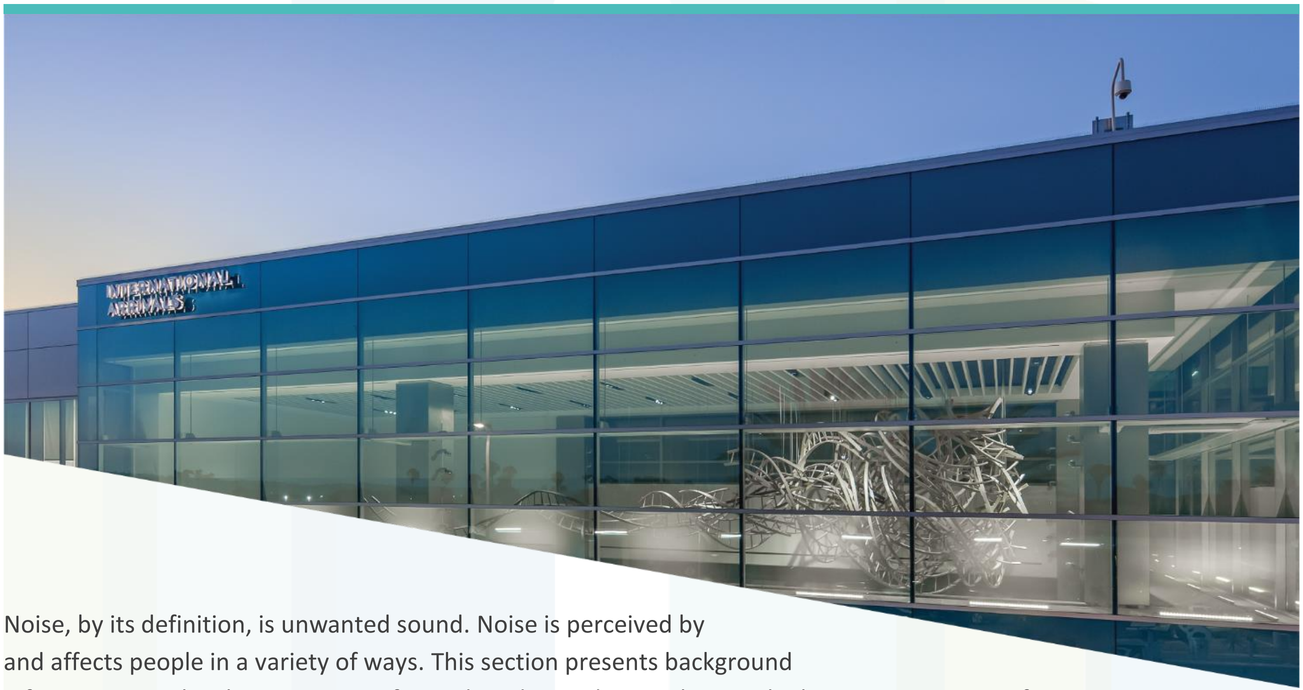
3 BACKGROUND INFORMATION ON NOISE AND ITS MEASUREMENTS

14 CFR PART 150 UPDATE

CHAPTER 3. BACKGROUND INFORMATION ON NOISE AND ITS MEASUREMENTS



Noise, by its definition, is unwanted sound. Noise is perceived by and affects people in a variety of ways. This section presents background information on the characteristics of sound, and provides insight into the human perception of noise and a means to relate the sound made by aircraft operating to and from San Diego International Airport (SDIA) to the noise in the surrounding communities. The metrics (how noise is measured or described) and methodologies used in this Title 14, Code of Federal Regulations (CFR) Part 150 Study Update (14 CFR Part 150 Study) to describe noise from aircraft operating at SDIA are also presented in this chapter. These metrics enable the characterization of existing and future noise. This section is divided into the following sub-sections shown in **Table 3.1**.

TABLE 3.1 **NOISE ANALYSIS SECTIONS**

Sub-section	Content
Characteristics of Sound	Presents properties of sound that are important for describing noise in an airport setting.
Factors Influencing Human Response to Sound	Discusses sound level conditions that produce subjective perceptions and elicit a response in humans.
Health Effects of Noise	Summarizes the potential disturbances and health effects of noise to humans.
Sound Rating Scales	Presents various sound rating scales and how these scales are applied to assessing noise from aircraft operations.
Noise/Land Use Compatibility Guidelines	Summarizes the current guidelines and regulations used to control the use of land in areas affected by aircraft noise.
Airport Noise Assessment Methodology	Describes computer modeling and on-site sound level measurements used to measure aircraft and other noise in the vicinity of airports.

3.1 CHARACTERISTICS OF SOUND

3.1.1 Sound Level and Frequency

Sound is described in terms of sound pressure (amplitude) and frequency (similar to pitch).

Sound pressure is a direct measure of the magnitude of a sound without consideration for other factors that may influence its perception. The range of sound pressures that occur in the environment is so large that it is convenient to express them on a logarithmic scale. The standard unit of measurement for sound pressure is the Decibel (dB). Zero decibels is used to describe the reference point of 20 micro Pascals or about 0.000000003 pounds per square inch of energy. Thus, 65 decibels is that amount to the 65th power. A logarithmic scale is used because of the difficulty in expressing such large numbers.

On the logarithmic scale, a sound level of 70 dB has 10 times the energy as a level of 60 dB, while a sound level of 80 dB has 100 times as much acoustic energy as 60 dB. This differs from the human perception to noise, which typically judges a sound 10 dB higher than another to be twice as loud, 20 dB higher to be four times as loud, and so forth.

The frequency of a sound is expressed as Hertz (Hz) or cycles per second. The normal audible frequency range for young adults is 20 Hz to 20,000 Hz. The prominent frequency range for community noise, including aircraft and motor vehicles, is between 50 Hz and 5,000 Hz. The human ear is not equally sensitive to all frequencies, with some frequencies judged to be louder for a given signal than others. As a result, research studies have analyzed how individuals make relative judgments as to the "loudness" or "annoyance" of a sound. The most prominent of these scales includes Loudness Level, Frequency-Weighted Contours (such as the A-weighted scale), and Perceived Noise Level. Noise metrics used in aircraft noise assessments are based upon these frequency weighting scales that most closely reflect that experienced by a human (A-weighted scale).

Highlights of Sound

Noise by definition is unwanted sound. There are many ways to describe noise (metrics), however, the most commonly relied on metric is the decibel (dB), which uses a weighting system (the A-weighted decibel – dBA – most closely reflects the human ear).

A number of factors affect sound, including weather, ground effects, as well as human reaction to the noise source. Health effects associated with aircraft noise are typically impacts to sleep and communication that cause stress.

Aircraft noise within the state of California is measured using the Community Noise Equivalent Level (CNEL), which is based on averaging dBA.

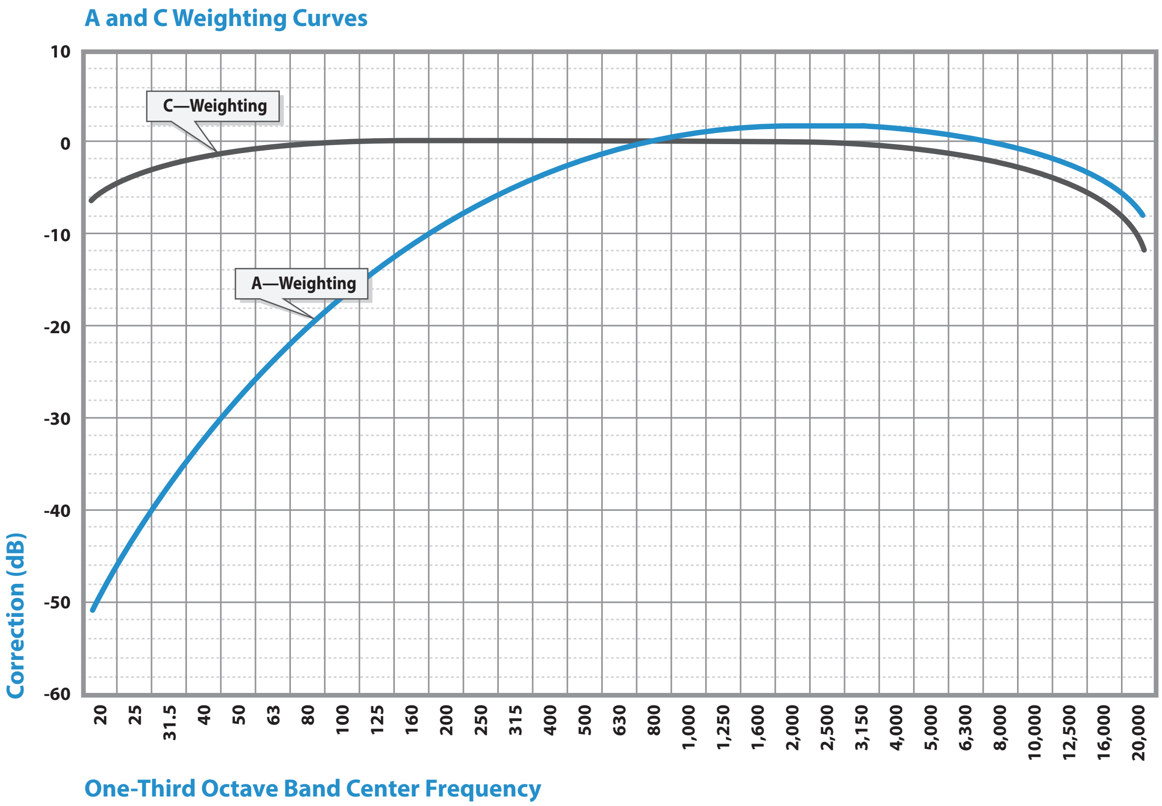
FAA and other federal agencies have established land use compatibility guidelines based on the CNEL (or the similar DNL), that identify the acceptability of various types of land use with aircraft noise exposure.

LOUDNESS LEVEL. This scale has been devised to approximate the human subjective assessment of the "loudness" of a sound. Loudness is the subjective judgment of an individual as to how loud or quiet a particular sound is perceived.

FREQUENCY-WEIGHTED CONTOURS (dBA, and dBC). To simplify the measurement and computation of sound loudness levels, frequency-weighted metrics are used. These frequency-weighted contours demonstrate different aspects of noise and are presented in **Figure 3.1.** The figure shows how the A and C-weighting in a sound meter are applied to sounds of various frequencies. The most common frequency weighting is the A-weighted noise curve. The A-weighted decibel scale (dBA) focuses on frequencies approximating the sensitivity of the human ear. In the dBA, everyday sounds normally range from 30 dBA (very quiet) to 100 dBA (very loud). C-weighted noise focuses on peak measurements and accounts for ground-based noise (usually associated with maintenance run-ups at airports). Most community noise analyses are based upon the dBA scale. Examples of various sound environments, expressed in dBA, are presented in **Figure 3.2**. **Figure 3.2** shows a table that identifies different A-weighted decibel sounds that can be heard in different environments. While it shows a threshold of 40 dBA for noise events, in a quiet park-like setting quieter noise events have been recorded below 40 dBA. Noise measured in park-like settings can show events measured below 10 dBA.

PERCEIVED NOISE LEVEL. Perceived noisiness was originally developed for the assessment of aircraft noise. Perceived noisiness is defined as "the subjective impression of the unwantedness of a not unexpected, non-pain or fear-provoking sound as part of one's environment." (Kryter, 1970) "Noisiness" curves differ from "loudness curves" in that they have been developed to rate the noisiness or annoyance of a sound as opposed to the loudness of a sound (i.e., perception of the noise).

Both loudness curves and noisiness curves have been developed from laboratory surveys of individuals. However, in noisiness surveys, individuals are asked to judge in a laboratory setting when two sounds are equally noisy or disturbing if heard regularly in their own environment. These surveys are more complex and are therefore subject to greater variability. Aircraft certification data are based upon these types of noisiness curves (see CFR Part 36 Regulations presented in the Noise and Land Use section of this chapter).



SOURCE: BridgeNet International, 2019.

FIGURE 3.1 **FREQUENCY WEIGHTED CONTOURS** (dBA, dBC)

EXAMPLES OF VARIOUS A-WEIGHTED DECIBEL SOUND ENVIRONMENTS

dB(A)	OVER-ALL LEVEL Sound Pressure Level Approx. 0.0002 Microbar	COMMUNITY (Outdoor)	HOME or INDUSTRY	LOUDNESS Human Judgement of Different Sound Levels
130		Military Jet Aircraft Takeoff with Afterburner from Aircraft Carrier @ 50 ft. (130)	Oxygen Torch (121)	120 dB(A) 32 Times as Loud
120 110	UNCOMFORTABLY LOUD	Concorde Takeoff (113)	Riveting Machine (110) Rock and Roll Band (108-114)	110 dB(A) 16 Times as Loud
100		Boeing 747-200 Takeoff (101)		100 dB(A) 8 Times as Loud
90	VERY LOUD	Power Mower (96) DC-10-30 Takeoff (96)	Newspaper Press (97)	90 dB(A) 4 Times as Loud
80		Car Wash @ 20 ft. (89) Boeing 727 Hushkit Takeoff (89)	Food Blender (88) Milling Machine (85) Garbage Disposal (80)	80 dB(A) 2 Times as Loud
70	MODERATELY LOUD	High Urban Ambient Sound (80) Passenger Car, 65 mph @ 25 ft. (77) Boeing 757 Takeoff (76)	Living Room Music (76) TV-Audio, Vacumn Cleaner	70 dB(A)
60		Propeller Airplane Takeoff (67) Air Conditioning Unit @ 100 ft. (60)	Cash Register @ 10 ft. (65-70) Electric Typewriter @ 10 ft. (64) Conversation (60)	60 dB(A) 1/2 Times as Loud
50	QUIET	Large Transformers @ 100 ft. (50)		50 dB(A) 1/4 Times as Loud
40		Bird Calls (44) Low Urban Ambient Sound (40)		40 dB(A) 1/8 Times as Loud

“Aircraft takeoı noise measured 6,500 meters from beginning of takeoı roll (Source: Advisory Circular AC-36-3G)”

SOURCE: Reproduced From Melville C. Branch And R. Dale Beland, "Outdoor Noise In The Metropolitan Environment". Published By The City Of Los Angeles, 1970.

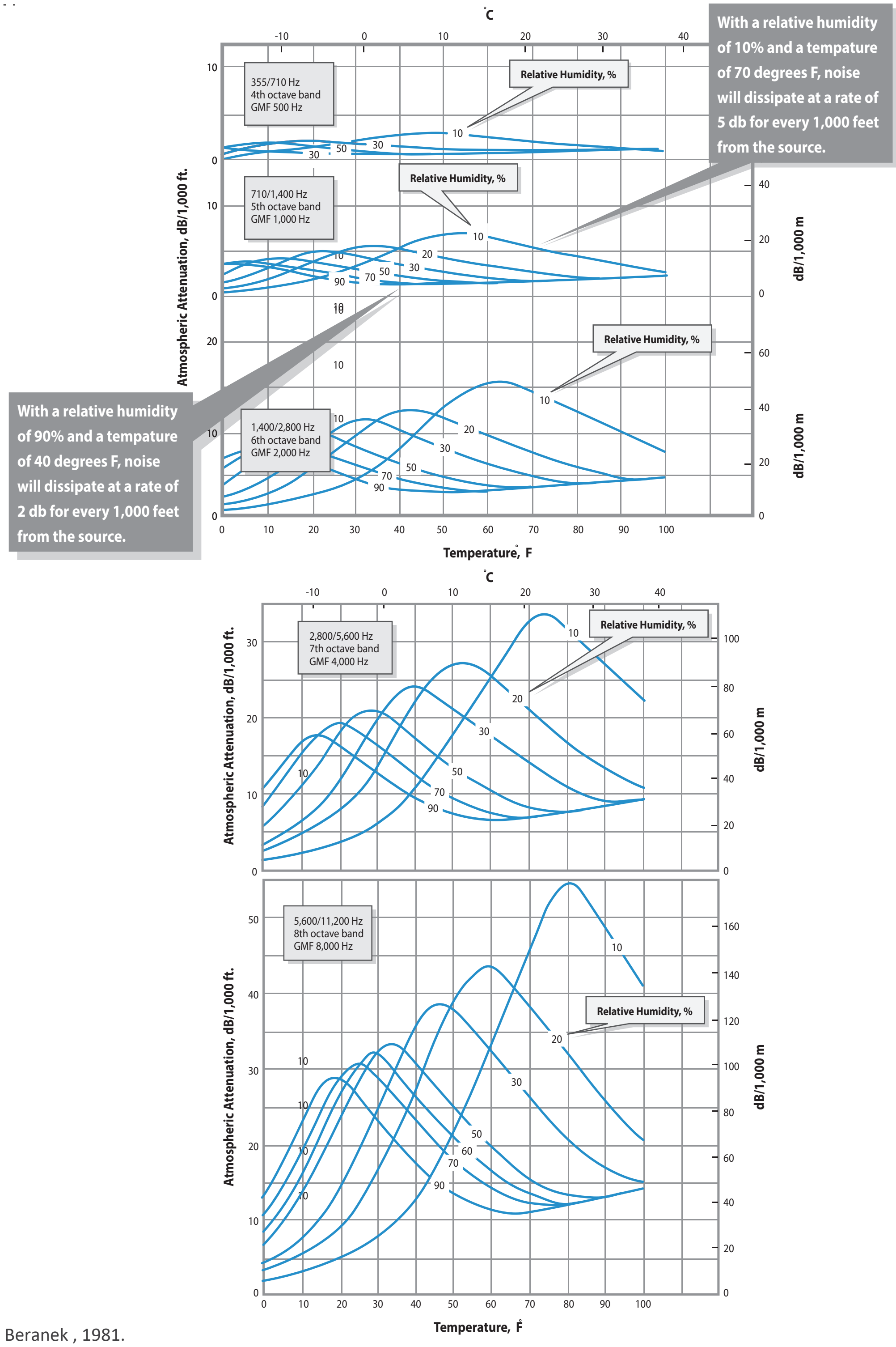
FIGURE 3.2 **EXAMPLE OF VARIOUS SOUND ENVIRONMENTS**

PROPAGATION OF NOISE. Outdoor sound levels decrease as a result of several factors, including increasing the distance from the sound source, atmospheric absorption (characteristics in the atmosphere that actually absorb sound), and ground attenuation (characteristics on the ground that absorb sound). Sound typically travels in spherical waves, similar to waves created from dropping a stone into water. As the sound wave travels away from the source, the sound energy is spread over a greater area, dispersing the sound power of the wave.

Temperature and humidity of the atmosphere also influence the sound levels at a particular location. These influences increase with distance and become particularly important at distances greater than 1,000 feet. The degree of absorption depends on the frequency of the sound, as well as humidity and air temperature. For example, when the air is cold and humid, and therefore denser, atmospheric absorption is lowest. Higher frequencies are more readily absorbed than the lower frequencies. Over large distances, lower frequency sounds become dominant as the higher frequencies are attenuated. Examples of the effects of temperature and humidity on sound absorption are presented in **Figure 3.3**.

DURATION OF SOUND. Duration of a noise event is important in a community setting. The longer the noise event, the more likely that the sound will be perceived as annoying. The "effective duration" of a sound starts when a sound rises above the background sound level and ends when it drops back below the background level. Studies have confirmed a relationship between duration and annoyance and established the amount a sound must be reduced to be judged equally annoying over an increased duration time.

This relationship between duration and noise level forms the basis of how the equivalent energy principal of sound exposure is measured. Reducing the acoustic energy of a sound by one-half results in a 3-dB reduction. Conversely, doubling the duration of the sound event increases the total energy of the event by 3 dB. This equivalent energy principle is based upon the premise that the potential for a noise to impact a person is dependent on the total acoustical energy content of the noise. Noise descriptors are all based upon this equivalent energy principle.



SOURCE: Beranek , 1981.

FIGURE 3.3 **ATMOSPHERIC ATTENUATION – HOW NOISE CHANGES OVER DISTANCE BASED ON HUMIDITY AND TEMPERATURE**

CHANGE IN NOISE LEVELS. The concept of change in sound levels is related to the reaction of the human ear to sound. The human ear detects relative differences between sound levels better than absolute values of levels. Under controlled laboratory conditions, a human listening to a steady unwavering pure tone sound can barely detect a change of approximately one decibel for sound levels in the mid-frequency region. However, when ordinary noises are heard, a young healthy ear can only detect changes of two to three decibels. A five-decibel change is noticeable while a 10-decibel change is judged by the majority of people as a doubling effect of the sound.

MASKING EFFECT. One characteristic of sound is its ability to interfere with the listener's ability to hear another sound, defined as the masking effect. The presence of one sound effectively raises the threshold of audibility for the hearing of a second sound, meaning the second sound must exceed the individual's threshold of hearing and the masking threshold for the background noise.

The masking characteristic is dependent upon many factors, including the spectral (frequency) characteristics of the two sounds, the sound pressure levels, and the relative start time of sound events. The masking effect is greatest when it is closest to the frequency of the signal. Low frequency sounds can mask higher frequency sounds; however, high frequency sounds do not easily mask low frequency sounds.

OVER WATER SOUND PROPAGATION. Aircraft noise travels through the air like a wave in still water caused by throwing a rock into the water. As the noise gets to the ground, the energy wave is either absorbed and/or reflected off into another direction. Soft ground surfaces such as a lawn or anything with soil and vegetation will absorb some of the noise energy wave while also reflecting some energy into another direction. In the case of water, the surface is hard and acts like a mirror that reflects an image. The noise energy wave will bounce off hard surface and adds more energy making the sound level higher.

HILL EFFECT. Terrain or hills can have multiple effects on noise levels depending on where a person is located related to the hill. If a hill is between an aircraft and a person on the ground, the hill will act like a barrier and reduce or block the noise energy from getting to the person. This has the same effects as putting a wall between a resident and a freeway. The wall blocks and absorbs most of the noise energy. If a person is between an aircraft and a hill, it is possible the noise energy from the aircraft could reflect off the hill and increase the level of noise heard by the person. This would depend on the angle of the noise energy wave to the hill and type of surface on the hill. If the hill is comprised of vegetation, the aircraft noise energy may get absorbed and would not increase the noise level. If the hill is mixed with soft and hard surfaces (e.g., vegetation and rock), some of the noise energy can be absorbed and reflected. Another effect of terrain is how high a person is. Sound levels reduce as the noise energy wave traveling distance increases. A person who is 1,000 feet closer to an aircraft compared to another person at sea level would hear a higher noise level.

GROUND EFFECT. This term describes the effects of vegetation on noise. As sound travels away from the source, some of it is absorbed by grass, plants, and trees. The amount of such ground attenuation (rate that noise level reduces at distances farther from the noise source) depends on the structure and density of trees and foliage, as well as the height of both the source and receiver and the frequency of the sound being absorbed. If the source and the receiver of the sound are both located below the average height of the intervening foliage, the ground covering will be most effective in reducing the noise level. If either rises above the height of the ground covering, the excess attenuation will become less effective. Reflected sound, however, will still be reduced.

3.2 FACTORS INFLUENCING HUMAN RESPONSE TO SOUND

Factors that influence how a sound is perceived and whether it is considered annoying to the listener include not physical characteristics of the sound and secondary influences, such as sociological and external factors. The "Handbook of Noise Control" describes human response to sound in terms of both acoustic and non-acoustic factors. These factors are summarized in **Table 3.2**.

Sound rating scales are developed to account for how humans respond to sound and how sounds are perceived in the community. Many non-acoustic parameters affect individual response to noise. Background sound, which is an additional acoustic factor, is important in describing sound in rural settings. Research has identified a clear association of reported noise annoyance and fear of an accident. In particular, there is firm evidence that noise annoyance is associated with:

- **The fear of an aircraft crashing or of danger from nearby surface transportation;**
- **The belief that aircraft noise could be prevented or reduced by pilots or authorities related to airlines; and**
- **An expressed sensitivity to noise generally.**

Thus, it is important to recognize that acoustic and non-acoustic factors contribute to human response to noise.

TABLE 3.2 **FACTORS THAT AFFECT INDIVIDUAL ANNOYANCE TO NOISE**

Primary Acoustic Factors
Sound Level
Frequency
Duration
Secondary Acoustic Factors
Spectral (Frequency) Complexity
Fluctuations in Sound Level
Fluctuations in Frequency
Rise-time of Noise
Localization of Noise Source
Non-Acoustic Factors
Physiology
Adaption and Past Experience
How the Listener's Activity Affects Annoyance
Predictability of When a Noise will Occur
Whether the Noise is Necessary
Individual Differences and Personality

SOURCE: C. Harris, 1979.

3.3 POTENTIAL EFFECTS OF NOISE

Noise is known to have adverse effects on people and lives. From these effects, criteria have been established to help protect the public health and safety and prevent disruption of certain human activities. These criteria are based on effects of noise on people, such as hearing loss (not a factor with typical community noise), communication interference, sleep interference, physiological responses, and annoyance. Each of these potential noise impacts is briefly discussed in the following points:

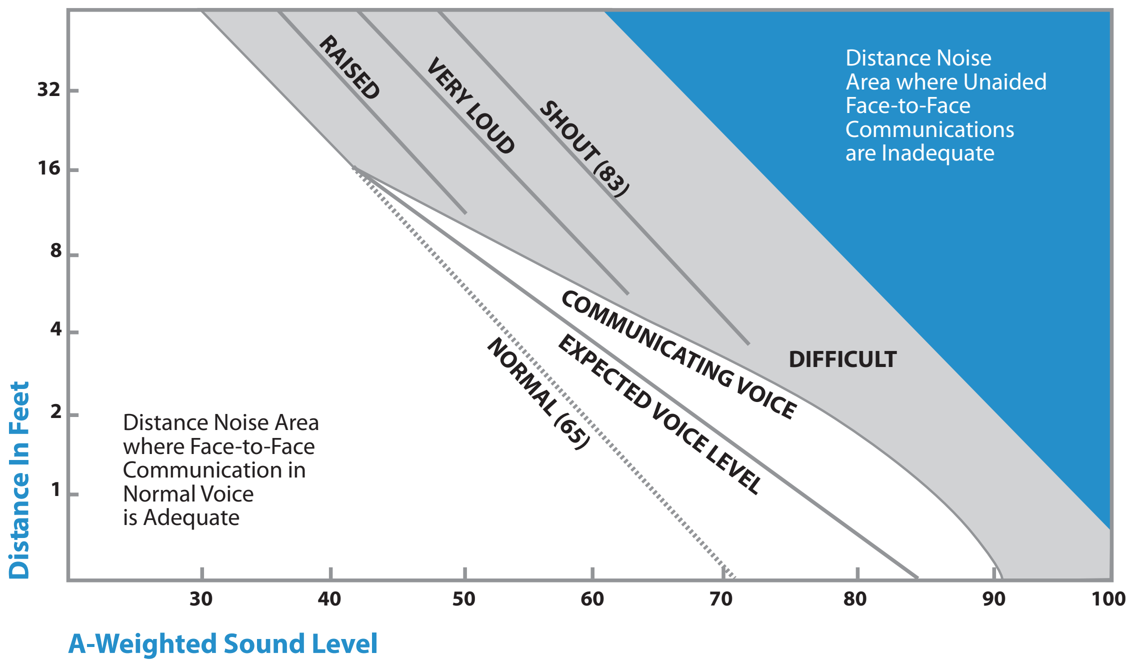
Hearing Loss is generally not a concern in community/aircraft noise situations, even when close to a major airport. The Occupational Safety and Health Administration (OSHA) identifies a noise exposure limit of 90 dBA for 8 hours per day to protect from hearing loss (higher limits are allowed for shorter duration exposures). Noise levels in neighborhoods near airports, even in very noisy neighborhoods, do not exceed the OSHA standards and are not sufficiently loud to cause hearing loss**.**

Communication Interference is one of the primary concerns with aircraft noise. Communication interference includes interference with hearing, speech, or other forms of communication such as watching television and talking on the telephone. Normal conversational speech produces sound levels in the range of 60 to 65 dBA, and any noise in this range or louder may interfere with the ability of another individual to hear or understand what is spoken. There are specific methods for describing speech interference as a function of the distance between speaker, listener, and voice level. **Figure 3.4** shows the relationship between the quality of speech communication and various noise levels**.**

*Sleep Interference***,** particularly during nighttime hours, is one of the major causes of annoyance due to noise. The issue of sleep interference from aircraft noise has played an important role in the development of aircraft noise-related regulations and guidance. Therefore, it is described here to give its background and role in developing noise-related regulation and guidance. Typical causes of reported awakening are illustrated in **Figure 3.5**, with aircraft causing approximately 5 percent of reported awakenings. As shown in **Figure 3.5**, aircraft noise is a minor contributor among a host of other factors that lead to awakening response.

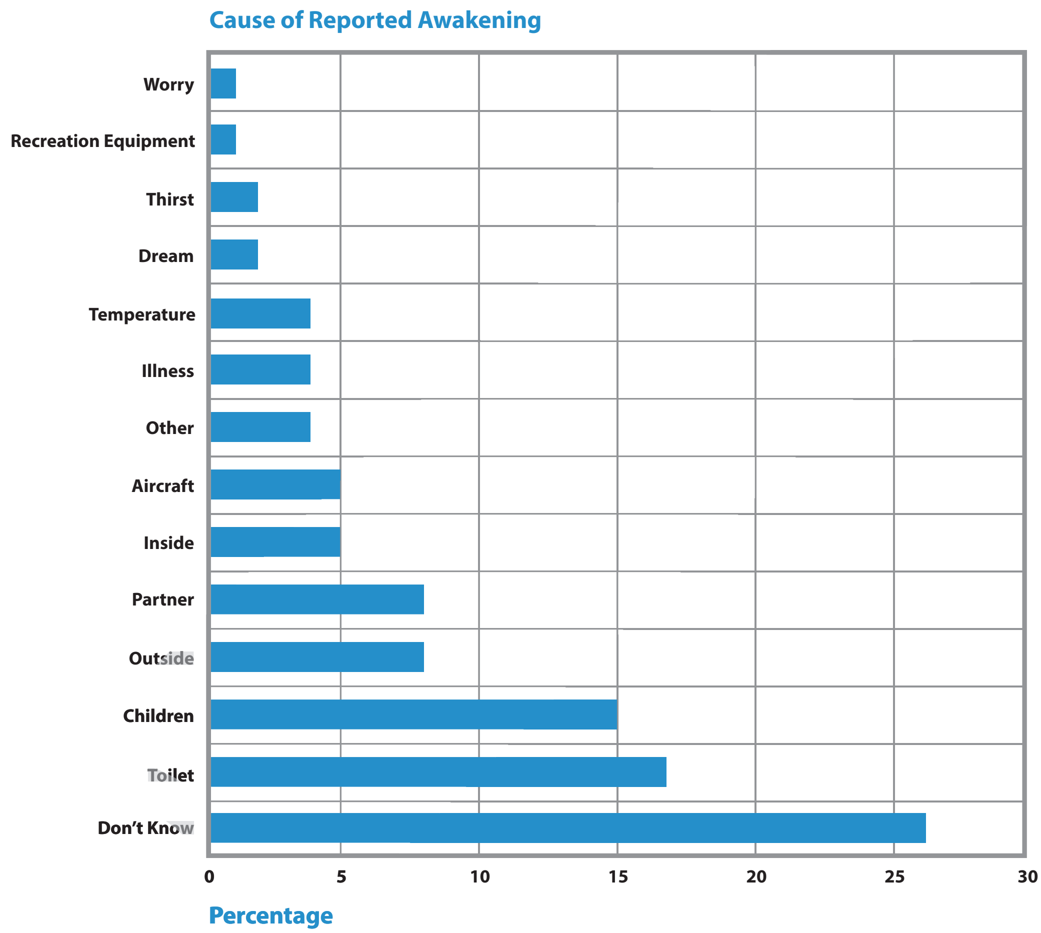
In a 1992 document entitled Federal Interagency Review of Selected Airport Noise Analysis Issues, the Federal Interagency Committee on Noise (FICON) recommended an interim dose-response curve for sleep disturbance based on laboratory studies of sleep disturbance. This review was updated in June 1997, when the Federal Interagency Committee on Aviation Noise (FICAN) replaced the FICON recommendation with an updated curve based on the more recent in-home sleep disturbance studies. The FICAN recommended a curve based on the upper limit of the data presented, and, therefore, considers the curve to represent the "maximum percent of the exposed population expected to be behaviorally awakened," or the "maximum awakened."

The FICAN recommendation is shown on **Figure 3.6**. A more common statistical curve for the data points is also reflected in **Figure 3.6**. For example, the FICAN curve shows a “maximum awakened” curve showing a 10% awakening rate at a level of approximately 80 dB Single Event Level (SEL). The full FICAN report can be found on the internet at www.fican.org. Sleep interference continues to be a major concern to the public and an area of debate among researchers.



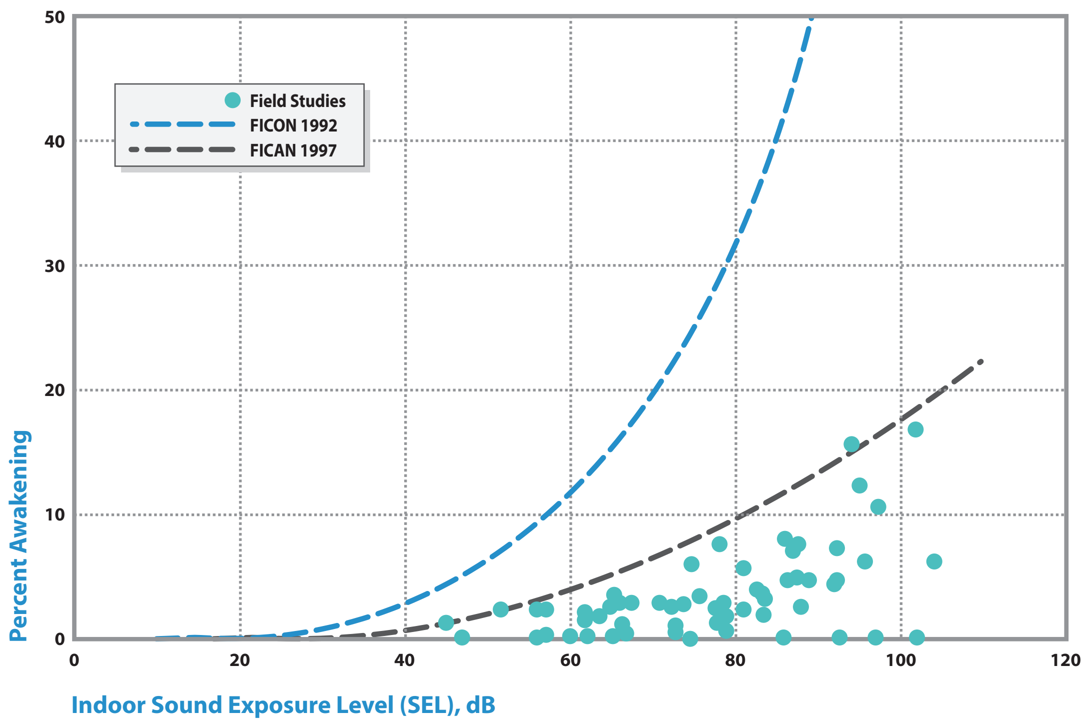
SOURCE: Noise Effects Handbook , EPA.

FIGURE 3.4 **QUALITY OF SPEECH IN RELATION TO THE DISTANCE BETWEEN THE TALKER AND THE LISTENER**



SOURCE: Report Of A Field Study Of Aircraft Noise And Sleep Disturbance, 1992. London Department Of Safety.

FIGURE 3.5 **CAUSES OF REPORTED AWAKENINGS**



SOURCE: FICAN Report, 1997.

FIGURE 3.6 **SAMPLE OF SLEEP DISTURBANCE**

Physiological Responses reflect measurable changes in pulse rate, blood pressure, etc. Generally, physiological responses reflect a reaction to a loud short-term noise, such as a rifle shot or a very loud jet over flight. While such effects can be induced and observed, the extent to which these physiological responses cause harm is not known.

Annoyance is the most difficult of all noise responses to describe. Annoyance is an individual characteristic and can vary widely from person to person. What one person considers tolerable may be unbearable to another of equal hearing capability. The level of annoyance also depends on the characteristics of the noise (i.e., loudness, frequency, time, and duration), and how much activity interference (e.g., speech interference and sleep interference) results from the noise. However, the level of annoyance is also a function of the attitude of the receiver. Attitudes are affected by the relationship between the listener and the noise source (if it is your dog barking or the neighbor's dog). Whether one believes that someone is trying to abate the noise will also affect their level of annoyance.

3.4 SOUND RATING SCALES

The description, analysis, and reporting of community sound levels are made difficult by the complexity of human response to sound, and the myriad of sound-rating scales and metrics that have been developed for describing acoustic effects. Various rating scales have been devised to approximate the human subjective assessment of "loudness" or "noisiness" of a sound.

Noise metrics can be categorized as cumulative metrics and single event metrics. Single event metrics describe the noise from individual events, such as an aircraft flyover. Cumulative metrics describe the noise in terms of the total noise exposure throughout the day. Cumulative noise metrics have been developed to assess community response to noise. They are useful because the scales attempt to include the loudness and duration of the noise, the total number of noise events, and the time of day these events occur into one rating scale.

3.4.1 Single Event Metrics

A-WEIGHTED METRICS DECIBEL (dBA). To simplify the measurement and computation of sound loudness levels, frequency weighted metrics have obtained wide acceptance. The dBA scale has become the most prominent of these scales and is widely used in community noise analysis. dBA metrics are designed to replicate how the human ear hears noise. This metric has shown good correlation with community response and may be easily measured. The metrics used in this 14 CFR Part 150 Study are all based upon the dBA scale.

MAXIMUM NOISE LEVEL (Lmax). The highest noise level reached during a noise event is called the "Maximum Noise Level," or Lmax. For example, as an aircraft approaches, the sound of the aircraft begins to rise above ambient noise levels. The closer the aircraft gets, the louder it is until the aircraft is at its closest point directly overhead. As the aircraft passes, the noise level decreases until the sound level settles to ambient levels. This is plotted at the top of the Single Event Sound Exposure Level (SENEL) section of **Figure 3.7**. It is this metric to which people generally respond when an aircraft flyover occurs.

SINGLE EVENT SOUND EXPOSURE LEVEL (SENEL). The duration of a noise event, or an aircraft flyover, is an important factor in assessing annoyance and is measured most typically as SENEL. The effective duration of a sound starts when a sound rises above the background sound level and ends when it drops back below the background level. An SENEL is calculated by summing the dB level at each second during a noise event (referring again to the shaded area at the top of **Figure 3.7**) and compressing that noise into one second. It is the level the noise would be if it all occurred in one second.

The SENEL value is the integration of all the acoustic energy contained within the event. This metric accounts for the maximum noise level of the event and the duration of the event. For aircraft flyovers, the SENEL value is numerically about 10 dBA higher than the maximum noise level a person will hear. Single event metrics are a convenient method for describing noise among individual aircraft events that have different noise event durations. Airport noise models contain aircraft noise curve data based upon the SENEL metric. In addition, cumulative noise metrics such as Equivalent Noise Level (LEQ) and Community Noise Equivalent Level (CNEL) can be computed from SENEL data (these metrics are described in the next paragraphs).

3.4.2 Cumulative Metrics

Cumulative noise metrics have been developed to assess community response to noise. They are useful because these scales attempt to include the loudness and duration of the noise, the total number of noise events, and the time of day these events occur into one rating scale.

EQUIVALENT NOISE LEVEL (LEQ). LEQ is the sound level corresponding to a steady-state dBA sound level containing the same total energy as a time-varying signal (noise that constantly changes over time) over a given sample period. LEQ is the "energy" average taken from the sum of all the sound that occurs during a certain time period; however, it is based on the observation that the potential for a noise to impact people is dependent on the total acoustical energy content. This is graphically illustrated in the middle graph of **Figure 3.7.** LEQ can be measured for any time period, but is typically measured for 15 minutes, 1 hour, or 24 hours. LEQ for one hour is used to develop the CNEL values for aircraft operations.

DAY NIGHT AVERAGES SOUND LEVEL (DNL). In 1981, the Federal Aviation Administration (FAA) formally adopted the Day Night Average Sound Level (DNL) as the primary measure for determining exposure of individuals to airport noise. The DNL is the annual, 24-hour average sound level, in decibels, obtained from the accumulation of all noise events, with the addition of 10 decibels to weighed sound levels from 10:00 p.m. to 6:59 a.m. The weighing of nighttime events accounts for the fact that noise events at night are more intrusive when ambient levels are lower, and people are trying to sleep. The 24-hour DNL is annualized to reflect noise generated by aircraft operations for an entire year and is identified by “noise contours” showing levels of aircraft noise.

DNL is the most widely accepted descriptor for aviation noise because of the following characteristics: DNL is a measurable quantity; DNL can be used by airport planners and the general public who are not familiar with acoustics or acoustical theory; DNL provides a simple method to compare the effectiveness of alternative airport scenarios; and DNL is based on a substantial body of scientific survey data regarding the reactions people have to noise.

COMMUNITY NOISE EQUIVALENT LEVEL (CNEL). CNEL is average equivalent A-weighted sound level over a 24-hour period. While DNL is the primary metric FAA uses to determine noise impacts, CNEL may be used in lieu of DNL in California per FAA Order 1050.1F. Like the DNL, CNEL is the equivalent sound level for a 24-hour period that adds a 10 dB penalty to each aircraft operation between 10:00 p.m. and 6:59 a.m.; but is different in that it also adds a 5 dB penalty for each aircraft operation during evening hours between 7:00 p.m. to 9:59 p.m. This evening noise penalty accounts for people's sensitivity to noise during evening hours when they may be outside and fewer noise producing activities occur. Therefore, CNEL is the State of California's noise standard that defines the airport's noise contour and is the metric that is used in this 14 CFR Part 150 Study. CNEL is graphically illustrated in the bottom of **Figure 3.7**.

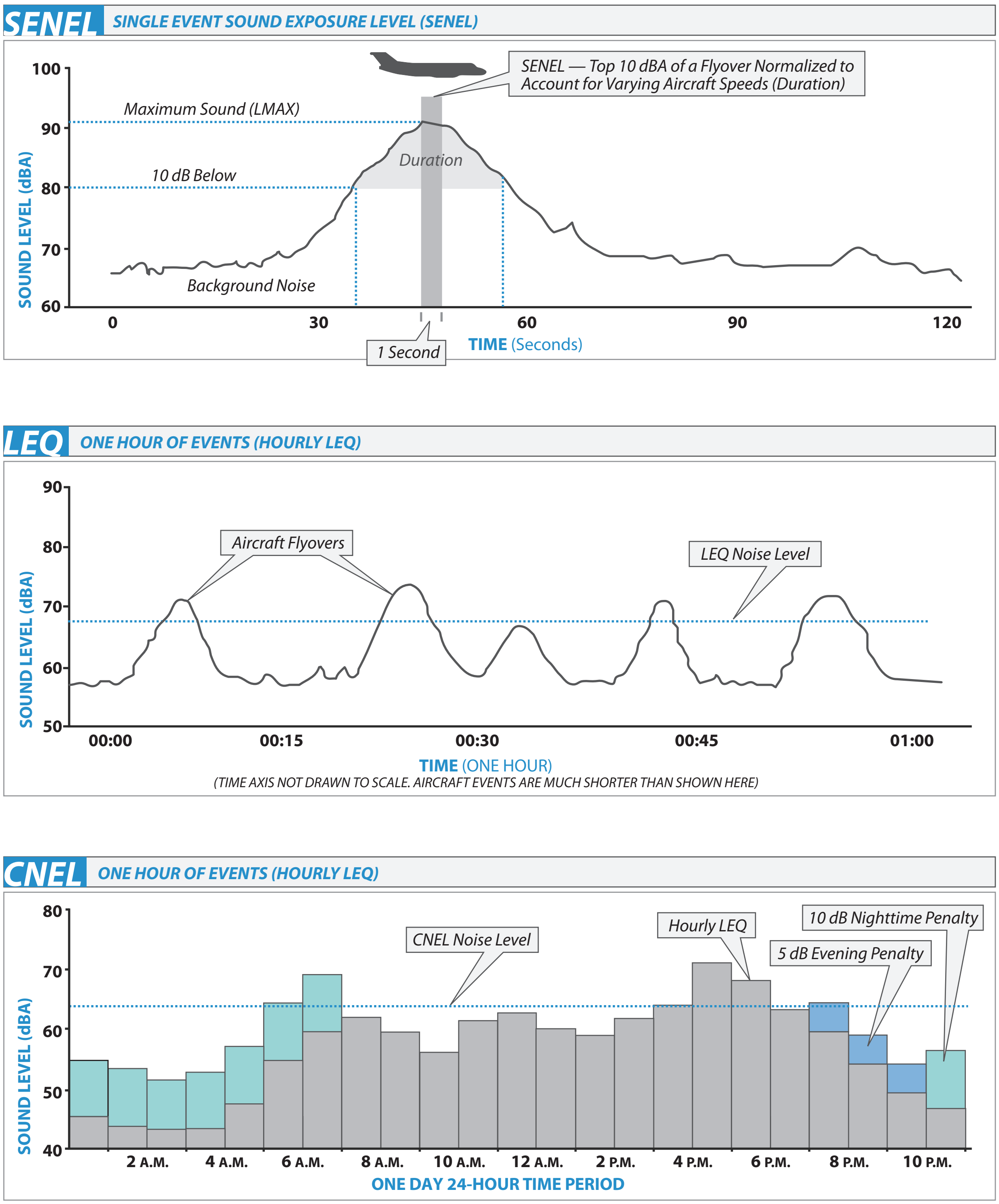


FIGURE 3.7 **EXAMPLES OF LMAX, SENEL, LEQ & CNEL NOISE LEVELS**

3.6 NOISE/LAND USE COMPATIBILITY STANDARDS AND GUIDELINES

Noise metrics describe noise exposure and help predict community response to various noise exposure levels. The public reaction to different noise levels has been estimated based upon extensive research on human responses to exposure of different levels of aircraft noise. Based on human response, land use compatibility guidelines have been developed that are defined in terms of the DNL. Note that references to DNL in this section are all applicable to CNEL for this 14 CFR Part 150 Study. Using these metrics and surveys, agencies have developed guidelines for assessing the compatibility of various land uses with the noise environment.

The most common noise/land use compatibility guideline or criteria used is 65 dBA DNL. The Schultz curve, which is the most widely accepted dose-response relationship between environmental noise (expressed as DNL) and annoyance, predicts approximately 14 percent of the exposed population would be highly annoyed with exposure to the 65 dBA DNL. At 60 dB DNL, it decreases to approximately 8 percent of the population highly annoyed. A summary of pertinent regulations and guidelines is presented below.

Highlights of Land Use Compatibility Guidelines

FAA and other federal agencies have established land use compatibility guidelines based on CNEL that identify the acceptability of various types of land use with aircraft noise exposure.

- **Residential uses are compatible with noise up to 65 CNEL and up to 70 CNEL with sound insulation;**
- **Schools are compatible with noise up to 65 CNEL and up to 70 CNEL with sound insulation;**
- **Commercial development is compatible with noise up to 75 CNEL.**

Numerous laws have been passed concerning aircraft noise.

- **Aviation Safety and Noise Abatement (ASNA): FAA required to use DNL**
- **California State noise standard requires use of CNEL**
- **Phase-out of noisiest aircraft (Stage 2) >75,000 lbs. in the year 2000**
- **Airport Noise and Capacity Act (ANCA) prevents adoption of airport access restrictions (i.e., curfews, and caps)**
- **Phase-out of Stage 2 aircraft less than 75,000 lbs. (business jets) on December 31, 2015.**

3.6.1 Primary Regulation

14 CFR, PART 150, "AIRPORT NOISE COMPATIBILITY PLANNING". As a means of implementing the Aviation Safety and Noise Abatement Act (ASNA), the FAA adopted 14 CFR Part 150, *Airport Noise Compatibility Planning Programs,* which established a uniform program for developing balanced and cost-effective programs for reducing existing and future aircraft noise at individual airports. Included in 14 CFR Part 150 was the FAA's adoption of noise and land use compatibility guidelines seen in **Figure 3.8.** An expanded version of these guidelines/chart appears in Aviation Circular (AC) 150/5020-1 (dated August 5, 1983). These guidelines offer recommendations for determining acceptability and compatibility of land uses. The guidelines specify the maximum amount of noise exposure (in terms of the cumulative noise metric DNL) that would be considered acceptable or compatible to people in living and working areas. This is the primary guidance used for this 14 CFR Part 150 Study, which is consistent with previous Part 150 Studies conducted for SDIA. Other supplementary guidance and regulatory frameworks are described below.

LAND USE	BELOW 65	YEARLY DAY-NIGHT NOISE LEVEL (DNL) IN DECIBELS 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

Numbers in parentheses refer to NOTES.

The designations contained in this table do not constitute a Federal determination that any use of land covered by the program is acceptable or unacceptable 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 KEY

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, 30 or 35 dB must be incorporated into design and construction of structure.

NOTES

(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 to 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 of 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 of 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 noise level is low.

(5) Land use compatible provided that special sound reinforcement systems are installed.

(6) Residential buildings require an NLR of 25.

(7) Residential buildings require an NLR of 30.

(8) Residential buildings not permitted.

SOURCE: 14 CFR Part 150 Guidelines.

FIGURE 3.8 **FAA PART 150 LAND USE COMPATIBILTY MATRIX**

3.6.2 Standards and Regulations Relating to Proposed Noise Abatement Alternatives

FAA ORDER 5050.4B AND ORDER 1050.1F. The FAA, like many other federal agencies, issues guidance for compliance with the National Environmental Policy Act (NEPA). FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*, identifies the procedures for complying with NEPA for all divisions of the FAA. FAA Order 5050.4B, National Environmental Policy Act (NEPA) Implementing Instructions for Airport Actions, supplements 1050.1F and identifies issues specific to the Airports Division of the FAA. These orders specify the processes for considering environmental factors when evaluating federal actions under NEPA, and include methodologies for assessing noise, as well as thresholds of significant project-related noise changes. While FAA Orders 1050.1F and 5050.4B do not apply to 14 CFR Part 150, implementation of noise abatement alternatives may trigger the need to complete an environmental review, subject to one of these orders, before they can be implemented. Therefore, noise abatement alternatives approved by the FAA in this Study are subject to environmental review prior to implementation.

TITLE 14, CODE OF FEDERAL REGULATIONS PART 36, "NOISE STANDARDS: AIRCRAFT TYPE AND AIRWORTHINESS CERTIFICATION". Originally adopted in 1960, Part 36 prescribes noise standards for issuance of new aircraft type certificates; it also limits noise levels for certification of new types of propeller-driven, small airplanes as well as for transport category, large airplanes. Subsequent amendments extended the standards to certain newly produced aircraft of older type designs. Other amendments extended the required compliance dates. Aircraft may be certificated as Stage 1, Stage 2, Stage 3, or Stage 4 (also called “Chapter Number” outside the U.S.) aircraft based on their noise level, weight, number of engines, and, in some cases, number of passengers.

14 CFR Part 36 has followed the regulatory requirements established by the International Civil Aviation Organization (ICAO) a world aviation industry standard setting organization. In June 2001, on the basis of recommendations made by the fifth meeting of the Committee on Aviation Environmental Protection (CAEP/5), ICAO adopted a new Chapter 4 (Stage 4 in the U.S.) noise standard, more stringent than that contained in Chapter 3. Effective January 1, 2006, all newly certificated aircraft/engines must meet this new standard.

The FAA adopted Stage 5 standards; aircraft for which type certificates are requested on or after December 31, 2017, are required to meet the newest Stage 5 standards if the aircraft has a maximum takeoff weight of over 121,254 pounds. Aircraft for which type certificates are requested on or after December 31, 2020, are required meet the newest Stage 5 standards if the aircraft has maximum takeoff weight less than 121,254 pounds. Stage 1 aircraft over 75,000 pounds are no longer permitted to operate in the U.S. Stage 2 aircraft over 75,000 pounds were phased out of the U.S. fleet effective at the start of 2000, as discussed below by the Airport Noise and Capacity Act of 1990. Stage 2 aircraft under 75,000 pounds were phased out effective December 31, 2015. There are no dates established for the phase out of Stage 3 aircraft.

AIRPORT NOISE AND CAPACITY ACT OF 1990 (ANCA). The Airport Noise and Capacity Act of 1990 (PL 101-508, 104 Stat. 1388), also known as ANCA or the Noise Act, established two broad directives for the FAA: (1) establish a method to review aircraft noise, and airport use or access restriction, imposed by airport proprietors, and (2) institute a program to phase-out Stage 2 aircraft over 75,000 pounds by December 31, 1999 [Stage 2 aircraft are older, noisier aircraft (B-737-200, B-727 and DC-9)].

To implement ANCA, FAA amended Part 91 to address the phase-out of large Stage 2 aircraft and the phase-in of Stage 3 aircraft. In addition, Part 91 states that all Stage 2 aircraft over 75,000 pounds were to be removed from the domestic fleet or modified to meet Stage 3 by December 31, 1999, and subsequently in December 2015, aircraft under 75,000 pounds were required to be Stage 3. There are a few exceptions, but only Stage 3 or 4 aircraft greater than 75,000 pounds are now in the domestic fleet per ANCA regulations. The airlines have phased out Stage 2 aircraft, and the mainland domestic fleet is now all Stage 3 or 4 aircraft, at a minimum. Currently, all new aircraft are to be manufactured to meet Stage 4 standards. With few exceptions, all aircraft in operation must meet Stage 3 standards. The international community approved a more stringent standard, which the FAA calls Stage 5, starting December 31, 2017, and December 31, 2020, for new type certificates depending on the weight of the aircraft.

TITLE 14, CODE OF FEDERAL REGULATIONS PART 161, "NOTICE AND APPROVAL OF AIRPORT NOISE AND ACCESS RESTRICTIONS". 14 CFR Part 161 was adopted to institute a highly stringent review and approval process for implementing use or access restrictions by airport proprietors and sets out the requirements and procedures necessary to do so for new use or access restrictions or changes to existing restrictions.

They must use the DNL metric to measure noise effects, and the 14 CFR Part 150 land use guideline table, including 65 DNL as the threshold contour to determine compatibility. ANCA applies to all local noise restrictions that are proposed after October 1990, and to amendments to existing restrictions proposed after October 1990. The FAA has approved only one completed Part 161 Study to date (for restricting Stage 2 corporate jets). Recent litigation has upheld the validity and reasonableness of that Part 161 restriction.

As detailed in **Chapter 1**, SDIA has a curfew that was instituted prior to ANCA for departures, and therefore is legacied in. However, any changes to this curfew would discontinue it.

FICON REPORT OF 1992. The use of the DNL metric criteria has been criticized by various interest groups concerning its usefulness in assessing aircraft noise impacts. As a result, at the direction of the EPA and the FAA, the FICON was formed to review specific elements of the assessment on airport noise impacts and to recommend procedures for potential improvements. FICON included representatives from the Departments of Transportation and Justice, Department of Defense, Veterans Affairs, Housing and Urban Development, the EPA, and the Council on Environmental Quality.

The FICON review focused primarily on the manner in which noise impacts are determined, including whether aircraft noise impacts are fundamentally different from other transportation noise impacts; how noise impacts are described; and, whether impacts outside of DNL 65 dB should be reviewed in a NEPA document. The committee determined that there are no new descriptors or metrics of sufficient scientific standing to substitute for the present DNL cumulative noise exposure metric.

In 1992, FICON determined that the DNL method contains appropriate dose-response relationships (expected community reaction for a given noise level) to determine that the noise impact is properly used to assess noise impacts at both civil and military airports. The report does support agency discretion in the use of supplemental noise analysis and recommends public understanding of the DNL and supplemental methodologies, as well as aircraft noise impacts.

FAA REAUTHORIZATION ACT. In 2018, the FAA Reauthorization Act included several elements related to noise. It states, "Not later than 1 year after the date of enactment of this Act, the Administrator of the Federal Aviation Administration shall complete the ongoing evaluation of alternative metrics to the current Day Night Level (DNL) 65 standard." It also makes commitments to initiate a study to review and evaluate existing studies, review the relationship between aircraft noise exposure and its effects on communities around airports.

3.6.3 Local Land Use Guidelines

Noise compatibility policies within the Airport Land Use Compatibility Plan (ALUCP) for SDIA are predicated on the San Diego County Regional Airport Authority (SDCRAA) noise contour maps for SDIA and are only applicable to new and redeveloped land/land uses. The ALUCP establishes 60 dB CNEL as the threshold for noise. According to the ALUCP, all new and redeveloped residential land use is permitted within the 70 dB CNEL and above only if:

- **The applicable general or community plan currently designates the property for residential use.**
- **The residence is capable of attenuating exterior noise to 45 dB CNEL.**

Educational, institutional, and public service land uses are permitted within the 60-65 dB CNEL given the facilities are capable of attenuating exterior noise to 45 dB CNEL. Most are not permitted above 65 dB CNEL. However, it is important to note that ALUCP does not have ultimate land use decision authority. The ALCUP is currently undergoing a revision, but it is not anticipated to be completed prior to the completion of this 14 CFR Part 150 Study.

3.7 NOISE ASSESSMENT METHODOLOGY

Existing and future aircraft noise environments for SDIA were determined through computer modeling using the FAA's Aviation Environmental Design Tool (AEDT). On-site sound level measurements were also used as they help establish the ambient (non-aircraft) noise environment and identify noise levels at specific areas of interest. The noise measurement collection and analysis methodology followed 14 CFR Part 150 guidelines and California Title 21 requirements. The following sub-sections explain the methodology and measurement tools.

3.7.1 Aircraft Noise and Operations Management System

SDIA operates a noise monitoring system to record noise levels in communities near the airport. The Aircraft Noise and Operations Management System (ANOMS) comprises 23 noise monitoring terminals (NMTs) located within noise impacted areas surrounding the airport, as illustrated in **Figures 3.9 and 3.10**. Thirteen NMT sites are located west of the airport, and predominantly measure departure noise from Runway 27; seven NMT sites predominantly measure Runway 27 arrival noise as they are to the east of the airport; and three NMT sites, which are located near or on the airfield, predominantly measure aircraft operations near or on the runway (i.e., takeoff noise on departure and reverse thrust noise on arrival). Upgrades to the technology and configuration of the NMTs over time has resulted in the decommissioning of terminals #5, #8, and #15. NMTs #1 (located approximately one mile from the arrival end of Runway 27) and #7 (located approximately one-half mile from the departure end of Runway 27) help to identify the loudest 10% of aircraft arriving and departing at SDIA in order to report noise exceedances to the Fly Quiet Program.

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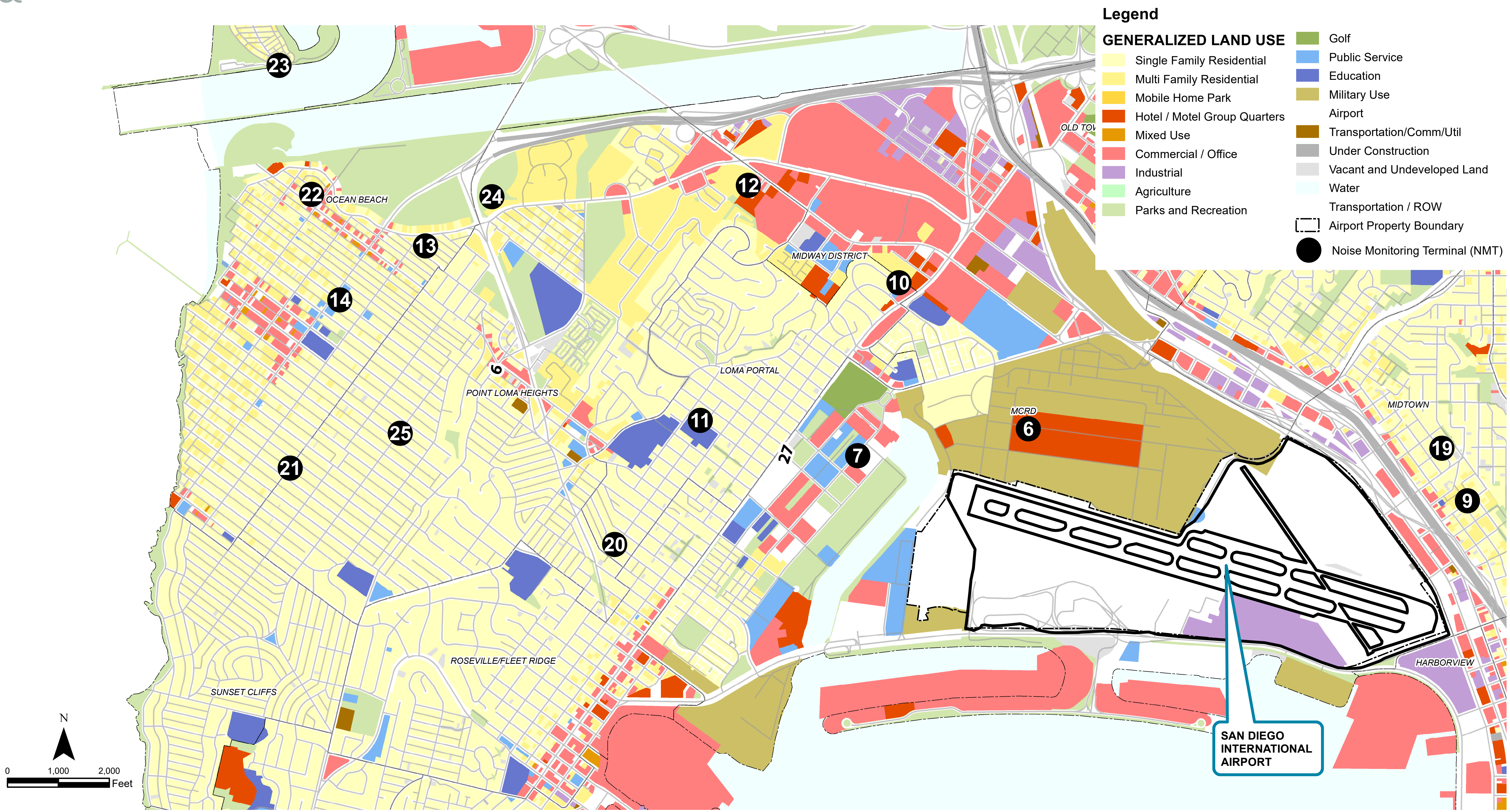

SOURCE: 1. SANDAG Technical Services - GIS, SANDAG Land Layers Inventory Mapping Source: SanGIS landbase (i.e. parcels), SANDAG, County Assessor's Master Property Records file, Cleveland National Forest, Bureau of Land Management (BLM), State Parks, other public agency contacts, and local agency review.
2. SDIA ANOMS 2019 and associated appendices.

FIGURE 3.9 **NOISE MONITORING TERMINAL LOCATIONS (EAST)** **14 CFR PART 150 REQUIRED MAP**

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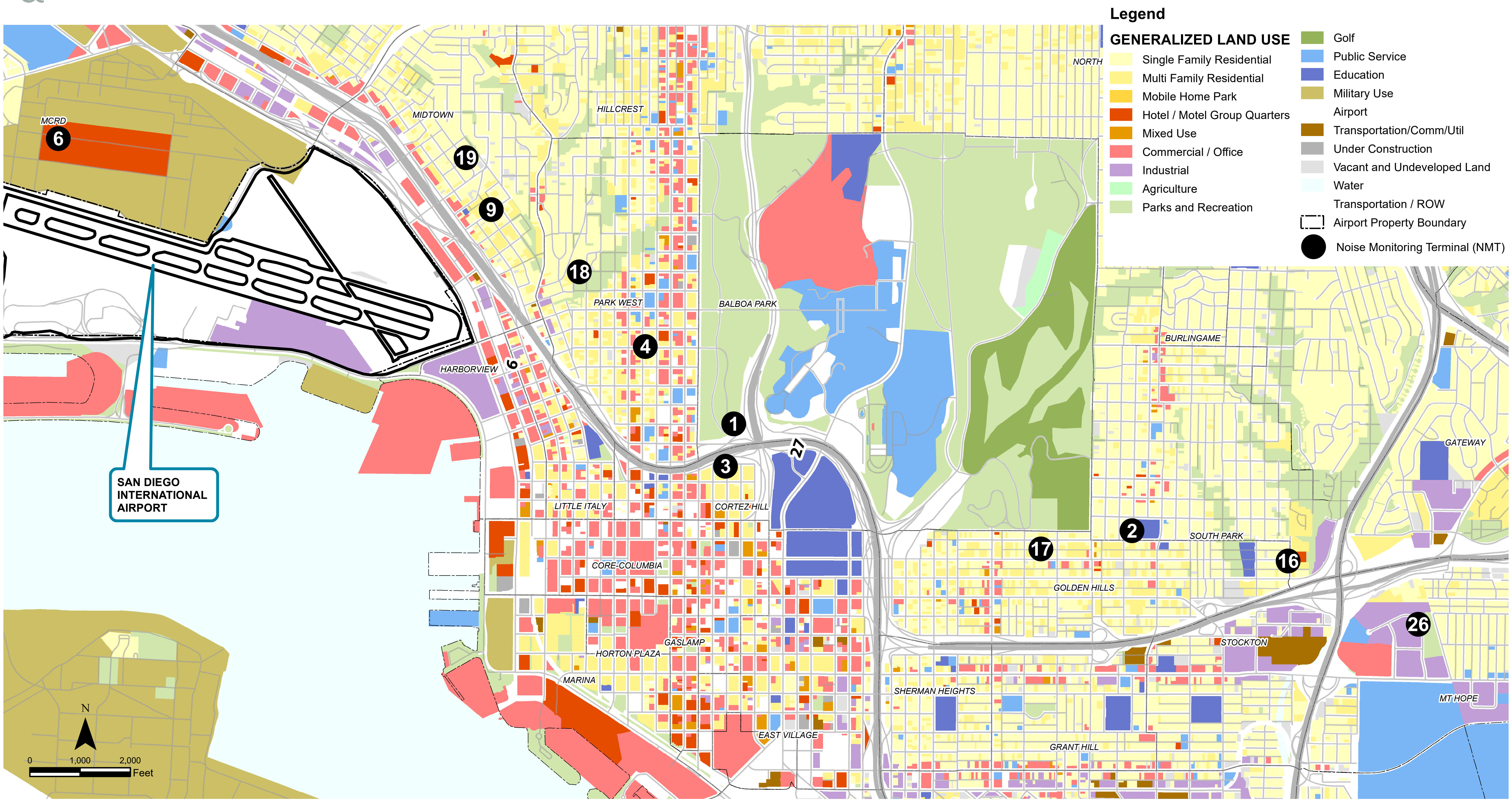

SOURCE: 1. SANDAG Technical Services - GIS, SANDAG Land Layers Inventory Mapping Source: SanGIS landbase (i.e. parcels), SANDAG, County Assessor's Master Property Records file, Cleveland National Forest, Bureau of Land Management (BLM), State Parks, other public agency contacts, and local agency review.
2. SDIA ANOMS 2019 and associated appendices.

FIGURE 3.10 **NOISE MONITORING TERMINAL LOCATIONS (EAST)** **14 CFR PART 150 REQUIRED MAP**

Each monitoring site collects the noise event data, and the ANOMS system analyzes the flight data and correlates that data with the noise events downloaded from the NMT sites. The radar data collected by ANOMS includes both FAA local area radar and a third-party flight data source to supplement flight track information. The correlated noise event information is then used to calculate daily and annual aircraft and community (non-aircraft) CNEL levels.
Noise event data including aircraft identification, weather, and complaint data are collected 24 hours a day and are sent to the ANOMS system in real-time. In turn, these data are used to respond to noise complaints and to provide detailed analysis for reporting required by the Aircraft Noise Office. ANOMS and the Aircraft Noise Office have been audited three times (in October 2000 by the State of California, and in 2009 and 2015 by SDCRAA internal audits) with no major findings.

3.7.2 Instrumentation

The monitoring program is consistent with state-of-the-art noise measurement procedures and equipment.
The ANOMS program, installed in 1991, was supported by both Technology Integrated, Inc. and the PASSUR Aerospace, Inc. flight tracking system provided by Megadata. In 2004, the SDCRAA installed the Environmental Monitoring Units (EMUs), which were produced and installed by the Lochard Corporation. Each NMT has wireless modem technology, and ten of the NMTs are powered by solar energy. The airport has consistently updated the monitoring system to include the latest technology.

The measurements consist of monitoring dBA in accordance with procedures and equipment that comply with specific International Standards (IEC), and measurement standards established by the American National Standards Institute (ANSI) for Type 1 instrumentation, as specified in FAA guidance concerning such measurement programs. All noise monitoring is consistent with 14 CFR Part 150 guidelines and Title 21.

3.7.3 Online Flight Tracking

SDIA provides an online flight tracking system as a community engagement tool to allow the public to view local airport area flight tracks (with a built-in 5-minute delay for safety reasons). When the tool was introduced in 2016, SDIA experienced a reduction in noise complaints due to the community's ability to research the aircraft flights that concerned them. When a member of the public identifies a particular operation of concern, he/she can file a complaint that is automatically sent to the Noise Office. The complaint includes aircraft type, operator/airline, time, and date, thereby allowing the Noise Office staff to review the correlation between the complaint and noise event. Further, the system allows the Noise Office staff to email a response to the submitter of the complaint, if requested, to provide further information.

3.8 COMPUTER MODELING

Computer modeling generates maps or tabular data of an airport's noise environment expressed in the metrics described above, such as CNEL. Computer models are most useful in developing contours that depict, like elevation contours on a topography map, areas of equal noise exposure. Accurate noise contours are largely dependent on the use of reliable, validated, and updated noise models, and collection of accurate aircraft operational data.

As stated earlier, existing, and future aircraft noise environments for SDIA were determined through computer modeling using AEDT. AEDT models civilian and military aviation operations and is required by FAA to be used for 14 CFR Part 150 Study aircraft noise analysis. The latest version at the time this 14 CFR Part 150 Study began was AEDT Version 2d, which was released for use in September 2017 and will be used for this analysis. The program includes standard aircraft noise and performance data for hundreds of aircraft types that can be tailored to the characteristics of specific individual airports.