November 24, 2014 Project 39743865

Assistant Chief. Ken Burkenbush
Town of Exeter
20 Court Street
Exeter, New Hampshire 03833
via email: asstchief@exeternh.org

Subject: Shooting Range Noise Measurement Study
Exeter Sportsman's Club
Exeter, NH

Dear Assistant Chief Burkenbush:

URS Corporation (URS) is pleased to provide the Town of Exeter with our report summarizing the noise study conducted at the Exeter Sportsman's Club located on Portsmouth Avenue in Exeter, New Hampshire. URS has performed sound level measurements at the Exeter Sportsman's Club firing range and three of the closest residential neighborhoods to determine the typical maximum firearm sound level readings prior to and following the installation of an approximate 32-foot wide and 8-foot high berm on the firing range property located in Exeter, New Hampshire.

URS conducted background noise level measurements at the Exeter Sportsman's Club firing range and in the Allen Street, Windemere Lane, and Thornton Street neighborhoods using Type 2 (re ANSI S1.4-1983) sound level meters.

Environmental Noise Parameters

Sound is caused by pressure fluctuations that generate energy waves in the surrounding air. Sound levels are typically measured using a logarithmic decibel (dB) scale. Sound that causes disturbance or annoyance, or unwanted sound, is often called noise. The terms sound and noise are used interchangeably in this report.

Human hearing varies in sensitivity for different sound frequencies. Frequency is the rate of variation of the pressure wave and is typically described in units of cycles per second or Hertz (Hz). Although we can hear sounds between roughly 20 and 20,000 Hz, the human ear is most sensitive to sound frequencies between 500 and 4,000 Hz and is less sensitive to sound frequencies below 250 Hz or above 10,000 Hz. Consequently, several different frequency weighting schemes have been developed to model the way the human ear responds to noise levels. The "A-weighted" decibel scale (dBA) is the most widely used for this purpose. A list of typical sound levels for example sound sources is presented in Table 1. Each increase of 10 dBA is typically perceived as a doubling of loudness and each decrease of 10 dBA is typically perceived as cutting the loudness in half.

URS Corporation
1155 Elm Street, Suite 401
Manchester, NH 03101
Tel.: 603.606.4800
Fax: 603.606.4801

Table 1
Sound Pressure Levels (in dBA) of Typical Noise Sources and Environments

Example Noise Source (at a Given Distance)	Sound Pressure Level in dBA	Example Noise Environment	Human Judgment of Noise Loudness
Commercial Jet Takeoff (200 ft)	120		Threshold of pain
Pile Driver (50 ft)	110	Rock Music Concert	*16 times as loud
Ambulance Siren (100 ft)	100		Very loud
Motorcycle (25 ft)	90	Boiler Room	*4 times as loud
Highway Vehicles (50 ft)	80		*2 times as loud
Passing Cars (25 ft)	70	Urban Daytime	*Reference Loudness
Normal Conversation (5 ft)	60	Busy Office	*1/2 as loud
Light Traffic (100 ft)	50	Suburban Daytime	*1/4 as loud
Bird Calls (distant)	40	Rural Daytime	Quiet
Soft Whisper (5 ft)	30	Quiet Bedroom	Very Quiet
--	20	Recording Studio	Just audible
--	0		Threshold of hearing

*Based on perception, relative to a reference sound pressure level of 70 dBA

Sound pressure at a specific location reduces with distance as it propagates over a larger area, generally in a spherical spreading pattern, away from a point source where the sound waves were generated. Generally speaking, the sound pressure level emitted from a point source (a sound source small in size compared to the distance of interest) decreases by approximately 6 dBA for each doubling of distance from the source. If a sound source can be characterized as a line rather than a point, as is the case for long trains or transmission lines, the sound pressure level drop-off rate generally reduces from 6 dBA to a rate of 3 dBA for each doubling of distance from the source. In addition to this decrease in sound pressure by divergence of sound energy with distance, sound propagation (and thus sound pressure levels at specific locations) is affected by atmospheric and ground conditions. An acoustically absorptive ground condition, as would be the case for loose soil or fresh snow, can add another 1.5 dBA per doubling of distance to the drop-off rate of sound pressure level from a point or line source. Atmospheric conditions, especially temperature and wind current gradients, can significantly affect noise propagation beyond 200 feet from a source, so sound levels are difficult to predict with certainty at large distances.

Applicable Regulations

Section 701 (Unnecessary Noise) of Chapter 7 (Conduct Regulations) in the Town of Exeter Code addresses noise generated by this facility. This regulation prohibits “unnecessary or unusually loud noises which are prolonged, unusual and unnatural in their time, place and use effect, and are a detriment to public health, comfort, convenience, safety, welfare and prosperity of the residents of the Town of Exeter.” Beyond that clause, a list of specific sound sources is provided with associated prohibited times of operation, but firing ranges are not included in that

list. Section 704 of the Code mentions the discharge of firearms, but only in terms of where that can take place. The Sportsman's Club is specifically mentioned in Section 704.3 as a location permitted for such use. There are therefore no quantitative noise limits related to the discharge of firearms at the Sportsman's Club.

Noise Monitoring

To address the potential change in community noise levels after the construction of a berm at the Sportsman's Club, URS monitored the sound levels of gunshots before the construction of the berm (on May 9, 2014) and after the construction of the berm (on November 3, 2014). In addition to monitoring the gunshots on the Sportsman's Club property, noise levels were monitored at representative locations of three of the closest residential communities to the south and northwest of the facility. Figure 1 shows these locations, along with the other closest properties to the proposed facility, superimposed on an aerial map.

The weather conditions during the May monitoring period were favorable for the sound level measurements, with minimal precipitation, light winds (less than 10 miles per hour), and temperatures in the 50s in degrees Fahrenheit. For the November readings, temperatures were in the 40s and there was no precipitation but winds were intermittently gusty. Since only the impulsive maximum levels from the gunshots were of interest, those readings were only recorded when winds were not gusty and the gunshots clearly produced the highest levels at the monitor.

The sound monitors were two Quest Technologies SoundPro DL2 Type 2 (re ANSI S1.4-1983) sound level meters (serial numbers BIN010005 and BIJ040001 for the May readings and BIJ090027 and BIJ090035 for the November readings), field-calibrated before and after the session with a Quest Technologies Model QC-10 calibrator (serial number QIL010345 for the May readings and QIO070216 for the November readings). All instruments had been factory-calibrated within 12 months of their use and field-calibrated before and after each set of readings. All measurement procedures were in accordance with standard industry-accepted practices.

Three types of firearms and associated ammunition were used for these readings, listed from the loudest to the quietest:

- A US Army Carbine Model M1 30-caliber rifle,
- A Ruger Blackhawk 44 Magnum revolver, and
- A US Army Model 1911 45-caliber ACP.

These are representative of the typical sound level range of firearms discharged at the facility. Maximum instantaneous (L_{max}) readings were recorded 50 feet from the firearms and in the representative community locations simultaneously by 2 technicians that were communicating by cell phone. Monitoring was performed at the same locations in May and November for the pre-berm and post-berm conditions, respectively. Figure 2 shows a photograph of the measurement location near the facility during the pre-berm measurements in May and Figure 3 shows that location after the berm was constructed for the November measurements.

The community monitoring locations were representative of three of the closest residences to the facility, namely:

- Intersection of Thornton Street and Towle Avenue, approximately 1200 feet to the south of the facility,
- End of Windemere Lane, approximately 1500 feet to the southeast of the facility, and
- End of Leary Court off of Allen Street, approximately 2500 feet northwest of the facility.

Figure 1. Study area showing the Sportsman's Club in relation to the neighborhood noise monitoring locations.

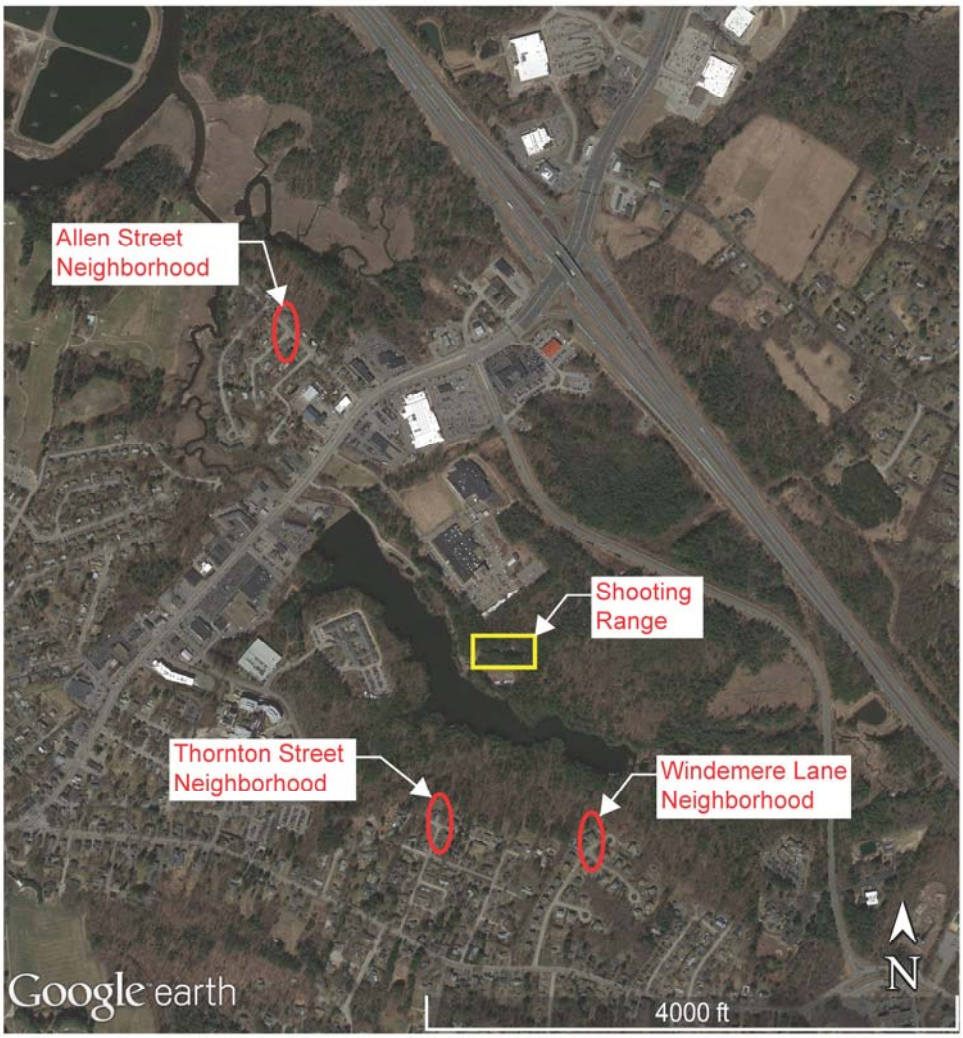

Figure 2. Pre-berm monitoring location outside firing range.

Figure3. Post-berm monitoring location outside firing range.

The results of the monitoring are summarized in Table 2. The gunshots from the facility were not audible during either test at the Leary Court location to the northwest but they were clearly audible at the other monitoring locations to the south. Table 2 shows a significant reduction of sound close to the new berm (between 5 and 14 dBA) but an unmeasurable difference in the closest communities. The large range of differences between pre- and post-berm conditions is indicative of atmospheric effects rather than any effects associated with the berm. This is expected since noise barriers are only effective for sound reduction within 200 feet. This is the case because of a combination of diffraction of sound over and around barriers with the unpredictable variation of sound propagation through continually changing atmospheric conditions. The most noise reduction to be expected from a barrier is up to 15 dBA close to it, which has been demonstrated by these measurements.

Table 2
Noise Monitoring Results Summary

Location	Gun Type	Pre-berm average L_{max} (dBA)	Post-berm average L_{max} (dBA)	Pre-berm/post-berm difference (dBA)
50 feet from firing ranges	M1 Carbine	100.3	86.0	14.3
	44 Magnum	87.8	82.3	5.5
	45 Caliber ACP	83.9	74.7	9.2
Thornton Street & Towle Avenue	M1 Carbine	56.1	64.5	-8.4
	44 Magnum	66.8	66.2	0.6
	45 Caliber ACP	67.0	43.4	23.6
Windemere Lane	M1 Carbine	56.2	56.7	-0.5
	44 Magnum	59.0	64.8	-5.8
	45 Caliber ACP	55.6	59.0	-3.4
Leary Court	M1 Carbine	56.9*	57.4*	N/A
	44 Magnum	60.5*	66.9*	N/A
	45 Caliber ACP	62.1*	70.4*	N/A

*- gunshots not audible above background sounds

In conclusion, the new berm provided a significant sound reduction on the Sportsman's Club property but the combination of distance and atmospheric effects between the berm and the closest residential communities resulted in no repeatable sound reduction from firing activities at those locations.

Feel free to contact us with any questions about this information.

Sincerely,
URS Corporation

Gary M. Garfield, PE
Principal Engineer
603-606-4812

James P. Cowan, INCE Bd.Cert.
Acoustic Engineer
603-606-4806