Geotechnical Evaluation Report

Museum Drive Reconstruction
Between Highway 22 and Sims Street
Dickinson, North Dakota

Prepared for

Highlands Engineering & Surveying

Professional Certification:
I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of North Dakota.

REGISTERED PROFESSIONAL ENGINEER
CHARLES W. DICKHUT
PE-9213
DATE 10/27/15
NORTH DAKOTA

Charles W. Dickhut, PE
Senior Engineer
Registration Number: PE-9213
October 27, 2015

Project B1508345

Braun Intertec Corporation

BRAUN INTERTEC
The Science You Build On.

Braun Intertec Corporation
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October 27, 2015

Project B1508345

Mr. Andrew Schrank
Highlands Engineering & Surveying
319 24th Street East
Dickinson, ND 58601

Re: Geotechnical Evaluation
Museum Drive Reconstruction
Museum Drive between Highway 22 and Sims Street
Dickinson, North Dakota

Dear Mr. Schrank:

We are pleased to present this Geotechnical Evaluation Report for the reconstruction of Museum Drive. A summary of our results, and a summary of our recommendations in light of the geotechnical issues influencing design and construction, is presented below. More detailed information and recommendations follow.

Summary of Results

We drilled two borings within the existing roadway to a depth of 6 feet. At the surface, both of the borings encountered bituminous pavement to depths of 6 to 7 inches. No aggregate base course was observed. One of the borings encountered existing fill composed of fat clay. The other boring encountered decomposed bedrock likely associated with the Sentinel Butte Formation that consisted of sandstone over claystone.

Groundwater was not observed during or immediately after drilling. The borings were backfilled immediately after completion of the boring; thus, a long-term observation period for groundwater measurements was not performed.

Summary of Recommendations

Due to the frost-susceptible nature of the clay-rich soils present at pavement subgrade elevations, consideration should be given to incorporating an aggregate base course layer into the pavement section. This will enhance subgrade drainage efforts and reduce the potential for pavement subgrades to become saturated and heave upon freezing; strength loss upon thawing will also be reduced.

The onsite clay soils appear to be near to above their optimum moisture content in the upper portion of the soil. Some moisture conditioning (drying) of those soils may be required to meet the project compaction and moisture specifications.

The pavement sections provided in this report are based on recompacting the native subgrade soils. The pavement section could be reduced by improving the existing subgrade. We have prepared a list of options that could be utilized at this site to reduce the amount of aggregate base required. We could assist in selecting design parameters that could be used in the evaluation of each option.

Remarks

Thank you for making Braun Intertec Corporation your geotechnical consultant for this project. If you have questions about this report, or if there are other services that we can provide in support of our work to date, please call Wes Dickhut at 701.355.5430.

Sincerely,

BRAUN INTERTEC CORPORATION

Eugene Belits, EI
Staff Engineer

Charles W. Dickhut, PE
Associate Principal - Senior Engineer

Table of Contents

Description **Page**

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A. Introduction

A.1. Project Description

This Geotechnical Evaluation Report addresses reconstruction of Museum Drive (also known as 12th Street West) between Highway 22 and Sims Street in Dickinson, North Dakota. The project is illustrated on the Boring Location Sketch in the Appendix. It is our understanding that reconstruction will be done by removal of the existing bituminous surfacing and aggregate base. The pavement subgrade will be reworked and new aggregate base and either concrete or bituminous surfacing will be placed.

A.2. Purpose

The purpose of our geotechnical evaluation will be to characterize subsurface geologic conditions at selected exploration locations and evaluate their impact on the design and reconstruction of Museum Drive.

A.3. Background Information and Reference Documents

To facilitate our evaluation, we were provided with or reviewed the following information or documents:

- Aerial photographs from Google Earth™ dated 6/15/94 to 9/25/2014
- Geology and Groundwater Resources of Hettinger and Stark Counties, US Geological Survey, 1975

A.4. Site Conditions

Based on our site visit during drilling, the area of the proposed road reconstruction slopes downward to the west about 5 feet. The roadway is about 1,200 feet long and consists of a two-lane road with wide shoulders.

Based on a cursory examination, the pavement condition was fair to poor. Visible deterioration in some areas includes longitudinal cracks with broken sections.

A.5. Scope of Services

Our scope of services for this project was originally submitted as a Proposal to Mr. Andrew Schrank of Highlands Engineering & Surveying. We received authorization to proceed from KC Homiston on August 24, 2015. Tasks performed in accordance with our authorized scope of services included:

- Performing a reconnaissance of the site to evaluate equipment access and traffic control requirements for the exploration locations.
- Staking and clearing exploration locations of underground utilities.
- Providing traffic control services during drilling.
- Performing two (2) standard penetration test borings to a depth of 5 feet.
- Obtaining two (2) bulk samples of the geologic materials encountered at the boring locations for classification and laboratory testing.
- Preparing boring logs, describing the materials encountered and presenting the results of our groundwater measurements and laboratory tests.
- Visual classification and logging soil samples by a geotechnical engineer in general accordance with ASTM D2487.
- Performing laboratory moisture content tests, Atterberg Limits, and sieve analysis on selected penetration test and bulk samples.
- Performing two (2) laboratory standard Proctor and two (2) California Bearing Ratio (CBR) tests on the bulk samples obtained from borings.
- Performed two (2) moisture density tests on selected thin-walled tube samples obtained from borings.
- Preparing this report containing a CAD sketch, exploration logs and a summary of the geologic materials encountered in results of laboratory tests, and recommendations for pavement subgrade preparation and recommendations for both bituminous and concrete pavement thicknesses.

B. Results

B.1. Exploration Logs

B.1.a. Log of Boring Sheets

Log of Boring sheets for our penetration test borings are included in the Appendix. The logs identify and describe the geologic materials that were penetrated, and present the results of penetration resistance and other in-situ tests performed within them, laboratory tests performed on penetration test samples retrieved from them, and groundwater measurements. A Fence Diagram summarizing the subsurface conditions encountered is located in the Appendix.

Strata boundaries were inferred from changes in the penetration test samples and the auger cuttings. Because sampling was not performed continuously, the strata boundary depths are only approximate. The boundary depths likely vary away from the boring locations, and the boundaries themselves may also occur as gradual rather than abrupt transitions.

B.1.b. Geologic Origins

Geologic origins assigned to the materials shown on the logs and referenced within this report were based on: (1) a review of the background information and reference documents cited above, (2) visual classification of the various geologic material samples retrieved during the course of our subsurface exploration, (3) penetration resistance and other in-situ testing performed for the project, (4) laboratory test results, and (5) available common knowledge of the geologic processes and environments that have impacted the site and surrounding area in the past.

B.2. Geologic Profile

B.2.a. Geologic Materials

Both of the borings initially encountered bituminous pavements to depths of 6 to 7 inches. Below the bituminous pavement in Boring ST-01, decomposed bedrock likely associated with the Sentinel Butte Formation was encountered. The decomposed bedrock consisted of sandstone (texturally classified as silty sand) to a depth of about 2 feet. Claystone (texturally classified as fat clay) was then encountered to the maximum explored depth of 6 feet. Penetration resistance values for boring ST-01 recorded in Sentinel Butte Formation deposits ranged from 11 to 16 blows per foot (BPF).

Below the bituminous pavement in Boring ST-2, fill was encountered that consisted of fat clay with sand that was brown and gray in color, and moist to wet. Penetration resistance values recorded in the fill ranged from 7 to 9 BPF.

B.2.b. Groundwater

Groundwater was not observed during or immediately after drilling. The borings were backfilled immediately after completion of the boring; thus, a long-term observation period for groundwater measurements was not performed. However, seasonal and annual fluctuations of groundwater should be anticipated.

B.3. Laboratory Test Results

B.3.a. Moisture Content Tests

Moisture content (MC) tests (ASTM D2216) were conducted on selected samples to assist in our classifications and estimations of the soils' engineering properties. The moisture content of the decomposed bedrock varied from approximately 21 percent to 26 percent. The moisture content of the existing fill ranged from 24 percent to 27 percent. The results of the moisture content tests are listed in the "MC" column of the Log of Boring sheets in the Appendix.

B.3.b. Unit Weight Tests

Unit weight tests were conducted on selected samples to assist in developing engineering parameters related to pavement subgrade preparation. The test indicated the decomposed bedrock had a dry density (DD) of 103 pounds per cubic foot (pcf) and a wet density (WD) of 125 pcf, and the existing fill had a DD of 100 pcf and a WD of 127 pcf. The results of the unit weight tests are listed in the "Tests or Notes" column on the attached Log of Boring sheets.

B.3.c. Atterberg Limits Tests

An Atterberg limits test (ASTM D4318) was performed on a selected sample of the existing fill for classification, evaluation of the range of soil plasticity, and an estimation of engineering parameters. The test indicated the clay sample had a liquid limit (LL) of 52, plastic limit (PL) of 18, and a plasticity index (PI) of 34. These results indicate that the existing fill is fat clay. The results of the Atterberg limits tests are listed in the "Tests or Notes" column on the attached Log of Boring sheets.

B.3.d. Percent Passing the #200 Sieve Tests

Percent passing the #200 sieve analysis tests (ASTM D1140) were performed to help classify and estimate the engineering properties of the granular materials. The results of the 200 washes indicated the soils encountered had silt- and clay-sized particles ranging from 44 percent to 65 percent.

B.3.e. Moisture-Density Relationship (Proctor Test)

Standard Proctor tests (per ASTM D698) were performed on bulk samples to aid in estimating the CBR value of the soils obtained from 1/2 to 6 feet. The results of the Proctor tests are provided in Table 1 below and in graphical representation attached in the Appendix.

B.3.f. California Bearing Ratio (CBR) Tests

California Bearing Ratio (CBR) tests (per ASTM D1883) were performed on remolded samples that were compacted to 92 percent to 95 percent of the material's standard Proctor maximum dry density, at a moisture content of 3 percent above optimum, to represent the existing subgrade conditions. The results of the CBR tests were used to establish pavement recommendations and are summarized in the following table and provided in the Appendix.

Table 1. Summary of Proctor and CBR Value Test Results

Boring/Depth	Soil Type	Maximum Dry Density (pcf)	Optimum Moisture (%)	CBR value
ST-01/0.6 to 6'	Fat Clay	108.3	17.4	1.8
ST-02/0.5 to 6'	Fat Clay	108.1	16.0	2.7

C. Basis for Recommendations

C.1. Design Details

C.1.a. Pavements and Traffic Loads

Highland Engineering estimated that this section of Museum Drive will experience less than 568,830 equivalent single axle loads (ESAL) for bituminous pavements and 1,404,649 ESALs for concrete pavements based on design lives of 20 and 30 years, respectively.

C.1.b. Anticipated Grade Changes

We were not provided with a grading plan of the reconstruction. We understand that the alignment will not be changed and that grade changes will be less than 1 foot.

C.1.c. Precautions Regarding Changed Information

We have attempted to describe our understanding of the proposed construction to the extent it was reported to us by others. Depending on the extent of available information, assumptions may have been made based on our experience with similar projects. If we have not correctly recorded or interpreted the project details, we should be notified. New or changed information could require additional evaluation, analyses and/or recommendations.

C.2. Design and Construction Considerations

Due to the frost-susceptible nature of the clay-rich soils present at pavement subgrade elevations, consideration should be given to incorporating an aggregate base course layer into the pavement section. This will enhance subgrade drainage efforts and reduce the potential for pavement subgrades to become saturated and heave upon freezing; strength loss upon thawing will also be reduced.

The onsite clay soils appear to be near to above their optimum moisture content in the upper portion of the soil. Some moisture conditioning (drying) of those soils may be required to meet the project compaction and moisture specifications.

The pavement sections provided in this report are based on recompacting the native subgrade soils. The pavement section could be reduced by improving the existing subgrade. We have prepared a list of options that could be utilized at this site to reduce the amount of aggregate base required. We could assist in selecting design parameters that could be used in the evaluation of each option.

- Providing subgrade stabilization using Portland cement (cement stabilization), for longer-term stabilization of the clayey subgrade soils.
- Overexcavating the subgrade soils and replacing with a subbase consisting of imported sand and gravel.
- Placing a reinforcing geogrid above the subgrade and below the aggregate base.

Based on discussions with Andrew Schrank regarding our findings, we were directed to develop the following recommendations for reconstruction of Museum Drive.

D. Recommendations

In accordance with our findings and discussions with Highlands Engineering & Surveying, below are our recommendations for the pavement design and reconstruction of the proposed road.

D.1. Pavement Subgrade Preparation

D.1.a. Excavations

We recommend the existing bituminous pavements be completely removed. We did not encounter any aggregate base materials below the bituminous surfacing; however, if aggregate base is encountered, we recommend it be removed as well.

After removal of existing pavements, we recommend the upper 1 foot of the resulting subgrade be scarified, moisture conditioned to 3 percent above its optimum moisture content, and compacted to a minimum of 95 percent of its standard Proctor maximum dry density. If there are areas that cannot be compacted, we recommend the unstable materials be subexcavated and replaced by onsite or imported materials that are able to be properly compacted and meet backfill requirements.

To provide lateral support to replacement backfill, additional required fill and the structural loads they will support, we recommend oversizing (widening) the excavations 1 foot horizontally beyond the outer edges of the pavement limits, for each foot the excavations extend below pavement subgrade elevations.

D.1.b. Excavation Dewatering

We believe that sumps and pumps will be effective for removing any water that accumulated in the excavations.

D.1.c. Selecting Excavation Backfill and Additional Required Fill

Based on the samples recovered from the borings, the subgrade soils will consist of fat clay fill or decomposed sandstone and claystone.

Onsite soils free of organic soil and debris can be considered for reuse as backfill and fill. The clay, however, being fine-grained and high plasticity, will be more difficult to compact if wet or allowed to become wet, or if spread and compacted over wet surfaces.

We recommend that aggregate base be compacted to 100 percent of its maximum standard Proctor dry density. We suggest specifying aggregate base meet the requirements of the North Dakota Department of Transportation (NDDOT) Specifications 816.02 for Class 5 Aggregate Base. Geotextile separation fabric should meet the NDDOT Specification 858 for Type S1 or S2 Separation fabrics (nonwoven). Providing drainage for the pavements will aid in maximizing the life of the pavements by improving subgrade conditions and reducing the potential for development of potholes.

D.1.d. Placement and Compaction of Backfill and Fill

Prior to placing fill or aggregate base, we recommend thoroughly scarifying, blending, moisture conditioning, and recompacting the soil in the upper foot of the excavations.

We recommend spreading backfill and fill in loose lifts of approximately 6 to 12 inches. We recommend compacting backfill and fill in accordance with the criteria presented below in Table 2.

Table 2. Compaction Recommendations Summary

Reference	Relative Compaction, percent (ASTM D 698 – standard Proctor)	Moisture Content Variance from Optimum, percentage points
Below pavements, within 3 feet of subgrade elevations	≥95	0 to +3 for Clay Soils, -3 to +3 for Granular Soils

D.1.e. Subgrade Proofroll

Prior to placing aggregate base material, we recommend proofrolling pavement subgrades to determine if the subgrade materials are loose, soft or weak, and in need of further stabilization, compaction or subexcavation and recompaction or replacement. A second proofroll should be performed after the aggregate base material is in place and prior to placing bituminous or concrete pavement.

We recommend that proofrolling of the pavement subgrades be observed by a geotechnical engineer to determine if the results of the procedure meet project specifications or delineate the extent of additional pavement subgrade preparation work.

D.2. Pavements

D.2.a. Design Sections

Laboratory tests to determine a CBR value for pavement design ranged from about 1.8 to 2.7. We recommend the pavements be designed for CBR values of 2. This value assumes that the existing soils will be recompacted in accordance with the recommendations in Section D.1.

D.2.b. Bituminous Pavement Design Section

For the bituminous-surfaced portions of the pavements, we utilized the simplified design chart for calculating pavement thicknesses presented in "Figure 3.1. - Design Chart for Flexible Pavements Based on Using Mean Values for Input", of the AASHTO Guide for Design of Pavement Structures (1993). The parameters used to perform the calculations were assumed/calculated as follows:

- Reliability = 90%
- Standard Deviation = 0.45
- ESALs = 570,000
- Effective Roadbed Soil Resilient Modulus (M_R) = 3,120 psi
- Design Serviceability Loss = 2.2 (Initial Serviceability = 4.2, Terminal Serviceability = 2.0)

The above design method provides an end result of a Design Structural Number (SN), which is then used to iteratively calculate the required pavement thickness. The Design Structural Number we calculated for these bituminous surfaced pavements is 4.2. The pavement thicknesses are calculated from the equation:

- $SN = (D_1 \times a_1) + (D_2 \times a_2 \times m_2)$
- D_1 = Bituminous Thickness (inches)
- a_1 = Structural Layer Coefficient for Bituminous = 0.40
- D_2 = Aggregate Base Thickness (inches)
- a_2 = Structural Layer Coefficient for Aggregate Base = 0.10
- m_2 = Drainage Modifier = 0.9 (assuming aggregate base and edge drains will be provided for the pavements)

Solving the above equation for a Structural Number of at least 4.2, we recommend the bituminous-surfaced pavement sections consist of three layers as shown below. Please note that at the City's preference, the thicknesses of the bituminous and aggregate base may be adjusted provided they attain a Structural Number of at least 4.3:

- 6" of Bituminous Surfacing over
- 20" of aggregate base over
- Geotextile separation fabric

This pavement design is based upon a 20-year performance life. This is the amount of time before major reconstruction is anticipated. This performance life assumes maintenance, such as seal coating and crack sealing, is routinely performed. The actual pavement life will vary depending on variations in weather, traffic conditions and maintenance.

D.2.c. Concrete Pavement Design Sections

For the concrete-surfaced portions of the pavements, we utilized the simplified design chart for calculating pavement thicknesses presented in "Figure 3.7. - Design Chart for Rigid Pavement Based on Using Mean Values for Each Input Variable", of the AASHTO Guide for Design of Pavement Structures (1993). The parameters used to perform the calculations were assumed/calculated as follows:

- Reliability = 90%
- Standard Deviation = 0.35
- ESALs = 1,400,000
- Effective Modulus of Subgrade Reaction = 150 psi
- Design Serviceability Loss = 2.2 (Initial Serviceability = 4.7, Terminal Serviceability = 2.5)
- Concrete elastic modulus (E_c) = 3.6×10^6 psi
- Mean concrete modulus of rupture = 600 psi
- Load transfer coefficient = 3.6 (assuming the pavements would be joint-reinforced)
- Drainage coefficient = 0.9

The above design method provides the following concrete thickness:

- 8" of joint reinforced concrete over
- 12" of aggregate base

This pavement design is based upon a 30-year performance life. This is the amount of time before major reconstruction is anticipated. This performance life assumes maintenance, such as seal coating and crack sealing, is routinely performed. The actual pavement life will vary depending on variations in weather, traffic conditions and maintenance.

D.2.d. Subgrade Drainage

Drainage will be necessary along the entire proposed pavement area. We recommend installing perforated drainpipes throughout pavement areas at low points and around catch basins. The drainpipes should be placed in small trenches extended at least 8 inches below aggregate base material.

D.3. Construction Quality Control

D.3.a. Excavation Observations

We recommend having a geotechnical engineer observe all excavations related to subgrade preparation and pavement construction. The purpose of the observations is to evaluate the competence of the geologic materials exposed in the excavations and the adequacy of required excavation oversizing.

D.3.b. Materials Testing

We recommend density tests be taken in excavation backfill and additional required fill placed below pavements with a frequency of 5,000 square feet each 1-foot lift.

D.3.c. Pavement Subgrade Proofroll

We recommend that proofrolling of the pavement subgrades be observed by a geotechnical engineer to determine if the results of the procedure meet project specifications, or delineate the extent of additional pavement subgrade preparation work.

D.3.d. Cold Weather Precautions

If site grading and construction is anticipated during cold weather, all snow and ice should be removed from cut and fill areas prior to additional grading. No fill should be placed on frozen subgrades. No frozen soils should be used as fill. Concrete should not be placed on frozen subgrades.

E. Procedures

E.1. Penetration Test Borings

The penetration test borings were drilled with a truck-mounted core and auger drill equipped with a hollow-stem auger. The borings were performed in accordance with ASTM D 1586. Penetration test samples were taken at 2 1/2- or 5-foot intervals. Actual sample intervals and corresponding depths are shown on the boring logs.

Penetration test boreholes were backfilled with auger cuttings, and bituminous patch was placed in the upper few inches of the boreholes.

E.2. Material Classification and Testing

E.2.a. Visual and Manual Classification

The geologic materials encountered were visually and manually classified in accordance with ASTM Standard Practice D 2488. A chart explaining the classification system is attached. Samples were placed in jars and returned to our facility for review and storage.

E.2.b. Laboratory Testing

The results of the laboratory tests performed on geologic material samples are noted on or follow the appropriate attached exploration logs. The tests were performed in accordance with ASTM procedures.

E.3. Groundwater Measurements

The drillers checked for groundwater as the penetration test borings were advanced and again after auger withdrawal. The boreholes were then backfilled and patched as noted on the boring logs.

F. Qualifications

F.1. Variations in Subsurface Conditions

F.1.a. Material Strata

Our evaluation, analyses and recommendations were developed from a limited amount of site and subsurface information. It is not standard engineering practice to retrieve material samples from exploration locations continuously with depth; therefore, strata boundaries and thicknesses must be inferred to some extent. Strata boundaries may also be gradual transitions and can be expected to vary in depth, elevation and thickness away from the exploration locations.

Variations in subsurface conditions present between exploration locations may not be revealed until additional exploration work is completed or construction commences. If any such variations are revealed, our recommendations should be reevaluated. Such variations could increase construction costs, and a contingency should be provided to accommodate them.

F.1.b. Groundwater Levels

Groundwater measurements were made under the conditions reported herein and shown on the exploration logs, and interpreted in the text of this report. It should be noted that the observation periods were relatively short, and groundwater can be expected to fluctuate in response to rainfall, flooding, irrigation, seasonal freezing and thawing, surface drainage modifications and other seasonal and annual factors.

F.2. Continuity of Professional Responsibility

F.2.a. Plan Review

This report is based on a limited amount of information, and a number of assumptions were necessary to help us develop our recommendations. It is recommended that our firm review the geotechnical aspects of the designs and specifications, and evaluate whether the design is as expected, if any design changes have affected the validity of our recommendations, and if our recommendations have been correctly interpreted and implemented in the designs and specifications.

F.2.b. Construction Observations and Testing

It is recommended that we be retained to perform observations and tests during construction. This will allow correlation of the subsurface conditions encountered during construction with those encountered by the borings, and provide continuity of professional responsibility.

F.3. Use of Report

This report is for the exclusive use of the parties to which it has been addressed. Without written approval, we assume no responsibility to other parties regarding this report. Our evaluation, analyses and recommendations may not be appropriate for other parties or projects.

F.4. Standard of Care

In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

Appendix

BRAUN INTERTEC

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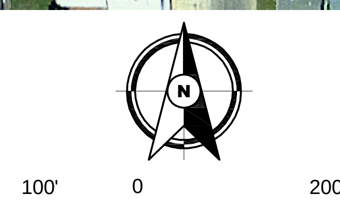
DENOTES APPROXIMATE LOCATION OF STANDARD PENETRATION TEST BORING



SCALE: 1" = 200'

Sheet: of	Project No:	B1508345
	Drawing No:	B1508345
Fig:	Scale:	1" = 200'
	Drawn By:	REJ
	Date Drawn:	10/23/15
	Checked By:	EB
	Last Modified:	10/26/15

SOIL BORING LOCATION SKETCH
GEOTECHNICAL EVALUATION
MUSEUM DRIVE RECONSTRUCTION
MUSEUM DRIVE BETWEEN HIGHWAY 22 AND SIMS STREET
DICKINSON, NORTH DAKOTA

BRAUN INTERTEC
The Science You Build On.

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PH. (701) 225-7090
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LOG OF BORING

Braun Project B1508345
Geotechnical Evaluation
Museum Drive Reconstruction
Highway 22 and Sims Street
Dickinson, North Dakota

BORING: **ST-01**

LOCATION: See sketch

DRILLER: M. Barrett | METHOD: 3 1/4" HSA, Autohammer | DATE: **10/7/15** | SCALE: **1" = 4'**

Elev. feet 152.7	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
152.1	0.6	BIT	7 inches of bituminous surfacing.				
150.7	2.0	SS	SENTINEL BUTTE FORMATION, SANDSTONE, brown, wet to moist, decomposed, very soft, sample retrieved as non-cemented "Silty Sand (SM)".	11		23	P200=44%
146.7	6.0	CLST	SENTNEL BUTTE FORMATION, CLAYSTONE, with Silt lenses, brown and gray, moist to wet, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)".	TW		21	WD=125 pcf, DD=103 pcf
				16		26	
			END OF BORING. Water not observed to cave-in depth of 4 feet immediately after withdrawal of auger. Boring then backfilled with auger cuttings. Surface repaired with bituminous patch.				Bag sample collected from 0.6 to 6 feet. Proctor Test CBR Test Benchmark: Surface elevations at the boring locations were referenced to the floor level of the McDonald's restaurant, with assumed elevation of 150 feet.

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\AX PROJECTS\2015\08345.GPJ BRAUN_V8_CURRENT.GDT 10/27/15 07:40

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LOG OF BORING

Braun Project B1508345
Geotechnical Evaluation
Museum Drive Reconstruction
Highway 22 and Sims Street
Dickinson, North Dakota

BORING: **ST-02**

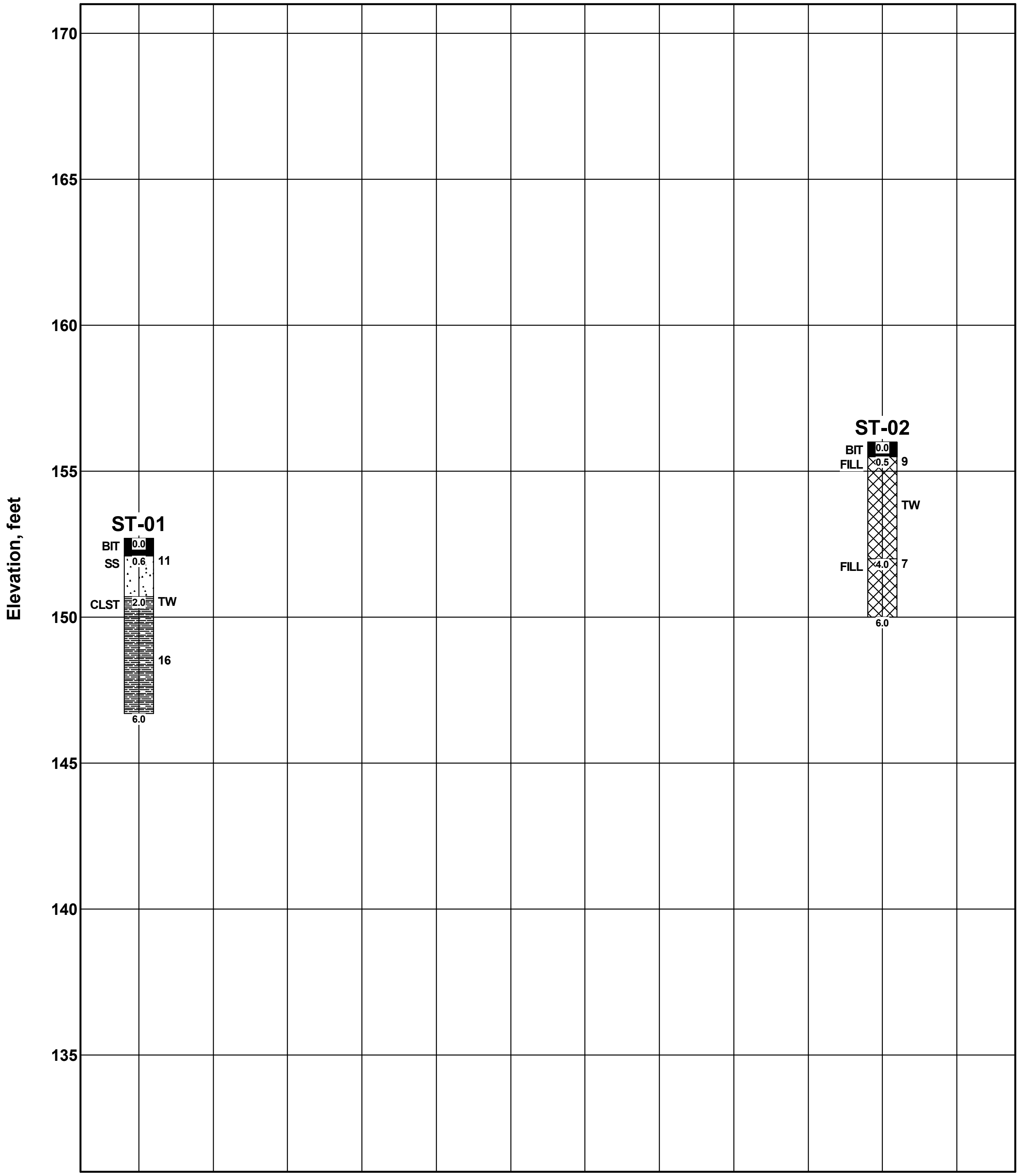
LOCATION: See sketch

DRILLER: M. Barrett | METHOD: 3 1/4" HSA, Autohammer | DATE: **10/7/15** | SCALE: **1" = 4'**

Elev. feet 156.0	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
155.5	0.5	BIT	6 inches bituminous surfacing.				
152.0	4.0	FILL	FILL: Fat Clay with Sand, brown and gray, moist to wet.	9		24	LL=52, PL=18, PI=34
				TW		27	WD=127 pcf, DD=100 pcf
150.0	6.0	FILL	FILL: Fat Clay with Sand, brown and gray, wet.	7		25	
			END OF BORING. Water not observed to cave-in depth of 4 feet immediately after withdrawal of auger. Boring then backfilled with auger cuttings. Surface repaired bituminous patch.				Bag Sample collected from 0.5 to 6 feet. Proctor Test CBR Test

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\AX PROJECTS\2015\08345.GPJ BRAUN_V8_CURRENT.GDT 10/27/15 07:40



Fence Diagram
(Horizontal distance not to scale)

Braun Project B1508345
Geotechnical Evaluation
Museum Drive Reconstruction
Highway 22 and Sims Street
Dickinson, North Dakota

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BRAUN INTERTEC

Braun Intertec Corporation
131 23rd Avenue East Unit #3
Dickinson, ND 58601
Phone: 701.225.7090

Proctor Report

Report No: PTR:W15-009126-S1
Issue No: 1

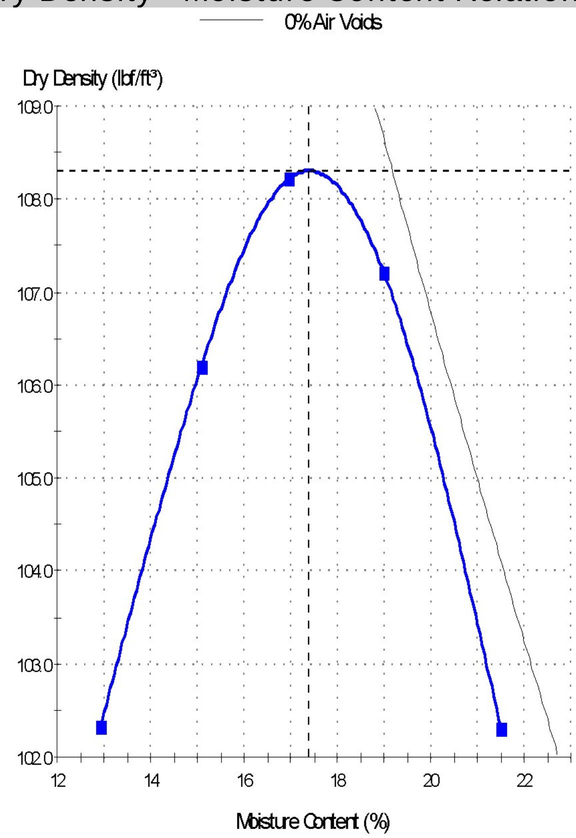
Client:	Andrew Schrank Highlands Engineering & Surveying, 319 24th St E Dickinson, ND, 58601
Project:	B1508345 Museum Drive Reconstruction Museum Drive between Highway 22 and Sims Street Dickinson, ND, 58601
TR:	Cody Wardien, cwardien@braunintertec.com

Kevin Krohn
Field Project Manager
Date of Issue: 10/8/2015

Sample Details

Sample ID:	W15-009126-S1	Alternate Sample ID:	P-01
Date Sampled:	10/7/2015	Date Submitted:	10/7/2015
Sampled By:		Sampling Method:	Auger Cuttings
Source:	On Site		
Material:			
Specification:	General Soil		
Location:	Boring #1 0-6'		
Date Tested:	10/8/2015		

Dry Density - Moisture Content Relationship



Test Results

ASTM D 698 - 07

Maximum Dry Density (lbf/ft³):	108.3
Corrected Maximum Dry Density (lbf/ft³):	108.3
Optimum Moisture Content (%):	17.4
Corrected Optimum Moisture Content (%):	17.4
Method:	A
Preparation Method:	Moist
Specific Gravity (Fines):	2.60
Specific Gravity Method:	Assumed
Retained Sieve No 4 (4.75mm) (%):	2
Passing Sieve No 4 (4.75mm) (%):	98
Visual Description:	Lean Clay (CL)

Comments

P200 = 58.2%

Braun Intertec Corporation
131 23rd Avenue East Unit #3
Dickinson, ND 58601
Phone: 701.225.7090

Proctor Report

Report No: PTR:W15-009126-S2
Issue No: 1

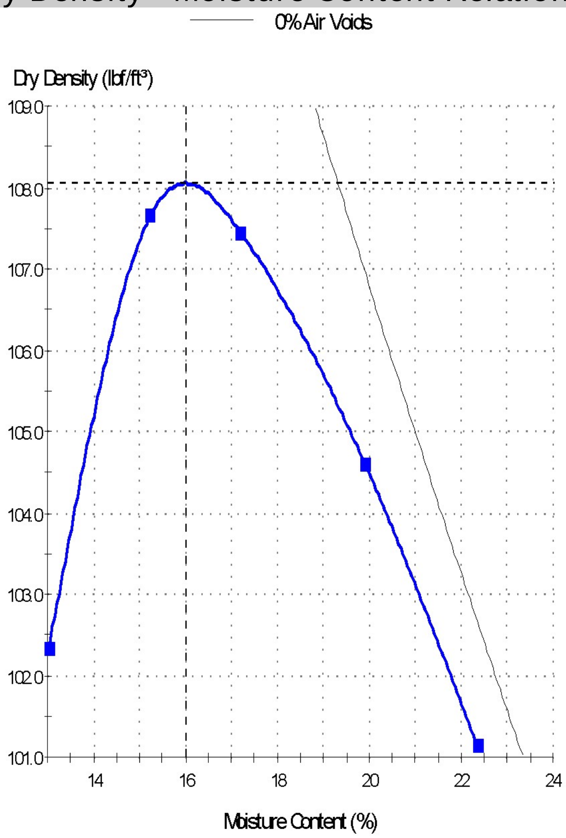
Client:	Andrew Schrank Highlands Engineering & Surveying, 319 24th St E Dickinson, ND, 58601
Project:	B1508345 Museum Drive Reconstruction Museum Drive between Highway 22 and Sims Street Dickinson, ND, 58601
TR:	Cody Wardien, cwardien@braunintertec.com

Kevin Krohn
Field Project Manager
Date of Issue: 10/8/2015

Sample Details

Sample ID:	W15-009126-S2	Alternate Sample ID:	P-02
Date Sampled:	10/7/2015	Date Submitted:	10/7/2015
Sampled By:		Sampling Method:	Auger Cuttings
Source:	On Site		
Material:			
Specification:	General Soil		
Location:	Boring #2 0-6'		
Date Tested:	10/8/2015		

Dry Density - Moisture Content Relationship



Test Results

ASTM D 698 - 07

Maximum Dry Density (lbf/ft³):	108.1
Corrected Maximum Dry Density (lbf/ft³):	108.1
Optimum Moisture Content (%):	16.0
Corrected Optimum Moisture Content (%):	16.0
Method:	A
Preparation Method:	Moist
Specific Gravity (Fines):	2.60
Specific Gravity Method:	Assumed
Retained Sieve No 4 (4.75mm) (%):	1
Passing Sieve No 4 (4.75mm) (%):	99
Visual Description:	Lean Clay (CL)

Comments

P200 = 65.3%

Braun Intertec Corporation
11001 Hampshire Avenue South
Minneapolis, MN 55438
Phone: 952.995.2000

California Bearing Ratio Test Report

Report No: CBR:W15-009187-S1
Issue No: 1

Client: Andrew Schrank
Highlands Engineering & Surveying,
319 24th St E
Dickinson, ND, 58601
Project: B1508345
Museum Drive Reconstruction
Museum Drive between Highway 22 and Sims Street
Dickinson, ND, 58601
TR: Cody Wardien, cwardien@braunintertec.com

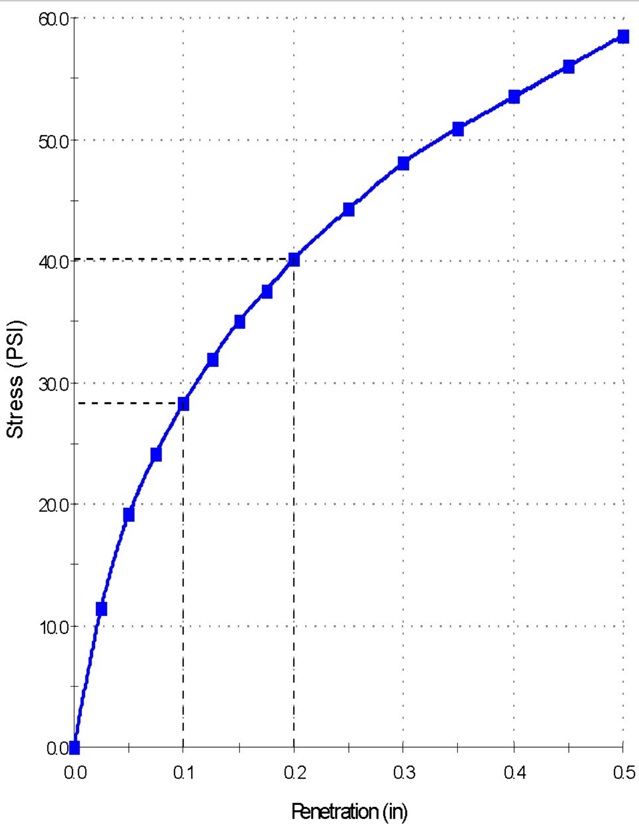
Laboratory Results Reviewed by:

Jason Limley
Engineering Technician III
Date of Issue: 10/16/2015

Sample Details

Sample ID:	W15-009187-S1	Alternate Sample ID:	P-01
Sampled By:		Date Sampled:	
Sampling Method:	Auger Cuttings	Source:	Onsite material
Material:		Specification:	General Soil
Sample Location:	Boring #1 0-6'		

Stress vs Penetration



Test Results

ASTM D 1883 - 07

CBR At 0.1in (%):	2.8
CBR At 0.2in (%):	2.7
Compactive Effort:	ASTM D 698
Number of Blows:	15
% of Maximum Dry Density:	92.6
Dry Density Before Soaking (lb/ft³):	100.3
MC Before Compaction (%):	20.2
MC After Compaction (%):	19.7
Moisture Content of Top 1in (%):	
Average Moisture Content (%):	
Maximum Dry Density (lb/ft³):	108.3
Optimum Moisture Content (%):	17.4
Sample Condition:	soaked
Swell (%):	0.6
Surcharge Mass (lb):	10.00
Oversize Material (%):	0.0
Date Tested:	10/16/2015

Comments

Braun Intertec Corporation
11001 Hampshire Avenue South
Minneapolis, MN 55438
Phone: 952.995.2000

California Bearing Ratio Test Report

Report No: CBR:W15-009187-S2
Issue No: 1

Client: Andrew Schrank
Highlands Engineering & Surveying,
319 24th St E
Dickinson, ND, 58601
Project: B1508345
Museum Drive Reconstruction
Museum Drive between Highway 22 and Sims Street
Dickinson, ND, 58601
TR: Cody Wardien, cwardien@braunintertec.com

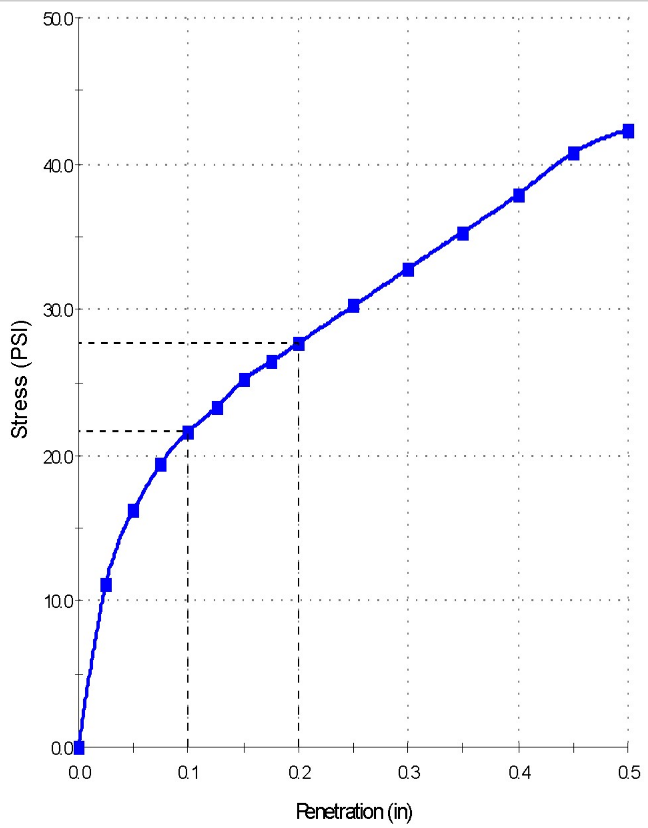
Laboratory Results Reviewed by:

Jason Limley
Engineering Technician III
Date of Issue: 10/16/2015

Sample Details

Sample ID:	W15-009187-S2	Alternate Sample ID:	P-02
Sampled By:		Date Sampled:	
Sampling Method:	Auger Cuttings	Source:	Onsite material
Material:		Specification:	General Soil
Sample Location:	Boring #2 0-6'		

Stress vs Penetration



Test Results

ASTM D 1883 - 07

CBR At 0.1in (%):	2.2
CBR At 0.2in (%):	1.8
Compactive Effort:	ASTM D 698
Number of Blows:	20
% of Maximum Dry Density:	95.6
Dry Density Before Soaking (lb/ft³):	103.3
MC Before Compaction (%):	18.8
MC After Compaction (%):	18.7
Moisture Content of Top 1in (%):	
Average Moisture Content (%):	
Maximum Dry Density (lb/ft³):	108.1
Optimum Moisture Content (%):	16.0
Sample Condition:	soaked
Swell (%):	1.7
Surcharge Mass (lb):	10.00
Oversize Material (%):	0.0
Date Tested:	10/16/2015

Comments

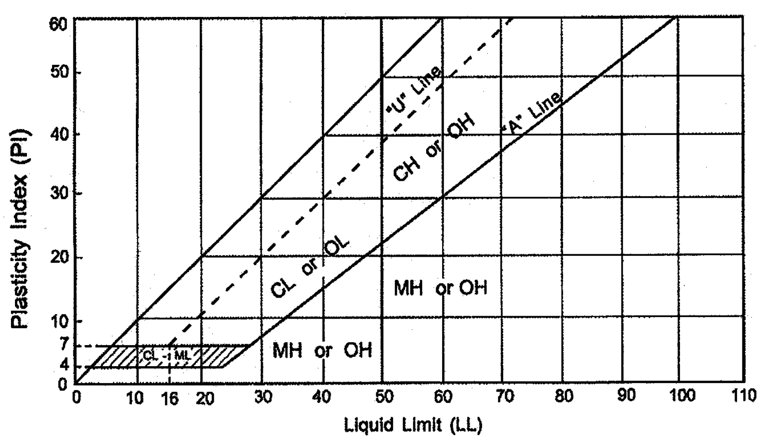
Descriptive Terminology of Soil

BRAUN INTERTEC

Standard D 2487 – 11
Classification of Soils for Engineering Purposes
(Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [a]				Soils Classification	
				Group Symbol	Group Name [b]
Coarse-grained Soils more than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines [e]	$C_u \geq 4$ and $1 \leq C_c \leq 3$ [c]	GW	Well-graded gravel [d]
			$C_u < 4$ and/or $1 > C_c > 3$ [c]	GP	Poorly graded gravel [d]
		Gravels with Fines More than 12% fines [e]	Fines classify as ML or MH	GM	Silty gravel [d f g]
			Fines classify as CL or CH	GC	Clayey gravel [d f g]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines [i]	$C_u \geq 6$ and $1 \leq C_c \leq 3$ [c]	SW	Well-graded sand [h]
			$C_u < 6$ and/or $1 > C_c > 3$ [c]	SP	Poorly graded sand [h]
		Sands with Fines More than 12% [i]	Fines classify as ML or MH	SM	Silty sand [f g h]
			Fines classify as CL or CH	SC	Clayey sand [f g h]
Fine-grained Soils 50% or more passed the No. 200 sieve	Silts and Clays Liquid limit less than 50	Inorganic	PI > 7 and plots on or above "A" line [j]	CL	Lean clay [k l m]
			PI < 4 or plots below "A" line [j]	ML	Silt [k l m]
		Organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay [k l m n]
				OL	Organic silt [k l m o]
	Silts and clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay [k l m]
			PI plots below "A" line	MH	Elastic silt [k l m]
		Organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay [k l m p]
				OH	Organic silt [k l m q]
Highly Organic Soils	Primarily organic matter, dark in color and organic odor			PT	Peat

a. Based on the material passing the 3-inch (75mm) sieve.
b. If field sample contained cobbles or boulders, or both, add "with cobbles or boulders or both" to group name.
c. $C_u = D_{60}/D_{10}$ $C_c = \frac{(D30)^2}{D_{10} \times D_{60}}$
d. If soil contains ≥15% sand, add "with sand" to group name.
e. Gravels with 5 to 12% fines require dual symbols:
   GW-GM well-graded gravel with silt
   GW-GC well-graded gravel with clay
   GP-GM poorly graded gravel with silt
   GP-GC poorly graded gravel with clay
f. If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
g. If fines are organic, add "with organic fines: to group name.
h. If soil contains ≥15% gravel, add "with gravel" to group name.
i. Sand with 5 to 12% fines require dual symbols:
   SW-SM well-graded sand with silt
   SW-SC well-graded sand with clay
   SP-SM poorly graded sand with silt
   SP-SC poorly graded sand with clay
j. If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
k. If soil contains 10 to 29% plus No. 200, add "with sand" or "with gravel" whichever is predominant.
l. If soil contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.
m. If soil contains ≥ 30% plus No. 200 predominantly grave, add "gravelly" to group name.
n. PI ≥ 4 and plots on or above "A" line.
o. PI < 4 or plots below "A" line.
p. PI plots on or above "A" lines.
q. PI plots below "A" line.



Laboratory Tests

DD	Dry density, pcf	**OC**	Organic content, %
WD	Wet density, pcg	**S**	Percent of saturation, %
MC	Natural moisture content, %	**SG**	Specific gravity
LL	Liquid limit, %	**C**	Cohesion, psf
PL	Plastic limits, %	**Ø**	Angle of internal friction
PI	Plasticity index, %	**qu**	Unconfined compressive strength, psf
P200	% passing 200 sieve	**qp**	Pocket penetrometer strength, tsf

Particle Size Identification

Boulders................. over 12"
Cobbles .... 3" to 12"
Gravel
  Coarse .... 3/4" to 3"
  Fine................ No. 4 to 3/4"
Sand
  Coarse .... No. 4 to No. 10
  Medium .... No. 10 to No. 40
  Fine................ No. 40 to No. 200
Silt .... <No. 200, PI< 4 or below "A" line
Clay .... <No. 200, PI ≥ 4 and on or about "A" line

Relative Density of Cohesionless Soils

Very Loose............ 0 to 4 BPF
Loose..................... 5 to 10 BPF
Medium dense .... 11 to 30 PPF
Dense .... 31 to 50 BPF
Very dense............ over 50 BPF

Consistency of Cohesive Soils

Very soft................ 0 to 1 BPF
Soft .... 2 to 3 BPF
Rather soft .... 4 to 5 BPF
Medium .... 6 to 8 BPF
Rather stiff .... 9 to 12 BPF
Stiff .... 13 to 16 BPF
Very stiff................. 17 to 30 BPF
Hard....................... over 30 BPF

Drilling Notes

Standard penetration test borings were advanced by 3 1/4" or 6 1/4" ID hollow-stem augers, unless noted otherwise. Jetting water was used to clean out auger prior to sampling only where indicated on logs. All samples were taken with the standard 2" OD split-tube samples, except where noted.

Power auger borings were advanced by 4" or 6" diameter continuous flight, solid-stern augers. Soil classifications and strata depths were inferred from disturbed samples augered to the surface, and are therefore, somewhat approximate.

Hand auger borings were advanced manually with a 1 1/2" or 3 1/4" diameter auger and were limited to the depth from which the auger could be manually withdrawn.

BPF: Numbers indicate blows per foot recorded in standard penetration test, also known as "N" value. The sampler was set 6" into undisturbed soil below the hollow-stem auger. Driving resistances were then counted for second and third 6" increments, and added to get BPF. Where they differed significantly, they are reported in the following form: 2/12 for the second and third 6" increments, respectively.

WH: WH indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

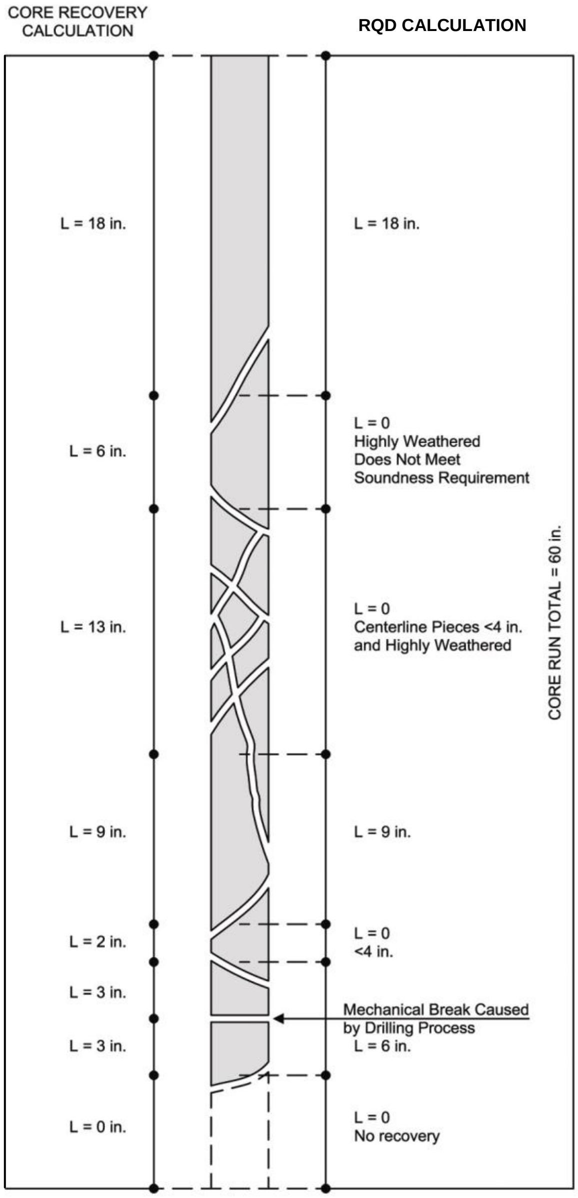
WR: WR indicates the sampler penetrated soil under weight of rods alone; hammer weight, and driving not required.

TW: TW indicates thin-walled (undisturbed) tube sample.

Note: All tests were run in general accordance with applicable ASTM standards.

Descriptive Terminology of Rock

Based on U.S. Army Corps of Engineers EM 1110-1-2908



Example Calculations

Core Recovery, CR = Total length of rock recovered / Total core run length

Example: $CR = \frac{(18 + 6 + 13 + 9 + 2 + 3 + 3)}{(60)}$

CR = 90%

RQD = Sum of sound pieces 4 inches or larger / Total core run length

RQD Percent	Rock Quality
< 25	very poor
25 < 50	poor
50 < 75	fair
75 < 90	good
90 < 100	excellent

Example: $RQD = \frac{(18 + 9 + 6)}{(60)}$

RQD = 55%

Weathering

Unweathered: No evidence of chemical or mechanical alteration.

Slightly weathered: Slight discoloration on surface, slight alteration along discontinuities, less than 10% of rock volume altered.

Moderately Weathered: Discoloration evident, surface pitted and altered with alteration penetrating well below rock surfaces, weathering halos evident, 10% to 50% of the rock altered.

Highly Weathered: Entire mass discolored, alteration pervading nearly all of the rock, with some pockets of slightly weathered rock noticeable, some mineral leached away.

Decomposed: Rock reduced to a soil consistency with relict rock texture, generally molded and crumbled by hand.

Hardness

Very soft:	Can be deformed by hand
Soft:	Can be scratched with a fingernail
Moderately hard:	Can be scratched easily with a knife
Hard:	Can be scratched with difficulty with a knife
Very hard:	Cannot be scratched with a knife

Texture

Sedimentary Rocks:	*Grain Size*
Coarse grained	2 – 5 mm
Medium grained	0.4 – 2 mm
Fine grained	0.1 – 0.4 mm
Very fine grained	< 0.1 mm

Igneous and Metamorphic Rocks:	
Coarse grained	5 mm
Medium grained	1 – 5 mm
Fine grained	0.1 – 1 mm
Aphanitic	< 0.1 mm

Thickness of Bedding

Massive:	3 ft. thick or greater
Thick bedded:	1 to 3 ft. thick
Medium bedded:	4 in. to 1 ft. thick
Thin bedded:	4 in. thick or less

Degree of Fracturing (Jointing)

Unfractured:	Fracture spacing 6 ft. of more
Slightly fractured:	Fracture spacing 2 to 6 ft.
Moderately fractured:	Fracture spacing 8 in. to 2 ft.
Highly fractured:	Fracture spacing 2 in. to 8 in.
Intensely fractured:	Fracture spacing 2 in. or less