HAGER-RICHTER
GEOSCIENCE, INC.

GEOPHYSICAL SURVEY
250 WATER STREET
MANHATTAN, NEW YORK

Prepared for:

Langan
21 Penn Plaza
360 West 31st Street, 8th Floor
New York, New York 10001-2727

Prepared by:

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File 20AM08
June 2020

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File 20AM08

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RE: Geophysical Survey
250 Water Street
Manhattan, New York

Dear Mr. Yanowitz:

In this report, we summarize the results of a geophysical survey conducted in June 2020 by Hager-Richter Geoscience, Inc., dba HR Geological Services in New York (HRGS), at 250 Water Street in Manhattan, New York for Langan. The scope of the project and area of interest were specified by Langan.

INTRODUCTION

The site is located at 250 Water Street (Block 98, Lot 1) in Manhattan, New York as shown on Figure 1. The site is bounded by Pearl Street to the North, Peck Slip to the East, Water Street to the South and Beekman Street to the West. Langan specified the area of interest (AOI) as the entire city block. The AOI comprises an active parking lot and adjacent sidewalks and is approximately 48,000 square feet in size. The site was formerly occupied by a thermometer factory and several other buildings that were demolished and paved over several decades ago. A portion of the site, located south of the entry gates, has developed a surface depression.

Langan requested a geophysical survey to determine whether sub-surface features such as underground storage tanks (USTs), utilities, former foundations, and voids are present in the accessible portions of the site. Langan was also interested in determining whether utilities were present at the proposed locations of 36 borings at the site.

OBJECTIVE

The objective of the geophysical survey was to detect, and if detected, to locate sub-surface features such as USTs, utilities, foundations and voids in the accessible portions of the AOI, and to clear utilities in the vicinity of 36 proposed boring locations.

THE SURVEY

Amanda Fabian, P.G., Alexis Martinez and Ariana Martinez, conducted the field operations on June 15 and 16, 2020. The project was coordinated with Mr. Joseph Yanowitz of Langan. Mr. Thomas Schiefer, also of Langan, specified the AOI and was present on site during the survey. Photos 1 and 2 show general site conditions within the parking lot.

Photo 1. General site conditions; looking northwest

Photo 2. Surface depression in western portion of site

The geophysical survey was conducted using three complementary geophysical methods: time domain electromagnetic induction (EM61), ground penetrating radar (GPR), and precision utility location (PUL). The EM61 data were acquired at approximately 8-inch intervals along lines spaced 5 feet apart in the accessible portions of the AOI. The EM survey detects and outlines areas containing buried metal. However, the EM method cannot provide information on the type of objects causing EM anomalies.

In order to aid in the identification of the objects, GPR data were acquired in two mutually perpendicular directions and spaced no more than 2 feet apart in one direction and 5 feet apart in a perpendicular direction across the accessible portions of the site. The GPR method is useful for detecting both metallic and non-metallic subsurface objects. The two-foot spacing was adequate to detect voids with a horizontal dimension of at least two feet with a high degree of confidence within the effective depth of GPR signal penetration.

The PUL system was used for tracking utilities in the AOI by connecting the transmitter to conductive surface features such as light poles, valves, and hydrants and by scanning the AOI for the presence of live electric lines.

EQUIPMENT AND PROCEDURES

EM61. For the EM61 survey, we used a Geonics EM61-MK2 time domain electromagnetic induction metal detector. The EM61 is a time-domain electromagnetic induction type instrument designed specifically for detecting buried metal objects. An air-cored 1-meter by ½-meter transmitter coil generates a pulsed primary magnetic field in the earth, thereby inducing eddy currents in nearby metal objects. The decay of the eddy current produces a secondary magnetic field that is sensed by two receiver coils, one coincident with the transmitter and one positioned 40 cm above the main coil. By measuring the secondary magnetic field after the current in the ground has dissipated but before the current in metal objects has dissipated, the instrument responds only to the secondary magnetic field produced by metal objects. Four channels of secondary response are measured in mV and are recorded on a digital data logger. The system is generally operated by pushing the coils as a wagon with an odometer mounted on the axle to trigger the data logger automatically at approximately 8-inch intervals.

GPR. The GPR survey was conducted using a Geophysical Survey Systems, Inc. UtilityScan HS system using a Hyper Stacking antenna with central frequency of 350 MHz and a 100 ns time window. The system includes a survey wheel that triggers the recording of the data at fixed intervals, thereby increasing the accuracy of the locations of features detected along the survey lines.

GPR uses a high-frequency electromagnetic pulse (referred to herein as “radar signal”) transmitted from a radar antenna to probe the subsurface. The transmitted radar signals are reflected from subsurface interfaces of materials with contrasting electrical properties. The travel times of the radar signal can be converted to approximate depth below the surface by correlation with targets of known depths, including stratigraphic horizons, pipes, cables, and other utilities, or by using handbook values of velocities for the materials in the subsurface. The acquisition of GPR data was monitored in the field on a graphic recorder and the real time images were immediately available for field use. The GPR data were also recorded digitally for subsequent processing. Interpretation of the records is based on the nature and intensity of the reflected signals and on the resulting patterns.

PUL. The PUL survey was conducted using a precision electromagnetic pipe and cable locator, Radiodetection RD7000 series. The RD7000 series consists of separate transmitter and receiver. The system can be used in "passive" and "active" modes to locate buried pipes by detecting electromagnetic signals carried by the pipes. In the "passive" mode, only the receiver unit is used to detect signals carried by the pipe from nearby power lines, live signals transmitted along underground power cables, or very low frequency radio signals resulting from long wave radio transmissions that flow along buried conductors. In the "active" mode of operation, the transmitter is used to induce a signal on a target pipe, and the receiver is used to trace the signal along the length of the pipe. Our system uses a 10W transmitter.

LIMITATIONS OF THE METHODS

> HAGER-RICHTER GEOSCIENCE, INC. MAKES NO GUARANTEE THAT ALL SUBSURFACE TARGETS OF INTEREST WERE DETECTED IN THIS SURVEY. HAGER-RICHTER GEOSCIENCE, INC. IS NOT RESPONSIBLE FOR DETECTING SUBSURFACE TARGETS THAT NORMALLY CANNOT BE DETECTED BY THE METHODS EMPLOYED OR THAT CANNOT BE DETECTED BECAUSE OF SITE CONDITIONS. GPR SIGNAL PENETRATION MAY NOT BE DEEP ENOUGH TO DETECT SOME TARGETS. HAGER-RICHTER GEOSCIENCE, INC. IS NOT RESPONSIBLE FOR MAINTAINING FIELD MARKOUTS AFTER LEAVING THE WORK AREA. THE CLIENT UNDERSTANDS THAT MARK-OUTS MADE DURING INCLEMENT WEATHER OR IN AREAS OF HIGH PEDESTRIAN OR VEHICULAR TRAFFIC MAY NOT LAST.

Field mark-outs. Utilities detected by the geophysical methods at the time of the survey are marked in the field, and the operator makes every attempt, field conditions permitting, to detect and mark as many utilities as possible at the time of survey. Adverse weather and site conditions (rain, snow, snow and soil piles, uneven surfaces, high traffic, etc.) can hamper in-field interpretation. Utility mark-outs made on wet pavement, snow, snow piles, gravel surfaces, or in active construction zones may not last. HRGS is not responsible for maintaining utility mark-outs after leaving the work area.

EM61. All electromagnetic geophysical methods, including the EM method used here, are affected by the presence of power lines and surface metal objects (steel sided buildings, dumpsters, vehicles, railroad tracks, reinforced concrete, etc.). Where such are present, the effects of materials in the subsurface may be masked, and firm conclusions about subsurface conditions cannot be made.

Detection and identification should be clearly differentiated. Detection is the recognition of the presence of a metal object, and the electromagnetic method is excellent for such purposes. Identification, on the other hand, is determination of the nature of the causative body (i.e., what is the body -- utilities, foundations, automobiles, white goods, etc.?). Although the EM61 data cannot be used to identify buried metal objects, they provide excellent guides to the identification of some objects. For example, buried metal utilities produce anomalies with lengths many times their widths.

GPR. There are limitations of the GPR technique as used to detect and/or locate targets such as those of the objectives of this survey: (1) surface conditions, (2) electrical conductivity of the ground, (3) contrast of the electrical properties of the target and the surrounding soil, and (4) spacing of the traverses. Of these restrictions, only the last is controllable by us.

The condition of the ground surface can affect the quality of the GPR data and the depth of penetration of the GPR signal. Sites covered with snow piles, high grass, bushes, landscape structures, debris, obstacles, soil mounds, etc. limit the survey access and the coupling of the GPR antenna with the ground. In many cases, the GPR signal will not penetrate below concrete pavement, especially inside buildings, and a target may not be detectable. The GPR method also commonly does not provide useful data under canopies found at some facilities. GPR surveys inside buildings may be severely constrained by space limitations and interference from above-grade structures.

The electrical conductivity of the ground determines the attenuation of the GPR signals, and thereby limits the maximum depth of exploration. For example, the GPR signal does not penetrate clay-rich soils, and targets buried in clay might not be detected.

A definite contrast in the electrical conductivities of the surrounding ground and the target material is required to obtain a reflection of the GPR signal. If the contrast is too small, possibly due to construction details or deeply corroded metal in the target, then the reflection may be too weak to recognize, and the target can be missed. In many cases, plastic, clay, asbestos concrete (transite), brick-lined, stone-lined, and other non-metallic utilities cannot be detected.

Spacing of the traverses is limited by access at many sites, but where flexibility of traverse spacing is possible, the spacing is adjusted to the size of the target. The GPR operator controls the spacing between lines, and the design of the survey is based on the dimensions of the smallest feature of interest. Targets with dimensions smaller than the spacing between GPR survey lines can be missed.

PUL. The PUL equipment cannot detect non-metallic utilities, such as pipes constructed of vitrified clay, transite, plastic, PVC, fiberglass, and unreinforced concrete, when used in passive mode alone. Such pipes can be detected if a wire tracer is installed with access to such tracer for transmission of a signal or where access (such as floor drains and clean-outs) permits insertion of a device on which a signal can be transmitted.

In some, but not all, cases, the subsurface utility designation equipment cannot detect metal utilities reliably under reinforced concrete because the signal couples onto the metal reinforcing in the concrete. Similarly, the method commonly cannot be used adjacent to grounded metal structures such as chain link fences and metal guardrails.

In congested areas, where several utilities are bundled or located within a short distance, the signal transmitted on one utility can couple onto adjacent utilities, and the accuracy of the location indicated by the instrument decreases.

RESULTS

The geophysical survey was conducted using EM61, GPR and PUL methods across the accessible portions of the specified AOI. Figure 2 is a color contour plot of the EM61 survey, and Figure 3 shows the locations of the GPR traverses, the approximate location of the former structures, and an integrated interpretation of the geophysical data.

In addition to the site-wide survey, a more detailed GPR survey was conducted in the vicinity of 36 proposed boring locations within the limits of the site to detect subsurface utilities or other buried structures prior to drilling activities. The features detected with the GPR and PUL in the vicinity of the proposed boring locations were marked in the field at the time of the survey. We note that after the office data review of the GPR data, numerous utilities and other subsurface objects were detected that were not marked in the field at the time of the survey.

EM61. Interpretation of EM data is based on the relative response of the instrument in millivolts to local conditions. The instrument is not calibrated to provide an absolute measure of a particular property, such as the conductivity of the soil or the strength of the earth's magnetic field. Subsurface metal objects produce sharply defined positive anomalies when the EM61 is positioned directly over them. Acquiring data at short intervals along closely spaced lines, as was done at the subject site, provides high spatial resolution of the location and footprint of the targets. Thus, buried metal is recognized in contour plots of EM data by positive anomalies roughly corresponding to the dimensions of the buried metal.

Several high amplitude EM anomalies are evident in Figure 2. Surface metal objects typically produce high amplitude EM anomalies, and those EM anomalies attributed to the effects of surface metal structures such as the parking attendant booth, the fence, reinforced concrete pads, etc. are indicated as such in Figure 3. We note that the presence or absence of subsurface metal in such areas cannot be determined based on the EM data alone due to the anomaly caused by the surface metal object.

Many low to high amplitude anomalies with an EM response >100 mV, not associated with surface metal, are present throughout the site indicating the widespread presence of metal objects in the subsurface. We note that the 100-mV threshold was selected for this specific site based on the high background EM levels. In urban sites with fill such as the subject site, the threshold is typically higher than for undeveloped areas due to fill and other metal object present at the surface and subsurface at urban sites. These anomalies are attributed to buried metal and are shown as red hatched areas on Figure 3. The GPR records for such locations were carefully examined to determine the cause. Several low amplitude linear EM61 anomalies were detected and are attributed to possible metallic utilities. The EM detected utilities were also detected by the GPR and/or PUL methods.

GPR. General. The locations of the GPR traverses and the integrated interpretation of the geophysical data are shown in Figure 3. Apparent GPR signal penetration was variable, with reflections received for about 25-45 nanoseconds. Based on velocity matching calibrations made for the area of interest, the GPR signal penetration is estimated to have been about 3-6 feet.

Subsurface Structures. GPR reflections typical for possible USTs were observed in the GPR records for the Site. Five possible USTs were detected, four of which were located under a portion of reinforced concrete pad near the fence along Peck Slip. The report for a previous geophysical survey at the site, conducted in 2015 by others, indicated the presence of a single tank at the same location. An additional UST was detected in the southwest portion of the site, but we note that there is no EM anomaly that coincides with the location of this possible UST and we therefore must conclude that this US is not of metal construction.

Numerous irregular reflections typical for widespread debris were present throughout the site making the GPR interpretation challenging by possibly obscuring potentially regularly shaped, deeper GPR reflections for former building foundations.

The GPR records exhibit linear reflections typical of utilities or former walls. Some of the alignments detected with the GPR in the parking lot coincide with walls from formers structures, and their location are shown with orange dashed lines on Figure 3. GPR reflections consistent with those expected for buried manhole covers were also identified. The GPR records corroborated the presence of steel in the concrete pads located at the entry on Pearl Street and along the fence adjacent to Peck Slip.

Whether buried structures such as USTs, utilities, foundations walls, etc. occur at a depth greater than the effective depth of investigation of the GPR (about 3-6 feet) or in areas inaccessible to the geophysical survey cannot be determined from the geophysical data.

Voids. The typical signature of air- or water-filled voids below an asphalt surface is a distinctive high-amplitude GPR reflection from the bottom of the pavement. The high-amplitude GPR reflection is due to the large contrast in dielectric properties between the pavement and the air gap. Moderate amplitude GPR reflections are interpreted to be caused by either thin air- or water filled voids, or poor coupling between the pavement and the soils below. Where good contact between the pavement and soils is present, there is typically no strong GPR reflector present.

Moderate- to high-amplitude GPR reflectors, indicating the presence of possible air-filled voids, were detected at several locations, primarily in the western portion of the site. Although possible voids were detected in the north-central portion of the parking lot, most of the possible voids were detected in and around the sunken section of the lot, including two small areas on the Water Street sidewalk. The locations of possible voids are shown in Figure 3.

PUL. The PUL transmitter was attached to conduits located in and on the perimeter of the site such as light poles and fire hydrants, etc. We also conducted a PUL survey in "passive" mode to detect signals carried by utilities from nearby power lines. Several Electric utilities were detected in the parking lot and on the Pearl Street, Peck Slip and Beekman Street sidewalks. The locations of utilities detected by the PUL method were marked in the field at the time of the survey and are shown in Figure 3.

CONCLUSIONS

The geophysical survey was completed using a wide range of surveying techniques and instruments (EM61, GPR, and PUL) to identify significant subsurface anomalies. The EM survey can detect the presence of a metal object; however, it cannot be used to identify what the object is. The GPR survey is conducted over the same areas to identify reflections that may be typical of significant subsurface anomalies. The PUL is used to locate subsurface utility lines. The results of the EM, GPR, and PUL surveys are compared with each other in order to identify significant subsurface anomalies. Based on the geophysical survey performed by Hager-Richter Geoscience, Inc. at 250 Water Street, in New York, New York, we conclude the following significant subsurface anomalies were identified:

- Four possible USTs under a portion of reinforced concrete pad near the fence along Peck Slip
- One possible USTs near the corner of Beekman Street and Water Street
- Several possible utilities in the parking lot and in the adjacent sidewalks.

Additional findings:

- Multiple areas of moderate to high amplitude GPR reflectors, possibly indicating the presence of air-filled voids, were detected within the parking lot and on the Water Street sidewalk
- Multiple areas of low to high amplitude EM results (>100 mV) were detected in the parking lot attributed to buried metal
- Several possible buried manhole covers were detected in the parking lot
- Possible former building foundation walls

Whether buried structures such as USTs, utilities, foundations, etc. occur at a depth greater than the effective depth of investigation of the GPR (about 3-6 feet) or in areas inaccessible to the geophysical survey cannot be determined from the geophysical data.

LIMITATIONS ON USE OF THE REPORT

This letter report was prepared for the exclusive use of Langan Engineering & Environmental Services and its client (collectively, Client). No other party shall be entitled to rely on this Report, or any information, documents, records, data, interpretations, advice, or opinions given to the Client by Hager-Richter Geoscience, Inc. (HRGS) in the performance of its work. The Report relates solely to the specific project for which HRGS has been retained and shall not be used or relied upon by the Client or any third party for any variation or extension of this project, any other project or any other purpose without the express written permission of HRGS. Any unpermitted use by the Client or any third party shall be at the Client's or such third party's own risk and without any liability to HRGS.

HRGS has used reasonable care, skill, competence, and judgment in the performance of its services for this project consistent with professional standards for those providing similar services at the same time, in the same locale, and under like circumstances. Unless otherwise stated, the work performed by HRGS should be understood to be exploratory and interpretational in character and any results, findings or recommendations contained in this Report or resulting from the work proposed may include decisions which are judgmental in nature and not necessarily based solely on pure science or engineering. It should be noted that our conclusions might be modified if subsurface conditions were better delineated with additional subsurface exploration including, but not limited to, test pits, soil borings with collection of soil and water samples, and laboratory testing.

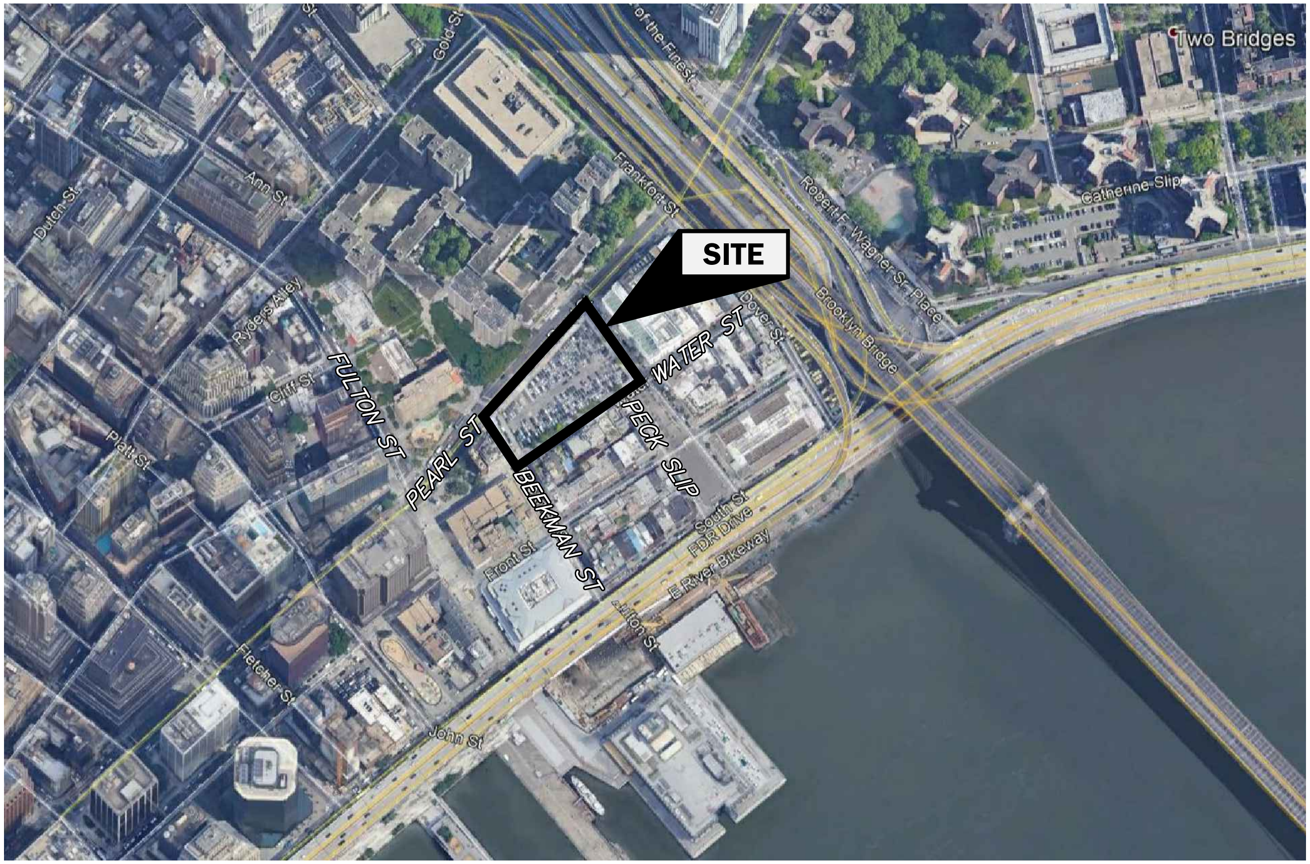
Except as expressly provided in this limitations section, HRGS makes no other representation or warranty of any kind whatsoever, oral or written, expressed or implied; and all implied warranties of merchantability and fitness for a particular purpose, are hereby disclaimed.

If you have any questions or comments on this letter report, please contact us at your convenience. It has been a pleasure to work with Langan on this project. We look forward to working with you again in the future.

Sincerely yours,
Hager-Richter GEOSCIENCE, INC.

José Carlos Cambero Calzada, P.G. (NY 000899)
Senior Geophysicist

Attachments: Figures 1 - 3



N

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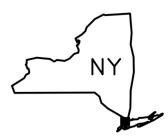
APPROXIMATE SCALE (feet)

0 1000 2000



LOCATION

NOTE:

Modified from Google Earth Pro aerial photograph.

* DBA HR Geological Services in New York

Figure 1
General Site Location
250 Water Street
Manhattan, New York

File 20AM08	June, 2020

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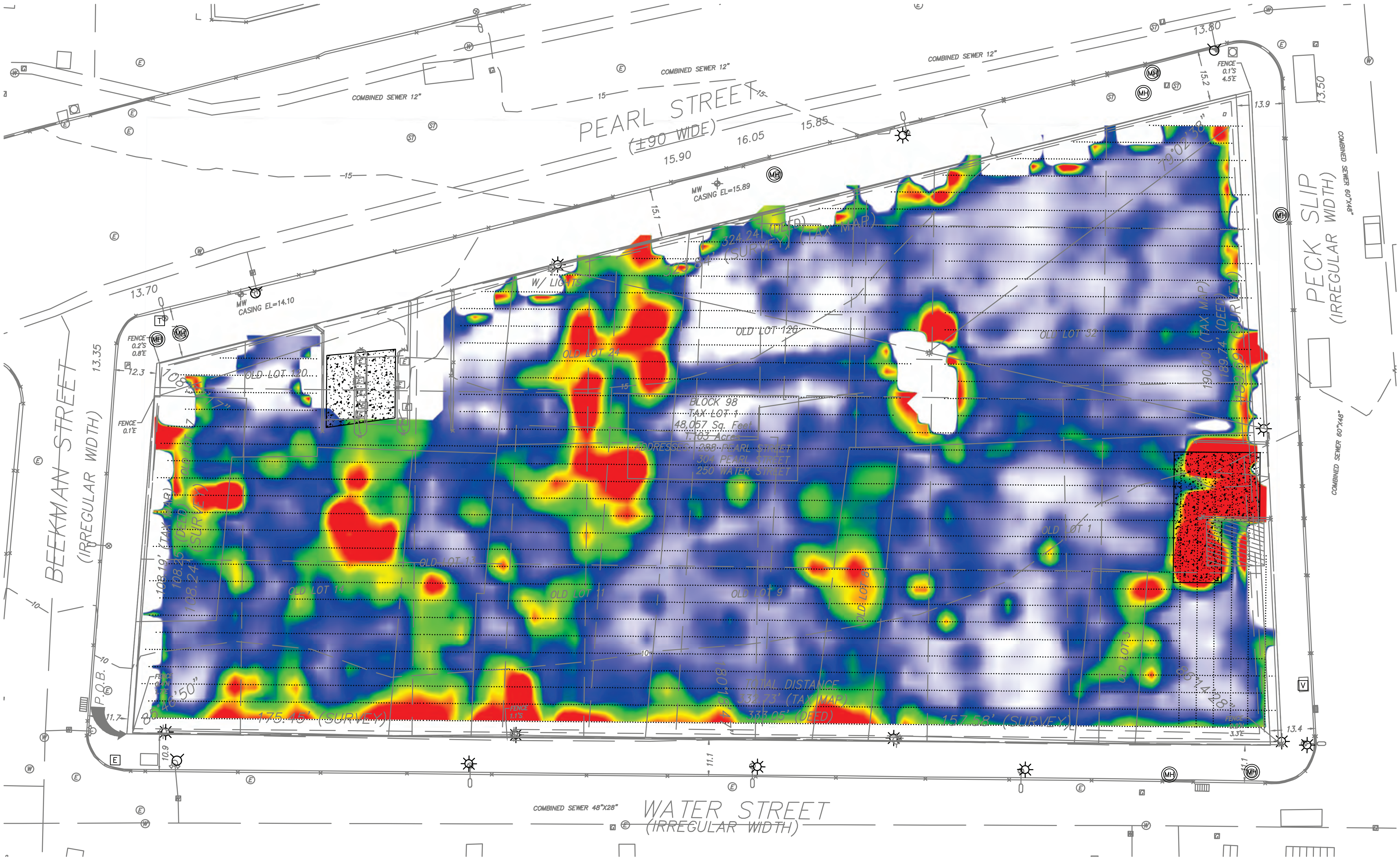
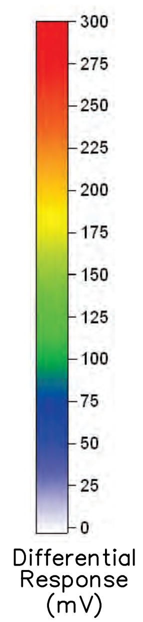
Salem, NH | Fords, NJ





LEGEND

....	DATA STATIONS
E	ELECTRIC VAULT
☼	LIGHT POLE
	HYDRANT
MH	MANHOLE
V	VAULT
S	SIGN
T	TRAFFIC LIGHT
	REINFORCE CONCRETE

SCALE (feet)

0 30 60

NOTES:

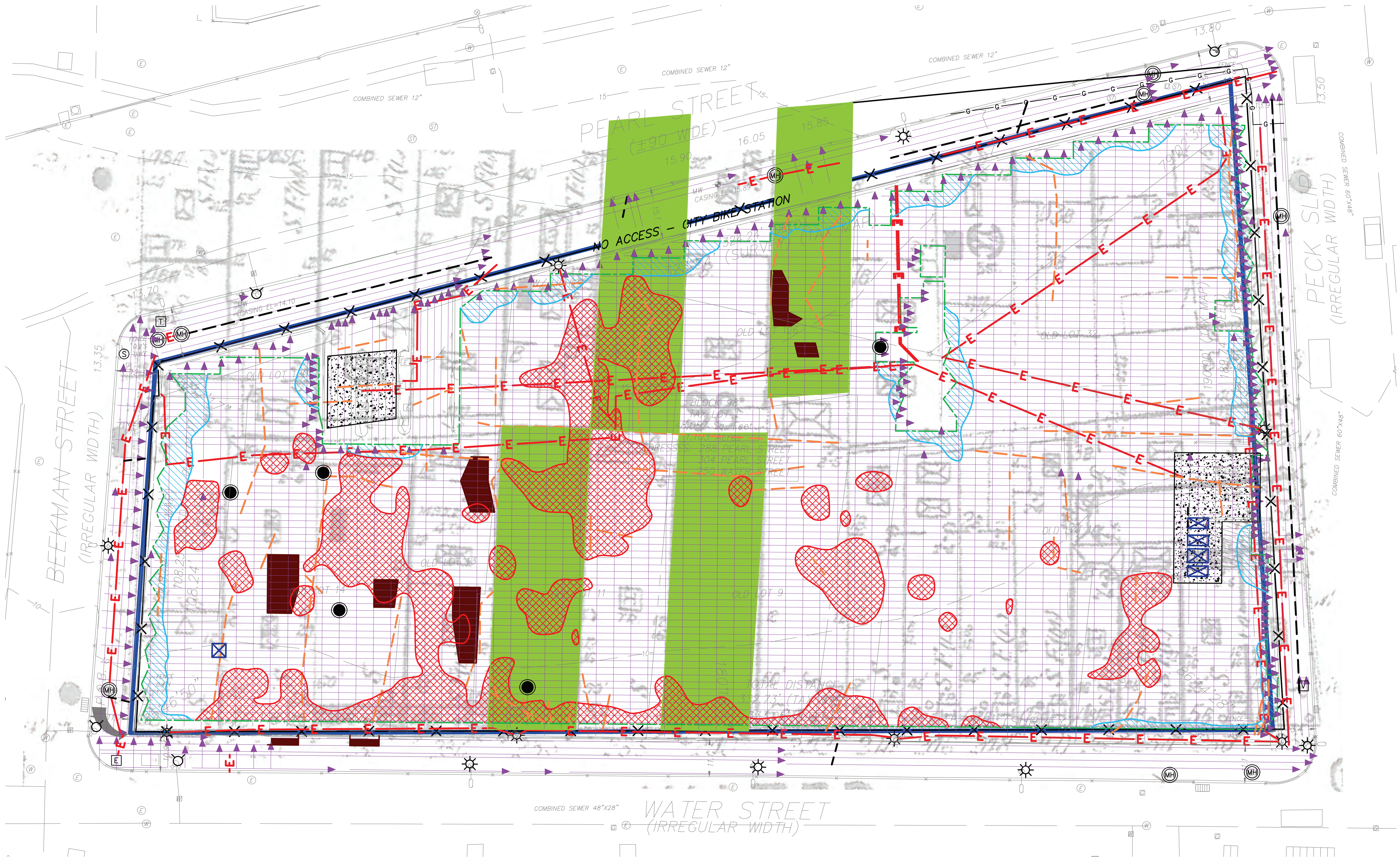
1. Modified from site plan provided by LANGAN, identified as, Figure 6 – AOC and BLP.dwg.
2. Data were acquired with Geonics EM61–MK2. Differential response shown.
3. Differential response equals top coil response – bottom coil response.

* DBA HR Geological Services in New York

Figure 2
EM Survey
250 Water Street
Manhattan, New York

File 20AM08	June, 2020

HAGER–RICHTER*
Salem, NH | Fords, NJ



LEGEND

- APPROXIMATE LIMITS OF EM SURVEY AREA
- GPR TRAVERSE
- AREAS OF EM RESPONSE >100 mV NOT ATTRIBUTED TO SURFACE METAL
- AREA OF POSSIBLE VOID
- POSSIBLE UST
- ELECTRIC LINE
- GAS LINE – MARKED BY OTHERS
- POSSIBLE UTILITY
- POSSIBLE FORMER FOUNDATION WALL
- POSSIBLE BURIED MANHOLE COVER
- EM ANOMALY ATTRIBUTED TO EFFECTS OF SURFACE OBJECTS. THE PRESENCE OR ABSENCE OF BURIED METAL WITHIN THIS AREA CANNOT BE DETERMINED ON THE BASIS OF THE EM61 DATA ALONE.
- ELECTRIC VAULT
- LIGHT POLE
- HYDRANT
- MANHOLE
- VAULT
- SIGN
- TRAFFIC LIGHT
- REINFORCE CONCRETE
- APPROXIMATE EXTENT OF HISTORICAL THERMOMETER FACTORY/WORKSHOPS FROM PDF PROVIDED BY LANGAN, IDENTIFIED AS FIGURE 7 – HISTORICAL 1923 SANBORN MAP

D

SCALE (feet)

0 30 60

N

H-R

NOTE:

Modified from site plan provided by LANGAN, identified as, Figure 6 – AOC and BLP.dwg.

* DBA HR Geological Services in New York

Figure 3
GPR Survey &
Integrated Interpretation
250 Water Street
Manhattan, New York

File 20AM08	June, 2020

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