March 8, 2023

Mr. Devin Howe
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SUBJECT: Environmental Sound Evaluation
Bartzak PV Solar Generating Facility
Holliston, MA

Dear Mr. Howe,

Cavanaugh Tocci has evaluated environmental sound impacts associated with the proposed Bartzak PV solar generating facility at 0 Bartzak Drive in Holliston, MA. The facility sound sources are four Sungrow SG125HV inverter units and one Square D 500 kVA transformer. The objective of this evaluation is to estimate the acoustic impact of the facility on the surrounding community, and to provide sound control recommendations if necessary.

This memo summarizes the results of the evaluation. Appendix A of this report is a glossary of relevant acoustic terminology.

Site and Vicinity

The facility is located to the east of Bartzak Drive in Holliston MA. Residences are located to the north and east along Praying Indian Way and Mohawk Path, at distances as close as 410 feet from the equipment pad.

State and Local Regulations

Commonwealth of Massachusetts requirements under 310 CMR Section 7.10 qualitatively prohibit noise under some circumstances. Interpretation is provided in the Massachusetts Department of Environmental Quality Engineering's Division of Air Quality Control (DAQC) Policy 90-001 dated February 1, 1990; and in the Department of Environmental Protection (MassDEP) Form BWP AQ Sound. The Massachusetts policy limits new noise intrusions to 10 dBA over the existing ambient (L_{90}) sound level. Tonal sound, defined as any octave band level which exceeds the levels in adjacent octave bands by 3 dB or more, is also not allowed.

A detailed interpretation of the MassDEP noise policy has been provided by the Department of Environmental Protection. Essentially, the noise policy enumerated above is strictly applied to protect residences, other sensitive receptors (e.g. schools, hospitals), and land that could be developed for acoustically sensitive use. However, a new noise source that would be located in an area that is not likely to be developed for residential use in the future, or in a commercial or industrial area with no sensitive receptors may not be required to mitigate noise impact on those areas, even if projected to cause noise levels at the facilities property line to exceed existing background sound levels by more than 10 dBA.

The Town of Holliston Zoning By-law[1] includes noise standards under article V-N, "Performance Standards". Paragraph 4 reads:

> 4. Noise. No use shall be permitted within the Town of Holliston which, by reason of excessive noise generated therefrom, would cause nuisance or hazard to persons or property. Exempt from the provisions of this subsection are (a) vehicles not controlled by an owner or occupant of a lot within the town, (b) temporary construction activities occurring during the hours of 7 a.m. to 6 p.m. on weekdays and 8 a.m. to 6 p.m. on Saturday, (c) occasionally used safety signals, warning devices, emergency pressure relief valves, or other such temporary activity, (d) use of power tools and equipment such as lawn mowers, snow blowers, chainsaws, tractors, and similar equipment for the maintenance of property between the hours of 7 a.m. and 8 p.m. on weekdays and 8 a.m. and 6 p.m. on weekends. For the purposes of this by-law the standards in the following shall apply:
>
> Ambient Noise Level. No person shall operate or cause to be operated any source sound in a manner that creates a sound level of 10 dBA above ambient, as set forth in 310 CMR 7.10, measured at the property boundary of the receiving land use nor shall any source produce a pure-tone condition at the property line (or at the nearest inhabited buildings). A pure tone condition exists if the sound pressure level, at any given octave band center frequency, exceeds the levels of the two adjacent octave bands by three (3) or more decibels. See http://www.airandnoise.com/MA310CMR710.html as may be updated by the Mass. DEP. *(Amended May 2019 – ATM, Art. 31)*

This language is consistent with MassDEP regulation; therefore, compliance requirements are identical.

Background Sound Measurements

Two sound monitors (Rion NL-52) were installed on the property to measure the ambient sound level over a one-week period, in order to establish a background sound level. One monitor (SM1) was located near the center of the proposed facility, and a second (SM2) was located at the south end of the proposed facility, as shown in Figure 1. The data measured by these monitors is presented in Figures 2 & 3. SM1 represents the sound conditions for residences along Praying Indian Way and the northern portion of Mohawk Path, while SM2 represents sound conditions of residences farther south on Mohawk Path.

We have assumed that the inverter units will be active only during the interval 6:00 AM to 8:00 PM. During this interval, the lowest background sound level (L_{90}) was 30 dBA at SM1 and 32 dBA at SM2. These levels will be used for evaluating Holliston/MassDEP compliance, resulting in MassDEP/Holliston limits of 40 and 42 dBA for north and south residences, respectively.

[1] https://www.townofholliston.us/building-department/pages/zoning-by-law-2022

Facility Sound Analysis

Facility-related sound impacts have been calculated using Cadna/A environmental sound modeling software (Version 2023, DataKustic GmbH). Cadna/A implements algorithms and procedures described in International Standard ISO 9613-2:1996 “Acoustics- Attenuation of sound during propagation outdoors – Part 2: General method of calculation”. This standard and its associated methodology are the most universally accepted approach for environmental sound modeling of industrial and transit sound sources. The methodology described in this standard provides estimates of A-weighted and octave band sound levels for meteorological conditions that are favorable for the propagation of sound (downwind with a wind speed of 1-5 meters/sec). This methodology is also valid for sound propagation under well-developed moderate ground-based temperature profile inversions, which commonly occur on clear calm nights.

Sound data for the inverter and transformer units was provided by the equipment manufacturers. The inverter data was provided in octave bands. Transformer data was provided only as an A-weighted sound level. In order to evaluate tonal sound characteristics for MassDEP tonal compliance, transformer octave-band sound levels were computed using the procedure outlined in the NEMA-TR1 standard.

Figure 4 shows the Cadna/A model of the facility. Inverter and transformer sources are shown at the equipment pad at northwest corner of the facility. Receptor locations R1-R8 are indicated, with paired receptors at property-line locations and residences. Property-line receptors are six feet above grade. Residence receptors are at the height of upper-floor windows: seventeen feet for two-story buildings and twenty-seven feet for three-story buildings. The modeled sound levels due to the facility are presented in Table 1.

Table 1. Modeled and measured sound levels (dBA)
Bartzak PV Solar Generating Facility, Holliston, MA

Receptor ID	Description	Facility Sound at Property Line	Facility Sound at Residence
R1	32 Praying Indian Way	18	17
R2	36 Praying Indian Way	21	20
R3	2 Mohawk Path	22	23
R4	5 Mohawk Path	20	21
R5	11 Mohawk Path	13	14
R6	17 Mohawk Path	12	15
R7	23 Mohawk Path	10	11
R8	27 Mohawk Path	9	10

Modeled sound levels at all locations are well below the background sound levels of 30/32 dBA and are therefore compliant with the Holliston/MassDEP limits of 40/42 dBA. In addition, we have determined that there is no violation of the MassDEP tonal criterion.

Conclusion

An environmental sound study was performed for the proposed Bartzak PV Solar Generating Facility. Ambient sound monitoring was performed to determine the background sound level. Sound propagation modeling was performed to calculate facility impacts on nearby residences. Our analysis has determined that sound levels of the proposed facility are compliant with both MassDEP noise regulations and the Town of Holliston Zoning By-law.

Sincerely,
CAVANAUGH TOCCI

Bradley M. Dunkin

Bradley M. Dunkin, *Associate Principal Consultant*

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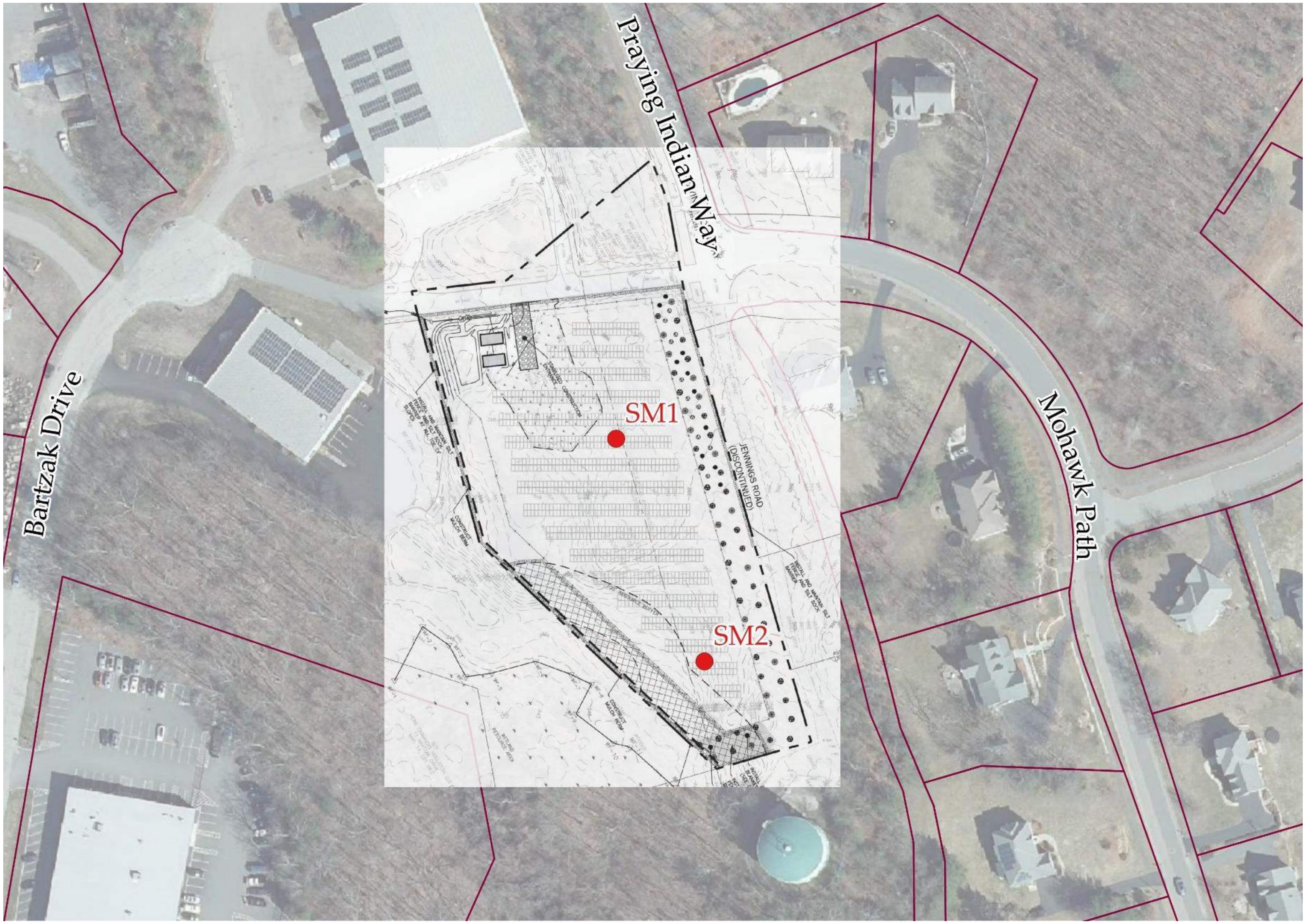
FIGURES



Sound Monitor Locations

Figure 1

Bartzak PV Solar Generating Facility Holliston, MA

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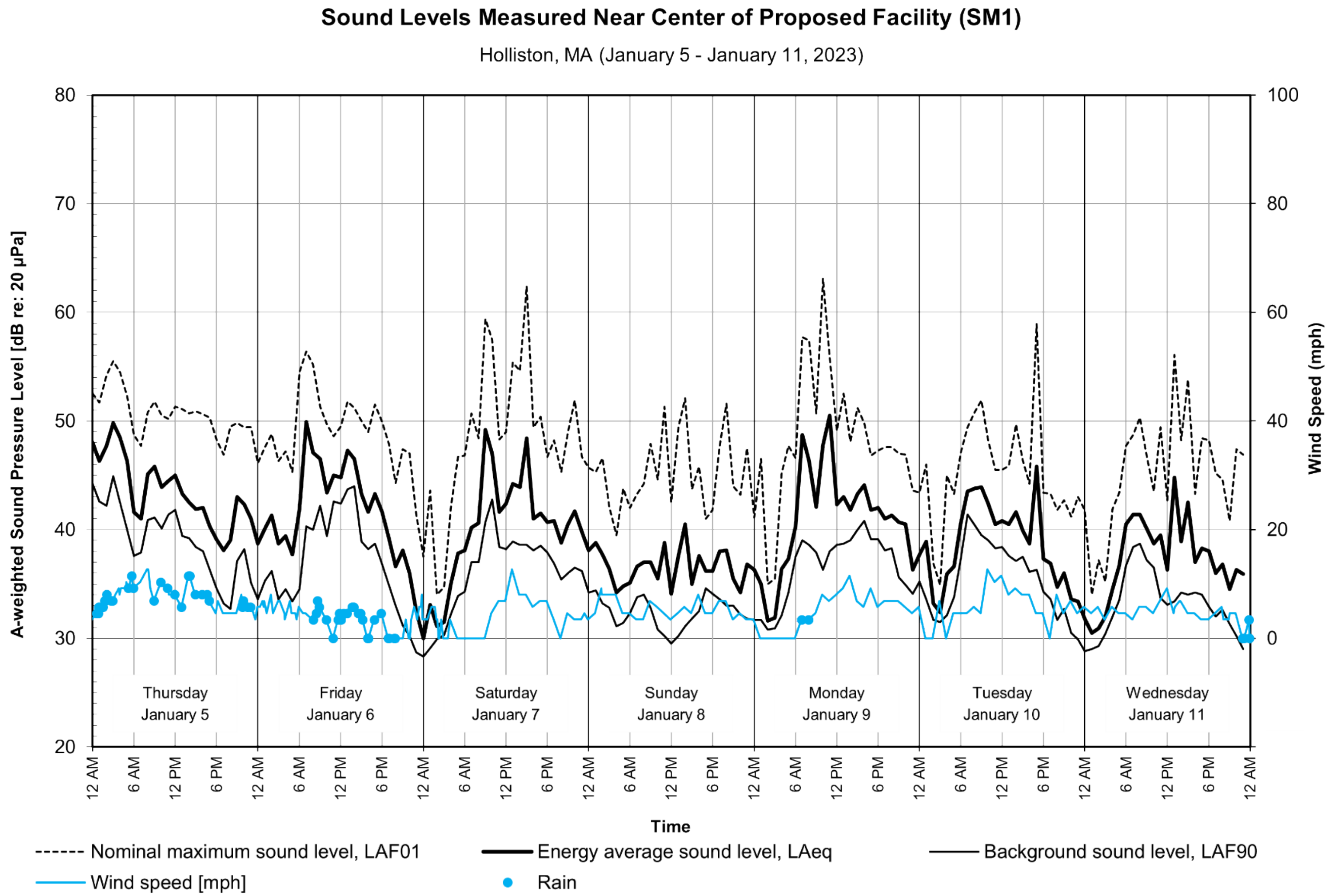

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Figure 2

Bartzak PV Solar Generating Facility Holliston, MA

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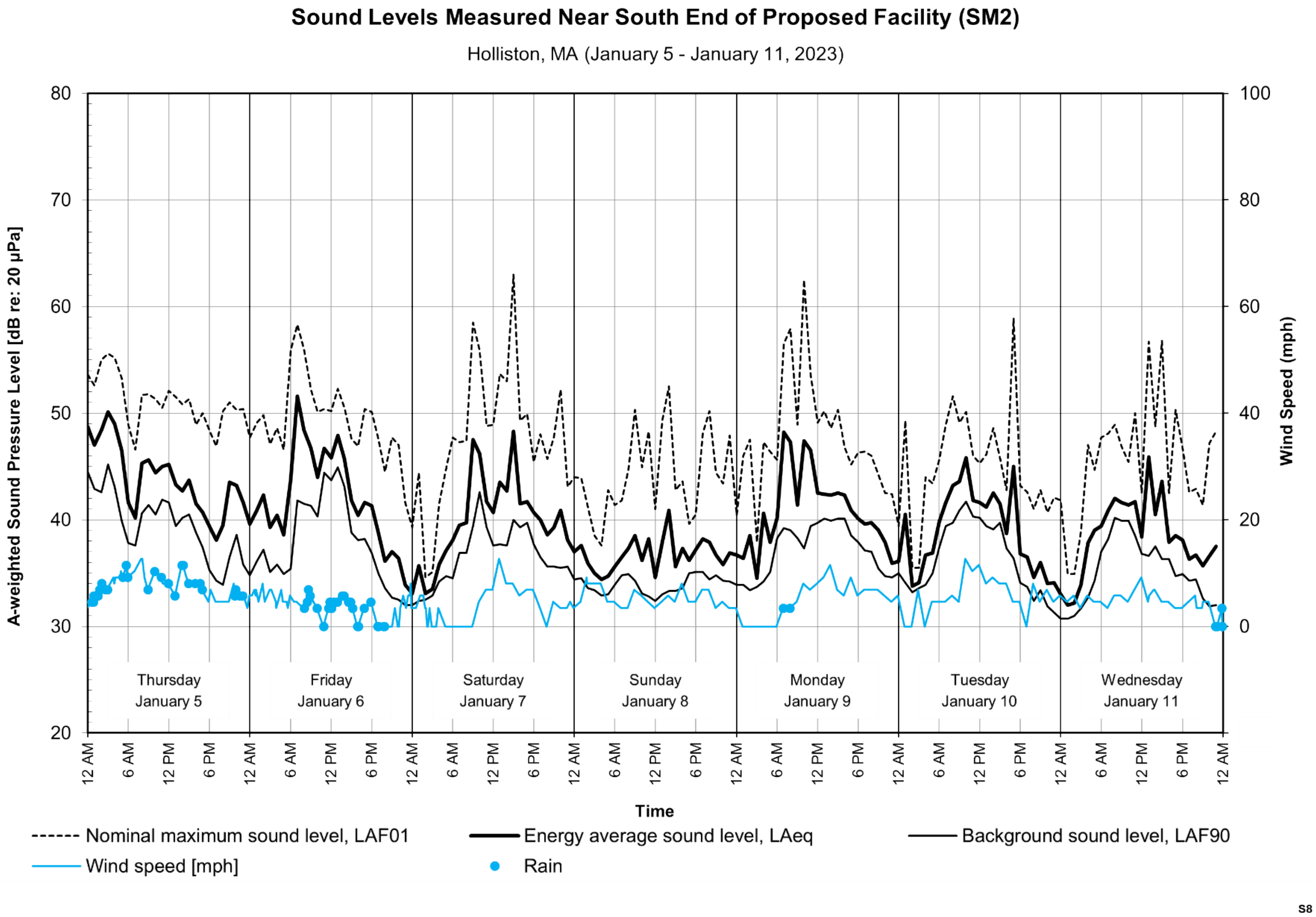

Figure 3

Bartzak PV Solar Generating Facility Holliston, MA

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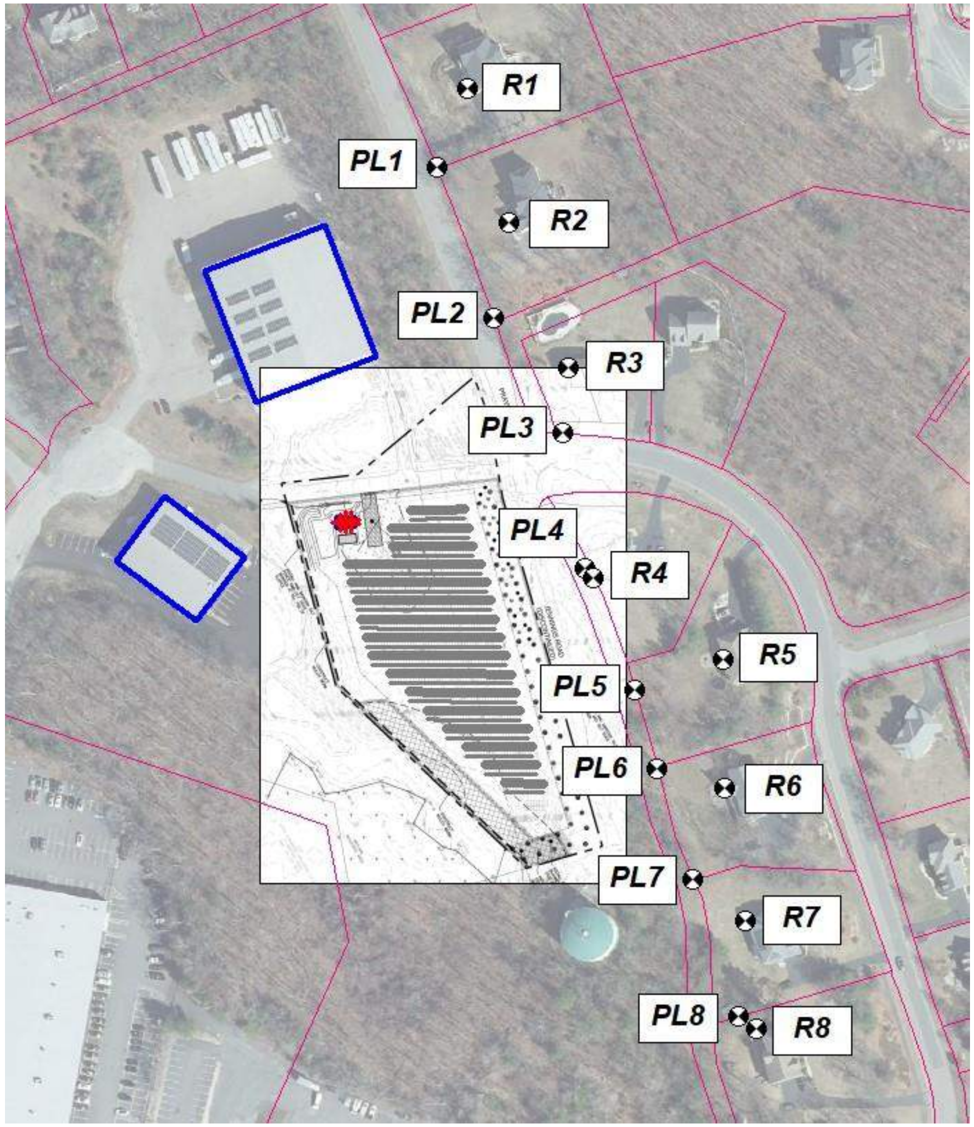

CadnaA Sound Model

Figure 4

Bartzak PV Solar Generating Facility Holliston, MA

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Appendix A

Sound Measurement Terminology

SOUND MEASUREMENT TERMINOLOGY

In order to quantify the amplitude, frequency, and temporal characteristics of sound, various acoustical descriptors are used. The following is an introduction to acoustic terminology that is used in this report.

Sound Level

Sound levels are typically quantified using a logarithmic decibel (dB) scale. The use of a logarithmic scale helps to compress the wide range of human sensitivity to sound amplitude into a scale that ranges from approximately 0 to 180 dB. Note however, that the use of the logarithmic scale prevents simple arithmetic operations when combining the cumulative impact of sources. For example, two sources of equal sound level operated simultaneously results in a combined sound level that is only 3 dB higher than if only one source was operated alone. An important feature of the human perception of continuous sound is that an increase or decrease in sound pressure level by 3 dB or less is barely perceptible, and an increase or decrease by 10 dB is perceived as a doubling or halving of noise level.

A-weighting

Generally, the sensitivity of human hearing is restricted to the frequency range of 20 Hz to 20,000 Hz. However, the human ear is most sensitive to sound in the 500 Hz to 5,000 Hz frequency range. Above and below this range, the ear becomes progressively less sensitive. To account for this feature of human hearing, sound level meters incorporate filtering of acoustic signals that corresponds to the varying sensitivity of the human ear to sound at different frequencies. This filtering is called A-weighting. Sound level measurements that are obtained using this filtering are referred to as A-weighted sound levels and are signified by the identifier, dBA. A-weighted sound levels are widely used for evaluating human exposure to environmental sounds. To help place A-weighted sound levels in perspective, Figure A-1 contains a scale showing typical sound levels for common interior and environmental sound sources.

Spectral Characteristics – Octave and 1/3 Octave Band Sound Levels

To characterize a sound, it is often necessary to evaluate the frequency distribution of the sound energy. As mentioned before, the frequencies of most interest where human exposure is concerned range between 20 Hz and 20,000 Hz. This frequency range is commonly divided into octave bands, where an octave band is a range of frequencies. Each octave band is referred to by its center frequency and has a bandwidth of one octave (a doubling of frequency). To cover the full range of human hearing, it is necessary to measure sound in 10 separate octave bands. Typically, the lowest frequency band measured has a center frequency of 31.5 Hz. The next frequency band has a center frequency of 63 Hz. This geometric series continues to the highest frequency band that has a center frequency of 16,000 Hz. A set of octave band sound levels to describe a particular sound is called an octave band spectrum. Covering the full range of hearing, an octave band spectrum would have 10 values, one for each band. Under certain circumstances, more frequency resolution in acoustical data is needed to identify the presence of tonal sounds. A 1/3 octave band spectrum uses filters that divide each octave band into 3 separate frequency bands. Note that octave band and 1/3 octave band sound levels are not usually A-weighted, with their units being dB.

Environmental Noise Descriptors

Sound levels in the environment are continuously fluctuating and it is difficult to quantify these time-varying levels with single number descriptors. Statistical approaches, which use *percentile sound levels* and *equivalent sound levels*, are often used to quantify the temporal characteristics of environmental sound.

Percentile sound levels (L_n) are the A-weighted sound levels that are exceeded for specific percentages of time within a noise measurement interval. For example, if a measurement interval is one hour long, the 50th percentile sound level (L_{50}) is the A-weighted sound level that is exceeded for 30 minutes of that interval.

- L_{90} is the sound level in dBA exceeded 90 percent of the time during the measurement period. The 90th percentile sound level represents the nominally lowest level reached during the monitoring interval and is typically influenced by sound of relatively low level, but nearly constant duration, such as distant traffic or continuously operating industrial equipment. The L_{90} is often used in standards to quantify the existing background or residual sound level.

- L_{50} is the median sound level: the sound level in dBA exceeded 50 percent of the time during the measurement period.

- 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 noises like those from passing motor vehicles or aircraft.

By using percentile sound levels, it is possible to characterize the sound environment in terms of the steady-state background sound (L_{90}) and occasional transient sound (L_{10}).

The equivalent sound level (L_{eq}) is the energy average of the A weighted sound level for the measurement interval. Sounds of low level and long duration, as well as sounds of high level and short duration influence this sound level descriptor.

Noise levels at night generally produce greater annoyance than do the same levels which occur during the day. It is generally agreed that a given level of environmental noise during the day would appear to be 10 dBA louder at night – at least in terms of potential for causing community concern. The day night average sound level (Ldn) is a 24 hour average A-weighted sound level where a 10 dB “penalty” is applied to sound occurring between the hours of 10:00 p.m. and 7:00 a.m. The 10 dB penalty accounts for the heightened sensitivity of a community to noise occurring at night.

When a steady continuous sound is measured, the L_{10}, L_{50}, L_{90} and L_{eq} are all equal. For a constant sound level, such as from a power plant operating continuously for a 24-hour period, the L_{dn} is approximately 6 dBA higher than the directly measured sound level.

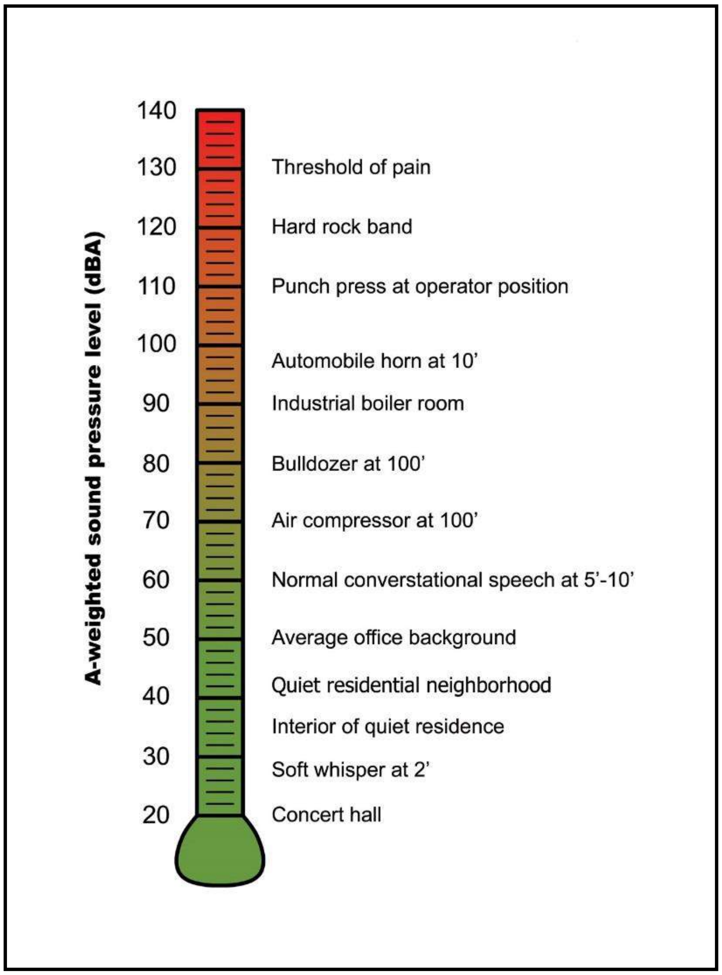

Figure A-1
Typical Sound Levels for Common Interior and Environmental Sources