GEOTECHNICAL ENGINEERING REPORT
PROPOSED SUMMIT FAIR LOT 10C
CHIPMAN ROAD AND WARD ROAD
LEE'S SUMMIT, MISSOURI

Prepared For:

FP Acquisitions, LLC
C/O
WSO Partners, LLC
P.O. Box 299
Liberty, Missouri 64069

Attn: Mr. John Davis

April 2024

PROJECT NO. 24-28620

www.roneengineers.com

Geotechnical Engineering
Earthworks Control
Environmental Consulting
Construction Material Testing

April 11, 2024

Mr. John Davis
FP Acquisitions, LLC
C/O:
WSO Partners, LLC
P.O. Box 299
Liberty, Missouri 64069

Re: **Geotechnical Engineering Report**
Proposed Summit Fair Lot 10C
Lee's Summit, Missouri
Rone Report No. 24-28620

Dear Mr. Davis:

Rone Engineering Services, LLC. (Rone) is pleased to submit the Geotechnical Engineering Report for the above-referenced project. The geotechnical engineering services performed for this study were carried out in general accordance with Rone Proposal No. P-37194-24, dated March 12, 2024.

This report presents engineering analyses and recommendations for site grading, foundations, and pavements with respect to known project and site characteristics. Detailed results of our field exploration and laboratory testing are provided in the appendix of the report.

We appreciate the opportunity to be of service to you on this project. We look forward to providing additional Geotechnical Engineering and Construction Materials Testing services as the project progresses through the final design and construction phases. Please contact us if you have any questions or if we can be of further assistance.

Respectfully submitted,

Courtney Dieckmann, E.I.
Project Engineer

STATE OF MISSOURI
KELLY E. ROTERT
NUMBER
E-26717
REGISTERED PROFESSIONAL ENGINEER

Kelly E. Rotert, P.E.
Executive Vice President 04.11.2024

TABLE OF CONTENTS

TABLE OF CONTENTS

APPENDIX A

APPENDIX B

APPENDIX C

GEOTECHNICAL ENGINEERING REPORT

1 PROJECT INFORMATION

1.1 Site Description

The project is located at the NW corner of NW Chipman Road and NW Ward Road in Lee's Summit, Missouri. We understand the project consists of developing 3 proposed fast food restaurants, with associated paved parking and drive lanes. A tabular summary of the site description is provided in Table 1 below.

Table 1: Site Description

Item	Description
Location	NW corner of NW Chipman Road and NW Ward Road in Lee's Summit, Missouri
Project Description	2,200 square foot building, 1,900 square foot building, 1,000 square foot building associated drives and parking
Existing Conditions	Undeveloped site previously covered with large tree vegetation
Topography	Sloping from 1002 feet at the northern end to 999 feet at the southern end.
Previous Studies	None that Rone was made aware of
Geologic Setting	Kansas City Group

Site vicinity and geology maps are attached as Plates A.1 and A.2, respectively in Appendix A of this report. Boring locations relative to the site plan are shown on the Boring Location Diagram, Plate A.3.

1.2 Site Development Plan

According to the site plan provided the proposed site will include 3 fast food restaurant buildings ranging from around 1,000 square feet to around 2,200 square feet. Each restaurant will include drive lanes and parking.

1.3 Design Information, Conditions and Assumptions

The following design conditions were provided for this project plan. The building loads for each proposed restaurant are less than 4 kips per foot for continuous footings and less than 50 kips for columns. The design conditions and all necessary assumptions are summarized in **Table 2** below:

Table 2: Project Design Parameters

Item	Value
Finished Pad Elevation (feet)	Within 3 feet of current grade
Cut (feet)	Up to 2 feet
Fill (feet)	Up to 2 feet
Maximum Column Loads (kips)	50 Kips
Wall Load (kip/lf)	4 kips per foot

2 PURPOSES AND SCOPE OF STUDY

The site investigation was scoped based on the site plan provided and design boundaries outlined above. The client and project team requested that all borings be terminated immediately if groundwater was encountered and that care be taken not to bring water to the ground surface during drilling operations.

The principal purposes of this study are to evaluate the general subsurface conditions at the project site and to develop geotechnical recommendations for the design and construction of foundations. For these purposes, the study was conducted in the following phases:

- Borings were drilled and sampled to evaluate the subsurface conditions at the boring locations and to obtain soil samples.
- Laboratory tests were conducted on selected samples recovered from the borings to evaluate the pertinent engineering characteristics of the foundation soils.
- Engineering analyses were performed using field and laboratory data to develop foundation recommendations.
- Onsite soils were evaluated for potential sources of fill materials required for the project.

As the Geotechnical Engineer of Record serving this project, it is recommended that a Rone engineer provide assistance during the design phase to verify the intent of the geotechnical recommendations have been satisfied. In addition, Rone should be retained to provide oversight during the construction phase to verify full compaction utilizing the advanced engineering tools as discussed throughout this report.

3 FIELD INVESTIGATION AND LABORATORY TESTING

Appropriate public sources were contacted to clear selected sample locations of any known buried utilities. Additionally, an ALTA map was provided indicating an abandoned utility easement near the western edge of the site. The boring locations were generally defined in the field by drilling personnel using site benchmarks, landmarks, maps and aerial photographs of the site. Ground surface elevations at the boring locations were estimated from Google Earth and topographic site plans provided by the client. The boring locations and elevations were not accurately located by a registered surveyor. The locations are generalized for mapping purposes and are accurate only to the extent implied by the technique used in their determination.

Soil samples were collected from soil borings. A total of twelve (12) borings were completed in March 2024. The borings were extended to depths ranging from 10 to 20 feet below the ground surface, auger refusal, where groundwater is encountered, or whichever is shallower. The approximate boring locations are shown on Plate A.3, Boring Location Diagram. Sample depth, description of soils, and classification (based on the Unified Soil Classification System) are presented on the Boring Logs, Plates A.4 through A.15. Keys to terms and symbols used on the logs are also included in Appendix A.

Laboratory tests were performed on selected samples recovered from the borings to confirm visual classification and determine the pertinent engineering properties of the materials encountered, and to assess strata and in-situ consolidation states. Unconfined compression test, and classification test results are presented on the Logs of Boring. Descriptions of the procedures used in the field and laboratory phases of this study are presented in Appendix B.

4 GENERAL SITE CONDITIONS

At the time of our field exploration, the site was undeveloped and was generally cleared and relatively flat.

4.1 Site Geology

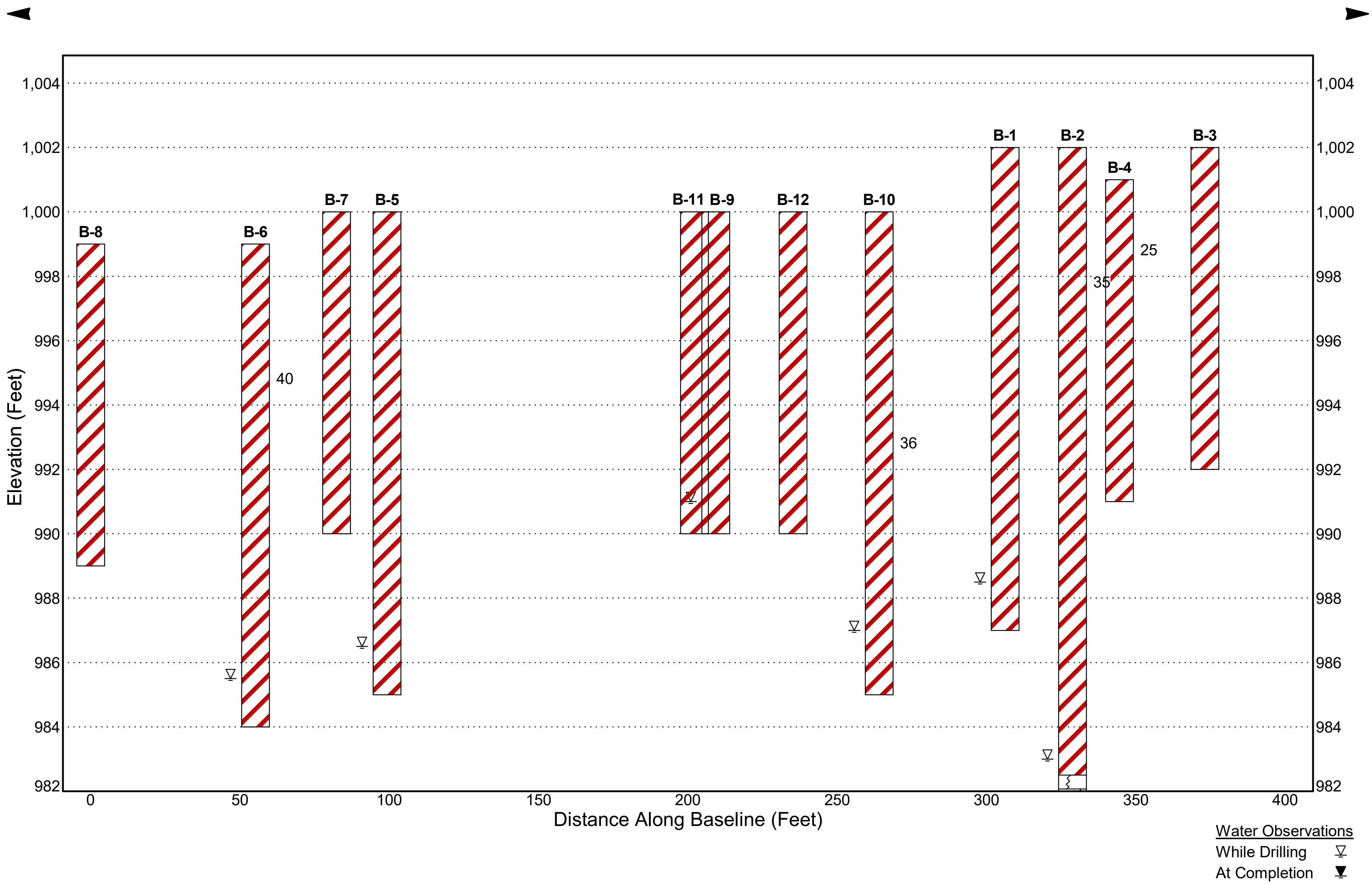
Based on the subsurface conditions encountered at the boring locations and the Missouri Geological survey, the site appears to be located within the Kansas City Group formation. This consists of clay over cyclic deposits of shale, limestone, and sandstone units.

4.2 Subsurface Soil Conditions

The results of the field and laboratory testing have been used to develop a generalized subsurface profile of the project site. The soil within the proposed building footprints and parking area generally consists fat clays.

The liquid limit (LL) and plasticity index (PI) of samples of the strata were 49 to 64 and 25 to 40 respectively, indicating generally high soil plasticity. While both lean and fat clay fractions shrink and swell with changes in moisture content, higher plasticity typically have greater sensitivity to shrink and swell and an increased potential for volume change.

The boring logs in Appendix A should be reviewed for specific information at individual boring locations. Stratification boundaries shown in the Boring Logs represent the approximate locations of changes in types of in-situ soil. The transition between material types may vary between borings and be gradual and indistinct. Variations will occur and should be expected across the site.



RONE ENGINEERING
An RMA Company

GENERALIZED SUBSURFACE PROFILE

Figure 1

Summit Fair Lot 10C
NEC of NW Chipman Road and NW Outerview Road
Lee's Summit, Missouri

PROJECT NO:	24-28620		
FILE NAME	24-28620.GPJ		
DRAWN BY:		DATE:	04-09-2024
REVISED BY:		DATE:	
REVISED BY:		DATE:	
APPROVED BY:		DATE:	04-09-2024

4.3 Groundwater

The borings were advanced using continuous flight augers. The borings were monitored during for the presence of water seepage and terminated immediately upon encountering water. Free water was observed in 6 of the 12 borings during drilling at depths ranging from 9 to 19 feet.

These observations were made during the field exploration, as indicated on the Boring Logs. A geo-hydrologic assessment of the vadose zone or upper groundwater was not conducted. As such, the study did not include monitoring of upper groundwater levels or perched water conditions. A geo-hydrologic study can be conducted upon request to assess the sources and variation of in-situ moisture content in the vadose zone and groundwater beneath the site, and how different site development alternatives can manage or alter those dynamics by plan or affect.

In general, groundwater levels and moisture content in the vadose zone vary climatically and seasonally depending on topography, land usage, surface hydrology, subsurface hydrogeology, proximity to bodies of water, etc. The rate and extent of these variations depend on many variables including subsurface stratigraphy, soil strata properties, capillary sources, consolidation states, soil structure, capillary strength, thermal cover, and surface infiltration and evapotranspiration rates.

5 ANALYSIS OF SITE AND FOUNDATION ALTERNATIVES

Foundation alternatives have been evaluated based on geotechnical site conditions, site development plans and design preferences.

5.1 Geotechnical Analysis

Foundation alternatives were evaluated based on site-specific geotechnical conditions, proposed development plans, and known design preferences. Subgrade preparation and foundation fill elements are critical components of all foundation systems. Foundation alternatives for the proposed buildings were evaluated based on the following engineering criteria.

- Bearing capacity of the in-situ subsurface soils
- Settlement potential of the in-situ subsurface soils
- Volume change (shrink-swell) potential of the in-situ subsurface soils

5.2 Seismic Site Class

The site class for seismic design is based on several factors that include soil profile, shear wave velocity, density, relative hardness, and strength, averaged over a depth of 100 feet. The borings for this project did not extend to a depth of 100 feet; therefore, we assumed the soil conditions below the depth of the borings to be similar to or stiffer than those encountered at the termination depth of the borings. Based on Section 1613.2.2 of the 2018 International Building Code and Table 20.3-1 of ASCE 7-16, we recommend using **Site Class D** for seismic design.

6 FOUNDATION SYSTEM RECOMMENDATIONS

Based on the site analysis and a limited study of alternatives and cost-benefit analyses, these foundation recommendations were prepared. Feasible alternatives were evaluated, though this report is prepared for the recommended alternatives. Design evaluations have been made for the foundation systems based on our current understanding of the project and the available subsurface information.

Based on assumed column loads the small restaurants may be supported on a shallow foundation systems. The report contains recommendations and commentary for shallow foundations, spread footings.

6.1 Excavation Safety Considerations

All excavations should be sloped, shored, or shielded in accordance with Occupational Safety and Health (OSHA) requirements. In accordance with Missouri State Law, the design and maintenance of excavation safety systems is the sole responsibility of the construction contractor. OSHA Standards 29 CFR – 1926 Subpart P, including Appendices A and B, should be referenced for guidance in the design of such systems.

7 SITE PREPARATION FOR CONSTRUCTION

7.1 General

Remove existing foundations, abandoned structures, deleterious materials, pavements, site debris, abandoned utilities and all other manmade features, and relocate utilities as required by the work and in accordance with the Plans and Specifications.

7.2 Existing Surface Grades

Clear and grub all tree stumps and root systems as required by the work except where trees or shrubs must be maintained according to the design drawings. Except as otherwise specified or indicated in the drawings or specifications, all materials resulting from clearing and grubbing operations shall be properly disposed of.

Clear all vegetation, pavements and strip at least the upper six (6) inches of topsoil as required to remove all roots and organic matter from all Work areas of the site. Stripping should extend at least 5 feet beyond the limits of grade supported structures, and at least 3 feet beyond pavement limits.

In no case shall any spoil or other material resulting from clearing, grubbing and stripping operations be utilized within the earthworks or fill materials or permanently placed onsite except where authorized by the Engineer.

8 CONSTRUCTION OF SUBGRADE FILLS

Foundation fill elements are critical components of any infrastructure foundation. All infrastructure, particularly shallow foundation infrastructure, depends on fill elements in some way as a part of the foundation system. Strength and stability of these elements is essential to control and prevent ground movement below all foundations and pavements. Mechanical soil compaction is designed and intended to improve the properties of soils in naturally compacted states, yet due to deficient compaction controls, most compaction does not achieve the required engineering compaction standards in construction. The soil construction specifications in this section provide for effective compaction control, with direct data verification and real-time control.

The fill construction specifications below are designed for the specific engineering requirements of each fill on this project. The specifications given provide the construction controls needed to prepare cohesive fills for saturation, and best prepare them for drying potential. If these specified controls are not implemented throughout all fill construction, the fills will be vulnerable to potential instability from adverse strength loss and swell conditions with saturation, and potential shrinkage conditions from drying. The initiation of shrinkage or swelling usually leads to shrink-swell cycles with moisture variation over time.

Though the construction specifications below prepare the cohesive fills for saturation, the environments of these fills must maintain a generally moist environment without excessive drying. In some cases, equilibrium moisture ranges can be established in the design, and in some cases that cannot be done without certain maintenance requirements after construction.

8.1 Subgrade Preparations

After site stripping, existing grades and cut grades must be prepared for construction of foundation fills. All cleared and stripped subgrade areas that will underlie foundation or pavement construction require varied ground modification measures as provided for in the following sections.

Existing stripped grades and cut grades at depths of 3 feet or less, shall be scarified to a depth of 8 inches and recompacted at wet-of the optimum moisture content at full compaction in construction. If testing of recompacted surface grades verifies that soft soils underlie any section of the recompacted surface, then those sections must be excavated deeper and recompacted in lifts as required by the Geotechnical Engineer

8.2 Subgrade Fill Construction

All foundations and pavements include a structural fill element. These fill elements are critical to ground modification requirements and the strength and stability of each foundation. Fill construction requirements depend on the design purpose and service conditions of each fill. Each fill element must be constructed to achieve the properties required for the long-term stability of each foundation.

8.2.1 Project Fills

The fill elements on this project are identified as follows:

- Scarification depths of existing cut grades within the upper 3 feet
- Subgrade reconstruction and grade raise fills for foundations and site paving
- Utility trench backfill
- General fills for site grading and drainage

8.2.2 Fill Material Requirements

The following table provides general property requirements and applications for the soils that may be used on this project.

Table 3: Compaction Specification Summary

Fill	Building Pads and Pavement Subgrade			General Site Grading	Utility Trench Backfill
Material	Lean Clay Fill (Cohesive)	Fat Clay Fill (Cohesive)	Granular Fill	non-load bearing	Cohesive or Granular
Proctor Type	Standard	Standard	Standard	Standard	Standard
Maximum Lift Thickness (inches)	8”	8”	8”	8”	8”
Frequency of Testing	1 per 2,500 ft^2 of fill placed / lift	1 per 2,500 ft^2 of fill placed / lift	1 per 2,500 ft^2 of fill placed / lift	1 per 6,000 ft^2 of fill placed / lift	1 per 150 lineal foot / lift
Moisture Content Range	-1 to +3 %	0 to +3%	-2 to +2 %	-3 to +3 %	-1 to +2 %
Minimum Dry Density (%)	95%	95%	95%	90%	95%

Fill soils should be free of organics, debris, rocks and all other deleterious material. Excessive, large-sized clay clods (based on the judgment of the Geotechnical Engineer of Record) should be avoided for fills, or added conditioning may be necessary before soil construction.

8.3 Borrow Selection

Rone can assist the constructor in the selection of borrow sources. For each material used on the site there should be at least one laboratory Proctor or Relative Density test. If the borrow or source of fill material changes, a new laboratory Proctor or Relative Density test should be performed to obtain a reference moisture density relationship.

Each test that does not comply with both the required dry density and the moisture content range shall be recorded, the location of the test recorded, and reported to the Contractor and Owner. A re-test of that area should be conducted after remedial measures are performed.

8.4 Fill Construction Specifications

In general, all fill soils should be placed in consistent loose lift thicknesses of eight (8) inches and compacted to at least 95% of the materials’ maximum dry density from the standard Proctor, and within a range of the optimum moisture contents in Table 3, in general accordance with ASTM procedures. Each lift of compacted-engineered fill should be tested and documented by a representative of the geotechnical engineer prior to placement of subsequent lifts. The edges of compacted fill should extend five (5) feet beyond the building footprint, or a distance equal to the depth of fill beneath the footings. Fill should be tested and documented by a Representative of the Geotechnical Engineer to evaluate placement.

All completed lifts should be protected and preserved by subsequent lift coverage placed as promptly as practical during construction. In the event of any work delays, no completed lifts shall be exposed to the elements for a period of time exceeding 5 days. Completed lifts to be exposed more than 2 days shall kept damp with light spraying. Completed lifts damaged by desiccation or other disturbances due to weathering such as erosion, destruction from traffic during wet conditions, etc. shall be scarified and re-compacted according to the process control requirements for that particular fill. Any lifts to be exposed to weathering for longer than a 5-day period shall be covered and protected with sacrificial soil layers or wet matting. Any finished fills to be exposed to weathering for extended periods shall be covered and protected with wet matting or sacrificial soil layers maintained in a wet state according to the Geotechnical Engineer of Record based on the depths and design requirements of each fill.

Moisture content changes higher than 3% above the plastic limit or lower than the plastic limit, in the highly plastic soils should not be permitted during or after construction. Increases in moisture content can cause swelling of the high plasticity soils during construction and increase shrinkage potentials due to drying after construction. If the exposed soils become inundated or desiccated, Rone recommends they be remediated prior to new fill placement.

8.4.1 Utility Trench Backfill

Uniformly compact trench backfill in 4-inch loose lifts at wet-of-optimum moisture contents to at least 95 percent of the maximum dry density, as determined from representative Standard Proctor curves normalized on the lab line-of-optimums for the soil range used and corrected according to standard dry unit weight relations.

8.4.2 Density Tests

Field density tests should be performed by the geotechnical engineer or his representative. Density tests should be taken in each layer of compacted fill below the disturbed surface. If the materials fail to meet the density specified, the course should be reworked as necessary to obtain the specified moisture content and compaction.

The specified moisture content and compaction must be maintained until placement of the overlying lift, or construction of overlying flatwork. Failure to maintain the moisture content and compaction could result in excessive soil movement and can have a detrimental effect on overlying structures such as shallow foundations and floor slabs. The contractor must provide some means of controlling the moisture content and compaction (such as water hoses, water trucks, etc.). Maintaining subgrade moisture and compaction is always critical, but will require extra effort during warm, windy and/or sunny conditions. Density and moisture testing is recommended to provide some indication that adequate earthwork is being provided; however, the quality of the fill is the sole responsibility of the contractor. Satisfactory testing is not a guarantee of the quality of the contractor's earthwork operations.

8.4.3 Excavation Safety Considerations

All excavations should be sloped, shored, or shielded in accordance with OSHA requirements. It should be noted that in accordance with Missouri State Law, the design and maintenance of excavation safety systems is the sole responsibility of the construction contractor. OSHA Standards 29 CFR – 1926 Subpart P, including Appendices A and B, should be referenced for guidance in the design of such systems.

9 BUILDING FOUNDATION STRUCTURES

9.1 Shallow Foundation Systems

Each of the proposed fast food restaurant buildings may be supported on shallow, continuous and/or spread footings bearing at least 36 inches below surrounding grade in controlled fill or existing clay soil. The minimum recommended widths for shallow foundations are 18 inches for continuous strip footings and 24 inches for isolated column footings. Shallow foundations may be designed using a net allowable bearing capacity of 2,100 psf and 1,800 psf for continuous and isolated foundations respectively when founded in native or properly constructed soils as required in this report.

9.2 Shallow Foundation Construction

The Geotechnical Engineer or his representative should monitor shallow foundation construction to confirm conditions are as anticipated. Foundation excavations should be dry and free of loose material. We recommend that the final 6 inches of the footing excavation be performed with a smooth bucket. Reinforcing steel and concrete should be placed within two days, or sooner, to reduce deterioration of the bearing surface. Prolonged exposure or inundation of the bearing surface will negatively affect strength and compressibility characteristics. If delays occur, the excavation should be deepened as necessary and cleaned to provide a fresh bearing surface. If prolonged exposure of the bearing surface is anticipated, a "mud-slab" should be used to protect the bearing surface. Shallow foundations may be earth-formed, provided that a smooth, vertical excavation can be established and maintained throughout placement of reinforcing steel and concrete. Properly designed and constructed shallow footings are estimated to experience foundation settlement of less than 1 inch.

9.3 Grade Supported Slab

The grade supported floor slab should be designed to tolerate some potential vertical subgrade movement. The slab can be supported by twenty-four (24) inches, minimum, of low volume change (LVC) structural fill. LVC material often consists of low plasticity clay soil, limestone screenings, or granular material. If desired, Portland cement, lime, or class “C” fly ash treatment of high plasticity clays can be accomplished to reduce the plasticity index, help to dry the soil, reduce shrink and swell potential, and improve the overall workability. The granular materials immediately beneath the slab can be counted as part of the 24 inches. Before fill placement and/or floor slab construction, proof-rolling should be performed to identify any soft or unstable soils which will need to be removed and replaced with compacted structural fill.

Select fill consisting of an aggregate material such as ¾ clean limestone or an AB-3, should be placed beneath the concrete slab.

10 PAVEMENTS

This report includes recommendations for both rigid and flexible pavements. The design team may select either pavement type depending on a number of considerations, including provisions in this report, site conditions, short- and long-term performance criteria, aesthetic preferences, expected life cycle costs, appearance, and initial cost. Flexible pavements are typically less expensive first cost construction. When the subgrade component of the pavement system is stable, maintenance costs are avoided or minor over the long term. While some differential movement can be expected at minor degrees, if the provisions of this report are strictly adhered to in construction, the pavement subgrades can be expected to be relatively stable. To the extent the provisions of this report are not adhered to in construction, ground risk will elevate, and more ground movement can be expected.

The design of the proposed pavement sections should factor the performance of the subgrade construction provided for in this report.

10.1 Rigid Pavements

For this project, traffic loading and frequency conditions were estimated for various conditions as no specific traffic information was provided. The following information was used in our analysis:

- design life of 20 years
- k-value of 100 pci for subgrade consisting of clay soils and 150 pci for lime treated subgrade.
- reliability of 85 percent
- initial serviceability, po, of 4.2 and a terminal serviceability, pt, of 2.0 for concrete pavements
- concrete modulus of rupture of 540 psi
- load transfer coefficient of 2.7
- drainage coefficient of 1.0

The pavement thickness determinations were performed in accordance with the "1993 AASHTO Guide for the Design of Pavement Structures" guidelines. The minimum pavement sections are presented in the table below. These pavement sections are estimates based on assumed traffic volumes. A more precise design can be made with detailed traffic loading information.

Table 4: Minimum Pavement Sections and Allowable Traffic

Traffic Use	Portland Cement Concrete (inches)	Calculated Design ESAL for Flexural/Compressive Strength (psi)
		580/4,000
Parking Areas for Autos and Light Trucks	4	280,000
Drive Lanes for Autos and Light Trucks	6	700,000
Dumpster Areas	7	1,600,000

1. Concrete pavements should have a 4" minimum MODOT Type 5 base.

The concrete minimum 28-day compressive strength should be selected based on the expected traffic.

Pavement recommendations are based on the estimated loading conditions and commonly accepted design procedures that should provide satisfactory performance for the design life of the pavement. Concrete pavement should have between 4 and 6 percent entrained air. Hand-placed concrete should have a maximum slump of 5 inches. All steel reinforcement, dowel spacing/diameter and pavement joints should conform to applicable city standards.

Saw cutting should be performed in specified locations to control cracking due to shrinkage. Saw cutting should begin as soon as the concrete has obtained enough strength to keep from raveling, but before cracks can be initiated internally. Saw cut depths generally range from ¼ to ⅓ of the pavement thickness but should be performed as directed by the civil engineer.

10.2 Flexible Pavements

The following information and assumptions were used in our flexible pavement analysis:

- design life of 20 years
- reliability of 80 percent
- initial serviceability, po, of 4.2 and a terminal serviceability, pt, of 2.0
- CBR of 3 untreated soils
- overall standard of deviation of 0.45

The pavement thickness determinations were performed in general accordance with the "1993 AASHTO Guide for the Design of Pavement Structures" guidelines. The minimum pavement sections are presented in the table below. These pavement sections are based on estimated traffic volumes. A more precise design can be made if detailed traffic loading information is provided to us.

Table 5: Flexible Pavement Sections

Traffic Use	Design ESAL Count	Material Thickness (inches)	
		Asphalt Wearing Surface	Crushed Stone Base[1]
Parking Areas for Autos	30,000	4	4
Drive Lanes for Autos and Light Trucks[2]	100,000	5	4
Heavy Duty	400,000	7	6
Semi-Truck Traffic/Dumpster Areas [3]	NA	NA	NA

1. Modot, Type 1 or 5.
2. Please refer to local municipal requirements for fire lanes. Use the design criteria which will result in the stronger, more durable pavement section.
3. Recommend minimum Portland cement concrete thickness of 7 inches

Periodic maintenance (i.e. sealing of cracks and joints) should be performed to reduce water intrusion into the base rock layer and underlying clay subgrade. The pavement surface should be contoured such that surface water drains off and away from the pavement or into inlets. Water allowed to pond on or near pavement surfaces could saturate the subgrade soils and lead to premature pavement failure.

10.3 Pavement Base Course

A 9-inch compacted subgrade is recommended below the base rock supporting asphalt or concrete pavement. The compacted subgrade should extend a minimum of 2 feet outside the curb line. This will improve the edge support of the pavement and reduce the edge effect associated with shrinkage during dry periods.

10.4 Pavement Construction and Maintenance Recommendations

It is crucial that the moisture content and compaction be maintained until the pavement is placed. Maintenance should include regular observation to identify and seal cracks. A flexible joint material should be used to seal cracks as they degrade, which can occur during the design life of pavements.

10.5 Surface Drainage

This report provides for maintenance of equilibrium moisture ranges in the subsurface surrounding the building. Pavement grades shall be designed to drain in accordance with the drawings. Temporary detention system designs utilizing parking areas for certain design storms are not recommended for the geotechnical conditions of this site.

11 SITE COMPLETION AND MAINTENANCE

11.1 Site Grading and Drainage

The geotechnical design for this project accounts for hydrogeologic and hydrologic conditions and intends to support best efforts maintenance of equilibrium moisture ranges after construction. Site grading and drainage plans should support this intention where possible. Site grading and drainage should be efficient in paved areas and less efficient in lawn and landscape areas. Roof runoff should be collected by gutters and downspouts, and discharge onto the graded paved areas draining away from the building.

11.2 Landscaping and Irrigation

Irrigated landscaping and lawn areas are acceptable with even layouts or distribution around the building footprint. These areas may serve as supplemental moisture maintenance sources and not moisture drying sources for the subsurface across the site and surrounding the building foundation.

12 STUDY CLOSURE

The analyses, conclusions and recommendations contained in this report are based on site conditions as they existed at the time of the field exploration and further on the assumption that the exploratory borings are representative of the subsurface conditions throughout the site with little variance beyond that found by the borings. If Rone is not serving a monitoring role during construction as advised, and different subsurface conditions from those encountered in our borings are observed or appear to be present in excavations, Rone must be advised promptly so that these conditions can be evaluated, and our recommendations can be reassessed as may be necessary. If there is a substantial lapse of time between submission of this report and the start of the work at the site, if conditions have changed due either to natural causes or to construction operations at or adjacent to the site, or if structure locations, structural loads or finish grades are changed, Rone should be promptly informed and retained if necessary if the changed conditions warrant review and reassessment.

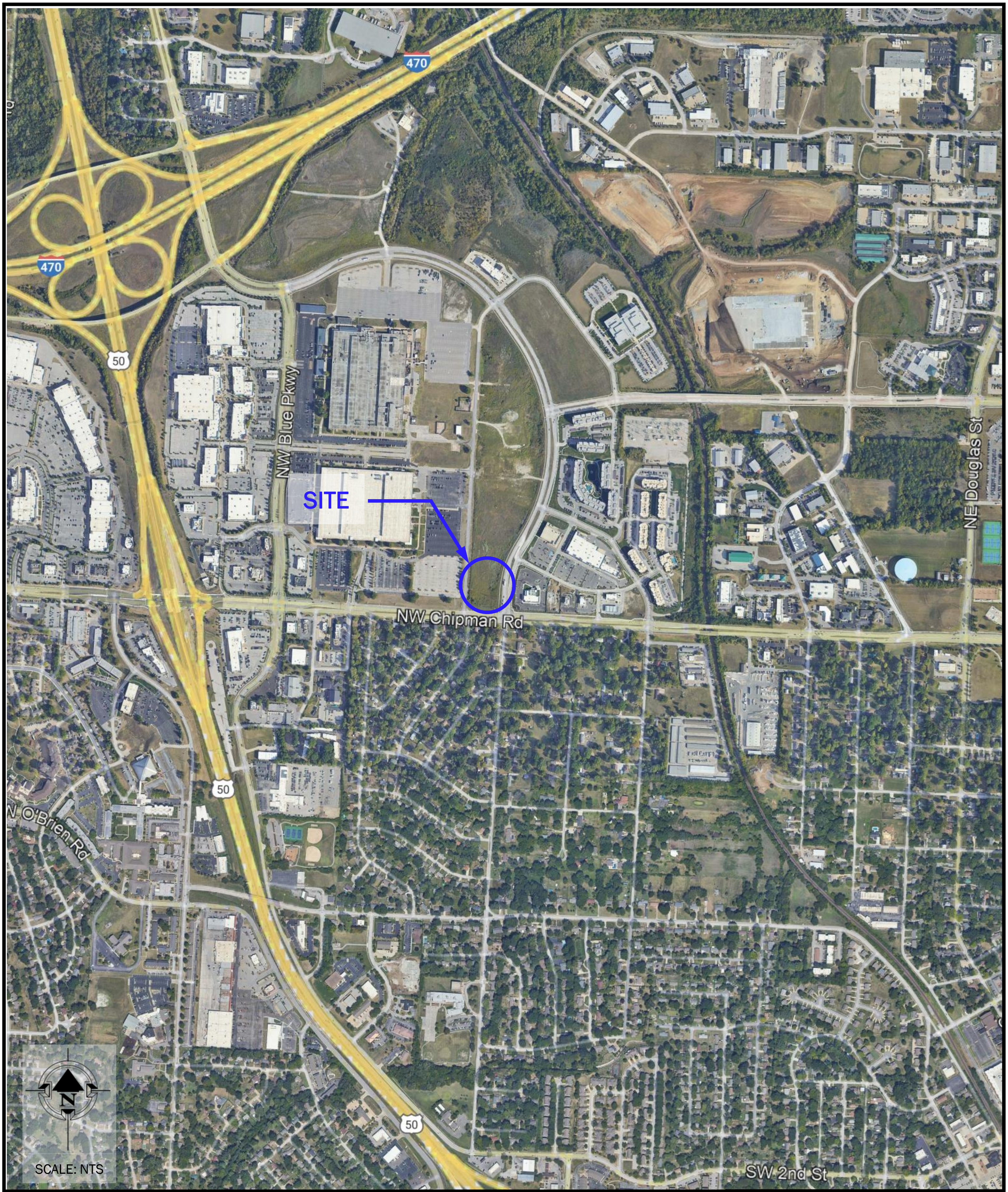
It is important that Rone be retained to assist in design reviews or review those portions of the plans and specifications that pertain to earthwork and foundation systems for this particular project to ensure the plans and specifications are consistent with the controls and recommendations provided in this report. It is also advised that Rone provide oversight and monitoring services during construction to ensure that the controls required for design requirements during earthworks construction are provided correctly and implemented effectively.

This study has been prepared for the exclusive use of the client and their designated agents for specific application to design and construction of this project. We have exercised a degree of care and skill exceeding that ordinarily exercised under similar conditions by reputable members of our profession practicing in the same or similar locality. The engineering services and solutions provided herein are considered advanced, and while design and construction controls are improved, no warranty, expressed or implied, can be made or intended.

13 COPYRIGHT 2024 RONE ENGINEERING SERVICES, LLC.

This report is a work product containing advanced engineering services. This report is in its entirety is the sole property of the Client and Rone Engineering and its affiliates. Use of this report is subject to all copyrights. This report may be used in practice or referenced by any project party as necessary, solely for the party's role on the project for which this report is prepared. Beyond that use no part of this report may be copied, downloaded, stored in a retrieval system, further transmitted, or otherwise reproduced, stored, disseminated, transferred, or used, in any form or means, except as permitted in writing by Rone Engineering Services, LLC. Each reproduction of any part of this report must include all copyright notices and registered trademark designations (®) and non-registered trademark designations (TM).

APPENDIX A



RONE ENGINEERING
An RMA Company

Plate A.1

VICINITY MAP

Summit Fair Lot 10C
NW Chipman Road and NW Ward Road
Lee's Summit, Missouri

PROJECT NO: 24-28620	
DRAWN BY: CD	DATE: 4/8/2024
APPROVED BY: KR	DATE: 4/8/2024

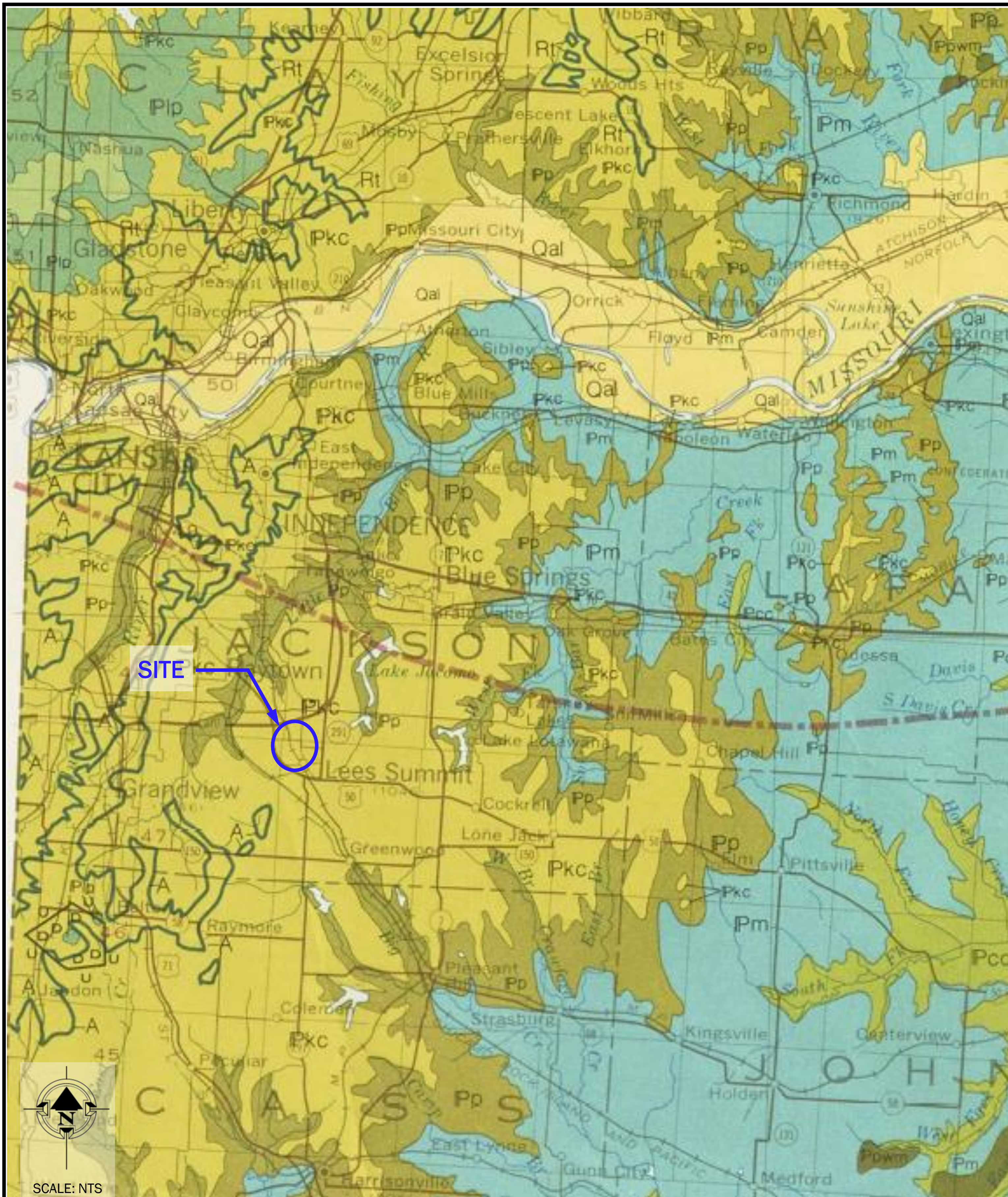


Plate A.2

GEOLOGY MAP

Summit Fair Lot 10C
NW Chipman Road and NW Ward Road
Lee's Summit, Missouri

RONE ENGINEERING
An RMA Company

PROJECT NO: 24-28620	
DRAWN BY: CD	DATE: 4/8/2024
APPROVED BY: KR	DATE: 4/8/2024

RONE ENGINEERING
An RMA Company

Plate A.3

BORING LOCATION DIAGRAM

Summit Fair Lot 10C
NW Chipman Road and NW Ward Road
Lee's Summit, Missouri

PROJECT NO: 24-28620	
DRAWN BY: CD	DATE: 4/8/2024
APPROVED BY: KR	DATE: 4/8/2024

Log	Project No.	Summit Fair Lot 10C NEC of NW Chipman Road and NW Outerview Road Lee's Summit, Missouri
B-1	**24-28620**	
Boring Location: **Lot 10D**		
Latitude: **38.92668° N**	Water Level Observations (feet)	Date: **3-20-24**
	While Drilling ∇	13.5
Longitude: **-94.39460° W**	At Completion	Not Observed
	End of Day	Not Measured

Approximate Surface Elevation = 1002.0 feet

Depth, ft.	Sample Type	Elevation, ft.	Stratum Description	Water Level Observations	SPT or TCP	Penetrometer Reading, tsf	Passing No. 200 Sieve %	Atterberg Limits LL-PL-PI	Moisture Content %	Swell %	Dry Unit Weight, pcf	Unconfined Compression, psf
0			**FAT CLAY (CH)** - brown									
0.5–2	SPT				3-3-4 N=7				24			
2–3.5	SPT		- silty gray yellow brown		2-4-5 N=9				26			
4–5.5	SPT				3-4-6 N=10				23			
6–8	Tube								25		99	3,200
8.5–10	SPT				3-4-6 N=10				27			
13.5				∇								
13.5–15	SPT	987.0			2-4-4 N=8				25			
15			Boring Terminated at Approximately 15 Feet									

Material boundaries are approximate; in situ, transitions may be gradual.

Driller: DH

Drilling Method: Continuous Flight Augers

Plate A.4

This boring log should not be considered valid if separated from the remainder of the geotechnical report.

Log	Project No.			
B-2	**24-28620**	**Summit Fair Lot 10C NEC of NW Chipman Road and NW Outerview Road Lee's Summit, Missouri**		RONE ENGINEERING An RMA Company
Boring Location: **Lot 10D**				
Latitude: **38.92673° N**	Water Level Observations (feet)		Date: **3-20-24**	
	While Drilling ▽	19		
Longitude: **-94.39437° W**	At Completion	Not Observed		
	End of Day	Not Measured		

Approximate Surface Elevation = 1002.0 feet

Depth, ft.	Elevation, ft.	Stratum Description	Water Level Observations	SPT or TCP	Penetrometer Reading, tsf	Passing No. 200 Sieve %	Atterberg Limits LL-PL-PI	Moisture Content %	Swell %	Dry Unit Weight, pcf	Unconfined Compression, psf
0		**FAT CLAY (CH)** - silty gray brown									
1–2.5				2-3-4 N=7				32			
3–5		- silty gray yellow brown				98	56-21-35	26		99	7,200
6–7.5				3-5-6 N=11				24			
8.5–10				2-4-5 N=9				26			
13.5–15				4-4-6 N=10				25			
18.5–20	982.5	- yellow brown gray	▽	7-14-19 N=33				21			
19.5	982.0	**WEATHERED LIMESTONE** -									
20		Boring Terminated at Approximately 20 Feet									

Material boundaries are approximate; in situ, transitions may be gradual.

Driler: DH
Drilling Method: Continuous Flight Augers

Plate A.5

This boring log should not be considered valid if separated from the remainder of the geotechnical report.

Log	Project No.	Summit Fair Lot 10C
B-3	**24-28620**	**NEC of NW Chipman Road and NW Outerview Road**
Boring Location		**Lee's Summit, Missouri**
Lot 10D		

Latitude	Water Level Observations (feet)		Date
38.92686° N	While Drilling	Not Observed	**3-20-24**
Longitude	At Completion	Not Observed	
-94.39443° W	End of Day	Not Measured	

RONE ENGINEERING An RMA Company

Depth, ft.	Symbol	Sample Type	Elevation, ft.	Stratum Description Approximate Surface Elevation = 1002.0 feet	Water Level Observations	SPT or TCP	Penetrometer Reading, tsf	Passing No. 200 Sieve %	Atterberg Limits LL-PL-PI	Moisture Content %	Swell %	Dry Unit Weight, pcf	Unconfined Compression, psf
				FAT CLAY (CH) - silty dark gray									
						6-6-7 N=13				21			
				- silty gray brown yellow		3-4-6 N=10				25			
5													
						4-6-7 N=13				24			
						4-6-7 N=13				28			
10			992.0	Boring Terminated at Approximately 10 Feet									

Material boundaries are approximate; in situ, transitions may be gradual.

Driller: DH
Drilling Method: Continuous Flight Augers

Plate A.6

This boring log should not be considered valid if separated from the remainder of the geotechnical report.

Log	Project No.	
B-4	**24-28620**	**Summit Fair Lot 10C** **NEC of NW Chipman Road and NW Outerview Road** **Lee's Summit, Missouri**
Boring Location: **Lot 10D**		

Latitude	Water Level Observations (feet)		Date
38.92680° N	While Drilling	Not Observed	**3-20-24**
Longitude	At Completion	Not Observed	
-94.39474° W	End of Day	Not Measured	

Stratum Description

Approximate Surface Elevation = 1001.0 feet

Depth, ft.	Elevation, ft.	Stratum Description	Water Level Observations	SPT or TCP	Penetrometer Reading, tsf	Passing No. 200 Sieve %	Atterberg Limits LL-PL-PI	Moisture Content %	Swell %	Dry Unit Weight, pcf	Unconfined Compression, psf
0		**FAT CLAY (CH)** - silty gray yellow brown									
1–3						95	49-24-25	26		95	3,400
3.5–5				3-4-5 N=9				28			
6–7.5				3-4-6 N=10				28			
8.5–10	991.0			4-5-6 N=11				27			
10		Boring Terminated at Approximately 10 Feet									

Material boundaries are approximate; in situ, transitions may be gradual.

Driller: DH
Drilling Method: Continuous Flight Augers

Plate A.7

This boring log should not be considered valid if separated from the remainder of the geotechnical report.

Log	Project No.	
B-5	**24-28620**	**Summit Fair Lot 10C NEC of NW Chipman Road and NW Outerview Road Lee's Summit, Missouri**
Boring Location: **Lot 10E**		

Latitude	Water Level Observations (feet)		Date
38.92614° N	While Drilling ▽	13.5	**3-21-24**
Longitude	At Completion	Not Observed	
-94.39481° W	End of Day	Not Measured	

Approximate Surface Elevation = 1000.0 feet

Depth, ft.	Elevation, ft.	Stratum Description	Water Level Observations	SPT or TCP	Penetrometer Reading, tsf	Passing No. 200 Sieve %	Atterberg Limits LL-PL-PI	Moisture Content %	Swell %	Dry Unit Weight, pcf	Unconfined Compression, psf
0		**FAT CLAY (CH)** - silty gray									
1–2.5				2-2-2 N=4				29			
3.5–5		- silty gray yellow brown		2-4-5 N=9				26			
6–7.5				4-4-5 N=9				26			
8–10								27		98	3,000
13.5			▽								
13.5–15	985.0			3-4-5 N=9				28			
15		Boring Terminated at Approximately 15 Feet									

Material boundaries are approximate; in situ, transitions may be gradual.

Driller: DH

Drilling Method: Continuous Flight Augers

Plate A.8

This boring log should not be considered valid if separated from the remainder of the geotechnical report.

RONE ENGINEERING An RMA Company

Log	Project No.	
B-6	**24-28620**	**Summit Fair Lot 10C NEC of NW Chipman Road and NW Outerview Road Lee's Summit, Missouri**
Boring Location: **Lot 10E**		

RONE ENGINEERING An RMA Company

Latitude	Water Level Observations (feet)		Date
38.92600° N	While Drilling ∇	13.5	**3-21-24**
Longitude	At Completion	Not Observed	
-94.39475° W	End of Day	Not Measured	

Stratum Description

Approximate Surface Elevation = 999.0 feet

Depth, ft.	Elevation, ft.	Stratum Description	Water Level Observations	SPT or TCP	Penetrometer Reading, tsf	Passing No. 200 Sieve %	Atterberg Limits LL-PL-PI	Moisture Content %	Swell %	Dry Unit Weight, pcf	Unconfined Compression, psf
0		**FAT CLAY (CH)** - silty dark gray									
1-2.5				3-4-5 N=9				23			
3-5		- silty gray brown yellow				92	64-24-40	26		99	4,400
6-7.5				3-5-8 N=13				25			
8.5-10				3-4-5 N=9				24			
13.5			∇								
13.5-15	984.0			3-4-5 N=9				30			
15		Boring Terminated at Approximately 15 Feet									

Material boundaries are approximate; in situ, transitions may be gradual.

Driller: DH

Drilling Method: Continuous Flight Augers

Plate A.9

This boring log should not be considered valid if separated from the remainder of the geotechnical report.

Log **B-7**	Project No. **24-28620**	**Summit Fair Lot 10C NEC of NW Chipman Road and NW Outerview Road Lee's Summit, Missouri**
Boring Location **Lot 10E**		

Latitude **38.92609° N**	Water Level Observations (feet)		Date **3-21-24**
Longitude **-94.39498° W**	While Drilling	Not Observed	
	At Completion	Not Observed	
	End of Day	Not Measured	

Stratum Description

Approximate Surface Elevation = 1000.0 feet

Depth, ft.	Elevation, ft.	Stratum Description	Water Level Observations	SPT or TCP	Penetrometer Reading, tsf	Passing No. 200 Sieve %	Atterberg Limits LL-PL-PI	Moisture Content %	Swell %	Dry Unit Weight, pcf	Unconfined Compression, psf
0		**FAT CLAY (CH)** - silty gray									
1-3								23		104	4,200
3.5-5				2-3-5 N=8				27			
6-7.5		- silty gray brown yellow		3-5-6 N=11				24			
8.5-10	990.0			4-6-7 N=13				24			
10		Boring Terminated at Approximately 10 Feet									

Material boundaries are approximate; in situ, transitions may be gradual.

This boring log should not be considered valid if separated from the remainder of the geotechnical report.

Driller: DH

Drilling Method: Continuous Flight Augers

Plate A.10

Log	Project No.		
B-8	**24-28620**	**Summit Fair Lot 10C NEC of NW Chipman Road and NW Outerview Road Lee's Summit, Missouri**	
Boring Location: **Lot 10E**			

Latitude	Water Level Observations (feet)		Date
38.92586° N	While Drilling	Not Observed	**3-21-24**
Longitude	At Completion	Not Observed	
-94.39477° W	End of Day	Not Measured	

Depth, ft.	Symbol	Sample Type	Elevation, ft.	Stratum Description Approximate Surface Elevation = 999.0 feet	Water Level Observations	SPT or TCP	Penetrometer Reading, tsf	Passing No. 200 Sieve %	Atterberg Limits LL-PL-PI	Moisture Content %	Swell %	Dry Unit Weight, pcf	Unconfined Compression, psf
				FAT CLAY (CH) - silty gray									
						3-4-4 N=8				26			
				- silty gray yellow brown		2-3-3 N=6				29			
5													
						2-4-4 N=8				30			
			989.0			3-4-5 N=9				27			
10				Boring Terminated at Approximately 10 Feet									

Material boundaries are approximate; in situ, transitions may be gradual.

Driler: DH
Drilling Method: Continuous Flight Augers

Plate A.11

This boring log should not be considered valid if separated from the remainder of the geotechnical report.

Log	Project No.		
B-9	**24-28620**	**Summit Fair Lot 10C** **NEC of NW Chipman Road and NW Outerview Road** **Lee's Summit, Missouri**	RONE ENGINEERING An RMA Company

Boring Location	
Lot 10F	

Latitude	Water Level Observations (feet)		Date
38.92612° N	While Drilling ▽	9	**3-21-24**
Longitude	At Completion	Not Observed	
-94.39438° W	End of Day	Not Measured	

Stratum Description

Approximate Surface Elevation = 1000.0 feet

Depth, ft.	Symbol	Sample Type	Elevation, ft.	Stratum Description	Water Level Observations	SPT or TCP	Penetrometer Reading, tsf	Passing No. 200 Sieve %	Atterberg Limits LL-PL-PI	Moisture Content %	Swell %	Dry Unit Weight, pcf	Unconfined Compression, psf
0				**FAT CLAY (CH)** - silty dark brown									
1–2.5						2-3-4 N=7				27			
3–5				- silty gray brown yellow						26		98	5,000
6–7.5						3-5-6 N=11				26			
8.5–10			990.0		▽	2-2-3 N=5				28			
10				Boring Terminated at Approximately 10 Feet									

Material boundaries are approximate; in situ, transitions may be gradual.

Driller: DH

Drilling Method: Continuous Flight Augers

Plate A.12

This boring log should not be considered valid if separated from the remainder of the geotechnical report.

Log	Project No.	Summit Fair Lot 10C
B-10	**24-28620**	**NEC of NW Chipman Road and NW Outerview Road**
Boring Location		**Lee's Summit, Missouri**
Lot 10F		

RONE ENGINEERING
An RMA Company

Latitude	Water Level Observations (feet)		Date
38.92600° N	While Drilling ▽	13	**3-20-24**
Longitude	At Completion	Not Observed	
-94.39439° W	End of Day	Not Measured	

Depth, ft.	Symbol	Sample Type	Elevation, ft.	Stratum Description (Approximate Surface Elevation = 1000.0 feet)	Water Level Observations	SPT or TCP	Penetrometer Reading, tsf	Passing No. 200 Sieve %	Atterberg Limits LL-PL-PI	Moisture Content %	Swell %	Dry Unit Weight, pcf	Unconfined Compression, psf
				FAT CLAY (CH) - silty dark brown									
						2-4-5 N=9				23			
				- silty gray yellow brown		3-4-5 N=9				27			
5													
				- silty dark brown gray				98	57-21-36	25		96	4,000
				- silty gray yellow brown		3-4-5 N=9				26			
10													
					▽								
			985.0			2-2-4 N=6				29			
15				Boring Terminated at Approximately 15 Feet									

Material boundaries are approximate; in situ, transitions may be gradual.

Driller: DH
Drilling Method: Continuous Flight Augers

Plate A.13

This boring log should not be considered valid if separated from the remainder of the geotechnical report.

Log	Project No.	Summit Fair Lot 10C NEC of NW Chipman Road and NW Outerview Road Lee's Summit, Missouri
B-11	**24-28620**	
Boring Location: **Lot 10F**		

Latitude	Water Level Observations (feet)		Date
38.92609° N	While Drilling	Not Observed	**3-21-24**
Longitude	At Completion	Not Observed	
-94.39455° W	End of Day	Not Measured	

Stratum Description

Approximate Surface Elevation = 1000.0 feet

Depth, ft.	Elevation, ft.	Stratum Description	Water Level Observations	SPT or TCP	Penetrometer Reading, tsf	Passing No. 200 Sieve %	Atterberg Limits LL-PL-PI	Moisture Content %	Swell %	Dry Unit Weight, pcf	Unconfined Compression, psf
0		**FAT CLAY (CH)** - silty dark brown									
1–2.5				3-3-4 N=7				26			
3.5–5		- silty gray yellow brown		3-4-6 N=10				27			
6–7.5		- silty gray		3-4-6 N=10				25			
8.5–10	990.0	- silty gray yellow brown						23			
10		Boring Terminated at Approximately 10 Feet									

Material boundaries are approximate; in situ, transitions may be gradual.

Driller: DH

Drilling Method: Continuous Flight Augers

Plate A.14

This boring log should not be considered valid if separated from the remainder of the geotechnical report.

Log	Project No.	
B-12	**24-28620**	**Summit Fair Lot 10C** **NEC of NW Chipman Road and NW Outerview Road** **Lee's Summit, Missouri**
Boring Location: **Lot 10F**		

Latitude	Water Level Observations (feet)		Date
38.92591° N	While Drilling	Not Observed	**3-21-24**
Longitude	At Completion	Not Observed	
-94.39431° W	End of Day	Not Measured	

Stratum Description

Approximate Surface Elevation = 1000.0 feet

Depth, ft.	Elevation, ft.	Stratum Description	Water Level Observations	SPT or TCP	Penetrometer Reading, tsf	Passing No. 200 Sieve %	Atterberg Limits LL-PL-PI	Moisture Content %	Swell %	Dry Unit Weight, pcf	Unconfined Compression, psf
0		**FAT CLAY (CH)** - silty gray yellow brown									
1–3								29		93	3,000
3.5–5				2-4-6 N=10				27			
6–7.5				2-4-4 N=8				26			
8.5–10	990.0			3-4-6 N=10				25			
10		Boring Terminated at Approximately 10 Feet									

Material boundaries are approximate; in situ, transitions may be gradual.

Driller: DH
Drilling Method: Continuous Flight Augers

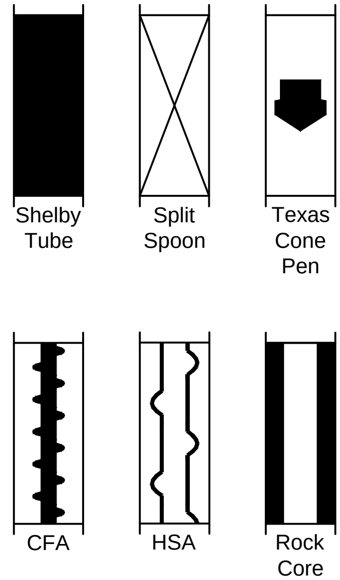
Plate A.15

This boring log should not be considered valid if separated from the remainder of the geotechnical report.

SOIL OR ROCK TYPES

Undocumented Fill	Well-Graded Sand (SW)
Lean Clay (CL)	Clayey Sand (SC)
Gravelly Lean Clay (CL)	Well-Graded Gravel (GW)
Fat Clay (CH)	Marl
Gravelly Fat Clay (CH)	Weathered Shale
Clayey Gravel (GC)	Shale
Silt (ML)	Weathered Limestone
Poorly-Graded Sand (SP)	Limestone

DRILLING AND SAMPLING METHODS



TERMS DESCRIBING CONSISTENCY, CONDITION, AND STRUCTURE OF SOIL

Fine Grained Soils (More than 50% Passing No. 200 Sieve)

Consistency	Penetrometer Reading, (tsf)	Unconfined Compression, (psf)
Very Soft	$\leq$ 0.5	$\leq$ 1000
Soft	0.5 to 1.0	1000 to 2000
Firm	1.0 to 2.0	2000 to 4000
Hard	2.0 to 4.0	4000 to 8000
Very Hard	> 4.0	> 8000

Coarse Grained Soils (More than 50% Retained on No. 200 Sieve)

Penetration Resistance (Blows / Foot)	Descriptive Item	Relative Density
0 to 4	Very Loose	0 to 20%
4 to 10	Loose	20 to 40%
10 to 30	Medium Dense	40 to 70%
30 to 50	Dense	70 to 90%
Over 50	Very Dense	90 to 100%

Soil Structure

Calcareous	Contains appreciable deposits of calcium carbonate; generally nodular
Slickensided	Having inclined planes of weakness that ate slick and glossy in appearance
Laminated	Composed of thin layers of varying color or texture
Fissured	Containing cracks, sometimes filled with fine sand or silt
Interbedded	Composed of alternated layers of different soil types, usually in approximately equal proportions

TERMS DESCRIBING PHYSICAL PROPERTIES OF ROCK

Hardness and Degree of Cementation

Very Soft or Plastic	Can be remolded in hand; corresponds in consistency up to hard in soils
Soft	Can be scratched with fingernail
Moderately Hard	Can be scratched easily with knife; cannot be scratched with fingernail
Hard	Difficult to scratch with knife
Very Hard	Cannot be scratched with knife
Poorly Cemented or Friable	Easily crumbled
Cemented	Bound together by chemically precipitated material; Quartz, calcite, dolomite, siderite, and iron oxide are common cementing materials.

Degree of Weathering

Unweathered	Rock in its natural state before being exposed to atmospheric agents
Slightly Weathered	Noted predominantly by color change with no disintegrated zones
Weathered	Complete color change with zones of slightly decomposed rock
Extremely Weathered	Complete color change with consistency, texture, and general appearance approaching soil

KEY TO CLASSIFICATION AND SYMBOLS **PLATE A.16**

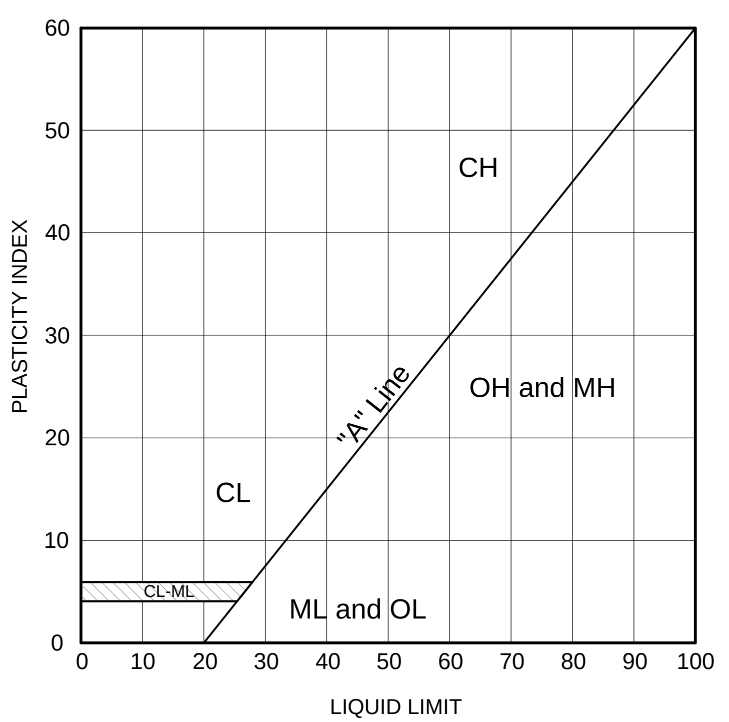
Major Divisions			Grp. Sym.	Typical Names	Laboratory Classification Criteria	
Coarse - Grained Soils (more than half of the material is larger than No. 200 Sieve size)	Gravels (more than half of coarse fraction is larger than No. 4 Sieve size)	Clean gravels (Little or no fines)	GW	Well graded gravels, gravel-sand mixtures, little or no fines	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4: $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines	Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GM	Silty gravels, gravel - sand - silt mixtures	Liquid and Plastic limits below "A" line or P.I. greater than 4	Liquid and plastic limits plotting in hatched zone between 4 and 7 are borderline cases requiring use of dual symbols
			GC	Clayey gravels, gravel - sand - clay mixtures	Liquid and Plastic limits above "A" line with P.I. greater than 7	
	Sands (more than half of coarse fraction is smaller than No. 4 Sieve size)	Clean sands (Little or no fines)	SW	Well graded sands, gravelly sands, little or no fines	$C_u = \frac{D_{60}}{D_{10}}$ greater than 6: $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines	Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM	Silty sands, sand silt mixtures	Liquid and Plastic limits below "A" line or P.I. less than 4	Liquid and plastic limits plotting between 4 and 7 are borderline cases requiring use of dual symbols
			SC	Clayey sands, sand clay mixtures	Liquid and Plastic limits above "A" line with P.I. greater than 7	
Fine - Grained Soils (more than half of the material is smaller than No. 200 Sieve)	Silts and Clays (Liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, and lean clays		
			OL	Organic silts and organic silty clays of low plasticity		
	Silts and Clays (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts		
			CH	Inorganic clays of high plasticity, fat clays		
			OH	Organic clays of medium to high plasticity, organic silts		
	Highly Organic soils		Pt	Peat and other highly organic soils		

Determine percentages of sand and gravel form grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows

Less than 5 percent......................GW,GP,SW,SP

More than 12 percent....................GM,GC,SM,SC

5 to 12 percent.....Borderline cases requiring dual symbols



PLASTICITY CHART

UNIFIED SOIL CLASSIFICATION SYSTEM

PLATE A.17

APPENDIX B

FIELD EXPLORATION

Subsurface conditions were defined by 12 sample borings located as shown on the Boring Location Diagram, Plate A.3. The borings were completed at locations staked in the field by drilling personnel. The borings were advanced between sample intervals using continuous flight auger drilling procedures. The results of each boring are shown graphically on the Logs of Boring. Sample depth, description, and soil classification based on the Unified Soil Classification System are shown on the Logs of Boring. Keys to the symbols and terms used on the Logs of Boring are presented in the appendix section of the report.

Relatively undisturbed samples of cohesive soils were obtained using nominal 3-inch diameter tube samplers at the locations shown on the Logs of Boring. The tube sampler consists of a steel tube with a sharp cutting edge connected to a head equipped with a ball valve threaded for rod connection. The tube is pushed into the soil by the hydraulic pulldown of the drilling rig. The soil specimens were extruded from the tube in the field, logged, tested for consistency with a hand penetrometer, sealed and packaged to limit loss of moisture.

Samples of stiff and/or granular materials were obtained using split-barrel sampling procedures in general accordance with ASTM D1586. In the split-barrel procedure, a disturbed sample is obtained in a standard 2-inch OD split-barrel sampler driven 18 inches into the ground using a 140-pound hammer falling freely 30 inches. The number of blows for the last 12 inches of the standard 18-inch penetration is recorded as the Standard Penetration Test resistance (N-value). The N-values are recorded on the logs of boring at the depth of sampling. The samples were sealed and returned to our laboratory for further examination and testing.

Groundwater observations during and at completion of drilling are shown on the logs of boring. Upon drilling completion, the boreholes were backfilled with auger cuttings to the ground surface.

LABORATORY TESTING

Laboratory tests were performed on selected samples retrieved from the borings to evaluate the engineering characteristics of the subsurface materials, and to provide data for developing engineering design parameters. The subsurface materials recovered during the field exploration were described by an engineering geologist or senior staff member in the field and/or the laboratory and were later refined based on results of the laboratory tests performed.

Classification Tests

All recovered soil samples were classified and described, in part, using the Unified Soil Classification System (USCS). Visual classification of soils was verified by index testing, including natural moisture content determinations, Atterberg limits determinations, and gradation tests (percent passing the No. 200 U.S. Standard Sieve). All testing was performed in general accordance with applicable American Society for Testing and Materials (ASTM) procedures as follows:

Test	ASTM Standard Number
Atterberg Limits	D4318
Percentage of Particles Passing the No. 200 Sieve	D1140
Moisture Content	D2216
Unconfined Compressive Strength	D2166

Unconfined Compression Strength Test - Soil

In the unconfined compression test, a cylindrical specimen is subjected to axial load at a constant rate of strain until failure occurs. Strengths determined by this test are tabulated at their respective sample depths on the logs of boring. Results of natural moisture content and dry unit weight determinations are also tabulated at the respective sample depths on the logs.

APPENDIX C

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept* *responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

Telephone: 301/565-2733
e-mail: info@geoprofessional.org www.geoprofessional.org

Copyright 2019 by Geoprofessional Business Association (GBA). Duplication, reproduction, or copying of this document, in whole or in part, by any means whatsoever, is strictly prohibited, except with GBA's specific written permission. Excerpting, quoting, or otherwise extracting wording from this document is permitted only with the express written permission of GBA, and only for purposes of scholarly research or book review. Only members of GBA may use this document or its wording as a complement to or as an element of a report of any kind. Any other firm, individual, or other entity that so uses this document without being a GBA member could be committing negligent