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July 23, 2020

Mr. Damon Garrett
South English Station Development, LLC
2703 Sparrows Point Place
Louisville, Kentucky 40245

Re: Preliminary Geotechnical Investigation
South English Station Residential Development
South English Station Road
Louisville, Kentucky
Project Number 20-115G

Dear Mr. Garrett:

Attached is the report of the preliminary geotechnical investigation that we carried out for the above referenced residential development.

This site has shallow rock and highly-plastic clay, so we have discussed treatment of fat clay as well as the use rock as fill and foundations bearing on either rock or soil. More detail regarding these and other aspects of foundation and pavement construction are provided in the body of the report.

If you have any questions in regard to this preliminary report, please call.

Sincerely,

GREENBAUM ASSOCIATES, INC.

Sandor R. Greenbaum

Sandor R. Greenbaum, P.E.
Principal Engineer

RECEIVED
AUG 24 2020
PLANNING & DESIGN
SERVICES

PRELIMINARY GEOTECHNICAL INVESTIGATION

FOR

SOUTH ENGLISH STATION RESIDENTIAL DEVELOPMENT

SOUTH ENGLISH STATION ROAD
LOUISVILLE, KENTUCKY

FOR

SOUTH ENGLISH STATION DEVELOPMENT, LLC
2703 SPARROWS POINT PLACE
LOUISVILLE, KENTUCKY 40245

BY

GREENBAUM ASSOCIATES, INC.
994 LONGFIELD AVENUE
LOUISVILLE, KENTUCKY 40215

JULY 23, 2020

SANDOR R.
GREENBAUM
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APPENDIX

1.0 Introduction

South English Station Development, LLC intends to build a multi-family residential development consisting of 168 multi-family units and 58 patio homes on ± 21.8-acres of land located on the north side of Interstate 64 and the west side of South English Station Road in Louisville, Kentucky. This site includes two valleys with about 74 feet of relief across the site, the low point being near the center of the west side of the site where a stream flows out from the property. High ground is along the east side of the property. The included drawing of Site Geology shows the locations of streams and contours showing relative elevation across the site. The included boring location plan shows the approximate footprints of the proposed buildings and site development on the south portion of the property along with the locations of the five borings that were performed. A site location plan is also included in the appendix of this report.

We were contracted by South English Station Development, LLC to carry out a preliminary geotechnical investigation directed at determining preliminary information relative to foundation support characteristics of the materials upon which these buildings and associated pavement will be supported. Work was coordinated through Mr. Damon Garrett of South English Station Development, LLC.

2.0 General Geology

The soils below this site are shown by the Kentucky Geological Survey to be residuum, the residual product of weathering of the local bedrock. Bedrock is shown to be the Brassfield Formation, covering a narrow strip along South English Station Road, with the Drakes formation covering the bulk of the property. The uppermost strata of the Drakes Formation is the Hitz Limestone Bed which is five feet or less in thickness and forms a narrow strip between the Brassfield Formation and the underlying Saluda Dolomite Member. The Saluda Dolomite Member underlies the major portion of the property, everywhere to the west of the two narrow strips discussed above. A map of site geology is included in the appendix of this report.

The Brassfield Formation is described by the Kentucky Geological Survey as:

> Description: Limestone and dolomite: Dominant limestone is grayish orange to pale yellowish brown, weathers yellowish gray to dark yellowish orange;

coarsely crystalline, possibly recrystallized; contains whole and broken fossils and scattered thin lenses of porcelaneous chert. Less abundant limestone is light gray with greenish gray and pale reddish brown mottling, weathers same to dark yellowish orange; very finely crystalline; dolomitic; grades to dolosiltite of similar colors. Limestone types inter--bedded and inter--graded; stylolitic; bedding is generally irregular, rubbly, and obscure; locally cross-bedded; bed thickness ranges from 0.1 to 2.5 feet. Glauconite locally abundant in topmost bed; bed near base contains pyrite and pellets, and clasts of limestone and dolomite from underlying unit. Fossils, locally silicified, include zaphrentid solitary corals, favositid and halysitid colonial corals, bryozoans, brachiopods, stromatoporoids, pelmatozoans, and laminated algal mat(?) remains. Mapped with overlying Osgood Formation. On some flat topped ridges the Brassfield is represented entirely by cherty red clay residue as much as 4 feet thick; absent locally due to non-deposition or pre Osgood erosion. Erosional unconformity at base on which relief is as much as 1.5 feet in cuts along Interstate Highway 64 west of English Station Road.

Hydrology:
Small sinkholes are common in the Rowland Member of the Drakes Formation, the Brassfield Formation and the underlying Hitz Limestone Bed of the Saluda Dolomite Member of the Drakes, and locally in the Laurel Dolomite. Joints in these units trend generally N. 40 E., N. 10 E., N. 5 W., and N. 30 W.; calcite fills many joints that trend N. 10 E.

The Hitz Limestone Bed is described by the Kentucky Geological Survey as:

Description: Limestone, dolomite, and shale: Limestone and dolomite are dark gray to olive gray, weather light gray to grayish orange, locally with reddish brown cast; very fine to medium grained, silty, laminated in part; hackly to blocky fracture; inter--bedded and inter-tongued. Limestone and dolomite occur in at least four distinct alternating layers 0.2 to 0.4 foot thick with limestone at base. Fossils include burrows, thin shelled brachiopods, cephalopods, gastropods, bryozoans, small pelmatozoan stem plates, and ostracodes. Pink calcite locally fills large fossil cavities. Shale is grayish black to dusky brown, carbonaceous, calcareous, strongly fissile; commonly in two beds, one about 0.5 foot thick near base and one 0.2 foot thick near top. Unit is best exposed along Interstate Highway 64 west of English Station Road, where upper 1.5 feet of dolomite is locally missing due to pre Brassfield erosion.

Hydrology:
Small sinkholes are common in the Rowland Member of the Drakes Formation, the Brassfield Formation and the underlying Hitz Limestone Bed of the Saluda Dolomite Member of the Drakes, and locally in the Laurel Dolomite. Joints in these units trend generally N. 40 E., N. 10 E., N. 5 W., and N. 30 W.; calcite fills many joints that trend N. 10 E.

The Saluda Dolomite is described by the Kentucky Geological Survey as:

Description: Dolomite, dolomudstone, limestone, and shale: Dolomite, greenish gray, light to medium light gray, grayish yellowish green, and light olive gray in distinct color bands, weathers same to grayish orange and yellowish gray; mottled in part owing to burrows 1 to 2 mm wide. Dolomite in upper three fourths of unit is laminated; laminations accentuated by color variation due to alternating layers of coarse and fine dolomite rhombohedra; calcareous; quartz silt and sand grains make up 0 to 3 percent; mud cracks and rip up clasts on some bedding planes; weathers blocky to massive in steep ravines, shaly to flaggy on weathered slopes. Lower one-fourth of unit is dolomudstone that lacks prominent lamination; fracture is subconchoidal; weathers shaly or to blocky prisms 1 to 2 inches across. Limestone is bluish gray, weathers olive gray to brownish gray; dense, micritic; conchoidal fracture; commonly as one or two beds 0.1 to 0.6 foot thick in lower part of laminated dolomite sequence. Shale, in same part of sequence, light gray to olive black, 0.1 to 1.0 foot thick.. Fossils sparse, dolomitized in part, include bryozoans, brachiopods, colonial corals, and, in limestone beds, ostracodes and gastropods. Basal 5 feet of unit locally contains very thin inter-beds of abundantly fossiliferous limestone characteristic of underlying Bardstown Member. Basal contact poorly exposed, largely inferred on basis of thickness observed in exposures along Interstate Highway 64 and Ky. Highway 155 in western part of quadrangle. Residuum thickest 3 to 7 feet on ridgetops.

Hydrology:
Water sufficient only for domestic and farm use is obtained from shallow wells in alluvium, the Laurel Dolomite, the Saluda Dolomite and Rowland Members of the Drakes Formation, and from the thick calcarenite in the upper part of the Grant Lake Limestone. Springs issue from the base of the Laurel and locally from limestone beds immediately above thick shale sections in the Rowland and from thick calcarenite in the Grant Lake Limestone.

3.0 Investigation

Five borings were carried out in accessible areas of the site by standard penetration procedures to auger refusal with one boring continued five feet into rock by rotary coring procedures. A Diedrich D-25 track-mounted drill rig was used to carry out the borings through the use of 3 ¼ inch inside diameter hollow stem augers and an automatic hammer. Boring locations were staked using a nylon tape from existing topography, so boring locations are only as accurate at this method allows.

The standard penetration procedure involves driving a standard 2-inch diameter split spoon in the formation at selected intervals using a 140-pound hammer falling through 30 inches. The blow counts for each 6 inches of drive, to a total of 18 inches, are recorded and the number of blows for the 12 inches after the first 6 inches is a standard measure of the condition of the soil. As the split spoon is removed from the ground, it retrieves a sample of the soil in a disturbed condition. Nevertheless, this sample is suitable for certain classification tests and is representative of the soils at the depth tested.

An NQ wireline double-tube core barrel with a diamond drill bit was used to core the rock. The double tube core barrel itself minimizes the erosive action of the drilling fluid on the core and thereby improves core recovery. A swivel type double tube core barrel was used. The core barrel consists of a core barrel head, an outer barrel, an inner core recovery tube, a reaming shell, a core lifter and a coring bit. In operation, the inner tube remains stationary while the outer barrel is rotated. This minimizes the possibility of core disturbance through torsional forces and thereby improves recovery. Water passages direct the flow of the drilling fluid into the annular space between the two tubes and vents provide for the exit of the water from the barrel. The inner tube assembly is suspended from the outer tube head in such manner that downward force can be applied to both tubes while only the outer tube is rotated.

Soil samples were returned to the laboratory where a program of testing was carried out. This testing included a grain size analysis, an Atterberg Limits test and a natural moisture determination.

Grain size determination arrives at a curve of grain size against that fraction of the soil that is finer than that particular grain size. It also allows the determination of the clay fraction, silt fraction, sand fraction, etc. in any particular soil sample. Based on this division of grain sizes, the field soils classifications are refined and the boring logs adjusted. In the case of fine grained soils, the soils are largely silt and clay; thus requiring that the soils be suspended in an aqueous medium and the rate at which the particles drop out is measured in order to arrive at the grain size distribution. Silt and clay grains are so fine that sieve analysis alone will not function in this range. The coarse fraction of this sample is separated from the fine and run through a nest of sieves in order to further detail the grain size distribution in the coarse range.

The Atterberg Limits determination arrives at those moisture contents at which the soil turns from a solid state to a plastic condition (the Plastic Limit) and then from a plastic condition to a liquid condition (The Liquid Limit). The points in question are arrived at by standard procedures that accept specific cohesive and flow properties of the soil as standards for these limits. Knowing the moisture content of the soil in relation to these limits provides a broad measure of the soil strength and soil characteristics. The arithmetic difference between these two limits is called the Plasticity Index and all three together are used for classifying the soils in a number of standard systems.

The natural moisture determination arrives at the in-situ moisture content of the soil and is useful for correlating the strength of various samples of like texture and in conjunction with the Atterberg limits, gives a strong measure of the strength range the soils are likely to be found in.

4.0 Findings

4.1 Boring Results

This site is covered by about 4- to 6-inches of topsoil. Below this soil is moist, stiff to very stiff, brown, fat clay. Auger refusal was encountered between 7.0- and 12.3-feet depth. Boring B-4 was core drilled five feet into rock and found competent limestone below the top, nearly foot, of weathered limestone with clay seams. Core recovery of the core run is 88 percent and Rock Quality Designation (RQD) of the core is 75. Boring B-3 encountered organic material. This may be trees and debris that has been buried. The extent of this material was not determined.

The table at the top of the following page provides a tabulation of N-values in the borings as determined by the standard penetration test, corrected for the energy of the automatic hammer, along with depth to auger refusal.

Depth	B-1	B-2	B-3	B-4	B-5
2 – 3.5 feet	13	17	5	34	10
5 – 6.5 feet	20	10	10	50/5"	53
10 – 11.5 feet		18	21		
Auger Refusal	7.9'	11.8	12.3'	6.0'	7.0'

No groundwater was encountered in any of the borings immediately after drilling was complete, but water is probably present seasonally, possibly perched on the bedrock surface.

4.2 Laboratory Results

A sample of soil was tested and classified and was found to be fat clay. The result of this testing is summarized in the table below with more detailed results provided in the appendix of this report.

Soil Sample	Grain Size Distribution			Atterberg Limits			Soil Classification	
	Percent Sand	Percent Silt	Percent Clay	Liquid Limit	Plastic Limit	Plasticity Index	Unified	AASHTO
B-1 @ 2' – 3.5'	1	29	70	71	27	44	CH	A-7-6

4.3 Seismicity

For soil bearing foundations, by the 2018 edition of the Kentucky/ International Building Code, this is a very dense soil and soft rock profile, site class C, where foundations bear on either virgin soil or soil fill. The Spectral Response Acceleration Coefficients, for this area, as provided by U.S.G.S., FEMA Design Parameters are:

$S_S = 0.181$ g	$S_{MS} = 0.235$ g	$S_{DS} = 0.157$ g
$S_1 = 0.094$ g	$S_{M1} = 0.141$ g	$S_{D1} = 0.094$ g

For rock bearing foundations, by the 2018 edition of the Kentucky/ International Building Code, this is a rock profile, site class B, where foundations bear bedrock. The Spectral Response Acceleration Coefficients, for this area, as provided by U.S.G.S., FEMA Design Parameters are:

$S_S = 0.181$ g $S_{MS} = 0.181$ g $S_{DS} = 0.121$ g

$S_1 = 0.094$ g $S_{M1} = 0.094$ g $S_{D1} = 0.063$ g

5.0 Preliminary Recommendations

5.1 Foundations

If soils are consistent with those encountered in this limited number of borings that were performed as part of this preliminary investigation, the proposed buildings may be supported on spread footings bearing on shallow soil or structural fill placed in accordance with section 5.3 of this report and designed based on an allowable net bearing capacity of up to 2,000 pounds per square foot. Foundations bearing on limestone bedrock may be designed based on an allowable net bearing capacity of up to 5,000 pounds per square foot. However, no single building should bear partially on rock and partially on soil. If bearing materials under part of a building are rock and part are soil, there is a choice between undercutting rock 12 inches or more and refilling with soil compacted to between 88 and 92 percent of the soils maximum dry density as determined by the Standard Proctor (ASTM D698) or removing all soil below the foundation bearing surfaces, replacing that soil with lean concrete ($f_c' \geq 2{,}000$ psi) to the foundation bearing level.

Once foundation bearing surfaces are exposed, an engineer or senior engineering technician from this office should be present to view all bearing surfaces. Where soft areas are encountered, undercut will need to extend to firm material or to a level determined to be acceptable by the geotechnical engineer and should be refilled with either lean concrete ($f_c' = 2{,}000$ psi) or open-graded stone such as Number 57 stone.

Soil bearing foundations exposed must bear at least 30 inches below finished grade in order to insulate the bearing strata from freezing. Interior foundations protected from freezing are exempt from this requirement. Continuous footings bearing on soil must be at least 16 inches wide and isolated footings bearing on soil must be at least 24 inches wide. Any foundations bearing on limestone bedrock must be at least 14 inches wide.

Settlement of foundations designed based on the above criteria should be below that which is considered acceptable for this type of construction; that is total settlement should be less than one inch and differential settlement should be less than three quarters of an inch. Foundations bearing on bedrock will undergo negligible settlement.

For shallow foundations, friction along the base of the footing can be used to resist lateral forces. A friction coefficient of 0.35 may be used, which assumes that the footing concrete is placed directly against the natural cut faces. The coefficient of friction value recommended is an ultimate value and a minimum factor of safety of 1.5 must be applied when determining the allowable sliding resistance.

5.2 Slab-On-Grade

Much of the soils at this site are fat clay, too plastic to remain in the subgrade of slab-on-grade. The reason for this is that fat clay is subject to volume change with change in moisture content and can cause irregular movement of slab-on-grade, resulting in cracking of the slab and distorting interior walls and doorways supported on thickened slab. If fat clay is to be used as fill, it should be used in the deeper fill that does not come into contact with foundations, slabs or pavement, or it should be used in areas to be covered with landscape.

Should fat clay be found to be in the subgrade of slab-on-grade, as will probably be the case, there are two means of preventing the problem of softening and swelling below the slab. These are:

- Lean clay should be used as fill in the top foot in fill areas and the top foot of soil in cut areas should be replaced with lean clay where fat clay is found to be present.
- The slab subgrade should be treated with 5 percent quicklime or hydraulic lime to at least 12 inches depth to modify the fat clay so that it is no longer subject to unacceptable volume change.

Chemical stabilization of the slab subgrade will probably prove to be the most cost-effective means of dealing with fat clay at this site since there probably is minimal lean clay present for use as fill. Also, it is more expensive to separate and stockpile different soils at a site so that lean clay can be reserved for certain areas. The geotechnical investigation that will be performed once the full site has been made accessible to a drill rig can better delineate the extent of lean and fat soils at this site so that a better assessment may be made of the need for chemical stabilization.

If the two options discussed above for treating the top foot of slab subgrade are not possible, measures may be taken to reduce moisture change below the buildings and limit shrink/swell of subgrade soils. However, alternate measures will only reduce moisture/volume change of these soils, not eliminate it by changing the nature of the material underlying the slab. These measures to limit moisture change, will be discussed in the following paragraph. At this site chemical stabilization will be the more effective, least expensive option, provided the construction schedule can be arranged so that multiple buildings and/or pavement subgrades may be stabilized at one time, thereby reducing the number of mobilizations of specialized equipment required for chemical stabilization of fat, subgrade soils.

To reduce moisture and volume change below the buildings, measures may be taken which include:

- Roof drainage should be controlled by gutters and downspouts which should be piped away from the buildings.
- The ground surface around the perimeter of the buildings should slope away from the buildings at a five percent grade extending at least 10 feet from the building. In paved areas, this grade may be reduced to two percent.
- Hose bibs, sprinkler heads, and any other external water connections should be placed at least 10 feet away from the perimeter of the buildings and should not spray within that 10-foot zone.
- No trees or shrubs over 6 feet in height should be planted within 10 feet of the building.
- Utility bedding should not include gravel or other permeable material near the perimeter of the building. Compacted clay or flowable fill should be used as backfill in a zone extending from 2 feet inside the building to 4 feet outside the building to prevent creating a channel for infiltration of water into the building subgrade.
- Paved areas around the building will work to maintain soil moisture equilibrium. Concrete flatwork or asphalt pavement around the building will reduce infiltration or surface water and reduce moisture change both due to precipitation and due to draught. The use of a clay cap over poly sheeting or impervious geosynthetic liner can be used between the building and nearby pavement to limit moisture change in those areas.

Prior to placement of the fill in the slab area, the subgrade must be proofrolled and carefully examined by a geotechnical engineer for areas of soft soil. If soft soils are encountered, they must be undercut and refilled in accordance with instructions given by the geotechnical engineer's on-site representative. Undercut and refill in soft areas consists of excavating to a depth up to two feet below subgrade elevation and refill should be with "Surge Rock", 6-inch minus or Number 3 stone. If fat clay is present, excavation must extend to firm strata and lean clay should be used to refill the resulting excavation.

Once necessary corrections are made, a conventionally designed slab-on-grade should perform satisfactorily. A floor slab that is structurally separated from the walls, columns and foundations is preferable, though thickened slab may be used. Separation of slab-on-grade from foundations will minimize the stress caused by possible differential settlement between the slabs and the foundations and between adjacent slabs. A vapor barrier must be incorporated into the design and at least four inches of Dense Graded Aggregate (DGA) should underlie the slab. The floor slab may be designed based on a Modulus of Subgrade Reaction of 85 pounds per cubic inch, 150 pounds per cubic foot if the subgrade is chemically stabilized.

5.3 Site Preparation and Earthwork

Prior to fill placement all vegetation and topsoil (soil containing more than 4 percent organic content) must be removed from below the area to be filled. Where trees or bushes have been present, the entire rootball should be removed and the resulting excavation should be refilled with soil compacted as described in this section of the report. Then, prior to placement of fill, the exposed subgrade should be proofrolled by a fully loaded tri-axle truck to delineate any yielding or rutting areas that may require treatment such as undercut and refill or drying.

Boring B-3 encountered organic material that will have to be removed and be replaced with engineered fill. In addition, wet organic soils will be encountered along the streams that cross this site. These soils will be too wet to provide adequate support and will have to be removed or stone will have to be used to bridge over them if fill is to be placed in those areas. These soils may only be used as fill in areas that will be covered by landscape, since they contain organic material and are likely to be very silty and wet.

At the time the geotechnical investigation is performed, reconnaissance should be performed for the presence of sinkholes and/or springs. It is likely that springs are present near the streams that traverse this property.

All fill should be placed in lifts not exceeding 8 inches in uncompacted thickness and must be compacted to at least 98 percent of the soils maximum dry density as determined by the Standard Proctor (ASTM D-698). Soil moisture content should be within 2 percent of optimum as determined from the Standard Proctor.

Soil from any off-site borrow sources should be tested and approved by this office prior to being used on the site. Satisfactory borrow materials are those falling in one of the following classifications: GC, SM, SC, ML, or CL. Soil types MH, CH and OH soils and peat are unsatisfactory borrow materials.

It is likely that rock excavation will be required at this site. Clean shot rock may be used as fill below buildings, pavement and in landscape areas. It will be problematic to excavate through shot rock, so its use in areas where footing and utility excavation will occur should be avoided. Where soil fill is to be placed above rock fill and the rock has open voids, a non-woven geotextile should be placed above the rock to prevent erosion of soil into those voids. If there is sufficient fines in the rock to fill the voids, the fabric will not be necessary.

Fill consisting of rock mixed with soil should not be used below structures. Its use should be limited to fill in landscape areas. It may be use below paved areas if there is too much shot rock to limit its use to landscape areas.

Rock fill and rock/soil fill that is primarily rock should be compacted by rolling it with at least 4 passes of a D6 dozer over the entire surface of the fill. This fill should be placed in lifts as thin as the rock dimension allows, but no thicker than two-foot lifts.

The site should be maintained in a well-drained condition both during and after construction. Site grading should provide for drainage of surface run-off away from the buildings and pavement.

Prior to fill placement all vegetation and topsoil (soil containing more than 4 percent organic content) must be removed from below the area to be filled. Where trees or bushes have been present, the entire rootball should be removed and the resulting excavation should be refilled with soil compacted as described in this section of the report.

The placement of compacted fill should be carried out by an experienced excavator with the proper materials. The excavator must be prepared to adapt his procedures, equipment and materials to the type of project, to weather conditions, and the structural requirements of the engineer. Methods and materials used in summer may not be applicable in winter; soil used in proposed fill may require wetting or drying for proper placement and compaction. Conditions may also vary during the course of a project or in different areas of this site. These needs should be addressed in the project drawings and specifications.

During freezing conditions, the fill must **not** be frozen when delivered to the site. It also must not be allowed to freeze during or after compaction. Since the ability to work the soil while keeping it from freezing depends in part on the soil type, the specifications should require the contractor to submit a sample of his proposed fill before construction starts, for laboratory testing. If the soil engineer determines that it is not suitable, it should be rejected. In general, silty sand, clayey sand, and cohesive/semi-cohesive soils should not be used as fill under freezing conditions. All frozen soil of any type should be rejected for use as compacted fill.

It is important that compacted fill be protected from freezing after it is placed. The excavator should be required to submit a plan for protecting the soil. The plan should include details on the type and amount of material (straw, blankets, extra loose fill, topsoil, etc.) proposed for use as frost protection. The need to protect the soil from freezing is ongoing throughout construction and applies both before **and** after concrete is placed, until backfilling for final frost protection is completed. Foundations placed on frozen soil can experience heaving and significant settlement, rotation, or other movement as the soil thaws. Such movement can also occur if the soil is allowed to freeze **after** the concrete is placed and then allowed to thaw. The higher the percentage of fines (clay and silt) in the fill, the more critical is the need for protection from freezing.

The contractor should be required to adjust the moisture content of the soil to within a narrow range near the optimum moisture content (as defined by the applicable Proctor or AASHTO Test). In general, fill should be placed within 2% of optimum moisture. The need for moisture control is more critical as the percentage of fines increases. Naturally occurring cohesive/semi-cohesive soil are often much wetter than the optimum. Placing and attempting to compact such soils to the specified density may be difficult. Even if compacted to the specified density, excessively wet soils may not be suitable as pavement subgrades due to pumping under applied load. This is especially true when wet cohesive/semi-cohesive soil is used as backfill in utility trenches and like situations. Excessively wet soil in thick fill sections may cause post-construction settlement beyond that estimated for fill placed at or near (±2%) the optimum moisture content.

5.4 Earth Pressures

Any retaining walls should be constructed with a drainage blanket of sand or a synthetic drainage material. Synthetic drainage media should be available from suppliers of geotextile. The wall should be drained at its base by a perforated

PVC underdrain or weepholes at a spacing of not more than 10 feet. Where a relatively thin drainage blanket is used, the retaining wall should be designed based on a coefficient of active earth pressure (K_a) of 0.36 and a soil unit weight (γ_w) of 130 pounds per cubic foot. This results in an equivalent fluid pressure of 47 pounds per cubic foot. Where granular backfill completely fills the area defined by a plane extending upward from the base of the wall at a 45 degree angle, the retaining wall may be designed based on a coefficient of active earth pressure (K_a) of 0.27 and a soil unit weight (γ_w) of 130 pounds per cubic foot. This results in an equivalent fluid pressure of 35 pounds per cubic foot.

However, where the wall is restrained from movement, as in the case of building basement walls bearing against the basement slab or building frame, the wall must be designed based on the "at rest" earth pressure. The coefficient of "at rest" earth pressure (K_o) is 0.47 with a soil unit weight (γ_w) of 130 pounds per cubic foot in the case of a thin drainage blanket behind the wall, resulting in an equivalent fluid of 61 pounds per cubic foot unit weight. Where granular backfill completely fills the area defined by a plane extending upward from the base of the wall at a 45-degree angle, the retaining wall may be designed based on a coefficient of "at rest" earth pressure (K_o) of 0.43 and a soil unit weight (γ_w) of 130 pounds per cubic foot. This results in an equivalent fluid pressure of 56 pounds per cubic foot.

The table below summarizes the design earth pressures.

	Active Earth Pressure Coefficient (K_a)	Passive Earth Pressure Coefficient (K_p)	Coefficient of Earth Pressure at Rest (K_o)	Equivalent Fluid Pressure on Cantilever Walls	Equivalent Fluid Pressure on Braced Walls
Fill Material/Local Soils	0.36	2.77	0.47	47 pcf	61 pcf
Granular Backfill	0.27	3.69	0.43	35 pcf	56 pcf

Surcharge above the wall will add additional load. A uniform surcharge must be multiplied by the appropriate coefficient of earth pressure to determine the additional load applied to the wall.

Any retaining wall design must use appropriate factors of safety. It is critical that drainage be provided as mentioned earlier in this section in order to avoid hydrostatic pressure. Hydrostatic pressure would increase pressure against the wall substantially.

5.5 Light- and Heavy-Duty Pavement

Pavement subgrade should be examined and proofrolled as described under "Floor Slabs". If yielding areas are encountered, the loose soils will need to be undercut and refilled in accordance with the instructions of the geotechnical engineer's on-site representative. Where fat clay is present in the pavement subgrade, the top foot of soil should either be replaced with lean clay or the top 16 inches should be chemically stabilized with lime as discussed in section 5.2 of this report.

A pavement analysis was conducted using a life cycle of 20 years and a cumulative 18-kip equivalent single axle load of 20,000 for light traffic loads and 160,000 for moderate traffic loads. Recommendations are provided for both flexible and rigid pavement systems. However, rigid pavement should be used in special truck traffic areas, such as those areas which receive frequent traffic by garbage trucks. The concrete pavement should extend throughout the areas that require extensive turning and maneuvering of garbage trucks or other heavy trucks. Heavily loaded pavement areas that are not designed to accommodate these conditions often experience localized pavement failures, particularly if flexible pavement sections are used.

The minimum recommended thickness for both hot mixed asphalt concrete (HMAC) and reinforced Portland cement concrete (PCC) pavement sections are presented in the table below for the described light, moderate and special traffic condition.

Recommended Pavement Section

Component	Light		Moderate		Special
	Rigid	Flexible	Rigid	Flexible	Rigid
Reinforced Portland Cement Concrete (PCC)	5 inches		6 inches		7 inches
Hot Mixed Asphalt Concrete (HMAC)		3 inches		4 inches	
Crushed Limestone Base (Dense Graded Aggregate)	4 inches	8 inches	4 inches	8 inches	4 inches
Prepared Subgrade	6 inches	6 inches	6 inches	6 inches	6 inches

The Portland cement concrete should be air-entrained and conform to ASTM C-94 (Standard Specifications for Ready-Mixed Concrete) and have a minimum compressive strength of 4,000 pounds per square inch. Reinforcing should meet the requirements of ACI.

Hot mix asphalt concrete and Dense Graded Aggregate should meet the requirements of the Kentucky Transportation Cabinet. The top inch of asphalt should be a surface mix, the remainder being a base mix.

5.6 Temporary Earth Slopes or Cuts

Temporary earth cuts necessary to construct foundations or utility lines should be no deeper than 4 feet without benching or sloping. Cuts deeper than this should be sloped no steeper than one horizontal to one vertical or should have benches every 2 feet of height equating to this slope. If vertical faces deeper than 4 feet are used, bracing designed for short term loads may be used. Excavations should comply with OSHA regulations. If soft soils are encountered, Greenbaum Associates, Inc. should view the cut face prior to personnel entering the excavation.

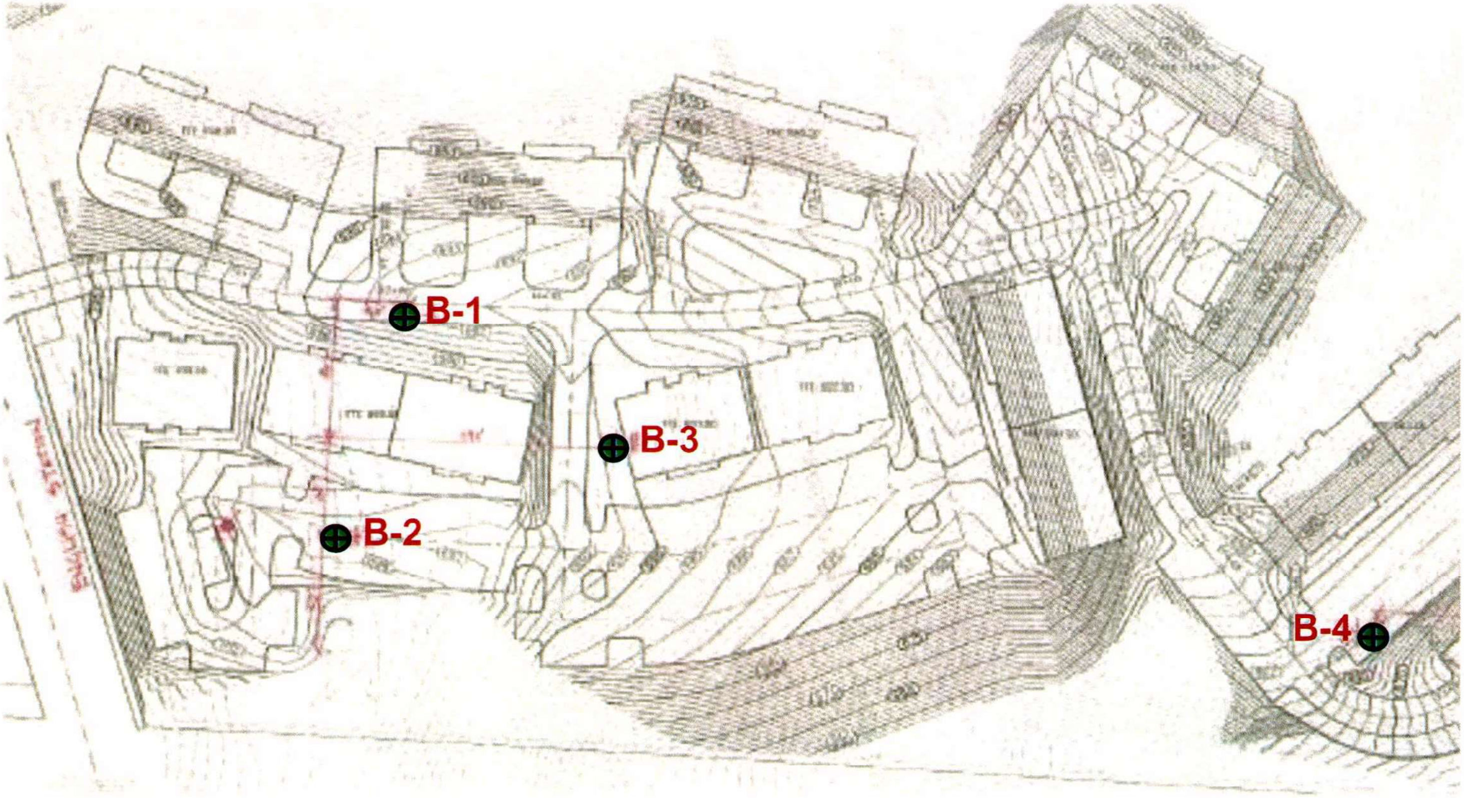
5.7 Limitations

The conclusions and recommendations offered in this report are based on the subsurface conditions encountered in a limited number of borings. No warranties can be made regarding the continuity of conditions between or beyond borings. If, during construction, soil conditions are encountered that differ from those indicated in this report, a representative of Greenbaum Associates, Inc. should inspect the site to determining if design modification is required. All recommendations are preliminary until a more thorough boring program is performed.

This preliminary study was directed at a specific buildings and associated pavement at this location to be constructed within a reasonably short period after this study. Use for any other location, structures or substantial changes in construction period may invalidate the recommendations. The geotechnical engineer should be consulted relative to any substantial change in these.

This study is directed at mechanical properties of the soils and includes no sampling, testing or evaluation for environmental considerations.

South English Station Development, LLC	Greenbaum Associates, Inc.	S South English Deve Greenbau



South English Station
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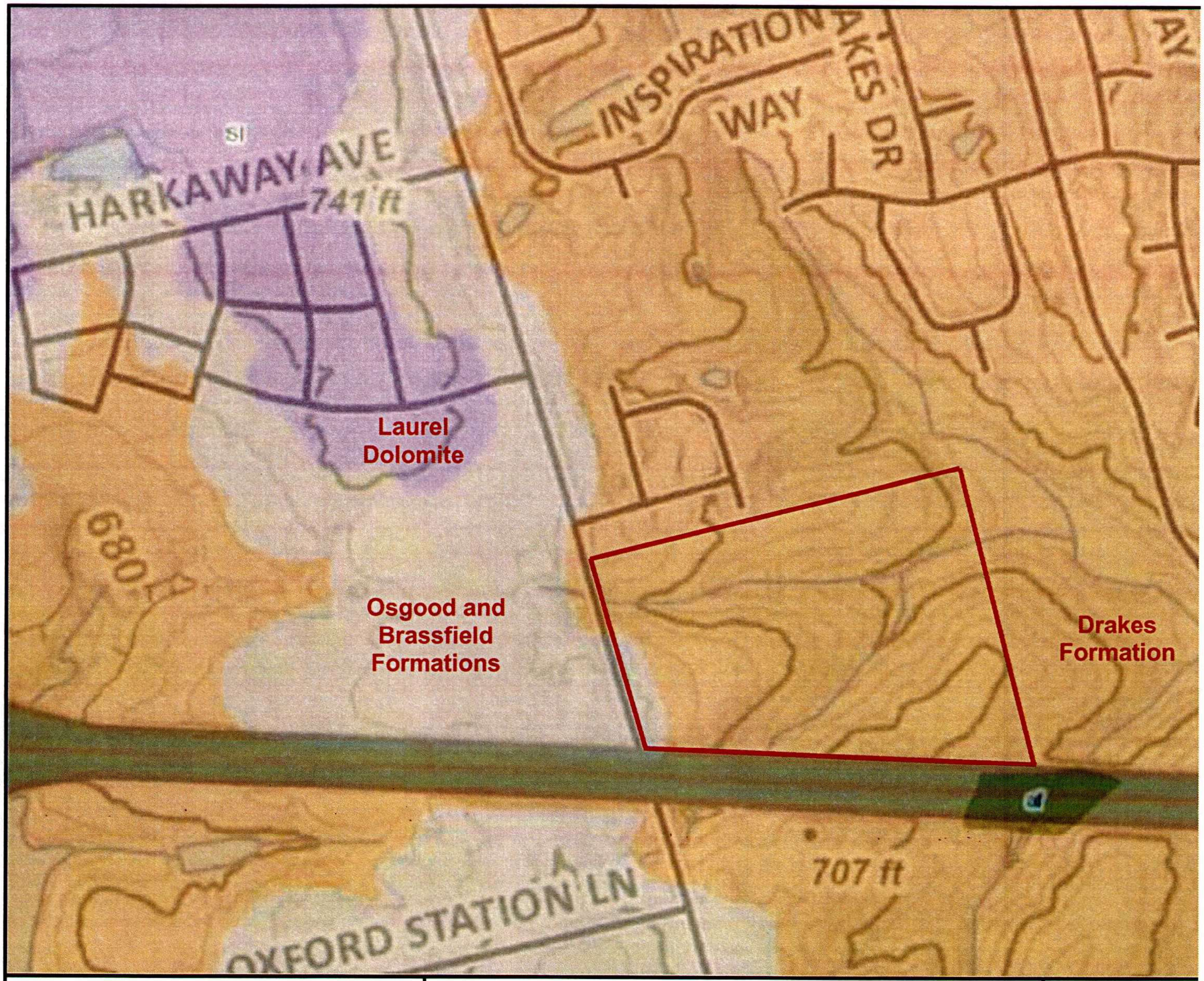

South English Station Development, LLC

Greenbaum Associates, Inc.

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SOIL DESCRIPTION TERMINOLOGY

Soils are identified and classified in this report according the the Unified Classification System with the following modifiers:

RELATIVE DENSITY OF GRANULAR SOILS

Description	Blows/Foot
Very Loose	0 to 4
Loose	5 to 10
Medium Dense	11 to 30
Dense	31 to 50
Very Dense	51 to 80
Extremely Dense	81+

CONSISTENCY OF COHESIVE SOILS

Description	N-value	q_u (tsf)
Very Soft	0 to 2	0 to 0.25
Soft	3 to 4	0.26 to 0.50
Medium Stiff	5 to 8	0.51 to 1.0
Stiff	9 to 15	1.1 to 2.0
Very Stiff	16 to 30	2.1 to 4.0
Hard	>30	4.1 to 8.0
Very Hard		8.1+

PARTICAL SIZES

Components		Size or Sieve No.
Boulders		over 12 inches
Cobbles		3 to 12 inches
Gravel -	Coarse	$^3/_4$ to 3 inches
	Fine	No. 4 to $^3/_4$ inch
Sand -	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40
Fines (silt and clay)		Finer than No. 200

SOIL MOISTURE

	Descriptive Term
Dry	Dry of Standard Proctor Optimum
Damp	Moist (sand only)
Moist	Near Standard Proctor Optimum
Wet	Wet of Standard Proctor Optimum
Saturated	Free Water in Sample

ROCK DESCRIPTION TERMINOLOGY

The Rock Quality Determination (Deere et. Al., 1969) method of determining rock quality as reported here was obtained by summing up the total length of core recovered in each run, counting only those pieces of core which are four inches (10 cm.) in length or longer and which are hard and sound. The sum is then represented as a percentage over the length of the run. If the core is broken by handling or by the drilling process, the fresh broken pieces are fitted together and counted as one piece provided that they the requisite length of four inches (10 cm.). RQD is reported as a percentage.

RELATIONSHIP BETWEEN RQD AND ROCK QUALITY

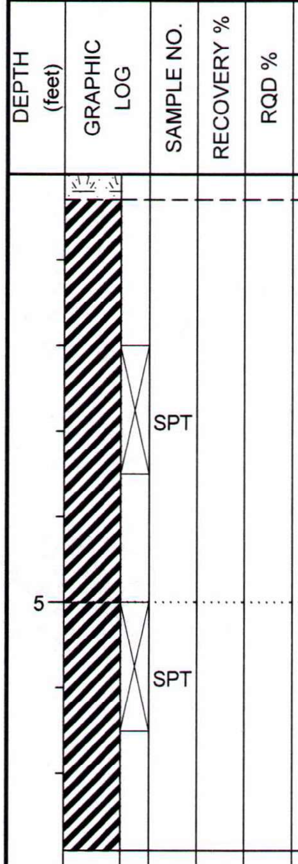
RQD (%)	Description of Rock Quality
0 to 25	Very Poor
26 to 50	Poor
51 to 75	Fair
76 to 90	Good
91 to 100	Excellent

Client: South English Station Development, LLC
Project: South English Station Residential Dev. Louisville, KY
Project No.: 20-115G

HOLE No. B-1

Sheet 1 of 1

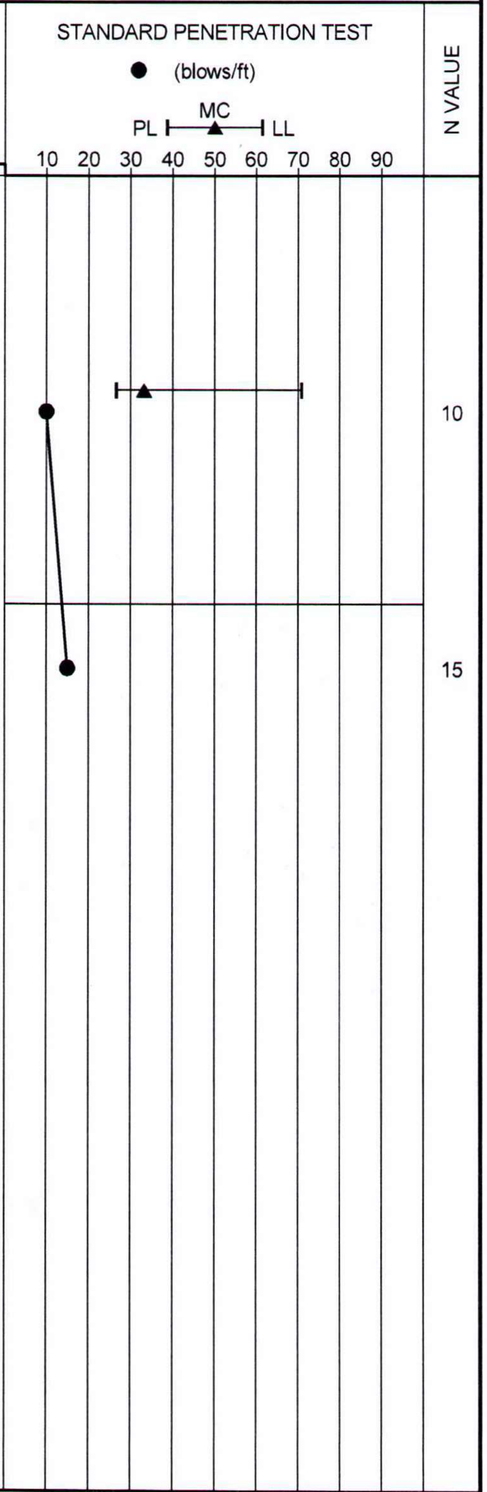
Boring Location: **See Boring Location Plan** Surface Elevation: **Ground** Station: **n/a**
Drilling Equipment: **D-25 Track-Mounted Drill w/ Autohammer** Drilling Method: **3 1/4 Inch Hollow Stem Auger**
Depth to water immediately: **Dry** Overburden: **7.9** Rock: **0** Total Depth: **7.9**
Logged By: **S. Greenbaum** Driller: **B. Sumler** Date Logged: **6/20/20 - 6/20/20**



MATERIAL DESCRIPTION

Topsoil (4 inches)	OL	Ground
Moist, Stiff, Brown, Fat Clay	CH	
Same, Very Stiff	CH	

AUGER REFUSAL @ 7.9 FEET



SAMPLER TYPE		DRILLING METHOD		Hole No.
SS - Split Spoon	NX - Rock Core, 2-1/8"	HSA - Hollow Stem Auger	RW - Rotary Wash	
ST - Shelby Tube	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core	
HQ - Rock Core, 2-1/2"	CT - Continuous Tube	DC - Driving Casing		**B-1**

Greenbaum Associates, Inc.
Louisville, KY 40215 (502) 361-8447

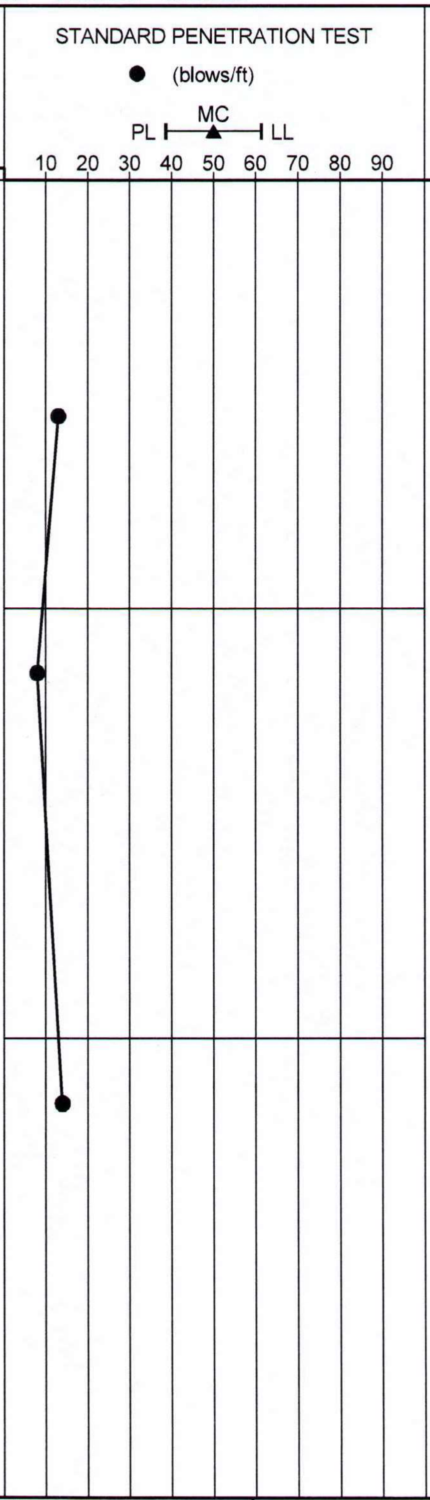
Client: South English Station Development, LLC
Project: South English Station Residential Dev. Louisville, KY
Project No.: 20-115G

HOLE No. B-2

Sheet 1 of 1

Boring Location: **See Boring Location Plan** Surface Elevation: **Ground** Station: **n/a**
Drilling Equipment: **D-25 Track-Mounted Drill w/ Autohammer** Drilling Method: **3 1/4 Inch Hollow Stem Auger**
Depth to water immediately: **Dry** Overburden: **11.8** Rock: **0** Total Depth: **11.8**
Logged By: **S. Greenbaum** Driller: **B. Sumler** Date Logged: **6/20/20 - 6/20/20**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION		ELEVATION (feet)	N VALUE
					Topsoil (4 inches)	OL	Ground	
					Moist, Very Stiff, Brown, Fat Clay w/ Gravel	CH		
		SPT						13
5					Moist, Stiff, Brown, Fat Clay	CH		
		SPT						8
10					Same, Very Stiff	CH		
		SPT						14
					AUGER REFUSAL @ 11.8 FEET			



SAMPLER TYPE
SS - Split Spoon
ST - Shelby Tube
HQ - Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD
HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No.
B-2

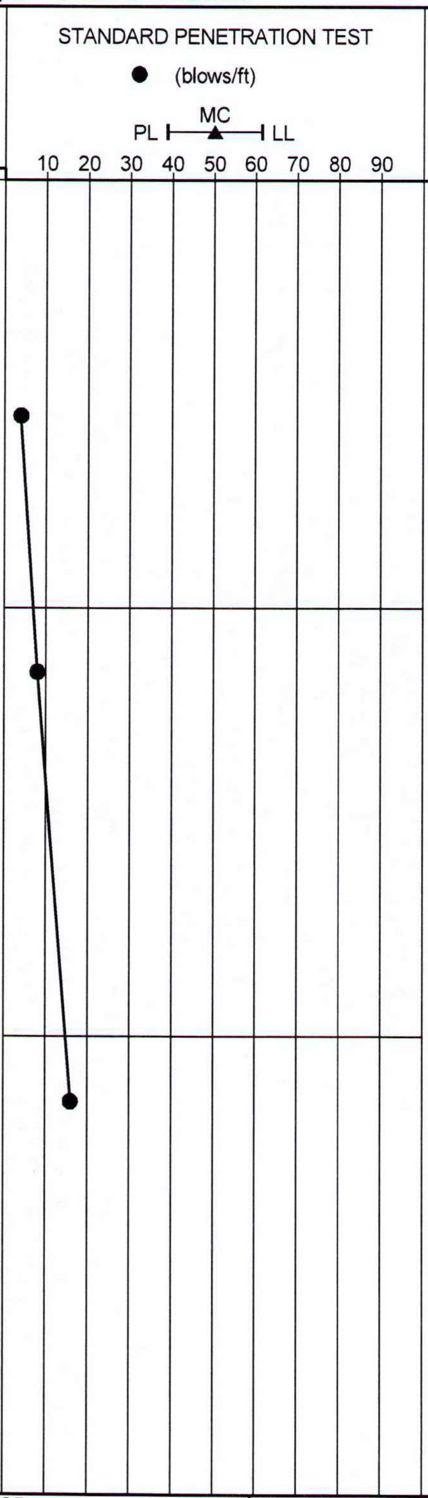
Client: South English Station Development, LLC
Project: South English Station Residential Dev. Louisville, KY
Project No.: 20-115G

HOLE No. B-3

Sheet 1 of 1

Boring Location: **See Boring Location Plan** Surface Elevation: **Ground** Station: **n/a**
Drilling Equipment: **D-25 Track-Mounted Drill w/ Autohammer** Drilling Method: **3 1/4 Inch Hollow Stem Auger**
Depth to water immediately: **Dry** Overburden: **12.3** Rock: **0** Total Depth: **12.3**
Logged By: **S. Greenbaum** Driller: **B. Sumler** Date Logged: **6/20/20 - 6/20/20**

DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION		ELEVATION (feet)	N VALUE
					Crushed Stone (18 inches)	GW	Ground	
		SPT			Moist, Medium Stiff, Brown, Organic Material	OL		4
5		SPT			Moist, Stiff, Brown, Fat Clay	CH		8
10		SPT			Same, Very Stiff	CH		16
					AUGER REFUSAL @ 12.3 FEET			



SAMPLER TYPE
SS - Split Spoon
ST - Shelby Tube
HQ - Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD
HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No.
B-3

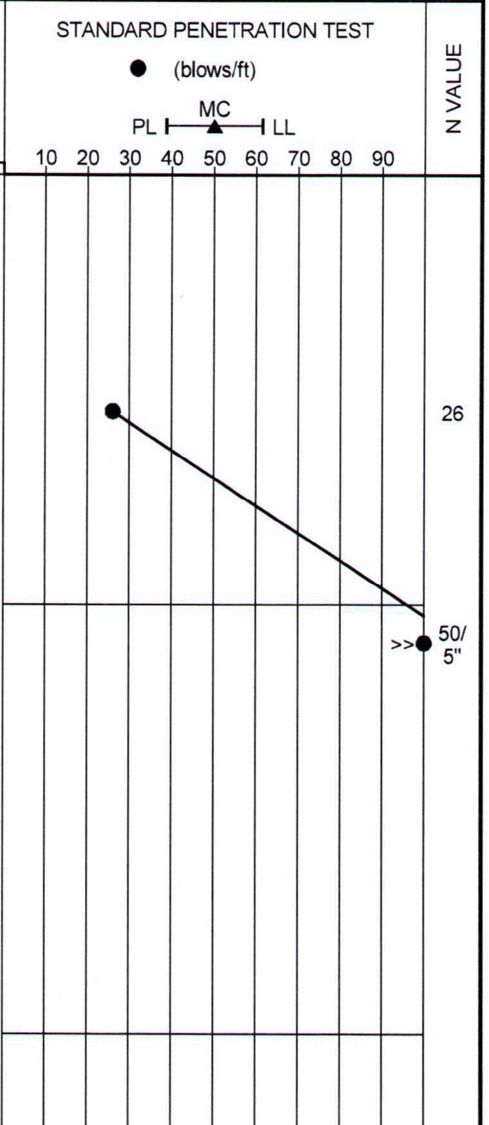
Client: South English Station Development, LLC
Project: South English Station Residential Dev. Louisville, KY
Project No.: 20-115G

HOLE No. B-4

Sheet 1 of 1

Boring Location: **See Boring Location Plan** Surface Elevation: **Ground** Station: **n/a**
Drilling Equipment: **D-25 Track-Mounted Drill w/ Autohammer** Drilling Method: **3 1/4 Inch Hollow Stem Auger**
Depth to water immediately: **Dry** Overburden: **6.0** Rock: **5** Total Depth: **11.0**
Logged By: **S. Greenbaum** Driller: **B. Sumler** Date Logged: **7/1/20 - 7/1/20**

DEPTH (feet)	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION		ELEVATION (feet)	N VALUE
0				Topsoil (6 inches)	OL	Ground	
				Moist, Hard, Brown, Fat Clay with Shale	CH		
	SPT						26
5	SPT						50/ 5"
6.0				AUGER REFUSAL @ 6.0 FEET			
				Dark Gray, Thin Bedded, Limestone with Clay Seams			
				Dark Gray, Thin- to Medium-Bedded Limestone with Fossiferous Zones			
	NX	88	75	Same, Thick Bedded			
10							
11.0				TERMINATED @ 11.0 FEET			



SAMPLER TYPE
SS - Split Spoon
ST - Shelby Tube
HQ - Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD
HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No. **B-4**

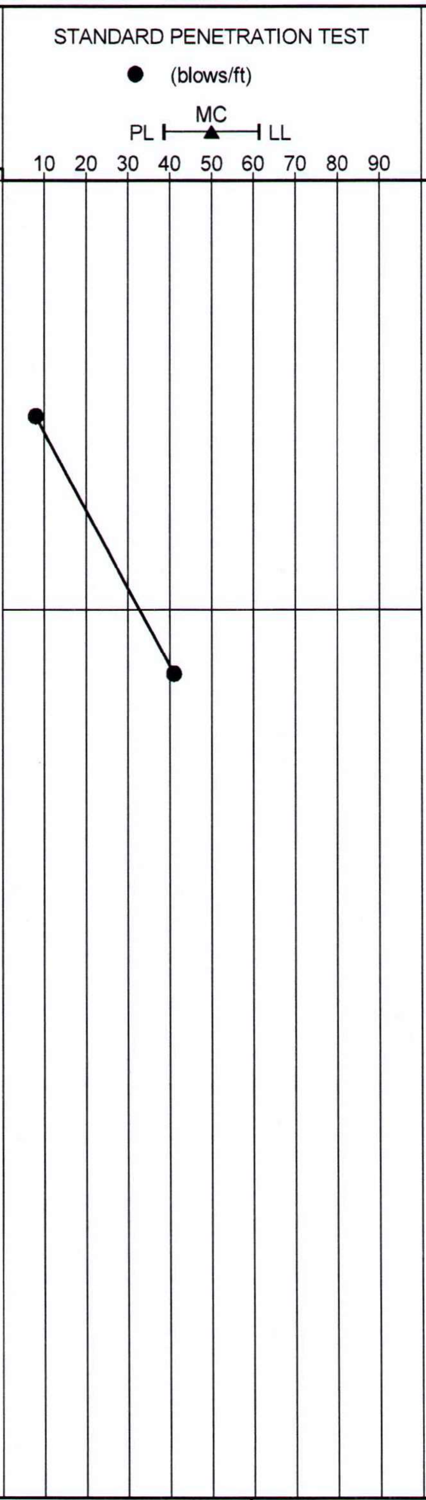
Greenbaum Associates, Inc.
Louisville, KY 40215 (502) 361-8447

Client: South English Station Development, LLC
Project: South English Station Residential Dev. Louisville, KY
Project No.: 20-115G

HOLE No. B-5

Sheet 1 of 1

Boring Location: **See Boring Location Plan** Surface Elevation: **Ground** Station: **n/a**
Drilling Equipment: **D-25 Track-Mounted Drill w/ Autohammer** Drilling Method: **3 1/4 Inch Hollow Stem Auger**
Depth to water immediately: **Dry** Overburden: **7.0** Rock: **10** Total Depth: **7.0**
Logged By: **S. Greenbaum** Driller: **B. Sumler** Date Logged: **6/20/20 - 6/20/20**



DEPTH (feet)	GRAPHIC LOG	SAMPLE NO.	RECOVERY %	RQD %	MATERIAL DESCRIPTION		ELEVATION (feet)	N VALUE
					Topsoil (6 inches)	OL	Ground	
					Moist, Stiff, Brown, Fat Clay	CH		
		SPT						8
5					Same, Hard	CH		
		SPT						41
					AUGER REFUSAL @ 7.0 FEET			

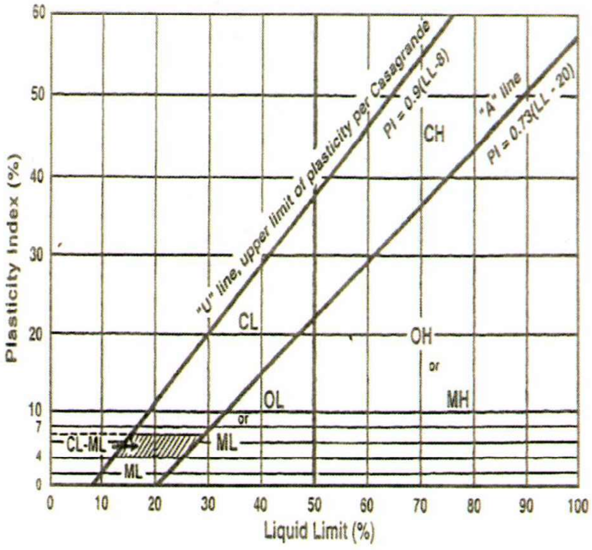
SAMPLER TYPE
SS - Split Spoon
ST - Shelby Tube
HQ - Rock Core, 2-1/2"
NX - Rock Core, 2-1/8"
CU - Cuttings
CT - Continuous Tube

DRILLING METHOD
HSA - Hollow Stem Auger
CFA - Continuous Flight Augers
DC - Driving Casing
RW - Rotary Wash
RC - Rock Core

Hole No.
B-5

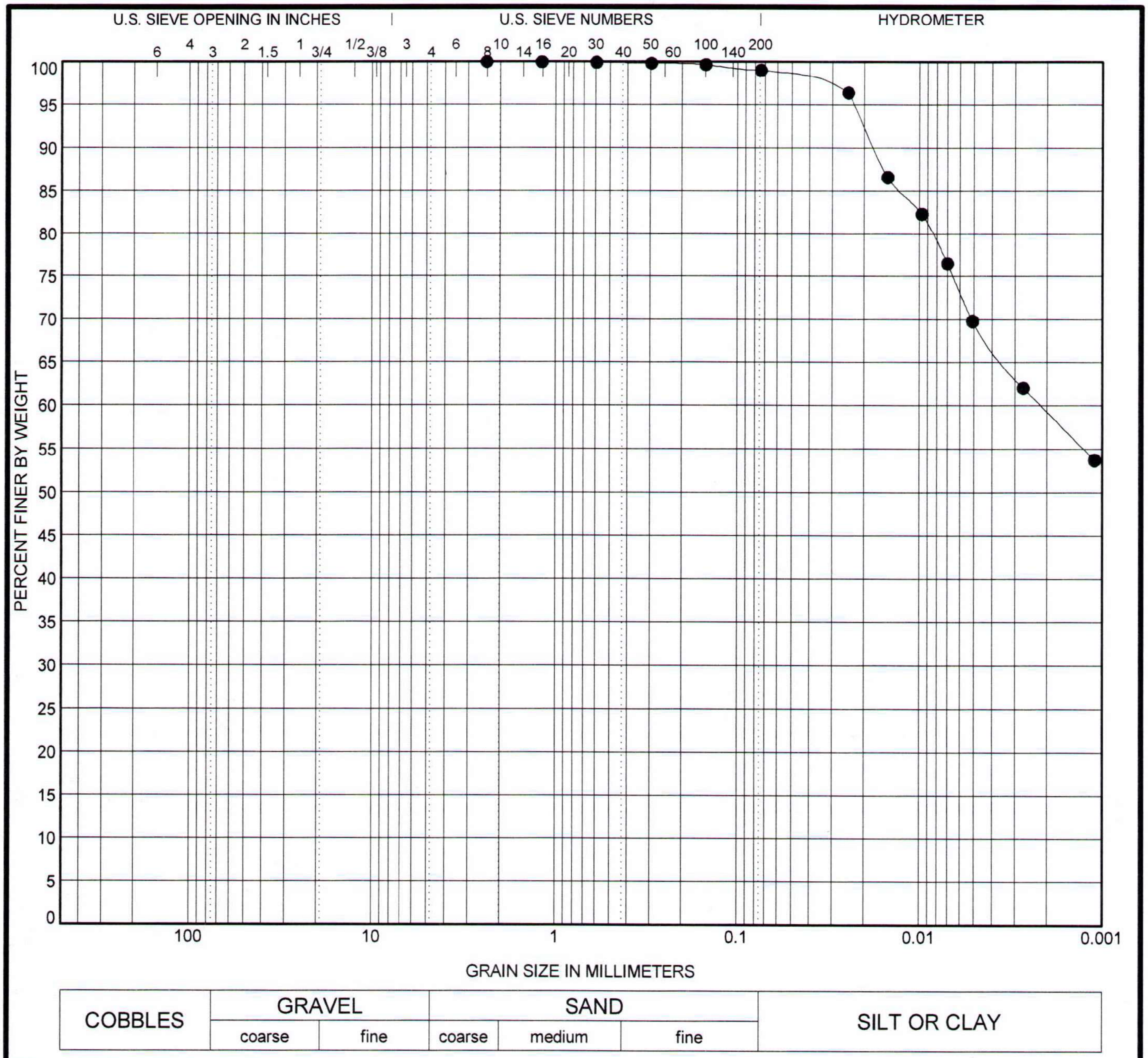
CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM D2487 and D2488

Major Divisions			Group Symbols		Typical Names	Laboratory Classification Criteria		
Coarse-grained soils (More than half of material is *larger* than No. 200 sieve size)	**Gravels** (More than half of coarse fraction is larger than No. 4 sieve)	**Clean Gravels** (Little or no fines)	**GW**		Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller that 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 requireing dual symbols[b]	$C_u=D_{60}/D_{10}$ greater than 4 $C_u=(D_{30})^2/(D_{10}\times D_{60})$ between 1 and 3	
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	**GM**[a]	d	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line with P. I. less than 4	Above "A" line with P. I. between 4 and 7 are *borderline* cases requireing us of dual symbols
				u				
			GC		Clayey gravels, gravel-sand-clay mixtures		Atterberg limits below "A" line with P. I. greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	**Clean Sands** (Little or no fines)	**SW**		Well-graded sands, gravelly sands, little or no fines		$C_u=D_{60}/D_{10}$ greater than 6 $C_u=(D_{30})^2/(D_{10}\times D_{60})$ between 1 and 3	
			SP		Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	**SM**[a]	d	Silty sands, sand-silt mixtures		Atterberg limits above "A" line or P.I. < 4	Limits plotting in hatched zone with P.I. between 4 and 7 are *borderline* cases requireing use of dual symbols
				u				
			SC		Clayey sands, sand-clay mixtures		Atterberg limits above "A" lime with P.I. > 7	
Fine-grained soils (More than half meterial is smaller than No. 200 sieve)	Silts and clays (Liquid limit less than 50)		**ML**		Inorganic silts and very fine sands, silty or clayey fine sands, or clayey silts with slight plasticity	 Plasticity Chart		
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL		Organic silts and organic siltyclays of low plasticity			
	Silts and clays (Liquid limit less that 50)		**MH**		Inorganic silts, micaceous or diatomaceous fine sand or silty soils, elastic silts			
			CH		Inorganic slays 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			

[a] Division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is based on Atterberg limits :suffix d used when L. L. is 28 or less and the P. I. is 6 or les; the suffix u used when L. L. is greater than 28.

[b] Borderline classifications, used for soils possessing characeristics of two groups, are designated by combinations of group symbols. For exampls: GW-GC, well-graded gravel-sand misture with clay binder.



Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● **B-1**	**2.5**	**FAT CLAY(CH)**	**71**	**27**	**44**		

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **B-1**	**2.5**	**2.38**	**0.002**			**0.0**	**1.0**	**29.4**	**69.6**

Greenbaum Associates, Inc.
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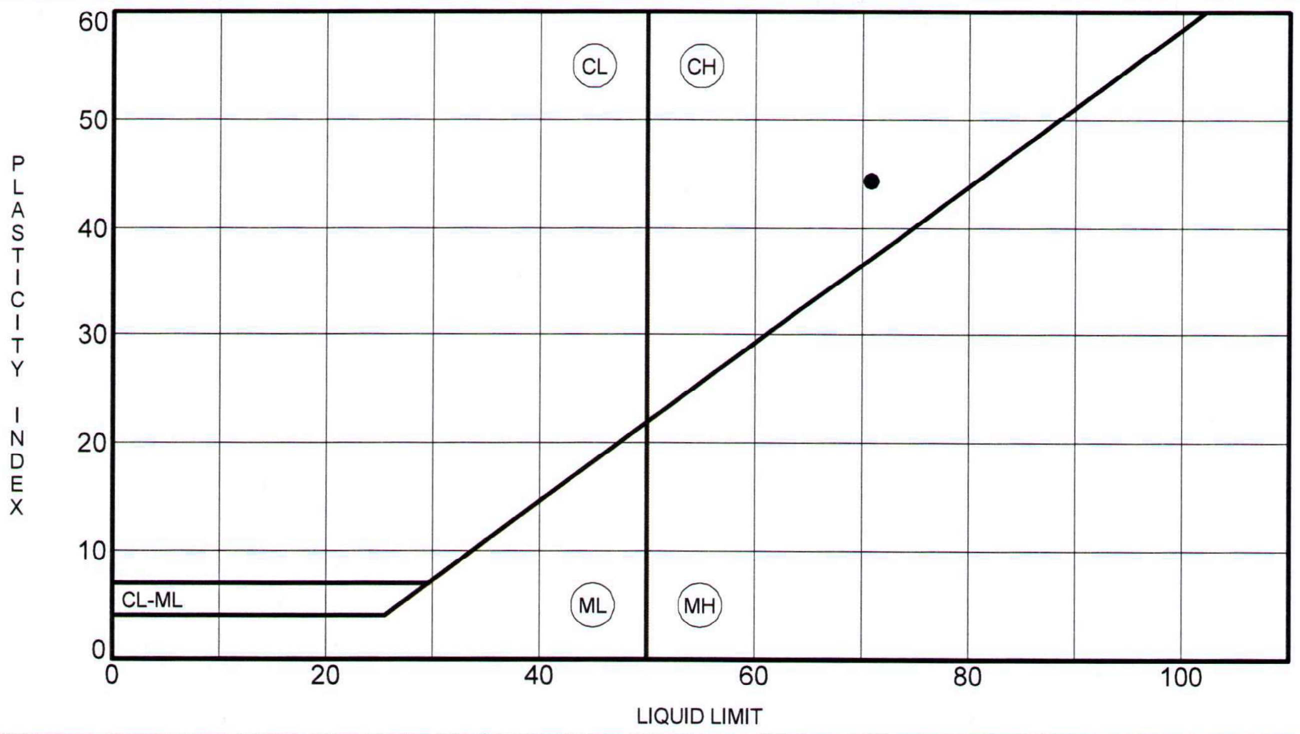
(502) 361-8447

GRAIN SIZE DISTRIBUTION

Project: South English Station Residential Dev.

Location: Louisville, KY

Number: 20-115G



	Specimen Identification		LL	PL	PI	Fines	Classification
●	**B-1**	**2.5**	**71**	**27**	**44**	**99**	**FAT CLAY(CH)**

Greenbaum Associates, Inc.
Louisville, KY 40215
(502) 361-8447

ATTERBERG LIMITS' RESULTS

Project: South English Station Residential Dev.

Location: Louisville, KY

Number: 20-115G

US ATTERBERG LIMITS 20-115.GPJ GREENBAUM.GDT 7/9/20