Geotechnical Engineering Report



TN Tower Parking Garage - STREAM
Nashville, Davidson County, Tennessee
October 21, 2022
Terracon Project No. 18225080

Prepared for:
Hurst-Rosche, Inc.
Hillsboro, Illinois

Prepared by:
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Nashville, TN

October 21, 2022

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Attn: Mr. David Pool – Principal
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Re: Geotechnical Engineering Report
TN Tower Parking Garage - STREAM
301 7th Ave N
Nashville, Davidson County, Tennessee
Terracon Project No. 18225080

Dear Mr. Pool:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. P18225080 dated May 25, 2022. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations, floor slabs, and pavements for the proposed project. Our preliminary findings were provided in DRAFT form on August 22, 2022. Email correspondence with Mr. Jim Siefert, P.E., of Hurst-Rosche, Inc. indicated that our preliminary conclusions and findings were acceptable and the report should be issued as final.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

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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

EXPLORATION AND TESTING PROCEDURES
PHOTOGRAPHY LOG
SITE LOCATION AND EXPLORATION PLANS
EXPLORATION RESULTS
SUPPORTING INFORMATION

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

Geotechnical Engineering Report

TN Tower Parking Garage - STREAM

301 7th Ave N

Nashville, Davidson County, Tennessee

Terracon Project No. 18225080

October 21, 2022

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed building to be located at 301 7th Ave N in Nashville, Davidson County, Tennessee. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

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

The geotechnical engineering Scope of Services for this project included the advancement of eleven (11) test borings to depths varying from approximately 20 ½ to 66 ½ feet below existing site grades. Borings were terminated approximately 10 feet below the maximum anticipated foundation depth based on our proposal and conversations with Hurst-Rosche.

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 rock core samples obtained from the site during the field exploration are included on the boring logs and/or as separate graphs 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 Gold Lot project is located at 301 7th Ave N in Nashville, Davidson County, Tennessee. The Blue Lot project is located at 301 Rosa L Parks Ave, Nashville, Davidson County, Tennessee. Approximately 1-acre paved lot (Gold) and 0.55-acre paved lot (Blue) for potential parking garage development 36.1636358, -86.7840880 (approximate) See **Site Location**
Existing Improvements	Paved parking lot and grass/sidewalk covered plaza space. The adjacent existing plaza to the Gold Lot is underlain by two to three levels of below grade office space. Adjoining building buildouts have below grade construction.
Existing Topography (Furnished elevation data, collected by Collier Engineering and furnished to Terracon by Mr. Jim Siefert via email correspondence on August 3, 2022)	**Gold Lot -** The primary lot (paved parking area) for investigation is a relatively flat asphalt parking lot. The adjacent grass and sidewalk covered plaza is relatively flat with a shallow gradient from north to south. Furnished elevation data collected by Collier Engineering, indicates surface elevation appears to be between 525 and 526 feet above mean sea level (MSL). **Blue Lot –** The secondary lot is graded from southeast draining to the northwest, with an approximate 25-foot elevation difference. Bedrock conditions are likely variable across the lot. A retaining wall owned and maintained by others runs along the southern perimeter. Surface elevation data collected by Collier Engineering appears to indicate elevations range from 489 to 495 feet above MSL.

We also collected photographs at the time of our field exploration program. Representative photos are provided in our **Photography Log**.

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	In accordance with information shared during a meeting held with Mr. David Pool with Hurst-Rosche and other project team members, we anticipate parking garage projects summing approximately 1,500 spaces to occur primarily on the eastern, paved lot at the corner of Union Street and 7th Avenue North in downtown, Nashville, Tennessee. The garage superstructure is expected to have between 3 and 5 floors below grade and up to 3 to 5 floors above grade. A second lot at the corner of Rosa L Parks and Dr. Martin Luther King Jr. Dr. will be investigated for feasibility of subgrade parking. We anticipate ongoing collaboration to discuss the construction requirements for this lot. We understand additional tunneling and pedestrian bridge work is proposed; and was not included for this phase of geotechnical work.
Project Description	The adjacent Tennessee Tower, War Memorial Building, and the State Capitol elevations govern the allowable heights and blasting considerations for the building. The plaza has existing offices extending two to three stories below grade. Additionally, the new garage structure may not extend above the War Memorial, nor encumber the footprint on the skyline. Likely, 580 feet MSL is the target elevation for the top of the garage, thus 3 to 5 levels above the existing grade and between 3 to 5 floors below grade. Finally, we understand the 'Travertine Marble' fascia of the Tennessee Tower was imported from Italy and is considered irreplaceable. As such, care should be taken to avoid damage during construction.
Building Construction	New parking garage with up to 5 stories above grade and 5 levels below grade to be constructed in the paved Gold lot. As many as 2 floors below grade are anticipated in the Blue lot. The garages are anticipated to be concrete construction with post-tensioned concrete parking levels.
Finished Floor Elevation	Finished floor elevation has not been provided to Terracon at this time. We anticipate bottom floor elevations could be about 570 to 580 feet for the Gold Lot and 530 to 540 feet for the Blue Lot.
Maximum Loads (assumed)	Pending final number of parking levels; however, maximum column loads are anticipated to be on the order of 2,000 kips or greater.
Grading/Slopes	We anticipate up to about 50 feet of cut could be required to develop final grade at the Gold Lot and up to about 15 to 20 feet of cut may be required at the Blue Lot. No significant slopes are anticipated.
Below-Grade Structures	Up to 5 levels of below grade parking
Pavements	Anticipated traffic is as follows: ■ Autos/light pickup trucks: 2,000 vehicles per day ■ Light delivery vehicles: 5 vehicles per day ■ Trash collection trucks: 2 vehicles per weeks The pavement design period is 20 years.
Estimated Start of Construction	FY 2024 or 2025

GEOTECHNICAL CHARACTERIZATION

Site Geology

Formation [1]	Description	Lot/Area Anticipated
Leipers and Catheys Formations	Nodular, shaly limestone; fine- to coarse-grained limestone; phosphatic calcarenite; and light-gray cryptograined limestone.	All of Gold Lot except SW Corner near ramps
Bigby-Cannon Limestone and Hermitage Formation	Brownish-gray phosphatic calcarenite and light-gray to brownish-gray, cryptograined to medium- grained, even-bedded limestone.	All of Blue Lot and SW Corner of Gold Lot

1. *Geologic Map of the Nashville West Quadrangle, Tennessee* published by the State of Tennessee Department of Conservation, Division of Geology (1966).

The site is underlain by carbonate limestone that is highly susceptible to dissolution along joints and bedding planes in the rock mass. This results in voids and solution channels within the rock strata and a highly irregular bedrock surface. The weathering of the bedrock over geologic time and subsequent collapse or erosion of the overburden into these openings results in what is referred to as karst topography. Any construction in karst topography is accompanied by some degree of risk for future internal soil erosion and ground subsidence that could affect the stability of the rock supported structure. Our review of the available topographic and geologic mapping did not note any sinkholes on the site. Furthermore, the borings and geophysical testing performed at the site did not disclose any obvious signs of impending overburden collapse or soil softening at depth or any deep soil slots in bedrock due to karst activity.

Subsurface Conditions

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	**Asphalt and/or Fill**	Asphalt, subbase materials, and deleterious or undocumented fills
2	**Low RQD Bedrock**	Very Poor to Fair Rock Quality Limestone Bedrock
3	**High RQD Bedrock**	Good to Excellent Rock Quality Limestone Bedrock

Borings B-1, B-2, B-8, and B-9 were drilled within the proposed Blue Lot garage footprint. Borings B-3 through B-7 were drilled within the proposed Gold Lot garage footprint. Additionally, information from five borings, drilled by Goodwin, Mills, and Cawood (GM&C) was furnished to Terracon by Mr. Jim Siefert, with Hurst-Rosche, Inc. on May 24, 2022 via email correspondence. Borings from this report were conducted within the Blue Lot and are referred to as FB-1 through FB-5.

Gold Lot – Borings initially penetrated a pavement section consisting of about 2 ½ to 6 inches of asphalt over approximately 6 to 9 ½ inches of crushed aggregate base. Underlying the surface cover of asphalt pavement, the borings typically encountered fill consisting of lean to fat clay with brick, gravel, and construction material fragments extending to auger refusal. Borings in the Gold Lot encountered auger refusal depths varying from about 1 ½ to 7 ½ feet below existing grade. Rock coring techniques were then utilized to extend the borings to an approximate termination depth 65 feet (64 ½ to 66 ½ feet). Boring B-5 appeared to encounter a utility or a concrete casing and was abandoned at a depth of about 4 ½ feet below existing grade. Soft dig techniques were conducted to clear an offset boring location (B-5A). Boring B-5A encountered auger refusal at a depth of 2 feet and was subsequently extended to a terminal depth of 65 feet using rock coring techniques.

Blue Lot – Borings initially penetrated a pavement section consisting of about 2 to 6 inches of asphalt over approximately 3 to 8 ½ inches of crushed aggregate base. Underlying the surface cover of asphalt pavement, the borings typically encountered fill consisting of lean to fat clay with brick, gravel, and construction material fragments extending to auger refusal. Borings in the blue lot generally encountered auger refusal between approximately 1 ½ to 4 ½ feet below existing grade during the initial geotechnical exploration performed by GM&C in August 2016. Current exploration efforts indicate auger refusal depths varying from about 9 ¾ and 11 ¾ feet. The current borings were extended below refusal depths using rock coring techniques to determine the character and continuity of the refusal materials, with termination depths of approximately 20 ½ to 25 feet below existing grade. The coring indicates that auger refusal occurred on limestone bedrock.

We note the prior GM&C geotechnical report recommended removal and replacement of fill materials prior to construction at the site. We understand repaving and construction efforts were completed in 2021 based on aerial imagery of the site and discussions with the State of Tennessee. We further understand the repaving efforts included raising site grades with additional fill, which may explain the difference in auger refusal depths encountered in our current study.

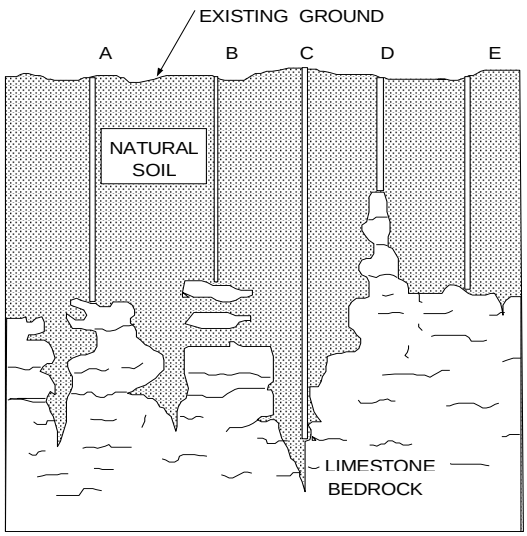
The following table summarizes the approximate fill thickness/depth to auger refusal, termination depth, and the approximate elevations of auger refusal and termination encountered at each boring location:

Boring No.	Existing Ground Elevation [1] (feet)	Approx. Thickness of Existing Fill/Depth to Auger Refusal (feet)	Termination Depth (feet)	Approximate Depth to Auger Refusal (feet)	Approximate Termination Elevation (feet)
B-1	483.5	10.4	20.4	473.1	463.1
B-2	488.3[1]	11.8	25	476.5	463.3[1]
B-3	526.7	7.5	65	519.2	461.7
B-4	525.9	1.5	64.5	524.4	461.4
B-5	526.6	1.5	4.5	525.1	522.1
B-5A	526.6	2	65	524.6	461.6
B-6	526.7	2.5	66	524.2	460.7
B-7	526.5	2.5	66.5	524	460
B-8	480.0	11.5	21.5	468.5	458.5
B-9	492.8	9.8	25	483	467.8
FB-1[3]	490[2]	2.5	2.5	487.5	487.5[2]
FB-2[3]	488[2]	3.1	3.1	484.9	484.9[2]
FB-3[3]	493[2]	1.3	1.3	491.7	491.7[2]
FB-4[3]	482[2]	3	3	479	479[2]
FB-5[3]	485[2]	4	4	481	481[2]

1. Elevation was interpolated by Collier Engineering, based on surrounding contour information.
2. Elevation was interpolated by USGS Lidar Derived Contour Data, collected in 2016 (USGS_LPC_TN_Eastern_2_16_B16)
3. Borings with FB designation were completed by GM&C prior to construction and repaving at the Blue Lot.

In an area of existing fill auger refusal can occur on man-made material, such as boulders, shot rock or construction debris such as similar to that encountered in boring B-5. In an area of limestone bedrock, auger refusal can result on slabs of unweathered limestone suspended in the residual soil matrix ("floaters" – shown as B), on rock "pinnacles" rising above the surrounding bedrock surface (shown as D), in widened joints that may extend well below the surrounding bedrock surface (shown as C), or on the upper surface of continuous bedrock (shown as E). Several of these possible auger refusal conditions are illustrated in the figure to the right.

AUGER REFUSAL ILLUSTRATION



THIS FIGURE IS FOR ILLUSTRATIVE PURPOSES ONLY AND DOES NOT NECESSARILY DEPICT THE SPECIFIC BEDROCK CONDITIONS AT THIS SITE

The limestone bedrock formations present beneath the project site are known for producing several obstructions that can cause the augers to refuse above sound bedrock. These obstructions, illustrated in examples A, B, C, and D, range from floaters (B) to rock pinnacles (D) as in the above figure. Depth to competent bedrock in areas of karst geology can vary greatly over short distances. The possibility of varying depths to bedrock should be considered when developing the design and construction plans for this project. In general, the top of rock surface is expected to be relatively consistent between and away from borings due to the prior construction at the site.

Rock coring procedures are generally required to determine the character and continuity of the auger refusal material and these factors must be considered when evaluating the depth to auger refusal in those test borings that are not cored. Rock core operations were performed at all borings to better explore the auger refusal materials at these locations. At these boring locations, auger refusal occurred on limestone bedrock. The bedrock materials sampled from the borings consist of medium gray, moderately weathered to unweathered, very thin to medium bedded limestone. Variation in the rock quality designation is expected and appears to be intermittent throughout the rock column, with much of the lowest RQD values occurring above the anticipated lowest level elevations of the garages. Cores obtained from the borings indicate the limestone is relatively continuous based on core recoveries varying from 70 to 100 percent and typically greater than 90 percent. Rock quality was very poor to excellent based on rock quality designation (RQD) values varying from 0 to 100 percent, with most of the cores collected having RQD values occurring between 70 and 100 (fair to excellent).

Geophysical Testing

Multi-Channel Analysis of Surface Waves – Terracon performed seismic testing consisting of four Multi-Channel Analysis of Surface Waves (MASW) arrays in each lot for a total of eight seismic lines. The locations of the geophysical and geotechnical tests are presented on Exhibit 1. The shear wave velocity cross-sections are displayed on Exhibit 2. The different seismic velocities, correlated with the boring logs of our investigation were used to identify the top of bedrock, changes in material/lithology, and potential karst/weathering features.

In general, low velocity zones (blue to light green on the color scale) are indicative of overburden, clay seams, and weathered/fractured rock. Higher velocity zones (dark green to red on the color scale) are indicative of competent bedrock. The primary goal of this survey was to assess conditions between and away from boring locations throughout the proposed garage footprint. A secondary objective was to determine a preliminary Seismic Site Classification in general accordance with procedures outlined in IBC 2018 and ASCE 7-16.

A variable top of rock surface was interpreted in Lines 1 through 4 (Gold Lot). The top of rock surface appears to vary between 30 feet below grade and 1 ½ feet below grade. We anticipate the top of rock surface at Line 1 may be impacted by the proximity to adjacent below grade construction and the actual top of rock surface will generally occur between 1 ½ and 15 feet below grade.

A consistent top of rock surface at the approximate 10-foot below ground surface depth was visible in lines 5 through 8 (Blue Lot). Line 4 was conducted in the only safely accessible array that also appeared to have a flat enough path for the MASW to be conducted on. Low velocity anomalies consistent with karst topography and weathering bedrock are outlined in magenta on our Exhibit 2. Additional information about the methods used to conduct our investigation is found in the **Exploration and Testing Procedures** section of this report.

Seismic Site Classification – Terracon also collected passive noise (also known as microtremor) records at the site. Individual one-dimensional plots were evaluated at each line location. We evaluated multiple scenarios for each seismic line (SSC) and the individual 1D plots are presented on Exhibit 3. To confirm the results of the passive testing, Terracon performed a downhole seismic test on August 23, 2022. The results of this testing are presented as an Appendix to this report and summarized in tabular form, below.

Line Number and Lot	Average Shear Wave Velocity (0 to 100 feet) in Feet Per Second	Average Shear Wave Velocity (Below Garage Footing Depth) in Feet Per Second	Depth of Assumed Garage Footing (feet)
Line 1 – Gold	1,804	3,236	50
Line 2 – Gold	2,086	4,156	50
Line 3 – Gold	2,115	4,221	50
Line 4 – Gold	1,998	4,115	50
Line 5 – Blue	1,996	3,720	15
Line 6 – Blue	1,976	3,427	15
Line 7 - Blue	2,265	N/A[1]	15
Line 8 - Blue	N/A[1]	N/A[1]	15
Downhole Seismic - Gold	8,741	9,372[2]	50

1. Results were not considered representative of actual geologic conditions due to the shallow nature of the investigation in the Blue Lot
2. The test refused early due to deviation within the borehole. As a result, the deepest value collected is assumed to extend to the 150-foot depth. Variation should be expected below the 50-foot depth.

A seismic site classification of A (greater than 5,000 feet per second) is acceptable for the site based on an average shear wave value of 9,372 feet per second in the Gold Lot. Based on the similar surface shear wave test results, similar geology, and previous project experience, a seismic site classification of A is also acceptable for the Blue Lot. Should specific shear wave values be required for this lot, independent of the Gold Lot values, Terracon should be contacted to provide a downhole seismic test in the Blue lot.

Depth to bedrock below the lowest level must be less than 10 feet for a seismic site classification of A. We anticipate the surficial soils will be removed at each proposed garage location and excavations will extend to a minimum of 15 feet into bedrock. Additional information can be found in the **Seismic Considerations** section of this report.

Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater was not observed in the 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 and bedrock 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 higher or lower than the termination depths shown on the boring logs. Perched water can also develop on top of bedrock or within the porous fill material. The possibility of groundwater level fluctuations and perched water should be considered when developing the design and construction plans for the project.

GEOTECHNICAL OVERVIEW

Based on the information obtained from our subsurface exploration, the site can be developed for the proposed parking garages. Due to the presence of existing undocumented fill and shallow rock, subgrade remediation will be required for building support. The limestone bedrock encountered at the site is suitable for building and pavement support. Based on the information obtained from our subsurface exploration, the following geotechnical considerations were identified:

- **Foundations** - Limestone bedrock is expected to be encountered at the anticipated garage foundation bearing subgrade elevations. Rock-bearing, shallow spread footings are recommended for the proposed structures due to expected relatively high column loads, shallow depth to bedrock, and based on the expected below grade garage elevations that foundation excavations by plan will extend to or within the bedrock surface. An allowable design bearing pressure of 100,000 psf will be appropriate for bedrock-supported footings. We recommend all footings be supported on relatively intact and fair or better quality limestone bedrock (REC/RQD values of at least 90/60% or better). Based on our borings, we expect good quality bedrock will typically be encountered at the planned foundation bearing elevation. Where intact bedrock is not encountered at the design footing bearing level, any loose or weathered rock pieces where present should be removed to expose intact natural bedrock and the area filled up to the planned footing contact elevation with lean concrete (Min. 2,000 psi strength). Care should be taken to not over-blast and loosen rock below the foundation-bearing elevation. Alternatively, footings may be extended and cast directly on intact bedrock. We recommend foundation predrilling or scratch test holes shall be performed beneath foundation bearing level to confirm the intact nature of the bedrock. The test holes shall extend into bedrock to a depth of at least 10 feet below foundation bearing level. We recommend that the geotechnical engineer be retained to observe and evaluate the foundation bearing materials and to confirm competent bedrock is encountered beneath foundation bearing.

Our boring data suggests that subgrade support conditions beneath the proposed garage floor slabs and pavements will predominantly include limestone bedrock though some areas may contain existing fill. Any existing fill remaining in slab and pavement areas where not penetrated by the planned building excavations should be removed and replaced with engineered granular rock fill to achieve suitable bearing for slab and pavement support.

Temporary shoring measures will be required where property lines or existing development limit the available space to lay back the overburden or highly weathered rock layers or deep soil pockets or slots in bedrock. Potential alternatives include soldier pile and lagging, soil nails with shotcrete, secant piles, and micropiles. Considering the expense of some of these options, consideration should be given to incorporating the shoring into the final retaining wall design.

- **Existing Fill** – About 1 ½ to 11 ¾ feet of existing fill was encountered in the borings. Fill consisted of lean to fat clay with brick, construction debris, and gravel fragments. Documentation regarding fill placement and compaction was not available to Terracon for review. Considering the project objectives of multiple below grade levels and uncertainties associated with the undocumented fill, we recommend the existing fill, where present within the proposed construction footprint, be undercut. We do not anticipate new fill will need to be placed based on the depth to bedrock and proposed garage depths. Terracon was informed that prior infrastructure may have been encountered during the previous repave of the Blue lot. Buried features including footings, slabs and utilities should be removed.

  The site is located in an area of downtown Nashville that has experienced several generations of development. In our experience, fill material is often present in these areas as a result of repeated development cycles. As such, there is the potential for the presence of contamination of these fill materials from undocumented sources, such as residue from railroad properties, former industrial operations, and coal burning / coal ash disposal. The presence of these “contaminated fill soils” is known locally as “urban soils”. The removal and disposal of these urban soils may have TDEC regulatory compliance requirements. During our review of the recovered samples, similar materials to those identified on other downtown properties that have classified as “urban soils” were noted in borings B-8 and B-9, located in the Blue Lot.

- **Rock Excavation –** All borings encountered auger refusal at relatively shallow depths on the order of about 1 ½ to 11 ¾ feet below existing grade on limestone bedrock, excluding B-5 which encountered concrete. Rippability of the bedrock will vary across the site depending on rock quality and depth of excavation. In general, the seismic velocities presented on our Exhibit 2 less than 2,500 feet per second are anticipated to be rippable if joints or fractures can be engaged with mechanical rippers. We expect the use of rock excavation equipment such as hoe-rams, jackhammers, rock trenchers and blasting will be required to remove more competent bedrock and achieve desired excavation depths for this project. The contractor

should exercise extreme care during rock excavation to minimize disturbance to the existing development in the proximity to the excavation.

- **Adjacent Structures –** Adjacent to the Gold Lot, the William Snodgrass Tennessee Tower has a Travertine Marble fascia installed. We understand that the initial construction and placement of the fascia included an epoxy resin to help anchor the individual panels to the building exterior. The fascia was imported from Italy and is considered irreplaceable. Terracon can provide vibration monitoring services and reporting during construction and blasting. The intention of this service is to monitor vibrations near the site and adjacent structures. Generally, risk of vibration damage to structures occurs above a certain peak particle velocity (PPV) established by a structural engineer and project stakeholders. In general, a PPV of no greater than 1.25 inches per second is allowed within 300 feet of a structure, 1.00 inches per second between 300 and 5,000 feet from a structure, and if distances are greater than 5,000 feet, 0.75 inches are acceptable, per the Blasting Standards Act of 2008.

- **Drainage** – We recommend a foundation drain be installed along the perimeter of the garages along the lower level to remove the expected water seepage or perched water on the bedrock surface or at water bearing seams or bedding planes below the current bedrock surface. We also recommend underdrains be installed below the floor slabs in the lower level of the garages. The drainage system for the below grade garages should also include an automatic sump pump with battery backup to remove the expected perched water on top of bedrock to outside the garage footprint.

- **Karst Risk** – The site is situated in karst terrain and is underlain by porous limestone and the risk for sinkhole development should be recognized in this geological setting. Our review of the available topographic and geologic mapping and site reconnaissance did not note any closed depressions/sinkholes at the site nor in close proximity of the site. However, blasting and rock excavation efforts may introduce near surface fractures that allow for soil raveling and erosion into the subsurface. Furthermore, deep soil slots in bedrock and vertical cutters and a highly irregular bedrock surface are common in karst topography and may be encountered during construction.

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

EARTHWORK

Earthwork is anticipated to include clearing, demolition 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

All existing above and below grade components of previous buildings including footings, slabs, walls, pavements, utilities, old undocumented fill, any vegetation and topsoil should be removed from the entire development area prior to placing any new fill and new construction. If soil subgrades are exposed at finished grades or are to receive fill, they should be proofrolled with a fully-loaded tandem-axle dump truck. The proofrolling should be performed under the direction of the Geotechnical Engineer. Areas excessively deflecting under the proofroll should be delineated and subsequently addressed by the Geotechnical Engineer.

After demolition, stripping and necessary excavations, the mass excavation may proceed to the proposed elevations for the below grade levels of the garages. Once rough subgrade elevation has been achieved across the construction footprint, any unstable soil, old fill, loose, or detached rock fragments should be removed from the entire construction footprint to intact limestone bedrock. The undercut areas in intact bedrock should be backfilled with lean concrete in footing areas and approved engineered granular fill in slab and pavement areas as directed by the geotechnical engineer and discussed herein.

Overburden and any loose and/or weathered rock, regardless of its stability, should be removed to intact bedrock from beneath all footings as outlined herein. Undercut areas should be backfilled with lean concrete to intact bedrock. Any deep soil slots in bedrock, where encountered below bearing level, will require further evaluation by a Terracon engineer and appropriate repairs for these features should be addressed on a case-by-case basis based on conditions observed by the engineer.

As noted in **Geotechnical Characterization**, borings encountered existing undocumented fill to depths varying from about 1 ½ to 11 ¾ feet. Based on boring data, most existing fill appears to have been placed in an uncontrolled manner and is characterized as “uncontrolled fill”. Therefore, we recommend existing fill, if not removed by planned building excavations, should be mass undercut to suitable natural subgrade within the building pads and 10 feet beyond the lateral limits of the building footprints. When fill is removed, the undercut subgrade should be proof-rolled with heavy loaded dump truck to aid in delineating areas of soft, or otherwise unsuitable soil. Any weak soils uncovered during proofroll should be repaired as directed by the project geotechnical engineer of his representative.

We expect mass grading cuts and building and utility excavations will engage the bedrock surface and will require rock excavation techniques to achieve the desired excavations depths. We expect blasting, use of rock trenchers, hoe ram equipment, line drilling, or hydraulic splitting will be required to remove bedrock and achieve desired excavation depths.

Where unstable soils are identified by proofrolling, stabilization could include scarification, moisture conditioning, and compaction, or full-depth removal and replacement with new engineered fill. The appropriate method of improvement, if required, would depend on factors

such as schedule, weather, the size of area to be stabilized, and the nature of the instability. More detailed recommendations can be provided during construction as the need for subgrade stabilization occurs. Performing site grading operations during warm, dry periods would help reduce the amount of subgrade stabilization required. Subgrade stabilization techniques are discussed in the following paragraphs:

- **Scarification and Recompaction** - It may be feasible to scarify, dry, and recompact the exposed soils. The success of this procedure would depend primarily upon favorable weather and sufficient time to dry the soils. Even with adequate time and weather, however, stable subgrades may not be achievable if the thickness of the soft soil is greater than 1 to 1-½ feet.

- **Chemical Stabilization –** If the required subgrade stabilization is relatively extensive, chemical modification may be more practical than scarification and recompaction, or undercutting and placement of crushed stone, with or without geotextiles. The use of Portland cement or by-product lime (lime kiln dust) could be considered for shallow stabilization, or stabilization after partial undercutting. We recommend stabilization methods be further evaluated at the time of construction. We recommend that a mix design be performed with samples of the chemical agent to be used and the site soils. This will aid in optimizing the mix design and evaluating for potential negative reactions such as sulfate induced heave. Since the agents can vary significantly in terms of chemical composition, it will be important that samples of the actual proposed modifying agent be used in the laboratory mix design. With all chemical modification methods, proper mixing and control of clod sizes, moisture conditions, and compaction are critical. We recommend that only experienced contractors perform chemical modification and that they provide detailed descriptions of their proposed procedures and equipment, as well as a list of projects successfully completed in the last 5 years.

- **Crushed Stone** - Crushed stone or gravel could be used to improve subgrade stability. Typical undercut depths would likely range from 2 to 4 feet below finished subgrade elevation. The use of high modulus geotextiles (i.e., engineering fabric or geogrid) could also be considered after underground work such as utility construction is completed. Equipment should not be operated above the fabric or geogrid until one full lift of crushed stone fill is placed above.

  The maximum particle size of granular material placed over geotextile fabric or geogrid should not exceed 1-½ inches. Geotextiles can also be considered for severe subgrade conditions during winter months. It should be expected that minimum of 12 to 18 inches of select fill will be required with any geogrid application. The geogrid product manufacturer should recommend select fill gradation requirements.

- **Shot Rock** – Clean well graded shot rock can also be used to stabilize unstable subgrade. The thickness of shot rock required to achieve bridging of the unstable subgrade will depend upon the extent of subgrade stability. A test strip should be initially prepared at the site to

determine the minimum required shot rock fill thickness to achieve subgrade stability. Shot rock particle size should not exceed 18 inches and should be compacted using a heavy-duty vibratory roller or D-6 size bulldozer.

Fill Material Types

Fill required to achieve design grade should be classified as structural fill. Structural fill is material used below, or within 10 feet of structures, pavements or constructed slopes. Compacted structural fill should meet the following material property requirements:

Fill Type [1]	USCS Classification	Acceptable Location for Placement
Lean concrete or flowable fill (min. 2,000 psi) [2]	--	Beneath footings
Well graded granular	GW [3]	Beneath floor slabs and pavements
Existing Fill	CL	Existing fill and/or clayey soils are not recommended for reuse. Clean approved natural clay can be used in pavements areas.
Clean well graded processed rock, shot rock (max. rock size 12 inches) or surge stone (max. rock size 8 inches) [4]	--	Beneath floor slabs and pavements

1. Structural and general fill should consist of approved materials 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 prior to use on this site.
2. Minimum 28-day compressive strength of 2,000 psi.
3. Similar to TDOT Section 903.05 Type A, Grading D crushed limestone aggregate, limestone screenings, or granular material such as well graded gravel or crushed stone (pug mix). Any fill to be used in footing undercut areas should consist of lean concrete.
4. Approval of shot rock and surge stone should be made prior to placement. Any rock fill containing more than 5% clay fines should not be used as engineered fill.

Fill Compaction Requirements

Structural and general fill should meet the following compaction requirements.

Item	Structural Fill
Maximum Lift Thickness	8 inches or less in loose thickness when heavy, self-propelled compaction equipment is used 4 to 6 inches in loose thickness when hand guided equipment (i.e., jumping jack or plate compactor) is used
Minimum Compaction Requirements [1, 2, 3]	98% of material's standard Proctor maximum dry density below foundations, floor slabs and pavement subgrades Shot rock should be placed in max. 18-inch thick lifts and compacted with a heavy-duty vibratory smooth drum roller or D-6 class dozer. Surge should be placed in max. 12-inch thick lifts. Each lift of shot rock or surge fill should be compacted using a minimum of ten passes, five in one direction and five that are at a right angle to the initial passes. A complete pass consists of complete coverage of the surface with the tracks (roller). Passes should continue until the rock fill does not yield.
Water Content Range [1]	Cohesive: -1% to +3% of optimum Granular: -2% to +2% of optimum

1. Maximum density and optimum water content as determined by the standard Proctor test (ASTM D 698).
2. High plasticity cohesive fill should not be compacted to more than 100 percent of standard Proctor maximum dry density.
3. If the granular material is a coarse sand or gravel, or of a uniform size, or has a low fines content, compaction comparison to relative density may be more appropriate. In this case, granular materials should be compacted to at least 70% relative density (ASTM D 4253 and D 4254).

Utility Trench Backfill

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

Grading and Drainage

Final surrounding grades should be sloped away from the structures on all sides to prevent ponding of water. Gutters and downspouts that drain water a minimum of 10 feet beyond the footprint of the proposed structures are recommended. This can be accomplished through the use of splash-blocks, downspout extensions, and flexible pipes that are designed to attach to the end of the

downspout. Flexible pipe should only be used if it is daylighted in such a manner that it gravity-drains collected water. Splash-blocks should also be considered below hose bibs and water spigots.

We recommend a foundation drain be installed along the perimeter of the garages along the lower level to remove the expected water seepage or perched water on the bedrock surface. We also recommend underdrains be installed below the floor slab in the lower level of the garages. The drainage system for the below grade garage should also include an automatic sump pump with battery backup to remove the expected perched water outside the garage footprint. Floor slab underdrains may consist of 4- to 6-inch diameter perforated pipes surrounded by #57 stone and wrapped with filter fabric (geotextile). Underdrain pipes should be properly sloped to the lowest sump pit area equipped with an automatic pump with a battery backup system. The rate of expected groundwater seepage is difficult to predict at this time and should be confirmed at the time of construction. Underdrains should be properly designed based on the expected seepage water flow. Based on our experience on other projects in the downtown Nashville area, underdrains are typically spaced at 25 to 75 feet on center depending upon the amount of seepage water. However, we recommend the underdrain spacing should be determined based on the actual flow rate of the seepage water. If a flow rate for seepage water is required, we recommend groundwater monitoring wells or piezometers be installed at the site to determine groundwater flow rate or a relatively conservative flow rate be used in design and then field verified at the time of construction and any adjustments be made in underdrain design.

Earthwork Construction Considerations

The quality of the bedrock as interpreted by our review of the core samples suggests that methods such as blasting, rock trenchers, hoe ram equipment, line drilling, hydraulic splitting, etc. will be required to remove bedrock at this site. The contractor should exercise extreme care during rock excavation to minimize disturbance to adjacent structures and other development. We recommend a pre-blast survey be conducted for the existing structures in close proximity, and this task is normally required of construction firms' insurance carriers for construction work occurring in developed areas in general and when blasting is concurrently utilized in particular. In addition, vibration monitoring should be performed at any existing nearby improvements considered critical or vibration sensitive during blasting.

Any areas where soil subgrade is cut to final grade within 1 to 2 feet of bedrock should be expected to be unstable and will require further undercutting to bedrock. The contractor should be prepared to perform additional undercut where soils just above the rock surface contain a high water content. Backfill at these locations typically requires a granular fill or clean shot rock.

Considering the expected depth of excavation within bedrock, we believe blasting will be required to achieve the desired excavation depths. Published geologic literature indicates the Bigby-Cannon Limestone Formation has an excavation difficulty rating of 2, and Hermitage Leipers and Catheys

Formations have an excavation difficulty rating of 3. An explanation of the ratings is shown in the following table.

Excavation Difficulty Rating	
Rating	**Description of Excavation Condition**
1	Very thick bedded limestone with cutter-pinnacle development. Rock breaks with difficulty even by blasting, large rock left after initial blast require secondary drilling and blasting
2	Medium bedded limestone with moderately even bedrock surface, blast transmitted uniformly
3	Thin bedded limestone, rock breaks readily with minimal blasting
4	Semi-consolidated or otherwise weak material that can be ripped (shale, chert beds in residuum, some thin bedded siltstone)
5	Unconsolidated material, blasting unnecessary, ordinary digging required.

The expected blasting may result in bedrock disturbance below the desired depth. Loosed bedrock pieces should be removed from beneath foundation bearing to undisturbed intact bedrock.

Where rock is relatively intact and good quality, the rock cut may be pre-split to near vertical configuration. Depending on the designer's preference, exterior faces for the basement levels in deep cut areas might consist of cast in place walls (using double-sided forms or with a single form and casting concrete against the rock cut), or the exposed fresh cut rock face. Site geometry and proximity to existing development (buildings, roads, sidewalks, and utilities), however, may not permit temporary layback of existing overburden along the proposed garage perimeter. Temporary engineer-designed shoring may possibly be required to retain overburden and help protect adjacent existing development. Considering the expense of some options (i.e., soldier piles with lagging, soil nails, secant piles, etc.), consideration may be given to incorporate such shoring into the final exterior wall design. Selection of the preferred method would be dictated by conditions encountered and by the logistics of the potential incorporation of the shoring system into the final wall configuration. Additional drilling, if desired, could be conducted to augment the current exploration data and to confirm shoring needs or to determine if near vertical cuts in bedrock could be achieved.

Weathered slots (mud cutters) or joints within limestone bedrock due to solution weathering are common in the geological setting present at the site. Any intervening soil which remains at the finished cut subgrade below foundations, which is expected to be predominately intact bedrock, should be removed (by hand tools if possible) and replaced with lean concrete to provide uniform bearing for spread footings. Compacted aggregate fill may be used in lieu of lean concrete for the floor slab. Our understanding of the plan for the lower level of the garages as well as the information obtained from borings suggest that rock bearing shallow spread footings would be

appropriate. However, in deep cutters where soil removal/replacement with lean concrete is not feasible due to excessive depth, a rock bearing deep foundation system such as drilled shafts or micropiles may be used.

Competent and/or relatively intact bedrock may be excavated or pre-split to a near-vertical face. Occasional deep soil filled cutters could exist within the bedrock excavation. The soils on this site may be preliminarily classified as Type C in accordance with OSHA regulations CFR 1926. The overburden material should be temporarily sloped no steeper than 1.5 horizontal to 1 vertical. Flatter slopes may be necessary depending on the overall stability of the excavated material.

The grading contractor, by his contract, is usually responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations as required, to maintain stability of both the excavation sides and bottom. All excavations should be sloped or braced to comply with applicable local, state and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

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, and/or state regulations.

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.

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 and topsoil, proofrolling, and mitigation of areas delineated by the proofroll to require mitigation.

Each lift of compacted fill should be tested, evaluated, and reworked, as necessary, until approved by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency of at least one test for every 2,500 square feet of compacted fill in the building areas and 5,000 square feet in pavement areas. One density and water content test should be performed for every 50 linear feet of compacted utility trench backfill.

In areas of foundation excavations, the bearing subgrade should be evaluated under the direction of the Geotechnical Engineer. If unanticipated conditions are encountered, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the

continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

SHALLOW FOUNDATIONS

Assuming the site is prepared as directed herein, the proposed garages can be supported on shallow spread footings bearing on intact fair or better quality limestone bedrock or on lean concrete (min. 2,000 psi strength) extending to intact bedrock. Any loose or weathered rock or clay seams, where encountered at/below foundation bearing, should be undercut to intact fair to good quality bedrock. The undercut should be backfilled with lean concrete to the planned bottom of footing elevation, or the footing extended to bear directly on the intact bedrock. Design recommendations for shallow foundations are presented below.

Design Parameters – Compressive Loads

Description	Column	Wall
Net allowable bearing pressure [1]	100,000 psf	100,000 psf
Minimum dimensions	30 inches	18 inches
Minimum embedment below exterior finished grade for frost protection [2]	18 inches	18 inches
Approximate total settlement [3]	< ½ inch	< ½ inch
Estimated differential settlement	< ½ inch between columns	<½ inch over 40 feet
Allowable passive pressure [4]	500 psf (4,000 psf for intact bedrock)	
Ultimate coefficient of sliding friction	0.65	

1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. Assumes footings are supported on intact limestone bedrock (REC/RQD values of at least 90/60 or better) and any soil and/or weathered or loose rocks, where present, will be undercut and replaced with lean concrete (min. 2,000 psi strength) extending to intact bedrock. Foundation predrilling or scratch test holes shall be performed beneath each foundation bearing level to confirm relatively intact and fair or better quality bedrock. The test holes shall extend into bedrock to at least 10 feet below foundation bearing level.
2. For perimeter footing and footings beneath unheated areas.
3. The foundation settlement will depend upon the variations within the subsurface profile, the structural loading conditions, the embedment depth of the footings, and the quality of the earthwork operations. The above settlement estimates have assumed that the footings will be supported on natural intact limestone bedrock and/or lean concrete extending to intact bedrock.
4. The sides of the excavation for the spread footing foundation must be nearly vertical and the concrete should be placed neat against these vertical faces for the passive earth pressure values

to be valid. If the loaded side is sloped or benched, and then backfilled, the allowable passive pressure will be significantly reduced.

Construction Adjacent to Existing Building

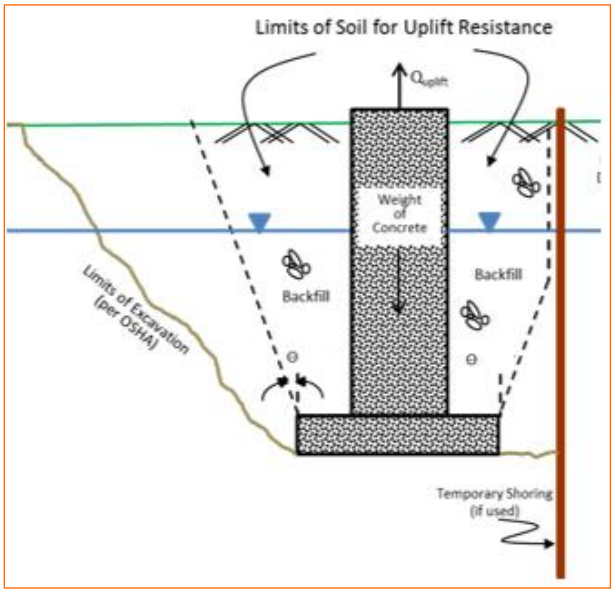
Differential settlement between the garage addition at the Gold Lot and the existing building is expected to approach the magnitude of the total settlement of the addition. Expansion joints should be provided between the existing building and the proposed addition to accommodate differential movements between the two structures. Underground piping between the two structures should be designed with flexible couplings and utility knockouts in foundation walls should be oversized, so minor deflections in alignment do not result in breakage or distress. Care should be taken during excavation adjacent to existing foundations, to avoid disturbing existing foundation bearing or removing foundation supporting material without providing support from other means.

New footings should bear at or near the bearing elevation of immediately adjacent existing foundations. Depending upon their locations and current loads on the existing footings, footings for the new addition could cause settlement of adjacent walls. To reduce this concern and risk, clear distances at least equal to the new footing widths should be maintained between the addition's footings and footings supporting the existing building.

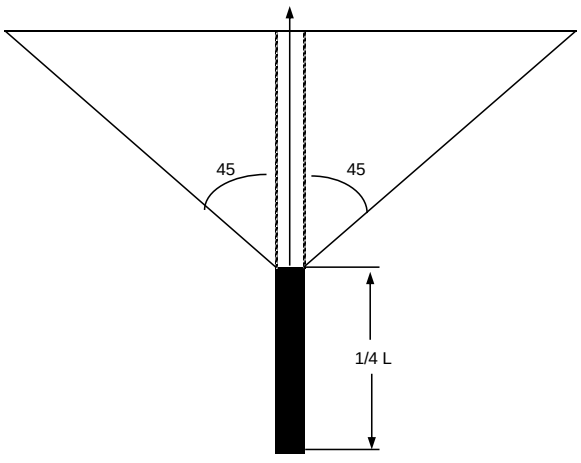
Depending on final design and method of construction, it is possible that existing foundations may support additional load from the new addition. Additional loads on the existing foundations could cause other building settlements to occur. The structural capacity of existing foundations should be evaluated by a licensed structural engineer, where increases in loading are planned.

Design Parameters - Uplift Loads

Uplift resistance of spread footings can be developed from the effective weight of the footing and the overlying soils. As illustrated on the subsequent figure, the effective weight of the soil prism defined by diagonal planes extending up from the top of the perimeter of the foundation to the ground surface at an angle, θ, of 20 degrees from the vertical can be included in uplift resistance. The maximum allowable uplift capacity should be taken as a sum of the effective weight of soil plus the dead weight of the foundation, divided by an appropriate factor of safety. A maximum total unit weight of 100 pcf should be used for the backfill. This unit weight should be reduced to 40 pcf for portions of the backfill or natural soils below the groundwater elevation.



While we have not been provided with uplift loads for the proposed structures at this time, similar structures supported on shallow foundations bearing on rock have utilized rock anchors as a feasible and cost-effective method of resisting uplift forces. Prior to any rock anchor and foundation construction, the base of all foundation excavations should be essentially horizontal and free of water, soil and loose or detached rocks prior to placing concrete. In addition, rock surfaces beneath foundations that are exposed after overburden removal and that are to be filled with lean concrete should be horizontal. Lateral loads and uplift loads can also be resisted using rock anchors. If foundations are designed with rock anchors, they should rest on relatively intact bedrock with no clayey seams and weathered rock lenses. Intact bedrock for the purposes of this report is any rock (that cannot be excavated with a large size trackhoe or other heavy-duty excavator) having REC/RQD values at least 90/60 or better.



Rock anchors should extend into competent bedrock a sufficient depth to provide ample resisting forces for upward movements, and to obtain adequate bond length with the grout and rock, and grout and anchor rod. Uplift capacity of individual rock anchors should be calculated based on the weight of a cone of rock as shown in the adjacent diagram. Additional resistance will be provided by the friction across the fractures which can be taken as an angle (ϕ) equal to 45 degrees. The apex of the cone should be placed from 0 to 1/4 of the way up from the bottom tip, depending on the anchor type. We recommend that a unit weight (γ) of 150

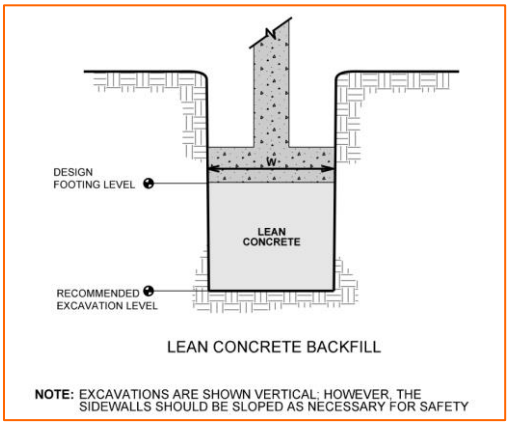
pounds per cubic foot (pcf) be used for intact bedrock. An allowable bond strength of 100 pounds per square inch (psi) should be adequate for the limestone-grout interface when 3,000 psi strength grout is used. A factor of safety of 2.0 has been used for calculating the allowable grout-rock bond strength. Bond strength between the grout and anchor will be dependent on the anchor type and grout strength.

A proof load test should be conducted on each anchor installed. For proof testing, the anchor is initially loaded with a seating load of 10 percent of the design load. Subsequently, the anchor is stressed in increments of 25 percent of the design load with elongation measurements recorded at each increment. Proof loading is applied in sequential increments in one cycle and is generally carried to 125 percent of the design load. A reasonable period of time is allowed between load increments so that the anchor elongation has stabilized before starting the next load increment. The maximum proof load is held for a period of between 5 minutes and one hour. In no case should an anchor be loaded to more than 80 percent of the ultimate tensile capacity of the steel tendon. Given the quality of the bedrock encountered, we recommend the test method described in ASTM D4435 be used for the load testing. This method tests the rock to anchor bond and does not test for rock cone failure.

Foundation Construction Considerations

As noted in **Earthwork**, the footing excavations should be evaluated under the direction of the Geotechnical Engineer. The boring results indicate that limestone bedrock should be exposed at the finished subgrade across the entire lower level of the garage footprints where cuts on the order of 15 to 20 feet are expected at the Blue Lot, and cuts of up to about 50 are expected at the Gold Lot.

Although not anticipated based on our exploratory borings, if soil seams or loose/weathered bedrock are encountered at the base of the planned footing excavation, the excavation should be extended deeper to suitable bedrock, and the footings could bear directly on the suitable bedrock at the lower level or on lean concrete backfill placed in the excavations. This is illustrated on the sketch below.



Foundation predrilling or scratch test holes shall be performed beneath foundation bearing level to confirm the intact nature of the bedrock. The test holes shall extend into bedrock to a depth of at least 10 feet below foundation bearing level. We recommend that the Geotechnical Engineer be retained to observe and evaluate the foundation bearing materials and to confirm competent, intact bedrock is encountered beneath foundation bearing elevations and establish acceptable criteria prior to placement of formwork. This additional testing is typical for rock bearing foundations in assisting the contractor in identifying the continuity of the underlying bedrock and potential for voids or clay filled seams that may require additional selective undercutting to reach more competent bearing material.

The base of all foundation excavations should be essentially horizontal and free of water, soil and loose or detached rocks prior to placing concrete. In addition, rock surfaces beneath foundations that are exposed after overburden removal and that are to be filled with lean concrete should be horizontal. Rock removal or excavation may result in bedrock disturbance below the desired depth. Loosed bedrock pieces should be removed and replaced with lean concrete.

SEISMIC CONSIDERATIONS

The seismic design requirements for buildings and other structures are based on Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7 and the International Building Code (IBC). The results of our seismic testing outlined above in the report should be considered as approximate. Based on the bedrock properties encountered at the site and as described on the exploration logs and results, it is our professional opinion that the **Seismic Site Classification is A** for both the Gold and Blue Lots. Subsurface explorations at this site were extended to a maximum depth of 65 feet. The site properties below the boring depth to 100 feet below the estimated footing depths were estimated based on our downhole and surface seismic shear wave testing results, experience, and knowledge of geologic conditions of the general area. A downhole seismic test was performed for the site to verify deep bedrock velocity profiles are representative. This method is generally considered as more accurate than surface shear wave results and the results from this test were used to determine the seismic site classification for the Gold Lot.

Description	Value
2018 International Building Code Site Classification	Gold Lot A [1,2,3]

Description	Value

1. Seismic site classification in general accordance with the *2018 International Building Code*, which refers to ASCE 7-16 for site class definition
2. Chapter 20 of ASCE 7 requires a site soil profile determination extending a depth of 100 feet for seismic site classification. The current scope requested does not include the required 100-foot soil profile determination. Borings for the buildings extended to a maximum depth of about 65 feet.
3. Site Class A is defined by the 2018 IBC as the "Hard Rock" Category. The 2018 IBC does not permit the use of Site Class A if more than 10 feet of soil is between the rock surface and the bottom of the spread footing. However, based on our understanding of the project and construction, the soils will be removed, and the foundations will rest on native bedrock or upon lean concrete extending to bedrock, allowing the use of this site class.

FLOOR SLABS

Based upon the anticipated finished lower level elevations of the garages, we anticipate intact bedrock to be present at the subgrade level, which will be undercut and replaced with approved structural fill such that the floor slab is supported on at least 12 inches of free-draining aggregate material or surge stone. We anticipate the use of an underslab drainage system for the proposed development and sloped towards sump areas.

Design parameters for floor slabs assume the requirements for **Earthwork** have been followed. Specific attention should be given to positive drainage away from the structure and positive drainage of the aggregate base beneath the floor slab.

Floor Slab Design Parameters

Item	Description
Floor Slab Support [1]	Minimum 12 inches of free-draining (less than 5% passing the U.S. No. 200 sieve) crushed aggregate compacted to at least 95% of ASTM D 698 [2, 3]
Estimated Modulus of Subgrade Reaction [2]	150 pounds per square inch per inch (psi/in) for point loads

1. Floor slabs should be structurally independent of building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
2. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in **Earthwork**, and the floor slab support as noted in this table. It is provided for point loads. For large area loads the modulus of subgrade reaction would be lower.
3. Free-draining granular material should have less than 5% fines (material passing the No. 200 sieve). Other design considerations such as cold temperatures and condensation development could warrant more extensive design provisions.

The use of a vapor retarder should be considered beneath concrete slabs on grade covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder,

the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

Saw-cut control joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations refer to the ACI Design Manual. Joints or cracks should be sealed with a water-proof, non-extruding compressible compound specifically recommended for heavy duty concrete pavement and wet environments.

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

Mitigation measures, as noted in **Earthwork**, are critical to the performance of floor slabs. In addition to the mitigation measures, the floor slab can be stiffened by adding steel reinforcement, grade beams and/or post-tensioned elements.

Floor Slab Construction Considerations

The Geotechnical Engineer should approve the condition of the floor slab subgrades immediately prior to placement of the floor slab support course, reinforcing steel, and concrete. Attention should be paid to high traffic areas that were rutted and disturbed earlier, and to areas where backfilled trenches are located.

Prior to construction of grade supported slabs, varying levels of remediation may be required to reestablish stable subgrades within slab areas due to construction traffic, rainfall, disturbance, desiccation, etc. As a minimum, the following measures are recommended.

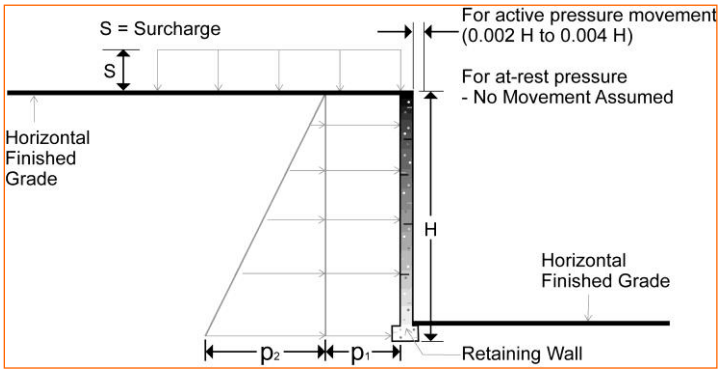
- Confirm that interior trench backfill placed beneath slabs is compacted in accordance with recommendations outlined in this report.
- All floor slab subgrade areas should be moisture-conditioned and properly compacted to the recommendations in this report immediately prior to placement of the stone base and concrete.

LATERAL EARTH PRESSURES

Design Parameters

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction

and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown 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 basement walls, loading dock walls, or other walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated).



Lateral Earth Pressure Design Parameters				
Earth Pressure Condition [1]	**Coefficient for Backfill Type** [2]	**Surcharge Pressure** [3, 4, 5] **p_1 (psf)**	**Effective Fluid Pressures (psf)** [2, 4, 5]	
			Unsaturated [6]	**Submerged** [6]
Active (Ka)	Granular - 0.31	(0.31)S	(40)H	(80)H
	Fine Grained - 0.41	(0.41)S	(50)H	(85)H
At-Rest (Ko)	Granular - 0.47	0.47)S	(55)H	(90)H
	Fine Grained - 0.58	(0.58)S	(70)H	(95)H
Passive (Kp)	Granular - 3.25	---	(390)H	(250)H
	Fine Grained - 2.46	---	(295)H	(205)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% 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. To achieve “Unsaturated” conditions, follow guidelines in **Subsurface Drainage for Below-Grade Walls** below. “Submerged” conditions are recommended when drainage behind walls is not incorporated into the design.

Backfill placed against structures should consist of granular soils 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.

Note that retaining walls which retain aggregate fill against intact bedrock can be designed using K'o from the Silo Equation provided below.

K'o = [1/ (2*Tan(delta))]*[(b/z)*[1-exp (-2Ko*Z/b*tan(delta))]

Gama = unit weight of aggregate fill

b = distance between wall and rock

z = depth below ground surface

delta = angle of friction between wall and fill

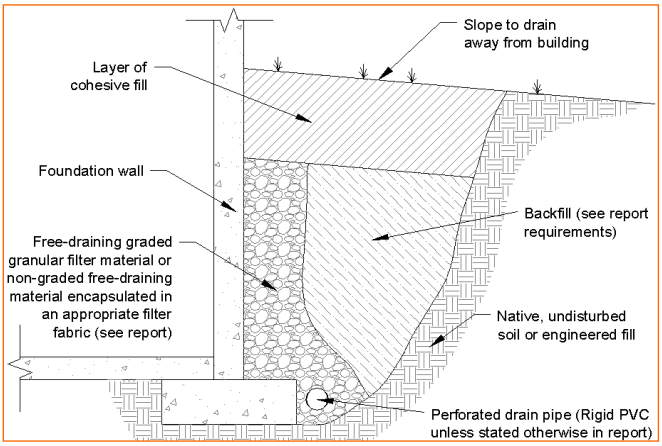
Phi = angle of internal friction of soil

Ka = active earth pressure

Ko = at rest earth pressure

Subsurface Drainage for Below-Grade Walls

A perforated rigid plastic drain line installed behind the base of walls and extends below adjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line around a below-grade building area or exterior retaining wall should be placed near foundation bearing level. The drain line should be sloped to provide positive gravity drainage to daylight or to a sump pit and pump. The drain line should be surrounded by clean, free-draining granular material having less than 5% passing the No. 200 sieve, such as No. 57 aggregate. The free-draining aggregate should be encapsulated in a filter fabric. The granular fill should extend to within 2 feet of final grade, where it should be capped with compacted cohesive fill to reduce infiltration of surface water into the drain system.



As an alternative to free-draining granular fill, a pre-fabricated drainage structure may be used. A pre-fabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion, and is fastened to the wall prior to placing backfill.

PAVEMENTS

General Pavement Comments

Pavement designs are provided for the traffic conditions and pavement life conditions as noted in **Project Description** and in the following sections of this report. A critical aspect of pavement performance is site preparation. Pavement designs noted in this section must be applied to the site which has been prepared as recommended in the **Earthwork** section.

On most project sites, the site grading is accomplished relatively early in the construction phase. Fills are placed and compacted in a uniform manner. However, as construction proceeds, excavations are made into these areas, rainfall and surface water saturates some areas, heavy traffic from concrete trucks and other delivery vehicles disturbs the subgrade and many surface irregularities are filled in with loose soils to improve trafficability temporarily. As a result, the pavement subgrades, initially prepared early in the project, should be carefully evaluated as the time for pavement construction approaches.

We recommend the moisture content and density of the top 12 inches of the subgrade be evaluated and the pavement subgrades be proof rolled within two days prior to commencement of actual paving operations. Areas not in compliance with the required ranges of moisture or density should be moisture conditioned and recompacted. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the materials with properly compacted fills. If a significant precipitation event occurs after the evaluation or if the surface becomes disturbed, the subgrade should be reviewed by qualified personnel immediately prior to paving. The subgrade should be in its finished form at the time of the final review.

Pavement Design Parameters

Traffic patterns and anticipated loading conditions were not available. However, we anticipate that traffic loads will be produced primarily by automobile traffic and a limited number of delivery and trash removal trucks. Two pavement section alternatives have been provided. The light duty section is for areas that receive only car traffic. The heavy-duty section assumes car traffic and 7 delivery vehicles and trash removal trucks per week. If heavier traffic loading is expected, this office should be provided with the information and allowed to review these pavement sections. A design life of 20 years was assumed to develop the total traffic used in thickness design. A California Bearing Ratio (CBR) value of 4 has been estimated for approved stable onsite clayey soils or new engineered fill. To help obtain this CBR value in the field, the upper 12 inches of pavement subgrades should be compacted to at least 98 percent of the standard Proctor density at moisture content within -1 to +2 percent of its optimum moisture. A modulus of subgrade reaction of 100 pci was use for the PCC pavement designs. The values were empirically derived based upon our experience with the describe soil type subgrade soils and our understanding of the quality of the subgrade as prescribed by the **Site Preparation** conditions as outlined in **Earthwork**. A modulus of rupture of 600 psi was used for pavement concrete.

Climatic conditions are considered in the design subgrade support value listed above and in the paving material characteristics. Recommended paving material characteristics, taken from the Tennessee Department of Transportation's (TDOT) 2015 edition of Standard Specifications for Road and Bridge Construction are included for the asphalt concrete sections.

Pavement Section Thicknesses

The following table provides options for AC and PCC Sections:

Asphaltic Concrete Design		
Layer	**Thickness (inches)**	
	Light Duty [1]	**Heavy Duty** [1]
AC Surface [2]	1.5	1.5
AC Binder [2]	1.5	2.5
Aggregate Base [2]	6	8

Asphaltic Concrete Design		
Layer	**Thickness (inches)**	
	Light Duty [1]	**Heavy Duty [1]**

1. See **Project Description** for more specifics regarding Light Duty and Heavy Duty traffic.
2. All materials should meet the current State of TN department of Transportation (TDOT) Standard Specifications for Highway and Bridge Construction.
   - Asphaltic Surface – TDOT Section 903.11 for Surface Course, Grading E
   - Asphaltic Base – TDOT Section 903.06 for Hot Mix Asphalt Leveling Course, Grading B-M
   - Section 903.05 for Aggregate Base Course material, Class A, Grading D □
   - A minimum 1.5-inch surface course should be used on ACC pavements

Portland Cement Concrete Design			
Layer	**Thickness (inches)**		
	Light Duty [1]	**Heavy Duty [1]**	**Dumpster Pad [3]**
PCC [2,4]	5	6 ½	7
Aggregate base [2]	4	4	4

1. See **Project Description** for more specifics regarding traffic classifications.
2. All materials should meet the current Tennessee Department of Transportation (TDOT) Standard Specifications for Highway and Bridge Construction.
3. In areas of anticipated heavy traffic, fire trucks, delivery trucks, or concentrated loads (e.g. dumpster pads), and areas with repeated turning or maneuvering of heavy vehicles.
4. Portland concrete should be 4,000 psi compressive strength at 28 days, 4-inch maximum slump and 5 to 7 percent air entrained, 6-sack min. mix. PCC pavements are recommended for trash container pads and in any other areas subjected to heavy wheel loads and/or turning traffic such as entrance aprons.

The estimated pavement sections provided in this report are minimums for the assumed design criteria, and as such, periodic maintenance should be expected. Areas for parking of heavy vehicles, concentrated turn areas, and start/stop maneuvers could require thicker pavement sections. Edge restraints (i.e., concrete curbs or aggregate shoulders) should be planned along curves and areas of maneuvering vehicles. A maintenance program including surface sealing, joint cleaning and sealing, and timely repair of cracks and deteriorated areas will increase the pavement's service life. As an option, thicker sections could be constructed to decrease future maintenance.

Concrete for rigid pavements should have a minimum 28-day compressive strength of 4,000 psi, and be placed with a maximum slump of 4 inches. Although not required for structural support, a minimum 4-inch thick base course layer is recommended to help reduce potential for slab curl, shrinkage cracking, and subgrade pumping through joints. Proper joint spacing will also be

required to prevent excessive slab curling and shrinkage cracking. Joints should be sealed to prevent entry of foreign material and dowelled where necessary for load transfer.

Where practical, we recommend early-entry cutting of crack-control joints in PCC pavements. Cutting of the concrete in its "green" state typically reduces the potential for micro-cracking of the pavements prior to the crack control joints being formed, compared to cutting the joints after the concrete has fully set. Micro-cracking of pavements may lead to crack formation in locations other than the sawed joints, and/or reduction of fatigue life of the pavement.

Openings in pavements, such as decorative landscaped areas, are sources for water infiltration into surrounding pavement systems. Water can collect in the islands and migrate into the surrounding subgrade soils thereby degrading support of the pavement. This is especially applicable for islands with raised concrete curbs, irrigated foliage, and low permeability near-surface soils. The civil design for the pavements with these conditions should include features to restrict or to collect and discharge excess water from the islands. Examples of features are edge drains connected to the storm water collection system, longitudinal subdrains, or other suitable outlet and impermeable barriers preventing lateral migration of water such as a cutoff wall installed to a depth below the pavement structure.

Dishing in parking lots surfaced with ACC is usually observed in frequently-used parking stalls (such as near the front of buildings), and occurs under the wheel footprint in these stalls. The use of higher-grade asphaltic cement, or surfacing these areas with PCC, should be considered. The dishing is exacerbated by factors such as irrigated islands or planter areas, sheet surface drainage to the front of structures, and placing the ACC directly on a compacted clay subgrade.

Pavement Drainage

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrade should be graded to provide positive drainage within the granular base section. Appropriate sub-drainage or connection to a suitable daylight outlet should be provided to remove water from the granular subbase.

Pavement Maintenance

The pavement sections represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, preventive maintenance should be planned and provided for through an on-going pavement management program. Maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment. Maintenance consists of both localized maintenance (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Preventive maintenance is usually the priority when implementing a pavement maintenance program. Additional engineering observation is

recommended to determine the type and extent of a cost-effective program. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required.

Pavement performance is affected by its surroundings. In addition to providing preventive maintenance, the civil engineer should consider the following recommendations in the design and layout of pavements:

- Final grade adjacent to paved areas should slope down from the edges at a minimum 2%.
- Subgrade and pavement surfaces should have a minimum 2% slope to promote proper surface drainage.
- Install below pavement drainage systems surrounding areas anticipated for frequent wetting.
- Install joint sealant and seal cracks immediately.
- Seal all landscaped areas in or adjacent to pavements to reduce moisture migration to subgrade soils.
- Place compacted, low permeability backfill against the exterior side of curb and gutter.
- Place curb, gutter and/or sidewalk directly on clay subgrade soils rather than on unbound granular base course materials.

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.

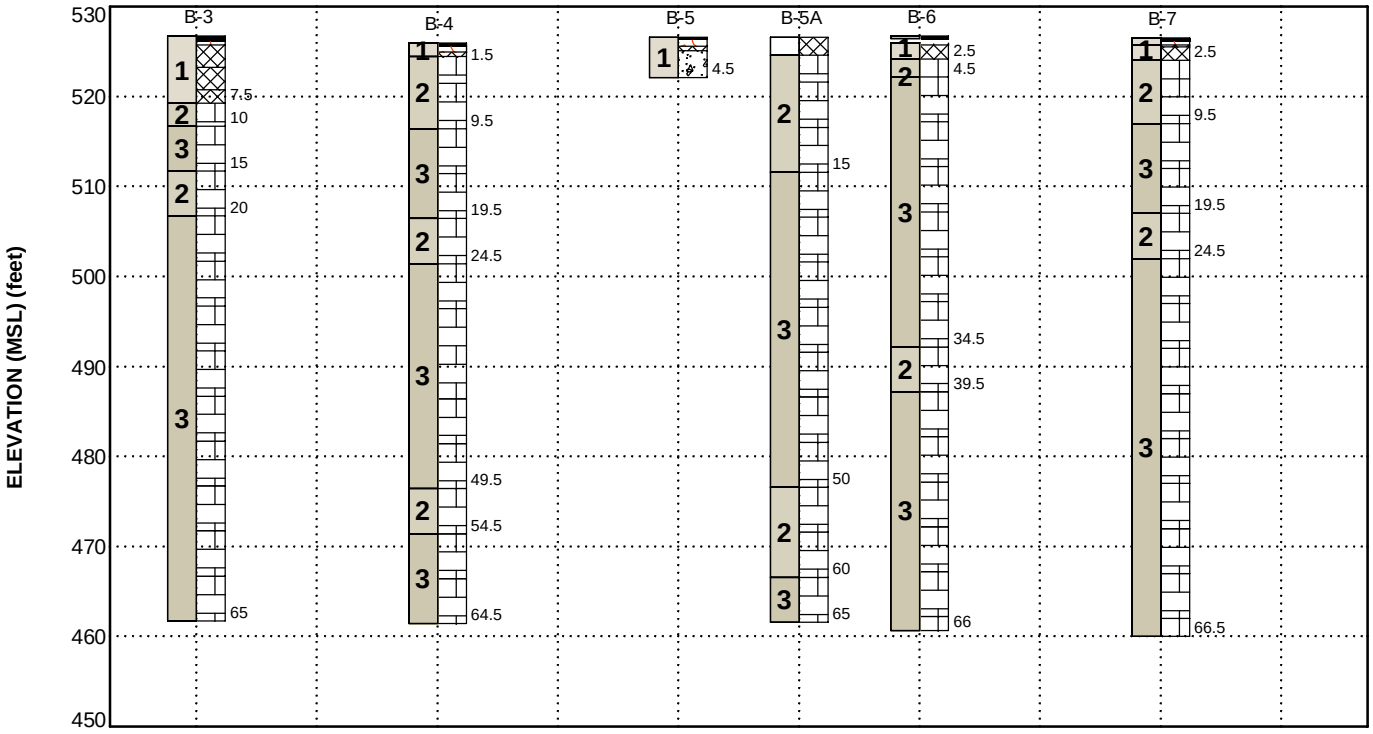
FIGURES

Contents:

GeoModel (2 Pages)
Geophysical Exploration Plan
Geophysical Cross-Sections
Seismic Site Classification (2 Pages)

GEOMODEL

TN Tower Parking Garage ■ Nashville, TN
Terracon Project No. 18225080



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	**Fill and Asphalt**	Undocumented fill materials, asphalt, and subbase materials.
2	**Low RQD Limestone**	Very Poor to Fair RQD limestone bedrock
3	**High RQD Limestone**	Good to Excellent RQD limestone bedrock

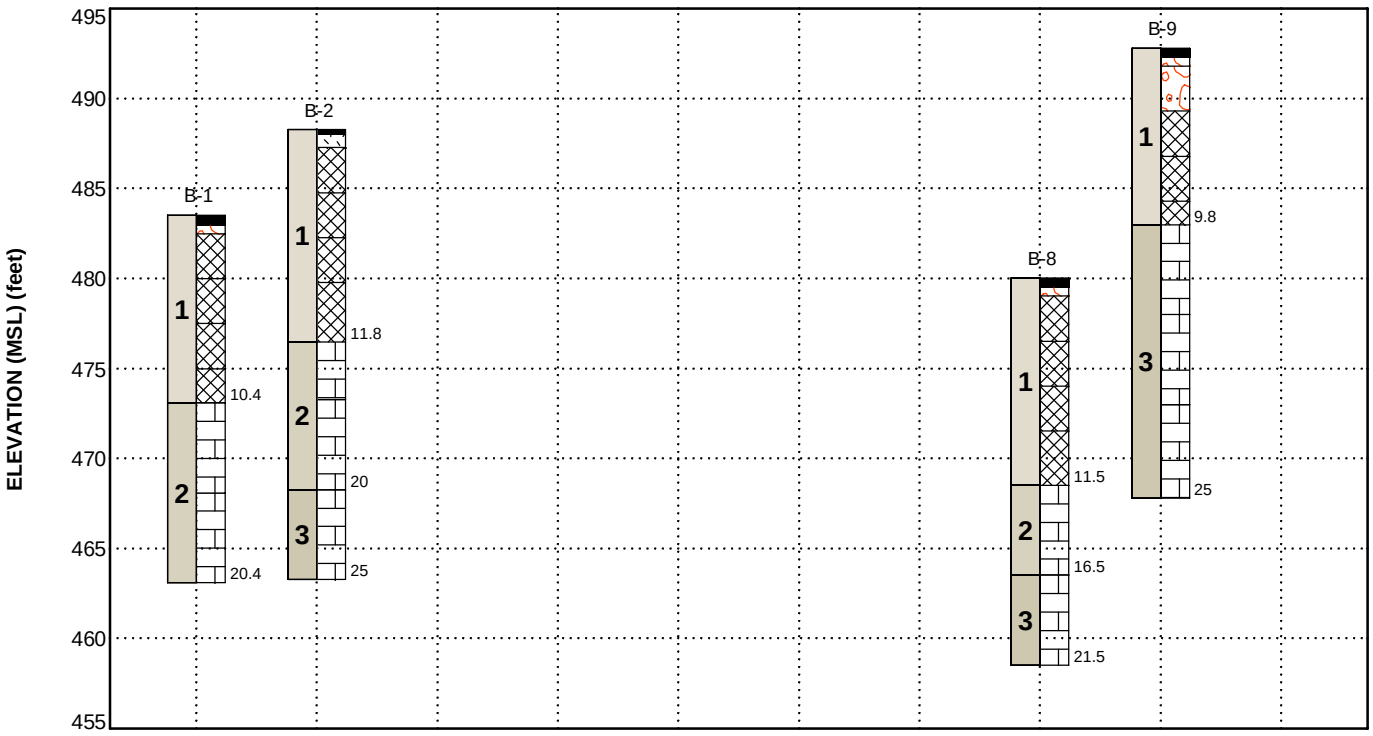
LEGEND

- Asphalt
- Aggregate Base Course
- Fill
- Limestone
- Concrete

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.

GEOMODEL

TN Tower Parking Garage ■ Nashville, TN
Terracon Project No. 18225080



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LEGEND

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- Aggregate Base Course
- Fill
- Limestone
- Base

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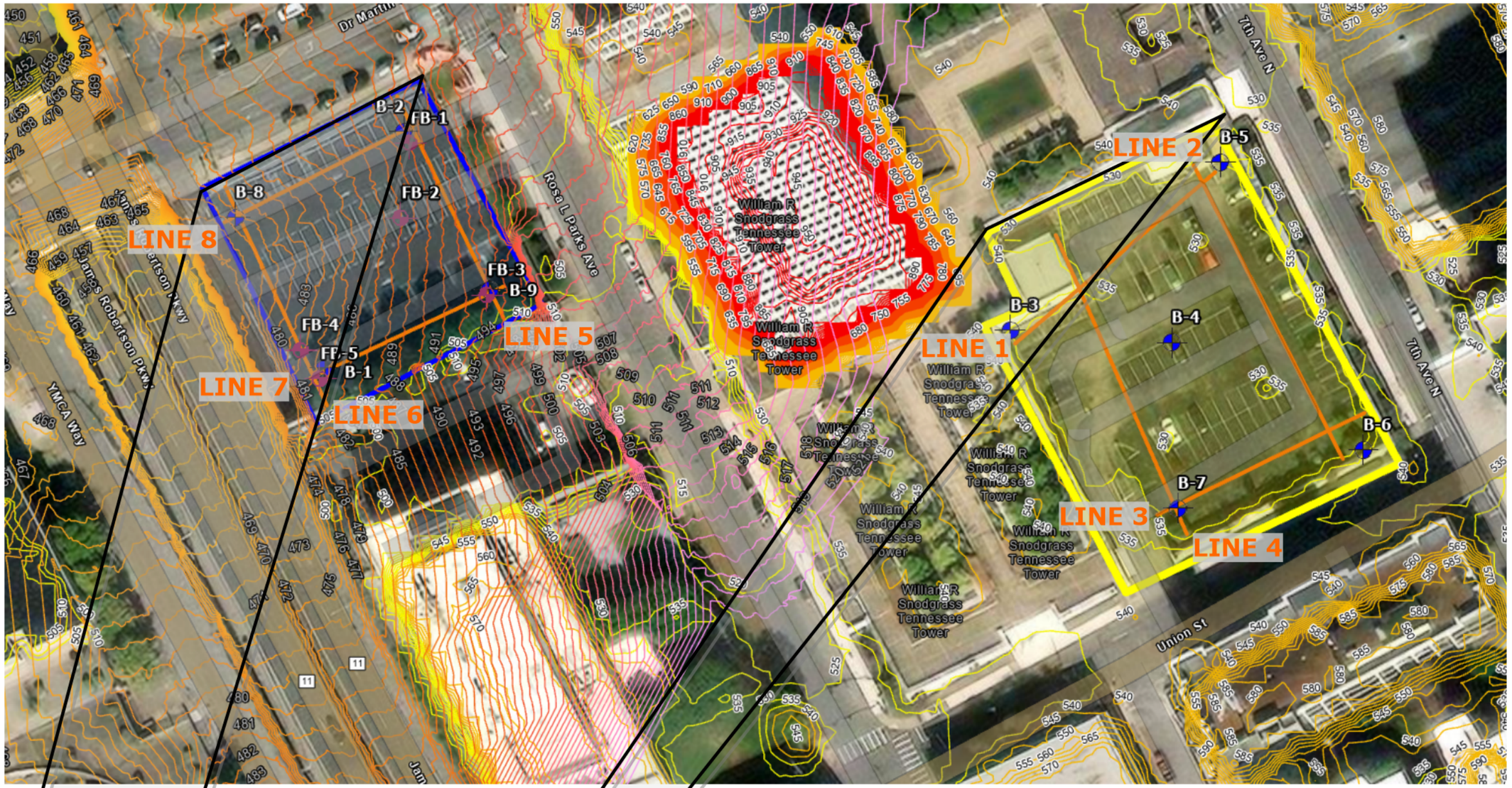
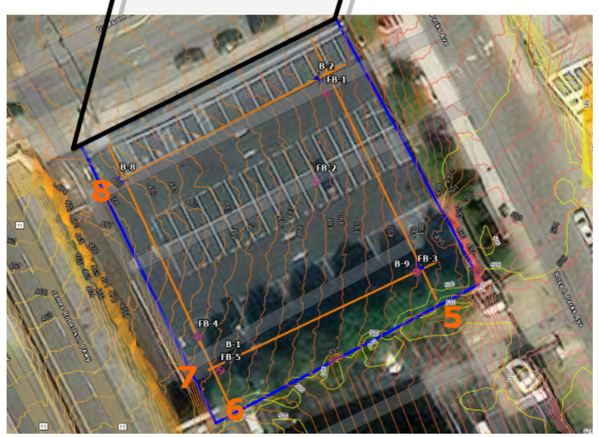






NOTES:

1.) THE MASW LINES PERFORMED BY TERRACON ON JUNE 27 AND 28, 2022 ARE SHOWN ABOVE. LABEL LOCATIONS INDICATE THE START, OR THE "0-FOOT", MARK OF THE LINES.

2.) ELEVATION DATA PRESENTED ABOVE IS INTERPRETED FROM PUBLICLY AVAILABLE USGS LIDAR DATA AND SHOULD BE CONSIDERED AS APPROXIMATE.

APPROXIMATE LOCATION OF MASW ARRAY

APPROXIMATE LOCATION OF FURNISHED BORING

APPROXIMATE LOCATION OF GEOTECHNICAL BORING

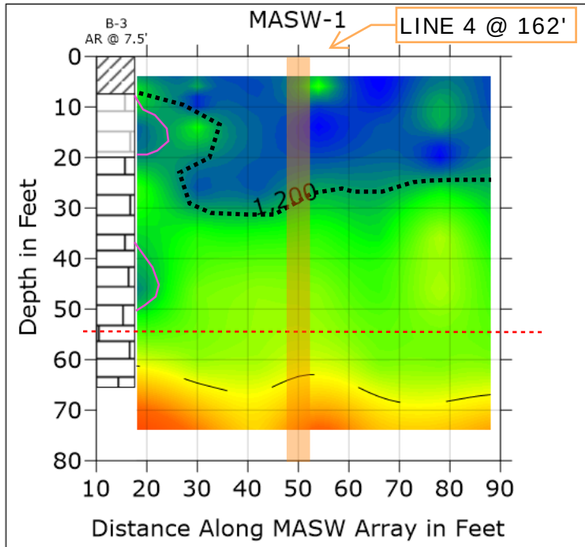
Project Manager: NBR	Project No. 18225080
Drawn by: NBR	Scale: NTS
Checked by: KJS	File Name: TNTowerEx2.srf
Approved by: JEA	Date: 8/8/2022

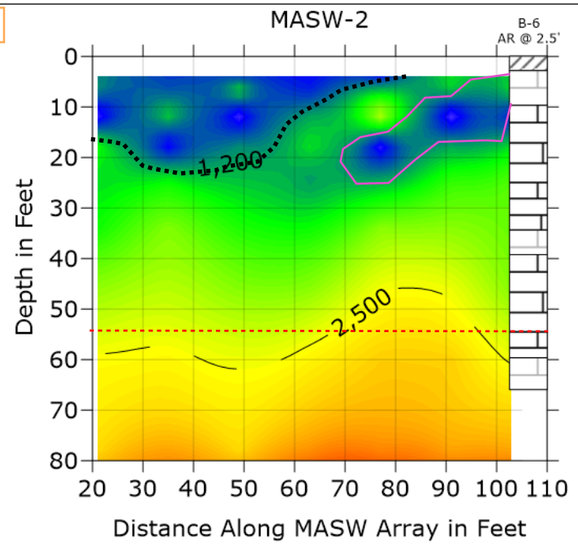
Terracon
5217 Linbar Drive, Suite 309
Nashville, TN 37211

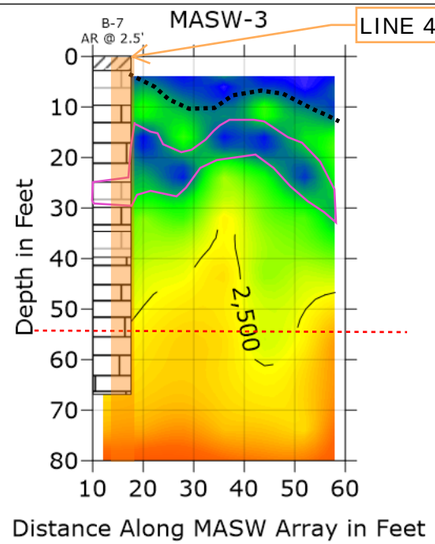
Geophysical Exploration Plan

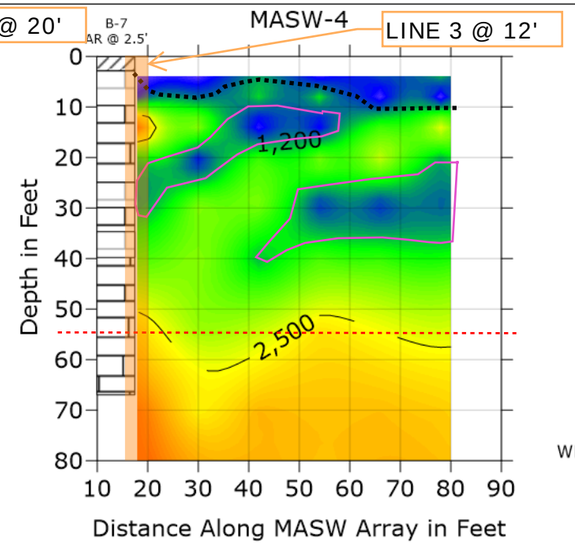
Tennessee Tower
Parking Garages
Nashville, Tennessee

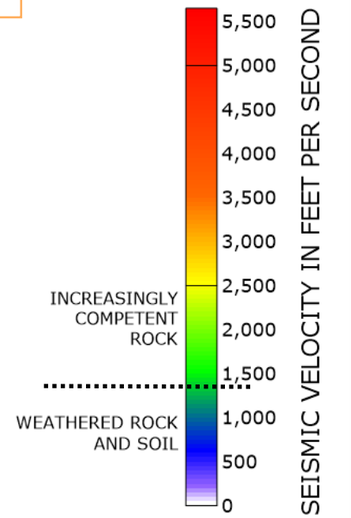
EXHIBIT 1

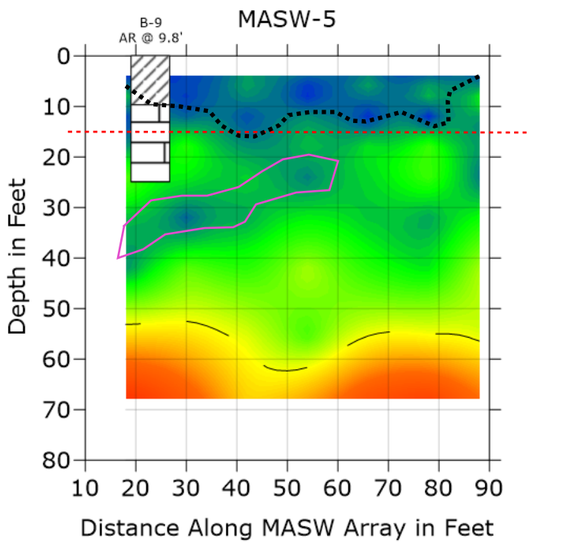


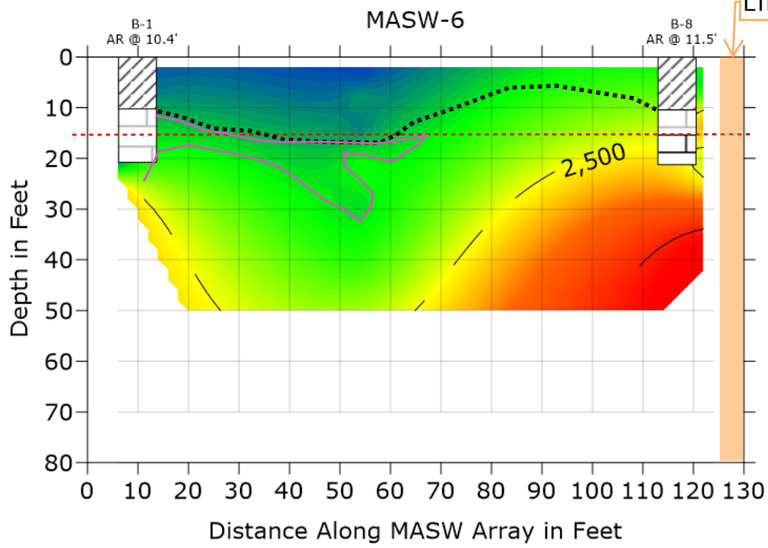


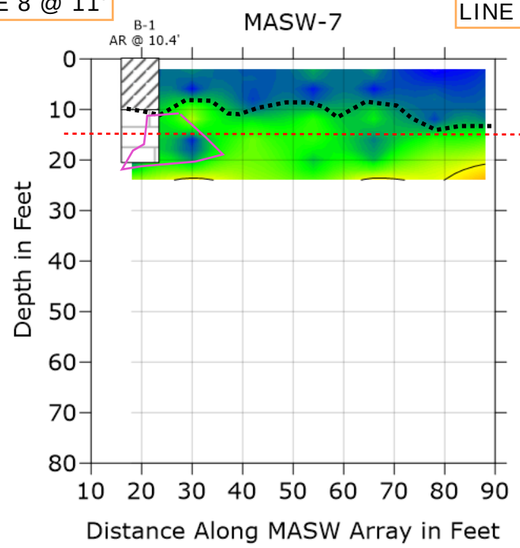


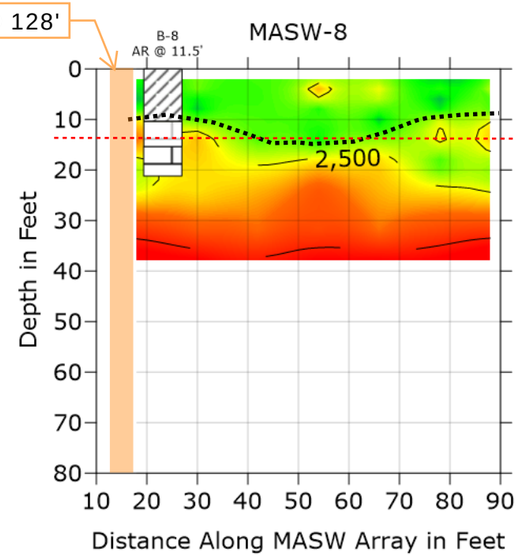


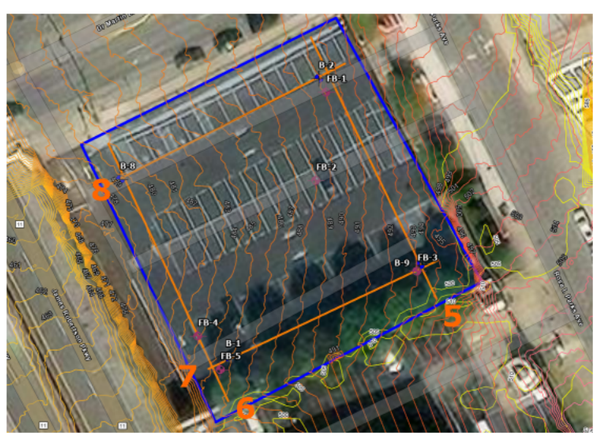














NOTES:

1.) THE MASW LINES PERFORMED BY TERRACON ON JUNE 27 AND 28, 2022 ARE SHOWN ABOVE. LABEL LOCATIONS INDICATE THE START, OR THE "0-FOOT", MARK OF THE LINES.

- INTERPRETED LOW DENSITY/VELOCITY ROCK ZONE
- GEOMODEL LAYER 1 - ASPHALT AND FILL
- GEOMODEL LAYER 2 - LOW RQD ROCK
- GEOMODEL LAYER 3 - HIGH RQD ROCK
- APPROXIMATE LOCATION OF MASW ARRAY
- APPROXIMATE LOCATION OF GEOTECHNICAL BORING
- INTERPOLOATED TOP OF ROCK SURFACE
- APPROXIMATE DEPTH TO GARAGE BEARING STRATUM

Project Manager:	NBR
Drawn by:	NBR
Checked by:	KJS
Approved by:	JEA
Project No.	18225080
Scale:	1" = 30'
File Name:	TNTowerEx2.srf
Date:	8/8/2022

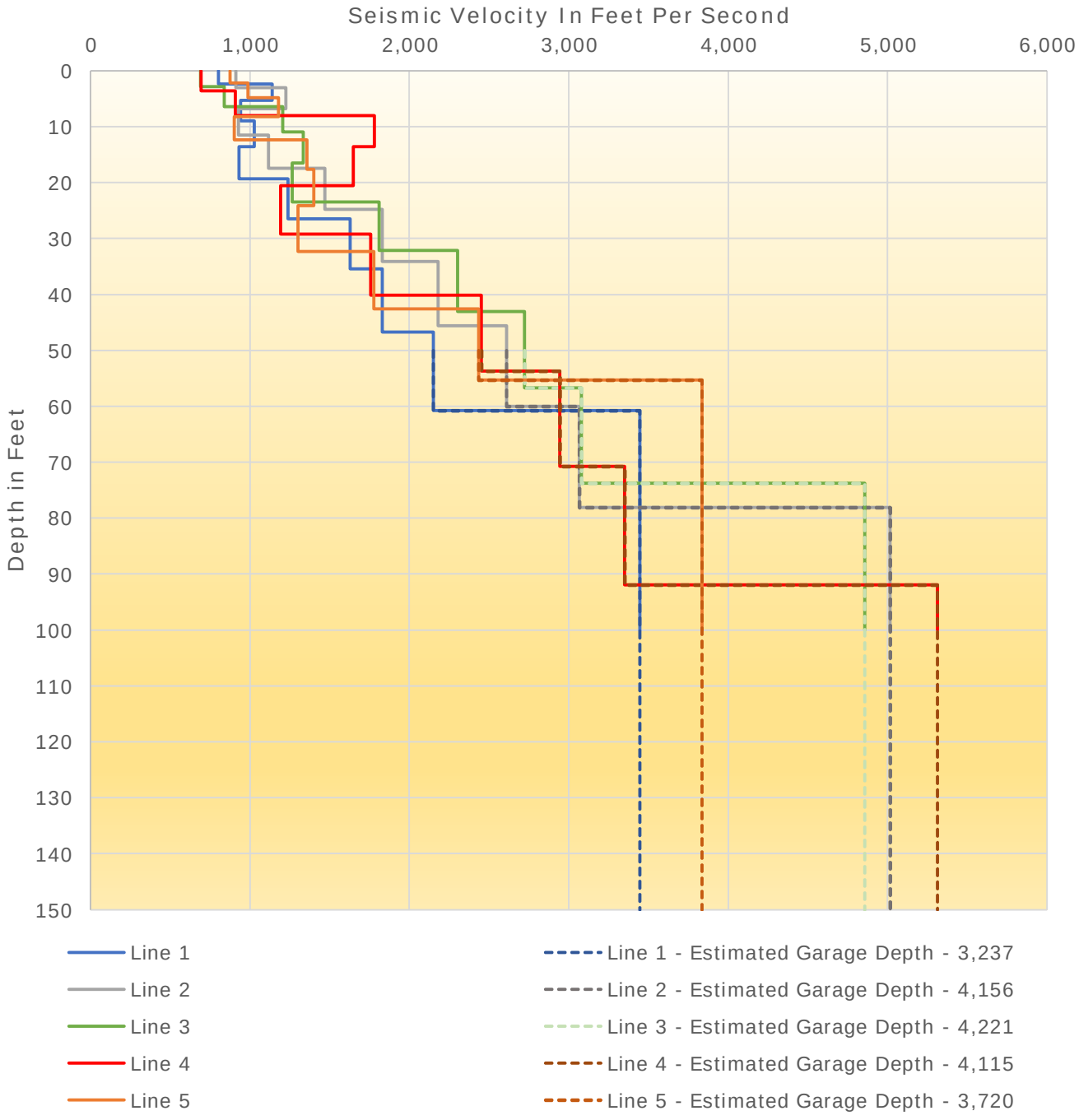
Terracon
5217 Linbar Drive, Suite 309
Nashville, TN 37211

Geophysical Test Cross Sections

Tennessee Tower
Parking Garages
Nashville, Tennessee

EXHIBIT 2

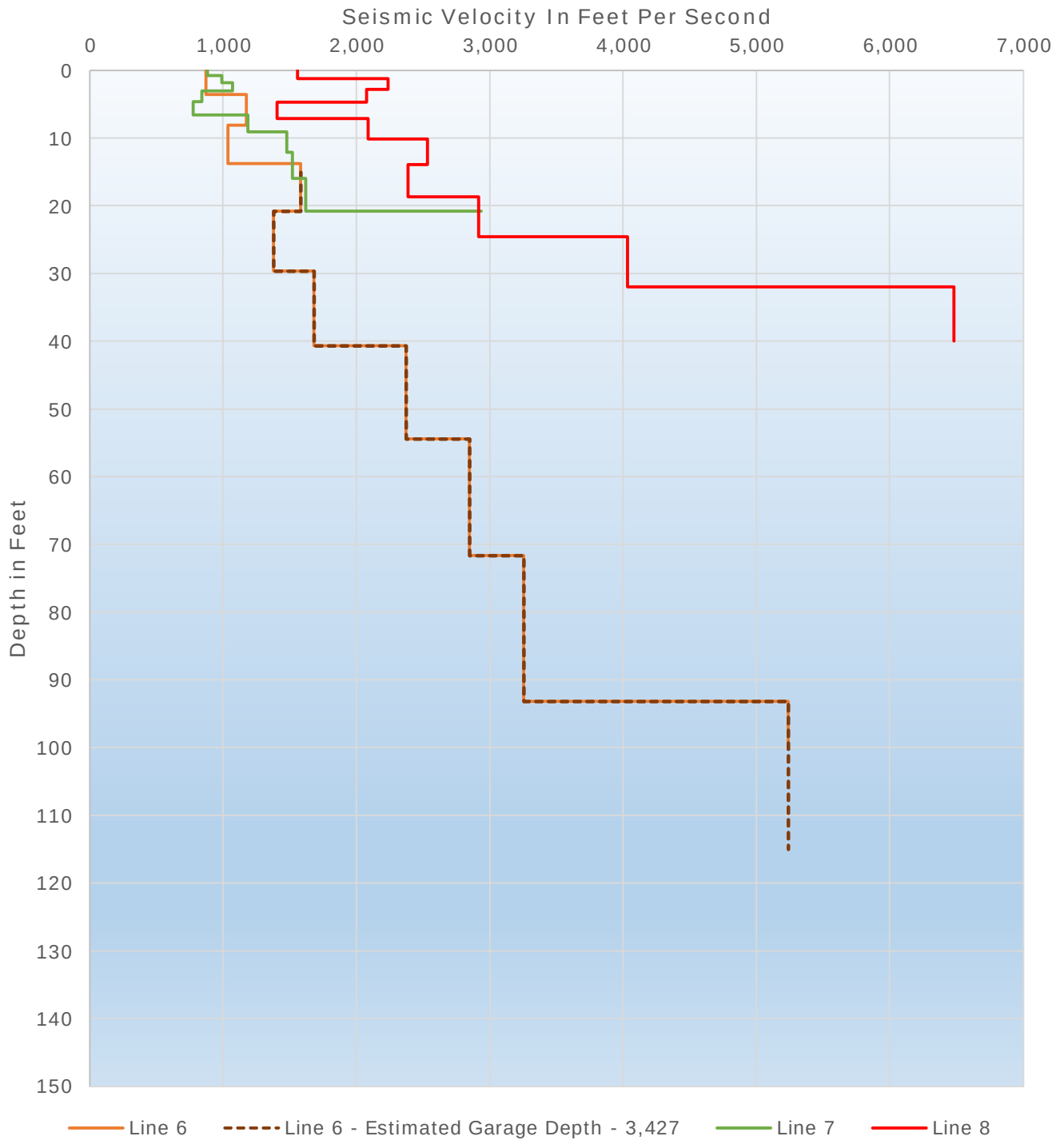
Vs100' Model
Gold Lot



Seismic Site Classification – “B” – 2,500 - 4,999 ft/sec

Project Manager: NBR	Project No. 18225080	Terracon 5127 Linbar Drive Ste 309 Nashville, TN 37211	TN Tower Garages Site Classification Data Nashville, TN	Exhibit 3-1
Drawn by: NBR	Scale: N.T.S.			
Checked by: KJS	File Name: Exhibit3.pdf			
Approved by: DAB	Date: 8/22/2022			

Vs100' Model
Blue Lot



Seismic Site Classification – “B” – 2,500 - 4,999 ft/sec

Project Manager: NBR	Project No. 18225080	Terracon 5127 Linbar Drive Ste 309 Nashville, TN 37211	TN Tower Garages Site Classification Data Nashville, TN	Exhibit 3-2
Drawn by: NBR	Scale: N.T.S.			
Checked by: KJS	File Name: Exhibit3.pdf			
Approved by: DAB	Date: 8/22/2022			

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Borings	Boring Depth (feet) [1]	Boring Location
5	AR and rock coring to approximate elevation 460	Gold Lot
4	AR and rock coring to approximate elevation 460	Blue Lot

1. Below ground surface.

Boring Layout and Elevations: Terracon personnel provided the boring layout. Coordinates were obtained with a handheld GPS unit (estimated horizontal accuracy of about ±10 feet). Elevations shown on boring logs were obtained from furnished elevation data provided to Terracon by Hurst-Rosche, Inc. and collected by Collier Engineering.

Subsurface Exploration Procedures: We advanced the borings with a track-mounted drill rig using continuous flight augers to the top of the rock surface. Four samples were obtained in the upper 10 feet of each boring. A standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. For safety purposes, all borings were backfilled with auger cuttings after their completion. Pavements were patched with cold-mix asphalt.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

The “percent recovery” is the ratio of the sample length retrieved to the drilled length, expressed as a percent. An indication of the actual in-situ rock quality is provided by calculating the sample’s Rock Quality Designation (RQD). The RQD is the ratio of the cumulative length of 4 inch or longer core sections (discounting mechanical breaks) to the length of the core run. The percent recovery and RQD are related to rock soundness and quality as illustrated below:

Relation of RQD and In-situ Rock Quality	
RQD (%)	**Rock Quality**
90 - 100	Excellent
75 - 90	Good
50 - 75	Fair
25 - 50	Poor
0 -25	Very Poor

Geophysical Testing

Multi-Channel Analysis of Surface Waves - Terracon performed geophysical exploration services consisting of a seismic survey using the Multi-Channel Analysis of Surface Waves (MASW) method. Our method of investigation utilized a fixed array set of MASW geophones. The array consisted of 24 4.5Hz geophones, spaced approximately 4 to 7 feet apart along a sensor cable. A source strike was completed with a sledgehammer at every other geophone location.

The data was returned to our office and processed using dispersion analysis software (SurfSeis, engineered by the Kansas Geological Survey) that extracts the fundamental-mode dispersion curve(s). The curves are inverted and modeled to yield a 1D shear-wave velocity profile along the array for a corresponding depth. At each source strike, the 1D profiles are created and then combined to yield a 2D profile. These 2D profiles are then examined for changes in shear wave velocities to indicate the top of bedrock and potential karst features within the bedrock. The individual 1D profiles and additional 1D profiles collected using passive noises at the site were collected, processed, and used to generate a Seismic Site Classification.

Eight (8) survey lines were conducted in total, at accessible locations in each existing lot. A description of each line is listed in the table below.

Line	General Location	Line Orientation	Length of Testing (feet)	Geophone Spacing Intervals (feet)
Line 1	North side of Gold Lot	West to East	150	6
Line 2	East side of Gold Lot	North to South	165	7
Line 3	South side of Gold Lot	West to East	100	4
Line 4	West side of Gold Lot	South to North	150	6
Line 5	East side of Blue Lot	South to North	150	6
Line 6	West side of Blue Lot	North to South	150	6
Line 7	South side of Blue Lot	West to East	150	6
Line 8	North side of Blue Lot	West to East	150	6

Geophysical Testing Limitations - All geophysical testing methods rely on instrument signals to indicate physical conditions in the field. Signal information can be affected by on-site conditions beyond the control of the operator, such as, but not limited to, cultural features, standing water, high subsurface moisture content, and other buried objects. Interpretation of those signals is based on a combination of known factors combined with the experience of the operator and geophysical scientist evaluating the results. The provided depth measurements are estimations based on an estimation of the seismic and density properties of the subsurface material.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests to understand the engineering properties of the various soil and rock strata, as necessary, for this project. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods were applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D7012 Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures

The laboratory testing program often included examination of soil samples by an engineer. Based on the material's texture and plasticity, we described and classified the soil samples in general accordance with the **Unified Soil Classification System** (ASTM D2487).

Rock classification was conducted using locally accepted practices for engineering purposes; petrographic analysis may reveal other rock types. Boring log rock classification was determined using the **Description of Rock Properties**, generally outlined in ASTM D5879.

PHOTOGRAPHY LOG



Photo 1 Seismic testing line (typical)



Photo 2 Drilling location (typical)

SITE LOCATION AND EXPLORATION PLANS

Contents:

Site Location Plan
Exploration Plan

Note: All attachments are one page unless noted above.

SITE LOCATION

TN Tower Parking Garage - STREAM ■ Nashville, Davidson County, Tennessee
October 21, 2022 ■ Terracon Project No. 18225080

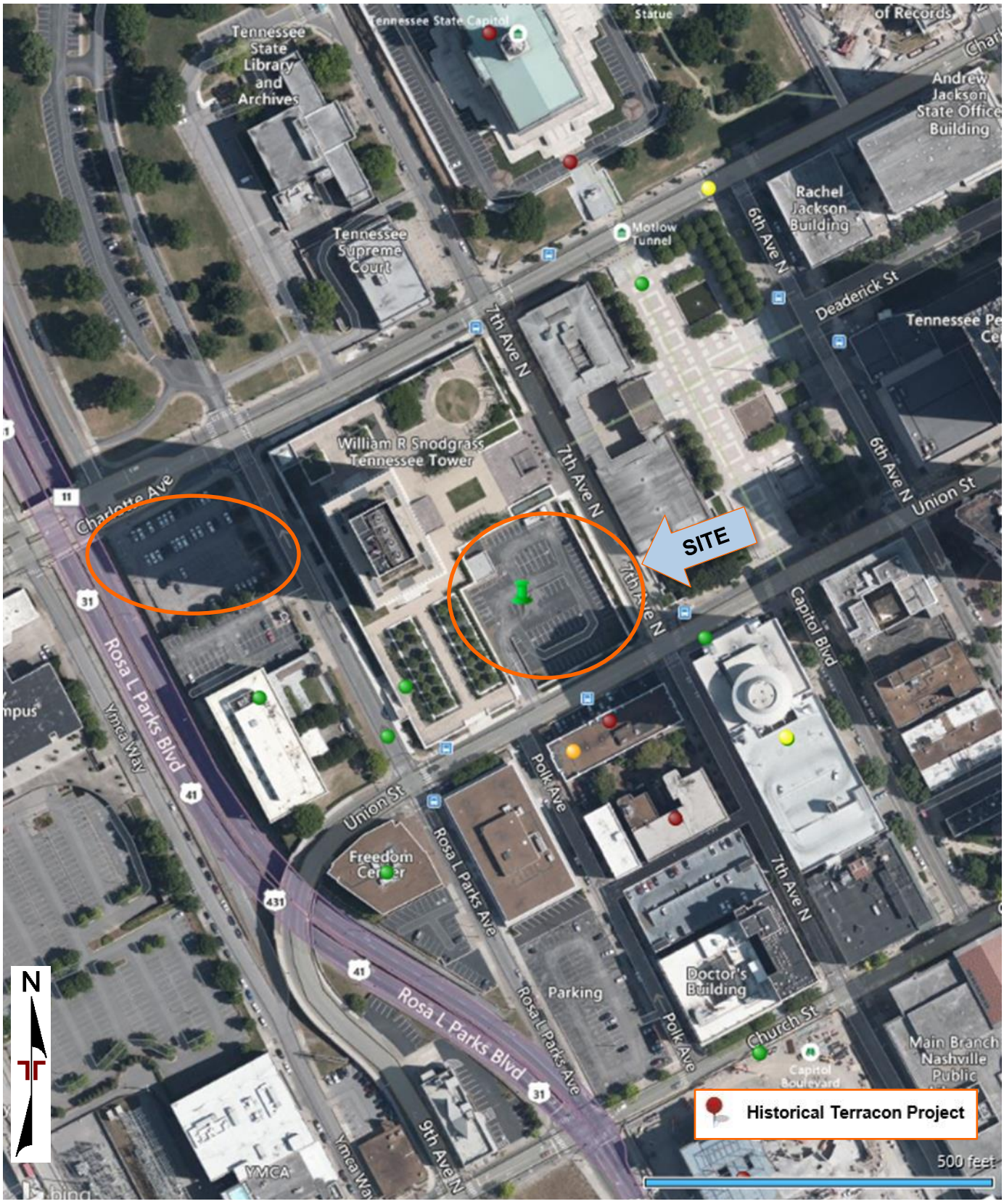
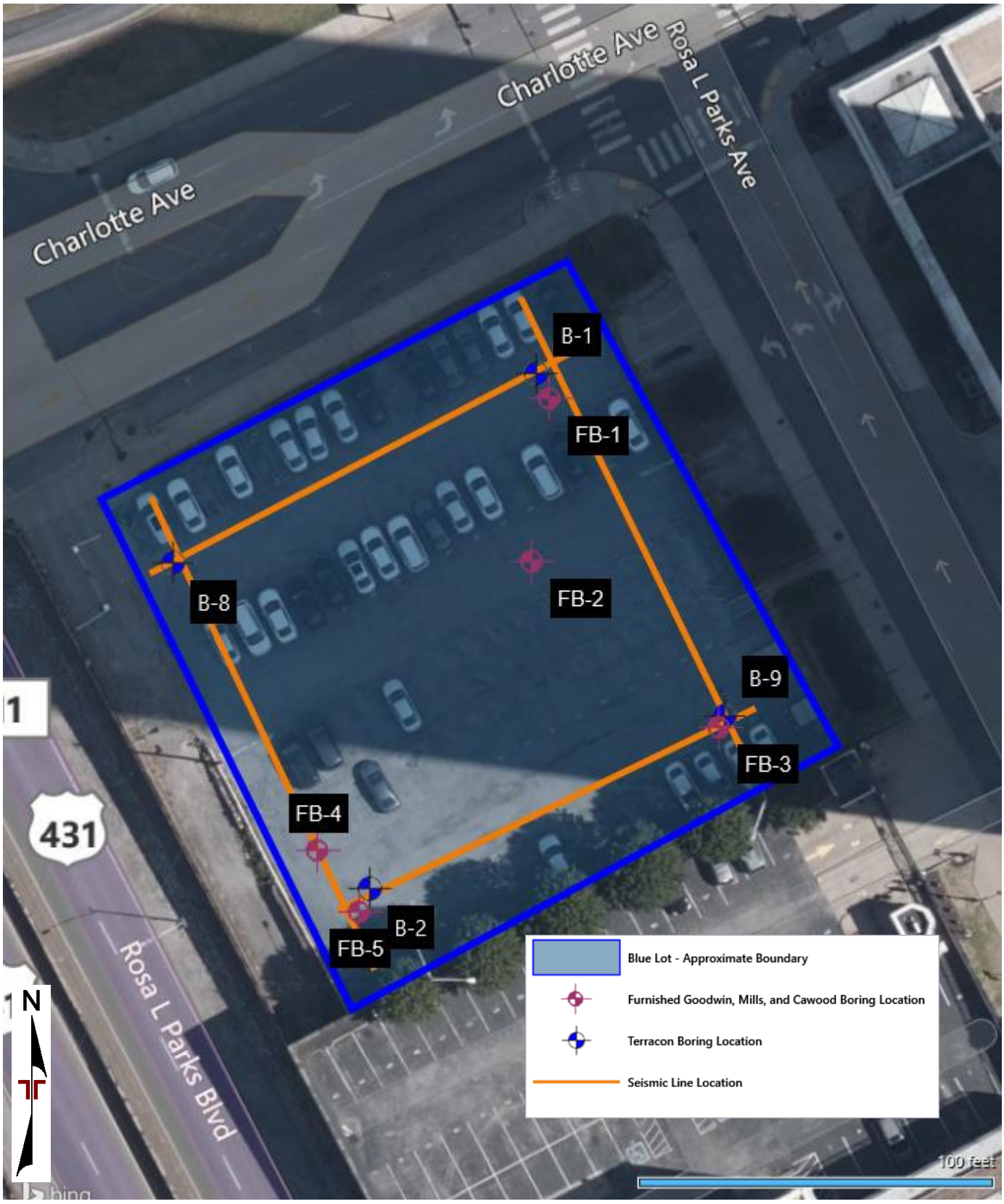


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS


Charlotte Ave
Rosa L Parks Ave
Charlotte Ave
B-1
FB-1
B-8
FB-2
B-9
FB-3
FB-4
B-2
FB-5
431
Rosa L Parks Blvd
N
Blue Lot - Approximate Boundary
Furnished Goodwin, Mills, and Cawood Boring Location
Terracon Boring Location
Seismic Line Location
100 feet
bing

EXPLORATION PLAN – GOLD LOT

TN Tower Parking Garage - STREAM ■ Nashville, Davidson County, Tennessee
October 21, 2022 ■ Terracon Project No. 18225080

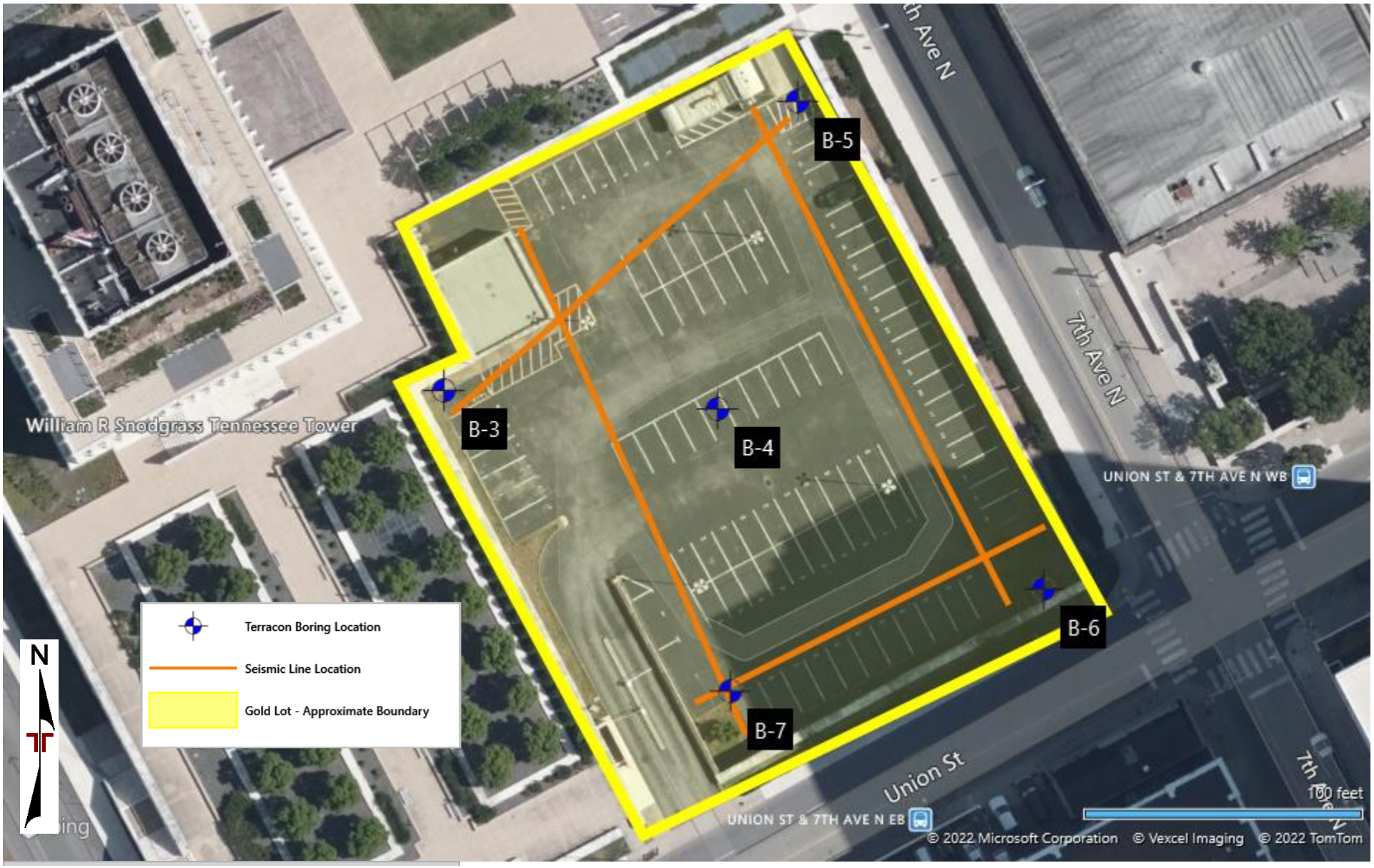


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Boring Logs (B-1 through B-9)
Rock Core Photo Log (17 Pages)

Note: All attachments are one page unless noted above.

BORING LOG NO. B-1

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1640° Longitude: -86.7857°

Surface Elev.: 483.5 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)
		0.5	483										
		1.0	482.5										
								7-4-5 N=9					
		3.5	480										
								1-2-2 N=4					
1		6.0	477.5	5									
								50/2"					
		8.5	475										
								50/4"					
		10.4	473.1	10									
2		15.4	468.1	15					90	51			
		20.4	463.1	20					98	63	UC		

LIMESTONE, with trace shale seams, vugs, and clay near the top of the run, light to dark gray, medium hard

LIMESTONE, with trace shales seams, clay, and vugs near the bottom of run, light to dark gray, medium hard

Boring Terminated at 20.4 Feet

FILL - SILTY CLAY (CL-ML), Silty clay, very dark gray, trace chert, trace brick, and some limestone rock fragments

FILL - FAT CLAY (CH), Dark brown fat clay, some brick, and trace chert

No recovery, interpreted as fill materials

No recovery, interpreted as fill materials

Auger Refusal at 10.4'

ASPHALT

BASESTONE

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

Advancement Method:
Hollow stem auger to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-18-2022 | Boring Completed: 07-18-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-2

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1636° Longitude: -86.7859°

Surface Elev.: 488.3 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)
		0.3	488.1										
		ASPHALT											
		1.0	487.3										
		BASESTONE											
		FILL - SILTY CLAY (CL-ML), No recovery, interpreted as fill materials						50/4"					
		3.5	484.8										
		FILL - , No recovery, interpreted as fill materials		5				50					
1		6.0	482.3										
		FILL - , No recovery, interpreted as fill materials						50/2"					
		8.5	479.8										
		FILL - , No recovery, interpreted as fill materials		10				50/1"					
		Auger refusal at 11.8'											
		11.8	476.5										
2		**LIMESTONE**, with trace shaley clay, vugs, some argillaceous seams, and fossiliferous zones, light to dark gray, highly fractured, moderately weathered, medium hard							70	0			
		15.0	473.3	15									
		LIMESTONE, with trace shaley clay, vugs, some argillaceous seams, and fossiliferous zones, light to dark gray, moderately weathered, medium hard							85	45			
		20.0	468.3	20									
3		**LIMESTONE**, trace vugs, and shale seams, light to dark gray, slightly weathered, medium hard							100	76	UC		
		25.0	463.3	25									
		Boring Terminated at 25 Feet											

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

Advancement Method:
Hollow stem auger to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-19-2022 | Boring Completed: 07-19-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-3

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1637° Longitude: -86.7845°

Surface Elev.: 526.7 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)
		0.5	526.2										
		ASPHALT											
		1.0	525.7										
		BASESTONE											
		FILL - , No recovery, interpreted fill materials						50/4"					
1		3.5	523.2										
1		**FILL - LIMESTONE ROCK FRAGMENTS**, Mostly limestone rock fragments, light to dark gray		5				7-10-13 N=23					
		6.0	520.7										
		FILL - , No recovery, interpreted fill materials						50/1"					
		7.5	519.2										
		Auger refusal at 7.5'											
2		**LIMESTONE**, with clay seam at top of run, and vertical fracture at bottom of run, light to dark gray, highly fractured, moderate to slightly weathered, medium hard							90	0			
		10.0	516.7	10									
3		**LIMESTONE**, with trace shale seams, and argillaceous seams, light to dark gray, slightly weathered, medium hard							96	81			
		15.0	511.7	15									
2		**LIMESTONE**, with trace shale seams, light to dark gray, slightly weathered, medium hard							98	74			
		20.0	506.7	20									
3		**LIMESTONE**, with trace shale seams, calcite seams, and argillaceous seams, light to dark gray, slightly weathered, medium hard							100	88			
		25.0	501.7	25									
		LIMESTONE, with trace vugs and shale seams, light to dark gray, slightly weathered, medium hard											

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

Advancement Method:
Hollow stem auger to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-14-2022 | Boring Completed: 07-14-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-3

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1637° Longitude: -86.7845°

Surface Elev.: 526.7 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)
3		30.0	496.7	30					98	92			
		LIMESTONE, with trace vugs and shale seams, light to dark gray, slightly weathered, medium hard *(continued)*											
		35.0	491.7	35					98	86			
		LIMESTONE, with trace vugs and shale seams, light to dark gray, slightly weathered, medium hard											
		40.0	486.7	40					100	90			
		LIMESTONE, with few shale seams and vugs, trace fossiliferous seams, light to dark gray, slightly weathered, medium hard											
		45.0	481.7	45					100	85	UC		
		LIMESTONE, with few shale seams and vugs, trace fossiliferous seams, light to dark gray, slightly weathered, medium hard											
		50.0	476.7	50					100	100			
		LIMESTONE, with fossiliferous seams at the top of run and trace shale seams at the bottom of the run, light to dark gray, slightly weathered, medium hard											
		LIMESTONE, with fossiliferous seams at the top of run, trace shale seams at the bottom of the run and calcite veins, light to dark gray, slightly weathered, medium hard											

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

Advancement Method:
Hollow stem auger to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-14-2022 | Boring Completed: 07-14-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-3

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1637° Longitude: -86.7845°

Surface Elev.: 526.7 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)
3		55.0	471.7	55					100	92			
		60.0	466.7	60					98	98			
		65.0	461.7	65					100	95	UC		

LIMESTONE, with fossiliferous seams at the top of run, trace shale seams at the bottom of the run and calcite veins, light to dark gray, slightly weathered, medium hard *(continued)*

LIMESTONE, few shale seams, and trace to few fossiliferous seams, light to dark gray, slightly weathered, medium hard

LIMESTONE, few shale seams, trace to few fossiliferous seams, and calcite veins, light to dark gray, slightly weathered, medium hard

Boring Terminated at 65 Feet

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

Advancement Method:
Hollow stem auger to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-14-2022 | Boring Completed: 07-14-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-4

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1637° Longitude: -86.7841°

Surface Elev.: 525.9 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)
1		0.3	525.7										
			ASPHALT										
		1.0	524.9										
			BASESTONE										
		1.5	524.4					50					
2			**BASESTONE W/ LIMESTONE ROCK FRAGMENTS**, Basestone w/ limestone rock fragments, medium hard Auger refusal at 1.5'						75	50			
		4.5	**LIMESTONE**, with clay seam at the bottom of run, light to dark gray, moderately weathered, medium hard	5									
			521.4										
			LIMESTONE, with clay seams throughout, and vertical fracture at approximately 8 feet, light to dark gray, slight to moderately weathered, medium hard						95	37			
		9.5	516.4										
3			**LIMESTONE**, with few argillaceous seams and trace vugs, light to dark gray, slightly weathered, medium hard	10					100	80			
		14.5	511.4										
			LIMESTONE, with few argillaceous seams and trace vugs, light to dark gray, slightly weathered, medium hard	15					100	89			
		19.5	506.4										
2			**LIMESTONE**, with trace argillaceous seams, light to dark gray, slightly weathered, medium hard	20					98	72			
		24.5	501.4										
3			**LIMESTONE**, with few shale seams, and fossil seams, light to dark gray, slightly weathered, medium hard	25									

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

Advancement Method:
Hollow stem auger to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-13-2022 | Boring Completed: 07-13-2022
Drill Rig: Track | Driller: Tri-State Drilling
Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-4

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1637° Longitude: -86.7841°

Surface Elev.: 525.9 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRAIN (%)
3			**LIMESTONE**, with few shale seams, and fossil seams, light to dark gray, slightly weathered, medium hard *(continued)*						100	100			
		29.5	496.4										
			LIMESTONE, with trace fossil seams, shale seams, and vugs, light to dark gray, slightly weathered, medium hard	30					100	88			
				35					90	76			
		39.5	486.4										
			LIMESTONE, with trace vugs, argillaceous seams through 44 feet, then fossiliferous, light to dark gray, slightly weathered, medium hard	40					100	90			
		44.5	481.4										
			LIMESTONE, with trace shale seams, and fossiliferous through 48 feet, light to dark gray, slightly weathered, medium hard	45					92	91	UC		
		49.5	476.4										
2			**LIMESTONE**, with shale seams and partings, trace pits, and fossiliferous, light to dark gray, slightly weathered, medium hard	50									

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

Advancement Method:
Hollow stem auger to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-13-2022 | Boring Completed: 07-13-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-4

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1637° Longitude: -86.7841°

Surface Elev.: 525.9 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)
2			**LIMESTONE**, with shale seams and partings, trace pits, and fossiliferous, light to dark gray, slightly weathered, medium hard *(continued)*						100	62			
		54.5	471.4										
3			**LIMESTONE**, with shale seams and partings, trace pits, fossiliferous, and vertical fracture near top of run, light to dark gray, slightly weathered, medium hard	55					100	95			
		59.5	466.4										
			LIMESTONE, with some fossiliferous seams, few shale seams, trace vugs, and argillaceous seams at bottom of the run, light to dark gray, slightly weathered, medium hard	60					100	98	UC		
		64.5	461.4										
			Boring Terminated at 64.5 Feet										

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

Advancement Method:
Hollow stem auger to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-13-2022 | Boring Completed: 07-13-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-5

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1640° Longitude: -86.7840°

Surface Elev.: 526.6 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRAIN (%)
		0.2	526.4										
		ASPHALT											
		1.0	525.6										
		FILL - BASESTONE											
		1.5	525.1										
		No recovery, interpreted as backfill materials						50					
1		**FILL - CONCRETE**, Boring terminated at 4 feet due to potential utility interference											
		4.5	522.1										
		Boring Terminated at 4.5 Feet											

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

Advancement Method:
Hollow stem auger to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-15-2022 | Boring Completed: 07-15-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-5A

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1639° Longitude: -86.7841°

Surface Elev.: 526.6 (Ft.)

MODEL LAYER	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRAIN (%)
		FILL - AGGREGATE BASE COURSE						
	2.0	524.6						
		LIMESTONE, with vertical fractures throughout, trace vugs, gray to dark gray, highly weathered, moderately hard		97	25			
	5.0	521.6	5					
2		**LIMESTONE**, with vertical fractures throughout, trace vugs, gray to dark gray, highly weathered, moderately hard		73	7			
	10.0	516.6	10					
		LIMESTONE, with trace vugs, calcite veins, shale partings, and fossiliferous zones, gray to dark gray, slightly weathered, moderately hard		100	58			
	15.0	511.6	15					
3		**LIMESTONE**, with trace vugs, calcite veins, shale partings, and fossiliferous zones, gray to dark gray, slightly weathered, moderately hard		100	95			
	20.0	506.6	20					
3		**LIMESTONE**, with trace vugs, calcite veins, shale partings, and fossiliferous zones, gray to dark gray, slightly weathered, moderately hard		100	80			
	25.0	501.6	25					

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

Advancement Method:
Hydro-excavation to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:
Soft dig refusal at 2', begin coring

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-22-2022 | Boring Completed: 07-22-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-5A

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1639° Longitude: -86.7841°

Surface Elev.: 526.6 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)
3		30.0	496.6	30					100	95			
			LIMESTONE, with trace vugs, calcite veins, shale partings, and fossiliferous zones, gray to dark gray, slightly weathered, moderately hard *(continued)*										
		35.0	491.6	35					100	92			
			LIMESTONE, with trace vugs, calcite veins, shale partings, and fossiliferous zones, gray to dark gray, slightly weathered, moderately hard										
		40.0	486.6	40					99	78	UC		
			LIMESTONE, with few shale seams, trace argillaceous zones, fossiliferous seams, and vugs, dark gray to light gray, moderately weathered, moderately hard										
		45.0	481.6	45					100	88			
			LIMESTONE, with few shale seams, trace argillaceous zones, fossiliferous seams, and vugs, dark gray to light gray, moderately weathered, moderately hard										
		50.0	476.6	50					98	78			
2			**LIMESTONE**, with few shale seams, trace argillaceous zones, fossiliferous seams, shale seams, and vugs, dark gray to light gray, slightly weathered, moderately hard										

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

Advancement Method:
Hydro-excavation to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-22-2022 | Boring Completed: 07-22-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-5A

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1639° Longitude: -86.7841°

Surface Elev.: 526.6 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)
			LIMESTONE, with few shale seams, trace argillaceous zones, fossiliferous seams, shale seams, and vugs, dark gray to light gray, slightly weathered, moderately hard *(continued)*						99	70			
		55.0	471.6	55									
2			**LIMESTONE**, with few shale seams, trace argillaceous zones, fossiliferous seams, shale seams, and vugs, dark gray to light gray, slightly weathered, moderately hard						100	73			
		60.0	466.6	60									
3			**LIMESTONE**, with few shale seams, trace argillaceous zones, fossiliferous seams, shale seams, and vugs, dark gray to light gray, slightly weathered, moderately hard						100	95	UC		
		65.0	461.6	65									
			Boring Terminated at 65 Feet										

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

Advancement Method:
Hydro-excavation to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-22-2022 | Boring Completed: 07-22-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-6

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1635° Longitude: -86.7837°

Surface Elev.: 526.7 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)
		0.3	526.5										
		ASPHALT											
		1.0	525.7										
1		**BASESTONE**											
		FILL - BASESTONE, with limestone fragments						13-50					
		2.5	524.2										
		Auger refusal at 2.5'											
2		**LIMESTONE**, with clay seams, light to dark gray, slightly weathered, medium hard							96	65			
		4.5	522.2										
3		**LIMESTONE**, with trace vugs and pits, fossiliferous zones, shaley mud, and clay seams, light to dark gray, moderately weathered, medium hard		5					100	75			
		9.5	517.2										
		LIMESTONE, with few shale seams and trace vugs, light to dark gray, slightly weathered, medium hard		10					97	87			
		14.5	512.2										
		LIMESTONE, with few fossiliferous zones, light to dark gray, slightly weathered, medium hard		15					100	88			
		19.5	507.2										
		LIMESTONE, with argillaceous zones, light to dark gray, slightly weathered, medium hard		20					100	96			
		24.5	502.2										
		LIMESTONE, with trace fossiliferous zones, vugs, and calcite veins, light to dark gray, slightly weathered, medium hard		25									

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

Advancement Method:
Hollow stem auger to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-12-2022 | Boring Completed: 07-12-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-6

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1635° Longitude: -86.7837°

Surface Elev.: 526.7 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)
3		29.5	497.2						100	92			
			LIMESTONE, with trace fossiliferous zones, vugs, and calcite veins, light to dark gray, slightly weathered, medium hard *(continued)*										
3		34.5	492.2	30					100	93			
			LIMESTONE, with trace vugs, some argillaceous zones, and vertical fratcure at the bottom of the run, light to dark gray, slightly weathered, medium hard										
2		39.5	487.2	35					100	63			
			LIMESTONE, with trace vugs, some fossiliferous zones, and a vertical fracture at the bottom of run, light to dark gray, slightly weathered, medium hard										
3		44.5	482.2	40					100	96	UC		
			LIMESTONE, with shale seams, vugs, shale partings, and some argillaceous zones, light to dark gray, slightly weathered, medium hard										
		49.5	477.2	45					100	100			
			LIMESTONE, with shale seams, some fossiliferous zones, and shale partings, light to dark gray, slightly weathered, medium hard										
			LIMESTONE, with shale seam, shale partings, fossiliferous zones and trace vugs, light to dark gray, slightly weathered, medium hard	50									

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

Advancement Method:
Hollow stem auger to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-12-2022 | Boring Completed: 07-12-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-6

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1635° Longitude: -86.7837°

Surface Elev.: 526.7 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)
3			**LIMESTONE**, with shale seam, shale partings, fossiliferous zones and trace vugs, light to dark gray, slightly weathered, medium hard *(continued)*						100	88			
		54.5	472.2										
			LIMESTONE, with shale seam, shale partings, fossiliferous zones and trace vugs, light to dark gray, slightly weathered, medium hard	55					99	99			
		59.5	467.2										
			LIMESTONE, with shale partings, fossiliferous zones, and trace vugs, light to dark gray, slightly weathered, medium hard	60					100	81	UC		
		64.5	462.2										
		66.0	**LIMESTONE**, with shale partings, fossiliferous zones, and trace vugs, light to dark gray, slightly weathered, medium hard 460.7	65					100	81			
			Boring Terminated at 66 Feet										

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

Advancement Method:
Hollow stem auger to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-12-2022 | Boring Completed: 07-12-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-7

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1634° Longitude: -86.7841°

Surface Elev.: 526.5 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)
		0.3	526.3										
		ASPHALT											
		0.8	525.7										
1		**BASESTONE**											
		1.0	525.5										
		FILL - LEAN CLAY						4-50/4"					
		2.5	524										
		FILL - LEAN CLAY, trace chert Auger refusal at 2.5'											
2		**LIMESTONE**, with few shale seams, light to dark gray, slightly weathered, medium hard							87	50			
		4.5	522										
		LIMESTONE, with clay seams and argillaceous zones, light to dark gray, moderate to severe weathering, medium hard		5					98	53			
		9.5	517										
3		**LIMESTONE**, with trace pits, light to dark gray, slight weathering, medium hard		10					100	100			
		14.5	512										
		LIMESTONE, with shale seams and fossiliferous zones, light to dark gray, slightly weathered, medium hard		15					100	88			
		19.5	507										
2		**LIMESTONE**, with shale seams, fossiliferous zones, and trace shale partings, light to dark gray, slightly weathered, medium hard		20					100	88			
		24.5	502										
3		**LIMESTONE**, with shale seams, fossiliferous zones, shale partings, and trace vugs, light to dark gray, slightly weathered, medium hard		25									

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

Advancement Method:
Hollow stem auger to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-11-2022 | Boring Completed: 07-11-2022
Drill Rig: Track | Driller: Tri-State Drilling
Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-7

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1634° Longitude: -86.7841°

Surface Elev.: 526.5 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)
3		29.5	497						100	45			
				30									
		34.5	492						98	85	UC		
		39.5	487	35					100	80			
		44.5	482	40					100	100			
		49.5	477	45					98	95			
				50									

LIMESTONE, with shale seams, fossiliferous zones, shale partings, and trace vugs, light to dark gray, slightly weathered, medium hard *(continued)*

LIMESTONE, with argillaceous zones and trace vugs, light to dark gray, slightly weathered, medium hard

LIMESTONE, with trace shale seams and pits, light to dark gray, slightly weathered, medium hard

LIMESTONE, with trace shale and some argillaceous zones, light to dark gray, slightly weathered, medium hard

LIMESTONE, with trace vugs, shale seams, and some argillaceous zones, light to dark gray, slightly weathered, medium hard

LIMESTONE, with argillaceous zones and trace shale seams, light to dark gray, slightly weathered, medium hard

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

Advancement Method:
Hollow stem auger to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-11-2022 | Boring Completed: 07-11-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-7

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1634° Longitude: -86.7841°

Surface Elev.: 526.5 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)
			LIMESTONE, with argillaceous zones and trace shale seams, light to dark gray, slightly weathered, medium hard *(continued)*						100	96			
		54.5		472									
			LIMESTONE, with argillaceous zones and trace shale seams, light to dark gray, slightly weathered, medium hard	55					94	86	UC		
3		59.5		467									
			LIMESTONE, with fossiliferous zones and trace pits, light to dark gray, slightly weathered, medium hard	60					91	91			
		64.5		462									
			LIMESTONE, with fossiliferous zones and trace pits, light to dark gray, slightly weathered, medium hard	65					81	81			
		66.5		460									
			Boring Terminated at 66.5 Feet										

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

Advancement Method:
Hollow stem auger to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-11-2022 | Boring Completed: 07-11-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-8

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1639° Longitude: -86.7861°

Surface Elev.: 480.0 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)
		0.5	479.5										
		ASPHALT											
		1.0	479										
		BASESTONE											
1		**FILL - LEAN CLAY (CL)**, Dark brown clay with trace chert, trace mineral nodules, trace brick, and trace limestone rock fragments						5-6-9 N=15					
		3.5	476.5										
		FILL - LEAN CLAY (CL), Yellowish brown clay with trace chert, trace limestone rock fragments, and gray mottling		5				1-2-2 N=4					
		6.0	474										
		FILL - LEAN CLAY (CL), Brown clay with trace limestone rock fragments and some brick						5-2-3 N=5					
		8.5	471.5										
		FILL - LEAN CLAY (CL), Brown clay with some brick and urban mix fill		10				2-2-1 N=3					
		11.5	468.5										
		Auger refusal at 11.5'											
2		**LIMESTONE**, with shale partings, fossiliferous zones, trace vugs and clay mud at bottom of run, light to dark gray, slight to moderately weathered, medium hard		15					99	68	UC		
		16.5	463.5										
3		**LIMESTONE**, with fossiliferous zones, pits and shale partings, light to dark gray, slightly weathered, medium hard		20					100	85			
		21.5	458.5										
		Boring Terminated at 21.5 Feet											

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

Advancement Method:
Hollow stem auger to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-19-2022 | Boring Completed: 07-19-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22

BORING LOG NO. B-9

PROJECT: TN Tower Parking Garage

CLIENT: Hurst-Rosche Inc
Hillsboro, IL

SITE: 301 7th Ave
Nashville, TN

LOCATION See Exploration Plan

Latitude: 36.1637° Longitude: -86.7855°

Surface Elev.: 492.8 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	Recovery %	RQD %	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)
		0.5	492.3										
		ASPHALT											
		1.0	491.8										
		BASESTONE											
		FILL -, No recovery, interpreted fill materials						50/5"					
		3.5	489.3										
1		**FILL -**, Urban mix fill w/ limestone rock fragments		5				5-50/5"					
		6.0	486.8										
		FILL -, No recovery, interpreted fill materials						50/5"					
		8.5	484.3										
		FILL -, No recovery, AR @9.8											
		9.8	483										
		Auger refusal at 9.8'											
		LIMESTONE, with shale seams and shale partings, light to dark gray, slightly weathered, medium hard		10					96	93			
		14.8	478										
		LIMESTONE, with shale seams, shale partings, and trace vugs, light to dark gray, slightly weathered, medium hard		15					100	90			
3		19.8	473										
		LIMESTONE, with fossiliferous zones, shale partings and shale seams, light to dark gray, slightly weathered, medium hard		20					100	89	UC		
		25.0	467.8										
		Boring Terminated at 25 Feet		25									

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

Advancement Method:
Hollow stem auger to auger refusal and NQ rock core to boring termination

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with asphalt

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

See Supporting Information for explanation of symbols and abbreviations.

Elevations were provided by others.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
5217 Linbar Dr, Ste 309
Nashville, TN

Boring Started: 07-18-2022 | Boring Completed: 07-18-2022

Drill Rig: Track | Driller: Tri-State Drilling

Project No.: 18225080

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 18225080 TN TOWER PARKING.GPJ TERRACON_DATATEMPLATE.GDT 8/22/22



Photo 1 B-1 10.4-20.4



Photo 2 B-2 11.8-20.0



Photo 3 B-2 20.0-25.0



Photo 4 B-3 7.5-15.0



Photo 5 B-3 15.0-25.0



Photo 6 B-3 25.0-35.0



Photo 7 B-3 35.0-45.0



Photo 8 B-3 45.0-55.0



Photo 9 B-3 55.0-65.0



Photo 10 B-4 1.5-9.5



Photo 11 B-4 9.5-19.5



Photo 12 B-4 19.5-29.5



Photo 13 B-4 29.5-39.5



Photo 14 B-4 39.5-49.5



Photo 15 B-4 49.5-59.5



Photo 16 B-4 59.5-64.5



Photo 17 B-5 1.5-4.5



Photo 18 B-6 2.5-9.5



Photo 19 B-6 9.5-19.5



Photo 20 B-6 19.5-29.5



Photo 21 B-6 29.5-39.5



Photo 22 B-6 39.5-49.5



Photo 23 B-6 49.5-59.5



Photo 24 B-6 59.5-66.0



Photo 25 B-7 2.5-9.5



Photo 26 B-7 9.5-19.5



Photo 27 B-7 19.5-29.5



Photo 28 B-7 29.5-39.5



Photo 29 B-7 39.5-49.5



Photo 30 B-7 49.5-59.5



Photo 31 B-7 59.5-66.5



Photo 32 B-8 11.5-21.5



Photo 33 B-9 9.8-19.8



Photo 34 B-9 19.8-25.0

SUPPORTING INFORMATION

Contents:

General Notes
Unified Soil Classification System
Description of Rock Properties

Note: All attachments are one page unless noted above.

GENERAL NOTES

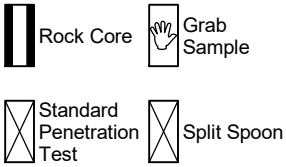
DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

TN Tower Parking Garages ■ **Nashville, TN**

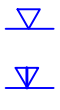
Terracon Project No. 18225080

Terracon GeoReport

SAMPLING



WATER LEVEL



Water Initially Encountered

Water Level After a Specified Period of Time

Water Level After a Specified Period of Time

Cave In Encountered

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.

FIELD TESTS

N	**Standard Penetration Test Resistance (Blows/Ft.)**
(HP)	**Hand Penetrometer**
(T)	**Torvane**
(DCP)	**Dynamic Cone Penetrometer**
UC	**Unconfined Compressive Strength**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

LOCATION AND ELEVATION NOTES

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. 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, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

RELEVANCE OF SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

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]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [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]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [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"		CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K, L, M, N]
			Liquid limit - not dried			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	< 0.75	OH	Organic clay [K, L, M, P]
			Liquid limit - not dried			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] $Cu = D_{60}/D_{10}$ $Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[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.

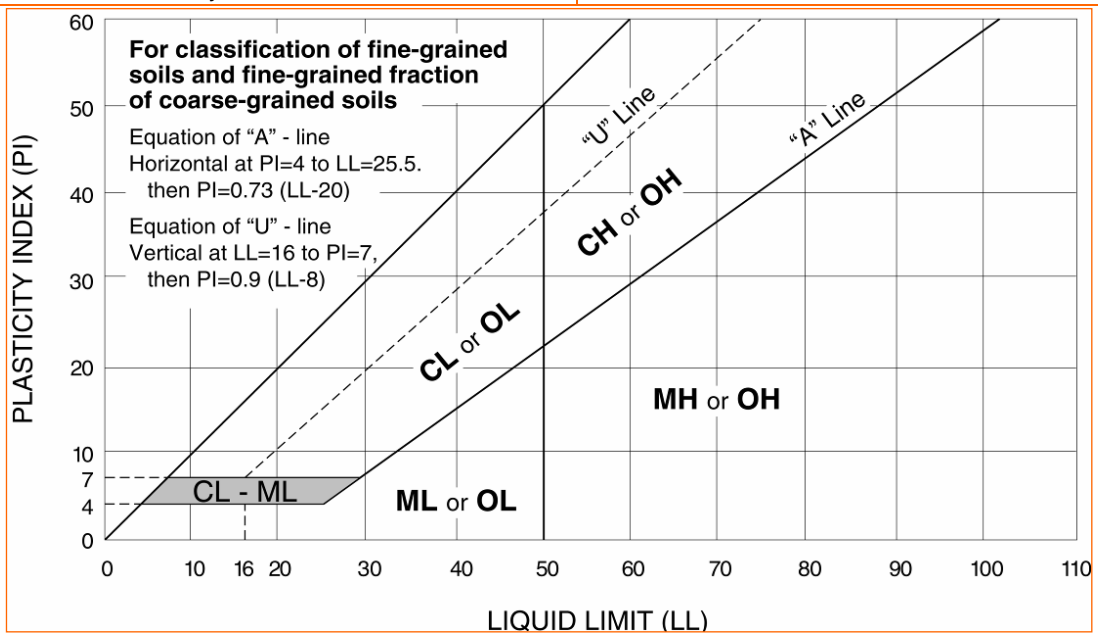
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[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.



DESCRIPTION OF ROCK PROPERTIES

WEATHERING	
Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" no discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)	
Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding, and Foliation Spacing in Rock [1]

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

1. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designator (RQD) [1]

RQD, as a percentage	Diagnostic description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

1. RQD (given as a percentage) = length of core in pieces 4 inches and longer / length of run

Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.

Appendix

Contents:

Downhole Seismic Testing Letter

Downhole Seismic Plates

Note: All attachments are one page unless noted above.

September 12, 2022

Hurst-Rosche, Inc.
561 Murfreesboro Pike
Nashville, Tennessee 37210

Subject: Borehole Geophysical Logging Investigation
Tennessee Tower
Southwest Corner of Union Street & 7th Avenue N
Nashville, Tennessee

NORCAL Job No: NS225107

Attention: Mr. Jim Siefert, P.E.

This report presents the findings of a Borehole Geophysical Logging (BGL) investigation performed by NORCAL Geophysical Consultants, Inc., a Terracon company (NORCAL), in support of a geotechnical study being conducted by Terracon Consultants for the Tennessee Tower project located in the parking lot at the southwest corner of Union Street and 7th Avenue N in Nashville, Tennessee. The BGL survey was authorized under an inter-office agreement with Terracon Nashville. The field work was performed on August 23rd, 2022 by NORCAL Professional Geophysicist Charles Carter (PGp. 1051). Safety and logistic support were provided by Nicholas Ratcliff of Terracon.

The BGL investigation was conducted in one geotechnical borehole designated as B-7. Borehole B-7 was located within a parking lot located northwest of the intersection of Union Street and 7th Avenue N in Nashville, Tennessee, as shown on Plate 1. The general geology encountered in the borehole consisted of 3-ft of surficial soils overlying limestone. The purpose of the BGL survey was to measure shear (S-) wave and compressional (P-) wave velocities versus depth in the borehole. The borehole was drilled to a depth of 65 feet below ground surface (bgs).

1.0 SCOPE OF SERVICES

Our scope of services for this project consisted of conducting a BGL investigation in Borehole B-7, processing and interpreting the BGL data and presenting our findings in a written report.

2.0 BOREHOLE CONDITIONS

The borehole was advanced using the air hammer drilling method with a 4-inch bit from the surface to the total depth of 65 feet bgs. Three logging runs were conducted in an effort to get to total depth of the borehole. However, the borehole was open to 53 feet on run one, 47 feet on run two and 53 feet on the final run. As a result, the PS-wave survey measured velocities to a maximum depth of 41-ft. The target depth of 80 feet bgs for the PS-wave velocity survey was not reached due to borehole instability.

3.0 BOREHOLE GEOPHYSICAL LOGGING SURVEY

Detailed descriptions of the PS-wave Suspension methodology, our data acquisition and data analysis procedures and results presentation, are provided in Appendix A. The appendix includes a table listing the interval P- and S-wave velocities measured in the borehole.

In addition to PS-wave Suspension logging, the caliper tool was used as a survey technique to assess the relative consolidation of the borehole. The caliper data were also used to identify borehole irregularities that may affect the PS-suspension data quality. Velocity anomalies are common in areas where the borehole walls have lost their natural rigidity due to sloughing or fracturing.

4.0 RESULTS

The results of the suspension borehole logging survey are illustrated by the velocity versus depth graph for B-7 as shown on Plate 2. The graph depicts the variations in S-wave velocity (Vs) and P-wave velocity (Vp) versus depth. Vs are indicated by the red triangles and Vp are indicated by the blue squares. These are interval velocities (see **PS-wave Suspension Velocity Survey**) which represent the average velocity over the 1 meter of sediment or rock between the two receivers at each given depth. To the right of the PS-wave velocity plots, we present the caliper logs (labeled as Borehole Diameter).

5.0 DISCUSSION

As shown on Plate 2, the seismic velocities measured in B-7 are between 5,500 and 10,500 feet per second (ft/s) for Vs, and between 15,000 and 21,000 ft/s for Vp. These velocities are generally high and are consistent with limestone bedrock. Seismic velocities in bedrock tend to vary with changes in degree of weathering, cementation and fracture density.

6.0 STANDARD CARE AND WARRANTY

The scope of NORCAL's services for this project consisted of using geophysical methods to characterize the subsurface. The accuracy of our findings is subject to specific site conditions and limitations inherent to the techniques used. We performed our services in a manner consistent with the standard of care ordinarily exercised by members of the profession currently employing similar methods. No warranty, with respect to the performance of services or products delivered under this agreement, express or implied, is made by NORCAL.

We appreciate the opportunity to provide our services to Hurst-Rosche, Inc. for this project. If you have any questions or require additional geophysical services, please do not hesitate to contact us.

Sincerely,
Terracon Consultants, Inc.

John E. Agee, P.E.
Regional Manager

Nicholas Ratcliff, P.G.
Group Manager

Enclosures: Plate 1: Borehole Location Map
Plate 2: Suspension P- and S-wave Velocity Profile, B-7
PS-wave Suspension Velocity Survey

PS-WAVE SUSPENSION VELOCITY SURVEY

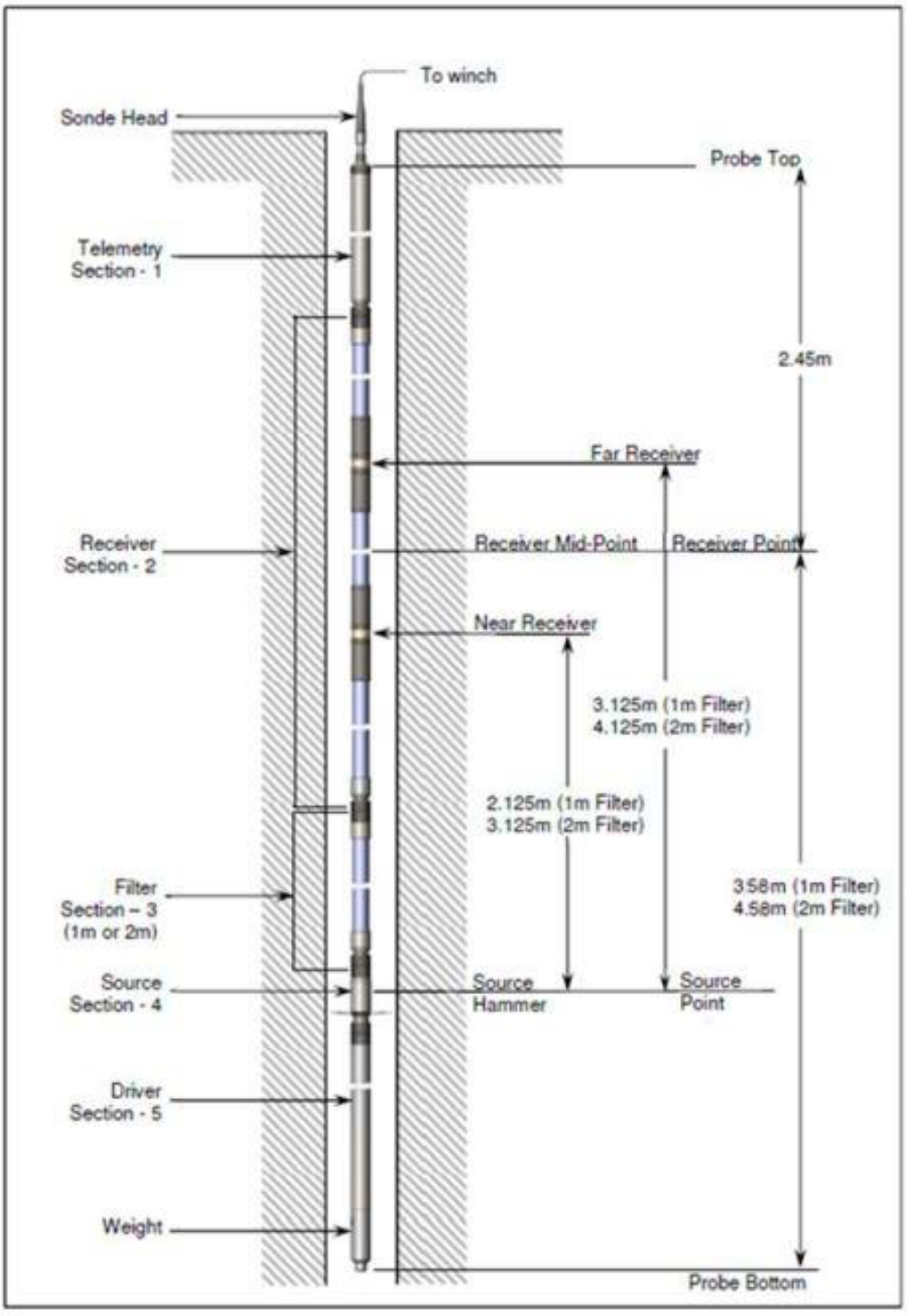
The Suspension logger is a highly specialized downhole tool that measures P- and S-wave velocities at discrete depths. The following presents a narrative on its operation and the data reduction procedures we used in computation of suspension P- and S-wave velocities. Also presented are tabulated velocity data tables interpreted for the suspension logging survey in Borehole B-7.

METHODOLGY

We measured downhole compressional (P-) and shear (S-) wave velocities using a Robertson Geologging, Ltd. digital suspension logging system. A schematic diagram depicting the probe configuration is shown in Figure A-1. The suspension logging tool is equipped with a dipole seismic energy source hammer located near the base of the probe and a pair of detectors (receivers) designated as near receiver (R1) and far receiver (R2), located within the middle to the upper sections of the probe. The distance from the energy source to the closest receiver is 6.97 feet (2.125 meters) when assembled with a detachable 1-meter isolation tube. The in-line distance between the receiver pair is 3.28 feet (1.0 meter). Each receiver contains one horizontal and one vertical oriented element. The horizontal receiver elements preferentially record shear wave motion. The vertical receiver elements preferentially record first arriving P-wave energy.

Suspension seismic data are collected at discrete depths in fluid-filled portions of the borehole. At each measurement depth, the energy source is activated via commands from the surface control console. This activation causes a metal solenoid to strike the metal strike cylinder. This hammer strike generates a pressure wave in the fluid which transmits energy to the borehole wall. The force of the pressure wave applied to the borehole wall produces seismic waves (both P-wave and S-waves) in the adjacent formation (C. Kitsunezaki, 2000). The seismic waves propagate up the borehole wall to the two detectors. The displacement caused by the seismic waves at the borehole wall creates a pressure gradient in the borehole fluid which is detected by the receiver elements within the probe which is suspended in the borehole fluid. The receivers in the suspension logger are hydrophones which detect pressure changes in the borehole fluid. The source hammer and horizontal elements in the receivers are oriented parallel to one another. By striking the metal strike cylinder on opposite sides of the probe (referred to as left strike and right strike) the amplitudes of both the positive and negative polarity S-waves are maximized

Figure A-1: Suspension logger schematic diagram



When assembled with a 1-meter isolation tube, the suspension logging tool is approximately 19.8 feet long (Figure A-1). By definition, the depth reference point of the tool is half-way between the two receivers. Since this point is approximately 12-ft from the probe tip, the maximum depth of a suspension logging survey, given a non-sloughing borehole, will be reported as at least 12 feet less than the total depth of the borehole. When in operation, the probe is centralized in the borehole with flexible rubber rings positioned just below the source. This is necessary to maintain a gap between the probe housing and borehole wall.

2.0 DATA ACQUISITION

We measured seismic velocities with the suspension logger at stationary depth positions in the fluid-filled borehole distributed vertically at 0.5-meter (1.6-ft) intervals in B-7. Borehole B-7 was drilled to a depth of 65 feet below ground surface (bgs). The borehole fluid did not drop below 5 feet from the surface during data acquisition. Since the PS logger needs a fluid-filled, open borehole to transmit energy from the source to the formation, the upper bound of the PS survey was approximately 8 feet bgs. Both receiver elements must be below the fluid level to detect the waves travelling in the formation which sets the probe depth reference point a minimum of 0.5 meters below the borehole fluid.

At each measurement station, the energy source fired 3 times in succession. This cycling of the seismic energy resulting in a “left” and “right” strike for the shear waves (recorded with the horizontal elements) and a third strike for the P-waves (recorded with the vertical elements). While recording P-waves and S-waves, an analog low pass filter of 20 KHz was applied to the signals detected by the vertical and horizontal receiver elements. This filtering was used to suppress interference from ambient acoustic noise. High frequency digital filters were used to filter out P-waves for shear-wave velocity picking.

3.0 DATA ANALYSIS

3.1 SEISMIC RECORDS

Suspension P- and S-wave velocities were calculated with the computer software program ***PS Logger*** published by ***Robertson Geologging.*** Sample suspension seismic records are presented in Figures A-2, A-3, and A-4. Each record displays six seismic wave traces. The upper four traces were detected by the near and far horizontal receiver elements. These traces are labeled according to the element type (H=horizontal), the polarity of the first arrival of the shear waves (n=normal and r=reverse) and the relative distance from the source. For example, the top

wave trace is labeled “far Hn” because it was recorded with the horizontal component furthest from the source using the first strike which produces shear waves with a normal polarity first arrival. The seismic wave traces produced by the second strike of the source produce shear waves with a reverse polarity first arrival.

The lower two traces were detected by the near and far vertical receiver elements and are used to identify P-wave arrivals. These traces are labeled according to the element type (V = vertical) and the relative distance from the source. For example, the bottom wave trace is labeled “near V” because it was recorded to identify P-waves with the vertical component of the near receiver. P-wave traces are produced during the third shot. The direction of impact is inconsequential for the P-waves detected by the vertical elements in the receivers and is therefore not addressed by separate waveforms

Figure A-2: Sample seismic record at depth 16.4 ft bgs.

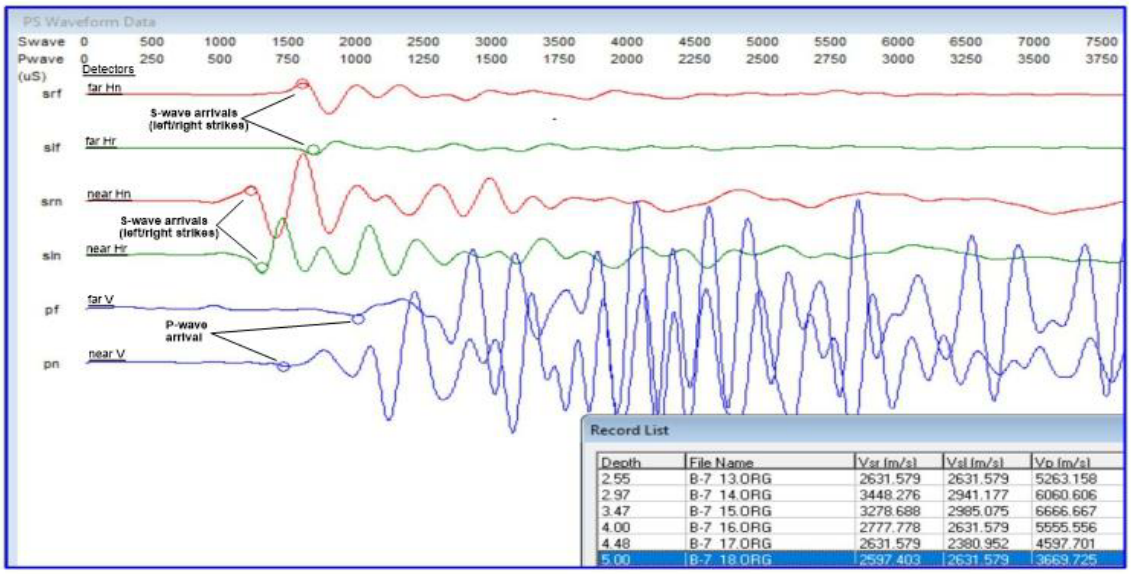


Figure A-3: Sample seismic record at depth 29.5 ft bgs

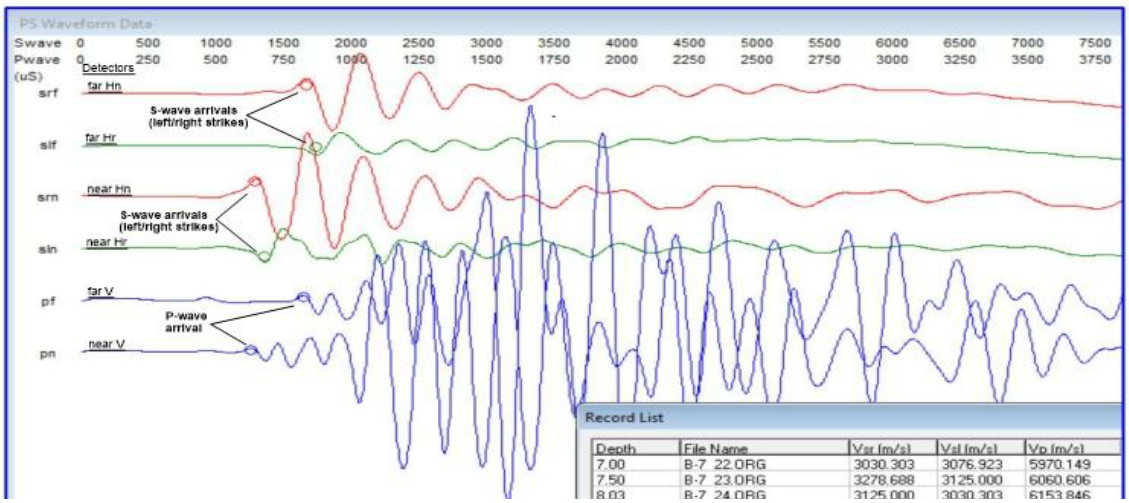
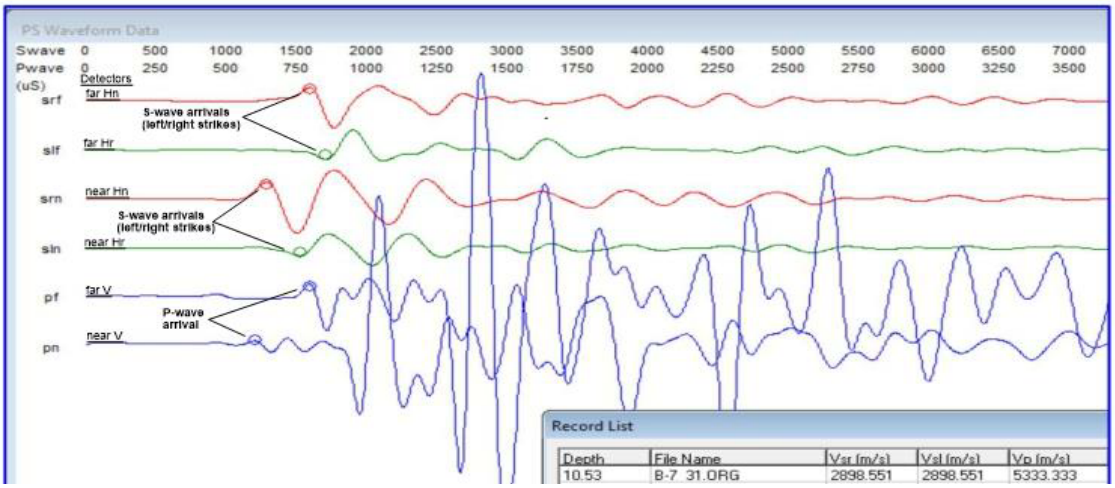


Figure A-4 Sample Waveform Record at a depth of 39.4 ft bgs



3.2 S-WAVE ARRIVALS

On the seismic records shown in Figures A-2, A-3 and A-4, the traces labeled “near Hn” and “far Hn” were created by right side hammer impacts and the traces labeled “near Hr” and “far Hr” were created by left side hammer impacts of the strike cylinder. Pairing the traces produced by opposite directions of impact reveals a phase reversal that is associated with the onset (arrival) of S-wave energy. However, because there can be slight discrepancies in timing between the first and second hammer strikes, the reversal point may not occur at the same exact time on both traces. Therefore, the onset of S-wave energy is further defined as the point where there is also a significant increase or decrease in amplitude within the phase reversal time window. S-waves are also distinguished from P-waves by the lower frequency wavelets. These arrival times are depicted by open red and green circles on the four wave traces recorded with the horizontal hydrophones.

3.3 P-WAVE ARRIVALS

P-wave arrivals are identified as the point where the wave traces produced by the final hammer strike (labeled near V and far V in Figures A-2 through A-4) change from horizontal straight lines to sinusoidal wave forms. These points are referred to as “first breaks”. First breaks may have a positive or negative polarity and exceed a minimum threshold. Often it is less ambiguous to pick the first peak of the wavelet from each receiver (R1 and R2). The point of the break or peak are represented by open blue circles on the vertical channels in the Figures above. The first breaks need only cross a zero-amplitude threshold and be either paired as positive or negative polarity first breaks.

3.4 SEISMIC VELOCITY CALCULATIONS

Velocities are calculated by dividing the distance between the two receivers R1 and R2 by the difference in arrival times (AT in seconds) to those receivers. These are considered interval velocities. The general form of the equation is as follows:

$V_{(R2\text{-}R1)} = (X_{R2}\text{-}X_{R1})/(AT_{R2}\text{-}AT_{R1})$

Where $(X_{R2}\text{-}X_{R1})$ = 1 meter (3.28 feet); AT_{R2} = arrival time at **far** detector, AT_{R1} = = arrival time at **near** detector.

The ***PS Logger*** program calculates two interval Vs velocities at each depth based on arrival time differences from the right strike polarity of cycle 1 (***Vs-right***) records and the left strike polarity of cycle 2 (***Vs-left***) records and one ***Vp*** interval velocity based on the arrival time differences selected from cycle 3 traces. The average of Vs-right and Vs-left is the shear wave velocity reported for each depth.

3.5 INTERVAL SEISMIC VELOCITIES

Final output of velocities and arrival times were made with the reduction program *PS Log Analysis*. The output of this program consists of two interval velocities at each depth, S-wave (Vs) and P-wave (Vp). The interval Vs were computed using an average of the lag times between the first peaks (both normal and reverse polarity) recorded with the near and far horizontal hydrophones. The interval Vp was computed using the lag time between the first arrivals recorded with the near and far vertical hydrophones.

3.6 POISSON'S RATIO

Poisson's ratio is a measure of the compressibility of soil and rock. Poisson's Ratio in rock ranges from 0.15 to 0.40 but can be higher than 0.4 below the water table. Poisson's Ratio in sediments is typically from 0.3 to 0.4 and between 0.4 to 0.5 in saturated sediments. Poisson's Ratio (v) can be determined from Vp and Vs velocities using the following relationship:

$$v = \frac{Vp^2 - 2Vs^2}{2(Vp^2 - Vs^2)}$$

Calculated Poisson's ratios are presented in Table A-1 with the P- and S-wave velocities.

4.0 DATA PRESENTATION

All P- and S-wave velocities interpreted from the receiver-to-receiver analysis for Borehole B-7 are presented in Table A-1 and are differentiated into both Metric and Imperial Units. The columns below indicating metric units are shown on the left. The columns indicating imperial units are shown on the right and present the Vs and Vp data as depths in feet and velocities in feet per second. These average or interval Vs and Vp velocities have columns shaded blue and are displayed graphically on the depth versus velocity profile on Plate 2 with the main body of the report. The depths of the measurements are based on a probe reference point that is half-way between the near and far receivers.

Table A-1, B-7 PS-wave Velocity Table

Borehole B-7,NW Corner of Union Street & 7th Avenue N,
Nashville, TN

NORCAL GEOPHYSICAL CONSULTANTS, INC. JOB NUMBER: NS225107

Client: TERRACON

PS-wave Velocity Table (R1R2), Survey Date: August 23, 2022

METRIC UNITS DEPTHS & INTERVAL VELOCITIES			IMPERIAL UNITS DEPTHS AND INTERVAL VELOCITIES			Poisson's Ratio
Depth	VsAvg	Vp	Depth	VsAvg	Vp	
Meters	M/sec.	M/sec.	Feet	Ft./sec.	Ft./sec.	
2.6	1681	5161	8.4	5513	16929	0.44
3.0	1804	5797	9.7	5918	19014	0.45
3.5	3102	6349	11.4	10176	20825	0.34
4.0	2705	5442	13.1	8871	17850	0.34
4.5	2506	5000	14.7	8221	16400	0.33
5.0	2614	4624	16.4	8576	15168	0.27
5.5	2703	5161	18.0	8866	16929	0.31
6.0	2837	5063	19.8	9305	16608	0.27
6.5	2941	5263	21.2	9647	17263	0.27
7.0	3054	5755	23.0	10016	18878	0.30
7.5	3202	6107	24.6	10502	20031	0.31
8.0	3078	6107	26.3	10095	20031	0.33
8.5	2759	6061	27.8	9049	19879	0.37
9.0	2632	5594	29.5	8632	18350	0.36
9.6	2941	5755	31.4	9647	18878	0.32
10.0	2910	5369	32.8	9545	17611	0.29
10.5	2920	5405	34.4	9579	17730	0.29
11.0	2620	5000	36.1	8595	16400	0.31
11.5	2584	4819	37.7	8476	15807	0.30
12.0	2611	5263	39.3	8565	17263	0.34
12.5	2857	5161	41.0	9372	16929	0.28

5.0 QUALITY ASSURANCE

For quality assurance purposes, a source-to-receiver analysis was conducted. Depth verses interval velocities are displayed below with velocities obtained from a source-to-near receiver (S-R1) analysis in Figure A-5. There is a 2.125 m separation between the source and near receiver. Therefore, the S-R1 velocities are an average velocity over 2.1 m rather than the average velocity over 1 m between the near and far receivers. The center point between the source and near receiver is 1.56 m lower on the probe than the mid-point between the two receivers. The S-R1

velocity for the record acquired at 10 m, for example, is reported at a depth of 11.6 m. The source to receiver velocity is calculated with the following equation

$V_{(S-R1)} = (X_S - X_{R1})/(AT_{R1} - SD)$

where the S-R1 separation is 2.125m, AT_{R1} = arrival time at **near** detector and SD is the source delay which was 0.13 milliseconds for B-7. The source delay is the time between the source trigger and the source impact and is influenced by the probe's internal electronics and the rigidity of the source springs. The results of this analysis show good agreement relative to the velocities obtained from the receiver to receiver (R1R2) analysis.



LEGEND

⊕	GEOPHYSICAL LOGGED BORING (APPROXIMATE LOCATION)

SCALE

0 50 100 200

(1 inch = 100 feet)

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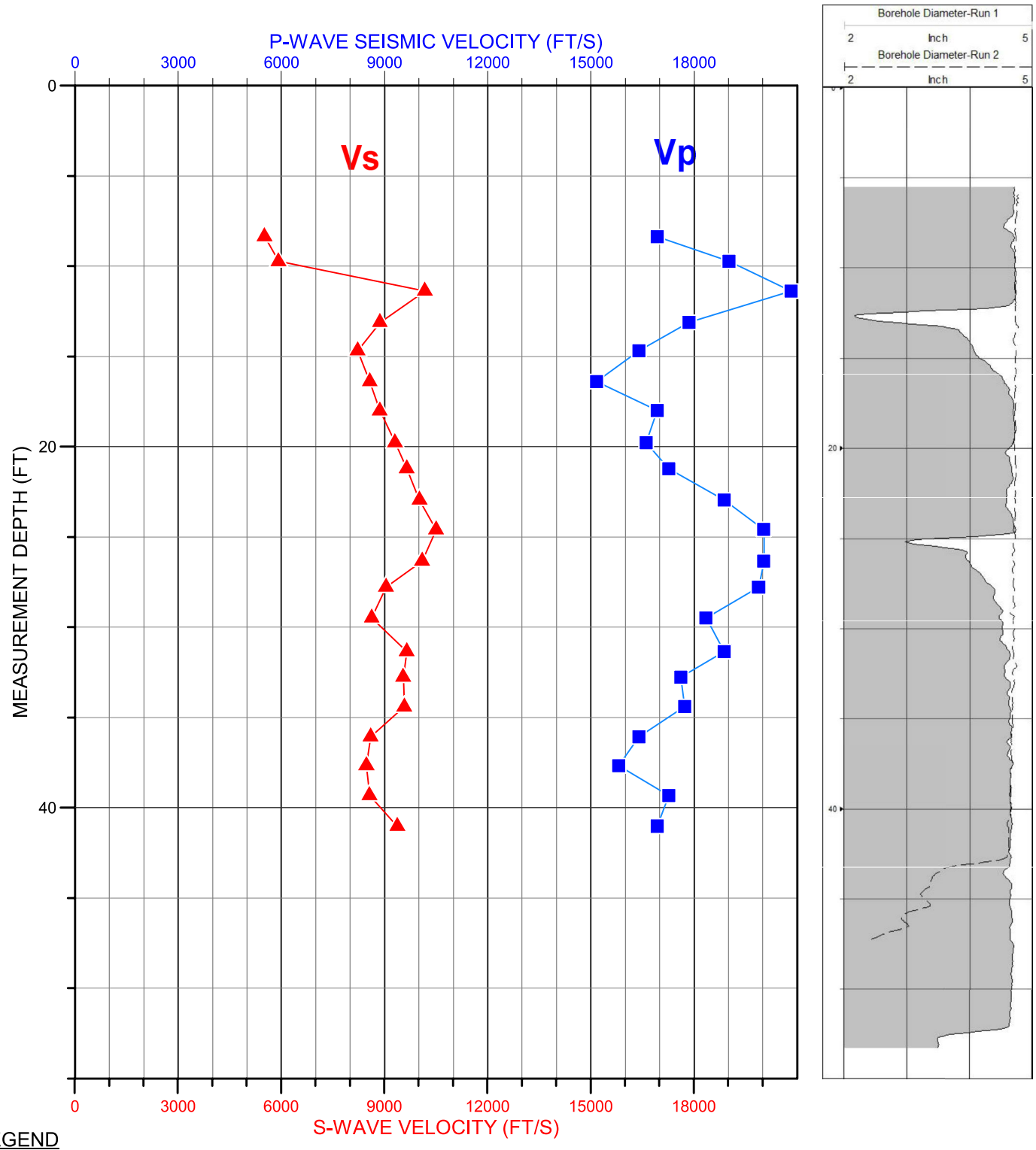
BOREHOLE LOCATION MAP
BOREHOLE GEOPHYSICAL LOGGING SURVEY
TENNESSEE TOWER PARKING GARAGE

LOCATION: 301 7TH AVENUE NORTH, NASHVILLE, TENNESSEE

CLIENT: HURST-ROSCHE INC

JOB #. NS225107	LOG DATE: 08/23/2022	PLATE 1
DRAWN BY: H.PHILSON	APPROVED BY: CGC	

Charles Carter 9/12/2022



LEGEND

Vs R1R2

Vp R1R2

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SUSPENSION P- AND S-WAVE VELOCITY PROFILE BOREHOLE B-7

LOCATION: NW Corner of Union Street & 7th Avenue N, Nashville, TN

CLIENT: TERRACON

JOB #: NS225107 | LOG DATE: 08/23/2022

DRAWN BY: C. CARTER | APPROVED BY: DJK

Charles Carter 9/12/2022

PLATE 2