Aircraft Noise

(Excerpt from the Oakland International Airport Master Plan Update – 2006)

Background

This report presents background information on the characteristics of noise. Noise analyses involve the use of technical terms that are used to describe aviation noise. This section provides an overview of the metrics and methodologies used to assess the effects of noise.

Characteristics of Sound

***Sound Level and Frequency* —** Sound can be technically described in terms of the 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.

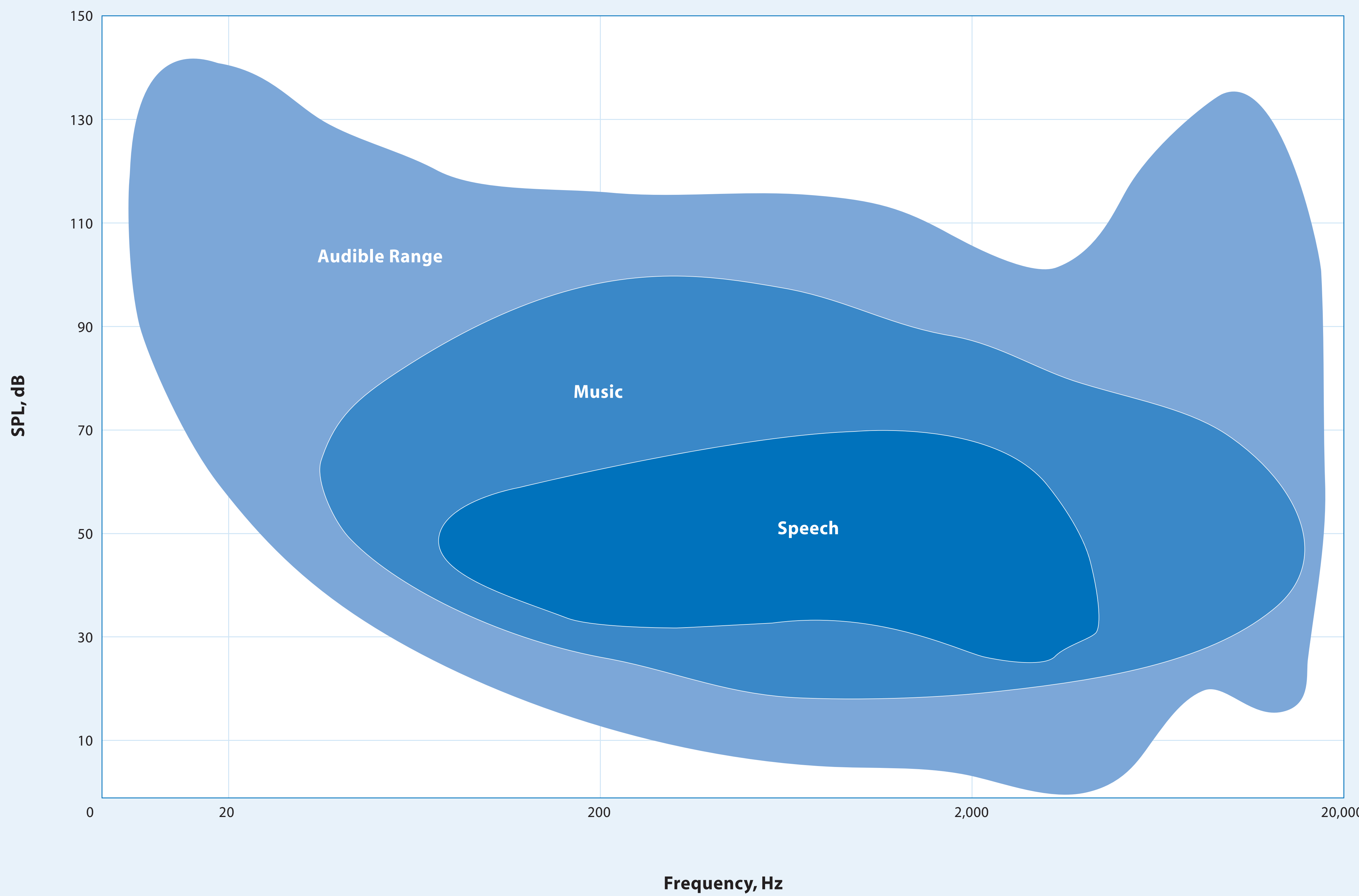
The range of sound pressures that occur in the environment is so large that it is convenient to express these pressures as sound pressure levels on a logarithmic scale that compresses the wide range of sound pressures to a more usable range of numbers. The standard unit of measurement of sound is the Decibel (dB) that describes the pressure of a sound relative to a reference pressure.

The frequency (pitch) of a sound is expressed as Hertz (Hz) or cycles per second. The normal audible frequency for young adults is 20 Hz to 20,000 Hz. Community noise, including aircraft and motor vehicles, typically ranges 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. See **Figure 6.2**. As a result of this, various methods of frequency weighting have been developed. 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. **Figure 6.3** shows the A-weighted scale compared to other scales such as the C-weighted scale, which is more sensitive to low frequency noise and used in assessing hearing loss in occupational or recreational exposures to noise. The C-weighted scale has also been used to quantify low frequency noise in the environment, but such use is crude and can be misleading. Changes in C-weighted scale noise do not mean changes in low frequency noise. The C-weighted scale also measures higher frequency sounds, and therefore a change in the C-weighted scale measurement could be due to low or high frequency sounds. If low frequency noise impacts are to be identified, measurements in frequency bands are the best method of defining low frequency noise.

***Sources of Aircraft Noise* —** The noise generated by an aircraft flight is quite complex. The sound sources can be described in four broad categories: jet noise (the mixing of high velocity exhaust gases with ambient air), combustor noise (the noise associated with the rapid oxidation of jet fuel and

Figure 6.2

Sound and Noise — What We Hear



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Sound and Noise — What We Hear

L E G E N D

Acronyms

dB Decibels
Hz Hertz
SPL Sound Pressure Level

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Sound and Noise — Frequency Weighting

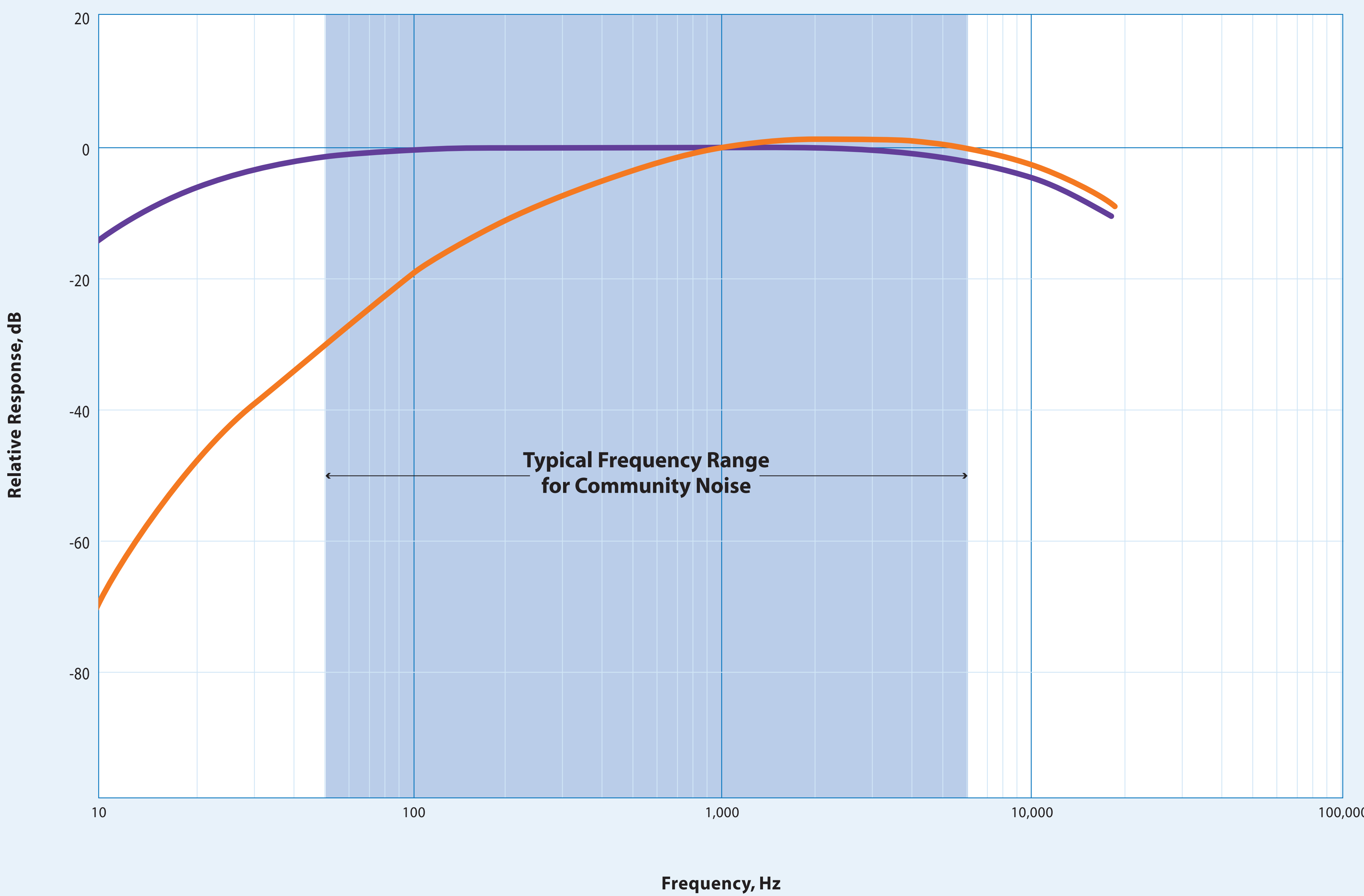

Figure 6.3

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Sound and Noise — Frequency Weighting

L E G E N D

- A Weighted
- C Weighted

Frequency Weighting is an effort to approximate the sensitivity of the human ear. The human ear is not equally sensitive to all frequencies.

Weighted Decibel Scales
The A-weighted decibel scale (dBA) discriminates 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. The C-weighted decibel scale is used in assessing hearing loss in occupational or recreational exposures to noise and is more influenced by low frequency noise than the A-weighted scale.

Acronyms

dB Decibels
Hz Hertz

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the associated release of energy), turbomachinery noise (often noticed as an aircraft is coming towards you), and aerodynamic noise (the noise associated with rapid air movement over the airframe and control surfaces). New technologies in modern aircraft have achieved significant reductions in jet noise and combustor noise. Turbomachinery noise has also been reduced in newer aircraft. Aerodynamic noise is a current area of acoustic research to reduce aircraft noise. As jet noise, combustor noise and turbomachinery noise are reduced, aerodynamic noise may remain as the major noise source on aircraft of the future.

***Propagation of Noise* —** Outdoor sound levels decrease as the distance from the source increases, and as a result of wave divergence, atmospheric absorption and ground attenuation. Sound radiating from a source in a homogeneous and undisturbed manner travels in spherical waves. As the sound wave travels away from the source, the sound energy is dispersed over a greater area decreasing the sound power of the wave. Spherical spreading of the sound wave reduces the noise level at a rate of 6 dB per doubling of the distance.

Atmospheric absorption also influences the levels 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 varies depending on the frequency of the sound as well as the humidity and temperature of the air. For example, atmospheric absorption is lowest (i.e., sound carries farther) at high humidity and high temperatures. Schematic atmospheric effects diagrams are presented in **Figure 6.4**. Turbulence and gradients of wind, temperature and humidity play a significant role in determining the propagation of sound over a large distance. At short distances between the source and receiver, atmospheric effects are minimal. Certain conditions, such as inversions, can channel or focus the sound waves resulting in higher noise levels than would result from simple spherical spreading. Absorption effects in the atmosphere vary with frequency. The higher frequencies are more readily absorbed than the lower frequencies. Over large distances, the lower frequencies become the dominant sound as the higher frequencies are attenuated.

The effect of sound reflecting across a water surface has an even more profound effect than weather. Sound propagating over water is louder than propagating over land as the result of the reflective characteristics of water. Shielding of noise by a structure also can have significant effects on noise. Structures such as buildings, homes, sound walls, etc., block the straight line propagation of sound. Homes shielded by these structures receive a lower noise level than without the intervening structures.

***Duration of Sound* —** Annoyance from a noise event increases with increased duration of the noise event (i.e., the longer the noise event, the more annoying it is). 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 the relationship between duration and annoyance and the amount 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

Effects of Weather on Sound

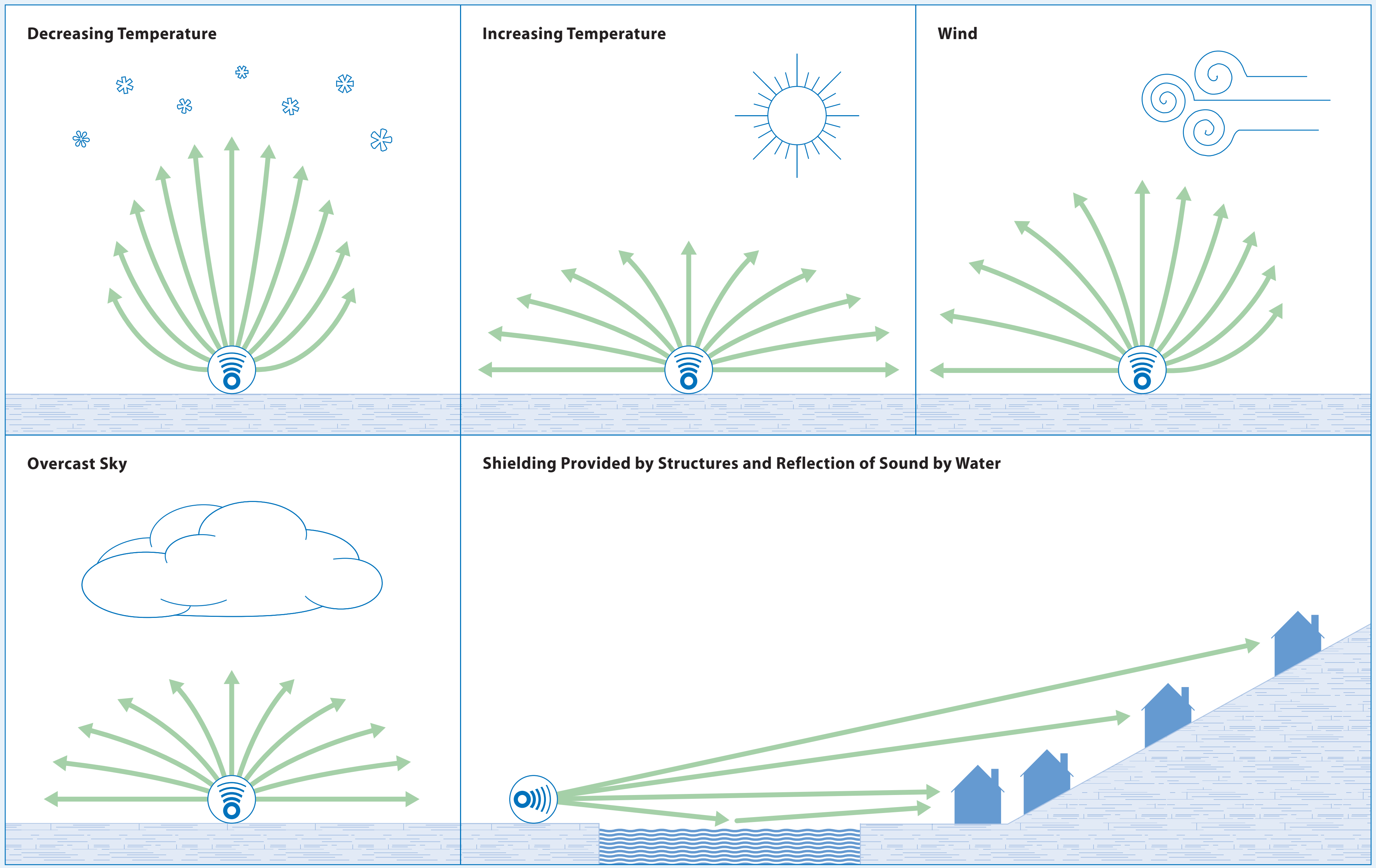

Figure 6.4

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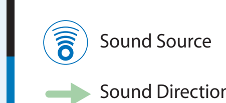
Effects of Weather on Sound

LEGEND



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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. Defined in the **Sound Rating Scales** section below, noise metrics such as CNEL, DNL, Leq and SEL are all based upon the equal energy principle.

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 that can be changed to slightly different sound levels, a person can just barely detect a sound level change of approximately 1 decibel for sounds in the mid-frequency region. When ordinary noises are heard, a young healthy ear can detect changes of two to 3 decibels. A 5 decibel change is readily noticeable while a 10 decibel change is judged by most people as a doubling or a halving of the loudness of the sound. It is typical in environmental documents to consider a 3 dB change as potentially discernable.

Sound Rating Scales

The description, analysis, and reporting of community sound levels is made difficult by the complexity of human response to sound and myriad of sound-rating scales and metrics developed to describe acoustic effects. Various rating scales approximate the human subjective assessment to the "loudness" or "noisiness" of a sound. Noise metrics have been developed to account for additional parameters such as duration and cumulative effect of multiple events.

Noise metrics are categorized as single event metrics and cumulative metrics. Single event metrics describe the noise from individual events, such as one aircraft flyover. Cumulative metrics describe the noise in terms of the total noise exposure throughout the day. Commonly used noise metrics are summarized below.

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. Its advantages are that it has shown good correlation with community response and is easily measured. The metrics used in most aircraft noise studies 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. Then as the aircraft passes, the noise level decreases until the sound level again settles to ambient levels. Such a history of a flyover is plotted at the top of **Figure**

6.5. It is this metric to which people generally instantaneously respond when an aircraft flyover occurs.

Single Event Noise Exposure Level (SENEL) or Sound Exposure Level (SEL) — Another metric that is reported for aircraft flyovers is the Sound Exposure Level (SEL). This metric is essentially equivalent to the metric Single Event Noise Exposure Level (SENEL). It is computed from dBA sound levels. Referring to Figure 6.5, the shaded area, or the area within 10 dB of the maximum noise level, is the area from which the SEL is computed. 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 Sound Exposure Level data.

The SEL 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, CNEL and DNL can be computed from SEL data.

Cumulative Metrics

Cumulative noise metrics assess community response to noise by including the loudness of the noise, the duration of the noise, the total number of noise events, and the time of day these events occur into one single number rating scale.

Equivalent Noise Level (Leq) — Leq is the sound level corresponding to a steady-state A-weighted sound level containing the same total energy as several SEL events during a given sample period. Leq is the “energy” average noise level during the time period of the sample. It is based on the observation that the potential for noise annoyance is dependent on the total acoustical energy content of the noise. This is graphically illustrated at the top of **Figure 6.6**. Leq can be measured for any time period, but is typically measured for 15 minutes, 1 hour, or 24 hours. Leq for a 1-hour period is used by the Federal Highway Administration for assessing highway noise impacts. Leq for 1 hour is called Hourly Noise Level (HNL) in the California Airport Noise Regulations and is used to develop Community Noise Equivalent Level (CNEL) values for aircraft operations.

Community Noise Equivalent Level (CNEL) — CNEL is a 24-hour, time-weighted energy average noise level based on the A-weighted decibel. It is a measure of the overall noise experienced during an entire day. The term “time-weighted” refers to the penalties attached to noise events occurring during certain sensitive time periods. In the CNEL scale, noise occurring between 7 PM and 10 PM is penalized by approximately 5 dB. This penalty accounts for the greater potential for noise to cause communication interference during these hours, as well as typically lower ambient noise levels during these hours. Noise that takes place during the night (10 PM to 7 AM) is penalized by 10 dB. This penalty was selected to attempt to account for the higher sensitivity to noise in the nighttime and the expected further decrease in background noise levels that typically occur in the nighttime.

CNEL is graphically illustrated in the bottom of **Figure 6.6**. Another way to think of a cumulative noise

Sound Exposure Level (SEL), Maximum Noise Level (Lmax) and Duration

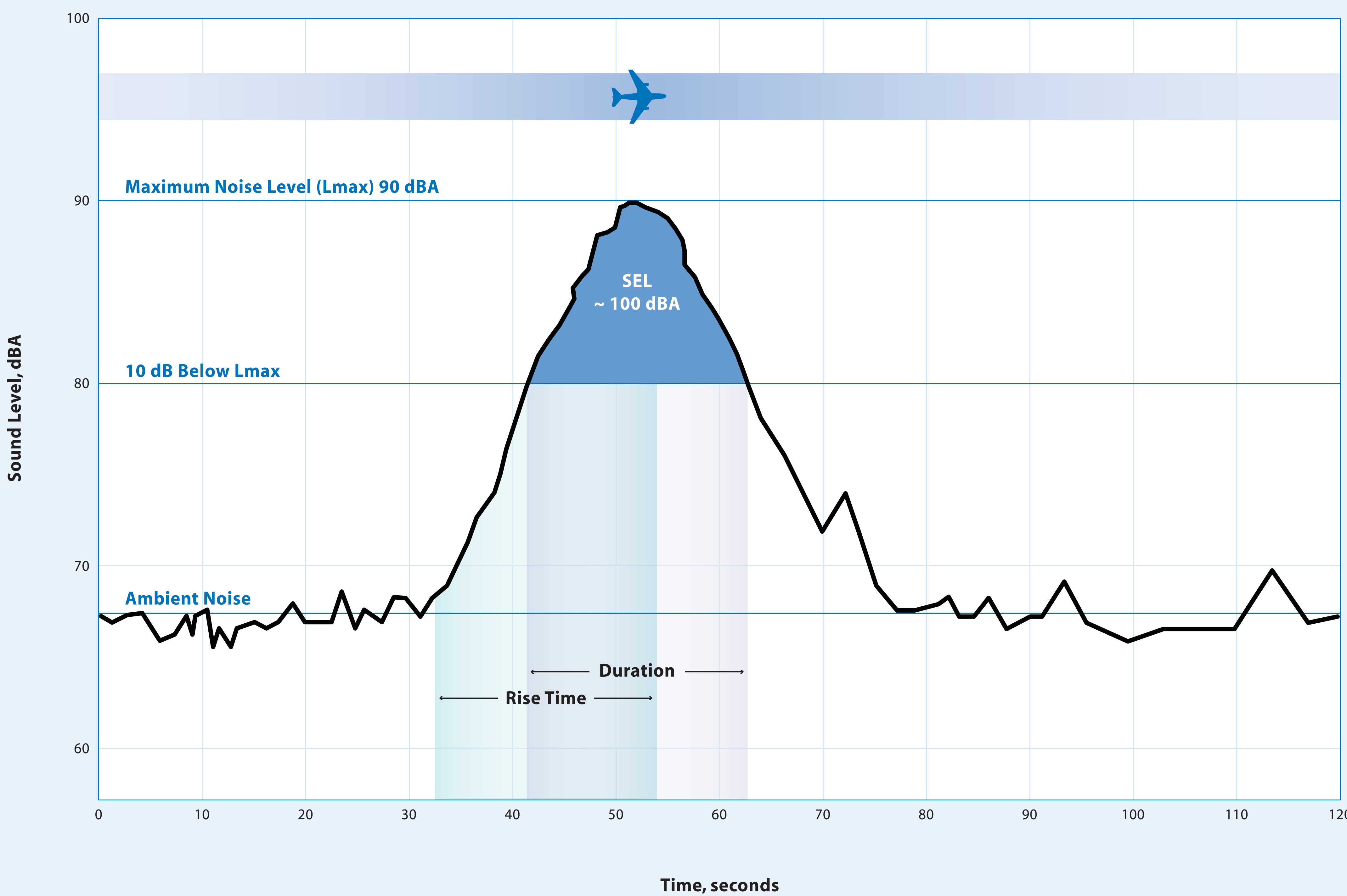

Figure 6.5

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Sound Exposure Level, Maximum Noise Level and Duration

L E G E N D

Acronyms

dB	Decibels
dBA	A-Weighted Decibels
Lmax	Maximum Noise Level
SEL	Sound Exposure Level

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Figure 6.6

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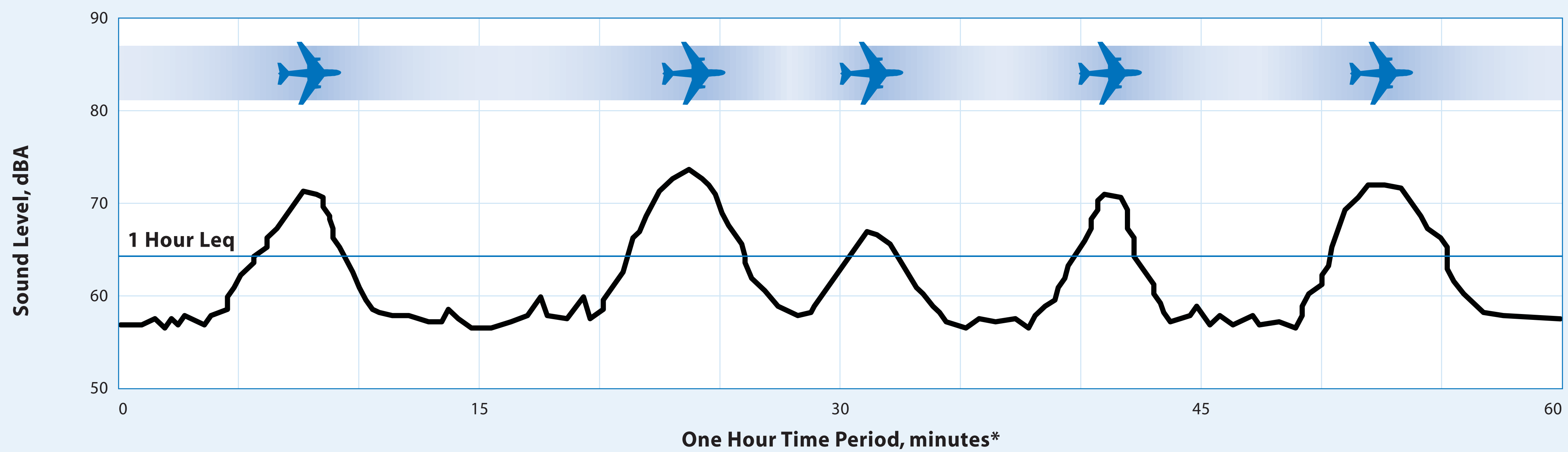
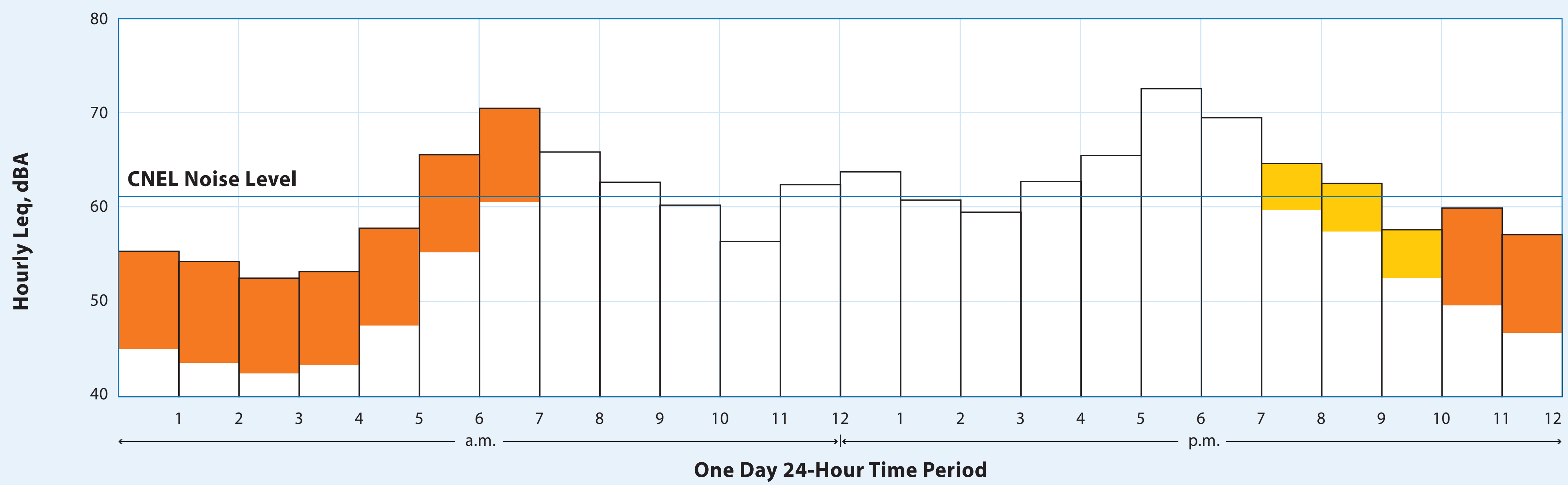
Noise Metrics

Noise Metrics





LEGEND

- Hourly Leq's (No Penalty)
- 5 dB Evening Penalty
- 10 dB Nighttime Penalty

Time Periods	
Day	7 am – 7 pm
Evening	7 pm – 10 pm
Night	10 pm – 7 am

* Time Axis not drawn to scale, Aircraft Events are much shorter than shown here

Acronyms

CNEL	Community Noise Equivalent Level
dB	Decibels
dBA	A-Weighted Decibels
Leq	Equivalent Noise Level

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metric like CNEL is to compare CNEL to a “noise bucket.” Each single event noise event contributes to the overall “noise bucket.” An event during evening hours counts as 3 events and an event at night counts as 10 events. This is shown schematically in **Figure 6.7**. Examples of various noise environments in terms of CNEL are presented in **Figure 6.8**. CNEL is specified for use in the California Airport Noise Regulations and is used by local planning agencies in their General Plan Noise Element for land-use compatibility planning.

Day Night Noise Level (DNL) — The DNL index is very similar to CNEL but does not include the evening (7 PM to 10 PM) penalty that is included in CNEL. It does however include the nighttime (10 PM to 7 AM) penalty. Typically DNL is about 1 dB lower than CNEL, although the difference may be greater if there is an abnormal concentration of noise events in the 7 AM to 10 PM time period. DNL is specified by the FAA for airport noise assessment and by the Environmental Protection Agency (EPA) for community noise and airport noise assessment. The FAA guidelines (described later) allow for the use of CNEL as a substitute to DNL.

Factors Influencing Human Response To Sound

Many factors influence sound perception and annoyance. 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, describes human response to sound in terms of both acoustic and non-acoustic factors. These factors are summarized in **Table 6.1**.

Factors That Affect Individual Annoyance to Noise — **Table 6.1**

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

Source: C. Harris 1979

Sound rating scales are developed in reaction to the factors affecting human response to sound. Nearly all of these factors are relevant in describing how sounds are perceived in the community. Many non-acoustic parameters play a prominent role in affecting individual response to noise. Fields, in his analysis of personal and situational variables on noise annoyance, has identified a clear association of reported annoyance and various other individual perceptions or beliefs. In particular, Fields 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.

Single Event Noise to Cumulative Noise (CNEL)

$$SEL + 10\log(1 \times Ops_{day} + 3 \times Ops_{evening} + 10 \times Ops_{night}) - 49.4 = CNEL$$

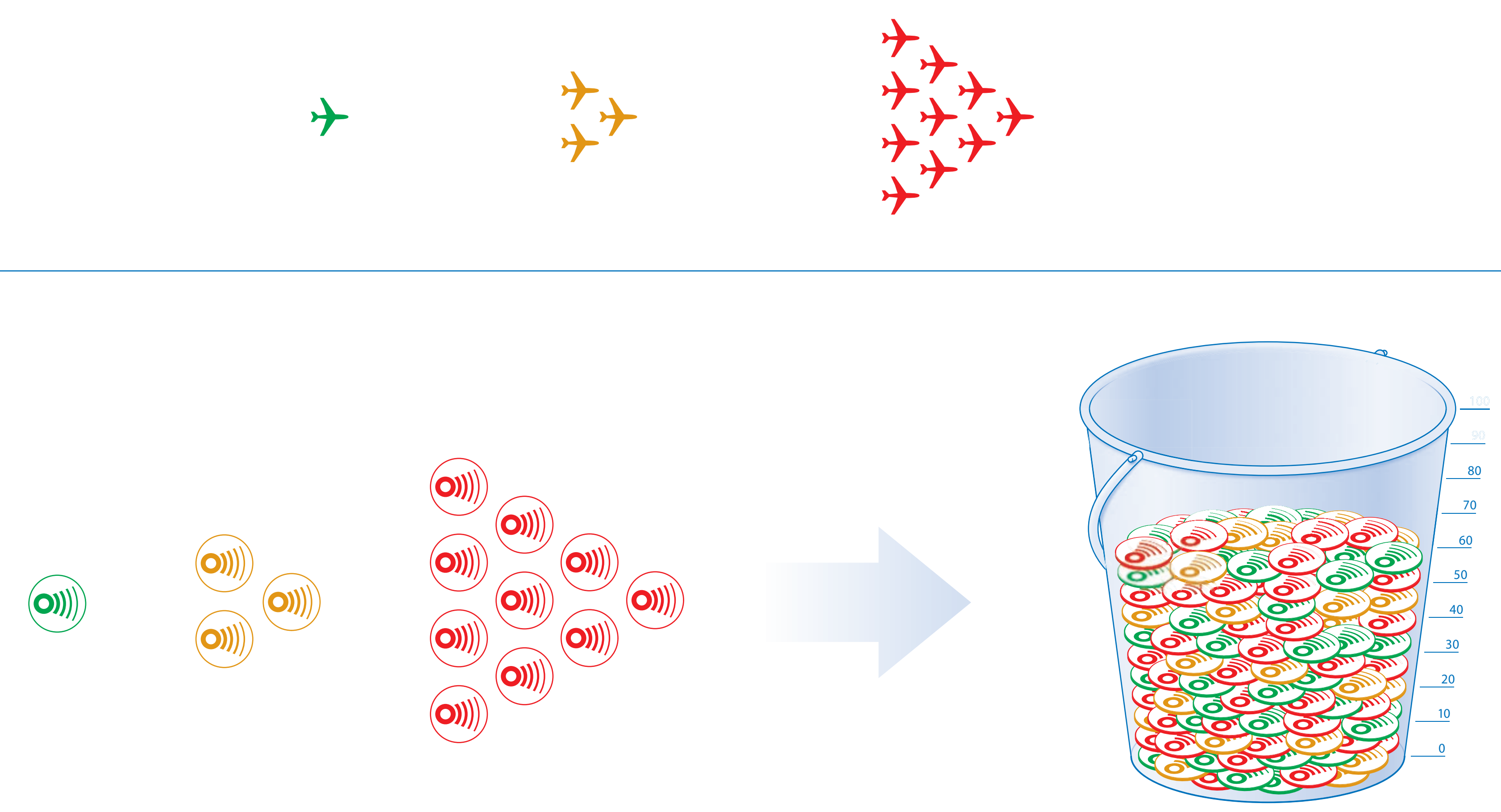

Figure 6.7

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Single Event Noise to Cumulative Noise (CNEL)

L E G E N D

Sound Source

Acronyms

- **CNEL** Community Noise Equivalent Level
- **dB** Decibels
- **Ops** Operations, sum of departures and arrivals
- **SEL** Sound Exposure Level, also known as SENEL

Time Periods	
Day	7 am – 7 pm
Evening	7 pm – 10 pm
Night	10 pm – 7 am

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Examples of Community Noise Equivalent Levels (CNEL)

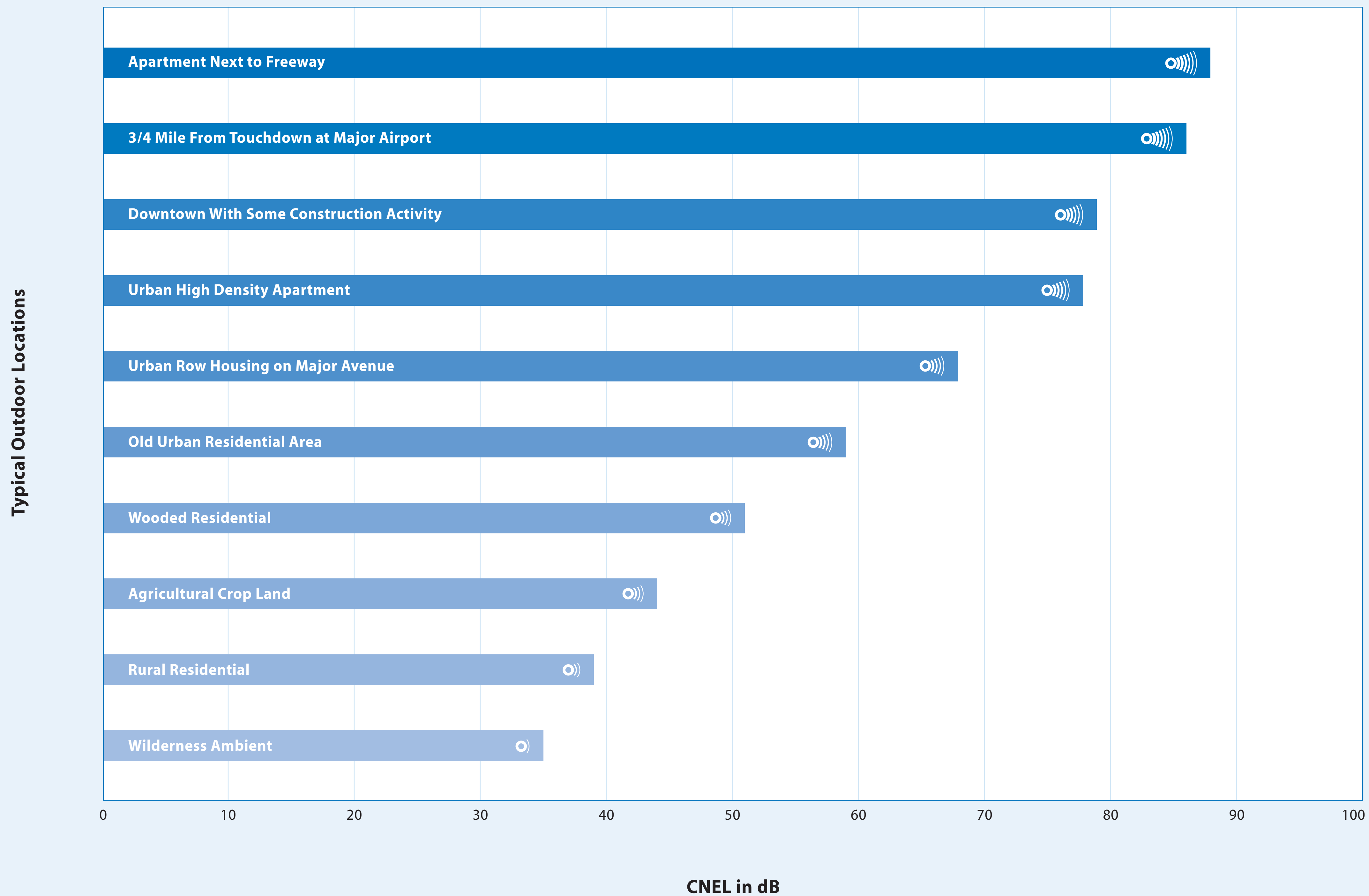

Figure 6.8

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Examples of Community Noise Equivalent Levels (CNEL)

LEGEND

Acronyms

CNEL Community Noise Equivalent Levels
dB Decibels

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Effects of Noise on Humans

Noise, often described as unwanted sound, is known to have several adverse effects on humans. From these known adverse effects of noise, 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 on people are briefly discussed in the following narrative.

Annoyance

Annoyance is the most difficult of all noise responses to describe. Annoyance is a very individual characteristic and can vary widely from person to person. What one person considers tolerable can be quite unbearable to another of equal hearing capability. The level of annoyance, of course, 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% of the population is highly susceptible to annoyance from any noise not of their own making, while approximately 20% are unaffected by noise. Attitudes are affected by the relationship between the person 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.

Annoyance levels have been correlated to CNEL levels. **Figure 6.9** relates CNEL noise levels to community response based on community response surveys. It displays the percent of a population that can be expected to be annoyed by various DNL (CNEL in California) values for residential land use with outdoor activity areas. At 65 dB DNL, the Schultz curve predicts approximately 14% of the exposed population reporting themselves to be “highly annoyed.” At 60 dB DNL this decreases to approximately 8% of the population.

The Schultz curve and recent updates include data having a very wide range of scatter with communities near some airports reporting much higher percentages of population highly annoyed at these noise exposure levels. While the precise reasons for this increased noise sensitivity were not identified, it is possible that non-acoustic factors, including political or the socioeconomic status of the surveyed population may have played an important role in increasing the sensitivity of this community during the period of the survey. Annoyance levels have never been correlated statistically to single event noise exposure levels in airport related studies.

Sleep Interference

Sleep interference is a major noise concern in noise assessment and, of course, is most critical during nighttime hours. Sleep disturbance is one of the major causes of annoyance due to community noise. Noise can make it difficult to fall asleep, create momentary disturbances of natural sleep patterns by causing shifts from deep to lighter stages and cause awakening. Noise may even cause awakening that a person may or may not be able to recall.

Annoyance and Community Noise Equivalent Level (CNEL)

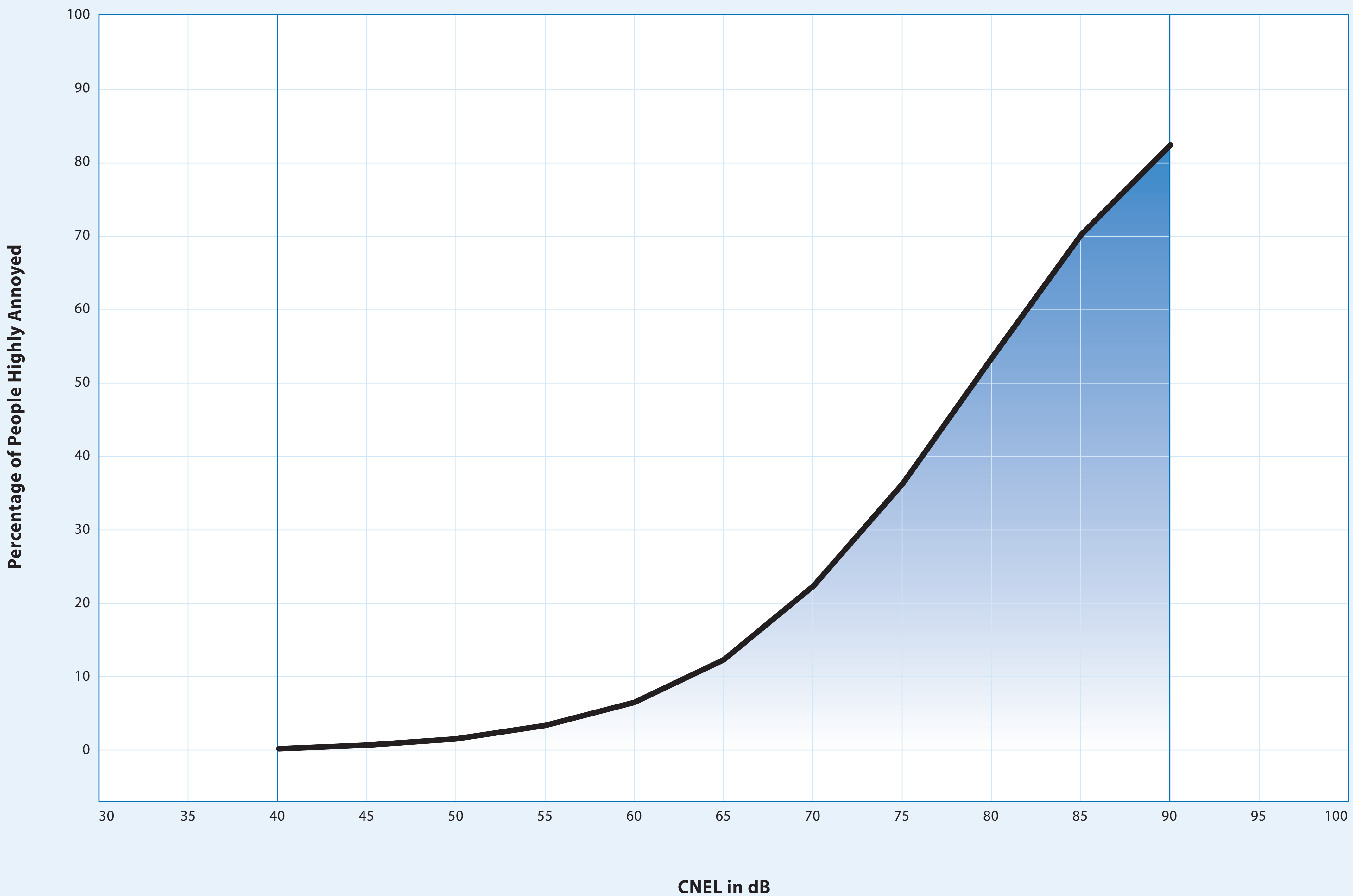

Figure 6.9

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Annoyance and Community Noise Equivalent Level (CNEL)

L E G E N D

Acronyms

CNEL Community Noise Equivalent Levels

dB Decibels

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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. In 1981, the National Association of Noise Control Officials published data on the probability of sleep disturbance with various single event noise levels. Based on laboratory experiments conducted in the 1970s, this data indicated noise exposure at 75 dBA interior noise level event will cause noise induced awakening in 30% of the cases.

However, recent research from England has shown that the probability for sleep disturbance is less than what had been reported in earlier research. These recent field studies conducted during the 1990s and using new sophisticated techniques indicate that awakenings can be expected at a much lower rate than had been expected based on earlier laboratory studies. 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 English 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. Some of this research has been criticized because it was conducted in areas where subjects had become habituated to aircraft noise. On the other hand, some of the earlier laboratory sleep studies had been criticized because of the extremely small sample sizes of most laboratory studies and because the laboratory was not necessarily a representative sleep environment.

The Federal Interagency Committee on Noise (FICON) in 1992 in a document entitled Federal Interagency Review of Selected Airport Noise Analysis Issues recommended an interim dose-response curve for sleep disturbance based on laboratory studies of sleep disturbance. In June of 1997, the Federal Interagency Committee on Aviation Noise (FICAN) updated the FICON recommendation with an updated curve based on the more recent in-home sleep disturbance studies that show lower rates of awakening compared to the laboratory 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 6.10**. This is a very conservative approach. A more common statistical curve for the data points reflected in Figure 6.10, for example, would indicate a 10% awakening rate at a level of approximately 100 dB SEL, while the “maximum awakened” curve reflected in Figure 6.10 shows the 10% awakening rate being reached at 80 dB SEL. (The full FICAN report can be found on the internet at www.fican.org.)

Hearing Loss

Hearing loss is generally not a concern in community noise problems, even very near a major airport or a major 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 expo
sure 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, are not sufficiently loud to cause hearing loss.

Sleep Interference

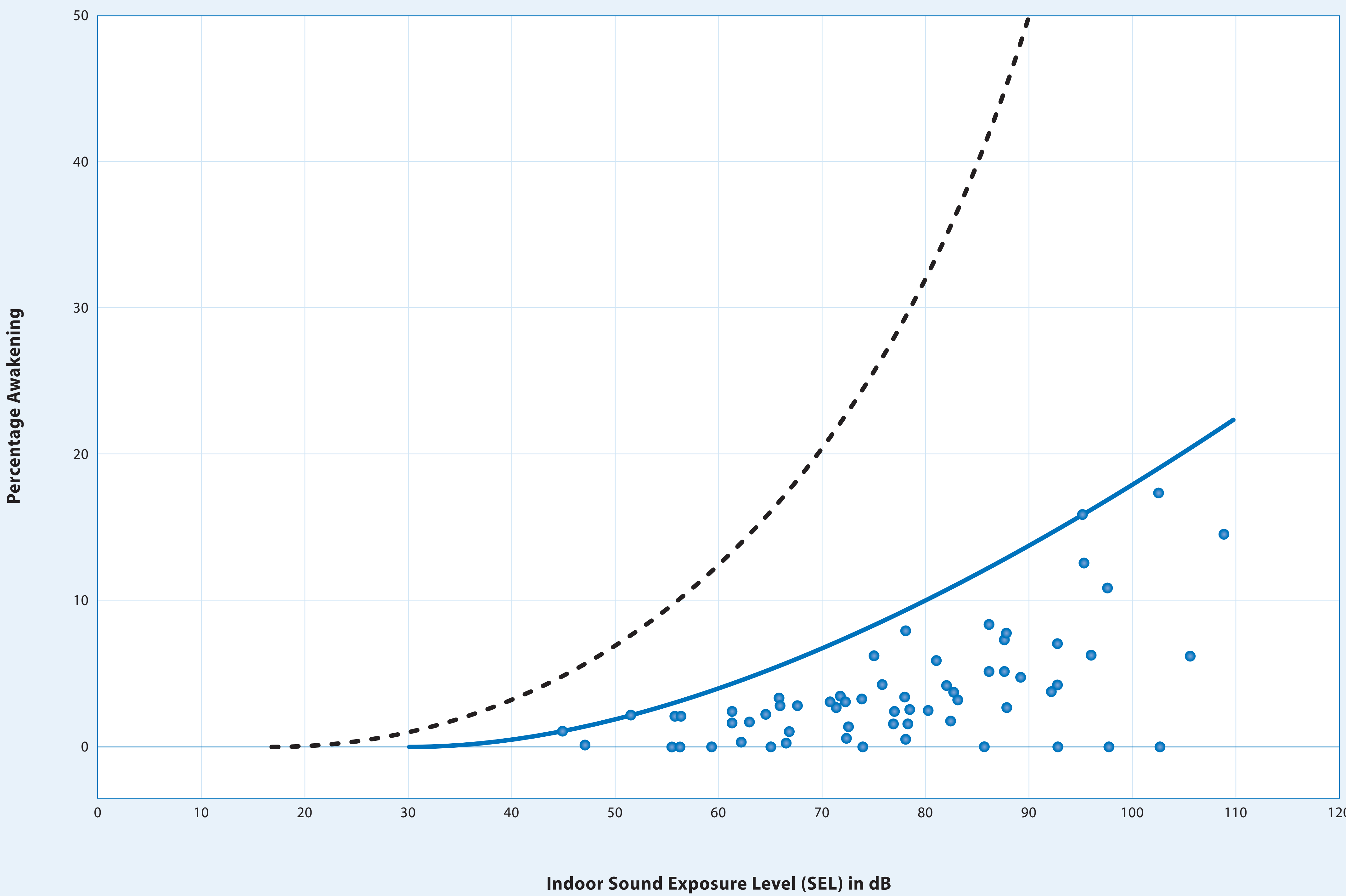

Figure 6.10

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Sleep Interference

L E G E N D

- Field Studies
- FICAN 1997
- FICON 1992

Acronyms

dB Decibels
FICAN Federal Interagency Committee on Aircraft Noise
FICON Federal Interagency Committee on Noise
SEL Sound Exposure Level

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Communication Interference

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 of describing speech interference as a function of distance between speaker and listener and voice level.

Physiological Responses

Physiological responses are those measurable effects of noise on people that are realized as changes in pulse rate, blood pressure, etc. While such effects can be induced and observed, the extent is not known to which these physiological responses cause harm or are a sign of harm. Generally, physiological responses are a reaction to a loud short-term noise such as a rifle shot or a very loud jet overflight.

Health effects from noise have been studied around the world for nearly 30 years. Scientists have attempted to determine whether high noise levels can adversely affect human health, apart from auditory damage that is amply understood. These research efforts have covered a broad range of potential impacts from cardiovascular response to fetal weight and mortality. Yet while a relationship between noise and health effects seems plausible, it has yet to be convincingly demonstrated (i.e., shown in a manner that can be repeated by other researchers while yielding similar results).

While annoyance and sleep / speech interference have been acknowledged, health effects, if they exist, are associated with a wide variety of other environmental stressors. Isolating the effects of aircraft noise alone as a source of long-term physiological change has proved to be almost impossible. In a review of 30 studies conducted worldwide between 1993 and 1998, a team of international researchers concluded that, while some findings suggest that noise can affect health, improved research concepts and methods are needed to verify or discredit such a relationship. They called for more study of the numerous environmental and behavioral factors than can confound, mediate, or moderate survey findings. Until science refines the research process, a direct link between aircraft noise exposure and non-auditory health effects remains to be demonstrated. The World Health Organization (WHO) has made quite specific findings on the potential of environmental noise to cause health impacts: “The overall conclusion is that cardiovascular effects are associated with long-term exposure to LAeq, 24h values in the range of 65–70 dB or more, for both air-and road-traffic noise. However, the associations are weak and the effect is somewhat stronger for ischemic heart disease than for hypertension. Other observed psycho-physiological effects, such as changes in stress hormones, magnesium levels, immunological indicators, and gastrointestinal disturbances are too inconsistent for conclusions to be drawn about the influence of noise pollution.” (Source: WHO Guidelines, Section 3.5, Cardiovascular and Physiological Effects). In other words, the World Health Organization believes that health effects do not occur at noise levels less than 65 CNEL.

School Room Effects

Interference with classroom activities and learning from aircraft noise is an important consideration and the subject of much recent research. Studies from around the world indicate that vehicle traffic, railroad, and aircraft noise can have adverse effects on reading ability, concentration, motivation, and long term learning retention. A complicating factor in this research is the extent of background noise from within the classroom itself. The studies indicating the most adverse effects examine cumulative noise levels equivalent to 65 CNEL or higher and single event maximum noise levels ranging from 85 to 95 dBA. In other studies, the level of noise is unstated or ambiguous. According to these studies, a variety of adverse school room effects can be expected from interior noise levels equal to or exceeding 65 CNEL and/or 85 dBA SEL.

Some interference with classroom activities can be expected with noise events that interfere with speech. As discussed above, speech interference begins at 65 dBA, which is the level of normal conversation. Typical construction attenuates outdoor noise by 20 dBA with windows closed and 12 dBA with windows open. Thus some interference of classroom activities can be expected at outdoor levels of 77 to 85 dBA.

Noise / Land-Use Compatibility Guidelines

Noise metrics are used to quantify community response to various noise exposure levels. The public reaction to different noise levels has been estimated from extensive research on human responses to exposure of different levels of aircraft noise. Noise standards generally are expressed in terms of the DNL 24-hour averaging scale (CNEL in California) based on the A-weighted decibel. Utilizing these metrics and surveys, agencies have developed standards for assessing the compatibility of various land uses with the noise environment. There are no single event noise based land-use compatibility criteria that have been adopted by the federal government or State of California.

A summary of some of the more pertinent regulations and guidelines are presented in the following paragraphs.

Federal Aviation Administration

Federal Aviation Regulations (FAR), 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. Part 36 prescribes limiting 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 have at various times 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 below 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. Stage 4 noise limits are in the process of being adopted.

Aviation Safety and Noise Abatement Act of 1979 — Further weight was given to the FAA's supporting role in noise compatibility planning by Congressional adoption of this legislation. Among the stated purposes of this act is "To provide assistance to airport operators to prepare and carry out noise compatibility programs." The law establishes funding for noise compatibility planning and sets the requirements by which airport operators can apply for funding. This is also the law by which Congress mandated that FAA develop an airport community noise metric that would be used by all federal agencies assessing or regulating aircraft noise. The result was DNL. Because California already had a well-established airport community noise metric in CNEL, and because CNEL and DNL are so similar, FAA expressly allows CNEL to be used in lieu of DNL in noise assessments performed for California airports. The law does not require any airport to develop a noise compatibility program.

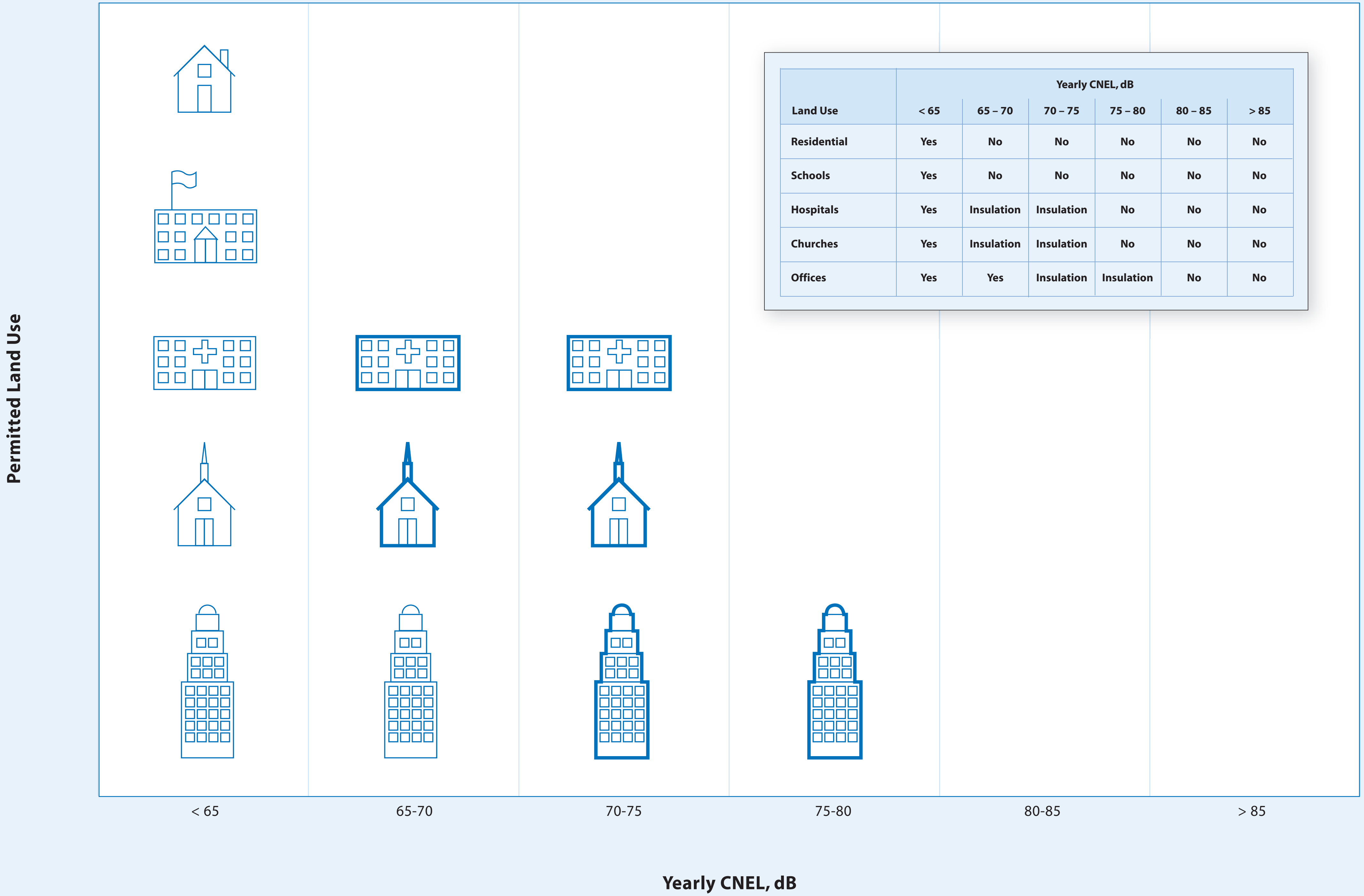
Federal Aviation Regulations (FAR), Part 150, "Airport Noise Compatibility Planning" — As a means of implementing the Aviation Safety and Noise Abatement Act, the FAA adopted regulations on Airport Noise Compatibility Planning programs. These regulations are contained in FAR Part 150. As part of the 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 FAA AC No. 150/5020-1 (dated August 5, 1983) and is provided in summary form in **Figure 6.11**.

These guidelines represent recommendations to local authorities for determining acceptability and permissibility of land uses. The guidelines recommend a maximum amount of noise exposure (in terms of the cumulative noise metric DNL) that might be considered acceptable or compatible to people in living and working areas. 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). However the FAA guidelines indicate that ultimately "the responsibility for determining the acceptability and permissible land uses remains with the local authorities."

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 to the FAA: (1) establish a method to review aircraft noise, airport use or airport access restrictions, 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 (Boeing 737-200, Boeing 727, and Boeing / McDonnell Douglas DC-9); Stage 3 aircraft are newer, quieter aircraft (Boeing 737-300, Boeing 757, Boeing / McDonnell Douglas MD80/90). To implement ANCA, FAA amended Part 91 and issued a new Part 161 of the Federal Aviation Regulations. Part 91 addresses the phase-out of large Stage 2 aircraft and the phase-in of Stage 3 aircraft. Part 161 establishes a stringent review and approval process for implementing use or access restrictions by airport proprietors.

Figure 6.11

Summary of FAA Part 150 Noise and Land Use Guidelines for New Development



Land Use	Yearly CNEL, dB < 65	65 – 70	70 – 75	75 – 80	80 – 85	> 85
Residential	Yes	No	No	No	No	No
Schools	Yes	No	No	No	No	No
Hospitals	Yes	Insulation	Insulation	No	No	No
Churches	Yes	Insulation	Insulation	No	No	No
Offices	Yes	Yes	Insulation	Insulation	No	No

Oakland International Airport Master Plan

March 2006

FAA Part 150 Noise and Land Use Guidelines for New Development

LEGEND

- Residential
- Schools
- Hospitals
- Churches
- Offices
- Insulation

Acronyms

CNEL Community Noise Equivalent Level
dB Decibels
FAA Federal Aviation Administration

PORT OF OAKLAND

Note: This graphic was prepared by the Port of Oakland as part of a master plan for Oakland International Airport. The master plan examined many possible ideas and planning concepts. This graphic is conceptual in nature and for planning purposes only. It does not propose any particular course of action (it might represent an idea or concept that was discarded), and must be interpreted in the context of the entire master plan document.

Part 91 generally required that all Stage 2 aircraft over 75,000 pounds be out of the domestic fleet by December 31, 1999. The State of Hawaii and Alaska are not affected by this regulation. The agency may, for individual cases, grant waivers through 2002. But for the most part, only Stage 3 aircraft greater than 75,000 pounds are in the domestic fleet as of that date.

Part 161 sets out the requirements and procedures for implementing new airport use and access restrictions by airport proprietors. Proprietors 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 to determine compatibility, unless there is a locally adopted standard that is more stringent. CNEL is an acceptable surrogate for DNL.

The regulation identifies three types of use restrictions and treats each one differently: (1) negotiated restrictions, (2) Stage 2 aircraft restrictions, and (3) Stage 3 aircraft restrictions. Generally speaking, any use restriction affecting 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 applies as well to the smaller aircraft. Negotiated restrictions are more favorable from the FAA's standpoint, but still require unwieldy procedures for approval and implementation. In order to be effective, the agreements normally must be agreed to by all airlines using the airport.

Stage 2 restrictions are more difficult because one of the major reasons for ANCA was to discourage local restrictions more stringent than 1999 phase-out already contained in ANCA. To comply with the regulation and institute a new Stage 2 restriction, the proprietor must generally do two things: (1) prepare a cost / benefit analysis of the proposed restriction and (2) 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 even more 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 new local noise restrictions and amendments to existing restrictions proposed after October 1990.

State of California

***California Airport Noise Regulations* —** The Aeronautics Division of the California Department of Transportation (Caltrans) enforces the California Airport Noise Regulations. These regulations establish 65 CNEL as a noise impact boundary within which there shall be no incompatible land uses. This requirement is based, in part, upon the determination in the Caltrans regulations that 65 CNEL is the level of noise which should be acceptable to "a reasonable man residing in the vicinity of an airport." Airports are responsible for achieving compliance with these regulations. Compliance can be achieved through noise abatement alternatives, land acquisition, land-use conversion, land-use restrictions, or sound insulation of structures. Airports not in compliance can operate under variance procedures established within the regulations.

California Noise Insulation Standards — California Noise Insulation Standards apply to all multi-family dwellings built in the State. Single-family residences are exempt from these regulations. With respect to community noise sources, the regulations require that all multifamily dwellings with exterior noise exposures greater than 60 CNEL be sound insulated such that the interior noise level will not exceed 45 CNEL. These requirements apply to all roadway, rail, and airport noise sources.

General Plan Requirements — The State of California requires that all municipal General Plans contain a Noise Element. The requirements for the Noise Element of the General Plan include describing the noise environment quantitatively using a cumulative noise metric such as CNEL or DNL, establishing noise / land-use compatibility criteria, and establishing programs for achieving and/or maintaining compatibility. Noise elements shall address all major noise sources in the community including mobile and stationary sources.

Airport Land Use Commissions — Airport Land Use Commissions were created by State Law for the purpose of establishing a regional level of land-use compatibility between airports and their surrounding environs. The Alameda County Airport Land Use Commission has adopted an Airport Environs Land Use Plan (AELUP) for Alameda airports including OAK. The AELUP establishes noise / land-use acceptability criteria for sensitive land uses at up to 70 CNEL for outdoor areas and 45 CNEL for indoor areas of residential land uses. The Alameda standard is considerably more permissive than the standard set by the State of California or the guidelines established by the FAA.

Noise Analysis Methodology

The methods used for describing existing noise and forecasting the future noise environment rely heavily on computer noise modeling. The noise environment is commonly depicted in terms of lines of equal noise levels, or noise contours. The computer noise models used for master plan aircraft noise analyses are described below.

Noise contour modeling is a key element of the aircraft noise analyses performed for this master plan. Generating accurate noise contours is largely dependent on the use of a reliable, validated, and updated noise model. The computer model can then be used to predict the changes to the noise environment as a result of any alternatives under consideration.

For the master plan, the FAA’s Integrated Noise Model (INM) Version 6.01c was used to model aircraft operations at OAK. The INM has an extensive database of civilian and military aircraft noise characteristics, and this most recent version of INM incorporates advanced plotting features. Noise contour files from the INM were loaded into Arcview Geographic Information System (GIS) software for plotting and land-use analysis. All of the noise contours presented in this master plan were developed by Brown-Buntin Associates as a subcontractor to Mestre Greve Associates.

Existing Noise Control Program

The Port has adopted a comprehensive noise control program to minimize and mitigate the effects of aircraft noise. This program affects various modeling assumptions. For example, it is assumed that all elements of the Port's existing noise control program would remain in effect through the 2010 to 2012 timeframe. This program can be described in terms of the following broad categories:

- Noise Management Measures
- Noise Abatement Procedures
- Community Outreach and Public Participation
- Community Land-Use Measures
- Noise Reduction Programs, Studies and Other Commitments

These elements of the program are described in outline form in **Figure 6.12**, and a detailed explanation of each program is contained in a program description from the Port's Aviation Noise / Environmental Management Office.

Aircraft Single Event Noise Contours

Single event noise levels, reported here in terms of Sound Exposure Level (SEL), vary by aircraft type. Even for a given aircraft type, airlines operate at different weights depending on destination and load factor. SEL contours are presented to compare the difference in noise level that different aircraft make. **Figure 6.13** and **Figure 6.14** show the SEL contours for arrivals and departures to Runway 29 for a variety of the major aircraft that use this runway. In Figure 6.13, single event contours are shown for the Boeing 727 Hushkit aircraft and the narrow-body twin-engine jet aircraft, such as the Boeing 737 and Airbus A320 family. The Boeing 727 Hushkit is one of the noisiest aircraft that operates at OAK, and the scale of the map used for the Boeing 727 contour set is much smaller than the scale used for the other contour sets. The Boeing 737 and Airbus A320 families are the main workhorses for air carrier operations at OAK. Figure 6.14 shows single event contour sets for the wide-body twin-engine aircraft such as the Boeing 767 and Airbus A300 family and contour sets for the 3-engine wide-body aircraft such as the Boeing / McDonnell Douglas MD-11 and older Boeing / McDonnell Douglas DC-10. The Boeing 767 and Airbus A300 contours are important because these are the aircraft that will likely replace the noisier, aging Boeing 727 Hushkit aircraft. Figure 6.13 and Figure 6.14 include tables comparing the existing number of average daily operations in 2004 and the forecast number in 2010 for these types of aircraft. Data are provided for the day, evening, and night hours (corresponding to the CNEL time periods) for departures and arrivals. These data show a decrease in the number of operations forecast for the B727 Hushkit aircraft, and an increase in the number of operations for the newer types of aircraft.

Existing CNEL Noise Contours

CNEL contours for 2004 are presented in **Figure 6.15**. These contours were developed by Brown-Buntin Associates for the Oakland Annual Noise Report for 2004 and are reproduced here on an aerial photograph. The 65 CNEL contour, shown as a dashed blue line, encroaches on the southern edge of

Oakland Noise Management Measures

Aircraft Engine Run-up Restrictions
The Airport's aircraft engine maintenance run-up restrictions policy has been in place since the 1970s.

Ground Run-up Enclosure
The Airport's engine run-up policy was substantially improved with the construction of a ground run-up enclosure (GRE) in 2002.

Runway Signage for Noise Abatement
Runway signage installed on North Field runways reminds pilots of the Airport's noise abatement departure procedures.

Aircraft Noise Monitoring System
Installed in 1990, the Airport Noise and Operations Monitoring System (ANOMS) now includes:
- 16 permanent and 4 portable noise monitoring sites
- Flight replay system and a noise complaint tracking system
- Full time staff of 5 in the Noise/Environmental Management Office
- Website providing noise program information

Noise Abatement Procedures Compliance Reports (Quarterly)
Detailed quarterly reports on compliance with aircraft noise abatement are provided to the Cities of Alameda and San Leandro, CLASS and KJOB, and are posted on the Airport's website. These reports determine if planes are flying in the preferred flight paths, include information on aircraft noise levels, and describe performance compliance with the following various procedures:
- Quiet Hours Program
- VFR aircraft departures
- North Field turbojet restrictions
- Silent 7 SID
- Runway 29 right turn departure restrictions
- Engine maintenance run-up restrictions

California Airport Noise Regulations Reports (Quarterly)
Quarterly reports evaluating aircraft noise levels are provided to meet the requirements of the California Airport Noise Regulation (California Code of Regulations, Title 21, Section 5025). They are posted on the Airport's website.

Aircraft Noise Abatement Procedures for North Field Program

General Policy
Safety permitting, aircraft flying by visual flight rules are to avoid flying over nearby residential areas when arriving or departing the Airport.

Day and Night

Aircraft Restrictions
The following aircraft shall not depart Runways 27R/L, nor land on Runways 9R/L except during emergencies. These aircraft must use Runway 11/29:
- Turbojet and turbofan powered aircraft
- Turboprop aircraft over 17,000 pounds
- Four-engine reciprocating powered aircraft
- Surplus military aircraft over 12,500 pounds
- Regularly scheduled passenger and cargo airlines or regional jet commercial passenger aircraft operations shall not land on Runways 27L/R at the North Field, except for emergencies or when Runway 11/29 is closed for maintenance or repairs.

Helicopter Restrictions
- Helicopters should fly over freeways and water as much as possible to avoid hotels and residential areas.
- Local training flight patterns (touch-and-go operations, etc.) should be restricted to Airport boundaries or adjacent commercial and industrial areas to the maximum extent possible.

Daytime (6:00 a.m. to 10:00 p.m.)

Aircraft Restrictions — Single and Twin Piston-engine Aircraft

VFR Departures
- Aircraft departing Runways 27R/L turn over San Leandro Bay, continue to the I-880 freeway.
- Straight out departures should not be approved.
- Aircraft departing Runway 33 turn right and fly over San Leandro Bay, continue to the I-880 freeway.
- Straight out or left crosswind/downwind departures should not be approved.

VFR Arrivals
- Aircraft should avoid flying over residential areas as much as possible on any North Field runway.
- Straight in arrivals to Runway 15 are not allowed unless required by wind or safety.

Touch-and-Go Operations
- Runway 27L is the preferred runway for these procedures.
- Aircraft should fly the standard traffic pattern thereby avoiding flying over residential areas.

Nighttime Quiet Hours (10:00 p.m. to 6:00 a.m.)

Aircraft Departures
- Aircraft should use Runway 9R (not 9L) as the preferred departure runway.
- Aircraft should use Runway 27R (not 27L) as the preferred departure runway.
- Aircraft should not turn left from Runways 9R/L on departure.
- Aircraft should not depart straight-out from Runway 9L.
- All aircraft over 75,000 pounds are directed to use Runway 11/29.
- Aircraft should use only full-length departures on the elected runway.
- Stage 2 corporate turbojet aircraft are directed to use Runway 11/29.

Pilots may choose between the following noise abatement departure procedures, wind and weather permitting:
VFR and SALAD IFR departures from Runway 27R
- VFR departures use right crosswind or additional downwind segment avoiding Alameda residences.
- The SALAD Standard Instrument Departure Procedure allows pilots not to use the OAK 313 radial or 310 heading departure.

VFR and IFR departures from Runway 9R/L
- For Runway 9R departures, use 140-180 degree departure headings
- For Runways 9R/L departures, use right turns over the Airport for north/northeast departures.

Aircraft Arrivals
- Aircraft should use Runway 27L as the preferred arrival runway.

Oakland International Airport Departure Routes

Aircraft Noise Abatement Procedures for South Field Program

Day and Night
Runway 11/29 is preferred for departures and arrivals of all turbojet and heavy aircraft.

Runway 29 Departures
- Turbojets shall not be turned north over Oakland Hills until leaving 3,000 feet.
- VFR aircraft that depart Runway 29 and request a right turn shall be instructed to proceed at least 2 miles west or climb to at least 1,500 feet before starting right turn.

Runway 29 Arrivals
- Air traffic controllers require turbojet aircraft on a visual or VFR approach northeast of OAK to cross the Oakland 100 radial at or above 3,000 feet.
- Between the hours of 10:00 p.m. to 6:00 a.m., and at other times when traffic permits, air traffic controllers keep turbojet aircraft over the Bay when approaching from the west, south of OAK.

Daytime (6:00 a.m. to 10:00 p.m.)

Touch-and-Go Operations
- Turbojet aircraft practicing instrument approaches south of OAK are to remain over the Bay when using Runway 29

Nighttime (10:00 p.m. and 7:00 a.m.)

Runway 29 Silent 7 Departure Procedure
- Reduces noise on Alameda and other East Bay communities
- Turns turbojet aircraft to the west and further out over the Bay when departing from Runway 29

Runway 11 Quiet Departure Procedure
- Reduces noise on San Leandro and other East Bay communities
- Turns turbojet aircraft to the right and further out over the Bay when departing from Runway 11

Rolling Take-off Departure Procedure
- Used for takeoffs in which engine power is applied and the takeoff roll commenced immediately as an aircraft is taxied onto the runway
- Reduces "back-blast" noise
- Applied to turbojet departures between 1:00 a.m. and 5:00 a.m.

Figure 6.12-1

Oakland International Airport Master Plan March 2006

Existing Airport Noise Control Program

Acronyms and Definitions

ADP	Airport Development Program
ANOMS	Airport Noise and Operations Management System
CLASS	Citizens League for Airport Safety and Serenity
FAA	Federal Aviation Administration
GRE	Ground run-up enclosure
IFR	Instrument Flight Rules
KJOB	Berkeley Keep Jets Over the Bay Committee
SALAD	An intersection of two airways
SID	Standard Instrument Departure
SIP	Sound Insulation Program
USPS	United States Postal Service
VFR	Visual Flight Rules

Sources

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Jim Buntin
Brown Buntin Associates

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Community Outreach and Public Participation

Oakland Airport-Community Noise Management Forum
Public participation is encouraged at the Oakland Airport-Community Noise Management Forum, which meets quarterly to address community noise concerns.

North Field Research Group
A technical sub-committee of the Forum, the North Field Research Group meets quarterly with community representatives, the FAA and Airport users.

South Field Research Group
Another technical sub-committee of the Forum, the South Field Research Group meets quarterly with community representatives, the FAA and Airport users.

Board of Port Commissioners Aviation Committee
The Aviation Committee of the Board of Port Commissioners holds meetings with representatives from the City of Alameda, CLASS and KJOB, and the San Leandro City Council Airport Committee three times per year for each group.

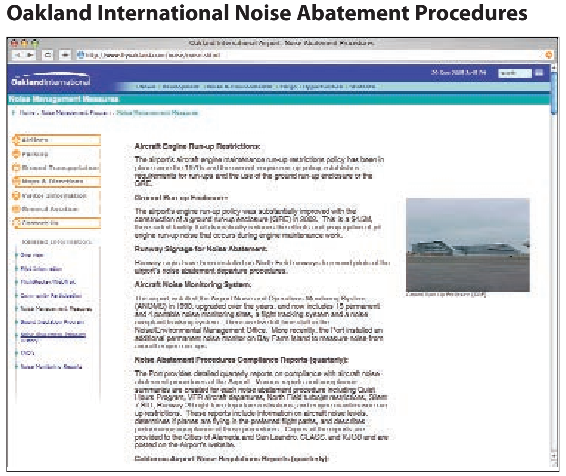
Pilot Brochure — Noise Abatement Procedures for North Field
Designed for pilots, this brochure includes a diagram of the Airport and an aerial photograph of the community.

Noise Management Brochure
This brochure describes the overall noise management program at Oakland International Airport.

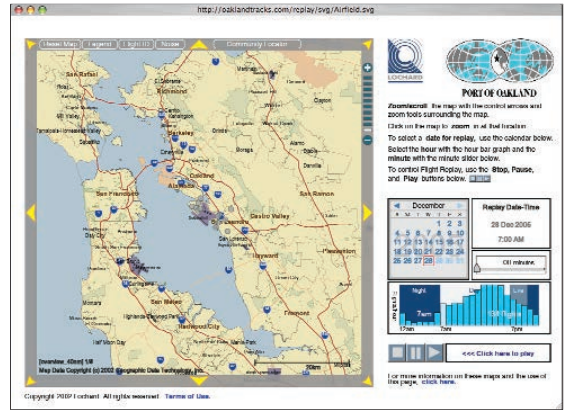
Noise Management Program Website
Located at *www.flyoakland.com,* this website provides:

- Basic information on Airport and aircraft noise programs
- Preferred daytime and nighttime aircraft flight procedures
- All routine noise abatement reports
- A flight replay system
- Educational materials such as ad-hoc reports, an airport noise glossary, Forum meeting information, and links to important and relevant websites

Oakland International Noise Abatement Procedures



Flight Replay on the Web



Community Land-Use Measures

Noise and Avigation Easements
City of Alameda:
A 1976 Settlement Agreement established avigation easement requirements for new homes on Bay Farm Island. Also, the City offers a residential Sound Insulation Program (SIP).

City of San Leandro Sound Insulation Program (SIP)
The City offers SIPs for:

- Participating homes located south of I-880
- Residences in the Heron Bay subdivision
- Five schools

Development Limits
1976 and 1980 Settlement Agreements with Alameda limit Bay Farm Island development to 3,200 dwelling units.

Zoning/Land-Use Controls
Alameda County Airport Land Use Policy Plan (1986) establishes noise land use compatibility standards for noise sensitive uses. The Plan encourages no residential development above 65 CNEL, but residential uses are permitted up to a 70 CNEL if sound insulation is provided.

City of San Leandro General Plan
The City of San Leandro's General Plan includes land-use requirements that are compatible with policies regarding development within the Airport environs.

City of Alameda General Plan
The City of Alameda's General Plan includes stipulations for Bay Farm Island residential and business park development that are in accordance with the 1976 and 1980 Settlement Agreements with the Port of Oakland.

Noise Reduction Programs, Studies and Other Commitments

City of Alameda — Residential Sound Insulation Program
To date, approximately 500 homes have been insulated on Bay Farm Island. The final one will be completed in 2006.

City of San Leandro — Residential Sound Insulation Program
The Port will fund insulation expenses for 200 homes in San Leandro that are located south of I-880, and will also fund up to $100,000 for city administration costs.

City of San Leandro — School Sound Insulation Program
The Port will fund insulation for the following schools in the San Leandro Unified School District. Each school will receive $1,200,600 to cover insulation expenses: Muir, Wilson, Monroe, Garfield and Corvallis Schools.

San Leandro Sound Studies
The Port conducted sound studies of the Mulford Gardens Branch Library and eight schools in San Leandro. The studies showed that existing conditions were sufficient to meet state law standards and that additional sound insulation was not required for the library and three schools identified in the Settlement Agreement.

Crosswind Runway Alignment Study
The Port, City of Alameda, and CLASS jointly undertook a noise study of single event and low frequency noise impacts associated with the cross wind runway alignments previously proposed by CLASS. The results showed that benefits were offest by noise increases in other communities east and south of the Airport.

Airport Tenant Orientation Program
The Port agreed to provide its existing and future tenants with information about the Airport's noise abatement procedures and to gain their commitment to follow the procedures. Statements are attached to lease agreements.

General Aviation VFR Aircraft Study
The Port, Alameda, and CLASS agreed to jointly undertake an evaluation of general aviation aircraft departures from Runways 27L/R and 33 under visual flight rules. This project was completed in 2002.

Preferential Runway Use Agreement for San Leandro
Representatives from the City of San Leandro and the Port will work together to prepare and coordinate with FAA a preferential runway use agreement for North Field that addresses the mutual noise mitigation concerns relative to North Field nighttime operations and touch-and-go operations.

Ongoing Noise Abatement Work with the FAA
The Port agreed to continue to work with the FAA to gain their cooperation in implementing the Airport's noise abatement procedures on the behalf of the City of Alameda, CLASS, and KJOB.

Master Plan
The Port agreed to prepare a 20-year Master Plan for the Airport in accordance with FAA Advisory Circular 150/5070-6A. Members of the Master Plan Stakeholder Committee include representatives from the cities of Alameda, San Leandro and Oakland, CLASS, and the San Leandro Unified School District. KJOB also was invited to participate.

Runway 11/29 Length Agreement
The Port agreed not to propose, approve, or construct any extension of Runway 11/29 that would give Runway 11/29 a total effective length in excess of 11,600 feet.

Meet and Confer Agreement
The petitioners agree to meet and confer in good faith with Port on any future efforts by Port to secure approvals for and construct an outboard runway at the Airport.

USPS Facilities Agreement
The Port agreed not to construct or enter into new leases that authorize construction of or modifications to the USPS facilities identified in the ADP as Project D.2 at any location on the Airport for at least 20 years.

Additional Noise Monitors Agreement
The Port agreed to install, operate, and maintain two remote monitoring terminals at the locations identified by KJOB when KJOB provides Port with written notice of the location for the noise monitoring sites and submits easements for the sites.

No New Runway Construction on North Field
The Port agreed not to construct any new runways on any portion of the North Field.

No Runway Expansion on North Field
The Port agreed that existing North Field runways may not be realigned or lengthened, or widened, etc., if the purpose of doing so is to increase the runway weight and load capacities to accommodate operations beyond alternate use by air carriers.

Acronyms and Definitions

ADP	Airport Development Program
ANOMS	Airport Noise and Operations Management System
CLASS	Citizens League for Airport Safety and Serenity
FAA	Federal Aviation Administration
GRE	Ground run-up enclosure
IFR	Instrument Flight Rules
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SID	Standard Instrument Departure
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VFR	Visual Flight Rules

Sources
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Mestre Greve Associates

Jim Buntin
Brown Buntin Associates

PORT OF OAKLAND

Figure 6.13

Oakland International Airport Master Plan

March 2006

Night Single Event Noise Contours

Boeing 727 HK Departure

	Average Daily Departures		
	Day	Evening	Night
Year 2004	3	1	4
Year 2010	1	0	2

Boeing 727 HK Arrival

	Average Daily Arrivals		
	Day	Evening	Night
Year 2004	3	2	3
Year 2010	1	1	1

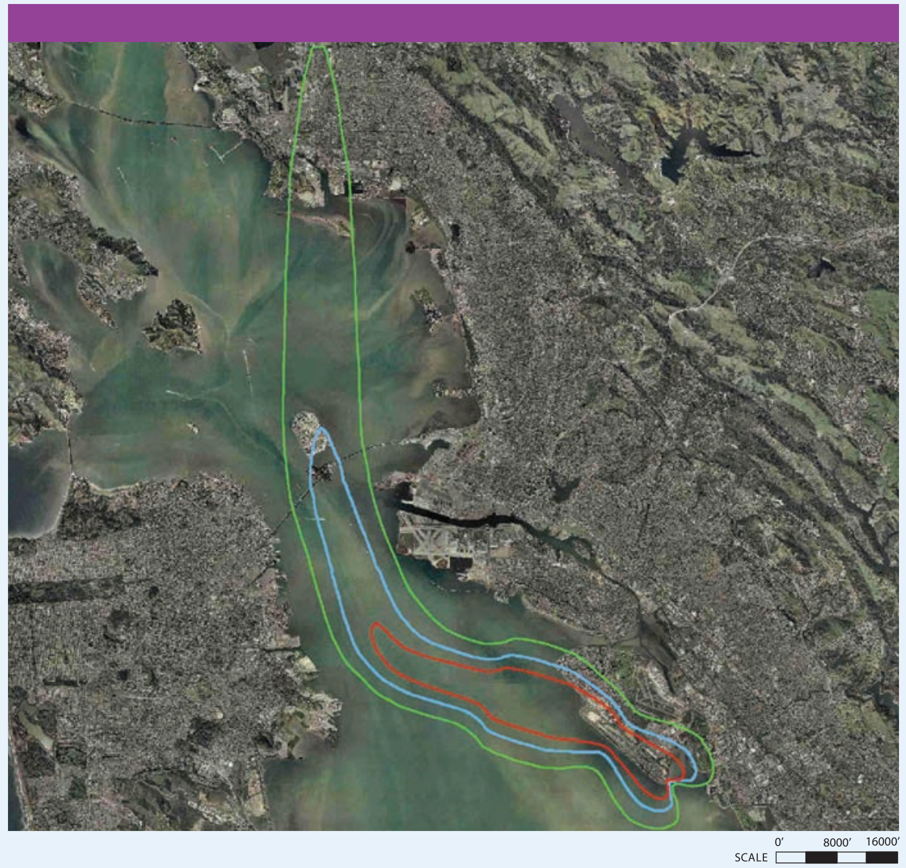
Boeing 737 & A319/320* Departure

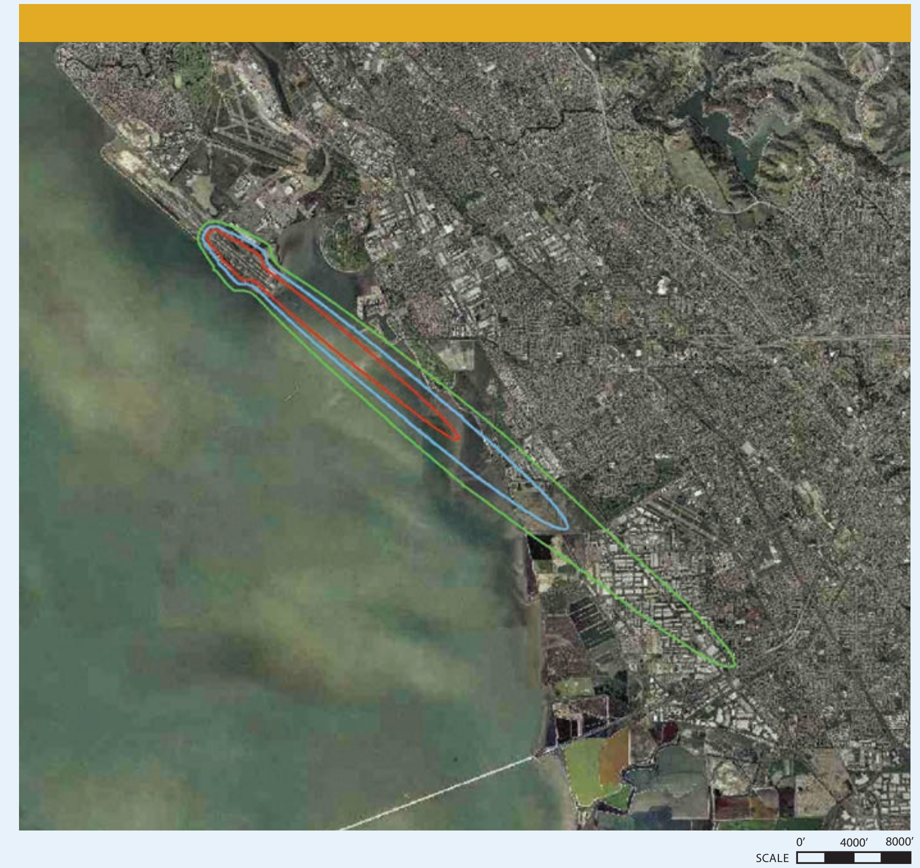
	Average Daily Departures		
	Day	Evening	Night**
Year 2004	116	37	22
Year 2010	185	32	33

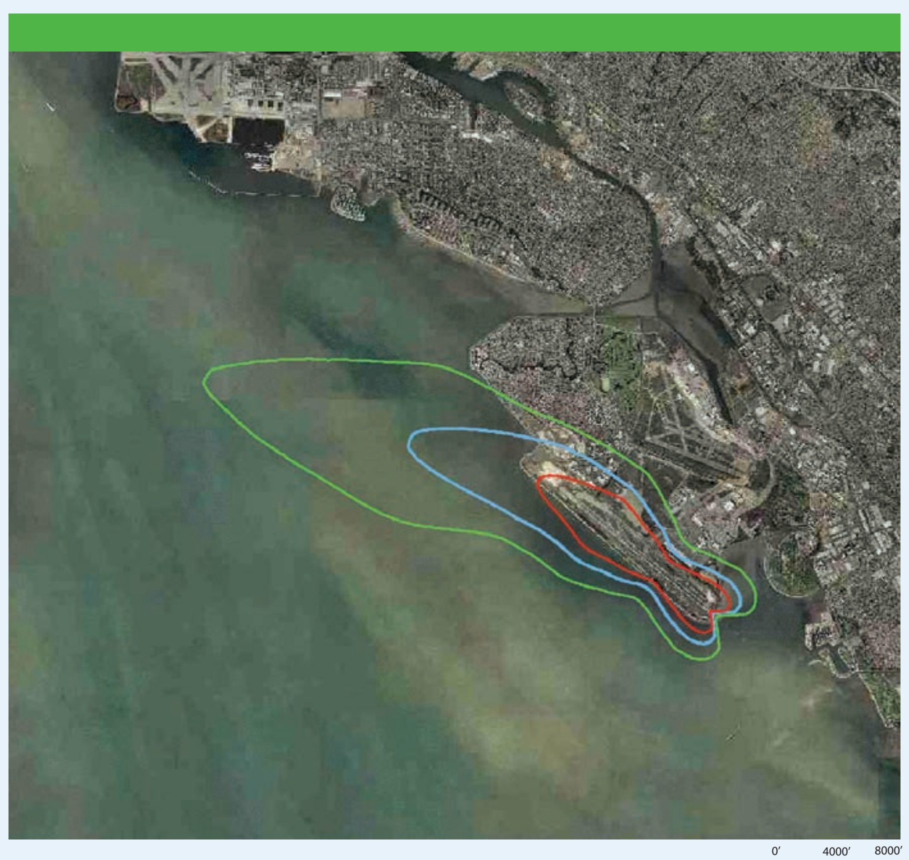
Boeing 737 & A319/320* Arrival

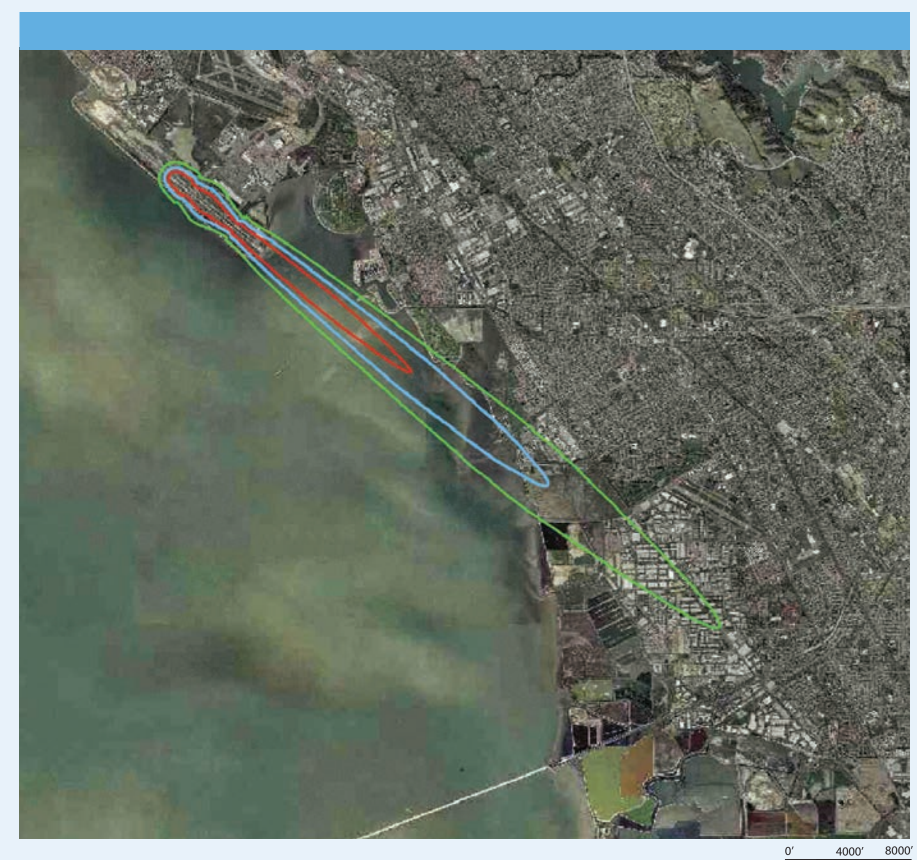
	Average Daily Arrivals		
	Day	Evening	Night**
Year 2004	104	48	23
Year 2010	179	38	33

*These aircraft do not have identical noise contour footprints, but are very similar and are grouped here for display purposes.
**Most night operations of B737 aircraft occur between the hours of 10pm and 11pm and between 6am and 7am









LEGEND

- 80 dB SEL
- 85 dB SEL
- 90 dB SEL

Time Periods	
Day	7 am – 7 pm
Evening	7 pm – 10 pm
Night	10 pm – 7 am

Acronyms

dB	Decibels
SEL	Sound Exposure Level, also known as SENEL

PORT OF OAKLAND

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Boeing 767 & A300/310* Departure

	Average Daily Departures		
	Day	Evening	Night
Year 2004	3	2	5
Year 2010	4	4	16

Boeing 767 & A300/310* Arrival

	Average Daily Arrivals		
	Day	Evening	Night
Year 2004	4	1	5
Year 2010	10	1	13

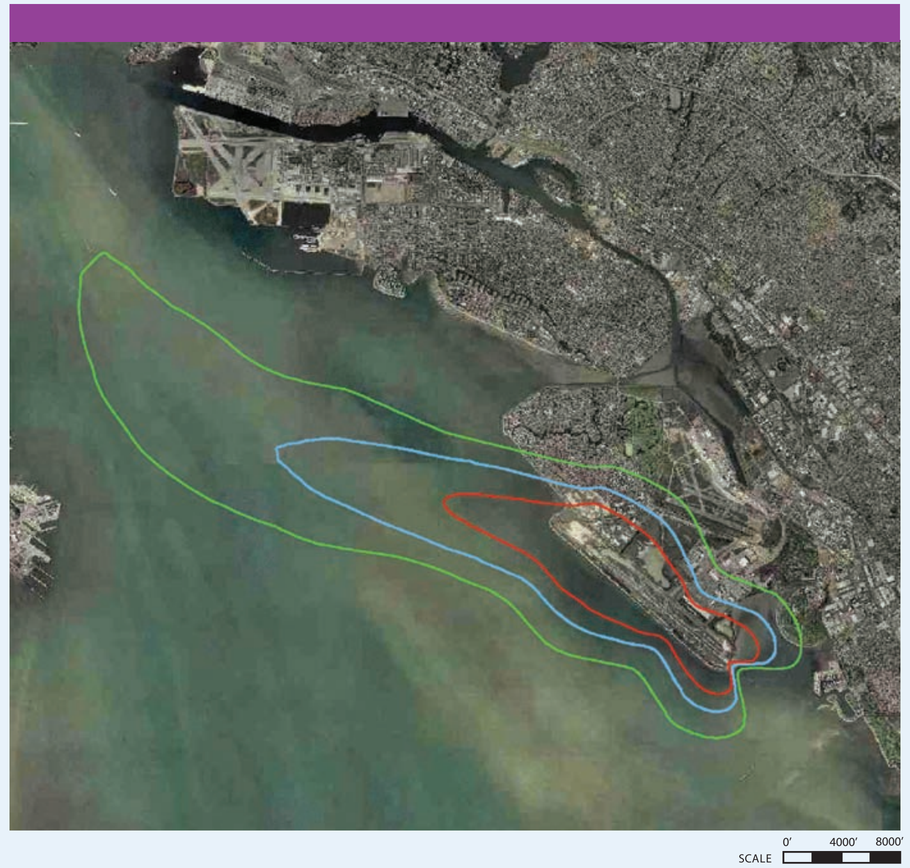
Boeing MD11/DC10* Departure

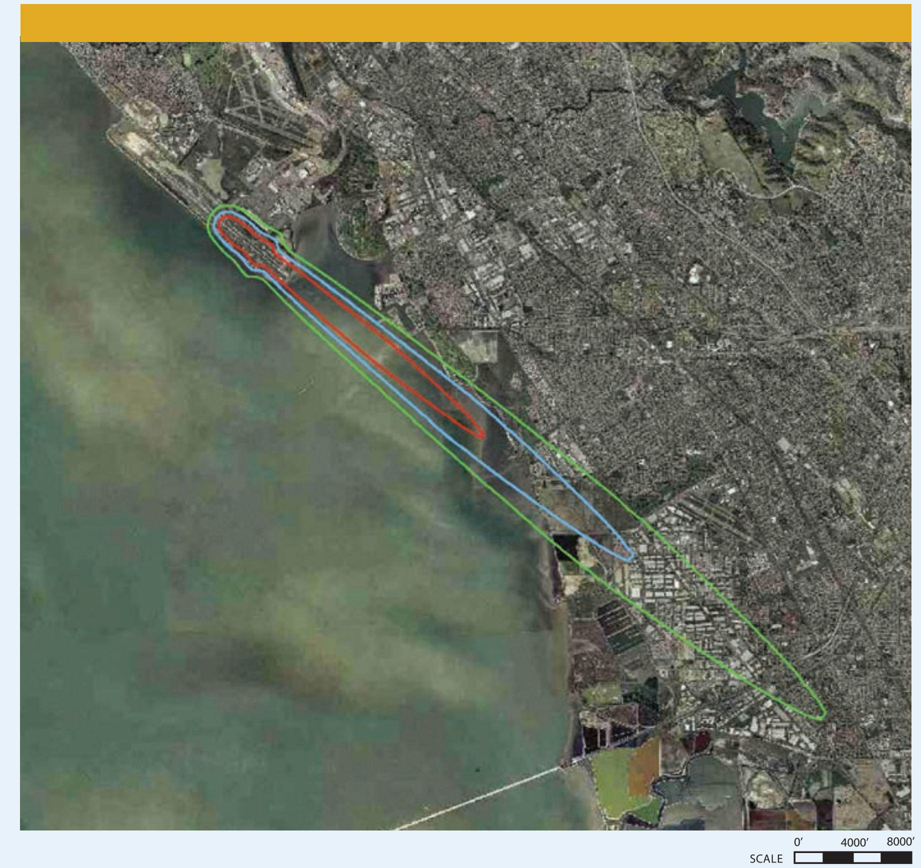
	Average Daily Departures		
	Day	Evening	Night
Year 2004	5	1	6
Year 2010	5	1	8

Boeing MD11/DC10* Arrival

	Average Daily Arrivals		
	Day	Evening	Night
Year 2004	5	1	6
Year 2010	6	1	7

*These aircraft do not have identical noise contour footprints, but are very similar and are grouped here for display purposes.





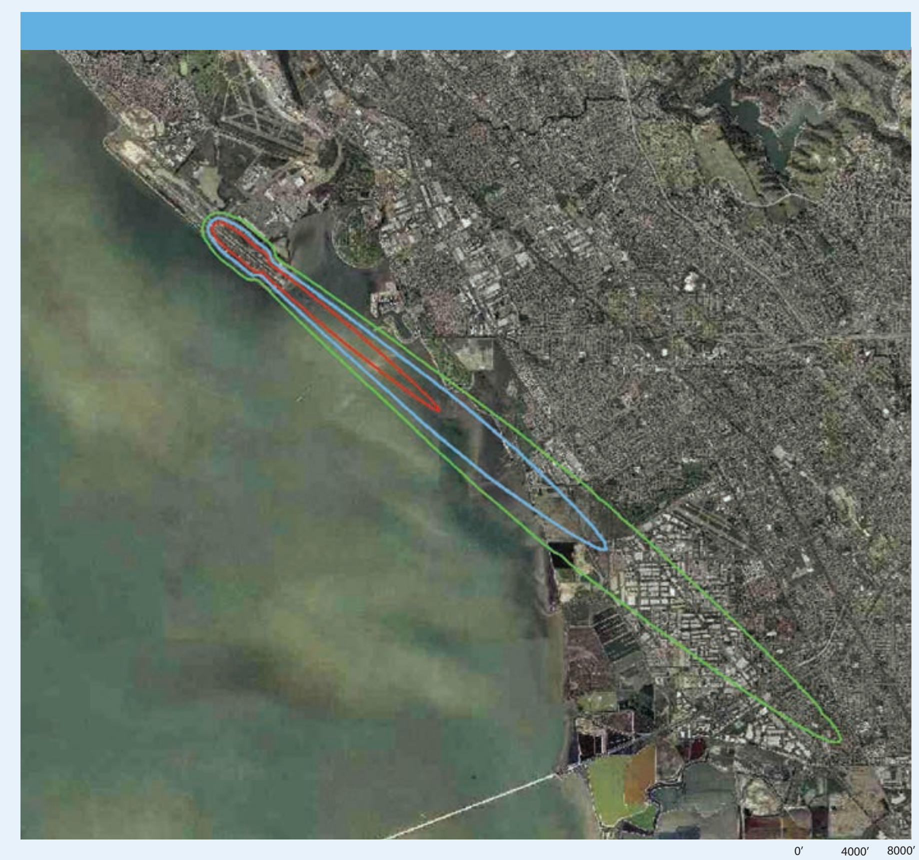


Figure 6.14

Oakland International Airport Master Plan

March 2006

Night Single Event Noise Contours

117

LEGEND

- 80 dB SEL
- 85 dB SEL
- 90 dB SEL

Time Periods	
Day	7 am – 7 pm
Evening	7 pm – 10 pm
Night	10 pm – 7 am

Acronyms

dB Decibels
SEL Sound Exposure Level, also known as SENEL

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Figure 6.15

Oakland International Airport Master Plan March 2006

Community Noise Equivalent Level (CNEL) Contours 2004

L E G E N D

60 dB CNEL

65 dB CNEL

70 dB CNEL

Acronyms

CNEL Community Noise Equivalent Level

dB Decibel

0' 4000' 8000'
SCALE

PORT OF OAKLAND

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Existing Noise Control Program

The Port has adopted a comprehensive noise control program to minimize and mitigate the effects of aircraft noise. This program affects various modeling assumptions. For example, it is assumed that all elements of the Port's existing noise control program would remain in effect through the 2010 to 2012 timeframe. This program can be described in terms of the following broad categories:

- Noise Management Measures
- Noise Abatement Procedures
- Community Outreach and Public Participation
- Community Land-Use Measures
- Noise Reduction Programs, Studies and Other Commitments

These elements of the program are described in outline form in **Figure 6.12**, and a detailed explanation of each program is contained in a program description from the Port's Aviation Noise / Environmental Management Office.

Aircraft Single Event Noise Contours

Single event noise levels, reported here in terms of Sound Exposure Level (SEL), vary by aircraft type. Even for a given aircraft type, airlines operate at different weights depending on destination and load factor. SEL contours are presented to compare the difference in noise level that different aircraft make. **Figure 6.13** and **Figure 6.14** show the SEL contours for arrivals and departures to Runway 29 for a variety of the major aircraft that use this runway. In Figure 6.13, single event contours are shown for the Boeing 727 Hushkit aircraft and the narrow-body twin-engine jet aircraft, such as the Boeing 737 and Airbus A320 family. The Boeing 727 Hushkit is one of the noisiest aircraft that operates at OAK, and the scale of the map used for the Boeing 727 contour set is much smaller than the scale used for the other contour sets. The Boeing 737 and Airbus A320 families are the main workhorses for air carrier operations at OAK. Figure 6.14 shows single event contour sets for the wide-body twin-engine aircraft such as the Boeing 767 and Airbus A300 family and contour sets for the 3-engine wide-body aircraft such as the Boeing / McDonnell Douglas MD-11 and older Boeing / McDonnell Douglas DC-10. The Boeing 767 and Airbus A300 contours are important because these are the aircraft that will likely replace the noisier, aging Boeing 727 Hushkit aircraft. Figure 6.13 and Figure 6.14 include tables comparing the existing number of average daily operations in 2004 and the forecast number in 2010 for these types of aircraft. Data are provided for the day, evening, and night hours (corresponding to the CNEL time periods) for departures and arrivals. These data show a decrease in the number of operations forecast for the B727 Hushkit aircraft, and an increase in the number of operations for the newer types of aircraft.

Existing CNEL Noise Contours

CNEL contours for 2004 are presented in **Figure 6.15**. These contours were developed by Brown-Buntin Associates for the Oakland Annual Noise Report for 2004 and are reproduced here on an aerial photograph. The 65 CNEL contour, shown as a dashed blue line, encroaches on the southern edge of

Bay Farm Island and the southern end of San Lorenzo near San Francisco Bay.

Future (2010) CNEL Noise Contours

CNEL contours for the forecast number of operations in 2010 are shown in **Figure 6.16**. The 2010 CNEL contours are compared with existing (2004) CNEL contours in **Figure 6.17**. Existing 2004 CNEL contours are shown as dashed lines, and forecast 2010 CNEL contours are shown as solid lines. The forecast 2010 CNEL contours are slightly smaller than the current (2004) contours. Because of the forecast change in the aircraft fleet mix, the contours are smaller even though the operations increase. In particular, the number of B727 Hushkit operations decrease (but are not eliminated) in 2010. It is important to note that all of the new technology aircraft being built today are quieter than the aircraft they replace. This is true for the newest members of the Boeing 737 family and particularly true for aircraft like the Boeing 777 and new Boeing 787. The transition to the newer, quieter technology aircraft is being enhanced by the lower fuel consumption of these aircraft, which provides a strong incentive for airlines to modernize their aircraft fleet.

Aircraft Noise — CNEL

Although CNEL noise contours are developed assuming all aircraft operations (airline, cargo, and general aviation), the evaluations here attempt to show how each type of operation contributes to the overall CNEL contours. Overall CNEL noise contours in 2010 (assuming the master plan aircraft operations forecasts) are smaller (less noise footprint) than the existing (2004) noise contours. In general, the modest increase in the number of passenger airline and general aviation operations do slightly increase the CNEL noise contours. However, anticipated changes in the air cargo fleet have a significant effect in reducing the CNEL contours in the future (2010 timeframe). That is, when the cargo airlines retire their older and noisier Boeing 727 aircraft and replace them with larger (to accommodate the increase in air cargo weight), quieter aircraft, the CNEL contours are anticipated to get smaller (less noise footprint).

Aircraft Noise — SEL / SENEL

Generally, this evaluation criteria represents a potential constraint as the number of operations increases because there will be more noise events. However, in the case of the cargo airlines, the increase in the number of operations is quite small (in fact, there are no anticipated new cargo airline flights at South Field in 2010 compared to 2004) and the cargo aircraft in 2010 are anticipated to be quieter than the existing air cargo fleet, as described above.

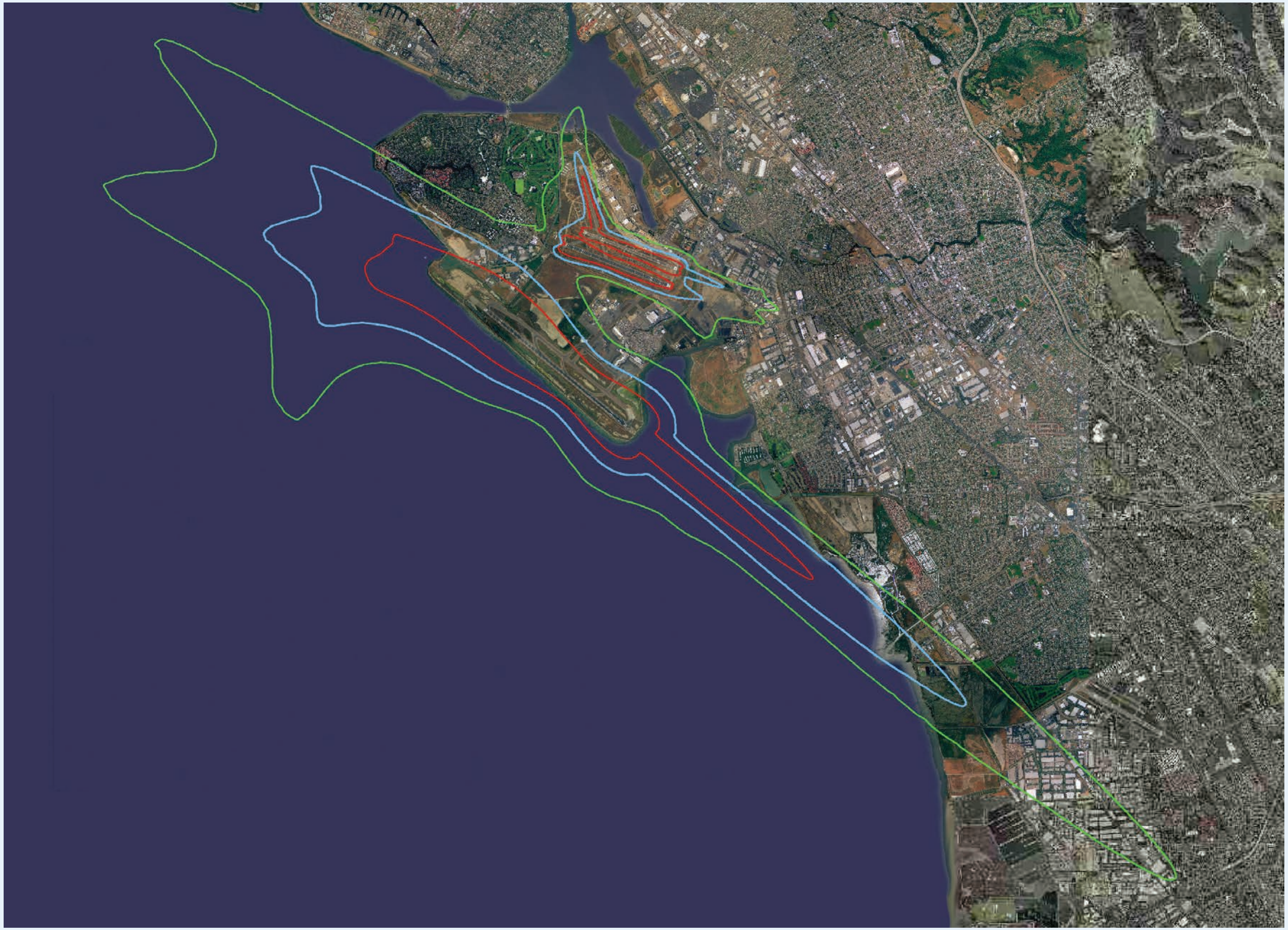

Figure 6.16

Oakland International Airport Master Plan March 2006

Community Noise Equivalent Level (CNEL) Contours 2010

L E G E N D

60 dB CNEL

65 dB CNEL

70 dB CNEL

Acronyms

CNEL Community Noise Equivalent Level

dB Decibel

0' 4000' 8000'
SCALE

PORT OF OAKLAND

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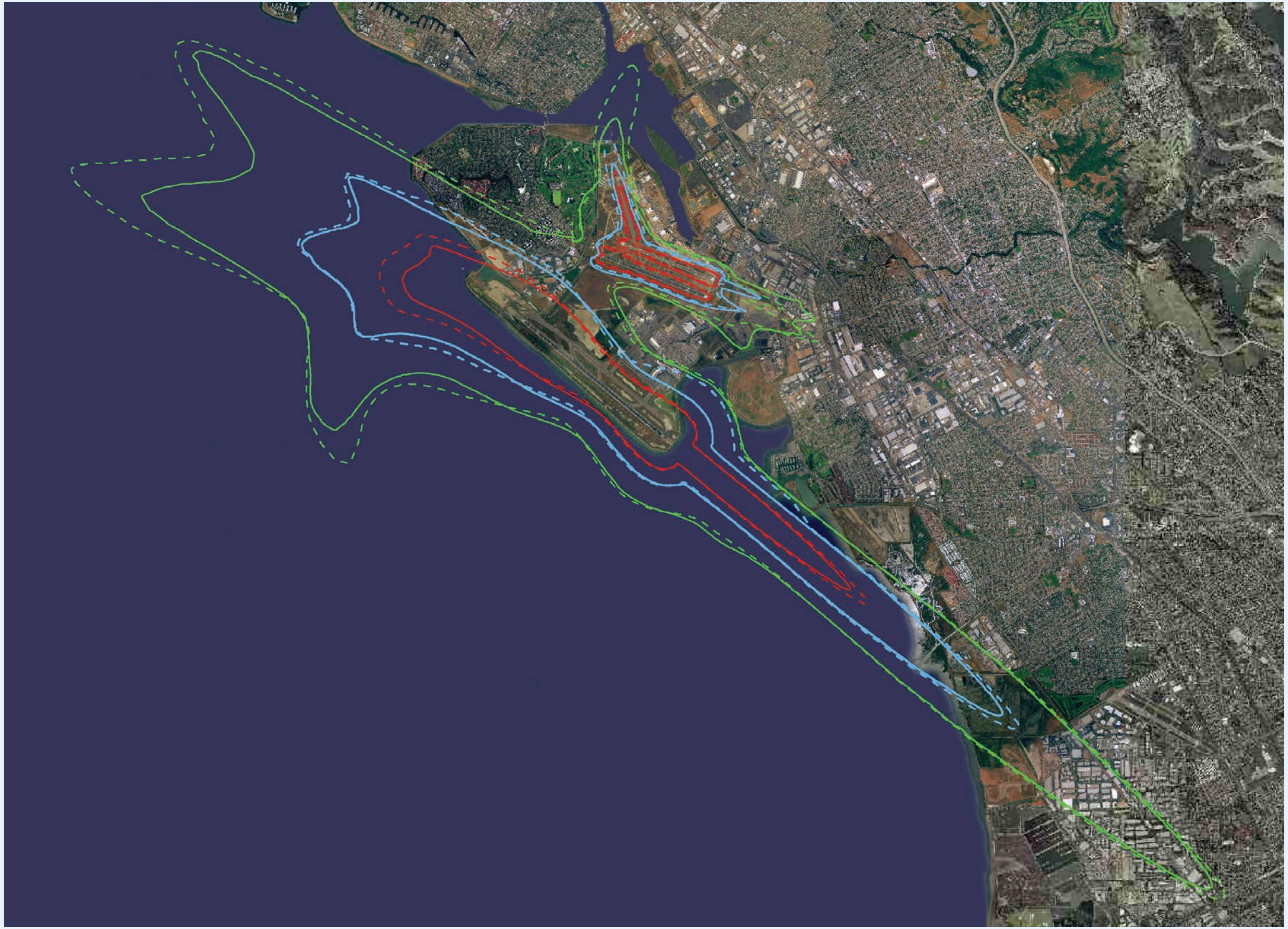
Figure 6.17

Oakland International Airport Master Plan March 2006

Community Noise Equivalent Level (CNEL) Contours 2004 and 2010



L E G E N D

- 60 dB CNEL Year 2004
- 65 dB CNEL Year 2004
- 70 dB CNEL Year 2004
- 60 dB CNEL Year 2010
- 65 dB CNEL Year 2010
- 70 dB CNEL Year 2010

Acronyms

CNEL Community Noise Equivalent Level
dB Decibel

N

0' 4000' 8000'
SCALE

PORT OF OAKLAND

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