Valley City Public Works Service Center

Geotechnical Engineering Report

July 25, 2024 | Terracon Project No. M1245034

Prepared for:

City of Valley City
254 2nd Avenue NE
Valley City, ND 58072

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July 25, 2024

City of Valley City
254 2nd Avenue NE
Valley City, ND 58072

Attn: Gwen Crawford, City Administrator
P: (701) 845-0380
E: gcrawford@valleycity.us

Re: Geotechnical Engineering Report
Valley City Public Works Service Center
1416 Main St. E
Valley City, North Dakota
Terracon Project No. M1245034

Dear Ms. Crawford:

We have completed the scope of Geotechnical Engineering services for the above referenced project in general accordance with Terracon Proposal No. PM1245034 dated April 30, 2024. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and floor slabs 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

REGISTERED PROFESSIONAL ENGINEER
CHAD A. COWLEY
PE-7111
DATE 07/25/2024
NORTH DAKOTA

Sajib Sarkar
Sajib Sarkar
Field Engineer

Chad A. Cowley, P.E.
Department Manager

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Attachments

Note: This report was originally delivered in a web-based format. **Blue 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 Terracon logo will bring you back to this page. For more interactive features, please view your project online at **client.terracon.com**.

Refer to each individual Attachment for a listing of contents.

Introduction

This report presents the results of our subsurface exploration and Geotechnical Engineering services performed for the proposed Public Works Service Center to be located at 1416 Main St. E in Valley City, North Dakota. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Seismic site classification per IBC
- Site preparation and earthwork
- Foundation design and construction
- Floor slab design and construction
- Frost considerations

The geotechnical engineering Scope of Services for this project included the advancement of test borings, laboratory testing, engineering analysis, and preparation of this report.

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

Project Description

Our final understanding of the project conditions is as follows:

Item	Description
Information Provided	An email request for proposal was provided by Nicholas Naujokas of EAPC on April 12. The request included conceptual plan drawings of the layout of the planned development.
Project Description	The project includes a single-story 30,000 square foot public works building.
Building Construction	Not provided; we anticipate the building will be constructed using concrete tilt-up panels and slab-on-grade construction techniques.

Item	Description
Finished Floor Elevation	Not provided; finished floor elevation for the building is anticipated to be within 2 feet of existing grade.
Maximum Loads	Anticipated structural loads were not provided. In the absence of loading information, we will use the following loads in estimating settlement based on our experience with similar projects. ▪ Columns: 100 kips ▪ Walls: 8 to 10 kips per linear foot (klf) ▪ Slabs: 150 pounds per square foot (psf)
Grading/Slopes	Based on the assumed finished floor elevation as described above and the site topography as described in the following table cuts and fills are not expected to exceed 1 to 2 feet to develop final grade. Final slopes are anticipated to be minimal and only to achieve positive drainage from the building.

Terracon should be notified if any of the above information is inconsistent with the planned construction, especially the grading limits and maximum anticipated loads, as modifications to our recommendations may be necessary.

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 at 1416 Main St. E in Valley City, North Dakota. Latitude: 46.9233° N, Longitude: 97.9826° W (See Site Location)
Existing Improvements	12,000 Square foot Admin building on west side of site with an Earthen Parking lot across the north portion of the site.
Current Ground Cover	Earthen parking lot
Existing Topography	Using available aerial imagery and the topographic map provided by Nicholas Naujokas, the site appears to be relatively level in the proposed building area, sloping downward to the

Item	Description
	south. Total change in elevation across the site is on the order of 15 feet with an elevation change of approximately 2 to 3 feet within the building footprint.

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 the site. Conditions observed at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** and the GeoModel can be found in the **Figures** attachment 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	**Fill 1**	Lean Clay with sand or gravel – dark brown to dark gray
2	**Fill 2**	Sand with Gravel - brown
3	**Topsoil**	Organic Clay - black
4	**Clay 1**	Fat Clay – varying amounts of sand, trace gravel, grayish brown, medium stiff to very stiff
5	**Clay 2**	Lean Clay - varying amounts of sand, trace gravel, grayish brown, soft to very stiff
6	**Sand 1**	Poorly Graded Sand – varying amounts of silt or gravel, brown, wet, loose to medium dense, fine to medium to coarse grained
7	**Sand 2**	Silty Sand or Clayey Sand – trace gravel, brown, loose to dense, fine to medium to coarse grained

Groundwater seepage 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. Due to the low permeability of the clays encountered in the borings, a relatively long period may be necessary for a groundwater level to develop and stabilize in a borehole. Based on the moisture condition of the samples encountered in the borings, we anticipate the groundwater level was below the termination depth of our borings at the time of our fieldwork. Groundwater conditions may be different at the time of construction. Groundwater conditions may change because of seasonal variations in rainfall, runoff, and other conditions not apparent at the time of drilling. Long-term groundwater monitoring was outside the scope of services for this project.

Seismic Site Class

The seismic design requirements for buildings and other structures are based on Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7 and the International Building Code (IBC). Based on the soil properties observed at the site and as described on the exploration logs and results, our professional opinion is for that a **Seismic Site Classification of D** be considered for the project. Subsurface explorations at this site were extended to a maximum depth of 30 feet. The site properties below the boring depth to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area. Additional deeper borings or geophysical testing may be performed to confirm the conditions below the current boring depth.

Geotechnical Overview

The site appears suitable for the proposed construction based upon geotechnical conditions encountered in the test borings, provided that the recommendations provided in this report are implemented in the design and construction phases of this project.

The soils which form the bearing stratum for shallow foundations are plastic and exhibit potential for shrink-swell movements with changes in moisture. The **Earthwork** section discusses the over-excavation of these soils and replacing them with a structural fill for shallow foundation systems and floor slabs. The **Shallow Foundations** section addresses support of the building bearing on structural fill. The **Floor Slabs** section addresses slab-on-grade support of the building.

As discussed in the **Geotechnical Characterization**, undocumented fill and buried topsoil was encountered in the boring to approximate depths ranging from two to nine feet. The 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 completely removing any undocumented fills encountered at this site and replacing them with a structural fill, as outlined in the **Earthwork** section.

The near surface, high plasticity fat clay and medium plasticity lean clay could become unstable with typical earthwork and construction traffic, especially after precipitation events. The effective drainage should be completed early in the construction sequence and maintained after construction to avoid potential issues. If possible, the grading should be performed during the warmer and drier times of the year. If grading is performed during the winter months, an increased risk for possible undercutting and replacement of unstable subgrade will persist. Additional site preparation recommendations, including subgrade improvement and fill placement, are provided in the **Earthwork** section.

Use of the existing subgrade soils for support of the parking lot is feasible. We recommend complete removal of the topsoil and undocumented fill prior to placing aggregate base for the pavements. The pavements should have good surface drainage to catch basins and a maintenance program that includes sealing cracks to reduce the infiltration of runoff into the pavement section.

Fat clay soils are present on this site which have a high potential for volume change with seasonal and annual changes in soil moisture content. These soils swell upon wetting and shrink upon drying. This report provides recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and (at least minor) cracking in the structure should be anticipated. The severity of cracking and other damage such as uneven floor slabs will probably increase if modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction.

The natural soils are extremely susceptible to frost heaving and ice lens formation. These soils will experience heaving over the winter months and a loss of strength and settlement during spring thaw. Therefore, seasonal movement and cracking of pavement and sidewalks should be expected due to the extreme temperature changes which will occur. The **Frost Considerations** section provides recommendations to reduce the potential for frost heaving.

The recommendations contained in this report are based upon the results of field and laboratory testing (presented in the **Exploration Results**), engineering analyses, and our current understanding of the proposed project. The **General Comments** section provides an understanding of the report limitations.

Earthwork

Earthwork is anticipated to include clearing and grubbing, excavations, and engineered 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 foundations, floor slabs, and pavements.

Site Preparation

Prior to placing engineered fill, we recommend all topsoil, undocumented fill, existing vegetation, and root mats, and any unsuitable materials be excavated from the proposed building and parking lot areas should be removed.

Mature trees are located within or near the footprint of the proposed building, which will require removal at the onset of construction. Tree root systems can remove substantial moisture from surrounding soils. Where trees are removed, the full root ball and all associated dry and desiccated soils should be removed. The soil materials which contain less than 5 percent organics can be reused as structural fill provided the material is moisture conditioned and properly compacted.

Although no evidence of fill or underground facilities (such as septic tanks, cesspools, basements, and utilities) was observed during the exploration and site reconnaissance, such features could be encountered during construction. If unexpected fills or underground facilities are encountered, such features should be removed, and the excavation thoroughly cleaned prior to backfill placement and/or construction.

Subgrade Preparation

We recommend that the soils within the footprint of the proposed structures be removed to a minimum depth 5 feet below the bottom of footings and floor slabs. Structural fill placed beneath the entire footprint of the foundations should extend horizontally a minimum distance of 2/3 times the depth of footings beyond the outside edge of footings. On-site soils free of organics may be suitable to be used as structural fill materials, but should be tested to ensure they meet the outlined requirements prior to use as structural fill.

The pavement 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 observation of the Geotechnical Engineer or representative. Areas excessively deflecting under the proofroll should be delineated and subsequently addressed by the Geotechnical Engineer.

Based upon the subsurface conditions determined from the geotechnical exploration, subgrade soils exposed during construction are anticipated to be relatively workable; however, the workability of the subgrade may be affected by precipitation, repetitive construction traffic or other factors. If unworkable conditions develop, workability may be improved by scarifying and drying.

Existing Fill

As noted in **Geotechnical Characterization**, borings encountered previously placed fill to depths ranging from about 2 to 9 feet. We have no records to indicate the degree of control, and consequently, the fill is considered unreliable for support of foundation loads and floor slabs. Support of pavements on or above existing fill soils is discussed in this report. However, even with the recommended construction procedures, inherent risk exists 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 but can be reduced by following the recommendations contained in this report.

If the owner elects to construct pavements on the existing fill, the following protocol should be followed. The existing soils can be removed to a minimum of 24 inches beneath proposed pavement sections. The exposed subgrade should then be scarified and recompacted to a minimum depth of 12 inches. A structural fill meeting the material requirements outlined below should be placed at a minimum in the upper 24 inches beneath the proposed pavement sections. Once the planned subgrade elevation has been reached, the entire pavement area should be proofrolled. Areas of soft or otherwise unsuitable material should be undercut and replaced with either new structural fill or suitable, existing on site materials.

Excavation

We recommend excavations for the proposed construction be performed by a Backhoe with a smooth cutting surface. The natural clays are highly susceptible to disturbance from construction traffic, even light foot traffic. The bottom of excavations should be thoroughly cleaned of loose soils and disturbed materials prior to backfill placement and/or construction. Fill placement should be made using equipment which will not travel directly on the sensitive clays. Care should be taken to avoid disturbance of the natural soils.

Fill Material Types

Fill required to achieve design grade should be classified as structural fill and general fill. Structural fill is material used below or within 10 feet of structures or pavements. General fill is material used to achieve grade outside of these areas.

Reuse of On-Site Soil: Excavated on-site soil may be selectively reused as fill. Portions of the on-site soil have an elevated fines content and will be sensitive to moisture conditions (particularly during seasonally wet periods) and may not be suitable for reuse when above optimum moisture content. It is common practice to reuse the fat clays as structural fill below pavements as a cost savings measure. With this, the pavement may be adequate from a structural standpoint, yet still experience cracking and deformation due to shrink/swell related movement of the subgrade.

Material property requirements for on-site soil for use as general fill and structural fill are noted in the table below:

Property	General Fill	Structural Fill
Composition	Free of deleterious material	Free of deleterious material
Maximum particle size	6 inches (or 2/3 of the lift thickness)	2 inches
Fines content	Not limited	Less than 20% Passing No. 200 sieve (SM only)
Plasticity	Not limited	Liquid Limit of less than 45
GeoModel Layer Expected to be Suitable[1]	All	1, 2, 5

1. Based on subsurface exploration. Actual material suitability should be determined in the field at time of construction.

Imported Fill Materials: Imported fill materials should meet the following material property requirements. Regardless of its source, compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade.

Soil Type [1]	USCS Classification	Acceptable Parameters (for Structural Fill)
Low Plasticity Cohesive	CL	Liquid Limit less than 45
Granular	GW, GP, GM, GC, SW, SP, SM, SC	100% passing 3-inch Sieve Less than 12% passing No. 200 sieve

Soil Type [1]	USCS Classification	Acceptable Parameters (for Structural Fill)
Non-Frost Susceptible (NFS)[2]	SW, SP	100% passing 3-inch Sieve Less than 40% passing No. 8 sieve Less than 8% passing No. 200 sieve

1. Structural and general fill should consist of approved materials free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation prior to use on this site.
2. See **Frost Considerations** for information on areas to consider for NFS fill.

Fill Placement and 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 4 to 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]	98% of maximum dry density within 1 foot of finished pavement subgrade 95% of max. below foundations, slabs, and more than 1 foot below finished pavement subgrade	90% of max.
Water Content Range [1]	Granular: as required to achieve min. compaction requirements Low plasticity cohesive: -3% to +3% of optimum High plasticity cohesive below pavements: -1% to +3%	Same as structural fill 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.

Utility Trench Backfill

Any soft or unsuitable materials encountered at the bottom of utility trench excavations should be removed and replaced with structural fill or bedding material in accordance with public works specifications for the utility to be supported. This recommendation is particularly applicable to utility work requiring grade control and/or in areas where subsequent grade raising could cause settlement in the subgrade supporting the utility. Trench excavation should not be conducted below a downward 1:1 projection from existing foundations without engineering review of shoring requirements and geotechnical observation during construction.

On-site materials are considered suitable for backfill of utility and pipe trenches from 1 foot above the top of the pipe to the final ground surface, provided the material is free of organic matter and deleterious substances.

Trench backfills should be mechanically placed and compacted as discussed earlier in this report. Compaction of initial lifts should be accomplished with hand-operated tampers or other lightweight compactors. Where trenches are placed beneath slabs or footings, the backfill should satisfy the gradation and expansion index requirements of engineered fill discussed in this report. Flooding or jetting for placement and compaction of backfill is not recommended.

For low permeability subgrades, utility trenches are a common source of water infiltration and migration. Utility trenches penetrating beneath the building should be effectively sealed to restrict water intrusion and flow through the trenches, which could migrate below the building. The trench should provide an effective trench plug that extends at least 5 feet from the face of the building exterior. The plug material should consist of cementitious flowable fill or low permeability clay. The trench plug material should be placed to surround the utility line. If used, the clay trench plug material should be placed and compacted to comply with the water content and compaction recommendations for structural fill stated previously in this report.

Grading and Drainage

All grades must provide effective drainage away from the building during and after construction and should be maintained throughout the life of the structure. Water retained next to the buildings can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential floor slab and/or foundation movements, cracked slabs and walls, and roof leaks. The roof should have gutters/drains with downspouts that discharge onto splash blocks at a distance of at least 10 feet from the buildings.

Exposed ground should be sloped and maintained at a minimum 5% away from the building for at least 10 feet beyond the perimeter of the building. Locally, flatter grades may be necessary to transition ADA access requirements for flatwork. After building construction and landscaping have been completed, final grades should be verified to document effective drainage has been achieved. Grades around the structure should also be periodically inspected and adjusted, as necessary, as part of the structure's maintenance program. Where paving or flatwork abuts the structure, a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration.

Earthwork Construction Considerations

Shallow excavations for the proposed building should only be performed using a Backhoe with a smooth cutting surface. Construction traffic over the natural fat clays will likely cause disturbance and weakening of the soils and result in additional excavation to remove.

Groundwater seepage may occur in excavations. We anticipate groundwater seepage in short term excavations would be controllable by sump pumping.

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.

Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of grade-supported improvements such as floor slabs and pavement. 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 floor slab construction.

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.

Excavations or other activities resulting in ground disturbance have the potential to affect adjoining properties and structures. Our scope of services does not include review of available final grading information or consider potential temporary grading performed by the contractor for potential effects such as ground movement beyond the project limits. A preconstruction/ precondition survey should be conducted to document nearby property/infrastructure prior to any site development activity. Excavation or ground disturbance activities adjacent or near property lines should be monitored or instrumented for potential ground movements that could negatively affect adjoining property and/or structures.

Construction Observation and Testing

The earthwork efforts should be observed by the Geotechnical Engineer (or others under their direction). Observation should include documentation of adequate removal of surficial materials (vegetation, topsoil, and pavements), evaluation and remediation of existing fill materials, as well as proofrolling and mitigation of unsuitable areas delineated by the proofroll.

Each lift of compacted fill should be tested, evaluated, and reworked, as necessary, as recommended 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 2,500 square feet of compacted fill in the building areas and 5,000 square feet in pavement areas. Where not specified by local ordinance, one density and water content test should be performed for every 100 linear feet of compacted utility trench backfill and a minimum of one test performed for every 12 vertical inches of compacted backfill.

In areas of foundation excavations, the bearing subgrade should be evaluated by the Geotechnical Engineer. If unanticipated conditions are observed, 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.

Shallow Foundations

If the site has been prepared in accordance with the requirements noted in **Earthwork**, the following design parameters are applicable for shallow foundations.

Design Parameters – Compressive Loads

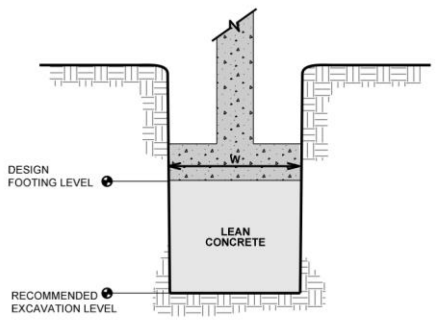
Item	Description
Maximum Net Allowable Bearing Pressure [1, 2]	2,500 psf
Required Bearing Stratum [3]	Structural fill
Minimum Foundation Dimensions	Per IBC 1809.7
Ultimate Passive Resistance[4] **(equivalent fluid pressures)**	300 pcf (granular backfill)
Sliding Resistance [5]	0.35 allowable coefficient of friction (granular material)
Minimum Embedment below Finished Grade [6]	Exterior footings in unheated areas: 72 inches Exterior footings in heated areas: 60 inches Interior footings in heated areas: 12 inches
Estimated Total Settlement from Structural Loads [2]	Less than 1 inch
Estimated Differential Settlement [2, 7]	About 1/2 of total settlement

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation.
2. Values provided are for maximum loads noted in **Project Description**. Additional geotechnical consultation will be necessary if higher loads are anticipated.
3. Unsuitable or soft soils should be overexcavated and replaced per the recommendations presented in **Earthwork**.
4. Use of passive earth pressures require the sides of the excavation for the spread footing foundation to be nearly vertical and the concrete placed neat against these vertical faces or that the footing forms be removed and compacted structural fill be placed against the vertical footing face. Assumes no hydrostatic pressure.
5. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Frictional resistance for granular materials is dependent on the bearing pressure which may vary due to load combinations. For fine-grained materials, lateral resistance using cohesion should not exceed ½ the dead load.
6. Embedment necessary to minimize the effects of frost and/or seasonal water content variations. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.
7. Differential settlements are noted for equivalent-loaded foundations and bearing elevation as measured over a span of 50 feet.

Foundation Construction Considerations

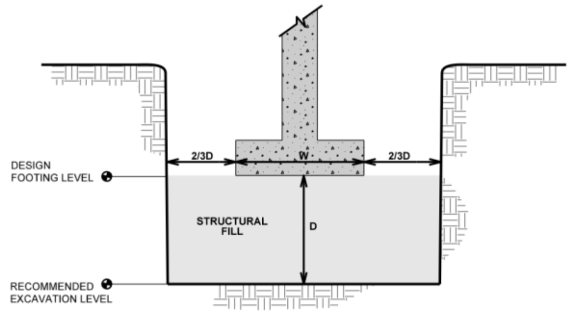
As noted in **Earthwork**, the footing excavations should be evaluated under the observation of the Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

As discussed in **Earthwork**, the high plasticity clays and undocumented fill encountered at the anticipated footing depth should be removed to a minimum of 60 inches below foundations. The over-excavation should then be backfilled up to the footing base elevation, with lean concrete or structural fill placed as recommended in the **Earthwork** section. This is illustrated in the following sketches.



LEAN CONCRETE BACKFILL

NOTE: EXCAVATIONS ARE SHOWN VERTICAL; HOWEVER, THE SIDEWALLS SHOULD BE SLOPED AS NECESSARY FOR SAFETY



OVER-EXCAVATION / BACKFILL ZONE

NOTE: EXCAVATIONS ARE SHOWN VERTICAL; HOWEVER, THE SIDEWALLS SHOULD BE SLOPED AS NECESSARY FOR SAFETY

Floor Slabs

Design parameters for floor slabs assume the requirements for **Earthwork** have been followed. Specific attention should be given to positive drainage away from the structure and positive drainage of the aggregate base beneath the floor slab.

The subgrade soils are comprised of existing fill, organic soil, and high plasticity clays exhibiting the potential to swell with increased water content. Construction of the floor slab, combined with the removal of trees, and revising site drainage creates the potential for gradual increased water contents within the clays. Increases in water content will cause the clays to swell and damage the floor slab. To reduce the swell potential, at least the upper 60 inches of subgrade soils below the floor slab should consist of structural fill.

Floor Slab Design Parameters

Item	Description
Floor Slab Support[1]	Use 6 inches base course meeting material specifications of ACI 302 directly below the floor slab[3]
Estimated Modulus of Subgrade Reaction [2]	100 pounds per square inch per inch (psi/in) for point loads

1. Floor slabs should be structurally independent of building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
2. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in **Earthwork**, and the floor slab support as noted in this table. It is provided for point loads. For large area loads the modulus of subgrade reaction would be lower.
3. Other design considerations such as cold temperatures and condensation development could warrant more extensive design provisions.

The use of a vapor retarder should be considered beneath concrete slabs on grade covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, when the project includes humidity-controlled areas, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

Saw-cut contraction joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations, refer to the ACI Design Manual. Joints or cracks should be sealed with a waterproof, non-extruding compressible compound specifically recommended for heavy duty concrete pavement and wet environments.

Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks beyond the length of the structural dowels. The Structural Engineer should account for potential differential settlement through use of sufficient control joints, appropriate reinforcing or other means.

Settlement of floor slabs supported on existing fill materials cannot be accurately predicted but could be larger than normal and result in some cracking. Mitigation measures, as noted in **Existing Fill** within **Earthwork**, are critical to the performance of floor slabs. In addition to the mitigation measures, the floor slab can be stiffened by adding steel reinforcement, grade beams, and/or post-tensioned elements.

Floor Slab Construction Considerations

Finished subgrade, within and for at least 10 feet beyond the floor slab, should be protected from traffic, rutting, or other disturbance and maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become damaged or desiccated prior to construction of floor slabs, the affected material should be removed, and structural fill should be added to replace the resulting excavation. Final conditioning of the finished subgrade should be performed immediately prior to placement of the floor slab support course.

The Geotechnical Engineer should observe the condition of the floor slab subgrades immediately prior to placement of the floor slab support course, reinforcing steel, and concrete. Attention should be paid to high traffic areas that were rutted and disturbed earlier, and to areas where backfilled trenches are located.

Frost Considerations

The soils on this site are frost susceptible, and small amounts of water can affect the performance of the slabs on-grade, sidewalks, and pavements. Exterior slabs should be anticipated to heave during winter months. If frost action needs to be eliminated in critical areas, we recommend the use of non-frost susceptible (NFS) fill or structural slabs (for instance, structural stoops in front of building doors). Placement of NFS material in large areas may not be feasible; however, the following recommendations are provided to help reduce potential frost heave:

- Provide surface drainage away from the building and slabs, and toward the site drainage system.
- Install drains around the perimeter of the building, stoops, below exterior slabs and pavements, and connect them to the site drainage system.
- Grade clayey subgrades so groundwater potentially perched in overlying fill or aggregate base, slope toward a site drainage system.
- Place NFS fill as backfill beneath slabs and pavements critical to the project.
- Place a 4 horizontal to 1 vertical (4H:1V) transition zone between NFS fill and other soils.
- Place NFS materials in critical sidewalk areas.

As an alternative to extending NFS fill to the full frost depth, consideration can be made to placing extruded polystyrene or cellular concrete under a buffer of at least 4 feet of NFS material.

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. 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 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 effect 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. Construction and site development have the potential to affect adjacent properties. Such impacts can include damages due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with contractor means and methods and are not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of surrounding development. 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

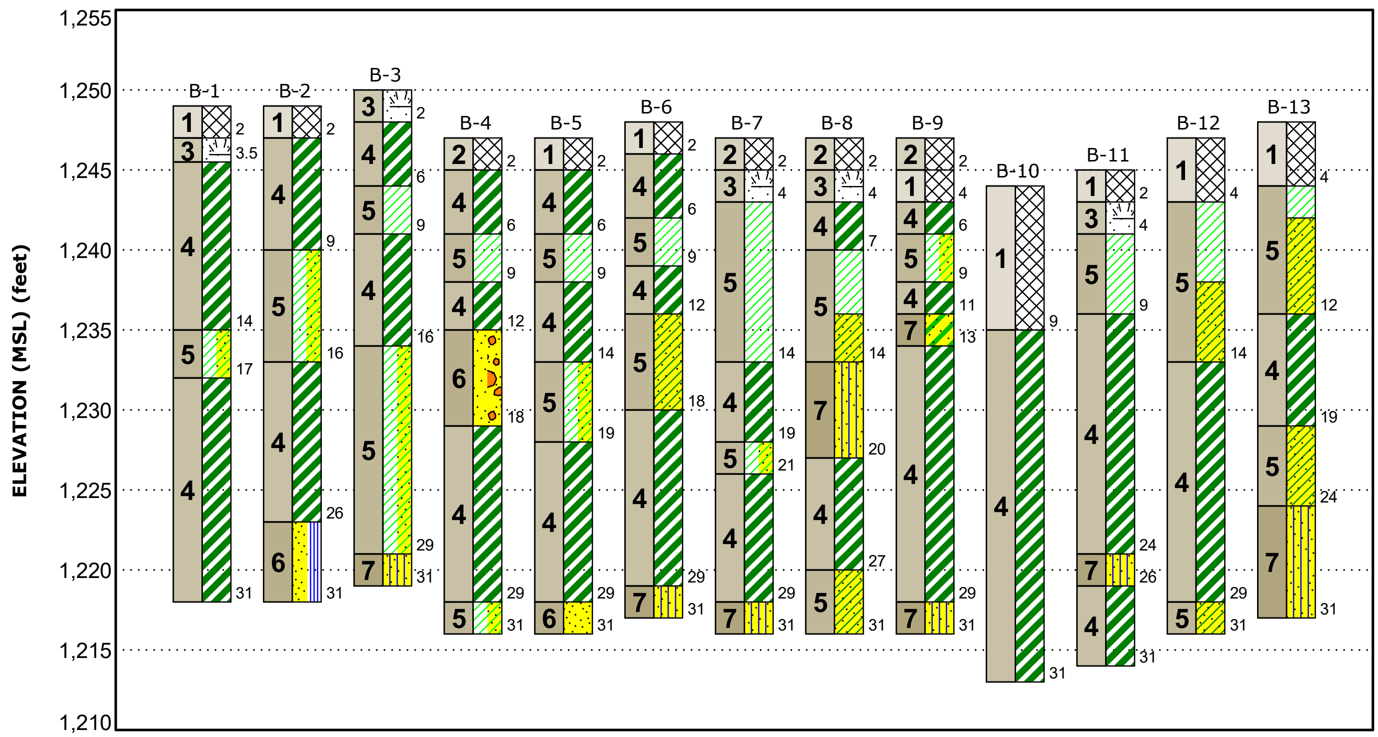
Contents:

GeoModel

Note: All attachments are one page unless noted above.

860 9th St. NE, Unit K
West Fargo, ND

GeoModel



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

Model Layer	Layer Name	General Description
1	**Fill 1**	Lean Clay with sand or gravel - dark brown to dark gray
2	**Fill 2**	Sand with Gravel - brown
3	**Topsoil**	Organic Clay - black
4	**Clay 1**	Fat Clay - varying amounts of sand, trace gravel, grayish brown, medium stiff to very stiff
5	**Clay 2**	Lean Clay - varying amounts of sand, trace gravel, grayish brown, soft to very stiff
6	**Sand 1**	Poorly Graded Sand - varying amounts of silt or gravel, brown, wet, loose to medium dense, fine to medium to coarse grained
7	**Sand 2**	Silty Sand or Clayey Sand - trace gravel, brown, loose to dense, fine to medium to coarse grained

Legend

- Fill
- Topsoil
- Fat Clay
- Lean Clay with Sand
- Poorly-graded Sand with Silt
- Lean Clay
- Silty Sand
- Poorly-graded Sand with Gravel
- Poorly-graded Sand
- Sandy Lean Clay
- Clayey Sand

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
9	30	Building area
4	30	Slope south of building area

Boring Layout and Elevations: Terracon personnel provided the boring layout using handheld GPS equipment (estimated horizontal accuracy of about ±10 feet) and referencing existing site features. Approximate ground surface elevations were estimated using google earth. If elevations and a more precise boring layout are desired, we recommend borings be surveyed.

Subsurface Exploration Procedures: We advanced the borings with an ATV-mounted rotary drill rig using hollow stem augers. Samples were obtained at 2 ½-foot intervals in the upper 15 feet of each boring and at intervals of 5 feet thereafter. In the thin-walled tube sampling procedure, a thin-walled, seamless steel tube with a sharp cutting edge was pushed hydraulically into the soil to obtain a relatively undisturbed sample. 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. For safety purposes, all borings were backfilled with auger cuttings after their completion.

We also observed the boreholes while drilling and at the completion of drilling for the presence of groundwater. Groundwater levels, if encountered, are shown on the attached boring logs.

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 observed 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. The laboratory testing program included the following types of tests:

- Water content
- Unit dry weight
- Atterberg limits
- Unconfined compressive strength
- Moisture-density relationship

The laboratory testing program often included examination of soil samples by an engineer. Based on the results of our field and laboratory programs, 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

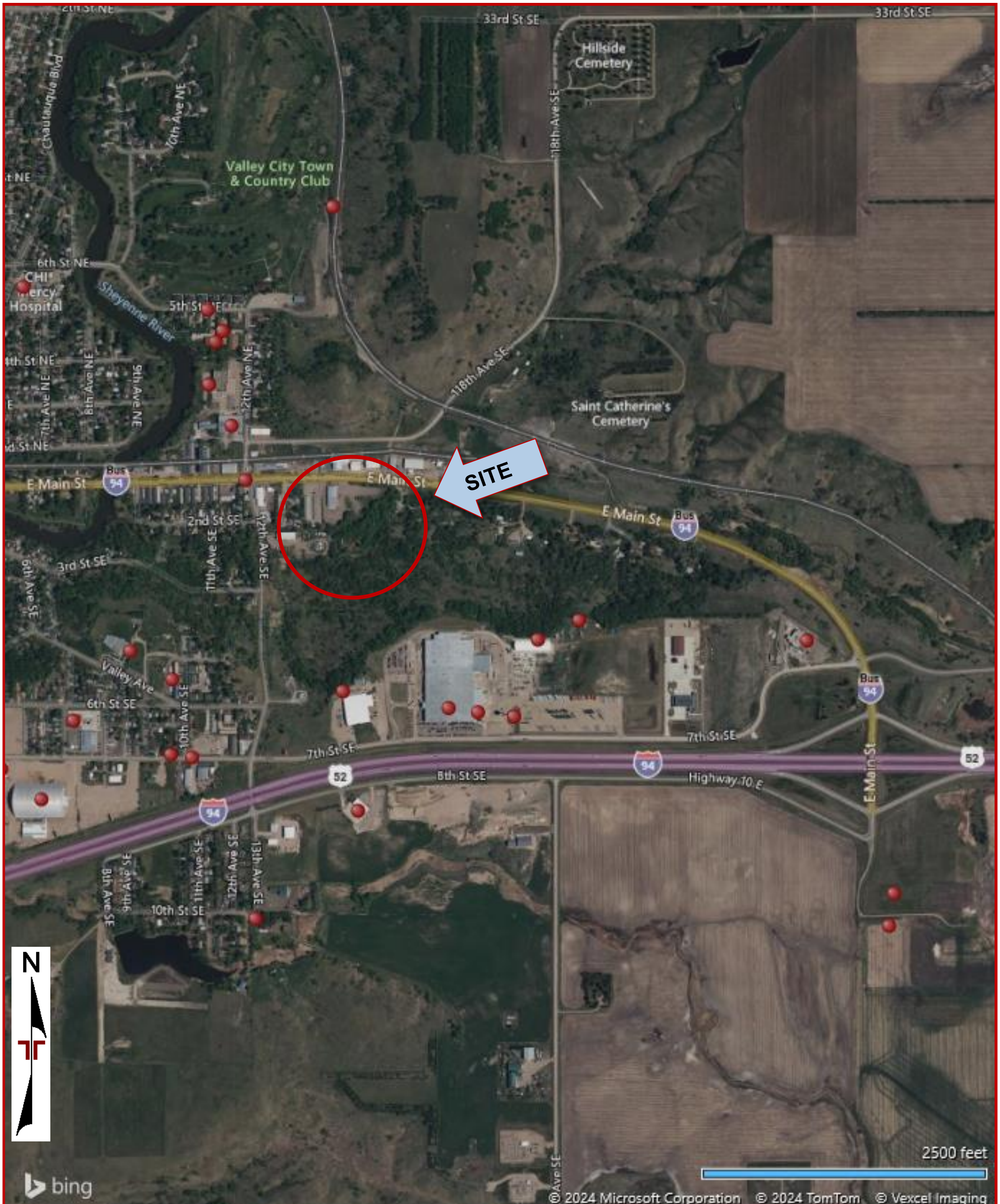


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES MAP PROVIDED BY MICROSOFT BING MAPS

Exploration and Laboratory Results

Contents:

Boring Logs (B-1 through B-13)
Moisture Density Relationship

Note: All attachments are one page unless noted above.

Terracon
860 9th St. NE, Unit K
West Fargo, ND

Boring Log No. B-1

Location: See Exploration Plan

Latitude: 46.9235° Longitude: -97.9831°

Depth (Ft.) Elevation: 1249 (Ft.) +/-

Model Layer	Depth (Ft.) / Description	Elevation	Sample Depth (Ft.)	Field Test Results	HP (psf)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1	**FILL - LEAN CLAY WITH GRAVEL**, dark brown		0.5				16.6			
	2.0	1247								
3	**TOPSOIL - ORGANIC CLAY (OH)**, black		2.5	2-5-7 N=12	4600 (HP)		39.5			
	3.5	1245.5								
4	**FAT CLAY (CH)**, grayish brown, mottled, stiff to very stiff		5	3-4-6 N=10	6800 (HP)		31.7			
			7.5	3-6-7 N=13	6400 (HP)		26.3			
			10		7000 (HP)	4250	25.7	96		
			12.5	5-5-6 N=11	8800 (HP)		25.0			
	14.0	1235								
5	**LEAN CLAY WITH SAND (CL)**, trace gravel, grayish brown, medium stiff		15	3-3-3 N=6	1000 (HP)		26.3			
	17.0	1232								
4	**FAT CLAY (CH)**, brownish gray, mottled, stiff		20	2-4-5 N=9	4000 (HP)		30.9			
			25	2-4-4 N=8	4000 (HP)		36.1			
			30	3-3-5 N=8	4000 (HP)		31.4			
	31.0	1218								

Boring Terminated at 31 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Elevations were estimated from Google Earth and should only be considered approximate

Water Level Observations
No free water observed

Notes

Advancement Method
3 1/4" Hollow Stem Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
1163- Mobile B57

Hammer Type
Automatic

Driller
MR

Logged by
JM

Boring Started
06-12-2024

Boring Completed
06-12-2024

Terracon
860 9th St. NE, Unit K
West Fargo, ND

Boring Log No. B-2

Location: See Exploration Plan

Latitude: 46.9234° Longitude: -97.9820°

Elevation: 1249 (Ft.) +/-

Model Layer	Depth (Ft.)	Material Description	Elevation (Ft.)
1	2.0	**FILL - LEAN CLAY WITH GRAVEL**, dark brown	1247
4	9.0	**FAT CLAY (CH)**, grayish brown, mottled, stiff to very stiff	1240
5	16.0	**LEAN CLAY WITH SAND (CL)**, trace gravel, grayish brown, stiff	1233
4	26.0	**FAT CLAY (CH)**, grayish brown, mottled, medium stiff to stiff	1223
6	31.0	**POORLY GRADED SAND WITH SILT (SP-SM)**, medium to coarse grained, brown, wet, loose	1218

Boring Terminated at 31 Feet

Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	HP (psf)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
			10-7-7 N=14			13.3			
			3-4-6 N=10	6600 (HP)		31.0		75-23-52	
5			3-3-6 N=9	8600 (HP)		22.8			
				6000 (HP)	5920	29.4	96		
10			3-4-9 N=13	4600 (HP)		18.9			
			5-6-4 N=10			18.4			
15			9-7-6 N=13			18.0			
20			1-2-3 N=5	4800 (HP)		30.0			
25			2-4-5 N=9	4200 (HP)		30.5			
30			4-2-4 N=6			23.0			

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Elevations were estimated from Google Earth and should only be considered approximate

Water Level Observations
No free water observed

Drill Rig
1163- Mobile B57

Hammer Type
Automatic

Driller
MR

Notes

Advancement Method
3 1/4" Hollow Stem Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Logged by
JM

Boring Started
06-12-2024

Boring Completed
06-12-2024

Terracon
860 9th St. NE, Unit K
West Fargo, ND

Boring Log No. B-3

Location: See Exploration Plan

Latitude: 46.9232° Longitude: -97.9831°

Depth (Ft.) Elevation: 1250 (Ft.) +/-

Model Layer	Graphic Log	Material Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	HP (psf)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
3		**TOPSOIL - ORGANIC CLAY (OH)**, black			X	5-6-6 N=12			27.8			
		2.0 — 1248										
4		**FAT CLAY (CH)**, grayish brown, mottled, very stiff			X	10-12-14 N=26	12000 (HP)		22.0			
			5		X	8-11-13 N=24	12000 (HP)		22.6			
		6.0 — 1244										
5		**LEAN CLAY (CL)**, grayish brown, medium stiff			X	4-4-4 N=8	6400 (HP)		22.5			
		9.0 — 1241										
4		**FAT CLAY (CH)**, grayish brown, mottled, medium stiff	10		X	2-3-4 N=7	6000 (HP)		32.7			
					X	1-2-3 N=5	3600 (HP)		33.6			
			15		X	2-2-3 N=5	4200 (HP)		29.9			
		16.0 — 1234										
5		**LEAN CLAY WITH SAND (CL)**, trace gravel, brown, medium stiff	20		X	1-2-3 N=5			23.6			
			25		X	3-3-5 N=8			27.6			
		29.0 — 1221										
7		**SILTY SAND (SM)**, trace gravel, fine to medium grained, brown, wet, loose	30		X	2-3-4 N=7			22.3			
		31.0 — 1219										
		Boring Terminated at 31 Feet										

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Elevations were estimated from Google Earth and should only be considered approximate

Water Level Observations
No free water observed

Drill Rig
1163- Mobile B57

Hammer Type
Automatic

Driller
MR

Notes

Advancement Method
3 1/4" Hollow Stem Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Logged by
JM

Boring Started
06-12-2024

Boring Completed
06-12-2024

Terracon
860 9th St. NE, Unit K
West Fargo, ND

Boring Log No. B-4

Location: See Exploration Plan

Latitude: 46.9232° Longitude: -97.9826°

Model Layer	Depth (Ft.)	Description	Elevation: 1247 (Ft.) +/-	Sample Depth (Ft.)	Water Level Observations	Field Test Results	HP (psf)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
2	0.0–2.0	**FILL - SAND WITH GRAVEL**, brown	1245	0–1.5 (bulk)					5.6			
4	2.0–6.0	**FAT CLAY (CH)**, gray to grayish brown, mottled, stiff	1241	2.0–3.5		3-5-8 N=13	5800 (HP)		33.0			
				4.5–6.0		3-4-9 N=13	9600 (HP)		28.3			
5	6.0–9.0	**LEAN CLAY (CL)**, grayish brown, stiff	1238	7.0–8.5		3-5-6 N=11	5400 (HP)		19.3			
4	9.0–12.0	**FAT CLAY (CH)**, grayish brown, mottled, stiff	1235	9.5–11.0		4-6-9 N=15	6600 (HP)		26.6			
6	12.0–18.0	**POORLY GRADED SAND WITH GRAVEL (SP)**, fine to medium grained, brown, medium dense	1229	12.0–14.0								
				14.5–16.0		5-11-7 N=18			11.0			
4	18.0–29.0	**FAT CLAY (CH)**, grayish brown, mottled, medium stiff to stiff	1218	19.5–21.0		1-1-3 N=4	3400 (HP)		28.7			
				24.5–26.0		3-4-5 N=9	3400 (HP)		29.3			
5	29.0–31.0	**LEAN CLAY WITH SAND (CL)**, trace gravel, grayish brown, stiff	1216	29.5–31.0		3-3-6 N=9	2000 (HP)		25.4			

Boring Terminated at 31 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Elevations were estimated from Google Earth and should only be considered approximate

Notes

Water Level Observations
No free water observed

Advancement Method
3 1/4" Hollow Stem Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
1163- Mobile B57

Hammer Type
Automatic

Driller
MR

Logged by
JM

Boring Started
06-12-2024

Boring Completed
06-12-2024

Terracon
860 9th St. NE, Unit K
West Fargo, ND

Boring Log No. B-5

Location: See Exploration Plan

Latitude: 46.9232° Longitude: -97.9821°

Elevation: 1247 (Ft.) +/-

Model Layer	Depth (Ft.)	Material Description	Elevation (Ft.)	Sample Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	HP (psf)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1	0.0–2.0	**FILL - LEAN CLAY WITH SAND**, dark gray	1245	0–1.5		Split spoon	5-10-9 N=19			14.3			
4	2.0–6.0	**FAT CLAY (CH)**, grayish brown, mottled, very stiff to stiff	1241	2–3.5		Split spoon	4-7-10 N=17	9000 (HP)		28.3			
				4.5–6		Split spoon	3-5-7 N=12	9400 (HP)		28.8			
5	6.0–9.0	**LEAN CLAY (CL)**, grayish brown, medium stiff	1238	7–8.5		Split spoon	3-2-4 N=6	6800 (HP)		25.5			
4	9.0–14.0	**FAT CLAY (CH)**, grayish brown, mottled, stiff to medium stiff	1233	9.5–11		Split spoon	3-4-5 N=9	6000 (HP)		27.3			
				12–13.5		Split spoon	2-3-4 N=7	2600 (HP)		32.0			
5	14.0–19.0	**LEAN CLAY WITH SAND (CL)**, grayish brown	1228	14.5–16		Auger							
4	19.0–29.0	**FAT CLAY (CH)**, grayish brown, mottled, medium stiff	1218	19.5–21		Split spoon	2-4-4 N=8	2600 (HP)		33.4			
				24.5–26		Split spoon	2-3-4 N=7	2400 (HP)		32.4			
6	29.0–31.0	**POORLY GRADED SAND (SP)**, trace gravel, fine to medium grained, brown, wet, loose	1216	29.5–31		Split spoon	2-2-3 N=5			19.5			

Boring Terminated at 31 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Elevations were estimated from Google Earth and should only be considered approximate

Water Level Observations
No free water observed

Drill Rig
1163- Mobile B57

Hammer Type
Automatic

Driller
MR

Notes

Advancement Method
3 1/4" Hollow Stem Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Logged by
JM

Boring Started
06-12-2024

Boring Completed
06-12-2024

Terracon
860 9th St. NE, Unit K
West Fargo, ND

Boring Log No. B-6

Location: See Exploration Plan

Latitude: 46.9229° Longitude: -97.9826°

Elevation: 1248 (Ft.) +/-

Model Layer	Depth (Ft.)	Elevation (Ft.)	Material Description
1	0.0–2.0	1246	**FILL - LEAN CLAY WITH SAND**, dark brown
4	2.0–6.0	1242	**FAT CLAY (CH)**, grayish brown, mottled, very stiff
5	6.0–9.0	1239	**LEAN CLAY (CL)**, trace gravel, grayish brown, stiff
4	9.0–12.0	1236	**FAT CLAY (CH)**, grayish brown, mottled, very stiff
5	12.0–18.0	1230	**SANDY LEAN CLAY (CL)**, grayish brown, stiff to medium stiff
4	18.0–29.0	1219	**FAT CLAY (CH)**, grayish brown, mottled, medium stiff
7	29.0–31.0	1217	**SILTY SAND (SM)**, trace gravel, fine to medium grained, brown, wet, medium dense

Boring Terminated at 31 Feet

Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	HP (psf)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
0–1.5		SPT	4-6-8 N=14			16.4			
2–3.5		SPT	5-9-12 N=21	12000 (HP)		25.3			
4.5–6		SPT	9-9-12 N=21	6600 (HP)		24.1			
7–8.5		SPT	3-3-5 N=8	6000 (HP)		23.5			
10–11.5		Shelby Tube		6000 (HP)	5190	32.2	89	65-23-42	96
12–13.5		SPT	3-5-5 N=10	2600 (HP)		21.8			
14.5–16		SPT	2-3-4 N=7			21.9			
19.5–21		SPT	1-2-3 N=5	2600 (HP)		29.7			
24.5–26		SPT	1-3-3 N=6	3200 (HP)		31.3			
29.5–31		SPT	5-5-6 N=11			18.3			

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Elevations were estimated from Google Earth and should only be considered approximate

Notes

Water Level Observations
No free water observed

Advancement Method
3 1/4" Hollow Stem Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
1163- Mobile B57

Hammer Type
Automatic

Driller
MR

Logged by
JM

Boring Started
06-12-2024

Boring Completed
06-12-2024

Boring Log No. B-7

Location: See Exploration Plan

Latitude: 46.9230° Longitude: -97.9826°

Model Layer	Graphic Log	Depth (Ft.) / Description	Elevation: 1247 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	HP (psf)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
2		**FILL - SAND WITH GRAVEL**, dark brown					3-3-6 N=9			19.4			
		2.0	1245										
3		**TOPSOIL - ORGANIC CLAY (OH)**, black					5-7-8 N=15			36.1			
		4.0	1243										
5		**LEAN CLAY (CL)**, grayish brown, stiff ro medium sitff		5			5-6-6 N=12			20.6			
							3-3-5 N=8	2800 (HP)		28.1			
				10			3-5-6 N=11	6000 (HP)		20.7			
								3000 (HP)	1160	32.7	92	41-17-24	94
		14.0	1233										
4		**FAT CLAY (CH)**, grayish brown, mottled, medium stiff		15			2-2-4 N=6	3600 (HP)		36.3			
		19.0	1228										
5		**LEAN CLAY WITH SAND (CL)**, grayish brown, soft		20			1-2-2 N=4	800 (HP)		28.0			
		21.0	1226										
4		**FAT CLAY (CH)**, grayish brown, mottled, soft		25			1-1-3 N=4	3200 (HP)		26.2			
		29.0	1218										
7		**SILTY SAND (SM)**, trace gravel, fine to medium grained, grayish brown, wet, medium dense		30			4-7-5 N=12			22.5			
		31.0	1216										
		Boring Terminated at 31 Feet											

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Elevations were estimated from Google Earth and should only be considered approximate

Notes

Water Level Observations
No free water observed

Advancement Method
3 1/4" Hollow Stem Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
1163- Mobile B57

Hammer Type
Automatic

Driller
MR

Logged by
JM

Boring Started
06-12-2024

Boring Completed
06-12-2024

Terracon
860 9th St. NE, Unit K
West Fargo, ND

Boring Log No. B-8

Location: See Exploration Plan

Latitude: 46.9230° Longitude: -97.9831°

Elevation: 1247 (Ft.) +/-

Model Layer	Depth (Ft.)	Description	Elevation	Sample Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	HP (psf)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
2	0.0–2.0	**FILL - SAND WITH GRAVEL**, dark brown	1245	0.0–1.5		SPT	3-6-9 N=15			10.6			
3	2.0–4.0	**TOPSOIL - ORGANIC CLAY (OH)**, black	1243	2.0–3.5		SPT	7-6-8 N=14	12000 (HP)		21.1			
4	4.0–7.0	**FAT CLAY (CH)**, brownish gray, mottled, very stiff	1240	4.5–6.0		SPT	5-7-10 N=17	12000 (HP)		22.9			
5	7.0–11.0	**LEAN CLAY (CL)**, brown, stiff to soft	1236	7.0–8.5		SPT	5-4-5 N=9			17.1			
				9.5–11.0		SPT	2-2-1 N=3			16.0			
5	11.0–14.0	**SANDY LEAN CLAY (CL)**, grayish brown, stiff	1233	12.0–13.5		SPT	3-5-4 N=9			27.9			
7	14.0–20.0	**SILTY SAND (SM)**, fine to medium grained, grayish brown, mottled, wet, medium dense	1227	14.5–16.0		SPT	9-8-6 N=14			22.4			
4	20.0–27.0	**FAT CLAY (CH)**, grayish brown, mottled, stiff to medium stiff	1220	19.5–21.0		SPT	3-3-5 N=8			11.3			
				24.5–26.0		SPT	2-2-4 N=6	4000 (HP)		31.6			
5	27.0–31.0	**SANDY LEAN CLAY (CL)**, trace gravel, grayish brown, stiff	1216	29.5–31.0		SPT	3-4-5 N=9			15.5			

Boring Terminated at 31 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Elevations were estimated from Google Earth and should only be considered approximate

Notes

Water Level Observations
No free water observed

Advancement Method
3 1/4" Hollow Stem Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
1163- Mobile B57

Hammer Type
Automatic

Driller
MR

Logged by
JM

Boring Started
06-12-2024

Boring Completed
06-12-2024

Terracon
860 9th St. NE, Unit K
West Fargo, ND

Boring Log No. B-9

Location: See Exploration Plan

Latitude: 46.9228° Longitude: -97.9836°

Depth (Ft.) Elevation: 1247 (Ft.) +/-

Model Layer	Graphic Log	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	HP (psf)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
2		**FILL - SAND WITH GRAVEL**, dark brown (2.0 / 1245)				5-5-6 N=11			16.3			
1		**FILL - LEAN CLAY WITH GRAVEL**, dark brown (4.0 / 1243)				3-4-5 N=9			15.8			
4		**FAT CLAY (CH)**, brownish gray, mottled, stiff (6.0 / 1241)	5			4-6-8 N=14	7200 (HP)		26.5			
5		**LEAN CLAY WITH SAND (CL)**, grayish brown, stiff (9.0 / 1238)				3-5-6 N=11			14.8			
4		**FAT CLAY (CH)**, brownish gray, mottled, stiff (11.0 / 1236)	10			3-4-7 N=11	6600 (HP)		25.0			
7		**CLAYEY SAND (SC)**, fine grained, brown (13.0 / 1234)										
4		**FAT CLAY (CH)**, grayish brown, mottled, medium stiff to soft, lenses and laminations of sand	15			2-3-4 N=7			29.2			
			20			1-1-2 N=3			28.5			
		(29.0 / 1218)	25			4-3-4 N=7			30.8			
7		**SILTY SAND (SM)**, trace gravel, fine to medium grained, grayish brown, wet, medium dense (31.0 / 1216)	30			4-6-9 N=15			19.8			
		Boring Terminated at 31 Feet										

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Elevations were estimated from Google Earth and should only be considered approximate

Water Level Observations
No free water observed

Drill Rig
1163- Mobile B57

Hammer Type
Automatic

Driller
MR

Notes

Advancement Method
3 1/4" Hollow Stem Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Logged by
JM

Boring Started
06-12-2024

Boring Completed
06-12-2024

Terracon
860 9th St. NE, Unit K
West Fargo, ND

Boring Log No. B-10

Location: See Exploration Plan

Latitude: 46.9235° Longitude: -97.9826°

Depth (Ft.) Elevation: 1244 (Ft.) +/-

Model Layer	Depth (Ft.) / Description	Elevation	Sample Depth (Ft.)	Field Test Results	HP (psf)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1	**FILL - LEAN CLAY WITH SAND**, trace gravel, dark brown		0-1.5	2-3-3 N=6			22.0			
			2-3.5	1-1-1 N=2			17.7			
			4.5-6	0-1-1 N=2			21.8			
			7-8.5	3-5-3 N=8	2000 (HP)		23.7			
	9.0	1235								
4	**FAT CLAY (CH)**, trace gravel, grayish brown, mottled, stiff to very stiff		9.5-11	3-4-6 N=10	3400 (HP)		26.9			
			12-13.5	2-4-5 N=9	4400 (HP)		21.9			
			14.5-16	2-3-4 N=7	3600 (HP)		31.1			
			19.5-21.5							
			24.5-26	3-4-6 N=10	4800 (HP)		35.2			
			29.5-31	5-7-9 N=16	12000 (HP)		29.1			
	31.0	1213								

Boring Terminated at 31 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Elevations were estimated from Google Earth and should only be considered approximate

Notes

Water Level Observations
No free water observed

Advancement Method
3 1/4" Hollow Stem Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
1163- Mobile B57

Hammer Type
Automatic

Driller
MR

Logged by
JM

Boring Started
06-12-2024

Boring Completed
06-12-2024

Terracon
860 9th St. NE, Unit K
West Fargo, ND

Boring Log No. B-11

Location: See Exploration Plan

Latitude: 46.9235° Longitude: -97.9820°

Elevation: 1245 (Ft.) +/-

Model Layer	Depth (Ft.)	Material Description	Elevation (Ft.)	Sample Depth (Ft.)	Field Test Results	HP (psf)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1	2.0	**FILL - LEAN CLAY WITH SAND**, trace gravel, dark brown	1243	0-1.5	3-5-5 N=10			10.6			
3	4.0	**TOPSOIL - ORGANIC CLAY (OH)**, black	1241	2-3.5	3-5-6 N=11			23.6			
5	9.0	**LEAN CLAY (CL)**, trace gravel, brownish gray, stiff	1236	4.5-6	5-6-9 N=15			23.8			
				7-8.5	4-5-6 N=11	6800 (HP)		28.6			
4	24.0	**FAT CLAY (CH)**, grayish brown, mottled, stiff to medium stiff	1221	9.5-11	2-3-7 N=10	5800 (HP)		33.5			
				12-13.5	3-3-5 N=8	5600 (HP)		33.2			
				14.5-16	3-4-4 N=8	4600 (HP)		31.7			
				19.5-21	2-2-2 N=4	1800 (HP)		37.1			
7	26.0	**SILTY SAND (SM)**, trace gravel, medium to coarse grained, brown, wet, loose	1219	24.5-26	2-2-3 N=5			13.7			
4	31.0	**FAT CLAY (CH)**, brownish gray, mottled, stiff	1214	29.5-31	4-6-6 N=12			28.2			

Boring Terminated at 31 Feet

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Elevations were estimated from Google Earth and should only be considered approximate

Water Level Observations
No free water observed

Drill Rig
1163- Mobile B57

Hammer Type
Automatic

Driller
MR

Notes

Advancement Method
3 1/4" Hollow Stem Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Logged by
JM

Boring Started
06-12-2024

Boring Completed
06-12-2024

Terracon
860 9th St. NE, Unit K
West Fargo, ND

Boring Log No. B-12

Location: See Exploration Plan

Latitude: 46.9234° Longitude: -97.9831°

Model Layer	Graphic Log	Depth (Ft.) / Description (Elevation: 1247 (Ft.) +/-)	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	HP (psf)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1		**FILL - LEAN CLAY WITH SAND**, trace gravel, dark brown				4-5-6 N=11			17.7			
						2-2-4 N=6			30.3			
		4.0 — 1243										
5		**LEAN CLAY (CL)**, grayish brown, medium stiff	5			2-3-5 N=8			33.4			
		9.0 — 1238										
		SANDY LEAN CLAY (CL), trace gravel, grayish brown, medium stiff	10			3-3-2 N=5			15.0			
						2-2-4 N=6			25.2			
		14.0 — 1233										
4		**FAT CLAY (CH)**, grayish brown, mottled, medium stiff	15			3-2-5 N=7	5200 (HP)		25.5			
			20			2-2-3 N=5	2400 (HP)		32.1			
			25			4-2-3 N=5	2400 (HP)		37.3			
		29.0 — 1218										
5		**SANDY LEAN CLAY (SC)**, trace gravel, grayish brown, very stiff	30			7-12-7 N=19	1800 (HP)		24.9			
		31.0 — 1216										
		Boring Terminated at 31 Feet										

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Elevations were estimated from Google Earth and should only be considered approximate

Water Level Observations
No free water observed

Drill Rig
1163- Mobile B57

Hammer Type
Automatic

Driller
MR

Notes

Advancement Method
3 1/4" Hollow Stem Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Logged by
JM

Boring Started
06-12-2024

Boring Completed
06-12-2024

Valley City New Public Works Service Center
1416 Main St. E | Valley City, ND
Terracon Project No. M1245034

Terracon
860 9th St. NE, Unit K
West Fargo, ND

Boring Log No. B-13

Location: See Exploration Plan

Latitude: 46.9234° Longitude: -97.9826°

Depth (Ft.) — Elevation: 1248 (Ft.) +/-

Model Layer	Description	Depth (Ft.)	Elevation
1	**FILL - LEAN CLAY WITH SAND**, trace gravel, dark brown	4.0	1244
	LEAN CLAY (CL), grayish brown, medium stiff	6.0	1242
5	**SANDY LEAN CLAY (CL)**, trace gravel, grayish brown, very stiff	12.0	1236
4	**FAT CLAY (CH)**, grayish brown, mottled, very stiff	19.0	1229
5	**SANDY LEAN CLAY (SC)**, trace gravel, grayish brown, medium stiff	24.0	1224
7	**SILTY SAND (SM)**, trace gravel, medium to coarse grained, brown, wet, loose to dense	31.0	1217

Boring Terminated at 31 Feet

Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	HP (psf)	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
						14.2			
			2-3-4 N=7	9000 (HP)		17.3			
5			2-3-3 N=6	7400 (HP)		25.6			
10			7-11-12 N=23	2200 (HP)		30.6			
			7-12-17 N=29			20.2			
15			12-13-12 N=25			13.5			
20			3-3-4 N=7	4800 (HP)		31.4			
25			6-5-3 N=8			21.1			
30			12-17-22 N=39						

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Elevations were estimated from Google Earth and should only be considered approximate

Notes

Water Level Observations
No free water observed

Advancement Method
3 1/4" Hollow Stem Auger

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Drill Rig
1163- Mobile B57

Hammer Type
Automatic

Driller
MR

Logged by
JM

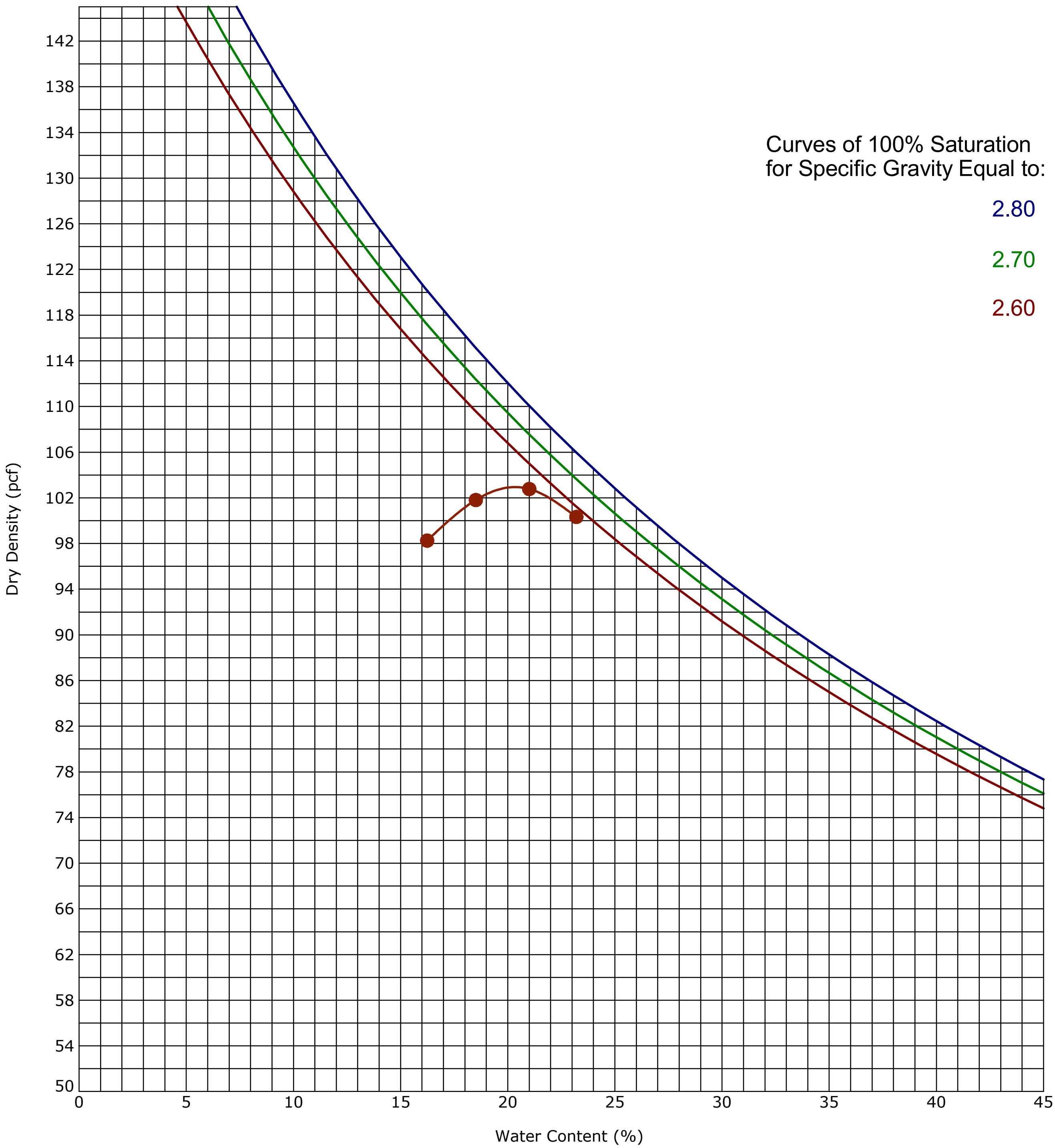
Boring Started
06-12-2024

Boring Completed
06-12-2024

860 9th St. NE, Unit K
West Fargo, ND

Moisture-Density Relationship

ASTM D698-Method A



Boring ID	Depth (Ft)	Description of Materials
B-13	1 - 6	Lean Clay

Fines (%)	Fraction > mm size	LL	PL	PI	Test Method	Maximum Dry Density (pcf)	Optimum Water Content (%)
	0.0				ASTM D698-Method A	102.9	20.3

Supporting Information

Contents:

Note: All attachments are one page unless noted above.

860 9th St. NE, Unit K
West Fargo, ND

General Notes

Sampling	Water Level	Field Tests
Auger Cuttings Shelby Tube Split Spoon	Water Initially Encountered Water Level After a Specified Period of Time Water Level After a Specified Period of Time Cave In Encountered 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.	N — Standard Penetration Test Resistance (Blows/Ft.) (HP) — Hand Penetrometer (T) — Torvane (DCP) — Dynamic Cone Penetrometer 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		
Relative Density	**Standard Penetration or N-Value (Blows/Ft.)**	**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 Exploration and Laboratory Test Results

Exploration/field results and/or laboratory test data contained within this document are intended for application to the project as described in this document. Use of such exploration/field results and/or laboratory test data should not be used independently of this document.

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]	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 above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	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:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	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] 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] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[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.