OAKLAND INTERNATIONAL AIRPORT
CROSSWIND RUNWAY
NOISE ANALYSIS

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Prepared for:

THE PORT OF OAKLAND
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CLASS

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1.0 OUTLINE OF NOISE ANALYSIS

This report contains five sections including this introduction. Section 2 presents background information on sound, noise, and how noise affects people. Section 3 describes the methodology used for this study. Section 4 describes the existing noise in the environs of Oakland International Airport. Section 5 describes potential benefits and impacts from a crosswind runway.

2.0 BACKGROUND INFORMATION

2.1 INTRODUCTION

This section presents background information on the characteristics of noise as it relates to the aviation alternatives and summarizes the methodologies used to study the noise environment. This section will give the reader an understanding of the metrics and methodologies used to assess noise impacts. This section is divided as follows:

- *Properties of sound that are important for technically describing sound*
- *Acoustic factors influencing human subjective response to sound.*
- *Potential disturbances to humans and health effects due to sound.*
- *Sound rating scales used in this study*
- *Summary of noise assessment criteria*

2.2 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 which 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) which 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. 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. Examples of various sound environments, expressed in dBA, are presented in Exhibit 2-1.

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 1000 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. Sample atmospheric attenuation graphs are presented in Exhibit 2-2. Turbulence and gradients of wind, temperature and humidity also play a significant role in determining the degree of attenuation. 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.

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 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] Defined in subsequent sections of this study, noise metrics such as CNEL, DNL, LEQ and SENEL 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 one decibel for sounds 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 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.

2.3 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* [2] describes human response to sound in terms of both acoustic and non-acoustic factors. These factors are summarized in Table 2-1.

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. Background sound, an additional acoustic factor not specifically listed, is also important in describing sound in rural settings. Fields, [3] in his analysis of the effects 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.

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

2.4 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 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. Noise metrics used in this study 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 this study are generally based upon the dBA scale. A separate discussion is presented concerning low-frequency noise impacts and the use of the C-weighted noise level (dBC) and Low Frequency Sound Level (LFSL).

- **Maximum Noise Level.** The highest noise level reached during a noise event is, not surprisingly, 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 Exhibit 2-3. 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 Single Event Noise Exposure Level (SENEL). This metric is essentially equivalent to the Sound Exposure (SEL) metric. It is computed from dBA sound levels. Referring again to the top of Exhibit 2-3, the shaded area, or the area within 10 dB of the maximum noise level, is the area from which the SENEL is computed. The SENEL value is the integration of all the acoustic energy contained within the event. Speech and sleep interference research can be assessed relative to Single Event Noise Exposure Level data.

The SENEL metric takes into account the maximum noise level of the event and the duration of the event. For aircraft flyovers, the SENEL 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 SENEL metric. In addition, cumulative noise metrics such as LEQ, CNEL and DNL can be computed from SENEL 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 in the middle graph of Exhibit 2-3. Leq can be measured for any time period, but is typically measured for 15 minutes, 1 hour or 24-hours. Leq for a one hour period is used by the Federal Highway Administration for assessing highway noise impacts. Leq for one hour is called Hourly Noise Level (HNL) in the California Airport Noise Regulations [4] 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 the hours of 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 Exhibit 2-3. Examples of various noise environments in terms of CNEL are presented in Exhibit 2-4. 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 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 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.

Supplemental Metrics

- **Time Above (TA).** The FAA developed the Time Above metric as a secondary 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 65 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 existing formal noise/land use compatibility standards defined in terms of a Time Above index.

The computer noise model developed by the FAA, the Integrated Noise Model, computes Time Above for any user set threshold. While there are no definitive land use standards for the Time Above metric, the metric is provided in this analysis as an additional description of the noise exposure because of its ready quantification of the amount of time that specific noise levels will be exceeded. This may be useful both in terms of judging this exposure as well as comparing alternatives or comparing the project to existing conditions. It also provides some quantificatoin of the potential for speech interference.

For purposes of this analysis three Time Above thresholds were used based on known speech interference levels associated with interfering noise. Speech interference is described in more detail in Section 2.5. In general, speech interference effects start when interfering noise, such as an aircraft, exceed 65 dBA for normal face to face conversation. Using this as a criteria threshold three Time Above thresholds were selected for this analysis, each corresponding to a level at which speech interference might occur. The three thresholds correspond to outdoor exposure to aircraft noise, indoor exposure with windows open and indoor exposure with windows closed. Given that outdoor to indoor noise reduction achieved by typical Southern California wood frame homes is 12 dBA with windows open and 20 dBA with windows closed (older homes built prior to UBC improved requirements for Energy Insulation), the three thresholds selected were 65 dBA, 77 dBA, and 85 dBA. These correspond directly to the beginning of speech interference outdoors, indoors with windows open and indoors with windows closed respectively. More modern homes could warrant the use of higher thresholds, but this analysis uses the more conservative values specified above.

- **Low Frequency Noise –** Special consideration is made in this study to account for potential impacts of low frequency noise. The A-weighted decibel is most sensitive to noise levels above 500 Hertz, where the ear is most sensitive and where most speech communication is located. However, people located close to certain aircraft operations may be impacted by low frequency noise that is not accounted for adequately by the A-weighted decibel. This is particularly true for residences near the sideline or behind aircraft during the initial takeoff roll or sideline or behind thrust reverser operations after landing. The C-weighting scale is more sensitive to low frequency noise as well as higher frequency noise. The A and C weighting scales are shown in Exhibit 2-5. Recent studies of low-frequency noise impacts near airports are summarized and studied in detail in a comprehensive report prepared for the Richfield -Metropolitan Airports Commission (MAC) for Minneapolis-St. Paul International Airport [5]. The expert panel convened to study low frequency noise impacts concluded that the C-weighting was not an adequate descriptor for low frequency noise and recommended the use of new noise metric called ‘Low Frequency Sound Level,’ or LFSL. “LFSL is a single event noise metric that sums the maximum one-third octave band sound levels from 25 to 80 Hz, inclusive, that occur during the course of an individual aircraft passby.” The annoyance due to low frequency sound was correlated to the noise induced ‘rattle’ in the residents home, and LFSL proved to be a good predictor of such rattle noise.

2.5 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:

- 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 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, 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 of describing speech interference as a function of distance between speaker and listener and voice level. Exhibit 2-6 shows the relation of quality of speech communication with respect to various noise levels.

- 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 which 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. Some years ago (1981) The National Association of Noise Control Officials [6] published data on the probability of sleep disturbance with various single event noise levels. Based on laboratory experiments conducted in the 1970's, this data indicated noise exposure, at 75 dBA interior noise level event will cause noise induced awakening in 30 percent of the cases.

However, recent research from England [7, 8] 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 1990's 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 1994 British sleep study compared the various causes of sleep disturbance using in home sleep studies. This field study assessed the effects of nighttime aircraft noise on sleep in 400 people (211 women and 189 men; 20-70 years of age; one per household) habitually living at eight sites adjacent to four U.K. airports, with different levels of night flying. The main finding was that only a minority of aircraft noise events affected sleep, and, for most subjects, that domestic and other non-aircraft factors had much greater effects. As shown in the Exhibit 2-7A, aircraft noise was a minor contributor among a host of other factors which lead to awakening response.

The Federal Interagency Committee on Noise (FICON) in 1992 in a document entitled *Federal Interagency Review of Selected Airport Noise Analysis Issues* [9] 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 which show lower rates of awakening compared to the laboratory studies [10]. 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 Exhibit 2-7B. This is a very conservative approach. A more common statistical curve for the data points reflected in Exhibit 2-7A, for example, would indicate a 10% awakening rate at a level of approximately 100 dB SENEL, while the "maximum awakened" curve reflected in Exhibit 2-7B shows the 10% awakening rate being reached at 80 dB SENEL. (The full FICAN report can be found on the internet at www.fican.org.)

- Physiological Responses are those measurable effects of noise on people which 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 over flight.

Health effects from noise have been studied around the world for nearly thirty years. Scientists have attempted to determine whether high noise levels can adversely affect human health-apart from auditory damage-which 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--that is, 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, [11] 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.

- 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 percent of the population is highly susceptible to annoyance from any noise not of their own making, while approximately 20 percent 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. Exhibit 2-8 relates DNL noise levels to community response from two of these surveys. One of the survey curves presented in Exhibit 2-8 is the well known Schultz curve, developed by Theodore Schultz [14]. It displays the percent of a populace 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. Annoyance levels have never been correlated statistically to single event noise exposure levels in airport related studies.

2.6 NOISE/LAND USE COMPATIBILITY GUIDELINES

Noise metrics 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 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 noise/land use compatibility criteria that have been adopted by the Federal Government or the State of California.

This section presents information regarding noise and land use criteria useful in the evaluation of noise impacts. The Federal Aviation Administration has a long history of publishing noise/land use assessment criteria for airports. These laws and regulations provide the basis for local development of airport plans, analyses of airport impacts, and the enactment of compatibility policies. Other agencies including the EPA, the Department of Defense, the State of California, the County of Alameda and most cities have developed noise/land use compatibility criteria. A summary of some of the more pertinent regulations and guidelines are presented in the following paragraphs.

Federal Aviation Administration

- **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 Exhibit 2-9.

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."

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

The FAA has developed guidelines (Order 5050.4D) for the environmental analysis of airports. Federal requirements now dictate that increases in noise levels in noise sensitive land uses of over 1.5 dB DNL within the 65 dB DNL contour are considered significant (1050.1D Directive 6.14.99). If the threshold of 1.5 dB within the 65 DNL is met, then further analysis in the range of 60 to 65 DNL should be conducted to determine if a 3 dB increase in DNL will occur. This information is to be used in the consideration of mitigation measures.

- **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 (B-737-200, B-727 and DC-9); Stage 3 aircraft are newer, quieter aircraft (B-737-300, B-757, 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.

Part 91 generally states that all Stage 2 aircraft, over 75,000 pounds, will 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 expected to be in the domestic fleet after that date. The airlines have options on how and when to phase-out or acoustically treat Stage 2 aircraft, but it is anticipated that the domestic fleet in the mainland will be all Stage 3 by the year 2000.

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 more stringent. CNEL would be 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. 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 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.

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, in response to a federal statutory mandate, the EPA published this document [1] (EPA 550/9-74-004) describing 55 dB DNL as the requisite level with an adequate margin of safety for areas with outdoor uses, including 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 type 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. The EPA "levels document" does not constitute a standard, specification or regulation, but identifies safe levels of environmental noise exposure without consideration for achieving these levels or other potentially relevant considerations. These EPA guidelines have not been adopted or recommended for use by the FAA, the State of California, or the Board of Supervisors.

Federal Interagency Committee on Noise (FICON) Report of 1992 [14]

- The use of the CNEL or DNL metric and the 65 dB CNEL criteria has been reviewed by various interest groups concerning its usefulness in assessing aircraft noise impacts. 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 of airport noise impacts and to make recommendations regarding potential improvements. FICON includes representatives from the Departments of Transportation, Defense, Justice, Veterans Affairs, Housing and Urban Development, the Environmental Protection Agency, and the Council on Environmental Quality.

FICON was formed to review Federal policies used to assess airport noise impacts and on the manner in which noise impacts are determined. This included whether aircraft noise impacts are fundamentally different from other transportation noise impacts; the manner in which noise impacts are described; and the extent to which impacts outside of DNL 65 should be reviewed in federal environmental impact statements.

The committee determined that there are no new descriptors or metrics of sufficient scientific standing to substitute for DNL. The DNL noise exposure metric and the dose-response relationships used to determine noise impact were determined to be proper for assessing noise from civil and military aviation in the general vicinity of airports. The report supported agency discretion in the use of supplemental noise analysis. The report recommended improvement in public understanding of the DNL, supplemental methodologies and aircraft noise impacts.

The report endorsed and expanded traditional FAA environmental screening criteria for potential airport noise impacts. FICON recommended that if screening analysis determines noise-sensitive areas at or above DNL 65 dB show an increase of DNL 1.5 dB or more, then further analysis should be conducted of noise sensitive areas between DNL 60-65 dB having an increase of DNL 3 dB or more, consistent with the most recent FAA guidelines 1050.1D.

State of California

- The Aeronautics Division of the California State Department of Transportation (Caltrans), enforces the California Airport Noise Regulations. These regulations establish 65 dB 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 dB 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.

- Californian Noise Insulation Standards [12] 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 multi-family dwellings with exterior noise exposures greater that 60 dB CNEL must be sound insulated such that the interior noise level will not exceed 45 dB CNEL. These requirements apply to all roadway, rail, and airport noise sources.

- The State of California requires that all municipal General Plans contain a Noise Element [13]. 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 were created by State Law [14] for the purpose of establishing a regional level of land use compatibility between airports and their surrounding environs. The Alameda County Airport Land Use Policy Plan (1986) establishes noise land use compatibility standards for noise sensitive uses around airports and noise impact zones where these standards apply. While the plan encourages no residential development above 65 CNEL, for Oakland Airport, residential uses are permitted up to a CNEL value of 70 dB provided that sound insulation is provided.

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3.0 METHODOLOGY

3.1 BACKGROUND

The methods used here 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. These noise contours are supplemented here with specific noise data for selected points on the ground. The computer noise models used here are described in the following below.

3.2 COMPUTER MODELING

Noise contour modeling is a very key element of this noise study. Generating accurate noise contours is largely dependent on the use of a reliable, validated, and updated noise model. It is imperative that these contours be accurate for the meaningful analysis of airport and roadway noise impacts. The computer model can then be used to predict the changes to the noise environment as a result of any of the development alternatives under consideration.:

AIRPORT NOISE MODELING

Airport noise contours were generated in this study using the INM Version 6.0c. [15] The original INM was released in 1977. The latest version, INM Version 6.0c, was released for use in 2001 and is the state-of-the-art in airport noise modeling. The INM is a large computer program developed to plot noise contours for airports. The program is provided with standard aircraft noise and performance data for over 100 civilian aircraft types that can be tailored to the characteristics of the airport in question, as well as a database of military aircraft types.

One of the most important factors in generating accurate noise contours is the collection of accurate operational data. The INM program requires the input of the physical and operational characteristics of the airport. Physical characteristics include runway coordinates, airport altitude, and temperature and optionally, topographical data. Operational characteristics include various types of aircraft data. This includes not only the aircraft types and flight tracks, but also departure procedures, arrival procedures and stage lengths (flight distance) that are specific to the operations at the airport. Aircraft data needed to generate noise contours include:

- Number of aircraft operations by type
- Types of aircraft
- Day/Evening/Night time distribution by type
- Flight tracks
- Flight track utilization by type
- Flight profiles
- Typical operational procedures
- Average Meteorological Conditions

4.0 EXISTING NOISE ENVIRONMENT

4.1 EXISTING AIRCRAFT NOISE

Oakland serves both general aviation and scheduled commercial passenger airline and cargo operations. Extensive data from its noise monitoring system enables precise modeling and prediction of noise levels. Radar tracings and sophisticated use of noise monitoring stations has produced very accurate depictions of flight tracks. The noise levels of all commercial aircraft operations and many general aviation operations are recorded at permanent noise monitoring stations around the airport. Both CNEL and SENEL are monitored and calculated for each day and each aircraft. In accordance with State of California Airport Noise standards, a detailed report is compiled every three months summarizing this information, and each year an annual CNEL contour is computer modeled and included in the quarterly report. Noise complaint data is also meticulously recorded and analyzed.

During the year 2001 there were 5,835 complaints filed with the airport from a total of 530 complaintants. Many complaintants filed more than one complaint, with one complainer filing a total of 2,405 complaints during the year. Exhibit 4-1 shows a plot of the noise complaint locations near the airport for the year 2001.The complaint map shows that the largest clusters of complaints come from Bayfarm Island and Alameda.

4.2 EXISITING OPERATIONS DATA

The operations and noise level for existing conditions, as defined by year 2001 operations, are those contained in the last quarterly Noise Abatement Report for 2001 which was produced for the Port of Oakland by Buntin Brown and Associates.

Existing year 2001 aircraft operations at OAK totaled 458,420 which corresponds to a daily average of 1,256 operations (628 departures and 628 arrivals). An average of 222 of these operations occur at night (10 pm to 7 am).

4.3 EXISITING FLEET MIX DATA

The type and number of air carrier aircraft using OAK during 2001 are summarized below. These data were taken directly from the data used by BBA for the development of the Noise Quarterly Report for the fourth quarter of 2001.

Table 4-1 shows a summary of the Year 2001 operations data. Table 4-2 identifies the number of average daily operations by aircraft type shown for day, evening and nighttime periods. Table 4-3 shows the number of operations by runway and time period.

Table 4-1

Summary of Year 2001 Operations Data

TOTAL ANNUAL OPERATIONS:	458,420		
TOTAL DAILY OPERATIONS:			
Total Operations:	1,256		
Total Arrivals:	552		
Total Departures:	536		
Total T+G Operations:	168		
OPERATIONS BY TIME OF DAY:			
Operation	Day	Evening	Night
Departures:	323.6	85.8	126.3
Arrivals:	254.6	222.9	74.3
Touch and Go's:	121.3	25.3	21.9
Total:	699.5	334.0	222.4
DAILY OPERATIONS PERCENTAGES BY TIME OF DAY:			
Operation	Day	Evening	Night
Departures:	60.4	16.0	23.6
Arrivals:	46.1	40.4	13.5
Touch and Go's:	72.0	15.0	13.0

Table 4-2
Average Daily Operations By Aircraft Type, Year 2001

Aircraft	Day Dept	Eve Dept	Nt Dept	Day Arr	Eve Arr	Nt Arr	Total
737700	135.5	43.8	19.3	129.1	58.7	22.2	408.7
727EM2	4.7	0.4	7.7	3.2	5.0	5.3	26.2
MD83	13.1	1.9	4.4	11.4	5.4	3.8	40.0
767JT9	0.8	2.4	2.8	2.5	0.3	3.5	12.3
A300	1.4	0.7	4.2	2.1	1.1	3.6	13.0
DC1030	2.7	1.8	2.1	2.5	0.9	3.5	13.6
DC1010	2.1	1.4	1.6	2.0	0.7	2.7	10.5
MD11GE	0.1	0.1	2.1	0.2	0.2	2.0	4.6
A320	3.3	0.3	3.1	3.0	2.2	1.9	13.8
757PW	0.0	0.0	0.0	0.9	1.0	1.6	3.5
737N17	5.6	1.9	0.3	5.3	1.6	1.3	16.1
LEAR35	25.7	2.8	4.2	9.0	19.2	2.2	63.1
FK27	0.0	0.0	1.1	0.0	0.3	0.9	2.3
MD9028	0.0	0.0	0.6	0.0	0.0	0.6	1.2
A310	0.3	0.0	0.2	0.2	0.1	0.3	1.1
74720A	0.3	0.2	1.1	1.1	0.4	0.1	3.2
CNA208	2.3	0.0	2.5	1.0	3.9	0.0	9.8
BEC58P	41.2	11.0	16.5	1.5	65.7	2.9	138.8
OAKTTP	5.6	0.0	35.6	0.9	39.4	1.7	83.3
BEC9F	0.1	0.0	0.5	0.0	0.6	0.0	1.2
DC870	0.0	0.6	0.1	0.7	0.1	0.0	1.5
DC95HW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DC860	0.0	0.0	0.0	0.0	0.0	0.0	0.0
777200	0.2	0.1	0.0	0.3	0.0	0.0	0.6
COMSEP	138.4	28.8	25.0	138.4	28.8	25.0	384.4
757RR	1.0	0.1	2.2	0.0	0.0	0.0	3.3

Table 4-3

Average Daily Operations By Runway, Year 2001

Runway		Day	Eve	Night	Total	% D/A
29	Departures:	192.4	56.7	66.1	315.1	50.2
	Arrivals:	157.1	116.1	50.1	323.3	51.5
27R	Departures:	45.8	9.8	21.8	77.4	12.3
	Arrivals:	72.6	41.1	13.1	126.7	20.2
27L	Departures:	9.2	2.0	4.3	15.4	2.5
	Arrivals:	5.8	53.5	1.3	60.6	9.6
	T + G's:	55.2	11.5	10.0	153.3	24.4
11	Departures:	15.2	4.1	4.9	24.1	3.8
	Arrivals:	11.7	6.8	5.1	23.6	3.8
09R	Departures:	1.0	0.2	1.2	2.4	0.4
	Arrivals:	7.4	5.0	4.4	16.8	2.7
	T + G's:	5.5	1.1	1.0	15.2	2.4
09L	Departures:	9.4	1.9	4.5	15.8	2.5
	Arrivals:	0.0	0.4	0.4	0.8	0.1
33	Departures:	46.8	10.0	22.2	79.0	12.6
	Arrivals:	0.0	0.0	0.0	0.0	0.0
30	Departures:	3.9	1.2	1.3	6.4	1.0
	Arrivals:	0.0	0.0	0.0	0.0	0.0

4.4 EXISITNG CNEL CONTOURS AND LAND USE IMPACTS

The CNEL contours used to depict existing noise exposure at OAK are derived from the Noise Abatement Quarterly report for the last quarter of 2001. They are depicted on Exhibit 4-2. The location of the permanent noise monitoring locations is shown on Exhibit 4-3. Also shown on this exhibit are additional receptor locations that are used for specific point analysis in this study. These additional specific point locations are the locations of residential areas of interest in the study area that are not represented by an existing noise monitoring site. The contours were developed by calibrating the results of INM modeling to the measurements from the permanent noise monitoring stations. This work was done by BBA for the Port of Oakland.

Note that the contours shown in this report do not include the adjustments made to contours to account for over-water sound propogation that occurs in the vicinity of monitoring site number 2. In this area the sideline propogation of sound results in higher noise levels than is predicted by the INM (which is based on over-land sound propogation). The effect is important only near site 2 which located on the small peninsula surrounding the San Leandro Marina. Sound levels in the residential areas inland of site 2 are not affected by the over-water sound propogation and therefore this special circumstance does not impact the analysis done is this study.

The 2001 65 CNEL contour encroached upon some residential land uses on Bayfarm Island. The area within the 65 CNEL contour consists of homes that were insulated to protect against aircraft noise. The State of California Airport Noise Regulations do not include sound insulated homes within the definition of the airport noise impact area, therefore no homes are identified in the airports quarterly noise report as impacted within the 65 CNEL contour. The specific point data discussed in the next paragraph identifies the CNEL at the homes on Bayfarm Island closest to the flight tracks.

In addition to the CNEL contours, specific CNEL values are calculated for each permanent noise measurement site shown on Exhibit 4-2. Table 4-4 displays CNEL values at each of the receptor sites for 2001.

Table 4-4
Year 2001 CNEL at Receptor Sites

Location	CNEL
1	61.8
2	56.8
3	58.1
4	62.3
5	62.1
6	61.9
7	61.7
8	58.0
9	61.1
10	54.2
11	53.3
12	51.9
13	46.9
AL	51.8
B1	65.8
B2	65.2
B3	61.2
CG	51.1

4.5 EXISITING AIRCRAFT TIME ABOVE THRESHOLD (TA)

This metric is described in Section 2.4. TA values were generated for existing noise at OAK at each of the specific point receptor sites. The values of 65 dBA, 77 dBA and 85dBA correlate respectively to speech interference outdoors, indoors with windows open and indoors with windows closed. Year 2001 TA values at the specific point receptor sites are presented on Table 4-5. These are the number of minutes per 24 hour as well as the number of minutes during the night hours that noise levels exceed the given thresholds.

Table 4-5
Time Above Values (TA) for Existing Year 2001 Aircraft Operations in Average Minutes Per Day.

GRID	TA 65 (min.) 24 Hr. Day	TA 77 (min.) 24 Hr. Day	TA85 (min.) 24 Hr. Day	TA 65 (min.) Night	TA 77 (min.) Night	TA85 (min.) Night
1	70.6	0.4	0.0	11.5	0.1	0.0
2	6.1	0.3	0.0	1.0	0.1	0.0
3	14.5	0.0	0.0	5.2	0.0	0.0
4	29.0	1.3	0.0	8.6	0.8	0.0
5	38.0	0.4	0.0	10.3	0.2	0.0
6	51.6	0.8	0.0	8.0	0.2	0.0
7	63.7	1.5	0.0	6.6	0.1	0.0
8	9.5	0.0	0.0	3.6	0.0	0.0
9	24.3	1.8	0.0	3.4	0.5	0.0
10	3.4	0.1	0.0	1.2	0.0	0.0
11	4.2	0.0	0.0	1.0	0.0	0.0
12	0.8	0.0	0.0	0.3	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0
AL	1.0	0.0	0.0	0.0	0.0	0.0
B1	59.4	6.0	0.2	13.8	1.0	0.1
B2	89.5	5.4	0.0	14.5	1.2	0.0
B3	66.0	0.7	0.0	5.2	0.1	0.0
CG	1.1	0.0	0.0	0.1	0.0	0.0

5.0 POTENTIAL FUTURE NOISE WITH EXISTING RUNWAYS

5.1 FUTURE OPERATIONS DATA

In order to make an assessment of potential future noise impacts associated with operations growth at the airport, a future noise contour was developed using an assumed growth air traffic. It is beyond the scope of this study to complete a specific forecast of future operations. Therefore, based on agreements with study participants (Port of Oakland, City of Alameda, and CLASS), a 50% increase in operations was examined. No attempt is made to say when such a growth may occur, but only to examine the noise impacts if such a growth did occur. In that sense, this analysis is more of a sensitivity analysis than a noise or aviation forecast.

Table 5-1 shows a summary of the Year 2001 operations data. Table 5-2 identifies the number of average daily operations by aircraft type shown for day, evening and nighttime periods. Table 5-3 shows the number of operations by runway and time period.

Table 5-1

Summary of Future Year Operations Data

TOTAL ANNUAL OPERATIONS:	687,639		
TOTAL DAILY OPERATIONS SUMMARY:			
Total Operations:	1,883.9		
Total Arrivals:	827.6		
Total Departures:	803.6		
Total T+G Operations:	252.7		
OPERATIONS BY TIME OF DAY:			
Operation	Day	Evening	Night
Departures:	485.5	128.7	189.4
Arrivals:	381.9	334.4	111.4
Touch and Go's:	182.0	37.9	32.9
Total:	1049.3	501.0	333.7
DAILY OPERATIONS PERCENTAGES BY TIME OF DAY:			
Operation	Day	Evening	Night
Departures:	60.4	16.0	23.6
Arrivals:	46.1	40.4	13.5
Touch and Go's:	72.0	15.0	13.0

Table 5-2

Average Daily Operations By Aircraft Type, Potential Future Year

Aircraft	Day Dept	Eve Dept	Nt Dept	Day Arr	Eve Arr	Nt Arr	Total
737700	203.3	65.8	28.9	193.7	88.1	33.4	613.0
727EM2	7.0	0.5	11.5	4.8	7.4	8.0	39.3
MD83	19.6	2.9	6.7	17.1	8.0	5.7	60.0
767JT9	1.2	3.5	4.3	3.7	0.4	5.3	18.4
A300	2.1	1.1	6.3	3.1	1.6	5.3	19.6
DC1030	4.0	2.7	3.2	3.8	1.4	5.3	20.4
DC1010	3.1	2.1	2.4	2.9	1.1	4.1	15.8
MD11GE	0.1	0.1	3.1	0.2	0.3	3.0	6.9
A320	4.9	0.4	4.7	4.5	3.3	2.9	20.7
757PW	0.0	0.0	0.0	1.3	1.6	2.3	5.2
737N17	8.4	2.9	0.5	8.0	2.4	2.0	24.1
LEAR35	38.5	4.2	6.3	13.5	28.9	3.2	94.6
FK27	0.0	0.0	1.7	0.0	0.5	1.3	3.5
MD9028	0.0	0.0	0.9	0.1	0.0	0.9	1.8
A310	0.5	0.1	0.2	0.3	0.1	0.4	1.6
74720A	0.4	0.3	1.6	1.7	0.6	0.2	4.7
CNA208	3.4	0.0	3.8	1.5	5.8	0.1	14.7
BEC58P	61.9	16.5	24.7	2.2	98.5	4.3	208.2
OAKTTP	8.5	0.0	53.4	1.3	59.1	2.6	124.9
BEC9F	0.1	0.0	0.7	0.0	0.8	0.0	1.7
DC870	0.1	0.9	0.1	1.0	0.1	0.0	2.2
DC95HW	0.0	0.0	0.0	0.0	0.0	0.0	0.1
DC860	0.0	0.0	0.0	0.0	0.0	0.0	0.0
777200	0.3	0.1	0.0	0.5	0.0	0.0	0.9
COMSEP	207.6	43.2	37.5	207.6	43.2	37.5	576.6
757RR	1.5	0.2	3.2	0.0	0.0	0.0	4.9

Table 5-3

Average Daily Operations By Runway, Potential Future Year

Runway		Day	Eve	Night	Total	% D/A
29	Departures:	288.5	85.0	99.1	472.7	50.2
	Arrivals:	235.7	174.2	75.1	485.0	51.5
27R	Departures:	68.7	14.7	32.8	116.1	12.3
	Arrivals:	108.8	61.6	19.6	190.0	20.2
27L	Departures:	13.7	2.9	6.5	23.2	2.5
	Arrivals:	8.7	80.3	1.9	90.9	9.6
	T + G's:	82.8	17.2	14.9	230.0	24.4
11	Departures:	22.8	6.1	7.3	36.1	3.8
	Arrivals:	17.6	10.2	7.7	35.5	3.8
09R	Departures:	1.6	0.3	1.7	3.6	0.4
	Arrivals:	11.0	7.4	6.7	25.2	2.7
	T + G's:	8.2	1.7	1.5	22.7	2.4
09L	Departures:	14.1	2.9	6.7	23.8	2.5
	Arrivals:	0.1	0.6	0.5	1.2	0.1
33	Departures:	70.2	15.0	33.2	118.4	12.6
	Arrivals:	0.0	0.0	0.0	0.0	0.0
30	Departures:	5.9	1.7	2.0	9.7	1.0
	Arrivals:	0.0	0.0	0.0	0.0	0.0

5.2 POTENTIAL FUTURE YEAR CNEL CONTOURS AND LAND USE IMPACTS

The CNEL contours used to depict potential future noise exposure at OAK are derived from INM Version 6.0c by inputing the future operations data. These contours are depicted on Exhibit 5-1.

In addition to the CNEL contours, specific CNEL values are calculated for each of the specific point receptor sites shown on Exhibit 4-2. Table 5-4 displays CNEL values at each of the receptor sites for 2001.

Table 5-4

Future Year CNEL at Receptor Sites

Location	Future
1	63.5
2	58.6
3	59.8
4	64.0
5	63.9
6	63.7
7	63.5
8	59.7
9	62.9
10	56.0
11	55.1
12	53.7
13	48.7
AL	53.5
B1	67.6
B2	66.9
B3	63.0
CG	52.9

5.3 POTENTIAL FUTURE AIRCRAFT TIME ABOVE THRESHOLD (TA)

This metric is described in Section 2.4. TA values were generated for existing noise at OAK at each of the specific point receptor sites. The values of 65 dBA, 77 dBA and 85dBA correlate respectively to speech interference outdoors, indoors with windows open and indoors with windows closed. The potential future TA values at the specific point receptor sites are presented on Table 5-5. These are the number of minutes per 24 hour as well as the number of minutes during the night hours that noise levels exceed the given thresholds.

Table 5-5
Time Above Values (TA) for Potential Future Aircraft Operations in Average Minutes Per Day.

GRID	TA 65 (min.) 24 Hr. Day	TA 77 (min.) 24 Hr. Day	TA85 (min.) 24 Hr. Day	TA 65 (min.) Night	TA 77 (min.) Night	TA85 (min.) Night
1	106.0	0.6	0.0	17.3	0.1	0.0
2	9.2	0.5	0.0	1.5	0.1	0.0
3	21.7	0.0	0.0	7.8	0.0	0.0
4	43.6	2.0	0.0	12.9	1.1	0.0
5	57.0	0.5	0.0	15.4	0.3	0.0
6	77.4	1.3	0.0	12.0	0.3	0.0
7	95.5	2.2	0.0	9.9	0.2	0.0
8	14.3	0.0	0.0	5.3	0.0	0.0
9	36.4	2.7	0.1	5.2	0.7	0.1
10	5.1	0.1	0.0	1.8	0.1	0.0
11	6.3	0.0	0.0	1.5	0.0	0.0
12	1.2	0.0	0.0	0.5	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0
AL	1.5	0.0	0.0	0.0	0.0	0.0
B1	89.0	9.0	0.3	20.7	1.6	0.1
B2	134.2	8.1	0.0	21.7	1.8	0.0
B3	99.1	1.1	0.0	7.9	0.1	0.0
CG	1.6	0.0	0.0	0.1	0.0	0.0

6.0 NOISE EFFECTS OF CROSSWIND RUNWAY

6.1 FLIGHT TRACKS FOR CROSSWIND RUNWAY DEPARTURES

The purpose of this section is to describe the development of the flight tracks that will be used to model noise from a new crosswind runway. The tracks were developed to minimize noise impacts on residential areas and to minimize airspace conflicts. Three main flight tracks were developed for the crosswind runway. These include 2 main departure tracks (right turn and left turn tracks) and one main arrival track. These are described below.

6.2 ARRIVAL TRACK

The arrival to a crosswind runway will accomplish the goal of reduced noise impact only if the arrival is completed from over the bay (south to north direction of flight). Note that for purposes of discussion in this report, the existing main runway at OAK is an east- west runway (heading is approximately 290 magnetic) named Runway 29 for west flow operations and Runway 11 for east flow operations. The new crosswind runway is a north-south runway and is named Runway 03 for north flow operations and Runway 21 for south flow operations.

A night arrival to the crosswind will require a straight-in segment at least 5 nautical miles in length prior to reaching the runway threshold. Aircraft would need to be aligned to the runway and stabilized at the 5 nautical mile point. This is shown in Exhibit 6-1. In order to be aligned and stable at the 5 nautical mile point the aircraft would line up some distance prior to this point. Such an approach would most certainly involve aircraft overflying the peninsula (See Exhibit 6-1) introducing new overflights over a noise sensitive area.

While an approach that flew down the middle of the bay would be preferable from a noise point of view, there are safety issues with that approach. An approach from the middle of the bay would require a short turning final at night over water where there are no visual clues to assist in a visual approach. Pilot organizations have historically objected to these types of approaches. In order to get to the 5 nautical mile point in the most noise sensitive manner, aircraft could fly the Quiet Bridge approach to SFO and execute a right turn to OAK (instead of shifting left for the SFO runways). While the Quiet Bridge is a preferred approach to SFO to minimize noise on Foster City, adding OAK night arrivals to this flow would increase noise over Foster City by increasing the apparent number of operations into SFO. It would also have a negative effect on capacity, as all arrivals into both airports would need to be in a single stream just east of Foster City.

Arrivals to the crosswind runway, Runway 03, would be ‘contra-flow’ to departures from the crosswind runway (departures on Runway 21). Contra-flow has a very negative impact on runway capacity. As discussed in the next section, air traffic rules would require at least a 5 minute separation between a departing OAK aircraft and an arriving aircraft to the same runway in a contra-flow direction. The 5 minute separation assumes that the departing aircraft turns immediately away from the arriving aircraft path (divergent paths). But as will be seen in the next paragraphs, noise reduction in Alameda is best accomplished by directing departing aircraft from the crosswind runway to the middle of the bay before turning north or south. An immediate turn off the end of the crosswind runway would put aircraft just south of the present Runway 29 or Runway 11 departure paths accomplishing little of what is expected of the crosswind runway.

The use of the crosswind runway for arrivals would reduce capacity making the runway available for fewer hours during the night, result in crosswind departures turning very early and thus not accomplishing the separation from the existing flight paths that is expected, and would increase the noise burden on Foster City. For these reasons, arrivals to the crosswind runway are not expected to occur and would not be one of the benefits of building a crosswind runway.

6.3 DEPARTURE FLIGHT TRACKS

Departure flight tracks were developed for the crosswind runway. The primary goal of the tracks is to minimize noise by locating the track as far as possible from residential areas and achieving the necessary separation between aircraft. Both a right turn and left turn track were developed. Flight track dispersion is also considered as part of this analysis.

The first step in developing the flight tracks is to examine the existing night tracks for SFO. These are shown for north flow conditions in a radar track map that show SFO and OAK operations in Exhibit 6-2. Of particular interest in Exhibit 6-2 are SFO departures off of Runways 01. This track corridor is shown on an aeronautical chart in Exhibit 6-3 and copied and translated to the OAK crosswind runway. Clearly, the OAK departure tracks must turn earlier and sharper in order to not cross the peninsula. Exhibit 6-4 shows the adjusting of the flight corridor to accomplish a ‘down the middle of the bay’ flight path. The center of the corridor is the nominal flight track. The edges of the corridor are where aircraft dispersion will cause aircraft to drift. For purposes of the noise analysis, the track dispersion traced from the SFO Runway 01 departures is also used here. However, a wider dispersion is also shown because there is a concern that the turns required for the OAK departure are such that more dispersion may be expected (a 10% error in a 30 degree turn is much smaller than a 10% error in a 115 degree turn).

The location of the right turn was derived in order to keep aircraft over the bay and avoid over flying the peninsula or Alameda. An aircraft that turns late or wide will overfly Hunters Point or possibly other areas of the peninsula. Aircraft that turn early and too sharp will overfly Alameda.

An important point must be made here regarding the navigation capabilities of new aircraft. Flight Management Systems and GPS capability on new aircraft reduce flight track dispersion and reduce the chances of overflight of the peninsula or Alameda. This would be expected for the B757, B767 and newer Airbus aircraft. However, the primary noise concern at night are the hushkitted B727 aircraft and the DC10 widebodies. These are older aircraft that in most cases do not have the new computerized navigation capabilities. Therefore, the issue of flight track dispersion is an important one and is particularly relevant to the noisiest aircraft that are of concern here.

Note that the left turn departure track is located such that aicraft will maintain a 3 nm separation from aircraft arriving to OAK Runway 11. Aircraft making an early turn would violate that separation and aircraft making a late turn may inadvertently overfly Foster City.

6.4 RUNWAY UTILIZATION WITH NEW CROSSWIND RUNWAY

Runway utilization is the percent of time that the crosswind runway would be used. It is determined by aircraft size and performance, meteorological and air traffic issues. The following is a brief and simplified description of the process through which the FAA, the airlines and the aircraft operators would initiate operations on a crosswind runway. Ultimately the decision on runway use would be determined by the pilots and the FAA. For purposes of this analysis it is assumed that the new crosswind runway is named 21/03, with departures occurring only on Runway 21 and arrivals, if any, occurring only on Runway 03.

Airlines and air cargo operators require changes to their Operations Specifications for Oakland International Airport prior to using Runway 21 or 03. The Operations Specifications are the approved procedures that a pilot may use when operating on Runways 21/03. The Operations Specifications include such information and the weight restrictions for each aircraft type based on wind, temperature and runway length, the departure procedure that will be used, and numerous safety related issues such as procedures for engine out operations, missed approach, etc.

The FAA will need to develop departure procedures for Runway 21 as well as approach procedures for Runway 03 and include these in the air traffic control procedures for Oakland as well as publish these procedures for pilot use. Consistent with current updating of the air traffic system, GPS and RNAV procedures would also be developed. The FAA will develop these procedures based on meteorological, air traffic and air space considerations.

Operator use of Runway 21 will begin with ATC assignment/approval for a departure on Runway 21. ATC may assign Runway 21 based on a number of considerations including but not limited to air traffic in the area, other runways that are in use (including OAK and SFO), and controller workload. The following is a description of issues related to FAA authorization for Runway 21 departures.

It is impossible to define these issues in a final and conclusive manner, as it is ultimately the responsibility of the FAA to design the procedures and to define the parameters under which they may be used. However, given the known airspace environment in the Bay area, it is possible to outline the constraints under which Runway 21 operations would occur.

Capacity – Advisory Circular 150/5060-5, 'Airport Capacity and Delay,' published by the FAA, defines capacity as "a measure of the maximum number of aircraft operations which can be accommodated on the airport or airport component in an hour." Runway capacity is critically dependent on the class of aircraft (single engine prop, heavy multi-engine jet), the number of runways, runway configuration, percentage arrivals and departures, etc. The theoretical capacity of a given runway configuration is based on the assumption that "there are no airspace limitations which would adversely impact flight operations or otherwise restrict aircraft which could operate at the airport." The runway configuration with the new crosswind runway would include Runways 11/29 and Runways 21/03. That configuration has a theoretical IFR hourly capacity of 59 air carrier operations per hour assuming 50% of operations are arrivals and there are no airspace limitations (No. 9, Figure 2-1, AC 150/5060-5).

The complicating factor at OAK is the presence of SFO departures from Runway 01 Left and Right. These are the primary noise abatement runways at SFO and they point towards OAK (Runway 28 at SFO and Runway 21 at OAK diverge at angle of about 12 degrees). Aircraft could not depart SFO Runways 01 Left or Right simultaneously with a departure from OAK Runway 21. If such a sequence of departures were to occur the aircraft would be heading towards each other and would violate necessary separation requirements. Exhibit 6-5 shows the extended runway centerlines and the aircraft separation at the center of the bay. Therefore, the operation of SFO Runways 01 and OAK Runway 21 would be dependent and all departures would have to be coordinated to ensure that departing aircraft maintain adequate separation.

In addition, arrivals to OAK and SFO must be considered in determining the amount of time that Runway 21 could be used for departures. It is important to note that for purposes of considering the separation of the aircraft, consideration must be given to procedures that will be used in the event of a problem. For example, approaching aircraft require not only the separation required for the landing operation, but consideration must also be made for a missed approach and the subsequent go-around. For OAK approaches to Runway 29, the missed approach procedure is a left turn over the bay and thus must be allowed for in considering Runway 21 departure operations. For a departure, allowance must be made for an aborted takeoff.

The important issue for this analysis is the capacity of the runway system formed by SFO and OAK when OAK is operating with departures on the crosswind runway. Any hour in which the sum of the SFO and OAK demand is less than this capacity, the crosswind runway may be used. The difficulty is to calculate the capacity of such a system of runways. AC 150/5060 does not address such a system and there is no system like it the aviation system. Operations from runways that result in converging traffic (Exhibit 6-5 shows that there would be less that 3 nautical miles separation) are avoided because of the negative effect such configurations have on capacity. The intent of the following analysis is to make a rough estimate of the capacity of the runway system that includes departures on an OAK crosswind runway.

A departure could occur on the OAK crosswind in a sequence in which there is sufficient separation from aircraft approaching OAK Runways 11 or 29 and aircraft departing SFO Runways 01 Left or Right. By describing the necessary separation and using typical aircraft airspeeds, the capacity of such a system can be estimated.

Required Aircraft Separation

<u>Landing Aircraft to OAK Runway 29 or Runway 11:</u> A landing aircraft must be sequenced so as to not cross the landing threshold until a departing aircraft from an intersecting runway has crossed the intersection.[1] In addition, in the event of a missed approach the aircraft shall not come within 3 nautical miles of an aircraft departing OAK or SFO unless there is at least a 1000 foot vertical separation (this is the requirement for level flight, vertical separation requirements for climbing or descending aircraft may be greater).

<u>Departing Aircraft from SFO Runways 01 Left or Right and OAK Runway 21</u>: This situation is not addressed in standard air traffic control procedures. There are minimum separation requirements for aircraft in trail. In normal circumstances aircraft are required to have a 3 nm in-trail separation, or 5 nm if the lead aircraft is a heavy (aircraft greater than 300,000 pounds maximum certificated takeoff weight, but also includes the B757 aircraft). Given typical aircraft speeds the time to achieve these separations can be estimated, and assuming a mix of 50% arrivals and 50% departures the capacity of the system can be estimated. The critical factor is the assumption that aircraft departing SFO on Runways 01 Right or Left could come within 3 nm of an aircraft departing OAK on Runway 21. In reality it is likely that air traffic would not release an SFO Runway 01 departure or OAK Runway 21 departure until the opposing aircraft had made the turn north or south and the following aircraft would have an in-trail separation of 3nm or 5nm for heavies. There is a similar situation that is accounted for in air traffic control. If a departing aircraft departs towards an arriving aircraft that will land on the same runway (in the opposite direction), and the departing aircraft will diverge from the oncoming aircraft by at least 45°, then there must be a 5 minute separation between the departing aircraft's turn and the arrival of the arriving aircraft.[1] This condition results in a separation of 5 minutes. At a typical approach speed this translates to 11 nm of separation. This lends credence to the assumption that a departing aircraft could not begin departure until the aircraft at the opposite airport had departed and completed the turn in middle of the bay, whether to the north or south.

Runway System Capacity

Assuming an OAK departure at typical aircraft departure speeds, a turn that begins at a point that places the flight track near the center of the bay, and a standard rate turn, the time from

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[1] Fundamentals of Air Traffic Control, Nolan, Wadsworth Publishing, 1990.

beginning of takeoff roll to completion of the turn through 90° (left turn) or 110° (right turn) is approximately 3 minutes. For an SFO departure the time to completion of the turn is closer to 2.5 minutes. This is shown in Exhibit 6-6. Examination of Exhibit 6-6 shows that 3 nm separation can be maintained if the SFO departure is begun no less than 2 minutes after an OAK departure. Conversely, an OAK departure doing a right turn must allow for a 3 minute delay after the SFO departure. If the lead aircraft is a an OAK heavy, then the delay times increase by about 2 minutes for the SFO departure.

Assuming the average time delay between departures is 2 1/2 minutes for non-heavy aircraft and 3 1/4 minutes for heavy aircraft and assuming 1 arrival for each departure, the hourly capacity of this system is approximately 21 departures per hour or 40 operations per hour. Note that if the actual separation is 5 minutes per departure, per the 5 minute ‘contraflow’ rule referenced earlier, then the hourly capacity drops to 12 departures per hour or 24 operations per hour. For purposes of completing the noise analysis of the crosswind runway, hours with a demand of less than 24 operations per hour are assumed compatible with crosswind operations and hours with demand exceeding 40 operations per hour would not support crosswind operations. Hours with demand between 24 and 40 operations per hour are considered marginal, and only portions of that hour may support crosswind operations.

RUNWAY DEMAND BY HOUR OF THE DAY

Detailed operations data were obtained in order to determine runway demand during the critical night hours. These data were obtained for SFO and OAK for the 2 week period beginning August 1, 2001 and ending August 14, 2001. This is a busy time of the year and precedes the September 11, 2001 tragedy. A summary of the 2 week data are presented in Table 6-1. These data are used here to represent existing conditions. Table 6-2 presents a forecast of future conditions based on an assumed growth of 50%.

Table 6-1 shows that during the hours of 1 am to 6 am existing demand is compatible with crosswind runway operations. Table 6-2 show that during the hours of 2 am to 6 am the future demand is compatible with crosswind runway operations. Note that the hour from 5 am to 6 am is somewhat unique, in that there is very little demand during the first 30 minutes of the hour (5 am to 5:30 am) and almost all of the hourly demand occurs after 5:30am. In reality the crosswind operation mode would cease at approximately 5:30 am.

It is interesting to examine the OAK departure demand during the night hours. Table 6-3 presents the hourly night departure demand by aircraft type for the hours of 11 pm through 7 am. It is clearly seen in this table that the aircraft of greatest noise concern, both in terms of loudness and number of operations is the B727 hushkit aircraft. These aircraft begin departures after 2 am and are completed by 5 am.

Table 6-1
Existing Hourly Demand At SFO and OAK*

	SFO			OAK			Combined		
Hour Beginning	Avg ops/hour	Avg Depts	Avg Arrivs	Avg ops/hour	Avg Depts	Avg Arrivs	Avg ops/hour	Avg Depts	Avg Arriv
0	18.4	8.1	10.3	7.9	4.1	3.7	26.2	12.2	14.
1	10.7	6.6	4.1	6.0	2.4	3.6	16.7	9.0	7.
2	5.1	3.1	2.1	7.7	5.9	1.8	12.9	9.0	3.
3	1.7	0.8	0.9	9.2	5.0	4.2	10.9	5.8	5.
4	4.0	2.1	1.9	9.5	5.0	4.5	13.5	7.1	6.
5	4.2	1.8	2.4	9.3	7.1	2.2	13.5	8.9	4.
6	39.5	25.4	14.1	23.5	20.1	3.4	63.0	45.5	17.
7	53.3	33.9	19.4	31.4	20.7	10.6	84.6	54.6	30.
8	59.2	39.2	20.0	38.5	22.1	16.4	97.7	61.3	36.
9	56.9	27.0	29.9	35.1	19.6	15.5	92.0	46.6	45.
10	53.6	21.8	31.9	36.6	19.1	17.4	90.2	40.9	49.
11	70.6	36.0	34.6	44.9	23.1	21.7	115.5	59.1	56.
12	67.7	31.8	35.9	51.9	27.8	24.1	119.6	59.6	60.
13	71.5	37.0	34.5	47.1	27.2	19.9	118.6	64.2	54.
14	72.2	40.6	31.6	46.4	25.3	21.1	118.6	65.9	52.
15	60.4	32.4	27.9	46.4	24.3	22.1	106.7	56.7	50.
16	58.4	28.9	29.6	54.7	23.9	30.8	113.1	52.8	60.
17	69.1	31.0	38.1	52.7	26.9	25.8	121.9	57.9	63.
18	57.2	29.9	27.4	58.8	21.1	37.6	116.0	51.0	65.
19	71.4	29.9	41.5	50.3	23.6	26.6	121.6	53.5	68.
20	54.5	19.6	34.9	40.7	16.2	24.5	95.2	35.9	59.
21	54.4	20.1	34.2	38.4	15.0	23.4	92.7	35.1	57.
22	53.3	26.9	26.4	26.1	6.3	19.8	79.4	33.2	46.
23	35.9	14.5	21.4	19.9	6.9	13.1	55.9	21.4	34.

*(average of August 1 through August 14, 2001)

Table 6-2
Forecast Future Hourly Demand At SFO and OAK

	SFO			OAK			Combined		
Hour Beginning	Avg ops/hour	Avg Depts	Avg Arrivs	Avg ops/hour	Avg Depts	Avg Arrivs	Avg ops/hour	Avg Depts	Avg
0	27.5	12.1	15.4	11.8	6.2	5.6	39.3	18.3	
1	16.1	10.0	6.1	9.0	3.5	5.5	25.1	13.5	
2	7.7	4.6	3.1	11.6	8.9	2.7	19.3	13.5	
3	2.6	1.2	1.4	13.8	7.5	6.3	16.4	8.7	
4	6.0	3.1	2.9	14.3	7.5	6.8	20.3	10.6	
5	6.3	2.7	3.6	13.9	10.6	3.3	20.3	13.3	
6	59.3	38.1	21.1	35.3	30.1	5.1	94.5	68.3	
7	79.9	50.8	29.1	47.0	31.1	16.0	127.0	81.9	
8	88.8	58.8	30.0	57.8	33.1	24.6	146.6	91.9	
9	85.4	40.5	44.9	52.6	29.4	23.3	138.0	69.9	
10	80.5	32.7	47.8	54.9	28.7	26.1	135.3	61.4	
11	106.0	54.0	52.0	67.3	34.7	32.6	173.3	88.7	
12	101.6	47.7	53.9	77.9	41.7	36.2	179.5	89.4	
13	107.3	55.5	51.8	70.6	40.8	29.8	177.9	96.3	
14	108.3	60.9	47.5	69.5	37.9	31.6	177.9	98.8	
15	90.5	48.6	41.9	69.5	36.4	33.1	160.1	85.1	
16	87.6	43.3	44.4	82.1	35.9	46.2	169.7	79.2	
17	103.7	46.5	57.2	79.1	40.4	38.7	182.8	86.9	
18	85.8	44.8	41.0	88.2	31.7	56.5	174.0	76.5	
19	107.0	44.8	62.3	75.4	35.5	40.0	182.5	80.3	
20	81.8	29.5	52.3	61.1	24.3	36.8	142.8	53.8	
21	81.5	30.2	51.3	57.5	22.5	35.0	139.1	52.7	
22	79.9	40.4	39.5	39.1	9.4	29.7	119.0	49.8	
23	53.9	21.8	32.1	29.9	10.3	19.6	83.8	32.0	

Table 3
OAK Night Average Number of Departures Per Hour By Aircraft Type

Hour Beginning	B72Q	DC10	MD11	A306	Boeing Twins	Other	Total
23	0.5	0.1	0.0	0.0	1.1	5.2	6.9
0	0.2	0.0	0.0	0.0	0.2	3.7	4.1
1	0.0	0.0	0.4	0.1	0.1	1.8	2.4
2	1.1	0.6	0.4	1.2	0.0	2.6	5.9
3	2.1	0.0	0.1	1.4	0.1	1.3	5.0
4	0.4	0.1	0.1	0.0	0.4	4.0	5.0
5	0.0	0.3	0.1	0.0	1.1	5.6	7.1
6	1.2	0.6	0.0	0.0	5.4	12.9	20.1

Crosswind Runway Effects on Number of OAK Runway Operations

For purposes of computing the CNEL contours for crosswind runway use, it is necessary to identify the number of operations that will be relocated from existing runways to the new crosswind runway. For existing operations all of the departures from 12:30 am until 5:30 am will be moved to the crosswind runway. This is approximately 24 departures per night. This compares to a 24 hour average of 399 departures. For the future forecast conditions, all of the departures from 1:30 am until 5:30 am will be moved to the crosswind runway. This is approximately 48 departures per night for existing conditions. This compares to a future 24 hour average of 598 departures.

6.5 SINGLE EVENT NOISE COMPARISON

The key analysis to determine the potential benefits or impacts of a new crosswind runway is a comparison of noise levels in the airport environs with and without the crosswind runway. In this section single event noise levels are compared using single event contours and single event noise data at specific point locations. The single event noise metric used here is the Sound Exposure Level (SEL). SEL was defined in Section 2.4 and is illustrated in Exhibit 2-3. SEL is dependent on the maximum noise level and the duration of a noise event. Two noise events that have the same maximum noise level, the one that has a longer duration will have the higher SEL value. Single event noise contours were developed for a series of air carrier and cargo aircraft that operate at OAK. These include the following aircraft:

- Boeing 727 with hushkits
- DC10
- Airbus 300
- Boeing 767
- Boeing 737-400
- Boeing 757

The single event contours were generated using INM Version 6.0c. All of the aircraft were analyzed using departure weights corresponding to flights to cargo hubs in Memphis and Louisville. Two sets of noise contours were developed for each crosswind departure, one using a left turn and one using a right turn.

Single event contours were developed for SEL values of 75 through 95 dBA. An SEL contour of 75 dBA would correspond to an A-weighted maximum noise level of approximately 65 dBA, a level that would be comparable to normal conversation. Thus the contours encompass the area for which some speech interference would be expected.

Exhibits 6-7 through 6-18 show the SEL contours for each aircraft type including one each showing a right turn and left turn. The noise contours for Runway 29 departures are shown as a solid line and departures on the new crosswind runway are shown using a dashed line. The following is a key to the exhibit numbers for the single event noise contours:

	Exhibit Number	
Aircraft	Right Turn	Left Turn
B727hushkit	6-7	6-8
DC10	6-9	6-10
A300	6-11	6-12
B767	6-13	6-14
B737-400	6-15	6-16
B757	6-17	6-18

Clearly the B727 is the noisiest aircraft and is a critical aircraft because of its use as a cargo aircraft at night. Exhibit 6-19 shows a plot of the difference between the Runway 29 and crosswind departures of a B727. These contours are in 1 dB increments from minus 10 dB (crosswind departure is quieter) to plus 10 dB (crosswind departure is noisier). Where the crosswind is quieter the contours are colored green and where the crosswind in noisier the contours are colored red. Exhibit 6-20 is the same plot, but zoomed in closer to the homes closest to the airport.

Another method of comparing the single event noise levels is to compare the SEL values at specific points around the airport. Table 6-4 compares the SEL values at specific point receptor locations for a right turn off of the crosswind runway. Table 6-5 provides the same comparison for a left turn. Table 6-6 compares the difference between SEL values at specific point receptor points for a right turn with a negative value indicating crosswind runway is quieter. Table 6-7 provides the same data for a left turn.

Table 6-4

Departure SENEL At Grid Point Location By Aircraft and Runway, Departures on Runway 29 Seven and Runway 21Right Turn

GRID	B727D21	B727D29	DC10D21	DC10D29	A300D21	A300D29	B767D21	B76
1	59.3	62.0	53.1	53.2	50.9	53.5	51.8	
2	71.0	77.7	65.0	70.2	62.3	70.2	62.8	
3	74.9	67.6	66.9	64.3	67.0	60.7	65.1	
4	83.3	77.7	76.3	77.8	75.4	73.8	73.5	
5	82.7	80.2	76.0	80.5	74.3	76.6	72.9	
6	78.3	82.6	72.0	81.5	69.6	78.1	69.3	
7	73.7	84.8	68.1	80.7	65.4	78.7	66.0	
8	76.9	74.0	69.3	71.4	69.1	68.3	67.2	
9	77.8	75.3	70.1	67.3	70.1	67.3	67.9	
10	76.3	73.2	68.3	64.9	68.4	65.0	66.2	
11	69.8	69.7	61.1	60.9	61.4	61.3	59.4	
12	72.0	76.7	64.3	68.8	63.6	68.9	62.2	
13	65.6	68.0	57.5	59.2	57.0	59.7	55.9	
AL	67.3	73.4	62.5	67.6	60.4	66.5	61.5	
B1	86.8	79.0	80.1	80.2	78.7	76.4	76.8	
B2	77.0	87.5	72.0	85.9	68.4	82.7	69.5	
B3	71.6	84.6	66.4	78.6	63.7	77.8	64.7	
CG	80.1	71.2	72.9	64.0	72.8	62.7	70.7	

Table 6-5

Departure SENEL At Grid Point Location By Aircraft and Runway, Departures on Runway 29 Sile Seven and Runway 21Left Turn

GRID	B727D21	B727D29	DC10D21	DC10D29	A300D21	A300D29	B767D21	B767D2
1	63.4	62.0	61.0	53.2	58.1	53.5	60.2	51.
2	71.2	77.7	65.6	70.2	63.0	70.2	63.7	68.
3	74.9	67.6	66.7	64.3	66.9	60.7	64.7	61.
4	83.3	77.7	76.3	77.8	75.4	73.8	73.5	74.
5	82.6	80.2	75.9	80.5	74.2	76.6	72.8	77.
6	78.2	82.6	71.9	81.5	69.4	78.1	69.0	77.
7	73.5	84.8	67.5	80.7	64.8	78.7	65.0	75.
8	76.9	74.0	69.1	71.4	69.0	68.3	66.9	67.
9	77.8	75.3	70.1	67.3	70.1	67.3	68.0	65.
10	76.3	73.2	68.3	64.9	68.4	65.0	66.3	62.
11	69.9	69.7	61.4	60.9	61.5	61.3	59.9	59.
12	72.1	76.7	64.7	68.8	63.9	68.9	62.8	66.
13	66.0	68.0	59.1	59.2	58.0	59.7	58.1	57.
AL	65.9	73.4	57.9	67.6	57.2	66.5	56.2	63.
B1	86.8	79.0	80.1	80.2	78.7	76.4	76.8	77.
B2	76.9	87.5	71.8	85.9	68.2	82.7	69.2	81.
B3	71.1	84.6	65.0	78.6	62.4	77.8	62.8	74.
CG	80.1	71.2	72.9	64.0	72.8	62.7	70.7	61.

Table 6-6

Change in SENEL, dBA Departure on Rwy 21 Right Turn Relative to Departure on Rwy 29

(Negative means noise level decreases with Cross-wind Runway, ie, Rwy 21 minus Rwy 29)

GRID POINT	B727	DC10	A300	B767	B734	B757
1	-2.7	-0.1	-2.6	0.1	-3.2	-0.5
2	-6.7	-5.2	-7.9	-5.2	-8.3	-5.7
3	7.3	2.6	6.3	3.8	7.0	5.9
4	5.6	-1.5	1.6	-0.9	2.2	0.5
5	2.5	-4.5	-2.3	-4.1	-1.5	-2.2
6	-4.3	-9.5	-8.5	-8.1	-7.1	-5.0
7	-11.1	-12.6	-13.3	-9.8	-11.2	-7.7
8	2.9	-2.1	0.8	-0.4	1.9	2.0
9	2.5	2.8	2.8	2.7	2.9	2.9
10	3.1	3.4	3.4	3.3	3.7	3.6
11	0.1	0.2	0.1	0.2	0.2	0.2
12	-4.7	-4.5	-5.3	-4.5	-5.9	-4.9
13	-2.4	-1.7	-2.7	-1.7	-2.8	-2.1
AL	-6.1	-5.1	-6.1	-2.2	-3.5	-2.8
B1	7.8	-0.1	2.3	-0.5	3.4	0.1
B2	-10.5	-13.9	-14.3	-11.8	-12.7	-8.2
B3	-13.0	-12.2	-14.1	-9.7	-11.1	-8.3
CG	8.9	8.9	10.1	8.9	11.0	9.4

Table 6-7

Change in SENEL, dBA Departure on Rwy 21 Left Turn Relative to Departure on Rwy 29

(Negative means noise level decreases with Cross-wind Runway, ie, Rwy 21 minus Rwy 29)

GRID POINT	B727	DC10	A300	B767	B734	B757
1	1.4	7.8	4.6	8.5	5.3	6.8
2	-6.5	-4.6	-7.2	-4.3	-7.7	-5.2
3	7.3	2.4	6.2	3.4	6.9	5.8
4	5.6	-1.5	1.6	-0.9	2.2	0.5
5	2.4	-4.6	-2.4	-4.2	-1.5	-2.3
6	-4.4	-9.6	-8.7	-8.4	-7.3	-5.2
7	-11.3	-13.2	-13.9	-10.8	-11.9	-8.2
8	2.9	-2.3	0.7	-0.7	1.8	1.9
9	2.5	2.8	2.8	2.8	2.9	2.9
10	3.1	3.4	3.4	3.4	3.7	3.6
11	0.2	0.5	0.2	0.7	0.3	0.4
12	-4.6	-4.1	-5.0	-3.9	-5.7	-4.6
13	-2.0	-0.1	-1.7	0.5	-1.7	-0.7
AL	-7.5	-9.7	-9.3	-7.5	-7.2	-6.6
B1	7.8	-0.1	2.3	-0.5	3.4	0.1
B2	-10.6	-14.1	-14.5	-12.1	-13.0	-8.3
B3	-13.5	-13.6	-15.4	-11.6	-12.6	-9.4
CG	8.9	8.9	10.1	8.9	11.0	9.4

6.5.1 LOW FREQUENCY SINGLE EVENT NOISE

Low frequency noise has been identified as a concern for areas near the runways where aircraft operations including departure roll and reverse thrust noise occurs on the runway. This concern has been studied recently in some detail for the neighborhoods around Minneapolis St Paul International Airport [5]. The MSP analysis included noise data collected at MSP, SFO and LAX. The MSP study made a critical observation that low frequency noise was a problem as a result of the noise induced rattle within nearby homes. The study identified a new noise metric to describe the potential for such noise induced rattle. This new noise metric was called Low Frequency Sound Level (LFSL). Near the runway the LFSL and C-weighted Maximum Noise Level (LmaxC) are nearly identical, and as the aircraft climbs above ground level the LFSL becomes smaller than the LmaxC. INM has the ability to produce C-weighted Lmax values but cannot calculate LFSL. For purposes of this study, the C-weighted Lmax will be used to estimate low frequency noise level impacts.

Exhibit 6-21 shows the LmaxC contours for a right turn from the crosswind runway compared to a departure on Runway 29. Exhibit 6-22 shows the same data for a left turn. In these plots the departures on Runway 29 are shown as a solid line and departures on the crosswind runway are shown with a dashed line. Exhibit 6-23 shows a plot of the difference between the Runway 29 and crosswind departures of a B727 in terms of LmaxC. These contours are in 1 dB increments from minus 10 dB (crosswind departure is quieter) to plus 10 dB (crosswind departure is noisier). Where the crosswind is quieter the contours are colored green and where the crosswind in noisier the contours are colored red.

6.6 CNEL COMPARISON

The effect of moving night operations from 12:30 am to 5:30 am to a crosswind runway on CNEL was analyzed by using the INM Version 6.0c to draw contours for existing and future operations using the crosswind runway. The operations data used for each case are the same as shown in Section 4 for existing operations and Section 5 for future operations. However, the runway utilization was modified to reflect the use of the crosswind during the night hours outlined above.

Table 6-8 shows the runway utilization for existing conditions and Table 6-9 shows the runway utilization for future conditions. These tables reflect the relocation of night departures to the crosswind runway during the hours of 12:30 am to 5:30 am. From these data is clear that for existing conditions and average of 48 night departures are moved to the crosswind runway for existing conditions and 72 night operations for future conditions.

Exhibit 6-24 and 6-25 show the CNEL contours for existing and future conditions respectivley for night use of the crosswind runway. The CNEL contours ins neighborhoods around the airport do not change by much (the contours from Exhibits 4-1 and 5-1 are included to show the contours using existing runways) because the change in operations occurs only during the 12:30 am to 5:30 am period when operations are low compared to the rest of the day.

Table 6-10 shows the CNEL at the specific point locations for existing and future conditions with and without the crosswind runway. Al.so included in Table 6-10 is the change in CNEL associated with the crosswind runway use.

Table 6-8

Runway Utilization For Existing Conditions With Crosswind Runway

Runway		Day	Eve	Night	Total	% D/A
29	Departures:	192.4	56.7	40.9	289.9	46.2
	Arrivals:	157.1	116.1	50.1	323.3	51.5
27R	Departures:	45.8	9.8	13.5	69.1	11.0
	Arrivals:	72.6	41.1	13.1	126.7	20.2
27L	Departures:	9.2	2.0	2.7	13.8	2.2
	Arrivals:	5.8	53.5	1.3	60.6	9.6
	T + G's:	55.2	11.5	10.0	153.3	24.4
11	Departures:	15.2	4.1	3.0	22.2	3.5
	Arrivals:	11.7	6.8	5.1	23.6	3.8
09R	Departures:	1.0	0.2	0.7	2.0	0.3
	Arrivals:	7.4	5.0	4.4	16.8	2.7
	T + G's:	5.5	1.1	1.0	15.2	2.4
09L	Departures:	9.4	1.9	2.8	14.1	2.2
	Arrivals:	0.0	0.4	0.4	0.8	0.1
33	Departures:	46.8	10.0	13.7	70.5	11.2
	Arrivals:	0.0	0.0	0.0	0.0	0.0
30	Departures:	3.9	1.2	0.8	5.9	0.9
	Arrivals:	0.0	0.0	0.0	0.0	0.0
21	Departures:	0.0	0.0	48.1	48.1	7.7
	Arrivals:	0.0	0.0	0.0	0.0	0.0

Table 6-9

Runway Utilization For Future Conditions With Crosswind Runway

Runway		Day	Eve	Night	Total	% D/A
29	Departures:	288.5	85.0	61.4	434.9	46.2
	Arrivals:	235.7	174.2	75.1	485.0	51.5
27R	Departures:	68.7	14.7	20.3	103.6	11.0
	Arrivals:	108.8	61.6	19.6	190.0	20.2
27L	Departures:	13.7	2.9	4.0	20.7	2.2
	Arrivals:	8.7	80.3	1.9	90.9	9.6
	T + G's:	82.8	17.2	14.9	230.0	24.4
11	Departures:	22.8	6.1	4.5	33.4	3.5
	Arrivals:	17.6	10.2	7.7	35.5	3.8
09R	Departures:	1.6	0.3	1.1	3.0	0.3
	Arrivals:	11.0	7.4	6.7	25.2	2.7
	T + G's:	8.2	1.7	1.5	22.7	2.4
09L	Departures:	14.1	2.9	4.2	21.2	2.2
	Arrivals:	0.1	0.6	0.5	1.2	0.1
33	Departures:	70.2	15.0	20.6	105.8	11.2
	Arrivals:	0.0	0.0	0.0	0.0	0.0
30	Departures:	5.9	1.7	1.3	8.9	0.9
	Arrivals:	0.0	0.0	0.0	0.0	0.0
21	Departures:	0.0	0.0	72.2	72.2	7.7
	Arrivals:	0.0	0.0	0.0	0.0	0.0

Table 6-10

CNEL At Grid Point Locations and Change in CNEL

Location	Base	Base Xwind	Future	Future Xwind	Change Base	Change Future
1	61.8	61.7	63.5	63.4	-0.1	-0.1
2	56.8	56.0	58.6	57.7	-0.8	-0.9
3	58.1	56.7	59.8	58.5	-1.4	-1.3
4	62.3	61.3	64.0	63.0	-1.0	-1.0
5	62.1	61.5	63.9	63.3	-0.6	-0.6
6	61.9	61.1	63.7	62.9	-0.8	-0.8
7	61.7	61.0	63.5	62.7	-0.7	-0.8
8	58.0	56.7	59.7	58.4	-1.3	-1.3
9	61.1	60.4	62.9	62.2	-0.7	-0.7
10	54.2	53.5	56.0	55.3	-0.7	-0.7
11	53.3	52.6	55.1	54.3	-0.7	-0.8
12	51.9	51.0	53.7	52.8	-0.9	-0.9
13	46.9	46.3	48.7	48.0	-0.6	-0.7
AL	51.8	51.3	53.5	53.1	-0.5	-0.4
B1	65.8	65.6	67.6	67.3	-0.2	-0.3
B2	65.2	64.1	66.9	65.9	-1.1	-1.0
B3	61.2	60.6	63.0	62.3	-0.6	-0.7
CG	51.1	52.4	52.9	54.2	1.3	1.3

As can be seen in Table 6-10, the change in CNEL is small at all locations. The net change, whether positive or negative, is less than 1.5 dB CNEL at all locations. The CNEL metric is just not very sensitive to the change in operations that occurs during the late night hours when activity is relatively low, even including the night time 10 dB penalty that is part of the definition of CNEL.

6.7 TIME ABOVE COMPARISON

The time above metric measures the number of minutes per day that certain noise level thresholds are exceeded. This metric is described in Section 2.4. TA values were generated for existing and future noise at OAK at each of the specific point receptor sites with and without the crosswind runway. The values of 65 dBA, 77 dBA and 85dBA correlate respectively to speech interference outdoors, indoors with windows open and indoors with windows closed. The TA values at the specific point receptor sites are presented on Table 6-11 for existing conditions and 6-12 for future conditions. Included in Table 6-11 and 6-12 are the minutes above the thresholds during a 24 hour period as well as the number of minutes during the night hours only (10 pm to 7 am). Tables 6-13 and 6-14 show the difference between existing conditions with and without the crosswind runway and future conditions with and without the crosswind runway. The change in Time Above data that are negative values mean that the noise levels with the crosswind runway are quieter than without the crosswind runway. Note that the change for the 24 hour period is the same as for night hours only (minor differences are due to roundoff). That is because all the change occurs at night. It is interesting to note that these results are not consistent with the single event noise contours and single event data at specific points that were presented earlier. It is not clear that the INM is adequately accounting for the directional characteristics of the noise behind the aircraft during the beginning of takeoff roll. That would account for the lack of impact on Time Above data in the Fernside and Columbian Gardens neighborhoods.

Table 6-11
Time Above For Existing Operations With Crosswind Runway

GRID	TA 65 (min.) 24 Hr. Day	TA 77 (min.) 24 Hr. Day	TA85 (min.) 24 Hr. Day	TA 65 (min.) Night	TA 77 (min.) Night	TA85 (min.) Night
1	70.4	0.4	0.0	11.3	0.0	0.0
2	5.7	0.3	0.0	0.6	0.0	0.0
3	12.5	0.0	0.0	3.2	0.0	0.0
4	26.9	1.0	0.0	6.4	0.5	0.0
5	35.8	0.4	0.0	8.0	0.2	0.0
6	48.8	0.8	0.0	5.3	0.2	0.0
7	61.5	1.4	0.0	4.4	0.1	0.0
8	8.2	0.0	0.0	2.2	0.0	0.0
9	23.6	1.6	0.0	2.8	0.3	0.0
10	2.9	0.0	0.0	0.7	0.0	0.0
11	3.9	0.0	0.0	0.7	0.0	0.0
12	0.6	0.0	0.0	0.2	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0
AL	1.0	0.0	0.0	0.0	0.0	0.0
B1	58.3	5.9	0.2	12.7	1.0	0.1
B2	84.1	4.9	0.0	9.1	0.7	0.0
B3	64.3	0.7	0.0	3.5	0.0	0.0
CG	1.1	0.0	0.0	0.0	0.0	0.0

Table 6-12
Time Above For Future Operations With Crosswind Runway

GRID	TA 65 (min.) 24 Hr. Day	TA 77 (min.) 24 Hr. Day	TA85 (min.) 24 Hr. Day	TA 65 (min.) Night	TA 77 (min.) Night	TA85 (min.) Night
1	105.6	0.5	0.0	16.9	0.1	0.0
2	8.6	0.4	0.0	0.9	0.1	0.0
3	18.7	0.0	0.0	4.9	0.0	0.0
4	40.3	1.6	0.0	9.6	0.7	0.0
5	53.7	0.5	0.0	12.1	0.3	0.0
6	73.2	1.2	0.0	7.9	0.2	0.0
7	92.2	2.2	0.0	6.5	0.0	0.0
8	12.3	0.0	0.0	3.3	0.4	0.0
9	35.4	2.4	0.0	4.2	0.0	0.0
10	4.4	0.1	0.0	1.1	0.1	0.0
11	5.8	0.0	0.0	1.0	0.0	0.0
12	1.0	0.0	0.0	0.3	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0
AL	1.5	0.0	0.0	0.0	0.0	0.0
B1	87.4	8.9	0.3	19.1	1.4	0.1
B2	126.1	7.4	0.0	13.6	1.1	0.0
B3	96.4	1.1	0.0	5.2	0.1	0.0
CG	1.6	0.0	0.0	0.1	0.0	0.0

Table 6-13

Change in Existing Time Above Existing Operations

GRID	TA 65 (min.) 24 Hr. Day	TA 77 (min.) 24 Hr. Day	TA85 (min.) 24 Hr. Day	TA 65 (min.) Night	TA 77 (min.) Night	TA85 (min.) Night
1	-0.2	0	0	-0.2	-0.1	0
2	-0.4	0	0	-0.4	-0.1	0
3	-2	0	0	-2	0	0
4	-2.1	-0.3	0	-2.2	-0.3	0
5	-2.2	0	0	-2.3	0	0
6	-2.8	0	0	-2.7	0	0
7	-2.2	-0.1	0	-2.2	0	0
8	-1.3	0	0	-1.4	0	0
9	-0.7	-0.2	0	-0.6	-0.2	0
10	-0.5	-0.1	0	-0.5	0	0
11	-0.3	0	0	-0.3	0	0
12	-0.2	0	0	-0.1	0	0
13	0	0	0	0	0	0
AL	0	0	0	0	0	0
B1	-1.1	-0.1	0	-1.1	0	0
B2	-5.4	-0.5	0	-5.4	-0.5	0
B3	-1.7	0	0	-1.7	-0.1	0
CG	0	0	0	-0.1	0	0

Table 6-14
Change in Future Time Above Existing Operations

GRID	TA 65 (min.) 24 Hr. Day	TA 77 (min.) 24 Hr. Day	TA85 (min.) 24 Hr. Day	TA 65 (min.) Night	TA 77 (min.) Night	TA85 (min.) Night
1	-0.4	-0.1	0	-0.4	0	0
2	-0.6	-0.1	0	-0.6	0	0
3	-3	0	0	-2.9	0	0
4	-3.3	-0.4	0	-3.3	-0.4	0
5	-3.3	0	0	-3.3	0	0
6	-4.2	-0.1	0	-4.1	-0.1	0
7	-3.3	0	0	-3.4	-0.2	0
8	-2	0	0	-2	0.4	0
9	-1	-0.3	-0.1	-1	-0.7	-0.1
10	-0.7	0	0	-0.7	0	0
11	-0.5	0	0	-0.5	0	0
12	-0.2	0	0	-0.2	0	0
13	0	0	0	0	0	0
AL	0	0	0	0	0	0
B1	-1.6	-0.1	0	-1.6	-0.2	0
B2	-8.1	-0.7	0	-8.1	-0.7	0
B3	-2.7	0	0	-2.7	0	0
CG	0	0	0	0	0	0

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