SECTION 2.0

BACKGROUND INFORMATION ON NOISE

2.1 Introduction

This section presents background information on the characteristics of noise and summarizes the methods and criteria used to assess aircraft noise impacts. This section is intended to give the reader a greater understanding of the noise metrics and methodologies used to assess noise impacts. This section is divided into the following sub-sections:

- <u>Characteristics of Sound</u> - Presents properties of sound that are important for technically describing noise in the airport setting.
- <u>Factors Influencing Human Response to Sound</u> -Presents audible factors to the human ear that affects a subjective perception and elicits a response.
- <u>Health Effects of Noise</u> - Sumarizes the potential human disturbances and health effects of noise.
- <u>Sound Rating Scales</u> - Presents various sound rating scales and how they may be applied to addressing aircraft operations.
- <u>Noise Assessment Guidelines</u> - Presents a summary of current noise assessment criteria, which is also used to assess the impacts on an aircraft level.

2.2 Characteristics of Sound

<u>Sound Level and Frequency.</u> Sound can be technically described in terms of the sound pressure (amplitude) and frequency (similar to pitch). Sound pressure is a direct measure of magnitude 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 these pressures as sound pressure levels on a logarithmic scale. This scale compresses the wide range in sound pressures to a more usable range of numbers. The standard unit of measurement is the Decibel (dB). This level describes the pressure a sound is relative to a reference point.

For example, a sound level of 70 dB has 10 times as much acoustic energy as a level of 60 dB while a sound level of 80 has 100 times as much acoustic energy as 60 dB. In terms of human response to noise, the perception is very different. A sound 10 dB higher than another is usually judged to be twice as loud, 20 dBA higher 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; some frequencies are 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" for a sound. The most prominent of these scales include are as follows: 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, and are discussed in the paragraphs below.

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. The human ear is not equally sensitive to all frequencies with some frequencies judged to be louder for a given signal than others). This sensitivity difference also varies for different sound pressure levels.

This data is obtained through group laboratory studies of human response to noise. Generally, a pure tone signal of 1000 hertz is played and after an elapsed interval a second tone of a different frequency is played. The listener adjusts the signal until the two tones are judged to be the same.

Frequency Weighted Contours (dBA, dBB, and dBC)

Frequency weighted networks have obtained wide acceptance as a means to simplify the measurement and computation of sound loudness levels. The equal loudness levels contours for 40 dB, 70 dB and 100 dB have been selected to represent human frequency response to low, medium, and loud sound levels. By inverting these equal loudness level contours, the A-weighted, B-weighted and C-weighted frequency weightings were developed. These frequency-weighting contours are presented in **Figure 2-1**.

The most common weighting is the A-weighted noise curve (dBA). The A-weighted decibel scale (dBA) performs this compensation by discriminating against frequencies in a manner approximating the sensitivity of the human ear. In the A-weighted decibel, everyday sounds normally range from 30 dBA (very quiet) to 100 dBA (very loud). Most community noise analyses are based upon the A-weighted decibel scale. Examples of various sound environments, expressed in dBA, are presented in **Figure 2-2**.

Some interest has developed to utilize a different noise curve other than A-weighting for lower frequency noise sources. For example, the C-weighted curve is used for the analysis of the noise impacts from artillery noise.

Perceived Noise Level. Perceived noisiness is another method of rating sound. It was originally developed to assess the impact of aircraft noise. Kryter explains that perceived noisiness is defined as the subjective impression of the unwanted, 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 versus just the loudness of a sound.

As with loudness curves, noisiness curves have been developed from laboratory psychoacoustics surveys of individuals. However, in noisiness surveys, individuals are asked to judge when two sounds are equally noisy or disturbing if heard regularly in one’s own environment. These surveys are more complex and therefore subject to greater variability. Aircraft certification data is based upon these types of noisiness scales.

Figure 2-1
Frequency Weighted Contours (dBA, dBB, dBC)
Flightseeing Noise Assessment -- City and Borough of Juneau

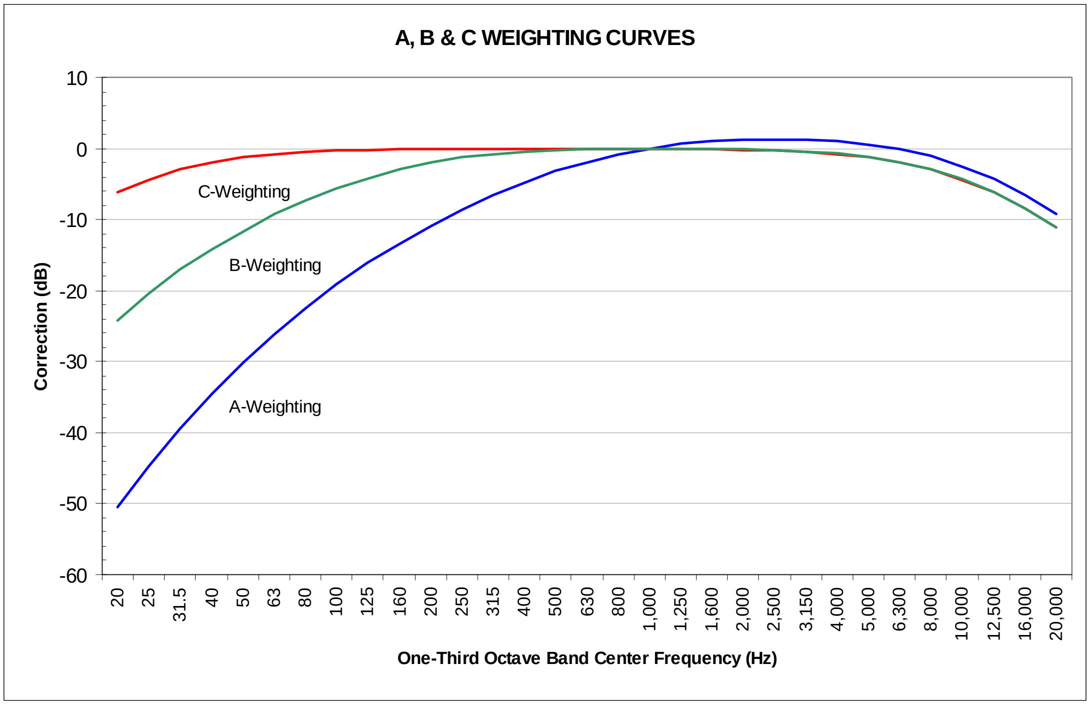


Figure 2-2
Typical Community Noise Levels (dBA)
Flightseeing Noise Assessment -- City and Borough of Juneau

SOUND LEVELS AND LOUDNESS OF ILLUSTRATIVE NOISES IN INDOOR AND OUTDOOR ENVIRONMENTS
(A-Scale Weighted Sound Levels)

dB(A)	OVER-ALL LEVEL Sound Pressure Level Approx. 0.0002 Microbars	COMMUNITY (Outdoor)	HOME OR INDUSTRY	LOUDNESS Human Judgement of Different Sound Levels
130	UNCOMFORTABLY	Military Jet Aircraft Take-Off With After-burner From Aircraft Carrier @ 50 Ft. (130)	Oxygen Torch (121)	120 dB(A) 32 Times as Loud
120 110	LOUD	Turbo-Fan Aircraft @ Take Off Power @ 200 Ft. (90)	Riveting Machine (110) Rock-N-Roll Band (108-114)	110 dB(A) 16 Times as Loud
100	VERY	Jet Flyover @ 1000 Ft. (103) Boeing 707. DC-8 @ 6080 Ft. Before Landing (106) Bell J-2A Helicopter @ 100 Ft. (100)		100 dB(A) 8 Times as Loud
90	LOUD	Power Mower (96) Boeing 737, DC-9 @ 6080 Ft. Before Landing (97) Motorcycle @25 Ft. (90)	Newspaper Press (97)	90 dB(A) 4 Times as Loud
80		Car Wash @ 20 Ft. (89) Prop. Airplane Flyover @ 1000 Ft. (88) Diesel Truck, 40 MPH @ 50 Ft. (84) Diesel Train, 45 MPH @ 100 Ft. (83)	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) Freeway @ 50 Ft. From Pavement Edge, 10:00 AM (76 +or- 6)	Living Room Music (76) TV-Audio, Vacuum Cleaner	70 dB(A)
60		Air Conditioning Unit @ 100 Ft. (60)	Cash Register @ 10 Ft. (65-70) Electric Typewriter @ 10 Ft. (64) Dishwasher (Rinse) @ 10 Ft. (60) Conversation (60)	60 dB(A) 1/2 as Loud
50	QUIET	Large Transformers @ 100 Ft. (50)		50 dB(A) 1/4 as Loud
40		Bird Calls (44) Lower Limit Urban Ambient Sound (40)		40 dB(A) 1/8 as Loud
	JUST AUDIBLE	(dB[A] Scale Interrupted)		
10	THRESHOLD OF HEARING			

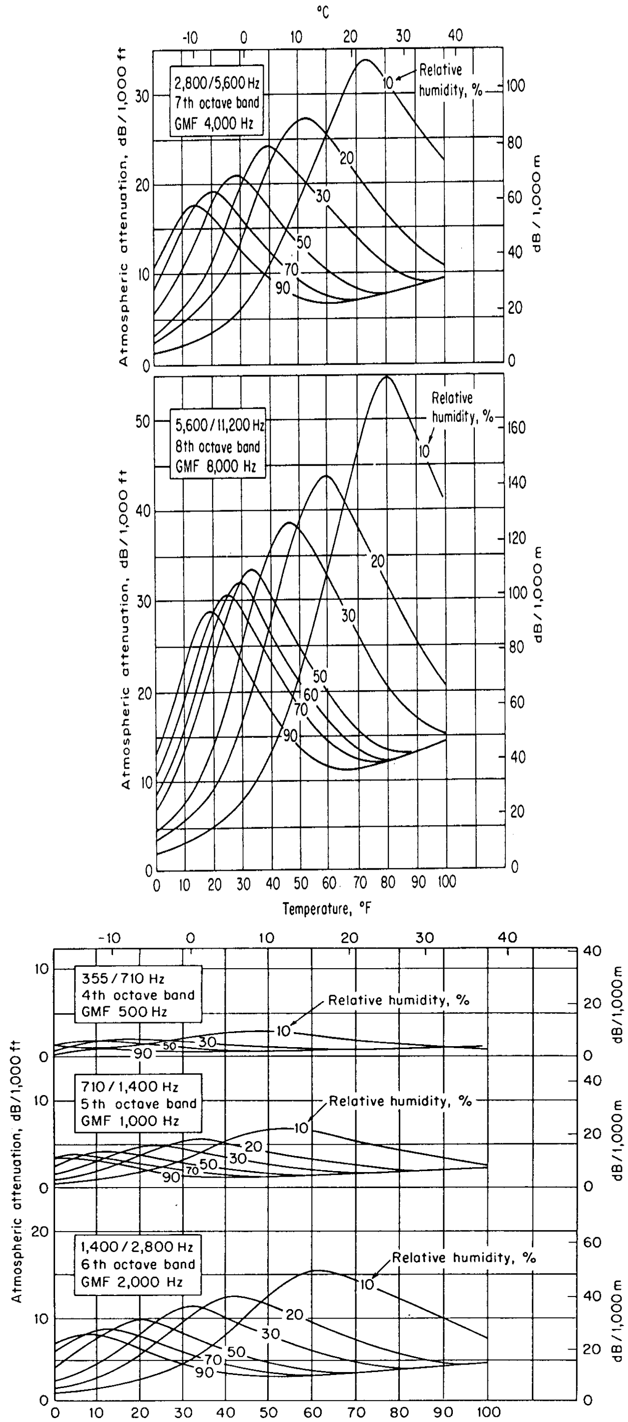
SOURCE: Reproduced from Melville C. Branch and R. Dale Beland, Outdoor Noise in the Metropolitan Environment, Published by the City of Los Angeles, 1970, p.2.

<u>Propagation of Noise.</u> Outdoor sound levels decrease as a function of distance from the source, and as a result of wave divergence, atmospheric absorption and ground attenuation. If sound is radiated from a source in a homogeneous and undisturbed manner, the sound travels as spherical waves. As the sound wave travels away from the source, the sound energy is dispersed over a greater area dispersing the sound power of the wave. Spherical spreading of sound waves reduces the noise level at a rate of 6 dB per doubling of the distance.

Atmospheric absorption also influences the levels that are received by the observer. The greater the distance traveled, the greater the influence of the atmosphere and the resultant fluctuations. Atmospheric absorption becomes important at distances of greater than 1,000 feet. The degree of absorption is a function relative to the frequency of the sound as well as the humidity and air temperature. For example, atmospheric absorption is lowest at high humidity and higher temperatures. Absorption effects in the atmosphere vary with frequency. The higher frequencies are more readily absorbed than the lower frequencies. Over large distances, the lower create a dominant sound as the higher frequencies are attenuated. Examples of the affects of temperature and humidity on the absorption effects of the atmosphere are presented in **Figure 2-3**.

The Juneau climate is characterized by high humidity that is often accompanied by overcast conditions. These conditions result in lower noise attenuation rates so that the noise levels are higher further from a noise source than the general occurrence of typical conditions. The overcast conditions have a tendency to facilitate an inversion, which increases the loudness of the aircraft noise in and around Juneau. In addition, the helicopter and float plane noise sources tend to be dominated by low frequency noise. Atmospheric attenuation is lowest in these frequencies.

Figure 2-3
Atmospheric Attenuation by Octave Band versus Relative Humidity
Flightseeing Noise Assessment -- City and Borough of Juneau



Source: Beranek, 1981

Duration of Sound. The annoyance from a noise event increases with increased duration of the noise event. The "effective duration" of a sound is the time between when a sound rises above the background sound level until it drops back below the background level. Psycho-acoustic studies have determined a relationship between duration and annoyance. These studies have established the limit that a sound must be reduced to be judged equally annoying for increased duration. Duration is an important factor in describing sound in a community setting.

The relationship between duration and noise level is the basis of the equivalent energy principal of sound exposure. Reducing the acoustic energy of a sound by one-half results in a 3 dB reduction. Doubling the duration of the sound increases the total energy of the event by 3 dB. This equivalent energy principal 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 [1]. DNL, LEQ and SEL are all based upon the equal energy principle and defined in subsequent sections of this study.

The duration factor is very important in Juneau. Many of the noise events are characterized by very long durations. The effect of duration is accounted for in the metrics listed above.

Change in Noise. The concept of change in ambient sound levels can be understood with an explanation of the hearing mechanism's reaction to sound. The human ear is a far better detector of relative differences in sound levels than absolute values of levels. Under controlled laboratory conditions, listening to a steady unwavering pure tone sound can be changed to slightly different sound levels. With this change, a person can slightly detect a change of approximately one decibel for sound levels in the mid-frequency region. When ordinary noises are heard, a young healthy ear can 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.

Recruitment of Loudness. Recruitment describes the perception of loudness in situations where the threshold of hearing is elevated by masking from a background sound. A listener's judgment of sound loudness will vary with different levels of background noise. In low-level background situations that are near the hearing threshold, the loudness level of a sound increases gradually. In these situations, a desired sound, such as music that is a level of 40 to 60 dB above the background, would be judged as comfortable. In loud background settings, a sound that is approximately 20 dB above the masking threshold will be perceived as if the sound would have been without a masking sound present.

Masking Effect. One characteristic of sound is its ability to interfere with the listener’s ability to hear another sound. This is defined as the masking effect. The presence of one sound effectively raises the threshold of audibility for the hearing of a second sound. For a signal to be heard, it must exceed the threshold of hearing for that particular individual and exceed 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. The masking effect is greatest when it is closest to the frequency of the signal. Low frequency sounds can mask higher frequency sounds; however, the reverse is not true.

Ground Absorption Effects. As sound travels away from the source, some of it is absorbed by the ground. Sound reduction due to grass, plants and trees between the source and receiver is known as excess ground attenuation and is a function of the structure and density of trees and foliage. This excess attenuation is dependent upon several factors, including the height of both the source and receiver, the frequency of the sound being absorbed and the height, type, and density of the vegetation between the source and receiver.

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. If either the source or the receiver rises above the height of the ground covering, the excess attenuation will become less effective. Reflected sound, however, will still be reduced. Water surface is a reflective surface and therefore there is less ground absorption than when the ground area is of foliage. Therefore, with respect Juneau, the extensive water areas such as the Gastineau Channel, the ground surface is more reflective than under typical conditions with foliage.

2.3 Factors Influencing Human Response to Sound

Many factors influence how a sound is perceived and whether or not it is considered annoying to the listener. This includes not only physical characteristics of the sound but also secondary influences such as sociological and external factors. Molino, in the Handbook of Noise Control [2] describes human response to sound in terms of both acoustic and non-acoustic factors. These factors are summarized in **Table 2-1**.

Table 2-1
Factors that Affect Individual Annoyance to Noise

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

Source: C. Harris, 1979

Sound rating scales are developed to account for factors that affect human response to sound. Nearly all of these factors are relevant in describing how sounds are perceived in the community. Many of the non-acoustic parameters play a prominent role in affecting individual response to noise. Background sound, an additional acoustic factor not specifically listed, is also important in describing sound in rural settings. Fields [4], in his analysis of the effects of personal and situational variables on noise annoyance, has identified a clear association of reported annoyance and fear of an accident. In particular, Fields has stated there is therefore firm evidence that noise annoyance is associated with : (1) the fear of an aircraft crashing or of danger from nearby surface transportation; (2) the belief that aircraft noise could be prevented or reduced by designers, pilots or authorities related to airlines; and (3) an expressed sensitivity to noise generally. Thus, it is important to recognize that non-acoustic factors such as the ones described above as well as acoustic factors contribute to human response to noise.

2.4 Health Effects of Noise

Noise is often described as unwanted sound and is known to have several adverse effects on people. 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 are briefly discussed in the following narrative:

- *Hearing Loss* is generally not a concern in community noise problems, even close to a major airport or a freeway. The potential for noise induced hearing loss is more commonly associated with occupational noise exposures in heavy industry, very noisy work environments with long term exposure, or certain very loud recreational activities such as target shooting, motorcycle or car racing, etc. 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, even in very noisy neighborhoods, do not exceed this standard and are not sufficiently loud to cause hearing loss.

- *Communication Interference* is one of the primary concerns in environmental noise problems. Communication interference includes speech interference and interference with activities such as watching television. Normal conversational speech is in the range of 60 to 65 dBA and any noise in this range or louder may interfere with speech. There are specific methods for describing speech interference as a function of the distance between speaker and listener and voice level. **Figure 2-4** shows the relationship between the quality of speech communication and to various noise levels.

- *Sleep Interference* is a major concern and is most critical during nighttime hours. Sleep disturbance is one of the major causes of annoyance due to community noise. Noise makes it difficult to fall asleep, creating momentary disturbances of natural sleep patterns by causing shifts from deep to lighter stages and cause awakening. It may even cause awakening to a point where a person may or may not be able to recall.

  Extensive research has been conducted on the effect of noise on sleep disturbance. Recommended values for desired sound levels in residential bedroom space range from 25 to 45 dBA with 35 to 40 dBA being the norm. The National Association of Noise Control Officials [3] have published data on the probability of sleep disturbance with various single event noise levels. Based on experimental sleep data as related to noise exposure, a 75 dBA interior noise level event will cause noise induced awakening in 30 percent of the cases.

  Recent research from England [4] and the USAF shows that the probability for sleep disturbance is less than what had been reported in earlier research. This research showed that once a person was asleep, it is much more unlikely that they will be awakened by a noise. The significant difference in the recent study is the use of actual in-home sleep disturbance patterns as opposed to laboratory data that had been the historic basis for predicting sleep disturbance. The results of this research are presented in **Figure 2-5**.

Figure 2-4
Speech Interference with Different Background Noise
Flightseeing Noise Assessment -- City and Borough of Juneau

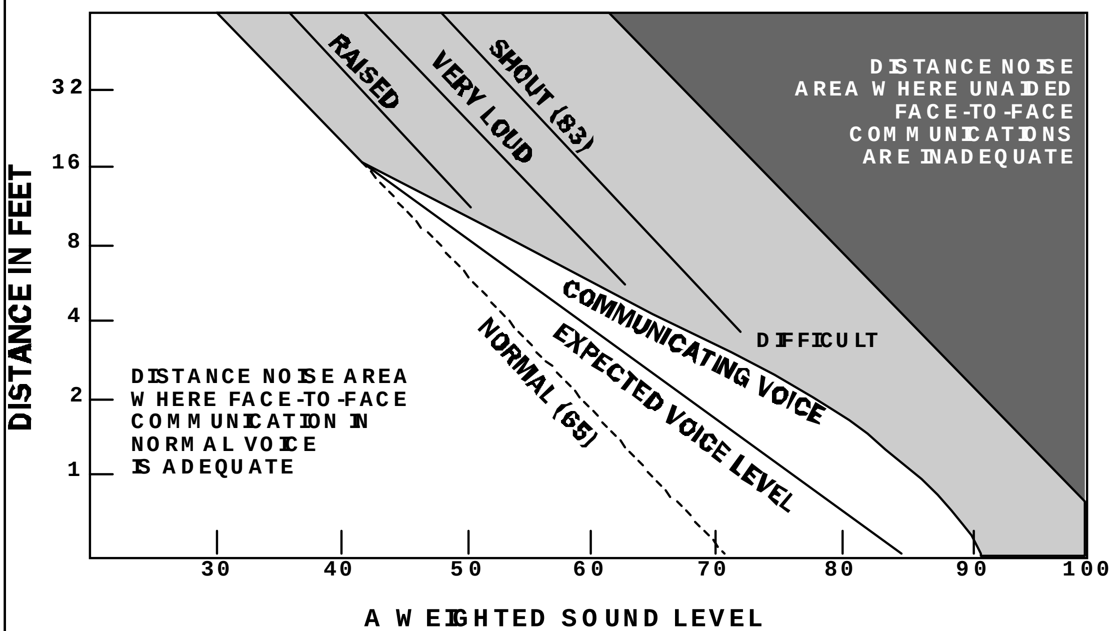
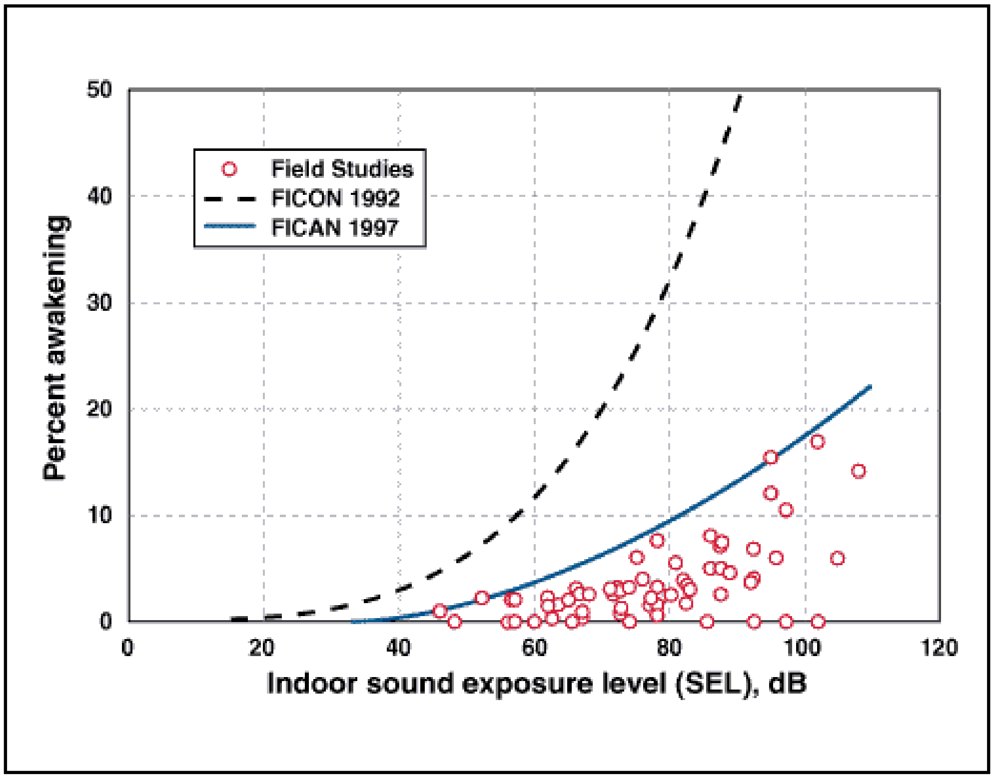


Figure 2-5
Sleep Disturbance Research
Flightseeing Noise Assessment -- City and Borough of Juneau



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 overflight. 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. Personal sensitivity to noise varies widely. It has been estimated that 2 to 10 percent of the population is highly susceptible to annoyance from noise not of their own making, while approximately 20 percent are unaffected by noise. Attitudes are affected by the relationship between the listener and the noise source. (Is it our dog barking or the neighbor's dog?) Whether we believe that someone is trying to abate the noise will also affect our level of annoyance.

2.5 Sound Rating Scales

The description, analysis, and reporting of community sound levels is 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 single event metrics and cumulative 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. The noise metrics used in this study are summarized below:

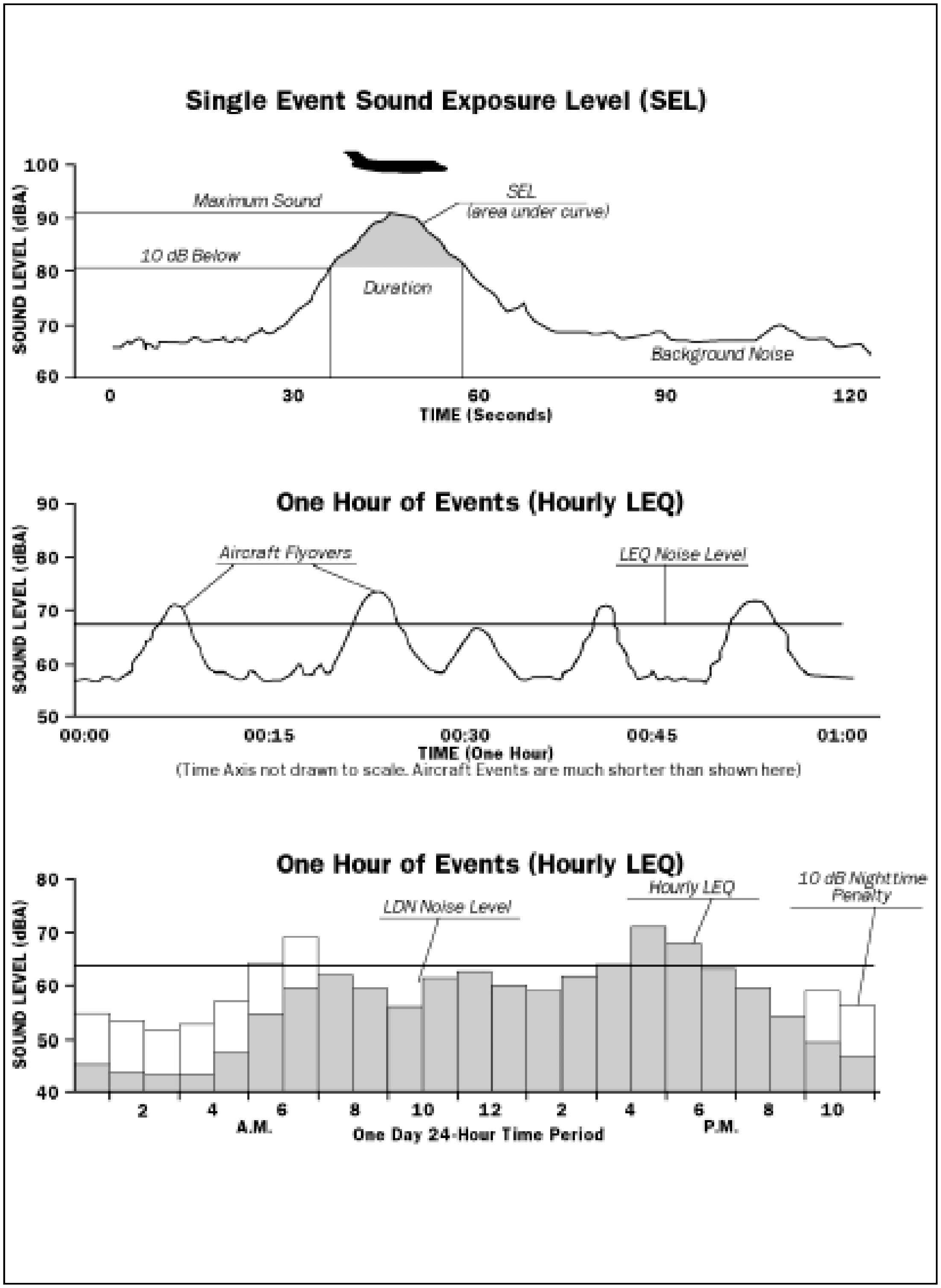
2.5.1 Single Event Metrics

- *Frequency Weighted Metrics (dBA*). In order to simplify the measurement and computation of sound loudness levels, frequency weighted networks have obtained wide acceptance. The A-weighting (dBA) scale has become the most prominent of these scales and is widely used in community noise analysis. This metric has shown good correlation with community response and may be easily measured. The metrics used in this study are all based upon the dBA scale.

- *Maximum Noise Level*. 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 **Figure 2-6**. It is this metric to which people generally respond when an aircraft flyover occurs.

- *Sound Exposure Level (SEL*). The SEL is another metric reported for aircraft flyovers. It is computed from dBA sound levels or the area within 10 dB of the maximum noise level, which is the area from where SEL is computed (referring again to the shaded area at the top of **Figure 2-6**). The SEL value is the integration of all the acoustic energy contained within the event. Speech and sleep interference research can be assessed relative to SEL data. This metric takes into account the maximum noise level of the event and the duration of the event. For aircraft flyovers, the SEL value is typically about 10 dBA higher than the maximum noise level. Single event metrics are a convenient method for describing noise from individual aircraft events. This metric is useful in that airport noise models contain aircraft noise curve data based upon the SEL metric. In addition, cumulative noise metrics such as LEQ and DNL can be computed from SEL data.

Figure 2-6
Examples of Lmax, SEL, Leq, and DNL Noise Levels
Flightseeing Noise Assessment -- City and Borough of Juneau



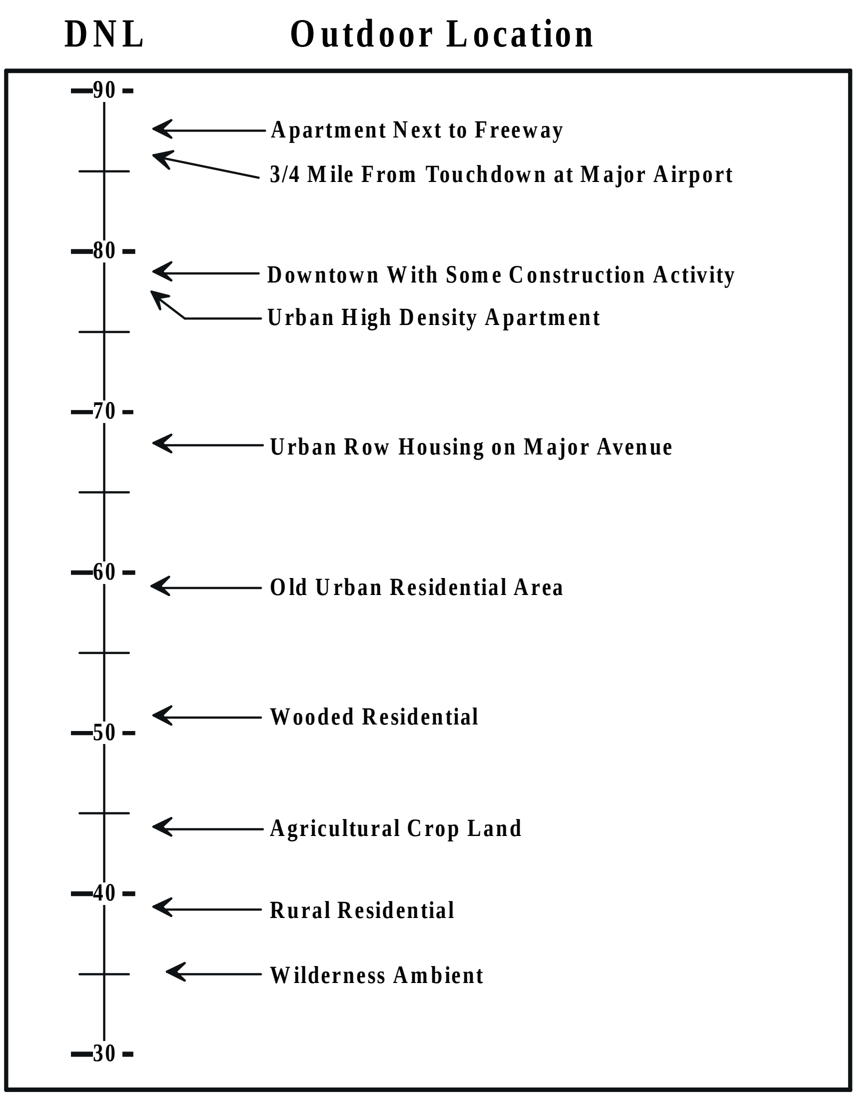
2.5.2 Cumulative Metrics

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 single number rating scale. They are designed to account for the known health effects of noise on people described earlier.

- *Equivalent Noise Level (LEQ)*. LEQ is the sound level corresponding to a steady-state A-weighted sound level containing the same total energy as a time-varying signal 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 from the total acoustical energy content. This is graphically illustrated in the middle graph of **Figure 2-6**. 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 Day Night Noise Level (DNL) values for aircraft operations.

- *Day Night Noise Level (DNL)*. The DNL index is a measure of the overall noise experienced during an entire (24-hour) day; which includes time-weighted energy average noise level based on the A-weighted decibel. Time-weighted refers to the fact that noise that occurs during certain sensitive time periods and is penalized for occurring at these times. In the DNL scale, noise occurring between the hours of 10 p.m. to 7 a.m. is penalized by 10 dB. This penalty was selected to account for the higher sensitivity to noise in the nighttime and the expected further decrease in background noise levels that typically occur at night. DNL is specified by the FAA for community and airport noise assessment as well as the Environmental Protection Agency (EPA). DNL is graphically illustrated in the bottom of **Figure 2-6**. Examples of various noise environments in terms of DNL are presented in **Figure 2-7**.

Figure 2-7
Typical Outdoor Noise Levels in Terms of DNL
Flightseeing Noise Assessment -- City and Borough of Juneau



2.5.3 Supplemental Metrics

- *Time Above (TA).* The FAA developed the Time Above metric as a second metric for assessing impacts of aircraft noise around airports. The Time Above index refers to the total time in seconds or minutes that aircraft noise exceeds certain dBA noise levels in a 24-hour period. It is typically expressed as Time Above 75 and 85 dBA sound levels. While this index is not widely used, it may be used by the FAA in environmental assessments of airport projects that show a significant increase in noise levels. There are no noise/land use standards in the Time Above index.

  The Time Above Certain levels can be used to illustrate the time that noise is above potential thresholds of disturbance. One such threshold is the Time Above 65 dBA, which generally represents the time when noise is above the level for which outdoor speech interference starts to occur. This metric will be used in the Juneau flightseeing noise study.

- *Percent Noise Level (L_N).* The PNL characterizes noise while accounting for intermittent or fluctuating noise. This level is the one that is exceeded n% of the time during the measurement period. It is usually measured in the A-weighted decibel, but can be an expression of any noise rating scale. Percent Noise Levels are another method of characterizing ambient noise where, for example, L_{90} is the noise level exceeded 90 percent of the time, L_{50} is the level exceeded 50 percent of the time, and L_{10} is the level exceeded 10 percent of the time. L_{90} represents the background or minimum noise level; L_{50} represents the median noise level, and L_{10} the peak or intrusive noise levels. Percent noise level is commonly used in community noise ordinances that regulate noise from mechanical equipment, entertainment noise sources, and the like. It is not normally used for transportation noise regulation (although the FHWA Leq criteria for roadways was originally stated as an L_{10} criteria).

  The Percent Noise Level can also be used to represent the ambient noise environment. The L90 noise level is commonly used to illustrate the ambient or background noise when other noise sources are not present. For the Juneau flightseeing noise study, the L90 is used to represent the background or ambient noise environment.

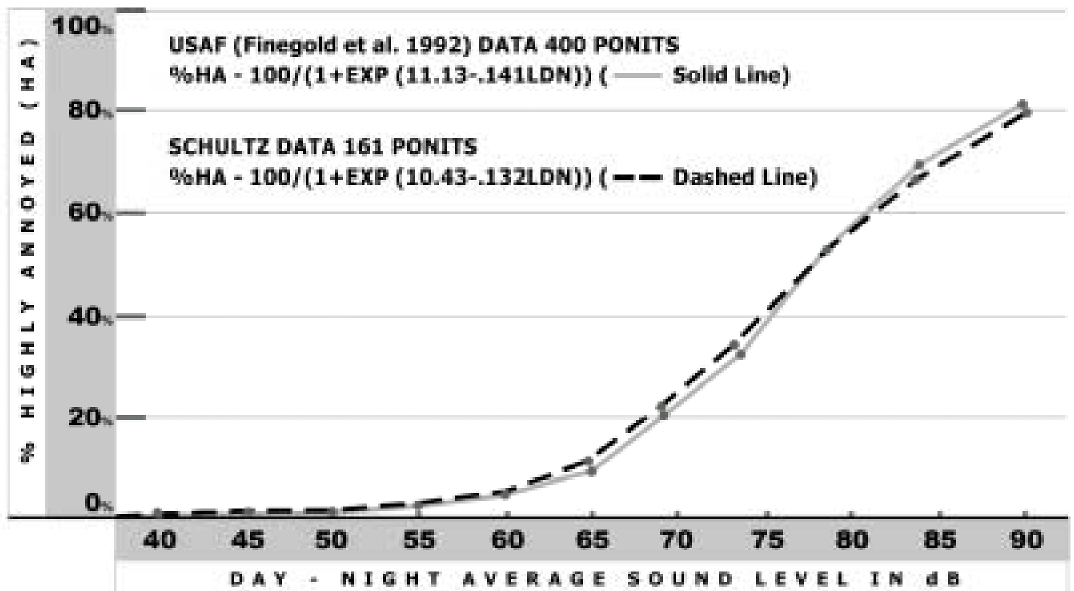
2.6 Noise/Land Use Compatibility Standards and Guidelines

Noise metrics are used to quantify community response to various noise exposure levels. Estimates of public reaction to noise is based on extensive research on human response to different levels of aircraft noise. **Figure 2-8** relates DNL noise levels to community response from one of these surveys. Community noise standards are derived from tradeoffs between community response surveys, such as this, and economic considerations for achieving these levels. These standards generally are in terms of the DNL 24-hour averaging scale that is based upon the A-weighted decibel. Utilizing these metrics and surveys, agencies developed standards for assessing the compatibility of various land uses with the noise environment.

Note, this research was developed around major airports exposed to jet aircraft noise, and not from helicopter dominated situations, which may have impacts on the Juneau situation.

The purpose of this section is to present information regarding noise and land use criteria that may be useful evaluating noise impacts. With respect to airports, the Federal Aviation Administration has a long history of publishing noise/land use assessment criteria. These laws and regulations provide the basis for local development of airport plans, analyses of airport impacts, and the enactment of compatibility policies.

Figure 2-8
Example of Community Reaction to Aircraft Noise
Flightseeing Noise Assessment -- City and Borough of Juneau



USAF	0.40	0.831	1.66	3.31	6.48	12.29	22.1	36.47	53.74	70.16	82.64
SCHULTZ	0.576	1.11	2.12	4.03	7.52	13.59	23.32	37.05	53.25	68.78	81.00

CALCULATED % HIGHLY ANNOYED (HA) POINTS

The most common noise/land use compatibility standard or criteria used is 65 dB DNL for residential land use with outdoor activity areas. At 65 dB DNL the Schultz curve predicts approximately 14% of the exposed population to be highly annoyed. At 60 dB DNL this decreases to approximately 8% of the population highly annoyed. Further, the data upon which the Schultz curve and recent updates include a wide range of data that depict a compilation of communities scattered around some of the airports, which report a noise exposure level that has a larger percentage in that population, resulting in highly annoyed areas. A summary of pertinent regulations and guidelines are presented below:

- *Federal Aviation Regulations, Part 36, "Noise Standards: Aircraft Type and Airworthiness Certification"*

  Originally adopted in 1960, FAR Part 36 prescribes noise standards for issuance of new aircraft type certificates; it also limited 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, or Stage 3 aircraft based on their noise level, weight, number of engines and in some cases number of passengers. Stage 1 aircraft are no longer permitted to operate in the U.S. Stage 2 aircraft are being phased out of the U.S. fleet as discussed in a later paragraph on the Airport Noise and Capacity Act of 1990. Although aircraft meeting Part 36 standards are noticeably quieter than many of the older aircraft, the regulations make no determination that such aircraft are acceptably quiet for operation at any given airport.

- *Federal Aviation Regulations, Part 150, "Airport Noise Compatibility Planning"*

  As a means of implementing the Aviation Safety and Noise Abatement Act, the FAA adopted Regulations on Airport Noise Compatibility Planning Programs. These regulations are spelled out in FAR Part 150. As part of the FAR Part 150 Noise Control program, the FAA published noise and land use compatibility charts to be used for land use planning with respect to aircraft noise. An expanded version of this chart appears in Aviation Circular 150/5020-1 (dated August 5, 1983) and is reproduced in **Figure 2-9**. These guidelines offer recommendations to local authorities 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 will be considered acceptable or compatible to people in living and working areas.

Figure 2-9
FAA FAR Part 150 Noise Compatibility Guidelines
Flightseeing Noise Assessment -- City and Borough of Juneau

Land Use	Yearly Day-Night Average Sound Level (Ldn) 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
Amusement parks, resorts and camps	Y	Y	Y	N	N	N
Golfcourses, 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 or 25, 30, or 35 dB must be incorporated into design and construction of the 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 and 30 dB should be incorporated into building codes and be considered in individual approvals. Normal residential construction can be expected to provide an 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 recieved, office areas, noise sensitive areas or where the normal noise level is low.

(5) Land use compatible provided 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 permited.

SOURCE: FAR Part 150

These noise levels are derived from case histories involving aircraft noise problems at civilian and military airports and the resultant community response. Note that residential land use is deemed acceptable for noise exposures up to 65 dB DNL. Recreational areas are also considered acceptable for noise levels above 65 dB DNL (with certain exceptions for amphitheaters, which are recommended not to exceed 65 dB DNL). Several important notes appear for the FAA guidelines including one that ultimately indicates "the responsibility for determining the acceptability and permissible land uses remains with the local authorities."

- *Federal Aviation Order 5050.4 and Directive 1050.1 for Environmental Analysis of Aircraft Noise Around Airports*

  The FAA has developed guidelines (Order 5050.4A) for the environmental analysis of airports. Federal requirements now dictate that increases in noise levels in more sensitive land uses of over 1.5 dB DNL within the 65 dB DNL contour are considered significant (1050.1D Directive 12.21.83). The FAA only are concerned for the noise impacts that occur at the 65 dB DNL or greater. No analysis is required beyond the 65 dB DNL.

- *Airport Noise and Capacity Act of 1990*

  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); Stage 3 aircraft are newer, quieter aircraft (B-737-300, B-757, MD-80/90). To implement ANCA, FAA amended Part 91, which address the phase-out of large Stage 2 aircraft and the phase-in of Stage 3 aircraft. In addition, Part 91 generally states that all Stage 2 aircraft over 75,000 pounds, will be removed from the domestic fleet by December 31, 1999. There are a few exceptions but only Stage 3 aircraft greater than 75,000 pounds will be in the domestic fleet after that date. The airlines have options on how and when to phase-out Stage 2 aircraft, but it is anticipated that the mainland domestic fleet will be all Stage 3 aircraft by the year 2000.

  Furthermore, Part 161 was a new issuance established with a more stringent review and approval process for implementing use or access restrictions by airport proprietors. Part 161 sets out the requirements and procedures for implementing new airport use and access restrictions by airport proprietors. They must use the DNL metric to measure noise effects, and the Part 150 land use guideline table, including 65 dB DNL as the threshold contour, which is used to determine compatibility, unless there is a locally adopted standard that is more detailed.

Part 161 identifies three types of use restrictions and treats each one differently: negotiated restrictions, Stage 2 aircraft restrictions and Stage 3 aircraft restrictions. Generally speaking, any use restriction which affects the number or times of aircraft operations will be considered an access restriction. Even though the Part 91 phase-out does not apply to aircraft under 75,000 pounds, FAA has determined that Part 161 limitations on proprietors' authority also apply to smaller aircraft.

Negotiated restrictions are more favorable from the FAA's standpoint, but still require complex procedures for approval and implementation: they must be agreed upon by all airlines, and public notice must be given.

Stage 2 restrictions are more difficult, as one of the major reasons for ANCA was to discourage local restrictions more stringent that the ANCA's 1999 phase-out. To comply with the regulation and institute a new Stage 2 restriction, the proprietor must generally do two things. It must prepare a cost/benefit analysis of the proposed restriction and give proper notice. The cost/benefit analysis is extensive and entails considerable evaluation. Stage 2 restrictions do not require approval by the FAA.

Stage 3 restrictions are especially difficult to implement. A Stage 3 restriction involves considerable additional analysis, justification, evaluation and financial discussion. In addition, a Stage 3 restriction must result in a decrease in noise exposure of the 65 dB DNL to noise sensitive land uses (residences, schools, churches, parks). The regulation requires both public notice and FAA approval.

ANCA applies to all local noise restrictions that are proposed after October 1990, and to amendments to existing restrictions proposed after October 1990.

- *Federal Interagency Committee on Noise (FICON) Report of 1992 [13]*

The use of the DNL metric and the 65 dB CNEL criteria has been subject to criticism from various interest groups concerning its usefulness in assessing aircraft noise impacts. As a result, at the direction of the EPA and the FAA, the Federal Interagency Committee On Noise (FICON) was formed to review specific elements of the assessment on airport noise impacts and to recommend procedures for potential improvements. FICON is composed of representatives from the Departments of Transportation, Defense, Justice, Veterans Affairs, Housing and Urban Development, the Environmental Protection Agency, and the Council on Environmental Quality.

The FICON review focused primarily on the manner in which noise impacts are determined. This includes whether aircraft noise impacts are fundamentally different from other transportation noise impacts; the manner in which noise impacts are described; and the extent of impacts outside of Day-Night Average A-Weighted Sound Level (DNL) 65 decibels (dB) that should be reviewed in a National Environmental Policy Act (NEPA) document.

The committee determined there are no new descriptors or metrics of sufficient scientific standing to substitute for the present DNL cumulative noise exposure metric. In the general vicinity of airports, the DNL method, which allows the noise exposure metric and appropriate dose-response relationships to determine the noise impact, is considered the proper one for civil and military aviation scenarios. The report does support agency discretion in the use of supplemental noise analysis, recommends public understanding of the DNL and supplemental methodologies, as well as aircraft noise impacts.

If screening analysis reflects a noise-sensitive area at or above DNL 65 dB, then this would have an increase of DNL 1.5 dB and further analysis should be conducted of noise sensitive areas between DNL 60-65 dB, which have an increase of DNL 3 dB or more due to the proposed airport noise exposure.

- *Environmental Protection Agency Noise Assessment Guidelines*

  Environmental Protection Agency, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety".

  In March 1974 the EPA published "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety" (EPA 550/9-74-004). In this document, 55 DNL is described as the requisite level with an adequate margin of safety for areas with outdoor uses. This includes residences, and recreational areas. This document does not constitute EPA regulations or standards. Rather, it is intended to "provide State and Local governments as well as the Federal Government and the private sector with an informational point of departure for the purpose of decision-making". Note that these levels were developed for suburban uses. In some urban settings, the noise levels will be significantly above this level, while in some wilderness settings, the noise levels will be well below this level. While this "levels document" does not constitute a standard, specification or regulation, it does identify safe levels of environmental noise exposure without consideration for economic cost for achieving these levels.

- *Studies of Aircraft Noise Impacts on National Parks*

  The National Park Service (NPS) has sponsored several recent studies on the impacts of aircraft noise, especially on national parks. These studies are described in the Report to Congress by the NPS in 1994, and in the report of Harris Miller Miller & Hanson in 1994. Major results are summarized below.

  One of the major issues discussed by the 1994 Report to Congress concerned the appropriate measure of impact. Contrary to the vast literature available regarding impacts of airport noise and their measurements of annoyance that were found near major metropolitan airports, the National Park Service argued that the amount of interference with enjoyment of natural quiet would be the most appropriate quantity to measure. A primary reason for visiting national parks is experiencing a soundscape generated by the natural world in the absence of human mechanical devices, which is both qualitatively different and usually much quieter than typical urban or suburban soundscapes. Thus, "natural quiet" was argued to be a resource whose preservation was mandated by Congress when it created the NPS.

  Measurements of interference with enjoyment of natural quiet can be made with similar precision to those of noise annoyance. When the same categories of the respective scales are included, the two are reasonably correlated although not identical. However, it was recommended that a wider range of survey respondents be included among those considered to be "impacted" in the national park context than is usually done with respondents near major airports. Noise impact near major airports is usually expressed as "percent highly annoyed," comprising the survey respondents who indicated that they were either "very" or "extremely" annoyed by the noise. The NPS argued that when natural quiet is an issue, this group should be broadened to include visitors reporting either "moderate," "very much," or "extreme" interference in reference to their enjoyment of natural quiet. The results of several social surveys on park visitors concurred that for any given level of noise exposure, referencing moderate to extreme annoyance, the amount of interference with enjoyment of the natural quiet is usually greater than that of annoyance.

  In addition to making the case for measuring interference with enjoyment of natural quiet, the Report to Congress summarized the findings of several important surveys of noise impact in national parks, including exit surveys of most of the major parks in the system. Among the relevant general results are the following:

  First, according to the McDonald, Baumgartner and Iachan's visitor survey (1994), overall approximately 20% of visitors to national parks heard aircraft during their visit, and approximately 2-3 % of visitors were annoyed by hearing aircraft or reported that it interfered with their appreciation of natural quiet. The number of aircraft heard and the annoyance levels reported varied widely across the parks that were surveyed.

Second, site-specific surveys in a few parks (Anderson et al, 1993) permitted development of dose-response curves that verified in the park context a relationship between exposure and annoyance or interference with natural quiet similar to that established for airport noise surveys by Schultz (1978) and modified several times since then (see FICON, 1992). In these curves, the amount of annoyance or interference increases with the percent of the time aircraft are audible and also with the 1-hour Leq. Moreover, such site-specific surveys often measured more annoyance in reference to specific overflights during a specific short time period than did the exit surveys in reference to overflights encountered in the context of an entire visit to the park. Also, in these surveys, measured annoyance was usually less than measured interference with natural quiet at any given level of aircraft audibility. Based on the dose response curves, the NPS suggested that in a generic park environment a maximum acceptable percentage of visitors impacted would be in the range of 20% to 30% (Report to Congress, 1994).

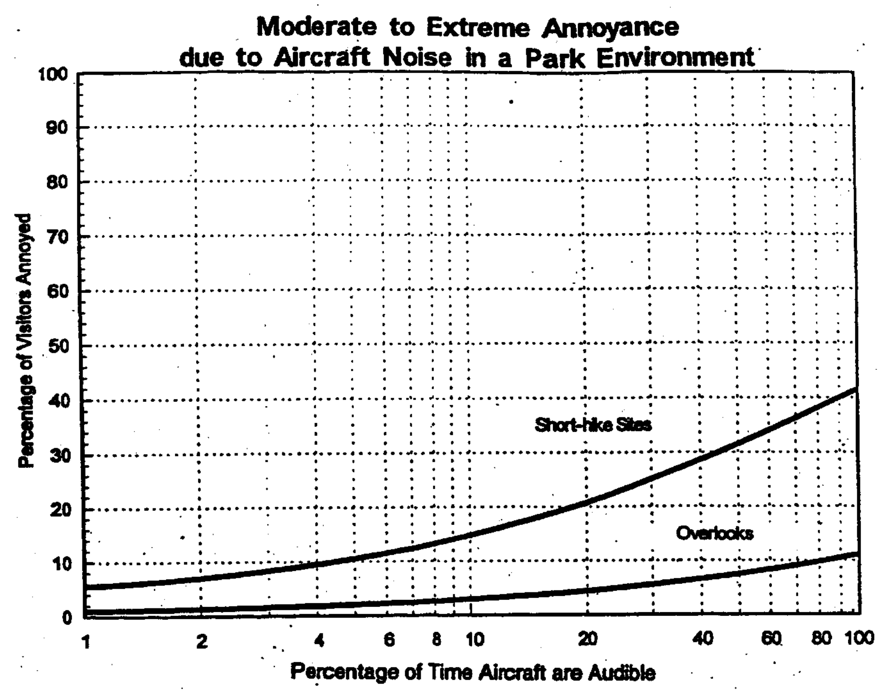
Finally, based on mail-in and exit surveys of backcountry permit users, the Report to Congress (1994) concluded these park users are considerably more sensitive to noise impacts than are others. In one survey (McDonald et al, 1994), 72% of back country permit holders contacted by mail reported they had heard aircraft during their visit; 35% reported being annoyed by this and 46% reported it interfered with their enjoyment of natural quiet. In contrast, only 22% of “front country users” surveyed as they exited a park reported hearing aircraft, with 3% reporting annoyance and 5% reporting experiencing interference with natural quiet. In exit survey of “back country users” 43 % reported hearing aircraft, 10% reported annoyance and 12% reporting experiencing interference with natural quiet.

The report by Harris Miller Miller & Hanson (1994) performed four tasks (not included in the Report to Congress). First, they reviewed and updated the dose-response curves they had reported earlier (and that had been used in the Report to Congress, 1994), with particular attention to their ability to predict visitor responses to aircraft noise based on standardized dose metrics such as hourly equivalent sound level. Second, they measured aircraft noise at Grand Canyon National Park and compared the measured values with those predicted by the FAA’s Integrated Noise Model (INM). Third, they validated the INM’s ability to predict exposure metrics such as hourly equivalent noise level. Finally, they were able to validate the model used by the NPS to predict noise levels anywhere in a park using a simulated flyby based on an aircraft noise source database and a terrain database.

The Park Service study developed Dose-response curves based upon surveys conducted in various national parks. These curves present methods for estimating impacts from aircraft overflights. These Dose-response curves are similar to the curves developed for traditional airport studies, except they utilize different noise metrics and are based upon surveys of visitors in park settings. These curves are defined by the percentage of time aircraft are audible and in terms of the hourly equivalent sound level (LEQ). The Dose-response curves can be used to predict the percentage of visitors that would experience moderate to extreme annoyance due to aircraft noise in a park environment. These curves are designed to measure the preservation of visitor enjoyment and are presented in **Figure 2-10**. Note that these are impact measures proposed by the National Park Service for aircraft noise in National Parks. They are not applicable for use in other settings, such as residential land uses or other non-park settings.

Figure 2-10
NPS Dose-Response Curves for Estimating Impacts at Sites Preserving Visitor Enjoyment
Flightseeing Noise Assessment -- City and Borough of Juneau

Impacts Based upon Percentage of Time Aircraft are Audible



Impacts Based upon Hourly Equivalent Sound Level