Appendix D-9

Preliminary Geotechnical Evaluation Report

Cart Creek Impoundment, Site 1
NE Quadrant of 86th Street NE & 131st Avenue NE
Mountain, North Dakota

Prepared for

Houston Engineering, 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.

Ezra Ballinger, PE
Principal/Senior Engineer
Registration Number: PE-7328
June 25, 2020

REGISTERED PROFESSIONAL ENGINEER
EZRA BALLINGER
PE 7328
DATE 6/25/2020
NORTH DAKOTA

Project B1904637

Braun Intertec Corporation

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The Science You Build On.

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June 25, 2020

Project B1904637

Zach Herrmann, PE
Houston Engineering, Inc.
1401 21st Avenue North
Fargo, ND 58102

Re: Preliminary Geotechnical Evaluation
Cart Creek Impoundment, Site 1
NE Quadrant of 86th Street NE & 131st Avenue NE
Mountain, North Dakota

Dear Mr. Herrmann:

We are pleased to present this Preliminary Geotechnical Evaluation Report for the proposed Cart Creek Impoundment, Site 1 project under consideration for construction east of Mountain, North Dakota. This report summarizes the results of our preliminary geotechnical exploration and laboratory tests. This report and data are intended for subsequent use in detailed geotechnical exploration and design and preparation of 30% and 50% construction plans, if the site is selected for further evaluation by the design team.

If you have questions about this report, or if there are other services we can provide in support of the project, please contact Ezra Ballinger at 701.232.8701 (eballinger@braunintertec.com).

Sincerely,

BRAUN INTERTEC CORPORATION

Corey Lindeman, PE
Project Engineer

Ezra Ballinger, PE
Principal/Senior Engineer

AA/EOE

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Description **Page**

BRAUN INTERTEC

A. Introduction

A.1. Project Description

The project will include constructing about 3 miles of dam that would retain water as it flows down the existing grade in the field toward Cart Creek. The top of the impoundment dam is currently planned to be at elevation 983.2. The embankment height gradually increases from none to about 15 feet as the existing grades lower from the west to the east. The preliminary cross section for the dam is a 10 foot wide top with 4H:1V (Horizontal:Vertical) side slopes. The preliminary design also contains a clay core with 1.5H:1V clay core. Soil within the pool area is anticipated to be used for the embankment construction. The project location and site layout are shown in Figure 1.

Figure 1. Site Layout

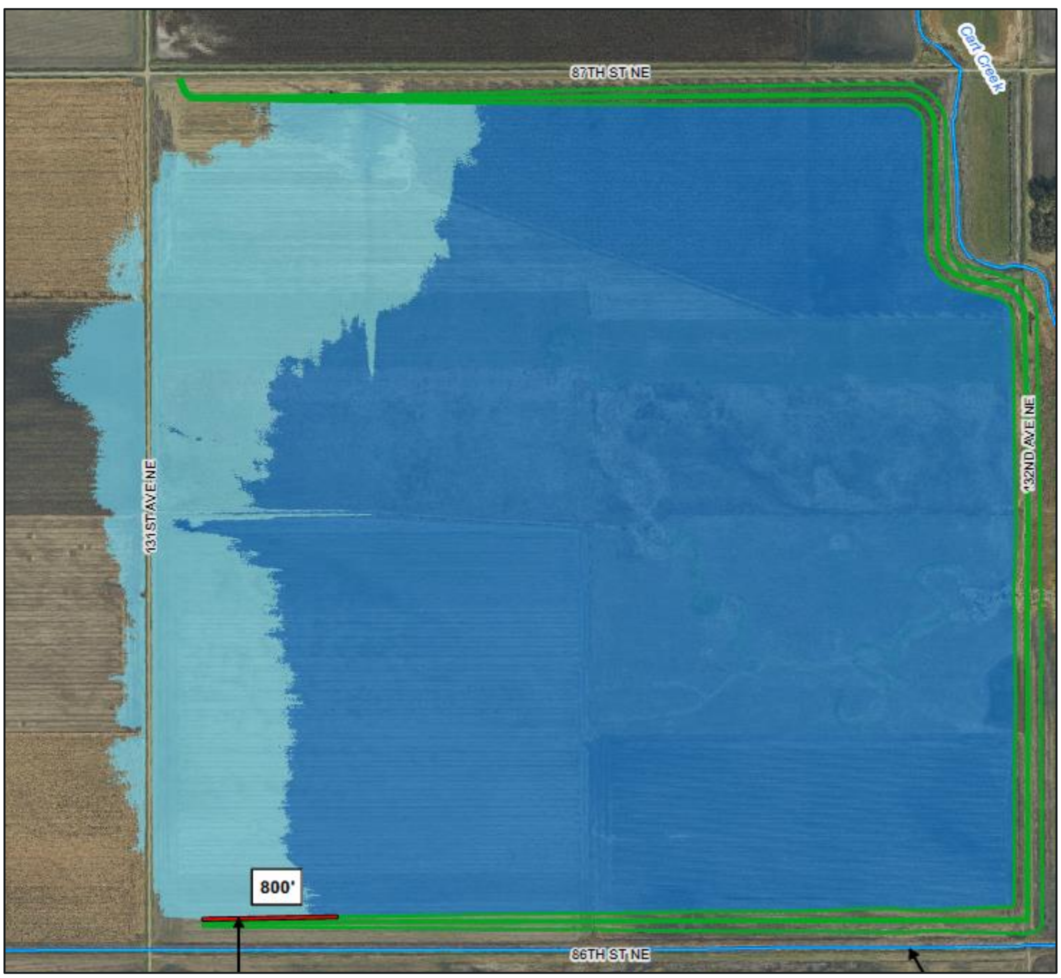

Figure provided by Houston Engineering, Inc. via email on August 26, 2019.

A.2. Dam Classification

You stated the dam will be a High Hazard Group A structure based on the potential downstream impacts of a failure. The Technical Release 210-60 document by the NRCS, dated March 2019, is understood to control design and operation of the impoundment.

A.3. Purpose

The purpose of our preliminary geotechnical evaluation is to characterize subsurface geologic conditions at selected exploration locations and preliminarily evaluate their impact on the feasibility and conceptual design of an impoundment dam at the site.

A.4. Background Information and Reference Documents

We reviewed the following information:

- *North Brank Park River Upper Pool Inundation,* site plan prepared by Houston Engineering, Inc. (HEI), HEI project number 8150-0002, dated August 26, 2019. The site plan was used to understand the scope of the project.
- *North Branch Park River Watershed Screening of Alternative for Detailed Review, Park River Joint Water Resource District, Cavalier, North Dakota,* sheets 3 and 4 of 5, plan and profile of existing grades and proposed dam prepared by HEI, HEI project number 8150-0002, dated March 25, 2019. The plan and profile was used to understand the elevation of the dam relative to existing grades.
- *Technical Release 210-60 Earth Dams and Reservoirs,* prepared by the NRCS, dated March 2019. We used the manual to select conditions for seepage and stability analyses and to understand the required factors of safety for stability analyses.
- *Plate 2 – Geology of Pembina County,* Part 1 – Plate 2 County Groundwater Studies 20 Bulletin 62, prepared by the North Dakota Geological Survey and the North Dakota State Water Commission, used to aid in our evaluation of the site geology.
- Communications with Zach Herrmann, PE regarding design details.

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

A.5. Scope of Services

We performed our scope of services for the project in accordance with our Proposal QTB098551 to HEI, dated April 24, 2019, and authorized on May 7, 2019. The following list describes the geotechnical tasks completed in accordance with our authorized scope of services.

- Reviewing the background information and reference documents previously cited.
- Performing a site reconnaissance to look for visually apparent historic slope movements along the dam alignment, evaluate drainage patterns, and evaluate access for our borings.
- Staking and clearing the exploration location of underground utilities. We selected and staked the new exploration locations based on the site maps provided. We obtained the elevation at the boring locations from the existing ground surface profile provided on the plan and profile view of the dam provided by HEI. The Soil Boring Location Sketch included in the Appendix shows the approximate locations of the borings.
- Performing four (4) standard penetration test (SPT) borings, denoted as ST-01 to ST-04, to nominal depths of 10 feet (Borings ST-03 and ST-04) or 50 feet (Borings ST-01 and ST-02) below grade across the site.
- Performing laboratory testing on select samples to aid in soil classification and engineering analysis.
- Perform preliminary engineering analysis related to the stability and seepage characteristics of the impoundment dam.
- Preparing this report containing a boring location sketch, logs of soil borings, a summary of the soils encountered, results of laboratory tests, and preliminary recommendations for dam cross sections and construction methods.

Our scope of services did not include environmental services or testing, and we did not train the personnel performing this evaluation to provide environmental services or testing. We can provide these services or testing at your request.

B. Results

B.1. Site Reconnaissance

We performed a site reconnaissance on May 8, 2019. During our reconnaissance, we observed the general area and took notes and photographs documenting the general condition of the topography, vegetation, visible geologic hazards and surficial drainage conditions. Based on our observation, the area is generally flat and appears to have been used as farm fields with some portions being plowed and seeded and other portions appear to be fallow for the year. A drainage channel runs from the west to the east near the center of the area. The field along the north side of the site has drain tile installed below it that collects into an outflow channel on the east side. The roadways on the perimeter are generally about 2 to 4 feet above the field grade. We did not observe surficial erosion, natural streams other than Cart Creek, springs or mining in the immediate vicinity of the site. Some of our observations are illustrated by the following photographs.

Photograph 1. Northwest corner of the impoundment area.

Photograph 2. Drainage channel looking east from west side.

Photograph 3. Southeast corner of the impoundment area.

Photograph 4. Looking north at east end of drainage channel.

Photograph 5. Looking north over Cart Creek at the northeast corner of the impoundment area.

B.2. Geologic Overview

The southwest portion of Pembina County is surfaced by alluvial soils associated with flows of the Tongue River, Park River and Cart Creek (among others) underlain by a mix of predominately glacially deposited soils. Glacial lake deposited soils associated with an offshore lagoon separated from Glacial Lake Agassiz are mapped to extend to depths of 80 to 100 feet. Beneath and surrounding the historic lagoon are glacial till soils associated with the glacial advances before the formation of Glacial Lake Agassiz. Bedrock is anticipated to be 150 to 200 feet below existing grades in the region.

We based the geologic origins used in this report on the soil types, in-situ and laboratory testing, and available common knowledge of the geological history of the site. Because of the complex depositional history, geologic origins can be difficult to ascertain. We did not perform a detailed investigation of the geologic history for the site.

B.3. Boring Results

Table 1 provides a summary of the soil boring results, in the general order we encountered the strata. Please refer to the Log of Boring sheets in the Appendix for additional details. The Descriptive Terminology sheets in the Appendix include definitions of abbreviations used in Table 1.

Table 1. Subsurface Profile Summary*

Strata	Soil Type - ASTM Classification	Range of Penetration Resistances	Commentary and Details
Topsoil	CL	--	▪ Lean clay and sandy lean clay ▪ Dark brown to black and contained organic matter ▪ Thicknesses at boring locations varied from 1 to 1 1/2 feet ▪ Moisture condition generally moist
Alluvial	SC, CH	3 to 9 BPF	▪ General penetration resistance of 4 to 8 BPF ▪ Predominantly fat clay with trace to a little sand ▪ One layer of fine-grained clayey sand encountered below 5 1/2 feet in Boring ST-04 ▪ Moisture condition generally moist
Glacial lake deposits	CH	5 to 12 BPF	▪ General penetration resistance of 7 to 9 BPF ▪ Fat clay with silt lenses and laminations ▪ Brown to gray in color ▪ Moisture condition general moist

*Abbreviations defined in the attached Descriptive Terminology sheets.

For simplicity in this report, we define existing fill to mean existing, uncontrolled or undocumented fill.

B.4. Groundwater

We observed groundwater in Borings ST-02 and ST-04 while drilling at a depths of 10 and 8 feet, respectively. We did not observe groundwater in the remaining borings. Groundwater may take days or longer to reach equilibrium in the boreholes and we immediately backfilled the boreholes, in accordance with our scope of work. For final design of the project, the project team should consider installing piezometers for an accurate determination of groundwater depth. Project planning should anticipate seasonal and annual fluctuations of groundwater.

B.5. Laboratory Test Results

The boring logs show the results of moisture content, unit weight and Atterberg limits testing we performed, next to the tested sample depth. We also performed mechanical sieve/hydrometer, standard Proctor, and hydraulic conductivity testing. The Appendix contains the results of these tests.

The moisture content of the soils varied from approximately 27 to 41 percent, indicating that the material was wet of its probable optimum moisture content.

Our mechanical analyses indicated that the soils contained 88 to 100 percent silt and clay by weight. Liquid limits determined for the soils ranged from 55 to 80; plastic limits ranged from 16 to 27. These results indicate the samples tested are classified as fat clay.

The standard Proctor and hydraulic conductivity were performed on a sample of material planned for use as borrow. The test result indicates that when compacted to near 95 percent of the maximum standard Proctor dry density at 1 ½ percentage points above optimum moisture content, the material has a hydraulic conductivity of about 1.1×10^{-8} centimeters per second.

B.6. Preliminary Stability and Seepage Analyses

B.6.a. Cross Sections

The cross section for the dam embankment was provided by HEI and consists of a 10 foot wide top with 4H:1V side slopes. The preliminary design also contains a clay core with 1.5H:1V clay core. We analyzed a cross section taken at Boring ST-01, approximate Station 200+00, and at Boring ST-02, approximate station 234+00. The existing ground surface elevation at each location was taken from the existing grade plan and profile prepared by HEI.

B.6.b. Hydraulic Conditions

HEI requested that we analyze the embankment storing the maximum height of water, elevation 893.2, for 30 days. We evaluated the condition where the water gradually recedes over the course of about 80 to 100 days and where it recedes over a period of 1 day (rapid drawdown). The resulting piezometric conditions at several timesteps were then used to perform stability analyses on the preliminary cross sections.

B.6.c. Material Properties

We developed the strength properties for our preliminary design using our experience with similar Glacial Lake Agassiz fat clay deposits in the Red River Valley. The geologic mapping data we reviewed indicates the soils on the project site were deposited in an offshore lagoon separated from Glacial Lake Agassiz and we anticipate the soils will have comparable characteristics.

We have performed stability analyses for private, municipal and United States Army Corps of Engineers projects throughout the valley and have developed a database of material properties for these glacial lake soils. The soils beneath the project site have blow counts that are about twice that of what we commonly see in the Red River Valley and moisture contents of the on site soils are about 60 to 80 percent of what we commonly see in the Red River Valley. Given these two conditions we anticipate that the actual strengths of the soils are likely somewhat higher than typical of the Red River Valley and therefore our analysis is likely conservative. Given the similar depositional characteristics, we anticipate the horizontal and vertical hydraulic conductivities will be similar to those seen in other deposits beneath Glacial Lake Agassiz. Regardless, if the project moves to final design, additional exploration and lab testing will be used to evaluate specific strengths of the soils on site. The hydraulic conductivity of the clay core was taken from the results of our laboratory testing on the borrow material.

We assigned the unit weight, shear strength, and hydraulic parameters shown in Table 2 for the material strata built into our analytical model.

Table 2. Material Properties.

Stratum Name	Unit Weight (pcf)	Total Stress Condition Cohesion (psf)	Effective Stress Condition		Horizontal Permeability (ft/day)	K_y/K_x Ratio
			Cohesion (psf)	Friction Angle (degrees)		
General Fill	115	500	100	22	0.01	1.0
Clay Core	120	900	100	24	3.1×10^{-5}	1.0
Fat Clay (Upper)	115	750	0	24	2.8×10^{-4}	0.1
Fat Clay (Lower)	110	900	0	18	2.8×10^{-4}	0.25
Sand Fill	125	--	0	32	1.0	1

B.6.d. Analytical Results

Included in the Appendix is a series of analytical graphics illustrating the results of our seepage and slope stability analyses. The graphics include piezometric conditions under construction conditions, rapid drawdown and steady state seepage and theoretical slope stability failure limits with associated factor of safety. There is a set of graphics for each of the two cross sections. The analytical summary included before the graphics, summarizes the factors of safety under each condition.

Initially we modeled the stability and seepage under the scenario of constructing the entire embankment out of general fill and clay core materials. With these conditions, the modeling demonstrated results that were less than acceptable factors of safety for drawdown. Consequently we added a zone of sand fill material at the upstream toe of the embankment to alleviate this condition. The wet side sand toe is comprised of material that will have a design friction angle of at least 32 degrees. This material will likely be specified as a silty sand or clayey sand that is properly compacted. More granular material will also meet these requirements. The geometry of the wet side sand toe as defined from the toe of the dam is 16 feet into the pool, 3 feet down from the toe at a 2:1 towards the dam, 20 feet in toward/under the dam and up at a 2:1 slope to intersect the dam limit. With this modification to the original cross section we obtained acceptable factors of safety from Figure 5-3 of the TR-60 manual by the NRCS referenced above.

Our analytical results demonstrate that from a preliminary seepage and stability condition the proposed dam will be able to meet the required minimum factors of safety set forth by the NRCS for a High Hazard Class A dam. While the wet side sand toe is needed for stability under rapid drawdown conditions, a toe drain on the dry side or other seepage control mechanism is not needed based on the current analyses.

The results also demonstrate the site is suitable for construction on the native soils from a bearing capacity standpoint.

As stated in other portions of this preliminary report, if the project moves to final design, additional seepage and stability analyses will need to be performed based on more site exploration and lab testing, further defined geometry and planned operating conditions. Further defined operating condition limits and available general fill soils could be such that the wet side sand toe is ultimately not needed.

C. Preliminary Findings

The current level of exploration, laboratory testing and analysis performed indicates that the site is likely feasible for support of a new earthen dam. From our work to date we have identified the design and construction considerations provided below.

C.1. Design Considerations

C.1.a. Groundwater

We could not precisely measure the depth of groundwater at or near the site due to the lack of reliable information. Our interpreted groundwater depth based on existing information is approximate. Further exploration should include installing piezometers at selected locations across the site to monitor groundwater level for final design and construction recommendations. The piezometric conditions will aid in evaluating if the project design needs to consider staged construction to allow pore water pressures to dissipate and avoid a bearing capacity failure.

C.1.b. Settlement

The deep unconsolidated clay could settle significantly over time from dam construction. Where the dam is 15 feet higher than existing grades we anticipate as much as 1 foot of settlement. Overbuilding the dam should be used to compensate for the loss of dam height from the settlement and to maintain the minimum required freeboard. The settlement will likely increase linearly as the embankment height increases but further exploration, laboratory testing and analysis will be needed to define zones and amount of settlement.

C.1.c. Reuse of Onsite Soils

The native materials encountered near the surface in Borings ST-01 and ST-02 along the proposed alignment as well as that encountered in Borings ST-03 and ST-04, where soils may be excavated to build the embankment, are suitable for construction of the proposed embankment. All of the soils encountered, with the exception of the topsoil, are suitable for embankment construction. The clayey sand soils from Boring ST-04 may need to be used as general fill outside of a clay core, however the remaining soils are suitable for a clay core.

Sand needed for the sand fill will need to be imported. Sand meeting ASTM Classifications of SM, SC, SP, SP-SM, GP, GM, GP-GM will meet the frictional requirements in our model. Based on our review of the geology maps, there are several locations surrounding Mountain, ND that are mapped as sand and gravel deposits and we thus we anticipate the material will be locally available.

C.1.d. Geometry

Our preliminary analyses demonstrate the stability and seepage suitability of the proposed embankment geometry using strength parameters selected based on our experience with soils similar to those on site. The proposed embankment has satisfactory factors of safety against failure under construction, rapid drawdown and steady state-impoundment full and steady state-impoundment drained conditions. Given the soil type we anticipate that steepening the side slopes may result in surficial failures over time and thus do not anticipate it will be preferable.

C.1.e. Inspection Trench

We recommend a 6-foot deep inspection trench be excavated beneath the centerline of the embankment after topsoil has been removed. The inspection trench depth can be reduced to match the height of the embankment where it is less than 6 feet above existing grades. The purpose of the inspection trench is to allow verification of the near surface soils along the entirety of the length of the impoundment. The inspection trench should be backfilled with clay meeting the same requirements as the clay core.

C.2. Construction Considerations

C.2.a. Groundwater

Groundwater was noted as high as 2 feet when the first borehole was rechecked the day after drilling. The native soils consist of fat clays with low permeability's and water flows are likely to be concentrated in lenses and laminations of silt or sand within the predominantly clay matrix. The amount of water that collects within excavations will be a function of the size and amount of silt layers encountered in the sidewall of the excavation and the duration of open excavations. We anticipate groundwater or surface water that collects within excavations can be controlled with sumps and pumps.

C.2.b. Construction Disturbance

It has been our experience that when native fat clays are encountered within the upper 2 to 5 feet of the ground surface they are generally stable enough to support rubber-tired equipment, with exception to periods during and following precipitation. Construction traffic over wet fat clay subgrades should be limited to low-pressure equipment as the soils are highly susceptible to strength loss under repetitive construction traffic when they are wet. The wetter the soils are (due to natural conditions or through precipitation) the weaker and more susceptible to disturbance by construction traffic they become. Ways to prevent the adverse effects of moisture sensitive clays include proper site drainage, appropriate dewatering, and limiting the duration of open excavations.

C.2.c. Moisture Conditioning

The native soils have moisture contents that are judged to be near to well above their estimated optimum moisture contents. The soils from borrow pits will need to be dried back in order to be placed per typical dam specifications. Generally in northeastern North Dakota, the months of June through September are most favored for grading operations, particularly where the clay-rich soils will require drying. Cooler temperatures and wet weather conditions earlier in the spring, in the fall and through the winter tend to slow or delay grading and construction. We recommend consideration be given to scheduling earthwork to take advantage of these favorable months as much as possible. Performing the construction in low and wet areas during the fall months will likely result in greater delays and decreased workability of the soils, due to cooler days (less drying time).

Clay-rich soils that become saturated during cool or wet periods will be difficult to dry and will provide limited support to heavy construction equipment; rubber-tire vehicles and even heavy tracked dozers can disturb otherwise competent soils, increasing the effort required to stabilize or correct subgrades.

As the native fat clays gain strength as they are dried, earthwork contractors will generally prefer to allow the fat clays to dry below their optimum moisture content to make them easier to work with. However, when the fat clays are dried below their optimum moisture content they will not meet the typical moisture specification for dam embankment construction and would need to be wetted again. Strict control of the moisture content of the native fat clays should be enforced.

C.2.d. Topsoil

Topsoil is not suitable for reuse as embankment fill. This material should be stockpiled separately for use as dressing on the exterior sides of the embankment after it is constructed.

D. Procedures

D.1. Penetration Test Borings

We drilled the penetration test borings with a flotation tire-mounted core and auger drill equipped with hollow-stem auger. We performed the borings in general accordance with ASTM D6151 taking penetration test samples at 2 1/2- or 5-foot intervals in general accordance to ASTM D1586. We collected thin-walled tube samples in general accordance with ASTM D1587 at selected depths. The boring logs show the actual sample intervals and corresponding depths. We also collected bulk samples of auger cuttings at selected locations for laboratory testing.

D.2. Exploration Logs

D.2.a. Log of Boring Sheets

The Appendix includes Log of Boring sheets for our penetration test borings. The logs identify and describe the penetrated geologic materials, and present the results of penetration resistance tests performed. The logs also present the results of laboratory tests performed on penetration test samples, and groundwater measurements. The Appendix also includes a Fence Diagram intended to provide a summarized cross-sectional view of the soil profile across the site.

We inferred strata boundaries from changes in the penetration test samples and the auger cuttings. Because we did not perform continuous sampling, the strata boundary depths are only approximate. The boundary depths likely vary away from the boring locations, and the boundaries themselves may occur as gradual rather than abrupt transitions.

D.2.b. Geologic Origins

We assigned geologic origins to the materials shown on the logs and referenced within this report, 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 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.

D.3. Material Classification and Testing

D.3.a. Visual and Manual Classification

We visually and manually classified the geologic materials encountered based on ASTM D2488. When we performed laboratory classification tests, we used the results to classify the geologic materials in accordance with ASTM D2487. The Appendix includes a chart explaining the classification system we used.

D.3.b. Laboratory Testing

The exploration logs in the Appendix note most of the results of the laboratory tests performed on geologic material samples. The remaining laboratory test results follow the exploration logs. We performed the tests in general accordance with ASTM or AASHTO procedures.

D.4. Groundwater Measurements

The drillers checked for groundwater while advancing the penetration test borings, and again after auger withdrawal. We then filled the boreholes or allowed them to remain open for an extended period of observation, as noted on the boring logs.

E. Qualifications

E.1. Variations in Subsurface Conditions

E.1.a. Material Strata

We developed our evaluation, analyses and recommendations 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, we must infer strata boundaries and thicknesses to some extent. Strata boundaries may also be gradual transitions, and project planning should expect the strata 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 performing additional exploration work, or starting construction. If future activity for this project reveals any such variations, you should notify us so that we may reevaluate our recommendations. Such variations could increase construction costs, and we recommend including a contingency to accommodate them.

E.1.b. Groundwater Levels

We made groundwater measurements under the conditions reported herein and shown on the exploration logs, and interpreted in the text of this report. Note that the observation periods were relatively short, and project planning can expect groundwater levels to fluctuate in response to rainfall, flooding, irrigation, seasonal freezing and thawing, surface drainage modifications and other seasonal and annual factors.

E.2. Continuity of Professional Responsibility

E.2.a. Plan Review

We based this report on a limited amount of information, and we made a number of assumptions to help us develop our recommendations. We should be retained to review the geotechnical aspects of the designs and specifications. This review will allow us to evaluate whether we anticipated the design correctly, if any design changes affect the validity of our recommendations, and if the design and specifications correctly interpret and implement our recommendations.

E.2.b. Additional Evaluations & Construction Observations and Testing

We recommend retaining us to perform the next phases of the project design and the required observations and testing during construction as part of the ongoing geotechnical evaluation. This will allow us to correlate the subsurface conditions noted in our borings to date with those encountered by additional borings, and eventually exposed during construction, and provide professional continuity from the design phase to the construction phase. If we do not perform the additional evaluation and observations and testing during construction, it becomes the responsibility of others to validate the assumption made during the preparation of this report and to accept further design and the construction-related geotechnical engineer-of-record responsibilities.

E.3. Use of Report

This report is for the exclusive use of the addressed parties. 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.

E.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

DENOTES APPROXIMATE LOCATION OF STANDARD PENETRATION TEST BORING

250' 0 500'

SCALE: 1"= 500'

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BRAUN INTERTEC
The Science You Build On.

11001 Hampshire Avenue S
Minneapolis, MN 55438
952.995.2000
braunintertec.com

Drawing Information

Project No:
B1904637

Drawing No:
B1904637

Drawn By: JAG
Date Drawn: 8/27/19
Checked By: EB
Last Modified: 8/28/19

Project Information

Cart Creek Site 1

Northwest Quadrant of 86th Street NE and 132nd Avenue NE Intersection

Mountain, North Dakota

Soil Boring Location Sketch

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B1904637 **Preliminary Geotechnical Evaluation** **Cart Creek Site 1** **Mountain, North Dakota**	BORING: **ST-01**		
	LOCATION: Approximate station 200 + 00, see attached sketch		
	LATITUDE: 48.65936	LONGITUDE: -97.79674	
DRILLER: G. Bevre	LOGGED BY: E. Ballinger	START DATE: 05/08/19	END DATE: 05/08/19
SURFACE ELEVATION: 968.0 ft	RIG: 7508 / METHOD: 3 1/4" HSA	SURFACING: Pastureland	WEATHER: Partly cloudy, cool

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample Depth	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
966.5 / 1.5		LEAN CLAY (CL), little Sand, with organic, black, moist (TOPSOIL)		1-2-3 (5) 8"			
		FAT CLAY (CH), trace Sand, brown, moist, soft to medium (ALLUVIUM)		2-2-2 (4) 18"	1.75	35	
			5	2-2-5 (7) 18"	2	35	LL=80, PL=27, PI=53
961.0 / 7.0		FAT CLAY (CH), trace Sand, brown, moist, medium to stiff (GLACIAL LAKE)		2-2-3 (5) 18"	2.5	36	
			10	2-2-4 (6) 18"	2	30	
				3-5-5 (10) 18"	2.75	31	
		Inclusions of crystals at 15 feet	15	3-3-3 (6) 18"	2.75	30	
				TW 24"	2	27	DD=95 pcf WD=121 pcf
		Brown and gray at 19 feet	20	2-3-3 (6) 24"	2.5	29	LL=59, PL=21, PI=38
				2-4-5 (9) 18"	2.5	36	
		Silt lenses and laminations below 25 feet	25	3-3-6 (9) 18"	2.5	33	
		Gray below 27 1/2 feet		3-3-3 (6) 18"	1.75	36	
			30	3-4-5 (9) 18"	2.5	30	

Continued on next page

LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B1904637
Preliminary Geotechnical Evaluation
Cart Creek Site 1
Mountain, North Dakota

BORING:	**ST-01**		
LOCATION: Approximate station 200 + 00, see attached sketch			
LATITUDE:	48.65936	LONGITUDE:	-97.79674
DRILLER:	G. Bevre	LOGGED BY:	E. Ballinger
START DATE:	05/08/19	END DATE:	05/08/19
SURFACE ELEVATION:	968.0 ft	RIG:	7508
METHOD:	3 1/4" HSA	SURFACING:	Pastureland
WEATHER:	Partly cloudy, cool		

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Depth	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
		FAT CLAY (CH), trace Sand, brown, moist, medium to stiff (GLACIAL LAKE)						
			35	TW	TW 24"	2	39	DD=80 pcf WD=110 pcf
			40	SS	2-5-7 (12) 18"	2.25	32	
			45	SS	2-3-5 (8) 18"	1.5	34	
917.0		*SILT layer at 50 feet*	50	SS	4-5-7 (12) 18"	2	36	
51.0		END OF BORING Boring immediately grouted						
			55					
			60					

LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B1904637 **Preliminary Geotechnical Evaluation** **Cart Creek Site 1** **Mountain, North Dakota**	BORING: **ST-02**		
	LOCATION: Approximate station 234 + 00, see attached sketch		
	LATITUDE: 48.66866	LONGITUDE: -97.79662	
DRILLER: G. Bevre	LOGGED BY: E. Ballinger	START DATE: 05/08/19	END DATE: 05/08/19
SURFACE ELEVATION: 970.0 ft	RIG: 7508	METHOD: 3 1/4" HSA	SURFACING: Pastureland; WEATHER: Partly cloudy, cool

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
969.0 1.0		LEAN CLAY (CL), little Sand, with organic, black, moist (TOPSOIL)		1-2-2 (4) 14"			
	▽	FAT CLAY (CH), trace Sand, dark gray, moist, medium (ALLUVIUM)		2-3-4 (7) 13"	1.75	29	
	▽						
		CLAYEY SAND layer, fine-grained at 5 feet	5	2-2-3 (5) 17"		27	
		a little Sand at 7 1/2 feet		2-3-3 (6) 18"		30	
	▼	*SANDY SILT layer at 10 feet*	10	TW 24"		41	LL=63, PL=18, PI=45 DD=80 pcf WD=113 pcf
958.0 12.0		FAT CLAY (CH), gray, moist, medium (GLACIAL LAKE)		2-3-5 (8) 17"	2.5	35	
			15	2-3-4 (7) 18"	2	35	
		Silt lenses and laminations at 17 1/2 feet		2-3-4 (7) 18"	2.25	37	
			20	2-3-4 (7) 18"	2.25	29	
		Silt lenses and laminations at 22 1/2 feet		3-4-4 (8) 18"	2	31	
			25	TW 24"		38	LL=55, PL=16, PI=39 DD=82 pcf WD=114 pcf
				2-4-2 (6) 18"	0.5	41	
			30	TW 24"		37	DD=85 pcf WD=116 pcf

Continued on next page

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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B1904637 **Preliminary Geotechnical Evaluation** **Cart Creek Site 1** **Mountain, North Dakota**	BORING: **ST-02**		
	LOCATION: Approximate station 234 + 00, see attached sketch		
	LATITUDE: 48.66866	LONGITUDE: -97.79662	
DRILLER: G. Bevre	LOGGED BY: E. Ballinger	START DATE: 05/08/19	END DATE: 05/08/19
SURFACE ELEVATION: 970.0 ft	RIG: 7508	METHOD: 3 1/4" HSA	SURFACING: Pastureland	WEATHER: Partly cloudy, cool

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
		FAT CLAY (CH), gray, moist, medium (GLACIAL LAKE)					
35		*SILT layer at 35 feet*	X	2-3-3 (6) 18"		32	
40			X	1-2-3 (5) 18"	0.5	50	
45			X	2-3-4 (7) 18"	0.25	40	
50		*Silt lenses and laminations at 50 feet*	X	1-2-4 (6) 18"		36	
919.0 51.0		END OF BORING Boring immediately grouted					Water observed at 10.0 feet with 51.0 feet of tooling in the ground at end of drilling. Water observed at 2.0 feet with a cave-in depth of 10.0 feet when rechecked 18 hours after drilling.
55							
60							

LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B1904637
Preliminary Geotechnical Evaluation
Cart Creek Site 1
Mountain, North Dakota

BORING:	**ST-03**		
LOCATION: See attached sketch			
LATITUDE:	48.65928	LONGITUDE:	-97.80748
START DATE:	05/09/19	END DATE:	05/09/19
SURFACING:	Pastureland	WEATHER:	

DRILLER:	G. Bevre	LOGGED BY:	E. Ballinger
SURFACE ELEVATION:		RIG: 7508	METHOD: 3 1/4" HSA

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
1.0		SANDY LEAN CLAY (CL), black, moist (TOPSOIL)	X	1-2-3 (5) 10"			
		FAT CLAY (CH), little Sand, brown and gray, moist, soft to medium (ALLUVIUM)	X	2-2-2 (4) 8"			
			X	1-2-2 (4) 17"			
			X	1-1-2 (3) 15"	0.75		
11.0			X	1-2-3 (5) 18"	1.75		Water not observed with 9.5 feet of tooling in the ground while drilling.
		END OF BORING Boring immediately grouted					

Depth scale: 5, 10, 15, 20, 25, 30

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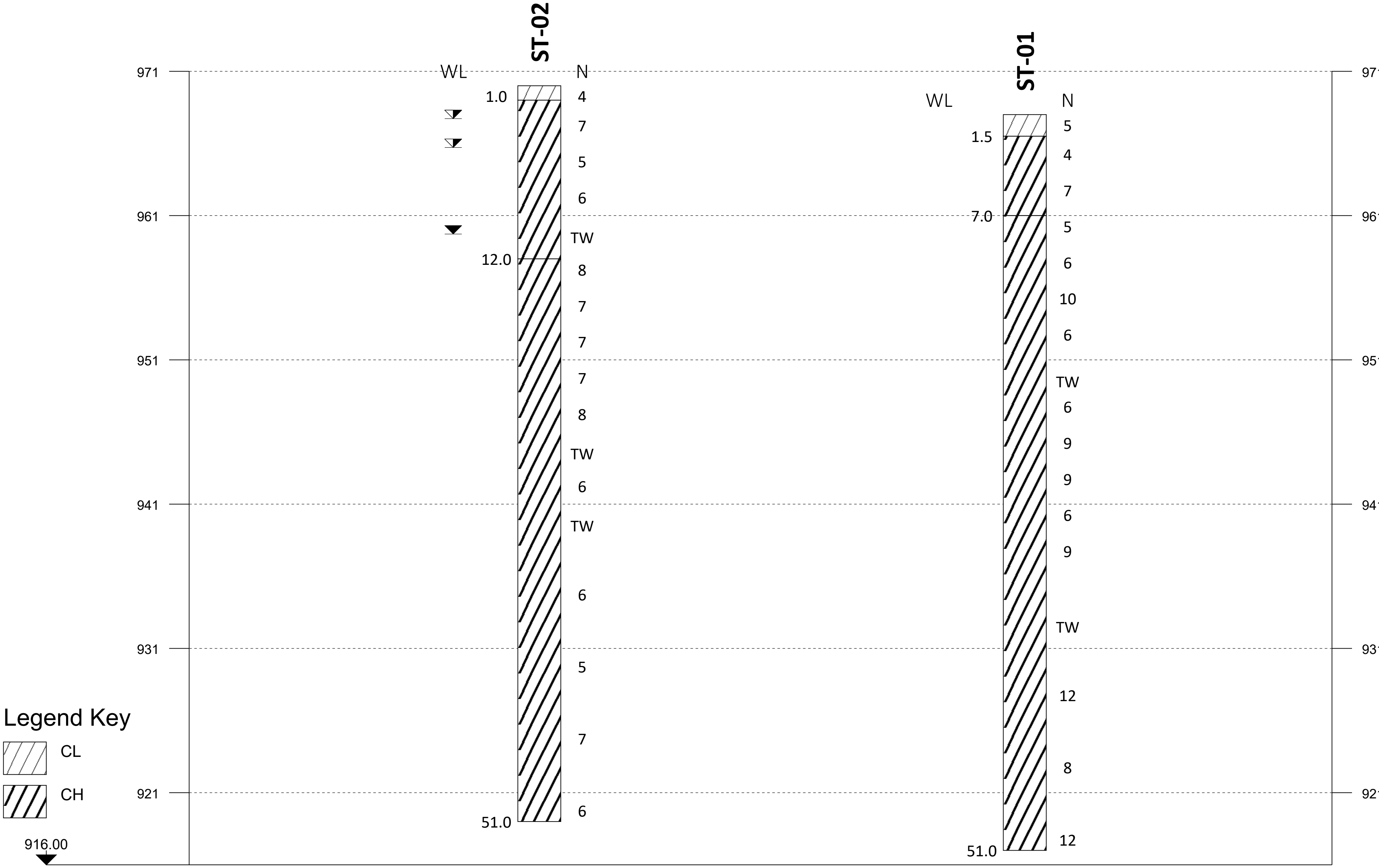
LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B1904637 **Preliminary Geotechnical Evaluation** **Cart Creek Site 1** **Mountain, North Dakota**	BORING: **ST-04**		
	LOCATION: See attached sketch		
	LATITUDE: 48.66892	LONGITUDE: -97.80740	
DRILLER: G. Bevre	LOGGED BY: E. Ballinger	START DATE: 05/09/19	END DATE: 05/09/19
SURFACE ELEVATION: / RIG: 7508	METHOD: 3 1/4" HSA	SURFACING: Pastureland	WEATHER:

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (N-Value) Recovery	q_p tsf	MC %	Tests or Remarks
1.0		SANDY LEAN CLAY (CL), with organic, black, moist (TOPSOIL)	X	2-4-5 (9) 18"			
5.5		FAT CLAY (CH), little Sand, brown, moist, medium (ALLUVIUM)	X	2-4-3 (7) 18"	2		Bag sample obtained from 2 to 8 feet
			X	2-2-2 (4) 18"			
11.0	▽	CLAYEY SAND (SC), fine sand, little Gravel, brown, moist, loose (ALLUVIUM) *Wet at 10 feet*	X	2-4-4 (8) 18"			
			X	2-4-4 (8) 18"			Water observed at 8.0 feet with 8.5 feet of tooling in the ground while drilling.
		END OF BORING Boring immediately grouted					



SECTION LINE 1

Fence Diagram

Preliminary Geotechnical Evaluation

Cart Creek Site 1

Mountain, North Dakota

Project ID: B1904637

Vert. Scale: 1"= xxx'

Hor. Scale: NTS

Date: 08-27-2019

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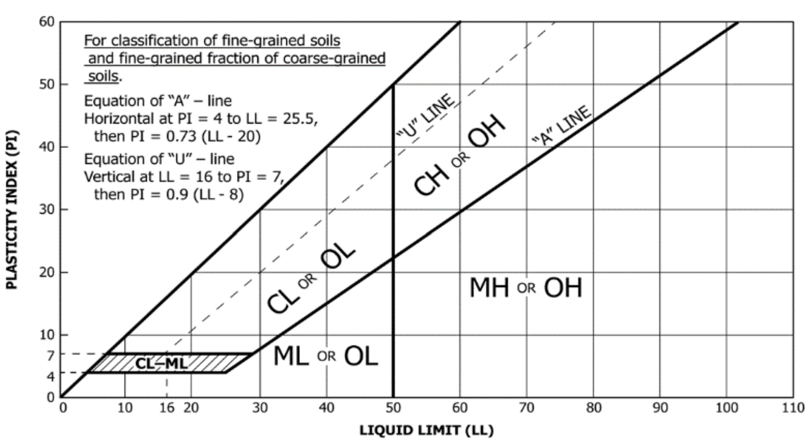
Descriptive Terminology of Soil

Based on Standards ASTM D2487/2488
(Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: 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[C])	$C_u \geq 4$ and $1 \leq C_c \leq 3$[D]	GW	Well-graded gravel[E]
			$C_u < 4$ and/or ($C_c < 1$ or $C_c > 3$)[D]	GP	Poorly graded gravel[E]
		Gravels with Fines (More than 12% fines[C])	Fines classify as ML or MH	GM	Silty gravel[E F G]
			Fines Classify as CL or CH	GC	Clayey gravel[E F G]
	Sands (50% or more coarse fraction passes No. 4 sieve)	Clean Sands (Less than 5% fines[H])	$C_u \geq 6$ and $1 \leq C_c \leq 3$[D]	SW	Well-graded sand[I]
			$C_u < 6$ and/or ($C_c < 1$ or $C_c > 3$)[D]	SP	Poorly graded sand[I]
		Sands with Fines (More than 12% fines[H])	Fines classify as ML or MH	SM	Silty sand[F G I]
			Fines classify as CL or CH	SC	Clayey sand[F G I]
Fine-grained Soils (50% or more passes 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] / 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] / 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 (75-mm) sieve.
B. If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
C. 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
D. $C_u = D_{60} / D_{10}$ $\quad C_c = (D_{30})^2 / (D_{10} \times D_{60})$
E. If soil contains ≥ 15% sand, add "with sand" to group name.
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. 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
I. If soil contains ≥ 15% gravel, add "with gravel" to group name.
J. If Atterberg limits plot in hatched area, soil is CL-ML, silty clay.
K. If soil contains 15 to < 30% 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 gravel, 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" line.
Q. PI plots below "A" line.



Particle Size Identification

Boulders............. over 12"
Cobbles................ 3" to 12"
Gravel
  Coarse............ 3/4" to 3" (19.00 mm to 75.00 mm)
  Fine................ No. 4 to 3/4" (4.75 mm to 19.00 mm)
Sand
  Coarse............. No. 10 to No. 4 (2.00 mm to 4.75 mm)
  Medium........... No. 40 to No. 10 (0.425 mm to 2.00 mm)
  Fine................. No. 200 to No. 40 (0.075 mm to 0.425 mm)
Silt....................... No. 200 (0.075 mm) to .005 mm
Clay..................... < .005 mm

Relative Proportions[L, M]

trace............................ 0 to 5%
little............................. 6 to 14%
with.............................. ≥ 15%

Inclusion Thicknesses

lens............................... 0 to 1/8"
seam............................ 1/8" to 1"
layer............................. over 1"

Apparent 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	Blows Per Foot	Approximate Unconfined Compressive Strength
Very soft	0 to 1 BPF	< 0.25 tsf
Soft	2 to 4 BPF	0.25 to 0.5 tsf
Medium	5 to 8 BPF	0.5 to 1 tsf
Stiff	9 to 15 BPF	1 to 2 tsf
Very Stiff	16 to 30 BPF	2 to 4 tsf
Hard	over 30 BPF	> 4 tsf

Moisture Content:

Dry: Absence of moisture, dusty, dry to the touch.
Moist: Damp but no visible water.
Wet: Visible free water, usually soil is below water table.

Drilling Notes:

Blows/N-value: Blows indicate the driving resistance recorded for each 6-inch interval. The reported N-value is the blows per foot recorded by summing the second and third interval in accordance with the Standard Penetration Test, ASTM D1586.

Partial Penetration: If the sampler could not be driven through a full 6-inch interval, the number of blows for that partial penetration is shown as #/x" (i.e. 50/2"). The N-value is reported as "REF" indicating refusal.

Recovery: Indicates the inches of sample recovered from the sampled interval. For a standard penetration test, full recovery is 18", and is 24" for a thinwall/shelby tube sample.

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

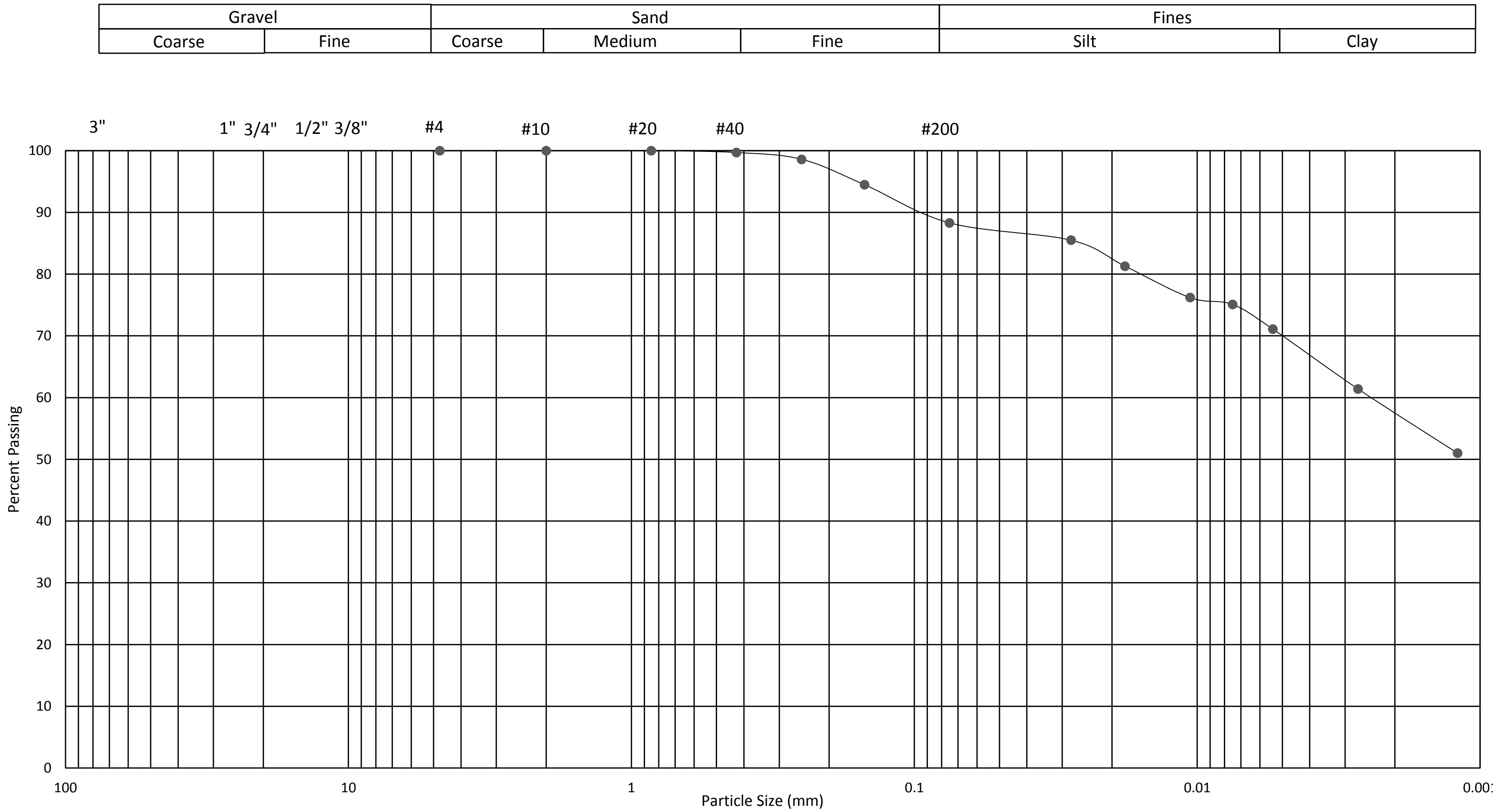
WOR: Indicates the sampler penetrated soil under weight of rods alone; hammer weight and driving not required.

Water Level: Indicates the water level measured by the drillers either while drilling (▽), at the end of drilling (▼), or at some time after drilling (▼).

Laboratory Tests

DD	Dry density, pcf	**OC**	Organic content, %	**LL**	Liquid limit
WD	Wet density, pcf	**q_p**	Pocket penetrometer strength, tsf	**PL**	Plastic limit
P200	% Passing #200 sieve	**MC**	Moisture content, %	**PI**	Plasticity index
		q_U	Unconfined compression test, tsf		

Grain Size Accumulation Curve (ASTM)



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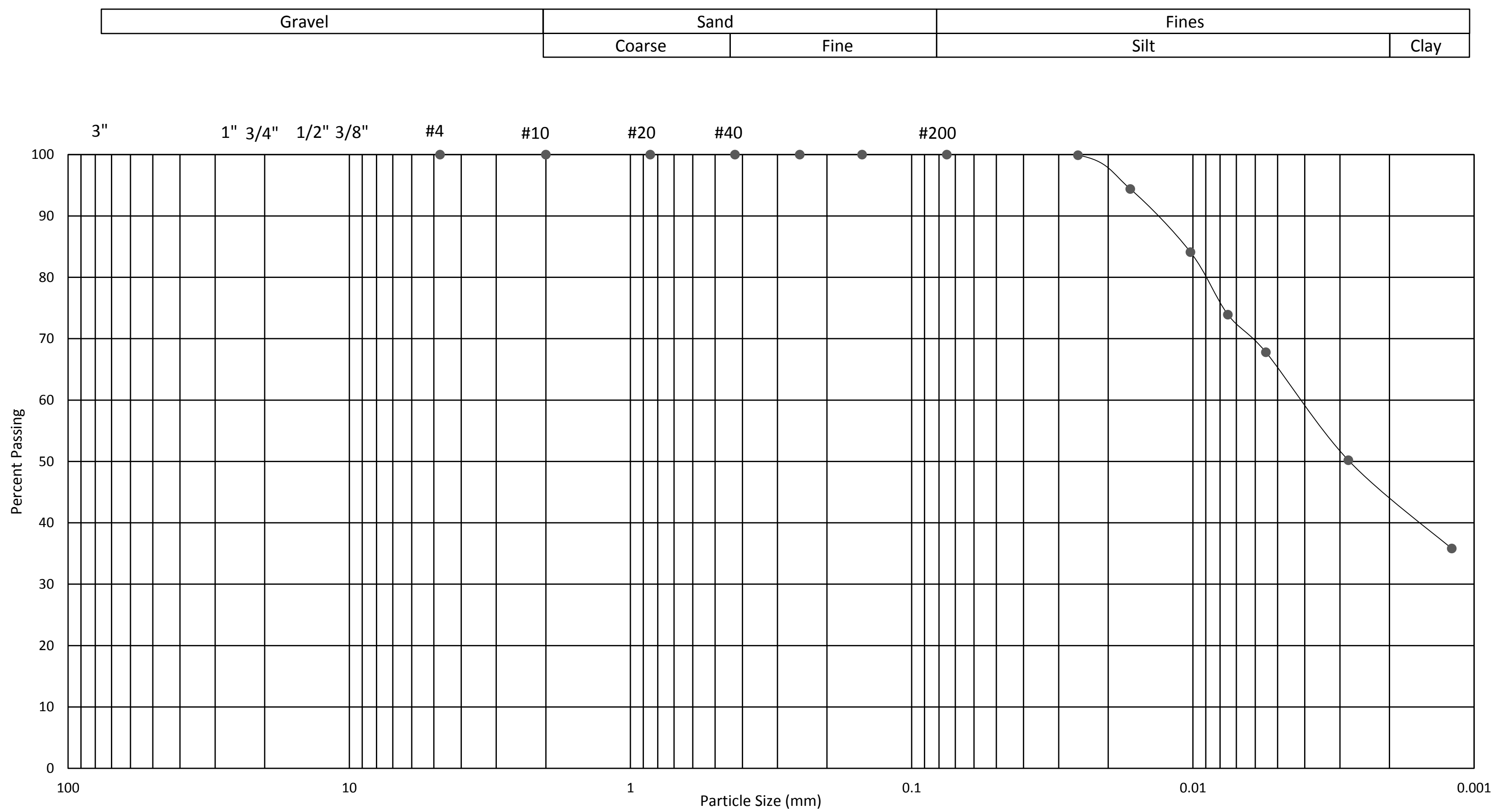
Project Number	B1904637
Sample Number	243431
Boring Number	ST-02
Depth	9' - 11'

Gravel	0.0		
Sand	11.7		
Silt	21.7		
Clay	66.6		
D60=	0.002	Cu=	n/a
D30=	n/a	Cc=	n/a
D10=	n/a		

Classification

FAT CLAY (CH)

Grain Size Accumulation Curve (AASHTO)



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Project Number	B1904637	Gravel	0.0			Classification
Sample Number	243433	Sand	0.0			Fat Clay (CH)
Boring Number	ST-2	Silt	55.6			
Depth	24.5' - 26.5'	Clay	44.4			
		D60=	0.004	Cu=	n/a	
		D30=	n/a	Cc=	n/a	
		D10=	n/a			

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11001 Hampshire Avenue S
Minneapolis, MN 55438
Phone: 952-995-2000

Standard Proctor M-D Relationship

ASTM D698

Client:

Houston Engineering, Inc.
6901 E Fish Lake Rd, Ste 140
Maple Grove, MN 55369

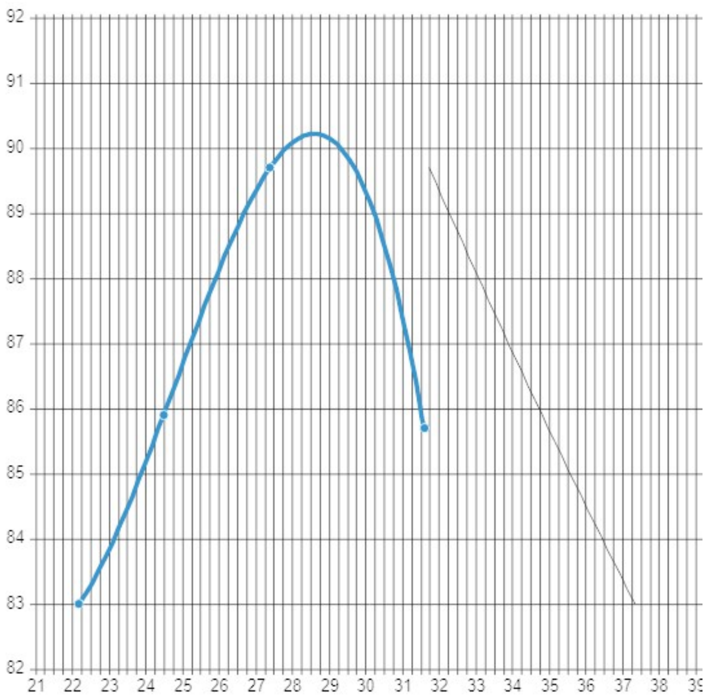
Project:

B1904637
Cart Creek Site 1
NE Quadrant of 86th Street NE & 131st Avenue ...
Mountain, ND 58262

Sample Information

Sample Number:	240208	**Sampled By:**	Miller, Kevin
Location:	Other		
Location Details:	ST-03, 1-11'		
Sample Date:	05/21/2019		
Received Date:	05/23/2019	**Lab:**	11001 Hampshire Ave S, Bloomington, MN
Tested Date:	05/23/2019	**Tested By:**	Kylander, Joshua

Laboratory Data



Proctor ID:	P-01-std		
Maximum Dry Density (pcf):	90.2		
Optimum Moisture (%):	28.6		
Method:	Method A		
Preparation Method:	Dry		
Rammer Type:	Manual Round		
Specific Gravity:	2.65		
Specific Gravity Source:	Assumed		
Passes #200 (%):	87.0	**Retained #200 (%):**	13.0
Retained On 3/4 (%):	0	**Retained On 3/8 (%):**	0
Retained On #4 (%):	0	**Passing #4 (%):**	100

Classification: CH Fat clay,fine to medium grained,gray

General

Remarks: The % passing the #200 is for informational purposes only.

Hydraulic Conductivity
ASTM D5084

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11001 Hampshire Avenue S
Minneapolis, MN 55438
Phone: 952-995-2000

Client:
Houston Engineering, Inc.
6901 E Fish Lake Rd, Ste 140
Maple Grove, MN 55369

Project:
B1904637
Cart Creek Site 1
NE Quadrant of 86th Street NE & 131st Avenue ...
Mountain, ND 58262

Sample Information

Sample Number: 240208

Sample Location : ST-03, 1-11'

Sample Date: 05/21/2019

Received Date: 05/23/2019 **Lab:** 11001 Hampshire Ave S, Bloomington, MN, 55438

Tested Date: 06/03/2019 **Tested By:** Streier, Jim

Laboratory Data

Type Of Specimen: Remolded **Back Pressure (psi):** 91.00

Permeant Liquid: Water **Specific Gravity:** 2.70 (Assumed)

Saturation B Coefficient: 1.00 **Effective Pressure (psi):** 8.00

Method: Method C Falling Head Rising Tailwater

Time Interval (sec)	Average Head Loss (cm)	Average Test Temperature (°C)	Quantity Of Flow (cm^3)	Hydraulic Gradient	K (cm/sec) At 20 °C
89400	213.416	22.0	0.0000	30.19	1.3E-08
26580	214.166	22.0	0.0000	30.30	1.1E-08
36600	213.916	22.0	0.0000	30.26	1.1E-08
19680	213.616	22.0	0.0000	30.22	1E-08

Average Of Last Four Hydraulic Conductivity (cm/sec): 1.1E-08

Saturation (%)	**Initial:**	86	**Final:**	96
Moisture Content (%)	**Initial:**	30	**Final:**	33.6
Dry Density Of Specimen (pcf)	**Initial:**	86.9	**Final:**	86.5

General