Environment, Energy & Acoustics

Noise Impact Assessment: Circus Smirkus Summer Camp

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for
Circus Smirkus

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1. INTRODUCTION

Circus Smirkus (CS) which is headquartered in Greensboro, Vermont, holds a summer camp each year. The summer camp has been historically held at area colleges and other facilities not owned by CS. CS is now planning to develop some land on the east side of Breezy Avenue in Greensboro to be used as a permanent summer camp facility. Resource Systems Group (RSG) was retained be CS to conduct a noise impact assessment of the proposed operation in preparation for permitting. The analysis includes monitoring of existing background sound levels near the site, modeling projected sound levels at nearby residences, and proposing mitigation as necessary.

This study includes:

- A description of the project area
- A noise primer
- A discussion of the applicable noise standard
- Monitoring results
- Modeling results
- Recommended mitigation

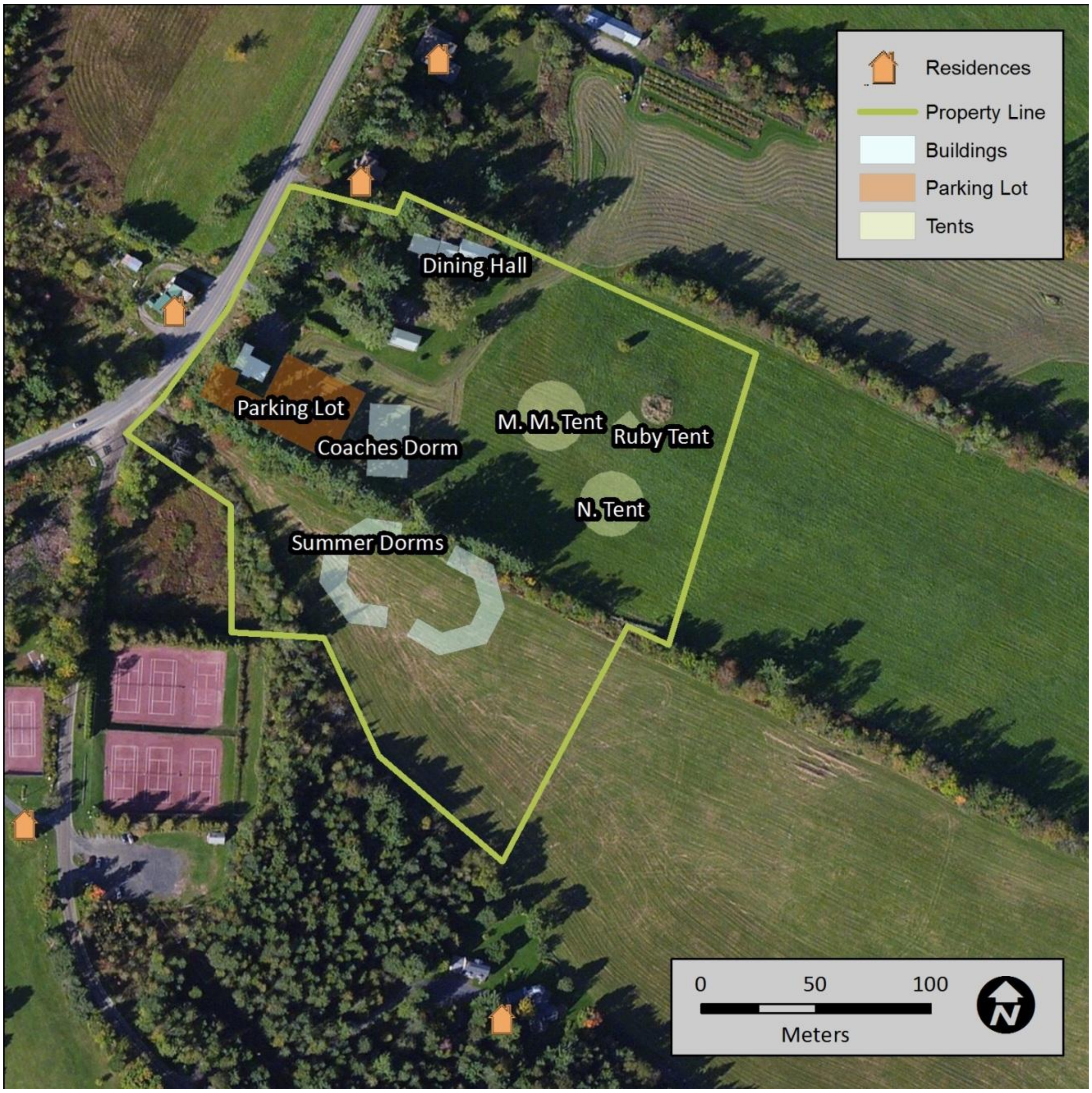
2. PROJECT DESCRIPTION

The proposed camp would be located on the east side of Breezy Avenue just north of Country Club Road. The maximum occupancy of the camp would be 122 people which includs 84 campers and 38 staff. Structures currently on-site include a farmhouse and barn which are connected and a garage. For this project, the farmhouse would serve as an administration building. The barn will be converted into a dining hall, and the structure that connects the barn to the house will be turned into a commercial kitchen. New structures to be built as part of this project include a coaches dorm and two camper dorms. From June to September, there will be up to four circus style tents installed at the site. The primary sources of noise from the camp includes amplified sound within the tents, kids playing outside and inside buildings, and a rooftop exhaust fan for the kitchen. These sources would operate primarily during the day with kids back in their dorm rooms by 9 PM.

The area surrounding the proposed camp site can be characterized as rural and is, in fact, in the Rural Lands Zoning District. The nearest residence to the project is approximately 25 meters northwest of the existing farm house. The nearest residence is also approximately 45 meters to the proposed kitchen, 55 meters to the dining hall, 70 meters to the nearest potential play area, 110 meters to the nearest circus tent, and 150 meters to the summer dorms. There are other nearby residences to the north, west, and south at distances between 150 and 200 meters to the circus tents.

A site map is shown in Figure 1.

Figure 1: Site Map



3. Noise Primer

3.1 What is Noise?

Noise is defined as "a sound of any kind, especially when loud, confused, indistinct, or disagreeable."[1] Passing vehicles, a noisy refrigerator, or an air conditioning system are sources of

[1] "The American Heritage Dictionary of the English Language," Houghton Mifflin Company, 1981.

noise which may be bothersome or cause annoyance. These sounds are a part of generally accepted everyday life, and can be measured, modeled, and, if necessary, controlled.

3.2 How is Sound Described?

Sound is caused by variations in air pressure at a range of frequencies. Sound levels that are detectable by human hearing are defined in the decibel (dB) scale, with 0 dB being the threshold of human hearing, and 135 dB causing pain and permanent damage to the ear. Figure 2 shows the sound levels of typical activities that generate noise.

The decibel scale can be weighted to mimic the human perception of certain frequencies. The most common of these weighting scales is the “A” weighting, which scale is used most frequently in environmental noise analysis. Sound levels that are weighted by the “A” scale are followed by the abbreviation “dBA” or “dB(A)”.

To account for changes over time, a weighted average sound level called the “equivalent” sound level (L_{eq}) is often used. L_{eq} is the average of actual sound pressure rather than decibel levels, and results in weighting loud and infrequent noises more heavily than quieter and more frequent noises. For example, a train passing by for one minute out of an hour could produce sound levels around 90 dBA while passing by, but the equivalent sound level for the entire hour would be 72 dBA. L_{eq} is also often used in environmental noise analysis.

3.3 What is the Difference between Sound Pressure Levels and Sound Power Levels?

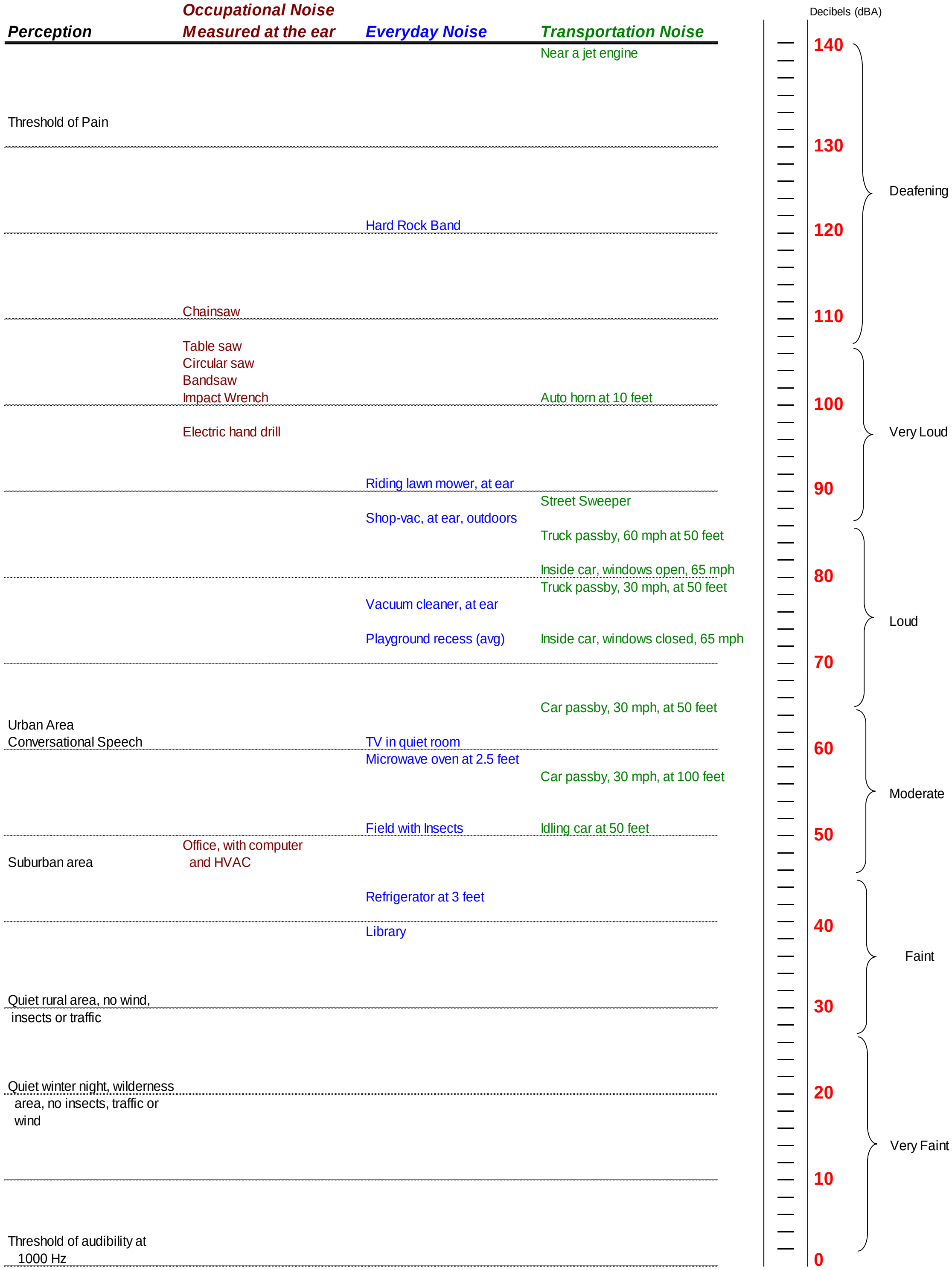
Both sound power and sound pressure levels are described in terms of decibels, but they are not the same thing. Sound power is a measure of the acoustic power emitted or radiated by a source. The sound power level of a source does not change with its surrounding conditions.

The sound pressure level is observed at a specific location and is related to the difference in air pressure above and below atmospheric pressure. This fluctuation in air pressure is a result of the sound power of a source, the distance at which the sound pressure level is being observed, and the characteristics of the path and environment around the source and receiver. When one refers to sound level, they are generally speaking of the perceived level, or sound pressure level.

For example, a coffee grinder will have the same sound power whether or not it is grinding indoors or outdoors. The amount of sound the coffee grinder generates is always the same. However, if you are standing six feet away from the coffee grinder indoors, you would experience a higher sound pressure level than you would if you were six feet away from the coffee grinder outdoors in an open field. The reason for this is that the sound being emitted from the coffee grinder would bounce off walls and other surfaces indoors which would cause sound to build up and raise the sound pressure level.

Sound power cannot be directly measured, but is calculated by measurements of sound pressure or sound intensity. It can be helpful to note that over soft ground outside, the sound pressure level of a small source observed 50 feet away is roughly 33 dB lower than its sound power level.

Figure 2: Basic Theory: Common Sounds in Decibels



3.4 How is Sound Modeled?

The decibel sound level is on a logarithmic scale. One manifestation of this is that sound *power* increases by a factor of 10 for every 10 dB increase. However, for every 10 dB increase, we *perceive* an approximate doubling of loudness. Small changes in sound level, below 3 dB, are not easily perceptible.

A point source's sound level diminishes or attenuates by 6 dB for every doubling of distance due to geometrical divergence. For example, if an idling truck is measured at 50 feet as 66 dBA, geometrical divergences will lower the sound pressure level at 100 feet to 60 dBA, and at 200 feet, 54 dBA. Along a road, sound is generated as a line source. Pure line sources attenuate their sound at 3 dB to 4.5 dB per doubling distance, depending on the reflectivity of the ground.

Other factors, such as intervening vegetation, terrain, walls, berms, buildings, and atmospheric absorption will also further reduce the sound level reaching the listener. In each of these, higher frequencies will generally attenuate faster than lower frequencies. Finally, the ground can also have an impact on sound levels. Harder ground generally increases and softer ground generally decreases the sound level at a receiver. Reflections off of buildings and walls can increase broadband sound levels by as much as 3 dB.

If we add two equal sources together, the resulting sound level will be 3 dB higher. For example, if one machine registers 76 dBA at 50 feet, two co-located machines would register 3 dB more, or 79 dBA at that distance. In a similar manner, at a distance of 50 feet, four machines, all operating at the same place and time, would register 82 dBA and eight machines would register 85 dBA. If the two sources differ in sound level then 0 to 3 dB will be added to the higher level as shown in Table 1.

Table 1: Decibel Addition

If Two Sources Differ By	Add
0-1 dB	3 dB
2-4 dB	2 dB
5-9 dB	1 dB
>9 dB	0 dB

4. NOISE STANDARDS

The Town of Greensboro does not have a noise ordinance and the Zoning Bylaw does not contain a quantitative noise standard applicable to this project. The Zoning Bylaw does briefly discuss noise in Section 5.4 "Conditional Uses" Item (C)7, which states, "Specific standards shall include: [...] Noise, air pollution and effects on the character of the neighborhood shall be considered."

The State of Vermont does not have a quantitative noise standard, nor is are we aware of any clear, quantitative precedent in Act 250 for a summer camp. The former Environmental Board has set some precedents for other projects through the Act 250 process is a daytime limit of 55 dBA Lmax[2] and a nighttime limit of 45 dBA Lmax at homes and areas of frequent human use. These precedents are only applicable if a project has been found to cause an adverse impact on aesthetics with regard

[2] Lmax as applied in Act 250 refers to the maximum 1-second Leq in the absence of background sound.

to noise. If a project's sound is in harmony with its surroundings or if it fits the acoustic context of the area within which it will be located, then the project's sound does not cause an adverse impact. If a project does have an adverse impact, it must be determined if it is unduly adverse. Part of the test under Act 250 to determine if the noise from the project is unduly adverse is to determine if the project is shocking and offensive to the average person. The previously state limits have been applied in Act 250 to determine if noise from a project would be shocking and offensive.

For this project, we have applied a design target of 55 dBA Lmax at residences and areas of frequent human use which would prevent the project from having an unduly adverse impact on aesthetics with regard to noise.

5. Sound Level Monitoring

RSG conducted a site visit on April 16, 2012. During the site visit, we installed a sound level monitor to gather background data from approximately 48 hours. The monitor was a Rion NL-22 ANSI Type 2 logging/integrating sound level meter. It was calibrated before and after the monitoring period, and the microphone was fitted with a wind screen. The monitor was set to log equivalent sound pressure levels (dBA) every 1-second.

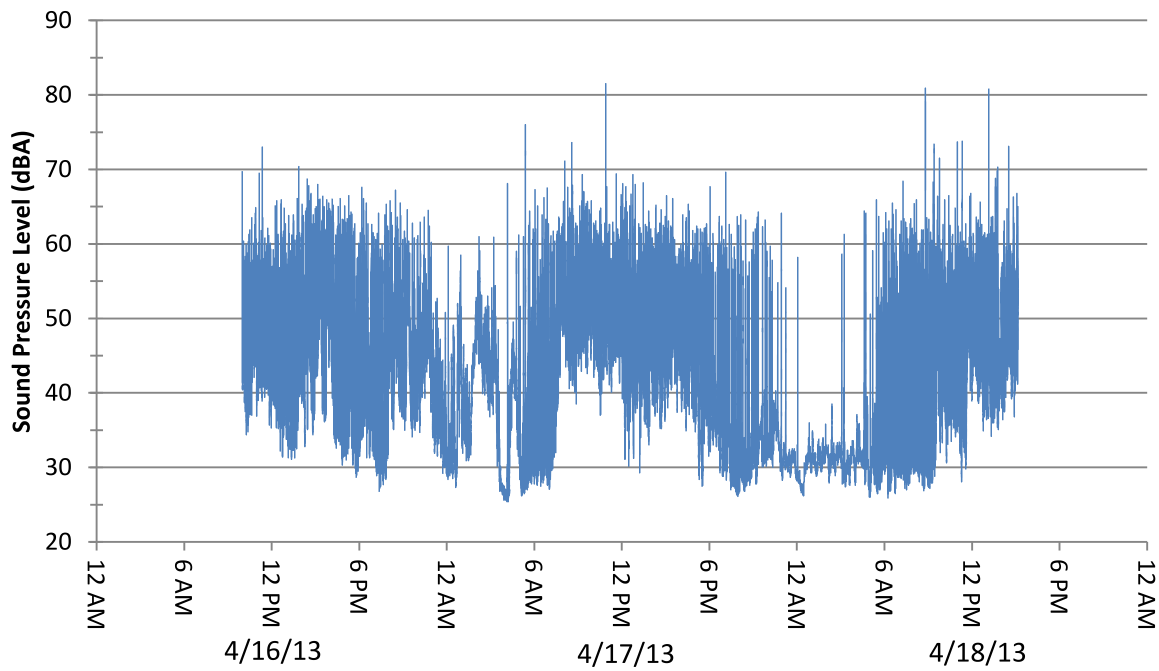
The monitor was placed in front of the existing farmhouse and was setback from Breezy Avenue approximately the same distance from the road as the nearest residence to the project. This location was selected to gather sound levels that are representative of the background sound levels experienced at nearby residences along Breezy Avenue. A photograph of the monitor looking north towards the nearest residence is provided in Figure 3.

Figure 3: Photograph of the Background Sound Level Monitor

The weather during the monitoring period included calm to 14 mph winds with sustained wind generally below 12 mph. Temperatures ranged from 34°F to 55°F, and the skies were mostly clear with some mostly cloudy intervals. Winds were quite high and gusty between midnight and 5 AM on April 17. Data during this time period should be disregarded as winds were too high to accurately monitor background sound levels. Vegetation on trees in the study area had yet to emerge at the time of the monitoring.

Background monitoring results are presented in Figure 4. Maximum daytime levels typically ranged between 60 and 70 dBA, and average daytime levels were approximately 50 dBA. Maximum nighttime levels were generally between 50 and 60 dBA, and average nighttime levels were approximately 32 dBA. The primary source of background sound levels in the area is local traffic on Breezy Avenue.

Figure 4: Background Sound Pressure Levels (dBA) - 1-second Leq



6. Sound Propagation Modeling

Modeling for the project was completed using the International Standards Organization ISO 9613-2 standard, "Acoustics – Attenuation of sound during propagation outdoors, Part 2: General Method of Calculation." The ISO standard states,

> "This part of ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level … under meteorological conditions favorable to propagation from sources of known sound emissions. These conditions are for downwind propagation …

or, equivalently, propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night."

The model takes into account source sound power levels, surface reflection and absorption, atmospheric absorption, geometric divergence, meteorological conditions, walls, barriers, berms, and terrain. Model input data is provided in Appendix A. The ISO standard was implemented in the Cadna A acoustical modeling software. Made by Datakustik GmbH, Cadna A is an internationally accepted acoustical model, used by many other noise control professionals in the United States and abroad. It has also been accepted for many years as a reliable noise modeling methodology by Act 250 commissions, the former Environmental Board, and the Vermont Superior Court Environmental Division.

Standard modeling methodology takes into account moderate nighttime inversions or moderate downwind conditions. For this study, we modeled the sound propagation in accordance with ISO 9613-2 with spectral ground attenuation.

A 5-meter by 5-meter grid of receivers was set up in the model covering approximately 500,000 square meters (124 acres) around the site. In addition, 12 discrete receivers were modeled at nearby residences. A receiver is a point above the ground at which the computer model calculates a sound level.

6.1 Model Results

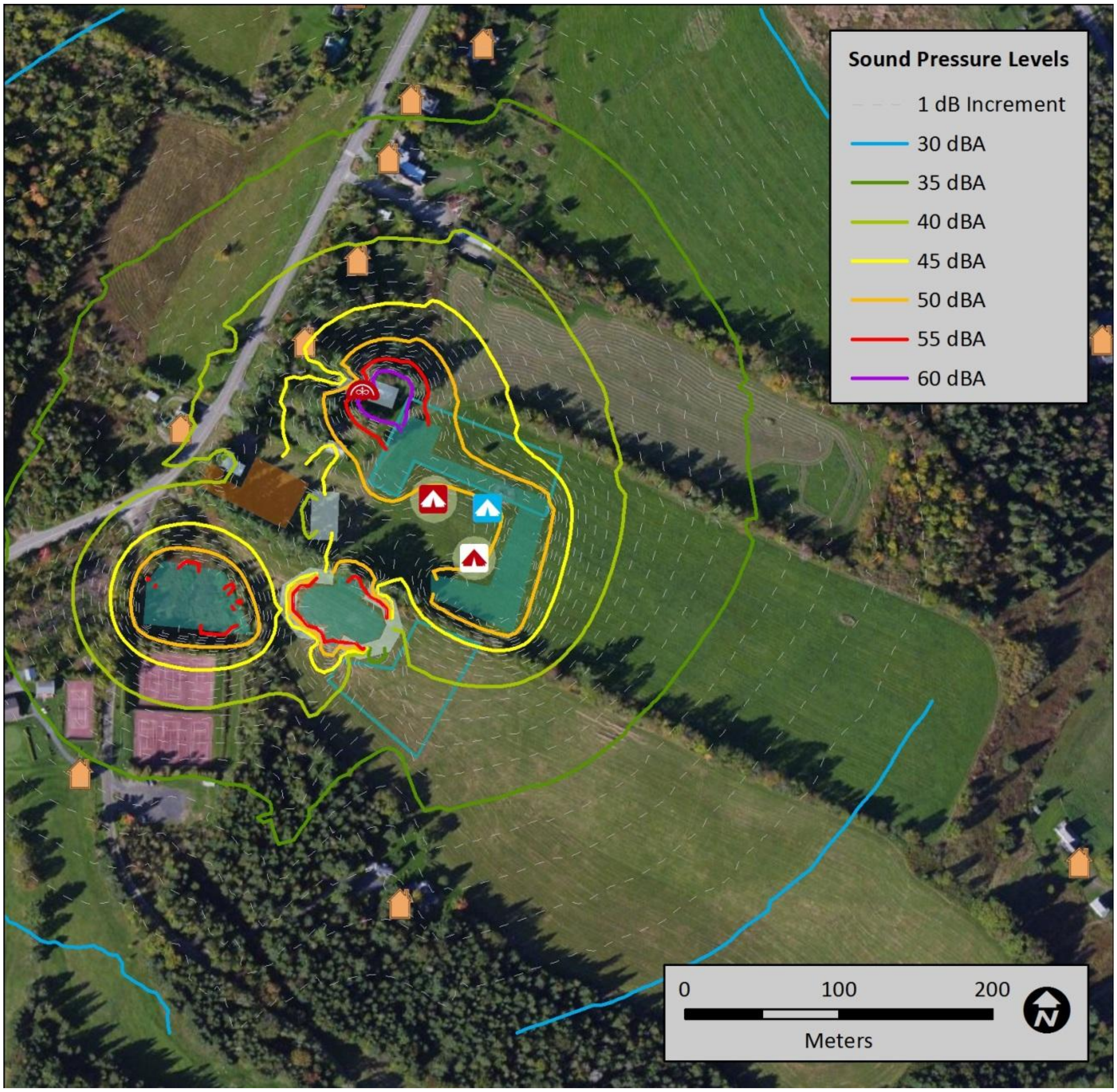
To assess the maximum sound pressure levels from the project, we have conservatively modeled the sound from the kitchen hood, breakout noise[3] from dining hall, breakout noise from three circus tents, and children playing in three different areas on the site, all occurring simultaneously. The modeled emission levels that were used for each of these sources are provided in Appendix A. A map of the modeled sources is provided in Figure 5.

The model results presented as sound pressure level isolines are provided in Figure 6. As shown in Figure 6, there are no residences within the 55 dBA isoline (red line). The maximum sound level from the proposed project at the nearest residence is 45 dBA. This maximum residential sound level is below the existing daytime average levels that occur at this location (Figure 4). The maximum sound levels at the closest residences to the west are approximately 40 dBA, and to the south, the maximum sound levels are between 30 and 35 dBA. In addition, given the conservative modeling assumptions, regular sound levels at the nearest residence from the proposed project would be less than those presented in Figure 6.

[3] Breakout noise is sound that occurs within a building or structure, is attenuated or reduced in level as it travels through the structure, and propagates outside.

Figure 5: Modeled Noise Sources

Figure 6: Sound Propagation Model Results (dBA)



7. Recommended Mitigation

We recommend that the kitchen hood be installed on the south side of the roof slope to mitigate sound propagating to the north. A hood exhaust fan should be selected for the project with sound emissions limited to 75 dBA at one meter. These mitigation recommendations have been included in the modeling results. No other mitigation is required to meet the project design target.

8. CONCLUSIONS

Circus Smirkus is proposed to develop a summer camp site on Breezy Avenue in Greensboro, Vermont. RSG was retained be CS to conduct a noise impact assessment of the proposed operation in preparation for permitting.

Background sound level monitoring was conducted at the site in an area that is representative of the background sound levels experienced by nearby residences along Breezy Avenue. Monitoring results showed that maximum daytime levels were typically between 60 and 70 dBA and average daytime levels were approximately 50 dBA. The primary source of background sound levels in the area is traffic on Breezy Avenue.

Sound propagation modeling was conducted to predict the maximum sound pressure levels from the proposed project throughout the area. Noise sources that were modeled include the sound from the kitchen hood, breakout noise from dining hall, breakout noise from three circus tents, and children playing in three different areas on the site. All of these sources were modeled as occurring simultaneously. All modeled residences were below the 55 dBA Lmax design target.

We recommended that the kitchen hood be placed on the south side of the roof slope to mitigate sound propagating to the north and that the sound emissions from the hood be limited to 75 dBA at one meter. No other mitigation is necessary to meet the project design target.

Given the noise limit precedent, and that the model results are below the existing average background sound levels, the proposed project will not have an undue adverse impact on aesthetics with regard to noise.

APPENDIX A

MODEL INPUT DATA

Table A 1: Modeled Source Emission Data

Source Name	*Type of Source*	*Type of Level*	*Octave Band Center Frequency (Hz)*									*dBA*
			31.5	*63*	*125*	*250*	*500*	*1000*	*2000*	*4000*	*8000*	
Dining Hall	Area Sources	Interior Sound Pressure Level	---	---	---	---	---	---	---	---	---	100
Kitchen Exhaust Fan	Point Source	Spectrum Sound Power	84	84	81	67	62	59	56	51	43	68
Tents	Point Source	Interior Sound Pressure Level	---	---	---	---	---	---	---	---	---	100
Outdoor Play Areas	Area Sources	Total Sound Power Level	---	---	---	---	---	---	---	---	---	94

Table A 2: Modeled Sound Transmission Classes (STC)

Source Name	*Material*	*Sound Transmission Class*
Dining Hall Roof*	28 Gauge Steel Sheething & 1.5" Hardwood (Oak)	1.5" Oak and 28 Gage Steel Plating (STC=31)
Dining Hall Walls	1.5" Hardwood	1.5" Oak (STC=30)
Dining Hall Windows	Single Pane Glass	Single Pane Glass (STC=29)
Tents (North and South)	18 oz. Vinyl	18 oz. Rubber (STC=8)

Table A 3: Modeled Building Dimensions

Building	*Number of Stories**	*Roof Height (m)***	*Total Height (m)*
Auxiliary Building North	2	2.75	8.25
Auxiliary Building West	2	2.75	8.25
Dining Hall	2	2.75	8.25
Garage	1	2.75	5.5
Kitchen	1.5	2.75	6.86
Pavilion	2	2.75	8.25
Staff Dorms	2	2.75	8.25
Summer Dorms (East and West)	3	no sloped roof	8.25

**With no access to plans, all dimensions were estimated based on visual inspection and photographs of the site. 1 story = 2.75 m*

***All roofs were estimated to be 1 story tall (2.75 m). The roofs were modeled as completely reflective vertical barriers in order to represent the acoustic shadow the roof would realistically provide.*

Table A 4: Model Settings

Parameter	Setting
Ground Absorption	ISO 9613-2 spectral, G=1
Atmospheric Absorption	Based on 10 degrees Celsius, 70% relative humidity
Foliage	No foliage
Search Radius	2000 meters from each source
Receiver Height	4 meters for sound contours & discrete receivers