Geotechnical Engineering Report

3M Warehouse Building

Cynthiana, Harrison County, Kentucky

November 3, 2017

Terracon Project No. N3175057

Prepared for:

3M Center

St. Paul, Minnesota

Prepared by:

Terracon Consultants, Inc.

Lexington, Kentucky

November 3, 2017

3M Center
Bldg. 275-6W-22
St. Paul, Minnesota 55144

Attn: Mr. Mike Maki – Chief Engineer
P: (651) 733 6802
E: example@client.com

Re: Geotechnical Engineering Report
3M Warehouse Building
1308 New Lair Road
Cynthiana, Harrison County, Kentucky
Terracon Project No. N3175057

Dear Mr. Maki:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with our proposal number PN3175057 dated September 19, 2017. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and floor slabs for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

STATE OF KENTUCKY
SAMUEL G. GUY
31238
LICENSED PROFESSIONAL ENGINEER
11/3/17

Samuel G. Guy, P.E.
Geotechnical Department Manager

For
Prasad S. Rege, P.E.
Senior Principal

REPORT TOPICS

Note: This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section, and clicking on the logo in the top right corner will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

REPORT SUMMARY

Topic [1]	Overview Statement [2]
Project Description	21,000-square foot structure Max. Column loads: 150 kips Up to 3 feet of fill to achieve final grade Minor excavation other than foundation construction
Geotechnical Characterization	Alluvial and fill soils to about 5 feet Residual soils below approximately 5 feet Limestone bedrock below a depth range of about 11 to 17 feet Groundwater not encountered
Earthwork	Recommendation related to moving the current building location such that the closest building corner is at least 30 feet away from the crown portion of an existing fill slope Existing lean clays can be used for engineered fill Clays are sensitive to moisture variation
Shallow Foundations	Shallow foundations will be sufficient Allowable bearing pressure = 2,500 psf Expected settlements: < 1 inch total, < ½ inch differential Detect and remove zones of fill as noted in **Earthwork**
Below Grade Structures	Proposed sump pit(s)
General Comments	This section contains important information about the limitations of this geotechnical engineering report.

1. If the reader is reviewing this report as a pdf, the topics above can be used to access the appropriate section of the report by simply clicking on the topic itself.
2. This summary is for convenience only. It should be used in conjunction with the entire report for design purposes.

Geotechnical Engineering Report

3M Warehouse Building
1308 New Lair Road
Cynthiana, Harrison County, Kentucky

Terracon Project No. N3175057
November 3, 2017

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed 3M Warehouse building to be constructed north of the existing manufacturing facility located at 1308 New Lair Road in Cynthiana, Harrison County, Kentucky. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil (and rock) conditions
- Groundwater conditions
- Site preparation and earthwork
- Frost considerations
- Excavation considerations
- Foundation design and construction
- Floor slab design and construction
- Seismic site classification per IBC
- Lateral earth pressures
- Dewatering considerations

The geotechnical engineering scope of services for this project included the advancement of 5 test borings to depths ranging from approximately 11.5 to 27 feet below existing site grades.

Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring logs in the **Exploration Results** section of this report.

GENERAL COMMENTS

Our services are conducted with the understanding of the project as described in the proposal, and will incorporate collaboration with the design team as we complete our services to verify assumptions. Revision of our understanding to reflect actual conditions important to our services will be based on these verifications and will be reflected in the final report. The design team should collaborate with Terracon to confirm these assumptions and to prepare the final design plans and specifications. This facilitates the incorporation of our opinions related to implementation of our geotechnical recommendations. Any information conveyed prior to the final report is for informational purposes only and should not be considered or used for decision-making purposes.

Our analysis and opinions are based upon our understanding of the geotechnical conditions in the area, the data obtained from our site exploration and from our understanding of the project. Variations will occur between exploration point locations, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in the final report, to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our scope of services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third party beneficiaries intended. Any third party access to services or correspondence is solely for information purposes only. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project site is located north of the existing manufacturing facility at 1308 New Lair Road in Cynthiana, Kentucky, with approximate site coordinates of 38.373717°, -84.295961°. See **Site Location**
Existing Improvements	Existing manufacturing plant with buildings, silos, concrete slabs, drive areas, and landscape areas
Current Ground Cover	Grass
Existing Topography	Relatively level
Geology	We have reviewed the Geology of the Shawhan and Cynthiana quadrangles, Kentucky prepared by the United States Geological Survey (USGS) in cooperation with the Kentucky Geological Survey (KGS). The site is located within the Alluvium Formation. The Alluvium Formation, of the Quaternary age, consists of primarily silt, clay, sand, and gravel. Areas north of the project site are located within the Clays Ferry Formation, and the Tanglewood Limestone Member and Millersburg Member of the Lexington Formation. Based on review of the Kentucky Geological Map Information Service, the site is within an area characterized as wide ranging with “non-karst to very high” karst potential. Small mapped sinkholes are located northwest, southwest, and southeast of the 3M campus and specific project site. The Commonwealth of Kentucky maintains a database of permitted surface and deep mines spatially referenced on maps of differing scales. According to available information, there appears to be no commercial-scale deep or surface mining in the project area.

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Our field exploration work included the drilling and sampling of exploratory soil borings consistent with the following:

Number of Borings	Boring Depth (feet) [2]	Planned Location [1]
5	11.5 to 27 feet	Proposed warehouse building

1. As requested by the client.
2. Exploration depth based on local experience with similar projects in the area.

Locations of soil borings are provided on our **Exploration Plan and Site Plan**. The locations of field exploration points were established in the field by the exploration team using a hand-held GPS unit to establish boring locations with reference to known points. The accuracy of the exploration points is usually within 20 feet of the noted location.

We advanced the soil borings with a track-mounted drill rig using hollow stem augers. We primarily obtained samples using the split-barrel sampling procedure. In the split-barrel sampling procedure, a standard, 2-inch O.D., split-barrel sampling spoon is driven into the boring with a 140-pound automatic Standard Penetration Test (SPT) hammer falling 30 inches. We recorded the number of blows required to advance the sampling spoon the last 12 inches of an 18-inch sampling interval as the standard penetration resistance value, N. Bedrock was not encountered during the field exploration.

We reported the sampling depths and the standard penetration resistance values on the boring logs. In the field, we placed the samples into containers, sealed them, and returned them to the laboratory for observation, testing and classification.

Our exploration team prepared field boring logs as part of the drilling operations. These field logs include visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in the laboratory.

Laboratory Testing

The project engineer examined soil samples in the laboratory. Based on the material's texture and plasticity, the field logs were updated to describe and re-classify soil samples in accordance with the Unified Soil Classification System. Various laboratory tests were also assigned to help confirm classifications and better understand the engineering properties of the various soil strata as necessary for this project. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216-10 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D4318-10e1 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- Pocket Penetrometer Readings

GEOTECHNICAL CHARACTERIZATION

Subsurface Profile

Subsurface conditions at the boring locations can be generalized as follows:

Stratum	Approximate Depth to Bottom of Stratum (feet)	Material Description	Consistency/Density
Surface	0.2 to 0.3	Topsoil	N/A
1	2.5 to 5	Fill consisting of lean clay with variable amounts of gravel[1]	N/A
2	11.5 to 17	Cohesive soils (alluvial and residual): silt, lean clay, and fat clay	Stiff to hard
2	Undetermined	Limestone	Strong bedrock hardness rating

1. Fill soils not encountered in boring W-2
2. Boring W-4 terminated within this stratum at a planned depth of approximately 27 feet

Conditions encountered at each boring location are indicated on the individual boring logs shown in the **Exploration Results** section and are attached to this report. Stratification boundaries on the boring logs represent the approximate location of changes in native soil types; in situ, the transition between materials may be gradual.

Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. No water was encountered while drilling or observed after drilling operations were completed in the borings.

The absence of observed water in the borings does not necessarily mean the borings terminated above groundwater, or the water levels summarized above are stable groundwater levels. Due to the low permeability of the soils encountered in the borings, a relatively long period may be necessary for a groundwater level to develop and stabilize in a borehole. Long term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed in the project planning stage. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Project Description	New warehouse building.
Proposed Structure	One story building Approximate dimensions: 120 feet wide x 180 feet long
Building Construction	Pre-fabricated metal building
Finished Floor Elevation (FFE)	729.50 feet
Maximum Loads	■ Columns: 150 kips (provided) (Assumes a 40-foot x 40-foot bay) ■ Floor Slabs: Assumed fork-lift truck traffic and a racking post load of 15 kips (provided) for a total of 30 kips per racking upright. Paper rolls (which are 52 inches in diameter) will weigh 3,000 pounds each and are proposed to be stacked 6 high. This will be in addition to a general area load of 250 psf. (provided)
Grading/Slopes	Based on provided existing grading information from the client and a provided FFE of 729.50 feet, it is proposed that approximately 3 feet of fill will be required for the building pad and no cuts will be required.

Item	Description
Below Grade Structures	Proposed sump pit(s)

GEOTECHNICAL OVERVIEW

This section describes pertinent geotechnical considerations identified by the exploration and laboratory testing. Site preparation recommendations, including subgrade improvement, fill placement, and excavations are provided in the **Site Preparation** section.

Five (5) borings, designated as W-1 through W-5, were performed in the proposed warehouse building location. The borings were advanced approximately 11.5 to 27 feet below the existing ground surface. Based on the information obtained from our subsurface exploration, the site can be developed for the proposed improvements. The following geotechnical considerations were identified:

- A site grading plan was not available at the writing of this report. However, a preliminary plan with the building footprint and existing grades was provided by the client. Based on this information, it appears the building is proposed to bear above and adjacent to an existing slope located on the north side of the property. Due to concerns with the building and associated loads promoting slope instability, it is recommended the proposed building footprint be relocated away from the crown of the existing slope, keeping a minimum distance of at least 30 feet between the building perimeter and edge of the slope. If the building cannot be relocated, additional measures will need to be considered.

- The borings encountered shallow fill soils consisting of lean clays with variable amounts of gravel underlain by alluvial deposits and residual layers of stiff to hard clay and silt overlying strong to very strong limestone. The bedrock was encountered at depths of approximately 11.5 to 17 feet.

- Conversations with the client indicate the existing fill that was previously stockpiled onsite was spread over the proposed building footprint with a grader and placed in a manner that involved limited control and compaction effort to level out the site. While blow counts, hand penetrometer readings, and visual observation indicate the fill has been paced with some manner of control, based on information provided by the client, the fill must be considered undocumented and uncontrolled.

- The site appears suitable for the use of shallow foundations for the proposed building, provided that the following construction recommendations are followed. The foundations should penetrate through the existing fill to bear on at least stiff native soils or bear on structural fill or lean concrete extending to suitable native soils.

- A thickened industrial floor slab is recommended for this site due to the anticipated relatively heavy floor slab loading. The existing fill, when encountered, should be undercut a minimum of two feet (in areas where it extends deeper than two feet) and replaced with properly compacted structural fill meeting low-volume change requirements stated in the **Fill Material Types** section of this report. The thickened slab should be kept independent of the shallow foundations and include a 1-foot thick layer of properly compacted granular structural fill (preferably consisting of dense graded aggregate) below base-of-slab prior to placement of the slab. This will provide for a uniform bearing support across the base of the slab.

- Close monitoring of the construction operations discussed herein will be critical in achieving the design subgrade support. We therefore recommend that Terracon be retained to monitor this portion of the work.

The borings indicated the presence of high plasticity soils with the potential for expansive behavior. Therefore, as discussed above, a 24-inch thick low volume change layer (12 inches of which would consist of granular structural fill) should be constructed beneath proposed floor slab to reduce exposure to these potentially expansive soils. The low volume change layer can also consist of an 12-inch thick layer of lime stabilized moderate to high plasticity soils lying below the 12-inch layer of granular structural fill bed to be located at the base of the proposed floor slab). Foundations (both exterior and interior) should bear a minimum of 3.5 feet below grade to reduce risks associated with high plasticity soils. The **Shallow Foundations** section addresses support of the building bearing directly on native stiff to hard fat clay or engineered fill. The **Floor Slabs** section addresses slab-on-grade support of the building.

Materials with potential for expansive behavior are present on this site. This report provides recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and (at least minor) cracking in the structure should be anticipated. The severity of cracking and other damage such as uneven floor slabs will probably increase if modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. Some of these options are discussed in this report such as complete replacement of expansive soils or a structural slab.

The **General Comments** section provides an understanding of the report limitations.

EARTHWORK

Earthwork will include clearing and grubbing, excavations and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria as necessary to render the site in the state considered in our geotechnical engineering evaluation for foundations, floor slabs, and pavements.

Proposed Grading

Existing surface grades surrounding the proposed building additions range from elevations of about 726 feet to 729 feet within the footprint of the proposed warehouse building. Based on the grading plan containing existing and proposed elevation contours provided by the client and a proposed finished floor elevation (FFE) of 729.5 feet, we anticipate no more than two feet of cut and fill will be performed at this site to achieve desired grades and elevations. If offset of the building is to be performed to address concerns with the current slope, it is anticipated that cut and fill will still be no more than 2 feet to reach proposed site grades.

On the following table we have included information related to the anticipated cuts and fills at various boring locations (for borings W-1 through W-5, located in the building expansion and fill areas) and structure areas of the site:

Boring No.[1]	Location	Existing Ground Surface Elev. (feet)[1]	Proposed Subgrade Elevation (feet)[2]	Cut (-)/ Fill(+) (feet)[3]	Material Anticipated at Subgrade
W-1	SE Building Corner	729	728	-1	Existing Fill
W-2	SW Building Corner	729	728	-1	Native Soil[4]
W-3	NW Building Corner	726	728	+2	New Structural Fill
W-4	NE Building Corner	726	728	+2	New Structural Fill
W-5	Building Center	728	728	0	Existing Fill[5]

1. Estimated based on provided existing site grades plan
2. Approx. subgrade elevation based on grading plan and provided FFE of 729.5 feet.
3. All cut/fill values are approximate and rounded to the nearest foot
4. Native silts with a medium stiff to stiff consistency
5. Existing fill consisting of lean clay with trace amounts of gravel

Encountered Conditions

Existing Fill Slope

The existing site grading plan provided by the client indicates that the building's north wall will run near the crest of an existing fill slope. A portion of the warehouse building is proposed to bear on or within this slope. Site grading plans that indicate how this portion of the site will be developed are not yet available for review at the writing of this report. Review of aerial imagery also indicates a small creek or other drainage feature lies adjacent to and at the base of the existing slope.

It is our opinion that crown loading of the slope due to area loads associated with the building in addition to potential undermining of the existing slope at its toe by the existing drainage feature could result in slope instability and eventual slope failure. Because of these concerns and the potential for other remediation measures to be more cost prohibitive, Terracon recommends that strong consideration be given to relocate the proposed warehouse building further south and west along the property site and away from the existing slope on the property's north and east side, removing the need for reconstruction of the slope or design and construction of a retaining wall. If relocation is considered, the building should rest a minimum of 30 feet away from the crest of the slope.

If it is determined that relocation of the building is not feasible, additional geotechnical exploration and analysis should be performed to determine suitable remediation measures for the existing fill slope prior to development of the site.

Existing Fill and Subgrade Soils

Shallow fill soils consisting mostly of lean clay with variable amounts of rock and sand were encountered at depths varying from about 2.5 to 5 feet. These soils were underlain by mostly stiff to hard native cohesive soils consisting of silts, lean clays and fat clays with limestone fragments. Bedrock was encountered at depths varying from 11.5 to 17 feet of depth.

The encountered fill soils appeared to be placed with some compactive effort. However, conversations with the client indicate that these soils were not placed in a controlled manner and, therefore, must be considered undocumented and uncontrolled.

Moderate to High Plasticity, Potentially Expansive Soils

Atterberg limit test results revealed mostly lean and silty clays near the ground surface in the boring logs. Based on visual classification, moderate to high-plasticity lean clays (CL) and fat clays (CH) were encountered in some of the borings at deeper depths. It is possible that moderate to high plasticity soils will be found near the foundation and floor slab elevations in areas not proposed to receive any structural fill. Moderate to high plasticity soils are potentially expansive and could adversely affect lightly loaded structures, such as foundations, floor slabs, and pavements. If these soils are encountered locally at pavement bearing elevations, an 18-inch undercut of these

soils and replacement with a layer of low volume change (LVC) soils be performed. A minimum 18-inch granular structural fill bed should be placed directly beneath all floor slabs.

Expansive soils are present on this site. This report provides recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and cracking in the structure should be anticipated. The severity of cracking and other damage such as uneven slabs will probably increase if any modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. Some of these options include replacement of expansive soils to deeper depths or post tensioned floor slabs with anchors, etc. are incorporated into the design. We would be pleased to discuss other construction alternatives with you upon request.

Karst Susceptible Rock

Karst features, including clay seams (as indicated by our subsurface exploration); caverns; sinkholes; and highly irregular rock surfaces, are common features within carbonate rocks like those encountered in this exploration. As earlier indicated under **Site Conditions**, the initial limited desktop study performed for this report found that the site is within an Alluvium formation with “non-karst” potential. Adjacent limestone and Clays Ferry formations are characterized by “low” to “very high” karst potential. While multiple karst features (including sinkholes) are mapped to the west and south of the 3M facility, no karstic features have been mapped within the project site.

The scope of services for this geotechnical engineering report did not include exploration for the presence of underground voids or solution cavities that are known to occur within this type of geology. To determine the likelihood of karst activity at the site, additional studies would need to be undertaken. Further assessment of specific, unusual features may include additional exploration and/or geophysical analysis (i.e., resistivity study) to better understand the risk and to aid in generating informed decisions. Because this project lies in a commercially developed area, it is possible that documentation exists regarding the extent of existing depressions and sink holes in the surrounding area and the risk these depressions pose to present infrastructure within the vicinity of the project area. If this documentation is available, it should be provided to Terracon so that we may reassess and revise our recommendations, if necessary.

It should be noted that any construction in karst topography is accompanied by some degree of risk for future internal soil erosion and ground subsidence that could affect the stability of structures situated above the karst features. Proper surface water control during and after construction is recommended so as not to activate old karst features that may be present beneath the site

Site Preparation

Site Preparation: General Recommendations

The following presents general recommendations for site preparation, excavation, and fill placement. Special considerations will be needed where site grading may expose unstable soils. Our recommendations presented for design and construction of earth supported elements (i.e. foundations, slabs, etc.) are contingent upon following the recommendations outlined in this section. All earthwork activities on the project should be observed and evaluated by Terracon.

Vegetation and otherwise unstable materials should be stripped from the site prior to grading operations. Topsoil or other loose, soft or otherwise unsuitable material should be removed from the entire construction area and any sources of on-site borrow material should be stockpiled outside of the construction area.

Removal and/or relocation of any “to be abandoned” utilities should also be performed prior to rough site grading activities. We would anticipate removal and relocation, or re-routing, of any existing utilities which currently exist within the footprint of the proposed development area that would interfere with new construction. Any abandoned underground pipes, left in place, should be fully grouted. Excavations created due to utility relocations or demolition activities should be backfilled with structural fill material, placed and compacted in accordance with the recommendations provided in the following paragraphs or with lean concrete or flowable fill. If lean concrete is used as backfill, the contractor should refer to all of the new build Mechanical-Electrical-Plumbing (MEP) and foundation drawings to confirm that the concrete backfill materials will not conflict with any new item installations or construction.

For the floor slab and any areas to receive structural fill, once any required undercutting is complete and prior to placement of structural fill, the exposed subgrade soils should be carefully proof-rolled under close observation by geotechnical personnel. Due to the presence of moderately to highly plastic soils at various locations through the site, this proof rolling program is very important with respect to evaluating structural fill and floor slab support areas. Proof rolling should be accomplished using a pneumatic-tired, fully-loaded minimum 20 ton tandem-axle dump truck. Soft or yielding areas should be undercut. The proof rolling program should consist of a minimum of 3 passes by the proof rolling equipment.

Based on the boring information stiff to very stiff native soils are anticipated at most locations where native soils are expected to be exposed. However, if undocumented fill soils and/or soft to medium stiff soils are encountered, undercut and/or stabilization may be required. Actual undercut/stabilization depths should be determined based on the results of the proofrolling and testing during construction. If groundwater is encountered during the undercutting process, measures should be implemented to control it during and after construction. Lime stabilization can also be considered in lieu of the undercut to stabilize soft to medium stiff or highly plastic soils. In

this case it will likely be necessary to undercut to a certain depth then lime stabilize the subgrade, as the maximum lime stabilization depths are generally limited to 18 inches for single layer applications. If this option is selected, laboratory testing should be performed to determine the optimum percentage of lime that would be required for stabilization.

After proof rolling and prior to the placement of structural fill in areas below design grade, the subgrade should be scarified, moisture conditioned and recompacted to the density recommended in the **Fill Compaction Requirements** section below. This process will further help to delineate soft or disturbed areas. Unstable areas identified during scarification and recompaction should be undercut to expose stable material.

Fill Material Types

Fill required to achieve design grade should be classified as structural fill and general fill. Structural fill is material used below, or within 10 feet of structures, pavements or constructed slopes. General fill is material used to achieve grade outside of these areas. Earthen materials used for structural and general fill should meet the following material property requirements:

Soil Type [1]	USCS Classification	Acceptable Location for Placement
Low Plasticity Cohesive	CL, CL-ML ML (LL<50)	> 12 inches below building finished grade
High Plasticity Cohesive	CH, MH (LL>50)	> 24 inches below building finished grade
Well graded granular (low-volume change material) [2]	GW, GP, GM, GC, SW, SP, SM, SC	All locations and elevations
On-Site Soils	ML, CL, CH	Onsite soils generally appear suitable for reuse as engineered fill, pending further testing. Highly plastic soils should be placed a minimum of 24 inches below floor slab elevation. Low-plasticity cohesive soils should be placed a minimum of 12 inches below floor slab elevation. Moisture conditioning of the on-site native soils may be required to achieve optimum moisture conditions for placement as engineered fill.

1. Compacted structural fill should consist of approved materials that are free of organic matter and debris. Maximum particle size should be 4 inches in any direction. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation.
2. Similar to KYTC's Dense Graded Aggregate or crushed limestone aggregate. If frost heave is not a concern, limestone screenings or granular material such as sand, gravel or crushed stone may also be used. Material should be approved by the geotechnical engineer.

Fill Compaction Requirements

Structural and general fill should meet the following compaction requirements.

Item	Structural Fill	General Fill
Maximum Lift Thickness	8 inches or less in loose thickness when heavy, self-propelled compaction equipment is used 4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used	Same as Structural fill
Minimum Compaction Requirements [1, 2, 3]	At least 98% of the material's standard Proctor maximum dry density (ASTM D 698)	At least 95% of the material's standard Proctor maximum dry density (provided long-term plans do not include a structure in these areas)
Water Content Range [1]	Low plasticity cohesive: -1% to +2% of optimum High plasticity cohesive: 0 to +4% of optimum Granular: -3% to +3% of optimum	As required to achieve minimum compaction requirements

1. Maximum density and optimum water content as determined by the standard Proctor test (ASTM D 698).
2. High plasticity cohesive fill should not be compacted to more than 100 percent of standard Proctor maximum dry density.
3. If the granular material is a coarse sand or gravel, or of a uniform size, or has a low fines content, compaction comparison to relative density may be more appropriate. In this case, granular materials should be compacted to at least 70% relative density (ASTM D 4253 and D 4254).

Utility Trench Backfill

All trench excavations should be made with sufficient working space to permit construction including backfill placement and compaction. If utility trenches are backfilled with relatively clean granular material, they should be capped with at least 18 inches of cohesive soil to reduce the infiltration and conveyance of surface water through the trench backfill. Backfill placed in utility trenches below pavements should consist of well graded granular materials.

Utility trenches are a common source of water infiltration and migration. All utility trenches that penetrate beneath the foundation should be effectively sealed to restrict water intrusion and flow through the trenches that could migrate below the foundation with a clay plug. The plug material should consist of clay compacted at a water content at or above the soils optimum water content. The clay fill should be placed to completely surround the utility line and be compacted in accordance with recommendations in this report.

Grading and Drainage

Adequate drainage during and after construction will be necessary to control and divert stormwater runoff away from the site. Construction activities should be performed during dryer weather. Some

subgrade instability should be anticipated if construction is planned during wet weather that may require undercutting and/or stabilization.

The design of this project should incorporate a drainage system that minimizes the potential for surface water runoff to collect on the site, especially in isolated areas near the building. Allowing water to pond on the property may cause soil piping to occur within weathered joints which could result in future collapse. This drainage system will require the use of collection basins in the parking lots that should be tied into a stormwater sewer system to carry the water off the property. Additionally, all roof drains should be tied into this system to minimize the added groundwater influx.

Final surrounding grades should be sloped away from the structure(s) on all sides to prevent ponding of water. Gutters and downspouts that drain water a minimum of 5 feet beyond the footprint of the proposed structure(s) are recommended. This can be accomplished through the use of splash-blocks, downspout extensions, and flexible pipes that are designed to attach to the end of the downspout. Flexible pipe should only be used if it is daylighted in such a manner that it gravity-drains collected water. Splash-blocks should also be considered below hose bibs and water spigots.

Earthwork Construction Considerations

Shallow excavations, for the proposed structure, are anticipated to be accomplished with conventional construction equipment. Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of floor slabs. Construction traffic over the completed subgrades should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over, or adjacent to, construction areas should be removed. If the subgrade freezes, desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted, prior to floor slab construction.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, “Excavations” and its appendices, and in accordance with any applicable local, and/or state regulations.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety, or the contractor's activities; such responsibility shall neither be implied nor inferred.

Construction Observation and Testing

The earthwork efforts should be monitored under the direction of the Geotechnical Engineer. Monitoring should include documentation of adequate removal of vegetation and top soil, proof-rolling and mitigation of areas delineated by the proof-roll to require mitigation.

Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency of at least one test for every 2,500 square feet of compacted fill in the building areas. One density and water content test for every 50 linear feet of compacted utility trench backfill.

In areas of foundation excavations, the bearing subgrade should be evaluated under the direction of the Geotechnical Engineer. In the event unanticipated conditions are encountered, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

SHALLOW FOUNDATIONS

Structural loading and foundation plans have not been confirmed at this time. Anticipated loads are based on discussions with the client and experience with similar projects. The anticipated loading conditions provided in this report should be confirmed by the project Structural Engineer. If loading conditions vary from those stated above, Terracon should be retained to review the recommendations in this report.

The foundations can be dimensioned for a net allowable soil bearing pressure of 2,500 psf for isolated spread footings and continuous walls, following the recommendations in this report and maximum structural loads of 150 kips or less. Please notify us if structural loading conditions differ from this assumption so we can revise our recommendations accordingly.

The proposed structure can be supported by spread footings penetrating through existing fill and bearing on at least stiff native soils, or engineered fill or lean concrete placed directly on at least stiff native soils. Any undercut and replacement of unsuitable soils should be replaced with new engineered fill meeting the requirements of the Material Types in the **Site Preparation** section of this report**.**

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

Design Parameters – Compressive Loads

Item	Description
Maximum Net Allowable Bearing pressure [1, 2]	2,500 psf
Required Bearing Stratum [3]	At least stiff native lean clay, engineered fill or lean concrete extending to bedrock or at least stiff lean clay
Minimum Foundation Dimensions	Columns: 24 inches Continuous: 18 inches
Ultimate coefficient of sliding friction	0.35
Minimum Embedment below Finished Grade [6]	24 inches (42 inches if bearing on native soils)
Estimated Total Settlement from Structural Loads [2]	Less than about 1.5 inches
Estimated Differential Settlement [2, 7]	About 2/3 of total settlement

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. An appropriate factor of safety has been applied. These bearing pressures can be increased by 1/3 for transient loads unless those loads have been factored to account for transient conditions. Values assume that exterior grades are no steeper than 20% within 10 feet of structure.
2. Values provided are for maximum loads noted in **Project Description**.
3. Unsuitable or soft soils should be over-excavated and replaced according to the recommendations presented in the **Earthwork**.
4. Use of passive earth pressures require the sides of the excavation for the spread footing foundation to be nearly vertical and the concrete placed neat against these vertical faces or that the footing forms be removed and compacted structural fill be placed against the vertical footing face.
5. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Should be neglected for foundations subject to net uplift conditions.
6. Embedment necessary to minimize the effects of frost and/or seasonal water content variations. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure. Any footings bearing on low-volume change structural fill or lean concrete extending to bedrock should have a minimum embedment below finished grade of 24 inches. To provide additional protection against seasonal shrink/swell and to reduce risk of differential settlement due to non-uniform bearing materials, any footings bearing on native soils should be deepened to extend at least 42 inches below finished exterior and interior grade.
7. Differential settlements are as measured over a span of 50 feet.

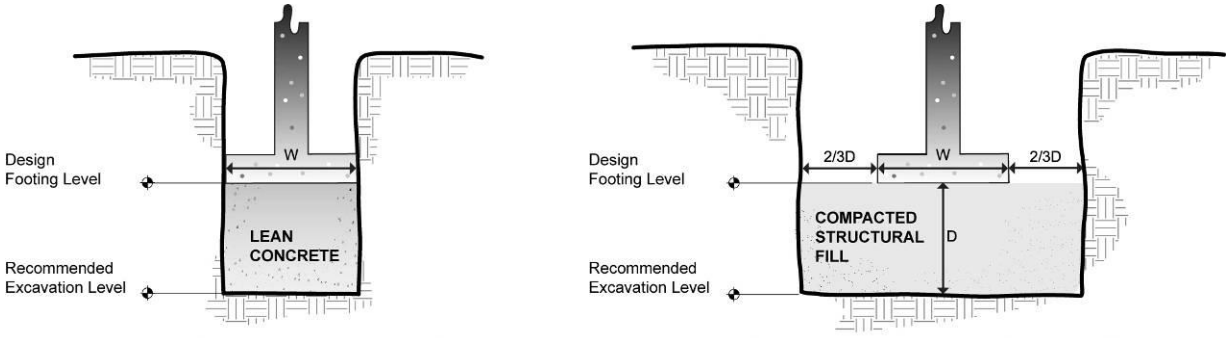
Foundation Construction Considerations

As noted in **Earthwork**, the footing excavations should be evaluated under the direction of the Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing

soil disturbance. Should the soils at bearing level become excessively dry, disturbed or saturated, or frozen, the affected soil should be removed prior to placing concrete. Place a lean concrete mud-mat over the bearing soils if the excavations must remain open over night or for an extended period of time. It is recommended that the geotechnical engineer be retained to observe and test the soil foundation bearing materials.

If unsuitable bearing soils are encountered in footing excavations, the excavations should be extended deeper to suitable soils and the footings could bear directly on these soils at the lower level or on lean concrete backfill (with a minimum strength of 1,000 psi) placed in the excavations. The footings could also bear on properly compacted structural backfill extending down to the suitable soils.

Overexcavation for structural fill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below footing base elevation. The overexcavation should then be backfilled up to the footing base elevation with engineered fill as described in the **Earthwork** section placed in lifts of 8 inches or less in loose thickness and compacted to at least 98 percent of the material's maximum dry density as defined by the Standard Proctor (ASTM D 698). If lean concrete is used as a backfill material, the footing excavation would not need to be widened laterally as would be required for structural fill soils. The overexcavation and backfill procedure is illustrated in the following figures for lean concrete or lean clay material backfill.



NOTE: Excavations in sketches shown vertical for convenience. Excavations should be sloped as necessary for safety.

SEISMIC CONSIDERATIONS

The seismic design requirements for buildings and other structures are based on Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7-10.

Description	Value
2012 International Building Code Site Classification (IBC) [1]	C [2]

1. Seismic site classification in general accordance with the *2012 International Building Code*, which refers to ASCE 7-10.
2. The 2012 International Building Code (IBC) uses a site profile extending to a depth of 100 feet for seismic site classification. Borings at this site were extended to a maximum depth of 27 feet. The site properties below the boring depth to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area. Additional deeper borings or geophysical testing may be performed to confirm the conditions below the current boring depth.

FLOOR SLABS

Client-provided information indicates that the proposed floor slab is going to support racking and paper rolls with estimated point loads of about 30,000 pounds per racking upright. Area loads are anticipated to reach 250psf.

Because it is anticipated there will be moderately-loaded floor slab areas (up to 250psf floor slab area load) and heavy point loads such as those provided above, we recommend the use of an industrial floor slab foundation (or thickened, heavily reinforced slab). It is anticipated that the thickened floor slab will bear at least stiff native soils, on structural fill extending to suitable native soils or on a minimum 2-foot thick structural fill buffer. We recommend that after completion of the site grading program the area directly beneath the slab footprint have at least a 1-foot thick buffer of granular structural fill beneath the bottom of mat/slab foundation level to provide for a uniform bearing material directly beneath the slab.

The majority of existing native soils near the ground surface and underlying the existing fill consisted of lean clays and silts. The clay soils tended to increase in plasticity with depth. High plasticity clays exhibit the potential to swell with increased water content. Construction of the floor slab, combined with revising site drainage creates the potential for gradual increased water contents within the clays. Increases in water content can cause the clays to swell and damage the floor slab. To reduce the swell potential to less than about 1 inch, at least the upper 24 inches of subgrade soils below the floor slab (excluding the floor slab support course) should be an approved Low Volume Change (LVC) material consisting of lean clays, with the upper 12 inches below base of floor slab consisting of the above-mentioned granular structural fill bed.

Due to the potential for significant moisture fluctuations of subgrade material beneath floor slabs supported at-grade, the Geotechnical Engineer should evaluate the material within 18 inches of the bottom of the LVC zone immediately prior to placement of additional fill or floor slabs. Soils below the specified water contents within this zone should be moisture conditioned or replaced with structural fill as stated in our **Earthwork** section.

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

Floor Slab Design Parameters

Item	Description
Floor Slab Support [1]	Minimum 6 inches of free-draining (less than 6% passing the U.S. No. 200 sieve) crushed aggregate compacted to at least 95% of ASTM D 698 [2, 4] At least 12 inches of granular structural fill meeting requirements in the **Earthwork** section of this report At least 18 inches of low plasticity cohesive or granular soils with at least 18% passing the U.S. No. 200 sieve material should be present below floor slabs where lean to fat clay or fat clay soils are present
Estimated Modulus of Subgrade Reaction – Point Loads [2]	100 pounds per square inch per inch (psi/in) for point loads
Estimated Modulus of Subgrade Reaction – Area Loads [3]	8 pounds per square inch per inch (psi/in) for uniformly distributed loads (or area loads)

1. Floor slabs should be structurally independent of building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
2. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in **Earthwork**, and the floor slab support as noted in this table. It is provided for point loads.
3. For large area loads the modulus of subgrade reaction would be lower. Based on an assumed 250 psf contact stress and anticipated settlement of 0.2 inch.
4. Free-draining granular material should have less than 5 percent fines (material passing the #200 sieve). Other design considerations such as cold temperatures and condensation development could warrant more extensive design provisions.

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

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

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

Floor Slab Construction Considerations

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

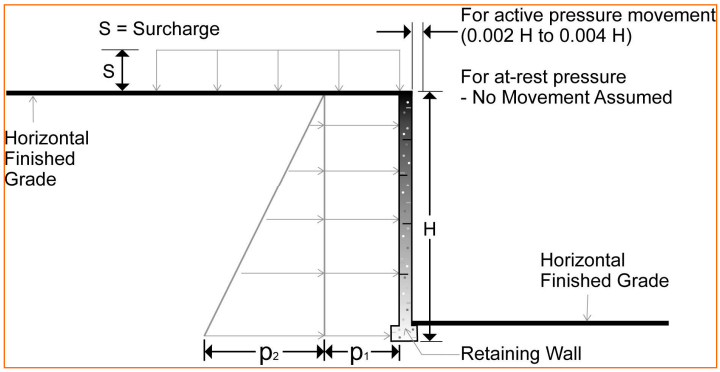
The Geotechnical Engineer should approve the condition of the floor slab subgrades immediately prior to placement of the floor slab support course, reinforcing steel and concrete. Attention should be paid to high traffic areas that were rutted and disturbed earlier, and to areas where backfilled trenches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

LATERAL EARTH PRESSURES

Information provided by the client indicates below-grade separation (or basement) retaining walls will be required for the proposed warehouse building sump pit.

Design Parameters

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls



(unless stated). The lateral earth pressure design parameters in the table below are based on the assumed bulk unit weight of 120 pcf for granular backfill and friction angle of 32 degrees for granular backfill.

Lateral Earth Pressure Design Parameters				
Earth Pressure Condition [1]	**Coefficient for Backfill Type** [2]	**Surcharge Pressure p_1 (psf)** [3, 4, 5]	**Effective Fluid Pressures (psf)** [2, 4, 5]	
			Unsaturated [6]	**Submerged** [6]
Active (Ka)	Granular - 0.31	(0.31)S	(40)H	(80)H
At-Rest (Ko)	Granular - 0.47	(0.47)S	(55)H	(90)H
Passive (Kp)	Granular - 3.25	--	(390)H	(250)H

1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance.
2. Uniform, horizontal backfill, compacted to at least 95 percent of the ASTM D 698 maximum dry density, rendering a maximum unit weight of 120 pcf.
3. Uniform surcharge, where S is surcharge pressure.
4. Loading from heavy compaction equipment is not included.
5. No safety factor is included in these values.
6. In order to achieve "Unsaturated" conditions, follow guidelines in **Subsurface Drainage for Below Grade Walls** below. "Submerged" conditions are recommended when drainage behind walls is not incorporated into the design.

Backfill placed against structures should consist of granular soils. For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively.

Subsurface Drainage for Below Grade Walls

A perforated rigid plastic drain line installed behind the base of walls and extends below adjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line around a below-grade building area or exterior retaining wall should be placed near foundation bearing level. The drain line should be sloped to provide positive gravity drainage to daylight or to a sump pit and pump. The drain line should be surrounded by clean, free-draining granular material having less than 5 percent passing the No. 200 sieve, such as No. 57 aggregate. The free-draining aggregate should be encapsulated in a filter fabric. The granular fill should extend to within 2 feet of final grade, where it should be capped with compacted cohesive fill to reduce infiltration of surface water into the drain system.

As an alternative to free-draining granular fill, a pre-fabricated drainage structure may be used. A pre-fabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion, and is fastened to the wall prior to placing backfill.

FROST CONSIDERATIONS

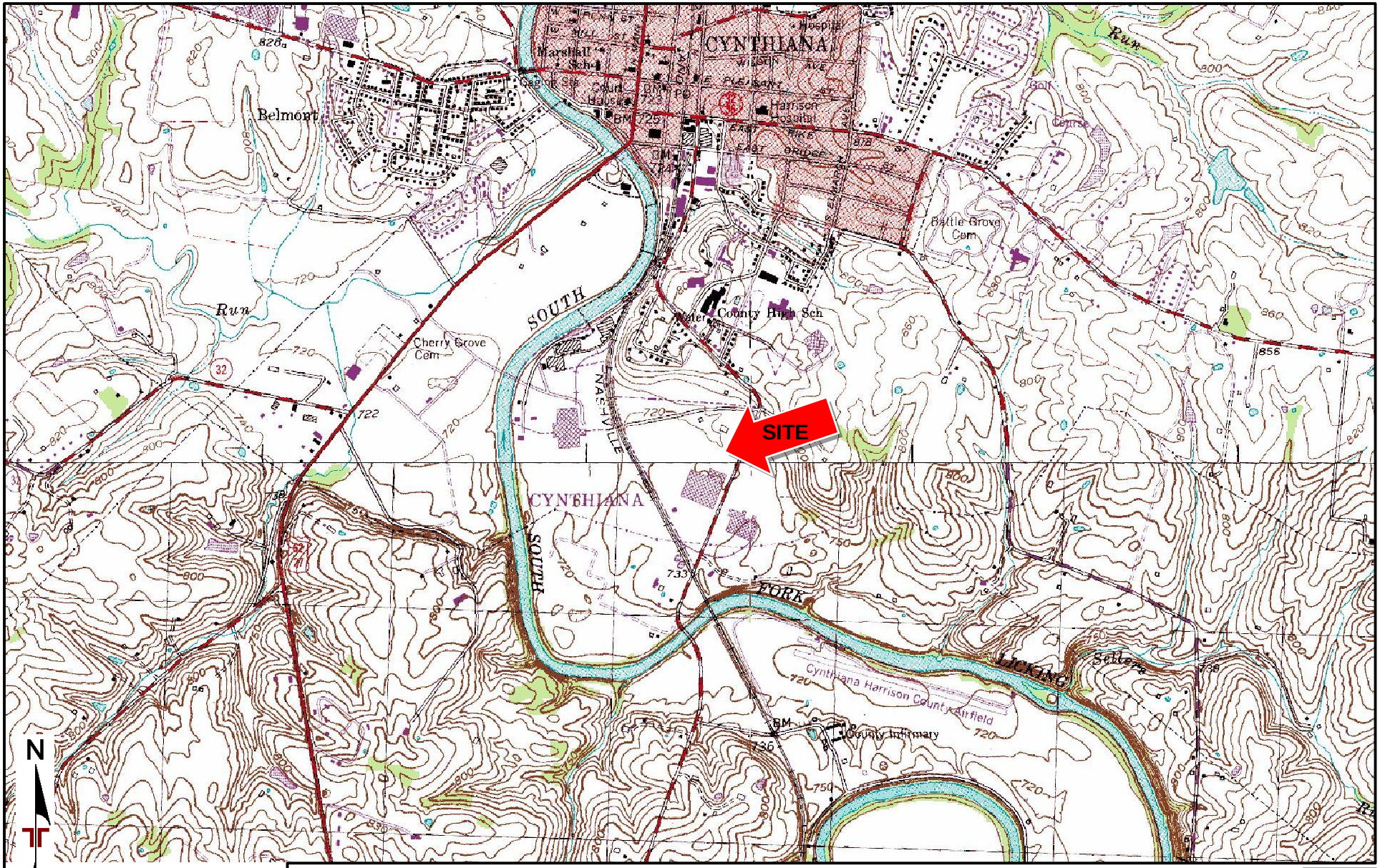
The soils on this site are frost susceptible, and small amounts of water can affect the performance of the slabs on-grade and sidewalks. Exterior slabs should be anticipated to heave during winter months. If frost action needs to be eliminated in critical areas, we recommend the use of non-frost susceptible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

- Provide surface drainage away from the building and slabs, and toward the site storm drainage system
- Install drains around the perimeter of the building, stoops, and below exterior slabs, and connect them to the storm drainage system
- Grade clayey subgrades, so groundwater potentially perched in overlying more permeable subgrades, such as sand or aggregate base, slope toward a site drainage system
- Place NFS fill as backfill beneath slabs critical to the project
- Place a 3 horizontal to 1 vertical (3H:1V) transition zone between NFS fill, and other soils
- Place NFS materials in critical sidewalk areas

As an alternative to extending NFS fill to the full frost depth, consideration can be made to placing extruded polystyrene or cellular concrete under a buffer of at least 2 feet of NFS material.

ATTACHMENTS

SITE LOCATION AND EXPLORATION PLANS



TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY QUADRANGLES INCLUDE: CYNTHIANA, KY (1/1/1978) and SHAWHAN, KY (1/1/1978).

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

Project Manager:	SGG
Drawn by:	JNW
Checked by:	SGG
Approved by:	PSR

Project No.	N3175057
Scale:	1"=2,000'
File Name:	Exhibit 1 & 2
Date:	10-18-2017

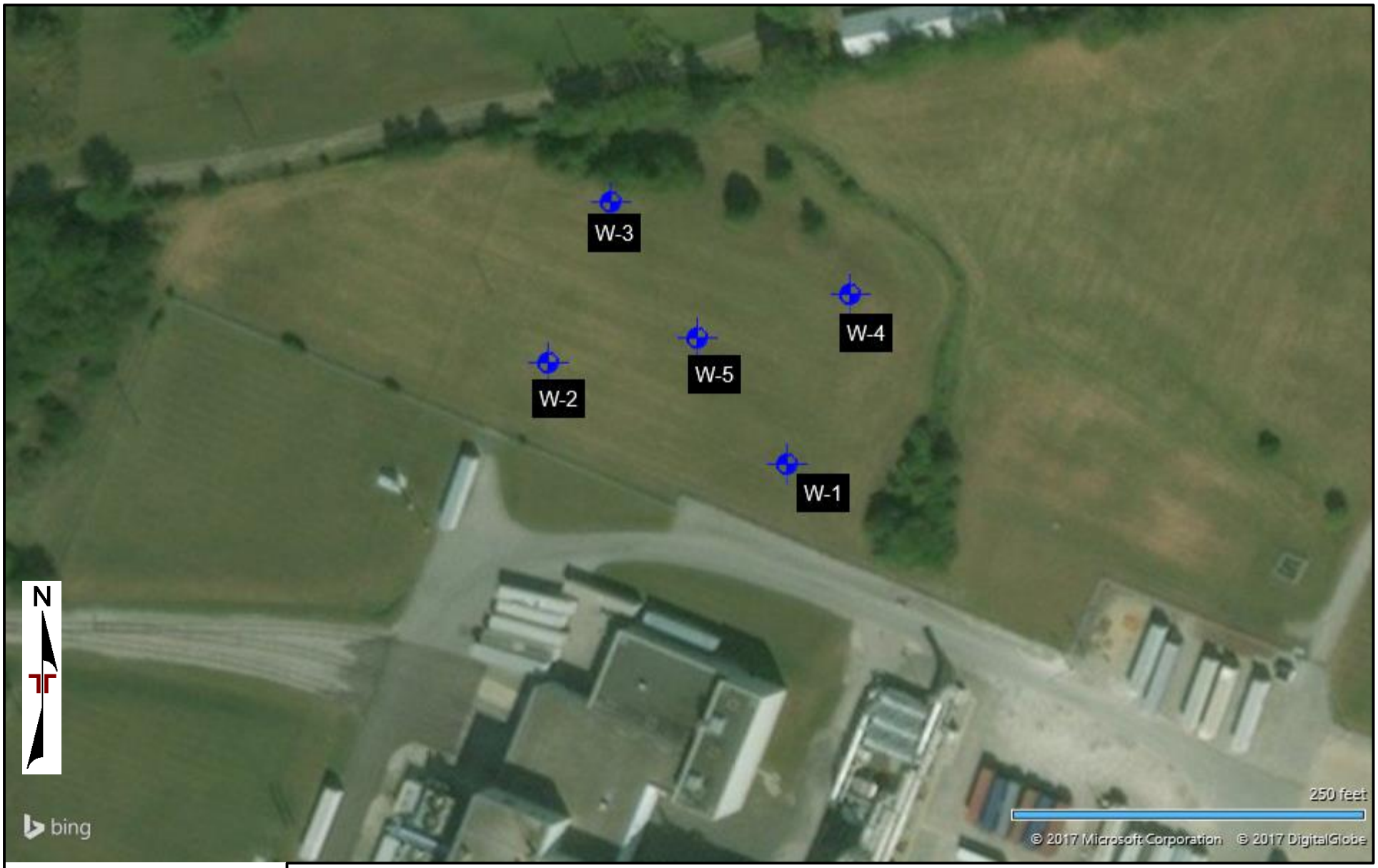
Terracon
2460 Palumbo Drive
Lexington, KY 40509-1117

SITE LOCATION

3M Warehouse Building - Cynthiana
1308 New Lair Road
Cynthiana, KY

Exhibit

A-1



AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

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

Project Manager:	SGG
Drawn by:	JNW
Checked by:	SGG
Approved by:	PSR

Project No.	N3175057
Scale:	AS SHOWN
File Name:	Exhibit 1 & 2
Date:	10-18-2017

Terracon
2460 Palumbo Drive
Lexington, KY 40509-1117

EXPLORATION PLAN

3M Warehouse Building - Cynthiana
1308 New Lair Road
Cynthiana, KY

Exhibit

A-2

EXPLORATION RESULTS

BORING LOG NO. W-1

PROJECT: 3M Warehouse Building - Cynthiana

CLIENT: 3M Facilities Engineering
St. Paul, MN

SITE: 1308 New Lair Road
Cynthiana, KY

LOCATION See Exploration Plan

Latitude: 38.3762° Longitude: -84.2945°

Approximate Surface Elev: 730 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD(%)	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
0.3	729.5+/-										
TOPSOIL											
FILL - LEAN CLAY (CL), trace gravel, gray to brown, noted plant roots				X	14	3-6-8 N=14					
2.5	727.5+/-										
LEAN CLAY (CL), medium to high plasticity, brown to black, stiff to very stiff, lower portion elastic silt like				X	16	6-7-7 N=14		3.5 (HP)		21	
		5		X	16	4-5-6 N=11		2.25 (HP)			
				X	18	4-5-8 N=13		2.75 (HP)		26	
		10		X	18	4-6-7 N=13		2.5 (HP)			49-27-22
14.7	715.5+/-										
Auger Refusal at 14.7 Feet					0	50/0"					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.25" HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
2460 Palumbo Dr
Lexington, KY

Boring Started: 10-04-2017 | Boring Completed: 10-04-2017

Drill Rig: Track | Driller: Steele

Project No.: N3175057

BORING LOG NO. W-2

PROJECT: 3M Warehouse Building - Cynthiana

CLIENT: 3M Facilities Engineering
St. Paul, MN

SITE: 1308 New Lair Road
Cynthiana, KY

LOCATION See Exploration Plan

Latitude: 38.3764° Longitude: -84.2951°

Approximate Surface Elev: 728 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD(%)	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
0.3	727.5+/-										
TOPSOIL											
SILT (ML), brown, medium stiff to stiff, noted plant roots, partly lean clay to silt				X	12	1-3-5 N=8					
2.0	726+/-										
LEAN CLAY WITH ROCK FRAGMENTS (CL), medium to high plasticity, brown, stiff to very stiff				X	13	5-6-6 N=12		4.25 (HP)		24	
		5									
				X	14	4-6-6 N=12		2.5 (HP)		26	
6.0	722+/-										
SILT WITH GRAVEL (ML), brown, stiff to very stiff, mottled black				X	18	5-6-7 N=13					
9.5	718.5+/-										
SANDY FAT CLAY WITH GRAVEL (CH), brown to black, stiff		10		X	14	5-7-7 N=14				23	
11.5	716.5+/-										
Auger Refusal at 11.5 Feet					0	50/0"					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.25" HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
2460 Palumbo Dr
Lexington, KY

Boring Started: 10-04-2017 | Boring Completed: 10-04-2017

Drill Rig: Track | Driller: Steele

Project No.: N3175057

BORING LOG NO. W-3

PROJECT: 3M Warehouse Building - Cynthiana

CLIENT: 3M Facilities Engineering
St. Paul, MN

SITE: 1308 New Lair Road
Cynthiana, KY

LOCATION See Exploration Plan

Latitude: 38.3767° Longitude: -84.295°

Approximate Surface Elev: 726 (Ft.) +/-

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD(%)	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
	0.2	726+/-										
		TOPSOIL				14	2-4-6 N=10					
		FILL - LEAN CLAY (CL), trace gravel, gray, noted plant roots, partly silty clay										
						18	5-8-10 N=18				15	
	5.0	721+/-										
		LEAN CLAY WITH ROCK FRAGMENTS (CL), medium to high plasticity, brown, very stiff to hard, mottled black	5			18	5-7-9 N=16		4.5+ (HP)			
	7.0	719+/-										
		GRAVELLY LEAN CLAY (CL), medium to high plasticity, brown, very stiff				14	6-9-11 N=20				24	
	9.5	716.5+/-										
		FAT CLAY (CH), brown to black, stiff to very stiff	10			18	4-5-7 N=12		3.0 (HP)			50-27-23
	12.0	714+/-										
		Auger Refusal at 12 Feet				0	50/0"					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.25" HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
2460 Palumbo Dr
Lexington, KY

Boring Started: 10-04-2017 | Boring Completed: 10-04-2017

Drill Rig: Track | Driller: Steele

Project No.: N3175057

BORING LOG NO. W-4

PROJECT: 3M Warehouse Building - Cynthiana

CLIENT: 3M Facilities Engineering
St. Paul, MN

SITE: 1308 New Lair Road
Cynthiana, KY

LOCATION See Exploration Plan

Latitude: 38.3765° Longitude: -84.2944°

Approximate Surface Elev: 728 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	RQD(%)	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
0.2	728+/-	**TOPSOIL**								
		FILL - LEAN CLAY (CL), trace gravel, gray to brown		16	1-4-6 N=10					
2.5	725.5+/-									
		LEAN CLAY WITH SAND (CL), gray to brown, stiff to very stiff, lean clay to silt		16	7-8-7 N=15					
5.8	722+/-		5							
		SILT (ML), gray to dark gray, stiff to very stiff		12	4-4-5 N=9		2.0 (HP)			
				14	3-4-6 N=10		2.0 (HP)			37-26-11
10.5	717.5+/-		10							
		LEAN CLAY (CL), gray to brown, stiff to very stiff		18	4-7-7 N=14		2.75 (HP)			
13.0	715+/-									
		LEAN CLAY WITH ROCK FRAGMENTS (CL), brown, stiff to very stiff, residual soil	15	17	4-4-50/5"		1.25 (HP)			43-24-19
17.0	711+/-									
		LIMESTONE, gray, extremely close fracture spacing, laminated to very thinly bedded, unweathered to slightly weathered, strong to very strong rock, moderately weathered from 17 to 19.2 feet, noted multiple residual soil seams from 17 to 19.2 feet, partly shaly	20	47		54				
				59		64		840.52		
			25							
27.0	701+/-			12		38				
		Boring Terminated at 27 Feet								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.25" HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
2460 Palumbo Dr
Lexington, KY

Boring Started: 10-04-2017 | Boring Completed: 10-04-2017

Drill Rig: Track | Driller: Steele

Project No.: N3175057

BORING LOG NO. W-5

PROJECT: 3M Warehouse Building - Cynthiana

CLIENT: 3M Facilities Engineering
St. Paul, MN

SITE: 1308 New Lair Road
Cynthiana, KY

LOCATION See Exploration Plan

Latitude: 38.3764° Longitude: -84.2948°

Approximate Surface Elev: 728 (Ft.) +/-

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD(%)	LABORATORY HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
	0.3	727.5+/-										
	TOPSOIL											
	FILL - LEAN CLAY (CL), trace gravel, gray to brown, noted plant roots					13	3-6-8 N=14					
						18	7-8-9 N=17					
	5.0	723+/-										
	LEAN CLAY WITH ROCK FRAGMENTS (CL), brown to gray, stiff to hard		5			18	3-6-8 N=14		2.5 (HP)		23	
						18	4-7-8 N=15		4.5+ (HP)			30-22-8
			10			16	3-6-6 N=12		3.5 (HP)		24	
	13.5	714.5+/-										
	Auger Refusal at 13.5 Feet					0	50/0"					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
4.25" HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
2460 Palumbo Dr
Lexington, KY

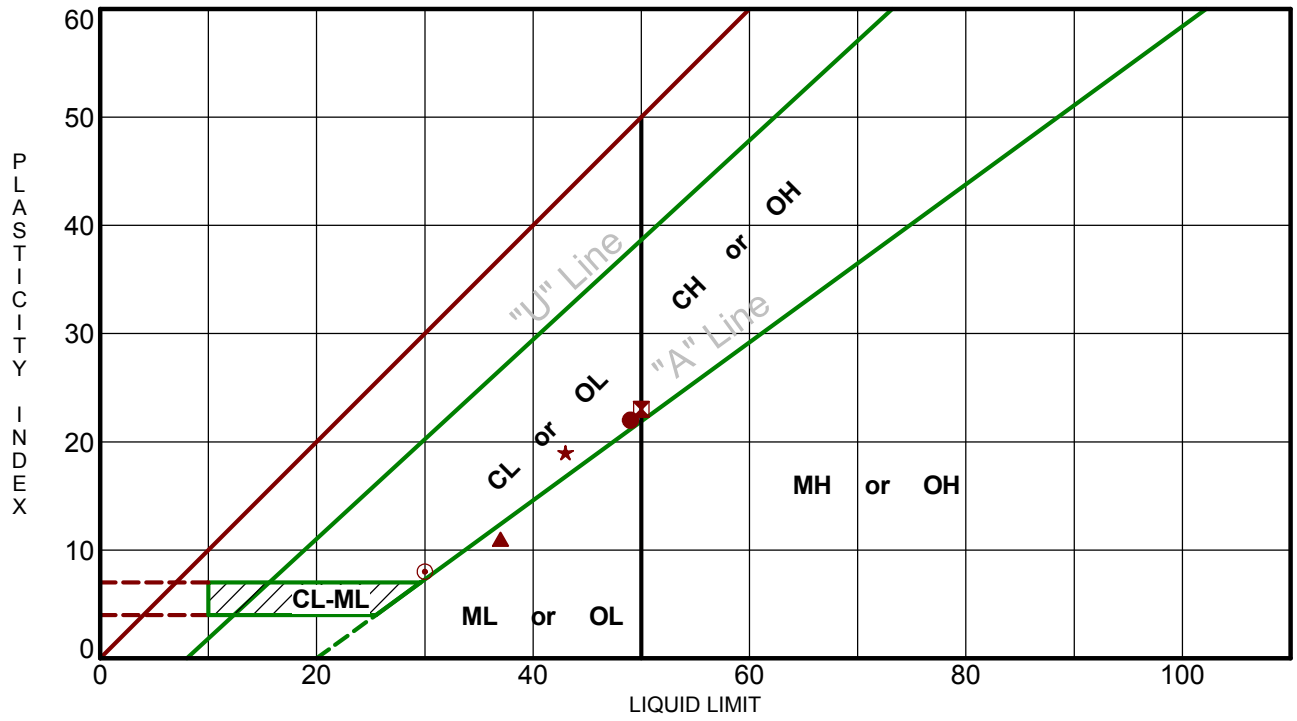
Boring Started: 10-04-2017 | Boring Completed: 10-04-2017

Drill Rig: Track | Driller: Steele

Project No.: N3175057

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID		Depth	LL	PL	PI	Fines	USCS	Description
●	W-1	10 - 11.5	49	27	22		CL	brown lean clay
⊠	W-3	10 - 11.5	50	27	23		CH	brown to black fat clay
▲	W-4	7.5 - 9	37	26	11		ML	gray to dark gray silt
★	W-4	15 - 16.4	43	24	19		CL	brown lean clay
⊙	W-5	7.5 - 9	30	22	8		CL	gray to brown lean clay

PROJECT: 3M Warehouse Building - Cynthiana

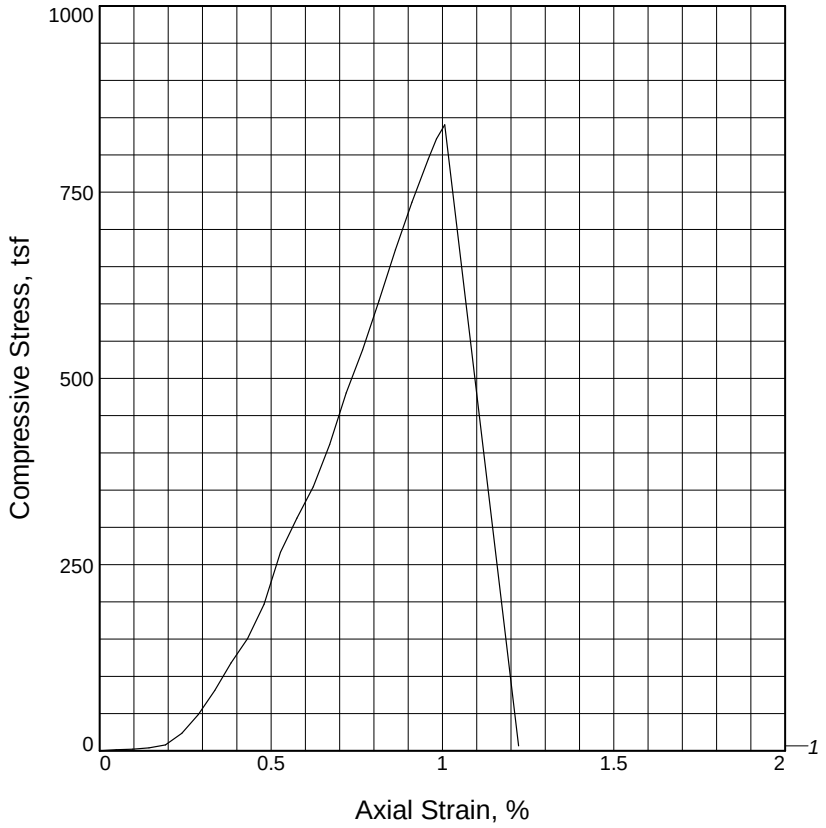
PROJECT NUMBER: N3175057

SITE: 1308 New Lair Road
Cynthiana, KY

Terracon
2460 Palumbo Dr
Lexington, KY

CLIENT: 3M Facilities Engineering
St. Paul, MN

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	840.516			
Undrained shear strength, tsf	420.258			
Failure strain, %	1.0			
Strain rate, in./min.	0.04			
Water content, %	0.2			
Wet density, pcf	163.2			
Dry density, pcf	162.9			
Saturation, %	N/A			
Void ratio	N/A			
Specimen diameter, in.	1.98			
Specimen height, in.	4.17			
Height/diameter ratio	2.10			

Description: LIMESTONE

LL =	**PL =**	**PI =**	**Assumed GS=**	**Type:** Limestone

Project No.: N3175057
Date Sampled: 10-24-17
Remarks:

Exhibit 8079

Client: 3M FACILITIES ENGINEERING

Project: 3M WAREHOUSE BUILDING-CYNTHIANA

Source of Sample: W-4 **Depth:** 22.1-22.8'
Sample Number: 2

UNCONFINED COMPRESSION TEST

Terracon, Inc.
Cincinnati, Ohio

Tested By: DR **Checked By:** GS

SUPPORTING INFORMATION

UNIFIED SOIL CLASSIFICATION SYSTEM

3M Warehouse Building ■ Cynthiana, Harrison County, Kentucky

November 3, 2017 ■ Terracon Project No. N3175057

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ³ 4 and 1 £ Cc £ 3 [E]		GW	Well-graded gravel [F]
			Cu < 4 and/or 1 > Cc > 3 [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ³ 6 and 1 £ Cc £ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3 [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above “A”		CL	Lean clay [K,L,M]
			PI < 4 or plots below “A” line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried	< 0.75	OL	Organic clay [K,L,M,N] / Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above “A” line		CH	Fat clay [K,L,M]
			PI plots below “A” line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried	< 0.75	OH	Organic clay [K,L,M,P] / Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add “with cobbles or boulders, or both” to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ³ 15% sand, add “with sand” to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add “with organic fines” to group name.

[I] If soil contains ³ 15% gravel, add “with gravel” to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add “with sand” or “with gravel,” whichever is predominant.

[L] If soil contains ³ 30% plus No. 200 predominantly sand, add “sandy” to group name.

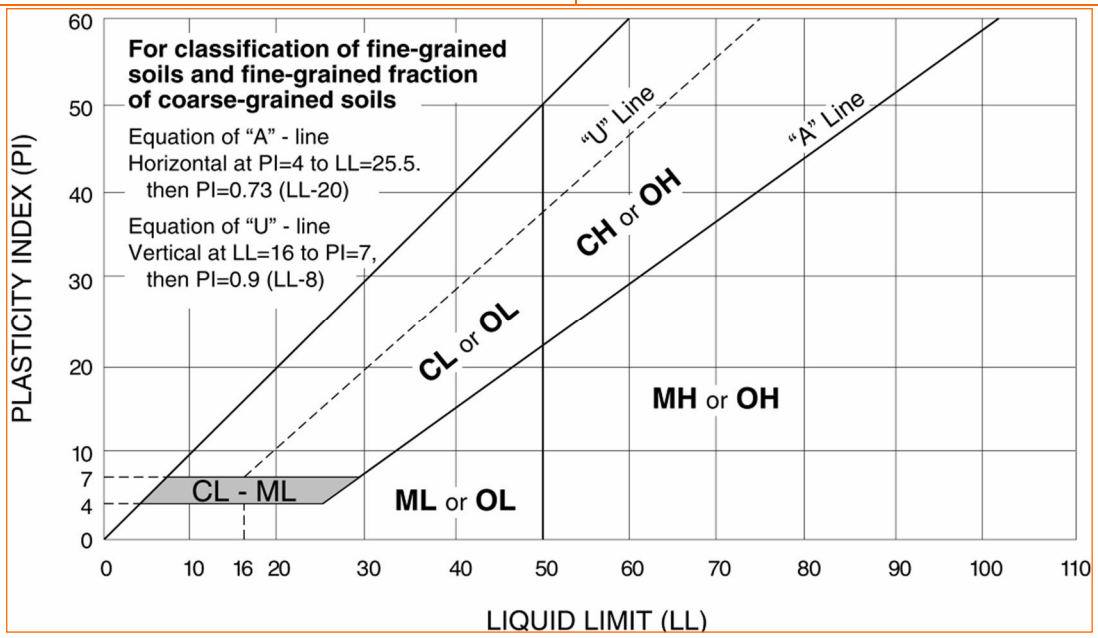
[M] If soil contains ³ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[N] PI ³ 4 and plots on or above “A” line.

[O] PI < 4 or plots below “A” line.

[P] PI plots on or above “A” line.

[Q] PI plots below “A” line.



DESCRIPTION OF ROCK PROPERTIES

3M Warehouse Building ■ Cynthiana, Harrison County, Kentucky

November 3, 2017 ■ Terracon Project No. N3175057

WEATHERING	
Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very Slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately Severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very Severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" no discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)	
Very Hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately Hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very Soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding, and Foliation Spacing in Rock [1]

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

1. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designator (RQD) [1]

RQD, as a percentage	Diagnostic description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

1. RQD (given as a percentage) = length of core in pieces 4 inches and longer / length of run

Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.