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Noise Impact Assessment

For The

WaterCharger Project
at
LSD 08-13-26-06-W5M

Prepared for:

TransAlta Corporation

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Executive Summary

aci Acoustical Consultants Inc. (aci) was retained by TransAlta Corporation (TransAlta) to conduct a noise impact assessment for the proposed Watercharger Project (the Project) near Ghost Lake, Alberta, at LSD 08-13-26-06-W5M. The purpose of the work was to conduct a site visit to determine existing noise sources and residential receptors within the study area and to generate a computer noise model of the *Baseline Case*, *Project-Only Case*, and *Application Case* conditions. The noise levels were compared to the applicable noise criteria as specified by the Alberta Utilities Commission (AUC) Rule 012 on Noise Control. The site visit was conducted for aci on October 25, 2021 by S. Bilawchuk, M.Sc., P.Eng.

The *Baseline Case* noise levels associated with the existing TransAlta Ghost hydro-electric facility and the Ghost 20S Substation (with the AUC Rule 012 prescribed average ambient sound levels included) are projected to be below the AUC Rule 012 permissible sound levels (PSLs) for all surrounding residential and theoretical 1,500 m receptors.

The *Project-Only* Case noise levels associated with just the Project noise sources (with the AUC Rule 012 prescribed average ambient sound levels included) are projected to be below the AUC Rule 012 PSLs for all surrounding residential and theoretical 1,500 m receptors.

The *Application Case* noise levels associated with the existing TransAlta Ghost hydro-electric facility and the Ghost 20S Substation and the Project related noise sources (with the AUC Rule 012 prescribed average ambient sound levels included) are projected to be below the AUC Rule 012 PSLs for all surrounding residential and theoretical 1,500 m receptors.

In addition, for all assessment cases, the dBC sound levels are projected to be less than 20 dB greater than the dBA sound levels, resulting in a low possibility of any low frequency tonal noise.

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1.0 Introduction

aci Acoustical Consultants Inc. (aci) was retained by TransAlta Corporation (TransAlta) to conduct a noise impact assessment for the proposed Watercharger Project (the Project) near Ghost Lake, Alberta, at LSD 08-13-26-06-W5M. The purpose of the work was to conduct a site visit to determine existing noise sources and residential receptors within the study area and to generate a computer noise model of the *Baseline Case*, *Project-Only Case*, and *Application Case* conditions. The noise levels were compared to the applicable noise criteria as specified by the Alberta Utilities Commission (AUC) Rule 012 on Noise Control. The site visit was conducted for aci on October 25, 2021 by S. Bilawchuk, M.Sc., P.Eng.

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2.0 Description

2.1. Location

The Project is located approximately 13 km west of the City of Cochrane, Alberta at LSD 08-13-26-06-W5M. As indicated in Figure1 and Figure 2, the Project is located on undeveloped land south of the Bow River, east of the existing TransAlta Ghost hydro-electric facility. Within approximately 3 km of the Project, the only existing significant regulated industrial facilities are the TransAlta Ghost hydro-electric facility and the Ghost 20S Substation. The existing noise sources consist of the three water driven turbines and electrical generators (housed in the generator building) and the associated electrical substation to the south of the generator building.

The only significant road within the study area is Highway 1A which runs generally east-west through the study area, approximately 900 m from the Project as indicated in Figure 1. The traffic volumes on Highway 1A are such that the road is considered heavily travelled[1] during the day-time and night-time.

As indicated in Figure 1, there are numerous receptors within 1,500 m of the Project and the existing TransAlta Ghost hydro-electric facility and the Ghost 20S Substation, the closest of which is 340 m north of the Project. Some of the receptors at further distances from the Project have population densities of less than 9 receptors per quarter section of land[2] and are greater than 500 m from Highway 1A. Other receptors

[1] The AUC Rule 012 defines "heavily travelled" as 90 vehicles during the 9-hour night-time period. Typically, this equates to approximately 900 vehicles per day. Traffic data obtained from the Alberta Transportation website indicates an AADT of 3370 vehicles per day on Highway 1A which equates to approximately 337 vehicles during the night-time.

[2] Denoted with a radius of 451 m from each residential receptor.

have the lower population density but are between 30 – 500 m from Highway 1A, while others have population densities between 9 – 160 dwellings per quarter section of land and are between 30 – 500 m from Highway 1A. The nearest residents to the north have a population density greater than 160 receptors per quarter section of land and are between 30 – 500 m from Highway 1A.

Topographically the land within the study area has a general downward slope from the north and south towards the Bow River. In addition, Ghost Lake is elevated several meters above the location of the Project because of the Hydro-Electric facility. Within 1,500 m of the Project and the existing TransAlta Ghost hydro-electric facility and the Ghost 20S Substation, there is an elevation change of approximately 127 m. Digital elevation contours were incorporated into the noise model for increased accuracy. Vegetation within the area is composed mainly of field grasses, bushes, and some trees. Given the relative distances involved between the Project and the nearest residential receptors the vegetative sound absorption is considered moderate.

2.2. Equipment Description

TransAlta has not yet selected the battery manufacturer for the Project. As such, a conservative layout, as indicated in Figure 2, was provided by TransAlta for the noise model. TransAlta expects the number of noise source units for the Project to be equal to or less than the following:

- 216 Battery Enclosures. Each battery enclosure will house a bank of batteries, electronics, and ventilation.
- 55 Inverters with integral transformers, switchgear, and other electronics.
- Overall site switchgear buildings
- 50 MVA Transformer located within the existing substation
- 180 MVA Transformer located within the existing substation
- 3.75 MVA Auxiliary Transformer

In addition, it is important to note that the Project will typically operate in a "standby" mode with the batteries fully charged and available for use. During the "standby" mode, the noise levels will be relatively low. The noise levels included in the noise model assessment cases are based on the peak noise during charge/discharge cycles when the cooling fans, transformers, inverters, etc. will be operating at their maximum.

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3.0 Modeling Methods

The computer noise modeling was conducted using the CADNA/A (Build 173.4950) software package. CADNA/A allows for the modeling of various noise sources such as road, rail, and various stationary sources. In addition, topographical features such as land contours, vegetation, and bodies of water can be included. Finally, meteorological conditions such as temperature, relative humidity, wind-speed and wind-direction can be included in the calculations. Note that all modeling methods used exceed the requirements of the AUC Rule 012 on Noise Control.

The calculation method used for noise propagation follows the ISO standard 9613-2. All receiver locations were assumed as being downwind from the source(s). In particular, as stated in Section 5 of the ISO document:

> *"Downwind propagation conditions for the method specified in this part of IS0 9613 are as specified in 5.4.3.3 of IS0 1996-2:1987, namely*
> - *wind direction within an angle of ± 45^0 of the direction connecting the centre of the dominant sound source and the centre of the specified receiver region, with the wind blowing from source to receiver, and*
> - *wind speed between approximately 1 m/s and 5 m/s, measured at a height of 3 m to 11 m above the ground.*
>
> *The equations for calculating the average downwind sound pressure level LAT(DW) in this part of IS0 9613, including the equations for attenuation given in clause 7, are the average for meteorological conditions within these limits. The term average here means the average over a short time interval, as defined in 3.1.*
> *These equations also hold, equivalently, for average propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs on clear, calm nights".*

Due to the size of the Project study area and the density of vegetation within the study area, vegetative sound absorption was included in the model. A ground absorption coefficient of 0.5 was used along with a temperature of 10^{0}C and a relative humidity of 70%. As a result, all sound level propagation calculations are considered conservatively representative of summertime conditions (as specified in the AUC Rule 012).

As part of the study, three noise modeling scenarios were conducted, including:

1) *Baseline Case*: This scenario included the noise sources associated with the existing TransAlta Ghost hydro-electric facility and the Ghost 20S Substation.
2) *Project-Only Case*: This scenario included the noise sources associated with the Project, without any of the existing noise sources.
3) *Application Case*: This scenario included the noise sources associated with the existing TransAlta Ghost hydro-electric facility and the Ghost 20S Substation as well as the Project.

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The computer noise modeling results were calculated in two ways. First, sound levels were calculated at specific receiver locations (i.e. adjacent residents and theoretical 1,500 m receptors). Next, the sound levels were calculated using a 10 m x 10 m grid over the entire study area. This provided color noise contours for easier visualization of the results. Refer to Appendix I for a description of the acoustical terminology, Appendix II for a list of common noise sources

3.1. Noise Sources

As part of the noise study, a site visit to the area was conducted on October 25, 2021. During the site visit, sound level measurements were conducted near existing operational regulated industrial noise sources. The sound level data obtained was used to determine the equipment sound power levels for use in the computer noise model. Refer to Appendix III for a description of the measurement equipment and methods used. Refer to Appendix IV for a listing of the modeled sound power levels.

The octave band noise data for the Project noise sources was provided by TransAlta through consultation with the equipment supplier. Refer to Appendix IV for a list of the Project related noise sources.

Finally, as specified in the AUC Rule 012, the average night-time ambient sound level (ASL) has been included in the noise modeling results as follows:

- For receptors with population densities less than 9 dwellings per quarter section and greater than 500 m from a heavily traveled road, the ASL is 35 dBA during the night-time and 45 dBA during the day-time. **This applies to R-05, R-06, R-09, and R-12.**
- For receptors with population densities less than 9 dwellings per quarter section and between 30 - 500 m from a heavily traveled road, the ASL is 40 dBA during the night-time and 50 dBA during the day-time. **This applies to R-01 to R-04 and R-11.**
- For receptors with population densities between 9 – 160 dwellings per quarter section and between 30 - 500 m from a heavily traveled road, the ASL is 43 dBA during the night-time and 53 dBA during the day-time. **This applies to R-07, R-08, and R-10.**
- For receptors with population densities greater than 160 dwellings per quarter section and between 30 - 500 m from a heavily traveled road, the ASL is 46 dBA during the night-time and 56 dBA during the day-time. **This applies to R-13 to R-37.**

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3.2. Modeling Confidence

The algorithms used for the noise modeling follow the ISO 9613 standard. The published accuracy for this standard is ±3 dBA between 100 m – 1,000 m. Accuracy levels beyond 1,000 m are not published. Experience based on similar noise models conducted over large distances shows that, as expected, as the distance increases, the associated accuracy in prediction decreases. Experience has shown that environmental factors such as wind, temperature inversions, topography and ground cover all have increasing effects over distances larger than approximately 1,500 m. As such, since all receptors are within approximately 1,500 m of the proposed station, the prediction confidence is considered high.

4.0 Permissible Sound Levels

Environmental noise levels from various sources (industrial, roads, railways, etc.) are commonly described in terms of equivalent sound levels or L_{eq}. This is the level of a steady sound having the same acoustic energy, over a given time period, as the fluctuating sound. In addition, this energy averaged level is A–weighted to account for the reduced sensitivity of average human hearing to low frequency sounds. These L_{eq} in dBA, which are the most common environmental noise measure, are often given for day-time (07:00 to 22:00) L_{eq}Day and night-time (22:00 to 07:00) L_{eq}Night while other criteria use the entire 24-hour period as L_{eq}24. The criteria used to evaluate the noise in the study area is the AUC Rule 012.

The AUC Rule 012 (2021) on Noise Control sets the PSL at the receiver location based on population density and relative distances to heavily traveled road and rail as shown in Table 1. The Project will not be a seasonal operation.

- For receptors with population densities less than 9 dwellings per quarter section and greater than 500 m from a heavily traveled road, the PSLs are an L_{eq}Night of 40 dBA and an L_{eq}Day of 50 dBA. **This applies to R-05, R-06, R-09, and R-12.**
- For receptors with population densities less than 9 dwellings per quarter section and between 30 - 500 m from a heavily traveled road, the PSLs are an L_{eq}Night of 45 dBA and an L_{eq}Day of 55 dBA. **This applies to R-01 to R-04 and R-11.**
- For receptors with population densities between 9 – 160 dwellings per quarter section and between 30 - 500 m from a heavily traveled road, the PSLs are an L_{eq}Night of 48 dBA and an L_{eq}Day of 58 dBA. **This applies to R-07, R-08, and R-10.**
- For receptors with population densities greater than 160 dwellings per quarter section and between 30 - 500 m from a heavily traveled road, the PSLs are an L_{eq}Night of 51 dBA and an L_{eq}Day of 61 dBA. **This applies to R-13 to R-37.**

Finally, AUC Rule 012 specifies that new or modified facilities must meet a PSL-Night of 40 dBA at 1,500 m from the facility fence-line if there are no closer dwellings. As such, the PSLs at a distance of 1,500 m are an **L_{eq}Night of 40 dBA and an L_{eq}Day of 50 dBA.** Refer to Appendix V for a detailed description of the PSL determination.

Table 1. Basic Night-Time Sound Levels (as per the AUC Rule 012)

Proximity to Transportation	Dwelling Density per Quarter Section of Land		
	1-8 Dwellings	9-160 Dwellings	>160 Dwellings
Category 1	40 dBA	43 dBA	46 dBA
Category 2	45 dBA	48 dBA	51 dBA
Category 3	50 dBA	53 dBA	56 dBA

Category 1 Dwelling units more than 500m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers
Category 2 Dwelling units more than 30m but less than 500m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers
Category 3 Dwelling units less than 30m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers

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5.0 Results and Discussion

5.1. *Baseline Case* Results

The results of the *Baseline Case* noise modeling are presented in Table 2 and illustrated in Figure 3. The Project will have the ability to operate at any time during a 24-hour period, so only the night-time results are provided, given the reduced PSLs during the night-time hours. The noise levels associated with the existing TransAlta Ghost hydro-electric facility and the Ghost 20S Substation in addition to the ASLs are projected to be below the PSLs for all adjacent residential and theoretical 1,500 m receptor locations.

In addition to the broadband A-weighted (dBA) sound levels, the modeling results at the adjacent residential and theoretical 1,500 m receptor locations indicated C-weighted (dBC) sound levels will be less than 20 dB above the dBA sound levels, as shown in Table 2. As specified in the AUC Rule 012, if the dBC minus dBA sound levels are less than 20 dB, the noise is not considered to have a low frequency tonal component.

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Table 2. *Baseline Case* Modeled Sound Levels

Receptor (Distance from Project)	ASL-Night (dBA)	Baseline Case L_{eq}Night (dBA)	ASL + Baseline Case L_{eq}Night (dBA)	PSL-Night (dBA)	Compliant		Baseline Case L_{eq}Night (dBC)	dBC - dBA	Tonal
Residential Receptors									
R-01 (1,500 m)	40.0	6.8	40.0	45.0	YES		24.7	17.9	NO
R-02 (700 m)	40.0	16.3	40.0	45.0	YES		34.8	18.5	NO
R-03 (750 m)	40.0	15.7	40.0	45.0	YES		34.3	18.6	NO
R-04 (1,140 m)	40.0	20.1	40.0	45.0	YES		36.9	16.8	NO
R-05 (1,480 m)	35.0	11.9	35.0	40.0	YES		31.3	19.4	NO
R-06 (1,460 m)	35.0	24.7	35.4	40.0	YES		38.0	13.3	NO
R-07 (1,200 m)	43.0	26.6	43.1	48.0	YES		40.1	13.5	NO
R-08 (1,100 m)	43.0	28.1	43.1	48.0	YES		40.5	12.4	NO
R-09 (1,500 m)	35.0	22.4	35.2	40.0	YES		35.7	13.3	NO
R-10 (650 m)	43.0	35.2	43.7	48.0	YES		43.7	8.5	NO
R-11 (830 m)	40.0	27.8	40.3	45.0	YES		40.0	12.2	NO
R-12 (1,650 m)	35.0	17.0	35.1	40.0	YES		32.6	15.6	NO
R-13 (350 m)	46.0	38.9	46.8	51.0	YES		51.3	12.4	NO
R-14 (340 m)	46.0	42.3	47.5	51.0	YES		52.0	9.7	NO
R-15 (335 m)	46.0	42.2	47.5	51.0	YES		52.0	9.8	NO
R-16 (350 m)	46.0	41.3	47.3	51.0	YES		51.6	10.3	NO
R-17 (365 m)	46.0	40.5	47.1	51.0	YES		51.2	10.7	NO
R-18 (375 m)	46.0	40.3	47.0	51.0	YES		50.9	10.6	NO
R-19 (390 m)	46.0	40.1	47.0	51.0	YES		50.7	10.6	NO
R-20 (400 m)	46.0	39.5	46.9	51.0	YES		50.3	10.8	NO
R-21 (420 m)	46.0	39.0	46.8	51.0	YES		50.0	11.0	NO
R-22 (430 m)	46.0	36.6	46.5	51.0	YES		49.4	12.8	NO
R-23 (450 m)	46.0	36.7	46.5	51.0	YES		49.2	12.5	NO
R-24 (460 m)	46.0	37.8	46.6	51.0	YES		49.2	11.4	NO
R-25 (470 m)	46.0	37.4	46.6	51.0	YES		49.0	11.6	NO
R-26 (480 m)	46.0	37.1	46.5	51.0	YES		48.8	11.7	NO
R-27 (480 m)	46.0	37.2	46.5	51.0	YES		48.7	11.5	NO
R-28 (485 m)	46.0	38.0	46.6	51.0	YES		48.6	10.6	NO
R-29 (490 m)	46.0	37.9	46.6	51.0	YES		48.5	10.6	NO
R-30 (495 m)	46.0	38.0	46.6	51.0	YES		48.3	10.3	NO
R-31 (495 m)	46.0	37.8	46.6	51.0	YES		48.2	10.4	NO
R-32 (500 m)	46.0	37.6	46.6	51.0	YES		48.0	10.4	NO
R-33 (500 m)	46.0	37.4	46.6	51.0	YES		47.8	10.4	NO
R-34 (505 m)	46.0	37.1	46.5	51.0	YES		47.5	10.4	NO
R-35 (510 m)	46.0	36.6	46.5	51.0	YES		47.2	10.6	NO
R-36 (535 m)	46.0	36.1	46.4	51.0	YES		46.8	10.7	NO
R-37 (535 m)	46.0	33.6	46.2	51.0	YES		46.0	12.4	NO
Theoretical 1,500 m Receptors									
North	35.0	23.7	35.3	40.0	YES		37.2	13.5	NO
Northeast	35.0	17.9	35.1	40.0	YES		34.0	16.1	NO
East	35.0	19.2	35.1	40.0	YES		33.7	14.5	NO
Southeast	35.0	14.6	35.0	40.0	YES		32.1	17.5	NO
South	35.0	7.0	35.0	40.0	YES		23.9	16.9	NO
Southwest	35.0	6.0	35.0	40.0	YES		23.2	17.2	NO
West	35.0	5.1	35.0	40.0	YES		21.5	16.4	NO
Northwest	35.0	15.8	35.1	40.0	YES		31.4	15.6	NO

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5.2. *Project-Only* Case Results

The results of the *Project-Only* Case noise modeling are presented in Table 3 and illustrated in Figure 4. The Project will have the ability to operate at any time during a 24-hour period, so only the night-time results are provided, given the reduced PSLs during the night-time hours. The noise levels associated with the Project in addition to the ASLs are projected to be below the PSLs for all adjacent residential and theoretical 1,500 m receptor locations.

In addition to the broadband A-weighted (dBA) sound levels, the modeling results at the adjacent residential and theoretical 1,500 m receptor locations indicated C-weighted (dBC) sound levels will be less than 20 dB above the dBA sound levels, as shown in Table 3. As specified in the AUC Rule 012, if the dBC minus dBA sound levels are less than 20 dB, the noise is not considered to have a low frequency tonal component.

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Table 3. *Project-Only* Case Modeled Sound Levels

Receptor (Distance from Project)	ASL-Night (dBA)	Project Case L_{eq}Night (dBA)	ASL + Project Case L_{eq}Night (dBA)	PSL-Night (dBA)	Compliant		Project Case L_{eq}Night (dBC)	dBC - dBA	Tonal
Residential Receptors									
R-01 (1,500 m)	40.0	24.6	40.1	45.0	YES		35.2	10.6	NO
R-02 (700 m)	40.0	31.9	40.6	45.0	YES		41.2	9.3	NO
R-03 (750 m)	40.0	31.2	40.5	45.0	YES		40.6	9.4	NO
R-04 (1,140 m)	40.0	27.8	40.3	45.0	YES		37.7	9.9	NO
R-05 (1,480 m)	35.0	23.6	35.3	40.0	YES		35.0	11.4	NO
R-06 (1,460 m)	35.0	25.9	35.5	40.0	YES		36.1	10.2	NO
R-07 (1,200 m)	43.0	28.2	43.1	48.0	YES		37.9	9.7	NO
R-08 (1,100 m)	43.0	28.8	43.2	48.0	YES		38.3	9.5	NO
R-09 (1,500 m)	35.0	24.5	35.4	40.0	YES		34.9	10.4	NO
R-10 (650 m)	43.0	38.5	44.3	48.0	YES		47.6	9.1	NO
R-11 (830 m)	40.0	36.2	41.5	45.0	YES		46.3	10.1	NO
R-12 (1,650 m)	35.0	23.6	35.3	40.0	YES		34.1	10.5	NO
R-13 (350 m)	46.0	39.8	46.9	51.0	YES		47.6	7.8	NO
R-14 (340 m)	46.0	40.8	47.1	51.0	YES		48.1	7.3	NO
R-15 (335 m)	46.0	40.2	47.0	51.0	YES		48.0	7.8	NO
R-16 (350 m)	46.0	40.0	47.0	51.0	YES		47.8	7.8	NO
R-17 (365 m)	46.0	40.0	47.0	51.0	YES		47.7	7.7	NO
R-18 (375 m)	46.0	41.3	47.3	51.0	YES		47.9	6.6	NO
R-19 (390 m)	46.0	41.6	47.3	51.0	YES		48.0	6.4	NO
R-20 (400 m)	46.0	40.4	47.1	51.0	YES		47.4	7.0	NO
R-21 (420 m)	46.0	39.1	46.8	51.0	YES		47.0	7.9	NO
R-22 (430 m)	46.0	38.9	46.8	51.0	YES		46.8	7.9	NO
R-23 (450 m)	46.0	38.8	46.8	51.0	YES		46.6	7.8	NO
R-24 (460 m)	46.0	38.9	46.8	51.0	YES		46.6	7.7	NO
R-25 (470 m)	46.0	39.0	46.8	51.0	YES		46.5	7.5	NO
R-26 (480 m)	46.0	38.7	46.7	51.0	YES		46.3	7.6	NO
R-27 (480 m)	46.0	39.2	46.8	51.0	YES		46.3	7.1	NO
R-28 (485 m)	46.0	40.4	47.1	51.0	YES		46.7	6.3	NO
R-29 (490 m)	46.0	40.5	47.1	51.0	YES		46.7	6.2	NO
R-30 (495 m)	46.0	40.4	47.1	51.0	YES		46.6	6.2	NO
R-31 (495 m)	46.0	40.1	47.0	51.0	YES		46.4	6.3	NO
R-32 (500 m)	46.0	40.0	47.0	51.0	YES		46.3	6.3	NO
R-33 (500 m)	46.0	39.4	46.9	51.0	YES		46.0	6.6	NO
R-34 (505 m)	46.0	39.1	46.8	51.0	YES		45.8	6.7	NO
R-35 (510 m)	46.0	37.4	46.6	51.0	YES		45.1	7.7	NO
R-36 (535 m)	46.0	36.2	46.4	51.0	YES		44.5	8.3	NO
R-37 (535 m)	46.0	35.9	46.4	51.0	YES		44.2	8.3	NO
Theoretical 1,500 m Receptors									
North	35.0	25.3	35.4	40.0	YES		35.6	10.3	NO
Northeast	35.0	22.9	35.3	40.0	YES		34.2	11.3	NO
East	35.0	25.5	35.5	40.0	YES		35.7	10.2	NO
Southeast	35.0	24.4	35.4	40.0	YES		34.8	10.4	NO
South	35.0	25.8	35.5	40.0	YES		36.0	10.2	NO
Southwest	35.0	24.9	35.4	40.0	YES		35.5	10.6	NO
West	35.0	24.0	35.3	40.0	YES		34.7	10.7	NO
Northwest	35.0	24.0	35.3	40.0	YES		34.7	10.7	NO

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5.3. *Application Case* Results

The results of the *Application Case* noise modeling are presented in Table 4 and illustrated in Figure 5. The Project will have the ability to operate at any time during a 24-hour period, so only the night-time results are provided, given the reduced PSLs during the night-time hours. The noise levels associated with the existing TransAlta Ghost hydro-electric facility and the Ghost 20S Substation and the Project in addition to the ASLs are projected to be below the PSLs for all adjacent residential and theoretical 1,500 m receptor locations. The order-ranked noise source contribution from the modeled noise sources at the nearest and/or most impacted residential receptors (R-10, R-14) are presented in Appendix VII.

In addition to the broadband dBA sound levels, the modeling results at the adjacent residential and theoretical 1,500 m receptor locations indicated dBC sound levels will be less than 20 dB above the dBA sound levels, as shown in Table 4. As specified in the AUC Rule 012, if the dBC minus dBA sound levels are less than 20 dB, the noise is not considered to have a low frequency tonal component.

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Table 4. *Application Case* Modeled Sound Levels

Receptor (Distance from Project)	ASL-Night (dBA)	Application Case L_{eq}Night (dBA)	ASL + Application Case L_{eq}Night (dBA)	PSL-Night (dBA)	Compliant		Application Case L_{eq}Night (dBC)	dBC - dBA	Tonal
Residential Receptors									
R-01 (1,500 m)	40.0	24.7	40.1	45.0	YES		35.6	10.9	NO
R-02 (700 m)	40.0	32.0	40.6	45.0	YES		42.0	10.0	NO
R-03 (750 m)	40.0	31.3	40.5	45.0	YES		41.5	10.2	NO
R-04 (1,140 m)	40.0	28.5	40.3	45.0	YES		40.3	11.8	NO
R-05 (1,480 m)	35.0	23.9	35.3	40.0	YES		36.6	12.7	NO
R-06 (1,460 m)	35.0	28.4	35.9	40.0	YES		40.2	11.8	NO
R-07 (1,200 m)	43.0	30.5	43.2	48.0	YES		42.1	11.6	NO
R-08 (1,100 m)	43.0	31.4	43.3	48.0	YES		42.6	11.2	NO
R-09 (1,500 m)	35.0	26.6	35.6	40.0	YES		38.3	11.7	NO
R-10 (650 m)	43.0	40.1	44.8	48.0	YES		49.1	9.0	NO
R-11 (830 m)	40.0	36.8	41.7	45.0	YES		47.2	10.4	NO
R-12 (1,650 m)	35.0	24.4	35.4	40.0	YES		36.4	12.0	NO
R-13 (350 m)	46.0	43.7	48.0	51.0	YES		53.1	9.4	NO
R-14 (340 m)	46.0	44.6	48.4	51.0	YES		53.5	8.9	NO
R-15 (335 m)	46.0	44.4	48.3	51.0	YES		53.5	9.1	NO
R-16 (350 m)	46.0	43.7	48.0	51.0	YES		53.1	9.4	NO
R-17 (365 m)	46.0	43.3	47.9	51.0	YES		52.8	9.5	NO
R-18 (375 m)	46.0	43.8	48.0	51.0	YES		52.7	8.9	NO
R-19 (390 m)	46.0	43.9	48.1	51.0	YES		52.6	8.7	NO
R-20 (400 m)	46.0	43.0	47.8	51.0	YES		52.1	9.1	NO
R-21 (420 m)	46.0	42.1	47.5	51.0	YES		51.8	9.7	NO
R-22 (430 m)	46.0	41.8	47.4	51.0	YES		51.5	9.7	NO
R-23 (450 m)	46.0	41.5	47.3	51.0	YES		51.3	9.8	NO
R-24 (460 m)	46.0	41.4	47.3	51.0	YES		51.1	9.7	NO
R-25 (470 m)	46.0	41.3	47.3	51.0	YES		50.9	9.6	NO
R-26 (480 m)	46.0	41.0	47.2	51.0	YES		50.7	9.7	NO
R-27 (480 m)	46.0	41.3	47.3	51.0	YES		50.7	9.4	NO
R-28 (485 m)	46.0	42.4	47.6	51.0	YES		50.8	8.4	NO
R-29 (490 m)	46.0	42.4	47.6	51.0	YES		50.7	8.3	NO
R-30 (495 m)	46.0	42.3	47.5	51.0	YES		50.6	8.3	NO
R-31 (495 m)	46.0	42.1	47.5	51.0	YES		50.4	8.3	NO
R-32 (500 m)	46.0	42.0	47.5	51.0	YES		50.2	8.2	NO
R-33 (500 m)	46.0	41.5	47.3	51.0	YES		50.0	8.5	NO
R-34 (505 m)	46.0	41.2	47.2	51.0	YES		49.7	8.5	NO
R-35 (510 m)	46.0	40.0	47.0	51.0	YES		49.3	9.3	NO
R-36 (535 m)	46.0	39.1	46.8	51.0	YES		48.8	9.7	NO
R-37 (535 m)	46.0	38.8	46.8	51.0	YES		48.5	9.7	NO
Theoretical 1,500 m Receptors									
North	35.0	27.6	35.7	40.0	YES		39.4	11.8	NO
Northeast	35.0	24.1	35.3	40.0	YES		37.1	13.0	NO
East	35.0	26.4	35.6	40.0	YES		37.8	11.4	NO
Southeast	35.0	24.9	35.4	40.0	YES		36.7	11.8	NO
South	35.0	25.9	35.5	40.0	YES		36.2	10.3	NO
Southwest	35.0	24.9	35.4	40.0	YES		35.8	10.9	NO
West	35.0	24.0	35.3	40.0	YES		34.9	10.9	NO
Northwest	35.0	24.7	35.4	40.0	YES		36.3	11.6	NO

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5.4. Noise Mitigation Measures

The results of the noise modeling indicated that no specific additional noise mitigation measures are required for the Project equipment.

5.4.1. Construction Noise

Although there are no specific construction noise level limits detailed by the AUC Rule 012, there are general recommendations for construction noise mitigation. This includes all activities associated with construction of the Project. The document states:

> "*Licensees must manage the impact of construction noise on nearby dwellings. The following mitigating measures should be used:*
>
> - *Conduct construction activity between the hours of 7 a.m. and 10 p.m. to reduce the duration impact of construction noise*
> - *Advise nearby residents of significant noise-causing activities and schedule these events to reduce disruption to them*
> - *Ensure that all internal combustion engines are well maintained with muffler systems.*
>
> *Should a noise complaint be filed during construction, the licensee must respond expeditiously and take prompt action to address the complaint."*

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6.0 Conclusion

The *Baseline Case* noise levels associated with the existing TransAlta Ghost hydro-electric facility and the Ghost 20S Substation (with the AUC Rule 012 prescribed average ambient sound levels included) are projected to be below the AUC Rule 012 PSLs for all surrounding residential and theoretical 1,500 m receptors.

The *Project-Only* Case noise levels associated with just the Project noise sources (with the AUC Rule 012 prescribed average ambient sound levels included) are projected to be below the AUC Rule 012 PSLs for all surrounding residential and theoretical 1,500 m receptors.

The *Application Case* noise levels associated with the existing TransAlta Ghost hydro-electric facility and the Ghost 20S Substation and the Project related noise sources (with the AUC Rule 012 prescribed average ambient sound levels included) are projected to be below the AUC Rule 012 PSLs for all surrounding residential and theoretical 1,500 m receptors.

In addition, for all assessment cases, the dBC sound levels are projected to be less than 20 dB greater than the dBA sound levels, resulting in a low possibility of any low frequency tonal noise.

A short form (AUC Rule 012 form) noise impact assessment is presented in Appendix VIII.

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7.0 References

- Alberta Utilities Commission (AUC), *Rule 012 on Noise Control, 2021*, Calgary, Alberta
- 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.

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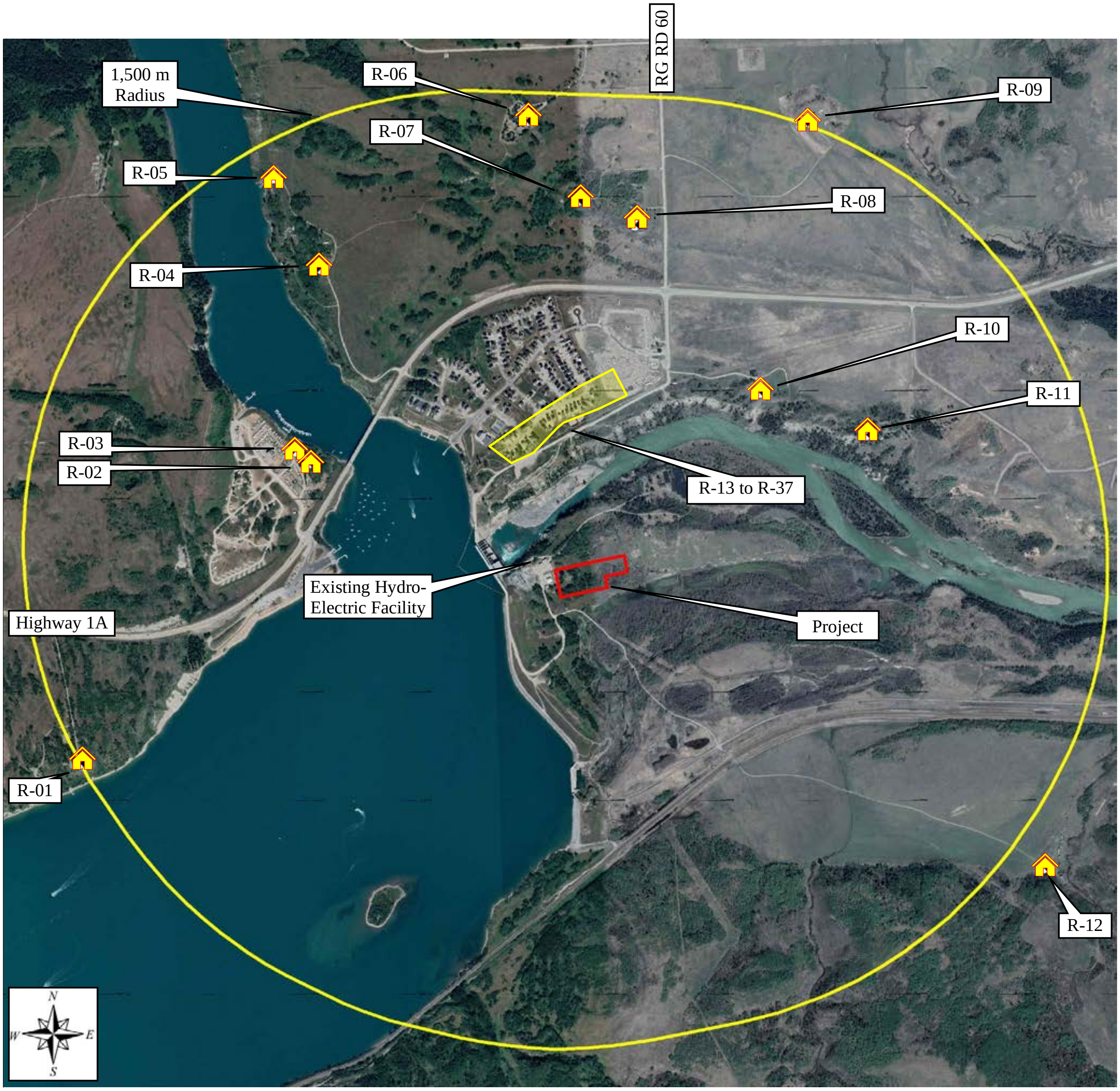

Figure 1. Study Area

Figure 2. Site Plan

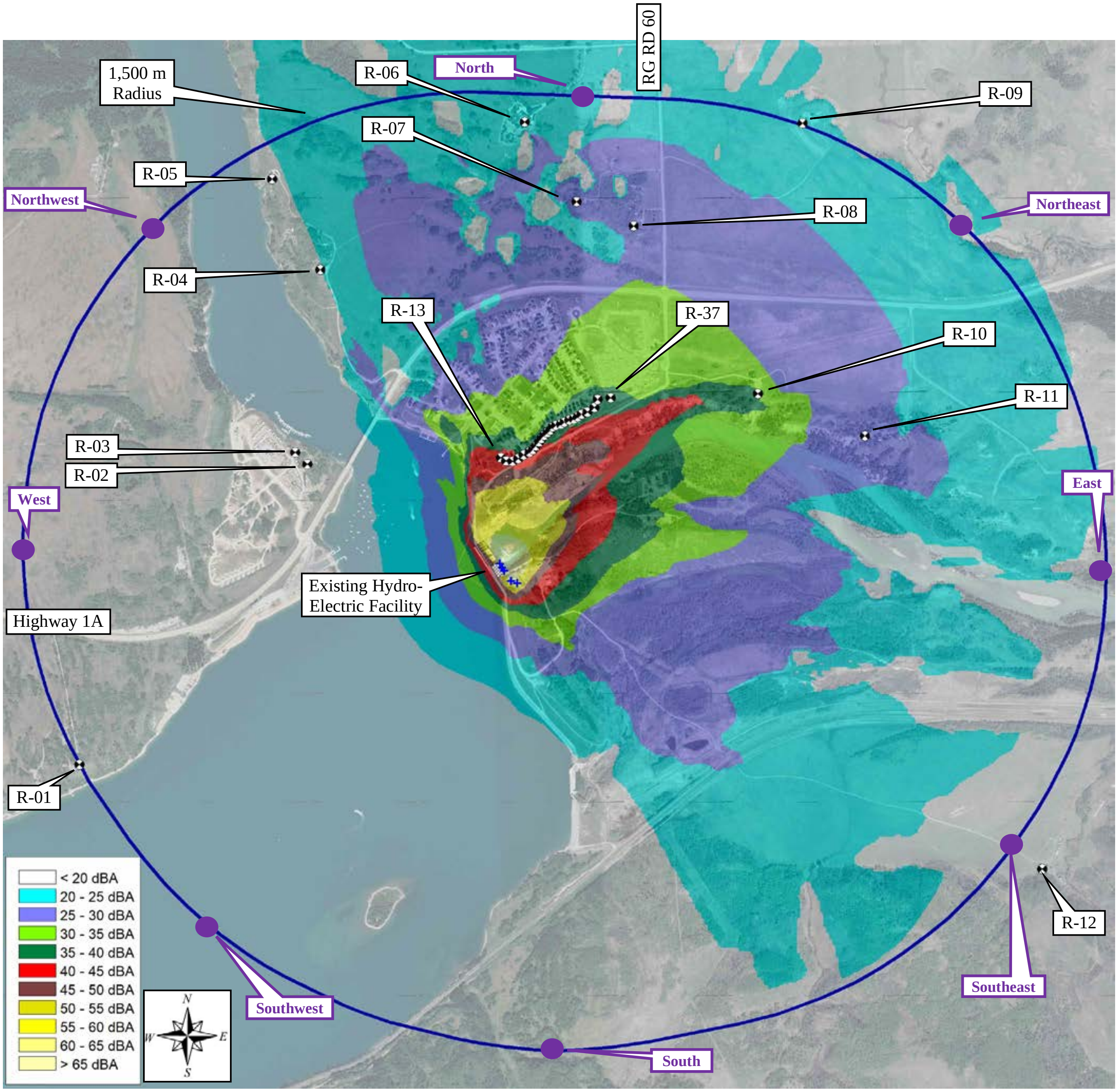

Figure 3. *Baseline Case* Noise Modeling L_{eq} Night-Time (Without ASL)

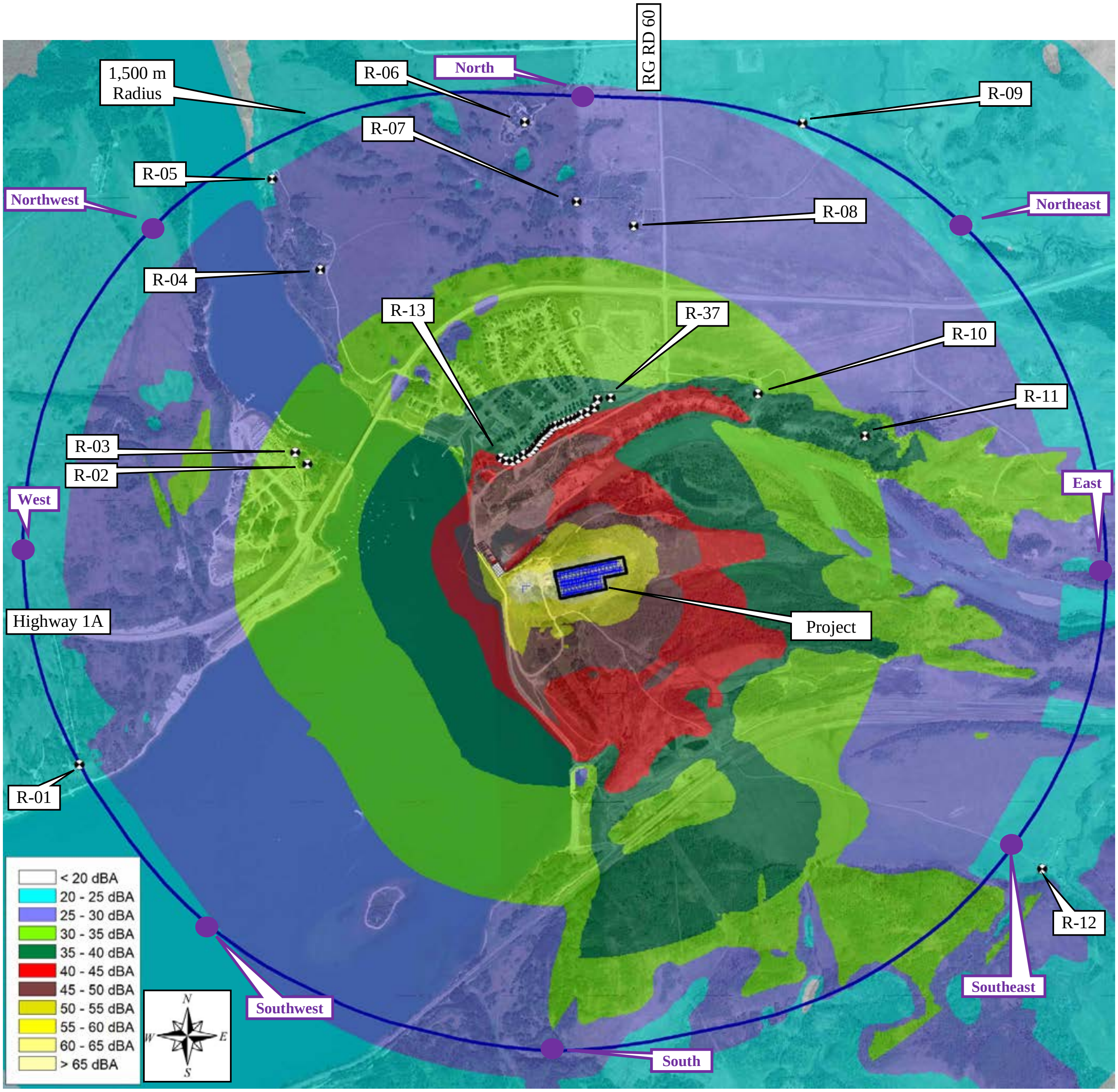

Figure 4. *Project-Only* Case Noise Modeling L_{eq} Night-Time (Without ASL)

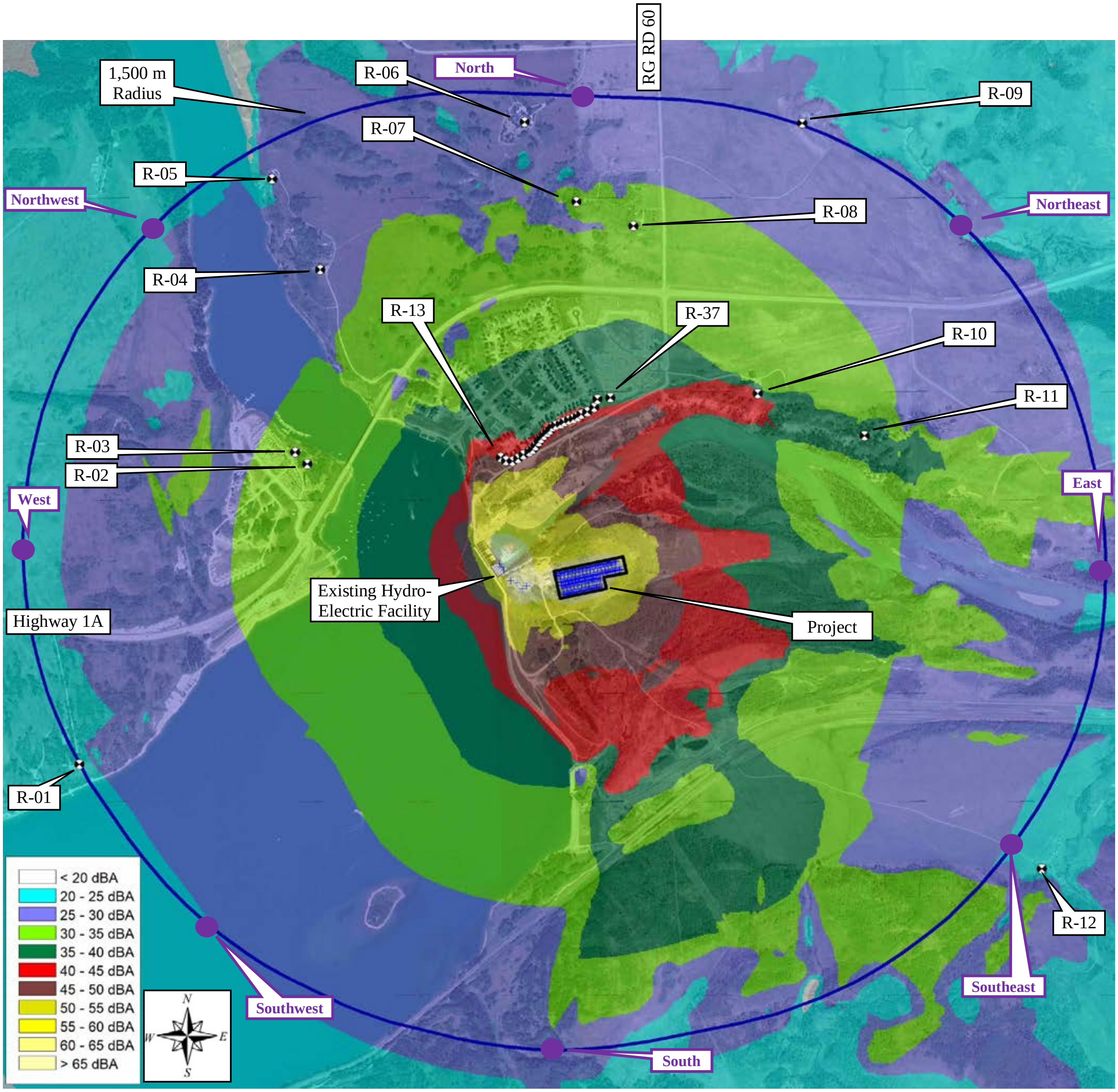

Figure 5. *Application Case* Noise Modeling L_{eq} Night-Time (Without ASL)

Appendix I. 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 ($P_{ref} = 2\text{x}10^{-5}$ Pa = 20 μPa)

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 μPa 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!

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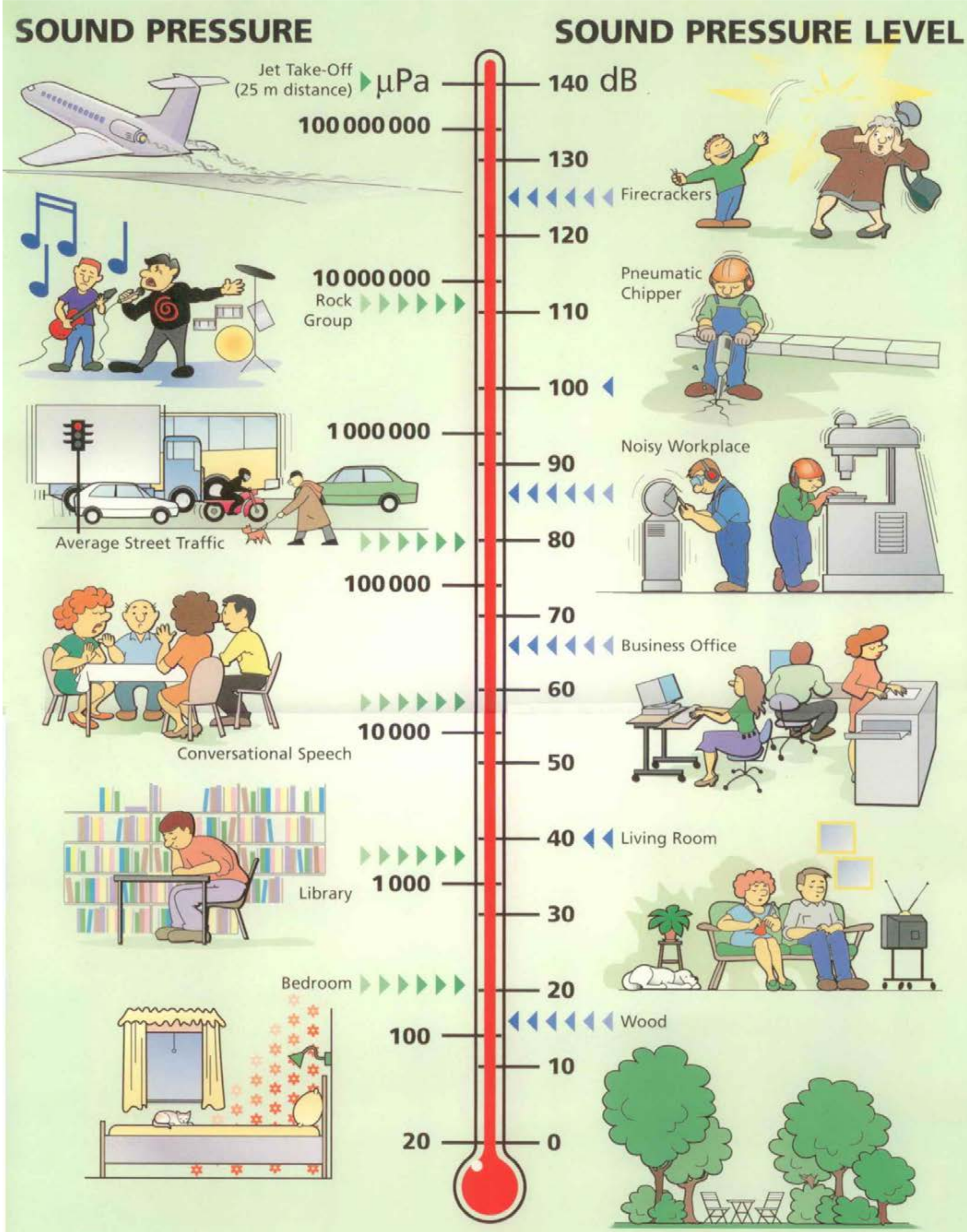
SOUND PRESSURE
SOUND PRESSURE LEVEL
Jet Take-Off
(25 m distance)
µPa
140 dB
100 000 000
130
Firecrackers
120
10 000 000
Rock
Group
110
Pneumatic
Chipper
100
1 000 000
Noisy Workplace
90
Average Street Traffic
80
100 000
70
Business Office
60
10 000
Conversational Speech
50
40
Living Room
Library
1000
30
Bedroom
20
Wood
100
10
20
0

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

Lower Band Limit	Center Frequency	Upper Band Limit
11	**16**	22
22	**31.5**	44
44	**63**	88
88	**125**	177
177	**250**	355
355	**500**	710
710	**1000**	1420
1420	**2000**	2840
2840	**4000**	5680
5680	**8000**	11360
11360	**16000**	22720

1/3 Octave

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

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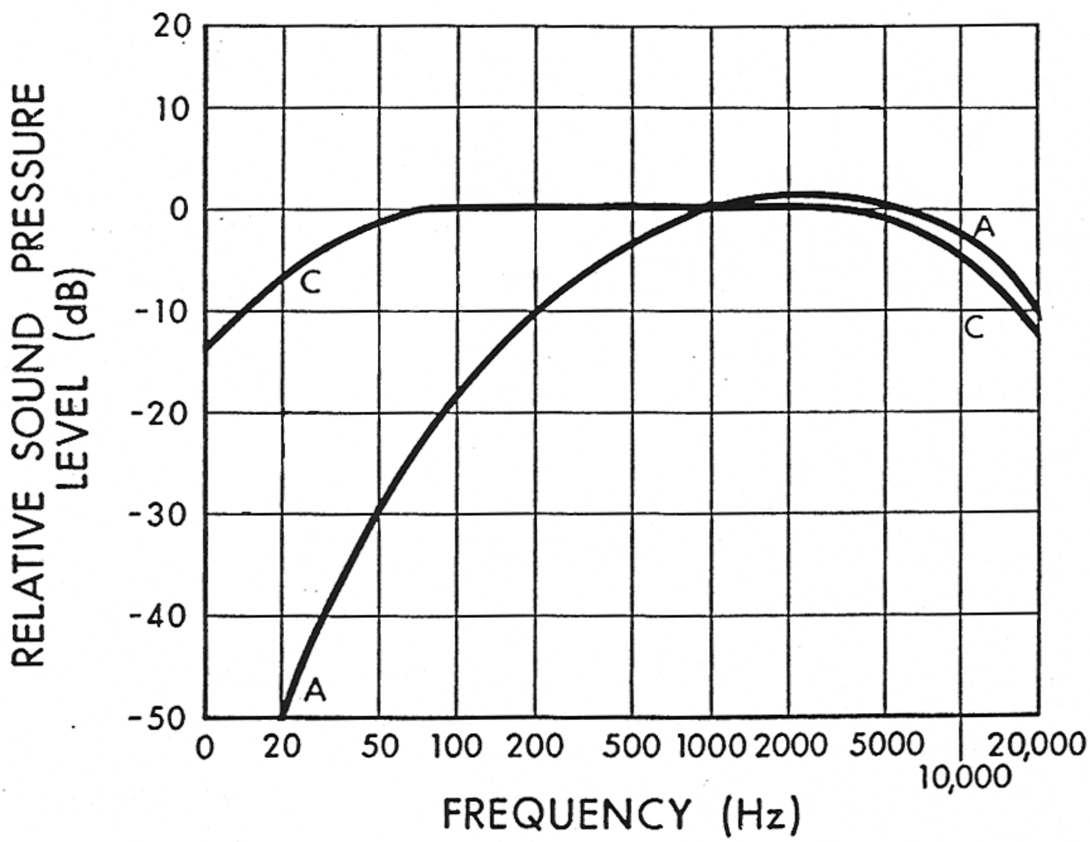
Human hearing is most sensitive at approximately 3500 Hz which corresponds to the ¼ wavelength of the ear canal (approximately 2.5 cm). Because of this range of sensitivity to various frequencies, we typically apply various weighting networks to the broadband measured sound to more appropriately account 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.

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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

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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.

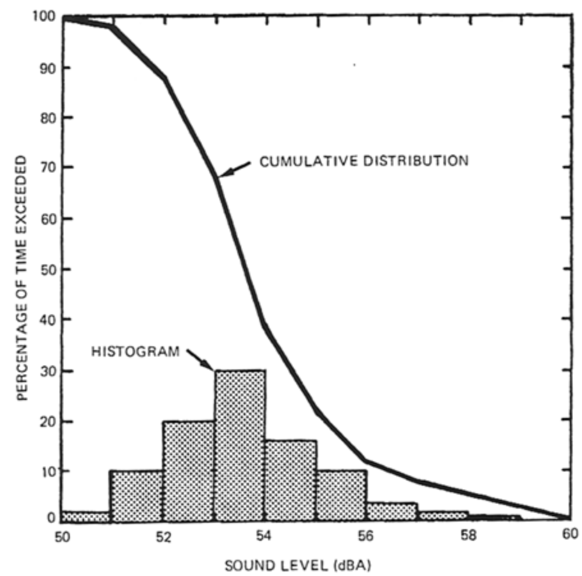

Figure 16.6 Statistically processed community noise showing histogram and cumulative distribution of A weighted sound levels.

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

L_{99} - 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.

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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: SPL_1 = sound pressure level at location 1, SPL_2 = 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 44 dB at 400m.
- A line source measuring 50 dB at 100m will be 40 dB at 1000m.

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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 °C	Relative Humidity (%)	Frequency (Hz) 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 tends to increase
- As Relative Humidity increases, absorption tends to decrease
- 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)**

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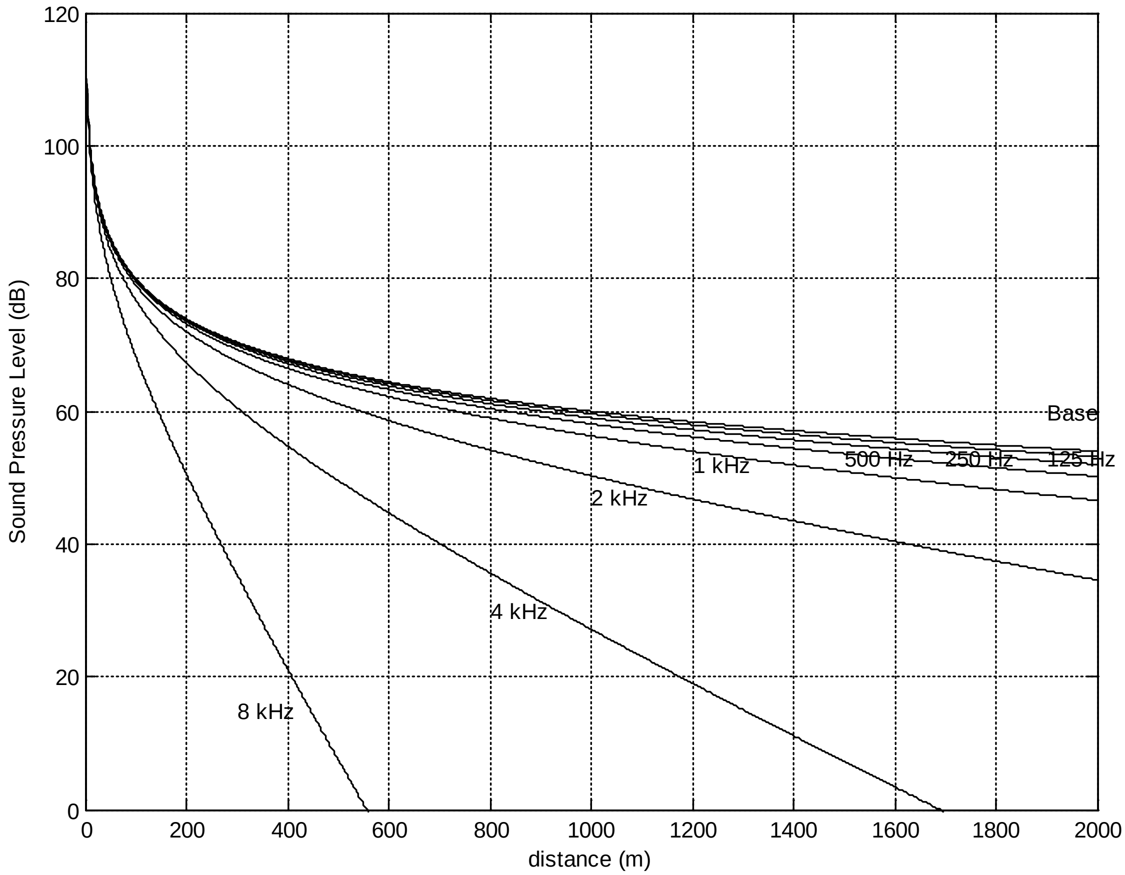

Atmospheric Absorption at 10ºC and 70% RH

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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 ±10dB 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.

Temperature

- 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 ±10dB are possible depending on gradient of temperature and distance from source.

Rain

- 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.

Summary

- 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.

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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

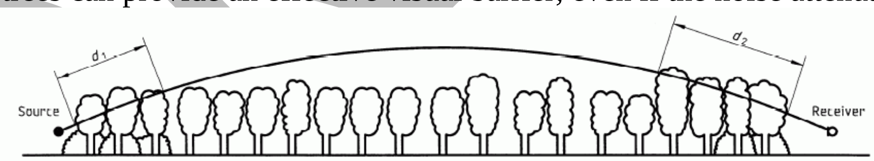
- Can be an effective absorber due to large area covered
- Only effective at low height above ground. Does not affect sound transmitted direct from source to receiver if there is line of sight.
- Typically less absorption than atmospheric absorption when there is line of sight.
- Approximate rule of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

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

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 — $d_f = d_1 + d_2$

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

Figure A.1 — Attenuation due to propagation through foliage increases linearly with propagation distance d_f through the foliage

Table A.1 — Attenuation of an octave band of noise due to propagation a distance d_f through dense foliage

Propagation distance d_f m	Nominal midband frequency Hz 63	125	250	500	1 000	2 000	4 000	8 000
$10 \leq d_f \leq 20$	Attenuation, dB: 0	0	1	1	1	1	2	3
$20 \leq d_f \leq 200$	Attenuation, dB/m: 0,02	0,03	0,04	0,05	0,06	0,08	0,09	0,12

Tree/Foliage attenuation from ISO 9613-2:1996

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.

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Appendix II. SOUND LEVELS OF FAMILIAR NOISE SOURCES

Used with Permission Obtained from the AER Directive 038 (February 2007)

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

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[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 the AER Directive 038 (February 2007)

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

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[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).

Appendix III. NOISE MEASUREMENT EQUIPMENT

The noise measurements were conduced using a Brüel and Kjær Type 2250 Precision Integrating Sound Level Meter with a windscreen. The system acquired data in 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 April 07, 2021 and the calibrator (type B&K 4231) was certified on March 03, 2021 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. All measurement methods and instrumentation conform to the requirements of the AUC Rule 012.

Site Calibration Results

Description	Date	Time	Pre / Post	Calibration Level	Calibrator Model	Serial Number
Pre-Calibration	October 25 2021	08:00	Pre	93.9 dBA	B&K 4231	2594693
Post-Calibration	October 25 2021	13:00	Post	93.9 dBA	B&K 4231	2594693

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B&K 2250 SLM Calibration Certificate

CALIBRATED BY TRANSCAT

CERTIFICATE OF CALIBRATION

Customer: ACI ACCOUSTICAL CONSULTANTS IN
5031-210 STREET NW
EDMONTON, AB T6M 0A8

PO Number: BILAWCHUK

ANAB ACCREDITED ISO/IEC 17025 CALIBRATION LABORATORY
ANAB AC-2489.07
ilac-MRA

Certificate/SO Number: 17-Q1X3X-40-1 Revision 0

Manufacturer: Bruel & Kjaer
Model Number: 2250
Description: Sound Level Meter
Serial Number: 3027810/3195885
ID: UNIT 9

As-Found: In Tolerance
As-Left: In Tolerance

Issue Date: Apr 07, 2021
Calibration Date: Apr 07, 2021

Calibrated To: Manufacturer Specification
Calibration Procedure: 1-AC28548-3

Transcat Calibration Laboratories have been audited and found in compliance with ISO/IEC 17025:2017. Accredited calibrations performed within the Lab?s Scope of Accreditation are indicated by the presence of the Accrediting Body?s Logo and Certificate Number. Any measurements on an accredited calibration not covered by that Lab?s Scope of Accreditation are listed in the notes section of the certificate. SCC, NRC, CLAS or ANAB do not guarantee the accuracy of an individual calibration by accredited laboratories.

Transcat calibrations, as applicable, are performed in compliance with the requirements of the Transcat Quality Manual QAC-P01-000, the customer?s Purchase Order and/or Quality Agreement requirements, ISO 9001:2015, ANSI/NCSL Z540.1-1994 (R2002) or NQA-1, as applicable. Complete records of work performed are maintained by Transcat and are available for inspection. Laboratory standards used in the performance of this calibration are listed on this certificate.

Transcat documents the traceability of measurements to the SI units through the National Institute of Standards and Technology(NIST), or the National Research Council of Canada (NRC), or other national measurement institutes (NMI) that are signatories to the CIPM Mutual Recognition Arrangement, or accepted fundamental and/or natural physical constants, or by the use of specified methods, consensus standards or ratio type measurements. Documentation supporting traceability information is available for review upon written request at a Transcat facility. The measured quantity and the measurement uncertainty are required for further dissemination of traceability.

A binary decision rule, utilizing simple acceptance, and simple rejection criteria is used for the determination of compliance, unless otherwise superseded by the client?s Decision Rule. When Calibration Tolerance compliance statements are present, they are reported without factoring in the effects of uncertainty and comply with the guidelines established by ASME B89.7.3.1-2001 (R2019) as follows:
-The acceptance zone is defined as: less than or equal to the high calibration tolerance limit, and/or greater than or equal to the low calibration tolerance limit. The rejection zones are defined as greater than the high calibration tolerance limit and/or less than the low calibration tolerance limit.
-Single measurement results in the acceptance zone are be identified as in-tolerance. Single measurement results in the rejection zone are identified as out-of-tolerance (OOT).
-When all measurement results are in the acceptance zone for repeated measurements, for the same characteristic, the test is identified as in-tolerance. For repeated characteristic measurements, a single measurement result in the rejection zone, will cause the test to be identified as out-of-tolerance (OOT).

Uncertainties are reported with a coverage factor k=2, providing a level of confidence of approximately 95%. All calibrations have been performed using processes having a TUR of 4:1 or better (3:1 for mass calibrations), unless otherwise noted. The Test Uncertainty Ratio (TUR) is calculated in accordance with NCSL International RP-18. For mass calibrations: Conventional mass referenced to 8.0 g/cm³.

The results in this report relate only to the item calibrated or tested. Recorded calibration data is valid at the time of calibration within the stated uncertainties at the environmental conditions noted. The determination of compliance to the specification is specific to the model/serial no./ID no. referenced above based on the tolerances shown; these tolerances are either the original equipment manufacturers(OEM?s) warranted specifications or the client?s requested specifications. This certificate may not be reproduced except in full, without the written approval of Transcat. Additional information, if applicable may be included on separate report(s).

Date Received: March 19, 2021
Service Level: R9

Certificate - Page 1 of 7

Customer Number: 9-330269-000
OPS-F20-014R8 04/01/21 FP014R0 4/2/2021

B&K 4231 Calibrator Calibration Certificate

Scantek, Inc.
CALIBRATION LABORATORY

ISO 17025: 2017, ANSI/NCSL Z540:1994 Part 1
ACCREDITED by NVLAP (an ILAC MRA signatory)

NVLAP®
CALIBRATION
NVLAP Lab Code: 200625-0

Calibration Certificate No.46831

Instrument: **Acoustical Calibrator**
Model: **4231**
Manufacturer: **Brüel and Kjær**
Serial number: **2594693**
Class (IEC 60942): **1**
Barometer type:
Barometer s/n:
Customer: **ACI Acoustical Consultants Inc.**
Tel/Fax: **780-414-6373 / 780-414-6376**

Date Calibrated: **8/26/2021** *Cal Due:*

Status:	Received	Sent
In tolerance:	X	X
Out of tolerance:		
See comments:		

Contains non-accredited tests: __Yes _X_ No

Address: **5031 - 210 Street, Edmonton, Alberta, CANADA T6M 0A8**

Tested in accordance with the following procedures and standards:
Calibration of Acoustical Calibrators, Scantek Inc., Rev. 10/1/2010

Instrumentation used for calibration: Nor-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal. Date	Traceability evidence Cal. Lab / Accreditation	Cal. Due
483B-Norsonic	SME Cal Unit	31052	Oct 31, 2020	Scantek, Inc./ NVLAP	Oct 31, 2021
DS-360-SRS	Function Generator	33584	Oct 23, 2019	ACR Env./ A2LA	Oct 23, 2021
34401A-Agilent Technologies	Digital Voltmeter	MY47011118	Feb 4, 2021	ACR Env. / A2LA	Feb 4, 2022
HM30-Thommen	Meteo Station	1040170/39633	Dec 7, 2020	ACR Env./ A2LA	Dec 7, 2021
140-Norsonic	Real Time Analyzer	1406423	Nov 3, 2020	Scantek / NVLAP	Nov 3, 2021
PC Program 1018 Norsonic	Calibration software	v.6.1T	Validated Nov 2014	Scantek, Inc.	-
4134-Brüel&Kjær	Microphone	173368	Oct 26, 2020	Scantek, Inc. / NVLAP	Oct 26, 2021
1203-Norsonic	Preamplifier	14059	March 3, 2021	Scantek, Inc./ NVLAP	March 3, 2022

Instrumentation and test results are traceable to SI (International System of Units) through standards maintained by NIST (USA) and NPL (UK)

Calibrated by:	Lydon Dawkins	Authorized signatory:	William Gallagher
Signature	Lydon Dawkins	Signature	William D Gallagher
Date	8/26/2021	Date	8/27/2021

Calibration Certificates or Test Reports shall not be reproduced, except in full, without written approval of the laboratory.
This Calibration Certificate or Test Reports shall not be used to claim product certification, approval or endorsement by NVLAP, NIST, or any agency of the federal government.
Document stored as: Y:\Calibration Lab\Cal 2021\BNK4231_2594693_M1.doc Page 1 of 2

Appendix IV. NOISE MODELING PARAMETERS

Existing Regulated Noise Source Octave Band Sound Power Levels (Re 10^{-12} Watts)

Item	dBA	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
Turbine Unit Discharge (each x3)	103.9	109.8	107.4	104.3	98.7	99.9	99.9	95.0	94.1	90.0
TransAlta XFR	85.0	86.4	84.7	91.5	84.3	83.9	80.5	69.8	62.4	60.8
TransAlta XFR	84.3	86.2	85.4	89.0	83.2	85.3	76.4	67.7	63.8	63.3

Project Noise Source Octave Band Sound Power Levels (Re 10^{-12} Watts, un-mitigated)

Item	dBA	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
Switchgear Buildings (each x6)	90.0	86.6	92.6	94.6	89.6	89.6	83.6	78.6	73.6	66.6
Auxiliary Transformers (each)	89.8	86.4	92.4	94.4	89.4	89.4	83.4	78.4	73.4	66.4
Substation Transformer (50 MVA)	99.9	99.5	102.5	104.5	99.5	99.5	93.5	88.5	83.5	76.5
Substation Transformer (180 MVA)	103.6	103.2	106.2	108.2	103.2	103.2	97.2	92.2	87.2	80.2
Battery Enclosure (each x216)	76.9	77.8	75.5	76.7	78.0	76.7	69.2	66.4	61.6	56.0
Inverter (each x 55)	90.2	85.8	91.0	84.6	86.2	85.4	84.8	84.7	79.3	74.7

Noise Modeling Parameters

Parameter	Value
Modeling Software	CADNA/A (Build 173.4950)
Standard Followed	ISO 9613-2
Ground Sound Absorption Coefficient	0.5
Wind Speed	1 - 5 m/s (3.6 - 18 km/hr)
Wind Direction	Downwind from all sources to all receptors
Temperature	10 °C
Humidity	70%
Topography	Used Digital Terrain Model Contours Provided by Client

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Appendix V. PERMISSIBLE SOUND LEVEL DETERMINATION

Residential Receptors Beyond 500 m From Heavily Traveled Road or Rail and With Population Density Less Than 9 Dwellings Per Quarter Section of Land, and Theoretical 1,500m Receptors

R-05, R-06, R-09, and R-12

Basic Sound Level

Proximity to Transportation	Dwelling Density (Per Quarter Section of Land): 1 - 8 Dwellings	9 - 160 Dwellings	> 160 Dwellings	Night-Time	Day-Time
Category 1	40	43	46	40	40
Category 2	45	48	51		
Category 3	50	53	56		
Basic Sound Level (dBA)				40	40

Time of Day Adjustment

Time of Day	Adjustment (dBA)	Night-Time	Day-Time
Night-time adjustment for hours 22:00 - 07:00	0	0	n/a
Day-time adjustment for hours 07:00 - 22:00	+10	n/a	+10
Time of day adjustment (dBA)		0	+ 10

Class A Adjustments

Class	Reason for Adjustment	Adjustment (dBA)	Night-Time	Day-Time
A1	Seasonal Adjustment (Winter)	0 to +5	0	0
A2	Ambient Monitoring Adjustment	-10 to +10	0	0
Sum of A1 and A2 cannot exceed maximum of 10 dBA Leq				
Class A Adjustment (dBA)			0	0

Class B Adjustments

Class	Duration of Activity	Adjustment (dBA)	Night-Time	Day-Time
B1	≤ 1 Day	+ 15	0	0
B2	≤ 7 Days	+ 10	0	0
B3	≤ 60 Days	+ 5	0	0
B4	> 60 Days	0	0	0
Can only apply one of B1, B2, B3, or B4				
Class B Adjustment (dBA)			0	0

	Night-Time	Day-Time
Total Permissible Sound Level (PSL) [dBA]	40	50

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Residential Receptors Between 30 – 500 m From A Heavily Traveled Road or Rail and With Population Density Less Than 9 Dwellings Per Quarter Section of Land

R-01 to R-04 and R-11

Basic Sound Level

Proximity to Transportation	Dwelling Density (Per Quarter Section of Land): 1 - 8 Dwellings	9 - 160 Dwellings	> 160 Dwellings	Night-Time	Day-Time
Category 1	40	43	46		
Category 2	45	48	51	45	45
Category 3	50	53	56		
Basic Sound Level (dBA)				45	45

Time of Day Adjustment

Time of Day	Adjustment (dBA)	Night-Time	Day-Time
Night-time adjustment for hours 22:00 - 07:00	0	0	n/a
Day-time adjustment for hours 07:00 - 22:00	+10	n/a	+10
Time of day adjustment (dBA)		0	+ 10

Class A Adjustments

Class	Reason for Adjustment	Adjustment (dBA)	Night-Time	Day-Time
A1	Seasonal Adjustment (Winter)	0 to +5	0	0
A2	Ambient Monitoring Adjustment	-10 to +10	0	0
Sum of A1 and A2 cannot exceed maximum of 10 dBA Leq				
Class A Adjustment (dBA)			0	0

Class B Adjustments

Class	Duration of Activity	Adjustment (dBA)	Night-Time	Day-Time
B1	≤ 1 Day	+ 15	0	0
B2	≤ 7 Days	+ 10	0	0
B3	≤ 60 Days	+ 5	0	0
B4	> 60 Days	0	0	0
Can only apply one of B1, B2, B3, or B4				
Class B Adjustment (dBA)			0	0

	Night-Time	Day-Time
Total Permissible Sound Level (PSL) [dBA]	45	55

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Residential Receptors Between 30 – 500 m From A Heavily Traveled Road or Rail and With Population Density Between 9 – 160 Dwellings Per Quarter Section of Land

R-07, R-08, and R-10

Basic Sound Level

Proximity to Transportation	Dwelling Density (Per Quarter Section of Land): 1 - 8 Dwellings	9 - 160 Dwellings	> 160 Dwellings	Night-Time	Day-Time
Category 1	40	43	46		
Category 2	45	48	51	48	48
Category 3	50	53	56		
Basic Sound Level (dBA)				48	48

Time of Day Adjustment

Time of Day	Adjustment (dBA)	Night-Time	Day-Time
Night-time adjustment for hours 22:00 - 07:00	0	0	n/a
Day-time adjustment for hours 07:00 - 22:00	+10	n/a	+10
Time of day adjustment (dBA)		0	+ 10

Class A Adjustments

Class	Reason for Adjustment	Adjustment (dBA)	Night-Time	Day-Time
A1	Seasonal Adjustment (Winter)	0 to +5	0	0
A2	Ambient Monitoring Adjustment	-10 to +10	0	0
Sum of A1 and A2 cannot exceed maximum of 10 dBA Leq				
Class A Adjustment (dBA)			0	0

Class B Adjustments

Class	Duration of Activity	Adjustment (dBA)	Night-Time	Day-Time
B1	≤ 1 Day	+ 15	0	0
B2	≤ 7 Days	+ 10	0	0
B3	≤ 60 Days	+ 5	0	0
B4	> 60 Days	0	0	0
Can only apply one of B1, B2, B3, or B4				
Class B Adjustment (dBA)			0	0

	Night-Time	Day-Time
Total Permissible Sound Level (PSL) [dBA]	48	58

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Residential Receptors Between 30 – 500 m From A Heavily Traveled Road or Rail and With Population Density Greater Than 160 Dwellings Per Quarter Section of Land

R-13 to R-37

Basic Sound Level

	Dwelling Density (Per Quarter Section of Land)			Night-Time	Day-Time
Proximity to Transportation	1 - 8 Dwellings	9 - 160 Dwellings	> 160 Dwellings		
Category 1	40	43	46		
Category 2	45	48	51	48	48
Category 3	50	53	56		
Basic Sound Level (dBA)				48	48

Time of Day Adjustment

Time of Day	Adjustment (dBA)	Night-Time	Day-Time
Night-time adjustment for hours 22:00 - 07:00	0	0	n/a
Day-time adjustment for hours 07:00 - 22:00	+10	n/a	+10
Time of day adjustment (dBA)		0	+ 10

Class A Adjustments

Class	Reason for Adjustment	Adjustment (dBA)	Night-Time	Day-Time
A1	Seasonal Adjustment (Winter)	0 to +5	0	0
A2	Ambient Monitoring Adjustment	-10 to +10	0	0
Sum of A1 and A2 cannot exceed maximum of 10 dBA Leq				
Class A Adjustment (dBA)			0	0

Class B Adjustments

Class	Duration of Activity	Adjustment (dBA)	Night-Time	Day-Time
B1	≤ 1 Day	+ 15	0	0
B2	≤ 7 Days	+ 10	0	0
B3	≤ 60 Days	+ 5	0	0
B4	> 60 Days	0	0	0
Can only apply one of B1, B2, B3, or B4				
Class B Adjustment (dBA)			0	0

	Night-Time	Day-Time
Total Permissible Sound Level (PSL) [dBA]	48	58

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Appendix VI. NOISE SOURCE ORDER-RANKING

Application Case R-10

Noise Source	dBA	Cumulative		31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Existing Generator	30.5	30.5		36.6	34.4	31.7	27.5	29.2	27.4	16.3	-8.3
Existing Generator	30.5	33.5		36.6	34.4	31.7	27.5	29.2	27.4	16.3	-8.3
Existing Generator	30.0	35.1		36.4	34.1	31.0	25.5	27.9	27.4	16.3	-8.3
Substation Transformer (180 MVA)	29.8	36.2		27.9	31.3	34.3	31.2	30.3	22.6	11.6	-16.4
Substation Transformer (50 MVA)	26.0	36.6		24.1	27.5	30.5	27.3	26.4	18.7	7.6	-20.8
Inverter	20.0	36.7		22.6	27.8	14.7	16.2	17.8	16.4	11.8	-10.6
Inverter	20.0	36.8		22.7	27.8	14.7	16.2	17.9	16.4	11.9	-10.5
Inverter	19.9	36.9		22.5	27.7	14.6	16.1	17.7	16.2	11.6	-11.0
Inverter	19.9	37.0		22.5	27.7	14.6	16.1	17.7	16.2	11.7	-11.0
Inverter	19.7	37.1		22.4	27.6	14.5	16.0	17.6	16.1	11.4	-11.5
Inverter	19.7	37.1		22.4	27.6	14.5	16.0	17.6	16.1	11.5	-11.4
Inverter	19.6	37.2		22.3	27.5	14.3	15.9	17.5	15.9	11.2	-11.9
Inverter	19.6	37.3		22.3	27.5	14.3	15.9	17.5	15.9	11.3	-11.8
Inverter	19.5	37.4		22.2	27.4	14.2	15.8	17.4	15.8	11.1	-12.2
Inverter	19.4	37.4		22.2	27.4	14.2	15.7	17.3	15.8	11.0	-12.3
Switchgear	19.3	37.5		21.8	27.8	22.7	17.8	20.1	12.9	2.5	-23.3
Switchgear	19.3	37.6		21.8	27.8	22.7	17.8	20.1	12.9	2.5	-23.3
Switchgear	19.3	37.6		21.8	27.8	22.7	17.8	20.1	12.9	2.5	-23.3
Switchgear	19.3	37.7		21.8	27.7	22.7	17.8	20.0	12.9	2.5	-23.3
Switchgear	19.3	37.8		21.8	27.7	22.7	17.8	20.0	12.9	2.5	-23.4
Inverter	19.3	37.8		22.1	27.2	14.1	15.6	17.2	15.6	10.8	-12.7
Inverter	19.3	37.9		22.1	27.3	14.1	15.7	17.2	15.7	10.9	-12.7
Switchgear	19.2	37.9		21.8	27.7	22.7	17.8	20.0	12.9	2.4	-23.4
Inverter	19.2	38.0		22.0	27.2	14.0	15.5	17.1	15.5	10.7	-13.1
Inverter	19.1	38.0		22.0	27.1	13.9	15.5	17.1	15.5	10.6	-13.2
Auxiliary Transformer	19.0	38.1		21.6	27.5	22.5	17.5	19.8	12.6	2.2	-23.8
Inverter	19.0	38.2		21.9	27.0	13.8	15.4	16.9	15.3	10.4	-13.6
Inverter	19.0	38.2		21.9	27.1	13.8	15.4	17.0	15.4	10.5	-13.5
Inverter	18.9	38.3		21.8	27.0	13.7	15.3	16.9	15.2	10.2	-14.0
Inverter	18.9	38.3		21.9	27.0	13.7	15.3	16.9	15.3	10.3	-13.8
Inverter	18.8	38.4		21.8	26.9	13.7	15.3	16.8	15.2	10.2	-14.1
Inverter	18.8	38.4		21.8	26.9	13.6	15.2	16.8	15.1	10.1	-14.3
Inverter	18.8	38.5		21.8	26.9	13.6	15.2	16.8	15.2	10.1	-14.2
Inverter	18.7	38.5		21.7	26.8	13.6	15.2	16.7	15.1	10.0	-14.5
Inverter	18.7	38.5		21.7	26.9	13.6	15.2	16.7	15.1	10.0	-14.4
Inverter	18.7	38.6		21.7	26.8	13.5	15.1	16.7	15.0	10.0	-14.6
Inverter	18.6	38.6		21.6	26.8	13.5	15.1	16.6	15.0	9.8	-14.9
Inverter	18.6	38.7		21.7	26.8	13.5	15.1	16.6	15.0	9.9	-14.7
Inverter	18.5	38.7		21.6	26.7	13.4	15.1	16.6	14.9	9.8	-14.9
Inverter	18.5	38.8		21.6	26.7	13.4	15.0	16.5	14.9	9.7	-15.1
Inverter	18.5	38.8		21.6	26.7	13.4	15.0	16.6	14.9	9.8	-15.0
Inverter	18.4	38.8		21.5	26.6	13.3	14.9	16.5	14.8	9.6	-15.4
Inverter	18.4	38.9		21.5	26.7	13.3	15.0	16.5	14.8	9.6	-15.3
Inverter	18.4	38.9		21.5	26.6	13.3	14.9	16.4	14.7	9.5	-15.5
Inverter	18.4	39.0		21.5	26.6	13.3	14.9	16.4	14.8	9.6	-15.5
Inverter	18.3	39.0		21.4	26.5	13.2	14.8	16.3	14.6	9.4	-15.9
Inverter	18.3	39.0		21.4	26.6	13.2	14.9	16.4	14.7	9.4	-15.7
Inverter	18.2	39.1		21.3	26.5	13.1	14.7	16.2	14.5	9.2	-16.2
Inverter	18.2	39.1		21.4	26.5	13.2	14.8	16.3	14.6	9.3	-16.0
Inverter	18.2	39.1		21.4	26.5	13.2	14.8	16.3	14.6	9.4	-15.9
Inverter	18.1	39.2		21.3	26.4	13.1	14.7	16.2	14.5	9.2	-16.3
Inverter	18.1	39.2		21.3	26.4	13.0	14.7	16.2	14.5	9.1	-16.4
Inverter	18.1	39.2		21.3	26.4	13.1	14.7	16.2	14.5	9.2	-16.3
Inverter	18.0	39.3		21.2	26.3	12.9	14.6	16.1	14.4	9.0	-16.7
Inverter	18.0	39.3		21.2	26.4	13.0	14.6	16.1	14.4	9.0	-16.6
Inverter	18.0	39.3		21.2	26.3	12.9	14.6	16.1	14.4	9.0	-16.7
Inverter	17.9	39.4		21.1	26.3	12.9	14.5	16.0	14.3	8.8	-17.1

Note: Octave band sound levels are linear (i.e. not A-weighted)

DRAFT

Application Case R-10 (Cont.)

Noise Source	dBA	Cumulative		31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Inverter	17.9	39.4		21.2	26.3	12.9	14.6	16.1	14.3	8.9	-16.8
Inverter	17.8	39.4		21.1	26.2	12.8	14.5	16.0	14.2	8.8	-17.2
Inverter	17.8	39.5		21.1	26.2	12.8	14.5	15.9	14.2	8.7	-17.3
Inverter	17.8	39.5		21.1	26.3	12.8	14.5	16.0	14.2	8.8	-17.2
Inverter	17.7	39.5		21.1	26.2	12.7	14.4	15.9	14.1	8.6	-17.5
Inverter	17.7	39.5		21.0	26.1	12.7	14.4	15.8	14.1	8.5	-17.7
Inverter	17.7	39.6		21.0	26.2	12.7	14.4	15.9	14.1	8.6	-17.6
Inverter	17.6	39.6		20.9	26.1	12.6	14.3	15.7	14.0	8.4	-18.0
Inverter	17.5	39.6		20.9	26.0	12.6	14.2	15.7	13.9	8.3	-18.2
Inverter	17.4	39.6		20.9	26.0	12.5	14.2	15.6	13.8	8.2	-18.5
Existing TransAlta XFR	13.3	39.7		20.6	18.8	18.5	11.9	13.4	8.3	-8.5	-39.4
Existing TransAlta XFR	12.9	39.7		20.3	19.4	15.9	10.7	14.7	4.1	-10.8	-38.4
Battery_Enclosure	8.2	39.7		14.7	12.3	6.9	8.1	9.2	0.9	-6.3	-28.0
Battery_Enclosure	8.2	39.7		14.7	12.4	6.9	8.1	9.2	0.9	-6.3	-27.9
Battery_Enclosure	8.1	39.7		14.6	12.2	6.8	8.0	9.1	0.7	-6.5	-28.4
Battery_Enclosure	8.1	39.7		14.6	12.3	6.8	8.0	9.1	0.7	-6.5	-28.3
Battery_Enclosure	8.1	39.7		14.7	12.3	6.8	8.0	9.2	0.8	-6.4	-28.2
Battery_Enclosure	8.1	39.7		14.7	12.3	6.9	8.1	9.2	0.8	-6.4	-28.1
Battery_Enclosure	8.1	39.7		14.6	12.3	6.8	8.0	9.1	0.7	-6.5	-28.3
Battery_Enclosure	8.1	39.7		14.6	12.2	6.8	8.0	9.1	0.7	-6.5	-28.4
Battery_Enclosure	8.0	39.7		14.6	12.2	6.7	7.9	9.0	0.6	-6.6	-28.6
Battery_Enclosure	8.0	39.7		14.6	12.2	6.7	7.9	9.1	0.7	-6.6	-28.6
Battery_Enclosure	8.0	39.7		14.5	12.2	6.7	7.9	9.0	0.6	-6.7	-28.7
Battery_Enclosure	8.0	39.7		14.6	12.2	6.7	8.0	9.1	0.7	-6.6	-28.5
Battery_Enclosure	8.0	39.7		14.6	12.2	6.7	7.9	9.0	0.6	-6.6	-28.6
Battery_Enclosure	7.9	39.7		14.4	12.1	6.6	7.8	8.9	0.5	-6.8	-29.1
Battery_Enclosure	7.9	39.7		14.5	12.1	6.6	7.8	8.9	0.5	-6.8	-29.0
Battery_Enclosure	7.9	39.7		14.5	12.1	6.6	7.9	9.0	0.6	-6.7	-28.8
Battery_Enclosure	7.9	39.7		14.5	12.1	6.7	7.9	9.0	0.6	-6.7	-28.8
Battery_Enclosure	7.9	39.7		14.5	12.1	6.6	7.8	8.9	0.5	-6.8	-29.0
Battery_Enclosure	7.9	39.7		14.5	12.1	6.6	7.8	8.9	0.5	-6.8	-28.9
Battery_Enclosure	7.9	39.7		14.5	12.1	6.7	7.9	9.0	0.6	-6.7	-28.8
Battery_Enclosure	7.8	39.7		14.4	12.0	6.5	7.7	8.8	0.4	-6.9	-29.3
Battery_Enclosure	7.8	39.7		14.4	12.0	6.5	7.8	8.9	0.4	-6.9	-29.2
Battery_Enclosure	7.8	39.7		14.4	12.0	6.5	7.7	8.8	0.4	-7.0	-29.4
Battery_Enclosure	7.8	39.7		14.4	12.0	6.5	7.8	8.9	0.4	-6.9	-29.2
Battery_Enclosure	7.8	39.7		14.4	12.1	6.6	7.8	8.9	0.5	-6.9	-29.2
Battery_Enclosure	7.7	39.7		14.3	11.9	6.4	7.6	8.7	0.3	-7.1	-29.7
Battery_Enclosure	7.7	39.7		14.3	11.9	6.4	7.6	8.7	0.3	-7.1	-29.7
Battery_Enclosure	7.7	39.7		14.3	12.0	6.4	7.7	8.8	0.3	-7.0	-29.5
Battery_Enclosure	7.7	39.8		14.4	12.0	6.5	7.7	8.8	0.4	-7.0	-29.4
Battery_Enclosure	7.7	39.8		14.3	11.9	6.4	7.6	8.7	0.3	-7.1	-29.6
Battery_Enclosure	7.7	39.8		14.3	12.0	6.4	7.7	8.8	0.3	-7.1	-29.6
Battery_Enclosure	7.7	39.8		14.4	12.0	6.5	7.7	8.8	0.4	-7.0	-29.4
Battery_Enclosure	7.6	39.8		14.2	11.9	6.3	7.6	8.6	0.2	-7.2	-29.9
Battery_Enclosure	7.6	39.8		14.3	11.9	6.3	7.6	8.7	0.2	-7.2	-29.9
Battery_Enclosure	7.6	39.8		14.2	11.9	6.3	7.5	8.6	0.2	-7.3	-30.0
Battery_Enclosure	7.6	39.8		14.3	11.9	6.3	7.6	8.7	0.2	-7.2	-29.9
Battery_Enclosure	7.6	39.8		14.3	11.9	6.4	7.6	8.7	0.2	-7.2	-29.8
Battery_Enclosure	7.5	39.8		14.1	11.8	6.2	7.4	8.5	0.1	-7.5	-30.4
Battery_Enclosure	7.5	39.8		14.1	11.8	6.2	7.5	8.5	0.1	-7.4	-30.3
Battery_Enclosure	7.5	39.8		14.2	11.8	6.3	7.5	8.6	0.1	-7.3	-30.2
Battery_Enclosure	7.5	39.8		14.2	11.8	6.3	7.5	8.6	0.1	-7.3	-30.1
Battery_Enclosure	7.5	39.8		14.2	11.8	6.2	7.5	8.6	0.1	-7.4	-30.3
Battery_Enclosure	7.5	39.8		14.2	11.8	6.2	7.5	8.6	0.1	-7.4	-30.2
Battery_Enclosure	7.5	39.8		14.2	11.8	6.3	7.5	8.6	0.2	-7.3	-30.1
Battery_Enclosure	7.4	39.8		14.1	11.7	6.1	7.4	8.5	0.0	-7.6	-30.6

Note: Octave band sound levels are linear (i.e. not A-weighted)

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Application Case R-10 (Cont.)

Noise Source	dBA	Cumulative		31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Battery_Enclosure	7.4	39.8		14.1	11.7	6.1	7.4	8.5	0.0	-7.5	-30.5
Battery_Enclosure	7.4	39.8		14.1	11.7	6.1	7.4	8.4	-0.1	-7.6	-30.7
Battery_Enclosure	7.4	39.8		14.1	11.7	6.1	7.4	8.4	0.0	-7.6	-30.6
Battery_Enclosure	7.4	39.8		14.1	11.7	6.2	7.4	8.5	0.0	-7.5	-30.5
Battery_Enclosure	7.4	39.8		14.1	11.8	6.2	7.4	8.5	0.0	-7.5	-30.4
Battery_Enclosure	7.3	39.8		14.0	11.6	6.0	7.3	8.3	-0.2	-7.8	-31.0
Battery_Enclosure	7.3	39.8		14.0	11.6	6.0	7.3	8.3	-0.1	-7.7	-31.0
Battery_Enclosure	7.3	39.8		14.0	11.7	6.1	7.3	8.4	-0.1	-7.7	-30.8
Battery_Enclosure	7.3	39.8		14.0	11.7	6.1	7.3	8.4	-0.1	-7.6	-30.8
Battery_Enclosure	7.3	39.8		14.0	11.6	6.0	7.3	8.4	-0.1	-7.7	-30.9
Battery_Enclosure	7.3	39.8		14.0	11.7	6.0	7.3	8.4	-0.1	-7.7	-30.9
Battery_Enclosure	7.2	39.8		13.9	11.6	5.9	7.2	8.3	-0.2	-7.9	-31.3
Battery_Enclosure	7.2	39.8		13.9	11.6	5.9	7.2	8.3	-0.2	-7.8	-31.2
Battery_Enclosure	7.2	39.8		13.9	11.5	5.9	7.2	8.2	-0.3	-7.9	-31.3
Battery_Enclosure	7.2	39.8		13.9	11.6	5.9	7.2	8.3	-0.2	-7.9	-31.3
Battery_Enclosure	7.2	39.8		14.0	11.6	6.0	7.2	8.3	-0.2	-7.8	-31.1
Battery_Enclosure	7.2	39.8		14.0	11.6	6.0	7.3	8.3	-0.2	-7.8	-31.1
Battery_Enclosure	7.2	39.8		13.9	11.6	5.9	7.2	8.3	-0.2	-7.9	-31.2
Battery_Enclosure	7.1	39.8		13.8	11.5	5.8	7.1	8.1	-0.4	-8.1	-31.7
Battery_Enclosure	7.1	39.8		13.8	11.5	5.8	7.1	8.2	-0.4	-8.0	-31.7
Battery_Enclosure	7.1	39.8		13.9	11.5	5.9	7.1	8.2	-0.3	-8.0	-31.5
Battery_Enclosure	7.1	39.8		13.9	11.5	5.9	7.2	8.2	-0.3	-7.9	-31.5
Battery_Enclosure	7.1	39.8		13.8	11.5	5.8	7.1	8.1	-0.4	-8.1	-31.7
Battery_Enclosure	7.1	39.9		13.9	11.5	5.8	7.1	8.2	-0.3	-8.0	-31.6
Battery_Enclosure	7.1	39.9		13.9	11.5	5.9	7.1	8.2	-0.3	-8.0	-31.5
Battery_Enclosure	7.1	39.9		13.8	11.5	5.8	7.1	8.2	-0.4	-8.0	-31.7
Battery_Enclosure	7.1	39.9		13.9	11.5	5.8	7.1	8.2	-0.3	-8.0	-31.6
Battery_Enclosure	7.1	39.9		13.9	11.5	5.9	7.2	8.2	-0.3	-8.0	-31.5
Battery_Enclosure	7.0	39.9		13.8	11.4	5.7	7.0	8.1	-0.4	-8.2	-31.9
Battery_Enclosure	7.0	39.9		13.8	11.4	5.8	7.0	8.1	-0.4	-8.1	-31.9
Battery_Enclosure	7.0	39.9		13.8	11.4	5.7	7.0	8.1	-0.5	-8.2	-32.0
Battery_Enclosure	7.0	39.9		13.8	11.4	5.7	7.0	8.1	-0.5	-8.2	-31.9
Battery_Enclosure	7.0	39.9		13.8	11.4	5.8	7.1	8.1	-0.4	-8.1	-31.8
Battery_Enclosure	7.0	39.9		13.8	11.4	5.7	7.0	8.1	-0.5	-8.2	-32.0
Battery_Enclosure	7.0	39.9		13.8	11.4	5.7	7.0	8.1	-0.5	-8.2	-32.0
Battery_Enclosure	7.0	39.9		13.8	11.4	5.8	7.1	8.1	-0.4	-8.1	-31.9
Battery_Enclosure	7.0	39.9		13.8	11.4	5.8	7.1	8.1	-0.4	-8.1	-31.8
Battery_Enclosure	6.9	39.9		13.7	11.3	5.6	6.9	8.0	-0.6	-8.4	-32.4
Battery_Enclosure	6.9	39.9		13.7	11.3	5.6	6.9	8.0	-0.6	-8.4	-32.3
Battery_Enclosure	6.9	39.9		13.7	11.4	5.7	7.0	8.0	-0.5	-8.3	-32.2
Battery_Enclosure	6.9	39.9		13.7	11.4	5.7	7.0	8.0	-0.5	-8.3	-32.1
Battery_Enclosure	6.9	39.9		13.7	11.3	5.6	6.9	8.0	-0.6	-8.4	-32.4
Battery_Enclosure	6.9	39.9		13.7	11.3	5.7	7.0	8.0	-0.5	-8.3	-32.2
Battery_Enclosure	6.9	39.9		13.7	11.3	5.7	7.0	8.0	-0.5	-8.3	-32.2
Battery_Enclosure	6.9	39.9		13.7	11.3	5.6	6.9	7.9	-0.6	-8.4	-32.4
Battery_Enclosure	6.9	39.9		13.7	11.3	5.7	7.0	8.0	-0.5	-8.3	-32.2
Battery_Enclosure	6.9	39.9		13.7	11.3	5.6	6.9	8.0	-0.6	-8.3	-32.3
Battery_Enclosure	6.9	39.9		13.7	11.3	5.6	7.0	8.0	-0.6	-8.3	-32.3
Battery_Enclosure	6.9	39.9		13.7	11.4	5.7	7.0	8.0	-0.5	-8.2	-32.1
Battery_Enclosure	6.8	39.9		13.6	11.3	5.5	6.9	7.9	-0.7	-8.5	-32.6
Battery_Enclosure	6.8	39.9		13.6	11.3	5.6	6.9	7.9	-0.7	-8.5	-32.6
Battery_Enclosure	6.8	39.9		13.6	11.2	5.5	6.9	7.9	-0.7	-8.5	-32.6
Battery_Enclosure	6.8	39.9		13.6	11.3	5.6	6.9	7.9	-0.7	-8.5	-32.6
Battery_Enclosure	6.8	39.9		13.7	11.3	5.6	6.9	7.9	-0.6	-8.4	-32.4
Battery_Enclosure	6.8	39.9		13.6	11.2	5.5	6.8	7.9	-0.7	-8.5	-32.7
Battery_Enclosure	6.8	39.9		13.6	11.2	5.5	6.9	7.9	-0.7	-8.5	-32.6
Battery_Enclosure	6.8	39.9		13.7	11.3	5.6	6.9	7.9	-0.6	-8.4	-32.5

Note: Octave band sound levels are linear (i.e. not A-weighted)

DRAFT

***Application Case* R-10 (Cont.)**

Noise Source	dBA	Cumulative		31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Battery_Enclosure	6.8	39.9		13.6	11.2	5.5	6.8	7.9	-0.7	-8.5	-32.7
Battery_Enclosure	6.8	39.9		13.6	11.2	5.5	6.8	7.9	-0.7	-8.5	-32.7
Battery_Enclosure	6.8	39.9		13.6	11.3	5.6	6.9	7.9	-0.6	-8.4	-32.5
Battery_Enclosure	6.8	39.9		13.7	11.3	5.6	6.9	7.9	-0.6	-8.4	-32.5
Battery_Enclosure	6.7	39.9		13.5	11.1	5.4	6.7	7.8	-0.8	-8.7	-33.1
Battery_Enclosure	6.7	39.9		13.5	11.2	5.4	6.8	7.8	-0.8	-8.7	-33.0
Battery_Enclosure	6.7	39.9		13.6	11.2	5.5	6.8	7.8	-0.7	-8.6	-32.8
Battery_Enclosure	6.7	39.9		13.6	11.2	5.5	6.8	7.8	-0.7	-8.6	-32.8
Battery_Enclosure	6.7	39.9		13.5	11.1	5.4	6.7	7.8	-0.8	-8.7	-33.1
Battery_Enclosure	6.7	39.9		13.5	11.2	5.4	6.8	7.8	-0.8	-8.7	-33.0
Battery_Enclosure	6.7	39.9		13.6	11.2	5.5	6.8	7.8	-0.7	-8.6	-32.9
Battery_Enclosure	6.7	39.9		13.6	11.2	5.5	6.8	7.8	-0.7	-8.6	-32.8
Battery_Enclosure	6.7	40.0		13.5	11.1	5.4	6.7	7.8	-0.8	-8.7	-33.1
Battery_Enclosure	6.7	40.0		13.5	11.2	5.4	6.8	7.8	-0.8	-8.7	-33.0
Battery_Enclosure	6.7	40.0		13.6	11.2	5.5	6.8	7.8	-0.8	-8.6	-32.9
Battery_Enclosure	6.7	40.0		13.6	11.2	5.5	6.8	7.8	-0.7	-8.6	-32.8
Battery_Enclosure	6.7	40.0		13.5	11.1	5.4	6.7	7.7	-0.8	-8.7	-33.1
Battery_Enclosure	6.7	40.0		13.5	11.2	5.5	6.8	7.8	-0.8	-8.6	-32.9
Battery_Enclosure	6.7	40.0		13.6	11.2	5.5	6.8	7.8	-0.8	-8.6	-32.9
Battery_Enclosure	6.6	40.0		13.5	11.1	5.4	6.7	7.7	-0.9	-8.8	-33.3
Battery_Enclosure	6.6	40.0		13.5	11.1	5.4	6.7	7.7	-0.9	-8.8	-33.2
Battery_Enclosure	6.6	40.0		13.5	11.1	5.4	6.7	7.7	-0.9	-8.8	-33.3
Battery_Enclosure	6.6	40.0		13.5	11.1	5.4	6.7	7.7	-0.9	-8.8	-33.3
Battery_Enclosure	6.6	40.0		13.4	11.1	5.3	6.6	7.7	-0.9	-8.9	-33.5
Battery_Enclosure	6.6	40.0		13.5	11.1	5.4	6.7	7.7	-0.9	-8.8	-33.3
Battery_Enclosure	6.6	40.0		13.5	11.1	5.4	6.7	7.7	-0.9	-8.8	-33.2
Battery_Enclosure	6.6	40.0		13.5	11.1	5.3	6.7	7.7	-0.9	-8.8	-33.4
Battery_Enclosure	6.6	40.0		13.5	11.1	5.3	6.7	7.7	-0.9	-8.8	-33.3
Battery_Enclosure	6.6	40.0		13.5	11.1	5.4	6.7	7.7	-0.8	-8.7	-33.2
Battery_Enclosure	6.5	40.0		13.4	11.0	5.2	6.6	7.6	-1.0	-9.0	-33.7
Battery_Enclosure	6.5	40.0		13.4	11.0	5.3	6.6	7.6	-1.0	-9.0	-33.7
Battery_Enclosure	6.5	40.0		13.4	11.0	5.3	6.6	7.6	-1.0	-8.9	-33.5
Battery_Enclosure	6.5	40.0		13.4	11.1	5.3	6.6	7.7	-0.9	-8.9	-33.5
Battery_Enclosure	6.5	40.0		13.4	11.0	5.2	6.6	7.6	-1.0	-9.0	-33.7
Battery_Enclosure	6.5	40.0		13.4	11.0	5.2	6.6	7.6	-1.0	-9.0	-33.7
Battery_Enclosure	6.5	40.0		13.4	11.0	5.3	6.6	7.6	-1.0	-8.9	-33.5
Battery_Enclosure	6.5	40.0		13.4	11.1	5.3	6.6	7.7	-0.9	-8.9	-33.5
Battery_Enclosure	6.5	40.0		13.4	11.0	5.2	6.6	7.6	-1.0	-9.0	-33.7
Battery_Enclosure	6.5	40.0		13.4	11.0	5.3	6.6	7.6	-1.0	-9.0	-33.7
Battery_Enclosure	6.5	40.0		13.4	11.0	5.3	6.6	7.6	-0.9	-8.9	-33.5
Battery_Enclosure	6.5	40.0		13.4	11.0	5.2	6.6	7.6	-1.0	-9.0	-33.8
Battery_Enclosure	6.5	40.0		13.4	11.0	5.3	6.6	7.6	-1.0	-8.9	-33.6
Battery_Enclosure	6.5	40.0		13.4	11.0	5.3	6.6	7.6	-1.0	-8.9	-33.6
Battery_Enclosure	6.4	40.0		13.3	10.9	5.1	6.5	7.5	-1.1	-9.2	-34.1
Battery_Enclosure	6.4	40.0		13.3	10.9	5.2	6.5	7.5	-1.1	-9.1	-34.0
Battery_Enclosure	6.4	40.0		13.3	11.0	5.2	6.5	7.5	-1.1	-9.1	-33.9
Battery_Enclosure	6.4	40.0		13.3	10.9	5.1	6.5	7.5	-1.1	-9.2	-34.1
Battery_Enclosure	6.4	40.0		13.3	10.9	5.2	6.5	7.5	-1.1	-9.1	-34.0
Battery_Enclosure	6.4	40.0		13.3	11.0	5.2	6.5	7.5	-1.1	-9.1	-33.9
Battery_Enclosure	6.4	40.0		13.3	10.9	5.1	6.5	7.5	-1.2	-9.2	-34.1
Battery_Enclosure	6.4	40.0		13.3	10.9	5.1	6.5	7.5	-1.1	-9.2	-34.1
Battery_Enclosure	6.4	40.0		13.3	11.0	5.2	6.5	7.5	-1.1	-9.1	-33.9
Battery_Enclosure	6.4	40.0		13.3	11.0	5.2	6.5	7.5	-1.1	-9.1	-33.9
Battery_Enclosure	6.4	40.0		13.3	10.9	5.2	6.5	7.5	-1.1	-9.1	-34.0
Battery_Enclosure	6.4	40.0		13.3	10.9	5.2	6.5	7.5	-1.1	-9.1	-34.0
Battery_Enclosure	6.4	40.0		13.4	11.0	5.2	6.6	7.6	-1.0	-9.0	-33.8
Battery_Enclosure	6.3	40.0		13.2	10.8	5.1	6.4	7.4	-1.2	-9.3	-34.4

Note: Octave band sound levels are linear (i.e. not A-weighted)

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***Application Case* R-10 (Cont.)**

Noise Source	dBA	Cumulative		31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Battery_Enclosure	6.3	40.0		13.2	10.9	5.1	6.4	7.4	-1.2	-9.3	-34.4
Battery_Enclosure	6.3	40.0		13.3	10.9	5.1	6.5	7.5	-1.2	-9.2	-34.2
Battery_Enclosure	6.3	40.0		13.2	10.8	5.1	6.4	7.4	-1.2	-9.3	-34.4
Battery_Enclosure	6.3	40.0		13.2	10.9	5.1	6.4	7.4	-1.2	-9.3	-34.3
Battery_Enclosure	6.3	40.0		13.3	10.9	5.1	6.5	7.5	-1.2	-9.2	-34.2
Battery_Enclosure	6.3	40.0		13.2	10.8	5.0	6.4	7.4	-1.3	-9.3	-34.5
Battery_Enclosure	6.3	40.0		13.2	10.9	5.1	6.4	7.4	-1.2	-9.3	-34.3
Battery_Enclosure	6.3	40.1		13.3	10.9	5.1	6.4	7.4	-1.2	-9.3	-34.3
Battery_Enclosure	6.3	40.1		13.2	10.8	5.0	6.4	7.4	-1.3	-9.3	-34.5
Battery_Enclosure	6.3	40.1		13.2	10.8	5.1	6.4	7.4	-1.2	-9.3	-34.4
Battery_Enclosure	6.3	40.1		13.3	10.9	5.1	6.4	7.4	-1.2	-9.2	-34.3
Battery_Enclosure	6.3	40.1		13.3	10.9	5.1	6.5	7.4	-1.2	-9.2	-34.2
Battery_Enclosure	6.2	40.1		13.1	10.7	4.9	6.3	7.3	-1.4	-9.5	-34.9
Battery_Enclosure	6.2	40.1		13.1	10.8	4.9	6.3	7.3	-1.4	-9.5	-34.8
Battery_Enclosure	6.2	40.1		13.2	10.8	5.0	6.3	7.3	-1.3	-9.4	-34.6
Battery_Enclosure	6.2	40.1		13.2	10.8	5.0	6.4	7.3	-1.3	-9.4	-34.6
Battery_Enclosure	6.2	40.1		13.1	10.8	4.9	6.3	7.3	-1.4	-9.5	-34.8
Battery_Enclosure	6.2	40.1		13.1	10.8	5.0	6.3	7.3	-1.4	-9.5	-34.8
Battery_Enclosure	6.2	40.1		13.2	10.8	5.0	6.4	7.3	-1.3	-9.4	-34.6
Battery_Enclosure	6.2	40.1		13.2	10.8	5.0	6.4	7.4	-1.3	-9.4	-34.6
Battery_Enclosure	6.2	40.1		13.1	10.8	5.0	6.3	7.3	-1.3	-9.5	-34.8
Battery_Enclosure	6.2	40.1		13.2	10.8	5.0	6.3	7.3	-1.3	-9.4	-34.7
Battery_Enclosure	6.2	40.1		13.2	10.8	5.0	6.4	7.4	-1.3	-9.4	-34.6
Battery_Enclosure	6.2	40.1		13.1	10.8	4.9	6.3	7.3	-1.4	-9.5	-34.9
Battery_Enclosure	6.2	40.1		13.2	10.8	5.0	6.3	7.3	-1.3	-9.4	-34.7
Battery_Enclosure	6.2	40.1		13.2	10.8	5.0	6.3	7.3	-1.3	-9.4	-34.6
Battery_Enclosure	6.1	40.1		13.1	10.7	4.9	6.2	7.2	-1.4	-9.6	-35.1
Battery_Enclosure	6.1	40.1		13.1	10.7	4.9	6.3	7.2	-1.4	-9.6	-35.0
Battery_Enclosure	6.1	40.1		13.1	10.7	4.8	6.2	7.2	-1.5	-9.7	-35.2
Battery_Enclosure	6.1	40.1		13.1	10.7	4.9	6.2	7.2	-1.5	-9.6	-35.1
Battery_Enclosure	6.1	40.1		13.1	10.7	4.9	6.3	7.2	-1.4	-9.6	-35.0
Battery_Enclosure	6.1	40.1		13.1	10.7	4.9	6.3	7.3	-1.4	-9.5	-34.9
Battery_Enclosure	6.1	40.1		13.1	10.7	4.9	6.2	7.2	-1.5	-9.6	-35.1
Battery_Enclosure	6.1	40.1		13.1	10.7	4.9	6.2	7.2	-1.4	-9.6	-35.1
Battery_Enclosure	6.1	40.1		13.1	10.7	4.9	6.3	7.3	-1.4	-9.5	-34.9
Battery_Enclosure	6.0	40.1		13.0	10.6	4.8	6.1	7.1	-1.6	-9.8	-35.5
Battery_Enclosure	6.0	40.1		13.0	10.6	4.8	6.1	7.1	-1.6	-9.8	-35.5
Battery_Enclosure	6.0	40.1		13.0	10.7	4.8	6.2	7.2	-1.5	-9.7	-35.3
Battery_Enclosure	6.0	40.1		13.0	10.7	4.8	6.2	7.2	-1.5	-9.7	-35.2
Battery_Enclosure	6.0	40.1		13.0	10.6	4.8	6.1	7.1	-1.6	-9.8	-35.6
Battery_Enclosure	6.0	40.1		13.0	10.6	4.8	6.2	7.1	-1.5	-9.8	-35.4
Battery_Enclosure	6.0	40.1		13.0	10.6	4.8	6.2	7.1	-1.5	-9.7	-35.4
Battery_Enclosure	6.0	40.1		13.0	10.6	4.8	6.1	7.1	-1.6	-9.8	-35.6
Battery_Enclosure	6.0	40.1		13.0	10.6	4.8	6.1	7.1	-1.6	-9.8	-35.5
Battery_Enclosure	6.0	40.1		13.0	10.6	4.8	6.2	7.1	-1.5	-9.7	-35.4
Battery_Enclosure	6.0	40.1		13.0	10.7	4.8	6.2	7.2	-1.5	-9.7	-35.3
Battery_Enclosure	5.9	40.1		12.9	10.5	4.7	6.1	7.0	-1.7	-9.9	-35.8
Battery_Enclosure	5.9	40.1		12.9	10.6	4.7	6.1	7.0	-1.7	-9.9	-35.8
Battery_Enclosure	5.9	40.1		13.0	10.6	4.7	6.1	7.1	-1.6	-9.9	-35.6
Battery_Enclosure	5.9	40.1		12.9	10.6	4.7	6.1	7.0	-1.7	-9.9	-35.8
Battery_Enclosure	5.9	40.1		12.9	10.6	4.7	6.1	7.0	-1.6	-9.9	-35.7
Battery_Enclosure	5.8	40.1		12.8	10.4	4.6	5.9	6.9	-1.8	-10.1	-36.3
Battery_Enclosure	5.8	40.1		12.8	10.5	4.6	6.0	6.9	-1.8	-10.1	-36.2
Battery_Enclosure	5.8	40.1		12.9	10.5	4.6	6.0	7.0	-1.7	-10.0	-36.1
Battery_Enclosure	5.8	40.1		12.9	10.5	4.6	6.0	7.0	-1.7	-10.0	-36.0
Battery_Enclosure	5.7	40.1		12.8	10.4	4.5	5.9	6.8	-1.9	-10.2	-36.5
Battery_Enclosure	5.7	40.1		12.8	10.4	4.5	5.9	6.9	-1.9	-10.2	-36.4

Note: Octave band sound levels are linear (i.e. not A-weighted)

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***Application Case* R-14**

Noise Source	dBA	Cumulative		31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Existing Generator	37.8	37.8		45.8	43.4	40.2	34.4	35.2	34.6	27.7	18.8
Existing Generator	37.5	40.7		45.5	43.1	39.9	34.0	34.9	34.3	27.2	18.1
Existing Generator	37.2	42.3		45.3	42.8	39.6	33.8	34.7	34.0	26.9	17.5
Substation Transformer (180 MVA)	36.7	43.3		35.0	38.1	40.1	35.3	35.9	32.2	24.6	9.9
Substation Transformer (50 MVA)	33.0	43.7		31.2	34.3	36.4	31.6	32.5	28.3	20.7	5.8
Switchgear	20.8	43.7		18.5	24.4	26.3	21.1	20.8	14.2	6.9	-7.1
Switchgear	20.7	43.8		18.4	24.4	26.3	21.1	20.8	14.2	6.9	-7.1
Switchgear	20.7	43.8		18.4	24.4	26.3	21.0	20.7	14.2	6.9	-7.1
Switchgear	20.7	43.8		18.4	24.4	26.2	21.0	20.7	14.1	6.9	-7.1
Switchgear	20.7	43.8		18.4	24.3	26.2	21.0	20.7	14.1	6.9	-7.0
Switchgear	20.7	43.9		18.3	24.3	26.2	21.0	20.7	14.1	6.9	-7.0
Auxiliary Transformer	20.4	43.9		18.0	24.0	25.9	20.7	20.4	13.9	6.8	-6.9
Inverter	19.4	43.9		17.5	22.7	16.2	17.5	16.4	15.1	12.6	-2.3
Inverter	19.3	43.9		16.5	21.7	15.2	16.6	15.7	14.8	13.4	-0.9
Inverter	19.2	43.9		17.4	22.6	16.1	17.4	16.3	14.9	12.3	-2.8
Inverter	19.2	43.9		17.2	22.4	15.9	17.3	16.1	14.9	12.5	-2.3
Inverter	19.2	43.9		16.7	21.9	15.4	16.8	15.8	14.8	12.9	-0.2
Inverter	19.1	44.0		17.4	22.5	16.0	17.3	16.2	14.8	12.2	-3.1
Inverter	19.0	44.0		17.3	22.5	15.9	17.3	16.1	14.7	12.0	-3.3
Inverter	19.0	44.0		17.2	22.3	15.8	17.2	16.0	14.7	12.1	-3.1
Inverter	18.9	44.0		17.2	22.4	15.9	17.2	16.0	14.6	11.9	-3.5
Inverter	18.9	44.0		17.1	22.3	15.8	17.1	15.9	14.6	11.9	-3.5
Inverter	18.8	44.0		17.1	22.3	15.8	17.1	15.9	14.5	11.8	-3.8
Inverter	18.8	44.0		17.0	22.2	15.7	17.0	15.8	14.5	11.8	-3.8
Inverter	18.8	44.1		16.7	21.8	15.3	16.7	15.6	14.5	12.2	-2.5
Inverter	18.8	44.1		16.4	21.6	15.1	16.5	15.5	14.4	12.4	-1.2
Inverter	18.7	44.1		17.0	22.2	15.7	17.0	15.8	14.4	11.7	-4.0
Inverter	18.6	44.1		16.9	22.1	15.6	16.9	15.7	14.3	11.5	-4.3
Inverter	18.6	44.1		17.0	22.1	15.6	16.9	15.7	14.4	11.6	-4.1
Existing TransAlta XFR	18.5	44.1		18.5	16.8	23.7	16.6	16.7	15.2	2.6	-14.2
Inverter	18.5	44.1		16.9	22.0	15.5	16.8	15.6	14.3	11.5	-4.3
Inverter	18.5	44.1		16.6	21.8	15.2	16.6	15.5	14.2	11.7	-3.6
Inverter	18.4	44.2		16.8	22.0	15.5	16.8	15.6	14.2	11.4	-4.6
Inverter	18.4	44.2		16.8	22.0	15.4	16.7	15.5	14.2	11.4	-4.6
Inverter	18.4	44.2		16.5	21.7	15.2	16.5	15.4	14.1	11.5	-4.2
Inverter	18.4	44.2		16.4	21.5	15.0	16.4	15.3	14.1	11.7	-3.3
Inverter	18.3	44.2		16.7	21.9	15.4	16.7	15.5	14.1	11.2	-4.8
Inverter	18.3	44.2		16.7	21.9	15.3	16.7	15.5	14.1	11.2	-4.8
Inverter	18.2	44.2		16.6	21.8	15.3	16.6	15.3	13.9	11.0	-5.1
Inverter	18.2	44.2		16.6	21.8	15.2	16.5	15.3	13.9	11.1	-5.1
Inverter	18.2	44.2		16.5	21.6	15.1	16.4	15.3	14.0	11.3	-4.6
Inverter	18.2	44.3		16.3	21.5	15.0	16.3	15.2	14.0	11.5	-4.0
Inverter	18.1	44.3		16.5	21.7	15.1	16.4	15.2	13.8	10.9	-5.3
Inverter	18.1	44.3		16.4	21.6	15.0	16.3	15.2	13.9	11.1	-4.9
Inverter	18.1	44.3		16.2	21.4	14.9	16.2	15.1	13.8	11.2	-4.6
Inverter	18.0	44.3		16.5	21.7	15.1	16.4	15.2	13.8	10.9	-5.4
Inverter	18.0	44.3		16.3	21.5	14.9	16.3	15.1	13.8	11.0	-5.2
Inverter	18.0	44.3		16.2	21.3	14.8	16.1	15.0	13.7	11.0	-4.9
Inverter	17.9	44.3		16.4	21.6	15.0	16.3	15.1	13.7	10.7	-5.8
Inverter	17.9	44.3		16.4	21.6	15.0	16.3	15.1	13.7	10.8	-5.6
Inverter	17.9	44.3		16.2	21.4	14.9	16.2	15.0	13.6	10.8	-5.5
Inverter	17.8	44.4		16.3	21.5	14.9	16.2	15.0	13.6	10.6	-5.9
Inverter	17.8	44.4		16.2	21.3	14.8	16.1	14.9	13.5	10.7	-5.7
Inverter	17.8	44.4		16.1	21.3	14.7	16.1	14.9	13.6	10.9	-5.2
Inverter	17.7	44.4		16.3	21.4	14.9	16.2	15.0	13.5	10.5	-6.1
Inverter	17.7	44.4		16.2	21.4	14.8	16.1	14.9	13.4	10.4	-6.3
Inverter	17.7	44.4		16.0	21.2	14.7	16.0	14.8	13.5	10.7	-5.5

Note: Octave band sound levels are linear (i.e. not A-weighted)

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Application Case R-14 (Cont.)

Noise Source	dBA	Cumulative		31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Inverter	17.6	44.4		16.2	21.3	14.8	16.1	14.8	13.4	10.3	-6.5
Inverter	17.6	44.4		16.1	21.2	14.7	16.0	14.8	13.4	10.5	-6.0
Inverter	17.6	44.4		15.9	21.1	14.6	15.9	14.7	13.4	10.5	-5.9
Inverter	17.5	44.4		16.0	21.2	14.7	15.9	14.7	13.2	10.2	-6.8
Inverter	17.5	44.4		16.1	21.2	14.7	16.0	14.8	13.3	10.2	-6.6
Inverter	17.5	44.5		16.0	21.1	14.6	15.9	14.7	13.3	10.4	-6.3
Inverter	17.5	44.5		15.8	21.0	14.5	15.8	14.6	13.3	10.4	-6.2
Inverter	17.4	44.5		16.0	21.1	14.6	15.9	14.6	13.2	10.1	-6.9
Inverter	17.3	44.5		15.8	20.9	14.4	15.7	14.5	13.1	10.2	-6.6
Existing TransAlta XFR	17.2	44.5		18.5	17.7	21.4	15.6	18.1	10.5	0.8	-12.3
Inverter	17.2	44.5		15.9	21.0	14.5	15.7	14.5	13.0	9.9	-7.2
Inverter	17.1	44.5		15.7	20.9	14.3	15.6	14.4	12.9	9.7	-7.5
Battery_Enclosure	7.5	44.5		9.7	7.3	8.4	9.5	7.8	-0.3	-5.5	-19.7
Battery_Enclosure	7.5	44.5		9.7	7.4	8.5	9.5	7.9	-0.3	-5.5	-19.7
Battery_Enclosure	7.5	44.5		9.7	7.3	8.4	9.5	7.8	-0.4	-5.6	-19.9
Battery_Enclosure	7.4	44.5		9.6	7.3	8.4	9.4	7.8	-0.4	-5.7	-20.0
Battery_Enclosure	7.4	44.5		9.6	7.3	8.3	9.4	7.7	-0.5	-5.8	-20.2
Battery_Enclosure	7.4	44.5		9.6	7.3	8.4	9.4	7.8	-0.4	-5.7	-20.1
Battery_Enclosure	7.4	44.5		9.6	7.3	8.4	9.4	7.7	-0.5	-5.8	-20.2
Battery_Enclosure	7.3	44.5		9.6	7.2	8.3	9.3	7.7	-0.5	-5.9	-20.3
Battery_Enclosure	7.3	44.5		9.5	7.2	8.3	9.3	7.6	-0.6	-5.9	-20.4
Battery_Enclosure	7.3	44.5		9.6	7.2	8.3	9.4	7.7	-0.5	-5.9	-20.3
Battery_Enclosure	7.3	44.5		9.5	7.2	8.3	9.3	7.6	-0.6	-5.9	-20.4
Battery_Enclosure	7.3	44.5		9.5	7.2	8.2	9.3	7.6	-0.6	-6.0	-20.5
Battery_Enclosure	7.2	44.5		9.5	7.2	8.2	9.3	7.6	-0.6	-6.0	-20.5
Battery_Enclosure	7.2	44.5		9.5	7.1	8.2	9.2	7.5	-0.7	-6.0	-20.7
Battery_Enclosure	7.2	44.5		9.4	7.1	8.2	9.2	7.5	-0.7	-6.1	-20.8
Battery_Enclosure	7.2	44.5		9.5	7.1	8.2	9.2	7.6	-0.7	-6.0	-20.6
Battery_Enclosure	7.2	44.5		9.4	7.1	8.2	9.2	7.5	-0.7	-6.1	-20.7
Battery_Enclosure	7.1	44.5		9.4	7.0	8.1	9.1	7.5	-0.8	-6.1	-20.8
Battery_Enclosure	7.1	44.5		9.3	7.0	8.1	9.1	7.4	-0.8	-6.2	-21.0
Battery_Enclosure	7.1	44.5		9.4	7.0	8.1	9.1	7.5	-0.8	-6.2	-20.9
Battery_Enclosure	7.1	44.5		9.3	7.0	8.1	9.1	7.4	-0.8	-6.2	-21.0
Battery_Enclosure	7.1	44.5		9.1	6.8	7.9	8.9	7.4	-0.7	-5.6	-19.4
Battery_Enclosure	7.1	44.5		9.1	6.8	7.9	9.0	7.4	-0.7	-5.6	-19.5
Battery_Enclosure	7.0	44.5		9.3	6.9	8.0	9.0	7.4	-0.9	-6.3	-21.1
Battery_Enclosure	7.0	44.5		9.2	6.9	8.0	9.0	7.3	-0.9	-6.4	-21.2
Battery_Enclosure	7.0	44.5		9.3	6.9	8.0	9.0	7.4	-0.9	-6.3	-21.1
Battery_Enclosure	7.0	44.5		9.1	6.7	7.8	8.9	7.3	-0.8	-5.9	-20.0
Battery_Enclosure	7.0	44.5		9.1	6.8	7.9	8.9	7.3	-0.8	-5.9	-20.1
Battery_Enclosure	7.0	44.5		8.9	6.5	7.6	8.7	7.2	-0.7	-5.4	-18.2
Battery_Enclosure	7.0	44.5		8.9	6.6	7.7	8.8	7.2	-0.7	-5.4	-18.5
Battery_Enclosure	6.9	44.5		9.2	6.9	7.9	8.9	7.3	-1.0	-6.4	-21.3
Battery_Enclosure	6.9	44.5		9.2	6.9	8.0	9.0	7.3	-0.9	-6.4	-21.2
Battery_Enclosure	6.9	44.5		9.1	6.8	7.9	8.9	7.2	-1.1	-6.5	-21.5
Battery_Enclosure	6.9	44.5		9.2	6.8	7.9	8.9	7.3	-1.0	-6.4	-21.4
Battery_Enclosure	6.9	44.5		9.0	6.7	7.8	8.8	7.2	-0.9	-6.1	-20.6
Battery_Enclosure	6.9	44.5		9.1	6.7	7.8	8.9	7.2	-0.9	-6.1	-20.6
Battery_Enclosure	6.9	44.5		8.3	6.0	7.2	8.3	7.0	-0.5	-3.8	-19.0
Battery_Enclosure	6.9	44.5		8.4	6.1	7.2	8.4	7.0	-0.5	-4.0	-18.9
Battery_Enclosure	6.9	44.5		8.9	6.5	7.6	8.7	7.1	-0.9	-5.8	-19.6
Battery_Enclosure	6.8	44.5		9.1	6.8	7.8	8.9	7.2	-1.1	-6.6	-21.6
Battery_Enclosure	6.8	44.5		9.1	6.8	7.9	8.9	7.2	-1.1	-6.5	-21.5
Battery_Enclosure	6.8	44.5		9.1	6.7	7.8	8.8	7.1	-1.1	-6.6	-21.6
Battery_Enclosure	6.8	44.5		9.0	6.7	7.7	8.8	7.1	-1.0	-6.3	-21.0
Battery_Enclosure	6.8	44.5		9.0	6.7	7.8	8.8	7.2	-1.0	-6.3	-21.0
Battery_Enclosure	6.8	44.5		9.0	6.6	7.7	8.8	7.1	-1.1	-6.4	-21.2

Note: Octave band sound levels are linear (i.e. not A-weighted)

DRAFT

Application Case R-14 (Cont.)

Noise Source	dBA	Cumulative		31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Battery_Enclosure	6.8	44.5		9.0	6.7	7.8	8.8	7.1	-1.1	-6.4	-21.2
Battery_Enclosure	6.8	44.5		8.8	6.5	7.6	8.7	7.1	-0.9	-5.8	-19.4
Battery_Enclosure	6.8	44.5		8.8	6.5	7.6	8.7	7.1	-1.0	-6.1	-20.3
Battery_Enclosure	6.7	44.5		9.0	6.7	7.8	8.8	7.1	-1.2	-6.6	-21.7
Battery_Enclosure	6.7	44.5		9.0	6.7	7.7	8.7	7.0	-1.2	-6.7	-21.9
Battery_Enclosure	6.7	44.5		9.0	6.7	7.8	8.8	7.1	-1.2	-6.7	-21.8
Battery_Enclosure	6.7	44.5		9.0	6.6	7.7	8.7	7.0	-1.2	-6.7	-21.9
Battery_Enclosure	6.7	44.5		8.9	6.6	7.7	8.7	7.0	-1.2	-6.5	-21.4
Battery_Enclosure	6.7	44.5		9.0	6.6	7.7	8.8	7.1	-1.1	-6.5	-21.4
Battery_Enclosure	6.7	44.5		8.9	6.6	7.7	8.7	7.0	-1.2	-6.6	-21.6
Battery_Enclosure	6.7	44.5		8.3	6.0	7.1	8.3	6.8	-0.8	-4.7	-19.1
Battery_Enclosure	6.7	44.5		8.3	6.0	7.2	8.3	6.9	-0.8	-4.9	-19.0
Battery_Enclosure	6.7	44.5		8.8	6.5	7.6	8.6	7.0	-1.0	-6.1	-20.2
Battery_Enclosure	6.7	44.5		8.8	6.5	7.6	8.6	7.0	-1.1	-6.3	-20.9
Battery_Enclosure	6.6	44.5		8.9	6.6	7.7	8.7	7.0	-1.3	-6.8	-22.0
Battery_Enclosure	6.6	44.5		8.9	6.5	7.6	8.6	6.9	-1.4	-6.9	-22.2
Battery_Enclosure	6.6	44.6		8.9	6.6	7.7	8.7	7.0	-1.3	-6.8	-22.1
Battery_Enclosure	6.6	44.6		8.9	6.6	7.6	8.7	7.0	-1.2	-6.6	-21.6
Battery_Enclosure	6.6	44.6		8.9	6.5	7.6	8.6	6.9	-1.3	-6.7	-21.8
Battery_Enclosure	6.6	44.6		8.9	6.6	7.6	8.7	7.0	-1.3	-6.7	-21.8
Battery_Enclosure	6.6	44.6		8.8	6.5	7.6	8.6	6.9	-1.3	-6.8	-21.9
Battery_Enclosure	6.6	44.6		8.9	6.5	7.6	8.6	6.9	-1.3	-6.7	-21.9
Battery_Enclosure	6.6	44.6		8.8	6.4	7.5	8.6	7.0	-1.2	-6.3	-20.9
Battery_Enclosure	6.6	44.6		8.7	6.4	7.5	8.5	6.9	-1.3	-6.5	-21.3
Battery_Enclosure	6.6	44.6		8.8	6.4	7.5	8.6	6.9	-1.2	-6.5	-21.3
Battery_Enclosure	6.5	44.6		8.8	6.5	7.6	8.6	6.9	-1.4	-7.0	-22.3
Battery_Enclosure	6.5	44.6		8.9	6.5	7.6	8.6	6.9	-1.4	-6.9	-22.2
Battery_Enclosure	6.5	44.6		8.8	6.5	7.5	8.5	6.8	-1.4	-7.0	-22.4
Battery_Enclosure	6.5	44.6		8.8	6.4	7.5	8.5	6.9	-1.4	-6.9	-22.1
Battery_Enclosure	6.5	44.6		8.8	6.5	7.6	8.6	6.9	-1.4	-6.8	-22.0
Battery_Enclosure	6.5	44.6		8.7	6.4	7.5	8.5	6.8	-1.4	-6.9	-22.2
Battery_Enclosure	6.5	44.6		8.8	6.4	7.5	8.5	6.8	-1.4	-6.9	-22.1
Battery_Enclosure	6.5	44.6		8.3	6.0	7.1	8.2	6.7	-1.1	-5.4	-19.1
Battery_Enclosure	6.5	44.6		8.3	6.0	7.1	8.2	6.7	-1.1	-5.5	-19.0
Battery_Enclosure	6.5	44.6		8.7	6.4	7.5	8.5	6.8	-1.3	-6.6	-21.5
Battery_Enclosure	6.5	44.6		8.7	6.4	7.5	8.5	6.9	-1.3	-6.6	-21.5
Battery_Enclosure	6.5	44.6		8.7	6.4	7.5	8.5	6.8	-1.4	-6.7	-21.7
Battery_Enclosure	6.4	44.6		8.8	6.4	7.5	8.5	6.8	-1.5	-7.0	-22.5
Battery_Enclosure	6.4	44.6		8.7	6.4	7.4	8.4	6.7	-1.6	-7.1	-22.6
Battery_Enclosure	6.4	44.6		8.8	6.4	7.5	8.5	6.8	-1.5	-7.1	-22.5
Battery_Enclosure	6.4	44.6		8.7	6.4	7.4	8.5	6.8	-1.5	-7.0	-22.3
Battery_Enclosure	6.4	44.6		8.7	6.4	7.5	8.5	6.8	-1.5	-7.0	-22.3
Battery_Enclosure	6.4	44.6		8.7	6.3	7.4	8.4	6.7	-1.6	-7.1	-22.5
Battery_Enclosure	6.4	44.6		8.7	6.4	7.4	8.5	6.8	-1.5	-7.0	-22.4
Battery_Enclosure	6.4	44.6		8.3	5.9	7.0	8.1	6.6	-1.3	-5.9	-19.2
Battery_Enclosure	6.4	44.6		8.3	6.0	7.1	8.2	6.6	-1.3	-5.9	-19.1
Battery_Enclosure	6.4	44.6		8.7	6.3	7.4	8.4	6.8	-1.4	-6.7	-21.8
Battery_Enclosure	6.4	44.6		8.6	6.3	7.4	8.4	6.7	-1.5	-6.9	-22.0
Battery_Enclosure	6.4	44.6		8.7	6.3	7.4	8.4	6.8	-1.4	-6.8	-22.0
Battery_Enclosure	6.4	44.6		8.6	6.3	7.4	8.4	6.7	-1.5	-6.9	-22.1
Battery_Enclosure	6.3	44.6		8.7	6.3	7.4	8.4	6.7	-1.6	-7.2	-22.8
Battery_Enclosure	6.3	44.6		8.7	6.4	7.4	8.4	6.7	-1.6	-7.2	-22.7
Battery_Enclosure	6.3	44.6		8.6	6.3	7.4	8.4	6.7	-1.6	-7.2	-22.8
Battery_Enclosure	6.3	44.6		8.6	6.3	7.4	8.4	6.7	-1.6	-7.1	-22.6
Battery_Enclosure	6.3	44.6		8.7	6.3	7.4	8.4	6.7	-1.6	-7.1	-22.5
Battery_Enclosure	6.3	44.6		8.6	6.2	7.3	8.3	6.6	-1.7	-7.2	-22.7
Battery_Enclosure	6.3	44.6		8.6	6.3	7.3	8.4	6.7	-1.6	-7.2	-22.7

Note: Octave band sound levels are linear (i.e. not A-weighted)

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Application Case R-14 (Cont.)

Noise Source	dBA	Cumulative		31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Battery_Enclosure	6.3	44.6		8.2	5.9	7.0	8.1	6.5	-1.4	-6.3	-19.7
Battery_Enclosure	6.3	44.6		8.3	5.9	7.0	8.1	6.6	-1.4	-6.3	-19.9
Battery_Enclosure	6.3	44.6		8.6	6.3	7.3	8.4	6.7	-1.5	-6.9	-22.2
Battery_Enclosure	6.3	44.6		8.6	6.2	7.3	8.3	6.6	-1.6	-7.0	-22.3
Battery_Enclosure	6.3	44.6		8.6	6.3	7.3	8.4	6.7	-1.5	-7.0	-22.3
Battery_Enclosure	6.3	44.6		8.6	6.2	7.3	8.3	6.6	-1.6	-7.1	-22.4
Battery_Enclosure	6.2	44.6		8.6	6.3	7.3	8.3	6.6	-1.7	-7.3	-22.9
Battery_Enclosure	6.2	44.6		8.5	6.2	7.3	8.3	6.5	-1.8	-7.4	-23.1
Battery_Enclosure	6.2	44.6		8.6	6.2	7.3	8.3	6.6	-1.7	-7.3	-23.0
Battery_Enclosure	6.2	44.6		8.5	6.2	7.2	8.2	6.5	-1.8	-7.4	-23.1
Battery_Enclosure	6.2	44.6		8.5	6.2	7.3	8.3	6.6	-1.7	-7.3	-22.8
Battery_Enclosure	6.2	44.6		8.6	6.2	7.3	8.3	6.6	-1.7	-7.2	-22.8
Battery_Enclosure	6.2	44.6		8.5	6.2	7.2	8.2	6.5	-1.8	-7.3	-23.0
Battery_Enclosure	6.2	44.6		8.5	6.2	7.3	8.3	6.6	-1.7	-7.3	-22.9
Battery_Enclosure	6.2	44.6		8.2	5.9	7.0	8.0	6.5	-1.6	-6.6	-20.7
Battery_Enclosure	6.2	44.6		8.2	5.9	7.0	8.1	6.5	-1.6	-6.6	-20.8
Battery_Enclosure	6.2	44.6		8.5	6.2	7.3	8.3	6.6	-1.6	-7.1	-22.5
Battery_Enclosure	6.2	44.6		8.5	6.2	7.2	8.2	6.6	-1.7	-7.2	-22.6
Battery_Enclosure	6.2	44.6		8.5	6.2	7.3	8.3	6.6	-1.6	-7.1	-22.6
Battery_Enclosure	6.2	44.6		8.5	6.1	7.2	8.2	6.5	-1.7	-7.2	-22.7
Battery_Enclosure	6.1	44.6		8.5	6.1	7.2	8.2	6.5	-1.8	-7.5	-23.3
Battery_Enclosure	6.1	44.6		8.5	6.1	7.2	8.2	6.5	-1.9	-7.5	-23.3
Battery_Enclosure	6.1	44.6		8.4	6.1	7.2	8.2	6.5	-1.8	-7.4	-23.1
Battery_Enclosure	6.1	44.6		8.5	6.1	7.2	8.2	6.5	-1.8	-7.4	-23.0
Battery_Enclosure	6.1	44.6		8.4	6.1	7.2	8.2	6.5	-1.8	-7.5	-23.2
Battery_Enclosure	6.1	44.6		8.2	5.8	6.9	8.0	6.4	-1.6	-6.7	-21.1
Battery_Enclosure	6.1	44.6		8.2	5.9	7.0	8.0	6.4	-1.6	-6.7	-21.2
Battery_Enclosure	6.1	44.6		8.2	5.8	6.9	8.0	6.4	-1.7	-6.9	-21.6
Battery_Enclosure	6.1	44.6		8.4	6.1	7.2	8.2	6.5	-1.7	-7.2	-22.7
Battery_Enclosure	6.1	44.6		8.4	6.1	7.1	8.2	6.5	-1.8	-7.3	-22.9
Battery_Enclosure	6.1	44.6		8.4	6.1	7.2	8.2	6.5	-1.8	-7.3	-22.8
Battery_Enclosure	6.1	44.6		8.4	6.0	7.1	8.1	6.4	-1.8	-7.4	-23.0
Battery_Enclosure	6.1	44.6		8.4	6.1	7.1	8.1	6.4	-1.8	-7.4	-23.0
Battery_Enclosure	6.0	44.6		8.4	6.1	7.1	8.1	6.4	-1.9	-7.6	-23.4
Battery_Enclosure	6.0	44.6		8.4	6.0	7.1	8.1	6.4	-2.0	-7.7	-23.6
Battery_Enclosure	6.0	44.6		8.4	6.1	7.1	8.1	6.4	-1.9	-7.6	-23.5
Battery_Enclosure	6.0	44.6		8.4	6.1	7.1	8.1	6.4	-1.9	-7.5	-23.2
Battery_Enclosure	6.0	44.6		8.3	6.0	7.1	8.1	6.4	-1.9	-7.6	-23.4
Battery_Enclosure	6.0	44.6		8.4	6.0	7.1	8.1	6.4	-1.9	-7.5	-23.3
Battery_Enclosure	6.0	44.6		8.3	6.0	7.1	8.1	6.3	-2.0	-7.6	-23.5
Battery_Enclosure	6.0	44.6		8.1	5.8	6.9	7.9	6.3	-1.7	-6.9	-21.5
Battery_Enclosure	6.0	44.6		8.1	5.8	6.9	7.9	6.3	-1.8	-7.0	-21.8
Battery_Enclosure	6.0	44.6		8.1	5.8	6.9	7.9	6.3	-1.8	-7.0	-21.9
Battery_Enclosure	6.0	44.6		8.3	6.0	7.1	8.1	6.4	-1.9	-7.5	-23.1
Battery_Enclosure	6.0	44.6		8.4	6.0	7.1	8.1	6.4	-1.9	-7.4	-23.1
Battery_Enclosure	6.0	44.6		8.3	5.9	7.0	8.0	6.3	-1.9	-7.5	-23.3
Battery_Enclosure	6.0	44.6		8.3	6.0	7.0	8.1	6.4	-1.9	-7.5	-23.2
Battery_Enclosure	5.9	44.6		8.3	6.0	7.0	8.0	6.3	-2.1	-7.8	-23.8
Battery_Enclosure	5.9	44.6		8.3	6.0	7.1	8.1	6.3	-2.0	-7.7	-23.7
Battery_Enclosure	5.9	44.6		8.3	5.9	7.0	8.0	6.3	-2.1	-7.8	-23.8
Battery_Enclosure	5.9	44.6		8.3	6.0	7.0	8.0	6.3	-2.0	-7.6	-23.5
Battery_Enclosure	5.9	44.6		8.2	5.9	7.0	8.0	6.3	-2.1	-7.7	-23.7
Battery_Enclosure	5.9	44.6		8.3	5.9	7.0	8.0	6.3	-2.0	-7.7	-23.6
Battery_Enclosure	5.9	44.6		8.1	5.7	6.8	7.9	6.2	-1.9	-7.2	-22.2
Battery_Enclosure	5.9	44.6		8.1	5.8	6.9	7.9	6.3	-1.9	-7.2	-22.3
Battery_Enclosure	5.9	44.6		8.0	5.7	6.8	7.8	6.2	-1.9	-7.3	-22.4
Battery_Enclosure	5.9	44.6		8.1	5.7	6.8	7.9	6.2	-1.9	-7.3	-22.4

Note: Octave band sound levels are linear (i.e. not A-weighted)

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Application Case R-14 (Cont.)

Noise Source	dBA	Cumulative		31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Battery_Enclosure	5.9	44.6		8.2	5.9	7.0	8.0	6.3	-2.0	-7.6	-23.4
Battery_Enclosure	5.9	44.6		8.3	5.9	7.0	8.0	6.3	-2.0	-7.6	-23.3
Battery_Enclosure	5.9	44.6		8.2	5.9	6.9	8.0	6.3	-2.0	-7.6	-23.5
Battery_Enclosure	5.8	44.6		8.2	5.9	7.0	7.9	6.2	-2.1	-7.9	-23.9
Battery_Enclosure	5.8	44.6		8.2	5.8	6.9	7.9	6.1	-2.2	-8.0	-24.1
Battery_Enclosure	5.8	44.6		8.2	5.9	6.9	7.9	6.2	-2.2	-7.9	-24.0
Battery_Enclosure	5.8	44.6		8.2	5.8	6.9	7.9	6.2	-2.1	-7.8	-23.8
Battery_Enclosure	5.8	44.6		8.2	5.9	6.9	7.9	6.2	-2.1	-7.8	-23.7
Battery_Enclosure	5.8	44.6		8.1	5.8	6.9	7.9	6.1	-2.2	-7.9	-23.9
Battery_Enclosure	5.8	44.6		8.2	5.8	6.9	7.9	6.2	-2.1	-7.8	-23.9
Battery_Enclosure	5.8	44.6		8.0	5.7	6.7	7.8	6.1	-2.0	-7.3	-22.6
Battery_Enclosure	5.8	44.6		8.0	5.7	6.8	7.8	6.2	-2.0	-7.3	-22.6
Battery_Enclosure	5.8	44.6		8.0	5.6	6.7	7.7	6.1	-2.1	-7.4	-22.8
Battery_Enclosure	5.8	44.6		8.0	5.7	6.7	7.8	6.1	-2.0	-7.4	-22.8
Battery_Enclosure	5.8	44.6		8.2	5.8	6.9	7.9	6.2	-2.1	-7.7	-23.5
Battery_Enclosure	5.8	44.6		8.1	5.8	6.9	7.9	6.2	-2.1	-7.7	-23.7
Battery_Enclosure	5.8	44.6		8.2	5.8	6.9	7.9	6.2	-2.1	-7.7	-23.6
Battery_Enclosure	5.7	44.6		8.1	5.8	6.8	7.8	6.1	-2.3	-8.1	-24.3
Battery_Enclosure	5.7	44.6		8.1	5.8	6.9	7.8	6.1	-2.2	-8.0	-24.2
Battery_Enclosure	5.7	44.6		8.1	5.7	6.8	7.8	6.1	-2.3	-8.0	-24.1
Battery_Enclosure	5.7	44.6		8.1	5.8	6.8	7.8	6.1	-2.2	-7.9	-24.1
Battery_Enclosure	5.7	44.6		8.1	5.7	6.8	7.8	6.0	-2.3	-8.1	-24.3
Battery_Enclosure	5.7	44.6		7.9	5.6	6.7	7.7	6.1	-2.1	-7.5	-22.9
Battery_Enclosure	5.7	44.6		8.0	5.6	6.7	7.7	6.1	-2.1	-7.5	-23.0
Battery_Enclosure	5.7	44.6		7.9	5.6	6.6	7.7	6.0	-2.2	-7.6	-23.1
Battery_Enclosure	5.7	44.6		7.9	5.6	6.7	7.7	6.0	-2.1	-7.6	-23.1
Battery_Enclosure	5.7	44.6		8.1	5.8	6.8	7.8	6.1	-2.2	-7.8	-23.8
Battery_Enclosure	5.7	44.6		8.0	5.7	6.8	7.8	6.1	-2.2	-7.9	-24.0
Battery_Enclosure	5.6	44.6		8.0	5.7	6.7	7.7	6.0	-2.3	-8.1	-24.4
Battery_Enclosure	5.6	44.6		8.0	5.7	6.7	7.7	6.0	-2.4	-8.2	-24.5
Battery_Enclosure	5.6	44.6		7.9	5.5	6.6	7.6	6.0	-2.2	-7.7	-23.3
Battery_Enclosure	5.6	44.6		7.9	5.6	6.6	7.7	6.0	-2.2	-7.7	-23.3
Battery_Enclosure	5.6	44.6		7.8	5.5	6.6	7.6	5.9	-2.3	-7.8	-23.4
Battery_Enclosure	5.6	44.6		7.8	5.5	6.6	7.6	5.9	-2.3	-7.7	-23.5
Battery_Enclosure	5.5	44.6		8.0	5.6	6.7	7.7	5.9	-2.4	-8.2	-24.6
Battery_Enclosure	5.5	44.6		7.9	5.6	6.6	7.6	5.9	-2.5	-8.3	-24.7
Battery_Enclosure	5.5	44.6		8.0	5.6	6.7	7.7	5.9	-2.4	-8.2	-24.6
Battery_Enclosure	5.5	44.6		7.9	5.6	6.6	7.6	5.9	-2.5	-8.3	-24.7
Battery_Enclosure	5.5	44.6		7.8	5.4	6.5	7.5	5.9	-2.4	-7.9	-23.7
Battery_Enclosure	5.5	44.6		7.8	5.5	6.5	7.6	5.9	-2.3	-7.8	-23.7
Battery_Enclosure	5.5	44.6		7.8	5.4	6.5	7.5	5.8	-2.4	-7.9	-23.9
Battery_Enclosure	5.4	44.6		7.9	5.5	6.6	7.6	5.8	-2.5	-8.3	-24.8
Battery_Enclosure	5.4	44.6		7.8	5.5	6.5	7.5	5.8	-2.6	-8.4	-25.0
Battery_Enclosure	5.4	44.6		7.8	5.5	6.6	7.5	5.8	-2.6	-8.4	-24.9
Battery_Enclosure	5.4	44.6		7.7	5.4	6.5	7.5	5.8	-2.4	-8.0	-23.9
Battery_Enclosure	5.4	44.6		7.7	5.4	6.4	7.4	5.7	-2.5	-8.1	-24.1
Battery_Enclosure	5.4	44.6		7.7	5.4	6.4	7.5	5.8	-2.5	-8.0	-24.1
Battery_Enclosure	5.3	44.6		7.8	5.4	6.5	7.4	5.7	-2.7	-8.5	-25.1
Battery_Enclosure	5.3	44.6		7.8	5.4	6.5	7.5	5.7	-2.6	-8.5	-25.0
Battery_Enclosure	5.3	44.6		7.7	5.4	6.4	7.4	5.7	-2.7	-8.5	-25.2
Battery_Enclosure	5.3	44.6		7.7	5.3	6.4	7.4	5.7	-2.5	-8.2	-24.3
Battery_Enclosure	5.3	44.6		7.6	5.3	6.4	7.4	5.6	-2.6	-8.3	-24.6
Battery_Enclosure	5.2	44.6		7.7	5.4	6.4	7.4	5.6	-2.7	-8.6	-25.2
Battery_Enclosure	5.2	44.6		7.7	5.3	6.4	7.3	5.6	-2.8	-8.6	-25.3
Battery_Enclosure	5.2	44.6		7.6	5.3	6.3	7.3	5.6	-2.8	-8.7	-25.4
Battery_Enclosure	5.2	44.6		7.6	5.3	6.3	7.3	5.5	-2.8	-8.7	-25.5
Battery_Enclosure	5.1	44.6		7.6	5.2	6.3	7.3	5.5	-2.9	-8.7	-25.5

Note: Octave band sound levels are linear (i.e. not A-weighted)

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Appendix VII. NOISE IMPACT ASSESSMENT SUMMARY

Licensee: **TransAlta Corporation**

Facility name: **Watercharger Project**

Type: **Battery Storage Facility**

Legal location: **08-13-26-06-W5M**

Contact: **Chris Teare** Telephone: **(403) 267-3723**

1. Permissible Sound Level (PSL) Determination (*Rule 012,* Section 2)

Complete the following for the most impacted dwelling(s) or at a distance of 1.5 km where there are no dwellings:

Dwelling Distance from facility	Dwelling Direction from facility	BSL (dBA)	Daytime adjustment (dBA)	Nighttime PSL (dBA)	Daytime PSL(dBA)
340 m	**North**	**51**	**10**	**51**	**61**

2. Sound Source Identification

For the new and existing equipment, identify major sources of noise from the facility, their associated sound power level (PWL) or sound pressure level (SPL), the distance (far or free field) at which it was calculated or measured, and whether the sound data are from vendors, field measurement, theoretical estimates, etc.

New Equipment	Predicted: X PWL (dBA) X SPL (dBA) OR Measured: X PWL (dBA) X SPL (dBA)	Data source	Distance calculated or measured (m)
Identified in Appendix IV			

Existing Equipment	X SPL (dBA) X SPL (dBA)	Data source	
Identified in Appendix IV			

Provide a Tentative Schedule and timing for the operation, maintenance, and testing of the equipment

- Construction Start: March, 2023
- Testing/Commissioning: December, 2023

3. Operating Conditions

When using manufacturer's data for expected performance, it may be necessary to modify the data to account for actual operating conditions (for example, indicate conditions such as operating with window/doors open or closed). Describe any considerations and assumptions used in conducting engineering estimates:

Equipment assumed to be operating at all times at maximum capacity

4. Modelling Parameters

If modelling was conducted, identify the parameters used (see Section 3.5):

Ground absorption 0.5, Temperature 10^0C, Relative Humidity 70%, all receptors downwind, Following ISO 9613

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5. Predicted Sound Level/Compliance Determination

Identify the predicted overall (cumulative) sound level at the nearest of most impacted residence. Typically, only the nighttime sound level is necessary, as levels do not often change from daytime to nighttime. However, if there are differences between day and night operations, both levels must be calculated.

Predicted sound level contribution from the new or modified facility alone at the nearest or most impacted dwelling or at a distance of 1.5 km where there are no dwellings.

Nighttime sound level:	**40.8 dBA L_{eq}**	Daytime sound level:	**40.8 dBA L_{eq}**
Assumed nighttime sound level:	**46.0 dBA L_{eq}**	Assumed daytime sound level:	**56.0 dBA L_{eq}**

Predicted sound level at the nearest or most impacted dwelling or at a distance of 1.5 km where there are no dwellings, from the new or modified facility including the cumulative effects of noise from energy-related facilities and the prescribed ambient level (ASL + new facility + existing energy-related facilities).

Nighttime sound level:	**48.4 dBA L_{eq}**	Nighttime Permissible sound level:	**51.0 dBA L_{eq}**
Daytime sound level:	**56.3 dBA L_{eq}**	Daytime Permissible sound level:	**61.0 dBA L_{eq}**

Is the predicted sound level less than the permissible sound level by a margin of three dBA? **NO**

If No, conduct a detailed NIA as per Section 3 of AUC Rule 012.

6. Supply any other relevant information you want to provide to the AUC. Submit additional pages if required
N/A

7. If the nighttime permissible sound level is higher than 40 dBA L_{eq}, provide supplementary information to support the use of such permissible sound level.
Appendix V

8. Explain what measures have been taken to address construction noise.
Advising nearby residents of significant noise sources and appropriately scheduling
Mufflers on all internal combustion engines
Taking advantage of acoustical screening
Limiting vehicle access during night-time

9. Acoustical practitioner's information (See Section 3.2 (12)):
Company: **ACI Acoustical Consultants Inc.**
Name: **Steven Bilawchuk, M.Sc., P.Eng.**
Experience: **- Acoustical Consultant since 2000**
- Hundreds of Noise Impact Assessments
- Teaching Acoustics and Noise Control Course to Senior Engineering Students at UofA 2005-2013
Title: **Director** Telephone: **(780) 414-6373** Date: **December 22, 2021**

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Resume for Steven Bilawchuk, M.Sc., P.Eng.

Mr. Bilawchuk is a private consultant specializing in environmental noise and vibration measurement and assessment. His M.Sc. work at the University of Alberta was in the field of Finite Element Modeling of Acoustical Silencers. In addition, he teaches a senior Mechanical Engineering course on Acoustics and Noise Control at the University of Alberta. His involvement with aci has gained him experience in various fields of noise and vibration measurement, assessment, and design. He is also an avid enthusiast of systems for home and mobile audio reproduction.

EDUCATION

M.Sc. 2002 Mechanical Engineering, University of Alberta, Canada
-Thesis work on Finite Element Modeling of Acoustical Silencers
-Courses of Acoustics, Vibrations, Signal Processing, Modeling

B.Sc. 2000 Mechanical Engineering, University of Alberta, Canada
-Co-Op Program, Degree with Distinction

WORK EXPERIENCE

aci Acoustical Consultants Inc. 2000 – present

Principal Partner / President

- Project work in environmental noise assessment, silencer design, energy industry noise mitigation, architectural acoustics, building and machine vibration, transportation vibration, HVAC acoustics, gymnasium and auditorium acoustics.
- Accounting and invoice management.
- Software design for acoustic and vibration analysis.
- Organization committee for acoustic conferences

Sessional Instructor, University of Alberta 2005 – 2013

-Teaching MecE 553 (Acoustics and Noise Control) to 4th/5th year students

UofA Mechanical Engineering Acoustics and Noise Unit Lab 2000 – 2002

- Measurements for Sound Transmission Class (STC) of various wall, door, window structures
- Measurements for Noise Reduction Coefficient (NRC) testing of various sound absorbing materials

PROFESSIONAL AND TECHNICAL ASSOCIATIONS

-P.Eng., Association of Professional Engineers and Geoscientists of Alberta (APEGA)
- Institute for Noise Control Engineering (INCE)
-Member, Canadian Acoustical Association (CAA)

PUBLICATIONS

-M.Sc. Thesis, Finite Element Modeling of Acoustical Silencers, 2002. University of Alberta
-Comparison and implementation of the various numerical methods used for calculating transmission loss in silencer systems. *Applied Acoustics*, 64 (2003), 903 – 916.

-Numerous conference publications and presentations on acoustical topics.

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