Geotechnical Engineering Report
Proposed Warehouse
Franklin Park, Illinois
November 30, 2017
Terracon Project No. MR175365

Prepared for:
Ridge Development Company
Chicago, Illinois

Prepared by:
Terracon Consultants, Inc.
Naperville, Illinois
November 30, 2017

Ridge Development Company
12345 Street Name
Chicago, Illinois 60606

Attn: Mr. Kevin Mohoney

Re: Geotechnical Engineering Report
Proposed Warehouse
9100 Belmont Avenue
Franklin Park, Illinois
Terracon Project No. MR175365

Dear Mr. Mohoney:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with our proposal number PMR175365 dated October 9, 2017. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations, floor slabs, and pavements 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.

Nathan J. Liggett, E.I.
Project Manager

Paul A. Tarvin, P.E.
Regional Geotechnical Manager
REPORT TOPICS

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ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES
SITE LOCATION AND EXPLORATION PLAN
EXPLORATION RESULTS
LABORATORY TESTING RESULTS
SUPPORTING INFORMATION
Geotechnical Engineering Report
Proposed Warehouse
9100 Belmont Avenue
Franklin Park, Illinois
Terracon Project No. MR175365
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INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed warehouse structure(s) to be located at 9100 Belmont Avenue in Franklin Park, Illinois. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Site preparation and earthwork
- Demolition considerations
- Excavation considerations
- Dewatering considerations
- Stormwater pond considerations
- Foundation design and construction
- Floor slab design and construction
- Seismic site classification per IBC
- Lateral earth pressures
- Pavement design and construction
- Frost considerations

The geotechnical engineering scope of services for this project included the advancement of thirteen (13) soil borings to depths ranging from approximately 15 to 35 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 and separate graphs in the Exploration Results section of this report.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and our final understanding of the project conditions is as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Description</td>
<td>A new warehouse structure and associated pavement and storm water management areas are planned at the site.</td>
</tr>
</tbody>
</table>
### Proposed Structures

We understand that there are two concepts currently under consideration. The first concept is to construct a single warehouse building having a footprint of about 176,000 square feet. The second concept is to construct two smaller warehouses, one having a footprint of about 90,000 square feet, and the second building having a footprint of about 88,500 square feet. Under either alternative, the structures will be single-story slab-on-grade buildings. Loading docks will be located on the north side of the larger single building concept, and on the east and west sides of the two-structure concept. Truck docks are expected to be depressed. Storm water detention basins will be located on the north and/or south sides of the parcel.

### Finished Floor Elevation

Not provided

### Maximum Loads

Structural loading was not provided to us. Terracon has assumed the following maximum loadings:

- **Columns**: 250 kips
- **Walls**: 5 kips per linear foot (klf)
- **Slabs**: 250 pounds per square foot (psf)

### Grading/Slopes

Up to 2 or 3 feet of cut and/or fill may be required to develop final site grade. The stormwater detention ponds will require deeper cuts, although exact depths of the ponds have not been provided.

### Below Grade Structures

None

### Free-Standing Retaining Walls

Truck loading docks retaining approximately 4 to 5 feet of soil.

### Below Grade Areas

None.

### Pavements

We assume both rigid (concrete) and flexible (asphalt) pavement sections will be considered.

Pavement loading has not been provided to Terracon. Anticipated traffic loading assumed is as follows:

- **Autos/light trucks**: 50 vehicles per day
- **Light delivery and trash collection vehicles**: 10 vehicles per week
- **Tractor-trailer trucks**: 1,000 vehicles per week

The pavement design period is assumed to be 20 years.

## GEOTECHNICAL CHARACTERIZATION

### Subsurface Profile

We have developed a general characterization of the subsurface soil and groundwater conditions based upon our review of the data and our understanding of the geologic setting. The following page provides a graphical representation of characterization. A statistical summary of field and laboratory data is also included.
The geotechnical characterization as illustrated on the subsequent page forms the basis of our geotechnical calculations and evaluation of site preparation, foundation options and pavement options. As noted in General Comments, the characterization is based upon widely spaced exploration points across the site, and variations are likely.

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

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Approximate Depth to Bottom of Stratum</th>
<th>Material Description</th>
<th>Consistency/Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface 1</td>
<td>1 to 6 inches</td>
<td>Topsoil</td>
<td>N/A</td>
</tr>
<tr>
<td>Surface 2</td>
<td>1 to 2½ feet</td>
<td>Gravel/Stone</td>
<td>N/A</td>
</tr>
<tr>
<td>1</td>
<td>1½ to 5 feet</td>
<td>Fill: Lean clay and sand, trace organics</td>
<td>N/A</td>
</tr>
<tr>
<td>1A</td>
<td>14 3</td>
<td>Fill: Lean clay with sand, trace organics</td>
<td>Medium-stiff to stiff Moisture content: 22% to 30% Dry unit weigh: 91 to 103 pcf</td>
</tr>
<tr>
<td>2</td>
<td>Undetermined: Borings terminated within this stratum at the termination depths of 15 to 35 feet</td>
<td>Native lean clay (CL) and silty clay (CL/ML); occasional sandy zones</td>
<td>Very stiff to hard Moisture content typically less than 22%</td>
</tr>
</tbody>
</table>

1. Encountered in Boring B-6 and B-12 only.
2. Borings B-1 and B-2 were located within the area of deep fill placement from recent environmental soil remediation.
3. Existing documentation provided by the client suggests that the fill may extend as much as 31 feet below existing grade in some areas of the remediated soil zone, although only 14 feet of fill was encountered at the chosen boring locations of B-1 and B-2.

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.

A modified Proctor test was performed on a composite sample of auger cuttings from the fill encountered in B-1 and B-2. The test results indicate a maximum dry density of 121 pounds per cubic foot (pcf) and an optimum water content of 12 percent. These results indicate that the deep fill placed during the environmental remediation were not placed with engineering controls, as the in-situ water content of the fill was approximately 10 to 18 percent above optimum, and the relative compaction of the fill ranged from 75 to 85 percent. If the fill had been placed with engineered controls, we would expect that the moisture content would be within -2 to +4 percent of the optimum, and the dry densities would be within 95 percent of the optimum dry density, in order to provide support of shallow spread foundations.
Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. The water levels observed in the boreholes can be found on the boring logs in Exploration Results, and are summarized below.

<table>
<thead>
<tr>
<th>Boring Number</th>
<th>Approximate Depth to Groundwater while Drilling (feet)</th>
<th>Approximate Depth to Groundwater after Drilling (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>B-2</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>B-10</td>
<td>8½</td>
<td>Dry at completion</td>
</tr>
</tbody>
</table>

1. Below ground surface

Groundwater was not observed in the remaining borings while drilling, or for the short duration the borings could remain open. However, this 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.

Another method to estimate the long-term position of the water table in fine grained soils is to observe the change of the color from brown to gray. The fine-grained soils in this area are typically brown above the water table where they have been oxidized, and gray below. The transition in color from brown to gray generally occurred at depths of about 10 to 12 feet below grade.

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.

GEOTECHNICAL OVERVIEW

The near surface, stiff to hard medium plasticity lean clay could become unstable with typical earthwork and construction traffic, especially after precipitation events. If possible, the grading should be performed during the warmer and drier time of the year. If grading is performed during the wetter months, an increased risk for possible undercutting and replacement of unstable
subgrade will persist. Additional site preparation recommendations including subgrade improvement and fill placement are provided in the Site Preparation section.

The Shallow Foundations section addresses support of the building(s) bearing on native stiff to hard lean clay or engineered fill. Shallow foundations can be proportioned for a net allowable bearing pressure of 4,000 psf.

In the area where existing deep fill is present, the foundations will require supplemental support if full over-excavation and replacement of the existing deep fill is deemed impractical. Supplemental support options are provided in the Specialty Foundations section, which include a discussion on Aggregate Piers and Helical Piers.

The Floor Slabs section addresses slab-on-grade support of the building(s). The floor slabs can be grade supported. Areas where floors are constructed over the existing deep fill will require partial over-excavation and replacement of the existing fill to a depth of at least 3 feet. Alternatively, aggregate piers could be utilized to improve the existing fill soils in lieu of the partial over-excavation and replacement option.

Rigid and flexible pavement system recommendations are provided in this report. The Pavements section addresses the design of pavement systems.

Construction of storm water detention ponds appears feasible at this site. The Stormwater Management section addresses the design of pavement systems.

Support of floor slabs and pavements on or above existing fill materials is discussed in this report. However, even with the recommended construction procedures, there is an inherent risk for the owner that compressible fill or unsuitable material within or buried by the fill will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill, but can be reduced by following the recommendations contained in this report. To take advantage of the cost benefit of not removing the entire amount of undocumented fill, the owner must be willing to accept the risk associated with building over the undocumented fills following the recommended reworking of the material.

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

**EARTHWORK**

Earthwork will include site stripping, existing structure demolition, 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.

Site Preparation

Existing pavement, foundations, floor slabs, utilities, and any loose, soft, or otherwise unsuitable materials should be removed from proposed construction areas. Existing foundations (if present) could remain in place provided they do not interfere with new foundation construction, and there is at least 2 feet of separation between the existing foundation and any new structural element. Any organic soils removed during site preparation should not be used as fill beneath the proposed new building or pavement areas.

Following removal of existing improvements and prior to placing new engineered fill, the exposed soils should be observed and tested by Terracon. A Terracon representative should observe proofrolling of the exposed soils. Proofrolling can be accomplished using a loaded tandem-axle dump truck with a gross weight of at least 25 tons, or similarly loaded equipment. Areas that display excessive deflection (pumping) or rutting during proofroll operations should be improved by scarification and compaction or by removal and replacement with an approved gradation of crushed stone aggregate.

Existing Fill

As noted in Geotechnical Characterization, most borings encountered existing undocumented fill to depths ranging from about 1 to 5 feet. Deeper fills were encountered in borings B-1 and B-2, where we understand environmental remediation was completed. Support of floor slabs and pavements on or above existing fill soils is discussed in this report. However, even with the recommended construction procedures, there is an inherent risk for the owner that compressible fill or unsuitable material within or buried by the fill will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill, but can be reduced by following the recommendations contained in this report.

If the owner elects to construct the floor slabs and pavement on the existing fill, the following protocol should be followed. Once the planned subgrade elevation has been reached the entire floor slab and pavement area should be proof-rolled. Areas of soft, or otherwise unsuitable material should be undercut and replaced with either new structural fill or suitable, existing on site materials.

Fill Material Types

It is expected that most of the inorganic cohesive site soils, with the limitations discussed in this report, could be considered for use as engineered fill for the project. Engineered fill for the project should meet the following material property requirements:
**Fill Type**, **USCS Classification**, **Acceptable Locations for Placement**

<table>
<thead>
<tr>
<th>Fill Type</th>
<th>USCS Classification</th>
<th>Acceptable Locations for Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohesive</td>
<td>CL³, CL/ML³, ML³ (LL ≤ 45 and PI ≤ 20)</td>
<td>Adjacent to footings Below/adjacent to floor slabs and pavement</td>
</tr>
<tr>
<td>Granular</td>
<td>GW, GP, GM, GC SW, SP, SM, SC</td>
<td>Below/adjacent to footings, floor slabs, and pavement</td>
</tr>
<tr>
<td>Unsuitable</td>
<td>CL/CH⁴, CH⁴, MH⁴, OL, OH⁴, PT</td>
<td>non-structural locations</td>
</tr>
</tbody>
</table>

1. Engineered fill should consist of approved materials that are free of organic matter and debris. 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 Terracon for evaluation prior to use on this site.
2. Any organic materials, rock fragments larger than 3 inches, and other unsuitable materials should be removed prior to use as engineered fill.
3. Highly susceptible to frost; unstable when wet, are commonly used for pavement support with the knowledge that additional maintenance and/or shorter pavement life are likely.
4. High plasticity. Not recommended beneath movement sensitive features such as foundations, floor slabs, or pavements.

### Fill Compaction Requirements

Engineered fill should meet the following compaction requirements.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Maximum fill lift thickness**     | ■ 9 inches or less in loose thickness when heavy, self-propelled compaction equipment is used  
                                        ■ 6 inches or less in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used |
| **Minimum compaction requirements** | ■ 95% of the modified Proctor (ASTM Standard D-1557) maximum dry density below foundations and within 1 foot of finished pavement subgrade elevation; the compaction effort should extend laterally beyond the foundations at least 8 inches for every foot of fill placed below the foundation elevation  
                                        ■ 92% below floor slabs, and more than 1 foot below finished pavement subgrade |
| **Moisture content range**          | ■ within 2% below to 4% above the modified Proctor optimum moisture content at the time of placement and compaction  
                                        ■ granular materials should be compacted within workable moisture levels |
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>We recommend that engineered fill be tested for moisture content and compaction during placement. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.</td>
</tr>
<tr>
<td>2.</td>
<td>If the granular material is a coarse sand, crushed limestone, or gravel, is of a uniform size, or has a low fines content, compaction comparison to relative density (ASTM D 4253 and D 4254) may be more appropriate. In this case, granular materials should be compacted to at least 60% and 65% of the maximum relative density for the 92% and 95% modified Proctor recommendations, respectively.</td>
</tr>
<tr>
<td>3.</td>
<td>Specifically, moisture levels should be maintained to achieved compaction without bulking during placement or pumping when proofrolled.</td>
</tr>
</tbody>
</table>

Utility Trench Backfill

For low permeability subgrades, utility trenches are a common source of water infiltration and migration. Utility trenches penetrating beneath the building(s) should be effectively sealed to restrict water intrusion and flow through the trenches, which could migrate below the building. The trench should provide an effective trench plug that extends at least 5 feet from the face of the building exterior. The plug material should consist of cementitious flowable fill or low permeability clay. The trench plug material should be placed to surround the utility line. If used, the clay trench plug material should be placed and compacted to comply with the water content and compaction recommendations for engineered fill stated previously in this report.

Grading and Drainage

All grades must provide effective drainage away from the building(s) during and after construction and should be maintained throughout the life of the structure. Water retained next to the building can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential floor slab and/or foundation movements, cracked slabs and walls, and roof leaks. The roof should have gutters/drains with downspouts that discharge onto splash blocks at a distance of at least 10 feet from the building.

Exposed ground should be sloped and maintained at a minimum 5 percent away from the building for at least 10 feet beyond the perimeter of the building. Locally, flatter grades may be necessary to transition ADA access requirements for flatwork. After building construction and landscaping, final grades should be verified to document effective drainage has been achieved. Grades around the structure should also be periodically inspected and adjusted as necessary as part of the structure’s maintenance program. Where paving or flatwork abuts the structure a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration.
Earthwork Construction Considerations

Terracon should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation, placement and compaction of engineered fills, and backfilling of excavations.

Upon completion of filling and grading, care should be taken to maintain the moisture content of the subgrade soils prior to construction of floor slabs. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Any water that collects over or adjacent to construction areas should be promptly removed. If the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and recompacted prior to floor slab construction and observed by Terracon.

Care should be taken to avoid disturbance of prepared subgrade soils. The near surface native and existing fill soils have elevated moisture contents, and are very easily disturbed, especially by construction traffic. Construction traffic should not operate directly on saturated or low strength soils. If the subgrade becomes saturated, desiccated, or disturbed, the affected materials should either be scarified and compacted, or be removed and replaced as previously discussed. Subgrades should be observed and tested by Terracon prior to construction.

Based on conditions encountered at the boring locations, shallow excavations for footing foundations are not expected to encounter the water table. However, if seepage is encountered, the contractor is responsible for employing appropriate dewatering methods to control seepage and facilitate construction. In our experience, dewatering of shallow excavations in clays and sands above the water table can typically be accomplished with sump pits and pumps.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, “Excavations” and its appendices, as well as other applicable codes, and in accordance with any applicable local, state, and federal safety regulations. The contractor should be aware that slope height, slope inclination, and excavation depth should in no instance exceed those specified by these safety regulations. The existing fill soils are considered Type “C” soils under the OSHA regulations, and the native very stiff to hard clays are considered Type “B” soils. Maximum slope inclinations for Type “C” and Type “B” soils under the OSHA regulations are 1.5H:1V and 1H:1V, respectively. Flatter slopes than those dictated by these regulations may be required depending upon the soil conditions encountered and other external factors. These regulations are strictly enforced and if they are not followed, the owner, the contractor, and/or earthwork and utility subcontractor could be liable and subject to substantial penalties. Under no circumstances should the information provided in this report be interpreted to mean that Terracon is responsible for construction site safety or the contractor’s activities. Construction site safety is the sole responsibility of the contractor who shall also be solely responsible for the means, methods, and sequencing of the construction operations.
SHALLOW FOUNDATIONS

It is our opinion that the warehouse can be supported on shallow spread foundations bearing at typical frost depths on the native very stiff to hard lean clay soils, or on engineered soil fill or lean concrete extending to suitable native bearing soils.

The footings should not be supported on the fill materials due to the lack of documentation available regarding the placement/compaction methods used for these soils and the variability observed in the field test data. The foundations will need to be extended through the undocumented fill and supported on the native very stiff to hard clay. The footings could then be supported at this lower elevation, or the undercut could be backfilled to the design footing elevation with engineered soil fill or lean concrete.

As noted in the Specialty Foundations section, consideration could also be given to improving the deep fills in place with rammed aggregate piers or directly supporting the proposed foundations on a series of helical piers.

Design Parameters

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum net allowable bearing pressure ¹</td>
<td>4,000 psf</td>
</tr>
<tr>
<td>Minimum embedment below finished grade for frost protection ²</td>
<td>3½ feet</td>
</tr>
<tr>
<td>Approximate total settlement from structural loads ³</td>
<td>approximately 1 inch</td>
</tr>
<tr>
<td>Approximate differential settlement ³</td>
<td>1/2 to 2/3 of the total settlement</td>
</tr>
<tr>
<td>Minimum foundation dimensions</td>
<td>Isolated spread footings: 30 inches Continuous footings: 18 inches</td>
</tr>
</tbody>
</table>

1. The recommended maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the foundation base elevation. This pressure may be increased by ⅓ for temporary loads such as wind.
2. For perimeter foundations beneath heated structures. It should be noted that the maximum frost penetration in unheated areas can extend to depths on the order of about 4 feet below grade. If it is desired to reduce the potential for frost heave, foundations below unheated structures, or those that will be exposed to freezing conditions during construction should extend to at least this depth.
3. Foundation settlements will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footings, the thickness of engineered fill, and the quality of the earthwork operations and footing construction, frequent control joints should be provided for walls.

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. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

If unsuitable bearing soils are encountered at the base of the planned footing excavation, the excavation should be extended deeper to suitable soils, and the footings could bear directly on these soils at the lower level or on lean concrete or structural soil backfill placed in the excavations. This is illustrated on the sketches below.

Over-excavation for engineered fill placement below footings should be conducted as shown. The over-excavation should be backfilled up to the footing base elevation, with compacted engineered placed, as recommended in the Earthwork section.

**SPECIALTY FOUNDATIONS**

Where deeper fills are present, those portions of the warehouse could also be supported on shallow spread footings bearing over a system of aggregate piers or helical piers in lieu of complete over-excavation and replacement of unsuitable soils. A discussion regarding these two types of foundation support are discussed in the following sections.

**Aggregate Piers**

Aggregate piers are an intermediate design-build soil reinforcement system that is commonly used to support structures as an alternative to soil over-excavation. The system allows the use of conventional spread footings and slabs cast on-grade, and typically provides settlement control to within 1-inch or less.

Aggregate piers are installed by densifying lifts of aggregate into a cavity that is created by either drilling or displacement methods. Densification takes place with a high-energy beveled tamper or vibratory probe that both densifies the aggregate and forces the aggregate laterally into the
sidewalls of the hole. This action increases the lateral stress in surrounding soil, thereby further stiffening the stabilized composite soil mass. The result of aggregate pier installation is a significant strengthening and stiffening of subsurface soils that then support slabs and conventional shallow spread footings. For the portions of the warehouse which are located within the zone of deep remediated fill placement, we recommend that the individual aggregate pier elements extend through the deep fill soils encountered in the upper 14 to 31 feet of the soil profile and terminate in the underlying very stiff to hard native clay and silty clay. The use of the displacement or drilling method is at the discretion of a design-build aggregate pier contractor.

Aggregate pier designs are based on a two-layer settlement analysis. Settlements within the “upper zone” (zone of soil that is reinforced with aggregate pier elements) are computed using a weighted modulus method that accounts for the stiffness of the aggregate pier elements, the stiffness of the matrix soil, and the area coverage of aggregate pier 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.

After reinforcement with the aggregate pier system, the building foundations may be designed as a conventional spread footing, sized for an allowable bearing pressure on the order of 4,000 psf. The above estimate should be considered preliminary and is based on our past experience with aggregate pier systems in similar soils. The allowable bearing pressure will vary depending on the size, installation methods and spacing of the individual piers. Thus, the actual allowable bearing pressure used in footing design should be developed by an experienced design-build aggregate pier contractor based on the actual pier geometry to be used for construction. We are able to provide a list of qualified aggregate pier design-build contractors at your request.

If the aggregate pier 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, and tests on the completed aggregate pier elements. Terracon can provide these services if requested.

**Helical Piers**

Alternatively, helical piers could be used to directly support the foundations located within the zone of deep fill. Helical piers function as an intermediate design-build foundation system and would distribute the building loads in end bearing to a competent bearing strata below the existing deep fill. Grade beams could then be constructed above the helical piers to support the column and wall loads for the proposed structure. We are able to provide a list of qualified helical pier design-build contractors at your request.

Helical piers consist of helical-shaped circular steel plates welded to a steel bar at a predetermined spacing. The piers are turned into the ground using standard truck or trailer mounted
Augering equipment until suitable bearing strata is reached. Threaded extension bars can be connected to the lead anchor bar in order to reach greater depths. An eye or suitable termination device is attached to the top end of the final extension bar to provide an attachment point for the axial load. Depending on the soil conditions, helical piers can be a cost effective means of providing both tension and compression anchorage for foundations subjected to uplift and overturning loads.

Based on the subsurface profile encountered in the borings, we recommend that the helical pier foundations be designed to bear within the native very stiff to hard lean clay and silty clay soils typically encountered below the existing fill. The design capacity should be determined by the helical pier installer based on the anticipated soil profile and torque to install the helices. The designer should check that the manufacturer rated structural capacity of the individual helices and anchor bar is not exceeded. Additionally, the designer should check that the installation torque required to penetrate a specific soil stratum does not exceed the manufacturer recommended installation torque for a given helix and anchor bar type.

Helical pier systems can be installed with one or multiple helices. The bearing capacity of an individual foundation pier is equal to the sum of the capacities of the individual helices. The individual helix capacity is estimated by calculating the unit bearing capacity of the soil and applying it to the individual helix areas. Friction along the lead bar should not be used when determining the ultimate capacity of the foundation pier. Friction or adhesion on the extension bars may be included if the bars are round and at least 3.5 inches in diameter. Friction may be used with square bar extensions, provided the shaft length is grouted. The helices should be spaced far enough apart to avoid overlapping of the stress zones at each helix. Most helical pier manufacturers produce piers with a minimum three-helix-diameter spacing, which has historically been sufficient to prevent one helix from significantly affecting the performance of another. A maximum of six helices is recommended for an individual anchor.

We recommend that the top helix project a minimum distance of three helix diameters into the prescribed bearing layer. A minimum factor of safety of 2.0 should be used to calculate the allowable bearing resistances for the individual helices, assuming that the actual capacities of the anchors will be verified in the field using torque measurement methods or load tests.

The minimum center to center spacing between individual helical piers should not be less than three times the maximum helix diameter, or three feet, whichever is greater, in order to avoid group effects. The anchor bars should also be checked for buckling.

Exterior pier caps or grade beams should be supported at a minimum depth of 3½ feet below grade for frost considerations. Interior pier caps or grade beams in heated structures can be supported above frost depth. The helical pier connections to the grade beam or pier cap should be designed by a licensed Structural Engineer in the State of Illinois.
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.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012 International Building Code Site Classification (IBC) 1</td>
<td>D 2</td>
</tr>
<tr>
<td>Site Latitude</td>
<td>41.9371</td>
</tr>
<tr>
<td>Site Longitude</td>
<td>87.8536</td>
</tr>
<tr>
<td>$S_{DS}$ Spectral Acceleration for a Short Period 3</td>
<td>0.149 g</td>
</tr>
<tr>
<td>$S_{D1}$ Spectral Acceleration for a 1-Second Period 3</td>
<td>0.099 g</td>
</tr>
</tbody>
</table>

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 35 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.
3. These values were obtained using online seismic design maps and tools provided by the USGS (http://earthquake.usgs.gov/hazards/designmaps/).

FLOOR SLABS

The floor slab for the new structures outside of the limits of the deep fill can be supported at grade on tested and approved existing fill, native lean clay that is relatively free of organic material, or on newly placed engineered soil fill used to raise site grades. We recommend that a minimum 8-inch thick granular leveling course be placed directly below the slab to provide uniform support.

In the area of the existing deep fill, floor slabs may also be grade supported provided that certain measures are taken, and assuming that the site grades will not be raised in this area. The upper 3-feet of the existing deep fill below the proposed floor slab elevation should be removed from within the proposed building footprint. The newly exposed subgrade should then be proofrolled as detailed in the Earthwork section. Assuming the proofroll passes, the excavated area can then be backfilled with newly placed engineered fill to within 8-inches of the proposed floor slab bearing elevation. We recommend that a minimum 8-inch thick granular leveling course be placed directly below the slab to provide uniform support.
Alternatively, floor slab support within the zone of deep fill could be supplemented by a system of rammed aggregate piers in lieu of the proposed partial excavation and replacement. Rammed aggregate piers are discussed in the **Specialty Foundations** section.

If the site grades are to be raised in the area of the existing deep fills, then construction of the floor slabs should be delayed several weeks to allow consolidation of the underlying soft, wet fills under the weight of the newly placed fills. It may be advisable to implement a settlement monitoring program to determine the magnitude and time rate of consolidation of the existing fills. Construction of the floor slabs can then commence once it has been determined that at least 90 percent consolidation of the fill has occurred.

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 out from beneath the floor slab. Additional floor slab recommendations are provided below

**Floor Slab Design Parameters**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Floor Slab Support</strong>&lt;sup&gt;1, 3&lt;/sup&gt;</td>
<td>Minimum 8 inches of free-draining (less than 5% passing the U.S. No. 200 sieve) crushed aggregate compacted to at least 95% of ASTM D 698</td>
</tr>
<tr>
<td><strong>Estimated Modulus of Subgrade Reaction</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
<td>150 pounds per square inch per inch (psi/in) for point loads</td>
</tr>
</tbody>
</table>

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. The recommended modulus value is based on a 12-inch square plate. The modulus value used in design should be adjusted based on the actual size of the floor slab according to the Naval Facilities Engineering Design Manual 7.2, page 7.2-155, Table 4.

3. Assumes that upper 3-feet of fill within the limits of the previous deep fill placement will be excavated and replaced with newly placed and compacted engineered fill.

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**

On most project sites, the site grading is generally accomplished early in the construction phase. However, as construction proceeds, the subgrade may be disturbed by utility excavations, construction traffic, desiccation, rainfall, etc. As a result, corrective action may be required prior to placement of the granular leveling course and concrete.

The condition of the floor slab subgrades should be reviewed and tested immediately prior to placement of the granular leveling course and construction of the slabs. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing the affected material and replacing it with engineered soil fill.

**LATERAL EARTH PRESSURES**

**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).
Lateral Earth Pressure Design Parameters

<table>
<thead>
<tr>
<th>Earth Pressure Condition</th>
<th>Coefficient for Backfill Type</th>
<th>Surcharge Pressure $p_1$ (psf)</th>
<th>Effective Fluid Pressures (psf) $^{2, 4, 5}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active (Ka)</td>
<td>Granular - 0.31</td>
<td>(0.31)S</td>
<td>Unsaturated 6</td>
</tr>
<tr>
<td>At-Rest (Ko)</td>
<td>Granular - 0.47</td>
<td>0.47)S</td>
<td>(80)H</td>
</tr>
<tr>
<td>Passive (Kp)</td>
<td>Granular - 3.25 Fine Grained - 2.46</td>
<td>---</td>
<td>(205)H Submerged 6</td>
</tr>
</tbody>
</table>

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 92 percent of the ASTM D 1557 maximum dry density, rendering a maximum total 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. 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. For interior locations, the granular fill should extend to the floor slab subgrade elevation.
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.

**PAVEMENTS**

**General Pavement Comments**

Estimates of minimum pavement thicknesses are provided for the traffic conditions and pavement life referenced in Project Description. A critical aspect of pavement performance is site preparation. The minimum pavement thicknesses are based on the subgrades being prepared as recommended in the Earthwork.

There is often a time lapse between the end of grading operations and the commencement of paving. Subgrades prepared early in the construction process can become disturbed by construction traffic. Non-uniform subgrades often result in poor pavement performance and local failures relatively soon after pavements are constructed. Depending on the paving equipment used by the contractor, measures may be required to improve subgrade strength to greater depths for support of heavily loaded trucks. Improvements should be made as recommended in Earthwork.

Before paving, and where recommended by Terracon, pavement subgrades should be proofrolled in the presence of a Terracon representative. Proofrolling of the subgrade should help locate soft, yielding, or otherwise unsuitable soil at or just below the exposed subgrade level. Unsuitable areas observed at this time should be improved by scarification and compaction or be removed and replaced with engineered fill. Proofrolling should be accomplished with a fully loaded, tandem-axle dump truck with a minimum gross weight of 25 tons or other equipment providing an equivalent subgrade loading.

Designs for new pavement sections for this project have been based on the procedures outlined in the 1993 Guideline for Design of Pavement Structures by the American Association of State Highway and Transportation Officials (AASHTO-1993). Pavement design methods are intended to provide structural sections with adequate thickness over a particular subgrade such that wheel loads are reduced to a level the subgrade can support.

**Pavement Design Parameters**

Design of Asphaltic Concrete (AC) pavements are based on the procedures outlined in the National Asphalt Pavement Association (NAPA) Information Series 109 (IS-109). Design of Portland Cement Concrete (PCC) pavements are based upon American Concrete Institute (ACI) 330R-01; Guide for Design and Construction of Concrete Parking Lots.
A subgrade CBR of 5 was used for the AC pavement designs, and a modulus of subgrade reaction of 150 pci was used for the PCC pavement designs. The values were empirically derived based upon our experience with the describe soil type subgrade soils and our understanding of the quality of the subgrade as prescribed by the Site Preparation conditions as outlined in Earthwork.

Pavement Section Thicknesses

All pavements should be designed for the types and volumes of traffic, subgrade and drainage conditions that are anticipated. Traffic patterns and anticipated loading conditions were not available at the time that this report was prepared; however, we anticipate that traffic loads will be produced primarily by truck traffic, automobile traffic, and occasional delivery and trash removal trucks. Based upon the traffic loads provided in Project Description, we have developed recommended minimum pavement sections for both bituminous and portland cement concrete, where the subgrade appears firm under proofrolling at the time of construction.

The recommended minimum pavement sections are provided in the following table. The minimum thicknesses provided are based on the assumption of 18-kip Equivalent Single Axle Load Applications (ESAL\textsubscript{18}) for standard duty and heavy duty traffic areas over a 20-year design life, and are provided in the table below. Greater pavement and/or base course thicknesses may be required for greater expected traffic loads and volumes, or if poorer subgrade conditions are encountered. The actual design thickness of pavements should be evaluated using expected traffic volumes, vehicle types, and vehicle loads and should be in accordance with local, city or county ordinances.

<table>
<thead>
<tr>
<th>Pavement Type</th>
<th>Location</th>
<th>Design ESAL’s Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Duty</td>
<td>Rigid (Concrete)</td>
<td>40,000</td>
</tr>
<tr>
<td></td>
<td>Flexible (Bituminous)</td>
<td>30,000</td>
</tr>
<tr>
<td>Heavy Duty</td>
<td>Rigid (Concrete)</td>
<td>4,280,000</td>
</tr>
<tr>
<td></td>
<td>Flexible (Bituminous)</td>
<td>2,475,000</td>
</tr>
</tbody>
</table>

The following pavement design parameters were used in our evaluation of estimating minimum pavement sections for the project.

<table>
<thead>
<tr>
<th>Input Parameter</th>
<th>Asphalt</th>
<th>Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>reliability</td>
<td>85%</td>
<td>85%</td>
</tr>
<tr>
<td>initial serviceability</td>
<td>4.2</td>
<td>4.5</td>
</tr>
<tr>
<td>terminal serviceability</td>
<td>2.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Based upon the expected traffic and subgrades being prepared as recommended in this report, the following estimated minimum pavement thicknesses should be considered as the minimum sections.

<table>
<thead>
<tr>
<th>Pavement Area</th>
<th>Pavement Type</th>
<th>Surface Course</th>
<th>Asphalt Binder</th>
<th>Base Course</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Duty</td>
<td>Rigid (Concrete)</td>
<td>5</td>
<td>-</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Flexible (Bituminous)</td>
<td>1½</td>
<td>2½</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Heavy Duty</td>
<td>Rigid (Concrete)</td>
<td>8</td>
<td>-</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Flexible (Bituminous)</td>
<td>2</td>
<td>4</td>
<td>10</td>
<td>16</td>
</tr>
</tbody>
</table>

7. Portland cement concrete pavements are recommended for areas subject to repeated truck traffic.
8. IDOT CA-6 or an approved alternategradation.
9. IDOT requires that the minimum AC binder lift thickness be 3 times the nominal maximum aggregate size. For a typical IDOT binder mix (IL-19.0 N50), the minimum lift thickness would be 2¼ inches.
10. If asphalt pavements are used in truck traffic areas, the owner must accept the potential for some rutting/shoving of the pavement surface. Frequent mill-and-overlay rehabilitation or other pavement repairs may be required if asphalt pavements are used in areas subject to turning trucks and/or heavy static loads (e.g., parked trucks/trailers).

Construction traffic on the pavements was not considered in developing the estimated minimum pavement thicknesses. If the pavements will be subject to construction equipment/vehicles, the pavement section should be revised to consider the additional loading.

Pavement Drainage

The pavement sections provided above are based on no significant increase in the moisture content of the subgrade soils. Paved areas should be sloped to provide rapid drainage of surface water and to drain water away from the pavement edges. Water should not be allowed to accumulate on or adjacent to the pavement, since this could saturate and soften the subgrade soils and subsequently accelerate pavement deterioration. Periodic maintenance of the pavements will be required. Cracks should be sealed, and areas exhibiting distress should be repaired promptly to help
prevent further deterioration. Even with periodic maintenance, some movement and related cracking may still occur and repairs may be required.

Even in the absence of shallow groundwater, a drainable base and drains can substantially increase pavement life. We recommend that drains be installed where a granular base is used or subsurface water is within 4 feet of the final subgrade elevation. The drainable base should be constructed with at least 6 inches of clean, well-graded crushed limestone with less than 5% passing the No. 200 sieve. The drainable base should hydraulically connect to the drains to allow for proper drainage. Upon request, we are available to discuss this further with you.

Pavement Maintenance

The pavement sections provided in this report represent minimum recommended thicknesses, and for this reason, periodic maintenance should be anticipated. Preventive maintenance should be planned and provided for through an on-going pavement management program. Preventive maintenance activities are intended to slow the rate of pavement deterioration. Preventive maintenance consists of both localized maintenance (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Preventive maintenance is usually the first priority when implementing a planned pavement maintenance program. Prior to implementing any maintenance, additional engineering observation is recommended to determine the type and extent of preventive maintenance.

STORMWATER MANAGEMENT

In our opinion, construction of detention ponds at this site appear feasible. Lean clay soils were encountered at depths extending to about 15 feet below grades in the storm water basin areas. Most of the clay materials (native and existing fill) encountered would likely be suitable for use as a liner, as long as they do not contain significant organic material, sand pockets, or gravel content.

The estimated infiltration rates based on the default tables provided in the WDNR Technical Standard 1002 would be on the order of about 0.07 inches per hour for the lean clay and silty clay soils encountered in the borings. Laboratory moisture-density relationship (Proctor) and remolded permeability tests could be performed on samples of the different clay soils from on-site and/or off-site sources to better evaluate their suitability for use as a liner material. We are available to perform these tests upon request.

Terracon should observe the exposed subgrade soils following removal of organic soils and prior to construction of the liner. Before placing any new fill, the subgrade soils should be scarified to a depth of approximately 9 inches, moisture conditioned, and compacted as recommended to the density and moisture content ranges recommended in this report. Scarification and compaction of the subgrade soils should help provide a firmer base for placing engineered fill and should help
delineate soft or disturbed areas that may exist at shallow depths. Unsuitable subgrade materials observed during this process should be improved by compaction or be removed and replaced with engineered fill.

In our opinion, the pond liner should consist of a minimum 2-foot thick layer of engineered clay fill or soil-bentonite mixture fill that is placed and compacted as recommended in this report. Clay fill materials or soil-bentonite mixture used for liner construction should be processed to be free of clods greater than about 1 inch in size and placed in horizontal lifts of 9 inches or less in loose thickness. Each lift should be compacted to at least 90% of the standard Proctor dry density. The liner material should be uniformly moisture conditioned at the time of compaction within 0 to +4% of the material’s optimum moisture content as determined by the modified Proctor test. The pond side slopes should be no steeper than 3H:1V.

The completed earthen liner should be protected from desiccation and cracking prior to filling the pond. If the liner becomes dry, desiccated, or cracked prior to filling or during the life of the pond, the clay liner should be scarified, moisture conditioned, and recompacted.

The clay liner should typically have a coefficient of permeability of $1 \times 10^{-7}$ cm/sec or lesser. On-site or imported clay fill materials used for liner construction should have a liquid limit of 45 or less and a plasticity index of at least 15. We recommend that potential import materials be evaluated by conducting laboratory permeability tests prior to bringing the material on-site.

**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.
EXPLORATION AND TESTING PROCEDURES
EXPLORATION AND TESTING PROCEDURES

Field Exploration

<table>
<thead>
<tr>
<th>Number of Borings</th>
<th>Boring Depth (feet)</th>
<th>Planned Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>20</td>
<td>Planned building areas</td>
</tr>
<tr>
<td>2</td>
<td>35</td>
<td>Remediated deep fill areas in planned building area</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>Storm water detention areas</td>
</tr>
</tbody>
</table>

**Boring Layout and Elevations:** The drill crew provided the boring layout in the field. Coordinates were obtained with a handheld GPS unit (estimated horizontal accuracy of about ±10 feet) and approximate elevations are obtained by interpolation from a provided site topographic plan. If elevations and a more precise boring layout are desired, we recommend the boring locations be surveyed.

**Subsurface Exploration Procedures:** The borings were advanced with a track-mounted rotary drill rig using continuous flight augers (solid stem and/or hollow stem as necessary depending on soil conditions). Typically, four samples are obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. The four borings within the storm water detention areas were sampled continuously to the boring termination depth. The two borings within the remediated fill area were sampled at 2.5-foot intervals throughout the fill depth. In the thin-walled tube sampling procedure, a thin-walled, seamless steel tube with a sharp cutting edge is pushed hydraulically into the soil to obtain a relatively undisturbed sample. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon is driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. We observe and record groundwater levels during drilling and sampling. For safety purposes, all borings are backfilled with a mixture of auger cuttings and bentonite chips after their completion. In addition to the soil sampling listed above, the crew obtained a bulk sample of the auger cuttings from borings B-1 and B-2 in order to perform a modified Proctor test in the lab.

The sampling depths, penetration distances, and other sampling information are recorded on the field boring logs. The samples are placed in appropriate containers and taken to our soil laboratory for testing and classification by a geotechnical engineer. Our exploration team prepares 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 are prepared from the field logs. The final boring logs represent the geotechnical
engineer’s interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

**Laboratory Testing**

The project engineer reviews the field data and assigns various laboratory tests to 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 because 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 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D422 Standard Test Method for Particle-Size Analysis of Soils
- ASTM D1557 Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort

The laboratory testing program often includes examination of soil samples by an engineer. Based on the material’s texture and plasticity, we describe and classify the soil samples in accordance with the Unified Soil Classification System.
SITE LOCATION AND EXPLORATION PLANS
SITE LOCATION
Belmont Warehouse ■ Franklin Park, IL
November 30, 2017 ■ Terracon Project No. MR175365

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

TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY QUADRANGLES INCLUDE: ELMHURST, IL (1/1/1997) and RIVER FOREST, IL (1/1/1997).
EXPLORATION RESULTS
NOTE: This boring log is not valid if separated from original report.

**LOCATION**
See Exploration Plan
Latitude: 41.9376° Longitude: -87.8541°
Approximate Surface Elev: 629 (FL) +/-

**FILL - LEAN CLAY WITH SAND**, black to dark brown

1.020.58
0.54
1.00
1.371.94

24272524221991515141211119

94939310098108
118117
127

615+/-
609+/-
604+/-
594+/

**LEAN CLAY (CL)**, trace sand and gravel, gray, very stiff

14.0 Geotextile membrane observed at approximately 14 feet

**SILTY CLAY (CL/ML)**, trace sand and gravel, gray, very stiff

20.0

**LEAN CLAY (CL)**, trace sand and gravel, gray, hard

14.0

**Boring Terminated at 35 Feet**

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

**ADVANCEMENT METHOD:**
3-1/4” Hollow Stem Auger

**ABANDONMENT METHOD:**
Boring backfilled with Auger Cuttings and/or Bentonite

**PROJECT:** Belmont Warehouse

**SITE:** 9100 Belmont Avenue
Franklin Park, Illinois

**CLIENT:** Ridge Development Company, LLC
Chicago, Illinois

**ELEVATIONS**
Approximate Surface Elev: 629 (FT.) +/- 615+/

**WATER LEVEL OBSERVATIONS**

<table>
<thead>
<tr>
<th>DEPTH (Ft.)</th>
<th>WATER LEVEL OBSERVATIONS</th>
<th>FIELD TEST RESULTS</th>
<th>SAMPLE NUMBER</th>
<th>LABORATORY UNCONFINED COMPRESSIVE STRENGTH (tsf)</th>
<th>WATER CONTENT (%)</th>
<th>DRY UNIT WEIGHT (pcf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>1</td>
<td>0.50 (HP)</td>
<td>10</td>
<td>1.02</td>
<td>24</td>
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<tr>
<td>9</td>
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<td>27</td>
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<td>8</td>
<td>3</td>
<td>1.00 (HP)</td>
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<tr>
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<td>0.50 (HP)</td>
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<tr>
<td>17</td>
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<td>0.50 (HP)</td>
<td>16</td>
<td>1.94</td>
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<td>117</td>
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<tr>
<td>20</td>
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<td>2.50 (HP)</td>
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<td>7.00</td>
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<td>18</td>
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<td>18</td>
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<td>6.00 (HP)</td>
<td>19</td>
<td>9.00</td>
<td>11</td>
<td>9</td>
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</tbody>
</table>

**Field Test Results:**

- Recovery (%)
- Field Test Results
- Sample Number
- Laboratory Unconfined Compressive Strength (tsf)
- Water Content (%)
- DRY UNIT WEIGHT (pcf)

**Notes:**

- Project No.: MR175365
- Driller: GEOCON/Robert
- Boring Started: 11-13-2017
- Boring Completed: 11-13-2017
- Drill Rig: D-120 ATV
- Driller: GEOCON/Robert
- 9' while sampling
- 15' upon completion

---

**Driller:** GEOCON
650 W Lake St Ste 420
Chicago, IL

---

**Boring Log No. B-1**

---

**BELMONT WAREHOUSE**

---

**GEO SMART LOG-NO WELL  MR175365 BELMONT WAREHOUSE.GPJ  TERRACON_DATATEMPLATE.GDT  11/30/17**

---

**Elevations estimated from a provided site topographic plan.**

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.
**BORING LOG NO. B-2**

**PROJECT:** Belmont Warehouse

**SITE:** 9100 Belmont Avenue
Franklin Park, Illinois

**CLIENT:** Ridge Development Company, LLC
Chicago, Illinois

**LOCATION**
See Exploration Plan
Latitude: 41.9377° Longitude: -87.8539°
Approximate Surface Elev: 629 (FL.) +/-

---

**FILL - LEAN CLAY WITH SAND**, black to dark brown

**LEAN CLAY (CL)**, trace sand and gravel, gray, very stiff to hard

**SILTY CLAY (CL/ML)**, trace sand and gravel, gray, very stiff, wet

**Boring Terminated at 35 Feet**

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

---

**FIELD TEST RESULTS**

<table>
<thead>
<tr>
<th>DEPTH (Ft.)</th>
<th>WATER LEVEL OBSERVATIONS</th>
<th>SAMPLE TYPE</th>
<th>FIELD TEST RESULTS</th>
<th>LABORATORY</th>
<th>UNCONFINED COMPRESSIVE STRENGTH (tsf)</th>
<th>WATER CONTENT (%)</th>
<th>DRY UNIT WEIGHT (pcf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
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<td>22</td>
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<td>7.25 (HP)</td>
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<tr>
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<td>N=6</td>
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<td>Dist.</td>
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<tr>
<td>16</td>
<td>4-4-5</td>
<td>N=9</td>
<td>14</td>
<td>2.75 (HP)</td>
<td>16</td>
<td></td>
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</tbody>
</table>

**Hammer Type:** Automatic

---

**ADVANCEMENT METHOD:**
3-1/4” Hollow Stem Auger

**ABANDONMENT METHOD:**
Boring backfilled with Auger Cuttings and/or Bentonite

---

**WATER LEVEL OBSERVATIONS**

- 7” while sampling
- 12’ upon completion

---

**Elevations estimated from a provided site topographic plan.**

---

**Notes:**

Boring Started: 11-13-2017
Boring Completed: 11-13-2017

Drill Rig: D-120 ATV
Driller: GEOCON/Robert

Project No.: MR175365

---

**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.**
**BORING LOG NO. B-3**

**PROJECT:** Belmont Warehouse  
**SITE:** 9100 Belmont Avenue  
Franklin Park, Illinois

**CLIENT:** Ridge Development Company, LLC  
Chicago, Illinois

### Location
See Exploration Plan
Latitude: 41.9375° Longitude: -87.8545°

**DEPTH (FL.)** | **ELEVATION (FL.)** | **ROOT ZONE** | **FILL** | **LEAN CLAY (CL)**
---|---|---|---|---
12.0 | 626+/− | 3 inches | Fill - Lean Clay, trace sand and gravel, greenish-brown | Lean Clay (CL), trace sand and gravel, grayish-brown, very stiff to hard
12.0 | 617+/− | 3-2-5 | N=7 | 3-5-3 |
12.0 | 609+/− | 6-7-7 | N=14 | 2.50 (HP) |

**Boring Terminated at 20 Feet**

### Water Level Observations
No free water observed

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

**Hammer Type:** Automatic

---

### Advancement Method:
3-1/4" Hollow Stem Auger

### Abandonment Method:
Boring backfilled with Auger Cuttings and/or Bentonite

---

### WATER LEVEL OBSERVATIONS

<table>
<thead>
<tr>
<th>DEPTH (Ft.)</th>
<th>WATER LEVEL OBSERVATIONS</th>
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</thead>
<tbody>
<tr>
<td>5</td>
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<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
</tr>
<tr>
<td>20</td>
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### Notes:
Boring Started: 11-13-2017  
Boring Completed: 11-13-2017

Drill Rig: D-120 ATV  
Driller: GEOCON/Robert

Project No.: MR175365

---

**ELEVATIONS ESTIMATED FROM A PROVIDED SITE TOPOGRAPHIC PLAN.**
**PROJECT:** Belmont Warehouse  
**SITE:** 9100 Belmont Avenue  
Franklin Park, Illinois  

**CLIENT:** Ridge Development Company. LLC  
Chicago, Illinois

**LOCATION**  
See Exploration Plan  
Latitude: 41.9381° Longitude: -87.8546°  
Approximate Surface Elev: 629.5 (FL) +/-

**FILL - LEAN CLAY**  
trace organics, sand, and gravel, dark brown to black  
627 +/-

**LEAN CLAY (CL)**  
trace sand and gravel, grayish-brown, very stiff to hard  
617.5 +/ -

**LEAN CLAY (CL)**  
trace sand and gravel, gray, hard

**ELEVATION (FL)**

**DEPTH (Ft.)**

<table>
<thead>
<tr>
<th>DEPTH (Ft.)</th>
<th>WATER LEVEL OBSERVATIONS</th>
<th>FIELD TEST RESULTS</th>
<th>SAMPLE RECOVERY (In.)</th>
<th>SAMPLE NUMBER</th>
<th>LABORATORY UNCONFINED COMPRESSIVE STRENGTH (tsf)</th>
<th>WATER CONTENT (%)</th>
<th>DRY UNIT WEIGHT (pcf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>3-5-7</td>
<td>1</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>4-7-5</td>
<td>2</td>
<td>5.50</td>
<td>19</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>3-4-6</td>
<td>3</td>
<td>4.25</td>
<td>20</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>5-6-10</td>
<td>4</td>
<td>5.50</td>
<td>20</td>
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<td>4-9-14</td>
<td>5</td>
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<td></td>
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<tr>
<td>14</td>
<td>4-5-8</td>
<td>6</td>
<td>4.50</td>
<td>17</td>
<td></td>
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<td>16</td>
<td>3-6-10</td>
<td>7</td>
<td>4.00</td>
<td>20</td>
<td></td>
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</table>

**Boring Terminated at 20 Feet**

Hammer Type: Automatic

**ADVANCEMENT METHOD:**  
3-1/4" Hollow Stem Auger

**ABANDONMENT METHOD:**  
Boring backfilled with Auger Cuttings and/or Bentonite

**GEOLOGICAL DESCRIPTION**

- **ROOT ZONE, 3 inches**
- **FILL - LEAN CLAY**, trace organics, sand, and gravel, dark brown to black
- **LEAN CLAY (CL)**, trace sand and gravel, grayish-brown, very stiff to hard
- **LEAN CLAY (CL)**, trace sand and gravel, gray, hard

**ROOT ZONE, 3 inches**

- **FILL - LEAN CLAY**, trace organics, sand, and gravel, dark brown to black

**Boring Terminated at 20 Feet**

**WATER LEVEL OBSERVATIONS**

- No free water observed

**Elevations estimated from a provided site topographic plan.**

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

**Elevations estimated from a provided site topographic plan.**

**Borehole Information**

- Boring Started: 11-13-2017  
- Boring Completed: 11-13-2017

**Drill Rig:** D-120 ATV  
**Driller:** GEOCON/Robert

**Notes:**

- See Supporting Information for explanation of symbols and abbreviations.

**PROJECT:** Belmont Warehouse  
**SITE:** 9100 Belmont Avenue  
Franklin Park, Illinois  

**CLIENT:** Ridge Development Company. LLC  
Chicago, Illinois
This Boring Log is not valid if separated from original report. GeoSmart Log-No Well MR175365 Belmont Warehouse GPJ Terracon_DATATEEMPLATE.GDT 11/30/17

Boring Log No. B-5

Project: Belmont Warehouse

Site: 9100 Belmont Avenue
   Franklin Park, Illinois

Client: Ridge Development Company, LLC
   Chicago, Illinois

Location: See Exploration Plan
Latitude: 41.9381° Longitude: -87.8537°

Graphical Log

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

Hammer Type: Automatic

Field Test Results

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Recovery (in)</th>
<th>Depth (ft)</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3-5-4</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>3-4-6</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>3-4-5</td>
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<td>3</td>
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<td>4</td>
<td>4-8-12</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>5-11-17</td>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>3-6-4</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>3-8-11</td>
<td>18</td>
<td>7</td>
</tr>
</tbody>
</table>

Water Level Observations

No free water observed

Elevations estimated from a provided site topographic plan.

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.

Advancement Method:
3-1/4" Hollow Stem Auger

Abandonment Method:
Boring backfilled with Auger Cuttings and/or Bentonite

Water Unconfined Compressive Strength (tsf)

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Laboratory HP (tsf)</th>
<th>Field Test HP (tsf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-5-4</td>
<td>3.50 (HP)</td>
<td>8</td>
</tr>
<tr>
<td>3-4-6</td>
<td>5.00 (HP)</td>
<td>26</td>
</tr>
<tr>
<td>3-4-5</td>
<td>5.00 (HP)</td>
<td>20</td>
</tr>
<tr>
<td>4-8-12</td>
<td>6.00 (HP)</td>
<td>19</td>
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<tr>
<td>5-11-17</td>
<td>6.00 (HP)</td>
<td>20</td>
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Notes:

Boring Started: 11-14-2017
Boring Completed: 11-14-2017
Drill Rig: D-120 ATV
Driller: GEOCON/Robert
Project No.: MR175365
**BORING LOG NO. B-6**

**PROJECT:** Belmont Warehouse  
**CLIENT:** Ridge Development Company, LLC  
**SITE:** 9100 Belmont Avenue, Franklin Park, Illinois

### GRAPHIC LOG
- **LOCATION**  
  - Latitude: 41.9381°  
  - Longitude: -87.8529°  
- **Approximate Surface Elev:** 630 (Ft.) +/-

### WATER LEVEL OBSERVATIONS

<table>
<thead>
<tr>
<th>DEPTH (Ft.)</th>
<th>FIELD TEST RESULTS</th>
<th>FIELD TEST RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
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<td></td>
</tr>
</tbody>
</table>

### ELEVATION (FL.)

- **CRUSHED STONE**
  - 2.5
- **FILL - LEAN CLAY** (CL), trace sand and gravel, greenish-brown
  - 5.0
- **LEAN CLAY (CL)**, trace sand and gravel, grayish-brown, very stiff
  - 12.0
- **LEAN CLAY WITH SAND (CL)**, trace gravel, gray, wet
  - 16.0
- **LEAN CLAY (CL)**, trace sand and gravel, gray, hard
  - 20.0

**Boring Terminated at 20 Feet**

<table>
<thead>
<tr>
<th>DEPTH (Ft.)</th>
<th>WATER LEVEL OBSERVATIONS</th>
<th>SAMPLE NUMBER</th>
<th>UNCONFINED COMPRESSIVE STRENGTH (tsf)</th>
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<td>3-6-10</td>
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<td>6.50 (HP)</td>
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<td>2-4-8</td>
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<td>3-4-6</td>
<td>6</td>
<td>3.25 (HP)</td>
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### Notes:
- **Advancement Method:** 3-1/4" Hollow Stem Auger
- **Abandonment Method:** Boring backfilled with Auger Cuttings and/or Bentonite
- **Elevations estimated from a provided site topographic plan.**
- **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.**
- **Dry at completion**

---

**Terracon**  
650 W Lake St Ste 420, Chicago, IL  
Drill Rig: D-120 ATV  
Driller: GEOCON/Robert

**Project No.: MR175365**
**BORING LOG NO. B-7**

**PROJECT:** Belmont Warehouse  
**SITE:** 9100 Belmont Avenue  
Franklin Park, Illinois  
**CLIENT:** Ridge Development Company, LLC  
Chicago, Illinois

**LOCATION**  
See Exploration Plan  
Latitude: 41.9381° Longitude: -87.8521°  
Approximate Surface Elev: 630 (FL) +/-  

**DEPTHS (FT.)**  

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Field Test Results</th>
<th>Sample Number</th>
<th>Laboratory HP (tsf)</th>
<th>Unconfined Compressive Strength (psi)</th>
<th>Water Content (%)</th>
<th>Dry Unit Weight (pcf)</th>
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<td>ROOT ZONE, 3 inches</td>
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<td>4.0</td>
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<td>2-3-3 N=6</td>
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<tr>
<td>12.0</td>
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<td>3-6-10 N=16</td>
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<td>5.50 (HP)</td>
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<td>16.0</td>
<td>LEAN CLAY (CL), trace sand and gravel, gray, very stiff to hard</td>
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<td>5-7-11 N=18</td>
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<td>5.50 (HP)</td>
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<td>18.0</td>
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<td>4-7-8 N=15</td>
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<tr>
<td>20.0</td>
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<td>15</td>
<td>4-14-19 N=33</td>
<td>7</td>
<td>5.50 (HP)</td>
<td>14</td>
</tr>
</tbody>
</table>

**WATER LEVEL OBSERVATIONS**  

No free water observed

---

**Advancement Method:** 3-1/4" Hollow Stem Auger  
**Abandonment Method:** Boring backfilled with Auger Cuttings and/or Bentonite

---

**Notes:**

- Boring Started: 11-14-2017  
- Boring Completed: 11-14-2017  
- Drill Rig: D-120 ATV  
- Driller: GEOCON/Robert  
- Project No.: MR175365

---

**Elevations estimated from a provided site topographic plan.**  
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.
### BORING LOG NO. B-8

**PROJECT:** Belmont Warehouse  
**SITE:** 9100 Belmont Avenue, Franklin Park, Illinois  
**CLIENT:** Ridge Development Company, LLC, Chicago, Illinois

#### GRAPHIC LOG

**LOCATION:** See Exploration Plan  
**Latitude:** 41.9376°  
**Longitude:** -87.852°  
**Approximate Surface Elev:** 630 (FL) +/-

#### DEPTH (FT.) | ELEVATION (FL.) |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>627 +/-</td>
</tr>
<tr>
<td>3.0</td>
<td>618 +/-</td>
</tr>
<tr>
<td>12.0</td>
<td>610 +/-</td>
</tr>
<tr>
<td>20.0</td>
<td>610 +/-</td>
</tr>
</tbody>
</table>

#### WATER LEVEL OBSERVATIONS

**No free water observed**

#### FIELD TEST RESULTS

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>WATER LEVEL OBSERVATIONS</th>
<th>RECOVERY</th>
<th>FIELD TEST RESULTS</th>
<th>RECOVERY</th>
<th>FIELD TEST RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>6-15-23</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>37-12-10</td>
<td>2</td>
<td>12</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>18</td>
<td>5-7-9</td>
<td>4</td>
<td>19</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>18</td>
<td>3-7-13</td>
<td>5</td>
<td>20</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>18</td>
<td>4-6-9</td>
<td>6</td>
<td>16</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>18</td>
<td>3-4-5</td>
<td>7</td>
<td>17</td>
<td>7</td>
<td>17</td>
</tr>
</tbody>
</table>

#### ADVANCEMENT METHOD:
- 3-1/4" Hollow Stem Auger

#### ABANDONMENT METHOD:
- Boring backfilled with Auger Cuttings and/or Bentonite

#### WATER LEVEL OBSERVATIONS

**No free water observed**

#### STRATIFICATION:

- **FILL - SANDY LEAN CLAY:** trace gravel and organics, dark brown to dark gray, petroleum odor
- **LEAN CLAY (CL):** trace sand and gravel, grayish-brown, hard
- **LEAN CLAY (CL):** trace sand and gravel, gray, very stiff

#### BORING TERMINATED AT 20 FEET

- Stratification lines are approximate. In-situ, the transition may be gradual.
- Hammer Type: Automatic

#### Notes:
- Boring Started: 11-14-2017
- Boring Completed: 11-14-2017
- Drill Rig: D-120 ATV
- Driller: GEOCON/Robert
- Project No.: MR175365

---

**Elevations estimated from a provided site topographic plan.**

**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.**
LOCATION: See Exploration Plan

Latitude: 41.9376° Longitude: -87.8529°

Approximate Surface Elev: 630 (Ft.) +/-

ELEVATION (Ft.)

DEPTH

FILL - SAND, trace clay and organics, dark brown

3.0 627 +/-

FILL - LEAN CLAY, trace sand and gravel, greenish-brown

6.0 625 +/-

LEAN CLAY (CL), trace sand and gravel, brown, hard

12.0 618 +/-

LEAN CLAY (CL), trace sand and gravel, gray, very stiff to hard

20.0 610 +/-

Boring Terminated at 20 Feet

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

Hammer Type: Automatic

Notes:

Boring Started: 11-14-2017
Boring Completed: 11-14-2017

Drill Rig: D-120 ATV
Driller: GEOCON/Robert

Elevations estimated from a provided site topographic plan.

See Supporting Information for explanation of symbols and abbreviations.
<table>
<thead>
<tr>
<th>DEPTH (Ft.)</th>
<th>WATER LEVEL OBSERVATIONS</th>
<th>FIELD TEST RESULTS</th>
<th>SAMPLE NUMBER</th>
<th>LABORATORY UNCONFINED COMPRESSIVE STRENGTH (tsf)</th>
<th>WATER CONTENT (%)</th>
<th>DRY UNIT WEIGHT (pcf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>FILL - LEAN CLAY, with organics, black to dark gray</td>
<td>2-3-5-4 N=8</td>
<td>1</td>
<td>28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td>LEAN CLAY (CL), trace sand and gravel, grayish-brown, hard</td>
<td>6-7-7-7 N=14</td>
<td>2</td>
<td>5.00 (HP)</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>11.0</td>
<td>LEAN CLAY (CL), trace sand and gravel, gray, very stiff to hard</td>
<td>5-4-7-6 N=11</td>
<td>3</td>
<td>4.50 (HP)</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>16.0</td>
<td></td>
<td>5-7-11-13 N=18</td>
<td>4</td>
<td>6.75 (HP)</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>18.0</td>
<td></td>
<td>5-6-13-11 N=21</td>
<td>5</td>
<td>4.25 (HP)</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>4-7-6-7 N=13</td>
<td>6</td>
<td>4.75 (HP)</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>5-9-12-13 N=21</td>
<td>7</td>
<td>5.00 (HP)</td>
<td>19</td>
<td></td>
</tr>
</tbody>
</table>

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

**Hammer Type:** Automatic

**Boring Terminated at 16 Feet**

**Notes:**

**Advancement Method:** 3-1/4" Hollow Stem Auger

**Abandonment Method:** Boring backfilled with Auger Cuttings and/or Bentonite

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.

Elevations estimated from a provided site topographic plan.

**Advancement Method:** 3-1/4" Hollow Stem Auger

**Abandonment Method:** Boring backfilled with Auger Cuttings and/or Bentonite

**Notes:**

**Advance Method:** 3-1/4" Hollow Stem Auger

**Abandonment Method:** Boring backfilled with Auger Cuttings and/or Bentonite

**Notes:**

**Advance Method:** 3-1/4" Hollow Stem Auger

**Abandonment Method:** Boring backfilled with Auger Cuttings and/or Bentonite

**Notes:**

**Advance Method:** 3-1/4" Hollow Stem Auger

**Abandonment Method:** Boring backfilled with Auger Cuttings and/or Bentonite

**Notes:**

**Advance Method:** 3-1/4" Hollow Stem Auger

**Abandonment Method:** Boring backfilled with Auger Cuttings and/or Bentonite

**Notes:**
## BORING LOG NO. B-11

**PROJECT:** Belmont Warehouse  
**SITE:** 9100 Belmont Avenue  
Franklin Park, Illinois

---

### Location
- **See Exploration Plan**
- **Latitude:** 41.9386°  
  **Longitude:** -87.8539°

### WATER LEVEL OBSERVATIONS

<table>
<thead>
<tr>
<th>Depth (Ft.)</th>
<th>Elevation (Ft.)</th>
<th>Water Level Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>627 +/-</td>
<td>No free water observed</td>
</tr>
<tr>
<td>8.0</td>
<td>617 +/-</td>
<td></td>
</tr>
<tr>
<td>12.0</td>
<td>613 +/-</td>
<td></td>
</tr>
<tr>
<td>16.0</td>
<td>613 +/-</td>
<td></td>
</tr>
</tbody>
</table>

### Stratification Lines
- Approximate Surface Elev: 629 (Ft.) +/-
- Stratification lines are approximate. In-situ, the transition may be gradual.

---

### Field Test Results

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Field Test Results</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Sample Number</td>
</tr>
<tr>
<td></td>
<td>Depth</td>
</tr>
</tbody>
</table>

### Sample Number

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Field Test Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sample Number</td>
</tr>
<tr>
<td></td>
<td>Depth</td>
</tr>
</tbody>
</table>

### Hammer Type
- **Automatic**

---

### Notes:
- **Advancement Method:** 3-1/4" Hollow Stem Auger
- **Abandonment Method:** Boring backfilled with Auger Cuttings and/or Bentonite
- **Elevations estimated from a provided site topographic plan.**
- **Elevations estimated from a provided site topographic plan.**
- **Elevations estimated from a provided site topographic plan.**
- **Elevations estimated from a provided site topographic plan.**
- **Elevations estimated from a provided site topographic plan.**

---

**Boring Terminated at 16 Feet**

---

**Notes:**

- **Project No.:** MR175365
- **Drill Rig:** D-120 ATV
- **Driller:** GEOCON/Robert

---

**Terracon**

650 W Lake St Ste 420  
Chicago, IL

---

**Supporting Information**

- **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.

---

**Terminology**

- **HP:** Hydraulic Pressure
- **tsf:** Ton per square foot
- **WATER CONTENT:** Percentage of water in the sample
- **DRY UNIT WEIGHT:** Pounds per cubic foot
**BORING LOG NO. B-12**

**PROJECT:** Belmont Warehouse  
**CLIENT:** Ridge Development Company, LLC  
**SITE:** 9100 Belmont Avenue, Franklin Park, Illinois

| LOCATION | See Exploration Plan  
|----------|----------------------|
| DEPTH (Ft.) | WATER LEVEL OBSERVATIONS  
| ELEVATION (Ft.) | FIELD TEST RESULTS  
| SAMPLE NUMBER | RECOVERY (In.) | SAMPLE | LABORATORY | UNCONFINED COMPRESSIVE STRENGTH (tsf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) |
| 2.5 | FILL - LEAN CLAY, with organics, black to dark gray  
| 626.5 +/- | 18 | 12-10-6-6 | N=16 | 4.25 | 23 |
| 24 | 5-6-12-13 | N=18 | 2 | 3.00 | 23 |
| 18 | 6-6-13-16 | N=21 | 3 | 5.00 | 20 |
| 12 | 4-5-7-9 | N=12 | 4 | 2.75 | 25 |
| 10 | SANDY LEAN CLAY/CLAYEY SAND (CL/SC), brown, very stiff, moist  
| 619 +/- | 20 | 5-9-13-17 | N=22 | 5 | 17 |
| 12 | 17-16-15-16 | N=31 | 6 | 2.25 | 17 |
| 15.0 | LEAN CLAY (CL), trace sand and gravel, gray, very stiff  
| 614 +/- | 12 | 5-6-9-9 | N=16 | 7 | 2.50 | 12 |

Boring Terminated at 15 Feet

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

Hammer Type: Automatic

**Notes:**

- **Advancement Method:** 3-1/4" Hollow Stem Auger
- **Abandonment Method:** Boring backfilled with Auger Cuttings and/or Bentonite
- **Boring Started:** 11-14-2017  
**Boring Completed:** 11-14-2017

**Elevations estimated from a provided site topographic plan.**

**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.**

**WATER LEVEL OBSERVATIONS**

- 8.5' while sampling  
- Dry at completion
# BORING LOG NO. B-13

**PROJECT:** Belmont Warehouse  
**SITE:** 9100 Belmont Avenue  
**CLIENT:** Ridge Development Company, LLC  
**LOCATION:** See Exploration Plan  
**Elevation (Ft.)** Approximate Surface Elev: 629 (Ft.) +/-  

<table>
<thead>
<tr>
<th>DEPTH (Ft.)</th>
<th>DEPTH ELEVATION (Ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>627.5 +/-</td>
</tr>
<tr>
<td>9.0</td>
<td>620 +/-</td>
</tr>
<tr>
<td>13.0</td>
<td>616 +/-</td>
</tr>
<tr>
<td>15.0</td>
<td>614 +/-</td>
</tr>
</tbody>
</table>

---

### WATER LEVEL OBSERVATIONS

**No free water observed**

---

### FIELD TEST RESULTS

<table>
<thead>
<tr>
<th>DEPTH (Ft.)</th>
<th>Sample Type</th>
<th>Recovery (In.)</th>
<th>Field Test Results</th>
<th>Sample Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>FILL - ORGANIC CLAY/ROOT ZONE</td>
<td>2-3-5-7</td>
<td>N=8</td>
<td>12</td>
</tr>
<tr>
<td>16</td>
<td>LEAN CLAY (CL)</td>
<td>2-3-5-3</td>
<td>N=8</td>
<td>16</td>
</tr>
<tr>
<td>14</td>
<td>LEAN CLAY (CL)</td>
<td>3-6-6-7</td>
<td>N=12</td>
<td>14</td>
</tr>
<tr>
<td>22</td>
<td>LEAN CLAY (CL)</td>
<td>4-6-10-12</td>
<td>N=16</td>
<td>22</td>
</tr>
<tr>
<td>24</td>
<td>LEAN CLAY (CL)</td>
<td>4-6-12-14</td>
<td>N=20</td>
<td>24</td>
</tr>
<tr>
<td>24</td>
<td>SILTY CLAY (CL/ML)</td>
<td>8-10-12-15</td>
<td>N=22</td>
<td>24</td>
</tr>
<tr>
<td>18</td>
<td>SILTY CLAY (CL/ML)</td>
<td>3-4-5-9</td>
<td>N=9</td>
<td>18</td>
</tr>
<tr>
<td>12</td>
<td>LEAN CLAY (CL)</td>
<td>3-4</td>
<td>N=4/6</td>
<td>12</td>
</tr>
</tbody>
</table>

---

### ADVANCEMENT METHOD

- **3-1/4" Hollow Stem Auger**

### ABANDONMENT METHOD

- Boring backfilled with Auger Cuttings and/or Bentonite

---

### Notes:

- **Project No.: MR175365**  
- **Drill Rig: D-120 ATV**  
- **Driller: GEOCON/Robert**  
- **Boring Started: 11-14-2017**  
- **Boring Completed: 11-14-2017**
LABORATORY TESTING RESULTS
**Project No.:** MR175365  
**Project Name:** BELMONT WAREHOUSE  
**Client:** RIDGE DEVELOPMENT COMPANY  
**Date Tested:** 11/21/2017

### Sample Information

<table>
<thead>
<tr>
<th>Boring / Source</th>
<th>B-1</th>
<th>B-1</th>
<th>B-1</th>
<th>B-2</th>
<th>B-2</th>
<th>B-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample No.</td>
<td>S-3</td>
<td>S-4</td>
<td>S-5</td>
<td>S-3</td>
<td>S-4</td>
<td>S-5</td>
</tr>
<tr>
<td>Depth (ft.)</td>
<td>6.0'-8.0'</td>
<td>8.0'-10.0'</td>
<td>11.0'-13.0'</td>
<td>6.0'-8.0'</td>
<td>8.0'-10.0'</td>
<td>11.0'-13.0'</td>
</tr>
<tr>
<td>Description</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Organic Content Test Data

<table>
<thead>
<tr>
<th>Tare No.:</th>
<th>B</th>
<th>L</th>
<th>D</th>
<th>G</th>
<th>A</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tare Wt. (gm):</td>
<td>19.55</td>
<td>21.98</td>
<td>20.25</td>
<td>20.71</td>
<td>21.68</td>
<td>17.44</td>
</tr>
<tr>
<td>Wet Wt. + Tare (gm):</td>
<td>54.68</td>
<td>65.94</td>
<td>58.68</td>
<td>63.70</td>
<td>57.27</td>
<td>63.88</td>
</tr>
<tr>
<td>Dry Wt. + Tare (gm):</td>
<td>47.61</td>
<td>57.37</td>
<td>51.62</td>
<td>54.99</td>
<td>48.99</td>
<td>53.85</td>
</tr>
</tbody>
</table>

| Moisture Content (%): | 25.20 | 24.22 | 22.51 | 25.41 | 30.32 | 27.55 |

| Wt. of Ash + Tare (gm): | 45.93 | 56.12 | 50.66 | 53.70 | 47.84 | 52.13 |
| Percent Ash: | 94.01 | 96.47 | 96.94 | 96.24 | 95.79 | 95.28 |

| Organic Content (%): | 5.99 | 3.53 | 3.06 | 3.76 | 4.21 | 4.72 |

**Note:** Test performed by heating the sample to 440 degrees Centigrade until constant weight of ash is attained.
**Moisture Density Characteristics of Soils**

*DATE:* 11/22/2017  
*PROJECT NO.:* MR175365  
*PROJECT:* BELMONT WAREHOUSE  
*Test specification:*  
ASTM D 1557-12 Method A Modified

---

### 100% SATURATION CURVES FOR SPEC. GRAV. EQUAL TO:

- 2.8
- 2.7
- 2.6

---

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Elev. or Depth</th>
<th>Material Description</th>
<th>Specific Gravity</th>
<th>LL</th>
<th>PL</th>
<th>Oversize</th>
<th>% &lt; #200</th>
</tr>
</thead>
<tbody>
<tr>
<td>○ BULK SAMPLE</td>
<td>GRAY AND BROWN LEAN CLAY WITH SAND TRACE GRAVEL CL</td>
<td>2.72</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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### Natural water content, percent

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>BULK SAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural water content, percent</td>
<td></td>
</tr>
<tr>
<td>Optimum water content, percent</td>
<td>11.8</td>
</tr>
<tr>
<td>Max dry density, pcf</td>
<td>121.2</td>
</tr>
</tbody>
</table>

---

**Remarks:** TEST PERFORMED 11/21/17  
*Project:* BELMONT WAREHOUSE  
*Project No.:* MR175365

---

**Location:** FRANKLIN PARK  
**Source:** B-1 & B-2

---

**Figure**
SUPPORTING INFORMATION
Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no current topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

<table>
<thead>
<tr>
<th>Descriptive Term (Consistency)</th>
<th>Unconfined Compressive Strength Qu, (tsf)</th>
<th>Standard Penetration or N-Value Blows/Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loose</td>
<td>less than 0.25</td>
<td>0 - 1</td>
</tr>
<tr>
<td>Medium Dens</td>
<td>0.25 to 0.50</td>
<td>2 - 4</td>
</tr>
<tr>
<td>Dense</td>
<td>0.50 to 1.00</td>
<td>4 - 8</td>
</tr>
<tr>
<td>Very Dense</td>
<td>1.00 to 2.00</td>
<td>8 - 15</td>
</tr>
<tr>
<td>Hard</td>
<td>&gt; 4.00</td>
<td>&gt; 30</td>
</tr>
</tbody>
</table>

RELATIVE DENSITY OF COARSE-GRAINED SOILS
(50% or more passing the No. 200 sieve.) Density determined by Standard Penetration Resistance

RELATIVE DENSITY OF FINE-GRAINED SOILS
(50% or more passing the No. 200 sieve.) Density determined by Standard Penetration Resistance

<table>
<thead>
<tr>
<th>Descriptor Term of other constituents</th>
<th>Percent of Dry Weight</th>
<th>Other Term of other constituents</th>
<th>Percent of Dry Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace</td>
<td>&lt;15</td>
<td>Trace</td>
<td>&lt;5</td>
</tr>
<tr>
<td>With</td>
<td>15-29</td>
<td>With</td>
<td>5-12</td>
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<tr>
<td>Modifier</td>
<td>&gt;30</td>
<td>Modifier</td>
<td>&gt;12</td>
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</tbody>
</table>

GRAIN SIZE TERMINOLOGY

<table>
<thead>
<tr>
<th>Major Component of Sample</th>
<th>Particle Size</th>
<th>Term</th>
<th>Plasticity Index</th>
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<tbody>
<tr>
<td>Boulders</td>
<td>Over 12 in. (300 mm)</td>
<td>Non-plastic</td>
<td>0</td>
</tr>
<tr>
<td>Cobbles</td>
<td>12 in. to 3 in. (300mm to 75mm)</td>
<td>Low</td>
<td>1 - 10</td>
</tr>
<tr>
<td>Gravel</td>
<td>3 in. to #4 sieve (75mm to 4.75 mm)</td>
<td>Medium</td>
<td>11 - 30</td>
</tr>
<tr>
<td>Sand</td>
<td>#4 to #200 sieve (4.75mm to 0.075mm)</td>
<td>High</td>
<td>&gt; 30</td>
</tr>
<tr>
<td>Silt or Clay</td>
<td>Passing #200 sieve (0.075mm)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PLASTICITY DESCRIPTION

<table>
<thead>
<tr>
<th>Tern</th>
<th>Plasticity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace</td>
<td>&lt;5</td>
</tr>
<tr>
<td>With</td>
<td>5-12</td>
</tr>
<tr>
<td>Modifier</td>
<td>&gt;12</td>
</tr>
</tbody>
</table>
**UNIFIED SOIL CLASSIFICATION SYSTEM**

Proposed Warehouse ■ Franklin Park, Illinois
November 30, 2017 ■ Terracon Project No. MR175365

### Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests

<table>
<thead>
<tr>
<th>Coarse-Grained Soils: More than 50% retained on No. 200 sieve</th>
<th>Clean Gravels: Less than 5% fines</th>
<th>Gravels with Fines: More than 12% fines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravels: More than 50% of coarse fraction retained on No. 4 sieve</td>
<td>Cu ≥ 4 and 1 ≤ Cc ≤ 3</td>
<td>Fines classify as ML or MH</td>
</tr>
<tr>
<td>Sands: 50% or more of coarse fraction passes No. 4 sieve</td>
<td>Cu &lt; 4 and/or 1 &gt; Cc &gt; 3</td>
<td>Fines classify as CL or CH</td>
</tr>
<tr>
<td>Clean Sands: Less than 5% fines</td>
<td>Cu ≥ 6 and 1 ≤ Cc ≤ 3</td>
<td>GC Clayey gravel F,G,H</td>
</tr>
<tr>
<td>Sands with Fines: More than 12% fines</td>
<td>Cu &lt; 6 and/or 1 &gt; Cc &gt; 3</td>
<td>SP Poorly graded sand I</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fine-Grained Soils: 50% or more passes the No. 200 sieve</th>
<th>Inorganic:</th>
<th>Organic:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silts and Clays: Liquid limit less than 50</td>
<td>PI &gt; 7 and plots on or above “A” line</td>
<td>Liquid limit - oven dried</td>
</tr>
<tr>
<td>Silts and Clays: Liquid limit 50 or more</td>
<td>PI ≤ 7 and plots on or above “A” line</td>
<td>Liquid limit - not dried</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Highly organic soils: Primarily organic matter, dark in color, and organic odor</th>
<th>PI ≥ 4 and plots on or above “A” line</th>
<th>PI &lt; 4 or plots below “A” line</th>
</tr>
</thead>
</table>

**Soil Classification**

- **GW** Well-graded gravel F
- **GP** Poorly graded gravel F
- **GM** Silty gravel F,G,H
- **GC** Clayey gravel F,G,H
- **SW** Well-graded sand I
- **SP** Poorly graded sand I
- **SM** Silty sand G,H,I
- **SC** Clayey sand G,H,I
- **CL** Lean clay K,L,M
- **ML** Silt K,L,M
- **OL** Organic clay K,L,M,N
- **OH** Organic clay K,L,M,P
- **PT** Peat

**Notes**

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-SC poorly graded sand with silt, SP-SC poorly graded sand with clay.

\[ Cu = \frac{D_{60}}{D_{10}} \times \frac{100}{D_{60}} \]

- **Cu** = D<sub>60</sub>/D<sub>10</sub> - Cc
- **Cc** = \( \frac{(D_{30})^2}{D_{10} \times D_{60}} \)
- **E** If soil contains ≥ 15% sand, add “with sand” to group name.

**For classification of fine-grained soils and fine-grained fraction of coarse-grained soils**

- **Equation of “A” - line**
  - Horizontal at PI=4 to LL=25.5.
  - Then PI=0.73 (LL-20)
- **Equation of “U” - line**
  - Vertical at LL=16 to PI=7.
  - Then PI=0.9 (LL-8)