Geotechnical Engineering Report

Proposed Oxford Elementary/High School Additions
Oxford, Kansas
April 9, 2019
Terracon Project No. 01195000

Prepared for:
USD No. 358
Oxford, Kansas

Prepared by:
Terracon Consultants, Inc.
Wichita, KS

April 9, 2019

Terracon GeoReport

USD No. 358
315 W. College Street
Oxford, Kansas 67119

Attn: Mr. Greg Mugler
P: (620) 455-2410
cc: E: chris@haarchitects.com

Re: Geotechnical Engineering Report
Proposed Oxford Elementary/High School Additions
USD 358 Campus
Oxford, Kansas
Terracon Project No. 01195000

Dear Mr. Mugler:

We have completed the Geotechnical Engineering exploration and report for the above referenced project. This study was performed in general accordance with Terracon Proposal No. P01195000 dated February 4, 2019. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and floor slabs for the proposed project.

We appreciate the opportunity to be of service to you on this project, and we are prepared to provide the construction observation and materials testing services recommended in this report (please contact the CMT manager in our office, Mr. Kurt Heimerman, kurt.heimerman@terracon.com). If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

JOHN KENNETH HEINZ LICENSED 12071 PROFESSIONAL ENGINEER 4/9/19

John K. Heinz, P.E.
Senior Project Manager

George A. Tannoury, P.E.
Principal/Geotechnical Dept. Manager

REPORT TOPICS

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

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

Geotechnical Engineering Report
Proposed Oxford Elementary/High School Additions
USD 358 Campus
Oxford, Kansas
Terracon Project No. 01195000
April 9, 2019

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed Oxford Elementary/High School additions to be located at USD 358 Campus in Oxford, Kansas. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Site preparation and earthwork
- Foundation design and construction
- Floor slab design and construction
- Lateral earth pressures
- Exterior slab subgrade preparation

The geotechnical engineering Scope of Services for this project included the advancement of four test borings to depths ranging from approximately 10 to 15 feet below existing site grades.

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

SITE CONDITIONS

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

Item	Description
Parcel Information	The project is located at the USD 358 Campus in Oxford, Kansas.
Existing Improvements	Additions connect to slab-on-grade single story structures
Current Ground Cover	Surfaced with asphalt/concrete or grass covered
Existing Topography	Relatively level

PROJECT DESCRIPTION

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

Item	Description
Information Provided	Provided via email from Mr. Chris Hanney with Hanney & Associates
Project Information	The project will include the following: ■ Elementary School addition: A single-story, slab-on-grade (non-basement) building addition. The approximately 5,000 ft^2 building addition will have maximum plan dimensions of about 75 feet by 75 feet. ■ High School addition: A single-story, slab-on-grade (non-basement) building addition. The approximately 5,000 ft^2 building addition will have maximum plan dimensions of about 40 feet by 120 feet.
Building Construction	Steel-frame construction with brick veneer
Finished Floor Elevation	Match existing floor slabs, approximately elevation 1,201.7 feet and 1,199 feet at the High School and Elementary School, respectively
Maximum Loads (estimated by Terracon)	■ Columns: 50 kips ■ Walls: 4 kips per linear foot (klf) ■ Slabs: 150 pounds per square foot (psf)
Grading/Slopes	We anticipate that cuts/fills of about 2 feet will be required to achieve final grades.
Retaining Walls	Up to about 3 feet of grade separation between the north side of the Elementary School addition and surrounding grade.
Pavements	Not anticipated

GEOTECHNICAL CHARACTERIZATION

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of site preparation and foundation options. Conditions encountered at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the GeoModel can be found in the **Figures** section of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	**Existing Fill**	lean clay, lean to fat clay
2	**Lean to Fat Clay**	medium stiff to stiff
3	**Lean Clay**	medium stiff to stiff
4	**Lean Clay with sand**	stiff

Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater was not observed in our borings while drilling, or for the short duration the borings could remain open. However, this does not necessarily mean the borings terminated above groundwater. Due to the low permeability of the soils encountered in the borings, a relatively long period may be necessary for a groundwater level to develop and stabilize in a borehole. Long term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be different than the levels indicated on the boring logs. Also, it is possible that groundwater could temporarily perch seasonally at shallow depths. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

GEOTECHNICAL OVERVIEW

Based on the information obtained from our subsurface exploration, it is our opinion that the sites can be developed for the proposed project. The **Earthwork** section addresses site preparation and compaction. The **Shallow Foundations** section addresses support of the building additions bearing on engineered fill or native stiff clays. The **Floor Slabs** section addresses slab-on-grade support of the building additions. The **Lateral Earth Pressures** addresses grade separation between inside and outside grades. The **Exterior Slab Subgrade Preparation** section addresses subgrade preparation adjacent to the additions. The **General Comments** section provides an understanding of the report limitations.

Existing fill materials were found to depths of about 1½ to 4 feet BGS at our boring locations. Fill should be expected to occur (possibly to a greater depth) in other areas across the sites. We are not aware that the existing fill has been placed with moisture and density control. Foundations and floor slabs supported on or above existing uncontrolled fill material that has not been uniformly placed and compacted with strict moisture and density control may not perform predictably. We consider the existing fill in its current condition to be unsuitable to support the proposed building additions. The depth and composition of the existing fill materials can vary greatly over relatively small lateral and vertical distances. Because of this variability, it may not be possible (until site grading is underway) to accurately predict the amount of fill that will need to be removed and replaced to develop suitable support for the proposed improvements. Caution should be exercised when using the depth and composition of the fill observed at the discrete boring locations, for estimating purposes.

The fill observed in our borings generally appears suitable for re-use as new controlled fill below the recommended Low Volume Change (LVC) zone, provided it is properly moisture conditioned and compacted. However, the fill could contain unobserved materials that would render it unsuitable for re-use as new controlled fill. We encourage the owner to secure a base bid for removing and replacing a specified quantity of the existing fill. The owner should also secure unit rates for adding or deducting quantities from the base bid that include costs for exporting unsuitable materials and importing approved replacement materials, if required.

Moderately expansive soils are present on this site. This report provides recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and cracking in the structures should be anticipated. The severity of cracking and other damage such as uneven floor slabs will probably increase if any modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. Some of these options could include increasing the thickness of the recommended low volume change zone and/or constructing structural slabs. We would be pleased to discuss other construction alternatives with you upon request.

The owner or contractor could consider a contingency budget to provide for additional earthwork items such as moisture conditioning dry subgrade soils, repairing soft subgrade soils, and removing unsuitable foundation bearing soils.

EARTHWORK

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

Site Preparation

We recommend removing all asphalt/concrete from building addition areas. Also, we recommend removing any vegetation/root mat, topsoil, and all existing fill from building addition areas. We also recommend removing from within and at least 5 feet beyond the building addition areas presently proposed for construction. After completing these operations and any cuts needed to allow for the moisture conditioned zone (if needed), we recommend the exposed subgrade be thoroughly proofrolled (under the observation of Terracon personnel) with a loaded tandem-axle dump truck or other heavy, rubber-tired construction equipment weighing at least 20 tons, to locate any zones that are soft or unstable. The subgrade in the building addition areas where excessive rutting or pumping occurs during proofrolling should be removed and replaced or aerated/reworked and recompacted in place to our recommendations for engineered fill (see below for details) prior to placement of areal fill.

Fill Material Types

Engineered fill should meet the following material property requirements:

Soil Type [1]	USCS Classification	Acceptable Parameters (for Structural Fill)
Lean Clay [2]	CL [3] (LL<46 & PI>15)	> 18 inches below building additions finished subgrade
Lean to Fat Clay [2]	CL/CH [3] (46≤LL<50)	> 18 inches below building additions finished subgrade
Fat Clay [2]	CH (LL≥50)	> 18 inches below building additions finished subgrade
Well-graded granular and silty gravel	GM-GW GM [4]	All locations and elevations
Low Volume Change Material (LVC) [5]	CL or GM-GW, GM [4] and (LL<40 & 5≤PI<15)	All locations and elevations
On-Site Soils	Varies	The on-site soils, free of organic matter and debris, typically appear suitable for reuse as engineered fill. However, these soils do not meet the low volume change zone criteria and these soils should not be utilized within 18 inches of finished subgrade beneath the proposed building additions.

Continued:

1. Controlled, compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation.
2. Delineation of fat clays and lean clays should be performed in the field by a qualified geotechnical engineer or their representative and could require additional laboratory testing.
3. By our definition, cohesive soils with a liquid limit of 46 to 49 are classified as lean to fat clay (with the borderline symbol CL/CH) to alert of the expansive potential of clay soils with liquid limits close to 50 (see ASTM D2487-11, Section 1.1, Note 1).
4. Similar to KDOT AB-3 crushed limestone aggregate, limestone screenings, or granular material such as sand, gravel or crushed stone containing at least 15% low plasticity fines (-#200).
5. Low volume change cohesive soil or granular soil having at least 15% low plasticity fines (-#200).

Fill Compaction Requirements

Structural fill should meet the following compaction requirements.

Item	Structural Fill
Lift Thickness	9-inches or less in loose thickness when heavy, self-propelled compaction equipment is used or 4 to 6 inches in loose thickness when hand-guided equipment (jumping jack or plate compactor) is use
Compaction Requirements [1]	At least 95%, but not more than 100%, of the material's maximum standard Proctor dry density (ASTM D698).
Moisture Content Cohesive Soils with PI of 35 and higher	At least 3 percentage points above the optimum moisture content value as determined by the standard Proctor test at the time of placement and compaction
Moisture Content Cohesive Soils with PI of 25 to 34	At least 2 percentage points above the optimum moisture content value as determined by the standard Proctor test at the time of placement and compaction
Moisture Content Cohesive Soils with PI of 18 to 24	Above the optimum moisture content value as determined by the standard Proctor test at the time of placement and compaction
Moisture Content Cohesive Soils with PI less than 18	No drier than 2 percentage points below the optimum moisture content value as determined by the standard Proctor test at the time of placement and compaction
Moisture Content Granular Material [2]	Workable moisture levels

1. We recommend the moisture content and compaction be determined for each lift of engineered fill during placement. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved. The zone of fill compacted to meet these criteria should extend at least 5 feet and 2 feet horizontally beyond the building addition footprints and exterior slab areas, respectively.
2. Specifically, moisture levels should be maintained low enough to allow for satisfactory compaction to be achieved without the cohesionless fill material pumping.

Utility Trench Backfill

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

Grading and Drainage

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

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

Earthwork Construction Considerations

It is anticipated that excavations for the proposed construction can be accomplished with conventional earthmoving equipment. These soils could become unstable with typical earthwork and construction traffic, especially after precipitation events. Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content prior to construction of floor slabs. Construction traffic over the completed subgrade should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrade or in excavations. If the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed, or these materials should be scarified, moisture conditioned, and recompacted prior to floor slab and pavement construction and observed by Terracon.

Surface water should not be allowed to pond on the site and soak into the soil during construction. Construction staging should provide drainage of surface water and precipitation away from the building addition areas. Any water that collects over or adjacent to construction areas should be promptly removed, along with any softened or disturbed soils. Surface water control in the form of sloping surfaces, drainage ditches and trenches, and sump pits and pumps will be important to avoid ponding and associated delays due to precipitation and seepage.

Based on our understanding of the proposed building additions, we do not expect groundwater to adversely affect construction. If groundwater is encountered during construction, some form of temporary or permanent dewatering may be required. Conventional dewatering methods, such as pumping from sumps, should likely be adequate for temporary removal of any groundwater encountered during excavation at the site.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, “Excavations” and its appendices, and in accordance with any applicable local, state, and federal safety regulations. The contractor should be aware that slope height, slope inclination, and excavation depth should in no instance exceed those specified by these safety regulations. Flatter slopes than those dictated by these regulations may be required depending upon the soil conditions encountered and other external factors. These regulations are strictly enforced and if they are not followed, the owner, contractor, and/or earthwork and utility subcontractor could be liable and subject to substantial penalties.

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

Fill Construction Observation and Testing

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

The exposed subgrade and each lift of compacted fill should be tested, evaluated, and reworked, as necessary, until approved by the geotechnical engineer’s representative prior to placement of additional lifts. We recommend that each lift of fill be tested for density and moisture content at a frequency of at least one test for every 1,000 square feet of compacted fill in the structure areas. We recommend at least one density and moisture content test for every 50 linear feet of compacted utility trench backfill.

SHALLOW FOUNDATIONS

In our opinion, the proposed building additions can be supported by a shallow, spread footing foundation system bearing on newly constructed compacted structural fill prepared in accordance with the requirements noted in the **Earthwork** section of this report or suitable native materials consisting of medium stiff to stiff clays. Design recommendations for shallow foundations are presented in the following paragraphs.

Design Recommendations and Parameters

Item	Column	Continuous
Net Allowable Bearing pressure [1] on newly constructed compacted structural fill [2] and/or suitable native soils consisting of medium stiff to stiff clays	2,000 psf	2,000 psf
Minimum footing width	30 inches	12 inches (trenched) 16 inches (formed)
Minimum embedment below finished grade for frost protection [3]	42 inches	42 inches
Estimated Total Settlement [4]	<1 inch	<1 inch
Estimated Differential Settlement [4]	<¾ inch between columns	<¾ inch over 40 feet

1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. Assumes any unsuitable fill or soft soils, if encountered, will be undercut and replaced with engineered fill.
2. All new engineered fill beneath footings should be constructed as recommended in **Fill Compaction Requirements** of the **Earthwork** section of this report.
3. And to reduce the effects of seasonal moisture variations in the subgrade soils. For perimeter footings and footings beneath unheated areas.
4. The foundation settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footings, the thickness of compacted fill, and the quality of the earthwork operations. The above settlement estimates have assumed that the maximum loads stated previously in the **Project Description** section of this report will not be exceeded

Foundation Construction Considerations

The footing excavations should be evaluated under the direction of the Terracon Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Should the soils at bearing level become excessively dry, disturbed or saturated, or frozen, the affected soil should be removed prior to placing concrete. Consider placing a lean concrete mud-mat over the bearing soils if the excavations must remain open over night or for an extended time.

Regarding construction of footings, we generally anticipate that material suitable for support of the design bearing pressure will be present at the base of the footings. However, there is a possibility that isolated zones of soft, low density fill or native soils could be encountered below footing bearing level, even though field density tests are expected to be performed during fill placement operations. Therefore, we recommend that the geotechnical engineer be retained to observe, test, and evaluate the soil foundation bearing prior to placing reinforcing steel and concrete to determine if additional footing excavation depth is needed.

If unsuitable bearing soils are encountered in footing excavations, the excavations should be extended deeper to suitable soils and the footings could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. As an alternative an overexcavation and backfill procedure could be utilized wherein the foundation could bear on properly compacted backfill extending down to suitable soils. The overexcavation for compacted backfill placement should extend laterally beyond the edges of the footing in all directions at least 8 inches per foot of overexcavation depth below design bearing level. The overexcavation should then be backfilled up to the footing base elevation with approved well-graded granular material constructed as described in section **Compaction Requirements** of the **Earthwork** section of this report.

Care should be taken during construction not to disturb the soils beneath the existing foundations. Some overlap of stresses between the new and existing footings will occur if the two foundation systems abut each other possibly causing some movement of the existing footings and supported structures. To reduce this overlap of stresses between the new and existing footings we recommend maintaining a clear distance between the edge of the new and existing footings at least equal to one-half the width of the new footings. Connections between the new and existing structures should accommodate some movement between the additions and adjoining existing buildings.

FLOOR SLABS

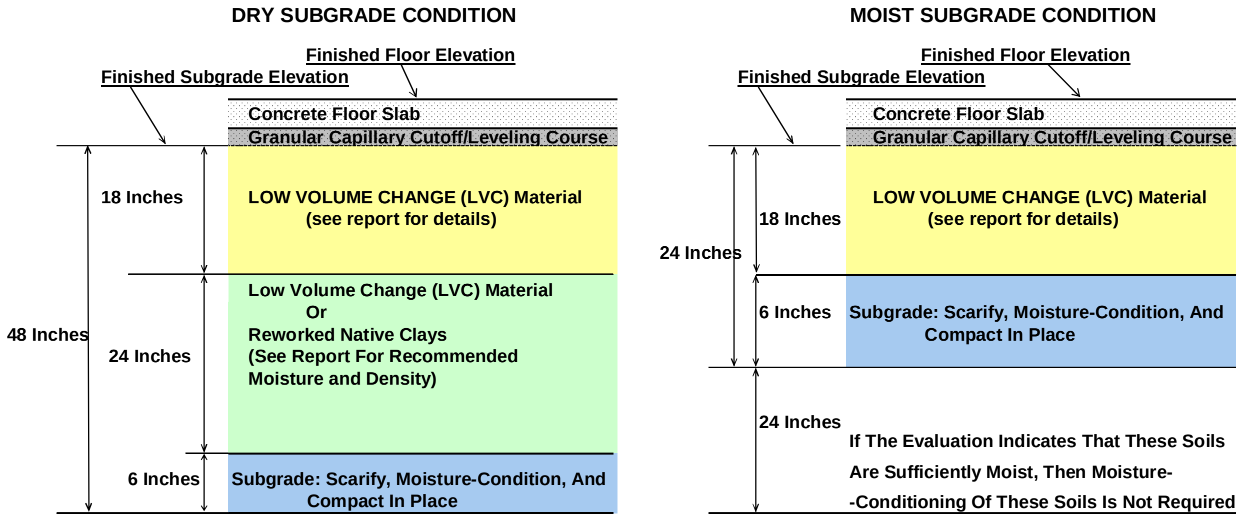
Building Pad Subgrade Preparation

In addition to providing a subgrade suitable from a strength perspective as addressed in the **Earthwork** section of this report, a factor affecting floor slab performance is the potential for the subgrade soils to shrink/swell due to variations in moisture content. Typically, some increase in the floor slab subgrade moisture content will occur because of gradual accumulation of capillary moisture, which would otherwise evaporate if the floor slab had not been constructed. A soil's swell potential is dependent primarily on its plasticity, and moisture content. The confining pressure provided by the weight of the floor slab and the overburden pressure (including the fill required to develop design grade) also effect swell potential. Subgrade soils with higher plasticity and lower moisture content and confining pressure, generally have greater swell potential.

The near-surface soils encountered in our borings have high plasticity and were generally in a relatively moist condition at the time of our subsurface exploration. Based on a method of analyses that uses Atterberg limits values, total unit weight, and our experience with similar soils, we estimated a potential vertical rise (PVR) greater than 1 inch for these soils. In our opinion, this amount of potential vertical rise could cause excessive heave of floor slabs. This potential to swell could increase if further drying occurs prior to, or during, construction. To reduce the swell potential to a relatively small amount, less than about 1 inch, we recommend that at least the upper 18 inches of subgrade soils below the floor slabs be low volume change (LVC) material that we describe in detail in **Fill Material Types** of the **Earthwork** section of this report.

Because we expect that the high plasticity clay materials could have greater swell potential if they are drier at the start of construction than they were at the time the borings were performed, constructing an 18-inch thick LVC zone may not be adequate to limit floor slab heave to a small amount. Therefore, we recommend that Terracon evaluate the material within at least 30 inches of the bottom of the LVC zone just prior to placement of any additional fill (see Building Subgrade Preparation Diagram below). Where the existing materials within this depth range at the start of construction are drier than the minimum moisture requirements stated in **Fill Compaction Requirements** of the **Earthwork** section of this report, we recommend corrective procedures be implemented. These procedures would include over-excavating if dry soils are present and either uniformly increasing their moisture content to the minimum moisture contents stated in **Fill Compaction Requirements** of the **Earthwork** section of this report and reworking/recompacting the soil in lifts or replacing them with LVC material. If LVC material is used to replace the dried soils, it should be placed at the moisture content values described in **Fill Compaction Requirements** of the **Earthwork** section of this report.

BUILDING SUBGRADE PREPARATION DIAGRAM (NOT TO SCALE)



Note: Presently the near surface soils are typically relatively moist. Also, remove and replace unsuitable materials including uncontrolled existing fill that may extend to greater depths than shown in the above diagrams.

Prior to placing additional areal fill where moisture conditioning (as described above) is not needed, we recommend the upper 6 inches of exposed subgrade be scarified and recompacted to the compaction requirements and at the moisture contents stated in **Fill Compaction Requirements** in the **Earthwork** section of this report.

Low Volume Change Zone

As stated previously, we recommend the upper 18 inches of material directly below the floor slabs be LVC material. This is primarily to help protect the newly placed fill from moisture fluctuations during construction and provide a layer of soil that will not experience significant volume change as the moisture content fluctuates.

By our definition, LVC materials have a liquid limit (LL) less than 40 and a plasticity index (PI) of at least 5, but less than 15. LVC materials that meet this requirement may include granular soils (such as limestone/concrete screenings or clayey sand) or possibly silty, sandy or lean clays, although laboratory testing of prospective LVC materials proposed for use by the contractor should be conducted to confirm their suitability prior to bidding/construction. Cohesive LVC soils may need extensive "wetting maintenance" by the contractor to maintain the required above optimum moisture content in the cohesive LVC material until construction of the floors. Based on the soils encountered in the borings, the near-surface fat clays do not meet the criteria for LVC material.

If cohesive material meeting the above criteria cannot be readily obtained, an LVC soil may be developed with the clay overburden soils by modifying them with hydrated lime, Class C fly ash, cement, or possibly Cement Kiln Dust (CKD) although using the dry agents may result in objectionable dusting problems. A lime slurry or cement slurry application (or the use of granular LVC materials) would reduce the dusting problems. It has been our experience that some CKD products have excessively high sulfate contents that would react adversely when mixed with soils, causing undesirable swell and heave. When CKD is considered, we recommend that a recent chemical laboratory analysis is submitted to us for review prior to approval of the CKD product.

For clay materials, it has been our experience that hydrated lime contents of 4% to 6%, cement contents of 5% to 6%, CKD contents of 6% to 8%, or Class C fly ash contents of 14% to 16, based on the dry weight of the soil, would typically be required to appreciably reduce the shrink/swell characteristics of clayey soils not meeting the previously described plasticity requirements for LVC materials. A more precise application rate should be developed based on additional laboratory testing. Recognized guidelines such as those specified by KDOT or City of Wichita (including minimum mixing temperatures) should be followed during the mixing and construction of the fly ash- or lime-modified subgrade. A lime/cement slurry application or the use of a granular LVC material may reduce the dusting problems that could occur with subgrade modification using dry products. The modified zone should extend at least 3 feet beyond the edges of the proposed building additions. Soils mixed with Class C fly ash should be compacted within 2 hours following blending operations.

The LVC soils should be placed in lifts not exceeding 9 inches in loose thickness and compacted to at least 95%, but not more than 100%, of maximum dry density. Cohesive soils should be placed and maintained at moisture contents not less than 2 percentage points below their optimum moisture content. Granular soils should be placed at workable moisture content. If lime- or fly ash-modified soils are used, they should be placed and maintained at moisture contents above their optimum moisture content.

Cohesive LVC materials can be swell susceptible if allowed to dry before constructing the floor slab; therefore, it is important that the recommended moisture content of the cohesive LVC material be maintained. As a check, we recommend the subgrade moisture content be evaluated about 3 to 4 days before placing concrete. If drying of the subgrade materials has occurred at this time, measures should be taken to increase the moisture content of the subgrade soils before placing the sand leveling course or concrete, which may also include recompaction. If the subgrade was modified with fly ash and recompaction is required, additional fly ash would be needed.

We suggest constructing the upper 4 to 6 inches of the LVC zone using crushed limestone silty gravel similar to KDOT AB-3-Type material to reduce the above stated swell potential associated with cohesive LVC materials or on-site soils that are allowed to dry excessively. This granular zone would reduce the moisture fluctuations in the bottom portion of the LVC zone and, also provide a more stable working surface during construction following inclement weather.

Floor Slab Construction Considerations

We recommend that all HVAC supply/return ducts be above floor level as air-flow and heat transfer through these ducts can cause substantial post-construction drying and shrinkage of clay subgrade and result in severe floor slab/interior wall distress.

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

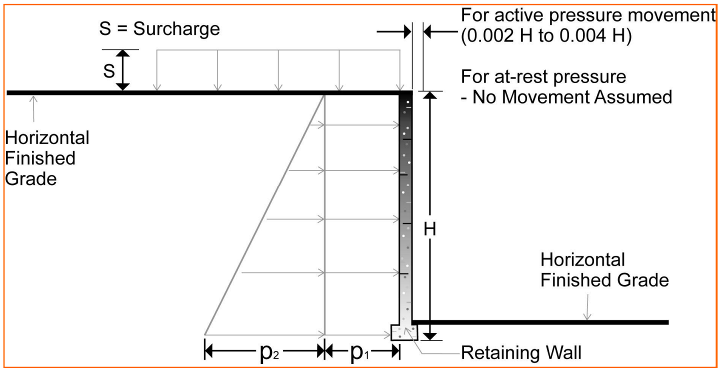
Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks beyond the length of the structural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

LATERAL EARTH PRESSURES

During construction, the sides of excavations should be sloped or braced for stability to comply with OSHA criteria. You should expect unbalanced lateral pressures to develop against walls with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to those indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained.

Design Parameters

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



Lateral Earth Pressure Design Parameters				
Earth Pressure Condition [1]	Coefficient for Backfill Type[2]	Surcharge Pressure, [3, 4, 5] p_1 (psf)	Effective Fluid Pressures, p_2 (psf) [2, 4, 5]	
			Unsaturated [6]	Submerged [6]
Active (Ka)	Granular - 0.33 Clay - 0.45	(0.33)S (0.45)S	(40)H (55)H	(85)H (90)H
At-Rest (Ko)	Granular - 0.45 Clay - 0.63	(0.45)S (0.63)S	(55)H (75)H	(90)H (100)H
Passive (Kp)	Granular - 3.0 Clay - 2.2	--- ---	(360)H (264)H	(235)H (190)H

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

Backfill placed against structures should consist of granular soils or low plasticity cohesive soils. For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively. To calculate the resistance to sliding, a value of 0.30 should be used as the ultimate coefficient of friction where the footing bears on suitable soil.

If continuous or isolated loads are imposed beyond the zone that extends up from the bottom of the wall at an angle no steeper than 1H:1V, the effect of the vertical loads on the wall would be negligible. Compaction of each lift of fill adjacent to walls should be accomplished with hand-operated tampers or other lightweight compactors. Over-compaction may cause excessive lateral earth pressures that could result in wall movement. Final exterior grades should be sloped to provide positive drainage away from foundations.

Subsurface Drainage for Below-Grade Walls

To reduce the potential for hydrostatic pressure behind walls, we recommend that drainage be provided. Although it appears that the groundwater table will be below wall foundation bearing level, groundwater level fluctuations and perched water conditions could develop seasonally at shallow depths after prolonged periods of rainfall, possibly resulting in hydrostatic loading on the walls. To prevent hydrostatic loading on walls with unbalanced backfill levels on opposite sides, we recommend constructing drain lines at the base of the wall or weep holes be installed along the base of the wall with a collection pipe leading to the weep holes. We recommend the drain lines be perforated, rigid plastic or metal drain pipes with a minimum diameter of 4 inches. The drain lines should daylight or be connected to a sump equipped with a pump.

To prevent intrusion of fines, the drain lines should be surrounded by a minimum thickness of 6 inches of appropriately-sized, graded, granular filter material. As an alternative, the drains could be surrounded with at least 6 inches of free-draining granular material, and the granular material encapsulated with suitable filter fabric. The area above the drain lines extending at least 24 inches out from the wall should be backfilled with free-draining coarse sand with no more than 2% passing the #200 sieve. As an alternative to free-draining granular fill, a pre-fabricated drainage structure may be used. A pre-fabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion and is fastened to the wall prior to placing backfill.

EXTERIOR SLAB SUBGRADE PREPARATION

The exterior slab subgrade should be prepared as described previously in the **Site Preparation** of the **Earthwork** section of this report. However, if the Owner is willing to accept the risks associated with constructing exterior slabs on existing fill (possible reduced performance or premature exterior slab failure), consideration could be given to leaving the existing fill in place unless failures are identified during proofrolling. Following proofrolling the upper 8 inches of subgrade should be scarified and compacted to at least 95% of its maximum dry density by ASTM D-698 at moisture contents above optimum moisture content. Any additional fill should be approved material free of organic matter and debris that is placed in lifts not to exceed 9 inches in loose thickness and compacted to at least 95% of its maximum dry density at moisture contents above optimum moisture content. We also recommend the final 18 inches of subgrade beneath exterior slabs meet the minimum moisture recommendations stated for additional fill in **Fill Compaction Requirements** of the **Earthwork** section of this report. This may require subgrade removal, moisture manipulation, and recompaction.

GENERAL COMMENTS

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

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

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

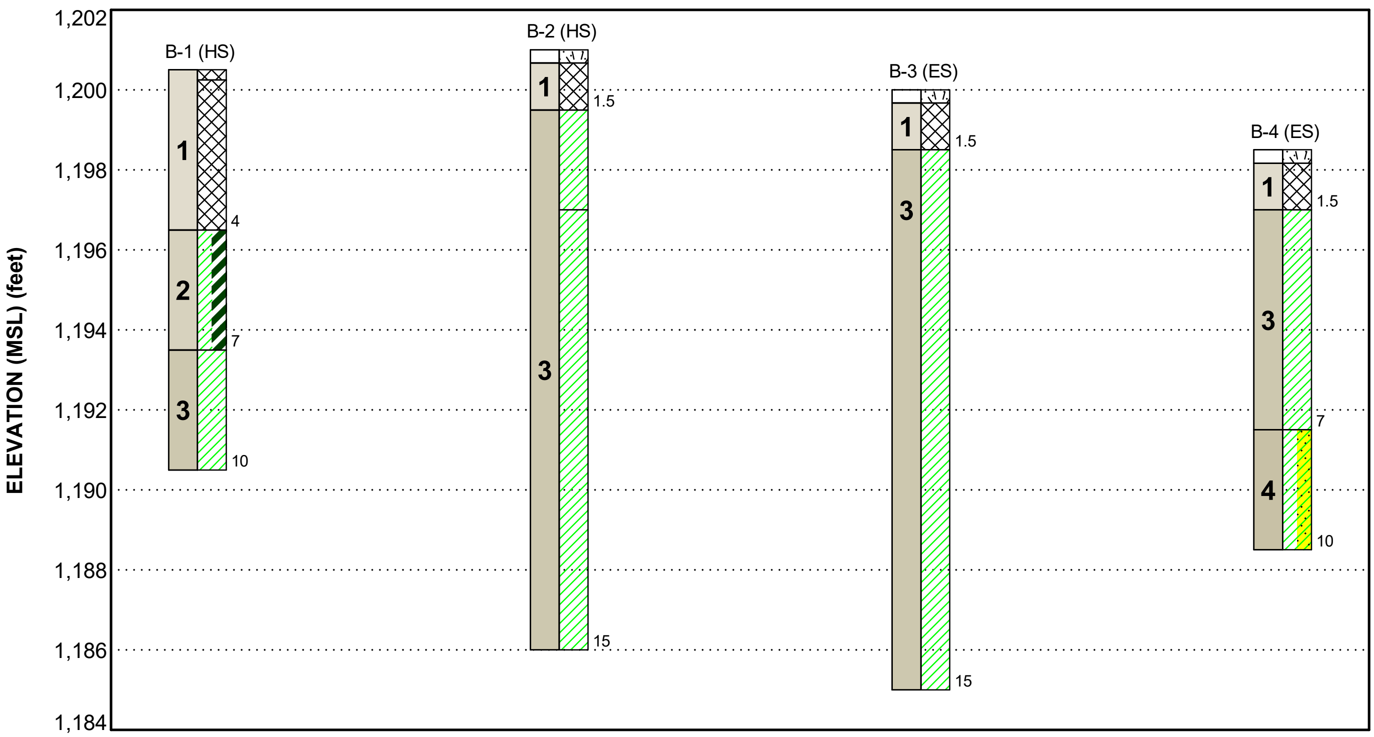
Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation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

FIGURES

Contents:

GEOMODEL

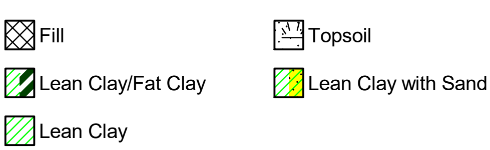
Proposed Oxford Elementary/High School Additions ■ Oxford, KS
4/9/2019 ■ Terracon Project No. 01195000



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	**Existing Fill**	lean clay, lean to fat clay
2	**Lean to Fat Clay**	medium stiff to stiff
3	**Lean Clay**	medium stiff to stiff
4	**Lean Clay with sand**	stiff

LEGEND



NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project. Numbers adjacent to soil column indicate depth below ground surface.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Boring Layout and Elevations: Terracon's drill crew used a hand-held GPS unit to establish our boring locations in the field at the locations indicated on our **Exploration Plan**. The ground surface elevations indicated on the boring logs are approximate and were obtained from topographic information available from Google Earth. Consider the approximate locations and ground surface elevations of the borings accurate only to the degree implied by these methods.

Subsurface Exploration Procedures: We drilled the borings with a truck-mounted drill rig using continuous flight augers to advance the boreholes. We obtained representative samples primarily by the split-barrel sampling procedure. In the split-barrel sampling procedure, a standard, 2-inch O.D., split-barrel sampling spoon is driven into the boring with a 140-pound hammer falling 30 inches. We recorded the number of blows required to advance the sampling spoon the last 12 inches of an 18-inch sampling interval as the standard penetration resistance value, N. We used an automatic SPT hammer to advance the split-barrel. A significantly greater efficiency is achieved with the automatic hammer compared with the conventional safety hammer operated with a cathead and rope. This higher efficiency has an appreciable effect on the standard penetration resistance blow count (N) values. We considered the effect of the automatic hammer's efficiency in our interpretation and analysis.

We also obtained a thin-walled tube sample. In the thin-walled tube sampling procedure, we hydraulically pushed a seamless steel tube with a sharpened cutting edge into the boring to obtain a relatively undisturbed sample of cohesive soil. We reported the sampling depths, penetration distances, and the standard penetration resistance values on the boring logs. In the field, we placed the samples into containers, sealed them, and returned them to the laboratory for observation, testing and classification.

Our drill crew prepared boring logs in the field as part of the drilling operations. These boring logs include visual classifications of the materials encountered during drilling and the driller's interpretation of the subsurface conditions between samples. The final boring logs included with this report represent the engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in the laboratory.

Laboratory Testing

We tested the split-barrel samples to determine their moisture contents. We estimated the unconfined compressive strength of the cohesive samples with a hand penetrometer. The hand penetrometer test values can be correlated with the unconfined compressive strengths and provide a better estimate of soil consistency than visual and tactual examination alone. We performed an Atterberg limits test on a representative portion of the near-surface soils to aid in classification and to evaluate their shrink/swell characteristics. The laboratory test results are provided on the boring logs included in the **Exploration Results** section of the report with this report.

An engineer examined the samples in the laboratory as part of the testing program. Based on the material's texture and plasticity, we described and classified the soil samples in accordance with our *General Notes* and the *Unified Soil Classification System*, respectively. The estimated group symbols using the *Unified Soil Classification System* are shown in the appropriate column on the boring logs. We are including our *General Notes* and a brief description of the Unified System in the **Supporting Information** section of the report.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Note: All attachments are one page unless noted above.

SITE LOCATION

Proposed Oxford Elementary/High School Additions ■ Oxford, Kansas
April 9, 2019 ■ Terracon Project No. 01195000

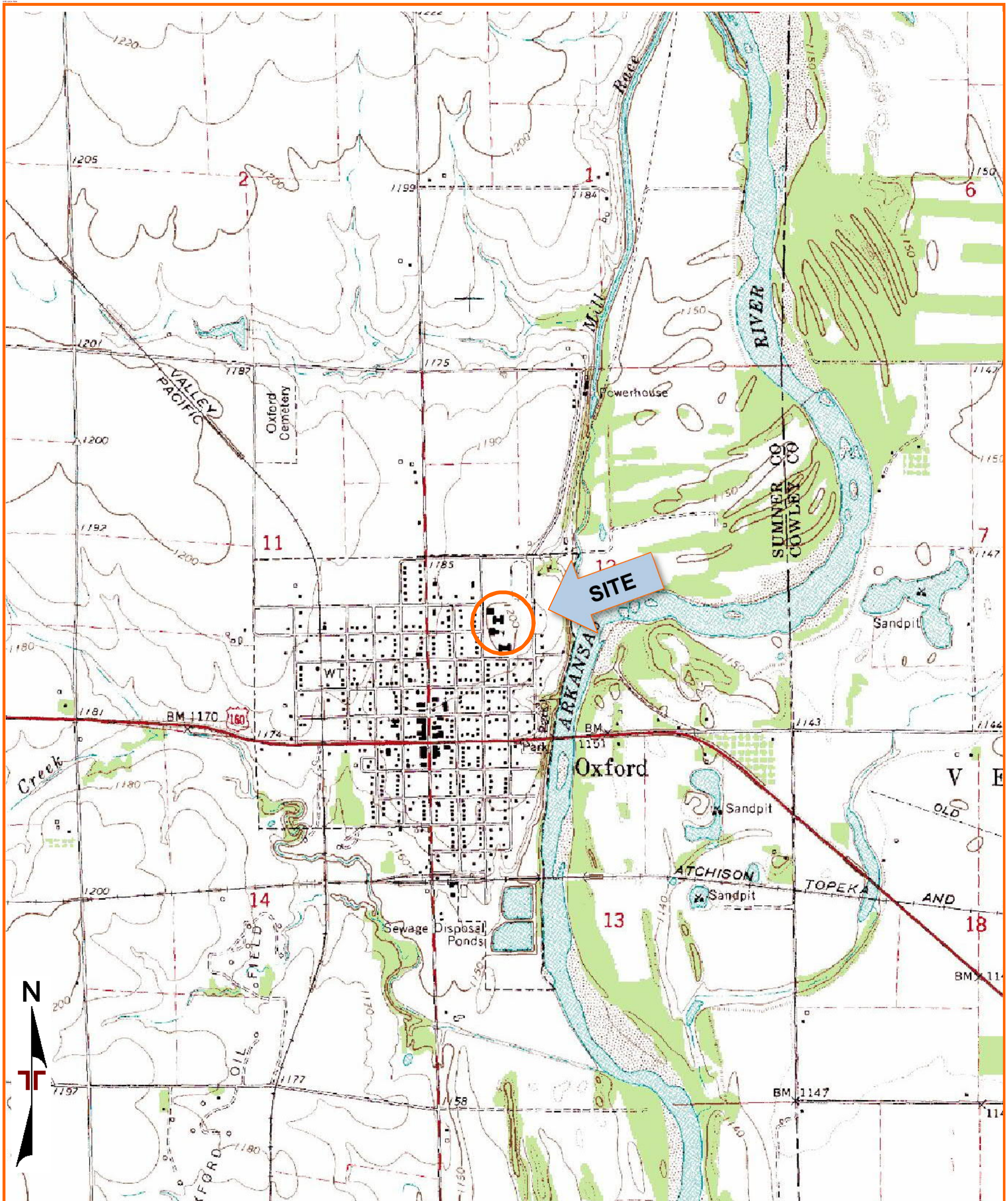


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Proposed Oxford Elementary/High School Additions ■ Oxford, Kansas
April 9, 2019 ■ Terracon Project No. 01195000

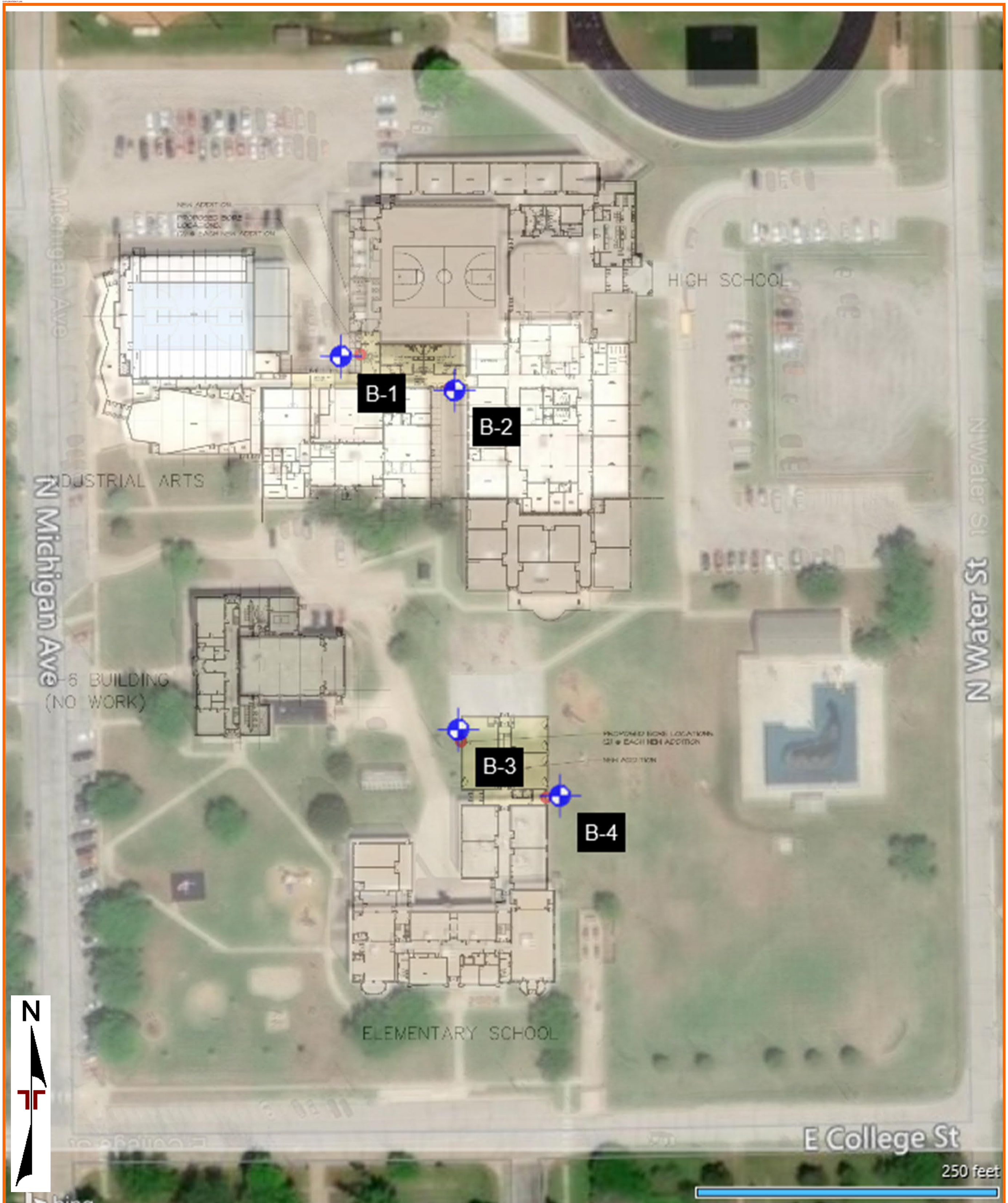


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Note: All attachments are one page unless noted above.

BORING LOG NO. B-1 (HS)

PROJECT: Proposed Oxford Elementary/High School Additions

CLIENT: USD #358 Oxford, KS

SITE: Oxford, KS

ARCHITECT: Hanney & Associates Wichita, KS

LOCATION See Exploration Plan

Latitude: 37.2794° Longitude: -97.1656°

Surface Elev.: 1200.5 (Ft.)

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE NUMBER	LABORATORY HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1	0.3	**FILL** - Gravel approximately 3" thick	1200.5											
1		**FILL - LEAN CLAY**, trace sand and gravel, brown				X	4	3-2-1 N=3	1	5000 (HP)		14		
1	4.0		1196.5			X	12	2-3-3 N=6	2	8000 (HP)		20		
2	7.0	**LEAN TO FAT CLAY (CL/CH)**, trace sand, brown, medium stiff	1193.5	5										
3	10.0	**LEAN CLAY (CL)**, trace sand, brown, stiff	1190.5	10		X	12	3-4-5 N=9	3	7500 (HP)		20		
		Boring Terminated at 10 Feet												

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1815 S Eisenhower St
Wichita, KS

Boring Started: 02-04-2019	Boring Completed: 02-04-2019
Drill Rig: 972	Driller: JD/JK
Project No.: 01195000	

BORING LOG NO. B-2 (HS)

PROJECT: Proposed Oxford Elementary/High School Additions

CLIENT: USD #358 Oxford, KS

SITE: Oxford, KS

ARCHITECT: Hanney & Associates Wichita, KS

LOCATION See Exploration Plan

Latitude: 37.2793° Longitude: -97.1653°

Surface Elev.: 1201 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE NUMBER	LABORATORY HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		0.3	Organic topsoil approximately 4" thick	1200.5											
1		1.5	**FILL - LEAN CLAY**, brown to dark brown	1199.5											
		4.0	**LEAN CLAY (CL)**, dark brown to brown, stiff	1197				12	3-3-7 N=10	1	8500 (HP)		24		
								14	4-4-5 N=9	2	8000 (HP)		22		
3			**LEAN CLAY (CL)**, trace sand, brown to gray-brown, stiff		5										
			- becoming orange-brown, medium stiff below 8'					14	2-2-3 N=5	3	3500 (HP)		23		
					10										
		15.0		1186				18	2-3-3 N=6	4	3500 (HP)		21		
			Boring Terminated at 15 Feet		15										

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1815 S Eisenhower St
Wichita, KS

Boring Started: 02-04-2019	Boring Completed: 02-04-2019
Drill Rig: 972	Driller: JD/JK
Project No.: 01195000	

BORING LOG NO. B-3 (ES)

PROJECT: Proposed Oxford Elementary/High School Additions

CLIENT: USD #358 Oxford, KS

SITE: Oxford, KS

ARCHITECT: Hanney & Associates Wichita, KS

LOCATION See Exploration Plan

Latitude: 37.2785° Longitude: -97.1652°

Surface Elev.: 1200 (Ft.)

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE NUMBER	LABORATORY HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	0.3	Organic topsoil approximately 4" thick	1199.5											
1	1.5	**FILL - LEAN CLAY**, dark brown to brown	1198.5											
3		**LEAN CLAY (CL)**, dark brown to brown, medium stiff					12	3-3-4 N=7	1	4000 (HP)		27		43-20-23
		- becoming brown below 3'		5			17		2	2500 (HP)		24	105	
		- trace sand below 9'		10			18	2-2-2 N=4	3	3000 (HP)		22		
	15.0		1185	15			18	2-2-2 N=4	4	2000 (HP)		22		
		Boring Terminated at 15 Feet												

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1815 S Eisenhower St
Wichita, KS

Boring Started: 02-04-2019	Boring Completed: 02-04-2019
Drill Rig: 972	Driller: JD/JK
Project No.: 01195000	

BORING LOG NO. B-4 (ES)

PROJECT: Proposed Oxford Elementary/High School Additions

CLIENT: USD #358, Oxford, KS

SITE: Oxford, KS

ARCHITECT: Hanney & Associates, Wichita, KS

LOCATION See Exploration Plan

Latitude: 37.2784° Longitude: -97.1649°

Surface Elev.: 1198.5 (Ft.)

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)
	0.3	Organic topsoil approximately 4" thick	1198
1	1.5	**FILL - LEAN TO FAT CLAY**, brown	1197
3	7.0	**LEAN CLAY (CL)**, trace sand, gray-brown, stiff	1191.5
4	10.0	**LEAN CLAY (CL)**, with sand, gray-brown, stiff	1188.5
		Boring Terminated at 10 Feet	

WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE NUMBER	LABORATORY HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	X	12	5-6-8 N=14	1	7000 (HP)		21		
	X	12	3-4-5 N=9	2	7000 (HP)		21		
	X	16	3-4-5 N=9	3	6500 (HP)		19		

DEPTH (Ft.): 5, 10

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

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

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
1815 S Eisenhower St
Wichita, KS

Boring Started: 02-04-2019	Boring Completed: 02-04-2019
Drill Rig: 972	Driller: JD/JK
Project No.: 01195000	

SUPPORTING INFORMATION

Contents:

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

Proposed Oxford Elementary/High School Additions ■ Oxford, KS

April 9, 2019 ■ Terracon Project No. 01195000

Terracon GeoReport

SAMPLING	WATER LEVEL		FIELD TESTS	
Shelby Tube	▽	**Water Initially Encountered**	**N**	**Standard Penetration Test Resistance (Blows/Ft.)**
Split Spoon	▽	**Water Level After a Specified Period of Time**	**(HP)**	**Hand Penetrometer**
	▼	**Water Level After a Specified Period of Time**	**(T)**	**Torvane**
			(DCP)	**Dynamic Cone Penetrometer**
			UC	**Unconfined Compressive Strength**
			(PID)	**Photo-Ionization Detector**
			(OVA)	**Organic Vapor Analyzer**

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

DESCRIPTIVE SOIL CLASSIFICATION

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

LOCATION AND ELEVATION NOTES

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

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (psf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 500	0 - 1
Loose	4 - 9	Soft	500 to 1,000	2 - 4
Medium Dense	10 - 29	Medium Stiff	1,000 to 2,000	4 - 8
Dense	30 - 50	Stiff	2,000 to 4,000	8 - 15
Very Dense	> 50	Very Stiff	4,000 to 8,000	15 - 30
		Hard	> 8,000	> 30

RELATIVE PROPORTIONS OF SAND AND GRAVEL		RELATIVE PROPORTIONS OF FINES	
Descriptive Term(s) of other constituents	Percent of Dry Weight	**Descriptive Term(s) of other constituents**	**Percent of Dry Weight**
Trace	<15	Trace	<5
With	15-29	With	5-12
Modifier	>30	Modifier	>12

GRAIN SIZE TERMINOLOGY		PLASTICITY DESCRIPTION	
Major Component of Sample	**Particle Size**	**Term**	**Plasticity Index**
Boulders	Over 12 in. (300 mm)	Non-plastic	0
Cobbles	12 in. to 3 in. (300mm to 75mm)	Low	1 - 10
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)	Medium	11 - 30
Sand	#4 to #200 sieve (4.75mm to 0.075mm	High	> 30
Silt or Clay	Passing #200 sieve (0.075mm)		

UNIFIED SOIL CLASSIFICATION SYSTEM

Terracon GeoReport

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E]	GW	Well-graded gravel [F]
			Cu < 4 and/or [Cc<1 or Cc>3.0] [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E]	SW	Well-graded sand [I]
			Cu < 6 and/or [Cc<1 or Cc>3.0] [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above “A” line	CL	Lean clay [K, L, M]
			PI < 4 or plots below “A” line [J]	ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay [K, L, M, N]
					Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above “A” line	CH	Fat clay [K, L, M]
			PI plots below “A” line	MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay [K, L, M, P]
					Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

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

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

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

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

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

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

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

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

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

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

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

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

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

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

[O] PI < 4 or plots below “A” line.

[P] PI plots on or above “A” line.

[Q] PI plots below “A” line.