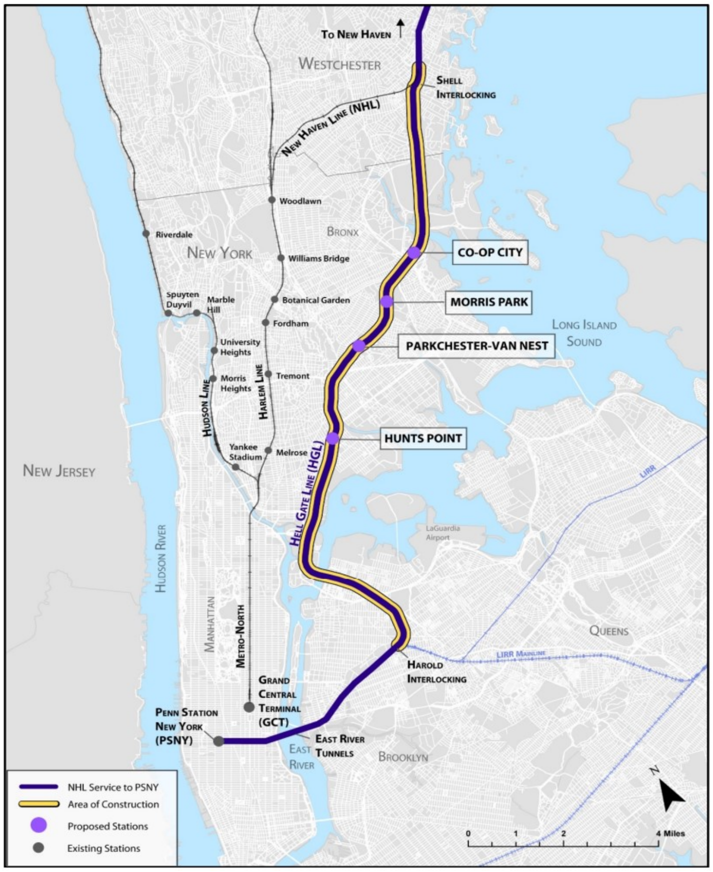
## MTA C&D Metro-North Railroad Penn Station Access

# Pre-Energization and Post-Energization Electromagnetic Survey Procedure




**Revision 1**
**July 5, 2022**

## Jacobs

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T U R N E R
E N G I N E E R I N G
C O R P O R A T I O N

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# Pre-Energization and Post-Energization
# Electromagnetic Survey Procedure

## 1 Introduction

The Penn Station Access project (PSA) is a Metropolitan Transportation Authority (MTA) Construction and Development (MTA C&D) public work project in the New York City area. The PSA will provide Metro-North customers with service to Penn Station by diverting some New Haven Line (NHL) trains via Amtrak's Hell Gate Line (HGL), creating a new route from Shell interlocking in Westchester, NY to Harold interlocking in Queens, NY. The Project will design and construct additional passenger tracks, AC and DC traction power substations, overhead contact systems (OCS), new interlockings, updated communication systems, and new signal systems within the approximately 16 mi of Amtrak's HGL right of way. The Project also includes the design and construction of four new Metro-North stations along the HGL in the eastern Bronx.

Under MTA C&D Contract CBX001, Halmar International / Railworks Joint Venture (HRJV) is the PSA contractor. Jacobs Engineering Group Inc. (Jacobs) is designing the expansion and support construction.

Jacobs and its Electromagnetic Compatibility (EMC) engineer Turner Engineering Corporation (Tenco) established a Penn Station Access Electromagnetic Compatibility Program Plan (EMCP) and will perform the PSA EMC program to control electromagnetic interference (EMI) and radio frequency interference (RFI) between elements of the PSA project and its environment, within the PSA scope:

- PSA equipment and facilities
- NHL and Amtrak's Hell Gate Line HGL equipment and facilities
- PSA neighbors' equipment and facilities
- PSA passengers, workers, and neighbors.

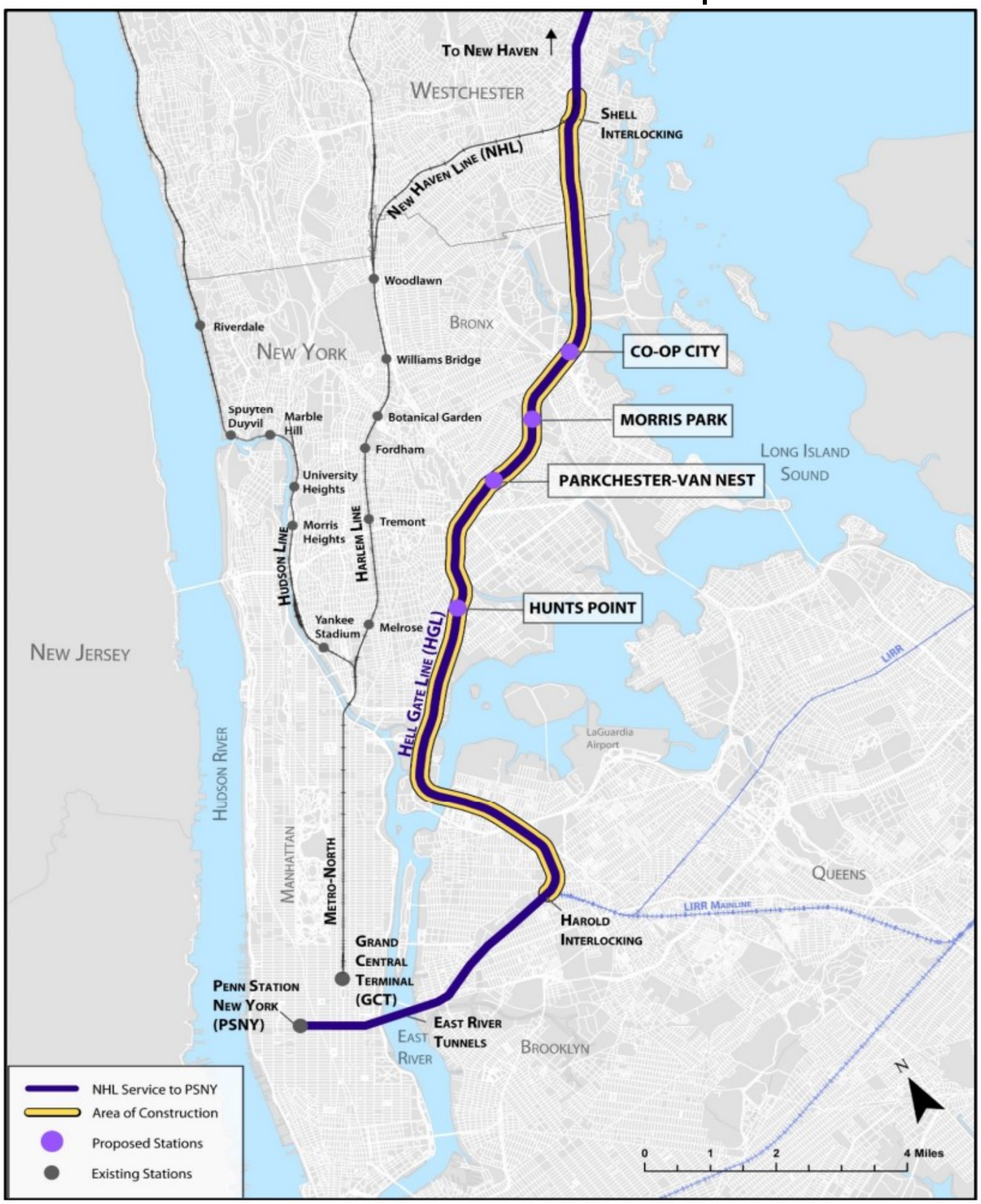
The EMC work includes a Pre-Energization Survey (PrES) of EMI/RFI conditions before energization of the traction power system, and a Post-Energization Survey (PoES) of the conditions at the same locations after energization. Each survey will consist of radiated electric field and magnetic field measurements at the same set of selected locations along the HGL between Shell Interlocking in New Rochelle and Harold Interlocking in Long Island City. See Figure 1-1 for the PSA route map.

The measurements will cover static and low frequency magnetic fields and radiated electric fields of up to 6 GHz. This is the electromagnetic field (EMF) range in which:

- Rail and other equipment typically operate in the urban and suburban environment
- Train lines and systems emit EMI
- EMI from other sources could interfere with sensitive MTA equipment.

This PSA Pre-Energization and Post-Energization Electromagnetic Survey Procedure (PESP) provides the procedure for performing both the PrES and PoES of EMF levels along the PSA.

**Figure 1-1**
**Penn Station Access Route Map**



## 1.1 PSA Pre-Energization and Post-Energization Survey Objectives

The objective of the PSA PrES is to determine the maximum and minimum existing ambient EMF along the HGL, before construction. The objective of the PoES is to measure EMF at the same locations at the PrES after energization of the traction power systems.

During the PrES, Tenco will document and present:

- Maximum and minimum measured ambient radiated and magnetic field levels along the PSA corridor
- Baseline EMF levels, for comparison with PoES measurements made after energizing the third rail and OCS, and before the start of revenue service
- PSA locations measured.

During the PoES, Tenco will reference and compare results to the PrES to determine if the PSA project affected or increased the ambient EMF environment.

The objective of this PESP is to document:

- Selected measurement sites
- Techniques to perform measurements and collect data
- Planned report format and contents.

## 1.2 PSA Pre-Energization and Post-Energization Surveys Scope

The PrES and PoES scope is the measurement, recording, reporting, and assessment of the ambient EMF environment along the HGL, before and after energization.

After the PrES, Tenco will use the measured data to provide a PSA Pre-Energization Survey Report (PPSR). The PPSR will provide results and will provide an assessment of measured results that considers:

- Possibility of impacts on existing magnetic and electric field levels and of neighbor high level EMI/RFI emitters on planned equipment, including Train Control, communications, traction power, and station equipment.

- Possibility of impacts of emissions from operation of the PSA on potential sensitive neighbor facilities

- Possible EMI/RFI mitigation measures if any appear to be needed.

After the PoES, Tenco will use the measured data to provide the PSA Post-Energization Survey Report (POSR) to Jacobs, using and comparing results from the PPSR.

The scope does not include:

- Measurements of emissions or immunity of HGL equipment such as track circuits, communications, equipment, etc.
- Characterizing emissions or measuring immunity of MTA in-service equipment such as traction power, trains, or communications equipment.

## 1.3 Acronyms and Abbreviations

**Table 1-2**
**Acronyms and Abbreviations**

| Acronym | Definition |
|---|---|
| AC | Alternating Current |
| AM | Amplitude Modulated |
| DC | Direct Current |
| DSA | Dynamic Signal Analyzer |
| EMC | Electromagnetic compatibility |
| EMCP | EMC Program Plan |
| EMF | Electromagnetic Field |
| EMI | Electromagnetic interference |
| HGL | Hell Gate Line |
| HRJV | Halmar International / Railworks Joint Venture |
| Hz | Hertz |
| IF | Intermediate Frequency |
| Jacobs | Jacobs Engineering Group Inc. |
| MTA | Metropolitan Transportation Authority |
| MTA C&D | Metropolitan Transportation Authority Construction and Development |
| NHL | New Haven Line |
| OCS | Overhead Contact System |
| PoES | Post-Energization Survey |
| POSR | PSA Post-Energization Survey Report |
| PESP | PSA Pre-Energization and Post-Energization Electromagnetic Survey Procedure |
| PPSR | PSA Pre-Energization Survey Report |
| PrES | Pre-Energization Survey |
| PSA | Penn Station Access |
| PSNY | Penn Station New York |
| RF | Radio Frequency |
| RFI | Radio Frequency Interference |
| ROW | Right-of-Way |
| RSTP | Rapid Transit Signaling Systems Volume II: Suggested Test Procedures |
| SA | Spectrum Analyzer |
| STA | Stationing |
| Tenco | Turner Engineering Corporation |
| UMTA | Urban Mass Transportation Administration (now Federal Transit Administration) |
| VAC | Volts of Alternating Current |

## 1.4 Reference Information

| Table 1-3<br>PSA EMC Survey Reference Information | | |
|---|---|---|
| **ID** | **Issued By** | **Title** |
| Technical Provisions Vol 3, Part 1 | MTA C&D | Design-Build Services For Metro-North Railroad Penn Station Access Project, September 20, 2021<br>RFP Documents. Volume 3 Technical Provisions Part 1 – Scope |
| Technical Provisions Vol 3, Part 3 | MTA C&D | Design-Build Services For Metro-North Railroad Penn Station Access Project, September 20, 2021<br>RFP Documents. Volume 3 Technical Provisions Part 1 – DB Requirements |
| Technical Specifications Vol 5 | MTA C&D | Design-Build Services For Metro-North Railroad Penn Station Access Project, September 20, 2021<br>RFP Documents. Volume 5 Technical Specifications |
| Technical Specifications Vol 8 | MTA C&D | Design-Build Services For Metro-North Railroad Penn Station Access Project, September 20, 2021<br>RFP Documents. Volume 8 Leggett Interlocking, Part 2 Technical Specifications |
| EMCP | Jacobs | MTA C&D Metro-North Railroad Penn Station Access Electromagnetic Compatibility Program Plan, Rev 0, May 2022 |
| UMTA-MA-06-0153-85-10 | FTA | Radiated Interference in Rapid Transit Systems - Volume I: Theory and Data |
| UMTA-MA-06-0153-85-11 | FTA | Radiated Interference in Rapid Transit Systems - Volume II: Suggested Test Procedures |
| EN 50121-2:2017 | CENELEC | Railway applications - Electromagnetic compatibility - Part 2: Emission of the whole railway system to the outside world. |

## 1.5 Contents of This Procedure

**Section 1:** The Introduction provides an overview of the PSA and the EMF survey objectives and scope.

**Section 2:** The EMF survey requirements.

**Section 3:** The Organization and Schedule describes the EMF survey participants and measurement schedule.

**Section 4:** The Measurement Locations section lists the locations at which tests will be performed.

**Section 5:** The Radiated Electric Field Measurement section describes the methods used to measure radiated electric fields.

**Section 6:** The Magnetic Field Measurement describes the methods used to measure magnetic fields.

**Section 7:** This section describes the structure of the Survey Reports (PPSR and POSR) to be produced from the surveys made following this procedure.

**Appendix A:** PSA EMF Survey Forms contains the forms used to record observations during the survey.

**Appendix B:** PSA EMF Survey Measurement Locations lists the measurement locations and provides maps and photos of the sites.

## 2 PSA Pre-Energization and Post-Energization Survey Requirements

The PSA EMCP outlines the EMF survey requirements For the PrES, the EMCP states:

> "The project will develop a procedure, plan and perform a survey of pre-energization PSA EMI/RFI characteristics at selected sites, assess the measured conditions considering the PSA design plans, and report the findings.
>
> The PSA Pre-Energization Survey Procedure (PPSP) will identify a suitable range of sites for pre-energization measurement. The project will measure at the same sites after energization, to document changes to EMI/RFI conditions due to the energized PSA equipment, systems, and operations.
>
> The PPSP measurements will consist of magnetic field levels from static to 800 Hz, and radiated electric field levels from 10 kHz to 6 GHz. The measurement methods will be consistent with EN 50121-2:2017, Railway applications - Electromagnetic compatibility - Part 2: Emission of the whole railway system to the outside world.
>
> The PSA Pre-Energization Survey Report (PPSR) will provide results and an assessment. The PPSP and PPSR will be submitted to MTA C&D for review, comment, and approval."

For the PoES, the EMCP states:

> "The project will develop a procedure, plan and perform a survey of post-energization PSA EMI/RFI characteristics at selected sites, assess the measured conditions considering the PSA as-built equipment and systems, and report the findings.
>
> The PSA Post-Energization Survey Procedure (POSP) will apply at the same sites as the PPSP. The purpose is to document changes to EMI/RFI conditions due to the energized PSA equipment, systems, and operations.
>
> In addition, the POSP will measure in at least one AC traction power station, to determine the magnetic field exposure for authorized staff working in those restricted facilities.
>
> The POSP measurements will consist of the same magnetic field levels from static to 800 Hz, and radiated electric field levels from 10 kHz to 6 GHz as in the PPSP, and will also apply EN 50121-2:2017.
>
> The PSA Post-Energization Survey Report (POSR) will provide results and an assessment of the measured EMI/RFI conditions on the as-built PSA systems and equipment.
>
> …
>
> The POSP and POSR will be submitted to MTA C&D for review, comment, and approval.
>
> The Final Report section of the POSR will summarize the results of the EMCP Program, any significant EMI/RFI findings or results, and next steps / actions, if required."

# 3 Organization and Schedule

## 3.1 Survey Organization

The team members with EMF survey responsibilities are:

- Turner Engineering Corporation
- Jacobs Engineering Group Inc.
- Metropolitan Transit Authority

Tenco will provide:

- Test engineers
- Measurement equipment
- Data media and measurement consumables
- Measurement operation, data collection, recording, and reporting.

Jacobs will direct, monitor and support Tenco, and is responsible to provide:

- Information needed to determine suitable measurement locations, including PSA plans, logistics, and design information
- Guidance based on review of selected sites
- Point of contact to gain permission from owners or authorities to set up and operate measurement equipment at the measurement locations, if needed
- Staff to coordinate with the owners and authorities on measurement days. Tenco will not require close access to the right-of-way (ROW), and will not foul the tracks or require flagging or other MTA protection, unless the project requires measurements to be performed on the ROW. This PESP does not include measurement sites within the ROW.

MTA will:

- Authorize Tenco and others to access MTA property to make the survey measurements, as necessary
- Provide security and supervision as required.

## 3.2 Survey Schedule

Table 3-1 shows the EMF Survey Schedule. Tenco will perform the EMF survey twice, first during the PrES and later during PoES. Tenco will perform EMF survey at two sites per day, during continuous measurement days. The order of the test sites does not matter, but for the test schedule it is preferred that the two sites be geographically close, to minimize travel between sites and make maximum use of daylight hours.

Tenco will perform the measurements in up to six measurement days, and one contingency day, with a minimum of nine working hours per day, with unlimited access to measurement sites and with all needed support from MTA and the contractor.

Table 3-2 shows a preliminary daily schedule. This schedule is subject to site availability, but shows that in general, Tenco will need approximately 4.5 hours per survey site.

**Table 3-1**
**EMF Survey Schedule**

| Sun | Mon | Tue | Wed | Thu | Fri | Sat |
|---|---|---|---|---|---|---|
| | | Travel | Unpack, setup, calibrate, and checkout EMI test equipment | Sites 1 and 2:<br><br>Radiated Electric Field Measurement<br><br>Magnetic Field Measurement | Sites 3 and 4:<br><br>Radiated Electric Field Measurement<br><br>Magnetic Field Measurement | Sites 5 and 6:<br><br>Radiated Electric Field Measurement<br><br>Magnetic Field Measurement |
| **Sun** | **Mon** | **Tue** | **Wed** | **Thu** | **Fri** | **Sat** |
| Sites 7 and 8:<br><br>Radiated Electric Field Measurement<br><br>Magnetic Field Measurement | Sites 9 and 10:<br><br>Radiated Electric Field Measurement<br><br>Magnetic Field Measurement | Sites 11 and 12:<br><br>Radiated Electric Field Measurement<br><br>Magnetic Field Measurement | Contingency Day | Pack and ship equipment<br><br>Travel | | |

**Table 3-2**
**Daily EMF Survey Schedule**

| Site | Time | Tenco Task |
|---|---|---|
| Morning Site | 8:00 am | Arrive at measurement sight |
| | 8:05 - 9:30 am | Set up RE test equipment, signal analyzer and antennas, draw site map, take photos. Find power source for test equipment or setup power generator |
| | 9:30 - 11:00 am | Record RET and Measurement results. Start Braking down equipment. |
| | 11:00 am - 12:15 pm | Set up Magnetic Field Measurement equipment and make measurements |
| | 12:15 - 12:30 pm | Finish equipment break down and pack up into test van. |
| Break | 12:30 - 2:00 pm | Break for lunch and move to next site |
| Afternoon Site | 2:00 pm | Arrive at measurement sight |
| | 2:05 - 3:30 pm | Set up RE test equipment, signal analyzer and antennas, draw site map, take photos. Find power source for test equipment or setup power generator |
| | 3:30 - 4:00 pm | Record RET and Measurement results. Start Braking down equipment. |
| | 4:00 - 5:15 pm | Set up Magnetic Field Measurement equipment and make measurements |
| | 5:15 pm - 5:30 pm | Finish equipment break down and pack up into test van. |

### 3.3 Measurement Sequence

The test engineers will:

1. Perform measurements during daytime, between 8 am and 6 pm
2. Use a passenger van to transport the measurement equipment to, and to provide shade and shelter at a predetermined set or representative locations
3. At each location, park in a safe location and set out traffic cones as necessary
4. As needed, access the vicinity of the railroad ROW. The plans do not require or permit the test staff or equipment to approach the ROW closely enough to require protection, flagging, etc. Survey staff will not approach the ROW closely enough to require protection, flagging, etc., without all such approved protections in place.
5. Set up two or three measurement antennas connected by cable to equipment in the van
6. Set up a 120 VAC power connection
7. Record data for up to two hours, depending on variability of environment
8. Pack up and move to the next location.

This sequence allows measurement of two or three sites per day.

# 4 Measurement Locations

Tenco will perform measurements at 12 locations. Location types include:

- Specific sensitive receptors adjacent to the track centerline
- Worst case ambient EMF locations, such as under high voltage power lines or near significant emitters such as TV broadcast stations
- "Quiet" locations, where the test team expects low ambient EMF levels
- Locations where the test team expects worst-case MTA trainset EMF levels
- Locations with significant public interaction, such as passenger stations.

Table 4-1 lists the locations where Tenco will make measurements.

Figure 4-1 is a map showing the measurement locations.

**Table 4-1**
## PSA EMF Survey Measurement Locations

| Site | Description | STA | GPS Coordinates | Nearest Landmark | Distance to Landmark (ft) |
|---|---|---|---|---|---|
| 1 | HG-01 DC Substation | 222+00 [Note 1] | 40.751163, -73.914592 | HG-01 DC Substation | 0 |
| 2 | HG-02 DC Substation | 277+00 [Note 1] | 40.760644, -73.903683 | HG-02 DC Substation | 0 |
| 3 | Bowery Bay AC Substation | 289+00 [Note 1] | 40.764293, -73.905214 | Bowery Bay AC Substation | 0 |
| 4 | Contact Rail End [Note 3] | 298+30 [Note 1] | 40.766444, -73.907289 | Bowery Bay AC Substation | 870 |
| 5 | Randall's Island Field #43 | 326+55 [Note 2] | 40.797109, -73.918248 | Oak AC Substation | 4560 |
| 6 | Electric Substation near Randall's Island | 336+31 [Note 2] | 40.798477, -73.914738 | Oak AC Substation | 3560 |
| 7 | Oak AC Substation [Note 4] | 371+96 | 40.806752, -73.906753 | Oak AC Substation | 0 |
| 8 | Parkchester-Van Nest Station [Note 4] | 562+11 | 40.842239, -73.861933 | Parkchester-Van Nest Station | 0 |
| 9 | Morris Park Station | 619+00 | 40.849332, -73.844453 | Morris Park Station | 0 |
| 10 | Co-op City Station | 677+32 | 40.858275, -73.828892 | Co-op City Station | 0 |
| 11 | Pelham Bay and Split Rock Golf Courses | 761+15 | 40.875269, -73.810160 | Co-op City Station | 11310 |
| 12 | New Rochelle AC Substation | 873+56 | 40.902644, -73.793171 | New Rochelle AC Substation | 0 |

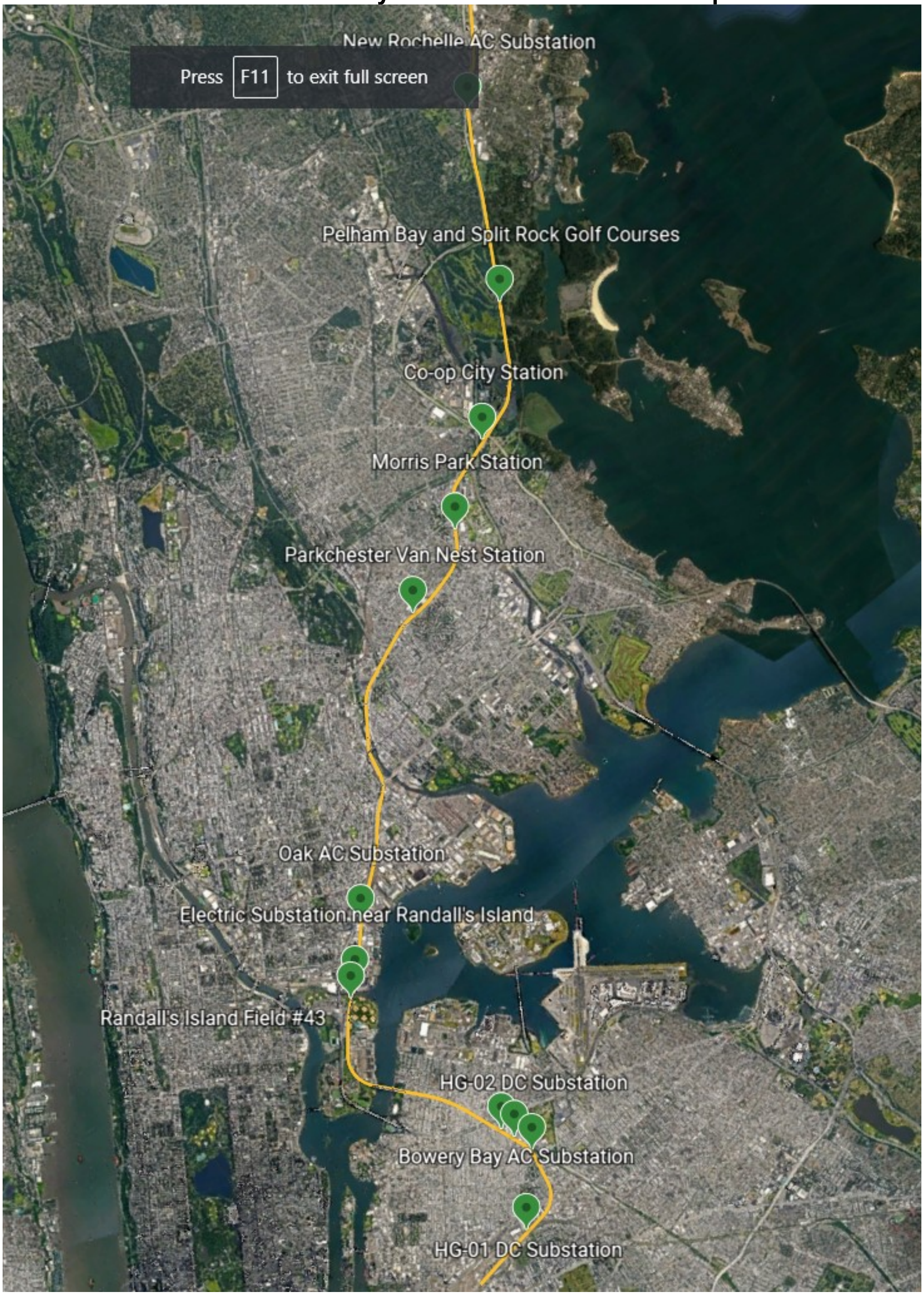
Notes:
1] These STA values were provided in the technical proposal drawing, but are measured from a different reference than Sites 5 to 12.

2] The STA values for these locations do not appear in any technical drawings. They are estimates of distance south of Oak AC Substation.

3] Exact location of this site to be provided by Jacobs

4] Tenco will determine the location of single phase 60 Hz cables and measure magnetic field strength per New York State limits as described in Section 6

**Figure 4-1**
## PSA EMF Survey Measurement Locations Map



# 5 Radiated Electric Field Measurement

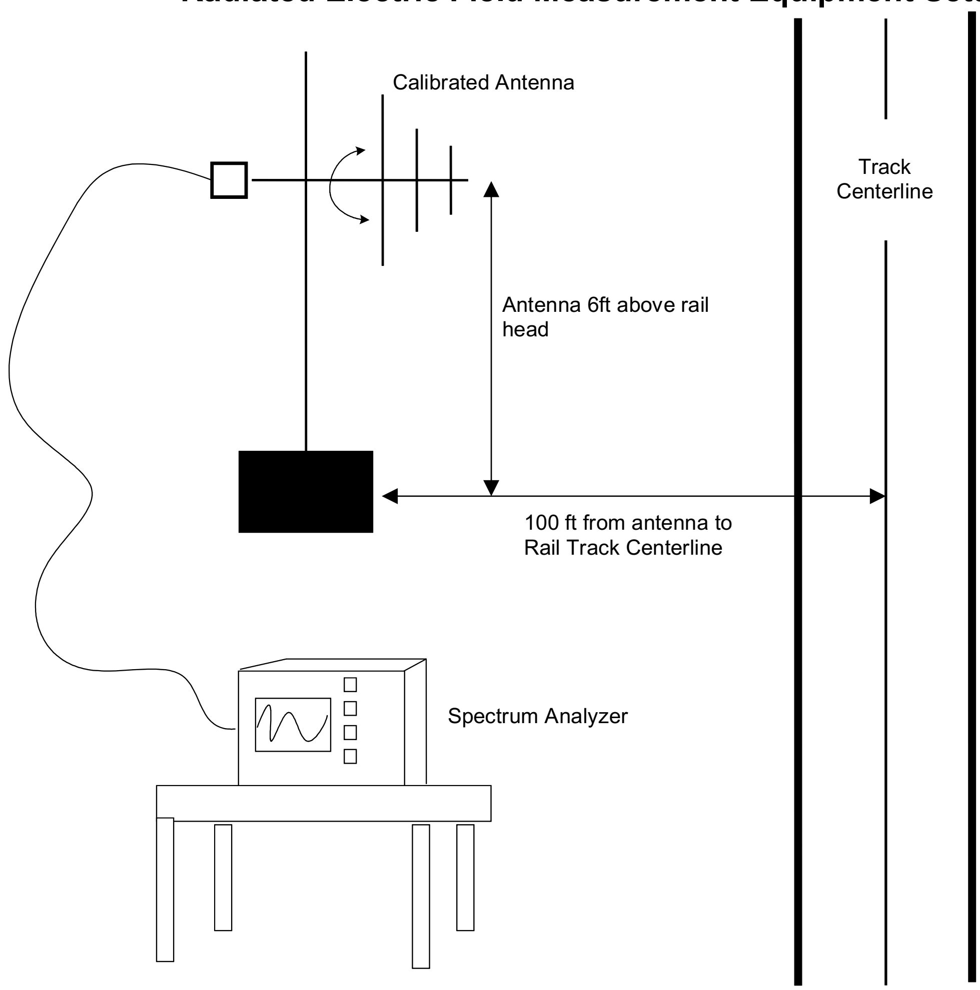
Tenco will perform the radiated electric field (RE) measurements per the general approach of Euronorm (EN) Standard 50121-2:2017 Railway applications - Electromagnetic compatibility Part 2: Emission of the whole railway system to the outside world.

Where practical, the survey crew will place the Radio Frequency (RF) antennas at an approximate lateral distance of 100 ft from the track centerline and 6 ft above the rail head. For survey sites where test team cannot set up antennas 100 ft from the track centerline and/or 6 ft above the rail head, the test team will make measurements at selected nearby locations, making note of the lateral and elevation distance to the track, the reason for the selected location, and nearby significant features.

The RSTP calls for measurements in units of dBμV/m, which are appropriate for the broadband emissions that electric railways typically emit.

Figure 5-1 shows the equipment setup for the RE measurement.

**Figure 5-1**
**Radiated Electric Field Measurement Equipment Setup**



## 5.1 Measurement Equipment

Table 5-1 lists the radiated electric field measurement equipment.

**Table 5-1**
**Radiated Electric Field Measurement Equipment List**

| # | Item | Comment |
|---|---|---|
| 1 | KT-9010A-507/P07/EDP 10 Hz – 7 GHz EXA Signal Analyzer with KT-N6141A/2TP EMI Measurement application or equivalent | For measuring EMF intensity between 10 Hz and 6 GHz. |
| 2 | PC Software, KT-N6141A/2TP EMI Measurement application or equivalent | For transfer of data from Spectrum Analyzer to PC |
| 3 | Inkjet Printer, or equivalent | For plotting emission spectra. Compatible with spectrum analyzer. |
| 4 | A.H Systems SAS-550-1: Active Monopole Antenna or equivalent, 10 kHz to 60 MHz | Calibrated antenna for Bands 1 – 4 |
| 5 | A.H. Systems SAS-521F-7: Bilogical Antenna or equivalent, 25 MHz to 7 GHz | Calibrated antenna for Bands 5 – 7 |
| 6 | Calibrated Coax | Calibrated Coax Cable for Bands 5 – 7 |
| 6 | Adjustable Antenna Tripods | To support antennas |
| 7 | Laptop computer | For control of printer and storage of measurement data results |
| 8 | AC Power Source | AC line, generator, or car battery inverter. |
| 9 | Sandbags, rope | Weights to secure antenna tripods, if necessary |
| 10 | Folding table and chairs | For test team and equipment |

The following subsections describe the major measurement equipment items.

### 5.1.1 Radio Frequency Spectrum Analyzer

The Keysight Technologies KT-9010A-507/P07/EDP Spectrum Analyzer (SA) measures intensity of the RF field over a frequency range of 10 kHz to 6 GHz. The SA:

- Measures and documents the field intensity received from calibrated antennas, on two traces, showing the maximum and minimum measured signal at each frequency

- Converts received signals from calibrated antennas into standard dBμV/m unit
- Stores system configuration including antenna factors and cable losses
- Has amplitude accuracy better than ±0.7 dB, adequate for the task
- Displays Limit Lines, to indicate EN 50121-2 specification limits for new equipment.

The test team will connect the SA to a laptop or PC by Ethernet cable for data acquisition, storage, and printing.

The test team will use standard techniques to assure calibration of the impulse bandwidth of the SAs. For SAs whose intermediate frequency (IF) stages have Gaussian passbands, such as the Keysight Technologies SA described here, the impulse bandwidth is 1.4 times the resolution bandwidth (-3 dB bandwidth) and is approximately equal to the -6 dB IF bandwidth.

#### 5.1.2 Antennas

The test team will mount antennas on a tripod with the antenna base plate 6 ft above rail level, where possible. The measurements will orient the antennas as stated below:

Active Monopole Antenna: The active monopole antenna covers the frequency of 10 kHz to 60 MHz. Measurements taken with this antenna are oriented vertically.

Bilogical Antenna: The bilogical antenna is a wide operating range antenna which covers the frequency range of 25 MHz to 7 GHz. The term 'bilogical' means that the antenna combines the characteristics and response of a biconical and log periodic antenna. Measurements taken with this antenna are oriented vertically, with the axis perpendicular to the ground, or oriented horizontally, with the axis parallel to the track.

Calibrated antennas receive and convert electrical field intensities into electrical signals with a known antenna conversion factor. The antenna supplier provides these antenna conversion factors and the test team enters them into the SA to display received signals in units of the corresponding electrical field intensity.

### 5.2 Spectrum Analyzer Calibration

The test engineers will perform the following steps to verify proper orientation of the radiated electric field measurement equipment:

1. Turn on the SA and let it warm up
2. Calibrate the SA per the user's manual
3. Verify cable loss matches the calibration record. The internal calibrator can be used for this measurement.

4. Verify antennas are operating properly, and that a nearby Amplitude Modulated (AM) does not saturate the active monopole broadcast antenna.

## 5.3 Measurement Bands

The test team will perform broadband emission measurements in the range of 10 kHz to 6 GHz using active rod bilogical antennas for horizontal and vertical polarizations, as appropriate.

The test team will divide measurements into eight measurement bands, shown in Table 5-2.

The test team will use the active rod bilogical antenna to cover the range from 10 kHz to 30 MHz, in five measurement sub-bands. Per the UMTA procedure, Tenco will measure with the active rod oriented vertically. The active rod antenna is omni-directional, so a single measurement will record fields in all compass directions.

The test team will use the bilogical antenna to cover the range from 30 MHz to 6 GHz, for both horizontal and vertical polarization.

**Table 5-2**
**Radiated Emissions Measurement Bands**

| ID | Band Frequency Range | Antenna | Antenna Orientation | Resolution Bandwidth |
|---|---|---|---|---|
| B0 | 10 kHz – 160 kHz | Active Monopole | Vertical | 1 kHz |
| B1 | 150 kHz – 650 kHz | Active Monopole | Vertical | 10 kHz |
| B2 | 500 kHz – 3 MHz | Active Monopole | Vertical | 10 kHz |
| B3 | 2.5 MHz – 7.5 MHz | Active Monopole | Vertical | 10 kHz |
| B4 | 5 MHz – 30 MHz | Active Monopole | Vertical | 100 kHz |
| B5h | 25 MHz – 325 MHz | Bilogical | Horizontal | 100 kHz |
| B5v | 25 MHz – 325 MHz | Bilogical | Vertical | 100 kHz |
| B6h | 300 MHz – 1.3 GHz | Bilogical | Horizontal | 300 kHz |
| B6v | 300 MHz – 1.3 GHz | Bilogical | Vertical | 300 kHz |
| B7h | 1 GHz – 6 GHz | Bilogical | Horizontal | 300 kHz |
| B7v | 1 GHz – 6 GHz | Bilogical | Vertical | 300 kHz |

## 5.4 Radiated Emission Limits

The EMCP specifies that measurement methods be consistent with EN 50121-2, shown in Table 5-3 and Figure 5-2. The graph and figure convert the lower frequency EN limits in dBµA/m to dBµV/m, to allow straightforward evaluation across the band. Tenco then converted the limits to apply at a measurement distance of 100 ft used in this procedure rather than the 10 m measurement distance specified in the EN standard. Tenco converted these limits using calculations in UMTA-MA-06-0153-85-10, Radiated Interference in Rapid Transit Systems - Volume I: Theory and Data. This procedure uses the measurement distance of 100 ft rather than 10 m, because it is safer, more accessible, and still provides directly useful data about the environmental effects of the new system. Further, the vertical offsets of the selected measurement locations from the track level must and will be noted and accepted, even when they significantly differ from the 2 m standard in the EN limit.

These RE limits are a reference during the PrES. These limits are useful to evaluate the effects of new PSA traction power system during the PoES.

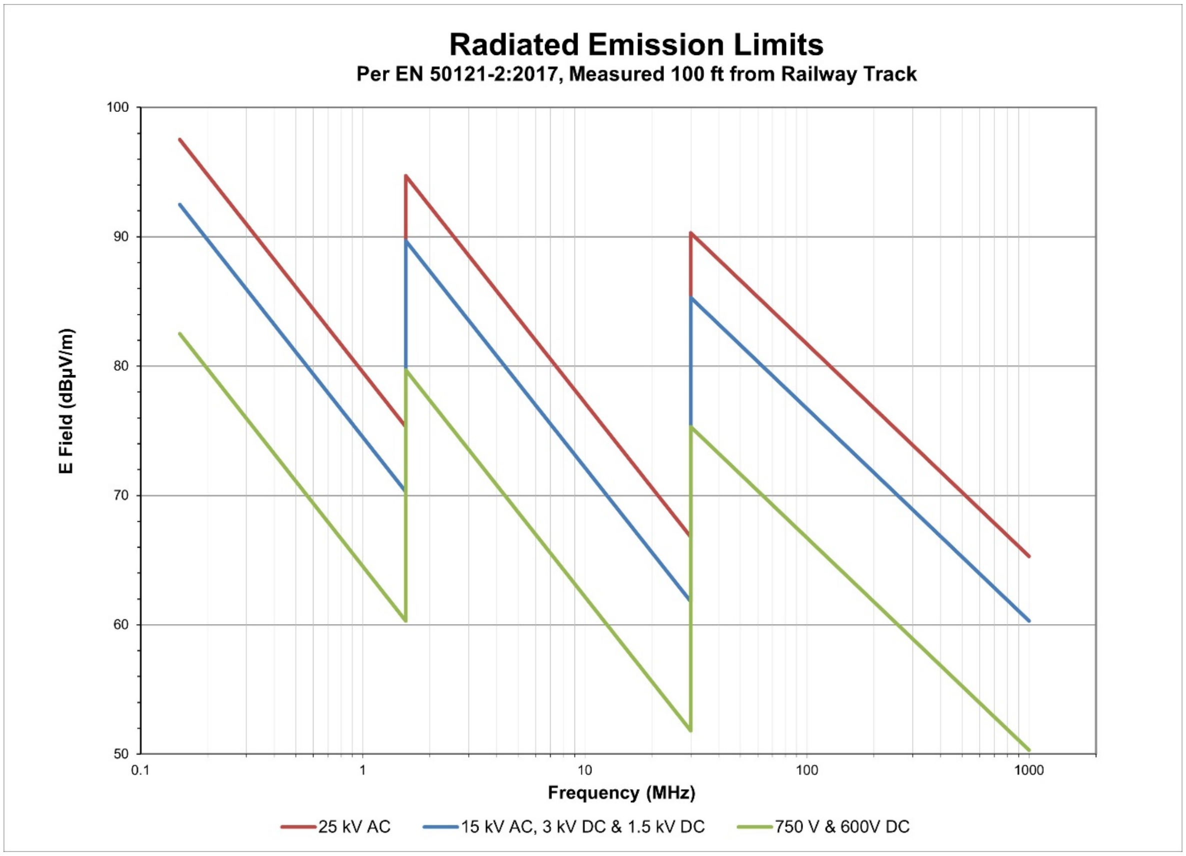
The limits also provide a basis for assessing the existing EMF levels. EMF levels in urban areas often exceed the EN limits.

To identify broadband emission levels observed at a particular frequency and polarization as distinct PSA emissions during the PoES, the emission levels must exceed the corresponding observed PrES ambient broadband level by 10 dB or more, in consistent sets of PrES and PoES measurements. The emission in question must be consistent within the measurement set, and at least twice the impulse bandwidth from any ambient narrowband signal producing receiver output greater than the observed broadband emission levels. If a questionable signal is found that would be excluded under these criteria, the test team will retest it later under similar conditions in an attempt to find a lower ambient condition and determine whether the signal is actually ambient or a PSA equipment emission.

**Table 5-3**
**EN 50121-2:2017 Radiated Emissions Limits**

| Frequency (MHz) | Limits (dBµV/m), measured 100 ft from railway track | | |
|---|---|---|---|
| | 25 kV AC | 15 kV AC, 3 kV DC & 1.5 kV DC | 750 V & 600V DC |
| 0.15 | 97.5 | 92.5 | 82.5 |
| 1.6 | 75.3 | 70.3 | 60.3 |
| 1.6 | 94.7 | 89.7 | 79.7 |
| 30 | 66.8 | 61.8 | 51.8 |
| 30 | 90.3 | 85.3 | 75.3 |
| 1000 | 65.3 | 60.3 | 50.3 |

**Figure 5-2**
**EN 50121-2:2017 Radiated Emission Limits**




## 5.5 Site Diagram

The test team will make a detailed diagram of each measurement site, including showing location, measurement point, nearby structures, emitters, track centerline, and other significant objects. The site diagrams will include the measurement site latitude and longitude and photographs of the measurement site.

The test team will provide a map showing all measurement sites and the track centerline.

## 5.6 Radiated Measurement Planning

Ambient radiated electric field conditions change frequently because neighbor radio and energy sources continually vary their operating conditions.

The test team will arrange measurements to measure worst-case (maximum and minimum) radiated emissions, considering time of day, intermittent events, and local actions.

The test team will perform sufficient repeated measurements to identify worst-case conditions and characterize their amplitude, frequency, duration, and repetition at each measurement site. If the test team measures high emissions, they will reorient the antenna and record the direction in which the highest emission level is measured.

## 5.7 Radiated Electrical Field Measurement Method

For each measurement, the test team will maintain a log of measurement type and band, measurement equipment configuration, measurement duration, external event or condition descriptions, comments, summary of measured data, and other relevant information. If the measurement includes a train, motor vehicle, or airplane, the test team will note it.

### 5.7.1 Radiated Electrical Field Measurement Steps

The test team will perform the following radiated electrical field measurement steps:

1. Set up at the measurement site

2. Calibrate the SA. Attach antenna to the SA. Set the SA to display the measurement band. Set the SA reference level offset to zero.

3. With the SA set to Min/Max hold, measure and record for 5 s time intervals. Reset trace from time to time to compare old peaks to present levels. Observe signal through range of conditions at site, such as traffic nearby, etc.

4. Identify and characterize worst-case conditions. Print the full emission spectrum.

### 5.7.2 Broadband Emission Evaluation

To identify broadband emissions observed at a particular frequency and polarization as a distinct wayside emission, the emission level must exceed the corresponding observed ambient broadband level by 10 dB or more. The frequency in question must be at least twice the impulse bandwidth from any ambient narrowband signal greater than the observed broadband emission levels.

If a questionable signal is found that would be excluded under these criteria, the test team will re-measure it later under similar conditions to determine whether the emission is an ambient variation or an actual wayside emission.

A set of regular peaks displayed on the SA could be either a set of harmonics emissions or the record of a periodic sequence of impulses. If such a set is found, the test team will:

1. Note the peaks in the log

2. Make another measurement with all settings the same but with a different SA sweep speed
   - If the peaks change spacing on the screen, they are a sequence of impulses
   - If the peaks maintain a constant spacing, they are a set of harmonics

3. Record the results in the log.

### 5.7.3 Field Reduction of Data

The test team will set up the SA to account for antenna factors, calibration factors, gain, and conversion units so that the emission amplitudes are recorded in dBμV/m. The test team will plot or print the SA data on completion of each frequency measurement run, annotating the measurement results as appropriate.

The test team will print out and save the data for each valid measurement run.

The test team will characterize the measurement and note:

- Key emissions in the measurement
- The extent to which the minimum and maximum traces differ, reflecting the broadband noise present
- Changes between the measurement and recent similar measurements
- Similarities or differences to other measurements in the same band at other locations
- Whether there is a set of periodic impulses or a set of harmonics
- Whether the measurement is an apparent worst case.

### 5.7.4 Measurement Data Collection

The test team will collect data, including for measurement equipment calibration and each ambient site measurement. Appendix A provides measurement forms.

**Equipment Calibration**: The test team will record calibration data for each major measurement equipment item. Calibration data will include the following:
Measurement equipment item

- Manufacturer
- Model
- Serial number
- Calibration date
- Calibration source
- Reference number
- Notes.

**Measurement Log**: The test team will maintain a measurement run log, recording the following for each measurement:

- Date
- Time
- Performed by
- Location
- Site conditions
- Event
- Run number
- Identification number for plot
- Measurement type
- Frequency band
- Measurement configuration data such as attenuation settings
- Summary results
- Notes.

# 6 Magnetic Field Measurement

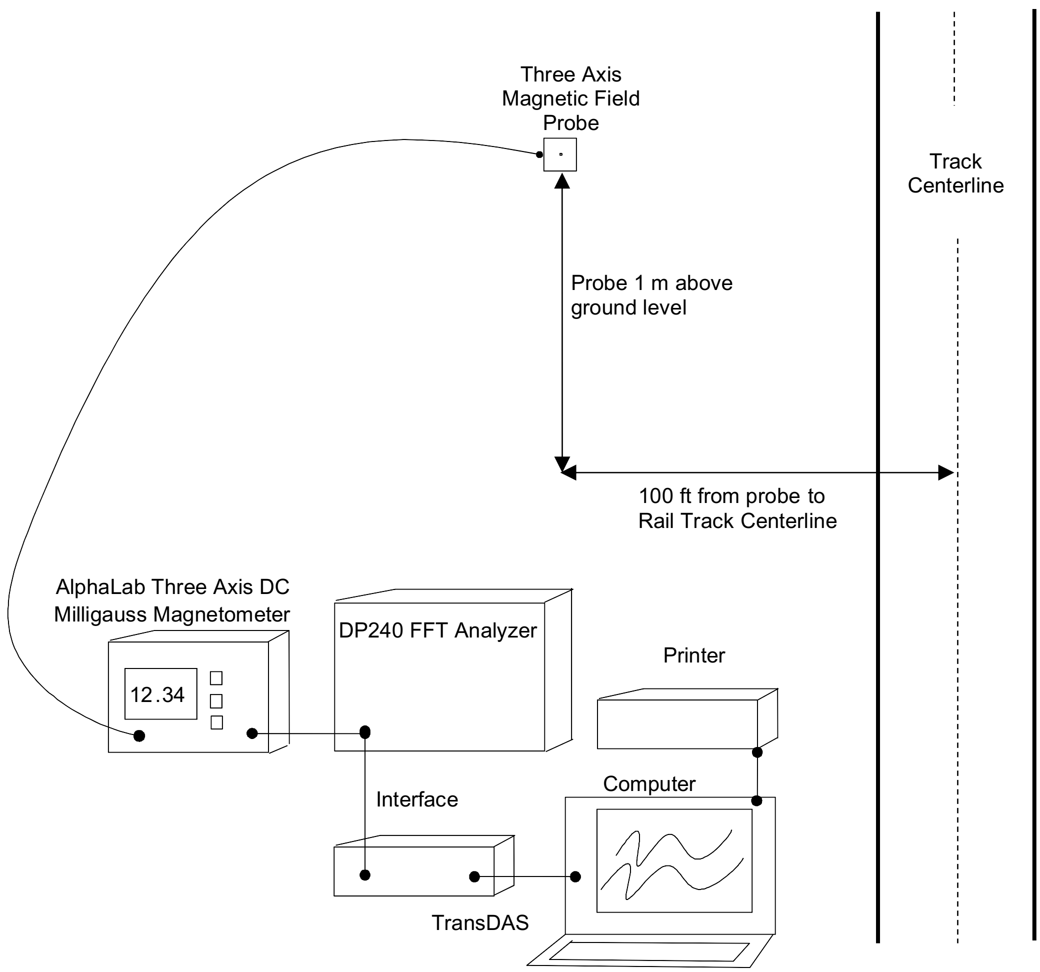
The magnetic field measurements cover the static and AC magnetic fields from DC to 800 Hz, in three axes, at a height of 1 m (3.3 ft) above the ground. The purpose is to find and record the strongest magnetic field strengths, vectors, and magnitudes, and changes related to ambient conditions.

During the PrES and PoES, Tenco will also measure the magnetic field at two locations where the PSA will install ductbanks to carry 138 kV single-phase circuits from Consolidated Edison (ConEd) utility transmission lines to traction power substations (TPSSs). The PSA project will install single phase ductbanks in two publicly accessible locations in Bronx NY:

- Under a ConEd parking lot near Van Nest (Site 8)
- Under a road and parking lot between ConEd Mott Haven Station and Oak Substation Station (Site 7).

Figure 6-1 shows the measurement equipment setup for the magnetic field measurement.

**Figure 6-1**
**Magnetic Field Measurement Equipment Setup**



The earth's static (or DC) total magnetic field in New York City is about 513 mG, per the NOAA National Centers for Environmental Information (https://www.ngdc.noaa.gov/geomag/calculators/magcalc.shtml#igrfwmm). The static magnetic field at any measurement point is significantly affected by nearby composition of the Earth, and by the presence of large steel objects nearby, including bridges, steel buildings, etc. Fluctuations in the magnetic field with durations of 1 to 10 s are caused by passing steel vehicles, such as cars, buses, trucks, and trains, and by the presence of fluctuating DC currents in nearby cables.

To measure the changes in DC magnetic field, the equipment must measure the magnetic field in three axes, subtract out the steady or 'offset' component to get the Delta DC Field, measure the three axis changes in the Delta DC Field, and calculate a combined Delta DC Field magnitude. The magnetometer and probe measure the DC field in three axes. The test team will use the Tenco TransDAS to subtract the offsets; measures the changes; calculates the combined Delta DC Field magnitude; and displays, records, and prints the results.

The magnetometer and probe measure the magnetic AC field in three axes. The Tenco TransDAS filters out two selected frequency components for each of the three axes, such as at 60 Hz and 80 Hz; presents the amplitude of the three axis selected frequency components; calculates a combined AC Field magnitude; and displays, records, and prints the results.

The AC magnetic field at a measurement site is most strongly due to AC currents in utility power cables, if any are nearby. The static magnetic field at a measurement site is most strongly due to the Earth's static magnetic field and to DC currents in traction power cables, running rails, and OCS, if any are nearby.

## 6.1 Measurement Equipment

Table 6-1 lists the magnetic field measurement equipment.

**Table 6-1**
**Magnetic Field Measurement Equipment List**

| # | Item | Comment |
|---|---|---|
| 1 | Four Channel FFT Signal Analyzer, Data Physics ACE DP240 or equivalent<br>or<br>Tenco TransDAS Smart Data Acquisition System | For measuring emission signals, typically FFT spectra |
| 2 | AlphaLab Inc. Three Axis DC Milligauss Magnetometer with Analog Outputs, or equivalent | For measuring magnetic field |
| 3 | Inkjet Printer, or equivalent | For plotting emission spectra. Compatible with 35670A Analyzer |
| 4 | Adjustable Antenna Tripod, non-metallic | To support magnetic field probe |
| 5 | AC Power Source | AC line, generator, or car battery inverter. |

| Table 6-1<br>Magnetic Field Measurement Equipment List | | |
|---|---|---|
| # | Item | Comment |
| 6 | Tenco TransDas™ Data Acquisition System | Data Acquisition System |
| 7 | Laptop computer | For control of printer and storage of measurement data results |

The following subsections describe the major measurement equipment items.

### 6.1.1 Three-Axis DC Milligauss Magnetometer and Three-Axis Probe

The test engineers will use an AlphaLab Three Axis DC Milligauss Magnetometer and Three-Axis Probe to measure and display the amplitude of the magnetic field in each of three axes in the frequency range of static to 900 Hz, for fields of amplitude from 0.01 mG to 2 G. The magnetometer includes, for each axis, digital displays, offset controls, zero controls, and range controls.

The magnetometer has an analog output for each of three axes, each of which is proportional to the magnetic field. The test team will connect the three analog outputs to the Dynamic Signal Analyzer (DSA), so the AC frequency components of the magnetic field can be measured and processed.

The three-axis probe is a one-inch cube which mounts three sensors and is sensitive to magnetic fields transverse to each flat surface.

### 6.1.2 Dynamic Signal Analyzer

The Data Physics DP240 Dynamic Signal Analyzer performs the following tasks:

- Measures the magnetometer outputs
- Converts from measured voltages into engineering units Gauss or Tesla
- Processes measured data to determine and display frequency components over the selected range
- Measures time sequence (waterfalls) or peak hold amplitudes
- Records to disk and prints out results on paper.

### 6.1.3 Tenco TransDAS Data Acquisition System

The Tenco TransDAS Data Acquisition System is an equivalent alternative to the Dynamic Signal Analyzer.

TransDAS is a laptop-based data acquisition system that uses the LabVIEW software development and operating environment to control data acquisition and perform analysis. A USB-connected, high-speed data acquisition module samples analog input signals at an aggregate of up to 500,000 samples per second and digitizes the result. The Tenco TransDAS stores the results in memory and calculates the quantities of interest for the test. The Tenco TransDAS provides fully annotated stripchart-type displays of selected variables versus time, with selectable calculation, processing, scaling, and labeling.

For this project, the Tenco TransDas performs the following tasks:

- Measures, records, and prints out the magnetometer outputs in an annotated stripchart forma

- Provide for input or selected DC offsets for each axis, subtracts the DC offset from DC magnetometer readings, combines the Delta DC Field components to get DC Field magnitude, selects two AC frequency components, filters two AC frequency components for each of the three axes, and combines two sets of AC axis frequency components to get AC Field magnitude at select frequencies

- Converts from measured voltages to engineering units Gauss or Tesla

- Filters and displays incoming waveforms

- Records and displays the DC slow variation of the magnitude of a selected frequency component

- Records to disk and prints out results on paper.

## 6.2 Measurement Bands

The test team will perform narrowband emission measurements in the range of static to 800 Hz, using the magnetometer, probe, and DSA or TransDAS. The test team will measure and process emissions in three axes to determine the orientation of the highest field.

If using TransDAS, the test team will measure magnetic field at the frequencies and bands listed in Table 6-2.

**Table 6-2**
**Magnetic Field Measurement Bands**

| ID | Frequency Range |
|---|---|
| FM0 | DC |
| FM1 | 60 Hz |
| FM2 | 100 Hz - 1000 Hz |
| FM3 | 30 Hz - 1000 Hz |
| FM4 | 30 Hz - 200 Hz |

If a measurement shows high levels of magnetic fields at a specific frequency, the test team will make a following measurement to zoom in on that frequency.

If using the DSA, the test team will make waterfall measurements and extract time sequence graphs of significant frequencies including DC, 60 Hz, 360 Hz, 720 Hz, etc.

### 6.2.1 Narrowband Measurements

The expected magnetic field components will be the earth's magnetic field, AC magnetic fields due to nearby 60 Hz utility power cables, and other AC magnetic fields due to other frequency currents in nearby cables.

Since all these expected components are narrowband in nature, the test team will make these measurements with a narrowband mode and calibration. The DSA and TransDAS are suitable instruments for making narrowband measurements.

## 6.3 Magnetic Field Maximum Permissible Exposure Limits

Per the EMCP, the test team will use the New York State (NYS) maximum permissible exposure (MPE) limits shown in Figure 6-2 and Table 6-3:

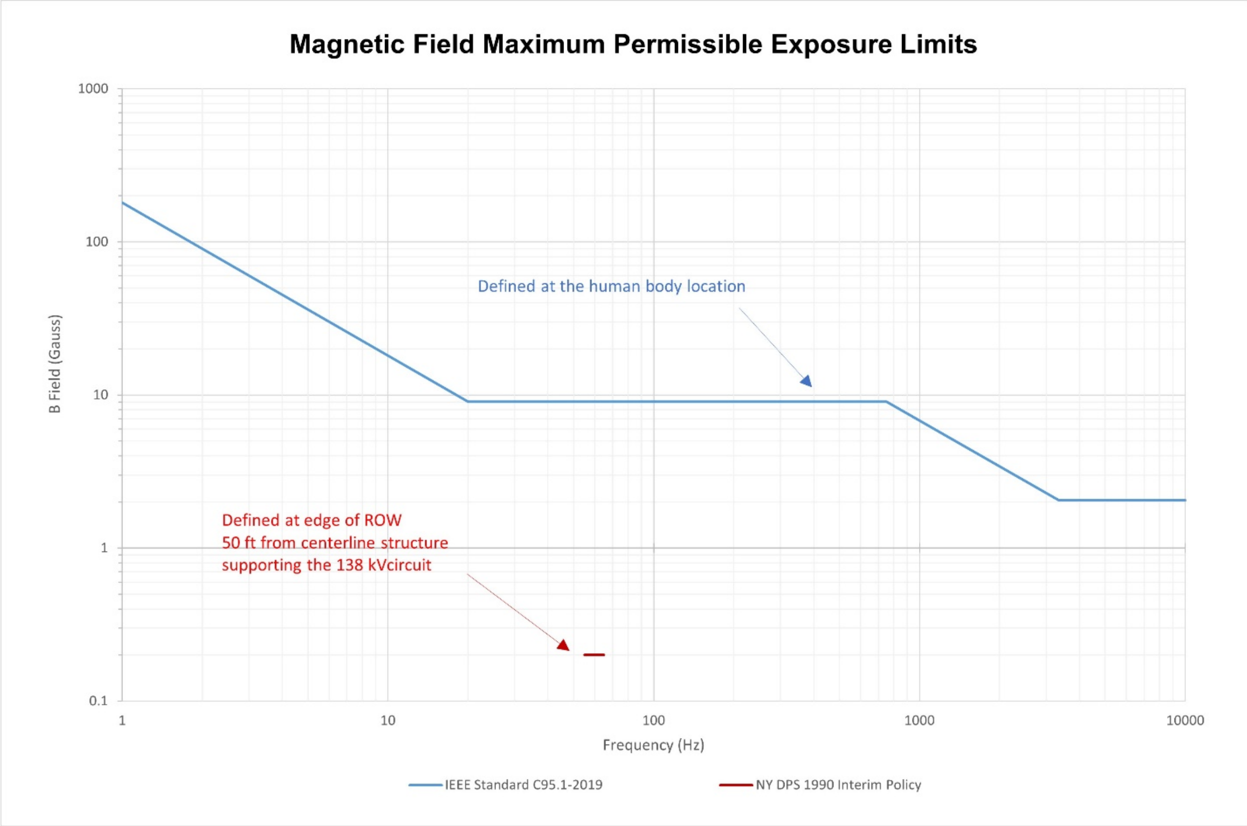
- The New York State Department of Public Service (DPS) Statement of Interim Policy (NYIP) on Magnetic Fields of Major Electric Transmission Facilities for 60 Hz Magnetic Fields near single 138 kV transmission lines (Sites 7 and 8)
- IEEE Std C95.1-2019 Table 2 unrestricted environments for all other EMF Survey Sites

These MPE limits are provided as a reference during the PrES. These limits only apply to the effects of new construction during the PoES, and not to existing background magnetic fields.

**Table 6-3**
**NYS Magnetic Field MPE Regulations and Standards**

<table>
<tr><th>Standard/Regulation</th><th>Full Standard Frequency Range</th><th>Full Standard B Field Limit (G)</th></tr>
<tr><td>NY DPS 1990 Interim Policy (NYIP)</td><td>60 Hz</td><td>0.2</td></tr>
<tr><td rowspan="5">IEEE Std C95.1-2019 Table 2 unrestricted environments</td><td>< 0.153 Hz</td><td>1180</td></tr>
<tr><td>0.153 – 20 Hz</td><td>181 / f</td></tr>
<tr><td>20 – 751 Hz</td><td>9.04</td></tr>
<tr><td>751 Hz – 3.35 kHz</td><td>6870 / f</td></tr>
<tr><td>3.35 – 500 kHz</td><td>2.05</td></tr>
<tr><td colspan="3">Notes:<br>1] The NYIP specifies limits at the edge of the right of way (ROW). If a ROW is not established, the standard specifies the edge of the right-of-way to be at a horizontal distance of 50 ft (15.2 m) from the centerline of the structures supporting the circuit for 138 kV systems. IEEE standards are specified at the location of the human body.</td></tr>
</table>

**Figure 6-1**
**New York Magnetic MPE limits**




## 6.4 Magnetometer Calibration

The test team will perform the following steps to verify proper operation of the magnetometer:

1. Turn on the magnetometer and let it warm up

2. After warm up, check the static magnetic field offset of each axis
    - Check the axis reading
    - Flip the probe cube over
        - If the magnetometer is properly zeroed, the axis reading should go from +xyz to -xyz
    - Repeat for each axis
    - Restore the probe to the nominal position

3. Check that the magnitude of the static electric field is close to the expected value for New York City.

## 6.5 Site Diagram

The test team will make a detailed diagram of each measurement site, showing location, measurement point, nearby structures, emitters, track centerline, and other significant objects. The site diagram will include the measurement site latitude and longitude and photographs of the measurement site.

The test team will provide a map showing all measurement sites and the track centerline.

## 6.6 Magnetic Field Measurement Planning

The test team will arrange measurements to measure worst-case (maximum and minimum) magnetic field conditions, considering time of day, intermittent events, and local actions. Ambient magnetic field conditions change frequently because neighbor energy sources continually vary their operating conditions.

The test team will perform sufficient repeated measurements to identify worst-case conditions and characterize their amplitude, frequency, duration, and repetition at each measurement site.

## 6.7 Magnetic Field Measurement Method

For each measurement, the test team will maintain a log of the measurement type, measurement equipment, configuration, external event or condition description, comments, summary of measured data, and other relevant information. If the measurement includes a train, motor vehicle, or airplane, the test team will note it. The test team will record the magnetometer probe axis which detects the peak level.

### 6.7.1 Magnetic Field Measurement Steps

The steps are:

1. Setup at the measurement site

2. Calibrate the magnetometer

3. With the Tenco TransDas and Data Physics DP240 set Max/Min, measure and record for 30 s time intervals. Observe measurements through range of conditions at particular site, such as traffic nearby, etc.

4. Identify and characterize worst-case conditions. Print the results.

### 6.7.2 Narrowband Emission Evaluation

The test team will measure magnetic field emissions and record narrowband levels.

#### 6.7.3 Field Reduction of Data

The test team will set up the DSA to display measurements in Gauss (G). The test team will print out and save the data for each valid measurement run.

The test team will characterize each measurement, noting:
- Key emissions in the measurement
- Changes between the measurement and recent similar measurements
- Similarities or differences to other measurements in the same band at other locations
- Whether the measurement is an apparent worst case.

#### 6.7.4 Measurement Data Collection

The test team will collect data, including for measurement equipment and each ambient site measurement.

**Equipment Calibration**: Record calibration data for each major measurement equipment item. Calibration data will include the following:
- Measurement equipment item
- Manufacturer
- Model
- Serial number
- Calibration date
- Calibration source
- Reference number
- Notes.

**Measurement Log**: Maintain a measurement run log, recording the following for each measurement:
- Date
- Time
- Performed by
- Location
- Site conditions
- Event
- Run number
- Identification number for plot
- Measurement type
- Frequency band
- Measurement configuration data such as attenuation settings
- Summary results
- Notes.

# 7 PSA Pre-Energization and Post-Energization Survey Reports

Tenco will document PrES and PoES measurement results, and provide the PPSR and POSR to Jacobs for project documentation and transmittal as appropriate.

The PPSR and POSR will each summarize the test schedule and scope; describe the most important results; and clearly state conclusions.

The PPSR and POSR will each consist of sections including, or equivalent to, the following:

**Introduction:** The Introduction section provides the purpose, scope, applicable requirements, participants, reference documents, test procedure overview, and organization for the rest of the report.

**Test Results and Conclusions:** The Test Results and Conclusions section provides tables of:

- Radiated electric field:
  - For each frequency band, worst-case emitters, including amplitude and frequency of emission, location, conditions, and preliminary assessment of impact
  - For each frequency band, most quiet condition
  - Notes on potential victim locations in the section.

- Magnetic field:
  - From static to 800 Hz, worst-case fields, including amplitude and frequency of emission, location, conditions, and preliminary assessment of impact
  - From static to 800 Hz, most quiet condition
  - Notes on potential victim locations in the section.

The section also provides the test schedule and scope and a top-level index of all measurements. It identifies, references, and describes the most important results, and states conclusions.

**Test Locations:** The Test Locations section describes each test location planned for the EMF survey, per Table 4-1 and Appendix B. It provides maps showing the site and the track centerline. It provides a detailed diagram and photographs for each site.

**Test Equipment Configuration:** The Test Equipment Configuration section describes the test equipment configuration, including a test equipment connection diagram, a list of measurement equipment with model numbers, and instrument calibration dates and calibration certificates.

This section provides complete information on the scale or conversion factors which apply to all measurement data, including Antenna or Probe outputs, data-time series charts, and Analyzer plots. It provides initial setup calibration data, which demonstrates that the Antennas, the RF Spectrum Analyzer, Magnetometer, DSA, transducers, and external instruments give correct, accurate, and repeatable results.

**Test Procedure:** The Test Procedure section summarizes the test steps and describes any differences between the "as-performed" test steps and the referenced specifications.

**Test Data:** The Test Data section describes significant measurement results, conclusions, or considerations. This section summarizes all data collected during the measurements. It includes a log and index of all measurements, print outs, and spectral plots. The log includes the Date, Measurement Participants, Location, and notes for all measurements. It provides the Measurement Number, Measurement Type and Time; IDs of hardcopies and data files; measurement description; measurement configuration data such as gain settings; summary result; and notes.

# Appendix A

# PSA EMF Survey Forms

The following survey forms are attached:

- PSA EMF Survey Measurement Equipment Calibration Record
- PSA EMF Survey Run Log
- PSA EMF Survey Directory, Electric Field and Magnetic Field
- PSA EMF Survey Site Plan.

**Recorded by:** ______________________________ **Date:** _________________________

| PSA EMF Survey Measurement Equipment Calibration Record | | | | |
|---|---|---|---|---|
| **#** | **Item** | **Manufacturer** | **Model/Serial Number** | **Calibration / Date** |
| 1 | RF Signal Analyzer with EMI Measurement application | Keysight Technologies | KT-9010A-507/P07/EDP<br>KT-N6141A/2TP | |
| 2 | PC Software, EMI Measurement application | Keysight Technologies | KT-N6141A/2TP | |
| 3 | Active Monopole Antenna 10 kHz to 60 MHz | A.H. Systems, Inc. | SAS-550-1 | |
| 4 | Bilogical Antenna 25 MHz to 7 GHz | A.H. Systems | SAS-521F-7 | |
| 5 | Laptop computer | Lenovo | | |
| 6 | TransDAS Data Acquisition System | Tenco | TransDas | |
| 7 | Three Axis DC Milligauss Magnetometer with Analog Outputs | AlphaLab Inc. | Model #3AMG | |
| 8 | Four Channel FFT Signal Analyzer | Data Physics | DP240 or equiv. | |
| 9 | Printer | Brother | MFC-J280W | |
| 10 | | | | |
| 11 | | | | |
| 12 | | | | |

# PSA EMF Survey Run Log

**Date:** ____________________ **Time:** ________________ **Weather:** ________________________ **Performed By:** ___________________________________________________

**Line:** ________________________ **Location:** ____________________________________ **Notes:** ___________________________________________________________

| Measure ment ID | Time | Type | Frequency Band | Location | Conditions | Results |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 0 | | | | | | |

**Date:** ____________________ **Time:** ________________ **Weather:** _________________ **Performed By:** ___________________________________________________

**Line:** ________________________ **Location:** ____________________________________ **Notes:** ___________________________________________________________

# PSA EMF Survey Radiated Electric Field Measurement Directory

| Site | | Frequency Band | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **B0: 10 to 160 kHz** Monopole Vertical 1 kHz res bw | **B1: 150 to 650 kHz** Monopole Vertical 10 kHz res bw | **B2: 500 kHz to 3 MHz** Monopole Vertical 10 kHz res bw | **B3: 2.5 to 7.5 MHz** Monopole Vertical 10 kHz res bw | **B4: 5 to 30 MHz** Monopole Vertical 100 kHz res bw | **B5: 25 to 325 MHz (Note V or H polarity)** Bilogical, 100 kHz res bw | **B6: 0.3 to 1.3 GHz (Note V or H polarity)** Bilogical, 300 kHz res bw | **B7: 1 GHz to 6 GHz (Note V or H polarity)** Bilogical, 300 kHz res bw |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

**Date:** ____________________ **Time:** ________________ **Weather:** _________________ **Performed By:** ___________________________________________________

**Line:** ________________________ **Location:** ____________________________________ **Notes:** ___________________________________________________________

## PSA EMF Survey Magnetic Field Measurement Directory

| Site | | FM0: DC | FM1: 60 Hz | FM2: 100 Hz - 1000 Hz | FM3: 30 Hz - 1000 Hz | FM4: 30 Hz - 200 Hz |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

**Date:** ____________________**Time:** _______________________ **Performed By:** ________________________________________________

**Configuration:** ________________________________ **Location:** ______________________________________________________

| PSA EMF Survey Site Plan |
|---|
| |

# Appendix B

# PSA EMF Survey Measurement Locations

**Figure B-1**
**Site 1: HG-01 DC Substation**
**STA: 222+00**
**GPS Coordinates: 40.751163, -73.914592**

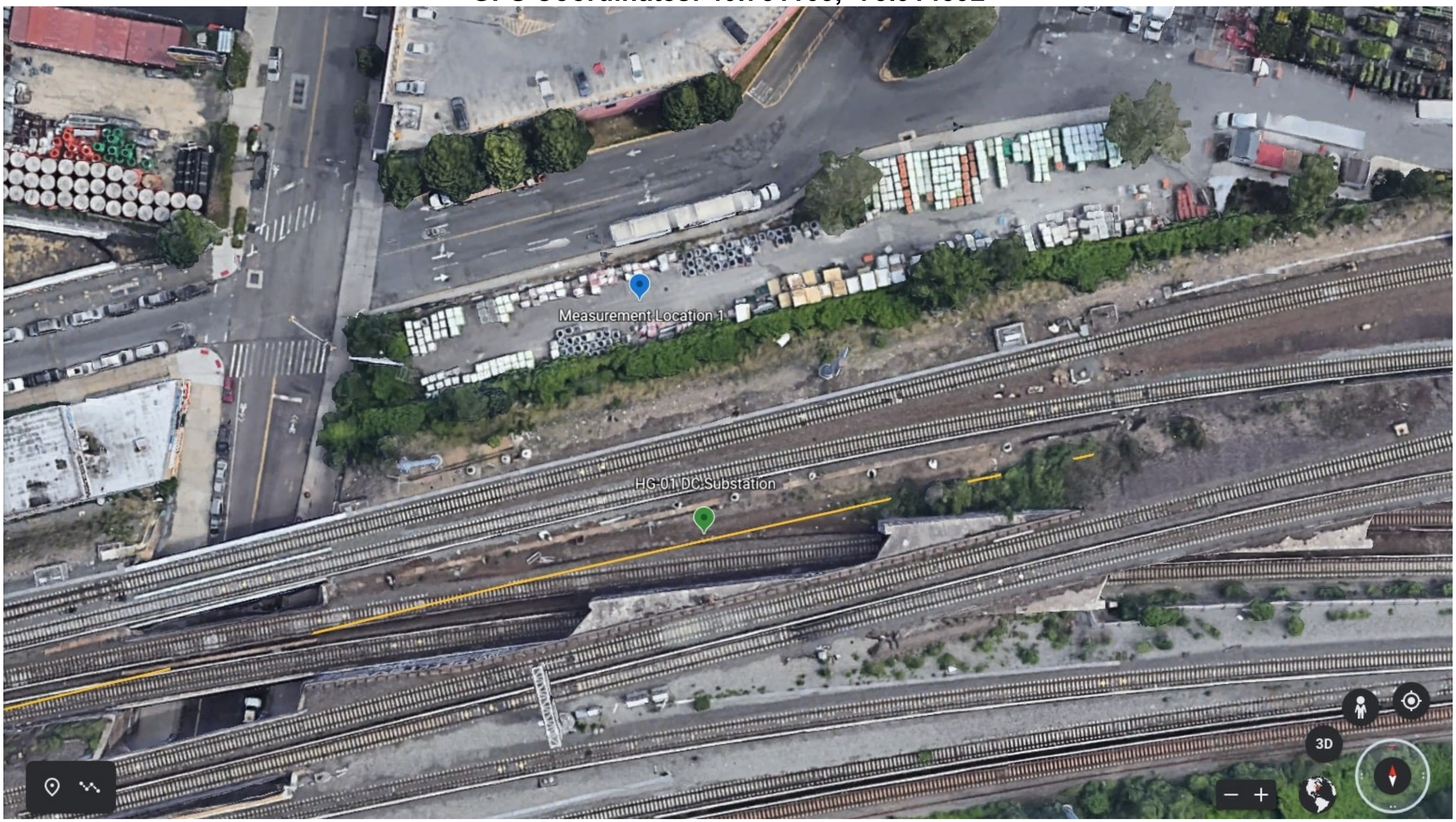


**Figure B-2**

## Site 2: HG-02 DC Substation
## STA: 277+00
## GPS Coordinates: 40.760644, -73.903683

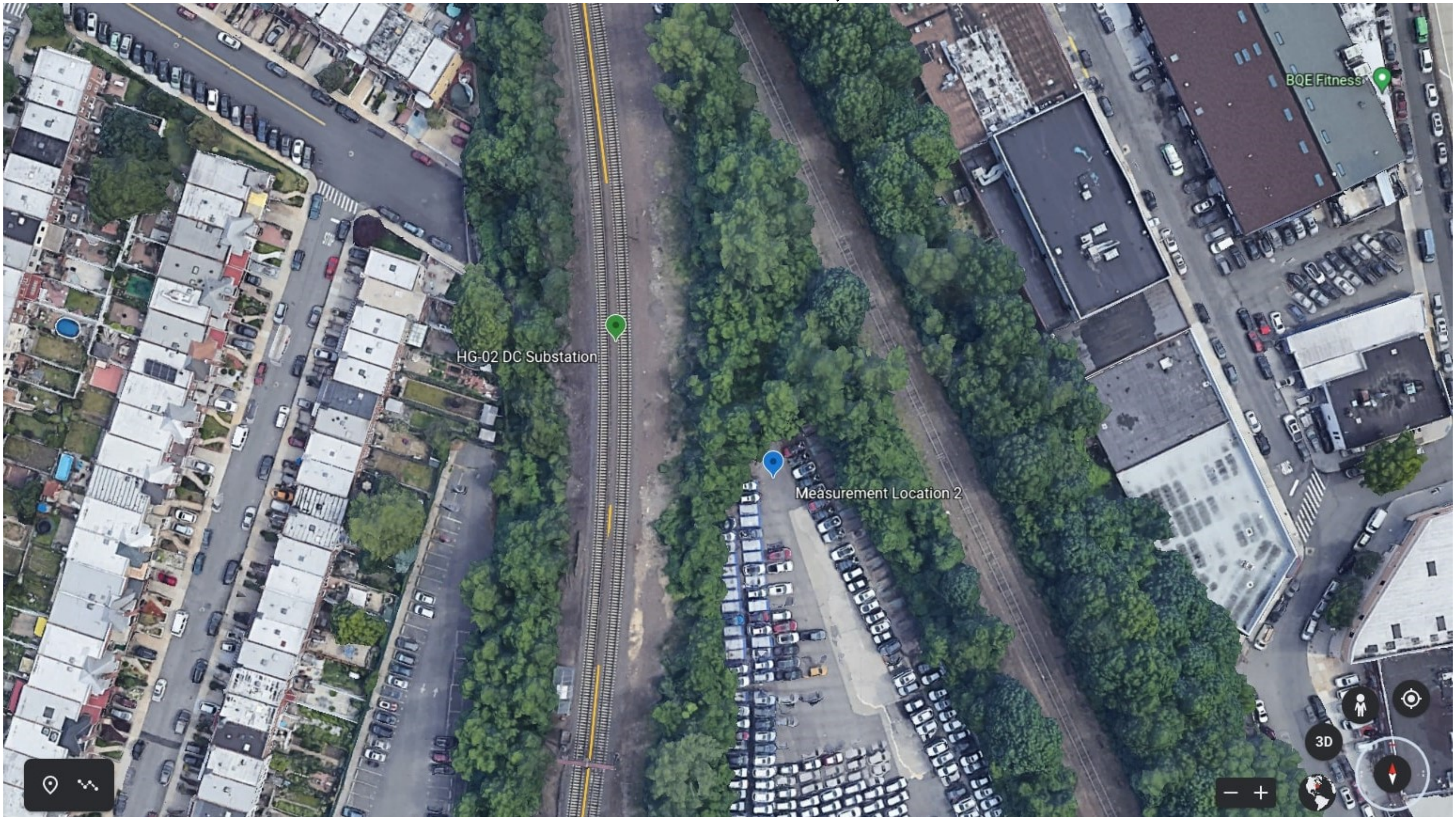


**Figure B-3**

**Site 3: Bowery Bay AC Substation**

**STA: 289+00**

**GPS Coordinates: 40.764293, -73.905214**

**Figure B-4**
**Site 4: Contact Rail End**
**STA: 298+30**
**GPS Coordinates: 40.766444, -73.907289**

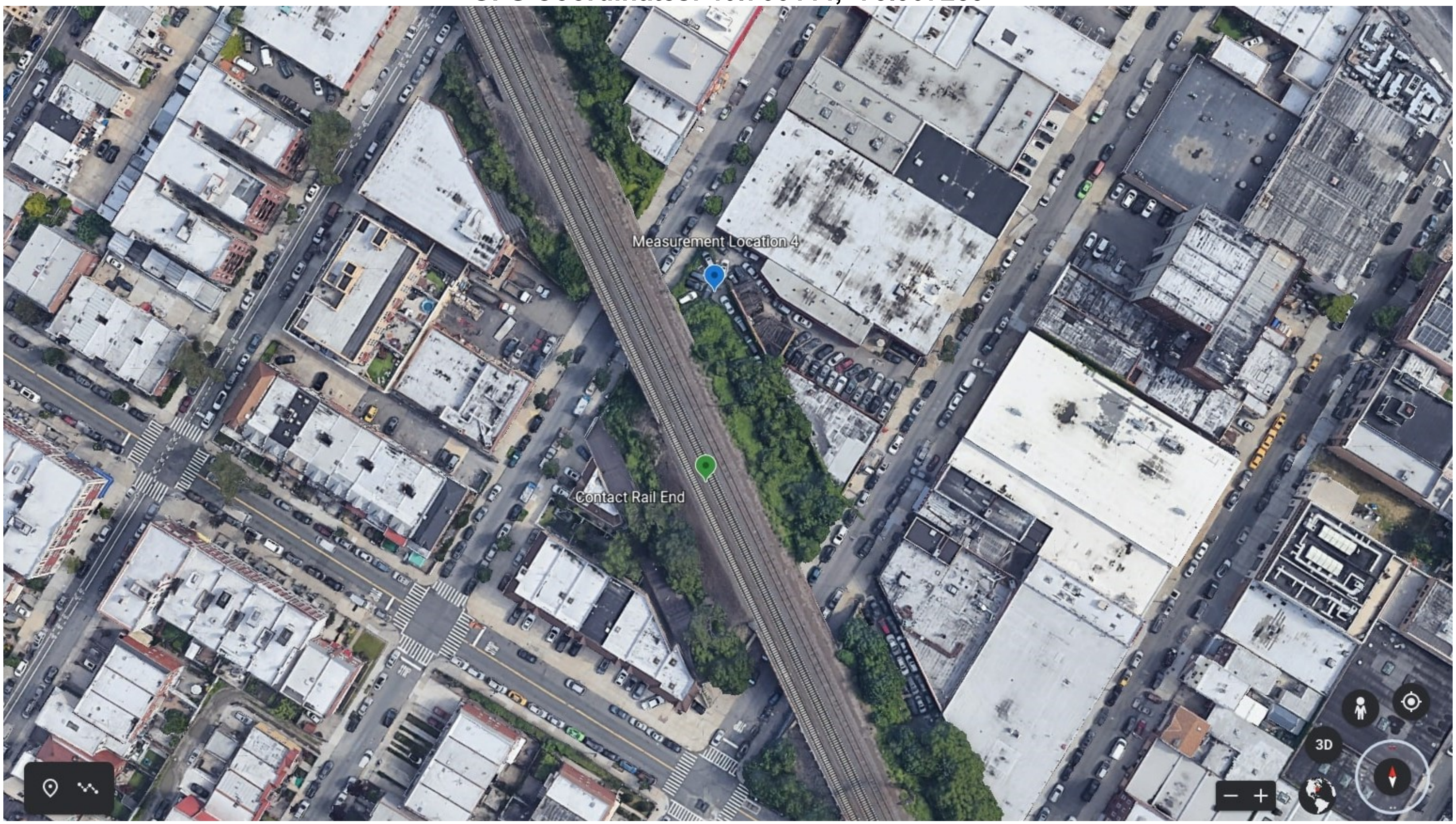


**Figure B-5**
**Site 5: Randall's Island Field #43**
**326+55**
**GPS Coordinates: 40.797109, -73.918248**

**Figure B-6**
**Site 6: Electric Substation near Randall's Island**
**STA: 336+31**
**GPS Coordinates: 40.798477, -73.914738**

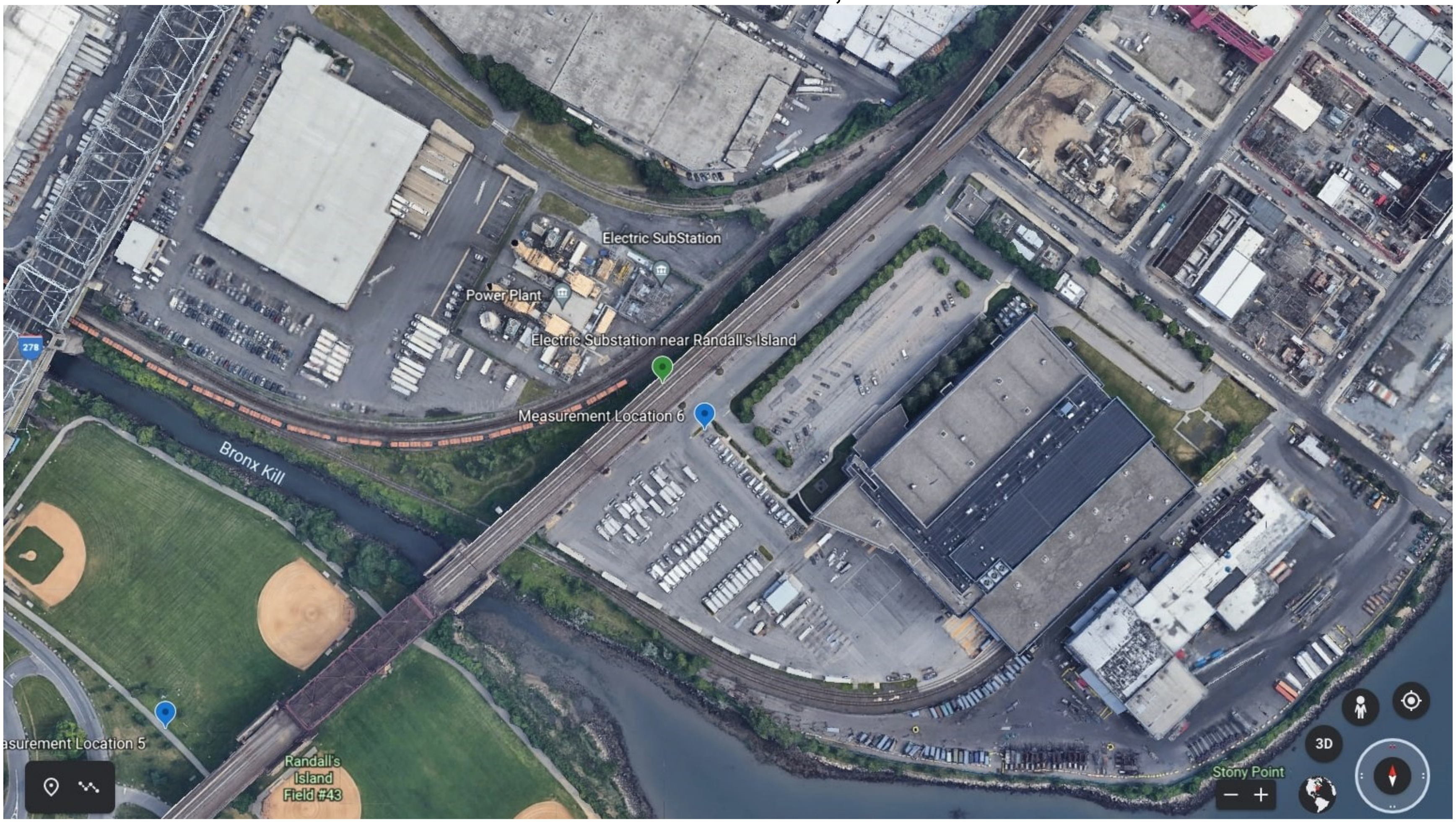


**Figure B-7**
**Site 7: Oak AC Substation**
**STA: 371+96**
**GPS Coordinates: 40.806752, -73.906753**

**Figure B-8**
**Site 8: Parkchester-Van Nest Station**
**STA: 562+11**
**GPS Coordinates: 40.842239, -73.861933**

**Figure B-9**
**Site 9: Morris Park Station**
**STA: 619+00**
**GPS Coordinates: 40.849332, -73.844453**

**Figure B-10**

**Site 10: Co-op City Station**

**STA: 677+32**

**GPS Coordinates: 40.858275, -73.828892**

**Figure B-11**
**Site 11: Pelham Bay and Split Rock Golf Courses**
**STA: 761+15**
**GPS Coordinates: 40.875269, -73.810160**

**Figure B-12**

## Site 12: New Rochelle AC Substation
## STA: 873+56
## GPS Coordinates: 40.902644, -73.793171