

**GEOTECHNICAL ENGINEERING REPORT
NEW YORK CITY BUILD IT BACK PROGRAM
BROAD CHANNEL
QUEENS, NY**

**AECOM
125 Broad Street
New York, NY 10004**

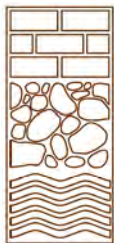
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REVIEWED BY
Lisa G. Amoia, RA

March 4, 2016

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WITH CONDITIONS**

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March 4, 2016

AECOM
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Attn: Ehab Shehata, Vice President - Northeast Region

Re: Geotechnical Engineering Report
NYC Build It Back Program
Broad Channel
Queens, NY
MRCE File No. 12481B

Dear Mr. Shehata:

In accordance with our agreement, Mueser Rutledge Consulting Engineers (MRCE) has completed a supplemental geotechnical subsurface investigation program for the New York City Build It Back (NYC BIB) neighborhood of Broad Channel, Queens. We summarize herein the results of our supplemental investigation program, our interpretation of the subsurface conditions and our recommendations for foundation design and construction for the one to two story homes in Broad Channel.

EXHIBITS

The following exhibits are attached:

<u>Exhibit</u>	<u>Description</u>
Figure No. 1	Geologic Map
Dwg Nos. BC-1 to BC-8	NYC Build It Back - Broad Channel Boring Location Plan
Dwg No. BC-9	Approximate Limits of Stratum O2
Drawing No. GS-R	MRCE Geotechnical Reference Standard
Figure No. 2	Groundwater Elevation Readings
Figure No. 3	Summary of Corrosion Testing
Figure No. 4	Gradation Curves
Table No. 1	NYC Build It Back Homes Addressed in this Report (2-23-16)
Appendix A	MRCE and Dynamic Earth LLC Boring Logs
Appendix B	2016 Supplemental Subsurface Investigation
Appendix C	Historic Boring Information
	As-Drilled Boring Survey

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PROJECT DESCRIPTION

The NYC BIB project involves the reconstruction or rehabilitation by elevation of hundreds of homes damaged or impacted by Super Storm Sandy in late October 2012. In general, the project encompasses many neighborhoods of New York City including those located in southern Brooklyn and Queens, and parts of Staten Island.

MRCE's scope of geotechnical engineering services includes compiling and reviewing historic geotechnical boring data, performing supplemental subsurface investigations, preparing neighborhood specific geotechnical reports summarizing new and historic subsurface data, and providing foundation design and construction recommendations for the one to two story homes that will receive new foundations as part of their reconstruction or rehabilitation. A total of 130 homes, located within the BIB neighborhood of Broad Channel are covered under the foundation design and construction recommendations contained in this report. The homes are identified on attached Table No. 1 entitled "Broad Channel Homes Addressed in this Report (February 23, 2016)".

SITE DESCRIPTION

Broad Channel is an island located within Jamaica Bay, in South Queens. It is connected to the borough of Queens by two bridges: the Joseph P. Addabbo Memorial Bridge to the North and the Cross Bay Veterans Memorial Bridge to the South. The exact BIB project limits for the Broad Channel neighborhood are shown on the attached set of drawings entitled "NYC Build It Back – Broad Channel Boring Location Plan: (see Drawing Nos. BC-1 through BC-8 for details).

Ground surface elevations within the project limits range from approximately Elev. +3.3 to Elev. +8.2 and are based on as-drilled survey elevations at boring locations from our 2015/2016 supplemental subsurface investigation program. Historic boring information indicates that ground surface elevations range from approximately Elev. +1.6 to Elev. +10.9. All elevations referenced in this report refer to the North American Vertical Datum of 1988 (NAVD 88).

SITE HISTORY

The subsurface geology along the South shore of Brooklyn and Queens is the product of a series of Pleistocene glacial advances and subsequent retreats with sea-level rise. The near surface geology reflects how the older glacial sediments were reworked by the Holocene and recent sea-level rise.

Along the southern shore of Queens, the Cretaceous age Coastal Plains sediments were eroded down and covered with the Jameco Gravel outwash sand during an older glaciation. This sand and gravel stratum is encountered at elevations ranging approximately between Elev. -175 to Elev. -200 below the Rockaway Peninsula. When the ice retreated, sea-level rose during the interglacial period and a marine clay, known as the Gardiners Clay, was deposited above the Jameco Gravel outwash. The Gardiners Clay is present at roughly Elev. -150. The next glaciation covered the Gardiners Clay with another layer of outwash sand known as the Merrick Formation. This outwash appears to be especially thick around the mouth of New York Harbor and thins eastward towards Suffolk County.

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This glaciation was followed by another sea-level rise, which deposited a layer of marine clay commonly known as the 20-Foot Clay (or the Wantagh Formation) above the outwash sand. The 20-Foot Clay was officially mapped by the USGS in Nassau and Suffolk counties. Its presence was acknowledged in New York City, but never publicly mapped. The stratum is discontinuous along the South shore, but where present it is typically encountered at elevations ranging between Elev. -40 and Elev. -100 below the barrier islands. On the mainland, its landward edge is found roughly around Elev. -20. The most recent late Wisconsin age glaciation covered the 20-Foot Clay with another layer of outwash sand known as the Bellmore Formation. In general, the older Merrick Formation tends to be denser, with higher N-values, than the younger Bellmore Formation, even in locations where the 20-Foot Clay is not present between the two formations.

During the Holocene the glacial ice retreated and the sea-level started to rise. Wave action reworked the glacial sediments into barrier islands that paralleled the mainland and migrated landward in-step with the rising sea-level. Over time the coastal marshes were flooded and covered with back-bay organic clays, which in turn were buried under outwash and barrier beach sands that are currently being submerged and developed into modern marshes. In the near surface, this action of the barrier islands “rolling over” has led to deposits of more recent marsh and marine organics interlayered with beach sands.

As shown on attached Figure No. 1, entitled “Geological Map”, Broad Channel consists of swamp and marsh deposits located within Jamaica Bay. The entire area was covered with a layer of manmade fill to raise grades and create usable land for development.

AVAILABLE INFORMATION

Historic boring information for Broad Channel including approximate boring locations and soil sample data, was provided to MRCE by the NYC Department of Design and Construction (DDC). The borings were performed for previous DDC projects in the area. In addition, we searched our in-house files and database for historic boring and subsurface information and included that data in the overall historic boring information reviewed in preparation of this report.

MRCE organized the historic boring information provided by assigning a reference number to each of the previous projects that the borings were made for. The “Existing Boring Summary Table” on attached Drawing No. BC-2 correlates the MRCE assigned reference numbers to the previous subsurface investigation work.

A total of 293 borings ranging in depth from 4.5 feet to 82 feet below ground surface were reviewed. Borings were made using different types of drilling and sampling equipment. For most of the historic borings provided, samples were obtained at 5 foot on center intervals. In some of the historic borings, continuous samples were obtained from 5 feet to 15 feet and at intervals of 5 foot on center thereafter. Many of the soil samples were obtained by driving a 2 inch O.D. split spoon sampler 18 or 24 inches using a 140 pound hammer free falling 30 inches. The number of blows required to drive the split spoon sampler through consecutive 6 inch increments was recorded. In soft or loose soils where the sampler was able to penetrate under the weight of the sampling hammer without being struck, the blow counts are indicated as “P” or “WH” for pushed by weight of hammer. Several undisturbed soil samples were obtained using a thin wall

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tube sampler (Reference No. 9).

Many historic boring soil samples were classified in accordance with the Unified Soil Classification System (USCS).

The historic boring information used to prepare this report is attached as Appendix B.

2015 - 2016 SUPPLEMENTAL SUBSURFACE INVESTIGATION

From December 2015 through February 2016, MRCE performed a supplemental subsurface investigation consisting of 39 borings and 6 observation wells. Three of the borings were made within the property limits of homes enrolled in the Broad Channel BIB program. The remaining borings were made in the sidewalk or street. The as-drilled locations of the borings are shown on Drawing Nos. BC-3 through BC-8. Boring locations were selected to obtain subsurface data in areas of structures currently enrolled in the BIB program and to provide an understanding of the general subsurface conditions within the BIB project limits of Broad Channel in the event that additional structures are added to the program in the future. The Broad Channel boring location plan was submitted to NYC Department of Buildings (DOB) for review and approval prior to the start of the supplemental boring program.

Boring Nos. BC-1 through BC-38 were made by Warren George, Inc. of Jersey City, New Jersey (WGI) from December 9, 2015 through January 20, 2016 under the continuous inspection of Resident Engineers from MRCE and Dynamic Earth, LLC (DE), a subcontractor to MRCE. Boring No. BC-39 was drilled by Aquifer Drilling and Testing, Inc. of Mineola, New York (ADT) on February 22, 2016 under the continuous inspection of MRCE Resident Engineers. The borings were made using truck-mounted drilling equipment utilizing mud-rotary drilling techniques with casing and drilling mud to stabilize the boreholes. Boring depths ranged from 52 feet to 77 feet below the ground surface. A survey of the as-drilled boring locations was performed by Hirani Engineering & Land Surveying, P.C., dated February 24, 2016 and attached to this report as Appendix C.

All borings were hand augered in the top 6 feet to clear utilities. Below the hand augered zone, continuous samples were obtained to a depth of 10 feet in each boring. Below 10 feet, soil samples were typically obtained at 5 feet intervals on center. Soil samples were obtained using a 2-inch O.D. split-spoon sampler driven with a 140 pound safety or donut hammer falling freely 30 inches. Boring No. BC-39 was made using an automatic sampling hammer. The number of blows required to drive the sampler through each of four consecutive six-inch increments was recorded. The sum of the blows for the second and third six-inch interval is defined as the Standard Penetration Test (SPT) Resistance, or N-value. The N-value is an index of the in-situ density of the material and is reported in blows per foot (bpf). In soft or loose soils where the sampler is able to penetrate under the weight of the drilling rods or sampling hammer without being struck, the N-Value is recorded as Weight of Rods (WR) or Weight of Hammer (WH). Borings that did not receive observation well installations were backfilled with soil cuttings upon completion.

Observation wells were installed in completed boreholes of Boring Nos. BC-2P, BC-5P, BC-12P, BC-13P, BC-20P and BC-23P to monitor groundwater levels at the site. The piezometers consist of 2-inch PVC standpipe and slotted screen. The slotted screen section is

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surrounded by filter sand to allow free water flow without movement of soil particles. A cap was installed flush with the surrounding ground surface to protect the observation well and facilitate obtaining future groundwater readings. All observation wells were flushed with water following installation to confirm proper function. Well construction details and water level readings are recorded on the piezometer records accompanying the boring logs and are attached to this report as Appendix A.

LABORATORY TESTING

All soil samples were delivered to the MRCE soil mechanics laboratory in NYC. Samples were reviewed and field descriptions revised as necessary for conformance with MRCE's Geotechnical Reference Standards, as noted on Drawing No. GS-R. Individual sample descriptions are included in the typed logs attached to this report as Appendix B.

The following laboratory testing was performed on selected soil samples:

Water Contents: Natural water contents as a percent of dry weight were obtained for fine grained soil samples (silt, clay and peat) from Strata O1 and O2. Natural water contents are reported on the boring logs.

Mechanical Analysis of Grain Size: Mechanical analyses of grain size distribution were performed on selected samples of granular soil samples. Gradation results are shown on attached Figure No. 4.

Organic Content: The percent of organic material was determined for selected soil samples from Strata O1 and O2 in accordance with ASTM D2974.

Corrosion Testing: Soil resistivity, soil pH, sulfate and chloride concentration tests were performed on selected samples in accordance with ASTM G57, G51, D512 and D516 respectively. The corrosion testing was performed by TerraSense, LLC of Totowa, New Jersey, on samples selected by MRCE. A summary of corrosion testing results is shown on attached Figure No. 3.

GENERAL SUBSURFACE CONDITIONS

General descriptions of the materials encountered at the site and their classification in accordance with the 2014 NYC Building Code (the Code) are summarized below in order of their occurrence with depth. Unless otherwise noted, the descriptions below are based on the 2015-2016 supplemental borings (2016 borings) and checked for general conformance with the historic data.

In general, the 2016 boring data confirms the subsurface conditions shown in the historic borings.

Stratum F - Fill (NYC Class 7): Miscellaneous manmade fill was encountered in 34 of the 39 2016 borings. The fill stratum typically consists of loose to medium compact brown, gray brown and gray fine to medium sand, some to trace silt, coarse sand and gravel, with traces of shells and miscellaneous construction debris such as glass, brick and wood. The thickness of Stratum F

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ranges from 4 feet to 13.5 feet, with an average thickness of approximately 8 feet. The historic borings indicate that the fill layer ranges in thickness from 1 foot to 16 feet with an average thickness of approximately 7 feet.

N-Values in Stratum F range from WH to 54 in the 2016 borings, with an average N-Value of 14. N-Values are not available in the top 6 feet of Stratum F because the borings were hand augered to clear utilities. Historic boring N-Values range from 2 to 36, with an average N-Value of 9. The wide range of N-values indicates that larger materials not recovered with the sampler may be present within the fill.

Stratum PF - Possible Fill (NYC Class 6): This stratum was encountered in 5 of the 39, 2016 borings. This stratum ranges in thickness from 6 feet to 10 feet, with an average thickness of approximately 7.5 feet. The possible fill stratum consists of loose brown and gray fine to medium sand, some to trace silt, gravel and coarse sand. In contrast to Stratum F, this stratum is free of miscellaneous debris and overlies the natural sands of Stratum S1. This stratum may consist of natural soils that were excavated from other areas of the neighborhood and reused as fill material.

N-Values in this stratum range from 2 to 8, with an average N-Value of 5. N-Values are not available in the top 6 feet of Stratum PF because the borings were hand augered to clear utilities.

Stratum O1 - Upper Marsh Deposit - Organic Silty Clay (NYC Class 6): Stratum O1 was encountered in 30 of the 39, 2016 borings directly underlying Stratum F. In two of the 2016 borings, Stratum O1 is interbedded within Stratum S1 to depths ranging up to 13.5 feet below the ground surface. Based on the historic borings and the 2016 borings, Stratum O1 was encountered sporadically throughout the neighborhood and may be present in all areas within the project limits. Stratum O1 consists of soft to medium dark gray and gray organic silty clay, trace to some peat and fine sand, with traces of shells, vegetation and wood. Several samples from Stratum O1 consist of dark brown peat with varying quantities of gray organic silty clay. The thickness of Stratum O1 ranges from 0.2 feet to 12 feet, with an average thickness of approximately 4 feet. Historic borings indicate that Stratum O1 ranges in thickness from 2 feet to 12 feet, with an average thickness of approximately 6 feet. One historic boring indicates that Stratum O1 could be as thick as 21 feet in certain areas of the neighborhood.

N-Values in Stratum O1 typically range from WR to 7 in the 2016 borings, with an average N-Value of 4. Boring BC-20P indicates one sample with an N-Value as high as 21 in this stratum. Historic boring N-Values typically range from WH to 14, with an average N-value of 7. Approximately 10 percent of the historic boring samples indicate N-Values greater than 14, with a maximum value of 33.

Natural water contents of samples from Stratum O1 range from 36 to 153. The wide range of water contents is due to the varying quantities of peat present in the samples. Organic contents from Stratum O1 range from approximately 5 to 8 percent.

Stratum S1 - Shorefront Sand (NYC Class 3b): Underlying Stratum F, Stratum PF and Stratum O1, where present, is a layer of shorefront sand deposited by wind and wave action. This stratum consists of compact to loose gray fine to medium sand, some to trace silt, with traces of coarse sand, gravel, mica, and shells. Eleven of the 39 2016 borings were terminated in this

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stratum. In borings that extended beyond Stratum S1, the thickness of this stratum ranged from 10 feet to 35 feet. In 12 of the 2016 borings where Stratum O2 was not encountered, the last sample obtained in this stratum is classified as loose fine to medium sand with some silt or clay, or loose clayey or silty sand. These samples are indicative of a transition zone between Strata S1 and O2 and were interpreted as a break between Strata S1 and S2.

N-Values in this stratum typically range from 5 to 60, with an average N-Value of 29. In the top 5 feet of Stratum S1, N-Values were relatively lower with some values as low as 2. Approximately 10 percent of samples from the 2016 borings indicate N-Values ranging from 60 to over 100. N-Values at the bottom of Stratum S1 within the transition zone described above are typically lower than 10. Historic borings indicate that the N-Values in this stratum typically range from 10 to 40, with an average N-Value of 28. Less than 10 percent of historic boring samples indicate N-values as low as weight of hammer and as high as 81.

Stratum O2 - Lower Marsh Deposit - Organic Silty Clay (NYC Class 6): This stratum was encountered in 14 of the 39, 2016 borings underlying Stratum S1. Based on the historic borings and the 2016 borings, Stratum O2 is present in the western areas of the neighborhood, primarily West of Cross Bay Boulevard. The approximate limits of Stratum O2 are shown on Drawing No. BC-9. Stratum O2 consists of soft dark gray and gray organic silty clay, trace to some fine sand, with traces of peat, shells and vegetation. This stratum was encountered at depths ranging from 29 feet to 44 feet below the ground surface and ranges in thickness from 3 feet to 17 feet, with an average thickness of 8 feet. Historic borings indicate that Stratum O2 was encountered between depths of 21 feet and 50 feet below the ground surface and ranges in thickness from 3 feet to 20 feet, with an average thickness of approximately 14 feet.

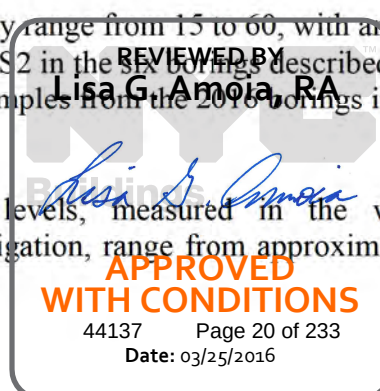
N-Values in this stratum range from WH to 5, with an average N-Value of 2. One sample from Boring No. BC-29 indicates an N-Value as high as 22 within this stratum. Historic boring N-Values range from weight of hammer to 11, with an average N-Value of 3.

Natural water content of samples from Stratum O2 ranges from 42 to 152 percent. The wide range of water contents is due to the varying quantities of peat present in the samples. Laboratory tests indicate that organic contents from Stratum O2 range from approximately 3 to 4 percent.

Stratum S2 - Outwash Sand (NYC Class 3a): Underlying Stratum S1 and Stratum O2 where present, is a glacial outwash deposit consisting of compact to medium compact gray, brown and gray brown fine to medium sand, trace to some silt, with traces of coarse sand. The depth to Stratum S2 ranges from 24 feet to 49 feet below the ground surface. Twenty eight of the 39 2016 borings were terminated in this stratum. In 6 of the 2016 borings, the samples from the the top of this stratum underlying Stratum O2 are classified as loose gray and brown fine to medium sand with some silt or organic clay, or loose clayey or silty gray and brown fine sand.

N-Values in Stratum S2 typically range from 15 to 60, with an average N-Value of 36. N-Values within the top 5 feet of Stratum S2 in the 39 borings described above are typically lower than 10. Approximately 10 percent of samples from the 2016 borings indicate N-Values ranging from 60 to over 100.

Groundwater: Groundwater levels, measured in the wells installed during the 2016 supplemental subsurface investigation, range from approximately 1.2 feet to 9.2 feet below the



ground surface, corresponding to approximately Elev. -2.2 to Elev. +3.3. In 23 of the 39 2016 borings, groundwater was observed at a depth shallower than 6 feet during hand augering.

In comparison, historic boring information indicates that the depth of the groundwater from the ground surface ranges from 2.8 feet to 6.0 feet, corresponding to approximately Elev. -0.5 to Elev. +2.7. Many of the historic borings indicate the depth at which the groundwater table was observed during drilling. The range of measured groundwater levels from historic borings may have been affected by drilling conditions and may not be indicative of the actual groundwater levels across the site.

Data from historic groundwater observation wells indicate that the groundwater table in Broad Channel may be subject to tidal influences ranging in depth of up to 2.5 feet. During our investigation, we observed tidal influences in the groundwater levels that typically range up to 1.5 feet. One set of groundwater level readings recorded on February 22, 2016 indicate that tidal influences could be as large as 4 feet under certain conditions.

SEISMIC CONSIDERATIONS

Based on Sections 1613.1 and 1614.1 of the Code, one and two family dwellings, three stories or less in height, are exempt from design and construction for the effects of earthquake motions. Based on correspondence with the NYC DOB, this exemption also applies to the assessment for liquefaction potential as outlined in Section 1813 of the Code.

FOUNDATION RECOMMENDATIONS

The subsurface conditions at Broad Channel consist of man-made fill overlying a layer of organic silty clay and peat marsh deposits. These shallow marsh deposits are underlain by compact to loose natural shorefront sands. Underlying the shorefront sands is a deeper organic silty clay marsh deposit. A deposit of compact to medium compact glacial outwash sand underlies the deeper marsh deposit. Drawing No. BC-10 depicts the approximate limits of Stratum O2 throughout the neighborhood of Broad Channel based on the historic borings and the 2016 supplemental subsurface investigation.

We understand that the proposed structures, whether renovated or new, will be lightly loaded wood frame structures supported above the design flood level on a foundation wall consisting of concrete masonry units (CMU blocks) with openings or on individual columns in lieu of CMU walls. These support structures will allow flood waters to pass through the structures in accordance with FEMA regulations. We have studied both shallow and deep foundation options for this project and the results of our studies are summarized below. Recommended foundation types based on results from our studies are summarized in the conclusion section of this report.

Shallow Foundations

Based on the boring data, shallow foundations are expected to bear in the fill (Stratum F) or the possible fill (Stratum PF) strata. Shallow foundations, if used, should consist of continuous strip footings interconnected to perform as a single framed unit or a mat foundation.



The Code requires that all shallow foundations must extend a minimum of 4 feet below the final surface grade or must be designed against frost heave in accordance with ASCE-32. Stratum F is classified as an uncontrolled fill in accordance with the Code. The Code limits the allowable bearing pressure for uncontrolled fill to 2 tons per square foot (tsf) and outlines that the following requirements must be met in order to construct shallow foundations in uncontrolled fill:

1. Test pits must be excavated at each column location to a minimum depth below the footing subgrade elevation equal to the smaller width of the footing. At least one of the test pits must extend to a minimum depth of 8 feet below the footing subgrade elevation. For strip footings, at least one test pit will be excavated for every 25 lineal feet of footing.
2. Borings may be used in lieu of test pits given that continuous samples having a minimum 3-inch diameter are obtained.
3. All deleterious material, soft zones, voids or otherwise unsuitable soil must be removed and replaced with structural fill.

Due to the loose nature and expected thickness of Stratum F, the proximity of the soft compressible soils of Stratum O1 to the foundation bearing subgrade level and shallow groundwater levels, we recommend that an allowable bearing pressure of 1 tsf be used in sizing shallow foundations in the fill.

Stratum PF is classified as a Class 6 nominally unsatisfactory bearing material in accordance with the Code. Based on the loose nature of the material and the shallow groundwater levels, we also recommend that an allowable bearing pressure of 1 tsf be used for sizing shallow foundations bearing in Stratum PF.

The soil subgrade will need to be inspected by a qualified Geotechnical Engineer to determine the nature of the soils. If the soil subgrade is determined to be Stratum F, the additional requirements for shallow foundations bearing on uncontrolled fill outlined above will be needed in accordance with the Code. If the subgrade soils are determined to be natural material, the additional requirements may not be necessary.

MRCE bearing capacity calculations estimate that the Stratum O1 organic soils have a low bearing capacity and are not suitable bearing material for shallow foundations. Based on the low bearing capacity of Stratum O1, the subgrade elevation for shallow foundations bearing in Strata F or PF must be a minimum of 3 feet above the top of Stratum O1 at the foundation location. Test pit excavations or an auger hole program at each foundation location will be required to determine the depth from the foundation subgrade elevation with respect to the top of Stratum O1.

Deep Foundations

Although shallow foundations can be used, we also investigated the use of deep foundations such as helical piles.



Helical Piles

Due to the limited space available to install pile foundations for the homes and the relatively light loads the piles will support, low capacity piles, such as helical piles, can be used for this project.

We recommend an allowable axial compression capacity of up to 10 tons (20 kips) for the helical piles. Although the Code criteria for helical piles includes a maximum allowable axial compression and tension capacity of 30 tons (60 kips), a reduced axial compression capacity of 10 tons (20 kips) or less will eliminate the need to perform Code required axial compression load tests provided the following conditions are satisfied:

1. The pile has a torque to capacity ratio approved in accordance with Section 28-113.2.1 of the Administrative Code.
2. The torque correlation shall demonstrate a factor of safety of 2.5 on the allowable load.

In addition, the relatively loose nature of shallow soil deposits would require significantly larger or longer helical piles to develop higher capacities.

The helical piles must extend through the fill and organic Strata O1 and O2 soils and bear in the natural sands of Strata S1 and S2. The depth of the helical piles will depend on the number of helices used and their diameters. Based on discussions with several helical pile manufacturers, we estimate that an allowable axial compression capacity up to 10 tons can be achieved at depths on the order of 50 feet to 80 feet with three levels of helices having 10, 12 and 14 inch diameters.

Additional considerations for helical pile design include:

1. The minimum center-to-center spacing for helical piles is 4 times the diameter of the largest helix plate.
2. The helical pile design must address the abrasive action that occurs in the installation process when protective exterior treatments are used to mitigate pile corrosion.
3. Helical piles must be checked for buckling when embedded in nominally unsatisfactory bearing materials. Under these conditions, the allowable axial compression load is limited to less than 2/3 of the calculated axial load to cause buckling.

If helical piles do not demonstrate a sufficient torque to capacity ratio during installation to satisfy the Code requirements for the required allowable axial compression capacity, a load test program may be implemented to establish a site-specific torque to capacity ratio. The parameters for this load test program, including the number and type of load tests required, will have to be reviewed and approved by the NYC DOB.

Settlement

For shallow foundations, MRCE performed a settlement analysis to estimate the consolidation settlement of the compressible soils from the loads on new foundation wall footings. Stratum O1 is sporadically present throughout the Broad Channel BIB project limits underlying the fill.

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MRCE analyzed a subsurface profile comprised of the average fill and Stratum O1 thickness encountered in the 2016 borings.

We used the WINSTRESS program to compute the increase in stress in the Stratum O1 soils due to the load from proposed wall footings. Consolidation properties of the organic silty clay were estimated based on a natural water content of 85 percent. The analysis assumed a 2 foot wide, 30 foot long strip load of 1 tsf below two exterior walls of a typical home. The footing bearing elevation was assumed to be 4 feet below ground surface. Stratum F was assumed to be 8 feet thick overlying a 4 feet thick layer of Stratum O1. The groundwater table was assumed to be at a depth of 5 feet below the ground surface.

The results of our analyses indicate that long term consolidation settlements would be on the order of 2 inches at the center of the wall footing and 1 inch at the end of the wall footing (at the corner of the home). Differential settlements are estimated to be on the order of 1 inch across the foundations. These estimates are based on an average amount of peat in Stratum O1. If a thicker layer of Stratum O1 or a higher peat content is present, consolidation settlements would be higher. In areas where Stratum O1 is relatively thin, less consolidation settlement can be expected.

Settlements for deep foundations will be negligible when compared to estimated settlements for shallow foundations provided that the piles are installed below the compressible soil layers. This will not be the case if deep foundations bear in Stratum S1 with the pile tips in close proximity to Stratum O2.

Corrosion Considerations

Attached Figure No. 3 depicts a summary of the soil corrosivity testing results that were obtained from selected samples of different soil strata at the site. Results within the red shaded zones on the plots indicate the possible presence of a corrosive environment as defined by the limits in Section 1812.2.1 of the Code. Figure No. 3 shows that soils from all of the soil strata at the site are potentially corrosive.

Due to the corrosive nature of the soils present across the Broad Channel site, pile corrosion must be considered in the pile design. We recommend that piles be double corrosion protected. For the helical piles, this can be accomplished by using galvanized steel to manufacture the piles then having a shop applied epoxy coating added to them.

Lateral Loads

We understand that the rehabilitated residential structures will be required to support lateral loads due to both wind and possible floods. The recommended pile foundation type cannot support significant lateral loads; therefore, we recommend that wall footings or grade beams be cast above the piles to act as a pile cap and distribute the loads to the piles and provide a rigid frame for the pile foundations.

Depending on the type of foundation selected by the project designers (i.e, shallow or deep foundations), we recommend designing the grade beam pile cap or shallow strip footings to resist applied lateral loads. Either foundation type should be designed to withstand the applied lateral

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loads by engaging the soil in passive resistance. We recommend using a total soil unit weight of 110 pounds per cubic foot and an internal angle of friction of 30 degrees to calculate earth pressures within the fill or possible fill strata. We estimate the grade beams or shallow strip footings would have to extend from approximately 2.5 feet to 3.0 feet below grade to develop enough passive pressure to support a lateral load of 1.0 kip per linear foot (klf) with an appropriate factor of safety. The soil around the grade beam or shallow strip footings would have to be compacted to minimize the movement needed to engage the soil's passive resistance.

Attached Homes

Several homes in Broad Channel are one and two story attached residential structures. In other words, a minimum of two homes are constructed adjacent to each other and share a common interior wall (party wall). Below the party wall is a common foundation that may have been constructed as a continuous wall footing or a series of independent footings supporting columns built within the party wall. In either case, party wall foundations support interior loads from the two attached residential structures.

We understand attached homes in the Broad Channel BIB program that require "rehabilitation by elevation" will not necessarily be elevated, rather, an extra floor will be constructed above the structure's existing upper floor. By adding an extra floor to the structure, the home's lowest livable space will be relocated to the floor above, thereby preventing flooding of the home's lowest livable space.

In order to re-use existing foundations, the project's Architect/Engineer (A/E) will have to confirm the capacity of existing foundations to support additional loads. The quality and size of the footings can be determined by test pits and, if required, coring of the footings. In addition, the bearing capacity of the subgrade below the existing footings will have to be determined via test pits to evaluate if the subgrade can support additional loads.

Alternatively, new foundations will be required to augment or replace existing foundations of the affected homes. Test pits at a select number of locations within and outside the affected homes will be required to determine the type(s) of foundations currently supporting the home so that the new foundation type can be selected.

We understand there are two possible scenarios for the rehabilitation of attached or semi-detached homes. The first scenario is for two homes that share a party wall are both scheduled for rehabilitation and the second scenario is for rehabilitating only one home that shares a party wall. In the case of the first scenario, new foundations can be installed at both homes and transfer beams used to transmit the loads from the existing party wall to the new foundations. For the second scenario, the new foundations would have to be installed inboard of the existing foundations which would reduce the interior space of the home's first level as the structural framing for the added floor would need to extend to new foundations.

In addition, determination of the bottom elevation of shallow foundations must take into account the need to prevent load transfer from one shallow foundation to another adjacent shallow foundation by load distribution through the bearing stratum. Where ever possible, maintaining the bottom elevation of shallow foundations at a constant elevation would prevent the inadvertent loading of adjacent shallow foundations to occur.

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Lisa G. Amola

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CONSTRUCTION CONSIDERATIONS

Due to the shallow groundwater table within the project limits, construction dewatering may be required for construction of shallow foundations or pile cap grade beams with a minimum embedment of 4 feet. A dewatering system such as a wellpoint system or closely spaced sumps would be required to lower the groundwater table a minimum of 2 feet below the final foundation subgrade elevation in advance of excavation. If test pit excavations are to be used for shallow foundations bearing in the fill, the groundwater table may need to be lowered beyond 2 feet below subgrade elevation in advance of excavation.

Subgrades for footings will have to be inspected by a Special Inspector prior to constructing the footing in accordance with the Code. Given the loose nature of the shallow bearing soils and the shallow groundwater table, the subgrade will be sensitive to disturbance and may require a concrete mud mat to limit disturbance.

Excavations for new foundations may undermine adjacent shallow home foundations. It is likely that some of the adjacent home foundations were installed above the frost line and excavations for new structures near adjacent structures could undermine these shallow foundations. In addition, if the adjacent home structure is in poor condition, the foundations could be susceptible to damage. Where these conditions exist and excavations for new grade beams will be adjacent to or lower than the adjacent foundations, we recommend a pre-construction condition survey be performed to assess the structural stability of the adjacent homes. Excavations for the new foundations should also be made in tightly sheeted pits to minimize potential lateral and vertical movement of the adjacent homes and their foundations.

Backfill around footings or grade beams and below slabs should consist of structural fill conforming to Code requirements for controlled structural fill. All structural fill should be placed in loose lifts not exceeding 12 inches and compacted to a minimum 95% of Modified Proctor maximum dry density (ASTM D1557). Fill density must be verified using in-place tests with fill placement and compaction subject to Special Inspection by a qualified Geotechnical Engineer.

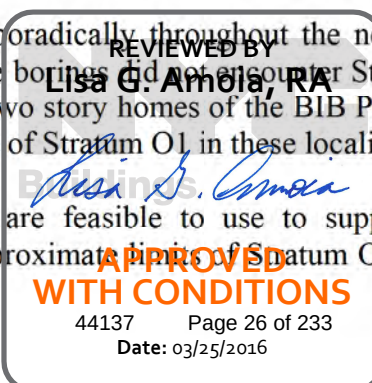
Backfilling is not permitted in freezing weather, with frozen materials, or upon frozen materials. Every effort must be made to prevent surface water runoff from entering excavations and backfill areas by using perimeter berms and dikes. Slopes, crowns and ditches on backfill surfaces should be maintained to ensure proper surface drainage and prevent surface water from ponding or softening backfill surfaces and soil subgrades.

Installation of helical piles will have to be inspected by a Special Inspector in accordance with the Code.

CONCLUSION

Stratum O1 was encountered sporadically throughout the neighborhood in 30 of the 39 2016 borings. In localized areas where borings did not encounter Stratum O1, shallow foundations can be used to support the one and two story homes of the BIB Program. Further investigations may be required to verify the absence of Stratum O1 in these localized areas.

Although shallow foundations are feasible to use to support one or two story residential structures located within the approximate limits of Stratum O1, we do not recommend that they



be used due to the thickness and elevation of Stratum O1 and the settlement that will result from the consolidation of Stratum O1. In addition, the shallow foundation alternative will require that additional investigations be performed in the field during construction to verify the adequacy of the subgrade and the potential for over-excavation and replacement with structural fill.

We believe that deep foundations, such as helical piles, would be a better alternative where Stratum O1 is present as it would provide a more robust foundation system that is less sensitive to settlement of the soft organic soils. The deep foundation alternative described in this report will limit the potential for construction dewatering, over-excavation and long term consolidation settlement of the homes.

We trust that this report will allow the Queens BIB Design Team to continue the design and construction of the foundations for the homes currently enrolled in the Broad Channel BIB program.

LIMITATIONS

The recommendations provided in this report are based in part on historical boring information and widely spaced supplemental borings made within the BIB neighborhood of Broad Channel. Subsurface conditions at localized areas may vary from the conditions encountered in borings and documented in this report. These variations may impact foundation design and construction.

Recommendations provided herein are intended for the home addresses listed on attached Table No. 1 entitled "Broad Channel Home Addressed in this Report (2-23-16)". If at a later date additional Broad Channel, Queens BIB Program homes are released to A/E's for design and construction work to follow, additional studies would be required to evaluate foundation recommendations for those homes.

MRCE did not perform a scour analysis for this site or evaluate the potential for erosion. We expect that work will be performed by other Queens BIB Design Team members.

Very truly yours,

MUESER RUTLEDGE CONSULTING ENGINEERS

By: 
Pablo V. Lopez, PE

By: 
Tony D. Canale, PE

Attachments

MTM:PVL:TDC

F:\124\12481-NYC BIB\12481B-Tishman\3. Broad Channel\Report\Final\12481B_3-4-16_EC_Final Geotech Report.docx

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Lisa G. Amoia, RA
Tony D. Canale, PE



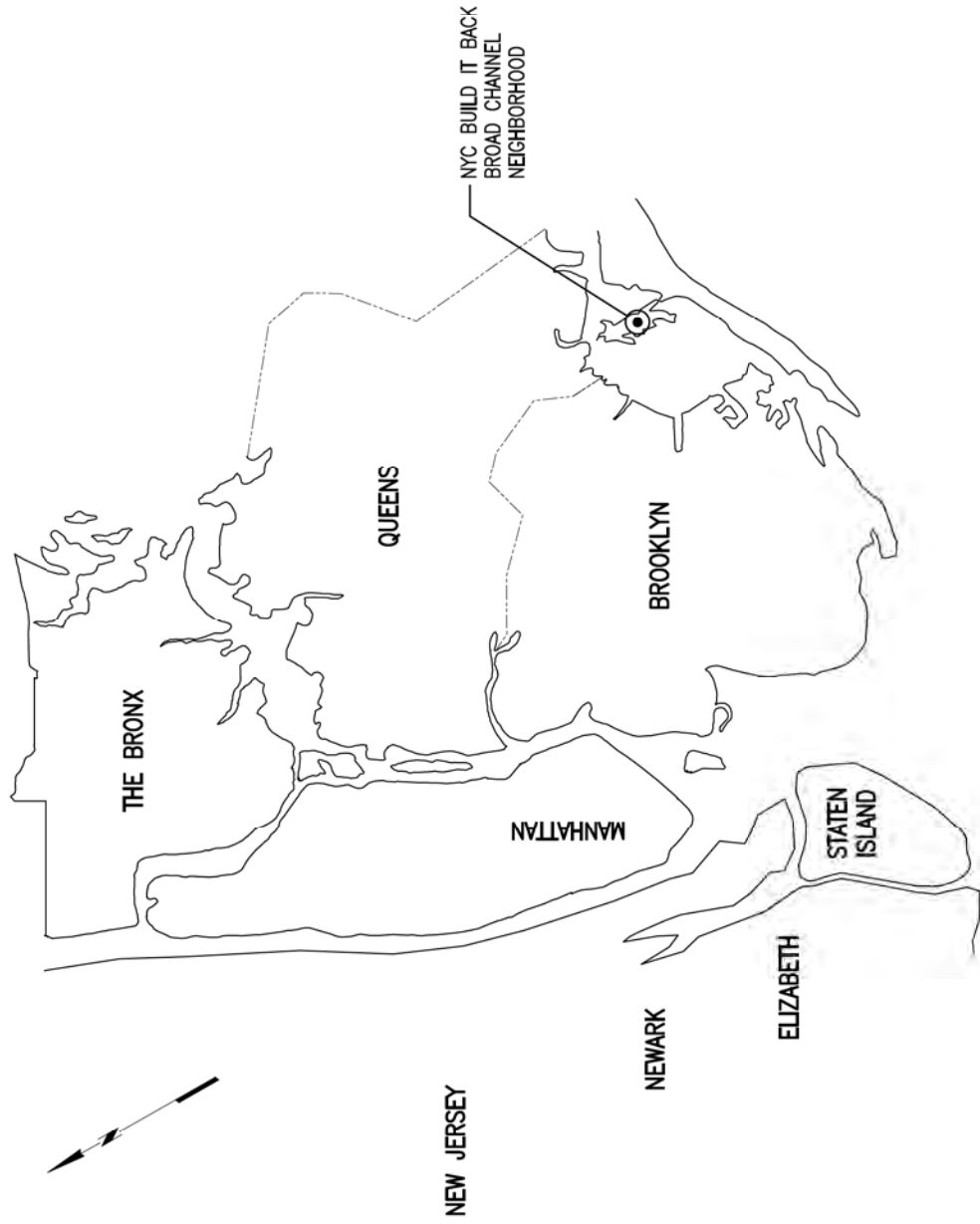
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EXHIBITS



NYC BUILD IT BACK BROAD CHANNEL



VICINITY MAP
SCALE: NO SCALE

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NOTES:
1. FOR GENERAL NOTES, SEE DRAWING NO. BC-2.

LEGEND:
--- PROJECT LIMITS

3	02-29-16	M.T.M.	UPDATED PROJECT LIMITS	NEW YORK
2	01-05-16	M.T.M.	UPDATED PROJECT LIMITS	
1	12-04-15	M.T.M.	UPDATED PROJECT LIMITS	
REV.	DATE	BY	DESCRIPTION	
NYC BUILD IT BACK BROAD CHANNEL				
QUEENS		NEW YORK		
NEW YORK		AECOM		
NEW YORK				
MUESER RUTLEDGE CONSULTING ENGINEERS				
14 PENN PLAZA – 225 W. 34TH STREET, NY, NY 10122				
SCALE	MADE BY: L.R.	DATE: 11-04-2015	FILE NUMBER	NEW YORK
GRAPHIC	CHKD BY: M.T.M.	DATE: 11-04-2015	12481B	
KEY PLAN			DRAWING NUMBER	BC-1

EXISTING BORING SUMMARY TABLE		
REFERENCE NUMBER	COMPANY	JOB NUMBER
1	DDC	SES 1503
2	DDC	SES 1533
3	DDC	SES 1541
4	DDC	SES 1542
5	DDC	SES 1882
6	DDC	SES 2152
7	DDC	SES 2937
8	DDC	SES 3174
9	DDC	SES 3933
10	DDC	WPA-QN-204
11	MRCE	MRCE-Q-380

GENERAL NOTES:

1. BASE PLAN WAS PROVIDED BY AECOM ON JULY 29, 2015.
2. PROJECT LIMITS SHOWN ON DRAWINGS WERE APPROVED BY AECOM ON NOVEMBER 1, 2015.
3. HISTORIC BORING INFORMATION WAS OBTAINED FROM MRCE FILES, THE CITY OF NEW YORK DEPARTMENT OF DESIGN AND CONSTRUCTION, AND OTHERS. HISTORIC BORING LOCATIONS ARE APPROXIMATE BASED ON INFORMATION PROVIDED.
4. FOR DETAILS ON EXISTING BORINGS, SEE REFERENCE NUMBERS ON EXISTING BORING SUMMARY TABLE.
5. LOCATIONS OF STRUCTURES ENROLLED IN BUILD IT BACK PROGRAM ARE APPROXIMATE BASED ON ADDRESSES PROVIDED BY AECOM.
6. BORING NOS. BC-1 THROUGH BC-38 WERE MADE BY WARREN GEORGE INC. BETWEEN DECEMBER 2015 AND JANUARY 2016 UNDER THE CONTINUOUS INSPECTION OF MRCE AND DYNAMIC EARTH, LLC RESIDENT ENGINEERS.
7. BORING NO. BC-39 WAS MADE BY AQUIFER DRILLING AND TESTING INC. IN FEBRUARY 2016 UNDER THE CONTINUOUS INSPECTION OF MRCE RESIDENT ENGINEERS.
8. AS-DRILLED LOCATIONS AND GROUND SURFACE ELEVATIONS FOR BORING NOS. BC-1 THROUGH BC-38 WERE SURVEYED BY HIRANI ENGINEERING AND LAND SURVEYING, P.C. DATED FEBRUARY 24, 2016. AS-DRILLED LOCATION AND GROUND SURFACE ELEVATION FOR BORING NO. BC-39 ARE APPROXIMATE BASED ON FIELD MEASUREMENTS.

BORING LOCATIONS:

1. ALL ATTEMPTS WERE MADE TO LOCATE THE BORINGS WITHIN SUBJECT PROPERTIES. IF DEEMED NECESSARY BY THE SPECIAL INSPECTOR, BORING LOCATIONS WERE RELOCATED TO THE SIDEWALK. IF THE SPECIAL INSPECTOR DEEMED IT NOT FEASIBLE TO ADVANCE THE BORING ON EITHER THE SUBJECT PROPERTY OR THE SIDEWALK DUE TO SITE RESTRICTIONS, BORINGS WERE RELOCATED TO THE STREET.

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3	02-29-16	M.T.M.	REVISED NOTES
2	01-05-16	M.T.M.	UPDATED NOTES
1	12-04-15	M.T.M.	UPDATED NOTES
REV.	DATE	BY	DESCRIPTION
NYC BUILD IT BACK BROAD CHANNEL			
QUEENS			NEW YORK
NEW YORK			NEW YORK
MUESER RUTLEDGE CONSULTING ENGINEERS 14 PENN PLAZA – 225 W. 34TH STREET, NY, NY 10122			
SCALE NONE	MADE BY: L.R. CHKD BY: M.T.M.	DATE: 11-04-2015 DATE: 11-04-2015	FILE NUMBER 12481B
NOTES			BC-2



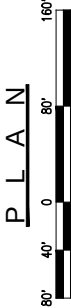
NOTE:
1. FOR SITE PLAN SEE DRAWING BC-1 AND FOR NOTES SEE DRAWING BC-2.

EXISTING BORING SUMMARY TABLE	
REFERENCE NUMBER	COMPANY
1	DDC
2	DDC
6	DDC

LEGEND:

- B-XX
XX — EXISTING BORING
REFERENCE NUMBER
- BC-XP
— 2016 MRCE BORING
P — INDICATES PIEZOMETER
- PROJECT LIMITS
- STRUCTURE ENROLLED IN BUILD IT BACK PROGRAM AS OF 02/24/2016

1	02-29-16	M.T.M.	ADDED AS-DRILLED LOCATIONS AND UPDATED PROJECT LIMITS
REV.	DATE	BY	DESCRIPTION
NYC BUILD IT BACK BROAD CHANNEL			
QUEENS		NEW YORK	
NEW YORK		AECOM	
NEW YORK		NEW YORK	
MUESER RUTLEDGE CONSULTING ENGINEERS 14 PENN PLAZA – 225 W. 34TH STREET, NY, NY 10122			
SCALE GRAPHIC	MADE BY: L.R. CHKD BY: M.T.M.	DATE: 11-04-2015 DATE: 11-04-2015	FILE NUMBER 12481B DRAWING NUMBER
BORING LOCATION PLAN SHEET 1 OF 6			BC-3



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NOTE:
1. FOR SITE PLAN SEE DRAWING BC-1 AND FOR NOTES SEE DRAWING BC-2.

EXISTING BORING SUMMARY TABLE	
REFERENCE NUMBER	COMPANY
1	DDC
4	DDC
6	DDC

LEGEND:

B-XX
XX
- EXISTING BORING
REFERENCE NUMBER

BC-XP
- 2016 MRCE BORING
P - INDICATES PIEZOMETER

-- PROJECT LIMITS

STRUCTURE ENROLLED IN BUILD IT BACK
PROGRAM AS OF 02/24/2016

REV.	DATE	BY	DESCRIPTION
3	02-29-16	M.T.M.	ADDED AS-DRILLED LOCATIONS AND UPDATED PROJECT LIMITS
2	01-05-16	M.T.M.	UPDATED PROJECT LIMITS AND PROPOSED BORING LOCATIONS
1	12-04-15	M.T.M.	UPDATED PROJECT LIMITS AND PROPOSED BORING LOCATIONS

QUEENS	NEW YORK	NEW YORK
NYC BUILD IT BACK BROAD CHANNEL		
AECOM		
NEW YORK	NEW YORK	NEW YORK

MUESER RUTLEDGE CONSULTING ENGINEERS
14 PENN PLAZA - 225 W. 34TH STREET, NY, NY 10122

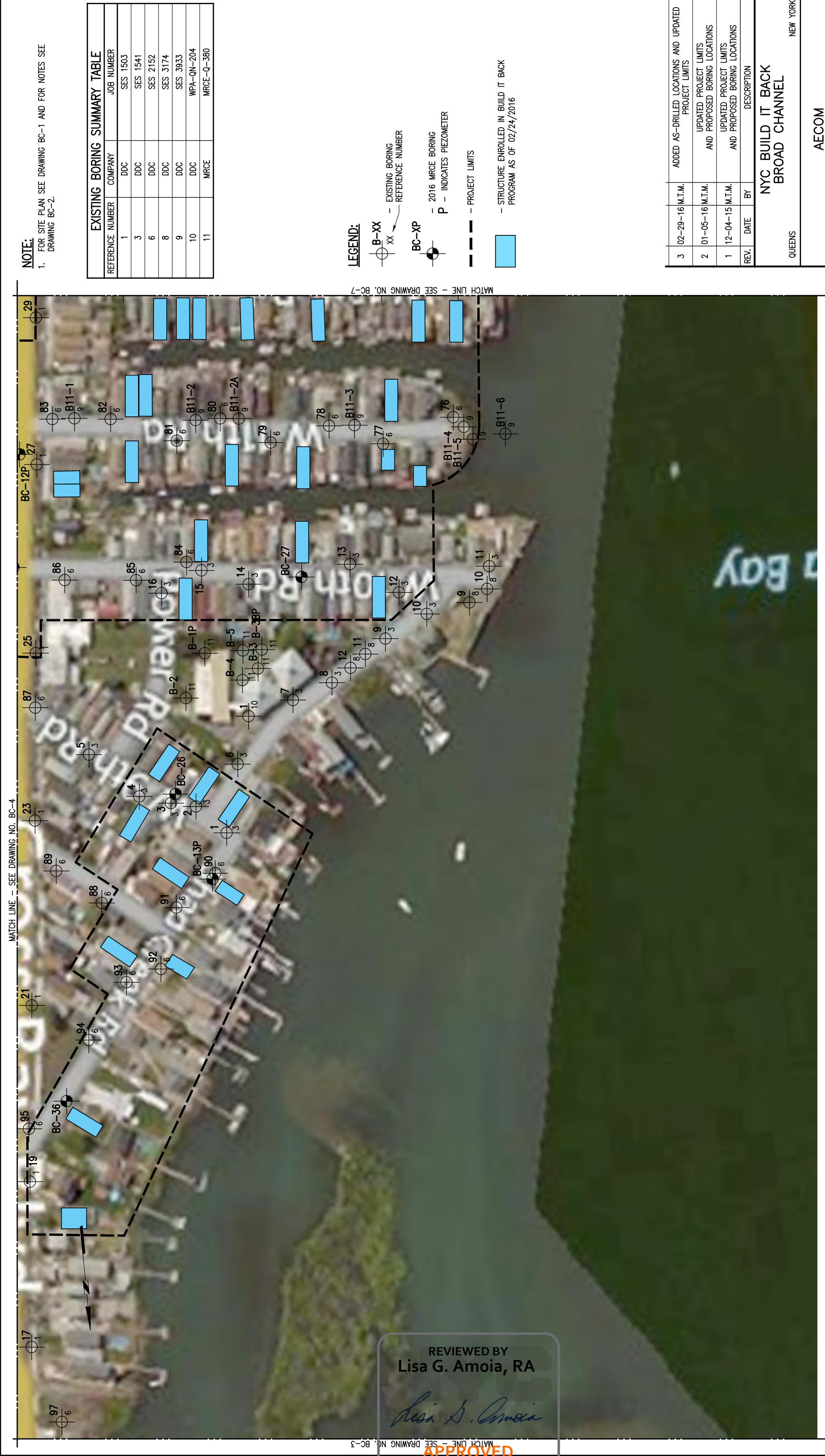
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GRAPHIC	CHKD BY: M.T.M.	DATE: 11-04-2015	12481B

BORING LOCATION PLAN SHEET 2 OF 6		BC-4
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Date: 03/25/2016



NOTE:
1. FOR SITE PLAN SEE DRAWING BC-1 AND FOR NOTES SEE DRAWING BC-2.

EXISTING BORING SUMMARY TABLE	
REFERENCE NUMBER	COMPANY
1	DDC
3	DDC
6	DDC
8	DDC
9	DDC
10	DDC
11	MRCE

JOB NUMBER
SES 1503
SES 1541
SES 2152
SES 3174
SES 3933
WPA-QN-204
MRCE-Q-380

LEGEND:

B-XX
XX
- EXISTING BORING
- REFERENCE NUMBER

BC-XP
P
- 2016 MRCE BORING
- INDICATES PIEZOMETER

- PROJECT LIMITS

- STRUCTURE ENROLLED IN BUILD IT BACK PROGRAM AS OF 02/24/2016

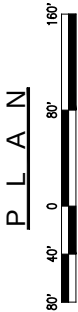
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2	01-05-16	M.T.M.	UPDATED PROJECT LIMITS AND PROPOSED BORING LOCATIONS
1	12-04-15	M.T.M.	UPDATED PROJECT LIMITS AND PROPOSED BORING LOCATIONS

NEW YORK		NEW YORK	
QUEENS		AECOM	
NYC BUILD IT BACK BROAD CHANNEL		NEW YORK	

NEW YORK		NEW YORK	
MUESER RUTLEDGE CONSULTING ENGINEERS		NEW YORK	
14 PENN PLAZA - 225 W. 34TH STREET, NY, NY 10122		NEW YORK	

SCALE	MADE BY: L.R.	DATE: 11-04-2015	FILE NUMBER
GRAPHIC	CHKD BY: M.T.M.	DATE: 11-04-2015	12481B

BORING LOCATION PLAN SHEET 3 OF 6		BORING LOCATION PLAN SHEET 3 OF 6	
BC-5		BC-5	



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Kesi S. Amala

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Date: 03/25/2016

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Date: 03/25/2016

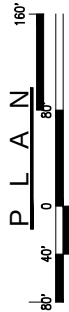
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Lisa G. Amoia, RA



MATCH LINE - SEE DRAWING NO. BC-7



NOTE:

1. FOR SITE PLAN SEE DRAWING BC-1 AND FOR NOTES SEE DRAWING BC-2.

EXISTING BORING SUMMARY TABLE		
REFERENCE NUMBER	COMPANY	JOB NUMBER
1	DDC	SES 1503
5	DDC	SES 1882
6	DDC	SES 2152

MATCH LINE - SEE DRAWING NO. BC-8

LEGEND:



BC-XP

— 2016 MRCE BORING

P – INDICATES PIEZOMETER

— PROJECT LIMITS

— STRUCTURE ENROLLED IN BUILD IT BACK
PROGRAM AS OF 02/24/2016

3	02-29-16	M.T.M.	ADDED AS-DRILLED LOCATIONS AND UPDATED PROJECT LIMITS
2	01-05-16	M.T.M.	UPDATED PROJECT LIMITS AND PROPOSED BORING LOCATIONS
1	12-04-15	M.T.M.	UPDATED PROJECT LIMITS AND PROPOSED BORING LOCATIONS
REV.	DATE	BY	DESCRIPTION

QUEENS
NEW YORK

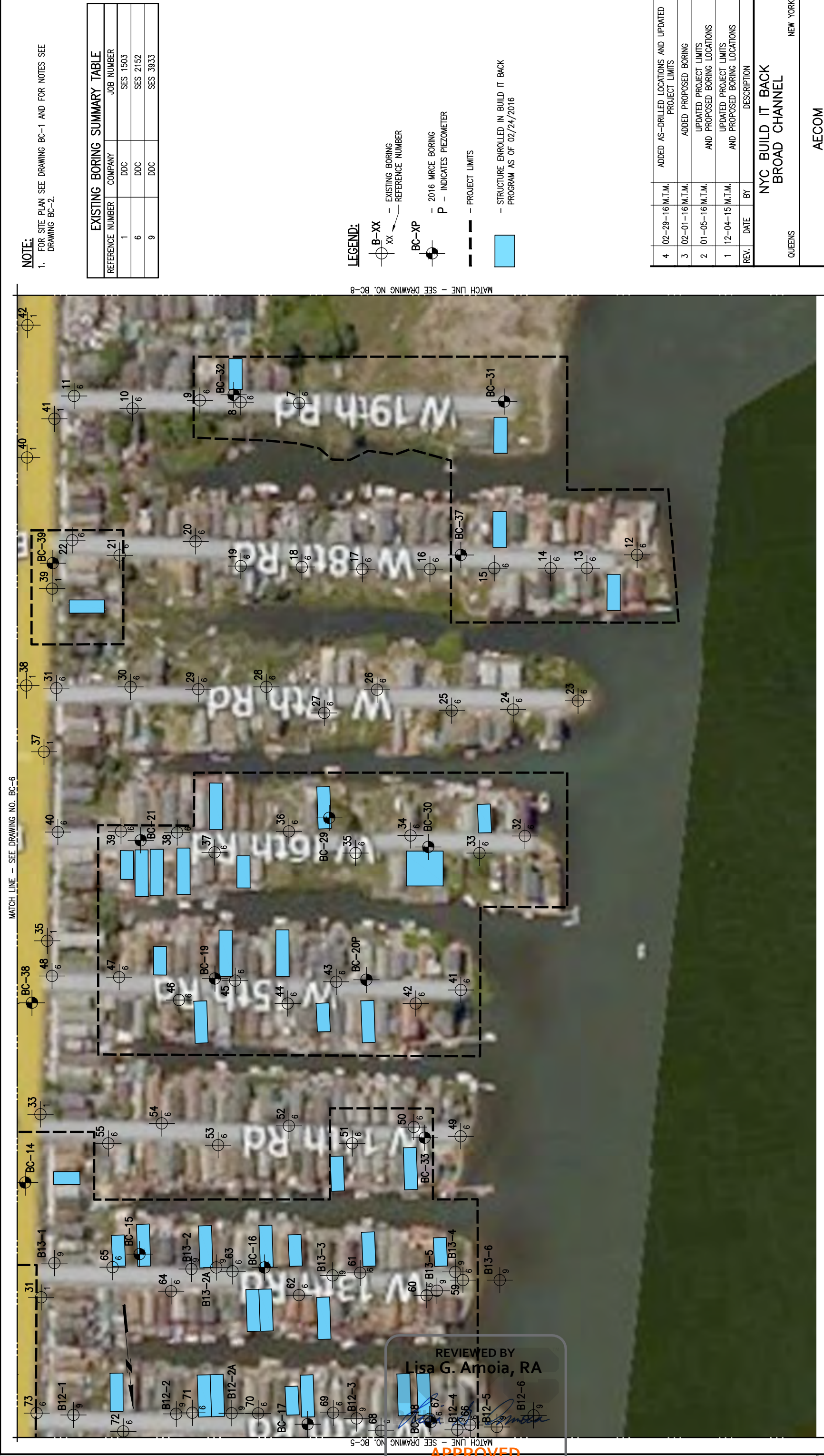
AECOM

NEW YORK NEW YORK

MUESER RUTLEDGE CONSULTING ENGINEERS
14 PENN PLAZA - 225 W. 34TH STREET, NY, NY 10122

SCALE	MADE BY: L.R.	DATE: 11-04-2015	FILE NUMBER
GRAPHIC	CH'KD BY: M.T.M.	DATE: 11-04-2015	12481B

BORING LOCATION PLAN
 SHEET 4 OF 6



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Date: 03/25/2016

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NOTE:
1. FOR SITE PLAN SEE DRAWING BC-1 AND FOR NOTES SEE DRAWING BC-2.

EXISTING BORING SUMMARY TABLE	
REFERENCE NUMBER	COMPANY
1	DDC
6	DDC
9	DDC

LEGEND:

B-XX
XX

BC-XP

P

--

STRUCTURE ENROLLED IN BUILD IT BACK PROGRAM AS OF 02/24/2016

4	02-29-16 M.T.M.	ADDED AS-DRILLED LOCATIONS AND UPDATED PROJECT LIMITS
3	02-01-16 M.T.M.	ADDED PROPOSED BORING
2	01-05-16 M.T.M.	UPDATED PROJECT LIMITS AND PROPOSED BORING LOCATIONS
1	12-04-15 M.T.M.	UPDATED PROJECT LIMITS AND PROPOSED BORING LOCATIONS
REV.	DATE	BY

NYC BUILD IT BACK BROAD CHANNEL	
QUEENS	NEW YORK

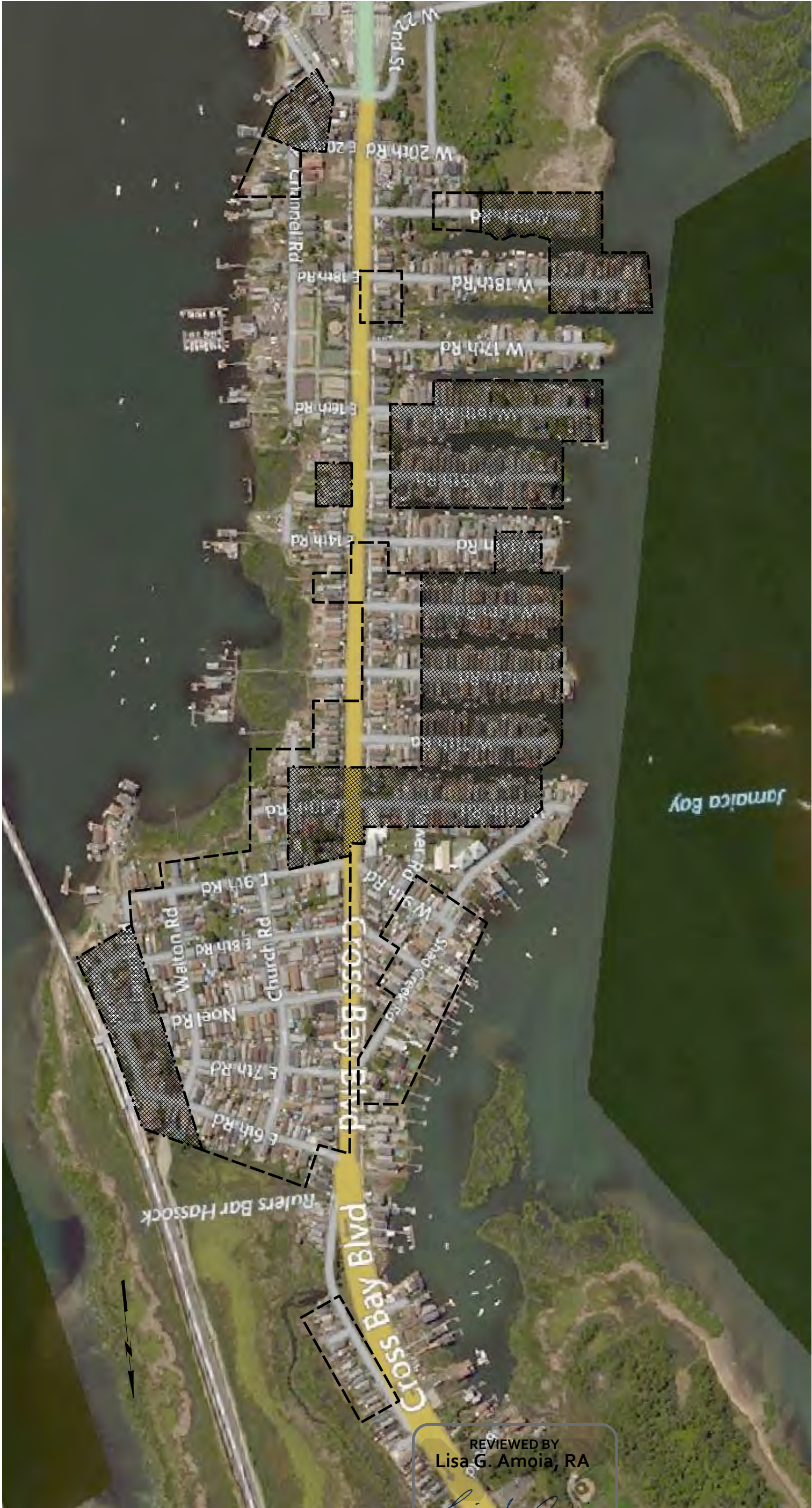
AECOM	
NEW YORK	NEW YORK

MUESER RUTLEDGE CONSULTING ENGINEERS 14 PENN PLAZA - 225 W. 34TH STREET, NY, NY 10122	
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GRAPHIC	CHKD BY: M.T.M.	DATE: 11-04-2015	12481B

BORING LOCATION PLAN SHEET 5 OF 6		BC-7
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- NOTES:**
1. APPROXIMATE LIMITS OF STRATUM O2 ARE BASED ON MRCE INTERPRETATION OF SUBSURFACE CONDITIONS ENCOUNTERED IN HISTORIC BORINGS AND 2015 SUPPLEMENTAL SUBSURFACE INVESTIGATION.

LEGEND:



APPROXIMATE LIMITS OF STRATUM O2.



PROJECT LIMITS

P L A N
SCALE: NO SCALE

APPROXIMATE LIMITS
OF STRATUM O1 & O2

QUEENS	NEW YORK
MUESER RUTLEDGE CONSULTING ENGINEERS	
14 PENN PLAZA - 225 WEST 34TH STREET, NEW YORK, NY 10122	
MADE BY: L.R.	DATE: 02-29-2016
CHKD BY: M.T.M.	
FILE NUMBER: 12481B	DRAWING NUMBER: BC-9