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AMENDED GEOTECHNICAL ENGINEERING STUDY for

45 Broad Street
New York, New York

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INTRODUCTION

This amended report updates the results of our amended geotechnical engineering study for the proposed development of 45 Broad Street in Manhattan, New York. The purpose of this study was to develop recommendations for foundations and other geotechnical aspects of design and construction. Our work was performed in accordance with our approved 19 November 2015 proposal. Our study included a review of available information, field investigations, engineering evaluation, and development of geotechnical recommendations in accordance with the 2014 New York City Building Code. Amendments to our 23 November 2010 report were made to:

1. Include information from a supplementary subsurface investigation performed in January and February of 2016;
2. Account for new design drawings prepared by the architect (CetraRuddy) and subsequent discussions with the project team and Madison 45 Broad Development;
3. Account for new foundation drawings prepared by the structural engineer (WSP) in March 2016.

Elevations given are based on the survey prepared by Empire State Layout, Inc., dated 21 January 2016, and are with respect to the North American Vertical Datum (NAVD88) unless otherwise noted.

SITE DESCRIPTION

The 45 Broad Street site is on the east side of Broad Street between Exchange Place and Beaver Street in lower Manhattan, New York. The site is identified as Block 25, Lot 7 on the New York City Tax Maps and is currently vacant. The site is within the block bound by Exchange Place on the north, Beaver Street on the south, Broad Street on the west, and William Street on the east. Existing buildings are adjacent to the site on the north, south, and east. Broad Street borders the site on the west. A New York City Transit (NYCT) tunnel is located under Broad Street. A site location map is presented in Figure 1.

The vacant site is T-shaped with about 63 feet of frontage on Broad Street and a site area of about 12,600 square feet (SF), with surface elevation varying from about el 9 to el 11. An eight-story structure with one cellar level was demolished in 2007 to make way for the previous owner's proposed redevelopment. The former cellar was backfilled with demolition debris to

sidewalk grade with the former foundations, including piles and pile caps and basement slab, left in place.

Adjacent Buildings

Existing structures adjacent to the site on the north, south, and east are shown in Figure 6:

41 Broad Street – Claremont Preparatory School

The Claremont Preparatory School (41 Broad Street) north of the site is a nine- to twelve-story brick and stone structure with a footprint of about 11,000 SF built in 1929. Available architectural drawings indicate that 41 Broad Street has two below-grade levels with the subcellar level having a finished-floor elevation about 28 feet below the adjacent sidewalk grades(about el -17.5). Available foundation drawings show the structure supported by spread footings. Bearing capacity was not indicated on the available plans. Construction drawings appear to indicate that, along the southern end of the site (adjacent to 45 Broad), the foundations consist of piers bearing on bedrock constructed by way of a continuous cofferdam.

25 Broad Street

25 Broad Street is a T-shaped lot to the east occupied by a 20-story brick and stone structure with a 263-foot frontage along Exchange Place, built around 1900. The building previously had an about 50-foot-wide section that extended to the south, adjacent to 41 and 45 Broad Street to the east. This 4,200-square-foot extension was demolished to be part of the previous 45 Broad Street development scheme. Available architectural drawings show that the entire building footprint of 25 Broad Street, including the demolished southern part, has one cellar level. The finished-floor elevations of the below-grade levels are not known, and no foundation drawings are available for this structure. A steam-line easement running in the north-south exists within the part of 25 Broad Street that was demolished.

40 Exchange Place

Beyond 25 Broad Street to the east is 40 Exchange Place, a 20-story brick and stone commercial building with one below-grade level, built in 1902. The finished-floor elevations of the below-grade levels are not known, and no foundation drawings are available for this structure.

15 William Street

Adjacent to 25 Broad Street to the southeast is 15 William Street, a 44-story concrete residential structure with below-grade levels that extend about 45 feet below the surrounding grades (about el -34.5) built in 2005. The foundation wall and excavation support system for 15 William Street consists of a permanent reinforced secant pile wall drilled into the underlying bedrock.

55 Broad Street

55 Broad Street, adjacent to the south, is a brick building varying from 6 to 31 stories, built in 1968. A one-story extension borders the project site to the southeast. Available drawings show that the building has one below-grade level at about el -7.5 and that the structure is supported on driven H-piles bearing on bedrock.

Adjacent NYCT Subway Structure

The existing NYCT subway tunnels and structures for the BMT and IND J, M, and Z lines run beneath Broad Street about 20 feet west of the site; in addition, the Broad Street station (servicing lines J and Z) is nearby. NYCT drawings (Broad Street Station, South-End, 1928) show that the subway consists of a reinforced concrete box constructed using cut-and-cover methods. Vents in the Broad Street sidewalk are as close as about 10.5 feet to the property line. The base of the rail closest to the site is at about el -12.5. The tunnel foundation level is at about el -16.5, which is about 28 feet below the adjacent sidewalk grades. Because the proposed construction will be within 200 feet of the subway tunnel, NYCT approval of excavation and foundation construction is required to obtain building permits.

PROPOSED DEVELOPMENT

According to CetraRuddy's architectural drawings, the project will consist of about 8,950 square feet of development with an 83-story (plus mechanical penthouse) tower. The tower will extend to about 1,150 feet above grade and will have about 30-foot setback from the south property line along Broad Street. The top of the ground floor slab will be about el 11.4. The development in the rear "hammerhead" portion of the site is not proposed.

The building will include three cellar levels below the podium to be used for storage and amenities, including a swimming pool. The top of lowest cellar slab will be about 32 feet below sidewalk grade; the corresponding elevation is about el -20.7.

The tower will be concrete and will have a central structural core extending the entire height of the structure, with perimeter columns carrying the remaining load. The foundation loads and contact pressure at the base of the tower is not yet available at the time of this report; however WSP expects the contact pressure to be below 40tsf.

REVIEW OF PUBLISHED INFORMATION

Regional Geology

The United States Geological Survey "Bedrock and Engineering Geologic Maps of New York County and Parts of Kings and Queens Counties, New York, and Parts of Bergen and Hudson Counties, New Jersey" (see Figure 2) shows the bedrock formation underlying the site is Manhattan Schist.

Pleistocene glacial activity modified the landscapes and surficial features of Manhattan, Brooklyn, Queens, and Long Island. Glaciers scoured uplands and deposited varying amounts of till (an unsorted mixture of sand, clay and boulders) across the lowlands and valleys. The USGS surficial geology map indicates that the site is underlain by glacial outwash deposits generally consisting of sand and gravel. See Figure 3 for the USGS surficial geology map.

Historical Land Use

We reviewed the "Sanitary & Topographical Map of the City and Island of New York" (Viele, 1856), which indicates the east portion of the site near Broad Street is on manmade land and the west part of the site was a meadow. Before being filled, Broad Street was an inlet from the East River known as Broad Canal. See Figure 4 for the relevant part of the Viele Map.

Flood Hazard

We reviewed the Federal Emergency Management Agency (FEMA) Preliminary Flood Insurance Rate Map (FIRM), dated 5 December 2013 (Community Panel No. 360497 0088 G). According to the Preliminary FIRM, the western part of the site is within Zone X (areas within the 0.2 percent annual chance floodplain, i.e., 500-year flood). The eastern part of the site is within Zone AE (areas within the 1 percent annual chance floodplain, i.e., 100-year flood), which has a base flood elevation of el 11 NAVD88. Design of the building must follow the flood protection requirements of the NYCT and ASCE-24. The relevant part of the Preliminary FIRM is presented in Figure 5.

SUBSURFACE EXPLORATION

A summary of our subsurface explorations performed in August 2007 and February 2016 are presented below.

2007 Borings

Six borings (B-1 through B-6) were drilled as part of our 2007 subsurface exploration. All borings were drilled by Craig Test Boring, Inc. with a CME track-mounted drill rig, under Langan's full-time special inspection. The borings were advanced using mud rotary drilling techniques and a tricone roller bit with drilling fluid and steel casing providing soil support. Borings were advanced to between 59 and 65 feet below grade.

The upper 10 feet of each boring was drilled without sampling to permit the boring to be advanced through demolition debris and the remnant cellar-floor slab. Standard Penetration Test (SPT)[1] N-values were measured and soil samples were typically obtained beginning at about 10 feet below the existing site grades and at 5-foot intervals thereafter. Samples were retrieved using a standard 2-inch outside-diameter split-spoon sampler driven by a 140-pound automatic hammer in accordance with ASTM D1586. NX-size rock cores were obtained at each boring location in accordance with ASTM D2113. Rock core recovery[2] and rock quality designation (RQD)[3] was recorded for each core run.

Recovered soil samples were visually examined and classified in the field in accordance with the Building Code. Soil classifications, N-values, and other field observations were recorded on field logs. See Appendix A for the boring logs and Figure 6 for the boring location plan.

2016 Borings

Two borings (B-7 and B-8) were drilled in the rear of the lot ("hammerhead") as part of our 2016 supplemental subsurface exploration program. The borings were drilled by Craig Geotechnical Drilling Co., Inc. with a truck-mounted drill rig under Langan's full-time special inspection. . The borings were advanced using mud-rotary drilling techniques and a tricone roller bit with drilling fluid and steel casing providing soil support. Both borings were advanced to 55 feet below grade.

[1] The Standard Penetration Test is a measure of the soil density and consistency. The SPT N-value is defined as the number of blows required to drive a 2-inch outside diameter split-barrel sampler 12-inches, after an initial penetration of 6-inches, using a 140-pound hammer free falling from a height of 30-inches.

[2] Core recovery is defined as the ratio of the total length of rock recovered to the total core run length, expressed as a percent.

[3] The RQD is defined as the ratio of the summation of each rock piece greater than 4-inches in length for NX cores to total core run length, expressed as a percent.

The upper 10 feet of each boring was drilled without sampling to permit the boring to be advanced through demolition debris and the remnant cellar floor slab. SPT N-values were measured and soil samples were typically obtained beginning at about 10 feet below the existing site grades and at 5-foot intervals thereafter. Samples were retrieved using a standard 2-inch outside-diameter split-spoon sampler driven by a 140-pound automatic hammer in accordance with ASTM D1586. NX-size rock cores were obtained at each boring location in accordance with ASTM D2113. Rock core recovery and RQD were recorded for each core run.

Recovered soil samples were visually examined and classified in the field in accordance with the Building Code. Soil classification, N-values, and other field observations were recorded on field logs. See Appendix A for the boring logs and Figure 6 for the boring location plan.

2016 Cone Penetration Tests (CPTs)

Two Cone Penetration Tests (CPT-1, CPT-2) were performed on 1 February 2016 in accordance with ASTMD-5778 as part of our supplemental subsurface exploration. The CPTs were performed by Craig Geotechnical Drilling Co., Inc. under the special inspection of Langan. A truck-mounted CPT rig was used to hydraulically push a 1.4-inch-diameter (36mm) electric cone penetrometer to about 35 feet (CPT-1) and 38 feet (CPT-2).

The upper 15 feet of each CPT was pre-drilled to penetrate through the demolition debris and the remnant cellar-floor slab. The cone penetrometer was pushed at an estimated rate of about 0.75 in/sec (20mm/s) and readings were taken every 0.5 to 2.0 inch. Seismic shear-wave velocity tests were performed approximately every 5 feet. Seven shear-wave tests were performed at CPT-1, and eight at CPT-2. See Figure 6 for CPT locations and Appendix E for the CPT report prepared by Craig Geotechnical Drilling Co., Inc.

2016 Test Pit

One test pit (TP-1) was excavated by J. Coffey Contracting Inc., Flushing, New York, from 17 through 22 February 2016 under the full-time special inspection of Langan. The purpose of the test pit was to explore the adjacent foundation condition at 55 Broad Street. The test-pit indicated the cellar slab for 55 Broad Street extends to about el -5.25 (which appears to be slightly higher than el -7.5 depicted on available drawings), and that foundation pile caps extend to about el -12.25. The test pit was backfilled to existing grade with excavated material upon completion of the exploration.

See Figure 6 for the test pit location and Appendix D for the test pit sketch and selected photographs.

Groundwater Observation Wells

Three groundwater monitoring wells were installed in completed borings B-1, B-6, and B-7 to monitor the groundwater level at the site. The wells consisted of 1¼-inch or 2-inch diameter PVC riser pipes and 10-foot- or 20-foot-long well screens with well depths ranging between about 26 and 49 feet. The water levels were measured during the exploration. Observation well construction logs are provided in Appendix B.

Laboratory Testing

Samples obtained during our 2007 and 2016 subsurface explorations were brought to our office for further analysis and laboratory tests. Soil classifications were verified by a senior engineer and selected soil and rock samples were sent to our laboratory for testing. Six grain-size analyses, 11 Atterberg Limits determinations, 17 moisture-content measurements, 4 unconfined compression tests, 2 elastic moduli determinations, and 2 splitting tensile strength tests were performed. See Appendix C for laboratory test results.

SUBSURFACE CONDITIONS

The subsurface conditions generally consist of about 13 to 17 feet of uncontrolled fill and demolition debris, about 21 to 27 feet of silt with discontinuous sand and clay seams, and about 3 to 15 feet of decomposed rock. Schist bedrock was encountered between about 38 to 49 feet below grade. Stabilized groundwater levels were observed at depths of about 13.5 feet in 2016 and 20 feet in 2007. A more detailed description of each layer is provided below. Representative subsurface profiles are presented on Figures 7 and 8.

Fill [Class 7][4]

A layer of uncontrolled fill and demolition debris ranging in thickness between 13 and 17 feet was encountered in the borings, test pits and CPTs. The upper fill generally consisted of brick, concrete, and rebar debris from previous demolition at the site. The former basement floor slab was encountered about 12 feet below the existing site grade. Fill encountered below the basement slab generally consisted of coarse to fine sand with varying amounts of silt, gravel, and debris. No soil sampling was performed within the upper 10 feet of each borehole because of obstructions within the fill from the demolition operations. In addition to the floor slab, former foundation elements and other large obstructions should be anticipated within the fill. The piles and pile caps from the former structure are also present below the slab.

[4] Numbers in brackets that follow the material designation indicate classification of soil and rock materials in accordance with the NYC Building Code.

The fill is highly variable and is designated as Building Code Class 7, "uncontrolled fill."

Silt and Clay [Class 5b, 4c, and 6]

A layer of low-plasticity silt about 21 to 27 feet thick was encountered below the fill layer. This silt is regionally known as "Bull's Liver". The silt is generally loose to medium-dense with varying amounts of fine sand and clay, and is known for having unconventional engineering properties because of its silt-sized particles with little to no plasticity. In a saturated state, this silt has been observed to behave like a gel or even flow like liquid under shock or vibration. The foundation contractor should consider this soil behavior because it can introduce significant challenges during excavation and foundation construction.

Discontinuous layers of fine silty sand were encountered within the silt in borings B-2, B-3, B-4, and B-8 (discussed below). In addition, pockets with more clay content were encountered within the silt layer in borings B-4, B-5, and B-7.

Standard Penetration Test (SPT) N-values for the silt ranged between 1 and 29 blows per foot. CPT results indicated that this layer has the behavior of "Clayey silt to silty clay" or "Silty sand to sandy silt" with small pockets of "Clay to silty clay" and "Clean sand to silty sand". In general terms the SPT sampling and CPT results correlate well.

Laboratory testing of collected samples yielded natural moisture contents from 27 to 40 percent. The liquid limit ranged between 26 and 33 (average about 30); the plastic limit ranged from 20 to 25 (average about 23); and the plasticity index ranged from 4 to 11 (average about 7). In most tests the water content is near or above the liquid limit indicating that the silt could behave similarly to a viscous liquid when disturbed by construction.

The silt is generally classified as ML, CL, and ML-CL, in accordance with Unified Soil Classification System (USCS). The silt is designated as Building Code Class 5b and 6 material, "medium dense silts" and "loose silts," respectively. The pockets with higher clay content are designated as Building Code Class 4c and 6 material, "medium stiff clays" and "soft clays," respectively.

Clayey Sand [Class 6]

Four to 7 feet thick pockets of clayey fine to coarse sand were encountered within the silt in borings B-2, B-3, B-4, and B-8. Typical N-values for these sand pockets ranged between 1 and 8 bpf. These thin pockets of "Clean sand to silty sand" were also encountered at CPT-1 and CPT-2.

The clayey sand is generally classified as SC in accordance with USCS and is designated as Building Code Class 6 material, "loose granular soils."

Decomposed Rock [Class 1d]

Decomposed rock, ranging in thickness between about 3 and 15 feet, was encountered below the silt. The top of the decomposed rock was found about 34 to 41 feet below the existing ground surface (about el -24 to el -32). The decomposed rock generally consisted of micaceous silt with varying proportions of gravel and sand, and gravel-sized fragments of schist. SPT N-values within the decomposed rock generally met split-spoon refusal at 100 blows over 3 inches.

The decomposed rock layer is classified as Building Code Class 1d material, "soft rock."

Bedrock [Class 1a, 1b, and 1c]

The site is underlain by Manhattan schist bedrock, and the top of rock was encountered at depths of about 38 to 49 feet below the existing site grades. The corresponding top or rock elevations range between about el -28 and el -40. Rock-core recoveries range between 58 and 100 percent. Rock quality designation (RQD) values range between 37 and 100 percent. Both core recoveries and RQD generally improve with depth.

The bedrock at the site is classified as Building Code Class 1a, 1b, and 1c material, "hard sound rock," "medium hard rock," and "intermediate rock," respectively. Laboratory testing performed on select rock cores show intact compressive strength ranging from 8,400 to 16,800 psi, with an average compressive strength of about 13,500 psi. The rock Elastic Modulus test results range from 6,500 to 9,100 ksi, with an average of about 7,800 ksi. Splitting Tensile test results range from 1,300 to 2,300 psi, with an average of about 1,600 psi.

Groundwater

Groundwater levels were measured between about 18 and 20 feet below the existing grades during our 2007 exploration (about el -8 and el -10). Groundwater levels were measured at about 13.5 feet below the existing grade (about el -3.5) during our 2016 exploration. Groundwater can be expected to fluctuate with weather, seasonal conditions, construction activity, or groundwater pumping. The NYCT tunnels in Broad and William streets may be causing a local depression of the groundwater table. Nearby construction or pumping activity can also affect groundwater elevations on this site. We recommend the groundwater level be monitored throughout the design phase.

EVALUATION AND DISCUSSION

The subsurface and surrounding conditions present several geotechnical design challenges:

1. The uncontrolled fill and low-plasticity silt are unsuitable to support the proposed high-rise tower.
2. Existing structures (buildings, a subway tunnel, and a steam tunnel) are adjacent to the site on all four sides; the excavation and foundations construction methods must not overstress or damage the adjacent structures.
3. Driven piles are not recommended because of the proximity to adjacent buildings and NYCT tunnel.

The building will include three cellar levels with the top of the lowest cellar slab at about 32 feet below sidewalk grade. Therefore, we recommend a mat foundation bearing directly on the underlying bedrock combined with permanent tie-down anchors to resist wind and hydrostatic uplift. Where the top of competent rock (Building Code Class 1b or better) is below the proposed bottom of the mat, the mat should rest on clean, concrete fill with a minimum 28-day strength of 4,000 psi, casted atop the rock. The excavation will require installing a permanent rigid support of excavation (SOE) system to provide groundwater cut-off. The rigid SOE system can be appropriately sized and reinforced to carry compression and tension perimeter building loads. Geotechnical parameters for the mat foundation, tie-down anchors, and support of excavation design are provided in subsequent sections.

Because the site is long-narrow shaped and the excavation will extend about 50 feet below existing grades, equipment access and material storage through the site during foundation construction could be challenging. Traditional bottom-up construction would require rather dense temporary bracing, which could restrict access and congest traffic. Therefore, top-down construction has been considered and discussed with Madison 45 Broad Development and the design team as a viable alternative. During the top-down (or up-down) construction the perimeter wall is installed first (as a drilled secant wall) and the cellar floors are constructed as the excavation progresses. When in place, the ground floor slab will be used as a lay-down area and allow equipment access across the site.

Because of the site's proximity to the adjacent subway tunnel, NYCT review and approval will be required to obtain an excavation and foundation permit from the NYC Department of Buildings. We expect that the interaction with NYCT will be extensive and that permitting process can take four to six months or more, which must be accounted for in the project schedule.

FOUNDATION DESIGN RECOMMENDATIONS

The following sections present our liquefaction evaluation, a discussion of the seismic design parameters, and our recommendations related to the design and construction of the foundation system for the proposed development. All discussions reference the 2014 Building Code.

Seismic Design Parameters

The proposed structure will be founded directly on rock; therefore, the Site Class is B. The Building Code seismic design parameters are summarized in Table 1.

Table 1 – Seismic Design Parameters

Description	Parameter	Recommended Value	Building Code Reference
Risk Category (Assumed; to be confirmed by structural engineer)		**II**	Section 1604.5
Site Class	**Rock**	**B**	Section 1613.5.2
Mapped Spectral Acceleration for short periods:	**S_s**	**0.281 g**	Section 1613.5.1
Mapped Spectral Acceleration for 1-sec period:	**S_1**	**0.073 g**	
Site Coefficient:	**F_a**	**1.00**	Section 1613.5.3
Site Coefficient:	**F_v**	**1.00**	
5%damped design spectral response acceleration at short periods:	**S_{DS}**	**0.187 g**	Section 1613.5.4
5% damped design spectral response acceleration at 1-sec period:	**S_{D1}**	**0.049 g**	Section 1613.5.4
Maximum considered Earthquake geometric mean (MCEG) peak ground acceleration	**PGA_M**	**0.17g**	Section 1813.2.1
Seismic Design Category (Based on assumed Risk Category)		**B**	Tables 1613.5.6 (1) & 1613.5.6 (2)

Based on the design spectral accelerations in Table 1 and the anticipated structural occupancy/risk category of the structure (identified as Structural Occupancy/Risk Category II) and in accordance with the Building Code, we have estimated that the design will be subject to the requirements of Seismic Design Category B. The Structural Occupancy/Risk Category must be confirmed by the architect and structural engineer.

Liquefaction Evaluation

The Building Code requires an evaluation of the liquefaction potential of noncohesive soil and cohesive soil with plasticity index 20 or less below the groundwater table and up to 50 feet below the ground surface. In accordance with the Building Code screening process for liquefaction, the SPT N_{60} values from the borings are plotted versus depth on the Liquefaction Assessment Diagram, presented as Figure 9. This plot shows a significant amount of soil in the "Liquefaction Probable" zone.

The proposed construction involves excavation and removal of all soil to support the structure directly on rock. Therefore, the risk of liquefaction is mitigated and a site-specific study is not required. If the development plan changes and excavation and removal of all liquefiable soil is no longer considered, the design team should address this change and re-evaluate the site classification and soil liquefaction potential.

Foundation System

We recommend the building be supported by a mat foundation bearing on bedrock. The recommended allowable rock bearing capacity is 40 tsf (Building Class 1b bock). The top of rock was encountered at depths of about 38 to 49 feet below the existing site grades and generally dips north to south. The corresponding top or rock elevations range from about el -28 to el -40. The bottom of a 9 to 12-foot-thick mat foundation as shown on preliminary design drawings prepared by WSP, will be at about el -29.5 to el -33. Therefore, the bottom of the proposed mat will not bear directly on rock at the majority of the site.

Wherever Building Class 1b rock is not encountered at the bottom of mat foundation elevation, all soil and decomposed rock should be excavated to the top of Building Class 1b rock and backfilled with 4,000 psi concrete fill. All rock bearing surfaces should have a maximum 10-percent slope as required by the Building Code. Otherwise, horizontal benches 10 feet long and wide, with vertical faces, should be created to satisfy the maximum slope requirement. Because the difference in the bottom of the mat elevation and the estimated top of rock can be as much as 8 feet or more, WSP should evaluate whether the concrete fill should be reinforced.

For initial design development, we recommend an average modulus of subgrade reaction of 1,500 psi/inch for Class 1b rock. The mat foundation design should be compatible with half and twice of this value. The subgrade modulus must be iterated until the geotechnical model and the structural model (which approximates the subgrade response via Winkler springs) converge (i.e., the spring value must be iterated until the settlement predicted by the geotechnical model matches that predicted by the structural model).

Foundation Settlement

The settlement of foundations is a function of the structural loads and are dependent on the layout of columns and shear walls and stiffness of the foundation. For the proposed building loads, we anticipate that the total and differential foundation settlements below the thick foundation mat will be ¾ inch or less.

Lateral Resistance

For a mat bearing directly on rock, lateral loads can be resisted by friction on the bottom of the mat. We recommend an ultimate frictional coefficient of 0.70 for mass concrete poured on clean sound rock. Where concrete fill underlies the mat foundation, WSP should confirm that the concrete fill-to-foundation concrete-to-rock interfaces can resist the proposed lateral loading. If additional resistance is needed, shear keys may be embedded into rock or concrete. We should be contacted to evaluate passive pressure if needed.

Rigid Perimeter Excavation Support

Below grade construction will require excavating to the top or rock or about 38 to 49 feet below the existing grades (about el -28 to el -40). To provide excavation support and temporary groundwater cut-off we recommend installing a rigid, continuous secant pile wall system on the south, east, and west foundation perimeter. The secant pile walls will abut the foundation wall of 41 Broad Street, which extends into the bedrock according to historic construction plans.

The secant pile wall installation begins with the construction of a guide wall at the ground surface. The guide wall ensures that the position, alignment and required overlap of subsequent secant piles are maintained. After the guide wall is formed, the primary piles (every other pile location) are installed by advancing steel casing to top of rock and continuing the rock socket to the design depth. The casing is then withdrawn as the pile is grouted. Secondary piles are then drilled in between such that they overlap with the primary piles. Reinforcing steel is added to the secondary piles based on the structural loading and

excavation support requirements. These systems are relatively stiff soil retention systems, necessary to limit wall deflection and movement of adjacent structures, and assist in groundwater control. To accommodate access of the drilling equipment close to the property line, the edge of casing is positioned at least 12 inches from the face of adjacent buildings. The contractor should note that obstructions such as remnant slabs and foundations including piles and pile caps exist within and below the fill and should be removed prior to or bypassed during the installation of the perimeter excavation support.

In addition to serving as temporary excavation support and water cut-off, the secant pile wall can serve as the permanent foundation wall and carry part of the foundation loads according to the foundation design. The structural loads on the secant pile wall were not available at the time of this report. If the secant piles are used to rest tension capacity, they must also be evaluated for global stability. In addition, the top level of the secant pile wall must be coordinated with the structural engineer to account for the continuous ring beam.

For top-down construction, lateral bracing is provided by the ground and cellar floors slabs, which are constructed as the excavation progresses. The Owner and design team are considering creating additional headroom during construction by constructing one of the cellar slabs after the foundation construction is complete; therefore additional temporary lateral support will be necessary at the bypassed slab elevation. Lateral support could consist of tiebacks on the east and west (below the NYCT tunnel influence line) and rakers or buttresses (additional secant piles perpendicular to the perimeter walls).

The NYC Department of buildings (DOB) requires that project-specific excavation support drawings be prepared as part of the new-building submission. The project-specific plans must be fully developed, in conjunction with developed structural building plans, to be reviewed and approved by DOB so that a construction permit for the new building (or foundations) can be issued. Excavation support plans will also need to be reviewed by the NYCT for potential impacts on the adjacent subway structures.

Permanent Rock Anchors

Permanent post-tensioned tie-downs anchored into bedrock will be required to resist uplift forces resulting from wind, buoyant, and seismic loads. We recommend using double corrosion-protected Grade 150 threaded bars meeting ASTM A-722 requirements or Grade 270 strand tendons meeting ASTM A-416 requirements for reinforcement steel. Double corrosion

protection should consist of PVC sheathing and grout encapsulation around the anchor bar or tendons. The anchor bar diameter should not exceed 3 inches; if higher capacity is required, strand anchors should be used. The anchor bond length should be proportioned using an allowable peripheral shear resistance in uplift of 100 psi. The free stress (un-bonded) length should be a minimum of 10 feet long, but additional length may be required for group effects and global uplift stability.

The free-stressing length of reinforcement should be proportioned such that the dead weight and tensile strength of the engaged rock mass is greater than the individual anchor load or the sum of the group anchor loads. Group and global stability analysis must be performed by Langan during design development. The free length of adjacent anchors can be alternated in a staggered pattern, if required by the group analysis. Table No. 2 and Table No. 3 present the estimated design capacity with corresponding bond lengths for both threaded bars and strand tendon options.

Table 2 – Threaded Bar Rock Anchor Capacities

Design Uplift Load (kips)	Threaded Bar Diameter (inch)	Threaded Bar Grade	Min. Drill Hole Diameter (inch)	Min. Free Length[1] (ft)	Min. Bond Length[2] (ft)
110	1-1/4	150	5	10	10
615	3	150	7	10	25

[1] The free stressing length will be defined by the global stability and group effect analysis

[2] This table represents minimum lengths for single anchors. Group effects must be analyzed during DD phase and may require longer anchors.

Table 3 – Strand Tendon Rock Anchor Capacities

Design Uplift Load (kips)	No. of Strand Tendons	Strand Tendon Cross Sectional Area (sq-inch)	Strand Tendon Grade	Min. Drill Hole Diameter (inch)	Min. Free Length[1] (ft)	Min. Bond Length[2] (ft)
110	4	0.868	270	5	10	10
615	18	3.906	270	7	10	25

[1] The free stressing length will be defined by the global stability and group effect analysis

[2] This table represents minimum lengths for single anchors. Group effects must be analyzed during DD phase and may require longer anchors.

A minimum of 10 anchors or two percent of the tie-down anchors (whichever is greater) should be performance-tested (creep) to 133% of their design loads in accordance with Post-Tensioning Institute (PTI) standards. The remaining anchors should be proof tested to 133% their design load per PTI standards. Lift-off testing should be performed to all anchors. Successfully tested anchors should be locked off at a load exceeding the sum of the design load, seating loss, and long-term losses.

Pressure Slabs

The lowest floor level will extend below groundwater and should be designed as a pressure slab. We recommend that the pressure slabs be designed assuming hydrostatic uplift corresponding to the design groundwater el 12 (BFE + 1ft). Where possible, pressure slabs should be keyed into the foundation walls and should be cast with integral water stops (PVC "dumbbells" and post construction grout tubes). Pressure slabs should be waterproofed according to the recommendations presented herein.

Permanent Groundwater Control

This section describes our recommendations for permanent groundwater control at the site.

Design Groundwater Level

During the 2007 subsurface exploration, the static groundwater was observed at about 18 to 20 feet below existing grade (about el -8 to el -10). During the 2016 subsurface exploration, the

static groundwater was observed at about 13.5 feet below existing grade (about el -3.5). This fluctuation could be related to seasonal variations, nearby construction or pumping activities.

Because the site is partially located within the Flood Zone AE, the foundation walls, ground level, and below-ground slabs should be flood-proofed and designed to resist hydrostatic pressure for groundwater rising to el 12. This Design Flood Elevation (DFE) corresponds to the base flood elevation of el 11 (BFE) plus 1-foot freeboard as per Chapter G5 Table 6.1 of the Building Code.

Foundation Waterproofing

To limit water seepage we recommend that the foundation raft and the perimeter secant pile wall be fully waterproofed to at least the design flood elevation (DFE). We recommend installing a membrane-type, positive-side waterproofing (installation on outside of structure). For horizontal applications, the waterproofing membrane should be installed on a two-inch-minimum concrete working surface (mud-slab), which will create a uniform substrate. For one-face wall vertical applications (conventional foundation wall and pit walls), plywood or other acceptable flat surfaces should be used to secure the waterproofing membrane. The membrane should be protected against damage during rebar placement, concrete placement, and general construction traffic.

Groundwater can be expected to seep through the joints in the secant pile wall. One scheme to accommodate the water leakage is to create a cavity wall using masonry block. The water is collected behind the partition walls via a series of scupper drains and directed to the lowest cellar level. The water is then ejected and discharged into the city sewer system.

An alternate scheme is to waterproof the inside face of the secant pile wall. This can be accomplished by installing a waterproofing membrane on the secant pile wall and casting an interior liner wall. Prior to the membrane application the secant wall surface should be purged and leveled. A concrete facing wall would then be cast against the secant piles to provide the necessary bond to the waterproofing and to hold the membrane in place. The minimum wall thickness is 4 inches (or as otherwise recommended by the waterproofing manufacturer) as needed for structural integrity. Special waterproofing details will need to be developed for locations of the secant pile wall – intermediate slabs interface and at the bracing locations. For the horizontal and vertical applications we recommend using Preprufe products by W.R. Grace or other equivalent. As a supplementary measure, waterproofing concrete admixtures such as

Hycrete's products can be added to the secant pile grout mix (for water control and corrosion protection) and the liner wall grout mix.

We recommend that warranties are obtained from the manufacturers and installers to cover materials and workmanship. Material and system compatibility needs to be confirmed if products from multiple manufacturers are selected. Only certified installers should be used to perform the work. Detailed oversight should be performed and a representative of the manufacturer should perform a final inspection of the waterproofing prior to concrete pours.

Depending on the use of the cellar space, installing a secondary control system may be warranted. For this purpose the following secondary measures can also be considered.

1. Install a second mud slab on top of the installed horizontal waterproofing membrane. This mud slab would protect the installed waterproofing from construction traffic during placement for the steel reinforcement.
2. Use a waterproofing additive in the foundation concrete. Addatives typically react with water to block pours and small cracks.
3. Install a connection layer and concrete slab over the mat slab. The draining layer can be gravel with collection pipes or a heavy duty prefabricated drainage board. This system will collect groundwater (that could intrude through damaged waterproofing) and guide it to a drain system.

Permanent Below-Grade Walls

Permanent below-grade walls including perimeter foundation and elevator pit walls should be designed to resist lateral loadings from static earth pressure, water pressure, and vertical surcharge. Backfill should not be placed against below-grade walls until the concrete has reached its 28-day compressive design strength and after adequate lateral bracing has been provided to prevent rotation of the wall, or as otherwise directed by the structural engineer. We recommend the following design parameters in Table 3 and subsequent paragraphs.

Table 3 – Horizontal Earth Pressure Parameters

Layer	Unit Weight Above WT (pcf)	Effective Unit Weight Below WT (pcf)	At Rest Earth Pressure Coefficient K_o
Fill [Class 7]	120	63	.50
Silt and Clay [Class 5b, 4c, 6]	110	57	.60
Decomposed Rock [Class 1d]	135	72	.35

- Hydrostatic pressures should be added as a triangular pressure distribution having an equivalent fluid weight of 62.4 pounds per square foot per foot of depth below the design groundwater level.

Surcharge loads should be considered in the design of below-grade walls. The walls should be designed for an additional uniform pressure distribution equal to 0.50 times the anticipated surcharge load. We recommend the following minimum surcharges be considered:

- Surficial traffic loads should be considered for the west perimeter walls (along Broad Street). We recommend a surcharge load of 300 psf for the street side walls to account for large trucks and emergency vehicles.

- Surficial loads should be considered for the east perimeter walls (along hammerhead). We recommend a surcharge of 100 psf for these walls.

- Construction surcharge loads should be considered along the west and east perimeter walls if they exceed the recommended values above.

- Walls must also be designed for surcharge loads from adjacent structures where the walls extend below the area of influence of the adjacent foundations. We understand 41 Broad Street is founded on rock, and 55 Broad Street is founded on piles such that only the surcharge from the neighboring slab needs to be considered.

GEOTECHNICAL CONSTRUCTION RECOMMENDATIONS

Our recommendations for excavation, subgrade preparation, temporary groundwater control, and pre-construction activities and construction monitoring are provided below.

Excavation

Site excavation within the fill and underlying silt and clay can be performed using conventional earth-moving equipment (e.g., backhoes, excavators, dozers, etc.). All excavations should be conducted in accordance with all OSHA requirements including, but not limited to, temporary shoring, trench boxes, and proper benching. Obstructions such as old foundations, slabs, pile caps and piles, and demolition debris should be expected and may require heavy demolition equipment to remove.

Note that obstructions such as remnant slabs and foundations including piles and pile caps exist within and below the fill. Specifically, the remnant cellar slab was encountered about 12 feet below existing grade. The contractor should be prepared to demolish and excavate through the existing slab and all obstructions, and remove the existing pile caps, piles, and slabs.

An alternative method to perform the foundation construction would be the "top-down" construction method. In general terms this option involves construction of the ground and cellar floor levels as the excavation progresses. Top-down construction begins with installation of exterior walls and load bearing elements to support subsequent floor slabs. The ground floor is then cast. The excavation is performed below the cast slab to the next slab level, with excavation spoils removed through shafts and access openings in the slabs. The process is repeated to the final mat level.

Subgrade Preparation for Foundation Mat on Rock

The foundation mat bearing surface should be level and clear of debris, standing or frozen water, and other deleterious materials. All rock bearing surfaces should have a maximum 10-percent slope as required by the Building Code. Otherwise, horizontal benches at least 10 feet long and wide with vertical faces should be created to satisfy the maximum slope requirement. Compressed air should be used to clean all rock surfaces. Rock, joints, foliation, and local zones of weathered or fractured rock may require locally deepening the excavations further into rock. The Building Code requires that all rock subgrade be inspected by Professional Engineer to verify the quality of the bedrock before installing reinforcing steel and concreting. The rock

subgrade must be inspected to verify bearing capacity and that foundations have been adequately cleaned and prepared.

Temporary Groundwater Control

Groundwater was encountered in the 2016 investigation at 13.5 feet below grade. The proposed deep excavation will require dewatering. The proposed SOE system using secant piles and tangent piles will provide groundwater cutoff such that the interior of the excavation can be locally dewatered. Collection of rainwater runoff will also be needed during the excavation and subgrade preparation work. Water runoff should be controlled with the use of gravel-lined collection trenches or pits and submersible pumps. Care should be taken to ensure that drainage is provided during all phases of excavation work so as to limit the disturbance of the subgrade materials and provide a workable surface. Any necessary environmental pre-treatment of groundwater should be coordinated with the applicable environmental regulations for the site. A DEP discharge permit will need to be furnished to discharge groundwater into the DEP combined sewer. It is the contractor's responsibility to estimate the daily groundwater discharge volume and to furnish all paperwork for the permit application.

Preconstruction Conditions Survey and Monitoring During Construction

A preconstruction-conditions survey report should be prepared for the adjacent buildings and the existing NYCT subway tunnel adjacent to the site. We recommend that a monitoring program be developed to observe the response of the existing buildings and subway tunnel adjacent to the site during foundation construction activities (i.e., excavation, SOE installation, bracing, etc.). According to our past discussions with NYCT, this program could consist of monitoring horizontal and vertical movements by optical surveying and inclinometers, and vibration monitoring using seismographs. The NYCT typically requires that the vibration monitoring data is collected manually, or at least has on site observation of an automated system.

Construction Documents and Quality Control

Design specifications and drawings should incorporate our recommendations to ensure that subsurface conditions and other geotechnical issues at the site are adequately addressed in construction documents. Langan should assist the design team in preparing specification sections related to geotechnical issues such as support of excavation, foundations, backfill, and excavation support. Langan should also review foundation design drawings and details, and all contractor submissions and construction procedures related to geotechnical work.

Geotechnical assessment and design is an ongoing process as additional information becomes available, including during construction. A geotechnical engineer familiar with the site subsurface conditions and design intent should perform the quality assurance observations and testing of geotechnical-related work during construction. According to the Building Code, construction of foundations (i.e., earthwork, subgrade preparation, etc.) and support of excavation require special inspection by a Professional Engineer licensed in the state of New York.

Owner and Contractor Obligations

Construction activities that alter the existing ground conditions such as excavation, fill placement, foundation construction, ground improvement, pile driving/drilling, dewatering, etc. can induce stresses, vibrations and movements on nearby structures. The Owner and all Contractors must ensure that these impacts will not adversely affect the performance of the structures and take adequate measures to protect the existing structures during construction.

Unless otherwise agreed to by Langan in writing, by using this report, the owner agrees to the following:

1) That Langan will not be held responsible for damage to adjacent structures caused by the actions of contractors involved in the project;

2) To have Langan added to the Foundation Contractor's General Liability insurance as an additional insured;

3) To require the Foundation Contractor to defend, indemnify and hold harmless the Owner and Langan against all claims related to damage to adjacent structures or properties

LIMITATIONS

The conclusions and recommendations provided in this report are based on subsurface conditions inferred from a limited number of borings, as well as information provided by Madison 45 Broad Development LLC, February 2016 concept design drawings and sketches provided by CetraRuddy, and subsequent discussions with the project team. Recommendations provided are dependent upon one another and no recommendation should be followed independent of the others.

Any proposed changes in structures or their locations should be brought to Langan's attention as soon as possible so that we can determine whether such changes affect our recommendations. Information on subsurface strata and groundwater levels shown on the logs

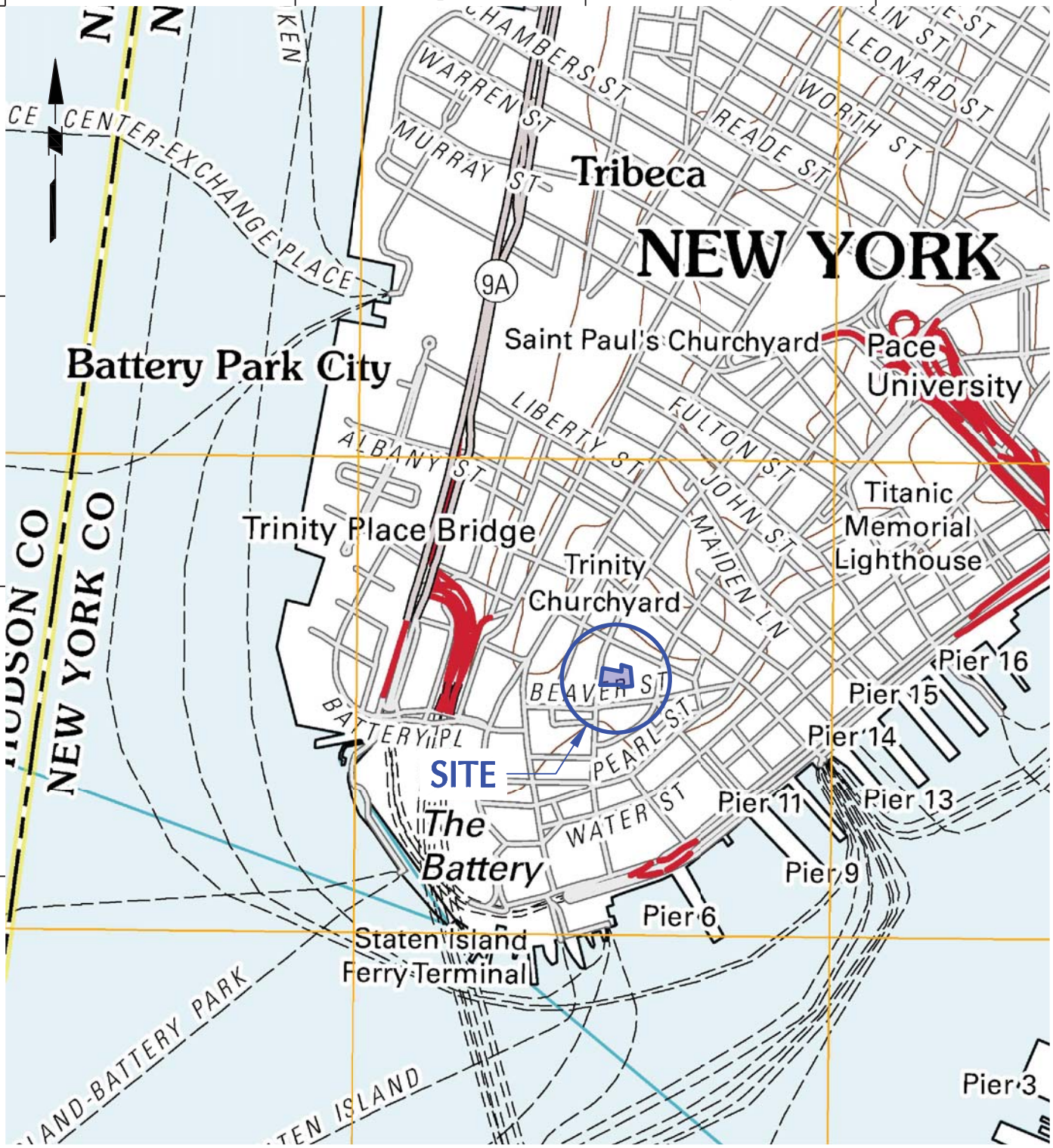
represent conditions encountered only at the locations indicated and at the time of investigation. If different conditions are encountered during construction, they should immediately be brought to Langan's attention for evaluation, as they may affect our recommendations.

This report has been prepared for 45 Broad Street, New York, New York, to assist the owner, architect, and structural engineer in the design process and is only applicable to the design of the specific project identified. The information in this report cannot be utilized or depended on by engineers or contractors who are involved in evaluations or designs of facilities (including underpinning, grouting, stabilization, etc.) on adjacent properties, which are beyond the limits of that which is the specific subject of this report.

Environmental issues (such as potentially contaminated soil and groundwater) are outside the scope of this study and should be addressed in a separate study.

\\Langan.com\data\NY\data2\170394201\Office Data\Reports\Geotechnical\Updated Geotechnical Report\2016-03-03 Geotechnical Engineering Study.docx

FIGURES



SOURCE: USGS JERSEY CITY, NJ-NY 7.5-MINUTE QUADRANGLE MAP, 9 JUNE 2011.

1000 0 500 1000

SCALE IN FEET

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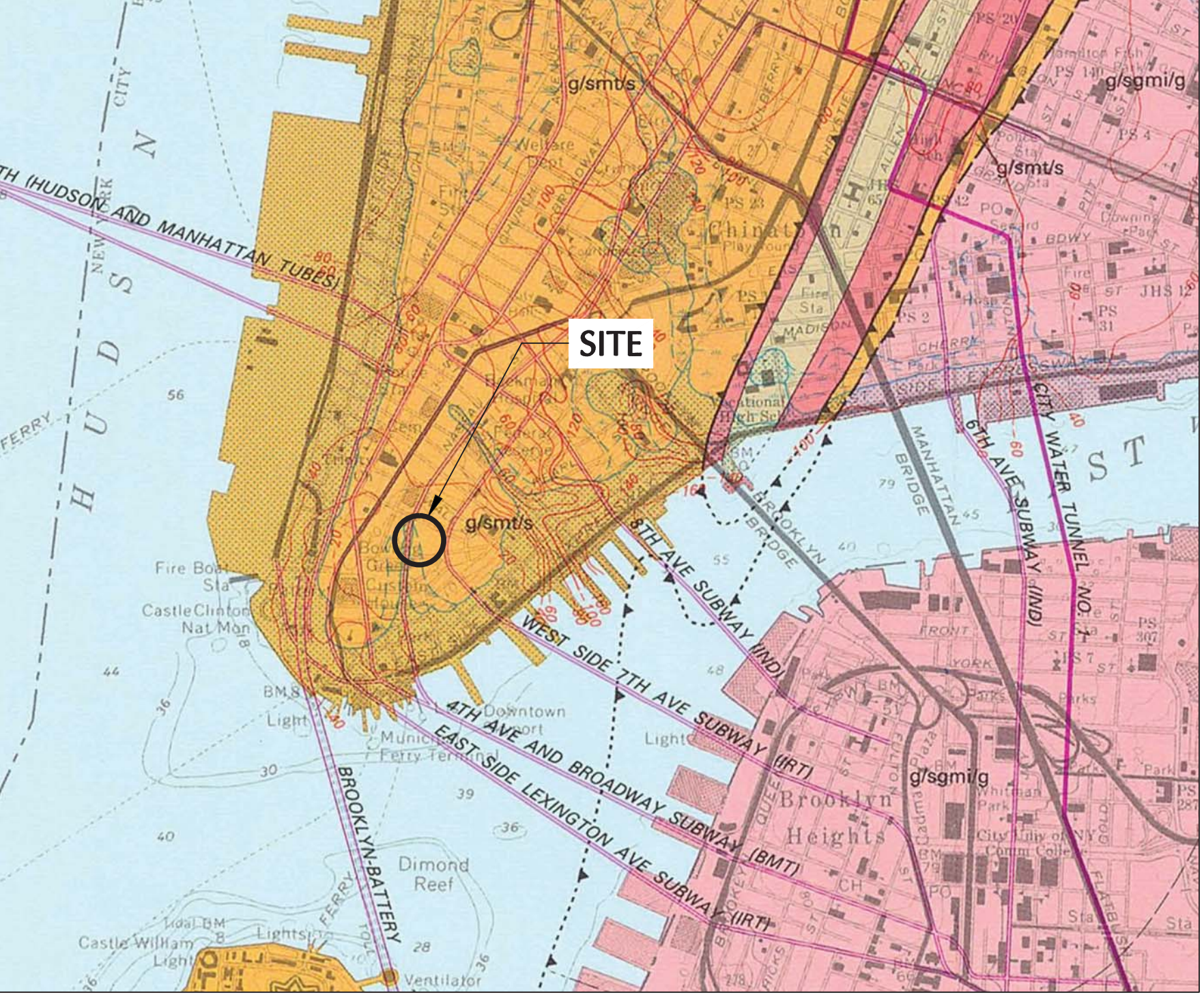
Project	45 BROAD STREET BLOCK No. 25, LOT No. 7 MANHATTAN NEW YORK NEW YORK
Drawing Title	SITE LOCATION MAP
Project No.	170394201
Date	12/30/2015
Scale	1"=1000'
Drawn By / Checked By	SWB / CAP
Submission Date	12/30/2015
Figure	1
Sheet	1 of 9

Filename: \\Langan.com\data\NY\data2\170394201\Cadd Data - 170394201\SheetFiles\Geotechnical\Geotechnical Engineering Study\FG01 SITE LOCATION MAP.dwg Date: 12/30/2015 Time: 08:54 User: sborecki Style Table: Langan.stb Layout: ANSIA-BP



EXPLANA

SUBSURFAC

City Water Tunnels

Old and New Croto with City Water T aqueduct

Subway, railroad, o underlies subway t

Consolidated Edison

Sewer tunnel

FORMER D

Former drainage an present drainage a pattern. Where ve segments probably

Former swamp or m marsh adjoins high

GEOLOGY—

Contact between ge dotted where unde under water, was l

Fault—Paired arrow downthrown side. under water; queri inclined dip, and s

Thrust fault—Sawte located; dotted wh Alternating solid a map view (near Ro

Crush or shear zone where known

Contours on the bed contours. Closed, l 20 ft, except 10 ft

Single outcrop or ar

EERING GEOLOGIC MAPS OF NEW YORK COUNTY AND QUEENS COUNTIES, NEW YORK, AND PART ON COUNTIES, NEW JERSEY" USGS, SHEET 2 OF 2

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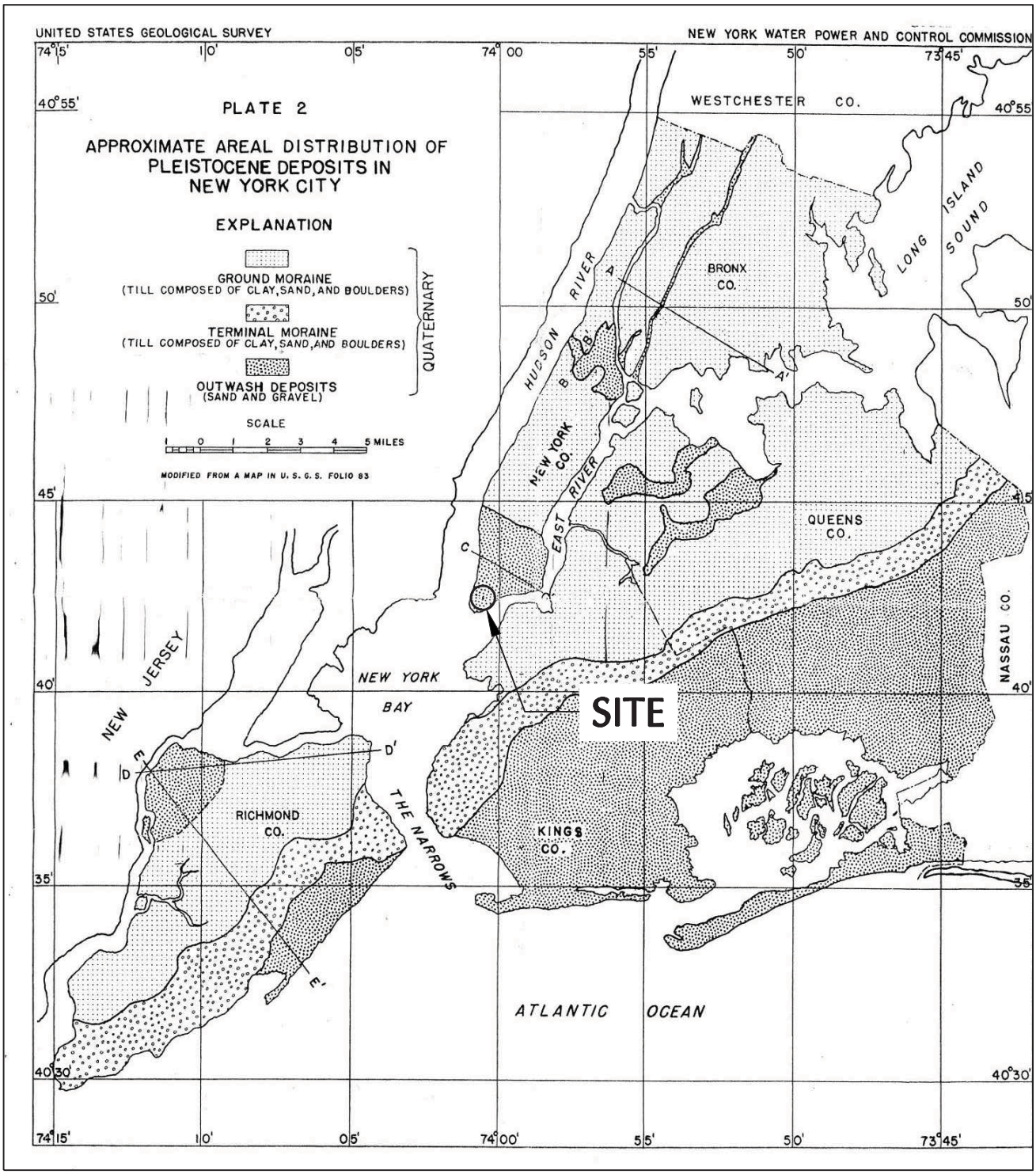
Project

45 BROAD STREET

Drawing Title

BEDROCK



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Project	45 BROAD STREET BLOCK No. 25, LOT No. 7 MANHATTAN NEW YORK NEW YORK
Drawing Title	SURFICIAL GEOLOGY MAP
Project No.	170394201
Date	12/30/2015
Scale	N.T.S.
Drawn By / Checked By	SWB / CAP
Submission Date	12/30/2015
Figure	3
Sheet	3 of 9

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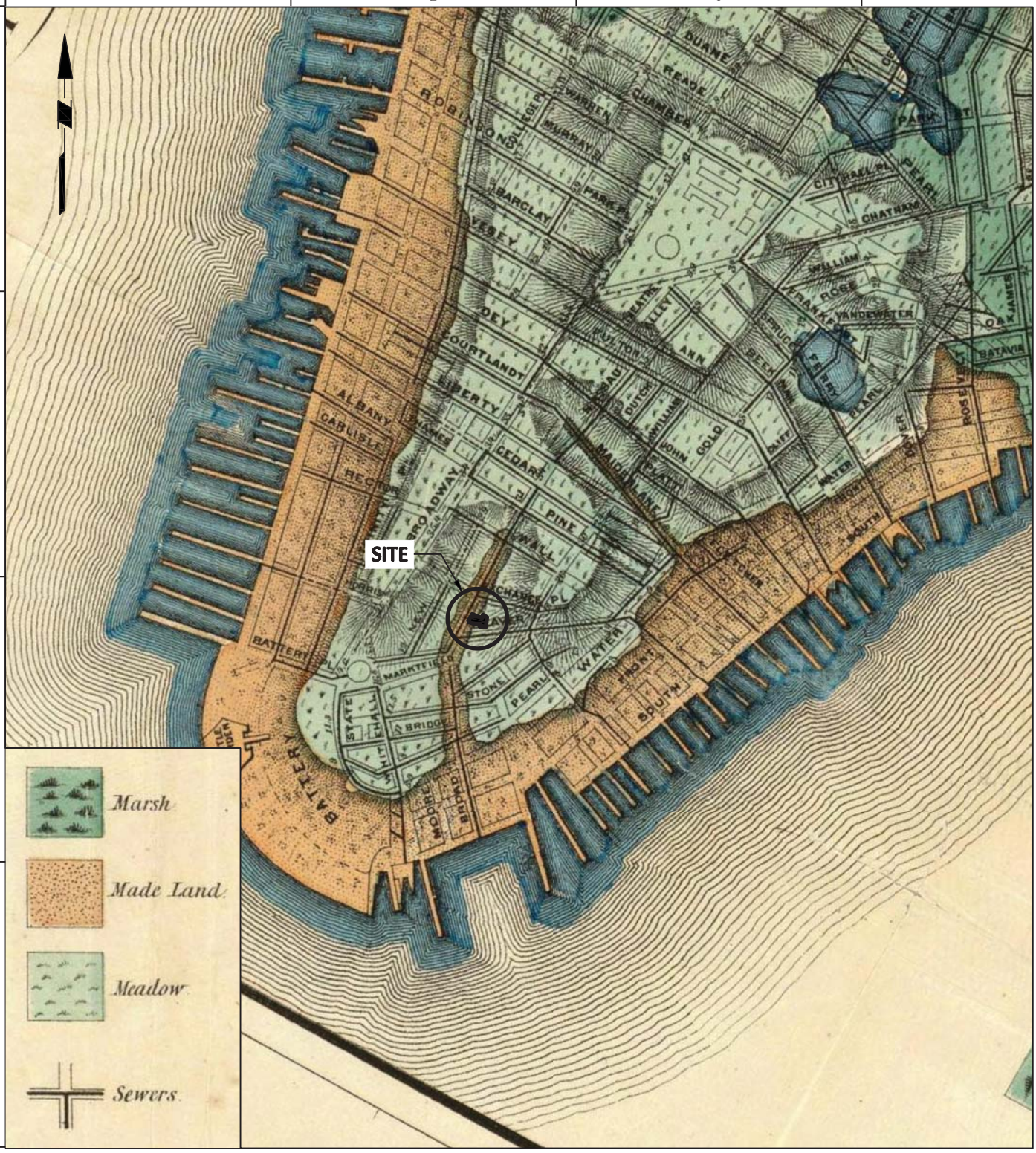

SOURCE: SANITARY & TOPOGRAPHIC MAP OF THE CITY OF NEW YORK, VIELE, 1865.

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45 BROAD STREET
BLOCK No. 25, LOT No. 7
MANHATTAN
NEW YORK NEW YORK

Drawing Title
VIELE MAP (1865)

Project No. 170394201	Figure 4
Date 12/30/2015	
Scale N.T.S.	
Drawn By SWB / Checked By CAP	
Submission Date 12/30/2015	Sheet 4 of 9

Filename: \\Langan.com\data\NY\data2\170394201\Cadd Data - 170394201\SheetFiles\Geotechnical\Geotechnical Engineering Study\FG04 Viele Map.dwg Date: 12/30/2015 Time: 08:52 User: sborecki Style Table: Langan.stb Layout: ANSIA-BPI

LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X — Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X — Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D — Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- 1% annual chance floodplain boundary
- 0.2% annual chance floodplain boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
- Limit of Moderate Wave Action
- 513 — Base Flood Elevation line and value; elevation in feet*
- (EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988

- Cross section line
- Transect line
- Culvert, Flume, Penstock or Aqueduct
- Road or Railroad Bridge
- Footbridge
- 87°07'45", 32°22'30" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere
- 1000-meter Universal Transverse Mercator grid values, zone 18
- 600000 FT — 5000-foot grid values: New York State Plane coordinate system, Long Island zone (FIPSZONE 3104), Lambert Conformal Conic projection
- DX5510 × — Bench mark (see explanation in Notes to Users section of this FIRM panel)
- M1.5 — River Mile

MAP REPOSITORY
Refer to listing of Map Repositories on Map Index

INITIAL NFIP MAP DATE
June 28, 1974

FLOOD HAZARD BOUNDARY MAP REVISIONS
June 11, 1976

FLOOD INSURANCE RATE MAP EFFECTIVE
November 16, 1983

FLOOD INSURANCE RATE MAP REVISIONS

FIRM
FLOOD INSURANCE R

CITY OF,
NEW YORK
NEW YORK
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QUEENS, AND KINGS COU

PANEL 184 OF 457

(SEE MAP INDEX FOR FIRM PAN

CONTAINS:

COMMUNITY	NUMBER
NEW YORK, CITY OF	360497

PRELIMINAR
DECEMBER 5, 2

Notice to User: The **Map Number** show used when placing map orders; the Co shown above should be used on insurance subject community.

MA
36

MA

Federal Emergency Manage

500 0 250 500

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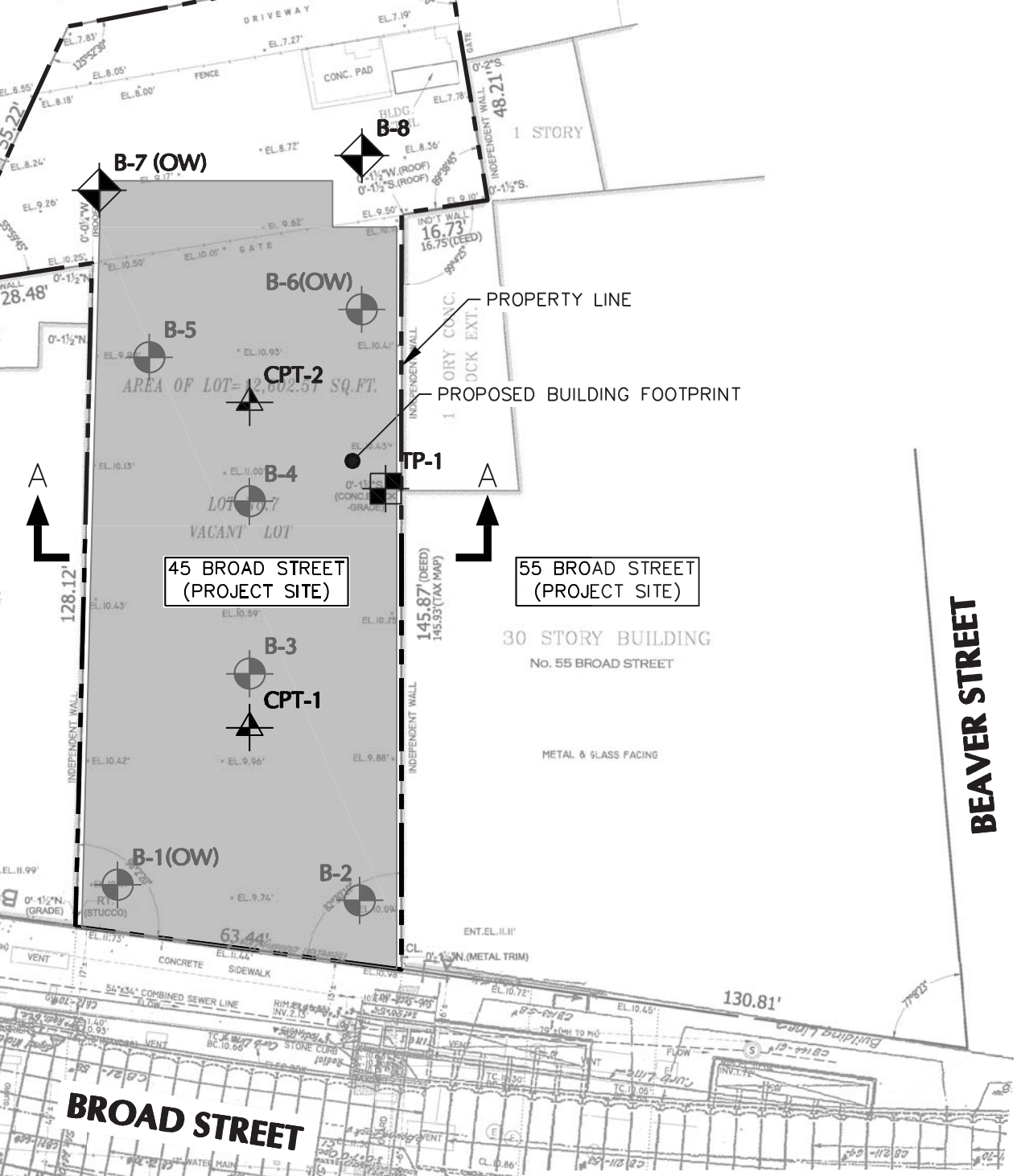
Project

45 BROAD STREET

Drawing Title

FEMA FLOOD INSURANCE



1. PROPERTY LOCATED AT 45 BROAD STREET, T
PROVIDED BY EMPIRE STATE LAYOUT INC., DATI

2. ALL ELEVATIONS REFER TO THE NORTH AMEI
OF 1988 (NAVD88),

3. BORING B-7(OW) AND B-8 WERE ADVANCED B
DRILLING CO, INC., BETWEEN 29 JANUARY A
UNDER THE FULL-TIME INSPECTION OF LANGAN

4. BORINGS B-1 THROUGH B-6 WERE A
GEOTECHNICAL DRILLING CO, INC. BETWEEN
SEPTEMBER 2007 UNDER THE FULL-TIME INSPE

5. TEST PIT TP-1 WAS EXCAVATED BY COFFEY
17 AND 22 FEBRUARY 2016 UNDER THE FUL
LANGAN.

6. CPT-1 AND CPT-2 WERE ADVANCED BY
DRILLING CO., INC. ON 1 FEBRUARY 2016
INSPECTION OF LANGAN.

7. BORING AND TEST PIT LOCATIONS ARE APPROX

8. REFER TO DRAWING NOS. 7 AND 8 FOR SUBSU

LEGEND:

PROPERTY LINE

PROPOSED BUILDING FOOTPRINT

B-7 — 2016 BORING LOCATION

(OW) — OBSERVATION WELL LOCATION

CPT-1 — 2016 CPT LOCATION

TP-1 — 2016 TEST PIT LOCATION

B-1 — 2007 BORING LOCATION

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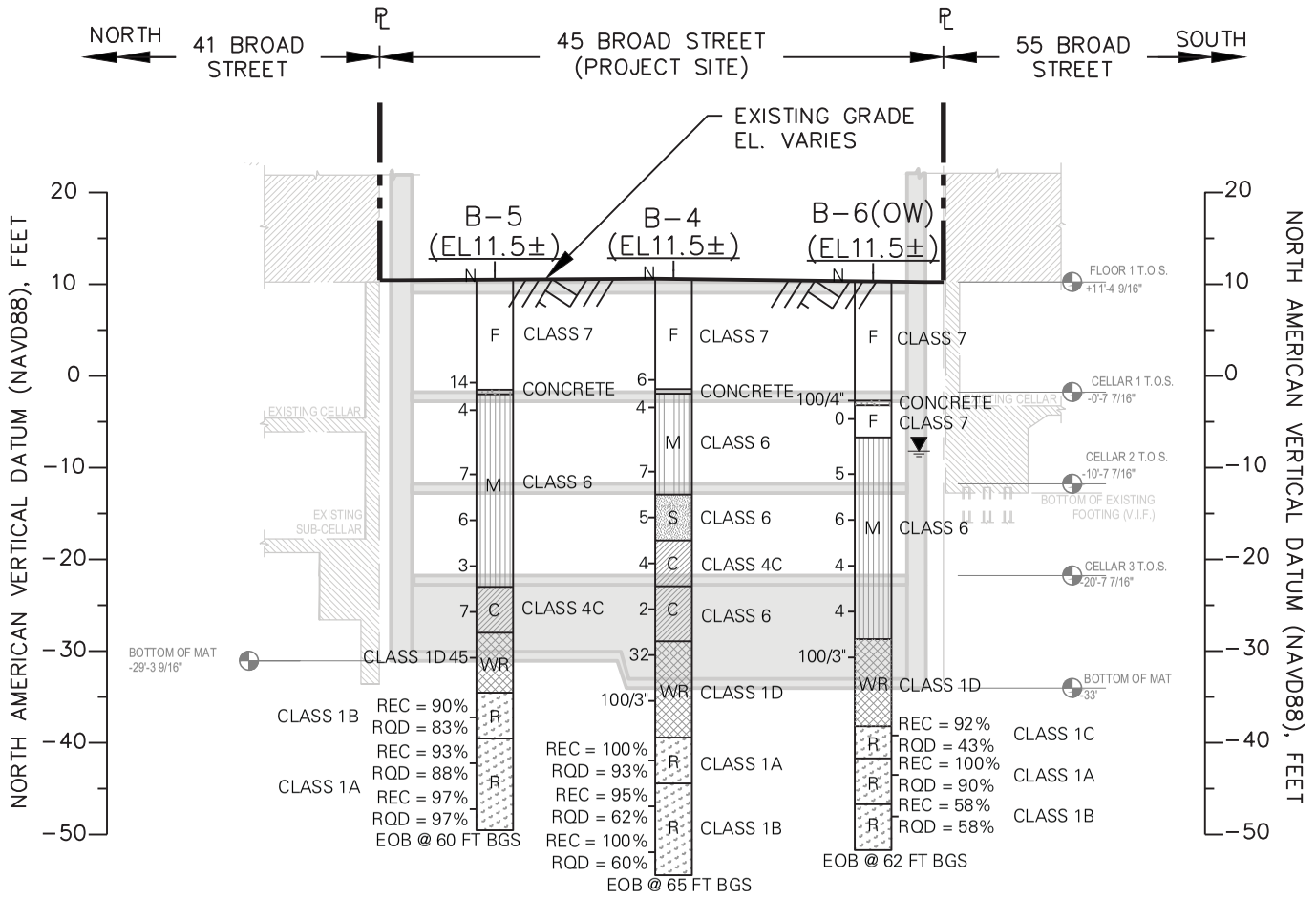
Project

45 BROAD STREET

Drawing Title

SUBSURFACE
INVESTIGATION



M SILT

WR WEATHERED ROCK

R BEDROCK

SUBSURFACE PROFILE A

FACING EAST

SCALE: 1" = 20'

OXIMATE.

A GENERALIZED SOIL CROSS SECTION INTERPRETED

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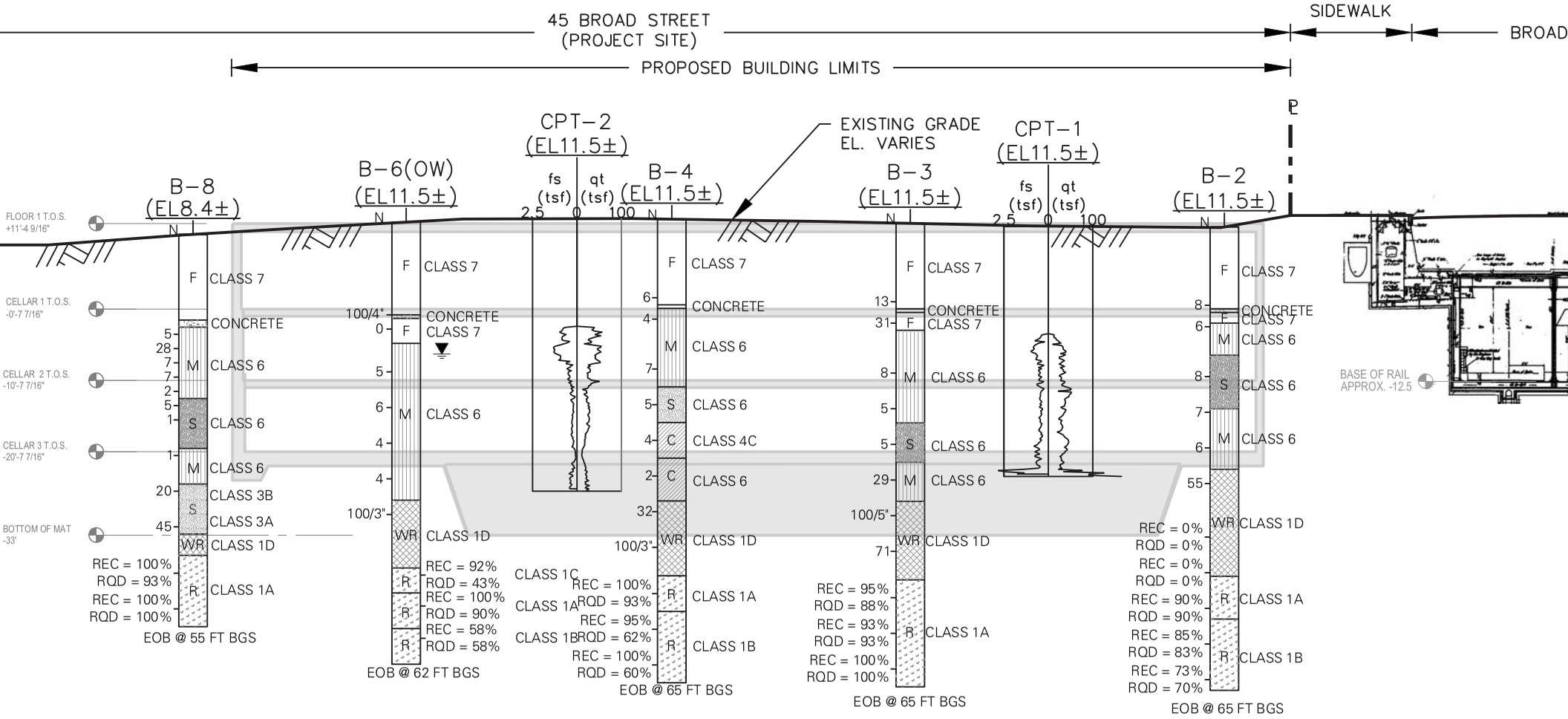
Project

45 BROAD STREET

Drawing Title

SUBSURFACE



SYMBOLS

NTROLLED FILL

M SILT

WR WEATHERED ROCK

R BEDROCK

SUBSURFACE PROFILE B

FACING SOUTH

SCALE: 1" = 20'

OXIMATE.

A GENERALIZED SOIL CROSS SECTION INTERPRETED

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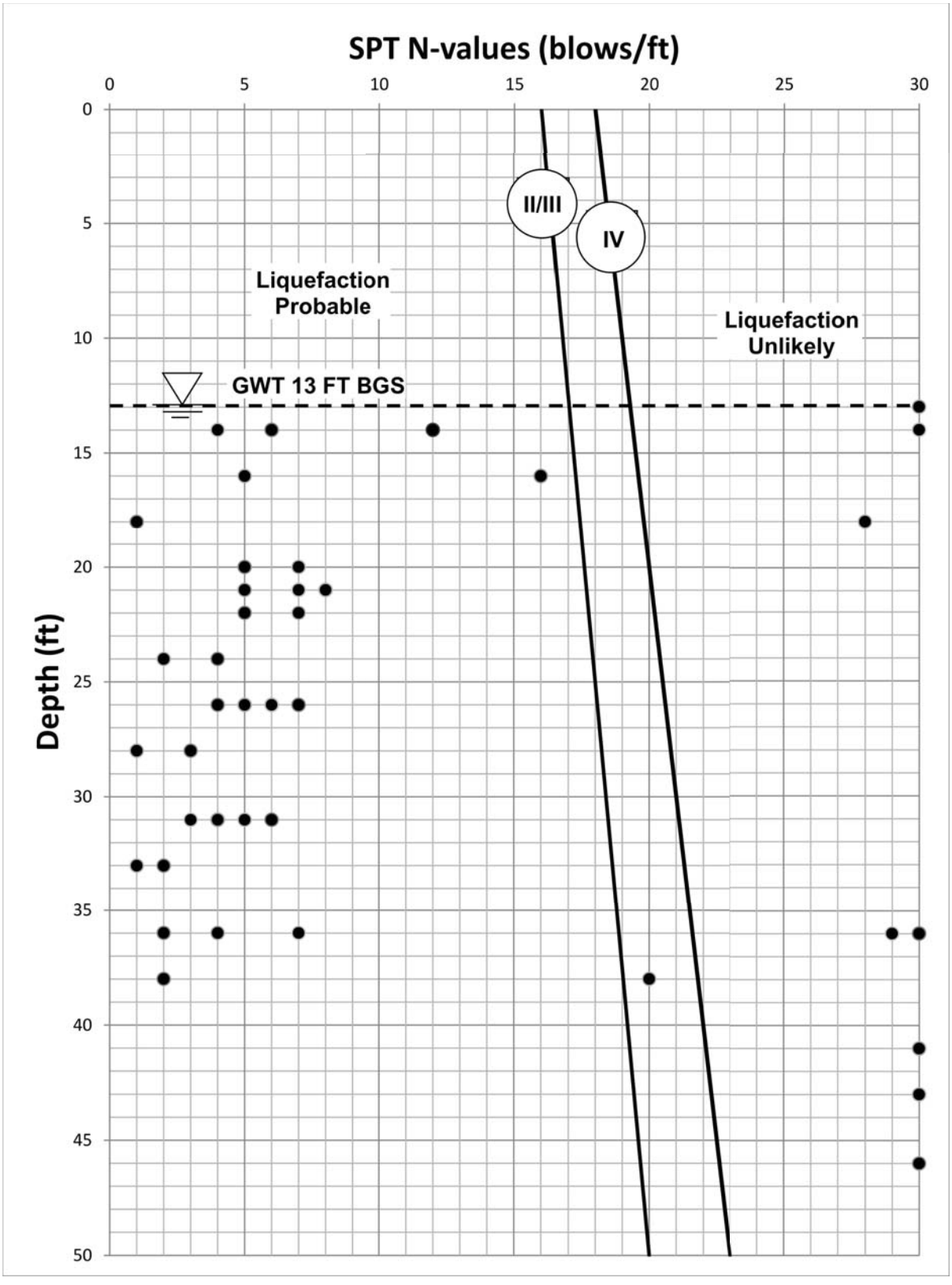
Project

45 BROAD STREET

Drawing Title

SUBSURFACE



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Project

45 BROAD STREET

BLOCK No. 25, LOT No. 7

MANHATTAN

NEW YORK NEW YORK

Drawing Title

NYCBC LIQUEFACTION CHART

Project No. 170394201	Drawing No. 9
Date 03/07/2016	
Scale N.T.S.	
Drawn By MLM / Checked By TP	
Submission Date 03/07/2016	Sheet 9 of 9

Filename: \\langan.com\data\NY\data2\170394201\Cadd Data - 170394201\SheetFiles\Geotechnical\Geotechnical Engineering Study UPDATED\DWG 09 - NYCBC Liquefaction Chart.dwg Date: 3/8/2016 Time: 18:10 User: mmatos Style Table: Langan.stb Layout: DWG 09

APPENDIX A-1
Boring Logs (Langan 2007)

LANGAN

Log of Boring **B-1 (OW)** Sheet 1 of 3

Project: 45 Broad Street	Project No.: 170394201
Location: 45 Broad Street, New York, NY	Elevation and Datum: El. 10.5 NAVD88
Drilling Company: Craig Test Boring	Date Started: 8/29/07 — Date Finished: 8/30/07
Drilling Equipment: CME 55 Track Mounted Rig	Completion Depth: 59 ft — Rock Depth: 39 ft
Size and Type of Bit: 3-7/8" Tri cone roller bit	Number of Samples: Disturbed 6 — Undisturbed - — Core 4
Casing Diameter (in): 4" ID Steel casing — Casing Depth (ft): 38	Water Level (ft.): First ▽ 25 — Completion ▼ - — 24 HR. ▼ 19.8
Casing Hammer: Auto — Weight (lbs): 140 — Drop (in): 30	Drilling Foreman: Rob Dollar
Sampler: 2" OD split spoon samplier	Inspecting Engineer: Michael Mudalel
Sampler Hammer: Auto — Weight (lbs): 140 — Drop (in): 30	

Material Symbol	Building Code	Sample Description	Coring (min)	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft) 10 20 30 40	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	Class 7	Brick, Concrete, and Rebar (FILL)		0–10						Hammer 4" casing to 8'
		Gray-red c-f SAND, so. concrete, so. brick, so. f. gravel (FILL) (moist)		10	S-1	SS	4	2 15 100/5"	100/5"	Roller bit to 10'
		1.5' Foundation Slab		11–12						Roller bit through foundation
	Class 6	Lt. brown-red Clayey SILT, tr. mica (ML) (moist) Moisture Content = 27.6% LL=28; PL=23; PI=5		13	S-2	SS	14	6 6 6 4	12	Smooth chatter 11.5' to 13' Hammer casing to 13'
			▼	14–20						Hammer casing to 18'

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Log of Boring **B-1 (OW)** Sheet 2 of 3

Project	Project No.
45 Broad Street	170394201
Location	**Elevation and Datum**
45 Broad Street, New York, NY	El. 10.5 NAVD88

Material Symbol	Building Code	Sample Description	Coring (min)	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
				20					10 20 30 40	Roller bit to 20'
		Lt. brown-red SILT, tr. mica (ML) (moist)		21	S-3	SS	14	3 4 4 4	8	
				22						
				23						
				24						
				25	S-4	SS	22	2 3 3 2	6	Roller bit to 25'
		Lt. brown-red SILT, tr. mica (ML) (wet) Moisture Content = 28.6%		26						
	Class 6			27						
				28						Hammer casing to 28'
				29						
				30	S-5	SS	18	2 2 2 3	4	Roller bit to 30'
		Lt. brown-reddish-lt. gray SILT, tr. mica (ML)(wet)		31						
				32						
				33						
				34						
				35	S-6	SS	16	20 40 69 49	109	Drilling resistance increased at 34.5' Roller bit to 35'
	Class 1d	Lt. brown-gray-green-black SILT, so. f. gravel, tr. f. sand, tr. glacial till, tr. mica (DECOMPOSED ROCK) (moist)		36						
				37						Rig chatter 35.5' to 38'
				38						Casing fell 1'
				39						Hammer casing to 38' Roller bit to 39' Refusal at 39'
			5	40	C-1	NX	REC=42"/60" =70%	RQD=35"/60" =58%		
			4	41						
	Class 1b	Gray-black-green GNEISS, so. mica schist, tr. granite (BEDROCK)	4	42						
			4	43						
			3	44	C-2	NX				No return at 44.5'
			4	45						

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Log of Boring **B-1 (OW)** Sheet 3 of 3

Project	Project No.
45 Broad Street	170394201
Location	**Elevation and Datum**
45 Broad Street, New York, NY	El. 10.5 NAVD88

Material Symbol	Building Code	Sample Description	Coring (min)	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft) 10 20 30 40	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
			3	45						
				46						Stop for greasing
			4							
		Gray-black-green GNEISS-SCHIST (BEDROCK)		47	C-2	NX	REC=36"/60" =60%	RQD=24"/60" =40%		
			6	48						
			7							
				49						
			4							
				50						
			5							
		Gray-white-black GNEISS-SCHIST, so. mica (BEDROCK)		51	C-3	NX	REC=36"/60" =60%	RQD=22"/60" =37%		
	Class 1b		3							
				52						
			7							
				53						
			6							
				54						Stop coring at 3:00 (8/29)
			4							
				55						Day 2 (8/30)
			5							
				56						
		Gray-white-black-green GNEISS-SCHIST, so. mica (BEDROCK)	4		C-4	NX	REC=51"/60" =85%	RQD=32"/60" =53%		
				57						
			6							
				58						Install 2" PVC MW
			5							
				59						E.O.B. @ 59'
				60						
				61						
				62						
				63						
				64						
				65						
				66						
				67						
				68						
				69						
				70						

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Log of Boring **B-2** Sheet 1 of 3

Project: 45 Broad Street	Project No.: 170394201
Location: 45 Broad Street, New York, NY	Elevation and Datum: El. 10 NAVD88
Drilling Company: Craig Test Boring	Date Started: 9/6/07 — Date Finished: 9/6/07
Drilling Equipment: CME 55 Track Mounted Rig	Completion Depth: 65 ft — Rock Depth: 49 ft
Size and Type of Bit: 3-7/8" Tri cone roller bit	Number of Samples: Disturbed 6 — Undisturbed - — Core 5
Casing Diameter (in): 4" ID Steel casing — Casing Depth (ft): 19	Water Level (ft.): First ▽ 20 — Completion ▼ - — 24 HR. ▼ -
Casing Hammer: Auto — Weight (lbs): 140 — Drop (in): 30	Drilling Foreman: Rob Dollar
Sampler: 2" OD split spoon samplier	Inspecting Engineer: Michael Mudalel
Sampler Hammer: Auto — Weight (lbs): 140 — Drop (in): 30	

Material Symbol	Building Code	Sample Description	Coring (min)	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft) 10 20 30 40	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	Class 7	Brick, Concrete, and Rebar (FILL)		0–5						Hammer casing to 4' Roller bit to 5'
		Gray-red-white GRAVEL, so. c-f sand, so. concrete, tr. brick, tr. metal (FILL) (wet)		5–10						Hammer casing to 9' Roller bit to 10'
				10	S-1	SS	3	3 5 3 100/3"	8	
		6" Foundation Slab		11–12						Roller bit through concrete slab
	Class 7			12–13						Smooth chatter 11.5' to 12'
		Lt. brown-reddish-gray SILT, so. f-c sand, so. f gravel (ML) (moist)		13–14	S-2	SS	19	2 3 3 19	6	
	Class 6			15–18						Rig chatter 18'-19'
	Class 6			19–20						Hammer casing to 19'

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Log of Boring **B-2** Sheet 2 of 3

Project	Project No.
45 Broad Street	170394201
Location	**Elevation and Datum**
45 Broad Street, New York, NY	El. 10 NAVD88

Material Symbol	Building Code	Sample Description	Coring (min)	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
				20					10 20 30 40	Roller bit to 20'
	Class 6	Lt. brown-reddish-gray clayey SILT, so f sand, tr. mica (ML)) (wet) Moisture Content = 27.0%		21	S-3	SS	12	4 4 4 5	8	
				22						
				23						
				24						
				25						Roller bit to 25'
				26	S-4	SS	18	2 3 4 4	7	
				27						
	Class 6			28						
				29						
				30						Roller bit to 30'
		Lt. brown-red SILT, so. f. sand, tr. mica (ML)(wet) Moisture Content = 29.2% LL=33; PL=25; PI=8		31	S-5	SS	17	3 3 3 3	6	
				32						
				33						
				34						
				35						Roller bit to 35'
				36	S-6	SS	20	11 18 37 31	55	
		Lt. brown-red-green SILT, so. f-c gravel, so. f-c sand, tr. decomposed rock (DECOMPOSED ROCK) (moist)		37						Heavy rig chatter at 37'
				38						Rig chatter at 38'
	Class 1d			39						
				40						Smooth rig chatter 39' to 40' Roller bit to 40'
			5	41						
			5	42	C-1	NX	REC=0"/60" =0%	RQD=0"/60" =0%		No return 40' to 45'
			7	43						
			3	44						
			4	45						

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Log of Boring **B-2** Sheet 3 of 3

Project	Project No.
45 Broad Street	170394201
Location	**Elevation and Datum**
45 Broad Street, New York, NY	El. 10 NAVD88

Material Symbol	Building Code	Sample Description	Coring (min)	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft) 10 20 30 40	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	Class 1d	Lt. brown-green-gray f. GRAVEL, so. f-c sand, so. decomposed rock (DECOMPOSED ROCK) (moist)	4 2 3 1	45 46 47 48 49	C-2	NX	REC=0"/60" =0%	RQD=0"/60" =0%		Rig chatter 45' to 49' No return 45'-50'
			2	50						Casing fell 1' when coring at 50'
	Class 1a	Lt. gray-black-white-red GNEISS-SCHIST, so. garnets, so. mica, tr. quartz (BEDROCK)	4 7 2 4 4	51 52 53 54 55	C-3	NX	REC=54"/60" =90%	RQD=54"/60" =90%		No return 50' to 55'
		Lt. gray-black-white-red GNEISS-SCHIST, so. garnets, so. mica, tr. quartz (BEDROCK)	4 5 6 7 4	56 57 58 59 60	C-4	NX	REC=51"/60" =85%	RQD=50"/60" =83%		Slight rig chatter 55' to 60' No return 55' to 60'
		Lt. gray-black-blue-red GNEISS-SCHIST, so. garnets, so. mica (BEDROCK)	5 6 4 4 5	61 62 63 64 65	C-5	NX	REC=44"/60" =73%	RQD=42"/60" =70%		Rig chatter 62' to 63' E.O.B. @ 65'
				66 67 68 69 70						

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Log of Boring **B-3** Sheet 1 of 3

Project: 45 Broad Street	Project No.: 170394201
Location: 45 Broad Street, New York, NY	Elevation and Datum: El. 10 NAVD88
Drilling Company: Craig Test Boring	Date Started: 9/5/07 — Date Finished: 9/5/07
Drilling Equipment: CME 55 Track Mounted Rig	Completion Depth: 65 ft — Rock Depth: 47 ft
Size and Type of Bit: 3-7/8" Tri cone roller bit	Number of Samples: Disturbed 8 — Undisturbed - — Core 3
Casing Diameter (in): 4" ID Steel casing — Casing Depth (ft): 19	Water Level (ft.): First ▽ 20 — Completion ▼ - — 24 HR. ▼ -
Casing Hammer: Auto — Weight (lbs): 140 — Drop (in): 30	Drilling Foreman: Rob Dollar
Sampler: 2" OD split spoon samplier	Inspecting Engineer: Michael Mudalel
Sampler Hammer: Auto — Weight (lbs): 140 — Drop (in): 30	

Material Symbol	Building Code	Sample Description	Coring (min)	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft) 10 20 30 40	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
				0						
				1						
				2						
				3						
				4						Hammer casing to 4'
		Brick, Concrete, and Rebar (FILL)		5						Roller bit to 5'
	Class 7			6						
				7						
				8						
				9						Hammer casing to 9'
				10						Roller bit to 10'
		Gray-red-yellow f. GRAVEL, so. concrete, so. brick, so. f-c sand (FILL)(wet)		11	S-1	SS	6	2 3 10 7	13	
		6" Foundation Slab		12						Roller bit thru concrete slab
				13						Smooth chatter 12' to 12.5'
	Class 7	Lt. brown-gray-red f. GRAVEL, so. f-c sand, tr. silt (FILL) (wet)		14	S-2	SS	14	4 16 15 7	31	
		?—?—?—?		15						
				16						
				17						
	Class 6			18						
				19						Hammer casing to 19'
			▽	20						

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Log of Boring **B-3** Sheet 2 of 3

Project	Project No.
45 Broad Street	170394201
Location	**Elevation and Datum**
45 Broad Street, New York, NY	El. 10 NAVD88

Material Symbol	Building Code	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
			20					10 20 30 40	Roller bit to 20'
	Class 6	Lt. brown-reddish-gray Clayey SILT, tr. f sand (ML) (wet)	21	S-3	SS	14	3 4 4 3	8	
			22						
			23						
			24						
			25						Roller bit to 25'
		Lt. brown-reddish-gray, Clayey SILT, tr. f. sand (ML) (wet)	26	S-4	SS	20	2 2 3 3	5	
			27						
			28						
			29						
			30						Roller bit to 30'
	Class 6	Lt. brown-red f-SAND, so. silt, (wet) (SP/SM) (wet)	31	S-5	SS	18	1 2 3 2	5	
			32						
			33						
			34						
			35						Roller bit to 35'
	Class 3b	Lt. brown-gray coarse-fine SAND, some silt, some clay, tr. decomposed rock (SC) (moist) Moisture Content = 21.2%	36	S-6	SS	14	4 14 15 37	29	
			37						Rig chatter at 36'
			38						
			39						Heavy rig chatter at 39'
			40						Roller bit to 40'
	Class 1d	Lt. brown-gray-green f. GRAVEL, so. f-c sand, so. silt, (DECOMPOSED ROCK) (moist)	41	S-7	SS	16	13 64 100/5"	100/5"	
			42						
			43						Heavy rig chatter 43' to 44'
			44						
			45						

Coring (min)

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Log of Boring **B-3** Sheet 3 of 3

Project	Project No.
45 Broad Street	170394201
Location	**Elevation and Datum**
45 Broad Street, New York, NY	El. 10 NAVD88

Material Symbol	Building Code	Sample Description	Coring (min)	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	Class 1d	Lt. brown-white-black-green f-c SAND, so. mica, tr. silt (DECOMPOSED ROCK) (moist)		45	S-8	SS	10	37 43 28 100/4"	71	Roller bit to 45'
				46						
				47						Smooth rig chatter 47' to 50'
				48						
				49						
				50						Roller bit to 50'
			5	51	C-1	NX	REC=57"/60" =95%	RQD=53"/60" =88%		Brownish return 50'-51'
			5	52						
		Gray-white-black-red-green GNEISS-MICA SCHIST, so. garnets (BEDROCK)	2	53						Gray return 51'-55'
			2	54						
			2	55						
			2	56	C-2	NX	REC=56"/60" =93%	RQD=56"/60" =93%		
			2	57						Gray return 55'-60'
	Class 1a	Gray-black-red-green GNEISS-SCHIST, so. garnets (BEDROCK)	2	58						
			2	59						
			2	60						Gray return 60'-65'
			1	61	C-3	NX	REC=60"/60" =100%	RQD=60"/60" =100%		
			2	62						
		Gray-black-red GNEISS-SCHIST, so. garnets (BEDROCK)	2	63						Rig chatter 62' to 63'
			2	64						
			3	65						E.O.B. @ 65'
				66						
				67						
				68						
				69						
				70						

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Log of Boring **B-4** Sheet 1 of 3

Project: 45 Broad Street	Project No.: 170394201
Location: 45 Broad Street, New York, NY	Elevation and Datum: El. 11 NAVD88
Drilling Company: Craig Test Boring	Date Started: 9/4/07 — Date Finished: 9/4/07
Drilling Equipment: CME 55 Track Mounted Rig	Completion Depth: 65 ft — Rock Depth: 45.5 ft
Size and Type of Bit: 3-7/8" Tri cone roller bit	Number of Samples: Disturbed 8 — Undisturbed - — Core 3
Casing Diameter (in): 4" ID Steel casing — Casing Depth (ft): 19	Water Level (ft.): First ▽ 20 — Completion ▼ - — 24 HR. ▼ -
Casing Hammer: Auto — Weight (lbs): 140 — Drop (in): 30	Drilling Foreman: Rob Dollar
Sampler: 2" OD split spoon samplier	Inspecting Engineer: Michael Mudalel
Sampler Hammer: Auto — Weight (lbs): 140 — Drop (in): 30	

Material Symbol	Building Code	Sample Description	Coring (min)	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft) 10 20 30 40	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	Class 7	Brick, Concrete, and Rebar (FILL)		0–10						Hammer casing to 4' Roller bit to 5' Hammer casing to 9' Roller bit to 10'
		Lt. brown f GRAVEL, so. f-c sand, tr. organics (FILL) (wet)		10–11	S-1	SS	3	2 1 5 100/5"	6	
		8" Foundation Slab		12						Roller bit thru concrete slab to 13'
	Class 6	Lt. brown-red Clayey SILT, tr. f-c sand (ML) (moist) Moisture Content = 27.4%		13–15	S-2	SS	10	3 2 2 2	4	
				16–20						Hammer casing to 19'

▽ Water level at 20 ft

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Log of Boring **B-4** Sheet 2 of 3

Project	Project No.
45 Broad Street	170394201
Location	**Elevation and Datum**
45 Broad Street, New York, NY	El. 11 NAVD88

Material Symbol	Building Code	Sample Description	Depth Scale	Sample Number	Sample Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	Class 6	Lt. brown-redish-gray Silty CLAY (ML/CL) (wet)	20–22	S-3	SS	14	3, 3, 4, 4	7	Roller bit to 20'
	Class 6	Lt. brown-red f-SAND, so. silt (SP) (wet)	25–27	S-4	SS	12	2, 3, 2, 2	5	Roller bit to 25'
	Class 4c	Lt. brown-red Silty CLAY (CL) (wet)	30–32	S-5	SS	17	1, 2, 2, 3	4	Roller bit to 30'
	Class 6	Lt. brown-red Silty CLAY, tr. f-c sand (CL-ML) (wet) Moisture Content = 28.0% LL=26; PL=20; PI=6	35–37	S-6	SS	20	0, 1, 1, 2	2	Roller bit to 35'
	Class 1d	Lt. brown-black-green-orange f-c SAND, so. silt, so. f gravel (DECOMPOSED ROCK) (moist)	40–42	S-7	SS	20	9, 11, 21, 51	32	Rig chatter at 39.5' Roller bit to 40'
		Lt. brown-green-gray f. GRAVEL, so. f-c sand, tr. silt,	45						

Coring (min)

N-Value (Blows/ft) scale: 10 20 30 40

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Log of Boring **B-4** Sheet 3 of 3

Project	Project No.
45 Broad Street	170394201
Location	**Elevation and Datum**
45 Broad Street, New York, NY	El. 11 NAVD88

Material Symbol	Building Code	Sample Description	Coring (min)	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft) 10 20 30 40	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	Class 1d	(DECOMPOSED ROCK) (moist)		45	S-8	SS	3	100/3"	100/3"	Roller bit to 45' Heavy rig chatter at 45' Take S-8
				46						
				47						
				48						
				49						Roller bit to 50'
				50						Smooth rig chatter 45.5' to 50'
			4	51						Start coring at 50'
		Gray-black-red GNEISS-MICA SCHIST, so. garnets, (BEDROCK)	3	52	C-1	NX	REC=60"/60" =100%	RQD=56"/60" =93%		
			3	53						
			4	54						
			3	55						
	Class 1a		3	56						
		Gray-black-red GNEISS-SCHIST, so. garnets, so. mica (BEDROCK)	1	57	C-2	NX	REC=57"/60" =95%	RQD=37"/60" =62%		Coring resistance decreased 57'-58'
			2	58						
			3	59						
			3	60						
			2	61						
		Gray-black-red GNEISS-SCHIST, so. garnets, so. mica (BEDROCK)	3	62	C-3	NX	REC=60"/60" =100%	RQD=36"/60" =60%		
			2	63						
			3	64						
				65						E.O.B. @ 65'
				66						
				67						
				68						
				69						
				70						

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Log of Boring **B-5** Sheet 1 of 3

Project: 45 Broad Street	Project No.: 170394201
Location: 45 Broad Street, New York, NY	Elevation and Datum: El. 10 NAVD88
Drilling Company: Craig Test Boring	Date Started: 8/31/07 — Date Finished: 8/31/07
Drilling Equipment: CME 55 Track Mounted Rig	Completion Depth: 60 ft — Rock Depth: 45 ft
Size and Type of Bit: 3-7/8" Tri cone roller bit	Number of Samples: Disturbed 7 — Undisturbed - — Core 3
Casing Diameter (in): 4" ID Steel casing — Casing Depth (ft): 19	Water Level (ft.): First ▽ 25 — Completion ▼ - — 24 HR. ▼ -
Casing Hammer: Auto — Weight (lbs): 140 — Drop (in): 30	Drilling Foreman: Rob Dollar
Sampler: 2" OD split spoon samplier	Inspecting Engineer: Michael Mudalel
Sampler Hammer: Auto — Weight (lbs): 140 — Drop (in): 30	

Material Symbol	Building Code	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft) 10 20 30 40	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	Class 7	Brick, Concrete, and Rebar (FILL)	0–10						Hammer casing to 9'
		Lt. brown-gray f GRAVEL, so. f-c sand, so. concrete (FILL) (wet)	10–12	S-1	SS	4	6 7 7 100/5"	14	Roller bit to 10' Roller bit through concrete slab to 13'
		6" Foundation Slab	12						
		Lt. brown-red SILT, tr. c-f sand (ML) (moist)	13–15	S-2	SS	8	3 2 2 2	4	
	Class 6		16–20						Hammer casing to 19'

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Log of Boring **B-5** Sheet 2 of 3

Project	Project No.
45 Broad Street	170394201
Location	**Elevation and Datum**
45 Broad Street, New York, NY	El. 10 NAVD88

Material Symbol	Building Code	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
			20						Roller bit to 20'
		Lt. brown Clayey SILT, tr. f. sand (ML) (moist) Moisture Content = 28.1%	21	S-3	SS	16	2 3 4 4	7	
			22						
			23						
			24						
			25						Roller bit to 25'
	Class 6	Lt. brown-red SILT (ML) (wet)	26	S-4	SS	14	2 3 3 2	6	
			27						
			28						
			29						
			30						Roller bit to 30'
		Lt. brown-red SILT, tr. clay (ML) (wet) Moisture Content = 35.4% LL=32; PL=25; PI=7	31	S-5	SS	16	1 1 2 2	3	
			32						
			33						
			34						
			35						Roller bit to 35'
	Class 4c	Lt. brown-reddish-gray Silty CLAY (CL) (wet)	36	S-6	SS	18	2 3 4 7	7	
			37						
			38						
			39						Rig chatter 38' to 40'
			40						Roller bit to 40'
	Class 1d	Lt. brown-gray SILT, so f-c sand, so f. gravel, tr. mica (DECOMPOSED ROCK) (moist)	41	S-7	SS	24	19 25 20 22	45	
			42						
			43						Rig chatter 43' to 43.5'
			44						Smooth chatter 43.5' to 44' Rock core at 44'
			45						

Coring (min)

N-Value (Blows/ft) scale: 10 20 30 40

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Log of Boring **B-5** Sheet 3 of 3

Project	Project No.
45 Broad Street	170394201
Location	**Elevation and Datum**
45 Broad Street, New York, NY	El. 10 NAVD88

Material Symbol	Building Code	Sample Description	Coring (min)	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft) 10 20 30 40	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
			5	45						Pull rock core barrel out of decomposed rock
			6	46						Roller bit through decomposed rock to 45'
			4	47						Rock core at 45'
	Class 1b	Gray-black-white-red GNEISS-MICA SCHIST, so. garnets (BEDROCK)	4	48	C-1	NX	REC=54"/60" =90%	RQD=50"/60" =83%		
			3	49						
			3	50						
			5	51						
		Gray-black-red GNEISS-SCHIST, so. mica, so. garnets (BEDROCK)	4	52	C-2	NX	REC=56"/60" =93%	RQD=53"/60" =88%		
			4	53						
			3	54						
	Class 1a		6	55						
			4	56						
			2	57						
		Gray-black-red GNEISS-SCHIST, so. garnets, so. mica (BEDROCK)	2	58	C-3	NX	REC=58"/60" =97%	RQD=58"/60" =97%		
			2	59						
				60						E.O.B. @ 60'
				61						
				62						
				63						
				64						
				65						
				66						
				67						
				68						
				69						
				70						

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Log of Boring **B-6 (OW)** Sheet 1 of 3

Project: 45 Broad Street	Project No.: 170394201
Location: 45 Broad Street, New York, NY	Elevation and Datum: El. 10.5 NAVD88
Drilling Company: Craig Test Boring	Date Started: 8/30/07 — Date Finished: 8/30/07
Drilling Equipment: CME 55 Track Mounted Rig	Completion Depth: 62 ft — Rock Depth: 48.5 ft
Size and Type of Bit: 3-7/8" Tri cone roller bit	Number of Samples: Disturbed 7 — Undisturbed - — Core 4
Casing Diameter (in): 4" ID Steel casing — Casing Depth (ft): 19	Water Level (ft.): First ▽ 25 — Completion ▼ - — 24 HR. ▼ 18.4
Casing Hammer: Auto — Weight (lbs): 140 — Drop (in): 30	Drilling Foreman: Rob Dollar
Sampler: 2" OD split spoon samplier	Inspecting Engineer: Michael Mudalel
Sampler Hammer: Auto — Weight (lbs): 140 — Drop (in): 30	

Material Symbol	Building Code	Sample Description	Coring (min)	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft) 10 20 30 40	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	Class 7	Brick, Concrete, and Rebar (FILL)		0–5						Hammer casing to 4'
										Roller bit to 10'
		Lt. gray, so. concrete, so f-c sand (FILL) (moist)		5–9						Hammer casing to 9'
										Roller bit to 10'
				10–12						Hammer casing to 12.5'
		6" Foundation Slab		13	S-1	SS	4	100/4"	100/4"	Smooth chatter 13' to 13.5'
	Class 7	No recovery		14–16	S-2	SS	NR	1 WOR WOR 1		Roller bit to 14'
		? ? ? ?		17						
	Class 6			18–19						Hammer casing to 19'
				20						

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Log of Boring **B-6 (OW)** Sheet 2 of 3

Project	Project No.
45 Broad Street	170394201
Location	**Elevation and Datum**
45 Broad Street, New York, NY	El. 10.5 NAVD88

Material Symbol	Building Code	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
			20						Roller bit to 20'
		Lt. brown-red silty CLAY, tr. f sand, tr. f gravel (CL) (moist) Moisture Content = 23.0% LL=32; PL=21; PI=11	21	S-3	SS	8	3 2 3 3	5	
			22						
			23						
			24						
			25						Roller bit to 25'
		Lt. brown-red SILT, tr. f sand (ML) (wet)	26	S-4	SS	20	2 3 3 3	6	
			27						
			28						
			29						
	Class 6		30						Roller bit to 30'
		Lt. brown-red SILT (ML) (wet) Moisture Content = 34.3%	31	S-5	SS	18	1 2 2 2	4	
			32						
			33						
			34						
			35						Roller bit to 35'
		Lt. brown-reddish-gray Clayey SILT (ML) (wet)	36	S-6	SS	18	3 2 2 2	4	
			37						
			38						
			39						Rig chatter at 39'
		Lt. brown-red SILT, tr. f-c sand (DECOMPOSED ROCK) (moist)	40	S-7	SS	9	6 100/3"	100/3"	Roller bit to 40'
	Class 1d		41						
			42	C-1	NX	NA	NA		Smooth rig chatter 40.5' to 42'
			43						
			44						Decrease in return 44' to 45'
			45						

Coring (min): 5, 6, 4

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Log of Boring **B-6 (OW)** Sheet 3 of 3

Project	Project No.
45 Broad Street	170394201
Location	**Elevation and Datum**
45 Broad Street, New York, NY	El. 10.5 NAVD88

Material Symbol	Building Code	Sample Description	Coring (min)	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft) 10 20 30 40	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	Class 1d	Lt. brown, gray, green f-c SAND, so. f gravel, tr silt, (DECOMPOSED ROCK), (wet)	3	45	C-1	NX	NA	NA		
			4	46						
			4	47						Rig chatter 45' to 49'
			2	48	C-2	NX	REC=55"/60" =92%	RQD=26"/60" =43%		
			5	49						Resistance increased at 49'
			3	50						
		Lt. Gray-greenish-red-black GNEISS-SCHIST, so. garnets, so. mica (BEDROCK)	5	51						No return 51' to 52
			6	52	C-3	NX	REC=60"/60" =100%	RQD=54"/60" =90%		
			4	53						
	Class 1c	Lt. Gray-greenish-red-black, GNEISS-SCHIST, so. garnets, so. mica (BEDROCK)	3	54						
			3	55						
			2	56						
			3	57	C-4	NX	REC=35"/60" =58%	RQD=35"/60" =58%		No return 54' to 57'
			3	58						
			3	59						
		Lt. Gray-red-black, GNEISS-SCHIST, so. garnets, so. mica (BEDROCK)	3	60						
			3	61						Install 2" PVC MW
			4	62						E.O.B. @ 62'
				63						
				64						
				65						
				66						
				67						
				68						
				69						
				70						

APPENDIX A-2
Boring Logs (Langan 2016)

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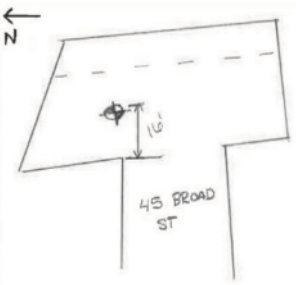
Log of Boring **B-7(OW)** Sheet 1 of 3

Project: 45 Broad Street		Project No.: 170394201	
Location: 45 Broad Street, New York, NY		Elevation and Datum: El. 9 NAVD88	
Drilling Company: Craig Geotechnical Drilling Co., Inc.		Date Started: 1/29/16	Date Finished: 1/29/16
Drilling Equipment: Truck Mounted Rig		Completion Depth: 55 ft	Rock Depth: 45 ft
Size and Type of Bit: 3-7/8" Tri cone roller bit		Number of Samples: Disturbed 10	Undisturbed - / Core 2
Casing Diameter (in): 4" ID Steel casing	Casing Depth (ft): 25	Water Level (ft.): First ▽ 15	Completion ▼ / 24 HR. ▼ 13.5
Casing Hammer: Auto	Weight (lbs): 140 / Drop (in): 30	Drilling Foreman: Ryan Warden	
Sampler: 2" OD split spoon samplier, NX Core Barrel		Inspecting Engineer: Maria Mis	
Sampler Hammer: Auto	Weight (lbs): 140 / Drop (in): 30		

Material Symbol	Building Code	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft) 10 20 30 40
	Class 7	Demolition Debris 0-12 ft Sampling not performed in demolition debris above remnant basement slab	0–12					
		Remnant basement slab (9" thick)	12–13					
	Class 7	Medium dense gray coarse GRAVEL [FILL]	13–15	S-1	SS	4	5 6 10 4	16
		Loose gray coarse GRAVEL, trace brick fragments [FILL]	15–17	S-2	SS	3	2 1 WOH 1	
	Class 6	Loose brown/gray CLAY (CL), trace coarse to fine sand (wet)	17–19	S-3	SS	2	1 2 3 4	5
			19–20	S-4	SS	6	2 2	5

Remarks
(Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)



Install casing to 10ft
Advance roller bit
Smooth drilling
Brown wash

Chatter at 12ft
Slow drilling
Gray wash
Break through at 12.75ft

Take S-1: 13-15ft

Take S-2: 15-17ft

Install casing to 15ft
Clean casing
Roller bit to 17ft
Take S-3: 17-19ft

Take S-4: 19-21ft

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Log of Boring **B-7(OW)** Sheet 2 of 3

Project	Project No.
45 Broad Street	170394201
Location	**Elevation and Datum**
45 Broad Street, New York, NY	El. 9 NAVD88

Material Symbol	Building Code	Sample Description	Depth Scale
		Loose brown/gray CLAY (CL), trace coarse to fine sand, trace wood fragments (wet) Moisture Content = 35.6% LL=33; PL=23; PI=10 Loose brown/gray CLAY (CL), trace fine sand (wet)	20
			21
			22
		Loose brown/gray silty CLAY (CL-ML) (wet) Moisture Content = 40.3% LL=26; PL=21; PI=5	23
			24
		Loose brown CLAY (CL), trace clay, trace fine sand (wet)	25
			26
			27
			28
			29
			30
	Class 6	Loose brown/gray CLAY (CL), trace fine sand, trace wood fragments (wet)	31
			32
			33
			34
			35
		Loose brown/gray CLAY (CL), trace fine sand (wet) Moisture Content = 34.6% LL=30; PL=22; PI=8	36
			37
			38
			39
			40
			41
	Class 1d	Black/green WEATHERED MICA SCHIST, some fine sand, trace silt, trace fine gravel	42
			43
			44
			45

Sample Data					Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	
S-4	SS	6	3 4	5	Install casing to 20ft Clean casing Roller bit to 22ft, brown wash Take S-5: 21-23ft
S-5	SS	2	1 2 2 2	4	
S-6	SS	10	1 2 2 2	4	Take S-6: 23-25ft Roller bit to 25ft Brown wash Take S-7: 25-27ft
S-7	SS	8	WOH 1 2 2	3	Casing to 25ft Roller bit to 30ft
S-8	SS	6	3 1 1 2	2	Take S-8: 30-32ft Roller bit to 35ft
S-9	SS	15	WOH 1 1 1	2	Take S-9: 35-37ft Roller bit to 40ft Brown wash
S-10	SS	18	21 36 100/4"	100/4"	Take S-10: 40-41.5ft Spoon refusal at 41.5ft Roller bit to 45ft Slight chatter

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Log of Boring **B-7(OW)** Sheet 3 of 3

Project	Project No.
45 Broad Street	170394201
Location	**Elevation and Datum**
45 Broad Street, New York, NY	El. 9 NAVD88

MATERIAL SYMBOL	Building Code	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft) 10 20 30 40	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	Class 1b	Black/gray MICA SCHIST with quartz and fieldspar intrusions, slightly weathered, slightly fractured, horizontal foliations, subvertical fractures	45	C-1	NX	REC=46"/60" =77%	RQD=46"/60" =77%		Take S-11 at 45ft Spoon refusal at 45ft Start core C-1: 45-50ft
			46						
			47						
			48						
			49						
			50						End C-1 at 50ft Start core C-2: at 50ft
	Class 1a	Black/gray MICA SCHIST with quartz intrusions, slightly to moderately weathered, slightly to moderately fractured, horizontal foliations, subvertical fractures	51	C-2	NX	REC=60"/60" =100%	RQD=53"/60" =88%		
			52						
			53						
			54						
			55						End core C-2 at 55ft End of Boring at 55ft
		End of Boring @ 55 ft BGS	56						Remove casing Install well See Well Construction Log B-7(OW) for details of well construction
			57						
			58						
			59						
			60						
			61						
			62						
			63						
			64						
			65						
			66						
			67						
			68						
			69						
			70						

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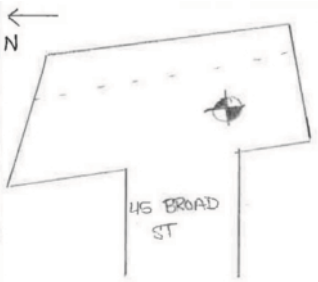
Log of Boring **B-8** Sheet 1 of 3

Project: 45 Broad Street	Project No.: 170394201
Location: 45 Broad Street, New York, NY	Elevation and Datum: El. 9 NAVD88
Drilling Company: Craig Geotechnical Drilling Co., Inc.	Date Started: 2/1/16 — Date Finished: 2/1/16
Drilling Equipment: Truck Mounted Rig	Completion Depth: 55 ft — Rock Depth: 45 ft
Size and Type of Bit: 3-7/8" Tri cone roller bit	Number of Samples: Disturbed 10 — Undisturbed - — Core 2
Casing Diameter (in): 4" ID Steel casing — Casing Depth (ft): 15	Water Level (ft.): First ▽ — Completion ▼ — 24 HR. ▼
Casing Hammer: Auto — Weight (lbs): 140 — Drop (in): 30	Drilling Foreman: Ryan Warden
Sampler: 2" OD split spoon samplier, NX Core Barrel	Inspecting Engineer: Maria Mis
Sampler Hammer: Auto — Weight (lbs): 140 — Drop (in): 30	

Material Symbol	Building Code	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft) 10 20 30 40	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	Class 7	Demolition debris Sampling not performed in demolition debris above remnant basement slab	0–12						 Predrilled through demolition debris and fill layer with 4-7/8in. tricone roller bit
		Remnant basement slab (9" thick)	12						Rig chatter at 12ft Broke through at 12.75ft
		Loose brown SILT (ML), trace fine sand (wet)	13–14	S-1	SS	12	6, 2, 3, 2	5	Take S-1: 13-15ft
	Class 6	Medium Dense brown SILT (ML), trace fine sand (wet) Moisture content = 32.8% LL=28; PL=23; PI=5	15–16	S-2	SS	15	7, 13, 15, 16	28	Take S-2: 15-17ft
		Loose brown SILT (ML), trace fine sand (wet)	17–18	S-3	SS	12	1, 3, 4, 4	7	Install casing to 15ft Clean-out casing with tricone roller bit Brown wash Take S-3: 17-19ft
		Loose brown/gray SILT (ML), trace fine sand (wet)	19–20	S-4	SS	3	6, 3	7	Take S-4: 19-21ft

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Log of Boring **B-8** Sheet 2 of 3

Project	Project No.
45 Broad Street	170394201
Location	**Elevation and Datum**
45 Broad Street, New York, NY	El. 9 NAVD88

Material Symbol	Building Code	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	Class 6	Loose brown/gray SILT (ML), trace fine sand (wet)	20–23	S-4	SS	3	4, 5	7	
				S-5	SS	15	WOH, 1, 1, 2	2	Take S-5: 21-23ft
	Class 6	Loose brown silty fine SAND (SM) (wet) Moisture Content = 30.3%	23–25	S-6	SS	18	1, 2, 3, 4	5	Take S-6: 23-25ft
		Loose brown silty fine SAND (SM), some silt, trace clay (wet)							Advance roller bit to 25ft
			25–27	S-7	SS	12	WOH, WOH, 1, WOH		Take S-7: 25-27ft
			27–30						Advance roller bit to 30ft Brown wash Smooth drilling
	Class 6	Loose brown/gray SILT (ML), some fine sand (wet)	30–32	S-8	SS	12	1, WOH, 1, 2		Take S-8: 30-32ft
			32–35						Advance roller bit to 35ft Brown wash Smooth drilling
			35–36	S-9	SS	18	WOH, 4, 16, 18	20	Take S-9: 35-37ft
	Class 3b	Medium dense gray/brown coarse to fine SAND (SM), some silt, trace decomposed mica schist (wet)	36–38						Advance roller bit to 40ft Brown wash Smooth drilling
	Class 3a	Dense brown/gray coarse to fine SAND (SM), some silt, trace clay, trace weathered rock (wet)	39–41	S-10	SS	18	14, 20, 25, 100/5"	45	Take S-10: 40-41.9ft Spoon Refusal at 41.9ft
	Class 1d	WEATHERED MICA SCHIST	42–45						Advance roller bit to 45ft Slow drilling Rig chatter

N-Value (Blows/ft) scale: 10 20 30 40

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Log of Boring **B-8** Sheet 3 of 3

Project	Project No.
45 Broad Street	170394201
Location	**Elevation and Datum**
45 Broad Street, New York, NY	El. 9 NAVD88

MATERIAL SYMBOL	Building Code	Sample Description	Depth Scale	Sample Data: Number	Type	Recov. (in)	Penetr. resist BL/6in	N-Value (Blows/ft) 10 20 30 40	Remarks (Drilling Fluid, Depth of Casing, Fluid Loss, Drilling Resistance, etc.)
	Class 1c	Black/gray MICA SCHIST with quartz and fieldspar intrusions, slightly weathered, slightly fractured, horizontal foliations, subvertical fractures	45	C-1	NX	REC=60"/60" =100%	RQD=56"/60" =93%		Take S-11 at 45ft Spoon refusal at 45ft Start core C-1: 45-50ft
			46						
			47						
			48						
			49						
			50						End C-1 at 50ft Start core C-2: 50-55ft
		Black/gray MICA SCHIST with quartz and fieldspar intrusions, slightly weathered, slightly fractured, horizontal foliations, subvertical fractures	51	C-2	NX	REC=60"/60" =100%	RQD=60"/60" =100%		
			52						
			53						
			54						
			55						End C-2 at 55ft End of Boring at 55ft Remove rods and casing
		End of Boring @ 55 ft BGS	56						
			57						
			58						
			59						
			60						
			61						
			62						
			63						
			64						
			65						
			66						
			67						
			68						
			69						
			70						

APPENDIX B-1
Observation Well Construction Logs (Langan 2007)

WELL CONSTRUCTION SUMMARY

Well No. MW-1

PROJECT 45 Broad St	PROJECT NO. PERMIT 5797401
LOCATION New York, NY	ELEVATION AND DATUM BPMD 9.90 Top of Casing
DRILLING AGENCY Craig Test Boring	DATE STARTED / DATE FINISHED 8/29/07 8/30/2007
DRILLING EQUIPMENT CME 55 Track Mounted Rig	DRILLER Rob Dollar
SIZE AND TYPE OF BIT 3-7/8" Tri-cone roller bit	INSPECTOR Michael Mudalel

METHOD OF INSTALLATION

A 2-inch PVC screen and riser were installed and the annular space was filled with No. 1 filter sand, a bentonite seal, backfilled with fill material.

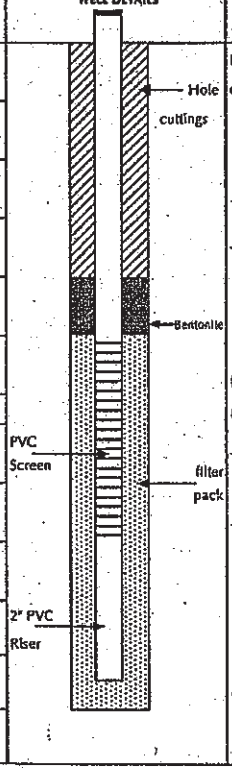
METHOD OF WELL DEVELOPMENT

Well was developed by surge and pump method for 60 minutes until discharge was clear of silt. A total of 5 gallons was purged.

TYPE OF CASING PVC	DIAMETER 2-inch	TYPE OF BACKFILL MATERIAL Hole cuttings	
TYPE OF SCREEN PVC	DIAMETER 2-inch	TYPE OF SEAL MATERIAL Bentonite	
BOREHOLE DIAMETER 4"		TYPE OF FILTER MATERIAL # 1 Sand	
TOP OF CASING	ELEVATION 9.90	DEPTH (ft) 0.00	
TOP OF SEAL	ELEVATION -13.10	DEPTH (ft) 23.00	
TOP OF FILTER	ELEVATION -16.13	DEPTH (ft) 25.00	
TOP OF SCREEN	ELEVATION -20.13	DEPTH (ft) 29.00	
BOTTOM OF WELL	ELEVATION -40.13	DEPTH (ft) 49.00	
SCREEN LENGTH 10 ft			
SLOT SIZE 0.01-in			

GROUNDWATER ELEVATIONS

ELEVATION	DATE	DEPTH TO WATER
-9.90	8/31/07	19.80
-10.30	9/4/07	20.20
-10.10	9/5/2007	20
-10.40	9/6/2007	20.3



SUMMARY SOIL CLASSIFICATION	DEPTH (FT) bgs
Demo debree, brick, concrete, and steel rebar	0.0
18" Concrete slab	11.5
Lt. brown-redish SILT, tr mica	29.0
Top of bed rock	38.0
Bed rock	59.0

LANGAN Engineering and Environmental Services, PC
21 Penn Plaza, 360 W 31st Street, 8th Floor, New York

WELL CONSTRUCTION SUMMARY

Well No. MW-6

PROJECT: 45 Broad St	PROJECT NO.: 5797401 PERMIT:
LOCATION: New York, NY	ELEVATION AND DATUM: BPMD 9.90 Top of Casing
DRILLING AGENCY: Craig Test Boring	DATE STARTED: 8/30/07 DATE FINISHED: 8/30/2007
DRILLING EQUIPMENT: CME 55 Track Mounted Rig	DRILLER: Rob Dollar
SIZE AND TYPE OF BIT: 3-7/8" Tri-cone roller bit	INSPECTOR: Michael Mudalel

METHOD OF INSTALLATION

A 2-inch PVC screen and riser were installed and the annular space was filled with No. 1 filter sand, a bentonite seal, backfilled with bentonite and fill material.

METHOD OF WELL DEVELOPMENT

Well was developed by surge and pump method for 60 minutes until discharge was clear of silt. A total of 5 gallons was purged.

TYPE OF CASING: PVC	DIAMETER: 2-inch	TYPE OF BACKFILL MATERIAL: Hole cuttings	
TYPE OF SCREEN: PVC	DIAMETER: 2-inch	TYPE OF SEAL MATERIAL: Bentonite	
BOREHOLE DIAMETER: 4"		TYPE OF FILTER MATERIAL: # 1 Sand	

	ELEVATION	DEPTH (ft)
TOP OF CASING	9.90	0.00
TOP OF SEAL	-8.10	18.00
TOP OF FILTER	-11.13	20.00
TOP OF SCREEN	-11.13	20.00
BOTTOM OF WELL	-31.13	40.00

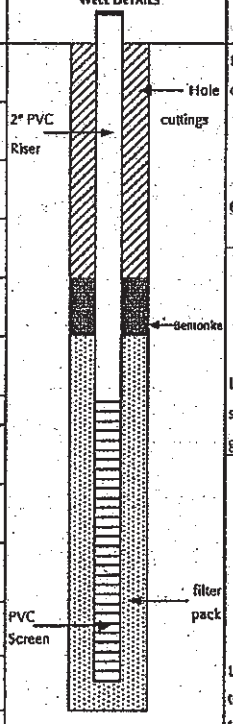
SCREEN LENGTH: 20 ft

SLOT SIZE: 0.01-in

GROUNDWATER ELEVATIONS

ELEVATION	DATE	DEPTH TO WATER
-8.50	9/4/07	18.40
-8.10	9/5/07	18.00
-8.10	9/6/07	18.00

WELL DETAILS



SUMMARY SOIL CLASSIFICATION	DEPTH (FT) bgs
Demo debree, brick, concrete, and steel rebar	0.0
6" Concrete slab	13.0
Lt brown-redish SILT, so. Clay, tr. f. sand, tr c. gravel	20.0
Lt brown- redish SILT, tr. decomposed rock, tr. f.-c. sand	40.0

LANGAN Engineering and Environmental Services, PC
21 Penn Plaza, 360 W 31st Street, 8th Floor, New York

APPENDIX B-2
Observation Well Construction Logs (Langan 2016)

OBSERVATION WELL CONSTRUCTION SUMMARY

Well No. B-7(OW)

PROJECT 45 Broad Street	**PROJECT NO.** 170394201
LOCATION New York, New York	**ELEVATION AND DATUM** 9.9 (NAVD88)
DRILLING AGENCY Craig Test Boring Inc.	**DATE STARTED** 1/29/2016 **DATE FINISHED** 1/29/2016
DRILLING EQUIPMENT Truck Mounted Rig	**DRILLER** Ryan Warden
SIZE AND TYPE OF BIT 3-7/8" Tricone Roller Bit	**INSPECTOR** Maria Mis

METHOD OF INSTALLATION

BORING WAS DRILLED TO 55 FEET. HOLE COLLAPSED TO 26 FEET. INSTALLED WELL TO 26 FEET. A 2.00 INCH PVC SCREEN (10 FT) AND RISER TO THE SURFACE WERE INSTALLED TO THE CORRECT DEPTH TO 26 FT; CASING WAS THEN REMOVED, AS THE CASING WAS REMOVED SAND FILTER AND BENTONITE PELLETS WERE PACKED RESPECTIVELY. A FLUSH-MOUNT WELL CAP WAS THEN INSTALLED AND CEMENTED IN.

METHOD OF WELL DEVELOPMENT

WELL WAS FLUSHED UNTIL WATER RETURN WAS CLEAR.

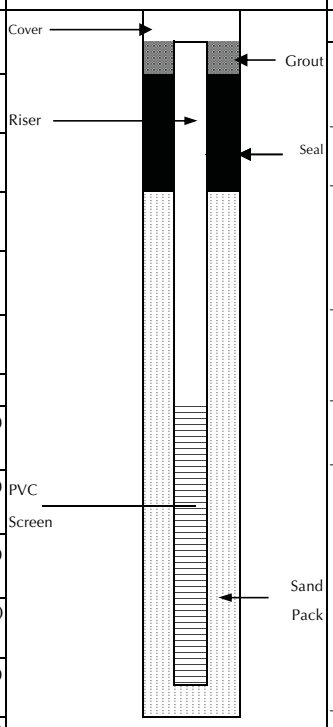
TYPE OF RISER PVC	**DIAMETER** 2.00 inches	**TYPE OF BACKFILL MATERIAL** SOIL CUTTINGS
TYPE OF SCREEN PVC	**DIAMETER** 2.00 inches	**TYPE OF SEAL MATERIAL** BENTONITE PELLETS
BOREHOLE NOMINAL DIAMETER 4 inches		**TYPE OF FILTER MATERIAL** NO. 1 FILTER SAND (SILICA QUARTZ SAND)

TOP OF CASING	**ELEVATION** 13.9	**DEPTH (ft)** -4
TOP OF SEAL	**ELEVATION (ft)** 7.4	**DEPTH (ft)** 2.5
TOP OF FILTER	**ELEVATION (ft)** 6.4	**DEPTH (ft)** 3.5
TOP OF SCREEN	**ELEVATION (ft)** -6.1	**DEPTH (ft)** 16
BOTTOM OF BORING	**ELEVATION (ft)** -16.1	**DEPTH (ft)** 26
SCREEN LENGTH		10 FT
SLOT SIZE		0.025-IN

GROUNDWATER ELEVATIONS

ELEVATION (ft)	DATE	DEPTH TO WATER (ft)
-5.1	1/29/2016	15.0
-3.6	2/1/2016	13.5
-3.6	2/1/2016	13.5

WELL DETAILS



SUMMARY SOIL CLASSIFICATION	DEPTH (FT)
	0.0
0 to 12 feet: FILL	2.5
0 to 12 feet: FILL	3.5
0 to 12 feet: FILL	
12 to12.8 feet: CONCRETE	12.8
12.8 to 17 feet: FILL	16.0
12.8 to 17 feet: FILL	17.0
17 to 38.5 feet: SILT	
	26.0

Note: N.T.S.

LANGAN Engineering, Environmental, Surveying and Landscape Architecture, D.P.C.
21 Penn Plaza, 360 W 31st Street, 7th Floor , New York, NY 10001

APPENDIX C-1
Laboratory Test Results (Langan 2007)

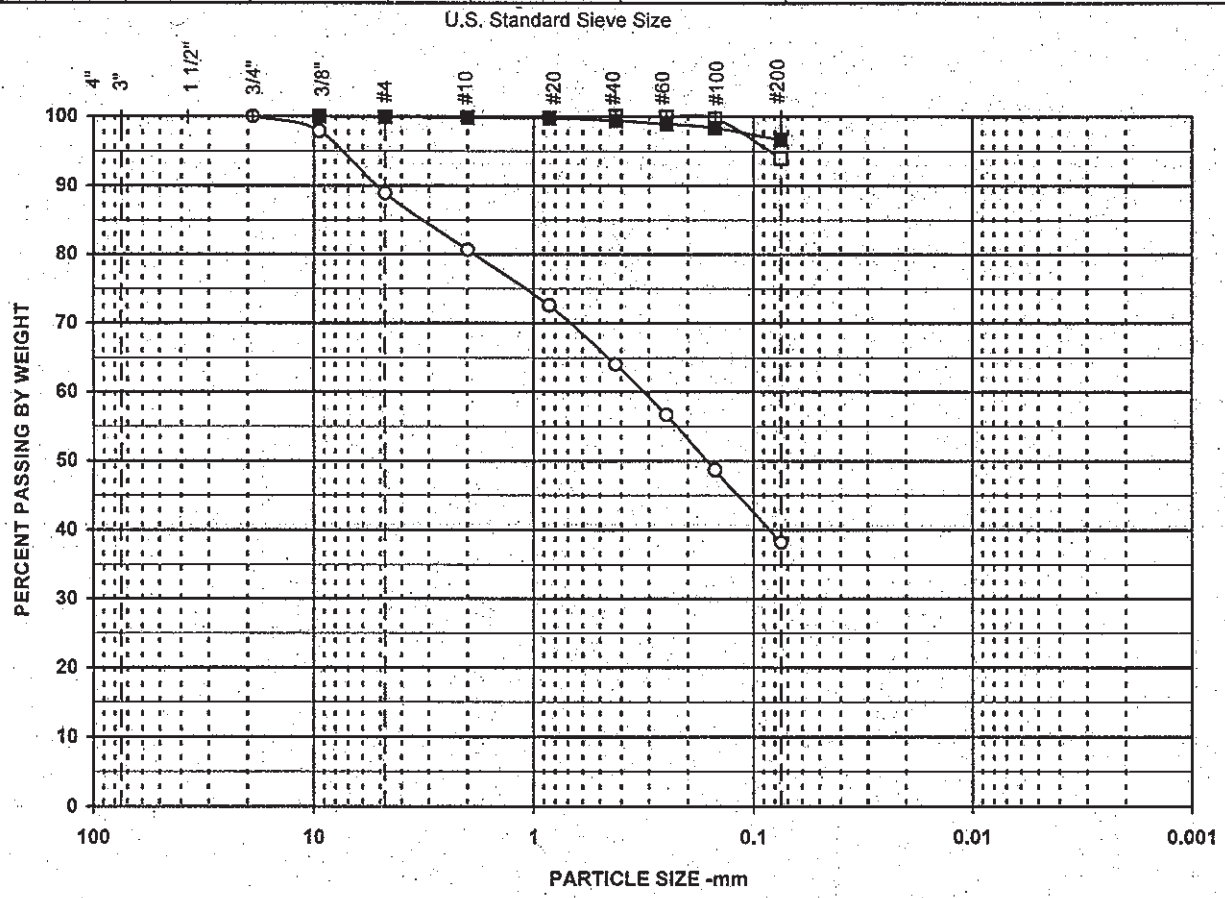
Langan #5797401

LABORATORY TESTING DATA SUMMARY

	BORING NO.	SAMPLE NO.	DEPTH (ft)	IDENTIFICATION TESTS						REMARKS
				WATER CONTENT (%)	LIQUID LIMIT (-)	PLASTIC LIMIT (-)	PLAS. INDEX (-)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	
SILT	LB-1	S-2	13-15	27.6	28	23	5	ML		
SILT	LB-1	S-4	25-27	28.6				ML	94.0	
	LB-2	S-3	20-22	27.0				ML	96.6	
SILT	LB-2	S-5	30-32	29.2	33	25	8	ML		
SILT	LB-3	S-3	20-22	28.9	27	23	4	ML		
SAND	LB-3	S-6	35-37	21.2				SC	38.2	
SILT	LB-4	S-2	13-15	27.4				ML	63.9	
CLAY	LB-4	S-6	35-37	28.0	26	20	6	CL-ML		
SILT	LB-5	S-3	20-22	28.1				ML	98.4	
SILT	LB-5	S-5	30-32	35.4	32	25	7	ML		
SILT	LB-6	S-3	20-22	23.0	32	21	11	CL		
SILT	LB-6	S-5	30-32	34.3				ML	98.6	

Note: (1) USCS symbol based on visual observation and Sieve and Atterberg limits reported.

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



SYMBOL	DESCRIPTION AND REMARKS
□	red SILT, trace f. sand.
■	red SILT, trace f. sand.
○	gray silty clayey c-f SAND, trace f. gravel.

Symbol	□	■	○
Boring	LB-1	LB-2	LB-3
Sample	S-4	S-3	S-6
Spec			
Depth	25-27	20-22	35-37
% +3"			
% Gravel		0.1	11.1
% SAND	6.0	3.3	50.7
% FINES	94.0	96.6	38.2
% -2μ			
Cc			
Cu			
LL			
PL			
PI			
USCS	ML	ML	SC
w (%)	28.6	27.0	21.2

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"			100.0
3/8"		100.0	97.9
4		99.9	88.9
10		99.8	80.6
20		99.8	72.6
40	100.0	99.4	64.0
60	99.9	98.9	56.7
100	99.7	98.3	48.7
200	94.0	96.6	38.2

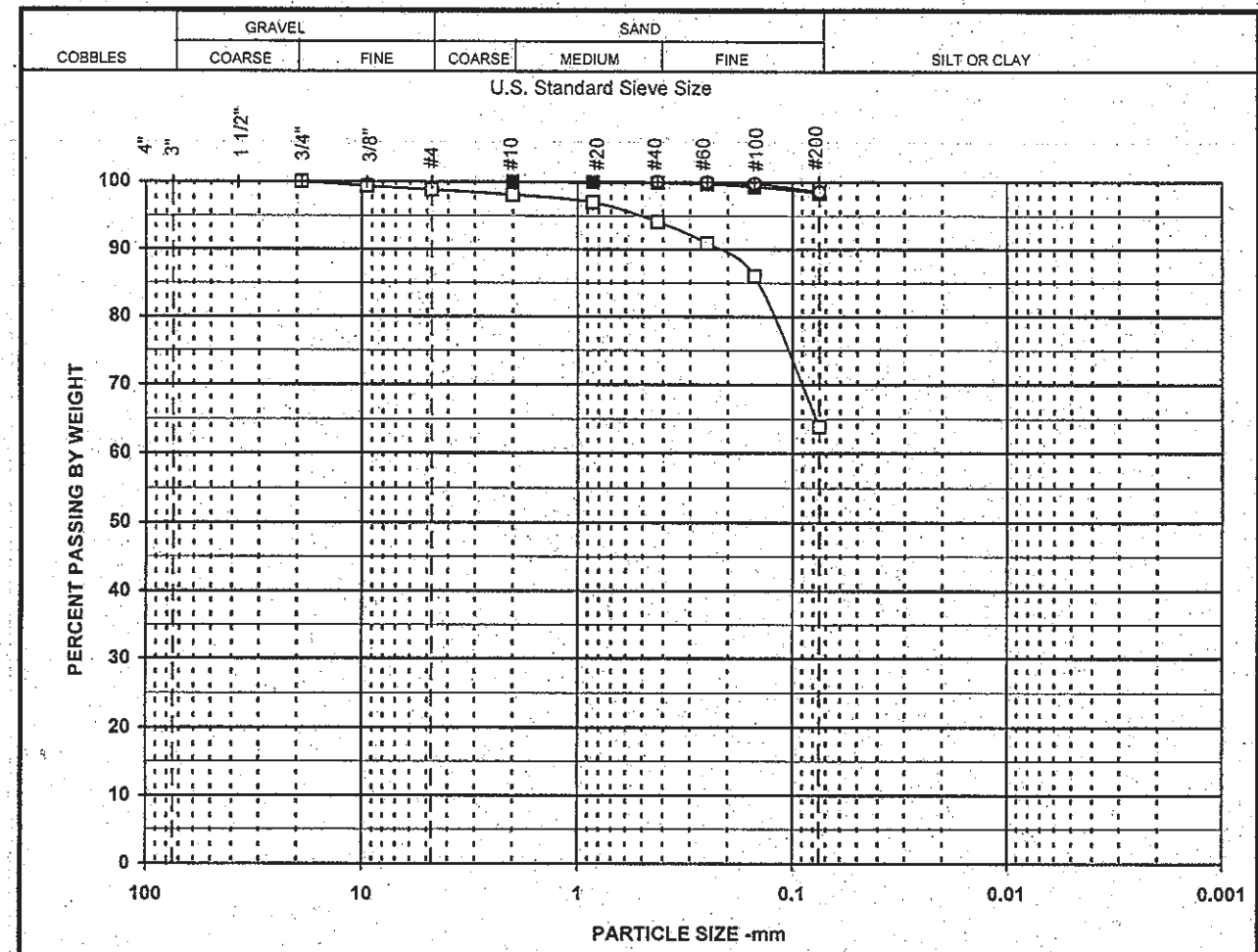
PARTICLE SIZE DISTRIBUTION

Langan #5797401

Project No.		Figure
31737700-728	September 2007	

Geotesting Services, Inc.

sieve1a.xls 9/26/2007



SYMBOL	DESCRIPTION AND REMARKS
□	brown sandy SILT, trace f. gravel.
■	red SILT, trace f. sand.
○	red SILT, trace f. sand.

Symbol	□	■	○
Boring	LB-4	LB-5	LB-6
Sample	S-2	S-3	S-5
Spec			
Depth	13-15	20-22	30-32
% +3"			
% Gravel	1.2		
% SAND	34.9	1.6	1.4
% FINES	63.9	98.4	98.6
% -2μ			
Cc			
Cu			
LL			
PL			
PI			
USCS	ML	ML	ML
w (%)	27.4	28.1	34.3

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"			
3/4"	100.0		
3/8"	99.4		
4	98.8		
10	98.1	100.0	
20	97.0	99.9	
40	94.1	99.9	100.0
60	90.9	99.7	99.9
100	86.0	99.3	99.8
200	63.9	98.4	98.6

PARTICLE SIZE DISTRIBUTION
Langan #5797401

Project No.		Figure
31737700-728	September 2007	

Geotesting Services, Inc.

APPENDIX C-2
Laboratory Test Results (Langan 2016)

Client:	Langan Engineering				
Project:	45 Broad St				
Location:	New York, NY			Project No:	GTX-304342
Boring ID:	---	Sample Type:	---	Tested By:	GA
Sample ID:	---	Test Date:	02/10/16	Checked By:	emm
Depth :	---	Test Id:	363604		

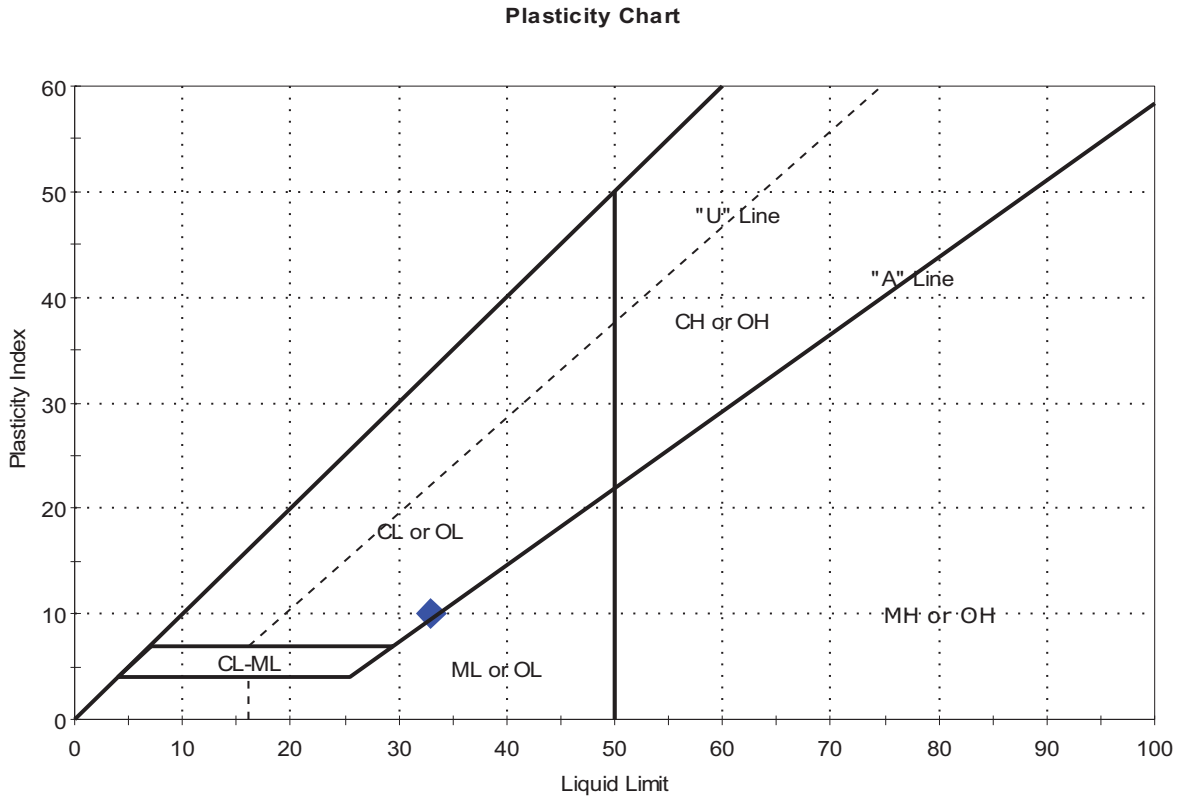
Moisture Content of Soil and Rock - ASTM D2216

Boring ID	Sample ID	Depth	Description	Moisture Content,%
B-7	S- 4	19-21 ft	Moist, brown clay	35.6
B-7	S- 6	23-25 ft	Wet, brown silty clay	40.3
B-7	S- 9	35-37 ft	Wet, brown clay	34.6
B-8	S- 2	15-17 ft	Wet, brown silt	32.8
B-8	S- 6	23-25 ft	Moist, brown silt	30.3

Notes: Temperature of Drying : 110º Celsius

Client:	Langan Engineering				
Project:	45 Broad St				
Location:	New York, NY			Project No:	GTX-304342
Boring ID:	B-7	Sample Type:	jar	Tested By:	GA
Sample ID:	S-4	Test Date:	02/10/16	Checked By:	emm
Depth :	19-21 ft	Test Id:	363595		
Test Comment:	---				
Visual Description:	Moist, brown clay				
Sample Comment:	---				

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S-4	B-7	19-21 ft	36	33	23	10	1.3	

Sample Prepared using the WET method

Dry Strength: HIGH

Dilatancy: NONE

Toughness: MEDIUM

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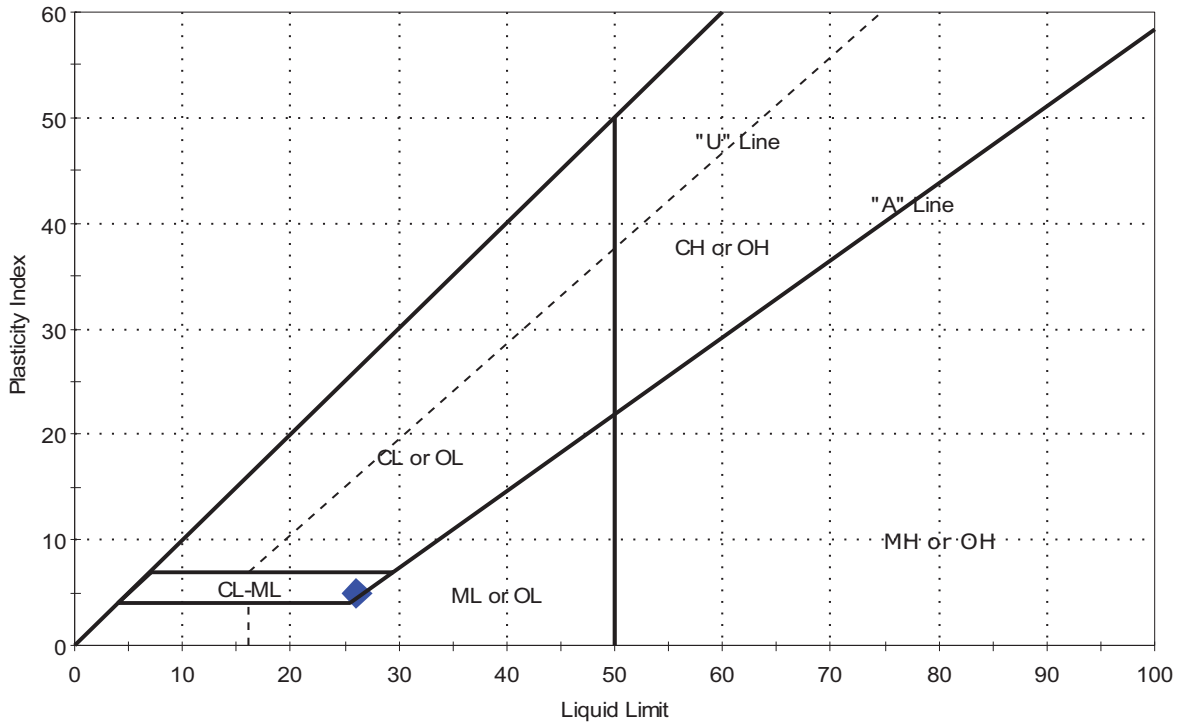
Client:	Langan Engineering				
Project:	45 Broad St				
Location:	New York, NY			Project No:	GTX-304342
Boring ID:	B-7	Sample Type:	jar	Tested By:	GA
Sample ID:	S-6	Test Date:	02/10/16	Checked By:	emm
Depth :	23-25 ft	Test Id:	363596		
Test Comment:	---				
Visual Description:	Wet, brown silty clay				
Sample Comment:	---				

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S-6	B-7	23-25 ft	40	26	21	5	3.9	

Sample Prepared using the WET method

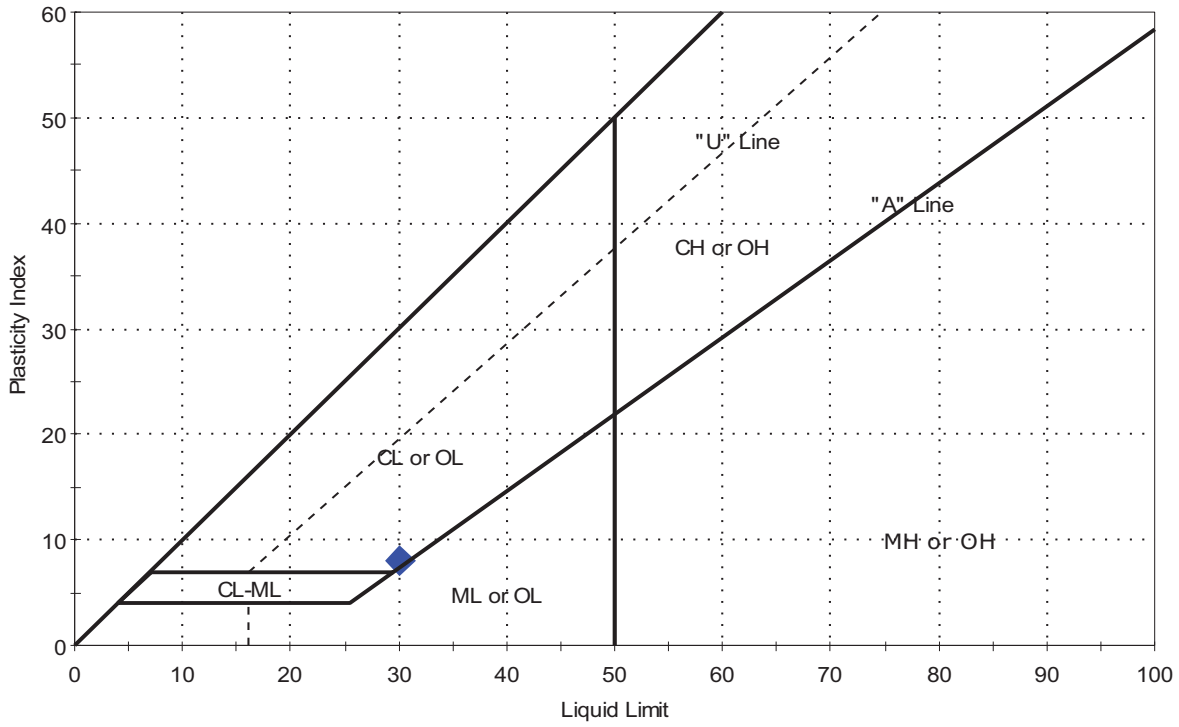
Dry Strength: HIGH

Dilatancy: SLOW

Toughness: MEDIUM

Client:	Langan Engineering				
Project:	45 Broad St				
Location:	New York, NY			Project No:	GTX-304342
Boring ID:	B-7	Sample Type:	jar	Tested By:	GA
Sample ID:	S-9	Test Date:	02/10/16	Checked By:	emm
Depth :	35-37 ft	Test Id:	363597		
Test Comment:	---				
Visual Description:	Wet, brown clay				
Sample Comment:	---				

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S-9	B-7	35-37 ft	35	30	22	8	1.6	

Sample Prepared using the WET method

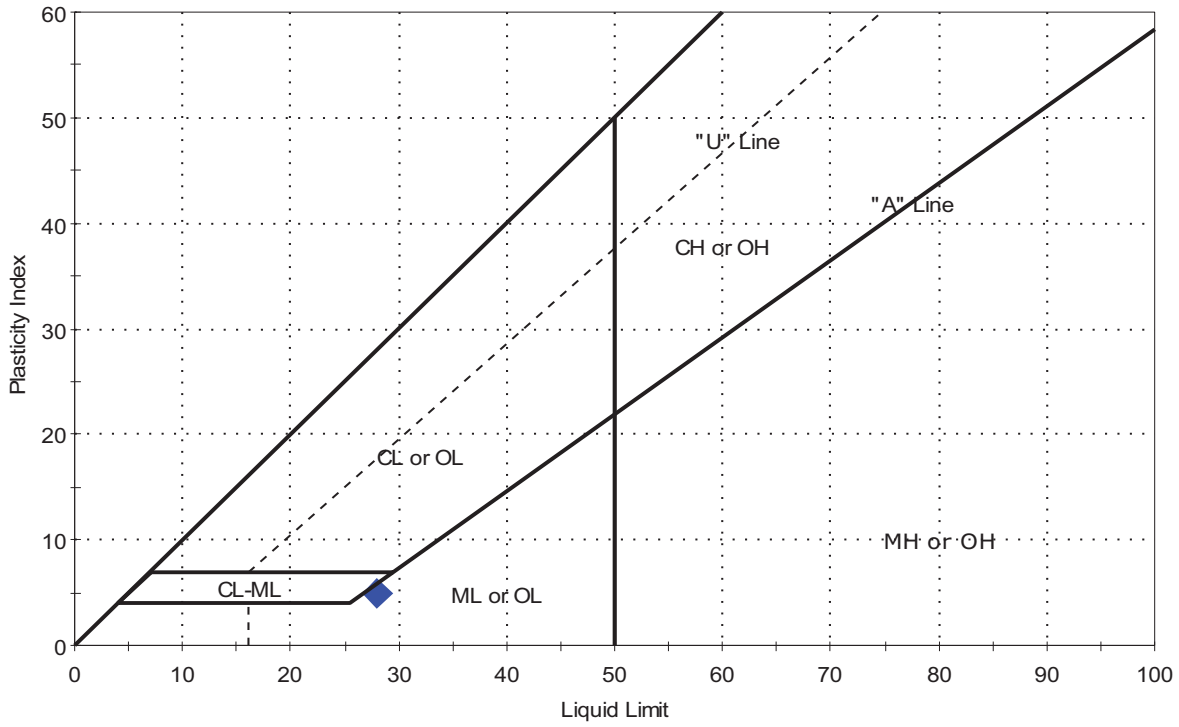
Dry Strength: HIGH

Dilatancy: SLOW

Toughness: MEDIUM

Client:	Langan Engineering				
Project:	45 Broad St				
Location:	New York, NY			Project No:	GTX-304342
Boring ID:	B-8	Sample Type:	jar	Tested By:	GA
Sample ID:	S-2	Test Date:	02/10/16	Checked By:	emm
Depth :	15-17 ft	Test Id:	363598		
Test Comment:	---				
Visual Description:	Wet, brown silt				
Sample Comment:	---				

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S-2	B-8	15-17 ft	33	28	23	5	2	

Sample Prepared using the WET method

Dry Strength: HIGH

Dilatancy: SLOW

Toughness: MEDIUM

Client:	Langan Engineering				
Project:	45 Broad St				
Location:	New York, NY			Project No:	GTX-304342
Boring ID:	B-8	Sample Type:	jar	Tested By:	GA
Sample ID:	S-6	Test Date:	02/10/16	Checked By:	emm
Depth :	23-25 ft	Test Id:	363599		
Test Comment:	---				
Visual Description:	Moist, brown silt				
Sample Comment:	---				

Atterberg Limits - ASTM D4318

Sample Determined to be non-plastic

Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S-6	B-8	23-25 ft	30	n/a	n/a	n/a	n/a	

Dry Strength: NONE

Dilatancy: RAPID

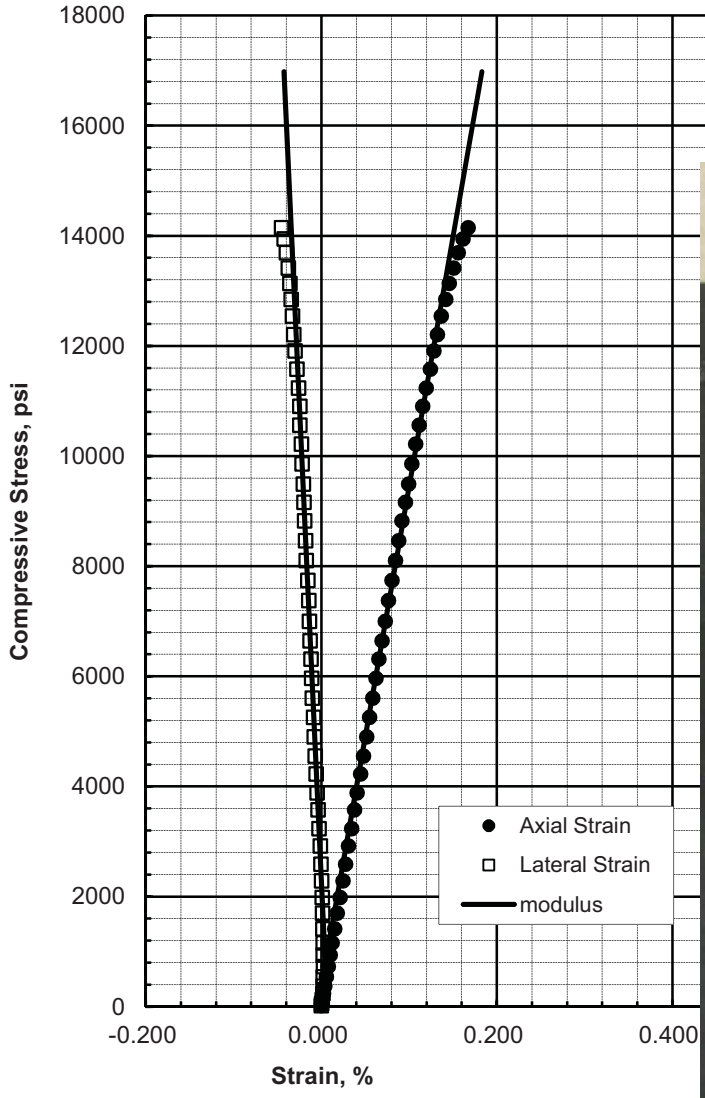
Toughness: n/a

The sample was determined to be Non-Plastic

Langan #170394201
45 Broad
SUMMARY OF ROCK TESTING

SAMPLE IDENTIFICATION			STATE PROPERTIES			ENGINEERING PROPERTY TESTS								REMARKS
Boring	Run	Depth	WATER CONTENT (1)	TOTAL UNIT WGT.	DRY UNIT WGT.	TEST TYPE (2)	ORIENTATION	Brazilian (ASTM D3967)	UNCONFINED COMPRESSION TESTS (ASTM D7012)					
								SPLITTING TENSILE STRENGTH	COMPRESSIVE STRENGTH	AXIAL STRAIN @ FAILURE	ESTIMATED (5) ELASTIC MODULUS	ELASTIC MODULUS	POISSON'S RATIO	
			(%)	(pcf)	(pcf)		(3)	(psi)	(psi)	(%)	(psi)	(psi)	(-)	
B-7	C-1	45.1-45.5	0.1	180	179	UCmod			14220	0.17		9.1E+06	0.26	
B-7	C-2	50.1-50.2	0.1	182	182	A	A	2311						
B-7	C-2	50.2-50.6	0.1	181	181	UC			16810	0.18	1.01E+07			
B-7	C-2	50.6-50.7	0.0	177	177	B	B	1341						
B-8	C-1	48.3-48.7	0.6	178	177	UCmod			8420	0.14		6.5E+06	0.31	
B-8	C-2	50.4-50.5	0.2	180	180	A	A	1428						
B-8	C-2	50.5-50.9	0.2	178	177	UC			14220	0.20	7.82E+06			
B-8	C-2	50.9-51.0	0.1	173	173	B	B	1510						

Notes: (1) Water contents determined after trimming and shearing.
(2) Test Type Abbreviations: UC: UC Compression test with estimated elastic moduli determination; Ucmod: UC compression test with direct elastic moduli determination
(3) Diametral orientation across core along bedding plane, axial perpendicular to bedding plane.
(5) Modulus estimated based on corrected gross deformations.



FAILURE PHOTO

Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.08	180	179	4.745	1.974

Specimen meets ASTM D4543 shape tolerances

Test Summary

Strain Rate (%/min)	Strain to Peak (%)	q_u (psi)	Elastic Modulus (psi)	Poisson's Ratio
0.11	0.17	14220	9.09E+06	0.26

Tested by: GT Test Date: Apr-16-16

Langan **Project # 170394201**	**45 Broad**	**COMPRESSIVE STRESS VS STRAIN** **UNCONFINED COMPRESSIVE STRENGTH AND** **AND ELASTIC MODULUS TEST** **Boring: B-7 Sample: C-1** **Depth 45.1-45.5 ft.**
TerraSense, LLC **Project # 7920-616**		

SPLITTING TENSILE (Brazilian) TEST

ASTM D 3967

Project Number: 7920-616 **Test by:** MHC **Sta:** B-7

Project Name: 45 Broad **Test Date:** 4/19/16 **Run:** C-2

SPECIMEN READINGS

	Test A	Test B
Test Number:	A	B
Depth:	50.1-50.2	50.6-50.7
Specimen mass(gm):	146.39	148.80

	Test A Thickness (inch)	Test A Diameter (inch)	Test B Thickness (inch)	Test B Diameter (inch)
	1.003	1.976	1.035	1.979
	0.994	1.975	1.042	1.978
	1.003	1.977	1.046	1.981
Average	1.000	1.976	1.041	1.979

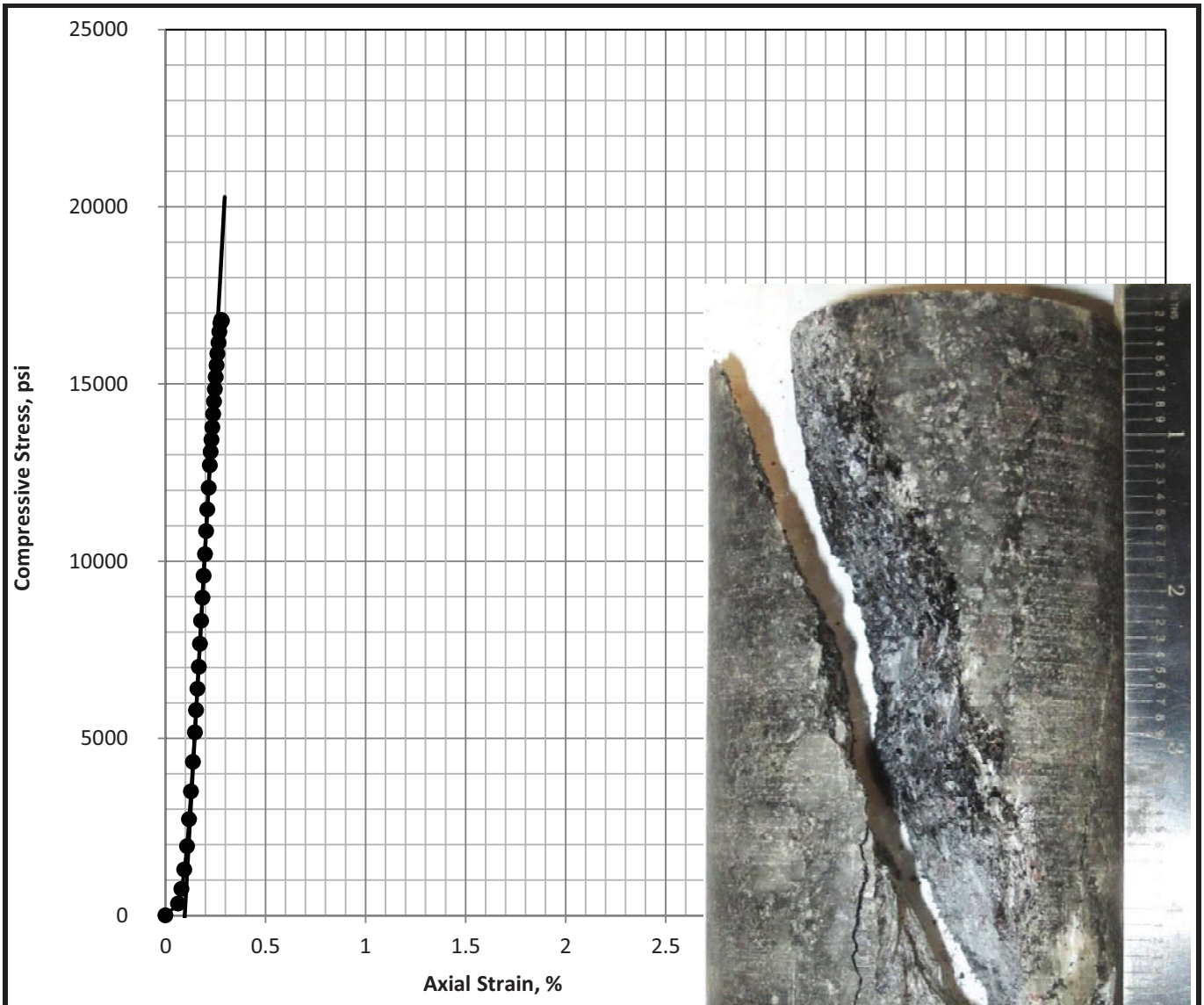
	Test A	Test B
Thickness / Diameter, (t/d):	0.51	0.53
t/D ratio between 0.2 and 0.75	yes	yes
Data Acquisition File	BR-B7-C2-A	BR-B7-C2-B
Maximum Load	7169 lb	4338 lb

A B

Failure Photo

	After Test A	After Test B
Container No.:	144A	930
Initial Mass + cont. (g):	356.94	363.23
Dry Mass + cont. (g):	356.85	363.16
Mass of cont. (g):	210.58	214.51
Water content (%):	**0.06**	**0.05**
Total unit weight (pcf):	181.95	177.12
Dry unit weight (pcf):	181.84	177.04
Splitting Tensile Strength (psi)	2310.64	1341.16

Langan	170394201	**45 Broad**	**DATA SHEET SPLITTING TENSILE STRENGTH TEST Sta: B-7 Run: C-2 Depth: 50.1-50.7 ft.**
TerraSense, LLC	7920-616		



FAILURE PHOTO

Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.05	181	181	4.873	1.977

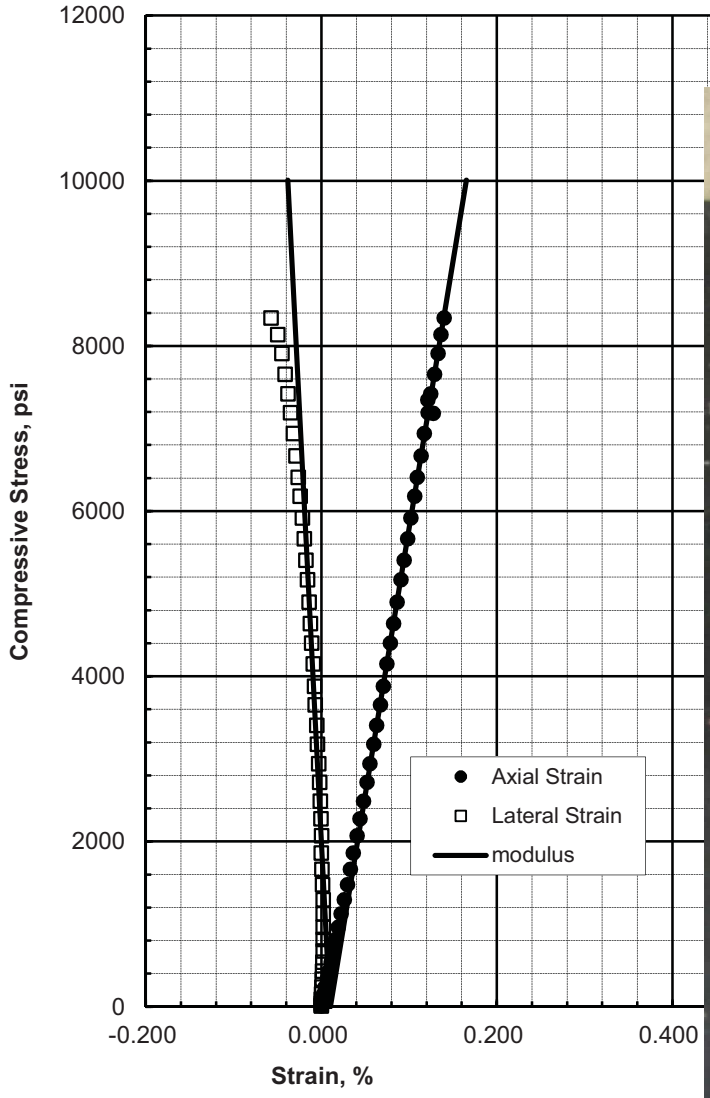
Specimen meets ASTM D4543 shape tolerances

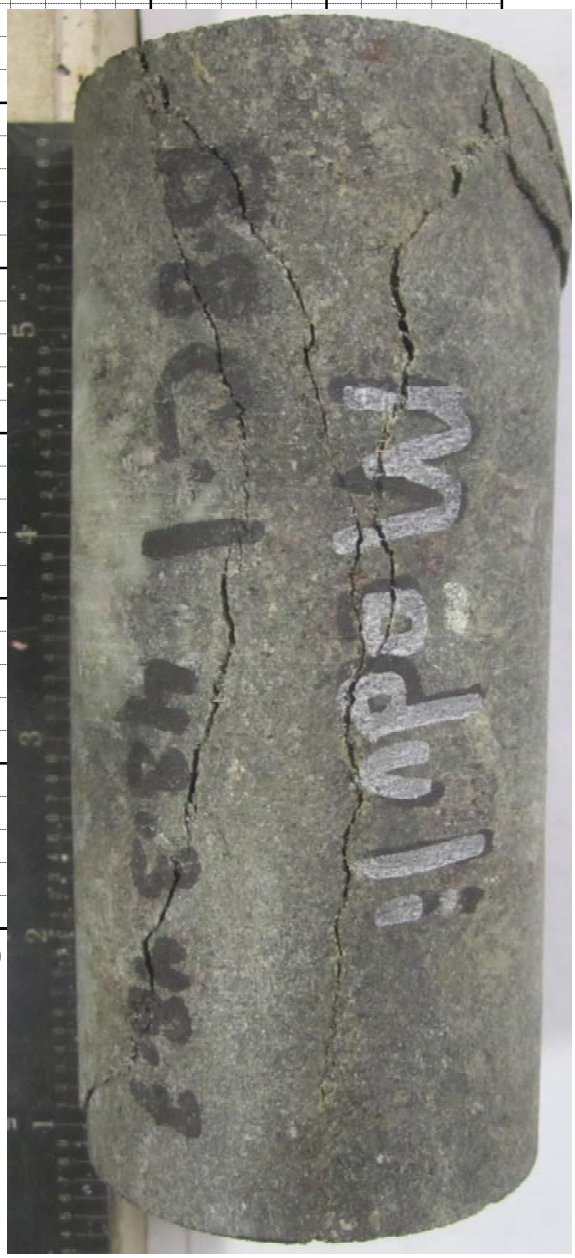
Test Summary

Strain Rate (%/min)	Corrected Strain to Peak (%)	q_u (psi)	Estimated (shown) Elastic Modulus (psi)
0.08	0.18	16810	1.01E+07

Test by: MHC
Test Date: Apr-19-16
Reviewed by: GET

Langan **Project # 170394201**	**45 Broad**	**COMPRESSIVE STRESS VS STRAIN** **UNCONFINED COMPRESSIVE STRENGTH TEST**
TerraSense, LLC **Project # 7920-616**		**Boring: B-7 Sample: C-2** **Depth 50.2-50.6 ft.**





FAILURE PHOTO

Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.58	178	177	4.834	1.976

Specimen meets ASTM D4543 shape tolerances

Test Summary

Strain Rate (%/min)	Strain to Peak (%)	q_u (psi)	Elastic Modulus (psi)	Poisson's Ratio
0.15	0.14	8420	6.47E+06	0.31

Tested by: GT Test Date: Apr-16-16

Langan **Project # 170394201**	**45 Broad**	**COMPRESSIVE STRESS VS STRAIN** **UNCONFINED COMPRESSIVE STRENGTH AND** **AND ELASTIC MODULUS TEST** **Boring: B-8 Sample: C-1** **Depth 48.3-48.7 ft.**
TerraSense, LLC **Project # 7920-616**		

SPLITTING TENSILE (Brazilian) TEST

ASTM D 3967

Project Number: 7920-616 **Test by:** MHC **Sta:** B-8

Project Name: 45 Broad **Test Date:** 4/19/16 **Run:** C-2

SPECIMEN READINGS

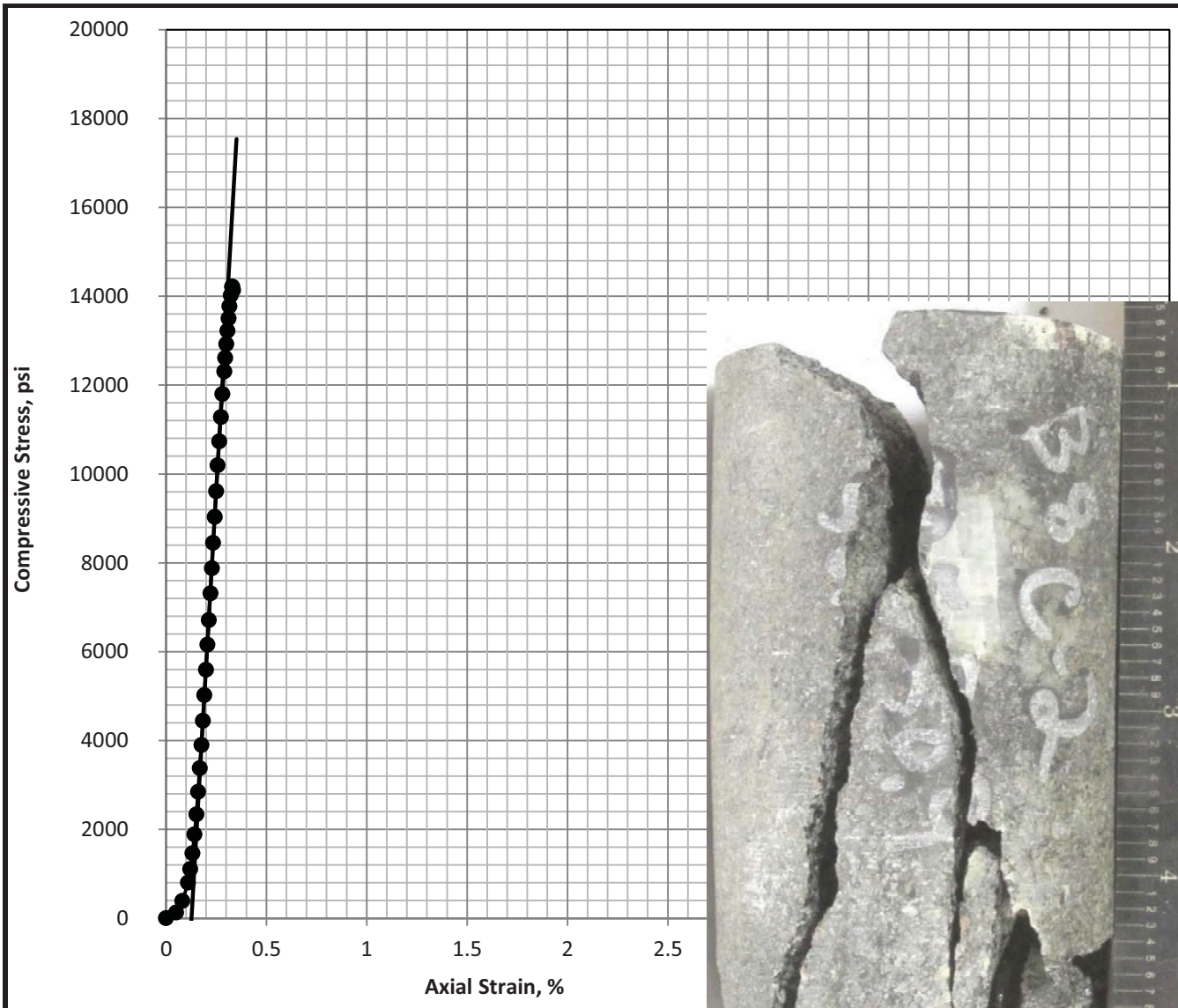
	A	B
Test Number:	A	B
Depth:	50.4-50.5	50.9-51.0
Specimen mass(gm):	153.00	144.35

	A Thickness (inch)	A Diameter (inch)	B Thickness (inch)	B Diameter (inch)
	1.050	1.980	1.042	1.985
	1.049	1.980	1.025	1.978
	1.054	1.979	1.030	1.975
Average	1.051	1.979	1.032	1.979
Thickness / Diameter, (t/d):		0.53		0.52
t/D ratio between 0.2 and 0.75		yes		yes
Data Acquisition File	BR-B8-C2-A		BR-B8-C2-B	
Maximum Load	4666 lb		4844 lb	
	After Test		**After Test**	
Container No.:	118		482	
Initial Mass + cont. (g):	363.99		357.05	
Dry Mass + cont. (g):	363.71		356.84	
Mass of cont. (g):	211.04		212.77	
Water content (%):	**0.18**		**0.15**	
Total unit weight (pcf):	180.27		173.24	
Dry unit weight (pcf):	179.94		172.99	
Splitting Tensile Strength (psi)	1428.14		1509.94	

A B

Failure Photo

Langan	170394201	**45 Broad**	**DATA SHEET** **SPLITTING TENSILE STRENGTH TEST**
TerraSense, LLC	7920-616		**Sta: B-8** **Run: C-2 Depth: 50.4-51.0 ft.**



Specimen Information

Water Content (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Length (inch)	Diameter (inch)
0.17	178	177	4.747	1.980

Specimen meets ASTM D4543 shape tolerances

FAILURE PHOTO

Test Summary

Strain Rate (%/min)	Corrected Strain to Peak (%)	q_u (psi)	Estimated (shown) Elastic Modulus (psi)
0.09	0.20	14220	7.82E+06

Test by: MHC
Test Date: Apr-19-16
Reviewed by: GET

Langan **Project # 170394201**	**45 Broad**	**COMPRESSIVE STRESS VS STRAIN** **UNCONFINED COMPRESSIVE STRENGTH TEST**
TerraSense, LLC **Project # 7920-616**		**Boring: B-8 Sample: C-2** **Depth 50.5-50.9 ft.**

APPENDIX D
Test Pit Log and Photographs (Langan 2016)

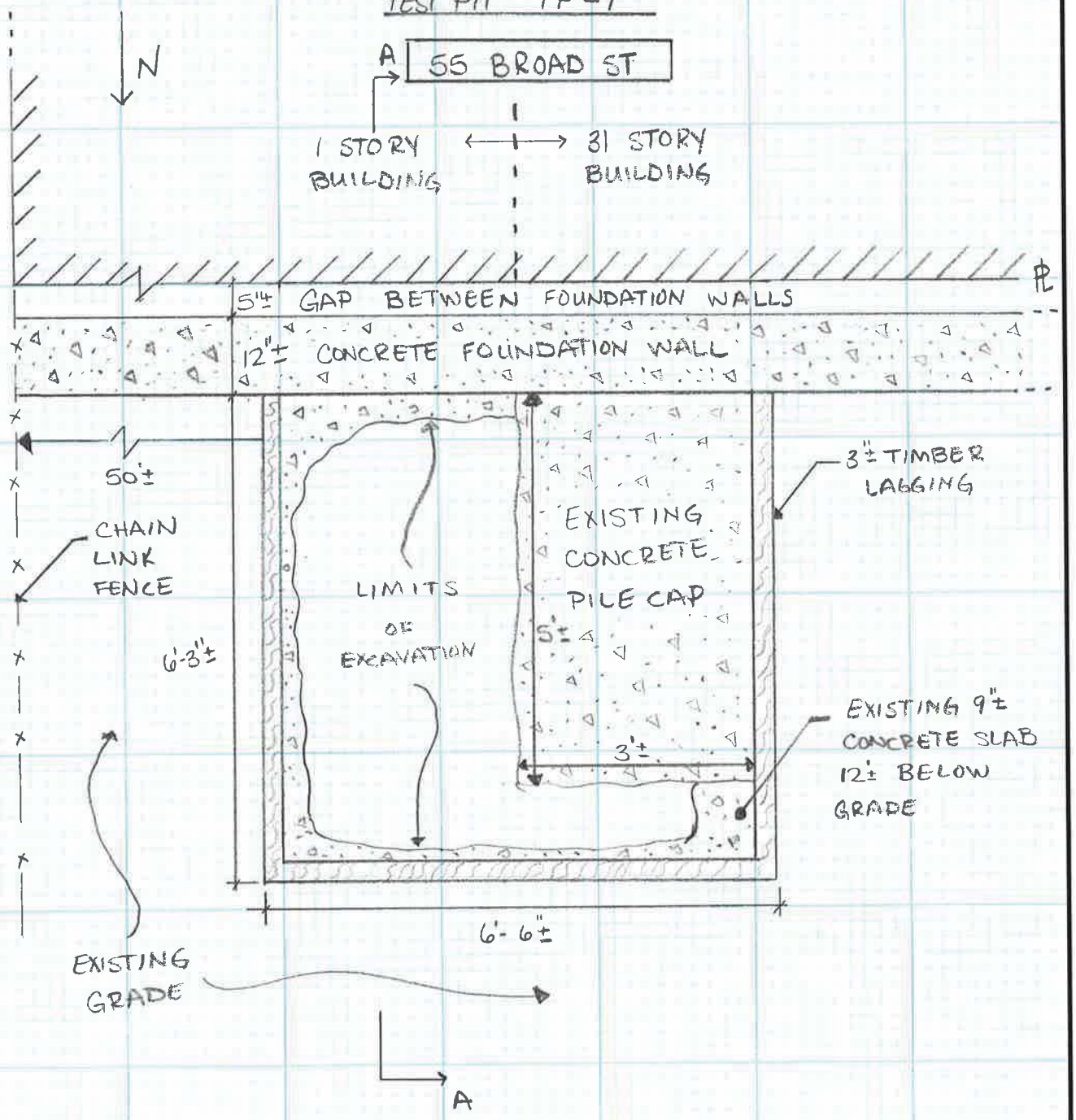
Test Pit TP-1

Test pit TP-1 was excavated along the south property line of the site to investigate the foundation properties of the adjacent building, 55 Broad Street. The excavation was 6 feet wide by 6 feet long by 23 feet deep. Existing grade is about el. 11.5.

The remaining portion of the 12-inch-thick foundation wall was encountered at the existing grade and extended to about 12 feet below the existing grade, corresponding to about el. -0.5. The foundation wall rested on a 9-inch-thick concrete slab with rebar. A 5-inch-wide gap separated the remaining foundation wall and the adjacent building. The test pit exposed the adjacent building's foundation wall and pile cap. The concrete foundation wall extended to about 16 feet below the existing grade, corresponding to about el. -4.5. Two feet of timber was encountered below the foundation wall, followed by an about 5-foot-thick pile cap. The bottom of the pile cap was encountered at about 23 feet below the existing grade, corresponding to about el. -11.5.

Demolition debris (brick, concrete, building material, etc.) mixed with brown coarse to fine sand was encountered in the first 12 feet of the test pit, above the existing basement slab. Gray-brown clayey silt was encountered beneath the concrete slab and extended throughout the explored depth of the test pit. Groundwater was encountered at about 18 feet below existing grade in TP-1 (about el. -6.5). The test pit was backfilled with the excavated material upon completion.

TEST PIT TP-1

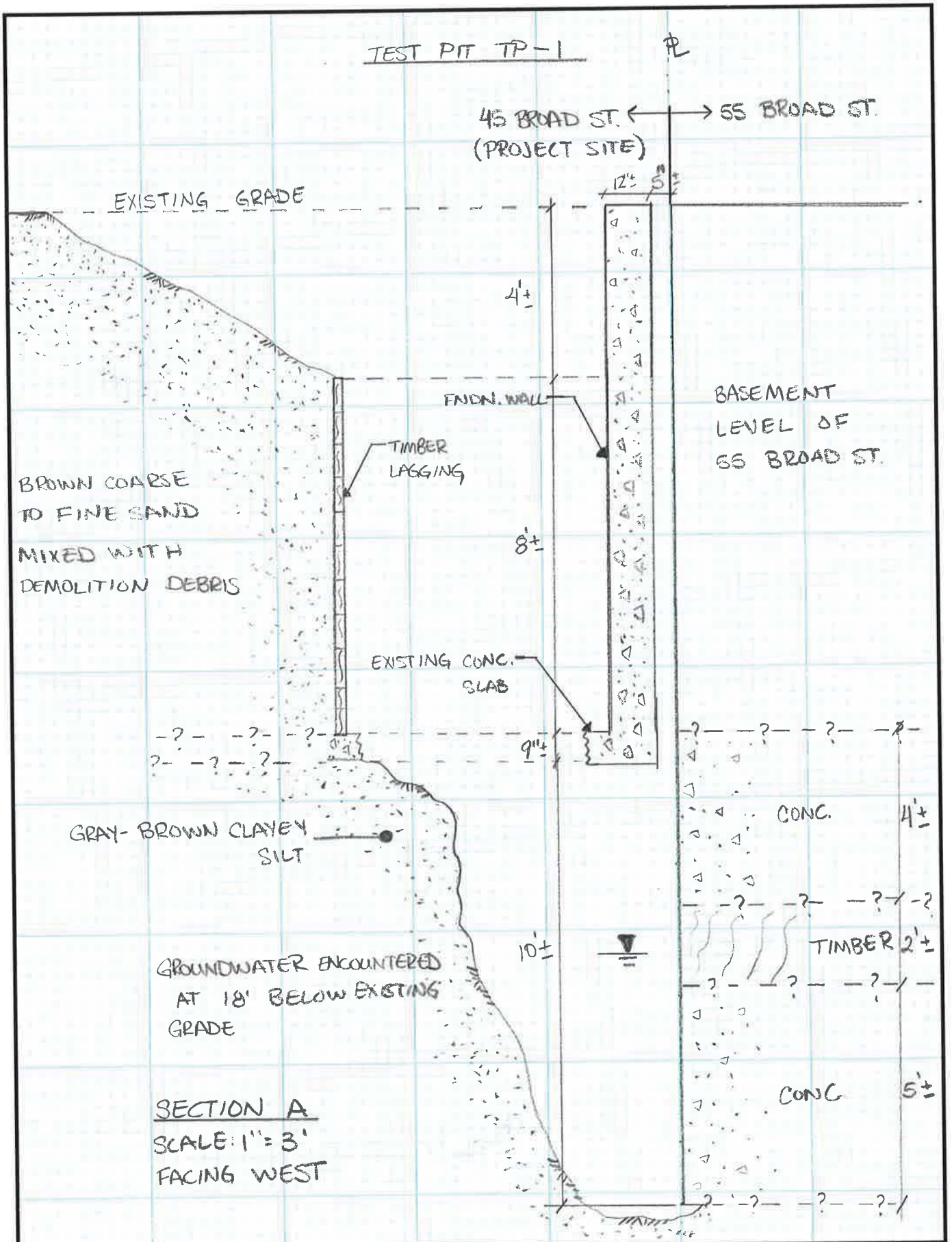


PLAN VIEW

SCALE: 1" = 2'

45 Broad Street, Manhattan, NY Test Pit, TP-1	BY MLM DATE 2/22/16 CKD. ____ DATE ____	PROJ. NO. 170394201 SHEET 1 OF 2

LANGAN



45 Broad Street, Manhattan, NY Test Pit TP-1 (cont.)	BY MLM DATE 2/22/16 CKD. ____ DATE ____	PROJ. NO. 170394201 SHEET 2 OF 2

LANGAN

Photo 001: General view of the existing foundation wall, facing southwest.

Photo 002: General view of the demolition debris excavated from the test pit, facing northeast.

Photo 003: General view of the basement slab encountered at 12 feet below the ground surface, facing south.

Photo 004: General view of the test pit showing rebar found underneath the 9-inch-thick concrete slab, facing southwest.

Photo 005: General view of the test pit showing the pile cap encountered, facing south.

Photo 006: General view of the test pit showing the foundation wall extending to 23 feet below the ground surface, facing south.

APPENDIX E
Cone Penetration Tests (CPTs) Report

CRAIG
GEOTECHNICAL DRILLING CO., INC.

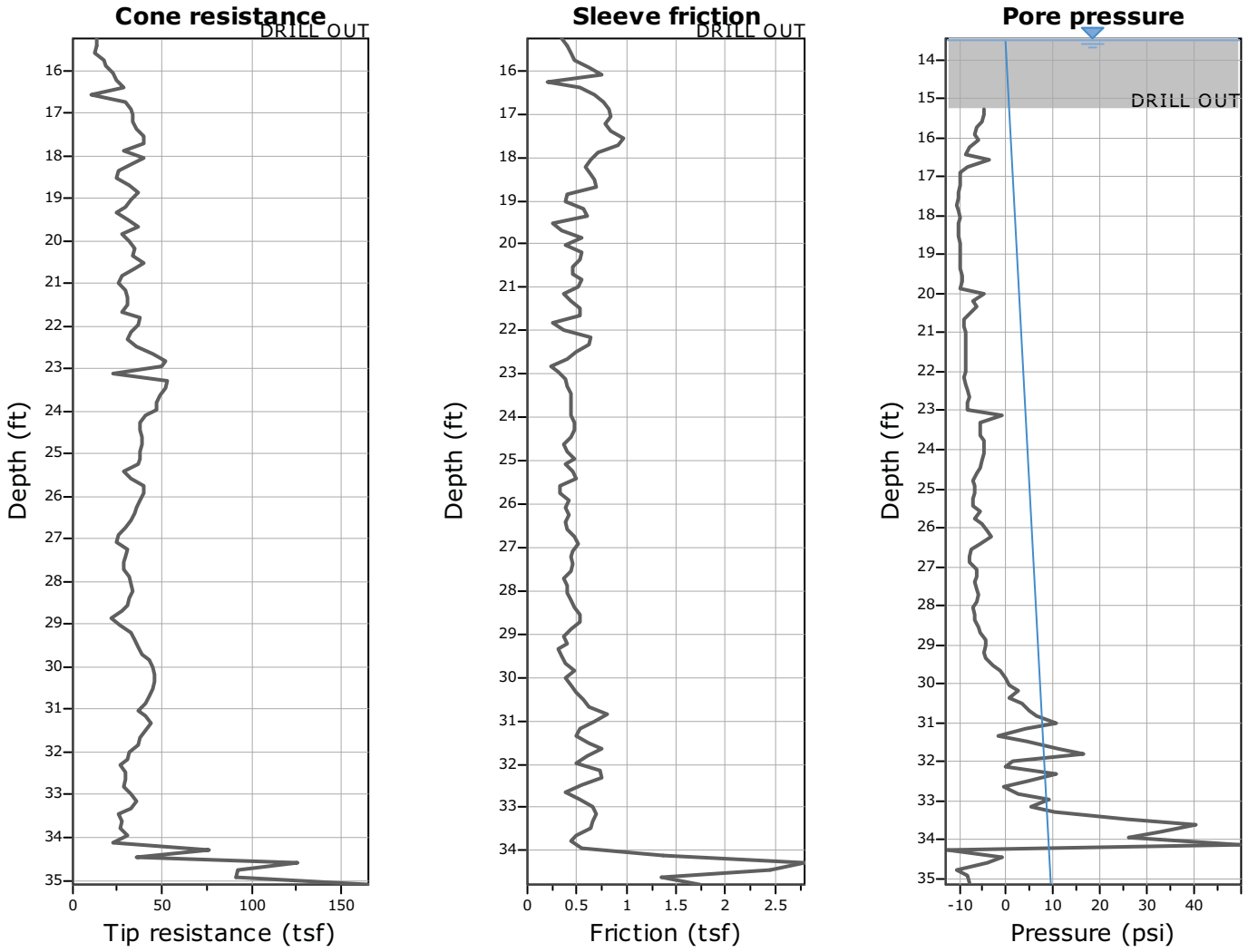
2/8/16 **Job#: 165015** Client: Langan Engineeri Location: 45 Broad Street, Manhattan NY

Date	CPT Sounding	Depth	Seicmic Tests	Comments
2/1/16	CPT-1	35.1	7	Pre-Drill 15ft.
2/1/16	CPT-2	38.22	8	Pre-Drill 15ft.

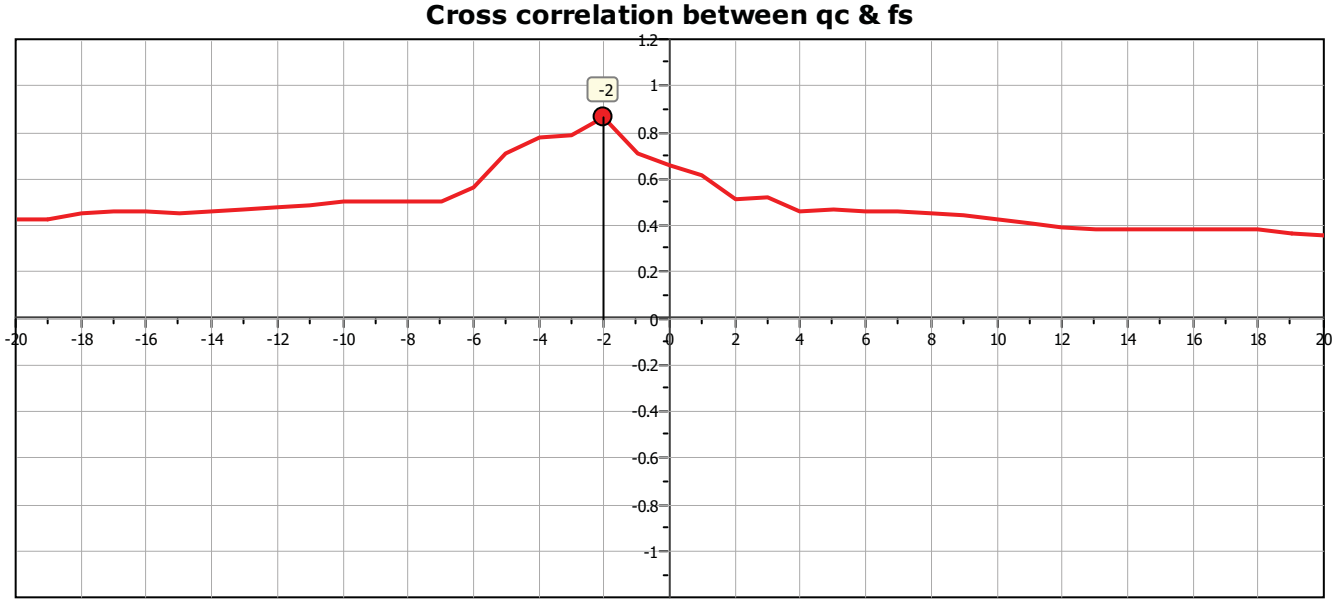
5435 Harding Hwy, Mays Landing, NJ, 08330
Tel: (609)625-4862 Fax: (609)625-4306 E-Mail:kcraig@craigtest.com Web Site: craigtest.com

CPT: LanganBroad Street CPT-1
Total depth: 35.10 ft, Date: 2/8/2016
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project: **Langan**
Location: **45 Broad Street, Manhattan NY**



The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

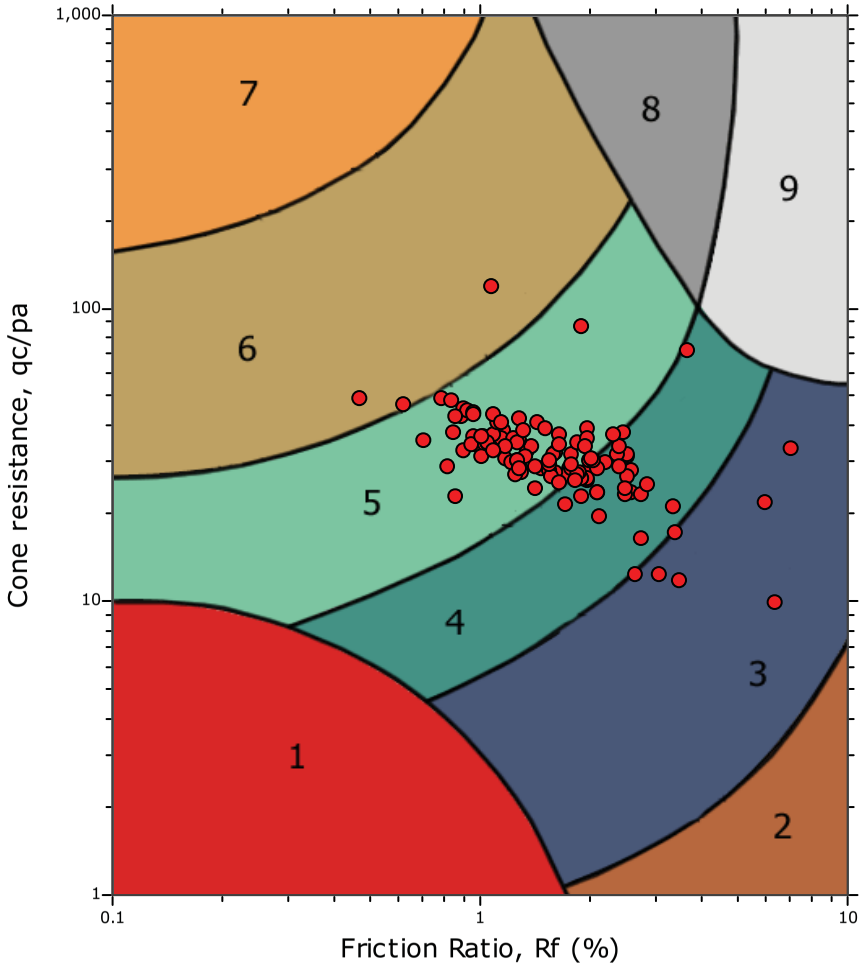


CPT: LanganBroad Street CPT-1
Total depth: 35.10 ft, Date: 2/8/2016
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

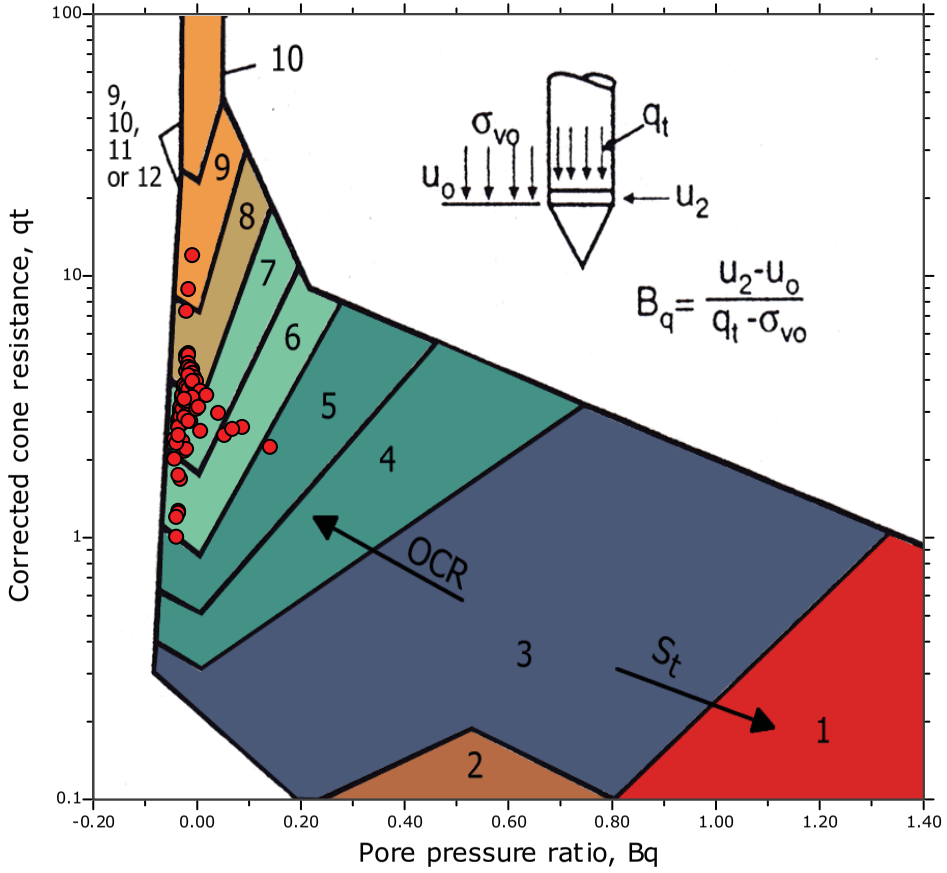
Project: Langan
Location: 45 Broad Street, Manhattan NY

SBT - Bq plots

SBT plot



Bq plot

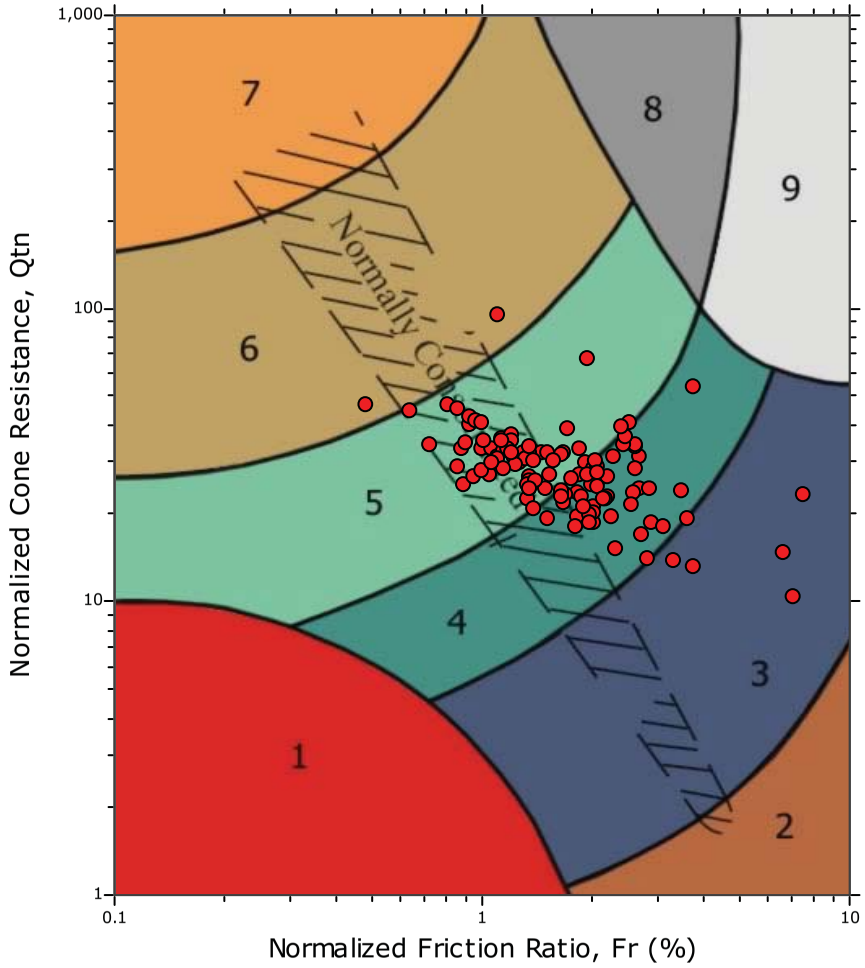


SBT legend

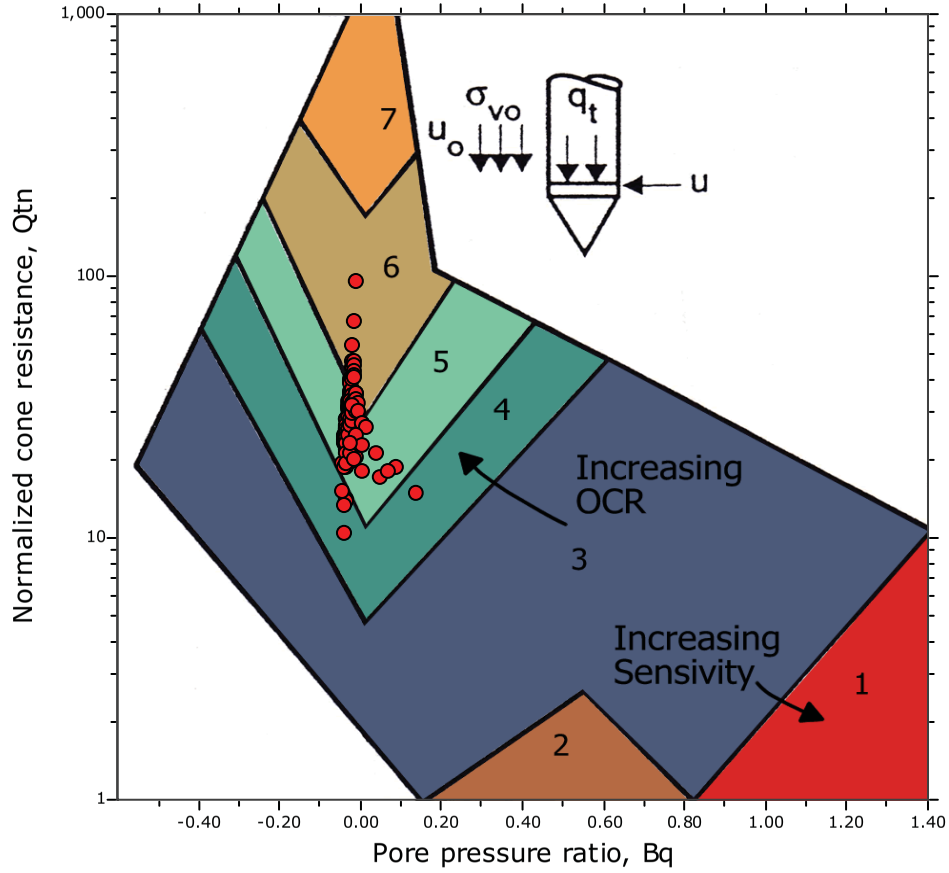
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

SBT - Bq plots (normalized)

SBTn plot



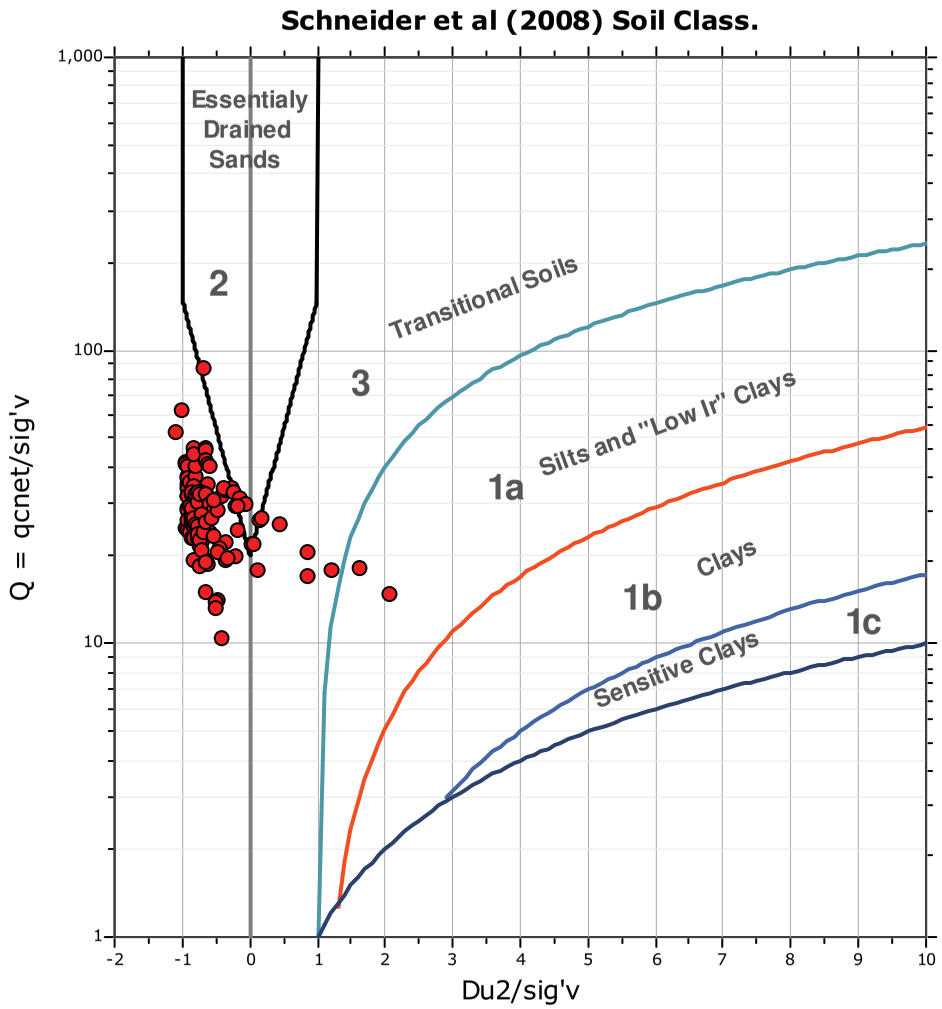
Normalized Bq plot

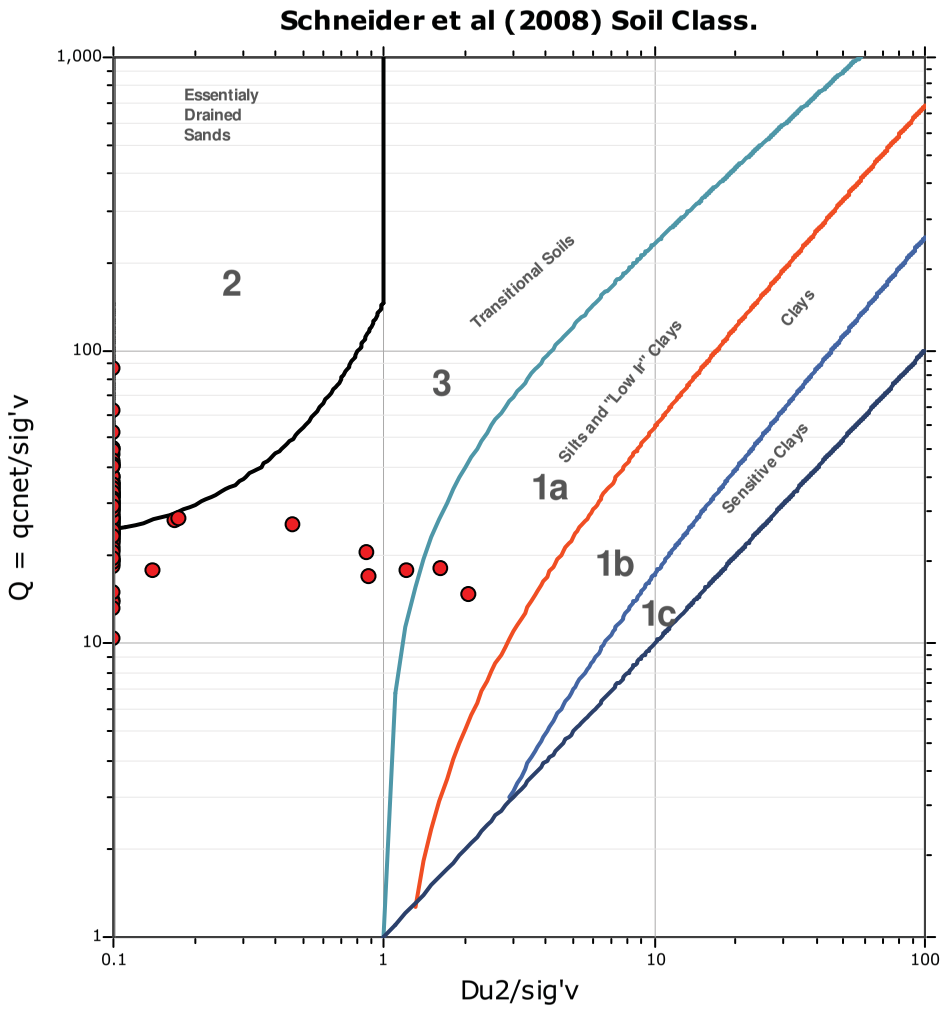


SBTn legend

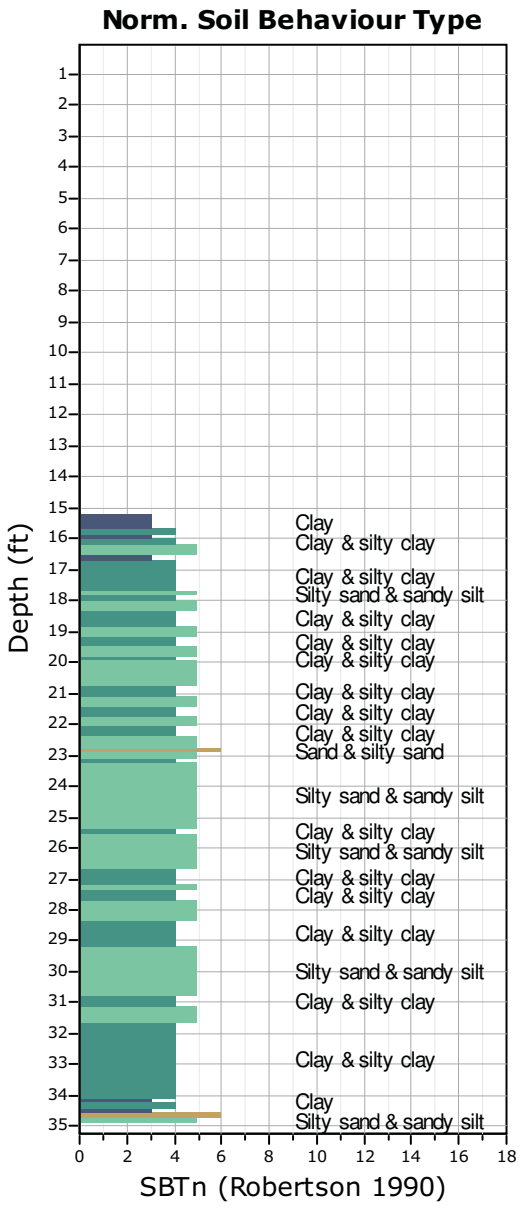
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

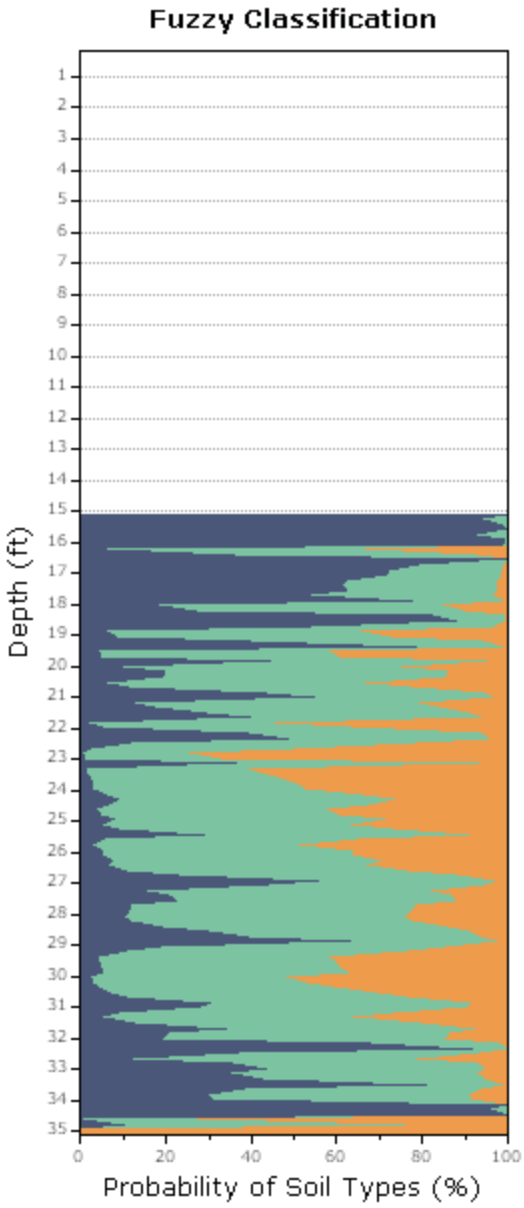
Bq plots (Schneider)





Project: **Langan**
Location: **45 Broad Street, Manhattan NY**

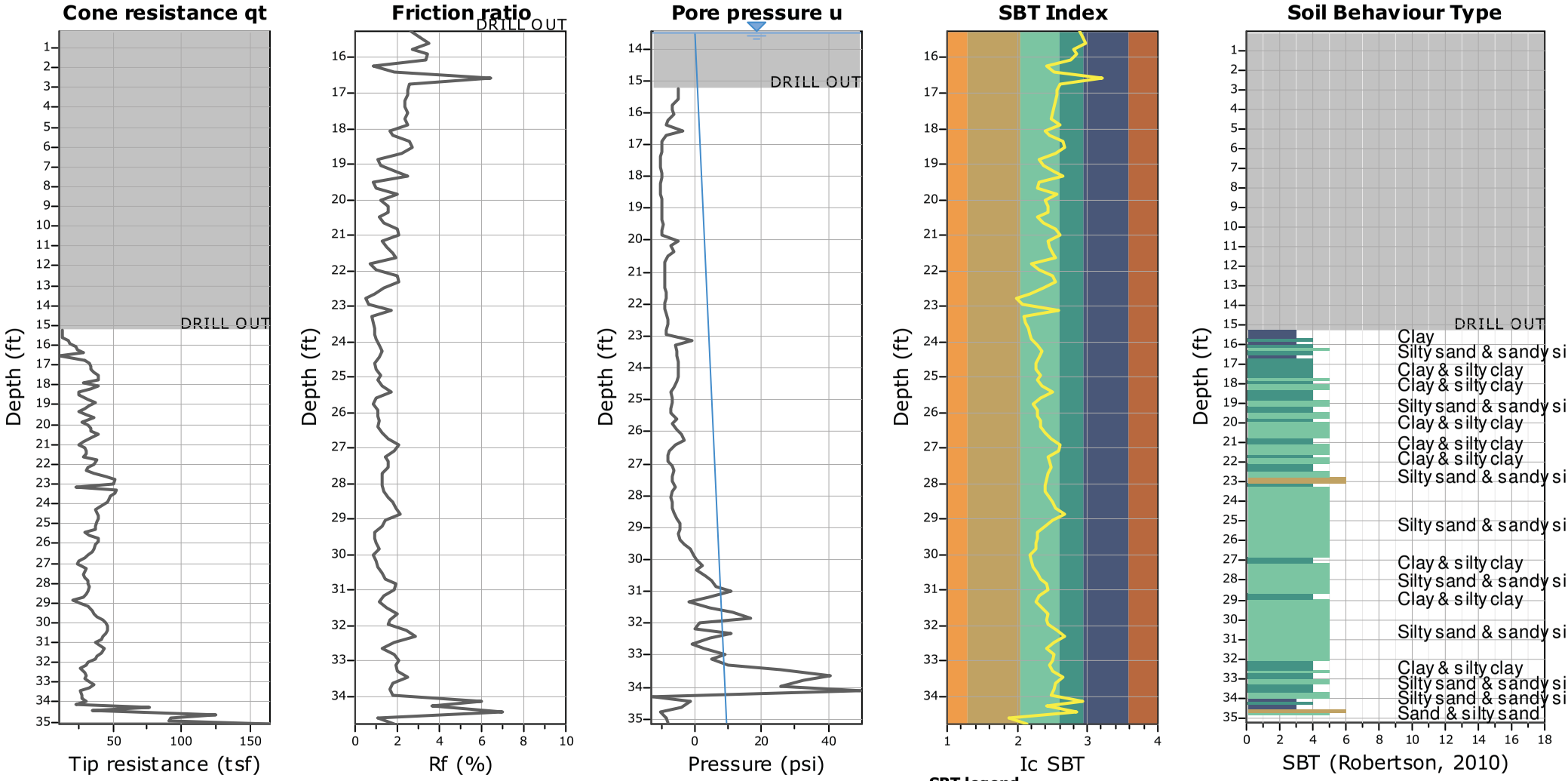




CRAIG
GEOTECHNICAL DRILLING CO., INC.

Project: Langan
Location: 45 Broad Street, Manhattan NY

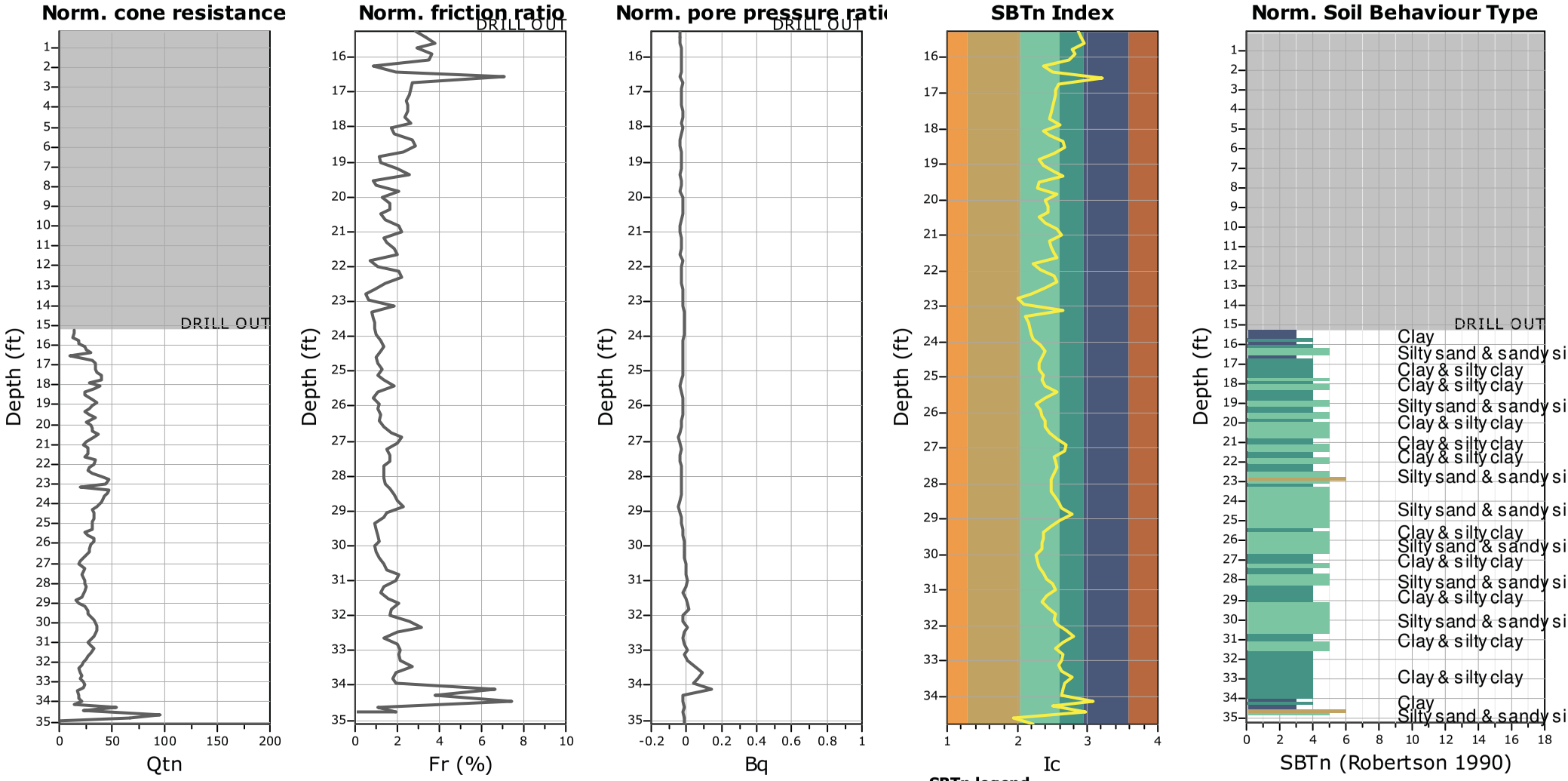
CPT: LanganBroad Street CPT-1
Total depth: 35.10 ft, Date: 2/8/2016
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



CRAIG
GEOTECHNICAL DRILLING CO., INC.

Project: Langan
Location: 45 Broad Street, Manhattan NY

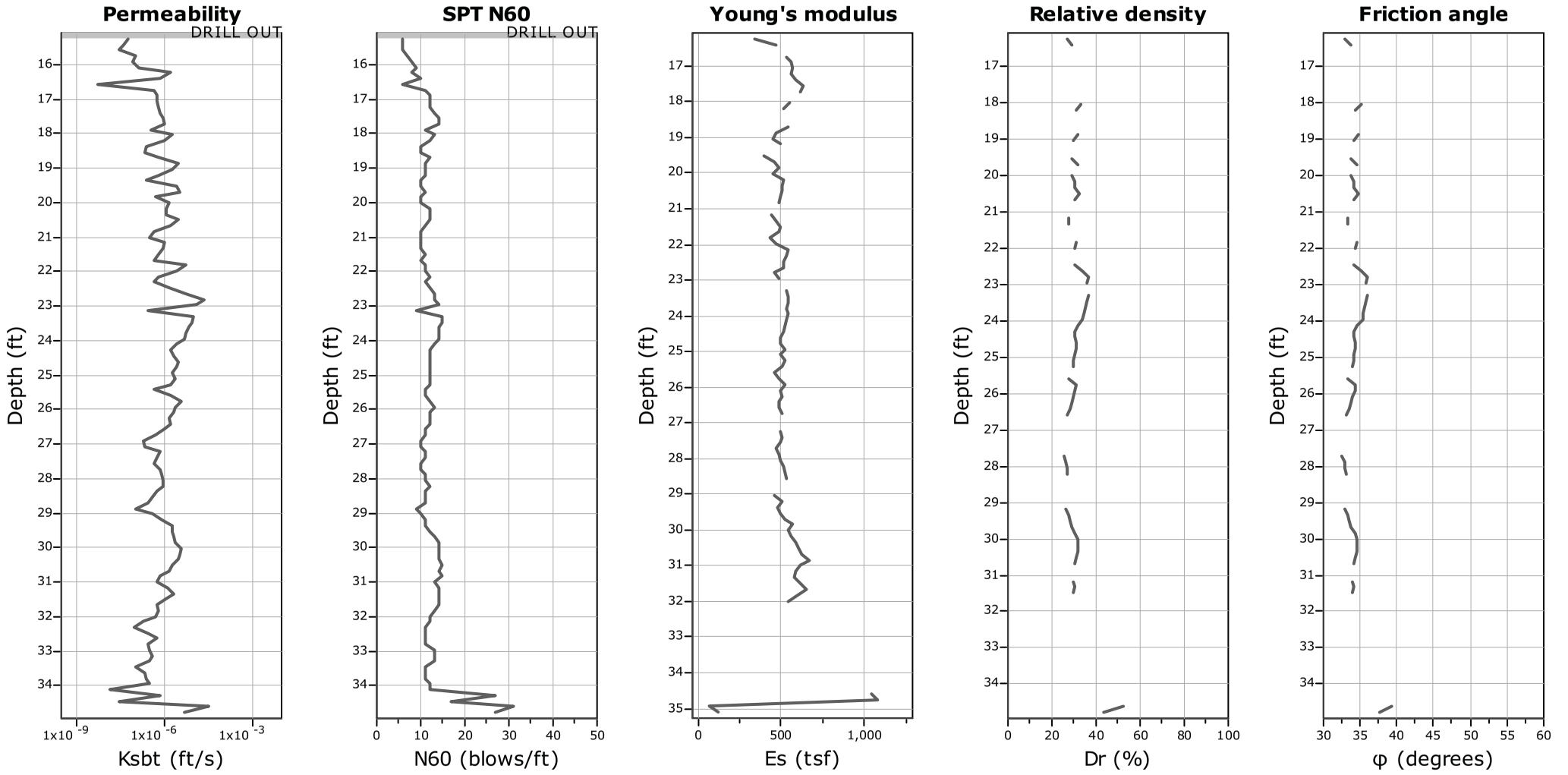
CPT: LanganBroad Street CPT-1
Total depth: 35.10 ft, Date: 2/8/2016
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



CRAIG
GEOTECHNICAL DRILLING CO., INC.

CPT: LanganBroad Street CPT-1
Total depth: 35.10 ft, Date: 2/8/2016
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project: **Langan**
Location: **45 Broad Street, Manhattan NY**



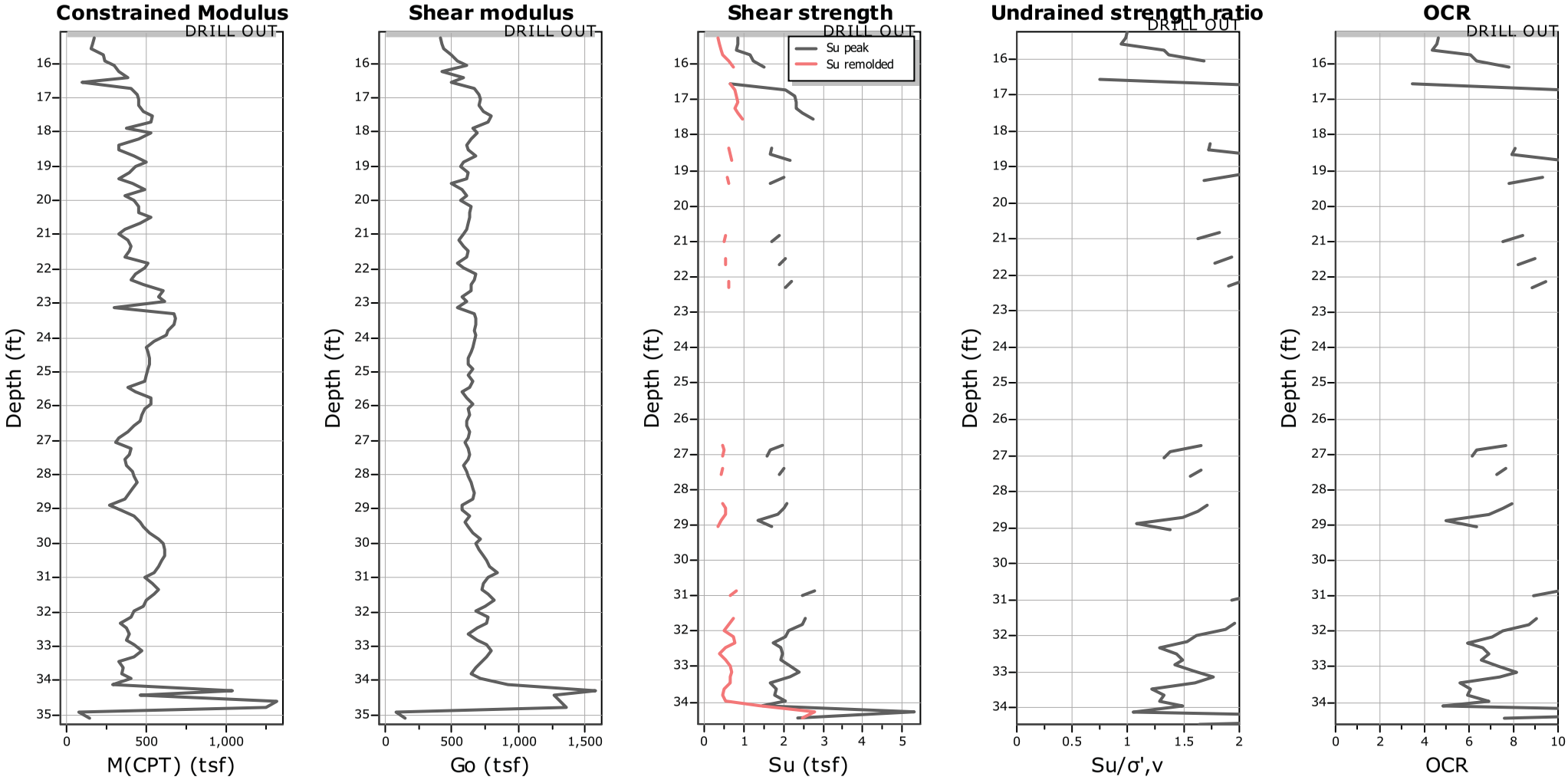
Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

CRAIG
GEOTECHNICAL DRILLING CO., INC.

CPT: LanganBroad Street CPT-1
Total depth: 35.10 ft, Date: 2/8/2016
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project: **Langan**
Location: **45 Broad Street, Manhattan NY**



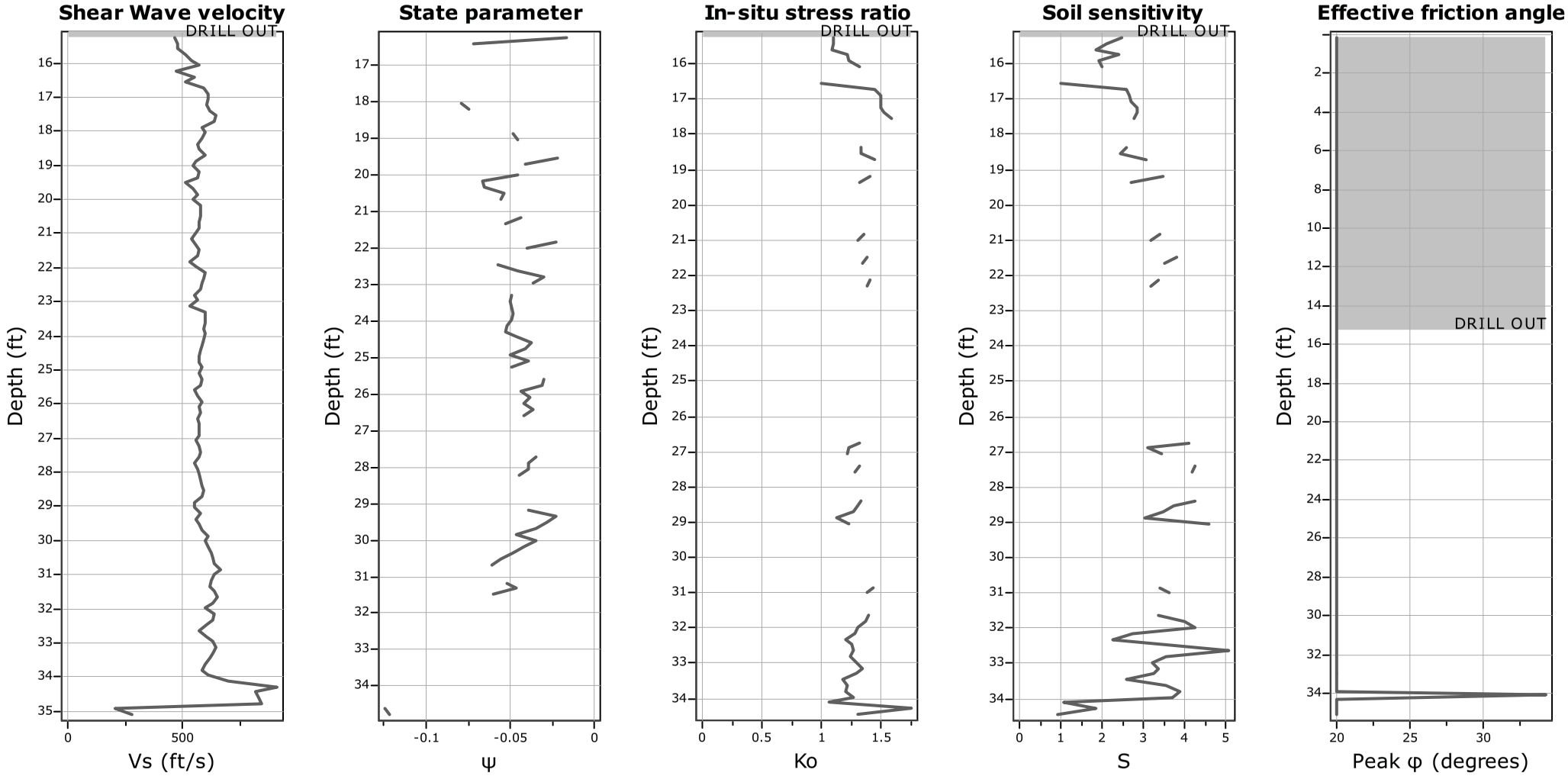
Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data

CRAIG
GEOTECHNICAL DRILLING CO., INC.

CPT: LanganBroad Street CPT-1
Total depth: 35.10 ft, Date: 2/8/2016
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project: **Langan**
Location: **45 Broad Street, Manhattan NY**

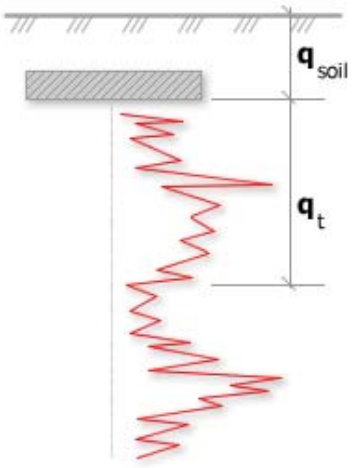


Calculation parameters

Soil Sensitivity factor, N_S: 7.00

User defined estimation data

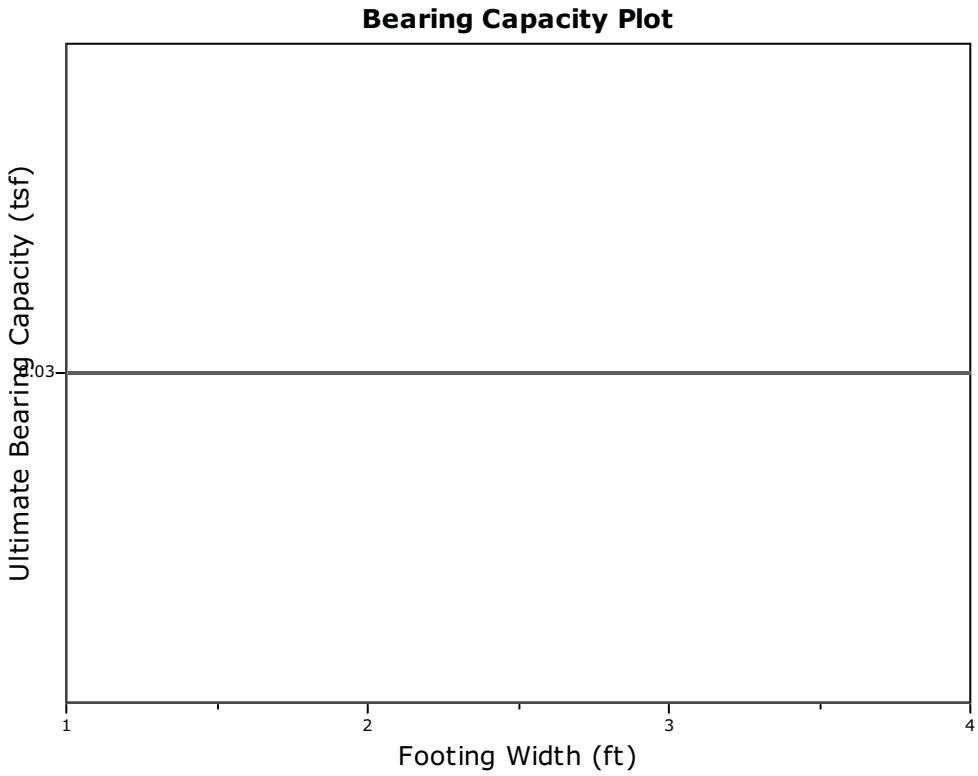
Project: **Langan**
Location: **45 Broad Street, Manhattan NY**



Bearing Capacity calculation is perfromed based on the formula:

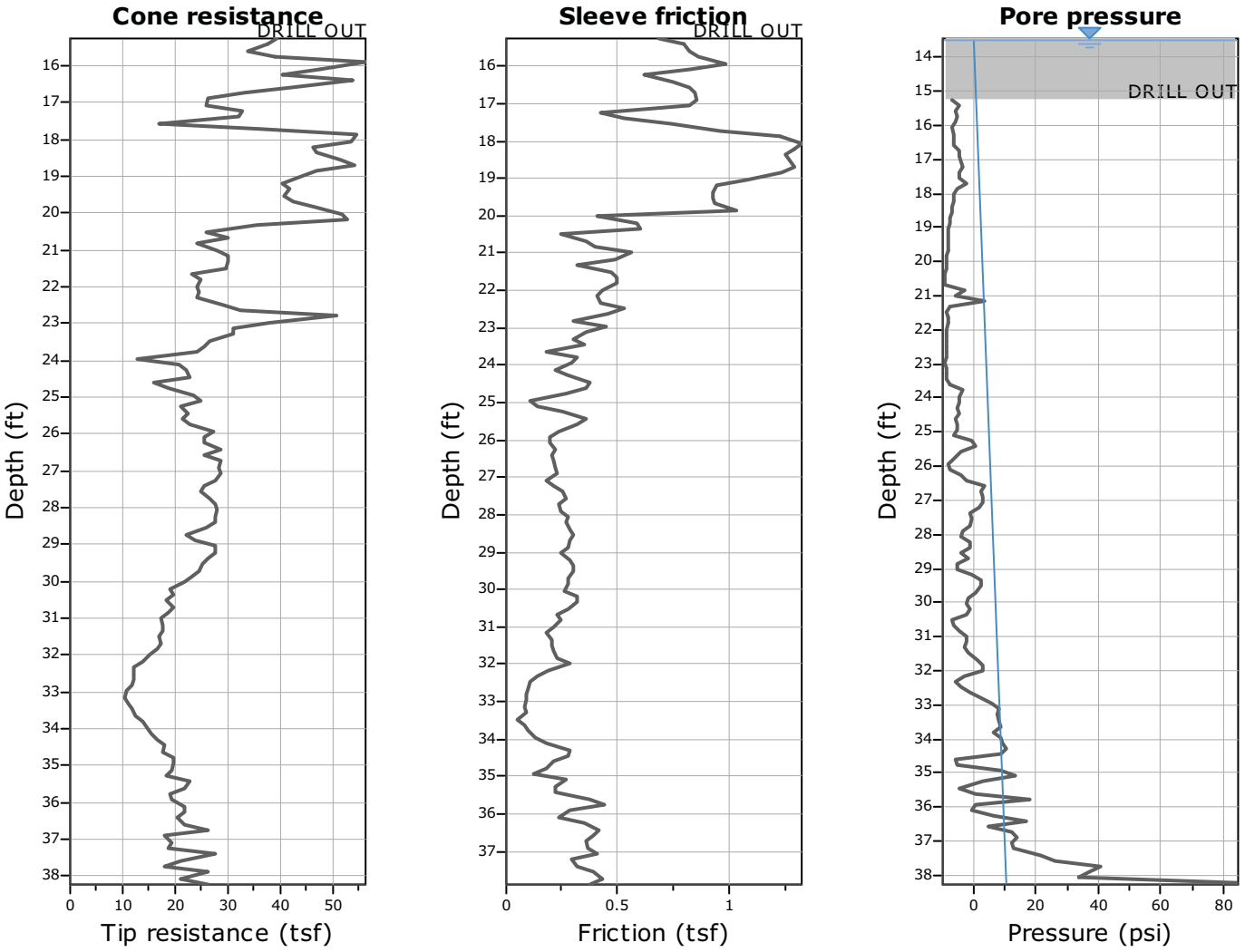
$$Q_{ult} = R_k \times q_t + q_{soil}$$

where:
R_k: Bearing capacity factor
q_t: Average corrected cone resistance over calculation depth
q_{soil}: Pressure applied by soil above footing

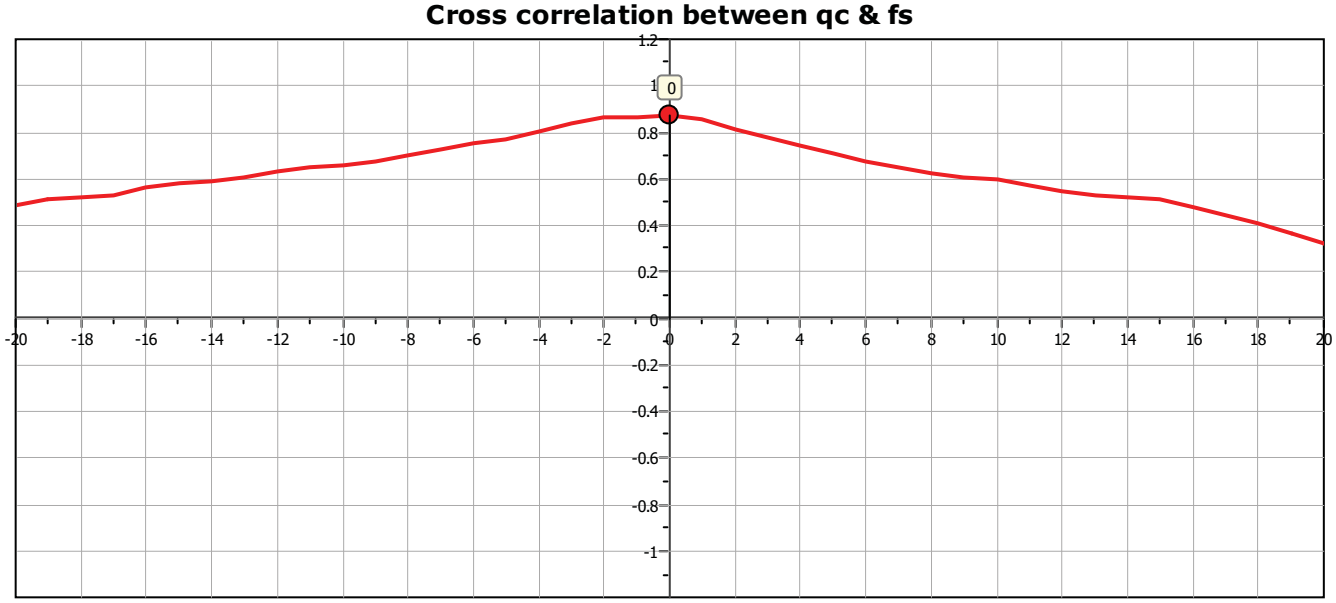


:: Tabular results ::

No	B (ft)	Start Depth (ft)	End Depth (ft)	Ave. q_t (tsf)	R_k	Soil Press. (tsf)	Ult. bearing cap. (tsf)
1	1.00	0.50	2.00	0.00	0.20	0.03	0.03
2	1.20	0.50	2.30	0.00	0.20	0.03	0.03
3	1.40	0.50	2.60	0.00	0.20	0.03	0.03
4	1.60	0.50	2.90	0.00	0.20	0.03	0.03
5	1.80	0.50	3.20	0.00	0.20	0.03	0.03
6	2.00	0.50	3.50	0.00	0.20	0.03	0.03
7	2.20	0.50	3.80	0.00	0.20	0.03	0.03
8	2.40	0.50	4.10	0.00	0.20	0.03	0.03
9	2.60	0.50	4.40	0.00	0.20	0.03	0.03
10	2.80	0.50	4.70	0.00	0.20	0.03	0.03
11	3.00	0.50	5.00	0.00	0.20	0.03	0.03
12	3.20	0.50	5.30	0.00	0.20	0.03	0.03
13	3.40	0.50	5.60	0.00	0.20	0.03	0.03
14	3.60	0.50	5.90	0.00	0.20	0.03	0.03
15	3.80	0.50	6.20	0.00	0.20	0.03	0.03
16	4.00	0.50	6.50	0.00	0.20	0.03	0.03

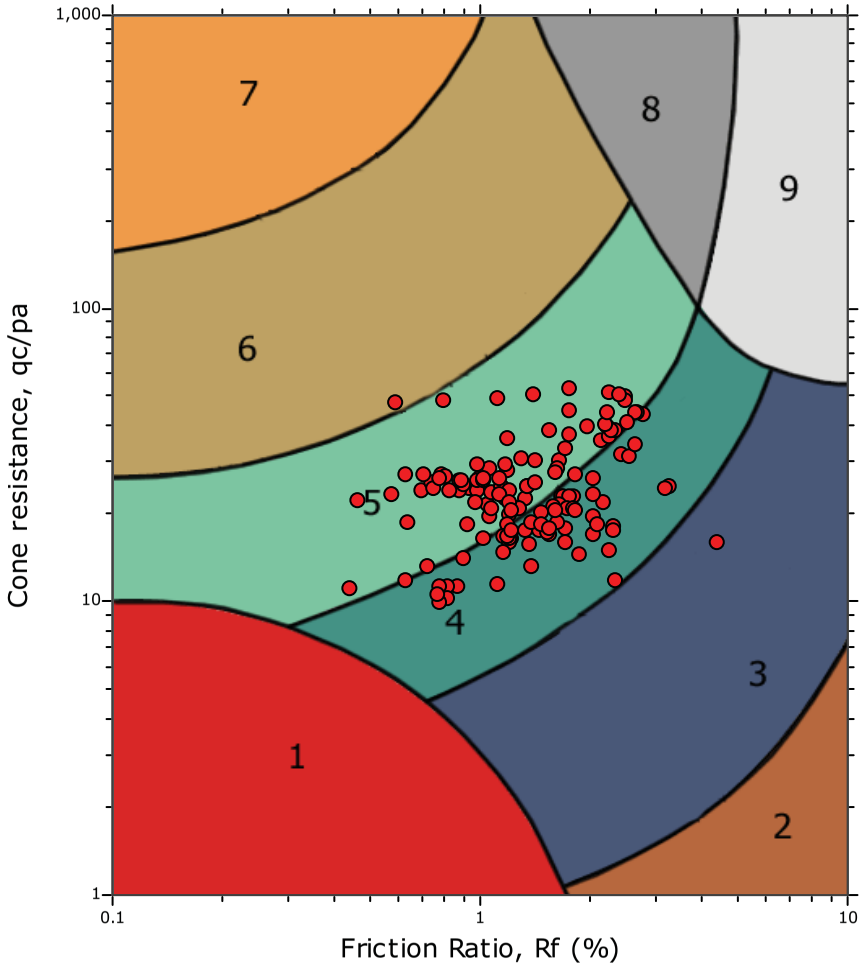


The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).

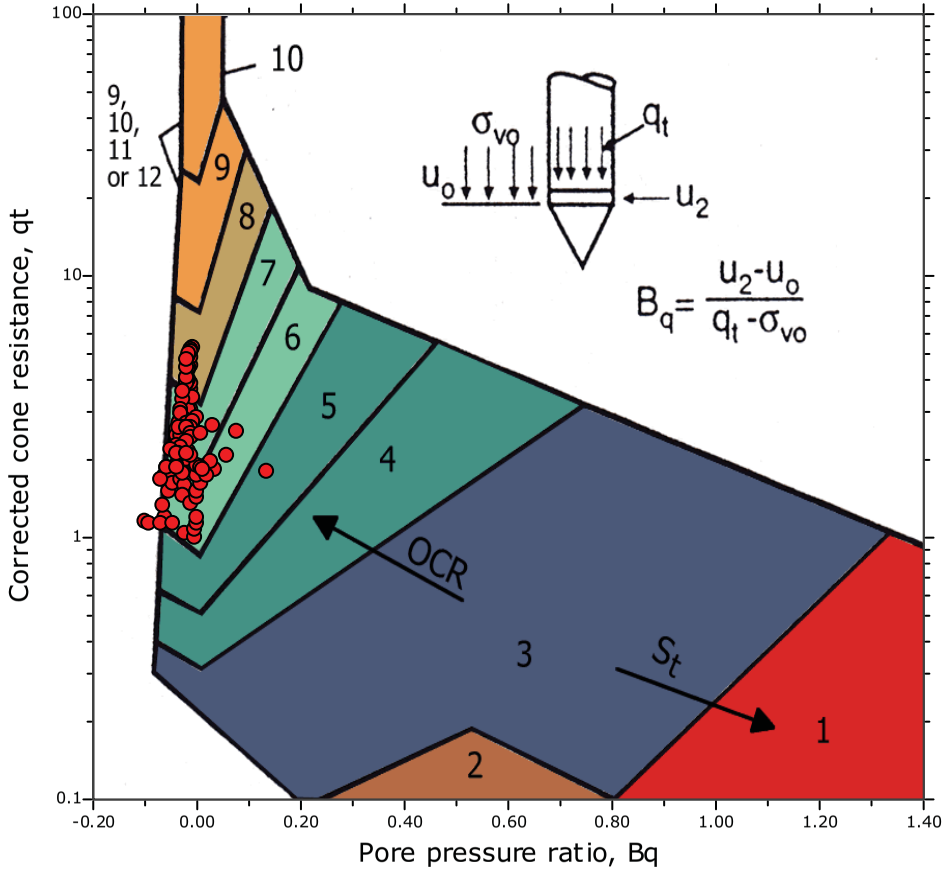


SBT - Bq plots

SBT plot



Bq plot

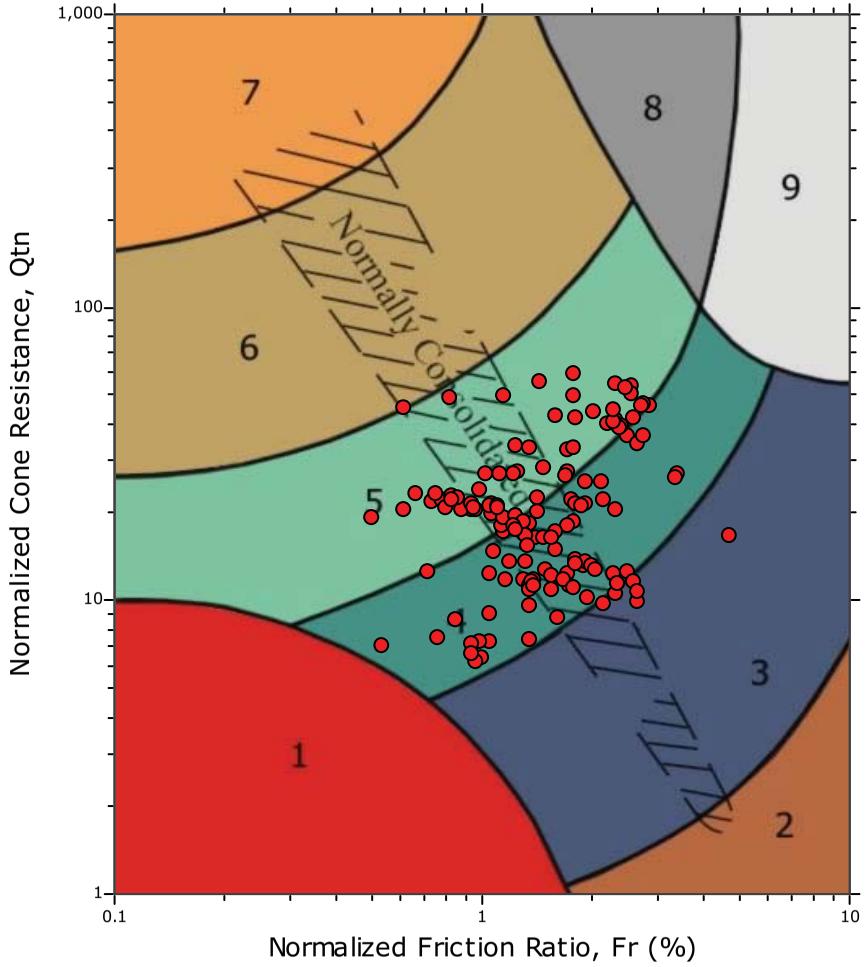


SBT legend

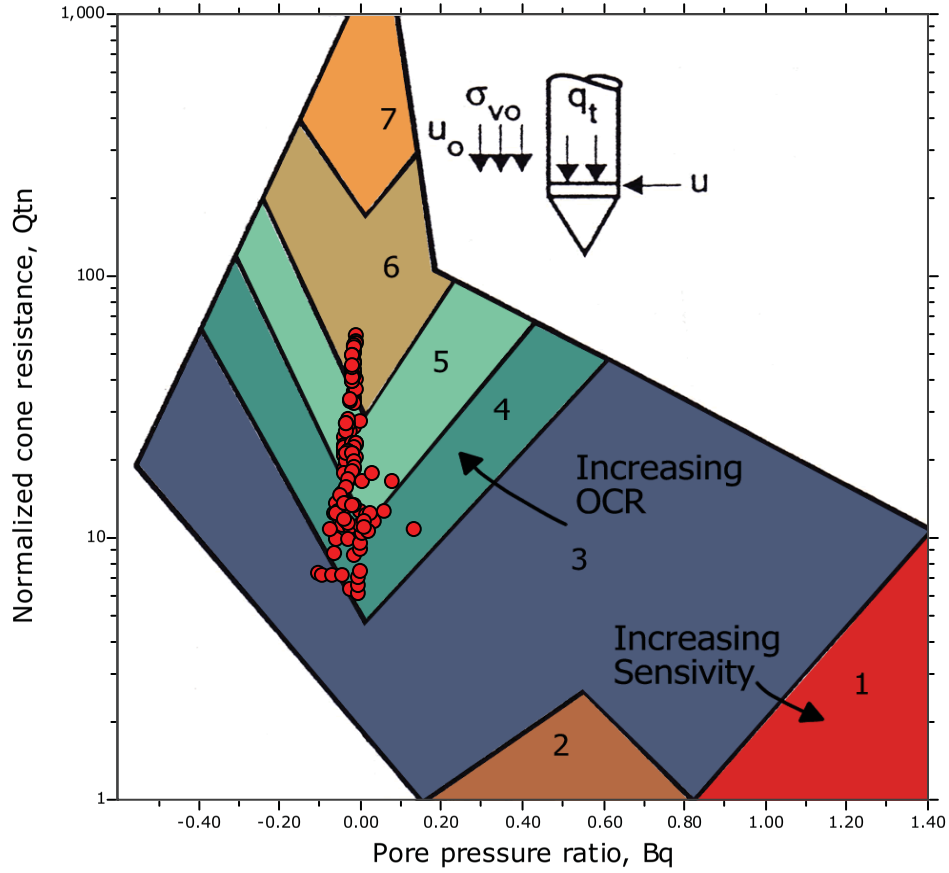
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

SBT - Bq plots (normalized)

SBTn plot



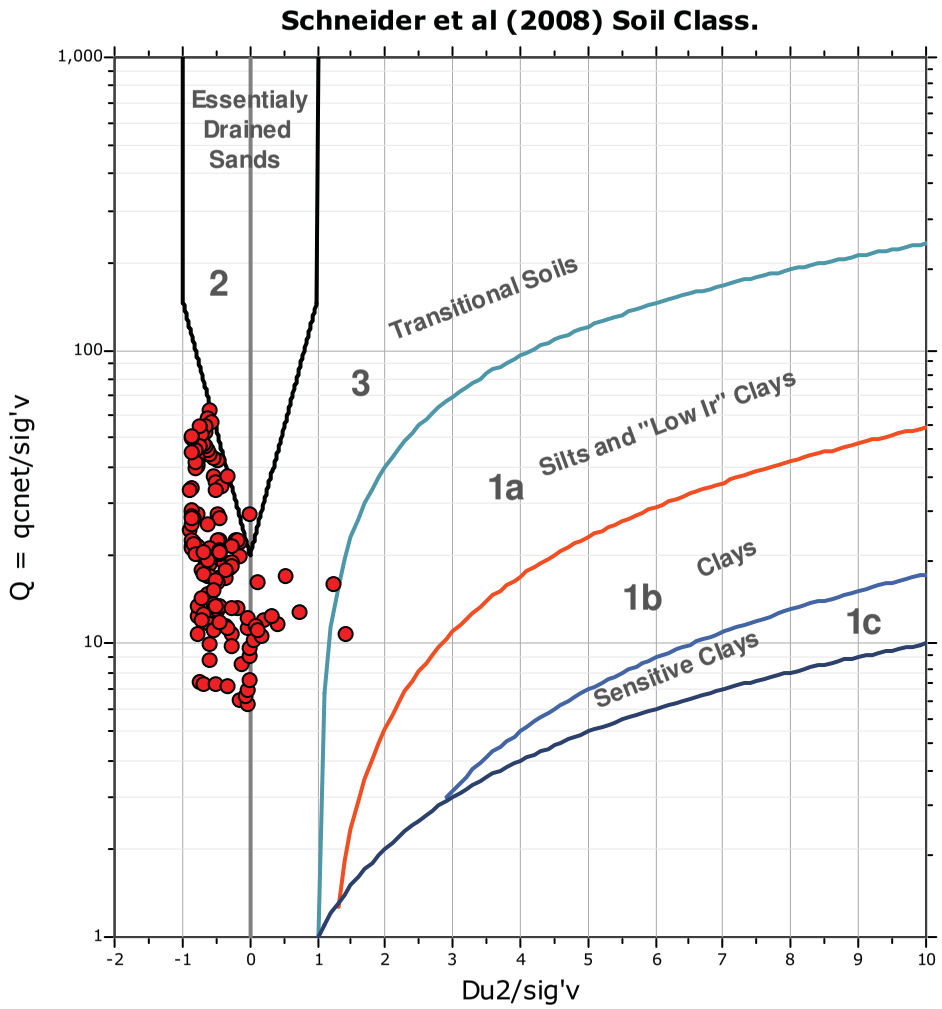
Normalized Bq plot

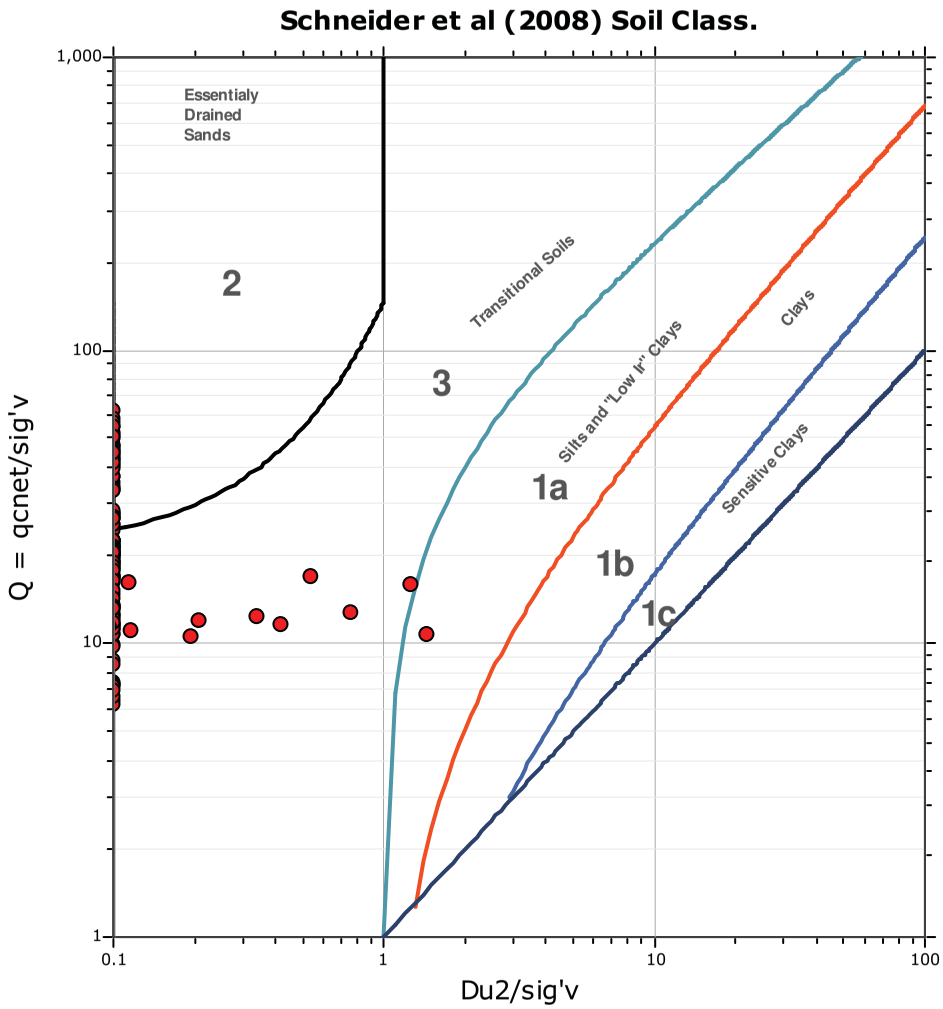


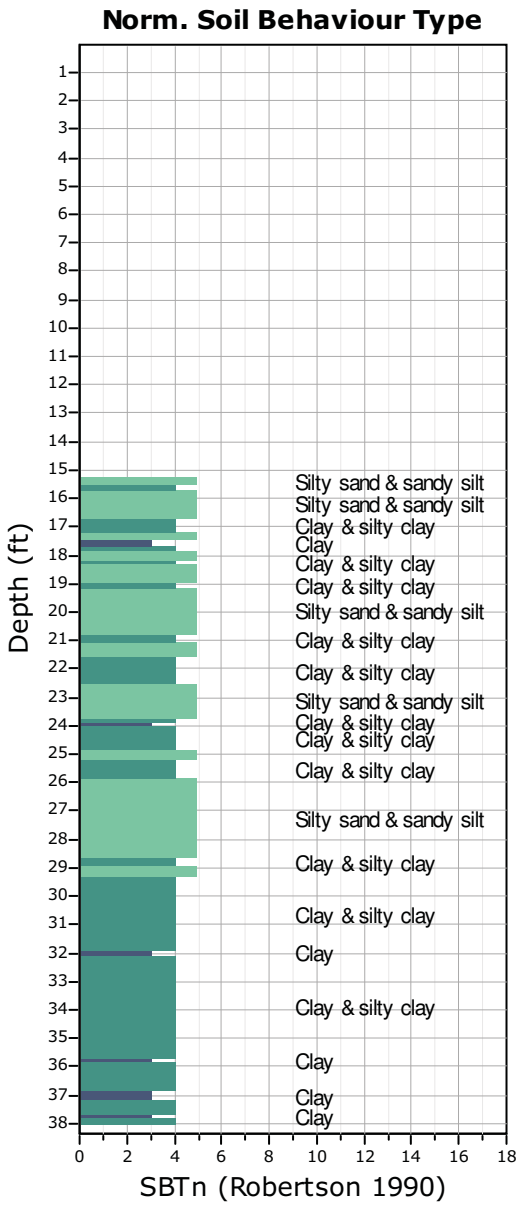
SBTn legend

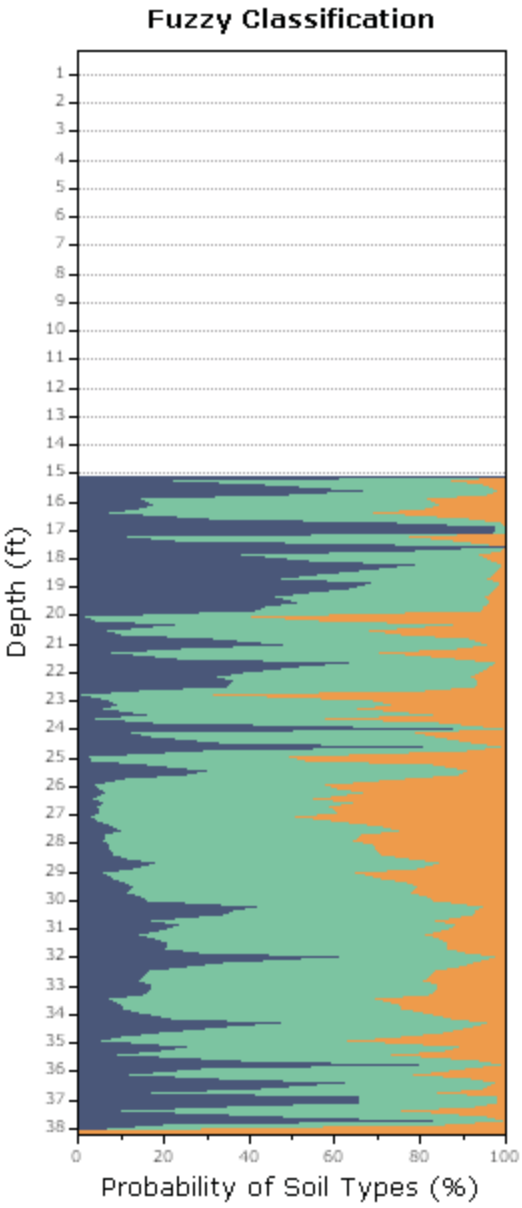
1. Sensitive fine grained	4. Clayey silt to silty clay	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to clayey sand
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

Bq plots (Schneider)





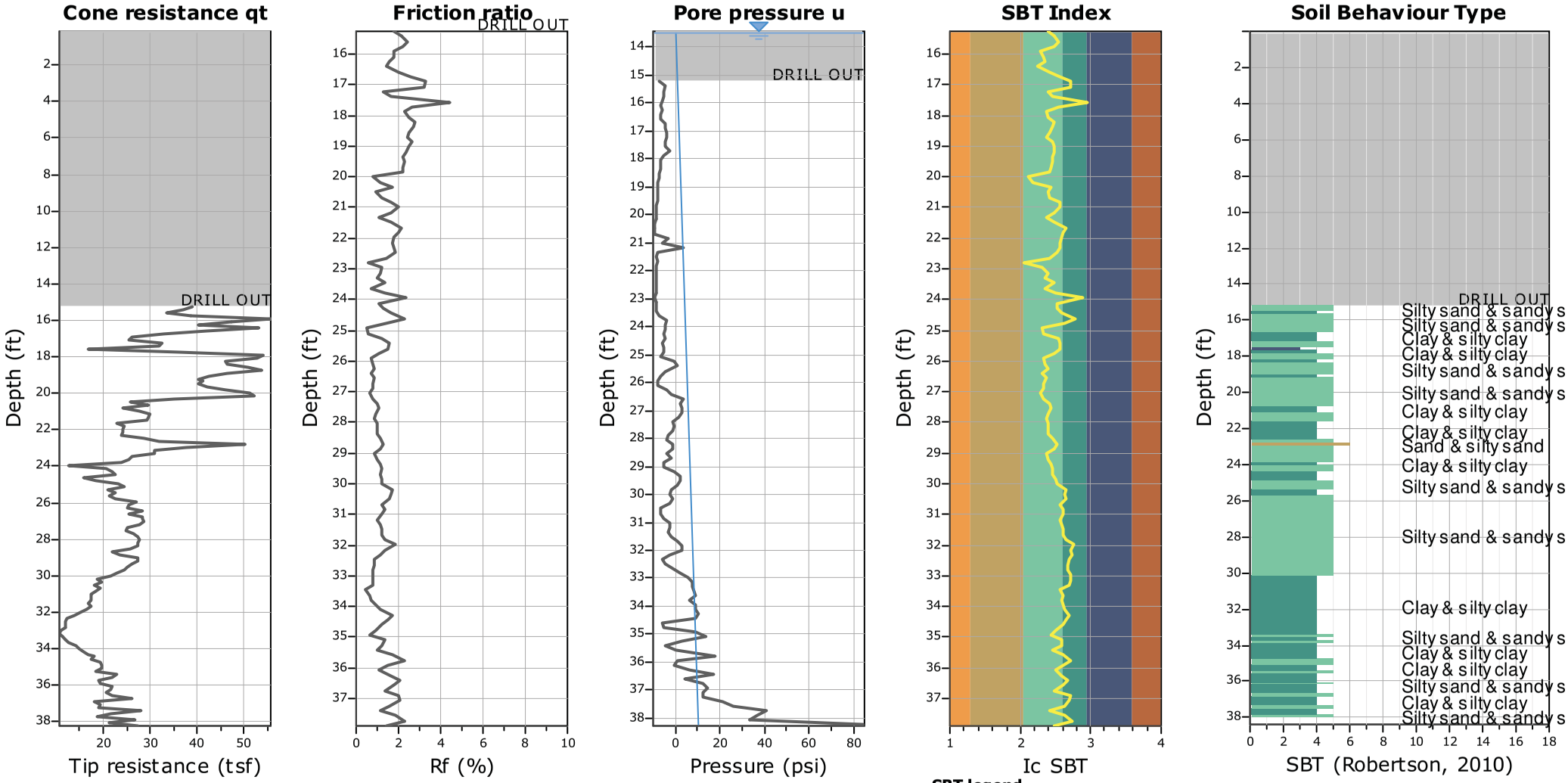

Norm. Soil Behaviour Type
Depth (ft)
SBTn (Robertson 1990)
Silty sand & sandy silt
Silty sand & sandy silt
Clay & silty clay
Clay
Clay & silty clay
Clay & silty clay
Silty sand & sandy silt
Clay & silty clay
Clay & silty clay
Silty sand & sandy silt
Clay & silty clay
Clay & silty clay
Clay & silty clay
Silty sand & sandy silt
Clay & silty clay
Clay & silty clay
Clay
Clay & silty clay
Clay
Clay
Clay


Fuzzy Classification
Depth (ft)
Probability of Soil Types (%)

CRAIG
GEOTECHNICAL DRILLING CO., INC.

Project: Langan
Location: 45 Broad Street, Manhattan NY

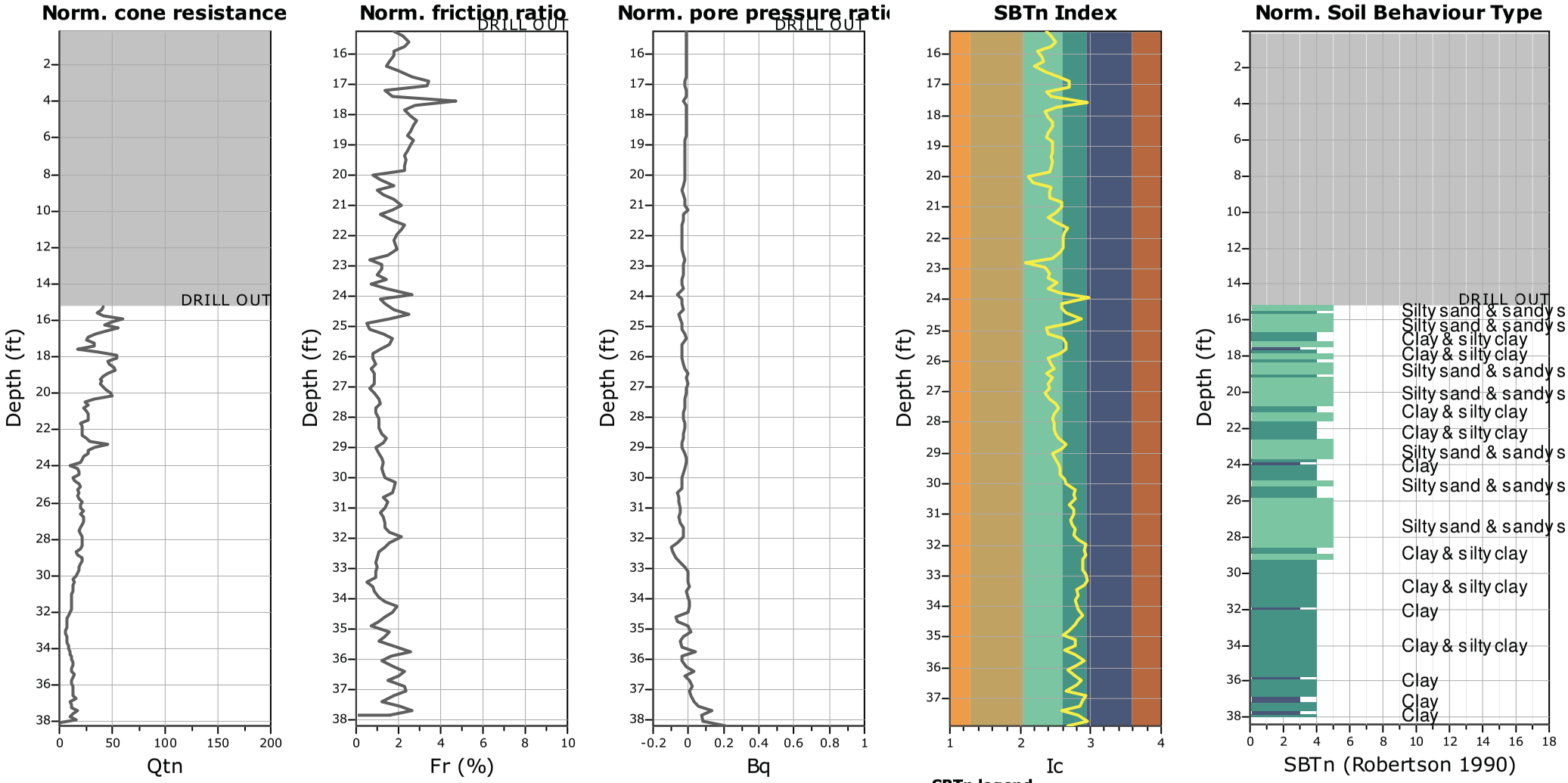
CPT: LanganBroad Street CPT-2c
Total depth: 38.22 ft, Date: 2/8/2016
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown



CRAIG
GEOTECHNICAL DRILLING CO., INC.

Project: Langan
Location: 45 Broad Street, Manhattan NY

CPT: LanganBroad Street CPT-2c
Total depth: 38.22 ft, Date: 2/8/2016
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

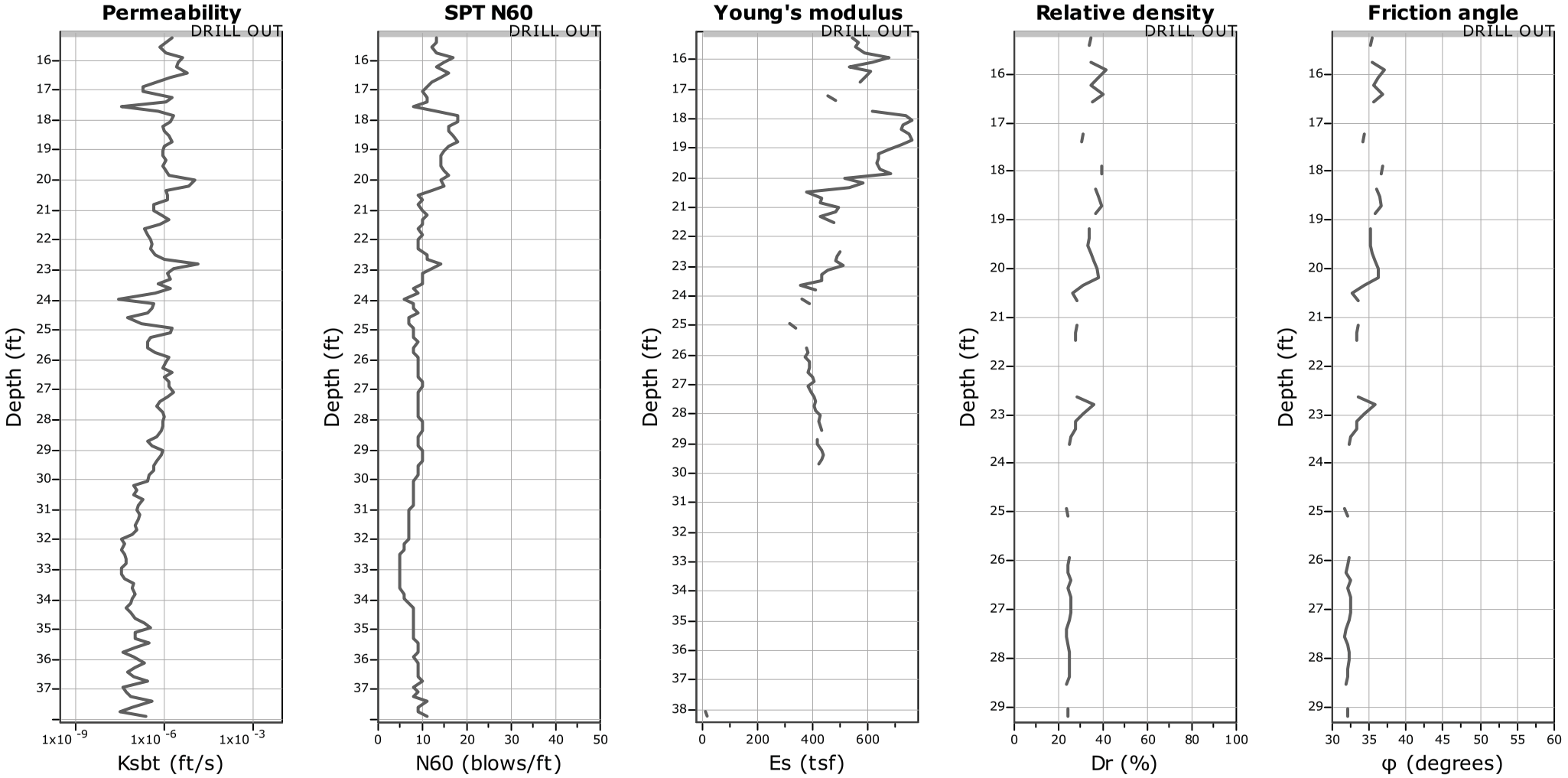


CRAIG GEOTECHNICAL DRILLING CO., INC.

CPT: LanganBroad Street CPT-2c

Total depth: 38.22 ft, Date: 2/8/2016
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type: Uknown
Cone Operator: Uknown

Project: **Langan**
Location: **45 Broad Street, Manhattan NY**



Calculation parameters

Permeability: Based on SBT_n
SPT N_{60}: Based on I_c and q_t
Young's modulus: Based on variable alpha using I_c (Robertson, 2009)
Relative desnisty constant, C_{Dr}: 350.0
Phi: Based on Kulhawy & Mayne (1990)
User defined estimation data

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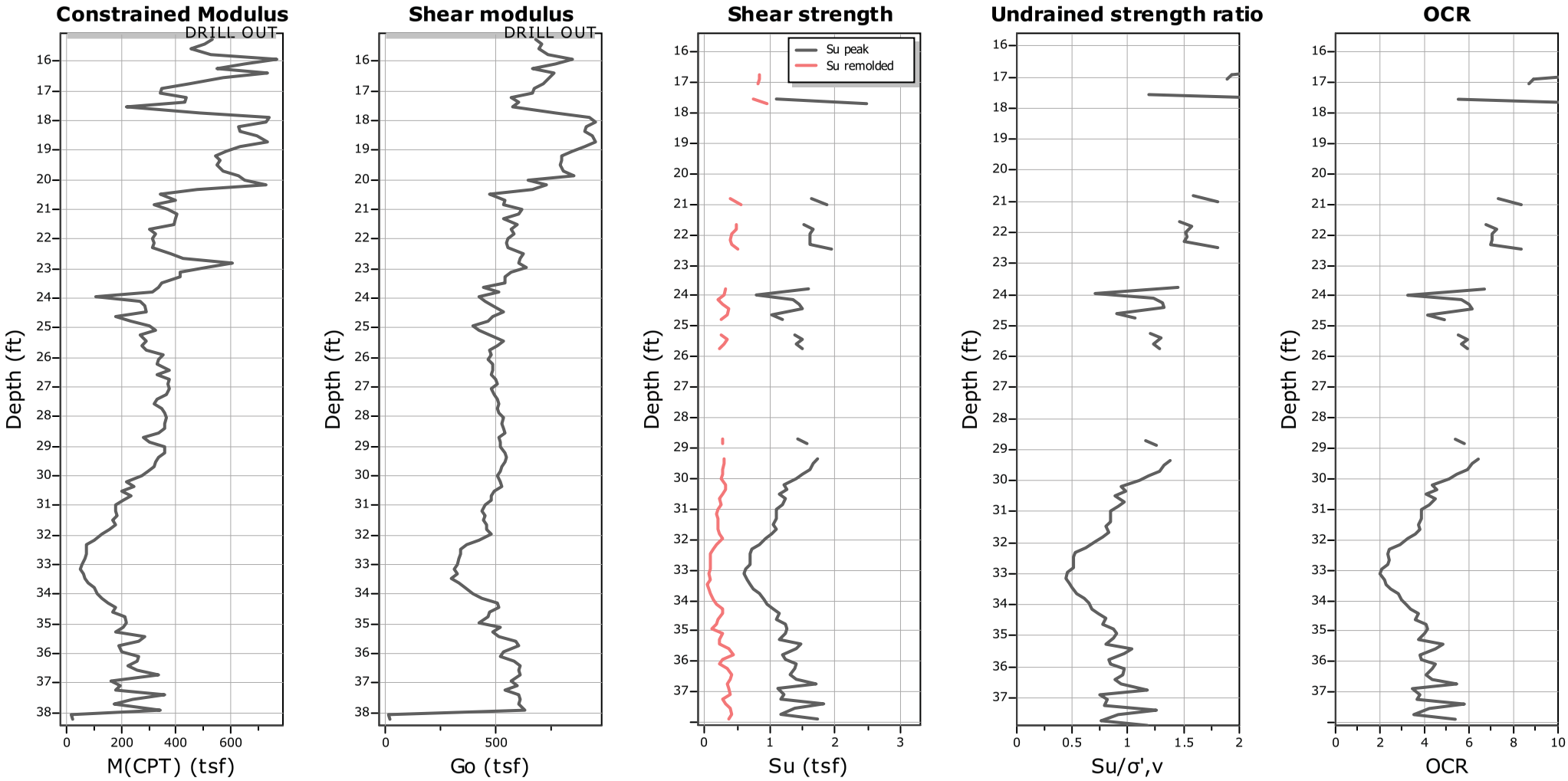

Calculation parameters

Constrained modulus: Based on variable *alpha* using I_c and Q_{tn} (Robertson, 2009)
Go: Based on variable *alpha* using I_c (Robertson, 2009)
Undrained shear strength cone factor for clays, N_{kt}: 14
OCR factor for clays, N_{kt}: 0.33
User defined estimation data

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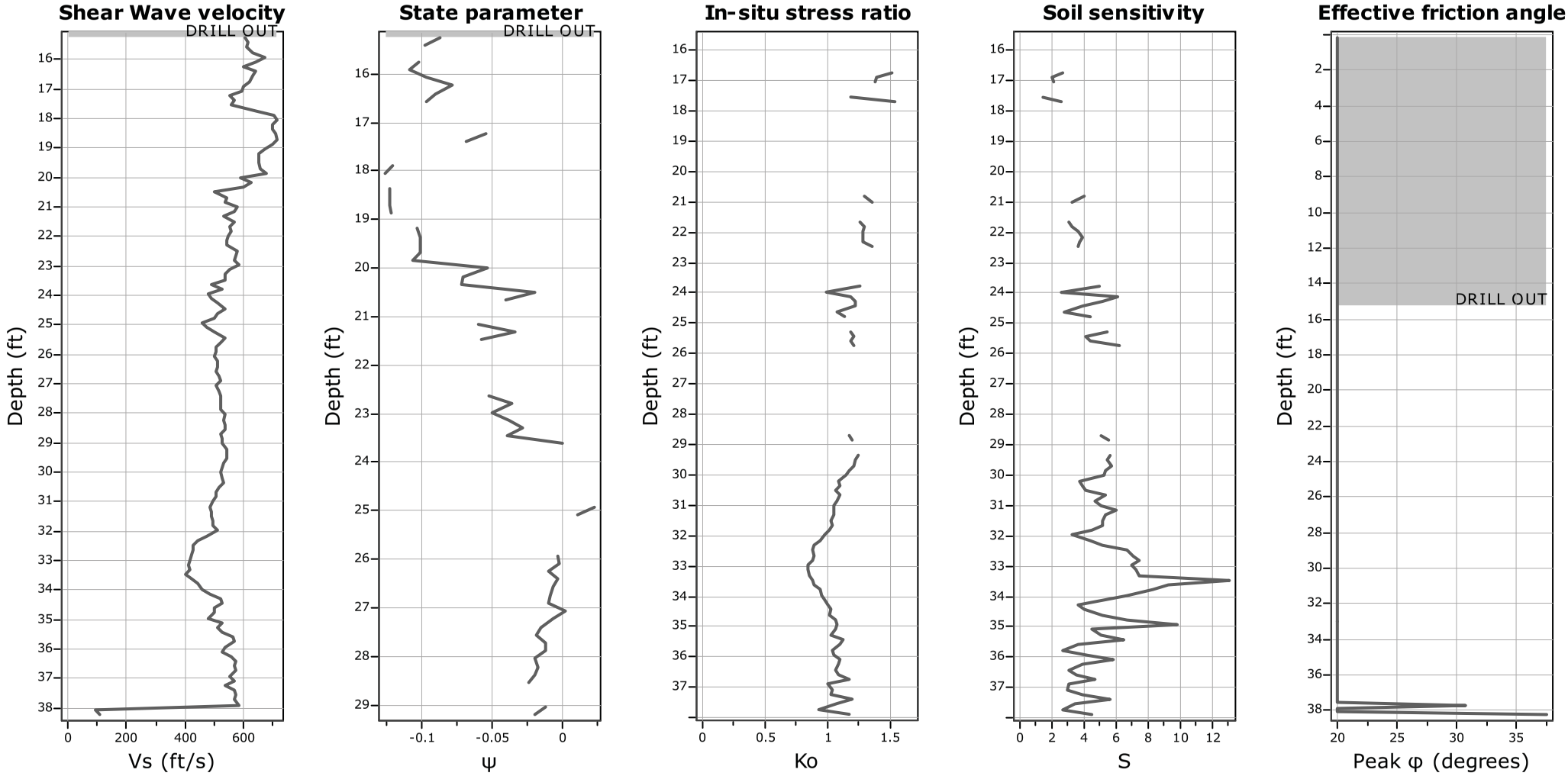
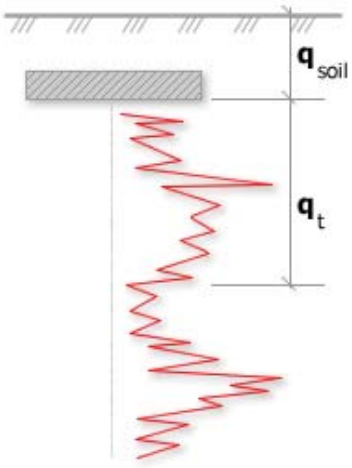


Calculation parameters

Soil Sensitivity factor, N_S: 7.00

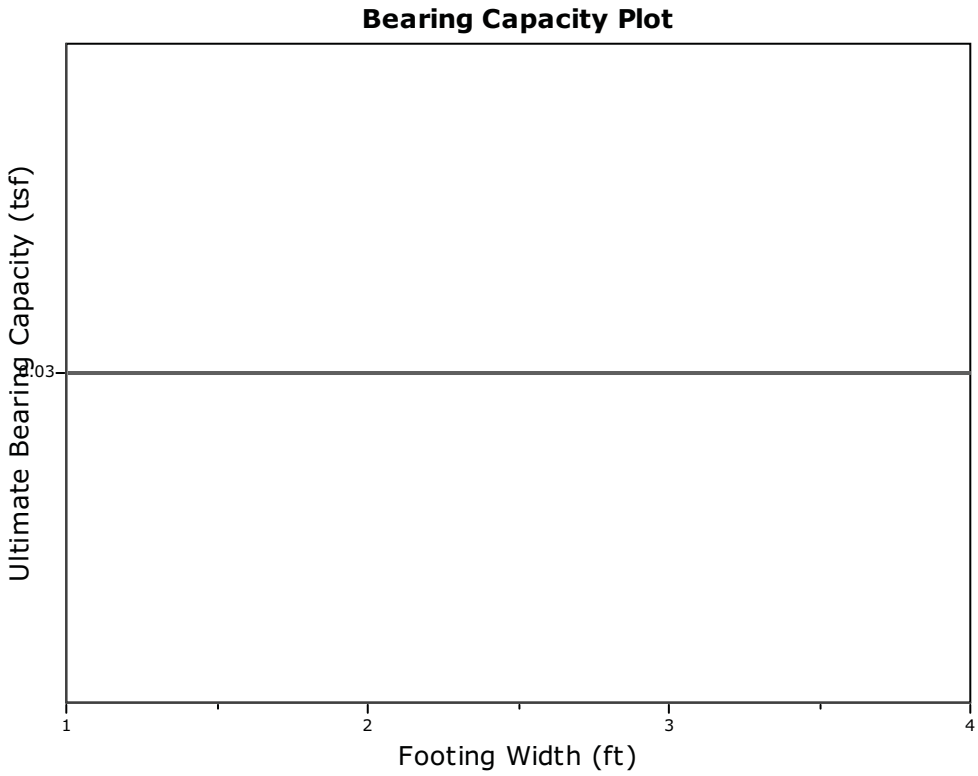
User defined estimation data



Bearing Capacity calculation is perfromed based on the formula:

$$Q_{ult} = R_k \times q_t + q_{soil}$$

where:
R_k: Bearing capacity factor
q_t: Average corrected cone resistance over calculation depth
q_{soil}: Pressure applied by soil above footing



:: Tabular results ::

No	B (ft)	Start Depth (ft)	End Depth (ft)	Ave. q_t (tsf)	R_k	Soil Press. (tsf)	Ult. bearing cap. (tsf)
1	1.00	0.50	2.00	0.00	0.20	0.03	0.03
2	1.20	0.50	2.30	0.00	0.20	0.03	0.03
3	1.40	0.50	2.60	0.00	0.20	0.03	0.03
4	1.60	0.50	2.90	0.00	0.20	0.03	0.03
5	1.80	0.50	3.20	0.00	0.20	0.03	0.03
6	2.00	0.50	3.50	0.00	0.20	0.03	0.03
7	2.20	0.50	3.80	0.00	0.20	0.03	0.03
8	2.40	0.50	4.10	0.00	0.20	0.03	0.03
9	2.60	0.50	4.40	0.00	0.20	0.03	0.03
10	2.80	0.50	4.70	0.00	0.20	0.03	0.03
11	3.00	0.50	5.00	0.00	0.20	0.03	0.03
12	3.20	0.50	5.30	0.00	0.20	0.03	0.03
13	3.40	0.50	5.60	0.00	0.20	0.03	0.03
14	3.60	0.50	5.90	0.00	0.20	0.03	0.03
15	3.80	0.50	6.20	0.00	0.20	0.03	0.03
16	4.00	0.50	6.50	0.00	0.20	0.03	0.03

Presented below is a list of formulas used for the estimation of various soil properties. The formulas are presented in SI unit system and assume that all components are expressed in the same units.

:: Unit Weight, g (kN/m³) ::

$$g = g_w \cdot \left(0.27 \cdot \log(R_f) + 0.36 \cdot \log(\frac{q_t}{p_a}) + 1.236 \right)$$

where g_w = water unit weight

:: Permeability, k (m/s) ::

$I_c < 3.27$ and $I_c > 1.00$ then $k = 10^{0.952-3.04 \cdot I_c}$

$I_c \leq 4.00$ and $I_c > 3.27$ then $k = 10^{-4.52-1.37 \cdot I_c}$

:: N_{SPT} (blows per 30 cm) ::

$$N_{60} = \left(\frac{q_c}{P_a} \right) \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

$$N_{1(60)} = Q_{tn} \cdot \frac{1}{10^{1.1268-0.2817 \cdot I_c}}$$

:: Young's Modulus, Es (MPa) ::

$(q_t - \sigma_v) \cdot 0.015 \cdot 10^{0.55 \cdot I_c + 1.68}$

(applicable only to $I_c < I_{c\_cutoff}$)

:: Relative Density, Dr (%) ::

$100 \cdot \sqrt{\frac{Q_{tn}}{k_{DR}}}$ (applicable only to SBT_n: 5, 6, 7 and 8 or $I_c < I_{c\_cutoff}$)

:: State Parameter, ψ ::

$\psi = 0.56 - 0.33 \cdot \log(Q_{tn,cs})$

:: Peak drained friction angle, φ (°) ::

$\varphi = 17.60 + 11 \cdot \log(Q_{tn})$

(applicable only to SBT_n: 5, 6, 7 and 8)

:: 1-D constrained modulus, M (MPa) ::

If $I_c > 2.20$

$\alpha = 14$ for $Q_{tn} > 14$

$\alpha = Q_{tn}$ for $Q_{tn} \leq 14$

$M_{CPT} = \alpha \cdot (q_t - \sigma_v)$

If $I_c \leq 2.20$

$M_{CPT} = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$

:: Small strain shear Modulus, Go (MPa) ::

$$G_0 = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 \cdot I_c + 1.68}$$

:: Shear Wave Velocity, Vs (m/s) ::

$$V_s = \left(\frac{G_0}{\rho} \right)^{0.50}$$

:: Undrained peak shear strength, Su (kPa) ::

$N_{kt} = 10.50 + 7 \cdot \log(F_r)$ or user defined

$$S_u = \frac{(q_t - \sigma_v)}{N_{kt}}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Remolded undrained shear strength, Su(rem) (kPa) ::

$S_{u(rem)} = f_s$ (applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Overconsolidation Ratio, OCR ::

$$k_{OCR} = \left[\frac{Q_{tn}^{0.20}}{0.25 \cdot (10.50 \cdot +7 \cdot \log(F_r))} \right]^{1.25}$$ or user defined

$OCR = k_{OCR} \cdot Q_{tn}$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: In situ Stress Ratio, Ko ::

$$K_O = (1 - \sin\varphi') \cdot OCR^{\sin\varphi'}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Soil Sensitivity, S_t ::

$$S_t = \frac{N_S}{F_r}$$

(applicable only to SBT_n: 1, 2, 3, 4 and 9 or $I_c > I_{c\_cutoff}$)

:: Effective Stress Friction Angle, φ' (°) ::

$\varphi' = 29.5° \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$

(applicable for $0.10 < B_q < 1.00$)

References

• Robertson, P.K., Cabal K.L., Guide to Cone Penetration Testing for Geotechnical Engineering, Gregg Drilling & Testing, Inc., 5th Edition, November 2012

• Robertson, P.K., Interpretation of Cone Penetration Tests - a unified approach., Can. Geotech. J. 46(11): 1337–1355 (2009)