Civil & Environmental Consultants, Inc.

April 10, 2018

Ms. Julie Vonderhaar
Administrator
Fairfield Township
6032 Morris Road
Fairfield Township, OH 45011

Dear Ms. Vonderhaar:

Subject: Report of Geotechnical Engineering Exploration
Fairfield Township Fire/EMT Station
Fairfield Township, Ohio 45011
CEC Project 161-305-0040

Civil & Environmental Consultants, Inc. (CEC) presents for your use our Geotechnical Engineering Exploration Report for the proposed Fairfield Township Fire/EMT Station planned to be constructed on the west side of Gilmore Road in Fairfield Township, Ohio. This report presents a summary of the encountered subsurface conditions at the referenced project site and our geotechnical engineering recommendations for design and construction of the planned structure foundations and pavements. CEC's opinions and recommendations contained herein are based on the data obtained at the test boring locations, site observations, laboratory testing, geotechnical engineering analyses, and our experience with similar projects.

The geotechnical exploration was performed and this report was prepared in general accordance with our Proposal for Surveying and Professional Engineering Services dated December 20, 2017. Ms. Julie Vonderhaar of Fairfield Township provided CEC with authorization to proceed on March 6, 2018.

CEC appreciates this opportunity to provide our services to Fairfield Township and we look forward to serving as your civil and geotechnical engineering consultant throughout this project. Please contact us if you have any questions regarding the information presented in this report.

Sincerely,

CIVIL & ENVIRONMENTAL CONSULTANTS, INC.

John B. Gronnett IV, P.E.
Staff Consultant

Anthony P. Amicon, P.E.
Vice President

Attachments: Geotechnical Engineering Exploration Report

P:\2016\161-305\-Final Documents\Geotech Report\161-305 Geotechnical Report.docx

# GEOTECHNICAL ENGINEERING EXPLORATION REPORT

# FAIRFIELD TOWNSHIP FIRE/EMT STATION
# FAIRFIELD TOWNSHIP, OHIO

**Prepared for:**

**FAIRFIELD TOWNSHIP**

**Prepared by:**

**CIVIL & ENVIRONMENTAL CONSULTANTS, INC.**
**CINCINNATI, OHIO**

**CEC Project 161-305-0040**

**April 10, 2018**

Civil & Environmental Consultants, Inc.

# TABLE OF CONTENTS

**Page**

1.0 INTRODUCTION .......... 1
    1.1 PURPOSE .......... 1
    1.2 SCOPE OF SERVICES .......... 1
    1.3 STANDARD OF CARE .......... 2
2.0 BACKGROUND INFORMATION .......... 3
3.0 FIELD EXPLORATIONS AND LABORATORY TESTING .......... 5
    3.1 FIELD EXPLORATIONS .......... 5
    3.2 LABORATORY TESTING .......... 6
4.0 EXPLORATORY FINDINGS .......... 8
    4.1 TOPSOIL .......... 9
    4.2 GLACIAL TILL .......... 9
    4.3 RESIDUAL .......... 10
    4.4 BEDROCK .......... 11
    4.5 GROUNDWATER .......... 11
5.0 CONCLUSIONS .......... 13
    5.1 RELATIVELY MOIST/WEAK SOILS .......... 14
        5.1.1 Yielding Subgrade Conditions .......... 14
        5.1.2 High Moisture Content Borrow Sources .......... 15
    5.2 HIGH GROUNDWATER .......... 15
    5.3 SHALLOW BEDROCK .......... 16
6.0 DESIGN AND CONSTRUCTION RECOMMENDATIONS .......... 17
    6.1 SITE PREPARATION AND EARTHWORK .......... 17
        6.1.1 Site Preparation .......... 17
        6.1.2 Engineered Fill .......... 18
        6.1.3 Permanent Soil and Detention Basin Slopes .......... 19
        6.1.4 Temporary Excavations and Backfill .......... 20
        6.1.5 Groundwater Considerations .......... 20
    6.2 BUILDING FOUNDATIONS .......... 21
        6.2.1 Foundation Design .......... 21
        6.2.2 Foundation Construction Considerations .......... 22
    6.3 CONCRETE SLAB-ON-GRADE .......... 23
    6.4 PAVEMENTS .......... 25
        6.4.1 Subgrade Preparation .......... 25
        6.4.2 Subgrade Support Design .......... 25
        6.4.3 General Pavement Design Recommendations .......... 25
    6.5 SEISMIC DESIGN .......... 26
7.0 CONSTRUCTION QUALITY CONTROL MEASURES .......... 28
8.0 BASIS FOR RECOMMENDATIONS .......... 29
9.0 CONSTRUCTION PLANS AND SPECIFICATION REVIEW .......... 30

## LIST OF FIGURES

**Figure**

Site Location Map ........................................ 1
Site and Vicinity Aerial Map ........................................ 2
Boring Location Plan ........................................ 3
Subsurface Diagram (Cross Section A-A’) ........................................ 4
Subsurface Diagram (Cross Section B-B’)........................................ 5

## LIST OF APPENDICES

**Appendix**

Important Information About This Geotechnical-Engineering Report ........................................ I
Test Boring Logs........................................ II
Laboratory Test Results ........................................ III

## 1.0 INTRODUCTION

### 1.1 PURPOSE

The purpose of this report is to present the findings of the geotechnical explorations performed for the subject project site in order to characterize the subsurface soil and groundwater conditions within the vicinity of the planned development, to perform geotechnical engineering analyses, and to develop geotechnical engineering design and construction recommendations for earthwork, building foundations, floor slabs, and pavements.

### 1.2 SCOPE OF SERVICES

The scope of services performed by CEC to meet the intended purpose included: a review of published geotechnical data, collection of soil samples from borings, laboratory testing of selected soil samples obtained from the borings, performance of geotechnical engineering analyses, and preparation of this summary report. The developed information, conclusions and recommendations contained within this summary report include the following:

- A summary of the project including; topographic site features, planned developments, and site grading;
- A review of our field and laboratory test procedures and the results of testing conducted;
- A review of subsurface conditions with pertinent available physical properties;
- Bedrock depths;
- Depths of water levels measured in the borings at the time of the field exploration;
- Identification of subsurface conditions that may impact the design or construction of the planned development (weak or compressible fill, settlement, shallow bedrock, high groundwater, etc.);
- Recommendations for site preparation including earthwork construction procedures and remediation of unsuitable soil subgrade materials;
- Recommendations for shallow foundation design criteria;
- An estimate of total and differential settlement for the recommended building foundations;
- A summary of general guides for building foundation construction;

- Recommendations for slab-on-grade design;
- Recommendations for Seismic Site Classification; and,
- Asphalt and concrete pavement design recommendations.

Our conclusions and recommendations are based on the results of our field explorations, selected laboratory tests and appropriate engineering analyses. The results of the field explorations and laboratory tests, which form the basis of our recommendations, are presented in the appendices.

While groundwater and drainage issues are addressed as part of this report, CEC is not a mold prevention consultant. None of the services performed as part of this exploration were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved. To prevent or reduce mold problems, an experienced mold prevention consultant should be retained.

This report has been prepared for Fairfield Township and their design consultants to be used solely in evaluating the soils underlying the subject site and presenting geotechnical engineering recommendations specific to this project. The report has not been prepared for use by other parties, and may not contain sufficient information for purposes of other parties nor other uses.

The assessment of general site environmental conditions or the presence of pollutants in the soil, rock and groundwater of the site was beyond the scope of this geotechnical exploration.

## 1.3 STANDARD OF CARE

The services performed by CEC were conducted in a manner consistent with the level of care and skill ordinarily exercised by members of the geotechnical engineering profession practicing contemporaneously under similar conditions in the locality of the project. No other warranty, expressed or implied, is made. Appendix I contains a document entitled "Important Information About This Geotechnical-Engineering Report." This document further explains the realities of geotechnical engineering and the limitations that exist in evaluating geotechnical issues.

# 2.0 BACKGROUND INFORMATION

CEC understands that Fairfield Township is planning to develop an approximate 2.3-acre property, situated on the west side of Gilmore Road in Fairfield Township, Ohio, for a new Fire/EMT Station. The project site is located between Hamilton Mason Road and State Route 129, north of a newly constructed senior living facility (StoryPoint of Fairfield). The approximate location of the project site is depicted on the enclosed Site Location Map and Site and Vicinity Aerial Map (Figures 1 and 2, respectively).

Overall, the project site is situated within the approximate northeast quadrant of a mostly undeveloped section of land that is bound by Gilmore Road to the east, a residential development to the west, Hamilton Mason Road to the south, and State Route 129 to the north. The site is currently moderately to densely wooded land, with vegetation consisting of mostly honeysuckle and small diameter trees. Based on our review of the site and topographic information contained on the Existing Conditions Plan (C100) created by CEC and dated March 2018, the current ground surface within the project boundary is relatively flat and near elevation 747 feet above mean sea level (amsl) from the east property line (near Gilmore Road) to the approximate east-west midpoint of the property. At about the east-west property midpoint, the existing ground surface transitions into a relatively gentle upward slope toward the west property line to an elevation of about 753 feet amsl. Based on our site reconnaissance and the information contained in the Site Assessment Summary report completed by CEC, Inc. dated January 16, 2018, an existing stream located just north of the north site boundary traverses the site in a west to east direction.

Based on a Preliminary Site Layout drawing (SK-1) created by CEC and dated February 2018, the subject site will be developed to include an approximately 14,000 square feet (sq. ft.) L-shaped building (about 154 feet long by 90 to 110 feet wide) that will be positioned centrally within the property and face Gilmore Road. Additionally, the development is proposed to include a U-shaped pavement driveway. The north driveway is planned to be approximately 30 feet in width and traverse in an east-west direction north of the proposed building. The south driveway is planned to be approximately 85 feet in width and will traverse in an east-west direction through the southern half of the proposed building. Each driveway will provide ingress/egress to Gilmore Road. The two referenced driveways will be connected by an approximately 30 feet wide driveway west of the proposed building, with thirteen parking spaces planned adjacent to and west of the connecting driveway. A stormwater detention basin is planned in the northeast corner of the site.

At the time of this report, the finish floor elevation, proposed exterior grades, building type details, structural loads, and traffic information are not available. However, based on our understanding, the proposed finish floor elevation of the new building will closely match the existing grades. On this basis, we have assumed a finish floor elevation of about 748 feet amsl for the proposed building. It is anticipated that the proposed site grading will require excavations within the western portion of the site and fill placement within the eastern portion of the site that will be less than about 2 feet. With respect to the proposed building structural loads, the foundation column loads and continuous wall loads are assumed to be less than 150 kips and 2 kips per linear foot, respectively. Building foundation settlement tolerances are assumed to be on the order of about 1-inch total and 0.5 inches differentially. Further, floor loads are expected to be less than 150 pounds per square foot (psf).

# 3.0 FIELD EXPLORATIONS AND LABORATORY TESTING

## 3.1 FIELD EXPLORATIONS

The soil and groundwater conditions at the subject project site were explored by drilling 10 test borings (designated as Borings B-1 through B-10). The test boring locations were selected by CEC to provide general coverage of the planned development areas of the site with the intent to evaluate subsurface soil and groundwater conditions within the planned building footprint and pavement areas. Each boring location was initially established in the field using a hand-held Global Positioning System (GPS) unit with sub-meter accuracy. Subsequent to the drilling activities, the boring locations and associated ground surface elevations were surveyed by CEC. The individual boring logs (included within Appendix II) include the established surveyed coordinate location (based on Ohio State Plane South NAD83) and corresponding ground surface elevation. The approximate test boring locations are depicted on Figure 3 (Boring Location Plan) enclosed with this report.

The boring program was performed on March 8, 2018. CSI Drilling, LLC was subcontracted by CEC to clear access to the proposed boring locations using a bulldozer and to perform the drilling services using an all-terrain vehicle (ATV) drill rig. Drilling was performed using 2.25-inch diameter solid-stem augers to advance the borings to the termination depths that varied from approximately 7.4 to 12.4 feet below ground surface (bgs). The borings were extended as appropriate through native soils to evaluate the subsurface conditions at the site. As each boring was advanced through soil, disturbed soil samples were obtained at selected depths. The disturbed soil samples were generally obtained at 2.5 foot intervals to a depth of 10 feet bgs, and then at 5 foot centers thereafter using a split-spoon sampler in accordance with the Standard Penetration Test (SPT) (ASTM D-1586). The SPT sampling consisted of driving a 2-inch outer diameter split barrel sampler using a 140-pound hammer freely falling a distance of 30 inches. The number of blows required to drive the sampler over three successive 6-inch increments was recorded. The first 6-inch increment is considered a seating interval and was not used to estimate soil conditions. The sum of blows for the second and third driving increments is considered the SPT value or “N” value of the soil. The N value is used to estimate the relative density of coarse-grained soil or the consistency of fine grained soil.  The soil samples obtained during the explorations were visually observed in the field by the CEC field representative and preserved for review by the Geotechnical Engineer and laboratory testing.

Groundwater level measurements were obtained both during and after the completion of drilling operations.  After completing the borings, the boreholes were backfilled with auger cuttings. However, three boreholes (i.e., Borings B-2, B-3 and B-7) were left open prior to backfilling for 16 to 19 hours in order to obtain extended groundwater level measurements.  After extended groundwater level measurements were taken, these borings were backfilled in the same manner as mentioned previously.  The groundwater level measurements are included on the individual boring logs.

The field exploration program was coordinated by a CEC Geotechnical Engineer.  A CEC field representative supervised the drilling operations and performed the following specific duties as directed by the Geotechnical Engineer: 1) reviewed soil samples recovered from the borings; 2) described the soil color, texture, apparent origin, and apparent relative moisture content of the SPT samples obtained; 3) preserved representative portions of the samples; 4) prepared a field log of each boring; 5) made seepage and groundwater observations; and, 6) estimated undrained shear strength values on specimens exhibiting cohesion (using a Pocket Penetrometer). The field logs were reviewed and modified by the CEC Geotechnical Engineer, if needed, based on a review of the developed field information, soil samples and laboratory test results (Section 3.2).  The final boring logs are included in Appendix II.  Appendix II also contains a summary of the definitions for standard terms and symbols used in the boring logs.

### 3.2 LABORATORY TESTING

Prior to shipment to the laboratory, the soil samples were visually reviewed by the Geotechnical Engineer to aid in the evaluation of the engineering properties of the subsurface soil.  The information was used to modify the soil descriptions contained on the field logs where necessary. In addition, representative samples were selected for laboratory testing.  The laboratory program, performed by CSI Inc. and ATC Associates Inc., included natural moisture content determinations, Atterberg Limits, Loss-on-Ignition (LOI), specific gravity test and an Unconsolidated-Undrained Triaxial Compression Test. The laboratory testing was performed in general accordance with applicable ASTM specifications. The individual laboratory data sheets and results are included in Appendix III. The final boring logs also include the moisture content, fines content and Atterberg Limits test results in graphical form.

## 4.0 EXPLORATORY FINDINGS

The subsurface soils encountered during CEC's explorations are described on each test boring log presented in Appendix II. These logs represent CEC's interpretation of the subsurface conditions encountered at each boring location based on our site observations, field logs prepared by CEC's field representative, visual review of the soil samples by the Geotechnical Engineer, and laboratory test results. The lines designating the interfaces between various soil strata on the boring logs represent the approximate interface location; the actual transition between strata may be gradual and indistinct. The characterizations included herein, including summary test data, are based on the subsurface findings from the geotechnical explorations performed by CEC for the proposed development on March 8, 2018.

In addition to the individual boring logs, two Subsurface Diagrams have been prepared and included with this report (Figures 4 and 5) which are based on Cross Section A-A' and Cross Section B-B', as depicted on the Boring Location Plan (Figure 3). The Subsurface Diagrams include a graphical interpretation of the soil strata identified in the borings, representative boring data (N values, Pocket Penetrometer readings and groundwater levels), current ground surface elevation, and a general interpretation of the strata between the borings.

In general, the surficial material across the wooded site consists of a root-matted topsoil layer that is about 6 to 12 inches thick. The topsoil is underlain by a stratum of moderately plastic glacial soil deposits, identified as glacial till, and residual soil that has weathered from the parent shale and limestone bedrock. The glacial till/residual soils are relatively compact and firm. The parent shale and limestone bedrock was encountered at relatively consistent depths nearly matching the ground surface topography at about 6 to 9 feet bgs. Groundwater was encountered in several boreholes at relatively shallow depths (i.e., from 0.4 to 3.0 feet bgs). The following sections present a more detailed description of the overburden soil layers, bedrock and groundwater conditions encountered in the explorations.

## 4.1 TOPSOIL

Topsoil was encountered in each of the borings and measured approximately 6 to 12 inches in thickness. Generally, the topsoil thicknesses are based on observations/measurements performed by CEC personnel at the time of drilling. To supplement our observations, six LOI tests were performed at select locations to determine the organic content of the topsoil. Specifically, LOI tests were performed at the following six locations: 1) Boring B-2 from 4 to 8 inches; 2) Boring B-2 from 8 to 12 inches; 3) Boring B-6 from 5 to 9 inches; 4) Boring B-6 from 9 to 13 inches; 5) Boring B-10 from 2 to 6 inches; and, 6) Boring B-10 from 6 to 10 inches. The LOI test results are as follows: 1) 6.7 percent; 2) 3.6 percent; 3) 5.3 percent; 4) 3.9 percent; 5) 7.2 percent; and, 6) 5.8 percent, respectively. The measured topsoil thicknesses are documented on the boring logs and the LOI results are included in Appendix III.

## 4.2 GLACIAL TILL

The natural soils encountered immediately beneath the topsoil are comprised of glacial soil deposits, also known as glacial till. The natural soil surface was present beneath the topsoil at depths ranging from about 0.5 to 1 feet bgs and extending to between approximately 3.5 to 6 feet bgs. The glacial till soil is generally characterized as moderately plastic soil that is primarily comprised of clay and silt with minor percentages of sand and gravel. Overall, the glacial till soils are classified as silt and clayey silt on the boring logs. However, relatively thin sand seams (up to about 6 inches in thickness) were observed at variable depths within several of the borehole locations.

Based on Atterberg Limits test results from selected samples of the glacial till, the Liquid Limit and Plastic Limit values range from 23 to 43 percent and 16 to 26 percent, respectively. Natural moisture content results from representative glacial till soil samples range from about 15 to 31 percent. However, the moisture contents are highest within the upper 3 feet, generally ranging from about 22 to 31 percent. Additional laboratory testing performed on a relatively undisturbed sample (Shelby tube) of the glacial till soil obtained from 3 to 5 feet bgs within Boring B-4 included: 1) specific gravity; and, 2) an Unconsolidated-Undrained Triaxial Compression Test.

glacial. The results of these laboratory tests are as follows: 1) a specific gravity of 2.756; and, 2) a shear strength of 13.5 pounds per square inch (psi). Further, a Standard Proctor test was performed on a bulk sample obtained from 1 to 5 feet bgs within Boring B-6. The corresponding test results were a maximum dry density of 115.5 pounds per cubic foot (pcf) and an associated optimum moisture content of 13.9 percent.

Regarding consistency, the glacial till soils are described as medium stiff to stiff as represented by N values ranging from about 5 to 14 blow per foot (bpf) and unconfined compressive strength values (estimated by means of a Pocket Penetrometer) ranging from approximately 0.75 to in excess of 4.0 tons per square foot (tsf). However, two relatively weak zones were encountered in Boring B-3 from 1 to 3.5 feet bgs and Boring B-7 from 3.5 to 6 feet bgs where N values were 4 and 2 bpf, respectively.

### 4.3 RESIDUAL

The soil stratum underlying the glacial till deposits is described as residual soil. These soils have formed through long-term weathering and decomposition of the parent bedrock (shale). The residual soil was encountered at depths between about 3.5 to 6 feet bgs (between elevations of about 747.4 and 740.6 feet amsl). The residuum extended to the bedrock surface (between depths of about 6.3 and 9.2 feet bgs or between elevations of about 743.9 and 737.6 feet amsl) with the exception of Boring B-7 which terminated in the residual soil at a depth of about 10 feet bgs (corresponding to an elevation of about 736.7 feet amsl). The corresponding thickness of the residual soil strata ranges from about 2.1 to 3.9 feet. Based on review of the residual soil samples obtained, the soil is described as clay containing a significant percentage of silt and a few limestone fragments. The consistency of the residual soil is described as very stiff to hard with N values between 17 and 40 bpf and unconfined compressive strengths (estimated by means of a Pocket Penetrometer) ranging from 2.5 to in excess of 4.5 tsf. One Atterberg Limits test and one moisture content test was performed on a sample of residual soil obtained from Boring B-1 from about 3.5 to 5 feet bgs, which yielded a Liquid and Plastic Limit of 35 and 20 percent, respectively, and a corresponding moisture content of 17 percent.

## 4.4 BEDROCK

Bedrock was visually confirmed in all of the borings with the exception of Boring B-7, which terminated in the residual soil strata. The bedrock surface was present at depths between about 6.3 and 9.2 feet bgs and consisted of shale interbedded with thin limestone layers. Based on the estimated bedrock surface across the site, it appears that the bedrock surface generally slopes downward from east to west (approximately paralleling the existing ground surface) and varies in elevation from about 743.9 and 737.6 feet amsl.

## 4.5 GROUNDWATER

The following groundwater measurements were taken during the drilling procedures: 1) during the drilling and sampling procedures; 2) upon completion of the drilling and removal of the augers; and, 3) after an extended period of time (select boreholes). Based on our field observations, groundwater was detected during the drilling operations in the followings boreholes: 1) Boring B-3 at a depth of about 4.0 feet bgs (corresponding to an elevation of approximately 743.9 feet amsl); 2) Boring B-4 at a depth of about 1.0 feet bgs (corresponding to an elevation of approximately 745.8 feet amsl); and, 3) Boring B-8 at a depth of about 0.4 feet bgs (corresponding to an elevation of approximately 746.5 feet amsl). At the completion of the drilling, groundwater was detected in the following borings: 1) Boring B-3 at a depth of about 2.6 feet bgs (corresponding to an elevation of approximately 745.3 feet amsl); 2) Boring B-4 at a depth of about 1.0 foot bgs (corresponding to an elevation of approximately 745.8 feet amsl); 3) Boring B-7 at a depth of about 3.0 feet bgs (corresponding to an elevation of 743.7 feet amsl); and, 4) Boring B-8 at a depth of about 0.4 feet bgs (corresponding to an elevation of approximately 746.5 feet amsl). Three of the ten borings were left open for about 16 to 19 hours in order to obtain extended groundwater measurements. The extended groundwater measurements were as follows: 1) Boring B-2 at a depth of about 2.3 feet bgs (corresponding to an elevation of approximately 744.9 feet amsl); 2) Boring B-3 at a depth of about 0.7 feet bgs (corresponding to an elevation of approximately 747.2 feet amsl); and, 3) Boring B-7 at a depth of about 1.0 feet bgs (corresponding to an elevation of approximately 745.7 feet amsl). It should be recognized that groundwater levels at the site are affected by many hydrologic characteristics in the area and may vary from those measured at the time of drilling. The specific groundwater readings are included on the individual boring logs within Appendix II.

## 5.0 CONCLUSIONS

The explorations at the project site identified that the subsurface soil profile consists of a relatively thick layer of topsoil (about 6 to 12 inches thick) underlain by about 6.3 to 9.2 feet of low to moderately plastic, firm overburden soils. The overburden strata can be divided into an upper layer of glacial till (mixture of silt, clay and sand) that extended to depths of about 3.5 to 6 feet bgs underlain by residual silt and clay soil. The upper overburden soil layer (glacial till) was generally comprised of relativity moist and weak soil that become more competent and had lower moisture contents with depth. The shale and limestone bedrock surface was encountered at depths of between about 6.3 and 9.2 feet bgs.

Relatively shallow groundwater was identified in five of the ten borings at depths ranging from approximately 0.7 to 4 feet bgs (i.e., Borings B-2, B-3, B-4, B-7 and B-8). The encountered groundwater appears to be generally located within relatively level, lower lying areas of the site (i.e., southern and eastern limits of the property).

Based on our evaluation of the subsurface conditions and our geotechnical engineering analysis of the site, it is CEC's opinion that the subsurface soil conditions within the project limits are suitable for construction of the planned building and associated site improvements. In general, the planned building can be supported on conventional shallow, spread-type foundations and the floor slabs and pavements can be constructed as at-grade structures atop the natural soils or newly compacted engineered fill. However, it is our opinion that the following items may have an impact on the site construction or require special design considerations: 1) relatively moist and weak near surface soils are present across a majority of the site; 2) high groundwater was encountered in the eastern and southern portions of the site; and, 3) bedrock is present at depths less than about 10 feet. The following subsections provide further discussion of the potential impacts or considerations. Further, associated geotechnical design and construction recommendations for the project are included in Section 6.0 of this report.

## 5.1 RELATIVELY MOIST/WEAK SOILS

The glacial till soils encountered within about 6 feet of the ground surface are estimated to possess moisture contents of about 26 percent on average, which is well above the optimum moisture content for these soils. As a result, these soils are relatively weak such that they will likely yield to construction traffic. These two soil characteristics will likely impact the means and methods of earthwork construction, as well as the associated construction schedule and cost. In specific, it is expected that these soils will: 1) yield to earthwork equipment and will not meet proofroll requirements for fill placement or subgrades (i.e., pavements and floor slabs); and, 2) produce on-site borrow soil that will require drying prior to placement as engineered fill. The following sections provide further discussion of these specific impacts.

### 5.1.1 Yielding Subgrade Conditions

It is our opinion that the natural subgrade soils exposed following topsoil stripping will be moist, weak, and yield to earthwork equipment. If yielding conditions are encountered, the weak soils will require stabilization prior to construction of floor slabs and pavements or the placement of engineered fill. As a minimum, the initial earthwork activities (following clearing and topsoil stripping) should include scarification, moisture conditioning (drying) and re-compaction of the exposed subgrade soils prior to proofroll acceptance determinations for subsequent construction (fill placement or subgrade preparation for floor slabs and pavements). Should yielding conditions occur following the scarification and re-compaction efforts, stabilization will be required to establish suitable subgrade support for further construction. Based on the potential depth extent of the weak soils, typical stabilization methods (i.e., scarification/re-compaction and undercut/replacement) may not be sufficient. Therefore, it is CEC's opinion that other stabilization methods will likely be required in areas of the site where the weak soils extend several feet below the ground surface or the planned excavation grades. The most cost effective stabilization method will vary depending on the specific site conditions, grading requirements, available materials, weather conditions, etc. The most likely alternate stabilization methods will include the addition of chemical admixtures (i.e., lime base products) or use of geotextiles with a layer of aggregate.

However, the Geotechnical Engineer should determine the most suitable stabilization method based on an evaluation of the site specifics.

### 5.1.2 High Moisture Content Borrow Sources

The natural overburden soils at the site are suitable for reuse as engineered fill. However, the moisture content of soils that may be excavated from within the upper portion of the natural soils/stratum (up to about 6 feet) will be above the optimum moisture content as it relates to reuse as engineered fill. The typical moisture contents are about 8 to 12 percentage points above the optimum moisture content. Therefore, the on-site borrow soils will require significant drying prior to placement as engineered fill. In order to dry the soils, the contractor will need to expose the soils to dry air and warm temperatures for a suitable period of time. It will also be necessary to disc or “turn” the soils during the drying efforts to facilitate efficient drying and to establish a uniform moisture content that is near the optimum. As a result, the site earthwork will likely require increased time and cost associated with drying the borrow soils. Alternately, thoroughly mixing chemical modifiers such as lime based products into the soils (i.e., using a pulverizing mixer) can be considered for drying purposes.

## 5.2 HIGH GROUNDWATER

Within the southern and eastern portions of the site groundwater generally accumulated within the boreholes to within about 0.7 to 4 feet bgs (corresponding to elevations varying between 747.2 and 743.7 feet amsl). Therefore, planned excavations at the site (i.e., foundations, utility trenches, stormwater basin, etc.) will likely encounter groundwater seepage and a collection of groundwater. Groundwater seepage will likely cause localized sloughing and failure of temporary excavation slopes which will require maintenance of the excavations (i.e., dewatering, over-excavation, etc.). A specific long-term concern with the high groundwater is the potential for chronic saturation of the bearing soils or floor slab subgrade soils. In order to mitigate the potential impact of elevated groundwater on the building foundations and floor slab, underdrain systems should be considered or the planned finished grades and associated foundation bearing elevations should be elevated above maximum expected groundwater elevations.

## 5.3 SHALLOW BEDROCK

Shale and limestone bedrock was encountered at relatively shallow depths throughout the majority of the site. Therefore, planned excavations exceeding about 6 feet bgs will likely encounter bedrock. As a result, planned excavation depths for underground utilities could encounter bedrock. It is CEC's opinion that the upper zones of the bedrock will be relatively weathered and fractured such that typical excavation equipment can be used. However, the competency of the shale and limestone bedrock increases with penetration such that large track hoe type equipment will likely be needed for extended excavations.

## 6.0 DESIGN AND CONSTRUCTION RECOMMENDATIONS

### 6.1 SITE PREPARATION AND EARTHWORK

### 6.1.1 Site Preparation

Prior to commencement of site excavations, fill placement or building construction, CEC recommends that clearing, grubbing and stripping be performed as necessary to remove trees, woody vegetation, topsoil, highly organic soil and other deleterious materials. Given the relatively high organic content of the root-matted topsoil across the site, measured to be about 6 to 12 inches thick, we recommend the entire topsoil layer be stripped. It should be expected that localized topsoil thicknesses across the site may be in excess of 12 inches; and therefore, an average thickness of 12 inches is recommended for planning purposes. The materials generated from site clearing and topsoil stripping should be either removed from the site or stockpiled in an approved area of the site. Further, CEC recommends that the entire root mass/bulb associated with trees and other woody vegetation be removed which will likely increase the localized grubbing and stripping depths. Where encountered, CEC recommends that localized excavations resulting from the grubbing and stripping activities be backfilled with engineered fill (refer to Section 6.1.2) to re-establish subgrade elevations.

Subsequent to site stripping, areas currently at grade or that require new fill to reach the planned subgrade elevation should be proofrolled to delineate soft or yielding soil conditions that require correction prior to beginning new fill construction. Proofrolling should be performed with a loaded off-road truck or tandem axle truck (minimum gross weight of 20 tons). Any near-surface soils exhibiting rutting, yielding and/or pumping during the proofrolling operations should either be undercut and replaced or stabilized prior to the placement of engineered fill. Because the near surface soils across the site are considered to be relatively weak and are above the optimum moisture content, CEC recommends that the earthwork procedures include scarifying the exposed surface (i.e., following topsoil stripping) to a depth of 12 inches, moisture conditioning the entire lift to adjust the moisture content near optimum, and re-compacting this surface layer in-place prior to proofrolling. CEC recommends that a representative of the Geotechnical Engineer observe the proofroll operations and make recommendations for unstable or unsuitable conditions encountered. If the exposed subgrade (following scarification and re-compaction) displays yielding or deformation under the weight of the construction equipment or proofroll vehicle, CEC recommends that the yielding area be stabilized. CEC recommends that the stabilization method be based on an evaluation of the site specific conditions encountered during construction. Provided that the yielding areas are limited with respect to plan dimension and depth, the areas should be over-excavated to reach firm material suitable for new fill construction and then backfill with engineered fill. Fill used to backfill over-excavated areas should be placed and compacted to meet the requirements of engineered fill (refer to Section 6.1.2). Should large plan areas be identified as yielding or over-excavations of more than 2 feet in depth be required to reach firm soil, CEC recommends the Geotechnical Engineer be consulted to evaluate and recommend an appropriate stabilization method, such as chemical modification (i.e., lime based chemicals) or geogrid overlain by aggregate.

### 6.1.2 Engineered Fill

CEC recommends that fill placed to support foundations, floor slabs and pavements, including utility trench backfill, be constructed as engineered fill. Further, CEC recommends that representative samples of the proposed fill materials (on-site and imported soil) be collected and tested to determine the laboratory compaction characteristics, plasticity, and natural moisture content prior to initiating the earthwork activities. These tests are needed to determine if the proposed fill material is acceptable for the planned use, to identify materials for specific areas of the site, and for quality control during compaction.

The following criteria are recommended for engineered fill material selection:

- Engineered fill materials should meet the following requirements: 1) maximum Liquid Limit of 50 percent 2) maximum Plastic Limit of 20 percent; 3) minimum laboratory maximum dry density of 100 pcf (ASTM D 698); 4) maximum particle size of 6 inches; and, 5) less than 3 percent by weight fibrous, organic matter; and,
- Silts classified as “ML” per the Unified Soil Classification System (USCS) (ASTM D 2487) should not be used within 2 feet of the planned pavement subgrade elevations.

Engineered fill must be spread in uniform, thin (8 inches or less) loose horizontal lifts, with each lift compacted to achieve a dry unit weight of at least 98 percent of the maximum dry unit weight, as determined in the laboratory by the Test Method for Laboratory Compaction Characteristics of Soils Using Standard Effort (ASTM D 698). CEC recommends that the top 12 inches of engineered fill required to establish the planned subgrade elevation (i.e., pavements and floor slabs) have an increased minimum compaction percentage of 100 percent. Engineered fill should be moisture conditioned as needed to maintain the moisture content of the engineered fill within 2 percentage points of the optimum moisture content. Granular fill soils or trench backfill containing less than 15 percent fines should be compacted to at least 75 percent of relative density. The fill should not be frozen during placement and should not be placed on frozen subgrade.

Based on the subsurface conditions encountered in the borings, the natural soils obtained from on-site excavations will be suitable for reuse as engineered fill. However, the natural soils, especially those within about 6 feet of the ground surface, generally have moisture contents above the optimum moisture content and will require moisture conditioning prior to compaction. CEC recommends that excavated on-site soil intended for reuse as engineered fill be approved by the Geotechnical Engineer or representative of the Geotechnical Engineer. Because of the relatively high moisture content of the natural soils, it is recommended that the contractor be prepared to implement appropriate means and methods in order to lower (dry) the on-site borrow, as needed, to meet the project specifications during fill placement.

### 6.1.3 Permanent Soil and Detention Basin Slopes

CEC recommends that permanent soil slopes (excavation or fill) be constructed no steeper than 3 horizontal to 1 vertical (3H:1V). CEC recommends that the interior slopes for the detention basin be constructed no steeper than 4H:1V or flatter. It is recommended that finished soil slopes be vegetated as soon as practical to reduce soil erosion.

### 6.1.4 Temporary Excavations and Backfill

CEC recommends that temporary excavations (utility trenches or foundation) comply with the most recent Occupational Safety and Health Administration (OSHA) Excavating and Trenching Standard, Title 29 of the Code of Federal Regulation (CFR) Part 1926, Subpart P. This document was issued to better provide for the safety of workers entering trenches or excavations. This federal regulation mandates that excavations, whether they be utility trenches, basement excavations or foundation excavations, be constructed in accordance with the OSHA guidelines. It is CEC’s understanding that these regulations are being strictly enforced and if they are not closely followed, the owner and the contractor could be liable for substantial penalties.

The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The contractor's "competent person", as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. 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. Based on the encountered subsurface conditions and proposed site grades, temporary excavations will likely expose natural cohesive soils (Type B Soils); therefore, CEC recommends that temporary excavation slopes (exceeding a depth of 3 feet) be laid back to at least 1H:1V. These slopes should be braced or backfilled if the excavation slope will be maintained for more than a daily work shift. Should groundwater seepage or localized soft soils be identified in the temporary slopes, the slopes should be laid back to 1.5H:1V or as needed to maintain stability.

CEC recommends that temporary excavations be backfilled with engineered fill meeting the requirements identified within Section 6.1.2 of this report.

### 6.1.5 Groundwater Considerations

Excavations extending below about elevation 746.0 feet amsl, specifically within the southern and eastern portions of the site, will likely encounter groundwater. Therefore, CEC recommends that the design and construction associated with planned on-site excavations that will extend below an approximate elevation of about 746.0 feet amsl should include means and methods necessary to address potential groundwater seepage. If encountered, it is expected that the seepage will be localized and of limited volume that can be controlled utilizing a sump pump. It is also recommended that permanent underground structures account for the high groundwater levels including: 1) hydrostatic pressures; 2) buoyancy; or 3) drainage systems.

## 6.2 BUILDING FOUNDATIONS

### 6.2.1 Foundation Design

CEC recommends that the proposed building be supported using conventional, shallow, spread-type foundations bearing on firm natural soil. Continuous and column pad foundations bearing on firm natural soil can be designed using a maximum allowable bearing pressure of 2,500 and 3,000 psf, respectively. We recommend that exterior foundations be founded at least 30 inches below the proposed grades for frost protection. Interior foundations may be supported at the most convenient depths, provided that suitable bearing soils are present. CEC recommends a minimum foundation width dimension of 18 inches and 30 inches for continuous strip foundations and individual column pad foundations, respectively. Spread foundations bearing on firm natural soil and conforming to our minimum width embedment recommendations may be designed using the above recommended allowable bearing capacities. A one-third increase in the bearing value may be used for wind or seismic loads. Based on the anticipated structural loads for foundation walls and columns, the total and differential foundation settlements are expected to be less than 1 inch and 0.5 inch, respectively.

As localized areas of weak and soft soils were encountered within the upper soil strata across the site (i.e., within about 6 feet of the natural ground surface), the bearing capacity of the exposed foundation soils should be confirmed by a Geotechnical Engineer or representative of the Geotechnical Engineer prior to concrete placement. For this, CEC recommends that a small diameter hand auger be used to explore and confirm that the soils below the design bearing surface exhibit the required minimum bearing capacity (minimum unconfined compressive strength of

1.25 tsf) to a minimum depth of 3 feet below the foundation bearing elevation. It is recommended that these confirmatory explorations be performed at regular intervals for foundation construction throughout the site. If unsuitable bearing soil (i.e., soft, loose or wet natural soil) is encountered at the bearing elevations during construction, CEC recommends that these soils be removed by means of an excavation or undercut until firm/dense natural soil or newly placed engineered fill is exposed. The appropriate depth of the undercut should be determined by a representative of the Geotechnical Engineer during foundation installation. After excavation to an adequate bearing material, the over-excavated areas can then be re-established to reach the proposed foundation bearing elevation by placing engineered fill, controlled density fill (CDF)/flowable fill (minimum compressive strength of 100 psi at 28 days) or lean concrete. Alternatively, the foundation can be extended (thickened) to bear directly on the firm soil.

CEC recommends that a foundation drainage system be installed for this building. As a minimum, it is recommended that a drain pipe be installed around the outside perimeter of the building foundation that provides gravity drainage of collected groundwater to a storm sewer or a sump. CEC recommends that a minimum 8-inch diameter perforated drain pipe be placed at or below the foundation bearing elevation. The pipe should be backfilled with AASHTO No. 57 stone and the stone backfill surrounded with a geotextile filter fabric. The drain pipe should be directed to a storm system or sump.

It is recommended that the bottom of foundation excavations not be higher than an imaginary line extended at a 2H:1V upward projection from the invert of a paralleling or nearly paralleling underground utility.

### 6.2.2 Foundation Construction Considerations

The following guides address protection of foundation subgrades and CEC's recommended foundation construction procedures:

- Retain the Geotechnical Engineer to observe and confirm that the site preparation and engineer fill construction is completed in accordance with the recommendations contained in Section 6.1 of this report.

- Retain the Geotechnical Engineer to observe foundation excavations to verify suitable bearing conditions exists and provide recommendations for treatment of unsuitable conditions encountered;
- Protect foundation support materials exposed in open excavations from freezing weather, severe drying, and water accumulation;
- Fill over-excavated foundation excavations immediately with structural or lean concrete backfill shortly after the bearing soils are approved;
- Remove bearing soils disturbed by exposure immediately prior to foundation concrete placement;
- Place a "lean" concrete mud-mat over the bearing soils if the excavations must remain open overnight or for an extended period of time;
- Remove loose soil, debris, and surface water from the bearing surface immediately prior to concrete placement;
- Place concrete neat within the foundation excavations without forms; and,
- Place concrete the same day as the excavations for the foundations, if possible.

## 6.3 CONCRETE SLAB-ON-GRADE

It is anticipated that the proposed floor slabs for the planned buildings will be supported on natural soil or newly placed engineered fill. Provided that the earthwork and site preparation construction is performed in accordance with the recommendations contained in Section 6.1 of this report, natural soil or newly placed compacted engineered fill will provide suitable support for the planned floor slabs. However, immediately prior to floor slab construction, CEC recommends that the established floor slab subgrade be proofrolled under the observation of a representative of a Geotechnical Engineer. We recommend that the proofrolling operations be performed using a tandem-axle, fully-loaded dump truck or other vehicle approved by the Geotechnical Engineer. Any yielding areas identified by the proofroll should be stabilized or undercut to a depth determined at the time of the proofroll and replaced with engineered fill. If undercut depths of greater than 24 inches are required to reach suitable subgrade soil, the Geotechnical Engineer should be consulted to explore alternative remedial measures.

It is CEC’s opinion that the static groundwater level will be near the planned floor slab elevations, provided that the finish floor elevations are at or near the existing grades. Therefore, CEC recommends that an underdrain system or drainage blanket be constructed beneath the entire floor slab to reduce the potential for saturated soil conditions immediately beneath the floors. The under-slab drainage blanket should be comprised of a minimum 12-inch thick layer of free draining compacted granular material. CEC recommends that the granular material be a crushed, poorly-graded aggregate that contains less than 5 percent passing a #200 size sieve and has a maximum size of 1 inch. Perforated drain pipes (minimum 4-inch diameter with a filter sock) should be placed around the perimeter of the drainage blanket and positively sloped to the recommended foundation drainage system. CEC recommends that a non-woven separation geotextile fabric be placed immediately beneath the aggregate drainage blanket. If desired, the drainage aggregate may be capped with a thin layer of dense graded aggregate to provide a constructible surface for the floor slab. The drainage aggregate (and aggregate base material if used) should be compacted using vibratory compaction equipment to achieve a density that is at least 75 percent of the relative density immediately prior to the slab construction. Provided that the subgrade preparation and drainage blanket construction is performed in accordance with the recommendations contained herein, CEC recommends that the slab-on-grade thickness design be based on a Modulus of Subgrade Reaction (K) of 145 pci.

CEC also recommends that a synthetic moisture barrier be installed. For this purpose, a minimum 10 millimeter thick vapor barrier is recommended, placed immediately below the floor slabs. The vapor barrier should meet the specifications of ASTM E 1745, Class A, and be placed in accordance with ASTM E 1643. If a moisture-sensitive floor covering is proposed in a humidity-controlled area, the floor covering manufacturer or installer should be consulted during design of the floor slab. If a vapor barrier is used, CEC recommends that measures be taken to reduce the potential for slab curling such as reduced joint spacing and/or using a concrete with low shrinkage potential. In addition, CEC recommends that the floor slabs be isolated from columns and load bearing walls.

## 6.4 PAVEMENTS

### 6.4.1 Subgrade Preparation

CEC recommends that the site earthwork preparation and engineered fill construction associated with the paved areas of the site be performed in accordance with the recommendations contained in Section 6.1 of this report. In all cases, CEC recommends that the final preparation of the pavement subgrade include proofrolling just prior to the pavement base aggregate construction. The proofroll should be performed using a fully-loaded tandem axle dump truck (minimum gross weight of 20 tons) and observed by the Geotechnical Engineer or a designated representative. Soft or yielding subgrade soils identified by the proofroll should be stabilized or undercut as needed to reach firm soil. Engineered fill should be used to replace undercut soils.

### 6.4.2 Subgrade Support Design

It is CEC's opinion that the pavement subgrade soil will consist primarily of low to moderately plastic cohesive soil. Based on the results of the laboratory testing, the recommended California Bearing Ratio (CBR) value for the on-site cohesive soils is 4, with a corresponding recommended Resilient Modulus of 4,800 psi. These values can be used for design of concrete and asphalt pavements. The design CBR and Resilient Modulus values are based on subgrade soils that have been properly compacted in accordance with the recommendations in this report (Section 6.1.2) and do not yield during proofrolling. If an off-site fill soil is placed to establish the pavement subgrade elevations above the current site elevations, the borrow soils should be tested to confirm that the material exhibits a CBR value of at least 4.

### 6.4.3 General Pavement Design Recommendations

For general design and construction of the asphalt and concrete pavement sections identified herein, CEC recommends the following:

- Aggregate base course materials should be compacted to at least 98 percent of maximum dry density with a moisture range of ±2 percent of the optimum moisture content, as determined by the Standard Proctor test method (ASTM D698). Compaction or placement of “dry” aggregate should be avoided.

- Maximum joint spacing of 15 feet should be used for non-reinforced concrete pavement sections.
- Concrete pavement should be saw cut (on a square pattern at an interval of 15 feet) soon after it sets to provide control joints.
- Provide minimum ¾-inch dowels at 18 inches on center for construction joints between new and existing concrete. The existing concrete edge shall be saw cut to the full depth of the concrete pavement and the dowel socketed into the concrete pavement with non-shrink grout. The dowels shall extend a minimum of 12 inches into the proposed concrete pavement.
- CEC recommends that both flexible and rigid pavement sections be designed and constructed such that there is positive drainage above and below the pavement section. Effective drainage measures include the use of an open-graded granular base, shoulder swales, perimeter edge drains, curbs/catch basins, or a combination of these features to collect surface water runoff and subsurface seepage from areas below and adjacent to the pavement.
- Pavement subsurface drainage should be considered during design to promote long-term performance. For effective drainage below the pavement section to occur, CEC recommends the following: positively sloped subgrade toward collection points, a minimum of ¼ inch per foot transverse slope should be provided; utilize open-graded subbase or base layers (granular soil with less than 5 percent fines) that have a geotextile filter fabric placed between the subgrade and aggregate; include drain pipes positively sloped to an outlet; and, divert surface water to catch basins or perimeter swales. Perforated underdrains should be installed at regular intervals within the free-draining aggregate base and either day lighted to appropriate locations to provide for positive drainage of the base course or be connected to catch basins within the pavements to positively drain the base course materials. As a minimum, CEC recommends that underdrains be installed at the interface of concrete and asphalt pavements or construction joints and extend 10 feet radially from each catch basin.
- Pavement materials and construction should be in accordance with the Ohio Department of Transportation (ODOT) Standard Specifications.

## 6.5 SEISMIC DESIGN

A seismic analysis of the subsurface conditions across the site was performed and CEC recommends that a Site Class C be used for structural design, in accordance with Chapter 16 (Section 1613) of the 2012 International Building Code (IBC) and the American Society of Civil Engineers (ASCE) Section 7. Specifically, the seismic analysis was performed using a soil profile that was developed using the N value method in Section 7 of ASCE. Based on the United States

Geological Survey, the mapped spectral accelerations for the site are $S_S$ = 0.141g and $S_1$ = 0.076g. Therefore, in consideration of the Site Classification C and the mapped spectral accelerations, the site coefficients $F_a$ and $F_v$ are 1.2 and 1.7, respectively, according to Tables 1613.3.3 (1) and (2). The corresponding maximum spectral accelerations for the site ($S_{MS}$ = 0.169g and $S_{M1}$ = 0.129g) can then be multiplied by a factor of 2/3 to calculate the design spectral response parameters $S_{DS}$ and $S_{D1}$, which are 0.113g and 0.086g, respectively. These spectral design values should be verified by the Structural Engineer and used in conjunction with an appropriately selected fundamental period of the structure for seismic analysis in accordance with the IBC. The Structural Engineer should also confirm the risk category and adjust the seismic design category accordingly.

## 7.0 CONSTRUCTION QUALITY CONTROL MEASURES

CEC recommends that a representative of the Geotechnical Engineer be retained to observe site preparation and earthwork, underground utility installations and backfill, and foundation construction. Based on the observations of the Geotechnical Engineer's representative, further recommendations can be made if site conditions vary from those at the boring locations.

The following construction monitoring and testing guides are recommended for this project:

- CEC recommends that a representative of the Geotechnical Engineer be present to the site stripping and initial site preparation activities. Additionally, the Geotechnical Engineer should observe a proofroll prior to the engineered fill placement activities to determine if the exposed soils are acceptable to receive new fill;
- Prior to construction of engineered fill, samples of potential fill materials should be collected to determine their suitability for use as a compacted fill. These samples should be tested to determine the dry density and optimum moisture contents, Atterberg Limits and grain size (in accordance with applicable ASTM standard test methods);
- CEC recommends that a Geotechnical Engineer or engineering technician under the direction of the Geotechnical Engineer observe the earthwork activities and confirm that the proofroll and fill placement procedures (i.e., lift thickness, compaction, moisture content, etc.) conform to the recommendations in this report;
- CEC recommends performing two in-place field density test in every 5,000 sq. ft. for each 8-inch thick compacted fill layer to determine if the compacted fill meets the requirements presented in this report;
- CEC recommends a minimum of two in-place field density test in every 5,000 sq. ft. for each aggregate base course layer;
- CEC recommends that a Geotechnical Engineer or his/her representative be present during foundation construction to perform the recommended verification of the bearing soils; and,
- CEC recommends that the Geotechnical Engineer or engineering technician under the direction of the Geotechnical Engineer observe pavement and floor slab subgrade preparation activities; including the initial proofroll, subgrade stabilization or undercutting procedures, and aggregate base course placement (i.e., lift thickness, compaction, moisture content, etc.).

## 8.0 BASIS FOR RECOMMENDATIONS

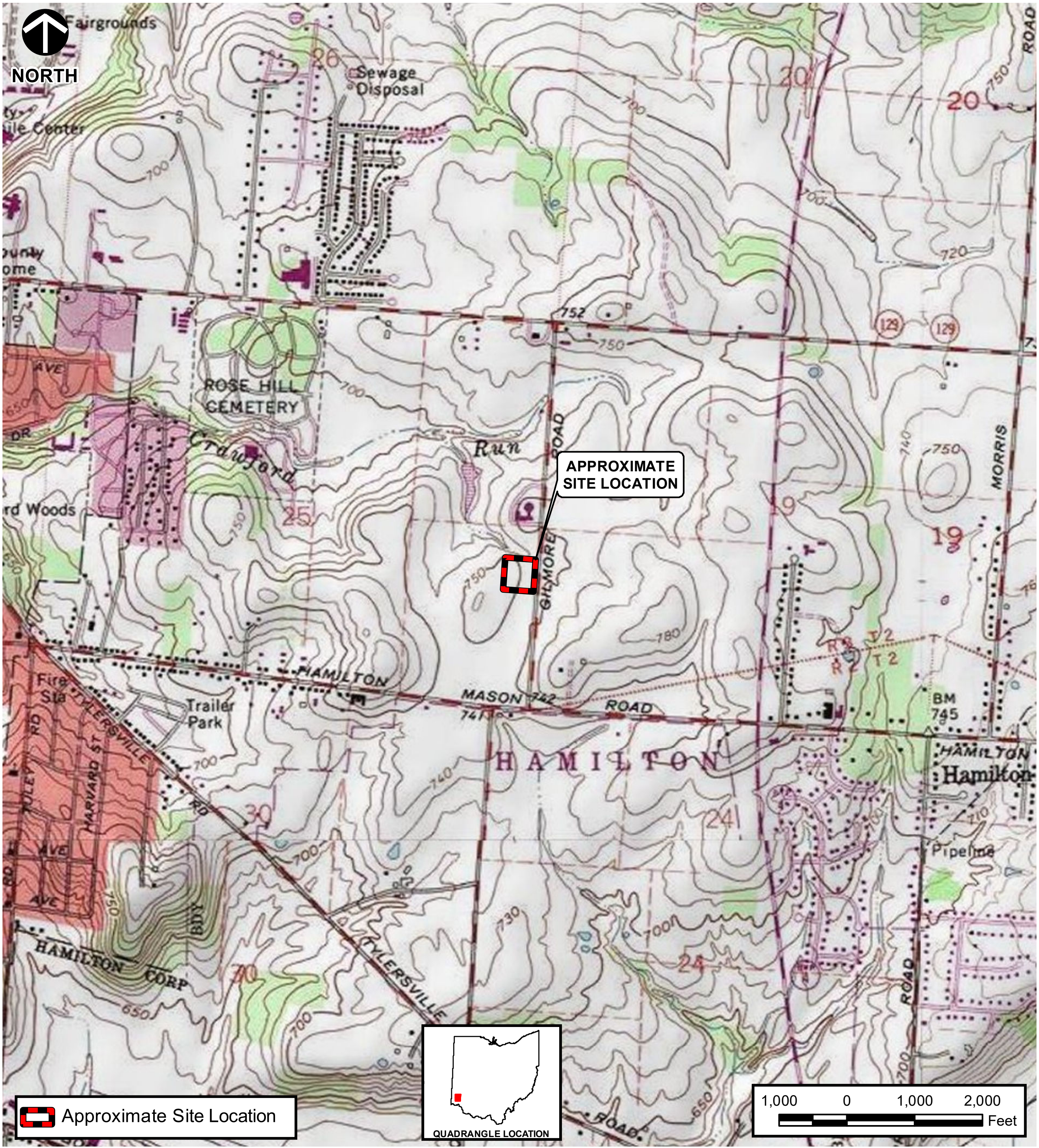
The recommendations provided in this report are based on our understanding of the project described herein and on our interpretation of the data collected during the subsurface exploration. These recommendations are based on experience with similar subsurface conditions under similar structural conditions. These recommendations apply to the assumed building design information discussed in this report; therefore, it is recommended that final site and building design criteria (i.e., building details, foundation loads, and site grades) be provided to us so that we may review our conclusions and recommendations and make necessary modifications.

Regardless of the thoroughness of the geotechnical exploration, there is always a possibility that conditions between the borings will be different than those encountered in the test borings, or the subsurface conditions may have changed since our investigation. Therefore, a Geotechnical Engineer or technician from our firm should monitor the earthwork and foundation construction to confirm that anticipated soil conditions exist.

# 9.0 CONSTRUCTION PLANS AND SPECIFICATION REVIEW

CEC recommends that we be retained to perform a review of the final construction drawings and specifications prepared from the recommendations presented in this report to determine if the plans and specifications are in compliance with the intent of our recommendations. Our report has been written in a guideline recommendation format and is not appropriate for use as a specification without being rewarded into a specification-type format. In addition, foundation loads, foundation dimensions and elevations, proposed grades and finished floor elevation were not available at the time of this report, which should be reviewed by the CEC Geotechnical Engineer to confirm that the intent of the design recommendations contained herein are appropriate for the actual foundation design loads.

# FIGURES



SOURCE: 1) PORTION OF THE USGS 7.5-MINUTE SERIES TOPOGRAPHIC QUADRANGLE MAPS - HAMILTON, OHIO - 1976; TRENTON, OHIO - 1983; GREENHILLS, OHIO - 1982; & GLENDALE, OHIO - 1982. 2) PROPOSED SITE PLAN OBTAINED FROM CEC DRAWING SK-1 "PRELIMINARY SITE LAYOUT" PREPARED BY CIVIL & ENVIRONMENTAL CONSULTANTS, INC. DATED FEBRUARY 2018.

CEC

**Civil & Environmental Consultants, Inc.**
5899 Montclair Boulevard - Cincinnati, OH 45150
513-985-0226 - 800-759-5614
www.cecinc.com

FAIRFIELD TOWNSHIP
FAIRFIELD TOWNSHIP FIRE/EMT STATION
FAIRFIELD TOWNSHIP, OHIO 45011

SITE LOCATION MAP

| | | | | | | |
|---|---|---|---|---|---|---|
| DRAWN BY: | MHS | CHECKED BY: | JBG | APPROVED BY: | APA* | FIGURE NO: 1 |
| DATE: | APRIL 03, 2018 | DWG SCALE: | 1 " = 2,000 ' | PROJECT NO: | 161-305-0040 | |

Signature on File *

P:\2016\161-305\-Other\161305 Task0040 Figure 1.mxd - 4/3/2018 - 4:30:21 PM (msimkins)

SOURCE: 1) ESRI WORLD IMAGERY / ARCGIS MAP SERVICE: HTTP://GOTO.ARCGISONLINE.COM/MAPS/WORLD_IMAGERY, ACCESSED 4/3/2018, IMAGERY DATE: JUNE 2016; 2) PROPOSED SITE PLAN OBTAINED FROM CEC DRAWING SK-1 "PRELIMINARY SITE LAYOUT" PREPARED BY CIVIL & ENVIRONMENTAL CONSULTANTS, INC. DATED FEBRUARY 2018.

**Civil & Environmental Consultants, Inc.**
5899 Montclair Boulevard - Cincinnati, OH 45150
513-985-0226 - 800-759-5614
www.cecinc.com

FAIRFIELD TOWNSHIP
FAIRFIELD TOWNSHIP FIRE/EMT STATION
FAIRFIELD TOWNSHIP, OHIO 45011

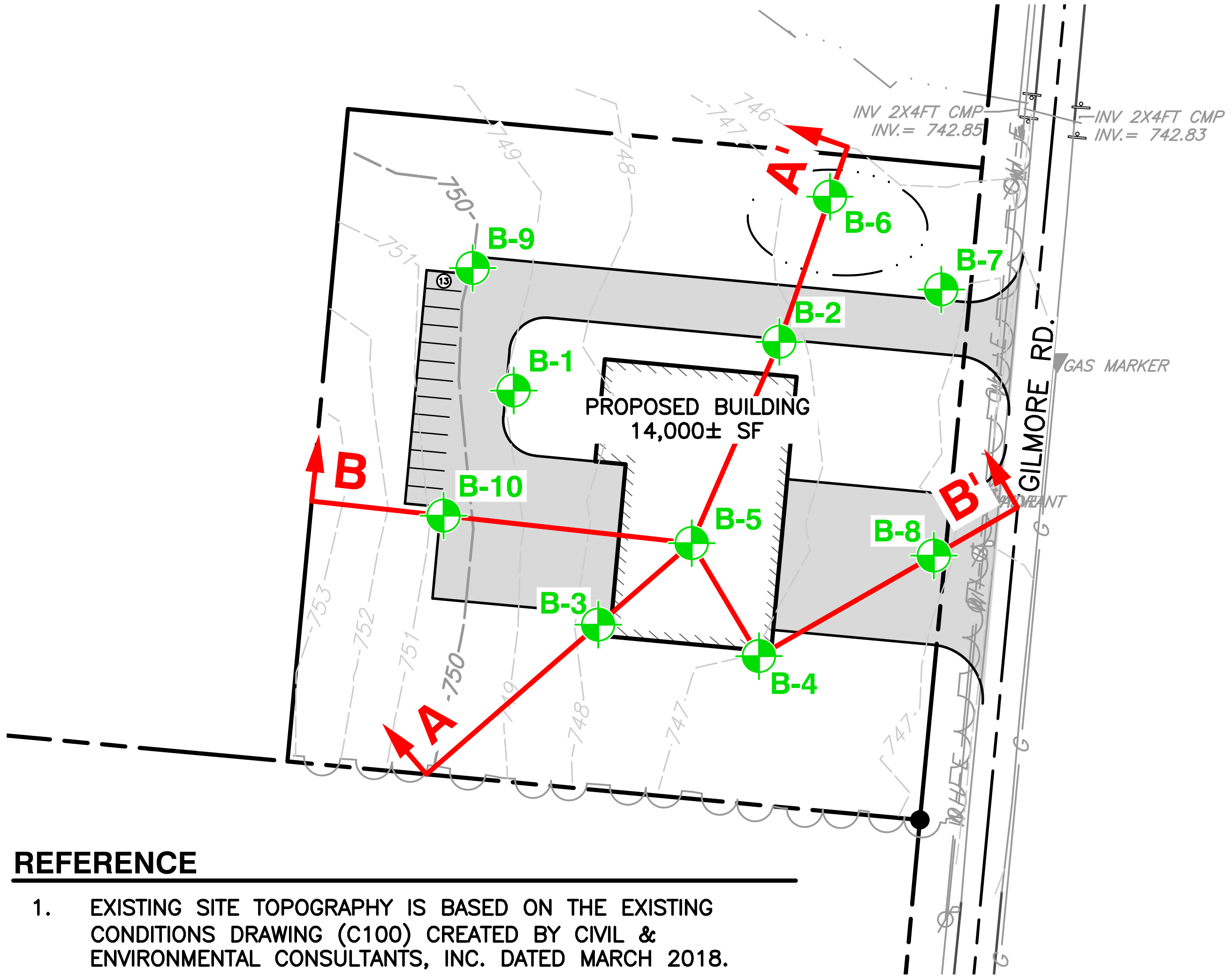
SITE AND VICINITY AERIAL MAP

| | | | | | | |
|---|---|---|---|---|---|---|
| DRAWN BY: MHS | CHECKED BY: JBG | APPROVED BY: APA* | FIGURE NO: 2 |
| DATE: APRIL 03, 2018 | DWG SCALE: 1 " = 100 ' | PROJECT NO: 161-305-0040 | |

Signature on File *

P:\2016\161-3051-Other\161305_Task0040_Figure 2.mxd - 4/3/2018 - 4:36:33 PM (msimkins)

P:\2016\161-305\-CADD\Dwg\Figures\161305-CV01-Boring Location Plan.dwg{BORING LOCATION PLAN} LS:(4/10/2018 - psimmons) - LP: 4/10/2018 8:53 AM



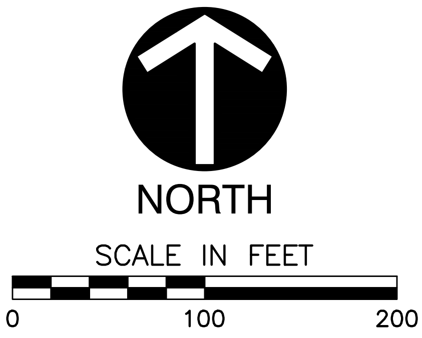
## LEGEND

| | |
|---|---|
| B-1 ⊕ | BORING LOCATION AND NUMBER |
| — — 695 — — | EXISTING INDEX CONTOUR |
| - - - 695 - - - | EXISTING INTERMEDIATE CONTOUR |
| ━ ━ ━ | PROPERTY BOUNDARY |
| — · · · — · · · — | PROPOSED STORMWATER DETENTION BASIN |
| ▨ | PROPOSED BUILDING |
| ▩ | PROPOSED PAVEMENT |
| A A' | CROSS SECTION LOCATION |

## REFERENCE

1. EXISTING SITE TOPOGRAPHY IS BASED ON THE EXISTING CONDITIONS DRAWING (C100) CREATED BY CIVIL & ENVIRONMENTAL CONSULTANTS, INC. DATED MARCH 2018.

2. PROPOSED SITE PLAN OBTAINED FROM CEC DRAWING SK-1 "PRELIMINARY SITE LAYOUT" PREPARED BY CIVIL & ENVIRONMENTAL CONSULTANTS, INC. DATED FEBRUARY 2018.



*HAND SIGNATURE ON FILE.

CEC

**Civil & Environmental Consultants, Inc.**

5899 Montclair Blvd. - Cincinnati, OH 45150
513-985-0226 · 800-759-5614
www.cecinc.com

FAIRFIELD TOWNSHIP
FAIRFIELD TOWNSHIP FIRE/EMT STATION
FAIRFIELD TOWNSHIP, OHIO 45011

BORING LOCATION PLAN

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| DRAWN BY: | PES | CHECKED BY: | JPH | APPROVED BY: | APA* | FIGURE NO.: | 3 |
| DATE: | MARCH 2018 | DWG SCALE: | 1"=100' | PROJECT NO: | 161-305-0040 | | |

Civil & Environmental Consultants, Inc.
5899 Montclair Boulevard
Cincinnati, Ohio 45150

**CLIENT** Fairfield Township

**PROJECT NUMBER** 161-305-0040

**PROJECT NAME** Fairfield Township Fire/EMT Station

**PROJECT LOCATION** Fairfield Township, Ohio 45011

# SUBSURFACE DIAGRAM
## Cross Section A-A'
## Figure 4

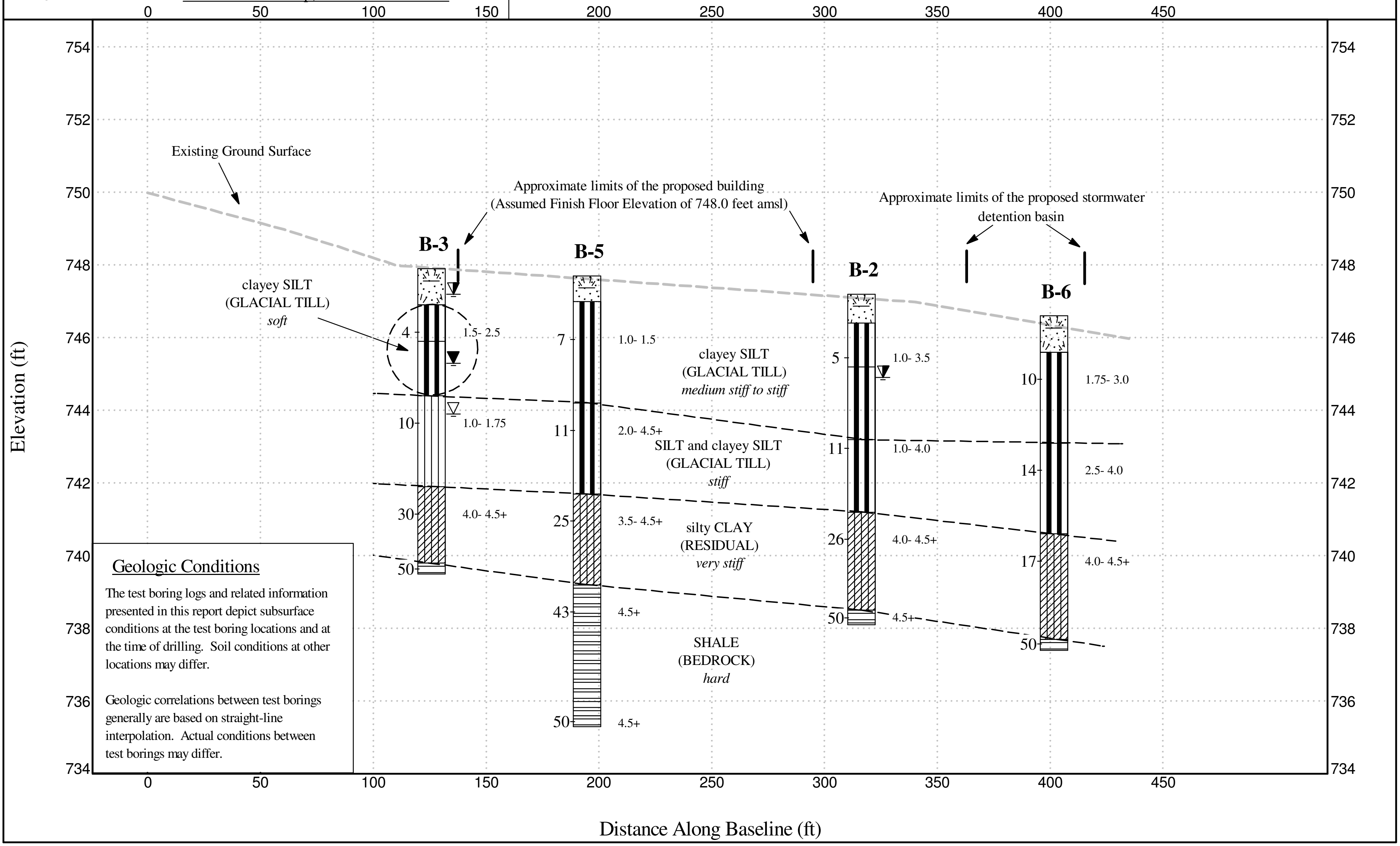
**LEGEND**

**Borehole Number**

N Value | Pocket Pen. (tsf)

▽ Water Level At Time of Drilling
▼ Water Level At End of Drilling
▼ Water Level After Drilling

▨ Topsoil
▨ Silty Clay
▥ Clayey Silt
▥ Silt
▤ Shale



### Geologic Conditions

The test boring logs and related information presented in this report depict subsurface conditions at the test boring locations and at the time of drilling. Soil conditions at other locations may differ.

Geologic correlations between test borings generally are based on straight-line interpolation. Actual conditions between test borings may differ.

STRATIGRAPHY & GW - A SIZE 161-305 DRAFT BORING LOGS.GPJ GOOD TEMPLATE.GDT 3/20/18

Civil & Environmental Consultants, Inc.
5899 Montclair Boulevard
Cincinnati, Ohio 45150

**CLIENT** Fairfield Township
**PROJECT NUMBER** 161-305-0040
**PROJECT NAME** Fairfield Township Fire/EMT Station
**PROJECT LOCATION** Fairfield Township, Ohio 45011

# SUBSURFACE DIAGRAM
## Cross Section B-B'
## Figure 5

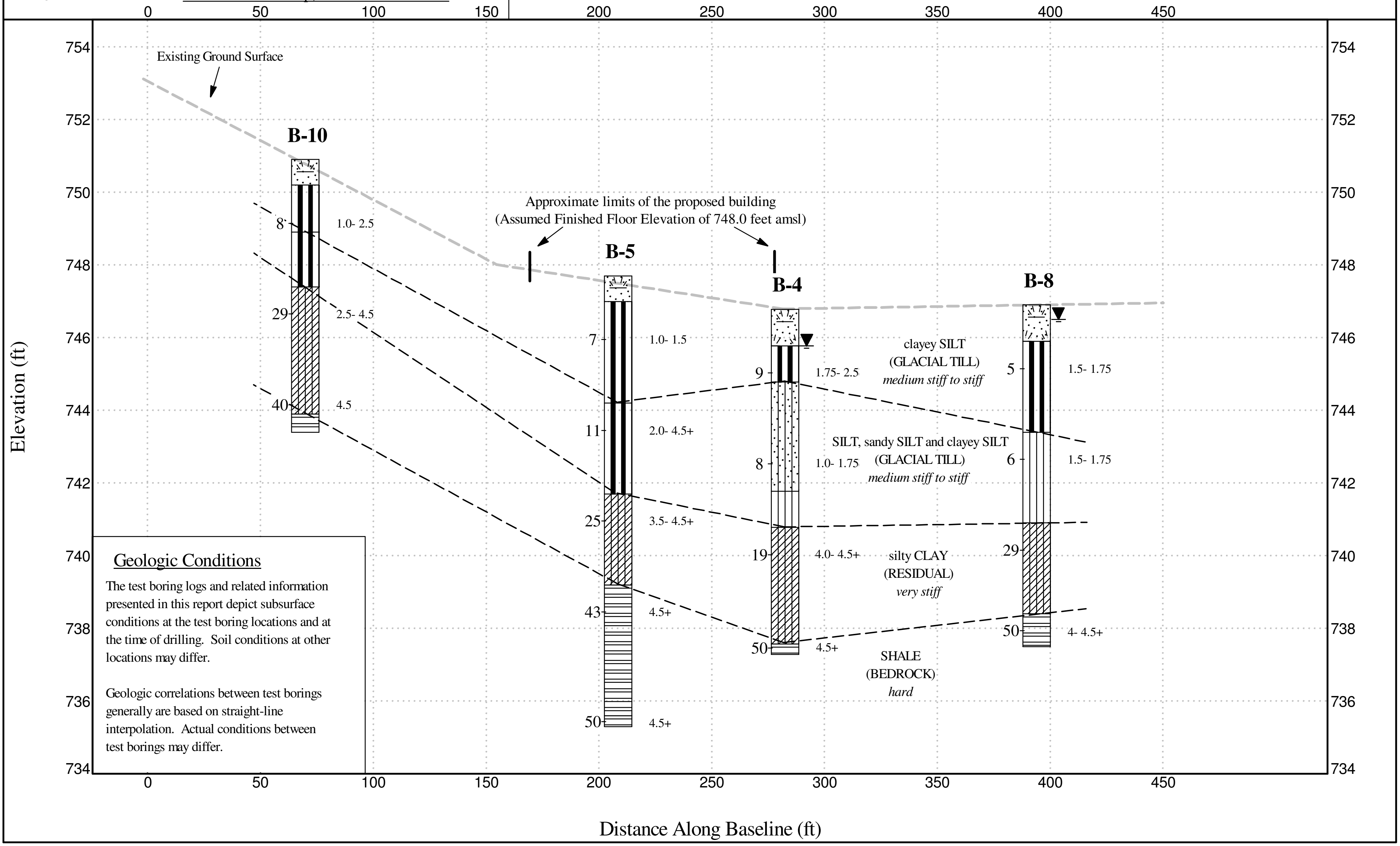
**LEGEND**

**Borehole Number**

N Value – Pocket Pen. (tsf)

▽ Water Level At Time of Drilling
▼ Water Level At End of Drilling
▼ Water Level After Drilling

▨ Topsoil
▤ Shale
▨ Silty Clay
▥ Clayey Silt
▨ Sandy Silt
▥ Silt



### Geologic Conditions

The test boring logs and related information presented in this report depict subsurface conditions at the test boring locations and at the time of drilling. Soil conditions at other locations may differ.

Geologic correlations between test borings generally are based on straight-line interpolation. Actual conditions between test borings may differ.

# APPENDIX I

# IMPORTANT INFORMATION ABOUT THIS GEOTECHNICAL-ENGINEERING REPORT

# 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, clients can benefit from a lowered exposure to the subsurface problems 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 below, contact your GBA-member geotechnical engineer. Active involvement in the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.**

## Geotechnical-Engineering Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs 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. *Those who rely on a geotechnical-engineering report prepared for a different client can be seriously misled.* No one except authorized client representatives should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one – not even you – should apply this report for any purpose or project except the one originally contemplated.*

## Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read it *in its entirety*. Do not rely on an executive summary. Do not read selected elements only. *Read this report in full.*

## You Need to Inform Your Geotechnical Engineer about Change

Your geotechnical engineer considered unique, project-specific factors when designing the study behind this report and developing the confirmation-dependent recommendations the report conveys. A few typical factors include:

- the client's goals, objectives, budget, schedule, and risk-management preferences;
- the general nature of the structure involved, its size, configuration, and performance criteria;
- the structure's location and orientation on the site; and
- other planned or existing site improvements, such as retaining walls, access roads, parking lots, and underground utilities.

Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project 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.*

## This Report May Not Be Reliable

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

- for a different client;
- for a different project;
- 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, that it could be unwise to rely on a geotechnical-engineering report whose reliability may have been 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 your geotechnical engineer has not indicated an "apply-by" date on the report, ask what it should be*, and, in general, *if you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying it. A minor amount of additional testing or analysis – if any is required at all – could prevent major problems.

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

Before construction begins, geotechnical engineers explore a site's subsurface through various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing were performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgment 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 from project start to project finish, so the individual can provide 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 not final*, because the geotechnical engineer who developed them relied heavily on judgment and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* revealed 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 full-time 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 on hand quickly 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 observation.

## 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 informational 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, but they may rely on the factual data relative to the specific times, locations, and depths/elevations referenced. 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. 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 Not 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 relate any 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 yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. As a general rule, *do not rely on an environmental report prepared for a different client, site, or project, or that is more than six months old.*

## 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, none of the engineer's services were designed, conducted, or intended to prevent uncontrolled 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 not 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 not building-envelope or mold specialists.***

GEOPROFESSIONAL
BUSINESS
ASSOCIATION

Telephone: 301/565-2733
e-mail: info@geoprofessional.org   www.geoprofessional.org

# APPENDIX II

# TEST BORING LOGS

# Glossary

**Alluvial Soil:** soil that has developed on a floodplain or delta, deposited by moving water.

**Bedrock:** general term describing solid rock underlying the soil or any other unconsolidated surficial cover that is in place and continuous.

**Colluvial Soil:** incoherent soil and rock deposits at the foot of a slope or cliff, deposited there principally by gravity.

**Fill:** material that has been placed by man in a controlled or uncontrolled manner; fill can include soil, rock, rubble, construction debris, etc.

**Glacial Outwash:** sand and gravel transported away from a glacier by streams of meltwater and deposited in a preexisting valley or over a plain in a sorted manner.

**Glacial Till:** a heterogeneous mixture of clay, sand, gravel, and boulders which is deposited by and underneath a glacier and is unsorted and unstratified.

**"N" Value:** is considered to be an indication of the relative density of coarse-grained soils (sand and gravel) or consistency of fine-grained soils (silt and clay).

**Percent Recovery:** total length of rock core retrieved in the core barrel divided by the total length of the core run.

**Residual Soil:** natural soil materials that retain relic structures of the underlying parent bedrock, such as bedding planes, but are soft enough to be penetrated by a split-spoon sampler.

**Refusal:** the depth at which 50 SPT hammer blows or more are required to drive the sampling spoon 6 inches or less.

**Rock Quality Designation (RQD):** the sum of the lengths of intact rock core pieces longer than 4 inches (excluding mechanical breaks) divided by the total length of the core run, expressed as a percentage.

**Shelby Tube:** a 2 to 3" thin walled sampling tube that is pushed into the soil to obtain a relatively undisturbed soil sample for geotechnical laboratory tests.

**Split Spoon Sampler:** a sampling tube which can be split-open lengthwise for easy removal and visual inspection of the soil obtained.

**Standard Penetration Test (SPT) ASTM D1586 :** in general the SPT consists of driving a 2-inch outside diameter split-spoon sampler 18 inches using a 140-pound hammer free falling a distance of 30 inches. The number of blows that is required to advance the spoon through successive 6-inch increments is recorded. The first increment is considered a seating of the sampler. The sum of the blows for the second and third increments is the "N" value.

# Unconsolidated Material

| Term | Grain Size (mm) | Example Size |
|---|---|---|
| Clay | <1/250 | can't see grains |
| Silt | 1/250 - 1/16 | grains seen w/ naked eye |
| Fine Sand | 1/16 - 1/4 | table salt to sugar |
| Med. Sand | 1/4 - 2.0 | openings in a window screen |
| Course Sand | 2.0 - 4.75 | sidewalk salt |
| Gravel | 4.75 - 75 | pea to tennis ball |
| Cobble | 75 - 300 | orange to tennis ball |
| Boulder | >300 | larger than a basketball |

## Modifiers for Soils with Two Grain Sizes

| Term | % | Term | % |
|---|---|---|---|
| Trace | < 12 | Some | 12-30 |
| Adjective (i.e. silty) | 30-45 | And | 45-55 |

## Moisture Content

**Dry**: Sample is dusty or very obviously very dry.
**Moist**: Anything that does not fit the definition of dry or wet.
**Wet**: Sample contains free water.

# N-Value Rating

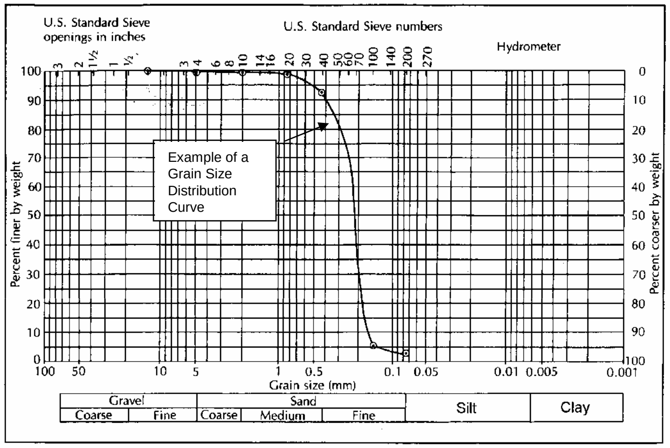
**Fine-Grained Soils**

| Consistency | Blows/ft |
|---|---|
| Very Soft | 0-2 |
| Soft | 3-4 |
| Medium Stiff | 5-8 |
| Stiff | 9-15 |
| Very Stiff | 16-30 |
| Hard | >30 |

**Coarse-Grained Soils**

| Relative Density | Blows/ft |
|---|---|
| Very Loose | 0-4 |
| Loose | 5-10 |
| Medium Dense | 11-30 |
| Dense | 31-50 |
| Very Dense | >50 |

# Grain Size Distribution Curve



### UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

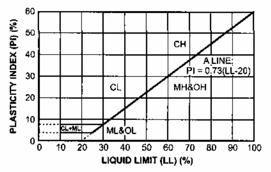
| | | |
|---|---|---|
| COARSE-GRAINED SOILS<br>(more than 50% of material is larger than No. 200 sieve size.) | | |
| | Clean Gravels (Less than 5% fines) | |
| **GRAVELS**<br>More than 50% of coarse fraction larger than No. 4 sieve size | GW | Well-graded gravels, gravel-sand mixtures, little or no fines |
| | GP | Poorly-graded gravels, gravel-sand mixtures, little or no fines |
| | Gravels with fines (More than 12% fines) | |
| | GM | Silty gravels, gravel-sand-silt mixtures |
| | GC | Clayey gravels, gravel-sand-clay mixtures |
| | Clean Sands (Less than 5% fines) | |
| **SANDS**<br>50% or more of coarse fraction smaller than No. 4 sieve size | SW | Well-graded sands, gravelly sands, little or no fines |
| | SP | Poorly graded sands, gravelly sands, little or no fines |
| | Sands with fines (More than 12% fines) | |
| | SM | Silty sands, sand-silt mixtures |
| | SC | Clayey sands, sand-clay mixtures |
| FINE-GRAINED SOILS<br>(50% or more of material is smaller than No. 200 sieve size.) | | |
| **SILTS AND CLAYS**<br>Liquid limit less than 50% | ML | Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts with slight plasticity |
| | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays |
| | OL | Organic silts and organic silty clays of low plasticity |
| **SILTS AND CLAYS**<br>Liquid limit 50% or greater | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts |
| | CH | Inorganic clays of high plasticity, fat clays |
| | OH | Organic clays of medium to high plasticity, organic silts |
| **HIGHLY ORGANIC SOILS** | PT | Peat and other highly organic soils |

### LABORATORY CLASSIFICATION CRITERIA

| | | |
|---|---|---|
| GW | $C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3 | |
| GP | Not meeting all gradation requirements for GW | |
| GM | Atterberg limits below "A" line or P.I. less than 4 | Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols |
| GC | Atterberg limits above "A" line with P.I. greater than 7 | |
| SW | $C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3 | |
| SP | Not meeting all gradation requirements for GW | |
| SM | Atterberg limits below "A" line or P.I. less than 4 | Limits plotting in shaded zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols. |
| SC | Atterberg limits above "A" line with P.I. greater than 7 | |

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:
Less than 5 percent .................................. GW, GP, SW, SP
More than 12 percent .................................. GM, GC, SM, SC
5 to 12 percent .................. Borderline cases requiring dual symbols

### PLASTICITY CHART



# Rock Types

| Rock Name | Characteristics | Symbol |
|---|---|---|
| Shale | Clay sized particles, shale has fissility which is a horizontal sheet-like or laminated feature. | ▤ |
| Claystone | Clay sized particles that are consolidated, lacking fissility. | ▨ |
| Siltstone | Composed of silt, normally breaks as irregular chunks | ▤ |
| Sandstone | Primarily sand sized particles modified w/ the descriptor fine, medium, or coarse. | ⁘ |
| Conglomerate | Gravel sized grains and larger held together by finer material, called a breccia if clasts are angular. | ◌ |
| Limestone | Effervesses w/ diluted HCl, can be composed of clay up to gravel particles (fossils). | ▦ |
| Coal | Black and shiny, can break into cubes or conchoidally. | ■ |

# Rock Quality Descriptions

## Weathering

**Completely Weathered**: All rock material is decomposed and/or disintegrated. The original rock structure may still be intact.

**Highly Weathered**: More than half of the rock material is decomposed. Fresh rock is present only as a discontinuous framework or as corestones.

**Moderately Weathered**: Less than half of the rock material is decomposed. Fresh rock is present at a discontinuous framework or as corestones.

**Slightly Weathered**: Discoloration or staining indicates weathering of rock material on discontinuity surfaces. Rock may be discolored and softened.

**Fresh**: No visible signs of rock material weathering.

## RQD

| Descriptor | % |
|---|---|
| Very Poor | <25 |
| Poor | 25-50 |
| Fair | 50-75 |
| Good | 75-90 |
| Excellent | >90 |

## Brokenness

| Descriptor | Fracture Spacing (in) |
|---|---|
| Very Broken | < 1 |
| Broken | 1-3 |
| Moderately Broken | 3-6 |
| Slightly Broken | >6 |

CEC
Civil & Environmental Consultants, Inc.

Definition of Standard Terms and Symbols

Civil & Environmental Consultants, Inc.
5899 Montclair Boulevard
Cincinnati, Ohio 45150

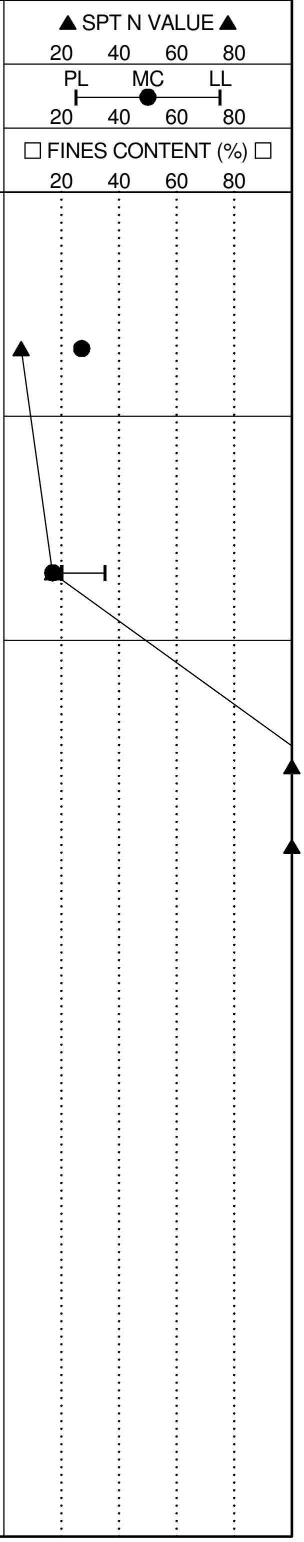
# BORING NUMBER B-1

PAGE 1 OF 1

**CLIENT** Fairfield Township
**PROJECT NAME** Fairfield Township Fire/EMT Station
**CEC PROJECT NUMBER** 161-305-0040
**PROJECT LOCATION** Fairfield Township, Ohio 45011
**DATE STARTED** 3/8/18 **COMPLETED** 3/8/18
**GROUND ELEVATION** 749.0 ft **HOLE SIZE** 6 inches
**DRILLING CONTRACTOR** CSI Drilling, LLC
**GROUND WATER LEVELS:**
**DRILLING METHOD** 2.25" Solid Stem Augers: Automatic Hammer
**AT TIME OF DRILLING** Dry
**LOGGED BY** CHW **CHECKED BY** JBG
**AT END OF DRILLING** Dry (caved at 6.5')
**LOCATION** N 510229.4, E 1398602.1
**AFTER DRILLING** Backfilled upon completion

| ELEVATION (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN (tsf) |
|---|---|---|---|---|---|---|---|
| 749.0 | | TOPSOIL (6 inches) | 0.0 | | | | |
| 748.5 | | Olive brown and brown clayey SILT, trace sand, few roots, moist, medium stiff (GLACIAL TILL) | 2.5 | SS 1 | 100 | 3-3-3 (6) | 1.0-2.5 |
| 745.5 | | Olive brown silty CLAY, few limestone fragments, moist, very stiff (RESIDUAL) | 5.0 | SS 2 | 100 | 5-8-9 (17) | 3.5-4.5+ |
| 742.7 | | Olive brown SHALE, few thin interbedded limestone layers, completely weathered, very broken, very soft | | SS 3 | 40 | 3-50/4" | 4.0-4.5+ |
| | | | | SS 4 | 100 | 50/3" | |
| 741.6 | | Bottom of hole at 7.4 feet. | | | | | |

Notes:
1. Auger refusal encountered at 7.2'.



Civil & Environmental Consultants, Inc.
5899 Montclair Boulevard
Cincinnati, Ohio 45150

# BORING NUMBER B-2

PAGE 1 OF 1

**CLIENT** Fairfield Township

**PROJECT NAME** Fairfield Township Fire/EMT Station

**CEC PROJECT NUMBER** 161-305-0040

**PROJECT LOCATION** Fairfield Township, Ohio 45011

**DATE STARTED** 3/8/18 **COMPLETED** 3/8/18

**GROUND ELEVATION** 747.2 ft **HOLE SIZE** 6 inches

**DRILLING CONTRACTOR** CSI Drilling, LLC

**GROUND WATER LEVELS:**

**DRILLING METHOD** 2.25" Solid Stem Augers: Automatic Hammer

**AT TIME OF DRILLING** Dry

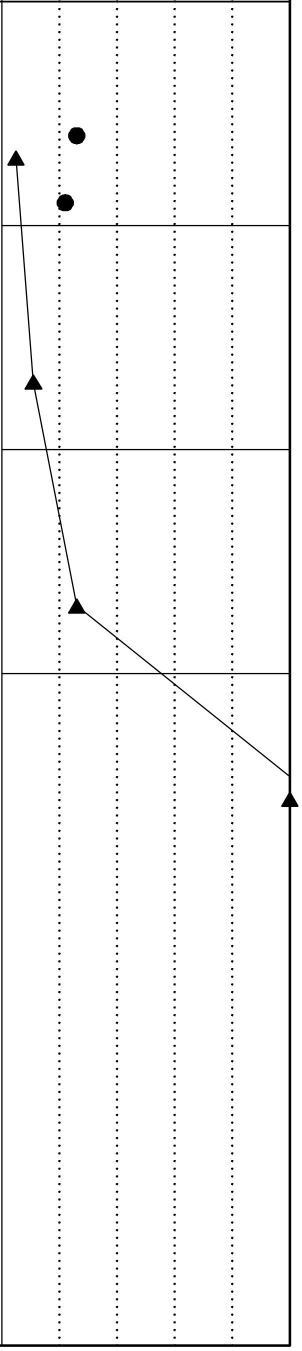
**LOGGED BY** CHW **CHECKED BY** JBG

**AT END OF DRILLING** Dry (caved at 6.5')

**LOCATION** N 510256.4, E 1398749.6

▼ **17 hours AFTER DRILLING** 2.3 ft / Elev 744.9 ft (caved at 5.4')

| ELEVATION (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN (tsf) | ▲ SPT N VALUE ▲ 20 40 60 80<br>PL MC LL 20 40 60 80<br>☐ FINES CONTENT (%) ☐ 20 40 60 80 |
|---|---|---|---|---|---|---|---|---|
| 747.2 | | TOPSOIL (12 inches) | 0.0 | | | | | |
| 746.2 | | Olive brown and brown clayey SILT, trace sand, few roots, moist, medium stiff (GLACIAL TILL) | | SS 1 | 67 | 3-2-3 (5) | 1.0-3.5 | |
| 745.2 | | ▼ Olive brown clayey SILT, few roots, noted sand seam at 4', moist, medium stiff becoming stiff (GLACIAL TILL) | 2.5 | | | | | |
| | | | | SS 2 | 44 | 4-5-6 (11) | 1.0-4.0 | |
| 743.2 | | Olive brown clayey SILT, trace sand, trace gravel, moist, stiff (GLACIAL TILL) | 5.0 | | | | | |
| 741.2 | | Olive brown and brown silty CLAY, few limestone fragments, wet becoming moist, very stiff (RESIDUAL) | 7.5 | SS 3 | 56 | 6-9-17 (26) | 4.0-4.5+ | |
| 738.5 | | Olive brown and gray SHALE, few thin interbedded limestone layers, completely weathered, very broken, very soft | | SS 4 | 100 | 50/5" | 4.5+ | |
| 738.1 | | Bottom of hole at 9.1 feet. | | | | | | |



Notes:
1. Topsoil samples obtained from 4" to 8" and 8" to 12".
2. Auger refusal encountered at 8.7'.

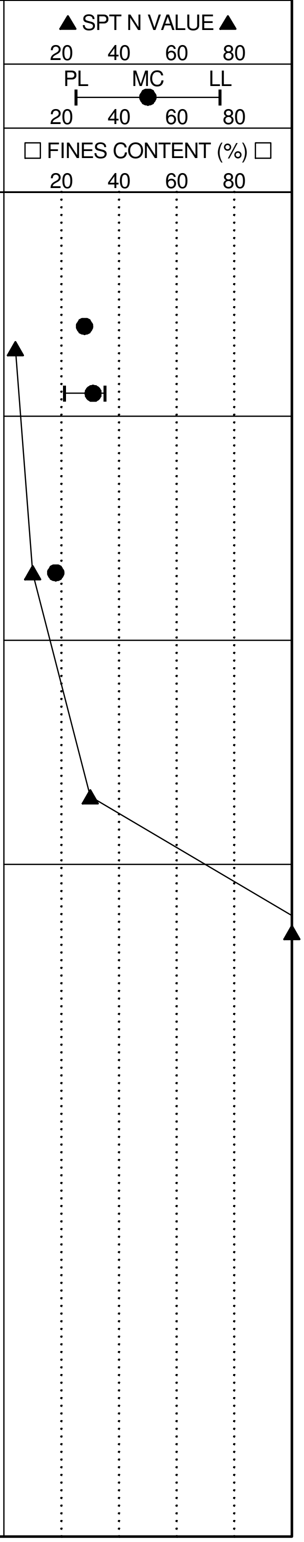
Civil & Environmental Consultants, Inc.
5899 Montclair Boulevard
Cincinnati, Ohio 45150

# BORING NUMBER B-3

PAGE 1 OF 1

**CLIENT** Fairfield Township
**PROJECT NAME** Fairfield Township Fire/EMT Station
**CEC PROJECT NUMBER** 161-305-0040
**PROJECT LOCATION** Fairfield Township, Ohio 45011
**DATE STARTED** 3/8/18 **COMPLETED** 3/8/18
**GROUND ELEVATION** 747.9 ft **HOLE SIZE** 6 inches
**DRILLING CONTRACTOR** CSI Drilling, LLC
**GROUND WATER LEVELS:**
**DRILLING METHOD** 2.25" Solid Stem Augers: Automatic Hammer
▽ **AT TIME OF DRILLING** 4.0 ft / Elev 743.9 ft
**LOGGED BY** CHW **CHECKED BY** JBG
▼ **AT END OF DRILLING** 2.6 ft / Elev 745.3 ft (caved at 6.4')
**LOCATION** N 510099.5, E 1398649.0
▼ **19 hours AFTER DRILLING** 0.7 ft / Elev 747.2 ft (caved at 6.4')

| ELEVATION (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN (tsf) |
|---|---|---|---|---|---|---|---|
| 747.9 | ▼ | TOPSOIL (12 inches) | 0.0 | | | | |
| 746.9 | ▼ | Olive brown and brown clayey SILT, trace sand, few roots, moist to wet, soft (GLACIAL TILL) | 2.5 | SS 1 | 83 | 3-2-2 (4) | 1.5-2.5 |
| 744.4 | ▽ | Olive brown, brown and gray SILT, some clay, some sand, trace gravel, noted sand seam at 4.5', wet, stiff (GLACIAL TILL) | 5.0 | SS 2 | 67 | 0-4-6 (10) | 1.0-1.75 |
| 741.9 | | Olive brown and brown silty CLAY, few limestone fragments, moist, very stiff (RESIDUAL) | 7.5 | SS 3 | 56 | 10-12-18 (30) | 4.0-4.5+ |
| 739.8<br>739.5 | | Olive brown and gray SHALE, few thin interbedded limestone layers, completely weathered, very broken, very soft | | SS 4 | 100 | 50/4" | |



Bottom of hole at 8.4 feet.

Notes:
1. Shelby tube obtained from 4' to 6' with 24" of recovery.
2. Auger refusal encountered at 8.1'.

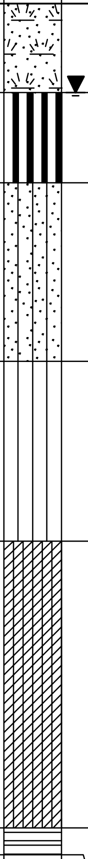
Civil & Environmental Consultants, Inc.
5899 Montclair Boulevard
Cincinnati, Ohio 45150

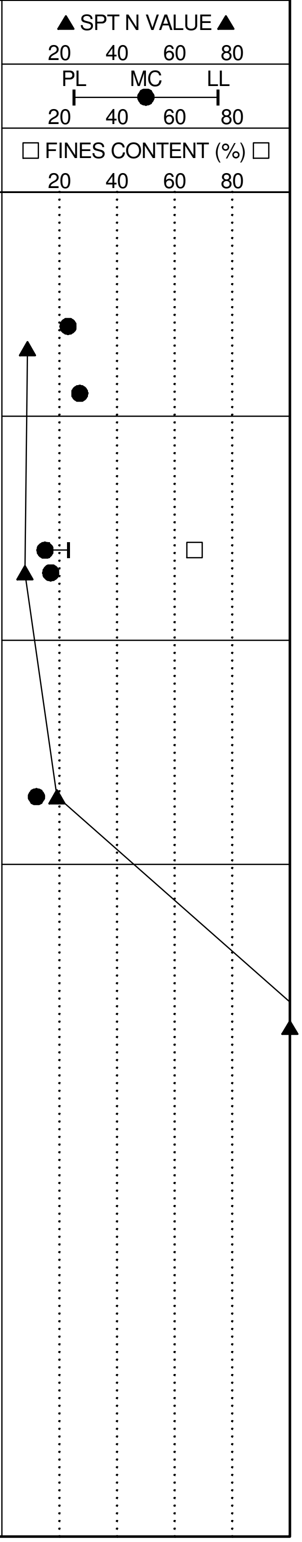
# BORING NUMBER B-4

PAGE 1 OF 1

**CLIENT** Fairfield Township
**PROJECT NAME** Fairfield Township Fire/EMT Station
**CEC PROJECT NUMBER** 161-305-0040
**PROJECT LOCATION** Fairfield Township, Ohio 45011
**DATE STARTED** 3/8/18 **COMPLETED** 3/8/18
**GROUND ELEVATION** 746.8 ft **HOLE SIZE** 6 inches
**DRILLING CONTRACTOR** CSI Drilling, LLC
**GROUND WATER LEVELS:**
**DRILLING METHOD** 2.25" Solid Stem Augers: Automatic Hammer
▽ **AT TIME OF DRILLING** 1.0 ft / Elev 745.8 ft
**LOGGED BY** CHW **CHECKED BY** JBG
▼ **AT END OF DRILLING** 1.0 ft / Elev 745.8 ft (caved at 8.8')
**LOCATION** N 510082.1, E 1398738.3
**AFTER DRILLING** Backfilled upon completion

| ELEVATION (ft) | MATERIAL DESCRIPTION | DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN (tsf) |
|---|---|---|---|---|---|---|
| 746.8 | TOPSOIL (12 inches) | 0.0 | | | | |
| 745.8 | Olive brown and brown clayey SILT, trace sand, few roots, moist, stiff (GLACIAL TILL) | | SS 1 | 100 | 3-4-5 (9) | 1.75-2.5 |
| 744.8 | Olive brown, brown and gray sandy SILT, some clay, trace gravel, moist, stiff becoming medium stiff (GLACIAL TILL) | 2.5 | | | | |
| 742.8 | Olive brown, brown and gray SILT, some clay, some sand, moist, stiff becoming medium stiff (GLACIAL TILL) | 5.0 | SS 2 | 44 | 0-0-8 (8) | 1.0-1.75 |
| 740.8 | Olive brown and brown silty CLAY, few limestone fragments, moist, very stiff (RESIDUAL) | 7.5 | SS 3 | 67 | 5-7-12 (19) | 4.0-4.5+ |
| 737.6 | Olive brown SHALE, noted thin interbedded limestone layer, completely weathered, very broken, very soft | | SS 4 | 100 | 50/3" | 4.5+ |
| 737.3 | Bottom of hole at 9.5 feet. | | | | | |





Notes:
1. Shelby tube obtained from 3' to 5' with 24" of recovery.
2. Bulk sample obtained from 1' to 5'.
3. Auger refusal encountered at 9.2'.

Civil & Environmental Consultants, Inc.
5899 Montclair Boulevard
Cincinnati, Ohio 45150

# BORING NUMBER B-5

**CLIENT** Fairfield Township

**PROJECT NAME** Fairfield Township Fire/EMT Station

**CEC PROJECT NUMBER** 161-305-0040

**PROJECT LOCATION** Fairfield Township, Ohio 45011

**DATE STARTED** 3/8/18 **COMPLETED** 3/8/18

**GROUND ELEVATION** 747.7 ft **HOLE SIZE** 6 inches

**DRILLING CONTRACTOR** CSI Drilling, LLC

**GROUND WATER LEVELS:**

**DRILLING METHOD** 2.25" Solid Stem Augers: Automatic Hammer

**AT TIME OF DRILLING** Dry

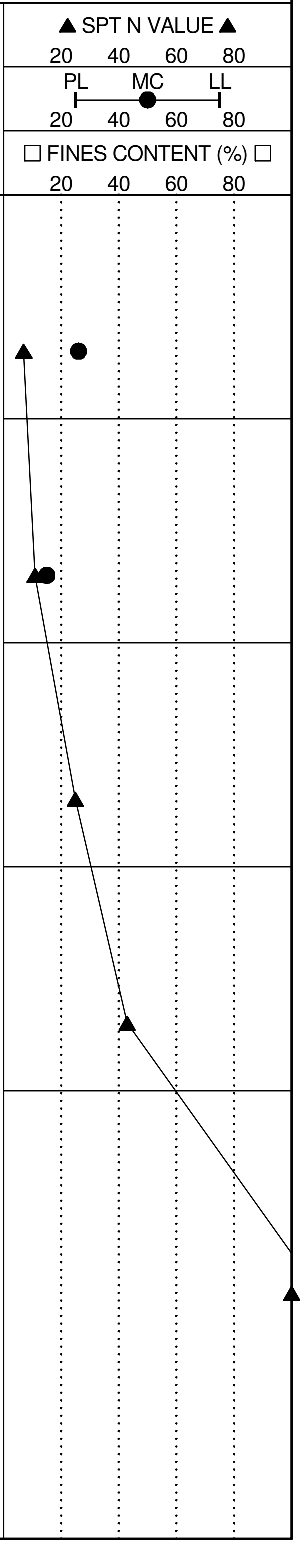
**LOGGED BY** CHW **CHECKED BY** JBG

**AT END OF DRILLING** Dry (caved at 11')

**LOCATION** N 510144.8, E 1398701.0

**AFTER DRILLING** Backfilled upon completion

| ELEVATION (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN (tsf) |
|---|---|---|---|---|---|---|---|
| 747.7 | | TOPSOIL (8 inches) | 0.0 | | | | |
| 747.0 | | Olive brown clayey SILT, trace sand, few roots, moist, medium stiff (GLACIAL TILL) | 2.5 | SS 1 | 100 | 3-3-4 (7) | 1.0-1.5 |
| 744.2 | | Brown SILT, some clay, some sand, trace gravel, moist, stiff (GLACIAL TILL) | 5.0 | SS 2 | 78 | 4-4-7 (11) | 2.0-4.5+ |
| 741.7 | | Brown silty CLAY, few limestone fragments, moist, very stiff (RESIDUAL) | 7.5 | SS 3 | 100 | 7-9-16 (25) | 3.5-4.5+ |
| 739.2 | | Olive brown SHALE, few thin interbedded limestone layers, completely weathered, very broken, very soft | 10.0 | SS 4 | 100 | 7-28-15 (43) | 4.5+ |
| 735.6 | | Gray SHALE, highly weathered, very broken, very soft | | SS 5 | 75 | 50/4" | 4.5+ |
| 735.3 | | Bottom of hole at 12.4 feet. | | | | | |



Notes:
1. Auger refusal encountered at 12.1'.

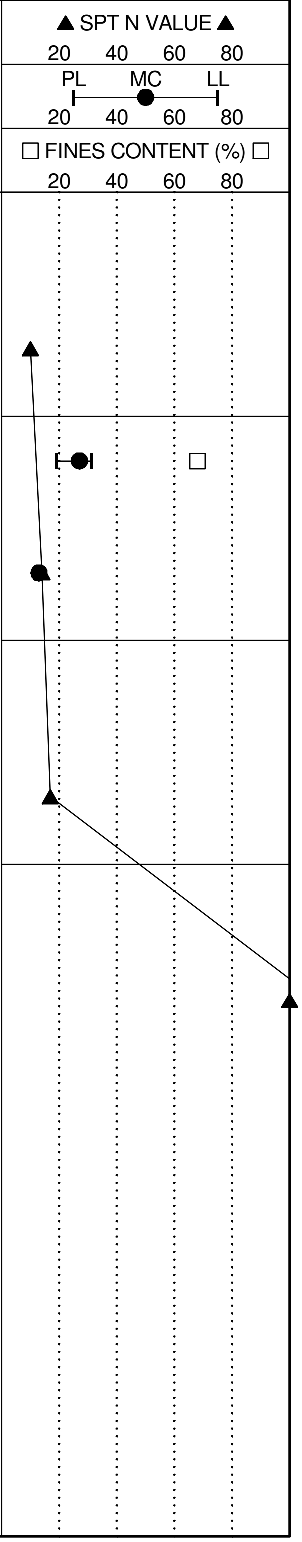
Civil & Environmental Consultants, Inc.
5899 Montclair Boulevard
Cincinnati, Ohio 45150

# BORING NUMBER B-6

PAGE 1 OF 1

**CLIENT** Fairfield Township
**PROJECT NAME** Fairfield Township Fire/EMT Station
**CEC PROJECT NUMBER** 161-305-0040
**PROJECT LOCATION** Fairfield Township, Ohio 45011
**DATE STARTED** 3/8/18 **COMPLETED** 3/8/18
**GROUND ELEVATION** 746.6 ft **HOLE SIZE** 6 inches
**DRILLING CONTRACTOR** CSI Drilling, LLC
**GROUND WATER LEVELS:**
**DRILLING METHOD** 2.25" Solid Stem Augers: Automatic Hammer
**AT TIME OF DRILLING** Dry
**LOGGED BY** CHW **CHECKED BY** JBG
**AT END OF DRILLING** Dry (caved at 8')
**LOCATION** N 510337.0, E 1398777.7
**AFTER DRILLING** Backfilled upon completion

| ELEVATION (ft) | MATERIAL DESCRIPTION | DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN (tsf) |
|---|---|---|---|---|---|---|
| 746.6 | TOPSOIL (13 inches) | 0.0 | | | | |
| 745.5 | Olive brown and dark gray clayey SILT, trace sand, few roots, moist, stiff (GLACIAL TILL) | 2.5 | SS 1 | 78 | 4-5-5 (10) | 1.75-3.0 |
| 743.1 | Olive brown, brown, and gray SILT, some clay, trace sand, trace gravel, moist, stiff (GLACIAL TILL) | 5.0 | SS 2 | 100 | 4-6-8 (14) | 2.5-4.0 |
| 740.6 | Olive brown silty CLAY, few limestone fragments, moist, very stiff becoming hard (RESIDUAL) | 7.5 | SS 3 | 67 | 6-7-10 (17) | 4.0-4.5+ |
| 737.7 | Olive brown SHALE, thin interbedded limestone layers, completely weathered, very broken, very soft | | SS 4 | 100 | 50/3" | |
| 737.4 | Bottom of hole at 9.2 feet. | | | | | |



Notes:
1. Topsoil samples obtained from 5" to 9" and 9" to 13".
2. Bulk sample obtained from 1' to 5'.
3. Auger refusal encountered at 8.9'.

Civil & Environmental Consultants, Inc.
5899 Montclair Boulevard
Cincinnati, Ohio 45150

# BORING NUMBER B-7

PAGE 1 OF 1

**CLIENT** Fairfield Township

**PROJECT NAME** Fairfield Township Fire/EMT Station

**CEC PROJECT NUMBER** 161-305-0040

**PROJECT LOCATION** Fairfield Township, Ohio 45011

**DATE STARTED** 3/8/18 **COMPLETED** 3/8/18

**GROUND ELEVATION** 746.7 ft **HOLE SIZE** 6 inches

**DRILLING CONTRACTOR** CSI Drilling, LLC

**GROUND WATER LEVELS:**

**DRILLING METHOD** 2.25" Solid Stem Augers: Automatic Hammer

**AT TIME OF DRILLING** Dry

**LOGGED BY** CHW **CHECKED BY** JBG

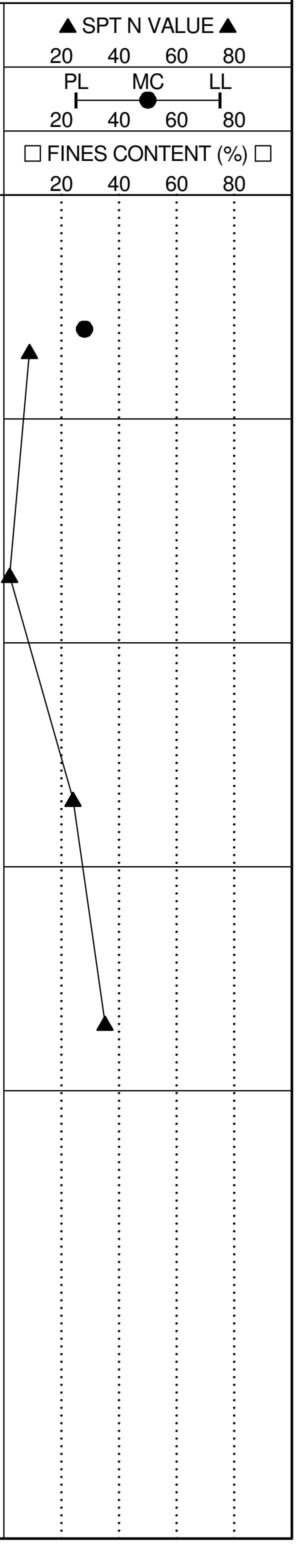
▼ **AT END OF DRILLING** 3.0 ft / Elev 743.7 ft (caved at 8')

**LOCATION** N 510285.5, E 1398839.5

▽ **16 hours AFTER DRILLING** 1.0 ft / Elev 745.7 ft (caved at 3.5')

| ELEVATION (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN (tsf) |
|---|---|---|---|---|---|---|---|
| 746.7 | | TOPSOIL (8 inches) | 0.0 | | | | |
| 746.0 | ▽ | Dark brown clayey SILT, trace sand, few roots, moist, stiff (GLACIAL TILL) | | SS 1 | 67 | 4-4-5 (9) | 1.0-3.0 |
| 744.7 | ▼ | Olive brown, brown, and gray clayey SILT, trace sand, trace gravel, moist, stiff becoming very soft (GLACIAL TILL) | 2.5 | | | | |
| 742.7 | | Olive brown sandy SILT, trace clay, wet, very soft (GLACIAL TILL) | | SS 2 | 56 | 0-0-2 (2) | |
| 742.2 | | Olive brown, brown, and gray SILT, some clay, trace sand, trace gravel, moist, very soft (GLACIAL TILL) | 5.0 | | | | 1.75 |
| 740.7 | | Olive brown silty CLAY, few limestone fragments, moist, very stiff becoming hard (RESIDUAL) | | SS 3 | 83 | 3-7-17 (24) | 3.5-4.5+ |
| | | | 7.5 | | | | |
| | | | | SS 4 | 56 | 5-8-27 (35) | 3.5-4.5+ |
| 736.7 | | Bottom of hole at 10.0 feet. | 10.0 | | | | |

Notes:
1. Bulk sample obtained from 1' to 5'.



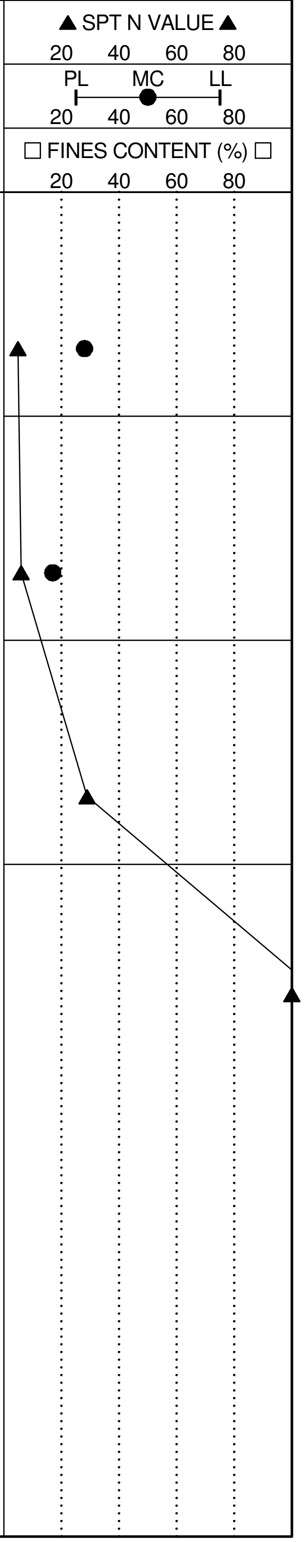
Civil & Environmental Consultants, Inc.
5899 Montclair Boulevard
Cincinnati, Ohio 45150

# BORING NUMBER B-8

PAGE 1 OF 1

**CLIENT** Fairfield Township
**PROJECT NAME** Fairfield Township Fire/EMT Station
**CEC PROJECT NUMBER** 161-305-0040
**PROJECT LOCATION** Fairfield Township, Ohio 45011
**DATE STARTED** 3/8/18 **COMPLETED** 3/8/18
**GROUND ELEVATION** 746.9 ft **HOLE SIZE** 6 inches
**DRILLING CONTRACTOR** CSI Drilling, LLC
**GROUND WATER LEVELS:**
**DRILLING METHOD** 2.25" Solid Stem Augers: Automatic Hammer
▽ **AT TIME OF DRILLING** 0.4 ft / Elev 746.5 ft
**LOGGED BY** CHW **CHECKED BY** JBG
▼ **AT END OF DRILLING** 0.4 ft / Elev 746.5 ft (caved at 7.2')
**LOCATION** N 510137.9, E 1398835.4
**AFTER DRILLING** Backfilled upon completion

| ELEVATION (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN (tsf) |
|---|---|---|---|---|---|---|---|
| 746.9 | | ▼ TOPSOIL (12 inches) | 0.0 | | | | |
| 745.9 | | Olive brown and brown clayey SILT, trace sand, few roots, moist, medium stiff (GLACIAL TILL) | 2.5 | SS 1 | 72 | 3-2-3 (5) | 1.5-1.75 |
| 743.4 | | Olive brown, brown and gray SILT, some clay, some sand, trace gravel, noted sand seam at 4.5', wet, medium stiff (GLACIAL TILL) | 5.0 | SS 2 | 100 | 2-3-3 (6) | 1.5-1.75 |
| 740.9 | | Olive brown silty CLAY, few limestone fragments, moist, very stiff (RESIDUAL) | 7.5 | SS 3 | 17 | 8-11-18 (29) | |
| 738.4 | | Olive brown and gray SHALE, few thin interbedded limestone layers, completely weathered, very broken, very soft | | SS 4 | 91 | 8-50/5" | 4.0-4.5+ |
| 737.5 | | Bottom of hole at 9.4 feet. | | | | | |



# BORING NUMBER B-9

PAGE 1 OF 1

Civil & Environmental Consultants, Inc.
5899 Montclair Boulevard
Cincinnati, Ohio 45150

**CLIENT** Fairfield Township

**PROJECT NAME** Fairfield Township Fire/EMT Station

**CEC PROJECT NUMBER** 161-305-0040

**PROJECT LOCATION** Fairfield Township, Ohio 45011

**DATE STARTED** 3/8/18 **COMPLETED** 3/8/18

**GROUND ELEVATION** 750.0 ft **HOLE SIZE** 6 inches

**DRILLING CONTRACTOR** CSI Drilling, LLC

**GROUND WATER LEVELS:**

**DRILLING METHOD** 2.25" Solid Stem Augers: Automatic Hammer

**AT TIME OF DRILLING** Dry

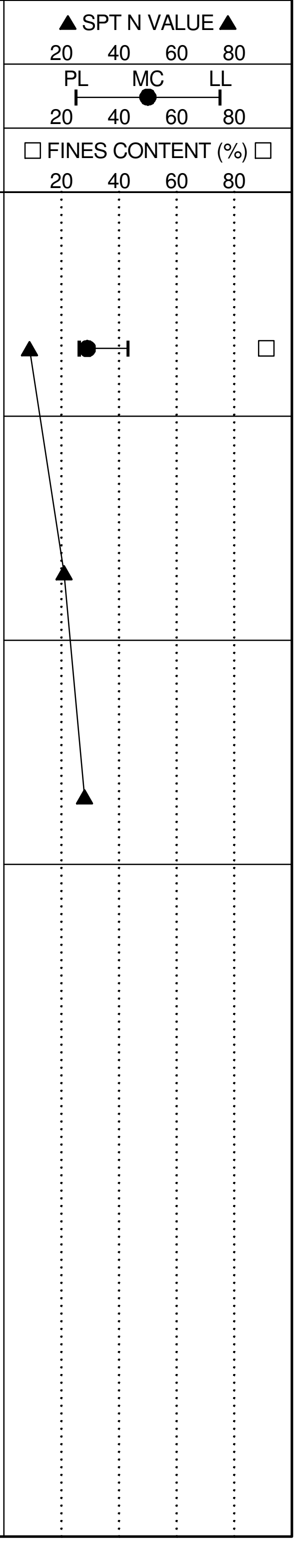
**LOGGED BY** CHW **CHECKED BY** JBG

**AT END OF DRILLING** Dry (caved at 8')

**LOCATION** N 510297.4, E 1398579.4

**AFTER DRILLING** Backfilled upon completion

| ELEVATION (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN (tsf) |
|---|---|---|---|---|---|---|---|
| 750.0 | | TOPSOIL (6 inches) | 0.0 | | | | |
| 749.5 | | Olive brown clayey SILT, trace sand, few roots, moist, medium stiff (GLACIAL TILL) | | | | | |
| | | | 2.5 | SS 1 | 44 | 3-4-5 (9) | 0.75-2.0 |
| 746.5 | | Olive brown and gray silty CLAY, few limestone fragments, moist, very stiff (RESIDUAL) | | | | | |
| | | | 5.0 | SS 2 | 67 | 8-9-12 (21) | 4.0-4.5+ |
| | | | 7.5 | SS 3 | 44 | 13-13-15 (28) | 4.25-4.5+ |
| 742.6 | | Olive brown SHALE, noted thin interbedded limestone layer, completely weathered, very broken, very soft | | | | | |
| 742.5 | | Bottom of hole at 7.5 feet. | | | | | |



Civil & Environmental Consultants, Inc.
5899 Montclair Boulevard
Cincinnati, Ohio 45150

# BORING NUMBER B-10

PAGE 1 OF 1

**CLIENT** Fairfield Township

**PROJECT NAME** Fairfield Township Fire/EMT Station

**CEC PROJECT NUMBER** 161-305-0040

**PROJECT LOCATION** Fairfield Township, Ohio 45011

**DATE STARTED** 3/8/18 **COMPLETED** 3/8/18

**GROUND ELEVATION** 750.9 ft **HOLE SIZE** 6 inches

**DRILLING CONTRACTOR** CSI Drilling, LLC

**GROUND WATER LEVELS:**

**DRILLING METHOD** 2.25" Solid Stem Augers: Automatic Hammer

**AT TIME OF DRILLING** Dry

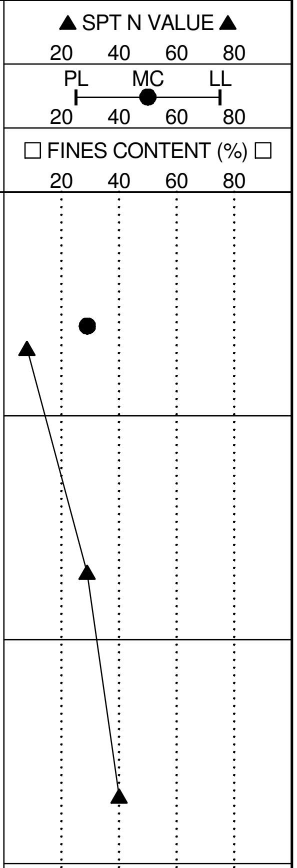
**LOGGED BY** CHW **CHECKED BY** JBG

**AT END OF DRILLING** Dry (caved at 5')

**LOCATION** N 510160.0, E 1398563.2

**AFTER DRILLING** Backfilled upon completion

| ELEVATION (ft) | GRAPHIC LOG | MATERIAL DESCRIPTION | DEPTH (ft) | SAMPLE TYPE NUMBER | RECOVERY % (RQD) | BLOW COUNTS (N VALUE) | POCKET PEN (tsf) |
|---|---|---|---|---|---|---|---|
| | | | 0.0 | | | | |
| 750.9 | | TOPSOIL (10 inches) | | | | | |
| 750.1 | | Olive brown clayey SILT, trace sand, few roots, moist, medium stiff (GLACIAL TILL) | | SS 1 | 94 | 3-4-4 (8) | 1.0-2.5 |
| 748.9 | | Olive brown, brown, and gray clayey SILT, trace sand, trace gravel, moist, medium stiff (GLACIAL TILL) | 2.5 | | | | |
| 747.4 | | Olive brown silty CLAY, few limestone fragments, moist, very stiff (RESIDUAL) | | SS 2 | 100 | 13-14-15 (29) | 2.5-4.5 |
| | | | 5.0 | | | | |
| | | | | SS 3 | 39 | 16-18-22 (40) | 4.5 |
| 743.9 | | Olive brown SHALE, few thin interbedded limestone layers, completely weathered, very broken, very soft | 7.5 | | | | |
| 743.4 | | Bottom of hole at 7.5 feet. | | | | | |



Notes:
1. Topsoil samples obtained from 2" to 6" and 6" to 10".

# APPENDIX III

# LABORATORY TEST RESULTS

# Summary of Laboratory Results

Sheet 1 of 1

| Borehole | Depth | Sample Type | Liquid Limit | Plastic Limit | Plasticity Index | Classification | Water Content (%) | Unconfined Compressive Strength (tsf) | Dry Density (pcf) | Wet Density (pcf) | Max. Dry Density (pcf) | Opt. Water Content (%) | CBR | Swell (%) | RQD | Organic Content (%) | Percent Finer (No. 200) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-1 | 1.0' | | | | | | 27.1 | | | | | | | | | | |
| B-1 | 3.5' | | 35 | 20 | 15 | **LEAN CLAY(CL) | 17.0 | | | | | | | | | | |
| B-2 | 1.0' | | | | | | 26.3 | | | | | | | | | | |
| B-2 | 2.0' | | | | | | 21.7 | | | | | | | | | | |
| B-2 | 4"-8" | | | | | | 26.3 | | | | | | | | | 6.7 | |
| B-2 | 8"-12" | | | | | | 21.7 | | | | | | | | | 3.6 | |
| B-3 | 1.0' | | | | | | 27.9 | | | | | | | | | | |
| B-3 | 2.0' | | 35 | 21 | 14 | **LEAN CLAY(CL) | 30.9 | | | | | | | | | | |
| B-3 | 3.5' | | | | | | 17.6 | | | | | | | | | | |
| B-4 | 1.0' | | | | | | 22.6 | | | | | | | | | | |
| B-4 | 2.0' | | | | | | 26.5 | | | | | | | | | | |
| B-4 | 3.0' | | 23 | 16 | 7 | SANDY SILTY CLAY(CL-ML) | 14.7 | | 119.0 | 136.5 | | | | | | | 63 |
| B-4 | 3.5' | | | | | | 16.5 | | | | | | | | | | |
| B-4 | 4.0' | | 23 | 16 | 7 | SILTY CLAY with SAND(CL-ML) | 14.7 | | 119.0 | 136.5 | | | | | | | 71 |
| B-4 | 6.0' | | | | | | 11.6 | | | | | | | | | | |
| B-5 | 1.0' | | | | | | 26.4 | | | | | | | | | | |
| B-5 | 3.5' | | | | | | 14.5 | | | | | | | | | | |
| B-6 | 1.0' | | 31 | 19 | 12 | SANDY LEAN CLAY(CL) | 27.0 | | | | 115.5 | 13.9 | | | | | 68 |
| B-6 | 3.5' | | | | | | 12.9 | | | | | | | | | | |
| B-6 | 5"-9" | | | | | | 26.3 | | | | | | | | | 5.3 | |
| B-6 | 9"-13" | | | | | | 21.7 | | | | | | | | | 3.9 | |
| B-7 | 1.0' | | | | | | 28.2 | | | | | | | | | | |
| B-8 | 1.0' | | | | | | 28.2 | | | | | | | | | | |
| B-8 | 3.5' | | | | | | 17.2 | | | | | | | | | | |
| B-9 | 1.0' | | 43 | 26 | 17 | LEAN CLAY(CL) | 28.6 | | | | | | | | | | 91 |
| B-10 | 1.0' | | | | | | 28.8 | | | | | | | | | | |
| B-10 | 2"-6" | | | | | | 26.3 | | | | | | | | | 7.2 | |
| B-10 | 6"-10" | | | | | | 21.7 | | | | | | | | | 5.8 | |

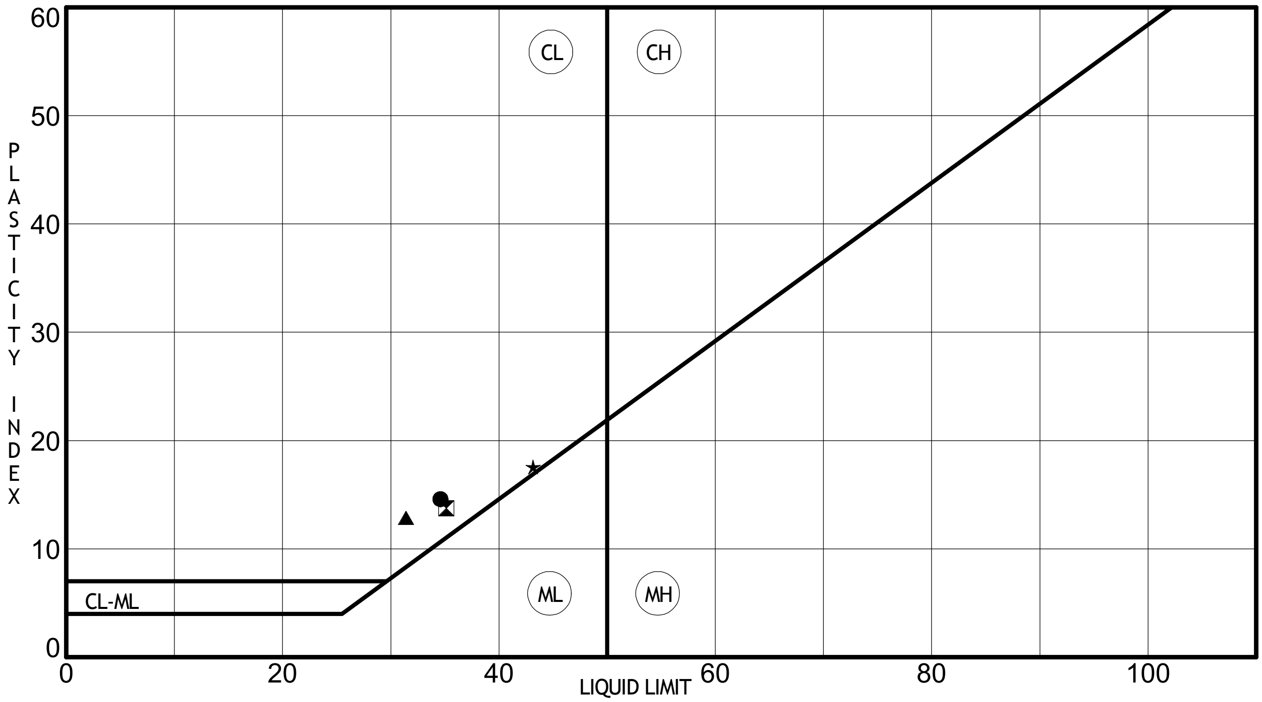
**CSI of Cincinnati**
11162 Luschek Drive
Cincinnati, Ohio 45241
Phone: 513.252.2059
Fax: 888.792.3121

SS - Split Spoon Sample GRAB - Bulk Grab Sample

**Visually Classified

PROJECT INFORMATION
Client: Civil and Environmental Consultants, Inc Project
Name: Fairfield Township Fire/EMT Station Project Number:
161-305-0040
Project Location: Fairfield Township, Ohio

# Liquid and Plastic Limits Test Report

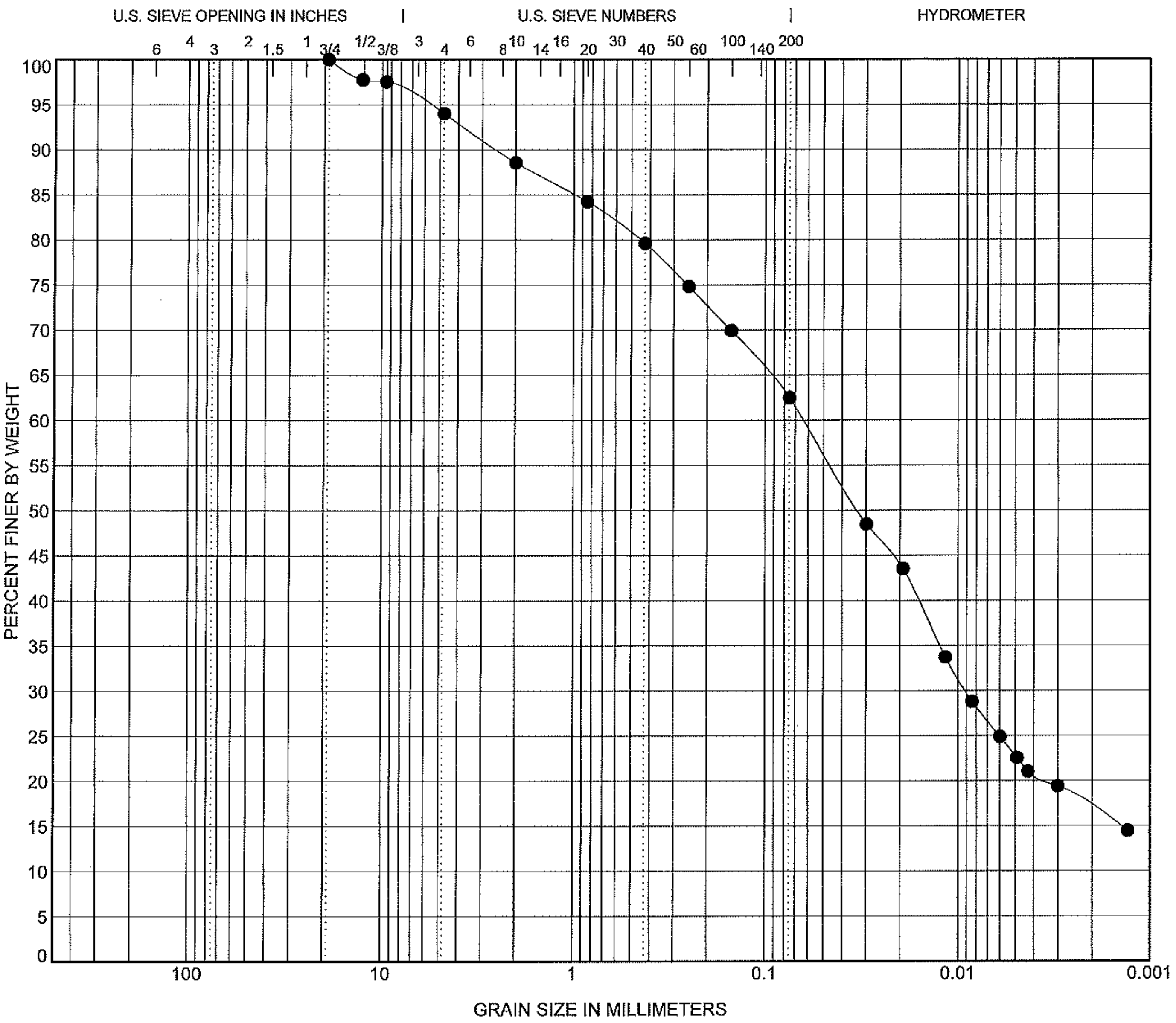


| | Boring | Depth (ft) | LL | PL | PI | Water Content | % < #40 | % < #200 | USCS | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | B-1 | 3.5 | 35 | 20 | 15 | 17.0 | | | | **LEAN CLAY(CL) |
| ⧗ | B-3 | 2.0 | 35 | 21 | 14 | 30.9 | | | | **LEAN CLAY(CL) |
| ▲ | B-6 | 1.0 | 31 | 19 | 12 | 27.0 | 83 | 68 | | SANDY LEAN CLAY(CL) |
| ★ | B-9 | 1.0 | 43 | 26 | 17 | 28.6 | 96 | 91 | | LEAN CLAY(CL) |

**CSI of Cincinnati**
11162 Luschek Drive
Cincinnati, Ohio 45241
Phone: 513.252.2059
Fax: 888.792.3121

PROJECT INFORMATION
Client: Civil and Environmental Consultants, Inc
Project Name: Fairfield Township Fire/EMT Station
Project Number: 161-305-0040
Project Location: Fairfield Township, Ohio

** Visually Classified



| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| | Specimen Identification | Classification | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● | **B-4 ST-1 @ 3' - 4'** | **SANDY SILTY CLAY (CL-ML)** | **23** | **16** | **7** | | |

| | Specimen Identification | D100 | D60 | D30 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● | **B-4 ST-1 @ 3' - 4'** | **19.1** | **0.064** | **0.009** | | **6.0** | **31.5** | **39.7** | **22.8** |

ATC

11121 Canal Road
Cincinnati, OH
Office (513) 771-2112
Fax (513) 782-6908

## GRAIN SIZE DISTRIBUTION

Project: Fairfield Fire / EMT Station

Location:

Number: 241MT00396

US_GRAIN_SIZE S:\MATERIALS TESTING\PROJECTS\CONSULTING SERVICES INCORPORATED (CSI)\241MT00396 FAIRFIELD FIRE - EMT STATION\LAB\SHELBY TUBE B-4 ST-1.GPJ 4/5/18

11121 Canal Road
Cincinnati, OH 45241
513-771-2112
Fax 513-782-6908
www.atcassociates.com

# ASTM D 854 - Specific Gravity by Water Pycnometer Method B

**Project Name:** Fairfield Fire / EMT Station
**Project No:** 241MT00396
**Client Project No.:** CN180029
Mat'l Description:

**Lab No.:** 18-043
Boring & Sample No.: B-4 ST-1 @ 3'
Technician & Date:
Checked by & Date:

| Minimum Sample Sizes based Pycnometer Size | | |
|---|---|---|
| Soil Type | Minimum Dry Mass (g) when using 250 mL pycnometer | Minimum Dry Mass (g) when using 500 mL pycnometer |
| SP, SP-SM | 60 ± 10 | 100 ± 10 |
| SP-SC, SM, SC | 45 ± 10 | 75 ± 10 |
| Silt or Clay | 35 ±5 | 50 ± 10 |

Total Sample Size: 798.62 g air dry

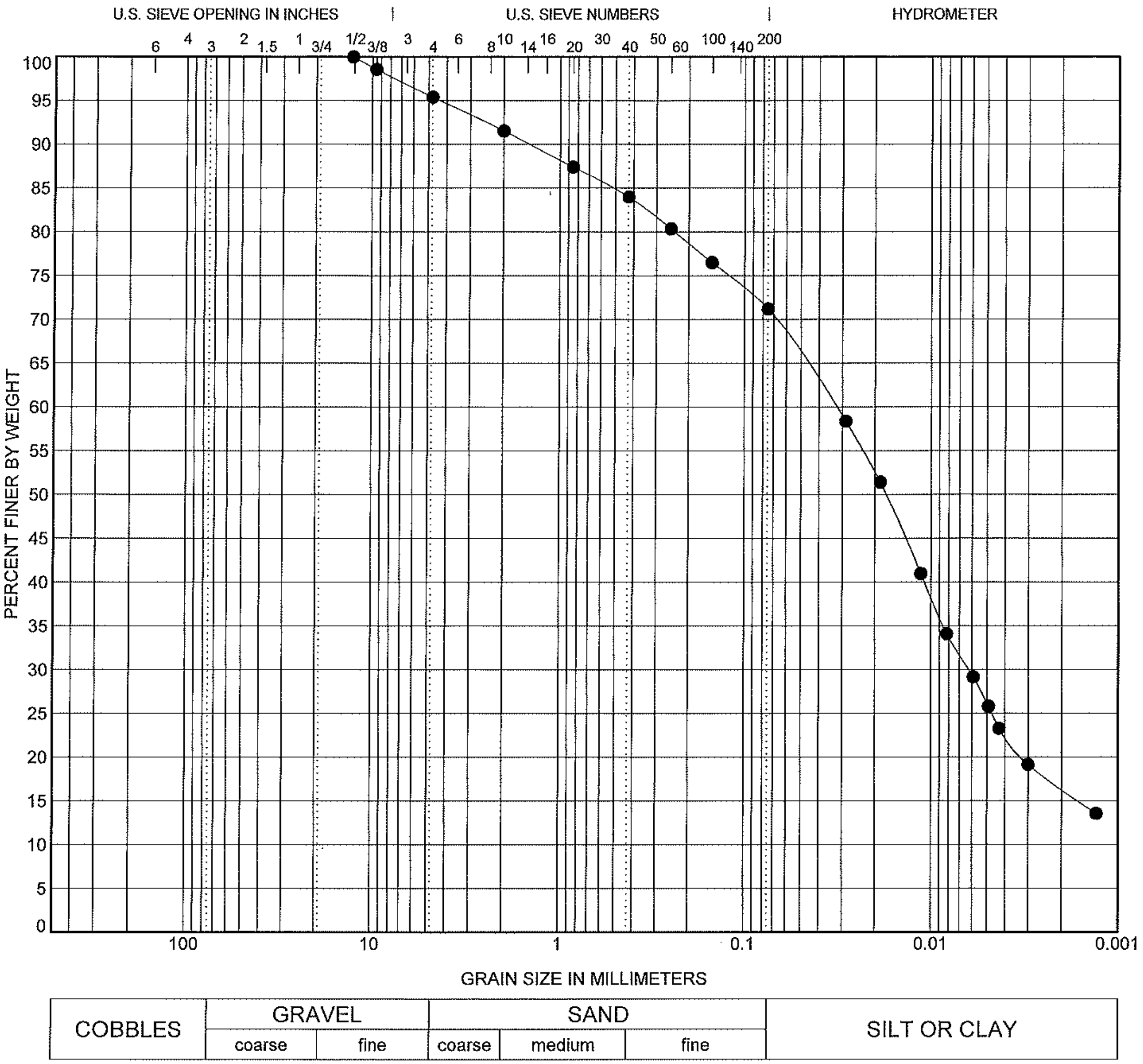
Sieves used: Square □ Round ■

Describe any materials excluded from sieve analysis or test: Test perfomed on material passing the No. 4 sieve.

| Sieve Size (in) | Sieve Size (mm) | Wt. Retained | | % Retained | | % Passing | | Specifications |
|---|---|---|---|---|---|---|---|---|
| | | Wt. | Cumulative | % | Cumulative | % | Cumulative | |
| No. 4 | 4.75 | 47.62 | 47.62 | 0 | 5.96 | | 94.04 | -- |
| PAN | --- | | | | | | | -- |

| | | |
|---|---|---|
| Average calibrated volume of the pycnometer, $V_p$ | mL | 499.40 |
| Average calibrated mass of the dry pycnometer, $M_p$ | grams | 165.40 |
| Test temperature, $T_t$ | °C | 21 |
| Density of water at the test temperature, $\rho_{w,t \text{ from D854 chart}}$ | g/mL | 0.99799 |
| The temperature coefficient, K | | 0.99978 |
| Mass of pycnometer, water, and soil solids at the test temperature, $M_{pws,t}$ | grams | 696.88 |
| Mass of the pycnometer and water at the the test temperature, $M_{pw,t}$ | grams | 663.80 |
| Mass of tare | grams | 376.76 |
| Mass of tare + oven dry soil solids | grams | 428.68 |
| Mass of the oven dry soil solids, $M_s$ | grams | 51.92 |
| Specific Gravity of soil solids at the test temperature, $G_t$ | | 2.756 |
| Specific Gravity of soil solids at 20°C, $G_{20°C}$ | | 2.756 |

| Calibration Data from 7/12/2017 | | | |
|---|---|---|---|
| Pycnometer Number | Cal. Volume (ml) | Cal. Mass (g) | **Pycnometer used for test** |
| 1a | 499.55 | 165.4 | ○ |
| 2a | 499.61 | 163.56 | |
| 2e | 499.44 | 156.14 | |
| 2f | 499.60 | 158.52 | |



| | Specimen Identification | Classification | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● | **B-4 ST-1 @ 4' - 5** | **SILTY CLAY with SAND (CL-ML)** | **23** | **16** | **7** | | |

| | Specimen Identification | D100 | D60 | D30 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● | **B-4 ST-1 @ 4' - 5** | **12.7** | **0.032** | **0.006** | | **4.6** | **24.2** | **45.0** | **26.2** |

ATC

11121 Canal Road
Cincinnati, OH
Office (513) 771-2112
Fax (513) 782-6908

## GRAIN SIZE DISTRIBUTION

Project: Fairfield Fire / EMT Station

Location:

Number: 241MT00396

ATC

11121 Canal Road
Cincinnati, OH 45241
513-771-2112
Fax 513-782-6908
www.atcassociates.com

# Laboratory Thinwall Shelby Tube Log

**Project Name:** Fairfield Fire / EMT Station
**Project No:** 241MT00396
**Client:** CSI
**Location:** Fairfield Township
Elevation:

**Lab No.:** 18-043
Boring & Sample No.: B-4 ST-1 Depth: 3' - 5'
Recovery: 20"
Technician & Date:
Datum:

## Soil Description

**0**

Light Brown and trace Gray
SANDY SILTY CLAY ( CL - ML )

**PPT** 1.00tsf

Classification in this area

**6**

**PPT** **1.25tsf**

**12**

Light Brown and trace Gray
SILTY CLAY with SAND ( CL - ML )

**Uu test from this area**
with Classification

**18**

**PPT** **1.25tsf**

**20**

**24**

## Laboratory

**Unit Weight** **Uu Sample**

Wet Density: 136.5 lbs/ft$^3$
Dry Density: 119.0 lbs/ft$^3$

**Water Content**

| | | | |
|---|---|---|---|
| Tare No: | 1 | | |
| Tare Weight: | 7.53 | g | A |
| Wet + Tare Weight: | 291.45 | g | B |
| Dry + Tare Weight: | 254.98 | g | C |
| Weight of Water: | 36.47 | g | (B-C) |
| Weight of Solids: | 247.45 | g | (C-A) |
| **Moisture Content:** | 14.7% | | (B-C)/(C-A) |

**Unit Weight**

| | | |
|---|---|---|
| Diameter: | 2.842 | in |
| Area: | 6.343 | in$^2$ |
| Height: | 5.534 | in |
| Volume: | 0.0203 | ft$^3$ |
| Weight: | 1257.99 | g |

Diameter Calculations

| | | |
|---|---|---|
| 1 | 2.846 | in |
| 2 | 2.839 | in |
| 3 | 2.842 | in |
| Avergage | 2.842 | in |

Height Calculations

| | | |
|---|---|---|
| 1 | 5.532 | in |
| 2 | 5.536 | in |
| 3 | 5.534 | in |
| Avergage | 5.534 | in |

Area = $\pi \times (D^2/4)$

Volume = Area x Height x 1728

Wet Density = (Weight /453.6)/Volume

Dry Density = Wet Density/(1 + Moisture Content)

*revised 1/8/16 by PJK*

# ASTM D 2850 - UU Triaxial Compressive Strength

11121 Canal Road
Cincinnati, OH 45241
513-771-2112
Fax 513-782-6908
www.atcassociates.com

**Project Name:** Fairfield Fire / EMS Station
**Project No:** 241MT00396
Load Frame ID: COM-1
Scale ID: MISC-7
Dial Gauge ID: DG-9

**Lab No.** 18-043
Boring & Sample No.: B-4 ST-1 @ 4' - 5'
Technician & Date: SWR
Checked by & Date:
Chamber Pressure: **5 psi**

Specimen: Intact ■ Remolded □ Reconstituted □
Mat'l Description: SILTY CLAY with SAND ( CL - ML )
Avg diameter ($D_o$): 2.842 inches
Initial Area ($A_o$): 6.344 square inches
Avg height ($L_o$): 5.534 inches
Height/Dia ratio: 1.947
Volume: 35.11 cubic inches

Liquid Limit: 23
Plastic Limit: 16

MC sample obtained: before shear ■ after shear
MC sample obtained from: trimmings ■ entire specimen
Moisture content tare No.: 1
Moisture content tare weight: 7.53 grams
Moisture content wet weight: 291.45 grams
Moisture content dry weight: 254.98 grams
Initial Moisture Content: 14.7%

Initial mass (wet): 1257.99 grams
Initial Wet Density: 136.5 pounds per cubic foot

Target strain rate ( 1% per minute): 0.055 (in/min) (used for preparing load frame)
Maximum strain (15% strain typical): 0.830 inches (used to determine maximum test strain)

**Laboratory Test Data** (Shaft Friction = ___lbs. subtract off of Axial load readings before recording data)

| Elapsed time (min) | Axial load (pounds) | Dial guage (inches) | Unit Strain (inches) | corrected area (square inches) | Deviator Stress (psi) |
|---|---|---|---|---|---|
| 0.00 | 0 | 0.010 | 0.000 | 6.344 | 0 |
| 0.50 | 14 | 0.038 | 0.005 | 6.376 | 2 |
| 1.00 | 24 | 0.068 | 0.005 | 6.378 | 4 |
| 1.50 | 34 | 0.095 | 0.005 | 6.375 | 5 |
| 2.00 | 42 | 0.123 | 0.005 | 6.376 | 7 |
| 2.50 | 51 | 0.152 | 0.005 | 6.377 | 8 |
| 3.00 | 58 | 0.180 | 0.005 | 6.376 | 9 |
| 3.50 | 65 | 0.208 | 0.005 | 6.376 | 10 |
| 4.00 | 73 | 0.237 | 0.005 | 6.377 | 11 |
| 4.50 | 79 | 0.266 | 0.005 | 6.377 | 12 |
| 5.00 | 86 | 0.295 | 0.005 | 6.377 | 13 |
| 6.00 | 98 | 0.352 | 0.010 | 6.410 | 15 |
| 7.00 | 107 | 0.410 | 0.010 | 6.411 | 17 |
| 8.00 | 117 | 0.470 | 0.011 | 6.413 | 18 |
| 8.50 | 122 | 0.493 | 0.004 | 6.370 | 19 |
| 9.00 | 125 | 0.523 | 0.005 | 6.378 | 20 |
| 9.50 | 129 | 0.551 | 0.005 | 6.376 | 20 |
| 10.00 | 133 | 0.581 | 0.005 | 6.378 | 21 |
| 10.50 | 136 | 0.610 | 0.005 | 6.377 | 21 |
| 11.00 | 140 | 0.638 | 0.005 | 6.376 | 22 |
| 11.50 | 143 | 0.667 | 0.005 | 6.377 | 22 |
| 12.00 | 145 | 0.696 | 0.005 | 6.377 | 23 |
| 12.50 | 148 | 0.724 | 0.005 | 6.376 | 23 |
| 13.00 | 151 | 0.752 | 0.005 | 6.376 | 24 |
| 13.50 | 153 | 0.782 | 0.005 | 6.378 | 24 |
| 14.00 | 156 | 0.810 | 0.005 | 6.376 | 24 |
| 14.50 | 158 | 0.838 | 0.005 | 6.376 | 25 |
| 15.00 | 160 | 0.868 | 0.005 | 6.378 | 25 |
| 15.50 | 162 | 0.896 | 0.005 | 6.376 | 25 |
| 16.00 | 164 | 0.924 | 0.005 | 6.376 | 26 |
| 16.50 | 166 | 0.952 | 0.005 | 6.376 | 26 |
| 17.00 | 168 | 0.980 | 0.005 | 6.376 | 26 |
| 17.50 | 170 | 1.008 | 0.005 | 6.376 | 27 |
| 18.00 | 171 | 1.036 | 0.005 | 6.376 | 27 |
|  |  |  |  |  |  |

Average strain rate during test: 0.057 (in/min)
Percent strain at failure: 18.5%
Final Moisture Content: **14.7 %**

Minor Principal total stress, $\sigma_3$: 5 psi
Major Principal total stress, $\sigma_1$: 32 psi
Unconfined Compressive Strength: **27 psi**

*revised 1/7/12 by PJK*

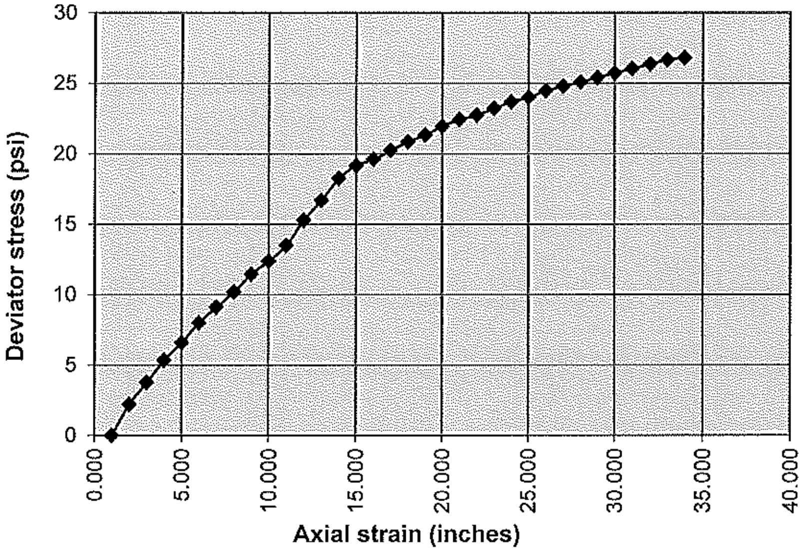
*Attach a photo or sketch of the specimen after failure to this form*

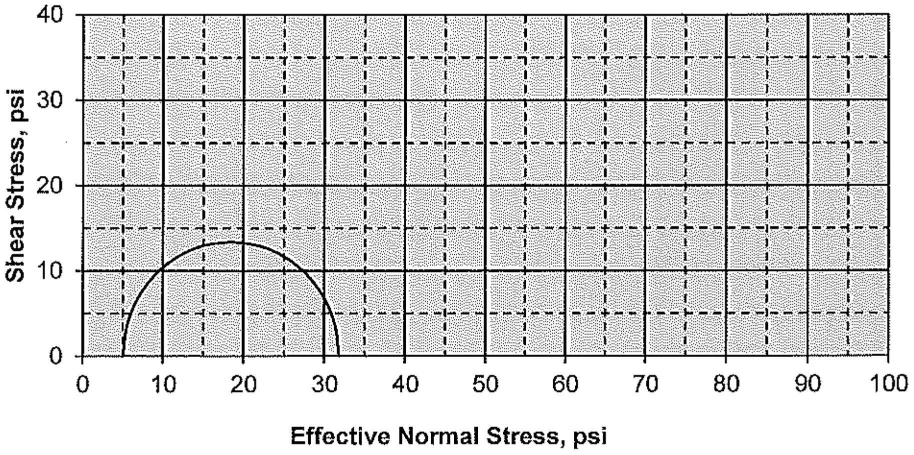
11121 Canal Road
Cincinnati, OH 45241
513-771-2112
Fax 513-782-6908
www.atcassociates.com

# ASTM D 2850 - UU Triaxial Compressive Strength

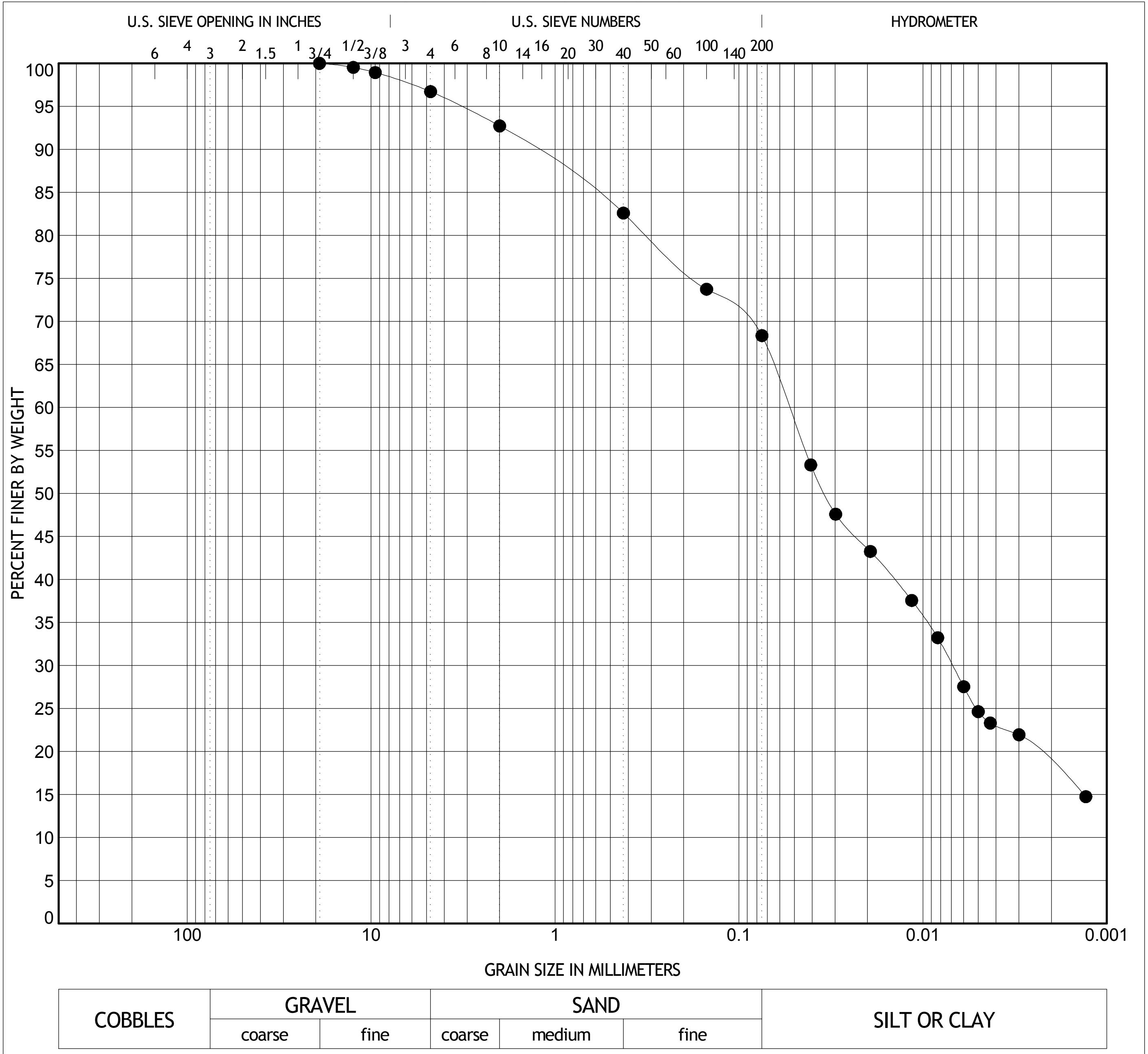
**Project Name:** Fairfield Fire / EMS Station
**Project No:** 241MT00396
**Client Project No.:** CN180029
Confining Pressure: 5 psi
Moisture Content: 14.7%
Dry Unit Weight: 119.0
Sample Description: SILTY CLAY with SAND ( CL - ML )

**Lab No.** 18-043
Technician & Date: SWR
Checked by & Date:
Sample: B-4 ST-1 @ 4' - 5'
Percent strain at failure : 18.5%
Unconfined Compressive Strength : 27 psi





# GRAIN SIZE DISTRIBUTION



| | Boring | Depth (ft) | Classification | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **B-6** | **1.0** | **SANDY LEAN CLAY(CL)** | **31** | **19** | **12** | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

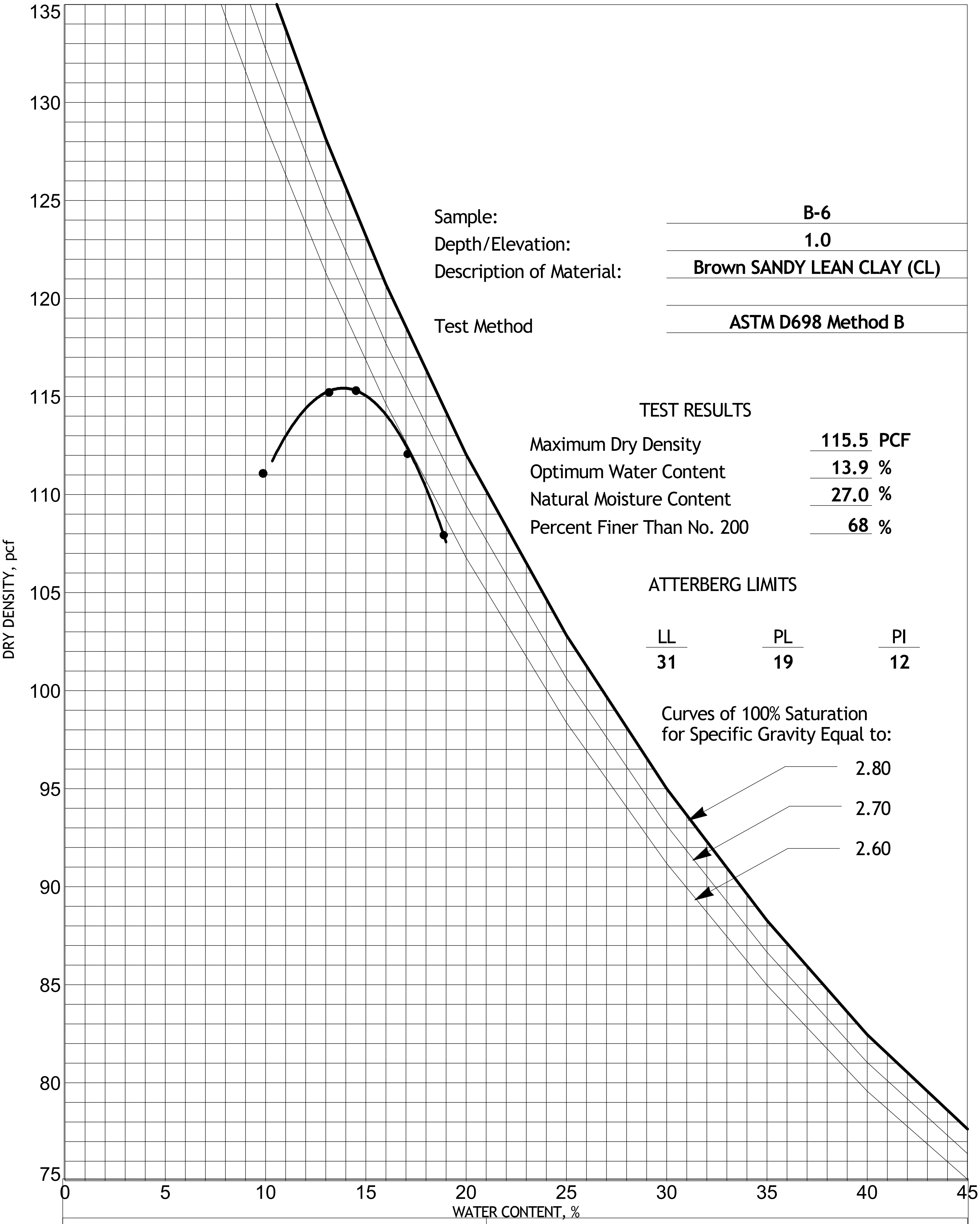
| | Boring | Depth (ft) | D95 | D60 | D50 | D30 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | **B-6** | **1.0** | **3.275** | **0.053** | **0.034** | **0.007** | | **3.3** | **28.4** | **43.7** | **24.6** |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

**CSI of Cincinnati**
11162 Luschek Drive
Cincinnati, Ohio 45241
Phone: 513.252.2059
Fax: 888.792.3121

## PROJECT INFORMATION

Client: Civil and Environmental Consultants, Inc
Project Name: Fairfield Township Fire/EMT Station
Project Number: 161-305-0040
Project Location: Fairfield Township, Ohio

# MOISTURE-DENSITY RELATIONSHIP



Sample: B-6
Depth/Elevation: 1.0
Description of Material: Brown SANDY LEAN CLAY (CL)

Test Method ASTM D698 Method B

TEST RESULTS

| | | |
|---|---|---|
| Maximum Dry Density | 115.5 | PCF |
| Optimum Water Content | 13.9 | % |
| Natural Moisture Content | 27.0 | % |
| Percent Finer Than No. 200 | 68 | % |

ATTERBERG LIMITS

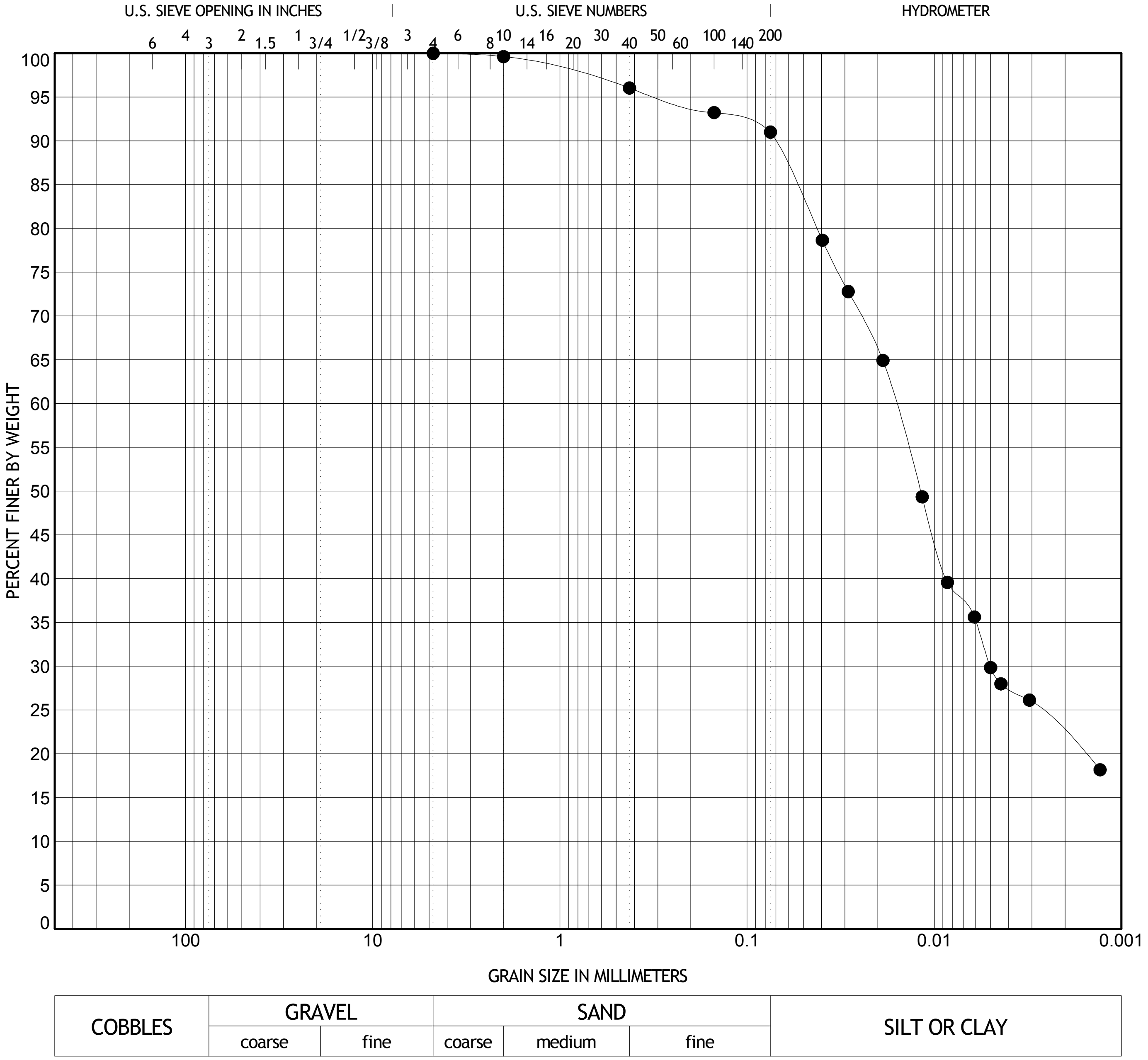
| LL | PL | PI |
|---|---|---|
| 31 | 19 | 12 |

**CSI of Cincinnati**
11162 Luschek Drive
Cincinnati, Ohio 45241
Phone: 513.252.2059
Fax: 888.792.3121

PROJECT INFORMATION

Client: Civil and Environmental Consultants, Inc
Project Name: Fairfield Township Fire/EMT Station
Project Number: 161-305-0040
Project Location: Fairfield Township, Ohio

# GRAIN SIZE DISTRIBUTION



| | Boring | Depth (ft) | Classification | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **B-9** | **1.0** | **LEAN CLAY(CL)** | **43** | **26** | **17** | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

| | Boring | Depth (ft) | D95 | D60 | D50 | D30 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | **B-9** | **1.0** | **0.289** | **0.016** | **0.012** | **0.005** | | **0.0** | **9.0** | **61.2** | **29.8** |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

**CSI of Cincinnati**
11162 Luschek Drive
Cincinnati, Ohio 45241
Phone: 513.252.2059
Fax: 888.792.3121

PROJECT INFORMATION

Client: Civil and Environmental Consultants, Inc
Project Name: Fairfield Township Fire/EMT Station
Project Number: 161-305-0040
Project Location: Fairfield Township, Ohio