN CLAY (CL)** trace gravel brown	914	10	▽	X	18	2-2-3 N=5	1.0 (HP)						
15.5	**STIFF SANDY LEAN CLAY (CL)** trace gravel, gray brown	913	15		X	18	3-4-5 N=9	1.75 (HP)						

Boring Terminated at 15.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

▽ *10½' (11/14/13)*

Cave in @ 12' (11/14/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/13/2013	Boring Completed: 11/13/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-384

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1488+00
Offset: 70 R

Surface Elev.: 929.7 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	**2 to 3" Root Zone (Grassy Shoulder)**	929.5												
1.0	**FILL - SANDY LEAN CLAY** dark brown	928.5												
3.0	**FILL - LEAN CLAY** trace sand, dark brown	926.5												
7.0	**MEDIUM STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel with occasional sand seams brown	922.5	5		X	8	3-3-3 N=6	3.5 (HP)						
10.2	**MEDIUM DENSE CLAYEY SAND (SC)** brown	919.5	10	▽	X	16	3-6-8 N=14							
14.0	**SAND (SP)** fine to coarse, brown	915.5		▽										
15.5	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel, gray brown	914	15		X	15	3-3-5 N=8	2.25 (HP)						

Boring Terminated at 15.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with bentonite after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *13' while drilling*

▽ *10' (11/13/13)*

Cave in @ 10' (11/13/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/12/2013	Boring Completed: 11/12/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-385

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1490+00
Offset: 20 L

Surface Elev.: 927.9 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	2 to 3" Root Zone (Grassy Median) **30" Topsoil / Fill (Lean Clay, dark brown)**													
2.5		925.5												
	MEDIUM STIFF SILTY CLAY (CL-ML) trace sand gray brown		5	▽	X	8	2-2-2 N=4	1.0 (HP)						
7.0		921												
	MEDIUM STIFF TO STIFF SANDY LEAN CLAY (CL) trace gravel brown		10		X	18	2-3-4 N=7	1.25 (HP)						
14.0		914												
	STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel gray brown		15		X	18	4-6-8 N=14	1.5 (HP)						
20.5		907.5	20		X	18	4-7-10 N=17	4.0 (HP)						
	Boring Terminated at 20.5 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

▽ *6' (11/14/13)*

Cave in @ 11½' (11/14/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/13/2013	Boring Completed: 11/13/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-386

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1492+00
Offset: 80 R

Surface Elev.: 929.1 (Ft.)

DEPTH	DESCRIPTION	ELEVATION (Ft.)
1.0	**2 to 3" Root Zone / 12" Topsoil (Grassy Ditch)**	928
3.0	**SILTY CLAY (CL-ML)** dark brown	926
4.5	**STIFF TO VERY STIFF LEAN CLAY (CL)**, trace sand brown and dark brown	924.5
9.0	**SANDY LEAN CLAY (CL)** brown gray Oxidation spots from about 5 to 5½ feet.	920
12.0	**STIFF SANDY LEAN CLAY (CL)** trace gravel brown	917
14.5	**MEDIUM DENSE POORLY GRADED SAND (SP)** brown	914.5
17.0	**MEDIUM STIFF SILT (ML)** brown	912
23.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel with occasional sand seams brown	906
30.5	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel with occasional sand seams gray brown	898.5
	Boring Terminated at 30.5 Feet	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
5		X	10	4-6-6 N=12	3.0 (HP)				26		
10	▽ (9½')	X	10	3-4-5 N=9	1.5 (HP)						
15	▽ (14')	X	13	3-5-5 N=10	1.0 (HP)				26		
20		X	14	4-5-7 N=12	3.25 (HP)						
25		X	18	5-8-10 N=18	4.25 (HP)				15		
30		X	13	2-6-9 N=15	1.25 (HP)						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with bentonite after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *14' while sampling*

▽ *9½' (11/13/13)*

Cave in @ 13½' (11/13/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/12/2013	Boring Completed: 11/12/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-387

PROJECT: US Hwy 30

**CLIENT: HDR Engineering, Inc.
Omaha, NE**

**SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa**

LOCATION Station: 1494+00
Offset: 127 L

Surface Elev.: 930.1 (Ft.)

DEPTH	Description	ELEVATION (Ft.)
1.5	**5 to 6" Root Zone / 18" Topsoil (Tall Grass / Weedy Ditch)**	928.5
5.5	**MEDIUM STIFF LEAN CLAY (CL)** trace sand with occasional sand seams brown gray	924.5
12.0	**STIFF SANDY LEAN CLAY** brown	918
15.3	**STIFF SANDY LEAN CLAY (CL)** trace gravel brown	915
25.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel gray brown	905
30.5	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel gray	899.5
	Boring Terminated at 30.5 Feet	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
5			16	1-2-2 N=4	0.5 (HP)						
10			19		1.0 (HP)	UC	1.69	15	16	117	
15			16	4-6-6 N=12	1.5 (HP)						
20			17	4-6-7 N=13	2.25 (HP)				17		
25			15	4-6-9 N=15	2.0 (HP)						
30			17	8-13-16 N=29	3.0 (HP)				14		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

5½' while sampling

3' (11/14/13)

Cave in @ 6½' (11/14/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/13/2013	Boring Completed: 11/13/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-388

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1496+00
Offset: 80 R

Surface Elev.: 928.8 (Ft.)

DEPTH	DESCRIPTION	ELEVATION (Ft.)
1.5	**4 to 5" Root Zone / 18" Topsoil (Grassy Ditch)**	927.5
4.0	**LEAN CLAY (CL)** trace sand, dark brown	925
9.0	**MEDIUM STIFF SANDY LEAN CLAY (CL)** trace gravel, brown	920
19.3	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel, gray brown	909.5
22.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel, gray	907
25.2	**STIFF SANDY LEAN CLAY (CL)** trace gravel with occasional sand seams, brown	903.5
26.0	**SILT (ML)** brown	903
30.5	**VERY STIFF SANDY LEAN CLAY (CL)** trace gravel, gray	898.5

Boring Terminated at 30.5 Feet

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
5			15	3-3-3 N=6	1.0 (HP)						
8	▽										
10			18		3.75 (HP)	UC	3.55	9.1	14	118	
15			18	3-4-6 N=10	3.5 (HP)						
20			18	5-6-7 N=13	3.0 (HP)				13		
25	▽		18	3-4-5 N=9	2.0 (HP)						
30			18	5-8-9 N=17	2.5 (HP)						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with bentonite after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *25' while sampling*

▽ *8' (11/13/13)*

Cave in @ 19½' (11/13/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/12/2013	Boring Completed: 11/12/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-389

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1498+00
Offset: 40 L

Surface Elev.: 930.0 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.3	**2 to 3" Root Zone (Grassy Median)**	930												
1.0	**SANDY LEAN CLAY (CL)** brown and dark brown	929												
4.5	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel, brown	925.5												
	STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel gray brown		5		X	18	3-4-6 N=10	2.5 (HP)				16		
			10		X	18	4-4-6 N=10	2.25 (HP)						
			15		X	18	4-6-8 N=14	3.75 (HP)				14		
20.5		909.5	20		X	17	4-8-8 N=16	3.0 (HP)						

Boring Terminated at 20.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/12/2013	Boring Completed: 11/12/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-390

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1500+00
Offset: 70 R

Surface Elev.: 925.8 (Ft.)

DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.4	**4 to 5" Root Zone (Grassy Ditch)**	925.5												
	SANDY LEAN CLAY (CL) trace gravel brown													
4.0		922												
	STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel gray brown		5		X	15	2-4-5 N=9	3.5 (HP)						
				▽										
	Oxidation spots from about 9 to 10½ feet.		10		X	14	2-4-5 N=9	1.5 (HP)						
			15		X	17	3-4-6 N=10	3.75 (HP)						
			20		X	18	3-6-9 N=15	2.75 (HP)						
24.3		901.5												
25.5	**VERY STIFF SANDY LEAN CLAY (CL)** trace gravel, gray	900.5	25	▽	X	17	6-8-8 N=16	3.25 (HP)						
	Boring Terminated at 25.5 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with bentonite after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *25' while sampling*

▽ *8½' (11/13/13)*

Cave in @ 17' (11/13/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/12/2013	Boring Completed: 11/12/2013
Drill Rig: CME-550	Driller: DL
Project No.: 06135064	

BORING LOG NO. RB30-391

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 1502+00
Offset: 35 L

Surface Elev.: 925.2 (Ft.)

DEPTH	DESCRIPTION	ELEVATION (Ft.)
0.3	**2 to 3" Root Zone (Grassy Median)**	925
9.5	**MEDIUM STIFF TO STIFF SANDY LEAN CLAY (CL)** trace gravel brown	915.5
13.0	**MEDIUM DENSE SAND (SP)** fine to medium brown	912
19.0	**MEDIUM DENSE SAND (SP)** fine to coarse, trace gravel brown	906
20.5	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel, brown	904.5
	Boring Terminated at 20.5 Feet	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
5	▽	X	15	2-3-3 N=6	1.75 (HP)				15		
10	▽	X	17	3-5-5 N=10	2.25 (HP)						
15		X	16	3-6-7 N=13					19		
20		X	15	5-6-9 N=15	2.5 (HP)						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with bentonite after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *9½' while sampling*

▽ *5' (11/13/13)*

Cave in @ 9' (11/13/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 11/12/2013

Boring Completed: 11/12/2013

Drill Rig: CME-550

Driller: DL

Project No.: 06135064

BORING LOG NO. RB23A-1

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 231420+50
Offset: 10 L

Surface Elev.: 882.0 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.2	**(Road Shoulder)**	882												
3.5	**LEAN CLAY (CL)** trace sand brown	878.5												
8.5	**MEDIUM STIFF TO STIFF SILTY CLAY (CL-ML)** dark gray	873.5	5		X	16	1-2-3 N=5	1.5 (HP)				35		
13.0	**MEDIUM STIFF TO STIFF SILTY CLAY (CL-ML)** brown gray	869	10	▽	X	18	2-2-3 N=5	1.5 (HP)						
20.0	**MEDIUM STIFF TO STIFF SANDY LEAN CLAY (CL)** trace gravel gray	862	15	▽	X	18	2-3-3 N=6	1.5 (HP)				16		
			20		X	18	2-3-4 N=7	2.0 (HP)						

Boring Terminated at 20 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

▽ *14' while sampling*

▽ *10' (12/12/13)*

Cave in @ 15½' (12/12/13)

2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/11/2013	Boring Completed: 12/11/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB23A-2

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 231425+00
Offset: 15 R

Surface Elev.: 889.6 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.2	**2" Gravel (Gravel Road Shoulder)**	889.5												
3.5	**LEAN CLAY (CL)** trace sand, brown	886												
8.0	**STIFF TO VERY STIFF SILTY CLAY (CL-ML)** brown	881.5	5		X	15	4-4-4 N=8	3.0 (HP)						
13.0	**MEDIUM STIFF TO STIFF SILTY CLAY (CL-ML)** brownish orange	876.5	10	▽ (13')	X	18	2-2-2 N=4	2.0 (HP)						
15.0	**STIFF TO HARD SANDY LEAN CLAY (CL)** trace gravel, gray	874.5	15		X	18	4-6-8 N=14	4.5 (HP)						

Boring Terminated at 15 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

▽ *13' (12/12/13)*

Cave in @ 13½' (12/12/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/11/2013	Boring Completed: 12/11/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB24A-1

PROJECT: US Hwy 30

CLIENT: HDR Engineering, Inc.
Omaha, NE

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

LOCATION Station: 241473+50
Offset: 15 L

Surface Elev.: 922.6 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**(Gravel Road Shoulder)**	922												
3.5	**LEAN CLAY (CL)** trace sand brown	919												
					X	17	2-2-2 N=4	1.5 (HP)						
8.0	**MEDIUM STIFF TO STIFF SANDY LEAN CLAY (CL)** trace gravel brown	914.5	5											
			10		X	18	4-5-7 N=12	2.5 (HP)						
15.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel brown gray	907.5	15	▽	X	11	5-6-8 N=14	3.5 (HP)						

Boring Terminated at 15 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

▽ *14' (12/11/13)*

Cave in @ 14' (12/11/13)

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/10/2013	Boring Completed: 12/10/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

BORING LOG NO. RB218-1

PROJECT: US Hwy 30

**CLIENT: HDR Engineering, Inc.
Omaha, NE**

**SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa**

LOCATION Station: 2503+00 Offset: 15 R

Surface Elev.: 923.9 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
0.5	**2" Gravel @ Surface (Gravel Shoulder)**	923.5												
3.5	**LEAN CLAY (CL)** trace sand brown	920.5												
	MEDIUM STIFF TO VERY STIFF SANDY LEAN CLAY (CL) trace gravel brown gray					17	2-2-1 N=3	1.0 (HP)				18		
			5											
						18	4-4-6 N=10	3.0 (HP)						
13.0		911	10											
15.0	**STIFF TO VERY STIFF SANDY LEAN CLAY (CL)** trace gravel, gray	909				18	2-4-7 N=11	2.5 (HP)				14		
	Boring Terminated at 15 Feet		15											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

No water while drilling and sampling.

No water encountered (12/11/13)

Cave in @ 13' (12/11/13)

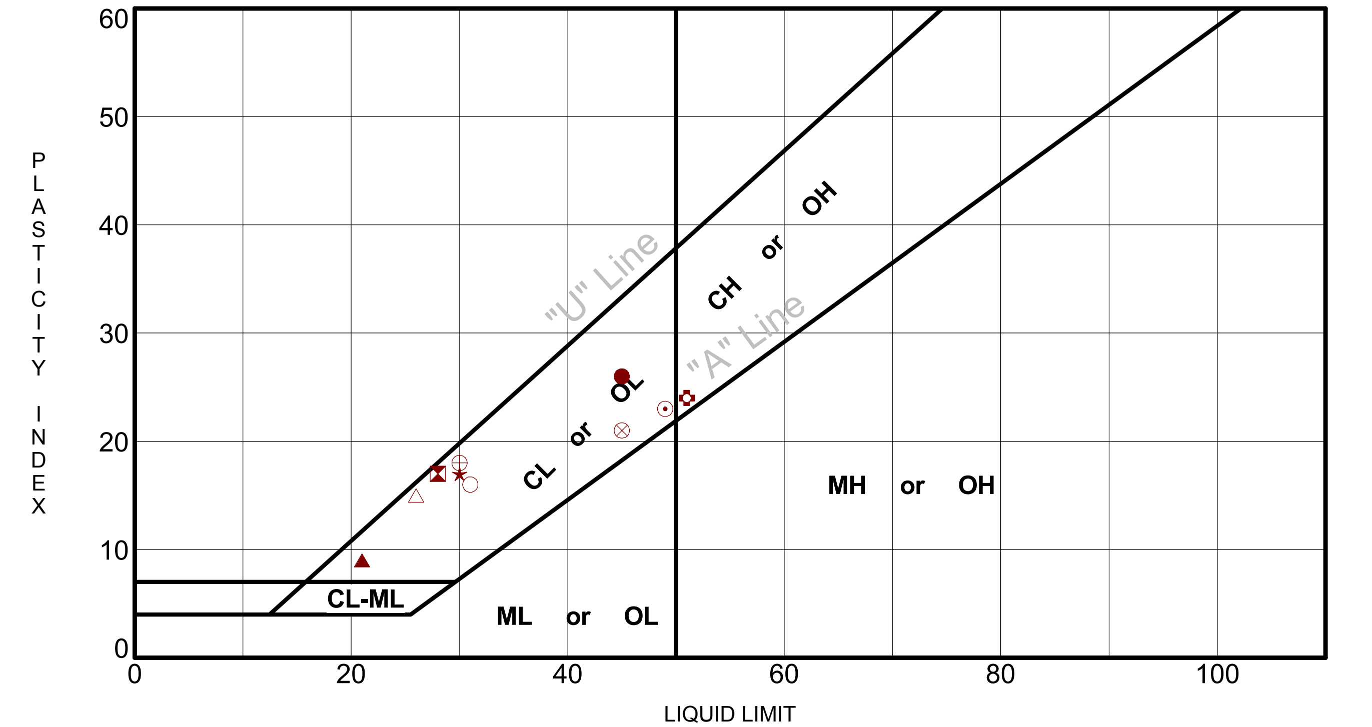
Terracon
2640 12th Street SW
Cedar Rapids, Iowa

Boring Started: 12/10/2013	Boring Completed: 12/10/2013
Drill Rig: Diedrich D-50	Driller: MR
Project No.: 06135064	

Boring	Station	Offset	Elevation (ft)	Sample Depth (ft)	MC (%)	γ_d (pcf)	γ_w (pcf)	UC (tsf)	Void Ratio	Saturation (%)	Atterberg Limit		P200 (%)	USCS Class.
											LL	PI		
RB30-283	1279+00	50 L	893.3	9.0	15.8	112.2	129.9	1.27	0.49	86				
RB30-291	1295+00	55 L	911.7	9.0	14.2	119.5	136.5	1.98	0.4	95				
RB30-294	1304+00	55 L	918.4	9.0	14.8	119.8	137.5	2.89	0.4	100				
RB30-297	1310+00	50 R	916.4	0.5	26.1	93.0	117.3	1.97	0.8	88	51	24		CH
RB30-301	1318+00	45 L	899.7	9.0	16.2	116.1	134.9	1.97	0.44	99				
RB30-304A	1326+00	125 L	899.1	9.0	30.2	88.8	115.6	0.54	0.88	91				
RB30-308	1332+00	100 L	911.0	9.0	14.7	118.4	135.8	2.05	0.41	96				
RB30-314	1344+00	50 R	908.1	8.0	14.1	117.4	134.0	1.82	0.42	89				
RB30-314	1344+00	50 R	908.1	18.0	12.7	122.3	137.8	4.42	0.37	92				
RB30-315	1346+00	60 L	903.3	9.0	15.2	116.9	134.7	2.89	0.43	94				
RB30-318	1353+00	50 R	883.7	0.5	26.6	94.4	119.5	2.79	0.77	92				
RB30-318	1353+00	50 R	883.7	8.0	16.7	111.2	129.8	1.07	0.5	89				
RB30-318	1353+00	50 R	883.7	18.0	13	122.1	138.0	3.96	0.37	94				
RB30-324	1365+00	50 R	874.6	0.5	26.4	84.0	106.2	2.19	0.99	71				
RB30-324	1365+00	50 R	874.6	8.0	21	106.8	129.2		0.64	93	31	16	63	CL
RB30-324	1365+00	50 R	874.6	18.0	13.6	120.4	136.8		0.45	85	26	15	62	CL
RB30-335	1388+50	40 L	872.6	9.0	15.2	112.9	130.1	1.72	0.48	84				
RB30-340	1400+50	50 R	868.6	0.5	35.3	80.5	108.9	1.25	1.08	88				
RB30-340	1400+50	50 R	868.6	8.0	12.9	118.2	133.4	2.39	0.42	83				
RB30-340	1400+50	50 R	868.6	18.0	13.7	119.4	135.8	2.36	0.4	92				
RB30-347	1413+00	57 L	880.3	9.0	12.5	124.1	139.6	3.57	0.35	96				
RB30-352	1425+00	50 R	881.0	0.5	27.3	79.5	101.2	1.05	1.1	66				
RB30-352	1425+00	50 R	881.0	18.0	21.4	96.6	117.3	0.34	0.73	78				
RB30-353	1425+75	120 L	885.3	9.0	14.4	105.8	121.0	0.84	0.58	66				
RB30-357	1434+00	40 L	893.9	9.0	13.4	114.6	130.0	3.97	0.46	78				
RB30-362	1444+00	50 R	906.2	1.0	30.4	91.3	119.1	3.31	0.83	98	45	21		CL
RB30-365	1450+00	40 L	906.3	9.0	15.3	115.6	133.3	2.23	0.45	92				
RB30-371	1462+00	45 L	908.0	9.0	21.3	106.9	129.7	0.67	0.57	101				
RB30-374	1468+00	90 R	906.9	13.0	15.7	115.9	134.1	1.87	0.44	95				
RB30-378	1476+00	70 R	922.5	9.0	16.9	111.9	130.8	1.36	0.49	92				
RB30-379	1478+00	20 L	920.3	9.0	14.9	118.4	136.0	3.87	0.41	97				
RB30-387	1494+00	127 L	930.1	9.0	15.6	117.1	135.4	1.69	0.43	97				
RC30-388	1496+00	80 R	928.8	9.0	14.5	118.5	135.7	3.55	0.41	94				

ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
●	**RB30-180**	**3.5**	**45**	**19**	**26**		**CL**	
⧗	**RB30-192**	**8.0**	**28**	**11**	**17**	**93**	**CL**	**LEAN CLAY**
▲	**RB30-198**	**3.5**	**21**	**12**	**9**		**CL**	
★	**RB30-248A**	**8.0**	**30**	**13**	**17**	**61**	**CL**	**SANDY LEAN CLAY**
⊙	**RB30-276**	**0.5**	**49**	**26**	**23**		**CL**	
✿	**RB30-297**	**0.5**	**51**	**27**	**24**		**CH**	
○	**RB30-324**	**8.0**	**31**	**15**	**16**	**63**	**CL**	**SANDY LEAN CLAY**
△	**RB30-324**	**18.0**	**26**	**11**	**15**	**62**	**CL**	**SANDY LEAN CLAY**
⊗	**RB30-362**	**1.0**	**45**	**24**	**21**		**CL**	
⊕	**RB21-8**	**9.0**	**30**	**12**	**18**	**57**	**CL**	**SANDY LEAN CLAY**

PROJECT: US Hwy 30

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

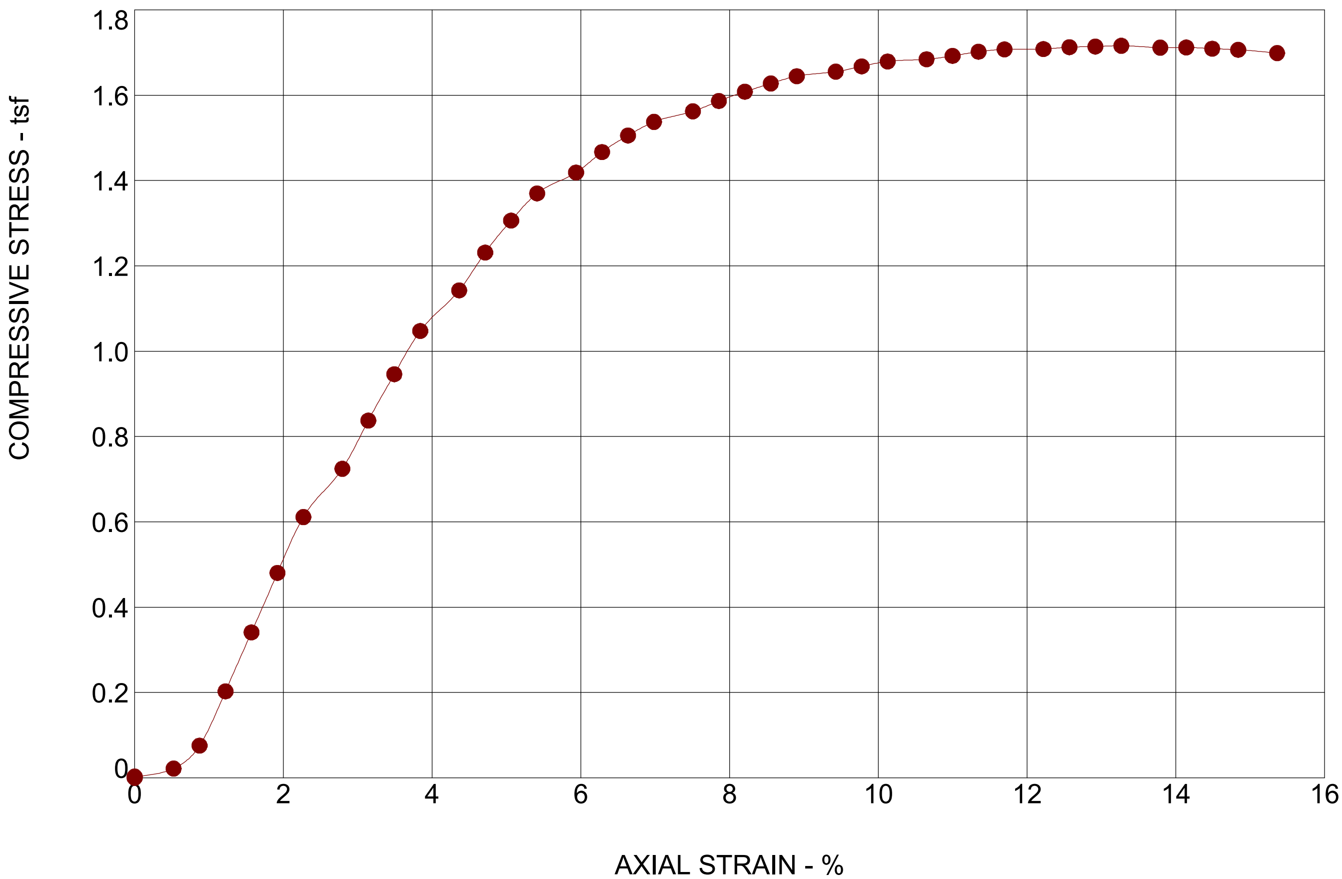
2640 12th Street SW
Cedar Rapids, Iowa

PROJECT NUMBER: 06135064

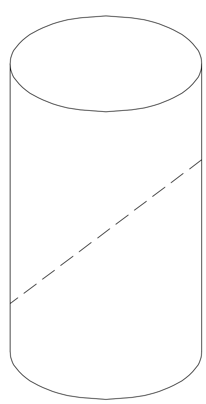
CLIENT: HDR Engineering, Inc.
Omaha, NE

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE MODE	SPECIMEN TEST DATA		
	Moisture Content:	%	15.2
	Dry Density:	pcf	112.9
	Diameter:	in.	2.87
	Height:	in.	5.73
	Height / Diameter Ratio:		1.99
	Calculated Saturation:	%	84.24
	Calculated Void Ratio:		0.48
	Assumed Specific Gravity:		2.68
	Failure Strain:	%	13.27
	Unconfined Compressive Strength	(tsf)	1.72
	Undrained Shear Strength:	(tsf)	0.86
	Strain Rate:	in/min	
	Remarks:		



Failure Mode: Shear (dashed)

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: RB30-335 @ 9 Feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: US Hwy 30

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

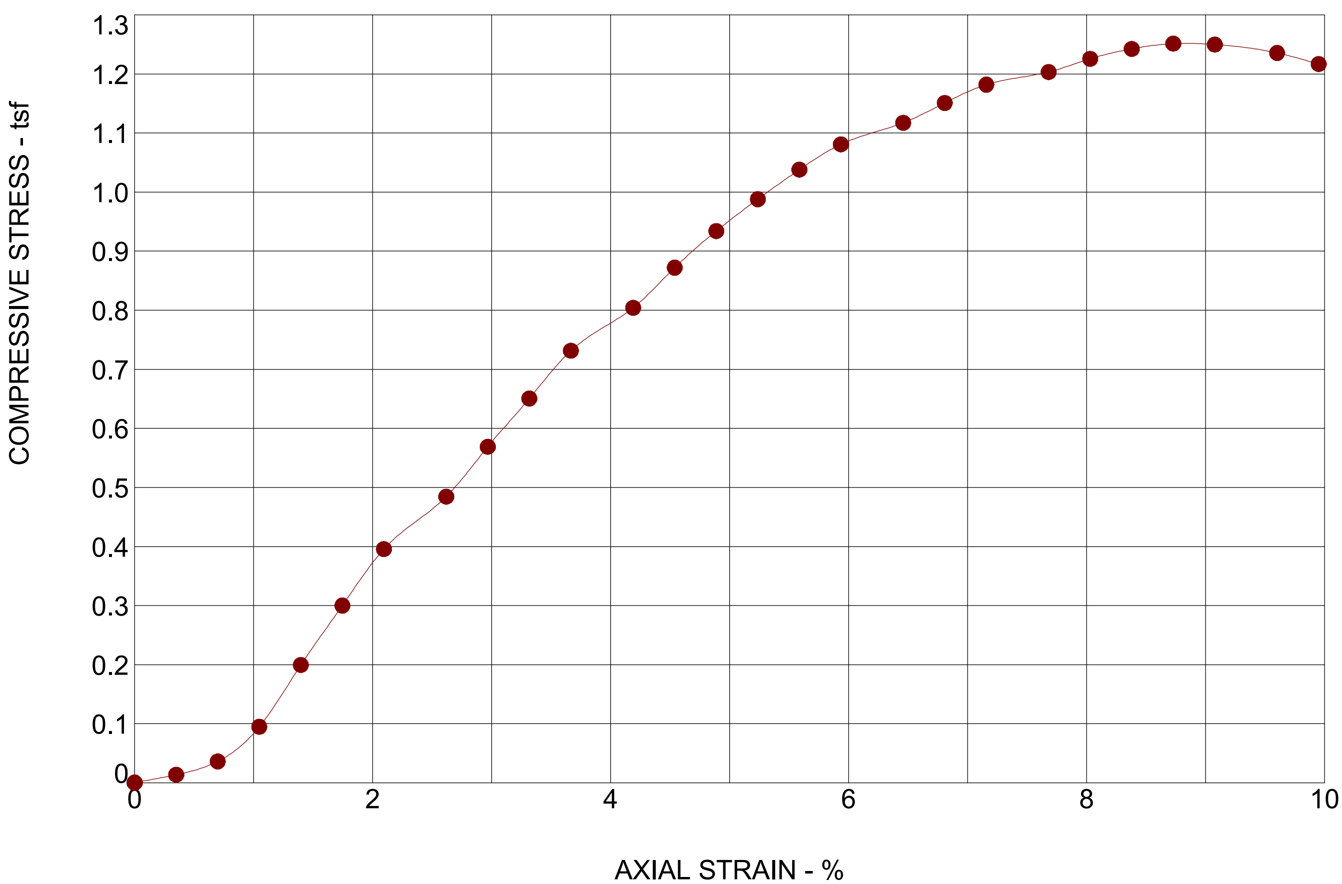
PROJECT NUMBER: 06135064

CLIENT: HDR Engineering, Inc.
Omaha, NE

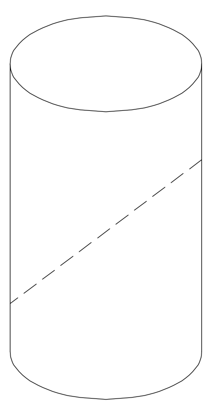
EXHIBIT: B-66

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE MODE	SPECIMEN TEST DATA		
	Moisture Content:	%	35.3
	Dry Density:	pcf	80.5
	Diameter:	in.	2.87
	Height:	in.	5.73
	Height / Diameter Ratio:		1.99
	Calculated Saturation:	%	87.82
	Calculated Void Ratio:		1.08
	Assumed Specific Gravity:		2.68
	Failure Strain:	%	8.73
	Unconfined Compressive Strength	(tsf)	1.25
	Undrained Shear Strength:	(tsf)	0.63
	Strain Rate:	in/min	
	Remarks:		



Failure Mode: Shear (dashed)

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: RB30-340 @ 0.5 Feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: US Hwy 30

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

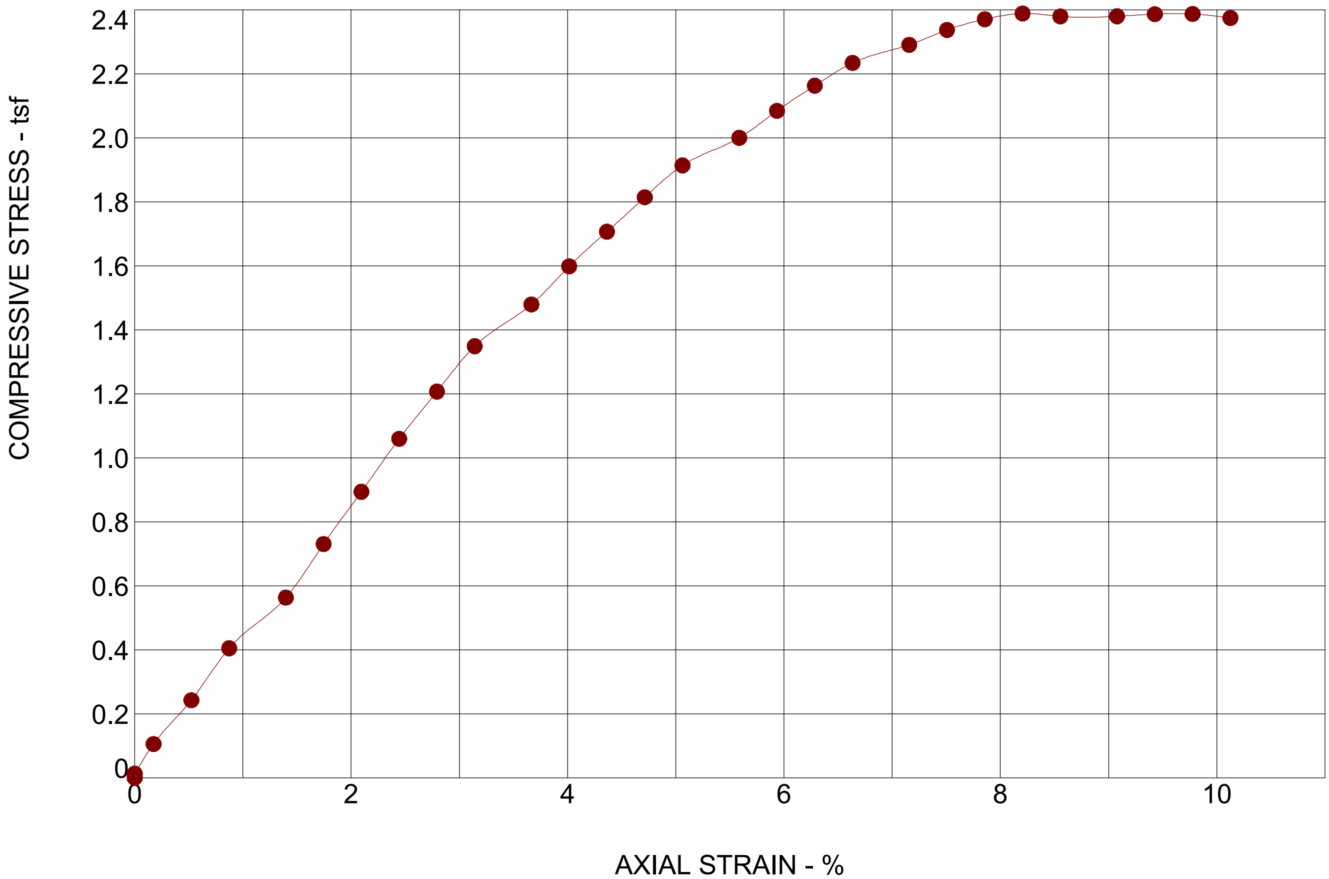
PROJECT NUMBER: 06135064

CLIENT: HDR Engineering, Inc.
Omaha, NE

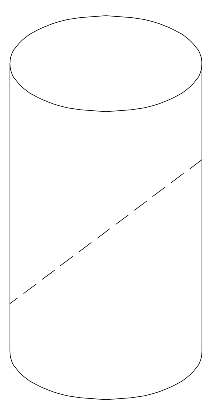
EXHIBIT: B-67

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE MODE	SPECIMEN TEST DATA		
	Moisture Content:	%	12.9
	Dry Density:	pcf	118.2
	Diameter:	in.	2.87
	Height:	in.	5.73
	Height / Diameter Ratio:		1.99
	Calculated Saturation:	%	83.44
	Calculated Void Ratio:		0.42
	Assumed Specific Gravity:		2.68
	Failure Strain:	%	8.20
	Unconfined Compressive Strength	(tsf)	2.39
	Undrained Shear Strength:	(tsf)	1.19
	Strain Rate:	in/min	
	Remarks:		



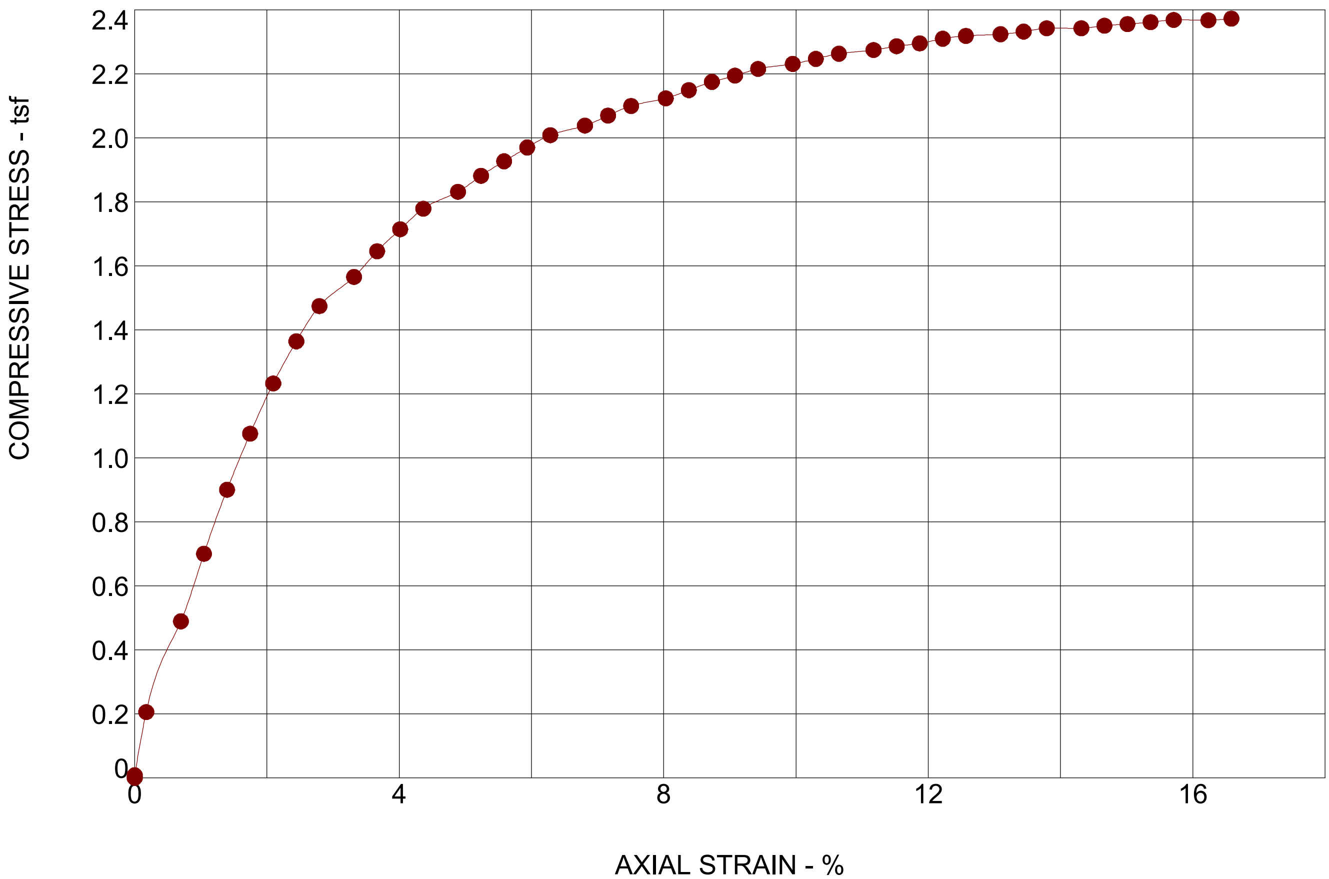
Failure Mode: Shear (dashed)

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: RB30-340 @ 8 Feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

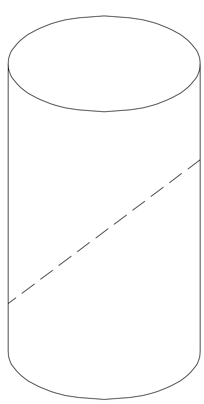
PROJECT: US Hwy 30	Terracon	PROJECT NUMBER: 06135064
SITE: IDOT Project No. NHS-030-6(87)--19-06 Benton County, Iowa	2640 12th Street SW Cedar Rapids, Iowa	CLIENT: HDR Engineering, Inc. Omaha, NE
		EXHIBIT: B-68

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE MODE	SPECIMEN TEST DATA		
	Moisture Content:	%	13.7
	Dry Density:	pcf	119.4
	Diameter:	in.	2.87
	Height:	in.	5.73
	Height / Diameter Ratio:		1.99
	Calculated Saturation:	%	91.69
	Calculated Void Ratio:		0.40
	Assumed Specific Gravity:		2.68
	Failure Strain:	%	15.00
	Unconfined Compressive Strength	(tsf)	2.36
	Undrained Shear Strength:	(tsf)	1.18
	Strain Rate:	in/min	
	Remarks:		



Failure Mode: Shear (dashed)

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: RB30-340 @ 18 Feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: US Hwy 30

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

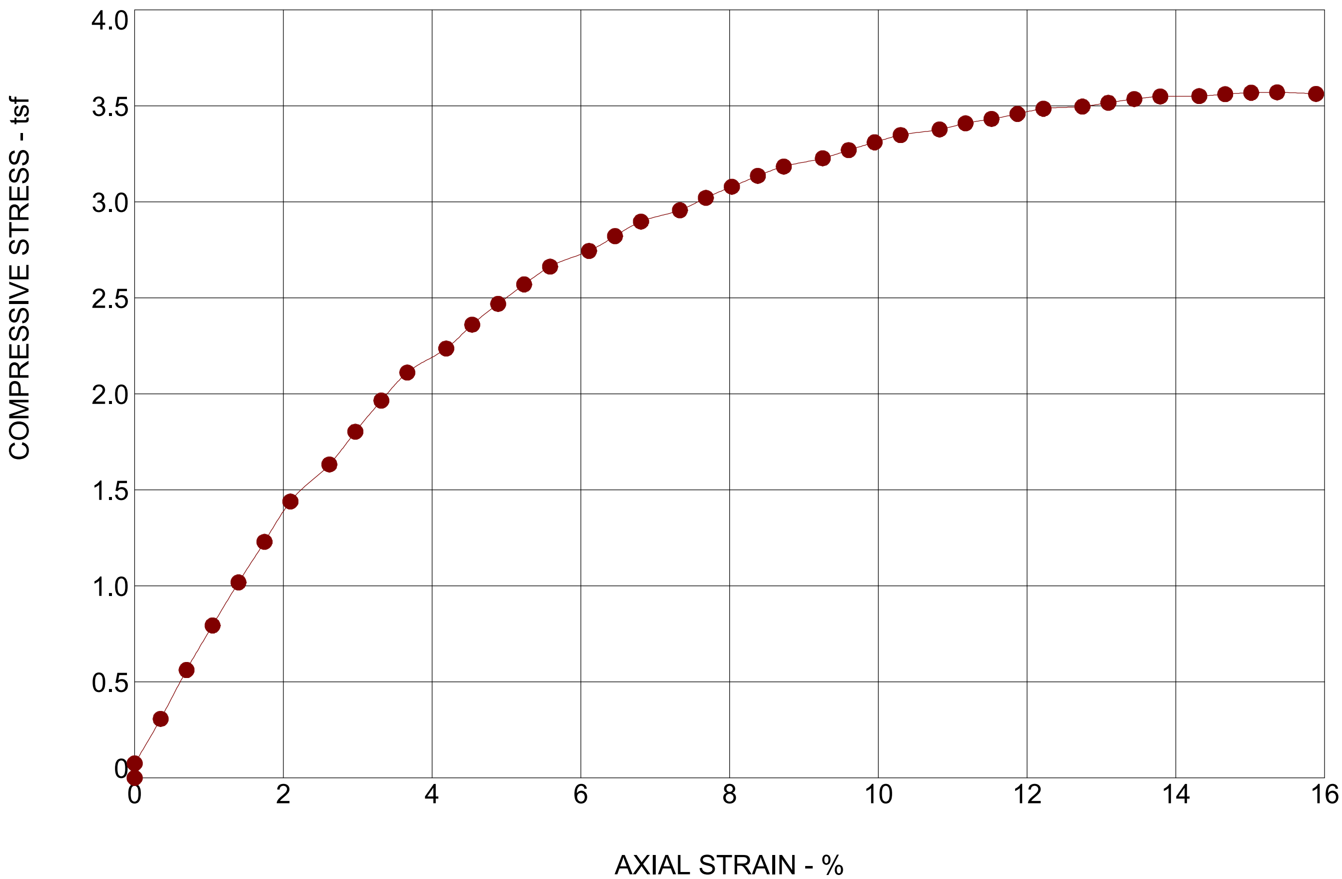
PROJECT NUMBER: 06135064

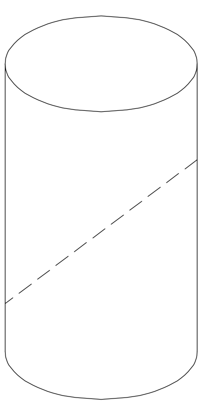
CLIENT: HDR Engineering, Inc.
Omaha, NE

EXHIBIT: B-69

UNCONFINED COMPRESSION TEST

ASTM D2166



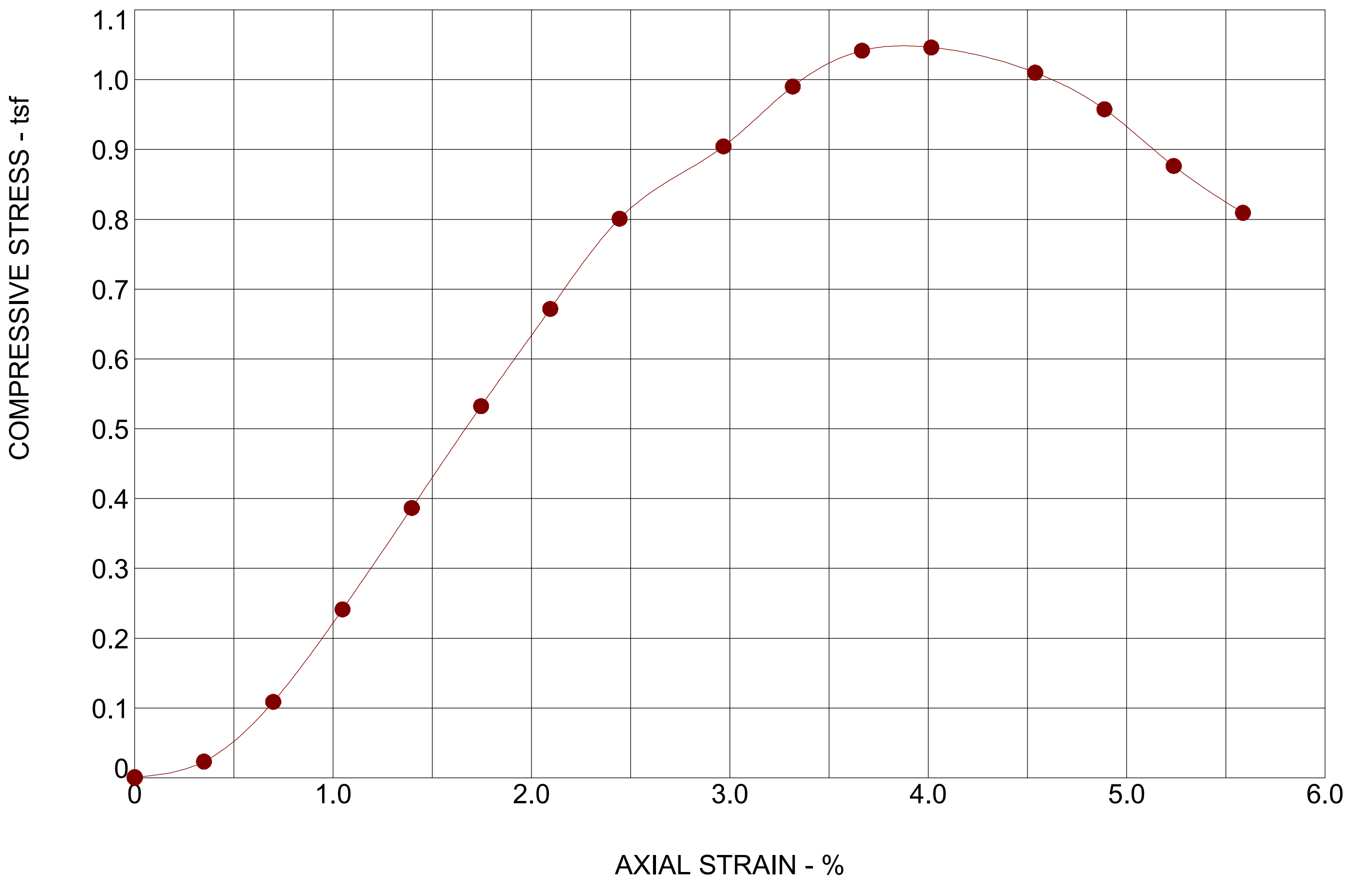
SPECIMEN FAILURE MODE	SPECIMEN TEST DATA		
 Failure Mode: Shear (dashed)	Moisture Content:	%	12.5
	Dry Density:	pcf	124.1
	Diameter:	in.	2.87
	Height:	in.	5.73
	Height / Diameter Ratio:		1.99
	Calculated Saturation:	%	96.41
	Calculated Void Ratio:		0.35
	Assumed Specific Gravity:		2.68
	Failure Strain:	%	15.00
	Unconfined Compressive Strength	(tsf)	3.57
	Undrained Shear Strength:	(tsf)	1.78
	Strain Rate:	in/min	
	Remarks:		

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: RB30-347 @ 9 Feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

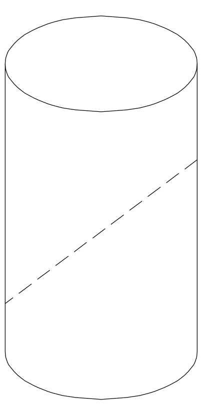
PROJECT: US Hwy 30	Terracon	PROJECT NUMBER: 06135064
SITE: IDOT Project No. NHS-030-6(87)--19-06 Benton County, Iowa	2640 12th Street SW Cedar Rapids, Iowa	CLIENT: HDR Engineering, Inc. Omaha, NE
		EXHIBIT: B-70

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE MODE	SPECIMEN TEST DATA		
	Moisture Content:	%	27.3
	Dry Density:	pcf	79.5
	Diameter:	in.	2.87
	Height:	in.	5.73
	Height / Diameter Ratio:		1.99
	Calculated Saturation:	%	66.39
	Calculated Void Ratio:		1.10
	Assumed Specific Gravity:		2.68
	Failure Strain:	%	4.02
	Unconfined Compressive Strength	(tsf)	1.05
	Undrained Shear Strength:	(tsf)	0.52
	Strain Rate:	in/min	
	Remarks:		



Failure Mode: Shear (dashed)

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: RB30-352 @ 0.5 Feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: US Hwy 30

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

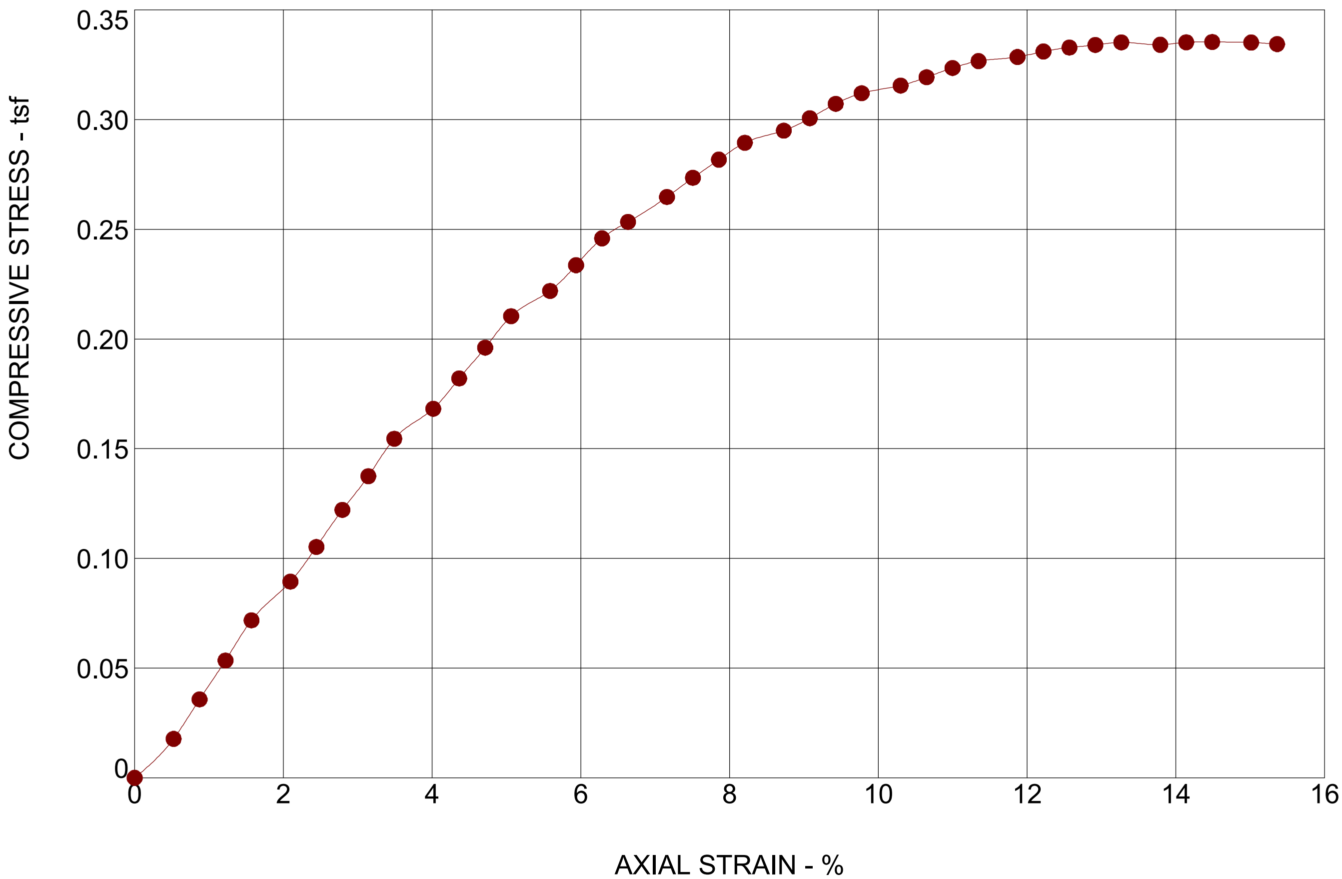
PROJECT NUMBER: 06135064

CLIENT: HDR Engineering, Inc.
Omaha, NE

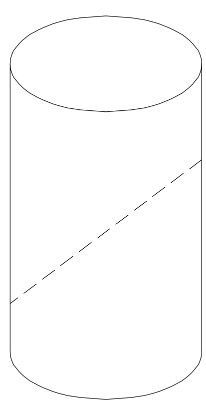
EXHIBIT: B-71

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE MODE



Failure Mode: Shear (dashed)

SPECIMEN TEST DATA

Moisture Content:	%	21.4
Dry Density:	pcf	96.6
Diameter:	in.	2.87
Height:	in.	5.73
Height / Diameter Ratio:		1.99
Calculated Saturation:	%	78.15
Calculated Void Ratio:		0.73
Assumed Specific Gravity:		2.68
Failure Strain:	%	14.49
Unconfined Compressive Strength	(tsf)	0.34
Undrained Shear Strength:	(tsf)	0.17
Strain Rate:	in/min	
Remarks:		

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: RB30-352 @ 18 Feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: US Hwy 30

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

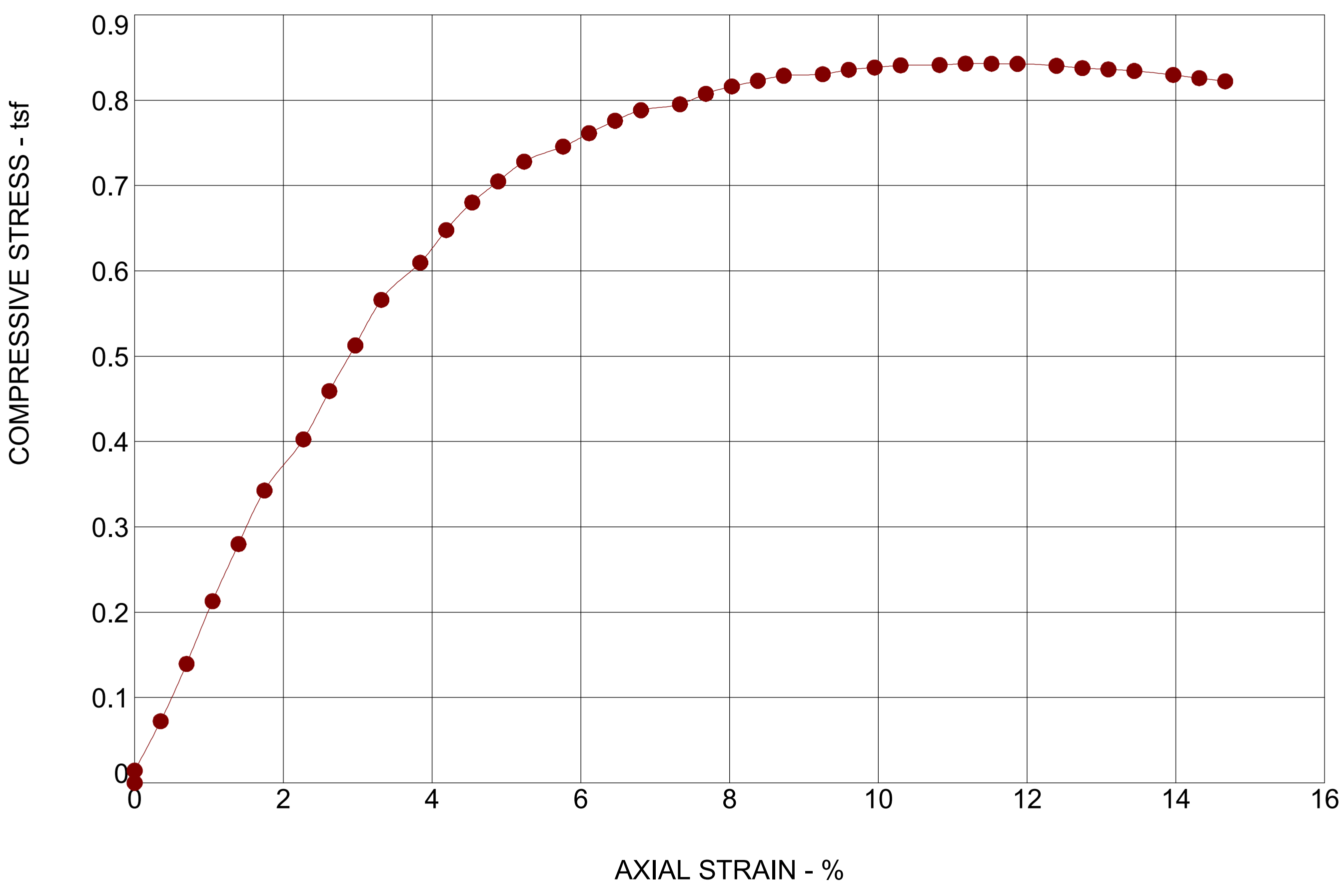
PROJECT NUMBER: 06135064

CLIENT: HDR Engineering, Inc.
Omaha, NE

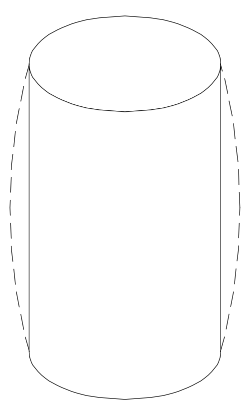
EXHIBIT: B-72

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE MODE



Failure Mode: Bulge (dashed)

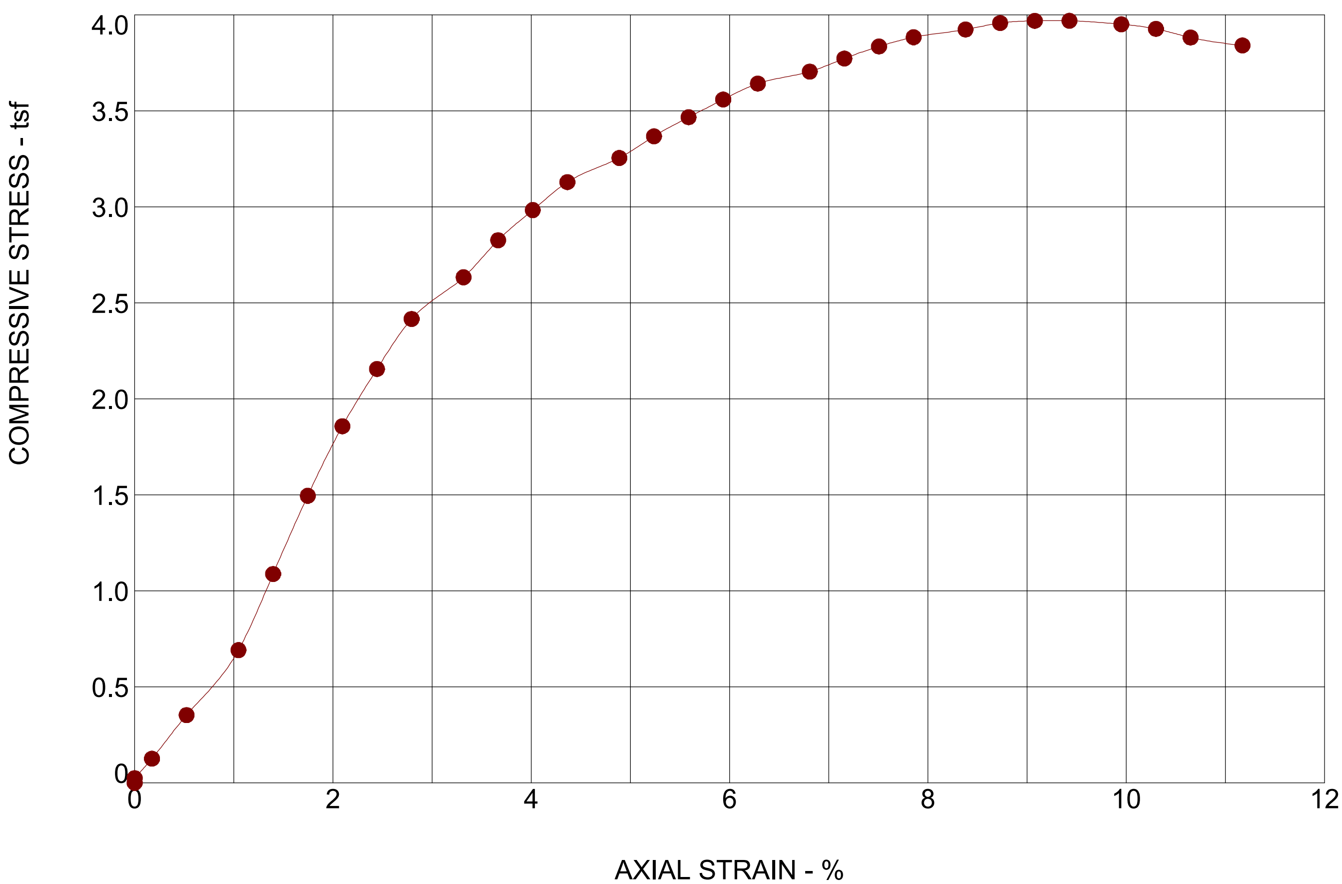
SPECIMEN TEST DATA		
Moisture Content:	%	14.4
Dry Density:	pcf	105.8
Diameter:	in.	2.87
Height:	in.	5.73
Height / Diameter Ratio:		1.99
Calculated Saturation:	%	66.48
Calculated Void Ratio:		0.58
Assumed Specific Gravity:		2.68
Failure Strain:	%	11.17
Unconfined Compressive Strength	(tsf)	0.84
Undrained Shear Strength:	(tsf)	0.42
Strain Rate:	in/min	
Remarks:		

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: RB30-353 @ 9 Feet				
DESCRIPTION:		LL	PL	PI	Percent < #200 Sieve

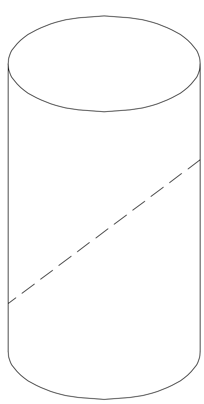
PROJECT: US Hwy 30	Terracon	PROJECT NUMBER: 06135064
SITE: IDOT Project No. NHS-030-6(87)--19-06 Benton County, Iowa	2640 12th Street SW Cedar Rapids, Iowa	CLIENT: HDR Engineering, Inc. Omaha, NE
		EXHIBIT: B-73

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE MODE	SPECIMEN TEST DATA		
	Moisture Content:	%	13.4
	Dry Density:	pcf	114.6
	Diameter:	in.	2.87
	Height:	in.	5.73
	Height / Diameter Ratio:		1.99
	Calculated Saturation:	%	78.21
	Calculated Void Ratio:		0.46
	Assumed Specific Gravity:		2.68
	Failure Strain:	%	9.43
	Unconfined Compressive Strength	(tsf)	3.97
	Undrained Shear Strength:	(tsf)	1.98
	Strain Rate:	in/min	
	Remarks:		



Failure Mode: Shear (dashed)

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: RB30-357 @ 9 Feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: US Hwy 30

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

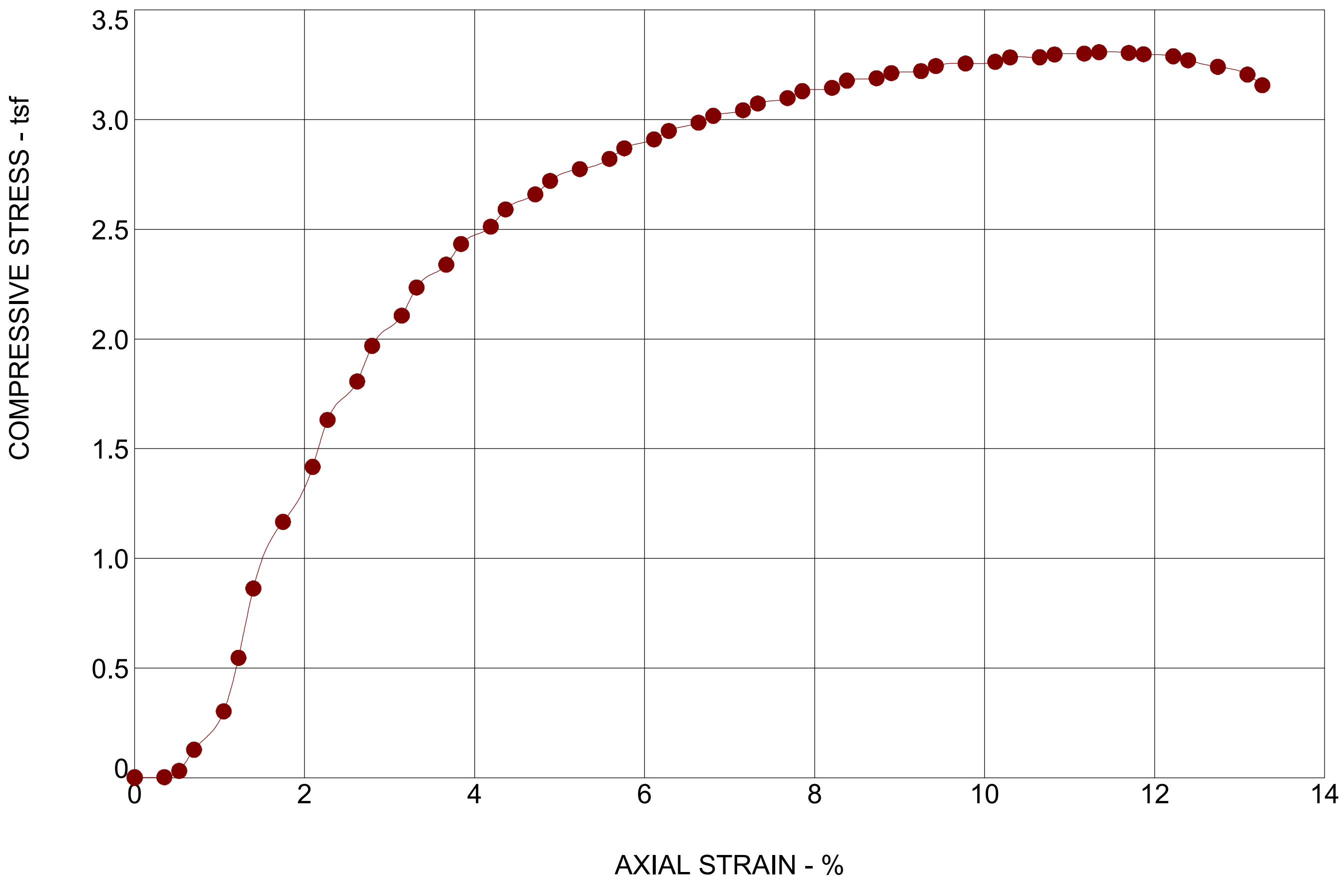
PROJECT NUMBER: 06135064

CLIENT: HDR Engineering, Inc.
Omaha, NE

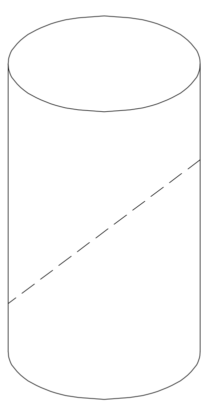
EXHIBIT: B-74

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE MODE	SPECIMEN TEST DATA		
	Moisture Content:	%	30.4
	Dry Density:	pcf	91.3
	Diameter:	in.	2.87
	Height:	in.	5.73
	Height / Diameter Ratio:		1.99
	Calculated Saturation:	%	98.02
	Calculated Void Ratio:		0.83
	Assumed Specific Gravity:		2.68
	Failure Strain:	%	11.35
	Unconfined Compressive Strength	(tsf)	3.31
	Undrained Shear Strength:	(tsf)	1.65
	Strain Rate:	in/min	
	Remarks:		



Failure Mode: Shear (dashed)

SAMPLE TYPE: Shelby Tube

SAMPLE LOCATION: RB30-362 @ 1 Feet

DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve
	45	24	21	

PROJECT: US Hwy 30

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

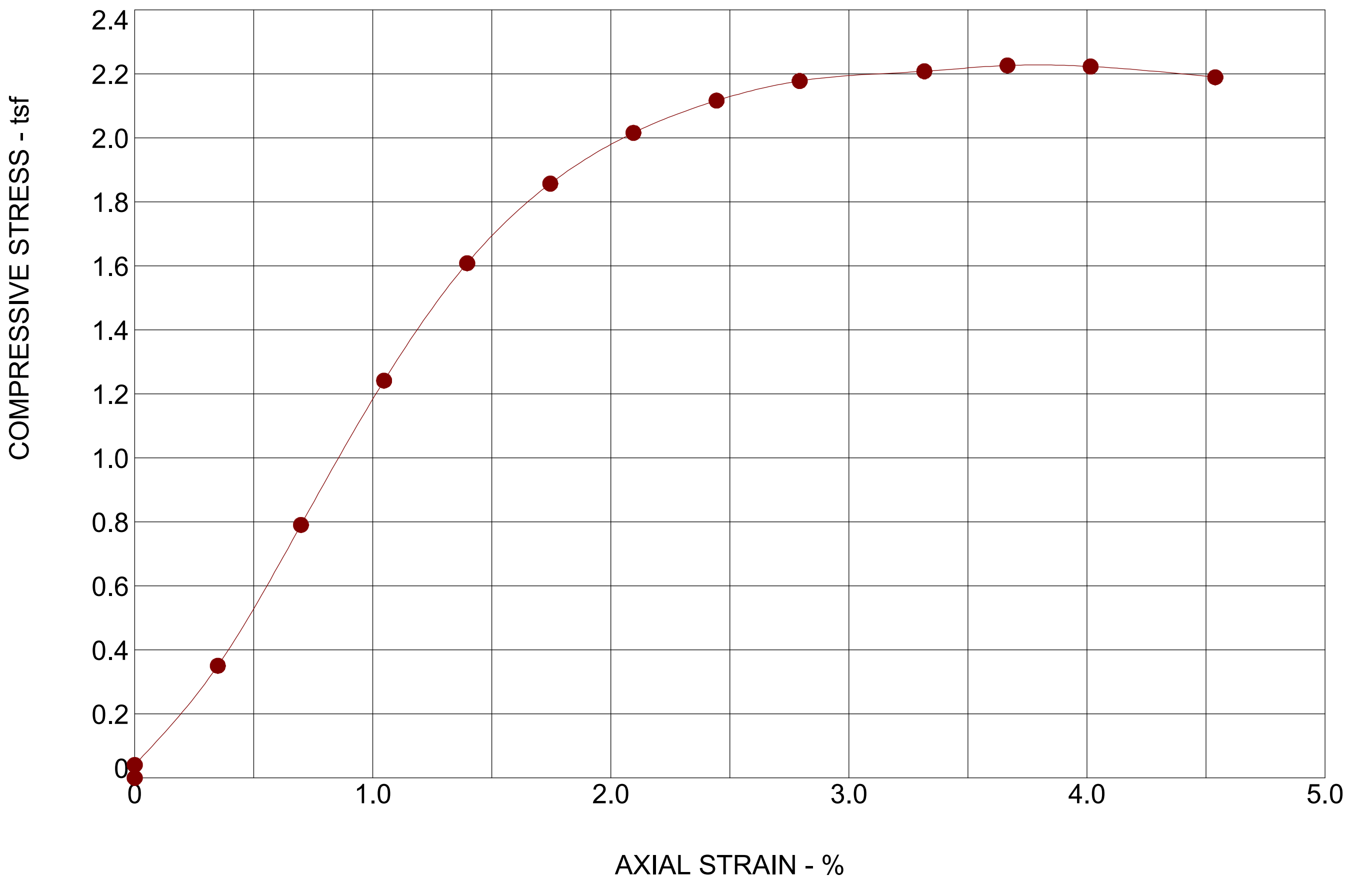
PROJECT NUMBER: 06135064

CLIENT: HDR Engineering, Inc.
Omaha, NE

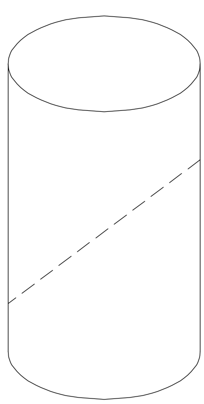
EXHIBIT: B-75

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE MODE



Failure Mode: Shear (dashed)

SPECIMEN TEST DATA

Moisture Content:	%	15.3
Dry Density:	pcf	115.6
Diameter:	in.	2.87
Height:	in.	5.73
Height / Diameter Ratio:		1.99
Calculated Saturation:	%	91.50
Calculated Void Ratio:		0.45
Assumed Specific Gravity:		2.68
Failure Strain:	%	3.67
Unconfined Compressive Strength	(tsf)	2.23
Undrained Shear Strength:	(tsf)	1.11
Strain Rate:	in/min	
Remarks:		

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: RB30-365 @ 9 Feet				
DESCRIPTION:		LL	PL	PI	Percent < #200 Sieve

PROJECT: US Hwy 30

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

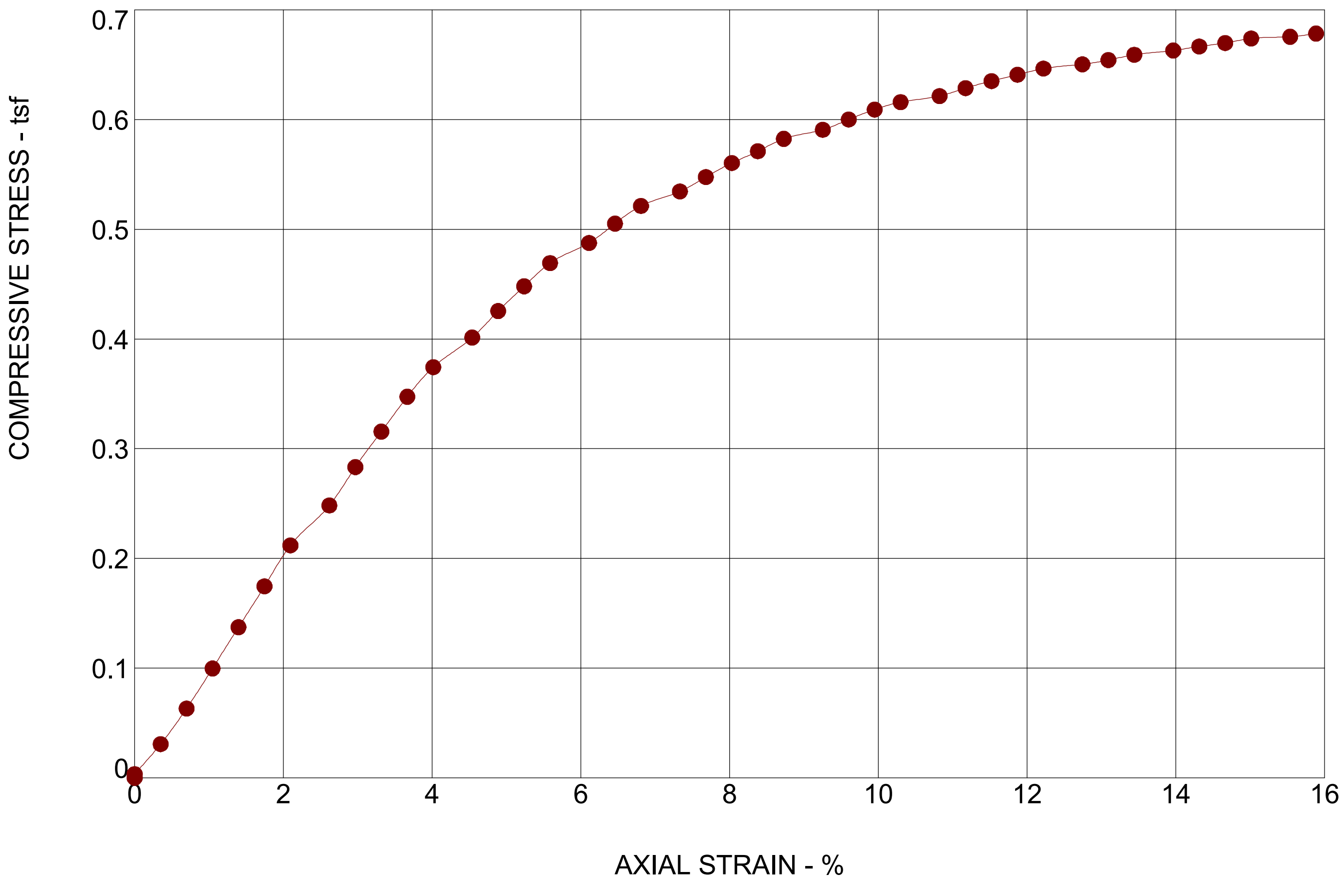
PROJECT NUMBER: 06135064

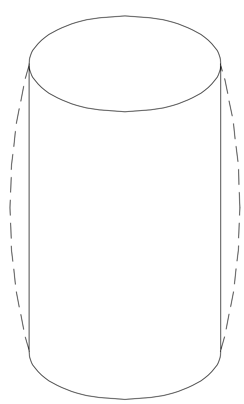
CLIENT: HDR Engineering, Inc.
Omaha, NE

EXHIBIT: B-76

UNCONFINED COMPRESSION TEST

ASTM D2166



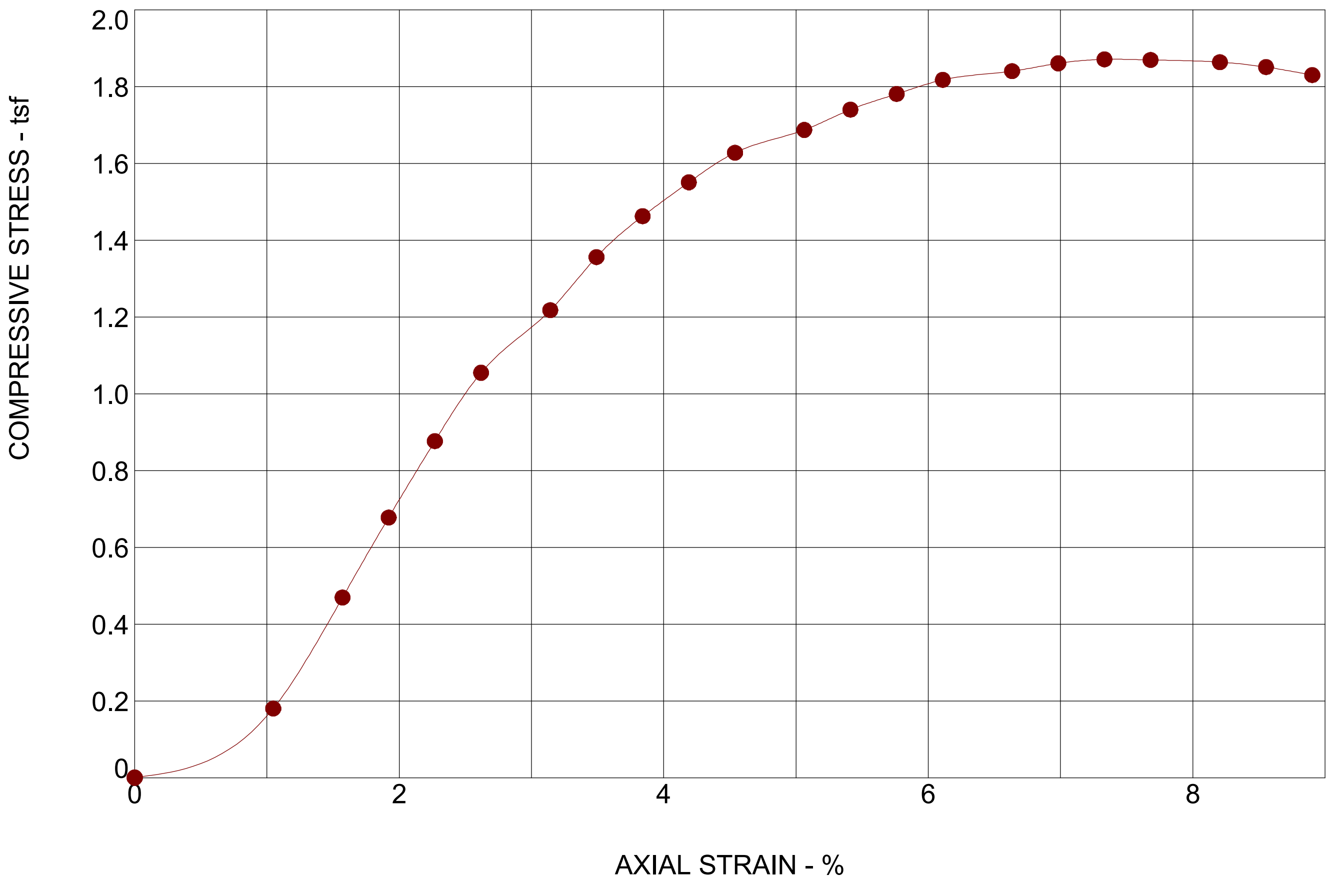
SPECIMEN FAILURE MODE	SPECIMEN TEST DATA		
 Failure Mode: Bulge (dashed)	Moisture Content:	%	21.3
	Dry Density:	pcf	106.9
	Diameter:	in.	2.87
	Height:	in.	5.73
	Height / Diameter Ratio:		1.99
	Calculated Saturation:	%	100.80
	Calculated Void Ratio:		0.57
	Assumed Specific Gravity:		2.68
	Failure Strain:	%	15.00
	Unconfined Compressive Strength	(tsf)	0.67
	Undrained Shear Strength:	(tsf)	0.34
	Strain Rate:	in/min	
	Remarks:		

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: RB30-371 @ 9 Feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

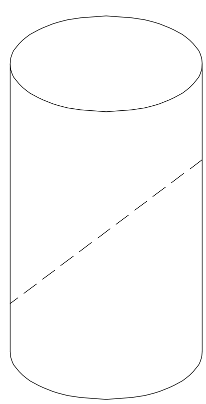
PROJECT: US Hwy 30	Terracon	PROJECT NUMBER: 06135064
SITE: IDOT Project No. NHS-030-6(87)--19-06 Benton County, Iowa	2640 12th Street SW Cedar Rapids, Iowa	CLIENT: HDR Engineering, Inc. Omaha, NE
		EXHIBIT: B-77

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE MODE	SPECIMEN TEST DATA		
	Moisture Content:	%	15.7
	Dry Density:	pcf	115.9
	Diameter:	in.	2.87
	Height:	in.	5.73
	Height / Diameter Ratio:		1.99
	Calculated Saturation:	%	94.61
	Calculated Void Ratio:		0.44
	Assumed Specific Gravity:		2.68
	Failure Strain:	%	7.33
	Unconfined Compressive Strength	(tsf)	1.87
	Undrained Shear Strength:	(tsf)	0.94
	Strain Rate:	in/min	
	Remarks:		



Failure Mode: Shear (dashed)

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: RB30-374 @ 13 Feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: US Hwy 30

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

2640 12th Street SW
Cedar Rapids, Iowa

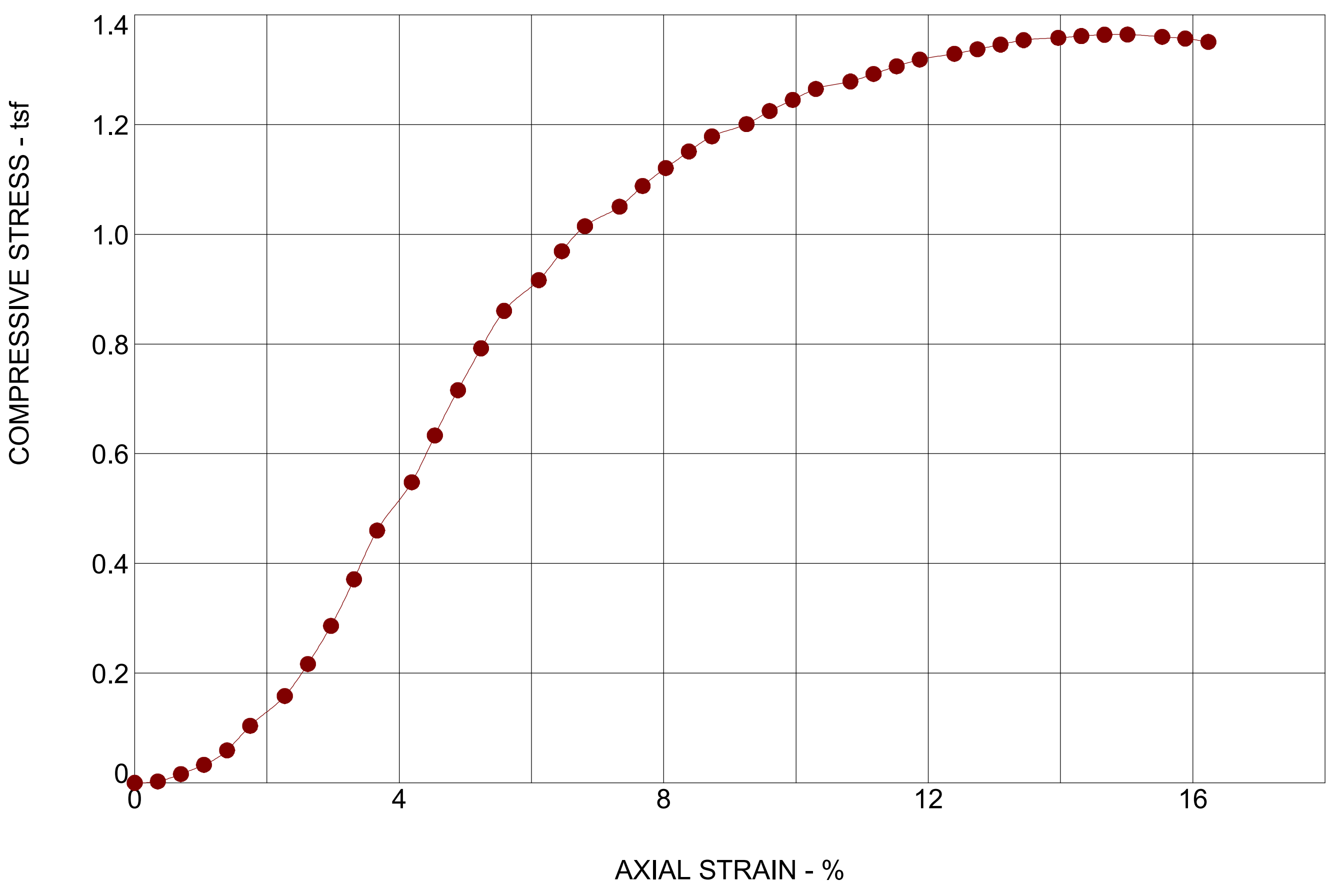
PROJECT NUMBER: 06135064

CLIENT: HDR Engineering, Inc.
Omaha, NE

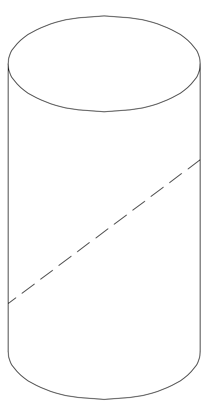
EXHIBIT: B-78

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE MODE	SPECIMEN TEST DATA		
	Moisture Content:	%	16.9
	Dry Density:	pcf	111.9
	Diameter:	in.	2.87
	Height:	in.	5.73
	Height / Diameter Ratio:		1.99
	Calculated Saturation:	%	91.51
	Calculated Void Ratio:		0.49
	Assumed Specific Gravity:		2.68
	Failure Strain:	%	15.00
	Unconfined Compressive Strength	(tsf)	1.36
	Undrained Shear Strength:	(tsf)	0.68
	Strain Rate:	in/min	
	Remarks:		



Failure Mode: Shear (dashed)

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: RB30-378 @ 9 Feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: US Hwy 30

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

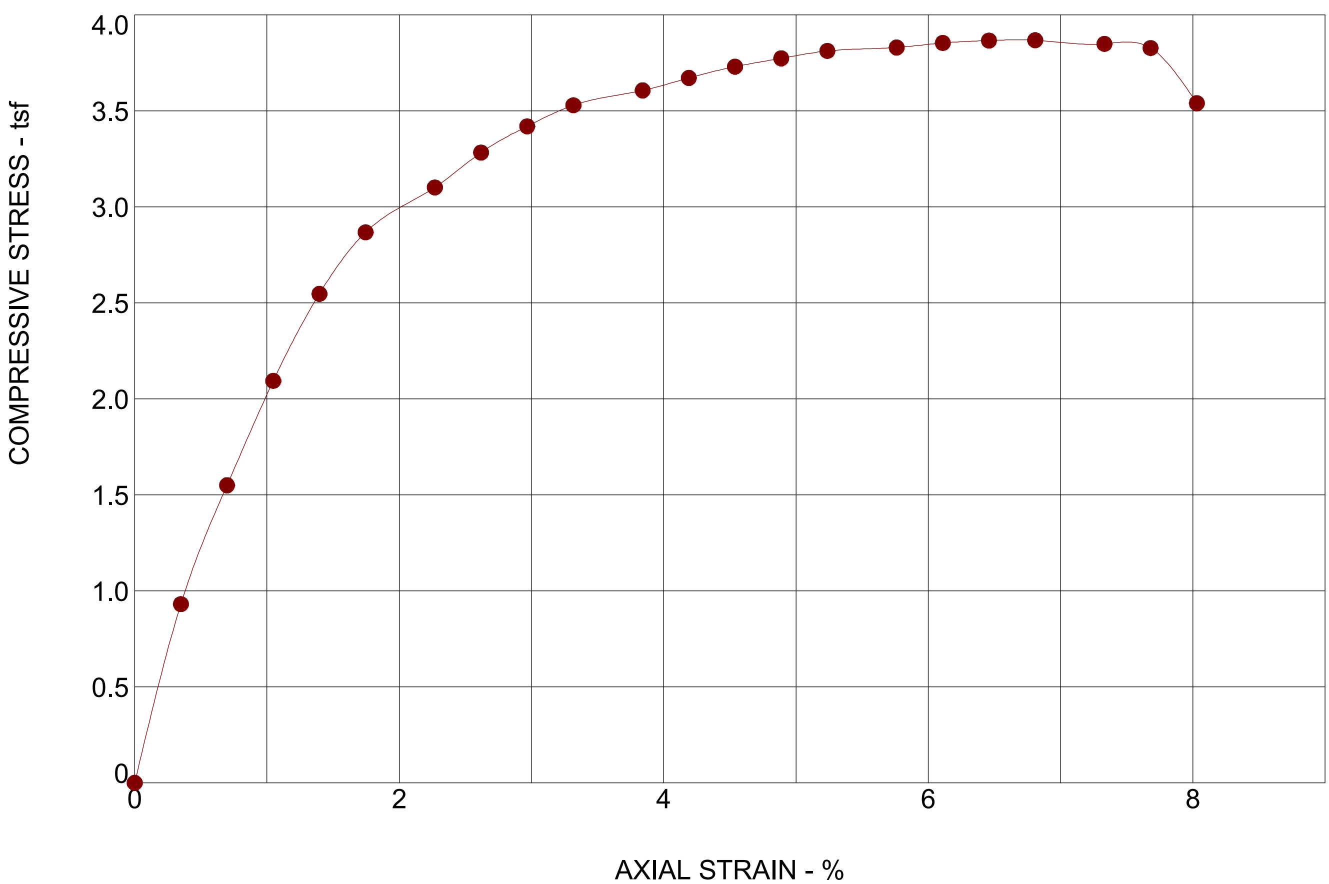
PROJECT NUMBER: 06135064

CLIENT: HDR Engineering, Inc.
Omaha, NE

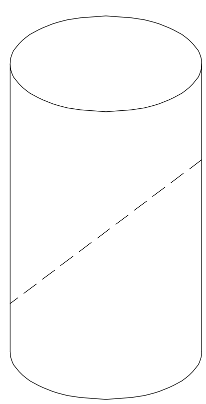
EXHIBIT: B-79

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE MODE	SPECIMEN TEST DATA		
	Moisture Content:	%	14.9
	Dry Density:	pcf	118.4
	Diameter:	in.	2.87
	Height:	in.	5.73
	Height / Diameter Ratio:		1.99
	Calculated Saturation:	%	96.95
	Calculated Void Ratio:		0.41
	Assumed Specific Gravity:		2.68
	Failure Strain:	%	6.81
	Unconfined Compressive Strength	(tsf)	3.87
	Undrained Shear Strength:	(tsf)	1.93
	Strain Rate:	in/min	
	Remarks:		



Failure Mode: Shear (dashed)

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: RB30-379 @ 9 Feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: US Hwy 30

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

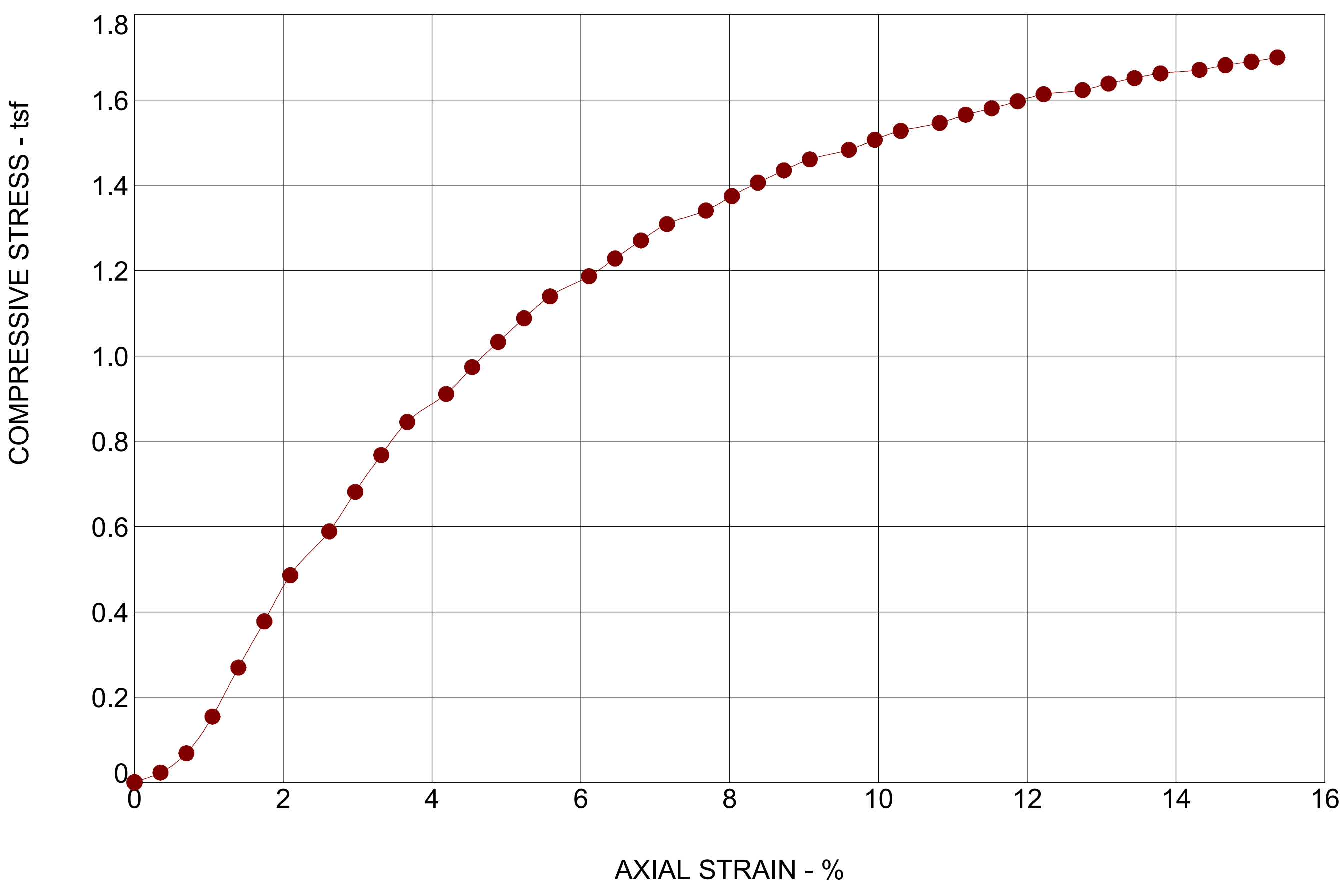
PROJECT NUMBER: 06135064

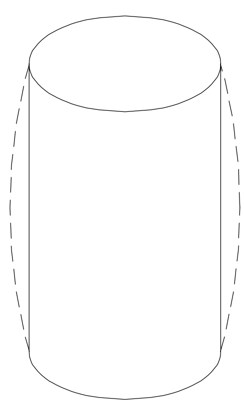
CLIENT: HDR Engineering, Inc.
Omaha, NE

EXHIBIT: B-80

UNCONFINED COMPRESSION TEST

ASTM D2166



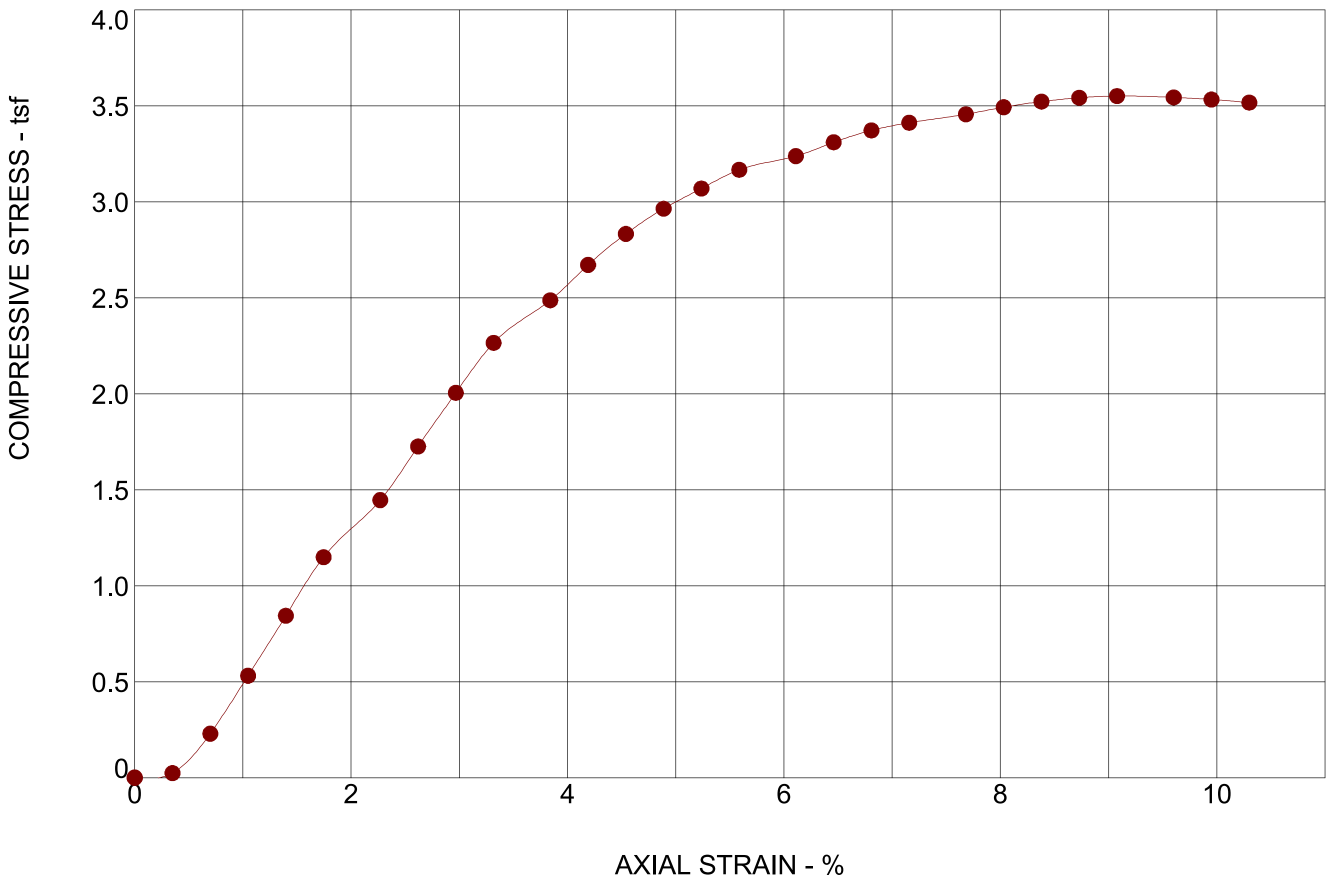
SPECIMEN FAILURE MODE	SPECIMEN TEST DATA		
 Failure Mode: Bulge (dashed)	Moisture Content:	%	15.6
	Dry Density:	pcf	117.1
	Diameter:	in.	2.87
	Height:	in.	5.73
	Height / Diameter Ratio:		1.99
	Calculated Saturation:	%	97.41
	Calculated Void Ratio:		0.43
	Assumed Specific Gravity:		2.68
	Failure Strain:	%	15.00
	Unconfined Compressive Strength	(tsf)	1.69
	Undrained Shear Strength:	(tsf)	0.84
	Strain Rate:	in/min	
	Remarks:		

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: RB30-387 @ 9 Feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

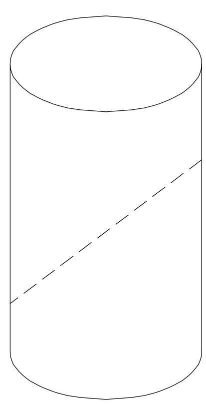
PROJECT: US Hwy 30	Terracon	PROJECT NUMBER: 06135064
SITE: IDOT Project No. NHS-030-6(87)--19-06 Benton County, Iowa	2640 12th Street SW Cedar Rapids, Iowa	CLIENT: HDR Engineering, Inc. Omaha, NE
		EXHIBIT: B-81

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE MODE	SPECIMEN TEST DATA		
	Moisture Content:	%	14.5
	Dry Density:	pcf	118.5
	Diameter:	in.	2.87
	Height:	in.	5.73
	Height / Diameter Ratio:		1.99
	Calculated Saturation:	%	94.04
	Calculated Void Ratio:		0.41
	Assumed Specific Gravity:		2.68
	Failure Strain:	%	9.08
	Unconfined Compressive Strength	(tsf)	3.55
	Undrained Shear Strength:	(tsf)	1.78
	Strain Rate:	in/min	
	Remarks:		



Failure Mode: Shear (dashed)

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: RC30-388 @ 9 Feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: US Hwy 30

SITE: IDOT Project No. NHS-030-6(87)--19-06
Benton County, Iowa

2640 12th Street SW
Cedar Rapids, Iowa

PROJECT NUMBER: 06135064

CLIENT: HDR Engineering, Inc.
Omaha, NE

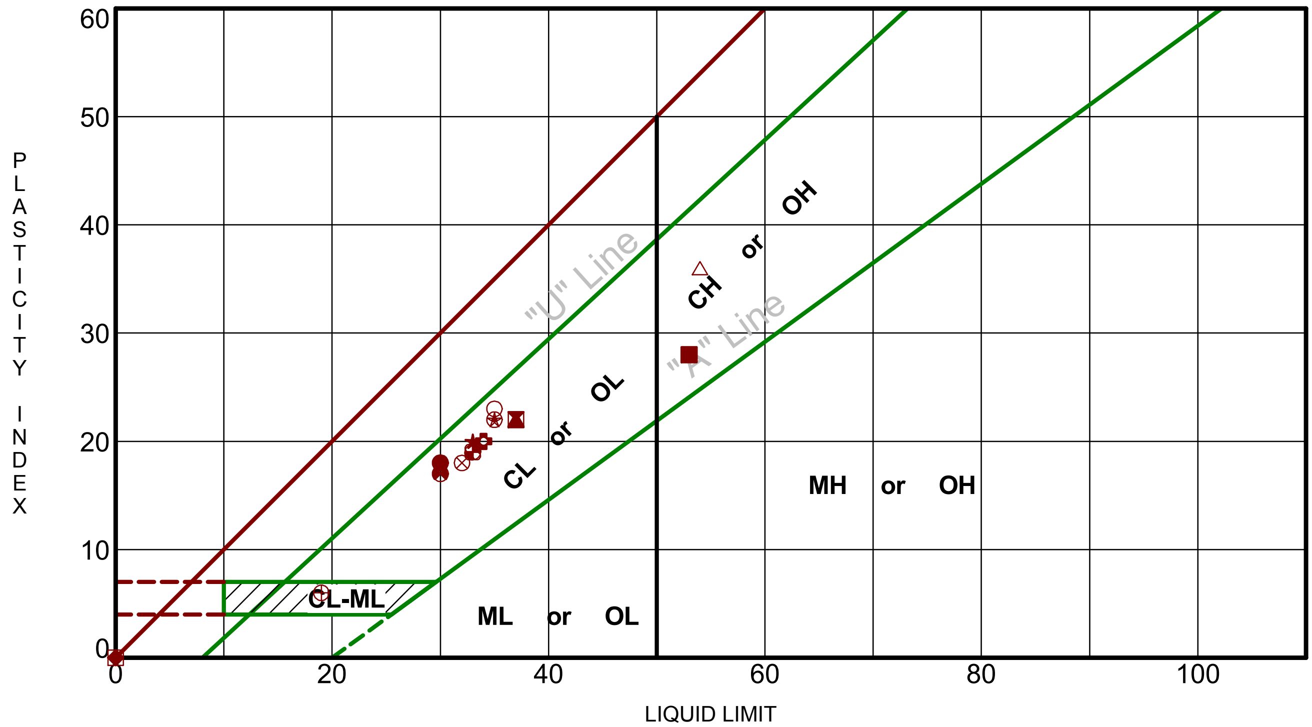
EXHIBIT: B-82

US Highway 30 / US Highway 218 Interchange: Tabulation of Field and Laboratory Soil Testing (All Samples)
D1154514
S2 Borings
Benton County, Iowa

Boring ID	Sample ID	Top Depth	Bottom Depth	Color	USCS	AASHTO Classification	USDA Classification	Pocket Penetrometer (tsf)	SPT Blow Count, N (bpf)	Corrected SPT Blow Count, N cor (bpf)	In-Situ Moisture Content, w (%)	Dry Density (pcf)	Wet Density (pcf)	Liquid Limit	Plastic Limit	Plastic Index	Pass #200 (%)	Preconsolidation Pressure, P0 (tsf)	Compressibility Index Cc	Swell Index, Cs	In-Situ Void Ratio, eo	Unconsolidation Undrained Shear Strength (tsf)	Unconfined Compressive Strength, UC (tsf)	Calculated Saturation	Calculated Void Ratio	D60	D30	D10	Station:	Offset:	Design Section
B-1	Bulk	0.5	5		CL	A-6 (6)	LOAM				24			30	12	18	54.7									0.127	0.009				
B-1	1	1	3	gray and brown mottled	CL			2.5			22	95.2	116.1																		
B-1	2	5.1	15	brown	CL																										
B-2	Bulk	2	6		CL																										
B-2	2	6	12	brown	SP																										
B-2	3	12	15	brown	CL																										
B-3		0	2		Topsoil																										
B-3	2	2	4	brown	CL																										
B-3	3	4	15	brown	CL																										
B-4	Bulk	1.99	5	dark brown and brown	CL	A-6 (14)	CLAY LOAM				29	97.3	114	37	15	22	72.6									0.034	0.003				
B-4	2	2	4	brown	CL			3																							
B-5	1	0.75	1.5	brown	Fill																										
B-5	2	2.3	5	dark brown	CL																										
B-5	3	5	8	brown	CL																										
B-5	4	8	15	brown	CL																										
B-6	1	1	3	dark brown and brown	Fill																										
B-6	2	3.5	5.5	brown	CL	A-6 (10)	LOAM	1.25			18	105.8	124.5	37	15	22	60.8					0.58				0.07	0.006				
B-6	3	8.5	10.5	brown	CL	A-6 (9)	LOAM	3			15	118.1	135.9	33	13	20	60.4	2.5	0.1317	0.0235	0.47	2.55				0.073	0.008				
B-6	5	13	25	gray	CL																										
B-6	4	13.5	15.5	gray	CL																										
B-7	1	0	1		Topsoil																										
B-7	2	3.5	5.5	gray and brown	CL	A-6 (11)	LOAM	3.25						35	13	22	63.8									0.06	0.007				
B-7	3	8.5	10.5	gray and brown	CL	A-6 (9)	LOAM	4.5+			15	118.9	136.3	34	14	20	62.3	4	0.1301	0.0258	0.44	3.1				0.066	0.006				
B-7	4	13.5	15.5	gray and brown	CL	A-6 (11)	LOAM	4.5+			15	119.4	137.4	35	12	23	61.8					3.3				0.068	0.007				
B-7	5	18	25	gray	CL																										
B-8	Bulk	0.5	5		CH	A-7-6 (34)	SILTY CLAY LOAM				31			54	18	36	90.1									0.014					
B-8	1	1	3	brown	Fill			4			16	104.2	121																		
B-8	2	6	12	brown	CL																										
B-8	3	12	15	brown	CL																										
B-9	1	1.5	15	brown	CL																										
B-10	1	0.4	15	brown	CL																										
B-11	Bulk	0.5	5		CL	A-6 (8)	LOAM				18			32	14	18	62.4									0.065	0.006				
B-11	1	1	3	brown	CL			3.25			23	87.2	107.3																		
B-11	2	13	15	gray	CL																										
B-12	1	2.5	4.5	brown	CL-ML	A-4 (0)	SANDY LOAM	2			17	110.3	129	19	13	6	52.8					0.44				0.138	0.015	0.001			
B-12	2	8.5	10.5	brown	ML	A-4 (0)	SANDY LOAM	3.5			18	107.7	127.4	0	0	0	58.8					1.22				0.078	0.036	0.007			
B-12	3	17	20	gray	CL																										
B-13	1	3.5	5.5	brown and gray	CL	A-6 (7)	LOAM	2			16	113.1	130.6	30	13	17	61.7					1.73				0.067	0.007				
B-13	2	8.5	10.5	brown and gray	CL	A-6 (8)	LOAM	3			14	118.3	135.1	33	14	19	60.3					3.01				0.074	0.008				
B-13	3	12	15	brown and gray	CL																										
B-14	1	0	2	brown	CL																										
B-14	2	2	3	brown and gray	CL																										
B-14	3	3.5	5.5	brown	CL	A-6 (10)	LOAM	3			17	115.4	135.6	35	13	22	62.4					1.37				0.063	0.005				
B-14	4	8.5	10.5	brown	CL	A-6 (8)	LOAM	3			15	113.6	131.1	33	14	19	61.1					2.17				0.069	0.006				
B-14	5	17	20	gray	CL																										
B-15	1	0	3	dark brown	CL																										
B-15	2	3.5	5.5	brown	CH	A-7-6 (30)	SILTY CLAY LOAM	2			19	95.3	113.4	53	25	28	94					1.32				0.014	0.001				
B-15	3	8.5	10.5	brown	SM	A-2-4 (0)	SANDY LOAM							0	0	0	22									0.3	0.153	0.003			

ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
●	B-1	0.5	30	12	18	55	CL	SANDY LEAN CLAY
⊠	B-4	2.0	37	15	22	73	CL	LEAN CLAY with SAND
▲	B-6	3.5	37	15	22	61	CL	SANDY LEAN CLAY
★	B-6	8.5	33	13	20	60	CL	SANDY LEAN CLAY
⊙	B-7	3.5	35	13	22	64	CL	SANDY LEAN CLAY
✥	B-7	8.5	34	14	20	62	CL	SANDY LEAN CLAY
○	B-7	13.5	35	12	23	62	CL	SANDY LEAN CLAY
△	B-8	0.5	54	18	36	90	CH	FAT CLAY
⊗	B-11	0.5	32	14	18	62	CL	SANDY LEAN CLAY
⊕	B-12	2.5	19	13	6	53	CL-ML	SANDY SILTY CLAY
□	B-12	8.5	NP	NP	NP	59	ML	SANDY SILT
◉	B-13	3.5	30	13	17	62	CL	SANDY LEAN CLAY
◕	B-13	8.5	33	14	19	60	CL	SANDY LEAN CLAY
☆	B-14	3.5	35	13	22	62	CL	SANDY LEAN CLAY
✣	B-14	8.5	33	14	19	61	CL	SANDY LEAN CLAY
■	B-15	3.5	53	25	28	94	CH	FAT CLAY
◆	B-15	8.5	NP	NP	NP	22	SM	SILTY SAND

PROJECT: US Highway 30 / US Highway 218 Interchange

SITE: S2 Borings
Benton County, Iowa

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

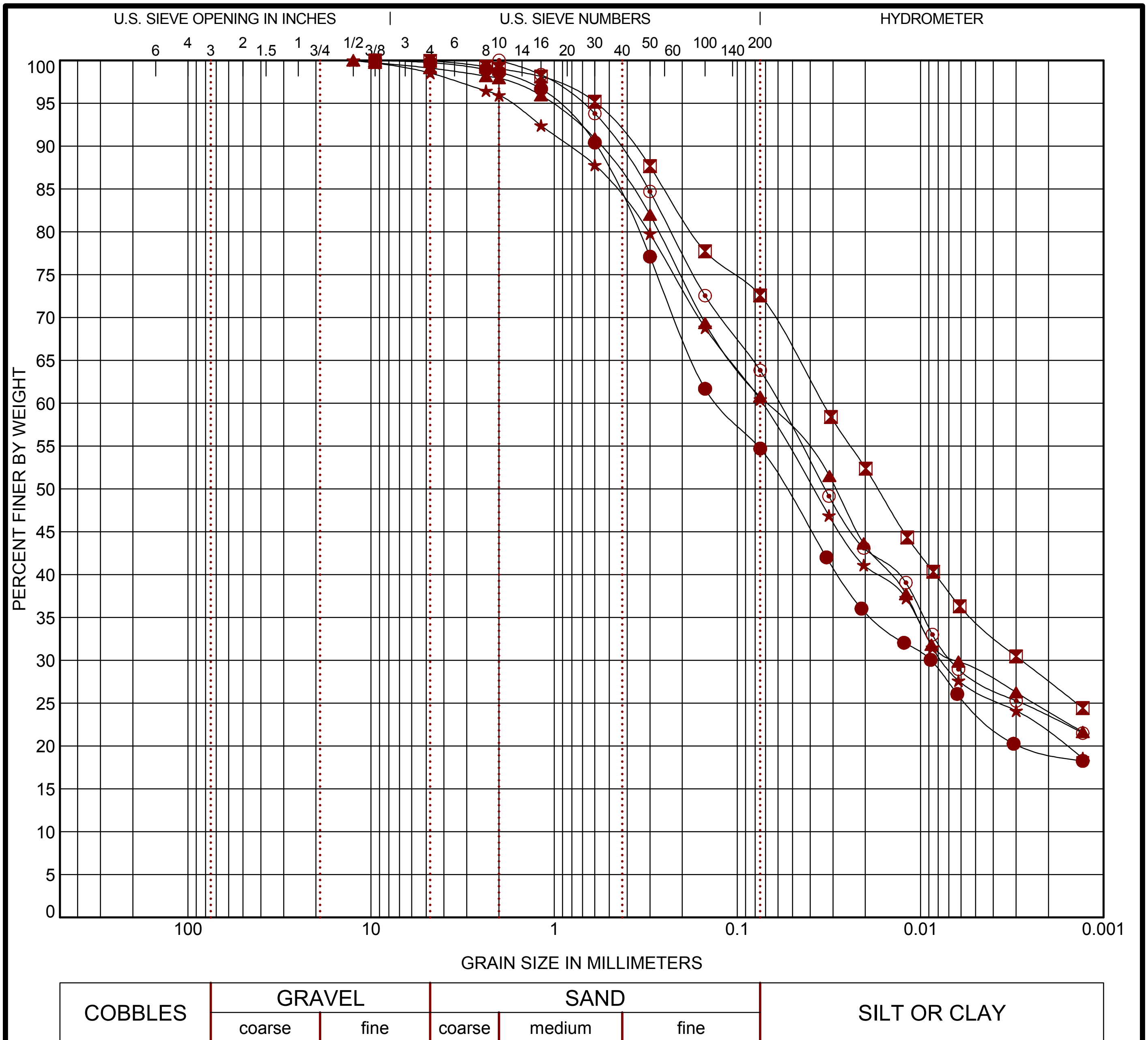
PROJECT NUMBER: D1154514

CLIENT: HDR Engineering, Inc.
Omaha, Nebraska

EXHIBIT: ATT-1

GRAIN SIZE DISTRIBUTION

ASTM D422



	Boring ID	Depth	USCS Classification	LL	PL	PI	Cc	Cu
●	B-1	0.5	SANDY LEAN CLAY(CL)	30	12	18		
⊠	B-4	2.0	LEAN CLAY with SAND(CL)	37	15	22		
▲	B-6	3.5	SANDY LEAN CLAY(CL)	37	15	22		
★	B-6	8.5	SANDY LEAN CLAY(CL)	33	13	20		
⊙	B-7	3.5	SANDY LEAN CLAY(CL)	35	13	22		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Clay
●	B-1	0.5	9.5	0.127	0.009		0.3	45.0	35.4	19.3
⊠	B-4	2.0	9.5	0.034	0.003		0.1	27.4	45.0	27.5
▲	B-6	3.5	12.5	0.07	0.006		0.9	38.3	36.7	24.0
★	B-6	8.5	12.5	0.073	0.008		1.5	38.1	39.0	21.4
⊙	B-7	3.5	2	0.06	0.007		0.0	36.2	40.4	23.4

PROJECT: US Highway 30 / US Highway 218 Interchange

SITE: S2 Borings
Benton County, Iowa

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

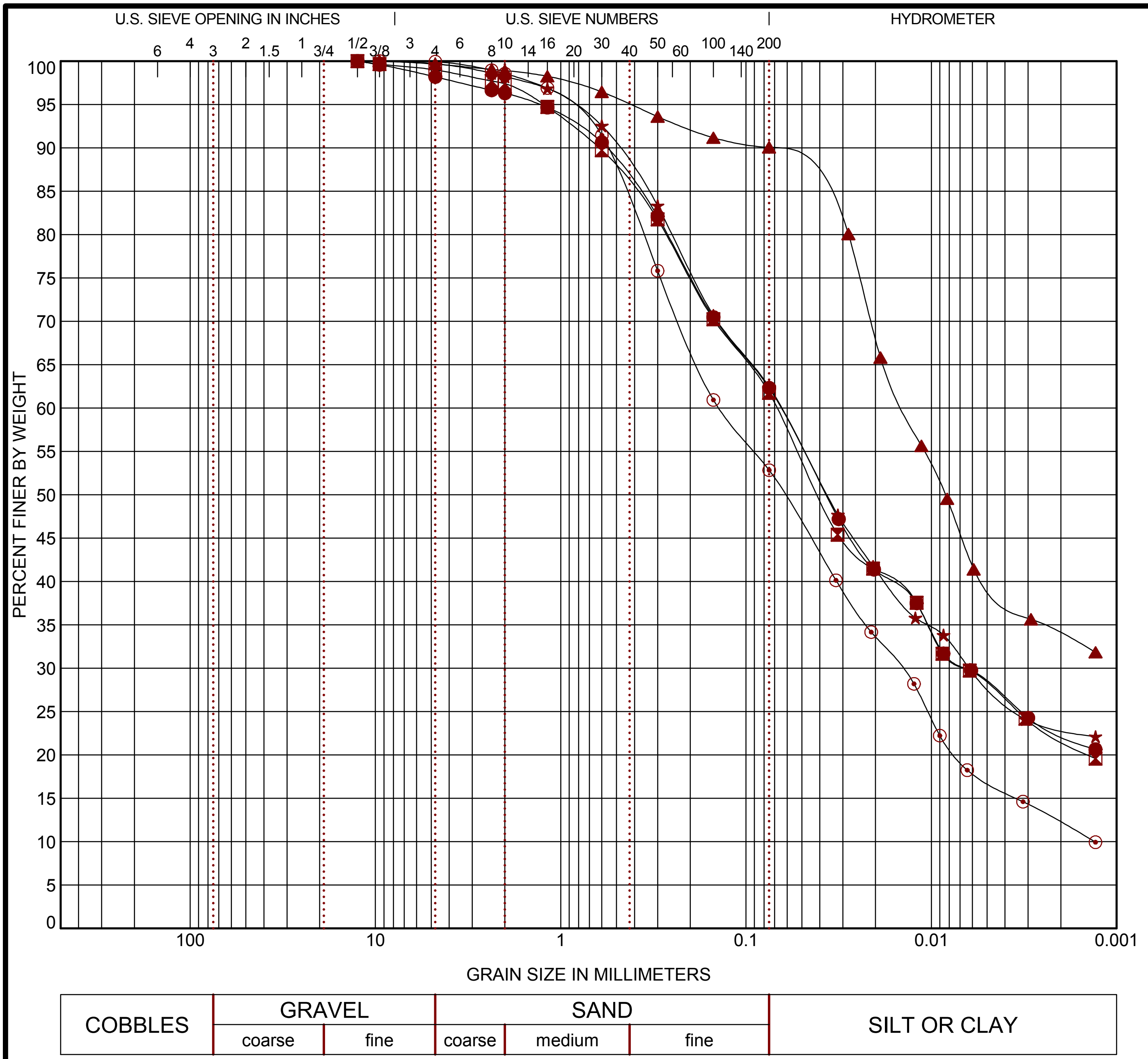
PROJECT NUMBER: D1154514

CLIENT: HDR Engineering, Inc.
Omaha, Nebraska

EXHIBIT: GRAD-1

GRAIN SIZE DISTRIBUTION

ASTM D422



Boring ID		Depth	USCS Classification	LL	PL	PI	Cc	Cu
●	B-7	8.5	SANDY LEAN CLAY(CL)	34	14	20		
⊠	B-7	13.5	SANDY LEAN CLAY(CL)	35	12	23		
▲	B-8	0.5	FAT CLAY(CH)	54	18	36		
★	B-11	0.5	SANDY LEAN CLAY(CL)	32	14	18		
⊙	B-12	2.5	SANDY SILTY CLAY(CL-ML)	19	13	6	1.16	105.22

Boring ID		Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Clay
●	B-7	8.5	12.5	0.066	0.006		1.8	35.9	39.8	22.5
⊠	B-7	13.5	12.5	0.068	0.007		1.0	37.2	39.9	21.9
▲	B-8	0.5	9.5	0.014			0.3	9.6	56.2	33.9
★	B-11	0.5	9.5	0.065	0.006		0.3	37.3	39.3	23.1
⊙	B-12	2.5	9.5	0.138	0.015	0.001	0.1	47.1	40.7	12.2

PROJECT: US Highway 30 / US Highway 218 Interchange

SITE: S2 Borings
Benton County, Iowa

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

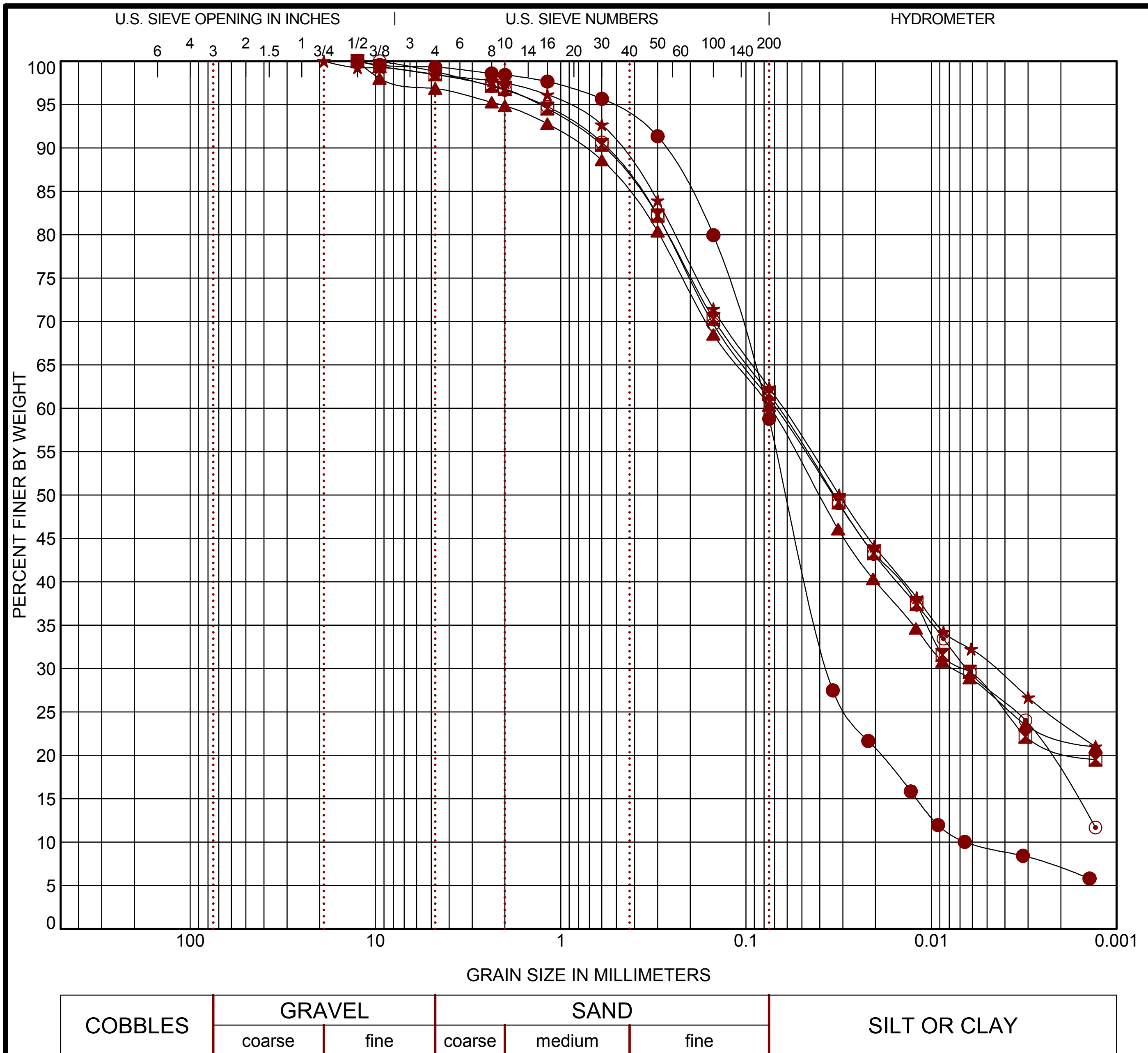
PROJECT NUMBER: D1154514

CLIENT: HDR Engineering, Inc.
Omaha, Nebraska

EXHIBIT: GRAD-2

GRAIN SIZE DISTRIBUTION

ASTM D422



Boring ID	Depth	USCS Classification	LL	PL	PI	Cc	Cu
● B-12	8.5	SANDY SILT(ML)	NP	NP	NP	2.58	11.95
⊠ B-13	3.5	SANDY LEAN CLAY(CL)	30	13	17		
▲ B-13	8.5	SANDY LEAN CLAY(CL)	33	14	19		
★ B-14	3.5	SANDY LEAN CLAY(CL)	35	13	22		
⊙ B-14	8.5	SANDY LEAN CLAY(CL)	33	14	19		

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Clay
● B-12	8.5	12.5	0.078	0.036	0.007	0.7	40.5	51.9	6.9
⊠ B-13	3.5	12.5	0.067	0.007		1.5	36.8	40.8	20.8
▲ B-13	8.5	12.5	0.074	0.008		3.2	36.6	38.1	22.2
★ B-14	3.5	19	0.063	0.005		1.6	36.1	38.5	23.9
⊙ B-14	8.5	9.5	0.069	0.006		1.2	37.7	43.3	17.8

PROJECT: US Highway 30 / US Highway 218 Interchange

SITE: S2 Borings
Benton County, Iowa

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

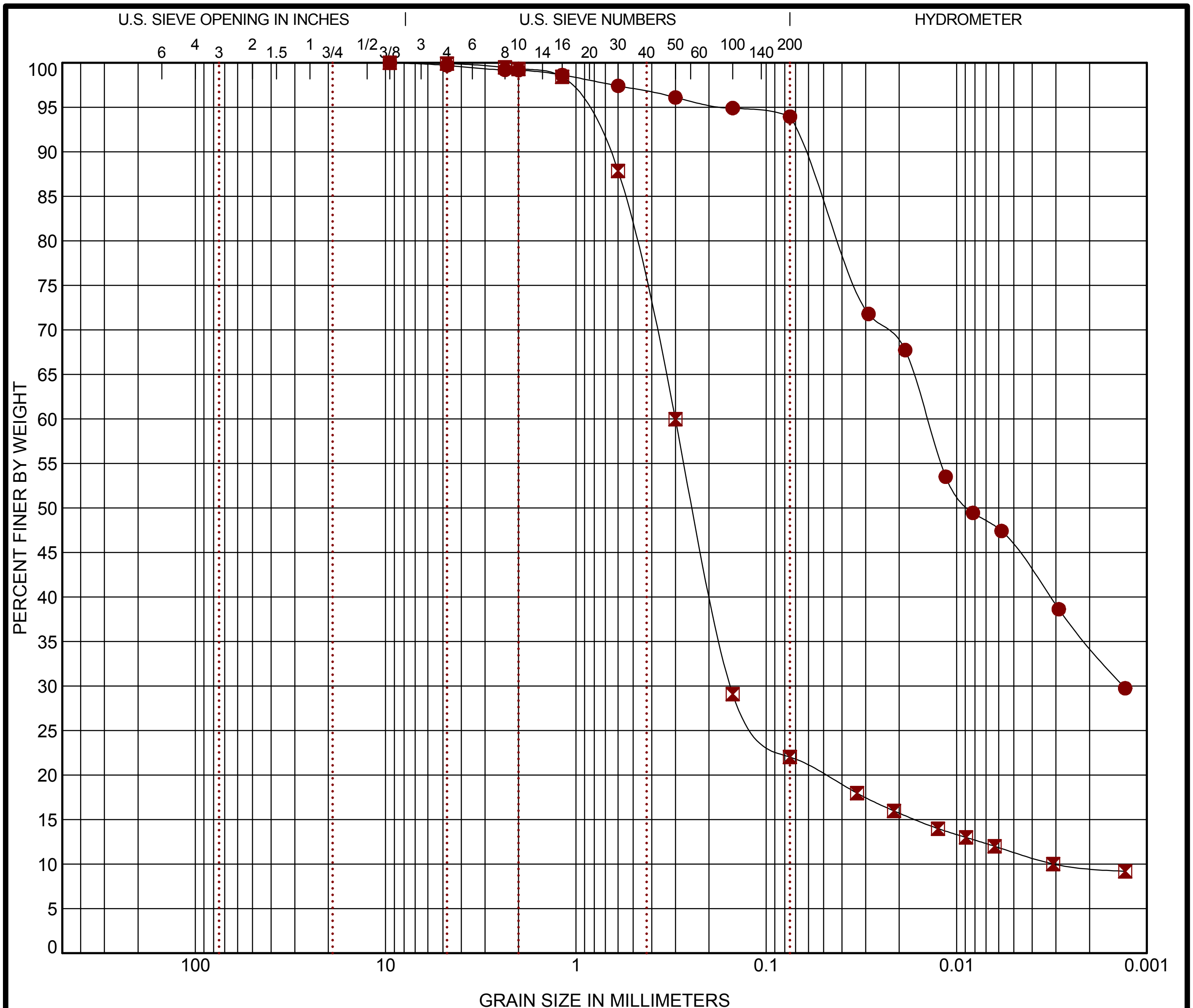
PROJECT NUMBER: D1154514

CLIENT: HDR Engineering, Inc.
Omaha, Nebraska

EXHIBIT: GRAD-3

GRAIN SIZE DISTRIBUTION

ASTM D422



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	LL	PL	PI	Cc	Cu
●	B-15	3.5	FAT CLAY(CH)	53	25	28		
⊠	B-15	8.5	SILTY SAND(SM)	NP	NP	NP	25.49	98.06

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Clay
●	B-15	3.5	9.5	0.014	0.001		0.3	5.8	59.4	34.5
⊠	B-15	8.5	9.5	0.3	0.153	0.003	0.1	77.9	12.4	9.6

PROJECT: US Highway 30 / US Highway 218 Interchange

SITE: S2 Borings
Benton County, Iowa

Terracon
2640 12th Street SW
Cedar Rapids, Iowa

PROJECT NUMBER: D1154514

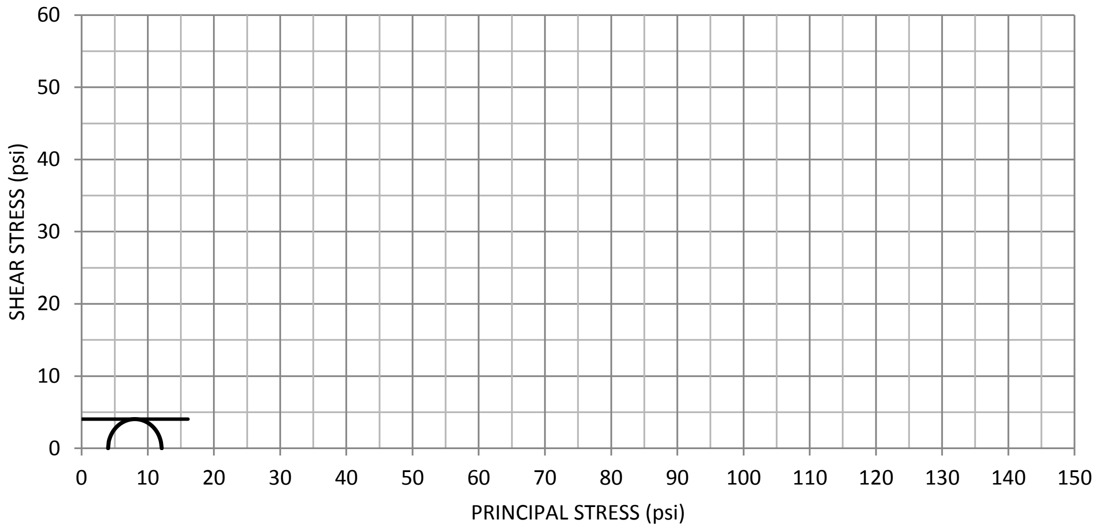
CLIENT: HDR Engineering, Inc.
Omaha, Nebraska

EXHIBIT: GRAD-4

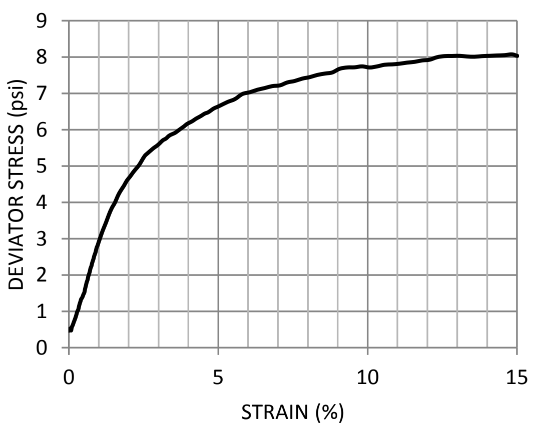
UNCONSOLIDATED UNDRAINED TRIAXIAL SHEAR TEST

ASTM D 2850

Terracon



TOTAL STRESS PARAMETERS	Φ = 0.0 degrees	c = 4.04 psi



SPECIMEN No.	Test 1	Test 2	Test 3
INITIAL DATA			
Moisture Content (%)	17.7		
Dry Density (pcf)	106.0		
Sample Diameter (in)	2.87		
Sample Height (in)	5.72		
TEST DATA			
Identifier Color			
Failure Stress (psi)	8.07		
Strain Rate (in/min)	0.0572		
Cell pressure (psi)	4.00		
Failure Strain (%)	14.83		
σ_1 at Failure (psi)	12.07		
σ_3 at Failure (psi)	4.00		

SAMPLE INFORMATION

Soil Type	SANDY LEAN CLAY, trace gravel, light olive brown (2.5Y 5/6)
Boring No.	6
Sample No.	2
Depth (ft)	4.5
Assumed SG	2.70

LL = 37 PL = 15 PI = 22

% Passing #200 = 61

Misc.:

PROJECT INFORMATION

Project Name	US Highway 30/ US Highway 218 Interchange
Location	Cedar Rapids, Iowa
Terracon Project No.	D1154514
Client	HDR
Date	12/17/2015

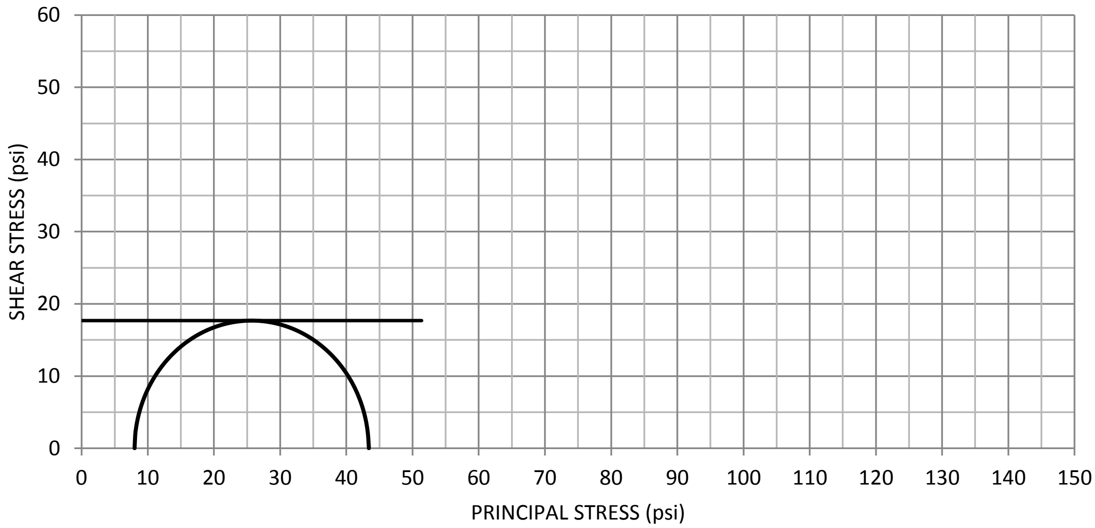
Comments:
Recovery: 13" QP: 1.25

Terracon
2640 12th Street SW

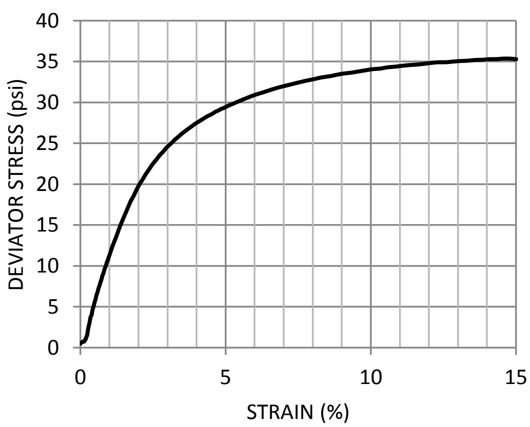
EXHIBIT UU - 1

UNCONSOLIDATED UNDRAINED TRIAXIAL SHEAR TEST

ASTM D 2850



TOTAL STRESS PARAMETERS	Φ = 0.0 degrees	c = 17.68 psi



SPECIMEN No.	Test 1	Test 2	Test 3
INITIAL DATA			
Moisture Content (%)	15.0		
Dry Density (pcf)	118.4		
Sample Diameter (in)	2.87		
Sample Height (in)	5.72		
TEST DATA			
Identifier Color			
Failure Stress (psi)	35.37		
Strain Rate (in/min)	0.0572		
Cell pressure (psi)	8.00		
Failure Strain (%)	14.59		
σ_1 at Failure (psi)	43.37		
σ_3 at Failure (psi)	8.00		

SAMPLE INFORMATION

Soil Type	SANDY LEAN CLAY, trace gravel, olive brown (2.5Y 4/4)
Boring No.	6
Sample No.	3
Depth (ft)	9.5
Assumed SG	2.70
LL = 33 PL = 13 PI = 20	
% Passing #200 = 60	
Misc.:	

PROJECT INFORMATION

Project Name	US Highway 30/ US Highway 218 Interchange
Location	Cedar Rapids, Iowa
Terracon Project No.	D1154514
Client	HDR
Date	12/17/2015

Comments:
Recovery: 18" QP: 3.0

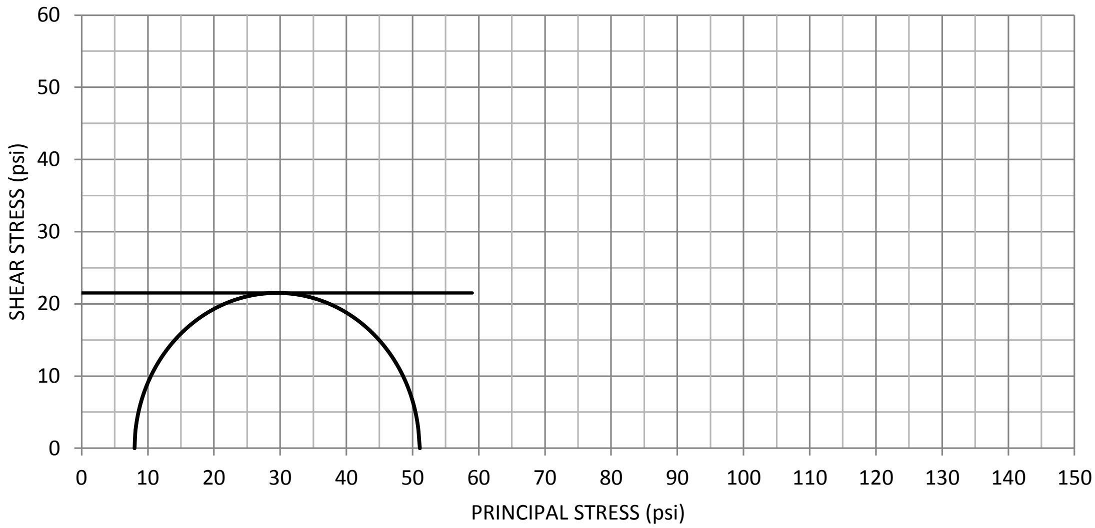
2640 12th Street SW

EXHIBIT UU-2

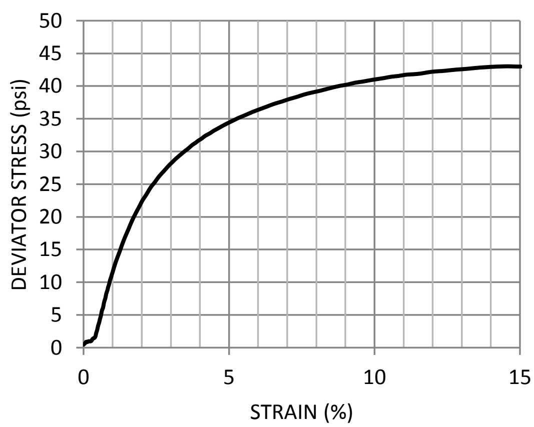
UNCONSOLIDATED UNDRAINED TRIAXIAL SHEAR TEST

ASTM D 2850

Terracon



TOTAL STRESS PARAMETERS	Φ = 0.0 degrees	c = 21.51 psi



SPECIMEN No.	Test 1	Test 2	Test 3
INITIAL DATA			
Moisture Content (%)	14.6		
Dry Density (pcf)	119.2		
Sample Diameter (in)	2.87		
Sample Height (in)	5.72		
TEST DATA			
Identifier Color			
Failure Stress (psi)	43.03		
Strain Rate (in/min)	0.0572		
Cell pressure (psi)	8.00		
Failure Strain (%)	14.59		
σ_1 at Failure (psi)	51.03		
σ_3 at Failure (psi)	8.00		

SAMPLE INFORMATION

Soil Type	SANDY LEAN CLAY, trace gravel, light olive brown, (2.5Y 5/6)
Boring No.	7
Sample No.	3
Depth (ft)	9.5
Assumed SG	2.70

LL = 34 PL = 14 PI = 20

% Passing #200 = 62

Misc.:

PROJECT INFORMATION

Project Name	US Highway 30/ US Highway 218 Interchange
Location	Cedar Rapids, Iowa
Terracon Project No.	D1154514
Client	HDR
Date	12/17/2015

Comments:
Recovery: 19" QP: 4.5+

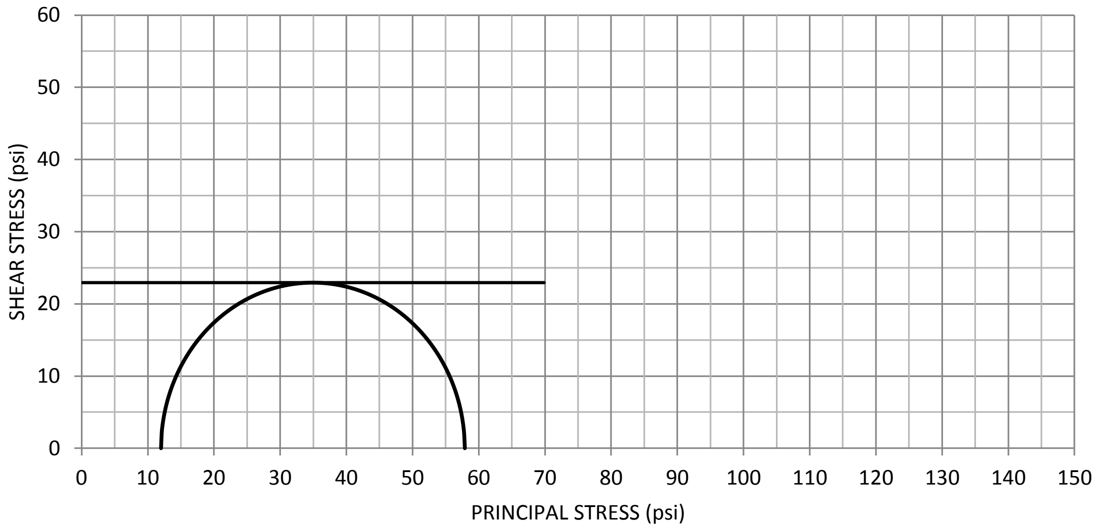
Terracon
2640 12th Street SW

EXHIBIT UU - 3

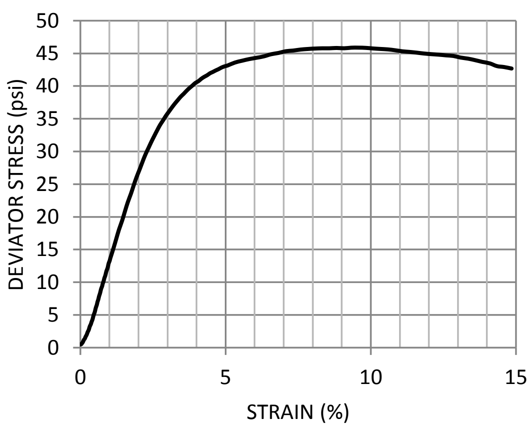
UNCONSOLIDATED UNDRAINED TRIAXIAL SHEAR TEST

ASTM D 2850

Terracon



TOTAL STRESS PARAMETERS	Φ = 0.0 degrees	c = 22.94 psi



SPECIMEN No.	Test 1	Test 2	Test 3
INITIAL DATA			
Moisture Content (%)	15.0		
Dry Density (pcf)	119.7		
Sample Diameter (in)	2.87		
Sample Height (in)	5.72		
TEST DATA			
Identifier Color			
Failure Stress (psi)	45.88		
Strain Rate (in/min)	0.0572		
Cell pressure (psi)	12.00		
Failure Strain (%)	9.58		
σ_1 at Failure (psi)	57.88		
σ_3 at Failure (psi)	12.00		

SAMPLE INFORMATION

Soil Type	SANDY LEAN CLAY, trace gravel, light olive brown (2.5Y 5/3)
Boring No.	7
Sample No.	4
Depth (ft)	14.5
Assumed SG	2.70

LL = 35 PL = 12 PI = 23

% Passing #200 = 62

Misc.:

PROJECT INFORMATION

Project Name	US Highway 30/ US Highway 218 Interchange
Location	Cedar Rapids, Iowa
Terracon Project No.	D1154514
Client	HDR
Date	12/16/2015

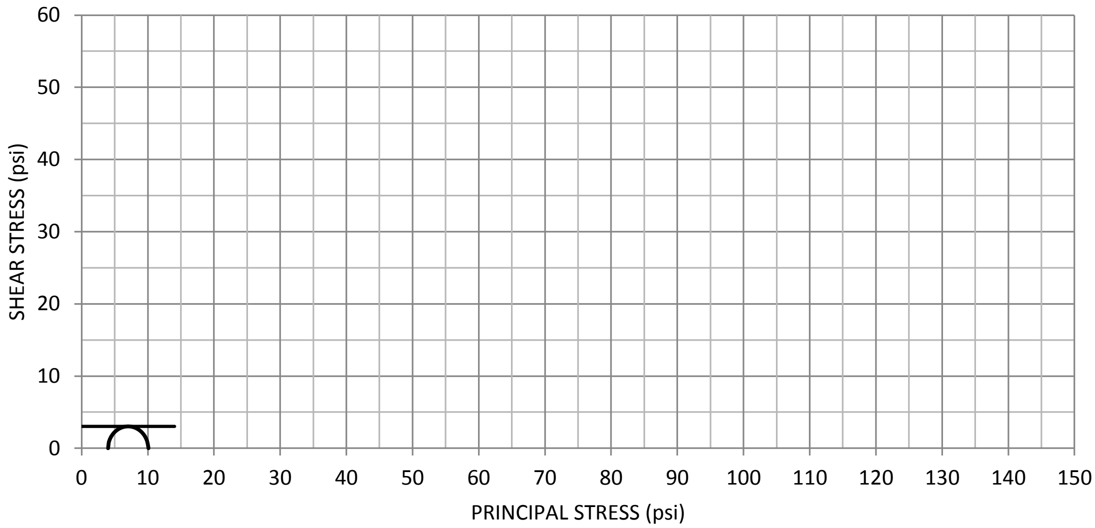
Comments:
Recovery: 21" QP: 4.5+

Terracon
2640 12th Street SW

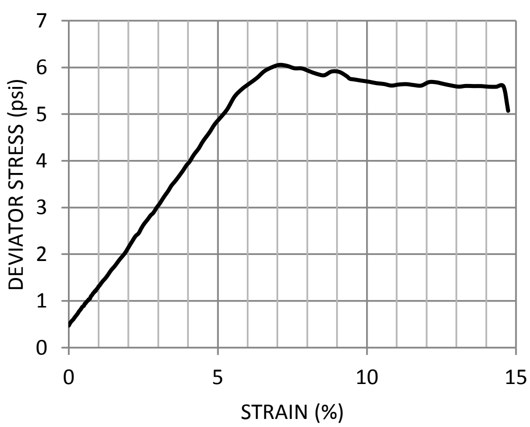
EXHIBIT UU - 4

UNCONSOLIDATED UNDRAINED TRIAXIAL SHEAR TEST

ASTM D 2850



TOTAL STRESS PARAMETERS	Φ = 0.0 degrees	c = 3.03 psi



SPECIMEN No.	Test 1	Test 2	Test 3
INITIAL DATA			
Moisture Content (%)	16.9		
Dry Density (pcf)	110.6		
Sample Diameter (in)	2.87		
Sample Height (in)	5.72		
TEST DATA			
Identifier Color			
Failure Stress (psi)	6.05		
Strain Rate (in/min)	0.0572		
Cell pressure (psi)	4.00		
Failure Strain (%)	7.06		
σ_1 at Failure (psi)	10.05		
σ_3 at Failure (psi)	4.00		

SAMPLE INFORMATION

Soil Type	SANDY SILTY CLAY, light olive brown (2.5Y 5/4)
Boring No.	12
Sample No.	1
Depth (ft)	3.5
Assumed SG	2.70
LL = 19 PL = 13 PI = 6	
% Passing #200 = 53	
Misc.:	

PROJECT INFORMATION

Project Name	US Highway 30/ US Highway 218 Interchange
Location	Cedar Rapids, Iowa
Terracon Project No.	D1154514
Client	HDR
Date	12/16/2015

Comments:
Recovery: 24" QP: 2.0

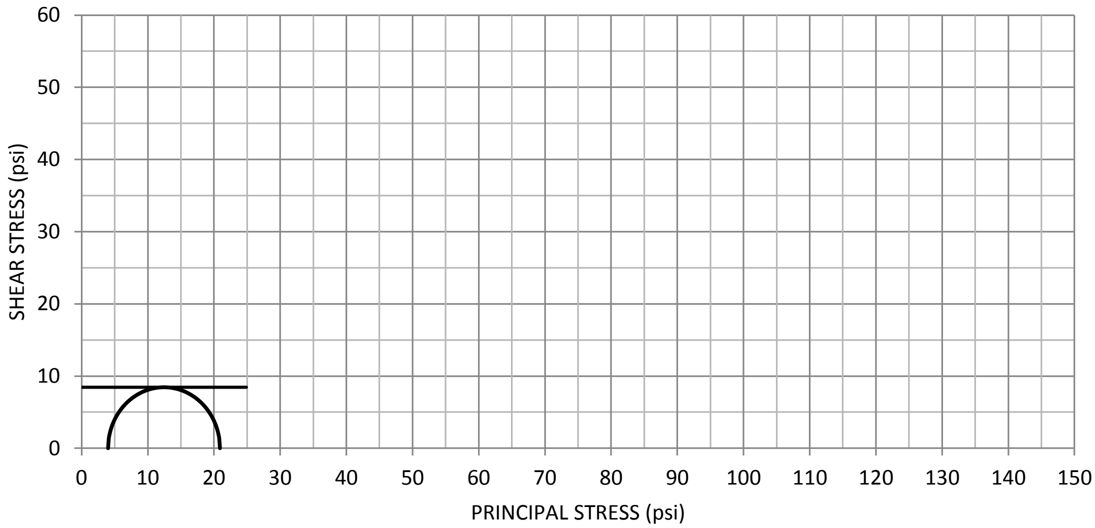
2640 12th Street SW

EXHIBIT UU - 5

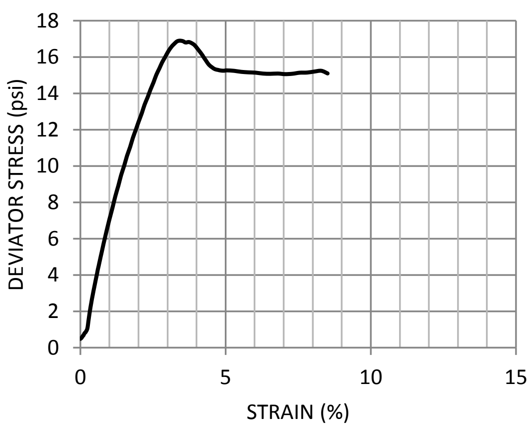
UNCONSOLIDATED UNDRAINED TRIAXIAL SHEAR TEST

ASTM D 2850

Terracon



TOTAL STRESS PARAMETERS	Φ = 0.0 degrees	c = 8.45 psi



SPECIMEN No.	Test 1	Test 2	Test 3
INITIAL DATA			
Moisture Content (%)	18.3		
Dry Density (pcf)	107.9		
Sample Diameter (in)	2.87		
Sample Height (in)	5.72		
TEST DATA			
Identifier Color	black	red	green
Failure Stress (psi)	16.90		
Strain Rate (in/min)	0.0572		
Cell pressure (psi)	4.00		
Failure Strain (%)	3.42		
σ_1 at Failure (psi)	20.90		
σ_3 at Failure (psi)	4.00		

SAMPLE INFORMATION

Soil Type	SANDY SILT, light olive brown (2.5Y 5/6)
Boring No.	12
Sample No.	2
Depth (ft)	9.5
Assumed SG	2.70
LL = NP PL = NP PI = NP	
% Passing #200 = 59	
Misc.:	

PROJECT INFORMATION

Project Name	US Highway 30/ US Highway 218 Interchange
Location	Cedar Rapids, Iowa
Terracon Project No.	D1154514
Client	HDR
Date	12/16/2015

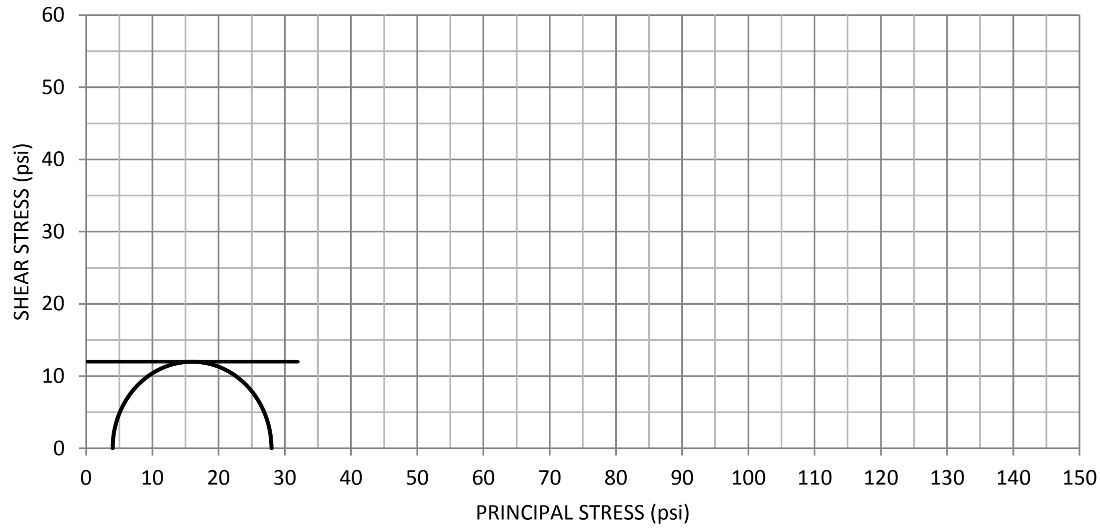
Comments:
Recovery: 22" QP: 3.5

Terracon
2640 12th Street SW

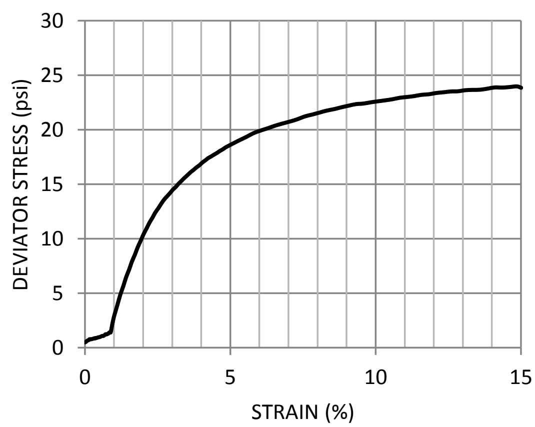
EXHIBIT UU - 6

UNCONSOLIDATED UNDRAINED TRIAXIAL SHEAR TEST

ASTM D 2850



TOTAL STRESS PARAMETERS	Φ = 0.0 degrees	c = 11.99 psi



SPECIMEN No.	Test 1	Test 2	Test 3
INITIAL DATA			
Moisture Content (%)	15.5		
Dry Density (pcf)	113.3		
Sample Diameter (in)	2.87		
Sample Height (in)	5.72		
TEST DATA			
Identifier Color			
Failure Stress (psi)	23.97		
Strain Rate (in/min)	0.0572		
Cell pressure (psi)	4.00		
Failure Strain (%)	14.86		
σ_1 at Failure (psi)	27.97		
σ_3 at Failure (psi)	4.00		

SAMPLE INFORMATION

Soil Type	SANDY LEAN CLAY, trace gravel, light olive brown (2.5Y 5/4)
Boring No.	13
Sample No.	1
Depth (ft)	3.5
Assumed SG	2.70

LL = 30 PL = 13 PI = 17

% Passing #200 = 62

Misc.:

PROJECT INFORMATION

Project Name	US Highway 30/ US Highway 218 Interchange
Location	Cedar Rapids, Iowa
Terracon Project No.	D1154514
Client	HDR
Date	12/17/2015

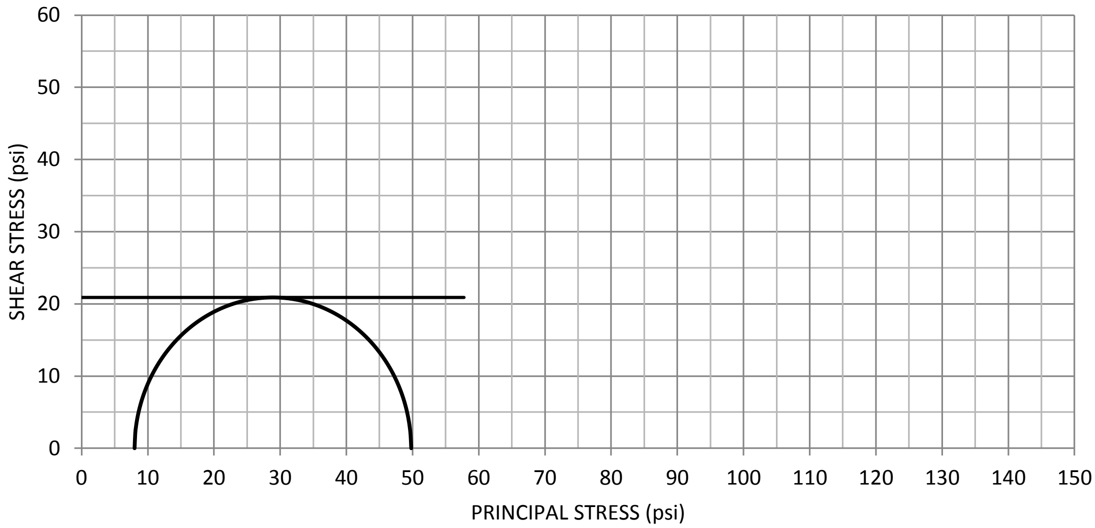
Comments:
Recovery: 15" QP: 2.0

2640 12th Street SW

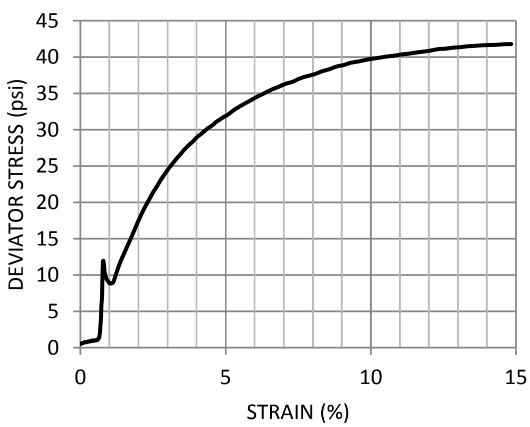
EXHIBIT UU - 7

UNCONSOLIDATED UNDRAINED TRIAXIAL SHEAR TEST

ASTM D 2850



TOTAL STRESS PARAMETERS	Φ = 0.0 degrees	c = 20.89 psi



SPECIMEN No.	Test 1	Test 2	Test 3
INITIAL DATA			
Moisture Content (%)	14.2		
Dry Density (pcf)	118.6		
Sample Diameter (in)	2.87		
Sample Height (in)	5.72		
TEST DATA			
Identifier Color			
Failure Stress (psi)	41.78		
Strain Rate (in/min)	0.0572		
Cell pressure (psi)	8.00		
Failure Strain (%)	14.84		
σ_1 at Failure (psi)	49.78		
σ_3 at Failure (psi)	8.00		

SAMPLE INFORMATION

Soil Type	SANDY LEAN CLAY, trace gravel, olive yellow (2.5Y 6/6)
Boring No.	13
Sample No.	2
Depth (ft)	9.5
Assumed SG	2.70
LL = 33 PL = 14 PI = 19	
% Passing #200 = 60	
Misc.:	

PROJECT INFORMATION

Project Name	US Highway 30/ US Highway 218 Interchange
Location	Cedar Rapids, Iowa
Terracon Project No.	D1154514
Client	HDR
Date	12/16/2015

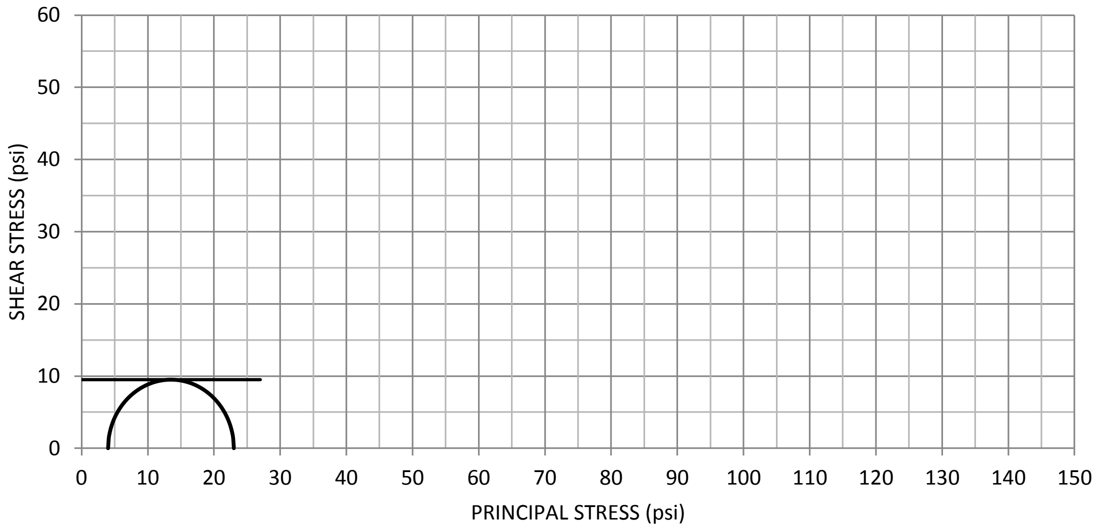
Comments:
Recovery: 16" QP: 3.0

2640 12th Street SW

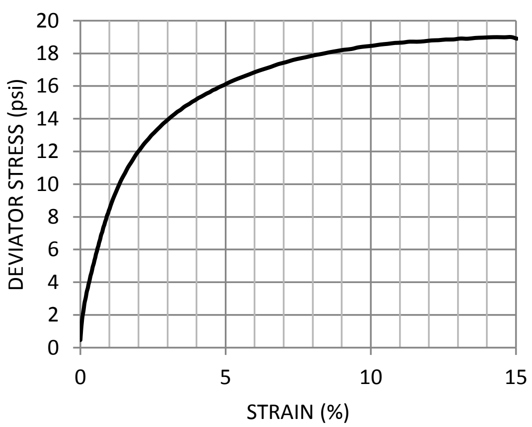
EXHIBIT UU -8

UNCONSOLIDATED UNDRAINED TRIAXIAL SHEAR TEST

ASTM D 2850



TOTAL STRESS PARAMETERS	Φ = 0.0 degrees	c = 9.50 psi



SPECIMEN No.	Test 1	Test 2	Test 3
INITIAL DATA			
Moisture Content (%)	17.5		
Dry Density (pcf)	115.6		
Sample Diameter (in)	2.87		
Sample Height (in)	5.72		
TEST DATA			
Identifier Color			
Failure Stress (psi)	19.00		
Strain Rate (in/min)	0.0572		
Cell pressure (psi)	4.00		
Failure Strain (%)	14.84		
σ_1 at Failure (psi)	23.00		
σ_3 at Failure (psi)	4.00		

SAMPLE INFORMATION

Soil Type	SANDY LEAN CLAY, trace gravel, olive brown (2.5Y 4/4)
Boring No.	14
Sample No.	3
Depth (ft)	4.5
Assumed SG	2.70

LL = 35 PL = 13 PI = 22

% Passing #200 = 62

Misc.:

PROJECT INFORMATION

Project Name	US Highway 30/ US Highway 218 Interchange
Location	Cedar Rapids, Iowa
Terracon Project No.	D1154514
Client	HDR
Date	12/17/2015

Comments:
Recovery: 20" QP: 3.0

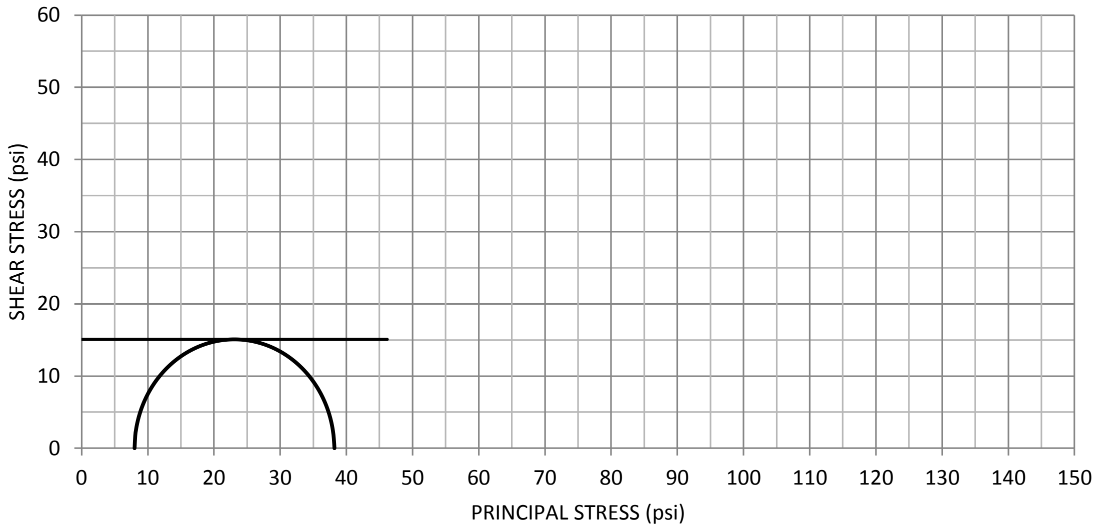
Terracon
2640 12th Street SW

EXHIBIT UU - 9

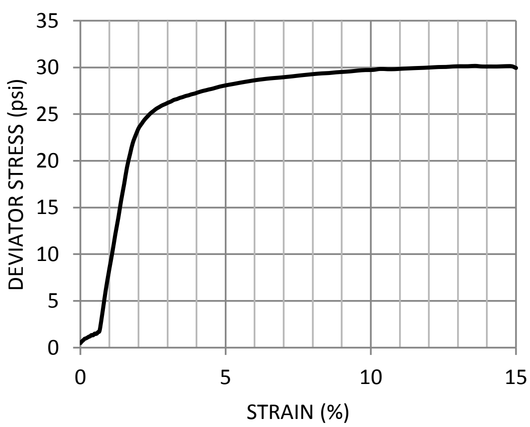
UNCONSOLIDATED UNDRAINED TRIAXIAL SHEAR TEST

Terracon

ASTM D 2850



TOTAL STRESS PARAMETERS	**Φ = 0.0 degrees**	**c = 15.08 psi**



SPECIMEN No.	Test 1	Test 2	Test 3
INITIAL DATA			
Moisture Content (%)	15.3		
Dry Density (pcf)	113.9		
Sample Diameter (in)	2.87		
Sample Height (in)	5.72		
TEST DATA			
Identifier Color			
Failure Stress (psi)	30.16		
Strain Rate (in/min)	0.0572		
Cell pressure (psi)	8.00		
Failure Strain (%)	13.59		
σ_1 at Failure (psi)	38.16		
σ_3 at Failure (psi)	8.00		

SAMPLE INFORMATION

Soil Type	SANDY LEAN CLAY, trace gravel, light olive brown (2.5Y 5/4)
Boring No.	14
Sample No.	4
Depth (ft)	9.5
Assumed SG	2.70

LL = 33 PL = 14 PI = 19

% Passing #200 = 61

Misc.:

PROJECT INFORMATION

Project Name	US Highway 30/ US Highway 218 Interchange
Location	Cedar Rapids, Iowa
Terracon Project No.	D1154514
Client	HDR
Date	12/16/2015

Comments:
Recovery: 16" QP: 3.0

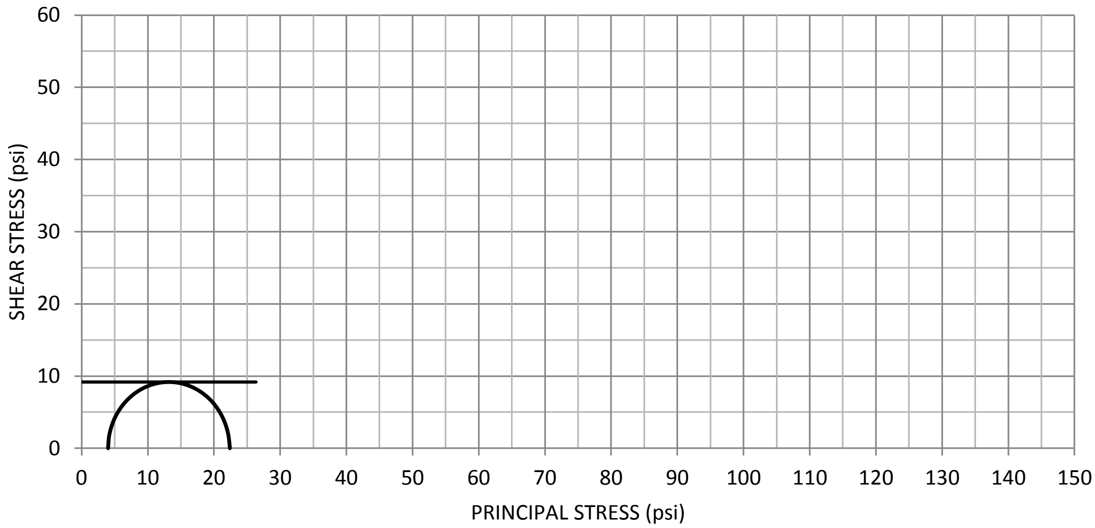
Terracon
2640 12th Street SW

EXHIBIT UU - 10

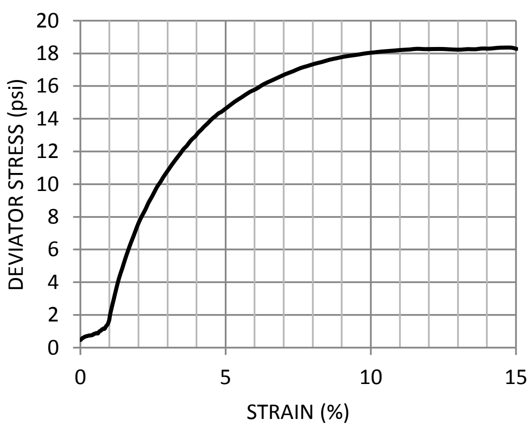
UNCONSOLIDATED UNDRAINED TRIAXIAL SHEAR TEST

ASTM D 2850

Terracon



TOTAL STRESS PARAMETERS	Φ = 0.0 degrees	c = 9.18 psi



SPECIMEN No.	Test 1	Test 2	Test 3
INITIAL DATA			
Moisture Content (%)	19.0		
Dry Density (pcf)	95.5		
Sample Diameter (in)	2.87		
Sample Height (in)	5.72		
TEST DATA			
Identifier Color			
Failure Stress (psi)	18.35		
Strain Rate (in/min)	0.0572		
Cell pressure (psi)	4.00		
Failure Strain (%)	14.58		
σ_1 at Failure (psi)	22.35		
σ_3 at Failure (psi)	4.00		

SAMPLE INFORMATION

Soil Type	FAT CLAY, trace sand, very dark grayish brown (2.5Y 3/2)
Boring No.	15
Sample No.	2
Depth (ft)	4.5
Assumed SG	2.70
LL = 53 PL = 25 PI = 28	
% Passing #200 = 94	
Misc.:	

PROJECT INFORMATION

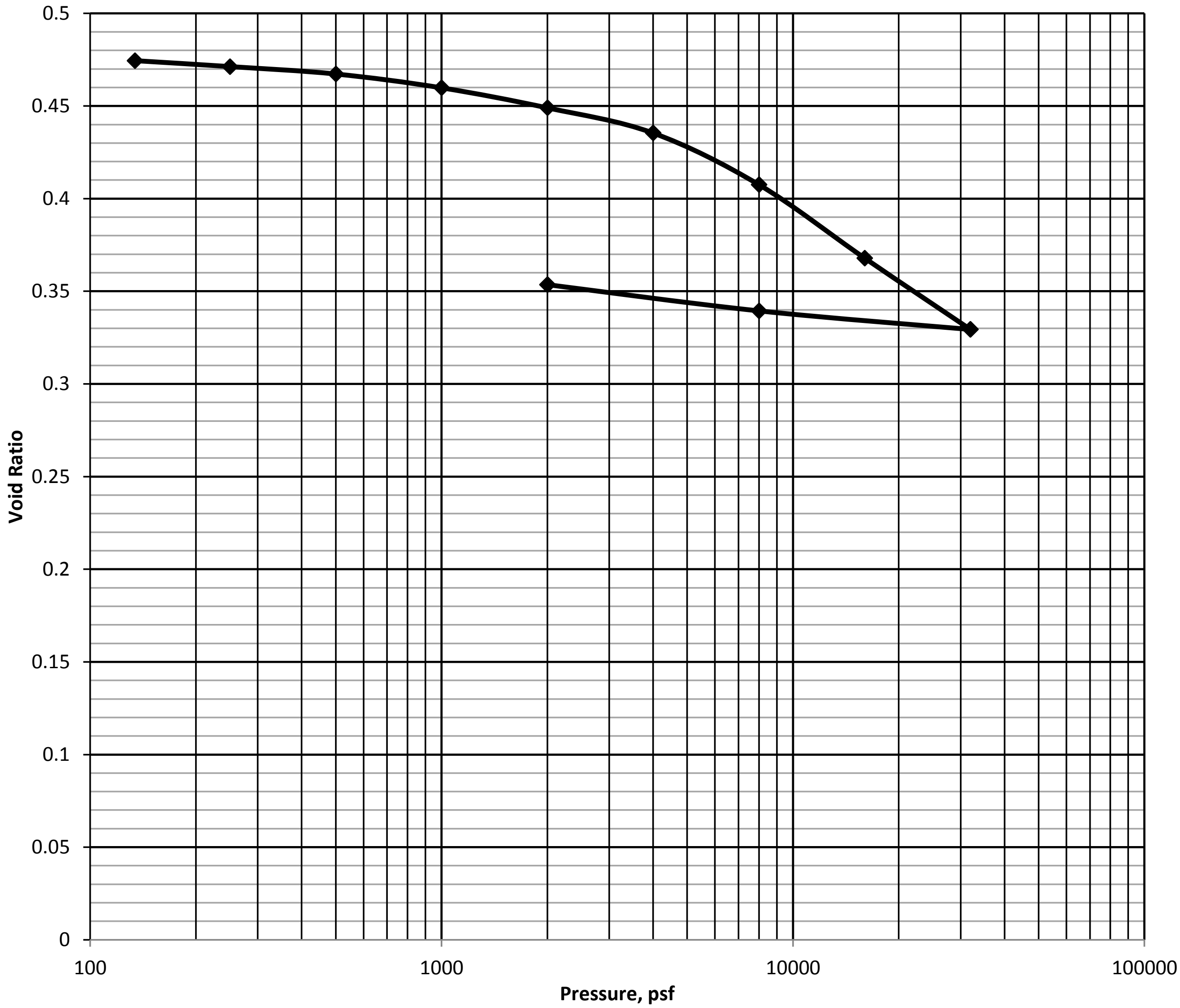
Project Name	US Highway 30/ US Highway 218 Interchange
Location	Cedar Rapids, Iowa
Terracon Project No.	D1154514
Client	HDR
Date	12/17/2015

Comments:
Recovery: 10" QP: 2.0

Terracon
2640 12th Street SW

EXHIBIT UU - 11

ONE-DIMENSIONAL CONSOLIDATION TEST
ASTM D 2435



DIAMETER, mm	63.5	HEIGHT, mm	25.4		BEFORE TEST		AFTER TEST
OVERBURDEN PRESSURE, psf		1140		MOISTURE, %	15.5		14.0
PRECONSOLIDATION PRESSURE, psf		5000		DRY DENSITY, pcf	114.3		124.5
				SATURATION, %	88.2		
COMPRESSION INDEX, Cc		0.1317		VOID RATIO	0.47		0.35
RECOMPRESSION INDEX, Cr		0.0235		SAMPLE TYPE	3" Shelby Tube		
LIQUID LIMIT	33	PLASTIC LIMIT	13	PLASTICITY INDEX	20	SPECIFIC GRAVITY	2.70
SAMPLE DESCRIPTION	SANDY LEAN CLAY, trace gravel, olive brown (2.5Y 4/4)						
BORING NO.	6	SAMPLE NO.		3	SAMPLE DEPTH, feet		9.5
COMMENTS	Recovery- 18" QP- 3.0 Sample Inundated at Beginning						

PROJECT:
HWY 30/ 218 Interchange

SITE:
Cedar Rapids

TESTED BY: AWM
APPROVED BY: 0
DATE: 12/21/2015

Terracon
2640 12th Street SW
Cedar Rapids, Iowa 52404

PROJECT NO.: D1154514

CLIENT: HDR

EXHIBIT: CONSOL -1

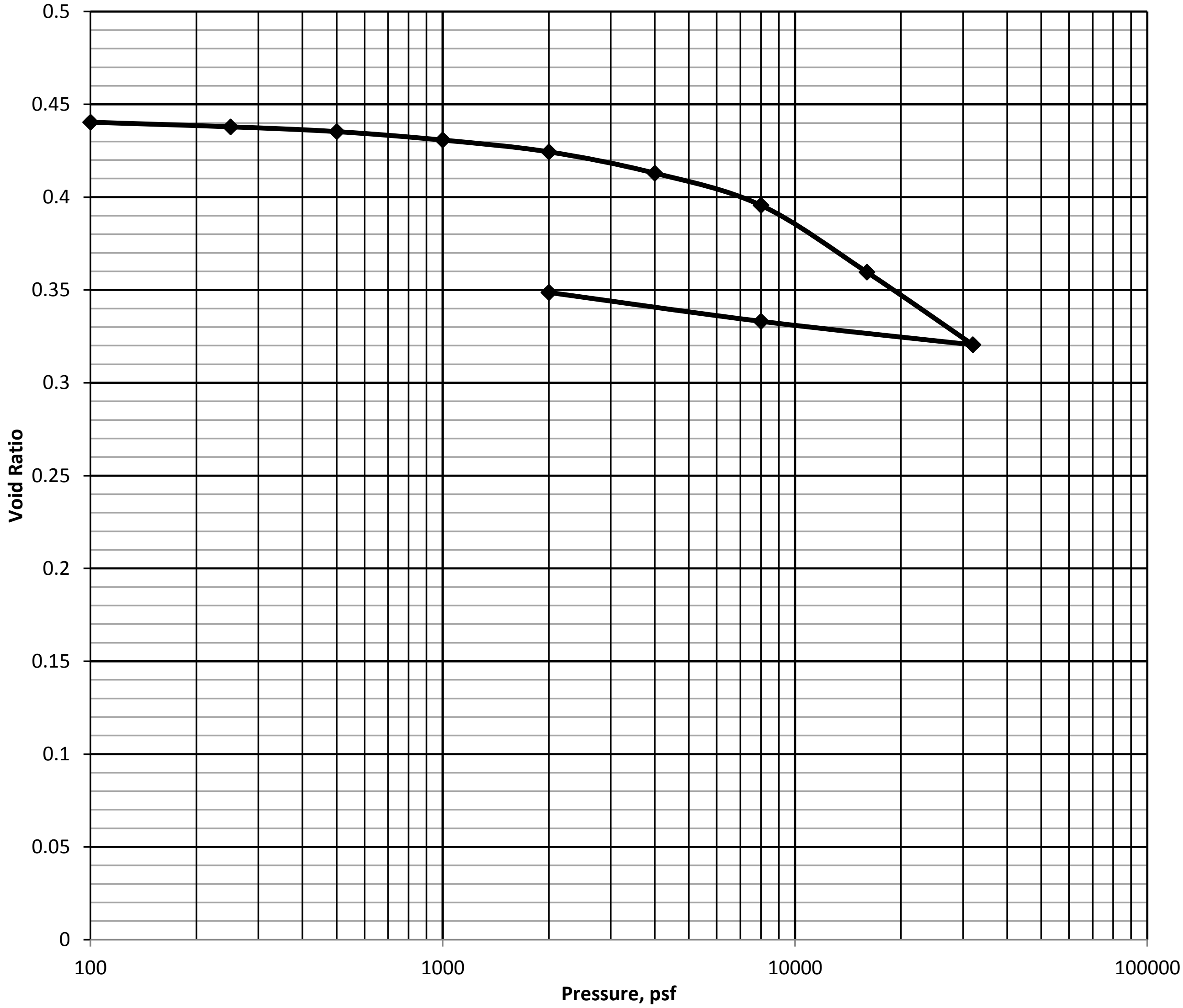
Project	HWY 30/ 218 Interchange
Location	Cedar Rapids
Terracon Project Number	D1154514
Date	12/21/2015

Boring Number	6	
Sample Number	3	
Sample Depth	9.5	feet

Soil Description	SANDY LEAN CLAY, trace gravel, olive brown (2.5Y 4/4)	
Liquid Limit	33	
Plastic Limit	13	
Plasticity Index	20	
Specific Gravity	2.70	assumed

Load (psf)	t90 (mins)	Avg sample height (inch)	Cv (cm^2/sec)	av cm^2/g	mv cm^2/g	k cm/sec
0		1.0000				
134	0	1.0000	#DIV/0!	-7.25E-03	-4.92E-03	#DIV/0!
250	3.24	0.9989	0.007020	5.64E-05	3.83E-05	2.69E-07
500	6.76	0.9965	0.003348	3.29E-05	2.24E-05	7.50E-08
1000	11.56	0.9926	0.001943	3.05E-05	2.09E-05	4.06E-08
2000	8.41	0.9864	0.002637	2.21E-05	1.53E-05	4.03E-08
4000	16	0.9781	0.001363	1.39E-05	9.70E-06	1.32E-08
8000	19.36	0.9641	0.001094	1.43E-05	1.01E-05	1.11E-08
16000	14.44	0.9412	0.001398	1.01E-05	7.42E-06	1.04E-08
32000	17.64	0.9147	0.001081	4.93E-06	3.71E-06	4.01E-09
8000		0.9050		8.56E-07	6.39E-07	
2000		0.9132		4.83E-06	3.57E-06	
						CONSOL - 1A

ONE-DIMENSIONAL CONSOLIDATION TEST
ASTM D 2435



DIAMETER, mm	63.5	HEIGHT, mm	25.4		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, psf		1140		MOISTURE, %	15.8	13.0
PRECONSOLIDATION PRESSURE, psf		8000		DRY DENSITY, pcf	117.0	124.9
				SATURATION, %	97.1	
COMPRESSION INDEX, Cc		0.1301		VOID RATIO	0.44	0.35
RECOMPRESSION INDEX, Cr		0.0258		SAMPLE TYPE	3" Shelby Tube	
LIQUID LIMIT	34	PLASTIC LIMIT	14	PLASTICITY INDEX	20	SPECIFIC GRAVITY 2.70
SAMPLE DESCRIPTION	SANDY LEAN CLAY, trace gravel, olive brown (2.5Y 4/4)					
BORING NO.	7	SAMPLE NO.	2	SAMPLE DEPTH, feet	9.5	
COMMENTS	Recovery- 19" QP- 4.5+ Sample Inundated at Beginning					

PROJECT:
HWY 30/ 218 Interchange

SITE:
Cedar Rapids

TESTED BY: AWM
APPROVED BY: 0
DATE: 12/21/2015

Terracon
2640 12th Street SW
Cedar Rapids, Iowa 52404

PROJECT NO.: D1154514

CLIENT: HDR

EXHIBIT: CONSOL -2

Project	HWY 30/ 218 Interchange
Location	Cedar Rapids
Terracon Project Number	D1154514
Date	12/21/2015

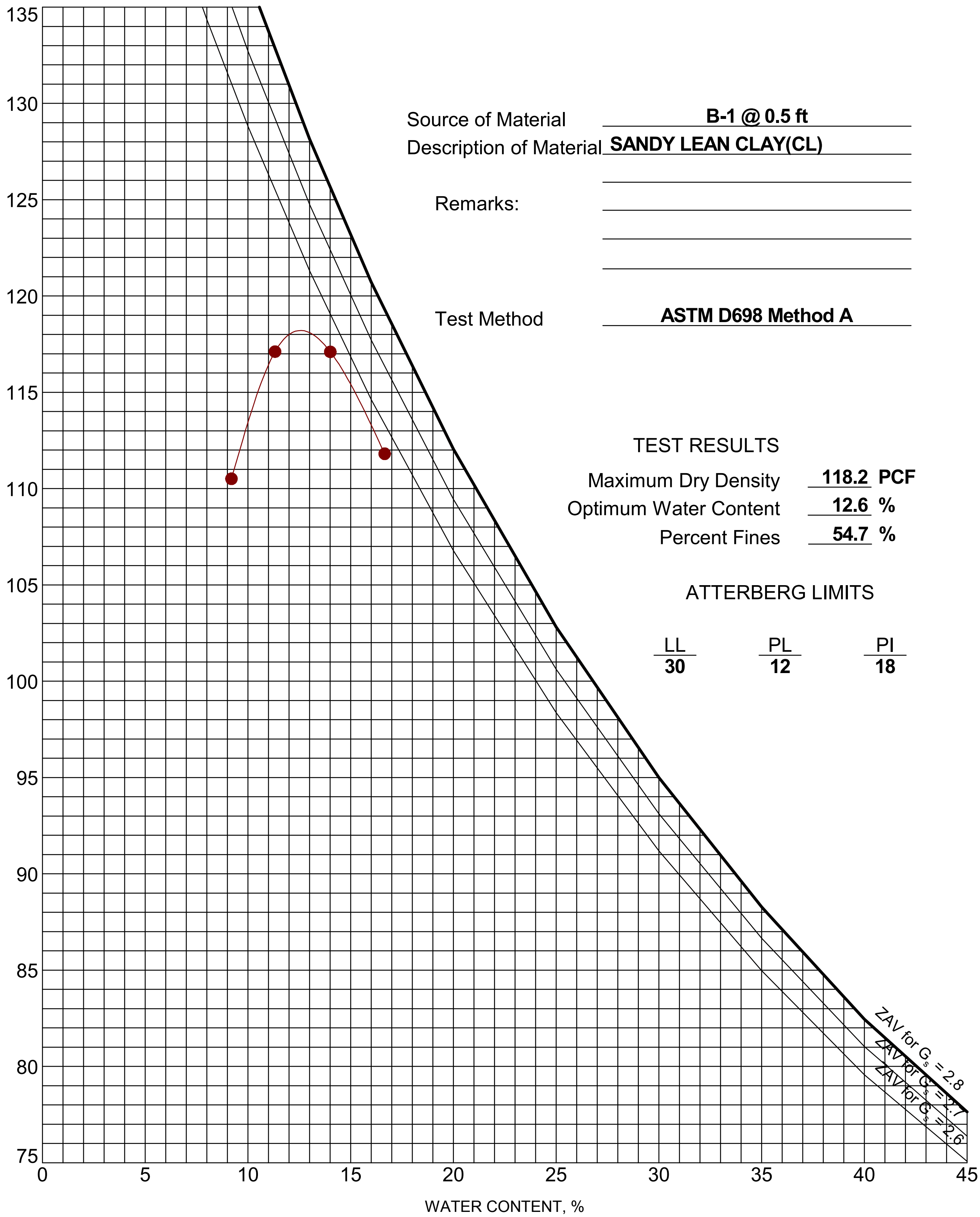
Boring Number	7	
Sample Number	2	
Sample Depth	9.5	feet

Soil Description	SANDY LEAN CLAY, trace gravel, olive brown (2.5Y 4/4)	
Liquid Limit	34	
Plastic Limit	14	
Plasticity Index	20	
Specific Gravity	2.70	assumed

Load (psf)	t90 (mins)	Avg sample height (inch)	Cv (cm^2/sec)	av cm^2/g	mv cm^2/g	k cm/sec
0		1.0000				
100	0	1.0000	#DIV/0!	-9.02E-03	-6.26E-03	#DIV/0!
250	1.21	0.9991	0.018807	3.40E-05	2.37E-05	4.45E-07
500	4.84	0.9974	0.004685	2.11E-05	1.47E-05	6.89E-08
1000	9	0.9949	0.002507	1.87E-05	1.31E-05	3.27E-08
2000	9.61	0.9911	0.002330	1.30E-05	9.11E-06	2.12E-08
4000	16	0.9849	0.001382	1.18E-05	8.33E-06	1.15E-08
8000	5.29	0.9749	0.004096	8.85E-06	6.34E-06	2.60E-08
16000	53.29	0.9564	0.000391	9.22E-06	6.78E-06	2.65E-09
32000	46.24	0.9303	0.000427	5.01E-06	3.80E-06	1.62E-09
8000		0.9211		1.08E-06	8.11E-07	
2000		0.9309		5.31E-06	3.94E-06	
						CONSOL -2A

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material **B-1 @ 0.5 ft**

Description of Material **SANDY LEAN CLAY(CL)**

Remarks:

Test Method **ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density	**118.2**	**PCF**
Optimum Water Content	**12.6**	**%**
Percent Fines	**54.7**	**%**

ATTERBERG LIMITS

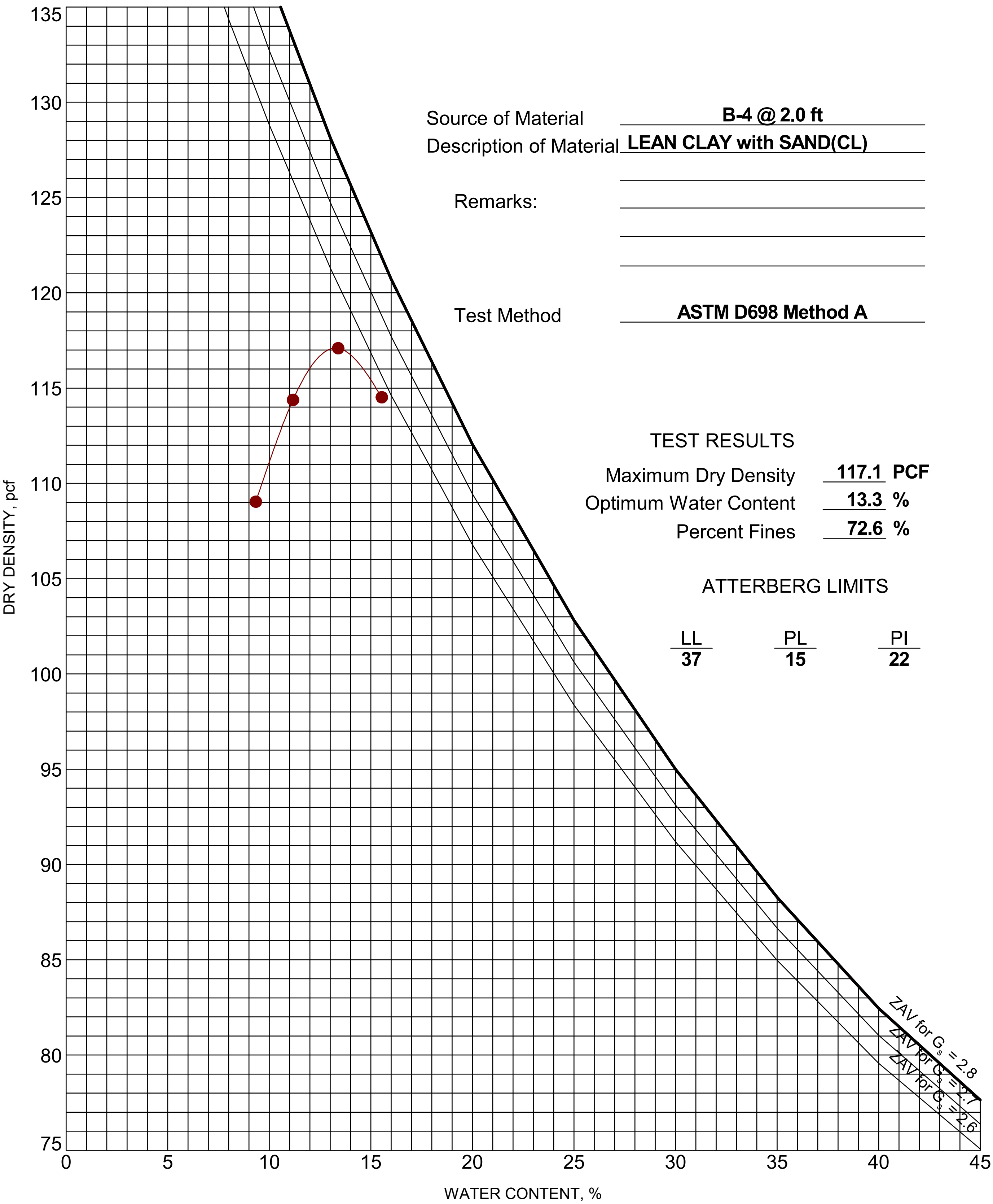
LL	PL	PI
30	**12**	**18**

PROJECT: US Highway 30 / US Highway 218 Interchange	Terracon	PROJECT NUMBER: D1154514
SITE: S2 Borings Benton County, Iowa	2640 12th Street SW Cedar Rapids, Iowa	CLIENT: HDR Engineering, Inc. Omaha, Nebraska
		EXHIBIT: B-1

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. COMPACTION - V2 D1154514 - US HIGHWAY 30 - US HIGHWAY 218 INTERCHANGE.GPJ HDR CUSTOM WIP TEMPLATE.GPJ 11/7/16

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material: **B-4 @ 2.0 ft**

Description of Material: **LEAN CLAY with SAND(CL)**

Remarks:

Test Method: **ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density **117.1 PCF**

Optimum Water Content **13.3 %**

Percent Fines **72.6 %**

ATTERBERG LIMITS

LL	PL	PI
37	**15**	**22**

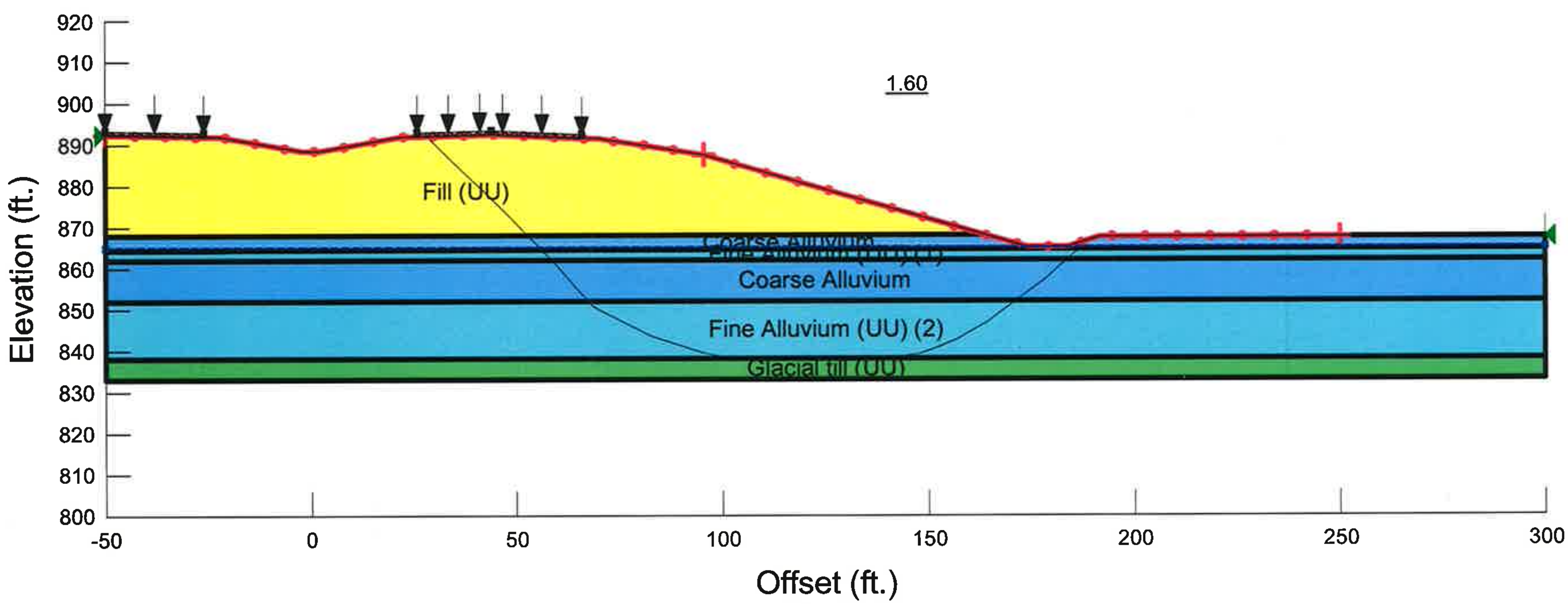
PROJECT: US Highway 30 / US Highway 218 Interchange	Terracon 2640 12th Street SW Cedar Rapids, Iowa	PROJECT NUMBER: D1154514
SITE: S2 Borings Benton County, Iowa		CLIENT: HDR Engineering, Inc. Omaha, Nebraska
		EXHIBIT: B-2

APPENDIX C: Slope Stability Analyses

✓ JAC 2/28/14

Project Name: US 30-Benton County
Title: Location 9 (STA 1361+00)
Name: Slope Stability (UU)
Description: End of Construction (undrained) Case
Method: Spencer
Date: 2/21/2014

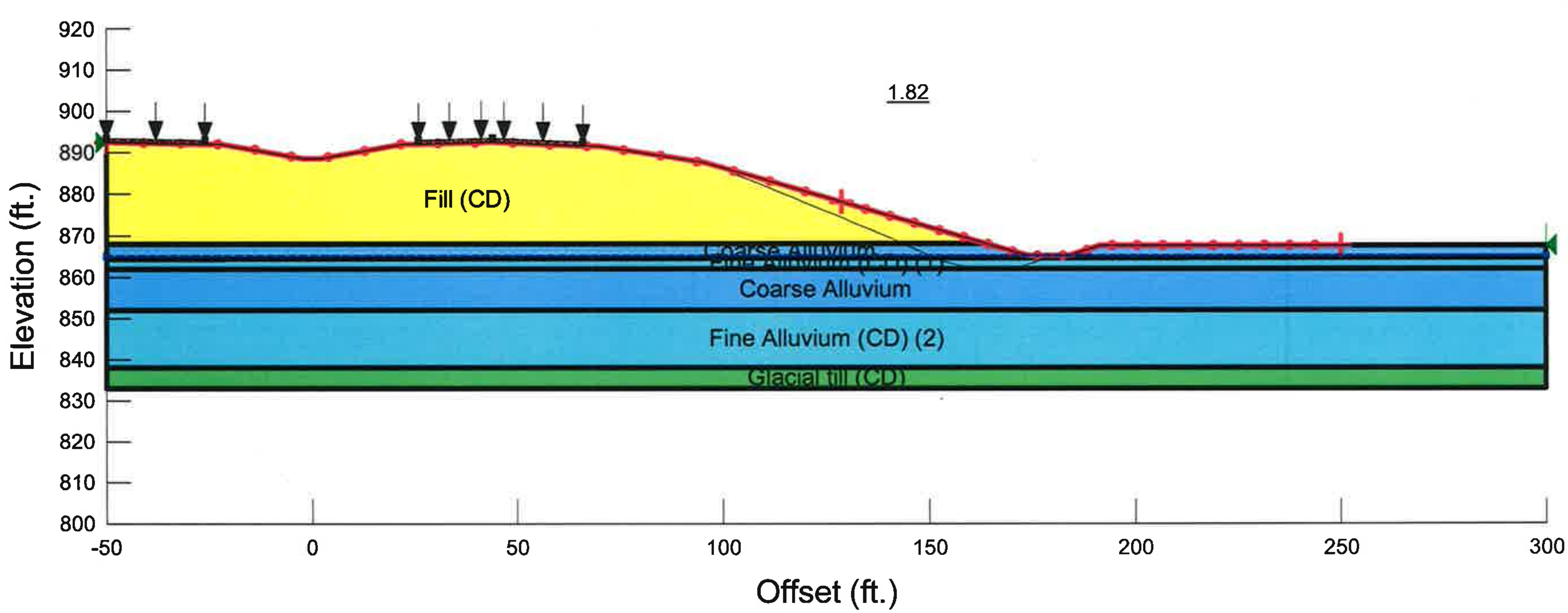
Name: Fill (UU)   Model: Mohr-Coulomb   Unit Weight: 125 pcf   Cohesion': 1,200 psf   Phi': 0 °
Name: Coarse Alluvium   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion': 0 psf   Phi': 30 °
Name: Fine Alluvium (UU) (1)   Model: Mohr-Coulomb   Unit Weight: 115 pcf   Cohesion': 500 psf   Phi': 0 °
Name: Fine Alluvium (UU) (2)   Model: Mohr-Coulomb   Unit Weight: 115 pcf   Cohesion': 750 psf   Phi': 0 °
Name: Glacial till (UU)   Model: Mohr-Coulomb   Unit Weight: 125 pcf   Cohesion': 2,500 psf   Phi': 0 °



✓ JAC 2/28/14

Project Name: US 30-Benton County
Title: Location 9 (STA 1361+00)
Name: Slope Stability (CD)
Description: Long Term (drained) Case
Method: Spencer
Date: 2/28/2014

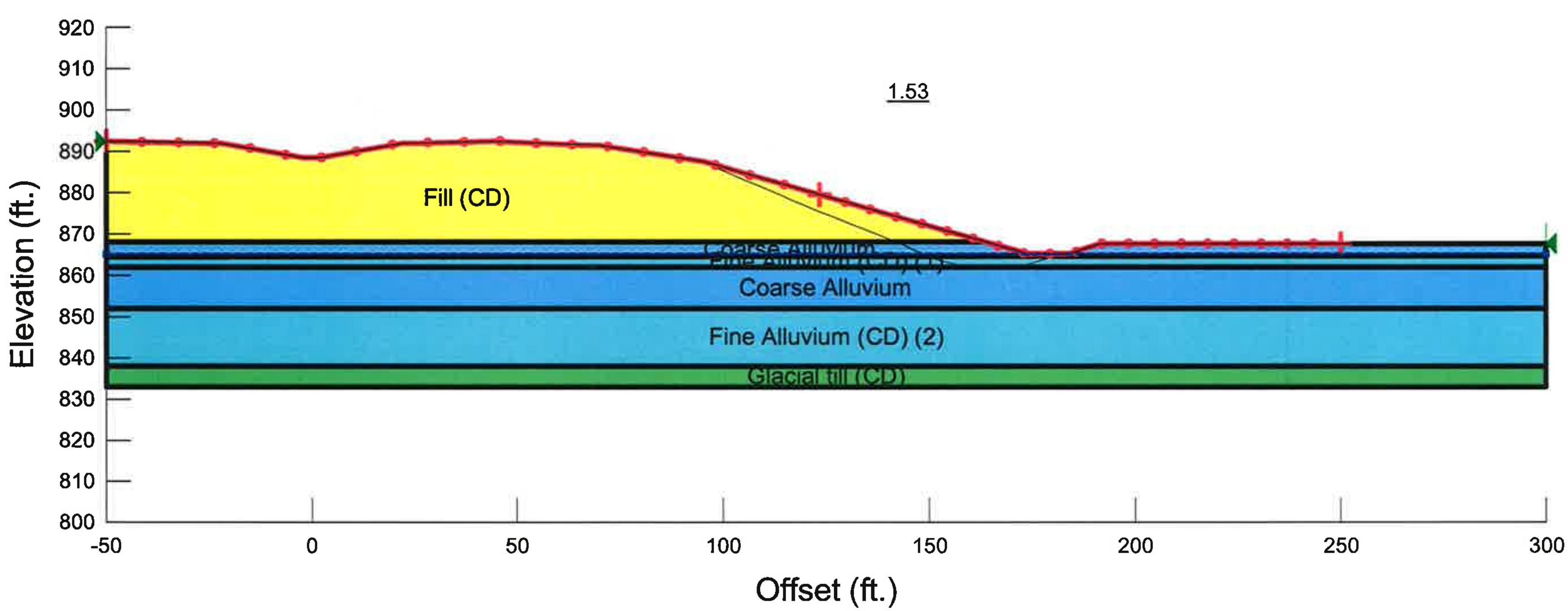
Name: Fill (CD)	Model: Mohr-Coulomb	Unit Weight: 125 pcf	Cohesion': 0 psf	Phi': 28 °
Name: Coarse Alluvium	Model: Mohr-Coulomb	Unit Weight: 120 pcf	Cohesion': 0 psf	Phi': 30 °
Name: Fine Alluvium (CD) (1)	Model: Mohr-Coulomb	Unit Weight: 115 pcf	Cohesion': 0 psf	Phi': 28 °
Name: Fine Alluvium (CD) (2)	Model: Mohr-Coulomb	Unit Weight: 115 pcf	Cohesion': 0 psf	Phi': 28 °
Name: Glacial till (CD)	Model: Mohr-Coulomb	Unit Weight: 125 pcf	Cohesion': 0 psf	Phi': 28 °



✓ JAC 2/28/14

Project Name: US 30-Benton County
Title: Location 9 (STA 1361+00)
Name: Slope Stability (CD w/ Seismic)
Description: Long Term (drained) Case, ah=0.05g
Method: Spencer
Date: 2/28/2014

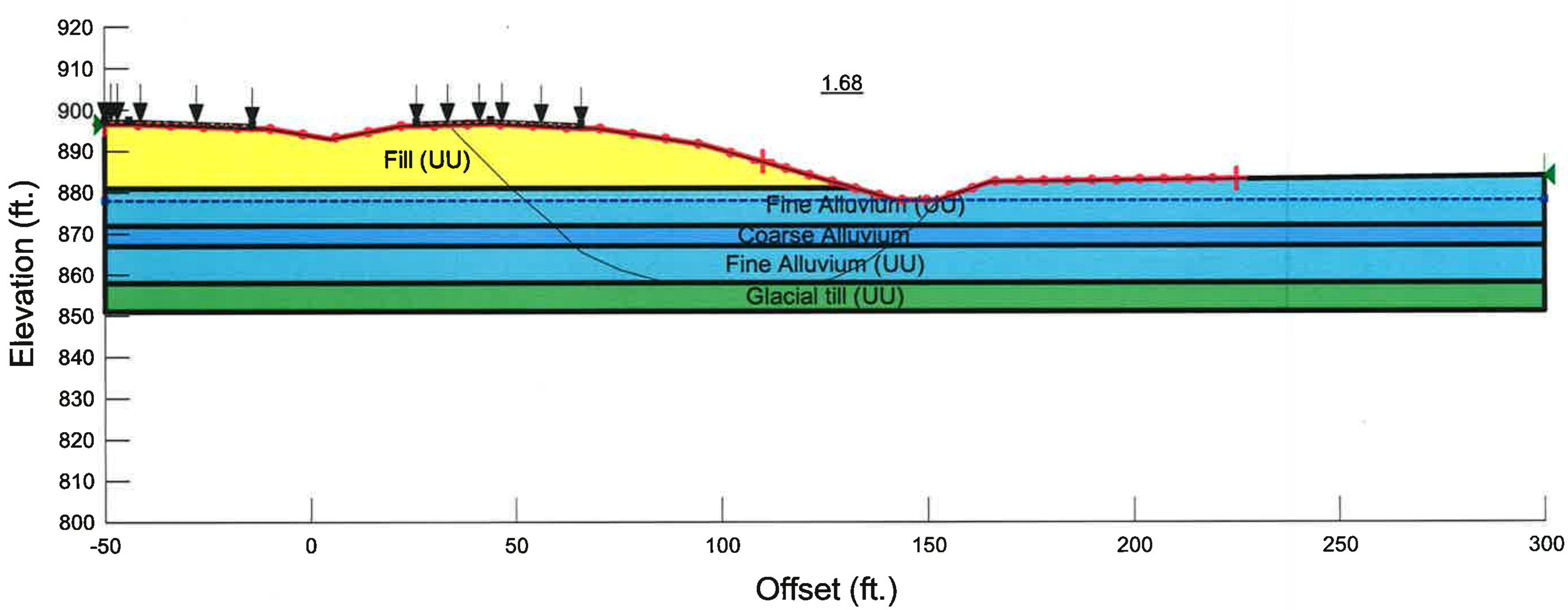
Name: Fill (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 28 °
Name: Coarse Alluvium Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 30 °
Name: Fine Alluvium (CD) (1) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 28 °
Name: Fine Alluvium (CD) (2) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 28 °
Name: Glacial till (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 28 °



✓ JAC 2/[illegible]/14

Project Name: US 30-Benton County
Title: Location 10 (STA 1425+00)
Name: Slope Stability (UU)
Description: End of Construction (undrained) Case
Method: Spencer
Date: 2/28/2014

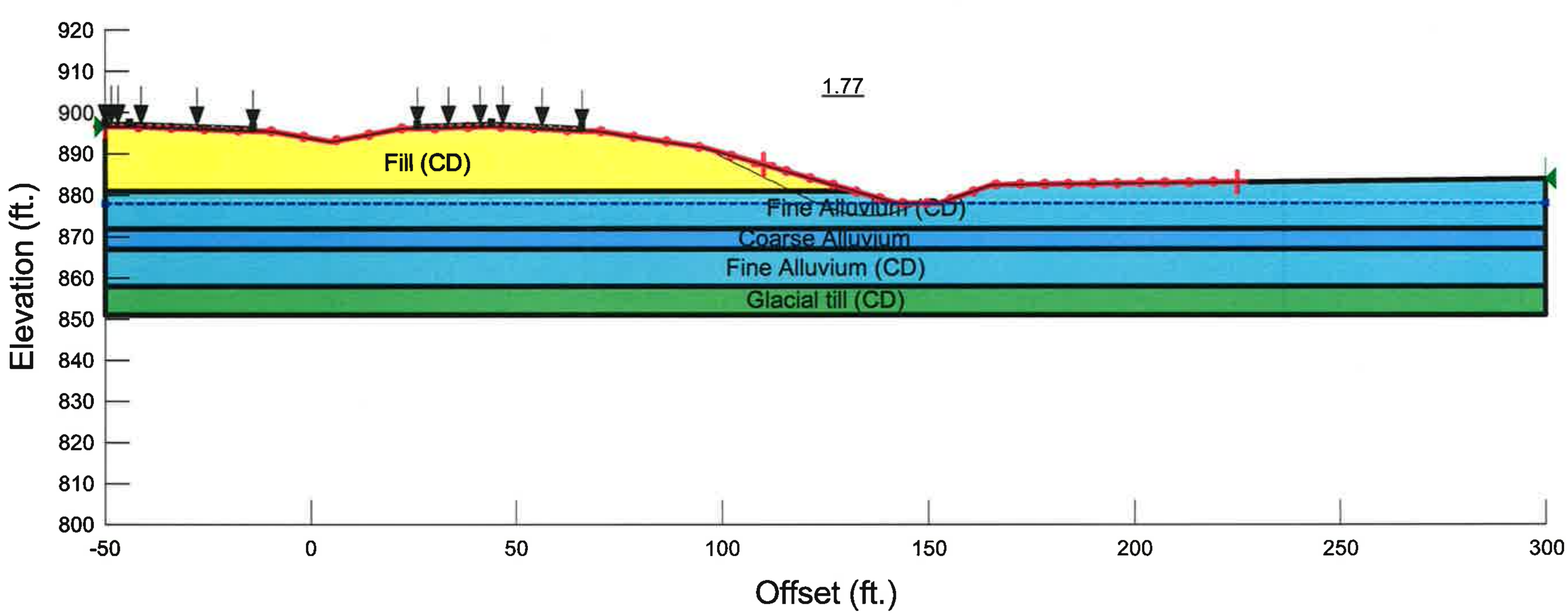
Name: Fill (UU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 1,200 psf Phi': 0 °
Name: Fine Alluvium (UU) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 500 psf Phi': 0 °
Name: Coarse Alluvium Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 30 °
Name: Glacial till (UU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 2,500 psf Phi': 0 °



✓ JAC 2/28/14

Project Name: US 30-Benton County
Title: Location 10 (STA 1425+00)
Name: Slope Stability (CD)
Description: Long Term (drained) Case
Method: Spencer
Date: 2/28/2014

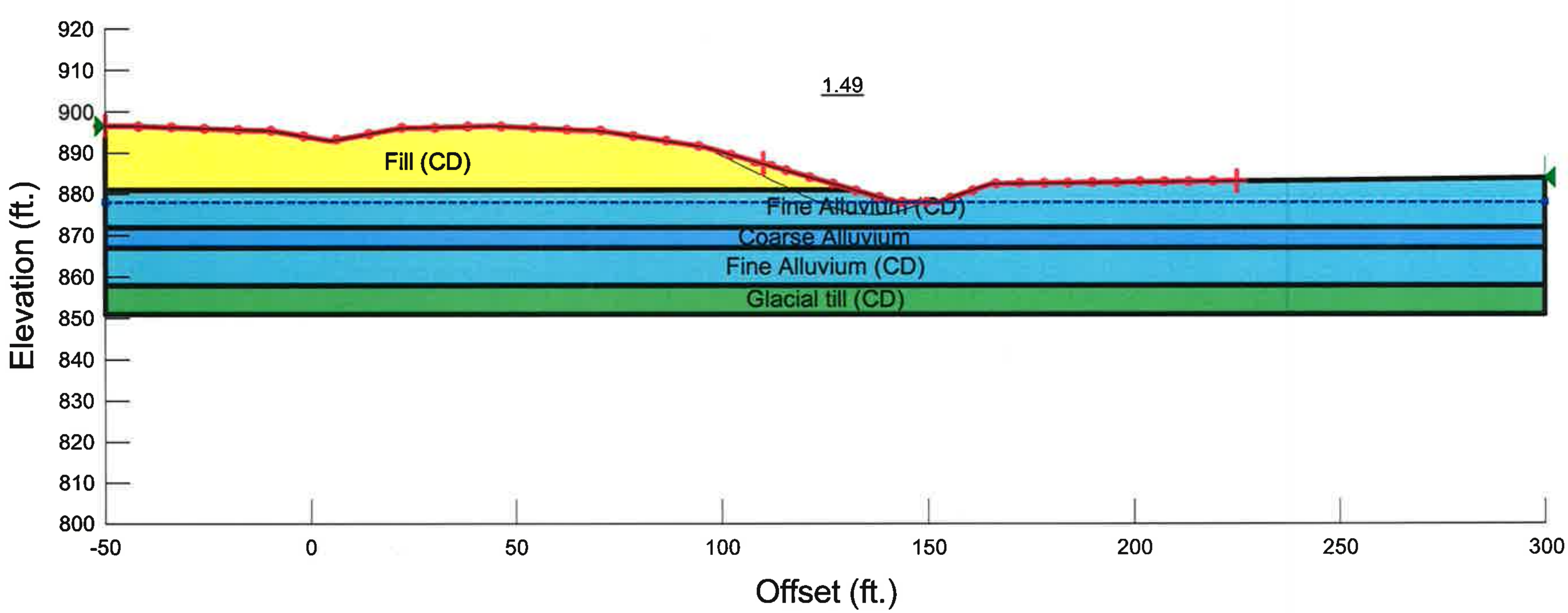
Name: Fill (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 28 °
Name: Fine Alluvium (CD) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 28 °
Name: Coarse Alluvium Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 30 °
Name: Glacial till (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 28 °



✓ JAC 2/28/14

Project Name: US 30-Benton County
Title: Location 10 (STA 1425+00)
Name: Slope Stability (CD w/ Seismic)
Description: Long Term (drained) Case, ah=0.05g
Method: Spencer
Date: 2/28/2014

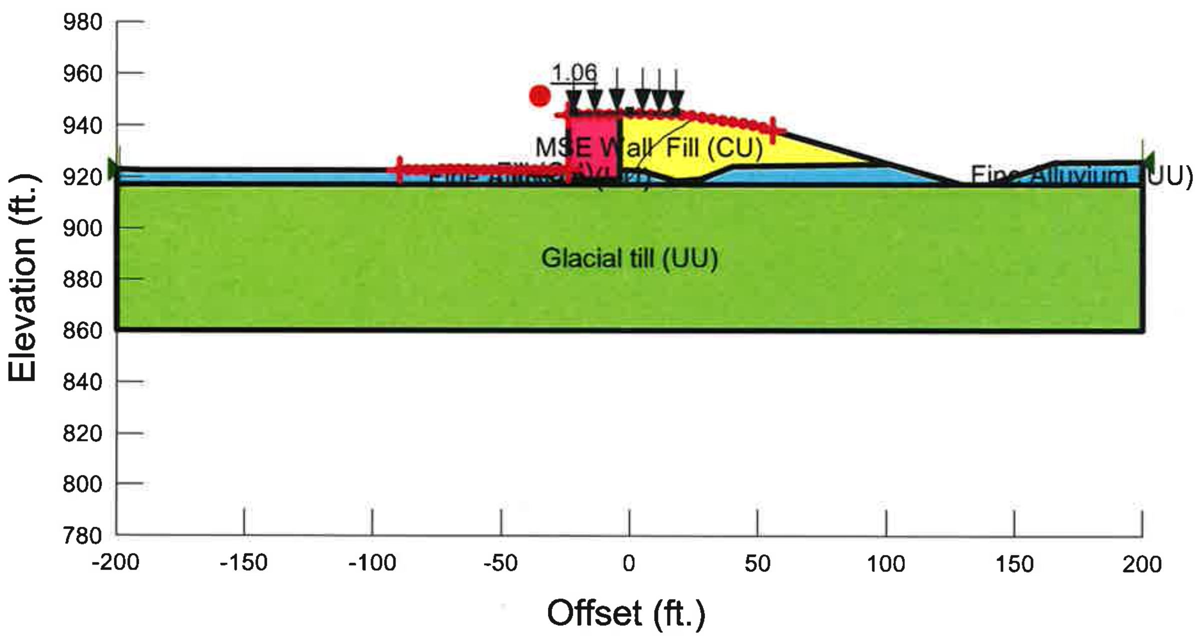
Name	Model	Unit Weight	Cohesion'	Phi'
Name: Fill (CD)	Model: Mohr-Coulomb	Unit Weight: 125 pcf	Cohesion': 0 psf	Phi': 28 °
Name: Fine Alluvium (CD)	Model: Mohr-Coulomb	Unit Weight: 115 pcf	Cohesion': 0 psf	Phi': 28 °
Name: Coarse Alluvium	Model: Mohr-Coulomb	Unit Weight: 120 pcf	Cohesion': 0 psf	Phi': 30 °
Name: Glacial till (CD)	Model: Mohr-Coulomb	Unit Weight: 125 pcf	Cohesion': 0 psf	Phi': 28 °



Project Name: IDOT-US 30 Benton County
Location: US 218 - STA 241474+00 L
Name: Critical Section Slope Stability (Short Term)
Description: Short Term (end of construction) Case
Method: Spencer
Date: 1/13/2016

✓ JAC 3/1/16

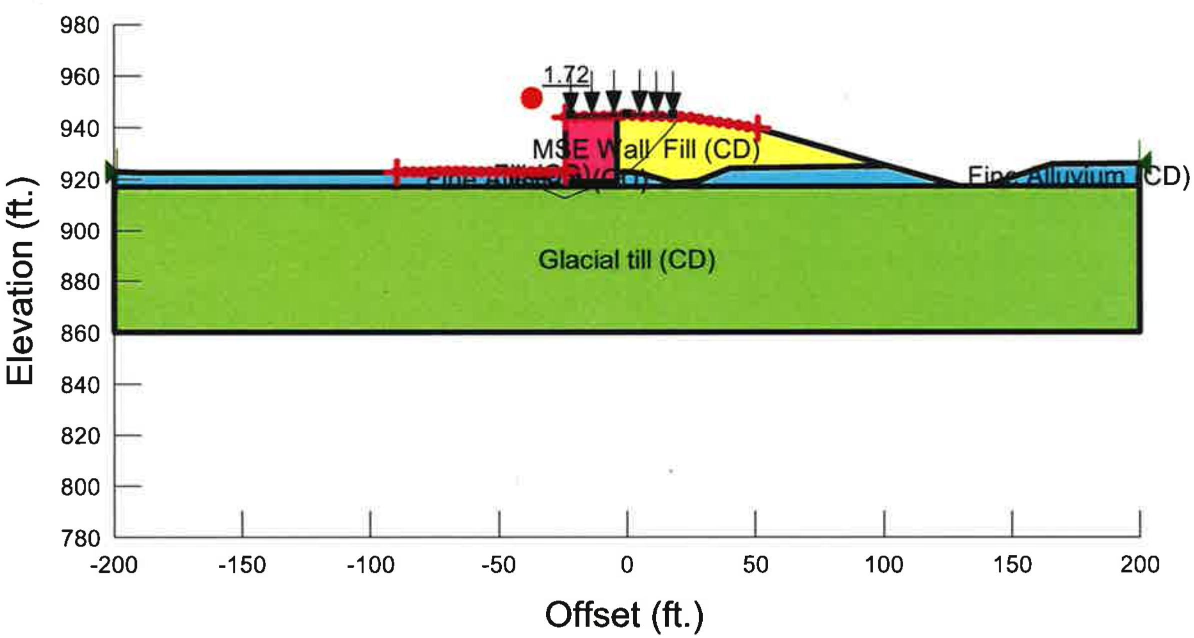
Name: Fill (CU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 600 psf Phi': 12 °
Name: Fine Alluvium (UU) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 600 psf Phi': 0 °
Name: Glacial till (UU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 2,500 psf Phi': 0 °
Name: MSE Wall Model: High Strength Unit Weight: 120 pcf



✓ JAC 3/1/16

Project Name: IDOT-US 30 Benton County
Location: US 218 - STA 241474+00 L
Name: Critical Section Slope Stability (Long Term)
Description: Long Term Case
Method: Spencer
Date: 1/13/2016

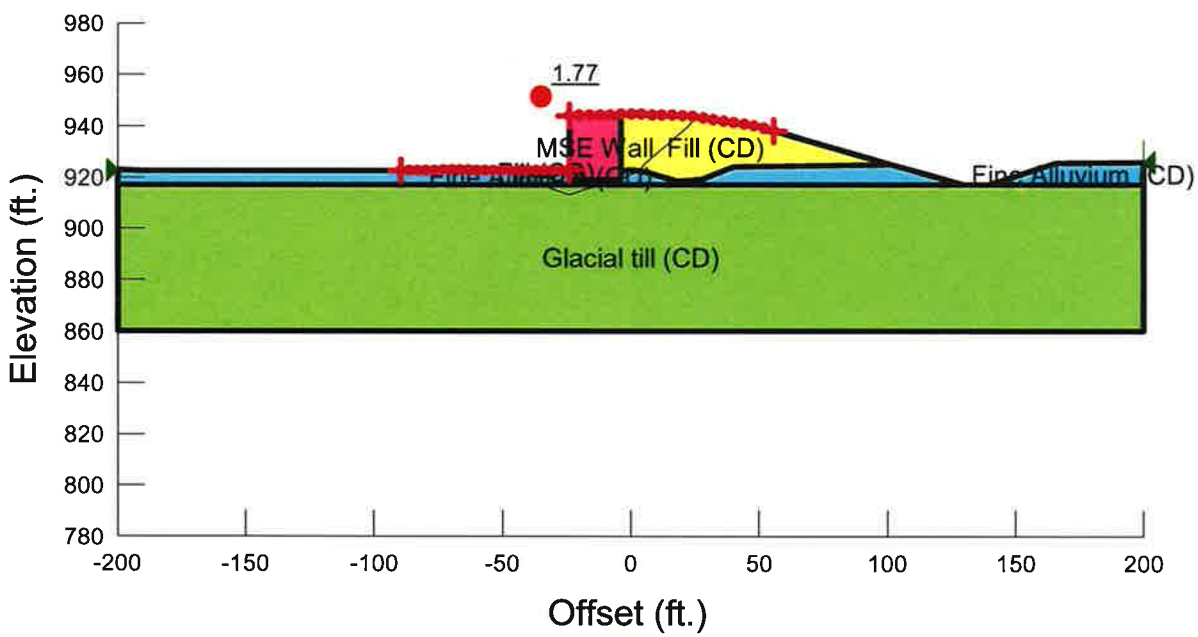
Name: Fill (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 150 psf Phi': 28 °
Name: Fine Alluvium (CD) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 50 psf Phi': 28 °
Name: Glacial till (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 100 psf Phi': 28 °
Name: MSE Wall Model: High Strength Unit Weight: 120 pcf



✓ JAC 3/1/16

Project Name: IDOT-US 30 Benton County
Location: US 218 - STA 241474+00 L
Name: Critical Section Slope Stability (Long Term w/ Seismic)
Description: Long Term Case w/ Seismic, ah=0.02g
Method: Spencer
Date: 1/13/2016

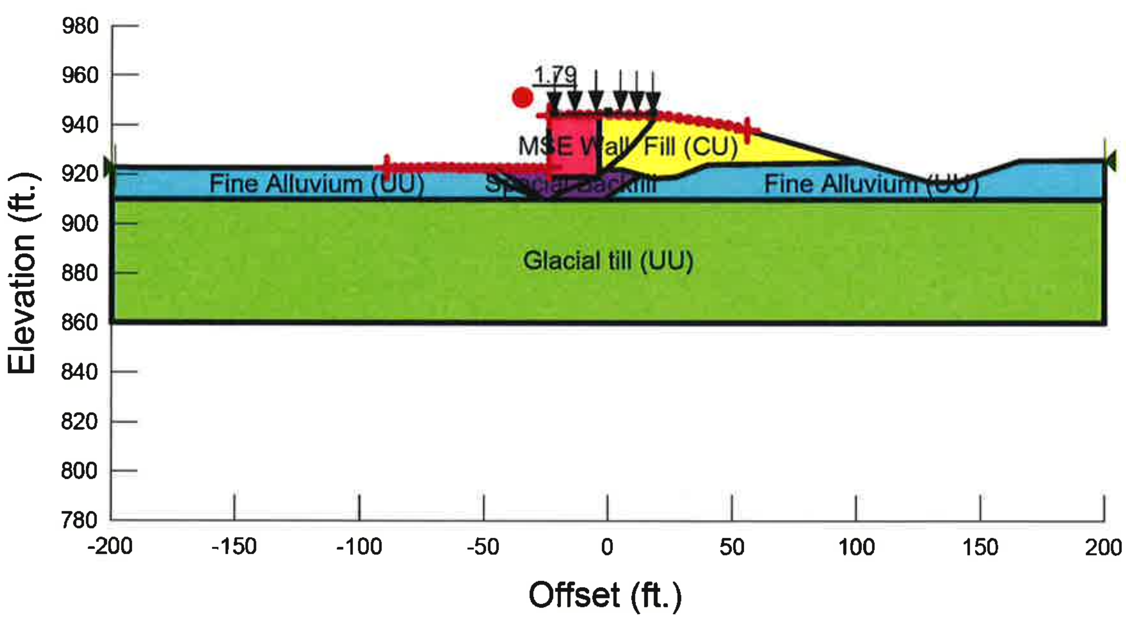
Name: Fill (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 150 psf Phi': 28 °
Name: Fine Alluvium (CD) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 50 psf Phi': 28 °
Name: Glacial till (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 100 psf Phi': 28 °
Name: MSE Wall Model: High Strength Unit Weight: 120 pcf



✓ JAC
2/28/17

Project Name: IDOT-US 30 Benton County
Location: US 218 - STA 241474+00 L
Name: Critical Section Slope Stability (Short Term)
Description: Short Term (end of construction) Case - Overexcavation
Method: Spencer
Date: 3/1/2017

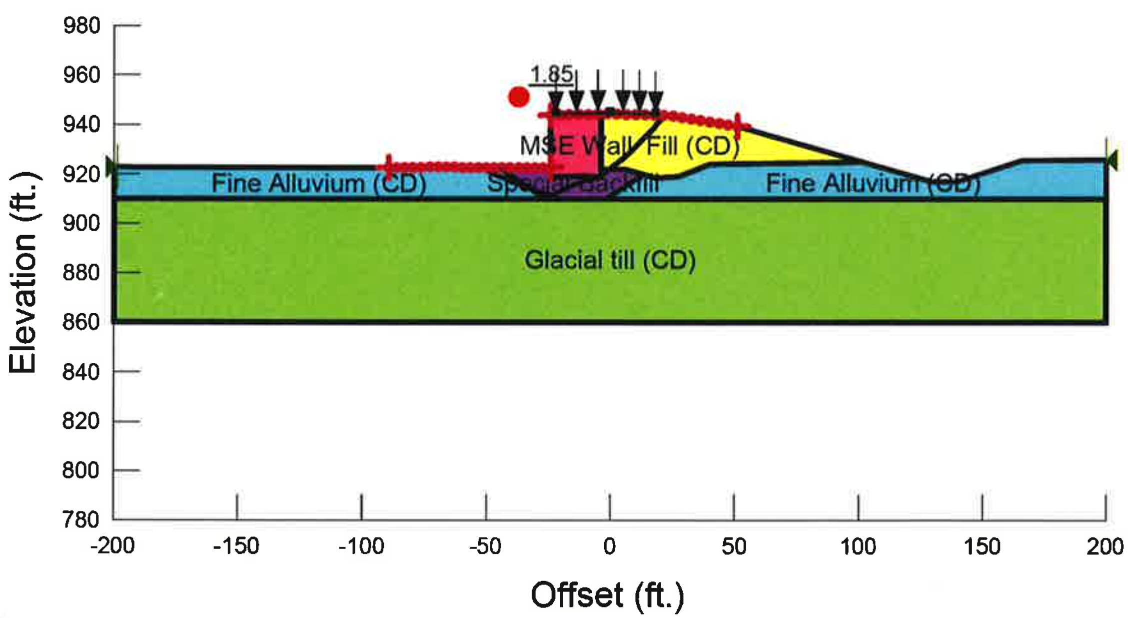
Name: Fill (CU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 600 psf Phi': 12 °
Name: Fine Alluvium (UU) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 600 psf Phi': 0 °
Name: Glacial till (UU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 2,500 psf Phi': 0 °
Name: MSE Wall Model: High Strength Unit Weight: 120 pcf
Name: Special Backfill Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 32 °



Project Name: IDOT-US 30 Benton County
Location: US 218 - STA 241474+00 L
Name: Critical Section Slope Stability (Long Term)
Description: Long Term Case - Overexcavation
Method: Spencer
Date: 3/1/2017

✓ JAC
2/28/17

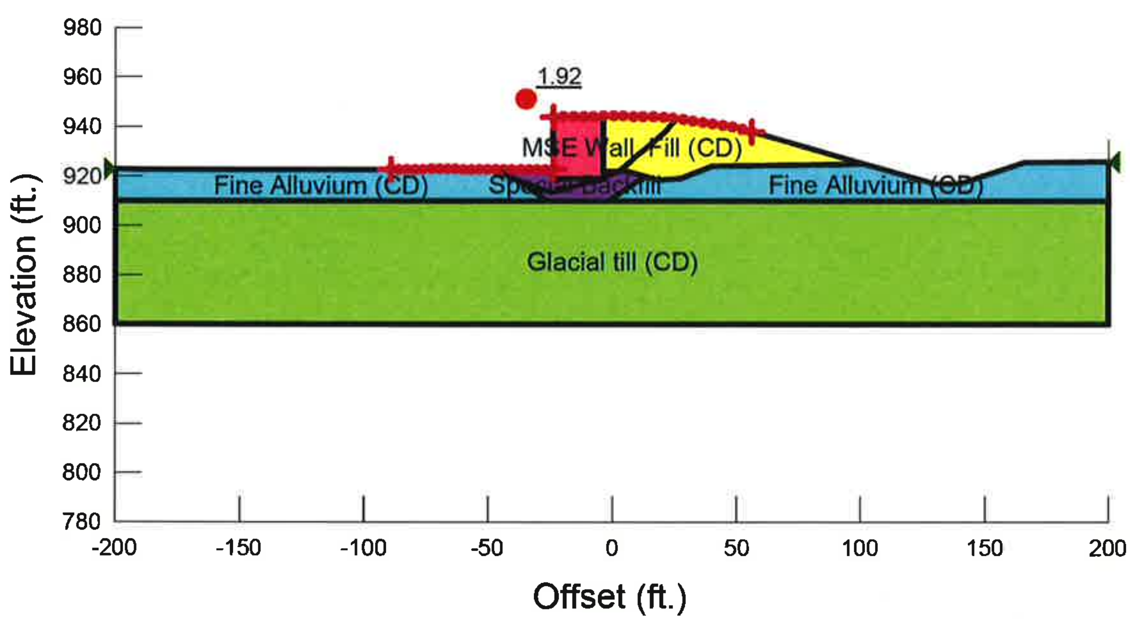
Name: Fill (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 150 psf Phi': 28 °
Name: Fine Alluvium (CD) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 50 psf Phi': 28 °
Name: Glacial till (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 100 psf Phi': 28 °
Name: MSE Wall Model: High Strength Unit Weight: 120 pcf
Name: Special Backfill Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 32 °



Project Name: IDOT-US 30 Benton County
Location: US 218 - STA 241474+00 L
Name: Critical Section Slope Stability (Long Term w/ Seismic)
Description: Long Term Case w/ Seismic, ah=0.02g - Overexcavation
Method: Spencer
Date: 3/1/2017

✓ JAC
2/28/17

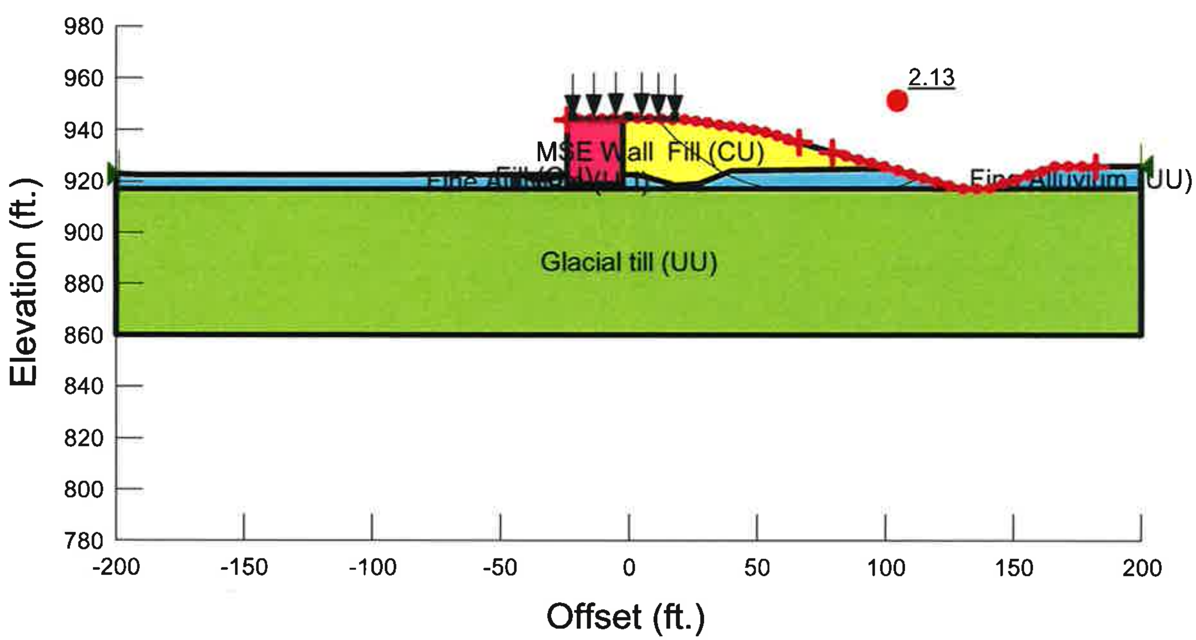
Name: Fill (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 150 psf Phi': 28 °
Name: Fine Alluvium (CD) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 50 psf Phi': 28 °
Name: Glacial till (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 100 psf Phi': 28 °
Name: MSE Wall Model: High Strength Unit Weight: 120 pcf
Name: Special Backfill Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 32 °



Project Name: IDOT-US 30 Benton County
Location: US 218 - STA 241474+00 R
Name: Critical Section Slope Stability (Short Term)
Description: Short Term (end of construction) Case
Method: Spencer
Date: 3/1/2016

✓ JAC 3/1/16

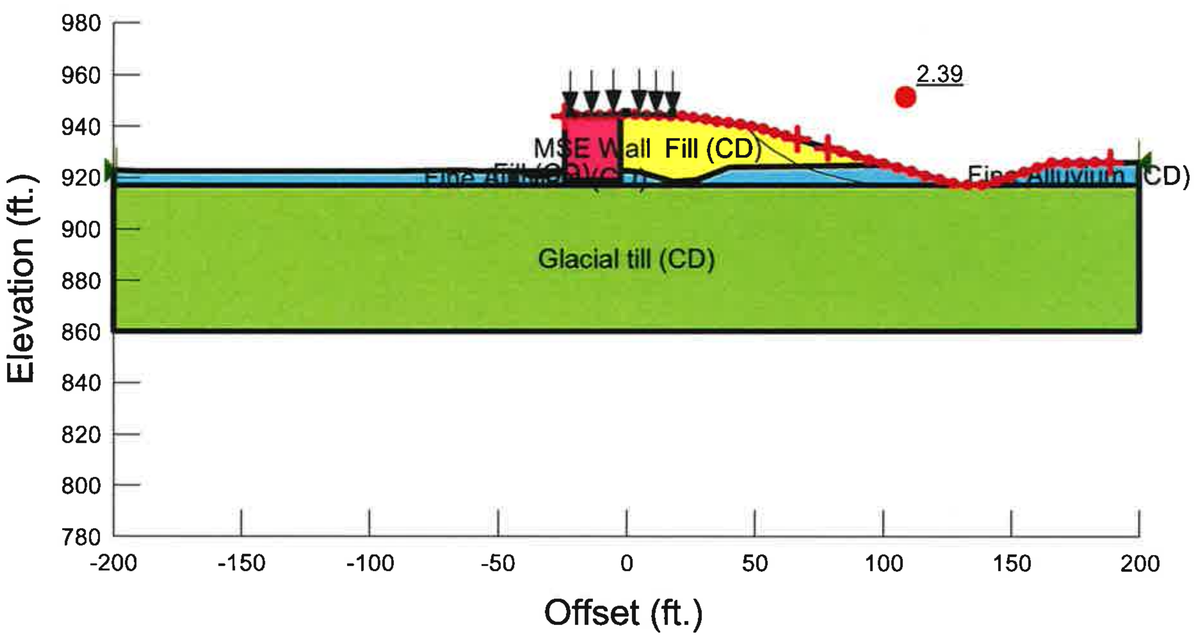
Name: Fill (CU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 600 psf Phi': 12 °
Name: Fine Alluvium (UU) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 600 psf Phi': 0 °
Name: Glacial till (UU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 2,500 psf Phi': 0 °
Name: MSE Wall Model: High Strength Unit Weight: 120 pcf



✓ JAC 3/1/16

Project Name: IDOT-US 30 Benton County
Location: US 218 - STA 241474+00 R
Name: Critical Section Slope Stability (Long Term)
Description: Long Term Case
Method: Spencer
Date: 3/1/2016

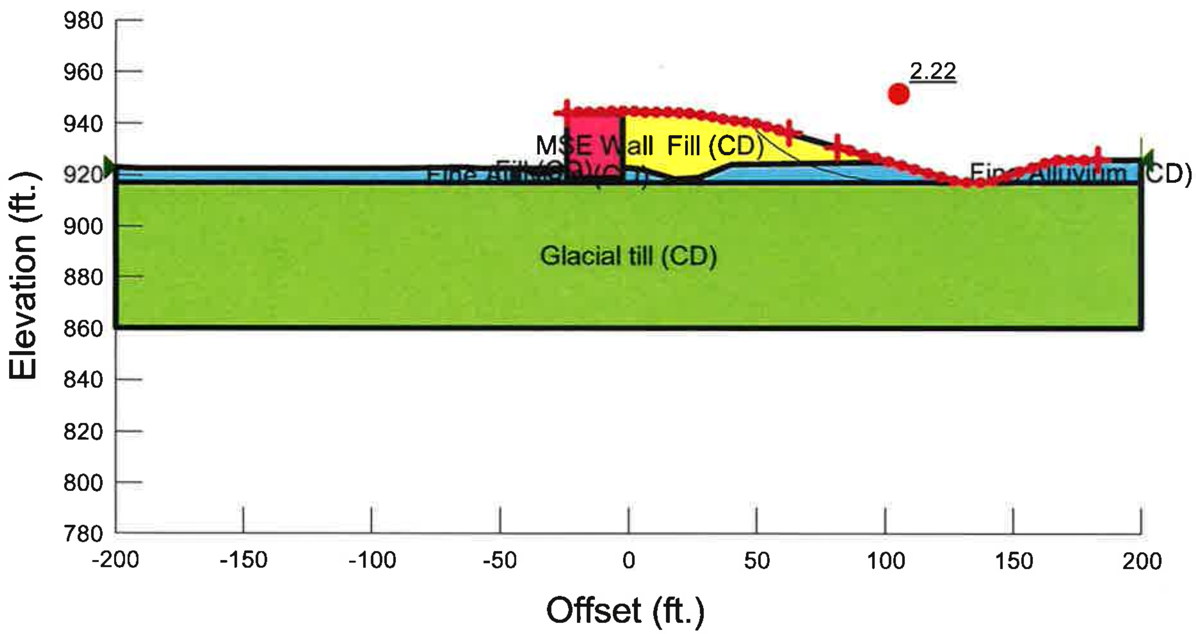
Name: Fill (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 150 psf Phi': 28 °
Name: Fine Alluvium (CD) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 50 psf Phi': 28 °
Name: Glacial till (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 100 psf Phi': 28 °
Name: MSE Wall Model: High Strength Unit Weight: 120 pcf



Project Name: IDOT-US 30 Benton County
Location: US 218 - STA 241474+00 R
Name: Critical Section Slope Stability (Long Term w/ Seismic)
Description: Long Term Case w/ Seismic, ah=0.02g
Method: Spencer
Date: 3/1/2016

✓JAC 3/1/16

Name: Fill (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 150 psf Phi': 28 °
Name: Fine Alluvium (CD) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 50 psf Phi': 28 °
Name: Glacial till (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 100 psf Phi': 28 °
Name: MSE Wall Model: High Strength Unit Weight: 120 pcf

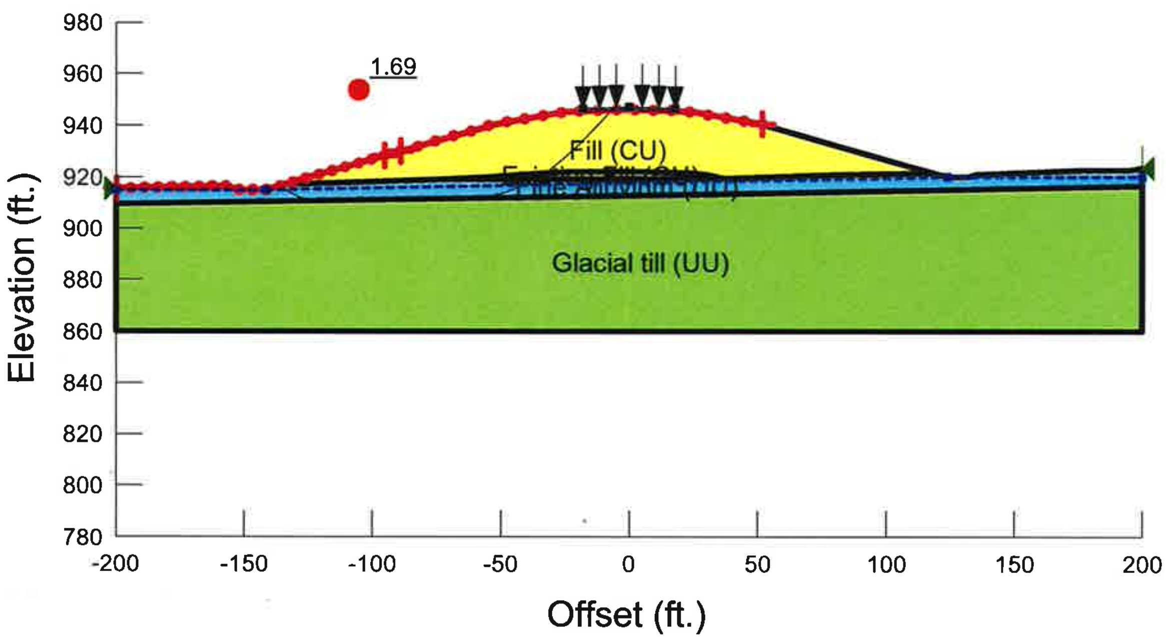


HDR

✓JAC 3/1/16

Project Name: IDOT-US 30 Benton County
Location: US 218 - STA 241478+00 L
Name: Critical Section Slope Stability (Short Term)
Description: Short Term (end of construction) Case
Method: Spencer
Date: 1/13/2016

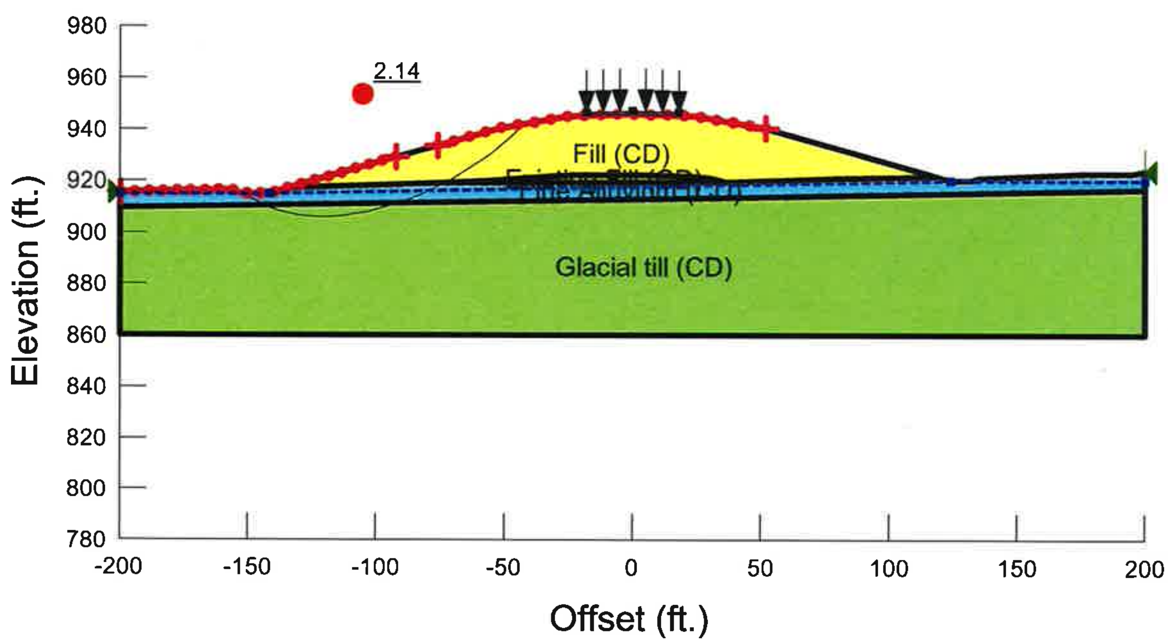
Name: Fill (CU)	Model: Mohr-Coulomb	Unit Weight: 125 pcf	Cohesion': 600 psf	Phi': 12 °
Name: Existing Fill (CU)	Model: Mohr-Coulomb	Unit Weight: 120 pcf	Cohesion': 600 psf	Phi': 12 °
Name: Fine Alluvium (UU)	Model: Mohr-Coulomb	Unit Weight: 115 pcf	Cohesion': 600 psf	Phi': 0 °
Name: Glacial till (UU)	Model: Mohr-Coulomb	Unit Weight: 125 pcf	Cohesion': 2,500 psf	Phi': 0 °



✓JAC 3/1/16

Project Name: IDOT-US 30 Benton County
Location: US 218 - STA 241478+00 L
Name: Critical Section Slope Stability (Long Term)
Description: Long Term Case
Method: Spencer
Date: 1/13/2016

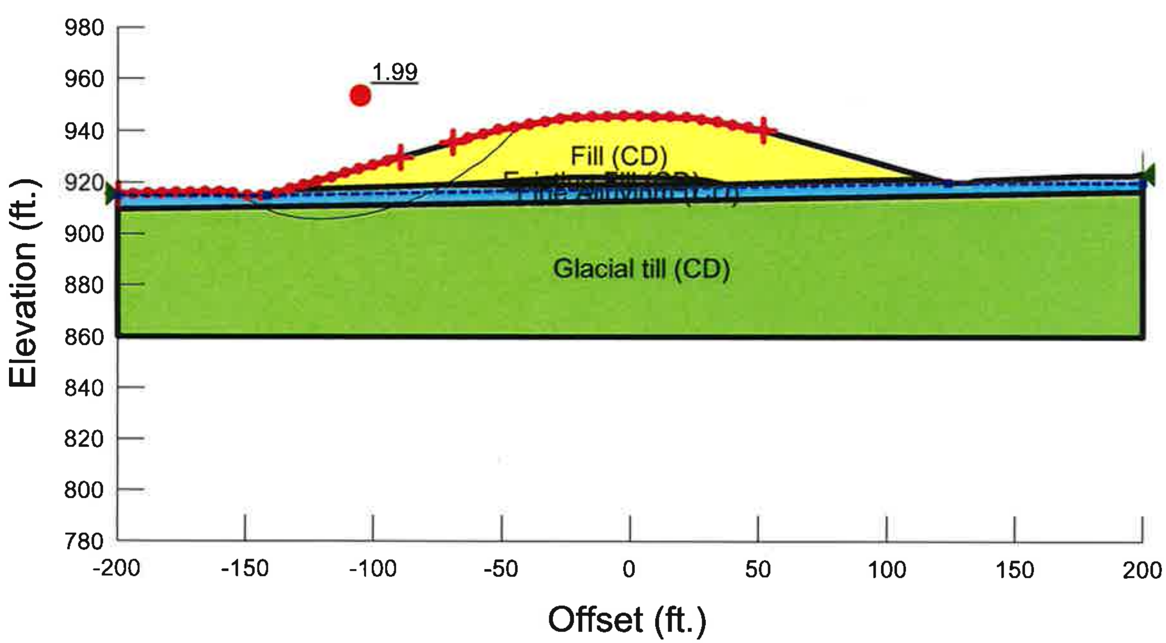
Name: Fill (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 150 psf Phi': 28 °
Name: Existing Fill (CD) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 150 psf Phi': 28 °
Name: Fine Alluvium (CD) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 50 psf Phi': 28 °
Name: Glacial till (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 100 psf Phi': 28 °



✓JAC 3/1/16

Project Name: IDOT-US 30 Benton County
Location: US 218 - STA 241478+00 L
Name: Critical Section Slope Stability (Long Term w/ Seismic)
Description: Long Term Case w/ Seismic, ah=0.02g
Method: Spencer
Date: 1/13/2016

Name: Fill (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 150 psf Phi': 28 °
Name: Existing Fill (CD) Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 150 psf Phi': 28 °
Name: Fine Alluvium (CD) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 50 psf Phi': 28 °
Name: Glacial till (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 100 psf Phi': 28 °

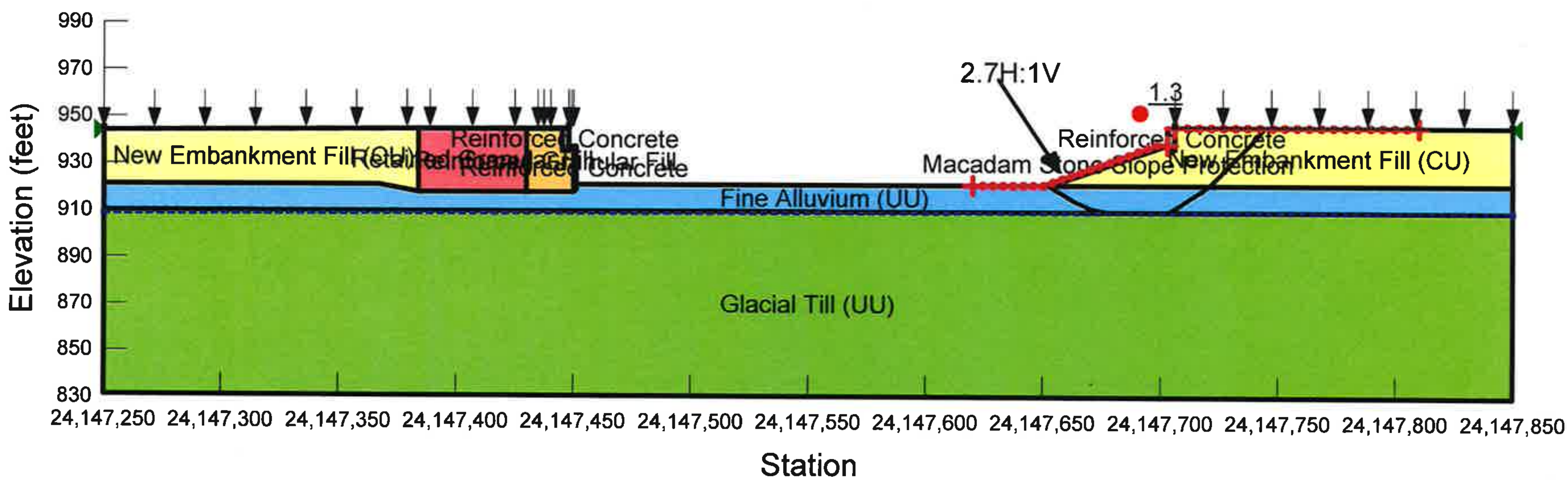


✓ JAC 11/29/16

Project Name: IDOT - US218/US30 Benton County
Location: US 218 Station 241474+47.22 to 241477+04.22
Name: North Abutment Slope Stability (Short Term)
Description: Short Term (end of construction) Case; Includes Live Load=240 psf
Method: Spencer

Name: Reinforced Concrete   Model: High Strength   Unit Weight: 150 pcf
Name: Macadam Stone Slope Protection   Model: Mohr-Coulomb   Unit Weight: 115 pcf   Cohesion': 0 psf   Phi': 35 °
Name: New Embankment Fill (CU)   Model: Mohr-Coulomb   Unit Weight: 125 pcf   Cohesion': 600 psf   Phi': 12 °
Name: Fine Alluvium (UU)   Model: Mohr-Coulomb   Unit Weight: 115 pcf   Cohesion': 650 psf   Phi': 0 °
Name: Glacial Till (UU)   Model: Mohr-Coulomb   Unit Weight: 125 pcf   Cohesion': 2,500 psf   Phi': 0 °
Name: Retained Granular Fill   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion': 0 psf   Phi': 34 °
Name: Reinforced Granular Fill   Model: High Strength   Unit Weight: 120 pcf

F of S: 1.3

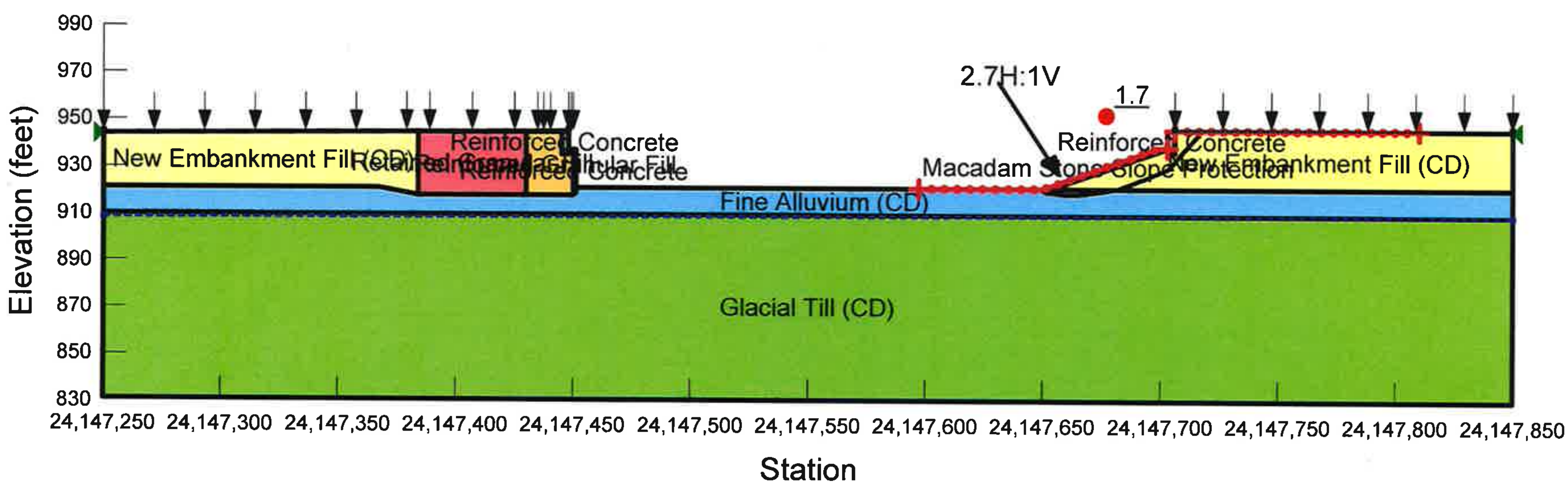


✓ JAC 11/29/16

Project Name: IDOT - US218/US30 Benton County
Location: US 218 Station 241474+47.22 to 241477+04.22
Name: North Abutment Slope Stability (Long Term)
Description: Long Term Case; Includes Live Load=240 psf
Method: Spencer

Name: New Embankment Fill (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 150 psf Phi': 28 °
Name: Fine Alluvium (CD) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 50 psf Phi': 28 °
Name: Glacial Till (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 100 psf Phi': 28 °
Name: Reinforced Concrete Model: High Strength Unit Weight: 150 pcf
Name: Macadam Stone Slope Protection Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 35 °
Name: Retained Granular Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: Reinforced Granular Fill Model: High Strength Unit Weight: 120 pcf

F of S: 1.7

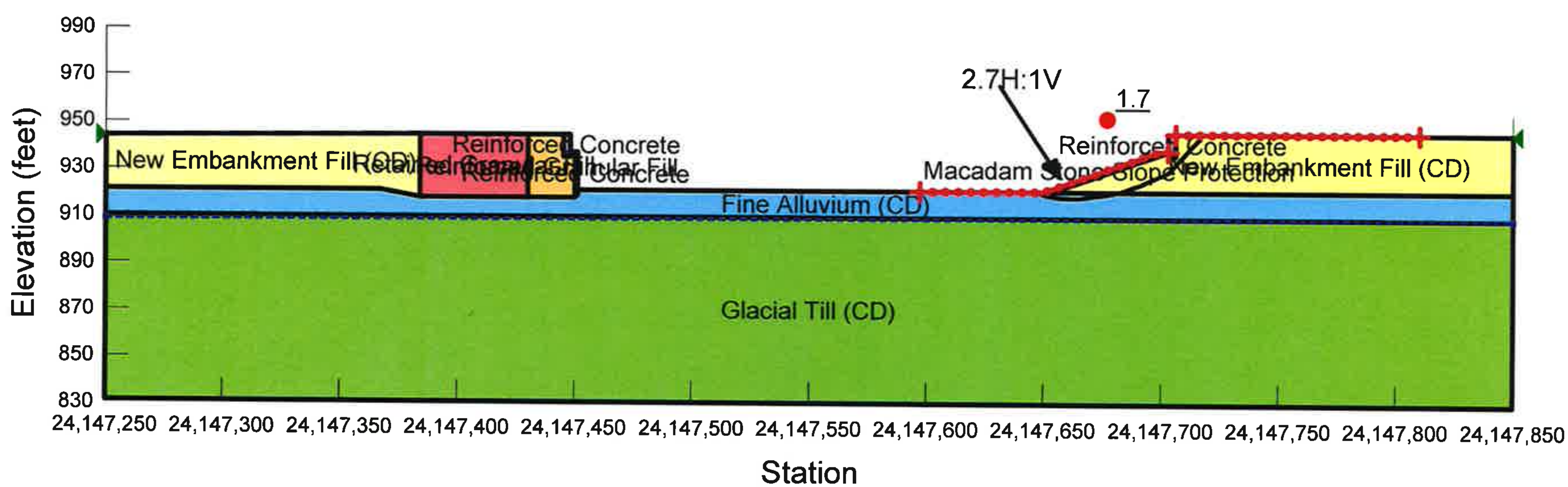


✓ JAC 11/29/16

Project Name: IDOT - US218/US30 Benton County
Location: US 218 Station 241474+47.22 to 241477+04.22
Name: North Abutment Slope Stability (Long Term w/ Seismic)
Description: Long Term Case w/ Seismic, ah=0.02g
Method: Spencer

Name: New Embankment Fill (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 150 psf Phi': 28 °
Name: Fine Alluvium (CD) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 50 psf Phi': 28 °
Name: Glacial Till (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 100 psf Phi': 28 °
Name: Reinforced Concrete Model: High Strength Unit Weight: 150 pcf
Name: Macadam Stone Slope Protection Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 35 °
Name: Retained Granular Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: Reinforced Granular Fill Model: High Strength Unit Weight: 120 pcf

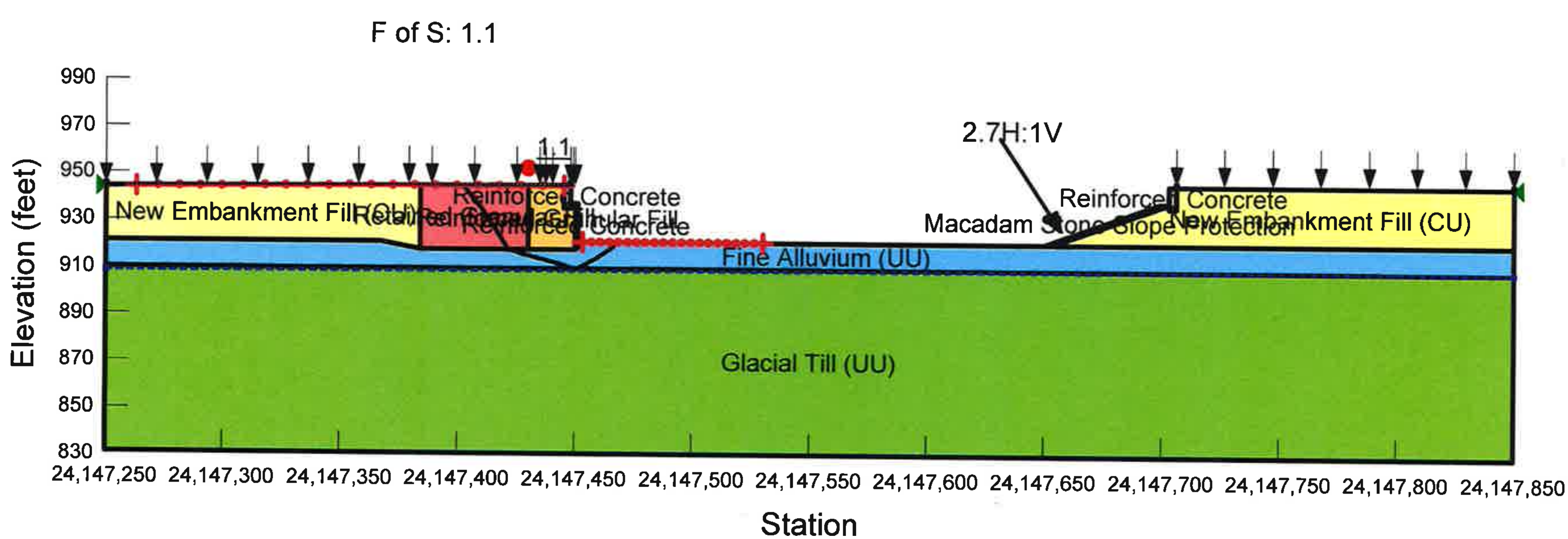
F of S: 1.7



√ JAC 11/29/16

Project Name: IDOT - US218/US30 Benton County
Location: US 218 Station 241474+47.22 to 241477+04.22
Name: South Abutment MSE Wall Stability (Short Term)
Description: Short Term (end of construction) Case; Includes Live Load=240 psf
Method: Spencer

Name: Reinforced Concrete Model: High Strength Unit Weight: 150 pcf
Name: Macadam Stone Slope Protection Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 35 °
Name: New Embankment Fill (CU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 600 psf Phi': 12 °
Name: Fine Alluvium (UU) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 650 psf Phi': 0 °
Name: Glacial Till (UU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 2,500 psf Phi': 0 °
Name: Retained Granular Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: Reinforced Granular Fill Model: High Strength Unit Weight: 120 pcf

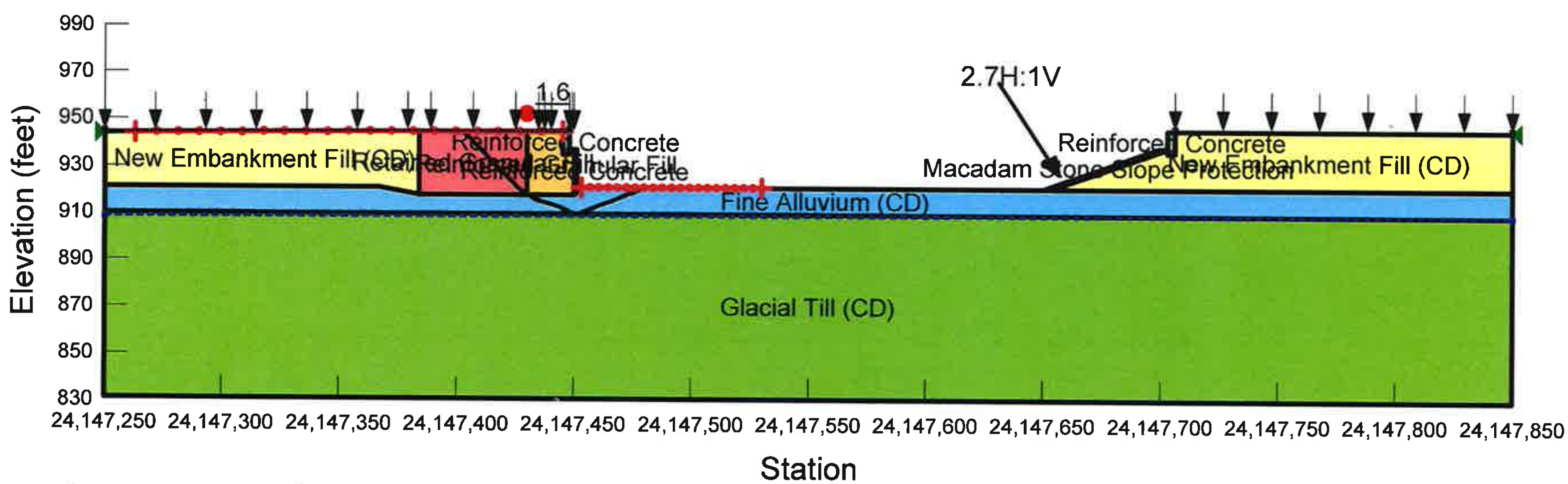


✓ JAC 11/29/16

Project Name: IDOT - US218/US30 Benton County
Location: US 218 Station 241474+47.22 to 241477+04.22
Name: South Abutment MSE Wall Stability (Long Term)
Description: Long Term Case; Includes Live Load=240 psf
Method: Spencer

Name: New Embankment Fill (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 150 psf Phi': 28 °
Name: Fine Alluvium (CD) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 50 psf Phi': 28 °
Name: Glacial Till (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 100 psf Phi': 28 °
Name: Reinforced Concrete Model: High Strength Unit Weight: 150 pcf
Name: Macadam Stone Slope Protection Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 35 °
Name: Retained Granular Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: Reinforced Granular Fill Model: High Strength Unit Weight: 120 pcf

F of S: 1.6

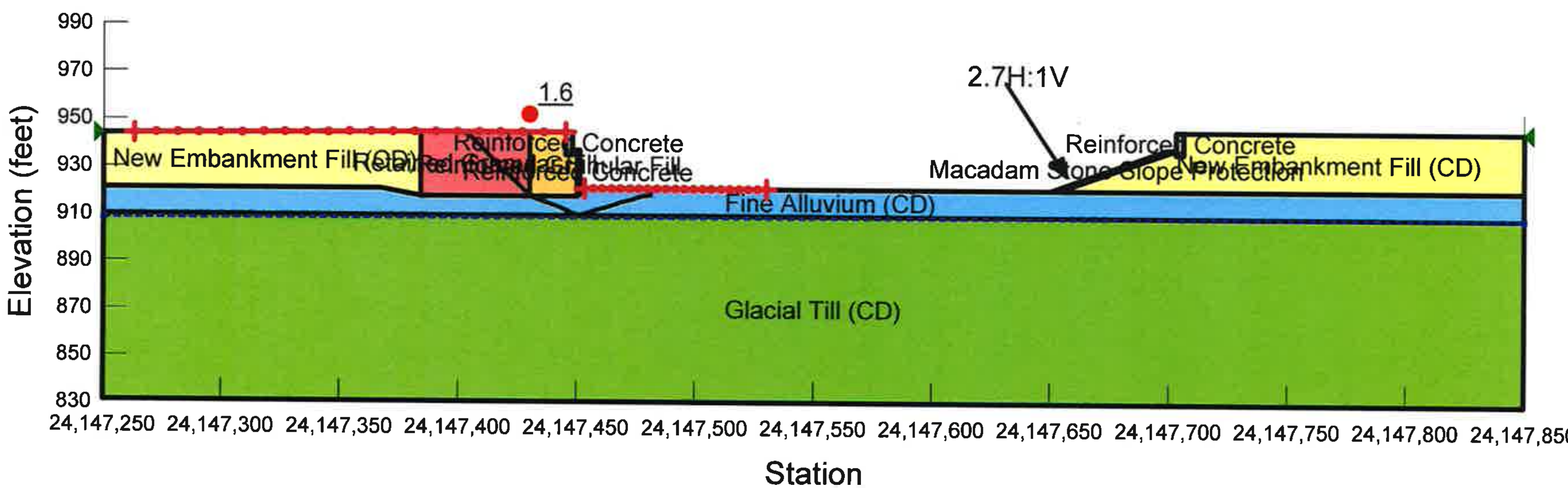


✓ JAC 11/29/16

Project Name: IDOT - US218/US30 Benton County
Location: US 218 Station 241474+47.22 to 241477+04.22
Name: South Abutment MSE Wall Stability (Long Term w/ Seismic)
Description: Long Term Case w/ Seismic, ah=0.02g
Method: Spencer

Name: New Embankment Fill (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 150 psf Phi': 28 °
Name: Fine Alluvium (CD) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 50 psf Phi': 28 °
Name: Glacial Till (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 100 psf Phi': 28 °
Name: Reinforced Concrete Model: High Strength Unit Weight: 150 pcf
Name: Macadam Stone Slope Protection Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 35 °
Name: Retained Granular Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: Reinforced Granular Fill Model: High Strength Unit Weight: 120 pcf

F of S: 1.6

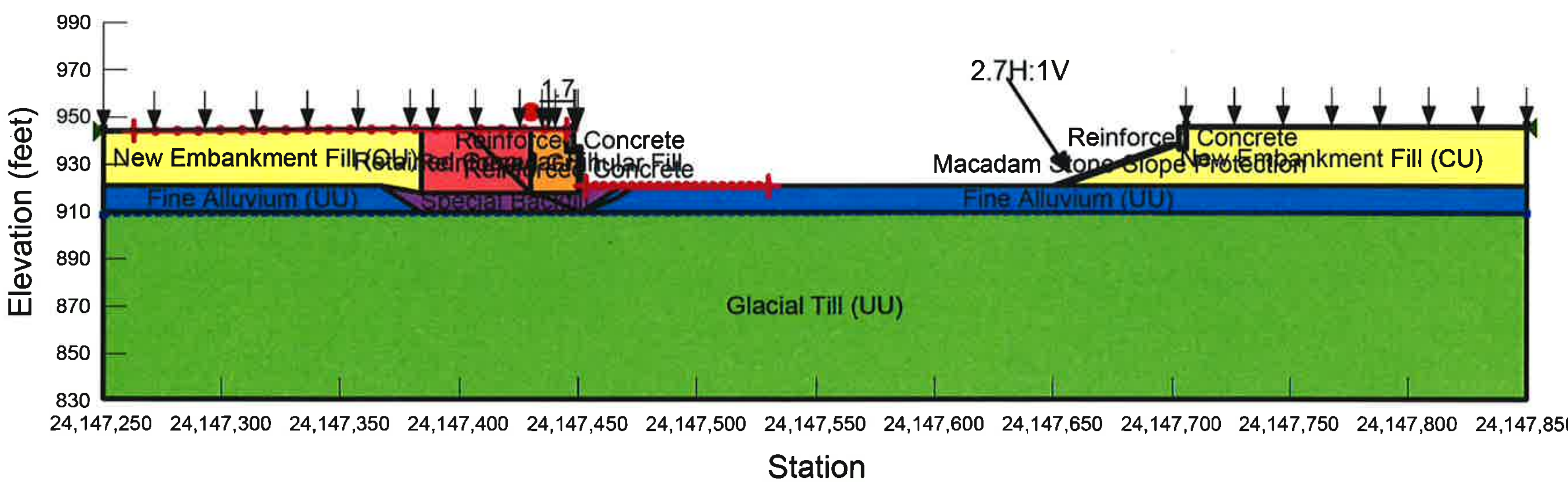


✓JAC
2/28/17

Project Name: IDOT - US218/US30 Benton County
Location: US 218 Station 241474+47.22 to 241477+04.22
Name: South Abutment MSE Wall Stability (Short Term)
Description: Short Term (end of construction) Case; Overex/Replace; Includes Live Load=240 psf
Method: Spencer

Name: Reinforced Concrete Model: High Strength Unit Weight: 150 pcf
Name: Macadam Stone Slope Protection Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 35 °
Name: New Embankment Fill (CU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 600 psf Phi': 12 °
Name: Fine Alluvium (UU) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 650 psf Phi': 0 °
Name: Glacial Till (UU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 2,500 psf Phi': 0 °
Name: Retained Granular Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: Reinforced Granular Fill Model: High Strength Unit Weight: 120 pcf
Name: Special Backfill Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 32 °

F of S: 1.7

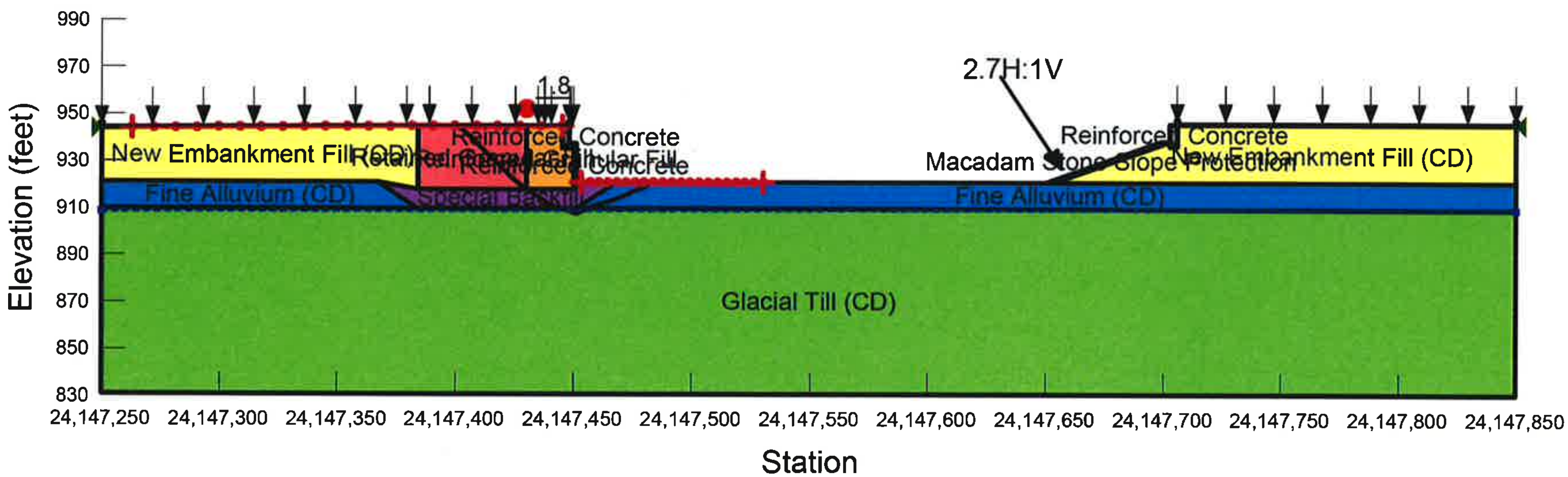


Project Name: IDOT - US218/US30 Benton County
Location: US 218 Station 241474+47.22 to 241477+04.22
Name: South Abutment MSE Wall Stability (Long Term)
Description: Long Term Case; Overex/Replace; Includes Live Load=240 psf
Method: Spencer

✓ JAC
2/28/17

Name: New Embankment Fill (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 150 psf Phi': 28 °
Name: Fine Alluvium (CD) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 50 psf Phi': 28 °
Name: Glacial Till (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 100 psf Phi': 28 °
Name: Reinforced Concrete Model: High Strength Unit Weight: 150 pcf
Name: Macadam Stone Slope Protection Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 35 °
Name: Retained Granular Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: Reinforced Granular Fill Model: High Strength Unit Weight: 120 pcf
Name: Special Backfill Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 32 °

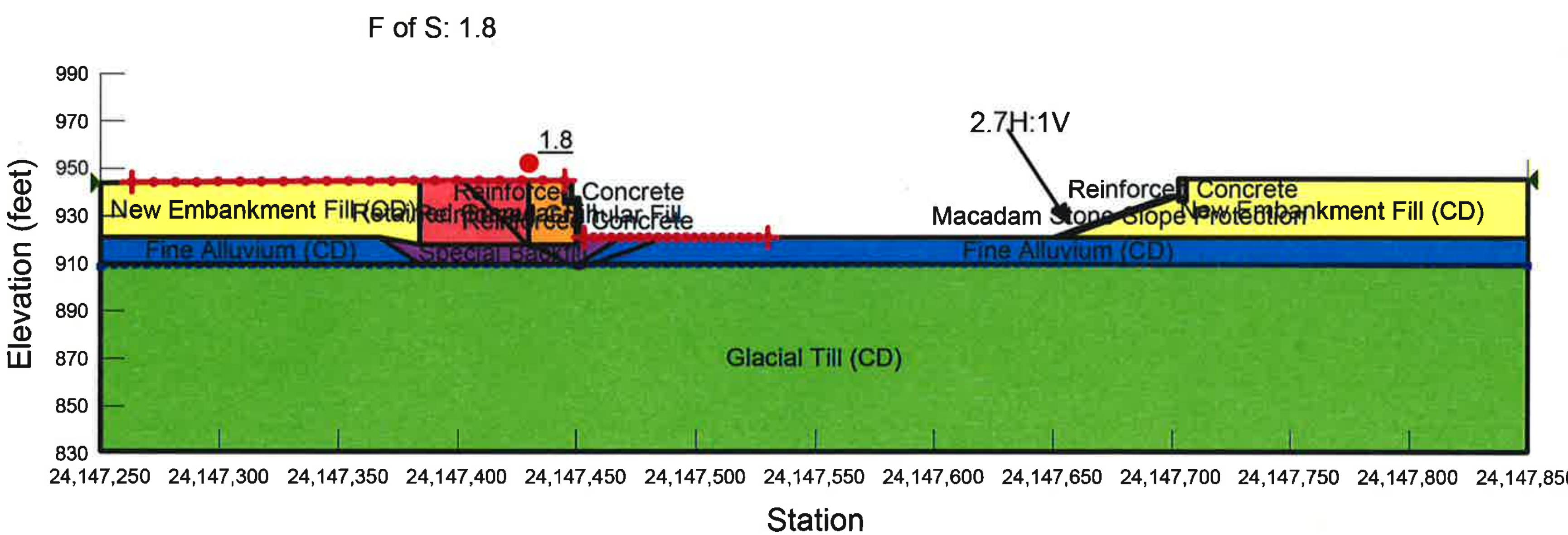
F of S: 1.8



Project Name: IDOT - US218/US30 Benton County
Location: US 218 Station 241474+47.22 to 241477+04.22
Name: South Abutment MSE Wall Stability (Long Term w/ Seismic)
Description: Long Term Case w/ Seismic, ah=0.02g; Overex/Replace
Method: Spencer

✓JAC
2/28/17

Name: New Embankment Fill (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 150 psf Phi': 28 °
Name: Fine Alluvium (CD) Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 50 psf Phi': 28 °
Name: Glacial Till (CD) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 100 psf Phi': 28 °
Name: Reinforced Concrete Model: High Strength Unit Weight: 150 pcf
Name: Macadam Stone Slope Protection Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion': 0 psf Phi': 35 °
Name: Retained Granular Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 0 psf Phi': 34 °
Name: Reinforced Granular Fill Model: High Strength Unit Weight: 120 pcf
Name: Special Backfill Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 32 °



APPENDIX D: Settlement Analyses

8408 Indian Hills Drive
Omaha, NE 68114

Phone (402) 399-1000
Fax (402) 399-4979
www.hdrinc.com

ONE COMPANY *Many Solutions*℠			
Project: US 30 Benton County	Computed: BMG	Date: 27-Feb-17	
Subject: Roadway Embankments	Checked: JAC	Date: 27-Feb-17	
Task: Consolidation Settlement Analyses	Page: 1 of 2		
Job #: 221364	Dept. No: 134		

Location: Station 1388+10 Eastbound and Westbound

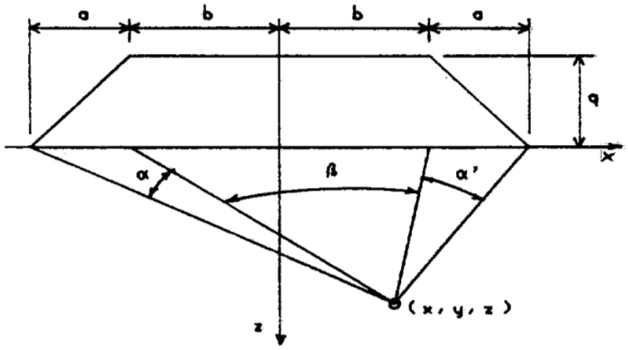
References:

1. EM 1110-1-1904 "Settlement Analyses" (1990)
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Full Height of Additional Embankment Fill



Groundwater Table:	D =	6	ft			
Embankment Height:	H =	20	ft			
Fill Unit Weight:	γ_{emb} =	125	pcf		q =	2500 psf
Surcharge:	P =	0	psf			
Width of Slope:	a =	66	ft	*3.5:1 Slope*		
Top half-width of Emb.:	b =	25	ft			
Distance from CL:	x =	0	ft			
Output Range:	z =	0	to	15	ft	
Drainage:	Double					

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	CL	3	1.5	0.0	0.0	3.0	2475.9	0	2475.9
2	CL	6	4.5	0.1	0.1	2.8	2427.8	0	2427.8
3	CL	9	7.5	0.2	0.2	2.6	2379.6	0	2379.6
4	CL	15	12	0.3	0.3	2.2	2307.1	0	2307.1
5									
6									
7									
8									
9									
10									

Note: Soil profile based on RB30-334 and RB30-335.

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_f}{\sigma'_0}\right) \right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_f<\sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_f}{\sigma'_0}\right) \right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c<\sigma'_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_c}{\sigma'_0}\right) + \frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_f}{\sigma'_c}\right) \right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	CL	3	115	173	2476	2648	2000	0.260	0.050	0.860	0.137
2	CL	6	115	518	2428	2945	2000	0.260	0.050	0.860	0.118
3	CL	9	53	770	2380	3149	1154	0.260	0.050	0.860	0.197
4	CL	15	63	1038	2307	3345	5000	0.150	0.030	0.510	0.061
5	0	0									
6	0	0									
7	0	0									
8	0	0									
9	0	0									
10	0	0									

1. Parameters based on consolidation test summary and design OCR Profile. **0.5** ft

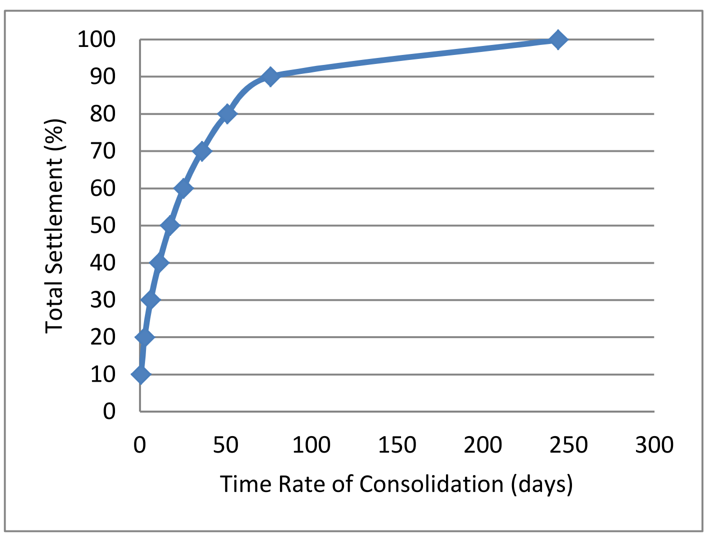
2. Water Table Elev. assumed at 6 foot depth. **Total Settlement** **6.1** in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft²/day)	Time (days)
10	0.01	6.5	0.47	1
20	0.03	6.5	0.47	3
30	0.07	6.5	0.47	6
40	0.13	6.5	0.47	11
50	0.20	6.5	0.47	18
60	0.28	6.5	0.47	25
70	0.40	6.5	0.47	36
80	0.57	6.5	0.47	51
90	0.85	6.5	0.47	76
99.9	2.71	6.5	0.47	244

1. Assume Double Drainage

2. C_v based on consolidation test summary.



ONE COMPANY
Many Solutions℠

Project:	US 30 Benton County	Computed: JAC	Date: 27-Feb-17
Subject:	Roadway Embankments	Checked: BTH	Date: 27-Feb-17
Task:	Consolidation Settlement Analyses	Page: 1 of 2	
Job #:	10020774	Dept. No: 134	

Station 1400+94 Eastbound

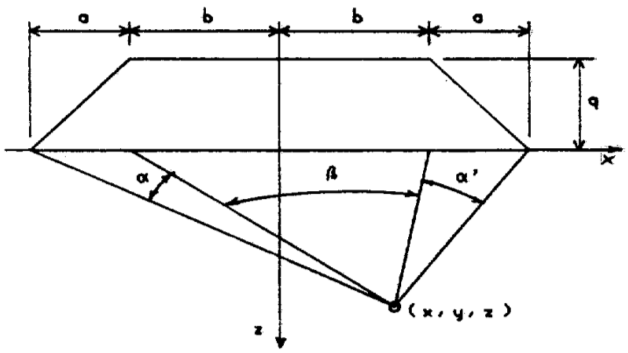
References:

1. EM 1110-1-1904 "Settlement Analyses" (1990)
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Full Height of Additional Embankment Fill



Groundwater Table:	D =	4	ft		
Embankment Height:	H =	16	ft		
Fill Unit Weight:	γ_{emb} =	125	pcf	*q* =	2000 psf
Surcharge:	P =	0	psf		
Width of Slope:	a =	62	ft	*3.5:1 Slope*	
Top half-width of Emb.:	b =	77	ft		
Distance from CL:	x =	0	ft		
Output Range:	z =	0	to	8	ft
Drainage:	Double				

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	CL	4	2	0.0	0.0	3.1	1983.5	0	1983.5
2	CL	6	5	0.0	0.0	3.0	1958.7	0	1958.7
3	CL	8	7	0.0	0.0	3.0	1942.1	0	1942.1
4									
5									
6									
7									
8									
9									
10									

Note: Soil profile based on RB30-340 and RB30-341.

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_0} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_f < \sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_0} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_c < \sigma'_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_c}{\sigma'_0} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_c} \right) \right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	CL	4	115	230	1983	2213	3000	0.260	0.050	0.860	0.106
2	CL	6	53	513	1959	2472	3000	0.260	0.050	0.860	0.037
3	CL	8	53	619	1942	2561	3000	0.260	0.050	0.860	0.033
4	0	0									
5	0	0									
6	0	0									
7	0	0									
8	0	0									
9	0	0									
10	0	0									

1. Parameters based on consolidation test summary and design OCR Profile. **0.2** ft

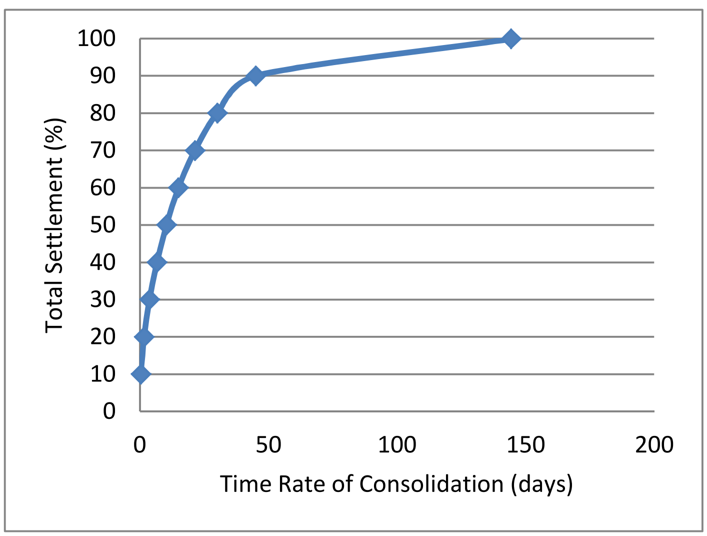
2. Water Table Elev. assumed at 4 foot depth. **Total Settlement** **2.1** in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft^2/day)	Time (days)
10	0.01	5	0.47	0
20	0.03	5	0.47	2
30	0.07	5	0.47	4
40	0.13	5	0.47	7
50	0.20	5	0.47	10
60	0.28	5	0.47	15
70	0.40	5	0.47	21
80	0.57	5	0.47	30
90	0.85	5	0.47	45
99.9	2.71	5	0.47	144

1. Assume Double Drainage

2. C_v based on consolidation test summary.



ONE COMPANY
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Project:	US 30 Benton County	Computed:	BMG	Date:	27-Feb-17
Subject:	Roadway Embankments	Checked:	JAC	Date:	27-Feb-17
Task:	Consolidation Settlement Analyses	Page:	1	of	2
Job #:	221364	Dept. No:	134		

Location: Station 1425+50 Eastbound

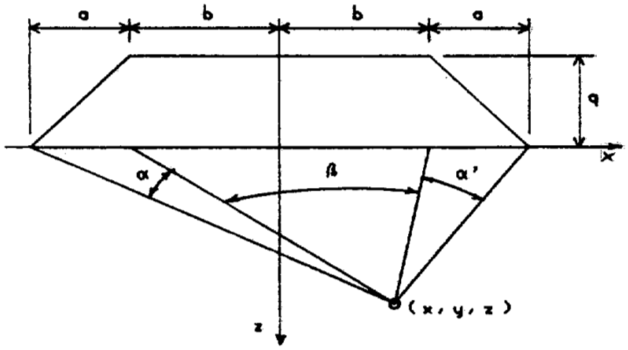
References:

1. EM 1110-1-1904 "Settlement Analyses" (1990)
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Full Height of Additional Embankment Fill



Groundwater Table:	D =	6.5	ft			
Embankment Height:	H =	15	ft			
Fill Unit Weight:	γ_{emb} =	125	pcf	*q* =	1875	psf
Surcharge:	P =	0	psf			
Width of Slope:	a =	62	ft	*3.5:1 Slope*		
Top half-width of Emb.:	b =	20	ft			
Distance from CL:	x =	0	ft			
Output Range:	z =	0	to	23	ft	
Drainage:	Double					

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	CL	3	1.5	0.1	0.1	3.0	1855.4	0	1855.4
2	CL	6.5	4.75	0.2	0.2	2.7	1812.9	0	1812.9
3	SP	8.5	7.5	0.3	0.3	2.4	1776.8	0	1776.8
4	CL	13	10.75	0.4	0.4	2.2	1733.9	0	1733.9
5	CL	18	15.5	0.5	0.5	1.8	1670.9	0	1670.9
6	SP	21	19.5	0.5	0.5	1.6	1617.9	0	1617.9
7	CL	23	22	0.6	0.6	1.5	1585.0	0	1585.0
8									
9									
10									

Note: Soil profile based on CPT Log No. RB-30-352a and Borings RB30-352 and RB30-353.

Normally Consolidated Soil

$$S = \sum\left[\frac{C_c}{1+e_0}\cdot H\cdot\log\left(\frac{\sigma'_f}{\sigma'_0}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_f<\sigma'_c$)

$$S = \sum\left[\frac{C_r}{1+e_0}\cdot H\cdot\log\left(\frac{\sigma'_f}{\sigma'_0}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c<\sigma'_f$)

$$S = \sum\left[\frac{C_r}{1+e_0}\cdot H\cdot\log\left(\frac{\sigma'_c}{\sigma'_0}\right)+\frac{C_c}{1+e_0}\cdot H\cdot\log\left(\frac{\sigma'_f}{\sigma'_c}\right)\right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	CL	3	115	173	1855	2028	3000	0.260	0.050	0.860	0.086
2	CL	6.5	115	546	1813	2359	3000	0.260	0.050	0.860	0.060
3	SP	8.5	58	806	1777	2582	-	0.000	0.000	0.455	0.000
4	CL	13	53	983	1734	2717	1474	0.260	0.050	0.860	0.188
5	CL	18	53	1235	1671	2905	1852	0.260	0.050	0.860	0.160
6	SP	21	58	1454	1618	3072	-	0.000	0.000	0.455	0.000
7	CL	23	63	1604	1585	3189	5000	0.150	0.030	0.510	0.012
8	0	0									
9	0	0									
10	0	0									

1. Parameters based on consolidation test summary and design OCR Profile.

2. Water Table Elev. assumed at 6.5 foot depth.

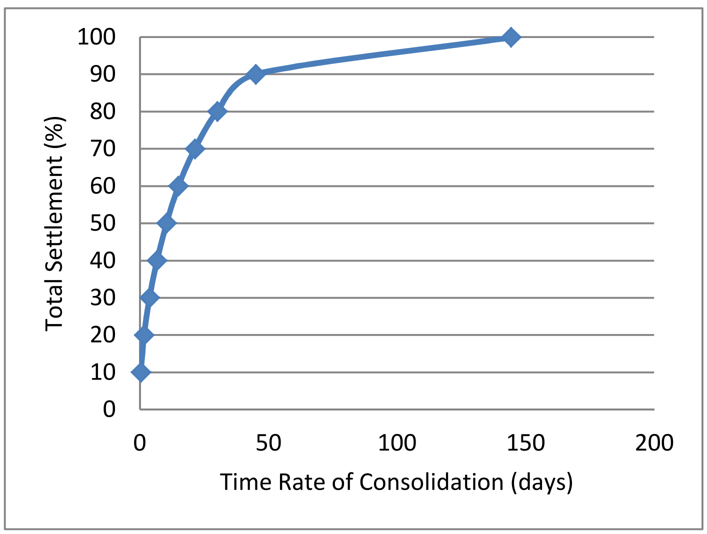
Total Settlement 0.5 ft; 6.1 in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft^2/day)	Time (days)
10	0.01	5	0.47	0
20	0.03	5	0.47	2
30	0.07	5	0.47	4
40	0.13	5	0.47	7
50	0.20	5	0.47	10
60	0.28	5	0.47	15
70	0.40	5	0.47	21
80	0.57	5	0.47	30
90	0.85	5	0.47	45
99.9	2.71	5	0.47	144

1. Assume Double Drainage

2. C_v based on consolidation test summary.



HDR ONE COMPANY *Many Solutions*℠

Project:	US 30 Benton County	Computed:	BMG	Date:	27-Feb-17
Subject:	Roadway Embankments	Checked:	JAC	Date:	27-Feb-17
Task:	Consolidation Settlement Analyses	Page:	1	of	2
Job #:	221364	Dept. No:	134		

Location: Station 1425+50 Westbound

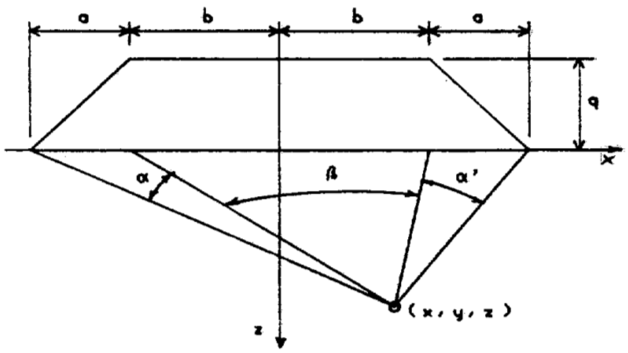
References:

1. EM 1110-1-1904 "Settlement Analyses" (1990)
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Full Height of Additional Embankment Fill



Groundwater Table:	D =	6.5	ft		
Embankment Height:	H =	16	ft		
Fill Unit Weight:	γ_{emb} =	125	pcf	*q* =	2000 psf
Surcharge:	P =	0	psf		
Width of Slope:	a =	62	ft	*3.5:1 Slope*	
Top half-width of Emb.:	b =	20	ft		
Distance from CL:	x =	0	ft		
Output Range:	z =	0	to	15.5	ft
Drainage:	Double				

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	CL	3	1.5	0.1	0.1	3.0	1979.0	0	1979.0
2	CL	6.5	4.75	0.2	0.2	2.7	1933.3	0	1933.3
3	SP	8.5	7.5	0.3	0.3	2.4	1894.6	0	1894.6
4	CL	13	10.75	0.4	0.4	2.2	1848.5	0	1848.5
5	CL	15.5	14.25	0.4	0.4	1.9	1798.8	0	1798.8
6									
7									
8									
9									
10									

Note: Soil profile based on CPT Log No. RB-30-352a and Borings RB30-352 and RB30-353.

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_0'}\right) \right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma_f'<\sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_0'}\right) \right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c<\sigma_f'$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_c'}{\sigma_0'}\right) + \frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_c'}\right) \right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	CL	3	115	173	1979	2151	3000	0.260	0.050	0.860	0.088
2	CL	6.5	115	546	1933	2480	3000	0.260	0.050	0.860	0.062
3	SP	8.5	58	806	1895	2700	-	0.000	0.000	0.455	0.000
4	CL	13	53	983	1849	2831	1474	0.260	0.050	0.860	0.200
5	CL	15.5	53	1168	1799	2967	1752	0.260	0.050	0.860	0.092
6	0	0									
7	0	0									
8	0	0									
9	0	0									
10	0	0									

1. Parameters based on consolidation test summary and design OCR Profile. **0.4** ft

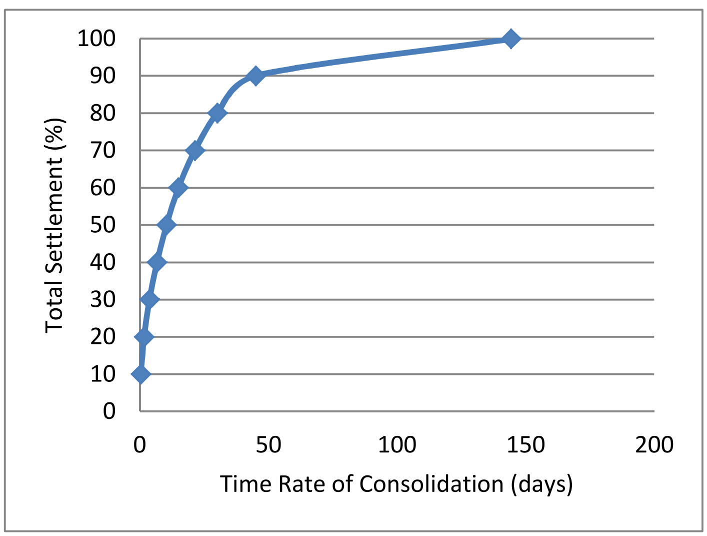
2. Water Table Elev. assumed at 6.5 foot depth. **Total Settlement** **5.3** in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft^2/day)	Time (days)
10	0.01	5	0.47	0
20	0.03	5	0.47	2
30	0.07	5	0.47	4
40	0.13	5	0.47	7
50	0.20	5	0.47	10
60	0.28	5	0.47	15
70	0.40	5	0.47	21
80	0.57	5	0.47	30
90	0.85	5	0.47	45
99.9	2.71	5	0.47	144

1. Assume Double Drainage

2. C_v based on consolidation test summary.



Location: Station 1454+00 Eastbound

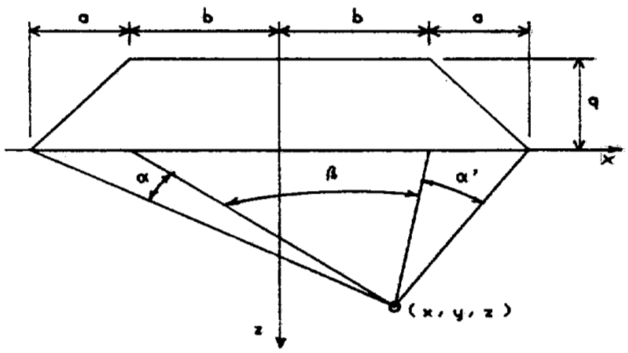
References:

1. EM 1110-1-1904 "Settlement Analyses" (1990)
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Full Height of Additional Embankment Fill



Groundwater Table:	D =	6	ft			
Embankment Height:	H =	13	ft			
Fill Unit Weight:	γ_{emb} =	125	pcf	q =	1625	psf
Surcharge:	P =	0	psf			
Width of Slope:	a =	52	ft	*3.5:1 Slope*		
Top half-width of Emb.:	b =	20	ft			
Distance from CL:	x =	0	ft			
Output Range:	z =	0	to	10	ft	
Drainage:	Double					

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right)\cdot\left(a\cdot\left(\alpha(z)+\beta(z)+\alpha'(z)\right)\right)+b\cdot(\alpha(z)+\alpha'(z))+x\cdot((\alpha(z)-\alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right]+a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right]-a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right]-a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	CL	2	1	0.0	0.0	3.0	1612.1	0	1612.1
2	CL	6	4	0.1	0.1	2.7	1573.3	0	1573.3
3	CL	10	8	0.3	0.3	2.4	1521.3	0	1521.3
4									
5									
6									
7									
8									
9									
10									

Note: Soil profile based on RB30-367.

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_f}{\sigma'_0} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_f<\sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_f}{\sigma'_0} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c<\sigma'_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_c}{\sigma'_0} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_f}{\sigma'_c} \right) \right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	CL	2	115	115	1612	1727	2000	0.260	0.050	0.860	0.063
2	CL	6	125	480	1573	2053	3000	0.260	0.050	0.510	0.084
3	CL	10	63	856	1521	2377	5000	0.150	0.030	0.510	0.035
4	0	0									
5	0	0									
6	0	0									
7	0	0									
8	0	0									
9	0	0									
10	0	0									

1. Parameters based on consolidation test summary and design OCR Profile. 0.2 ft

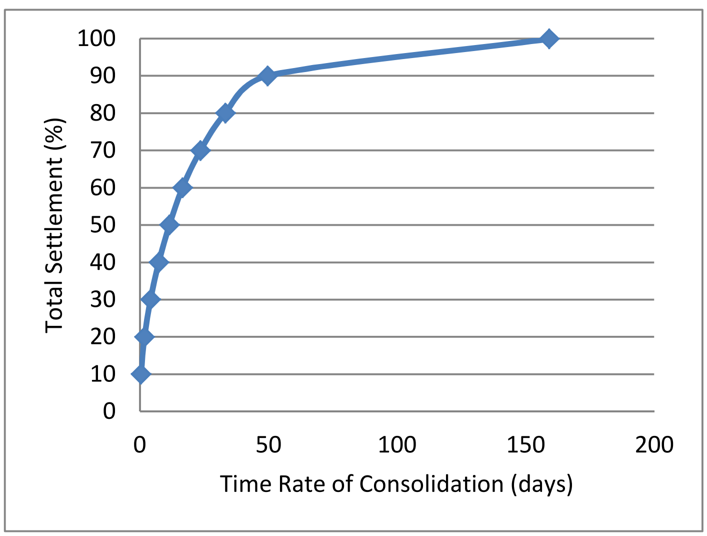
2. Water Table Elev. assumed at 6 foot depth. **Total Settlement** **2.2** in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft^2/day)	Time (days)
10	0.01	5.25	0.47	0
20	0.03	5.25	0.47	2
30	0.07	5.25	0.47	4
40	0.13	5.25	0.47	7
50	0.20	5.25	0.47	12
60	0.28	5.25	0.47	17
70	0.40	5.25	0.47	24
80	0.57	5.25	0.47	33
90	0.85	5.25	0.47	50
99.9	2.71	5.25	0.47	159

1. Assume Double Drainage

2. C_v based on consolidation test summary.



Location: Station 1454+00 Westbound

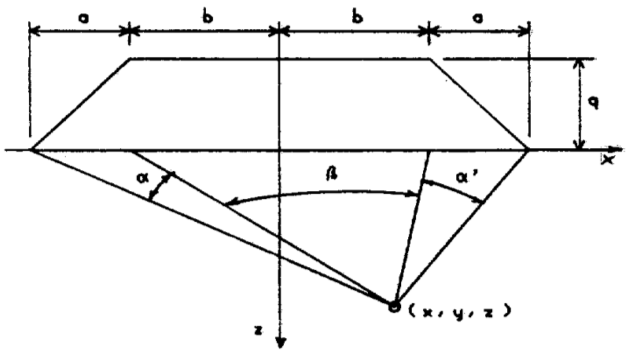
References:

1. EM 1110-1-1904 "Settlement Analyses" (1990)
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Full Height of Additional Embankment Fill



Groundwater Table:	D =	6	ft		
Embankment Height:	H =	10	ft		
Fill Unit Weight:	γ_{emb} =	125	pcf	q =	1250 psf
Surcharge:	P =	0	psf		
Width of Slope:	a =	52	ft	*3.5:1 Slope*	
Top half-width of Emb.:	b =	20	ft		
Distance from CL:	x =	0	ft		
Output Range:	z =	0	to	10	ft
Drainage:	Double				

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	CL	2	1	0.0	0.0	3.0	1240.4	0	1240.4
2	CL	6	4	0.1	0.1	2.7	1211.5	0	1211.5
3	CL	10	8	0.3	0.3	2.4	1172.7	0	1172.7
4									
5									
6									
7									
8									
9									
10									

Note: Soil profile based on RB30-367.

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma_f' < \sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_c < \sigma_f'$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_c'}{\sigma_0'} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_c'} \right) \right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	CL	2	115	115	1240	1355	2000	0.260	0.050	0.860	0.058
2	CL	6	125	480	1212	1692	3000	0.260	0.050	0.510	0.072
3	CL	10	63	856	1173	2029	5000	0.150	0.030	0.510	0.030
4	0	0									
5	0	0									
6	0	0									
7	0	0									
8	0	0									
9	0	0									
10	0	0									

1. Parameters based on consolidation test summary and design OCR Profile. — **0.2** ft

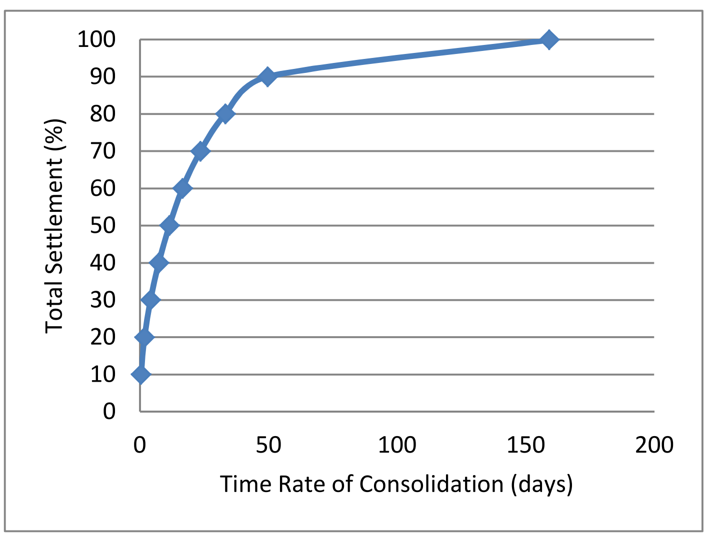
2. Water Table Elev. assumed at 6 foot depth. — **Total Settlement** **1.9** in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft^2/day)	Time (days)
10	0.01	5.25	0.47	0
20	0.03	5.25	0.47	2
30	0.07	5.25	0.47	4
40	0.13	5.25	0.47	7
50	0.20	5.25	0.47	12
60	0.28	5.25	0.47	17
70	0.40	5.25	0.47	24
80	0.57	5.25	0.47	33
90	0.85	5.25	0.47	50
99.9	2.71	5.25	0.47	159

1. Assume Double Drainage

2. C_v based on consolidation test summary.



Project:	US 30 Benton County	Computed:	BMG	Date:	27-Feb-17
Subject:	Roadway Embankments	Checked:	JAC	Date:	27-Feb-17
Task:	Consolidation Settlement Analyses	Page:	1	of	2
Job #:	221364	Dept. No:	134		

HDR ONE COMPANY *Many Solutions*℠

Location: Station 1460+75 Eastbound

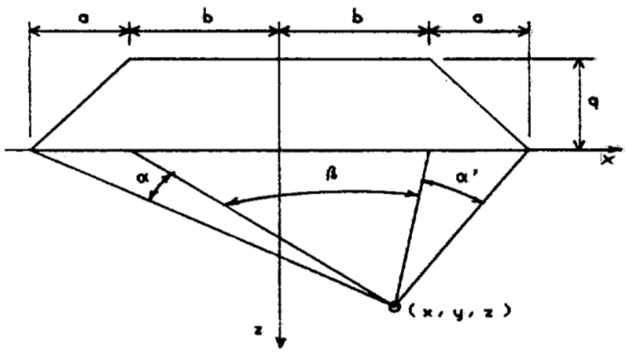
References:

1. EM 1110-1-1904 "Settlement Analyses" (1990)
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Full Height of Additional Embankment Fill



Groundwater Table:	D =	6.5	ft		
Embankment Height:	H =	10	ft		
Fill Unit Weight:	γ_{emb} =	125	pcf	q =	1250 psf
Surcharge:	P =	0	psf		
Width of Slope:	a =	45	ft	*3.5:1 Slope*	
Top half-width of Emb.:	b =	10	ft		
Distance from CL:	x =	0	ft		
Output Range:	z =	0	to	13	ft
Drainage:	Double				

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	CL	3	1.5	0.1	0.1	2.8	1230.7	0	1230.7
2	CL	5.5	4.25	0.3	0.3	2.3	1195.1	0	1195.1
3	CL	6.5	6	0.4	0.4	2.1	1172.2	0	1172.2
4	CL	9	7.75	0.5	0.5	1.8	1149.0	0	1149.0
5	CL	13	11	0.6	0.6	1.5	1105.6	0	1105.6
6									
7									
8									
9									
10									

Note: Soil profile based on RB30-370 and RB30-371.

Project:	US 30 Benton County	Computed: BMG	Date: 27-Feb-17
Subject:	Roadway Embankments	Checked: JAC	Date: 27-Feb-17
Task:	Consolidation Settlement Analyses	Page: 2 of 2	
Job #:	221364	Dept. No:	134

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Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_f}{\sigma'_0}\right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_f < \sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_f}{\sigma'_0}\right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_c < \sigma'_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_c}{\sigma'_0}\right) + \frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_f}{\sigma'_c}\right) \right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	CL	3	115	173	1231	1403	2000	0.260	0.050	0.860	0.073
2	CL	5.5	115	489	1195	1684	2000	0.260	0.050	0.860	0.036
3	CL	6.5	125	695	1172	1867	5000	0.150	0.030	0.510	0.009
4	CL	9	63	836	1149	1985	5000	0.150	0.030	0.510	0.019
5	CL	13	63	1041	1106	2147	5000	0.150	0.030	0.510	0.025
6	0	0									
7	0	0									
8	0	0									
9	0	0									
10	0	0									

1. Parameters based on consolidation test summary and design OCR Profile. **0.2** ft

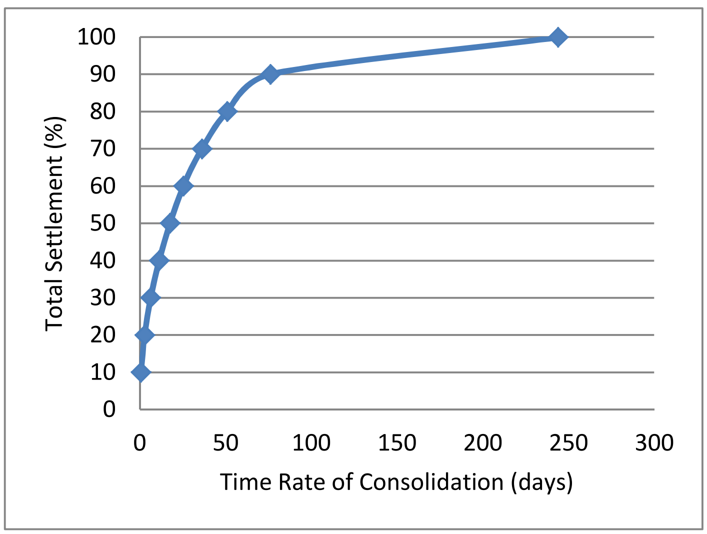
2. Water Table Elev. assumed at 6.5 foot depth. **Total Settlement** **1.9** in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft^2/day)	Time (days)
10	0.01	6.5	0.47	1
20	0.03	6.5	0.47	3
30	0.07	6.5	0.47	6
40	0.13	6.5	0.47	11
50	0.20	6.5	0.47	18
60	0.28	6.5	0.47	25
70	0.40	6.5	0.47	36
80	0.57	6.5	0.47	51
90	0.85	6.5	0.47	76
99.9	2.71	6.5	0.47	244

1. Assume Double Drainage

2. C_v based on consolidation test summary.



Location: Station 1493+85 Eastbound

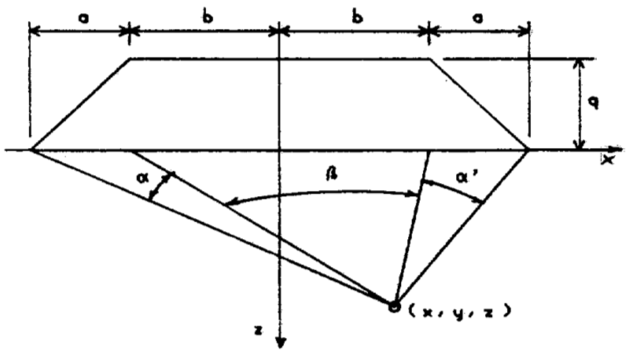
References:

1. EM 1110-1-1904 "Settlement Analyses" (1990)
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Full Height of Additional Embankment Fill



Groundwater Table:	D =	3	ft			
Embankment Height:	H =	5.5	ft			
Fill Unit Weight:	γ_{emb} =	125	pcf		q =	687.5 psf
Surcharge:	P =	0	psf			
Width of Slope:	a =	27	ft	*3.5:1 Slope*		
Top half-width of Emb.:	b =	10	ft			
Distance from CL:	x =	0	ft			
Output Range:	z =	0	to	12	ft	
Drainage:	Double					

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	CL	3	1.5	0.1	0.1	2.8	671.9	0	671.9
2	CL	6.5	4.75	0.3	0.3	2.3	637.9	0	637.9
3	CL	8.5	7.5	0.4	0.4	1.9	608.8	0	608.8
4	CL	12	10.25	0.5	0.5	1.5	579.8	0	579.8
5									
6									
7									
8									
9									
10									

Note: Soil profile based on RB30-387.

Normally Consolidated Soil

$$S = \sum\left[\frac{C_c}{1+e_0}\cdot H\cdot\log\left(\frac{\sigma'_f}{\sigma'_0}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_f<\sigma'_c$)

$$S = \sum\left[\frac{C_r}{1+e_0}\cdot H\cdot\log\left(\frac{\sigma'_f}{\sigma'_0}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c<\sigma'_f$)

$$S = \sum\left[\frac{C_r}{1+e_0}\cdot H\cdot\log\left(\frac{\sigma'_c}{\sigma'_0}\right)+\frac{C_c}{1+e_0}\cdot H\cdot\log\left(\frac{\sigma'_f}{\sigma'_c}\right)\right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	CL	3	115	173	672	844	2000	0.260	0.050	0.860	0.056
2	CL	5.5	53	411	638	1049	2000	0.260	0.050	0.860	0.027
3	CL	8.5	63	572	609	1181	5000	0.150	0.030	0.510	0.019
4	CL	12	63	777	580	1357	5000	0.150	0.030	0.510	0.017
5	0	0									
6	0	0									
7	0	0									
8	0	0									
9	0	0									
10	0	0									

1. Parameters based on consolidation test summary and design OCR Profile. **0.1** ft

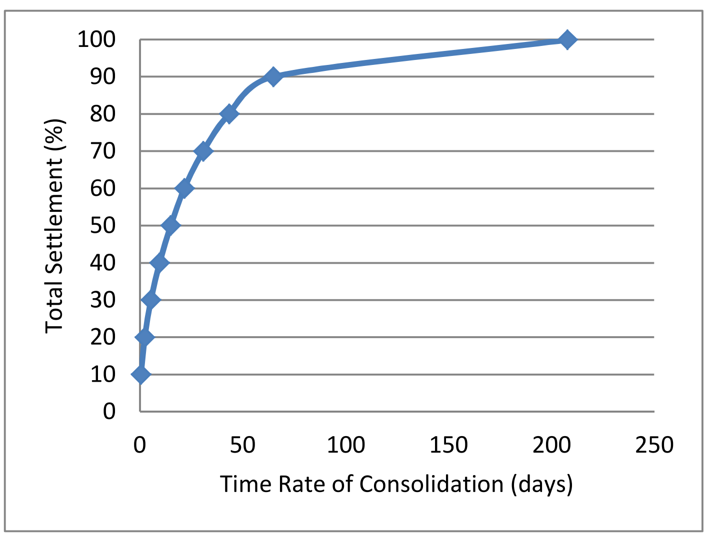
2. Water Table Elev. assumed at 3 foot depth. **Total Settlement** **1.4** in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft^2/day)	Time (days)
10	0.01	6	0.47	1
20	0.03	6	0.47	2
30	0.07	6	0.47	5
40	0.13	6	0.47	10
50	0.20	6	0.47	15
60	0.28	6	0.47	22
70	0.40	6	0.47	31
80	0.57	6	0.47	43
90	0.85	6	0.47	65
99.9	2.71	6	0.47	208

1. Assume Double Drainage

2. C_v based on consolidation test summary.



Location: Ramp D - Station 41476+17

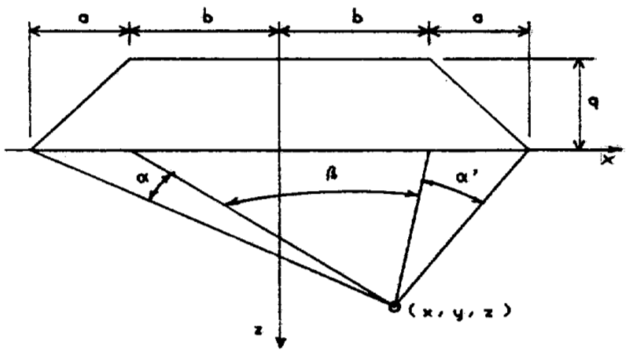
References:

1. EM 1110-1-1904 "Settlement Analyses" (1990)
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Full Height of Additional Embankment Fill



Groundwater Table:	D =	3	ft		
Embankment Height:	H =	20	ft		
Fill Unit Weight:	γ_{emb} =	125	pcf	*q* =	2500 psf
Surcharge:	P =	0	psf		
Width of Slope:	a =	85	ft	*3.5:1 Slope*	
Top half-width of Emb.:	b =	27	ft		
Distance from CL:	x =	0	ft		
Output Range:	z =	0	to	12	ft
Drainage:	Double				

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	CL	3	1.5	0.0	0.0	3.0	2481.0	0	2481.0
2	CH	6	4.5	0.1	0.1	2.8	2442.8	0	2442.8
3	CL	12	9	0.2	0.2	2.5	2385.4	0	2385.4
4									
5									
6									
7									
8									
9									
10									

Note: Soil profile based on B-8 and B-10.

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_f<\sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_0} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c<\sigma_f'$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma_c'}{\sigma_0'} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_c'} \right) \right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	CL	3	120	180	2481	2661	2000	0.150	0.030	0.860	0.081
2	CH	6	53	440	2443	2882	2000	0.260	0.050	0.860	0.120
3	CL	12	53	678	2385	3063	2000	0.260	0.050	0.860	0.231
4	0	0									
5	0	0									
6	0	0									
7	0	0									
8	0	0									
9	0	0									
10	0	0									

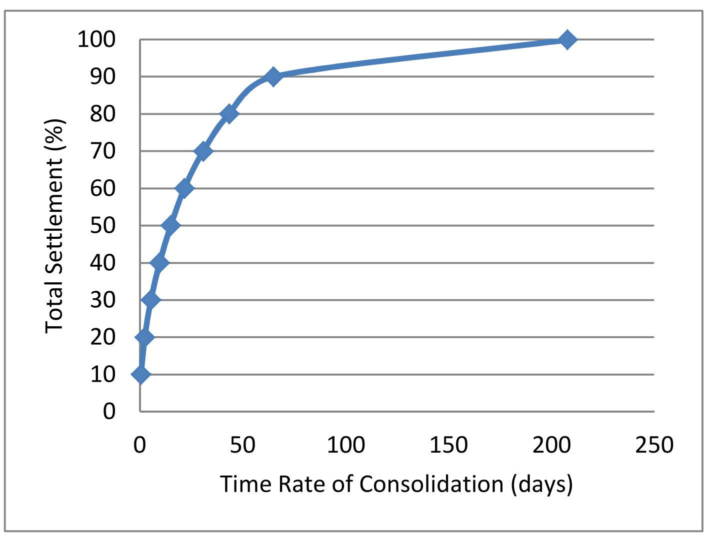
1. Parameters based on consolidation test summary and design OCR Profile.
2. Water Table Elev. assumed at 3 foot depth.

	0.4	ft
Total Settlement	**5.2**	in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft^2/day)	Time (days)
10	0.01	6	0.47	1
20	0.03	6	0.47	2
30	0.07	6	0.47	5
40	0.13	6	0.47	10
50	0.20	6	0.47	15
60	0.28	6	0.47	22
70	0.40	6	0.47	31
80	0.57	6	0.47	43
90	0.85	6	0.47	65
99.9	2.71	6	0.47	208

1. Assume Double Drainage
2. C_v based on consolidation test summary.



Location: Ramp D - Station 41482+00

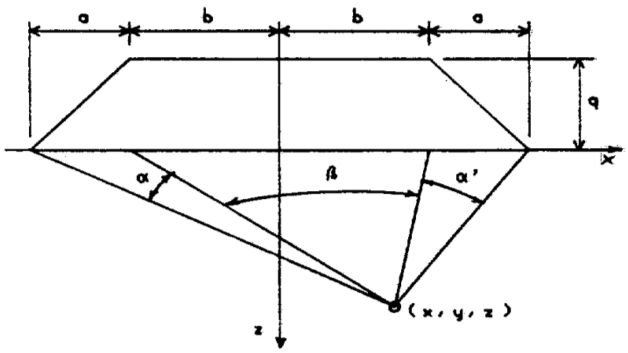
References:

1. EM 1110-1-1904 "Settlement Analyses" (1990)
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Full Height of Additional Embankment Fill



Groundwater Table:	D =	10.5	ft		
Embankment Height:	H =	14.5	ft		
Fill Unit Weight:	γ_{emb} =	125	pcf	*q* =	1813 psf
Surcharge:	P =	0	psf		
Width of Slope:	a =	130	ft	*3.5:1 Slope*	
Top half-width of Emb.:	b =	30	ft		
Distance from CL:	x =	0	ft		
Output Range:	z =	0	to	10.5	ft
Drainage:	Double				

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	CL	2	1	0.0	0.0	3.1	1806.9	0	1806.9
2	CL	4	3	0.1	0.1	2.9	1795.7	0	1795.7
3	CL-ML	9	6.5	0.2	0.2	2.7	1776.0	0	1776.0
4	CL	10.5	9.75	0.3	0.3	2.5	1757.5	0	1757.5
5									
6									
7									
8									
9									
10									

Note: Soil profile based on RB30-383 after reviewing Web Soil Survey maps. Borings RB30-382, B-9, B-10, and B-11 were also evaluated.

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_0'}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma_f'<\sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_0'}\right)\right]$$

Overlyconsolidated Soil ($\sigma'_0<\sigma'_c<\sigma_f'$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_c'}{\sigma_0'}\right) + \frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma_f'}{\sigma_c'}\right)\right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	CL	2	115	115	1807	1922	2000	0.260	0.050	0.860	0.066
2	CL	4	115	345	1796	2141	2000	0.260	0.050	0.860	0.049
3	CL-ML	9	115	748	1776	2524	1121	0.260	0.050	0.860	0.270
4	CL	10.5	125	1129	1757	2886	5000	0.150	0.030	0.510	0.012
5	0	0									
6	0	0									
7	0	0									
8	0	0									
9	0	0									
10	0	0									

1. Parameters based on consolidation test summary and design OCR Profile. **0.4** ft

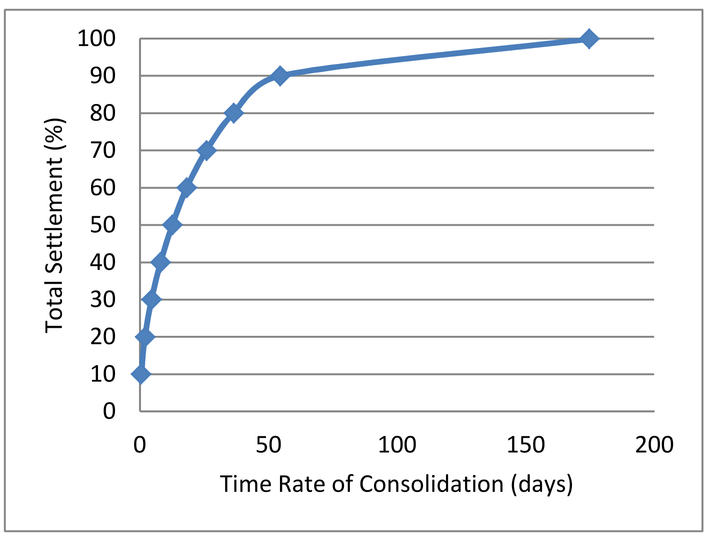
2. Water Table Elev. assumed at 10.5 foot depth. **Total Settlement** **4.8** in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft^2/day)	Time (days)
10	0.01	5.5	0.47	1
20	0.03	5.5	0.47	2
30	0.07	5.5	0.47	5
40	0.13	5.5	0.47	8
50	0.20	5.5	0.47	13
60	0.28	5.5	0.47	18
70	0.40	5.5	0.47	26
80	0.57	5.5	0.47	37
90	0.85	5.5	0.47	55
99.9	2.71	5.5	0.47	175

1. Assume Double Drainage

2. C_v based on consolidation test summary.



HDR ONE COMPANY *Many Solutions*℠				
Project:	US 30 Benton County	Computed: JAC	Date:	27-Feb-17
Subject:	Roadway Embankments	Checked: BTH	Date:	27-Feb-17
Task:	Consolidation Settlement Analyses	Page:	1 of 2	
Job #:	10020774	Dept. No:	134	

Location: US 218 - Station 241478+10

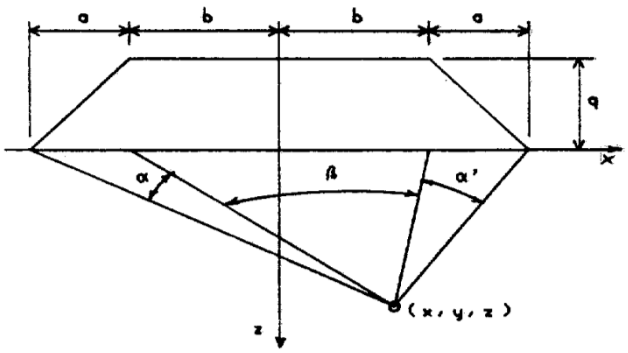
References:

1. EM 1110-1-1904 "Settlement Analyses" (1990)
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Full Height of Additional Embankment Fill



Groundwater Table:	D =	3.5	ft		
Embankment Height:	H =	23	ft		
Fill Unit Weight:	γ_{emb} =	125	pcf	*q* =	2875 psf
Surcharge:	P =	0	psf		
Width of Slope:	a =	90	ft	*3.5:1 Slope*	
Top half-width of Emb.:	b =	25	ft		
Distance from CL:	x =	0	ft		
Output Range:	z =	0	to	8	ft
Drainage:	Double				

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	CL	3.5	1.75	0.1	0.1	3.0	2849.9	0	2849.9
2	CL	6	4.75	0.1	0.1	2.8	2806.8	0	2806.8
3	CL	8	7	0.2	0.2	2.6	2774.3	0	2774.3
4									
5									
6									
7									
8									
9									
10									

Note: Soil profile based on RB218-1 and B-6.

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma_f' < \sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_c < \sigma_f'$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma_c'}{\sigma_0'} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_c'} \right) \right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	CL	3.5	115	201	2850	3051	2000	0.260	0.050	0.860	0.184
2	CL	6	53	469	2807	3276	2000	0.260	0.050	0.860	0.117
3	CL	8	63	598	2774	3372	3000	0.150	0.030	0.510	0.038
4	0	0									
5	0	0									
6	0	0									
7	0	0									
8	0	0									
9	0	0									
10	0	0									

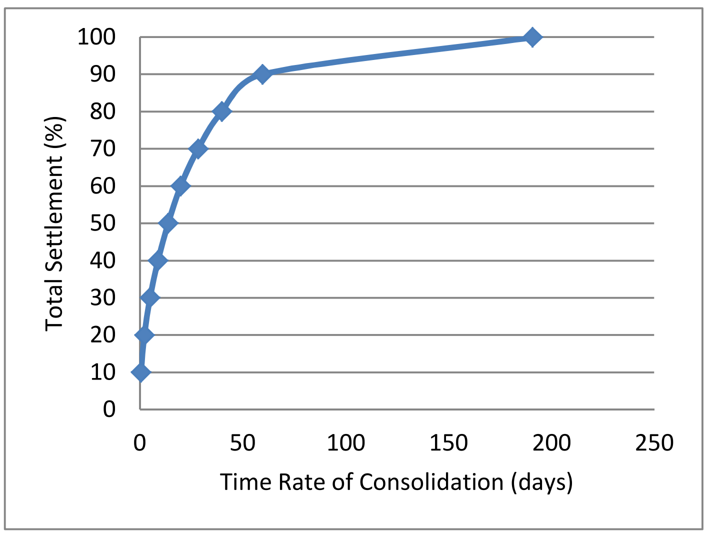
1. Parameters based on consolidation test summary and design OCR Profile.
2. Water Table Elev. assumed at 3.5 foot depth.

	0.3	ft
Total Settlement	**4.1**	in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft^2/day)	Time (days)
10	0.01	5.75	0.47	1
20	0.03	5.75	0.47	2
30	0.07	5.75	0.47	5
40	0.13	5.75	0.47	9
50	0.20	5.75	0.47	14
60	0.28	5.75	0.47	20
70	0.40	5.75	0.47	28
80	0.57	5.75	0.47	40
90	0.85	5.75	0.47	60
99.9	2.71	5.75	0.47	191

1. Assume Double Drainage
2. C_v based on consolidation test summary.



HDR ONE COMPANY *Many Solutions*[SM]

Project:	US 30 Benton County	Computed: JAC	Date: 27-Feb-17
Subject:	Roadway Embankments	Checked: BTH	Date: 27-Feb-17
Task:	Consolidation Settlement Analyses	Page: 1 of 2	
Job #:	10020774	Dept. No: 134	

Location: US 218 - Station 241473+20

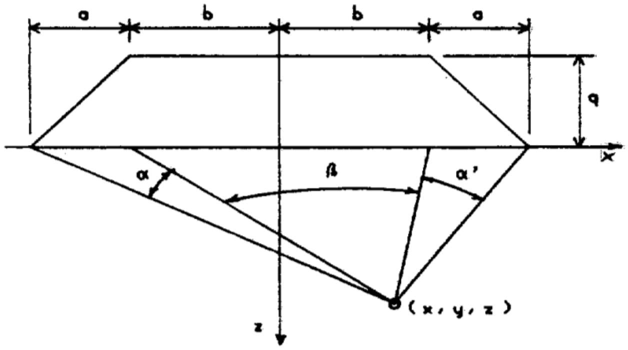
References:

1. EM 1110-1-1904 "Settlement Analyses" (1990)
2. Advanced Soil Mechanics (2nd Edition) - B. M. Das (1997)
3. Training Course in Geotechical & Foundation Engineering - Publication No. FHWA HI-97-021 (1997)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.

Stress Due to Full Height of Additional Embankment Fill



Groundwater Table:	D =	3.5	ft			
Embankment Height:	H =	24	ft			
Fill Unit Weight:	γ_{emb} =	125	pcf		*q* =	3000 psf
Surcharge:	P =	0	psf			
Width of Slope:	a =	65	ft	*3.5:1 Slope*		
Top half-width of Emb.:	b =	25	ft			
Distance from CL:	x =	0	ft			
Output Range:	z =	0	to	8	ft	
Drainage:	Double					

$$\sigma_v(z) = \left(\frac{q}{\pi \cdot a}\right) \cdot \left(a \cdot \left(\alpha(z) + \beta(z) + \alpha'(z)\right)\right) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot ((\alpha(z) - \alpha'(z)))$$

$$\beta(z) = a\tan\left[\frac{(b-x)}{z}\right] + a\tan\left[\frac{(b+x)}{z}\right]$$

$$\alpha'(z) = a\tan\left[\frac{(a+b-x)}{z}\right] - a\tan\left[\frac{(b-x)}{z}\right]$$

$$\alpha(z) = a\tan\left[\frac{(a+b+x)}{z}\right] - a\tan\left[\frac{(b+x)}{z}\right]$$

Layer No.	Soil Description	Bottom Layer	z	α(z)	α'(z)	β(z)	σ_v (psf)	P (psf)	$\Delta\sigma_z'$ (psf)
1	CL	3.5	1.75	0.1	0.1	3.0	2965.4	0	2965.4
2	CL	6	4.75	0.1	0.1	2.8	2906.0	0	2906.0
3	CL	8	7	0.2	0.2	2.6	2861.5	0	2861.5
4									
5									
6									
7									
8									
9									
10									

Note: Soil profile based on RB24A-1, B-7 and B-13.

ONE COMPANY *Many Solutions*℠			
Project: US 30 Benton County		Computed: JAC	Date: 27-Feb-17
Subject: Roadway Embankments		Checked: BTH	Date: 27-Feb-17
Task: Consolidation Settlement Analyses		Page: 2 of 2	
Job #: 10020774		Dept. No: 134	

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_f}{\sigma'_0}\right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_f < \sigma'_c$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_f}{\sigma'_0}\right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_c < \sigma'_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_c}{\sigma'_0}\right) + \frac{C_c}{1+e_0} \cdot H \cdot \log\left(\frac{\sigma'_f}{\sigma'_c}\right) \right]$$

Layer No.	Soil Description	Bottom Layer	γ'_{soil} (pcf)	σ_o' (psf)	$\Delta\sigma_z'$ (psf)	σ_f' (psf)	σ_c' (psf)	C_c (1)	C_r (1)	e_o (1)	S
1	CL	3.5	115	201	2965	3167	2000	0.260	0.050	0.860	0.191
2	CL	6	53	469	2906	3375	5000	0.150	0.030	0.860	0.035
3	CL	8	63	598	2862	3460	5000	0.150	0.030	0.510	0.030
4	0	0									
5	0	0									
6	0	0									
7	0	0									
8	0	0									
9	0	0									
10	0	0									

1. Parameters based on consolidation test summary and design OCR Profile. **0.3** ft

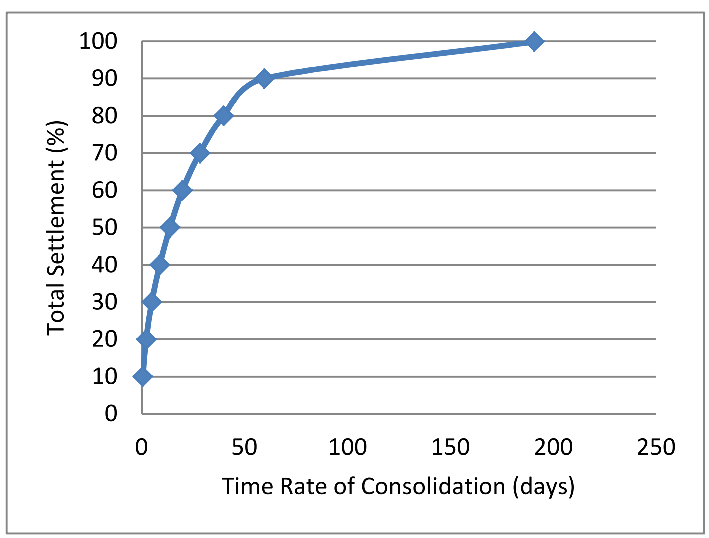
2. Water Table Elev. assumed at 3.5 foot depth. **Total Settlement 3.1** in

TIME RATE OF CONSOLIDATION

U_{av}	T_v	H_{dr}	C_v (ft^2/day)	Time (days)
10	0.01	5.75	0.47	1
20	0.03	5.75	0.47	2
30	0.07	5.75	0.47	5
40	0.13	5.75	0.47	9
50	0.20	5.75	0.47	14
60	0.28	5.75	0.47	20
70	0.40	5.75	0.47	28
80	0.57	5.75	0.47	40
90	0.85	5.75	0.47	60
99.9	2.71	5.75	0.47	191

1. Assume Double Drainage

2. C_v based on consolidation test summary.



APPENDIX E: Summary of Structures Settlement

Form 610011
05-15

Consultant HDR

Summary of Structure Settlement

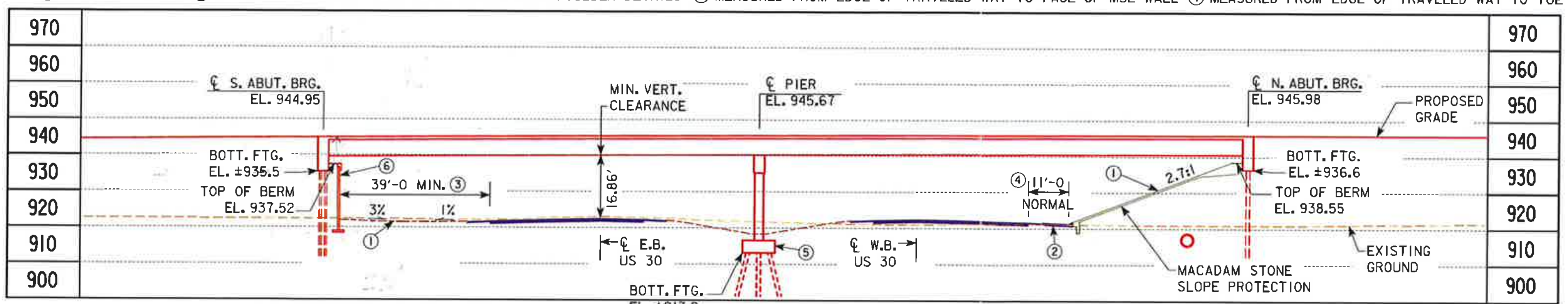
County Benton Project NHSX-030-6(231)--3H-06 Road # US 30 Location See remarks

Station	Structure	Estimated Settlement (Inches)	Approximate Fill Height (Feet)	Compressible Soils (Feet)	Remarks
1388+10	54" RCB - Stage 1 EB	6.1	20	15	US 30
1388+10	54" RCB - Stage 2 WB	5.5	18	15	US 30
1400+94	8'x8' RCB - Stage 1 EB	2.1	18	8	US 30
1400+94	8'x8' RCB - Stage 2 WB	2.1	18	8	US 30
1425+50	72" RCP - Stage 1 EB	6.1	15	23	US 30
1425+50	72" RCP - Stage 2 WB	5.3	16	15.5	US 30
1454+00	36" RCP - Stage 1 EB	2.2	13	10	US 30
1454+00	36" RCP - Stage 2 WB	1.9	10	10	US 30
1460+75	42" RCP-Stage 1 WB (Jacked)	1	3.5	13	US 30
1460+75	42" RCP - Stage 1 EB	1.9	10	13	US 30
1470+00	36" RCP - Stage 1 EB	negligible	1	9	US 30
1470+00	36" RCP - Stage 2 WB	0.9	4	9	US 30
1493+85	24" RCP -Stage 1 WB (Jacked)	0.7	2	12	US 30
1493+85	24" RCP - Stage 1 EB	1.4	5.5	12	US 30
21474+00	44" x 27" LCP	0.9	4	9	Loop B
31453+75	24" RCP	0.7	3	7	Ramp C
41476+17	24" RCP	5.2	20	12	Ramp D
41482+00	42" RCP	4.8	14.5	10.5	Ramp D

APPENDIX F: MSE Wall Analyses

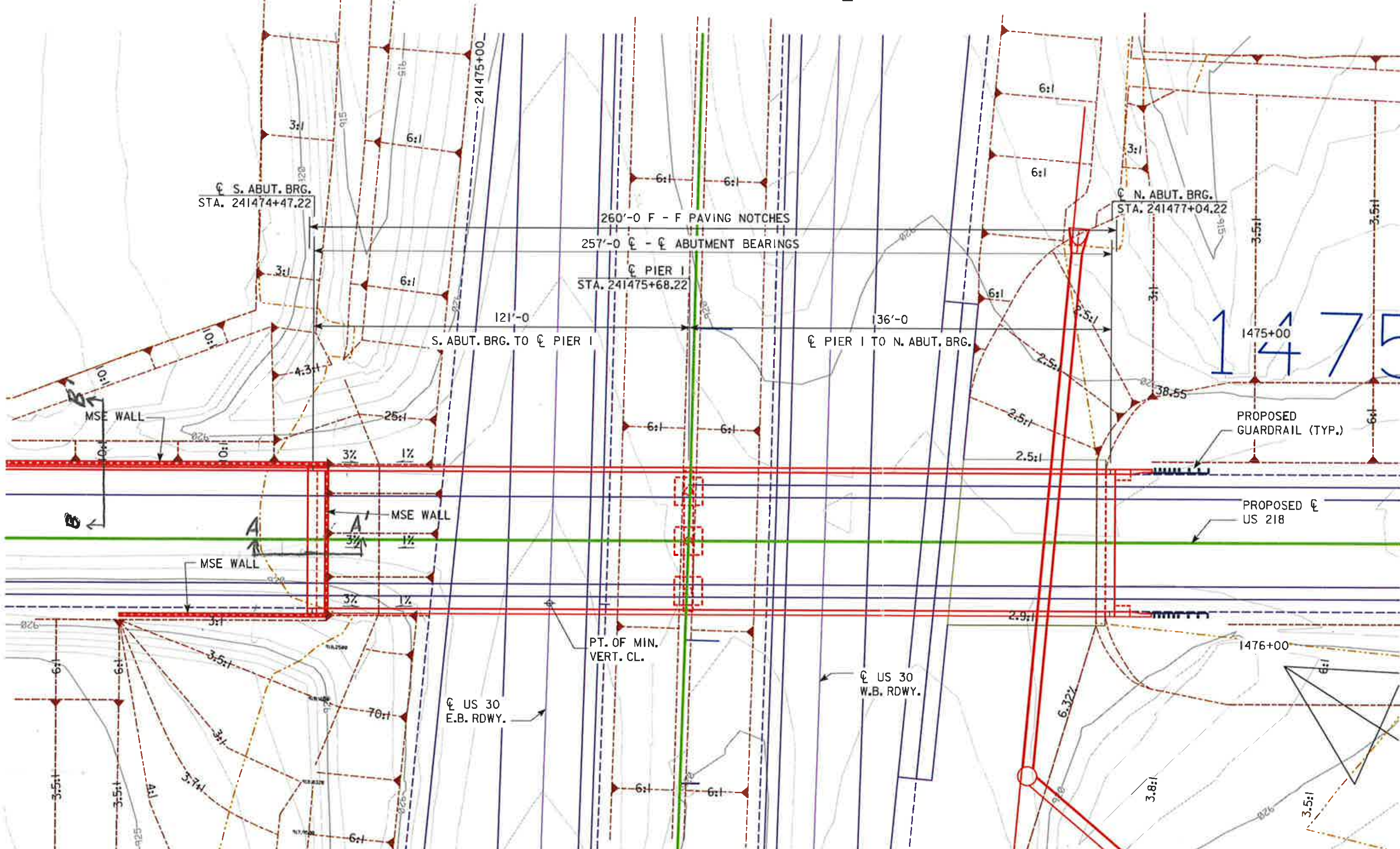
BENCH MARK NO.

① GRADING SURFACE ② REFER TO STANDARD ROAD PLAN EW-204 FOR SHOULDER DETAILS ③ MEASURED FROM EDGE OF TRAVELED WAY TO FACE OF MSE WALL ④ MEASURED FROM EDGE OF TRAVELED WAY TO TOE OF BERM ⑤ FRAME PIER ⑥ MSE WALL



NOTE: TOP OF BRIDGE DECK CROWN 0.03' BELOW PROFILE GRADE.

LONGITUDINAL SECTION ALONG ℄ APPROACH ROADWAY



SITUATION PLAN

VPI STA = 1486+00.00
VPI ELEV = 937.97
VC = 3,000'
1.440% -0.400%
STA = 1471+00.00
ELEV = 916.37
STA = 1501+00.00
ELEV = 931.97

PROPOSED PROFILE US 30

VPI STA = 241474+00.00
VPI ELEV = 949.68
VC = 1,200'
2.600% -0.800%
STA = 241468+00.00
VPI ELEV = 934.08
STA = 241480+00.00
VPI ELEV = 944.88

PROPOSED PROFILE US 218

MINIMUM VERTICAL CLEARANCE

OVERHEAD STATION = 241475+23.69, 20.08' RT
OVERHEAD ELEVATION = 945.11
DEPTH OF SUPERSTRUCTURE = 5.33'
US 30 STATION = 1475+89.69, 44' RT
US 30 ELEVATION = 922.92
MINIMUM VERTICAL CLEARANCE = 16.86'

TRAFFIC ESTIMATE-US 30

2017 AADT	6,971	V.P.D.
2037 AADT	10,859	V.P.D.
202_ DHV	-	V.P.H.
TRUCKS	16	%
TOTAL DESIGN ESALs	-	

LOCATION

US 218 OVER US 30
T-83N R-10W
SECTION 29
ELDORADO TOWNSHIP
BENTON COUNTY
BRIDGE MAINT. NO. ?
LATITUDE °
LONGITUDE °

0 ENGLISH 40
SCALE IN FEET

PRELIMINARY

DESIGN FOR 0° SKEW

257'-0 X 44'-0 PRETENSIONED PRESTRESSED CONCRETE BEAM BRIDGE

121'-0, 136'-0 SPANS

SITUATION PLAN

STATION 23999+56.07 BTD BEAM

BENTON COUNTY

IOWA DEPARTMENT OF TRANSPORTATION - HIGHWAY DIVISION

DESIGN SHEET NO. ___ OF ___ FILE NO. ______ DESIGN NO. ______

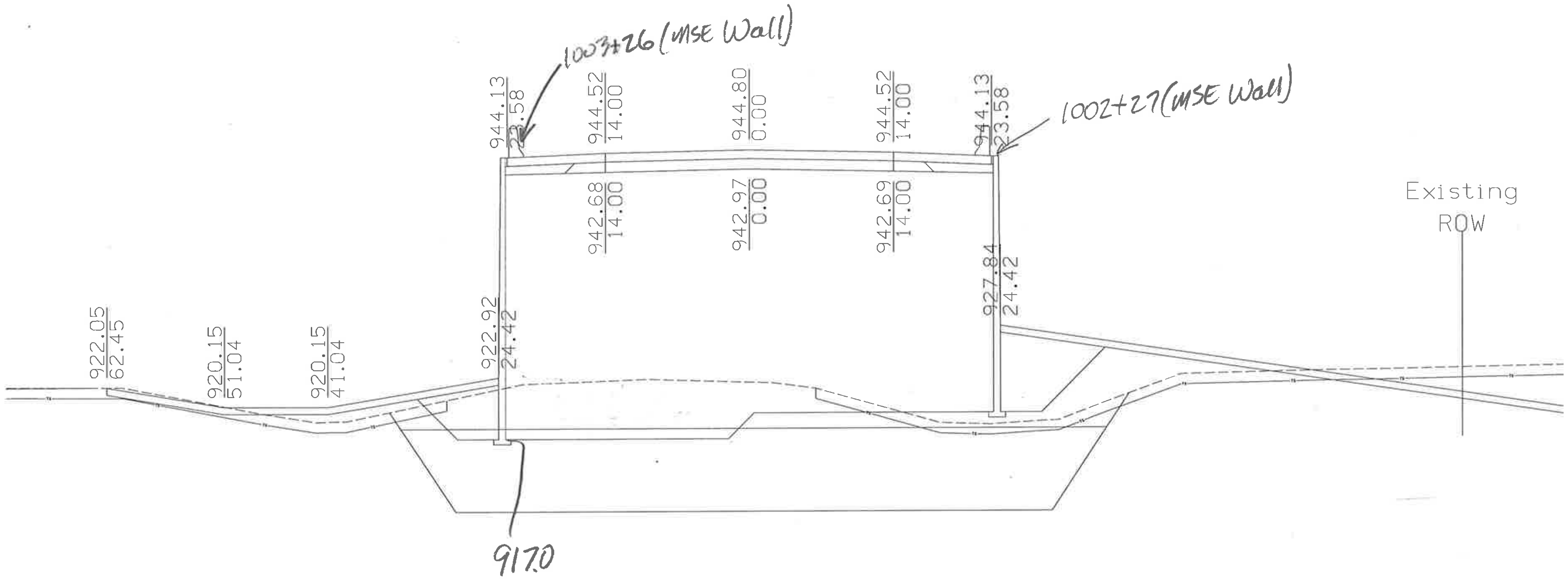
DESIGN TEAM | COUNTY | PROJECT NUMBER | SHEET NUMBER

3/8/2016 11:25:06 AM dmulhol pw:\\projectwise.dot.int.lan:PWMain\Documents\Projects\0603003092\BRPrelim\06030230.str TSL_06_0117 11x17_pdf.pltcfg

NHSX-030-6(182)--3H-06 V.1

241474+25 (US 218)

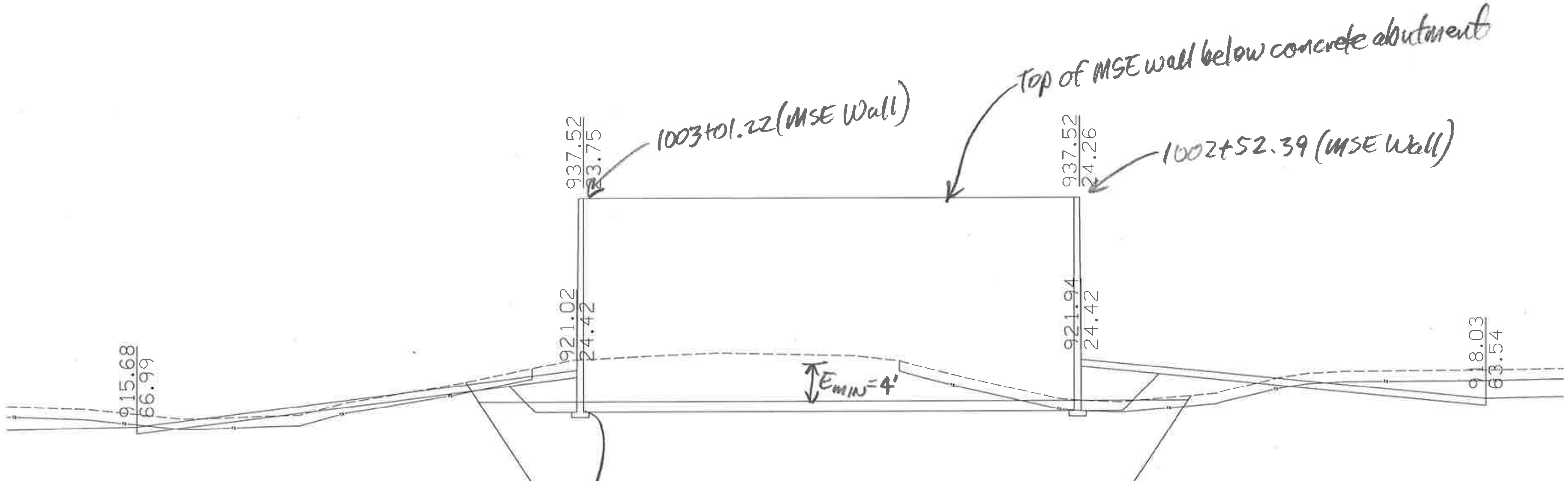
Section A-A' is cut perpendicular to page at roadway centerline



Effective Wall Height at abutment = 944.95 From V.1 & South Abut.
−917 Top of levelling pad
28'

$0.8 \times H = 22.4' \rightarrow$ Say 22.5' Strap Length

241474+50 (US 218)
South Abutment
Section A-A' is cut perpendicular to page at roadway centerline



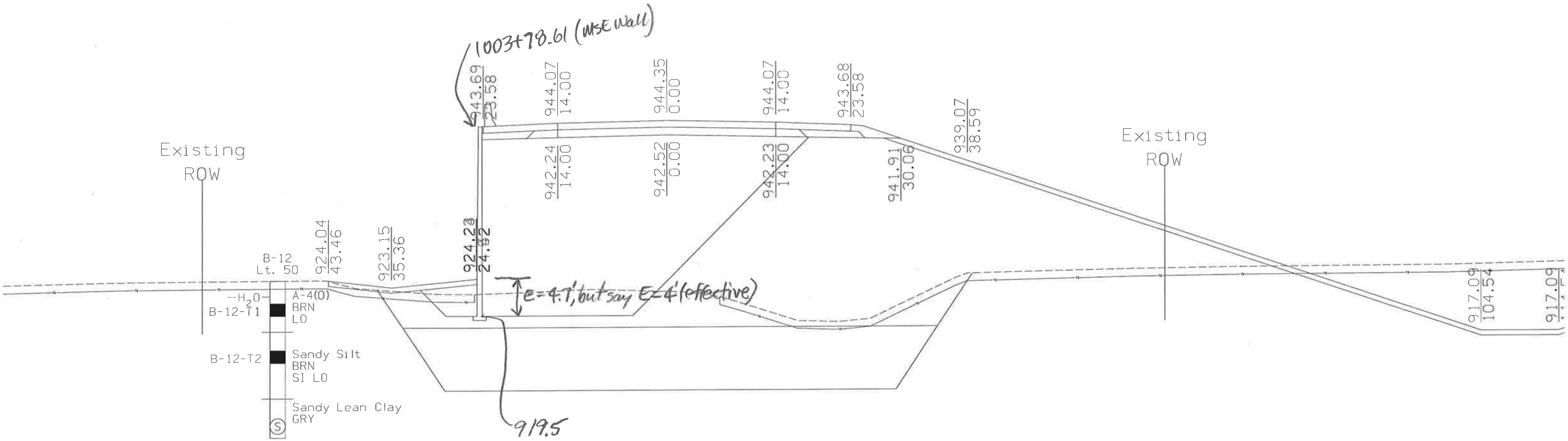
917.0 MSE Wall facing height at abutment = 937.5 Top of MSE Wall Facing
−917 Top of levelling pad
20.5'

Dead load surcharge height = 944.95
−937.5
7.5'

Dead load surcharge = (7.5 ft)(120 pcf) = 900 psf

Section B-B'

241+73+75 (US 218)



Wall Height = 944.35 Highest point in reinf. zone

−919.5 Top of levelling pad

24.9'

0.8×H = 19.9' → Say 20' strap length

AASHTO 2007 (LRFD)
US 30/US 218 Interchange

PROJECT IDENTIFICATION

Title:	US 30/US 218 Interchange
Project Number:	10019606
Client:	Iowa DOT
Designer:	Brian Havens
Station Number:	South Abutment_Wall Height of 28 feet_Station 1002+75, Section A-A'

Description:

Analysis of wall using LRFD procedures and both non-seismic and seismic loading

Company's information:

/PHP 2-9-17

Name: HDR Engineering, Inc.
Street: 8404 Indian Hills Drive

Omaha, NE 68114
Telephone #: (402) 399-1123
Fax #: (402) 399-4979
E-Mail: brian.havens@hdrinc.com

Original file path and name: G:\Projects\134 - 221364 US 30 Benton Co Iowa DOT\S2 S3.....
.....D_South Abutment.BEN
Original date and time of creating this file: Thu Oct 31 13:18:22 2013

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using METAL STRIPS as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ 120.0 lb/ft³ ✓

Design value of internal angle of friction, ϕ 34.0 °

RETAINED SOIL

Unit weight, γ 120.0 lb/ft³ ✓

Design value of internal angle of friction, ϕ 34.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$ 125.0 lb/ft³ ✓

Equivalent internal angle of friction, $\phi_{equiv.}$ 32.0 °

Equivalent cohesion, $c_{equiv.}$ 0.0 lb/ft²

- overex. of alluvium
- placement of special backfill

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Ka (external stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N γ= 30.21

SEISMICITY

Maximum ground acceleration coefficient, A = 0.040
Design acceleration coefficient in Internal Stability: Kh = Am = 0.056
Design acceleration coefficient in External Stability: Kh = 0.056 (Am = 0.000)

Kae (Kh > 0) = 0.3142 Kae (Kh = 0) = 0.2827 Δ Kae = 0.0315 (see eq. 37 in DEMO 82)
Seismic soil-metal strip friction coefficient, F* is 80.0% of its specified static value.

INPUT DATA: Metal strips (Analysis)

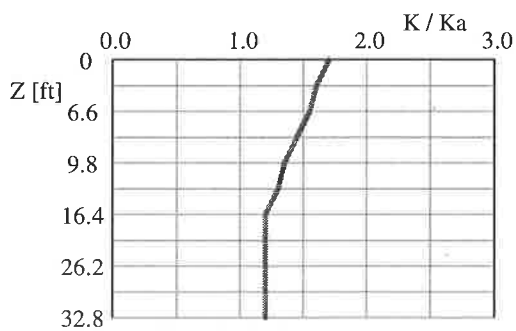
D A T A	Metal strip type #1	Metal strip type #2	Metal strip type #3	Metal strip type #4	Metal strip type #5
Yield strength of steel, Fy [kips/in ^{2}]	65.3	N/A	N/A	N/A	N/A
Gross width of strip, b [in]	4.0	N/A	N/A	N/A	N/A
Vertical spacing, Sv [ft]	Varies	N/A	N/A	N/A	N/A
Design cross section area, Ac [in ^{2}]	0.46	N/A	N/A	N/A	N/A

Ribbed steel strips.
Uniformity Coefficient of reinforced soil, Cu = D60/D10 = 4.0

Friction angle along reinforcement-soil interface,	ρ				
@ the top	60.97	N/A	N/A	N/A	N/A
@ 19.7 ft or below	34.00	N/A	N/A	N/A	N/A
Pullout resistance factor, F*					
@ the top	1.80	N/A	N/A	N/A	N/A
@ 19.7 ft or below	0.67	N/A	N/A	N/A	N/A
Scale-effect correction factor, α	1.00	N/A	N/A	N/A	N/A

Variation of Lateral Earth Pressure Coefficient With Depth

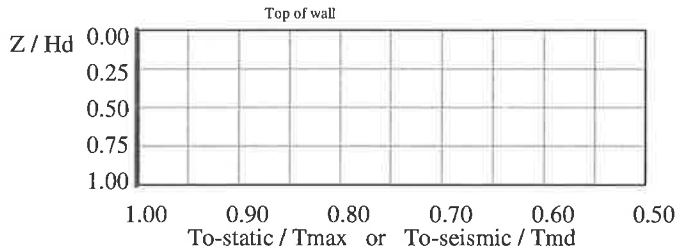
Z	K / Ka
0 ft	1.70
3.3 ft	1.60
6.6 ft	1.55
9.8 ft	1.45
13.1 ft	1.35
16.4 ft	1.30
19.7 ft	1.20



INPUT DATA: Facia and Connection (Analysis)

FACIA type: Segmental precast concrete panels.
Depth of panel is 0.66 ft. Horizontal distance to Center of Gravity of panel is 0.33 ft.
Average unit weight of panel is γ_f = 152.78 lb/ft ^{3}

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	Metal Str..	N/A	N/A	N/A	N/A
Strength reduction at the connection, CRu = Fyc / Fy	1.00	N/A	N/A	N/A	N/A

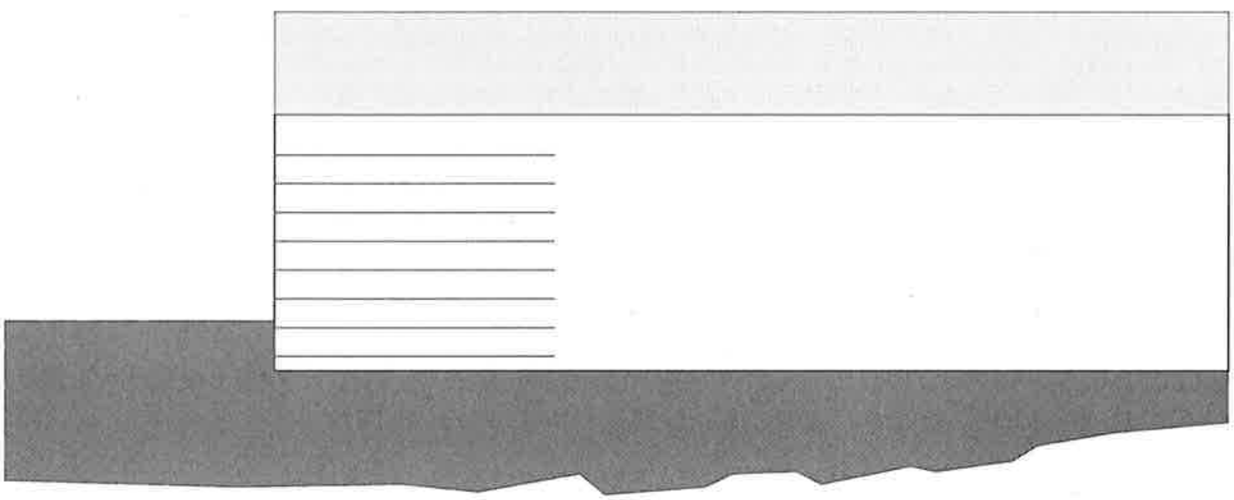
INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd	20.50	[ft]	{ Embedded depth is E = 4.00 ft, and height above top of finished bottom grade is H = 16.50 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

UNIFORM SURCHARGE

Uniformly distributed dead load is 900.0 [lb/ft ²], and live load is 240.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10[ft]

AASHTO 2007 (LRFD) Input Data

INTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2:	$\gamma_{p\text{-}EV}$	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	$\gamma_{p\text{-}EQ}$	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Metal Strips:		0.75	1.00
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Metal Strips:		0.75	1.00
Resistance factor for reinforcement pullout from Table 11.5.6-1:	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2 and Figure C11.5.5-2:		Static		Combined Static/Seismic
Sliding and Eccentricity	$\gamma_{p\text{-}EV}$	1.00	$\gamma_{p\text{-}EQ}$	1.00
Bearing Capacity	$\gamma_{p\text{-}EV}$	1.35	$\gamma_{p\text{-}EQ}$	1.35

Load factor of active lateral earth pressure, EH, from Table 3.4.1-2 and Figure C11.5.5-2:	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces from Table 10.5.5.2.2-1:		Static	Combined Static/Seismic
Reinforced Soil and Foundation	ϕ_τ	1.00	1.00
Reinforced Soil and Reinforcement	ϕ_τ	1.00	1.00
Resistance factor for bearing capacity of shallow foundation from Table 10.5.5.2.2-1:		Static	Combined Static/Seismic
	ϕ_b	0.65	0.65

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 2.02, Meyerhof stress = 5908 lb/ft².

Foundation Interface: Direct sliding, CDR = 2.255, Eccentricity, e/L = 0.1048, CDR-overturning = 4.77

METAL STRIP				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [metal strip strength]	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	1.15	22.50	1	N/A	2.35	2.35	2.349	3.049	2.546	0.0951	Metal Strip
2	3.45	22.50	1	N/A	2.44	2.44	2.436	3.223	2.807	0.0770	Metal Strip
3	5.75	22.50	1	N/A	2.56	2.56	2.555	3.313	3.137	0.0604	Metal Strip
4	8.05	22.50	1	N/A	2.71	2.71	2.708	3.323	3.571	0.0455	Metal Strip
5	10.35	22.50	1	N/A	2.87	2.87	2.866	3.227	4.174	0.0323	Metal Strip
6	12.65	22.50	1	N/A	3.07	3.07	3.068	3.329	5.086	0.0209	Metal Strip
7	14.95	22.50	1	N/A	3.37	3.37	3.374	3.416	6.674	0.0116	Metal Strip
8	17.25	22.50	1	N/A	2.12	2.12	2.121	1.926	10.331	0.0045	Metal Strip

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

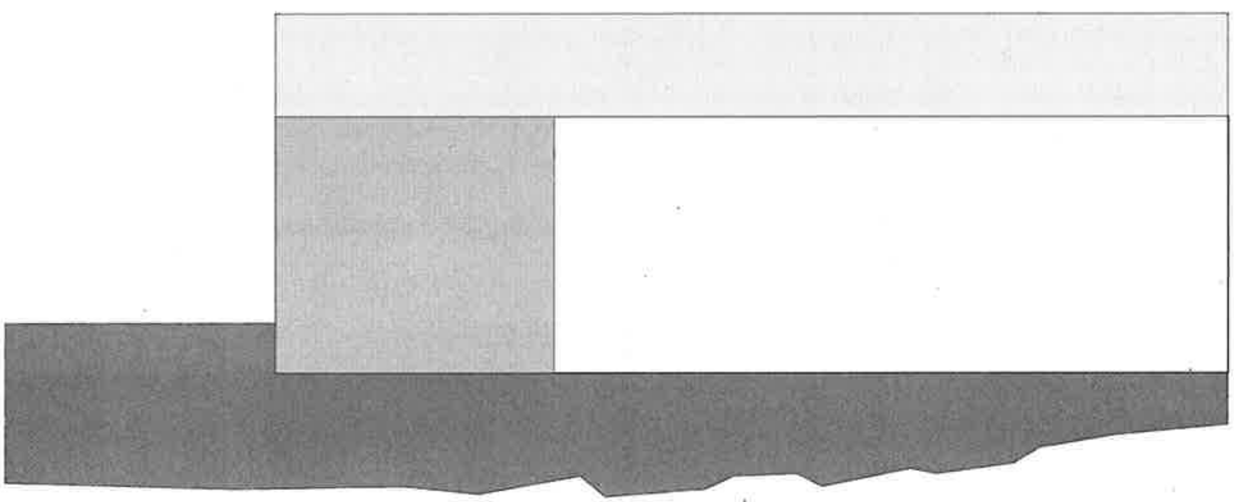
Bearing capacity, CDR = 1.95, Meyerhof stress = 6013 lb/ft².

Foundation Interface: Direct sliding, CDR = 2.075, Eccentricity, e/L = 0.1162, Fs-overturning = 4.30

METAL STRIP				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [metal strip strength]	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	1.15	22.50	1	N/A	3.06	3.06	3.056	3.173	2.347	0.1051	Metal Strip
2	3.45	22.50	1	N/A	3.17	3.17	3.171	3.357	2.601	0.0845	Metal Strip
3	5.75	22.50	1	N/A	3.33	3.33	3.328	3.452	2.924	0.0658	Metal Strip
4	8.05	22.50	1	N/A	3.53	3.53	3.529	3.464	3.350	0.0491	Metal Strip
5	10.35	22.50	1	N/A	3.74	3.74	3.736	3.366	3.946	0.0345	Metal Strip
6	12.65	22.50	1	N/A	3.99	3.99	3.993	3.466	4.851	0.0221	Metal Strip
7	14.95	22.50	1	N/A	4.38	4.38	4.382	3.549	6.433	0.0120	Metal Strip
8	17.25	22.50	1	N/A	2.78	2.78	2.781	2.020	10.087	0.0046	Metal Strip

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table is at wall base elevation)			
Ultimate bearing capacity, q-ult	11909	11701	[lb/ft ²]
Meyerhof stress, σ_V	5908.1	6013	[lb/ft ²]
Eccentricity, e	1.56	1.73	[ft]
Eccentricity, e/L	0.069	0.077	
CDR calculated	2.02	1.95	
Base length	22.50	22.50	[ft]



SCALE:

0 2 4 6 8 10[ft]

DIRECT SLIDING for GIVEN LAYOUT
(for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 2.255 and CDR-seismic = 2.075

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	1.15	22.50	2.546	2.347	1	Metal Strip
2	3.45	22.50	2.807	2.601	1	Metal Strip
3	5.75	22.50	3.137	2.924	1	Metal Strip
4	8.05	22.50	3.571	3.350	1	Metal Strip
5	10.35	22.50	4.174	3.946	1	Metal Strip
6	12.65	22.50	5.086	4.851	1	Metal Strip
7	14.95	22.50	6.674	6.433	1	Metal Strip
8	17.25	22.50	10.331	10.087	1	Metal Strip

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.1048, e/L seismic = 0.1162; Overturning: CDR-static = 4.77, CDR-seismic = 4.30

#	Metal strip Elevation [ft]	Metal strip Length [ft]	e / L Static	e / L Seismic	Metal strip Type #	Product name
1	1.15	22.50	0.0951	0.1051	1	Metal Strip
2	3.45	22.50	0.0770	0.0845	1	Metal Strip
3	5.75	22.50	0.0604	0.0658	1	Metal Strip
4	8.05	22.50	0.0455	0.0491	1	Metal Strip
5	10.35	22.50	0.0323	0.0345	1	Metal Strip
6	12.65	22.50	0.0209	0.0221	1	Metal Strip
7	14.95	22.50	0.0116	0.0120	1	Metal Strip
8	17.25	22.50	0.0045	0.0046	1	Metal Strip

RESULTS for STRENGTH [NLive Load included in calculating Tmax\ctual stress)]

#	Metal strip Elevation [ft]	Coverage ratio, Rc=b/Sh	Horizontal spacing, Sh [ft]	Long-term strength Fy·Ac·Rc/b [lb/ft]	Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum CDR static	Actual calculated CDR static	Specified minimum CDR seismic	Actual calculated CDR seismic
1	1.15	0.136	2.460	9153	3896.54	96.68	N/A	2.349	N/A	3.056
2	3.45	0.136	2.460	9153	3757.95	90.57	N/A	2.436	N/A	3.171
3	5.75	0.136	2.460	9153	3582.16	84.45	N/A	2.555	N/A	3.328
4	8.05	0.136	2.460	9153	3379.93	78.33	N/A	2.708	N/A	3.529
5	10.35	0.136	2.460	9153	3194.13	72.48	N/A	2.866	N/A	3.736
6	12.65	0.136	2.460	9153	2983.75	72.48	N/A	3.068	N/A	3.993
7	14.95	0.136	2.460	9153	2712.81	72.48	N/A	3.374	N/A	4.382
8	17.25	0.136	2.460	9153	4315.95	72.48	N/A	2.121	N/A	2.781

RESULTS for PULLOUT Live Load included in calculating Tmax

NOTE: Live load is not included in calculating the overburden pressure used to assess pullout resistance.

#	Metal strip Elevation [ft]	Coverage Ratio Rc=b/Sh	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft] (see NOTE)	La [ft]	Avail.Static Pullout, Pr [lb/ft]	Specified Static CDR	Actual Static CDR	Avail.Seism. Pullout, Pr [lb/ft]	Specified Seismic CDR	Actual Seismic CDR
1	1.15	0.136	3896.5	96.7	21.81	0.69	11879.4	N/A	3.049	12671.3	N/A	3.173
2	3.45	0.136	3758.0	90.6	20.43	2.07	12110.4	N/A	3.223	12917.8	N/A	3.357
3	5.75	0.136	3582.2	84.4	19.05	3.45	11867.1	N/A	3.313	12658.2	N/A	3.452
4	8.05	0.136	3379.9	78.3	17.67	4.83	11230.6	N/A	3.323	11979.3	N/A	3.464
5	10.35	0.136	3194.1	72.5	16.35	6.15	10306.8	N/A	3.227	10993.9	N/A	3.366
6	12.65	0.136	2983.8	72.5	16.35	6.15	9931.7	N/A	3.329	10593.8	N/A	3.466
7	14.95	0.136	2712.8	72.5	16.35	6.15	9266.6	N/A	3.416	9884.3	N/A	3.549
8	17.25	0.136	4316.0	72.5	16.35	6.15	8311.3	N/A	1.926	8865.4	N/A	2.020

RESULTS for CONNECTION (static conditions)
Live Load included in calculating Tmax

#	Metal strip Elevation [ft]	Coverage ratio Rc=b/Sh	Horizontal spacing, Sh [ft]	Connection force, To [lb/ft]	Reduction factor for connection break, CRu	Long-term connection strength,Tac (break criterion) [lb/ft]	Metal strip long-term strength, [lb/ft]	CDR connection break Specified	CDR connection break Actual	CDR Metal strip strength Specified	CDR Metal strip strength Actual	Product name
1	1.15	0.136	2.460	3897	1.00	9153	9153	N/A	2.35	N/A	2.35	Metal Strip
2	3.45	0.136	2.460	3758	1.00	9153	9153	N/A	2.44	N/A	2.44	Metal Strip
3	5.75	0.136	2.460	3582	1.00	9153	9153	N/A	2.56	N/A	2.56	Metal Strip
4	8.05	0.136	2.460	3380	1.00	9153	9153	N/A	2.71	N/A	2.71	Metal Strip
5	10.35	0.136	2.460	3194	1.00	9153	9153	N/A	2.87	N/A	2.87	Metal Strip
6	12.65	0.136	2.460	2984	1.00	9153	9153	N/A	3.07	N/A	3.07	Metal Strip
7	14.95	0.136	2.460	2713	1.00	9153	9153	N/A	3.37	N/A	3.37	Metal Strip
8	17.25	0.136	2.460	4316	1.00	9153	9153	N/A	2.12	N/A	2.12	Metal Strip

RESULTS for CONNECTION (seismic conditions)
Live Load included in calculating Tmax

#	Metal strip Elevation [ft]	Coverage ratio Rc=b/Sh	Horizontal spacing, Sh [ft]	Connection force, To [lb/ft]	Reduction factor for connection break, CRu	Long-term connection strength,Tac (break criterion) [lb/ft]	Metal strip long-term strength, [lb/ft]	CDR connection break Specified	CDR connection break Actual	CDR Metal strip strength Specified	CDR Metal strip strength Actual	Product name
1	1.15	0.136	2.460	3993	1.00	12204	9153	N/A	3.06	N/A	3.06	Metal Strip
2	3.45	0.136	2.460	3849	1.00	12204	9153	N/A	3.17	N/A	3.17	Metal Strip
3	5.75	0.136	2.460	3667	1.00	12204	9153	N/A	3.33	N/A	3.33	Metal Strip
4	8.05	0.136	2.460	3458	1.00	12204	9153	N/A	3.53	N/A	3.53	Metal Strip
5	10.35	0.136	2.460	3267	1.00	12204	9153	N/A	3.74	N/A	3.74	Metal Strip
6	12.65	0.136	2.460	3056	1.00	12204	9153	N/A	3.99	N/A	3.99	Metal Strip
7	14.95	0.136	2.460	2785	1.00	12204	9153	N/A	4.38	N/A	4.38	Metal Strip
8	17.25	0.136	2.460	4388	1.00	12204	9153	N/A	2.78	N/A	2.78	Metal Strip

AASHTO 2007 (LRFD)
US 30/US 218 Interchange

PROJECT IDENTIFICATION

Title:	US 30/US 218 Interchange
Project Number:	10019606
Client:	Iowa DOT
Designer:	Brian Havens
Station Number:	South Abutment Sidewall_Wall Height of 25 feet_Station 1003+60_Section B-B'

Description:

Analysis of wall using LRFD procedures and both non-seismic and seismic loading

Company's information:

✓ BHH 2-9-17

Name: HDR Engineering, Inc.
Street: 8404 Indian Hills Drive

Omaha, NE 68114
Telephone #: (402) 399-1123
Fax #: (402) 399-4979
E-Mail: brian.havens@hdrinc.com

Original file path and name: G:\Projects\134 - 221364 US 30 Benton Co Iowa DOT\S2 S3..... .....butment Sidewall.BEN
Original date and time of creating this file: Thu Oct 31 13:18:22 2013

PROGRAM MODE: ANALYSIS of a SIMPLE STRUCTURE using METAL STRIPS as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ 120.0 lb/ft³
Design value of internal angle of friction, ϕ 34.0 °

RETAINED SOIL

Unit weight, γ 125.0 lb/ft³
Design value of internal angle of friction, ϕ 28.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$ 125.0 lb/ft³
Equivalent internal angle of friction, $\phi_{equiv.}$ 32.0 °
Equivalent cohesion, $c_{equiv.}$ 0.0 lb/ft²

- overex. of alluvium
- placement of special backfill

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Ka (external stability) = 0.3610 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N_γ = 30.21

SEISMICITY

Maximum ground acceleration coefficient, A = 0.040
Design acceleration coefficient in Internal Stability: Kh = Am = 0.056
Design acceleration coefficient in External Stability: Kh = 0.056 (Am = 0.000)

Kae (Kh > 0) = 0.3967 Kae (Kh = 0) = 0.3610 Δ Kae = 0.0357 (see eq. 37 in DEMO 82)
Seismic soil-metal strip friction coefficient, F* is 80.0% of its specified static value.

INPUT DATA: Metal strips
(Analysis)

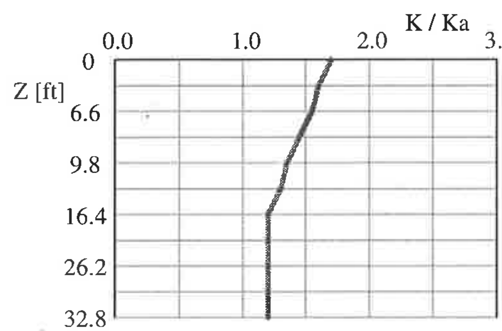
D A T A	Metal strip type #1	Metal strip type #2	Metal strip type #3	Metal strip type #4	Metal strip type #5
Yield strength of steel, Fy [kips/in ²]	65.3	N/A	N/A	N/A	N/A
Gross width of strip, b [in]	4.0	N/A	N/A	N/A	N/A
Vertical spacing, Sv [ft]	Varies	N/A	N/A	N/A	N/A
Design cross section area, Ac [in ²]	0.46	N/A	N/A	N/A	N/A

Ribbed steel strips.
Uniformity Coefficient of reinforced soil, Cu = D60/D10 = 4.0

Friction angle along reinforcement-soil interface,	ρ				
@ the top	60.97	N/A	N/A	N/A	N/A
@ 19.7 ft or below	34.00	N/A	N/A	N/A	N/A
Pullout resistance factor, F*					
@ the top	1.80	N/A	N/A	N/A	N/A
@ 19.7 ft or below	0.67	N/A	N/A	N/A	N/A
Scale-effect correction factor, α	1.00	N/A	N/A	N/A	N/A

Variation of Lateral Earth Pressure Coefficient With Depth

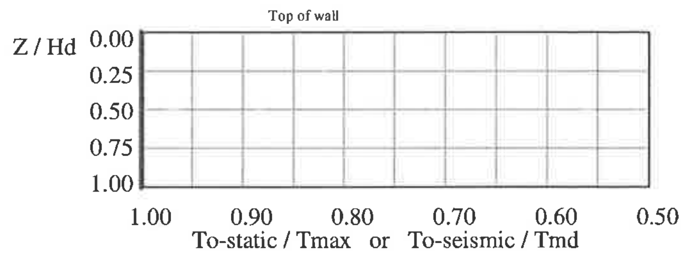
Z	K / Ka
0 ft	1.70
3.3 ft	1.60
6.6 ft	1.55
9.8 ft	1.45
13.1 ft	1.35
16.4 ft	1.30
19.7 ft	1.20



**INPUT DATA: Facia and Connection
(Analysis)**

FACIA type: Segmental precast concrete panels.
Depth of panel is 0.66 ft. Horizontal distance to Center of Gravity of panel is 0.33 ft.
Average unit weight of panel is γ_f = 152.78 lb/ft ³

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	Metal Str..	N/A	N/A	N/A	N/A
Strength reduction at the connection, CRu = Fyc / Fy	1.00	N/A	N/A	N/A	N/A

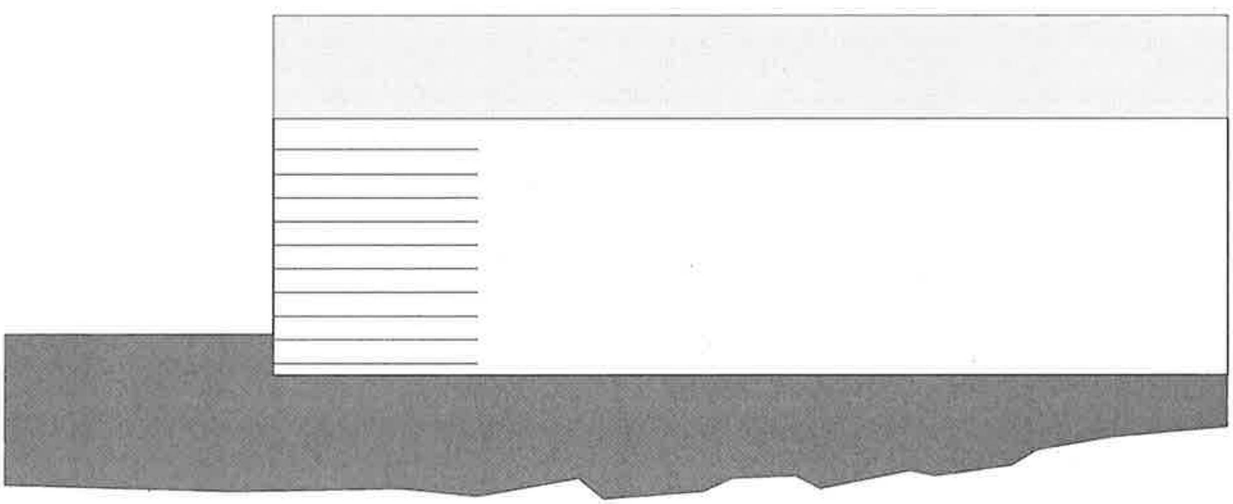
INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd	25.00	[ft]	{ Embedded depth is E = 4.00 ft, and height above top of finished bottom grade is H = 21.00 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

UNIFORM SURCHARGE

Uniformly distributed dead load is 0.0 [lb/ft ²], and live load is 240.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10[ft]

AASHTO 2007 (LRFD) Input Data

INTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2:	$\gamma_{p\text{-}EV}$	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	$\gamma_{p\text{-}EQ}$	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Metal Strips:		0.75	1.00
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Metal Strips:		0.75	1.00
Resistance factor for reinforcement pullout from Table 11.5.6-1:	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2 and Figure C11.5.5-2:		Static		Combined Static/Seismic
Sliding and Eccentricity	$\gamma_{p\text{-}EV}$	1.00	$\gamma_{p\text{-}EQ}$	1.00
Bearing Capacity	$\gamma_{p\text{-}EV}$	1.35	$\gamma_{p\text{-}EQ}$	1.35

Load factor of active lateral earth pressure, EH, from Table 3.4.1-2 and Figure C11.5.5-2:	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces from Table 10.5.5.2.2-1:		Static	Combined Static/Seismic
Reinforced Soil and Foundation	ϕ_τ	1.00	1.00
Reinforced Soil and Reinforcement	ϕ_τ	1.00	1.00
Resistance factor for bearing capacity of shallow foundation from Table 10.5.5.2.2-1:		Static	Combined Static/Seismic
	ϕ_b	0.65	0.65

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 1.55, Meyerhof stress = 5962 lb/ft².
Foundation Interface: Direct sliding, CDR = 1.503, Eccentricity, e/L = 0.1864, CDR-overturning = 2.68

#	METAL STRIP Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [pullout resistance]	CDR [connection break]	CDR [metal strip strength]	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	1.15	20.00	1	N/A	2.74	2.74	2.738	2.717	1.688	0.1714	Metal Strip
2	3.45	20.00	1	N/A	3.00	3.00	2.999	2.498	1.837	0.1432	Metal Strip
3	5.75	20.00	1	N/A	3.25	3.25	3.253	2.316	2.015	0.1175	Metal Strip
4	8.05	20.00	1	N/A	3.48	3.48	3.482	2.377	2.232	0.0943	Metal Strip
5	10.35	20.00	1	N/A	3.80	3.80	3.802	2.364	2.500	0.0736	Metal Strip
6	12.65	20.00	1	N/A	4.23	4.23	4.232	2.286	2.842	0.0554	Metal Strip
7	14.95	20.00	1	N/A	4.77	4.77	4.771	2.350	3.292	0.0396	Metal Strip
8	17.25	20.00	1	N/A	5.56	5.56	5.564	2.341	3.911	0.0264	Metal Strip
9	19.55	20.00	1	N/A	6.72	6.72	6.719	2.180	4.816	0.0156	Metal Strip
10	22.00	20.00	1	N/A	6.22	6.22	6.217	1.215	6.394	0.0069	Metal Strip

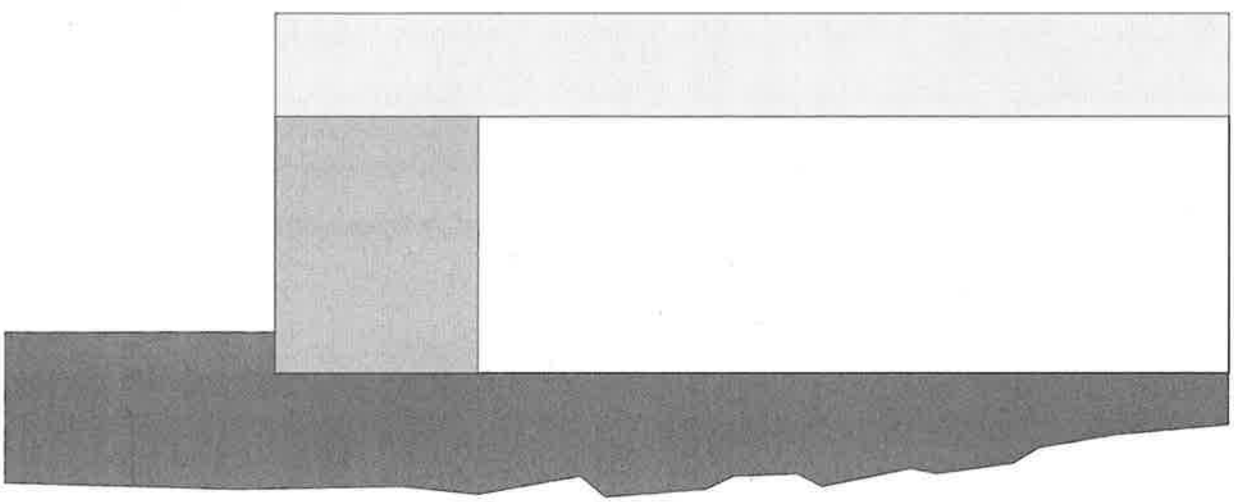
ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 1.38, Meyerhof stress = 6309 lb/ft².
Foundation Interface: Direct sliding, CDR = 1.351, Eccentricity, e/L = 0.2171, Fs-overturning = 2.30

#	METAL STRIP Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [pullout resistance]	CDR [connection break]	CDR [metal strip strength]	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	1.15	20.00	1	N/A	3.52	3.52	3.518	2.793	1.518	0.1994	Metal Strip
2	3.45	20.00	1	N/A	3.85	3.85	3.851	2.565	1.655	0.1660	Metal Strip
3	5.75	20.00	1	N/A	4.18	4.18	4.176	2.378	1.819	0.1357	Metal Strip
4	8.05	20.00	1	N/A	4.47	4.47	4.473	2.443	2.019	0.1084	Metal Strip
5	10.35	20.00	1	N/A	4.89	4.89	4.885	2.430	2.269	0.0841	Metal Strip
6	12.65	20.00	1	N/A	5.44	5.44	5.437	2.350	2.589	0.0629	Metal Strip
7	14.95	20.00	1	N/A	6.10	6.10	6.101	2.404	3.015	0.0446	Metal Strip
8	17.25	20.00	1	N/A	7.07	7.07	7.067	2.378	3.607	0.0293	Metal Strip
9	19.55	20.00	1	N/A	8.45	8.45	8.450	2.194	4.489	0.0171	Metal Strip
10	22.00	20.00	1	N/A	7.85	7.85	7.852	1.228	6.070	0.0073	Metal Strip

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table is at wall base elevation)			
Ultimate bearing capacity, q-ult	9212	8705	[lb/ft ²]
Meyerhof stress, σ_V	5961.5	6309	[lb/ft ²]
Eccentricity, e	2.50	2.91	[ft]
Eccentricity, e/L	0.125	0.146	
CDR calculated	1.55	1.38	
Base length	20.00	20.00	[ft]



SCALE:

0 2 4 6 8 10[ft]

DIRECT SLIDING for GIVEN LAYOUT
(for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 1.503 and CDR-seismic = 1.351

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	1.15	20.00	1.688	1.518	1	Metal Strip
2	3.45	20.00	1.837	1.655	1	Metal Strip
3	5.75	20.00	2.015	1.819	1	Metal Strip
4	8.05	20.00	2.232	2.019	1	Metal Strip
5	10.35	20.00	2.500	2.269	1	Metal Strip
6	12.65	20.00	2.842	2.589	1	Metal Strip
7	14.95	20.00	3.292	3.015	1	Metal Strip
8	17.25	20.00	3.911	3.607	1	Metal Strip
9	19.55	20.00	4.816	4.489	1	Metal Strip
10	22.00	20.00	6.394	6.070	1	Metal Strip

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.1864, e/L seismic = 0.2171; Overturning: CDR-static = 2.68, CDR-seismic = 2.30

#	Metal strip Elevation [ft]	Metal strip Length [ft]	e / L Static	e / L Seismic	Metal strip Type #	Product name
1	1.15	20.00	0.1714	0.1994	1	Metal Strip
2	3.45	20.00	0.1432	0.1660	1	Metal Strip
3	5.75	20.00	0.1175	0.1357	1	Metal Strip
4	8.05	20.00	0.0943	0.1084	1	Metal Strip
5	10.35	20.00	0.0736	0.0841	1	Metal Strip
6	12.65	20.00	0.0554	0.0629	1	Metal Strip
7	14.95	20.00	0.0396	0.0446	1	Metal Strip
8	17.25	20.00	0.0264	0.0293	1	Metal Strip
9	19.55	20.00	0.0156	0.0171	1	Metal Strip
10	22.00	20.00	0.0069	0.0073	1	Metal Strip

RESULTS for STRENGTH [NLive Load included in calculating Tmax\ctual stress)]

#	Metal strip Elevation [ft]	Coverage ratio, Rc=b/Sh	Horizontal spacing, Sh [ft]	Long-term strength Fy·Ac·Rc/b [lb/ft]	Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum CDR static	Actual calculated CDR static	Specified minimum CDR seismic	Actual calculated CDR seismic
1	1.15	0.136	2.460	9153	3342.54	126.53	N/A	2.738	N/A	3.518
2	3.45	0.136	2.460	9153	3051.80	117.49	N/A	2.999	N/A	3.851
3	5.75	0.136	2.460	9153	2813.72	108.44	N/A	3.253	N/A	4.176
4	8.05	0.136	2.460	9153	2628.78	99.40	N/A	3.482	N/A	4.473
5	10.35	0.136	2.460	9153	2407.66	90.36	N/A	3.802	N/A	4.885
6	12.65	0.136	2.460	9153	2162.68	81.91	N/A	4.232	N/A	5.437
7	14.95	0.136	2.460	9153	1918.39	81.91	N/A	4.771	N/A	6.101
8	17.25	0.136	2.460	9153	1644.99	81.91	N/A	5.564	N/A	7.067
9	19.55	0.136	2.460	9153	1362.28	81.91	N/A	6.719	N/A	8.450
10	22.00	0.136	2.460	9153	1472.32	81.91	N/A	6.217	N/A	7.852

RESULTS for PULLOUT Live Load included in calculating Tmax

NOTE: Live load is not included in calculating the overburden pressure used to assess pullout resistance.

#	Metal strip Elevation [ft]	Coverage Ratio Rc=b/Sh	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft] (see NOTE)	La [ft]	Avail.Static Pullout, Pr [lb/ft]	Specified Static CDR	Actual Static CDR	Avail.Seism. Pullout, Pr [lb/ft]	Specified Seismic CDR	Actual Seismic CDR
1	1.15	0.136	3342.5	126.5	19.31	0.69	9082.6	N/A	2.717	9688.1	N/A	2.793
2	3.45	0.136	3051.8	117.5	17.93	2.07	7622.2	N/A	2.498	8130.3	N/A	2.565
3	5.75	0.136	2813.7	108.4	16.55	3.45	6515.9	N/A	2.316	6950.3	N/A	2.378
4	8.05	0.136	2628.8	99.4	15.17	4.83	6249.4	N/A	2.377	6666.1	N/A	2.443
5	10.35	0.136	2407.7	90.4	13.79	6.21	5690.9	N/A	2.364	6070.3	N/A	2.430
6	12.65	0.136	2162.7	81.9	12.50	7.50	4944.4	N/A	2.286	5274.1	N/A	2.350
7	14.95	0.136	1918.4	81.9	12.50	7.50	4508.2	N/A	2.350	4808.8	N/A	2.404
8	17.25	0.136	1645.0	81.9	12.50	7.50	3850.2	N/A	2.341	4106.8	N/A	2.378
9	19.55	0.136	1362.3	81.9	12.50	7.50	2970.3	N/A	2.180	3168.3	N/A	2.194
10	22.00	0.136	1472.3	81.9	12.50	7.50	1789.1	N/A	1.215	1908.4	N/A	1.228

RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Metal strip Elevation [ft]	Coverage ratio Rc=b/Sh	Horizontal spacing, Sh [ft]	Connection force, To [lb/ft]	Reduction factor for connection break, CRu	Long-term connection strength,Tac (break criterion) [lb/ft]	Metal strip long-term strength, [lb/ft]	CDR connection break Specified	CDR connection break Actual	CDR Metal strip strength Specified	CDR Metal strip strength Actual	Product name
1	1.15	0.136	2.460	3343	1.00	9153	9153	N/A	2.74	N/A	2.74	Metal Strip
2	3.45	0.136	2.460	3052	1.00	9153	9153	N/A	3.00	N/A	3.00	Metal Strip
3	5.75	0.136	2.460	2814	1.00	9153	9153	N/A	3.25	N/A	3.25	Metal Strip
4	8.05	0.136	2.460	2629	1.00	9153	9153	N/A	3.48	N/A	3.48	Metal Strip
5	10.35	0.136	2.460	2408	1.00	9153	9153	N/A	3.80	N/A	3.80	Metal Strip
6	12.65	0.136	2.460	2163	1.00	9153	9153	N/A	4.23	N/A	4.23	Metal Strip
7	14.95	0.136	2.460	1918	1.00	9153	9153	N/A	4.77	N/A	4.77	Metal Strip
8	17.25	0.136	2.460	1645	1.00	9153	9153	N/A	5.56	N/A	5.56	Metal Strip
9	19.55	0.136	2.460	1362	1.00	9153	9153	N/A	6.72	N/A	6.72	Metal Strip
10	22.00	0.136	2.460	1472	1.00	9153	9153	N/A	6.22	N/A	6.22	Metal Strip

RESULTS for CONNECTION (seismic conditions)

Live Load included in calculating Tmax

#	Metal strip Elevation [ft]	Coverage ratio Rc=b/Sh	Horizontal spacing, Sh [ft]	Connection force, To [lb/ft]	Reduction factor for connection break, CRu	Long-term connection strength,Tac (break criterion) [lb/ft]	Metal strip long-term strength, [lb/ft]	CDR connection break Specified	CDR connection break Actual	CDR Metal strip strength Specified	CDR Metal strip strength Actual	Product name
1	1.15	0.136	2.460	3469	1.00	12204	9153	N/A	3.52	N/A	3.52	Metal Strip
2	3.45	0.136	2.460	3169	1.00	12204	9153	N/A	3.85	N/A	3.85	Metal Strip
3	5.75	0.136	2.460	2922	1.00	12204	9153	N/A	4.18	N/A	4.18	Metal Strip
4	8.05	0.136	2.460	2728	1.00	12204	9153	N/A	4.47	N/A	4.47	Metal Strip
5	10.35	0.136	2.460	2498	1.00	12204	9153	N/A	4.89	N/A	4.89	Metal Strip
6	12.65	0.136	2.460	2245	1.00	12204	9153	N/A	5.44	N/A	5.44	Metal Strip
7	14.95	0.136	2.460	2000	1.00	12204	9153	N/A	6.10	N/A	6.10	Metal Strip
8	17.25	0.136	2.460	1727	1.00	12204	9153	N/A	7.07	N/A	7.07	Metal Strip
9	19.55	0.136	2.460	1444	1.00	12204	9153	N/A	8.45	N/A	8.45	Metal Strip
10	22.00	0.136	2.460	1554	1.00	12204	9153	N/A	7.85	N/A	7.85	Metal Strip

APPENDIX G: Historical Information

GRADING
LETTING DATE March 24 1998
NHS-30-6(62)--19-06

BENTON CO.

TOTAL

PROJECT NUMBER
NHS-30-6(62)--19-06
R.O.W. PROJECT NUMBER
FN-30-6(64)--21-06
PROJECT IDENTIFICATION NUMBER
92-06040-1

STANDARD ROAD PLANS

105-4
06-17-77

The following Standard Road Plans shall be considered applicable to construction work on this project.

NUMBER	DATE	NUMBER	DATE	NUMBER	DATE
RA-13A	01-19-88	RF-19B	03-29-94	RL-1A	12-03-96
RA-16C	02-28-89	RF-19C	04-28-92	RL-1B	12-03-96
RC-12	04-28-92	RF-19E	07-15-97	RL-2A	12-03-96
RC-13	10-19-73	RF-19F	03-28-95	RL-4	07-16-91
RC-16	04-28-92	RF-21	11-22-74	RL--7	12-03-96
RF-1	09-03-76	RF-26	02-17-87	RL-9	12-09-77
RF-2	02-23-93	RF-30A	03-28-95	RL-14	03-26-96
RF-3	07-15-97	RF-30B	03-28-95	RP-1	05-13-86
RF-5	03-28-95	RF-31	03-28-95	RP-2	05-13-86
RF-7	11-08-74	RF-32	03-28-95	RS-2	04-30-96
RF-13	07-15-97	RF-41	10-31-95	RS-3	12-03-96
RF-14	04-28-92	RF-42	07-15-97	RS-26A	10-28-97
RF-19A	07-15-97				

Iowa Department of Transportation

Project Development Division

PLANS OF PROPOSED IMPROVEMENTS ON THE

PRIMARY ROAD SYSTEM
BENTON COUNTY
GRADING

FROM WEST OF WEST JCT. U.S. 218
EAST TO WEST OF JCT. IA. 201

SCALES: As Noted

The Iowa Department of Transportation Standard Specifications for Highway and Bridge Construction, series of 1997, plus current Supplemental Specifications and Special Provisions shall apply to construction work on this project.

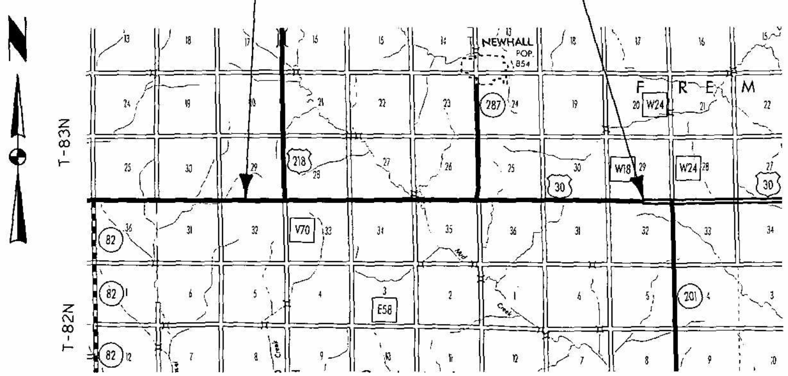
Value Engineering Saves. Refer to Standard Notation 203-4 on Sheet C.04

INDEX OF SHEETS

105-3
07-21-87

STA. 687+93.63
BEGIN PROJECT
M.P. 231.44

STA. 1006+00.00
END PROJECT
M.P. 237.41



R-10W R-09E

LOCATION MAP SCALE
0 1 2 3
Miles

445

MILEAGE SUMMARY

105-1
09-27-94

DIV.	LOCATION	LIN. FT.	MILES
	Sta. 687+93.63 to Sta. 1003+00.00 M.P = 231.44 M.P. = 237.41	31,506.37	
	Eq: Sta. 734+31.24 = Sta. 734+30.68 (Lengthens Line)	0.56	
	Bridge at Sta. 820+77	113.00	
	Eq: Sta. 908+22.91 = Sta. 908+22.05 (Lengthens Line)	0.86	
	Eq: Sta. 978+36.66 = Sta. 978+39.98 (Shortens Line)	3.32	
	Eq: Sta.1002+70.97 = Sta.1002+74.08 (Shortens Line)	3.11	
	Net Length of Roadway in Project	31,388.36	5.943
	Net Length of Bridge in Project	113.00	0.021
	Total Length of Project	31,501.36	5.966

10-31-95 101-4

DESIGN DATA RURAL

1999 AADT	5445	V.P.D.
2019 AADT	7070	V.P.D.
2019 DHV	780	V.P.H.
TRUCKS	22	%
ESALs per day	___	

150

REVISIONS

LICENSED PROFESSIONAL ENGINEER
Raymond J. Schoenrock
04165
IOWA

I hereby certify that this plan was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Iowa.

Raymond J. Schoenrock 2-12-98
Signature Date
Raymond J. Schoenrock
Printed or Typed Name

My license renewal date is December 31, 19 99

Pages or sheets covered by this seal: A.01-A.03, B.01-B.05, C.01-C.07, D.01-D.11, E.01-E.05, G.01-G.05, J.01-J.02, L.01-L.08, T.01-T.07, U.01,U.02, V.01, V.11 W.01-W.99, X.01-X.21, Y.01-Y.33

LIST OF SUBDRAIN WORK

Refer to Standard Road Plans RF-3, RF-5,RF-19A, RF-19B, RF-19C, RF-19E, RF-19F and RF-22

✱Not a bid item

104-5C
07-15-97

LOCATION			PIPE			APRONS		OUTLETS				CONNECTED PIPE JOINTS ✱		TRENCH DRAIN	GRANULAR MATERIAL	POROUS BACKFILL✱	CLASS "A" CRUSHED STONE ✱	REMARKS
NO.	STATION	TYPE OF INSTALLATION	CONCRETE, C.M.P., C.M.P. COATED, PLASTIC OR CLAY	DIA. Inches	LENGTH Lin. Ft.	RF-3 No.	RF-5 No.	RF-19E No.	RF-19F Type	RF-19F No.	RF-22 No.	Type	No.	Lin. Ft.	Blanket Cu. Yds.	Cu. Yds.	Cu. Yds.	
1	914+37±	RF-19A Type 2	Perf. Plastic	4	58				"B"	1				382	2.5			Refer to Sheet No. Q.12

① Refer to Standard Road Plan RF-19C.
② Refer to Soils Sheets

TABULATION OF LONGITUDINAL SUBDRAIN SHOULDER AND BACKSLOPE

✱Not a bid item

104-9
09-29-92

Line No.	LOCATION				Depth (D)	LONGITUDINAL SUBDRAIN				CMP SUBDRAIN OUTLET RF-19E or RF-22			POROUS ✱ BACKFILL	Class 'A' ✱ Crushed Stone	REMARKS
	Road or Lane Ident.	Station to Station		Side	Inch.	Shoulder ① Size	Shoulder ① Lin. Ft.	Backslope ② Size	Backslope ② Lin. Ft.	Station	Size	Type	Cu. Yds.	Cu. Yds.	
	US 30	988+00	998+00	Rt.	66			4"	1016	988+00	6"	19E	125		
										998+00	6"	19E			

PROPOSED SUBGRADE TREATMENT

(For Additional Details see Soils Survey Sheet No. Q.01 to Q.12 .)

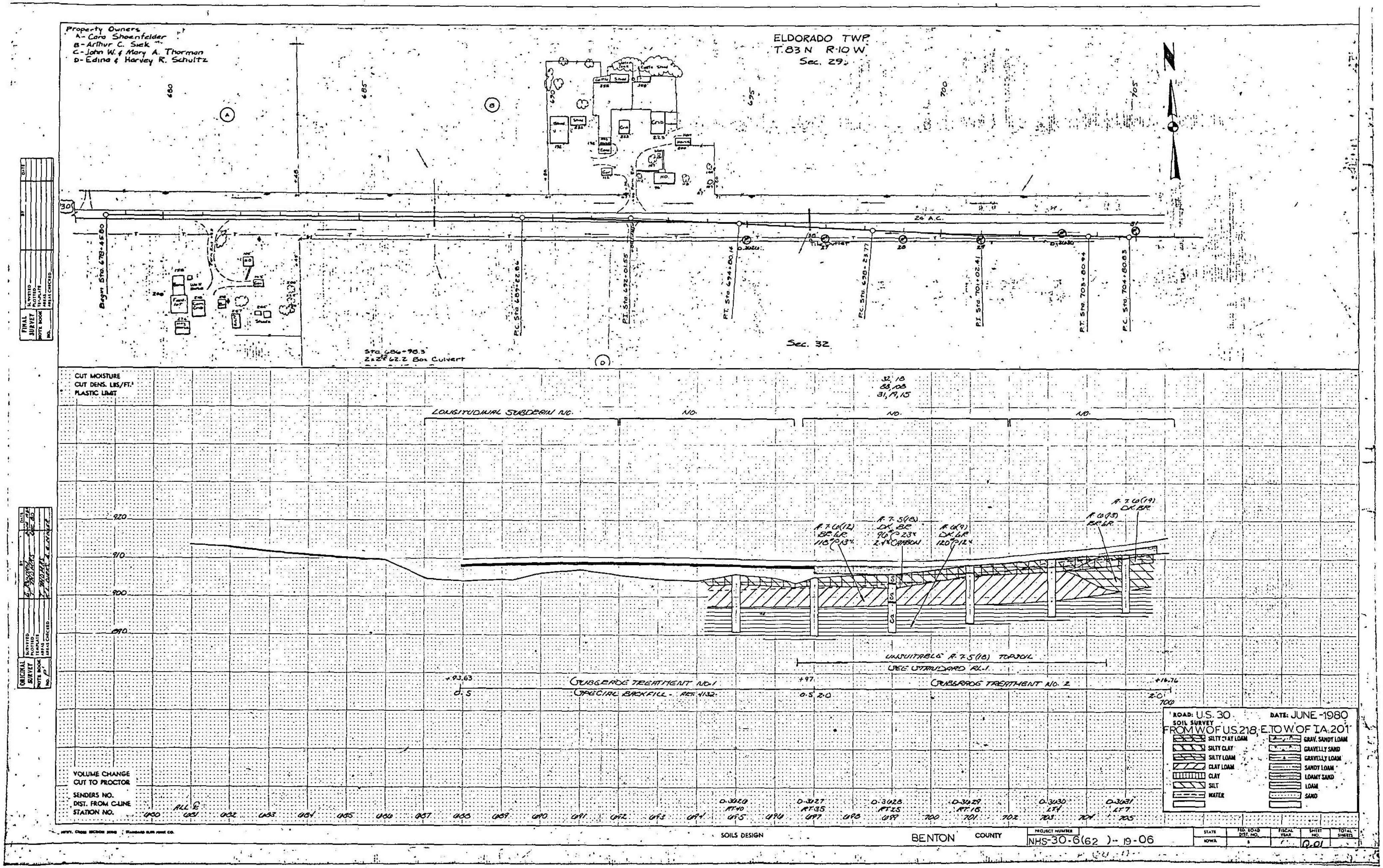
103-3
06-07-94

NO.	LOCATION	DESCRIPTION			TYPE		QUANTITY		POLYMER GRID	AVAILABLE FROM		REMARKS
	Station to Station	Side	Depth	Width	Material + Shrink %		Cu. Yds.	Tons	Sq. Yds.	Quantity	Station to Station	
					GRADING CONTRACTOR							
2	696+97 - 706+16.76	EBR	2.0	32.0	Loam - Clay Loam	F+10%	2,399			40,875	730+00 - 749+00	
3	706+16.76 - 711+41.10	EBR	2.0	(A)	Loam - Clay Loam	F+10%	2,168			40,875	730+00 - 749+00	
4	711+41.10 - 759+31.84	EBR	2.0	32.0	Loam - Clay Loam	F+10%	12,489			40,875	730+00 - 749+00	
5	759+31.84 - 764+07	EBR	2.0	(B)	Loam - Clay Loam	F+10%	1,809			6,408	772+00 - 782+00	
6	764+07 - 772+00	EBR	2.0	32.0	Loam - Clay Loam	F+10%	2,067			6,408	772+00 - 782+00	
7	772+00 - 774+00.02	EBR	2.0	32.0	Loam - Clay Loam	F+10%	783			6,408	772+00 - 782+00	
8	774+00.02 - 812+13.06	EBR	2.0	32.0	Loam - Clay Loam	F+10%	9,941			25,743	806+00 - 815+00	
9	812+13.06 - 817+79.86	EBR	2.0	(D)	Loam - Clay Loam	F+10%	2,618			25,743	806+00 - 815+00	
9B	3805+00 - 3813+34.17	S.R.	2.0	(E)	Loam - Clay Loam	F+10%	2,126			25,743	806+00 - 815+00	Co. Road W-12
10	817+79.86 - 819+50.50	EBR	2.0	32.0	Loam - Clay Loam	F+10%	446			25,743	806+00 - 815+00	
11	822+03.50 - 862+41.91	EBR	2.0	32.0	Loam - Clay Loam	F+10%	10,529			25,743	806+00 - 815+00	
12	862+41.91 - 867+28.18	EBR	2.0	(B)	Loam - Clay Loam	F+10%	1,914			5,741	854+00 - 860+00	
13	867+28.18 - 907+50	EBR	2.0	32.0	Loam - Clay Loam	F+10%	10,484			10,853	896+00 - 903+00	
14	907+50 - 912+00	EBR	3.0	32.0	Loam - Clay Loam	F+10%	1,758			36,880	Borrow 'A'	
15	912+00 - 917+72.07	EBR	2.0	32.0	Loam - Clay Loam	F+10%	1,497			36,880	Borrow 'A'	
16	917+72.07 - 922+46.22	EBR	1.0	(B)	Special Backfill	Art. 4132		1,461				
17	922+46.22 - 949+50	EBR	2.0	32.0	Loam - Clay Loam	F+10%	7,046			36,880	Borrow 'A'	
18	949+50 - 952+50	EBR	3.0	32.0	Loam - Clay Loam	F+10%	1,175			36,880	Borrow 'A'	
19	952+50 - 970+55.40	EBR	2.0	32.0	Loam - Clay Loam	F+10%	4,705			6,888	952+00 - 959+00	
20	970+55.40 - 975+18.53	EBR	2.0	(B)	Loam - Clay Loam	F+10%	1,664			6,888	952+00 - 959+00	
21	975+18.53 - 1003+00	EBR	2.0	32.0	Loam - Clay Loam	F+10%	7,238			11,019	962+00 - 970+00	
					Paving Contractor							
1	687+93.63 - 696+97	EBR	0.5	Vari.	Special Backfill	Art. 4132		611				Stage 2
5A	2762+85.36 - 2762+27.32		1.0	(C)	Special Backfill	Art. 4132		490				Stage 2
9A	3814+70.23 - 3815+02.23		1.0	(C)	Special Backfill	Art. 4132		514				Stage 2
12A	4869+02.40 - 4869+34.40		1.0	(C)	Special Backfill	Art. 4132		445				Stage 2
16A	5920+32.76 - 5920+64.76		1.0	(C)	Special Backfill	Art. 4132		497				Stage 2
20A	6974+00.86 - 6974+32.86		1.0	(C)	Special Backfill	Art. 4132		507				Stage 2
22	990+60		1.0	(F)	Special Backfill	Art. 4132						Stage 2

NOTES:

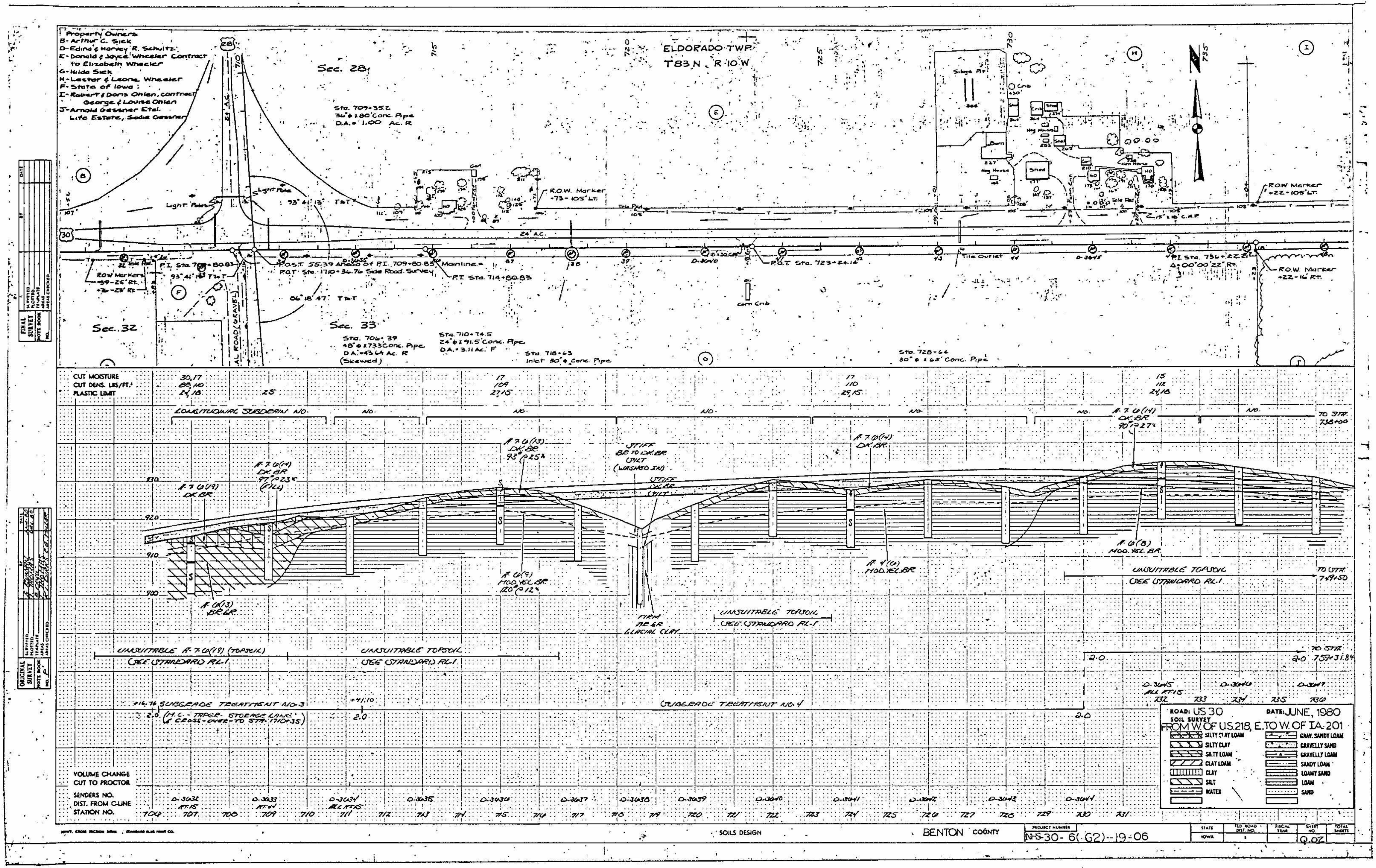
EBR = Eastbound Roadway
All treatments are 3.0' outside of pavement edge.

(A) Vari. Width - Includes Lt. Turn Lane, Taper, and Median Crossover.
(B) Vari. Width - Includes Lt. Turn Lane, Taper, and Median Crossover to Median Centerline.
(C) Vari. Width - Includes Lt. Turn Lane, Taper and Median Crossover to Median Centerline to Westbound Roadway Pavement.
(D) Vari. Width - Includes Lt. Turn Lane, Taper and Median Crossover to Median Centerline.
Also includes Side Road intersection return from Sta. 3813+34.17 to edge of Eastbound Roadway Pavement.
(E) Vari. Width - Includes Side Road intersection. Return to Sta. 3813+34.17.
(F) Paved Median Crossover.

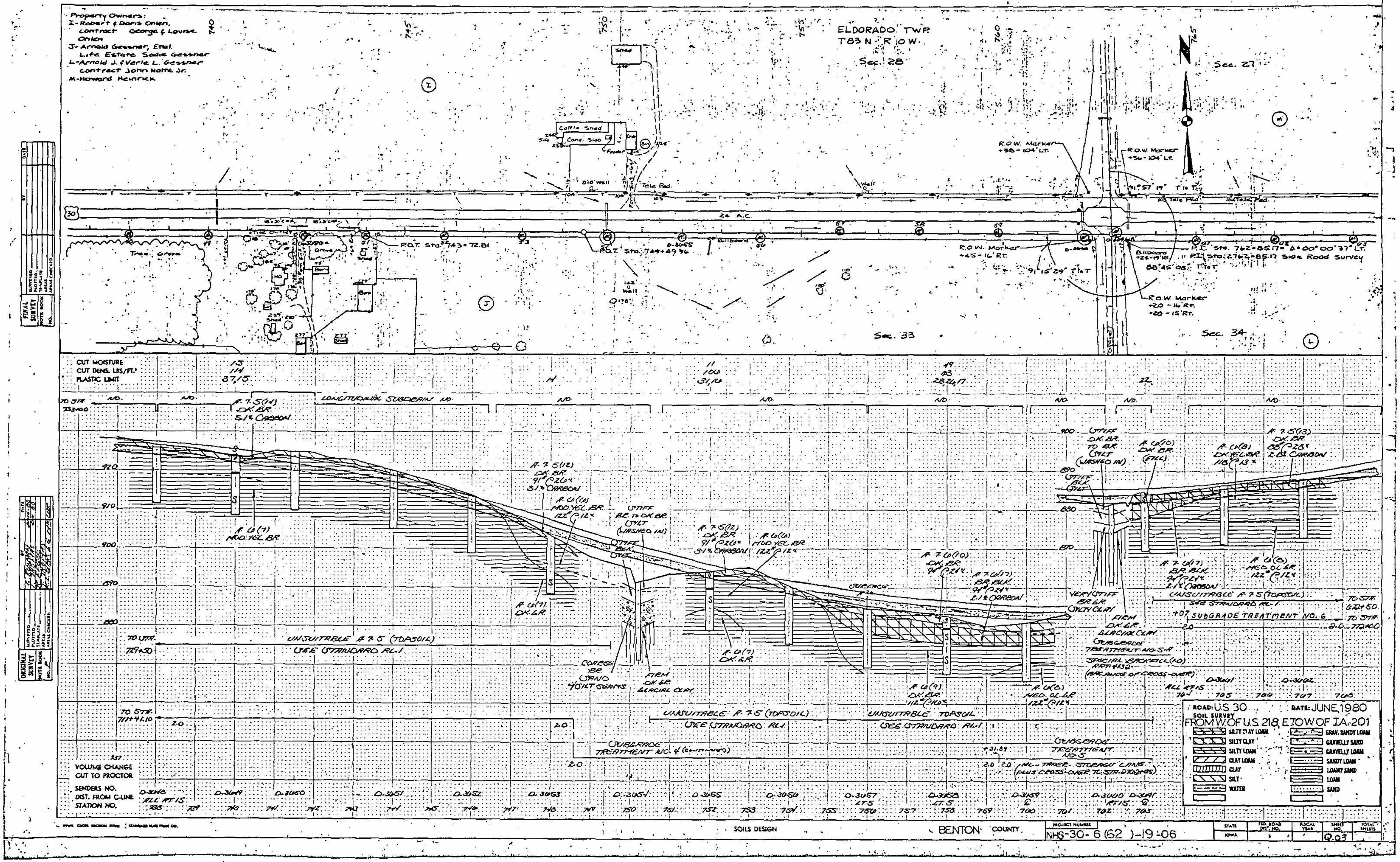


Property Owners
A - Cora Shoenfelder
B - Arthur C. Suek
C - John W. & Mary A. Thorman
D - Edina & Harvey R. Schultz
ELDORADO TWP.
T.83 N R.10 W.
Sec. 29
Sec. 32
Begin Sta. 678+45.80
P.C. Sta. 687+22.86
P.I. Sta. 692+01.55
P.T. Sta. 694+80.16
P.C. Sta. 698+23.77
P.I. Sta. 701+02.41
P.T. Sta. 703+80.94
P.C. Sta. 704+80.83
Sta. 686+98.3
2-2'x2' 62.2 Box Culvert
24' A.C.
CUT MOISTURE
CUT DENS. LBS/FT.³
PLASTIC LIMIT
32, 18
88, 108
31, 19, 15
LONGITUDINAL SUBDRAIN NO.
NO.
NO.
NO.
920
910
900
890
A-7-6(12) BR. LR. 118° P.13%
A-7-5(18) DK. BR. 96° P.23% 2.1% CARBON
A-6(9) DK. LR. 120° P.12%
A-6(9.5) BR. LR.
A-7-6(19) DK. BR.
UNSUITABLE A-7-5(18) TOPSOIL
(SEE STANDARD RL-1)
+93.63
SUBGRADE TREATMENT NO. 1
SPECIAL BACKFILL - REF. 4132
0.5
+97
0.5 2.0
SUBGRADE TREATMENT NO. 2
+16.76
2.0
700
VOLUME CHANGE
CUT TO PROCTOR
SENDERS NO.
DIST. FROM C-LINE
STATION NO.
ALL ℄
D-3026 RT 40
D-3027 RT 35
D-3028 RT 25
D-3029 RT 18
D-3030 LT 4
D-3031 LT 7
680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705
ROAD: U.S. 30
DATE: JUNE - 1980
SOIL SURVEY
FROM W. OF U.S. 218 E. TO W. OF IA. 201
SILTY CLAY LOAM
SILTY CLAY
SILTY LOAM
CLAY LOAM
CLAY
SILT
WATER
GRAV. SANDY LOAM
GRAVELLY SAND
GRAVELLY LOAM
SANDY LOAM
LOAMY SAND
LOAM
SAND
SOILS DESIGN
BENTON COUNTY
PROJECT NUMBER NHS-30-6(62)--19-06
STATE IOWA
SHEET NO. Q.01
FINAL SURVEY
ORIGINAL SURVEY

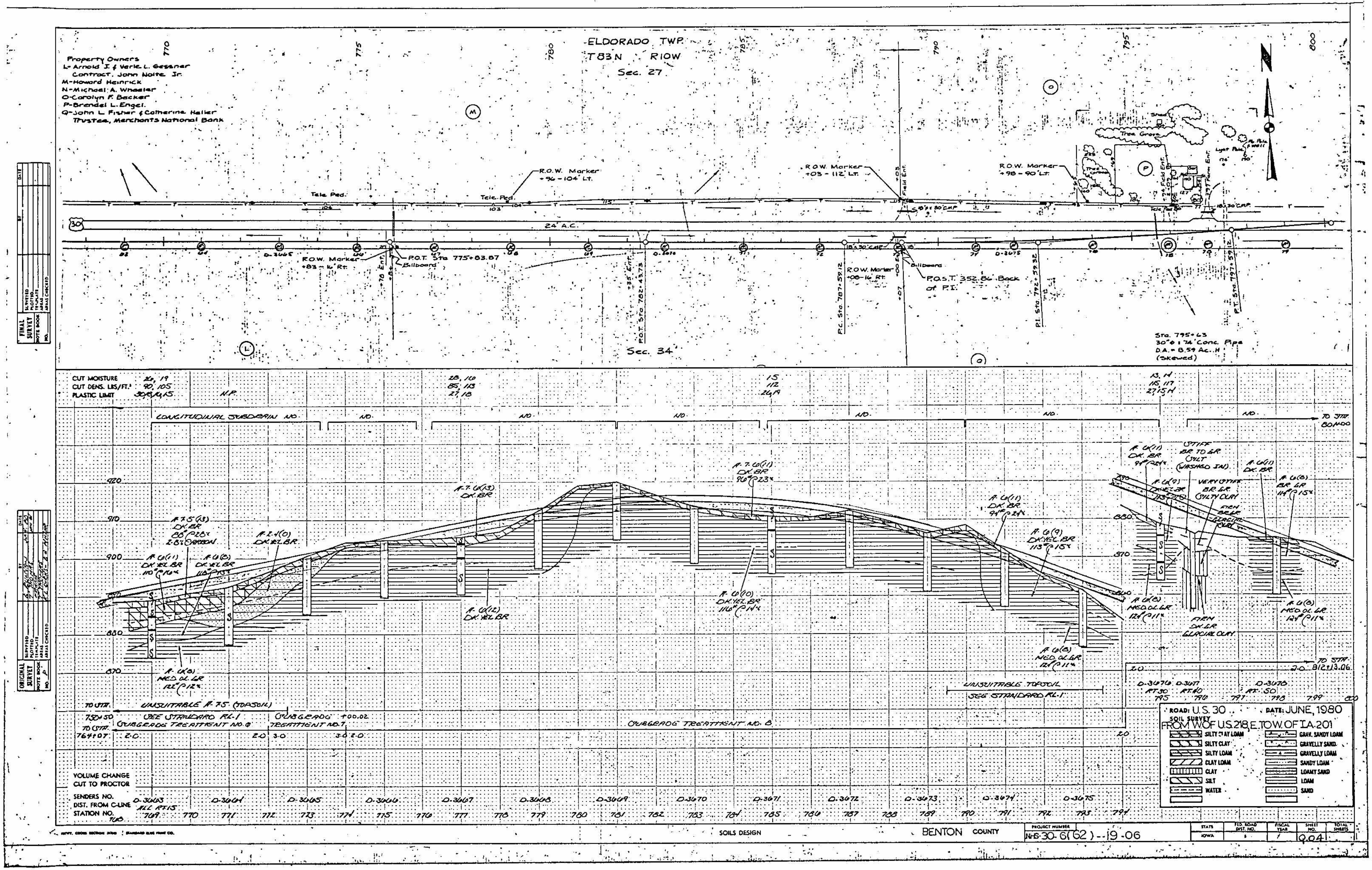
D1



Property Owners
B-Arthur C. Siek
D-Edina & Harley R. Schultz
E-Donald & Joyce Wheeler Contract to Elizabeth Wheeler
G-Hilda Siek
H-Lester & Leona Wheeler
F-State of Iowa
I-Robert & Doris Ohlen, contract George & Louise Ohlen
J-Arnold Gessner Etal. Life Estate, Sadie Gessner
ELDORADO TWP.
T83N, R10W
Sec. 28
Sec. 32
Sec. 33
Sta. 709+35±
36" ø x 180' Conc. Pipe
D.A. = 1.00 Ac. R
R.O.W. Marker +73-105' Lt.
ROW Marker +22-105' LT.
R.O.W. Marker +22-16' RT.
ROW Markers +39-25' Rt. +76-23' Rt.
Light Pole
24' A.C.
P.I. Sta. 709+80.83
93° 41' 13" T to T
P.O.S.T. 55.39 Ahead of P.I. 709+80.83 = Mainline
P.O.T. Sta. 1710+36.76 Side Road Survey
P.T. Sta. 714+80.83
P.O.T. Sta. 723+24.14
P.I. Sta. 736+22.21
0° 00' 22" Rt.
06° 18' 47" T to T
Tile Outlet
Corn Crib
Silage Pit
Barn
Hog House
Shed
Sta. 706+39
48" ø x 733' Conc. Pipe
D.A. = 43.6 Ac. R
(Skewed)
Sta. 710+74.5
24" ø x 91.5' Conc. Pipe
D.A. = 3.11 Ac. F
Sta. 718+63
Inlet 30" ø Conc. Pipe
Sta. 728+64
30" ø x 65' Conc. Pipe
CUT MOISTURE
CUT DENS. LBS/FT.³
PLASTIC LIMIT
LONGITUDINAL SUBDRAIN NO.
TO STA. 738+00
A-7-6(13) DK.BR. 93 @ 25%
A-7-6(14) DK.BR. 97 @ 23% (FILL)
A-7-6(9) DK.BR.
STIFF BR. TO DK.BR. SILT (WASHED IN)
STIFF DK.BR. SILT
A-7-6(14) DK.BR.
A-7-6(14) DK.BR. 90 @ 27%
A-6(8) MOD.YEL.BR.
A-6(9) MOD.YEL.BR. 120 @ 12%
A-4(6) MOD.YEL.BR.
A-6(13) BR.GR.
FIRM BR.GR. GLACIAL CLAY
UNSUITABLE TOPSOIL (SEE STANDARD RL-1)
TO STA. 749+50
UNSUITABLE A-7-6(19) (TOPSOIL) (SEE STANDARD RL-1)
TO STA. 759+31.84
+16.76 SUBGRADE TREATMENT NO. 3
+41.10
SUBGRADE TREATMENT NO. 4
2.0 (M.C. - TAPER - STORAGE LANE & CROSS-OVER TO STA. 1710+35)
VOLUME CHANGE
CUT TO PROCTOR
SENDERS NO.
DIST. FROM C-LINE
STATION NO.
ROAD: US 30
DATE: JUNE, 1980
SOIL SURVEY
FROM W. OF US 218, E. TO W. OF IA. 201
SILTY CLAY LOAM
SILTY CLAY
SILTY LOAM
CLAY LOAM
CLAY
SILT
WATER
GRAV. SANDY LOAM
GRAVELLY SAND
GRAVELLY LOAM
SANDY LOAM
LOAMY SAND
LOAM
SAND
SOILS DESIGN
BENTON COUNTY
PROJECT NUMBER NHS-30-6(62)--19-06
STATE IOWA
SHEET NO. Q.02
ORIGINAL SURVEY
FINAL SURVEY
D1

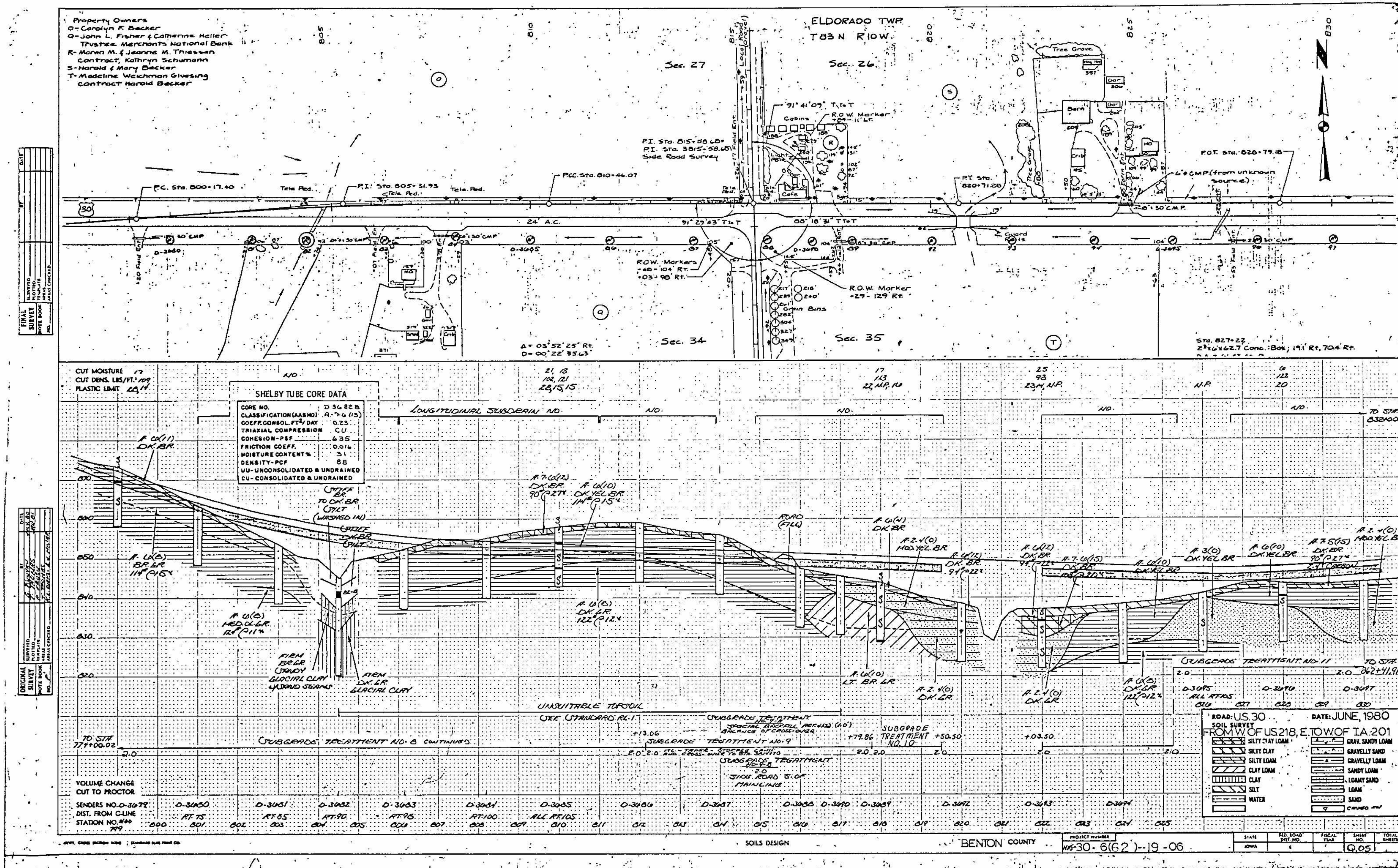

Property Owners:
I-Robert & Doris Ohlen, contract George & Louise Ohlen
J-Arnold Gessner, Etal. Life Estate Sadie Gessner
L-Arnold J. & Verle L. Gessner contract John Notte Jr.
M-Howard Heinrick
ELDORADO TWP. T83N R10W.
Sec. 28
Sec. 27
Sec. 33
Sec. 34
Cattle Shed
Conc. Slab
Tree Grove
Billboard
P.O.T. Sta. 743+72.81
P.O.T. Sta. 749+49.96
R.O.W. Marker
P.I. Sta. 762+85.17 Δ=00°00'37" LT.
CUT MOISTURE
CUT DENS. LBS/FT.³
PLASTIC LIMIT
LONGITUDINAL SUBDRAIN NO.
UNSUITABLE A-7-5 (TOPSOIL)
SEE STANDARD RL-1
UNSUITABLE TOPSOIL
SUBGRADE TREATMENT NO. 4 (CONTINUED)
SUBGRADE TREATMENT NO. 5
SUBGRADE TREATMENT NO. 6
SURFACE
VOLUME CHANGE
CUT TO PROCTOR
SENDERS NO.
DIST. FROM C-LINE
STATION NO.
ROAD: U.S. 30
DATE: JUNE, 1980
SOIL SURVEY
FROM W. OF U.S. 218, E. TO W. OF IA-201
SILTY CLAY LOAM
SILTY CLAY
SILTY LOAM
CLAY LOAM
CLAY
SILT
WATER
GRAV. SANDY LOAM
GRAVELLY SAND
GRAVELLY LOAM
SANDY LOAM
LOAMY SAND
LOAM
SAND
SOILS DESIGN
BENTON COUNTY
PROJECT NUMBER NHS-30-6(62)-19-06
STATE IOWA
SHEET NO. Q.03

D1



ELDORADO TWP.
T83N R10W
Sec. 27
Sec. 34
Property Owners
L-Arnold J. & Verle L. Gessner
Contract. John Nolte Jr.
M-Howard Heinrick
N-Michael A. Wheeler
O-Carolyn F. Becker
P-Brendel L. Engel.
Q-John L. Fisher & Catherine Heller
Trustee, Merchants National Bank
Tele. Ped.
24' A.C.
R.O.W. Marker +96 - 104' LT.
R.O.W. Marker +03 - 112' LT.
R.O.W. Marker +98 - 90' LT.
R.O.W. Marker +83 - 16' RT.
R.O.W. Marker +08 - 16' RT.
P.O.T. Sta. 775+83.67
P.O.T. Sta. 782+43.73
P.C. Sta. 787+59.12
P.I. Sta. 792+59.32
P.T. Sta. 797+59.12
P.O.S.T. 352.86' Back of P.I.
Billboard
Field Ent.
Tree Grove
Shed
Sta. 795+63
30" ø x 74' Conc. Pipe
D.A. = 8.59 Ac. H
(Skewed)
CUT MOISTURE
CUT DENS. LBS/FT.³
PLASTIC LIMIT
LONGITUDINAL SUBDRAIN NO.
TO STA. 801+00
UNSUITABLE A-7.5 (TOPSOIL)
SEE STANDARD RL-1
SUBGRADE TREATMENT NO. 8
SUBGRADE TREATMENT NO. 7
SUBGRADE TREATMENT NO. 6
UNSUITABLE TOPSOIL
SEE STANDARD RL-1
VOLUME CHANGE
CUT TO PROCTOR
SENDERS NO.
DIST. FROM C-LINE
STATION NO.
ALL RT 15
ROAD: U.S. 30
DATE: JUNE, 1980
SOIL SURVEY
FROM W. OF U.S. 218 E. TO W. OF IA. 201
SILTY CLAY LOAM
SILTY CLAY
SILTY LOAM
CLAY LOAM
CLAY
SILT
WATER
GRAV. SANDY LOAM
GRAVELLY SAND
GRAVELLY LOAM
SANDY LOAM
LOAMY SAND
LOAM
SAND
SOILS DESIGN
BENTON COUNTY
PROJECT NUMBER
NHS-30-6(62)--19-06
STATE
IOWA
FED. ROAD DIST. NO.
FISCAL YEAR
SHEET NO.
TOTAL SHEETS
9.04

D1



Property Owners
O-Carolyn F. Becker
Q-John L. Fisher & Catherine Heller Trustee Merchants National Bank
R-Marvin M. & Jeanne M. Thiessen Contract, Kathryn Schumann
S-Harold & Mary Becker
T-Madeline Weichman Gluesing Contract Harold Becker
ELDORADO TWP.
T83N R10W
Sec. 27
Sec. 26
Sec. 34
Sec. 35
P.C. Sta. 800+17.40
P.I. Sta 805+31.93
P.C.C. Sta. 810+44.07
P.I. Sta. 815+58.68
P.I. Sta. 3815+58.68
Side Road Survey
P.T. Sta. 820+71.28
P.O.T. Sta. 828+79.18
24' A.C.
Tele. Ped.
Cabins
Grain Bins
Tree Grove
Barn
Crib
R.O.W. Markers
R.O.W. Marker
6" CMP (from unknown source)
Δ = 03°52'25" Rt.
D = 00°22'35.63"
Sta. 827+22
SHELBY TUBE CORE DATA
CORE NO. D 36828
CLASSIFICATION (AASHO) A-7-6 (13)
COEFF. CONSOL. FT²/ DAY 0.23
TRIAXIAL COMPRESSION CU
COHESION-PSF 635
FRICTION COEFF. 0.016
MOISTURE CONTENT % 31
DENSITY-PCF 88
UU-UNCONSOLIDATED & UNDRAINED
CU-CONSOLIDATED & UNDRAINED
CUT MOISTURE
CUT DENS. LBS/FT.³
PLASTIC LIMIT
LONGITUDINAL SUBDRAIN NO
UNSUITABLE TOPSOIL
SEE STANDARD RL-1
SUBGRADE TREATMENT NO. 8 CONTINUED
SUBGRADE TREATMENT NO. 9
SUBGRADE TREATMENT NO. 10
SUBGRADE TREATMENT NO. 11
TO STA. 862+41.91
VOLUME CHANGE
CUT TO PROCTOR
SENDERS NO.
DIST. FROM C-LINE
STATION NO.
ROAD: U.S. 30
DATE: JUNE, 1980
SOIL SURVEY
FROM W. OF US 218, E. TO W. OF I.A. 201
SILTY CLAY LOAM
SILTY CLAY
SILTY LOAM
CLAY LOAM
CLAY
SILT
WATER
GRAV. SANDY LOAM
GRAVELLY SAND
GRAVELLY LOAM
SANDY LOAM
LOAMY SAND
LOAM
SAND
SOILS DESIGN
BENTON COUNTY
PROJECT NUMBER
NHS-30-6(62)--19-06
STATE IOWA
FED. ROAD DIST. NO. 5
FISCAL YEAR
SHEET NO. Q.05
TOTAL SHEETS