REPORT OF GEOTECHNICAL EXPLORATION
LAKEWOOD BUSINESS PARK-LOT 35
LEE'S SUMMIT, MISSOURI

Presented to:
SALLEE DEVELOPMENT
Lee's Summit, Missouri

Attn: Mr. Tyler Sallee

Prepared by:
Otto J. Kruger, Jr., P.E.
Tadele M. Akalu

KTI
Lenexa, Kansas

KTI Project No. 219188G

January 8, 2020

KRUGER TECHNOLOGIES, INC.

GEOTECHNICAL ■ ENVIRONMENTAL ■ TESTING ■ INSPECTION
8271 MELROSE DRIVE ■ LENEXA, KANSAS 66214 ■ VOICE 913-498-1114 ■ FAX 913-498-1116 ■ EMAIL KTIKC@KTIONLINE.COM

January 8, 2020

Mr. Tyler Sallee
Sallee Development
3730 NE Troon Drive
Lee's Summit, MO 64064

Re: KTI Project No. 219188G
Lakewood Business Park-Lot 35
Lee's Summit, Missouri

Dear Mr. Sallee:

KTI has completed the subsurface exploration and geotechnical report for the above referenced project. The purpose of this report is to describe the surface and subsurface conditions encountered at the site, analyze and evaluate this information, and prepare a summary of existing conditions, subsurface material characteristics, and geotechnical design recommendations.

We thank you for the opportunity to work with Sallee Development. If you have any questions, please contact us at 913.498.1114.

Respectfully submitted,
Kruger Technologies, Inc.

Otto J. Kruger, Jr., P.E.
Missouri: 23994

STATE OF MISSOURI
O. J. KRUGER, JR.
NUMBER
PROFESSIONAL ENGINEER

Tadele M. Akalu
Laboratory Manager

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LAKEWOOD BUSINESS PARK-LOT 35
LEE'S SUMMIT, MISSOURI

AUTHORIZATION

The following table presents the authorization documentation history for the work performed and presented in this report by Kruger Technologies, Inc.

Project: Lakewood Business Park-Lot 35		
Document:	**Date:**	**Requested/Provided:**
Request for Proposal	12-05-19	Adam Miller–KAT Excavation
KTI Proposal 19GT040	12-05-19	Dylan Kruger – Kruger Technologies, Inc.
Notice to Proceed	12-06-19	Tyler Sallee–Sallee Development

PURPOSE AND SCOPE

The purpose of this investigation was to explore the surface and subsurface conditions present within the site and provide recommendations regarding the following:

- Seismic Considerations
- Site Preparation and Engineered Fill
- Shallow Building Foundation
- Slab on Grade
- Surface and Subsurface Drainage
- Excavation Considerations
- Trench Backfill Recommendations
- Manhole/Inlet Structure Backfill Recommendations
- Pavement Recommendations

SITE DESCRIPTION

The project site is located on the east side of NE Port Drive and north of NE Lakewood Way in Lee's Summit, Missouri. The site has approximately 30 feet (931 to 961) of elevation difference across the proposed site. There is an existing Tarmac International Inc building bordering to the north with a 3 to 5 feet high retaining wall and open ground to the east. At the time of the investigation the site was mostly grass covered with some areas being partially covered with small stockpiles of rock.

PROJECT DESCRIPTION

We understand that the project consists of the design and construction of a new 24,000 square foot single-story commercial building and related site improvements, including drives, parking lots and retaining walls to be located at 4101 NE Port Drive in Lee's Summit, Missouri. We assumed that the new building will utilize metal frame construction and slab on grade construction.

FIELD EXPLORATION PROCEDURES

Eleven (11) total test borings, five in the building footprint, three in the parking areas, two in the retaining wall areas and one in the detention areas, were completed for the above referenced project on December 20, 2019. The boring locations were selected by the client and field staked by KTI using a plan drawing provided by the client. The borings were drilled using a Geoprobe 8277T. Advancement of the test holes was accomplished using a 6-inch continuous flight augers and direct push micro cores. Soil sampling was performed by hydraulically pushing thin wall steel (Shelby) tubes.

Site soils were visually and manually classified in general accordance with ASTM D 2488 by the drill crew chief as drilling progressed. All the soil samples were delivered to the laboratory for verification of the field classifications. The boring logs were created as the borings were advanced and supplemented with information from lab test results; the boring logs are attached in Appendix I.

LABORATORY TESTS

Laboratory tests were performed on the recovered samples to determine the engineering characteristics and for additional verification of the field classifications in accordance with ASTM D 2487. The results of these tests, including in-situ moisture content, dry density, plasticity (Atterberg Limits), and unconfined compressive strength of soil are presented in Appendix II.

GEOLOGY/SUBSURFACE CONDITIONS

The site soils consist of topsoil, fill and natural clay soils. Highly weathered shale and limestone bedrock was encountered within 1.5 to 13.5-foot depths from existing surface elevations during the exploration. The majority of the top 1 foot was a topsoil with a grass cover. Small boulder stockpiles were encountered throughout the site. This was underlain by fill material from 1.0 to 5.0 feet consisting of fat clay, trace gravel and limestone fragments. The natural clay site soils from 5.0 to 8.0 feet are generally comprised of high plasticity (fat) clays. The underlying rock

materials are highly weathered shale and limestone bedrock. The existing natural clay soils are generally moist and exhibit medium stiff to stiff consistency. The Unified Soil Classification System classifies low plasticity (lean) clay soils as CL and high plasticity (fat) clay soils as CH.

During advancement of the borings, free water was not encountered in any of the test borings. It should be noted that water level determinations made in relatively impervious (clay) soils might not present a reliable indication of the actual water table. However, water level determinations made in relatively pervious (sand/silt) soils are considered an accurate indication of the water table at the time that those measurements are made. Fluctuations in the water table should be expected with changing seasons and annual differences.

DESIGN CRITERIA AND RECOMMENDATIONS

Laboratory test results of the recovered samples showed the following characteristics that were used as criteria for determining the recommendations for bearing values and design data:

In-Situ Moisture	17.3 to 29.6%
Dry Density	90.2 to 104.7 pcf
Liquid Limit	51 to 74
Plasticity Index	34 to 51
Unconfined Compressive Strength	1,281 to 5,535 psf

Seismic Considerations

Based on the International Building Code (IBC) Section 1615.1.1, the subsurface stratigraphy, and the use of shallow foundations bearing on existing limestone bedrock, the general Site Class Definition for the structures bearing on soil is Site Class B.

Site Preparation and Engineered Fill

A site grading plan was available at the time of exploration and based on the site topography five to twenty foot cuts would be anticipated. We anticipate that the majority of the site weathered shale and limestone formation can be cut with a heavy-duty excavator or dozer. However, competent and harder beds of limestone will likely require an excavator mounted with a hydraulic hammer.

Areas to receive fill should be stripped of vegetation, topsoil, pavement, and any other deleterious materials. Any isolated areas of soft or deleterious materials encountered at

subgrade elevation should be removed and replaced with engineered fill. The moisture content of the subgrade soils should be appropriate to achieve the required compaction.

Proper drainage of the construction area should be provided to protect foundations, floor slabs, and pavement subgrades from the detrimental effects of weather conditions. Excavations should be kept as dry as possible. Any loose or soft materials which accumulate or develop on subgrade or bearing surfaces should be removed prior to the placement of concrete or pavement sections. Concrete should be placed in footing excavations as soon as possible after excavations are complete.

Trucks and other heavy construction vehicles should be restricted as much as possible from trafficking on the finished subgrade in the building to prevent unnecessary disturbances of subgrade soils. Excessive rutting or pumping of the subgrade could occur from construction traffic, particularly during periods of wet weather. If such disturbed areas develop, the subgrade may have to be excavated and replaced with properly compacted fill.

Concrete for foundations should be placed as soon after completion of the excavations as possible to avoid disturbance of the bearing material by inflow of surface water, groundwater, or precipitation.

Supplemental engineered fill should be placed in uniform horizontal lifts, with loose thicknesses not exceeding eight inches. The thickness must be appropriate for the method of compaction and the type of equipment used. The geotechnical engineer should approve any off-site material proposed for use as fill. Engineered fill should be compacted to a minimum of 95 percent of maximum density as determined by ASTM D698 (standard Proctor test) at moisture content between 0 and 4 percent above optimum moisture for high plasticity clay material and from -2 to +2 from optimum moisture content for low plasticity clays. The existing site soils cannot be used for fill material as they do not meet the requirements presented in the Building Pad Fill or Parking Lot Fill sections below.

The fill should be benched in any sloped areas greater than one vertical to five horizontal in order to maintain relatively horizontal lifts. The benching should be placed at not less than 12-inch rises over those areas where it is required as the work is brought up in layers.

Building Pad

Based on the available site topography, it is anticipated that the building subgrade will be at or below the site bedrock material. A levelling course of crushed rock (MoDOT Type-5) may be required.

Detention Pond

A detention pond is planned in the southwest portion of the development. This site is represented by Boring B-11. The top three feet of the fill material at this location contains gravel and is not suitable for a detention pond. The pond should be lined with low permeability soil to limit water seepage from the pond. The on-site materials such as at Boring B-8, (Liquid Limit of 74 and Plasticity Index of 51), are high plasticity soils and are suitable for use as a pond liner. However, any organic matter or rock fragments should be removed from the pond liner material. Once the pond has been excavated to the bottom of liner grade, we recommend that 12 inches of soil beneath the bottom of liner grade be reworked if necessary and compacted to a minimum of 95 percent of the material's maximum dry density as determined by the standard Proctor laboratory compaction test. The moisture content of the reworked material should be at 0 to +4 percent above its optimum moisture content. The base would then be ready for placement of the 12 inches of liner material.

Segmental Retaining Wall

Borings B-9 and B-10 were drilled in the vicinity of the proposed retaining wall, located at the east side of the site. At this location, 1 foot of topsoil is underlain by fill materials consisting of low to high plasticity clays. The fill extends to an approximate depth of three feet below existing grade. The fill materials are generally moist and exhibit medium to stiff consistency. The undisturbed soils are high plasticity clays approximately 5-10 feet thick that are moist and exhibit stiff consistency.

Severely to moderately weathered shale and or limestone bedrock is present at a depth of about 8.5 feet at Boring B-9 and approximately 11 feet at Boring B-10 below existing grade. The borings were discontinued at auger refusal at 13.5 feet (B-9) and 13.0 feet (B-10) depth of in moderately weathered, medium dense limestone. The borings were dry during and upon completion of drilling and sampling operations.

Design Procedures

The proposed segmental retaining wall should be designed in accordance with the current edition of the National Concrete Masonry Association's (NCMA's) Design Manual For Segmental Retaining Walls. If big blocks are used for construction of the wall, then the wall should be designed in accordance with the manufacturer's recommendations using generally accepted factors of safety. The factors of safety generally accepted in the SRW industry are those presented in NCMA's Design Manual for Segmental Retaining Walls.

Lateral Earth Pressures For Retaining Wall Design

The following K values may be used for the evaluation of lateral soil/bedrock resistance for retaining walls:

Site Cohesive Soils (Estimated ϕ of 18°)

K_a = 0.55
K_p = 1.90
K_o = 0.70
Coefficient of sliding friction = 0.30
Wet density of in place soil, average (γ) = 125 pcf

Granular backfill (Estimated ϕ of 35°)

K_a = 0.30
K_p = 3.33
K_o = 0.43
Coefficient of sliding friction = 0.47
Wet density of in-place granular backfill = 130 pcf

Site weathered Shale/Limestone Bedrock (Estimated ϕ of 27°)

K_a = 0.40
K_p = 2.65
K_o = 0.55
Coefficient of sliding friction = 0.55
Wet density of in-place shale bedrock = 135 pcf

Retaining Wall Foundation

The SRW should be supported and keyed into bedrock. An allowable contact pressure of 5000 psf is suggested for the SRW bearing on the site weathered limestone. Weathered limestone was found at 13.5 feet below top of boring for B-9 and 13.0 feet below top of boring for B-10.

Drain Lines

On slopes where the bedrock units outcrop or are immediately below the soil mantle, groundwater seepage can occur at the base of the weathered shale units. It is recommended that a perforated drain line be installed at the wall foundation base in a trench excavated at the base of the shale unit before the placement of any fill.

Permanent Slopes

Permanent cut or fill slopes should be no steeper than 3(H) to 1(V) to maintain long-term stability and to provide ease of maintenance. Steeper slopes are susceptible to erosion, will be difficult to maintain, and could experience problems with instability. The crest or toe of cut or fill slopes should be no closer than 10 feet from any foundation and no closer than 5 feet from the edge of any pavement. If slopes steeper than 3H:1V are planned, these steepened slopes will likely need to be reinforced in order to be stable.

Shallow Foundations

We understand that the finished floor for the proposed building is set to be 940.00. Based on the site topography the site will require 5 to 20 feet of cut. The majority of the building foundations are assumed to be on site limestone bedrock. Where bedrock is encountered within the proposed building footprint an option for shallow spread footings is recommended with allowable bearing capacity of 5 ksf. Bedrock excavation may result in uneven bearing surfaces. MoDOT Type 5 aggregate placed at 95% of standard Proctor density to design bearing elevation would provide the same 5 ksf bearing capacity.

In no case should footings bear on both site soil and bedrock materials. In order to minimize the potential of differential settlement, we recommend that all footings bear in the same type and consistency of the site limestone bedrock material. Shallow foundation system supported by limestone bedrock or controlled Type 5 fill will result in essentially no settlement of the new structure.

Slab on Grade

Based on the available site topography, the slab subgrade will be at or below the site bedrock formation. A levelling course may be required and well graded crushed aggregate materials such as MODOT Type-5 are acceptable.

Movement between slabs on grade and walls may occur. To minimize the effects of this movement, we recommend that slip joints be incorporated between all slabs and walls. All slabs should contain crack control and construction joints, which are formed on 15 to 25-foot centers, each way, or as designed by the project structural engineer. To prevent moisture movement through the slab on grade a capillary moisture barrier is recommended be placed under the slabs. This barrier should be a minimum of a 6-inch thick layer of clean granular material extending to the limits of the foundation walls (Drainage layer crushed aggregate gradation requirement is specified in the Manhole/Inlet Structure Backfill section of this report). Should additional moisture protection be desired, it should consist of 6-mil polyethylene sheeting placed between the slab and the base course. The use of clean gravel for a capillary break or polyethylene would not be necessary if another form of moisture protection is planned to be used. Appropriate consideration of slab curing for this condition should be undertaken. For the purpose of slab design, a modulus of subgrade reaction (k) of 200 pounds/cubic inch is suggested for a subgrade consisting of site bedrock materials. Actual slab thickness will depend on anticipated loading but is not recommended to be less than 4 inches.

Surface Drainage

In order to reduce the problems related to water infiltration, it is recommended that the final grade around the structure perimeters have a positive slope extending at least six feet away from the structure. Backfill of soils around the foundation should be compacted at a minimum of 95 percent of maximum dry density at moisture content between optimum and four percent above optimum in accordance with ASTM D 698.

Subsurface Drainage

Groundwater was not encountered and is not expected to be a problem, although infiltration of surface water and/or perched groundwater could occur. It would be prudent to construct a drain system around the perimeter of below-grade structures or footings. The perimeter drain system should consist of 4-inch PVC or equivalent pipe with at least ¼-inch perforations routed to a sump or by gravity to the exterior. The pipe should be laid with the perforations down and enveloped with gravel. The gravel should be surrounded with Mirafi 140 filter cloth or equivalent.

Excavation Considerations

We believe that the project soils are Type B as classified in the OSHA Excavation Standard Handbook 29 CFR Parts 1926.650 through 1926.652. Type B soils are characterized by cohesive soils above the water table with unconfined compressive strengths greater than 0.5 tons per square foot (tsf) but less than and 1.5 tsf. Type B soils include any fill soils meeting or exceeding the above criteria, as well as undisturbed soils with unconfined compressive strengths of >1.5 tsf which are subject to vibration from traffic. Temporary excavation slopes for Type B soils can be one horizontal to one vertical with a maximum excavation depth of 20 feet.

Excavations deeper than 20 feet may require the use of supplemental shoring and will require the preparation of an excavation design prepared by a registered professional engineer.

Excavation of trenches may extend into the weathered bedrock materials. Excavation of the upper zones of the weathered bedrock material may be performed with conventional excavation equipment. At borings and elevations where augur refusal was encountered, additional effort may be required to excavate the weathered bedrock materials (i.e. rock hammer, etc.).

Trench Backfill

According to our findings, excavated site materials may be used as backfill for trench excavation. Backfill should not be placed on soft materials or frozen ground. Soil backfill overlying the bedding should be placed in uniform horizontal lifts, with loose thicknesses not exceeding eight inches. The thickness must be appropriate for the method of compaction and the type of equipment used. The geotechnical engineer should approve any off-site material proposed for use as fill. Trench backfill under driveways/parking lots should be compacted to a minimum of 95 percent of maximum density as defined by Standard Proctor (ASTM D 698) at moisture content according to the recommendations presented in the Site Preparation and Engineered Fill section of this report. In common yard areas, the soil backfill should be compacted to a minimum of 90 percent of maximum density (ASTM D 698) using the above moisture parameters. After preparation of the trench bottom, a pipe bed of a minimum of 6” shall be prepared using crushed stone or crushed gravel meeting the following requirements:

Nominal Pipe Size Diameter	AASHTO M43 Size
15” or Less	67, 7, 8 or washed #9
Greater than 15”	57, 6, or 67

Manhole/Inlet Structure Backfill

Soil backfill around structures should be placed in uniform horizontal lifts, with loose thicknesses not exceeding eight inches. The thickness must be appropriate for the method of compaction and the type of equipment used. The geotechnical engineer should approve any off-site material proposed for use as fill. Backfill should be compacted to a minimum of 95 percent of maximum density as defined by Standard Proctor (ASTM D 698) at a moisture content between 0 and 4 percent above optimum moisture (preferred average of plus 2 percent). Another option is to backfill with a Controlled Low Strength Material (CLSM), or flowable fill. The flowable fill should exhibit a minimum unconfined compressive strength of 250 psi after 28 days. Bedding material for manhole/inlet structure should be clean crushed rock conforming to the following gradation:

Sieve Designation	Percent Passing by Weight
1 ½"	100
No. 4	0 – 35
No. 200	0 – 8

PAVEMENT RECOMMENDATIONS

Pavement Subgrade Preparation

Pavement subgrades should be prepared in accordance with the recommendations presented in the SITE PREPARATION and ENGINEERED FILL section of this report. Construction scheduling, involving paving and grading by separate contractors, typically results in a time lapse between the end of grading operations and the commencement of paving. Disturbance, desiccation, and/or wetting of the subgrade between grading and paving can result in deterioration of the previously completed subgrade. A non-uniform subgrade can result in poor pavement performance and local failures relatively soon after pavements are constructed.

Based on the site topography, the subgrade of the pavement is anticipated to be at or below the site bedrock material. A levelling course would be required and well graded crushed limestone such as MODOT Type-5 should be compacted at 95 percent of maximum dry density per ASTM D698.

The following options for construction of the parking lot are being considered for the project. It is understood that low to moderate levels of truck traffic may be experienced by the proposed parking lot. The options are minimum recommendations based on the assumption that pavements will bear on excavated bedrock/compacted crushed limestone as discussed above.

Asphaltic Cement Concrete Pavements

Full depth recommended flexible pavement sections including aggregate base are presented in Table 1. The pavement profiles presented below for drive lanes and parking stalls assume only passenger vehicle loading. A heavy-duty pavement section is presented for emergency vehicles and garbage trucks. Passenger vehicles are defined as two-axle, four-wheel vehicles (cars, trucks, vans and SUVs).

Table 1

Asphaltic Cement Concrete Pavement on Modified Subgrade (Minimum)

Material	Parking Stalls	Drive Lanes	Heavy Duty
Surface Course	1.5-inch	2-inch	2-inch
Base Course	2.5-inch	4-inch	6-inch

The asphaltic base course should be compacted to a minimum of 95% of the mixture's Marshall density, when determined in accordance with ASTM D 6926. The surface course should have a minimum Marshall stability of 1800 pounds and be compacted to a minimum of 97% of the mixture's Marshall density, when determined in accordance with ASTM D 6926.

Portland Cement Concrete Pavements

Based on the anticipated bedrock material types encountered in the proposed parking lot and previous experience with subgrade materials a resilient modulus of 200-pci is suggested.

Portland cement concrete (PCC) pavements are recommended for drive approaches; loading dock aprons, trash dumpster pads and approaches, loading/unloading areas, and other areas where heavy wheel loads will be concentrated. We recommend that the concrete pavements in areas receiving heavy truck traffic have a minimum thickness of 8 inches. If PCC pavements are considered for passenger vehicle areas, we recommend a minimum thickness of 5 inches.

It is also recommended that a 4-inch levelling and drainage course of clean, crushed rock be placed below all PCC pavements and that appropriate subdrainage or connection to a suitable gravity outfall be provided to remove water from the drainage layer.

The mixture should be designed to develop a minimum compressive strength of 4000 psi at 28 days with a 4-inch maximum slump and 5 to 7 percent entrained air. Where Portland cement concrete is used, load transfer devices should be installed at all construction joints or post-placement sawed joints.

Construction Considerations

Construction traffic on the pavements has not been considered in the recommended typical sections. If construction scheduling dictates the pavements will be subject to traffic by construction equipment/vehicles, the pavement thickness should be reconsidered to include the effects of the additional traffic loading. Construction traffic should not be allowed on partially completed pavements as the pavements will not have adequate structural capacity and could be damaged.

Periodic maintenance of all of the pavements should be anticipated. This should include sealing of cracks and joints and by maintaining proper surface drainage to avoid ponding water on or near the pavement areas.

Pavement Drainage

The granular section should be graded to adjacent storm sewer inlets or drainage ditches and provisions should be made to provide drainage from the granular section into the storm sewer. Drainage of the granular base is particularly important where two different sections of pavements (such as full-depth asphaltic concrete and Portland cement concrete with aggregate base) abut, so that water does not pond beneath the pavements and saturate the subgrade soils.

The performance of pavements will be dependent upon a number of factors, including subgrade conditions at the time of paving, rainwater runoff, and traffic. Rainwater runoff should not be allowed to seep below pavements from adjacent areas. All pavements should be sloped approximately 1/4 inch per foot to provide rapid surface drainage. Proper drainage below the pavement section helps prevent softening of the subgrade and has a significant impact on

pavement performance and pavement life. Therefore, we recommend that a granular blanket drain be constructed at all storm sewer inlets within the pavement areas. The blanket drain should consist of clean, crushed stone aggregate extending a minimum of 6 inches below pavement subgrade level. The blanket drains should extend radially a minimum of 8 feet from each of the storm sewer inlets. The grade within the blanket drain should be sloped toward the storm sewer inlet, and weep holes should be drilled through the inlet to provide drainage of the granular section into the inlet. Placement of geotextile filter fabric across the weep holes could be considered to prevent loss of aggregate through the weep holes. These recommendations are very important for long-term performance of the pavements. Because pavements typically have relatively low factors of safety, it will be very important that the specifications are followed closely during pavement construction.

Based on our experience with similar projects, irrigation systems are commonly installed in the landscaped areas adjacent to portions of the pavement areas. If such an irrigation system is to be installed, we recommend that consideration be given to installing subsurface drainage lines between irrigated areas and the planned pavements. It has been our experience that the quantity of subsurface seepage originating from irrigated areas can be substantial and can adversely affect the performance of the pavement subgrade. Therefore, consideration should be given to constructing edge drain lines along the pavements located adjacent to irrigated areas, to intercept and divert subsurface water flows from beneath the pavements. These lines should be constructed behind the curb lines, on the upgradient side of the pavements, and should be sloped to provide positive gravity flow to a suitable outfall.

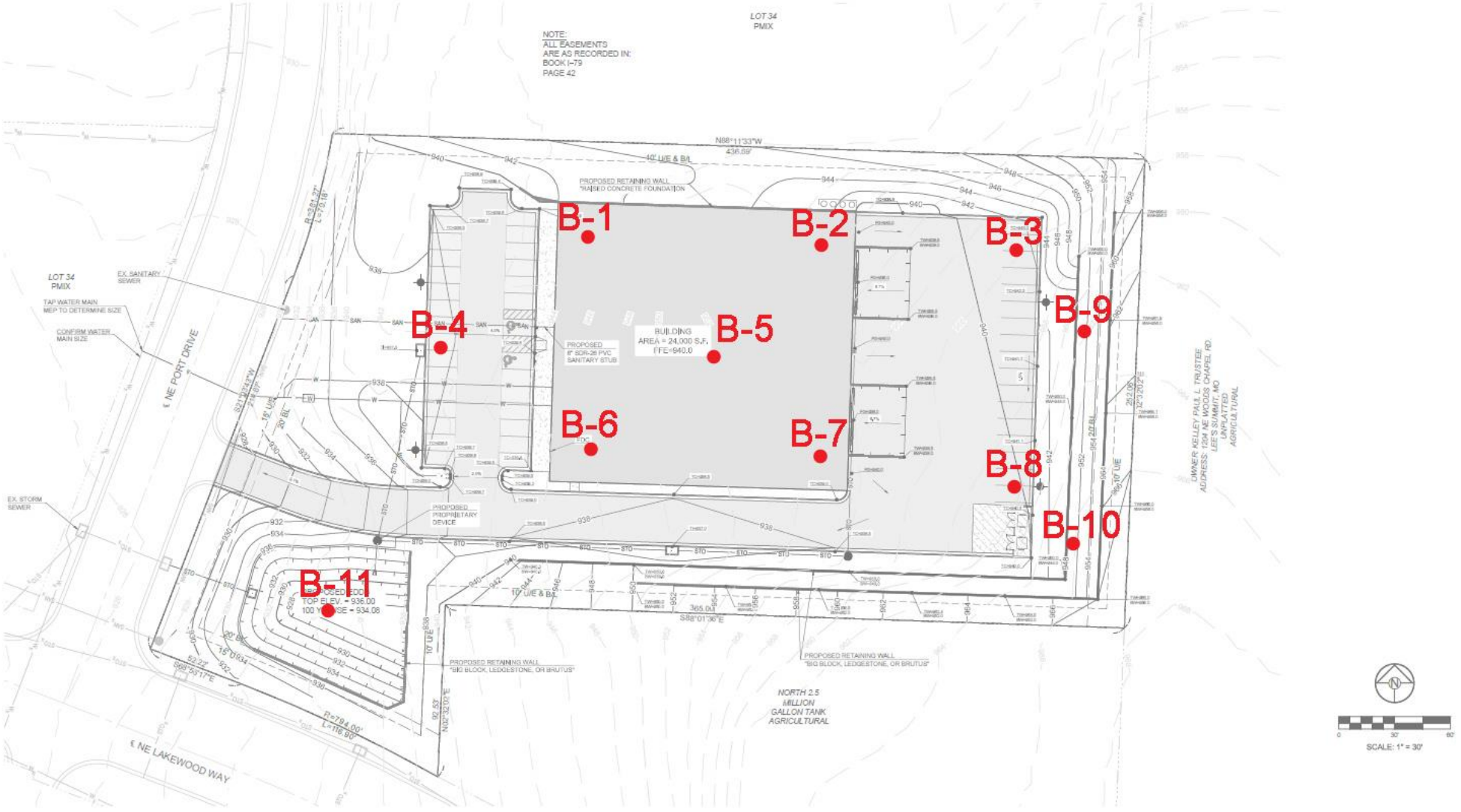
REMARKS

It is recommended that the geotechnical engineer be retained to review the plans and specifications for the project so that an evaluation and comments can be provided regarding the proper incorporation of information from this geotechnical report into the final construction documents. We further recommend that the geotechnical engineer be retained during construction phases for earthwork, pavement, and foundations to provide observation and testing to aid in determining that design intent has been accomplished.

The findings, recommendations, and suggestions contained in this report are our opinions based on data acquired to date and are assumed to be representative of conditions at locations between borings. Due to the fact that the area at the borings is very small relative to the overall site, and for other reasons, we make no statement warranting the conditions below our borings or at other locations throughout the site. In addition, we do not warrant that the general strata logged at the borings are necessarily typical of the remaining areas of the site.

Reports shall not be reproduced except in full, without written approval of KTI. Information in this report applies only to the referenced project in its present configuration and location and shall not be used for any other project or location.

BORING LOCATION DIAGRAM



Boring Location Diagram
Lakewood Business Park-Lot 35
Lee's Summit, Missouri

KRUGER TECHNOLOGIES, INC.

Drawn: TMA	Date: 1/8/2020	KTI Project No. 219188G

APPENDIX I

Boring Logs

LOG OF TEST BORING
BORING B-1

PROJECT: Lakewood Business Park-Lot 35
CLIENT: Lakewood Business Park-Lot 35
PROJECT NO.: 219188G **START:** 12/20/19
BORING LOCATION: See Boring Location Plan
METHOD OF DRILLING: 4" Continuous Flight Augers
DEPTH TO - water None **caving**

DATE: 1/6/2020
ELEVATION:
FINISH: 12/20/19

LOGGER: TMA
DATE CHECKED:

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Sample # & Type	Density pcf	Moist-ure, %	Qu, psf
0		T	Topsoil				
1		W	Weathered limestone, very stiff, to hard, gray				
2			Drilling discontinued at auger refusal at 1.5 feet				
3							
4							
5							
6							
7							

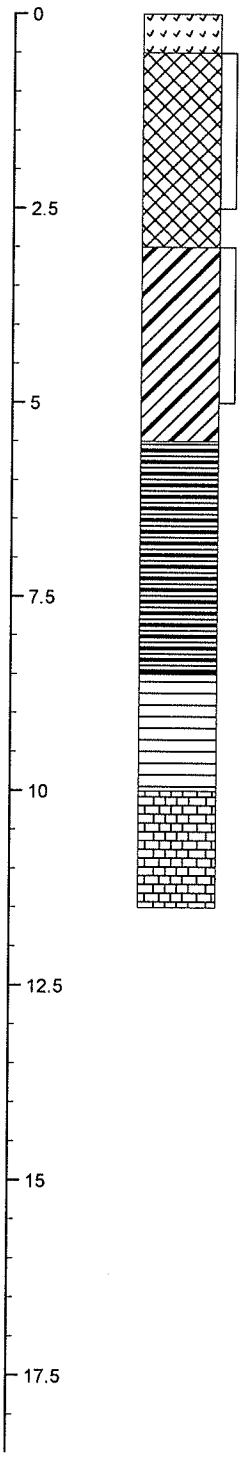
Notes:

LOG OF TEST BORING
BORING B-2

PROJECT: Lakewood Business Park-Lot 35
CLIENT: Lakewood Business Park-Lot 35
PROJECT NO.: 219188G **START:** 12/20/19
BORING LOCATION: See Boring Location Plan
METHOD OF DRILLING: 4" Continuous Flight Augers
DEPTH TO - water None **caving**

DATE: 1/6/2020
ELEVATION:
FINISH: 12/20/19

LOGGER: TMA
DATE CHECKED:



ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Sample # & Type	Density pcf	Moist-ure, %	Qu, psf
		T	Topsoil				
		FILL	Fill, fat clay, stiff, red, moist	1, ST	96.2	2.9	
		CL-CH	Lean to fat clay, trace gravel, reddish brown, moist	2, ST	99.6	22.7	2330
		W	Highly weathered shale, very stiff, gray, moist				
		Sh	Shale, weathered, very stiff to hard, gray, moist to dry				
		L	Limestone, weathered, very stiff to hard, gray				
			Drilling discontinued at auger refusal 11.5 feet				

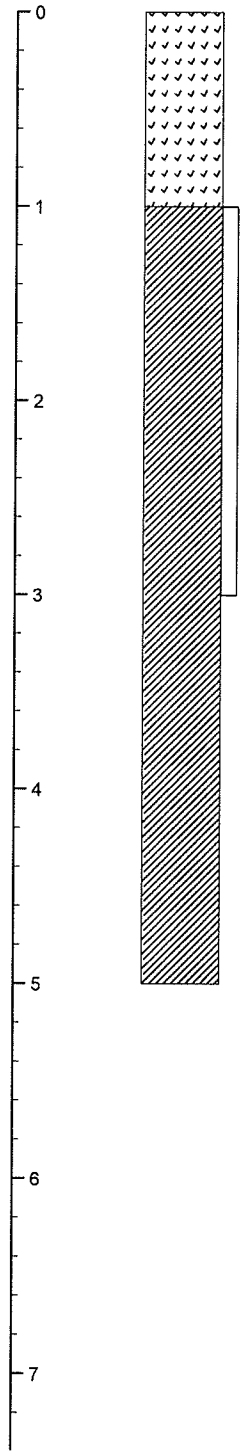
Notes:

LOG OF TEST BORING
BORING B-3

PROJECT: Lakewood Business Park-Lot 35
CLIENT: Lakewood Business Park-Lot 35
PROJECT NO.: 219188G **START:** 12/20/19
BORING LOCATION: See Boring Location Plan
METHOD OF DRILLING: 4" Continuous Flight Augers
DEPTH TO - water None **caving**

DATE: 1/6/2020
ELEVATION:
FINISH: 12/20/19

LOGGER: TMA
DATE CHECKED:



ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Sample # & Type	Density pcf	Moist-ure, %	Qu, psf
		T	Topsoil				
		CH	Fat clay, stiff, light brown, moist	1, ST	91.8	28.7	1928
			Drilling discontinued at 5.0 feet				

Notes:

LOG OF TEST BORING
BORING B-4

PROJECT: Lakewood Business Park-Lot 35
CLIENT: Lakewood Business Park-Lot 35
PROJECT NO.: 219188G **START:** 12/20/19
BORING LOCATION: See Boring Location Plan
METHOD OF DRILLING: 4" Continuous Flight Augers
DEPTH TO - water None **caving**

DATE: 1/6/2020
ELEVATION:
FINISH: 12/20/19

LOGGER: TMA
DATE CHECKED:

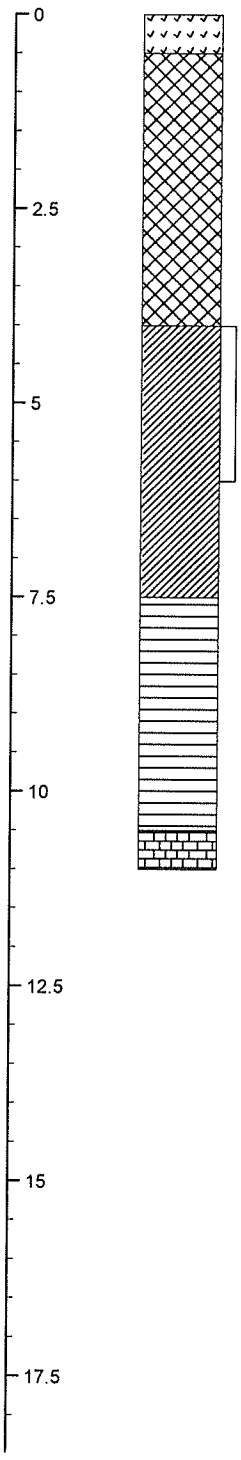
ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Sample # & Type	Density pcf	Moist-ure, %	Qu, psf
0		T	Topsoil				
1		W	Weathered limestone, very stiff, to hard, gray				
2			Drilling discontinued at auger refusal at 1.8 feet				
3							
4							
5							
6							
7							

Notes:

LOG OF TEST BORING
BORING B-5

PROJECT: Lakewood Business Park-Lot 35
CLIENT: Lakewood Business Park-Lot 35
PROJECT NO.: 219188G **START:** 12/20/19
BORING LOCATION: See Boring Location Plan
METHOD OF DRILLING: 4" Continuous Flight Augers
DEPTH TO - water None **caving**

DATE: 1/6/2020
ELEVATION:
FINISH: 12/20/19
LOGGER: TMA
DATE CHECKED:



ELEVATION/ DEPTH	USCS	Description	Sample # & Type	Density pcf	Moist-ure, %	Qu, psf
	T	Topsoil				
	FILL	Fill, clayey gravel, reddish brown, moist with boulders				
	CH	Fat clay, stiff, olive gray, moist	1, ST	100.9	24.3	2749
	Sh	Shale, weathered, very stiff to hard, gray, moist to dry				
	L	Limestone, weathered, very stiff to hard, gray				
		Drilling discontinued at auger refusal 11.0 feet				

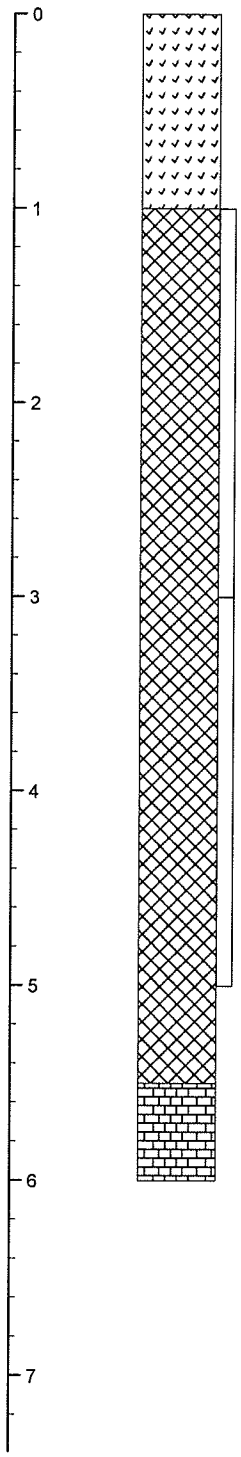
Notes:

LOG OF TEST BORING
BORING B-6

PROJECT: Lakewood Business Park-Lot 35
CLIENT: Lakewood Business Park-Lot 35
PROJECT NO.: 219188G **START:** 12/20/19
BORING LOCATION: See Boring Location Plan
METHOD OF DRILLING: 4" Continuous Flight Augers
DEPTH TO - water None **caving**

DATE: 1/6/2020
ELEVATION:
FINISH: 12/20/19

LOGGER: TMA
DATE CHECKED:



ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Sample # & Type	Density pcf	Moist-ure, %	Qu, psf
		T	Topsoil				
		FILL	Fill, fat clay, trace gravel, stiff, red, moist	1, ST	91.3	25.3	1281
		FILL	Fill, fat clay with rock fragments, very stiff, reddish brown, moist	2, ST	104.7	17.3	5535
		L	Limestone, highly weathered, very stiff to hard, gray				
			Drilling discontinued at auger refusal at 6.0 feet				

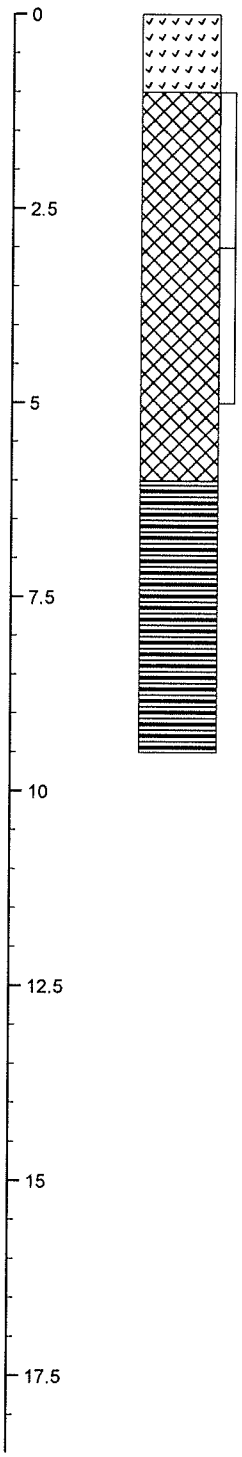
Notes:

LOG OF TEST BORING
BORING B-7

PROJECT: Lakewood Business Park-Lot 35
CLIENT: Lakewood Business Park-Lot 35
PROJECT NO.: 219188G **START:** 12/20/19
BORING LOCATION: See Boring Location Plan
METHOD OF DRILLING: 4" Continuous Flight Augers
DEPTH TO - water None **caving**

DATE: 1/6/2020
ELEVATION:
FINISH: 12/20/19

LOGGER: TMA
DATE CHECKED:



ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Sample # & Type	Density pcf	Moist-ure, %	Qu, psf
		T	Topsoil				
		FILL	Fill, fat clay, trace gravel, stiff, greenish gray, moist	1, ST	90.2	26.3	
		FILL	Fill, lean to fat clay with gravel, very stiff, light brown, moist	2, ST	108.3	19.7	
		W	Highly weathered shale, very stiff to hard, gray, moist to dry				
			Limestone, weathered, very stiff, to hard, light gray				
			Drilling discontinued at auger refusal at 9.5 feet				

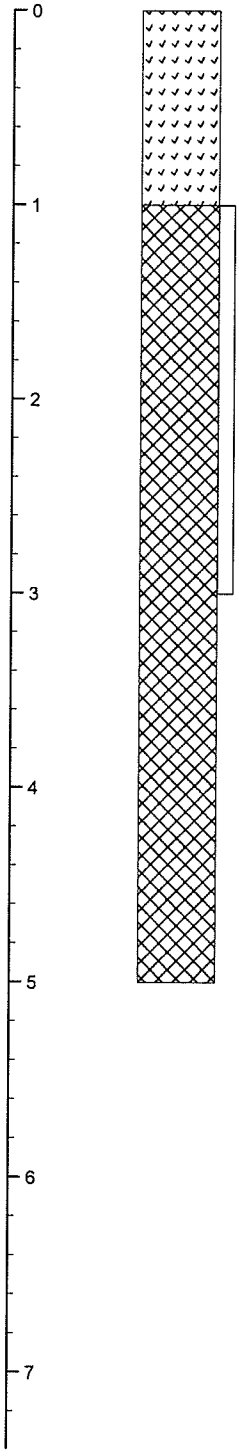
Notes:

LOG OF TEST BORING
BORING B-8

PROJECT: Lakewood Business Park-Lot 35
CLIENT: Lakewood Business Park-Lot 35
PROJECT NO.: 219188G **START:** 12/20/19
BORING LOCATION: See Boring Location Plan
METHOD OF DRILLING: 4" Continuous Flight Augers
DEPTH TO - water None **caving**

DATE: 1/6/2020
ELEVATION:
FINISH: 12/20/19

LOGGER: TMA
DATE CHECKED:



ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Sample # & Type	Density pcf	Moist-ure, %	Qu, psf
		T	Topsoil				
		FILL	Fill, fat clay, trace gravel, stiff, greenish gray, moist	1, ST	90.7	29.6	
			with limestone fragments				
			Drilling discontinued at 5.0 feet				

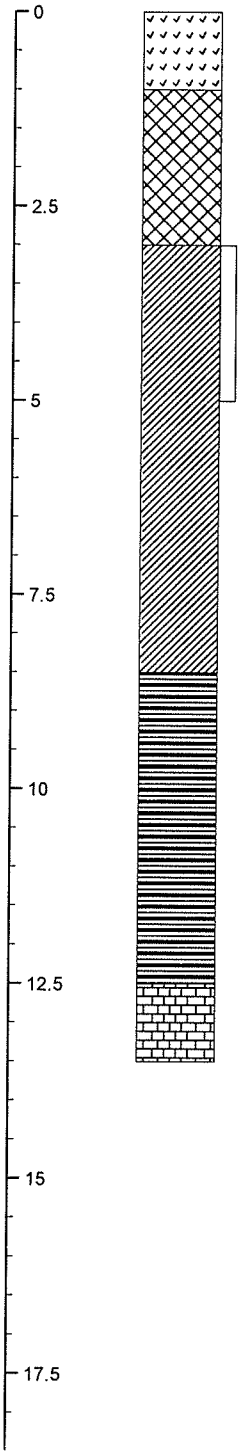
Notes:

LOG OF TEST BORING
BORING B-9

PROJECT: Lakewood Business Park-Lot 35
CLIENT: Lakewood Business Park-Lot 35
PROJECT NO.: 219188G **START:** 12/20/19
BORING LOCATION: See Boring Location Plan
METHOD OF DRILLING: 4" Continuous Flight Augers
DEPTH TO - water None **caving**

DATE: 1/6/2020
ELEVATION:
FINISH: 12/20/19

LOGGER: TMA
DATE CHECKED:



ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Sample # & Type	Density pcf	Moist-ure, %	Qu, psf
		T	Topsoil				
		FILL	Fill, lean to fat clay, with gravel, stiff, reddish brown, moist				
		CH	Fat clay, stiff, light gray, moist	1, ST	96.0	27.6	4213
		CH	becoming yellowish brown				
		W	Weathered shale, very stiff, gray, moist to dry				
		L	Limestone, highly weathered, very stiff to hard, light gray				
			Drilling discontinued at auger refusal at 13.5 feet				

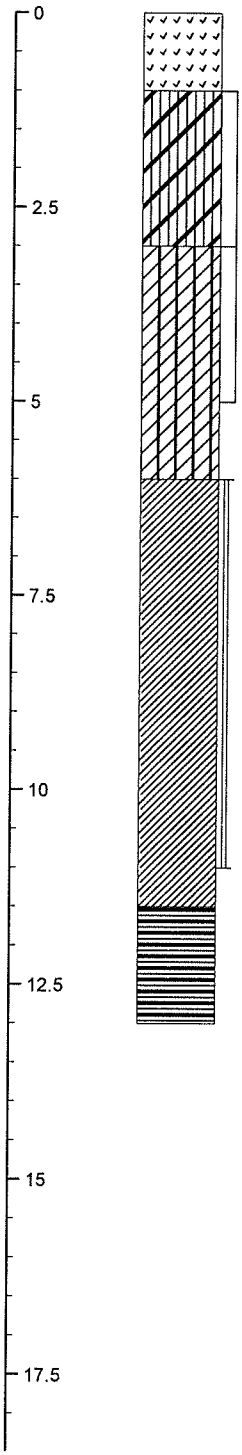
Notes:

LOG OF TEST BORING
BORING B-10

PROJECT: Lakewood Business Park-Lot 35
CLIENT: Lakewood Business Park-Lot 35
PROJECT NO.: 219188G **START:** 12/20/19
BORING LOCATION: See Boring Location Plan
METHOD OF DRILLING: 4" Continuous Flight Augers
DEPTH TO - water None **caving**

DATE: 1/6/2020
ELEVATION:
FINISH: 12/20/19

LOGGER: TMA
DATE CHECKED:



ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Sample # & Type	Density pcf	Moist-ure, %	Qu, psf
		T	Topsoil				
		CL-ML	Fill, lean to fat clay, with gravel, stiff, light brown, moist	1, ST	94.5	26.9	
		CL	Lean clay, stiff, brown, moist	2, ST	99.0	23.6	3947
		CH	Fat clay, reddish brown, stiff, moist	1, V			
		W	Weathered limestone, very stiff, light gray				
			Drilling discontinued at auger refusal at 13.0 feet				

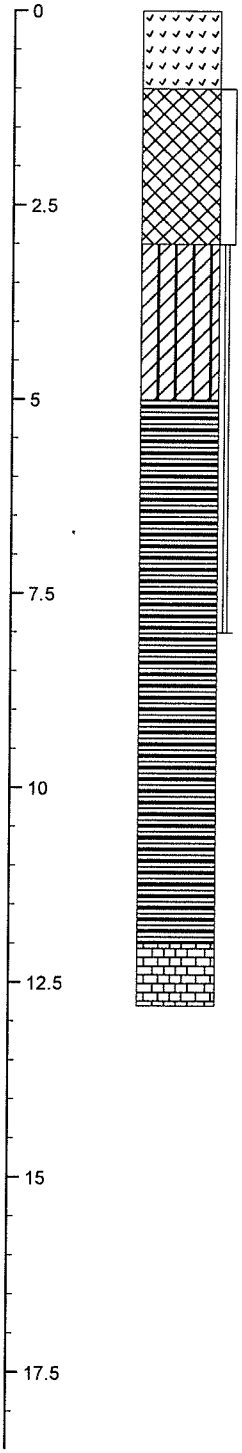
Notes:

LOG OF TEST BORING
BORING B-11

PROJECT: Lakewood Business Park-Lot 35
CLIENT: Lakewood Business Park-Lot 35
PROJECT NO.: 219188G **START:** 12/20/19
BORING LOCATION: See Boring Location Plan
METHOD OF DRILLING: 4" Continuous Flight Augers
DEPTH TO - water None **caving**

DATE: 1/6/2020
ELEVATION:
FINISH: 12/20/19

LOGGER: TMA
DATE CHECKED:



ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Sample # & Type	Density pcf	Moist-ure, %	Qu, psf
		T	Topsoil				
		FILL	Fill, lean to fat clay, with gravel, stiff,grayish brown brown, moist	1, ST	98.6	24.8	
		CL	Lean clay, stiff, dark brown, moist				
		W	Weathered shale, very stiff, gray, moist to dry	1, V			
		L	Limestone, highly weathered, very stiff to hard, gray				
			Drilling discontinued at auger refusal at 12.8 feet				

Notes:

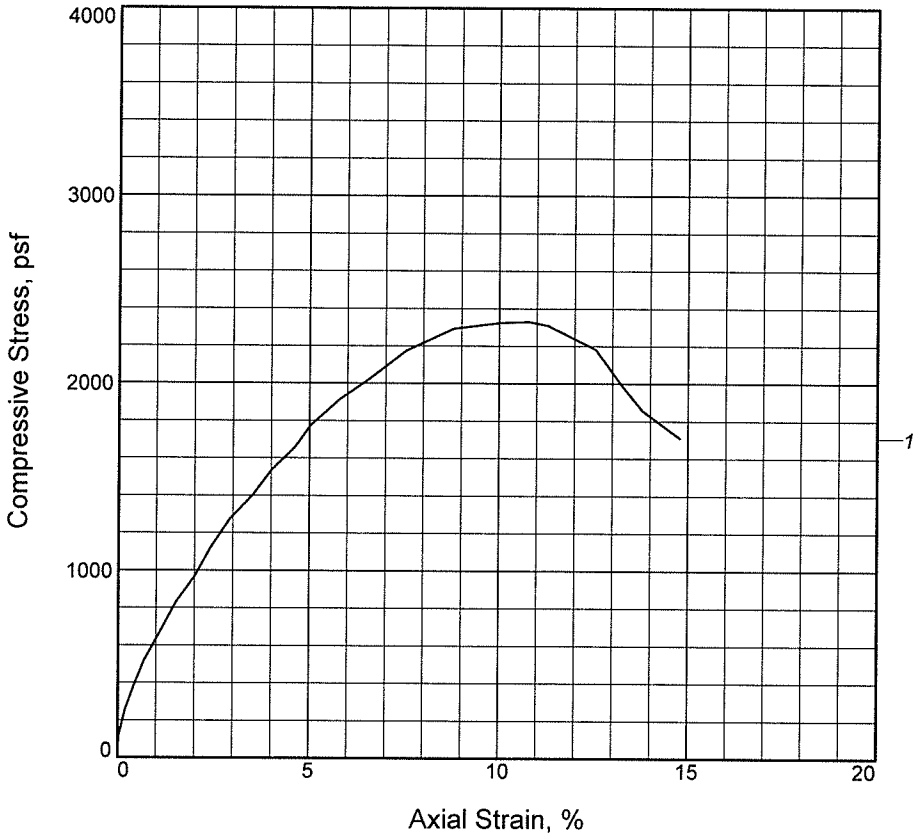
APPENDIX II

Laboratory Results

SUMMARY OF LABORATORY TEST RESULTS

Boring	Depth (Ft)	Sample No./Type	Natural Moisture %	Natural Dry Density (pcf)	Unconfined Compressive Strength (psf)	Atterberg Limits		Soil Type
						Liquid Limit %	Plasticity Index %	
B-2	1.0-3.0	ST-1	25.9	96.2		51	34	CH
B-2	3.0-5.0	ST-2	22.7	99.6	2330			
B-3	1.0-3.0	ST-1	28.7	91.8	1928	63	47	CH
B-5	4.0-6.0	ST-1	24.3	100.9	2749			
B-6	1.0-3.0	ST-1	25.3	91.3	1281	67	40	CH
B-6	3.0-5.0	ST-2	17.3	104.7	5535			
B-7	1.0-3.0	ST-1	26.3	90.2		66	42	CH
B-7	3.0-5.0	ST-2	19.7	108.3				
B-8	1.0-3.0	ST-1	29.6	90.7		74	51	CH
B-9	3.0-5.0	ST-1	27.6	96.0	4213			
B-10	1.0-3.0	ST-1	26.9	94.5				
B-10	3.0-5.0	ST-2	23.6	99.0	3947			
B-11	1.0-3.0	ST-1	24.8	98.6				

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	2330			
Undrained shear strength, psf	1165			
Failure strain, %	10.8			
Strain rate, in./min.	0.050			
Water content, %	22.7			
Wet density, pcf	122.3			
Dry density, pcf	99.6			
Saturation, %	87.8			
Void ratio	0.7046			
Specimen diameter, in.	1.82			
Specimen height, in.	3.99			
Height/diameter ratio	2.19			

Description: Lean to fat clay, trace gravel, reddish brown, moist

LL =	PL =	PI =	**Assumed GS=** 2.72	**Type:** ST

Project No.: 219188G
Date Sampled: 12/20/19
Remarks:

Figure _____

Client: Lakewood Business Park-Lot 35

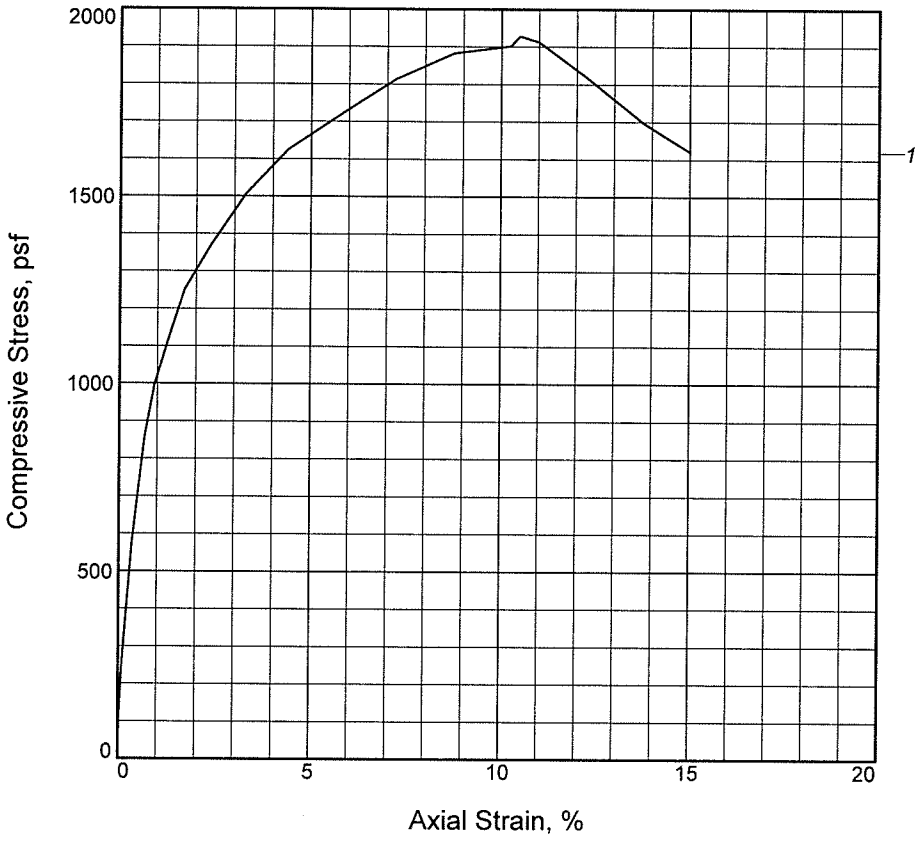
Project: Lakewood Business Park-Lot 35

Source of Sample: B-2 **Depth:** 3
Sample Number: 2

UNCONFINED COMPRESSION TEST
KRUGER TECHNOLOGIES, INC.
LENEXA, KS

Tested By: TMA **Checked By:** OJK

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	1928			
Undrained shear strength, psf	964			
Failure strain, %	10.5			
Strain rate, in./min.	0.050			
Water content, %	28.7			
Wet density, pcf	118.2			
Dry density, pcf	91.8			
Saturation, %	91.9			
Void ratio	0.8489			
Specimen diameter, in.	1.80			
Specimen height, in.	3.99			
Height/diameter ratio	2.22			

Description: Fat clay, stiff, light brown, moist

LL = 63	**PL** = 16	**PI** = 47	**Assumed GS=** 2.72	**Type:** ST

Project No.: 219188G
Date Sampled: 12/20/19
Remarks:

Figure _____

Client: Lakewood Business Park-Lot 35

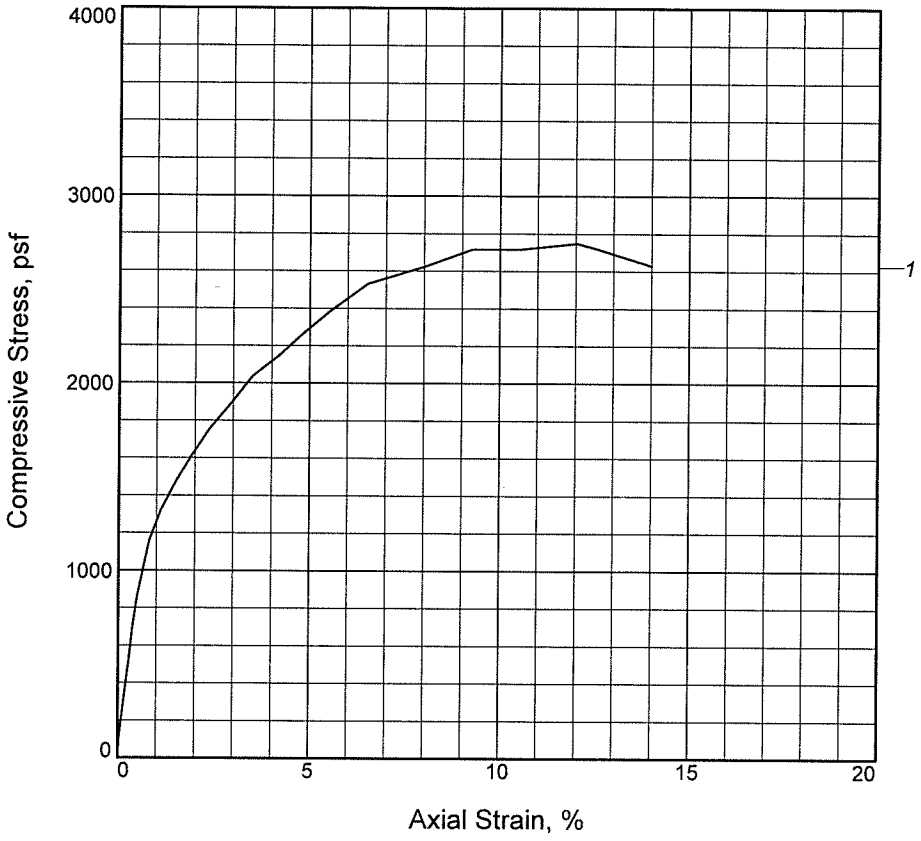
Project: Lakewood Business Park-Lot 35

Source of Sample: B-3 **Depth:** 1
Sample Number: 1

UNCONFINED COMPRESSION TEST
KRUGER TECHNOLOGIES, INC.
LENEXA, KS

Tested By: TMA **Checked By:** OJK

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	2749			
Undrained shear strength, psf	1374			
Failure strain, %	12.0			
Strain rate, in./min.	0.050			
Water content, %	24.3			
Wet density, pcf	125.5			
Dry density, pcf	100.9			
Saturation, %	97.0			
Void ratio	0.6825			
Specimen diameter, in.	1.85			
Specimen height, in.	3.98			
Height/diameter ratio	2.15			

Description: Fat clay, stiff, olive gray, moist

LL =	**PL =**	**PI =**	**Assumed GS=** 2.72	**Type:** ST

Project No.: 219188G
Date Sampled: 12/20/19
Remarks:

Figure _____

Client: Lakewood Business Park-Lot 35

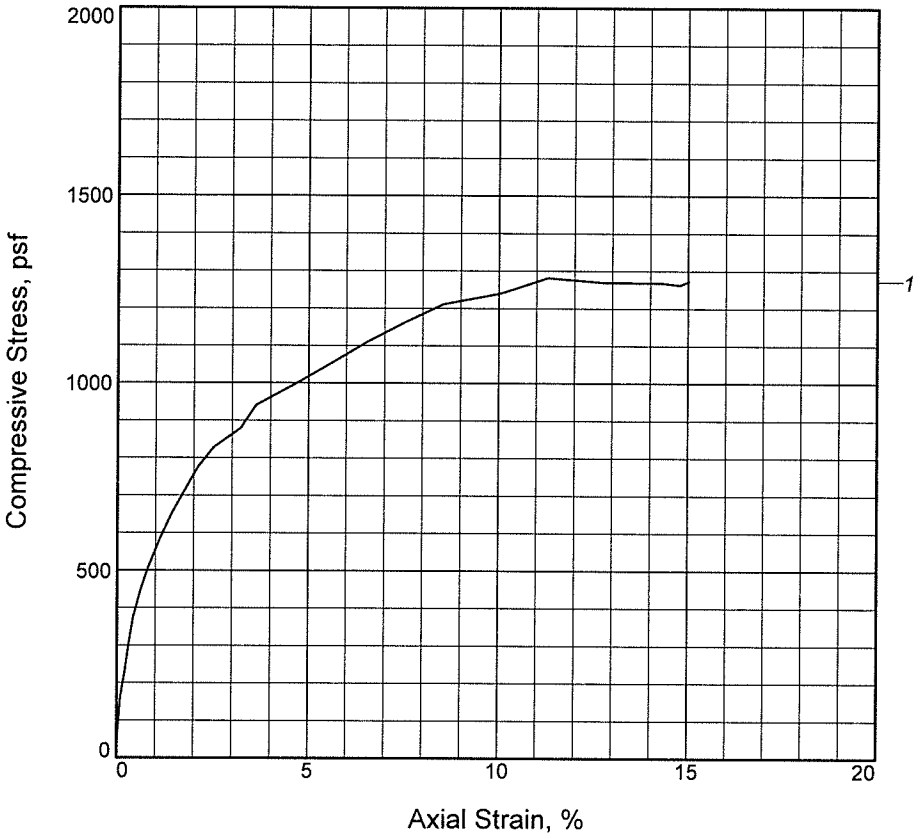
Project: Lakewood Business Park-Lot 35

Source of Sample: B-5 **Depth:** 4
Sample Number: 1

UNCONFINED COMPRESSION TEST
KRUGER TECHNOLOGIES, INC.
LENEXA, KS

Tested By: TMA **Checked By:** OJK

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	1281			
Undrained shear strength, psf	641			
Failure strain, %	11.3			
Strain rate, in./min.	0.050			
Water content, %	25.3			
Wet density, pcf	114.4			
Dry density, pcf	91.3			
Saturation, %	80.1			
Void ratio	0.8602			
Specimen diameter, in.	1.80			
Specimen height, in.	3.97			
Height/diameter ratio	2.21			

Description: Fill, fat clay, trace gravel, stiff, red, moist

LL = 67	**PL** = 27	**PI** = 40	**Assumed GS=** 2.72	**Type:** ST

Project No.: 219188G
Date Sampled: 12/20/19
Remarks:

Figure _____

Client: Lakewood Business Park-Lot 35

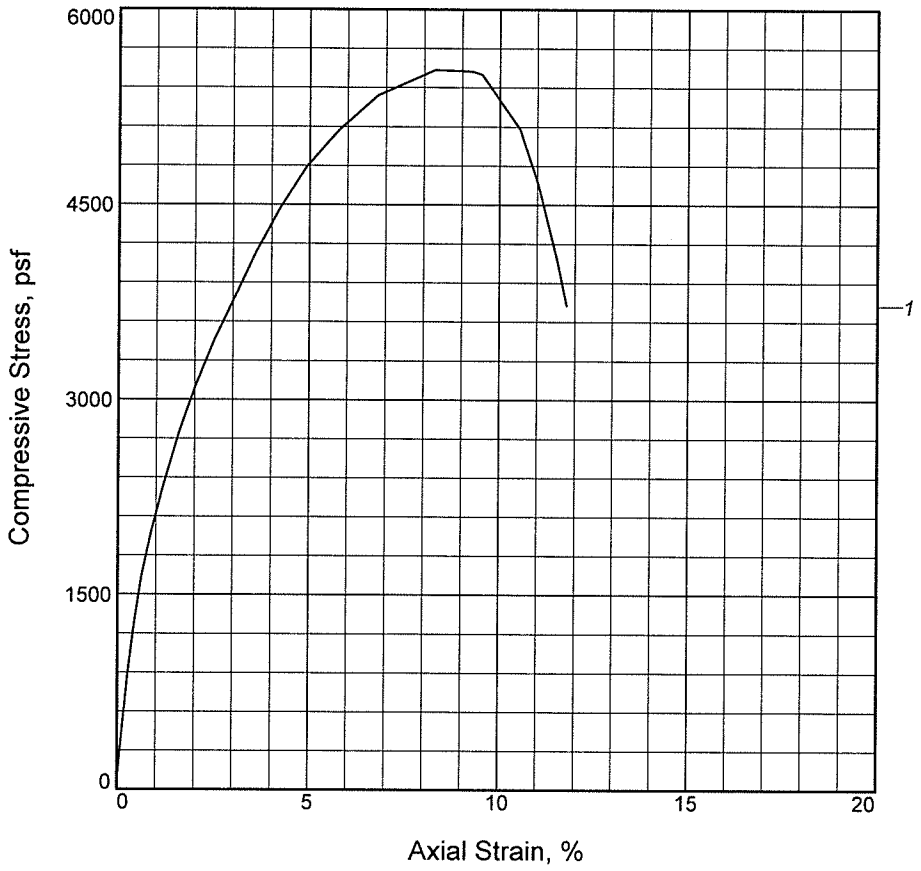
Project: Lakewood Business Park-Lot 35

Source of Sample: B-6 **Depth:** 1
Sample Number: 1

UNCONFINED COMPRESSION TEST
KRUGER TECHNOLOGIES, INC.
LENEXA, KS

Tested By: TMA **Checked By:** OJK

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	5535			
Undrained shear strength, psf	2767			
Failure strain, %	8.3			
Strain rate, in./min.	0.050			
Water content, %	17.3			
Wet density, pcf	122.8			
Dry density, pcf	104.7			
Saturation, %	75.5			
Void ratio	0.6216			
Specimen diameter, in.	1.80			
Specimen height, in.	3.97			
Height/diameter ratio	2.21			

Description: Fill, fat clay with rock fragements, very stiff, reddish brown, moist

LL =	PL =	PI =	Assumed GS= 2.72	Type:

Project No.: 219188G
Date Sampled:
Remarks:

Figure _____

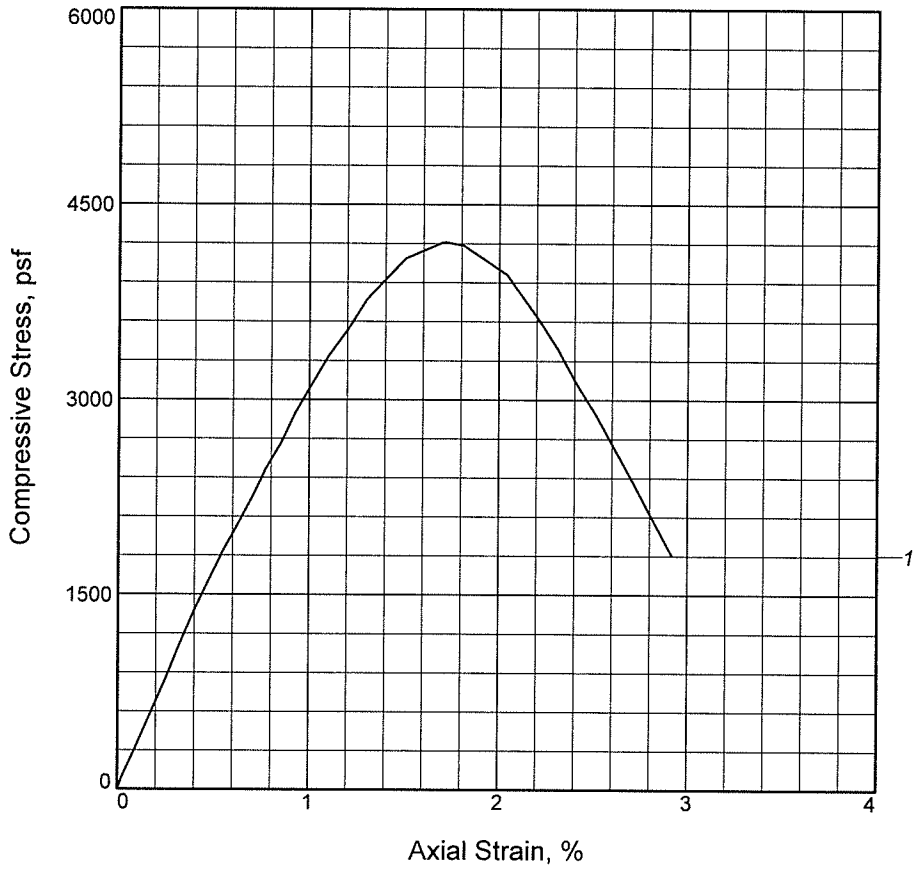
Client: Lakewood Business Park-Lot 35

Project: Lakewood Business Park-Lot 35

Source of Sample: B-6 **Depth:** 3
Sample Number: 2

UNCONFINED COMPRESSION TEST
KRUGER TECHNOLOGIES, INC.
LENEXA, KS

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	4213			
Undrained shear strength, psf	2107			
Failure strain, %	1.7			
Strain rate, in./min.	0.050			
Water content, %	27.6			
Wet density, pcf	122.4			
Dry density, pcf	96.0			
Saturation, %	97.5			
Void ratio	0.7696			
Specimen diameter, in.	1.82			
Specimen height, in.	3.99			
Height/diameter ratio	2.19			

Description: Fat clay, stiff, light gray, moist

LL =	PL =	PI =	Assumed GS= 2.72	Type:

Project No.: 219188G
Date Sampled:
Remarks:

Figure _____

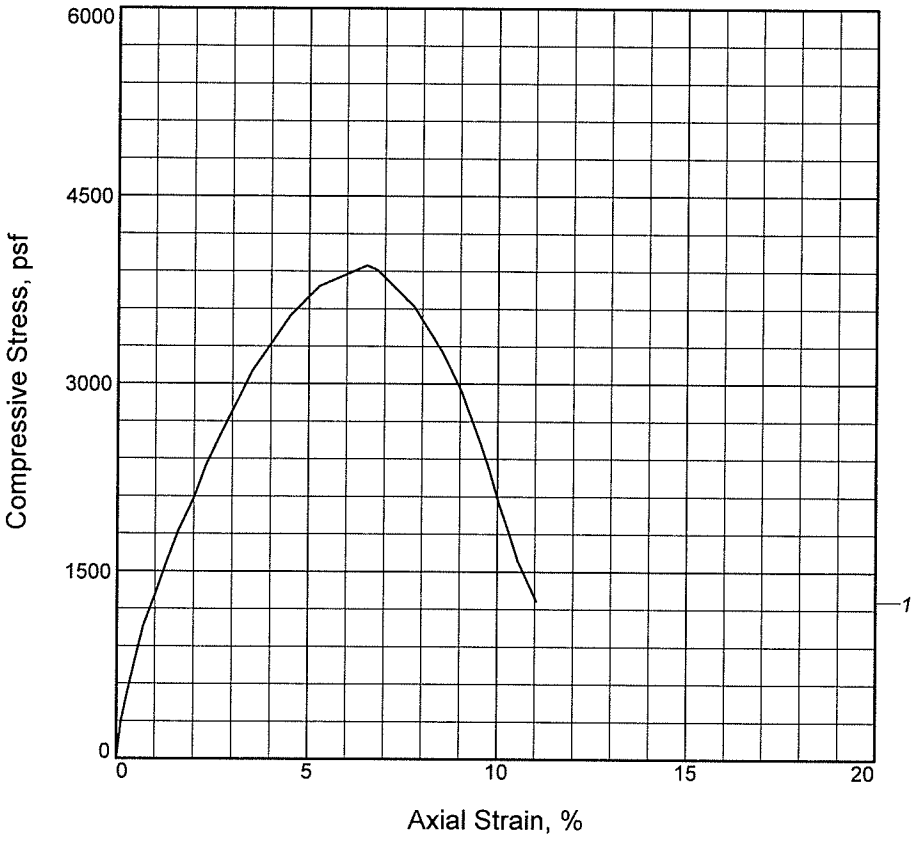
Client: Lakewood Business Park-Lot 35

Project: Lakewood Business Park-Lot 35

Source of Sample: B-9 **Depth:** 3
Sample Number: 1

UNCONFINED COMPRESSION TEST
KRUGER TECHNOLOGIES, INC.
LENEXA, KS

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	3947			
Undrained shear strength, psf	1974			
Failure strain, %	6.5			
Strain rate, in./min.	0.050			
Water content, %	23.6			
Wet density, pcf	122.3			
Dry density, pcf	99.0			
Saturation, %	89.7			
Void ratio	0.7155			
Specimen diameter, in.	1.83			
Specimen height, in.	3.98			
Height/diameter ratio	2.17			

Description: Fat clay, stiff, light gray, moist

LL =	PL =	PI =	**Assumed GS=** 2.72	**Type:** ST

Project No.: 219188G
Date Sampled: 12/20/19
Remarks:

Figure _____

Client: Lakewood Business Park-Lot 35

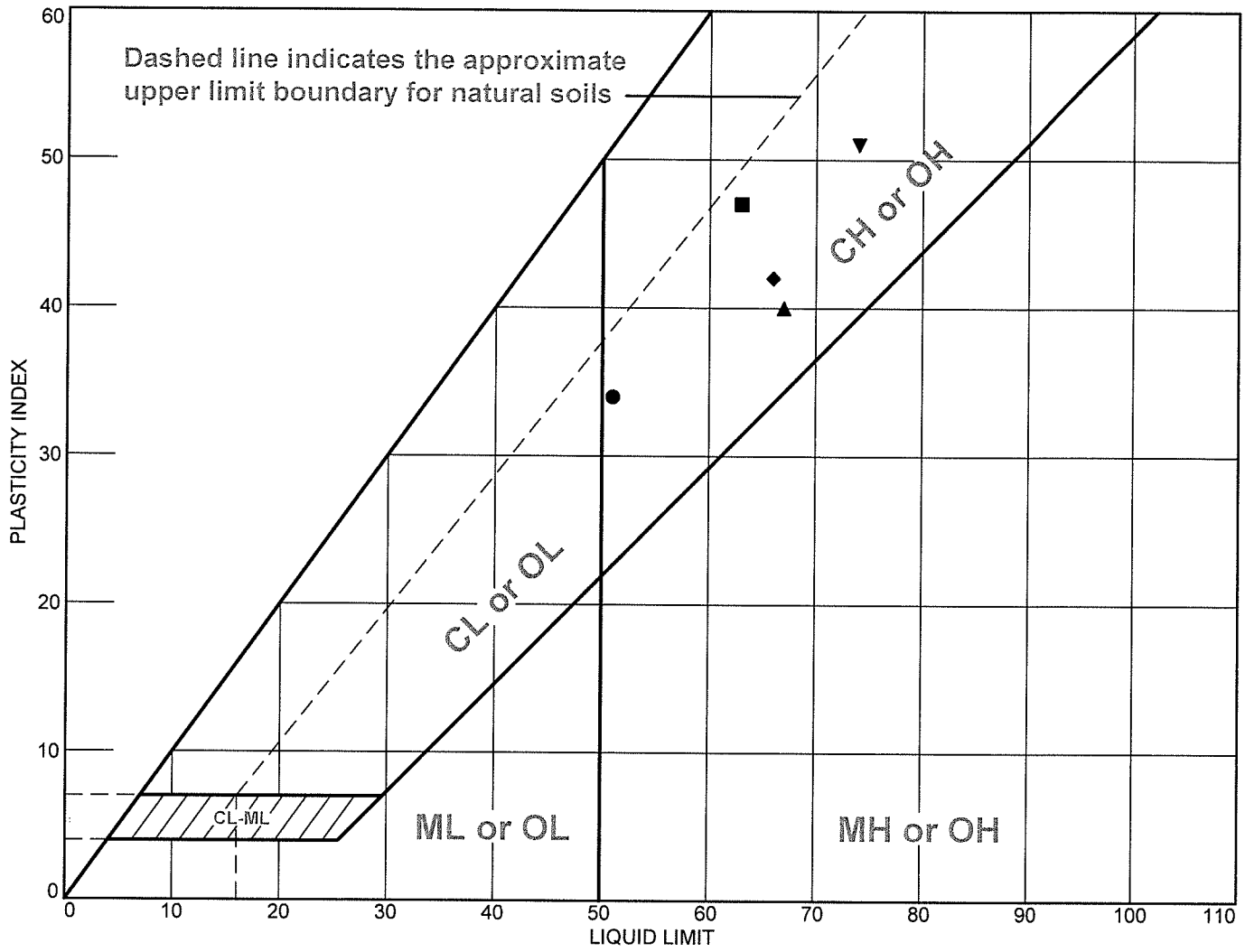
Project: Lakewood Business Park-Lot 35

Source of Sample: 10 **Depth:** 3
Sample Number: 1

UNCONFINED COMPRESSION TEST
KRUGER TECHNOLOGIES, INC.
LENEXA, KS

Tested By: TMA **Checked By:** OJK

LIQUID AND PLASTIC LIMITS TEST REPORT ASTM D 4318



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fill, fat clay, stiff, red, moist	51	17	34			CH
■	Fat clay, stiff, light brown, moist	63	16	47			CH
▲	Fill, fat clay, trace gravel, stiff, red, moist	67	27	40			CH
◆	Fill, fat clay, trace gravel, stiff, red, moist	66	24	42			CH
▼	Fat clay, stiff, light brown, moist	74	23	51			CH

Project No. 219188G **Client:** Lakewood Business Park-Lot 35

Project: Lakewood Business Park-Lot 35

● **Source of Sample:** B-2 **Depth:** 0.5 **Sample Number:** 1

■ **Source of Sample:** B-3 **Depth:** 1 **Sample Number:** 1

▲ **Source of Sample:** B-6 **Depth:** 1 **Sample Number:** 1

◆ **Source of Sample:** B-7 **Depth:** 1 **Sample Number:** 1

▼ **Source of Sample:** B-8 **Depth:** 1 **Sample Number:** 1

KRUGER TECHNOLOGIES, INC.

LENEXA, KS

Remarks:

Figure

GLOSSARY OF GEOTECHNICAL TERMS

ALLUVIUM	Sediments deposited by streams, including riverbeds and floodplains.
ARGILLACEOUS	Rocks composed of or having a notable portion of fine silt and/or clay in their composition.
ATTERBERG LIMITS	Water contents, in percentage of dry weight of soil, that correspond to the boundaries between the states of consistency, i.e. the boundary between the liquid and plastic states (liquid limit) and the boundary between the plastic and solid states (plastic limit).
BEDROCK-IN-PLACE	Continuous rock mass which essentially has not moved from its original depositional position.
CALCAREOUS	Containing calcium carbonate determined by effervescence when tested with dilute hydrochloric acid.
CHANNEL SANDSTONE	Sandstone that has been deposited in a streambed or other channel eroded into the underlying beds.
COLLUVIAL	Rock debris of various sizes loose from in-place bedrock mass, often shifted down gradient in conjunction with soil.
CROSS-BEDDING	Stratification which is inclined to the original horizontal surface upon which the sediment accumulated.
FISSILE BEDDING	Term applied to bedding which consists of laminae less than 2 millimeters in thickness.
FORMATION	A distinctive body of rock that serves as a convenient unit for study and mapping.
FOSSIL DETRITUS	The accumulation of broken, fragmented fossil debris.
FOSSILIFEROUS	Containing organic remains.
GLACIAL ERRATIC	A transported rock fragment different from the bedrock on which it lies, either free or as part of a sediment.
GLACIAL TILL	Nonsorted, nonstratified sediment carried or deposited by a glacier.
GLACIOFLUVIAL	Primarily deposited by streams from glaciers.
GROUP	A lithostratigraphic unit consisting of two or more formations.
JOINT	A fracture in a rock along which no appreciable displacement has occurred.
LIMESTONE	A sedimentary rock composed mostly of calcium carbonate ($CaCO_3$).

LOESS	A homogenous, nonstratified, unindurated deposit consisting predominantly of silt, with subordinate amounts of very fine sand and/or clay.
MICA	A mineral group, consisting of phyllosilicates, with sheetlike structures.
MEMBER	A specially developed part of a varied formation is called a member, if it has considerable geographic extent.
NODULE	A small, irregular, knobby, or rounded rock that is generally harder than the surrounding rock.
PERMEABILITY	The capacity of a material to transmit a fluid.
RECOVERY	The percentage of bedrock core recovered from a core run length.
RELIEF	The difference in elevation between the high and low points of a land surface.
RESIDUAL SOIL	Soil formed in place by the disintegration and decomposition of rocks and the consequent weathering of the mineral materials.
ROCK QUALITY DESIGNATION (RQD)	Refers to percentage of core sample recovered in unbroken lengths of 4 inches or more.
SANDSTONE	Sedimentary rock composed mostly of sand sized particles, usually cemented by calcite, silica, or iron oxide.
SERIES	A time-stratigraphic unit ranked next below a system.
SHALE	A fine-grained plastic sedimentary rock formed by consolidation of clay and mud.
STRATIGRAPHY	Branch of geology that treats the formation, compositions, sequence, and correlation of the stratified rocks as parts of the earth's crust.
SYSTEM	Designates rocks formed during a fundamental chronological unit, a period.
UNCONFORMITY	A surface of erosion or nondeposition, usually the former, which separates younger strata from older rocks.
WEATHERING	The physical and chemical disintegration and decomposition of rocks and minerals.