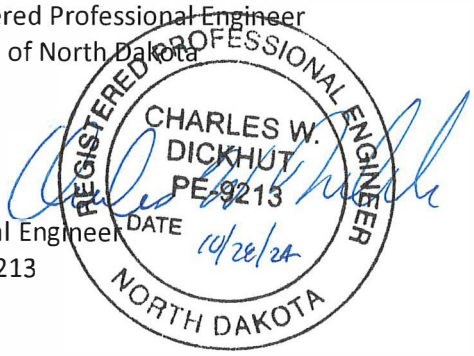
Geotechnical Evaluation Report

CERP-0221(085) PCN 24082
CR 21, North of Bayshore Resort
Barnes County, North Dakota

Prepared for

KLJ Engineering

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



Charles W. Dickhut, PE
Associate Director, Principal Engineer
Registration Number: PE-9213
Date: October 28, 2024

Project B2400867

Braun Intertec Corporation
ND Company Registration PE-201

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October 28, 2024 Project B2400867

Bryan Tykwinski, PE
KLJ Engineering
1010 4th Ave SW
Valley City, ND 58072

Re: Geotechnical Evaluation
CERP-0221(085) PCN 24082
CR 21, North of Bayshore Resort
Barnes County, North Dakota

Dear Mr. Tykwinski:

We are pleased to present this Geotechnical Evaluation Report for the embankment instability at the reference location. We concluded that a sheet pile or soldier pile wall will provide reliable support for the highway that is being affected by movement of the embankment downslope.

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 contact Wes Dickhut at 701.934.1618 (wdickhut@braunintertec.com)

Sincerely,

BRAUN INTERTEC CORPORATION

Charles W. Dickhut, PE
Associate Director, Principal Engineer

Steven P. Nagle, PE
Vice President, Principal Engineer

AA/EOE

Table of Contents

Description **Page**

Table of Contents (continued)

Description **Page**

A. Introduction

A.1. Project Description

This Geotechnical Evaluation Report addresses the design and construction of the proposed road stabilization for CR 21, located about 1,000 feet north of the entrance to the Bayshore Resort in Barnes County, North Dakota.

The photograph below shows an aerial image of the site. More recent photographs are available but have lower detail. The red line approximately indicates the area where the shoulder is distressed.

Photograph 1. Site in 2016

Aerial image from Google Earth™ dated May 16, 2016.

Our Analysis indicates the shoulder distress is due to movement of the landslide mass below the slope. The scarp is visible in the air photo above as the dark line south and to the west of the red line. The landslide mass moves as a relatively thin layer of material downslope.

Based on the relatively flat inclination of the slope in the right of way and the pasture below, we concluded that stabilizing the overall slope would require extensive earthwork outside the right of way.

We discussed limiting the improvement to stabilizing the road shoulder and making the improvement resilient enough to tolerate futures slope movements. We considered a soil nail wall, but concluded since the landslide movement is skew to the roadway, the soil nail elements could develop shear forces they are not designed to support. We therefore evaluated a soldier pile wall with lagging, and a sheet pile wall in greater detail.

We understand that the county would prefer to use a cable-type guard rail system at the site since a W-beam guard rail accumulates snow and requires more frequent clearing. KLJ described that the ideal cross section includes a zone about 5 feet wide from the edge of the pavement to the guardrail with a maximum slope of 10H:1V. The guardrail will prevent cars from going over the wall.

A.2. Site Conditions and History

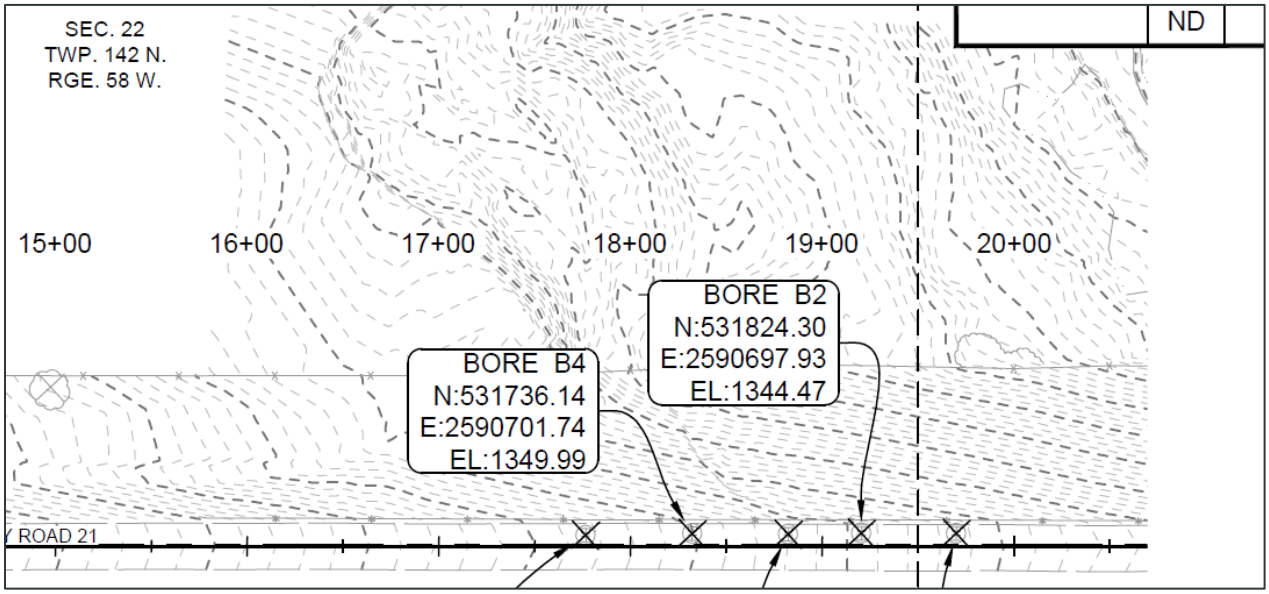
County Highway 21 is located on the upland prairie, east of the Sheyenne River Valley and now Lake Ashtabula. The road crosses an intermittent tributary of the Sheyenne River with a large embankment. Historically, the transitions from cut to deep fills have been areas that require continued maintenance due to instability. We are aware that this portion of Highway 21 has had maintenance issues since 2010. However, the landslide that is southwest of the embankment became more apparent in the last several years.

As can be seen in Photo 1 below, an instability has impacted the west slope of the embankment. There are signs that additional pavement has been placed on the south bound lane to compensate for pavement deformation, though the extent of the patching was not apparent, due to recent surface improvements. Currently, the shoulder has slumped downward about 3 feet below the surface of the road. The distress along the road is approximately 200 feet long.

Photo 1. Located on West side of Embankment Looking North

The embankment has a culvert which allows water from an intermittent stream to pass below the road. There is up to 35 feet of relief between the roadway and the intermittent stream. The instability that is impacting the west embankment is part of a larger landslide to the southwest of the embankment. KLJ surveyed the area and measured the inclination of the slope to the west that was about 3-horizontal to 1-vertical. As seen in this excerpt from the topographic survey, the transition area becomes hummocky and less uniform past the right of way to the north.

Figure 1. Topographic Map Excerpt



Excerpt from preliminary Plan and Profile prepared by KLJ.

A.3. Purpose

The purpose of the geotechnical engineering services is to identify and evaluate the geotechnical aspects of the embankment to aid in design and construction of the repair.

A.4. Background Information and Reference Documents

We reviewed the following information:

- Bedrock and surficial geology map titled Geology and ground water resources of Barnes County, North Dakota, scale 1:126,720, by Kelly, T.E. and Block, D.A., dated 1967. Geology and ground water resources of Barnes County, North Dakota: part I, geology (usgs.gov)
- Preliminary Plan and Profile prepared by KLJ.
- Aerial imagery of the site dated from 1994 to 2023 from Google Earth™. The imagery was utilized in our evaluation of drill rig access and selection of our soil boring locations.
- Communications with Bryan Tykwinski and Shawn Mayfield regarding project scope and recommendations.

In addition to the provided sources, we have used several publicly available sources of information.

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 PCN 24082, dated December 5, 2023, and authorized by Task Order No 2302-01469-1 dated January 16, 2023.
The following list describes the geotechnical tasks completed in accordance with our authorized scope of services.

- We performed a site reconnaissance on March 1, 2024, to review the existing site conditions, length of distress, and conditions. We also used the site reconnaissance to evaluate equipment access and to plan traffic control signage.

- Reviewing the background information and reference documents previously cited.

- Staking and clearing the exploration location of underground utilities. We selected and staked the new exploration locations. We acquired the surface elevations and locations with GPS technology using a Trimble Catalyst GPS Receiver. The Soil Boring Location Sketch included in the Appendix shows the approximate locations of the borings.

- Performing 5 standard penetration test (SPT) borings, denoted as B-01 to B-05, to nominal depths of 40 to 50 feet below grade along the highway.

- Performing laboratory testing on select samples to aid in soil classification and engineering analysis.

- Perform engineering analysis including evaluating the existing subsurface conditions encountered, evaluating the existing topography of the highway shoulder and embankment, recommendations for supporting the highway shoulder, discussion of the landslide mechanism downslope, and an overview of alternatives that may be considered.

- Preparing this report containing a boring location sketch, logs of soil borings, a summary of the soils encountered, results of laboratory tests, and recommendations for design and construction of the stabilization system.

Our scope of services did not include environmental services or testing and our geotechnical personnel performing this evaluation are not trained to provide environmental services or testing. We can provide environmental services or testing at your request.

B. Results

B.1. Site Reconnaissance

We visited the site on March 9, 2024, and observed the distress in the shoulder and the lower slope instability. We selected boring locations along the shoulder.

We returned to the site on October 11, 2024, to evaluate if the extent of the distress had changed and to confirm the length requiring stabilization. The distressed area is approximately 200 feet long; including a 25-ft-long buffer on the ends of the repair brings the length of the stabilization to 250 feet.

B.2. Geologic Overview

Barnes County is dominated by glacial till and end moraines heading south, described as an unsorted, unbedded mixture of angular, subangular, and rounded blocks of cobbles, gravel, and sand in loose, silty-clayey matrix but possess greater strength and are less compressible. The Pierre Formation, gray to black shale with gray marl and numerous beds of bentonite, is found along the Sheyenne River near or at the surface. Colluvium deposits can also be found around the end moraines overlying the Peirre Formation, likely from historic landslides. Embankment fill is typically obtained from nearby borrow materials composed of moderately to highly plastic clays with varying sand and gravel content.

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
Pavement section			▪ Overall thickness ranges from 10 to14 inches. ▪ Bituminous thickness 6 to 7 inches. ▪ Apparent aggregate base is 5 to 7 inches. ▪ Boring in shoulder encountered 14 inches apparent aggregate base.
Fill	ML, SC	5 to 19	▪ General penetration resistance in the low teens. ▪ Moisture condition generally moist. ▪ Thicknesses at boring locations varied from 10 to 28 feet.

Strata	Soil Type - ASTM Classification	Range of Penetration Resistances	Commentary and Details
			▪ Fill consisted of silt with sand and clayey sand with gravel.
Buried Topsoil	CL	10 BPF	▪ Encountered below fill in B-01, B-02, and B-05. ▪ Thickness approximately 2 to 3 feet. ▪ Moisture condition generally moist. ▪ Dark brown. ▪ Consisted of lean clay with roots.
Glacial deposits	SP-SM, SC	5 to 24 BPF	▪ General penetration resistance of mid-teens. ▪ Intermixed layers of glacial outwash and till. ▪ Variable amounts of gravel; may contain cobbles and boulders. ▪ Moisture condition generally moist.
	CL, CH	10 BPF to 50 blows per 2 inches	
Bedrock	Pierre Shale	14 to 40 BPF	▪ Top of bedrock varied from elevation 1298to 1320 feet, becoming deeper to the north. ▪ Bedrock consisted of decomposed gray shale.

*Abbreviations defined in the attached Descriptive Terminology sheets.

We did not perform gradation analysis on the apparent aggregate base material encountered as part of the pavement section, in accordance with our scope of work. Therefore, we cannot conclusively determine if the encountered material satisfies a particular specification, and it should not be assumed it is suitable for reuse.

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

B.4. Groundwater

We did not observe groundwater while performing our 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. If the project team identifies a need for more accurate determination of groundwater depth, we can install piezometers. Project planning should anticipate seasonal and annual fluctuations of groundwater.

B.5. Laboratory Test Results

The boring logs show the results of Atterberg Limit, moisture content, organic content, and percent passing the No. 200 sieve testing we performed, next to the tested sample depth. The Appendix contains the results of these tests.

Tables 2 present a summary of the results of our laboratory tests.

Table 2. Laboratory Classification Test Results

Description	USCS	Moisture Content (w, %)	Percent Passing a #200 Sieve	Organic Content (%)	Liquid Limit	Plastic Index
Fill	ML SC	18-24 23-38	68-76 38-49	-	32 34	7 18
Topsoil	CL	18-20	-	2-4	40	23
Glacial Till	CH	22-40	-	-	61-63	42
Glacial Outwash	SC	16	42	-	42	24
Pierre Shale	CH	28-28	-	-	62-74	41-50

We also performed a unit weight test on an undisturbed sample of the fill. The sample had a wet density of 101 pcf, and a dry density of 82 pcf.

B.6. Slope stability analyses.

We performed a cursory evaluation of slope stability of the road, embankment, and natural slope based on the topography provided by KLJ. We used Slide2 by Rocsience using the General Limit Equilibrium and Spencer's methods. We used a traffic surcharge of 250 psf. We estimated the strength of the soils encountered in our borings using clay fraction and Atterberg Limits tests and the procedures of Dr. Tim Stark at the University of Illinois to estimate fully softened and residual strength. We assumed long term (drained) conditions controlled since there would be little change to the slope geometry during and after construction. Our stability evaluations are attached.

We found that the existing slope had a safety factor that was slightly less than one through the steep shoulder, and was slightly greater than one below. For reference, permanent slopes typically are required to have a safety factor of 1.3 to 1.5 for long term stability. We chose to isolate the shoulder from the slope below using a sheet pile structure.

B.7. Sheet Pile Analyses

A sheet pile wall consists of interlocking, deformed steel plates installed by driving in a line. The shape of the sheet pile provides a reliable structural shape that is used to evaluate the resistance of the sheet pile to bending. Based on the soil properties, we used the program Shoring Suite 8.20c by CivilTech Software to evaluate the required sheet pile section and embedment depth to support the road and a vertical wall. We assumed future slope movement would be less than 5 feet based on the existing failure scarps, but with the need to support the elevated roadway prism with level ground, we used 8 feet. We found that the PZC 18 sheet piles driven to a depth of 36 feet below the roadway would be effective at stabilizing the shoulder. Other sheet piles are suitable provided that the pile section modulus exceeds 10.3 in 3/ft for Grade 50 steel. Our design included an unsupported wall height of 8 feet, with the face of the sheetpile wall at least 5 feet from the edge of the road. The slope below the wall may be restored to match the slope of the embankment below, but we anticipate the slope below the wall will periodically move and require regrading. Since the wall is designed to retain 8 feet, regrading can be deferred.

C. Conclusions and Recommendations

C.1. General Considerations

The roadway shoulder is being impacted by the shallow landslide that extends through the right of way far down the embankment slope. We do not believe it is practical to mitigate the landslide because it is already relatively flat, and the construction of a toe berm to improve stability may do little to improve the local conditions near the shoulder. Rather, we recommend stabilizing the shoulder of the highway by installing a retaining wall, and allowing the slope below the retaining wall to continue to move.
The construction of the wall may improve the local conditions of the slope below the wall incidentally, but the wall will be designed so that the lower slope can continue to move.

We believe that a sheet pile wall or shoulder pile wall would be effective. A sheet pile wall has the potential to impound water behind the wall, but since this is an embankment, the source of water would be limited to runoff and snowmelt. We have provided a drainage provision to decrease the potential for water to infiltrate behind the wall.

A solider pile wall with lagging would also be effective, but lagging boards between soldier piles have an indefinite life. Even with the use of oversized timber elements and pressure treatment, the timber lagging boards would have an expected life of about 30 years and would be susceptible to fire. Using precast concrete lagging boards or a cast-in-place concrete wall attached to the soldier piles would be more expensive than a typical soldier pile wall.

We do not believe that anchors will be required for this wall. However, since the lower slope instability will not be mitigated, there is the potential that the slope will continue to move and expose more of the wall than the 8 feet we intend based on its design. Drilled in anchors with wale beams may be considered to stabilize the wall if excessive movement occurs. We consider the possibility remote.

C.2. Sheet Pile Wall Construction

The recommended sheet piles are hot rolled sheets with ball-and-socket interlocks. The steel must have a strength of 50 ksi or better. Alternate sections that meet or exceed the section modulus of 10.3 in3/ft may be used. We anticipate that the sheet piles will be driven or vibrated. We estimated the sheet piles must be driven 36 feet to achieve an overall safety factor of 1.5. Based on the borings, the sheet piles will be driven through the existing fill into glacial till, glacial outwash, and decomposed shale. We recommend installing the sheet piles between Sta 17+50 and 20+00.

It would be practical to install the sheet piles on a level bench excavated a few feet below the road surface. To avoid unsupported segments of the road left open overnight, we recommend excavating the soil in this zone between the shoulder of the road and face of the slope in segments that are equal to the amount of sheet piles that can be installed in a day. Excavated soil can be stockpiled nearby.

We understand that the roadway geometry requires guardrails. Hi-tension cables are currently installed, and KLJ indicated that it may be preferred to splice sections back into the guardrail system after the work is complete. The horizontal position of the sheet pile wall may be adjusted away from the edge of the road to provide adequate space for the guardrail. The design geometry accommodates up to 8 feet of retained soil with a slope below the wall.

C.3. Slope Construction

C.3.a. General Excavations

We anticipate that most of the soil excavated will be suitable for reuse as engineered fill to backfill against the sheet pile wall. Surfaces exposed by general removals should be observed by a geotechnical engineer or an engineering technician working under the direction of a geotechnical engineer. The silty soils expected at the bottom of the excavation are extremely moisture sensitive and susceptible to erosion. Gentle grading and use of erosion control products will be required.

C.3.b. Excavated Slopes

Based on the borings, we anticipate on-site soils in excavations will consist of fill composed of silt. These soils are typically considered Type C Soil under OSHA (Occupational Safety and Health Administration) guidelines. OSHA guidelines indicate unsupported excavations in Type C soils should have a gradient no steeper than 1.5H:1V. Slopes constructed in this manner may still exhibit surface sloughing. OSHA requires an engineer to evaluate slopes or excavations over 20 feet in depth.

An OSHA-approved qualified person should review the soil classification in the field. Excavations must comply with the requirements of OSHA 29 CFR, Part 1926, Subpart P, "Excavations and Trenches." This document states excavation safety is the responsibility of the contractor. The project specifications should reference these OSHA requirements.

C.3.c. Engineered Fill Materials and Compaction

Table 3 below contains our recommendations for engineered fill materials.

Table 3. Engineered Fill Materials*

Locations To Be Used	Engineered Fill Classification	Possible Soil Type Descriptions	Gradation	Additional Requirements
▪ Drainage layer ▪ Non-frost-susceptible	▪ Free draining ▪ Non-frost-susceptible fill	GP, GW, SP, SW	100% passing 1-inch sieve < 50% passing #40 sieve < 5% passing #200 sieve	< 2% OC
Pavements	Pavement fill	SP, SM, SC, CL	100% passing 3-inch sieve	< 2% OC PI < 15%
Below landscaped surfaces	Non-structural fill		100% passing 6-inch sieve	< 10% OC

* More select soils comprised of coarse sands with < 5% passing #200 sieve may be needed to accommodate work occurring in periods of wet or freezing weather.

We recommend spreading engineered fill in loose lifts of approximately 8 inches thick. We recommend compacting engineered fill in accordance with the criteria presented below in Table 4. The project documents should specify relative compaction of engineered fill, based on the structure located above the engineered fill, and vertical proximity to that structure.

Table 4. Compaction Recommendations Summary

Reference	Relative Compaction, percent (ASTM D698 – Standard Proctor)	Moisture Content Variance from Optimum, percentage points	
		< 12% Passing #200 Sieve (typically SP, SP-SM)	> 12% Passing #200 Sieve (typically CL, SC, ML, SM)
Below pavement	100	±3	-1 to +3
Below landscaped surfaces	90	±5	±4

*Increase compaction requirement to meet compaction required for structure supported by this engineered fill.

The project documents should not allow the contractor to use frozen material as engineered fill or to place engineered fill on frozen material. Frost should not penetrate under foundations during construction.

We recommend performing density tests in engineered fill to evaluate if the contractors are effectively compacting the soil and meeting project requirements.

C.3.d. Slope Protection

We assume that others will evaluate the ability of or need for conventional slope vegetation to limit surface erosion and develop specifications for vegetation or other forms of surface protection such as erosion control blanket. We recommend providing the vegetation or product without delay on all disturbed surfaces after the soil has been placed below the wall.

We recommend reconstructing the roadway shoulder after construction and paving to the sheet pile wall to prevent infiltration of rain or snowmelt. A shallow swale could be used to divert water along the wall. We recommend that water not be allowed to flow over the wall or pond behind it.

We anticipate that the slope below the sheet pile wall will continue to move. The wall could be backfilled with soil after construction at an inclination that matches the existing slope for ease of mowing and maintenance. We anticipate that at least 2 to 3 feet of the wall will be exposed initially.

We note that as more fill is placed on the downslope side of the wall, the driving forces are increased so that the slope movement will occur sooner. Eventually the movement could slow so that a lower, permanent level may be practical that exposes more wall but results in a stable surface.

C.4. Construction Quality Control

C.4.a. Excavation Observations

We recommend having a geotechnical engineer or an engineering technician working under the direction of a geotechnical engineer observe the exposed subgrade surface after completion of the excavation activities. The purpose of the observations is to evaluate the origin, composition, and competence of the materials found in the excavation.

C.4.b. Materials Testing

WE recommend density test be taken in the excavation backfill. We recommend first once very vertical foot at a minimum of every 50 lineal feet of sheet pile wall backfill.

C.4.c. Cold Weather Precautions

If construction is anticipated during cold weather, we recommend that all snow and ice be removed from fill areas prior to backfilling. No backfill should be placed on frozen subgrades. No frozen soils should be used as backfill.

D. Procedures

D.1. Penetration Test Borings

We drilled the penetration test borings with a truck-mounted 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 with 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 and other in-situ 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 and other in-situ testing performed for the project, (4) laboratory test results, and (5) available common knowledge of the geologic processes and environments that have impacted the site and surrounding area in the past.

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 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. Construction Observations and Testing

We recommend retaining us to perform the required observations and testing during construction as part of the ongoing geotechnical evaluation. This will allow us to correlate the subsurface conditions exposed during construction with those encountered by the borings and provide professional continuity from the design phase to the construction phase. If we do not perform 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 the construction-related geotechnical engineer-of-record responsibilities.

E.3. Use of Report

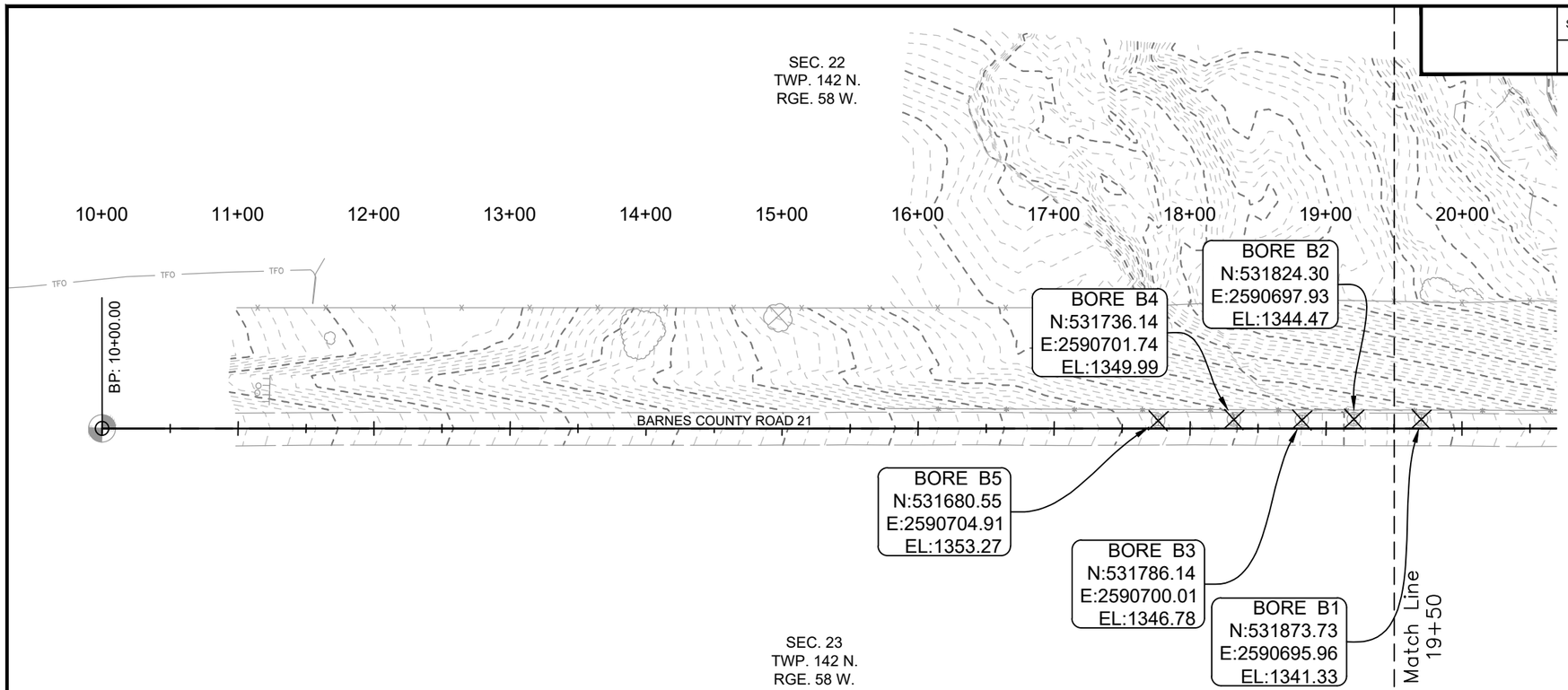
This report is for the exclusive use of the addressed parties. Without written approval, we assume no responsibility to other parties regarding this report. Our evaluation, analyses and recommendations may not be appropriate for other parties or projects.

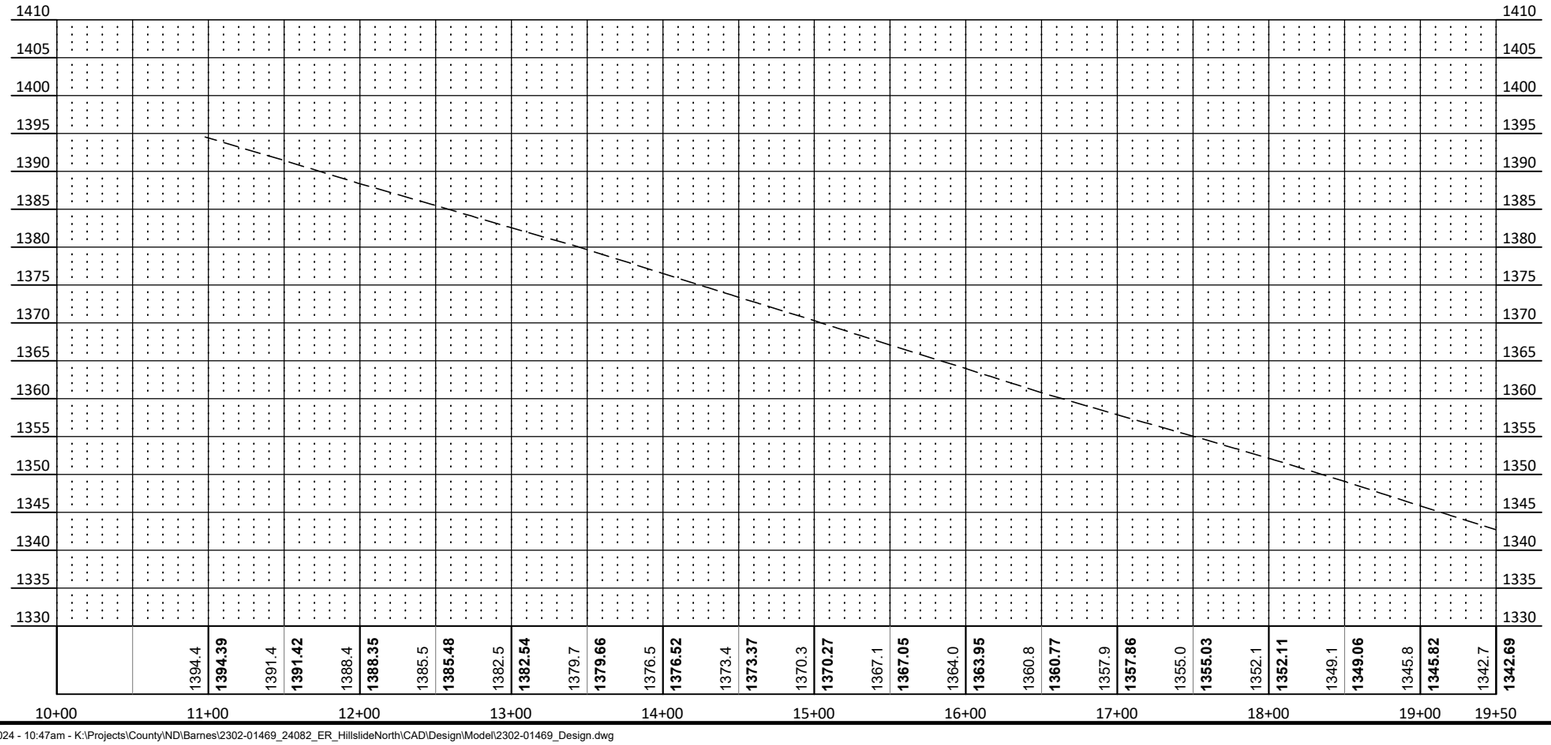
E.4. Standard of Care

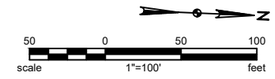
In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

Appendix

STATE	PROJECT NO.	SECTION NO.	SHEET NO.
ND	CERP-0221(085)	60	1







This drawing is preliminary and not for recording or implementation purposes.

Preliminary

CERP-0221(085)
BARNES COUNTY, NORTH DAKOTA

KLJ

PLAN & PROFILE
STA. 10+00 TO 19+50

DRWN. BY	CHK'D BY	PROJECT NO.
ZRV	BJT	2302-01469

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CROSS-SECTIONS

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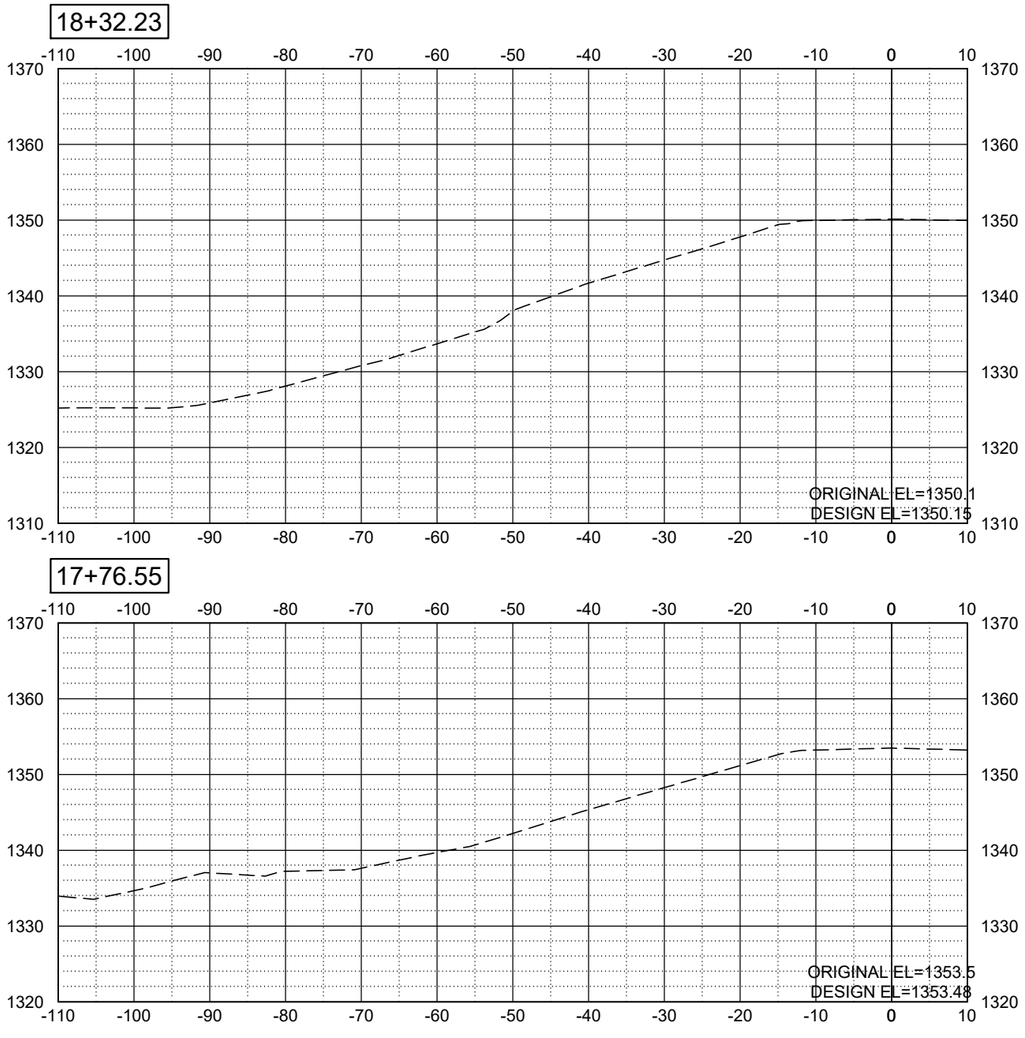

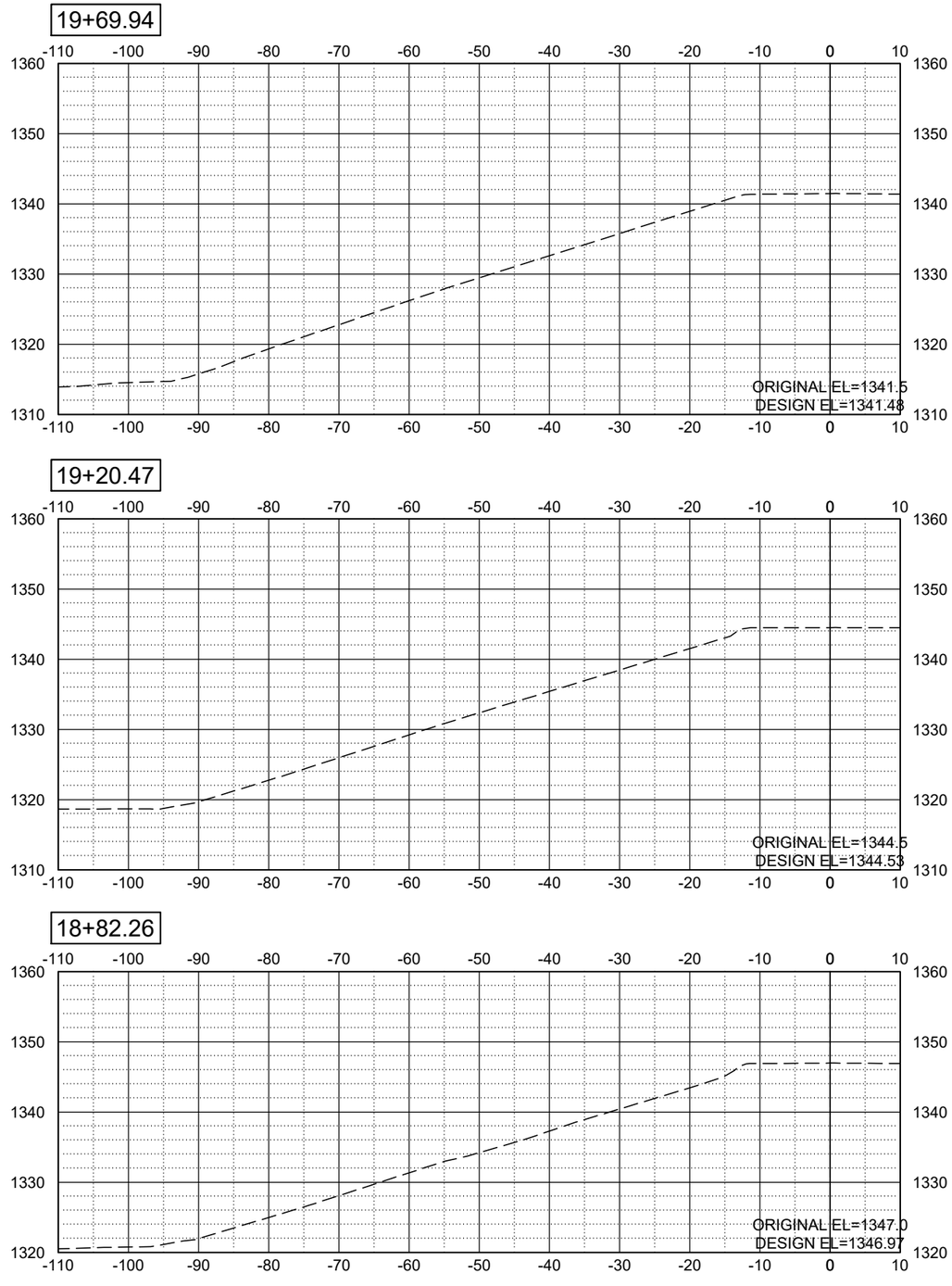

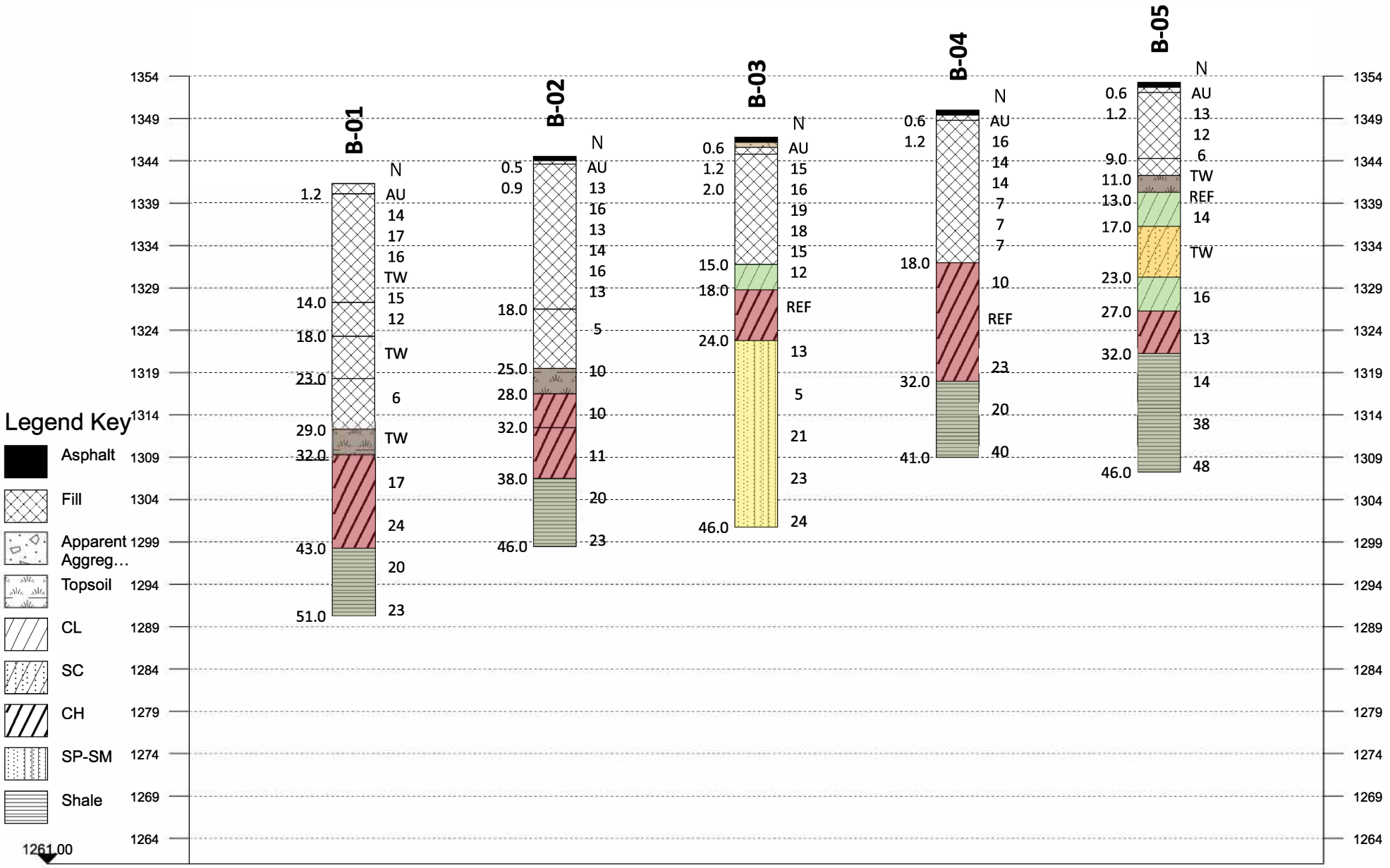

SECTION LINE 1

Fence Diagram

Geotechnical Evaluation
CERP-0221(085) PCN 24082
County Highway 21
Valley City, North Dakota

Project ID: B2400867
Vert. Scale: 1"= 16'
Hor. Scale: NTS
Date: 10/28/2024

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LOG OF BORING

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Project Number B2400867
Geotechnical Evaluation
CERP-0221(085) PCN 24082
County Highway 21
Valley City, North Dakota

BORING: **B-01**
LOCATION: Captured with RTK GPS. STA 19+69.44
DATUM: WGS 84
LATITUDE: 47.097955 LONGITUDE: -98.001375
DRILLER: C.Gorman LOGGED BY: K.Dragos START DATE: 03/08/24 END DATE: 03/08/24
SURFACE ELEVATION: 1341.3 ft RIG: 7508 METHOD: 3 1/4" HSA SURFACING: Bituminous WEATHER: Clear

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
1340.1		FILL: LEAN CLAY with SAND (CL), trace Gravel, brown, moist		AU			
1.2		FILL: SILT with SAND (ML), trace Gravel, brown, moist		8-7-7 (14) 16"			
			5	7-7-10 (17) 16"		20	
				6-8-8 (16) 18"			
			10	TW		22	LL=32, PL=25, PI=7 P200=76% DD=103 pcf WD=125 pcf
				4-6-9 (15) 18"		20	
1327.3							
14.0		FILL: LEAN CLAY with SAND (CL), trace Gravel, brownish gray, moist *With iron oxide staining from 14 to 16 feet*	15	5-5-7 (12) 16"			
1323.3							
18.0		FILL: SILT with SAND (ML), brown, moist					
			20	TW		24	P200=88% DD=82 pcf WD=101 pcf
1318.3							
23.0		FILL: CLAYEY SAND with GRAVEL (SC), brown, moist *With iron oxide staining from 24 to 26 feet*	25	3-3-3 (6) 10"			
1312.3							
29.0		LEAN CLAY (CL), with roots, trace Sand, dark brown, moist (BURIED TOPSOIL)	30	TW		20	LL=40, PL=17, PI=23 OC=4%
1309.3							
32.0		Continued on next page					

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Project Number B2400867
Geotechnical Evaluation
CERP-0221(085) PCN 24082
County Highway 21
Valley City, North Dakota

BORING: **B-01**
LOCATION: Captured with RTK GPS. STA 19+69.44
DATUM: WGS 84
LATITUDE: 47.097955 LONGITUDE: -98.001375
DRILLER: C.Gorman LOGGED BY: K.Dragos
START DATE: 03/08/24 END DATE: 03/08/24
SURFACE ELEVATION: 1341.3 ft RIG: 7508 METHOD: 3 1/4" HSA
SURFACING: Bituminous WEATHER: Clear

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), brown, moist, very stiff, iron oxide staining (GLACIAL TILL)					
		With Sand seams from 34 to 36 feet	35	4-7-10 (17) 16"		25	LL=63, PL=21, PI=42
			40	10-12-12 (24) 14"		30	
1298.3 / 43.0		PIERRE FORMATION, SHALE, gray, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	45	7-8-12 (20) 16"		28	LL=74, PL=24, PI=50
			50	10-11-12 (23) 18"		28	
1290.3 / 51.0		END OF BORING					Water not observed while drilling.
		Boring then backfilled with auger cuttings					
			55				
			60				

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See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2400867
Geotechnical Evaluation
CERP-0221(085) PCN 24082
County Highway 21
Valley City, North Dakota

BORING: **B-02**
LOCATION: Captured with RTK GPS. STA 19+20.47
DATUM: WGS 84
LATITUDE: 47.097819 LONGITUDE: -98.001373
DRILLER: C.Gorman LOGGED BY: K.Dragos
START DATE: 03/08/24 END DATE: 03/08/24
SURFACE ELEVATION: 1344.5 ft RIG: 7508 METHOD: 3 1/4" HSA
SURFACING: Bituminous roadway WEATHER: Clear

Elev./ Depth ft	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
1344.0	BITUMINOUS, 6 inches					
0.5	FILL: CLAYEY SAND (SC), trace Gravel, brown, moist		AU			
1343.6	FILL: SILT with SAND (ML), brown, moist		8-6-7 (13) 18"		24	
0.9		5	4-7-9 (16) 16"			
			6-6-7 (13) 16"		24	
		10	5-7-7 (14) 16"			
			6-6-10 (16) 18"		21	
	Possible roots from 14 to 16 feet	15	5-6-7 (13) 16"		18	P200=68%
1326.5						
18.0	FILL: CLAYEY SAND (SC), trace Gravel, brown, moist	20	3-2-3 (5) 14"		19	P200=49%
1319.5						
25.0	LEAN CLAY (CL), few roots, dark brown, moist (BURIED TOPSOIL)	25	4-4-6 (10) 8"		18	OC=2%
1316.5						
28.0	FAT CLAY with SAND (CH), trace Gravel, brown, moist, stiff (GLACIAL TILL) *With iron oxide staining and mineralization from 29 to 31 feet*	30	4-4-6 (10) 10"		29	LL=61, PL=19, PI=42
1312.5						
32.0						

Continued on next page

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See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2400867
Geotechnical Evaluation
CERP-0221(085) PCN 24082
County Highway 21
Valley City, North Dakota

BORING: **B-02**
LOCATION: Captured with RTK GPS. STA 19+20.47
DATUM: WGS 84
LATITUDE: 47.097819 LONGITUDE: -98.001373
DRILLER: C.Gorman LOGGED BY: K.Dragos START DATE: 03/08/24 END DATE: 03/08/24
SURFACE ELEVATION: 1344.5 ft RIG: 7508 METHOD: 3 1/4" HSA SURFACING: Bituminous roadway WEATHER: Clear

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), trace Gravel, brown to gray, moist, stiff (GLACIAL TILL)					
		With iron oxide staining from 34 to 36 feet	35	5-5-6 (11) 18"		33	
1306.5							
38.0		PIERRE FORMATION, SHALE, gray, moist, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	40	5-9-11 (20) 18"		26	LL=70, PL=22, PI=48
			45	8-10-13 (23) 18"			
1298.5							
46.0		END OF BORING					Water not observed while drilling.
		Boring then backfilled with auger cuttings					
			50				
			55				
			60				

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See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2400867
Geotechnical Evaluation
CERP-0221(085) PCN 24082
County Highway 21
Valley City, North Dakota

BORING: **B-03**
LOCATION: Captured with RTK GPS. STA 18+82.26
DATUM: WGS 84
LATITUDE: 47.097715 LONGITUDE: -98.001369
DRILLER: C.Gorman LOGGED BY: K.Dragos
START DATE: 03/07/24 END DATE: 03/07/24
SURFACE ELEVATION: 1346.8 ft RIG: 7508 METHOD: 3 1/4" HSA
SURFACING: Bituminous roadway WEATHER: Clear

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
1346.2		BITUMINOUS, 6 inches		AU			
0.6		APPARENT AGGREGATE BASE, 6 inches					
1345.6		FILL: CLAYEY SAND (SC), brown, moist					
1.2		FILL: SILT with SAND (ML), brown, moist		10-7-8 (15) 12"		22	
1344.8							
2.0			5	5-7-9 (16) 14"			
				6-8-11 (19) 18"		23	
			10	6-8-10 (18) 16"			
		Brown and gray from 12 to 15 feet		6-6-9 (15) 16"		24	
1331.8			15	6-6-6 (12) 14"		23	
15.0		LEAN CLAY with SAND (CL), trace roots, brown and gray, moist, stiff (GLACIAL TILL)					
1328.8							
18.0		SANDY FAT CLAY (CH), trace Gravel, brown, moist, hard (GLACIAL TILL)	20	5-50/5" (REF) 11"		22	LL=76, PL=23, PI=53
1322.8							
24.0		POORLY GRADED SAND with SILT (SP-SM), brown, moist, medium dense to loose (GLACIAL OUTWASH)	25	6-6-7 (13) 14"			
		With iron oxide staining from 29 to 31 feet	30	2-2-3 (5) 10"			
		Continued on next page					

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Project Number B2400867
Geotechnical Evaluation
CERP-0221(085) PCN 24082
County Highway 21
Valley City, North Dakota

BORING: **B-03**
LOCATION: Captured with RTK GPS. STA 18+82.26
DATUM: WGS 84
LATITUDE: 47.097715 LONGITUDE: -98.001369
DRILLER: C.Gorman LOGGED BY: K.Dragos
START DATE: 03/07/24 END DATE: 03/07/24
SURFACE ELEVATION: 1346.8 ft RIG: 7508 METHOD: 3 1/4" HSA
SURFACING: Bituminous roadway WEATHER: Clear

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
		POORLY GRADED SAND with SILT (SP-SM), brown, moist, medium dense to loose (GLACIAL OUTWASH)	35	6-8-13 (21) 16"			
			40	6-9-14 (23) 18"			
			45	7-10-14 (24) 18"			
1300.8 46.0		END OF BORING Boring then backfilled with auger cuttings					Water not observed while drilling.
			50				
			55				
			60				

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See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2400867
Geotechnical Evaluation
CERP-0221(085) PCN 24082
County Highway 21
Valley City, North Dakota

BORING: **B-04**
LOCATION: Captured with RTK GPS. STA 18+32.2
DATUM: WGS 84
LATITUDE: 47.097577 LONGITUDE: -98.001369
DRILLER: C.Gorman LOGGED BY: K.Dragos START DATE: 03/08/24 END DATE: 03/08/24
SURFACE ELEVATION: 1350.0 ft RIG: 7508 METHOD: 3 1/4" HSA SURFACING: Bituminous WEATHER: Clear

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
1349.4		BITUMINOUS					
0.6		FILL: CLAYEY SAND (SC), dark brown, moist		AU			
1348.8		FILL: SILT with SAND (ML), brown, moist		10-7-9 (16) 14"		21	
1.2			5	7-7-7 (14) 16"			
				5-5-9 (14) 10"		22	
			10	4-3-4 (7) 10"			
				2-2-5 (7) 10"		22	
			15	3-3-4 (7) 8"			
1332.0							
18.0		FAT CLAY (CH), brown to gray, moist, stiff to hard (GLACIAL TILL)	20	3-4-6 (10) 14"		40	
			25	50/2" (REF) 0"			
			30	15-13-10 (23) 3"		27	
1318.0							
32.0							

Continued on next page

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See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2400867
Geotechnical Evaluation
CERP-0221(085) PCN 24082
County Highway 21
Valley City, North Dakota

BORING: **B-04**
LOCATION: Captured with RTK GPS. STA 18+32.2
DATUM: WGS 84
LATITUDE: 47.097577 LONGITUDE: -98.001369
DRILLER: C.Gorman LOGGED BY: K.Dragos START DATE: 03/08/24 END DATE: 03/08/24
SURFACE ELEVATION: 1350.0 ft RIG: 7508 METHOD: 3 1/4" HSA SURFACING: Bituminous WEATHER: Clear

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
		PIERRE FORMATION, SHALE, gray, moist, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	35	8-9-11 (20) 14"		25	
			40	12-16-24 (40) 18"			
1309.0 41.0		END OF BORING Boring then backfilled with auger cuttings					Water not observed while drilling.
			45				
			50				
			55				
			60				

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See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2400867
Geotechnical Evaluation
CERP-0221(085) PCN 24082
County Highway 21
Valley City, North Dakota

BORING: **B-05**
LOCATION: Captured with RTK GPS. STA 17+76.55
DATUM: WGS 84
LATITUDE: 47.097425 LONGITUDE: -98.001363
DRILLER: C.Gorman LOGGED BY: K.Dragos
START DATE: 03/07/24 END DATE: 03/07/24
SURFACE ELEVATION: 1353.3 ft RIG: 7508 METHOD: 3 1/4" HSA
SURFACING: Bituminous roadway WEATHER: Clear

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
1352.7		BITUMINOUS, 7 inches					
0.6		FILL: LEAN CLAY with SAND (CL), dark brown, moist		AU			
1352.1		FILL: CLAYEY SAND (SC), trace Gravel, brown, moist		10-7-6 (13) 14"		13	
1.2			5	6-6-6 (12) 14"		15	P200=38%
1344.3				6-3-3 (6) 14"		23	
9.0		FILL: CLAYEY SAND (SC), fine to coarse-grained, trace Gravel, brown, moist	10	TW		17	LL=34, PL=16, PI=18 P200=49%
1342.3							
11.0		LEAN CLAY with GRAVEL (CL), dark brown, moist (BURIED TOPSOIL)		50/3" (REF) 3"		16	
1340.3		*Apparent large Aggregate from 11 to 13 feet, caused difficult drilling with chatter*					
13.0		SANDY LEAN CLAY (CL), trace Gravel, brown, moist (GLACIAL TILL)	15	6-6-8 (14) 14"			
1336.3							
17.0		CLAYEY SAND (SC), fine to coarse-grained, trace Gravel, brown, moist (GLACIAL TILL)	20	TW		16	LL=42, PL=18, PI=24 P200=42%
1330.3							
23.0		SANDY LEAN CLAY (CL), trace Gravel, brown, moist (GLACIAL TILL)	25	4-6-10 (16) 18"		19	
1326.3							
27.0		FAT CLAY with SAND (CH), trace Gravel, gray, moist (GLACIAL TILL)	30	4-5-8 (13) 18"			
1321.3							
32.0							

Continued on next page

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Project Number B2400867
Geotechnical Evaluation
CERP-0221(085) PCN 24082
County Highway 21
Valley City, North Dakota

BORING: **B-05**
LOCATION: Captured with RTK GPS. STA 17+76.55
DATUM: WGS 84
LATITUDE: 47.097425 LONGITUDE: -98.001363
DRILLER: C.Gorman LOGGED BY: K.Dragos START DATE: 03/07/24 END DATE: 03/07/24
SURFACE ELEVATION: 1353.3 ft RIG: 7508 METHOD: 3 1/4" HSA SURFACING: Bituminous roadway WEATHER: Clear

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
		PIERRE FORMATION, SHALE, gray, moist, decomposed, very soft, hand deformed sample classified as "Fat Clay (CH)"	35	2-6-8 (14) 16"		27	LL=62, PL=21, PI=41
			40	16-18-20 (38) 18"			
			45	10-20-28 (48) 18"			
1307.3 46.0		END OF BORING Boring then backfilled with auger cuttings					Water not observed while drilling.
			50				
			55				
			60				

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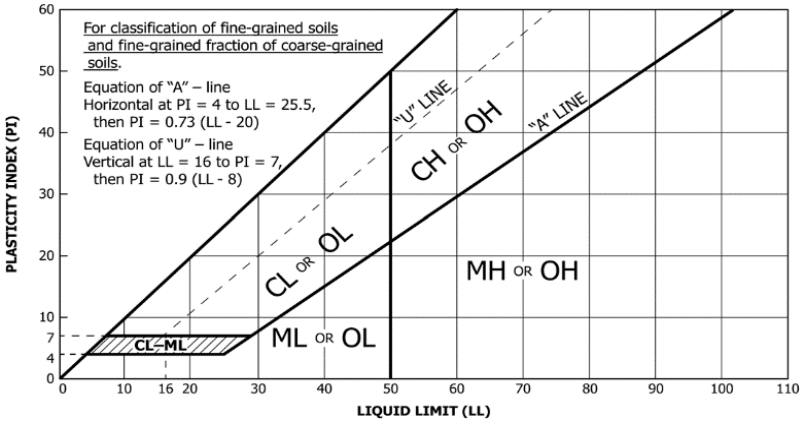
Descriptive Terminology of Soil

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	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. $C_u = D_{60} / D_{10}$ $C_c = (D_{30})^2 / (D_{10} \times D_{60})$
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.



Laboratory Tests

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

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.

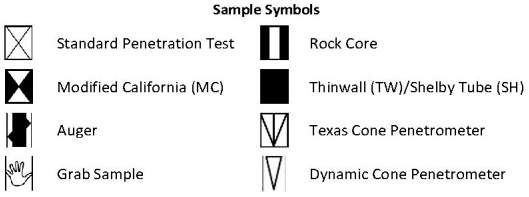
Recovery: Indicates the inches of sample recovered from the sampled interval. For a standard penetration test, full recovery is 18", and is 24" for a thinwall/shelby tube sample.

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 (⧩).

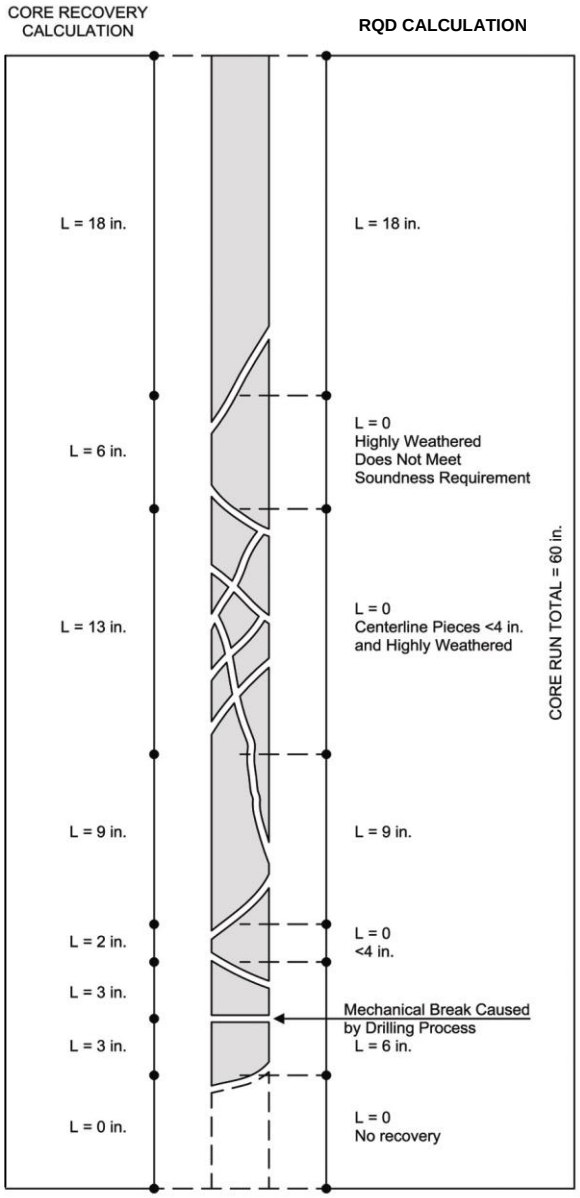
Sample Symbols



5/2021

Descriptive Terminology of Rock

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



Example Calculations

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

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

CR = 90%

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

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

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

RQD = 55%

Weathering

Unweathered: No evidence of chemical or mechanical alteration.

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

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

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

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

Hardness

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

Texture

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

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

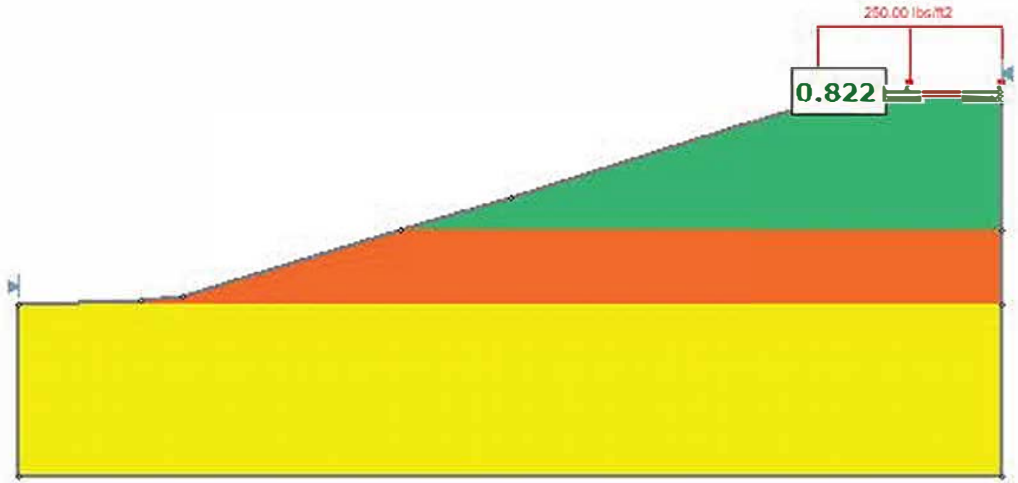
Thickness of Bedding

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

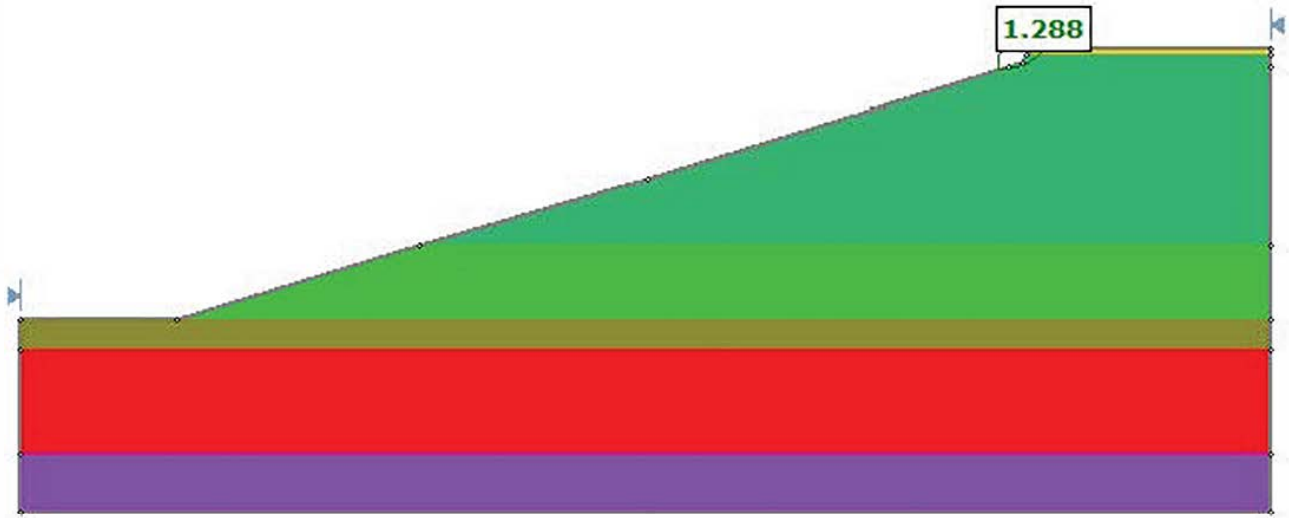
Degree of Fracturing (Jointing)

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

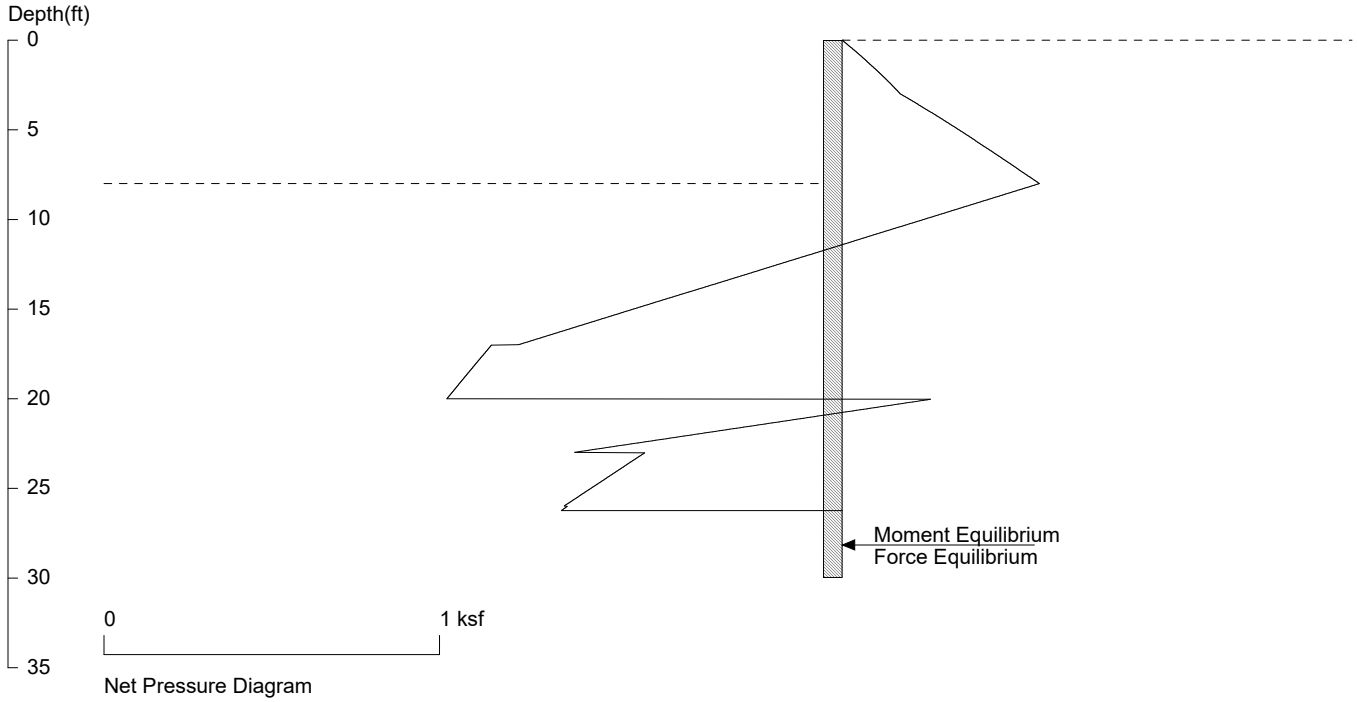
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Road		135	Mohr-Coulomb	0	35	None	0
Embankment		120	Mohr-Coulomb	0	31	None	0
Till		125	Mohr-Coulomb	0	26	None	0
Outwash		120	Mohr-Coulomb	0	32	None	0

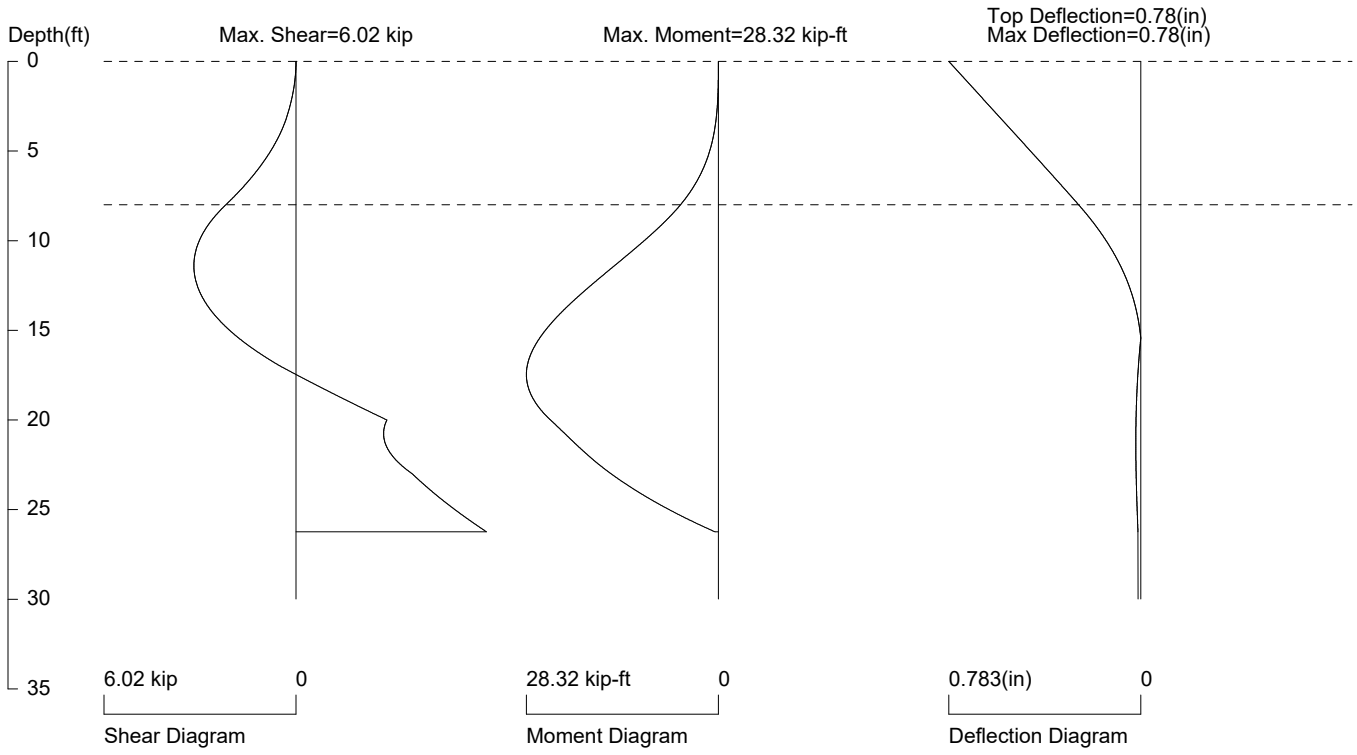


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Road		135	Mohr Coulomb	0	35	None	0
Embankment: Mi		120	Mohr Coulomb	0	31	None	0
Embankment: CL		120	Mohr Coulomb	0	28	None	0
Subsoil		115	Mohr Coulomb	0	26	None	0
Soft Clay		110	Mohr Coulomb	0	24	None	0
Shale		125	Mohr Coulomb	0	14	None	0



B2400867 CERP-0221(085) PCN 24082





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 1.0 foot or meter

User Input Pile, PZC18: E (ksi)=29000.0, I (in4)/foot=255.5

File: C:\Users\dkim\OneDrive - Braun Intertec Corp\B2400867 CERP-0221(085) PCN 24082\Geo-Structures\Calcs\ShoringSuites\8 ft CSP.sh8