ECS Midwest, LLC

Revised Geotechnical Engineering Report

The Mingo Residential Development Phase I – Woodburn

Hoffman Playground
Cincinnati, Hamilton County, Ohio 45206

ECS Project No. 66:1448R1

June 5, 2024

ECS MIDWEST, LLC
Geotechnical • Construction Materials • Environmental • Facilities

June 5, 2024

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ECS Project No. 66:1448R1

Reference: Revised Geotechnical Engineering Report
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Hoffman Playground
Cincinnati, Hamilton County, Ohio 45206

Dear Mr. Ndukwe:

ECS Midwest, LLC (ECS) has completed the subsurface exploration, laboratory testing, and geotechnical engineering analyses for the above-referenced project. Our services were performed in general accordance with our agreed scope of work. This report presents our understanding of the geotechnical aspects of the project along with the results of the field exploration and laboratory testing conducted, and our design and construction recommendations. The report has been reissued to revise the elevations of Borings B-02 and B-05.

It has been our pleasure to be of service to Kingsley + Co during the design phase of this project. We would appreciate the opportunity to remain involved during the continuation of the design phase, and we would like to provide our services during construction phase operations as well to verify subsurface conditions determined for this report. Should you have any questions concerning the information contained in this report, or if we can be of further assistance to you, please contact us.

Respectfully submitted,

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"ONE FIRM. ONE MISSION."

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EXECUTIVE SUMMARY

The following summarizes the main findings of the exploration, particularly those that may have a cost impact on the planned development. Further, our principal recommendations are summarized. Information gleaned from the Executive Summary should not be utilized in lieu of reading the entire geotechnical report.

- Based on the provided project documentation, the proposed development consists of a four-story residential building with paved parking and driveway areas.
- <u>Deep undocumented fill soils with varying amounts of deleterious construction debris were encountered to depths of 6 to 28 ½ feet throughout the project site.</u> In some areas, the fill soils exhibited very low shear strengths. Additionally, a buried concrete slab was encountered in one of the soil borings (which is likely an old basement slab).
- The proposed structures should be supported on improved ground such as rammed aggregate piers (RAPs) or Vibrated Stone Columns (VSCs) due to the compressible weak soil below the project site. The piers must extend to bear within the stiff native soil stratum located below the fill soil mass. Very low shear strengths within the soil mass were determined during drilling activities which will provide poor support for the new structure. Maximum net allowable bearing pressures on the order of 3,000 to 5,000 psf on the stiff underlying natural soil can be used for design.
- The building floor slab thickness may be determined based on an assumed modulus of subgrade reaction of 125 pounds per cubic inch (pci), provided the subgrade soils proofroll satisfactorily.
- For pavement design purposes, a California Bearing Ratio (CBR) of 3 should be utilized for compacted natural soil or new engineered fill.

1.0 INTRODUCTION

The purpose of this study was to provide geotechnical information for the design of new foundations, slabs, and pavements for the proposed multi-family residence. The recommendations developed for this report are based on project information supplied by Kingsley + Co.

Our services were provided in accordance with ECS Proposal No. 66:1871R1GP, dated January 9, 2024, as authorized by Mr. Chinedum Ndukwe of Kingsley + Co on March 29, 2024 which includes the Terms and Conditions of Service outlined within our Proposal.

This report contains the procedures and results of our subsurface exploration and laboratory testing programs, review of existing site conditions, engineering analyses, and recommendations for the design and construction of the project.

The report includes the following items:

- A brief review and description of our field and laboratory test procedures and the results of the testing conducted.
- A review of surface topographical features and site conditions.
- A review of area and site geologic conditions.
- A review of subsurface soil/rock stratigraphy with pertinent physical properties.
- Records of the field exploration (test boring logs) prepared in accordance with the standard practice for geotechnical engineering.
- Recommendations for site preparation and construction of compacted fills, including an evaluation of on-site soils for use as compacted fills and identification of potentially unsuitable soils and/or soils exhibiting excessive moisture at the time of sampling.
- Recommended foundation types.
- Recommended seismic Site Class.
- Recommendations for site retaining walls.
- An evaluation of the on-site soil characteristics encountered in the soil borings and suitability of the on-site materials for reuse as engineered fill to support pavements and grade slabs, including compaction requirements and suitable material guidelines.
- General recommendations for pavement design including a recommended design CBR value.
- Evaluation and recommendations relative to groundwater control, including recommendations for pavement underdrains.
- An evaluation of soil and rock excavation issues.
- Slope stability calculations and retaining wall design were not included in these scope-of-services.

2.0 PROJECT INFORMATION

The following information explains our understanding of the planned development, including proposed buildings and related infrastructure. This understanding is based on our review of a set of Architectural Drawings prepared by Berardi + Partners, Inc. (dated December 7, 2023) which were provided by Kingsley + Co.

2.1 PROJECT LOCATION AND SITE HISTORY

The project site is generally located west of the intersection of Woodburn Avenue and Dexter Avenue in Cincinnati, Hamilton County, Ohio. The project site measures approximately 2.2 acres and is currently an existing park (Hoffman Playground). The playground includes a baseball field near the southeast corner and a one-story building near the northeast corner. A sloped concrete retaining wall separates the parking lot of the former school from the playground. The site location is outlined in **blue** in the Figure below and on the Site Location Diagram included in Appendix A:

Site Location Map

ECS reviewed the topographic plan provided in the architectural drawings mentioned above. This topographic plan indicated that the existing grades in the area of the proposed development range from approximate elevations 767 to 777 feet above mean sea level (MSL). ECS also reviewed the historical record of a USGS Topographic Map of the subject region, dated 1898. A comparison of the relatively recent topographic plan of the area as obtained from the above-noted ESRI Base Map with the historical USGS topographic map indicates that no significant earthwork activities have been performed in the area of the proposed development.

Using *Google Earth, Google Street View,* and the online historical map viewer maintained by Nationwide Environmental Title Research, LLC (NETR), ECS reviewed aerial photographs of the subject site dated between 1932 and 2023. Based on this review, the existing buildings were constructed prior to 1932. Historical images indicate that a deep swimming pool was located adjacent to the south side of the Hoffman Park building. Several outbuildings were previously located along the border between the existing church building and the playground. The swimming pool and outbuildings were demolished in 2011. It is unknown whether the foundations, slabs, or below-grade portions of these structures were removed. A second baseball field was previously located to the west of the swimming pool and was removed in 2017. A jungle gym located near the northwest corner of the development area was demolished between 2023 and 2024. It appears that no other significant earthwork operations have been performed in the area of the proposed development since 1932.

2.2 PROPOSED CONSTRUCTION

Based on the project information provided by Kingsley + Co, the proposed development will include a four-story, slab-on-grade building encompassing approximately 34,130 square feet in plan with associated parking and drive areas. The parking lot will be located to the south and southwest of the building, with an entrance from Woodburn Avenue at the southeast corner of the site.

ECS understands the following construction related details.

- The finished floor elevation (FFE) of the proposed building has not yet been established. Based on existing site grades, it is anticipated that minimal amounts of earthwork will be required to achieve finished grades.
- Proposed grading for the pavement improvements was not available at the time of this proposal.
- The following loads are estimated for the building:
  - Continuous footings: 5 kips per lineal foot
  - Isolated columns: 250 kips
- Settlement tolerances for this type of construction are assumed to be in the order of about 1 inch total and ½ inch differentially.
- The design traffic counts to be used in the pavement design analysis will be supplied by the Client.
- ECS requested but has not been provided with the succinct design traffic counts to be used in the pavement design analysis. Therefore, it was necessary for ECS to use arbitrarily selected design traffic volumes. Based on similar developments, we estimated a maximum daily traffic volume of 500 automobiles, and truck traffic consisting of 5 daily 18,000-pound equivalent single-axle loads (ESALs) for heavy duty pavement areas, and a maximum daily traffic volume of 200 automobiles, and truck traffic consisting of 2 daily 18,000-pound ESALs for light duty pavement areas.

If our understanding of the proposed project is inaccurate or the design changes, please contact ECS immediately so we can review (and revise, if necessary) the recommendations provided herein.

3.0 FIELD EXPLORATION AND LABORATORY TESTING

3.1 FIELD EXPLORATION

ECS performed the field exploration with the objective to characterize the subsurface conditions in general geotechnical and geological terms, and to evaluate subsequent field and laboratory data to assist in the determination of geotechnical recommendations.

3.1.1 Test Borings

Our field services included drilling eight (8) soil borings extending to terminal depths of about 16 ½ to 30 feet. Geotechnical exploration procedures employed by ECS are explained in Appendix B, including the insert titled Subsurface Exploration Procedure. The test boring locations were selected by ECS and were established in the field by ECS using a hand-held Global Positioning System (GPS) unit with sub-meter accuracy. The approximate locations are shown on the Boring Location Plan in Appendix A. The ground elevation at each boring location was estimated using the provided topographic survey. The actual elevations at the boring locations should be surveyed prior to final foundation and pavement design.

Central Star Drilling was subcontracted by ECS to perform the drilling services using an all-terrain rig (ATV) and utilizing continuous flight hollow stem augers (HSA). Prior to drilling, ECS contacted the Ohio Utilities Protection Service (OUPS) to clear and mark underground utilities in the vicinity of the project site. ECS also engaged a private utility locator, GPRS, who identified on-site utilities within an approximately 5-foot radius of each soil boring location.

3.2 SITE GEOLOGY

Information obtained from the Quaternary and Bedrock maps of Ohio, both prepared by the Ohio Department of Natural Resources (ODNR), Division of Geological Survey indicates that the surface soils in the area of the subject site are mapped primarily with soils associated with an Illinoian-Age ground moraine. These soils, which are predominantly sands and silts interbedded with silts and silty clays, are characterized as glacial.

3.3 SUBSURFACE CHARACTERIZATION

The following Table provides a generalized characterizations of the soil strata encountered by the soil borings. For more detailed information, please refer to the boring logs and subsurface profile in Appendix B.

GENERALIZED SUBSURFACE STRATIGRAPHY						
Approximate Depth Increment (ft)	**Approximate Elevation (1) (ft, MSL)**	**Stratum No.**	**Soil Description**	**Calibrated Penetrometer Resistance (tsf)**	**SPT (2) N-values (bpf)**	**Natural Moisture Content (%)**
Surface	770 – 773	N/A	3 to 3 ½-inch- thick ASPHALT underlain by 3-inch-thick CONCRETE and/or 4 to 5-inch- thick GRAVEL BASE [Borings B-01 and B-02] 3-inch-thick TOPSOIL [Borings B-03, B-04, B-06, and B-07]	N/A	N/A	N/A
6 – 18 ½	742 ½ – 767	I-A	**Undocumented Fill**: Very Soft to Firm LEAN CLAY with Sand (CL), SANDY LEAN CLAY (CL), SILTY CLAY (CL/ML), or Loose CLAYEY SAND (SC) with varying amounts of **deleterious** construction debris and buried concrete. [Borings B-04, B-06, B-07, and B-08]	0 – ¾	2 – 6	15 – 43
6 – 23 ½	747 ½ – 769 ½	I-B	**Undocumented Fill**: Firm to Very Stiff LEAN CLAY (CL), SANDY LEAN CLAY (CL), LEAN to FAT CLAY (CL/CH), or Medium Dense SAND with Gravel (SP) [Borings B-01, B-02, B-04, B-05, B-06, and B-08]	½ – 3 ½	5 – 19	14 – 27
13 ½ – 30 (end of boring)	741 – 757 ½	II	Stiff to Hard, LEAN CLAY (CL), SANDY LEAN CLAY (CL), or SILTY CLAY (CL/ML) [Borings B-01 through B-08]	1 – 4 ½	10 – 49	5 – 38
19 (end of boring)	756	III	**Apparent Bedrock**: Very Soft, Highly Weathered SHALE [Boring B-02]	N/A	49 – 50+	19 – 21

Notes:

(1) Please note that the ground surface elevations at the boring locations were not surveyed by a licensed surveyor. These elevations are approximate based on the provided topographic survey; therefore, elevation ranges are approximate within several feet.

(2) Standard Penetration Testing

A graphical presentation of the subsurface conditions is shown on the Subsurface Soil Profile Diagrams included in Appendix A.

3.3.1 Existing Buried Structures

Based on communications with the drilling crew, Boring B-06 encountered what appeared to be a buried concrete slab from a depth of about 7 ½ to 8 ½ feet below existing grade (i.e., El. 763 ½ to 764 ½ ft MSL). The size of this slab and the locations of associated structures such as foundations are unknown (but likely are the remnants of an old basement). Additional buried structures not encountered by the soil borings may be present on the project site.

3.4 GROUNDWATER OBSERVATIONS

The measured free ground water levels at the time of drilling activities are reported on the boring logs in Appendix B. Groundwater was not observed in the borings during or upon completion of drilling. Based upon our interpretation of the test boring observations, it is our interpretation that the long-term groundwater table within the project site is located below the depths explored by the borings.

Variations in the long-term water table elevation can occur due to changes in precipitation, evaporation, surface water runoff, construction activities, and other factors. The groundwater level may take days or weeks to stabilize in the boreholes. Perched water conditions may also develop and/or exist at shallower or variable depths seasonally, particularly within more permeable soil underlain by less permeable soil, within existing fill, within existing utility and structure backfill, and within fissured soil.

3.5 LABORATORY TESTING

The laboratory testing consisted of selected tests performed on samples obtained during our field exploration operations. Moisture content testing per ASTM D2216 was performed on the split-spoon samples obtained from the borings. In addition, the unconfined compressive strength of the split-spoon samples was estimated using a calibrated handheld penetrometer. Classification and index property tests were performed on representative soil samples. The results of the laboratory tests are included in Appendix C of this report.

Each sample was visually classified based on texture and plasticity in accordance with ASTM D2488 Standard Practice for Description and Identification of Soils (Visual-Manual Procedures) and including USCS classification symbols. After classification, the samples were grouped in the major zones noted on the boring logs in Appendix B. The group symbols for each soil type are indicated in parentheses along with the soil descriptions. The stratification lines between strata on the logs are approximate; in situ, the transitions may be gradual.

4.0 DESIGN RECOMMENDATIONS

4.1 FOUNDATIONS

Based on the subsurface exploration, undocumented fill is present across the site extending to significant depths of 6 to 28 ½ feet. These deep undocumented materials contain deleterious materials and were not compacted in a controlled (engineered) manner. Thus, ECS anticipates unacceptable settlements (total and differential) if the proposed structure is supported using shallow foundations. ECS recommends that ground improvement techniques such as aggregate piers be used to support the superstructures to maintain the settlements within the generally acceptable industry standards.

Prudent and economical ground improvement techniques that could be used to support the proposed structure are presented in the following text. Other alternatives using deep foundations such as drilled shafts, driven piles, or auger-cast-in place-piles could also be used but will be vastly more expensive compared to the aforementioned ground improvement techniques.

4.1.1 Aggregate Piers

Aggregate piers are columns of compacted stone installed to reinforce poor soil. Aggregate piers are formed when lifts of stone are introduced to an open hole and compacted or vibrated using high-energy densification equipment. Aggregate piers may be installed either rammed (rammed aggregate pier) or vibrated (vibro stone column). Although similar, vibro stone column (VSC) and Rammed Aggregate Piers (RAP) are created slightly differently.

Rammed Aggregate Piers are generally made by pre-drilling a hole into the soil, adding the aggregates, and then tamping the aggregate into the hole. This process is repeated until the hole is filled with aggregate. Vibratory stone columns create the compacted fill by way of a vibratory probe either in a pre-drilled hole or with custom rigging.

Each method forms a high modulus aggregate pier or stone column element. These elements are designed and installed in groups to improve the ground's ability to support structures. Each constructed element replaces a percentage of the existing soil with compacted stone. The resulting stone column causes pre-straining and pre-stressing of the adjacent soil matrix. Each column serves as stiff vertical inclusion within the existing soil. The installation of these elements through the existing soil results in a soil matrix with better soil strength and reduced compressibility properties than the existing soil alone. The degree of improvement (and resulting bearing pressure and estimated settlement) is generally a function of the replacement ratio (i.e., the diameter and spacing of the RAP or VSC elements) and existing soil matrix.

The main advantage of utilizing controlled modulus columns is the volume of spoils resulting from the installation will be smaller than the amount resulting from complete removal and replacement of the soft soils.

Design of RAPs and VSCs is typically done by a specialty contractor. However, for preliminary evaluation purposes, a net allowable bearing pressure of approximately 3,000 psf to 5,000 psf will be possible with these systems. ECS can provide contact information for RAP and VSC contractors if requested.

The holes for RAP are normally drilled without casing, but shallow groundwater conditions or especially very loose or soft ground conditions may necessitate the use of temporary casing to maintain an open hole for the placement and compaction of the stone or an alternative aggregate pier system. The initial lift (bottom lift) of aggregate fill is typically a clean, open-graded stone, and successive lifts are comprised of a well-graded stone. When aggregate columns are installed in a shallow groundwater setting, they may be entirely comprised of clean, open-graded stone.

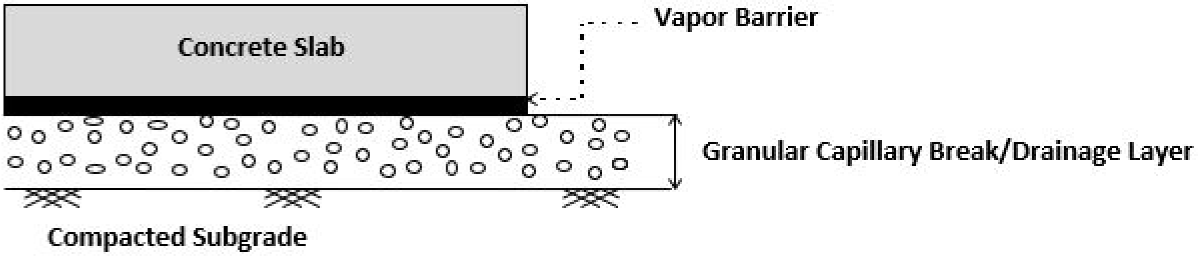
The design stiffness modulus is recommended to be verified by field modulus tests. The final RAP or VSC system should be designed and installed by a qualified contractor to preclude plastic bulging deformations at the top-of–pier design stress and to preclude significant tip stresses as determined from the shape of the telltale test curve from telltales installed in the modulus test.

It is recommended that the width of all continuous wall footings be made at least equal (although ideally larger) than the width of the aggregate pier or stone column elements and isolated foundations at least 30 inches square, regardless of calculated dimensions. In addition, footings should be placed at a depth to provide adequate frost cover protection. For this region, we recommend the exterior footings and footings beneath unheated areas be placed at a minimum depth of 32 inches below finished grade. Interior footings in heated areas can be placed at a minimum of 2 feet below grade provided that suitable soils are encountered and that the foundations will not be subjected to freezing weather either during or after construction.

4.2 SLABS ON GRADE

Based on the borings and the expected subgrade soil, undercutting might be necessary to develop a suitable sub-grade, especially if the subgrade is subjected to wet weather and/or construction traffic disturbance. ECS recommends soil stabilization below the slab-on-grade and parking areas for this site given the undocumented fill materials encountered by the test borings.

The following graphic depicts our soil-supported slab recommendations based on the anticipated subgrade soils and floor loading:



Notes:

(1) **Concrete Slab:** Minimum 5 inches thick
(2) **Drainage Layer:** Minimum 6 inches thick
(3) **Drainage Layer Material:** GRAVEL (GP, GW) having a maximum aggregate size of 1 inch and no more than 5 percent passing the No. 200 sieve.
(4) **Compacted Subgrade:** Compacted to at least 98 percent of the maximum dry density per ASTM D698.

A thicker slab may be needed depending on the actual floor loads. The structural engineer should determine the actual slab thickness and other requirements such as steel reinforcement. Adequate construction joints, contraction joints and isolation joints in the slab must be provided to reduce the impacts of cracking and shrinkage. The ACI 302.1R04 *Guide for Concrete Floor and Slab Construction* should be consulted for additional information regarding concrete slab joint design. The slab should be reinforced with welded wire fabric or include an appropriate fiber mesh admixture to help control shrinkage cracking.

Positive drainage around the perimeter of the proposed structures should be used to reduce the potential for water accumulation under the floor slab and foundation elements. Exterior grades adjacent to the building should be sloped such that runoff is directed away from the building walls. Building downspouts should be directed away from the building walls/foundations. Slab and pavement surface runoff should be directed to appropriate stormwater infrastructure.

Subgrade Modulus: Provided that the Subgrade is prepared, and any Engineered fill and the Granular Drainage Layer are constructed in accordance with our recommendations, the slab may be designed assuming an unfactored modulus of subgrade reaction, k of 125 pounds per cubic inch (pci). The modulus of subgrade reaction value is based on a 1 ft by 1 ft plate load test basis.

Vapor Barrier: Before the placement of concrete, a vapor barrier may be placed on top of the granular drainage layer to provide additional protection against moisture penetration through the floor slab. When a vapor barrier is used, special attention should be given to surface curing of the slab to reduce the potential for uneven drying, curling and/or cracking of the slab. Depending on proposed flooring material types, the structural engineer and/or the architect may choose to eliminate the vapor barrier.

Slab Isolation: Soil-supported slabs should be isolated from the foundations and foundation-supported elements of the structure so that differential movement between the foundations and slab will not induce excessive shear and bending stresses in the floor slab. Where the structural configuration prevents the use of a free-floating slab, such as in a drop-down footing/monolithic slab configuration, the slab should be designed with suitable reinforcement and load transfer devices to preclude overstressing of the slab.

Frost Susceptible Areas: Exterior patios and sidewalks, and portions of the floor slab, such as at doorways, and entrance/exit vestibules may be susceptible to frost heave movement during freezing weather. Additional insulation, installation of subgrade drainage, and/or replacement to the frost depth with non-frost-susceptible backfill should be considered for these areas. Pavement and ground surface grades are recommended to be sloped away from the building and flatwork, to reduce water infiltration and potential frost heave problems.

4.3 SEISMIC DESIGN CONSIDERATIONS

Seismic Site Classification: The 2015 International Building Code (IBC) requires site classification for seismic design based on the upper 100 feet of a soil profile. At least two methods are utilized in classifying sites, namely the shear wave velocity (v_s) method and the Standard Penetration Resistance (N-value) method. The second method (Standard Penetration Resistance) was used in classifying this site.

SEISMIC SITE CLASSIFICATION			
Site Class	**Soil Profile Name**	**Shear Wave Velocity, V_s (ft./s)**	**N value (bpf)**
A	Hard Rock	$V_s > 5,000$	N/A
B	Rock	$2,500 < V_s \le 5,000$	N/A
C	Very dense soil and soft rock	$1,200 < V_s \le 2,500$	>50
D	Stiff Soil Profile	$600 \le V_s \le 1,200$	15 to 50
E	Soft Soil Profile	$V_s < 600$	<15

Chapter 20 of ASCE 7 requires the Site Class be based on the upper 100 feet of the soil profile. The borings performed for this project were drilled to a maximum depth of 30 feet. Therefore, the conditions below this depth were estimated based on our experience with the soils in the general site vicinity and engineering judgment. Based upon our interpretation of the subsurface conditions, the appropriate **Seismic Site Classification is "D"** as shown in the preceding Table.

Ground Motion Parameters: In addition to the seismic site classification, ECS has determined the design spectral response acceleration parameters following the IBC methodology. The Mapped Responses were estimated from the ASCE website https://ascehazardtool.org/. The design responses for the short (0.2 sec, S_{DS}) and 1-second period (S_{D1}) are noted in the following Table:

GROUND MOTION PARAMETERS (ASCE 7-22 METHOD)						
Period (sec)	**Mapped Spectral Response Accelerations (g)**		**Maximum Spectral Response Acceleration Adjusted for Site Class (g)**		**Design Spectral Response Acceleration (g)**	
0.2	S_S	0.22	S_{MS}	0.27	$\mathbf{S_{DS}=2/3\,S_{MS}}$	**0.18**
1.0	S_1	0.088	S_{M1}	0.19	$\mathbf{S_{D1}=2/3\,S_{M1}}$	**0.12**

The Site Class definition should not be confused with the Seismic Design Category designation which the Structural Engineer typically assesses. If a higher site classification is beneficial to the project, we can provide additional testing methods that may yield more favorable results.

4.4 PAVEMENTS

Subgrade Characteristics: A California Bearing Ratio (CBR) test is commonly used to determine soil support parameters for pavement design. An CBR test was not part of the scope for this project, so it was necessary to estimate the CBR design value. Based on the results of the soil borings, it appears that the pavement subgrades in cut areas will consist mainly of lean clay (CL), which is generally considered a poor subgrade material during prolonged contact with water. ECS has estimated a design CBR value of 3 for the flexible pavement and a preliminary design modulus of subgrade reaction, k_{v1}, of 125 psi/in for the rigid pavement. These factors, along with a 20-year design service life and regional climatic conditions, were used to develop the recommended minimum pavement sections. The pavement design recommendations assume the subgrade consists of suitable materials evaluated by ECS, and the subgrade is prepared as recommended in the **Subgrade Preparation** and **Earthwork Operations** sections of this report. A CBR of 6 can be used for design if the soil subgrade is soil (chemically) stabilized as described in this report (thus reducing the pavement section thickness).

The subgrade soils are considered moderately to highly susceptible to frost heave. A reduced service life, increased pavement maintenance and associated costs should be expected where the frost susceptible soil is present. The risk associated with frost susceptible soils can be reduced by removal of frost susceptible soils and replacement with properly drained low frost susceptible engineered fill. The greater the depth of frost susceptible material removed, the lower the risk of frost heave up to the commonly used area frost depth of 32 inches. It has been our experience that removal depths in the range of 2 to 3 feet with appropriate drainage have often been successful in reducing frost-related issues. In areas where the pavement grade will be raised, low frost susceptible fill should be used.

Pavement Sections: The recommended minimum pavement sections listed in the following Table are based on the anticipated usage at the project site and a 20-year design service life, but were not developed based on specific traffic patterns, loading and resiliency factors, as those parameters were not provided by the design team. **If the anticipated traffic will exceed that estimated in the Proposed Construction section, ECS should be contacted for revised pavement design recommendations; otherwise, increased pavement maintenance and a shortened pavement life should be expected.**

The estimate for the light-duty pavement section is that typical traffic loads will be limited to standard automobiles and does not account for more heavily loaded vehicles (i.e., multiple axle trucks) and should be used for parking lanes. The heavy-duty rigid pavement section is recommended for frequent traffic areas such as drive lanes, drive through lanes, delivery areas, loading dock aprons, trash enclosure pads, and points of ingress or egress. Pavement materials and construction should be in accordance with the Guidelines for AASHTO Pavement Design and the Ohio Department of Transportation (ODOT) Construction and Material Specifications.

MINIMUM PAVEMENT SECTION RECOMMENDATIONS			
Pavement Material	Compacted Material Thicknesses (Inches)		
	Flexible Pavement		Rigid Pavement (Heavy Duty)
	(Light Duty)	(Heavy Duty)	
ODOT Item 452 Non-Reinforced Concrete Pavement, Class QC1	--	--	6
ODOT Item 441 Surface Course, Type 1, PG64-22	1½	1½	--
ODOT Item 301 Asphalt Concrete Base, PG64-22	2½	3	--
ODOT Item 304 Aggregate Base	6	8	4
Total Pavement Section Thickness	10	12½	10

Notes:
To aid in promoting subsurface drainage, the bottom 3 to 4 inches of the recommended ODOT No. 304 may be replaced with a crushed AASHTO No. 57 stone.

The pavement sections in the Table above do not provide an allowance for construction traffic conditions or traffic conditions in excess of typical residential development traffic. If pavements will be constructed early during site development to accommodate construction traffic, consideration should be given to the construction of designated haul roads, where thickened pavement sections can be provided to accommodate the construction traffic, as well as the future in-service traffic. ECS can provide additional design assistance with pavement sections for haul roads if requested.

We recommend the crushed granular base course be compacted to at least 98 percent of the maximum dry density obtained in accordance with ASTM D698, Standard Proctor Method. The hot mix asphalt should be compacted to a minimum of 93 percent of the maximum theoretical density value.

Rigid Concrete Pavements: We recommend a rigid pavement section be used in frequent traffic areas such as where trucks frequently turn, delivery areas, trash enclosure pads, and points of ingress or egress. The Portland cement concrete pavement section should consist of air-entrained Portland cement concrete having a minimum 28-day compressive strength of 4,000 psi. The rigid pavement section should be provided with construction joints at appropriate intervals per PCA requirements. The construction joints should be reinforced with dowels to transfer loads across the joints.

Pavement Drainage: An important consideration with the design and construction of pavements is surface and subsurface drainage. Where standing water develops, either on the pavement surface or within the base course layer, softening of the subgrade and other problems related to the deterioration of the pavement can be expected. Based on our estimated groundwater level, we consider surface water infiltration would be the main source of water to be considered for pavement design on this project.

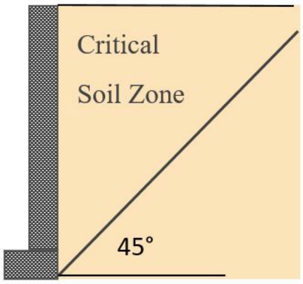
The final pavement surface should be shaped or crowned to properly direct surface water to suitable on or off-site storm water drainage infrastructure. The clay pavement subgrade must be property sloped to avoid dips or pockets where water may become trapped. Dips in the silty clay subgrade could result in a “bathtub” effect, which may trap water and potentially soften the subgrade. The subgrade in areas requiring undercut and backfill with granular soils are recommended to be graded to drain toward a drain tile. The drain tile should be sloped a minimum of ½ to 1 percent to discharge to nearby storm sewers, drainage ditches or other appropriate drainage facilities. Edge drains should be installed where site grades slope toward the pavement edge to reduce the potential for water to enter the base course layer. Slope edge drains to the nearest appropriate drainage facility. Water that accumulates and ponds on the subgrade surface can lead to deterioration of the subgrade soils, reduction of the base course support characteristics and pavement heave. Good drainage should help reduce the possibility of the subgrade materials being wet over a long period of time.

To reduce the potential for shallow perched water to develop in areas of the site, “stub” or “finger” drains should be installed around catch basins and in other low-lying areas of the parking lot to reduce the accumulation of water above and within the subgrade soils and aggregate base. As an alternative to the use of stub or finger drains, perforate existing manholes and storm sewer inlets with 1-inch-diameter holes at 2-foot centers and wrap the manhole/inlet with a non-woven geotextile to reduce migration of material into the manhole/inlet. The holes could be placed at 90-degree intervals around the perimeter of the manhole, and the excavation around the manhole backfilled with free draining granular materials. The installation of pavement edge drains or trench drains should be considered to reduce the accumulation of water within the base course and on the subgrade soils.

Pavement Maintenance Considerations: A sound maintenance program should be implemented to help maintain and enhance the performance of pavements and help attain the design service life. A preventative maintenance program should be started early in the pavement life to be effective. The research-supported industry standard indicates that preventative maintenance should typically begin within 2 to 5 years of the placement of pavement. Failure to perform preventative maintenance will reduce the service life of the pavement and increase the costs for corrective maintenance and full pavement rehabilitation. Seal joints and cracks with elastomeric caulk in a timely manner to help reduce water infiltration through the pavement section into the base course layer, which may result in softening of the subgrade and deterioration of the pavement. Observe pavements for distresses, such as cracks, depressions, and poor drainage, at least twice a year, typically once in the spring and once in the fall.

4.5 SITE RETAINING WALLS

Site retaining walls were not shown on the provided site plan; however, based on the existing grades, ECS anticipates that retaining walls may be constructed along the west side of the development area. Unlike below grade walls, site retaining walls are free to rotate at the top (not restrained). For these walls the "active" (k_a) soil condition should be used along with a triangular distribution of earth pressures. In addition, site retaining walls should be designed to withstand lateral earth pressures exerted by the backfill and any surcharge loads within the "Critical Soil Zone". The Critical Zone is defined as the area between the back of the retaining wall footing and an imaginary line projected upward and rearward at a 45-degree angle.



Critical Soil Zone

The lateral earth pressures developed behind site retaining walls are a function of the backfill soil type, backfill slope angle, and any surcharge loads. Please note that both internal and external (global) stability of the wall MUST be determined by the wall designer. Factors-of-safety for **all potential modes of failure** must be calculated. Otherwise, instability can result. For the design of site retaining walls, we recommend the soil parameters provided in the following Table.

RETAINING WALL BACKFILL REQUIREMENTS IN THE CRITICAL SOIL ZONE	
Soil Parameter	**Estimated Value**
Soil Classification	Silty SAND (SM) or more granular
Fines Content	Max. 20%>#200 Sieve
Coefficient of Active Earth Pressure (K_a)	0.31
Retained Soil Moist Unit Weight (γ)	125 pcf
Cohesion (C)	0 psf
Angle of Internal Friction (ϕ)	32°
Active Equivalent Fluid Pressure	39H (psf)

RETAINING WALL FOUNDATION SOILS	
Soil Parameter	**Estimated value**
Allowable Soil Bearing Pressure	2,500 psf
Minimum Wall Embedment Below Grade	24 inches
Coefficient of Passive Earth Pressure (K_p)	2.0
Soil Moist Unit Weight (γ)	120 pcf
Cohesion (C)	100 psf
Interface Friction Angle [Concrete on Soil] (ϕ_f)	18°
Sliding Friction Coefficient [Concrete on Soil] (μ)	0.32
Passive Equivalent Fluid Pressure	240H (psf)

It is critical that the soils used for retaining wall backfill meet the soil parameters recommended above. If the soils available do not meet those parameters, then ECS should be contacted to provide revised values, and to confirm that only suitable soils will be used for wall backfill.

Care should be used to avoid the operation of heavy equipment to compact the wall backfill since it may overload and damage the wall. In addition, such loads are not typically considered in the design of site retaining walls and are not provided for in our recommendations.

Wall Drainage: Retaining walls should be provided with a wall and foundation drainage system to relieve hydrostatic pressures which may develop behind the walls. This system should consist of weepholes through the wall and/or a 4-inch perforated, closed joint drain line located along the backside of the walls above the top of the footing. The drain line should be surrounded by a minimum of 6 inches of AASHTO #57 Stone wrapped with an approved non-woven geotextile, such as Mirafi 140-N or equivalent. Wall drains can consist of a 12-inch-wide zone of free draining gravel, such as AASHTO #57 Stone, employed directly behind the wall and separated from the soils beyond with a non-woven geotextile. Alternatively, the wall drain can consist of a suitable geocomposite drainage board material. The wall drain should be hydraulically connected to the foundation drain.

5.0 SITE CONSTRUCTION RECOMMENDATIONS

5.1 SUBGRADE PREPARATION

5.1.1 Existing Utilities

All existing utilities must be located. Utilities planned to be maintained should be relocated outside the proposed building area, if possible. For utilities not reused, they should be capped-off and removed, or properly abandoned in-place in accordance with local codes and ordinances. Excavations for utilities to be removed in the influence zone of new construction must be backfilled with engineered fill. Grading operations must be done carefully so that existing utilities are not damaged or disturbed. Utility invert elevations, depths, and sizes should be checked relative to the planned foundation elevations to determine what specific concerns are present.

5.1.2 Stripping and Initial Site Preparation

The subgrade preparation should consist of stripping all vegetation, rootmat, topsoil, existing FILL, asphalt, concrete, and other soft or unsuitable materials from the 10-foot expanded building and 5-foot expanded pavement limits and to 5 feet beyond the toe of engineered fills. The topsoil observed in the soil borings extended to a depth of about 3 inches. ECS should be called on to verify that topsoil and unsuitable surficial materials have been completely removed prior to the placement of Engineered Fill or construction of structures.

Proper demolition and removal of the existing building, foundation walls and associated foundations, playground equipment, underground utilities, below-grade structures, existing pavements, etc. within the planned footprint of the proposed construction will be critical to the successful and long-term performance of the components of the new structures. It is important that both the existing at-grade and below-ground structures are removed from within the planned building footprint and the planned subgrade elevations are re-established with properly compacted fill (i.e., engineered fill). ECS recommends that existing below-ground structures (building foundations, slabs, underground utilities, etc.) be completely removed from within the influence area of the proposed building. The proposed building influence area should be defined by the building dimensions plus 10 feet all around. Existing structures and underground utilities located outside the influence zone of the building may remain in-place, if approved by the Geotechnical Engineer. However, any pipe or cavity left in place (beyond the influence area of the building) must be fully grouted or backfilled with engineered fill.

Construction debris generated from demolition is not considered suitable for use in on-site fills, unless the oversize materials, which are not deleterious, can be sorted and broken down sufficiently to meet the requirements of engineered fill (refer to the **Engineered Fill** section of this report) and approved by the owner and Geotechnical Engineer. It is recommended that demolition debris be hauled to an appropriate landfill, properly recycled, or stockpiled in an approved area of the site. ECS recommends that a designated representative of the Geotechnical Engineer be retained to observe and document the demolition activities. The geotechnical representative can verify that the intent of the demolition recommendations contained herein are implemented, as well as identify and act upon unknown or unforeseen underground structures/utilities that are uncovered during the demolition.

5.1.3 Proofrolling

Prior to fill placement or other construction on subgrades, the subgrades should be evaluated by an ECS field technician. The exposed subgrade should be thoroughly proofrolled with construction equipment having a minimum axle load of 10 tons (e.g., fully loaded tandem-axle dump truck). Proofrolling should be traversed in two perpendicular directions with overlapping passes of the vehicle under the observation of an ECS technician. This procedure is intended to assist in identifying any localized yielding materials. The axis of all utility trenches which are located below roadways must be succinctly targeted by the proofrolls to evaluate performance of the subgrade prior to paving.

Where proofrolling identifies areas that are unstable or "pumping" subgrade those areas should be repaired prior to the placement of any subsequent Engineered Fill or other construction materials. Methods of stabilization include undercutting, moisture conditioning, or chemical stabilization. The situation should be discussed with ECS to determine the appropriate procedure. Test pits may be excavated to explore the shallow subsurface materials to help in determining the cause of the observed unstable materials, and to assist in the evaluation of appropriate remedial actions to stabilize the subgrade.

Seasonal reduction of the near surface soil strength can occur during wet times of the year (such as during the spring and fall months) or immediately following extended periods of rain. This may result in additional unstable or pumping subgrade areas. High moisture content clay materials may be encountered near the ground surface at some localized areas. These materials may not pass a proofroll and may need to be undercut or repaired. Some undercutting or repair of unstable subgrade soils should be anticipated during slab and pavement subgrade preparation. The actual quantity of the subgrade undercut, or stabilization should be determined at the time of construction.

The method to be chosen to repair unstable subgrades to establish a suitable support condition may be influenced by several factors such as weather and schedule, as well as the area, depth, and nature of the unstable subgrade soils. Depending on these and other factors, subgrade repair methods may include:

Scarification and Compaction: Soils can be scarified, moisture conditioned (i.e., dried or wetted) to within a narrow range of the material's optimum moisture content and compacted. Scarification and compaction are generally most applicable where very shallow unstable conditions are encountered and at times when the soil can be properly dried or wetted to within a narrow range of the material's optimum moisture content.

Undercut and Replacement: We recommend soft or yielding soils be evaluated in approximately 6- to 12-inch intervals to help limit the required volume of undercuts. If soft or yielding soils are identified, the contractor should remove only 6 to 12 inches of material at a time in the subject area and then proofroll/evaluate the undercut subgrade to determine if additional undercut is needed. This may take more time but could potentially reduce the removal of more soil than necessary. Use of a geogrid could also be considered to reduce undercut depths. A geogrid, if used, should be placed after underground work, such as utility construction, is complete. Do not operate equipment on the geogrid until after 1 foot of engineered fill is placed above it. Depending on the conditions at the time of repair, use of an aggregate engineered fill, such as crushed stone, crushed concrete, or gravel, may be needed.

Chemical Modification: Alternatively, if these soils cannot be stabilized by conventional methods, chemical modification of the subgrade soils, such as with lime kiln dust, cement, cement kiln dust, or other materials, may be utilized to reduce the moisture content and/or provide additional stabilization. An experienced pre-qualified contractor that has successfully chemically modified similar-sized projects with similar soil conditions is recommended to be used. The soil modification procedure, such as determination of the type and quantity of additive, and mixing and curing procedures, should be evaluated before implementation. This evaluation may include testing the soil for pH, resistivity, sulphates, and chloride to check if an adverse chemical reaction could occur. The contractor should be required to minimize dusting or implement dust control measures. For preliminary estimating purposes, the approximate incorporation rate (based on dry weight of soil) is 6 to 7 percent for hydrated lime or lime by-products, and 5 to 7 percent for Portland cement. Typically, the percentage needed is less for hydrated lime than other lime byproducts because the available calcium oxide content of lime by-products tends to be lower. Insufficient mellowing of modified soils could lead to heaving after placement. Subgrade modification can result in the creation of an 'aquiclude' layer which will allow water to pond above the stabilized surface within the base course. Such water, if not drained properly, can freeze in cold weather potentially resulting in significant heave of the pavement. Alterations to the pavement sections to include additional drainage, such as an open-graded drainage aggregate layer, may be needed if a chemically modified subgrade is used. A minimum stabilization depth of 12 inches must be used.

5.1.4 Site Temporary Dewatering

Groundwater observations are discussed in the **Groundwater Observations** section of this report. Surface runoff may also introduce water into the project site. The Contractor should be prepared to remove any accumulated water prior to the placement of new engineered fill and concrete. We believe the use of sump pumps along with trenches to direct water should be adequate to maintain a dry excavation. The sump pits should ideally be located around the perimeter of the excavation.

The contractor shall make their own assessment of temporary dewatering needs based upon the limited subsurface groundwater information presented in this report. Soil and groundwater conditions may vary between sampling intervals. If the contractor believes additional subsurface information is needed to assess dewatering needs, the contractor should obtain such information at their own expense. ECS makes no warranties or guarantees regarding the adequacy of the provided information to determine dewatering requirements; such recommendations are beyond our scope of services.

Dewatering systems are a critical component of many construction projects. Dewatering systems must be selected, designed, and maintained by a qualified and experienced (specialty or other) contractor familiar with the geotechnical and other aspects of the project. The failure to properly design and maintain a dewatering system for a given project can result in delayed construction, unnecessary undercuts, detrimental phenomena such as 'running sand' conditions, heaved subgrades, internal erosion (i.e., 'piping'), the migration of 'fines' down-gradient towards the dewatering system, localized settlement of nearby infrastructure, foundations, slabs-on-grade, pavements, etc. Water discharged from site dewatering systems is recommended to be discharged in accordance with local, state, and federal requirements.

5.2 EARTHWORK OPERATIONS

5.2.1 Existing Man-Placed Fill

The undocumented fill encountered in the borings drilled for the proposed development provides a concern for the performance of the floor slab and pavement system. The owner should be aware of the increased risk for a reduced floor slab or pavement performance associated with constructing concrete slab or pavements on low strength natural soils and undocumented fill. The risk exists because these soils have a higher potential for variable density. In addition, this risk tends to increase with the presence of organic soils (more than 5 percent organics). However, because of natural soil variability, every construction site has at least a very low risk for reduced pavement performance.

Based on the subsurface conditions indicated by the borings, we anticipate the soils at the final subgrade elevation will consist of existing undocumented fill material. We typically recommend removing undocumented fill from project areas. Complete removal of the existing fill within the building footprint may result in approximate excavation depths of up to 28 ½ feet deep to remove existing fill based on the borings drilled in the proposed building area. Because complete removal and replacement of the existing fill will likely be cost prohibitive, ECS recommends that the existing fill be improved using aggregate piers as discussed in the **Foundations** section of this report.

5.2.2 Excavation Into Weathered Rock and Rock

Based on boring data obtained during the exploration, we anticipate that the shale rock within the proposed site can be excavated by conventional methods using large excavators and hoe-rams; however, materials requiring difficult, or rock excavation techniques may be encountered in localized areas during site grading and excavation to planned subgrades.

The excavation of weathered rock and rock can have a substantial impact on the cost and schedule of the proposed construction. This discussion considers two general classes of materials for purposes of describing excavatability. Residuum and weathered rock will be used as the terms for the materials to be excavated.

In mass excavations for general site work, overburden soils with standard penetration test N-values of 30 bpf or less can usually be removed with conventional earth excavation equipment. Residual soils or soft weathered bedrock with N-values of 30 to 60 bpf can generally be removed with conventional earth moving equipment after first being loosened with a large single-tooth ripper attached to a large crawler tractor. The actual excavatability of the bedrock material will be greatly controlled by in-situ jointing and bedding and may vary from location to location.

5.2.3 Engineered Fill

Prior to placement of Engineered Fill, representative bulk samples (about 50 pounds) of on-site and/or off-site borrow should be submitted to ECS for laboratory testing, which will typically include Atterberg limits, natural moisture content, grain-size distribution, and moisture-density relationships (i.e., Proctors) for compaction. Import materials should be tested prior to being hauled to the site to determine if they meet project specifications. Alternatively, Proctor data from other accredited laboratories can be submitted if the test results are within the last 90 days.

Satisfactory Engineered Fill Materials: Materials satisfactory for use as Engineered Fill should consist of inorganic soils with the following engineering properties and compaction requirements.

ENGINEERED FILL INDEX PROPERTIES	
Subject	**Property**
Liquid Limit	Less than 40
Plasticity Index	Less than 20
Maximum Particle Size	4 inches
Maximum Organic Content	5% by dry weight

ENGINEERED FILL COMPACTION REQUIREMENTS	
Subject	**Requirement**
Compaction Standard	Standard Proctor, ASTM D698
Required Compaction	98% of Maximum Dry Density
Moisture Content	-2 to +3 % points of the soil's Optimum Moisture
Loose Thickness	8 inches prior to compaction

Unsatisfactory Materials: Unsatisfactory engineered fill materials, which do not satisfy the requirements for suitable materials, include topsoil and organic materials (PT, OH, OL), silt (ML), sandy silt (ML), elastic Silt (MH), and sandy silty clay (CL/ML). <u>ECS does not recommend the use of high plasticity soils such as FAT CLAY (CH) for use as Engineered Fill without chemical stabilization using a material such as lime kiln dust (LKD).</u> Topsoil is not recommended to be used as engineered fill but may be suitable for use within future landscape areas. A landscape architect should approve any materials proposed for use in future landscape areas.

Pea gravel is not recommended to be used as engineered fill. Pea gravel has round/smooth characteristics, no fines and does not interlock when compacted, which makes it more susceptible to future movement and instability resulting in excessive and variable settlement.

On-Site Borrow Suitability: The on-site soil may be feasible to use as engineered fill but should be further evaluated and approved by ECS prior to its use. On-site soil used as engineered fill must not contain an adverse amount of organic matter, and must be free of frozen matter, deleterious materials, over-sized material (maximum 3-inch particle diameter), or chemicals that may result in the material being classified as "contaminated." Some conditions at the time of construction, such as wet or freezing weather, may preclude the use of on-site soil, and it may be necessary to use an imported less moisture sensitive or less frost susceptible granular material. The soils must be compacted within a narrow range of the material's optimum moisture content. The soil should not be compacted too dry as it may lose its apparent stability if it later becomes wet. The suitability of engineered fill materials should be checked by ECS prior to placement.

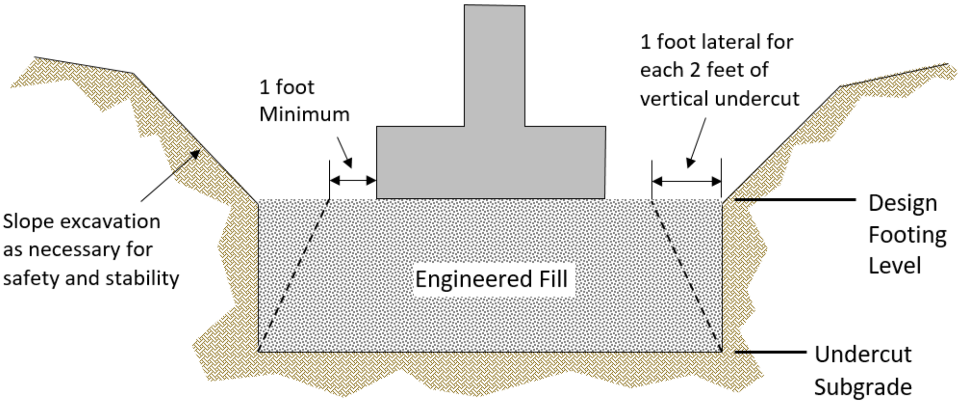
Compaction: Engineered Fill within the expanded building, pavement, and embankment limits should be placed in maximum 8-inch loose lifts, moisture conditioned as necessary to within -2 and +3 % of the soil's optimum moisture content and be compacted with suitable equipment to a dry density of at least 98% of the Standard Proctor maximum dry density (ASTM D698). Beyond these areas, compaction of at least 95% should be achieved. ECS should be called on to document that proper fill compaction has been achieved.

Fill Compaction Control: The expanded limits of the proposed construction areas should be well defined, including the limits of the fill zones for buildings, pavements, and slopes, etc., at the time of fill placement. Grade controls should be maintained throughout the filling operations. All filling operations should be observed on a full-time basis by a qualified representative of the construction testing laboratory to determine that the minimum compaction requirements are being achieved. Field density testing of fills will be performed at the frequencies shown in the following Table, but not less than 1 test per lift:

FREQUENCY OF COMPACTION TESTS IN FILL AREAS	
Location	**Frequency of Tests**
Expanded Building Limits	1 test per 2,500 sq. ft. per lift
Pavement Areas	1 test per 10,000 sq. ft. per lift
Utility Trenches	1 test per 200 linear ft. per lift
Outparcels/SWM Facilities	1 test per 5,000 sq. ft. per lift
All Other Non-Critical Areas	1 test per 10,000 sq. ft. per lift

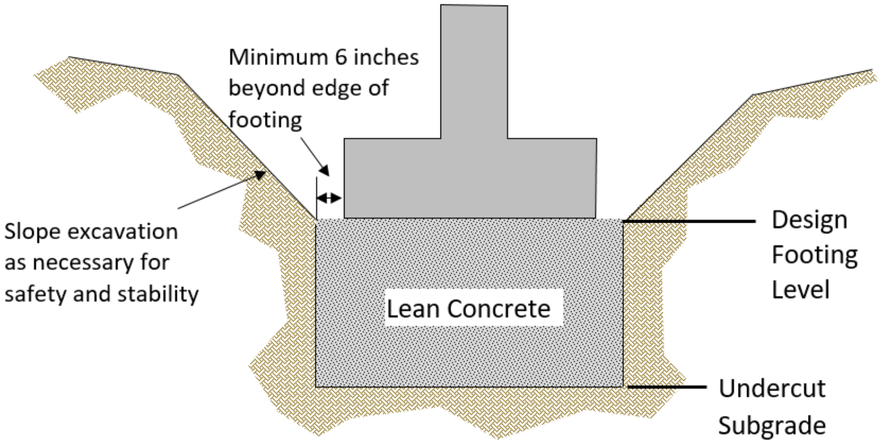
Compaction Equipment: Compaction equipment suitable for the soil type being compacted should be used to compact the subgrades and fill materials. Sheepsfoot compaction equipment should be suitable for the fine-grained soils (Clays and Silts). A vibratory steel drum roller should be used for compaction of coarse-grained soils (Sands) as well as for sealing compacted surfaces.

Engineered Fill below Foundations: <u>Footings will be supported on the recommended ground improvement elements.</u> Where necessary and as applicable, recompact unsuitable bearing soils encountered at the proposed foundation bearing grade or within the foundation influence zone, if feasible, or removed to a suitable bearing subgrade and to a lateral extent, as conceptually shown in the Figure below. The zone of the engineered fill placed below the foundations is recommended to extend 1 foot beyond the outside edges of the footings and from that point, outward laterally 1 foot for every 2 feet of fill thickness below the footing.



Extent of Engineered Fill Below Foundations

Alternatively, the footing trench excavations may be made within the footprint of the proposed new footings as neatly as possible, and that the excavated soils be replaced with lean concrete up to design bottom of footing level. The compressive strength of the lean concrete backfill should not be less than 1,000 pounds per square inch (psi). The design structural footing can then be constructed on top of the lean concrete. If lean concrete is utilized the excavation is recommended to be 1 foot wider than the footing (6 inches on each side), as conceptually shown in the figure below, and the lean concrete should be allowed to sufficiently harden prior to placement of the foundation concrete. Use of lean mix concrete to limit lateral over-excavation may not be effective where excavations extend into the granular soil due to caving of excavation sidewalls.



Lean Concrete Backfill Below Foundations

Fill Placement Considerations: Fill materials should not be placed on frozen soils, on frost-heaved soils, and/or on excessively wet soils. Borrow fill materials should not contain frozen materials at the time of placement, and all frozen or frost-heaved soils should be removed prior to placement of Engineered Fill or other fill soils and aggregates. Excessively wet soils or aggregates should be scarified, aerated, and moisture conditioned.

At the end of each workday, fill areas should be graded to facilitate drainage of any precipitation and the surface should be sealed by use of a smooth-drum roller to limit infiltration of surface water. During placement and compaction of new fill at the beginning of each workday, the Contractor may need to scarify existing subgrades to a depth on the order of 4 inches so that a weak plane will not be formed between the new fill and the existing subgrade soils.

Drying and compaction of wet soils is typically difficult during the cold, winter months. Accordingly, earthwork should be performed during the warmer, drier times of the year, if practical. Proper drainage should be maintained during the earthwork phases of construction to prevent ponding of water which tends to degrade subgrade soils. Alternatively, if these soils cannot be stabilized by conventional methods as previously discussed, additional modifications to the subgrade soils such as lime or cement stabilization may be utilized to adjust the moisture content. If lime kiln dust (LKD) or Portland cement are utilized to control moisture contents and/or for stabilization, Calciment® or regular Type 1 Portland cement can be used. The construction testing laboratory should evaluate proposed lime or cement soil modification procedures, such as quantity of additive and mixing and curing procedures before implementation. Admixture concentrations on the order of 5 to 7 percent by dry unit weight are typical for this type of soil. Also, sufficient water must be available in the soil to hydrate the admixture to achieve its optimal strength. The contractor must be required to minimize dusting or implement dust control measures.

Where fill materials will be placed to widen existing embankment fills, or placed up against sloping ground, the soil subgrade should be scarified, and the new fill benched or keyed into the existing material (see ODOT Construction and Material Specifications Section 203.05). Fill material should be placed in horizontal lifts. In confined areas such as utility trenches, portable compaction equipment and thin lifts of 3 inches to 4 inches may be required to achieve specified degrees of compaction.

We recommend that the grading contractor have equipment on site during earthwork for both drying and wetting fill soils. We do not anticipate significant problems in controlling moisture within the fill during dry weather, but moisture control may be difficult during winter months or extended periods of rain. The control of moisture content of higher plasticity soils is difficult when these soils become wet. Further, such soils are easily degraded by construction traffic when the moisture content is elevated.

5.3 FOUNDATION AND SLAB OBSERVATIONS

Protection of Foundation Excavations: Exposure to the environment may weaken the soils at the footing bearing level if the foundation excavations remain open for too long a time. Therefore, foundation concrete should be placed the same day that excavations are made. If the bearing soils are softened by surface water intrusion or exposure, the softened soils must be removed from the foundation excavation bottom immediately prior to placement of concrete. If the excavation must remain open overnight, or if rainfall becomes imminent while the bearing soils are exposed, a 1- to 3-inch-thick “mud mat” of “lean” concrete should be placed on the bearing soils before the placement of reinforcing steel.

Footing Subgrade Observations: It is important to have ECS observe the foundation subgrade prior to placing foundation concrete, to confirm the bearing soils are what was anticipated. If soft or unsuitable soils are observed at the footing bearing elevations, the unsuitable soils should be undercut and removed. Any undercut should be backfilled with lean concrete ($f'_c \geq 1,000$ psi at 28 days) up to the original design bottom of footing elevation; the original footing shall be constructed on top of the hardened lean concrete.

Slab Subgrade Verification: A representative of ECS should be called on to observe exposed subgrades within the expanded building limits prior to Engineered Fill placement to assure that adequate subgrade preparation has been achieved. Proofrolling using a drum roller or loaded dump truck should be performed in their presence at that time. Once subgrades have been prepared to the satisfaction of ECS, subgrades should be properly compacted and new engineered fill can be placed. Engineered fill should be moisture conditioned to within a narrow range of optimum moisture content then be compacted to the required density. If there will be a significant time lag between the site grading work and final grading of concrete slab areas prior to the placement of the subbase stone and concrete/bituminous, a representative of ECS should be called on to verify the condition of the prepared subgrade. Prior to final slab construction, the subgrade may require scarification, moisture conditioning, and re-compaction to restore stable conditions.

5.4 UTILITY INSTALLATIONS

Utility Subgrades: The soil encountered in our exploration are expected to be generally suitable for support of utility pipes. The pipe subgrades should be observed and probed for stability by ECS. Any loose or unsuitable materials encountered should be removed and replaced with suitable compacted Engineered Fill, or pipe stone bedding material.

Utility Backfilling: The granular bedding material (often AASHTO No. 57 stone) should be at least 4 inches thick, but not less than that specified by the civil engineer’s project drawings and specifications. We recommend that the bedding materials be placed up to the springline of the pipe. Fill placed for support of the utilities, as well as backfill over the utilities, should satisfy the requirements for Engineered Fill and Fill Placement.

Utility Excavation Dewatering: Perched water may be encountered by utility excavations. It is expected that removal of perched water which seeps into excavations could be accomplished by pumping from sumps in the trench bottom and are backfilled with open graded bedding material.

5.5 GENERAL CONSTRUCTION CONSIDERATIONS

Construction Observation and Testing: We recommend that all earthwork, foundation, and slab construction be observed and tested by ECS. If we are not consulted during this critical aspect of the subgrade and earthwork operations and foundation construction, ECS cannot be responsible for long term performance of the ground-supported construction. The importance of the observations cannot be over-emphasized due to the presence of undocumented fill, possible buried organic soils, and high moisture content and low strength soils at the site.

Subgrade Protection: Measures should also be taken to limit site disturbance, especially from rubber-tired heavy construction equipment, and to control and remove surface water from development areas. It would be advisable to designate a haul road and construction staging area to limit the areas of disturbance and to prevent construction traffic from excessively degrading sensitive subgrade soils and existing pavement areas. Haul roads and construction staging areas could be covered with excess depths of aggregate to protect those subgrades. The aggregate can later be removed and used in pavement areas.

Surface Drainage: Surface drainage conditions should be properly maintained. Surface water should be directed away from the construction area, and the work area should be sloped away from the construction area at a gradient of 1 percent or greater to reduce the potential of ponding water and the subsequent saturation of the surface soils. At the end of each workday, the subgrade soils should be sealed by rolling the surface with a smooth drum roller to minimize infiltration of surface water.

Excavation Safety: All excavations and slopes should be made and maintained in accordance with OSHA excavation safety standards. The Contractor is solely responsible for designing and constructing stable, temporary excavations and slopes and should shore, slope, or bench the sides of the excavations and slopes as required to maintain stability of both the excavation sides and bottom. The Contractor's responsible person, as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the Contractor's safety procedures.

Contractors should be familiar with applicable OSHA codes to ensure that adequate protection of the excavations and trench walls is provided. We recommend construction excavation less than 20 feet should be sloped 1½H:1V or flatter. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations. ECS is providing this information solely as a service to our client. ECS is not assuming responsibility for construction site safety or the Contractor's activities; such responsibility is not being implied and should not be inferred.

Erosion Control: The surface soil may be erodible. Therefore, the Contractor should provide and maintain good site drainage during earthwork operations to maintain the integrity of the surface soils. All erosion and sedimentation controls should be in accordance with sound engineering practices and local requirements.

Existing Fill Considerations: Existing fill was encountered at some of the test boring locations. Unsuitable materials may be buried beneath the site surface not identified by the borings. Questionable material encountered is recommended to be evaluated by ECS to determine if removal and replacement with engineered fill is necessary. Alteration to the recommendations of this report may be needed, if conditions different than those noted on the test boring logs are revealed.

Bidding/Estimating Considerations: Contractors bidding or undertaking any work at the site should examine the results of the subsurface exploration, satisfy themselves as to the adequacy of the information for bidding and construction, make their own interpretation of the data, and consider the effect it may have on their cost proposal, construction techniques, schedule, and equipment capabilities. Furthermore, contractors should complete any additional fieldwork and investigation they deem necessary to properly prepare a cost proposal for the site work. Soil borings do not provide the same wide-scale view of the subsurface conditions that is obtained during site grading, excavation, or other aspects of earthwork construction. Additional scope may be required to obtain more detailed subsurface information needed for earthwork bid preparation, which could include test pits to better understand the lateral and vertical extents of the subsurface materials of concern such as existing undocumented fill. Even with this additional information, budget contingencies should be carried in construction to help cover potential variations in subsurface conditions.

6.0 CLOSING

ECS has prepared this report to guide the geotechnical-related design and construction aspects of the project. We performed these services in accordance with the standard of care expected of professionals in the industry performing similar services on projects of like size and complexity at this time in the region. No other representation expressed or implied, and no warranty or guarantee is included or intended in this report.

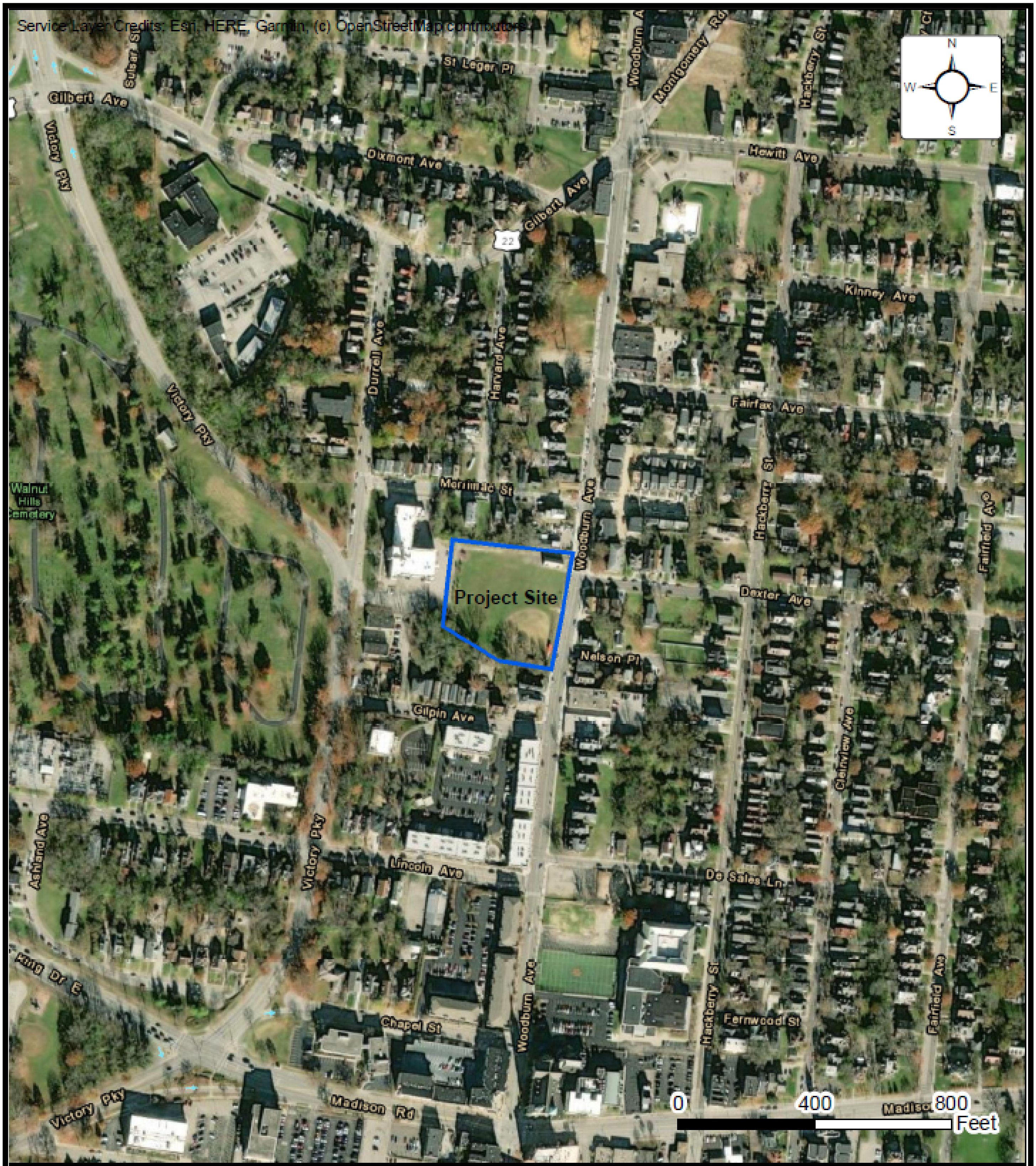
The description of the proposed project is based on information provided to ECS by Kingsley + Co. If any of this information is inaccurate or changes, either because of our interpretation of the documents provided or site or design changes that may occur later, ECS should be contacted so we can review our recommendations and provide additional or alternate recommendations that reflect the proposed construction.

We recommend that ECS review the project plans and specifications so we can confirm that those plans/specifications are in accordance with the recommendations of this geotechnical report.

Field observations, and quality assurance testing during earthwork and foundation installation are an extension of, and integral to, the geotechnical design. We recommend that ECS be retained to apply our expertise throughout the geotechnical phases of construction, and to provide consultation and recommendation should issues arise.

ECS is not responsible for the conclusions, opinions, or recommendations of others based on the data in this report.

Appendix A - Drawings and Reports



SITE LOCATION DIAGRAM

THE MINGO RESIDENTIAL DEVELOPMENT

PHASE I - WOODBURN

HOFFMAN PLAYGROUND, CINCINNATI, OHIO

KINGSLEY + COMPANY

ENGINEER
CJL

SCALE
AS NOTED

PROJECT NO.
66:1448

FIGURE
1 OF 1

DATE
4/1/2024

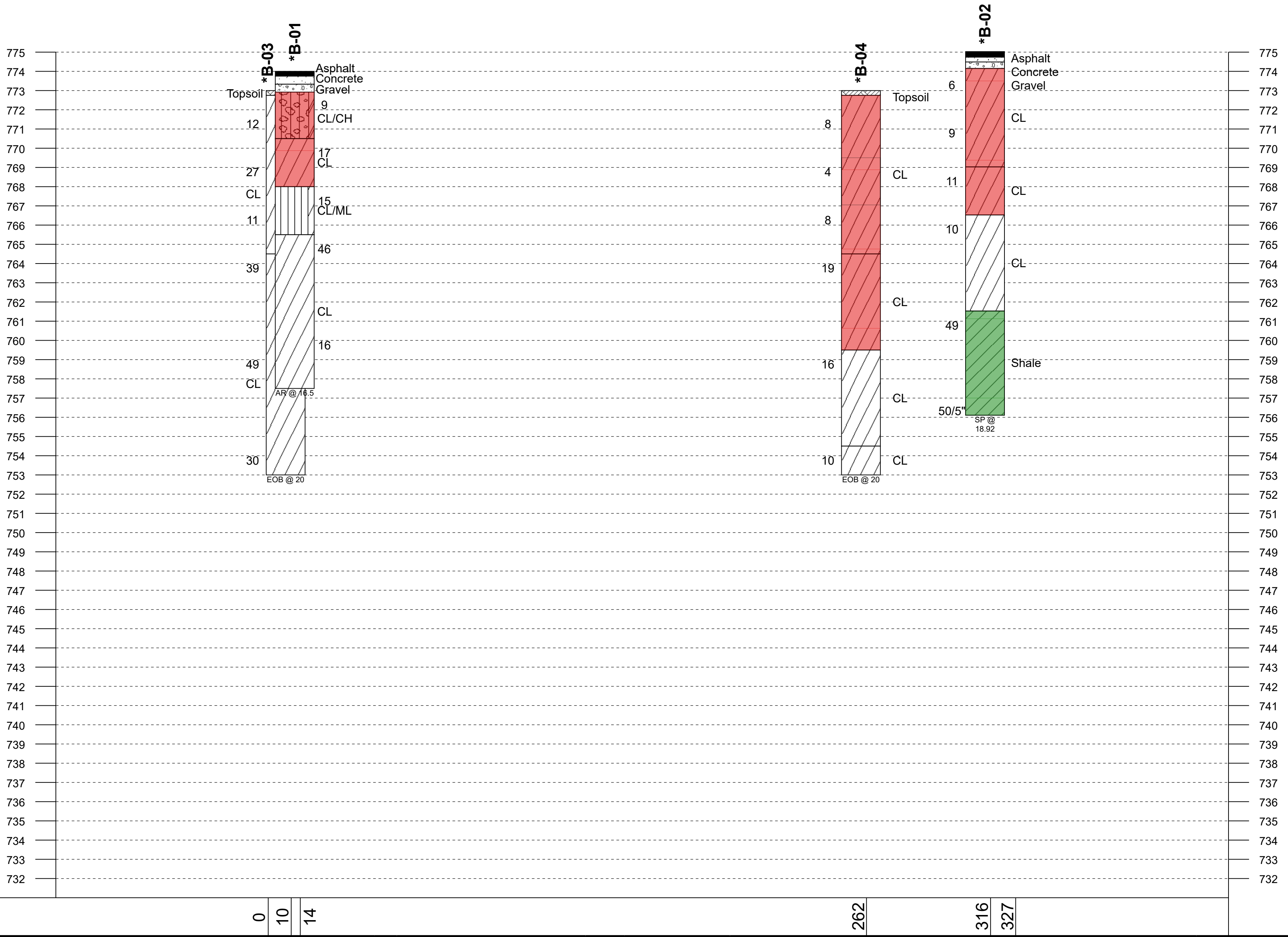
BORING LOCATION PLAN

The Mingo Residential Development - Phase I Woodburn

PROJECT NO. 66:1448

Hoffman Playground, Cincinnati, Hamilton County, Ohio 45206

Kingsley + Co



Legend Key

- ■ Asphalt
- ▨ Concrete
- ▨ Gravel
- ▨ Topsoil
- ▨ Lean to Fat Clay
- ▨ Lean Clay
- ▨ Silty Clay
- ▨ Shale

Notes:

1- EOB: END OF BORING AR: AUGER REFUSAL SR: SAMPLER REFUSAL.
2- THE NUMBER BELOW THE STRIPS IS THE DISTANCE ALONG THE BASELINE.
3- SEE INDIVIDUAL BORING LOG AND GEOTECHNICAL INFORMATION.
4- STANDARD PENETRATION TEST RESISTANCE IN BLOWS PER FOOT (ASTM D1586).

Plastic Limit Water Content Liquid Limit
X——●——△
[Fines Content %]
Bottom of Casing
Loss of Circulation
○ Calibrated Penetrometer

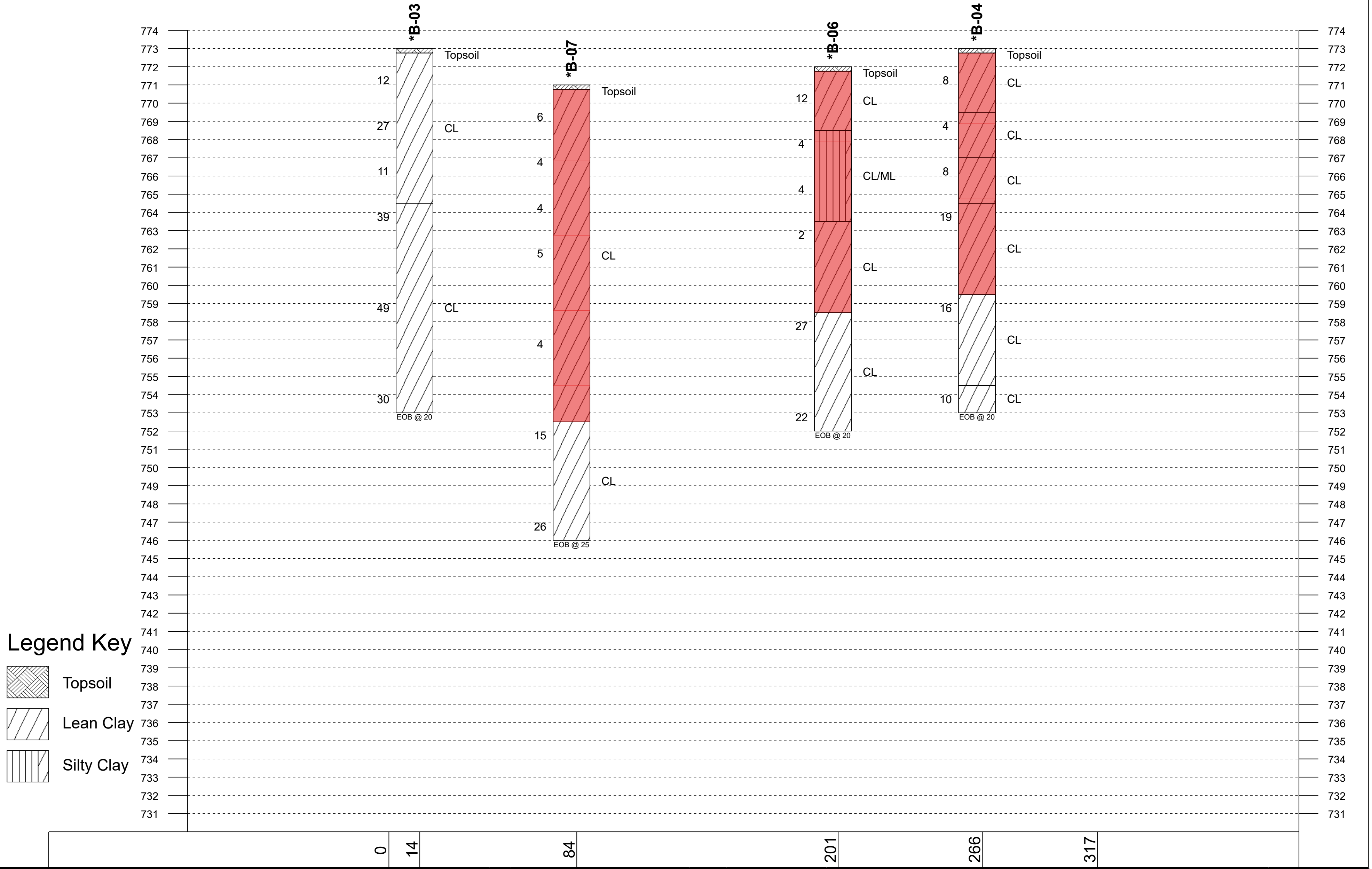
▽ WL (First Encountered)
▼ WL (Completion)
WL (Estimated Seasonal High Water)
WL (Stabilized)

🟥 Fill
🟪 Possible Fill
🟥 Probable Fill
🟩 Rock

GENERALIZED SUBSURFACE SOIL PROFILE
Section A

The Mingo Residential Development - Phase I Woodburn
KINGSLEY COMPANY
Hoffman Playground, Cincinnati, Ohio, 45206

Project No: 66:1448
Date: 04/22/2024



Notes:

1- EOB: END OF BORING AR: AUGER REFUSAL SR: SAMPLER REFUSAL.
2- THE NUMBER BELOW THE STRIPS IS THE DISTANCE ALONG THE BASELINE.
3- SEE INDIVIDUAL BORING LOG AND GEOTECHNICAL INFORMATION.
4- STANDARD PENETRATION TEST RESISTANCE (LEFT OF BORING) IN BLOWS PER FOOT (ASTM D1586).

Plastic Limit Water Content Liquid Limit X———●———△	▽ WL (First Encountered)	🟥	Fill
[Fines Content %]	▼ WL (Completion)	🟪	Possible Fill
➧ Bottom of Casing	▼ WL (Estimated Seasonal High Water)	🟥	Probable Fill
⟩100⟩ Loss of Circulation	▽ WL (Stabilized)	🟩	Rock
○ Calibrated Penetrometer			

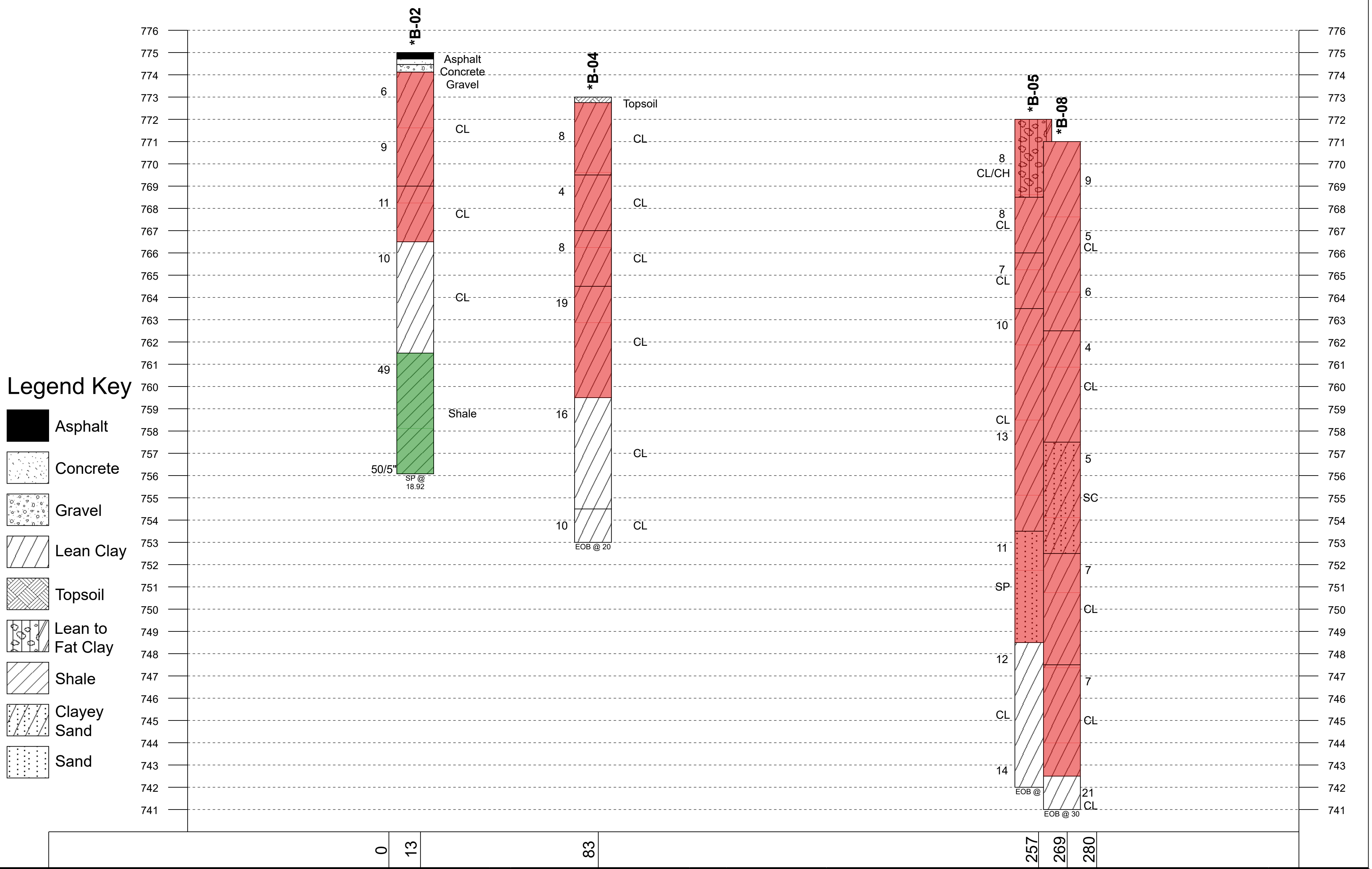
GENERALIZED SUBSURFACE SOIL PROFILE
Section B

The Mingo Residential Development - Phase I Woodburn

KINGSLEY COMPANY

Hoffman Playground, Cincinnati, Ohio, 45206

Project No: 66:1448
Date: 04/22/2024



Notes:

1- EOB: END OF BORING AR: AUGER REFUSAL SR: SAMPLER REFUSAL.
2- THE NUMBER BELOW THE STRIPS IS THE DISTANCE ALONG THE BASELINE.
3- SEE INDIVIDUAL BORING LOG AND GEOTECHNICAL INFORMATION.
4- STANDARD PENETRATION TEST RESISTANCE (LEFT OF BORING) IN BLOWS PER FOOT (ASTM D1586).

Plastic Limit X Water Content ● Liquid Limit △	▽ WL (First Encountered)	🟥	Fill
[Fines Content %]	▼ WL (Completion)	🟪	Possible Fill
➡ Bottom of Casing	▽ WL (Estimated Seasonal High Water)	🟥	Probable Fill
Loss of Circulation	▽ WL (Stabilized)	🟩	Rock
○ Calibrated Penetrometer			

ECS

GENERALIZED SUBSURFACE SOIL PROFILE

Section C

The Mingo Residential Development - Phase I Woodburn

KINGSLEY COMPANY

Hoffman Playground, Cincinnati, Ohio, 45206

Project No: 66:1448 | Date: 06/05/2024

Appendix B – Field Operations

REFERENCE NOTES FOR BORING LOGS

MATERIAL[1,2]

■		**ASPHALT**
⁙		**CONCRETE**
⁘		**GRAVEL**
▨		**TOPSOIL**
□		**VOID**
▤		**BRICK**
○		**AGGREGATE BASE COURSE**
●	**GW**	**WELL-GRADED GRAVEL** **gravel-sand mixtures, little or no fines**
○	**GP**	**POORLY-GRADED GRAVEL** **gravel-sand mixtures, little or no fines**
▥	**GM**	**SILTY GRAVEL** **gravel-sand-silt mixtures**
▧	**GC**	**CLAYEY GRAVEL** **gravel-sand-clay mixtures**
▪	**SW**	**WELL-GRADED SAND** **gravelly sand, little or no fines**
⁚	**SP**	**POORLY-GRADED SAND** **gravelly sand, little or no fines**
⁞	**SM**	**SILTY SAND** **sand-silt mixtures**
▨	**SC**	**CLAYEY SAND** **sand-clay mixtures**
▥	**ML**	**SILT** **non-plastic to medium plasticity**
▥	**MH**	**ELASTIC SILT** **high plasticity**
▧	**CL**	**LEAN CLAY** **low to medium plasticity**
▧	**CH**	**FAT CLAY** **high plasticity**
≀	**OL**	**ORGANIC SILT or CLAY** **non-plastic to low plasticity**
≀	**OH**	**ORGANIC SILT or CLAY** **high plasticity**
⁂	**PT**	**PEAT** **highly organic soils**

DRILLING SAMPLING SYMBOLS & ABBREVIATIONS

SS	Split Spoon Sampler	PM	Pressuremeter Test
ST	Shelby Tube Sampler	RD	Rock Bit Drilling
WS	Wash Sample	RC	Rock Core, NX, BX, AX
BS	Bulk Sample of Cuttings	REC	Rock Sample Recovery %
PA	Power Auger (no sample)	RQD	Rock Quality Designation %
HSA	Hollow Stem Auger		

PARTICLE SIZE IDENTIFICATION

DESIGNATION		PARTICLE SIZES
Boulders		12 inches (300 mm) or larger
Cobbles		3 inches to 12 inches (75 mm to 300 mm)
Gravel:	Coarse	¾ inch to 3 inches (19 mm to 75 mm)
	Fine	4.75 mm to 19 mm (No. 4 sieve to ¾ inch)
Sand:	Coarse	2.00 mm to 4.75 mm (No. 10 to No. 4 sieve)
	Medium	0.425 mm to 2.00 mm (No. 40 to No. 10 sieve)
	Fine	0.074 mm to 0.425 mm (No. 200 to No. 40 sieve)
Silt & Clay ("Fines")		<0.074 mm (smaller than a No. 200 sieve)

COHESIVE SILTS & CLAYS

UNCONFINED COMPRESSIVE STRENGTH, QP[4]	SPT[5] (BPF)	CONSISTENCY[7] (COHESIVE)
<0.25	<2	Very Soft
0.25 - <0.50	2 - 4	Soft
0.50 - <1.00	5 - 8	Firm
1.00 - <2.00	9 - 15	Stiff
2.00 - <4.00	16 - 30	Very Stiff
4.00 - 8.00	31 - 50	Hard
>8.00	>50	Very Hard

RELATIVE AMOUNT[7]	COARSE GRAINED (%)[8]	FINE GRAINED (%)[8]
Trace	≤5	≤5
With	10 - 20	10 - 25
Adjective *(ex: "Silty")*	25 - 45	30 - 45

GRAVELS, SANDS & NON-COHESIVE SILTS

SPT[5]	DENSITY
<5	Very Loose
5 - 10	Loose
11 - 30	Medium Dense
31 - 50	Dense
>50	Very Dense

WATER LEVELS[6]

▽	WL (First Encountered)
▼	WL (Completion)
▼	WL (Seasonal High Water)
▽	WL (Stabilized)

FILL AND ROCK

🟥	🟪	🟥	🟩
FILL	**POSSIBLE FILL**	**PROBABLE FILL**	**ROCK**

---

[1] Classifications and symbols per ASTM D 2488-17 (Visual-Manual Procedure) unless noted otherwise.

[2] To be consistent with general practice, "POORLY GRADED" has been removed from GP, GP-GM, GP-GC, SP, SP-SM, SP-SC soil types on the boring logs.

[3] Non-ASTM designations are included in soil descriptions and symbols along with ASTM symbol [Ex: (SM-FILL)].

[4] Typically estimated via pocket penetrometer or Torvane shear test and expressed in tons per square foot (tsf).

[5] Standard Penetration Test (SPT) refers to the number of hammer blows (blow count) of a 140 lb. hammer falling 30 inches on a 2 inch OD split spoon sampler required to drive the sampler 12 inches (ASTM D 1586). "N-value" is another term for "blow count" and is expressed in blows per foot (bpf). SPT correlations per 7.4.2 Method B and need to be corrected if using an auto hammer.

[6] The water levels are those levels actually measured in the borehole at the times indicated by the symbol. The measurements are relatively reliable when augering, without adding fluids, in granular soils. In clay and cohesive silts, the determination of water levels may require several days for the water level to stabilize. In such cases, additional methods of measurement are generally employed.

[7] Minor deviation from ASTM D 2488-17 Note 14.

[8] Percentages are estimated to the nearest 5% per ASTM D 2488-17.

REFERENCE NOTES FOR ROCK CORES

ROCK CLASSIFICATION TYPES

Igneous	Sedimentary	Metamorphic
Coarse Grained	**Clastic (sediment)**	**Foliated**
DIABASE	SHALE	GNEISS
DIORITE	SILTSTONE	PHYLLITE
GABBRO	SANDSTONE	SCHIST
GRANITE	CONGLOMERATE	SLATE
PEGMATITE	LIMESTONE, OOLITIC	**Non-Foliated**
PERIDOTITE	**Chemically Formed**	AMPHIBOLITE
SYENITE	DOLOSTONE	HORNFELS
Fine Grained	GYPSUM	MARBLE
ANDESITE	HALITE	QUARTZITE
BASALT	LIMESTONE	
RHYOLITE	**Organic Remains**	
TRACHYTE	CHALK	
Pyroclastic	COAL	
OBSIDIAN	COQUINA	
PUMICE		
TUFF		

HARDNESS

Very Soft	Deformed by hand
Soft	Scratched with a fingernail
Moderately Hard	Scratched easily with a knife
Hard	Scratched with difficulty with a knife
Very Hard	Cannot be scratched with a knife

JOINT/FRACTURE SPACING

Fractured/Jointed	Spacing
Very Widely	> 10 feet
Slightly	3 - 10 feet
Moderately	1 - 3 feet
Highly	2 inches - 1 foot
Intensely	< 2 inches

BEDDING

Thinly	≤ 0.3 ft.
Medium	>0.3 ft. ≤ 1 ft.
Thickly	>1 ft. ≤ 3 ft.
Massive	>3 ft.

JOINT OR FRACTURE CONTINUITY

It shall be noted whether the joints or fractures are continuous or discontinuous. If continuity of joints is not discernable at the scale of the rock core, continuous joints or fractures shall be assumed.

JOINT/FRACTURE ORIENTATION

The range or average orientation of each joint set or fracture trend shall be measured in degrees from a horizontal plane where possible. If no measurement is possible, the qualitative terms High, Moderate or Low-angle shall be used. Record whether the joints are present in Conjugate sets (i.e. having an opposite sense of dip)

High	61-90 degree
Moderate	31-60 degree
Low-angle	0-30 degree
Dip-angle	(1-90) ____ degrees (if measured)

Recovery (REC(%))

$$\frac{\text{Total rock recovered from run}}{\text{Total Run Length}}$$

Rock Quality Designation (RQD(%))*

$$\frac{\text{Sum of core pieces} \geq 4 \text{ inches long}}{\text{Total Run Length}}$$

RQD%	Description of Rock Quality
0-25%	Very Poor
>25%-50%	Poor
>50%-75%	Fair
>75%-90%	Good
>90%	Excellent

WEATHERING

Unweathered	No evidence of any chemical or mechanical alteration.
Slightly Weathered	Slight discoloration on surface, slight alteration along discontinuities, less than 10 percent of the rock volume altered.
Moderately Weathered	Discoloring evident, surface pitted and altered with alteration penetrating well below rock surfaces, weathering 'halos' evident. 10 to 50 percent of the rock altered.
Highly Weathered	Entire mass discolored, alteration pervading nearly all of the rock, with some pockets of slightly weathered rock noticeable, some minerals leached away.
Decomposed	Rock reduced to a soil with relict rock structure remaining (i.e. saprolite). Generally molded and crumbled by hand (friable).

JOINT/FRACTURE SURFACE CONDITION

The following qualitative terms shall be used to describe surface condition of joints and fractures. Multiple terms can be used.

Very rough	Slightly rough	Slickensided	Gouge

WALL ROCK CONDITION

The qualitative terms 'hard wall rock' or 'soft wall rock' shall be used to describe the condition of the parent rock on either side of the joint or fracture.

Description Sequence	Example Rock Classification Description
ROCK TYPE, [REC=_%,RQD=_%], Weathering, Hardness, Bedding, Joint/Fracture Spacing, Joint/Fracture Surface Condition, Wall Rock Condition, Joint or Fracture Continuity, Joint/Fracture Orientation, Color, Additional Features	LIMESTONE, [REC=95%,RQD=60%], Highly Weathered, Hard, Thinly Bedded, Slightly Fractured/Jointed, Slightly Rough, Hard Wall Rock, Continuous, Moderate-angle Dip, Gray White

*ASTM D6032-17: RQD is performed on cores using BQ to PQ sized bits (1.433 to 3.345 inch diameter cores, respectively)

SUBSURFACE EXPLORATION PROCEDURE: STANDARD PENETRATION TESTING (SPT)
ASTM D 1586
Split-Barrel Sampling

Standard Penetration Testing, or **SPT**, is the most frequently used subsurface exploration test performed worldwide. This test provides samples for identification purposes, as well as a measure of penetration resistance, or N-value. The N-Value, or blow counts, when corrected and correlated, can approximate engineering properties of soils used for geotechnical design and engineering purposes.

SPT Procedure:

- Involves driving a hollow tube (split-spoon) into the ground by dropping a 140-lb hammer a height of 30-inches at desired depth

- Recording the number of hammer blows required to drive split-spoon a distance of 18-24 inches (in 3 or 4 Increments of 6 inches each)

- Auger is advanced* and an additional SPT is performed

- One SPT typically performed for every two to five feet. An approximate 1.5 inch diameter soil sample is recovered.

**Drilling Methods May Vary—* The predominant drilling methods used for SPT are open hole fluid rotary drilling and hollow-stem auger drilling.

CLIENT: **KINGSLEY COMPANY**

PROJECT NO.: **66:1448**

BORING NO.: **B-01**

SHEET: **1 of 1**

PROJECT NAME: **The Mingo Residential Development - Phase I Woodburn**

DRILLER/CONTRACTOR: **Central Star Drilling Inc.**

SITE LOCATION: **Hoffman Playground, Cincinnati, Ohio, 45206**

LOSS OF CIRCULATION 100%

BOTTOM OF CASING

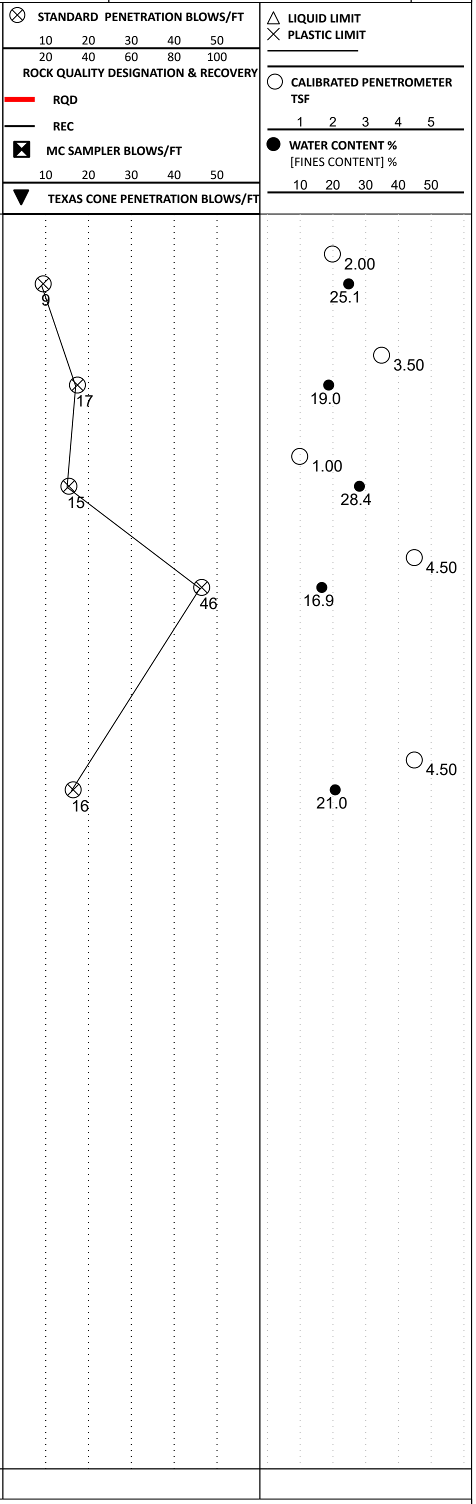
LATITUDE: **39.134305**

LONGITUDE: **-84.477420**

STATION:

SURFACE ELEVATION: **774.0**

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (TCP/MC/SPT-N value)*	STANDARD PENETRATION BLOWS/FT	CALIBRATED PENETROMETER TSF	WATER CONTENT %
					Asphalt Thickness[3.00"]						
					Concrete Thickness[5.00"]						
	S-1	SS	18	18	Gravel Thickness[5.00"]			3-4-5 (9)	9	2.00	25.1
					(CL/CH FILL) FILL, LEAN TO FAT CLAY, trace organics, mottled brown, moist, stiff to very stiff						
5	S-2	SS	18	18	(CL FILL) FILL, SANDY LEAN CLAY, trace gravel, mottled brown, moist, very stiff		769	6-7-10 (17)	17	3.50	19.0
	S-3	SS	18	18	(CL/ML) SILTY CLAY, trace sand, brown, moist, stiff			5-7-8 (15)	15	1.00	28.4
10	S-4	SS	18	18	(CL) SANDY LEAN CLAY, contains rock fragments, brown, dry to moist, very stiff to hard		764	7-13-33 (46)	46	4.50	16.9
15	S-5	SS	18	16			759	3-6-10 (16)	16	4.50	21.0
					AUGER REFUSAL AT 16.5 FT						
20							754				
25							749				
30							744				



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

▽	WL (First Encountered)	**DRY**
▼	WL (Completion)	**DRY**
▽	WL (Seasonal High Water)	**N/A**
▽	WL (Stabilized)	**DRY**

BORING STARTED: **Apr 09 2024**

CAVE IN DEPTH: **11.00**

BORING COMPLETED: **Apr 09 2024**

HAMMER TYPE: **Auto**

EQUIPMENT: **ATV**

LOGGED BY: **AMA2**

DRILLING METHOD: **2 1/4 HSA**

GEOTECHNICAL BOREHOLE LOG

CLIENT: **KINGSLEY COMPANY**

PROJECT NO.: **66:1448**

BORING NO.: **B-02**

SHEET: **1 of 1**

PROJECT NAME: **The Mingo Residential Development - Phase I Woodburn**

DRILLER/CONTRACTOR: **Central Star Drilling Inc.**

SITE LOCATION: **Hoffman Playground, Cincinnati, Ohio, 45206**

LOSS OF CIRCULATION ⟩100%⟩

BOTTOM OF CASING ▶

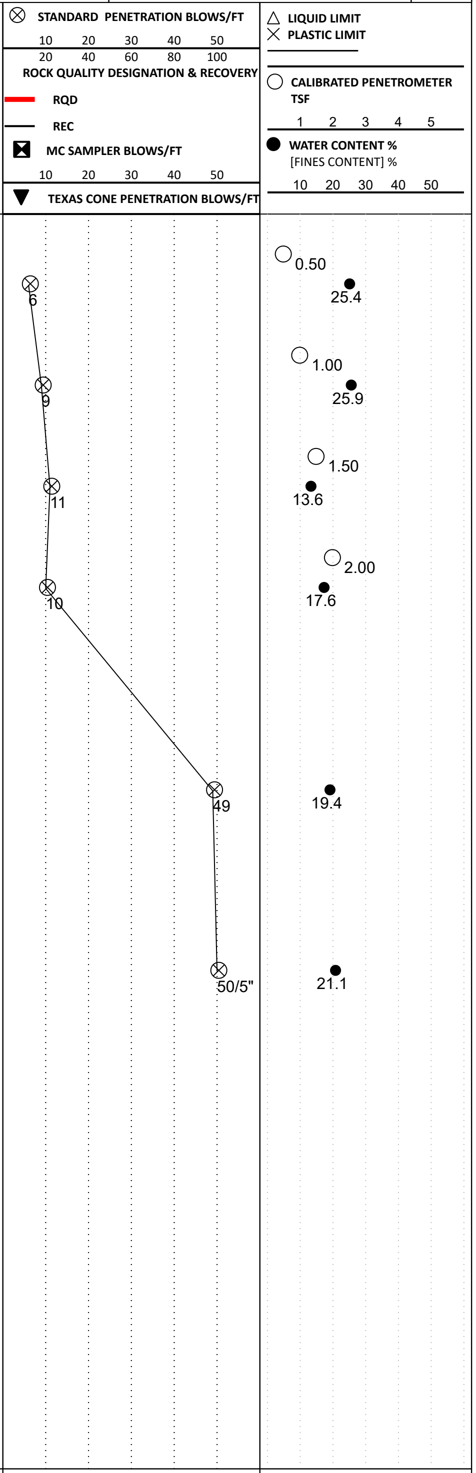
LATITUDE: **39.134255**

LONGITUDE: **-84.476357**

STATION:

SURFACE ELEVATION: **775.0**

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (TCP/MC/SPT-N value)*
					Asphalt Thickness[3.50"] Concrete Thickness[3.00"] Gravel Thickness[4.00"]			
	S-1	SS	18	10	(CL FILL) FILL, SANDY LEAN CLAY, trace gravel, mottled brown and gray, moist, firm to stiff			1-2-4 (6)
5	S-2	SS	18	18			770	5-4-5 (9)
	S-3	SS	18	18	(CL FILL) FILL, SANDY LEAN CLAY, contains rock fragments, mottled brown, moist, stiff			4-5-6 (11)
10	S-4	SS	18	18	(CL) SANDY LEAN CLAY, trace gravel, brown, moist, stiff to very stiff		765	4-4-6 (10)
15	S-5	SS	18	18	SHALE, Highly Weathered, contains rock fragments, olive brown and gray, moist, very soft		760	14-24-25 (49)
	S-6	SS	5	5				50/5" (50/5")
					SPOON REFUSAL AT 18.92 FT			
20							755	
25							750	
30							745	



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

▽ WL (First Encountered) **DRY**

▼ WL (Completion) **DRY**

▽ WL (Seasonal High Water) **N/A**

▽ WL (Stabilized) **DRY**

BORING STARTED: **Apr 09 2024**

BORING COMPLETED: **Apr 09 2024**

EQUIPMENT: **ATV**

LOGGED BY: **AMA2**

CAVE IN DEPTH: **15.00**

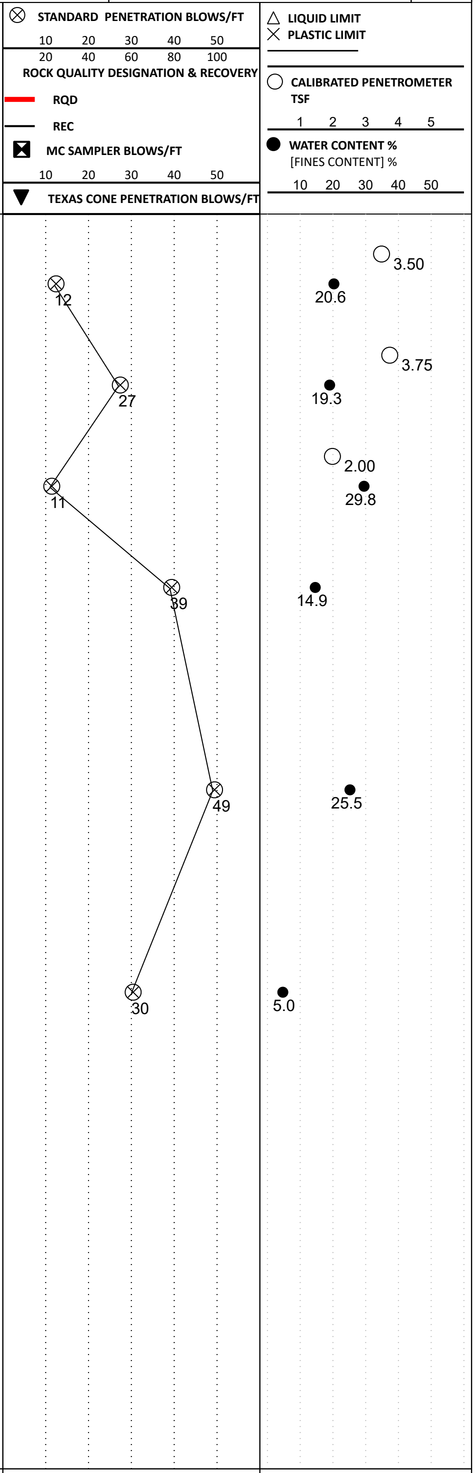
HAMMER TYPE: **Auto**

DRILLING METHOD: **2 1/4 HSA**

GEOTECHNICAL BOREHOLE LOG

CLIENT: **KINGSLEY COMPANY**	PROJECT NO.: **66:1448**	BORING NO.: **B-03**	SHEET: **1 of 1**
PROJECT NAME: **The Mingo Residential Development - Phase I Woodburn**	DRILLER/CONTRACTOR: **Central Star Drilling Inc.**		
SITE LOCATION: **Hoffman Playground, Cincinnati, Ohio, 45206**			LOSS OF CIRCULATION 100%
LATITUDE: **39.134162**	LONGITUDE: **-84.477446**	STATION:	SURFACE ELEVATION: **773.0**
			BOTTOM OF CASING

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (TCP/MC/SPT-N value)*
					Topsoil Thickness[3.00"]			
	S-1	SS	18	18	(CL) SANDY LEAN CLAY, trace gravel, brown, moist, stiff to very stiff			3-5-7 (12)
	S-2	SS	18	18				8-11-16 (27)
5							768	
	S-3	SS	18	18				4-5-6 (11)
	S-4	SS	18	18	(CL) SANDY LEAN CLAY, trace gravel, contains rock fragments, brown, dry to moist, hard			8-8-31 (39)
10							763	
	S-5	SS	18	16				5-35-14 (49)
15							758	
	S-6	SS	18	10				8-9-21 (30)
20					**END OF BORING AT 20 FT**		753	
25							748	
30							743	



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

▽ WL (First Encountered) **DRY**	BORING STARTED: **Apr 09 2024**		CAVE IN DEPTH: **16.00**
▼ WL (Completion) **DRY**	BORING COMPLETED: **Apr 09 2024**		HAMMER TYPE: **Auto**
▼ WL (Seasonal High Water) **N/A**	EQUIPMENT: **ATV**	LOGGED BY: **AMA2**	DRILLING METHOD: **2 1/4 HSA**
▽ WL (Stabilized) **DRY**			

GEOTECHNICAL BOREHOLE LOG

CLIENT:	PROJECT NO.:	BORING NO.:	SHEET:
KINGSLEY COMPANY	**66:1448**	**B-04**	**1 of 1**

PROJECT NAME: **The Mingo Residential Development - Phase I Woodburn**

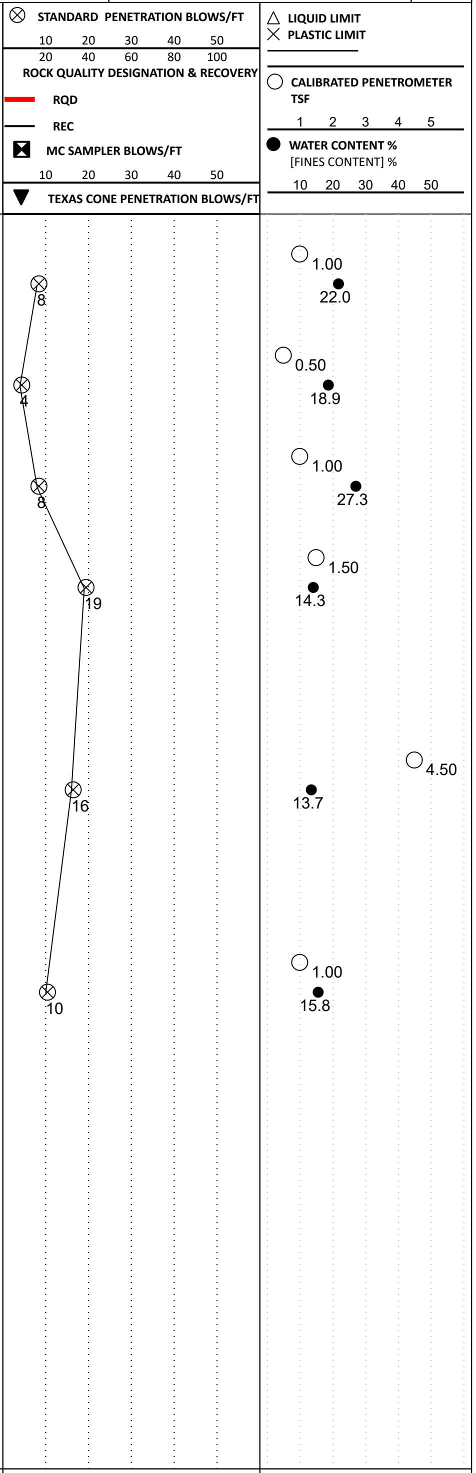
DRILLER/CONTRACTOR: **Central Star Drilling Inc.**

SITE LOCATION: **Hoffman Playground, Cincinnati, Ohio, 45206**

LOSS OF CIRCULATION

BOTTOM OF CASING

LATITUDE:	LONGITUDE:	STATION:	SURFACE ELEVATION:
39.134085	**-84.476563**		**773.0**



DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (TCP/MC/SPT-N value)*	STANDARD PENETRATION BLOWS/FT	CALIBRATED PENETROMETER TSF	WATER CONTENT %
					Topsoil Thickness[3.00"]						
	S-1	SS	18	18	(CL FILL) FILL, SANDY LEAN CLAY, trace gravel, contains rock fragments and brick, dark brown, moist, firm to stiff			6-4-4 (8)	8	1.00	22.0
5	S-2	SS	18	14	(CL FILL) FILL, SANDY LEAN CLAY, trace gravel, contains rock fragments and brick, dark brown, moist, soft to firm		768	2-2-2 (4)	4	0.50	18.9
	S-3	SS	18	18	(CL FILL) FILL, SANDY LEAN CLAY, trace gravel, contains rock fragments and brick, dark brown, moist, firm to stiff			2-4-4 (8)	8	1.00	27.3
10	S-4	SS	18	18	(CL FILL) FILL, SANDY LEAN CLAY, trace gravel, contains rock fragments, brown, moist, stiff to very stiff		763	6-9-10 (19)	19	1.50	14.3
15	S-5	SS	18	18	(CL) SANDY LEAN CLAY, trace gravel, brown, moist, very stiff to hard		758	5-7-9 (16)	16	4.50	13.7
20	S-6	SS	18	18	(CL) LEAN CLAY, trace organics, trace gravel, gray, moist, stiff		753	6-4-6 (10)	10	1.00	15.8
					END OF BORING AT 20 FT						
25							748				
30							743				

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

WL (First Encountered)	**DRY**
WL (Completion)	**DRY**
WL (Seasonal High Water)	**N/A**
WL (Stabilized)	**DRY**

BORING STARTED: **Apr 09 2024**

BORING COMPLETED: **Apr 09 2024**

EQUIPMENT: **ATV**

LOGGED BY: **AMA2**

CAVE IN DEPTH: **16.00**

HAMMER TYPE: **Auto**

DRILLING METHOD: **2 1/4 HSA**

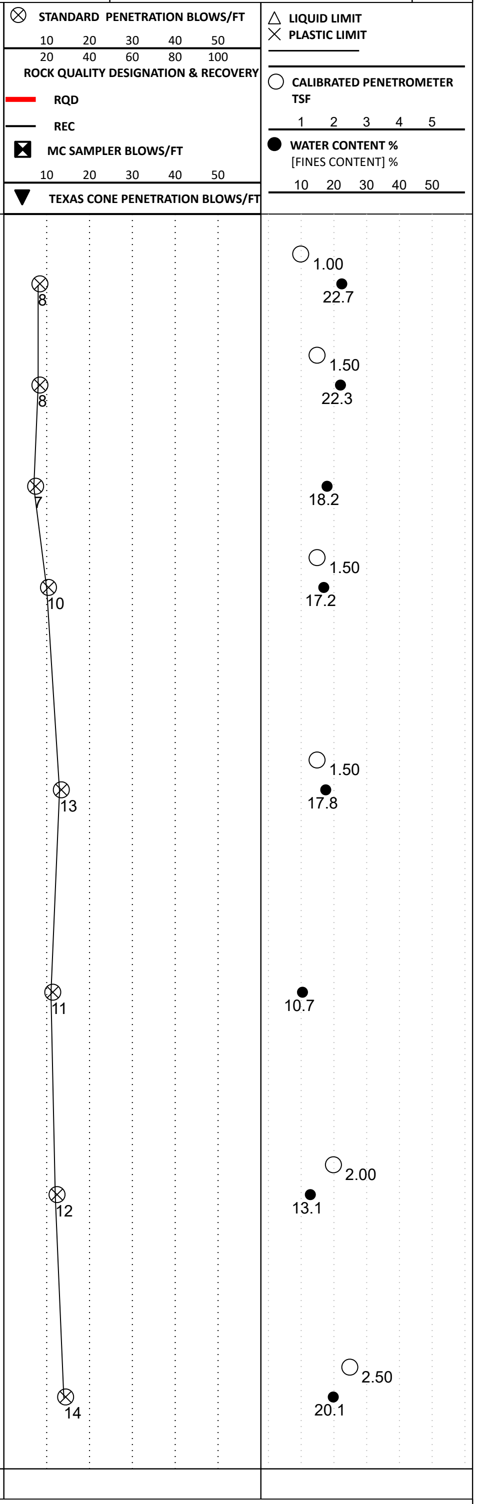
GEOTECHNICAL BOREHOLE LOG

CLIENT: **KINGSLEY COMPANY**	PROJECT NO.: **66:1448**	BORING NO.: **B-05**	SHEET: **1 of 1**
PROJECT NAME: **The Mingo Residential Development - Phase I Woodburn**	DRILLER/CONTRACTOR: **Central Star Drilling Inc.**		
SITE LOCATION: **Hoffman Playground, Cincinnati, Ohio, 45206**			
LATITUDE: **39.133593**	LONGITUDE: **-84.476502**	STATION:	SURFACE ELEVATION: **772.0**

LOSS OF CIRCULATION 100%

BOTTOM OF CASING

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (TCP/MC/SPT-N value)*
	S-1	SS	18	16	(CL/CH FILL) FILL, LEAN TO FAT CLAY, trace gravel, mottled brown, moist, firm to stiff			3-4-4 (8)
5	S-2	SS	18	16	(CL FILL) FILL, SANDY LEAN CLAY, trace gravel, brown, moist, firm to stiff		767	3-4-4 (8)
	S-3	SS	18	18	(CL FILL) FILL, SANDY LEAN CLAY, trace gravel, contains asphalt, dark brown, moist, firm			2-3-4 (7)
10	S-4	SS	18	18	(CL FILL) FILL, SANDY LEAN CLAY, trace gravel, brown, moist, stiff		762	4-4-6 (10)
15	S-5	SS	18	18			757	4-5-8 (13)
20	S-6	SS	18	12	(SP FILL) FILL, SAND WITH GRAVEL, contains rock fragments and brick, brown, moist, medium dense		752	6-6-5 (11)
25	S-7	SS	18	18	(CL) SANDY LEAN CLAY, trace gravel, brown, moist, stiff to very stiff		747	4-5-7 (12)
30	S-8	SS	18	18			742	4-6-8 (14)
					END OF BORING AT 30 FT			



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

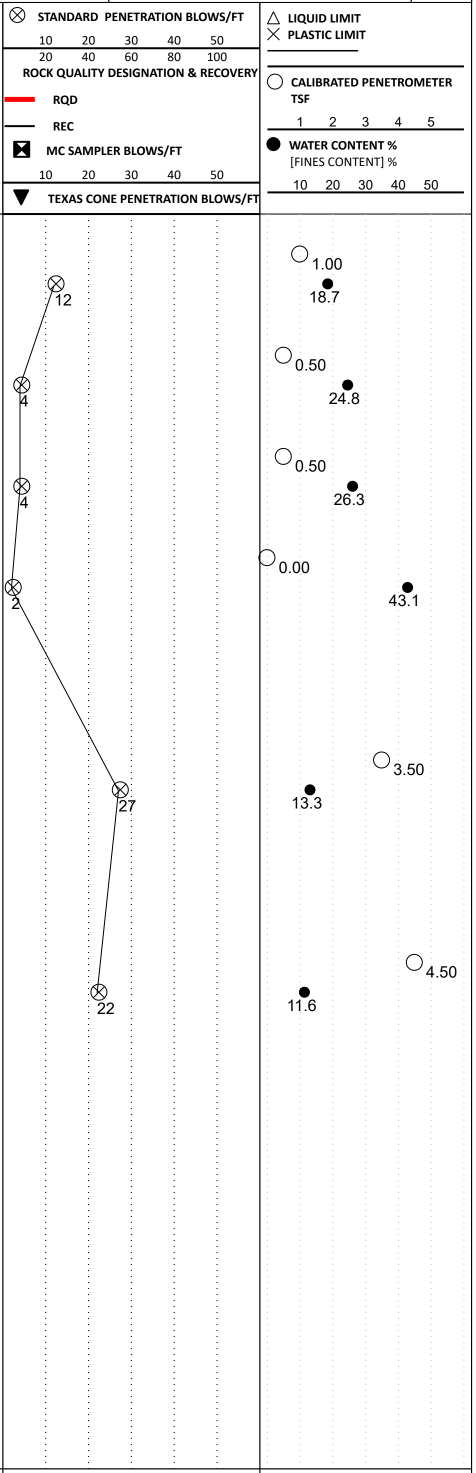
▽ WL (First Encountered)	**DRY**	BORING STARTED:	**Apr 09 2024**	CAVE IN DEPTH:	**18.00**
▼ WL (Completion)	**DRY**	BORING COMPLETED:	**Apr 09 2024**	HAMMER TYPE:	**Auto**
▽ WL (Seasonal High Water)	**N/A**	EQUIPMENT: **ATV**	LOGGED BY: **AMA2**	DRILLING METHOD:	**2 1/4 HSA**
▽ WL (Stabilized)	**DRY**				

GEOTECHNICAL BOREHOLE LOG

CLIENT: **KINGSLEY COMPANY**	PROJECT NO.: **66:1448**	BORING NO.: **B-06**	SHEET: **1 of 1**
PROJECT NAME: **The Mingo Residential Development - Phase I Woodburn**	DRILLER/CONTRACTOR: **Central Star Drilling Inc.**		
SITE LOCATION: **Hoffman Playground, Cincinnati, Ohio, 45206**		LOSS OF CIRCULATION	
LATITUDE: **39.133887**	LONGITUDE: **-84.476806**	STATION:	SURFACE ELEVATION: **772.0**
		BOTTOM OF CASING	

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	BLOWS/6" (TCP/MC/SPT-N value)*
				Topsoil Thickness[3.00"]	
S-1	SS	18	18	(CL FILL) FILL, SANDY LEAN CLAY, trace gravel, contains asphalt, dark brown, moist, stiff	4-6-6 (12)
S-2	SS	18	12	(CL/ML FILL) FILL, SILTY CLAY WITH SAND, trace gravel, contains asphalt, dark brown, moist, soft to firm	2-2-2 (4)
S-3	SS	18	18		2-2-2 (4)
S-4	SS	18	6	(CL FILL) FILL, LEAN CLAY WITH SAND, contains brick, dark brown and gray, wet, very soft	7-1-1 (2)
S-5	SS	18	18	(CL) SANDY LEAN CLAY, contains rock fragments, brown, dry to moist, very stiff	8-10-17 (27)
S-6	SS	18	18		8-10-12 (22)
				END OF BORING AT 20 FT	

DEPTH (FT)	ELEVATION (FT)
5	767
10	762
15	757
20	752
25	747
30	742



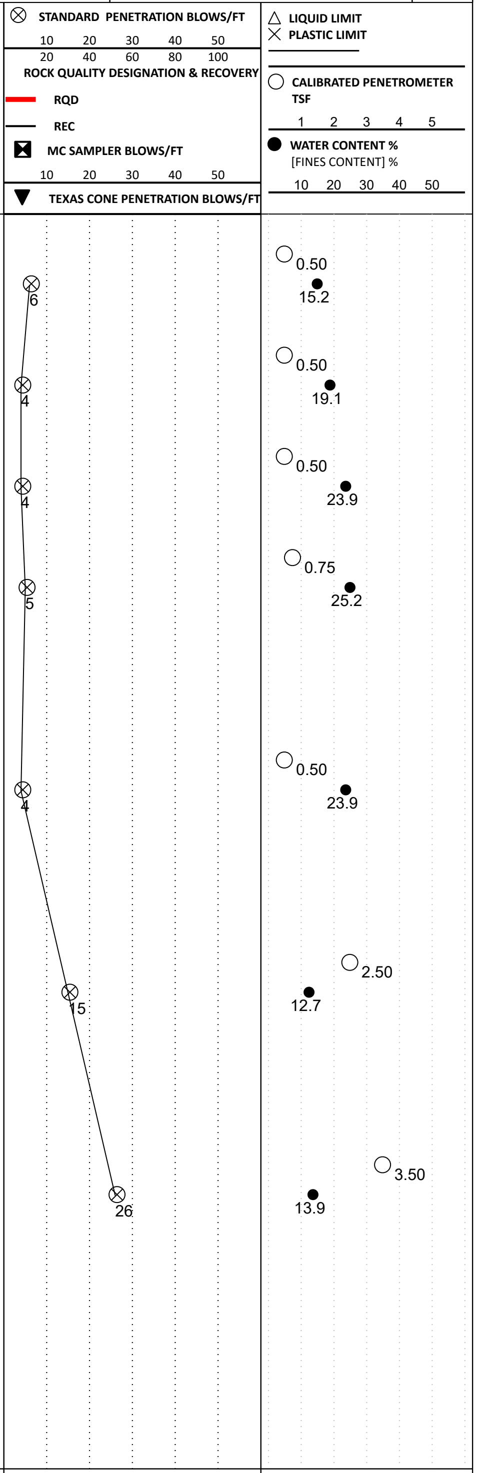
THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

WL (First Encountered)	**DRY**	BORING STARTED: **Apr 09 2024**	CAVE IN DEPTH:
WL (Completion)	**DRY**	BORING COMPLETED: **Apr 09 2024**	HAMMER TYPE: **Auto**
WL (Seasonal High Water)	**N/A**	EQUIPMENT: **ATV** LOGGED BY: **AMA2**	DRILLING METHOD: **2 1/4 HSA**
WL (Stabilized)	**DRY**		

GEOTECHNICAL BOREHOLE LOG

CLIENT: **KINGSLEY COMPANY**
PROJECT NO.: **66:1448**
BORING NO.: **B-07**
SHEET: **1 of 1**
PROJECT NAME: **The Mingo Residential Development - Phase I Woodburn**
DRILLER/CONTRACTOR: **Central Star Drilling Inc.**
SITE LOCATION: **Hoffman Playground, Cincinnati, Ohio, 45206**
LOSS OF CIRCULATION
BOTTOM OF CASING
LATITUDE: **39.133718**
LONGITUDE: **-84.477232**
STATION:
SURFACE ELEVATION: **771.0**

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (TCP/MC/SPT-N value)*
					Topsoil Thickness[3.00"] (CL FILL) FILL, SANDY LEAN CLAY, trace gravel, contains asphalt and brick, brown and gray, moist, soft to firm			
	S-1	SS	18	16				4-3-3 (6)
	S-2	SS	18	14				2-2-2 (4)
5							766	
	S-3	SS	18	18				2-2-2 (4)
	S-4	SS	18	18				2-2-3 (5)
10							761	
	S-5	SS	18	18				2-2-2 (4)
15							756	
	S-6	SS	18	18	(CL) SANDY LEAN CLAY, trace gravel, brown, dry to moist, stiff to very stiff			4-7-8 (15)
20							751	
	S-7	SS	18	18				7-9-17 (26)
25					**END OF BORING AT 25 FT**		746	
30							741	



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

▽	WL (First Encountered)	**DRY**
▼	WL (Completion)	**DRY**
▽	WL (Seasonal High Water)	**N/A**
▽	WL (Stabilized)	**DRY**

BORING STARTED: **Apr 09 2024**
CAVE IN DEPTH: **20.00**
BORING COMPLETED: **Apr 09 2024**
HAMMER TYPE: **Auto**
EQUIPMENT: **ATV**
LOGGED BY: **AMA2**
DRILLING METHOD: **2 1/4 HSA**

GEOTECHNICAL BOREHOLE LOG

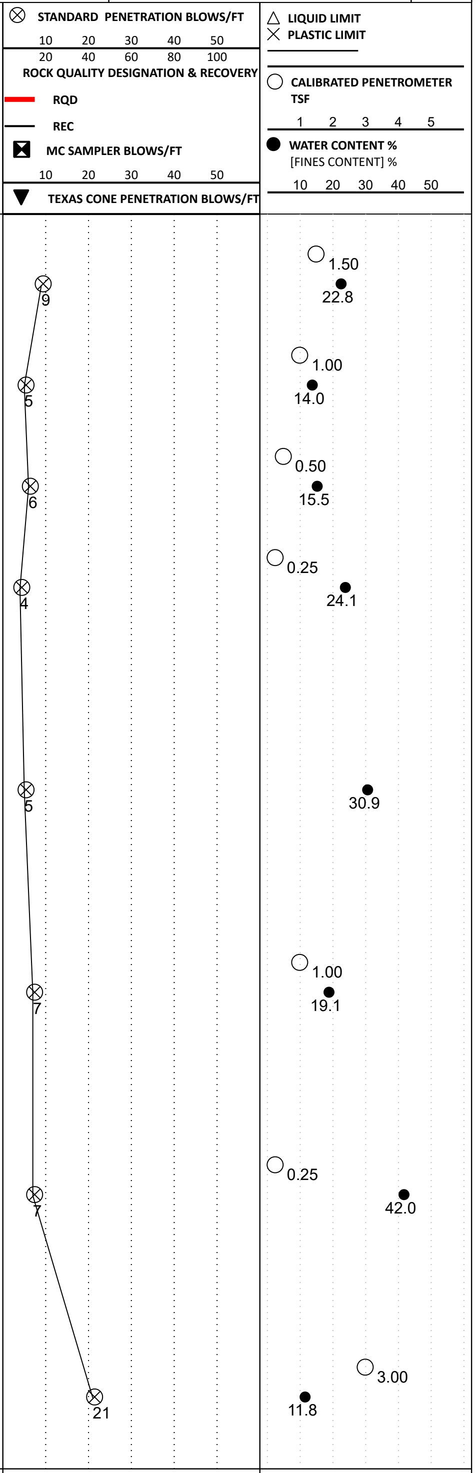
CLIENT:	PROJECT NO.:	BORING NO.:	SHEET:
KINGSLEY COMPANY	**66:1448**	**B-08**	**1 of 1**

PROJECT NAME:	DRILLER/CONTRACTOR:
The Mingo Residential Development - Phase I Woodburn	**Central Star Drilling Inc.**

SITE LOCATION:	
Hoffman Playground, Cincinnati, Ohio, 45206	LOSS OF CIRCULATION ⟩100%⟩
	BOTTOM OF CASING ■

LATITUDE:	LONGITUDE:	STATION:	SURFACE ELEVATION:
39.133602	**-84.476828**		**771.0**

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6" (TCP/MC/SPT-N value)*
	S-1	SS	18	18	(CL FILL) FILL, SANDY LEAN CLAY, trace gravel, contains asphalt, brown, moist, firm to stiff			3-4-5 (9)
	S-2	SS	18	16				3-3-2 (5)
5							766	
	S-3	SS	18	16				5-4-2 (6)
	S-4	SS	18	18	(CL FILL) FILL, LEAN CLAY, trace gravel, mottled brown, moist, soft			2-2-2 (4)
10							761	
	S-5	SS	18	16	(SC FILL) FILL, CLAYEY SAND, contains cinders, trace gravel, black, moist, loose			3-2-3 (5)
15							756	
	S-6	SS	18	18	(CL FILL) FILL, SANDY LEAN CLAY, trace gravel, brown, moist, firm to stiff			2-3-4 (7)
20							751	
	S-7	SS	18	18	(CL FILL) FILL, SANDY LEAN CLAY WITH GRAVEL, trace gravel, contains anthracite cinders, black, wet, soft to firm			3-4-3 (7)
25							746	
	S-8	SS	18	18	(CL) SANDY LEAN CLAY, trace gravel, brown, moist, very stiff			9-10-11 (21)
30					**END OF BORING AT 30 FT**		741	



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

▽ WL (First Encountered)	**DRY**	BORING STARTED:	**Apr 09 2024**	CAVE IN DEPTH:	**23.00**
▼ WL (Completion)	**DRY**	BORING COMPLETED:	**Apr 09 2024**	HAMMER TYPE:	**Auto**
▼ WL (Seasonal High Water)	**N/A**	EQUIPMENT: **ATV**	LOGGED BY: **AMA2**	DRILLING METHOD:	**2 1/4 HSA**
▽ WL (Stabilized)	**DRY**				

GEOTECHNICAL BOREHOLE LOG

Appendix C – Other Information

GBA - Geotechnical Engineering Report Information Sheet

Important Information about This

Geotechnical-Engineering Report

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

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

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

Understand the Geotechnical-Engineering Services Provided for this Report

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

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

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

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

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

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

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

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

Read this Report in Full

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

You Need to Inform Your Geotechnical Engineer About Change

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

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

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

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

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

This Report's Recommendations Are Confirmation-Dependent

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

This Report Could Be Misinterpreted

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

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

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

Give Constructors a Complete Report and Guidance

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

Read Responsibility Provisions Closely

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

Geoenvironmental Concerns Are <u>Not</u> Covered

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

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

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

GEOPROFESSIONAL
BUSINESS
ASSOCIATION

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e-mail: info@geoprofessional.org www.geoprofessional.org