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AFOEHL REPORT

89-041EH0377ENA

Community Noise Assessment of a Proposed Semi-Enclosed Small Arms Range Facility at Willow Grove Air Reserve Facility, Willow Grove PA

ALI Y. ALI, 1Lt, USAF, BSC
JOHN F. SEIBERT, Maj, USAF, BSC

May 1989

Final Report

AF Occupational and Environmental Health Laboratory
Human Systems Division (AFSC)
Brooks Air Force Base, Texas 78235-5501

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This report has been reviewed and is approved for publication.

ALI Y. ALI, 1Lt, USAF, BSC
Consultant, Industrial Hygiene

DENNIS R. SKALKA, Lt Col, USAF, BSC
Chief, Consultant Services Division

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James C. Rock

JAMES C. ROCK, Colonel, USAF, BSC
Commander

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This report predicts the maximum (Lmax) community noise levels generated from weapons firing at a proposed small arms range at the Willow Grove Air Reserve Facility on Willow Grove Naval Air Station PA, and compares these levels to local noise ordinances. Present noise levels at Willow Grove exceed allowable levels for Horsham and Warrington township ordinances. "Wind noise" measured with a standard foam wind screen over the microphone dominated the low frequencies (1.6-300 Hz) and exceeded the noise ordinances. Willow Grove traffic noise and other existing noise sources exceeded the noise ordinances at frequencies above 300 Hz. Noise measured at a firing range of the proposed design at Grand Forks AFB during weapons firing (M-16, M-60 and M-9 pistol) gave noise levels predominantly in the 500-8000 Hz frequency range. Noise levels in these frequencies exceeded the Willow Grove community noise ordinances and existing Willow Grove noise levels. This report also gives maximum noise

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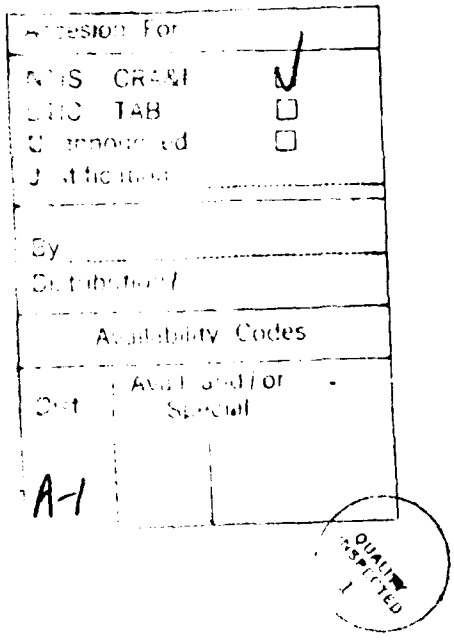
levels expected for all angles surrounding the standard Air Force small arms range design as built at Grand Forks AFB. These data are available as a reference for siting other small arms ranges where community noise ordinances use Lmax noise levels.

ACKNOWLEDGEMENT

The dedicated efforts of the AFOEHL noise survey team, consisting of Maj John C. Ellis II, Capt Terry M. Fairman, and 1Lt Winston J. Shaffer II, during the Grand Forks AFB Small Arms Range noise survey, made this report possible. I would like also to thank Mr James Penn of HQ AFRES/DEPR for making site maps and design drawings available for us and Mr Jonathan Bach of the 913 TAC Clinic/SGPB, Willow Grove Air Reserve Facility PA for his assistance during Willow Grove noise survey. Finally, I thank MSgt McIntire of the Combat Arms and the Combat Arms personnel of the 842nd Security Police Group, Grand Forks Small Arms Range, Grand Forks AFB ND, who supported us before and during courses of weapons firing.



CONTENTS

I. INTRODUCTION

A. Purpose: This study examined the potential community noise impact of building a standard Air Force semi-enclosed firing range at the Willow Grove Air Reserve Facility (ARF), Willow Grove PA. The study was performed at the request of HQ Air Force Reserve/DEP and SGP.

B. Problem: A November 1987 Navy contract study assessed the noise impact of the proposed small arms range and predicted the proposed site will exceed the established surrounding community noise ordinances. However, the study made several assumptions which led to questionable results. Noise measurements from weapons firing had been measured at Fort Dix, an open firing range, although the proposed Air Force design was semi-enclosed and would provide noise reduction. The study also converted the community noise ordinance to Day-Night Average Noise Levels (DNL) by assuming weapons firing noise had a frequency spectrum identical to A-Weighted white noise. Further, the study assumed noise emissions were of equal intensity in all directions (omnidirectional). HQ Air Force Reserve/DEP and SGP requested this noise study to reevalute the noise impact of the proposed small arms firing range.

C. Scope: This study reports the community noise levels to be expected from constructing the proposed small arms range facility at Willow Grove ARF, and compares those levels to the local community noise ordinances. Because of the opportunity to collect noise data of the standard Air Force design for a semi-enclosed firing range, additional noise data was collected to provide a reference for siting of firing ranges of this design at any Air Force base. Weapons fired at this range included the M-9 (9 mm pistol), the M-16 rifle, and the M-60 machine gun. Two sites were considered for this study, an initial and a revised site (Phase I and Phase II). Recommendations are made regarding compliance of noise emissions with Willow Grove community noise ordinances.

II. DISCUSSION

A. Standards: Willow Grove ARF is bounded by Horsham Township, and is in close proximity to Warrington Township. Each township has published its own noise ordinance (Appendix A) for community noise. While there are differences between the ordinances, both give maximum sound pressure levels (SPLs) not to be exceeded within specified frequency ranges. This approach of using maximum SPLs (Lmax) is very different from the Day-Night Average Noise Level (DNL) recommended by the Environmental Protection Agency (EPA). The DNL is used by the Office of Housing and Urban Development (HUD) and most community noise ordinances (Appendix A). Also, the frequency ranges specified in the Willow Grove ordinances are typical of frequency ranges used by sound level meters used in the 1950s and 1960s. Sound level meters currently used in the United States conform with the frequency ranges of American National Standards Institute (ANSI) Standard S1.6-1984 "American National Standard Preferred Frequencies, Frequency Levels, and Band Numbers for Acoustical Measurements," 1984, and ANSI Standard S1.11-1966 "American Standard for Octave, Half-Octave, and Third-Octave Band Filter Sets," 1966. For this survey, noise levels were measured using the frequency ranges (frequency bands) specified in ANSI S1.6 and S1.11, and were compared to the noise ordinance frequency bands where possible. (Table 1).

Table 1. Comparison between Octave Bands Frequency Ranges for Horsham Township, Warrington Township Noise Ordinances and ANSI Standard S1.6-1984

ANSI S1.6 OCTAVE BAND		HORSHAM TOWNSHIP ORDINANCE			WARRINGTON TOWNSHIP ORDINANCE	
		OCTAVE BAND FREQUENCY RANGE (Hz)	MAXIMUM PERMITTED SOUND PRESSURE LEVEL (dB)		OCTAVE BAND FREQUENCY RANGE (Hz)	MAXIMUM PERMITTED SOUND PRESSURE LEVEL (dB)
CENTER FREQ. (Hz)	FREQUENCY RANGE (Hz)		RESIDENTIAL	OTHER		
2	1.4 - 2.8					
4	2.8 - 5.7					
8	5.7 - 11.3					
16	11.3 - 22.5	0 to 75	72	79		
31.5	22.5 - 44.5				0 to 150	67
63	44.5 - 89					
125	89 - 178	75 to 150	67	74		
250	178 - 354	150 to 300	59	66	150 to 300	59
500	354 - 707	300 to 600	52	59	300 to 600	52
1000	707 - 1414	600 to 1200	46	53	600 to 1200	48
2000	1414 - 2828	1200 to 2400	40	47	1200 to 2400	40
4000	2828 - 5656	2400 to 4800	34	41	2400 to 4800	34
8000	5656 - 11314	Above 4800	32	39	Above 4800	32
16000	11314 - 22627					

B. Methodology

1. Measurement Locations: Appendix B shows the Study Area, Measurement Locations and Range Design. Sound survey locations at Willow Grove were selected to determine existing "background" SPLs at political boundaries and at the most sensitive residential and recreational areas (Figures B-1, B-2 and B-3). Noise samples were collected over a five day period covering Tuesday through Saturday. Sound measurements of weapons firing were then performed at the Grand Forks AFB ND, Combat Arms Range, a recently constructed small arms range of the standard Air Force design proposed for Willow Grove ARF (Figures B-4, B-5). Measurement locations at the Grand Forks small arms range were selected as being physically equivalent to the initial proposed site locations previously measured at Willow Grove (Figure B-6, Phase I Proposed Site). SPLs from weapons firing were then compared directly to their equivalent Willow Grove background levels. In addition to the Willow Grove equivalent positions, sound was measured on a 1500 foot radius at 20 degree intervals surrounding the firing range. These radial measurements were used to characterize the noise emissions from the range, and allow predictions of SPLs at virtually any distance or angle from a firing range of the same design to include any alternate site (Phase II Proposed Site, Figure 6). Radial measurement locations at 80, 100 and 160 from the direction of firing were not used because physical obstacles between the firing range and those locations would have reduced the measured noise levels. Radial measurement locations at 180 for the M-60 and 200 for the M-16 were dominated by aircraft noise. Measurements dominated by aircraft noise were not used.

2. Measurement Procedures: Sound data were collected on portable tape recorders for later analysis at AFOEHL (Appendix C). A microphone with wind screen was held at a height of 1.6 meters above the ground by a hand held pole. At Willow Grove ARF, the microphone was pointed toward the proposed firing range site, and the sound levels were recorded for approximately 30 seconds. At the Grand Forks AFB firing range, the microphone was pointed toward the center of the firing range. One complete volley of weapons fire and 30 seconds of background noise were collected sequentially at each Grand Forks location by two survey teams. The background noise was used to account for any interferences such as wind or aircraft noise occurring during weapons firing.

3. Data Analysis: Recorded data were played back through an oscilloscope and a loudspeaker to make sure the recorded signals were free of interfering signals. Selected signals were fed to a 1/3 octave band frequency analyzer configured to measure SPLs in the same way as a sound level meter complying with ANSI Standard S1.6 set to 'SLOW' meter response (one second exponential averaging time) and 'MAX HOLD' (maximum encountered noise level, Lmax). Values for each 1/3 octave band were stored in an HP9000 microcomputer and combined mathematically into full octave band SPLs.

C. Results:

1. A total of 52 background noise measurements at Willow Grove community locations were analyzed and compared to the noise ordinances (Appendix D). Comparisons of background noise, ordinance levels and M-16

weapons noise for two key Willow Grove locations are graphed (Figures 1 & 2). These graphs demonstrate maximum background noise levels exceeded the noise ordinance levels for all octave bands, and, median background levels exceeded the noise ordinances for frequency bands of 125 Hertz (Hz) or greater.

2. Grand Forks AFB weapons firing noise was masked at frequencies below 250 Hz by wind noise. For octave bands at and above 500 Hz, noise levels from M-16 and M-60 weapons firing exceeded the Warrington and Horsham noise ordinances at all locations. As examples, M-16 weapons firing noise levels were above Willow Grove background levels and noise ordinance levels for most frequency bands at Location L8 (Figure 1) and at Location L9 (Figure 2).

3. Radial noise measurements for the Grand Forks AFB firing range (Appendix E) were used to generate equal sound level contours that show where the Horsham township noise ordinance levels would be exceeded (Appendix F). These contours were used as an overlay for the Willow Grove base map to look at the alternate firing range site. These contours show that weapons firing at the alternate site will also generate noise in excess of the Horsham noise ordinance.

D. Observations:

1. Willow Grove background noise levels on the Warrington Township line and in Horsham Township exceeded the noise ordinance in the frequency range of 1.6 to 250 Hz due to noise generated by the wind blowing across the microphone (low frequency "wind noise"). This occurred in spite of using a standard foam wind screen over the microphone. This makes enforcement of the noise ordinances in this frequency range possible only if noise sources exceed wind noise during a noise survey, or if specially designed wind screens are used.

2. M-9, M-16 and M-60 weapons firing generated noise levels primarily in the frequency range of 500 to 10,000 Hz.

3. While background noise levels at locations L7 and L8 along County Line Road appear to exceed the Warrington Township noise ordinance because of road traffic, the ordinance excludes noise produced by "transportation sources." Horsham Township has no exclusion for transportation sources.

4. The Grand Forks small arms range could be modified in several ways to reduce noise emissions from weapons firing.

a. Earthen berms could be placed behind the firing range buildings to form a complete circle of noise attenuating barriers. Existing berms could be built higher to provide increased attenuation.

b. The M-60 firing "tubes" could be lined with sound absorbing spray-on foam.

c. The M-16 and M-60 firing range buildings could be lined with sound absorbing material to reduce reverberant buildup within the buildings.

d. Overhead bullet traps on the M-16 range could be covered with sound absorbing material to reduce the reflection of sound to the rear of the shooters.

III. CONCLUSIONS

A. Measuring noise levels for compliance with Horsham and Warrington Township noise ordinances is very difficult due to the high noise levels generated at low frequencies from wind on the microphone with a standard wind screen.

B. Existing sound levels in the vicinity of Willow Grove exceeded allowable levels for Horsham and Warrington noise ordinances at all frequencies.

C. Noise generated from weapons firing at the originally proposed small arms range site and the alternate site would exceed the Warrington and Horsham township noise ordinances.

D. The standard small arms range design used at Grand Forks could be modified to reduce the noise emissions. However, the ability of the modified range to meet the Willow Grove noise ordinances is unknown.

IV. RECOMMENDATIONS

A. Request exemptions to the Horsham and/or Warrington township noise ordinances as required for the firing range site chosen.

B. Contact AFOEHL if assistance or coordination is needed in planning modifications to the small arms range to reduce noise emissions.

Figure 1. Background SPLs and Predicted M–16 SPLs at Location L8 (1919 County Line Road)

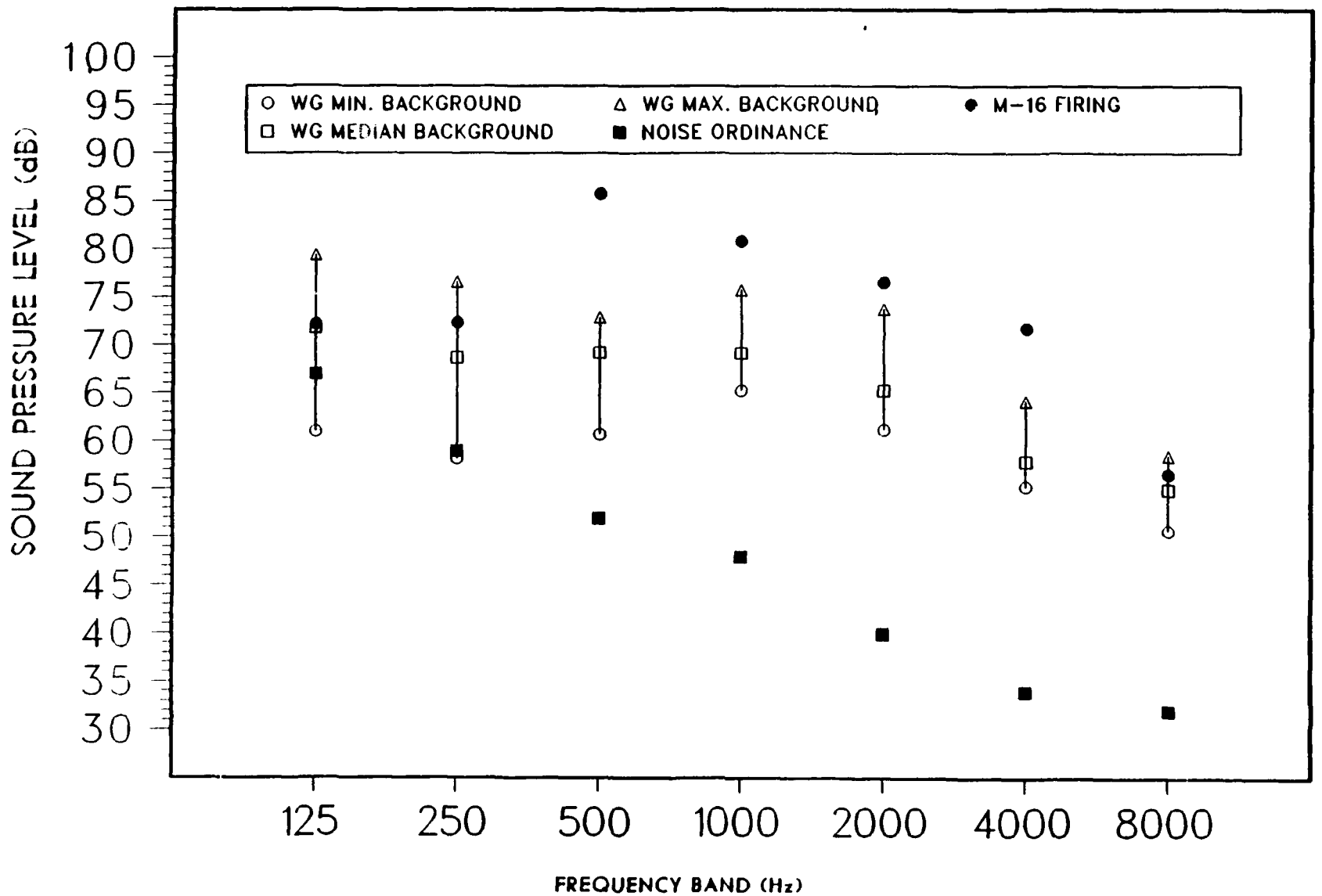
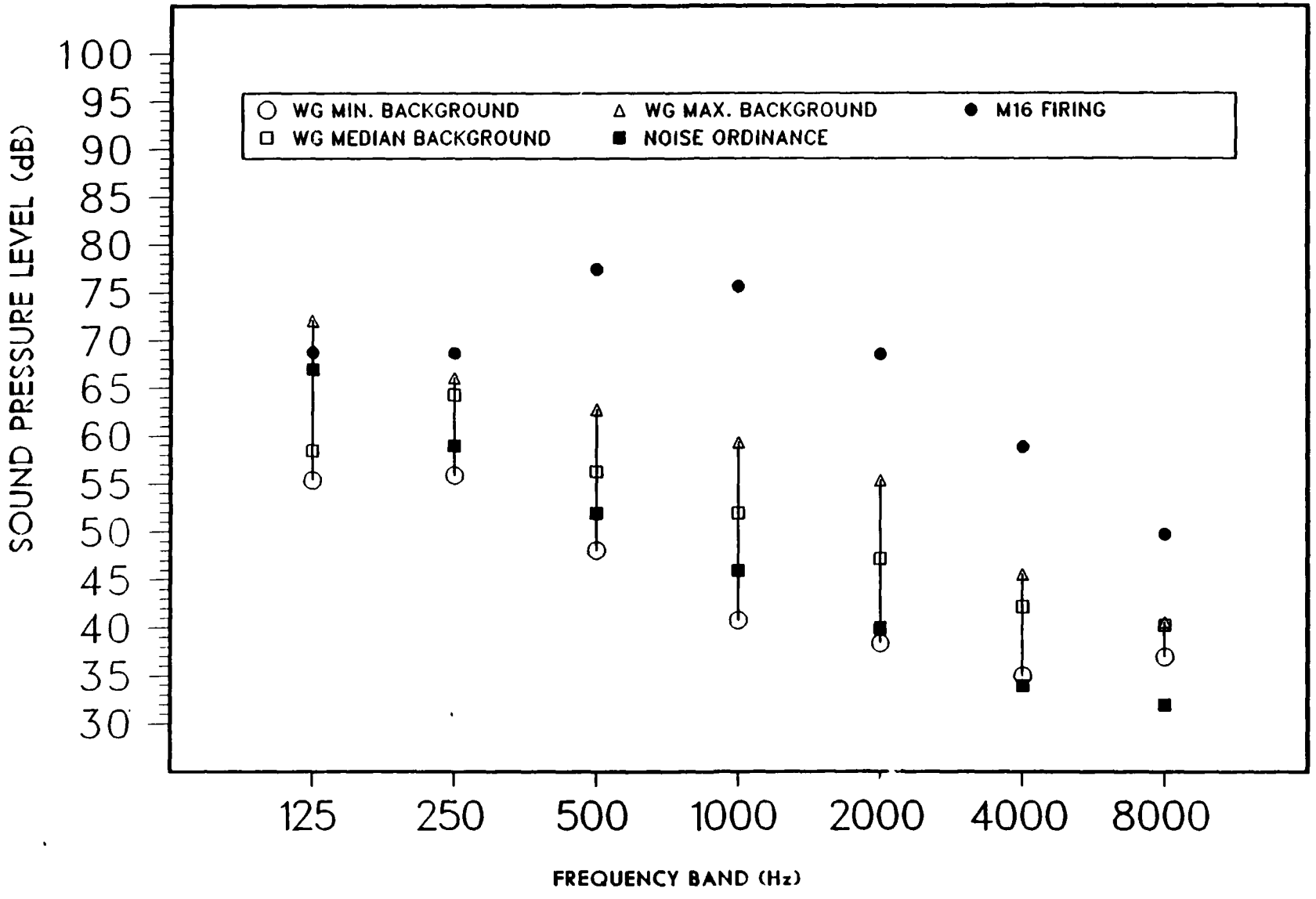


Figure 2. Background SPLs and Predicted M-16 SPLs at Location L9 (Horsham Residential Zone Boundary)



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12. Johnson, Daniel L. "Highlights of the Guidelines for Environmental Impact Statements with Respect to Noise." Aerospace Medical Research Laboratory Technical Report No. AMRL-TR-78-14, (Dec 1979)

13. MIL-STD-1474B(MI), Noise Limits for Army Materiel (18 June 1979)

APPENDIX A
NOISE CRITERIA

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3. Slopes in excess of 25% - a minimum of 85% of this area shall be considered restricted.

E. Forest - In areas designated as forest, a minimum of 80% will be considered restricted resource protection area and shall not be cleared for development.

D. ARTICLE XXI

1. [ADD] "Section 2118 - Environmental Performance Standards" as follows:

A. Erosion and Sediment Control

All construction shall protect streams and waterbodies including lakes, ponds, and wetlands from sedimentation, and shall control erosion in accordance with the Clean Streams Law (P.L. Chapter 102).

B. All construction shall limit stormwater runoff to off-site areas to an amount not greater than that which was generated by the site in the undeveloped state. All applicants proposing construction in the Township should review their proposals with the Township to assess the impacts on and potential for development of regional stormwater controls. All Stormwater Management Plans must comply with a Stormwater Management Act (Act 166) and the Pennsylvania Dam Safety Act (Act 325). Procedures and requirements for stormwater management shall be in accordance with standards set forth in the Warrington Township Subdivision and Land Development Regulations.

C. Noise

The sound level of any operation (other than the operation of motor vehicles or other transportation facilities, the construction or demolition of structures, emergency alarm signals or time signals) shall not exceed the decibel levels in the designated octave bands as stated below. The sound-pressure level shall be measured with a Sound Level Meter and an Octave Band Analyzer that conform to specifications published by the American Standards Association. (American National Standard Specifications for Sound Level Meters, S1.4-1971, American National Standards Institute, Inc., New York, New York, and the American Standard Specification for an Octave, Half Octave and Third Octave Band Filter Sets, S1.11-1966 (R 1971, American Standards Association, Inc., New York, New York shall be used).

(RRL.228)

Sound-pressure levels shall be measured at the property line upon which the emission occurs. The maximum permissible sound-pressure levels for smooth and continuous noise shall be as follows:

Frequency Band (Cycles Per Second)	Maximum Permitted Sound-Pressure Level (Decibels)
0-150	67
150-300	59
300-600	52
600-1200	48
1200-2400	40
2400-4800	34
Above 4800	32

If the noise is not smooth and continuous or is radiated during sleep hours, one or more of the corrections below shall be added to or subtracted from each of the decibel levels given above.

Type of Operation or Character of Noise	Corrections in Decibels
1. Noise occurs between the hours of 10 P.M. and 7 A. M.	-3
2. Noise occurs less than five (5) percent of any one-hour period.	+5
3. Noise is of periodic character (hum, scream, etc.), or is of impulsive character (hammering, etc.). (In the case of impulsive noise, the correction shall apply only to the average pressure during an impulse; impulse peaks shall not exceed the basic standards given above.)	-5

D. Smoke

No smoke shall be emitted from any chimney, or other source of visible gray opacity greater than No. 1 on the Ringleman Smoke Chart as published by the U.S. Bureau of Mines, except smoke of a shade not darker than No. 2 on the Ringleman Chart may be emitted for not more than four (4) minutes in any thirty (30) minute period. Smoke from residential fireplaces and wood stoves shall be exempt from this limitation.

E. Dust, Fumes, Vapors, and Gases

1. The emission of dust, dirt, fly ash, fumes, vapors, or gases which can cause damage to human health, animals,

3. These provisions, applicable to visible gray smoke, shall also apply to visible smoke of a different color, but with an equivalent apparent capacity.

Section 509: Dust and Dirt, Fly Ash, and Fumes, Vapors & Gases

1. No emission shall be made which can cause any damage to health, to animals or vegetation or other forms of property or which can cause any excessive soiling at any point.

2. No emission of liquid or solid particles from any chimney or otherwise shall exceed 0.3 grains per cubic foot of the covering gas at any point.

3. For measurement of the amount of particles in gases resulting from combustion, standard correction shall be applied to a stack temperature of five hundred (500) degrees F. and fifth (50) percent excess air.

Section 510: Noise

At no point on the boundary of a Residential, Industrial or Commercial District sound pressure level of any operation exceed the decibel levels in the designated octave bands shown below for the districts indicated.

Octave Band in Cycles per second	Along Residential District Boundaries Maximum permitted Sound Level in Decibels	At any other Point on the Lot Boundary Maximum Permitted Sound in Decibels
0 to 75	72	79
75 to 150	67	74
150 to 300	59	66
300 to 600	52	59
600 to 1200	46	53
1200 to 2400	40	47
2400 to 4800	34	41
Abcve 4800	32	39

Average Day-night Sound Level [Ldn] Community Noise Criteria

The Department of Housing and Urban Development (HUD) uses a standard of 65 dB for a Ldn criterion around airports using a noise assessment guideline prepared for HUD by Bolt Beranek and Newman, Inc. (BBN). HUD does not typically approve HUD funding for housing in areas with noise levels exceeding 65 dB Ldn. Ldn is a 24 hour A-weighted equivalent sound level, with a 10 dB penalty applied to the nighttime sound levels occurring from 2200 to 0700. The abbreviations LDN and DNL are also used by various authors for Ldn. Ldns are calculated by the equation:

$$Ldn = 10 \log 1/24 \left[15X10^{(Ld/10)} + 9X10^{(Ln+10/10)} \right]$$

Ld = Daytime equivalent A-weighted sound level between the hours of 0700 and 2200.

Ln = Nighttime equivalent A-weighted sound level between the hours of 2200 and 0700.

A-Weighted Sound Level [dB(A)]: The ear does not respond equally to sounds of all frequencies. The ear is less efficient at detecting low and high frequency sounds than it is at mid-range or speech range frequencies. In order to obtain a single number representing the sound pressure level of a noise containing a wide range of frequencies in a manner approximating the response of the ear, it is necessary to reduce or weight, the effects of the low and high frequencies relative to the mid-range frequencies. Therefore, the low and high frequencies are de-emphasized with A-weighting.

Appendix B
Study Area, Measurement Locations and Range Design

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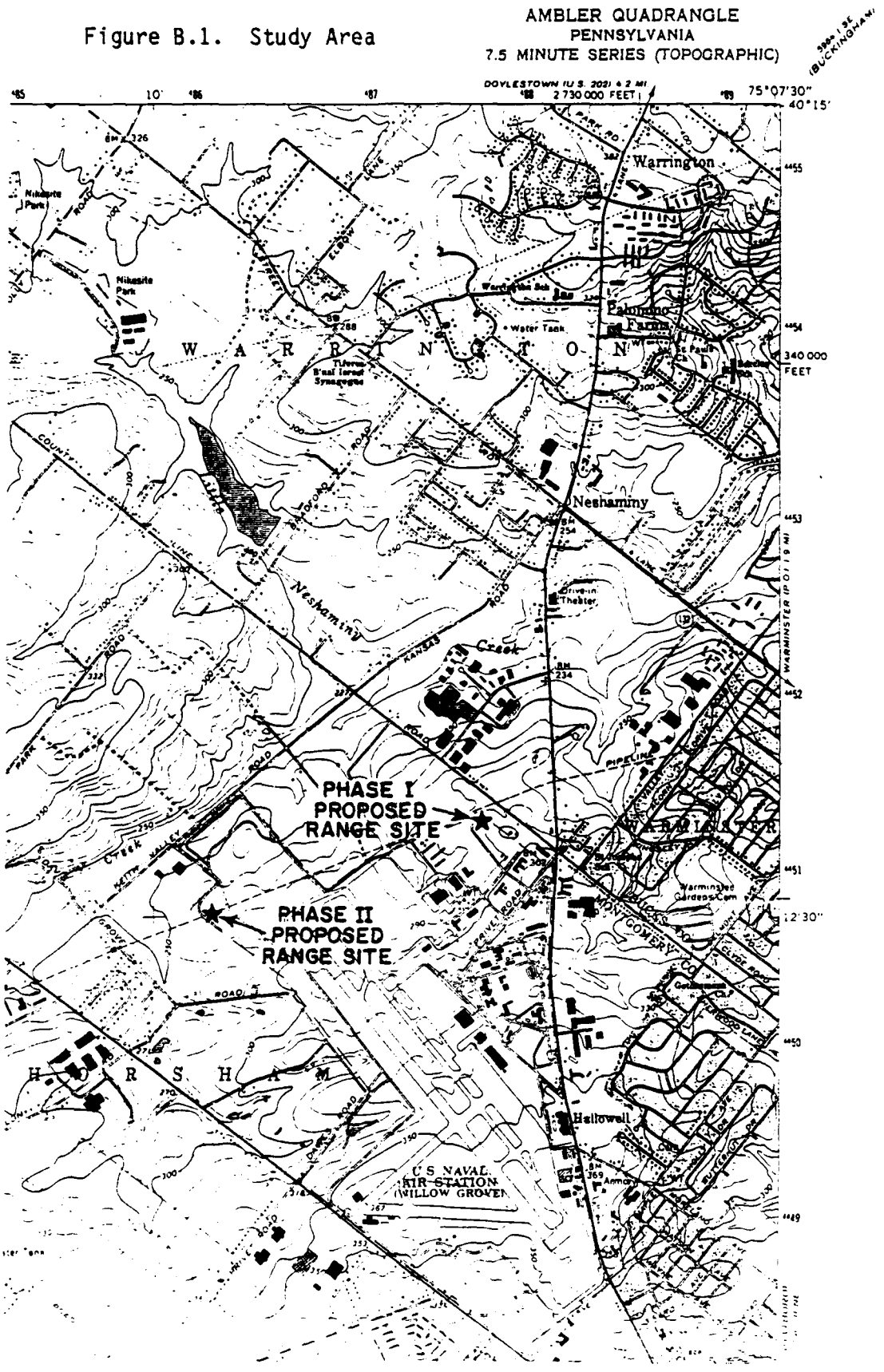
Figure B.1. Study Area



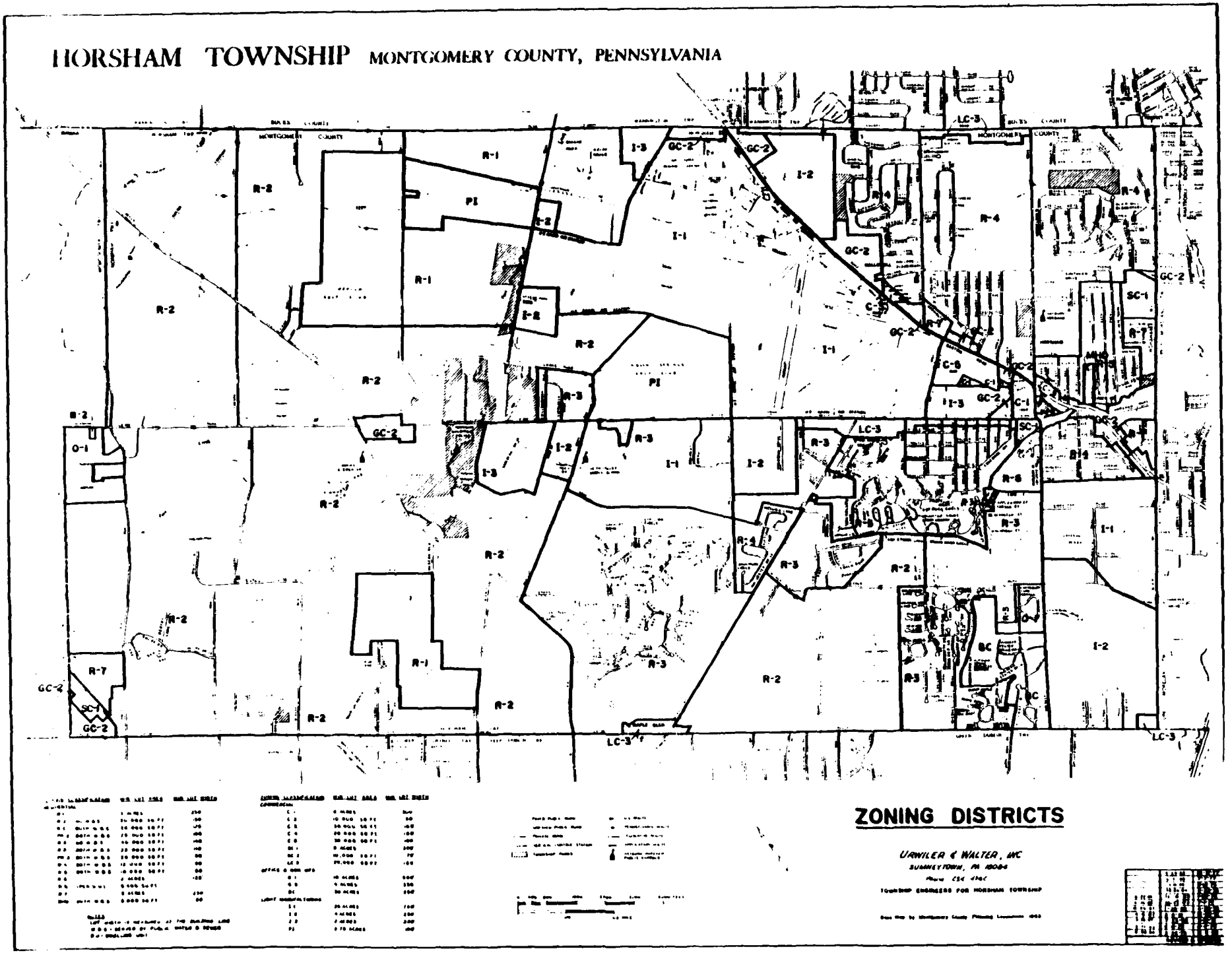


Figure B.2. Study Area

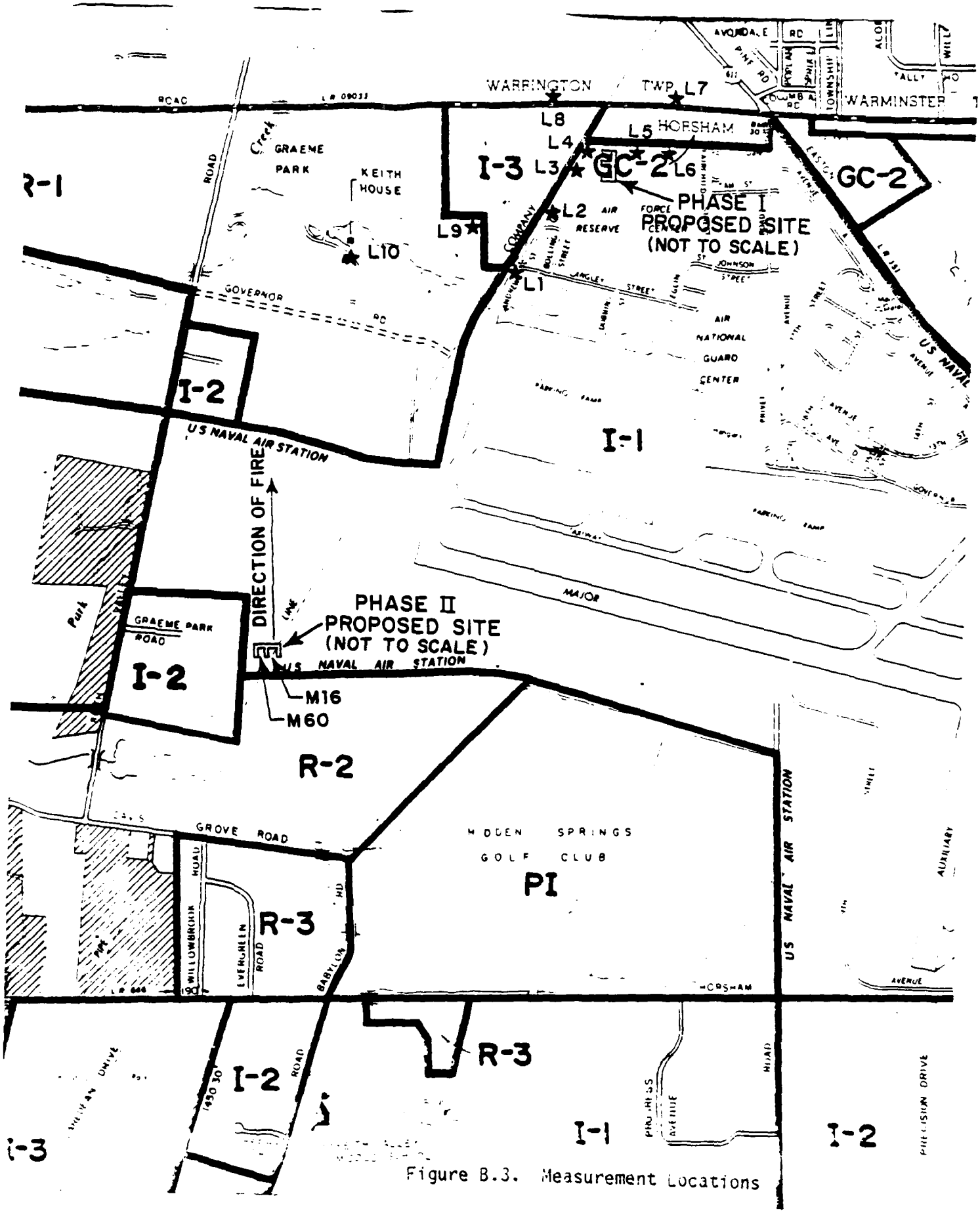


Figure B.3. Measurement Locations

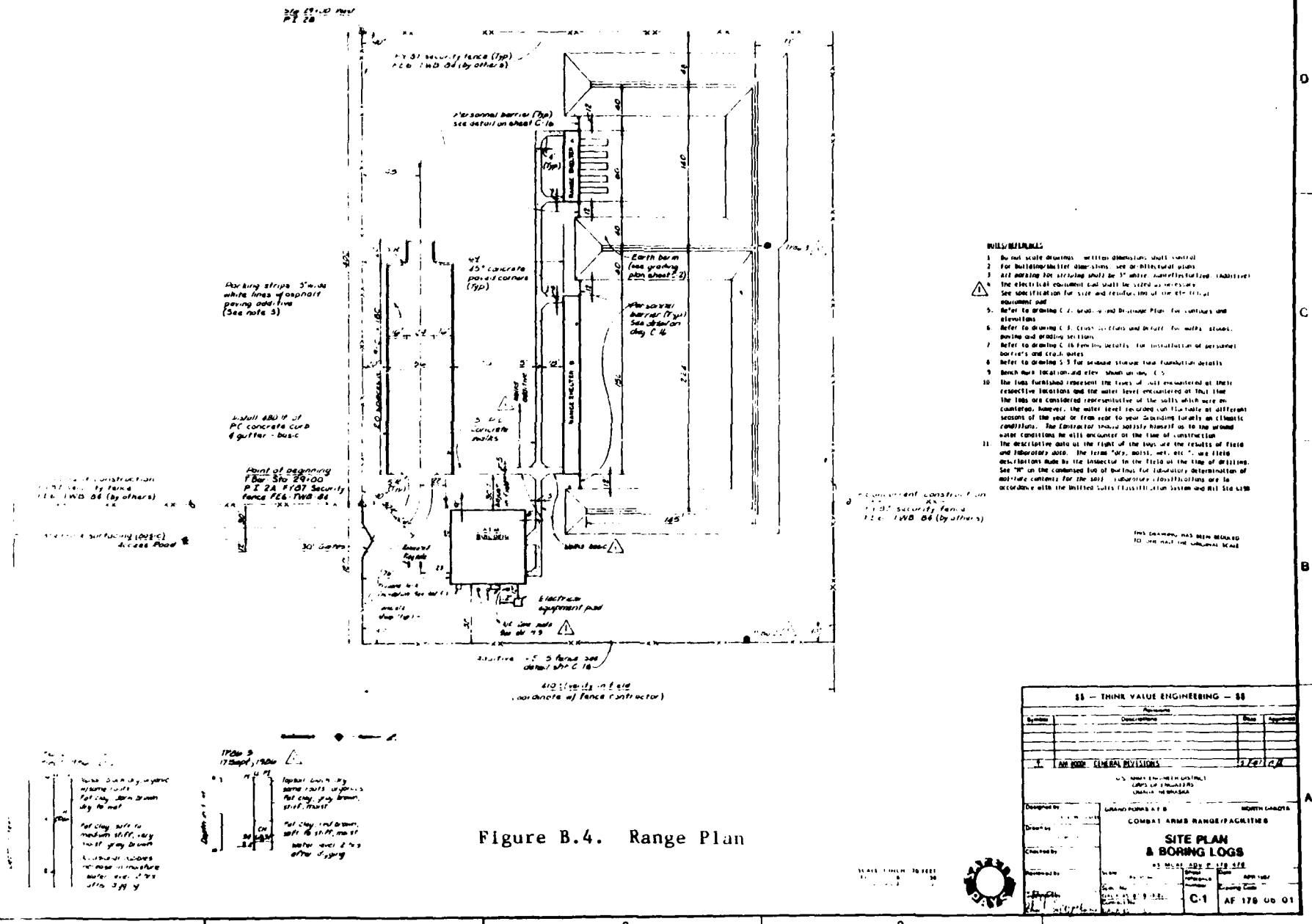


Figure B.4. Range Plan

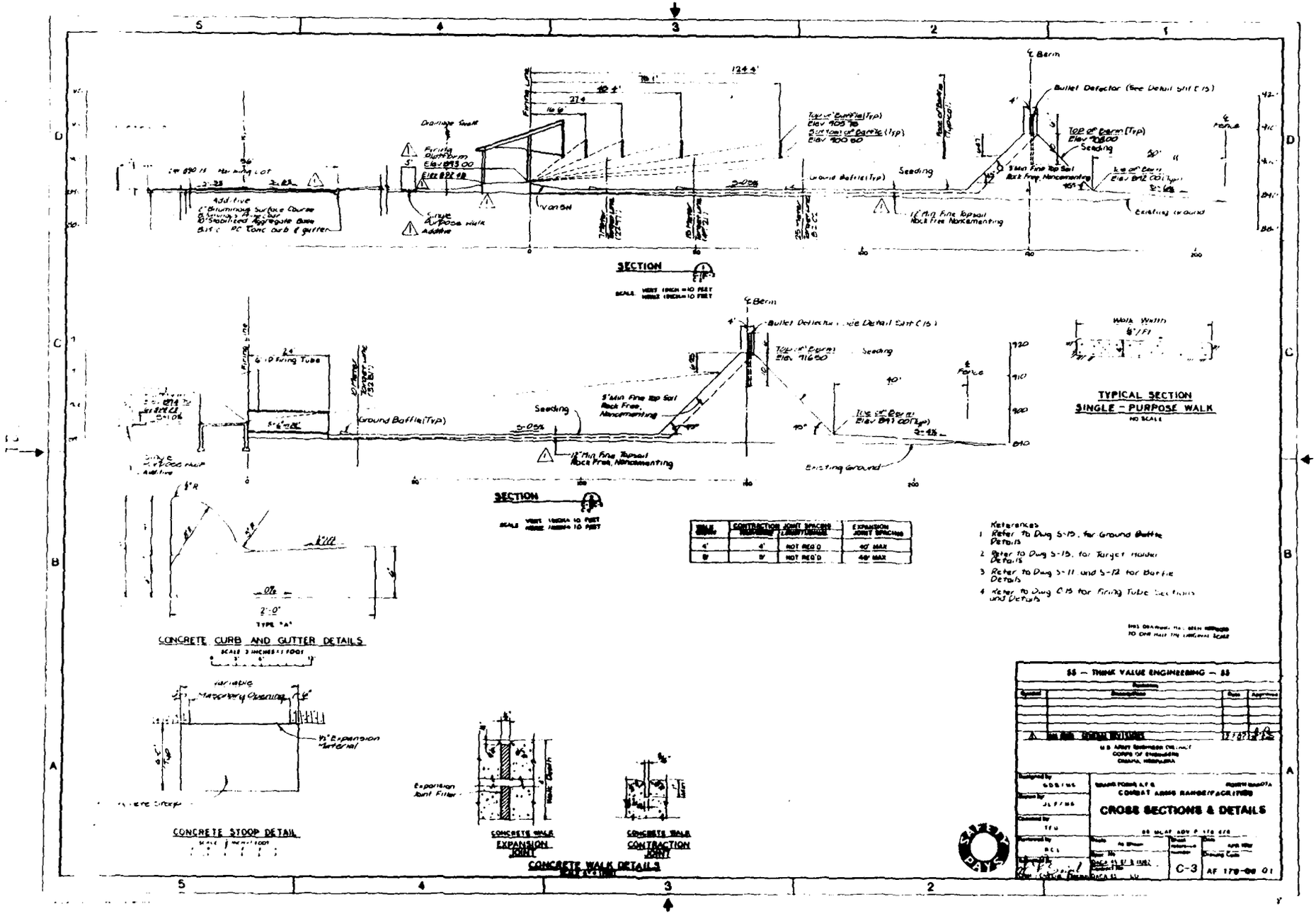


Figure B.5. Range Cross Sections

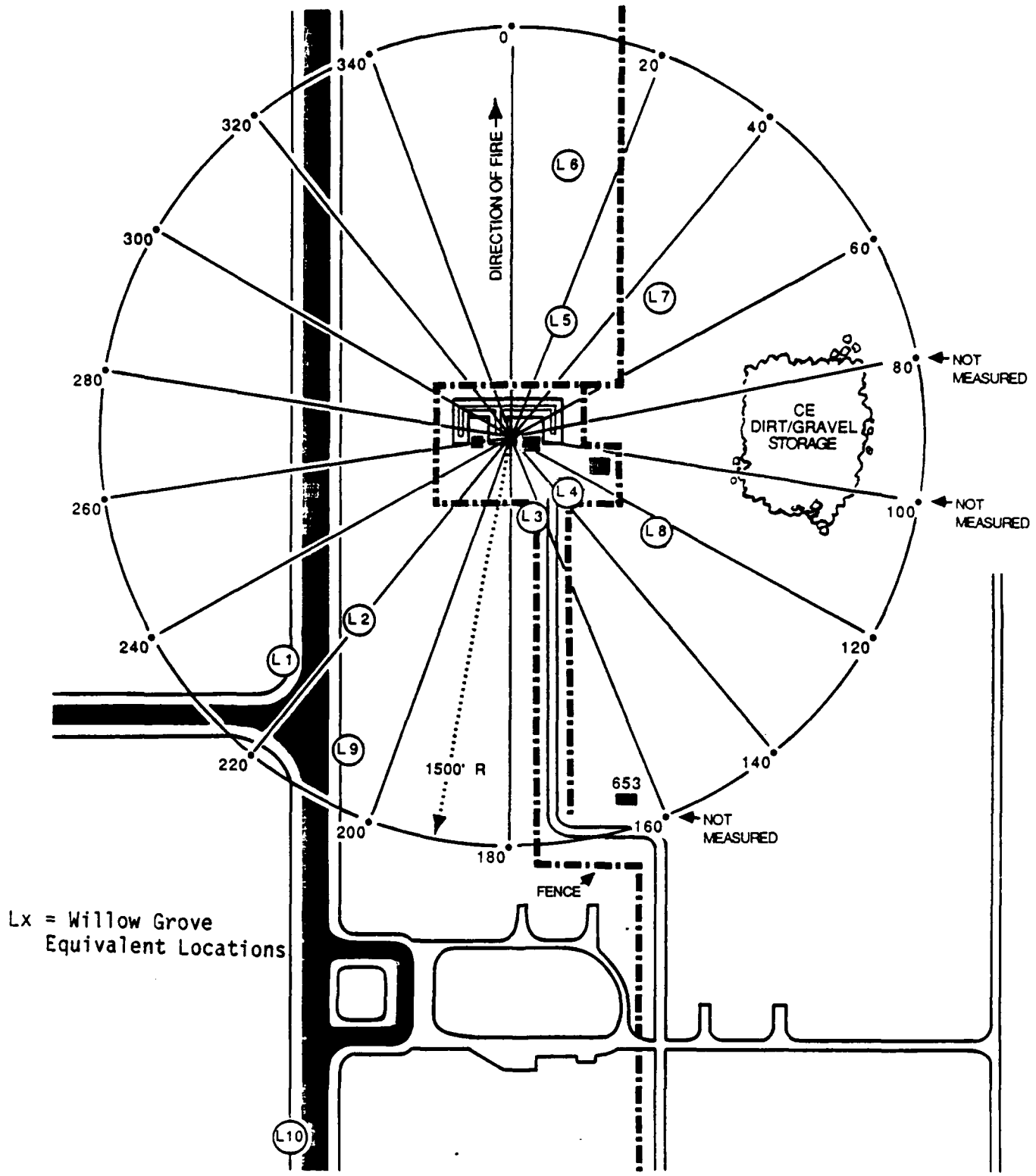


Figure B.6. Grand Forks Measurement Locations

Appendix C
Survey Equipment List

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B&K 7006 RECORDING SYSTEM CONFIGURATION LIST

Equipment/Instrument	Model/Type	Serial Number(s)
2 B&K Tape Recorders	7006	130750 & 130751
2 B&K Power Supplies	2808	1338121 & 1338144
3 B&K Microphone Preamplifiers	2639	1334751, 1334752 & 594027
2 B&K FM Units (Channel 1)	ZM0053	N/A
2 B&K FM Units (Channel 2)	ZM0053	N/A
2 B&K FM Units (Channel 3)	ZM0053	N/A
2 B&K FM Units (Channel 4)	ZM0053	N/A
2 LARSON/DAVIS Microphone	2541	1069 & 1070

B&K 7006 RECORDING SYSTEM CALIBRATION INSTRUMENT LIST

Equipment/Instrument	Model/Type	Serial Number(s)
B&K Calibrator	4230	1275078
B&K Piston Phone Calibrator	4220	1048870
H.P. Distortion Analyzer	334A	1140A11082
H.P. Synthesizer/Function Generator	3325A	2512A22219

DATA ANALYSIS INSTRUMENT LIST

Instrument	Model/Type	Serial Number
B&K Digital Frequency Analyzer	2131	1123172
H.P. Desktop Computer	9000/226	2406A28155
Nicolet Digital Oscilloscope	4094B	88B02987

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Appendix D
Willow Grove Primary Site SPL Data

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Table D.1. Comparison between Grand Forks Small Arms Range Sound Pressure Levels (SPL) and the Corresponding Willow Grove Background SPL at Location L1

FREQ Hz	OBOL dB	WILLOW GROVE BACKGROUND SPL			GRAND FORKS AFB SMALL ARMS RANGE SPL					
					9MM		M16		M60	
		MIN	MEDIAN	MAX	BKGRND	FIRING	BKGRND	FIRING	BKGRND	FIRING
2	79	65.8	70.3	85.4*	82.0*	83.8*	X	X	85.4*	81.2*
4	79	58.5	68.4	83.0*	74.6	79.4*	X	X	79.3*	77.9
8	79	56.1	65.5	77.7	67.9	74.3	X	X	75.2	70.2
16	79	57.3	67.0	76.8	65.5	68.7	X	X	70.2	65.8
31.5	79	63.0	65.0	79.0	60.5	65.1	X	X	61.8	70.1
63	79	58.6	71.0	85.3*	55.8	60.9	X	X	61.7	71.6
125	74	54.1	68.8	75.4*	49.8	58.7	X	X	63.9	70.1
250	66	52.3	66.7*	72.3*	44.7	60.4	X	X	55.1	63.9
500	59	48.2	62.8*	74.2*	42.3	65.7*	X	X	53.8	63.3
1000	53	48.9	59.9*	76.9*	42.8	65.4*	X	X	57.5	57.0
2000	47	39.5	53.7*	76.2*	41.5	58.0*	X	X	47.0	47.6
4000	41	46.3*	47.6*	54.3*	43.1*	49.3*	X	X	44.3*	44.4*
8000	39	40.8*	42.2*	49.2*	45.2*	50.0*	X	X	47.5*	46.0*

X M16 data is not usable due to wind overloads.
* SPL above the corresponding octave band ordinance level (OBOL).

Table D.2. Comparison between Grand Forks Small Arms Range Sound pressure Levels (SPL) and the Corresponding Willow Grove Background SPL at Location L2

FREQ Hz	OBOL dB	WILLOW GROVE BACKGROUND SPL			GRAND FORKS AFB SMALL ARMS RANGE SPL					
					9MM		M16		M60	
		MIN	MEDIAN	MAX	BKGRND	FIRING	BKGRND	FIRING	BKGRND	FIRING
2	79	68.4	71.9	80.2	87.6*	88.0*	X	X	78.0	82.3*
4	79	61.8	70.0	74.7	80.9*	83.4*	X	X	74.3	78.1
8	79	58.7	65.1	70.4	73.2	74.9	X	X	69.9	71.7
16	79	58.0	59.9	66.1	67.0	69.5	X	X	63.9	71.6
31.5	79	58.0	59.8	61.3	64.7	68.8	X	X	60.2	74.3
63	79	56.4	61.6	62.3	59.9	64.7	X	X	61.3	77.4
125	74	58.1	63.4	65.7	60.8	67.1	X	X	58.1	70.7
250	66	52.8	54.9	68.3	57.0	63.2	X	X	53.8	67.5*
500	59	53.4	53.6	66.1*	54.0	64.3*	X	X	52.0	68.6*
1000	53	45.4	52.0	62.5*	51.4	69.8*	X	X	47.6	61.8*
2000	47	40.6	49.6*	56.8*	46.9	64.9*	X	X	42.7	52.5*
4000	41	37.4	46.8*	47.2*	45.5*	56.0*	X	X	43.8*	47.2*
8000	39	38.8	42.3*	44.1*	46.9*	49.3*	X	X	46.3*	47.6*

X M16 data is not usable due to wind overloads.
* SPL above the corresponding octave band ordinance level (OBOL).

Table D.3. Comparison between Grand Forks Small Arms Range Sound Pressure Levels (SPL) and the Corresponding Willow Grove Background SPL at Location L3

FREQ Hz	OBOL dB	WILLOW GROVE BACKGROUND SPL			GRAND FORKS AFB SMALL ARMS RANGE SPL					
					9MM		M16		M60	
		MIN	MEDIAN	MAX	BKGRND	FIRING	BKGRND	FIRING	BKGRND	FIRING
2	79	60.5	72.1	80.2*	81.9*	86.1*	85.5*	92.9*	77.0	77.1
4	79	55.5	66.8	73.7	76.2	80.0*	72.5	86.1*	71.0	68.9
8	79	55.3	65.8	69.2	73.9	77.7	67.7	81.1*	68.3	67.1
16	79	57.2	63.1	65.0	66.7	71.9	65.9	77.1	60.5	76.9
31.5	79	58.1	62.3	70.4	61.4	67.2	68.3	72.8	61.1	83.1
63	79	59.4	66.9	73.0	55.9	67.0	69.2	79.4*	60.6	81.9
125	74	58.8	68.3	82.8*	48.4	71.9	57.9	83.9*	52.5	79.8*
250	66	47.2	65.1	83.3*	43.3	75.9*	51.3	84.2*	46.0	86.6*
500	59	45.3	64.0*	80.7*	42.0	83.0*	46.6	88.1*	46.9	86.0*
1000	53	45.0	61.1*	77.4*	43.3	85.0*	47.3	87.7*	62.9	73.8*
2000	47	45.3	52.6*	70.6*	42.1	78.8*	46.0	80.5*	57.4	64.0*
4000	41	37.7	41.6*	56.3*	43.3*	73.1*	43.0	73.9*	45.7	58.5*
8000	39	36.7	39.8*	44.6*	47.5*	61.3*	44.4	62.5*	46.8	50.4*

* SPL above the corresponding octave band ordinance level (OBOL).

Table D.4. Comparison between Grand Forks Small Arms Range Sound Pressure Levels (SPL) and the Corresponding Willow Grove Background SPL at Location L4

FREQ Hz	OBOL dB	WILLOW GROVE BACKGROUND SPL			GRAND FORKS AFB SMALL ARMS RANGE SPL					
					9MM		M16		M60	
		MIN	MEDIAN	MAX	BKGRND	FIRING	BKGRND	FIRING	BKGRND	FIRING
2	79	60.5	72.1	80.2*	88.4*	88.5*	86.7*	86.5*	66.1	62.7
4	79	55.8	66.8	73.7	80.0*	86.4*	80.8*	74.9	59.6	60.5
8	79	55.3	65.8	69.2	75.3	84.3*	70.5	71.7	56.1	62.5
16	79	57.2	63.1	65.0	70.8	80.2*	68.3	64.5	53.6	77.0
31.5	79	58.1	62.3	70.4	68.0	75.6	63.9	70.1	57.7	85.9*
63	79	59.4	66.9	73.0	58.8	74.1	59.4	79.1*	60.9	80.6*
125	74	58.8	68.3	82.8*	59.5	76.4*	51.2	84.1*	57.6	75.6*
250	66	47.2	65.1	83.3*	52.1	75.4*	46.3	86.5*	45.8	74.2*
500	59	45.3	64.0*	80.7*	47.7	79.6*	44.9	90.8*	43.9	73.2*
1000	53	45.0	61.1*	77.4*	43.1	81.5*	44.0	86.7*	50.3	63.9*
2000	47	43.5	52.6*	70.6*	42.7	76.2*	45.4	81.0*	45.0	56.0*
4000	41	41.6*	41.6*	56.3*	44.6*	71.6*	44.4*	74.1*	40.0	52.8*
8000	39	36.7	39.8*	44.6*	49.0*	61.6*	46.8*	63.9*	42.6*	55.2*

* SPL above the corresponding octave band ordinance level (OBOL).

Table D.5. Comparison between Grand Forks Small Arms Range Sound Pressure Levels (SPL) and the Corresponding Willow Grove Background SPL at Location L5

FREQ Hz	OBOL dB	WILLOW GROVE BACKGROUND SPL			GRAND FORKS AFB SMALL ARMS RANGE SPL					
					9MM		M16		M60	
		MIN	MEDIAN	MAX	BKGRND	FIRING	BKGRND	FIRING	BKGRND	FIRING
2	79	65.5	67.6	77.2	89.2*	94.4*	89.0*	90.8*	71.9	71.4
4	79	61.6	62.7	71.5	85.2*	88.1*	80.2*	89.4*	60.0	65.6
8	79	56.5	58.3	69.1	79.9*	85.5*	76.6	81.1*	50.5	68.5
16	79	53.6	59.8	63.8	75.7	77.6	72.8	75.9	56.9	64.5
31.5	79	54.3	58.9	60.0	70.8	73.2	68.1	77.6	61.6	78.1
63	79	57.7	59.7	62.8	60.9	65.7	59.9	74.9	60.7	76.7
125	74	53.1	57.8	61.2	51.0	65.6	49.0	75.0*	59.4	70.1
250	66	47.0	52.4	57.8	46.3	61.8	43.9	68.0*	42.9	64.3
500	59	45.4	48.6	54.1	45.8	72.4*	41.9	76.7*	47.2	76.4*
1000	53	47.2	48.4	50.6	45.5	73.9*	42.1	72.0*	51.1	72.3*
2000	47	41.9	43.2	46.2	44.8	67.3*	40.7	66.5*	48.5*	59.4*
4000	41	36.7	38.5	40.2	45.3*	59.7*	43.1*	58.8*	41.1*	53.4*
8000	39	35.4	38.6	39.1	50.0*	51.7*	47.7*	50.5*	43.6*	48.7*

* SPL above the corresponding octave band ordinance level (OBOL).

Table D.6. Comparison between Grand Forks Small Arms Range Sound Pressure Levels (SPL) and the Corresponding Willow Grove Background SPL at Location L6

FREQ Hz	OBOL dB	WILLOW GROVE BACKGROUND SPL			GRAND FORKS AFB SMALL ARMS RANGE SPL					
					9MM		M16		M60	
		MIN	MEDIAN	MAX	BKGRND	FIRING	BKGRND	FIRING	BKGRND	FIRING
2	79	64.2	75.7	77.1	88.9*	91.7*	95.1*	93.4*	70.5	65.8
4	79	60.5	72.6	72.9	80.1*	84.3*	92.0*	91.3*	63.3	63.3
8	79	57.1	65.6	67.7	73.3	76.8	84.6*	85.2*	62.9	60.7
16	79	54.4	60.4	61.8	67.4	74.6	77.5	81.1*	65.6	64.6
31.5	79	59.8	60.0	61.2	65.5	66.7	76.1	77.3	65.4	75.6
63	79	63.5	63.7	69.9	63.6	63.7	64.3	68.5	65.9	75.3
125	74	65.3	67.2	74.1*	51.1	52.6	53.8	60.8	57.1	70.6
250	66	65.7	70.4*	76.0*	43.5	46.7	47.6	52.9	49.1	63.9
500	59	63.5	66.3*	75.3*	43.8	49.4	45.3	58.8	49.0	70.7*
1000	53	59.8*	60.9*	69.2*	42.4	52.3	45.5	57.2*	51.1	67.6*
2000	47	52.4*	52.7*	60.1*	40.8	48.2*	44.8	52.4*	47.7*	58.9*
4000	41	40.3	42.3*	47.3*	43.6*	46.8*	45.8*	47.6*	45.0*	51.5*
8000	39	40.8*	40.9*	47.3*	47.9*	49.7*	50.3*	49.9*	43.7*	44.7*

* SPL above the corresponding octave band ordinance level (OBOL).

Table D.7. Comparison between Grand Forks Small Arms Range Sound Pressure Levels (SPL) and the Corresponding Willow Grove Background SPL at Location L7

FREQ Hz	OBOL dB	WILLOW GROVE BACKGROUND SPL			GRAND FORKS AFB SMALL ARMS RANGE SPL					
					9MM		M16		M60	
		MIN	MEDIAN	MAX	BKGRND	FIRING	BKGRND	FIRING	BKGRND	FIRING
2	67	75.3*	83.4*	87.5*	75.6*	88.7*	77.7	86.6*	70.5*	72.7*
4	67	69.5*	75.0*	80.7*	71.5*	82.9*	77.4	87.0*	61.7	63.7
8	67	66.1	66.9	76.1*	70.8*	79.3*	68.6	81.8*	58.1	57.4
16	67	63.7	66.5	71.8*	67.8*	71.2*	65.4	74.3*	61.4	69.4*
31.5	67	61.5	65.7	71.0*	64.9	64.4	58.2	74.2*	64.8	76.6*
63	67	62.2	71.4*	80.5*	58.8	61.1	59.7	76.6*	67.6*	73.3*
125	67	62.1	66.9	81.9*	53.8	61.3	64.1	74.3*	64.7	68.7*
250	59	57.3	63.2*	72.9*	60.2*	56.3	54.0	66.2*	50.2	58.2
500	52	49.5	62.2*	66.9*	54.9*	56.3*	44.8	73.1*	48.4	66.0*
1000	48	58.8*	64.3*	68.2*	48.5*	54.7*	44.9	75.5*	54.4*	59.5*
2000	40	52.5*	61.5*	65.1*	45.7*	48.8*	47.1	69.3*	53.6*	54.2*
4000	34	48.7*	55.9*	60.0*	45.9*	46.6*	44.1	63.0*	45.0*	47.9*
8000	32	48.2*	52.6*	54.2*	48.4*	48.6*	53.6	50.3*	45.8*	46.4*

* SPL above the corresponding octave band ordinance level (OBOL).

Table D.8. Comparison between Grand Forks Small Arms Range Sound Pressure Levels (SPL) and the Corresponding Willow Grove Background SPL at Location L8

FREQ Hz	OBOL dB	WILLOW GROVE BACKGROUND SPL			GRAND FORKS AFB SMALL ARMS RANGE SPL					
					9MM		M16		M60	
		MIN	MEDIAN	MAX	BKGRND	FIRING	BKGRND	FIRING	BKGRND	FIRING
2	67	75.9*	82.3*	91.9*	75.6*	80.2*	85.5*	96.6*	68.6*	69.6*
4	67	66.5	73.2*	83.5*	71.5*	77.8*	76.3*	89.2*	64.5	65.2
8	67	60.9	65.7	79.7*	70.8*	71.7*	72.6*	86.9*	69.9*	67.0
16	67	60.7	67.9*	75.5*	67.8*	64.9	67.4*	80.9*	70.5*	72.2*
31.5	67	61.0	65.3	74.9*	64.9	58.2	63.9	72.6*	72.3*	79.6*
63	67	61.6	69.7*	82.1*	58.8	58.8	64.7	72.6*	72.9*	72.0*
125	67	61.0	71.8*	79.4*	53.8	58.6	57.3	72.2*	67.4*	67.5*
250	59	58.2	68.7*	76.6*	60.2*	56.6	40.9	72.4*	55.8	62.0*
500	52	60.7*	69.2*	72.9*	54.9*	68.7*	50.2	85.8*	54.9*	60.7*
1000	48	65.3*	69.2*	75.8*	48.5*	69.9*	47.4	80.9*	56.8*	56.0*
2000	40	61.2*	65.3*	73.8*	45.7*	62.2*	44.4*	76.6*	53.2*	53.0*
4000	34	55.3*	57.9*	64.2*	45.9*	54.2*	43.9*	71.8*	45.5*	49.0*
8000	32	50.7*	55.0*	58.5*	48.4*	48.8*	47.7*	56.6*	44.2*	54.7*

(1) Background noise data for the 9MM are taken from the 9MM background noise levels at location L7.

* SPL above the corresponding octave band ordinance level (OBOL).

Table D.9. Comparison between Grand Forks Small Arms Range Sound Pressure Levels (SPL) and the Corresponding Willow Grove Background SPL at Location L9

FREQ Hz	OBOL dB	WILLOW GROVE BACKGROUND SPL			GRAND FORKS AFB SMALL ARMS RANGE SPL					
					9MM		M16		M60	
		MIN	MEDIAN	MAX	BKGRND	FIRING	BKGRND	FIRING	BKGRND	FIRING
2	72	57.9	68.8	76.0*	88.1*	83.6*	91.6*	93.1*	75.0*	75.5*
4	72	54.0	62.5	70.7	82.8*	81.6*	80.9*	88.6*	67.3	69.1
8	72	52.0	59.1	65.5	78.6*	78.8*	78.8*	83.8*	64.7	64.2
16	72	53.8	61.3	69.6	73.1*	73.2*	74.8*	82.2*	63.9	69.3
31.5	72	51.9	60.5	67.2	68.9	68.2	69.8	78.0*	62.6	70.2
63	72	53.1	58.5	63.7	62.8	66.7	67.0	69.9	61.3	73.5*
125	67	55.4	64.3*	72.1*	51.4	54.0	65.2	68.8	56.3	70.1*
250	59	55.9	56.3*	66.1*	48.8	58.9*	61.7*	68.7*	55.2	63.0*
500	52	48.1	56.3*	62.8*	44.9	63.9*	51.0	77.5*	52.1	63.9*
1000	46	40.8	52.0*	59.4*	44.3*	70.2*	46.1*	75.7*	48.0	56.7*
2000	40	38.4	47.2*	55.4*	42.5*	66.2*	46.0*	68.6*	41.5*	48.8*
4000	34	35.0*	42.2*	45.6*	43.5*	56.2*	45.8*	58.9*	41.3*	44.2*
8000	32	37.0*	40.6*	42.2*	47.3*	49.1*	48.9*	49.8*	44.1*	44.8*

* SPL above the corresponding octave band ordinance level (OBOL).

Table D.10. Comparison between Grand Forks Small Arms Range Sound Pressure Levels (SPL) and the Corresponding Willow Grove Background SPL at Location L10

FREQ Hz	OBOL dB	WILLOW GROVE BACKGROUND SPL			GRAND FORKS AFB SMALL ARMS RANGE SPL					
					9MM		M16		M60	
		MIN	MEDIAN	MAX	BKGRND	FIRING	BKGRND	FIRING	BKGRND	FIRING
2	72	70.2	77.1*	78.0*	78.7*	86.5*	X	X	X	X
4	72	62.9	72.0	72.7*	74.3*	83.8*	X	X	X	X
8	72	56.2	68.2	68.5	67.7	76.2*	X	X	X	X
16	72	62.6	63.4	66.5	66.3	69.9	X	X	X	X
31.5	72	55.6	57.1	66.2	62.6	64.5	X	X	X	X
63	72	52.5	55.5	86.0*	56.1	56.5	X	X	X	X
125	67	49.1	57.8	76.3*	48.4	51.1	X	X	X	X
250	59	47.6	59.9*	80.1*	39.7	48.2	X	X	X	X
500	52	45.6	57.3*	80.8*	39.2	61.3*	X	X	X	X
1000	46	43.5	53.7*	70.0*	41.9	64.2*	X	X	X	X
2000	40	41.7*	47.3*	73.2*	42.2*	55.0*	X	X	X	X
4000	34	39.2*	41.9*	59.5*	43.7*	46.4*	X	X	X	X
8000	32	37.5*	43.2*	52.5*	46.0*	49.0*	X	X	X	X

* SPL above the corresponding octave band ordinance level (OBOL).

Table D.11. Comparison between the Measured Octave Band Background Sound Pressure levels (OBBSPL) in Decibels and their Corresponding Ordinance (OBOL) at Location L1 (Horsham Township Non Residential Zone)

FREQ	OBOL	DATE/TIME						RANGE		
Hz	dB	13 JUL 0924	14 JUL 1129	15 JUL 1300	16 JUL 0900	16 JUL 1420	17 JUL 0930	MIN	MEDIAN	MAX
2	79	70.3	68.7	71.9	65.8	85.4*	77.9	65.8	70.3	85.4*
4	79	58.5	65.2	68.4	60.7	83.0*	72.2	58.5	68.4	83.0*
8	79	65.3	61.5	65.5	56.1	77.7	69.6	56.1	65.5	77.7
16	79	76.8	61.7	62.0	57.3	75.4	67.0	57.3	67.0	76.8
31.5	79	79.0	64.7	63.0	61.3	73.3	65.0	63.0	65.0	79.0
63	79	77.5	74.1	85.3*	64.9	71.0	58.6	58.6	71.0	85.3*
125	74	74.2*	75.4*	68.3	57.4	68.8	54.1	54.1	68.8	75.4*
250	66	71.1*	72.3*	60.4	52.8	66.7*	52.3	52.3	66.7*	72.3*
500	59	62.8*	74.2*	59.4*	48.2	64.4*	51.0	48.2	62.8*	74.2*
1000	53	59.9*	76.9*	59.4*	48.9	60.9*	46.2	48.9	59.9*	76.9*
2000	47	53.7*	76.2*	59.1*	45.7	54.4*	39.5	39.5	53.7*	76.2*
4000	41	46.3*	68.7*	54.3*	47.6*	47.7*	41.3*	46.3*	47.6*	54.3*
8000	39	42.2*	48.7*	41.6*	40.8*	49.2*	41.8*	40.8*	42.2*	49.2*

* SPL above the corresponding octave band ordinance level (OBOL).

Table D.12. Comparison between the Measured Octave Band Background Sound Pressure levels (OBBSPL) in Decibels and their Corresponding Ordinance (OBOL) at Location L2 (Horsham Township Non-Residential Zone)

FREQ	OBOL	DATE/TIME			RANGE		
Hz	dB	16 JUL 0924	16 JUL 1415	17 JUL 1300	MIN	MEDIAN	MAX
2	79	71.9	68.4	80.2	68.4	71.9	80.2*
4	79	70.0	61.8	74.7	61.8	70.0	74.7*
8	79	65.1	58.7	70.4	58.7	65.1	70.4
16	79	59.9	58.0	66.1	58.0	59.9	66.1
31.5	79	59.8	58.0	61.3	58.0	59.8	61.3
63	79	62.3	61.6	56.4	56.4	61.6	62.3
125	74	63.4	65.7	58.1	58.1	63.4	65.7
250	66	54.9	68.3*	52.8	52.8	54.9	68.3
500	59	53.6	66.1*	53.4	53.4	53.6	66.1*
1000	53	52.0	62.5*	45.4	45.4	52.0	62.5*
2000	47	49.6*	56.8*	40.6	40.6	49.6*	56.8*
4000	41	47.2*	46.8*	37.4	37.4	46.8*	47.2*
8000	39	44.1*	38.8	42.3*	38.8	42.3*	44.1*

* SPL above the corresponding octave band ordinance level (OBOL).

Table D.13. Comparison between the Measured Octave Band Background Sound Pressure levels Decibels and their Corresponding Ordinance (OBOL) at Location L3, Horsham Township Non Residential Zone (Background noise data is taken from L3 and L4 due to the close distance between them)

FREQ	OBOL	DATE/TIME						RANGE		
Hz	dB	13 JUL 0930	14 JUL 1135	15 JUL 1305	16 JUL 0921	16 JUL 1356	17 JUL 0945	MIN	MEDIAN	MAX
2	79	63.0	64.4	76.2	60.5	80.2*	72.1	60.5	72.1	80.2*
4	79	60.9	59.8	70.6	55.5	73.7	66.8	55.5	66.8	73.7
8	79	56.8	56.8	66.6	55.3	69.2	65.8	55.3	65.8	69.2
16	79	60.2	57.2	65.0	61.2	63.7	63.1	57.2	63.1	65.0
31.5	79	60.7	62.3	70.4	67.2	58.7	58.1	58.1	62.3	70.4
63	79	64.8	66.9	73.0	71.1	62.4	59.4	59.4	66.9	73.0
125	74	59.8	59.2	82.8*	72.4	68.3	58.8	58.8	68.3	82.8*
250	66	47.2	48.6	83.3*	68.5*	65.1	56.2	47.2	65.1	83.3*
500	59	45.5	45.3	80.7*	64.0*	66.0*	53.9	45.3	64.0*	80.7*
1000	53	46.8	45.0	77.4*	61.1*	62.8*	49.3	45.0	61.1*	77.4*
2000	47	45.5	43.8	70.6*	54.1*	52.6*	43.5	43.5	52.6*	70.6*
4000	41	43.7*	41.6*	56.3*	44.2*	39.9	37.7	37.7	41.6*	56.3*
8000	39	38.2	36.7	44.6*	39.8*	43.9*	37.8	36.7	39.8*	44.6*

* SPL above the corresponding octave band ordinance level (OBOL).

Table D.14. Comparison between the Measured Octave Band Background Sound Pressure levels Decibels and their Corresponding Ordinance (OBOL) at Location L4 (Corner of Fence), Horsham Township Non Residential Zone (Background noise data are taken from L3 and L4 due to the short distance between them)

FREQ	OBOL	DATE/TIME						RANGE		
Hz	dB	13 JUL 0930	14 JUL 1135	15 JUL 1305	16 JUL 0921	16 JUL 1356	17 JUL 0945	MIN	MEDIAN	MAX
2	79	63.0	64.4	76.2	60.5	80.2*	72.1	60.5	72.1	80.2*
4	79	60.9	59.8	70.6	55.5	73.7	66.8	55.5	66.8	73.7
8	79	56.8	56.8	66.6	55.3	69.2	65.8	55.3	65.8	69.2
16	79	60.2	57.2	65.0	61.2	63.7	63.1	57.2	63.1	65.0
31.5	79	60.7	62.3	70.4	67.2	58.7	58.1	58.1	62.3	70.4
63	79	64.8	66.9	73.0	71.1	62.4	59.4	59.4	66.9	73.0
125	74	59.8	59.2	82.8*	72.4	68.3	58.8	58.8	68.3	82.8*
250	66	47.2	48.6	83.3*	68.5*	65.1	56.2	47.2	65.1	83.3*
500	59	45.5	45.3	80.7*	64.0*	66.0*	53.9	45.3	64.0*	80.7*
1000	53	46.8	45.0	77.4*	61.1*	62.8*	49.3	45.0	61.1*	77.4*
2000	47	45.5	43.8	70.6*	54.1*	52.6*	43.5	43.5	52.6*	70.6*
4000	41	43.7*	41.6*	56.3*	44.2*	39.9	37.7	37.7	41.6*	56.3*
8000	39	38.2	36.7	44.6*	39.8*	43.9*	37.8	36.7	39.8*	44.6*

* SPL above the corresponding octave band ordinance level (OBOL).

Table D.15. Comparison between the Measured Octave Band Background Sound Pressure levels (OBBSPL) in Decibels and their Corresponding Ordinance (OBOL) at Location L5 (Horsham Township Non Residential Zone)

FREQ	OBOL	DATE/TIME					RANGE		
Hz	dB	13 JUL 0935	14 JUL 1138	15 JUL 1310	16 JUL 0938	17 JUL 0950	MIN	MEDIAN	MAX
2	79	66.3	77.2	65.5	67.6	73.4	65.5	67.6	77.2
4	79	62.7	71.5	61.8	61.6	67.3	61.6	62.7	71.5
8	79	58.3	69.1	56.8	56.5	66.2	56.5	58.3	69.1
16	79	59.8	63.8	53.6	58.0	63.8	53.6	59.8	63.8
31.5	79	59.8	58.9	54.3	57.7	60.0	54.3	58.9	60.0
63	79	62.8	59.7	57.7	59.1	59.8	57.7	59.7	62.8
125	74	57.8	53.1	54.1	61.2	58.9	53.1	57.8	61.2
250	66	47.2	47.0	52.4	57.0	57.8	47.0	52.4	57.8
500	59	47.5	45.4	48.6	53.6	54.1	45.4	48.6	54.1
1000	53	48.9	48.0	47.2	50.6	48.4	47.2	48.4	50.6
2000	47	46.2	43.2	41.9	43.5	42.2	41.9	43.2	46.2
4000	41	40.2	38.0	36.7	41.7*	38.5	36.7	38.5	40.2
8000	39	36.9	38.6	35.4	39.1*	38.6	35.4	38.6	39.1*

* SPL above the corresponding octave band ordinance level (OBOL).

Table D.16. Comparison between the Measured Octave Band Background Sound Pressure levels (OBBSPL) in Decibels and their Corresponding Ordinance (OBOL) at Location L6 (Horsham Township Non Residential Zone)

FREQ	OBOL	DATE/TIME			RANGE		
Hz	dB	13 JUL 0940	14 JUL 1145	16 JUL 1350	MIN	MEDIAN	MAX
2	79	75.7	77.1	64.2	64.2	75.7	77.1
4	79	72.9	72.6	60.5	60.5	72.6	72.9
8	79	67.7	65.6	57.1	57.1	65.6	67.7
16	79	61.8	60.4	54.4	54.4	60.4	61.8
31.5	79	59.8	61.2	60.0	59.8	60.0	61.2
63	79	63.5	69.9	63.7	63.5	63.7	69.9
125	74	67.2	74.1*	65.3	65.3	67.2	74.1*
250	66	65.7	76.0*	70.4*	65.7	70.4*	76.0*
500	59	63.5	75.3*	66.3*	63.5	66.3*	75.3*
1000	53	59.8*	69.2*	60.9*	59.8*	60.9*	69.2*
2000	47	52.7*	60.1*	52.4*	52.4*	52.7*	60.1*
4000	41	42.3*	47.4	40.3	40.3	42.3*	47.3*
8000	39	40.9*	47.3*	40.8*	40.8*	40.9*	47.3*

Table D.17. Comparison between the Measured Octave Band Background Sound Pressure levels (OBBSPL) n Decibels and their Corresponding Ordinance (OBOL) at Location L7 (County Line Road Fence Company, Warrington Township Residential Zone)

FREQ	OBOL	DATE/TIME							RANGE		
Hz	dB	13 JUL 1010	14 JUL 1155	15 JUL 1330	16 JUL 1016	16 JUL 1145	16 JUL 1433	17 JUL 1008	MIN	MEDIAN	MAX
2	67	79.0*	81.8*	87.5*	85.4*	83.4*	85.9*	75.3*	75.3*	83.4*	87.5*
4	67	71.4*	69.5*	78.9*	75.0*	79.7*	80.7*	70.3*	69.5*	75.0*	80.7*
8	67	66.2	66.1	72.9*	66.9	76.1*	75.4*	66.1	66.1	66.9	76.1*
16	67	64.3	63.8	67.6*	63.7	71.8*	69.4*	66.5	63.7	66.5	71.8*
31.5	67	67.6*	64.2	71.0*	61.5	65.7	63.7	67.3*	61.5	65.7	71.0*
63	67	71.4*	72.1*	80.5*	66.3	69.8*	62.2	77.4*	62.2	71.4*	80.5*
125	67	72.7*	66.9	73.2*	62.1	64.5	62.2	81.9*	62.1	66.9	81.9*
250	59	66.1*	63.2*	72.9*	58.3	61.5*	57.3	67.9*	57.3	63.2*	72.9*
500	52	65.9*	64.5*	66.9*	59.6*	62.1*	49.5	62.2*	49.5	62.2*	66.9*
1000	48	68.2*	65.6*	66.4*	64.0*	64.3*	58.8*	63.8*	58.8*	64.3*	68.2*
2000	40	61.5*	62.0*	64.0*	59.7*	60.8*	52.5*	61.6*	52.5*	61.5*	65.1*
4000	34	59.0*	55.9*	60.0*	53.8*	56.0*	48.7*	54.7*	48.7*	55.9*	60.0*
8000	32	53.3*	51.0*	54.2*	52.6*	53.1*	51.4*	48.2*	48.2*	52.6*	54.2*

* SPL above the corresponding octave band ordinance level (OBOL).

Table D.18. Comparison between the Measured Octave Band Background Sound Pressure levels (OBBSPL) in Decibels and their Corresponding Ordinance (OBOL) at Location L8 (1919 County Line Road, Warrington Township Residential Zone)

FREQ	OBOL	DATE/TIME								RANGE		
Hz	dB	13 JUL 1100	14 JUL 1200	15 JUL 1345	16 JUL 1037	16 JUL 1050	16 JUL 1140	16 JUL 1439	17 JUL 1025	MIN	MEDIAN	MAX
2	67	77.5*	78.8*	91.9*	75.3*	83.4*	82.3*	87.8*	79.9*	75.9*	82.3*	91.9*
4	67	66.5	68.5*	78.1*	69.9*	73.2*	76.8*	83.5*	71.5*	66.5	73.2*	83.5*
8	67	60.9	62.0	65.7	64.1	67.1*	72.8*	79.7*	65.7	60.9	65.7	79.7*
16	67	67.4*	60.7	75.3*	72.6*	63.8	67.9*	73.0*	62.2	60.7	67.9*	75.5*
31.5	67	68.6*	61.0	74.9*	65.3	61.9	64.6	65.8	59.5	61.0	65.3	74.9*
63	67	82.1*	62.3	73.0*	61.6	75.7*	68.9*	69.7	62.4	61.6	69.7*	82.1*
125	67	73.7*	63.8	77.0*	71.8*	65.7	65.9	79.4*	61.0	61.0	71.8*	79.4*
250	59	68.7*	58.2	75.0*	66.6*	62.5*	70.4*	76.0*	65.8*	58.2	68.7*	76.6*
500	52	69.2*	60.7*	72.9*	65.4*	63.7*	71.8*	72.0*	66.4*	60.7*	69.2*	72.9*
1000	48	70.3*	65.3*	75.8*	64.5*	66.9*	68.7*	69.7*	69.2*	65.3*	69.2*	75.8*
2000	40	66.6*	62.8*	73.8*	61.2*	65.3*	65.2*	65.3*	64.9*	61.2*	65.3*	73.8*
4000	34	61.8*	56.9*	64.2*	55.3*	57.9*	59.4*	57.2	57.3*	55.3*	57.9*	64.2*
8000	32	57.9*	51.8*	58.5*	50.8*	52.7*	55.0*	55.6*	50.7*	50.7*	55.0*	58.5*

* SPL above the corresponding octave band ordinance level (OBOL).

Table D.19. Comparison between the Measured Octave Band Background Sound Pressure levels (OBBSPL) in Decibels and their Corresponding Ordinance (OBOL) at Location L9 (IRP Monitoring Well DM12 Position, Horsham Township Residential Zone).

OBCF	OBOL	DATE/TIME					RANGE		
Hz	dB	13 JUL 1536	14 JUL 1207	15 JUL 1400	16 JUL 1126	16 JUL 1502	MIN	MEDIAN	MAX
2	72	63.3	57.9	68.8	70.9	76.0*	57.9	68.8	76.0*
4	72	59.3	54.0	62.5	67.3	70.7	54.0	62.5	70.7
8	72	56.4	52.0	59.1	62.6	65.5	52.0	59.1	65.5
16	72	61.3	53.8	69.6	64.8	59.2	53.8	61.3	69.6
31.5	72	67.2	51.9	57.9	61.5	59.2	51.9	59.2	67.2
63	72	60.5	63.7	59.5	53.1	60.6	53.1	60.5	63.7
125	67	60.7	72.1*	58.5	55.4	58.4	55.4	58.5	72.1*
250	59	66.1*	64.3*	64.8*	58.9	55.9	55.9	64.3*	66.1*
500	52	61.6*	53.5*	62.8*	56.3*	48.1	48.1	56.3*	62.8*
1000	46	59.4*	44.7	58.8*	52.0*	40.8	40.8	52.0*	59.4*
2000	40	55.4*	39.3	52.0*	47.2*	38.4	38.4	47.2*	55.4*
4000	34	45.6*	35.0*	42.2*	42.7*	39.2*	35.0*	42.2*	45.6*
8000	32	38.0*	37.0*	40.2*	40.3*	40.6*	37.0*	40.6*	42.3*

* SPL above the corresponding octave band ordinance level (OBOL).

Table D.20. Comparison between the Measured Octave Band Background Sound Pressure levels (OBBSPL) in Decibels and Their Corresponding Ordinance (OBOL) at Location Number L10 (Graeme Park parking lot, Horsham Township Residential Zone)

OBCF	OBOL	DATE/TIME			RANGE		
Hz	dB	15 JUL 1600	16 JUL 1515	17 JUL 1014	MIN	MEDIAN	MAX
2	72	78.0*	70.2	77.1*	70.2	77.1*	78.0*
4	72	72.7*	62.9	72.0	62.9	72.0	72.7*
8	72	68.2	56.2	68.5	56.2	68.2	68.5
16	72	66.5	63.4	62.6	62.6	63.4	66.5
31.5	72	66.2	55.6	57.1	55.6	57.1	66.2
63	72	86.0*	55.5	52.5	52.5	55.5	86.0*
125	67	76.3*	57.8	49.1	49.1	57.8	76.3*
250	59	80.1*	59.9*	47.6	47.6	59.9*	80.1*
500	52	80.8*	57.3*	45.6	45.6	57.3*	80.8*
1000	46	79.0*	53.7*	43.5	43.5	53.7*	70.0*
2000	40	73.2*	47.3*	41.7*	41.7*	47.3*	73.2*
4000	34	59.5*	39.2*	41.9*	39.2*	41.9*	59.5*
8000	32	52.5*	37.5*	43.2*	37.5*	43.2*	52.5*

* SPL above the corresponding octave band ordinance level (OBOL).

Appendix E
Grand Forks Radial SPL Data

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TABLE E.1. Maximum Sound Pressure Level at a Radius of 1500 Feet Grand Forks AFB Small Arms Range 23-28 Trainees Firing for the M-16 Qualification Course

OCTAVE BAND FREQ. (Hz)	0 DEGREE BACKGROUND	0 DEGREE FIRING	20 DEGREE BACKGROUND	20 DEGREE FIRING	40 DEGREE BACKGROUND	40 DEGREE FIRING
2	94	96.2	88.3	90.3	72.6	93
4	90.2	92.4	85.4	88.6	72.4	88.6
8	86.7	88	76.6	84.3	65.7	84.3
16	82.8	83.8	69.3	76.4	62.1	82.4
31.5	74.1	79.5	60.8	72.3	54.9	76.6
63	63.8	73.8	55.7	63.5	51.9	68.1
125	55.7	62.2	49.2	61.6	45.9	60.6
250	51.1	54.7	44	54	41.9	51.7
500	46.5	57.5	41.2	54.2	39.7	54.6
1000	45.7	53.6	43.5	52.4	42.4	54.4
2000	44.8	48	44.8	48	43.6	50.4
4000	45.8	45.8	44.7	47.3	41.9	46.9
8000	50.8	50.1	48.2	49.9	43.6	49.7
16000	65.8	55.5	58.6	62	58.2	62

TABLE E.1. (CONT)

OCTAVE BAND FREQ. (Hz)	60 DEGREE BACKGROUND	60 DEGREE FIRING	120 DEGREE BACKGROUND	120 DEGREE FIRING	140 DEGREE BACKGROUND	140 DEGREE FIRING
2	86	90.4	86.9	90.6	76.8	88.2
4	82	86	79.6	84.1	76.2	81
8	79.4	85.2	74.3	78.7	67.9	74.4
16	76.5	80.1	70.2	76	62.1	71.3
31.5	66.8	74.6	63.6	68.5	58.8	67
63	59.3	67.7	58.8	62	54.6	64.8
125	50.8	63.5	52	62.4	49.1	61.5
250	46.7	56.7	46.5	67.8	43.9	64.1
500	45	60.3	42.5	71.5	41.5	77.7
1000	45.6	59.8	47.5	75	49.1	75.5
2000	45.5	54.5	43.6	67.8	41.8	69.4
4000	46.7	49.8	45.5	58.7	43.8	58
8000	48.8	49.8	52.8	50.8	47	49.5
16000	60.5	62	59.7	62	60.7	62.2

TABLE E.1. (CONT)

OCTAVE BAND FREQ. (Hz)	180 DEGREE BACKGROUND	180 DEGREE FIRING	220 DEGREE BACKGROUND	220 DEGREE FIRING	240 DEGREE BACKGROUND	240 DEGREE FIRING
2	82.7	86.6	85.8	87.5	90.5	93.6
4	81	83.5	83	82.3	85.5	89.1
8	77.5	79.2	81.5	80.4	80.4	83.7
16	71.3	76.4	73.3	75.4	79.6	81.1
31.5	69.3	74	67.5	68.9	71.5	74.4
63	66.2	73.9	63.5	64.4	64	66.8
125	60.3	68.2	51.3	60.3	58.6	60.6
250	48.9	65.7	46.2	58.9	53	57.2
500	48.9	78.9	40.5	65.7	46.3	63.8
1000	50	77.8	41.8	63.1	46	65
2000	46.1	67.2	41.5	55.6	44.8	61.2
4000	43.9	53.6	44.9	47.5	46.1	52.3
8000	47	49.9	48.6	50	44.8	44.8
16000	58.4	61.4	59.7	61.8	57.5	57.5

TABLE E.1 (CONT)

OCTAVE BAND FREQ. (Hz)	260 DEGREE BACKGROUND	260 DEGREE FIRING	280 DEGREE BACKGROUND	280 DEGREE FIRING	300 DGEREE BACKGROUND	300 DEGREE FIRING
2	81.8	89.4	92	95.8	95	97.4
4	79.5	85.3	87.9	90.4	88.4	92.9
8	80	79.1	81.8	86.1	80.7	85.6
16	72.8	73.5	80.9	81.7	79.1	83.4
31.5	66	66.4	73.5	76.7	74.7	77.6
63	59.9	59.8	64.2	67.8	69	70
125	50.1	53	54.3	57.5	59.2	62.7
250	46.7	55.6	50	52.6	52.4	56.6
500	40.4	62.3	46.1	50.6	48.6	52
1000	41.2	65.4	45.3	50	46.9	49.7
2000	40.2	60.3	44.8	48.1	45.3	46
4000	43.4	51.2	45.8	46.4	46.1	46
8000	34.8	44.8	44.8	44.8	44.8	44.8
16000	47.5	57.5	57.5	57.5	57.5	57.5

TABLE E.1. (CONT)

OCTAVE BAND FREQ. (Hz)	320 DEGREE BACKGROUND	320 DEGREE FIRING	340 DEGREE BACKGROUND	340 DEGREE FIRING	0 DEGREE BACKGROUND	0 DEGREE FIRING
2	93.1	93.8	90.4	94.2	94	96.2
4	87.4	90.2	83.5	88.9	90.2	92.4
8	81.8	85.7	78.8	82.8	86.7	88
16	77.9	80.2	77	78.3	82.8	83.8
31.5	75.9	75.7	74.5	76	74.1	79.5
63	66.9	70.3	70.2	71.8	63.8	73.8
125	58.1	62.5	59.9	63.2	55.7	62.2
250	51.1	53.6	51.9	53.8	51.1	54.7
500	50.3	50.9	47.5	51.8	46.5	57.5
1000	50.3	49.1	47.2	49.9	45.7	53.6
2000	46.4	46.6	45.5	47	44.8	48
4000	45.8	46.3	45.8	46.3	45.8	45.8
8000	44.8	44.8	44.8	44.8	50.8	50.1
16000	57.5	57.5	57.5	57.5	65.8	55.5

TABLE E.2 Maximum Sound Pressure Level at a Radius of 1500 Feet
Grand Forks AFB Small Arms Range
3 Trainees Firing for the M-60 Qualification Course

OCTAVE BAND FREQ. (Hz)	0 DGEREE BACKGROUND	0 DEGREE FIRING	20 DEGREE BACKGROUND	20 DEGREE FIRING	40 DEGREE BACKGROUND	40 DEGREE FIRING
2	76.5	80.4	66.6	62.4	77.7	73.4
4	71.4	74.8	65.2	60.3	72.9	71.2
8	66.8	72.5	61.8	57.7	68	72.3
16	74.1	69.6	61.5	59.5	71.5	69.1
31.5	70.2	73.7	66.4	65.7	69.2	70.3
63	67.9	72	71.8	66.8	68.7	69
125	56.2	65	71	62.4	66.3	67.4
250	46.8	56.5	62.5	56.4	55.3	56.3
500	49.9	67.1	52.3	51.8	46.9	55.5
1000	49.7	65	45.6	47.5	54.2	56
2000	47	53.3	43.6	44	47.5	50.2
4000	42.2	45.5	41	40.6	42.8	42.9
8000	44.1	46	43.3	42.8	44.4	44.6
16000	58.6	58.3	56.6	55.8	56.5	56.4

TABLE E.2. (CONT)

OCTAVE BAND FREQ. (Hz)	60 DGEREE BACKGROUND	60 DEGREE FIRING	120 DEGREE BACKGROUND	120 DEGREE FIRING	140 DEGREE BACKGROUND	140 DEGREE FIRING
2	62.9	70.8	76.8	81.2	73.5	62.2
4	59.3	60.2	76.4	72.1	66.4	52.2
8	59.6	56.5	72.1	70.1	56.2	56.7
16	59.4	65.9	64.5	61.6	55.7	64.3
31.5	60.6	72.4	62.8	65	58.7	68.3
63	64.4	66.3	67.7	64.9	64.7	67.9
125	61.7	57.2	64.9	61.7	57.2	57.9
250	50.5	47.8	52.2	48.1	47.9	45.9
500	42.7	49.4	43.2	44.6	46	50.7
1000	46.3	48.3	46	45.6	49.7	50.6
2000	46.7	45.1	44.5	43.4	45.1	44.9
4000	40.7	41.1	42.9	42.6	40.4	40.1
8000	43.8	43.2	49.4	45.8	43.6	42.9
16000	56.4	56.8	57	56.5	57.2	56.4

TABLE E.2. (CONT)

OCTAVE BAND FREQ. (Hz)	200 DEGREE BACKGROUND	200 DEGREE FIRING	220 DEGREE BACKGROUND	220 DEGREE FIRING	240 DEGREE BACKGROUND	240 DEGREE FIRING
2	77.1	77.2	79.1	77.7	71	71.9
4	73.8	73.8	71.9	76.2	59.9	66.7
8	70.6	71.4	68.3	70.3	61	65.9
16	65.8	67.4	61.8	66.1	60.6	66.6
31.5	60.2	68.3	63.2	70.4	62.7	71.7
63	60.1	71.7	60.3	71	61.3	67.6
125	59.8	63.7	49.8	61.7	54	60.8
250	53.1	55.9	42	58.5	51.6	52.9
500	49.8	59	43.3	65.3	47.6	53.8
1000	51.9	56	44.6	58.2	49.3	51.5
2000	47.7	49.2	43.2	49.4	47.5	49.6
4000	42.9	43.4	42.7	43.6	40.5	43.1
8000	44.6	45.2	46.5	46.6	43.3	43.9
16000	57.2	56.7	59.4	58.9	59.4	59.3

TABLE E.2. (CONT)

OCTAVE BAND FREQ. (Hz)	260 DEGREE BACKGROUND	260 DEGREE FIRING	280 DEGREE BACKGROUND	280 DEGREE FIRING	300 DEGREE BACKGROUND	300 DEGREE FIRING
2	70.4	71.2	79.7	77.7	78.2	74.4
4	63.9	63	73.1	73.5	76	68.2
8	60	61.8	71.8	70.9	70.4	65.2
16	58	72.9	67.2	71.2	64.3	67.3
31.5	60.8	72.3	62	70.8	61.5	72.4
63	62.5	68.8	63.4	71.4	69.7	75.6
125	51.6	57.3	51.8	55.4	59.4	65.9
250	43	50.7	40.6	57.7	46.8	59
500	45.3	56.6	43.6	64.5	44.3	73.9
1000	46.1	57.7	44.5	63.6	47.6	73.7
2000	42.9	52.9	34.8	54.2	43.4	62.4
4000	40.5	45.7	34.8	46.2	42	53.9
8000	43.5	43.6	35.4	45.3	45.8	46.6
16000	59.2	59	49.1	59	58.8	60.6

TABLE E.2. (CONT)

OCTAVE BAND FREQ. (Hz)	320 DEGREE BACKGROUND	320 DEGREE FIRING	340 DEGREE BACKGROUND	340 DEGREE FIRING	0 DGEREE BACKGROUND	0 DEGREE FIRING
2	73.7	71.1	82.9	67.7	76.5	80.4
4	71.1	67.7	77	64.9	71.4	74.8
8	66.6	66	72	63.7	66.8	72.5
16	59.1	63.1	65.2	58.6	74.1	69.6
31.5	55.1	76.5	60.1	65.7	70.2	73.7
63	65	77.8	62.2	65.2	67.9	72
125	52.3	68.3	54.1	54.6	56.2	65
250	44.8	64.7	45.6	51.3	46.8	56.5
500	44.8	77.1	45	65.4	49.9	67.1
1000	51	73.9	47.5	58	49.7	65
2000	44.8	63.2	42.8	46.8	47	53.3
4000	44.8	54.3	43.2	38	42.2	45.5
8000	45.2	46.4	46	35.8	44.1	46
16000	59	60.7	59.3	49.3	58.6	58.3

Appendix F
Noise Contours for Horsham Noise Ordinance

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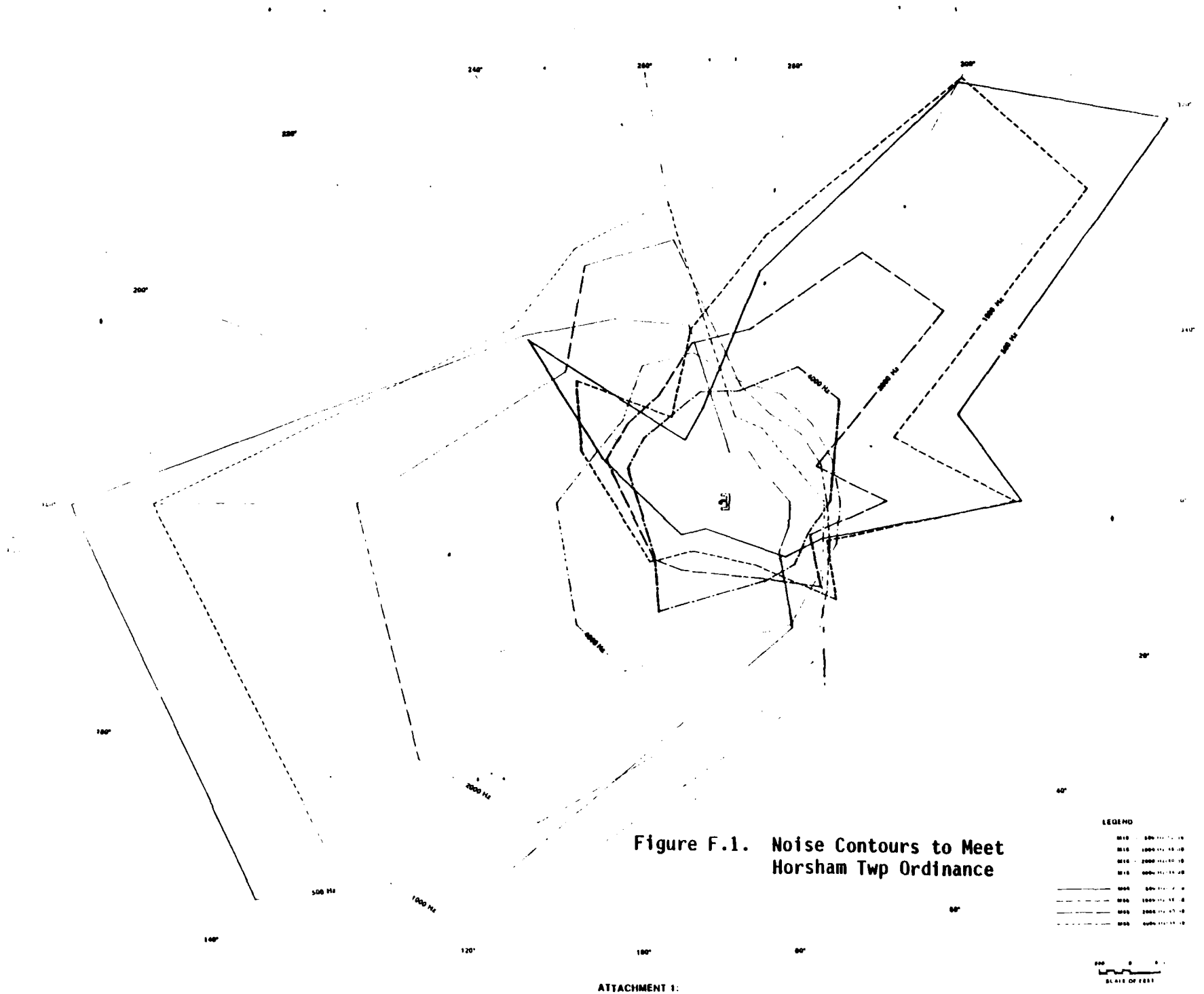

Figure F.1. Noise Contours to Meet Horsham Twp Ordinance

ATTACHMENT 1:
EQUAL SOUND PRESSURE FOR NOISE GENERATED
BY 23-28 M16s AND 3 M60s FIRING SEPARATELY

Table F.1. Distances for Equal SPLs During 23-28 M16s Firing (to Meet Horsham Township Residential Zone Ordinance)

OCTAVE BAND FREQ. (Hz)	SPL (dB)	ANGLE AND CORRESPONDING DISTANCE IN FEET																
		0	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340
500	52	1,770	1,870	1,950	3,670	*	*	10,700	16,660	*	16,750	N/A	6,680	5,350	4,560	1,280	1,480	1,310	1,460
1,000	46	2,660	2,820	3,400	6,330	*	*	12,660	13,370	*	14,620	N/A	6,910	7,430	7,730	2,180	2,130	2,000	2,160
2,000	40	2,720	2,980	3,560	4,700	*	*	9,400	10,120	*	9,340	N/A	5,150	6,910	6,740	3,000	2,560	2,680	2,750
4,000	34	3,060	3,160	3,150	3,600	*	*	4,950	4,830	*	4,210	N/A	3,250	4,000	3,840	3,090	3,160	3,060	3,060

* Not Obtained. Physical barrier between noise source and sample location.
N/A Not Analysed. Noise source sample spectrum dominated by aircraft background noise.

Table F.2. Distances for equal SPLs During 3 M60's Firing (to Meet Horsham Township Residential Zone Ordinace)

OCTAVE BAND FREQ. (Hz)	SPL (dB)	ANGLE AND CORRESPONDING DISTANCE IN FEET																	
		0	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340
500	52	7,740	2,770	2,170	1,160	•	•	770	1,310	•	N/A	3,220	6,430	1,810	2,430	5,910	12,260	16,030	6,480
1,000	46	7,550	2,910	3,870	1,870	•	•	1,440	2,360	•	N/A	3,800	4,830	2,510	4,420	6,840	12,420	12,320	4,710
2,000	40	4,260	2,460	3,380	2,270	•	•	1,990	2,550	•	N/A	3,130	3,110	3,120	4,100	4,450	7,300	7,520	2,600
4,000	34	2,800	2,380	2,490	2,320	•	•	2,440	2,220	•	N/A	2,530	2,560	2,520	2,850	2,850	3,950	3,990	2,030

• Not obtained. Physical barrier between noise source and sample location.
N/A Not Analysed. Noise source sample spectrum dominated by aircraft background noise.

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