

**Noise Technical Report for
Rocky Mountain Metropolitan Airport
Runway Safety Area
Environmental Assessment**

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1 INTRODUCTION

1.1 Overview

Harris Miller Miller & Hanson Inc. (HMMH) was retained by RS&H to evaluate the potential noise impacts associated with proposed Runway Safety Area (RSA) improvements at Rocky Mountain Metropolitan Airport (RMMA). The proposed action will involve relocating portions of State Highway 128 (SH 128) and Interlocken Boulevard in Broomfield, Colorado as a result of the airfield improvements. No changes in aircraft operations or runway geometry are anticipated. The information contained within this report will help produce the “noise section” to the environmental documentation required by Federal Aviation Administration (FAA) to show compliance with the National Environmental Policy Act (NEPA).

Though no changes in aircraft noise are anticipated, this report presents details about the regulatory context and thresholds of significance for aircraft noise under NEPA as outlined in the FAA Order 1050.1E, FAA Order 5050.4A, and the Council on Environmental Quality’s (CEQ) Regulations for Implementing the National Environmental Policy Act. The traffic noise analysis was conducted in accordance with Colorado Department of Transportation (CDOT)¹ and Federal Highway Administration (FHWA) noise policy, including Title 23 of the United States Code of Federal Regulations Part 772 (23 CFR 772).²

This report presents a description of the applicable standards and criteria, an evaluation of the existing noise conditions, a projection of future noise levels, and consideration of noise abatement measures. In addition, Section 7 of the report provides a preliminary evaluation of noise during the project’s construction phase.

1.2 Study Zone

Under the National Environmental Policy Act (NEPA), the Airport must analyze the environmental effects of the Proposed Action. To capture those effects, the study area typically must include not only the immediate airport environs where aircraft flight paths are aligned with the runways, it also must include other potentially affected areas beyond that, over which aircraft will fly as they follow flight corridors that join the surrounding airspace. As the proposed action will result in changes in roadway noise, but not result in any changes in aircraft operation or noise, the area of analysis will be limited to a smaller study zone.

Proposed improvements at RMMA would affect two roadways classified as “Major Arterial” according to the City and County of Broomfield. Existing SH 128, a two-lane asphalt road, travels west to east along the northwestern perimeter of RMMA. SH 128 currently has a variable width ranging from 50 to 72 feet with acceleration and turning lanes and 5.5 percent grade. The second affected roadway, Interlocken Blvd., runs south into State Highway 128 forming a “T” intersection with three traffic signals and two pedestrian crossings. Interlocken Boulevard is a two-lane asphalt road with a right hand turn lane, width of 52 feet, and eight percent grade.

¹ Colorado Department of Transportation, “Noise Analysis and Abatement Guidelines,” December 1, 2002.

² 23 CFR 772, as amended 70 FR 16707, April 1, 2005 – “Procedures for Abatement of Highway Traffic Noise and Construction Noise,” U.S. Department of Transportation, Federal Highway Administration.

The existing intersection of SH 128 and Interlocken Boulevard would be relocated approximately 270 feet northwest of its present location. Future SH 128 would expand to the northwest, adding 410 linear feet of pavement with a 72 foot width and seven percent grade. The future Interlocken Boulevard would shift to the northwest and thus be reduced in length by 200 feet while maintaining its current 52 foot width and eight percent grade.

Noise impact was assessed at noise-sensitive land use within the study zone, which is defined by CDOT as the area extending 500 feet “around the extents of work.”³

1.3 Summary of Results

Aircraft Noise Evaluation

No changes in aircraft flight paths, fleet mix, level of operations, or runway geometry are anticipated due to the Proposed Action. Thus, the proposed action will cause no change in aircraft noise levels at RMMA and no impact due to changes in aircraft noise.

Traffic Noise Evaluation

Noise-sensitive land use within the study zone is limited to an outdoor basketball court and portions of a golf course. No residences are located within the study zone. Loudest-hour noise levels at these two active recreation facilities do not currently approach or exceed the applicable Noise Abatement Criteria (NAC). Due to increased traffic volumes, future loudest-hour L_{eq} noise levels under the No-action Alternative are expected to increase by about one to two decibels compared to existing conditions. Under the Proposed Action, future loudest-hour noise levels are expected to increase by about one to five decibels compared to existing conditions. This increase would be caused by the realignment of SH 128 and Interlocken Boulevard, as well as increased traffic volumes. The projected changes are below the 10-decibel increase identified by CDOT as a substantial increase. Predicted future noise levels also would be below the applicable NAC; therefore no traffic noise impacts are expected to occur under either the Proposed Action or the No-action Alternative. Because no noise impacts are predicted, consideration of traffic noise abatement is not warranted.

Construction Noise Evaluation

The preliminary analysis of potential noise effects during construction indicated that expected noise levels would not exceed either the daytime or nighttime default limits provided by the FHWA Roadway Construction Noise Model (RCNM). Nonetheless, a number of low-cost, common sense attenuation measures may reduce the amount of noise impact on the surrounding community including: limiting nighttime construction; ensuring all equipment utilizes properly maintained mufflers; using ambient sensing, manually adjusting, or detector type backup alarms on all equipment; locating haul roads and truck traffic away from noise-sensitive areas; routing truck traffic so backing up is minimized or not required; placing equipment on the site as far away from noise-sensitive receptors as possible; and public outreach to make the community aware of the steps being taken to reduce noise, including publicizing in advance the schedule of activities with the potential to generate high noise levels.

³ CDOT, p. 10.

2 NOISE STANDARDS AND CRITERIA

The reader's comprehension of the noise analysis in the EA will depend heavily on his or her understanding of the common metrics used to describe and evaluate noise. The most pertinent noise metrics discussed in this document are:

- The Day Night Average Sound Level, or DNL;
- The Equivalent A-weighted Sound Level, or L_{eq} ; and
- The Maximum A-weighted Sound Level, or L_{max} .

Definitions of these and many of the other metrics used in various noise analyses are given in Appendix A of this report.

2.1 Aircraft Noise

2.1.1 Regulatory Context

The FAA is under the U.S. Department of Transportation (DOT) with regulatory responsibility for civil aviation. Since the FAA has the responsibility to approve the Project, compliance with NEPA is required.

Aircraft noise analyses for federal actions must be completed in accordance with the FAA Order 1050.1E, *Environmental Impacts: Policies and Procedures*, FAA Order 5050.4A, *Airport Environmental Handbook*, and the National Environmental Policy Act as specified in the Council on Environmental Quality's (CEQ) *Regulations for Implementing the National Environmental Policy Act* (40 CFR 1500-1508).^{4,5}

FAA Order 1050.1E CHG 1, effective March 20, 2006, specifies a number of requirements for the noise analyses, including which noise models are acceptable under various circumstances, what constitutes significant impact, and when supplemental noise analyses are needed. The Integrated Noise Model (INM), the Helicopter Noise Model (HNM), or the Noise Integrated Routing System (NIRS) must be used to determine the significance of changes in exposure; and the INM or HNM must be used to produce DNL 75 dB, DNL 70 dB, and DNL 65 dB contours and others as needed. Since the issuance of this Order, the FAA has integrated the HNM with the INM in the version 7.0 release in 2007 and issued guidance with the release that INM is to be used for helicopter noise analyses, thus eliminating the use and support of the HNM.

2.1.2 Thresholds of Significance

Both Orders identify the threshold of "significant impact" based on the yearly day-night average sound level (DNL). If a location of incompatible land use is exposed to a project-related increase in noise level of DNL 1.5 dB or more, and that location lies within the 65 dB DNL noise contour for the "with action" condition, then the location is considered to be significantly impacted by noise and must be identified as such in environmental evaluations.

4 FAA Order 1050.1E CHG 1, *Environmental Impacts: Policies and Procedures*, 20 March 2006.

5 FAA Order 5050.4A, *Airport Environmental Handbook*, 8 October 1985.

In 1992, the Federal Interagency Committee on Noise (FICON)⁶ recommended that in addition to significant impacts, less-than-significant noise level changes be identified for noise-sensitive locations exposed to Project-related increases. FICON recommended reporting any changes in DNL of 3 dB or more between 60 and 65 dB DNL, and increases of DNL 5 dB or more between 45 and 60 dB DNL. The FAA's subsequent Air Traffic Noise Screening (ATNS) procedure⁷ further emphasized the importance of these changes in DNL, so that they, also, are now included in FAA Order 1050.1E. These recommendations only apply to cases where the significant threshold (increase of 1.5 dB or more within the 65 dB DNL contour) is met or exceeded. Levels of significance for noise sensitive locations are summarized below.

Significant noise impact:

- DNL increase of 1.5 dB or more in areas of 65 dB DNL and higher

Less than significant impact:

- DNL increase of 3 dB or more in areas between 60 and 65 dB DNL
- DNL increase of 5 dB or more in areas between 45 and 60 dB DNL

2.2 Roadway Noise

The noise impact of the proposed roadway relocation was assessed in accordance with FHWA and CDOT noise assessment guidelines. To assess the degree of traffic noise impact on human activity, the FHWA established Noise Abatement Criteria (NAC) for different categories of land use (see Table 1). These levels “represent the upper limit of acceptable traffic noise conditions.” The NAC “represent a balancing of that which may be desirable with that which may be achievable.” According to the regulations, traffic noise impact occurs when the predicted traffic noise levels approach or exceed the Noise Abatement Criteria, or when the predicted traffic noise levels substantially exceed the existing noise levels. The regulations further state that noise impact should be assessed for the loudest hour of the day in the design year.

The NAC are given in terms of the hourly, A-weighted, equivalent sound level in decibels (dBA). The A-weighted sound level is a single number measure of sound intensity with weighted frequency characteristics that corresponds to human subjective response to noise. Most environmental noise (and the A-weighted sound level) fluctuates from moment to moment, and it is common practice to characterize the fluctuating level by a single number called the equivalent sound level (L_{eq}). The L_{eq} is the value or level of a steady, non-fluctuating sound that represents the same sound energy as the actual time-varying sound evaluated over the same time period. For traffic noise assessment, L_{eq} is typically evaluated over a one-hour period, and may be denoted as $L_{eq(h)}$. Appendix A provides further information on the noise metrics used in this report.

Within this project area, no residential areas exist within 500 feet of the proposed project's extents of work. Two active sports areas, a golf course and an outdoor basketball court, are the only noise-sensitive land uses within the study limits. Active sports areas are included under Category B in Table 1. For Category B, noise impact is assumed to occur when computed exterior noise levels due to the project reach 66 dBA L_{eq} during the loudest hour of the day. Noise impact also would occur

⁶ Federal Agency Review of Selected Airport Noise Analysis Issues, Federal Interagency Committee on Noise, Washington, D.C., August 1992.

⁷ Air Traffic Noise Screening Model, Version 2.0 User Manual, January 1999.

wherever project noise causes a substantial increase over existing noise levels. CDOT defines a substantial increase as an increase of 10 decibels or more above existing noise levels.

When the predicted design-year Build case noise levels equal or exceed the NAC during the loudest hour of the day or cause a substantial increase in existing noise, consideration of traffic noise reduction measures is necessary. If it is found that such mitigation measures will cause adverse social, economic or environmental effects that outweigh the benefits received, they may be dismissed from consideration. For this study, noise levels throughout the study zone were determined for Existing (2011) conditions and for the Design Year (2030) No-action and Build alternatives.

Table 1. CDOT Noise Abatement Criteria (NAC), Based on FHWA Noise Abatement Criteria, 23 CFR772

Category	$L_{eq}(h)$, dBA*	Description of Activity Category
A	56 (Exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	66 (Exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals
C	71 (Exterior)	Developed lands, properties, or activities not included in Categories A or B above.
D	--	Undeveloped lands.
E	51 (Interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals and auditoriums.

* Hourly A-weighted Sound Level in Decibels, reflecting a 1 dBA "Approach" Value Below 23CFR772 Values.

Source: CDOT Noise Analysis and Abatement Guidelines.

3 METHODOLOGY

The Proposed Action does not involve any changes to the operation of aircraft at RMMA and no aircraft noise modeling was conducted for the EA.

Due to the relatively limited scope of the roadway relocation and the limited amount of noise-sensitive land use in proximity to the project area, the traffic noise analysis study was conducted at a screening level as follows:

- The latest version of the FHWA Traffic Noise Model (FHWA TNM 2.5)⁸ was used to determine screening distances at which traffic noise impact would occur.
- The noise modeling accounted distance from the road, roadway widths, presence of acoustically soft ground, traffic speed, and hourly traffic volumes, including percentages of medium and heavy trucks.
- The modeling used simplified straight-line roadway geometries to determine noise-impact screening distances.
- As a conservative assumption, the modeling did not account for shielding provided by terrain or intervening structures.
- Traffic data were provided for existing (2011) and future (2030) conditions by RS&H. The project was assumed not to affect traffic volumes or level of service (LOS), therefore the same traffic was used for both the 2030 Proposed Action and No-action Alternative. Appendix B provides a summary of the traffic data used in the evaluation.

⁸Anderson, G.S., C.S.Y. Lee, G.G. Fleming, and C.W. Menge, "FHWA Traffic Noise Model, Version 1.0 User's Guide". Federal Highway Administration Report No. FHWA-PD-96-009, January 1998.

4 EXISTING NOISE ENVIRONMENT

This section of the report provides information on noise-sensitive land use followed by results of the existing conditions noise analysis.

4.1 Noise-sensitive Land Use

In accordance with CDOT guidance, potential impacts were assessed at noise-sensitive land uses within 500 feet of the proposed project's extents of work. No residential areas fall within this zone. The only noise-sensitive land uses within 500 feet of the project are two active sports areas. CDOT guidance states that "when determining impacts, primary consideration is to be given to exterior areas of frequent human use where a lowered noise level will be of benefit."⁹

The first active sports area is a golf course located to the west of the project area. Potential noise impacts were assessed at the portions of fairways, greens, or tees closest to the existing and proposed project roads. Portions of the golf course outside of the fairways, greens, and tees were not considered in the analysis because they were judged not to meet the standard of "frequent human use where a lowered noise level will be of benefit." The closest noise-sensitive portion of the golf course to any project road is approximately 250 feet from Interlocken Boulevard (both existing and future alignments). The closest noise-sensitive portion of the golf course to SH 128 is approximately 750 feet from existing SH 128 and approximately 430 feet from the future alignment.

The second active sports area is an outdoor basketball court located at a business park northwest of both the existing and relocated SH 128 / Interlocken Boulevard intersection. The basketball court is about 330 feet from Interlocken Boulevard (both existing and future alignments) and over 500 feet from both existing and relocated SH 128.

4.2 Computed Existing Noise Levels

Using the methodology described above, loudest-hour L_{eq} noise levels were computed for existing conditions at representative noise-sensitive locations within 500 feet of the future project site. Table 2 provides the computed existing conditions noise levels.

- Although no noise-sensitive portions of the golf course currently are within 500 feet of SH 128, existing noise levels were computed at two locations that will be within 500 feet of relocated SH 128. At Site 1, which currently is 750 feet from SH128 and 500 feet from Interlocken Boulevard, the existing loudest-hour noise level was computed to be 52 dBA.
- At Site 2, also 750 feet from SH128 but only 300 feet from Interlocken Boulevard, the loudest-hour noise level was computed to be 56 dBA.
- At Site 3, located on the golf course about 250 feet from existing Interlocken Boulevard, the existing loudest-hour noise level also was computed to be 57 dBA.
- At Site 4, the basketball court, approximately 330 feet from existing Interlocken Blvd., the loudest-hour noise level was computed to be 54 dBA.

⁹ CDOT, p. 9.

As described above, the TNM analysis was conducted at a screening-level. Therefore, computed noise levels should be considered to be approximate.

Table 2. Computed Existing (2011) Traffic-Noise Levels

Site No.	Description	Approximate Distance to Project Road(s) under Existing Conditions (feet)	Loudest-hour L_{eq} (dBA) Existing (2011)
1	Golf course, fairway closest to existing SH 128 (away from Interlocken Blvd.)	SH 128: 750 Interlocken Blvd.: 500	52
2	Golf course, fairway closest to future, relocated intersection	SH 128: 750 Interlocken Blvd.: 300	56
3	Golf course, fairway closest to Interlocken Blvd.	Interlocken Blvd.: 250	57
4	Basketball court	Interlocken Blvd.: 330	54

Source: HMMH, 2011

5 FUTURE CONDITIONS

Traffic noise levels were assessed for both the Proposed Action and the No-action Alternative in the design year (2030). The project is not expected to affect traffic volumes, vehicle mix, or levels of service. Using the same methodology as described above, the TNM was used to conduct a screening-level analysis. Noise impact was assessed at noise-sensitive land use within the study zone, which is defined by CDOT as the area extending 500 feet back from the extent of work. As described above, noise impact would occur wherever project noise levels are expected to equal or exceed 66 dBA, L_{eq} at noise-sensitive outdoor land uses during the loudest hour of the day. Noise impact also would occur wherever project noise levels cause a substantial increase over existing noise level; CDOT considers an increase of 10 dB or more to be substantial.

Table 3 shows computed loudest-hour noise levels at noise-sensitive locations. For comparison, the table also displays existing noise levels (from Table 2).

- At Site 1, which currently is 750 feet from SH128 and 500 feet from Interlocken Boulevard, the future loudest-hour noise level under the No-action Alternative would increase by about two decibels to 54 dBA. Under the Proposed Action, this site would be about 500 feet from relocated SH 128 and the loudest-hour sound level would increase to 57 dBA.

Table 3. Computed Existing (2011) and Future (2030) Traffic-Noise Levels

Site No.	Description	Approximate Distance to Project Road(s) under Proposed Action (feet)	Loudest-hour L_{eq} (dBA)		
			Existing (2011)	No-action (2030)	Proposed Action (2030)
1	Golf course, fairway closest to existing SH 128 (away from Interlocken Blvd.)	SH 128: 500 Interlocken Blvd.: 500	52	54	57
2	Golf course, fairway closest to future, relocated intersection	SH 128: 430 Interlocken Blvd.: 300	56	57	59
3	Golf course, fairway closest to Interlocken Blvd.	Interlocken Blvd.: 250	57	58	58
4	Basketball court	Interlocken Blvd.: 330	54	55	55

Source: HMMH, 2011

- At Site 2, which currently is 750 feet from SH128 and 300 feet from Interlocken Boulevard, the loudest-hour noise level under the No-action Alternative would increase by about one decibel to 57 dBA. Under the Proposed Action, SH 128 would be relocated to the north, closer to the golf course, and would pass within approximately 430 feet of this site. The predicted loudest-hour noise level at this closest noise-sensitive location to the relocated intersection would be approximately 59 dBA.

- In the design year, the closest noise-sensitive portion of the golf course to any project road will be approximately 250 feet from Interlocken Boulevard, the same as under existing conditions. Due to increased traffic on Interlocken Boulevard, the predicted loudest-hour noise level at this location (Site 3) is expected to increase by about one decibel to 58 dBA, L_{eq} . Because the distance to this portion of Interlocken Boulevard would be the same under either the Proposed Action or the No-action Alternative, the predicted noise level would be the same for either case.
- In the design year, Site 4, the basketball court would remain about 330 feet from the closest portion of Interlocken Boulevard, the same as under existing conditions. Due to increased traffic on Interlocken Boulevard, the predicted sound level at this location is expected to increase by about one decibel to 55 dBA, L_{eq} . Because the distance to this portion of Interlocken Boulevard would be the same under either the Proposed Action or the No-action Alternative, the predicted noise level would be the same for either case.

Due to increased traffic volumes, future loudest-hour L_{eq} noise levels under the No-action Alternative are expected to increase by about one decibel compared to existing conditions. Under the Proposed Action, future loudest-hour noise levels are expected to increase by about one to five decibels compared to existing conditions. This increase would be caused by the realignment of SH 128 and Interlocken Boulevard, as well as increased traffic volumes. Because noise levels are not expected to increase by 10 decibels at any noise-sensitive sites, noise impact based on substantial increases in existing noise will not occur anywhere within the study zone. Predicted future noise levels also would be below the applicable NAC; therefore no traffic noise impacts are expected to occur under either the Proposed Action or the No-action Alternative.

As described above, the TNM analysis was conducted at a screening-level. Therefore, computed noise levels should be considered to be approximate.

6 NOISE ABATEMENT MEASURES

Because no noise impacts are projected to occur, consideration of noise abatement measures is not warranted.

7 CONSTRUCTION NOISE

7.1 Noise Impact Criteria

Neither FHWA nor CDOT have established specific limits for construction noise. CDOT guidance states that “the approach to [the discussion of construction noise] should be general in scope and consider the temporary nature of construction activities. Included should be the types of activities that are expected to be performed and the equipment that will be used. If desired, noise levels that are associated with these activities can be researched through product or process literature and presented in the report.”¹⁰ FHWA’s Roadway Construction Noise Model (RCNM)¹¹ provides default noise limit criteria based on prior specifications. For residential areas, the default noise limit criteria for maximum sound levels (L_{max}) are 85 dBA during daytime and evening (7 AM to 10 PM) and 80 dBA for nighttime (10 PM to 7 AM).¹² Although these are not official criteria, they have been used in this screening level analysis in the absence of other applicable criteria.

7.2 Noise Projections

Projections of construction noise levels at noise-sensitive receptors abutting a construction site depend on the types and number of pieces of construction equipment in use at any one time, and are generally governed by the noisiest equipment at the site. RS & H provided a list of construction equipment that will be used throughout the project. Each piece of equipment in this list was then cross-referenced with noise emission levels (maximum sound level at a distance of 50 feet) obtained from the RCNM.¹³ In some cases, where exact matches were not available, similar types of equipment were substituted. Table 4 provides the list of equipment along with the RCNM noise emission levels.

¹⁰ Colorado Department of Transportation, *Noise Analysis and Abatement Guidelines*, “Construction Considerations,” December 2002, page 24.

¹¹ U.S. Department of Transportation, Federal Highway Administration, *Roadway Construction Noise Model User’s Guide*, Final Report, FHWA-HEP-05-054, January 2006.

¹² *Ibid.*, Table 2. “Default Noise Limit Criteria,” p. 11.

¹³ *Ibid.*, Table 1. “CA/T equipment noise emissions and acoustical usage factors database,” p. 3.

Table 4. Construction Equipment and Noise Emission Levels

Equipment	L_{max} at 50' (dBA)
8-ton Truck Crane	81
Backhoe	78
Breakdown Roller	80
CAT 12M Grader	85
CAT 623G Elevating Scraper	84
CAT CS64 Vibe Compactor	83
Concrete Truck	81
End Dump, Dump Truck	76
Finish Roller	80
Front End Loader	79
Intermediate Roller	80
Manual Lift	75
Paint Truck*	76
Paver	77
Service Trucks	75
Skidster**	79
Truck, Seed/Mulch Blower*	76
Water Truck*	76
Notes: *Substituted Dump Truck emission level **Substituted Front End Loader emission level	

Source: RS&H, 2011 (equipment list) and FHWA Roadway Construction Noise Model (noise emission levels)

Although no residential areas exist within 500 feet of the project limits, a golf course is located within several hundred feet northwest of the project site. In addition, a business park with an outdoor basketball court is located within several hundred feet northeast of the project site. The closest point on the golf course to the project area is on a fairway approximately 250 feet west of Interlocken Boulevard. The closest point at the business park basketball court to the project area is approximately 330 feet north of Interlocken Boulevard.

Using the same calculation methodology employed by the RCNM, maximum sound levels for each type of equipment were calculated at these two worst-case, closest locations. Table 5 provides the computed maximum sound level associated with each type of equipment, as heard at the two worst-case locations. Maximum sound levels from each of the three loudest types of equipment (grader, scraper, and vibratory compactor) were predicted to range from approximately 69 to 71 dBA at the closest golf course location and from approximately 67 to 69 dBA at the basketball court. At either location, the predicted sound levels would be well below either the daytime limit of 85 dBA or the nighttime limit of 80 dBA, even if all three of the loudest equipment types were to operate simultaneously.

Table 5. Predicted Construction Noise Levels at Closest Receptors

Equipment	Computed Maximum Sound Level (L_{max} , dBA)	
	Closest golf course fairway (250 feet from project site)	Business park basketball court (330 feet from project site)
8-ton Truck Crane	67	65
Backhoe	64	62
Breakdown Roller	66	64
CAT 12M Grader	71	69
CAT 623G Elevating Scraper	70	68
CAT CS64 Vibe Compactor	69	67
Concrete Truck	67	65
End Dump, Dump Truck	62	60
Finish Roller	66	64
Front End Loader	65	63
Intermediate Roller	66	64
Manual Lift	61	59
Paint Truck*	62	60
Paver	63	61
Service Trucks	61	59
Skidster**	65	63
Truck, Seed/Mulch Blower*	62	60
Water Truck*	62	60

Source: HMMH, 2011

7.3 Construction Noise Attenuation Measures

A number of measures can be taken to help control the noise from construction activities. The following are possible low-cost, common sense attenuation measures that may reduce the amount of noise impact on the surrounding community:

- Do not conduct construction operations at night. People are more sensitive to noise at night; nighttime ambient noise levels are lower during the night. By not working at night, the impact on a community can be greatly reduced.
- Ensure that all equipment utilizes properly maintained mufflers.
- Use ambient sensing, manually adjusting, or detector type backup alarms on all equipment.
- Locate haul roads and truck traffic away from noise-sensitive areas, if possible.
- Route truck traffic so backing up is minimized or not required.
- Place equipment on the site as far away from noise-sensitive receptors as possible.
- Use public outreach to make the community aware of the steps being taken to reduce noise and publicize in advance the schedule of activities with the potential to generate high noise levels.

APPENDIX A NOISE TERMINOLOGY

To assist reviewers in interpreting the complex noise terminology used in evaluating noise, we present below an introduction to relevant fundamentals of acoustics and noise terminology.

A.1 Introduction to Acoustics and Noise Terminology

Five acoustical descriptors of noise are introduced here in increasing degree of complexity:

- Decibel, dB
- A-weighted decibel
- Maximum Sound Level, L_{max}
- Time Above, TA
- Sound Exposure Level, SEL
- Equivalent Sound Level, Leq
- Day-Night Average Sound Level, DNL

These descriptors form the basis for the majority of noise analysis conducted at most airports throughout the U.S.

A.1.1 Decibel, dB

All sounds come from a sound source -- a musical instrument, a voice speaking, an airplane passing overhead. It takes energy to produce sound. The sound energy produced by any sound source is transmitted through the air in sound waves -- tiny, quick oscillations of pressure just above and just below atmospheric pressure. These oscillations, or sound pressures, impinge on the ear, creating the sound we hear.

Our ears are sensitive to a wide range of sound pressures. Although the loudest sounds that we hear without pain have about one million times more energy than the quietest sounds we hear, our ears are incapable of detecting small differences in these pressures. Thus, to better match how we hear this sound energy, we compress the total range of sound pressures to a more meaningful range by introducing the concept of sound pressure level.

Sound pressure levels are measured in decibels (or dB). Decibels are logarithmic quantities reflecting the ratio of the two pressures, the numerator being the pressure of the sound source of interest, and the denominator being a reference pressure (the quietest sound we can hear).

The logarithmic conversion of sound pressure to sound pressure *level* (SPL) means that the quietest sound that we can hear (the reference pressure) has a sound pressure level of about 0 dB, while the loudest sounds that we hear without pain have sound pressure levels of about 120 dB. Most sounds in our day-to-day environment have sound pressure levels on the order of 30 to 100 dB.

Because decibels are logarithmic quantities, combining decibels is unlike common arithmetic. For example, if two sound sources each produce 100 dB operating individually and they are then operated together, they produce 103 dB -- not the 200 decibels we might expect. Four equal sources operating simultaneously produce another three decibels of noise, resulting in a total sound pressure level of 106 dB. For every doubling of the number of equal sources, the sound pressure level goes up another three decibels. A tenfold increase in the number of sources makes the sound pressure level go up 10 dB. A hundredfold increase makes the level go up 20 dB, and it takes a thousand equal sources to increase the level 30 dB.

If one noise source is much louder than another, the two sources operating together will produce virtually the same sound pressure level (and sound to our ears) that the louder source would produce alone. For example, a 100 dB source plus an 80 dB source produce approximately 100 dB of noise when operating together (actually, 100.04 dB). The louder source "masks" the quieter one. But if the quieter source gets louder, it will have an increasing effect on the total sound pressure level such that, when the two sources are equal, as described above, they produce a level three decibels above the sound of either one by itself.

Conveniently, people also hear in a logarithmic fashion. Two useful rules of thumb to remember when comparing sound levels are: (1) a 6 to 10 dB increase in the sound pressure level is perceived by individuals as being a doubling of loudness, and (2) changes in sound pressure level of less than about three decibels are not readily detectable outside of a laboratory environment.

A.1.2 A-Weighted dB

Another important characteristic of sound is its frequency, or "pitch." This is the rate of repetition of the sound pressure oscillations as they reach our ear. When analyzing the total noise of any source, acousticians often break the noise into frequency components (or bands) to determine how much is low-frequency noise, how much is middle-frequency noise, and how much is high-frequency noise. This breakdown is important for two reasons:

- People react differently to low-, mid-, and high-frequency noise levels. This is because our ear is better equipped to hear mid and high frequencies but is quite insensitive to lower frequencies. Thus, we find mid- and high-frequency noise to be more annoying.
- Engineering solutions to a noise problem are different for different frequency ranges. Low-frequency noise is generally harder to control.

The normal frequency range of hearing for most people extends from a low frequency of about 20 Hz to a high frequency of about 10,000 to 15,000 Hz. People respond to sound most readily when the predominant frequency is in the range of normal conversation, typically around 1,000 to 2,000 Hz. Psycho-acousticians have developed several filters which roughly match this sensitivity of our ear and thus help us to judge the relative loudness of various sounds made up of many different frequencies. The so-called A-weighting network does this best for most environmental noise sources. Sound pressure levels measured through this filter are referred to as A-weighted sound levels (measured in A-weighted decibels, or dBA).

The A-weighting network significantly discounts those parts of the total noise that occur at lower frequencies (those below about 500 Hz) and also at very high frequencies (above 10,000 Hz) where we do not hear as well. The network has very little effect, or is nearly "flat," in the middle range of frequencies between 500 and 10,000 Hz where our hearing is most sensitive. Because this network generally matches our ears' sensitivity, sounds having higher A-weighted sound levels are judged to be louder than those with lower A-weighted sound levels, a relationship which otherwise might not be true. It is for this reason that A-weighted sound levels are normally used to evaluate environmental noise sources. Figure A1 presents typical A-weighted sound levels of several common environmental sources.

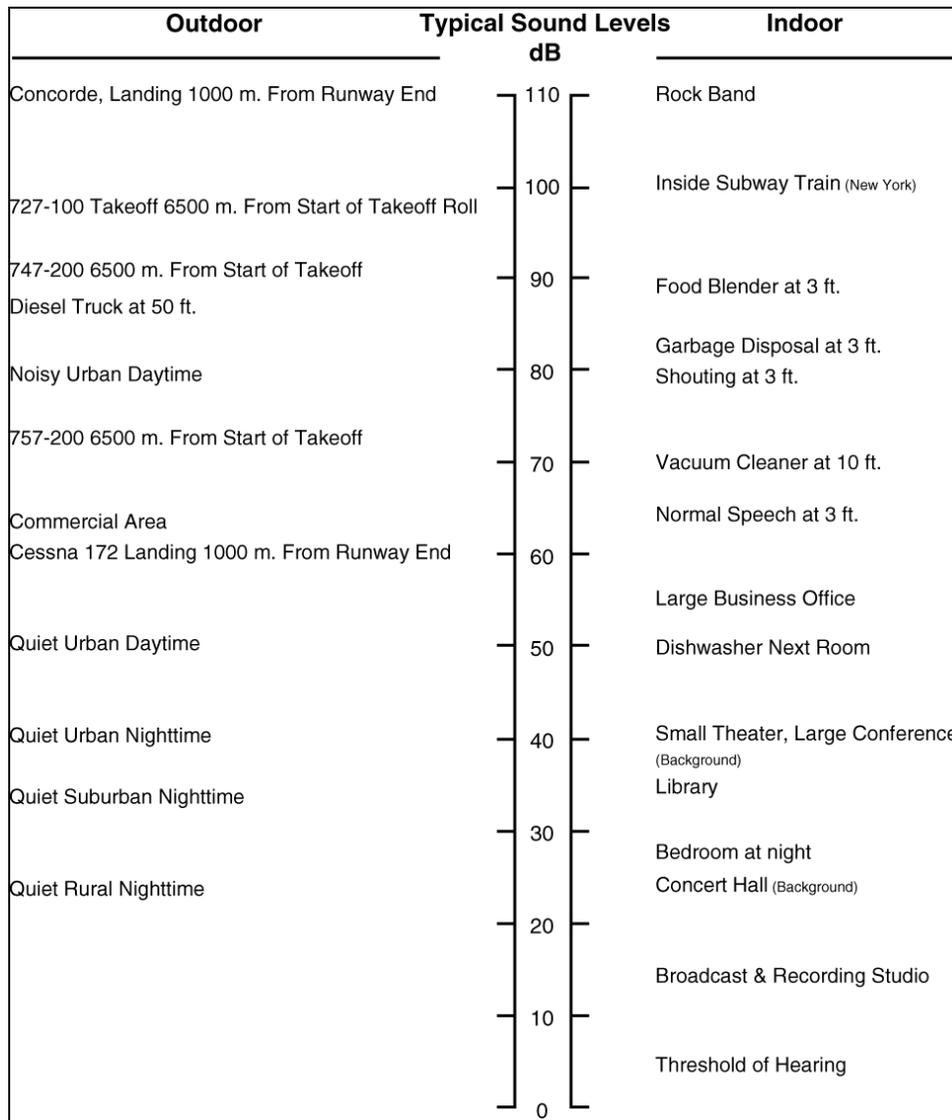


Figure A1 Common A-weighted environmental sound levels

An additional dimension to environmental noise is that A-weighted levels vary with time. For example, the sound level increases as an aircraft approaches, then falls and blends into the background as the aircraft recedes into the distance (though even the background varies as birds chirp, the wind blows, or a vehicle passes by). This is illustrated in Figure A2.

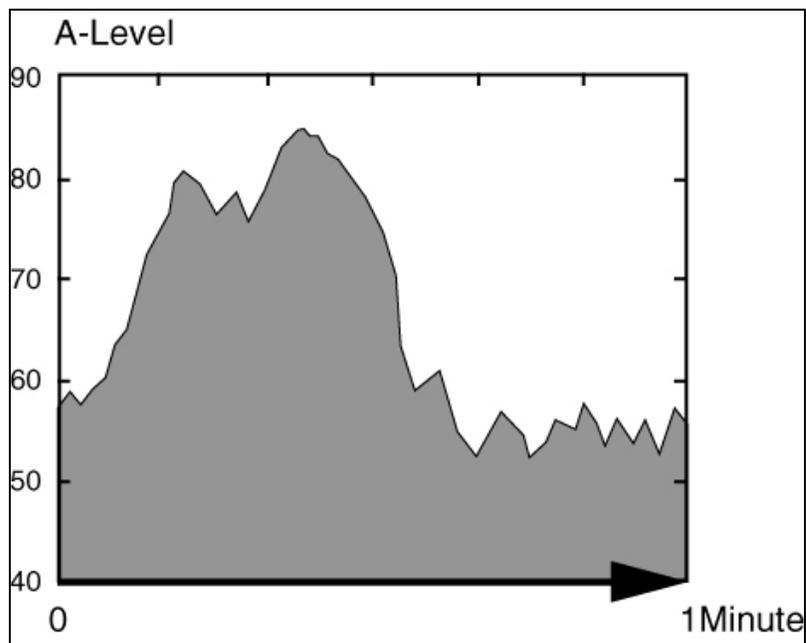


Figure A2 Variation of A-weighted sound level over time

A.1.3 Maximum sound level, L_{max} and Time Above, TA

Because of this variation, it is often convenient to describe a particular noise "event" by its maximum sound level, abbreviated as L_{max} . In Figure A2, the L_{max} is approximately 85 dBA. However, the maximum level describes only one dimension of an event; it provides no information on the cumulative noise exposure generated by a sound source. Two events with identical maximum levels may produce very different total exposures. One may be of very short duration, while the other may continue for an extended period and be judged much more annoying. The following metrics, Time Above and Sound Exposure Level, account for event duration and total exposure, respectively.

A.1.4 Time Above, TA

The Time Above is simply the amount of time that an event or set of events exceeds a given noise threshold. It is often notated as TA with a threshold value (e.g. TA_{65} is the amount of time which the noise level exceeds 65 dBA). By matching a TA threshold to a particular noise effect (e.g. speech interference), the amount of time a noise effect occurs can be stated using the TA metric.

A.1.5 Sound Exposure Level, SEL

The most common measure of cumulative noise exposure for a single aircraft fly-over is the Sound Exposure Level, or SEL . SEL is an accumulation of the sound energy over the duration of a noise event. The lightly shaded area in Figure A3 illustrates the portion of the sound energy included in this dose. To account for the variety of durations that occur among different noise events, the noise dose is normalized (standardized) to a one-second duration. This normalized dose is the SEL ; it is shown as the darkly shaded area in Figure A3. Mathematically, the SEL is the summation of all the noise energy compressed into one second.

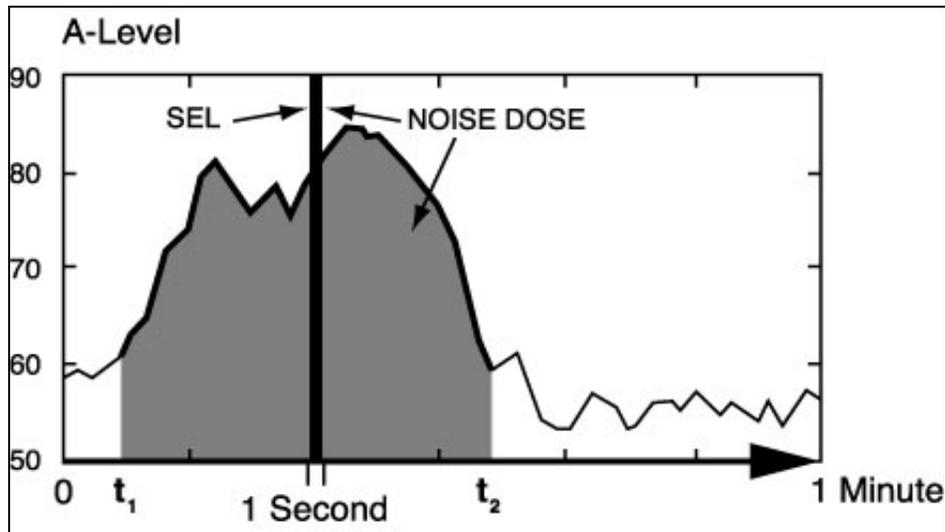


Figure A3 Graphic display of Sound Exposure Level, SEL

Note that because the SEL is normalized to one second, it will almost always be larger in magnitude than the maximum A-weighted level for the event. In fact, for most aircraft overflights, the SEL is on the order of 7 to 12 dBA higher than the L_{max} . Also, the fact that it is a cumulative measure means that not only do louder fly-overs have higher SEL than do quieter ones, but also fly-overs with longer durations have greater SEL than do shorter ones.

With this metric, we now have a basis for comparing noise events that generally matches our impression of the sound -- the higher the SEL, the more annoying it is likely to be. In addition, SEL provides a comprehensive way to describe a noise event for use in modeling noise exposure. Computer noise models base their computations on these SELs.

A.1.6 Equivalent Sound Level, L_{eq}

The Equivalent Sound Level, abbreviated L_{eq} , is a measure of the exposure resulting from the accumulation of A-weighted sound levels over a particular period of interest -- for example, an hour, an eight-hour school day, nighttime, or a full 24-hour day. However, because the length of the period can be different depending on the time frame of interest, the applicable period should always be identified or clearly understood when discussing the metric.

L_{eq} may be thought of as a constant sound level over the period of interest that contains as much sound energy as the actual time-varying sound level. This is illustrated in Figure A4. The equivalent level is, in a sense, the total sound energy that occurred during the time in question, but spread evenly over the time period. It is a way of assigning a single number to a time-varying sound level. Since L_{eq} includes all sound energy, it is strongly influenced by the louder events.

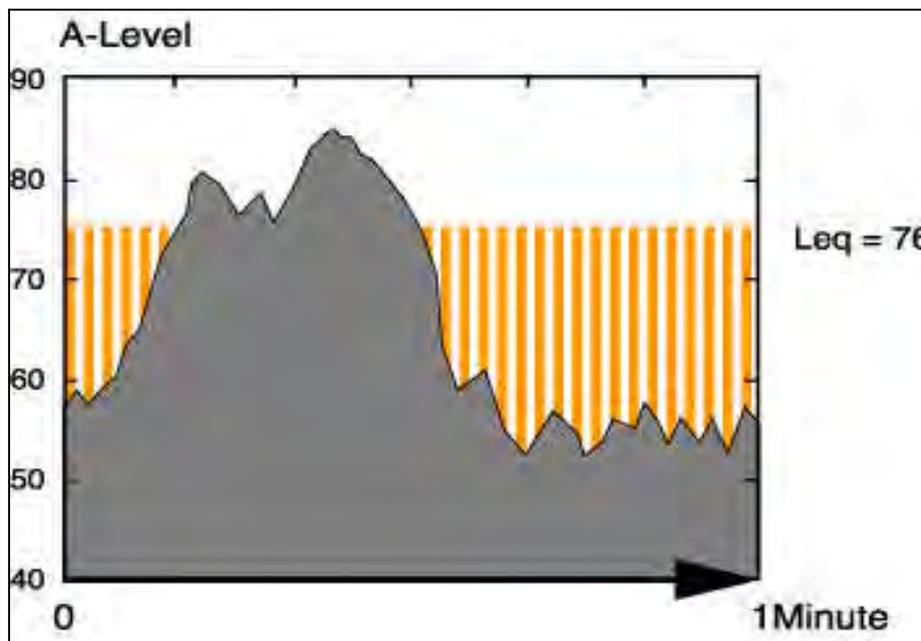


Figure A4 Graphical display of a one-minute Equivalent Sound Level, L_{eq}

As for its application to airport noise issues, L_{eq} is often presented for consecutive one-hour periods to illustrate how the hourly noise dose rises and falls throughout a 24-hour period as well as how certain hours are significantly affected by a few loud aircraft.

A.1.7 Day-Night Average Sound Level, DNL

In the previous sections, we have been addressing noise measures that account for the moment-to-moment or short-term fluctuations in A-weighted levels as sound sources come and go affecting our overall noise environment. The Day-Night Average Sound Level (DNL) represents a concept of noise dose as it occurs over a 24-hour period. It is the same as a 24-hour L_{eq} , with one important exception; DNL treats nighttime noise differently from daytime noise. In determining DNL, it is assumed that the A-weighted levels occurring at night (10 p.m. to 7 a.m.) are 10 dB louder than they really are. This 10 dB penalty is applied to account for greater sensitivity to nighttime noise, and the fact that events at night are often perceived to be more intrusive because nighttime ambient noise is less than daytime ambient noise.

Earlier, we illustrated the A-weighted level due to an aircraft event. The example is repeated in the top frame of Figure A5. The level increases as the aircraft approaches, reaching a maximum of 85 dBA, and then decreases as the aircraft passes by. The ambient A-weighted level around 55 dBA is due to the background sounds that dominate after the aircraft passes. The shaded area reflects the noise dose that a listener receives during the one-minute period of the sample.

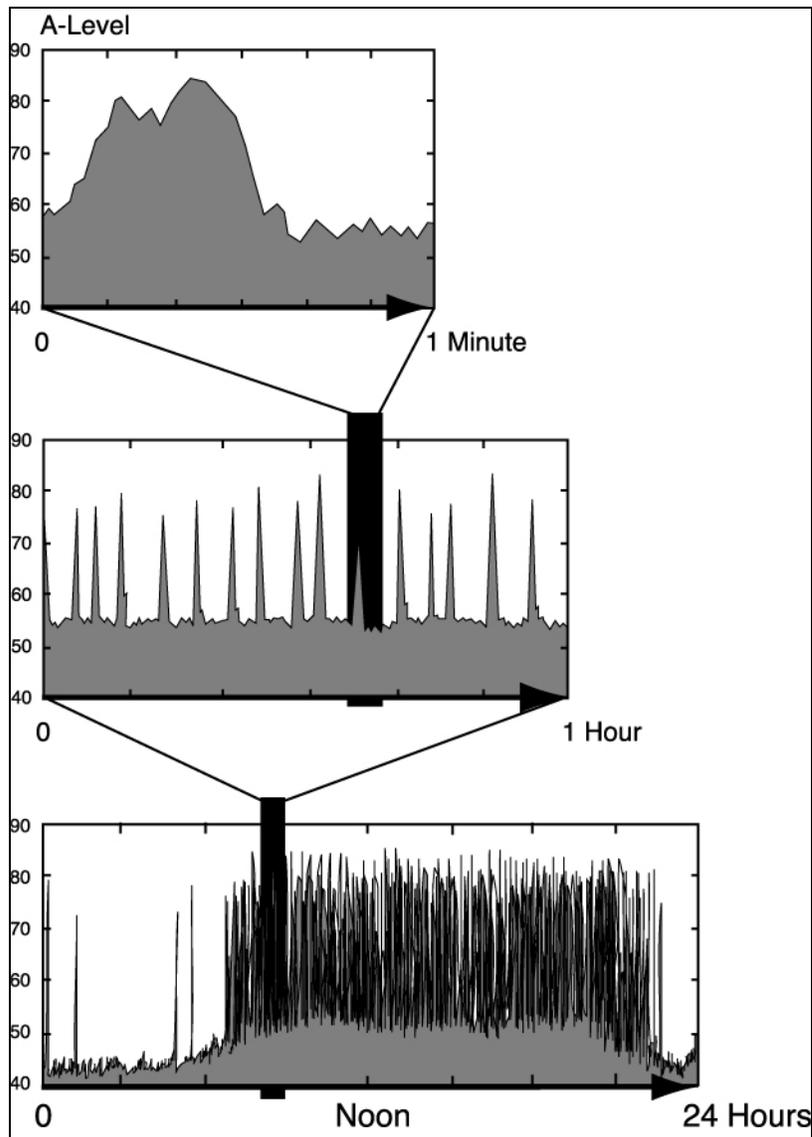


Figure A5 Sound level fluctuation and noise dose

The center frame of Figure A5 includes this one-minute interval within a full hour. Now the shaded area represents the noise dose during that hour when sixteen aircraft pass nearby, each producing a single event dose represented by an SEL. Similarly, the bottom frame includes the one-hour interval within a full 24 hours. Here the shaded area represents the noise dose over a complete day. Note that several overflights occur at night, when the background noise drops some 10 decibels, to approximately 45 dBA.

Values of DNL are normally measured with standard monitoring equipment or are predicted with computer models. Measurements are practical for obtaining DNL values for only relatively limited numbers of locations, and, in the absence of a permanently installed monitoring system, only for relatively short time periods. Thus, most airport noise studies utilize computer-generated estimates of DNL, determined by accounting for all of the SEL from individual aircraft operations that comprise the total noise dose at a given location on the ground. This principle is used in all airport noise modeling.

Computed values of DNL are usually depicted as noise contours that are lines of equal exposure around an airport (much as topographic maps have contour lines of equal elevation). The contours usually reflect long-term (annual average) operating conditions, taking into account the average flights per day, how often each runway is used throughout the year, and where over the surrounding communities the aircraft normally fly.

Figure A6 presents a representative sample of DNL (denoted L_{dn} in the figure) measured at various locations in the U.S.

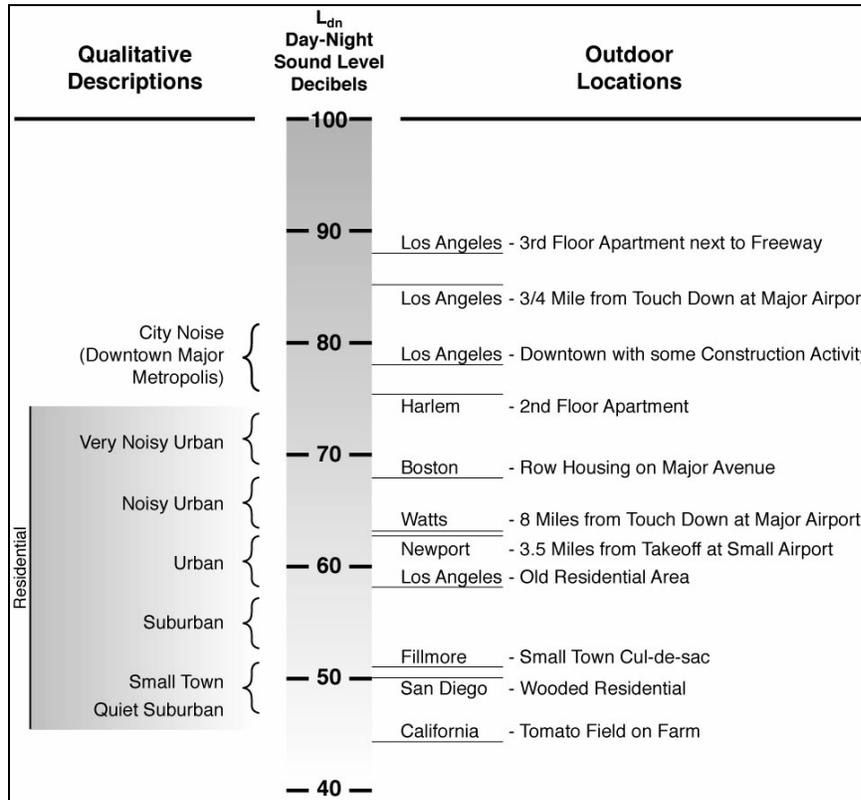


Figure A6 Representative Examples of Day-Night Average Sound Levels, DNL

Source: United States Environmental Protection Agency, Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, March 1974, p.14

APPENDIX B TRAFFIC DATA USED IN NOISE MODELING

This Appendix provides the traffic volumes and speeds used in the noise analysis as provided by RS&H.

Table B-1 provides modeled traffic both for existing conditions (2011) and the design year (2030). Because the project is not expected to affect traffic volumes, vehicle mix, or Levels of Service, the same traffic was used for both the Proposed Action and the No-action Alternative in the design year. The data consists of vehicle volumes by vehicle type (automobiles, medium trucks with two axles and six tires [MT], and heavy trucks [HT] with more than two axles) and speeds for each project roadway in the study area.

Table B-1. Traffic Volumes and Speeds for Loudest-Hour Conditions

Roadway	Existing (2011)				Design Year (2030)			
	Autos (vph)	MT (vph)	HT (vph)	Speed (mph)	Autos (vph)	MT (vph)	HT (vph)	Speed (mph)
SH 128 west of Interlocken Boulevard (EB)	559	13	13	50	1,219	28	28	50
SH 128 west of Interlocken Boulevard (WB)	559	13	13	50	1,219	28	28	50
SH 128 east of Interlocken Boulevard (EB)	755	17	17	50	1,377	32	32	50
SH 128 east of Interlocken Boulevard (WB)	755	17	17	50	1,377	32	32	50
Interlocken Boulevard (NB)	899	21	21	40	1,171	27	27	40
Interlocken Boulevard (SB)	899	21	21	40	1,171	27	27	40

Notes: Loudest-hour volumes based on 10% of Average Daily Traffic (ADT).
Truck percentage of 4.4% assumed to be 2.2% MTs and 2.2% HTs.

Source: RS&H, 2011