APPENDIX G
NOISE

G.1 BACKGROUND AND CHARACTERISTICS OF NOISE

Sound is created by a vibrating source that induces vibrations in the air. The vibration produces alternating bands of relatively dense and sparse particles of air, spreading outward from the source like ripples on a pond. Sound waves dissipate with increasing distance from the source. Sound waves can also be reflected, diffracted, refracted, or scattered. When the source stops vibrating, the sound waves disappear almost instantly and the sound ceases.

Sound conveys information to listeners. It can be instructional, alarming, pleasant and relaxing, or annoying. Identical sounds can be characterized by different people, or even by the same person at different times, as desirable or unwanted. Unwanted sound is commonly referred to as "noise."

Sound can be defined in terms of three components:

1. Level (amplitude)
2. Pitch (frequency)
3. Duration (time pattern)

G.1.1 SOUND LEVEL

The level of sound is measured by the difference between atmospheric pressure (without the sound) and the total pressure (with the sound). Amplitude of sound is like the relative height of the ripples caused by the stone thrown into the water. Although physicists typically measure pressure using the linear Pascal scale, sound is measured using the logarithmic decibel (dB) scale. This is because the range of sound pressures detectable by the human ear can vary from *1 to 100 trillion units*. A logarithmic scale allows us to discuss and analyze noise using more manageable numbers. The range of audible sound ranges from approximately 1 to 140 dB, although everyday sounds rarely rise above about 120 dB. The human ear is extremely sensitive to sound pressure fluctuations. A sound of 140 dB, which is sharply painful to humans, contains *100 trillion (10^{14}) times more* sound pressure than the least audible sound.

By definition, a 10 dB increase in sound is equal to a tenfold (10^1) increase in the mean square sound pressure of the reference sound. A 20 dB increase is a 100-fold (10^2) increase in the mean square sound pressure of the reference sound. A 30 dB increase is a 1,000-fold (10^3) increase in mean square sound pressure.

A logarithmic scale requires different mathematics than used with linear scales. The sound pressures of two separate sounds, expressed in dB, are not arithmetically additive. For example, if a sound of 80 dB is added to another sound of 74 dB, the total is a 1 dB increase in the louder sound (81 dB), not the arithmetic sum of 154 dB

(See **Exhibit G-1, *Example of Addition of Two Decibel Levels***). If two equally loud noise events occur simultaneously, the sound pressure level from the combined events is 3 dB higher than the level produced by either event alone.

Logarithmic averaging also yields results that are quite different from simple arithmetic. Consider the example shown in **Exhibit G-2, *Example of Sound Level Averaging***. Two sound levels of equal duration are averaged. One has an Lmax of 100 dB, the other 50 dB. Using conventional arithmetic, the average would be 75 dB. The true result, using logarithmic math, is 97 dB. This is because 100 dB has far more energy than 50 dB (100,000 times as much!) and is overwhelmingly dominant in computing the average of the two sounds.

Human perceptions of changes in sound pressure are less sensitive than a sound level meter. People typically perceive a tenfold increase in sound pressure, a 10 dB increase, as a doubling of loudness. Conversely, a 10 dB decrease in sound pressure is normally perceived as half as loud. In community settings, most people perceive a 3 dB increase in sound pressure (a doubling of the sound pressure or energy) as just noticeable. (In laboratory settings, people with good hearing are able to detect changes in sounds of as little as 1 dB.)

G.1.2 SOUND FREQUENCY

The pitch (or frequency) of sound can vary greatly from a low-pitched rumble to a shrill whistle. If we consider the analogy of ripples in a pond, high frequency sounds are vibrations with tightly spaced ripples, while low rumbles are vibrations with widely spaced ripples. The rate at which a source vibrates determines the frequency. The rate of vibration is measured in units called "Hertz" -- the number of cycles, or waves, per second. One's ability to hear a sound depends greatly on the frequency composition. Humans hear sounds best at frequencies between 1,000 and 6,000 Hertz. Sound at frequencies above 10,000 Hertz (high-pitched hissing) and below 100 Hertz (low rumble) are much more difficult to hear.

If we are attempting to measure sound in a way that approximates what our ears hear, we must give more weight to sounds at the frequencies we hear well and less weight to sounds at frequencies we do not hear well. Acousticians have developed several weighting scales for measuring sound. The A-weighted scale was developed to correlate with the judgments people make about the loudness of sounds. The A-weighted decibel scale (dBA) is used in studies where audible sound is the focus of inquiry. The U.S. Environmental Protection Agency (USEPA) has recommended the use of the A-weighted decibel scale in studies of environmental noise.[1] Its use is required by the FAA in airport noise studies.[2] For the purposes of this analysis, dBA was used as the noise metric and dB and dBA are used interchangeably in this document.

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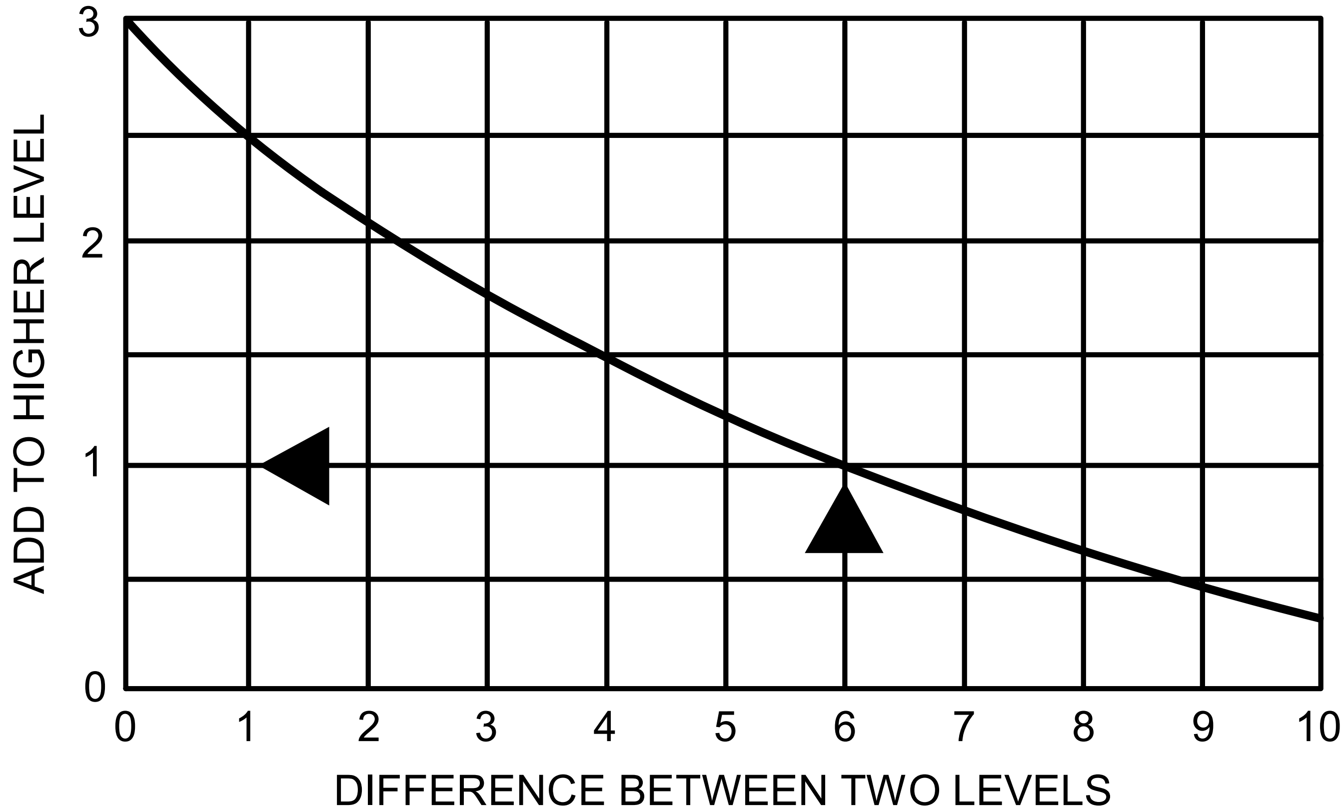
1 Information on Levels of Environmental Noise Requisite to Protect Health and Welfare with an Adequate Margin of Safety. U.S. Environmental Protection Agency, Office of Noise Abatement and Control. 1974, P. A-10.

2 "Airport Noise Compatibility Planning." 14 CFR Part 150, Sec. A150.3.

Decibel Addition



Example: 80 dB + 74 dB = 81 dB

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Example of Addition of Two Decibel Levels

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G-1

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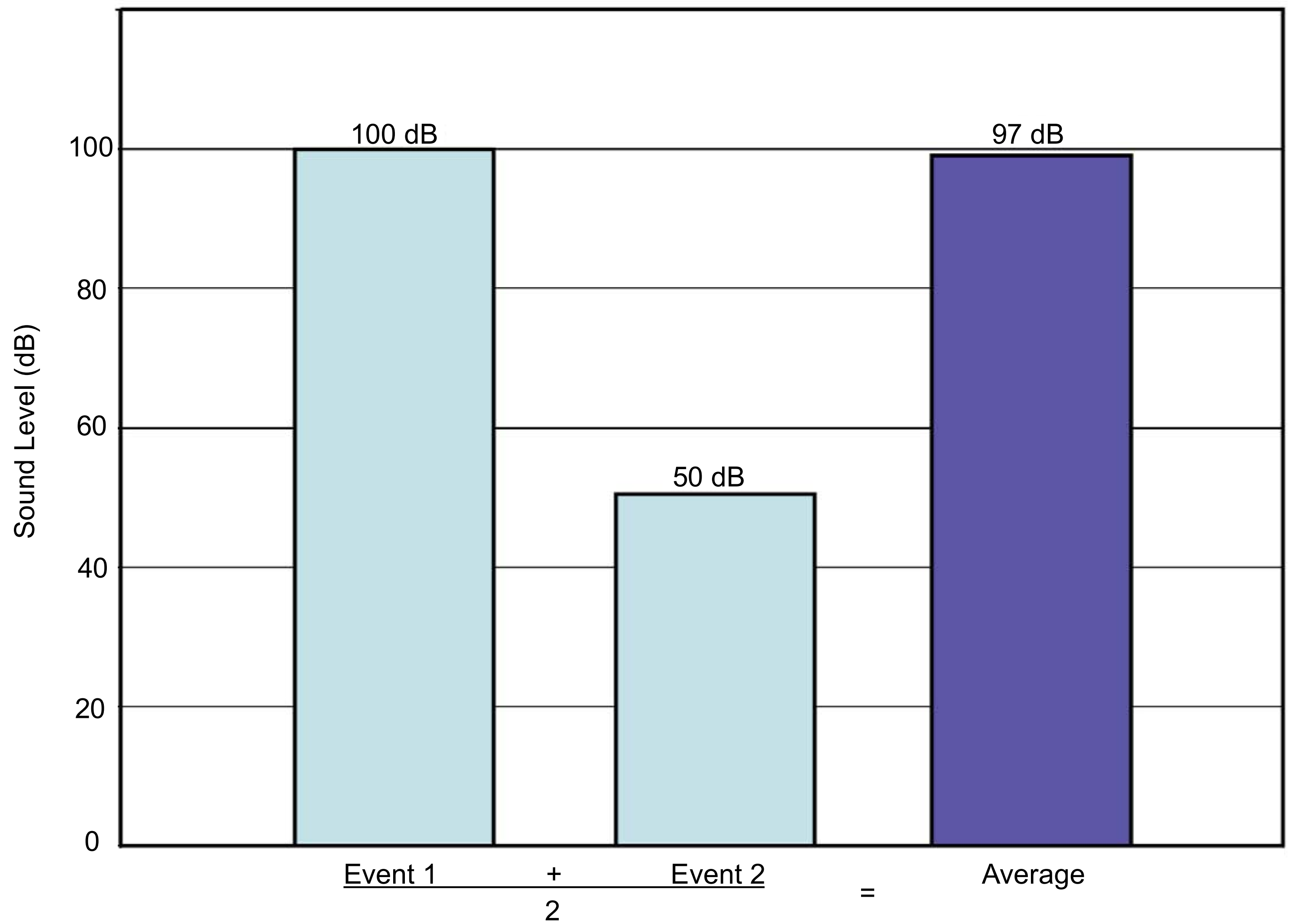
Assume two sound levels of equal duration...
What is the average level?



(100dB + 50dB) / 2 = 97dB

The decibel (dB) scale is logarithmic -
100 dB is 100,000 times more energy than 50 dB!

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G.1.3 DURATION OF SOUNDS

The duration of sounds – their patterns of loudness and pitch over time – can vary greatly. Sounds can be classified as *continuous* like a waterfall, *impulsive* like a firecracker, or *intermittent* like aircraft overflights. Intermittent sounds are produced for relatively short periods, with the instantaneous sound level during the event roughly appearing as a bell-shaped curve. An aircraft event is characterized by the period during which it rises above the background sound level, reaches its peak, and then recedes below the background level.

G.2 STANDARD NOISE DESCRIPTORS

Given the multiple dimensions of sound, a variety of descriptors, or metrics, have been developed for describing sound and noise. Some of the most commonly used metrics are discussed in this section. They include:

1. Maximum Level (**Lmax**)
2. Time Above Level (**TA**)
3. Sound Exposure Level (**SEL**)
4. Equivalent Sound Level (**Leq**)
5. Day/Night Average Sound Level (**DNL**)

G.2.1 MAXIMUM LEVEL (LMAX)

Lmax is simply the highest sound level recorded during an event or over a given period of time. It provides a simple and understandable way to describe a sound event and compare it with other events. In addition to describing the peak sound level, Lmax can be reported on an appropriate weighted decibel scale (A-weighted, for example) so that it can disclose information about the frequency range of the sound event in addition to the loudness.

Lmax, however, fails to provide any information about the duration of the sound event. This can be a critical shortcoming when comparing different sounds. Even if they have identical Lmax values, sounds of greater duration contain more sound energy than sounds of shorter duration. Research has demonstrated that for many kinds of sound effects, the total sound energy, not just the peak sound level, is a critical consideration.

G.2.2 TIME ABOVE LEVEL (TA)

The "time above," or TA, metric indicates the amount of time that sound at a particular location exceeds a given sound level threshold. TA is often expressed in terms of the total time per day that the threshold is exceeded. The TA metric explicitly provides information about the duration of sound events, although it conveys no information about the peak levels during the period of observation.

G.2.3 SOUND EXPOSURE LEVEL (SEL)

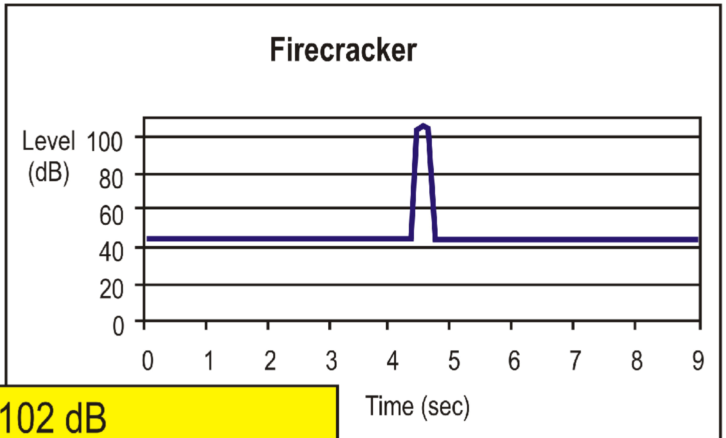
The sound exposure level, or SEL metric, provides a way of describing the total sound energy of a single event. In computing the SEL value, all sound energy occurring during the event, within 10 dB of the peak level (Lmax), is mathematically integrated over one second. (Very little information is lost by discarding the sound below the 10 dB cut-off, since the highest sound levels completely dominate the integration calculation.) Consequently, the SEL is always greater than the Lmax for events with a duration greater than one second. SELs for aircraft overflights typically range from five to 10 dB higher than the Lmax for the event.

Exhibit G-3, *Comparison of Different Types of Sounds* shows graphs of instantaneous sound levels for three different events: an aircraft flyover, roadway noise, and a firecracker. The Lmax and the duration of each event differ greatly. The pop of the firecracker is quite loud, 102 dB but lasts less than a second. The aircraft flyover has a considerably lower Lmax at 90 dB, but the event lasts for over a minute. The Lmax from the roadway noise is even quieter at only 72 dB, but it lasts for 15 minutes. By considering the loudness and the duration of these very different events simultaneously, the SEL metric reveals that the total sound energy of all three is identical. This can be a critical finding for studies where total noise dosage is the focus of study. As it happens, research has shown conclusively that noise dosage is crucial in understanding the effects of noise on animals and humans.

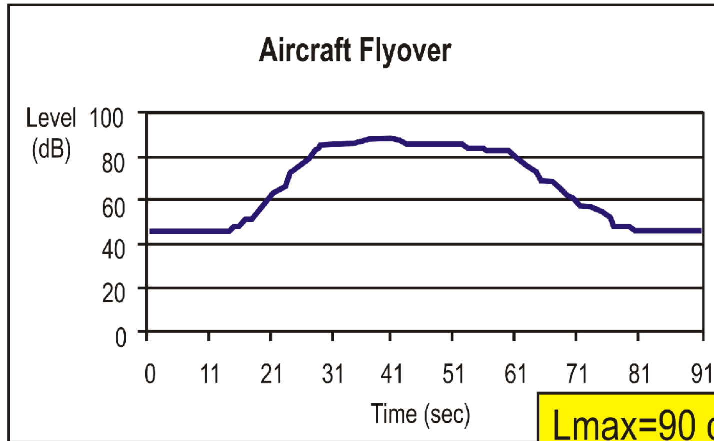
G.2.4 EQUIVALENT SOUND LEVEL (LEQ)

The equivalent sound level (Leq) metric may be used to define cumulative noise dosage, or noise exposure, over a period of time. In computing Leq, the total noise energy over a given period of time, during which numerous events may have occurred, is logarithmically averaged over the time period. The Leq represents the steady sound level that is equivalent to the varying sound levels actually occurring during the period of observation. For example, an 8-hour Leq of 67 dB indicates that the amount of sound energy in all the peaks and valleys that occurred in the 8-hour period is equivalent to the energy in a continuous sound level of 67 dB. Leq is typically computed for measurement periods of 1 hour, 8 hours, or 24 hours, although any time period can be specified.

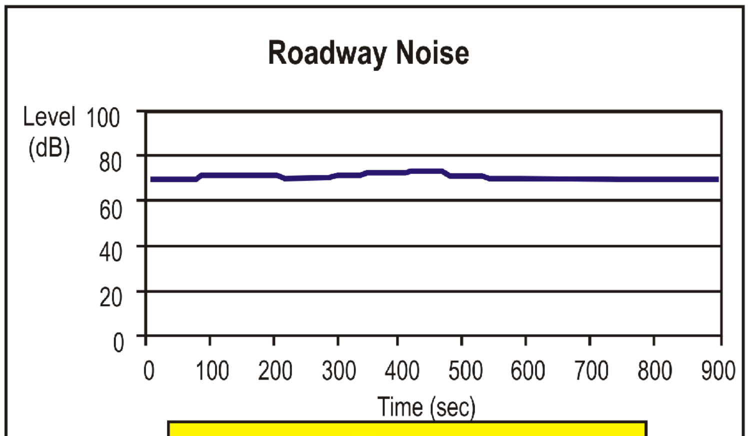
Exhibit G-4, *Relationship Among Noise Metrics* shows the relationship of Leq to Lmax and SEL. In this example, a single aircraft event lasting 18 seconds is represented. The instantaneous noise levels for the event range from 64 to an Lmax of 101 dBA. The area under the curve represents the sound energy accumulated during the entire event. The compression of this energy into a single second results in an SEL of 105 dBA. The Leq average of the sound energy for each second during the event would be 93 dB. If this event were the only event to occur during an hour, the aircraft sound energy for the other 3,582 seconds would be considered to be zero. When converted to an hourly LEQ, the level would be nearly 70 dB of Leq. This again indicates the dominance of loud events in noise summation and averaging computations.



Lmax=102 dB
SEL=100 dB
Leq=105
Event Duration=0.3 seconds



Lmax=90 dB
SEL=100 dB
Leq=82
Event Duration=70 seconds



Lmax=72 dB
SEL=100 dB
Leq=71
Event Duration=900 seconds

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Comparison of Different Types of Sound

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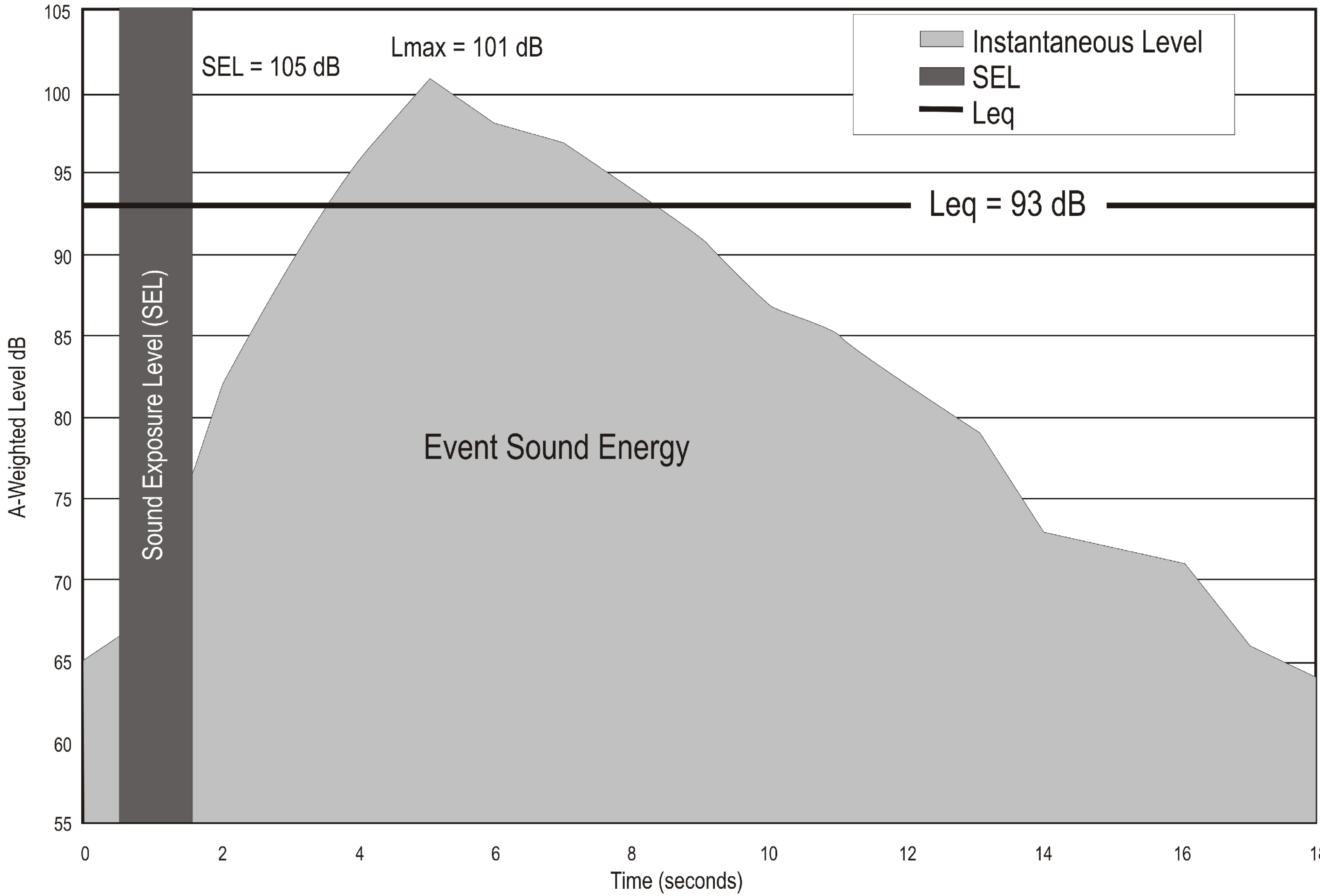

Environmental Impact Statement

Tucson International Airport

Relationship Among Noise Metrics

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Leq is a critical noise metric for many kinds of analysis where total noise dosage, or noise exposure, is under investigation. As already noted, noise dosage is important in understanding the effects of noise on both animals and people. Indeed, research has led to the formulation of the "equal energy rule." This rule states that it is the total acoustical energy to which people are exposed that explains the effects the noise will have on them. That is, a very loud noise with a short duration will have the same effect as a lesser noise with a longer duration if they have the same total sound energy.

G.2.5 DAY/NIGHT AVERAGE SOUND LEVEL (DNL)

The DNL metric is really a variation of the 24-hour Leq metric. Like Leq, the DNL metric describes the total noise exposure during a given period. Unlike Leq, however, DNL, by definition, can only be applied to a 24-hour period. In computing DNL, an extra weight of 10 dB is assigned to any sound levels occurring between the hours of 10:00 p.m. and 6:59 a.m. This is intended to account for the greater annoyance that nighttime noise is presumed to cause for most people. Recalling the logarithmic nature of the dB scale, this extra weight treats one nighttime noise event as equivalent to 10 daytime events of the same magnitude.

As with Leq, DNL values are strongly influenced by the loud events. For example, 30 seconds of sound of 100 dB, followed by 23 hours, 59 minutes, and 30 seconds of silence would compute to a DNL value of 65 dB. If the 30 seconds occurred at night, it would yield a DNL of 75 dB.

This example can be roughly equated to an airport noise environment. Recall that an SEL is the mathematical compression of a noise event into one second. Thus, 30 SELs of 100 dB during a 24-hour period would equal DNL 65 dB, or DNL 75 dB if they occurred at night. This situation could actually occur in places around a real airport. If the area experienced 30 overflights during the day, each of which produced an SEL of 100 dB, it would be exposed to DNL 65 dB. Recalling the relationship of SEL to the peak noise level (Lmax) of an aircraft overflight, the Lmax recorded for each of those overflights (the peak level a person would actually hear) would typically range from 90 to 95 dB.

G.3 FEDERAL LAWS AND POLICIES AND RESEARCH RELATED TO NOISE

This section presents information regarding noise and land use criteria that may be useful in the evaluation of noise impacts. The FAA has a long history of publishing noise and use assessment criteria. A summary of some of the more pertinent regulations and guidelines is presented in the following paragraphs.

G.3.1 NOISE CONTROL ACT

Congress passed the Noise Control Act (42 U.S.C. §4901 et seq.) in 1972, which established a national policy to promote an environment for all Americans free from noise that jeopardizes their health and welfare. The act set forth the foundation for conducting research and setting guidelines to restrict noise pollution.

G.3.2 FEDERAL AVIATION NOISE ABATEMENT POLICY

On November 18, 1976, the U.S. Department of Transportation and FAA jointly issued the Federal Aviation Noise Abatement Policy. This policy recognized aircraft noise as a major constraint on the further development of the commercial aviation established key responsibilities for addressing aircraft noise. The policy stated that the Federal Government has the authority and responsibility to regulate noise at the source by designing and managing flight procedures to limit the impact of aircraft noise on local communities; and by providing funding to airports for noise abatement planning.

G.3.3 AVIATION SAFETY AND NOISE ABATEMENT ACT OF 1979

The Aviation Safety and Noise Abatement Act of 1979 (ASNA), which is codified as 49 U.S.C. 47501-47510, set forth the foundation for the airport noise compatibility planning program outlined in 14 Code of Federal Regulations (CFR) Part 150. The act established the requirements for conducting noise compatibility planning and provided assistance to, and funding for which airport operators could apply to undertake such planning.

G.3.4 AIRPORT NOISE AND CAPACITY ACT OF 1990

The Airport Noise and Capacity Act (ANCA) of 1990 established two broad directives for the FAA: 1) to establish a method by which to review airport noise and access/use restrictions imposed by airport proprietors, and 2) to institute a program to phase out Stage 2 aircraft over 75,000 lbs. by December 31, 1999.[3] To implement ANCA, the FAA amended 14 CFR Part 91 and issued 14 CFR Part 161 which sets forth noise levels that are permitted for aircraft of various weights, engine number.

[3] Title 14, Part 36 of the CFR sets forth noise levels that are permitted for aircraft of various weights, engine number, and date of certification. Aircraft were divided into three classes according to noise level, Stage 1, Stage 2, and Stage 3, with Stage three being the quietest. Per 14 CFR Part 36, to be designated as Stage 3, aircraft must meet noise levels defined by the FAA at takeoff, sideline, and approach measurement locations.

G.3.5 FEDERAL REQUIREMENTS TO USE DNL IN ENVIRONMENTAL NOISE STUDIES

DNL is the standard metric used for environmental noise analysis in the U.S. This practice originated with the USEPA's effort to comply with the Noise Control Act of 1972. The USEPA designated a task group to "consider the characterization of the impact of airport community noise and develop a community noise exposure measure."[4] The task group recommended using the DNL metric. The USEPA accepted the recommendation in 1974, based on the following considerations:

- The measure is applicable to the evaluation of pervasive, long-term noise in various defined areas and under various conditions over long periods of time.
- The measure correlates well with known effects of the noise environment on individuals and the public.
- The measure is simple, practical, and accurate.
- Measurement equipment is commercially available.
- The metric at a given location is predictable, within an acceptable tolerance, from knowledge of the physical events producing the noise.[5]

Soon thereafter, the Department of Housing and Urban Development (HUD), Department of Defense, and the Veterans Administration adopted the use of DNL.

At about the same time, the Acoustical Society of America developed a standard (ANSI S3.23-1980) which established DNL as the preferred metric for outdoor environments. This standard was reevaluated in 1990 and they reached the same conclusions regarding the use of DNL (ANSI S12.40-1990).

In 1980, the Federal Interagency Committee on Urban Noise (FICUN) met to consolidate Federal guidance on incorporating noise considerations in local land use planning. The committee selected DNL as the best noise metric for the purpose, thus endorsing the USEPA's earlier work and making it applicable to all Federal agencies.[6]

In response to the requirements of the ASNA Act of 1979 and the recommendations of FICUN and USEPA, the FAA established DNL in 1981 as the single metric for use in airport noise and land use compatibility planning. This decision was incorporated into the final rule implementing ASNA, 14 CFR Part 150, in 1985. Part 150 established the DNL as the noise metric for determining the exposure of individuals to aircraft noise and identified residential land uses as being normally compatible with noise levels below DNL 65 dB.

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[4] Information on Levels of Environmental Noise Requisite to Protect Health and Welfare with an Adequate Margin of Safety. U.S. Environmental Protection Agency, Office of Noise Abatement and Control. 1974, P. A-10.

[5] Information on Levels of Environmental Noise Requisite to Protect Health and Welfare with an Adequate Margin of Safety. U.S. Environmental Protection Agency, Office of Noise Abatement and Control. 1974, Pp. A-1–A-23.

[6] *Guidelines for Considering Noise in Land Use Planning and Control*. Federal Interagency Committee on Urban Noise (FICUN). 1980.

As shown in **Table G-1**, all land uses within areas below DNL 65 dB are considered to be compatible with airport operations. Residential land uses are generally incompatible with noise levels above DNL 65 dB. In some areas, residential land use may be permitted in the DNL 65 dB to 70 dB range with appropriate sound insulation measures implemented. This is done at the discretion of local communities. Schools and other public use facilities located between DNL 65 dB to 70 dB are generally incompatible without sound insulation. Above DNL 75 dB, schools, hospitals, nursing homes, and churches are considered incompatible land uses. The information presented is meant to act as a guideline. According to 14 CFR Part 150, "Adjustments or modifications of the descriptions of the land-use categories may be desirable after consideration of specific local conditions."[7]

In the early 1990s, Congress authorized the creation of a new interagency committee to study airport noise issues. The FICON was formed with membership from the USEPA, the FAA, the U.S. Air Force, the U.S. Navy, HUD, the Department of Veterans Affairs, and others. FICON concluded in its 1992 report that Federal agencies should "continue the use of the DNL metric as the principal means for describing long term noise exposure of civil and military aircraft operations."[8] FICON further concluded that there were no new sound descriptors of sufficient scientific standing to substitute for the DNL cumulative noise exposure metric.[9]

In 1993, the FAA issued its *Report to Congress on Effects of Airport Noise*. Regarding DNL, the FAA stated, "Overall, the best measure of the social, economic, and health effects of airport noise on communities is the Day-Night Average Sound Level (DNL)."[10] According to this report, DNL 65 dB "…as a criterion of significance, and of the land use compatibility guidelines in Part 150 is reasonable."[11]

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7 *14 CFR Part 150, Part B Noise Exposure Map Development, Section A150.101 Noise contours and land usages, paragraph (c).*

8 *Federal Agency Review of Selected Airport Noise Analysis Issues*. Federal Interagency Committee on Noise (FICON). August 1992, Pp. 3-1.

9 *Federal Agency Review of Selected Airport Noise Analysis Issues, Technical Report, Volume 2. Federal Interagency Committee on Noise (Technical). August 1992, Pp. 2-3.*

10 *Report to Congress on Effects of Airport Noise. Federal Aviation Administration. 1993, P. 1.*

11 *Report to Congress on Effects of Airport Noise. Federal Aviation Administration. 1993, P. 13.*

Table G-1
LAND USE COMPATIBILITY GUIDELINES - 14 CFR PART 150
Tucson International Airport

LAND USE	YEARLY DAY-NIGHT AVERAGE SOUND LEVEL (DNL) IN DECIBELS					
	BELOW 65	65-70	70-75	75-80	80-85	OVER 85
RESIDENTIAL						
Residential, other than mobile homes and transient lodgings	Y	N(1)	N(1)	N	N	N
Mobile home parks	Y	N	N	N	N	N
Transient lodgings	Y	N(1)	N(1)	N(1)	N	N
PUBLIC USE						
Schools	Y	N(1)	N(1)	N	N	N
Hospitals and nursing homes	Y	25	30	N	N	N
Churches, auditoriums, and concert halls	Y	25	30	N	N	N
Governmental services	Y	Y	25	30	N	N
Transportation	Y	Y	Y(2)	Y(3)	Y(4)	Y(4)
Parking	Y	Y	Y(2)	Y(3)	Y(4)	N
COMMERCIAL USE						
Offices, business and professional	Y	Y	25	30	N	N
Wholesale and retail—building materials, hardware and farm equipment	Y	Y	Y(2)	Y(3)	Y(4)	N
Retail trade—general	Y	Y	25	30	N	N
Utilities	Y	Y	Y(2)	Y(3)	Y(4)	N
Communication	Y	Y	25	30	N	N
MANUFACTURING AND PRODUCTION						
Manufacturing, general	Y	Y	Y(2)	Y(3)	Y(4)	N
Photographic and optical	Y	Y	25	30	N	N
Agriculture (except livestock) and forestry	Y	Y(6)	Y(7)	Y(8)	Y(8)	Y(8)
Livestock farming and breeding	Y	Y(6)	Y(7)	N	N	N
Mining and fishing, resource production and extraction	Y	Y	Y	Y	Y	Y
RECREATIONAL						
Outdoor sports arenas and spectator sports	Y	Y(5)	Y(5)	N	N	N
Outdoor music shells, amphitheaters	Y	N	N	N	N	N
Nature exhibits and zoos	Y	Y	N	N	N	N
Amusements, parks, resorts and camps	Y	Y	Y	N	N	N
Golf courses, riding stables and water recreation	Y	Y	25	30	N	N

Note: The designations contained in this table do not constitute a Federal determination that any use of land covered by the program is acceptable under Federal, State, or local law. The responsibility for determining the acceptable and permissible land uses and the relationship between specific properties and specific noise contours rests with the local authorities. FAA determinations under Part 150 are not intended to substitute federally determined land uses for those determined to be appropriate by local authorities in response to locally determined needs and values in achieving noise compatible land uses.

Table G-1, *Continued*
LAND USE COMPATIBILITY GUIDELINES - 14 CFR PART 150
Tucson International Airport

Key to Table G-1

SLUCM=Standard Land Use Coding Manual.
Y (Yes)=Land Use and related structures compatible without restrictions.
N (No)=Land Use and related structures are not compatible and should be prohibited.
NLR=Noise Level Reduction (outdoor to indoor) to be achieved through incorporation of noise attenuation into the design and construction of the structure.
25, 30, or 35=Land use and related structures generally compatible; measures to achieve NLR of 25, 0, or 35 dB must be incorporated into design and construction of structure.

Notes for Table G-1

(1) Where the community determines that residential or school uses must be allowed, measures to achieve outdoor to indoor Noise Level Reduction (NLR) of at least 25 dB and 30 dB should be incorporated into building codes and be considered in individual approvals. Normal residential construction can be expected to provide a NLR of 20 dB, thus, the reduction requirements are often stated as 5, 10 or 15 dB over standard construction and normally assume mechanical ventilation and closed windows year round. However, the use of NLR criteria will not eliminate outdoor noise problems.
(2) Measures to achieve NLR 25 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.
(3) Measures to achieve NLR of 30 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.
(4) Measures to achieve NLR 35 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal level is low.
(5) Land use compatible provided special sound reinforcement systems are installed.
(6) Residential buildings require an NLR of 25 dB.
(7) Residential buildings require an NLR of 30 dB.
(8) Residential buildings not permitted.

Source: 14 CFR Part 150 *Airport Noise Compatibility Planning*, Appendix A, Table 1.

G.4 NOISE MONITORING

A noise monitoring program was conducted from July 18 through July 20, 2017 in which noise measurements were collected from various locations around the Airport. Short-term field measurements of approximately an hour were collected at 24 sites around the Airport to provide measurements of individual aircraft overflight events and obtain typical background noise levels. The information collected during the noise monitoring program included continuous noise exposure data, statistical analysis, and individual exceedances, as measured at the noise monitoring sites, as well as aircraft operation information and aircraft types.

Aircraft noise monitoring was conducted for daytime and evening periods. The noise monitoring program concentrated on the collection of a variety of single overflight noise information, and included commercial passenger, cargo, general aviation, and military operations.

Noise monitoring conducted for short periods of time are unique to that one period, and do not represent the average of the events that would occur at that location over a longer period of time. The data from short-term measurements may be used for verifying modeling accuracy using single events. These measurements may also provide insight to the local ambient levels.

G.4.1 NOISE MONITORING LOCATIONS

Short-term noise monitoring was conducted for approximately one-hour periods at 24 different sites. The sites were chosen based on their proximity to the Airport, the flow of aircraft operations during the monitoring program, and areas of past noise concerns. General sites were selected on the basis of ambient noise level (or more specifically, the absence of loud ambient noise such as vehicular traffic), locations of flight tracks derived from previous studies, locations of noise complaints received by the TAA, and the locations of concentrations of residential land uses that experience significant numbers of aircraft overflights. Specific selection criteria included the following:

- Emphasis on areas of numerous aircraft noise events according to earlier evaluations;
- Representative sampling of all major types of operations and aircraft operating at TUS;
- Screening of each site for local noise sources or unusual terrain characteristics, which could affect measurements; and
- Location in or near areas from which complaints about aircraft noise were received, or where there are concentrations of people exposed to numerous aircraft overflights.

Information collected during the noise monitoring program included single-event maximum noise levels during noise events (L_{max}), event duration, time of occurrence and aircraft type. **Exhibit G-5, *Noise Monitoring Sites*,** presents the locations of the short-term noise monitoring sites.

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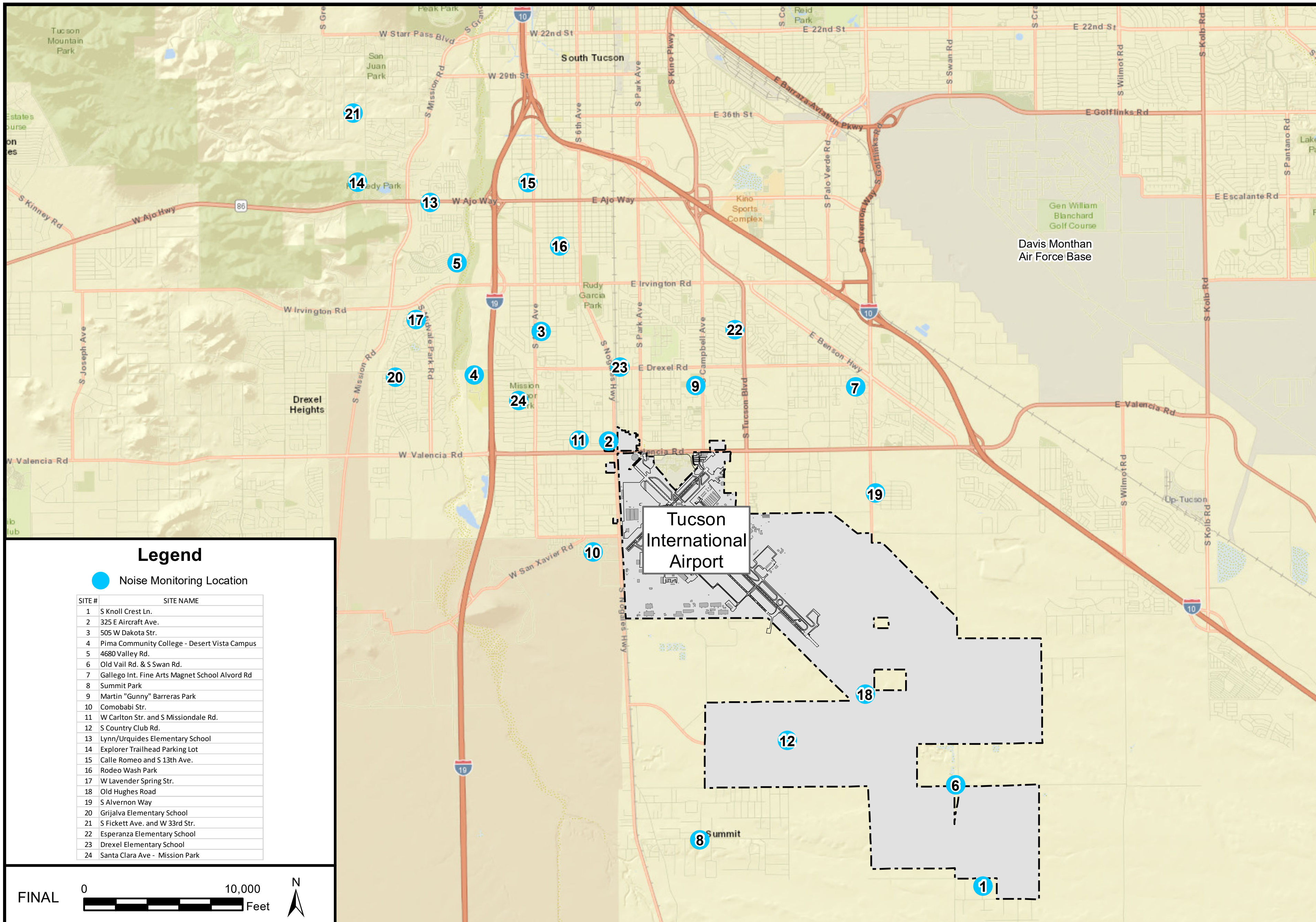

Legend

Noise Monitoring Location

SITE #	SITE NAME
1	S Knoll Crest Ln.
2	325 E Aircraft Ave.
3	505 W Dakota Str.
4	Pima Community College - Desert Vista Campus
5	4680 Valley Rd.
6	Old Vail Rd. & S Swan Rd.
7	Gallego Int. Fine Arts Magnet School Alvord Rd
8	Summit Park
9	Martin "Gunny" Barreras Park
10	Comobabi Str.
11	W Carlton Str. and S Missiondale Rd.
12	S Country Club Rd.
13	Lynn/Urquides Elementary School
14	Explorer Trailhead Parking Lot
15	Calle Romeo and S 13th Ave.
16	Rodeo Wash Park
17	W Lavender Spring Str.
18	Old Hughes Road
19	S Alvernon Way
20	Grijalva Elementary School
21	S Fickett Ave. and W 33rd Str.
22	Esperanza Elementary School
23	Drexel Elementary School
24	Santa Clara Ave - Mission Park

FINAL

0 10,000 Feet

N

Environmental Impact Statement

Tucson International Airport

Noise Monitoring Sites

EXHIBIT: **G-5**

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G.4.2 NOISE MONITORING METHODOLOGY

The field noise measurement program was conducted in accordance with 14 CFR Part 150 guidelines as provided in Section A150.5.

Acoustical instrumentation and analysis equipment was used in order to obtain acoustical data to compare with standard data associated with aircraft noise. The major instrumentation that was used for collecting short-term and long-term measurements is listed in **Table G-2**.

Table G-2
ACOUSTICAL MEASUREMENT INSTRUMENTATION –
NOISE MONITORING PROGRAM
Tucson International Airport

SOUND LEVEL METER	MICROPHONE	PRE-AMP
Larson Davis 824 SN2846 Larson Davis 824 SN2677	GRAS 40AQ SN13796 PCB 377B02 SN163697	PRM902 SN3433 PRM902 SN1328

Aircraft noise levels were recorded for the short-term monitoring program using the equipment indicated in the above table for each of the short-term noise monitoring sites. The short-term noise monitoring program was designed to provide a sampling of single events throughout the study area. It was not designed to record cumulative noise levels. Every day, the equipment was calibrated in the morning and a calibration check was performed at the end of the day. The noise monitors were attended while all significant noise events were documented to separate aircraft noise events from other noise sources. The noise monitor was set to trigger noise level exceedances that were five to ten dBA above the ambient levels. For each exceedance, the monitor recorded the date, time, duration, SEL and L_{max} of the noise event. Noise events typically had a duration of 30-60 seconds for commercial passenger operations, and one to four minutes for military activity. Due to the nature of the military procedures conducted at TUS, some events included multiple aircraft being recorded simultaneously. After the event, the consultant documented the exact time of the event and a description that included aircraft type and operational characteristics. During the one-hour noise monitoring period, the noise monitor was set to determine the ambient noise characteristics and statistical analysis. The short-term noise monitoring program provided for the collection of a number of single-event measurements at a variety of locations throughout the community at distances ranging from several hundred feet to several miles between the aircraft and the monitoring site.

G.4.3 WEATHER INFORMATION

The noise measurements taken during this study were obtained during a period of the year that has historically represented an average of the annual weather conditions. The measurements were recorded during both clear and overcast conditions. During a majority of the noise monitoring period, conditions favored southeast flow (arrivals to and departures from Runways 11L and 11R), which is consistent with the annual wind patterns. However, wind patterns shifted for a portion of the monitoring period, requiring the use of northwest flow (arrivals to and departures from Runways 29L and 29R). Weather conditions did not dictate the consistent use of the crosswind runway by all aircraft during the noise monitoring period; however, use of this runway by general aviation/commuter aircraft was observed during the noise monitoring period.

G.4.4 NOISE MONITORING RESULTS

The noise monitoring program provided insight into the noise exposure from aircraft activity in the areas surrounding the airport. **Table G-3** provides a summary of the noise modeling results.

The measured noise levels from departing aircraft tended to produce peak decibel levels several decibels higher than those of arriving aircraft. This difference is caused by two characteristics of the separate operations. First, exposure to noise above the background levels from arriving aircraft is typically shorter than from departing aircraft. Second, the power settings used during approach are lower than those necessary to climb during the takeoff, resulting in measured noise levels of arrivals at several decibels less than measured at similar locations during departure. It should be noted that the L_{max} noise levels represent the maximum noise level for each individual aircraft event and should not be confused with the average Day-Night Level (DNL) contours.

Table G-3
NOISE MONITORING RESULTS
Tucson International Airport

Site Number	Location	Date Monitored	Time Monitored	Ambient Noise L90 / L50 (dBA)	Operation	Number Aircraft Events	L_{max} (dBA) (Loudest Aircraft Event)	Loudest Aircraft	SEL Range (dBA)
1	S Knoll Crest Ln.	7/18/2017	7:58am - 8:58am	30.2 / 33.7	DEP	3	58.5	Regional Jet	66.9 - 75.3
2	325 E Aircraft Ave.	7/18/2017	9:27am - 10:27am	46.3 / 48.1	ARR	8	86.5	Jet	75.5 - 93.7
3	505 W Dakota Str.	7/18/2017	10:44am - 11:44am	49.5 / 53.5	ARR	13	68.2	Jet	67.0 - 78.4
4	Pima Community College - Desert Vista Campus	7/18/2017	12:09pm - 11:11pm	49.3 / 52.2	ARR	4	74.2	F16	78.2 - 80.5
5	4680 Valley Rd.	7/18/2017	4:53pm - 5:53pm	42.5 / 46.4	ARR+OVER	8	83.5	F16	74.2 - 90.1
6	Old Vail Rd. & S Swan Rd.	7/18/2017	7:38am - 8:45am	31.7 / 36.8	DEP	3	70.2	Jet	74.6 - 79.7
7	Gallego Int. Fine Arts Magnet School	7/18/2017	9:37am - 10:37am	39.7 / 43.6	OVER	1	59.0	Helicopter	67.1
8	Summit Park	7/18/2017	11:27am - 12:27pm	42.3 / 50.0	-	0	-	-	-
9	Martin "Gunny" Barreras Park	7/18/2017	1:27pm - 2:27pm	46.1 / 48.1	-	0	-	-	-
10	Comobabi Str.	7/18/2017	2:43pm - 3:43pm	48.4 / 50.0	DEP	8	79.3	F16	69.5 - 89.6
11	W Carlton Str. and S Missiondale Rd.	7/18/2017	4:47pm - 5:47pm	51.8 / 56.7	ARR+OVER	6	72.6	Jet	76.5 - 80.9
12	S Country Club Rd.	7/19/2017	6:44am - 7:45am	43.3 / 47.8	DEP	5	64.9	Regional Jet	63.5 - 74.7
13	Lynn/Urquides Elementary School	7/19/2017	8:25am - 9:28am	46.0 / 49.7	ARR	15	70.2	Helicopter	64.0 - 83.1

Table G-3, *Continued*
NOISE MONITORING RESULTS
Tucson International Airport

Site Number	Location	Date Monitored	Time Monitored	Ambient Noise L90 / L50 (dBA)	Operation	Number Aircraft Events	L_{max} (dBA) (Loudest Aircraft Event)	Loudest Aircraft	SEL Range (dBA)
14	John F. Kennedy Park	7/19/2017	9:40am - 11:05am	38.0 / 41.8	ARR	11	77.5	Jet Arr + 2 F16 Over	66.0 - 83.8
15	Calle Romero and S 13th Ave.	7/19/2017	12:14am - 1:20pm	52.1 / 53.8	Audible	2	-	Jets	-
16	Rodeo Wash Park	7/19/2017	1:35pm - 2:30pm	50.3 / 52.1	DEP	1	58.5	Jet	70.1
17	W Lavender Spring Str.	7/19/2017	3:00pm - 3:42pm	41.4 / 47.7	Dep+OVER	8	89.0	2 F16s	65.1 - 97.6
18	Old Hughes Road	7/19/2017	6:45am - 7:45am	48.7 / 52.6	DEP	6	84.4	Jet	85.2 - 93.1
19	S Alvernon Way	7/19/2017	8:10am - 9:10am	52.8 / 56.7	-	0	-	-	-
20	Grijalva Elementary School	7/20/2017	8:29am - 9:30am	44.7 / 49.5	ARR+OVER	4	64.9	2 F16s Over	62.7 - 73.7
21	S Ficket Ave. and W 33rd Str.	7/20/2017	9:54am - 11:04am	39.0 / 43.2	ARR+OVER	6	67.2	2 Helicopters	66.6 - 79.2
22	Esperanza Elementary School	7/20/2017	12:48pm - 1:48pm	48.1 / 50.9	DEP	2	62.9	Twin Turbo Prop	67.8 - 68.4
23	Drexel Elementary School	7/20/2017	2:09pm - 3:55pm	48.7 / 55.7	DEP	12	81.6	2 F16s	71.4 - 94.4
24	Mission Manor Park	7/20/2017	2:30pm - 3:41pm	46.7 / 49.4	DEP	10	91.4	F16	68.7 - 101.7