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September 12, 2023

Mr. Tom Corbett
Project Manager
ZPB-2020-20 LLC
c/o Zero-Point Development, Inc.
1 Mercantile Street, Suite 630
Worcester MA, 01608

Re: Three Energy Storage Systems, Winchendon, MA – Sound Study ***Ref. 4886***

Dear Tom:

Tech Environmental, Inc. (Tech) is pleased to provide Zero-Point Development, Inc. (ZPD) with this a sound study for the proposed energy storage systems at Sites A and B (Project) at 445 Murdock Avenue in Winchendon, MA. It is our understanding that ZPD plans to install three (3) identical energy storage systems. Each energy storage system will include eight (8) battery cell units, two (2) inverter units and two (2) 2,500 kVA transformer units. Tech assumes that peak power operating hours will be 3:00 p.m. to 9:00 p.m. Site A will include one (1) energy storage system. Site A also houses Saloom Furniture, which manufactures wood furniture. The facility will remain in operation at the site. The building includes a blower exhaust system that operates Monday through Friday from 6:00 a.m. to 2:30 p.m. Site B will include two (2) energy storage system. The goal of the sound study will be to determine if the proposed Project would comply with the sound limit within Winchendon Solar Collection System Bylaw.

Tech performed short-term ambient sound monitoring at four (4) property line locations on Sunday, August 13, 2023 to capture daytime ambient sound levels without the operation of the Saloom Furniture blower system. The ambient L_{90} sound levels ranged from 35 to 37 dBA. The lowest ambient L_{90} sound level of 35 dBA was selected to represent ambient sound conditions at all three property line locations. The acoustic modeling included three (3) property line locations surrounding the Project site. The results of the sound study were compared to the Winchendon Solar Collection System Bylaw. For the Project, the predicted change in sound levels would range from 3 to 13 dBA above the ambient L_{90} sound levels. Tech performed acoustic modeling to assess sound mitigation walls for the Site B southern energy storage system. A 15-foot-high L-shaped sound wall is proposed to reduce the sound level increase on the southern property line to below 10 dBA from the Site B southern energy storage system. Therefore, the Project demonstrates compliance with Winchendon Solar Collection System Bylaw. Tech recommends that post-construction sound monitoring be performed to confirm the results of the analysis prior to the installation of the sound mitigation wall or any other feasible sound mitigation strategy.

1.0 THE DECIBEL SCALE FOR SOUND

All sounds originate with a source – a human voice, vehicles on a roadway, or an airplane overhead. The sound energy moves from the source to a person's ears as sound waves, which are minute variations of air pressure. The loudness of a sound depends on the sound pressure level, which has units of decibel

(dB). The decibel scale is logarithmic to accommodate the wide range of sound intensities to which the human ear is subjected. On this scale, the quietest sound we can hear is 0 dB, while the loudest is 120 dB. Every 10-dB increase is perceived as a doubling of loudness. Most sounds we hear in our daily lives have sound pressure levels in the range of 30 dB to 90 dB.

Community noise studies and regulations use an A-weighting scale (dBA) when measuring sound pressure levels as this approximates the response of the human ear to sounds, we experience in everyday life. Typical sound levels associated with various activities and environments are presented in **Figure 1**. Here are examples of sound levels we all encounter. A quiet suburban area at night without any traffic typically has an average sound level of 40 to 45 dBA. The freight train you hear in the distance may be 50 dBA, and crickets and tree frogs in the summer sing a sound level of 55 dBA. Two people having a conversation in a normal tone of voice will hear each other speak at 65 dBA. Standing near a road, a car passing by can produce 75 dBA, and a truck passing by is louder at 80 dBA.

There are various measures of sound pressure designed for different purposes. To establish the background ambient sound level in an area, the L_{90} metric, which is the sound level exceeded 90 percent of the time, is typically used. The L_{90} can also be thought of as the level representing the quietest 10 percent of any time period. The L_{10} metric, which is the sound level exceeded 10 percent of the time is typically used to assess transient noise highway or rail activities. The L_{eq}, or equivalent sound level, is the steady-state sound level over a period of time that has the same acoustic energy as the fluctuating sounds that actually occurred during that same period. It is commonly referred to as the average sound level. The L_{max}, or maximum sound level, represents the one second peak level experienced during a given time period. These are broadband sound pressure measurements, i.e., it includes sounds at all frequencies.

Sound level measurements typically include an analysis of the sound spectrum into its various frequency components to determine tonal characteristics. The unit of frequency is Hertz (Hz), measuring the cycles per second of the sound pressure waves, and typically the frequency analysis examines eleven octave bands from 16 to 16,000 Hz.

2.0 APPLICABLE NOISE REGULATIONS

The Town of Winchendon has established pre-construction ambient sound monitoring requirements and a sound limit specific to solar energy collection systems under Section 6.11 Solar Collection System in the General Bylaw. Section 6.11.6 c. states "*A statement bearing the seal of a licensed professional engineer stating the measured normal pre construction noise levels at points (generally 100 feet apart) along the property lines and the expected operational noise levels at the same locations. Particular attention shall be paid to property lines abutting developed sites. A properly calibrated sound level meter meeting ANSI class 2 standards shall be used for all measurements.*"

The nearest abutting residential developed sites to the Project site are located at Brown Court and Pearl Drive. Therefore, the assessment of sound impacts from the Project were focused on these abutting property lines.

Under Section 6.11.12 Design Standards, part a. states "*If the noise level measured at any property line of the system in normal operation is more than 10 db greater than the reported pre construction noise level at the same location, sound deadening measures may be required as a condition of allowing further operation of the system.*"

For the purposes of this sound study, Tech assumes that 10 db refers to 10 decibels (A-weighted) (dBA) and that a 10-dBA above measured pre-construction ambient sound levels is a violation of the Bylaw sound limit requiring sound mitigation. And that ambient is defined as the quietest 10 percent of the time of a sound measurement designated as the L_{90} sound level.

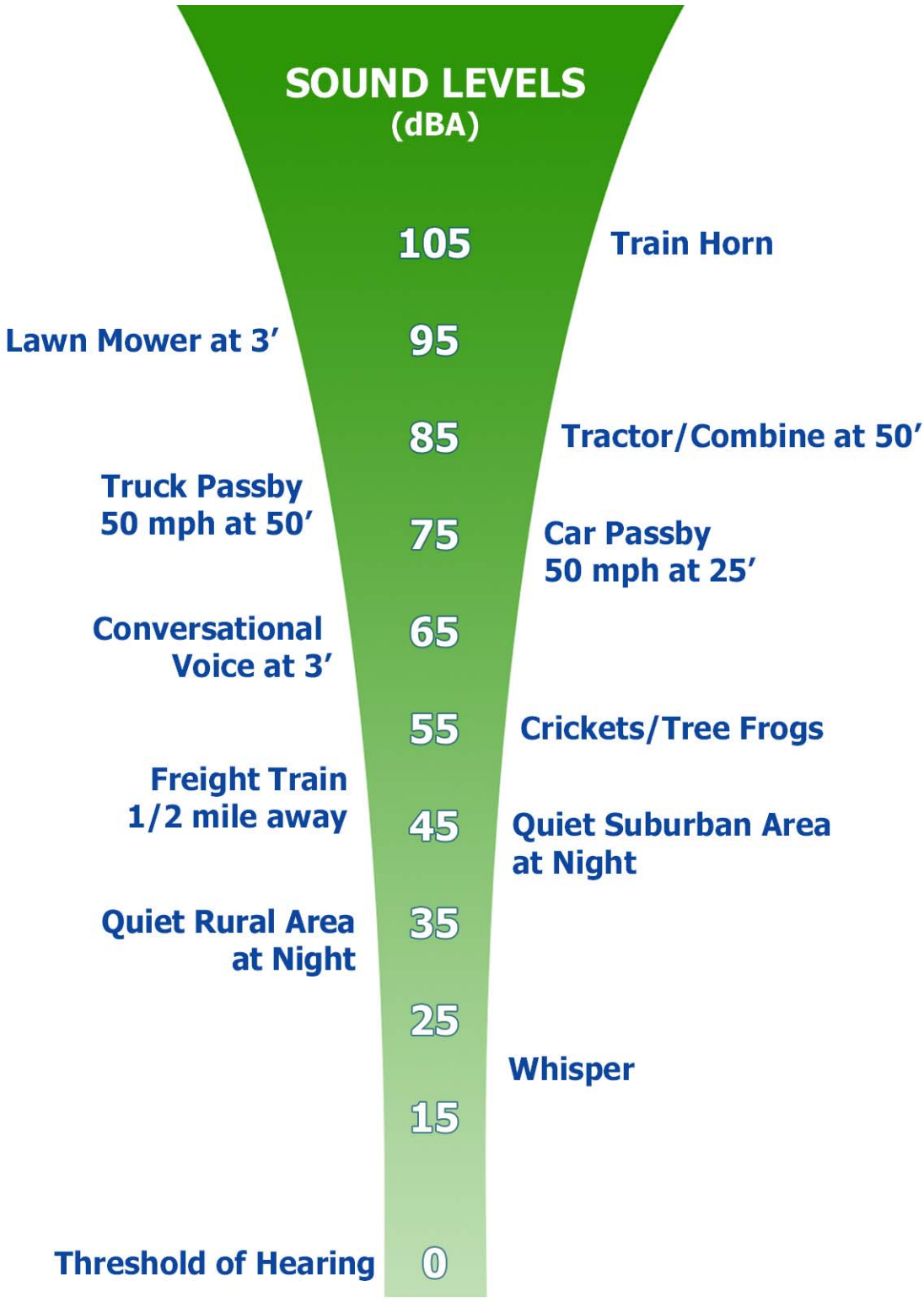

FIGURE 1.
Common Outdoor Sound Levels

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3.0 PRE-CONSTRUCTION SOUND MONITORING

This section provides a summary of the pre-construction sound monitoring procedures and results.

3.1 Monitoring Procedures

Tech performed ambient sound monitoring to collect short-term 20-minute sound measurements at four (4) Project site property line locations on Sunday August 13, 2023 from 9:24 a.m. to 10:33 a.m. The purpose of the sound monitoring was to establish the ambient sound levels for the Project site with Saloom Furniture blower system is off. **Figure 2** shows the location of the short-term measurements.

Sound measurements were taken with a Brüel & Kjaer real-time sound level analyzer. The analyzer was equipped with a 1/2" precision condenser microphone and has an operating range of 5 dB to 140 dB, and an overall frequency range of 3.5 to 20,000 Hz. The analyzer meets or exceeds all requirements set forth in the American National Standards Institute (ANSI) Standards for Type 1 for quality and accuracy. Prior to and immediately following the measurement session, the sound analyzer was calibrated (no level adjustment was required) with an ANSI Type 1 calibrator, which has an accuracy traceable to the National Institute of Standards and Technology (NIST). All instrumentation was laboratory calibrated per ANSI recommendations. For the measurement session, the microphone was fitted with an environmental windscreen to negate the effect of air movement and tripod-mounted at a height of five feet. The sound monitoring was performed in conformance with the requirements of American National Standards Institute (ANSI) S12.18.[1]

The sound analyzer was programmed to measure continuous real-time peak (L_{max}), average (L_{eq}), and background level (L_{90}), higher transient levels (L_{10}), and whole octave band frequency measurements throughout the monitoring period. The lowest L_{90} sound level will be used to establish ambient conditions.

3.2 Monitoring Results

The sound monitoring results are summarized in **Table 1**. The dominant sound source at Project site was traffic along Route 12 and side streets. Insects (i.e., crickets) at Location 2 were causing high pitch tonal sounds in the 8,000 Hz octave band. To screen out the insects sound, Tech excluded the sound levels measured in the 2,000, 4,000, 8,000 and 16,000 Hz. These corrected sound levels represent the existing ambient sound levels without the effects of any insects for Location 2.

The L_{90} sound levels ranged from 35 to 37 dBA. These sound levels are consistent with ambient sounds in a suburban area. The lowest one-hour corrected L_{90} level was measured at 10:33 a.m. at Property Line Location #4. Therefore, the sound limit for the Project is 45 dBA (i.e., 35 dBA +10 dBA).

[1] Acoustic Society of America, American National Standard S12.18-1994, "Procedures for Outdoor Measurement of Sound Pressure Level," reaffirmed 2009.

TABLE 1

EXISTING SOUND LEVELS MEASURED AT
445 MURDOCK AVE, WICHENDON, MA
AUGUST 13, 2023
9:24 a.m. to 10:33 a.m.

Location	Time	L_{90} (dBA)
1	9:24 a.m.	36
2	9:47 a.m.	36**
3	10:08 a.m.	37
4	10:33 a.m.	35*

*Lowest ambient L_{90} sound level.
** Corrected for insects sound

4.0 ACOUSTIC MODELING APPROACH AND RESULTS

This section provides a summary of the acoustic modeling approach and results.

4.1 Acoustic Modeling Approach

The future sound levels from the Project, when it is producing maximum electrical power, were calculated with the Cadna/A acoustic model. Cadna/A is a three-dimensional model for sound propagation and attenuation based on International Standard ISO 9613[2]. Atmospheric absorption, the process by which sound energy is absorbed by the air, was calculated using ANSI S1.26-1995.[3] Digital terrain data for the Project areas were analyzed to obtain terrain heights. The model assumes the most-favorable sound propagation conditions, as occur under downwind conditions or during a ground-based temperature inversion on a clear night. Under these atmospheric conditions, sound travels further than if a person is upwind from a source and the atmosphere is well mixed, which would dampen the sound.

The Project will include three (3) energy storage systems which each will include eight (8) battery cell units, two (2) inverter units and two (2) 2,500 kVA transformer units. Site A will have one (1) energy storage system and Site B will include two (2) energy storage systems. Site A also houses Saloom Furniture, which manufactures wood furniture. The facility will remain in operation at the site. The building includes a blower exhaust system that operates Monday through Friday from 6:00 a.m. to 2:30 p.m. The broadband and octave band sound source data used in the model was a combination of manufacturer and Tech sound measurements. The broadband and octave band sound data for the battery cell units were from a noise test report by Sungrow[4]. The broadband sound data for the inverter units were also from a noise test report by Sungrow[5]. Tech used octave band sound data we collected for a

[2] International Standard, ISO 9613-2, Acoustics – Attenuation of Sound During Propagation Outdoors, -- Part 2 General Method of Calculation
[3] American National Standards Institute, ANSI S1.26-1995, "American National Standard Method for the Calculation of the Absorption of Sound by the Atmosphere," 1995.
[4] Sungrow, "Noise Internal Test Report for ST2752UX-US".
[5] Sungrow, "Noise Test Report".

similar size inverter to be used for the proposed inverter units in the model. Tech also used broadband and octave band sound data we collected for a similar size transformer to be used for the proposed transformer units in the model. **Attachment A** provides the broadband and octave band sound power levels for each sound source. **Figure 2** shows the location of the three energy storage systems. The modeling analysis assumes that all equipment will operate at maximum load during operation hours. The model does not include the operation of Saloom Furniture.

The nearest abutting residential properties to the Project site are located at Brown Court and Pearl Drive. Therefore, the assessment of sound impacts from the Project were focused at 1 and 5 Brown Court and 52 Pearl Drive (see **Figure 2).**

4.2 Acoustic Modeling Results

The predicted sound level increases would increase from 3 to 13 dBA above the existing lowest ambient L_{90} sound level. The predicted sound level increase at 52 Pearl Drive (R3) exceeded the 10-dBA allowable increase over ambient by 3 dBA. Because the southern energy storage system on Site B is the closest to R3, Tech performed acoustic modeling to assess sound mitigation walls for the Site B southern energy storage system. A 15-foot-high L-shaped sound wall is proposed to reduce the sound level increase on the southern property line to below 10 dBA from the Site B southern energy storage system. **Table 2** shows the ambient L_{90} sound level and the predicted mitigated sound levels at the nearby residence. The predicted mitigated sound level increases would increase from 3 to 9 dBA. Therefore, the Project demonstrates compliance with Winchendon Solar Collection System Bylaw.

A decibel-level contour map of the predicted Project mitigated sound levels is presented in **Figure 3**.

5.0 CONCLUSION

A sound study was performed for the proposed three energy storage system at 445 Murdock Avenue in Winchendon, MA. The results of the sound study show that the operations of the proposed three energy storage system for the Project will comply with the Winchendon Solar Collection System Bylaw. Tech recommends that post-construction sound monitoring be performed to confirm the results of the analysis prior to the installation of the sound mitigation wall or any other feasible sound mitigation strategy.

Please call if you have any questions regarding this report.

Sincerely,

TECH ENVIRONMENTAL, INC.

Marc C. Wallace, QEP, INCE
Vice President
4886/Sound Study Report

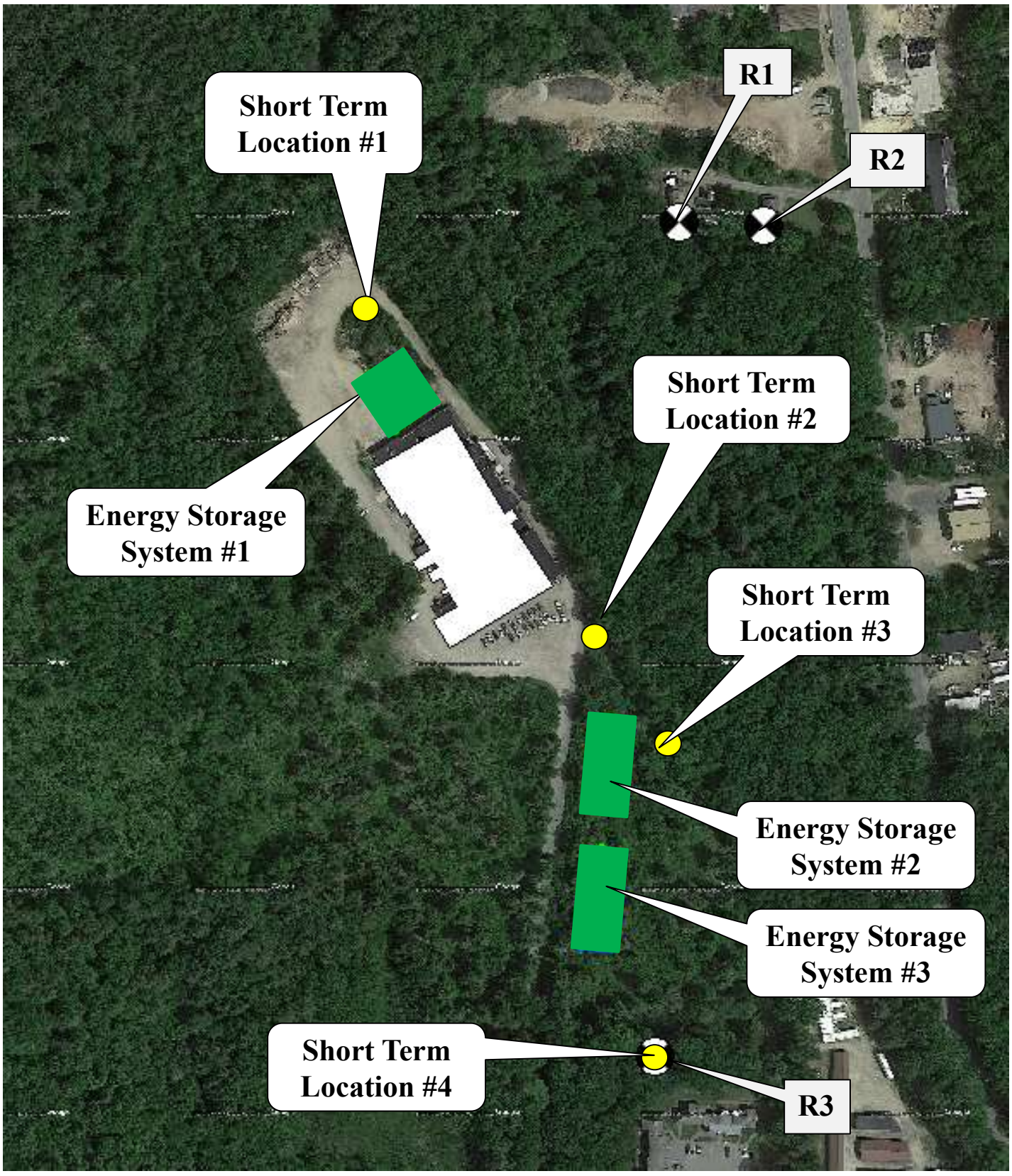

Figure 2
Short Term Locations
445 Murdock Avenue, Winchendon, MA

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TABLE 2

PREDICTED MITIGATED SOUND LEVELS AT PROPERTY LINE LOCATIONS

Receptor ID	Residence Address	Predicted Sound Level (dBA)	Ambient Sound Level (dBA)	Total Predicted Sound Level (dBA)	Predicted Sound Level Increase (dBA)
R1	5 Brown Court	41	35	42	7
R2	1 Brown Court	36	35	38	3
R3	52 Pearl Drive	44	35	44	9

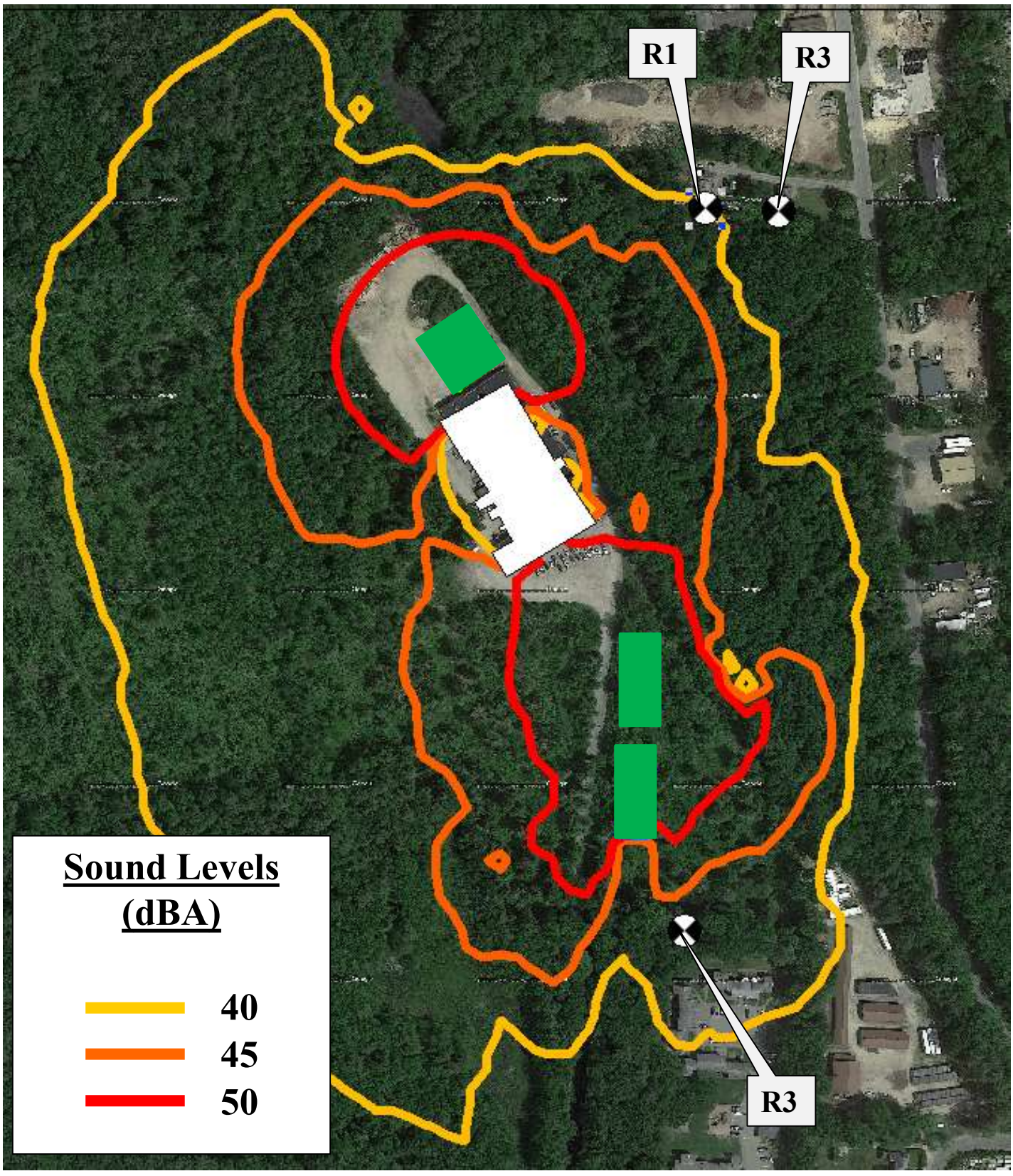

Figure 3
Predict Mitigated Sound Level Contours
445 Murdock Avenue, Winchendon, MA

ATTACHMENT A – REFERENCE SOUND POWER LEVELS (L_w, dB)*

Sound Source	31 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1K Hz	2K Hz	4K Hz	8K Hz	Total (dBA)
Battery Cell (1 Unit)	45.6	55.3	64.4	79.0	83.5	81.9	80.6	76.7	77.1	**87.2**
Inverter (1 Unit)	68.0	72.0	80.5	83.0	85.2	83.2	80.5	75.1	70.2	**87.7**
Transformers (2 Units)	67.8	68.0	67.6	69.9	65.6	62.5	54.7	55.5	47.2	**67.7**

***** The acoustic energy level of a source is known as its sound power level (L_w), which is also measured on a decibel scale. The sound power level of a source is the same at any distance; therefore, L_w values do not have reference distances.