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September 20, 2019

Mr. Robert Romine
Project Engineer
Ravenswood Development, LLC

**Re: Ravenswood Updated Acoustical Analysis & Recommendations
Proposed Battery Storage Facility – Long Island City, Queens, New York**

Dear Mr. Romine:

In response to Ravenswood Development, LLC's (Ravenswood) request to outline an approach that would allow prospective design/build contractors a greater degree of flexibility in developing the most cost-effective approach to meeting all applicable noise codes and standards, AKRF has completed the following updated acoustical analysis for the proposed battery storage facility located on the northeastern portion of the existing Ravenswood Generating Station site in Long Island City, Queens, NY. This updated acoustical analysis, which is intended to supplement the discussion in Section 3(G) of the Expanded Environmental Assessment prepared for the project, does not alter any of the conclusions set forth in the prior analysis including confirmation that the project will comply with all applicable noise standards.

The purpose of the acoustical analysis is to assess existing noise conditions, and evaluate noise emissions from the proposed battery storage facility. The project will need to comply with the New York City (NYC) Noise Control Code Local Law 113 (§24-227 and §24-232), NYC Mechanical Code (Section MC 928), and New York State Department of Environmental Conservation (NYSDEC) Noise Impact Criteria at the closest residential dwellings. In addition, the project will need to comply with NYC Manufacturing District Regulations (§42-213) at property boundaries. This report summarizes the analysis/findings and recommendations.

EXECUTIVE SUMMARY
The proposed battery storage facility is anticipated to comply with all applicable noise regulations. Primary noise-producing components of the project will include rooftop air-conditioning equipment, transformers, and electrical inverter equipment. The actual battery units do not produce noise, and all battery units will be located within air-conditioned buildings. Upon review and analysis of all noise-producing components for the project, it has been determined that mitigation will be required for the project inverters. The analysis has been updated to provide a property-line acoustical performance specification for the project inverters that must be met for the project to comply with NYC Noise Control Code Local Law 113. The property-line acoustical performance requirement will provide flexibility while ensuring compliance with applicable standards. No other mitigation is required for the project.

A. NOISE

INTRODUCTION

Noise pollution in an urban area comes from many sources. Some sources are activities essential to the health, safety, and welfare of a city's inhabitants, such as noise from emergency vehicle sirens, garbage collection operations, and construction and maintenance equipment. Other sources, such as traffic, are essential to the viability of a city as a place to live and do business. Although these and other noise-producing activities are necessary to a city, the noise they produce is undesirable. Urban noise detracts from the quality of the living environment, and there is increasing evidence that excessive noise represents a threat to public health.

A noise assessment was performed to determine whether the proposed project would produce significant impacts on ambient noise levels and to determine whether noise produced by the project would be consistent with applicable noise regulations.

NOISE FUNDAMENTALS

Quantitative information on the effects of airborne noise on people is well documented. If sufficiently loud, noise may adversely affect people in several ways. For example, noise may interfere with human activities, such as sleep, speech communication, and tasks requiring concentration or coordination. It may also cause annoyance, hearing damage, and other physiological problems. Although it is possible to study these effects on people on an average or statistical basis, the stated effects of noise on people vary greatly with the individual. Several noise scales and rating methods are used to quantify the effects of noise on people. These scales and methods consider such factors as loudness, duration, time of occurrence, and changes in noise level with time.

NOISE MEASUREMENT

A number of factors affect sound as perceived by the human ear. These include the actual sound (or noise) levels, frequencies, period of exposure, and changes or fluctuations in noise levels during exposure. Noise levels are measured in units called decibels (dBs). Since the human ear cannot perceive all pitches or frequencies equally well, this measure is adjusted or weighted to correspond to human hearing. A measurement system that simulates the response of the human ear, the “A-weighted sound level” or “dBA,” is used in view of its widespread recognition and its close correlation with human judgment of loudness and annoyance. In this construction noise analysis, all measured levels are reported in dBA or A-weighted decibels. Typical sound levels for various types of activities are shown in **Table 1**.

Table 1
Common Noise Levels

Sound Source	(dBA)
Military jet, air raid siren	130
Amplified rock music	110
Jet takeoff at 1,640 feet	100
Freight train at 100 feet	95
Train horn at 100 feet	90
Heavy truck at 50 feet	80-90
Busy city street, loud shout	80
Busy traffic intersection	70-80
Highway traffic or train at 50 feet	70
Predominantly industrial area	60
Light car traffic at 50 feet, city or commercial areas, or residential areas close to industry	50-60
Background noise in an office	50
Suburban areas with medium density transportation	40-50
Public library	40
Soft whisper at 15 feet	30
Threshold of hearing	0

Note: A 10 dBA increase in level appears to double the loudness, and a 10 dBA decrease halves the apparent loudness.

Source: Cowan, James P. *Handbook of Environmental Acoustics,* Van Nostrand Reinhold, New York, 1994.
Egan, M. David, Architectural Acoustics. McGraw-Hill Book Company, 1988.

ABILITY TO PERCEIVE CHANGES IN NOISE LEVELS

The average ability of an individual to perceive changes in noise levels is well documented (see **Table 2**). Generally, changes in noise levels less than 3 dBA are barely perceptible to most listeners, whereas 10 dBA changes are normally perceived as doublings (or halvings) of noise levels. These guidelines permit direct estimation of an individual's probable perception of changes in noise levels.

Table 2
Average Ability to Perceive Changes in Noise Levels

Change (dBA)	Human Perception of Sound
2-3	Barely perceptible
5	Readily noticeable
10	A doubling or halving of the loudness of sound
20	A "dramatic change"
40	Difference between a faintly audible sound and a very loud sound

Source: Bolt Beranek and Newman, Inc., *Fundamentals and Abatement of Highway Traffic Noise*, Report No. PB-222-703. Prepared for Federal Highway Administration, June 1973.

NOISE DESCRIPTORS USED IN IMPACT ASSESSMENT

Because a sound pressure level measured in dBA describes a noise level at just one moment, and very few noises are constant, other ways of describing noise over more extended periods have been developed. One way of describing fluctuating sound is to describe the fluctuating noise heard over a specific period as if it had been a steady, unchanging sound. For this condition, a descriptor called the "equivalent sound level," or "L_{eq}", can be computed. L_{eq} is the constant sound level in a given situation and period (e.g., 1 hour, denoted by $L_{eq(1)}$, or 24 hours, denoted by $L_{eq(24)}$) that conveys the same sound energy as the actual time-varying sound. Statistical sound level descriptors, such as L_1, L_{10}, L_{50}, L_{90}, and L_x, are used to indicate noise levels that are exceeded 1, 10, 50, 90, and x percent of the time, respectively. Discrete event peak levels are given as L_{01} levels. The L_{max} noise descriptor represents the maximum instantaneous noise level recorded during a measurement.

For purposes of the proposed project, the maximum 1-hour equivalent sound level ($L_{eq(1)}$), L_1, L_{10}, and L_{max} have been selected as the noise descriptors to be used in this noise impact evaluation. $L_{eq(1)}$ is the noise descriptor used to comparison CEQR impact thresholds as outlined in the *CEQR Technical Manual*. The 1-hour L_{10} is the noise descriptor suggested in the *CEQR Technical Manual* noise exposure guidelines for City environmental impact review classification. The L_1 was selected for evaluation of the noise due to operations regarding the New York City Zoning Resolution Performance Standards for Manufacturing Districts, and is used to provide an indication of highest expected sound levels.

NOISE STANDARDS AND CRITERIA

Noise levels associated with the construction and operation of the proposed project would be subject to the emission source provisions of the NYC Zoning Resolution Performance Standards for Manufacturing Districts, New York City Noise Control Code, and to noise criteria suggested in the 2012 *CEQR Technical Manual.*

PERFORMANCE STANDARDS FOR MANUFACTURING DISTRICTS

The City's Zoning Resolution §42-213 states that in all manufacturing districts, the sound pressure level resulting from any activity, whether open or enclosed, shall not exceed, at any point on or beyond any lot line, the maximum permitted sound level for the designated octave band indicated in **Table 3** for an M3 zone.

The Performance Standards in New York's Zoning Resolution are specified in "old" octave bands. These bands have not been used in almost 40 years, and instrumentation is no longer available to measure per these specifications. The American National Standards Institute (ANSI) has promulgated a standard on the conversion of old octave bands to the current preferred values (and vice versa), to allow measurement and assessment. Converted criteria are provided in **Table 3**.

Table 3
City of New York Noise Performance Standards for M3 Manufacturing District

Old Octave Bands	Current Octave Bands	
Octave Band (Hz)	**Octave Band (Hz)**	**M3 District (dB)**
20 to 75	63	78
75 to 150	125	75
150 to 300	250	69
300 to 600	500	63
600 to 1200	1000	57
1200 to 2400	2000	52
2400 to 4800	4000	49
Above 4800	8000	45
Source: City of New York Performance Standards for Manufacturing Districts §42-213		

NEW YORK CITY NOISE CONTROL CODE
The NYC Noise Control Code as amended in December 2005 contains: prohibitions regarding unreasonable noise; requirements for noise due to construction activities; and specific noise standards, including plainly audible criteria for specific noise sources. In addition, the amended code specifies that no sound source operating in connection with any commercial or business enterprise may exceed the decibel levels in the designated octave bands shown in **Table 4** at the specified receiving properties.

Table 4
New York City Noise Control Code

Octave Band Frequency (Hz)	Maximum Sound Pressure Levels (dB) as Measured Within a Receiving Property as Specified Below	
	Residential receiving property for mixed-use building and residential buildings (as measured within any room of the residential portion of the building with windows open, if possible)	*Commercial receiving property (as measured within any room containing offices within the building with windows open, if possible)*
63	61	64
125	53	56
250	46	50
500	40	45
1000	36	41
2000	34	39
4000	33	38
8000	32	37
Source: §24-232 of the Administrative Code of the City of New York, as amended December 2005.		

NYSDEC NOISE IMPACT CRITERIA
The NYSDEC has published a policy and guidance document, *Assessing and Mitigating Noise Impacts* (DEP-00-1, February 2, 2001), which presents noise impact assessment methods, identifies thresholds for significant impacts, and discusses potential avoidance and mitigation measures to reduce or eliminate noise impacts.[1]

NYSDEC's guidance document sets forth thresholds that can be used in determining whether a noise increase due to a project may constitute a significant adverse impact, noting that these thresholds should be viewed as guidelines subject to adjustment as appropriate for the specific circumstances. According to DEP-00-1:

[1] http://www.dec.ny.gov/docs/permits_ej_operations_pdf/noise2000.pdf.

- Increases in noise ranging from 0 to 3 dBA should have no appreciable effect on receptors;
- Increases of 3 to 6 dBA may have the potential for adverse impacts only in cases where the most sensitive of receptors (e.g., hospital or school) are present;
- Increases of more than 6 dBA may require a closer analysis of impact potential depending on existing noise levels and the character of surrounding land use and receptors; and
- Increases of 10 dBA or greater deserve consideration of avoidance and mitigation measures in most cases.

The guidance document also sets forth noise thresholds that can be used in identifying whether a noise level due to a project should be considered a significant adverse impact. According to the guidance, the addition of any noise source in a non-industrial setting should not raise the ambient noise level above a maximum of 65 dBA, and ambient noise levels in industrial or commercial areas may exceed 65 dBA with a high end of approximately 79 dBA. As set forth in the guidance, projects that exceed these levels should explore the feasibility of implementing mitigation.

Based on these criteria, an increase of 6 dBA over baseline noise levels is considered significant, and therefore a “noise disturbance.”

NOISE ANALYSIS METHODOLOGY

To determine potential noise impacts due to the proposed project, a screening analysis was performed. The screening analysis consisted of the following:

- Determine a receptor location to represent noise-sensitive land uses (i.e. residences, churches, schools, etc.) closest to the Ravenswood Energy Storage Facility within the adjacent study area;
- Measure existing ambient noise levels at the selected receptor location during the quietest time of the day/night when the proposed project equipment may be operating. In order to capture the lowest noise levels at locations adjacent to the proposed project, a continuous noise measurement was taken for 24 hours over the course of two weekdays;
- Determine individual equipment sound power levels or sound pressure levels based on best available manufacturer data and published material;
- Determine the location of individual equipment on the project site;
- Calculate noise levels at sensitive receptor locations and the project’s site boundary using acoustical fundamentals; and
- Compare calculated noise levels with standards and existing ambient noise levels.

EXISTING CONDITIONS

SITE DESCRIPTION

The project site is located on the existing Ravenswood Generating Station at the southwest corner of 36th Avenue and Vernon Boulevard in Long Island City, Queens, NY.

CONTINUOUS NOISE MONITORING

One continuous noise measurement site was analyzed in the vicinity of the proposed battery storage facility. The monitoring location was chosen based on proximity to the project site and proximity to nearby noise sensitive receptors. The selected noise monitoring site represents the residential and commercial receivers across Vernon Boulevard where maximum project impacts would be expected.

The monitoring location is shown on **Figure 1**. Land uses shown in **Figure 1** are based on Geographic Information System (GIS) land use data. The continuous 24-hr. measurement was performed at the Northeast corner of the Ravenswood Generating Station at the lot line. The microphone was elevated to approximately 10 feet in order to have direct line of site to Vernon Boulevard over the exterior wall surrounding the site. This monitoring location represents four-story residential receivers at the southeast corner of 36th Avenue and Vernon Boulevard. Existing equipment within the Ravenswood Generating Station and vehicular traffic on Vernon Boulevard were the dominant noise sources at the survey location.

Figure 1: Noise Monitoring Location

Existing noise levels were measured continuously over a 24-hour period beginning on the morning of Tuesday, November 20, 2018. Noise levels late at night represent the lowest ambient noise levels.

EQUIPMENT USED DURING NOISE MONITORING

Measurements were performed using a Brüel & Kjær Sound Level Meters (SLM) Type 2250, a Brüel & Kjær 1/2-inch microphone Type 4189, and a Brüel & Kjær Sound Level Calibrator Type 4231. The SLM had laboratory calibration dates within one year of the measurements, as is standard practice. The Brüel & Kjær SLM is a Type 1 instrument according to ANSI Standard S1.4-1983 (R2006). The instrument/microphone was mounted at a height of approximately 10 feet above the ground. The microphone was mounted at least approximately 5 feet away from any large reflecting surfaces. The SLM was calibrated before and after readings with a Brüel & Kjær Type 4231 Sound Level Calibrator using the appropriate adaptor. Measurements at each location were made on the A-scale (dBA). The data were digitally recorded by the sound level meter and displayed at the end of the measurement period in units of dBA. Measured quantities included L_{eq}, L_1, L_{10}, L_{50}, L_{90}, and 1/3 octave band levels. A windscreen was used during all sound measurements except for calibration. All measurement procedures were based on the guidelines outlined in ANSI Standard S1.13-2005.

RESULTS OF BASELINE (EXISTING) NOISE MEASUREMENTS

Table 5 shows the minimum measured $L_{eq(1h)}$ noise levels at the receptor location, which was used as baseline levels for the noise analysis. The full results of the existing noise level measurements are shown in **Appendix A**. In general, the measured noise levels are moderate and directly related to the volume of traffic on Vernon Boulevard as well as the amount of activity occurring in the existing Ravenswood Generating Station. The lowest measured noise levels occurred during the very early hours of the morning, when vehicular traffic was at the lowest level.

Table 5
Lowest Measured Existing Background Noise Levels (in dBA)

Site	Location	$L_{eq(1)}$
1	Northeast Corner of Ravenswood Generating Station along Vernon Boulevard	61.5
Notes: Field measurements were performed on November 20, 2018.		

ANALYSIS RESULTS

NOISE MODELLING ASSUMPTIONS

The proposed project would include three (3) main buildings that contain lithium-ion battery storage units. The battery units produce no noise, but require temperature control through air-conditioning units which are proposed as rooftop units on each of the three main battery buildings. The buildings are surrounded by a total of 136 inverters and 68 generator step-up transformers, which are located on the proposed site in clusters. In addition, two station step-up transformers located outdoors within the Ravenswood Generating Station are proposed as part of this project. A generalized site plan for the proposed project is shown in **Figure 2**, indicating the inverters, transformers and approximate rooftop air conditioning units (RTU's).

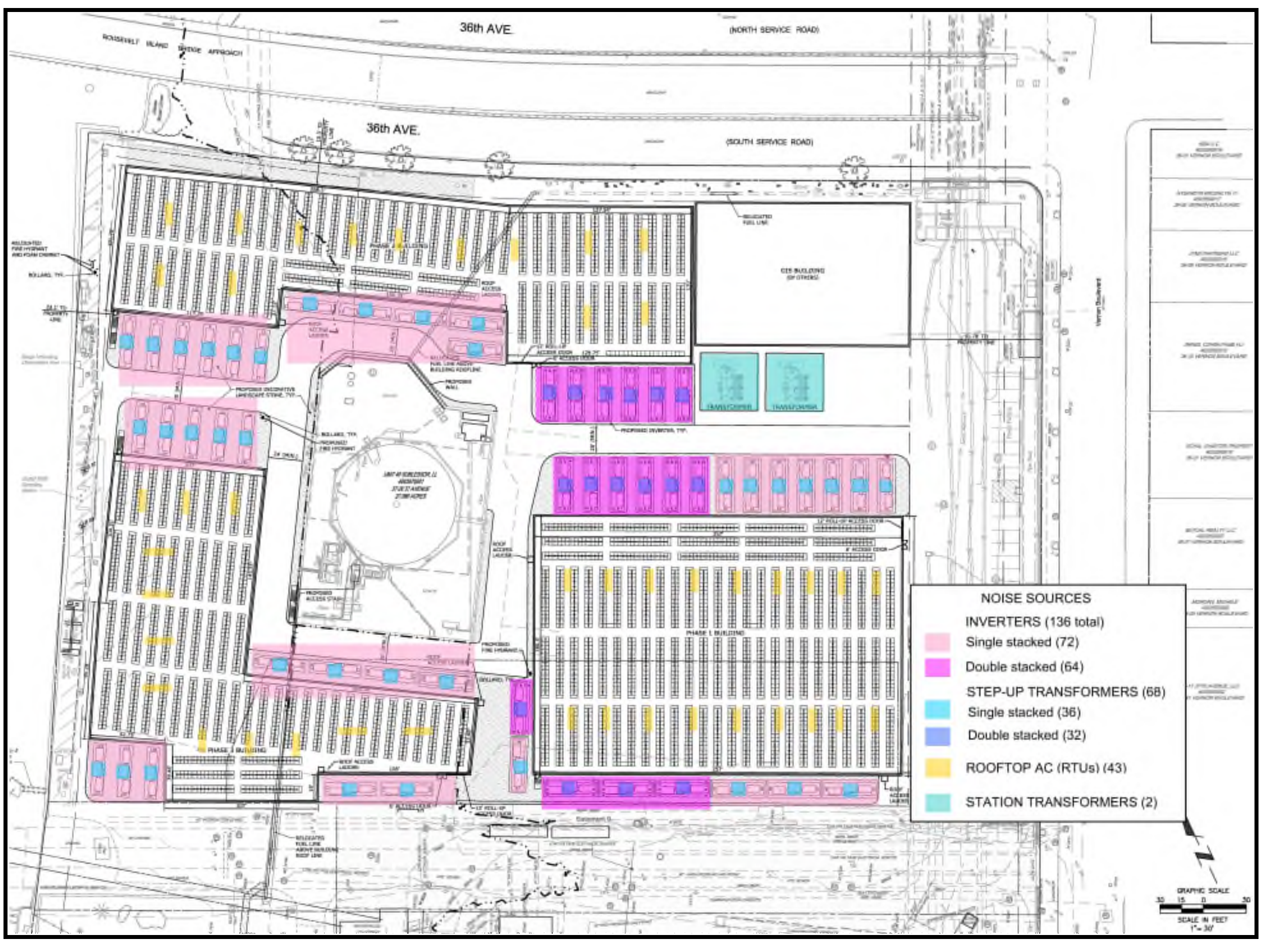

Figure 2 – Ravenswood Battery Storage Facility Noise Sources

Manufacturer-provided noise emission information for the inverters, transformers and the RTUs is shown in **Table 6**. While actual equipment procured may vary, the noise emissions of the procured equipment will be similar to that modeled for the project.

Table 6
Equipment Sound Pressure Levels[1], in dB

Equipment Model	Qty. in Project	Octave Band Center Frequencies, in Hertz								Overall Sound Level in dBA
		63	125	250	500	1k	2k	4k	8k	
Sunny Central Storage 2500-EV-US Inverter[2,3]	136	64	62	69	62	56	56	44	37	64
5,600 kVA Transformer (for inverter pair)[4]	68	42	54	56	62	59	55	50	41	65
AAON Rooftop AC (RTU) Units[5]	43	60	65	63	62	60	57	53	47	65
Main Power (GIS) Transformer[6]	2	88	83	85	83	82	78	69	63	86

Notes:
[1] *Sound Pressure Levels in dB ref: 20 micropascals (μPa)*
[2] *Sound pressure levels measured at a distance of 33 feet.*
[3] *Octave Band Data predicted based on total noise emission provided by SMA and octave band data for similar equipment.*
[4] *Sound pressure levels measured at a distance of 1 feet.*
[5] *Sound pressure levels measured at a distance of 10 feet.*
[6] *Sound pressure levels based on data from a 160 mVA Transformer measured at 1 foot, as provided by client. Assumes full load with fans operating. Octave Band Data predicted based on total noise emission provided by SMA and octave band data for similar equipment.*

Two separate analyses were performed: 1) whether the proposed project would result in an increase in ambient noise levels that would be expected to exceed NYSDEC noise impact criteria, and 2) whether noise levels produced by the proposed project would be expected to result in exceedances of the NYC Noise Control Code or NYC Zoning Resolution Performance Standards for Manufacturing Districts.

Initial analyses indicated that noise from the inverters/transformer skids result in an exceedance of NYC Noise Control Code limits, and that a noise control design would be required. AKRF investigated noise control options readily available from the manufacturer (i.e., low noise inverters), but determined that these options would not sufficiently reduce inverter noise to code-compliant levels. As a result, AKRF evaluated inclusion of an additional level of noise controls that would be required to achieve code compliance. AKRF's initial analysis identified the use of sound-attenuating enclosures; however, compliance may also be achieved through other methods including, but not limited to, specialized "quiet" inverters and sound-attenuating inverter kits in connection with the inverter manufacturing process and detailed design. As such, AKRF's updated analysis identifies a property line acoustical performance requirement which will provide flexibility to perspective contractors while ensuring compliance with applicable standards. The acoustical performance requirement for the inverters was incorporated into the analysis findings below.

NYSDEC IMPACT ANALYSIS
Future noise levels with the proposed project in operation were predicted at the property line of the closest residential receptor using the methodology described above. The predicted future noise levels at the closest residential receptor site along with the incremental change in noise levels are shown in **Table 7**.

Table 7
Future with the Proposed Project (in dBA)

Receptor Location	Location	Existing Measured L_{eq}	Project Generated L_{eq}[1]	Future With Project L_{eq}	Increase Over Existing L_{eq}
1	Northeast Corner of Ravenswood Generating Station along Vernon Boulevard	61.5	61.0	64.3	2.8

The maximum predicted increase in noise levels due to the operation of the project at the nearest residential receptor is anticipated to be less than 3 dBA which represents a barely perceptible change in noise levels and is below the NYSDEC threshold for appreciable effects at any receptor.

NEW YORK CITY NOISE CONTROL CODE
Using the methodology described above, noise levels due to the operation of the proposed project were calculated at the nearest receptor location. **Table 8** shows the calculated noise levels compared to §24-232 of the NYC Noise Code for all octave band and A-weighted limits.

Table 8
Anticipated Compliance with NYC Noise Code at Nearest Sensitive Receptor

Octave Band (Hz)	63	125	250	500	1k	2k	4k	8k	A-Weighted
Sound Pressure Level at Nearest Receptor [1] (dB)	55	51	45	39	36	34	32	31	43
NYC Noise Code Criteria (dB)	61	53	46	40	36	34	33	32	45
Exceedance?	No	No	No	No	No	No	No	No	No
Note: [1] As measured 3 feet inside closest open window									

As shown in **Table 8**, the noise levels from the project are predicted to be below NYC Noise Code limits at the closest residential location representing neighboring properties that would experience the greatest noise levels from the project (e.g., worst-case scenario); therefore, exceedances are not anticipated at properties farther from the project site.

NEW YORK CITY ZONING RESOLUTION PERFORMANCE STANDARDS FOR MANUFACTURING DISTRICTS
Using the methodology described above, project noise levels were modeled at lot line locations, per NYC Zoning Resolution Performance Standards.

As shown in **Table 9**, the proposed project would not result in noise levels that would exceed the noise level criteria set forth in the NYC Zoning Resolution Performance Standards for Manufacturing Districts in any of the octave band frequencies.

Table 9
Anticipated Compliance with NYC Zoning Resolution Noise Performance Standards for M3 Manufacturing District at Nearest Sensitive Receptor

Octave Band (Hz)	63	125	250	500	1k	2k	4k	8k
Sound Pressure Level at Lot Line (dB)	64	63	61	56	50	45	44	33
NYC Zoning Resolution Performance Standards (dB)	78	75	69	63	57	52	49	45
Exceedance?	No	No	No	No	No	No	No	No

NOISE CONTROL DESIGN REQUIREMENTS

As previously indicated, the above noise impact analysis is predicated upon the incorporation of noise control design requirements for the project's inverter/transformer skids, which are the largest noise source for the project. Noise controls in the form of specialized "quiet" inverters, sound-attenuating inverter kits, sound-attenuating enclosures, or other appropriate means will be incorporated into the final project design as necessary in order to address the "Not to Exceed" property line noise limits listed in **Table 10**, which will ensure compliance with applicable noise standards is achieved.

Table 10
Not to Exceed Property Line Noise Limits for All Project Inverters

Octave Band (Hz)	63	125	250	500	1k	2k	4k	8k	A-Weighted
Maximum Sound Pressure Level [1] (dB)	69	61	51	46	42	41	39	36	51

Note: (1) As measured at an elevation of 10 ft. above ground level at property line, with all inverters operating at full load

CONCLUSION

As discussed above, an updated noise assessment was performed to determine compliance with applicable noise regulations. With the incorporation of proper inverter noise controls, predicted noise levels from the proposed project are not expected to exceed the criteria in Section 24-232 of the NYC Noise Code or the noise level criteria set forth in the NYC Zoning Resolution Performance Standards for Manufacturing Districts in any of the octave band frequencies. The anticipated worst case incremental change in noise levels over existing noise levels is less than 3 dBA, which is considered a barely perceptible change, and below NYSDEC thresholds for further mitigation. The proposed project would not result in any significant adverse noise impacts.