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Environmental Noise Monitoring

For

Northwest Stoney Trail in Calgary, AB

Prepared for: Alberta Transportation

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> aci Project #: 10-031 April 30, 2011

Executive Summary

aCi Acoustical Consultants Inc., of Edmonton AB, was retained by Alberta Transportation (AT) to conduct a environmental noise monitorings along the northeast and northwest sections of Stoney Trail in Calgary, Alberta. The purpose of this work was to conduct 24-hour noise monitorings at a total of 25 locations along Stoney Trail to be used as a calibration tool for a computer noise model of the study area. This report pertains to the 16 noise monitoring locations along the northwest section of Stoney Trail. The site work was conducted for **aCi** by P. Froment, B.Sc., B.Ed. under the supervision of S. Bilawchuk, M.Sc., P.Eng.

The results of the baseline noise monitoring indicated sound levels ranging from 48.3 - 67.6 dBA $L_{eq}24^{1}$. At all locations, the noise climate was dominated by Stoney Trail or by local traffic on the adjacent roads. The monitoring indicated the noise climate was generally broadband in nature with no tonal components and no dominant stationary sources. Finally, it has been indicated by Alberta Transportation that additional noise monitoring are to be conducted along Stoney Trail between Country Hills Boulevard NW and the Bow River upon completion of the interchanges at Crowchild Trail and Nose Hill Drive.

¹ The term L_{eq} represents the energy equivalent sound level. This is a measure of the equivalent sound level for a specified period of time accounting for fluctuations.



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1.0 Introduction

aci Acoustical Consultants Inc., of Edmonton AB, was retained by Alberta Transportation (AT) to conduct a environmental noise monitorings along the northeast and northwest sections of Stoney Trail in Calgary, Alberta. The purpose of this work was to conduct 24-hour noise monitorings at a total of 25 locations along Stoney Trail to be used as a calibration tool for a computer noise model of the study area. This report pertains to the 16 noise monitoring locations along the northwest section of Stoney Trail. The site work was conducted for **aci** by P. Froment, B.Sc., B.Ed. under the supervision of S. Bilawchuk, M.Sc., P.Eng.

2.0 Location Description

The current sections of Stoney Trail span from 17 Avenue SE (on the east side of Calgary) to Highway 1 NW (on the west side of Calgary), as indicated in Figs. 1A & 1B. Throughout the entire span (approximately 45 km), Stoney Trail is a twinned road with at least 2-lanes in each direction and some sections with 3-lanes in each direction. The posted speed limit throughout is 100 km/hr. The current and future interchanges/intersections are as follows:

- 17 Avenue SE (currently a light-controlled intersection. Scheduled to be an interchange in the near future)
- 16 Avenue NE (grade separated interchange)
- McKnight Blvd NE (grade separated interchange)
- Airport Trail NE (grade separated interchange not yet operational)
- Country Hills Blvd NE (grade separated interchange)
- Deerfoot Trail (grade separated interchange)
- 11 Street NE (currently no intersection. Future grade separated interchange)
- Harvest Hills Blvd NE (currently a light-controlled intersection. Grade separated interchange under construction)
- 14 Street NW (currently no intersection. Future grade separated interchange)
- Beddington Trail NW (grade separated interchange)
- Shaganappi Trail NW (Fly-over with westbound Stoney Trail Access. Full interchange access under construction)
- Sarcee Trail NW (grade separated interchange)
- Country Hills Blvd NW (grade separated interchange)
- Crowchild Trail NW (currently a light-controlled intersection. Grade separated interchange under construction)
- Scenic Acres Link (grade separated interchange with modifications related to the Crowchild Trail Interchange)



- Nose Hill Drive (currently a light-controlled intersection. Scheduled to be an interchange in the near future)
- Highway 1 (grade separated interchange)

There will therefore be 18 grade separated interchanges within the study area for the future case assessment scenario¹.

The study area is primarily composed of single family detached residential areas with houses that back onto Stoney Trail. At some locations, there are houses that side or front onto Stoney Trail. There are also sections with multi-family 3 and 4 storey residential buildings adjacent to Stoney Trail. Finally, there are commercial areas and areas which have yet to be developed. In particular, there are no residential receptors adjacent to Stoney Trail between Airport Trail NE and 11 Street NE.

Topographically, the land in between Stoney Trail and the residential receptors for northeast Stoney Trail is relatively flat with no significant berms for shielding. Most of the residential lots have direct line-of-sight to Stoney Trail. For the northwest portion of Stoney Trail, there are sections with relatively flat ground in between the road and the adjacent houses and other sections with significant berms blocking the line-of-sight. In addition, for the northwest section, there are significant changes in elevation throughout. The vegetation in the areas between the residential locations and Stoney Trail consists mainly of field grasses with small sections of bushes and trees.

¹ The Interchange at Metis Trail has been ignored because it is too far from the NE and NW residential study areas to have an impact on the noise climate.



3.0 <u>Measurement Methods</u>

As part of the study a total of twenty-five (25) 24-hour environmental noise monitorings were conducted throughout the study area. Sixteen (16) of these locations were in the northwest portion of Stoney Trail. The noise monitoring locations, as indicated in Fig. 1, were selected based on their proximity to Stoney Trail and adjacent interchanges. A detailed description of each location for northwest Stoney Trail is provided below. Refer to Appendix I for a detailed description of the measurement equipment used, Appendix II for a description of the acoustical terminology, and Appendix III for a list of common noise sources. All noise measurement instrumentation was calibrated at the start of the measurements and then checked afterwards to ensure that there had been negligible calibration drift over the duration of the measurements.

Monitor 10

Noise Monitor 10 was located approximately 75 m south of Stoney Trail EB and 3.2 km west of Hwy. 2 NE as shown in Figs. 1 and 2. This placed the monitor approximately 10 m north of the house at 175 Coville Close. At this location, there was a partial fence and a slight berm between the monitor and Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 17:12 on Thursday October 21, 2010 and ran for 24-hours until 17:12 on Friday October 22, 2010.

Monitor 11

Noise Monitor 11 was located on public land approximately 95 m east of Stoney Trail NB and 950 m northeast of Beddington Trail NW as shown in Figs. 1 and 3. At this location, there was direct line-of-sight to Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 12:55 on Thursday July 29, 2010 and ran for 24-hours until 12:55 on Friday July 30, 2010.

Monitor 12

Noise Monitor 12 was located on public land approximately 120 m west of Stoney Trail SB and 1.2 km northeast of Beddington Trail NW as shown in Figs. 1 and 4. At this location, there was direct line-of-sight to Stoney Trail. There was no significant vegetation between the monitor and the road. The noise



monitor was started at 13:30 on Monday June 28, 2010 and ran for 24-hours until 13:30 on Tuesday June 29, 2010.

Monitor 13

Noise Monitor 13 was located approximately 110 m north of Stoney Trail WB and 500 m west of Beddington Trail NW as shown in Figs. 1 and 5. This put the monitor approximately 5 m southeast of the house at 129 Kincora Bay. At this location, there was not direct line-of-sight to Stoney Trail as there was a significant berm between the resident and Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 12:55 on Monday June 28, 2010 and ran for 24-hours until 12:55 on Tuesday June 29, 2010.

Monitor 14

Noise Monitor 14 was located approximately 85 m south Stoney Trail EB and 480 m east of Shaganappi Trail NW as shown in Figs. 1 and 6. This placed the monitor just east of a storm water retention pond. This location had direct line-of-sight to the road. Additionally, there was no significant vegetation between the monitor and the road. The noise monitor was started at 12:02 on Thursday September 9, 2010 and ran for 24-hours until 12:02 on Friday September 10, 2010.

Monitor 15

Noise Monitor 15 was located on the top of the embankment for the Sarcee Trail EB off-ramp. This placed the monitor approximately 120 m south of Stoney Trail EB and 110 m east of Sarcee Trail NW as shown in Figs. 1 and 7. At this location, there was direct line-of-sight to Stoney Trail. In addition, there was no significant vegetation between the monitor and the road. The noise monitor was started at 12:55 on Thursday July 29, 2010 and ran for 24-hours until 12:55 on Friday July 30, 2010.

Monitor 16

Noise Monitor 16 was located on public land approximately 210 m north of Stoney Trail WB and 560 m west of Shaganappi Trail NW as shown in Figs. 1 and 8. At this location, there was direct line-of-sight to Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 12:25 on Monday June 28, 2010 and ran for 24-hours until 12:25 on Tuesday June 29, 2010.



Monitor 17

Noise Monitor 17 was located on public land approximately 65 m south of Stoney Trail EB and 840 m west of Sarcee Trail NW as shown in Figs. 1 and 9. At this location the monitor was placed at the foot of a slight berm and therefore did not have direct line-of-sight to Stoney Trail. The noise monitor was started at 11:30 on Thursday September 9, 2010 and ran for 24-hours until 11:30 on Friday September 10, 2010.

Monitor 18

Noise Monitor 18 was located on public land approximately 30 m southeast of Stoney Trail NB and 650 m north of Country Hills Blvd NW as shown in Figs. 1 and 10. At this location, there was direct line-of-sight to Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 11:45 on Thursday July 29, 2010 and ran for 24-hours until 11:45 on Friday July 30, 2010.

Monitor 19

Noise Monitor 19 was located on public land approximately 250 m east of Stoney Trail NB and 300 m south of Country Hills Blvd NW as shown in Figs. 1 and 11. There was not direct line-of-sight to Stoney Trail because of a significant berm between the monitor and Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 11:05 on Thursday July 29, 2010 and ran for 24-hours until 11:05 on Friday July 30, 2010.

Monitor 20

Noise Monitor 20 was located on public land approximately 85 m southeast of Stoney Trail EB and 615 m northeast of Crowchild Trail NW as shown in Figs. 1 and 12. At this location the monitor was placed at the foot of a small hill and therefore did not have direct line-of-sight to Stoney Trail. The noise monitor was started at 16:40 on Thursday October 21, 2010 and ran for 24-hours until 16:40 on Friday October 22, 2010.

Monitor 21

Noise Monitor 21 was located on public land approximately 175 m northwest of Stoney Trail SB and 640 m southwest of Country Hills Blvd NW as shown in Figs. 1 and 13. At this location, there was



direct line-of-sight to Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 11:35 on Monday June 28, 2010 and ran for 24-hours until 11:35 on Tuesday June 29, 2010.

Monitor 22

Noise Monitor 22 was located on public land approximately 200 m west of Stoney Trail SB and 150 m north of Tuscany Blvd NW shown in Figs. 1 and 14. At this location, there was direct line-of-sight to Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 16:15 on Thursday October 21, 2010 and ran for 24-hours until 16:15 on Friday October 22, 2010.

Monitor 23

Noise Monitor 23 was located on public land approximately 80 m east of Stoney Trail NB and 600 m north of Scenic Acres Link NW as shown in Figs. 1 and 15. At this location, there was a slight berm between the monitor and Stoney Trail which blocked the line-of-sight. There was no significant vegetation between the monitor and the road. The noise monitor was started at 10:40 on Thursday September 9, 2010 and ran for 24-hours until 10:40 on Friday September 10, 2010.

Monitor 24

Noise Monitor 24 was located on public land approximately 130 m east of Stoney Trail NB and 660 m north of Nose Hill Drive NW as shown in Figs. 1 and 16. There was not direct line-of-sight to Stoney Trail due to the significant berm between the monitor and Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 11:00 on Monday June 28, 2010 and ran for 24-hours until 11:00 on Tuesday June 29, 2010.

Monitor 25

Noise Monitor 25 was located on public land approximately 220 m west of Stoney Trail SB and 590 m north of Hwy. 1 NW as shown in Figs. 1 and 17. At this location, there was direct line-of-sight to Stoney Trail. There was no significant vegetation between the monitor and the road. The noise monitor was started at 10:20 on Monday June 28, 2010 and ran for 24-hours until 10:20 on Tuesday June 29, 2010.



4.0 <u>Results and Discussion</u>

4.1. Noise Monitoring

The results obtained from the environmental noise monitorings are shown in Table 1 and Figs. 18-49 (broadband A-weighted L_{eq} sound levels and 1/3 octave band L_{eq} sound levels provided). It should be noted that the data have been adjusted by the removal of non-typical noise events such as loud aircraft flyovers (the noise modeling does not account for aircraft), pedestrians making noise nearby, abnormally loud vehicle passages, etc.

Monitor	L _{eq} 24 (dBA)	L _{eq} Day (dBA)	L _{eq} Night (dBA)
M10	56.5	57.4	54.5
M11	58.8	59.6	56.8
M12	57.0	58.4	52.7
M13	53.3	54.7	48.8
M14	60.1	61.5	55.6
M15	59.9	61.2	56.1
M16	51.6	52.9	47.6
M17	54.1	55.5	50.0
M18	67.6	69.0	63.3
M19	48.3	48.8	47.2
M20	51.9	52.7	50.2
M21	53.0	54.3	48.9
M22	50.2	51.2	47.8
M23	52.7	54.0	48.7
M24	49.1	49.7	48.1
M25	51.9	53.1	48.4

Table 1. Baseline Noise Monitoring Results

Monitor 10 was dominated by traffic along Stoney Trail. Lower noise levels at this location can be attributed to the monitor being placed in the backyard of a residential location (i.e. further away from the road, small amount of shielding provided by the fence). A sharp rise in the 25 Hz 1/3 octave band can be seen in Fig. 46. After reviewing the associated audio recording it was concluded that the tone could be attributed to unidentified low frequency machinery (not related to road noise) operating in the vicinity of the monitor. This tone did not influence the broadband A-weighted sound levels.

The noise climate at Monitors 11, 12, 14, 16 - 25 was determined entirely by traffic along Stoney Trail. Again, this was expected due to the current traffic volumes on Stoney Trail and the absence of any other major noise sources. The higher noise levels at Monitor 18 were a result of its proximity (30 m) and direct line-of-sight to Stoney Trail. Lower levels at other Monitors (those below 55 dBA) can be attributed to their increased distance from Stoney Trail and/or shielding from berms.

Monitor 25 has two minor spikes in the 5 kHz and 8 kHz 1/3 octave bands. These spikes are not related to road noise. Again, this did not influence the broadband A-weighted sound levels.

Monitor 13 was also dominated by traffic along Stoney Trail. Lower noise levels at this location despite its proximity to Stoney Trail, can be attributed to the monitor being placed in the backyard of a residential location in addition to it being shielded by a small hill as seen in Fig.14.

The noise climate at Monitor 15 was determined by traffic along Sarcee Trail in combination with Stoney Trail. The noise monitor at this location was elevated and thus had direct line-of-sight to both roadways.

Lastly, Monitor 19 resulted in the lowest measured noise levels due to the significant shielding provided by the large hill found between the monitor and Stoney Trail. At this location Stoney Trail was again the dominant source but subjectively it was substantially quieter than at other monitoring locations.

At all locations, the resultant 1/3 octave band L_{eq} sound levels were very similar. All locations show the typical trend of low frequency noise (near 63 - 80 Hz) resulting from engines and exhaust, mid-high frequency noise (near 1,000 Hz) resulting from tire noise. These results confirm that the noise levels being measured by the noise monitors were largely attributed to Stoney Trail in addition to the other major roadways.

4.2. Weather Conditions

Subjectively, the weather conditions for Monitors 12, 13, 16, 21, 24 and 25 to start were sunny with a light south wind. The wind remained calm while shifting from various directions until the early morning when it increased for approximately 3 hours. By the end of the monitoring the weather was sunny with a light east wind. The weather for Monitors 15, 18 and 19 started with an overcast sky and a calm west wind. The wind periodically increased but remained predominantly from the west for the entire monitoring period. The weather conditions for Monitors 14, 17 and 23 were overcast with light wind from the west. The weather remained from the west-northwest throughout the entire monitoring period



for these locations. The weather conditions for Monitors 10, 20 and 22 were partially cloudy to start with a light northwest wind. The wind shifted from various directions but remained predominantly from the north. There was partial sun and calm conditions the following afternoon. Weather data for the duration of the environmental noise monitorings is presented in Appendix IV.

5.0 Conclusion

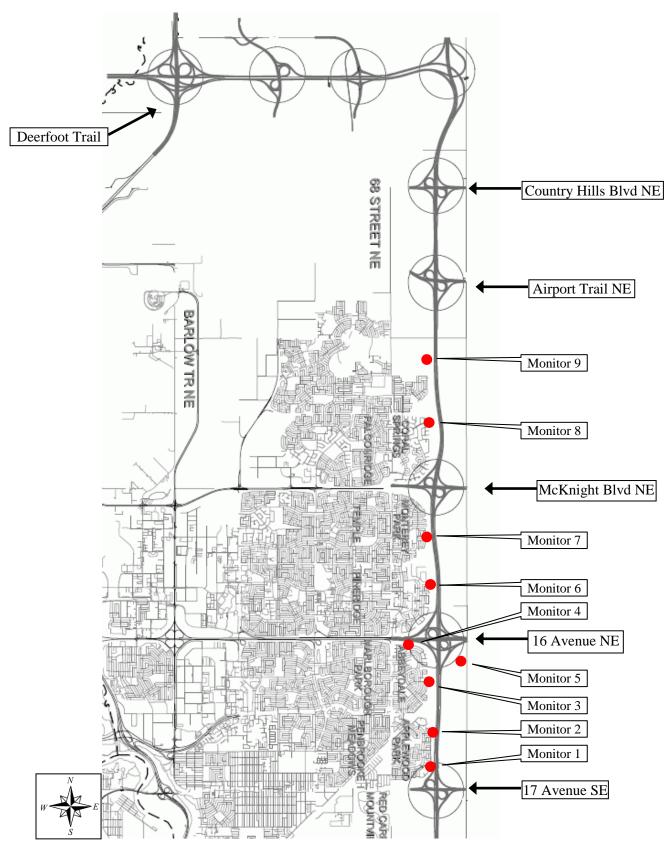
The results of the baseline noise monitoring indicated sound levels ranging from 48.3 - 67.6 dBA L_{eq}24. At all locations, the noise climate was dominated by Stoney Trail or by local traffic on the adjacent roads. The monitoring indicated the noise climate was generally broadband in nature with no tonal components and no dominant stationary sources. Finally, it has been indicated by Alberta Transportation that additional noise monitoring are to be conducted along Stoney Trail between Country Hills Boulevard NW and the Bow River upon completion of the interchanges at Crowchild Trail and Nose Hill Drive.

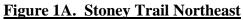


6.0 <u>References</u>

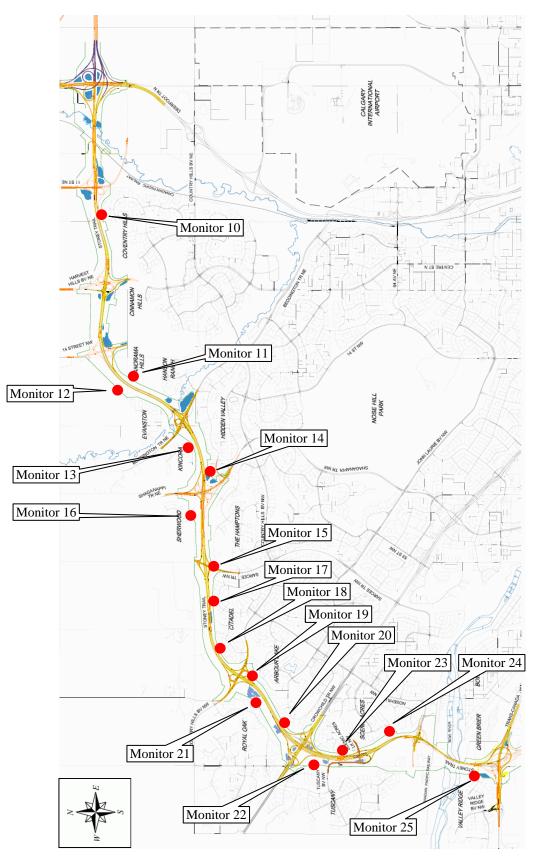
- International Organization for Standardization (ISO), Standard 1996-1, Acoustics Description, measurement and assessment of environmental noise Part 1: Basic quantities and assessment procedures, 2003, Geneva Switzerland.
- International Organization for Standardization (ISO), *Standard 9613-1, Acoustics Attenuation* of sound during propagation outdoors Part 1: Calculation of absorption of sound by the atmosphere, 1993, Geneva Switzerland.
- International Organization for Standardization (ISO), Standard 9613-2, Acoustics Attenuation of sound during propagation outdoors – Part 2: General method of calculation, 1996, Geneva Switzerland.

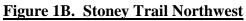














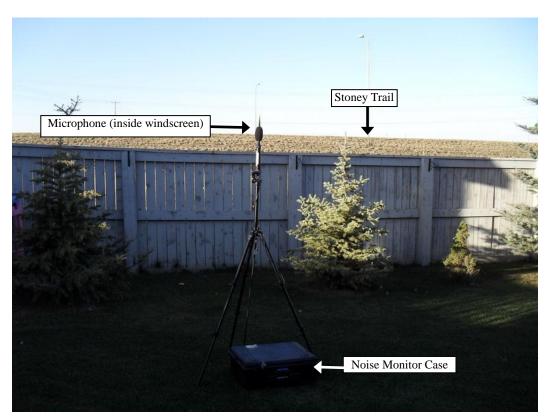


Figure 2. Noise Monitor at Location 10

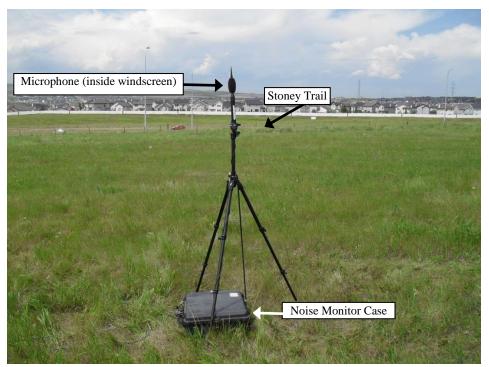


Figure 3. Noise Monitor at Location 11



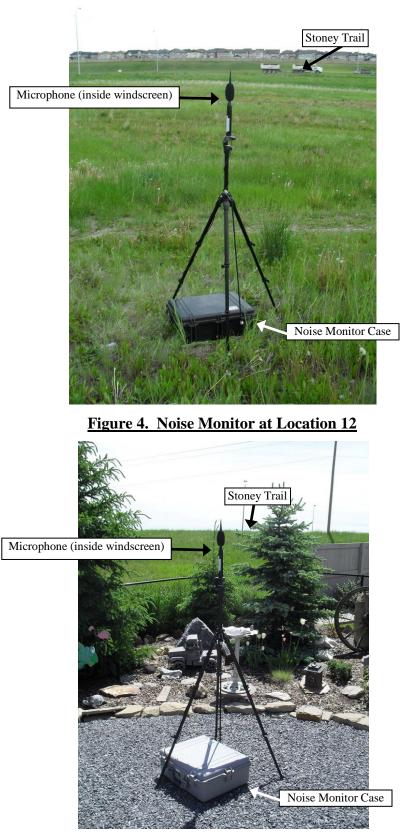


Figure 5. Noise Monitor at Location 13



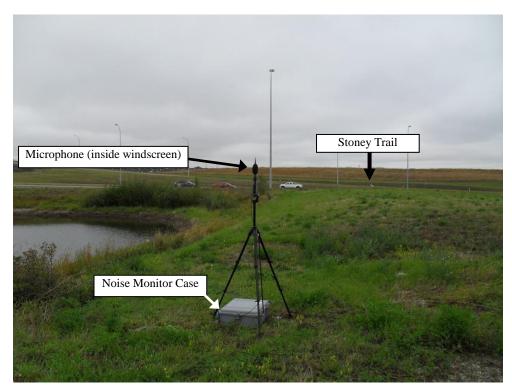


Figure 6. Noise Monitor at Location 14

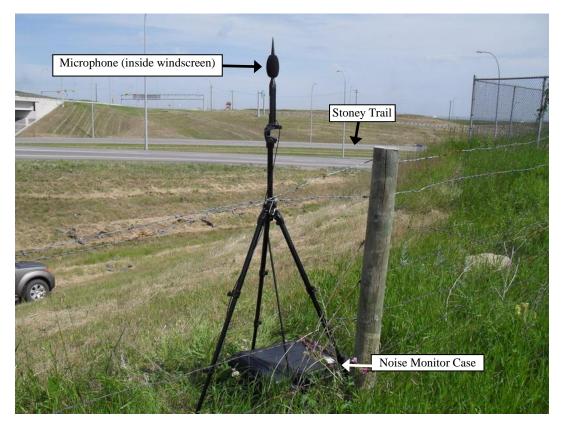


Figure 7. Noise Monitor at Location 15



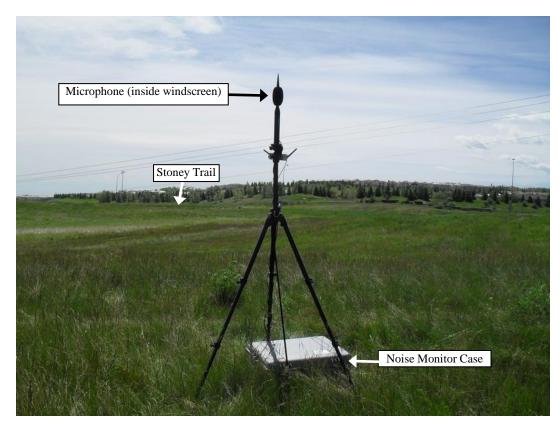


Figure 8. Noise Monitor at Location 16

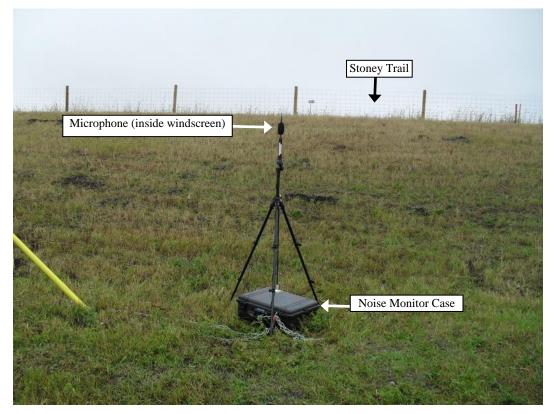


Figure 9. Noise Monitor at Location 17



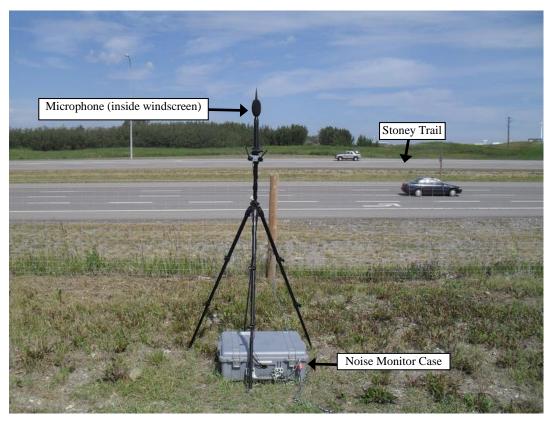


Figure 10. Noise Monitor at Location 18

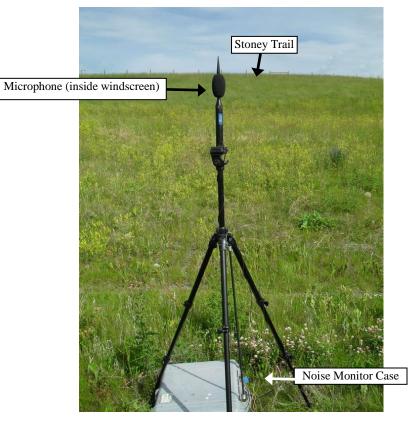


Figure 11. Noise Monitor at Location 19





Figure 12. Noise Monitor at Location 20

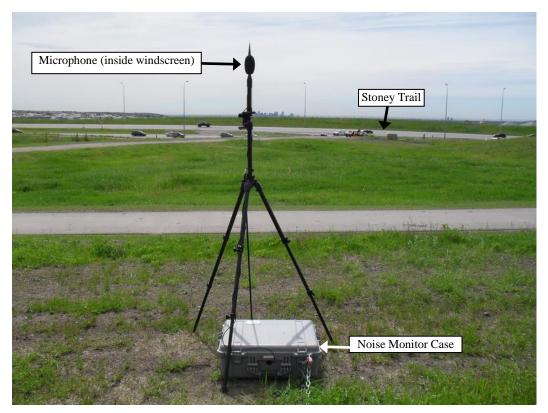


Figure 13. Noise Monitor at Location 21



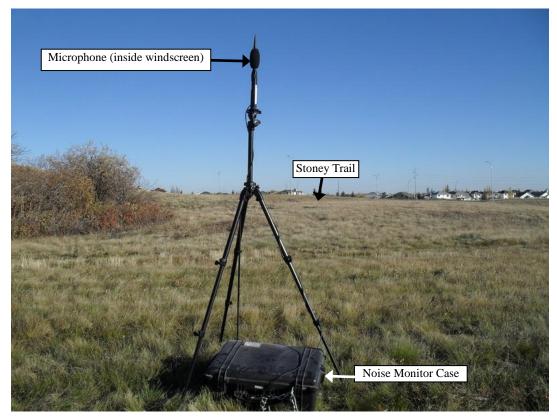


Figure 14. Noise Monitor at Location 22

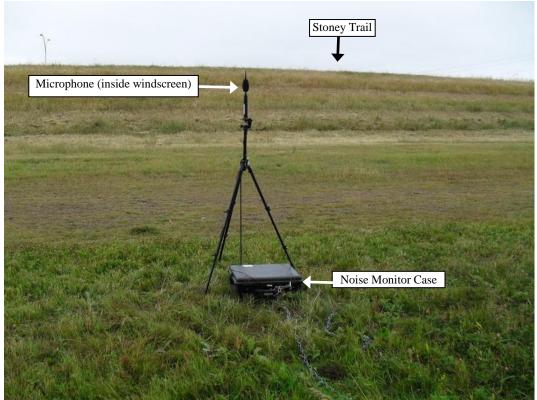


Figure 15. Noise Monitor at Location 23



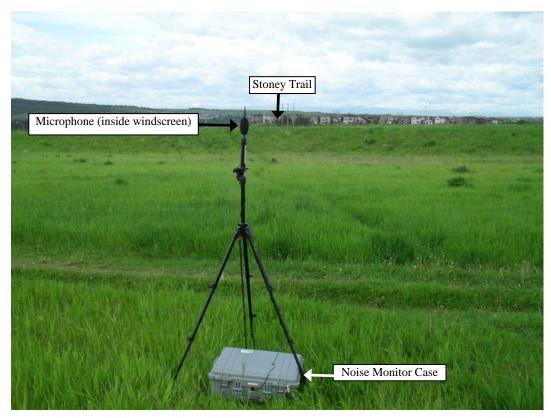


Figure 16. Noise Monitor at Location 24

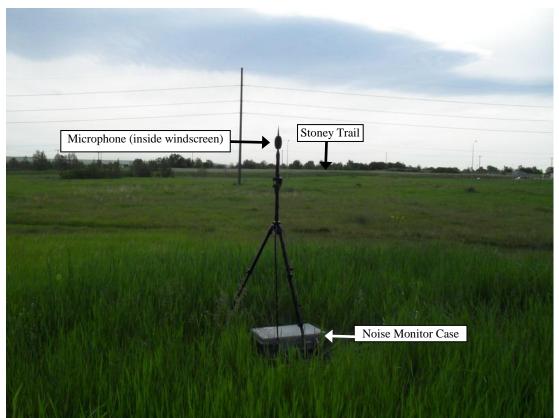


Figure 17. Noise Monitor at Location 25



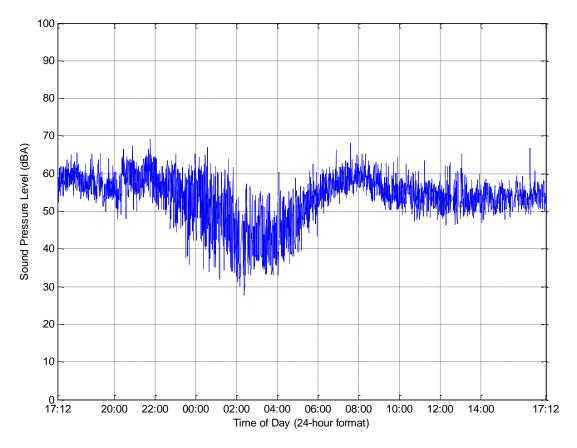


Figure 18. 24-Hour Broadband A-Weighted Leg Sound Levels at Monitor Location 10

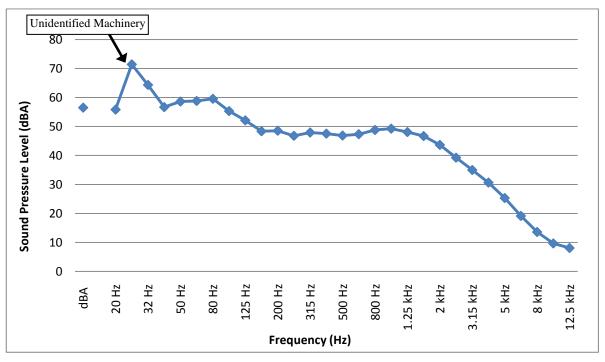


Figure 19. 24-Hour 1/3 Octave Band L_{eq} Sound Levels at Monitor Location 10



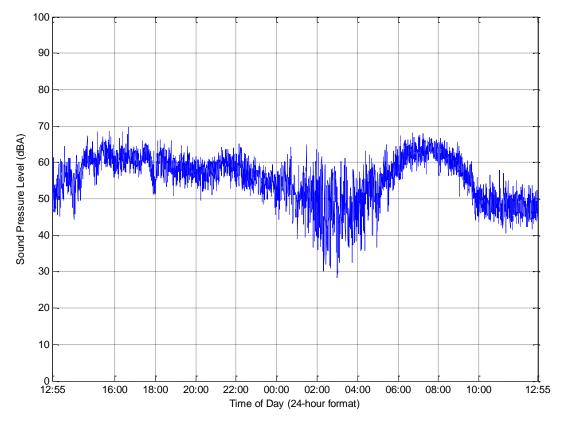


Figure 20. 24-Hour Broadband A-Weighted Leg Sound Levels at Monitor Location 11

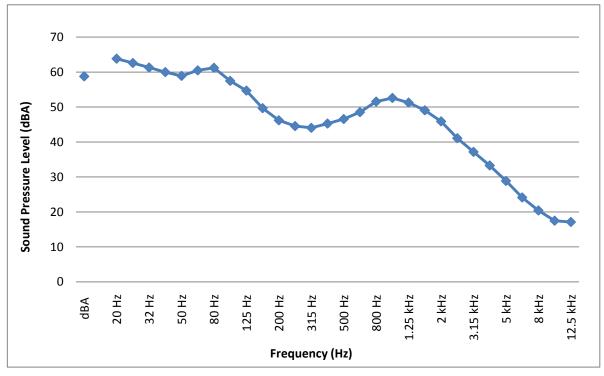


Figure 21. 24-Hour 1/3 Octave Band Leq Sound Levels at Monitor Location 11

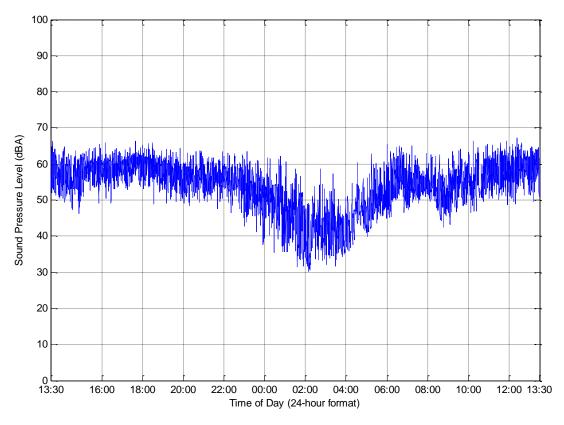


Figure 22. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 12

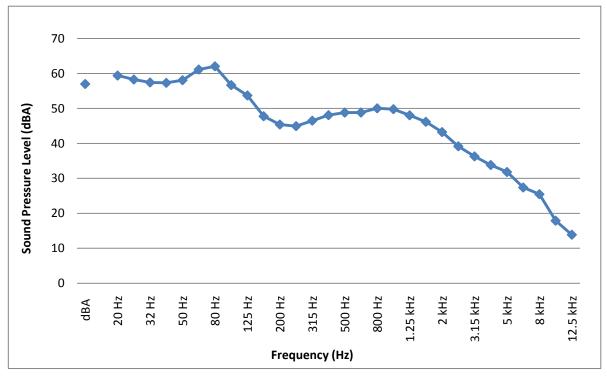


Figure 23. 24-Hour 1/3 Octave Band Levels at Monitor Location 12



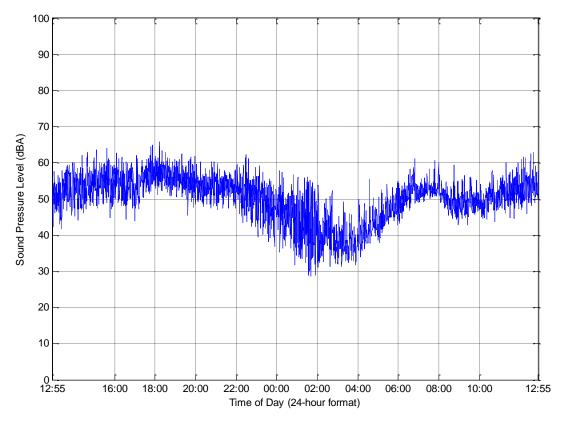


Figure 24. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 13

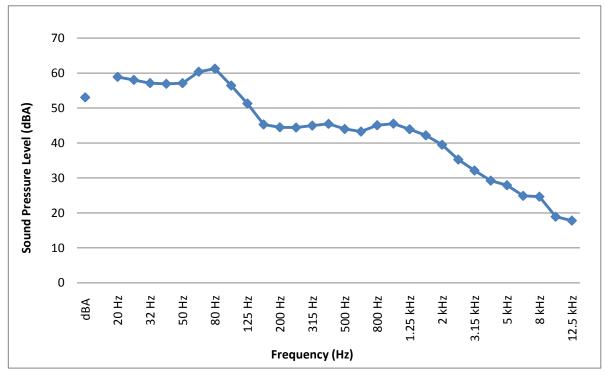


Figure 25. 24-Hour 1/3 Octave Band Levels at Monitor Location 13



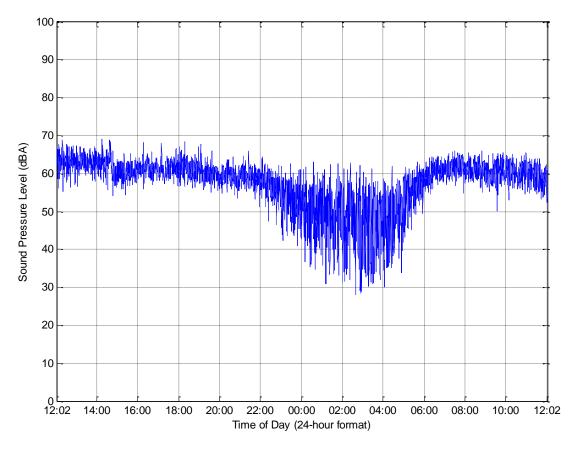


Figure 26. 24-Hour Broadband A-Weighted Leg Sound Levels at Monitor Location 14

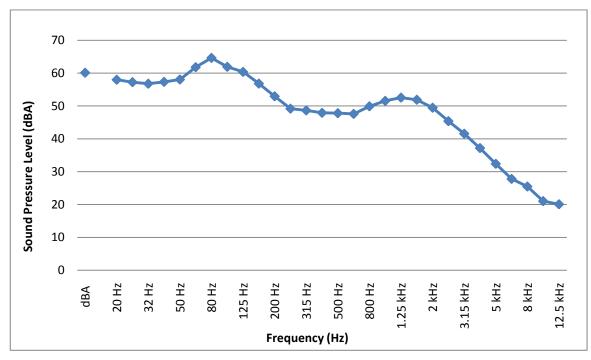


Figure 27. 24-Hour 1/3 Octave Band Leg Sound Levels at Monitor Location 14

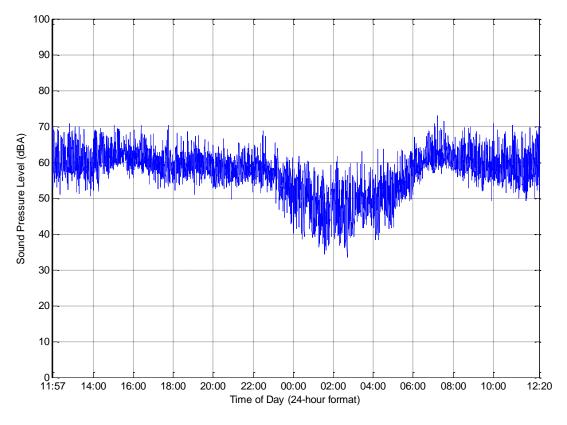


Figure 28. 24-Hour Broadband A-Weighted Leg Sound Levels at Monitor Location 15

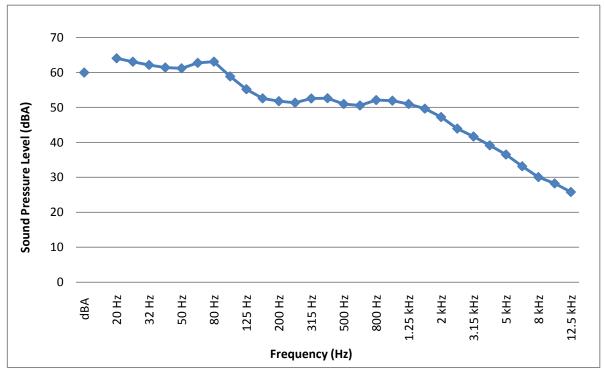


Figure 29. 24-Hour 1/3 Octave Band Leg Sound Levels at Monitor Location 15



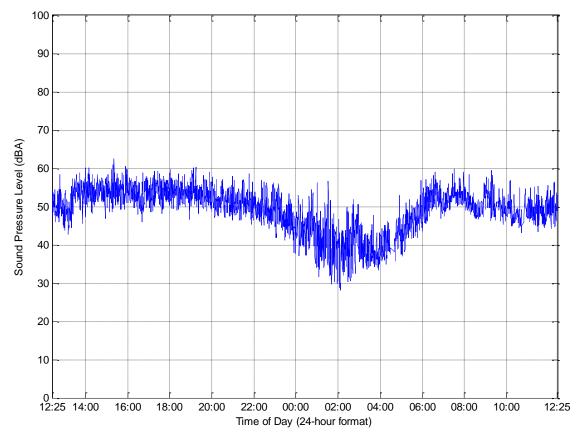


Figure 30. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 16

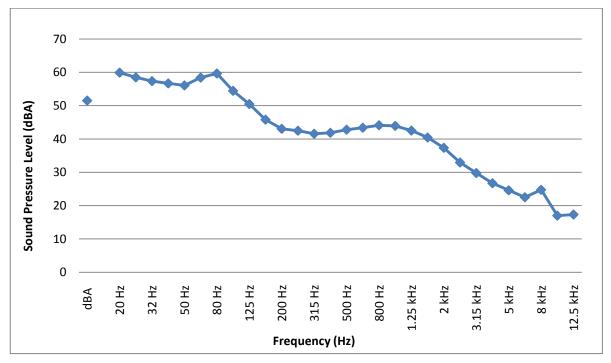


Figure 31. 24-Hour 1/3 Octave Band Leg Sound Levels at Monitor Location 16



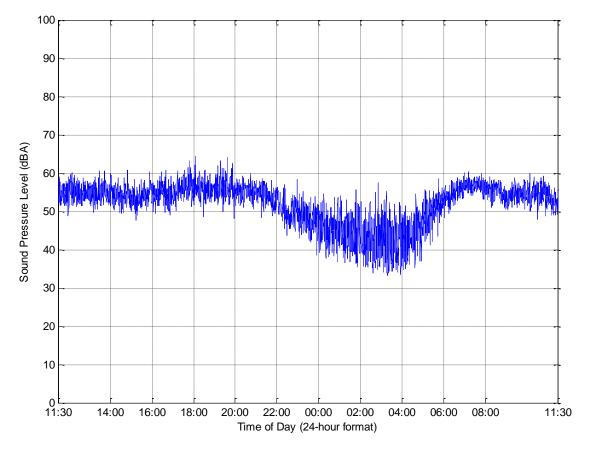


Figure 32. 24-Hour Broadband A-Weighted Leg Sound Levels at Monitor Location 17

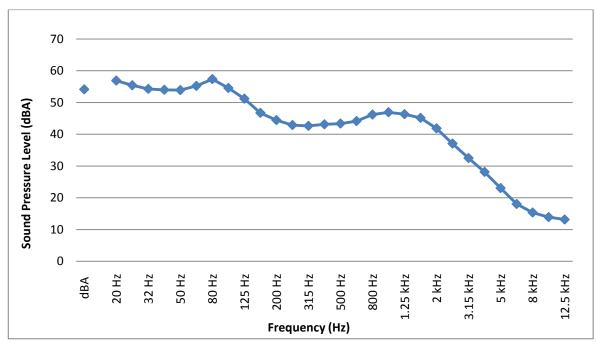


Figure 33. 24-Hour 1/3 Octave Band Leg Sound Levels at Monitor Location 17



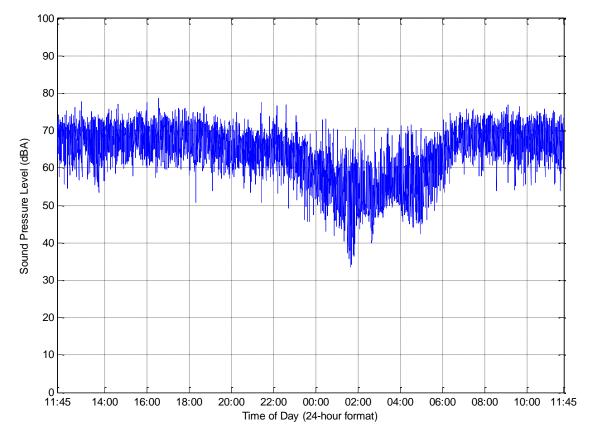


Figure 34. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 18

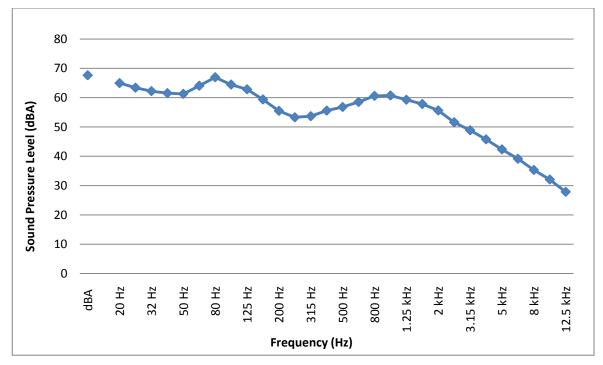


Figure 35. 24-Hour 1/3 Octave Band Levels at Monitor Location 18



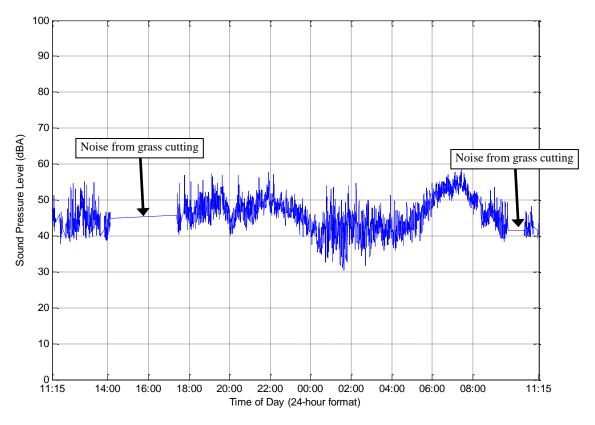


Figure 36. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 19

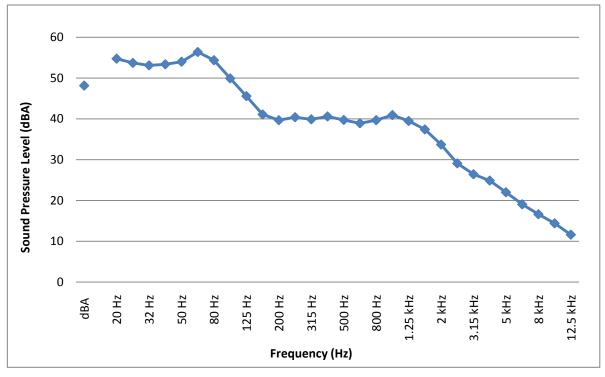


Figure 37. 24-Hour 1/3 Octave Band Leg Sound Levels at Monitor Location 19



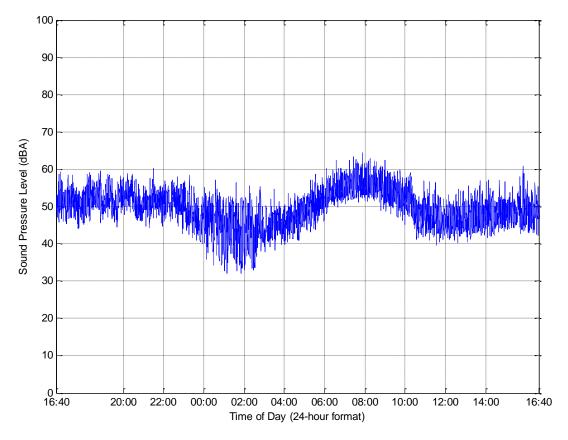
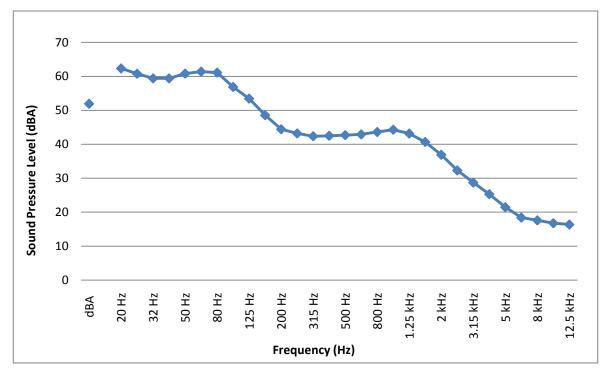


Figure 38. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 20







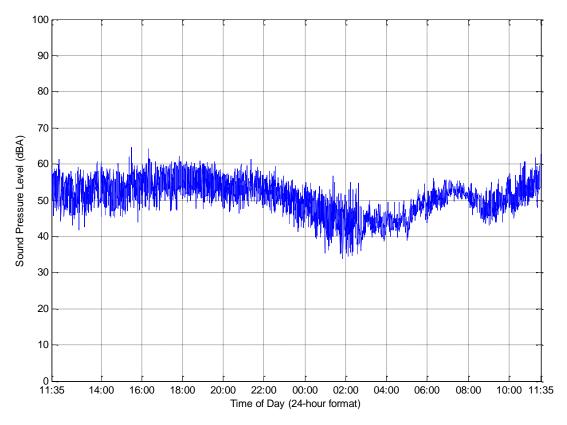


Figure 40. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 21

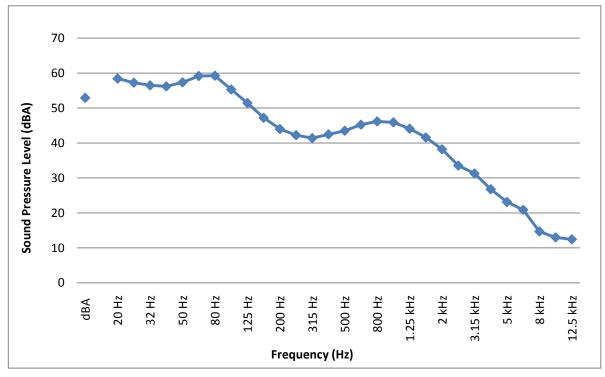


Figure 41. 24-Hour 1/3 Octave Band Levels at Monitor Location 21



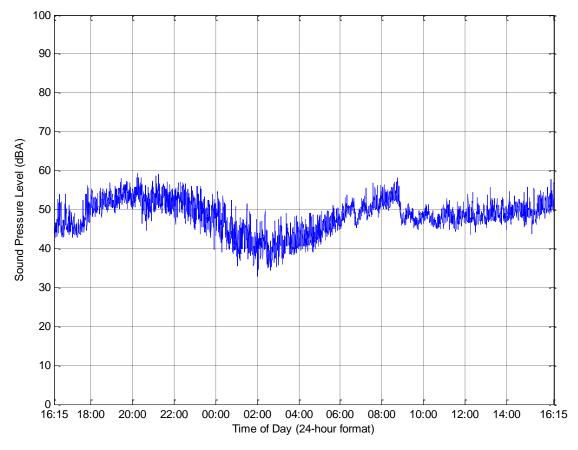


Figure 42. 24-Hour Broadband A-Weighted Leg Sound Levels at Monitor Location 22

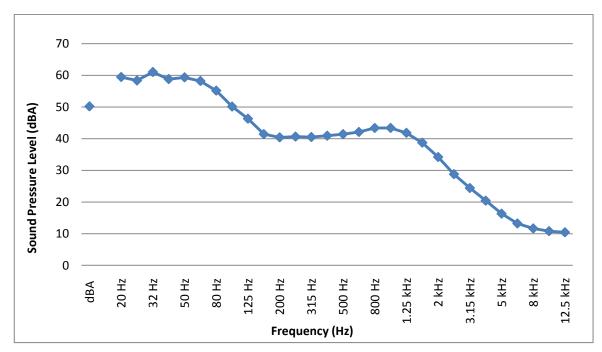


Figure 43. 24-Hour 1/3 Octave Band Leq Sound Levels at Monitor Location 22



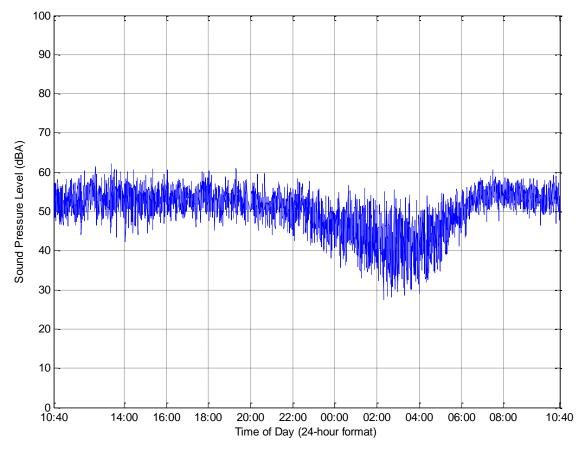


Figure 44. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 23

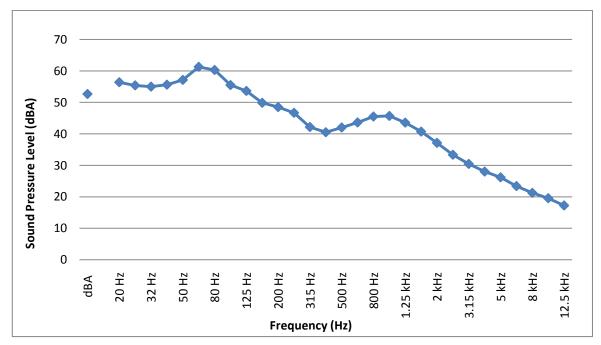


Figure 45. 24-Hour 1/3 Octave Band Leg Sound Levels at Monitor Location 23



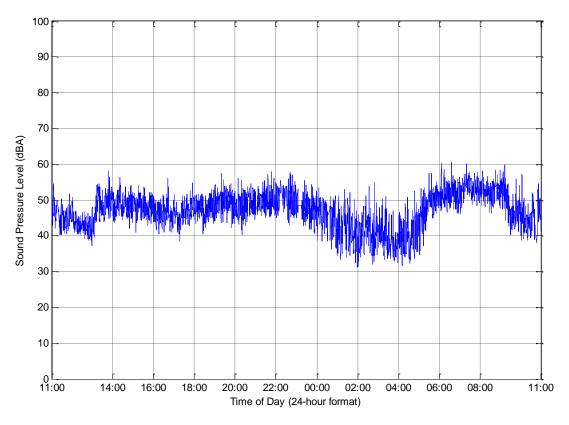


Figure 46. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 24

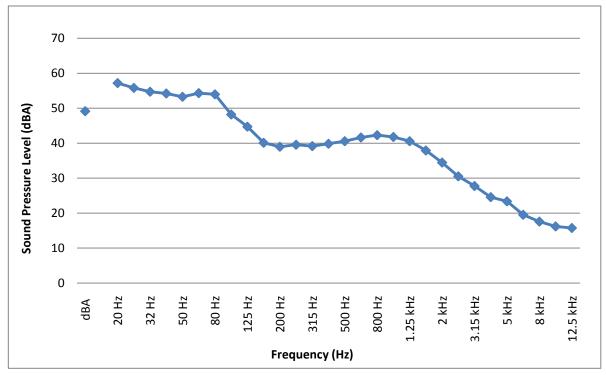


Figure 47. 24-Hour 1/3 Octave Band Leg Sound Levels at Monitor Location 24



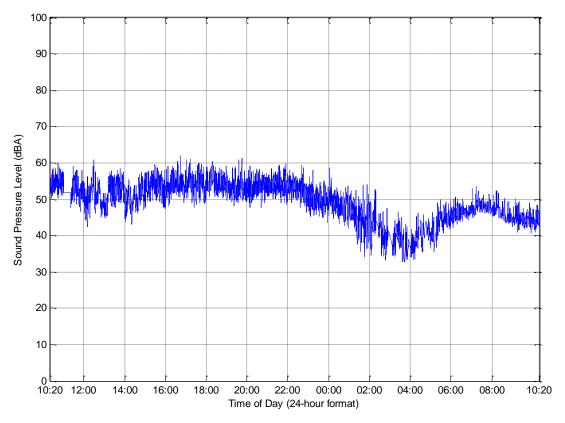


Figure 48. 24-Hour Broadband A-Weighted Leq Sound Levels at Monitor Location 25

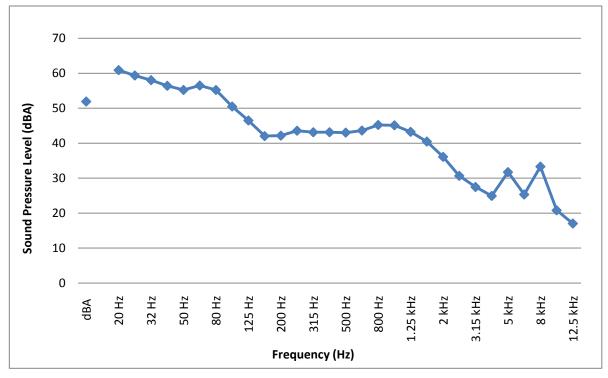


Figure 49. 24-Hour 1/3 Octave Band Leg Sound Levels at Monitor Location 25



Appendix I. MEASUREMENT EQUIPMENT USED

Brüel and Kjær 2250/2270 (Unit 1 / Unit 2/ Unit 3/ Unit 4 / Unit 5 / Unit 6 / Unit 7)

The environmental noise monitoring equipment used during the monitorings consisted of a Brüel and Kjær Type 2250 Precision Integrating Sound Level Meter enclosed in an environmental case, a tripod, a weather protective microphone hood. The system acquired data in 15-second L_{eq} samples using 1/3 octave band frequency analysis and overall A-weighted and C-weighted sound levels. The sound level meter conforms to Type 1, ANSI S1.4, ANSI S1.43, IEC 61672-1, IEC 60651, IEC 60804 and DIN 45657. The 1/3 octave filters conform to S1.11 – Type 0-C, and IEC 61260 – Class 0. The calibrator conforms to IEC 942 and ANSI S1.40. The sound level meter, pre-amplifier and microphone were certified on May 29, 2009 / May 15, 2009 / November 2, 2009 / August 13, 2008 / October 27, 2008 / October 27, 2008 / June 29, 2010 and the calibrator (type B&K 4231) was certified on June 21, 2010 / June 21, 2010 / November 2, 2009 / November 3, 2009 / November 2, 2009 / November 3, 2009 / November 2, 2009 / Novemb

Brüel and Kjær 2260

The environmental noise monitoring equipment used during the monitorings consisted of a Brüel and Kjær Type 2260 Precision Integrating Sound Level Meter enclosed in an environmental case, a tripod, a weather protective microphone hood, and an external battery. The system acquired data in 15-second L_{eq} samples using 1/3 octave band frequency analysis and overall A-weighted and C-weighted sound levels. The sound level meter conforms to Type 1, ANSI S1.4, ANSI S1.43, IEC 61672-1, IEC 60651, IEC 60804 and DIN 45657. The 1/3 octave filters conform to S1.11 – Type 0-C, and IEC 61260 – Class 0. The calibrator conforms to IEC 942 and ANSI S1.40. The sound level meter, pre-amplifier, and microphone were certified on January 16, 2009 by a NIST NVLAP Accredited Calibration Laboratory for all requirements of ISO 17025: 1999 and relevant requirements of ISO 9002:1994, ISO 9001:2000 and ANSI/NCSL Z540: 1994 Part 1. Simultaneous digital audio recording was conducted with a Marantz PMD-670 professional grade audio recorder utilizing a sample rate of 48 kHz and an MP3 conversion rate of 80 kbps. The audio signal was passed directly from the sound level meter. Refer to the next section in the Appendix for a detailed description of the various acoustical descriptive terms used.



		_	-			
Description	Date	Time	Pre / Post	Calibration Level	Calibrator Model	Serial Number
Location #10 Noise Monitor	October 21 2010	17:10	Pre	93.9 dBA	B&K 4231	2575493
Location #10 Noise Monitor	October 22 2010	17:15	Post	93.8 dBA	B&K 4231	2575493
Location #11 Noise Monitor	luby 20, 2010	12:50	Pre	93.9 dBA	B&K 4231	2575402
Location #11 Noise Monitor	July 29 2010	12:50	Post	93.9 dBA 93.9 dBA	B&K 4231 B&K 4231	2575493 2575493
Location #11 Noise Monitor	July 30 2010	13.00	FUSI	93.9 UDA	Dan 4231	2575495
Location #12 Noise Monitor	June 28 2010	13:30	Pre	93.9 dBA	B&K 4231	2575493
Location #12 Noise Monitor	June 29 2010	13:35	Post	93.9 dBA	B&K 4231	2575493
Lagation #12 Naion Manitar	lune 28 2010	12:55	Dro		B&K 4231	2575402
Location #13 Noise Monitor	June 28 2010 June 29 2010	12.55	Pre	93.9 dBA 93.8 dBA	B&K 4231 B&K 4231	2575493 2575493
Location #13 Noise Monitor	Julie 29 2010	13.00	Post	93.0 UDA	Dan 4231	2575495
Location #14 Noise Monitor	September 9 2010	15:35	Pre	93.9 dBA	B&K 4231	2656414
Location #14 Noise Monitor	September 10 2010	15:45	Post	93.8 dBA	B&K 4231	2656414
Location #15 Noise Monitor	July 29 2010	12:00	Pre	93.9 dBA	B&K 4231	2575493
Location #15 Noise Monitor	July 30 2010	12:20	Post	93.9 dBA	B&K 4231	2575493
Location #16 Noise Monitor	June 28 2010	12:20	Pre	93.9 dBA	B&K 4231	2575493
Location #16 Noise Monitor	June 29 2010	12:25	Post	93.8 dBA	B&K 4231	2575493
Location #17 Noise Monitor	September 9 2010	11:25	Pre	93.9 dBA	B&K 4231	2656414
Location #17 Noise Monitor	September 10 2010	11:40	Post	93.8 dBA	B&K 4231	2656414
		44.00	_	00.0.154		0575400
Location #18 Noise Monitor	July 29 2010	11:30	Pre	93.9 dBA	B&K 4231	2575493
Location #18 Noise Monitor	July 30 2010	11:55	Post	93.9 dBA	B&K 4231	2575493
Location #19 Noise Monitor	July 29 2010	11:05	Pre	93.9 dBA	B&K 4231	2478139
Location #19 Noise Monitor	July 30 2010	11:30	Post	93.8 dBA	B&K 4231	2478139
Location #20 Noise Monitor	October 21 2010	16:35	Pre	93.9 dBA	B&K 4231	2656414
Location #20 Noise Monitor	October 22 2010	16:45	Post	93.8 dBA	B&K 4231	2656414
Location #21 Noise Monitor	June 28 2010	11:35	Pre	93.9 dBA	B&K 4231	2575493
Location #21 Noise Monitor	June 29 2010	11:40	Post	93.8 dBA	B&K 4231	2575493
Location #22 Noise Monitor	October 21 2010	16:15	Pre	93.9 dBA	B&K 4231	2656414
Location #22 Noise Monitor	October 22 2010	16:20	Post	93.8 dBA	B&K 4231	2656414
Lapotion #00 Nation Marily	Contorritory 0.0040	10.00	Dec	02.0 -10.4		0050444
Location #23 Noise Monitor	September 9 2010	10:30	Pre	93.9 dBA	B&K 4231	2656414
Location #23 Noise Monitor	September 10 2010	11:55	Post	93.7 dBA	B&K 4231	2656414

Record of Calibration Results



Location #24 Noise Monitor	June 28 2010	10:55	Pre	93.9 dBA	B&K 4231	2575493
Location #24 Noise Monitor	June 29 2010	11:10	Post	93.9 dBA	B&K 4231	2575493
Location #25 Noise Monitor	June 28 2010	10:00	Pre	93.9 dBA	B&K 4231	2575493
Location #25 Noise Monitor	June 29 2010	10:45	Post	93.8 dBA	B&K 4231	2575493

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Instrument: Model: Manufacturer: Serial number:	2250 Brüel 24884		r	-1122	Date Calibra Status: In tolerance: Out of tolera See comment	Received X unce:	29/2009 Sent X
Tested with: Type (class):			189 s/n 24' C0032 s/n		Contains nor	n-accredited tests: service: <u>Basic</u>	
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		Pressure Ir Humidity	& Temp.	790/00-04 V3820001	Nov 21, 2008 May 7, 2008	Vaisala / A2LA	Nov 7, 2009
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<u>B&K 2250/2270 Unit #1 Microphone Calibration Certificate</u>

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483B-Norsonic	SME Cal Unit	25747	Jan 2, 2009	Scantek,	Inc./NVLAP	Jan 2, 2010
483B-Norsonic DS-360-SRS	Function Generator	61646	Nov 19, 2007	Scantek, Davis Ind	Inc./NVLAP otek / A2LA	Jan 2, 2010 Nov 19, 2009
483B-Norsonic DS-360-SRS 34401A-Agilent Technologies	Function Generator Digital Multimeter	61646 MY41022043	Nov 19, 2007 Nov 13, 2008	Scantek, Davis Ind Transcat	Inc./NVLAP otek / A2LA : / NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009
483B-Norsonic DS-360-SRS	Function Generator	61646	Nov 19, 2007	Scantek, Davis Ind Transcat	Inc./NVLAP otek / A2LA / NVLAP / NVLAP	Jan 2, 2010 Nov 19, 2009
483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic	Function Generator Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software	61646 MY41022043 790/00-04 V3820001 v.46	Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 May 7, 2008 Validated Feb 2006	Scantek, Davis Ind Transcat Transcat Vaisala /	. Inc./NVLAP otek / A2LA : / NVLAP : / NVLAP A2LA	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009 -
483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic 1253-Norsonic	Function Generator Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software Calibrator	61646 MY41022043 790/00-04 V3820001 v.46 28326	Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 May 7, 2008 Validated Feb 2006 Feb 16, 2009	Scantek, Davis Ind Transcat Transcat Vaisala / - Scantek	Inc./NVLAP otek / A2LA / NVLAP / NVLAP A2LA , Inc. / NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009 - Feb 16, 2010
483B-Norsonic DS-360-SRS 34401A-Agilent Technologies DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic 1253-Norsonic 1203-Norsonic	Function Generator Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software Calibrator Preamplifier	61646 MY41022043 790/00-04 V3820001 v.46 28326 14051	Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 May 7, 2008 Validated Feb 2006 Feb 16, 2009 Jan 2, 2009	Scantek, Davis Ind Transcat Transcat Vaisala / - Scantek Scantek,	Inc./NVLAP otek / A2LA / NVLAP / NVLAP A2LA , Inc. / NVLAP Inc./ NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009 - Feb 16, 2010 Jan 2, 2010
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DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP PC Program 1018 Norsonic	Digital Voltmeter Meteo Station Audio Analyzer Calibration software	1040170/39633 2514A05691 v.5.0	Jul 10, 2009 Jan 2, 2008 Validated July 2009	Transcat / A	A2LA	- 18
DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP PC Program 1018 Norsonic 1253-Norsonic	Digital Voltmeter Meteo Station Audio Analyzer Calibration software Calibrator	1040170/39633 2514A05691 v.5.0 31959	Jul 10, 2009 Jan 2, 2008 Validated	Transcat / A - Scantek, In	A2LA c./ NVLAP	- Dec 7, 2010
DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP PC Program 1018 Norsonic	Digital Voltmeter Meteo Station Audio Analyzer Calibration software	1040170/39633 2514A05691 v.5.0	Jul 10, 2009 Jan 2, 2008 Validated July 2009 Dec 7, 2009	Transcat / A - Scantek, In Scantek, In	A2LA c./ NVLAP c./ NVLAP	- 18
DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP PC Program 1018 Norsonic 1253-Norsonic 1203-Norsonic 4180-Bruel&Kjaer Instrumentation and fi standards maintained	Digital Voltmeter Meteo Station Audio Analyzer Calibration software Calibrator Preamplifier Microphone est results are tr by NIST (USA) a	1040170/39633 2514A05691 v.5.0 31959 14059 2246115 raceable to \$ and NPL (UK	Jul 10, 2009 Jan 2, 2008 Validated July 2009 Dec 7, 2009 Jan 4, 2010 Dec 14, 2009 SI (Internati	Transcat / / - Scantek, In Scantek, In NPL (UK) /	a2LA c./ NVLAP c./ NVLAP UKAS em of Units	- Dec 7, 2010 Jan 4, 2011 Dec 14, 2011 s) through
DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP PC Program 1018 Norsonic 1253-Norsonic 1203-Norsonic 4180-Bruel&Kjaer Instrumentation and fi standards maintained Calibrated by	Digital Voltmeter Meteo Station Audio Analyzer Calibration software Calibrator Preamplifier Microphone	1040170/39633 2514A05691 v.5.0 31959 14059 2246115 raceable to \$ and NPL (UK	Jul 10, 2009 Jan 2, 2008 Validated July 2009 Dec 7, 2009 Jan 4, 2010 Dec 14, 2009 SI (Internati Checked	Transcat / / - Scantek, In Scantek, In NPL (UK) / onal Syste	A2LA c./ NVLAP c./ NVLAP UKAS	- Dec 7, 2010 Jan 4, 2011 Dec 14, 2011 s) through
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<u>B&K 2250/2270 Unit #1 Calibrator Calibration Certificate</u>



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Model:	2250 Duii d	d View			Status: In tolerance:	2 - CO - D - 	eceived X	SentX
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Type (class):	1				Calibration s	ervice:	Basic X	Standard
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Tel/Fax:	780-4	14-6373/ -	6376				, Alberta T6E 0G9	
Instrumentati Instrumen	t -		bration:	Nor-1504 No s/N	Cal. Date	Traceab	ility evidence	Cal. Due
Manufactur	rer	SME Cal U		25747	Jan 2, 2009		/ Accreditation	Jan 2, 2010
483B-Norsonic DS-360-SRS		Function G		61646	Nov 19, 2007		ek / A2LA	Nov 19, 2009
34401A-Agilent Tec	hnologies	Digital Mu		MY41022043	Nov 13, 2008	Transcat /	NVLAP	Nov 13, 2009
DPI 141-Druck	5	Pressure In	dicator	790/00-04	Nov 21, 2008	Transcat /	NVLAP	Nov 21, 2010
HMP233-Vaisala Oy	ij	Humidity & Transmitter		V3820001	May 7, 2008	Vaisala / A	A2LA	Nov 7, 2009
	orsonic	Calibration	software	v.46	Validated Dec 2006	-		
PC Program 1019 N		Calibrator		25726	Jan 2, 2009	Scantek, I	nc./NVLAP	Jan 2, 2010
1253-Norsonic		toot root	ulto aro ti	raceable to	SI (Internation	nal Syst	em of Units) through
1253-Norsonic Instrumentati standards ma	aintaine	d by NIS	T (USA)	and NPL (U	K).			
1253-Norsonic Instrumentati standards ma Environment	aintaine al cond	d by NIS itions:	T (USA)	and NPL (U	K).	Rela	ative Humidit	y (%)
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ACCREDITED by NV	ments of ISO 9002:1 LAP (an ILAC and gnatory)		N	VLAP Lat	b Code: 20062	5-0
Calib	oration (Certifi	icate I	No.1	19786	
Instrument: Micro Model: 4189 Manufacturer: Brüel Serial number: 25737	& Kjær		Date Calibrat Status: In tolerance: Out of toleran See comments Contains non-	R	5/15/200 eceived X X d tests:Yes	Sent X
	tical Consultants In 4-6373/ -6376	nc.	E	dmonton	9920-63 Ave , Alberta T6E 0G9	
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		N-1504 Nors	sonic Test Sys	stem: Traceat Cal. Lab	oility evidence	Cal. Due Jan 2, 2010
Instrument - Manufacturer	Description SME Cal Unit Function Generator	N-1504 Nors S/N 25747 61646	Cal. Date Jan 2, 2009 Nov 19, 2007	Stem: Traceat Cal. Lab Scantek, Davis Inc	ility evidence / Accreditation Inc./NVLAP itek / A2LA	Jan 2, 2010 Nov 19, 2009
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologie	Description SME Cal Unit Function Generator s Digital Multimeter	N-1504 Nors S/N 25747 61646 MY41022043	Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008	Stem: Traceat Cal. Lab Scantek, Davis Ino Transcat	ility evidence / Accreditation Inc./NVLAP tek / A2LA / NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologie DPI 141-Druck	Description SME Cal Unit Function Generator s Digital Multimeter Pressure Indicator	N-1504 Nors S/N 25747 61646 MY41022043 790/00-04	Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008	Stem: Traceate Cal. Lab Scantek, Davis Ino Transcate Transcate	ility evidence / Accreditation Inc./NVLAP tek / A2LA / NVLAP / NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologie DPI 141-Druck HMP233-Vaisala Oyj	Description SME Cal Unit Function Generator s Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter	N-1504 Nors S/N 25747 61646 MY41022043 790/00-04 V3820001	Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 May 7, 2008 Validated Feb	Stem: Traceat Cal. Lab Scantek, Davis Ino Transcat	ility evidence / Accreditation Inc./NVLAP tek / A2LA / NVLAP / NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologie DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic	Description SME Cal Unit Function Generator s Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software	N-1504 Nors S/N 25747 61646 MY41022043 790/00-04 V3820001 v.46	Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 May 7, 2008 Validated Feb 2006	Stem: Traceat Cal. Lab Scantek, Davis Ino Transcat Transcat Vaisala / -	hility evidence / Accreditation Inc./NVLAP tek / A2LA / NVLAP / NVLAP A2LA	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologie DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic 1253-Norsonic	Description SME Cal Unit Function Generator s Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software Calibrator	N-1504 Nors S/N 25747 61646 MY41022043 790/00-04 V3820001 v.46 28326	Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 May 7, 2008 Validated Feb 2006 Feb 16, 2009	stem: Traceat Cal. Lab Scantek, Davis Ino Transcat Transcat Vaisala / - Scantek,	hility evidence / Accreditation Inc./NVLAP tek / A2LA / NVLAP / NVLAP A2LA , Inc. / NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009 - Feb 16, 2010
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologie DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic 1253-Norsonic 1203-Norsonic	Description SME Cal Unit Function Generator s Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software Calibrator Preamplifier	N-1504 Nors S/N 25747 61646 MY41022043 790/00-04 V3820001 v.46 28326 14051	Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 May 7, 2008 Validated Feb 2006 Feb 16, 2009 Jan 2, 2009	stem: Traceata Cal. Lab Scantek, Davis Inco Transcat Transcat Vaisala / Scantek, Scantek,	hility evidence / Accreditation Inc./NVLAP tek / A2LA / NVLAP / NVLAP A2LA , Inc. / NVLAP Inc./ NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009 - Feb 16, 2010 Jan 2, 2010
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologie DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic 1253-Norsonic 1203-Norsonic 4180-Bruel&Kjaer Instrumentation and by NPL (UK) and NIS	Description SME Cal Unit Function Generator s Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software Calibrator Preamplifier Microphone test results are tr T (USA)	N-1504 Nors S/N 25747 61646 MY41022043 790/00-04 V3820001 v.46 28326 14051 2246115	Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 May 7, 2008 Validated Feb 2006 Feb 16, 2009 Jan 2, 2009 Mar 7, 2008	stem: Traceat Cal. Lab Scantek, Davis Inc Transcat Transcat Vaisala / Scantek, Scantek, NPL (UK rough state)	hility evidence / Accreditation Inc./NVLAP tek / A2LA / NVLAP / NVLAP A2LA , Inc. / NVLAP Inc./ NVLAP) / UKAS andards mai	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009 - Feb 16, 2010 Jan 2, 2010 Mar 7, 2010 ntained
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologie DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic 1253-Norsonic 1203-Norsonic 4180-Bruel&Kjaer Instrumentation and by NPL (UK) and NIS Calibrated by	Description SME Cal Unit Function Generator s Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software Calibrator Preamplifier Microphone test results are tr	N-1504 Nors S/N 25747 61646 MY41022043 790/00-04 V3820001 v.46 28326 14051 2246115	Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 May 7, 2008 Validated Feb 2006 Feb 16, 2009 Jan 2, 2009 Mar 7, 2008 SI - BIPM thr Checked	stem: Traceat Cal. Lab Scantek, Davis Inc Transcat Transcat Vaisala / Scantek, Scantek, NPL (UK rough states)	hility evidence / Accreditation Inc./NVLAP tek / A2LA / NVLAP / NVLAP A2LA , Inc. / NVLAP Inc./ NVLAP Inc./ NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009 - Feb 16, 2010 Jan 2, 2010 Mar 7, 2010 ntained
Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent Technologie DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic 1253-Norsonic 1203-Norsonic 4180-Bruel&Kjaer Instrumentation and by NPL (UK) and NIS Calibrated by Signature	Description SME Cal Unit Function Generator s Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software Calibrator Preamplifier Microphone test results are tr T (USA)	N-1504 Nors S/N 25747 61646 MY41022043 790/00-04 V3820001 v.46 28326 14051 2246115	Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 May 7, 2008 Validated Feb 2006 Feb 16, 2009 Jan 2, 2009 Mar 7, 2008	stem: Traceat Cal. Lab Scantek, Davis Inc Transcat Transcat Vaisala / Scantek, Scantek, NPL (UK rough states)	ility evidence / Accreditation Inc./NVLAP / NVLAP / NVLAP A2LA / Inc. / NVLAP Inc./ NVLAP / UKAS andards mai	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009 - Feb 16, 2010 Jan 2, 2010 Mar 7, 2010 ntained Buzduga
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<u>B&K 2250/2270 Unit #2 Calibrator Calibration Certificate</u>

relevant requirements of IS NVLAP (an ILA	SI/NCSL Z540:19 3O 9002:1994 ACCI C and APLAC sign:	REDITED by		NVLAP	Lab Code: 20	00625-0
Calibr	ration C	ertific	ate N	l o.2	1910	
Model: 42 Manufacturer: Bi	coustical Calibrato 31 'üel and Kjær 75493	r	Date Calibra Status: In tolerance: Out of tolera See comment Contains nor	 nce:	6/21/2 Received X d tests:Ye	Sent X
	coustical Consultar 0-414-6373 / -6376		Address:	5031 - 21 Edmonto Canada '	on, Alberta	
Calibration of Acoustic	al Calibrators, Sca	antek Inc., 06	8/06/2005	System:		
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Calibration of Acoustic Instrumentation used Instrument - Manufacture 483B-Norsonic	al Calibrators, Sca I for calibration: I r Description	antek Inc., 06 Nor-1504 No s/N 31052	6/06/2005 orsonic Test Cal. Date	System: Traceabi Cal. Lab /	Accreditation	
Calibration of Acoustic Instrumentation used Instrument - Manufacture 483B-Norsonic DS-360-SRS 34401A-Agilent	al Calibrators, Sca for calibration: Description SME Cal Unit Function Generator Digital Voltmeter	antek Inc., 06 Nor-1504 No <u>\$/N</u> 31052 33584 US36120731	6/06/2005 prsonic Test Cal. Date Jan 20, 2010 Oct 5, 2009 Aug 27, 2009	System: Traceabi Cal. Lab / Scantek, Ir ACR. Env / ACR Env. /	Accreditation nc./NVLAP / A2LA / A2LA	Jan 20, 2011 Oct 5, 2011 Aug 27, 2010
Calibration of Acoustic Instrumentation used Instrument - Manufacture 483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen	al Calibrators, Sca for calibration: Description SME Cal Unit Function Generator Digital Voltmeter Meteo Station	antek Inc., 06 Nor-1504 No 31052 33584 US36120731 1040170/3963	6/06/2005 rsonic Test Cal. Date Jan 20, 2010 Oct 5, 2009 Aug 27, 2009 3Jul 10, 2009	System: Traceabi Cal. Lab / Scantek, Ir ACR. Env / ACR Env / Transcat /	Accreditation nc./NVLAP / A2LA / A2LA A2LA	Jan 20, 2011 Oct 5, 2011 Aug 27, 2010 Jul 10, 2010
Calibration of Acoustic Instrumentation used Instrument - Manufacture 483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen	al Calibrators, Sca for calibration: Description SME Cal Unit Function Generator Digital Voltmeter Meteo Station Audio Analyzer	Antek Inc., 06 Nor-1504 No 31052 33584 US36120731 1040170/3963 2514A05691	Group Group <th< td=""><td>System: Traceabi Cal. Lab / Scantek, Ir ACR. Env / ACR Env. /</td><td>Accreditation nc./NVLAP / A2LA / A2LA A2LA</td><td>Jan 20, 2011 Oct 5, 2011 Aug 27, 2010</td></th<>	System: Traceabi Cal. Lab / Scantek, Ir ACR. Env / ACR Env. /	Accreditation nc./NVLAP / A2LA / A2LA A2LA	Jan 20, 2011 Oct 5, 2011 Aug 27, 2010
Calibration of Acoustic Instrumentation used Instrument - Manufacture 483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP	al Calibrators, Sca for calibration: Description SME Cal Unit Function Generator Digital Voltmeter Meteo Station	Antek Inc., 06 Nor-1504 No 31052 33584 US36120731 1040170/3963 2514A05691	Group Group <th< td=""><td>System: Traceabi Cal. Lab / Scantek, Ir ACR. Env / ACR Env / Transcat /</td><td>Accreditation nc./NVLAP / A2LA / A2LA A2LA</td><td>Jan 20, 2011 Oct 5, 2011 Aug 27, 2010 Jul 10, 2010</td></th<>	System: Traceabi Cal. Lab / Scantek, Ir ACR. Env / ACR Env / Transcat /	Accreditation nc./NVLAP / A2LA / A2LA A2LA	Jan 20, 2011 Oct 5, 2011 Aug 27, 2010 Jul 10, 2010
Calibration of Acoustic Instrumentation used Instrument - Manufacture 483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP	al Calibrators, Sca for calibration: Description SME Cal Unit Function Generator Digital Voltmeter Meteo Station Audio Analyzer	Antek Inc., 06 Nor-1504 No 31052 33584 US36120731 1040170/3963 2514A05691	Group Group <th< td=""><td>System: Traceabi Cal. Lab / Scantek, Irr ACR. Env / ACR Env / Transcat / Transcat / - Scantek, Ir</td><td>Accreditation nc./NVLAP / A2LA / A2LA A2LA A2LA A2LA nc./ NVLAP</td><td>Jan 20, 2011 Oct 5, 2011 Aug 27, 2010 Jul 10, 2010</td></th<>	System: Traceabi Cal. Lab / Scantek, Irr ACR. Env / ACR Env / Transcat / Transcat / - Scantek, Ir	Accreditation nc./NVLAP / A2LA / A2LA A2LA A2LA A2LA nc./ NVLAP	Jan 20, 2011 Oct 5, 2011 Aug 27, 2010 Jul 10, 2010
Calibration of Acoustic Instrumentation used Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP PC Program 1018 Norsonic 1253-Norsonic 1203-Norsonic	al Calibrators, Sca for calibration: I Description SME Cal Unit Function Generator Digital Voltmeter Meteo Station Audio Analyzer Calibration software Calibrator Preamplifier	Antek Inc., 06 Nor-1504 No 31052 33584 US36120731 1040170/3963 2514A05691 v.5.0 31959 14059	Group Group <th< td=""><td>System: Traceabi Cal. Lab / Scantek, Ir ACR. Env. / ACR. Env. / ACR. Env. / Transcat / Transcat / Scantek, Ir Scantek, Ir</td><td>Accreditation nc./NVLAP / A2LA / A2LA A2LA A2LA A2LA A2LA nc./ NVLAP nc./ NVLAP</td><td>Jan 20, 2011 Oct 5, 2011 Aug 27, 2010 Jul 10, 2010 Jan 2, 2011 - Dec 7, 2010 Jan 4, 2011</td></th<>	System: Traceabi Cal. Lab / Scantek, Ir ACR. Env. / ACR. Env. / ACR. Env. / Transcat / Transcat / Scantek, Ir Scantek, Ir	Accreditation nc./NVLAP / A2LA / A2LA A2LA A2LA A2LA A2LA nc./ NVLAP nc./ NVLAP	Jan 20, 2011 Oct 5, 2011 Aug 27, 2010 Jul 10, 2010 Jan 2, 2011 - Dec 7, 2010 Jan 4, 2011
Calibration of Acoustic Instrumentation used Instrument - Manufacturer 483B-Norsonic DS-360-SRS 34401A-Agilent HM30-Thommen 8903-HP PC Program 1018 Norsonic 1253-Norsonic 1203-Norsonic	al Calibrators, Sca for calibration: I Description SME Cal Unit Function Generator Digital Voltmeter Meteo Station Audio Analyzer Calibration software Calibrator	Antek Inc., 06 Nor-1504 No 31052 33584 US36120731 1040170/3963 2514A05691 20.5.0 31959	Group Group <th< th=""><th>System: Traceabi Cal. Lab / Scantek, Ir ACR. Env. / ACR. Env. / ACR. Env. / Transcat / Transcat / Scantek, Ir Scantek, Ir</th><th>Accreditation nc./NVLAP / A2LA / A2LA A2LA A2LA A2LA A2LA nc./ NVLAP nc./ NVLAP</th><th>Jan 20, 2011 Oct 5, 2011 Aug 27, 2010 Jul 10, 2010 Jan 2, 2011 - Dec 7, 2010</th></th<>	System: Traceabi Cal. Lab / Scantek, Ir ACR. Env. / ACR. Env. / ACR. Env. / Transcat / Transcat / Scantek, Ir Scantek, Ir	Accreditation nc./NVLAP / A2LA / A2LA A2LA A2LA A2LA A2LA nc./ NVLAP nc./ NVLAP	Jan 20, 2011 Oct 5, 2011 Aug 27, 2010 Jul 10, 2010 Jan 2, 2011 - Dec 7, 2010
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		d APLAC				NVLAP La	ib Code: 20	00625-0
Instrument: S Model: 2	Sound 2250	Level Me	ter	Certifi	Date Calil Status:	brated: R	11/2/. eceived	2009 Sent
Serial number: 2 Tested with: N	260049 Micro Pream	and Kjær 98 phone 413 plifier ZC	89 s/n 2			erance:		
		tical Cons	ultants	Inc.		Suite 107, 9	920-63 A	
Tel/Fax: 7	780-41	4-6373/ -6	6376			Edmonton, CANADA		
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Calibration of SLM & Dosime	Sound eters -	Level Met - Acoustica I for calib	ers, Sca Il Tests, pration ption	antek Inc., 06/ Scantek Inc., Nor-1504 N	07/2005 06/15/2005 Norsonic Test	System:	creditation	Cal. Due Jan 2, 2010
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Calil	oration (Certifi	cate I	No.2	20670	-
Instrument: Micro	phone		Date Calibrat	ed:	11/2/200	19
Model: 4189			Status:	R	leceived	Sent
Manufacturer: Brüel Serial number: 25956	& Kjær		In tolerance: Out of toleran		X	X
Serua number: 23930	51		See comments			
					d tests:Yes	X No
Customer: Acou	tical Consultants In	nc.	Address: S	uite 107,	9920-63 Ave	
Tel/Fax: 780-4	14-6373/ -6376				, Alberta	
			C	ANADA	T6E 0G9	
Tested in accordanc Procedure for Ca Instrumentation use	ibration of Measure	ement Micro	phones, Scar	ntek Inc.,	06/15/2005	
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Procedure for Ca Instrumentation use Instrument - Manufacturer 483B-Norsonic DS-360-SRS	ibration of Measure d for calibration: I Description SME Cal Unit Function Generator	ement Micro N-1504 Nors s/N 25747 61646	phones, Scar sonic Test Sy: Cal. Date Jan 2, 2009 Nov 19, 2007	stem: Traceat Cal. Lab Scantek, Davis Inc	bility evidence / Accreditation Inc./NVLAP btek / A2LA	Jan 2, 2010 Nov 19, 2009
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Procedure for Ca Instrumentation use Instrument - Manufacturen 483B-Norsonic DS-360-SRS 34401A-Agilent Technologie DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic 1253-Norsonic	bration of Measure d for calibration: I Description SME Cal Unit Function Generator Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software Calibrator	ement Micro N-1504 Nors S/N 25747 61646 MY41022043 790/00-04 V3820001 v.46 28326	phones, Scar sonic Test Sy: Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 May 7, 2008 Validated Feb 2006 Feb 16, 2009	tek Inc., stem: Cal. Lab Scantek, Davis Inc Transcat Transcat Vaisala / - Scantek	hility evidence / Accreditation Inc./NVLAP tek / A2LA / NVLAP / NVLAP A2LA , Inc. / NVLAP	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009 - Feb 16, 2010
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Procedure for Ca Instrumentation use Instrument - Manufacturen 483B-Norsonic DS-360-SRS 34401A-Agilent Technologie DPI 141-Druck HMP233-Vaisala Oyj PC Program 1017 Norsonic 1253-Norsonic 1253-Norsonic 1203-Norsonic 4180-Bruel&Kjaer Instrumentation and by NPL (UK) and NIS	ibration of Measure d for calibration: I Description SME Cal Unit Function Generator is Digital Multimeter Pressure Indicator Humidity & Temp. Transmitter Calibration software Calibrator Preamplifier Microphone test results are tr	ement Micro N-1504 Nors S/N 25747 61646 MY41022043 790/00-04 V3820001 v.46 28326 14051 2246115 raceable to	phones, Scar conic Test Sys Cal. Date Jan 2, 2009 Nov 19, 2007 Nov 13, 2008 Nov 21, 2008 May 7, 2008 Validated Feb 2006 Feb 16, 2009 Jan 2, 2009 Mar 7, 2008 SI - BIPM thr	tek Inc., stem: Traceat Cal. Lab Scantek, Davis Inc Transcat Transcat Vaisala / - Scantek, Scantek, NPL (UK	hility evidence / Accreditation Inc./NVLAP / NVLAP / NVLAP A2LA , Inc. / NVLAP Inc./ NVLAP Inc./ NVLAP) / UKAS andards mai	Jan 2, 2010 Nov 19, 2009 Nov 13, 2009 Nov 21, 2010 Nov 7, 2009 - Feb 16, 2010 Jan 2, 2010 Mar 7, 2010 ntained
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B&K 2250/2270 Unit #4 Calibration Certificate(s)





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	nents of ISO 9002 ED by NVLAP	: 1994			P Lab Code: 2	
	applace signatory		cate I			
	oustical Calibrat		Date Calibr		11/2/	2000
Model: 42		or	Status:	alea.	Received	Sent
Manufacturer: Br	üel and Kjær		In tolerance	a: —	X	X
	42956		Out of toler	20		
Class (IEC 60942): 1			See commer			
Barometer type: Barometer s/n:			Contains no	on-accredit	ed tests: <u>Y</u>	es X No
	oustical Consulta 0-414-6373/ -6376		Address:	Edmon	07, 9920-63 ton, Alberta DA T6E 0G9	Ave
Tested in accordance Calibration of Acoustica	al Calibrators, So	antek Inc., 0	06/06/2005			
	al Calibrators, So	antek Inc., 0	06/06/2005	t System: Traceabi	lity evidence Accreditation	Cal. Due
Calibration of Acoustica Instrumentation used Instrument - Manufacturer 483B-Norsonic	al Calibrators, So for calibration: Description SME Cal Unit	cantek Inc., 0 Nor-1504 N <u>S/N</u> 25747	06/06/2005 lorsonic Test Cal. Date Jan 2, 2009	t System: Traceabi Cal. Lab / Scantek, In	Accreditation c./NVLAP	Jan 2, 2010
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B&K 2250/2270 Unit #4 Calibrator Calibration Certificate

B&K 2250/2270 Unit #5 Calibration Certificate(s)











<u>B&K 2250/2270 Unit #6 Calibration Certificate(s)</u>





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B&K 2250/2270 Unit #7 Calibrator Calibration Certificate

MANUFACTURER'S CERTIFICATE OF CONFORMANCE

We certify that Brüel & Kjær -2250--- Serial No. 2722859 has been tested and passed all production tests, confirming compliance with the manufacturer's published specification at the date of the test.

The final test has been performed using calibrated equipment, traceable to National or International Standards or by ratio measurements.

Brüel & Kjær is certified under ISO 9001:2008 assuring that all test data is retained on file and is available for inspection upon request.

Nærum 29-jun-2010

Vice President, Operations

Torben Bjørn

arly

Please note that this document is not a calibration certificate. For information on our calibration services please contact your nearest Brüel & Kjær office.

HEADQUARTERS: Brüel & Kjær Sound & Vibration Measurement A/S - DK-2850 Nærum - Denmark Telephone: +45 77412000 - Fax: +45 45801405 - www.bksv.com - info@bksv.com Local representatives and service organisations worldwide



Bruel & Kjær Serial No:	Prepolarized 1/2" Microphe Calibration Chart 2710791	Free- one T	field ype 4189
Open-circuit Sensitiv	vity*, So:	-26.1	dB re 1V/Pa
Equivalent to:			mV/Pa
Uncertainty, 95 %	confidence level	0.2	dB
Capacitance:		12.8	pF
Valid At: Temperature: Ambient Static Pr Relative Humidity Frequency: Polarization Volta;	:	23 101.3 50 251.2 0	%
Sensitivity Traceable DPLA: Danish Pri	-	tics	IV LISA
IEC 61094-4: Type W			,,
Environmental Calibr 101.5 kPa			
Procedure: 704215	Date: 29. Jun. 2010	Signa	ture: S.L.
*K ₀ = - 26 - S ₀ Exam	ple: K ₀ = - 26 - (- 26.2)		



B&K 2260 SLM Calibration Certificate









Appendix II. THE ASSESSMENT OF ENVIRONMENTAL NOISE (GENERAL)

Sound Pressure Level

Sound pressure is initially measured in Pascal's (Pa). Humans can hear several orders of magnitude in sound pressure levels, so a more convenient scale is used. This scale is known as the decibel (dB) scale, named after Alexander Graham Bell (telephone guy). It is a base 10 logarithmic scale. When we measure pressure we typically measure the RMS sound pressure.

$$SPL = 10\log_{10}\left[\frac{P_{RMS}^{2}}{P_{ref}^{2}}\right] = 20\log_{10}\left[\frac{P_{RMS}}{P_{ref}}\right]$$

Where:

SPL = Sound Pressure Level in dB

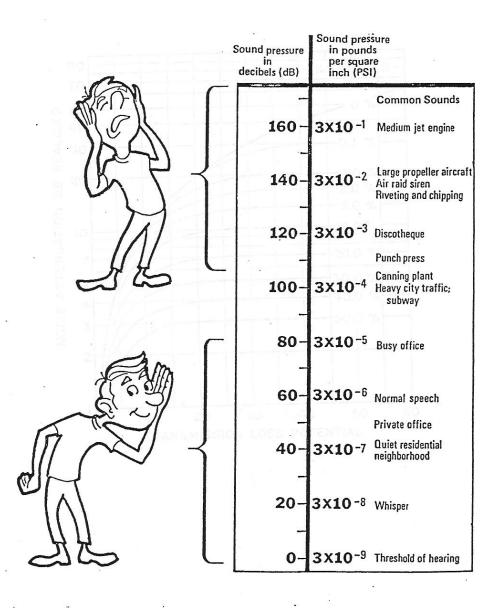
 P_{RMS} = Root Mean Square measured pressure (Pa)

 P_{ref} = Reference sound pressure level ($P_{ref} = 2 \times 10^{-5} \text{ Pa} = 20 \text{ }\mu\text{Pa}$)

This reference sound pressure level is an internationally agreed upon value. It represents the threshold of human hearing for "typical" people based on numerous testing. It is possible to have a threshold which is lower than 20 μ Pa which will result in negative dB levels. As such, zero dB does not mean there is no sound!

In general, a difference of $1 - 2 \, dB$ is the threshold for humans to notice that there has been a change in sound level. A difference of 3 dB (factor of 2 in acoustical energy) is perceptible and a change of 5 dB is strongly perceptible. A change of 10 dB is typically considered a factor of 2. This is quite remarkable when considering that 10 dB is 10-times the acoustical energy!







Frequency

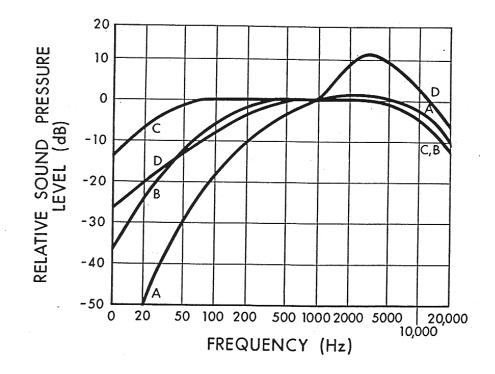
The range of frequencies audible to the human ear ranges from approximately 20 Hz to 20 kHz. Within this range, the human ear does not hear equally at all frequencies. It is not very sensitive to low frequency sounds, is very sensitive to mid frequency sounds and is slightly less sensitive to high frequency sounds. Due to the large frequency range of human hearing, the entire spectrum is often divided into 31 bands, each known as a 1/3 octave band.

The internationally agreed upon center frequencies and upper and lower band limits for the 1/1 (whole octave) and 1/3 octave bands are as follows:

	Whole Octave			1/3 Octave	
Lower Band	Center	Upper Band	Lower Band	Center	Upper Band
Limit	Frequency	Limit	Limit	Frequency	Limit
11	16	22	14.1	16	17.8
			17.8	20	22.4
			22.4	25	28.2
22	31.5	44	28.2	31.5	35.5
			35.5	40	44.7
			44.7	50	56.2
44	63	88	56.2	63	70.8
			70.8	80	89.1
			89.1	100	112
88	125	177	112	125	141
			141	160	178
	250		178	200	224
177		355	224	250	282
			282	315	355
355	500		355	400	447
		710	447	500	562
			562	630	708
			708	800	891
710	1000	1420	891	1000	1122
			1122	1250	1413
			1413	1600	1778
1420	2000	2840	1778	2000	2239
			2239	2500	2818
			2818	3150	3548
2840	4000	5680	3548	4000	4467
			4467	5000	5623
			5623	6300	7079
5680	8000	11360	7079	8000	8913
			8913	10000	11220
			11220	12500	14130
11360	16000	22720	14130	16000	17780
			17780	20000	22390



Human hearing is most sensitive at approximately 3500 Hz which corresponds to the ¹/₄ wavelength of the ear canal (approximately 2.5 cm). Because of this range of sensitivity to various frequencies, we typically apply various weighting networks to the broadband measured sound to more appropriately account for the way humans hear. By default, the most common weighting network used is the so-called "A-weighting". It can be seen in the figure that the low frequency sounds are reduced significantly with the A-weighting.



Combination of Sounds

When combining multiple sound sources the general equation is:

$$\Sigma SPL_n = 10\log_{10} \left[\sum_{i=1}^n 10^{\frac{SPL_i}{10}} \right]$$

Examples:

- Two sources of 50 dB each add together to result in 53 dB.
- Three sources of 50 dB each add together to result in 55 dB.
- Ten sources of 50 dB each add together to result in 60 dB.
- One source of 50 dB added to another source of 40 dB results in 50.4 dB

It can be seen that, if multiple similar sources exist, removing or reducing only one source will have little effect.



Sound Level Measurements

Over the years a number of methods for measuring and describing environmental noise have been developed. The most widely used and accepted is the concept of the Energy Equivalent Sound Level (L_{eq}) which was developed in the US (1970's) to characterize noise levels near US Air-force bases. This is the level of a steady state sound which, for a given period of time, would contain the same energy as the time varying sound. The concept is that the same amount of annoyance occurs from a sound having a high level for a short period of time as from a sound at a lower level for a longer period of time. The L_{eq} is defined as:

$$L_{eq} = 10\log_{10}\left[\frac{1}{T}\int_{0}^{T}10^{\frac{dB}{10}}dT\right] = 10\log_{10}\left[\frac{1}{T}\int_{0}^{T}\frac{P^{2}}{P_{ref}^{2}}dT\right]$$

We must specify the time period over which to measure the sound. i.e. 1-second, 10-seconds, 15-seconds, 1-minute, 1-day, etc. An L_{eq} is meaningless if there is no time period associated.

In general there a few very common L_{eq} sample durations which are used in describing environmental noise measurements. These include:

- L_{eq}24 Measured over a 24-hour period
- L_{eq} Night Measured over the night-time (typically 22:00 07:00)
 - $L_{eq}Day$ Measured over the day-time (typically 07:00 22:00)
- L_{DN} Same as $L_{eq}24$ with a 10 dB penalty added to the night-time



Statistical Descriptor

Another method of conveying long term noise levels utilizes statistical descriptors. These are calculated from a cumulative distribution of the sound levels over the entire measurement duration and then determining the sound level at xx % of the time.

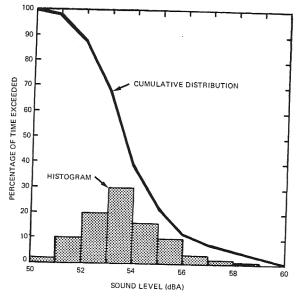


Figure 16.6 Statistically processed community noise showing histogram and cumulative distribution of A weighted sound levels.

Industrial Noise Control, Lewis Bell, Marcel Dekker, Inc. 1994

The most common statistical descriptors are:

L _{min}	- minimum sound level measured
L ₀₁	- sound level that was exceeded only 1% of the time
L ₁₀	- sound level that was exceeded only 10% of the time.
	- Good measure of intermittent or intrusive noise
	- Good measure of Traffic Noise
L ₅₀	- sound level that was exceeded 50% of the time (arithmetic average)
	- Good to compare to L_{eq} to determine steadiness of noise
L ₉₀	- sound level that was exceeded 90% of the time
	- Good indicator of typical "ambient" noise levels
L99	- sound level that was exceeded 99% of the time
L _{max}	- maximum sound level measured

These descriptors can be used to provide a more detailed analysis of the varying noise climate:

- If there is a large difference between the L_{eq} and the L_{50} (L_{eq} can never be any lower than the L_{50}) then it can be surmised that one or more short duration, high level sound(s) occurred during the time period.
- If the gap between the L_{10} and L_{90} is relatively small (less than 15 20 dBA) then it can be surmised that the noise climate was relatively steady.



Sound Propagation

In order to understand sound propagation, the nature of the source must first be discussed. In general, there are three types of sources. These are known as 'point', 'line', and 'area'. This discussion will concentrate on point and line sources since area sources are much more complex and can usually be approximated by point sources at large distances.

Point Source

As sound radiates from a point source, it dissipates through geometric spreading. The basic relationship between the sound levels at two distances from a point source is:

$$\therefore SPL_1 - SPL_2 = 20\log_{10}\left(\frac{r_2}{r_1}\right)$$

Where:

ere: SPL₁ = sound pressure level at location 1, SPL₂ = sound pressure level at location 2 r_1 = distance from source to location 1, r_2 = distance from source to location 2

Thus, the reduction in sound pressure level for a point source radiating in a free field is **6 dB per doubling of distance**. This relationship is independent of reflectivity factors provided they are always present. Note that this only considers geometric spreading and does not take into account atmospheric effects. Point sources still have some physical dimension associated with them, and typically do not radiate sound equally in all directions in all frequencies. The directionality of a source is also highly dependent on frequency. As frequency increases, directionality increases.

Examples (note no atmospheric absorption):

- A point source measuring 50 dB at 100m will be 44 dB at 200m.
- A point source measuring 50 dB at 100m will be 40.5 dB at 300m.
- A point source measuring 50 dB at 100m will be 38 dB at 400m.
- A point source measuring 50 dB at 100m will be 30 dB at 1000m.

Line Source

A line source is similar to a point source in that it dissipates through geometric spreading. The difference is that a line source is equivalent to a long line of many point sources. The basic relationship between the sound levels at two distances from a line source is:

$$SPL_1 - SPL_2 = 10 \log_{10} \left(\frac{r_2}{r_1} \right)$$

The difference from the point source is that the '20' term in front of the 'log' is now only 10. Thus, the reduction in sound pressure level for a line source radiating in a free field is **3 dB per doubling of distance**.

Examples (note no atmospheric absorption):

- A line source measuring 50 dB at 100m will be 47 dB at 200m.
- A line source measuring 50 dB at 100m will be 45 dB at 300m.
- A line source measuring 50 dB at 100m will be 34 dB at 400m.
- A line source measuring 50 dB at 100m will be 40 dB at 1000m.



Atmospheric Absorption

As sound transmits through a medium, there is an attenuation (or dissipation of acoustic energy) which can be attributed to three mechanisms:

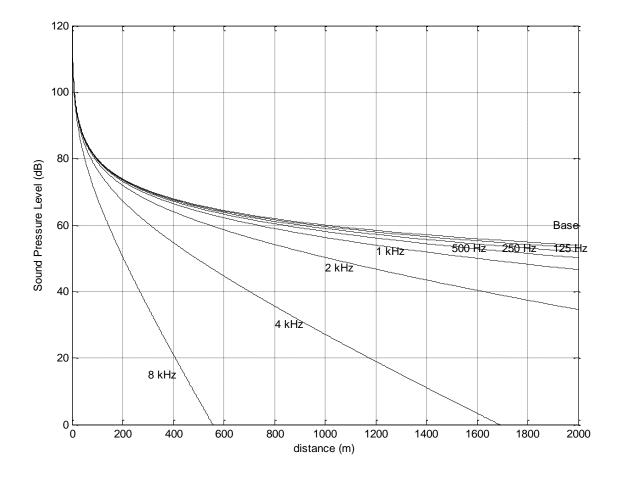
- 1) **Viscous Effects** Dissipation of acoustic energy due to fluid friction which results in thermodynamically irreversible propagation of sound.
- 2) **Heat Conduction Effects** Heat transfer between high and low temperature regions in the wave which result in non-adiabatic propagation of the sound.
- 3) **Inter Molecular Energy Interchanges** Molecular energy relaxation effects which result in a time lag between changes in translational kinetic energy and the energy associated with rotation and vibration of the molecules.

The following table illustrates the attenuation coefficient of sound at standard pressure (101.325 kPa) in units of dB/100m.

Temperature	Relative Humidity	Frequency (Hz)					
°C	(%)	125	250	500	1000	2000	4000
30	20	0.06	0.18	0.37	0.64	1.40	4.40
	50	0.03	0.10	0.33	0.75	1.30	2.50
	90	0.02	0.06	0.24	0.70	1.50	2.60
20	20	0.07	0.15	0.27	0.62	1.90	6.70
	50	0.04	0.12	0.28	0.50	1.00	2.80
	90	0.02	0.08	0.26	0.56	0.99	2.10
10	20	0.06	0.11	0.29	0.94	3.20	9.00
	50	0.04	0.11	0.20	0.41	1.20	4.20
	90	0.03	0.10	0.21	0.38	0.81	2.50
0	20	0.05	0.15	0.50	1.60	3.70	5.70
	50	0.04	0.08	0.19	0.60	2.10	6.70
	90	0.03	0.08	0.15	0.36	1.10	4.10

- As frequency increases, absorption increases
- As Relative Humidity increases, absorption decreases
- There is no direct relationship between absorption and temperature
- The net result of atmospheric absorption is to modify the sound propagation of a point source from 6 dB/doubling-of-distance to approximately 7 – 8 dB/doubling-of-distance (based on anecdotal experience)





Atmospheric Absorption at 10°C and 70% RH



Meteorological Effects

There are many meteorological factors which can affect how sound propagates over large distances. These various phenomena must be considered when trying to determine the relative impact of a noise source either after installation or during the design stage.

Wind

- Can greatly alter the noise climate away from a source depending on direction
- Sound levels downwind from a source can be increased due to refraction of sound back down towards the surface. This is due to the generally higher velocities as altitude increases.
- Sound levels upwind from a source can be decreased due to a "bending" of the sound away from the earth's surface.
- Sound level differences of ± 10 dB are possible depending on severity of wind and distance from source.
- Sound levels crosswind are generally not disturbed by an appreciable amount
- Wind tends to generate its own noise, however, and can provide a high degree of masking relative to a noise source of particular interest.

<u>Temperature</u>

- Temperature effects can be similar to wind effects
- Typically, the temperature is warmer at ground level than it is at higher elevations.
- If there is a very large difference between the ground temperature (very warm) and the air aloft (only a few hundred meters) then the transmitted sound refracts upward due to the changing speed of sound.
- If the air aloft is warmer than the ground temperature (known as an *inversion*) the resulting higher speed of sound aloft tends to refract the transmitted sound back down towards the ground. This essentially works on Snell's law of reflection and refraction.
- Temperature inversions typically happen early in the morning and are most common over large bodies of water or across river valleys.
- Sound level differences of ± 10 dB are possible depending on gradient of temperature and distance from source.

<u>Rain</u>

- Rain does not affect sound propagation by an appreciable amount unless it is very heavy
- The larger concern is the noise generated by the rain itself. A heavy rain striking the ground can cause a significant amount of highly broadband noise. The amount of noise generated is difficult to predict.
- Rain can also affect the output of various noise sources such as vehicle traffic.

<u>Summary</u>

- In general, these wind and temperature effects are difficult to predict
- Empirical models (based on measured data) have been generated to attempt to account for these effects.
- Environmental noise measurements must be conducted with these effects in mind. Sometimes it is desired to have completely calm conditions, other times a "worst case" of downwind noise levels are desired.



Topographical Effects

Similar to the various atmospheric effects outlined in the previous section, the effect of various geographical and vegetative factors must also be considered when examining the propagation of noise over large distances.

Topography

- One of the most important factors in sound propagation.
- Can provide a natural barrier between source and receiver (i.e. if berm or hill in between).
- Can provide a natural amplifier between source and receiver (i.e. large valley in between or hard reflective surface in between).
- Must look at location of topographical features relative to source and receiver to determine importance (i.e. small berm 1km away from source and 1km away from receiver will make negligible impact).

Grass

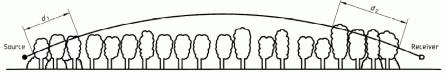
- Can be an effective absorber due to large area covered
- Only effective at low height above ground. Does not affect sound transmitted direct from source to receiver if there is line of sight.
- Typically less absorption than atmospheric absorption when there is line of sight.
- Approximate rule of thumb based on empirical data is:

$$A_g = 18\log_{10}(f) - 31$$
 (*dB*/100*m*)

Where: A_g is the absorption amount

Trees

- Provide absorption due to foliage
- Deciduous trees are essentially ineffective in the winter
- Absorption depends heavily on density and height of trees
- No data found on absorption of various kinds of trees
- Large spans of trees are required to obtain even minor amounts of sound reduction
- In many cases, trees can provide an effective visual barrier, even if the noise attenuation is negligible.



NOTE — $d_f = d_1 + d_2$

Figure A.1 — Attenuation due to propagation through foliage increases linearly with propagation distance $d_{\rm t}$ through the foliage

Table A.1 — Attenuation of an octave band of noise due to propagation a distance $d_{ m f}$ through	
dense foliage	

Propagation distance $d_{\rm f}$	Nominal midband frequency							
	Hz							
m	63	125	250	500	1 000	2 000	4 000	8 000
	Attenuatio	on, dB:						
$10 \le d_{\rm f} \le 20$	0	0	1	1	1	1	2	3
	Attenuation, dB/m:							
$20 \le d_{\rm f} \le 200$	0,02	0,03	0,04	0,05	0,06	0,08	0,09	0,12

Tree/Foliage attenuation from ISO 9613-2:1996



For calculating d_1 and d_2 , the curved path radius may be assumed to be 5 km.

Bodies of Water

- Large bodies of water can provide the opposite effect to grass and trees.
- Reflections caused by small incidence angles (grazing) can result in larger sound levels at great distances (increased reflectivity, Q).
- Typically air temperatures are warmer high aloft since air temperatures near water surface tend to be more constant. Result is a high probability of temperature inversion.
- Sound levels can "carry" much further.

Snow

- Covers the ground for approximately 1/2 of the year in northern climates.
- Can act as an absorber or reflector (and varying degrees in between).
- Freshly fallen snow can be quite absorptive.
- Snow which has been sitting for a while and hard packed due to wind can be quite reflective.
- Falling snow can be more absorptive than rain, but does not tend to produce its own noise.
- Snow can cover grass which might have provided some means of absorption.
- Typically sound propagates with less impedance in winter due to hard snow on ground and no foliage on trees/shrubs.



Appendix III. SOUND LEVELS OF FAMILIAR NOISE SOURCES

Used with Permission Obtained from EUB Guide 38: Noise Control Directive User Guide (November 1999)

Source ¹	Sound Level (dBA)
Bedroom of a country home	30
Soft whisper at 1.5 m	30
Quiet office or living room	40
Moderate rainfall	50
Inside average urban home	50
Quiet street	50
Normal conversation at 1 m	60
Noisy office	60
Noisy restaurant	70
Highway traffic at 15 m	75
Loud singing at 1 m	75
Tractor at 15 m	78-95
Busy traffic intersection	80
Electric typewriter	80
Bus or heavy truck at 15 m	88-94
Jackhammer	88-98
Loud shout	90
Freight train at 15 m	95
Modified motorcycle	95
Jet taking off at 600 m	100
Amplified rock music	110
Jet taking off at 60 m	120
Air-raid siren	130

¹ Cottrell, Tom, 1980, *Noise in Alberta*, Table 1, p.8, ECA80 - 16/1B4 (Edmonton: Environment Council of Alberta).



SOUND LEVELS GENERATED BY COMMON APPLIANCES

Used with Permission Obtained from EUB Guide 38: Noise Control Directive User Guide (November 1999)

Source ¹	Sound level at 3 feet (dBA)
Freezer	38-45
Refrigerator	34-53
Electric heater	47
Hair clipper	50
Electric toothbrush	48-57
Humidifier	41-54
Clothes dryer	51-65
Air conditioner	50-67
Electric shaver	47-68
Water faucet	62
Hair dryer	58-64
Clothes washer	48-73
Dishwasher	59-71
Electric can opener	60-70
Food mixer	59-75
Electric knife	65-75
Electric knife sharpener	72
Sewing machine	70-74
Vacuum cleaner	65-80
Food blender	65-85
Coffee mill	75-79
Food waste disposer	69-90
Edger and trimmer	81
Home shop tools	64-95
Hedge clippers	85
Electric lawn mower	80-90

¹ Reif, Z. F., and Vermeulen, P. J., 1979, "Noise from domestic appliances, construction, and industry," Table 1, p.166, in Jones, H. W., ed., *Noise in the Human Environment*, vol. 2, ECA79-SP/1 (Edmonton: Environment Council of Alberta).



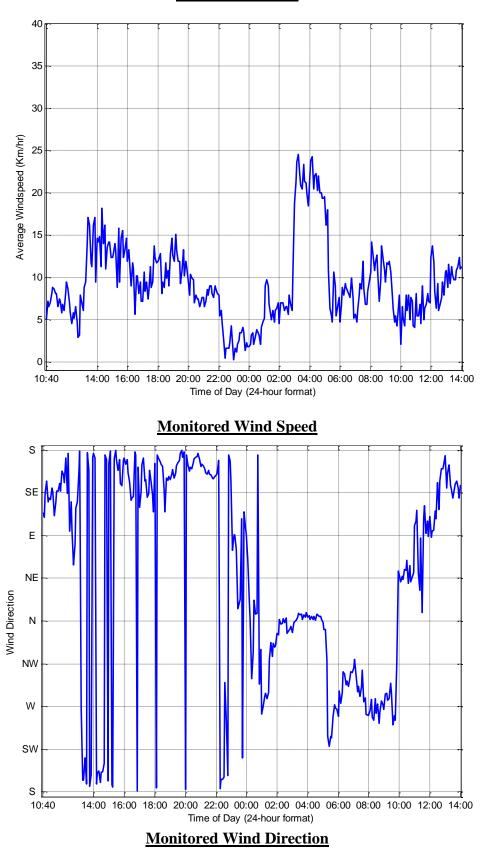
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June 23, 2010 ¹							
Time	Temperature (°C)	Relative Humidity (%)	Wind Direction	Wind Speed (km/hr)	Weather		
00:00	12.8	88	South-West	9	Mainly Clear		
01:00	12.5	88	South-West	11	Clear		
02:00	11.8	85	South-West	6	Clear		
03:00	10.7	89	North	0	Mainly Clear		
04:00	10.4	92	North-West	4	Clear		
05:00	9.8	90	North-West	7	Mainly Clear		
06:00	12.0	86	North	0	Mainly Clear		
07:00	13.4	83	South	7	Mainly Clear		
08:00	15.3	75	South	4	Mostly Cloudy		
09:00	17.5	64	South	7	Mostly Cloudy		
10:00	18.8	58	South-East	11	Mostly Cloudy		
11:00	19.6	55	South-East	7	Mostly Cloudy		
12:00	20.6	54	East	11	Mostly Cloudy		
13:00	20.7	54	South	4	Mostly Cloudy		
14:00	21.3	53	East	7	Cloudy		
15:00	20.7	54	South-East	17	Rain Showers		
16:00	20.8	58	East	11	Mostly Cloudy		
17:00	21.8	58	East	22	Mostly Cloudy		
18:00	20.9	48	South-East	15	Mostly Cloudy		
19:00	16.8	68	South-West	22	Thunderstorms, Heavy Rain Showers		
20:00	16.4	58	North-East	13	Thunderstorms, Rain Showers		
21:00	15.4	65	North	11	Mostly Cloudy		
22:00	13.8	73	North	17	Mostly Cloudy		
23:00	12.9	75	North-West	15	Mainly Clear		

Appendix IV. WEATHER DATA

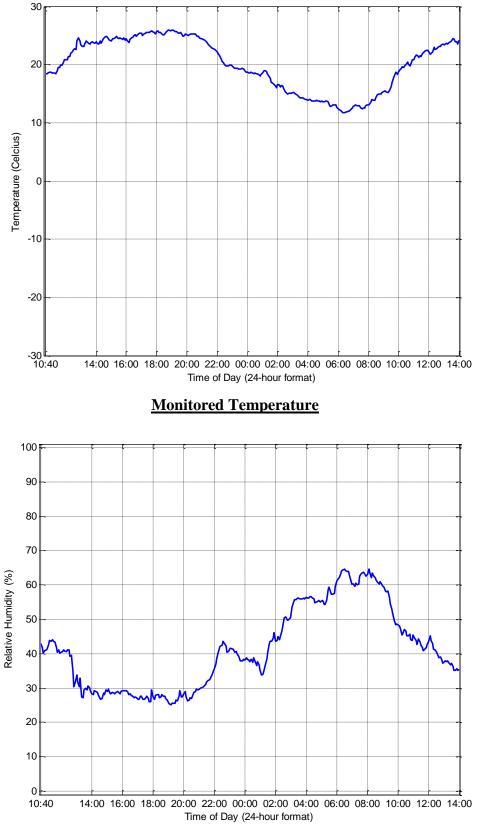
¹ Data was obtained from Environment Canada at the Calgary International Airport. This was the only monitoring period that weather was taken from Environment Canada as the monitoring locations where in close proximity of the airport.





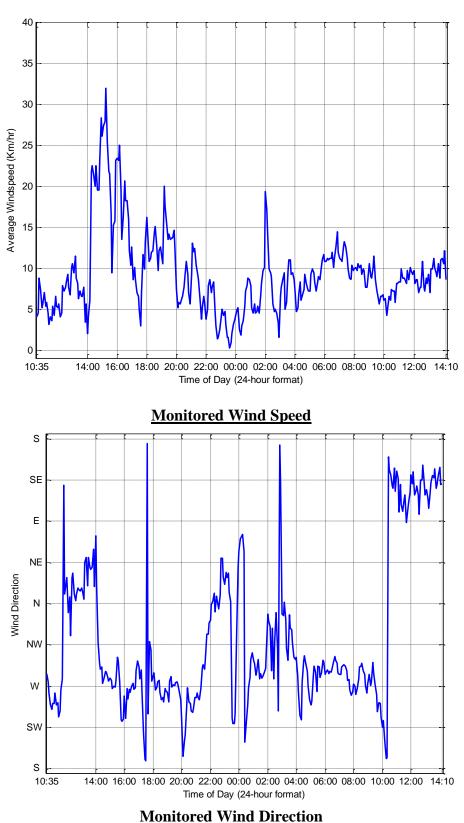
June 28 - 29, 2010





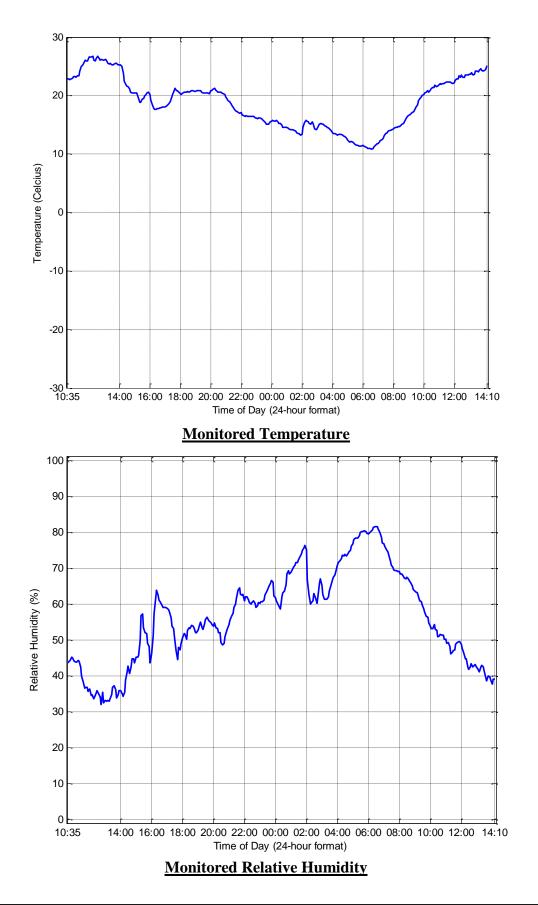




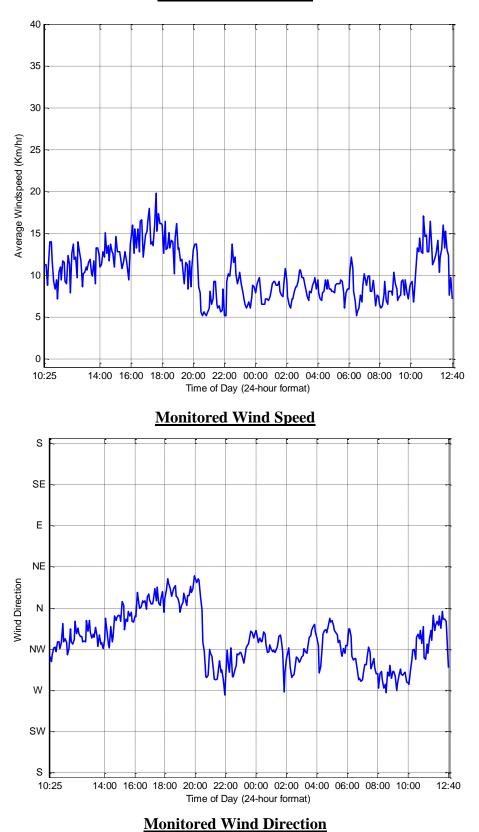


July 29 - 30, 2010



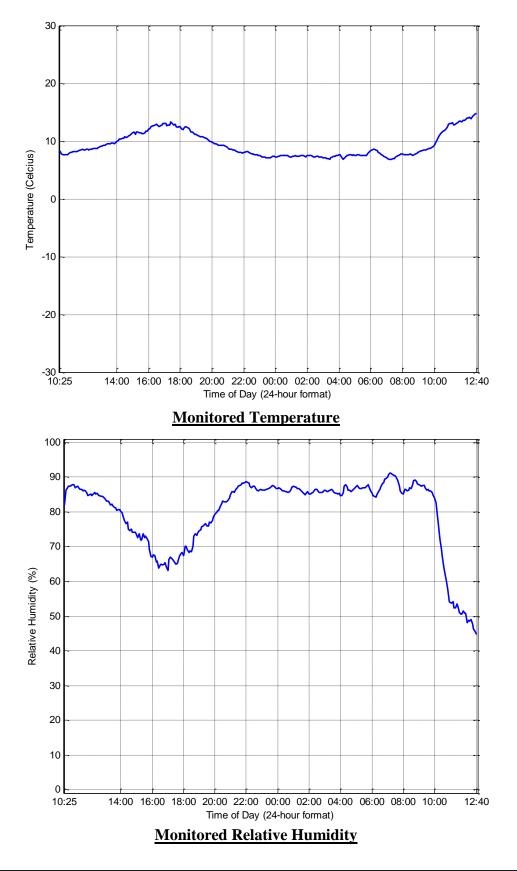




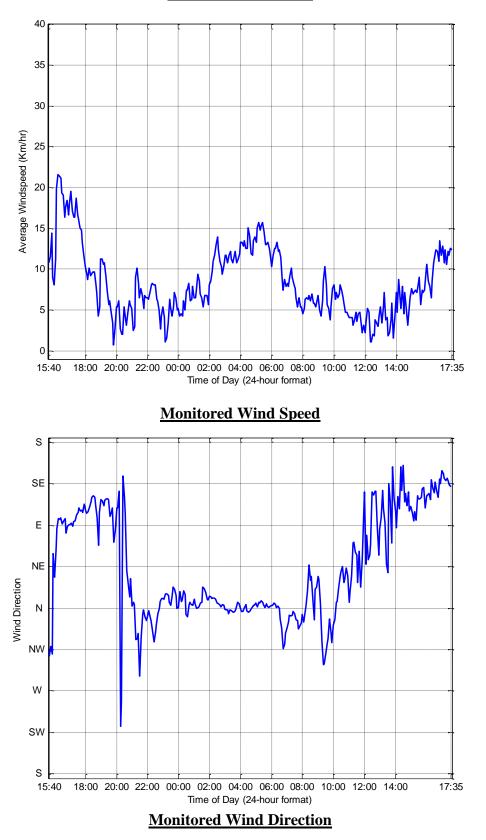


September 9 - 10, 2010









October 21 - 22, 2010



