GEOTECHNICAL ENGINEERING REPORT

Lawrence MSO Field Operations Facility

E 19th Street and O'Connell Road
Lawrence, Kansas
CFS Project No. 19-1196

Prepared For

The City of Lawrence
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Lawrence, Kansas 66044

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October 1, 2020

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Mr. Dan Maginn, AIA
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Subject: Geotechnical Engineering Report
Lawrence MSO Field Operations Facility
E. 19th Street & O'Connell Road
Lawrence, Kansas
Project No. 19-1196

Dear Mr. Maginn:

We have completed the subsurface exploration and geotechnical engineering evaluation for the above referenced project. The purpose of the exploration was to obtain information on the subsurface conditions at the proposed building site and, based on this information to provide geotechnical recommendations for design and construction of the proposed buildings and pavement areas.

In summary, the borings encountered undocumented fill and naturally deposited clay soils underlain by interbedded layers of shale, sandstone and limestone bedrock that continued to the depths explored. The following report summarizes the information obtained from the borings and laboratory test results, describes the subsurface conditions that were observed, and presents an assessment of the subsurface and geologic conditions that will likely have an impact on the construction of the proposed buildings and parking lots.

This report completes our current scope of services for this project. We appreciate the opportunity to be of service to you on this project and are prepared to provide the recommended construction services.

Respectfully submitted,

Cook, Flatt & Strobel Engineers, P.A.

JOHN J. ZEY
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John J. Zey, P.E.
Senior Geotechnical Engineer

Cc: The City of Lawrence, Kansas

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LAWRENCE, KANSAS

Project No. 19-1196
October 1, 2020

INTRODUCTION

CFS Engineers has completed the subsurface exploration and geotechnical engineering evaluation of the site for the proposed Lawrence MSO Field Operations Facility, which will be located northeast of E. 19th Street and O'Connell Road in Lawrence, Kansas. The subsurface exploration and geotechnical engineering services for this project were performed in general accordance with the scope of work in our December 12, 2019 contract for professional services with Dake Wells Architecture.

PROJECT DESCRIPTION

The Architectural Concept Plans that were provided to CFS Engineers indicated that the proposed Lawrence Field Operations Facility will include: the MSO Building Complex, the Central Maintenance Garage, the Solid Waste Building, the Facilities Building, the Forestry and Horticulture Building and the Household Hazardous Waste Building, along with associated parking lots, drives and appurtenant structures.

The MSO Building Complex will consist of three administration buildings that will contain the Traffic, Water, Wastewater, Streets, Stormwater and Inspection Divisions, and a Conditioned Vehicle Storage structure that will be adjacent to the administration buildings. The administration buildings will be two story, steel frame structures, with grade supported lower level floor slabs. These buildings will be stepped down the west side of the site to follow the existing grade and minimize the amount of site grading work that will be required. Based on the building type and anticipated column spacing, maximum foundation loads for the administration buildings are anticipated to be less than 75 kips for isolated interior columns and 3 kips per lineal foot for load bearing walls. The finished floor elevations of these buildings had not been determined at the time our report was prepared. For the purpose of our analysis, we have assumed that the upper level floor elevation of the south building will be set at about elevation 886 ± feet, with the upper level floors of the middle and north buildings at about 876 ± feet and 866 ± feet, respectively. At these proposed floor elevations, it is anticipated that less than 10 feet of cut and/or new fill will be required to develop finished grades in each of the individual administration building areas.

The Conditioned Vehicle Storage structure will be located adjacent to the west side of the Administration Buildings of the MSO Complex. It is our understanding that this building will be a high wall, single story, steel frame structure, with a grade supported floor slab. The overall plan dimensions of this structure will be about 196 by 910 feet. Foundation loads for the Conditioned Vehicle Storage structure were not known at the time our report was prepared. Based on the Architectural Concept Drawings, the maximum column spacing for this structure is anticipated to be on the order of 25 by 98 feet, with maximum interior column loads estimated to be on the order of 250 kips or less. The floor slab of the Conditioned Vehicle Storage structure will be sloped downward from the south to the north end of the structure to approximately match the natural site grade.

It is our understanding that the Central Maintenance Garage Building will be a one story, high wall, steel frame structure, with a grade supported floor slab. An upper level mezzanine will be located in the southwest portion of the building to provide office space. The building will have overall plan dimensions of about 220 by 340 feet, with maximum interior column spacing estimated to be about 25 by 50 feet. Foundation loads for this structure were not known at the time our report was prepared. We have assumed that maximum foundation loads will be less than 125 kips for isolated interior columns and 3 kips per lineal foot for load bearing walls. The finished floor elevation of this building had not been determined at the time our report was prepared. For the purpose of our analysis, we have assumed that the floor elevation of the building will be set at about elevation 886 ± feet. At this floor elevation, up to 6 feet of cut will be required to develop finished grades in the proposed building area.

The Solid Waste Building will be a single story, steel frame structure, with a grade supported floor slab. The west end of the building will contain the administration area, with a large shop in the middle of the building, and maintenance and wash bays at the eastern end. This building will have overall plan dimensions of about 190 by 350 feet, and maximum interior column spacing estimated to be about 25 by 50 feet. Foundation loads for this structure were not known at the time our report was prepared. We have assumed that maximum foundation loads will be less than 125 kips for isolated interior columns and 3 kips per lineal foot for load bearing walls. The finished floor elevation of this building had not been determined at the time our report was prepared. For the purpose of our analysis, we have assumed that the floor elevation of the building will be set at about elevation 886 ± feet. At this floor elevation, up to 6 feet of cut will be required to develop finished grades in the proposed building area.

We understand that the Facilities Building will be a single story, steel frame structure, with a grade supported floor slab. The building will contain offices, conference, storage and warehouse areas, with a large conditioned vehicle storage area and a loading dock next to the warehouse areas. This building will have overall plan dimensions of about 130 by 250 feet, and maximum interior column spacing estimated to be about 25 by 50 feet. Foundation loads for this structure were not known at the time our report was prepared. We have assumed that maximum foundation loads will be less than 125 kips for isolated interior columns and 3 kips per lineal foot for load bearing walls. The finished floor elevation of this building had not been determined at the time our report was prepared. For the purpose of our analysis, we have assumed that the floor elevation of the building will be set at about elevation 845 ± feet. At this floor elevation, less than 2 feet of cut and/or new fill will be required to develop finished grades in the proposed building area.

The Forestry and Horticulture Building will be a single story, steel frame structure, with a grade supported floor slab. The building will contain offices, conference, storage and interior greenhouse areas, with a large conditioned vehicle storage area. This building will have overall plan dimensions of about 140 by 310 feet, and maximum interior column spacing estimated to be about 25 by 50 feet. Foundation loads for this structure were not known at the time our report was prepared. We have assumed that maximum foundation loads will be less than 125 kips for isolated interior columns and 3 kips per lineal foot for load bearing walls. The finished floor elevation of this building had not been determined at the time our report was prepared. For the purpose of our analysis, we have assumed that the floor elevation of the building will be set at about elevation 850 ± feet. At this floor elevation, less than 2 feet of cut and/or new fill will be required to develop finished grades in the proposed building area.

The Household Hazardous Waste Building will be a single story, steel frame structure, with a grade supported floor slab. The building will contain offices, storage areas and a testing lab. This building will have overall plan dimensions of about 65 by 140 feet. Foundation loads for this structure were not known at the time our report was prepared. We have assumed that maximum foundation loads will be less than 50 kips for isolated interior columns and 3 kips per lineal foot for load bearing walls. The finished floor elevation of this building had not been determined at the time our report was prepared. For the purpose of our analysis, we have assumed that the floor elevation of the building will be set at about elevation 892 ± feet. At this floor elevation, up to 3 feet of cut and new fill will be required to develop finished grades in the proposed building area.

In addition, light duty parking lots, drives and other appurtenant structures are planned at the site. The parking lots will provide space for automobiles and other light personnel vehicles, with occasional semi-trailer delivery and garbage trucks.

The scope of the exploration and engineering evaluation for this study, as well as the conclusions and recommendations in this report, were based on our understanding of the project as described above. If pertinent details of the project have changed or otherwise differ from our descriptions, we should be notified and engaged to review the changes and modify our recommendations, if needed.

DRILLING AND SAMPLING PROCEDURES

The field work for this project was performed between August 17 and 27, 2020. A total of 60 exploratory test borings were drilled in the proposed building and pavement areas. Figure 1 in the Appendix shows the approximate locations of the borings with reference to the existing site features. The boring locations were staked by CFS Engineers, prior to the start of the field work. Borings B-14, B-17, B-32 and B-35 were offset from their originally staked locations due to power lines and other site obstructions. The coordinates and ground surface elevations shown on the boring logs were determined by CFS Engineers following completion of the borings.

The borings were performed with a truck-mounted rotary drill rig, using 6-inch diameter flight augers equipped with carbide cutting teeth to advance the boreholes. Representative samples of the overburden soils and weathered bedrock units were obtained at selected intervals using the split-barrel sampling procedure as outlined in ASTM Specification D-1586. The split-barrel sampling procedure utilizes a standard 2-inch O.D.

split-barrel sampler that is driven into the bottom of the borings with an automatic hammer. The number of blows required to advance the sampler the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Resistance Value (N). These "N" values are indicated on the boring logs at their depth of occurrence and provide an indication of the consistency of cohesive and moderately cohesive soils, the relative density of sands and the relative hardness of weathered bedrock units. A higher efficiency is achieved with the automatic hammer compared to the safety hammer, which is operated with a cathead and rope. This higher efficiency has an appreciable effect on the Standard Penetration Resistance Values (N). The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

Boring logs are included in the Appendix of this report and present such data as soil and bedrock descriptions, consistency, relative density and relative hardness evaluations, depths, sampling intervals and observed groundwater conditions. Conditions encountered in each of the borings were monitored and recorded by the drill crew. Field logs were prepared by the drill crew that included visual classification of the materials encountered during drilling, as well as drilling characteristics. Our final boring logs represent the geotechnical engineer's interpretation of the field logs combined with laboratory observation and testing of the samples. Stratification boundaries indicated on the boring logs were based on observations during our field work, an extrapolation of information obtained by examining samples from the borings and comparisons of soils and/or bedrock types with similar engineering characteristics. Locations of these boundaries are approximate, and the transitions between soil and bedrock types may be more gradational in nature rather than clearly defined.

LABORATORY TESTING PROGRAM

Laboratory tests were performed on representative samples of the onsite soil and weathered bedrock units to evaluate pertinent engineering properties of these materials. Laboratory tests were performed in general accordance with ASTM and other applicable standards. The split-barrel samples were tested to determine the moisture contents of the onsite soils and weathered bedrock units. A calibrated hand penetrometer was used to determine the approximate unconfined compressive strength of the cohesive and moderately cohesive soil samples. The hand penetrometer has been correlated with unconfined compression tests, and provides a better estimate of the consistency and strength than visual observation alone. The results of the laboratory tests are indicated on the respective boring logs in the Appendix of this report.

In addition, Atterberg Limits tests were conducted on representative samples of the onsite soils and weathered bedrock. These tests provide information on the plasticity of these materials, which is a basis for classification and for estimating the potential of subgrade materials to change volume with variations in moisture content. The results of the Atterberg Limits tests are also shown on the respective boring logs.

As part of the testing program, the soil samples were classified by a geotechnical engineer using visual and manual procedures outlined in ASTM D-2487 and D-2488. The descriptions of the soils indicated on the boring logs are in accordance with the enclosed General Notes and the Unified Soil Classification System. Estimated group symbols according to the Unified Soil Classification System are shown on the boring logs. A brief description of this classification system is included in the Appendix of this report.

The bedrock units encountered in the borings were described in accordance with the enclosed General Notes for Bedrock on the basis of visual classification of disturbed auger cuttings and drilling characteristics. Core samples may reveal other rock types.

PREVIOUS SUBSURFACE INFORMATION

CFS Engineers reviewed the "Preliminary Geotechnical Report”, prepared by GeoSource in March of 2012 and “Geotechnical Exploration” reports prepared by CFS Engineers in August of 2012 and September of 2014 that were all conducted at the former Farmland Industries site. The subsurface information from these previous site investigations were used in our evaluation of the site geology and subsurface conditions and in the formulation of the geotechnical engineering recommendations that are presented in the following sections of this report.

SITE AND SUBSURFACE CONDITIONS

The proposed Lawrence MSO Field Operations Facility will be located northeast of the intersection of E 19th Street and O’Connell Road in Lawrence, Kansas. The site is bounded on the north by the BNSF Railroad, on the east by the East Hills Business Park, on the west by a residential subdivision and the southern boundary of the site extends to East 19th Street. The site was previously occupied by the former Farmland Industrial Plant, which manufactured fertilizer and other related products for agricultural use. At the time the borings were performed, most of the former structures had been removed, although some water storage tanks, old structure foundations and paved areas remain in some areas. The existing pavements, tanks and old foundations will be removed prior to and/or during the site preparation work for the new buildings and pavements. There were also two existing buildings at the site, the Bag Warehouse and Bulk Warehouse shown on Figure 1 are to remain.

The following presents a general summary of the major strata encountered during our subsurface exploration and includes a discussion of the results of field and laboratory tests conducted. Specific subsurface conditions encountered at the boring locations are presented on the individual boring logs in the Appendix of this report. Figures 2, 3 and 4 in the Appendix show Generalized Subsurface Profiles, based on the information obtained from the borings. The stratification lines shown on the boring logs and profiles represent the approximate boundaries between soil and bedrock types; in-situ, the transition between materials may be more gradational in nature rather than clearly defined.

Most of the borings encountered a thin layer of topsoil or gravel at the surface. The topsoil and gravel layers ranged from about 4 to 14 inches in thickness at the boring locations. Beneath the topsoil and gravel layers, the borings encountered undocumented fill and naturally deposited soils and/or weathered bedrock that continued to the depths explored. Undocumented fill was encountered in about two-thirds of the 60 borings that were performed. The fill was generally composed of moderate to high plasticity clays, with variable amounts of gravel, rock fragments, sand, silt, cinders and miscellaneous construction debris. The thickness of the undocumented fill varied from about 1 to 12 feet at the boring locations. At Borings B-11, B-28 and B-52, the undocumented fill was most likely building backfill. At Boring B-28, the upper 2 feet of the fill section was comprised of crushed limestone aggregate. At Boring B-11, about 2 feet of buried topsoil was encountered below the fill and at Boring B-52 a layer fine to medium grained sand was encountered within the fill section. Standard Penetration Tests performed in the undocumented fill yielded “N” values that ranged from 2 to 24 blows for one foot of penetration. Atterberg Limits performed on selected samples of the fill indicated Liquid Limits in the range of 26 to 58, with Plasticity Indices of 6 to 35.

The topsoil and undocumented fill layers were underlain by naturally deposited glacial till and residual clay soils. These soils were visually described as lean clays, silty lean clays and shaly clays (CL), lean to fat clays (CL/CH), fat clays (CH), and clayey silts (CL/ML). In general, the consistency of the soils varied from medium stiff to very stiff, with moisture contents in the range of 18.4 to 40.8 percent. A layer of very soft, saturated clayey silt (ML) was encountered in Boring B-32 below a depth of 3 feet. Standard Penetration Tests performed in these soils yielded “N” values that ranged from 4 to 20 blows for one foot of penetration. Atterberg Limits performed on selected samples of the naturally deposited soils indicated Liquid Limits in the range of 30 to 82, with Plasticity Indices of 15 to 53.

The composition of the glacial till deposits is often erratic due to the random nature of its deposition. Glacial deposits frequently contain isolated pockets of water bearing sands and gravel, as well as erratics that range from small cobbles to large boulders.

The undocumented fill and overburden soils were underlain by interbedded layers of shale, limestone and sandstone bedrock units that are part of the Pennsylvanian Age Douglas Group. The weathered top of the bedrock was encountered at depths ranging from about 1 to more than 15 feet below the existing ground surface at the boring locations. The uppermost bedrock unit encountered in the borings is thought to be the Haskell Limestone. This limestone unit is quite variable in thickness in the Lawrence area, ranging from a few inches to as much as 10 feet thick in areas where the limestone is unweathered. Some of the borings encountered auger refusal on apparent limestone bedrock that may be an old buried foundation from the former Farmland Facility instead of limestone bedrock that was indicted on the boring logs.

Beneath the Haskell Limestone, the borings encountered the Stranger Formation, which was comprised of shale and sandstone bedrock, with one or more minor coal seams. The upper 5 to 10 feet of the shale bedrock units are typically weathered. The weathered shale was described as soft to moderately hard and yellowish tan to gray brown in color. The unweathered shale is typically hard and gray in color. The Stranger Formation also contains the Tonganoxie Sandstone Member. This sandstone unit was described as a light brown to tan, silty to shaly, fine grained sandstone that is poorly cemented to cemented, with interbedded shale seams. Standard Penetration Tests performed in the shale and sandstone bedrock units yielded "N" values in the range of 28 to 96 blows for 1 to 12 inches of penetration.

GROUNDWATER OBSERVATIONS

Groundwater observations were made both during drilling and upon completion of the borings. Groundwater was encountered in 16 of the 60 borings that were performed for this project. The depth to water in the boreholes ranged from about 2 to 18.5 feet below the existing ground at the time that the exploration work was performed. The observed groundwater levels are shown on the individual boring logs in the Appendix and are also indicated on the Generalized Subsurface Profiles using the usual inverted delta symbol. Most of the borings remained dry and no visible groundwater was observed. The soils and bedrock units encountered in the borings have relatively low permeabilities and observations over an extended period of time through use of cased borings or piezometers would be required to better define current groundwater conditions.

Perched groundwater is commonly observed near the soil mantle/bedrock contact. A perched groundwater condition occurs when surface water percolates downward through the relatively permeable soil deposits to the less permeable bedrock. This sometimes creates a zone of saturated soils above the bedrock that have relatively low strength and high compressibility. Groundwater quantities, where perched conditions exist, are normally small and any dewatering can generally be accomplished with conventional sump pumps and/or area French drains.

The composition of the glacial soils is often erratic due to the random nature of its deposition. Glacial deposits frequently contain isolated pockets of water bearing sands and gravel, as well as cobbles and large boulder size materials. Water bearing lenses within natural glacial deposits are generally limited in extent. Excavations encountering such lenses typically experience a sudden influx of groundwater, due to the high permeability of the materials within the lens. Foundation and other excavations that encounter trapped water within the glacial soils can normally be dewatered using conventional sump pumps.

Fluctuations of groundwater levels can occur due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the borings were performed. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of our evaluation, it is our professional opinion that the proposed project site can be developed for the proposed buildings using conventional grading and foundation construction techniques. We have recommended that lightly loaded buildings be supported on shallow spread footings that bear in stiff, naturally deposited clay soils, controlled structural fill and/or weathered bedrock. We have recommended that buildings with higher foundation loads be supported on drilled pier foundations that are socketed into the bedrock units that underlie the site. Drilled piers and/or rock bearing footings should also be considered for building areas that require more than 15 feet of new fill to reduce the potential for differential settlement.

The primary geotechnical concerns are related to the presence of undocumented fill and expansive clay soils at this site. The existing fill at this site was apparently placed without any testing or supervision. Because of this, there is no way of knowing whether the fill was properly compacted and whether unsuitable materials have been incorporated in the fill section. The borings that were recently performed indicated that the fill was generally comprised of inorganic soils, with some gravel and rock fragments. However, the fill at some of the borings contained a significant amount of organic material, rubble or other unsuitable materials. Also, it is certainly possible that buried foundations, walls, and slabs from the former industrial buildings and other structures may be present beneath portions of the site. Because of this, we have recommended that the undocumented fill be completely removed from the proposed building areas and replaced with controlled structural fill. It is anticipated that much of the undocumented fill can be reused as structural fill, provided that the fill is not obtained from onsite areas that have need designated as contaminated and provided that the fill is moisture conditioned and properly recompacted. Rotating screens or other similar equipment may be required to remove oversized rubble and debris from the undocumented fill so that it can be reused as structural fill.

Another concern, from a geotechnical engineering standpoint, is the presence of soils having moderate to high shrink-swell potential. To reduce the potential for subgrade volume change and floor slab movement, we have recommended that a minimum of 24 inches of select, low volume change material be placed below building floor slabs. Depending on the finished floor elevations of the buildings, it may be necessary to undercut the proposed building areas to allow placement of the recommended select fill layer.

In areas where more than 15 feet of new fill will be required in building areas, it is recommended that the fill be placed as early as possible to allow time for the underlying soils consolidate under the weight of the new fill, thereby reducing the long-term settlement of the completed buildings. With early placement of the fill section and pre-consolidation of the soils, the proposed buildings could be founded on conventional spread footings. The long-term performance of the foundations will depend to a large degree on the thoroughness of the site preparation work and the sequencing of fill placement with the construction of the buildings, pavements and other structures.

As an alternative to removal and replacement of undocumented fill or using drilled pier foundations, buildings with higher foundation loads could be supported on a *Geopier®* reinforced subgrade, which are also as known rammed aggregate piers. Rammed aggregate piers may be a viable option and may potentially provide an economic benefit to this project. Based on our experience, it is anticipated that rammed aggregate piers could be used to increase the net allowable soil bearing pressure at this site while limiting foundation settlement. Additional information for using a *Geopier®* reinforced subgrade is presented in a later section of this report.

Thorough site preparation will be required to correct areas that were disturbed during the previous site grading work and construction activity at the proposed building site. The recommendations presented in the following sections outline procedures for site preparation and/or treatment of the onsite soils that are intended to produce structural fill sections and subgrades that are suitable for support of building foundations, floor slabs and pavements.

These recommendations are based, in part, upon the data obtained from our subsurface exploration and from the previous exploration work that was conducted at the site. The nature and extent of subsurface variations that may exist at the proposed project site will not become evident until construction. If variations appear evident, then the recommendations presented in this report should be evaluated. In the event that any changes in the nature, design, locations or floor elevations of the proposed buildings are planned, the conclusions and recommendations contained in this report will not be considered valid unless the changes are reviewed by the geotechnical engineer and our recommendations modified in writing.

SITE PREPARATION

Initial site preparation for the proposed project should commence with demolition of the existing structures within proposed construction areas. Demolition should include complete removal of all grade supported slabs, sidewalks, pavements and shallow spread footings. All broken concrete, asphalt and other debris from demolition of these structures should be removed from the site. Areas disturbed during demolition of the existing structures should be thoroughly evaluated by the geotechnical engineer prior to placement of structural fill. All disturbed soils should be undercut prior to placement of structural fill.

In areas where vegetation and topsoil are present, the vegetation and topsoil should be removed from planned building and pavement areas. Based on the borings, an average stripping depth of approximately 6 to 14 inches would be anticipated for most areas. The stripping depths required will likely vary and should be adjusted to remove all vegetation and root systems. A representative of CFS Engineers should observe the stripping operations to evaluate that all unsuitable materials have been removed. Soils removed during site stripping operations could be used for final site grading outside the building and pavement areas. Care should be exercised to separate these materials to avoid incorporation of the organic matter in structural fill sections.

Any required tree removal should also be accomplished at this time. Care should be taken to thoroughly remove all root systems from the planned building and pavement areas. Materials disturbed during removal of stumps should be undercut and replaced with structural fill. A zone of desiccated soils may exist in the vicinity of the trees. The desiccated soils have a higher swell potential and should also be undercut and replaced with structural fill.

Relocation of any existing utility lines within the zone of influence of proposed construction areas should also be completed as part of the site preparation. The lines should be relocated to areas outside of the proposed construction. Excavations created during the removal of the existing lines should be cut wide enough to allow for use of heavy construction equipment to recompact the fill. In addition, the base of the excavations should be thoroughly evaluated by a geotechnical engineer or engineering technician prior to placement of fill. All fill should be placed in accordance with the recommendations presented in the Structural Fill section of this report.

Following stripping, it is recommended that the proposed building areas be undercut to a level that will allow placement of a minimum of 24 inches of select, low volume change fill and/or stabilized soil below the building floor slabs and leveling course. Additional undercutting will be required in building areas underlain by undocumented fill. In areas underlain by undocumented fill, the undercut should extend to stable natural soils and/or to weathered bedrock. The undercut should extend a minimum of 10 feet beyond the proposed building lines. The purpose of the select, low volume change fill and/or stabilized section is to surcharge and to limit moisture changes in the underlying moderate to high plasticity clay soils; thereby reducing the potential for volume changes resulting from moisture changes in these soils. For the purposes of this report, low volume change materials are defined as soils having a Liquid Limit of 50 or less.

Following undercutting and prior to placement of structural fill, it is recommended that the exposed grade be scarified to a minimum depth of 8 inches and be moisture conditioned to bring the moisture content of the soils into the range recommended for structural fill. Moisture conditioning is the process of adjusting the moisture content of the scarified materials to a moisture content that is within a range of 0 to 4 percent above the optimum moisture content as determined by the Standard Proctor (ASTM D-698) compaction procedure. Following moisture conditioning, the scarified materials should be recompacted to a minimum of 95 percent of Standard Proctor (ASTM D-698) maximum dry density. Soft or unstable areas that hamper compaction of the subgrade should be undercut and replaced with controlled structural fill. Suitable structural fill should then be placed to design grades as soon as practical after reworking the subgrade to avoid moisture changes in the underlying soils.

Following moisture conditioning, it is recommended that the exposed grade be proofrolled. Proofrolling of the subgrade provides a more stable base for placement of structural fill and aids in identifying soft or disturbed areas. Unsuitable areas identified by the proofrolling operation should be undercut and replaced with structural fill. Proofrolling can be accomplished through use of a fully-loaded, tandem-axle dump truck or similar equipment providing an equivalent subgrade loading.

If soft or unstable conditions are encountered during the proofrolling operation, stabilization of the soils may be required. Clean crushed rock having a particle diameter of 3 to 6 inches could be used to stabilize the subgrade prior to placement of structural fill. After initial undercutting, the large rock would be spread over the unstable subgrade and worked into the soft soils by close tracking with a bulldozer or other suitable construction equipment. Additional rock would be added until the subgrade becomes firm enough to support construction equipment. The use of a geotextile fabric, in conjunction with crushed rock, could also be considered as a means of stabilizing the exposed grade.

Where fill is being placed on a slope steeper than 5 (H) to 1 (V), the existing slope should be benched as fill placement progresses. These benches should be vertically stepped no more than 2 to 3 feet. This procedure would better key the fill into the original slope and will facilitate compaction of the fill.

Subgrade preparation for pavement areas will not need to be as extensive as recommended for the building areas. After the pavement areas have been stripped, it is recommended that they be undercut to a level that will allow placement of a minimum of 9 inches of low volume change fill and/or stabilized soil below the pavement section. Prior to placement of select fill or stabilized soil, the exposed subgrade soils should be thoroughly proofrolled. Any soft or unstable areas observed during proofrolling should be undercut and brought up to planned grade with controlled structural fill.

It is recommended that the site grading work be performed well ahead of the start of construction of the proposed buildings. Major fill sections, (15 feet or more), should be completed at least 3 to 4 months in advance of construction, in order to allow time for consolidation of the underlying soils to occur. Surcharging of critical areas could be considered to reduce the time required for settlement to occur and also to reduce net settlement of the completed structure. If surcharging of the site is performed, the surcharge should have a minimum height of 5 feet above design grades and extend a minimum of 10 feet beyond the outside perimeter of the structure. Instrumentation should be installed to monitor the amount and rate of settlement.

CLIMATIC CONDITIONS

Weather conditions will influence the site preparation required. In spring and late fall, following periods of rainfall, the moisture content of the near surface soils may be significantly above the optimum moisture content. Additionally, it is common to encounter wet, unstable soils upon removal of the site pavements or flatwork as a result of moisture becoming trapped beneath relatively impervious pavements. Perched ground water may also develop above dense cemented soils or impervious bedrock units (such as shale) saturating near surface materials. These conditions could seriously impede grading by causing an unstable subgrade condition. Typical remedial measures include aerating the wet subgrade, removal of the wet materials and replacing them with dry materials or treating the wet material with fly ash.

If site grading commences during summer months, the moisture contents of the onsite clay soils may be abnormally low, which can significantly increase the swell potential of these materials. Typically, discing and moisture conditioning of the exposed subgrade materials to the moisture content criteria outlined in the Structural Fill section will reduce this swell potential of the dry materials. As an alternative, the dry materials could be undercut and replaced with structural fill.

EXCAVATIONS

Excavations will be required for site grading, foundations and utilities. Based on the borings, it is anticipated that most of the excavations for this project will be in clay soils and/or in weathered shale or sandstone bedrock above the water table. The onsite clay soils and the soft, highly weathered shale and poorly cemented sandstone with a Standard Penetration Resistance (N) value of less than 25 blows per foot can generally be excavated with conventional heavy equipment such as backhoes, loaders, etc. Excavations that extend into the underlying harder, less weathered shale, cemented sandstone or limestone bedrock units will be more difficult and will probably require the use of rock teeth, pneumatic breakers, or some other method of hard rock removal to complete the excavations. It is anticipated that the cemented sandstone and the unweathered shale bedrock units can be excavated by ripping with a single tooth ripper on a large bulldozer

Temporary construction slopes should be designed in strict compliance with the most recent governing regulations. The naturally deposited clay soils encountered in the borings would generally be classified as Type B soils, under Part 1926 of the OSHA regulations pertaining to open excavations. For these soils, it is recommended that temporary construction slopes be no steeper than 1(H) to 1(V). Construction slopes should be closely observed for signs of mass movement: tension cracks near the crest, bulging at the toe, etc. If potential stability problems are observed, the geotechnical engineer should be immediately contacted. The responsibility for excavation safety and stability of temporary construction slopes should lie solely with the contractor.

STRUCTURAL FILL

All structural fill should consist of approved materials, free of organic matter and debris. Fill placed within 24 inches of the building floor slabs and leveling course gravel should consist of a lower plasticity cohesive soil having a Liquid Limit less than 50. Higher plasticity soils could be used as structural fill in the lower portion of deep fill sections in the building areas and/or as structural fill in pavement areas, where more movement can be tolerated. Fill should be placed in lifts having a maximum loose lift thickness of 9 inches. All fill should be compacted to a minimum of 95 percent of the material's maximum dry density as determined by ASTM D-698 (standard Proctor compaction). The moisture content of the fill at time of compaction should be within a range of 0 to 4 percent above optimum moisture content as defined by the standard Proctor compaction procedure. Moisture contents should be maintained within this range until completion of building floor slabs. Periodic sprinkling may be required to maintain the subgrade soils within the recommended moisture content range.

Based on information obtained from the borings, there appears to be a limited quantity of onsite soil that will meet the criteria for the select, low volume change zone that has been recommended below building floor slabs. During the site preparation work, suitable low plasticity materials encountered during site grading work should be stockpiled. It is not known whether there is a sufficient volume of low volume change material available from onsite sources to complete the required select fill section. In addition, double handling of this material may be required and should be anticipated.

The onsite weathered shale and sandstone could be ripped and pulverized for use to construct structural fill sections. It is anticipated that the sandstone and shale units can be broken down sufficiently with heavy compaction equipment to develop satisfactory fill sections for support of structures and pavements. The sandstone and shale should be pulverized into pieces having a maximum size of no more than 2 inches. We anticipate that significant amounts of water will have to be added to the shale and sandstone to increase moisture contents of these materials to levels necessary to achieve the required degree of compaction. Larger size fragments of limestone and cemented sandstone, excavated from the cut areas, should be placed outside planned structure and pavement areas, so that these materials do not hamper excavation of foundations and utilities.

In lieu of importing low plasticity material for use as low plasticity fill beneath the building floor slab, the onsite moderate to high plasticity clay soils could be stabilized with either hydrated lime or Portland cement. The amount of lime and cement that is typically required to achieve the desired reduction in shrink-swell potential is on the order of 5 percent and 8 percent for lime and cement, respectively (dry weight basis). Laboratory tests will be necessary to determine the actual amount required. Recommendations and typical specifications for this method of stabilization could be provided if desired.

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.

Drainage should be carefully controlled to prevent migration of surface water into excavations. It is recommended that the contractor develop excavation plans for all new structures. As a minimum, the plans should indicate: the proposed method of excavation, the expected length of time that the excavation will be open, excavation side slopes, locations of stockpiles, as well as any temporary bracing, sheeting and/or dewatering measures that will be used. The plans should be submitted to the owner and engineer well in advance of the start of construction for review and comments regarding the impact of the planned construction on the existing structures and facility operations.

FOUNDATIONS

The types of foundation that would be suitable for support of the proposed buildings are dependent on the final location, configuration and finished floor levels of the buildings, as well as the magnitude of the foundation loads, sensitivity to differential settlement, thickness of new fill required for site development and other factors.

Buildings that have light foundation loads, (less than 100 kips), and a relatively minor amount of site grading can generally be supported on shallow spread footing that are founded in stiff, natural clay soils, controlled structural fill and/or weathered bedrock. Buildings that have higher foundation loads and/or more than 15 feet of new fill should be supported on drilled pier foundation and/or rock bearing footings to reduce the potential for adverse differential settlement of these structures. Recommendations for design and construction of shallow spread footings, as well as drilled pier foundations and rock bearing footings are presented in the following sections of our report.

SPREAD FOOTINGS

With the recommended site preparation procedures, it is anticipated that most of the proposed buildings can be supported on conventional spread footings that are founded in stiff, natural clay soils and/or in controlled structural fill and/or in weathered bedrock. The exception may be the MSO Building Complex, where there is a significant amount of grade change across the planned building areas and where column loads are expected to be much higher for the Conditioned Vehicle Storage portion of the structure. Support of footings on or above existing undocumented fill is not recommended and could result in adverse differential movement of buildings and other structures. Footings founded in the recommended materials may be proportioned for a maximum allowable bearing pressure of 2,500 psf. The recommended bearing pressure includes a safety factor of at least 3 against a bearing failure.

Formed continuous footings should have a minimum width of 16 inches and isolated spread footings should have a minimum width of 30 inches. Lightly loaded trench footings (bearing pressure less than 1,500 psf) should have a minimum width of 12 inches. All exterior footings and footings founded in the unheated portions of the structures should be supported a minimum of 3 feet below final exterior grade to provide protection against frost penetration. Where possible, footings should be earth-formed, i.e., poured to lines of neat excavation.

In areas where footings are supported on controlled structural fill, it is recommended that the structural fill extend a minimum of 5 feet beyond the footing lines and to a depth of at least one footing width or 3 feet, whichever is greater, below footing bearing elevation.

In areas where spread footings are supported on bedrock, it is recommended that these footings have a minimum width of 24 inches and be adequately reinforced to bridge over joint cracks or other discontinuities that may occur in the bedrock bearing surface. Rock bearing footings should extend a minimum of 2 feet below final exterior grade for minimal frost protection. The contractor should include a contingency to cover the cost of removing highly weathered and/or unsuitable rock.

Any uplift loads acting on the footings can be resisted by the effective dead weight of the footings plus the weight of the soil above the foundation element. For design purposes, soil backfill above the footings should be assumed to have a unit weight of 110 pcf.

Lateral loads acting on shallow footings resulting from short term dynamic loads, such as wind, may be resisted by the passive resistance of the native soils and by friction acting at the base of the foundation. The lateral load capacity of the structure foundation can be determined using an allowable equivalent fluid unit weight of 280 pounds per cubic foot (pcf) for calculating the passive lateral earth pressure acting on the edge of footings. The allowable equivalent fluid pressure includes a factor of safety of about 1.5. The recommended passive pressure parameter is applicable for earth-formed foundations and should be determined from final grade to the bottom of the foundation; however, the passive resistance provided in the upper 3 feet of the profile should be ignored, as this is the zone subject to moisture changes and frost penetration. For sliding friction, an allowable friction coefficient of 0.28 could be assigned to the base of the foundation. The recommended sliding friction value includes a factor of safety of about 1.5.

The base of all footing excavations should be clean and dry and free of all water and loose materials, prior to placement of concrete. Concrete should be placed as soon as possible after excavating so that excessive drying of bearing materials does not occur. Should the bearing materials become excessively wet or dry, the affected material should be removed prior to placement of concrete.

It is recommended that all footing excavations be observed and evaluated by the geotechnical engineer or his representative immediately prior to placement of foundation concrete. Unsuitable areas identified at this time should be corrected. Corrective procedures would be dependent upon conditions encountered and may include deepening of foundation elements, or undercutting of unsuitable materials and replacement with lean concrete or flowable fill.

Long-term structural settlement for shallow spread footings designed and constructed as outlined above should be minor; i.e., 1 inch or less. Differential structural settlement due to foundation loading of up to ¾ inch should be anticipated across individual structures, since some footings will be founded on undisturbed soils or controlled structural fill while other footings are founded in weathered bedrock.

DRILLED PIER FOUNDATIONS

For structures that will have foundation loads that are greater than 100 kips and/or for buildings that require more than 15 feet of new fill for site development, we recommend that drilled pier foundations be used. If drilled pier foundations are used, it is recommended that all drilled piers be socketed a minimum of one shaft diameter or 5 feet, whichever is greater, into approved bedrock. Greater penetration into the bedrock may be required at some locations depending on the extent and severity of the weathering of the bedrock. In areas where the suitable bedrock is encountered at relatively shallow depths, rock bearing spread footings may be used in combination with drilled piers. Rock bearing footings should extend at least 2 feet into approved bedrock. Drilled piers that are founded in approved bedrock may be designed and proportioned using a net allowable end bearing pressure of 25,000 psf. Spread footings that are founded in approved bedrock may be designed and proportioned using a net allowable end bearing pressure of 12,000 psf. The recommended bearing pressures include a safety factor of at least 3 against a bearing failure.

Any uplift loads acting on the foundations can be resisted by the effective dead weight of the piers plus an allowable side friction value of 250 psf for the portion of the shaft in stiff, natural clay soils and/or structural fill and 1,500 psf for the portion of the shaft in weathered bedrock. Side friction should be neglected in the upper 5 feet of the shaft.

All drilled piers should have a minimum shaft diameter of 30-inches in order to accommodate dewatering equipment and/or to permit access for proper hand cleaning and observation of the base. To minimize disturbance to the bearing surfaces caused by ponding of water, it is recommended that concrete be placed the same day that the drilled shafts are completed. The bottom of the pier excavation should be clean and dry and free of all water and loose materials prior to placement of the reinforcing steel and concrete. Concrete placement should be continuous from the bottom to the top elevation of the shaft. For dry excavations, concrete may be placed by the free fall method, provided that it can be directed down the center of the shaft without hitting the reinforcing steel or sides of the excavation. Wet excavated shafts will require that the concrete either be pumped from the bottom up or placed using a tremie. The tremie pipe should be clean and have a sufficient inside diameter for use with the specific concrete mix, but not less than 10 inches. The discharge end of the tremie should allow free radial flow of the concrete and be immersed at least 10 feet in concrete and maintain a positive pressure differential during placement to prevent water or spoil intrusion.

We anticipate that the piers can be installed with conventional drilling equipment. Rock augers and/or core barrels will probably be required to penetrate the bedrock and obtain the recommended rock socket.

It is recommended that all drilled pier and/or rock bearing footing excavations be observed and evaluated by the geotechnical engineer or his representative immediately prior to placement of foundation concrete. Unsuitable areas identified at this time should be corrected. Corrective procedures would be dependent upon conditions encountered and will most probably include deepening of the footings or drilled piers. The suitability of the bedrock will be evaluated by visual observation at the base of the excavation.

Long-term structural settlement of drilled piers and rock bearing footings designed and constructed as outlined above should be minor; i.e., ½ inch or less.

GEOPIER FOUNDATION SYSTEM

As an alternate to removal of the undocumented fill and supporting the proposed buildings on drilled pier foundations, shallow foundation support bearing on a *Geopier*® reinforced subgrade (rammed aggregate piers) appears to be a viable option for this project and may potentially provide an economic benefit to this project. Based on our experience with rammed aggregate piers, we anticipate that rammed aggregate pier reinforced subgrade could be designed to increase the net allowable soil bearing pressure at this site while limiting foundation settlement.

Rammed aggregate piers have been used for a number of years to support structures as an alternative to deep foundations and/or to the removal and replacement of unsuitable fill and soft soils. The system allows the use of conventional spread footings and floor slabs and reliably controls settlement to within design tolerances.

The *Geopier* soil reinforcement system consists of highly densified aggregate piers. The rammed aggregate pier elements are installed by drilling 30-inch diameter holes, and ramming thin lifts of well-graded aggregate within the holes to form very stiff, high-density aggregate piers. The drilled holes are typically spaced about 5 feet apart and would extend through the undocumented fill and naturally deposited soils to the underlying bedrock. Following drilling of the Geopier hole, well graded aggregate is compacted in 12-inch loose lifts in the drill hole. Ramming takes place with a high-energy beveled tamper that both densifies the aggregate and forces the aggregate laterally into the sidewalls of the hole. This action increases the lateral stress in surrounding soils, thereby further stiffening the reinforced composite soil mass. The result of *Geopier* installation is a significant strengthening and stiffening of subsurface soils that then support floor slabs and high-capacity footings.

Geopier designs are based on a two-layer settlement analysis as described by Lawton et al. (1994) and in the *Geopier* Reference Manual. Settlements within the “upper zone” (zone of soil that is reinforced with *Geopier* elements) are computed using a weighted modulus method that accounts for the stiffness of the *Geopier* elements, the stiffness of the matrix soil, and the area coverage of *Geopier* elements below supported footings. Settlements within the “lower zone” (zone of soils beneath the upper zone which receives lower intensity footing stresses) are computed using conventional geotechnical settlement methods.

The *Geopier* soil reinforcement system is a proprietary design-build system and *Geopier*/Tensar should be contacted to provide engineering analyses and project specific design information for this project. The local contact in our area is Mr. Aaron Gaul, PE, with *Geopier*/Tensar at (816) 421-4334. *Geopier*/Tensar will provide information regarding the final system design, including the allowable foundation bearing pressure, *Geopier* shaft lengths and spacing, anticipated floor slab thickness, and a cost to support the proposed buildings.

If the *Geopier* system is selected, Quality Assurance testing should be performed during installation, including documentation of the soil conditions encountered, the shaft lengths, amount of aggregate used, verification of the modulus test readings, and tests on the compacted aggregate lifts. CFS Engineers would be pleased to provide this service.

SEISMIC HAZARDS DETERMINATION

Earthquake hazard evaluation is a complex task. Seismic sources must be identified and characterized, path effects evaluated (i.e., selection of appropriate attenuation relationships), and ground motions must be completed. Finally, an analysis of the motion with respect to the proposed construction must be made. In addition to the multi-discipline nature of this process, there is substantial parameter and modeling uncertainty associated with each of the steps. Typically, code-based approaches are used for seismic hazard analyses. Our seismic hazard evaluation follows the IBC 2015 procedures.

Seismic Soil Classification. Table 1 presents the spectral acceleration parameters and accelerations from the United States Geological Survey (USGS) Design Maps website for this project location. From the USGS data in Table 1, the site geotechnical conditions are best characterized by a “Class D” seismic design category according to the 2015 International Building Code.

Table 1 - Seismic Parameters

Seismic Parameters	Value
S_s	0.096g
S_1	0.065g
S_{MS}	0.153g
S_{M1}	0.157g
S_{DS}	0.102g
S_{D1}	0.105g

BUILDING FLOOR SLABS

The recommendations outlined in the Site Preparation and Structural Fill sections of this report are intended to produce subgrades that are suitable for support of building floor slabs. These recommendations include undercutting of the building areas to allow placement of a minimum of 24 inches of select, low volume change material or stabilized soil below the floor slab and leveling course. The select fill and/or stabilized soil layer below the floor slabs has been recommended to reduce the potential for subgrade volume change and floor slab movement. The recommended low plasticity structural fill thickness is in addition to any granular section that will be required below the floor slabs. The moisture content of the subgrade soils should be maintained within the recommended range until floor slabs are completed. Depending upon weather conditions, periodic wetting may be required.

Immediately prior to construction of the building floor slabs, it is recommended that the exposed subgrade be evaluated to determine whether moisture contents are within the recommended range and to identify areas disturbed by construction operations. Unsuitable or disturbed areas should be reworked prior to placement of the granular leveling course and construction of the floor slab.

Details regarding proper backfill of utility trenches and stem walls below building floor slab areas should be planned. Suitable low to moderate plasticity clays or granular material should be used as backfill materials. The backfill should be placed and compacted in accordance with the recommendations previously discussed.

Where possible, floor slabs should be designed and constructed as free slabs to allow for some differential movement between the walls, column points and floor slabs. It is recommended that a granular leveling course, having a minimum thickness of 4 inches, be used below normally loaded building floor slabs supported on soil subgrades. The granular section provides a capillary moisture break and acts as a leveling course. Clean crushed limestone gravel, with a nominal size of ½ to ¾ inch, would be recommended for the leveling course. A modulus of subgrade reaction of 100 pci may be used to design floor slabs constructed on an untreated clay subgrade.

In areas where floor loads are greater than 200 psf, it is recommended that a minimum of 12 inches of crushed limestone aggregate be placed below the building floor slab. The crushed rock may be substituted for a portion of 24 inches of select, low volume change fill layer recommended for normally loaded floor slabs. The purpose of the crushed rock is to provide an improved subgrade for the more heavily loaded floor slab areas. In addition, the crushed rock will also provide a good working surface during construction. It is recommended that the crushed rock have a gradation similar to KDOT AB-1. The crushed rock should be placed in 6-inch lifts and compacted to a minimum of 95 percent of the material's maximum dry density as determined by ASTM D 698. The moisture content of the crushed rock should be between plus and minus 3 percent of the optimum moisture content at the time of compaction. A modulus of subgrade reaction of 250 pci may be used to design floor slabs constructed on 12 inches of compacted crushed limestone aggregate.

Subsurface moisture and moisture vapor naturally migrate upward through the soil and, where the soil is covered by a building or pavement, this moisture will collect. To reduce the impact of this subsurface moisture and the potential impact of future induced moisture (such as landscape irrigation or precipitation), the current industry standard is to place a vapor retarder below the compacted crushed limestone layer. This membrane typically consists of visquene or polyvinyl plastic sheeting, having a thickness of at least 10 mils. It should be noted that although vapor barrier systems are currently the industry standard, this system may not be completely effective in preventing floor slab moisture problems. These systems typically will not necessarily assure that floor slab moisture transmission rates will meet floor covering manufacturer standards and that indoor humidity levels be appropriate to inhibit mold growth. The design and construction of such systems are totally dependent on the proposed use and design of the proposed building and all elements of building design and function should be considered in the slab-on-grade floor design. Building design and construction may have a greater role in perceived moisture problems since sealed buildings/rooms or inadequate ventilation may produce excessive moisture in a building and affect indoor air quality. Coordinate the City Environmental Consultant and Architect for vapor barrier recommendations due to site soil contamination issues.

Special precautions must be taken during the placement and curing of all concrete slabs. Excessive slump (high water-cement ratio) of the concrete and/or improper curing procedures used during either hot or cold weather conditions could lead to excessive shrinkage, cracking or curling of the slabs. High water-cement ratio and/or improper curing also greatly increase the water vapor permeability of the concrete. We recommend that all concrete placement and curing operations be performed in accordance with the American Concrete Institute (ACI) Manual.

The above procedures should reduce the potential for subgrade moisture variations and consequently reduce floor slab movement and cracking. However, these procedures will not completely eliminate the volume change characteristics of the natural clay soils and, because of the presence of unaltered clay soils that extend to much greater depths, some long-term volume change may occur along with some floor slab movement and cracking. Isolation of floor slabs from walls and columns should be considered to accommodate minor differential movement of floor slabs. If it is desired to further minimize the potential for subgrade volume change, the use of a greater thickness of low volume change material beneath the floor slab should be considered.

LATERAL EARTH PRESSURES

Based on our experience with soils similar to those encountered at the site, all basement walls and other below grade walls that are subject to an unbalanced lateral earth pressure should be designed using an equivalent fluid pressure of 55 pounds per cubic foot. This lateral earth pressure assumes an "at rest" stress distribution condition; i.e., no wall rotation is allowed. For retaining walls that are not fixed at the top and able to rotate, the equivalent fluid pressure may be reduced to 45 pounds per cubic foot. Neither of the previous load distributions includes a factor of safety or take into account the influence of any hydrostatic loading of the wall. Also, the stress distributions do not include the influence of any foundations, pavements or other surcharge loads located in or adjacent to wall backfill.

To prevent hydrostatic loading on the walls and/or seepage into the lower building levels, it is recommended that a perforated drain line be installed at the base of all below grade walls. The drain line should be sloped to provide positive gravity drainage outside the building areas or should extend to a sump where water can be collected and removed. The drain line should be wrapped with filter fabric to prevent intrusion of fines. The drain line should be backfilled with free draining granular material extending vertically above the drain line to within 2 feet of final grade. The remaining portion of the excavation should be backfilled with cohesive soils to minimize the infiltration of surface water. The granular section behind the wall should have a minimum width of 2 feet and should be encapsulated in the suitable filter fabric to minimize intrusion of fines. The use of a prefabricated drainage blanket on the foundation wall could also be considered to prevent hydrostatic loading. Drainage blankets should be installed in accordance with the manufacturer's recommendations.

PAVEMENTS

Parking and drive area subgrades should be prepared in accordance with the recommendations given in the Site Preparation and Structural Fill sections of this report. The site soils and structural fill sections constructed with these soils are considered poor subgrade materials for support of pavements. Based on the soil types encountered at this site and previous experience with materials of this type, a design CBR value of 3 is recommended for design of pavement sections. For this design value, a full-depth asphaltic concrete section having a minimum thickness of 6 inches is recommended for automobile parking areas and 7.5 inches is recommended for the access drives that are not used by heavy trucks. For asphaltic concrete pavements, a minimum surface course thickness of 2 inches is normally recommended. Tables 2 and 3 show recommended options for Light Duty Pavements for Parking Lots and Heavy Duty Pavements used by heavy truck traffic.

Table 2: Light Duty Pavement Thicknesses (Parking Lots)

Asphalt Pavement	**Option 1**	**Option 2**	**Option 3**
Surface Mix - KDOT HMA Commercial Grade 12.5A	2.0”	2.0”	
Base Mix - KDOT HMA Commercial Grade 12.5A	4.0”	4.0”	
Cement or Lime Stabilized Subgrade	9.0”	no	
Crushed Rock Base KDOT AB-1	no	9.0”	
Concrete Pavement			5.0”
Clean Rock ASTM C-33, No. 57			4.0”
Crushed Rock or Stabilized Subgrade			5.0”

Table 3: Heavy Duty Pavement Thicknesses (Truck Drives)

Asphalt Pavement	**Option 1**	**Option 2**	**Option 3**
Surface Mix - KDOT HMA Commercial Grade 12.5A	2.0”	2.0”	
Base Mix - KDOT HMA Commercial Grade 12.5A	8.0”	8.0”	
Cement or Lime Stabilized Subgrade	9.0”	no	
Crushed Rock Base KDOT AB-1	no	9.0”	
Concrete Pavement			8.0”
Clean Rock ASTM C-33, No. 57			4.0”
Crushed Rock or Stabilized Subgrade			5.0”

Portland cement concrete pavements are recommended for approach slabs, dock aprons, truck drives and parking areas, trash dumpster pads and other areas where heavy wheel loads will be concentrated. These areas should have concrete pavements with a minimum thickness of 8 inches as indicated in Table 3.

In lieu of importing crushed rock for use below pavements and building floor slabs, it should be feasible to recycle the existing onsite concrete obtained during the demolition of pavements and old foundations of the former structures. Any reinforcing steel in the concrete should be removed and the old concrete could then be crushed and screened to produce recycled concrete with either an AB-1 gradation for use below pavements or an ASTM C-33, No. 57 gradation for use as a leveling course below building floor slabs. This should reduce both the cost of disposal of the old concrete and the cost of importing crushed rock to the site.

We recommend that the pavement subgrades be evaluated by proofrolling immediately prior to paving. The moisture content and density of the top 8 inches of the subgrade should be checked within two days prior to commencement of actual paving operations. If the material is not in compliance with the required ranges of moisture or density, the subgrade should then be moisture conditioned and recompacted. If any significant event, such as precipitation, occurs after the evaluation, the subgrade should be reviewed by qualified personnel immediately prior to placing the pavement. The subgrade should be in its finished form at the time of the final review.

Proper drainage is a key to the long-term performance of any pavement section. It is recommended that all pavements be properly sloped to provide rapid runoff of surface water. Water should not be allowed to pond on or adjacent to pavements, since this could result in saturation of the subgrade and cause premature deterioration of pavements. Pavements in Kansas are normally subjected to 30 or more freeze-thaw cycles in any given year. Because of this, periodic maintenance of all of the pavements is essential to long term performance and should be anticipated. This should include sealing of all cracks and joints and by maintaining proper surface drainage next to paved areas.

PLANS AND SPECIFICATIONS REVIEW

It is recommended that the geotechnical engineer be provided the opportunity to review the plans and specifications so that comments can be made regarding the interpretation and implementation of our geotechnical engineering recommendations in the design and specifications. In the event that CFS Engineers is not given the opportunity to perform this recommended review, we will assume no responsibility for misinterpretation of our geotechnical engineering recommendations.

CONSTRUCTION OBSERVATION AND TESTING

To effectively achieve the intent of the geotechnical recommendations presented in this report and to maintain continuity from design through construction, CFS Engineers should be retained to provide observation and testing services during earthwork and foundation construction phases of the project. This will provide the geotechnical engineer with the opportunity to observe the subsurface conditions encountered during construction, evaluate the applicability of the geotechnical recommendations presented in our report as they relate to the soil and bedrock conditions encountered, and to provide follow up recommendations if conditions differ from those described in our report.

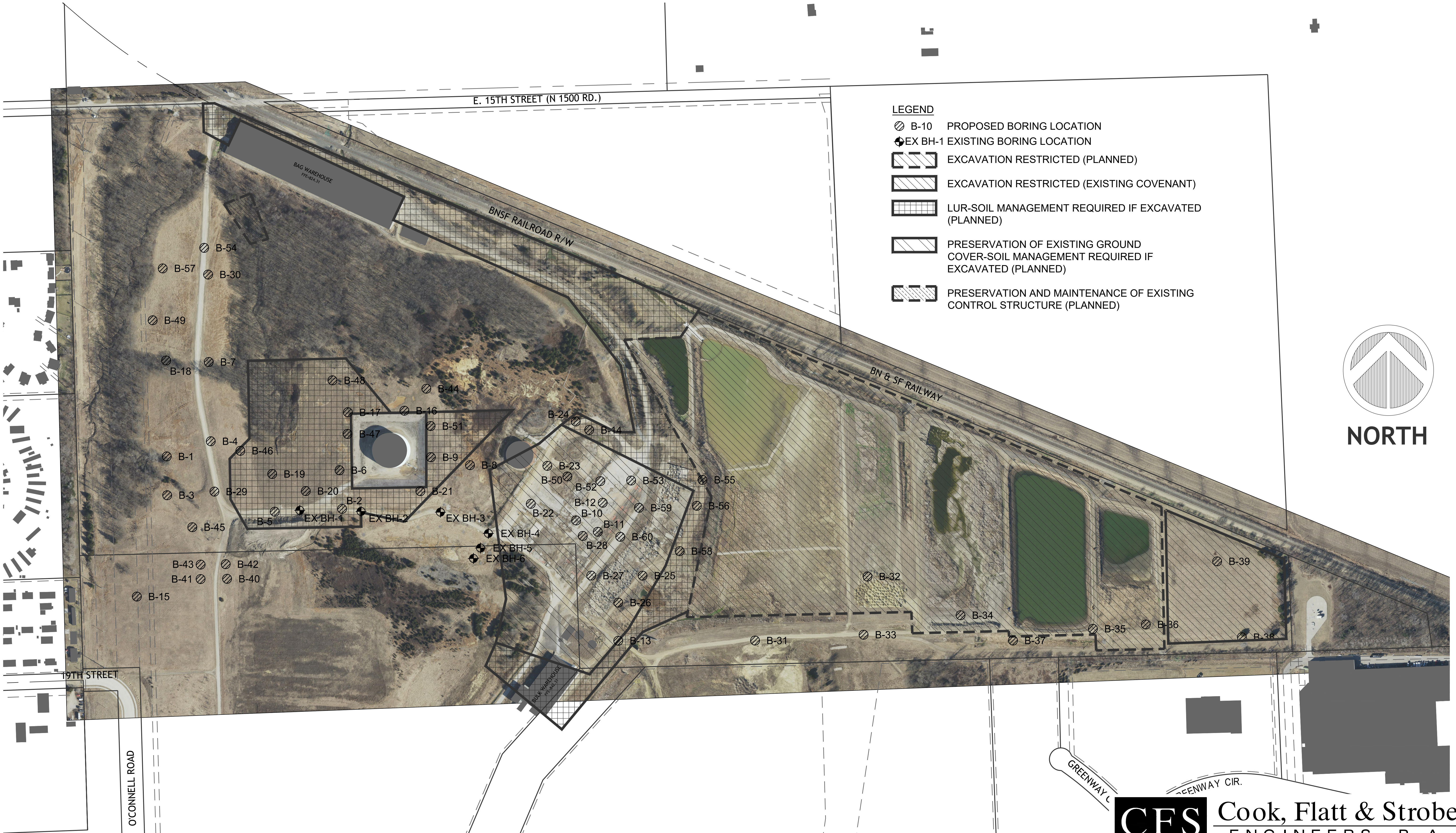
LIMITATIONS

The analysis and recommendations submitted in this report are based in part upon the subsurface information obtained from the exploration points performed at the indicated locations and our present knowledge of the proposed construction as outlined in the Project Description. Subsurface conditions may vary between the exploration points and across the site and our report does not reflect any variations which may occur. The nature and extent of such variations may not become evident until construction. If subsurface conditions are encountered during construction that differ from those described in this report, CFS Engineers should be notified immediately so that a review may be made and any supplemental recommendations provided. If the scope of the proposed construction, including the proposed loads, floor slab elevations or locations, changes from that described in this report, our recommendations should also be reviewed and the recommendations modified accordingly.

This report has been prepared in accordance with the generally accepted geotechnical engineering practice as it exists in the area at the time of our study. No warranty is expressed or implied. The recommendations provided in this report are based on the assumption that an adequate program of observation and testing will be conducted during the construction phase in order to evaluate compliance with our recommendations. Our scope of services did not include any environmental assessment or exploration for the presence of hazardous or toxic materials in the soil, surface water, groundwater or air, on, below or around this site.

This report has been prepared for the exclusive use of our client for specific application to the project discussed. Any party other than the client who wishes to use this report shall notify CFS Engineers in writing of such intended use. Additional work may be required before an updated report can be issued. Non-compliance with any of these requirements will release CFS Engineers from any liability resulting from the use of this report by any unauthorized party and client agrees to defend, indemnify and hold harmless CFS Engineers from any claim or liability associated with such unauthorized or non-compliance.

APPENDIX

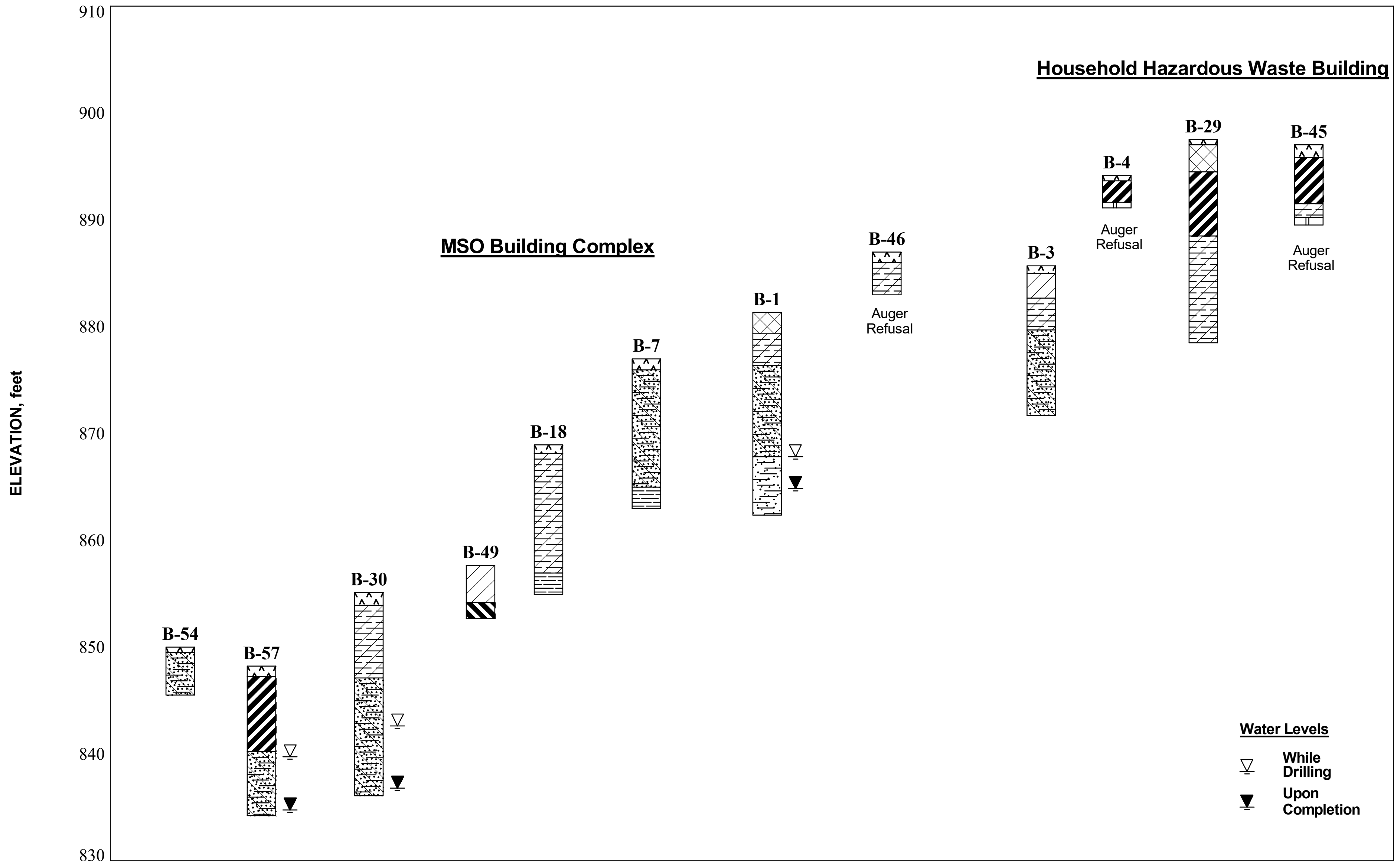


Boring Location Sketch for MSO Facility

CFS Cook, Flatt & Strobel
ENGINEERS, P.A.

2121 Moodie Road
Lawrence, Kansas 66046
785.856.9600

Figure 1



GENERALIZED SUBSURFACE PROFILE

FIGURE 2

MSO Field Operations Facility
19th Street & O'Connell Road
Lawrence, Kansas

Approved By: JJZ

Project No.: 19-1196

LEGEND

- Topsoil
- Gravel
- Fill
- Silty Clay
- Fat Clay
- Lean Clay
- Weathered Shale
- Weathered Sandstone
- Lean to Fat Clay
- Shale
- Sandstone
- Limestone

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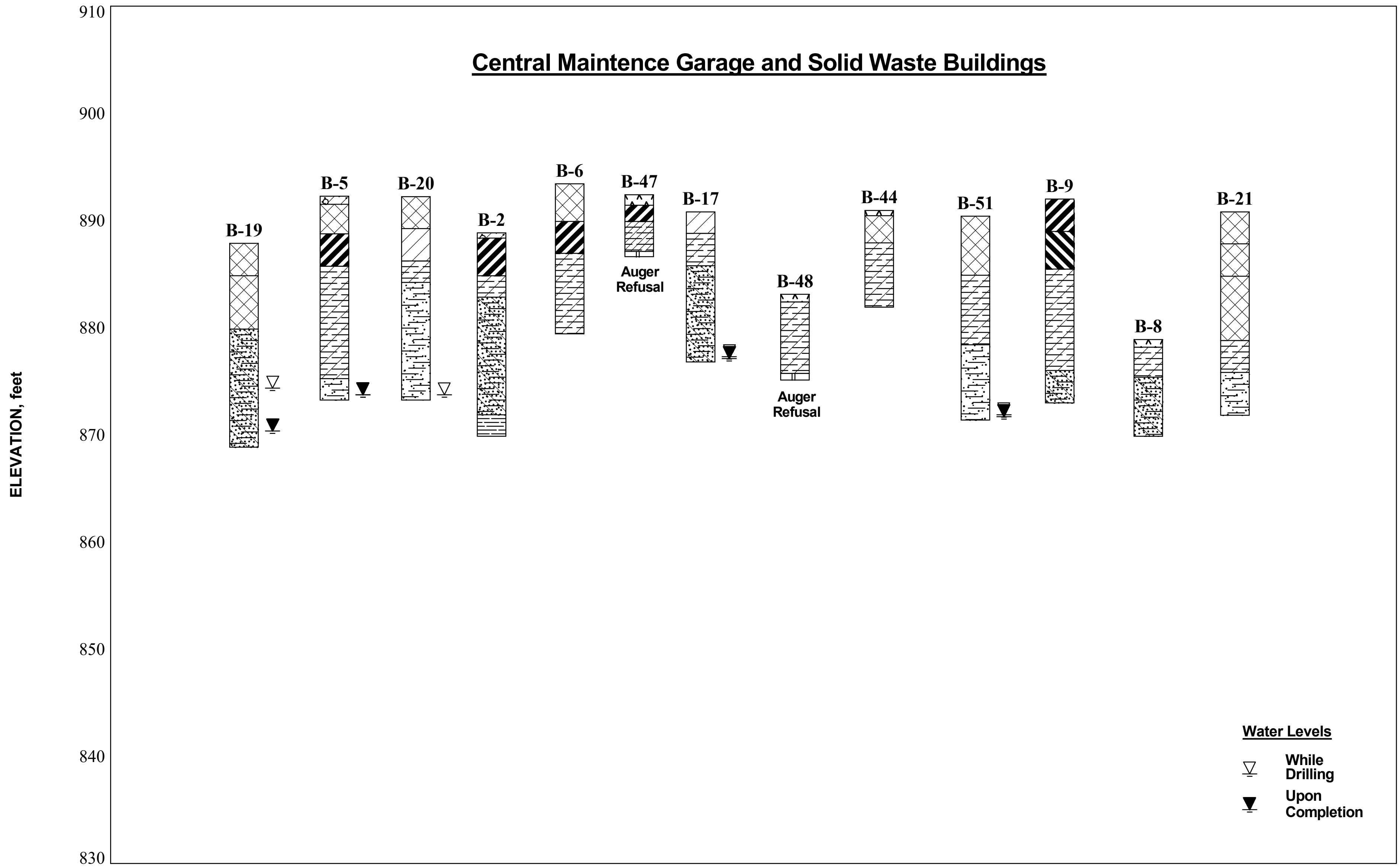
Central Maintence Garage and Solid Waste Buildings



GENERALIZED SUBSURFACE PROFILE

FIGURE 3

MSO Field Operations Facility
19th Street & O'Connell Road
Lawrence, Kansas

Approved By: JJZ

Project No.: 19-1196

LEGEND

Topsoil	Silty Clay	Weathered Shale	Shale
Gravel	Fat Clay	Weathered Sandstone	Sandstone
Fill	Lean Clay	Lean to Fat Clay	Limestone

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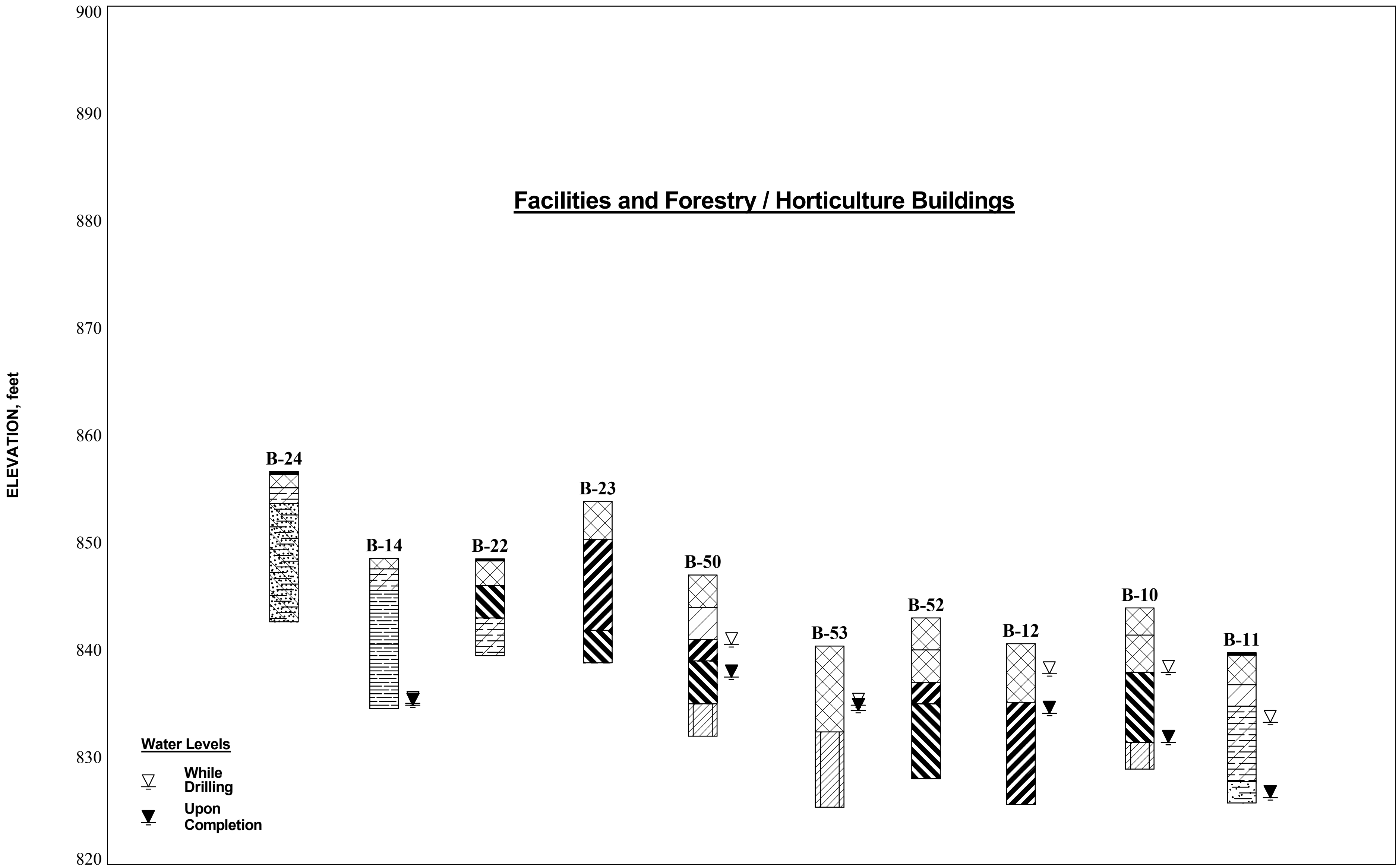

GENERALIZED SUBSURFACE PROFILE

FIGURE 4

MSO Field Operations Facility

19th Street & O'Connell Road
Lawrence, Kansas

Approved By: JJZ

Project No.: 19-1196

LEGEND

- ▨ Topsoil
- ▨ Gravel
- ☒ Fill
- ▤ Shaly Clay
- ▨ Fat Clay
- ▨ Lean Clay
- ▨ Weathered Shale
- ▨ Weathered Sandstone
- ▨ Lean to Fat Clay
- ▤ Shale
- ▨ Sandstone
- ▦ Limestone

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BOREHOLE INFORMATION **Page 1 of 2**

STATION OFFSET

NORTHING **237,857.0** EASTING **2,107,498.0**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-1

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

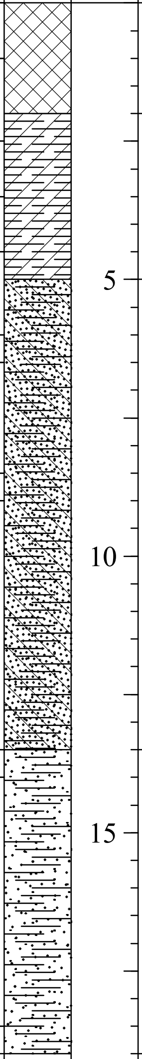
OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	SS	15	55/10"	*4500		16.9	CL
	PA						
2	SS	9	69/9"			18.0	
	PA						
3	SS	4	50/4"			15.0	
	PA						
4	SS	3	50/3"			14.8	
	PA						
5	SS	2	50/2"			23.6	
	PA						
6	SS	2	50/2"			16.5	

** compressive strength in psi * Calibrated Penetrometer

GRAPHIC LOG

DEPTH, Feet.



MATERIAL DESCRIPTION

Surface Elevation: **881.3**

FILL, lean clay, very stiff, reddish brown to yellowish brown, with sandstone fragments

2.0 879.3

****SANDY SHALE**, weathered, mod. hard, yellowish tan to gray brown

5.0 876.3

****SHALY SANDSTONE**, weathered, poorly cemented, fine grained, light brown to tan

13.5 ▽ 867.8

****SANDSTONE**, weathered, poorly cemented to cemented, fine grained, light brown ▼

19.0 862.3

BOTTOM OF BORING

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **13.5 feet W.D.**

▼ **16.5 feet A.B.**

Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-26-20**		
Boring Completed	**8-26-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 2 of 2**

STATION OFFSET

NORTHING **237,857.0** EASTING **2,107,498.0**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-1

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION
										ATTERBERG LIMITS Sample 1, Depth 1-2.5 feet LL 26 PL 20 PI 6 **Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **13.5 feet W.D.**

▼ **16.5 feet A.B.**

Backfilled @ Completion

CFS ENGINEERS cfse.com

Boring Started	**8-26-20**		
Boring Completed	**8-26-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 2**

STATION OFFSET

NORTHING **237,625.6** EASTING **2,108,272.6**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-2

PROJECT NAME **MSO Field Operations Facility**

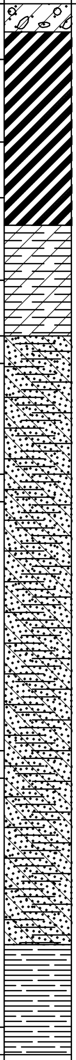
SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	SS	12	16	*8500		20.9	CH
	PA						
2	SS	18	61			19.9	
	PA						
3	SS	3	50/3"			14.0	
	PA						
4	SS	3	50/3"			14.4	
	PA						
5	SS	2	50/2"			14.7	
	PA						
6	SS	3	50/3"			16.5	

** compressive strength in psi * Calibrated Penetrometer

GRAPHIC LOG



MATERIAL DESCRIPTION

Surface Elevation: 888.9

DEPTH, Feet.		
0.5	**Crushed Limestone Gravel (6")**	888.4
4.0	**FAT CLAY**, very stiff, reddish brown	884.9
6.0	****SHALE**, weathered, sandy, mod. hard to hard, yellowish tan	882.9
17.0	****SHALY SANDSTONE**, weathered, poorly cemented, fine grained, light brown	871.9
19.0	****SANDY SHALE**, hard, gray brown	869.9
	BOTTOM OF BORING	

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS
cfse.com

Boring Started	**8-25-20**		
Boring Completed	**8-25-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 2 of 2**

STATION OFFSET

NORTHING **237,625.6** EASTING **2,108,272.6**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-2

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION
										**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS
cfse.com

Boring Started	**8-25-20**		
Boring Completed	**8-25-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,685.8** EASTING **2,107,499.8**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-3

PROJECT NAME **MSO Field Operations Facility**

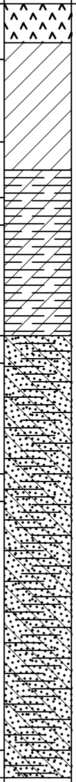
SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	SS	12	16	*7500		18.4	CL
	PA						
2	SS	6	50/6"			15.3	
	PA						
3	SS	4	50/4"			14.7	
	PA						
4	SS	2	50/2"			14.1	
	PA						
5	SS	3	50/3"			18.1	

** compressive strength in psi * Calibrated Penetrometer

GRAPHIC LOG



MATERIAL DESCRIPTION

Surface Elevation: **885.7**

DEPTH, Feet.	MATERIAL DESCRIPTION	Elevation
0.7	**Topsoil**, dark brown (8")	885.0
3.0	**LEAN CLAY**, very stiff, brown to yellowish tan, with shale fragments (Possible Fill)	882.7
6.0	****SHALE**, weathered, mod. hard to hard, yellowish tan to rusty brown	879.7
14.0	****SHALY SANDSTONE**, weathered, poorly cemented, fine grained, light brown to tan	871.7

BOTTOM OF BORING

ATTERBERG LIMITS
Sample 1, Depth 1-2.5 feet

LL	PL	PI
41	19	22

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS cfse.com ENGINEERS

Boring Started	**8-27-20**
Boring Completed	**8-27-20**
Drill Rig **RC-550**	Driller **LC**
Approved By: **JJZ**	Project No. **19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,924.2** EASTING **2,107,692.4**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-4

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION	
										Surface Elevation:	**893.7**
	PA							^^^	0.5	**Topsoil**, dark brown (6")	893.2
1	SS	8	16	*6500		19.9	CH	▨	2.5	**<u>FAT CLAY</u>**, very stiff, reddish brown	891.2
	PA							▦	3.0	**<u>**LIMESTONE</u>**, hard	890.7

AUGER REFUSAL @ 3.0 FEET

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

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ENGINEERS

Boring Started	**8-25-20**		
Boring Completed	**8-25-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 2**

LOG OF BORING NO. B-5

STATION OFFSET

NORTHING **237,613.2** EASTING **2,107,975.3**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	SS	10	16	*8500		22.1	CH
	PA						
2	SS	12	12	*5500		24.3	CH
	PA						
3	SS	14	30	*8500		29.8	
	PA						
4	SS	3	50/3"			14.1	
	PA						
5	SS	2	50/2"			16.2	
	PA						
6	SS	2	50/2"			22.0	

** compressive strength in psi * Calibrated Penetrometer

MATERIAL DESCRIPTION

Surface Elevation: 892.2

DEPTH, Feet.	MATERIAL DESCRIPTION	
0.8	**Gravel and Clay Mixture (8")**	891.5
3.5	**FILL**, fat clay, very stiff, reddish brown and brown mixed	888.7
6.5	**FAT CLAY**, very stiff, brown	885.7
17.0	****SHALE**, weathered, mod. hard to hard, yellowish gray brown to gray brown	875.2
19.0	****SANDSTONE**, weathered, poorly cemented, fine grained, light brown, moist ▼	873.2
	BOTTOM OF BORING	

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **18.5 feet W.D.**

▼ **18.5 feet A.B.**

Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-17-20**		
Boring Completed	**8-17-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 2 of 2**

STATION OFFSET

NORTHING **237,613.2** EASTING **2,107,975.3**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-5

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION

ATTERBERG LIMITS

Sample 1, Depth 1-2.5 feet

LL	PL	PI
58	23	35

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS
∇ **18.5 feet W.D.**
▼ **18.5 feet A.B.**
Backfilled @ Completion

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ENGINEERS

Boring Started	**8-17-20**		
Boring Completed	**8-17-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,796.2** EASTING **2,108,261.5**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-6

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	SS	14	13	*6500		22.9	CL
	PA						
2	SS	11	20	*8000		22.6	CH
	PA						
3	SS	14	28	9000		25.1	
	PA						
4	SS	4	50/4"			11.9	
	PA						
5	SS	2	50/2"			13.9	

** compressive strength in psi * Calibrated Penetrometer

MATERIAL DESCRIPTION

Surface Elevation: **893.4**

FILL, lean clay, very stiff, dark brown and light brown mixed, trace fine sand

3.5 889.9

FAT CLAY, very stiff, reddish brown

6.5 886.9

****SHALE**, weathered, soft to mod. hard, yellowish tan to gray brown

14.0 879.4

BOTTOM OF BORING

ATTERBERG LIMITS
Sample 2, Depth 3.5-5 feet

LL	PL	PI
59	25	34

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

DEPTH, Feet.: 5, 10

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS cfse.com ENGINEERS

Boring Started	**8-17-20**		
Boring Completed	**8-17-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **238,274.4** EASTING **2,107,683.5**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-7

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION **Surface Elevation: 877.0**
	PA									**Topsoil**, dark brown (12") 1.0 876.0
1	SS	6	50/6"			13.3				****SHALY SANDSTONE**, weathered, poorly cemented, fine grained, light brown to tan
	PA									
2	SS	3	50/3"			12.9				
	PA								5	
3	SS	3	50/3"			16.7				
	PA									
4	SS	3	50/3"			17.4				
	PA								10	12.0 865.0 ****SHALE**, hard, light gray
5	SS	3	50/3"			10.2				14.0 863.0

BOTTOM OF BORING

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

$\underline{\nabla}$ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

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Boring Started	**8-25-20**		
Boring Completed	**8-25-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,818.6** EASTING **2,108,838.0**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

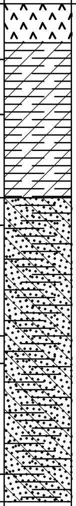
LOG OF BORING NO. B-8

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.		MATERIAL DESCRIPTION	
											Surface Elevation:	**878.7**
	PA									0.7	**Topsoil**, dark brown (8")	878.0
1	SS	10	86/10"			12.6					****SHALE**, weathered, mod. hard to hard, yellowish tan	
	PA									3.5		875.2
2	SS	4	50/4"			13.0					****SHALY SANDSTONE**, weathered, poorly cemented, fine grained, light brown to tan	
	PA								5			
3	SS	3	50/3"			15.2						
	PA											
4	SS	3	50/3"			15.8				9.0		869.7



BOTTOM OF BORING

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

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Boring Started	**8-21-20**
Boring Completed	**8-21-20**
Drill Rig **RC-550**	Driller **LC**
Approved By: **JJZ**	Project No. **19-1196**

BOREHOLE INFORMATION **Page 1 of 2**

STATION OFFSET

NORTHING **237,853.6** EASTING **2,108,665.2**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-9

PROJECT NAME **MSO Field Operations Facility**

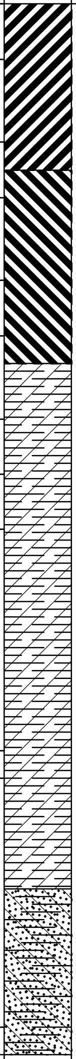
SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	SS	12	6	*2500		25.4	CH
	PA						
2	SS	14	19	*5000		23.1	CL CH
	PA						
3	SS	18	19	*7500		17.4	
	PA						
4	SS	8	80/8"			18.6	
	PA						
5	SS	3	50/3"			15.5	
	PA						
6	SS	2	50/2"			15.6	

** compressive strength in psi * Calibrated Penetrometer

GRAPHIC LOG



DEPTH, Feet.

MATERIAL DESCRIPTION

Surface Elevation: **892.0**

FAT CLAY, stiff, brown (Possible Fill)

3.0 889.0

LEAN TO FAT CLAY, very stiff, brown

6.5 885.5

****SHALE**, weathered, soft to hard, yellowish tan to gray brown

16.0 876.0

****SHALY SANDSTONE**, weathered, poorly cemented, fine grained, light brown

19.0 873.0

BOTTOM OF BORING

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS cfse.com ENGINEERS

Boring Started	**8-18-20**		
Boring Completed	**8-18-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 2 of 2**

LOG OF BORING NO. B-9

STATION OFFSET

NORTHING **237,853.6** EASTING **2,108,665.2**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION

ATTERBERG LIMITS
Sample 2, Depth 3.5-5 feet

LL	PL	PI
49	21	28

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS
cfse.com

Boring Started	**8-18-20**		
Boring Completed	**8-18-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

LOG OF BORING NO. B-10

STATION OFFSET

NORTHING **237,574.5** EASTING **2,109,306.9**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

Surface Elevation: 844.3

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	DEPTH, Feet.	MATERIAL DESCRIPTION
	PA								**FILL**, lean to fat clay, stiff, dark brown and brown mixed, trace gravel
1	SS	8	14	*6000		12.4	CL CH	2.5	841.8
	PA								**FILL**, silty lean clay, soft, dark gray brown to black, trace organics
2	SS	18	4	*1000		27.3	CL	5	
	PA							6.0	▽ 838.3
3	SS	18	16	*6500		23.7	CL CH		**LEAN TO FAT CLAY**, very stiff to stiff, brown (Possible Fill)
	PA								
4	SS	18	7	*2000		24.2	CL CH	10	
	PA							12.5	▼ 831.8
									SILTY LEAN CLAY, stiff, tan mottled light gray, trace fine sand
5	SS	16	10	*4000		25.3	CL	15 — 15.0	829.3

BOTTOM OF BORING

ATTERBERG LIMITS
Sample 3, Depth 6-7.5 feet

LL	PL	PI
49	20	29

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **6.0 feet W.D.**

▼ **12.5 feet A.B.**

Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-18-20**		
Boring Completed	**8-18-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,524.4** EASTING **2,109,402.8**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-11

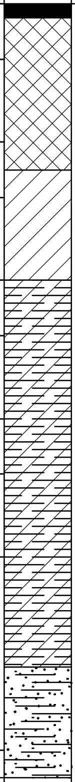
PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	SS	14	10	*4000		18.7	CL
	PA						
2	SS	18	8	*3000		20.2	CL
	PA						
3	SS	18	28	*7500		20.5	
	PA						
4	SS	18	42	*9000		14.7	
	PA						
5	SS	4	50/4"			21.4	

GRAPHIC LOG



DEPTH, Feet.

MATERIAL DESCRIPTION

Surface Elevation: **840.8**

DEPTH, Feet.	MATERIAL DESCRIPTION	
	Asphaltic Concrete (3")	
3.0	**FILL**, lean clay, stiff, dark gray brown and brown mixed, with some sand and gravel	837.8
5.0	**LEAN CLAY**, stiff, dark brown (Possible Fill or Buried Topsoil)	835.8
12.0	**SHALE, weathered, soft to mod. hard, olive tan to gray brown ▽	828.8
14.0	**SANDSTONE, weathered, poorly cemented, fine grained, light brown ▼	826.8

BOTTOM OF BORING

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **6.5 feet W.D.**

▼ **13.5 feet A.B.**

Backfilled @ Completion

CFS
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ENGINEERS

Boring Started	**8-20-20**		
Boring Completed	**8-20-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,652.8** EASTING **2,109,424.4**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-12

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG
	PA							☒
1	SS	10	3	*2500		26.6	CL CH	☒
	PA							☒
2	SS	18	6	*7000		14.9	CL CH	☒
	PA							▨
3	SS	18	15	*4500		22.7	CH	▨
	PA							▨
4	SS	18	10	*3000		27.9	CH	▨
	PA							▨
5	SS	18	11	*3000		27.4	CH	▨

DEPTH, Feet.	MATERIAL DESCRIPTION	
	Surface Elevation:	**841.0**
	FILL, lean to fat clay, soft to medium stiff, brown and dark brown mixed, trace sand ▽	
5.5		835.5
	FAT CLAY, very stiff to stiff, brown mottled light gray, trace iron nodules ▼	
15.0		826.0
	BOTTOM OF BORING	

ATTERBERG LIMITS
Sample 3, Depth 6-7.5 feet

LL	PL	PI
70	22	48

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **2.8 feet W.D.**

▼ **6.5 feet A.B.**

Backfilled @ Completion

CFS cfse.com ENGINEERS

Boring Started	**8-19-20**
Boring Completed	**8-19-20**
Drill Rig **RC-550**	Driller **LC**
Approved By: **JJZ**	Project No. **19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

LOG OF BORING NO. B-13

STATION OFFSET

NORTHING **237,043.1** EASTING **2,109,493.3**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	**MATERIAL DESCRIPTION** **Surface Elevation: 835.3**
	PA									**Gravel (3")** **<u>FILL</u>**, lean to fat clay, stiff to very stiff, brown, reddish brown and dark brown mixed, with gravel and some fine sand
1	SS	6	11	*5500		25.6	CL CH			
	PA									
2	SS	15	10	*4500		21.7	CL CH		5	5.0 830.3
										BOTTOM OF BORING

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-20-20**		
Boring Completed	**8-20-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

LOG OF BORING NO. B-14

STATION OFFSET

NORTHING **237,973.9** EASTING **2,109,364.6**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	SS	6	50/6"			12.3	
	PA						
2	SS	5	50/5"			15.2	
	PA						
3	SS	4	50/4"			13.7	
	PA						
4	SS	3	50/3"			13.9	
	PA						
5	SS	4	50/4"			12.2	

** compressive strength in psi * Calibrated Penetrometer

MATERIAL DESCRIPTION

Surface Elevation: **848.8**

DEPTH, Feet.	MATERIAL DESCRIPTION	
1.0	**FILL**, lean, brown, with gravel	847.8
3.0	****SHALE**, weathered, mod. hard to hard, light brown	845.8
8.0	****SANDY SHALE**, hard, light brown	840.8
14.0	****SHALE**, hard, light gray	▽ ▼ 834.8

BOTTOM OF BORING

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **13.5 feet W.D.**

▼ **13.7 feet A.B.**

Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-20-20**		
Boring Completed	**8-20-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,238.2** EASTING **2,107,365.9**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-15

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	SS	8	7	*2500		25.6	CH
	PA						
2	SS	16	54/10"			24.1	CL

MATERIAL DESCRIPTION

Surface Elevation: **892.8**

DEPTH, Feet.	MATERIAL DESCRIPTION	
0.5	**Topsoil**, dark brown (6")	892.3
2.5	**FILL**, fat clay, stiff, brown	890.3
4.4	**LEAN CLAY**, very stiff, brown to reddish brown	888.4
5.0	****SANDSTONE**, weathered, yellowish tan	887.8

5

BOTTOM OF BORING

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS
cfse.com

Boring Started	**8-27-20**
Boring Completed	**8-27-20**
Drill Rig **RC-550**	Driller **LC**
Approved By: **JJZ**	Project No. **19-1196**

BOREHOLE INFORMATION	**Page 1 of 1**
STATION	OFFSET
NORTHING **238,059.0**	EASTING **2,108,547.9**
DRILLING COMPANY **RC Drilling, Inc.**	
METHOD **6-inch Flight Augers**	HAMMER **Auto**

LOG OF BORING NO. B-16

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION Surface Elevation:	893.7
	PA									**FILL**, lean clay, very stiff, light brown and tan mixed, with some shale fragments and gravel	
1	SS	6	50/6"	*5000		11.2	CL		1.5		892.2
	PA								1.9	****LIMESTONE**, hard	891.8

AUGER REFUSAL @ 1.9 FEET

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS
▽ **Dry W.D.**
▼ **Dry A.B.**
Backfilled @ Completion

CFS ENGINEERS
cfse.com

Boring Started	**8-17-20**		
Boring Completed	**8-7-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **238,059.8** EASTING **2,108,317.0**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-17

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

Offset 20 feet east-northeast

MATERIAL DESCRIPTION

Surface Elevation: 891.2

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION
	PA							▨		**LEAN CLAY**, stiff, brown
1	SS	14	13	*5000		24.3	CL	▨	2.0	889.2
	PA							▤		**SHALE, weathered, soft to hard, yellowish tan and rust to gray brown
2	SS	6	50/6"			13.5		▤		
	PA							▤	5	5.0 886.2
								▩		**SHALY SANDSTONE, weathered, poorly cemented, fine grained, light brown
3	SS	4	50/4"			14.6		▩		
	PA							▩		
4	SS	3	50/3"			15.1		▩		
	PA							▩	10	
5	SS	2	50/2"			16.4		▩	14.0	∇▼ 877.2

BOTTOM OF BORING

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS
∇ 13.5 feet W.D.
▼ 13.7 feet A.B.
Backfilled @ Completion

CFS ENGINEERS
cfse.com

Boring Started	8-17-20		
Boring Completed	8-17-20		
Drill Rig	RC-550	Driller	LC
Approved By:	JJZ	Project No.	19-1196

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **238,281.1** EASTING **2,107,495.2**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-18

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	SS	18	15	*5500		15.8	
	PA						
2	SS	11	74/11"			13.3	
	PA						
3	SS	5	50/5"			11.1	
	PA						
4	SS	4	50/4"			11.6	
	PA						
5	SS	4	50/4"			10.6	

** compressive strength in psi * Calibrated Penetrometer

GRAPHIC LOG

DEPTH, Feet. 5 10

MATERIAL DESCRIPTION

Surface Elevation: **868.9**

0.8 **Topsoil**, dark brown (9") 868.1

**<u>SHALE</u>, weathered, soft to hard, sandy, yellowish tan to gray brown

12.0 856.9

**<u>SHALE</u>, hard, light gray

14.0 854.9

BOTTOM OF BORING

<u>ATTERBERG LIMITS</u>
Sample 1, Depth 1-2.5 feet

<u>LL</u>	<u>PL</u>	<u>PI</u>
33	21	12

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**
▼ **Dry A.B.**
Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-25-20**
Boring Completed	**8-25-20**
Drill Rig **RC-550**	Driller **LC**
Approved By: **JJZ**	Project No. **19-1196**

BOREHOLE INFORMATION **Page 1 of 2**

LOG OF BORING NO. B-19

STATION OFFSET

NORTHING **237,779.6** EASTING **2,107,964.1**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

MATERIAL DESCRIPTION

Surface Elevation: 888.1

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG
	PA							▨
1	SS	18	7	*2000		32.5	CH	▨
	PA							▨
2	SS	15	11	*6500		23.0	CL CH	▨
	PA							▨
3	SS	14	12	*7500		25.0	CL CH	▨
	PA							░
4	SS	17	80/11"			16.3		░
	PA							░
5	SS	2	50/2"			18.2		░
	PA							░
6	SS	3	50/3"			22.8		░

** compressive strength in psi * Calibrated Penetrometer

DEPTH, Feet.	MATERIAL DESCRIPTION	Elevation
	FILL, fat clay, stiff, light brown and reddish brown mixed, trace gravel	
3.0		885.1
	FILL, fat to fat clay, very stiff, light brown and brown mixed, trace gravel	
8.0		880.1
	****SHALY SANDSTONE**, weathered, poorly cemented to cemented, fine grained, light brown	
	∇	
	▼	
19.0		869.1
	BOTTOM OF BORING	

Depth scale: 5, 10, 15

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **13.5 feet W.D.**

▼ **17.5 feet A.B.**

Backfilled @ Completion

CFS ENGINEERS cfse.com

Boring Started	**8-17-20**		
Boring Completed	**8-17-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 2 of 2**

STATION OFFSET

NORTHING **237,779.6** EASTING **2,107,964.1**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-19

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	**MATERIAL DESCRIPTION**

ATTERBERG LIMITS

Sample 1, Depth 1-2.5 feet

LL	PL	PI
51	23	28

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **13.5 feet W.D.**

▼ **17.5 feet A.B.**

Backfilled @ Completion

CFS cfse.com ENGINEERS

Boring Started	**8-17-20**
Boring Completed	**8-17-20**
Drill Rig **RC-550**	Driller **LC**
Approved By: **JJZ**	Project No. **19-1196**

BOREHOLE INFORMATION **Page 1 of 2**

STATION OFFSET

NORTHING **237,704.3** EASTING **2,108,112.3**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-20

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	SS	17	10	*4000		22.5	CL CH
	PA						
2	SS	18	16	*7500		24.5	CL
	PA						
3	SS	4	50/4"			13.6	
	PA						
4	SS	2	50/2"			14.9	
	PA						
5	SS	2	50/2"			17.4	
	PA						
6	SS	2	50/2"			18.2	

GRAPHIC LOG

DEPTH, Feet. 5 10 15

MATERIAL DESCRIPTION

Surface Elevation: **892.2**

FILL, lean to fat clay, stiff to very stiff, dark brown, brown and tan, with shale fragments and trace gravel

3.0 889.2

LEAN CLAY, very stiff, brown to reddish brown

6.0 886.2

****SHALE**, weathered, mod. hard, gray brown

8.0 884.2

****SANDSTONE**, weathered, poorly cemented to cemented, fine grained, light brown

19.0 ∇ 873.2

BOTTOM OF BORING

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **18.5 feet W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS cfse.com ENGINEERS

Boring Started	**8-17-20**
Boring Completed	**8-17-20**
Drill Rig **RC-550**	Driller **LC**
Approved By: **JJZ**	Project No. **19-1196**

BOREHOLE INFORMATION **Page 2 of 2**

STATION OFFSET

NORTHING **237,704.3** EASTING **2,108,112.3**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-20

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	**MATERIAL DESCRIPTION**
										ATTERBERG LIMITS Sample 2, Depth 3.5-5 feet LL PL PI 46 23 23 **Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **18.5 feet W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-17-20**		
Boring Completed	**8-17-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 2**

STATION OFFSET

NORTHING **237,703.8** EASTING **2,108,618.6**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-21

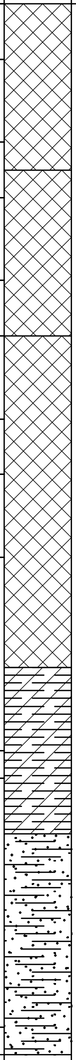
PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	SS	6	7	*2500		17.1	CH
	PA						
2	SS	14	6	*2000		27.4	CL
	PA						
3	SS	14	11	*4000		20.7	CL CH
	PA						
4	SS	18	11	4500		21.3	CL CH
	PA						
5	SS	6	50/6"			14.1	
	PA						
6	SS	2	50/2"			17.4	

GRAPHIC LOG



MATERIAL DESCRIPTION

Surface Elevation: **890.8**

DEPTH, Feet	MATERIAL DESCRIPTION	Elevation
	FILL, fat clay, stiff, dark brown and brown mixed	
3.0		887.8
	FILL, lean clay, stiff, brown and tan mixed, with shale fragments and trace gravel	
6.0		884.8
	FILL, lean to fat clay, stiff to very stiff, dark gray brown to black, trace gravel	
12.0		878.8
	**SHALE, weathered, mod. hard to hard, light brown mottled light gray	
15.0		875.8
	**SANDSTONE, weathered, poorly cemented, fine grained, light brown	
19.0		871.8
	BOTTOM OF BORING	

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-18-20**
Boring Completed	**8-18-20**
Drill Rig **RC-550**	Driller **LC**
Approved By: **JJZ**	Project No. **19-1196**

BOREHOLE INFORMATION **Page 2 of 2**

STATION OFFSET

NORTHING **237,703.8** EASTING **2,108,618.6**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-21

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION
										**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-18-20**		
Boring Completed	**8-18-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,647.9** EASTING **2,109,106.7**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-22

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

MATERIAL DESCRIPTION

Surface Elevation: 848.9

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION
	PA									**Asphaltic Concrete (2")** **FILL**, lean clay, stiff to very stiff, desiccated, dark brown, with gravel
1	SS	16	11	*4500		16.6	CL			
										2.5 846.4
	PA									**LEAN TO FAT CLAY**, stiff to very stiff, gray brown and rust
2	SS	18	10	*4000		20.5	CL CH			
	PA								5	5.5 843.4
3	SS	9	81/9"			14.3				****SHALE**, weathered, mod. hard to hard, sandy, light brown
	PA									
4	SS	3	50/3"			14.8				9.0 839.9

BOTTOM OF BORING

ATTERBERG LIMITS
Sample 1, Depth 1-2.5 feet

LL	PL	PI
41	19	22

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS cfse.com ENGINEERS

Boring Started	**8-20-20**		
Boring Completed	**8-20-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,815.5** EASTING **2,109,179.8**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-23

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG
	PA							▩
1	SS	10	7	*2500		21.4	CL CH	▩
	PA							▩
2	SS	18	6	*2000		25.4	CH	▨
	PA							▨
3	SS	18	7	*3000		25.2	CH	▨
	PA							▨
4	SS	18	19	*7500		26.8	CH	▨
	PA							▨
5	SS	18	10	*5500		23.4	CL CH	▧

** compressive strength in psi * Calibrated Penetrometer

MATERIAL DESCRIPTION

Surface Elevation: 854.0

DEPTH, Feet.	MATERIAL DESCRIPTION	Elevation
	FILL, lean to fat clay, stiff, dark gray brown to black	
3.5		850.5
	FAT CLAY, stiff, brown - very stiff below 8 feet	
12.0		842.0
	LEAN TO FAT CLAY, stiff, reddish brown mottled light gray, trace fine sand	
15.0		839.0

BOTTOM OF BORING

ATTERBERG LIMITS

Sample 2, Depth 3.5-5 feet

LL	PL	PI
58	19	39

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS cfse.com

Boring Started	**8-18-20**		
Boring Completed	**8-18-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

LOG OF BORING NO. B-24

STATION OFFSET

NORTHING **238,011.6** EASTING **2,109,355.3**

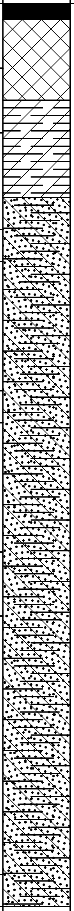
DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG
	PA							
1	SS	9	62/9"			14.8		
	PA							
2	SS	4	50/4"			14.8		
	PA							
3	SS	4	50/4"			14.6		
	PA							
4	SS	8	88/8"			12.8		
	PA							
5	SS	3	50/3"			14.0		

** compressive strength in psi * Calibrated Penetrometer

DEPTH, Feet.

Offset 50' east, due to power line

MATERIAL DESCRIPTION

Surface Elevation: **857.5**

Asphaltic Concrete (3")
FILL, lean clay, stiff, brown, with gravel

1.5 856.0

**SHALE, weathered, soft to mod. hard, light brown

3.0 854.5

**SHALY SANDSTONE, weathered, poorly cemented to cemented, fine grained, light brown

5

10

14.0 843.5

BOTTOM OF BORING

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

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Boring Started	**8-20-20**		
Boring Completed	**8-20-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,330.5** EASTING **2,109,600.7**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-25

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.
	PA								
1	SS	12	13	*5000		19.1	CL		
	PA								
2	SS	12	8	*3500		26.0	CL		5

MATERIAL DESCRIPTION

Surface Elevation: **842.4**

Topsoil, dark brown (3"), weeds

<u>FILL</u>, lean clay, very stiff to stiff, brown and dark brown mixed, with gravel and some fine sand

5.0 837.4

BOTTOM OF BORING

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-20-20**		
Boring Completed	**8-20-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,211.5** EASTING **2,109,493.5**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-26

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

MATERIAL DESCRIPTION

Surface Elevation: 842.8

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION
	PA							▨		**Gravel (3")** **FILL**, lean to fat clay, stiff to very stiff, brown and dark brown mixed, with gravel and some fine sand
1	SS	10	12	*5500		18.6	CL CH	▨		
	PA							▨		
2	SS	18	15	*6000		25.0	CL CH	▨	5	5.0 837.8
										BOTTOM OF BORING

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-20-20**		
Boring Completed	**8-20-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,330.8** EASTING **2,109,373.6**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-27

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG
	PA							▩
1	SS	18	24	*8000		17.3	CL ML	▩
	PA							▨
2	SS	18	8	*2500		25.5	CL	▨

** compressive strength in psi * Calibrated Penetrometer

MATERIAL DESCRIPTION

Surface Elevation: **840.7**

DEPTH, Feet.	MATERIAL DESCRIPTION	
	FILL, clayey silt, very stiff, brown, trace gravel	
3.0		837.7
	LEAN CLAY, stiff, dark brown, trace fine sand (Possible Fill)	
5	5.0	835.7

BOTTOM OF BORING

ATTERBERG LIMITS
Sample 1, Depth 1-2.5 feet

LL	PL	PI
28	20	8

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS cfse.com ENGINEERS

Boring Started	**8-19-20**		
Boring Completed	**8-19-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

LOG OF BORING NO. B-28

STATION OFFSET

NORTHING **237,506.1** EASTING **2,109,346.3**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG
	PA							▨
1	SS	6	50/6"			8.0	GM	▨
	PA							▨
2	SS	18	21	*4500		22.2	CL CH	▨

MATERIAL DESCRIPTION

Surface Elevation: 843.9

DEPTH, Feet.	MATERIAL DESCRIPTION	
	<u>**FILL**</u>, crushed limestone gravel, very dense, gray	
2.0		841.9
	<u>**FILL**</u>, lean to fat clay, very stiff, dark gray brown, trace gravel and cinders	
5		
5.0		838.9
	BOTTOM OF BORING	

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-19-20**
Boring Completed	**8-19-20**
Drill Rig **RC-550**	Driller **LC**
Approved By: **JJZ**	Project No. **19-1196**

BOREHOLE INFORMATION **Page 1 of 2**

STATION OFFSET

NORTHING **237,701.9** EASTING **2,107,708.6**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-29

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG
	PA							
1	SS	8	12	*6500		20.0	CL CH	
	PA							
2	SS	14	6	*2000		20.7	CH	
	PA							
3	SS	18	6	*2500		25.3	CH	
	PA							
4	SS	15	22	*9000		16.0		
	PA							
5	SS	9	83/9"			22.3		
	PA							
6	SS	3	50/3"			17.0		

** compressive strength in psi * Calibrated Penetrometer

MATERIAL DESCRIPTION

Surface Elevation: **897.5**

DEPTH, Feet.	MATERIAL DESCRIPTION	
	Topsoil, dark brown (6")	
	FILL, lean to fat clay, very stiff, dark gray brown and brown mixed, trace gravel	
3.0		894.5
	FAT CLAY, medium stiff to stiff, brown to reddish brown	
9.0		888.5
	****SHALE**, weathered, soft to hard, yellowish tan to gray brown	
19.0		878.5
	BOTTOM OF BORING	

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS cfse.com ENGINEERS

Boring Started	**8-26-20**		
Boring Completed	**8-26-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION	**Page 2 of 2**
STATION	OFFSET
NORTHING **237,701.9**	EASTING **2,107,708.6**
DRILLING COMPANY **RC Drilling, Inc.**	
METHOD **6-inch Flight Augers**	HAMMER **Auto**

LOG OF BORING NO. B-29

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION

ATTERBERG LIMITS

Sample 2, Depth 3.5-5 feet

LL	PL	PI
58	20	38

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

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Boring Started	**8-26-20**		
Boring Completed	**8-26-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION	Page 1 of 2
STATION	OFFSET
NORTHING **238,660.6**	EASTING **2,107,680.7**
DRILLING COMPANY **RC Drilling, Inc.**	
METHOD **6-inch Flight Augers**	HAMMER **Auto**

LOG OF BORING NO. B-30

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION Surface Elevation: 855.1
	PA									**Topsoil**, brown (14")
										1.2 853.9
1	SS	18	50			11.0				**__SHALE__, weathered, sandy, mod. hard to hard, sandy, yellowish tan to gray brown
	PA									
2	SS	16	76/10"			15.6				
	PA								5	
3	SS	6	50/6"			14.4				
	PA									8.0 847.1
4	SS	4	50/4"			18.5				**__SHALY SANDSTONE__, weathered, poorly cemented, fine grained, light brown to tan
	PA								10	∇
5	SS	6	50/6"			19.1				
	PA								15	▼
6	SS	4	50/4"			18.9				19.0 836.1
										BOTTOM OF BORING

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS	
∇	**12.5 feet W.D.**
▼	**18.3 feet A.B.**
	Backfilled @ Completion

CFS cfse.com ENGINEERS

Boring Started	**8-26-20**		
Boring Completed	**8-26-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 2 of 2**

STATION OFFSET

NORTHING **238,660.6** EASTING **2,107,680.7**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-30

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION

ATTERBERG LIMITS

Sample 1, Depth 1-2.5 feet

LL	PL	PI
24	18	6

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **12.5 feet W.D.**

▼ **18.3 feet A.B.**

Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-26-20**		
Boring Completed	**8-26-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,044.0** EASTING **2,110,097.7**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-31

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION
										Surface Elevation: 838.0
	PA									0.5 **Topsoil**, dark brown (6") 837.5
1	SS	9	96/9"			14.6				****SANDSTONE**, weathered, poorly cemented to cemented, light brown 2.0 836.0
	PA									****SHALE**, weathered, mod. hard to hard, sandy, yellowish
2	SS	5	50/5"			12.8				4.0 834.0

BOTTOM OF BORING

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS
cfse.com

Boring Started	**8-21-20**		
Boring Completed	**8-21-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,356.8** EASTING **2,110,594.7**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-32

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

Offset 30 feet north

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.
	PA							▩	
1	SS	18	4	*1000		21.9	CL ML	▩	
	PA							▩ / ░	
2	SS	18	WOH			40.8	ML	░	5

MATERIAL DESCRIPTION

Surface Elevation: **832.7**

FILL, clayey silt, soft to medium stiff, light brown, trace fine sand ▼

3.0 829.7

CLAYEY SILT, very soft, light gray brown, with some fine sand

5.0 827.7

BOTTOM OF BORING

Note: WOH - Weight of Hammer

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **2.0 feet W.D.**

▼ **2.0 feet A.B.**

Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-21-20**
Boring Completed	**8-21-20**
Drill Rig **RC-550**	Driller **LC**
Approved By: **JJZ**	Project No. **19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

LOG OF BORING NO. B-33

STATION OFFSET

NORTHING **237,069.5** EASTING **2,110,577.3**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	**MATERIAL DESCRIPTION** **Surface Elevation: 830.3**
	PA							▨		<u>**FILL**</u>, lean to fat clay, very stiff to stiff, dark gray brown
1	SS	18	19	*8500		15.3	CL CH	▨		
	PA							▨		
2	SS	18	9	*3000		19.5	CL CH	▨	5	5.0 825.3
										BOTTOM OF BORING

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS	
∇	**Dry W.D.**
▼	**Dry A.B.**
	Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-21-20**		
Boring Completed	**8-21-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION	**Page 1 of 1**
STATION	OFFSET
NORTHING **237,155.7**	EASTING **2,111,005.8**
DRILLING COMPANY **RC Drilling, Inc.**	
METHOD **6-inch Flight Augers**	HAMMER **Auto**

LOG OF BORING NO. B-34

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	**MATERIAL DESCRIPTION** **Surface Elevation: 829.0**
	PA									**FILL**, lean clay, stiff, dark brown and brown mixed, trace gravel
1	SS	18	6	*2500		14.5	CL			
	PA									3.0 — 826.0
										SILTY LEAN CLAY, medium stiff, light brown
2	SS	18	5	*2000		20.6	CL ML		5	5.0 — 824.0
										BOTTOM OF BORING

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS	
▽	**Dry W.D.**
▼	**Dry A.B.**
	Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-21-20**		
Boring Completed	**8-21-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

LOG OF BORING NO. B-35

STATION OFFSET

NORTHING **237,095.8** EASTING **2,111,570.8**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

Offset 20' west, due to power line

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	**MATERIAL DESCRIPTION** Surface Elevation: 827.8
	PA							▨		**<u>FILL</u>**, lean clay, stiff, dark gray brown, trace gravel
1	SS	14	7	*2000		23.8	CL	▨		
	PA							▨		
2	SS	18	7	*2500		25.2	CL	▨		5.0 822.8
									5	**BOTTOM OF BORING**

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS	
∇	**Dry W.D.**
▼	**Dry A.B.**
	Backfilled @ Completion

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Boring Started	**8-21-20**		
Boring Completed	**8-21-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,115.1** EASTING **2,111,824.6**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-36

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	**MATERIAL DESCRIPTION** **Surface Elevation: 828.0**
	PA							▨		**FILL**, lean clay, stiff to soft, brown and gray mixed, trace gravel
1	SS	15	10	*3500		15.9	CL	▨		
	PA							▨		
2	SS	18	3	*1000		21.4	CL	▨		5.0 823.0
									5	**BOTTOM OF BORING**

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

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Boring Started	**8-21-20**		
Boring Completed	**8-21-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,044.1** EASTING **2,111,237.6**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-37

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION **Surface Elevation: 821.0**
	PA							▨		**FILL**, lean to fat clay, very stiff to medium stiff, dark brown
1	SS	18	11	*6000		20.9	CL CH	▨		
	PA							▨		
2	SS	18	5	*1500		34.9	CL CH	▨	5	5.0 816.0
										BOTTOM OF BORING

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS
∇ **Dry W.D.**
▼ **Dry A.B.**
Backfilled @ Completion

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Boring Started	**8-21-20**		
Boring Completed	**8-21-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,059.0** EASTING **2,112,248.9**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-38

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	**MATERIAL DESCRIPTION** **Surface Elevation: 822.8**
	PA							▨		**FAT CLAY**, medium stiff to stiff, dark brown to brown
1	SS	15	6	*2000		28.1	CH	▨		
	PA							▨		
2	SS	18	9	*3500		28.8	CH	▨	5	5.0 817.8
										BOTTOM OF BORING

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

$\underline{\nabla}$ **Dry W.D.**

$\blacktriangledown$ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS cfse.com

Boring Started	**8-21-20**		
Boring Completed	**8-21-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,393.8** EASTING **2,112,139.8**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-39

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	**MATERIAL DESCRIPTION** **Surface Elevation: 828.7**
	PA							▨		**FILL**, lean to fat clay, very stiff to stiff, brown, trace gravel and sand
1	SS	18	11	*4500		29.1	CL CH	▨		
	PA							▨		
2	SS	18	7	*2500		25.7	CL CH	▨	5	5.0 823.7
										BOTTOM OF BORING

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

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Boring Started	**8-21-20**		
Boring Completed	**8-21-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,316.7** EASTING **2,107,764.6**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-40

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

MATERIAL DESCRIPTION

Surface Elevation: 894.9

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION	
	PA							▩	1.0	**FILL**, lean clay, stiff, dark brown	893.9
1	SS	8	9	*4500		29.4	CH	▨		**FAT CLAY**, very stiff, brown	
	PA							▨			
2	SS	18	11	*6500		23.2	CH	▨	5		
	PA							▨	5.8	▽	889.1
3	SS	1	50/1"			5.1		▤	6.3	****LIMESTONE**, hard ▼	888.6

AUGER REFUSAL @ 6.3 FEET

ATTERBERG LIMITS
Sample 2, Depth 3.5-5 feet

LL	PL	PI
51	20	31

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **5.8 feet W.D.**

▼ **6.1 feet A.B.**

Backfilled @ Completion

CFS ENGINEERS
cfse.com

Boring Started	**8-27-20**		
Boring Completed	**8-27-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,315.6** EASTING **2,107,647.5**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-41

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.
	PA								
1	SS	9	12	*5500		25.8	CL CH		
	PA								
2	SS	18	9	*4000		20.5	CL		
	PA								5
3	SS	18	47	*5000		26.5	CH		
	PA								

MATERIAL DESCRIPTION

Surface Elevation: **896.7**

	FILL, lean to fat clay, very stiff, dark gray brown	
2.5		894.2
	SILTY LEAN CLAY, stiff, brown, trace fine sand	
6.0		890.7
	FAT CLAY, very stiff, light brown	
7.3		889.4
7.9	****LIMESTONE**, hard	888.8

AUGER REFUSAL @ 7.9 FEET

ATTERBERG LIMITS
Sample 2, Depth 3.5-5 feet

LL	PL	PI
32	16	16

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS
cfse.com

Boring Started	**8-27-20**		
Boring Completed	**8-27-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,381.3** EASTING **2,107,758.6**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-42

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG
	PA							
1	SS	6	12	*6500		25.4	CH	
	PA							
2	SS	18	9	*3000		21.3	CL	
	PA							
3	SS	10	54/10"	*5000		29.5	CL	
	PA							

** compressive strength in psi * Calibrated Penetrometer

MATERIAL DESCRIPTION

Surface Elevation: **897.6**

DEPTH, Feet.	MATERIAL DESCRIPTION	
	Topsoil, dark brown (12")	
1.0		896.6
	FAT CLAY, very stiff, dark brown	
3.0		894.6
	SILTY LEAN CLAY, stiff, brown, trace fine sand	
5		
6.8		890.8
7.3	****LIMESTONE**, hard	890.3

AUGER REFUSAL @ 7.3 FEET

ATTERBERG LIMITS
Sample 2, Depth 3.5-5 feet

LL	PL	PI
30	15	15

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS cfse.com ENGINEERS

Boring Started	**8-27-20**
Boring Completed	**8-27-20**
Drill Rig **RC-550**	Driller **LC**
Approved By: **JJZ**	Project No. **19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,379.3** EASTING **2,107,647.5**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-43

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG
	PA							⁂
1	SS	9	6	*2000		24.1	CL CH	▩
	PA							▩
2	SS	18	7	*3000		20.9	CL	▨
	PA							▨
3	SS	18	12	*5000		22.5	CL	▤
	PA							▤
4	SS	3	50/3"			15.2		▦

** compressive strength in psi * Calibrated Penetrometer

MATERIAL DESCRIPTION

Surface Elevation: 898.5

DEPTH, Feet.	MATERIAL DESCRIPTION	
	Topsoil, dark brown (12")	
1.0		897.5
	LEAN TO FAT CLAY, medium stiff, dark brown	
3.0		895.5
	LEAN CLAY, stiff, brown, trace fine sand	
5		
6.0		892.5
	SHALY CLAY, very stiff, light brown	
8.4		890.1
	**LIMESTONE, hard	
9.0		889.5

AUGER REFUSAL @ 9.0 FEET

ATTERBERG LIMITS

Sample 1, Depth 1-2.5 feet

LL	PL	PI
49	22	27

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS cfse.com

Boring Started **8-27-20**

Boring Completed **8-27-20**

Drill Rig **RC-550** Driller **LC**

Approved By: **JJZ** Project No. **19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **238,156.5** EASTING **2,108,645.2**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-44

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	SS	6	13	*7500		27.5	CL CH
	PA						
2	SS	12	70/11"	*8500		26.6	
	PA						
3	SS	4	50/4"			13.1	
	PA						
4	SS	4	50/4"			14.1	

** compressive strength in psi * Calibrated Penetrometer

DEPTH, Feet. 5

MATERIAL DESCRIPTION

Surface Elevation: 890.9

0.5 **Topsoil**, dark brown (6") 890.4

FILL, lean to fat clay, very stiff, brown and reddish brown mixed, trace gravel

3.0 887.9

****SHALE**, weathered, mod. hard to hard, sandy, light gray brown to tan and light gray

9.0 881.9

BOTTOM OF BORING

ATTERBERG LIMITS

Sample 2, Depth 3.5-5 feet

LL	PL	PI
25	19	6

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS
cfse.com

Boring Started	**8-18-20**
Boring Completed	**8-18-20**
Drill Rig **RC-550**	Driller **LC**
Approved By: **JJZ**	Project No. **19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,544.3** EASTING **2,107,610.9**

DRILLING COMPANY **RC Drilling, Inc.**

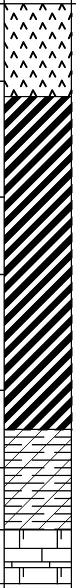
METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-45

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**



SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION Surface Elevation: 897.0	
	PA									**Topsoil**, dark brown (14")	
									1.2		895.8
1	SS	10	6	*2500		21.7	CH			**FAT CLAY**, medium stiff, brown to light brown	
	PA										
2	SS	12	5	*2000		28.4	CH				
	PA								5		
									5.5		891.5
3	SS	10	58/10"	*9000		18.9				****SHALE**, weathered, mod. hard to hard, yellowish tan	
									6.8		890.2
	PA									****LIMESTONE**, hard	
									7.5		889.5

AUGER REFUSAL @ 7.5 FEET

ATTERBERG LIMITS
Sample 2, Depth 3.5-5 feet

LL	PL	PI
82	29	53

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS	
⊻	**Dry W.D.**
▼	**Dry A.B.**
	Backfilled @ Completion

CFS cfse.com ENGINEERS

Boring Started	**8-26-20**		
Boring Completed	**8-26-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION		**Page 1 of 1**	
STATION		OFFSET	
NORTHING	**237,882.1**	EASTING	**2,107,823.2**
DRILLING COMPANY	**RC Drilling, Inc.**		
METHOD	**6-inch Flight Augers**	HAMMER	**Auto**

LOG OF BORING NO. B-46

PROJECT NAME	**MSO Field Operations Facility**
SITE LOCATION	**19th Street & O'Connell Road** **Lawrence, Kansas**
OWNER / ARCHITECT	**Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	**MATERIAL DESCRIPTION** **Surface Elevation: 887.0**
	PA									**Topsoil**, dark brown (12")
									1.0	886.0
1	SS	18	88			14.0				****SHALE**, weathered, mod. hard to hard, yellowish tan
	PA									
0	SS	6	50/6"			14.5			4.0	883.0

BOTTOM OF BORING

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

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Boring Started	**8-25-20**		
Boring Completed	**8-25-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,956.6** EASTING **2,108,297.0**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-47

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION **Surface Elevation: 892.4**
	PA									**Topsoil**, dark brown (12") 1.0 891.4
1	SS	12	20	*7500		18.5	CH			**<u>FAT CLAY</u>**, very stiff, brown 2.5 889.9
	PA									**<u>SHALY CLAY</u>**, very stiff, yellowish tan, with shale fragments
2	SS	18	14	*6000		18.4	CL		5	5.3 887.1
	PA									5.8 **<u>LIMESTONE</u>, hard 886.6

AUGER REFUSAL @ 5.8 FEET

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS cfse.com

Boring Started	**8-27-20**		
Boring Completed	**8-27-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **238,193.3** EASTING **2,108,230.2**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-48

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.
	PA								
1	SS	18	53			14.6			
	PA								
2	SS	5	50/5"			15.3			
	PA								5
3	SS	6	50/6"			19.2			
	PA								

MATERIAL DESCRIPTION

Surface Elevation: **883.8**

Topsoil, dark brown (8")

0.7 883.1

****SHALE**, weathered, mod. hard to hard, yellowish tan to gray brown

7.4 876.4

****LIMESTONE**, hard

8.0 875.8

AUGER REFUSAL @ 8.0 FEET

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS cfse.com ENGINEERS

Boring Started	**8-25-20**		
Boring Completed	**8-25-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **238,458.5** EASTING **2,107,435.7**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-49

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION **Surface Elevation: 857.7**
	PA							▨		**LEAN CLAY**, soft to medium stiff, dark gray brown, trace organics (Topsoil)
1	SS	12	4	*2500		24.7	CL OL	▨		
	PA							▨		3.5 854.2
2	SS	15	6	*3000		27.2	CL CH	▨		**LEAN TO FAT CLAY**, medium stiff to stiff, brown 5.0 852.7
									5	**BOTTOM OF BORING**

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS
cfse.com

Boring Started	**8-26-20**		
Boring Completed	**8-26-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,768.6** EASTING **2,109,268.4**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-50

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	SS	4	2	*500		20.6	CL
	PA						
2	SS	18	9	*4000		25.6	CL
	PA						
3	SS	18	7	*3000		26.0	CH
	PA						
4	SS	18	6	*2500		26.3	CL CH
	PA						
5	SS	18	4	*1500		27.6	CL

** compressive strength in psi * Calibrated Penetrometer

MATERIAL DESCRIPTION

Surface Elevation: **847.4**

DEPTH, Feet	MATERIAL DESCRIPTION	
	FILL, lean clay, soft to very soft, dark gray brown, trace wood, gravel and rubber	
3.0		844.4
	LEAN CLAY, stiff, gray brown mottled reddish brown, trace fine sand	
6.0		841.4
	FAT CLAY, stiff, dark brown to gray ▽	
8.0		839.4
	LEAN TO FAT CLAY, medium stiff to stiff, gray ▼	
12.0		835.4
	SILTY LEAN CLAY, soft to medium stiff, light brown mottled light gray, trace fine sand	
15.0		832.4

BOTTOM OF BORING

ATTERBERG LIMITS
Sample 2, Depth 3.5-5 feet

LL	PL	PI
42	17	25

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **6.5 feet W.D.**
▼ **9.5 feet A.B.**
Backfilled @ Completion

CFS cfse.com ENGINEERS

Boring Started	**8-19-20**		
Boring Completed	**8-19-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 2**

LOG OF BORING NO. B-51

STATION OFFSET

NORTHING **237,991.3** EASTING **2,108,664.0**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	SS	10	15	*7500		18.5	CL
	PA						
2	SS	15	7	*2500		22.8	CL
	PA						
3	SS	4	50/4"	*3500		16.7	
	PA						
4	SS	5	50/5"			15.1	
	PA						
5	SS	2	50/2"			16.2	
	PA						
6	SS	2	50/2"			21.9	

MATERIAL DESCRIPTION

Surface Elevation: **889.9**

DEPTH, Feet.	MATERIAL DESCRIPTION	Elevation
	FILL, lean clay, very stiff to stiff, dark gray brown and brown mixed, trace gravel	
5.5		884.4
	****SHALE**, weathered, mod. hard to hard, light gray brown	
12.0		877.9
	****SANDSTONE**, weathered, poorly cemented to cemented, shaley, fine grained, light brown to light gray	
19.0	▼ ∇	870.9
	BOTTOM OF BORING	

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **18.5 feet W.D.**

▼ **18.7 feet A.B.**

Backfilled @ Completion

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Boring Started	**8-18-20**		
Boring Completed	**8-18-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 2 of 2**

STATION OFFSET

NORTHING **237,991.3** EASTING **2,108,664.0**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-51

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION

ATTERBERG LIMITS
Sample 1, Depth 1-2.5 feet

LL	PL	PI
43	19	24

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **18.5 feet W.D.**

▼ **18.7 feet A.B.**

Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-18-20**		
Boring Completed	**8-18-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,748.1** EASTING **2,109,414.1**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-52

PROJECT NAME **MSO Field Operations Facility**

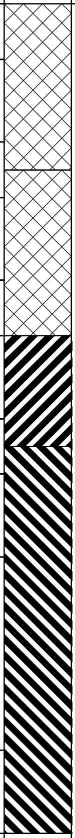
SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL
	PA						
1	SS	3	6	*2000		15.5	CL
	PA						
2	SS	18	21			7.4	SP
	PA						
3	SS	18	25	*8500		21.2	CH
	PA						
4	SS	18	15	*6500		22.2	CL CH
	PA						
5	SS	18	20	*7500		23.1	CL CH

** compressive strength in psi * Calibrated Penetrometer

GRAPHIC LOG



DEPTH, Feet.

MATERIAL DESCRIPTION

Surface Elevation: 843.2

<u>FILL</u>, lean clay, stiff, light brown and brown mixed, with shale fragments

3.0 840.2

<u>FILL</u>, sand, medium dense, fine to medium grained, poorly graded, brown

5

6.0 837.2

<u>FAT CLAY</u>, very stiff, gray brown

8.0 835.2

<u>LEAN TO FAT CLAY</u>, very stiff, brown to light brown mottled reddish brown

10

15 15.0 828.2

BOTTOM OF BORING

<u>ATTERBERG LIMITS</u>
Sample 3, Depth 6-7.5 feet

LL	PL	PI
54	23	31

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS cfse.com

Boring Started	**8-18-20**		
Boring Completed	**8-18-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,750.8** EASTING **2,109,550.2**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-53

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG
	PA							▩
1	SS	8	10			6.4	GM	▩
	PA							▩
2	SS	8	8			4.5	GM	▩
	PA							▩
3	AS					6.1	GM	▩
	PA							▨
4	SS	18	7	*2000		27.1	CL	▨
	PA							▨
5	SS	18	14	*3500		30.8	CL	▨

** compressive strength in psi * Calibrated Penetrometer

MATERIAL DESCRIPTION

Surface Elevation: **840.3**

DEPTH, Feet.	MATERIAL DESCRIPTION	
	FILL, crushed limestone aggregate, loose, brown	
5	∇ ▼	
8.0		832.3
	SILTY LEAN CLAY, medium stiff to stiff, reddish brown, trace fine sand	
10		
15.0		825.3
15	**BOTTOM OF BORING**	

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **5.5 feet W.D.**

▼ **6.0 feet A.B.**

Backfilled @ Completion

CFS cfse.com ENGINEERS

Boring Started	**8-19-20**		
Boring Completed	**8-19-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **238,778.4** EASTING **2,107,663.3**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-54

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG
	PA							
1	SS	11	93/11"			13.4		
	PA							
2	SS	11	92/11"			11.6		

** compressive strength in psi * Calibrated Penetrometer

MATERIAL DESCRIPTION

Surface Elevation: **850.0**

DEPTH, Feet.	MATERIAL DESCRIPTION	
0.5	**Topsoil**, dark brown (4")	849.5
4.5	**SHALY SANDSTONE, weathered, poorly cemented, fine grained, light brown to tan	845.5

BOTTOM OF BORING

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS
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Boring Started	**8-26-20**		
Boring Completed	**8-26-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,753.5** EASTING **2,109,865.2**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-55

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION **Surface Elevation: 841.8**
	PA							▨		<u>**FILL**</u>, lean to fat clay, medium stiff to stiff, dark gray brown and brown mixed
1	SS	11	6	*2000		21.3	CL CH	▨		
	PA							▨		
2	SS	18	7	*2500		28.1	CL CH	▨	5	5.0 836.8
										BOTTOM OF BORING

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS ENGINEERS cfse.com

Boring Started	**8-19-20**		
Boring Completed	**8-19-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

LOG OF BORING NO. B-56

STATION OFFSET

NORTHING **237,639.0** EASTING **2,109,840.4**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.
	PA							▨	
1	SS	10	7	*2500		19.3	CL CH	▨	
	PA							▨	
2	SS	14	10	*4500		17.2	CL CH	▨	5

MATERIAL DESCRIPTION

Surface Elevation: **842.3**

Topsoil, dark brown (3"), weeds

<u>FILL</u>, lean to fat clay, stiff to very stiff, brown and dark brown mixed, with gravel and some fine sand

5.0 837.3

BOTTOM OF BORING

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS
∇ **Dry W.D.**
▼ **Dry A.B.**
Backfilled @ Completion

CFS ENGINEERS
cfse.com

Boring Started	**8-20-20**		
Boring Completed	**8-20-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **238,687.7** EASTING **2,107,480.1**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-57

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

Surface Elevation: 848.2

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION
	PA							^^^	1.0	**Topsoil**, dark brown (12") 847.2
1	SS	18	9	*3500		27.2	CH	▨		**FAT CLAY**, stiff, brown to light brown
	PA							▨		
2	SS	15	7	*2500		27.1	CH	▨		
	PA							▨	5	
3	SS	18	9	*4000		25.3	CH	▨		
	PA							▨	8.0	840.2
4	SS	6	50/6"			13.7		▒		∇ **SHALY SANDSTONE, weathered, poorly cemented, fine grained, light brown to tan
	PA							▒	10	
5	SS	6	50/6"			19.6		▒	14.0	▼ 834.2

BOTTOM OF BORING

ATTERBERG LIMITS
Sample 1, Depth 1-2.5 feet

LL	PL	PI
57	20	37

**Rock classification is based on drilling characteristics and visual observation of disturbed samples. Core samples may reveal other rock types.

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **8.5 feet W.D.**

▼ **13.5 feet A.B.**

Backfilled @ Completion

CFS cfse.com ENGINEERS

Boring Started	**8-26-20**		
Boring Completed	**8-26-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

STATION OFFSET

NORTHING **237,438.7** EASTING **2,109,764.5**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

LOG OF BORING NO. B-58

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

Surface Elevation: 841.5

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION
	PA							▨		**FILL**, fat clay, stiff to soft, light brown and reddish brown mixed, trace gravel
1	SS	14	7	*3500		22.0	CH	▨		
	PA							▨		
2	SS	11	3	*1500		27.3	CH	▨		5.0 836.5
									5	**BOTTOM OF BORING**

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

CFS cfse.com ENGINEERS

Boring Started	**8-20-20**		
Boring Completed	**8-20-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

LOG OF BORING NO. B-59

STATION OFFSET

NORTHING **237,630.4** EASTING **2,109,584.9**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	**MATERIAL DESCRIPTION** **Surface Elevation: 840.0**
	PA							▨		**FILL**, lean clay, very stiff, desiccated, dark gray brown and brown mixed, trace gravel
1	SS	12	18	*9000		16.5	CL	▨		2.5 837.5
	PA							▨		**FILL**, lean to fat clay, very stiff, desiccated, dark gray brown and brown mixed, trace gravel
2	SS	16	15	*5500		20.6	CL CH	▨	5	5.0 835.0

BOTTOM OF BORING

ATTERBERG LIMITS

Sample 1, Depth 1-2.5 feet

LL	PL	PI
42	20	22

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

∇ **Dry W.D.**

▼ **Dry A.B.**

Backfilled @ Completion

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Boring Started	**8-19-20**		
Boring Completed	**8-19-20**		
Drill Rig	**RC-550**	Driller	**LC**
Approved By:	**JJZ**	Project No.	**19-1196**

BOREHOLE INFORMATION **Page 1 of 1**

LOG OF BORING NO. B-60

STATION OFFSET

NORTHING **237,502.2** EASTING **2,109,501.9**

DRILLING COMPANY **RC Drilling, Inc.**

METHOD **6-inch Flight Augers** HAMMER **Auto**

PROJECT NAME **MSO Field Operations Facility**

SITE LOCATION **19th Street & O'Connell Road**
Lawrence, Kansas

OWNER / ARCHITECT **Dake | Wells Architecture**

SAMPLE NO.	SAMPLE TYPE	RECOVERY	STANDARD PENETRATION BLOWS/FT.	UNCONFINED STRENGTH PSF	DRY DENSITY PCF	MOISTURE CONTENT, %	UNIFIED SOIL SYMBOL	GRAPHIC LOG	DEPTH, Feet.	MATERIAL DESCRIPTION Surface Elevation: 840.5
	PA							▨		**FILL**, lean to fat clay, stiff to very stiff, dark gray brown and brown mixed, trace gravel
1	SS	10	8	*3500		24.6	CL CH	▨		
	PA							▨		
2	SS	18	15	*7000		17.4	CL CH	▨	5	5.0 835.5
										BOTTOM OF BORING

** compressive strength in psi * Calibrated Penetrometer

The stratification lines represent the approximate boundary lines between soil and rock types. In-situ the transition may be more gradational in nature.

WATER LEVEL OBSERVATIONS

▽ **Dry W.D.**

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UNIFIED SOIL CLASSIFICATION (ASTM D-2487-98)

MATERIAL TYPES	CRITERIA FOR ASSIGNING SOIL GROUP NAMES			GROUP SYMBOL	SOIL GROUP NAMES & LEGEND
COARSE-GRAINED SOILS >50% RETAINED ON NO. 200 SIEVE	GRAVELS >50% OF COARSE FRACTION RETAINED ON NO 4. SIEVE	CLEAN GRAVELS <5% FINES	Cu>4 AND 1<Cc<3	GW	WELL-GRADED GRAVEL
			Cu>4 AND 1>Cc>3	GP	POORLY-GRADED GRAVEL
		GRAVELS WITH FINES >12% FINES	FINES CLASSIFY AS ML OR CL	GM	SILTY GRAVEL
			FINES CLASSIFY AS CL OR CH	GC	CLAYEY GRAVEL
	SANDS >50% OF COARSE FRACTION PASSES ON NO 4. SIEVE	CLEAN SANDS <5% FINES	Cu>6 AND 1<Cc<3	SW	WELL-GRADED SAND
			Cu>6 AND 1>Cc>3	SP	POORLY-GRADED SAND
		SANDS AND FINES >12% FINES	FINES CLASSIFY AS ML OR CL	SM	SILTY SAND
			FINES CLASSIFY AS CL OR CH	SC	CLAYEY SAND
FINE-GRAINED SOILS >50% PASSES NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT<50	INORGANIC	PI>7 AND PLOTS>"A" LINE	CL	LEAN CLAY
			PI>4 AND PLOTS<"A" LINE	ML	SILT
		ORGANIC	LL (oven dried)/LL (not dried)<0.75	OL	ORGANIC CLAY OR SILT
	SILTS AND CLAYS LIQUID LIMIT>50	INORGANIC	PI PLOTS >"A" LINE	CH	FAT CLAY
			PI PLOTS <"A" LINE	MH	ELASTIC SILT
		ORGANIC	LL (oven dried)/LL (not dried)<0.75	OH	ORGANIC CLAY OR SILT
HIGHLY ORGANIC SOILS		PRIMARILY ORGANIC MATTER, DARK IN COLOR, AND ORGANIC ODOR		PT	PEAT

BEDROCK AND OTHER MATERIAL SYMBOLS

- Weathered Shale
- Shale
- Seamy Limestone
- Joint or Void
- Limestone
- Weathered Sandstone
- Sandstone
- Coal
- Topsoil
- Asphaltic Concrete
- Concrete
- Fill
- Rubble or Debris Fill
- Boulders and Cobble
- Granular Baserock
- Lean to Fat Clay

BEDROCK PROPERTIES & DESCRIPTIONS

ROCK QUALITY DESIGNATION

DESCRIPTION	RQD (%)
Very Poor	0 - 25
Poor	25 - 50
Fair	50 - 75
Good	75 - 90
Excellent	90 -100

BEDDING CHARACTERISTICS

TERM	THICKNESS (inches)
Massive	> 60
Very Thick Bedded	36 - 60
Thick Bedded	12 - 36
Medium Bedded	4 - 12
Thin Bedded	1 - 4
Very Thin Bedded	0.4 - 1
Laminated	< 0.4

DEGREE OF WEATHERING

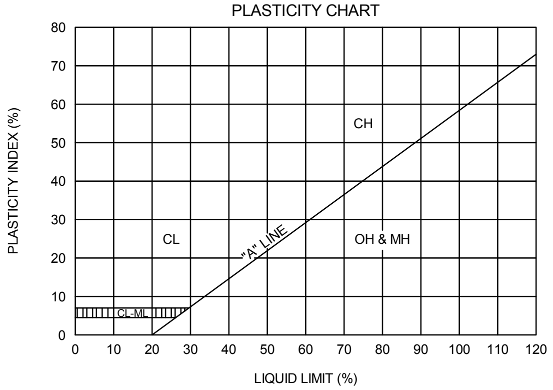
Slightly Weathered - Slight decomposition of Parent material in joints and seams.

Weathered - Well-developed and decomposed joints and seams.

Highly Weathered - Rock highly decomposed, may be extreemly broken.

BEDROCK DISCONTINUITIES

Bedding Planes	Planes dividing the individual layers, beds or strata of rocks.
Joints	Fractures in rock, generally more or less vertical to the bedding.
Seams	Applies to bedding planes with an unspecified degree of weathering.



PENETRATION RESISTANCE
(RECORDED AS BLOWS / 0.5 FT)

SAND & GRAVEL		SILT & CLAY		
RELATIVE DENSITY	BLOWS/FOOT*	CONSISTENCY	BLOWS/FOOT*	COMPRESSIVE STRENGTH (TSF)
VERY LOOSE	0 - 4	VERY SOFT	0 - 2	0 - 0.25
LOOSE	4 - 10	SOFT	2 - 4	0.25 - 0.50
MEDIUM DENSE	10 - 30	MEDIUM STIFF	4 - 8	0.50 - 1.0
DENSE	30 - 50	STIFF	8 - 15	1.0 - 2.0
VERY DENSE	OVER 50	VERY STIFF	15 - 30	2.0 - 4.0
		HARD	OVER 30	OVER 4.0

* NUMBER OF BLOWS OF 140 LB HAMMER FALLING 30 INCHES TO DRIVE A 2 INCH O.D. (1-3/8 INCH I.D.) SPLIT-BARREL SAMPLER THE LAST 12 INCHES OF AN 18-INCH DRIVE (ASTM-1586 STANDARD PENETRATION TEST).

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General Notes and Terms

BORING LOG SYMBOLS

SURFACE MATERIALS

- ▨ TOPSOIL
- ▨ FILL MATERIAL
- ■ ASPHALTIC CONCRETE
- ▨ CONCRETE
- ▨ GRANULAR BASE

COHESIVE SOILS

- ▨ SILT
- ▨ CLAYEY SILT
- ▨ LEAN CLAY
- ▨ LEAN TO FAT CLAY
- ▨ FAT CLAY

LARGE GRANULAR SOILS

- ▨ COBBLES & BOULDERS
- ▨ WELL GRADED GRAVEL
- ▨ POORLY GRADED GRAVEL
- ▨ SILTY GRAVEL
- ▨ CLAYEY GRAVEL

GRANULAR SOILS

- ▨ SANDY SILT
- ▨ SILTY SAND
- □ FINE SAND
- ▨ POORLY GRADED SAND
- ▨ WELL GRADED SAND
- ▨ GRAVELLY SAND

BEDROCK UNITS

- ▨ SHALE
- ▨ FISSILE SHALE
- ▨ SANDSTONE
- ▨ LIMESTONE
- ▨ COAL

WEATHERED BEDROCK

- ▨ JOINT OR VOID
- ▨ WEATHERED SHALE
- ▨ WEATHERED SANDSTONE
- ▨ WEATHERED LIMESTONE

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Key to Soil Symbols and Terms

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE-GRAINED SOILS (major portions retained on No. 200 sieve): includes (1) clean gravel and sands and (2) silty or clayey gravels and sands. Condition is rated according to relative density as determined by laboratory tests or standard penetration resistance tests.

Descriptive Terms	Relative Density	SPT Blow Count
Very loose	0 to 15 %	< 4
Loose	15 to 35 %	4 to 10
Medium dense	35 to 65 %	10 to 30
Dense	65 to 85 %	30 to 50
Very dense	85 to 100 %	> 50

FINE-GRAINED SOILS (major portions passing on No. 200 sieve): includes (1) inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as indicated by penetrometer readings, SPT blow count, or unconfined compression tests.

Descriptive Terms	Unconfined Compressive Strength kPa	SPT Blow Count
Very soft	< 25	< 2
Soft	25 to 50	2 to 4
Medium stiff	50 to 100	4 to 8
Stiff	100 to 200	8 to 15
Very stiff	200 to 400	15 to 30
Hard	> 400	> 30

GENERAL NOTES

1. Classifications are based on the United Soil Classification System and include consistency, moisture, and color. Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate.

2. Descriptions on the boring logs apply only at the specific boring locations and at the time the borings were made. They are not guaranteed to be representative of subsurface conditions at other locations or times.

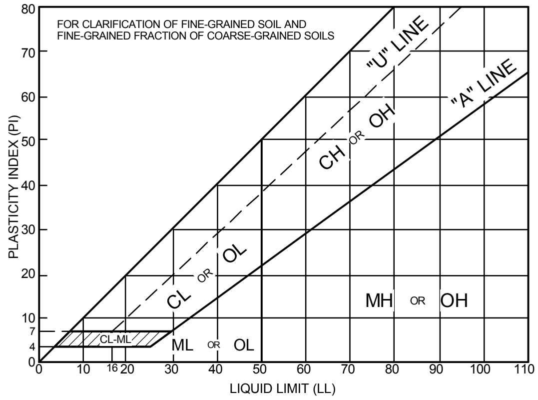
WATER LEVEL OBSERVATIONS

Water level shown on the boring logs were measured at the times indicated, In sands and other granular soils, the indicated levels may reflect the location of groundwater. In clays and other low permeability soils, the accurate determination of the level of the groundwater is not possible with only short-term observations.

WATER LEVEL OBSERVATION DESIGNATION

W.D. - While Drilling
A.B. - After Boring
B.C.R. - Before Casing Removal
A.C.R - After Casing Removal
24 hr. - Water Level takes at approximately 24 hours after boring completion

Major Divisions			Group Symbols		Typical Names	Laboratory Classification Criteria		
Coarse-Grained soils (More than half the material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravel (Little or no fines)	GW		Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain size curve, Depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows: Less than 5 percent...... GW, GP, SW, SP More than 12 percent...... GM, GC, SM, SC 6 to 12 percent...... Borderline case4s requiring dual symbols**	$C_U = \frac{D_{60}}{D_{10}}$ 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	
		Gravel with fines (Appreciable amount of fines)	GM*	d u	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			GC		Clayey gravels, gravel-sand-silt mixtures		Atterberg limits above "A" line or 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*	d u	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			SC		Clayey sands, sand-clay mixtures		Atterberg limits above "A" line or P.I. greater than 7	
Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Silts and Clays (Liquid limit less than 60)		ML		Inorganic silts and very fine sands, rock floor, 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, lean clays			
			OL		Organic silts and organic silty clays of low plasticity			
	Silts and Clays (Liquid limit greater than 60)		MH		Inorganic silts, micaceous or disto-maceous fine sandy or silty soils, organic 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			



Plasticity Chart

Material		Particle Size mm	Particle Size Sieve sizes
Silt or clay		< 0.074	< #200
Sand	Fine	0.074 to 0.42	#200 to #40
	Medium	0.42 to 2.00	#40 to #10
	Coarse	2.00 to 4.76	#10 to #4
Gravel	Fine	4.76 to 19.1	#4 to 3/4 in.
	Coarse	19.1 to 76.2	3/4 in. to 3 in.
Cobble		76.2 to 304.8	3 in. to 12 in.
Boulders		304.8 to 914.4	12 in. to 36 in.

* Division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is based on Atterberg Limits: suffix d used when L.L. is 23 or less and the P.I. is 6 or less; the suffix is used when L.L. is greater than 26.

** Borderline classifications used for soils possessing characteristics of two groups are designated by combinations of groups symbols. For example; GW-GC, well-graded gravel-sand mixture with clay binder.