24-0376 LetterReportSound_MadisonCTSolar.docx

December 4, 2024 Epsilon Ref. 24-0376

Mr. James Schwartz
391 Durham LLC
9 Novelty Lane, Unit 9B
Essex, CT 06426
Via email: JSchwartz@independencesolar.com

Subject: Sound Level Analysis
Madison CT Solar Project, Madison Township, Connecticut

Dear Mr. Schwartz:

Epsilon Associates, Inc. (Epsilon) is pleased to provide this letter report to 391 Durham LLC (391 Durham) for the Madison CT Solar Project (Project) located at 391 Durham Road in Madison, New Haven County, CT. The Project is expected to be approximately 2 MW in size. The Project will consist of eight photovoltaic (PV) inverters, one transformer, and solar panel arrays. A sound level study of the facility was performed using data provided by 391 Durham, the proposed site layout, and the CadnaA sound propagation modeling software. The results of this study are summarized within this report.

Regulatory Limits

The Project is required to comply with the State of Connecticut noise control regulation issued by the Connecticut Department of Energy & Environmental Protection (CT DEEP) as defined in §22a-69-1 to §22a-69-7. The sound level limits vary by land classification that is based on land use. There are three use classes that generally fall into the categories of industrial, commercial, and residential and the land classification of both the emitter and the receptor must be considered. The proposed land use will be for utility purposes which falls under Class C. The sound level limits for Class C emitters are shown in Table 1.

Table 1 Connecticut Sound Limits for Class C Emitters

Emitter's Zone: Class C (Industrial)	
Receptor's Zone	**Maximum Level (dBA)**
Class C (Industrial)	70
Class B (Commercial)	66
Class A (Residential) / Day	61
Class A (Residential) / Night	51

The Project is a solar facility which only emits sound from the inverters in sunlight when solar energy is produced. When there is no sunlight shining on the panels, the inverters do not produce sound, although the Project transformer may still be energized during this timeframe. Nighttime is defined by the CT DEEP as 10:00 PM to 7:00 AM. While many days of the year in Connecticut experience sunlight before 7:00 AM, the solar inverter manufacturer has indicated, and 391 Durham's experience confirms, that the inverter sound is mainly attributable to cooling components running under stronger sunlight conditions. As such, the inverters will generate minimal, if any, noise during the early morning hours and may be excluded from a nighttime evaluation.

The Connecticut regulation also limits sources from emitting prominent discrete tones (PDTs) as defined in §22a-69-3.3. PDTs are defined in the regulation using one-third octave bound sound levels (§22a-69-1.2(r)). If continuous sound level measured at a receptor contains a PDT, the sound level limits in Table 1 are to be reduced by 5 dBA.

Epsilon did not find any quantitative sound level limits applicable to this project at the local level. The Madison Municipal Code, Section 13-1 "Noisemaking devices" was reviewed and does not contain any quantitative sound level limits.

Sound Level Modeling

The primary sources of sound from the Project will be the inverters and the transformer. Eight Solectria XGI 1500 string inverters along with one 2 MVA transformer are proposed. Each inverter is rated at 225-250 kW AC output. 391 Durham provided the latest layout for the Project dated 2024-11-04 showing the general locations of the solar inverters and the transformer. These were utilized to locate sound sources in the model. The proposed inverters, solar panel arrays, transformer, and Project Boundary are identified in Figure 1 and Figure 2 which correspond to the modeled daytime (all equipment) and nighttime (transformer only) scenarios, respectively.

Sound pressure levels for the worst-case condition of the inverters were provided to Epsilon. Epsilon estimated the broadband sound power level of the inverters based on the sound pressure level from the manufacturer and equipment dimensions. The sound power level of the 2 MVA transformer was estimated using techniques in the Electric Power Plant Environmental Noise Guide[1]. Table 2 presents the sound power levels that were used to calculate the sound pressure levels in the community from the operation of the Project.

Table 2 Estimated Inverter and Transformer Sound Power Levels (per device)

Project Component	Broadband Sound Power Level (dBA)[1]
Solectria XGI 1500 Inverter[2]	91
Transformer[3]	74

Notes:

1. One-third octave band information was available and utilized for the Solectria solar inverters; however, only whole octave band information was able to be estimated for the transformer.
2. The sound power level (per inverter) was calculated from the sound pressure level measured at a reference distance and the dimensions of the unit.
3. The sound power level of the transformer was estimated for a 2 MVA transformer using techniques in the EEI guide.
4. This table does not include a 2 dBA uncertainty factor used in the model.

Sound levels from operation of the Project were predicted using the CadnaA noise calculation software developed by DataKustik GmbH. This software uses the ISO 9613-2 international standard for sound propagation (Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation). The benefits of this software are a refined set of computations due to the inclusion of topography, ground attenuation, multiple building reflections, drop-off with distance, and atmospheric absorption. Elevation contours for the modeling domain were directly imported into CadnaA which allowed for consideration of terrain shielding where appropriate. The terrain height contour elevations for the modeling domain were generated from elevation information derived from Digital Elevation Models (DEMs) developed by the U.S. Geological Survey.

1 Bolt Beranek and Newman Inc. (1984). *Electric Power Plant Environmental Noise Guide* (2nd ed.). Edison Electric Institute.

Several modeling assumptions inherent in the ISO 9613-2 calculation methodology, or selected as conditional inputs by Epsilon, were implemented in the CadnaA model to ensure conservative results (i.e., higher sound levels), and are described below:

- In each modeling scenario, all modeled sources were assumed to be operating simultaneously at their maximum sound level corresponding to the greatest sound level impacts.
- An additional 2 dBA was added to each sound source to allow for flexibility in the equipment manufacturer's reference data, and to provide conservatism in the results.
- As per ISO 9613-2, the model assumed favorable conditions for sound propagation, corresponding to a moderate, well-developed ground-based temperature inversion, as might occur on a calm, clear night, or equivalently downwind propagation.
- Meteorological conditions assumed in the model (T=10℃/RH=70%) were selected to minimize atmospheric attenuation in the 500 Hz and 1 kHz octave bands where the human ear is most sensitive.
- No additional attenuation due to tree shielding, air turbulence, or wind shadow effects was considered in the model.

Epsilon identified nine discrete modeling receptor locations that represent the closest neighboring property boundaries. The receptors were modeled as discrete points at a height of 1.5 meters above ground level to mimic the ears of a typical standing person. These receptors are shown in Figure 1 and Figure 2 and are labeled with their modeling ID number.

Epsilon used CadnaA, the proposed site plan, and the sound level data in Table 2 to predict "Project Only" sound levels. A modeling grid with a 10-meter spacing was calculated within and around the entire Project area. The grid was modeled at a height of 1.5 meters above ground level to match the receptor points. This modeling grid allowed for the creation of sound level isolines.

Sound Level Modeling Results & Evaluation

Sound levels from the Project were output by CadnaA for evaluation against the CT DEEP limits. The one-third octave band levels were evaluated initially to determine whether any prominent discrete tones were predicted from the Project in either the daytime or nighttime modeling scenarios as this would impact the broadband sound level evaluation. All modeled sound levels are A-weighted equivalent sound levels (L_{eq}, dBA). The daytime PDT evaluation data are shown in Table 3 attached to this letter. The CT DEEP thresholds are shown at the bottom of in Table 3 for reference. As shown in the table, there are PDTs identified in the 800 Hz and 1600 Hz one-third octave bands; therefore, the sound level limits are reduced by 5 dBA. Because one-third octave band information was not available for the proposed 2 MVA transformer and transformers are often tonal by nature, the PDT penalty has been assumed for the nighttime evaluation as well.

The daytime modeled sound levels at each modeling receptor are shown sorted by modeling ID in Table 4. The nighttime modeled sound levels at each modeling receptor are shown sorted by modeling ID in Table 5. The predicted daytime sound levels at the modeling locations with all equipment operating range from 46 to 54 dBA and the predicted nighttime sound levels range from 20 to 29 dBA. In addition to the discrete modeling points, daytime and nighttime sound level isopleths generated from the modeling grid are shown in Figure 1 and Figure 2 respectively. The Residential Standard limits shown on these figures assume the 5 dBA reduction due to the presence of PDTs. The sound levels presented in this report are Project Only and do not include any contribution from existing sound sources in the area.

Conclusion

The broadband sound level modeling results have been evaluated against the CT DEEP broadband sound level limits reduced by 5 dBA as shown in Table 4 and Table 5. As shown in Table 4 and Table 5, the modeled sound levels from the Project during the day and at night meet the state regulatory limits at all locations.

If you have any questions on this letter report, please feel free to call me at (978) 461-6216, or e-mail me at asavino@epsilonassociates.com.

Sincerely,

EPSILON ASSOCIATES, INC.

Anthony J. Savino

Anthony J. Savino, Jr., INCE
Project Scientist

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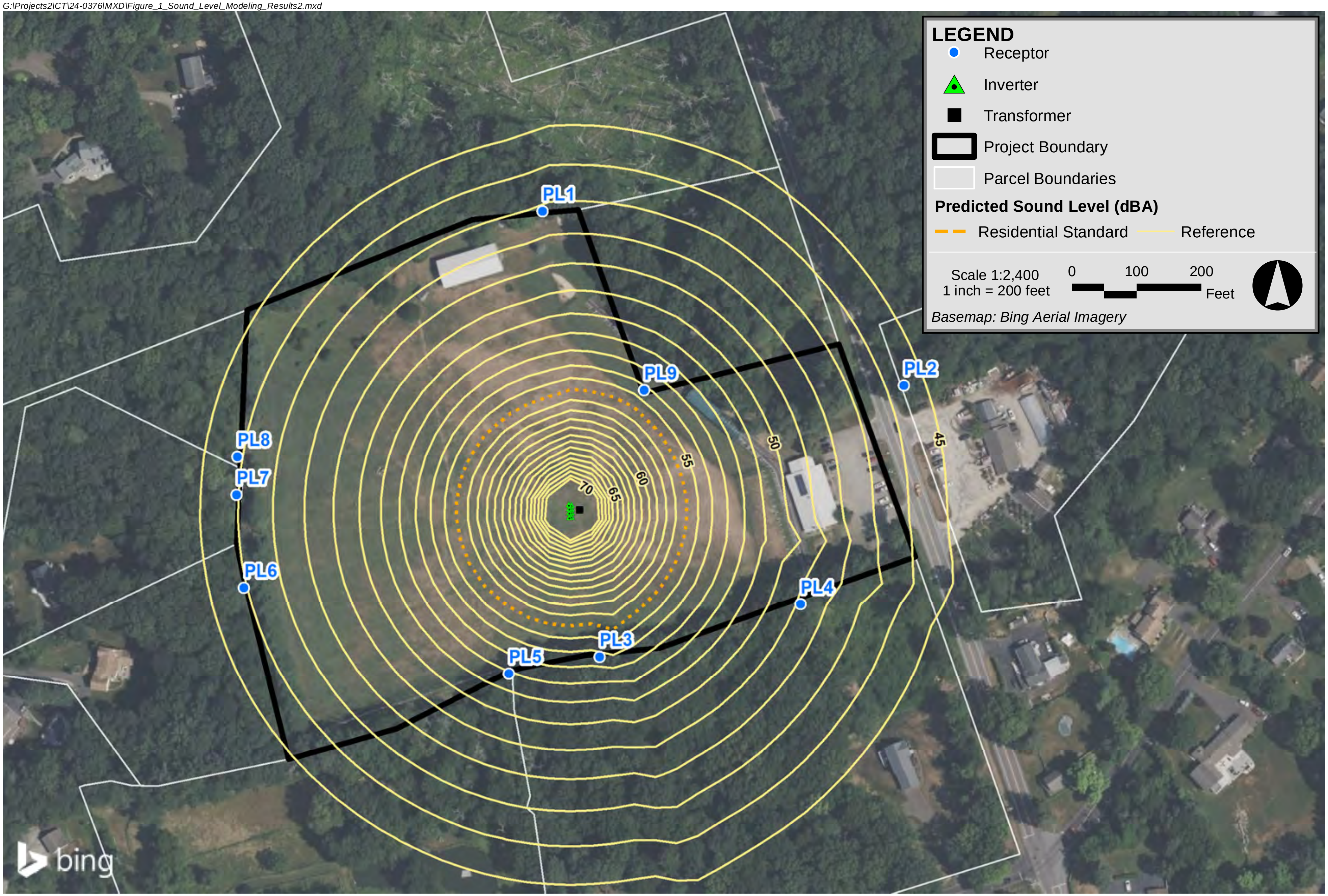

Madison CT Solar Project   Madison, Connecticut

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Figure 1

Daytime Sound Level Modeling Results

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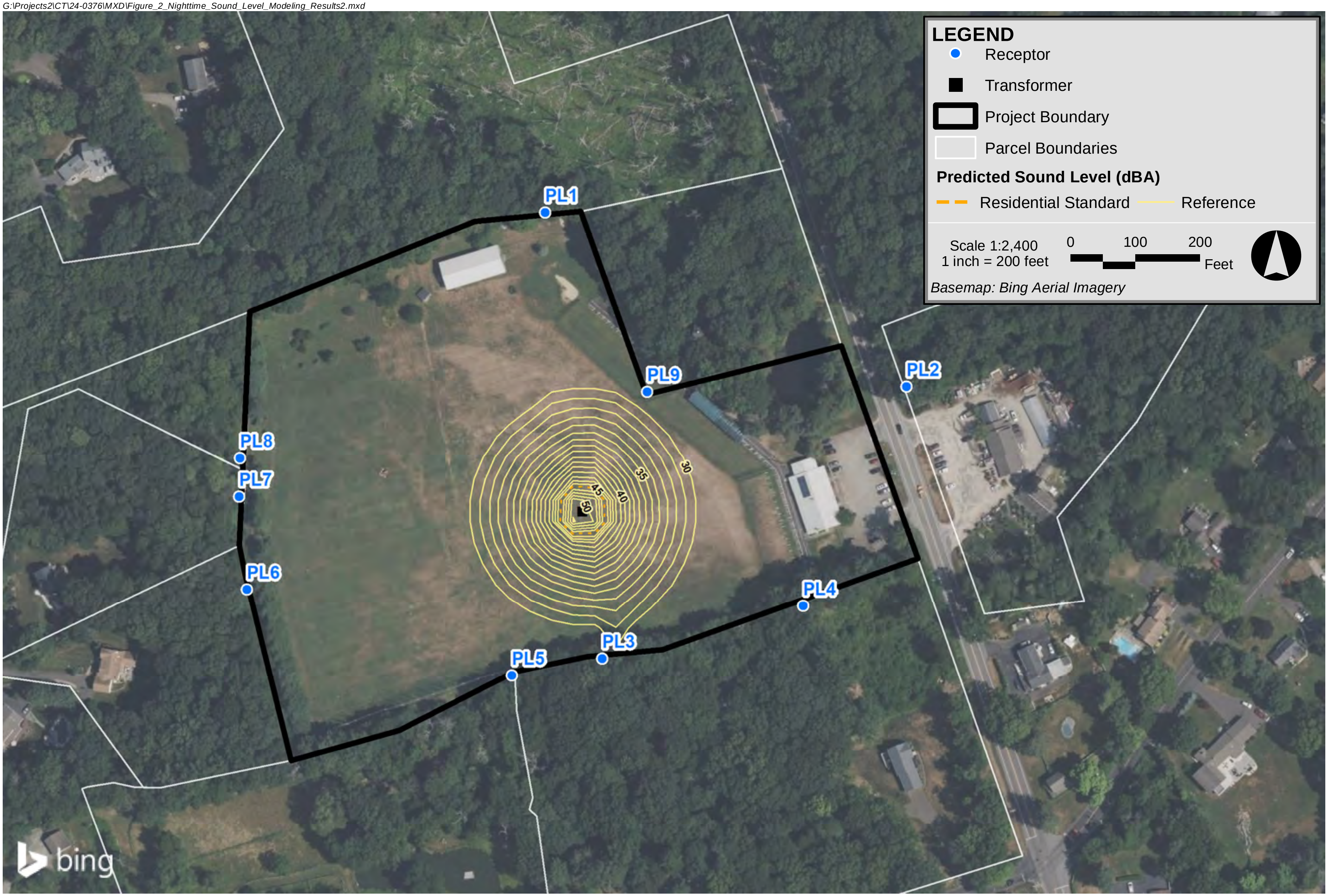

Madison CT Solar Project   Madison, Connecticut

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Figure 2

Nighttime Sound Level Modeling Results

Table 3: Daytime Prominent Discrete Tone Evaluation

Receptor ID	One-Third Octave Band Center Frequencies																				
	100 Hz	**125 Hz**	**160 Hz**	**200 Hz**	**250 Hz**	**315 Hz**	**400 Hz**	**500 Hz**	**630 Hz**	**800 Hz**	**1000 Hz**	**1250 Hz**	**1600 Hz**	**2000 Hz**	**2500 Hz**	**3150 Hz**	**4000 Hz**	**5000 Hz**	**6300 Hz**	**8000 Hz**	**10000 Hz**
PL1	31	30	28	29	38	32	32	32	32	39	37	38	42	33	32	33	29	28	27	24	14
PL2	29	29	26	27	36	30	30	30	30	38	35	36	41	31	31	31	27	25	24	20	8
PL3	37	36	34	35	44	38	38	38	38	45	42	44	48	39	39	40	37	37	38	38	32
PL4	32	32	29	31	40	33	33	34	33	41	38	40	44	34	34	35	31	30	31	28	20
PL5	35	35	32	34	43	36	36	37	36	44	41	42	47	37	37	38	35	35	36	35	29
PL6	30	29	26	27	36	30	30	31	30	38	35	37	41	32	31	31	28	26	25	21	11
PL7	30	29	26	27	36	30	30	31	30	38	36	37	41	32	31	31	28	26	25	21	11
PL8	30	29	26	27	36	30	30	30	30	38	35	37	41	31	31	31	28	26	25	21	10
PL9	37	37	34	37	46	40	39	40	39	46	43	45	49	40	40	41	38	37	39	39	34
Thresholds [dB]																					
	16	14	12	11	9	8	7	6	6	5	4	4	4	3	3	3	3	4	4	5	6

Table 4: Daytime Sound Level Modeling Results Sorted by Receptor ID

Receptor ID	Coordinates UTM NAD83 Zone 18N		Project Only Broadband Leq Sound Level (dBA)	CT DEEP Daytime Standard for Industiral Source [dBA]	Meets CT DEEP Standard?
	X [m]	Y [m]			
PL1	700366.88	4575465.02	47	56	Yes
PL2	700536.81	4575383.13	46	56	Yes
PL3	700393.80	4575255.46	53	56	Yes
PL4	700488.17	4575280.18	49	56	Yes
PL5	700351.18	4575247.51	52	56	Yes
PL6	700226.64	4575287.91	46	56	Yes
PL7	700223.05	4575331.67	46	56	Yes
PL8	700223.42	4575349.61	46	56	Yes
PL9	700414.79	4575380.72	54	56	Yes

Table 5: Nighttime Sound Level Modeling Results Sorted by Receptor ID

Receptor ID	Coordinates UTM NAD83 Zone 18N		Project Only Broadband Leq Sound Level (dBA)	CT DEEP Nighttime Standard for Industiral Source [dBA]	Meets CT DEEP Standard?
	X (m)	Y (m)			
PL1	700366.88	4575465.02	22	46	Yes
PL2	700536.81	4575383.13	20	46	Yes
PL3	700393.80	4575255.46	28	46	Yes
PL4	700488.17	4575280.18	23	46	Yes
PL5	700351.18	4575247.51	25	46	Yes
PL6	700226.64	4575287.91	20	46	Yes
PL7	700223.05	4575331.67	20	46	Yes
PL8	700223.42	4575349.61	20	46	Yes
PL9	700414.79	4575380.72	29	46	Yes

ATTACHMENT A - Sound Terminology

There are several ways in which sound levels are measured and quantified. All of them use the logarithmic decibel (dB) scale. The following information defines the sound level terminology used in this report.

The decibel scale is logarithmic to accommodate the wide range of sound intensities found in the environment. A property of the decibel scale is that the sound pressure levels of two or more separate sounds are not directly additive. For example, if a sound of 50 dB is added to another sound of 50 dB, the total is only a 3-decibel increase (53 dB), which is equal to doubling in sound energy, but not equal to a doubling in decibel quantity (100 dB). Thus, every 3-dB change in sound level represents a doubling or halving of sound energy. The human ear does not perceive changes in the sound pressure level as equal changes in loudness. Scientific research demonstrates that the following general relationships hold between sound level and human perception for two sound levels with the same or very similar frequency characteristics[2]:

- 3 dB increase or decrease results in a change in sound that is just perceptible to the average person,
- 5 dB increase or decrease is described as a clearly noticeable change in sound level, and
- 10 dB increase or decrease is described as twice or half as loud.

Another mathematical property of decibels is that if one source of sound is at least 10 dB louder than another source, then the total sound level is simply the sound level of the higher-level source. For example, a sound source at 60 dB plus another sound source at 47 dB is equal to 60 dB.

A sound level meter (SLM) that is used to measure sound is a standardized instrument. It contains “weighting networks” (e.g., A-, C-, and Z-weightings) to adjust the frequency response of the instrument. Frequencies, reported in Hertz (Hz), are detailed characterizations of sounds, often addressed in musical terms as “pitch” or “tone”. The most commonly used weighting network is the A-weighting because it most closely approximates how the human ear responds to sound at various frequencies. The A-weighting network is the accepted scale used for community sound level measurements; therefore, sounds are frequently reported as detected with a sound level meter using this weighting. A-weighted sound levels emphasize middle frequency sounds (i.e., middle pitched – around 1,000 Hz), and de-emphasize low and high frequency sounds. These sound levels are reported in decibels designated as “dBA”. The C-weighting network has a nearly flat response for frequencies between 63 Hz and 4,000 Hz and is noted as dBC. Z-weighted sound levels are measured sound levels

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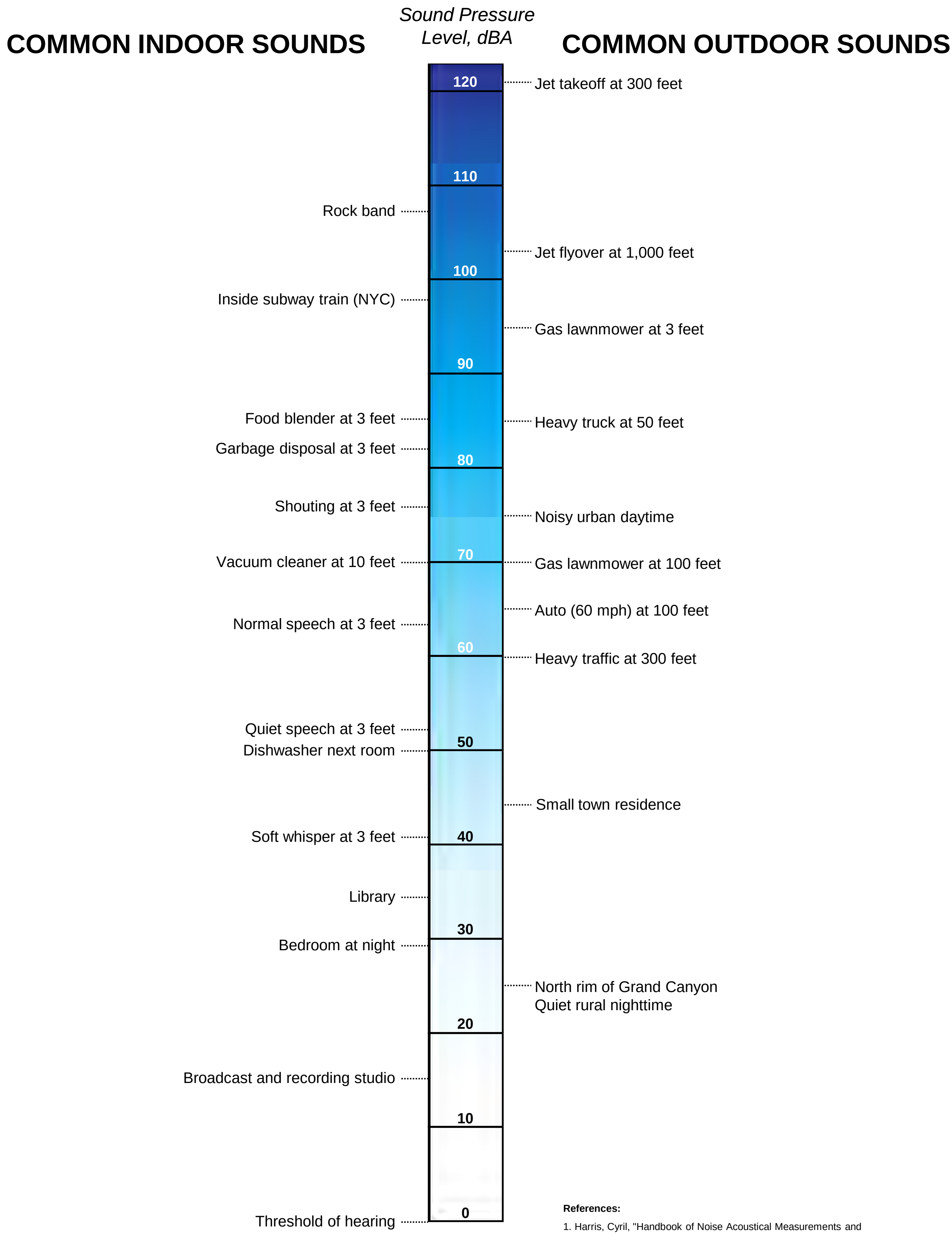
2 Bies, David, and Colin Hansen. 2009. *Engineering Noise Control: Theory and Practice*, 4th Edition. New York: Taylor and Francis.

without any weighting curve and are otherwise referred to as “unweighted”. Sound pressure levels for some common indoor and outdoor environments are shown in Figure 3 — Attachment A.

Because the sounds in our environment vary with time they cannot simply be described with a single number. Two methods are used for describing variable sounds. These are exceedance levels and the equivalent level, both of which are derived from some number of moment-to-moment A-weighted sound level measurements. Exceedance levels are values from the cumulative amplitude distribution of all of the sound levels observed during a measurement period. Exceedance levels are designated L_n, where n can have a value between 0 and 100 in terms of percentage. Several sound level metrics that are reported in community sound monitoring are described below.

- L_{10} is the sound level exceeded only 10 percent of the time. It is close to the maximum level observed during the measurement period. The L_{10} is sometimes called the intrusive sound level because it is caused by occasional louder sounds like those from passing motor vehicles.
- L_{50} is the sound level exceeded 50 percent of the time. It is the median level observed during the measurement period. The L_{50} is affected by occasional louder sounds like those from passing motor vehicles; however, it is often found comparable to the equivalent sound level under relatively steady sound level conditions.
- L_{90} is the sound level exceeded 90 percent of the time during the measurement period. The L_{90} is close to the lowest sound level observed. It is essentially the same as the residual sound level, which is the sound level observed when there are no obvious nearby intermittent sound sources.
- L_{eq}, the equivalent level, is the level of a hypothetical steady sound that would have the same energy (*i.e.,* the same time-averaged mean square sound pressure) as the actual fluctuating sound observed. The equivalent level is designated L_{eq} and is typically A-weighted. The equivalent level represents the time average of the fluctuating sound pressure, but because sound is represented on a logarithmic scale and the averaging is done with linear mean square sound pressure values, the L_{eq} is mostly determined by loud sounds if there are fluctuating sound levels.



References:

1. Harris, Cyril, "Handbook of Noise Acoustical Measurements and Noise Control", p 1-10., 1998
2. "Controlling Noise", USAF, AFMC, AFDTC, Elgin AFB, Fact Sheet, August 1996
3. California Dept. of Trans., "Technical Noise Supplement", Oct, 1998

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Figure 3—Attachment A

Common Indoor and Outdoor Sound Levels