Geotechnical Engineering Report

Street and Utility Improvements
Beach, North Dakota
October 21, 2020
Terracon Project No. M2205093

Prepared for:
City of Beach
Beach, ND

Prepared by:
Terracon Consultants, Inc.
Bismarck, ND

October 21, 2020

City of Beach
PO Box 278
Beach, ND 58621

Attn: Mr. Henry Gerving - Mayor
P: (701) 872 4103
E: cityofbeach@midstate.net

Re: Geotechnical Engineering Report
Street and Utility Improvements
Beach, North Dakota
Terracon Project No. M2205093

Dear Mr. Gerving:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. PM2205093 dated September 16, 2020. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of pavements for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Chad A. Cowley, P.E.
Department Manager

REGISTERED PROFESSIONAL ENGINEER
CHAD A. COWLEY
PE-7111
DATE 10/21/2020
NORTH DAKOTA

Alex L. Sprunk, P.E.
Project Engineer

REPORT TOPICS

Note: This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the ***GeoReport*** logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

Geotechnical Engineering Report

Street and Utility Improvements

Beach, North Dakota

Terracon Project No. M2205093

October 21, 2020

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed street and utility improvements in Beach, North Dakota. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Pavement design and construction

The geotechnical engineering Scope of Services for this project included the advancement of five test borings to a depth of approximately 16 feet below existing site grades.

Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring logs and/or as separate graphs in the **Exploration Results** section.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project is located on various streets on the south side of Beach, North Dakota Latitude: 46.9099° N, Longitude: 104.0019° W (approximate) See **Site Location**
Existing Improvements	Paved streets, residential structures
Current Ground Cover	Asphalt paved streets

PROJECT DESCRIPTION

Our understanding of the project conditions is as follows:

Item	Description
Information Provided	Information used to develop our project understanding was provided to us through email correspondence with AE2S.
Project Description	The project will include water main and water service replacement and asphalt street reconstruction.
Grading/Slopes	We anticipate the final grade of the roads will match the existing grade and existing subgrade soils will be used for construction.
Pavements	We anticipate flexible (asphalt) pavement sections are being considered. Anticipated traffic is as follows: ■ Autos/light trucks: 250 vehicles per day ■ Light delivery and trash collection vehicles: 10 vehicles per week ■ Tractor-trailer trucks: <1 vehicle per week The pavement design period is 20 years.

GEOTECHNICAL CHARACTERIZATION

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed **GeoModel**, forms the basis of our geotechnical calculations and evaluation of site preparation. Conditions encountered at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the **GeoModel** can be found in the **Figures** section of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the **GeoModel**.

Model Layer	Layer Name	General Description
1	**Surface**	1 to 4 inches of asphalt followed by 1 to 2 inches of aggregate base
2	**Fill**	Sandy Lean Clay – brown
3	**Clay 1**	Lean Clay with Sand – light brown, soft to very stiff
4	**Sand**	Silty Sand – light brown or light gray, very loose to very dense, fine grained
5	**Clay 2**	Fat Clay – light gray or olive brown, medium stiff to very stiff
6	**Silt**	Sandy Silt – light brown, medium stiff to hard
7	**Coal**	Lignite – very dark brown

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater was not observed in the borings while drilling, or for the short duration the borings could remain open. However, this does not necessarily mean the borings terminated above groundwater. Long term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

GEOTECHNICAL OVERVIEW

As discussed in the **Geotechnical Characterization**, undocumented fill was encountered in a majority of the borings. This undocumented fill may be variable in consistency, density and moisture, and therefore may have the potential to increase or decrease in volume with variations in moisture content. Furthermore, there is an inherent risk for the owner that compressible fill or unsuitable material within or buried by the fill will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill. Therefore, we recommend reworking the undocumented fills encountered at this site, as outlined in the **Earthwork** section.

The **Pavements** section addresses the design of pavement systems.

The **General Comments** section provides an understanding of the report limitations.

EARTHWORK

Earthwork is anticipated to include clearing and grubbing, excavations, and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for pavements.

Site Preparation

As noted in **Geotechnical Characterization**, our borings encountered existing fill to a depth of approximately 2 feet. We have no records to indicate the degree of control or placement methods of the fill, so we consider it undocumented. This undocumented fill may be variable in consistency, density and moisture, and therefore may have the potential to increase or decrease in volume with variations in moisture content. We recommend the exposed subgrade should be scarified and recompacted to a minimum depth of 18 inches.

The subgrade should be proofrolled with an adequately loaded vehicle such as a fully-loaded tandem-axle dump truck. The proofrolling should be performed under the direction of the Geotechnical Engineer. Areas excessively deflecting under the proofroll should be delineated and subsequently addressed by the Geotechnical Engineer. Such areas should either be removed or modified by stabilizing with a geogrid product. Excessively wet or dry material should either be removed or moisture conditioned and recompacted.

Fill Material Types

Fill required to achieve design grade should be classified as structural fill and general fill. Structural fill is material used below pavements. General fill is material used to achieve grade outside of these areas. Earthen materials used for structural fill should meet the following material property requirements:

On-site soils free of vegetation, organic matter and other deleterious materials or low volume change import materials approved by Terracon may be used as fill/backfill material on the site.

In general, imported materials meeting the properties presented below should be acceptable for use on the site. However, imported soils should be evaluated and approved by the geotechnical engineer prior to delivery to the site.

Fill Type [1, 2]	USCS Classification	Acceptable Parameters
Cohesive Soils [3]	CL, CL-ML	100% Passing 2-inch sieve LL < 40
Granular Soils	SW, SW-SM, SW-SC, SP, SP-SM, SP-SC, SM, SC	**All:** 100% Passing 2-inch sieve **SM Only:** Less than 20% Passing #200 sieve

1. The on-site soils typically appear suitable for use as fill, however they should be tested prior to placement to ensure they meet the recommendations for structural fill as outlined above.
2. Structural fill is material used below, or within 10 feet of structures, pavements or constructed slopes.
3. On-site materials can be reworked and reused under pavements.

Fill Compaction Requirements

Structural and general fill should meet the following compaction requirements.

Item	Structural Fill	General Fill
Maximum Lift Thickness	9 inches or less in loose thickness when heavy, self-propelled compaction equipment is used 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used	Same as Structural fill
Minimum Compaction Requirements [1, 2]	95% of max.	90% of max.
Water Content Range [1]	**Granular:** As required to work the material and achieve minimum compaction requirements **Low plasticity cohesive:** -3% to +3% of optimum	As required to achieve min. compaction requirements Same as Structural fill **High plasticity cohesive:** 0 to +4% of optimum

1. Maximum density and optimum water content as determined by the standard Proctor test (ASTM D 698).
2. High plasticity cohesive fill should not be compacted to more than 100% of standard Proctor maximum dry density.

Grading and Drainage

Positive drainage should be provided during construction and maintained throughout the life of the development. Infiltration of water into utility trenches should be prevented during construction.

Earthwork Construction Considerations

Excavations are anticipated to be accomplished with conventional construction equipment. Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of pavements. Construction traffic over the completed subgrades should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over or adjacent to construction areas should be removed. If the subgrade freezes, desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted prior to pavement construction.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local, and/or state regulations.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety, or the contractor's activities; such responsibility shall neither be implied nor inferred.

Construction Observation and Testing

The earthwork efforts should be monitored under the direction of the Geotechnical Engineer. Monitoring should include documentation of adequate removal of vegetation and topsoil, proofrolling, and mitigation of areas delineated by the proofroll to require mitigation.

Each lift of compacted fill should be tested, evaluated, and reworked, as necessary, until approved by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency of at least one test for every 5,000 square feet in pavement areas. One density and water content test should be performed for every 50 linear feet of compacted utility trench backfill.

In areas of foundation excavations, the bearing subgrade should be evaluated under the direction of the Geotechnical Engineer. If unanticipated conditions are encountered, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

PAVEMENTS

General Pavement Comments

Pavement designs are provided for the traffic conditions and pavement life conditions as noted in **Project Description** and in the following sections of this report. A critical aspect of pavement performance is site preparation. Pavement designs, noted in this section, must be applied to the site, which has been prepared as recommended in the **Earthwork** section.

Based on the planned grading, we anticipate the onsite soils will be utilized in subgrade construction. A California Bearing Ratio (CBR) has been determined on a composite blend of material encountered in boring B-5 from an approximate depth of one to five feet below existing grade. This material was compacted at about 95 percent of the standard Proctor maximum dry density at about optimum moisture. The moisture-density relationship and CBR test are presented in the **Exploration Results** section.

Pavement Design Parameters

A subgrade CBR of 9 was used for the AC pavement designs. The values were empirically derived based upon our experience with the describe soil type subgrade soils and our understanding of the quality of the subgrade as prescribed by the **Site Preparation** conditions as outlined in **Earthwork**.

Pavement design recommendations for this project have been based on procedures outlined in the AASHTO Guide for Design of Pavement Structures, 1993, coupled with publications by the Asphalt Institute and the American Concrete Institute on the design of parking lots and our local experience. Pavement design input parameters and resulting pavement sections are provided in the following table:

Pavement Thickness Design Parameters	
Input Parameter	**Flexible (asphalt)**
Reliability	85%
Initial Serviceability	4.2
Terminal Serviceability	2.0
Standard Deviation	0.45
Drainage	1.0
Design ESAL Value: Anticipated Traffic	30,000

Pavement Section Thicknesses

The following table provides options for AC Sections:

Asphaltic Concrete Design Thickness (inches)				
Traffic Area	**Asphalt Surface [1]**	**Asphalt Base [1]**	**Aggregate Base [2]**	**Total Thickness**
City Street	2.0	2.0	6.0	10.0

1. NDDOT Superpave FAA41.
2. NDDOT Class 5 Aggregate Base or Salvage Base Course in accordance with NDDOT Section 817.

Pavement Drainage

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrade should be graded to provide positive drainage within the granular base section. Appropriate sub-drainage or connection to a suitable daylight outlet should be provided to remove water from the granular subbase.

Due to frost susceptible soils and the possibility of perched groundwater, consideration should be given to installing a pavement subdrain system to control subgrade moisture, improve stability, and improve long term pavement performance.

We recommend minimum thicknesses of free-draining granular material (aggregate base) be placed beneath the pavements as outlined in the **Pavement Section Thicknesses** section. The use of a free draining granular base will also reduce the potential for frost action. We recommend pavement subgrades be crowned at least 2 percent, to promote the flow of water towards the subdrains, and to reduce the potential for ponding of water on the subgrade.

The subdrains should be hydraulically connected to the free-draining granular base layer. Subdrains should be sloped to provide positive gravity drainage to reliable discharge points such as the storm water detention basin. Periodic maintenance of subdrains is required for long-term proper performance.

The pavement surfacing and adjacent sidewalks should be sloped to provide rapid drainage of surface water. Water should not be allowed to pond on or adjacent to these grade supported slabs, since this could saturate the subgrade and contribute to premature pavement or slab deterioration.

Pavement Maintenance

The pavement sections represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, preventive maintenance should be planned and provided for through an on-going pavement management program. Maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment. Maintenance consists of both localized maintenance (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Preventive maintenance is usually the priority when implementing a pavement maintenance program. Additional engineering observation is recommended to determine the type and extent of a cost-effective program. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required.

Pavement performance is affected by its surroundings. In addition to providing preventive maintenance, the civil engineer should consider the following recommendations in the design and layout of pavements:

- Final grade adjacent to paved areas should slope down from the edges at a minimum 2%.
- Subgrade and pavement surfaces should have a minimum 2% slope to promote proper surface drainage.
- Install below pavement drainage systems surrounding areas anticipated for frequent wetting.
- Install joint sealant and seal cracks immediately.
- Seal all landscaped areas in or adjacent to pavements to reduce moisture migration to subgrade soils.
- Place compacted, low permeability backfill against the exterior side of curb and gutter.
- Place curb, gutter and/or sidewalk directly on clay subgrade soils rather than on unbound granular base course materials.

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

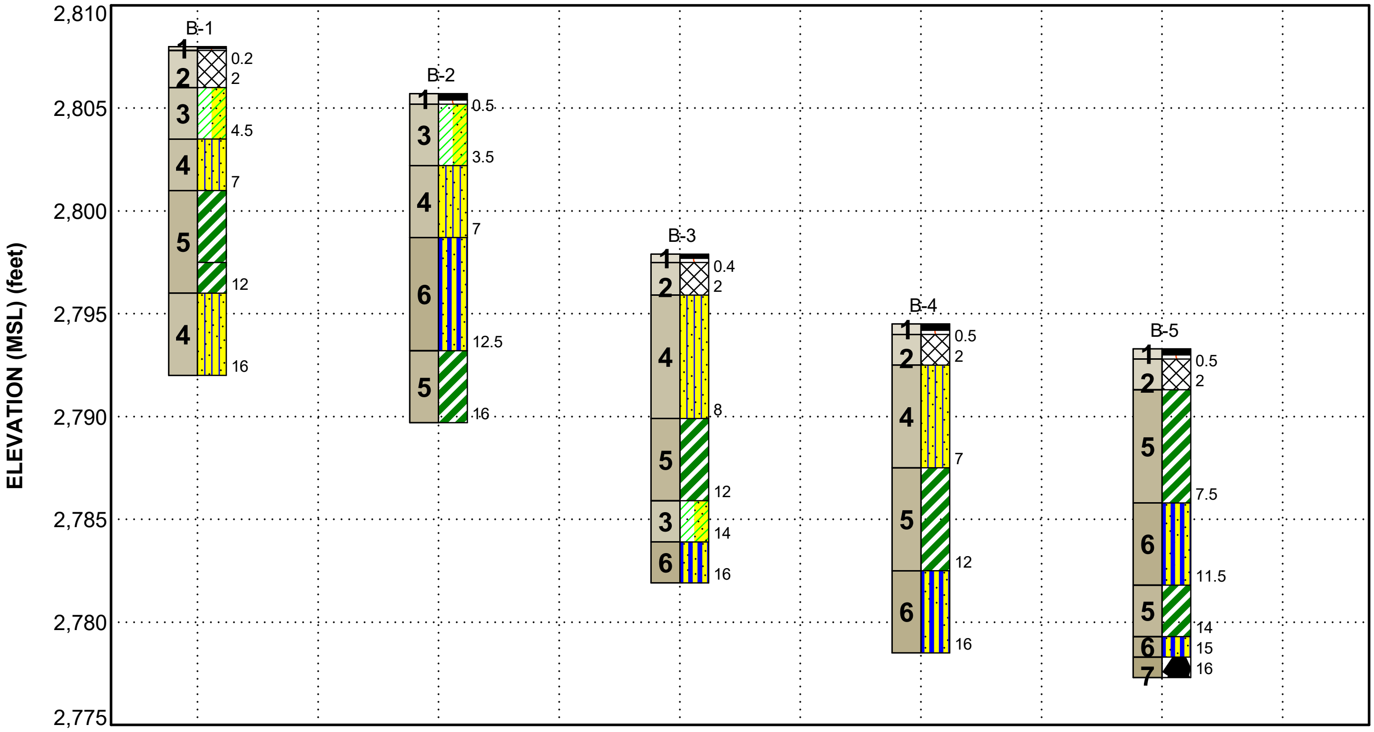
Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

FIGURES

Contents:

GeoModel

Note: All attachments are one page unless noted above.



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

LEGEND

Model Layer	Layer Name	General Description
1	Surface	1 to 4 inches of asphalt followed by 1 to 2 inches of aggregate base
2	Fill	Sandy Lean Clay - brown
3	Clay 1	Lean Clay with Sand - light brown, soft to very stiff
4	Sand	Silty Sand - light brown or light gray, very loose to very dense, fine-grained
5	Clay 2	Fat Clay - light gray or olive brown, medium stiff to very stiff
6	Silt	Sandy Silt - light brown, medium stiff to hard
7	Coal	Lignite - very dark brown

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Borings	Boring Depth (feet)	Location
5	16	Scattered Streets

Boring Layout and Elevations: The borings were marked in the field and elevations were provided by AE2S prior to our arrival on site. Coordinates were obtained with a handheld GPS unit (estimated horizontal accuracy of about ±10 feet).

Subsurface Exploration Procedures: We advanced the borings with a track-mounted rotary drill rig using continuous flight augers. Samples were obtained at 2½-foot intervals in the upper 15 feet of each boring using split-barrel sampling procedures. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. We observed and recorded groundwater levels during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings after their completion. Pavements were patched with cold-mix asphalt and/or pre-mixed concrete, as appropriate.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests to understand the engineering properties of the various soil strata, as necessary, for this project. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods were applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D1140 Standard Test Methods for Determining the Amount of Material Finer than No. 200 Sieve in Soils by Washing
- ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort
- ASTM D1883 Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

The laboratory testing program often included examination of soil samples by an engineer. Based on the material's texture and plasticity, we described and classified the soil samples in accordance with the Unified Soil Classification System.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Note: All attachments are one page unless noted above.

SITE LOCATION

Street and Utility Improvements ■ Beach, North Dakota

October 21, 2020 ■ Terracon Project No. M2205093

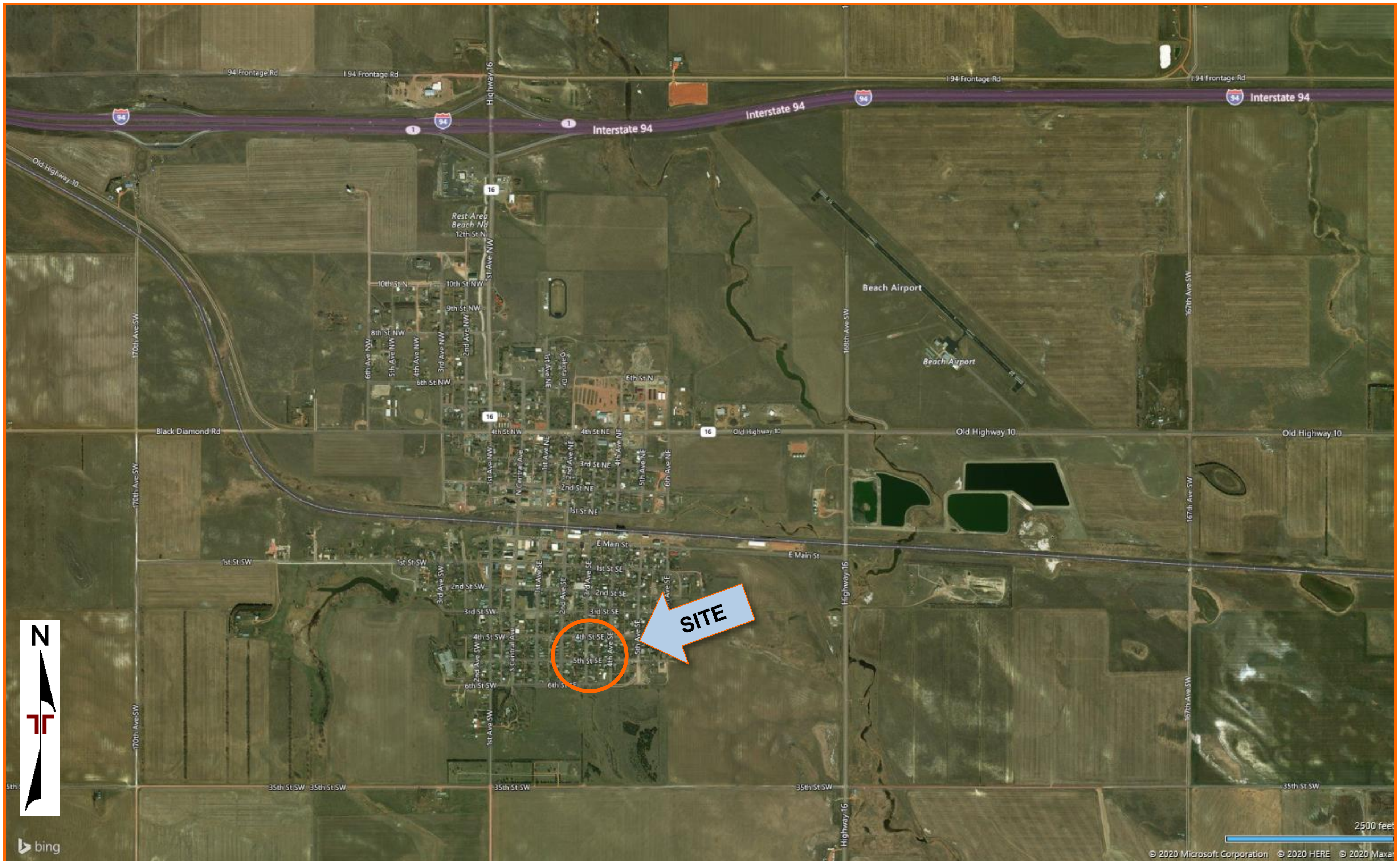


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Street and Utility Improvements ■ Beach, North Dakota

October 21, 2020 ■ Terracon Project No. M2205093

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Note: All attachments are one page unless noted above.

BORING LOG NO. B-1

PROJECT: Beach Street and Utility Improvements

CLIENT: City of Beach ND
Beach, North Dakota

SITE: Various Streets
Beach, North Dakota

LOCATION See Exhibit A-2

Latitude: 46.909° Longitude: -104.0048°

DEPTH	Material Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.1	**ASPHALT**							
0.2	**AGGREGATE BASE COURSE**							
2.0	**FILL - SANDY LEAN CLAY**, brown			X	3-5-7 N=12	13.2		
4.5	**LEAN CLAY WITH SAND (CL)**, light brown, medium stiff			X	3-3-4 N=7	24.7		
7.0	**SILTY SAND (SM)**, light brown, very loose, fine-grained	5		X	1-1-1 N=2	14.5		
10.5	**FAT CLAY (CH)**, light gray, stiff			X	2-4-5 N=9	17.8		
12.0	**FAT CLAY (CH)**, olive brown, very stiff	10		X	5-10-11 N=21	16.8		
16.0	**SILTY SAND (SM)**, light gray, very dense, fine-grained			X	12-22-46 N=68	9.0		
		15		X	21-37-52 N=89	11.9		
	Boring Terminated at 16 Feet							

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

Hammer Type: Automatic

Advancement Method:
3¼" Inside Diameter, Hollow Stem Auger 0-14½'

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

Latitude and Longitude obtained with a handheld GPS unit.

WATER LEVEL OBSERVATIONS

None Encountered

Reversed Auger Out

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 10-06-2020	Boring Completed: 10-06-2020
Drill Rig: Mobile B-57	Driller: Mike R.
Project No.: M2205093	Exhibit: A-1

BORING LOG NO. B-2

PROJECT: Beach Street and Utility Improvements

CLIENT: City of Beach ND
Beach, North Dakota

SITE: Various Streets
Beach, North Dakota

LOCATION See Exhibit A-2

Latitude: 46.9098° Longitude: -104.0034°

DEPTH	Description
0.3	**ASPHALT**
0.5	**AGGREGATE BASE COURSE**, brown
3.5	**LEAN CLAY WITH SAND (CL)**, light brown, soft
7.0	**SILTY SAND (SM)**, light brown, very loose, fine-grained
12.5	**SANDY SILT (ML)**, light brown, very stiff
16.0	**FAT CLAY (CH)**, olive brown, stiff to very stiff
	Boring Terminated at 16 Feet

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		X	2-2-2 N=4	25.9		
		X	1-1-2 N=3	12.3		58
5		X	2-1-1 N=2	7.6		
		X	3-6-10 N=16	16.2		
10		X	7-9-11 N=20	18.4		
	Cave in at 12.5'	X	4-4-5 N=9	31.1		
15		X	5-8-14 N=22	20.7		

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

Hammer Type: Automatic

Advancement Method:
3¼" Inside Diameter, Hollow Stem Auger 0-14½'

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:

Latitude and Longitude obtained with a handheld GPS unit.

WATER LEVEL OBSERVATIONS

None Encountered

Reversed Auger Out

Cave in at 12.5'

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 10-06-2020	Boring Completed: 10-06-2020
Drill Rig: Mobile B-57	Driller: Mike R.
Project No.: M2205093	Exhibit: A-2

BORING LOG NO. B-3

PROJECT: Beach Street and Utility Improvements

CLIENT: City of Beach ND
Beach, North Dakota

SITE: Various Streets
Beach, North Dakota

LOCATION See Exhibit A-2

Latitude: 46.9108° Longitude: -104.002°

DEPTH	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.2	**ASPHALT**							
0.4	**AGGREGATE BASE COURSE**, brown							
2.0	**FILL - SANDY LEAN CLAY**, brown			X	4-4-4 N=8	10.2		
8.0	**SILTY SAND (SM)**, light brown, loose, fine-grained			X	3-2-3 N=5	7.2		
		5		X	2-2-3 N=5	6.4		29
				X	3-4-4 N=8	9.8		
12.0	**FAT CLAY (CH)**, olive brown, stiff	10		X	4-7-11 N=18	20.6		
14.0	**LEAN CLAY WITH SAND (CL)**, light brown, very stiff			X	7-7-9 N=16	17.6		
16.0	**SANDY SILT (ML)**, light brown, stiff to very stiff	15		X	9-11-16 N=27	9.2		
	Boring Terminated at 16 Feet							

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

Hammer Type: Automatic

Advancement Method:
3¼" Inside Diameter, Hollow Stem Auger 0-14½'

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:
Latitude and Longitude obtained with a handheld GPS unit.

WATER LEVEL OBSERVATIONS

None Encountered

Reversed Auger Out

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 10-06-2020	Boring Completed: 10-06-2020
Drill Rig: Mobile B-57	Driller: Mike R.
Project No.: M2205093	Exhibit: A-3

BORING LOG NO. B-4

PROJECT: Beach Street and Utility Improvements

CLIENT: City of Beach ND
Beach, North Dakota

SITE: Various Streets
Beach, North Dakota

LOCATION See Exhibit A-2

Latitude: 46.9095° Longitude: -104.0005°

DEPTH	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.3	**ASPHALT**							
0.5	**AGGREGATE BASE COURSE**, brown							
2.0	**FILL - SANDY LEAN CLAY**, brown			X	3-4-3 N=7	17.9		
7.0	**SILTY SAND (SM)**, light brown, loose, fine-grained			X	3-2-3 N=5	6.2	NP	
		5		X	2-1-2 N=3	3.6		20
12.0	**FAT CLAY (CH)**, olive brown, stiff			X	3-6-8 N=14	21.4		
		10		X	2-4-7 N=11	21.6		
16.0	**SANDY SILT (MH)**, light brown, hard			X	12-17-21 N=38	16.2		
		15		X	13-18-23 N=41	13.0		
	Boring Terminated at 16 Feet							

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

Hammer Type: Automatic

Advancement Method:
3¼" Inside Diameter, Hollow Stem Auger 0-14½'

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:
Latitude and Longitude obtained with a handheld GPS unit.

WATER LEVEL OBSERVATIONS

None Encountered

Reversed Auger Out

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 10-06-2020	Boring Completed: 10-06-2020
Drill Rig: Mobile B-57	Driller: Mike R.
Project No.: M2205093	Exhibit: A-4

BORING LOG NO. B-5

PROJECT: Beach Street and Utility Improvements

CLIENT: City of Beach ND
Beach, North Dakota

SITE: Various Streets
Beach, North Dakota

LOCATION See Exhibit A-2

Latitude: 46.9105° Longitude: -103.9989°

DEPTH	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.3	**ASPHALT**							
0.5	**AGGREGATE BASE COURSE**, brown							
2.0	**FILL - SANDY LEAN CLAY**, brown			X	1-1-1 N=2	19.3		
7.5	**FAT CLAY (CH)**, olive brown, medium stiff			X	1-2-4 N=6	20.7		
		5		X	4-3-5 N=8	21.5		
11.5	**SANDY SILT (ML)**, light brown, very stiff			X	6-10-14 N=24	15.1		
		10		X	8-11-15 N=26	12.5		
14.0	**FAT CLAY (CH)**, gray, stiff			X	5-4-6 N=10	30.9		
15.0	**SANDY SILT (ML)**, light brown, medium stiff							
16.0	**COAL**, very dark brown	15		X	4-4-3 N=7	14.4		

Boring Terminated at 16 Feet

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

Hammer Type: Automatic

Advancement Method:
3¼" Inside Diameter, Hollow Stem Auger 0-14½'

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations were provided by others.

Notes:
Latitude and Longitude obtained with a handheld GPS unit.

WATER LEVEL OBSERVATIONS

None Encountered

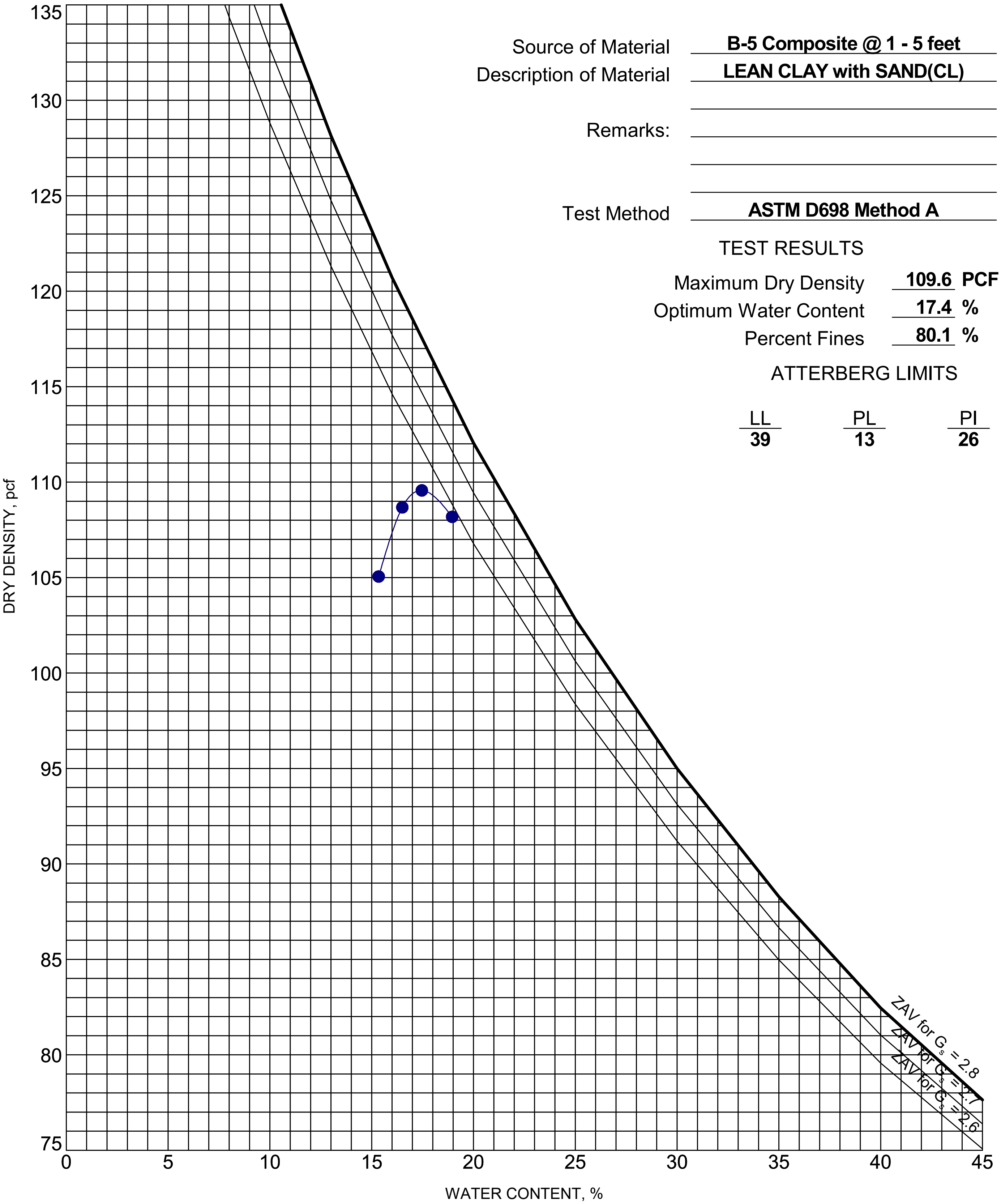
Reversed Auger Out

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

Boring Started: 10-06-2020	Boring Completed: 10-06-2020
Drill Rig: Mobile B-57	Driller: Mike R.
Project No.: M2205093	Exhibit: A-5

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material: **B-5 Composite @ 1 - 5 feet**

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

Remarks:

Test Method: **ASTM D698 Method A**

TEST RESULTS

Maximum Dry Density **109.6 PCF**

Optimum Water Content **17.4 %**

Percent Fines **80.1 %**

ATTERBERG LIMITS

LL	PL	PI
39	**13**	**26**

PROJECT: Beach Street and Utility Improvements	Terracon 1805 Hancock Dr PO Box 2084 Bismarck, ND	PROJECT NUMBER: M2205093
SITE: Various Streets Beach, North Dakota		CLIENT: City of Beach ND Beach, North Dakota
		EXHIBIT: B-1

California Bearing Ratio of Laboratory-Compacted Soils

Client

City of Beach ND
Beach, North Dakota

Project

Geotechnical Engineering Report
Beach Street and Utility Improvements
Beach, North Dakota

Project No. M2205093

SAMPLE INFORMATION

Sample Type:	Auger Sample	Proctor Method:	ASTM D698-Method A
Boring Number:	B-5	Maximum Dry Density (pcf):	109.6
Sample Location:	See Exploration Plan	Optimum Moisture (%):	17.6
Depth (ft.):	1-5'	Liquid Limit:	39
Material Description:	Lean Clay with Sand	Plasticity Index:	13
		Percent Passing No. 200 Sieve:	80.1

CBR TEST DATA

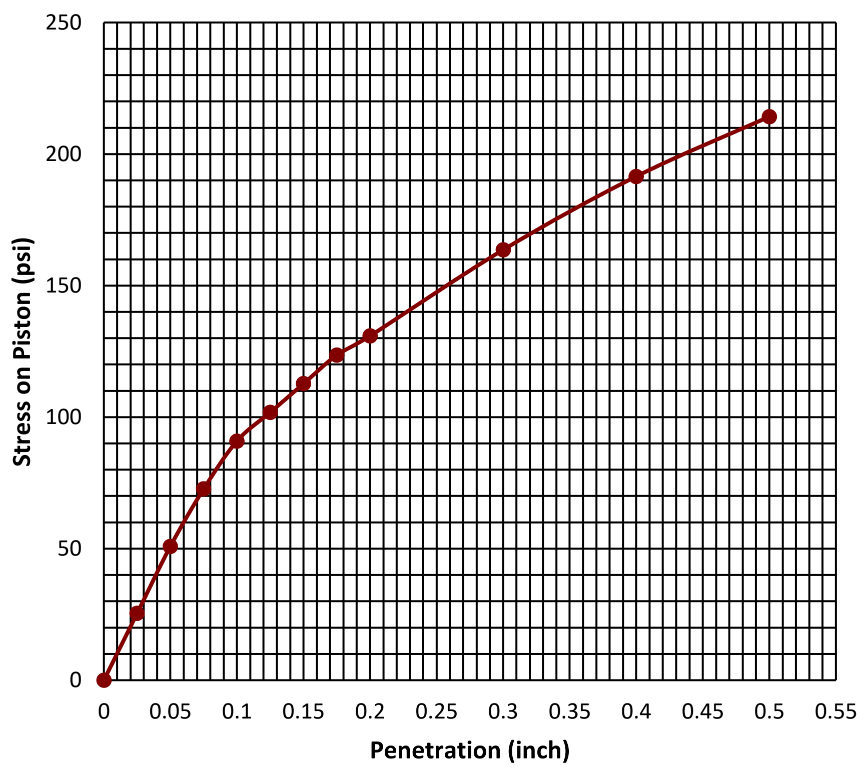
CBR Value at 0.100 inch:	**9.1**
CBR Value at 0.200 inch:	**8.7**
Surcharge Weight (lbs):	10
Soaking Condition:	Soaked
Length of Soaking (hours):	96
Swell (%):	2.6

DENSITY DATA

Dry Density Before Soaking (pcf):	104.3
Compaction of Proctor (%):	95.1

MOISTURE DATA

Before Compaction (%):	17.7
After Compaction (%):	17.5
Top 1" After Soaking (%):	23.6
Average After Soaking (%):	18.4



Comments: Remolded at 95% of maximum dry density and optimum moisture content. ASTM
Test Methods: D698-Method A

SUPPORTING INFORMATION

Contents:

Note: All attachments are one page unless noted above.

GENERAL NOTES

SAMPLING	WATER LEVEL		FIELD TESTS	
Auger Cuttings	▽	**Water Initially Encountered**	**N**	**Standard Penetration Test Resistance (Blows/Ft.)**
Split Spoon	▼	**Water Level After a Specified Period of Time**	**(HP)**	**Hand Penetrometer**
	▽	**Water Level After a Specified Period of Time**	**(T)**	**Torvane**
		Cave In Encountered	**(DCP)**	**Dynamic Cone Penetrometer**
	Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.		**UC**	**Unconfined Compressive Strength**
			(PID)	**Photo-Ionization Detector**
			(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

LOCATION AND ELEVATION NOTES

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		**CONSISTENCY OF FINE-GRAINED SOILS** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (psf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 500	0 - 1
Loose	4 - 9	Soft	500 to 1,000	2 - 4
Medium Dense	10 - 29	Medium Stiff	1,000 to 2,000	4 - 8
Dense	30 - 50	Stiff	2,000 to 4,000	8 - 15
Very Dense	> 50	Very Stiff	4,000 to 8,000	15 - 30
		Hard	> 8,000	> 30

RELEVANCE OF SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

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]	Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E]		GW	Well-graded gravel [F]
			Cu < 4 and/or [Cc<1 or Cc>3.0] [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F, G, H]
			Fines classify as CL or CH		GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or [Cc<1 or Cc>3.0] [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G, H, I]
			Fines classify as CL or CH		SC	Clayey sand [G, H, 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	< 0.75	OL	Organic clay [K, L, M, N]
			Liquid limit - not dried			Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K, L, M]
			PI plots below "A" line		MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K, L, M, P]
			Liquid limit - not dried			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] 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.

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200, predominantly 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.