

Geotechnical Evaluation Report

Proposed Halliburton Wash and Shop Buildings
34th Street West and ND Highway 22
Dickinson, North Dakota

Prepared for

FCI Constructors, Inc.

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.

Mark E. Kvas, P.E.
Project Engineer
Registration Number: PE-6392
June 6, 2011



Project BM-11-01121

Braun Intertec Corporation

June 6, 2011

Project BM-11-01121

Matt Lierz
FCI Constructors, Inc.
P.O. Box 1767
Grand Junction, CO 81502

Re: Geotechnical Evaluation
Halliburton Wash and Shop Buildings
34th Street West and ND Hwy 22
Dickinson, North Dakota

Dear Mr. Lierz:

We are pleased to present this Geotechnical Evaluation Report for the proposed wash and shop buildings at the above referenced site. A summary of our results and a summary of our recommendations in light of the geotechnical issues influencing design and construction are presented below. More detailed information and recommendations follow.

Summary of Results

A total of 11 penetration test borings were completed at the proposed site. Borings ST-01 through ST-06 were completed for the proposed shop building, and Borings ST-07 through ST-11 were completed for the proposed wash building.

At the surface the borings encountered topsoils to depths ranging from about ½- to 1 ½ feet. Below the topsoil in the shop building area, the borings encountered lean clay, silty sand and clayey sand glacial deposits to approximate depths of 4 to 6 ½ feet. The borings in the wash building also encountered similar glacial deposits to approximate depths of 6 ½ to 14 feet. Under the glacial deposits the borings encountered claystone, sandstone, and shale associated with the Sentinel Butte Formation to the borings' termination depths.

Groundwater was observed in all but one of the borings during drilling at depths ranging from 5 to 25 feet corresponding to elevations ranging from 2497 to 2486 feet. All of the borings were allowed to remain open for a period of time ranging from 1 to 25 hours. After the wait period groundwater was observed at depths ranging from 3 to 16 feet, corresponding to elevations ranging from 2503 ½ to 2495 feet. Seasonal and annual fluctuations of groundwater levels should be anticipated. In particular, elevated levels should be anticipated following flooding events, spring thaw and wet weather.

Summary of Recommendations

The main concern for the design and construction of the proposed buildings is potential settlement. At both the shop building and wash building locations, the borings encountered relatively soft and compressible materials to depths ranging from about 4 to 10 below existing grades. These soft and

compressible materials extend below the anticipated foundation depths at both building locations. If left in place below the structures' foundations, we have calculated that the soft and compressible materials would experience post-construction settlements on the order of about 2 to 3 inches. These settlements would cause unacceptable distress to the structures. To limit settlements to an acceptable tolerance (<1 ¼ inch), portions of the soft and compressible soils will need to be removed from below the floors and foundations and be replaced by imported granular backfills. After the specified removals and replacements are performed, the structures may be supported over typical frost-depth spread footing foundations designed for a net allowable bearing pressure up to 2000 psf.

An additional challenge for the project will be the presence of groundwater. At one of the borings in the shop building, and at all of the borings within the wash building, groundwater was observed above or within 1 vertical foot below the recommended foundation overexcavation depths. Dewatering of the foundation trench excavations will likely be necessary. We wish to note, however, that the borings were performed during an exceptionally wet spring; thus, the groundwater levels observed in the borings may be higher than observed during the summer construction months.

The foundation excavation bottoms will be wet and will be easily disturbed by equipment and worker traffic. All foundation excavations should be performed with a backhoe fitted with a smooth-ended bucket (toothed buckets typically leave a disturbed layer at the bottom of the excavation) working from outside of the excavations. If the materials excavated from the foundation excavations are planned to be reused as backfill across the site, they will likely need to be dried by farming/discing to lower their moisture contents to a range that will allow for adequate compaction.

Remarks

Thank you for making Braun Intertec 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 Mark at 701.255.7180 or by email at mkvas@braunintertec.com.

Sincerely,

BRAUN INTERTEC CORPORATION



Mark E. Kvas, PE
Project Engineer



Sean S. Swartz, PE
Principal/Senior Engineer

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Boring Location Sketch

Fence Diagram

Log of Boring Sheets

Descriptive Terminology (2)

A. Introduction

A.1. Project Description

This Geotechnical Evaluation Report addresses the design and construction of the proposed Halliburton Wash and Shop Buildings located on the east side of North Dakota Highway 22 and south of 34th Street West, approximately 1 mile north of Dickinson, North Dakota.

It is our understanding that the wash building will have overall dimensions of 90 feet by 180 feet and will be a slab-on-grade, single-story, steel framed structure. The shop building will have overall dimensions of 100 feet by 250 feet and will be a slab-on-grade, single-story, steel-framed structure. The shop building will have over head cranes located within the proposed structure. The proposed structures are planned to bear on typical frost depth spread footings. The general layout of the project is shown on the attached Boring Location Sketch.

A.2. Purpose

The purpose of this geotechnical evaluation was to assist FIC Constructors, Inc., in designing foundations and slabs, and in preparing plans and specifications for construction of the proposed Halliburton Wash and Shop Buildings.

A.3. Background Information and Reference Documents

To facilitate our evaluation, we were provided us with a site sketch which indicated the proposed building locations and ground surface contour elevations. The site sketch was titled "Halliburton Dickinson Field Camp", was prepared by FCI constructors, and was not dated. We also reviewed a geologic map of North Dakota prepared by the North Dakota Geological Survey, dated 1980.

A.4. Site Conditions

The proposed project area is an agricultural field. Based on the site sketch provided, the ground surface elevation appears to slope down from the west towards the east side of the site. The existing ground surface elevations in the proposed shop area building range from 2507 feet on the west side of the

proposed building to approximately 2510 feet on the east side of the proposed building. The existing ground surface elevations in the proposed wash building range from 2503 feet on the west side of the proposed building to near 2501 feet on the east side of the proposed building.

A.5. Scope of Services

Our scope of services for this project was originally submitted as a Proposal to Mr. Matt Lierz, on March 31, 2011. We were authorized to perform the work by a subcontract with FCI Constructors, Inc. on April 22, 2011. Tasks completed in accordance with our authorized scope of services are described below.

Our scope of services was performed under the terms of subcontract number 01 18022 SUB.

A.5.a. Staking and Surveying

We staked the boring locations by measuring dimensions from the intersection of Highway 22 and 34th Street West with a cloth tape and by estimating right angles. Surface elevations were measured using a surveyor's level. We referenced the ground surface elevations at the boring locations to the ground surface at the northeast property corner stake. We estimated the elevation of this point from the site sketch provided and was estimated to be 2503.5.

A.5.b. Subsurface Exploration

We performed 11 standard penetration test borings at the approximate locations shown on the Boring Location Sketch in the Appendix. The borings were extended to depths ranging from 20 to 30 feet. Prior to commencing with our subsurface exploration activities, we cleared the exploration locations of underground utilities through North Dakota One Call.

A.5.c. Geotechnical Evaluation, Analysis and Reporting

Information obtained from the soil borings was used to identify the geotechnical issues influencing design and construction, qualify the nature of their impact, and outline alternatives for their mitigation. Upon reviewing our results and performance expectations for the project, we developed baseline recommendations for:

- Structure subgrade preparation, including excavations and ground improvement.
- Excavation dewatering.
- Preparing structure subgrades and the selection, placement and compaction of excavation backfill and other structural fill.
- Designing foundations and slabs.
- Providing quality control and evaluating differing site conditions during construction.

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 and groundwater measurements.

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, (4) and available common knowledge of the geologic processes and environments that have impacted the site and surrounding area in the past.

B.2. Geologic Profile

A total of 11 penetration test borings were completed at the proposed site. Borings ST-01 through ST-06 were completed for the proposed shop building, and Borings ST-07 through ST-11 were completed for the proposed wash building.

B.2.a. Glacial Deposits

At the surface the borings encountered topsoils to depths ranging from about ½- to 1 ½ feet. Below the topsoil in the shop building area, the borings encountered glacial deposits consisting of lean clay with sand, silty sand and clayey sand to approximate depths of 4 to 6 ½ feet. The borings in the wash building also encountered similar deposits to approximate depths of 6 ½ to 14 feet.

B.2.b. Bedrock

Under the glacial deposits the borings encountered decomposed claystone, sandstone, and shale associated with the Sentinel Butte Formation to the borings' termination depths. Hand-deformed samples of the bedrock were texturally classified as lean clay, fat clay and silty sand.

B.2.c. Penetration Resistances

Penetration resistance values recorded in the glacial till/outwash soils ranged from 2 to 13 blows per foot (BPF), indicating the soils ranged from very loose/soft to medium dense/rather stiff. Penetration resistances measured in the bedrock materials indicate that the majority of the materials encountered within the upper 10 to 20 feet of the ground surface can be excavated with standard equipment.

B.2.d. Groundwater

Groundwater was observed in all but one of the borings during drilling at depths ranging from 5 to 25 feet corresponding to elevations ranging from 2497 to 2486. All of the borings were allowed to remain open for a period of time ranging from 1 to 25 hours. After the wait period groundwater was observed at depths ranging from 3 to 16 feet, corresponding to elevations ranging from 2503 ½ to 2495. The following table summarizes the highest observed groundwater levels in the borings.

Table 1. Summary of Groundwater Observations

Boring No.	Highest Observed Groundwater Depth (feet)	Highest Observed Groundwater Elevation (feet)
Shop Building		
ST-01	16	2495
ST-02	14	2493 ½
ST-03	10	2498 ½
ST-04	13	2498
ST-05	10	2499
ST-06	3	2503 ½
Wash Building		
ST-07	5	2497
ST-08	6	2495
ST-09	6	2495 ½
ST-10	6	2496 ½
ST-11	6	2495 ½

Seasonal and annual fluctuations of groundwater levels should be anticipated. In particular, elevated water levels perched in the near-surface glacial deposits should be anticipated following flooding events and spring thaw and wet weather.

B.3. Laboratory Test Results

B.3.a. Moisture Content Tests

We performed 30 moisture content (MC) tests on selected samples to aid in our classifications and estimations of the soils' engineering properties. The moisture content of the soils tested ranged from 15 to 30 percent indicating the soils were generally near to over their estimated optimum moisture contents. The results of the moisture content tests are listed in the "MC" column of the Log of Boring Sheets attached in the Appendix.

B.3.b. Unit Weight Tests

We performed eight (8) unit weight tests on selected samples to use within settlement and bearing capacity calculations. The tests indicated the soils had dry densities (DD) ranging from 89 to 121 pounds per cubic foot (pcf) and wet densities (WD) ranged from 101 to 139 pcf. The results of the density tests are listed in the "Tests or Notes" column on the attached Log of Boring sheets.

B.3.c. Atterberg Limits Tests

We performed two (2) Atterberg limits tests on selected samples for classification, evaluation of the soils' plasticity, and estimation of engineering parameters related to consolidation to aid in settlement calculations. The tests indicated the selected clay samples had liquid limits (LL) of 23 and 38 percent, plastic limits (PL) of 16 and 20 percent, and plasticity indices (PI) of 7 and 18 percent, indicating the soils tested were lean clay and likely have a low potential for shrinking/swelling. The results of the Atterberg Limits test are listed in the "Tests or Notes" column on the attached Log of Boring sheets.

B.3.d. Unconfined Compression Tests

We performed two (2) unconfined compression tests to measure the soils' undrained shear strength for bearing capacity calculations. The results of the tests indicated the soils had unconfined compressive strengths (Q_u) of 2660 and 2820 pounds per square foot (psf), indicating undrained shear strengths of 1330 and 1410 psf. The results of the unconfined compression tests are listed in the "Tests or Notes" column on the attached Log of Boring sheets.

C. Basis for Recommendations

C.1. Design Details

C.1.a. Structure Loads

Mr. Chris Bauer with AE₂S indicated that the maximum isolated column load in the proposed shop building will be 115 kips (about 75 kips live load and 40 kips dead load). Depending on mezzanine construction, wall loads will range from 6 kips per linear foot (klf) to 2.5 klf.

The proposed wash building will have one isolated column loaded to 100 kips with the remaining isolated columns loaded to 50 kips. We have assumed distributed floor slab loads will be less than 500 pounds per square foot (psf). If the loads are higher than what we have assumed, we should be notified.

C.1.b. Anticipated Grade Changes

Existing ground surface elevations within the shop building range from about 2511 to 2506 ½ feet. The proposed shop building's finished floor elevation is planned at elevation 2510.2, which will require cuts/fill ranging from -1 to +3 ½ feet to achieve finished grade.

Existing ground surface elevations within the wash building range from about 2502 ½ to 2501 feet. The proposed wash building's finished floor elevation is planned at 2504 feet, requiring fills of +1 ½ to +3 feet to achieve finished grade.

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

The main concern for the design and construction of the proposed buildings is potential settlement. At both the shop building and wash building locations, the borings encountered relatively soft and compressible materials to depths ranging from 4 to 10 below existing grades. These soft and compressible materials extend below the anticipated foundation depths at both building locations.

If left in place below the structures' foundations, we have calculated that the soft and compressible materials would experience post-construction settlements on the order of about 2 to 3 inches. These settlements would cause unacceptable distress to the structures. To limit settlements to an acceptable tolerance (<1 ¼ inch), portions of the soft and compressible soils will need to be removed from below the floors and foundations and be replaced by imported granular backfills. After the specified removals and replacements are performed, the structures may be supported over typical frost-depth spread footing foundations.

An additional challenge for the project will be the presence of groundwater. At one of the borings in the shop building, and at all of the borings within the wash building, groundwater was observed above or within 1 vertical foot below the recommended foundation overexcavation depths. Dewatering of the foundation trench excavations will likely be necessary. We wish to note, however, that the borings were performed during an exceptionally wet spring; thus, the groundwater levels observed in the borings may be higher than observed during the summer construction months.

The foundation excavation bottoms will be wet and will be easily disturbed by equipment and worker traffic. All foundation excavations should be performed with a backhoe fitted with a smooth-ended bucket (toothed buckets typically leave a disturbed layer at the bottom of the excavation) working from outside of the excavations. If the materials excavated from the foundation excavations are planned to be reused as backfill across the site, they will likely need to be dried by farming/discing to lower their moisture contents to a range that will allow for adequate compaction.

D. Recommendations

D.1. Building Subgrade Preparation

D.1.a. Excavations

Below the buildings and their foundations, we recommend removing all vegetation, topsoils, existing utilities and their associated backfills, existing fills and any otherwise soft or unstable materials.

Specific to the excavations for the *shop building*, we recommend that all glacial deposits be completely removed from below the proposed foundations. The glacial deposits were encountered in Borings ST-1 to ST-6 to depths of about 4 to 6 ½ feet, and consisted of lean clay (CL), silty sand (SM), and clayey sand (SC). We also recommend the glacial deposits be removed from within 1 foot below the bottom of the

proposed floor slab (e.g. for a 6-inch thick floor slab, glacial deposits should be removed down to an elevation of 2508.7 feet).

Specific to the excavations for the *wash building*, we recommend overexcavating below all foundations to uniform depth of 3 feet. We also recommend overexcavating all native soils to a minimum depth of 2 feet below the floor slab (e.g. for a 6-inch thick floor slab, the excavation should extend to an elevation of 2501.5).

We have summarized the anticipated excavation depths at each of the building locations within the following Table 2.

Table 2. Summary of Anticipated Overexcavation Depths Below Foundations

Boring No.	Ground Surface Elevation (ft)	Bottom of Footing Elevation (ft)	Estimated Removal Depth (ft)	Estimated Removal Bottom Elevation (ft)	Estimated Groundwater Elevation (ft)*	Total Estimated Subcut Under Foundations (ft)
Shop Building (FFE = 2510.2)**						
ST-01	2511	2505	4	2507	2495	Not Required
ST-02	2507 ½	2505	4	2503 ½	2493 ½	1 ½
ST-03	2508 ½	2505	6.5	2502	2498 ½	3
ST-04	2511	2505	4	2507	2498	Not Required
ST-05	2509	2505	6.5	2502 ½	2499	2 ½
ST-06	2506 ½	2505	4	2502 ½	2503 ½	2 ½
Wash Building (FFE = 2504.0)						
ST-07	2502	2499	6	2496	2497	3
ST-08	2501	2499	5	2496	2495	3
ST-09	2501	2499	5	2496	2495 ½	3
ST-10	2502 ½	2499	6 ½	2496	2496 ½	3
ST-11	2501 ½	2499	5 ½	2496	2495 ½	3

* The observed groundwater elevations that are within 1 foot of the bottom of the excavation are highlighted in **bold**. Dewatering will likely be required at these locations. Refer to Section D.1.c below for dewatering recommendations.

** The estimated removal depths within the shop building are estimated based on the results of the borings. It should be noted that the depths of the glacial deposits within the shop building area may be deeper between the borings, requiring deeper excavations.

The above removals should include the foundations' 1H:1V oversize areas. Oversize areas are those areas extending down and away from the bottom outside edges of the proposed foundations at a 1H:1V gradient.

All of the recommended removals should be observed and verified by an on-site geotechnical engineer.

The soils/decomposed bedrock encountered at the bottoms of the excavations will likely be wet or waterbearing and will be easily disturbed by equipment or foot traffic. These excavations should be performed with a backhoe equipped with a smoothed edge bucket working from the existing grades. If soils below the excavation depths become disturbed/weakened they should also be removed and replaced with compacted granular material.

D.1.b. Excavation Support

The soils encountered in the anticipated excavations will be considered Type C Soil under OSHA guidelines. Unsupported excavations in these soils should therefore be maintained at a gradient no steeper than 1.5H:1V.

D.1.c. Excavation Dewatering

Based on the recommended excavation depths and groundwater elevations observed in the borings, we anticipate dewatering of groundwater will be necessary. We anticipate dewatering will be necessary for the foundation overexcavations near the northeast corner of the shop building, and for all of the foundation overexcavations in the wash building area.

Specific to the *shop building*, we anticipate that dewatering can likely be accomplished by pumping from sumps or ditches extending into the underlying decomposed claystone bedrock layer at the bottoms of the excavations. The borings indicate that the groundwater is likely perched over the decomposed bedrock.

Specific to the *wash building*, we anticipate that dewatering can likely be accomplished by pumping from sumps or ditches excavated into the clayey soils at the bottoms of the overexcavations. Where the trench bottom consists of sands (such as the silty sand (SM) encountered near Boring ST-7), we recommend that groundwater be drawn down at least 2 feet below the excavation bottom. This should be performed by excavating one or more sump pits adjacent the excavation (prior to excavating) to lower the groundwater level before starting the foundation excavation.

Regardless, we recommend consulting with a dewatering contractor to review the result of our borings and provide a plan for dewatering of the trench excavations.

D.1.d. Backfill and Fill Materials

D.1.d.1. Foundation Backfill

Backfills placed below the structures' foundations and their 1H:1V oversize areas should consist of non-organic materials specified to meet the following requirements:

- Where placed below, or within 1 vertical foot above, groundwater:
 - 100% passing a 2-inch sieve;
 - ≤50% passing a #40 sieve;
 - ≤5% passing a #200 sieve; and
 - ≥35% crushed particles.
- Where placed more than 1 vertical foot above groundwater:
 - 100% passing a 1-inch sieve;
 - 35% to 70% passing a #4 sieve; and
 - ≤10% passing a #200 sieve.

We anticipate the first specification can be obtained as a 1 ½- to a 3/4-inch minus crushed aggregate or a concrete sand. If it is planned to dewater the trench excavations directly from these materials, a geotextile separation fabric should be placed below and adjacent the sides of the aggregate/sand materials.

The second specification is a well graded sandy gravel or gravelly sand (i.e. NDDOT Class 5 road base aggregate – NDDOT Spec. 816.03B for Class 5). This second specification is recommended to be used above groundwater elevations since this material does not compact well when wet or when placed over a wet excavation.

The above specified materials are not available on-site and will need to be imported.

D.1.d.2. Floor Slab Backfill

Backfills and fills placed below the buildings' floor slabs (above the foundations) and their 1H:1V oversize areas should be specified to consist of the following:

- On-site or imported soils that are free of organic or foreign materials;
- Soils classified with USCS or ASTM Group symbols with a prefix letter of S, C or G (e.g. SM, CL, GP, etc.), with exception to SC-SM, CL-ML, CH and GC-GM, which should not be used;

- Soils having a liquid limit (LL) less than 40 percent and a plastic index (PI) less than 25 percent;
- Able to be placed, moisture-conditioned and compacted per the requirements of this report.

Based on the samples recovered from the borings, it appears that the lean clay and silty sand materials encountered within the borings can likely be reused as backfill below the building floors. Reuse of the materials may require drying/farming to maintain them with the specified moisture contents for compaction (see Section D.1.e below).

Exterior wall backfill should consist of topsoils and lean clays only. Excavated claystone materials should not be reused below the building pad. The claystone may be reused in landscape or pavement areas.

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

We recommend spreading clayey backfill and fill in loose lifts of approximately 4 to 8 inches. Granular materials may be placed in loose lifts of approximately 6 to 12 inches. We recommend compacting backfill and fill in accordance with the criteria presented below in Table 3. The relative compaction of the backfill should be evaluated based on the structure below which it is installed, and vertical proximity to that structure.

Table 3. Compaction Recommendations Summary

Reference	Relative Compaction, percent (ASTM D 698 – standard Proctor)	Moisture Content Variance from Optimum, percentage points
Below foundations *	≥ 100	Granular Soils (+/- 3) Clay Soils (-1 to +3)
Below floor slabs	≥ 98	
Below exterior slabs	≥ 98	
Below landscaped surfaces	≥ 90	

* Compaction of the clean gravel or sand materials placed in the bottoms of wet excavations will be difficult to perform and measure. We recommend that compaction of clean gravel or sand materials placed within 2 vertical feet of groundwater levels be performed by placing the materials in 6- to 12-inch loose lifts and “pressing” them into place with the back side of a backhoe bucket until no additional yield is observed.

D.2. Spread Footings

D.2.a. Embedment Depth

We recommend all foundations (perimeter and interior) for heated structures bear at a depth of at least 5 feet below exposed grades for protection from frost-related movements. We recommend foundations not heated during winter construction, and other unheated footings associated with canopies, stoops or sidewalks bear at a depth of at least 6 feet below the lowest exterior grade.

D.2.b. Net Allowable Bearing Pressure

Based on the results of the borings, and the overexcavation/backfill recommendations listed in Section D.1 above, it is our opinion the footings may be designed for a net allowable bearing pressure up to 2,000 psf. Prior to foundation construction, we recommend the allowable bearing pressure be verified with cone penetrometer tests performed by a Braun Intertec geotechnical engineer or qualified engineering assistant.

The above value includes a safety factor of at least 3.0 with regard to bearing capacity failure. The net allowable bearing pressure can be increased by one-third its value for occasional transient loads, but not for repetitive loads due to traffic or for other live loads from snow or occupancy.

D.2.c. Settlement

Based on the borings, and assuming that the building pads and foundation subgrades are prepared as recommended above, we anticipate total and differential settlement of the proposed footings will be less than 1 ¼ and ¾-inch, respectively. Buildings such as this can generally tolerate settlements of this magnitude.

D.3. Interior Slabs

D.3.a. Subgrade Preparation

We anticipate the building floor slab subgrade will consist of on-site silty and clayey materials removed from the excavations. In order to allow for typical slab designs, we recommend the floor slab be supported over a minimum of 9 inches of a stabilizing aggregate (such as NDDOT Class 5 Aggregate Base and/or a sand "choker" course) placed and compacted per the recommendations stated in Section D.1 above.

D.3.b. Subgrade Modulus

Provided the floor slab is supported over compacted sand or gravel, we recommend using a modulus of subgrade reaction, k , of 150 pounds per square inch per inch of deflection (pci) to design the floor slabs. We should be contacted if a higher value is needed.

D.3.c. Moisture Vapor Protection

We recommend that a vapor retarder or vapor barrier be placed beneath the slab. Some contractors prefer to bury the vapor retarder or barrier beneath a layer of sand to reduce curling and shrinkage, but this practice risks trapping water between the slab and vapor retarder or barrier.

Regardless of where the vapor retarder or barrier is placed, we recommend consulting with floor covering manufacturers regarding the appropriate type, use and installation of the vapor retarder or barrier to preserve warranty assurances.

D.4. Exterior Slabs

Exterior slabs will potentially be underlain by clays and silty sand that is considered moderate to high frost susceptible. If these soils become saturated and freeze, unfavorable amounts of heaving could occur. Grading to direct surface drainage away from buildings helps limit the potential for saturation and subsequent heaving to occur. Still, even limited amounts of movement can create tripping hazards to workers and the public.

One method to reduce frost-related heave is to place at least 2 inches of extruded polystyrene foam insulation below the slabs and extend it approximately 5 feet beyond the outer edges of the slabs. The insulation may have to be buried below a cushion of sand or gravel to protect it during construction.

Another alternative is to support the slabs on frost-depth footings, and suspending the slabs at least 4 inches above the underlying subgrade soils to accommodate heaving without it affecting the slabs.

E. Construction Quality Control

E.1. Excavation Observations

We recommend having a professional geotechnical engineer or an engineering assistant working under the direction of a professional geotechnical engineer observe all excavations related to subgrade preparation and spread footing and slab-on-grade construction.

E.2. Materials Testing

E.2.a. Field Testing

We recommend relative moisture and compaction tests be taken in excavation backfill and additional required fill placed below spread footings, slab-on-grade construction, and beside foundation walls. We recommend the following testing frequencies for relative moisture and compaction tests:

- Building Areas: 1/2500 square feet of floor per every 2 vertical feet of backfill.
- Foundation Backfill: 1/50 linear feet of foundation.

Since it will not be possible to measure the compaction of coarse gravel materials placed in wet excavations, we recommend the placement and compaction of these materials be observed on a full-time basis by a geotechnical engineer, or an engineering assistant working under the direction of a geotechnical engineer.

We also recommend slump, air content and strength tests of Portland cement concrete per ACI guidelines.

E.2.b. Laboratory Testing of Soils

We recommend the following laboratory testing be performed on the proposed backfill materials:

- A minimum of one (1) standard Proctor test (ASTM D698) for each soil type;
- A minimum of one (1) Atterberg limits test (ASTM D4318) for each clay soil type used;
- A minimum of one (1) sieve analysis (ASTM D1140) for each imported sand or gravel material placed below foundations.

E.3. 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 delivered to the site should meet the temperature requirements of ASTM C 94. Concrete should not be placed on frozen subgrades. Concrete should be protected from freezing until the necessary strength is attained. Frost should not be permitted to penetrate below footings.

F. Procedures

F.1. Penetration Test Borings

The penetration test borings were drilled with a truck-mounted auger drill equipped with 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.

F.2. Material Classification and Testing

F.2.a. Visual and Manual Classification

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

F.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 or allowed to remain open for an extended period of observation as noted on the boring logs.

G. Qualifications

G.1. Variations in Subsurface Conditions

G.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, and 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 re-evaluated. Such variations could increase construction costs, and a contingency should be provided to accommodate them.

G.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 period was 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.

G.2. Continuity of Professional Responsibility

G.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.

G.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.

G.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.

G.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

NORTHWEST
CORNER OF
SECTION 27

SEC. LINE

3
REPLAT OF

4
BURWICK

5
FIRST

6
SUB.

BUR
SECOND
7
SUB.

UNPLATTED

LOT 1

LOT 2

LOT 1

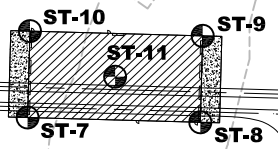
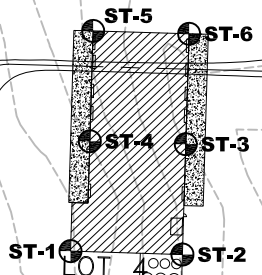
Block 1

LOT 3

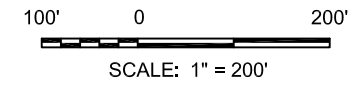
LOT 5

LOT 4

LOT 4



⊕ DENOTES APPROXIMATE LOCATION OF
STANDARD PENETRATION TEST BORING

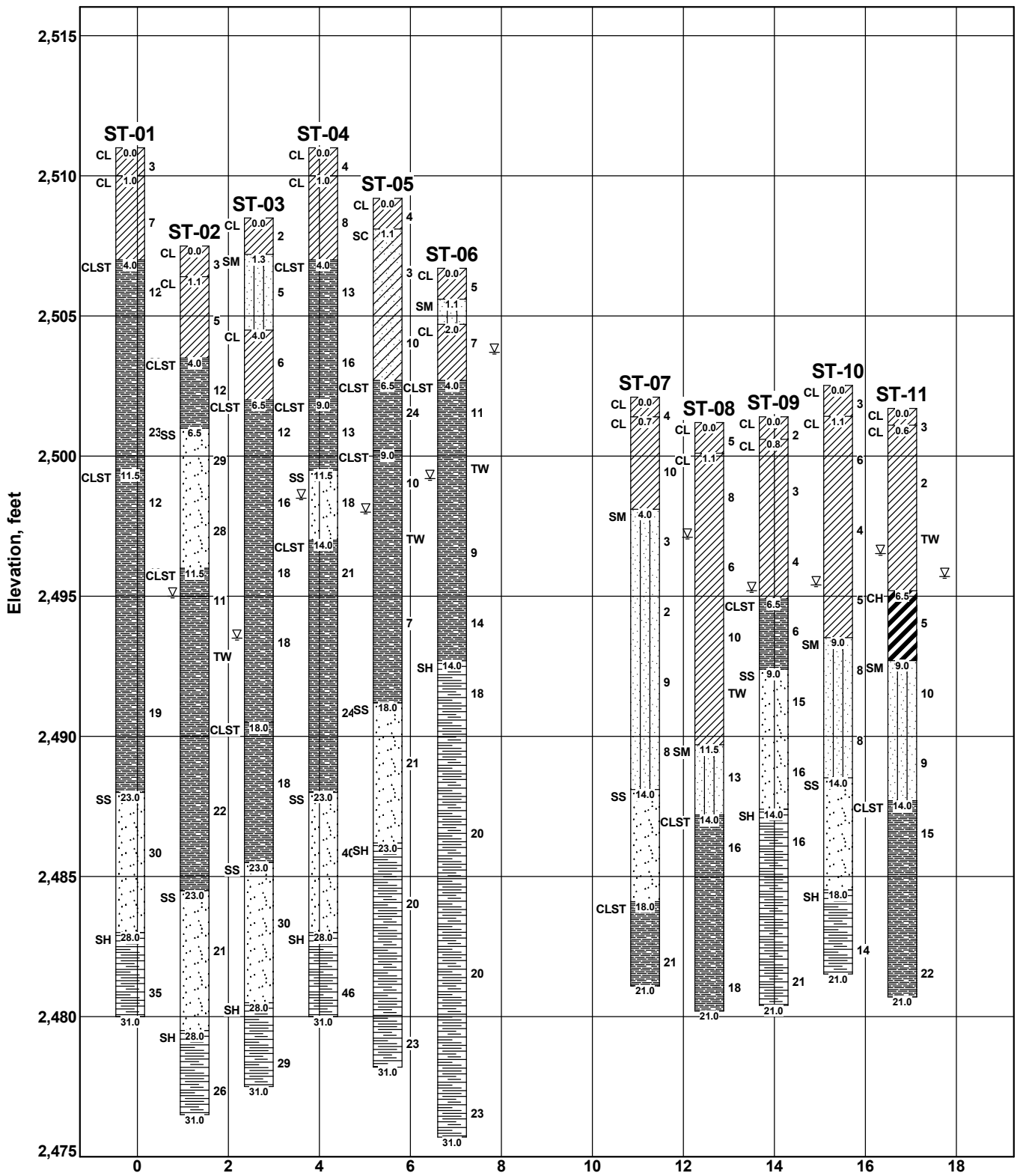


SOIL BORING LOCATION SKETCH
GEOTECHNICAL EVALUATION
HALLIBURTON WASH / SHOP BUILDINGS
34th STREET WEST & ND HIGHWAY 22
DICKINSON, NORTH DAKOTA

Project No:	BM1101121
Drawing No:	BM1101121
Scale:	1" = 200'
Drawn By:	BJB
Date Drawn:	6/2/11
Checked By:	MEK
Last Modified:	6/2/11

Sheet: of Fig:

ELEVATION & DISTANCE SCALES N:\GINT\PROJECTS\BISMARCK\2011\01121.GPJ BRAUN_V8_CURRENT.GDT 6/2/11 21:25



Fence Diagram

Braun Project BM-11-01121
Geotechnical Evaluation
Halliburton Wash and Shop Buildings
34th St. W. and ND Hwy 22
Dickinson, ND



(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\BISMARCK\2011\01121.GPJ BRAUN_V8_CURRENT.GDT 6/5/11 08:41

Braun Project BM-11-01121 Geotechnical Evaluation Halliburton Wash and Shop Buildings 34th St. W. and ND Hwy 22 Dickinson, ND				BORING: ST-01				
DRILLER: S. Wenko		METHOD: 3 1/4" HSA, Autohammer		DATE: 5/3/11				
Elev. feet		Depth feet		SCALE: 1" = 6'				
Elev. feet	Depth feet	Symbol	Description of Materials (Soil- ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	qp tsf	MC %	Tests or Notes
2511.0	0.0							
2510.0	1.0	CL	LEAN CLAY, dark brown, moist. (Topsoil)	3				
		CL	LEAN CLAY with SAND, brown, moist, medium. (Glacial Till)	7			24	
2507.0	4.0							
		CLST	SENTINEL BUTTE FORMATION, CLAYSTONE, brown, moist, decomposed, very soft, hand deformed sample classified as "Lean Clay (CL)"	12			15	LL=38, PL=20, PI=18
				20				
				23				
2499.5	11.5							
		CLST	SENTINEL BUTTE FORMATION, CLAYSTONE, brown to gray, moist, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	12		4.5+	27	DD=93 pcf, WD=118 pcf
				19	▽	4.5+		
				19			24	
2488.0	23.0							
		SS	SENTINEL BUTTE FORMATION, SANDSTONE, gray, moist, decomposed, very soft, sample retrieved as non-cemented "Silty Sand (SM)".	30				
2483.0	28.0							
		SH	SENTINEL BUTTE FORMATION, SHALE, with Lignite lenses, gray, moist, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	35				
2480.0	31.0							
			END OF BORING.					
			Water observed at a depth of 25 feet while drilling.					
			Water observed at a depth of 16 feet immediately after withdrawal of auger.					
			Water observed at a depth of 16 feet when rechecked 22 hours after withdrawal of auger.					

(See Descriptive Terminology sheet for explanation of abbreviations)

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Braun Project BM-11-01121 Geotechnical Evaluation Halliburton Wash and Shop Buildings 34th St. W. and ND Hwy 22 Dickinson, ND				BORING: ST-02 LOCATION: Shop Building. See Sketch.			
DRILLER: S. Wenko		METHOD: 3 1/4" HSA, Autohammer		DATE: 5/3/11		SCALE: 1" = 6'	
Elev. feet	Depth feet	Symbol	Description of Materials (Soil- ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
2507.5	0.0						
2506.4	1.1	CL	LEAN CLAY, dark brown, moist. (Topsoil)	3			
		CL	LEAN CLAY with SAND, brown, wet, rather soft. (Glacial Till)	5		23	
2503.5	4.0	CLST	SENTINEL BUTTE FORMATION, CLAYSTONE, brown, moist, decomposed, very soft, hand deformed sample classified as "Lean Clay (CL)"	12		15	
2501.0	6.5	SS	SENTINEL BUTTE FORMATION, SANDSTONE, brown, moist, decomposed, very soft, sample retrieved as non-cemented "Silty Sand (SM)".	29			
				28			
2496.0	11.5	CLST	SENTINEL BUTTE FORMATION, CLAYSTONE, brown to gray, moist, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	11	▽		
				TW		22	MC=22%, DD=101 pcf, WD=123, Qu=2660 psf
				22		26	
2484.5	23.0	SS	SENTINEL BUTTE FORMATION, SANDSTONE, gray, moist, decomposed, very soft, sample retrieved as non-cemented "Silty Sand (SM)".	21			
2479.5	28.0	SH	SENTINEL BUTTE FORMATION, SHALE, with Lignite lenses, gray, moist, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	26			
2476.5	31.0		END OF BORING.				
			Water observed at a depth of 30 feet while drilling.				
			Water observed at a depth of 14 feet immediately after withdrawal of auger.				
			Water observed at a depth of 14 feet when rechecked 25 hours after withdrawal of auger.				

LOG OF BORING (See Descriptive Terminology sheet for explanation of abbreviations)

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Braun Project BM-11-01121 Geotechnical Evaluation Halliburton Wash and Shop Buildings 34th St. W. and ND Hwy 22 Dickinson, ND				BORING: ST-03 LOCATION: Shop Building. See Sketch.			
DRILLER: S. Wenko		METHOD: 3 1/4" HSA, Autohammer		DATE: 5/3/11		SCALE: 1" = 6'	
Elev. feet	Depth feet	Symbol	Description of Materials (Soil- ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
2508.5	0.0						
2507.2	1.3	CL	LEAN CLAY, dark brown, moist. (Topsoil)	2			
		SM	SILTY SAND, fine- to medium-grained, brown, wet, loose.	5			
2504.5	4.0		(Glacial Outwash)				
		CL	LEAN CLAY with SAND, brown, moist, medium (Glacial Till)	6		20	
2502.0	6.5	CLST	SENTINEL BUTTE FORMATION, CLAYSTONE, brown, damp, decomposed, very soft, hand deformed sample classified as "Lean Clay (CL)"	12		13	DD=89 pcf, WD=101 pcf
				16	▽		
				18			
				18		27	
2490.5	18.0	CLST	SENTINEL BUTTE FORMATION, CLAYSTONE, gray, damp, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	18			
2485.5	23.0	SS	SENTINEL BUTTE FORMATION, SANDSTONE, brown, moist, decomposed, very soft, sample retrieved as non-cemented "Silty Sand (SM)".	30			
2480.5	28.0	SH	SENTINEL BUTTE FORMATION, SHALE, with Lignite lenses, gray, moist, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	29			
2477.5	31.0		END OF BORING.				
			Water not observed with 29 1/2 feet of hollow stem auger in the ground.				
			Water observed at a depth of 10 feet when rechecked 24 hours after withdrawal of auger.				

(See Descriptive Terminology sheet for explanation of abbreviations)

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Braun Project BM-11-01121 Geotechnical Evaluation Halliburton Wash and Shop Buildings 34th St. W. and ND Hwy 22 Dickinson, ND				BORING: ST-04 LOCATION: Shop Building. See Sketch.			
DRILLER: S. Wenko		METHOD: 3 1/4" HSA, Autohammer		DATE: 5/3/11		SCALE: 1" = 6'	
Elev. feet	Depth feet	Symbol	Description of Materials (Soil- ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
2511.0	0.0						
2510.0	1.0	CL	LEAN CLAY, dark brown, moist. (Topsoil)	4			
		CL	LEAN CLAY with SAND, brown and gray, wet, medium. (Glacial Till)	8		21	
2507.0	4.0	CLST	SENTINEL BUTTE FORMATION, CLAYSTONE, brown, moist, decomposed, very soft, hand deformed sample classified as "Lean Clay (CL)"	13		19	
				16			
2502.0	9.0	CLST	SENTINEL BUTTE FORMATION, CLAYSTONE, brown to gray, moist, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	13			
2499.5	11.5	SS	SENTINEL BUTTE FORMATION, SANDSTONE, brown, moist, decomposed, very soft, sample retrieved as non-cemented "Silty Sand (SM)".	18	▽		
2497.0	14.0	CLST	SENTINEL BUTTE FORMATION, CLAYSTONE, brown, moist, decomposed, very soft, hand deformed sample classified as "Lean Clay (CL)"	21		26	
				24			
2488.0	23.0	SS	SENTINEL BUTTE FORMATION, SANDSTONE, brown, moist, decomposed, very soft, sample retrieved as non-cemented "Silty Sand (SM)".	40			
2483.0	28.0	SH	SENTINEL BUTTE FORMATION, SHALE, with Lignite lenses, gray, moist, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	46			
2480.0	31.0		END OF BORING.				
			Water observed at a depth of 25 feet while drilling.				
			Water observed at a depth of 27 feet immediately after withdrawal of auger.				
			Water observed at a depth of 13 feet when rechecked 23 hours after withdrawal of auger.				

(See Descriptive Terminology sheet for explanation of abbreviations)

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Braun Project BM-11-01121 Geotechnical Evaluation Halliburton Wash and Shop Buildings 34th St. W. and ND Hwy 22 Dickinson, ND				BORING: ST-05				
DRILLER: S. Wenko		METHOD: 3 1/4" HSA, Autohammer		DATE: 5/4/11				
Elev. feet 2509.2		Depth feet 0.0		SCALE: 1" = 6'				
Elev. feet	Depth feet	Symbol	Description of Materials (Soil- ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	qp tsf	MC %	Tests or Notes
2508.1	1.1	CL	LEAN CLAY, dark brown, moist. (Topsoil)	4				
		SC	CLAYEY SAND, fine-grained, brown, moist to wet, very loose to loose. (Glacial Outwash)	3				
2502.7	6.5	CLST	SENTINEL BUTTE FORMATION, CLAYSTONE, brown, moist, decomposed, very soft, hand deformed sample classified as "Lean Clay (CL)"	10				
2500.2	9.0	CLST	SENTINEL BUTTE FORMATION, CLAYSTONE, brown to gray, moist to wet, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	24			15	
				10	▽	4	28	DD=93 pcf, WD=118 pcf
2491.2	18.0	SS	SENTINEL BUTTE FORMATION, SANDSTONE, brown, moist, decomposed, very soft, sample retrieved as non-cemented "Silty Sand (SM)".	7				
2486.2	23.0	SH	SENTINEL BUTTE FORMATION, SHALE, with Lignite lenses, gray, moist, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	21				
2478.2	31.0		END OF BORING.	23				
			Water observed at a depth of 15 feet while drilling.					
			Water observed at a depth of 22 feet immediately after withdrawal of auger.					
			Water observed at a depth of 10 feet when rechecked 8 hours after withdrawal of auger.					

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 (See Descriptive Terminology sheet for explanation of abbreviations)

Braun Project BM-11-01121 Geotechnical Evaluation Halliburton Wash and Shop Buildings 34th St. W. and ND Hwy 22 Dickinson, ND				BORING: ST-06				
DRILLER: S. Wenko		METHOD: 3 1/4" HSA, Autohammer		DATE: 5/4/11				
SCALE: 1" = 6'		LOCATION: Shop Building. See Sketch.						
Elev. feet	Depth feet	Symbol	Description of Materials (Soil- ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	qp tsf	MC %	Tests or Notes
2506.7	0.0							
2505.6	1.1	CL	LEAN CLAY, dark brown, moist. (Topsoil)	5				
2504.7	2.0	SM	SILTY SAND, fine-grained, brown, moist. (Glacial Outwash)	7	▽	3		
2502.7	4.0	CL	LEAN CLAY with SAND, brown, moist to wet, medium. (Glacial Till)	11		4	20	
		CLST	SENTINEL BUTTE FORMATION, CLAYSTONE, brown, moist, decomposed, very soft, hand deformed sample classified as "Lean Clay (CL)"	TW				
				9				
2492.7	14.0	SH	SENTINEL BUTTE FORMATION, SHALE, gray, moist, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	14			28	
				18				
				20			29	
				20				
2475.7	31.0		END OF BORING.	23				
			Water observed at a depth of 25 feet while drilling.					
			Water observed at a depth of 19 feet immediately after withdrawal of auger.					
			Water observed at a depth of 3 feet when rechecked 6 hours after withdrawal of auger.					

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Braun Project BM-11-01121 Geotechnical Evaluation Halliburton Wash and Shop Buildings 34th St. W. and ND Hwy 22 Dickinson, ND				BORING: ST-07 LOCATION: Wash Building. See Sketch.			
DRILLER: S. Wenko		METHOD: 3 1/4" HSA, Autohammer		DATE: 5/4/11		SCALE: 1" = 6'	
Elev. feet	Depth feet	Symbol	Description of Materials (Soil- ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
2502.1	0.0						
2501.4	0.7	CL	LEAN CLAY, dark brown, moist. (Topsoil)	4			
		CL	LEAN CLAY with SAND, brown, damp to wet, rather stiff.	10		18	
2498.1	4.0		(Glacial Till)				
		SM	SILTY SAND, fine-grained, brown, wet to waterbearing, very loose to loose. (Glacial Outwash)	3	▽		
				2			
				9			
				8			
2488.1	14.0						
		SS	SENTINEL BUTTE FORMATION, SANDSTONE, brown, moist, decomposed, very soft, sample retrieved as non-cemented "Silty Sand (SM)".	13			
2484.1	18.0						
		CLST	SENTINEL BUTTE FORMATION, CLAYSTONE, brown to gray, moist, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"				
2481.1	21.0			21			
			END OF BORING.				
			Water observed at a depth of 5 feet while drilling.				
			Water observed at a depth of 9 feet immediately after withdrawal of auger.				
			Water observed at a depth of 7 feet when rechecked 5 hours after withdrawal of auger.				

(See Descriptive Terminology sheet for explanation of abbreviations)

Braun Project BM-11-01121 Geotechnical Evaluation Halliburton Wash and Shop Buildings 34th St. W. and ND Hwy 22 Dickinson, ND				BORING: ST-08 LOCATION: Wash Building. See Sketch.				
DRILLER: S. Wenko		METHOD: 3 1/4" HSA, Autohammer		DATE: 5/4/11		SCALE: 1" = 6'		
Elev. feet	Depth feet	Symbol	Description of Materials (Soil- ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	qp tsf	MC %	Tests or Notes
2501.2	0.0							
2500.1	1.1	CL	LEAN CLAY, dark brown, moist. (Topsoil)	5				
		CL	LEAN CLAY with SAND, brown, moist to wet, medium to rather stiff. (Glacial Till)	8		4.5+	15	DD=121 pcf, WD=139 pcf
				6	▽		26	LL=23, PL=16, PI=7
				10		4		
2489.7	11.5			TW			19	MC=19%, DD=107 pcf, WD=127 pcf, Qu=2820 psf
		SM	SILTY SAND, fine-grained, gray, waterbearing, medium dense. (Glacial Outwash)	13				
2487.2	14.0							
		CLST	SENTINEL BUTTE FORMATION, CLAYSTONE, brown, moist to wet, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	16		3		
2480.2	21.0			18				
			END OF BORING.					
			Water observed at a depth of 10 feet while drilling.					
			Water observed at a depth of 7 feet immediately after withdrawal of auger.					
			Water observed at a depth of 6 feet when rechecked 3 hours after withdrawal of auger.					

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(See Descriptive Terminology sheet for explanation of abbreviations)

Braun Project BM-11-01121 Geotechnical Evaluation Halliburton Wash and Shop Buildings 34th St. W. and ND Hwy 22 Dickinson, ND				BORING: ST-09				
DRILLER: S. Wenko		METHOD: 3 1/4" HSA, Autohammer		DATE: 5/4/11				
Elev. feet		Depth feet		SCALE: 1" = 6'				
Elev. feet	Depth feet	Symbol	Description of Materials (Soil- ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	qp tsf	MC %	Tests or Notes
2501.4	0.0							
2500.6	0.8	CL	LEAN CLAY, dark brown, moist. (Topsoil)	2				
		CL	LEAN CLAY with SAND, brown, wet, soft to rather soft. (Glacial Till)	3			20	
				4	▽			
2494.9	6.5	CLST	SENTINEL BUTTE FORMATION, CLAYSTONE, gray, moist, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	6			29	
2492.4	9.0	SS	SENTINEL BUTTE FORMATION, SANDSTONE, brown, moist, decomposed, very soft, sample retrieved as non-cemented "Silty Sand (SM)".	15				
				16				
2487.4	14.0	SH	SENTINEL BUTTE FORMATION, SHALE, gray, moist, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	16		4.5+	25	
				21		4.5+		
2480.4	21.0		END OF BORING.					
			Water observed at a depth of 10 feet while drilling.					
			Water observed at a depth of 18 feet immediately after withdrawal of auger.					
			Water observed at a depth of 6 feet when rechecked 2 hours after withdrawal of auger.					

(See Descriptive Terminology sheet for explanation of abbreviations)

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Braun Project BM-11-01121 Geotechnical Evaluation Halliburton Wash and Shop Buildings 34th St. W. and ND Hwy 22 Dickinson, ND				BORING: ST-10				
DRILLER: S. Wenko		METHOD: 3 1/4" HSA, Autohammer		DATE: 5/4/11				
Elev. feet 2502.5		Depth feet 0.0		SCALE: 1" = 6'				
Elev. feet	Depth feet	Symbol	Description of Materials (Soil- ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	qp tsf	MC %	Tests or Notes
2501.4	1.1	CL	LEAN CLAY, dark brown, moist. (Topsoil)	3		2		DD=107 pcf, WD=136 pcf
		CL	LEAN CLAY with SAND, brown, moist, rather soft to medium. (Glacial Till)	6		3/4	17	
				4	▽	3/4	27	
				5				
2493.5	9.0	SM	SILTY SAND, fine-grained, brown, moist, loose. (Glacial Outwash)	8				
				8				
2488.5	14.0	SS	SENTINEL BUTTE FORMATION, SANDSTONE, brown, moist, decomposed, very soft, sample retrieved as non-cemented "Silty Sand (SM)".	14				
2484.5	18.0	SH	SENTINEL BUTTE FORMATION, SHALE, gray, moist, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	14				
2481.5	21.0		END OF BORING.	14		4.5+		
			Water observed at a depth of 7 feet while drilling.					
			Water observed at a depth of 6 feet immediately after withdrawal of auger.					
			Water observed at a depth of 6 feet when rechecked 1 hour after withdrawal of auger.					

Braun Project BM-11-01121 Geotechnical Evaluation Halliburton Wash and Shop Buildings 34th St. W. and ND Hwy 22 Dickinson, ND					BORING: ST-11 LOCATION: Wash Building. See Sketch.				
DRILLER: S. Wenko		METHOD: 3 1/4" HSA, Autohammer		DATE: 5/4/11		SCALE: 1" = 6'			
Elev. feet	Depth feet	Symbol	Description of Materials (Soil- ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	qp tsf	MC %	Tests or Notes	
2501.7	0.0								
2501.1	0.6	CL	LEAN CLAY, dark brown, moist. (Topsoil)	3					
		CL	LEAN CLAY with SAND, brown and gray, wet, soft. (Glacial Till)	2			22		
					TW				
2495.2	6.5				▽				
		CH	FAT CLAY with SAND, gray, moist, rather soft. (Glacial Outwash)	5		4.5+	23	DD=100 pcf, WD=123 pcf	
2492.7	9.0								
		SM	SILTY SAND, fine-grained, brown, wet, loose. (Glacial Outwash)	10					
2487.7	14.0								
		CLST	SENTINEL BUTTE FORMATION, CLAYSTONE, brown, moist, decomposed, very loose, hand deformed sample classified as "Lean Clay (CL)"	15			30		
2480.7	21.0								
			END OF BORING.						
			Water observed at a depth of 10 feet while drilling.						
			Water observed at a depth of 7 feet immediately after withdrawal of auger.						
			Water observed at a depth of 6 feet when rechecked 4 hours after withdrawal of auger.						

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\BISMARCK\2011\01121.GPJ BRAUN_V8_CURRENT.GDT 6/5/11 08:41



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 5% or less 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 fg}
			Fines classify as CL or CH	GC	Clayey gravel ^{d fg}
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands 5% or less 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 ^{fg h}
			Fines classify as CL or CH	SC	Clayey sand ^{fg 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 < 0.75	OL	Organic clay ^{k l m n}
			Liquid limit - not dried < 0.75	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 < 0.75	OH	Organic clay ^{k l m p}
			Liquid limit - not dried < 0.75	OH	Organic silt ^{k l m q}
Highly Organic Soils	Primarily organic matter, dark in color and organic odor			PT	Peat

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 above "A" line

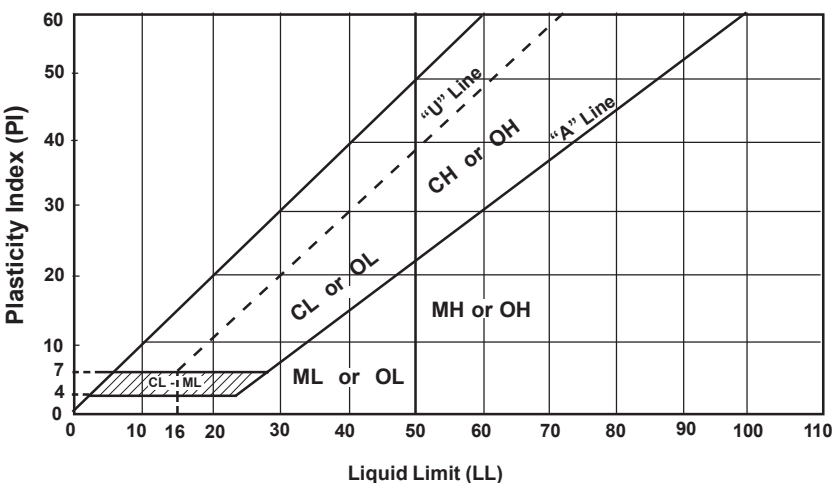
Relative Density of Cohesionless Soils

Very loose 0 to 4 BPF
Loose 5 to 10 BPF
Medium dense 11 to 30 BPF
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

- Based on the material passing the 3-in (75mm) sieve.
- If field sample contained cobbles or boulders, or both, add "with cobbles or boulders or both" to group name.
- $C_u = D_{60} / D_{10}$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
- If soil contains ≥ 15% sand, add "with sand" to group name.
- 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
- If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
- If fines are organic, add "with organic fines" to group name.
- If soil contains ≥ 15% gravel, add "with gravel" to group name.
- Sands 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
- If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
- If soil contains 10 to 29% plus No. 200, add "with sand" or "with gravel" whichever is predominant.
- If soil contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.
- If soil contains ≥ 30% plus No. 200 predominantly gravel, add "gravelly" to group name.
- PI ≥ 4 and plots on or above "A" line.
- PI < 4 or plots below "A" line.
- PI plots on or above "A" line.
- PI plots below "A" line.



Laboratory Tests

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

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. Standard penetration test borings are designated by the prefix "ST" (Split Tube). All samples were taken with the standard 2" OD split-tube sampler, except where noted.

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

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. Hand auger borings are indicated by the prefix "H."

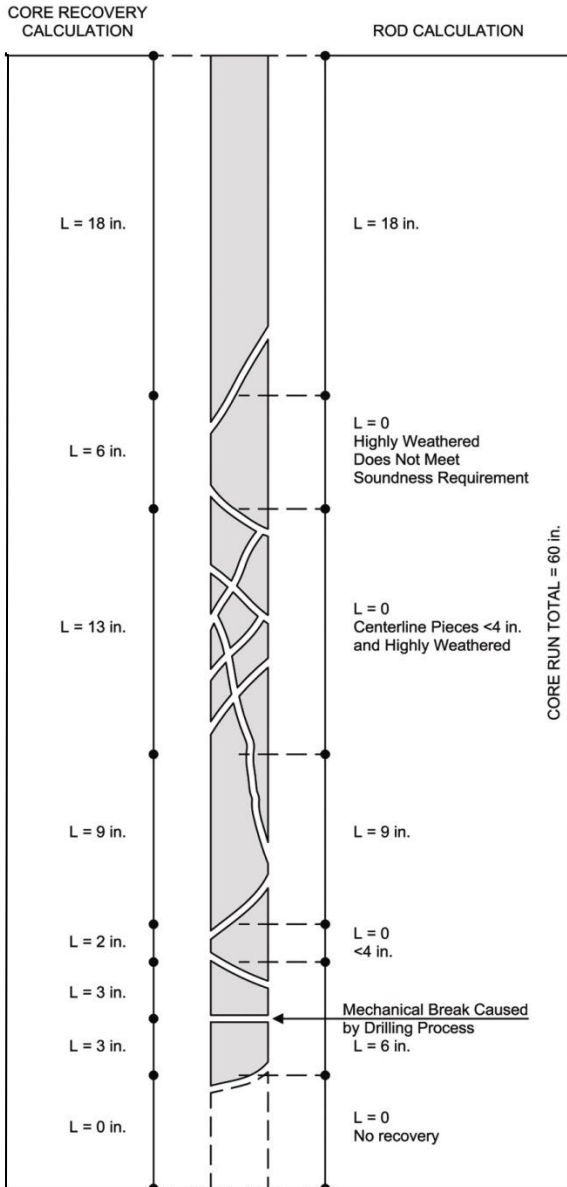
BPF: Numbers indicate blows per foot recorded in standard penetration test, also known as "N" value. The sampler was set 6" into undisturbed soil below the hollow-stem auger. Driving resistances were then counted for second and third 6" increments and added to get BPF. Where they differed significantly, 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 indicates thin-walled (undisturbed) tube sample.

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



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. or 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

Example Calculations

Core Recovery, CR = $\frac{\text{Total length of rock recovered}}{\text{Total core run length}}$

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

$$CR = 90\%$$

RQD = $\frac{\text{Sum of sound pieces longer than 4 inches}}{\text{Total core run length}}$

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

$$\text{Example: } RQD = \frac{(18 + 9 + 4 + 6)}{(60)}$$

$$RQD = 62\%$$