Sloan Pond and Wetland – BUC 871015D

Geotechnical Engineering Report

December 11, 2023 | Terracon Project No. 13225084

Prepared for:

Shive-Hattery, Inc. Architecture & Engineering
4125 Westown Parkway, Suite 100
West Des Moines, Iowa 50266

JASON P. HEINZ
18348

I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Iowa.

_______________________December 11, 2023______

Jason Patrick Heinz, P.E. Date
My license renewal date is December 31, 2024.

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December 11, 2023

Shive-Hattery, Inc. Architecture & Engineering
4125 Westown Parkway, Suite 100
West Des Moines, Iowa 50266

Attn: Dan Jensen, P.E.
P: (515) 223-8104, ext. 175536
E: djensen@shive-hattery.com

Re: Geotechnical Engineering Report
Sloan Pond and Wetland – BUC 871015D
Everly Avenue and 310th Street
Brandon, Iowa
Terracon Project No. 13225084

Dear Mr. Jensen:

We have performed the scope of Geotechnical Engineering services for the referenced project in general accordance with Terracon Proposal No. P13225084Rev1 dated October 10, 2023. This report presents the findings of the subsurface exploration and provides soil parameters for use in sheet pile design and geotechnical discussion regarding use of borrow area soils in a dike 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

Kurt A. Drilling
Senior Staff Geologist

Jason P. Heinz, P.E.
Department Manager
Geotechnical Services

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Figures

Attachments

Note: This report was delivered in a web-based format. **Blue Bold** text in the report indicates a referenced section heading. The PDF version 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 Pond and Wetland – BUC 871015D to be located northeast of the intersection of Everly Avenue and 310th Street in rural Brandon, Iowa. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Borrow for dike construction
- Soil parameters for sheet pile design

The geotechnical engineering Scope of Services for this project included the advancement of four (4) test borings to depths ranging from approximately 9 to 10 feet below existing site grades Maps showing the site and boring locations are attached in Site Location and Exploration Plan. The results of the laboratory testing performed on portions of recovered samples are included on the boring logs in the attached Exploration Results.

Project Description

Item	Description
Proposed Construction	A sheet pile weir is planned about 1,400 feet north and 2,100 feet east of the intersection of Everly Avenue and 310th Street. The sheet pile weir is planned to have a width of about 80 feet, a crest elevation of about 879.5 feet, and a drop height of about 4.5 feet. The weir is planned to create about 7.6 acres of wetlands with a maximum water depth of about 4.5 feet.

Site Conditions

Item	Description
Site Location	The project is located northeast of the intersection of Everly Avenue and 310th Street in rural Brandon, Iowa. The approximate latitude and longitude of the site is 42.3447° N 91.9887° W. See Site Location
Existing Improvements	Potential for field tiles

Item	Description
Current Ground Cover	various vegetation and agricultural crops
Existing Topography	Based on the topographic site plan provided, surface elevations range from about 873 to 885 feet. Two unnamed tributaries, from the northwest and west, merge and exit the site to the southeast.

Geotechnical Characterization

Subsurface Profile

We have developed a general characterization of the subsurface conditions based on 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 evaluation of the site. Conditions observed at the boring locations are indicated on attached logs and can be found in the Exploration and Laboratory Results. The GeoModel can be found in the Figures of this report.

As part of our evaluation, we identified the following model layers within the subsurface profile.

Model Layer	Layer Name	General Description
1	Surface	■ Topsoil ■ Lean Clay, trace sand and organics
2	Alluvium	■ Sand, trace gravel ■ Sandy Lean to Fat Clay, trace gravel
3	Bedrock	■ Silty Clay, with limestone gravel (residual soil) ■ Limestone, highly weathered and broken, with clay layers

Groundwater Observations

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater level observations are included on the boring logs in the Exploration and Laboratory Results and are summarized in the following table.

Boring No.	Depth to Groundwater while Drilling/Sampling (feet)	Groundwater Elevation while Drilling/Sampling (feet)	Depth to Groundwater after Drilling/Sampling (feet)	Groundwater Elevation after Drilling/Sampling (feet)
1	6	871	5	872
2	None observed	-	5	872
3	6	872	6	872
4	None observed	-	None observed	-

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. Perched (trapped) water can also develop within more ‘permeable’ soils/materials overlying and/or within lower ‘permeability’ soil. Therefore, groundwater levels during construction or at other times during the life of the development may be higher or lower than the levels indicated on the boring logs. Groundwater level fluctuations should be considered when developing the design and construction plans for the project.

The groundwater observations provide an approximate indication of the groundwater conditions at the time the observations were performed. For groundwater observations in relatively low ‘permeability’ of the fine-grained soils, a relatively long period is necessary for a groundwater level to develop and stabilize in the borehole. While groundwater level observations made within granular soils are usually a reliable indication of the current groundwater conditions. Long-term observations in piezometers or groundwater observation wells, sealed from the influence of surface water, would be required to provide a better evaluation of groundwater levels in materials of this type.

A review of the Buchanan County, Iowa Soil Survey published by the United States Department of Agriculture / Soil Conservation Service indicates that Sparta Loamy Sand, Clyde Clay Loam, Clyde-Floyd Complex, and Olin Sandy Loam are present at the site. According to the soil survey, Sparta Loamy Sand soils have seasonally high groundwater levels of greater than 6 feet, are excessively drained, and not subject to flooding. Clyde Clay Loam soils reportedly have seasonally high groundwater levels at or near existing grades, are poorly drained, and not subject to flooding. Clyde-Floyd Complex soils reportedly have seasonally high groundwater levels at or near existing grades, are poorly drained, and not subject to flooding. Olin Sandy Loam soils have seasonally high groundwater levels of greater than 6 feet, are well drained, and not subject to flooding.

Geotechnical Overview

Based on the project information and the results of the subsurface exploration, laboratory testing, and our limited evaluation, geotechnical considerations for this project related to the use of the proposed borrow areas for construction of a dike include:

- The presence of relatively thick layers of partly organic soils
- The presence of granular soils and relatively shallow groundwater
- The presence of shallow residual soil and bedrock

A suitable and relatively uniform source of clay borrow is critical to the satisfactory performance of an earthen dike. Materials encountered in the proposed borrow areas consisted of topsoil over sand, a thin clay layer, and residual soil over sedimentary bedrock. Based on the results of the subsurface exploration and laboratory testing, it does not appear that a significant source of non-organic clay is present in the proposed borrow areas.

Zones of unsuitable partly organic soil, sand and silt are present at the project site. Where encountered in a borrow area, thorough mixing of the material with lean clay or sandy lean clay, or wasting of the material, will be necessary for a suitable borrow source for dike fill. Residual soil at this site generally consists of limestone that has been chemically altered to a “soil like” matrix. Residual soil often contains varying sizes of remnant parent rock. Removal of cobbles and boulders should be anticipated if residual soil is planned to be used for dike fill.

Construction of a relatively uniform dike will require proper fill placement and compaction operations. Fill placement and compaction operations ultimately affect whether the in-place strength and hydraulic conductivity meet the project design requirements. Control of fill moisture content and thorough discing and mixing will be required during construction. The moisture content of each previous lift must be maintained prior to placement of each subsequent lift of fill. This will require that watering, moisture conditioning, and protection of working subgrades be provided throughout construction. The sizes of the fill material pieces, or clod sizes, affects the hydraulic conductivity of the compacted element. Discing, pulverizing, or tining will therefore be required during construction. The contractor must select appropriate equipment with sufficient weight or force capable of breaking each lift of fill into an acceptable clod size prior to and during moisture conditioning. Each lift of fill should be placed and compacted under strict moisture and compaction/density control and each lift of fill should be tested. In addition to in-place moisture and compaction testing, undisturbed samples of in-place fill should be obtained and tested for hydraulic conductivity throughout dike construction.

Groundwater levels across the site varied. Based on the results of the subsurface exploration, it appears that groundwater could be encountered. The amount of groundwater requiring removal to facilitate construction will depend on the actual extent of granular seams and layers, prevailing weather conditions during construction, and depths and method of borrow removal. The use of ditches or “french drains” to intercept and convey water may be a satisfactory means to drain borrow and excavation areas. Where extensive areas of water-bearing granular deposits are present, or if it is not possible to gravity drain an area, it would be necessary to utilize sump pits and pumps or well points to maintain groundwater levels below the working construction grade.

Residual soil and sedimentary bedrock were encountered at relatively shallow depths in most of the borings, and granular soil was encountered overlying the residual soil and bedrock in Boring 3. The bedrock surface does not appear to be uniform in elevation and cobbles and boulders above the bedrock surface may obstruct installation of sheeting. The presence of granular soils and the ‘very poor’ to ‘poor’ quality or broken condition of the bedrock should be considered for this project during evaluation of a sheet pile ‘cutoff’. The designer should consider whether water seepage through and below sheet pile are acceptable for the overall project concept and for the long-term integrity of the sheet pile and dike.

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.

Sheet Pile Design Parameters

The following soil parameters were estimated based on the results of the subsurface exploration and laboratory testing, and may be used in the sheet pile design. Please note that recommendations for design and construction of the dike and sheet pile are beyond our scope of services for this project.

Recommended Sheet Pile Parameters				
Soil Classification	Topsoil	Medium Stiff Clay	Loose Sand	Residual Soil
Total ‘Saturated’ Density (pcf)	110	115	110	120
Submerged Density (pcf)	45	50	45	55
Effective friction angle (degrees)	22	24	32	26
Cohesion (psf)	0	250	0	150

Recommended Sheet Pile Parameters				
Soil Classification	Topsoil	Medium Stiff Clay	Loose Sand	Residual Soil
Steel-soil interface friction angle	-	-	14	-
Active Pressure coefficient (K_a)	0.45	0.42	0.31	0.39
Passive Pressure coefficient (K_p)	2.20	2.38	3.25	2.56

General Comments

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, and other earth-related construction phases of the project.

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.

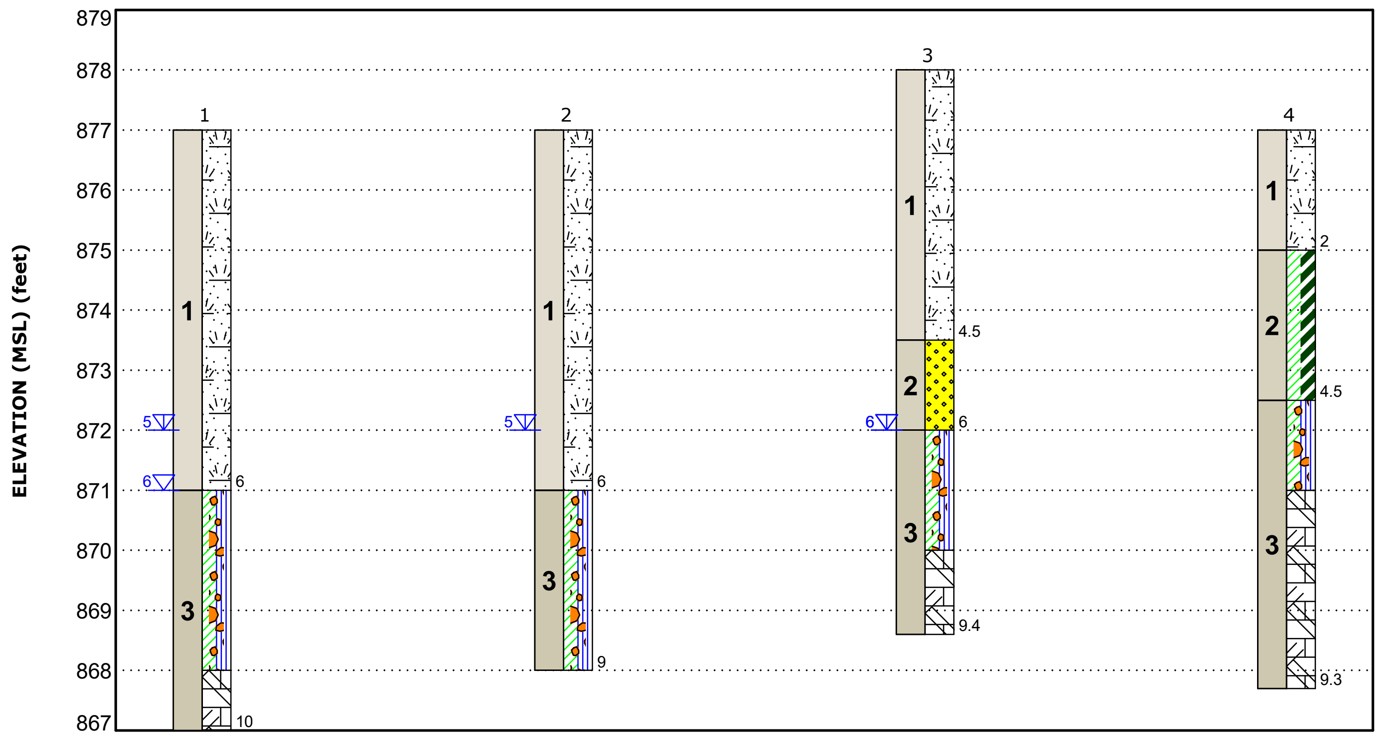
Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly affect excavation 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:

3105 Capital Way, Ste 5
Cedar Falls, IA

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	Legend
1	Surface	Topsoil Lean Clay, trace sand and organics	Topsoil; Silty Clay with Gravel
2	Alluvium	Sand, trace gravel Sandy Lean to Fat Clay, trace gravel	Weathered Limestone; Well-graded Sand
3	Bedrock	Silty Clay, with limestone gravel (residual soil) Limestone, highly weathered and broken, with clay layers	Lean Clay/Fat Clay

First Water Observation
Second Water Observation

Groundwater levels are temporal. The levels shown are representative of the date and time of our exploration. Significant changes are possible over time.
Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

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. Numbers adjacent to soil column indicate depth below ground surface.

Attachments

Exploration and Testing Procedures

Field Exploration

Number of Borings	Approximate Boring Depth (feet)	Location
2	9 to 10	Sheet Pile Weir
2	9.5	Borrow Area

Boring Layout and Elevations: Shive Hattery will determine the boring locations and stake the locations in the field. Approximate elevations were also determined by Shive Hattery. The locations and elevations of the borings should be considered accurate only to the degree implied by these methods.

Subsurface Exploration Procedures: We advanced the borings with an atv-mounted, rotary drill rig using continuous flight, solid-stem augers. Soil sampling was performed using thin-wall tube and split-barrel sampling procedures. In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a hammer with a free fall of 30 inches, is the standard penetration resistance value (N). A CME automatic SPT hammer was used to estimate the relative density of granular soils, and to a lesser extent, the consistency of fine-grained soils. 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.

Our exploration team prepared field boring logs as part of the drilling operations. These field logs include visual classifications of the materials encountered during drilling and the exploration team's interpretation of the subsurface conditions between samples. The sampling interval depths, penetration resistances, recoveries, and other sampling information are recorded on the field boring logs. The samples were containerized and transported to our laboratory for further testing and classification.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests. The laboratory testing program included the following types of tests:

- Moisture Content
- Dry Unit Weight
- Unconfined Compression
- Organic Content

The laboratory testing program included examination of soil samples by geologists. Based on the results of our field and laboratory programs, we described and classified the soil samples in general 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

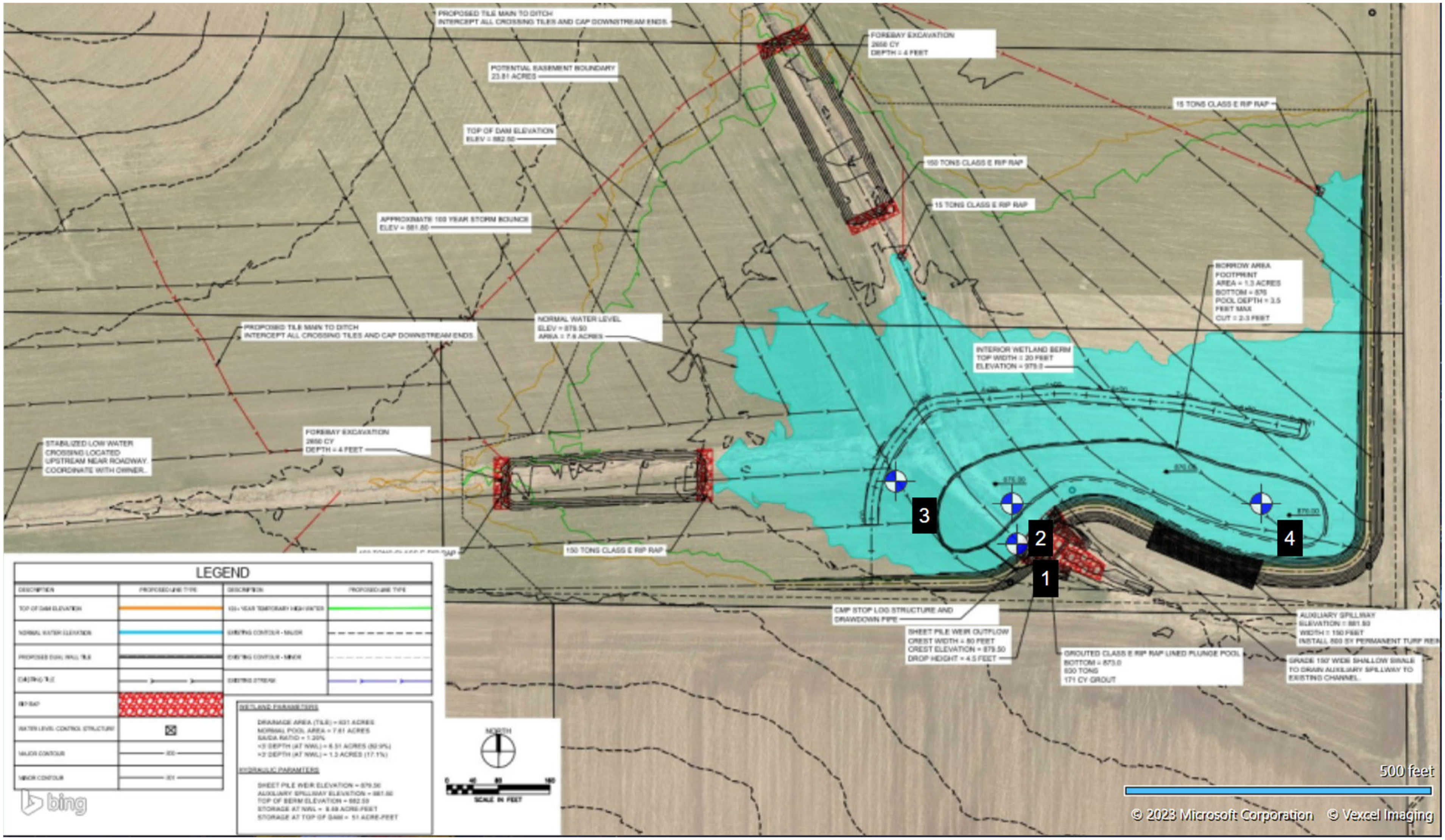


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY SHIVE-HATTERY AND MICROSOFT BING MAPS

Exploration and Laboratory Results

Contents:

Note: All attachments are one page unless noted above.

Terracon
3105 Capital Way, Ste 5
Cedar Falls, IA

Boring Log No. 1

Location: See Exploration Plan

Latitude: 42.3448° Longitude: -91.9890°

Elevation.: 877.0 (Ft.)

Model Layer	Depth (Ft.) / Description	Elevation	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	HP (psf)	Strength Test: Test Type	Strength Test: Compressive Strength (psf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Organic Content (%)
1	**LEAN CLAY (CL)**, trace sand and organics, dark brown (topsoil)													
					X	4	3-3-5 N=8					30.3		
			5	▽ (5')	X	4	1-1-2 N=3					29.5		9.8
	6.0	871		▽ (6')										
3	**SILTY CLAY (CL-ML)**, with limestone gravel, light brown (residual soil)													
					X	7	6-8-12 N=20					13.4		
	9.0	868		Cave-in (9')										
	LIMESTONE, highly weathered and broken, with clay layers, light brown				X	4	50/4"					9.6		
	10.0	867	10											

Practical Auger Refusal at 10 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.

Notes

Water Level Observations
▽ 6' observed while drilling
▽ 5' observed after drilling
Cave-in at 9' after drilling

Advancement Method
Solid Stem Auger

Abandonment Method
Boring backfilled with soil cuttings upon completion.

Drill Rig
589

Hammer Type
Automatic

Driller
WE

Logged by
CR

Boring Started
10-30-2023

Boring Completed
10-30-2023

Terracon
3105 Capital Way, Ste 5
Cedar Falls, IA

Boring Log No. 2

Location: See Exploration Plan

Latitude: 42.3450° Longitude: -91.9890°

Depth (Ft.) Elevation.: 877.0 (Ft.)

Model Layer	Depth (Ft.)	Elevation (Ft.)	Material Description	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	HP (psf)	Test Type	Compressive Strength (psf)	Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Organic Content (%)
1	0.0–6.0	877–871	**LEAN CLAY (CL)**, trace sand and organics, dark brown (topsoil)											
					Split spoon	5	3-3-3 N=6					29.8		
				5' observed after drilling	Split spoon	2	2-1-1 N=2					24.5		
3	6.0–9.0	871–868	**SILTY CLAY (CL-ML)**, with limestone gravel, light brown (residual soil)											
				Cave-in at 8' after drilling	Shelby tube	9	7000 (HP)					17.6		
	9.0	868	***Practical Auger Refusal at 9 Feet***			0	50/0"							

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.

Notes

Water Level Observations

None observed while drilling

5' observed after drilling

Cave-in at 8' after drilling

Advancement Method
Solid Stem Auger

Abandonment Method
Boring backfilled with soil cuttings upon completion.

Drill Rig
589

Hammer Type
Automatic

Driller
WE

Logged by
CR

Boring Started
10-30-2023

Boring Completed
10-30-2023

Terracon
3105 Capital Way, Ste 5
Cedar Falls, IA

Boring Log No. 3

Location: See Exploration Plan

Latitude: 42.3451° Longitude: -91.9897°

Depth (Ft.) Elevation.: 878.0 (Ft.)

Model Layer	Description	Depth (Ft.) / Elevation (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	HP (psf)	Strength Test: Test Type	Strength Test: Compressive Strength (psf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Organic Content (%)
1	**LEAN CLAY (CL)**, trace sand and organics, dark brown (topsoil)	4.5 / 873.5		X	6	2-2-3 N=5					27.2		
2	**SAND (SW)**, trace gravel, fine to coarse grained, brown, loose	6.0 / 872		X	8	3-2-4 N=6					16.7 / 12.0		
3	**SILTY CLAY (CL-ML)**, with limestone gravel, light brown (residual soil)	8.0 / 870	Cave-in at 6'	X	11	4-4-3 N=7 5500 (HP)					11.9		
3	**LIMESTONE**, highly weathered and broken, with clay layers, light brown	9.4 / 868.6		X	5	50/5"					10.2		

Practical Auger Refusal at 9.4 Feet

Depth scale: 5

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.

Notes

Water Level Observations
- 6' observed while drilling
- 6' observed after drilling
- Cave-in at 6' after drilling

Advancement Method
Solid Stem Auger

Abandonment Method
Boring backfilled with soil cuttings upon completion.

Drill Rig
589

Hammer Type
Automatic

Driller
WE

Logged by
CR

Boring Started
10-30-2023

Boring Completed
10-30-2023

3105 Capital Way, Ste 5
Cedar Falls, IA

Boring Log No. 4

Location: See Exploration Plan

Latitude: 42.3450° Longitude: -91.9875°

Elevation.: 877.0 (Ft.)

Model Layer	Depth (Ft.)	Material Description	Elevation (Ft.)	Sample Type	Recovery (In.)	Field Test Results	HP (psf)	Strength Test: Test Type	Strength Test: Compressive Strength (psf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Organic Content (%)
1	2.0	**LEAN CLAY (CL)**, trace sand and organics, dark brown (topsoil)	875										
2	4.5	**SANDY LEAN TO FAT CLAY (CL/CH)**, trace gravel, brown, medium stiff	872.5		6	2-2-4 N=6					26.2 15.1		
3	6.0	**SILTY CLAY (CL-ML)**, with limestone gravel, light brown (residual soil)	871		12						14.7		
3	9.3	**LIMESTONE**, highly weathered and broken, with clay layers, light brown	867.7		2	50/3"					11.3		
					3	50/3"					8.7		

Practical Auger Refusal at 9.3 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.

Notes

Water Level Observations
None observed while drilling
None observed after drilling

Advancement Method
Solid Stem Auger

Abandonment Method
Boring backfilled with soil cuttings upon completion.

Drill Rig
589

Hammer Type
Automatic

Driller
WE

Logged by
CR

Boring Started
10-30-2023

Boring Completed
10-30-2023

Supporting Information

Contents:

Note: All attachments are one page unless noted above.

Terracon
3105 Capital Way, Ste 5
Cedar Falls, IA

General Notes

Sampling	Water Level	Field Tests
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 (tsf)**	**Standard Penetration or N-Value (Blows/Ft.)**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

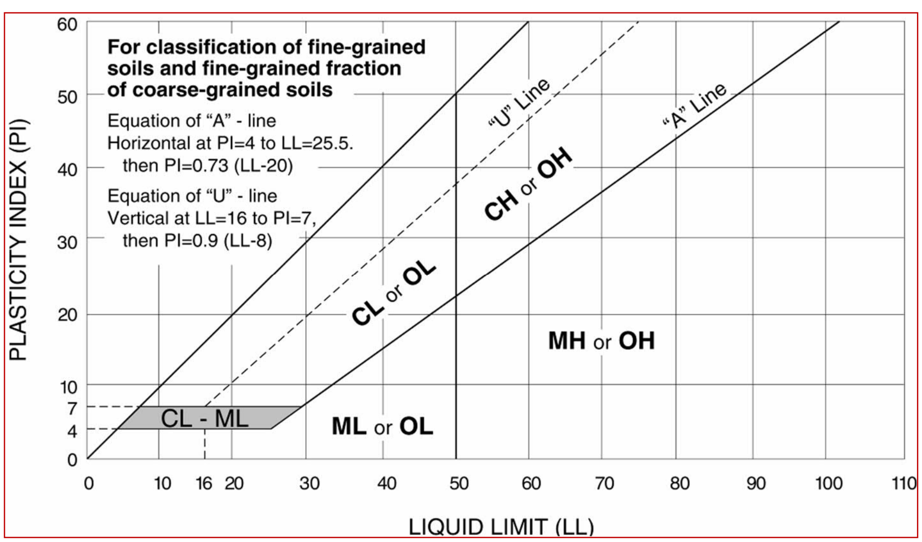
Relevance of Exploration and Laboratory Test Results

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.



General Notes – Sedimentary Rock Classification

DESCRIPTIVE ROCK CLASSIFICATION:

Sedimentary rocks are composed of cemented clay, silt and sand sized particles. The most common minerals are clay, quartz and calcite. Rock composed primarily of calcite is called limestone; rock of sand size grains is called sandstone, and rock of clay and silt size grains is called mudstone or claystone, siltstone, or shale. Modifiers such as shaly, sandy, dolomitic, calcareous, carbonaceous, etc. are used to describe various constituents. Examples: sandy shale; calcareous sandstone.

LIMESTONE	Light to dark colored, crystalline to fine-grained texture, composed of CaCo3, reacts readily with HCI.
DOLOMITE	Light to dark colored, crystalline to fine-grained texture, composed of CaMg(CO3)2, harder than limestone, reacts with HCI when powdered.
CHERT	Light to dark colored, very fine-grained texture, composed of micro-crystalline quartz (SiO2), brittle, breaks into angular fragments, will scratch glass.
SHALE	Very fine-grained texture, composed of consolidated silt or clay, bedded in thin layers. The unlaminated equivalent is frequently referred to as siltstone, claystone or mudstone.
SANDSTONE	Usually light colored, coarse to fine texture, composed of cemented sand size grains of quartz, feldspar, etc. Cement usually is silica but may be such minerals as calcite, iron-oxide, or some other carbonate.
CONGLOMERATE	Rounded rock fragments of variable mineralogy varying in size from near sand to boulder size but usually pebble to cobble size (1/2 inch to 6 inches). Cemented together with various cementing agents. Breccia is similar but composed of angular, fractured rock particles cemented together.

DEGREE OF WEATHERING:

SLIGHT	Slight decomposition of parent material on joints. May be color change.
MODERATE	Some decomposition and color change throughout.
HIGH	Rock highly decomposed, may be extremely broken.

Classification of rock materials has been estimated from disturbed samples.
Core samples and petrographic analysis may reveal other rock types.