TED STEVENS ANCHORAGE INTERNATIONAL AIRPORT COMPREHENSIVE GROUND NOISE STUDY

FINAL REPORT

HMMH REPORT NO. 297270

MARCH 15, 2002

Prepared for:

Ted Stevens Anchorage International Airport

Prepared by:

HARRIS MILLER MILLER & HANSON INC.

HARRIS MILLER MILLER & HANSON INC.

Consultants in Noise and Vibration Control

TED STEVENS ANCHORAGE INTERNATIONAL AIRPORT COMPREHENSIVE GROUND NOISE STUDY

FINAL REPORT

HMMH REPORT NO. 297270

MARCH 15, 2002

D.E. Barrett
L.D. Meister
R.D. Behr
S.R. Alverson

Prepared for:

Ted Stevens Anchorage International Airport

Prepared by:

HARRIS MILLER MILLER & HANSON INC.
15 New England Executive Park
Burlington, MA 01803

URS/Dames & Moore
Mullins Acoustics
Earthscape

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

1. EXECUTIVE SUMMARY AND OVERVIEW OF REPORT

This report describes the methodology and presents the findings of the Ted Stevens Anchorage International Airport (ANC) Comprehensive Ground Noise Study. Because ANC provides vital transportation services and economic benefits to the State of Alaska and the Anchorage area, a proactive Noise Compatibility Program (NCP) is essential if the Airport is to continue to grow and provide these important benefits to the community. Recognizing that noise is a significant side effect of aviation, ANC has developed and continues to refine a program that limits the impact of aircraft noise on the Anchorage community. The recently-completed update to ANC's NCP recognizes that ground noise and low-frequency noise are increasingly important issues in Anchorage. The ANC Comprehensive Ground Noise Study is the result of a commitment made during the NCP update process to further investigate these noise sources and to pursue operational and structural abatement and mitigation measures to address ground noise, including low-frequency noise, created by aviation operations at the Airport.

This section of the report includes an executive summary, which summarizes the study's findings and recommendations, followed by an overview of the remainder of the report.

1.1 Executive Summary

1.1.1 Sources and Effects of Ground Noise at ANC

A wide variety of individual noise sources and types of operations contribute to the overall ground noise environment at ANC. Each of these noise sources has different characteristics in terms of loudness, duration, characteristics of the noise (e.g., low-frequency rumble versus high-pitched whine or tone), frequency of occurrence, usual time of occurrence (daytime, evening, early morning, etc.), and proximity to different residential neighborhoods. In general terms, however, it is possible to divide the different types of noise events caused by these sources into two distinct categories, both of which can cause annoyance in residential areas:

- *Events that are relatively loud and of comparatively short duration.* Relatively loud, fairly-short duration events include start-of-takeoff roll, use of thrust reversers, and general aviation (GA) aircraft start-up procedures. Although these events may occur many times throughout the day and night, each event has a short and generally predictable duration. In some residential areas near the Airport, these events have the potential to cause short-term speech interference or sleep disturbance and also may be associated with low-frequency noise and vibration. The primary effect of low-frequency aircraft noise in residential areas is rattle-related annoyance due to vibration of windows, doors, and household paraphernalia. Low-frequency aircraft noise poses no known health risks, nor a risk of structural damage, and is not typically associated with speech interference or sleep disturbance.
- *Events that are comparatively quieter but of longer duration.* Noise events that are not as loud but are of longer duration include aircraft taxiing and idling, use of auxiliary power units (APUs), aircraft maintenance ground run-ups, and use of airfield maintenance and snow-removal equipment. At times, multiple individual noise sources are indistinguishable from one another, and may be perceived in community locations as a single, continuous event. Although these noise events typically are not loud enough to cause speech disturbance or sleep interference in residential areas (even when several

events occur simultaneously), they often are audible, and may dominate the background sound level for extended periods, particularly during quiet times of the evening, night, or early morning.

1.1.2 Mitigation Recommendations

As described above, annoyance related to airport ground noise at ANC is caused by two general types of noise events:

- relatively loud, short-duration events that may contribute to short-term speech interference and sleep disturbance and also may cause rattle-induced annoyance due to low-frequency noise, and
- quieter, longer-duration events which may contribute to annoyance due to their persistent nature.

Because of the importance of each of these issues, mitigation recommendations must address both types of events to effectively reduce annoyance caused by ground noise.

Section 7 of this report provides a full list of all mitigation measures considered during this study (Table 7-1) followed by a discussion and a recommendation for each measure. Table 1.1-1 provides an abridged summary of the full list of mitigation options; those options for which no action is recommended are not included in the abridged list (although they are discussed in Section 7 of the report and included in Table 7-1). It should be recognized that all of the mitigation options presented should be evaluated within the context of overall operational efficiency and the Master Plan process. In addition, to receive FAA approval, recommended mitigation measures must meet the following FAR Part 150 requirements:

- The measure must not derogate safety or adversely affect the safe and efficient use of airspace;
- To the extent practicable, the measure must meet both local needs and needs of the national air transportation system, considering tradeoffs between economic benefits derived from the Airport and the noise impact;
- The measure must not impose an undue burden on interstate and foreign commerce;
- It must be possible to implement the measure in a manner consistent with all the powers and duties of the Administrator of the FAA;
- The measure must reduce existing noncompatible uses and prevent or reduce the probability of the establishment of additional noncompatible uses; and
- The measure must not be unjustly discriminatory.

As a result of these requirements, some of the mitigation options presented may not be feasible at ANC.

1.2 Overview of Report

The remainder of the report is divided into the following sections:

Sections 2, 3, and 4 provide introductory and background material.

- Section 2 provides an introduction to the study including the study's purpose and descriptions of airport ground noise and its potential effects.

Table 1.1-1. Abridged Summary of Mitigation Options

Noise Source	Mitigation Option
Start of Takeoff	Once an FAA low-frequency noise standard is in place, assess the feasibility and costs associated with incorporating low-frequency treatments/standards during residential sound insulation
	Utilize Taxiway K, L, and M intersection departures on Runway 32 whenever feasible
	Relocate Runway 6R/24L to west, utilize Taxiway D intersection departures on Runway 24L, coordinate with Master Plan process and Air Traffic Control (ATC)
Reverse Thrust	Once an FAA low-frequency noise standard is in place, assess the feasibility and costs associated with incorporating low-frequency treatments/standards during residential sound insulation
	Construct additional high-speed taxiways; examine feasibility of preferential taxiway use with airlines, coordinate with Master Plan process
	Examine feasibility of reduced-thrust procedures with airlines
	Relocate Runway 6R/24L to west to reduce noise effects of thrust reversers, coordinate with Master Plan process and ATC
	Prioritize arrivals on Runway 6R, coordinate with ATC
Taxiing and Idle	Construct new taxiways, including high-speed exits and a west-side north/south taxiway, in context of overall airport efficiency and the Master Plan process
	Queue Runway 32 departures on Taxiways K and L (rather than R), coordinate with Master Plan process and ATC
	Implement voluntary reduced-engine taxi procedures on carrier-specific basis in coordination with aircraft operators and ATC
Auxiliary Power Units	Provide access to ground power and pre-conditioned air at all existing and new passenger terminals and cargo facilities
	In coordination with tenants, design new North Airpark cargo facilities to provide noise shielding
	Park aircraft with APU exhaust directed away from residences, coordinate with ATC to assess impact on line of sight from ATC tower
	In coordination with aircraft operators, develop recommendations on the reduction of APU use, educate tenants in benefits of reduced APU use
	If operational measures insufficient, conduct design study and construct East Airpark barrier or berm
Maintenance Run-ups	Develop new run-up location west of Runway 14/32 in coordination with planning for proposed taxiway improvement projects, coordinate with ATC, Airport Operations, and tenants
	Amend Airport Bulletin 2000-16 to include additional Taxiway J run-up heading; provide airfield markings and signs, coordinate with Airport Operations and Planning
	Require reporting of actual run-up data; consider implementing additional nighttime restrictions
	If operational measures and/or a new location deemed insufficient, construct a noise barrier or berm at new run-up location
GA Aircraft Start-up and Departure	Conduct noise barrier/berm design study in conjunction with affected community to evaluate alternative locations near gravel strip
	Provide education to GA pilots in noise-sensitive departure procedures
	In coordination with GA Operations and Planning personnel, optimize orientation of any new tie-downs near residential areas
Field Maintenance Equipment	As feasible, limit nighttime field maintenance operations near residential areas
	Require use of variable-volume back-up alarms on all new ANC maintenance equipment and all contractor equipment

- Section 3 describes the noise metrics and criteria used throughout the report. Appendix A includes additional information on noise metrics.
- Section 4 describes the methodology used in the study.

Sections 5 and 6 provide the results of measurements and modeling conducted to identify sources of ground noise and quantify related noise levels in residential areas near ANC.

- Section 5 describes the effects in communities near ANC of each identified source of ground noise, provides information on low-frequency noise and vibration, and provides information on the daily cycle of ground noise events at ANC.
- Section 6 discusses seasonal variations in sound levels, including the influence of weather on sound propagation and other seasonal factors. Appendix C provides additional general information regarding the effects of weather on long-distance sound propagation.

Sections 7 and 8 discuss mitigation options and public involvement throughout the study.

- Section 7 provides a summary of all mitigation options considered and a discussion and recommendation for each individual measure.
- Section 8 provides information on public involvement including public comments received through a questionnaire and at public meetings and a description of the event logging conducted by residents during the measurement programs.

Throughout the report, all of the figures within each sub-section are located together at the end of that sub-section.

2. INTRODUCTION

This report describes the methodology and presents the findings of ANC's Comprehensive Ground Noise Study. This section of the report describes the purpose the study, provides a description of airport ground noise, and describes the potential effects of ground noise.

2.1 Purpose of Study

Because ANC provides vital transportation services and economic benefits to the State of Alaska and the Anchorage area, a proactive Noise Compatibility Program is essential if the Airport is to continue to grow and provide these important benefits to the community. Recognizing that noise is a significant side effect of aviation, ANC has developed and continues to refine a program that limits the impact of aircraft noise on the Anchorage community. The recently-completed update to ANC's NCP recognizes that ground noise and low-frequency noise are increasingly important issues in Anchorage. The Comprehensive Ground Noise Study is the result of a commitment made during the NCP update process to further investigate these noise sources and to pursue operational and structural abatement and mitigation measures to address ground noise, including low-frequency noise, created by aviation operations at the Airport.

The objectives of this study are to:

- Evaluate the effects of ground-based noise sources, based upon criteria for community annoyance.
- Conduct preliminary feasibility analysis of structural and procedural noise abatement and mitigation options, including barriers, berms, run-up enclosures, and operational procedures.
- Conduct a community-involvement process concurrent with the study.

2.2 Description of Airport Ground Noise

Airport ground noise is a broad term including all noise generated by aircraft from the time their wheels touch down on arrival at an airport to the time when their wheels lift up on departure. This comprehensive ground noise study also includes noise generated by aircraft support and airport maintenance equipment. Sources of ground-operations noise at ANC include: start-of-takeoff roll; use of thrust reversers upon landing; engine maintenance run-ups; aircraft idling and taxiing; operation of APUs and ground power units (GPUs); GA aircraft start-up, taxiing, preflight run-ups, and start-of-takeoff at Lake Hood and the gravel strip (Runway 13/31); and airport maintenance and snow-clearing operations. In contrast to noise from aircraft flight operations, which typically can be associated with a single aircraft event, ground noise may include the combination of many simultaneous noise events, sometimes making individual sources difficult to distinguish in community locations.

2.3 Potential Effects of Airport Ground Noise

As with noise from airborne aircraft, airport ground noise can cause annoyance in residential areas and has the potential to cause speech interference and sleep disturbance. Annoyance related to airport ground noise at ANC is caused by two general types of noise events:

- relatively loud, short-duration events that may contribute to short-term speech interference and sleep disturbance and also may cause rattle-induced annoyance due to low-frequency noise, and
- quieter, longer-duration events which may contribute to annoyance due to their persistent nature.

The relatively-high sound levels generated by such events as start-of-takeoff roll and use of thrust reversers may be associated with short-term speech interference and cause difficulty in direct communication and telephone conversations or with listening to television and radio. Sufficiently-high sound levels may also cause sleep disturbance.

Low-frequency noise is generated during aircraft takeoff roll and during the use of thrust reversers. The primary effect of low-frequency aircraft noise on residential areas located near runway ends and sidelines is rattle-related annoyance due to "secondary emissions." Secondary emissions typically are rattling noises caused by vibration of windows, doors, and household paraphernalia. Although structural vibration may sometimes be perceptible to residents, vibration levels associated with aircraft noise typically are well below even the most stringent vibration damage criteria, which apply to fragile and historic structures. Low-frequency aircraft noise poses no known health risks, and is not typically associated with speech interference or sleep disturbance.

Noise events that generally are not as loud, but are of longer duration, include aircraft taxiing and idling, use of APUs, aircraft maintenance run-ups, and use of airfield maintenance and snow-removal equipment. These events often are audible in residential areas near ANC, and may dominate the background sound level for extended periods, particularly during quiet times of the evening, night, or early morning. At times, multiple individual noise sources are indistinguishable from one another, and may be perceived in community locations as a single, continuous event. Although these noise events typically are not loud enough to cause speech disturbance or sleep interference in residential areas (even when several events occur simultaneously), they may cause annoyance.

Annoyance is not a trivial effect of aircraft noise exposure. The Federal Interagency Committee on Aviation Noise (FICAN) recognizes annoyance as the best indication of adverse community reaction to aircraft noise and the prevalence of high annoyance provides much of the rationale for federal and state policies concerning mitigation of aircraft noise impacts in residential areas[1].

[1] "Findings of the Low-Frequency Noise Expert Panel of the Richfield-MAC Noise Mitigation Agreement of 17 December 1998," September 30, 2000, page I-3.

3. NOISE METRICS, CRITERIA, AND GUIDELINES

The Federal Aviation Administration (FAA) requires the use of the cumulative-exposure metric Day-Night Average Sound Level (DNL or L_{dn}), to determine noise exposure and land use compatibility. Often, in ground noise analyses, however, the overall contribution of ground-operations noise, when evaluated in terms of DNL, is dominated by aircraft flight operations. Single-event analysis is necessary to help evaluate the intrusiveness of a single event (such as a late-night maintenance run-up) that might be overshadowed by many other events when considered only with cumulative-exposure analysis. For this reason, the FAA stipulates the use of single-event metrics to demonstrate the effectiveness of proposed mitigation for sources of ground noise.

The primary single-event descriptor used throughout this study is the maximum sound level (L_{max}). The L_{max} is the maximum A-weighted sound level that occurs during a particular noise event (such as an aircraft taxiing past a location). Although L_{max} does not take into account the duration of a noise event or the number of times that an event is repeated, it is a useful measure for comparing the loudness of different events and for estimating whether or not an event will interfere with conversation or sleep (this study addresses the frequency of occurrence and duration of events in other ways). Because multiple noise sources may operate simultaneously, in some cases the L_{max} is also used to characterize the combined sound level from several sources. Appendix A provides further background on noise descriptors.

Although the FAA does not provide noise impact criteria based on L_{max}, guidelines for speech interference and sleep disturbance may provide benchmarks to help assess the potential effects of maximum sound levels caused by airport ground operations. Speech interference can disrupt conversation and the use of telephones, televisions, and radios. For normal levels of voice effort and hearing ability at listener-speaker distances of about three feet, the following guidelines are conservative predictors of interference with conversation:

- Speech interference may occur outdoors when the sound level is 60 to 65 dBA or higher[2]. (This is a conservative guideline since normal voice sentence intelligibility is 95% with a steady background level of 65 dBA.)
- Speech interference may occur indoors, with windows open, when the *outdoor* sound level is 70 to 75 dBA or higher[3].
- Speech interference may occur indoors, with windows closed, when the *outdoor* sound level is 75 to 80 dBA or higher[3].

(When indoors, open windows reduce the outdoor A-weighted noise level by about 15 dB. Closed windows provide about 25 dB of reduction to the A-weighted noise level.)

Noise-induced sleep disturbance has been studied, but the results are somewhat ambiguous and the response of individuals to intruding noise sources vary widely. If sleep data collected on

[2]United States Environmental Protection Agency, Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, Mar. 1974, p. D-5.

[3]Indoor speech interference guidelines based upon: von Gierke, Henning E. and Kenneth McK. Eldred, "Effects of Noise on People," *Noise/News International*, Vol. 1, No. 2, June 1993, p. 75.

people in their homes are used, awakening may occur for two percent of the population when the *outdoor* sound level associated with a single event exceeds:

- 70 to 75 dBA, L_{max} (windows open), or
- 80 to 85 dBA, L_{max} (windows closed)[4].

FICAN has recommended slightly more conservative guidelines for assessing sleep disturbance.[5] The FICAN guidelines, which are intended to represent the *maximum* percent of the population expected to be awakened, would predict awakenings in about six percent of the population with the maximum sound levels provided above. The guidelines provided for speech interference and sleep disturbance in this study are intended only to serve as benchmarks to provide context for the sound levels discussed in the report and should not be interpreted as impact criteria.

Annoyance also may be caused by events causing community sound levels below the guidelines for speech interference and sleep disturbance. As stated above, annoyance is not a trivial effect of aircraft noise exposure. FICAN recognizes annoyance as the best indication of adverse community reaction to aircraft noise and the prevalence of high annoyance provides much of the rationale for federal and state policies concerning mitigation of aircraft noise impacts in residential areas[6].

[4]von Gierke and Eldred, p. 77.

[5] "Effects of Aviation Noise on Awakenings from Sleep," FICAN, 1997.

[6] "Findings of the Low-Frequency Noise Expert Panel . . . ."

4. METHODOLOGY

The comprehensive ground noise study included the acquisition of noise data during both winter and non-winter conditions at ANC and an extensive effort to obtain operations data from airport tenants. In some cases, when adequate noise measurement data could not be obtained, computer modeling, based upon actual measurement data, was used to supplement the measurement data.

4.1 Noise Measurements

The study team conducted measurements in the vicinity of ANC during September of 2000 and again during February of 2001 to obtain data on the sound levels in residential areas caused by sources of ground noise at ANC. The primary objective of the measurement program was to measure sound levels from a substantial number of each of the sources of interest at various representative community locations. During the program, measurements were conducted simultaneously at reference locations on the Airport and at noise-sensitive community locations. During periods of observation, observers at the Airport measurement locations identified noise events that occurred at the Airport while observers at community locations logged audible airport noise events and other community noise events. By using the observers' logs and simultaneous measurement data, measured sound levels in the community were correlated with specific noise events occurring at ANC.

4.1.1 September Measurements

During the September noise measurements, noise monitors were set-up at 13 locations in residential areas around ANC. The sites were selected to be representative both of the neighborhoods closest to the Airport and of neighborhoods somewhat farther away. Some of the measurement sites were at homes adjacent to the airport, while others were located up to approximately one mile from the closest airport facilities. Although, under some conditions, airport ground noise is audible farther from ANC, interference from other community noise sources made data collection at more distant locations impractical. Nonetheless, many of the mitigation recommendations included in Section 7 of the report would benefit more distant, as well as closer, residential areas.

In addition to the residential sites, noise monitors were located at seven measurement sites on airport property to help correlate noise levels in the community locations with specific events occurring at the Airport. Table 4.1-1 lists the locations of the 20 measurement sites and the dates during which measurements were conducted at each site. Figure 4.1-1 shows the locations of the measurement sites and Figure 4.1-2 provides the Airport Layout Plan (ALP) showing the locations of runways, taxiways, and other airport facilities discussed throughout the report. *(These figures are located at the end of Section 4.1; throughout the report, the figures for each sub-section are located together at the end of that sub-section*).

During the September measurements, over 1,000 data points were identified and logged. To qualify, each data point had to (1) have an L_{max} recorded by a noise monitor at the measurement site, (2) be judged to be free of contamination from other noise sources by an observer, and (3) be correlated with a particular noise event occurring at the Airport.

4.1.2 February Measurements

The primary purpose of the February measurements was to determine the influence of winter weather conditions on noise levels measured in community locations. Four days of measurements were repeated at six of the community sites and two of the on-airport sites used during the September measurements. To maximize the amount of useful data collected, the February measurements concentrated on the two loudest sources of ground noise, start-of-takeoff roll and use of thrust reversers. The information on seasonal variations in sound levels determined from examining these sources also applied to other quieter sources that were more difficult to measure in community locations. Because the measurements were conducted at exactly the same locations during the two sets of measurements and because noise levels were correlated with specific types of noise sources, differences in the measured sound levels between the two seasons are due primarily to changes in sound-propagation conditions.

Table 4.1-1. Measurement Sites, September 21-27, 2000 and February 14-17, 2001

Site No.	Address/Location	Dates
1	South Tug Road near dep. end Rwy. 32	9/25 to 9/27
2	South Airpark/Kulis ANGB	9/25 to 9/27 and 2/14 to 2/17
3	South Tug Road opposite East Airpark	9/23 to 9/27
4	Txwy. U at Txwy. R (south of FedEx Ramp)	9/21 to 9/25 and 2/14 to 2/17
5	Turnagain Bog Snow Dump	9/21 to 9/23
6	Gravel Strip	9/21 to 9/25
7	East Airpark (near Polar Air Cargo Ramp)	9/23 to 9/27
8	4169 Westwood Dr.	9/21 to 9/23 and 2/14 to 2/17
9	3140 B Wendys Way	9/21 to 9/23
10	3451 Orbit Circle	9/21 to 9/23 and 2/14 to 2/17
11	4201 Bridle Cir.	9/21 to 9/23
12	3001 McCollie Ave.	9/21 to 9/23
13	3935 Balchen Dr.	9/23 to 9/25 and 2/14 to 2/17
14	3725 A W. 44th St.	9/23 to 9/25
15*	2805 Breezewood Dr.	9/23 to 9/25 and 2/14 to 2/17
16	4706 Melvin Ave.	9/23 to 9/25
17*	6324 Air Guard Rd.	9/25 to 9/27 and 2/14 to 2/17
18	6059 Blackberry Dr.	9/25 to 9/27
19	7331 Silver Birch Dr.	9/25 to 9/27
20*	6134 Tanaina Dr.	9/25 to 9/27 and 2/14 to 2/17
*Low-Frequency Noise and Vibration Site		

4.1.3 Low-frequency Noise and Vibration Measurements

Although building vibrations induced by aircraft noise seldom, if ever, are a source of structural damage, residents sometimes perceive rattling of windows or objects on walls as sources of annoyance and are concerned about the potential effects of vibration. To address these concerns, during both the September and the February measurement programs, specialized measurements were conducted to characterize low-frequency noise. In addition, during the September measurements, A-weighted and C-weighted noise levels were recorded simultaneously while vibration levels were measured inside homes[7].

4.1.4 Source-level Measurements

Whenever possible, noise levels reported in this study were based upon actual sound levels measured in community locations. In some cases, however, sound levels associated with some sources of ground noise were difficult to measure in the community either because (1) the noise source operated sporadically (such as with airfield maintenance equipment or operations on certain runways) or (2) because the noise source was relatively quiet (compared to other louder noise sources) and may have been partially masked by other louder noise sources. For these noise sources, source-level measurements were conducted to assist in projecting community sound levels.

Source-level measurements, intended to characterize a particular noise source, typically are conducted at a relatively short reference distance so that the measurements will not be significantly affected by propagation effects (such as wind conditions) or contaminated by other noise sources. The measured sound levels can then be used to assist in projections of the sound level caused by the particular noise source at a given prediction location. In addition to airfield maintenance and snowplowing equipment, source-level measurements conducted at ANC included aircraft APUs, taxiing aircraft, and GA aircraft start-ups[8].

---

[7] A-weighted noise levels (which are used throughout this report) generally correspond well with human perception of noise while C-weighted noise levels often provide better correlation with vibration induced by low-frequency noise.

[8] Source-level measurements of airfield maintenance and snowplowing equipment were conducted at ANC in September, 2000. Measurements of aircraft APUs, taxiing aircraft, and GA aircraft start-ups were conducted at ANC in October, 1999.

Figure 4.1-1. Noise Measurement Locations

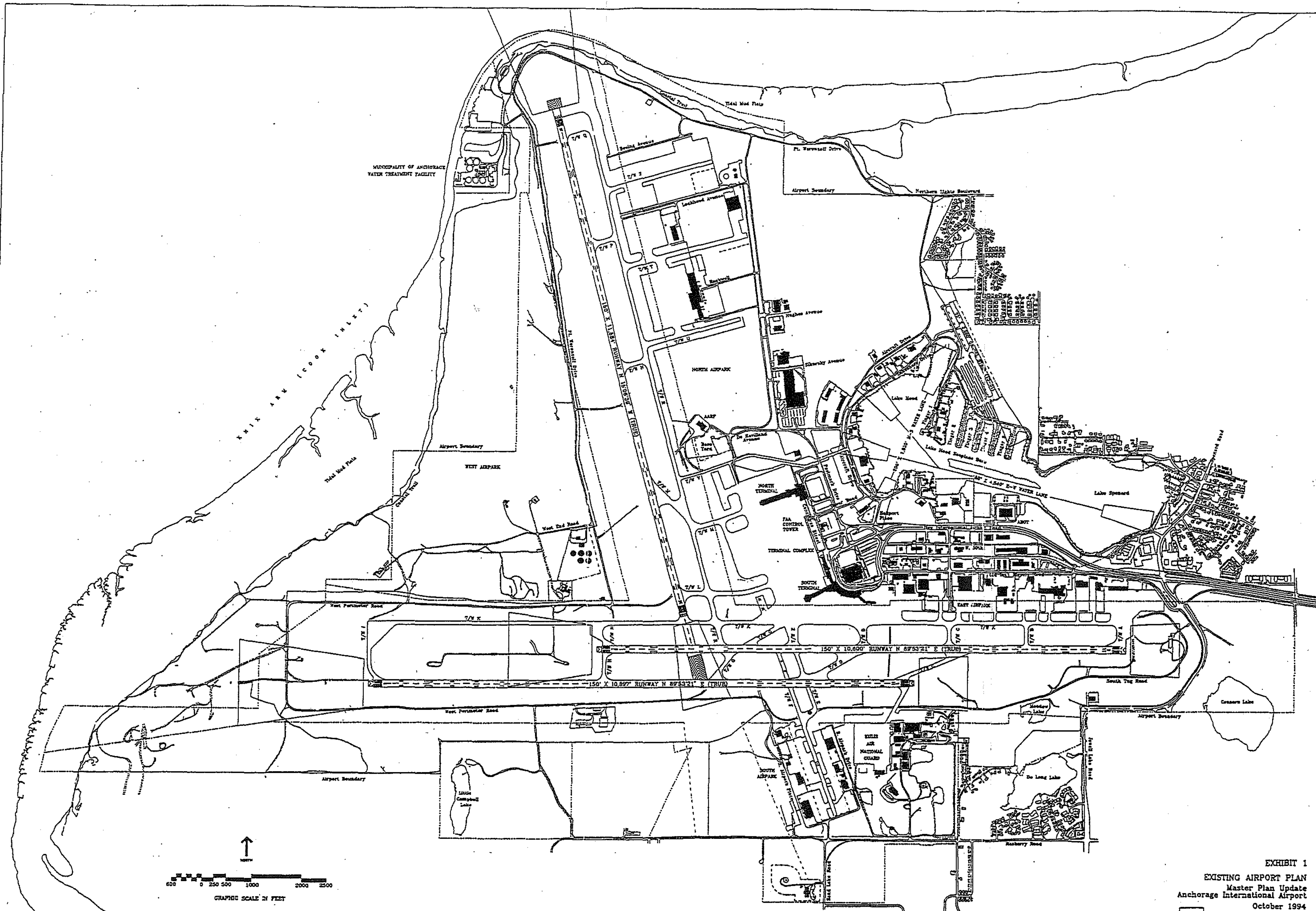


EXHIBIT 1

EXISTING AIRPORT PLAN
Master Plan Update
Anchorage International Airport
October 1994

LFA LEIGH FISHER ASSOCIATES

(Revised April 1996)

4.2 Operations Data

In addition to two noise measurement programs, an extensive survey was conducted of all airport tenants believed to operate equipment potentially contributing to ground noise at ANC. Following briefings at airport tenant meetings, approximately 45 tenants, including all passenger and air-cargo operators at ANC and the Alaska Air National Guard were contacted with a mailing and follow-up phone calls. This survey provided detailed information, in addition to the observations during the two measurement programs, of the duration and frequency of occurrence of ground operations at ANC.

The study team obtained operations data from airport tenants such as types and numbers of aircraft ground operations, typical periods of APU use, airfield maintenance operations, and aircraft dwell times at gates and cargo facilities. The operations data were then used to develop a typical "profile" or "schedule" of ground-operations noise throughout the day at ANC. Combined with measured sound level data, this "profile" provides a representation of the frequency and times of occurrence, approximate duration, and sound levels associated with various ground noise events at representative community locations throughout the day and night.

5. EFFECTS OF GROUND NOISE IN THE COMMUNITY NEAR ANC

This section of the report describes the effects of ground noise in residential areas near ANC.

- Section 5.1 describes the characteristics and effects of each source of ground noise addressed in this study including: start-of-takeoff roll, use of thrust reversers, aircraft taxiing and idle, use of APUs, aircraft maintenance run-ups, GA aircraft start-up and departure, and airfield maintenance and snow-removal equipment. For each noise source, the report describes the typical maximum sound levels caused by the source in various affected community locations, and compares these levels to guidelines for speech interference and sleep disturbance.
- Section 5.2 describes and discusses the potential effects of low-frequency noise and vibration. Although low-frequency noise and vibration is not limited to any one source of ground noise, most typically it is associated with start-of-takeoff roll and use of thrust reversers. This section of the report provides a brief overview of low-frequency noise and vibration, presents the results of the low-frequency noise and vibration measurements conducted during the measurement program, and discusses the measured levels with respect to guidelines for human perception and damage to structures.
- Section 5.3 provides information on the typical "profile" or "schedule" of ground-operations noise that occurs throughout the day at ANC. The profile was developed based upon published flight-schedule information and a survey of all airport tenants believed to operate equipment potentially contributing to ground noise at ANC. Combined with measured and projected sound level data, this profile provides a representation of the frequency of occurrence, approximate duration, and sound levels associated with various ground noise events at representative community locations during the day and the night.

5.1 Characteristics of Individual Sources of Ground Noise

A wide variety of individual noise sources and types of operations contribute to the overall ground noise environment at ANC. Each of these noise sources has different characteristics in terms of loudness, duration, characteristics of the noise (e.g., low-frequency rumble versus high-pitched whine or tone), frequency of occurrence, usual time of occurrence (daytime, evening, early morning, etc.), and proximity to different residential neighborhoods. In general terms, however, it is possible to divide the different types of noise events caused by these sources into two distinct categories:

- *Events that are relatively loud and of comparatively short duration.* Relatively loud, fairly-short duration events include start-of-takeoff roll, use of thrust reversers, and GA aircraft start-up. Although these events may occur many times throughout the day and night, each event has a short and generally predictable duration. For example, a typical takeoff roll may last for about 30 seconds and a typical application of reverse thrust may last from about five to 20 seconds. These events may have the potential to cause short-term speech interference or sleep disturbance in residential areas and also may be associated with low-frequency noise and vibration (discussed separately in Section 5.3).

- *Events that are comparatively quieter but of longer duration.* Noise events that are not as loud but are of longer duration include aircraft taxiing and idling, use of APUs, aircraft maintenance run-ups (although individual run-ups may have durations of a few minutes or less, run-ups may need to be repeated several times over an extended period of 30 minutes or more), and use of airfield maintenance and snow-removal equipment. Often, multiple individual events (such as several taxiing aircraft queuing for departure or APUs operating on multiple aircraft) are indistinguishable from one another and may be perceived in community locations as a single, continuous event. Although these noise events typically are not loud enough to cause speech disturbance or sleep interference except in the closest residential areas (even when several events occur simultaneously), they often are audible, and may dominate the background sound level, particularly during quiet periods of the evening, night, or early morning. In addition, the long and sometimes unpredictable durations of these events can contribute to annoyance since, in contrast to a short-duration event such as an aircraft departure roll, there is no indication to the listener of when the event will end.

The following portions of the report describe the characteristics and the effects of start-of-takeoff roll, use of thrust reversers, aircraft taxiing and idle, use of APUs, aircraft maintenance run-ups, GA aircraft start-up and departure, and airfield maintenance and snow-removal equipment.

5.1.1 Start-of-Takeoff Noise

Summary

In terms of maximum sound level, start-of-takeoff noise is one of the most prominent sources of aircraft ground noise at ANC. Typical start-of-takeoff events are characterized by a short rise time (i.e., a rapid increase in the sound level), relatively high sound level (compared to other ground noise events), and duration of approximately 30 to 40 seconds, after which the aircraft is airborne. A second peak in the sound level often will occur once the aircraft is airborne and the shielding and attenuating effects of terrain and other obstructions are reduced. Because the second peak occurs while the aircraft is airborne, it is not considered to be ground noise and is not described in detail in this report[9].

During the predominant periods when aircraft are departing to the north on Runway 32, the highest start-of-takeoff-roll sound levels in residential areas occur to the south of ANC in Sand Lake, followed by areas to the east of the Airport in Turnagain. Overall, however, the highest sound levels generated in residential areas during takeoff roll occur to the east and the south of ANC in portions of Spenard and Sand Lake during relatively infrequent departures to the west on Runways 24R and 24L. (Although higher sound levels are generated during overflights of residential areas during departures on Runways 6R, 6L, and 14, these noise events occur after the aircraft are airborne.)

Many of the start-of-takeoff events measured in residential areas had the potential to cause outdoor speech interference, with the L_{max} of approximately one-half of the measured events exceeding 60 dBA in some locations. Only a very small percentage of the measured events,

[9] The noise exposure contours included in the *Anchorage International Airport Part 150 Update Noise Exposure Map* include the effects of both the takeoff roll and the airborne portion of each aircraft departure.

however, would be likely to cause indoor speech interference or sleep disturbance, even with open windows.

Measured Sound Levels

Table 5.1-1 summarizes the ranges of measured sound levels caused by the start-of-takeoff roll portion of aircraft departures. The measured sound levels do not include the airborne portion of the departures. Figures 5.1-1 through 5.1-4 provide similar information graphically for each of the neighborhoods indicated in the table *(throughout the report, the figures for each sub-section are located together at the end of that sub-section)*. Each graphed data point represents the L_{max} that occurred during the takeoff-roll portion of one departure and the clusters of data points are grouped by measurement site. The figures include measured sound levels for approximately 450 departure events. Horizontal lines on the graphs also indicate the guidelines for indoor and outdoor speech interference and sleep disturbance provided in Section 3 of this report.

Table 5.1-1. Measured Start-of-Takeoff Roll Sound Levels

Measurement Site	L_{max} (dBA): Average[1] and [Approximate Range] of Measured Data			
	Runway 32	Runway 14	Runways 6L/6R	Runways 24L/24R
Turnagain (North of Lake Hood)				
8. Westwood Dr.	56 [48 to 66]	60 [55 to 66]	--[2]	[57 to 64][3]
9. Wendys Way	58 [50 to 69]	61 [54 to 71]	--[2]	--[2]
10. Orbit Cir.	57 [47 to 69]	60 [51 to 68]	--[2]	[52 to 62][3]
11. Bridle Cir.	56 [45 to 68]	59 [50 to 66]	--[2]	[54 to 56][3]
12. McCollie Ave.	53 [41 to 65]	58 [52 to 64]	--[2]	--[2]
Turnagain/Spenard (North and East of Lake Spenard)				
13. Balchen Dr.	54 [44 to 62]	--[2]	--[2]	--[2]
14. W. 44th St.	53 [42 to 61]	--[2]	--[2]	--[2]
15. Breezewood Dr.	56 [48 to 64]	--[2]	--[2]	63 [54 to 80]
16. Melvin Ave.	53 [45 to 62]	--[2]	--[2]	--[2]
Sand Lake (South of International Airport Road)				
17. Air Guard Rd.	61 [51 to 71]	--[2]	[63 to 77][3]	--[2]
18. Blackberry Dr.	59 [50 to 68]	--[2]	[67 to 71][3]	--[2]
19. Silver Birch Dr.	63 [48 to 79]	--[2]	--[2]	--[2]
20. Tanaina Dr.	59 [47 to 70]	--[2]	[58 to 69][2]	--[2]

[1]Arithmetic mean of measured L_{max}s.
[2]Due to limited use of this runway for departures, insufficient measurement data was collected at this site to provide results.
[3] Due to limited use of this runway for departures, only a small number of operations were recorded at this site and only the overall range of measured values is reported.

The overwhelming majority of air carrier departures at ANC occur on Runway 32. Because of the predominant use of Runway 32 for departures, only limited measurement data were collected for departures from other runways at some of the measurement sites. Notes in Table 5.1-1 indicate these sites and Figures 5.1-1 and 5.1-4 provide data for only those measurement sites and departure runways for which substantial amounts of data were collected. To supplement the measurement data, modeled start-of-takeoff roll contours are provided below, following the discussion of measured noise levels.

- *Runway 32 Departures:* Runway 32 is used for approximately 76% of all air carrier departures at ANC[10]. During departures on Runway 32, the loudest sound levels associated with takeoff roll occur to the south of the Airport in the Sand Lake area (measurement sites 17 through 20). In this neighborhood, the average measured L_{max} was approximately 60 dBA, the sound level associated in this report with the onset of outdoor speech interference. Although roughly half of the Runway 32 departures potentially would cause outdoor speech interference in this area, very few of the departures were loud enough to cause indoor speech interference or sleep disturbance either with open or closed windows.

  In the Turnagain and Spenard areas, average sound levels associated with takeoff roll for Runway 32 departures were slightly lower (about 53 to 58 dBA) than to the south of the Airport. These areas, however, (particularly Turnagain) are exposed to higher sound levels from the airborne portion of Runway 32 departures. In Turnagain, to the north and east of Lake Hood (measurement sites eight through 12), approximately the loudest one-third of the recorded start-of-takeoff events have the potential to cause outdoor speech interference. None of these events would be expected to cause indoor speech interference or sleep disturbance either with open or closed windows. In Spenard, to the east of Lake Spenard (measurement Sites 13 through 16), only the loudest of the recorded start-of-takeoff events would have the potential to cause outdoor speech interference and none would be expected to cause indoor speech interference or sleep disturbance either with open or closed windows.

- *Runway 6R and 6L Departures:* Together, Runways 6R and 6L account for approximately 14% of all air carrier departures at ANC, with the majority using Runway 6R. During departures on Runways 6R and 6L, the loudest sound levels associated with start-of-takeoff roll occur to the south of the Airport in Sand Lake (measurement sites 17 through 20). In these neighborhoods, the average measured L_{max} associated with takeoff roll for Runway 6R and 6L departures was approximately 65 dBA, with the highest average sound levels recorded at Site 17 (Air Guard Road) and Site 18 (Blackberry Drive). The loudest events measured at these sites would have the potential to cause indoor speech interference or sleep disturbance either with open or closed windows.

- *Runway 14 Departures:* Runway 14 is used for approximately 5% of all air carrier departures at ANC. During departures on Runway 14, the loudest sound levels associated with takeoff roll occur to the east of the Airport in Turnagain (measurement

[10] All runway-use percentages from *Anchorage International Airport FAR Part 150 Update, Noise Exposure Map,* prepared by Harris Miller Miller & Hanson Inc., 1998, Tables 5.4 and 5.5, pages 54 and 55.

sites eight through 12). In these neighborhoods, the average measured L_{max} associated with takeoff roll for Runway 14 departures was approximately 60 dBA, with the highest average sound levels recorded at Site 9 (Wendys Way), the measurement site located closest to Runway 14. The loudest events measured at these sites would have the potential to cause indoor speech interference or sleep disturbance either with open or closed windows.

- *Runway 24R and 24L Departures:* Together, Runways 24R and 24L account for approximately 5% of all air carrier departures at ANC. During departures on these runways, the loudest sound levels associated with start-of-takeoff roll occur to the east of the Airport in Spenard (measurement sites 13, 15 and 16) and south of the Airport in Sand Lake (measurement sites 17 through 20). At Site 15 (Breezewood Dr.), the average measured L_{max} associated with takeoff roll for Runway 24L/24R departures was approximately 65 dBA, with the loudest measured events ranging from 70 to 80 dBA. The loudest events would have the potential to cause indoor speech interference or sleep disturbance either with open or closed windows.

Start-of-Takeoff Roll Contours

Because of the predominant use of Runway 32 for departures, only limited measurement data were collected for departures from other runways at some of the measurement sites. To supplement the measurement data, Figures 5.1-5 through 5.1-10 provide start-of-takeoff roll contours for each of the six departure runways at ANC that were developed using the FAA's Integrated Noise Model 6.0b (INM). Each figure provides L_{max} departure contours for a B747-100 (shown in yellow) and a B737-400 (shown in green). The B747-100 is intended to represent a worst-case heavy cargo aircraft, while the B737-400 represents a typical air carrier passenger aircraft.

The solid portion of each contour represents the L_{max} contour generated during only the ground-roll portion of each departure, while the dashed portion shows the sound level as the aircraft becomes airborne. Although the airborne portion of the departure event (represented by the dashed contour) is not addressed in this ground noise study, it is shown on the figure to provide a comparison of the sound levels associated with the takeoff roll and the airborne portion of the departure.

The INM does not take into account the various weather conditions encountered during actual measurements or noise shielding provided by buildings. In addition, the measurement data presented above are for a wide variety of aircraft types, while the INM contours are for only two representative aircraft types. Finally, during the measurements, many aircraft turned soon after departure, while the modeled aircraft were assumed to continue on the runway heading after departure (although this would not affect the ground-roll portion of the L_{max} contour). For these reasons, the INM contours should be interpreted primarily as providing a comparison of the relative sound levels associated with departures on the various runways. Actual measured start-of-takeoff roll sound levels would be expected to vary from the representative sound levels depicted by the contours.

5.1.2 Reverse Thrust Noise

Summary

Aircraft utilize reverse thrust after landing to help slow the aircraft to a safe runway exit speed by deploying thrust reversers, which redirect engine exhaust towards the front of the aircraft. Reverse thrust may range in duration anywhere from just a few seconds up to approximately 20 seconds and may vary greatly in terms of power. The duration and magnitude of the use of thrust reversers depends on many conditions including the type of aircraft, runway conditions (including wet or icy pavement and slope), aircraft load, intended exit taxiway, pilot technique, and operating procedures of each airline. Some airlines, for example, require the use of thrust reversers until the aircraft slows to 80 knots. In terms of maximum sound levels, noise resulting from the use of thrust reversers is second only to start-of-takeoff among sources of ground noise at ANC. Although generally of shorter duration than departure events, reverse thrust noise may be difficult to distinguish from start-of-takeoff roll in community locations.

Runways 6L and 6R are used for approximately 89% of all air carrier arrivals at ANC. Runway 14 is used for approximately 9% of air carrier arrivals, and Runways 32, 24R, and 24L combined account for only about 2% of the air carrier arrivals[11]. Because of the high percentage of arrivals on Runways 6L and 6R at ANC, homes south of the runways in the Sand Lake area are exposed most often to the loudest noise levels from reverse thrust, although these events are audible to the east of the Airport in Turnagain and Spenard as well.

The highest community sound levels caused by use of thrust reversers occur to the south of ANC in Sand Lake with over half of the measured events in residential areas exceeding 60 dBA and having the potential to cause outdoor speech interference. In the closest residential areas to the arrival end of Runway 6R (Tanaina Hills), approximately one half of the measured events may have caused indoor speech interference with open windows and a small number of the loudest recorded events had the potential to cause speech interference with closed windows. During relatively infrequent arrivals on Runways 32 and 14, areas to the east of the Airport also are exposed to noise from reverse thrust events.

Measured Sound Levels

Table 5.1-2 summarizes the ranges of measured sound levels caused by use of thrust reversers. Figures 5.1-11 through 5.1-15 provide similar information graphically for each of the neighborhoods indicated in the table. Each graphed data point represents the L_{max} that occurred during the reverse thrust portion of one departure and the clusters of data points are grouped by measurement site. The figures include measured sound levels for approximately 340 thrust reverser events. Horizontal lines on the graphs also indicate the guidelines for indoor and outdoor speech interference and sleep disturbance provided in Section 3 of this report. Because of very limited use of Runways 24R, 24L and 32 for arrivals, only limited measurement data are available for Runway 32 arrivals and no data are available for Runway 24L/24R arrivals.

[11] All runway-use percentages from *Anchorage International Airport FAR Part 150 Update, Noise Exposure Map*, prepared by Harris Miller Miller & Hanson Inc., 1998, Tables 5.4 and 5.5, pages 54 and 55.

Table 5.1-2. Measured Reverse Thrust Sound Levels

Measurement Site	L_{max} (dBA): Average[1] and [Approximate Range] of Measured Data			
	Runway 32	Runway 14	Runways 6L/6R	Runways 24L/24R
Turnagain (North of Lake Hood)				
8. Westwood Dr.	--[2]	63 [57 to 69]	59 [49 to 67]	--[2]
9. Wendys Way	--[2]	66 [62 to 71]	57 [52 to 63]	--[2]
10. Orbit Cir.	--[2]	61 [54 to 72]	56 [47 to 64]	--[2]
11. Bridle Cir.	--[2]	61 [48 to 69]	54 [44 to 68]	--[2]
12. McCollie Ave.	--[2]	60 [53 to 67]	56 [53 to 58]	--[2]
Turnagain/Spenard (North and East of Lake Spenard)				
13. Balchen Dr.	--[2]	--[2]	50 [40 to 63]	--[2]
14. W. 44th St.	--[2]	--[2]	49 [41 to 53]	--[2]
15. Breezewood Dr.	--[2]	--[2]	55 [48 to 66]	--[2]
16. Melvin Ave.	--[2]	--[2]	50 [45 to 61]	--[2]
Sand Lake (South of International Airport Road)				
17. Air Guard Rd.	58 [53 to 64]	--[2]	61 [52 to 73]	--[2]
18. Blackberry Dr.	56 [52 to 62]	--[2]	60 [55 to 64]	--[2]
19. Silver Birch Dr.	59 [51 to 68]	--[2]	62 [54 to 72]	--[2]
20. Tanaina Dr.	62 [55 to 70]	--[2]	68 [58 to 76]	--[2]

[1]Arithmetic mean of measured L_{max}s.
[2]Due to limited use of this runway for arrivals, insufficient measurement data was collected at this site to provide results.

- *Runway 6L and 6R Arrivals:* The loudest sound levels in residential areas associated with the use of thrust reversers at ANC occur during arrivals on Runways 6L and 6R in the Tanaina Hills area (immediately south of Raspberry Road and west of Sand Lake Road) to the south of the Airport, represented by measurement Site 20 (Tanaina Drive). With an average L_{max} of approximately 68 dBA, nearly all of the recorded reverse thrust events were loud enough to potentially cause outdoor speech interference (over 60 dBA), and nearly half could cause indoor speech interference with open windows (over 70 dBA outdoors). A small number of the loudest recorded events had the potential to cause speech interference with closed windows (over 75 dBA outdoors).

  During Runway 6L and 6R arrivals, recorded sound levels due to use of thrust reversers were somewhat lower at the other measurement sites throughout the Sand Lake area (measurement sites 17 through 19), with average L_{max}s of 60 to 62 dBA. At these sites, approximately half of the recorded reverse thrust events would have the potential to cause outdoor speech interference. Only the loudest recorded events at Site 17 (Air Guard Road) and Site 19 (Silver Birch Drive), however, were loud enough to cause indoor speech interference or sleep disturbance either with open or closed windows. None of the recorded events at Site 18 (Blackberry Drive) would be expected to cause indoor speech interference or sleep disturbance either with open or closed windows.

In the Turnagain and Spenard areas (measurement sites 8 through 16), recorded sound levels associated with reverse thrust on Runways 6L and 6R were lower than in the Sand Lake area. On average, L_{max}s in these areas ranged from 49 to 59 dBA. Although some of the recorded reverse thrust events were loud enough to potentially interfere with speech outdoors, none were loud enough to cause indoor speech interference or sleep disturbance either with open or closed windows.

- *Runway 14 Arrivals:* During arrivals on Runway 14, the loudest sound levels associated with use of thrust reversers occur to the east of the Airport in Turnagain (measurement sites eight through 12). In these neighborhoods, the average measured L_{max} associated with reverse thrust noise for Runway 14 arrivals was approximately 60 to 66 dBA, with the highest average sound levels recorded at Site 8 (Westwood Drive) and Site 9 (Wendys Way), the two measurement sites located closest to the arrival end of Runway 14. Many of the recorded reverse thrust events (over half) would have the potential to cause outdoor speech interference in this area. Very few of the recorded events, however, were loud enough to cause indoor speech interference or sleep disturbance either with open or closed windows.

5.1.3 Taxiing and Idle Noise

Summary

Aircraft taxiing and idle noise is generated both by arriving and departing aircraft. Upon arrival, the taxi/idle event includes the aircraft taxiing from the arrival runway to the passenger gate or cargo facility until the engines are shut down. At ANC, the typical time from exiting the arrival runway to engine shut-down is about five minutes, depending upon the arrival runway and the gate or ramp location to which the aircraft is taxiing. For departures, the taxi/idle noise event includes starting the aircraft's engines at the gate or ramp location and taxiing to the departure runway. The noise event also may include holding or queuing time at the ramp or gate, in a holding area, or (most commonly at ANC) on the taxiway near the departure runway. At ANC, start-up and taxi time prior to departure may be as little as five minutes, or may extend to 15 or 20 minutes if multiple aircraft are queued waiting for departure. Taxi noise sometimes is associated with the high-pitched fan noise directed from the front of the engines on large turbofan aircraft, including many of the heavy cargo jets operating at ANC.

Although noise from taxiing and idling aircraft is lower in sound level than other sources of ground noise such as start-of-takeoff and reverse thrust, it often is audible in community locations near ANC and has the potential to cause annoyance, particularly during evening, nighttime, or early morning when background sound levels are lowest. In addition, during certain periods of heavy activity during both the day and night at ANC, several aircraft may be taxiing or holding short of a runway in preparation for departure, resulting in continuous taxiing and idle noise for an hour or more. In these situations, contributions from individual aircraft may be indistinguishable and noise from multiple aircraft often is perceived in the community as one continuous event, with contributions from several taxiing or idling aircraft combining to increase the overall sound level. Although taxi and idle noise is not expected to cause indoor speech interference or sleep disturbance, sound levels in the closest residential areas have the potential to cause outdoor speech interference, particularly during periods when multiple aircraft are operating.

Measured and Projected Sound Levels

Because of the relatively low sound levels associated with taxi and idle noise, only the loudest taxi and idle events (often associated with multiple aircraft operating simultaneously) could be measured in community locations. As a result, the sound levels included in this report are based on a combination of:

- Taxi/idle sound levels measured at residential sites during the measurement program for this project (typically the loudest events), and
- Projections based upon source-level measurements previously conducted by HMMH of aircraft operating at ANC[12]. The measurements were conducted approximately 185 feet east of the Taxiway Romeo centerline at the western edge of Postmark Bog.

Table 5.1-3 provides a summary of the source-level measurements used to make projections in various residential areas (although the measurements were conducted at a distance of 185 feet, the sound levels reported in the table have been normalized to a distance of 100 feet). In addition, the table provides representative projected sound levels in community locations associated with an individual aircraft operating within certain areas of the Airport. The sound levels are reported in 10-decibel ranges to reflect the effects of weather on long-distance sound propagation. Long-distance ground-to-ground sound propagation (as opposed to "air-to-ground" sound propagation from aircraft in flight) is affected by a variety of factors, including weather conditions and topography, which are less critical at shorter distances. Weather conditions, such as wind and temperature gradients, can cause sound levels at observer locations to vary by 10 decibels or more seasonally, daily, or even hourly. Because of the inherent variability in long-distance sound propagation conditions, it is useful to express projected sound levels in ranges intended to represent most typical propagation conditions. Under some conditions, it is possible that sound levels either above or below the projected ranges could occur. The sound levels shown in the table do not include any shielding from buildings, terrain, or vegetation. In addition, the computed levels do not include any attenuation from ground effects, which may reduce sound levels under some conditions. For these reasons, the upper ends of the ranges of sound levels shown in Table 5.1-3 are the worst-case (loudest) sound levels expected for individual single events under typical conditions.

Assuming similar sound levels for each aircraft, multiple taxiing or idling aircraft would increase sound levels as follows (as compared to a single aircraft):

- Two aircraft: + 3 dB
- Three aircraft: +5 dB
- Five aircraft: +7 dB
- Ten aircraft: +10 dB

[12] Source-level measurements typically are conducted at a relatively short reference distance so that the measurements will not be significantly affected by propagation effects (such as wind conditions) or contaminated by other noise sources. The measured sound levels can then be used as input to a noise prediction model to assess the contribution of a particular noise source at a given location.

The loudest sound levels in residential areas due to taxi and idle noise occur in Spenard near Site 15 (Breezewood Drive, north of East Airpark) and near Connors and DeLong Lakes near Sites 18 (Blackberry Drive, south of East Airpark) and Site 17 (Air Guard Road, southwest of East Airpark) during taxiing at the east end of Taxiway Kilo and Runway 6L/24R near East Airpark. The closest homes near Site 15 and Site 18 are within approximately 2,000 feet and 3,000 feet, respectively, of these locations, with little shielding provided by intervening terrain or buildings. Projected sound levels due to individual taxiing aircraft near East Airpark range from about 53 to 67 dBA at the closest residential areas in Spenard and may cause outdoor speech interference.

Table 5.1-3. Measured Aircraft Taxi Sound Levels at 100 feet and Projected Sound Levels in Community Locations

Aircraft Type	Measured Sound Level at 100 feet (dBA)	Projected Sound Level at Closest Residences (dBA)[1]		
		No. Airpark to Turnagain (approx. 5,500 ft.)	Taxiway K, East Airpark to Spenard (approx. 2,000 feet)	Taxiway K and R intersection to Tanaina Hills (approx. 4,300 feet)
B767	92	39 to 49	53 to 63	43 to 53
B747	96	43 to 53	57 to 67	47 to 57
A300	92	39 to 49	53 to 63	43 to 53
DC10	94	41 to 51	55 to 65	45 to 55
MD11	94	41 to 51	55 to 65	45 to 55

[1]Worst-case projections based on 20log (d_1/d_2) + 1.5 dB atmospheric absorption/1,000 ft.; ranges intended to account for influence of atmospherics.
Source-level measurements conducted October 1999 by HMMH at ANC (*Ted Stevens Anchorage International Airport Wetlands Permit Application Noise Assessment Report*, September 18, 2000, HMMH Report No. 296690).

The Tanaina Hills area of Sand Lake, and other residential areas south of ANC are exposed to noise from aircraft preparing to depart on Runway 32 as they taxi south from North Airpark and queue on Taxiway Romeo, or taxi from the terminal complex and queue on Taxiways Kilo and Lima, about 4,300 feet away. As aircraft taxi south or hold on Taxiway Romeo, these neighborhoods are exposed to the high-pitched fan noise directed from the front of the aircraft's engines. Projected sound levels due to individual taxiing aircraft in these locations range from about 43 to 57 dBA at the closest residential areas. Although these projected sound levels for individual aircraft are below the levels associated with the onset of outdoor speech interference (60 dBA), the taxi and idle noise may be clearly audible during periods of the day or night, and would be somewhat higher during periods when multiple aircraft are either taxiing or idling.

The closest portions of Turnagain to North Airpark (east of the Gravel Strip) may experience sound levels ranging from about 39 to 53 dBA for individual aircraft taxiing on Taxiway Romeo, about 6,500 feet away. Although these sound levels are below the levels associated with the onset of outdoor speech interference (60 dBA), the taxi and idle noise may be clearly audible during periods of the day or night, and would be somewhat higher during periods when multiple aircraft are either taxiing or idling.

5.1.4 Auxiliary Power Units (APUs)

Summary

APUs are small jet engines, often located near the tail of an aircraft, that are used to provide electrical power and heat or air conditioning to aircraft when they are on the ground with their main engines shut down. In addition, compressed air generated by APUs sometimes is used to start the aircraft's main engines. Although many of the cargo and passenger airlines at ANC use quieter alternative sources of power (typically, diesel ground power units, also known as GPUs) when aircraft will be on the ground for extended periods, APUs frequently are used during normal operations. Although cargo and passenger aircraft APUs do not make significant contributions to overall noise levels in most residential areas nor are they typically loud enough to exceed guidelines for speech interference or sleep disturbance at residential locations near ANC, they are audible under some conditions, particularly at night when background sound levels are lowest. Due to the extended nature of APU operations (lasting up to several hours), noise from APUs has the potential to be annoying despite relatively low sound levels (compared, for example, to start-of-takeoff roll or use of thrust reversers).

Measured and Projected Sound Levels

Because of the relatively low sound levels associated with APUs, only the loudest APU events (typically APUs on multiple aircraft operating simultaneously) could be measured in community locations. As a result, the sound levels included in this report are based on a combination of:

- APU sound levels measured at residential sites during the measurement program for this project (typically loudest events), and
- Projections based upon source-level measurements previously conducted by HMMH of aircraft operating at ANC.

Table 5.1-4 provides a summary of the source-level measurements used to make projections in various residential areas. In addition, the table provides projected sound levels in community locations associated with an individual APU operating in the specified part of the Airport. As discussed above, the projected sound levels are reported in 10-decibel ranges to reflect the effects of weather on long-distance sound propagation. Under some conditions, it is possible that sound levels either above or below the projected ranges could occur. The sound levels shown in the table do not include any shielding from buildings, terrain, or vegetation. In addition, the computed levels do not include any attenuation from ground effects, which may reduce sound levels under some conditions. For these reasons, the upper ends of the ranges of sound levels shown in Table 5.1-4 are the worst-case (loudest) sound levels expected for individual single events under typical conditions.

Assuming similar orientations with respect to residences, multiple APUs operating simultaneously would increase sound levels as follows (as compared to a single APU):

- Two aircraft: + 3 dB
- Three aircraft: +5 dB
- Five aircraft: +7 dB
- Ten aircraft: +10 dB

The loudest sound levels in residential areas due to APUs occur in Spenard near Site 15 (Breezewood Drive, north of East Airpark) and near Connors and DeLong Lakes near Sites 18 (Blackberry Drive, south of East Airpark) and Site 17 (Air Guard Road, southwest of East Airpark) during operation of cargo aircraft APUs in East Airpark. The closest homes near Site 15 and Site 18 are within about 2,000 feet and 3,000 feet, respectively, of parked aircraft with little shielding provided by intervening terrain or buildings. Projected and measured sound levels due to APUs at East Airpark (primarily B747s) range from about 41 to 59 dBA in these areas. During periods when several APUs are in use, sound levels at the closest homes may exceed 60 dBA. Even when APU sound levels are below the levels associated with the onset of outdoor speech interference (60 dBA), APU noise may dominate the background sound level during quiet periods of the day or night.

Table 5.1-4. Measured APU Sound Levels at 100 feet and Projected Sound Levels in Community Locations

Aircraft Type	Measured Sound Level at 100 feet (dBA)[1]	Projected Sound Level at Closest Residences (dBA)[2]		
		Spenard[3] (approx. 2,000 feet from East Airpark)	Connors/DeLong Lakes[4] (approx. 3,000 feet from East Airpark)	Turnagain (5,000 feet from North Airpark)
B767	83 to 94	--	--	32 to 53
B747-100	84 to 91	45 to 55	43 to 57	33 to 50
B747-200	84 to 93	45 to 55	41 to 59	33 to 52
A300	72 to 81	--	--	21 to 40
DC10	85 to 95	--	--	34 to 54
MD11	84 to 93	--	--	33 to 52

[1]Ranges due to directionality of noise source; lower sound levels typically to front of aircraft.
[2]Worst-case projections based on 20log (d_1/d_2) + 1.5 dB atmospheric absorption/1,000 ft.; ranges intended to account for influence of atmospherics.
[3]Projections for Spenard assume B747s parked with residences within approximately ±45 degrees of front of aircraft; other aircraft types typically not located at East Airpark.
[4]Projections for Connors/DeLong Lakes assume B747s parked with residences within approximately ±45 degrees of rear of aircraft; other aircraft types typically not located at East Airpark.
Source-level measurements conducted October 1999 by HMMH at ANC (*Ted Stevens Anchorage International Airport Wetlands Permit Application Noise Assessment Report*, September 18, 2000, HMMH Report No. 296690).

Portions of Turnagain also are exposed to noise from APUs of passenger and cargo aircraft parked in the vicinity of the terminal complex and cargo aircraft at North Airpark. The closest homes in Turnagain are located approximately 5,000 feet from either of these locations and, in some cases, benefit somewhat from shielding provided either by the terminal complex or by North Airpark cargo facility buildings. As a result, projected and measured sound levels associated with APUs are somewhat lower in these areas, ranging from about 32 to 54 dBA for most aircraft at North Airpark. Although these sound levels are below the levels associated with the onset of outdoor speech interference (60 dBA), noise from APUs may be clearly audible for extended periods of the day or night and has the potential to cause outdoor speech interference when multiple APUs are operating.

5.1.5 Aircraft Maintenance Engine Run-ups

Summary

Maintenance run-ups are a necessary part of typical aircraft engine maintenance. During a maintenance run-up, an engine typically is brought up to and maintained at a certain power setting, ranging from idle-power to takeoff-power, depending upon the particular maintenance check being performed. The power setting may be maintained anywhere from a few seconds to several minutes. The procedure may be repeated several times and potentially could last for 30 to 60 minutes, and go through several engine-run cycles. Although maintenance run-ups occur much less frequently than aircraft departures at ANC, they have the potential to be annoying because they can generate high noise levels (especially during high-power run-ups) for long periods of time. In addition, maintenance run-ups often are performed at night (when the aircraft are not needed for regularly scheduled service) when ambient sound levels are lowest and residents are most sensitive to intruding noise events.

Existing Run-up Procedures and Level of Activity at ANC

Anchorage International Airport Bulletin No. 2000-16 provides noise abatement procedures for conducting run-ups, including designated aircraft locations and orientations for engine run-ups above idle power. The two designated locations are:

- Taxiway Juliet with the aircraft nose heading east at a compass heading of 060 degrees (magnetic).
- Taxiway Quebec with the aircraft nose heading south at a compass heading of 170 degrees (magnetic).

For nighttime run-ups (10:00 PM to 7:00 AM), any variance in compass heading must be coordinated with Airport Operations in advance.

In addition, the bulletin restricts nighttime run-ups above idle power "to those aircraft which are hard scheduled for a flight prior to 0800 local time" and states that "every effort should be made to avoid engine run-ups during quiet hours." All nighttime run-ups must be approved in advance by the on-duty Airport Operations Officer. Although no restrictions are placed on idle-power runs during nighttime hours, notification of Airport Operations is required in advance.

Table 5.1-5 provides a record of nighttime run-up activity at ANC recorded by Airport Operations between September 13 and October 1, 2000. This period included the September 2000 noise measurement program. The table provides the date, time and duration of each run-up, as well as the aircraft type, power setting, and the run-up location[13]. Because the log is filled-out by the on-duty Airport Operations Officer as run-ups are requested, it is a record of intended run-ups, not actual activities. As a result, the duration shown for each run-up in the log is an estimate; the actual run-up may have required either more or less time.

[13] The actual logs maintained by the Airport also include the airline, flight number, intended departure time, and reason for the run-up.

Table 5.1-5. ANC Nighttime Run-up Activity, September 13 to October 1, 2000

Date	Time	Duration (Minutes)	Aircraft Type	Power	Location
9/13/00	06:20	20	DC6	Ground Idle	NAC Ramp
9/14/00	03:25	15	Convair	Ground Idle	ERA Ramp
9/14/00	03:45	5	DC6	Ground Idle	ACE Ramp
9/14/00	05:20	5	DC6	Ground Idle	ACE Ramp
9/14/00	05:50	5	Convair	Ground Idle	ERA Ramp
9/15/00	01:05	5	DC6	Ground Idle	ACE Ramp
9/15/00	03:20	20	DC6	Ground Idle	NAC Ramp
9/16/00	*00:15*	*45*	*Electra*	*Full*	*Txwy. J*
9/16/00	***03:45***	***30***	***MD80***	***Full***	***Txwy. J***
9/16/00	*05:45*	*45*	*Electra*	*Full*	*Txwy. J*
9/18/00	*01:25*	*30*	*BE1900*	*Full*	*Txwy. J*
9/18/00	***03:05***	***10***	***B737***	***Full***	***Txwy. J***
9/18/00	***03:30***	***10***	***B737***	***Full***	***Txwy. J***
9/19/00	03:45	10	B747	Ground Idle	Polar Ramp
9/20/00	04:50	5	Convair	Ground Idle	ERA Ramp
9/20/00	*05:40*	*30*	*L382*	*Full*	*Txwy. J*
9/21/00	00:55	15	DC6	Ground Idle	NAC Ramp
9/21/00	01:50	5	DC6	Ground Idle	ACE Ramp
9/21/00	*05:45*	*30*	*Electra*	*Full*	*Txwy. J*
9/22/00	***01:15***	***5***	***B747***	***Full***	***Txwy. J***
9/22/00	02:15	5	DC6	Ground Idle	ACE Ramp
9/22/00	03:30	5	DC6	Ground Idle	ACE Ramp
9/22/00	*05:30*	*10*	*BE1900*	*Full*	*Txwy. Q*
9/22/00	*05:45*	*10*	*BE1900*	*Full*	*Txwy. Q*
9/23/00	01:10	5	DC6	Ground Idle	ACE Ramp
9/23/00	01:40	5	DC6	Ground Idle	ACE Ramp
9/23/00	*03:45*	*45*	*Dash8*	*Full*	*Txwy. J*
9/24/00	*03:00*	*45*	*Convair*	*Full*	*Txwy. J*
9/24/00	*04:45*	*15*	*Saab*	*Full*	*Txwy. Q*
9/24/00	04:50	10	DC6	Ground Idle	NAC Ramp
9/24/00	*06:45*	*15*	*BE1900*	*Full*	*Txwy. Q*
9/26/00	04:40	5	DC6	Ground Idle	NAC Ramp
9/27/00	*02:00*	*30*	*Saab*	*Full*	*Txwy. Q*
9/27/00	04:40	5	DC6	Ground Idle	NAC Ramp
9/28/00	***04:15***	***40***	***MD80***	***Full***	***Txwy. J***
9/28/00	*05:15*	*40*	*BE1900*	*Full*	*Txwy. Q*
9/30/00	06:30	5	Electra	Ground Idle	RAA Ramp
10/01/00	***00:01***	***30***	***B737***	***Full***	***Txwy. J***
10/01/00	***01:40***	***30***	***B737***	***Full***	***Txwy. J***
10/01/00	***23:00***	***15***	***B747***	***Full***	***Txwy. J***

Notes:
(1) Full-power run-ups shown in *italics*.
(2) Full-power jet run-ups shown in ***bold italics***.

logs from multiple measurement sites (including an observer and noise monitor at the gravel strip) indicated that, except at the closest homes, noise from departing GA aircraft often is not distinguishable until the aircraft are airborne. As a result, the sound levels included in this report are based primarily on projections using source-level measurements conducted by HMMH both during this study and previously at ANC.

Table 5.1-6 provides a summary of the source-level measurements used to make projections in various residential areas. In October 1999, HMMH made calibrated tape recordings of a Cessna C182 aircraft conducting stationary controlled run-ups at both idle (500 rpm) and 50% (1,700 rpm) power for later use in modeling typical GA-aircraft start-up procedures. The measurements were conducted at a reference distance of 50 feet from the aircraft's propeller, at several angles around the aircraft for each power setting, and later normalized to a reference distance of 100 feet. The ranges shown in the table reflect the variation in sound level measured at different angles around the aircraft, with the highest noise levels generally towards the front of the aircraft.

In September 2000, HMMH conducted additional source-level measurements of GA aircraft taxi and departure noise at the gravel strip. The results of these measurements, normalized to a reference distance of 100 feet, also are provided in Table 5.1-6. The range in sound levels indicates the variation of measured values and depended upon aircraft type, power settings, and individual pilot technique. The loudest measured departures, which included a prominent tone as the plane of the propeller passed perpendicular to the noise monitor, were about 15 dB to 20 dB louder than the average measured departure. This tone, which is generated as the tips of the propeller blades surpass the speed of sound, generally can be avoided through improved pilot technique.

In addition to measured source levels, Table 5.1-6 provides projected community sound levels associated with GA aircraft start-up and idle, taxi, pre-flight run-up, and departure run both at the gravel strip and at Lake Hood. As discussed above, the projected sound levels are reported in 10-decibel ranges to reflect the effects of weather on long-distance sound propagation. Under some conditions, it is possible that sound levels either above or below the projected ranges could occur. The sound levels shown in the table do not include any shielding from buildings, terrain, or vegetation. In addition, the computed levels do not include any attenuation from ground effects, which may reduce sound levels under some conditions. For these reasons, the upper ends of the ranges of sound levels shown in the table are the worst-case (loudest) sound levels expected for individual single events under typical conditions.

It should be noted that actual sound levels, particularly in residential locations shielded by one or more rows of buildings, may be considerably lower than the worst-case sound levels shown in Table 5.1-6. As stated above, sound levels associated with GA aircraft start-up, taxi, and pre-flight run-ups often were difficult to clearly distinguish from other noise sources in residential areas during the measurement program. Cross-checking of noise-monitor data and observer logs from multiple measurement sites indicated that, except at the closest homes, noise from departing GA aircraft often is not distinguishable until the aircraft are airborne.

Table 5.1-6. Measured GA Sound Levels at 100 feet and Projected Sound Levels in Community Locations

Operation Type	Meas. Sound Level at 100 feet (dBA)	Projected Maximum Sound Level at Nearby Residences (dBA)[2]				
		Closest Homes	Site 9 (Wendys Way)	Site 10 (Orbit Circle)	Site 11 (Bridle Circle)	Site 14 (W. 44th Street)
Gravel Strip						
Start-up (idle power)	68 to 76[1]	39 to 57 (800 feet from parking area)	27 to 45 (2,300 feet from parking area)	35 to 53 (1,200 feet from parking area)	26 to 44 (2,600 feet from parking area)	28 to 46 (2,200 feet from parking area)
Taxi	60 to 71	35 to 56 (500 feet from runway end)	27 to 48 (1,100 feet from runway end)	32 to 53 (700 feet from runway end)	24 to 45 (1,500 feet from runway end)	22 to 43 (1,800 feet from runway end)
Run-up (50% power)	82 to 90[1]	57 to 75 (500 feet from runway end)	49 to 67 (1,100 feet from runway end)	54 to 72 (700 feet from runway end)	46 to 64 (1,500 feet from runway end)	44 to 62 (1,800 feet from runway end)
Departure roll	81 to 105	56 to 90 (500 feet from runway end)	48 to 82 (1,100 feet from runway end)	53 to 87 (700 feet from runway end)	45 to 79 (1,500 feet from runway end)	43 to 77 (1,800 feet from runway end)
Lake Hood						
Start-up (idle power)	68 to 76[1]	39 to 57 (800 feet from floatplane slips)	21 to 39 (3,700 feet from floatplane slips)	26 to 44 (2,600 feet from floatplane slips)	20 to 38 (4,000 feet from floatplane slips)	36 to 54 (1,100 feet from floatplane slips)
Taxi	60 to 71	30 to 51 (900 feet from E-W lane)	Up to 32 (4,200 feet from E-W lane)	up to 36 (3,300 feet from E-W lane)	up to 30 (5,000 feet from E-W lane)	30 to 51 (900 feet from E-W lane)
Run-up (50% power)	82 to 90[1]	52 to 70 (900 feet from E-W lane)	33 to 51 (4,200 feet from E-W lane)	37 to 55 (3,300 feet from E-W lane)	31 to 49 (5,000 feet from E-W lane)	52 to 70 (900 feet from E-W lane)
Departure run	81 to 105	51 to 85 (900 feet from E-W lane)	32 to 66 (4,200 feet from E-W lane)	36 to 70 (3,300 feet from E-W lane)	30 to 64 (5,000 feet from E-W lane)	51 to 85 (900 feet from E-W lane)

[1]Ranges due to directionality of noise source; higher sound levels typically to front of aircraft.
[2]Worst-case projections based on 20log (d_1/d_2) + 1.5 dB atmospheric absorption/1,000 ft.; ranges intended to account for influence of atmospherics.
Start-up and run-up source-level measurements conducted October 1999 by HMMH at ANC (*Ted Stevens Anchorage International Airport Wetlands Permit Application Noise Assessment Report*, September 18, 2000, HMMH Report No. 296690). Departure-roll and taxi source-level measurements conducted September 2000 by HMMH at ANC.

Table 5.1-6 indicates that worst-case sound levels of up to 90 dBA may occur at the closest residences during GA aircraft takeoff runs. As noted above, the loudest departure levels generally occur when certain aircraft take off at full power. A particularly loud tone is created when the tips of larger diameter propellers surpass the speed of sound. Cessna 185s, Cessna 206s, and DeHaviland Beavers are particularly prone to this phenomenon. This problem can be minimized or avoided through improved pilot technique, namely reducing the full-throttle rpm of the propeller slightly. On average, maximum sound levels at the closest homes are 15 dB to 20 dB lower (70 to 75 dBA) than the worst-case levels. These projected sound levels include no shielding due to rows of homes or terrain and would be somewhat lower farther back into residential areas. In addition, the loudest sound levels during takeoff run typically occur only momentarily as the plane of the propeller passes the listener (i.e. at the point when the aircraft passes perpendicular to the listener) at residences located along the runway or water lane sideline. At most other locations, the maximum sound level occurs once the aircraft is airborne.

The loudest start-of-takeoff events briefly have the potential to cause indoor speech interference and sleep disturbance even with closed windows. Typical departure-run events, with sound levels of 70 to 75 dBA at the closest homes, have the potential to cause indoor speech interference and sleep disturbance with open windows. Pre-flight run-ups also have the potential to cause indoor speech interference and sleep disturbance with open windows, but would not be expected to cause speech interference and sleep disturbance with closed windows. Sound levels associated with other GA ground operations, including aircraft start-up and idle and taxiing, are all below 60 dBA at the closest residences and would not be expected to cause outdoor or indoor speech disturbance and sleep interference, although they are audible under some conditions.

5.1.7 Airfield Maintenance Equipment

During the measurement program, source-level measurements were conducted, with the assistance of ANC Maintenance Staff, of the primary types of maintenance and snow-clearing equipment used at ANC (Figures 5.1-17 through 5.1-19). Table 5.1-7 provides a summary of the maximum sound levels measured 50 feet from each piece of equipment. The table also provides projected sound levels at three representative distances (1,500 feet, 3,000 feet, and 6,000 feet) along with examples of these distance measured from points on the Airport (where maintenance equipment may operate) to residential areas.

Table 5.1-7. Measured Maintenance and Snow-Clearing Equipment Sound Levels at 50 feet and Projected Sound Levels at Representative Distances

Equipment Type	Measured Sound Level at 50 feet (L_{max}, dBA)[1]	Projected Sound Level at Representative Distances to Residential Areas (dBA)[2]		
		1,500 feet (Runway 24L to Connors/ DeLong Lakes)	3,000 feet (Runway 6R to Tanaina Hills)	6,000 feet (Taxiway Romeo to Turnagain)
Plow truck (Oshkosh) and runway broom/blower (Stewart & Stevenson), passby at 50 ft.	97	55 to 65	47 to 57	36 to 46
Snow Thrower (Stewart & Stevenson), passby at 50 ft.	83	41 to 51	33 to 43	22 to 32
Vacuum Truck (Vactor 2000), engine at idle, blower at full throttle	83	41 to 51	33 to 43	22 to 32
Back-up Alarm (Snow Thrower)	79	37 to 47	29 to 39	18 to 28

[1] L_{max}, A-weighted, fast response.
[2] Worst-case projections based on 20log (d_1/d_2) + 1.5 dB atmospheric absorption/1,000 ft; ranges intended to account for influence of atmospherics.
Source-level measurements conducted September 2000 by Mullins Acoustics and HMMH at ANC.

The loudest measured piece of equipment was a plow truck and runway broom/blower combination, with a maximum sound level of 97 dBA at 50 feet. At a distance of 1,500 feet, which is approximately the distance from the closest residences to any of the paved runways at ANC, the L_{max} would be approximately 55 to 65 dBA, and would have the potential to cause outdoor speech interference under some conditions. The other measured types of equipment, a snow thrower and a vacuum truck, had maximum sound levels at 50 feet of about 83 dBA, resulting in projected sound levels of about 41 to 51 dBA at 1,500 feet. At the other representative distances shown in the table, the projected sound levels would be considerably lower.

Based on these measurements and projections, the absolute sound levels associated with maintenance and snow-clearing equipment generally are expected to be below the threshold for outdoor speech interference (60 dBA), except at the closest residences during operation of the loudest types of equipment. At other locations however, and during operation of quieter types of equipment, the distinctive sounds generated by the equipment would be audible during quiet periods of the day or night and may cause annoyance. In addition, at the closest locations to the Airport, the louder pieces of equipment may dominate the background sound level during periods of operation.

Back-up Alarms

Table 5.1-7 also provides measured and projected levels for back-up alarms. The Occupational Safety and Health Standards for the Construction Industry (29CFR Part 1926.601) state that "No employer shall use any motor vehicle equipment having an obstructed view to the rear unless: (i) The vehicle has a reverse signal alarm audible above the surrounding noise level; or (ii) The vehicle is backed up only when an observer signals that it is safe to do so." To meet the requirement of being "audible above the surrounding noise level," backup alarms are designed to emit a distinct, tonal sound. Often, tonal noise sources are judged to be more intrusive and annoying than other noise sources with equivalent sound levels. Although projected sound levels in residential areas caused by backup alarms on maintenance equipment are relatively low, they may be clearly audible because of their tonal nature.

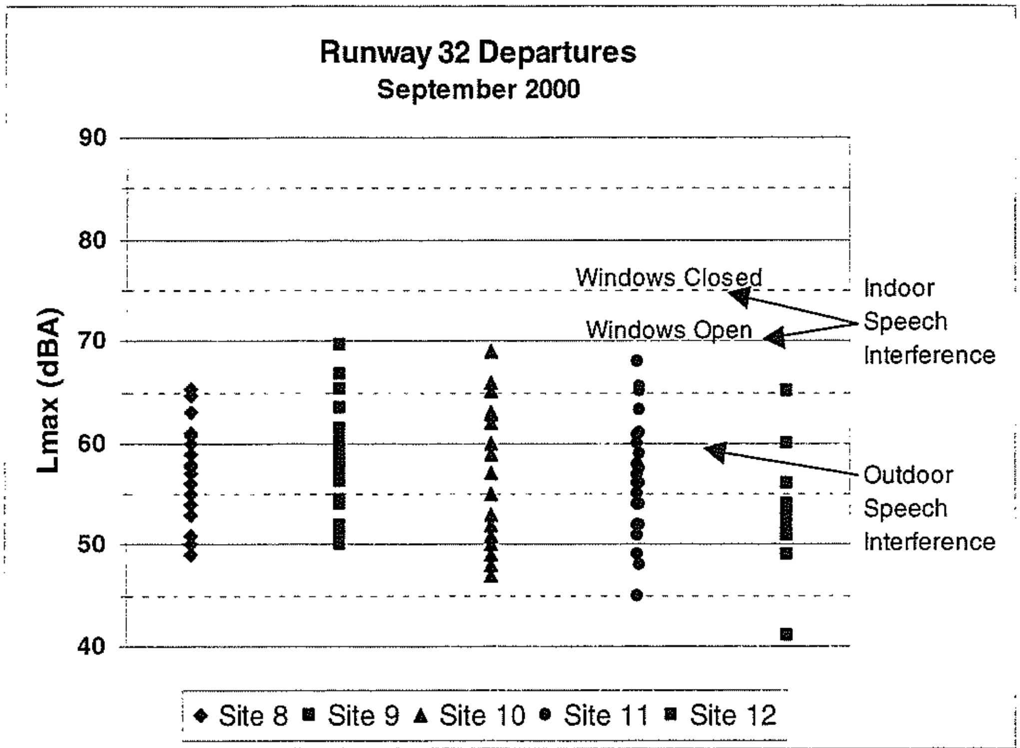


Figure 5.1-1. Measured Start-of-Takeoff Sound Levels – Runway 32, Turnagain

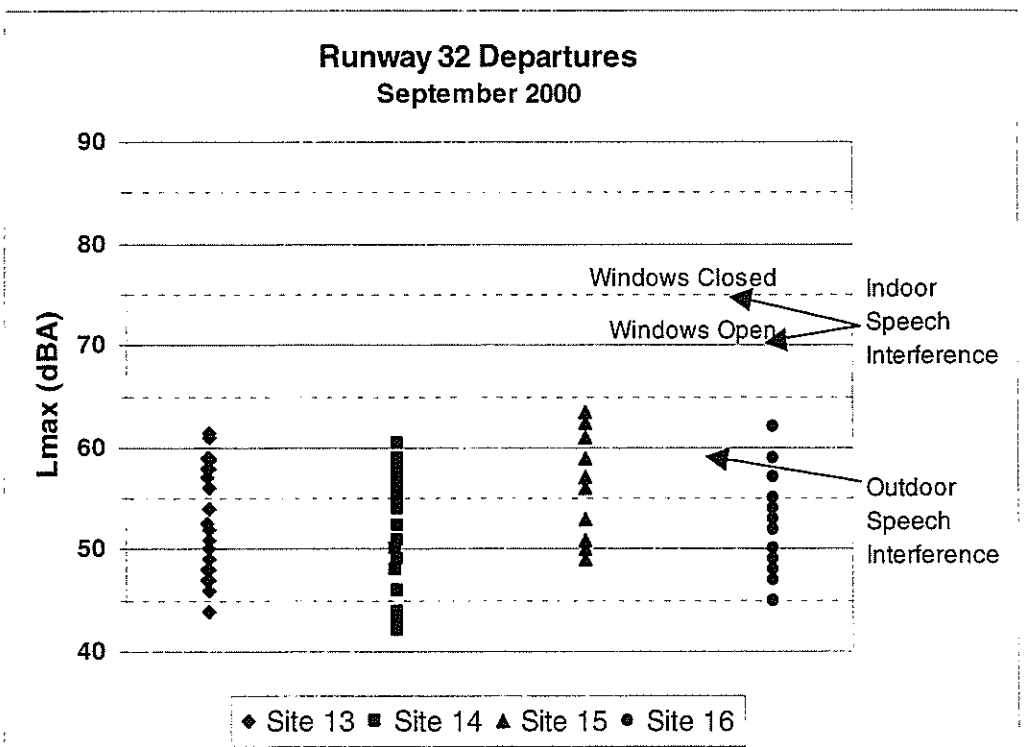


Figure 5.1-2. Measured Start-of-Takeoff Sound Levels – Runway 32, Turnagain/Spenard

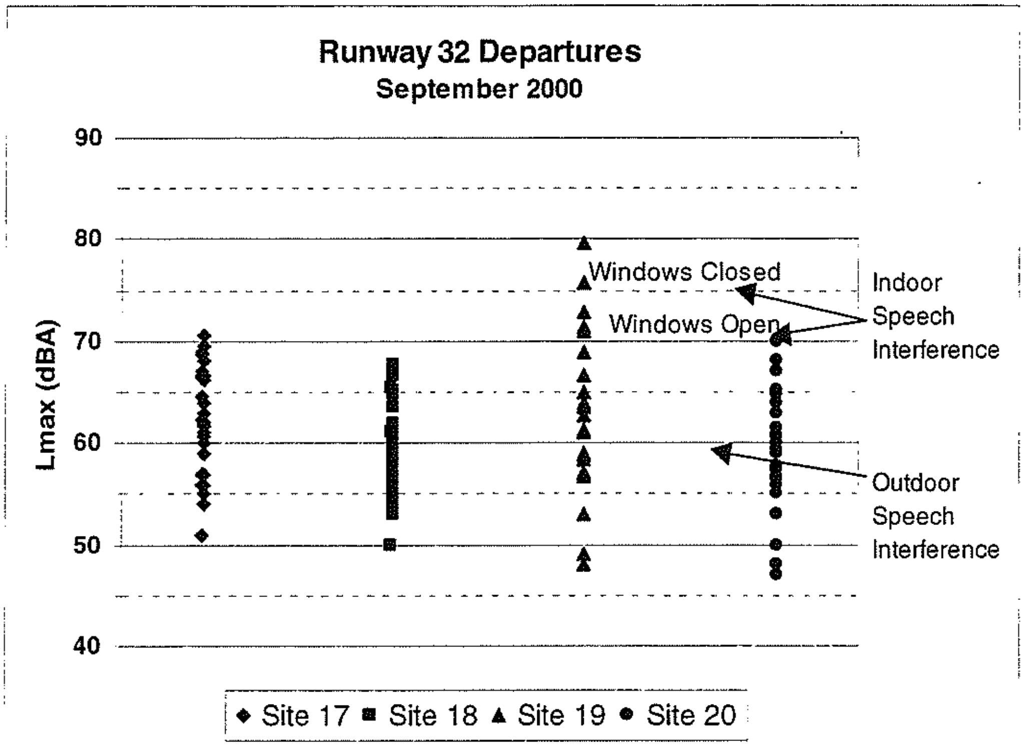


Figure 5.1-3. Measured Start-of-Takeoff Sound Levels – Runway 32, Sand Lake

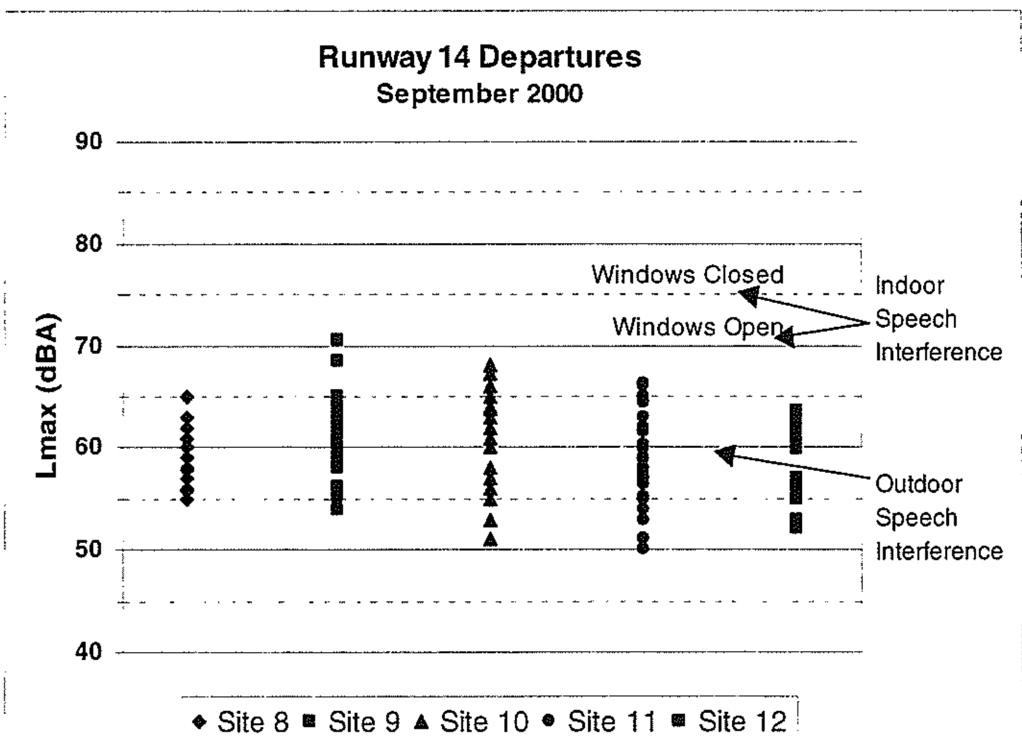


Figure 5.1-4. Measured Start-of-Takeoff Sound Levels – Runway 14, Turnagain

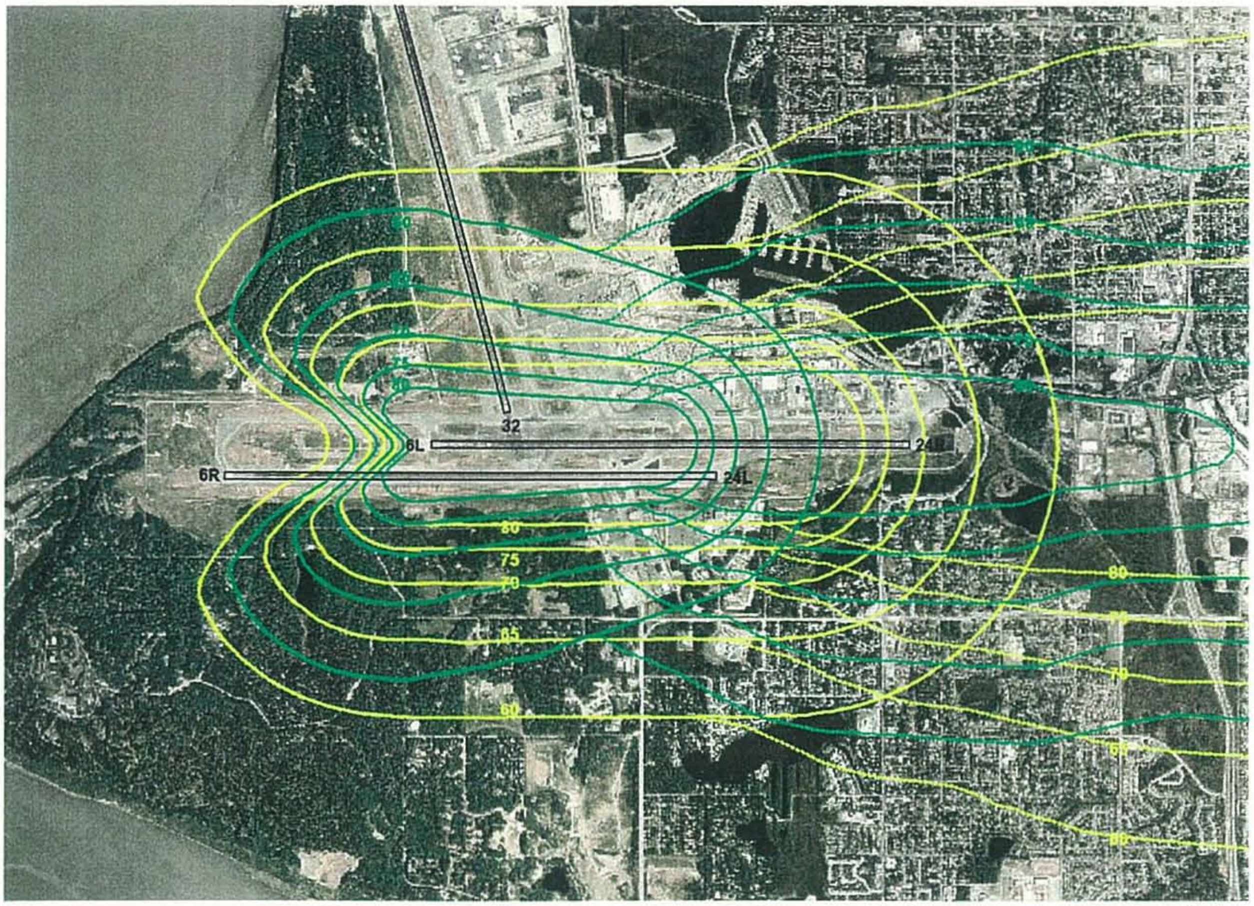


Figure 5.1-5. Start-of-Takeoff Contours, Runway 6L

B747-100 (yellow) and B737-400 (green): 60, 65, 70, 75, and 80 dBA, L_{max}
(Solid contours indicate ground roll, dashed contours indicate aircraft airborne)

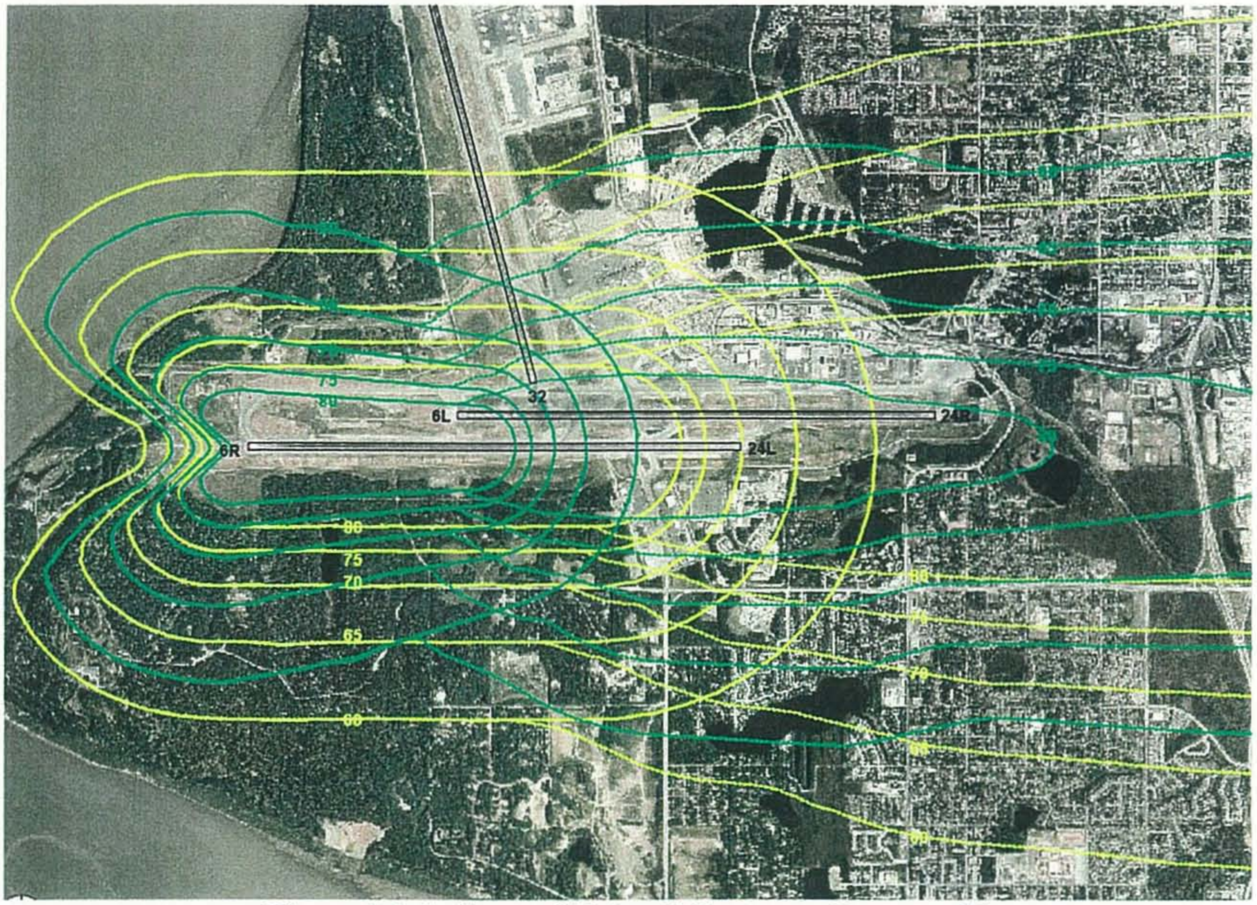


Figure 5.1-6. Start-of-Takeoff Contours, Runway 6R

B747-100 (yellow) and B737-400 (green): 60, 65, 70, 75, and 80 dBA, L_{max}
(Solid contours indicate ground roll, dashed contours indicate aircraft airborne)

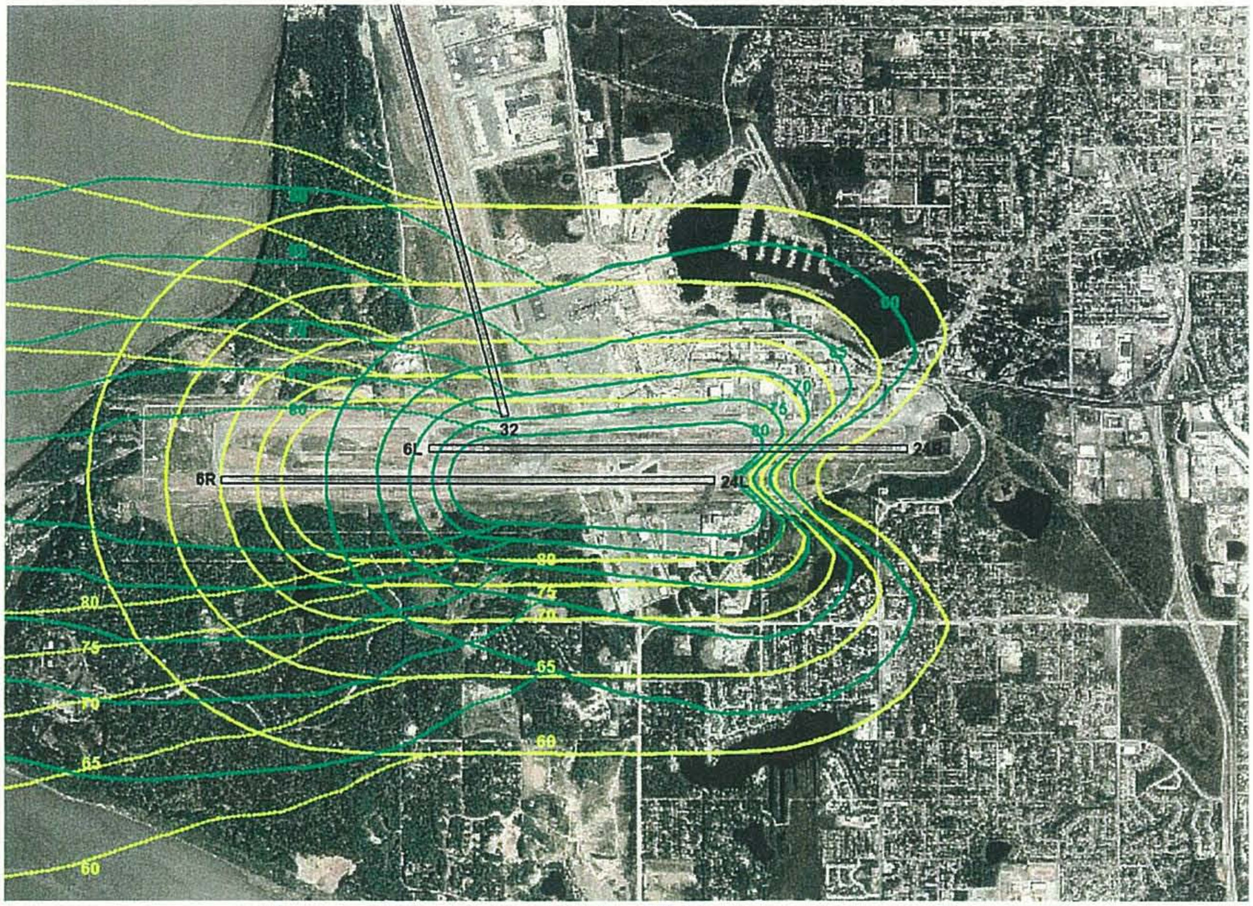


Figure 5.1-7. Start-of-Takeoff Contours, Runway 24L

B747-100 (yellow) and B737-400 (green): 60, 65, 70, 75, and 80 dBA, L_{max}
(Solid contours indicate ground roll, dashed contours indicate aircraft airborne)

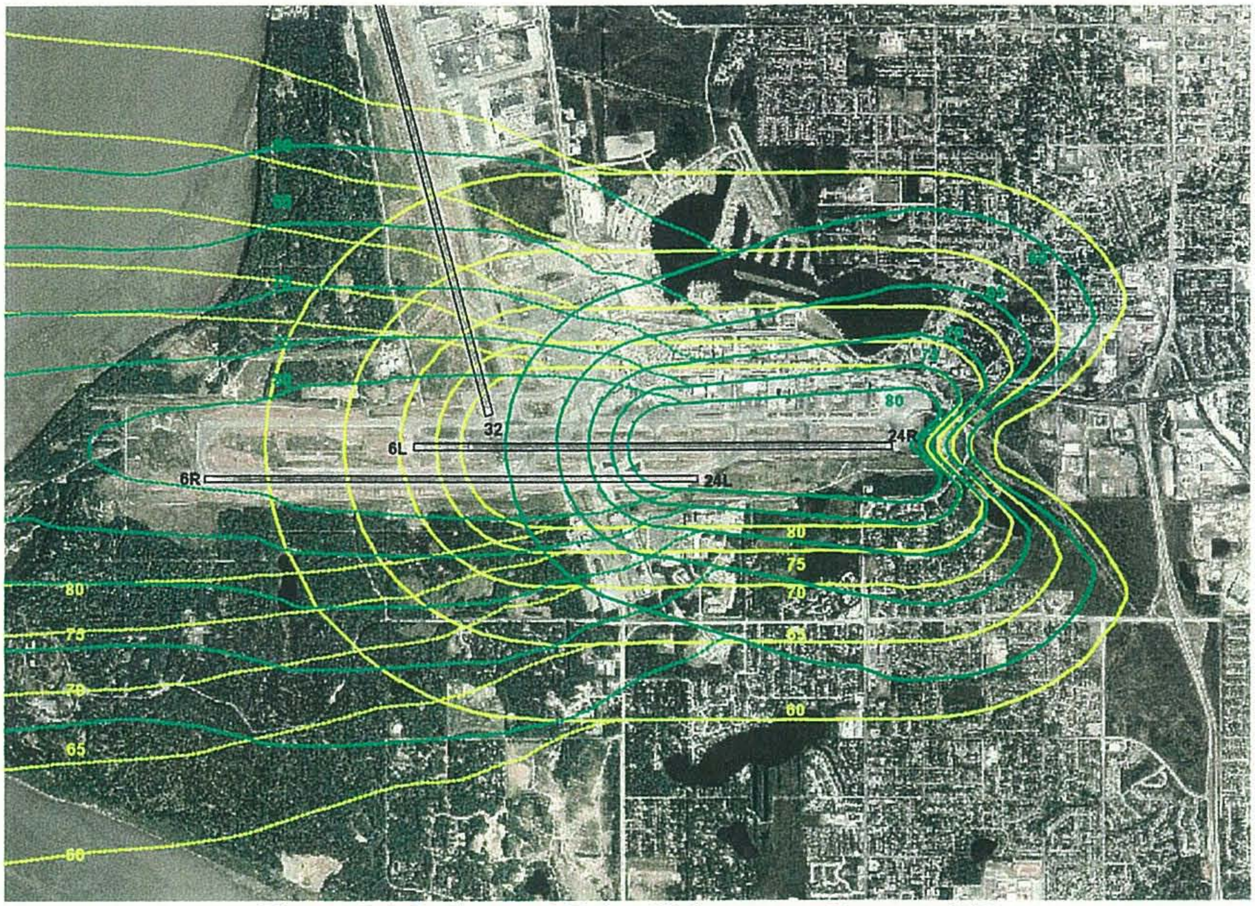


Figure 5.1-8. Start-of-Takeoff Contours, Runway 24R

B747-100 (yellow) and B737-400 (green): 60, 65, 70, 75, and 80 dBA, L_{max}
(Solid contours indicate ground roll, dashed contours indicate aircraft airborne)

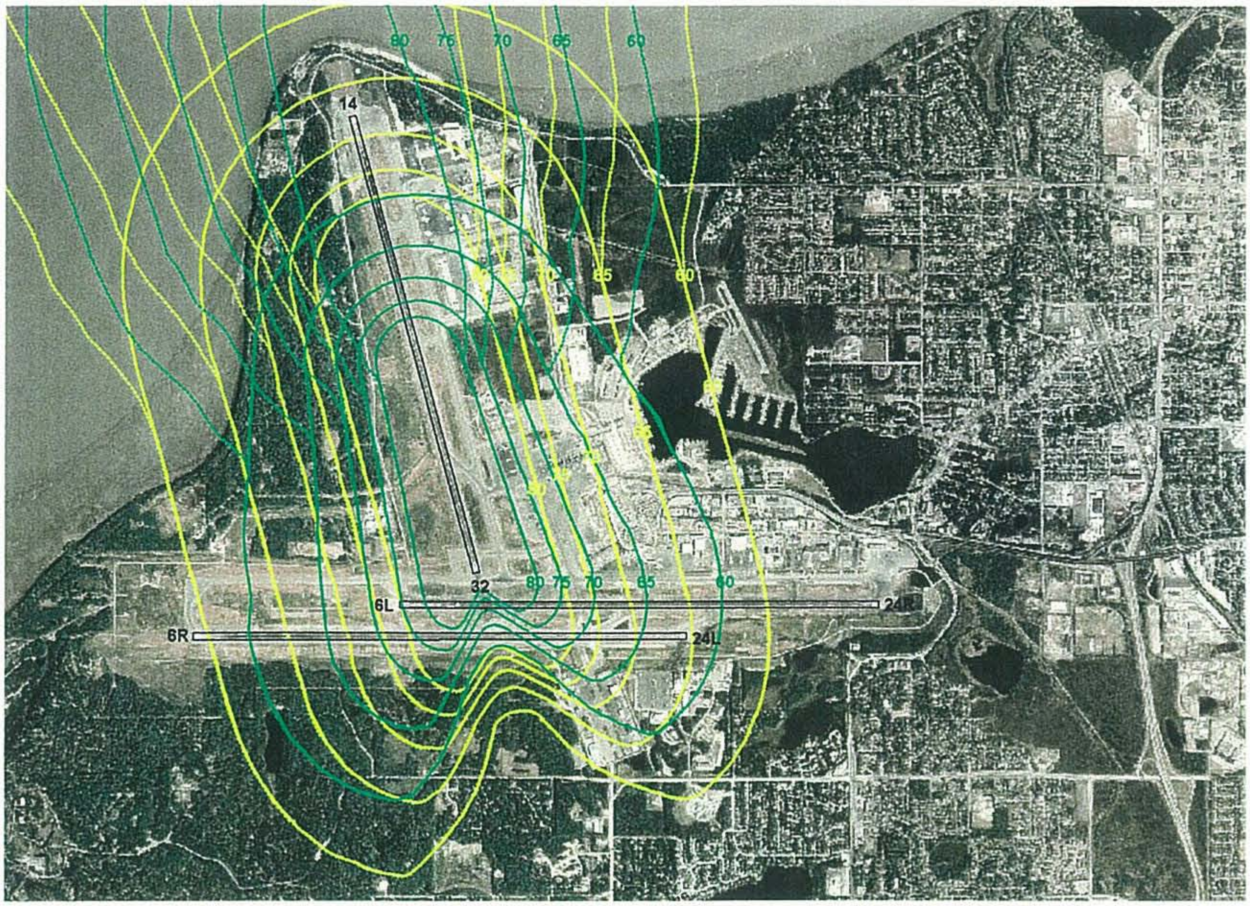


Figure 5.1-9. Start-of-Takeoff Contours, Runway 32

B747-100 (yellow) and B737-400 (green): 60, 65, 70, 75, and 80 dBA, L_{max}
(Solid contours indicate ground roll, dashed contours indicate aircraft airborne)

(B737-400 departure from Taxiway Kilo, B747-100 departure from Runway 32 Extension)

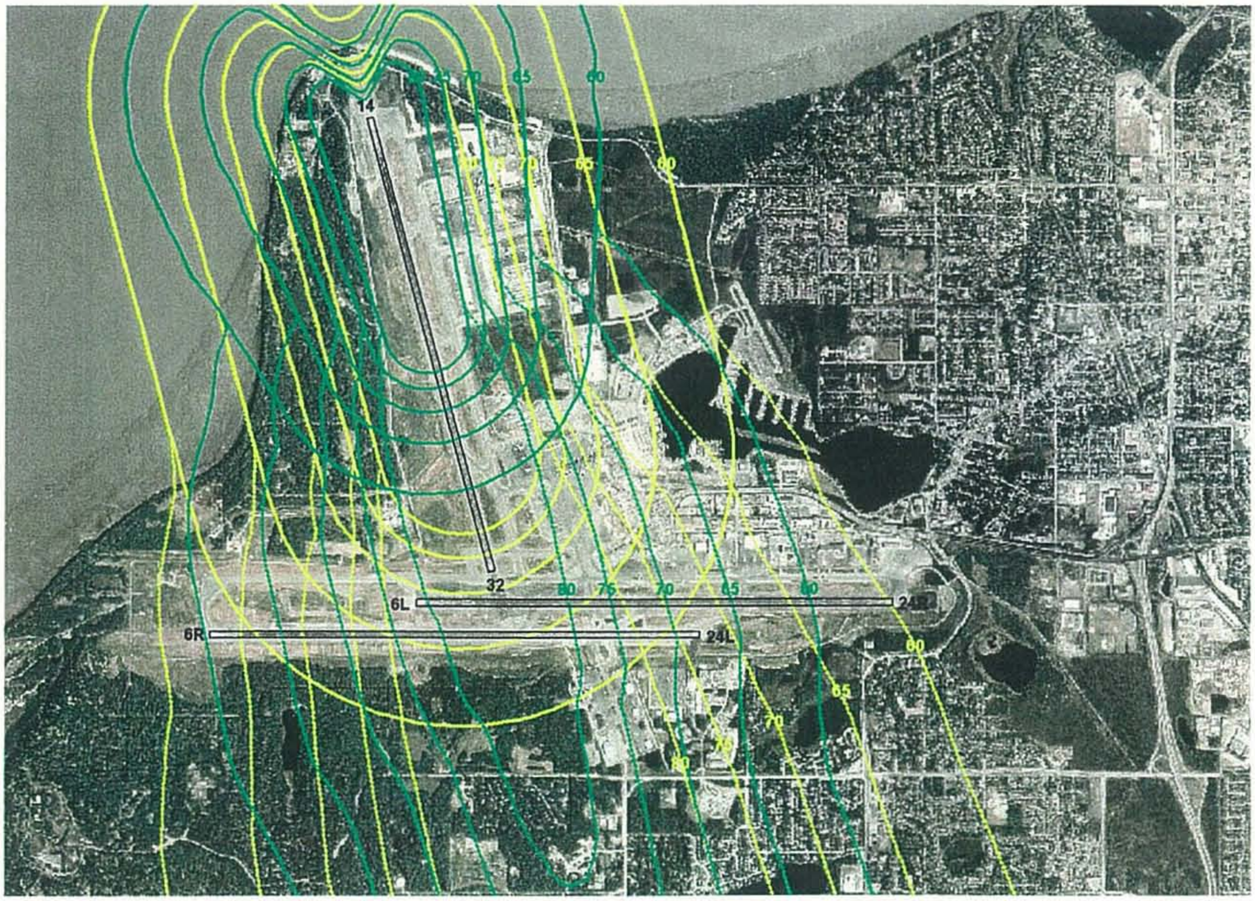


Figure 5.1-10. Start-of-Takeoff Contours, Runway 14

B747-100 (yellow) and B737-400 (green): 60, 65, 70, 75, and 80 dBA, L_{max}
(Solid contours indicate ground roll, dashed contours indicate aircraft airborne)

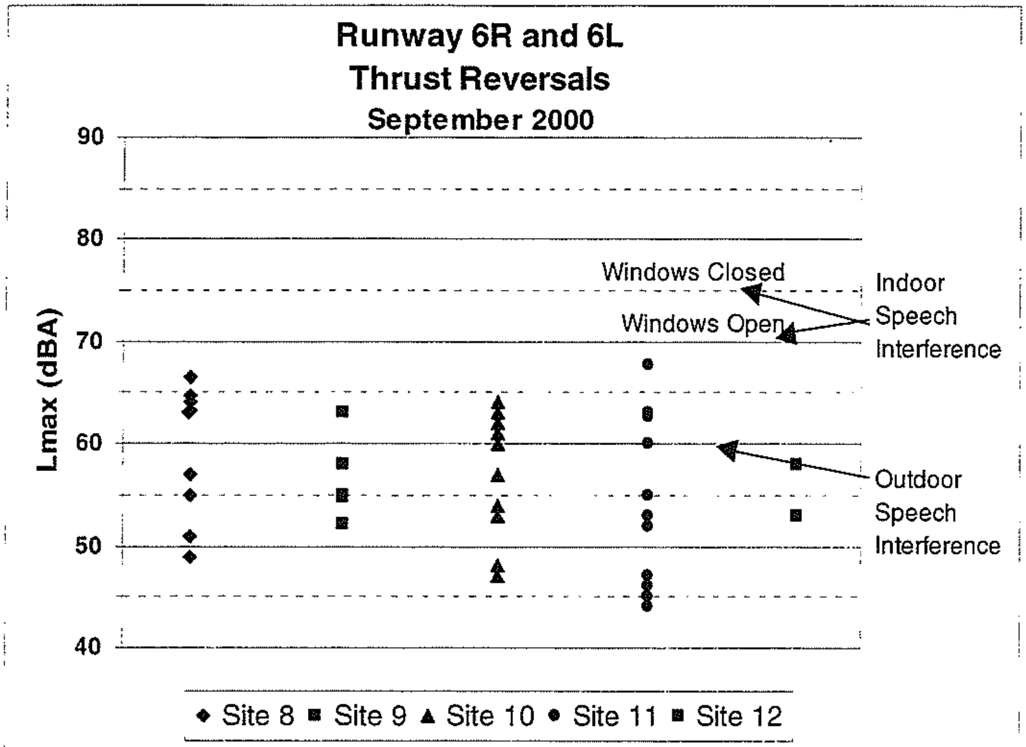


Figure 5.1-11. Measured Reverse Thrust Sound Levels – Runways 6L & 6R, Turnagain

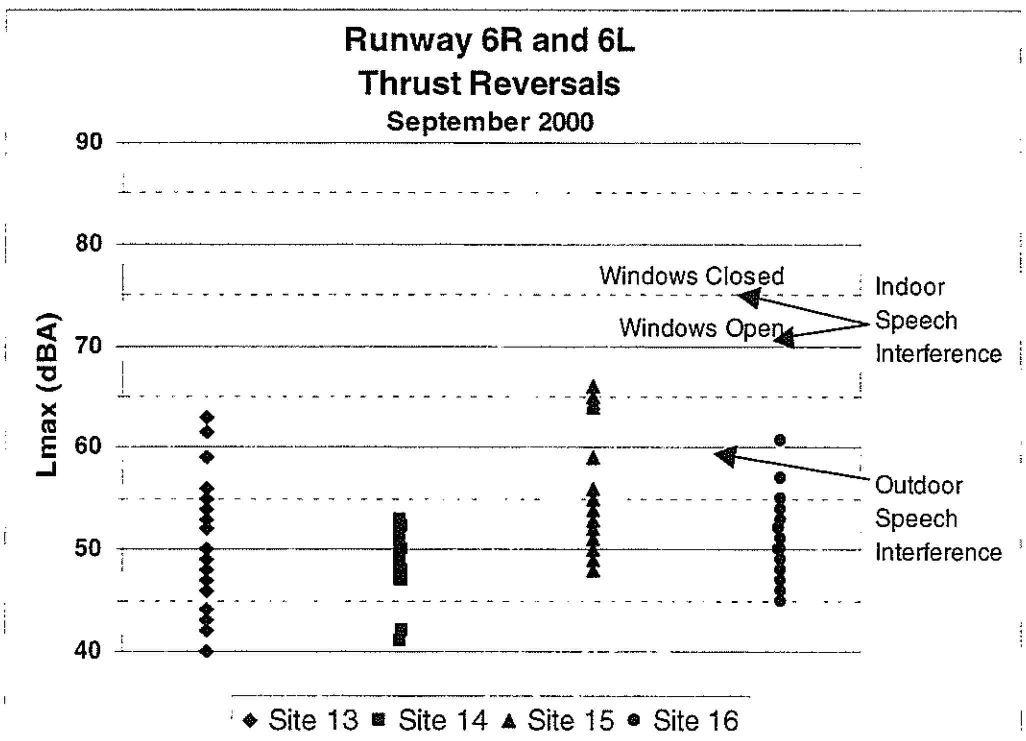


Figure 5.1-12. Measured Reverse Thrust Sound Levels – Runways 6L & 6R, Turnagain/Spenard

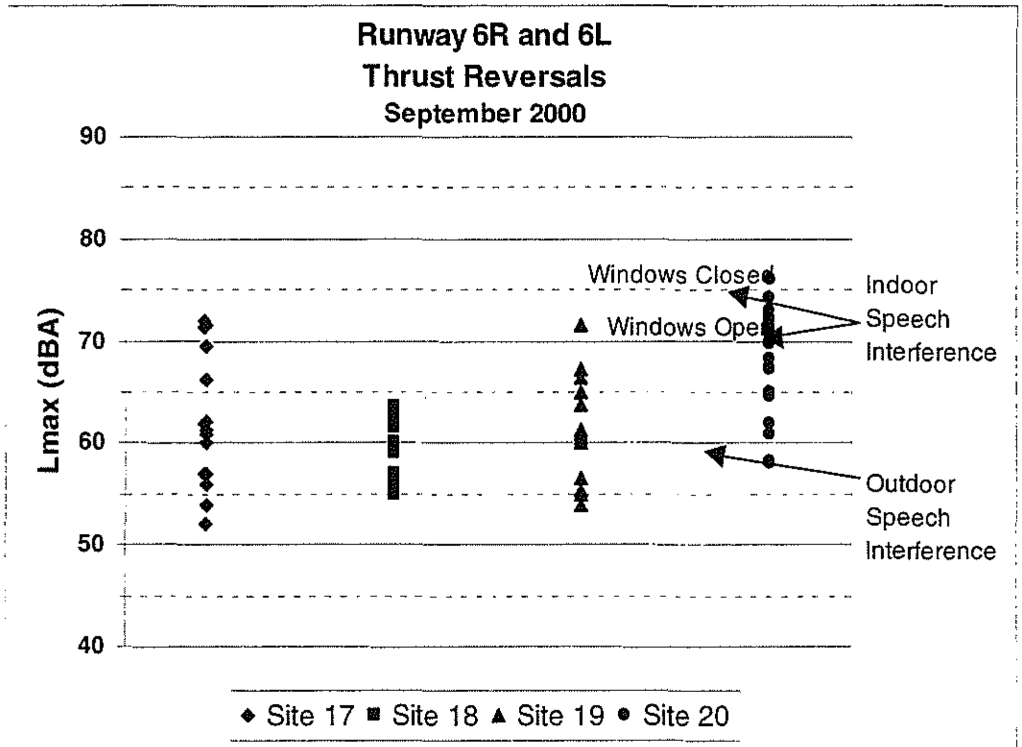


Figure 5.1-13. Measured Reverse Thrust Sound Levels – Runways 6L & 6R, Sand Lake

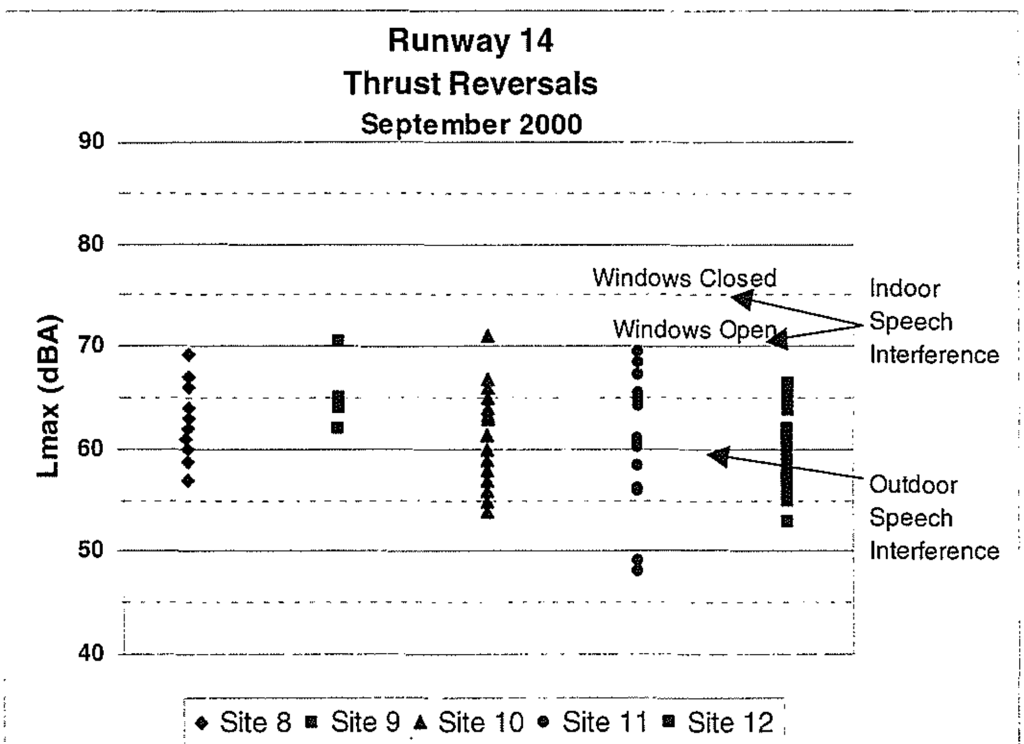


Figure 5.1-14. Measured Reverse Thrust Sound Levels – Runway 14, Turnagain

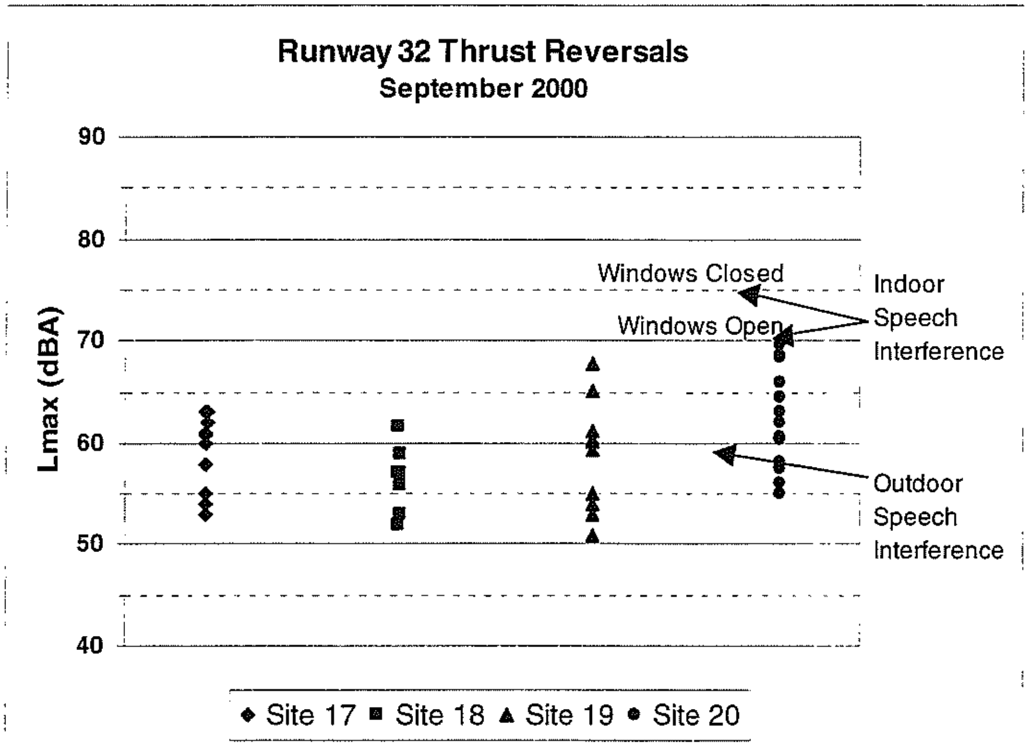


Figure 5.1-15. Measured Reverse Thrust Sound Levels – Runway 32, Sand Lake

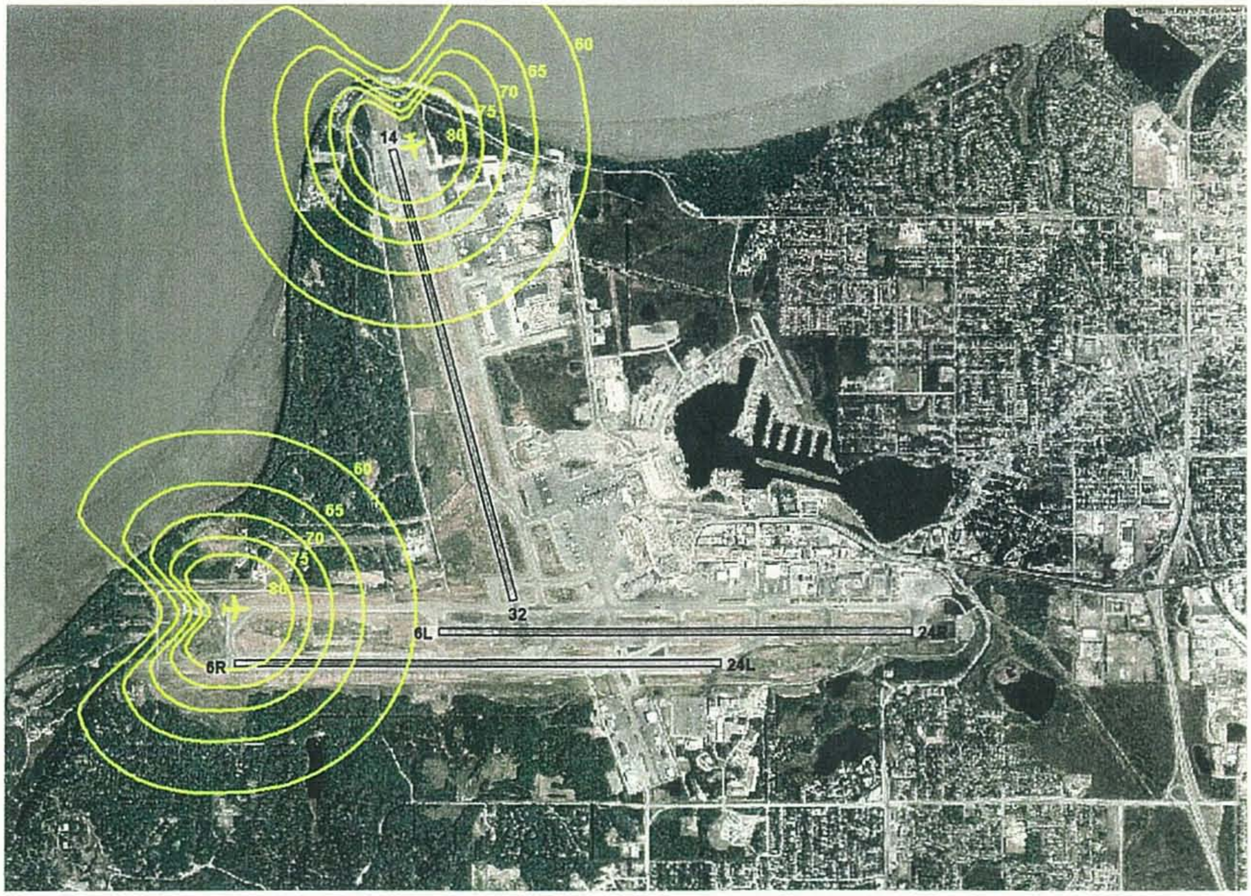


Figure 5.1-16. Existing Takeoff-Power Run-up Contours, Taxiways J & Q

B747-100: 60, 65, 70, 75, and 80 dBA, L_{max}

Figure 5.1-17. Snow Thrower

Figure 5.1-18. Vacuum Truck

Figure 5.1-19. Plow Truck & Runway Broom/Blower

5.2 Effects of Low-frequency Noise

Low-frequency noise has been identified as an issue at a number of airports over the last several years including: San Francisco International, Baltimore-Washington International, Boston-Logan International, and Minneapolis-St. Paul International. At present, however, the United States does not have a uniform national policy on the assessment or mitigation of low-frequency noise. The FAA is interested in developing a consistent low-frequency noise policy and has turned to FICAN for input on the technical aspects of the issue, particularly assessment of the problem and metrics used for its evaluation. FICAN currently is reviewing the subject and expects to issue a statement in the near future[14]. (As of the date of this Final Report, FICAN has completed its review and is finalizing a statement to be issued shortly.)

5.2.1 Summary

General Description

Low-frequency noise is generated during aircraft takeoff roll, during the use of thrust reversers, and during high-power run-ups. The primary effect of low-frequency aircraft noise on residential areas located near runway ends and sidelines is rattle-related annoyance due to "secondary emissions." Secondary emissions typically are rattling noises caused by vibration of windows, doors, and household paraphernalia. While secondary noise emissions and structural vibrations may be perceptible to residents, low-frequency aircraft noise poses no known health risks, nor a risk of structural damage. In addition, low-frequency noise is not expected to interfere with indoor speech, nor is low-frequency noise itself likely to awaken people. Annoyance, however, is not a trivial effect of aircraft noise exposure. FICAN recognizes annoyance as the best indication of adverse community reaction to aircraft noise and the prevalence of high annoyance provides much of the rationale for federal and state policies concerning mitigation of aircraft noise impacts in residential areas[15].

Effects at ANC

Residents living near ANC have identified low-frequency noise and vibration, especially when generated by departing aircraft during the start of takeoff roll, as a source of annoyance. Although vibration induced by low-frequency noise from commercial air carrier aircraft at ANC is not of sufficient magnitude to cause structural damage in standard residential construction, residents sometimes perceive rattling windows or objects on walls as sources of annoyance and are concerned about the potential effects of vibration. To address these concerns, during both the September and the February measurement programs, specialized measurements were conducted to characterize low-frequency noise. In addition, during the September measurements, A-weighted and C-weighted noise levels were recorded simultaneously while vibration levels were measured inside homes in three representative areas[16].

---

[14] Press Release: "FICAN Reviews Low Frequency Noise Issues," June 28, 2001.

[15] "Findings of the Low-Frequency Noise Expert Panel of the Richfield-MAC Noise Mitigation Agreement of 17 December 1998," September 30, 2000, page I-3.

[16] A-weighted noise levels (which are used throughout this report) generally correspond well with human perception of noise while C-weighted noise levels often provide better correlation with vibration induced by low-frequency noise.

Overall, measured vibration levels were well-below the threshold of cosmetic damage for typical residential construction. Inside residences near ANC, measured vibration levels induced by low-frequency aircraft noise typically were 10 to 20 VdB below the most stringent vibration damage criteria, with even the highest vibration levels 10 VdB below the damage criteria[17]. These criteria apply to fragile and extremely fragile structures, resulting in a very conservative estimation of the potential for damage from vibration on structures. At some locations, although vibration generated by low-frequency aircraft departure noise exceeded both the threshold for human perception and typical guidelines for predicting annoyance, even the highest measured levels were comparable to vibration caused by residents walking in their homes or shutting/slamming doors.

5.2.2 Methodology

Low-frequency noise and vibration measurements were conducted at three homes exposed to comparatively high levels of noise from start-of-takeoff roll and/or use of thrust reversers where residents had expressed concern over this issue. During the low-frequency noise and vibration measurements, vibration levels were monitored inside the homes by affixing vibration-detection instruments (accelerometers) to the walls and floors. Simultaneously, outdoor noise levels were monitored while an observer in the Airport's air traffic control tower logged aircraft operations. The outdoor noise measurements were conducted simultaneously with two side-by-side noise monitors, one collecting A-weighted data and the other collecting C-weighted data. Measured vibration levels were then compared to criteria for structural damage and for annoyance.

5.2.3 Measurement Results

Figures 5.2-1 through 5.2-6 summarize the results of simultaneous noise and vibration measurements conducted at Site 15 (Breezewood Drive), Site 17 (Air Guard Road), and Site 20 (Tanaina Drive). Each figure plots measured outdoor noise levels, using both A-weighted and C-weighted scales, versus measured indoor vibration levels. Each noise/vibration event is plotted twice, with squares indicating the A-weighted L_{max} and circles indicating the simultaneously-measured C-weighted L_{max}. In general, the measured C-weighted sound levels were about 10 dB to 15 dB higher than the A-weighted sound levels for the same events. The highest recorded sound levels occurred at Site 15 during departures on Runways 24L and 24R and at Site 17 during departures on Runway 32 (up to about 81 dBA and 94 dBC).

The vibration level for each event is plotted on the horizontal axis. On each graph, vertical lines indicate the typical human threshold of perception for vibration events (65 VdB), the annoyance criterion used by the Federal Transit Administration (FTA) for residences (72 VdB), and the threshold of structural damage (100 VdB). The damage threshold indicates the level at which the onset of minor cosmetic damage may occur in fragile buildings. The figures indicate that although many of the recorded events exceeded the threshold for human perception of vibration and, at some locations, the FTA annoyance criteria, all measured vibration levels were well-below the threshold for cosmetic damage to buildings. In addition, even the highest measured levels were comparable to vibration caused by residents walking in their homes or shutting/slamming doors.

[17] The abbreviation "VdB" is used for vibration decibels to reduce the potential for confusion with sound decibels. Vibration velocity levels in this report are described in VdB relative to 1 micro-inch per second.

The figures also include two regression lines, one for the A-weighted data points, and one for the C-weighted data points. The regression lines show the best straight-line fit representing the trend of each set of data points. On all of the plots, the C-weighted regression line (the solid line) slopes upward, indicating a positive correlation between the measured C-weighted sound levels and the measured vibration levels. That is, as the measured C-weighted sound level increased, the measured vibration level increased as well. The A-weighted regression lines (the dashed lines) do not indicate this consistent correlation. On some graphs, the line slopes upwards (positive correlation), while on others it slopes downward (negative correlation), and on some it is relatively flat (no correlation). This demonstrates that, for these measurements, the C-weighted noise levels provided a better correlation with the measured vibration levels than did the A-weighted noise levels. Other measurements of vibration in residences induced by low-frequency aircraft noise also have shown better correlation with C-weighted maximum outdoor noise levels than with maximum A-weighted noise levels[18].

[18] "Study of Low Frequency Aircraft Takeoff Noise at Baltimore-Washington International Airport," HMMH Report No. 294730.03/293100.09, prepared for the Maryland Aviation Administration and the Federal Aviation Administration, April 1998.

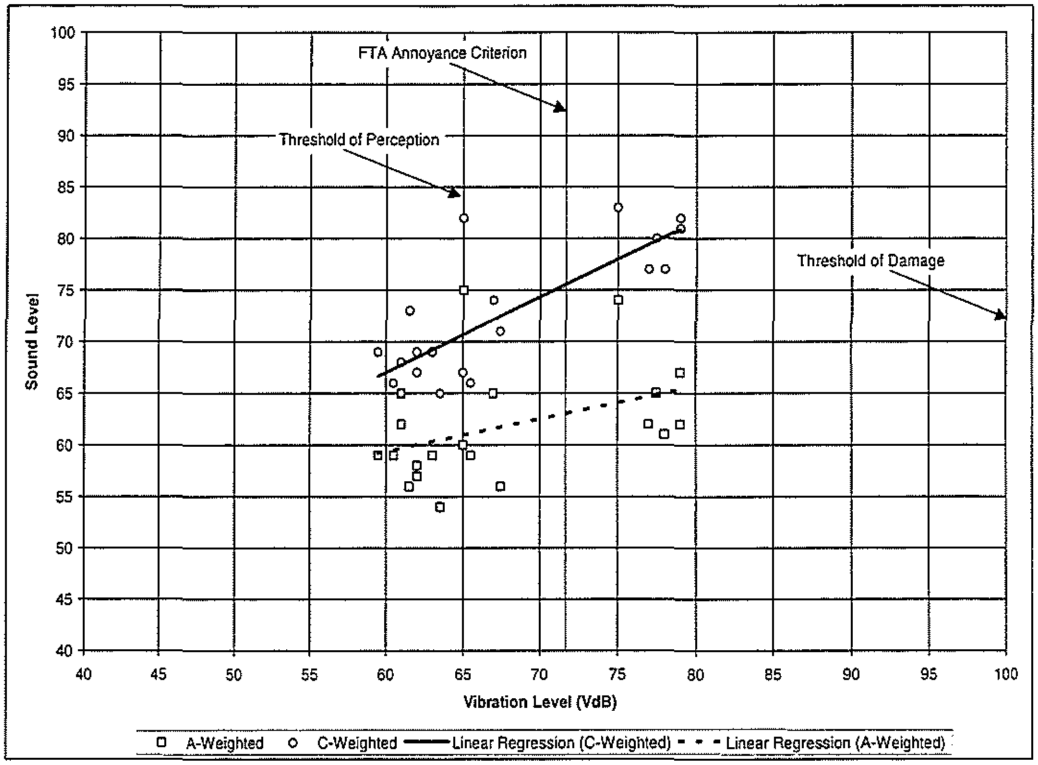


Figure 5.2-1. Measured Low Frequency Noise and Vibration: Site 15, Facing Wall

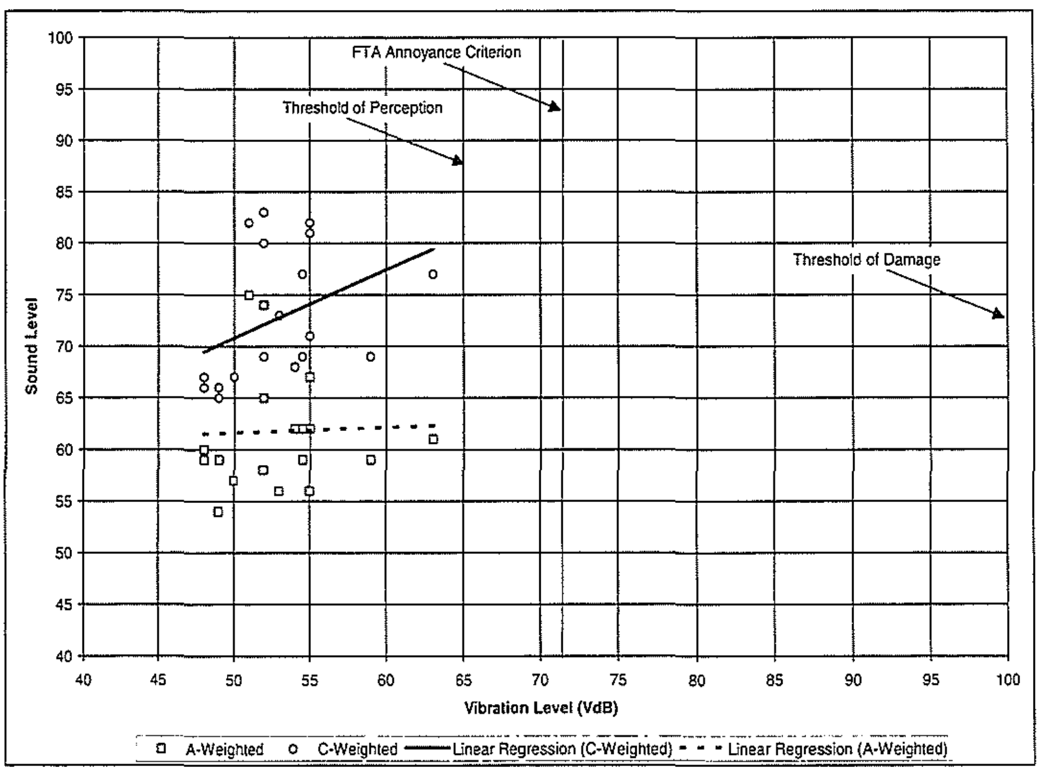


Figure 5.2-2. Measured Low Frequency Noise and Vibration: Site 15, Floor

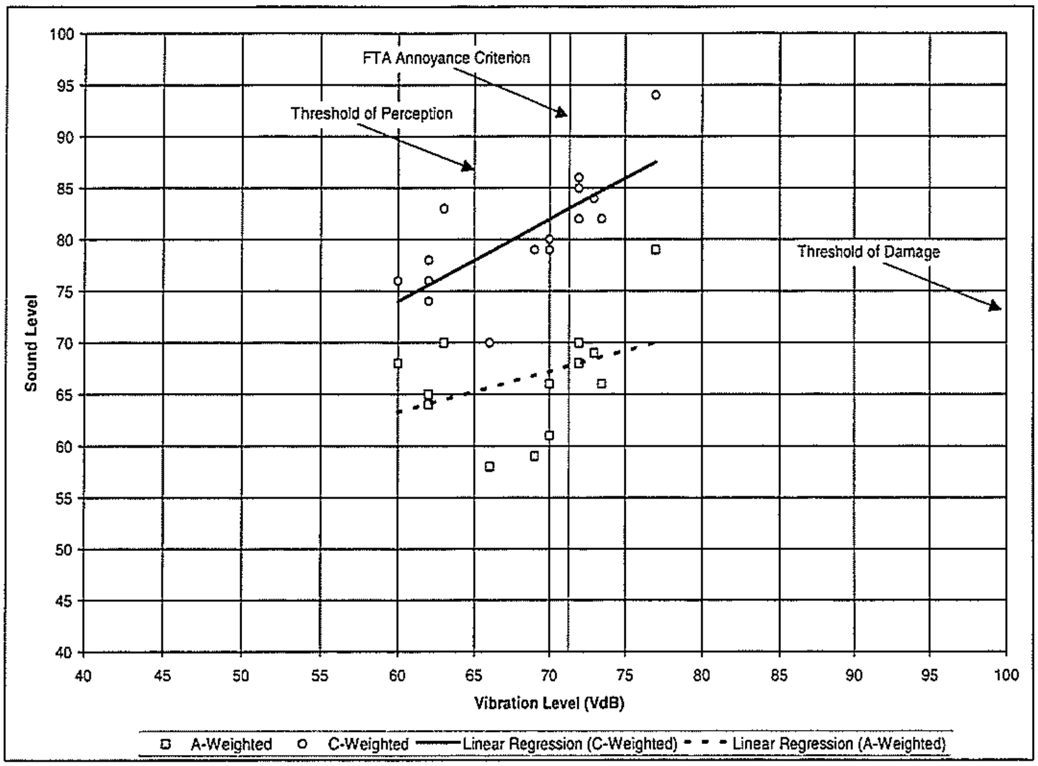


Figure 5.2-3. Measured Low Frequency Noise and Vibration: Site 17, Facing Living Room Wall

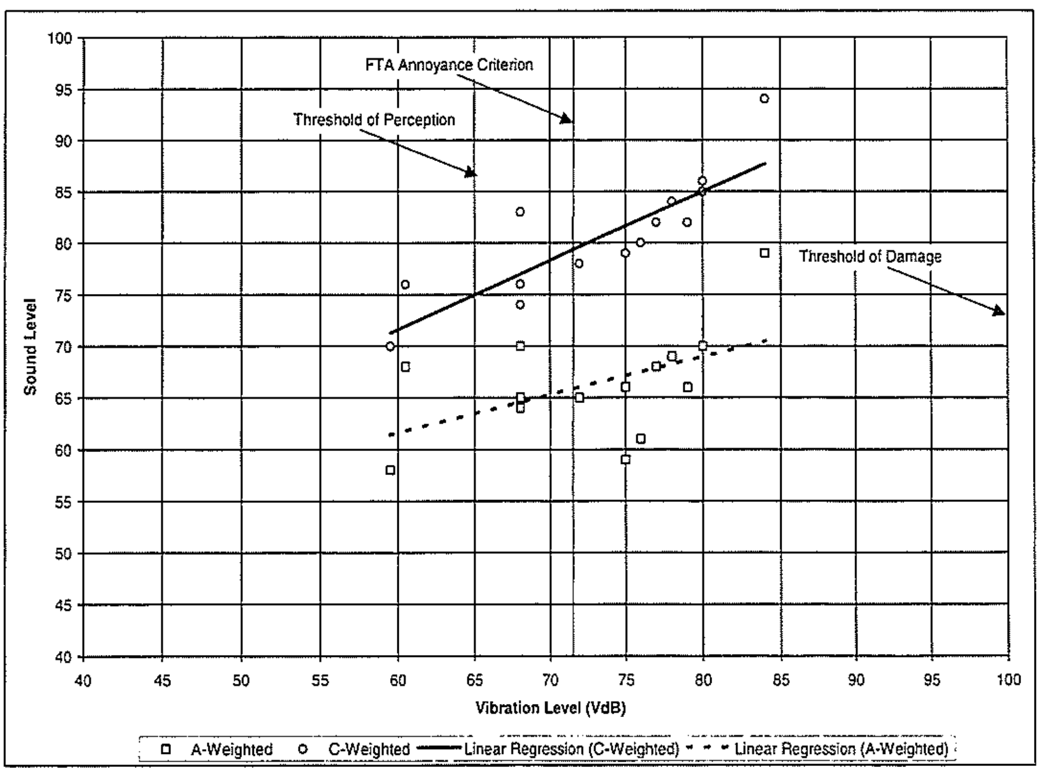


Figure 5.2-4. Measured Low Frequency Noise and Vibration: Site 17, Facing Bedroom Wall

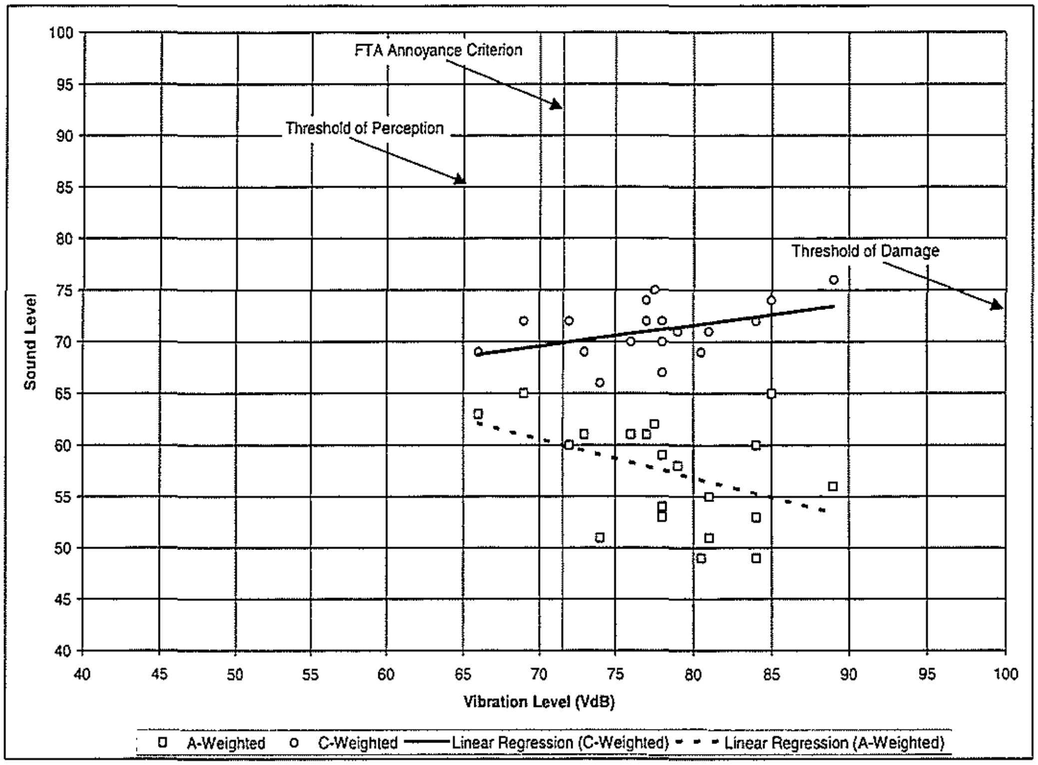


Figure 5.2-5. Measured Low Frequency Noise and Vibration: Site 20, Facing Wall

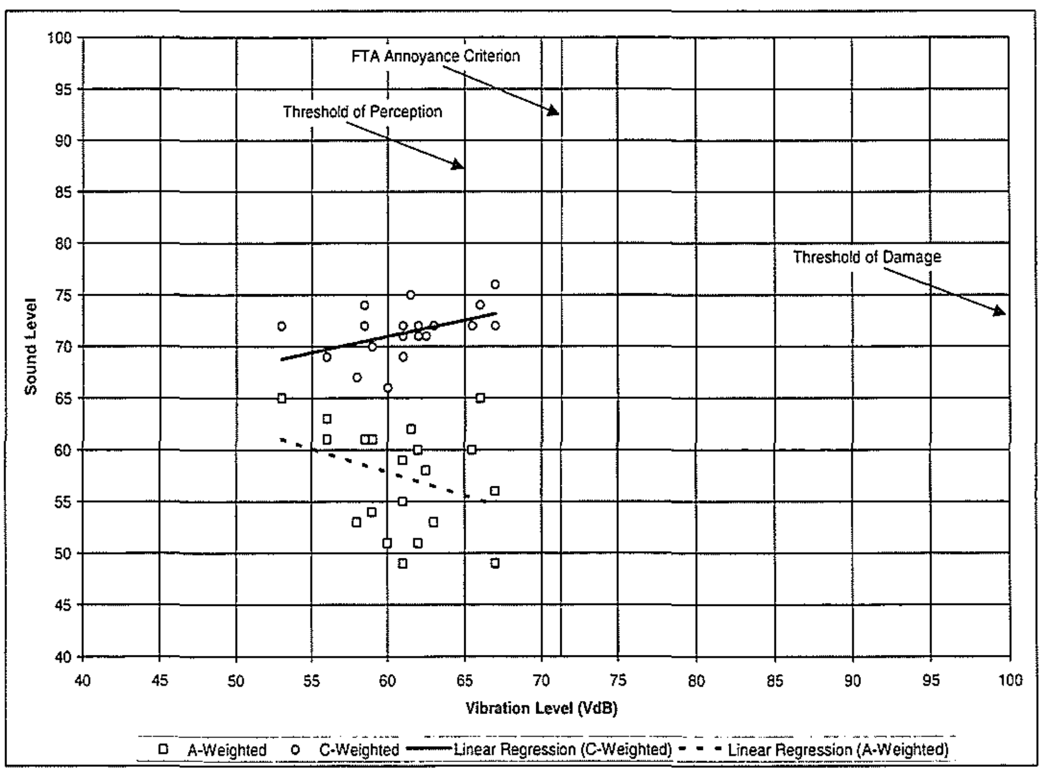


Figure 5.2-6. Measured Low Frequency Noise and Vibration: Site 20, Side Wall

5.3 Daily Cycle of Ground Noise Events and Levels from Combined Events

5.3.1 Purpose and Methodology

The FAA requires the use of the cumulative-exposure metric day-night level (DNL or L_{dn}), to determine noise exposure and land use compatibility. Often, in ground noise analyses, however, the overall contribution of ground-operations noise, when evaluated in terms of DNL, is dominated by aircraft flight operations. Single-event analysis is necessary to help evaluate the intrusiveness of a single event (such as a late-night maintenance run-up) that might be overshadowed by many other events when considered only with cumulative-exposure analysis. For this reason, the FAA stipulates the use of single-event metrics to demonstrate the effectiveness of proposed mitigation for sources of ground noise.

The primary single-event noise descriptor used throughout this study is L_{max}. Although L_{max} is a useful measure for comparing the loudness of different events and evaluating the intrusiveness of a particular noise event, it does not take into account other important factors including the duration, frequency of occurrence, and the usual time of occurrence (daytime, evening, early morning, etc.). To address these factors, a typical "profile" or "schedule" of ground-operations noise that occurs throughout the day at ANC was developed based upon published flight-schedule information and a survey of all airport tenants believed to operate equipment potentially contributing to ground noise at ANC. Combined with measured and projected sound level data, this profile provides a representation of the frequency of occurrence, approximate duration, and sound levels associated with various ground noise events at representative community locations during the day and the night. In addition, the profile was used to develop graphical depictions showing combined noise levels from multiple noise sources such as several taxiing aircraft or multiple APUs operating simultaneously.

A survey was conducted of all airport tenants believed to operate equipment potentially contributing to ground noise at ANC. Following briefings at airport tenant meetings, approximately 45 tenants, including all passenger and air-cargo operators at ANC and the Alaska Air National Guard were contacted with a mailing and follow-up phone calls. Through the survey, the study team obtained operations data from airport tenants such as types and numbers of aircraft ground operations, typical periods of APU use, airfield maintenance operations, and aircraft dwell times at gates and cargo facilities. The operations data were then used to develop a typical "profile" or "schedule" of ground-operations noise throughout the day at ANC.

5.3.2 24-Hour Schedule of Operations

Table 5.3-1 provides an hourly summary of a "typical" day of scheduled passenger and air-cargo operations at ANC. Although schedules may vary somewhat from day to day and month to month, the total number of scheduled operations remains relatively constant throughout the year. For each hour of the day, the number of scheduled air carrier (including passenger and air cargo) departures and arrivals is listed. For example, during the hour starting at 6:00 AM, 13 arrivals and 16 departures were scheduled to occur. The table shows that the hourly level of operations remains fairly high between about 6:00 AM and 6:00 PM with nearly 70% of the day's total arrivals and departures occurring during that interval. The period of highest activity is between 11:00 AM when 2:00 PM, when 109, or over 20% of the day's operations are scheduled. Although operations decrease somewhat during the night, 125 operations (an average of approximately 14 per hour) are scheduled to occur between 10:00 PM and 7:00 AM. Appendix B provides a more detailed listing of daily operations including actual scheduled departure and arrival times, aircraft type, and operator for typical mid-week days in both January and July.

Table 5.3-1. Hourly Summary of Scheduled Operations (ANC Passenger and Air-cargo)

Hour	Arrivals	Departures	Total Operations
00:00 – 01:00	7	9	16
01:00 – 02:00	5	7	12
02:00 – 03:00	4	1	5
03:00 – 04:00	2	4	6
04:00 – 05:00	6	9	15
05:00 – 06:00	6	10	16
06:00 – 07:00	13	16	29
07:00 – 08:00	11	15	26
08:00 – 09:00	6	16	22
09:00 – 10:00	14	16	30
10:00 – 11:00	22	8	30
11:00 – 12:00	17	17	34
12:00 – 13:00	20	20	40
13:00 – 14:00	17	18	35
14:00 – 15:00	14	17	31
15:00 – 16:00	14	14	28
16:00 – 17:00	12	14	26
17:00 – 18:00	10	14	24
18:00 – 19:00	5	7	12
19:00 – 20:00	17	4	21
20:00 – 21:00	7	8	15
21:00 – 22:00	8	6	14
22:00 – 23:00	7	4	11
23:00 – 00:00	11	4	15
Totals	255	258	513

Based upon observations during the measurement program and the tenant survey, estimates also were developed regarding the typical duration of each type of event. Table 5.3-2 summarizes these findings.

Table 5.3-2. Estimated Durations of Typical Ground Noise Events

Ground Noise Event	Typical Duration
Air Carrier Start-of-Takeoff Roll	30 to 45 seconds
Reverse Thrust	5 to 15 seconds
Taxiing/Idle	5 minutes with each departure and arrival
APU use	30 minutes to 2 hours per operation, depending on operator
GA Aircraft Start-up and Pre-flight Run-up	5 minutes idle, one-minute run-up
GA Aircraft Departure Run	Gravel strip: 10 seconds, Lake Hood: 30 seconds

5.3.3 Detailed Hourly Analysis

In addition to the 24-hour summary in Table 5.3-1 and the detailed 24-hour schedules included in Appendix B, detailed time-history plots were developed for 6:00 AM to 7:00 AM and for 7:00 PM to 8:00 PM at each of three representative sites located in Turnagain, Spenard, and Sand Lake. These two hours were selected for detailed analysis because many of the complaints received by the Airport regarding ground noise pertain to evening and early morning hours. Of these time periods, the selected hours included the most scheduled events. Figures 5.3-1 through 5.3-8 provide detailed information for one of the hours evaluated at each of the three measurement sites (detailed information for an additional hour is provided for Site 10 in Turnagain). Appendix B provides the time-history plots for the other hours evaluated at each of the three sites.

The figures are presented in pairs with the first graph of each pair providing the actual measured time-history trace at that site during the noted hour. The figure shows the time-varying A-weighted sound level as measured throughout the hour along with horizontal lines indicating the thresholds for the onset of indoor and outdoor speech interference. Many of the significant noise events occurring during the hour have been annotated on these figures based upon observations during the measurement. The actual measured sound levels include all types of ANC operations (including both airborne operations and ground noise) in addition to other noise sources such as local and distant street traffic.

The second graph of each pair provides the same measured time-history trace as the first graph. In addition, the shaded areas superimposed in front of the *measured* levels indicate the approximate sound levels and durations of *scheduled* operations for that hour. The information on the scheduled events was derived from the detailed daily schedules in Appendix B and the results of the operator survey. These figures are intended to show, in a schematic way, the approximate frequency of occurrence, duration, and sound-level contribution of each noise source during the representative hour. While an approximate correspondence should be expected between the numbers of scheduled and actual operations during a given hour, exact correspondence is not expected and no attempt was made to match the scheduled events to the actual measured events. In addition, the sound levels shown for the scheduled operations are based upon average measured or projected sound levels associated with the ground noise portion level measured during the hour at this site, although other community noise sources (e.g., the automobile passbys noted above) contributed to overall noise levels.

Site 20, Tanaina Drive (Sand Lake)

Figure 5.3-7 provides the continuous time history of sound levels measured at Site 20 from 6:00 AM to 7:00 AM on September 26, 2000. During this hour, aircraft were departing to the north on Runway 32 and arriving to the east on Runways 6L and 6R. The loudest recorded sound levels at this site were from the use of thrust reversers on aircraft arriving on Runway 6R, with maximum sound levels ranging between about 65 dBA and 75 dBA. Departures on Runway 32 also stand out on the graph, but with sound levels somewhat lower (approximately 55 to 70 dBA) than the reverse thrust events described above. In addition, the graph shows two periods when Dash 8 Turboprop aircraft were starting-up and taxiing away from the ERA hangar at South Airpark. The background sound level (below which the sound level never dropped) was about 47 dBA.

Figure 5.3-8 shows the expected contributions of the various aircraft operations scheduled for this hour over the actual measured time-history trace. The purple bars indicate the 13 jet departures that were scheduled for this hour and the narrow, dark-red bars indicate the application of reverse thrust associated with the 10 scheduled arrivals. As described above, the blue regions indicate taxiing aircraft and the light-red area represents APU use. The yellow areas represent aircraft start-up and taxi at South Airpark. Together, the contributions of noise from APUs and taxiing aircraft combine to generate noise levels close to the measured background level, although other community noise sources (such as distant traffic and wind in the trees) also contributed to measured sound levels.

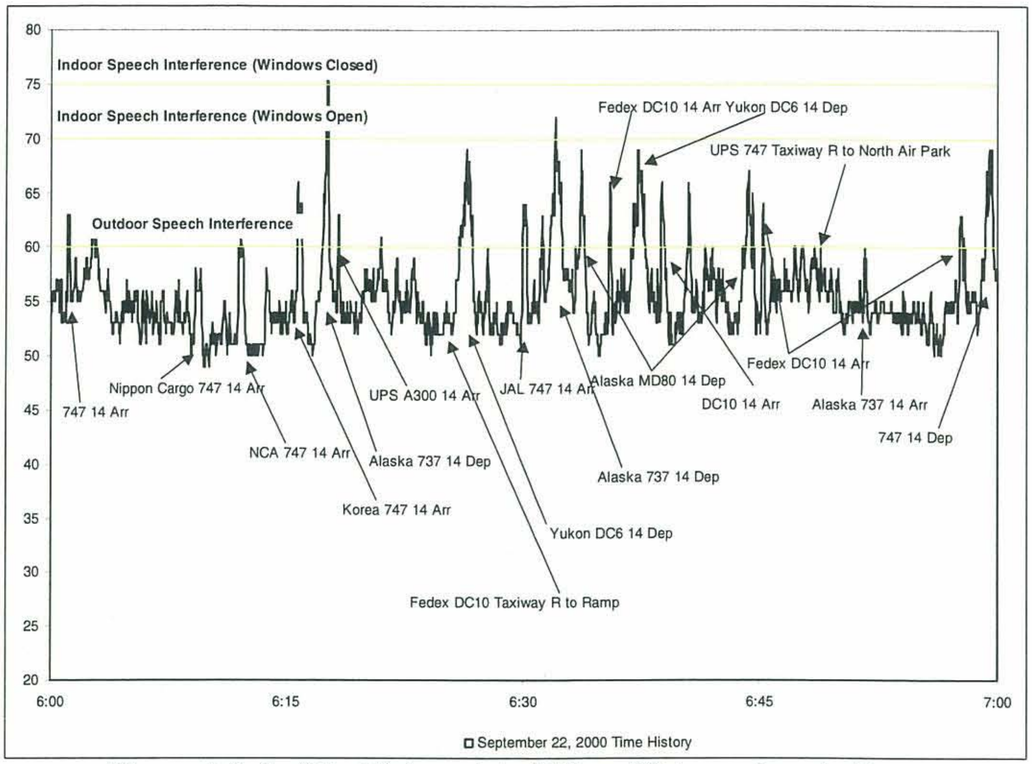


Figure 5.3-1. Site 10 Annotated Time History, 6 am to 7 am

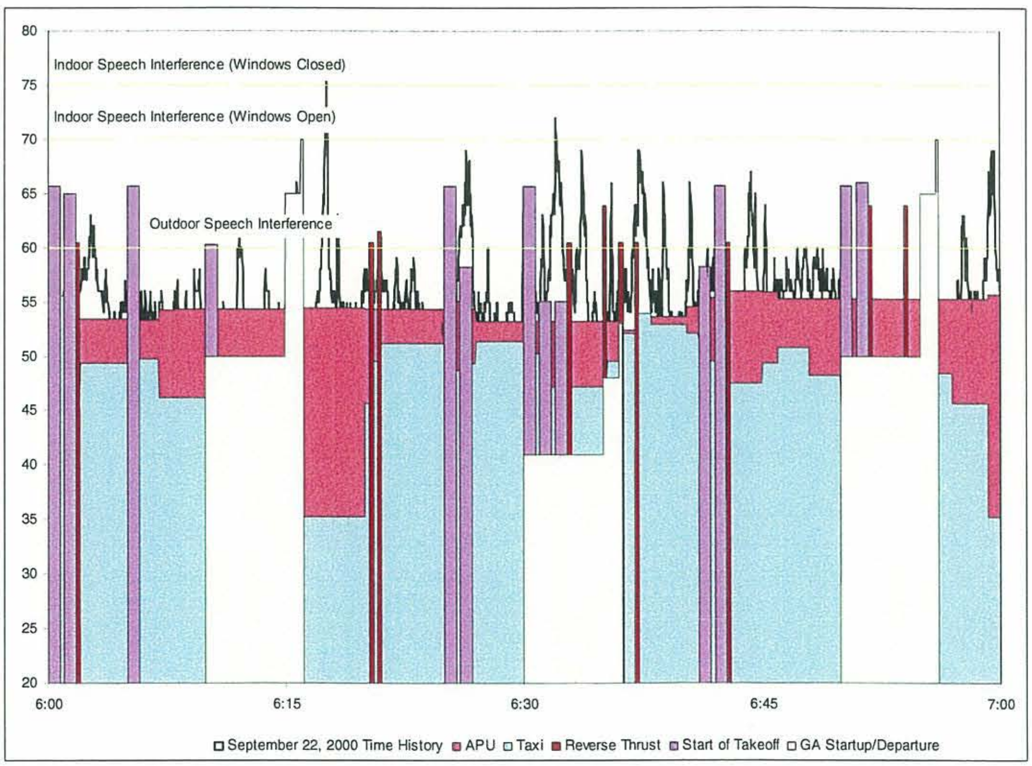


Figure 5.3-2. Site 10 Time History with Scheduled Event Contributions, 6 am to 7 am

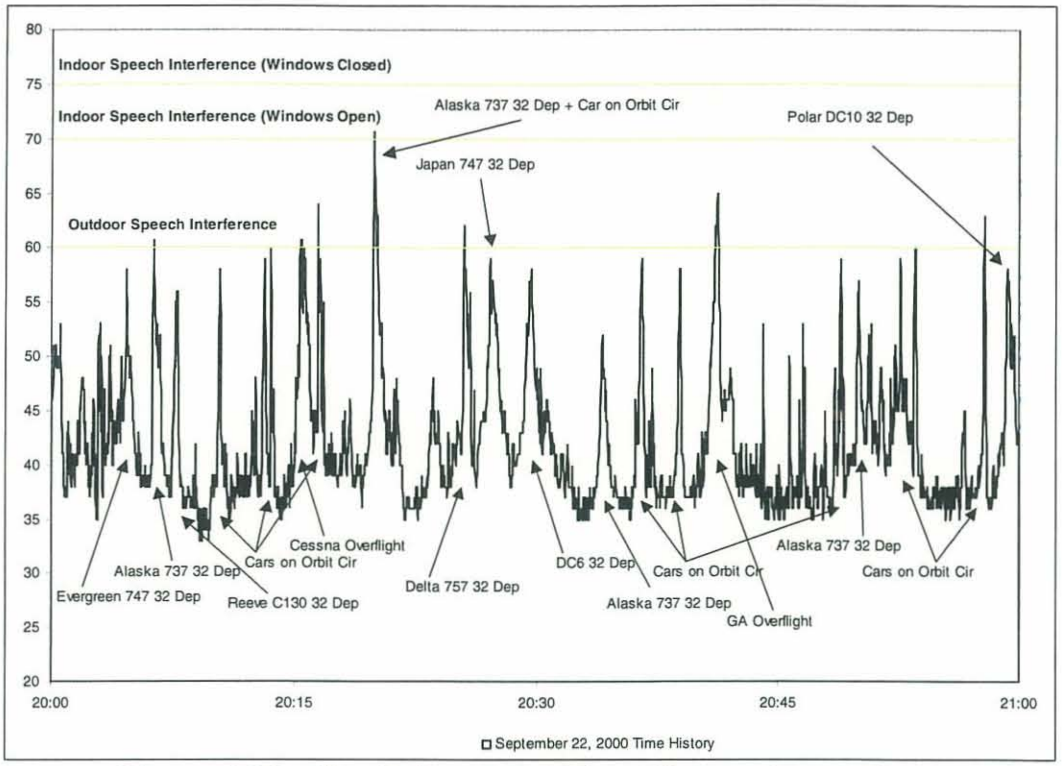


Figure 5.3-3. Site 10 Annotated Time History, 8 pm to 9 pm

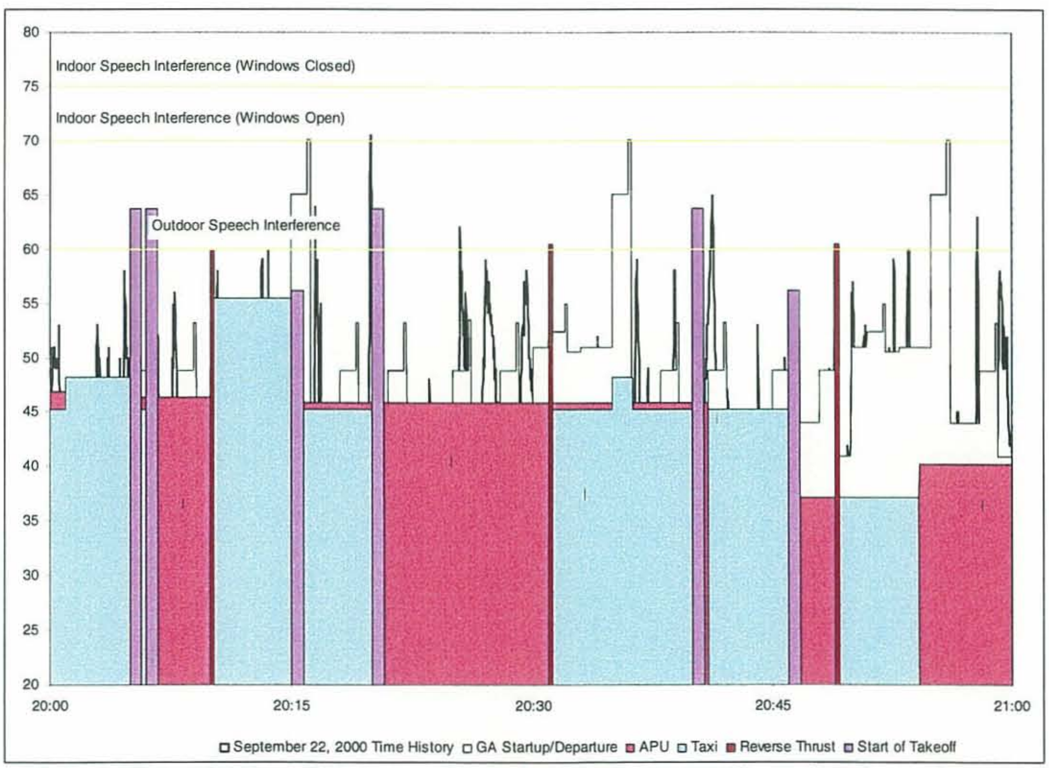


Figure 5.3-4. Site 10 Time History with Scheduled Event Contributions, 8 pm to 9 pm

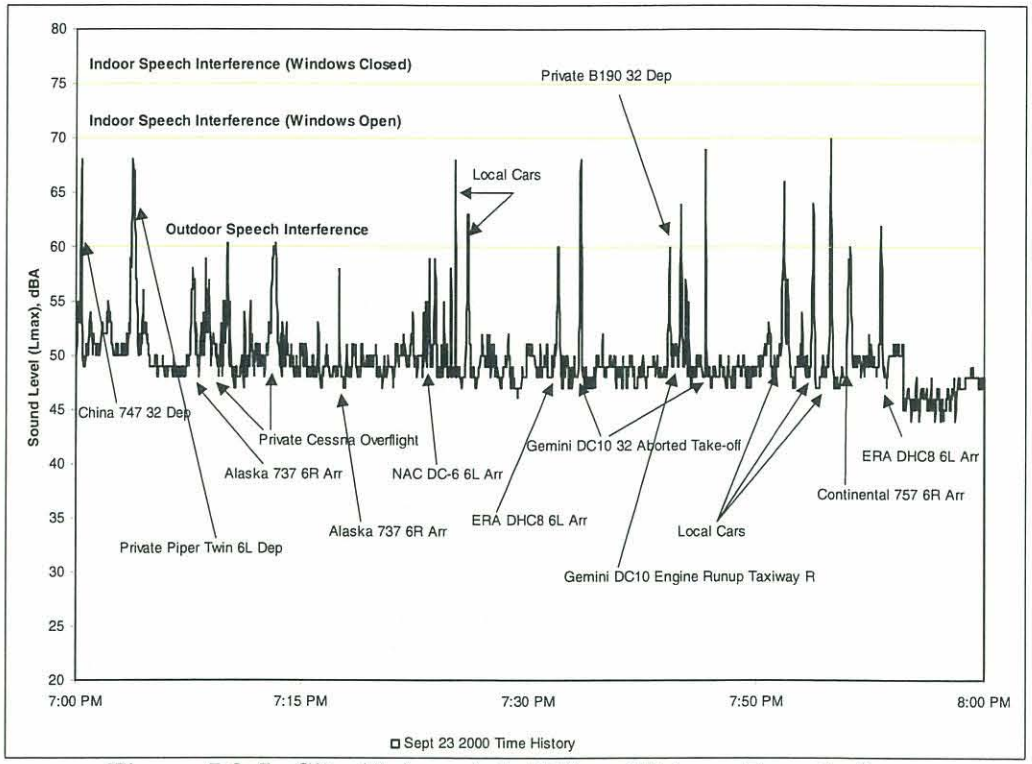


Figure 5.3-5. Site 15 Annotated Time History, 7 pm to 8 pm

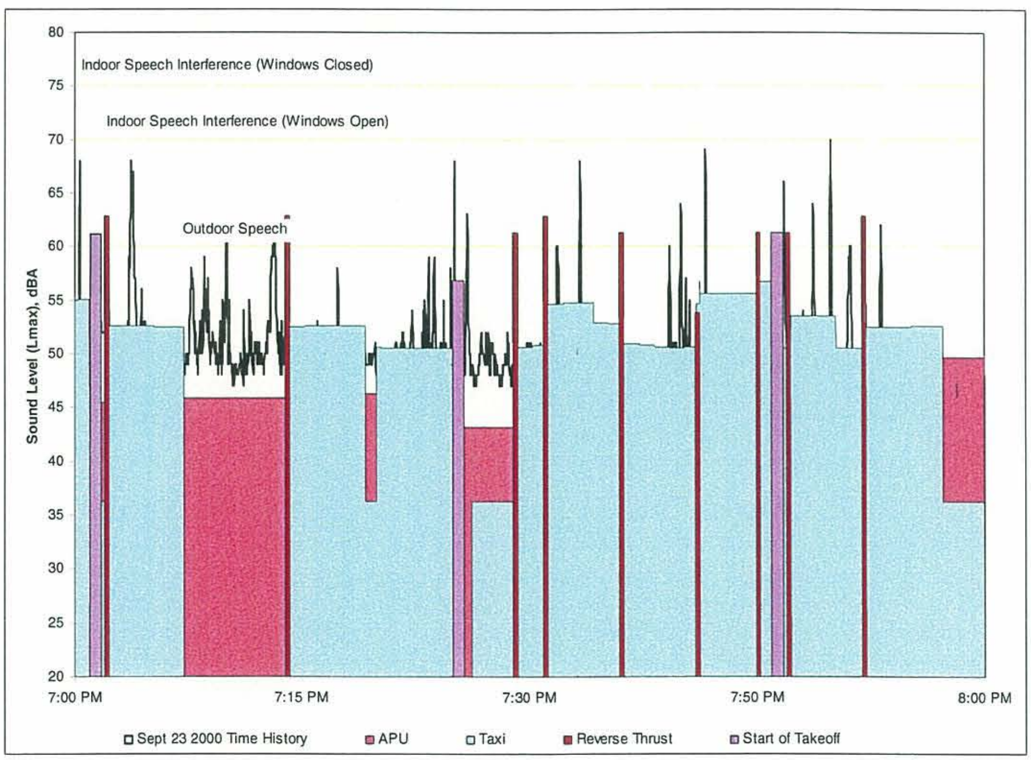


Figure 5.3-6. Site 15 Time History with Scheduled Event Contributions, 7 pm to 8 pm

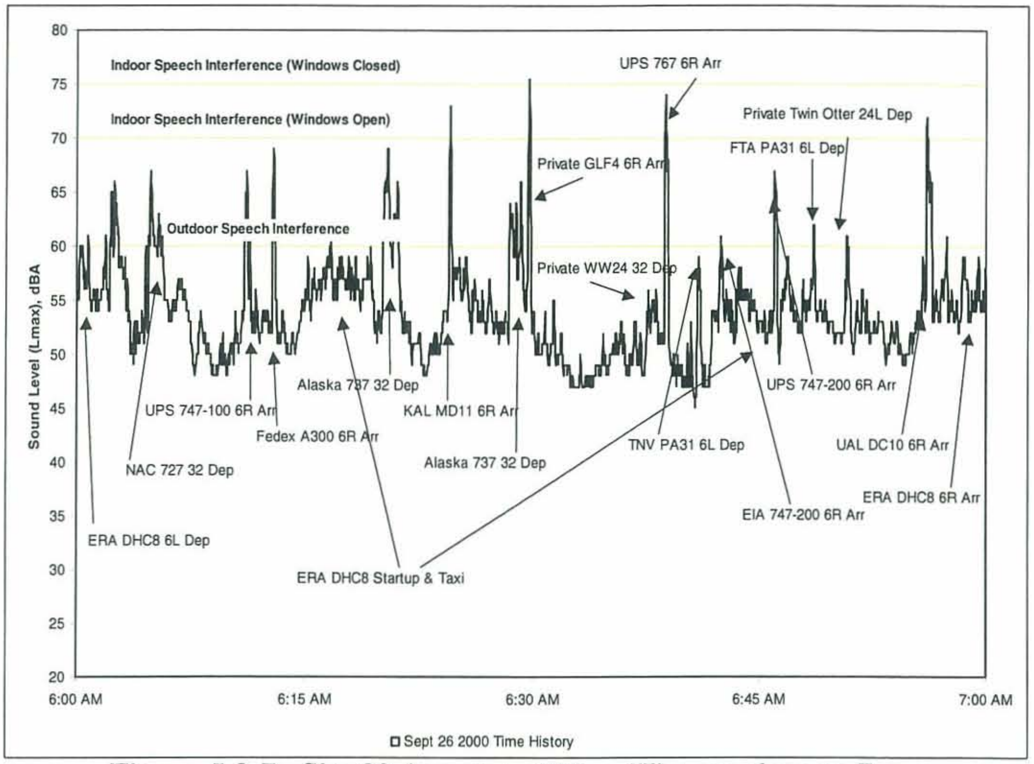


Figure 5.3-7. Site 20 Annotated Time History, 6 am to 7 am

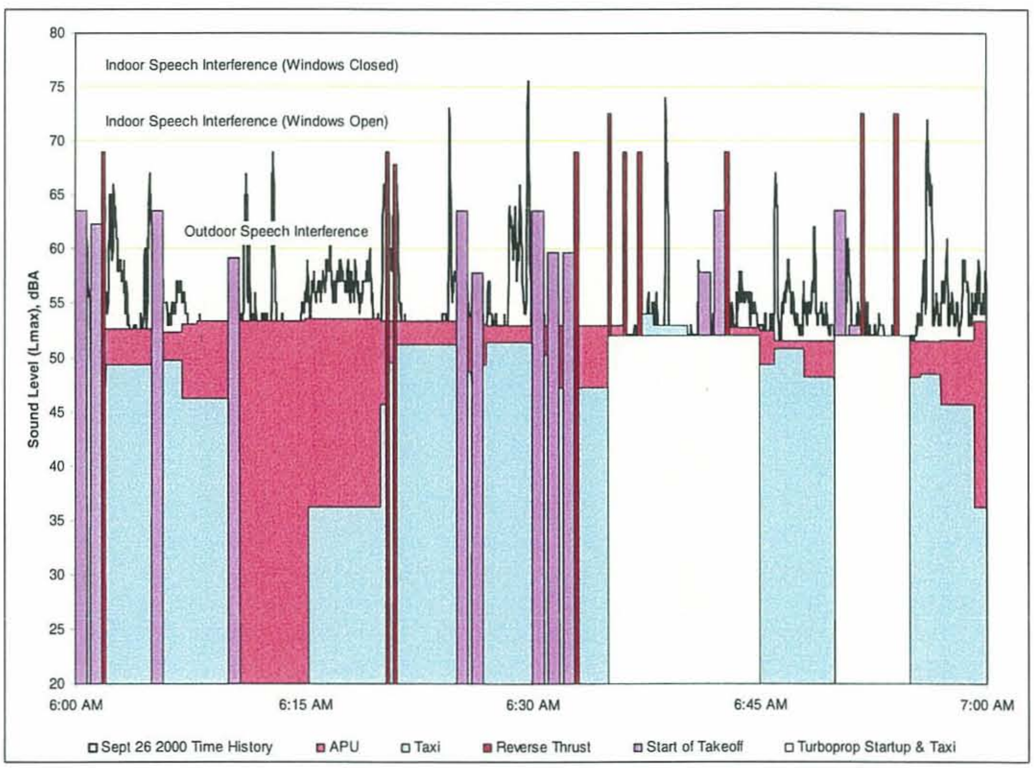


Figure 5.3-8. Site 20 Time History with Scheduled Event Contributions, 6 am to 7 am

6. SEASONAL VARIATIONS IN SOUND LEVELS

6.1 Summary

Residents living near ANC sometimes perceive that sound levels associated with various sources of ground noise vary seasonally. In an effort to quantify and better understand this perception, measurements were repeated during February 2001 at six of the community sites and two of the on-airport sites used during the September 2000 measurements. The measurements indicated that, in general, sources of airport ground noise caused higher noise levels in community locations during February than during September due to specific weather conditions that occur more commonly during the winter than during non-winter months. On any given winter day, however, either higher or lower sound levels may occur at a particular location than during non-winter periods, because the variations in sound propagation are caused by specific weather conditions rather than the season. In addition, perceived seasonal variations in noise levels of ANC ground operations may be due, in part, to several factors unrelated to changes in sound-propagation conditions including seasonal variations in ambient noise levels, seasonal changes in airport activities, heightened awareness of airport activities due to other factors, and variations in time spent outdoors or with open windows.

6.2 Causes of Variations

Perceived variations in sound level from season to season may be caused both by the seasonal changes in sound propagation conditions discussed in Section 6.2.1 and the additional factors described in Section 6.2.2.

6.2.1 Influence of Weather on Sound Propagation

Seasonal variations in weather have the potential to affect long-distance sound propagation, although temperature itself has only a relatively small effect. Instead, seasonal variations in sound propagation conditions are caused primarily by (1) the presence or absence of temperature inversions and (2) seasonal differences in prevailing wind direction.

- *Temperature Inversions:* Normally, during the daytime, the temperature of the air decreases with increasing height; this condition is known as temperature lapse. In temperature lapse conditions, sound waves curve (are refracted) upwards and an acoustical shadow zone may exist at some distance from the noise source. Under certain weather conditions, however, a layer of cool air may be trapped beneath a layer of warmer air. The effect of an inversion is just the opposite of lapse conditions, and sound propagating through the atmosphere curves downward. Often, the downward refraction caused by temperature inversions enhances the audibility of distant sounds by allowing sound rays with originally upward-sloping paths to bypass obstructions and ground effects.

  Although temperature inversions in Anchorage may occur during any season of the year, inversions generally are most prevalent during the winter months. Winter inversions typically occur as cool, dense air drains down the slopes of surrounding mountains into the Anchorage bowl, resulting in a layer of cool air trapped below a layer of displaced warmer air. Fairly consistent inversion conditions caused by this effect can occur starting in late October or November and are highly likely to occur during calm, clear nights[20]. During the summer, "marine inversions" can occur as cooler, denser air moves from over the comparatively cool waters of Cook Inlet to adjacent land, displacing warmer, less-dense air. During either period, stable atmospheric conditions help to strengthen and prolong the occurrence of the inversion[21].

- *Wind Effects:* Just as there is a temperature gradient in the atmosphere, there is also a wind gradient; typically, higher wind speeds exist at greater heights above the ground. The wind gradient affects sound propagation similarly to the temperature gradient by causing upward or downward curving of sound propagation paths. Wind results in downward refraction downwind and upward refraction upwind. Listeners in a predominately downwind direction will experience higher sound levels, and those upwind will experience lower sound levels. Sound propagating perpendicular to the wind direction will not be affected.

  In Anchorage, the prevailing wind direction changes seasonally. During the colder months of the year, generally October to April, gravity-induced airflow occurs as cooler air from the mountains to the north drains into the Anchorage bowl, resulting in prevailing winds from the north to northeast. During the warmer months, the direction of the prevailing winds typically is influenced by cooler, denser air moving from over Cook Inlet and Turnagain Arm into regions of comparatively warmer, less-dense air over adjacent areas of land, resulting in prevailing winds predominately from a southerly direction.[22]

Appendix C provides a more detailed summary of the effects of atmospheric conditions on long-distance sound propagation.

6.2.2 Other Seasonal Factors

In addition to the weather-related sound-propagation issues described above, perceived seasonal variations in ground noise may be due, in part, to the following factors:

- Lower ambient noise levels during winter months (due to reduced human and natural outdoor activities) may increase the audibility of airport noise sources.
- Decreased foliage during winter months may allow airport activities to be more visible from some residential areas. Although loss of foliage has only a small effect on actual sound levels, increased awareness of airport noise sources may contribute to a perception of higher noise levels.
- Seasonal changes in airport activities may expose residents to different types or frequencies of occurrence of noise sources. For example, snow-clearing operations occur

---

[20] An average of 38 clear (24-hour) days have occurred in Anchorage during the six-month October through March period over the past 45 years (Dave Vonderheide, National Weather Service, Anchorage, March 11, 2002).

[21] Information on seasonal variations in Anchorage area weather conditions provided by Dave Vonderheide, National Weather Service, Anchorage, June 25, 2001.

[22] Dave Vonderheide.

only during winter months while some types of maintenance and construction are more likely to occur during warmer months. In addition, seasonal changes in the prevailing wind direction may influence use of departure and arrival runways.

- Increased outdoor activities and open windows during warmer months may increase awareness of airport activities and increase the potential for activity interference and annoyance.

6.3 Seasonal Measurements

6.3.1 Methodology

During February 2001, four days of measurements were repeated at six of the community sites and two of the on-airport sites used during the September 2000 measurements primarily to determine the influence of winter weather conditions on noise levels measured in community locations. The six sites were selected based upon: (1) the quantity and the quality of the data obtained during the first set of measurements and (2) the ability of the sites to represent affected portions of Turnagain, Spenard, and Sand Lake. To maximize the amount of useful data collected, the February measurements concentrated on the two loudest sources of ground noise, start-of-takeoff roll and use of thrust reversers. Information on seasonal variations in sound levels determined from examining these noise sources could then be applied to other quieter sources that were more difficult to measure in community locations. Because the measurements were conducted at exactly the same locations during the two sets of measurements and because noise levels were correlated with specific types of noise sources, differences in the measured sound levels between the two seasons are due primarily to changes in sound-propagation conditions.

6.3.2 Results

Figures 6.3-1 through 6.3-12 summarize and compare over 1,020 start-of-takeoff roll and thrust-reverser noise events as measured at six residential sites near ANC in September 2000 and in February 2001. The graphs are presented in pairs for each of the six sites.

The first graph in each pair provides the actual measured sound levels for each type of event during each measurement period. Each circle on the graph represents the maximum sound level recorded during either a single takeoff-roll or reverse-thrust event. The clusters of data are sorted by event type, runway, and season. These graphs show not only the range of measured sound levels at each location, but also the distribution of measured sound levels throughout the range.

On the second graph in each pair, the small square on each vertical line indicates the average (arithmetic mean) of all of the recorded maximum sound levels for each data group and the vertical line represents the 95% confidence interval. The confidence interval indicates the range within which we would expect the mean to fall 95% of the time if similar measurements were conducted many times. By comparing the mean values and the confidence intervals for corresponding sets of September and February measurements, one may determine whether the differences in the means of the measured data are significant.

For example, Figure 6.3-11 shows 205 data points collected at Site 20 (Tanaina Drive) during the two sets of measurements. The measurement results include departures on Runway 32, departures on Runways 6R and 6L (combined together), and application of reverse thrust on Runways 6R and 6L (combined together). The figure shows that while a considerable amount of data was collected for Runway 32 departures and Runway 6L/6R arrivals, only a small amount was collected for Runway 6L/6R departures.

Figure 6.3-12 shows the means and confidence intervals for the same data as seen on the proceeding figure. For Runway 32 departures, the average L_{max} in February was about seven decibels higher in February than in September. In addition, because the confidence intervals are quite small (due to the large amount of data) and do not overlap, one can be highly confident that the difference between the computed means is significant, as opposed to being caused by uncertainty in the measurements. On the same figure, for Runway 6L/6R departures, the confidence intervals are much larger (due to the small number of data points) and overlap one another. Because of this, one cannot conclude that either set of measurements, on average, was louder than the other. The conclusion is similar for use of reverse thrust on Runway 6L/6R arrivals. Although the confidence intervals are small (due, once again, to the large amount of data), the means of the two data sets are different by less than one decibel and the confidence intervals overlap considerably. Thus, one cannot conclude that either set of measurements, on average, was louder than the other.

Table 6.3-1. Comparison of September and February Measurements

Measurement Site	Event Type	Measured Difference (Feb. mean minus Sept. mean)	Difference Significant at 95% Level?
Turnagain (North of Lake Hood)			
8. Westwood Dr.	Rwy. 32 Dep.	2.1 dB	No
10. Orbit Cir.	Rwy. 32 Dep.	-3.3 dB	No
	Rwy. 6L/R Thr. Rev.	-1.2 dB	No
Turnagain/Spenard (North and East of Lake Spenard)			
13. Balchen Dr.	Rwy. 32 Dep.	2.2 dB	No
	Rwy. 6L/R Thr. Rev.	**6.2 dB**	**Yes**
15. Breezewood Dr.	Rwy. 32 Dep.	3.0 dB	No
	Rwy. 6L/R Thr. Rev.	**5.5 dB**	**Yes**
Sand Lake (South of International Airport Road)			
17. Air Guard Rd.	**Rwy. 32 Dep.**	**-3.4 dB**	**Yes**
	Rwy. 6L/R Thr. Rev.	-2.2 dB	No
20. Tanaina Dr.	**Rwy. 32 Dep.**	**7.3 dB**	**Yes**
	Rwy. 6L/R Thr. Rev.	0.7 dB	No

Table 6.3-1 summarizes the results of the measurements. The table shows that the average sound levels measured in February were higher than the averages measured in September for seven of

the 11 measured data sets (each data set corresponds to one type of aircraft operation measured at one community site). The differences in the measured averages, however, were significant at a 95% confidence level for only four of the data sets (shown in bold). Of the four data sets showing significant differences, the February sound levels were louder for three sets and the September sound levels were louder for the fourth.

In summary, specific weather conditions that enhance sound propagation may occur more commonly during the winter than during non-winter months. These weather conditions include prevailing north/northeast winds (which may increase sound levels south of the Airport) and strong, stable temperature inversions (which may increase sound levels in all directions). On any given winter day, however, either higher or lower sound levels may occur at a particular location than during non-winter periods, because the variations in sound propagation are caused by specific weather conditions rather than the season. During the non-winter months, although prevailing south/southeast winds would tend to decrease sound levels in residential areas to the south and east of ANC, marine inversions also may enhance sound propagation.

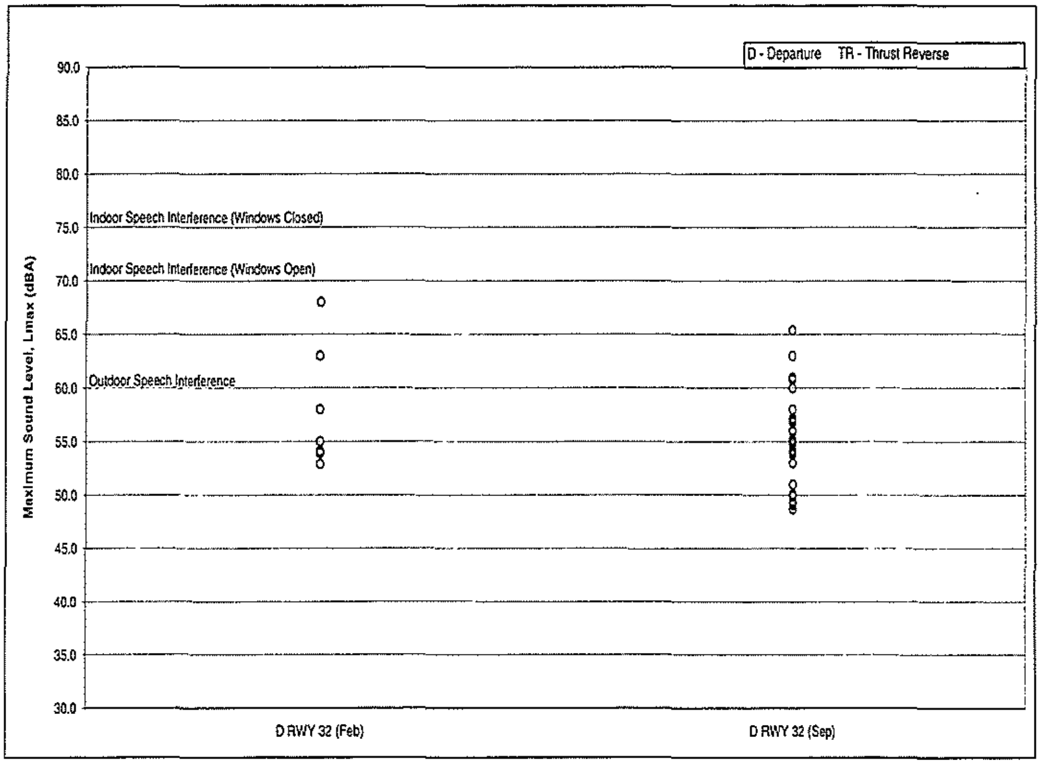


Figure 6.3-1. Site 8 September/February Data Comparison

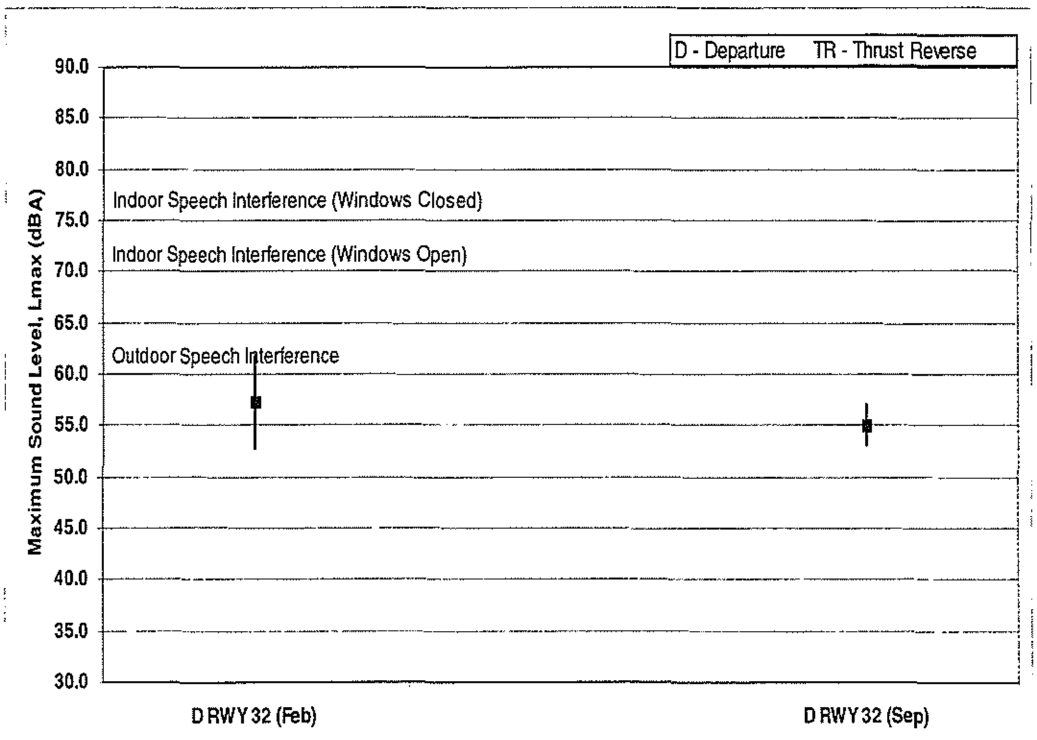


Figure 6.3-2. Site 8 September/February Mean & 95% Confidence Interval

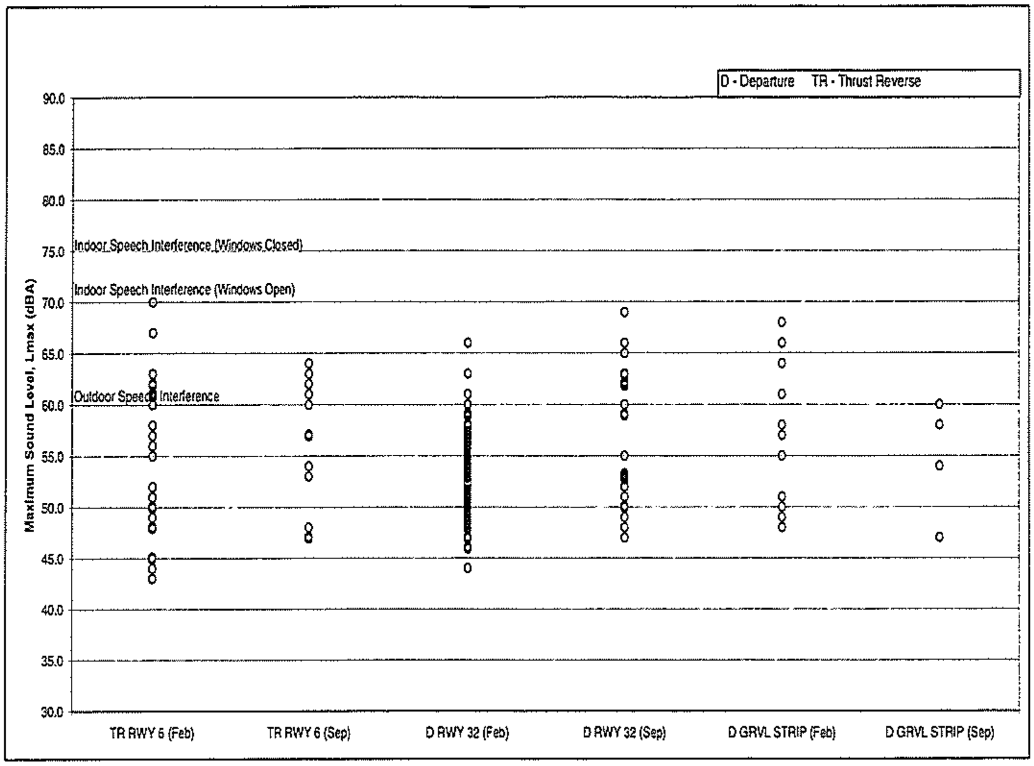


Figure 6.3-3. Site 10 September/February Data Comparison

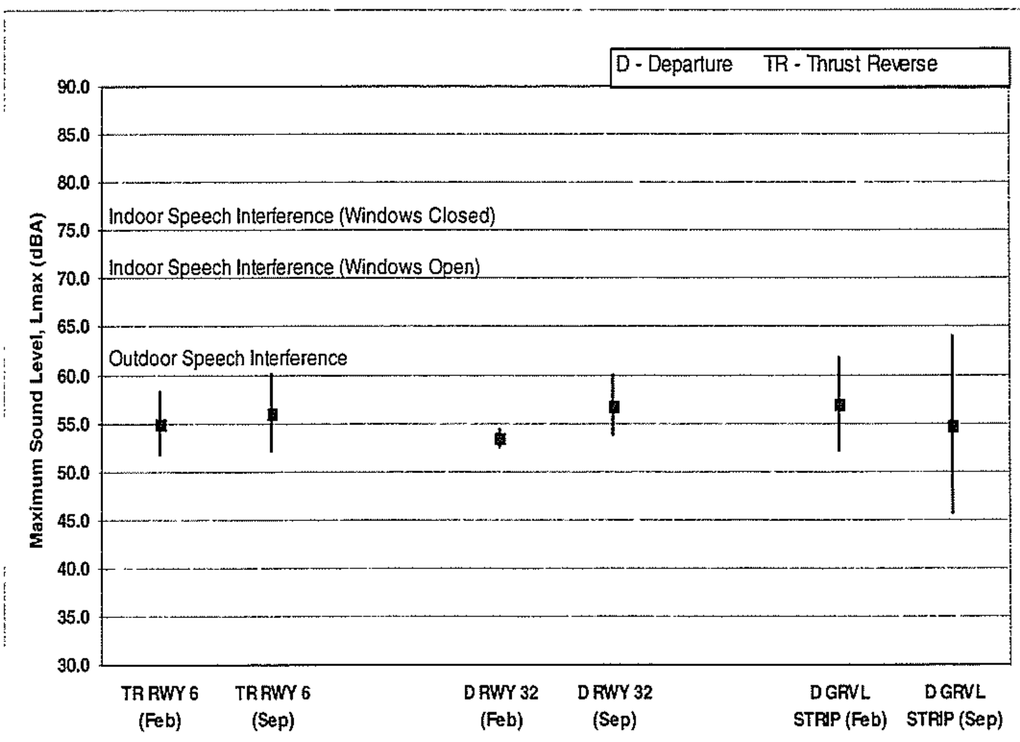


Figure 6.3-4. Site 10 September/February Mean & 95% Confidence Interval

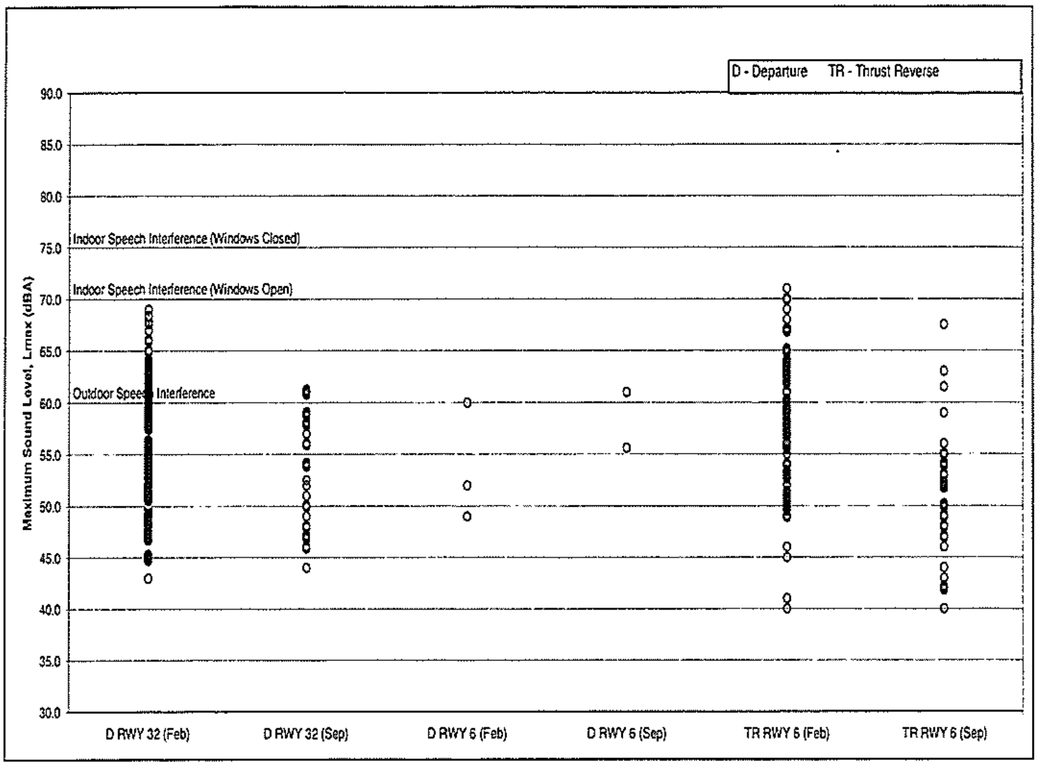


Figure 6.3-5. Site 13 September/February Data Comparison

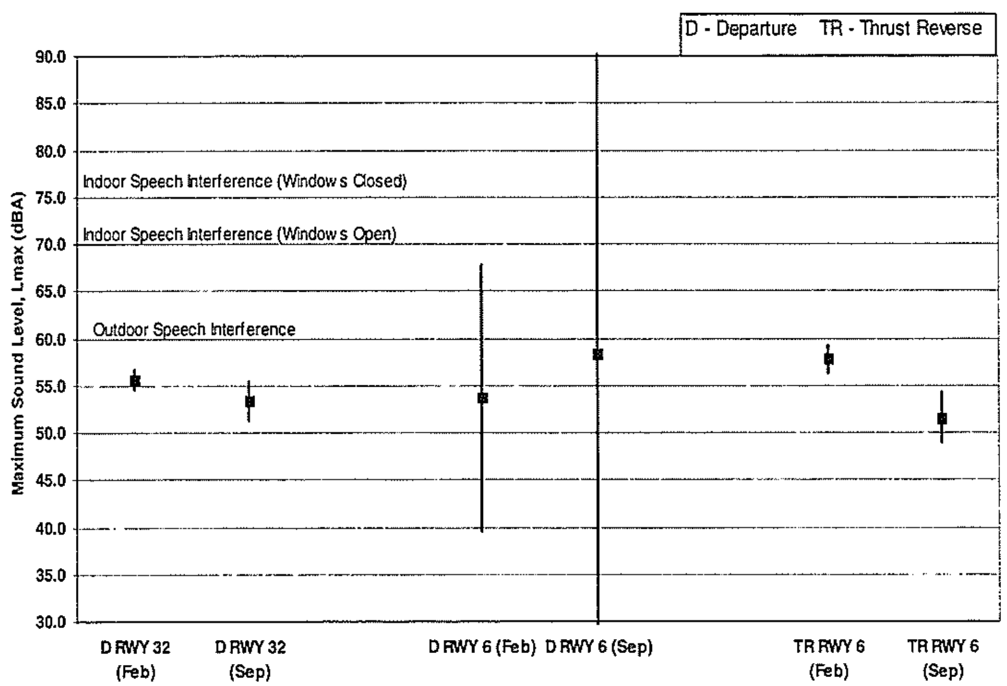


Figure 6.3-6. Site 13 September/February Mean & 95% Confidence Interval

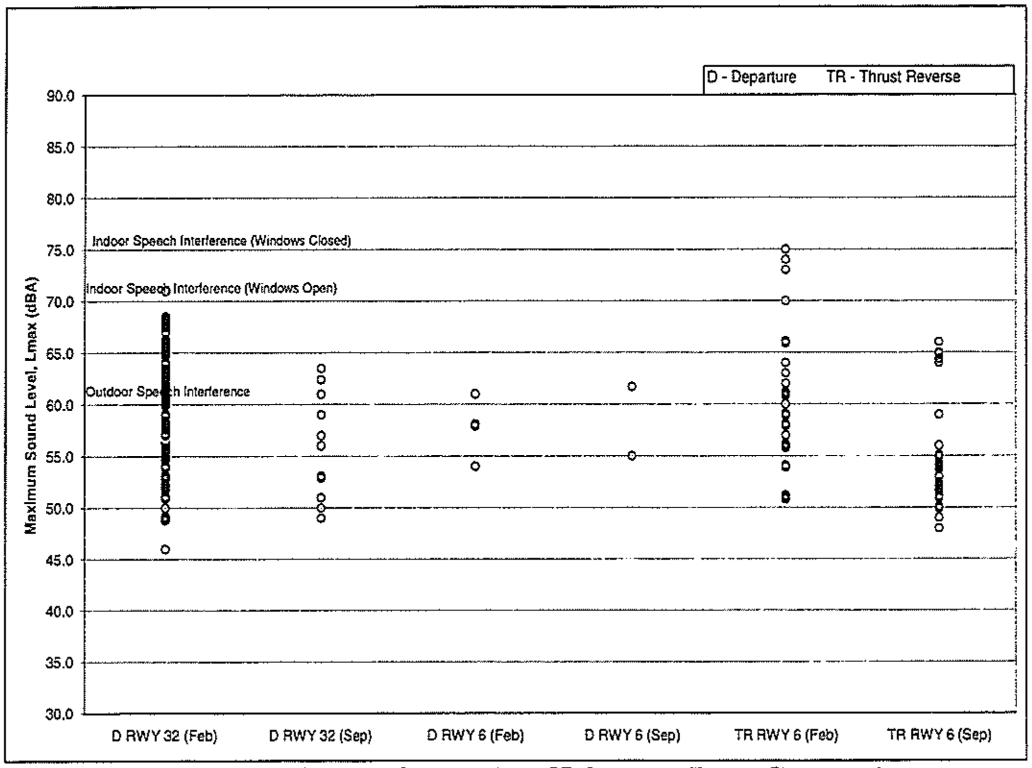


Figure 6.3-7. Site 15 September/February Data Comparison

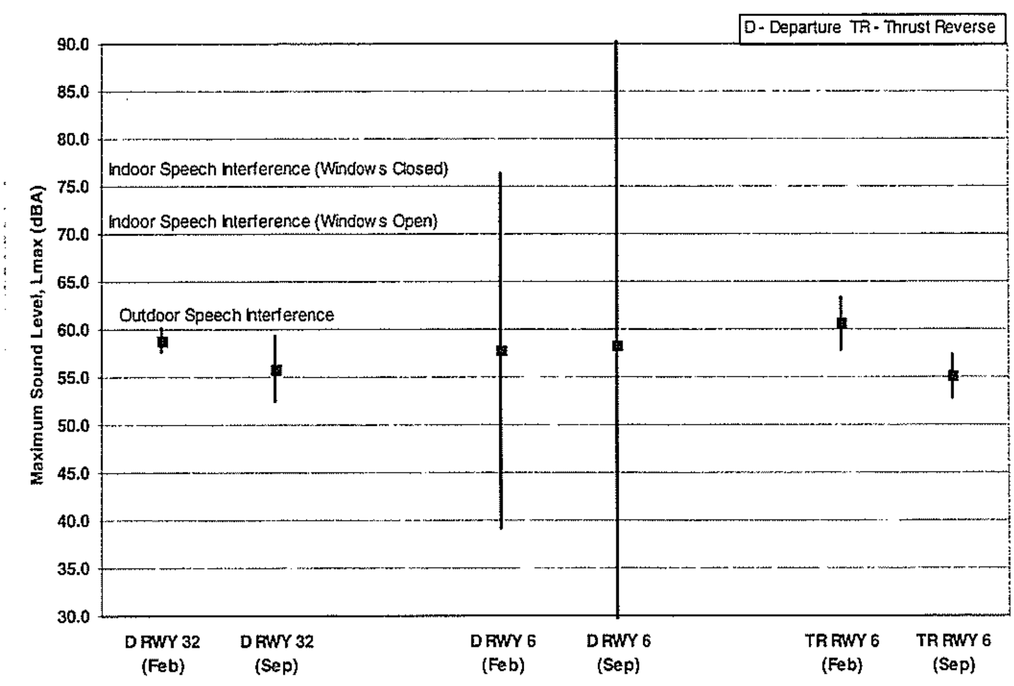


Figure 6.3-8. Site 15 September/February Mean & 95% Confidence Interval

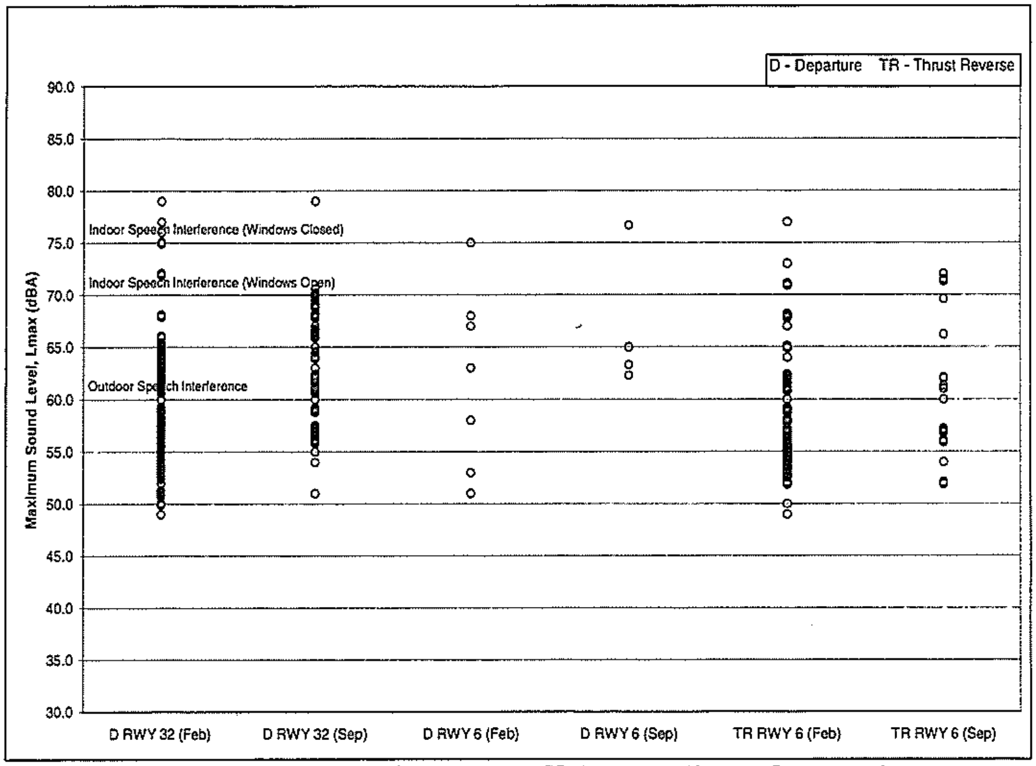


Figure 6.3-9. Site 17 September/February Data Comparison

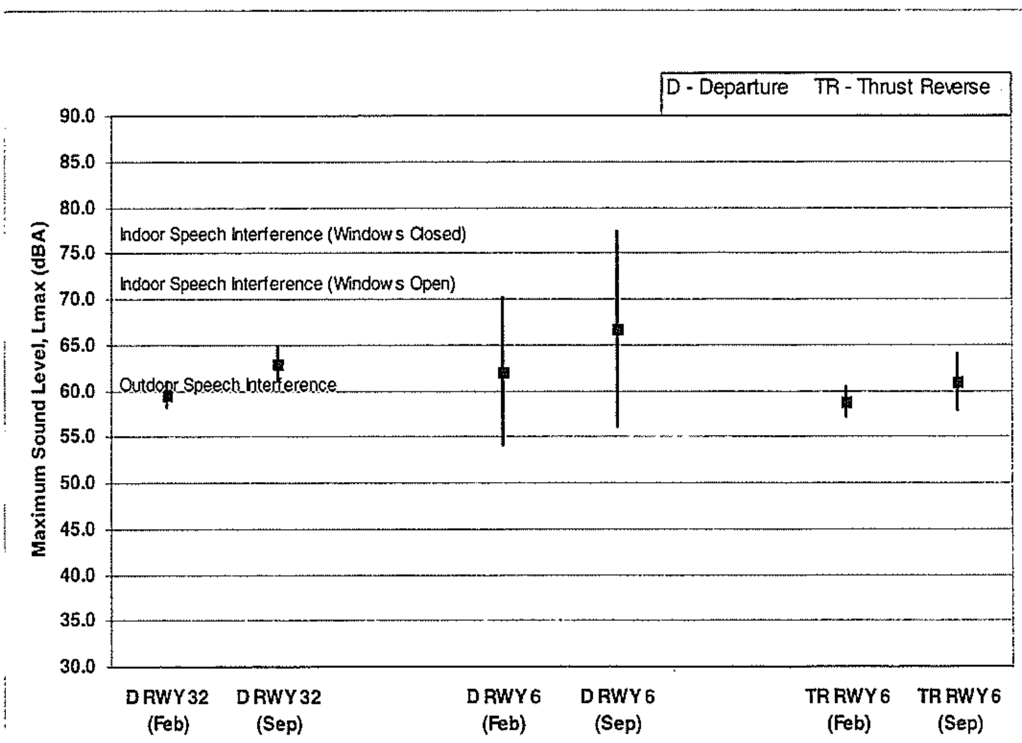


Figure 6.3-10. Site 17 September/February Mean & 95% Confidence Interval

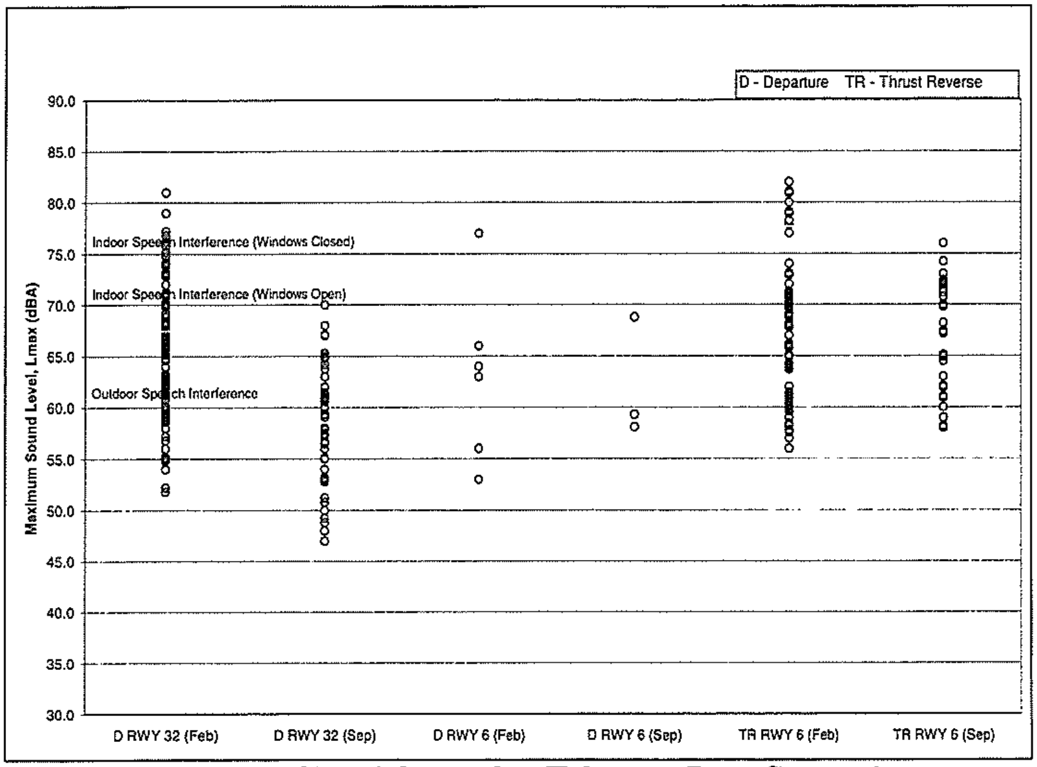


Figure 6.3-11. Site 20 September/February Data Comparison

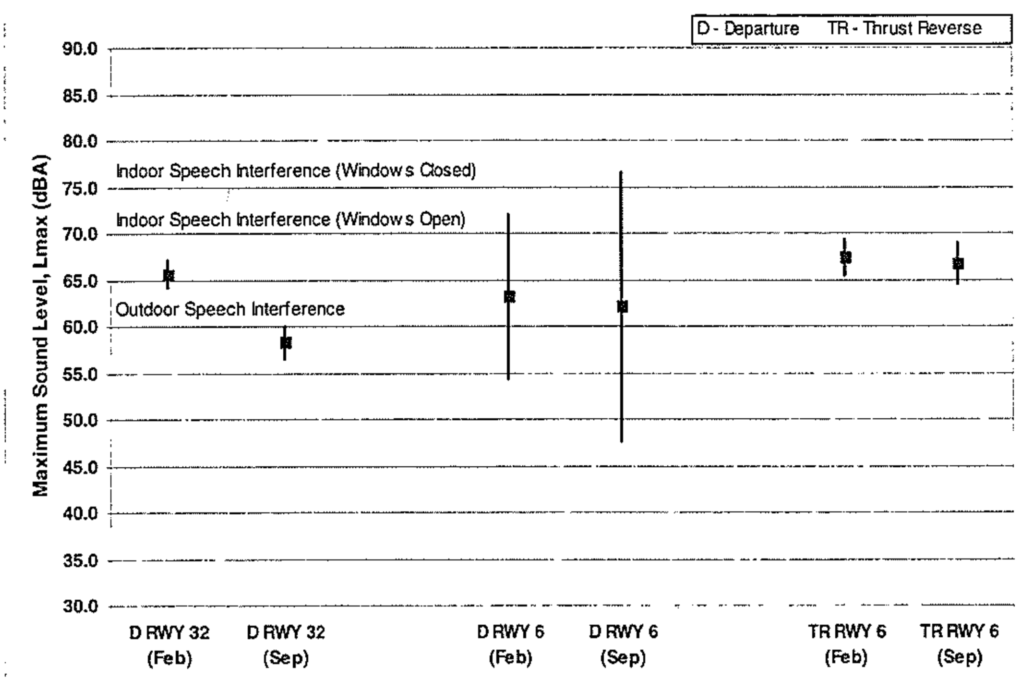


Figure 6.3-12. Site 20 September/February Mean & 95% Confidence Interval

7. MITIGATION OPTIONS

This section of the report provides a discussion of the various mitigation options that are available for each of the sources of ground noise discussed above in Section 5. As described in Section 5, annoyance related to airport ground noise at ANC is caused by two general types of noise events:

- relatively loud, short-duration events that may contribute to short-term speech interference and sleep disturbance and also may cause rattle-induced annoyance due to low-frequency noise, and
- quieter, longer-duration events which may contribute to annoyance due to their persistent nature.

Because of the importance of each of these issues, mitigation recommendations must address the sources of both types of events to effectively reduce annoyance caused by ground noise.

For the majority of the noise sources, the report presents several mitigation options, some of which may be feasible and some of which may not be feasible at ANC. It should be recognized that all of the mitigation options presented should be evaluated within the context of overall operational efficiency and the Master Plan process. In addition, to receive FAA approval, recommended mitigation measures must meet the following FAR Part 150 requirements:

- The measure must not derogate safety or adversely affect the safe and efficient use of airspace;
- To the extent practicable, the measure must meet both local needs and needs of the national air transportation system, considering tradeoffs between economic benefits derived from the Airport and the noise impact;
- The measure must not impose an undue burden on interstate and foreign commerce;
- It must be possible to implement the measure in a manner consistent with all the powers and duties of the Administrator of the FAA;
- The measure must reduce existing noncompatible uses and prevent or reduce the probability of the establishment of additional noncompatible uses; and
- The measure must not be unjustly discriminatory.

Table 7-1 provides a summary of the sources of ground noise addressed in this study and the various mitigation options considered. Following the summary table, the various mitigation measures proposed for each noise source are discussed in detail.

Table 7-1. Summary of Mitigation Options

Noise Source	Mitigation Option	Recommendation
1. Start of Takeoff	1.1 Preferential Runway Use	No action recommended
	1.2 Intersection Departures	Utilize Taxiway K, L, and M intersection departures on Rwy. 32 whenever feasible
	1.3 Relocation of Runway 6R/24L to West	Relocate Rwy. 6R/24L to west and utilize Taxiway D intersection departures on relocated Rwy. 24L, coordinate with Master Plan process and ATC
	1.4 Noise Barriers or Berms	No action recommended
	1.5 Residential Sound Insulation	Once an FAA standard is in place regarding low-frequency noise, assess the feasibility and costs associated with incorporating low-frequency treatments/standards during residential sound insulation
	1.6 Nighttime Departure Curfew	No action recommended
2. Reverse Thrust	2.1 Reduction of Use of Thrust Reversers	Examine feasibility of reduced-thrust procedures with airlines
	2.2 Preferential Runway Use	Prioritize arrivals on Runway 6R, coordinate with ATC
	2.3 New High-speed Taxiways and Preferential Taxiway Use	Construct additional high-speed taxiways; examine feasibility of preferential taxiway use with airlines, coordinate with Master Plan process
	2.4 Relocation of Runway 6R/24L to West	Relocate Rwy. 6R/24L to west to reduce noise effects of thrust reversers, coordinate with Master Plan process and ATC
	2.5 Noise Barriers or Berms	No action recommended
	2.6 Residential Sound Insulation	Once an FAA standard is in place regarding low-frequency noise, assess the feasibility and costs associated with incorporating low-frequency treatments/standards during residential sound insulation
	2.7 Nighttime Arrival Curfew	No action recommended
3. Taxiing and Idle	3.1 Options to Minimize Queuing	No action recommended
	3.2 Taxi with Single Engine	Implement voluntary reduced-engine taxi procedures on carrier-specific basis in coordination with aircraft operators and ATC
	3.3 Preferential Taxiway Use	Queue Runway 32 departures on Taxiways K and L (rather than R), coordinate with Master Plan process and ATC

Noise Source	Mitigation Option	Recommendation
	3.4 Construction of New Taxiways	Construct new taxiways, including high-speed exits and a west-side north/south taxiway in the context of overall airport efficiency and the Master Plan process
	3.5 Noise Barriers or Berms	No action recommended
	3.6 Residential Sound Insulation	No special consideration needed during sound insulation program
4. Auxiliary Power Units	4.1 Discontinuation of Non-essential APU Use	In coordination with aircraft operators, develop recommendations on the reduction of APU use, educate tenants in benefits of reduced APU use
	4.2 Substitution of Ground Power and Pre-conditioned Air	Provide ground power outlets and pre-conditioned air at all existing and new passenger terminals; provide access to ground power (either outlets or GPUs) and pre-conditioned air at new and existing cargo facilities
	4.3 Reorientation of Aircraft	Park North Airpark and East Airpark aircraft with APU exhaust directed away from residences, coordinate with ATC to assess impact on line of sight from ATC tower
	4.4 Use of Buildings to Provide Noise Shielding	In coordination with tenants, design new North Airpark cargo facilities to provide noise shielding
	4.5 Noise Barriers or Berms	If operational measures are deemed insufficient, conduct design study and construct barrier or berm for East Airpark
5. Maintenance Run-ups	5.1 Additional Nighttime Restrictions	Require reporting of actual run-up data; consider implementing additional nighttime restrictions in close coordination with airport tenants
	5.2 Optimization of Aircraft Orientation and Location	Amend Airport Bulletin 2000-16 to include additional Taxiway Juliet run-up heading; provide airfield markings and signs, coordinate with Airport Operations and Planning
	5.3 New Run-up Location	Develop new run-up location west of Runway 14/32 in coordination with planning for proposed taxiway improvement projects; review feasibility and attractiveness of proposed locations with Airport Operations, ATC staff, and tenants
	5.4 Noise Barriers or Berms	If operational measures and/or a new location are deemed insufficient, construct a noise barrier or berm at new run-up location
	5.5 Ground Run-up Enclosure	Not warranted at this time

Noise Source	Mitigation Option	Recommendation
6. GA Aircraft Start-up and Departure	6.1 Pilot Education to Reduce Takeoff Noise Levels	Provide education to GA pilots in noise-sensitive departure procedures
	6.2 Optimization of Parking Orientation	In coordination with GA Operations and Planning personnel, optimize orientation of any new tie-downs near residential areas
	6.3 Noise Barrier or Berm	Conduct a noise barrier/berm design study in conjunction with the affected community to evaluate alternative locations near gravel strip
7. Field Maintenance Equipment	7.1 Limit Nighttime Maintenance	As feasible, limit nighttime field maintenance operations near residential areas
	7.2 Variable-Volume Back-up Alarms	Require use on all new ANC maintenance equipment and all contractor equipment

7.1 Start of Takeoff Noise

At most residential locations, start-of-takeoff noise is one of the loudest aircraft ground noise sources at ANC. Several operational and structural noise mitigation and abatement measures were considered to decrease the effects of start-of-takeoff noise:

- The existing ANC Preferential Runway Use Program, which is intended to reduce noise from aircraft in flight, also helps to minimize the effects of start-of-takeoff noise.
- Increased use of intersection departures, as is feasible within the framework of the Preferential Runway Use Program, would provide additional benefit.
- Noise-shielding structures such as barriers or berms are unlikely to provide effective reduction of takeoff-roll noise at ANC due to limitations imposed by the airport layout and local topography.

7.1.1 Preferential Runway Use

ANC currently employs a Preferential Runway Use Program, which was developed to ensure that "aircraft noise is minimized in residential neighborhoods surrounding the Airport, consistent with safe aircraft operations" (Airport Bulletin 2000-16, August 1, 2000). The procedures are in compliance with the runway use preferences in the Environmental Impact Statement for the construction of the North/South runway, the Environmental Assessment for the Runway 32 extension, and the FAA-approved FAR Part 150 Noise and Land Use Compatibility Study Update.

The preferred flow of aircraft operations at ANC for noise abatement purposes, contingent upon weather conditions and traffic volume, is to land to the east on Runways 6L and 6R and depart to the north on Runway 32. A secondary preference is to land to the south on Runway 14 and depart to the west on Runways 24L and 24R. As such, Runways 6R, 6L, and 14 have been designated noise sensitive runways for departures and should be used for departures only when operational or safety considerations limit the use of Runways 32, 24L, and 24R. The preferential runways for departures, as denoted by Airport Bulletin 2000-16, are shown below in Table 7.1-1 in order of priority. Although Runway 6R is listed as the second priority departure runway during daytime hours in recognition of air traffic considerations, Runway 24L should be used as the second priority departure runway during daytime hours when weather and traffic conditions allow.

Recommendation: The Preferential Runway Use Program was designed to minimize overall noise exposure from all aircraft operations and was intended primarily to limit direct overflights of residential areas and reduce runway sideline noise. Although prioritizing the use of Runways 14 and 6R for departures would minimize noise from start-of-takeoff, it also would increase noise due to direct overflights of residential areas and would be counter to the purpose of the Preferential Runway Use Program. For this reason, no changes are recommended to the Preferential Runway Use Program for the purpose of reducing aircraft ground noise.

Table 7.1-1. Departure Runways in Order of Priority

Preference	Daytime (07:00 to 22:00)	Nighttime (22:00 to 07:00)
1	Rwy. 32	Rwy. 32
2	Rwy. 6R*	Rwy. 24L
3	Rwy. 6L	Rwy. 24R
4	Rwy. 24L	Rwy. 6R
5	Rwy. 24R	Rwy. 6L
6	Rwy. 14	Rwy. 14

*Although Runway 6R is listed as the second priority departure runway during daytime hours in recognition of air traffic considerations, Runway 24L should be used as the second priority departure runway during daytime hours if weather and traffic conditions allow. Source: ANC Airport Bulletin 2000-16, August 2000.

7.1.2 Intersection Departures

As described above, Runway 32 is ANC's preferred departure runway for both daytime and nighttime operations. In 1997, Runway 32 was extended 888 feet to the south and 200 feet to the north to optimize the length of the runway for north departures and to reduce Runway 6L and 6R departures. Airport Bulletin 2000-12 (July 21, 2000) defines the parameters for use of the Runway 32 extension. Although the extension provides for a Take-Off Run Available (TORA) of 11,584 feet, the extension is normally used only if an aircraft's weight, stage length (distance to the aircraft's destination which affects fuel loading, and hence takeoff weight), or other condition, necessitate a "Runway 32 extension takeoff" and it is specifically requested by the pilot. Otherwise, aircraft will normally depart on Runway 32 from the Taxiway Kilo intersection.

According to ANC Air Traffic Control (ATC), current standard operating practice as required by Anchorage Tower facility directive is to assign air carrier and commuter aircraft departing Runway 32 to Taxiway Kilo. Normally, departures from other intersections are only assigned upon request of the pilot or if it provides an operational advantage.[23]

[23] John Craft, Air Traffic Manager, ANC Traffic Control Tower, August 6, 2001.

Use of the Taxiway Kilo and Lima intersection departures, rather than the full Runway extension, reduces exposure from start-of-takeoff noise in residential areas to the south of the Airport. In addition, to the extent feasible for aircraft requiring shorter TORAs, departures from the Taxiway Mike intersection would further minimize noise exposure in residential areas to the south of the Airport, by moving the start-of-takeoff roll point approximately 2,500 feet farther from these residential areas than departures from the Taxiway Kilo intersection, or approximately 3,250 feet farther than departures from the runway-extension takeoff threshold. The TORA from the Taxiway Mike intersection is approximately 8,335 feet, which is adequate for many of the passenger aircraft destined for the Lower 48. Taxiway Kilo and Mike departures are not feasible for some aircraft, particularly heavy cargo aircraft, due to takeoff weight.

It is recognized that the Pilot-in-Command would need to determine if a Taxiway Mike departure is safe for his or her aircraft and that many airlines may require use of the full available runway on departure. In addition, Taxiway Mike departures may result in wake-turbulence delays of up to three minutes for subsequent departing aircraft, which may be unacceptable during busy periods.

Recommendation: Use of the Taxiway Kilo and Lima intersection departures, rather than the full Runway extension, is recommended whenever possible and safe to minimize exposure from start-of-takeoff noise in residential areas to the south of the Airport. In addition, to the extent feasible for aircraft requiring shorter TORAs, departures from the Taxiway Mike intersection are recommended whenever possible and safe to further minimize noise exposure in residential areas to the south of the Airport.

ATC has indicated that, from their perspective, this option is feasible and currently is assigned when requested by pilots or when an operational benefit would exist. ATC also recognizes "that most carriers require pilots to use the entire available runway for departure and that carriers discourage use of intersection departure" and recommends that implementation of this option would be most effective by airport coordination with air carrier representatives and drafting guidelines to aid tower personnel in assignment of intersection departures to operators who have indicated they typically will accept them[24].

7.1.3 Relocation of Runway 6R/24L to West

The relocation of Runway 6R/24L approximately 1,500 feet to the west would permit intersection departures to occur on Runway 24L from Taxiway Delta, approximately 1,500 feet west of the runway's current eastern end. Starting Runway 24L takeoff rolls 1,500 feet farther to the west would reduce maximum sound levels in homes east of the runway, most notably in Spenard and the northeast portions of Sand Lake. At the closest homes to Runway 24L, which are located on Air Guard Road near Site 17, this measure could provide a noticeable reduction of about five decibels in maximum sound levels occurring at the start of takeoff. This measure would have little effect on homes located in Tanaina Hills and other areas south of the runway.

Figure 7.1-1 depicts maximum sound level contours for B747-100 and B737-400 departures on Runway 24L from this location. This figure may be compared to Figure 5.1-7, which provides similar contours for departures from the eastern runway end. On each figure, the solid portion of

[24] J. Craft

each contour represents the L_{max} during only the ground-roll portion of each departure. Although the airborne portion of the departure event (represented by the dashed contour) is not addressed in this ground noise study, it is shown on the figure to provide a comparison of the sound levels associated with the takeoff roll and the airborne portion of the departure. As described in Section 5.1.1, the INM contours should be interpreted primarily as providing a comparison of the relative sound levels associated with departures from various locations. Actual measured start-of-takeoff roll sound levels would be expected to vary from the representative sound levels depicted by the contours.

ATC has concerns about this option. Wake turbulence from departing aircraft may have adverse effects on aircraft arriving on Runways 6R/6L and greatly increase complexity as pilots and air traffic controllers must cope with high closure rates. In addition, required separations of up to 20 miles between a heavy jet departing on Runway 24L and a Runway 6R arrival may result in airborne delays and additional arrival and/or departure spacing.[25]

Recommendation: Although Runway 24L departures occur relatively infrequently, relocating Runway 6R/24L 1,500 feet to the west to allow intersection departures on Runway 24L from Taxiway Delta would provide a noticeable reduction in maximum sound levels at homes to the east of the runway during these departures. If the runway relocation is warranted, within the context of overall airport efficiency and the Master Plan process, the noise reduction provided by Taxiway Delta intersection departures would provide an additional benefit. Based upon ATC's concerns regarding this recommendation, any further consideration should be closely coordinated with ATC to establish procedures for the use of Runway 24L that would minimize operational impacts. In addition, due to concerns regarding wind shear near the bluffs at the western end of the relocated runway, a thorough review of the potential effects of winds on safety and operational feasibility would be required.

7.1.4 Noise Barriers or Berms

In some cases, noise barriers or earth berms may provide an effective means of reducing the effects of some sources of airport ground noise. Their usefulness may be limited at ANC, however, for the reasons described below.

- *Noise barriers or berms reduce noise levels by blocking the direct sound transmission path from the noise source to the listener. When the direct sound propagation path already is broken by intervening structures, terrain, or by dense, broad areas of trees and heavy vegetation, noise barriers may provide very little, if any, incremental benefit.* Most residential areas around ANC do not have a direct line of sight to the on-the-ground portion of takeoff roll. Direct line of sight to most areas south of the Airport from all departure runways generally is shielded by terrain. For areas to the east of the Airport, direct line of sight to start of takeoff for Runway 32 departures is blocked by the terminal complex and other support buildings. For Runway 24 departures, the surrounding terrain generally rises from the Airport to the closest residential areas both to the northeast (east of Spenard Road and north of International Airport Road) and to the southeast (east of Jewel Lake Road and north of Raspberry Road) of the runway end, limiting the ability of a barrier to block the direct sound path.

[25] J. Craft

Figure 7.1-2a provides a schematic cross-section view of an aircraft on the ground, a nearby residential area, and an intervening noise barrier. The dashed arrows represent sound spreading from the aircraft towards the residences (in reality, sound spreads in all directions from the aircraft). Although the trees may provide a visual buffer, only very broad, dense areas of trees (typically, hundreds of feet of dense vegetation) provide substantial noise reduction. The noise barrier, however, because of its dense, solid construction reduces sound levels by blocking the direct sound-propagation path towards the residential area. Although the barrier blocks the direct path and reduces the noise level, the aircraft still may be audible because sound paths can "bend" over and around obstructions.

Figure 7.1-2b depicts the situation when surrounding terrain (or, in some cases, large buildings or rows of houses) blocks the direct line of sight to the noise source. In this case, the direct sound-propagation path is blocked, much as it would be by a noise barrier. Because of this, a noise barrier typically will provide little, if any, additional benefit when the direct propagation path already is blocked. As noted above, although the direct path is blocked, the aircraft still may be audible because sound paths can "bend" over and around obstructions.

- *Noise barriers or berms are most effective when they can be located close to either the noise source or to the listener. Barriers or berms are least effective when they are located approximately midway between the source and the listener.* Because of FAR Part 77 restrictions (governing locations and heights of structures near runways) and operational requirements (including maintaining access to taxiways and ramps and allowing FAA tower personnel to maintain visual contact with aircraft on the ground), there are no feasible locations for noise barriers or berms close to Runway 32, the primary departure runway. Noise barriers or berms located along the Airport's property line (the closest that they could feasibly be located to residences) would still be a considerable distance from many homes affected by start-of-takeoff noise.

- *The benefits of noise barriers or berms may be reduced substantially by certain weather conditions, including wind blowing from the noise source towards the listener or temperature inversions. Under either of these weather conditions, sound may propagate in downward-curving (or "refracted") paths, circumventing the barrier's effectiveness. This reduction in benefit is most pronounced when the barrier is not close to either the noise source or to the listener.* As described above, it is not feasible to locate noise barriers or berms close to either the noise source or the listener. This would make any selected barrier location particularly susceptible to weather effects. In addition, during use of Runway 32, which is the primary departure runway due to the Preferential Runway Use Program, there often is a component of the prevailing wind from the north (Airport Bulletin 2000-16 allows selection of the next preferential departure runway whenever crosswind components exceed 15 knots or tailwind components exceed five knots); i.e., in the acoustically disadvantageous case when the wind is blowing from the departing aircraft towards residential areas south of the Airport.

Figure 7.1-2c depicts sound propagation when the sound traveling downwind (i.e. when the wind is blowing from the aircraft towards the observer) or during a temperature inversion. In these cases, sound paths that initially were directed into the sky are bent downward in curving arcs. As a result, sound may travel over a barrier and then curve downward, increasing sound levels at a location behind the barrier. As depicted in the figure, this effect is most pronounced when the barrier is not close to either the noise source or the listener; it can be reduced somewhat by locating noise barriers close to either the noise source or the listener. Appendix C describes in more detail the effects of weather on sound propagation.

- *Noise barriers or berms provide no benefit during the airborne portion of aircraft departures.* For areas to the south of the Airport, departures on Runway 32 often are heard as noise events lasting for one to three minutes with two distinct peaks. The sound level typically reaches the first peak at the start of takeoff when takeoff power is applied and the aircraft is closest to residences. The sound level gradually decreases during the aircraft's ground roll (typically about 30 seconds in duration) and then achieves a second peak when the aircraft becomes airborne and, although farther away, loses the noise-reducing effects of shielding and ground attenuation. Noise barriers or berms would have no effect on this second, airborne portion of a departure event, which may last for about one to two minutes.
- *Noise barriers or berms are most effective at controlling high-frequency noise sources and are least effective at controlling noise sources with significant low-frequency content.* Start-of-takeoff noise from jet aircraft is characterized by significant low-frequency components, which are more difficult to reduce through the use of noise barriers or berms.

Recommendation: Because of these issues, combined with the limitations imposed by the locations and orientations of runways at ANC, the locations of affected communities relative to potential noise barrier locations, and local topography, it is unlikely that noise barriers would provide a noticeable reduction in start-of-takeoff noise for residential areas near ANC and further study is not recommended.

7.1.5 Residential Sound Insulation

As a recommendation of the FAR Part 150 Study, ANC currently is initiating a residential sound insulation program. The goal of the program will be to reduce noise levels within qualifying residences through the use of sound-insulation treatments. Such treatments typically may include replacing window and doors with special acoustical windows and doors, reducing the effects of "flanking paths" and "leaks" such as ventilation openings and poorly-fitting door gaskets, and, in some cases, retrofitting roofs and/or walls.

The FAA generally determines eligibility for sound insulation based upon the level of A-weighted cumulative noise exposure (measured with the DNL metric) from all aircraft events. Because overall A-weighted values of noise exposure typically are dominated by noise from flight operations, aircraft ground noise usually has little impact on eligibility for sound insulation. In addition, acceptance-testing criteria for residential sound insulation programs typically are based on (1) post-treatment A-weighted interior noise levels and (2) reduction in A-weighted noise levels.

Because of the effects of low-frequency noise from start-of-takeoff in residential areas near ANC, reliance upon only A-weighted standards may result in sound-insulation treatments that meet the program's requirements but provides limited reduction of low-frequency noise and vibration. For example, field measurements conducted at Minneapolis-Saint Paul International Airport (MSP) determined that the acoustical treatment provided by the MSP Residential Sound Insulation Program, although increasing the mid- and high-frequency noise reduction of houses, did not improve the low-frequency noise reduction of residences[26]. In addition, reduction of mid- and high-frequency noise without a corresponding reduction in low-frequency noise may make the low-frequency noise more noticeable.

Options available for reducing low-frequency noise and vibrations and rattles caused by low-frequency noise in existing residences include:

- Increasing surface mass by adding dense material to the exterior and/or interior cladding; or
- Adding one or more separated layers to walls to create complex wall structures; and/or
- Incorporation of sound-absorbing or vibration-isolating provisions into walls.

In residential areas near Baltimore/Washington International Airport (BWI), the FAA provided special funding for treatments of homes to increase their low-frequency noise reduction. These treatments consisted primarily of adding mass to interior and exterior walls and to ceiling and roof structures[27], and resulted in additional C-weighted noise reductions averaging approximately four decibels. The treatments, which included "major wall modifications and triple[-glazed] windows with an overall thickness of over 12 inches" cost about 40% more than standard residential sound insulation treatments[28].

The Residential Sound Insulation Program at Boston's Logan International Airport uses another approach in which one room in each residence is designated as the Room of Preference (ROP). In addition to the standard treatment provided for all living areas, the ROP receives additional sound insulation, which has been calculated to provide additional C-weighted noise reductions of about five decibels. The ROP treatments added approximately $5,000 to $6,000 to the cost of sound insulation for each home.[29]

Recommendation: Currently, there is no FAA approved standard to measure or assess the effects of low-frequency noise, and there is still a debate on the effectiveness and benefit of any residential sound insulation that addresses low-frequency noise. Once an FAA standard is in place regarding low-frequency noise, the Airport should assess the feasibility and costs associated with incorporating low-frequency treatments/standards during residential sound insulation. At that time, areas where additional sound insulation would be required to address low-frequency noise and candidate treatments for their effectiveness not only in reducing A-weighted noise levels, but also for reducing low-frequency noise and vibration should be evaluated. In addition, the added costs associated with low-frequency sound insulation should be

---

[26] "Findings of the Low-Frequency Noise Expert Panel of the Richfield-MAC Noise Mitigation Agreement of 17 December 1998," September 30, 2000, page II-68.

[27] "Findings of the Low-Frequency Noise Expert Panel . . .," pages III-108, 109.

[28] "Status of Low-frequency Aircraft Noise Research and Mitigation," Prepared for: Noise Abatement Office, San Francisco International Airport, Prepared by: Wyle Acoustics Group, September 2001, page 3-4.

[29] *Ibid.*, pages 3-4 and 3-5.

evaluated at that time and acceptance-testing standards accounting for reduction in low-frequency noise should be considered.

7.1.6 Nighttime Departure Curfew

Through its actions and statements since the passage of the Aircraft Noise and Capacity Act of 1990 and FAR Part 161, the FAA has clearly indicated that it would vigorously oppose new airport use restrictions. In addition, a nighttime curfew on aircraft operations is counter to the federal grant assurances agreed to by the State Department of Transportation and Public Facilities (DOT and PF). Due to the level of nighttime operations at ANC for both passenger and air cargo aircraft, prohibiting departures at night may prevent air carriers from meeting the demands of air travelers and air shippers and, to the extent that the FAA perceives a nighttime curfew on departures as a de facto access restriction, a FAR Part 161 study would be required prior to implementing a nighttime curfew. For these reasons, a nighttime departure curfew is not recommended at this time.

Recommendation: No action is warranted at this time.

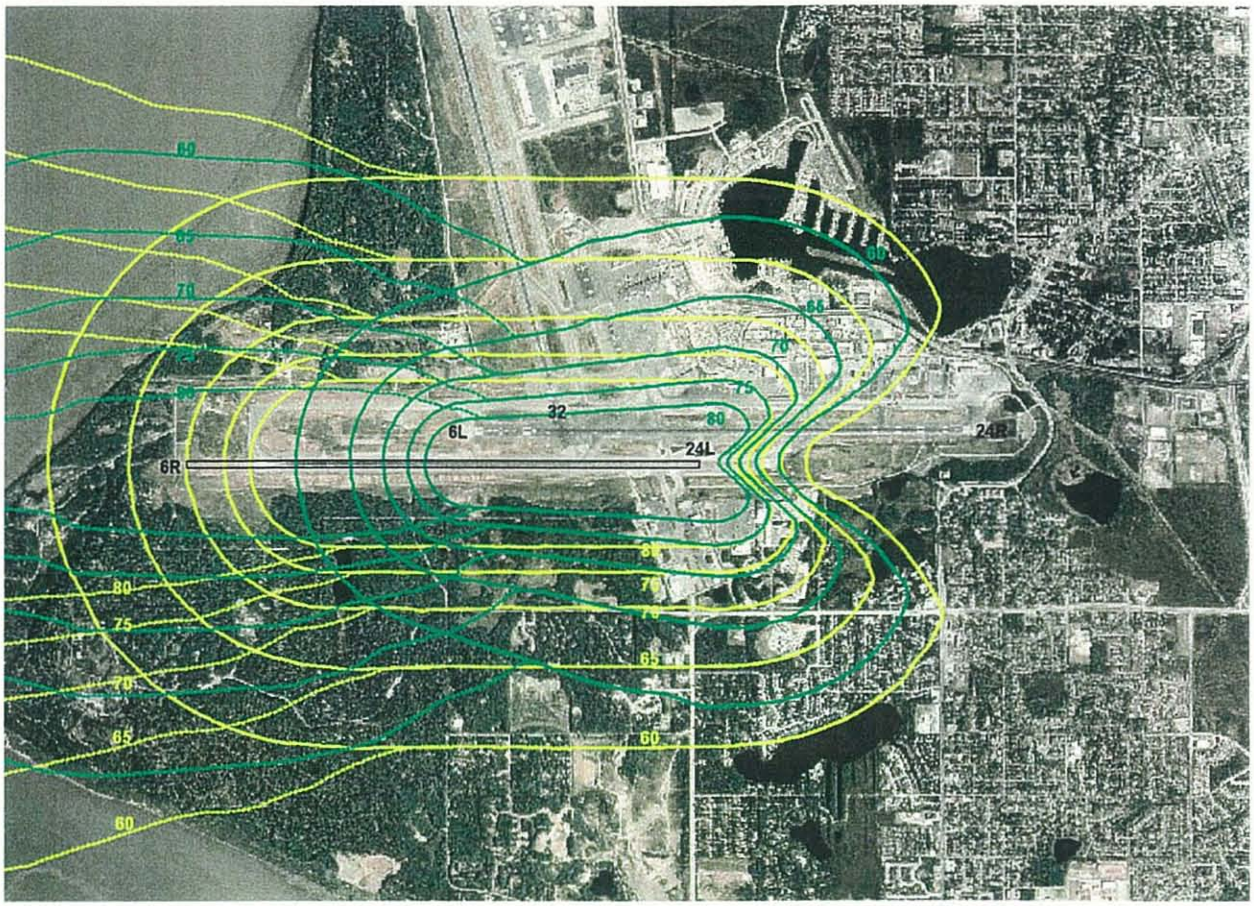


Figure 7-1.1. Start-of-Takeoff Contours, Rwy. 24L Intersection Departure from Taxiway Delta

(Runway shown relocated approximately 1,500 feet to west)

B747-100 (yellow) and B737-400 (green): 60, 65, 70, 75, and 80 dBA, L_{max}
(Solid contours indicate ground roll, dashed contours indicate aircraft airborne)

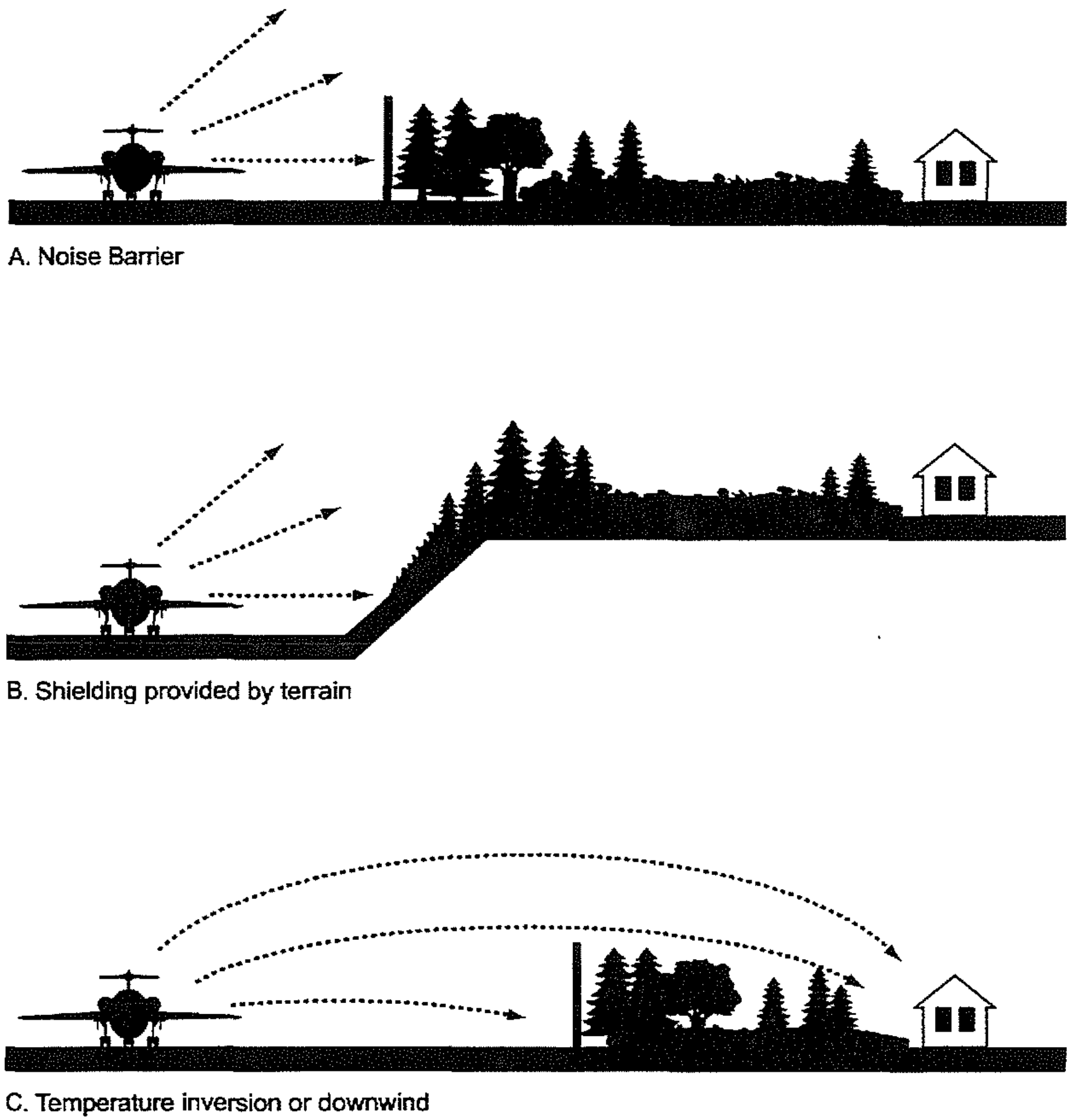


Figure 7-1.2. Noise Barrier Concepts

7.2 Reverse Thrust Noise

As with start-of-takeoff noise, options for minimizing noise generated during the use of thrust reversers include operational measures (including reduced use of thrust reversers and preferential use of runways and taxiways), noise-reducing barriers and berms, and sound insulation.

7.2.1 Reduction of Use of Thrust Reversers

Many factors influence the noise levels generated during the use of thrust reversers. These may include aircraft type, aircraft weight, weather conditions, the condition of the runway surface (as it influences the aircraft's ability to brake), the intended taxiway to be used when exiting the runway, operating procedures of each airline, and the individual technique of the pilot. Although many of these factors cannot be readily controlled, a preliminary analysis at Seattle-Tacoma International Airport showed that special procedures employed by Alaska Airlines to minimize the use of thrust reversers appear to reduce noise levels by about five decibels[30]. It is recognized that reduced use of thrust reversers may result in increased runway occupancy times and, therefore, may be feasible only during periods of low operations.

Lambert-St. Louis International Airport, Norfolk International Airport, Santa Monica Airport, and T.F. Green Airport (Providence) provide examples of airports that encourage the use of minimum reverse thrust consistent with safety, runway conditions, and available runway length to reduce aircraft ground noise. As a result of reduced wear and tear on aircraft engines and reduced fuel consumption, it is likely that the use of minimum reverse thrust would represent a cost savings to the airlines.

Recommendation: It is recommended that ANC discuss with airlines and ATC the feasibility of employing reduced thrust, especially during nighttime or other periods of low operations when noise from thrust reversers is likely to be most noticeable and when increased runway occupancy times are not critical.

In addition to airline operating procedures to minimize use of thrust reversers, the following sections regarding preferential runway use and preferential taxiway use offer recommendations to further minimize the use of thrust reversers through airport operating policies.

7.2.2 Preferential Runway Use

As described above, ANC employs a Preferential Runway Use Program, which was developed to ensure that "aircraft noise is minimized in residential neighborhoods surrounding the Airport, consistent with safe aircraft operations." The normal flow of aircraft operations at ANC, contingent upon weather conditions, is to land to the east or to the south and to depart to the north or to the west. The preferential runways for arrivals are shown below in Table 7.2-1 in order of priority.

As discussed above, the Preferential Runway Use Program was designed to minimize overall noise exposure from all aircraft operations and was intended primarily to limit direct overflights of residential areas and to reduce runway sideline noise. Within the priorities of this program,

[30] "Port of Seattle, Sea-Tac International Airport, Ground Noise Study – Phase II, Final Report," Prepared by Mestre Greve Associates, December 1996, page 5-5.

the following recommendations may be made, however, to minimize the effects of noise from reverse thrust.

Table 7.2-1. Arrival Runways in Order of Priority

Preference	Daytime (07:00 to 22:00)	Nighttime (22:00 to 07:00)
1	Rwy. 6R/6L/14	Rwy. 6R/6L/14
2	Rwy. 32	Rwy. 32
3	Rwy. 24L/24R	Rwy. 24L/24R
Source: ANC Airport Bulletin 2000-16, August 2000.		

Runways 6R and 6L

It is recommended that Runway 6R be given the highest priority for arrivals (based on the Preferential Runway Use Program, Runways 6R and 6L share highest priority with Runway 14 for arrivals). Although Runway 6R is slightly closer to residential areas south of the Airport than Runway 6L, the relatively small difference in distances is insignificant[31]. Use of Runway 6R, however, may allow for lower power settings or shorter durations of reverse thrust because the location of most airport facilities (such as the passenger terminal complex and North Airpark) relative to the end of the runway. In contrast, pilots landing aircraft on Runway 6L have an incentive to stop the aircraft as quickly as possible to minimize taxi distances.

Arrivals on Runway 14

When considering only the effects of noise from reverse thrust, Runway 14 would be recommended as the preferred arrival runway because (1) residential areas are located farthest from the typical area on the runway where thrust reversers are employed, compared to the other available runways[32], and (2) because the passenger terminal complex is located near the end of Runway 14, arriving pilots have little incentive to use thrust reversers to exit this runway early (although an exception is cargo aircraft going to North Airpark).

The standard operating configuration at ANC, however, which provides the highest capacity and minimizes noise impacts, is to arrive on Runway 6R and to depart on Runway 32. Use of Runway 14 for arrivals during use of Runway 32 (the preferred departure runway) for departures would require head-to-head operations and may be feasible only during periods of low activity and when weather conditions permit. In addition, ATC has commented that the configuration with ANC landing on Runway 14 and Elmendorf Air Force Base (EDF) landing on Runway 5 reduces the landing capacity of both facilities significantly[33]. For these reasons, it is

[31] Based only on spherical divergence of sound energy, the L_{max} for a thrust reversal on Runway 6L would be about 1.5 dB less than on Runway 6R. Differences in A-weighted sound levels of less than 3 dB generally are difficult to distinguish.

[32] Measured from the midpoint of each runway, the closest residences to Runway 14 are approximately 6,800 feet away, compared to 3,200 and 3,500 feet for Runways 6R/24L and 6L/24R, respectively.

[33] J. Craft.

recommended that this option be considered only during nighttime periods of low activity when thrust reverser noise may be most noticeable.

Recommendation: Within the context of the existing Preferential Runway Use Program, consider the feasibility of prioritizing arrivals on Runways 6R and 14. It is recognized that use of Runway 14 for arrivals while departures are occurring on Runway 32 would require head-to-head operations, which create safety concerns for ATC. In addition, arrivals on Runway 14 may result in reduced capacity both at ANC and at EDF. For these reasons, use of Runway 14 arrivals for noise abatement purposes may be feasible only during periods of very low activity and certain favorable weather conditions and should be discussed with ATC prior to further action.

7.2.3 New High-speed Taxiways and Preferential Taxiway Use

Pilots should be encouraged to use existing high-speed taxiways, to the extent that this measure would limit use of thrust reversers and reduce runway dwell times. In addition, within the context of overall airport efficiency and the Master Plan process, ANC should improve existing taxiways or construct new high-speed taxiways. It is likely that these measures would decrease congestion by reducing the time spent before arriving aircraft exit runways, as well as reducing use of thrust reversers.

When high-speed taxiways are not available, pilots should be encouraged to exit runways using later, rather than earlier, taxiways, thus reducing the incentive for use of reverse thrust. Because implementation of this measure may increase runway dwell times, taxi distances and times, and taxiway congestion, it is likely that would be feasible only at night or during other periods of reduced operations.

Recommendation: It is recommended that ANC discuss with aircraft operators and ATC the feasibility of implementing a program of preferential taxiway use for exiting runways after arrival. In addition to preferential use of existing taxiways, it is recommended that ANC study the need and the feasibility for additional high-speed taxiways. Potential candidates include improvements to Taxiways Golf and Mike to facilitate high-speed movement off of Runways 6R and 14, respectively, and the addition of a north-south taxiway, possibly with high-speed exits, located west of Runway 14/32 to reduce congestion on Taxiway Romeo for aircraft exiting Runway 14. Because of the potential effects on circulation of aircraft at ANC, these recommendations should be evaluated within the context of overall airport efficiency and the Master Plan process.

7.2.4 Relocation of Runway 6R/24L to West

Pilots arriving on Runway 6R who are destined for the terminal complex or North Airpark via Taxiway Romeo may prefer to exit the runway at either Taxiway Golf (preferably) or Taxiway Delta to reduce overall taxiing time. These pilots, therefore, have an incentive for substantial use of reverse thrust. The relocation of Runway 6R/24L approximately 1,500 feet to the west would have the potential to reduce the effects of noise from the use of thrust reversers during arrivals on Runway 6R in two ways:

- The primary benefit of landing farther to the west would be the reduction in the use of thrust reversers (in terms both of power and duration) required to allow aircraft to exit the runway on Taxiways Golf or Delta.

- A secondary benefit would be that thrust reversers generally would be used farther from most residential areas. However, both because thrust reversers are used within a fairly long stretch of the runway and because the change in distance to most homes would be relatively small, this secondary benefit would be modest.

Recommendation: Relocating Runway 6R/24L 1,500 feet to the west would have the potential to reduce the effects of noise during Runway 6R arrivals primarily by reducing the amount of reverse thrust required to allow aircraft to exit the runway on Taxiways Golf or Delta. If the runway relocation were warranted for other operational reasons, such as improving airport efficiency or safety, the noise reduction provided by reduced use of thrust reversers would provide an additional benefit and should be evaluated within the context of overall airport efficiency and the Master Plan process. Because of ATC's concerns regarding the potential operational impacts of relocating Runway 6R/24L (as described in Section 7.1.3), it is recommended that further consideration of this option should be closely coordinated with ATC to establish procedures that would minimize operational impacts.

7.2.5 Noise Barriers or Berms

Much of the above discussion regarding noise barriers and berms to reduce start-of-takeoff noise relates directly to noise from use of thrust reversers. In addition, many of the same factors limiting the effectiveness of barriers and berms for reducing start-of-takeoff departure noise also apply to noise from use of thrust reversers. For the reasons described below, combined with the locations and orientations of runways at ANC, the locations of affected communities relative to potential noise barrier locations, and local topography, it is unlikely that noise barriers would provide a noticeable reduction in reverse thrust noise for residential areas near ANC.

- *Noise barriers or berms reduce noise levels by blocking the direct sound transmission path from the noise source to the listener. When the direct sound propagation path already is broken by intervening structures, terrain, or by dense, broad areas of trees and heavy vegetation, noise barriers may provide very little, if any, incremental benefit.* Most residential areas around ANC do not have a direct line of sight to the portion of runways where thrust reversers are employed. Direct line of sight to most areas south of the Airport from all departure runways generally is shielded by terrain. For areas to the east of the Airport, although direct line of sight to the central portion of Runway 14/32 is only partially blocked by buildings, there is no feasible location for a substantial noise barrier in the vicinity of the runway. Although it is possible that a substantial noise barrier or berm located along the Airport's boundary east of the gravel strip could provide some benefit, it is likely that it would be limited to only the first one or two rows of homes[34].
- *Noise barriers or berms are most effective when they can be located close to either the noise source or to the listener. Barriers and berms are least effective when they are located approximately midway between the source and the listener.* Because of FAR Part 77 restrictions (governing locations and heights of structures near runways) and operational requirements (including maintaining access to taxiways and ramps and allowing FAA tower personnel to maintain visual contact with aircraft on the ground,

[34] Such a barrier would provide little benefit for departure noise since homes in this area are exposed to the highest noise levels from departures on Runways 32, 6R, and 6L once the aircraft are airborne.

there are no feasible locations for noise barriers or berms close to Runway 32. As discussed above, although it is possible that a substantial noise barrier or berm located along the Airport's boundary east of the gravel strip could provide some benefit, it is likely that it would be limited to only the first one or two rows of homes.

- *The benefits of noise barriers or berms may be reduced substantially by certain weather conditions, including wind blowing from the noise source towards the listener or temperature inversions. Under either of these weather conditions, sound may propagate in downward-curving paths (or "refracted") paths, circumventing the barrier's effectiveness. This reduction in benefit is most pronounced when the barrier is not close to either the noise source or to the listener.* To the extent that it is not feasible to locate noise barriers or berms close to either the noise source or the listener, any selected barrier location would be particularly susceptible to the effects of weather.
- *Noise barriers or berms are most effective at controlling high-frequency noise sources and are least effective at controlling noise sources with significant low-frequency content.* Reverse-thrust noise, like start-of-takeoff noise from jet aircraft, is characterized by significant low-frequency components.

Recommendation: Because of these issues, combined with the limitations imposed by the locations and orientations of runways at ANC, the locations of affected communities relative to potential noise barrier locations, and local topography, it is unlikely that noise barriers would provide a noticeable reduction in reverse thrust noise for residential areas near ANC and further study is not recommended.

7.2.6 Residential Sound Insulation

Because of the similarity in the low-frequency components of noise from start-of-takeoff and from use of thrust reversers, the sound insulation discussion provided previously in Section 7.1.5 for start-of-takeoff applies to reverse thrust as well.

Recommendation: Currently, there is no FAA approved standard to measure or assess the effects of low-frequency noise, and there is still a debate on the effectiveness and benefit of any residential sound insulation that addresses low-frequency noise. Once an FAA standard is in place regarding low-frequency noise, the Airport should assess the feasibility and costs associated with incorporating low-frequency treatments/standards during residential sound insulation. At that time, areas where additional sound insulation would be required to address low-frequency noise and candidate treatments for their effectiveness not only in reducing A-weighted noise levels, but also for reducing low-frequency noise and vibration should be evaluated. In addition, the added costs associated with low-frequency sound insulation should be evaluated at that time and acceptance-testing standards accounting for reduction in low-frequency noise should be considered.

7.2.7 Nighttime Arrival Curfew

Through its actions and statements since the passage of the Aircraft Noise and Capacity Act of 1990 and FAR Part 161, the FAA has clearly indicated that it would vigorously oppose new airport use restrictions. In addition, a nighttime curfew on aircraft operations is counter to the federal grant assurances agreed to by the State DOT and PF. Due to the level of nighttime operations at ANC for both passenger and air cargo aircraft, prohibiting arrivals at night may prevent air carriers from meeting the demands of air travelers and air shippers and, to the extent that the FAA perceives a nighttime curfew on departures as a de facto access restriction, a FAR Part 161 study may be required prior to implementing the nighttime curfew. For these reasons, a nighttime arrival curfew is not recommended at this time.

Recommendation: No action is warranted at this time.

7.3 Taxiing and Idle Noise

Although noise from taxiing and idling aircraft is lower in sound level than other sources of ground noise such as start-of-takeoff and reverse thrust, it has the potential to be annoying, especially when several taxiing aircraft combine to increase the overall sound level and when queuing of aircraft prior to departure increases overall taxiing/idle time. In these situations, noise from multiple aircraft often is perceived in the community as one continuous event and contributions from individual aircraft may be indistinguishable. Options to reduce the effects of taxiing and idle noise include minimizing queuing through operational measures, taxiing with only one engine, preferential use of taxiways, construction of new taxiways to reduce congestion and taxiing time, noise barriers and berms, and residential sound insulation. In general, recommendations affecting ground movements of aircraft at ANC (such as operational measures to minimize queuing, preferential use of taxiways, and construction of new taxiways) should be evaluated in concurrence with overall considerations of efficient circulation and within the context of the Master Plan process.

7.3.1 Options to Minimize Queuing

Noise from taxiing aircraft is most noticeable when aircraft are in departure queues near the ends of runways for the following reasons:

- In some cases, this is when the aircraft are at the closest point to residential areas.
- Multiple aircraft waiting to depart result in higher combined noise levels.
- High-frequency compressor or turbine noise from the front of the engines is the most noticeable source of annoyance with taxiing aircraft. Aircraft queued on certain taxiways (including Taxiway Romeo waiting for departure on Runway 32) are oriented with the front of the engines towards community areas.
- During periods of high activity, several aircraft may be queued for several minutes each causing a prolonged, continuous noise event.

Recommendation: Because options intended to reduce queuing at runway ends, such as holding aircraft at gate areas or other holding areas, would be likely to have negative operational impacts and would provide relatively modest benefit, further consideration is not recommended. In addition, ATC does not support this option due to anticipated negative operational effects, including delays, additional complexity, and controller workload not related to providing aircraft separation services[35].

[35] J. Craft.

7.3.2 Taxi with Single Engine Operating

Noise from taxiing aircraft may be reduced by taxiing on one engine (or fewer than the maximum) from the terminal or ramp area to the departure threshold as well as from the runway after landing to the ramp or terminal. The aircraft engine most distant from the residential area would be designated as the taxi engine due to the shielding provided by the aircraft fuselage. Implementing this type of procedure would be on a voluntary basis and would need to be coordinated with the aircraft operators and air traffic control personnel.

Due to the close proximity of the passenger terminal to the Runway 32 departure threshold and Runway 6 landing rollout point, this type of procedure may be impractical to implement for aircraft originating at or destined for the terminal complex when aircraft are departing on Runway 32 and landing on Runway 6. The procedure may be beneficial for aircraft taxiing for departure from: (1) North Airpark to Runway 32, 6, and 24; (2) East Airpark to Runway 14 or Runway 6; and (3) South Airpark to Runway 6, 32, or 14. The procedure may also benefit aircraft landing on: (1) Runway 32 destined for the terminal complex, East Airpark, and South Airpark; (2) Runway 14 destined for North Airpark, East Airpark, and South Airpark; (3) Runway 6 destined for North Airpark; and (4) Runway 24 destined for all areas.

It is recognized that this measure could increase queuing time on taxiways and may be more likely to be implemented with arriving rather than departing aircraft. In addition, it may not be feasible for some aircraft, particularly heavy cargo aircraft. As noted by some operators, most airlines employ single-engine taxiing, at the pilot's discretion, when conditions warrant. A prime consideration is the issue of breakaway thrust, especially if multiple starts and stops are required during taxiing. There also is some evidence that single-engine taxiing may increase overall operating costs. If aircraft operators and air traffic control personnel are supportive of this measure, strategically placed airfield signage may request the use of reduced-engine taxi and remind pilots of "all engine start" near departure thresholds.

Recommendation: Implement voluntary reduced-engine taxi procedures on carrier-specific basis in coordination with aircraft operators and air traffic control personnel.

7.3.3 Preferential Taxiway Use

Use of taxiways (1) located farther from residential areas and (2) oriented such that the front of the taxiing aircraft's engines are not directed toward residences would minimize the effects of taxi and idle noise.

As an example, Boston's Logan International Airport has noise abatement procedures for aircraft taxiing to departure runways, which include "hold short" lines on certain taxiways. In addition, jet and turboprop aircraft are not permitted to taxi under their own power, except when moving directly to or from a runway in connection with a takeoff or landing by that aircraft.

Recommendation: Because of the existing runway and taxiway layout at ANC, few options exist for taxiing to runways prior to departure or from runways after arrival. To the extent feasible, however, it is recommended that aircraft waiting to depart on Runway 32 queue on Taxiways Kilo or Lima (instead of Taxiway Romeo) to minimize exposure of residences south of ANC to the high-frequency noise emitted from the front of aircraft engines. ATC does not support this option due to the potential for ground delays resulting from aircraft having to taxi farther to reach departure runways and limiting of taxiways for aircraft crossing and exiting the east-west runways and en-route to the domestic terminal and east airfield areas[36]. Because of potential effects on airport circulation, these measures should be considered in coordination with ATC and within the context of overall airport efficiency and the Master Plan process.

7.3.4 Construction of New Taxiways

Construction of new taxiways would help to reduce congestion on taxiways and would reduce overall taxi times. New high-speed exit taxiways, in addition to potentially reducing use of thrust reversers (as discussed previously in Section 7.2.3), would allow arriving aircraft to exit runways more quickly, thus reducing taxi and idle time for aircraft queuing for departure. The construction of a new north/south taxiway on the west side of Runway 14/32 would provide additional access to and from North Airpark, thus reducing congestion and overall taxiing time during busy periods.

Recommendation: The construction of new taxiways, including additional high-speed runway exits and a new north/south taxiway on the west side of Runway 14/32, would provide noise-reduction benefits by reducing overall time spent by aircraft taxiing and holding on taxiways. These measures should be considered within the context of overall airport efficiency and the Master Plan process.

7.3.5 Noise Barriers and Berms

As described above, noise barriers and berms are most effective when located close either to the noise source or to the listener. Because (1) taxiing occurs throughout the Airport and (2) the locations of barriers close to runways and taxiways is significantly restricted by FAR Part 77 surfaces, locating noise barriers close to taxiways to reduce taxi noise is not a feasible option. Also as described above, because of the locations and orientations of taxiways and runways at ANC, the locations of affected communities relative to potential noise barrier locations, and local topography, it is unlikely that noise barriers would provide a noticeable reduction in aircraft taxi and idle noise for residential areas near ANC.

Recommendation: Because of these issues, it is unlikely that noise barriers or berms would provide a noticeable reduction in aircraft taxi and idle noise for residential areas near ANC and further study is not recommended.

7.3.6 Residential Sound Insulation

Although it is unlikely that residential sound insulation would be recommended primarily to reduce noise from taxiing aircraft, a residential sound insulation program intended to reduce noise levels from louder events such as start-of-takeoff roll and reverse thrust also would be effective in reducing interior noise levels due to taxiing aircraft. Because taxiing aircraft typically generate less low-frequency noise than aircraft starting takeoff roll and using thrust reversers, taxi noise can be reduced more effectively through the use of standard sound insulation treatments. As a result, standard treatments such as retrofitting window and doors with special acoustical windows and doors and reducing the effects of "flanking paths" and "leaks" such as ventilation openings and poorly-fitting door gaskets, generally will be effective in reducing noise from taxiing aircraft.

[36] J. Craft.

Recommendation: Although it is unlikely that residential sound insulation would be recommended solely to mitigate noise from taxiing and idling aircraft, implementation of a sound insulation program would provide mitigation for these noise sources.

7.4 Auxiliary Power Units

Noise from APUs is audible under some conditions in residential areas. Due to the sometimes extended nature of APU operations (lasting up to several hours), APU noise has the potential to be annoying despite relatively low sound levels, particularly at night when background sound levels are lowest. Available abatement measures include discontinuing non-essential APU use, substituting ground power for APUs, re-orienting aircraft during APU use, noise barriers or berms, and use of airport buildings to provide noise shielding. Although noise from APUs may be reduced significantly by these measures, it is unlikely that APU use can be completely eliminated since, in addition to providing ground power, APUs typically are used to start the aircraft's main engines and to heat or cool the aircraft.

7.4.1 Discontinuation of Non-essential APU Use

During some layover periods, when electrical service and heating or cooling are not required on aircraft, it may be possible to discontinue APU use. This option may be practical for overnight layovers of passenger aircraft, or for cargo aircraft with extended waits between unloading and loading. The Airport should develop recommendations on the reduction of non-essential APU use that could be satisfied either by discontinuing APU use or by using ground power (see below for discussion of ground power).

The following airports provide examples of those that have implemented APU operating restrictions:

- *T.F. Green Airport* (Providence, Rhode Island): APU use prohibited between midnight and 6:00 AM.
- *San Francisco International Airport:* APU use prohibited between 10:00 PM and 6:00 AM with the following exceptions: 30 minutes prior to departure, when aircraft is under tow, when passengers are aboard, and when needed to test other aircraft equipment.
- *Sarasota-Bradenton International Airport:* APU use prohibited between 10:00 PM and 7:00 AM.
- *Mercer County Airport* (Trenton, New Jersey): APU use prohibited between midnight and 6:00 AM.
- *Hanscom Field* (Bedford, Massachusetts): APU and GPU use prohibited outside of hangars between 11:00 PM and 7:00 AM unless part of takeoff procedures or necessary maintenance procedures.

It is likely that these reductions would represent a cost savings to the airlines because it reduces wear and tear on the APU and reduces fuel consumption. This reduction of APU use may also have the additional benefit of reducing emissions.

Recommendation: In coordination with aircraft operators, and in conjunction with the implementation of increased availability of ground power, develop recommendations on the reduction of non-essential APU use. In addition, develop a bulletin noting possible options to reduce APU use and educate tenants on the benefits of reduced usage.

7.4.2 Substitution of Ground Power and Pre-conditioned Air for APUs

APU noise may be reduced by using ground power units (GPUs) or through the use of "plug-in" ground power outlets and the use of pre-conditioned air.

- GPUs are portable diesel- or gasoline-powered generators that can be used to supply power to aircraft while they are stationary on the ground. Although the noise levels produced by GPUs are not insignificant (they are similar to an idling diesel truck), they are considerably lower than the noise levels produced by a typical APU. In addition, intervening buildings and noise barriers located between the ramp and residential areas provide more effective shielding for noise from GPUs, which are located only several feet above pavement level, than noise from APUs, which typically are located on the aircraft 15 to 25 feet above pavement level.
- "Plug-in" ground power may be provided either by 400-Hz solid-state units (typically attached to passenger boarding bridges) or by building-powered motor generator sets (that may supply several gates).
- Pre-conditioned air, either for heating or cooling, is provided to aircraft through ducts (typically attached to passenger boarding bridges) from a central heating/cooling plant.

Currently at ANC, ground power outlets, maintained by the airlines, are available at only a limited number of passenger terminal gates, including B Concourse at the South Terminal and Gates N1 and N3 at the North Terminal[37]. None of the A Concourse gates currently are equipped with operable ground power outlets. Although plug-in ground power is not available for cargo operators at ANC, some operators use GPUs under some circumstances. For example, some cargo operators currently use GPUs when aircraft will be on the ground for extended periods, but APUs are used extensively during daily operations.

Even if ground power were made available at all passenger and cargo facilities, it would not, however, completely eliminate the use of APUs for the following reasons:

- APUs are needed to start the aircraft's main engines. Typically, the APU would be started approximately 30 minutes before the scheduled departure.
- APUs are used to heat the aircraft. Although pre-conditioned air can be delivered to passenger aircraft via ductwork attached to passenger boarding bridges, on-site compressors and extensive ducts may be required to reach cargo aircraft distributed around large ramp areas.
- Maintenance sometimes is performed on cargo and passenger aircraft during cargo unloading/loading or passenger deplaning/enplaning. Often, the maintenance procedures require the APU to be running.

[37] Both building-powered motor generator sets (that may normally supply several gates) and 400 Hz solid-state units attached to the passenger boarding bridges are used at ANC.

- Maintenance requiring operation of the APU may sometimes need to be performed at locations where alternative power is not readily available.
- There may be reluctance to use ground power for short periods because frequent starting and stopping of APUs on aircraft can contribute to excessive wear on the APU.

Several operators have indicated that they would support reduced APU use, provided that stable alternative ground power can be provided. APUs are less fuel efficient than most ground power units and are expensive to run from a maintenance standpoint. Given these economics, most airlines would prefer not to run APUs beyond what is required.

Many airports including San Francisco International and Boston's Logan International provide ground power and pre-conditioned air at all gates. The new North Terminal project at San Diego International Airport will include 400-Hz ground power and pre-conditioned air at all gates, and new passenger boarding bridges installed at Sacramento International Airport during the fall of 2001 feature 400-Hz power hook-ups.

It is likely that this reduction would represent a cost savings to the airlines because it reduces wear and tear on the APU and reduces fuel consumption. This reduction of APU use may also have the additional benefit of reducing emissions.

Recommendation: It is recommended that ground power and pre-conditioned air be provided at all existing and new passenger terminal gates, including the new C Concourse, to reduce the use of APUs at the passenger terminals. In addition, it is recommended that access to ground power and pre-conditioned air be installed at new cargo facilities, as they are constructed. Although the absence of passenger boarding bridges and other gate facilities is likely to make retrofitting existing cargo facilities with ground power and pre-conditioned air more costly than passenger terminals, it is recommended that the feasibility of retrofitting cargo areas be determined. If the use of ground power outlets is not feasible for cargo facilities, GPUs (instead of APUs) should be used whenever feasible.

7.4.3 Re-orientation of Aircraft During Periods of APU Use

For most aircraft, the highest sound levels from APUs generally occur to the rear of the aircraft, at about a 45-degree angle from the aircraft's tail. Because of this, orienting APU exhaust ports away from residences may reduce sound levels in residential areas. Whenever feasible, the orientation of parked aircraft should be considered when designing new facilities. This measure also can be considered for existing facilities, although re-orienting parked aircraft may not be feasible due to space restrictions, existing taxiways, and other existing infrastructure such as light posts. Re-orientation of parking locations at existing facilities also may require additional tugging and pushing-in and may present safety issues due to jet blast. In addition, because the parking orientations of passenger aircraft are dictated by the existing terminal and jetway locations, this measure can not readily be applied to passenger aircraft.

As an example, Boston's Logan International Airport requires that aircraft be positioned so that the APU exhaust is shielded from the nearest residential area by the aircraft's fuselage.

If considered as a part of planning new facilities, the cost of this measure should be minimal.

Recommendation: To the extent feasible within the constraints of existing airport infrastructure, aircraft operators should be encouraged to orient parked aircraft with APU exhausts away from the closest residential locations:

- Noise levels in the Turnagain area caused by cargo aircraft APUs at North Airpark facilities could be reduced by orienting parked aircraft with APU exhausts oriented away from the closest residences to the east.
- Annoyance caused by APUs of air cargo B747s in East Airpark may be reduced by parking aircraft with APU exhausts oriented away from the closest residential areas to the northeast in Spenard.

It is recognized that this option may not be feasible at some existing facilities due to space restrictions, taxiing requirements, and jet-blast issues. In addition, implementation of this measure should be coordinated with ATC to assess any impact it may have on line of sight from the ATC tower.

7.4.4 Use of Buildings to Provide Noise Shielding

Passenger terminals and cargo facility buildings can provide effective noise reduction, by acting as noise barriers, if they are sufficiently high, are located between the aircraft and residential areas, and if the aircraft are parked sufficiently close to the building. The South Terminal provides significant shielding for the Turnagain area, which will be increased with the completion of C Concourse. Existing cargo facilities in the North Airpark also provide some shielding for the Turnagain area.

These are examples of airport buildings that have purposely been constructed or configured to provide shielding from ground operations noise:

- At Boston's Logan International Airport, a 45-foot high revenue-producing office building was constructed by Massport (the airport's operator) to serve as a noise barrier to benefit a nearby residential community.
- Fort Lauderdale Executive Airport requires new buildings in certain areas to be linked by noise barrier walls, effectively creating a continuous noise barrier comprised largely of airport buildings.
- At Tampa International Airport, a noise barrier was constructed to link two large maintenance hangars, creating a contiguous noise barrier incorporating the hangars.
- At Baltimore/Washington International Airport, the Mid-Field Cargo Facility was designed with the building located between the community and aircraft parking locations. In addition, all parked aircraft are situated so that engine and APU exhaust ports are directed towards the airport rather than the community.

If considered as a part of planning new facilities, the cost of this measure should be minimal, although it may reduce the potential number of aircraft parking spaces.

Recommendation: New cargo facilities proposed for the North Airpark area should be designed so that buildings are located between the aircraft ramp area and residences to the east, parallel to Taxiway Romeo. It is recognized that this recommendation may impact operational efficiency of the planned facilities and therefore would need to be developed in close coordination with the tenants.

7.4.5 Noise Barriers or Berms

In some situations, noise barriers or berms may help to reduce noise caused by APUs, particularly if the noise barrier can be located relatively close to the parked aircraft. This mitigation measure would provide the most benefit in locations such as East Airpark where aircraft are parked relatively close to residential areas and noise from APUs is sometimes noticeable as a distinct, individual noise source. A noise barrier in such a location, where parked aircraft are visible from community locations, would provide a visual buffer in addition to reducing noise from taxiing and engine start-up and idle.

Because APUs are located high above the ground on many aircraft (for example, the APU exhaust outlet on a B747 is approximately 25 feet above ground level), a noise barrier would have to be sufficiently high to block the direct sound propagation path from this height. Due to this issue, it is possible that construction of noise barriers may be infeasible due to interference with FAR Part 77 surfaces or not economically reasonable, compared to other mitigation measures such as the use of ground power or the reorientation of parked aircraft. For example, a noise barrier or berm for the East Airpark area that is 30 feet in height and 1,000 feet in length may reduce APU noise levels by about 5 to 10 decibels in nearby residential areas. A lower noise barrier would provide little or no noise reduction from APUs on B747 aircraft. Figure 7.4-1 shows the potential location for such a barrier between the air cargo ramp and the Airport Access Road.

A wide variety of materials is available including concrete or metal panels, masonry block, wood, earth berms, or berm/barrier combinations. The majority of these materials provide similar acoustical benefits, but vary in durability, appearance, upkeep and cost. If fill material is available, earth berms provide an attractive option because they require minimal upkeep. Because earth berms typically require at least a 2:1 (horizontal:vertical) slope, however, they require considerable space. For example, a 30-foot high berm would require at least a 120-foot wide footprint. The width of the berm may be reduced by using a berm/barrier combination. For example, a 15-foot high berm could be constructed with a 15-foot high wall running along the top. The barrier/berm combination would provide approximately the same benefit as a 30-foot high berm, but would require only a 60-foot wide footprint.

Based on a rough cost estimate of $20 per square foot, a 1,000-foot long, 30-foot high barrier would cost approximately $600,000. This unit cost includes materials, footings, and installation, but does not include engineering design, provision for relocation of utilities or drainage, or landscaping. Actual costs may vary considerably. Because of high variability in the cost of fill, we have not provided cost estimates for berm or berm/barrier combinations. Approximately 30 of the closest homes between Spenard Road and International Airport Road are clustered in an area where a noise barrier or berm may have the potential to reduce APU sound levels by approximately 5 to 10 decibels. The approximate noise-reduction values and costs provided here are preliminary estimates. A design study should be performed by a qualified acoustical consultant prior to construction to ensure that the barrier or berm provides the intended benefit. In addition, although a preliminary review of FAR Part 77 surfaces indicates that the recommended height would be feasible, a thorough review should be conducted to ensure that the barrier complies with all applicable regulations.

The following are examples of noise barriers constructed to provide shielding from airport ground operations noise:

- At Miami International Airport a noise barrier shields residents in the adjacent community from noise generated by aircraft ground operations at the Airport's North Side cargo facility.
- At San Diego International Airport, a 25-foot high noise barrier is under design to shield an adjacent Marine Corps training facility from aircraft ground operations noise.
- At New York City's LaGuardia Airport a noise barrier along the airport's western boundary shields the adjacent neighborhood from airport ground operations noise.
- At Tampa International Airport, a noise barrier links two large maintenance hangars, shielding a neighboring residential area from ramp noise.

Recommendation: The East Airpark area is the only feasible location that has been identified where a noise barrier may be effective in reducing noise from APUs. Because of the potentially high cost, however, it is recommended that alternative methods of reducing APU noise, in particular the use of ground power or the reorientation of parked aircraft, be considered as higher priorities. If operational measures are deemed insufficient and/or if the additional benefits of a barrier (such as providing a visual screen and reducing noise from engine start-up, idle, and taxiing) are perceived as valuable at this location, a noise barrier feasibility and design study should be conducted.

Figure 7.4-1. Potential East Airpark Noise Barrier Location
(Red line indicates noise barrier alignment)

7.5 Aircraft Maintenance Engine Run-ups

Alternatives to reduce annoyance caused by aircraft maintenance engine run-ups include more stringent nighttime restrictions, optimizing the orientation of aircraft conducting run-ups with respect to residential areas, construction of a new run-up area, use of noise barriers or berms, and construction of a Ground Run-up Enclosure (GRE).

7.5.1 Nighttime Restrictions

Currently at ANC, Airport Bulletin No. 2000-16 limits nighttime run-ups above idle power "to those aircraft which are hard scheduled for a flight prior to 0800 local time." In addition, the Bulletin states "every effort should be made to avoid engine run-ups during quiet hours." All nighttime run-ups must be approved in advance by the Airport Operations Officer on duty. Although no restrictions are placed on idle-power runs during nighttime hours, notification of Airport Operations is required in advance.

Airports that require approval of nighttime run-ups often keep detailed logs of the run-up activity including the aircraft operator, run-up location and orientation, aircraft type, start time, end time, and power setting. These logs are valuable for a number of reasons including investigation of run-up noise complaints, correlating run-up activity with measured noise levels, tracking the number and types of run-ups, and discussing the need for further restrictions on run-up activity. Although ANC currently keeps logs of run-up activity based upon requests to conduct nighttime run-ups, the logs indicate intended run-up activities rather than actual events. The value of these logs would be enhanced if operators reported the information described above following completion of the run-up, in addition to requesting permission to conduct run-ups in advance.

As an example, for any run-ups between 10:00 PM and 7:00 AM (other than idle-power checks of single engines limited to five minutes or less), San Francisco International Airport requires prior approval by the Operations Supervisor. *After* the run-up is conducted, the airline's Maintenance Supervisor must provide the Airport a monthly report detailing the following: date and time of the run-up, type of aircraft, aircraft identification, run-up location, run-up duration, explanation of the circumstances making the run-up necessary.

Annoyance from nighttime run-ups at ANC could be reduced further through the implementation of more stringent regulations further restricting the time and/or allowable duration of nighttime run-ups. Examples of more restrictive regulations in use at other airports include (1) the complete prohibition of nighttime run-ups above idle power, (2) restrictions limiting run-ups to one or two hours before the aircraft's scheduled departure time, and (3) limiting nighttime full-power run-ups to a one-time run-up of less than two minutes duration.

Summaries of Nighttime Run-up Policies

The nighttime run-up policies of four airports are summarized below. The complete policies are reproduced in Appendix D. These policies are intended to provide examples of restrictions that have been implemented at other airports. Because these policies may have dramatic effects on aircraft operators, it is recommended that implementation of any additional restrictions on nighttime run-ups be conducted in close coordination with affected airport tenants.

Baltimore-Washington: The run-up policy at BWI prohibits run-ups between 10:00 pm and 6:00 am. Nighttime run-ups are allowed, however, with prior permission if "it can be shown that failure to conduct the run-up will delay departure of a scheduled passenger flight." Approved run-ups may occur at any time during the night. In addition, run-ups are restricted to specified locations and headings and run-ups above idle power are limited to "a maximum of 60 seconds or less at a time."

Seattle-Tacoma: The run-up policy at SEA prohibits run-ups between 10:00 pm and 7:00 am, with the exception of aircraft that are scheduled to depart between 7:00 am and 8:30 am. These aircraft may conduct idle-power run-ups after 6:00 am, with prior approval of Airport Operations. If it is "absolutely necessary" to conduct a full-power run-up before 7:00 am, a one-time run-up of less than two minutes duration may be conducted, after 6:00 am, with prior approval. The policy also limits maintenance run-ups to "locations specified by the Director." These run-up locations are marked on the airfield.

Portland, Oregon: A GRE recently was completed at PDX with the intention of permitting 24-hour unrestricted run-ups in compliance with State noise regulations. Prior to completion of the GRE, the PDX run-up policy prohibited run-ups between 11:00 pm and 7:00 am with certain exemptions, including: most turboprop aircraft (with prior approval), run-ups of jet aircraft at idle power, emergency operations (such as Life Flight or aircraft diverted to PDX and requiring engine tests before continuation of the flight) and unscheduled maintenance up to two hours before a scheduled departure, but no earlier than 4:00 am. Nighttime run-ups for unscheduled maintenance had to receive prior approval from the Airport and be followed-up by a written report. All run-ups had to be conducted at locations approved by the airport manager.

Fort Lauderdale: The policy at FLL prohibits all full-power run-ups between 11:00 pm and 7:00 am and has no provision for exemptions. Idle-power run-ups may be conducted at night only with prior approval. Scheduled nighttime runs at idle power must be requested at least three days prior to the event. Unscheduled nighttime idle-power run-ups must be followed-up by a Letter of Justification. In addition, the policy restricts the locations of idle-power run-ups. (Full-power run-ups may occur between 7:00 am and 11:00 pm, but only at specified locations.)

Comparison of Nighttime Run-up Policies

Full-Power Run-ups: Table 7.5-1 summarizes and compares the run-up policies described above. The policies at all four airports prohibit full-power run-ups at nighttime (defined as 10:00 or 11:00 pm to 6:00 or 7:00 am), although at BWI, SEA, and PDX, full-power run-ups may be conducted during certain nighttime hours with prior permission. Only FLL completely prohibits full-power run-ups at night.

The two columns in Table 7.5-1 labeled "Period of Prohibition of Full-Power" and "Period of Prohibition of Idle-Power" show when run-ups are not permitted under any circumstances (except at PDX, which has a provision for emergencies). Of the four run-up policies compared here, only the BWI policy does not have a no-exemption period for full-power run-ups.

SEA and PDX both limit the timing of approved nighttime run-ups based upon the scheduled departure time of the aircraft. In addition, each of these airports places an absolute restriction on how early in the morning full-power run-ups may occur (6:00 am at SEA and 4:00 am at PDX). SEA further restricts approved full-power run-ups before 7:00 am by allowing only one run-up of not more than two minutes duration. BWI limits run-ups above idle power to 60 seconds at a time, but does not limit the number of repetitions or the time of an approved nighttime run-up.

Idle-Power Run-ups: SEA places the strongest restriction on idle-power run-ups by imposing the same limits as for full-power run-ups (including the absolute prohibition on run-ups between 10:00 pm and 6:00 am). Although the BWI policy restricts idle as well as full-power run-ups, run-ups may be conducted at any time of night with prior approval. FLL approves nighttime idle-power run-ups on a case-by-case basis and PDX allows idle-power run-ups at any time without prior approval.

Table 7.5-1. Summary of Nighttime Run-up Policies

Airport	Nighttime Restricted Period*	Period of Prohibition of Full-Power	Period of Prohibition of Idle-Power	Duration Limit
BWI	10:00 pm to 6:00 am	None	None	Run-ups above idle power limited to 60 seconds or less at a time
SEA	10:00 pm to 7:00 am	10:00 pm to 6:00 am	10:00 pm to 6:00 am	Full-power run-ups limited to a total of two minutes from 6:00 - 7:00 am
PDX	11:00 pm to 7:00 am	11:00 pm to 4:00 am (except emergencies)	None	None
FLL	11:00 pm to 7:00 am	11:00 pm to 7:00 am	None	None
*Nighttime restricted period may allow exemptions, see text.				

Due to the range of possible restrictions and their effects, it is not feasible within the scope and budget of this study to estimate the cost of nighttime run-up restrictions.

Recommendation: ANC's nighttime run-up policy is less restrictive than any of the four other policies provided here. This implies that it may be possible to implement a more stringent policy without imposing an unreasonable burden on airport tenants. Because of ANC's unique role as a major trans-Pacific cargo hub, however, it is likely that nighttime maintenance needs are considerably different at ANC than at other airports. Because adaptation of a more stringent policy may dramatically affect aircraft operators, it is recommended that implementation of any additional restrictions on nighttime run-ups be conducted in close coordination with affected airport tenants.

In addition, it is recommended that Airport Bulletin No. 2000-16 be amended to require tenants to report actual run-up data (including operator, start time, end time, run-up location and orientation, aircraft type, and power setting) to Airport Operations following completion of each run-up.

7.5.2 Optimization of Aircraft Orientation at Existing Run-up Locations

Jet engines, particularly at high power settings, are highly directional noise sources, meaning that the engines are louder in some directions than others (typically, the maximum sound level occurs between 120 and 150 degrees from the engine inlet, depending upon the aircraft type). In addition, the frequency spectrum of the engine noise, which affects its long-distance propagation characteristics, varies considerably with direction. Because of this, the location and orientation of an aircraft during a run-up, with respect to residential areas, can have a significant effect on noise levels heard in community locations.

Anchorage International Airport Bulletin No. 2000-16 provides noise abatement procedures for conducting run-ups, including designated aircraft locations and orientations for engine run-ups above idle power. The two designated locations and orientations are:

- Taxiway Juliet with the aircraft nose heading east at a compass heading of 060 degrees (magnetic).
- Taxiway Quebec with the aircraft nose heading south at a compass heading of 170 degrees (magnetic).

For nighttime run-ups (10:00 pm to 7:00 am), any variance in compass heading must be coordinated with Airport Operations in advance.

The headings presently stipulated by the Airport Bulletin are effective for reducing noise levels in residential areas caused by high-power run-ups because the loudest directional components are directed to non-populated areas (primarily Knik Arm). Under wind conditions requiring orientation of the aircraft nose either to the north or to the west, noise levels in residential areas could be considerably higher. In particular, residences in the Tanaina Hills area south of the Airport may be affected during west-heading run-ups at the Taxiway Juliet location and residences in Turnagain may be affected during north-heading run-ups at the Taxiway Romeo location. Although increased noise effects are unavoidable if aircraft require run-ups during winds from the north or the west, a procedure involving prioritized alternative headings would minimize impacts.

Recommendation: Table 7.5-2 provides a summary of proposed run-up headings and locations recommended to minimize noise impacts. In addition to the two locations and orientations already included in Bulletin 2000-16, the table includes an additional heading (225 degrees true) at the existing Taxiway J location. Figure 7.5-1 displays INM-generated run-up contours showing maximum sound level contours generated by a B747-100 conducting a takeoff-power run-up with one engine at the proposed additional run-up heading (Figure 5.1-16 shows run-up contours for the currently-designated headings). The additional heading is intended to direct the loudest directional components of the run-up noise away from the closest residential areas while allowing run-ups to occur when winds are from the south and west.

Table 7.5-2. Recommended Run-up Locations and Headings

Run-up Location	Aircraft Heading (degrees True)
Taxiway Q	165*
Taxiway J	090*
Taxiway J	225
*Current heading under Airport Bulletin No. 2000-16.	

Under some wind conditions, run-ups may not be feasible at any of the recommended headings, and Airport Operations may need to grant requests for alternate headings. In addition, to the extent that this recommendation would have the potential to restrict use of taxiways and runways, it should be evaluated for feasibility in concurrence with overall considerations of airport efficiency.

Because of the minimal costs associated with this measure, it is recommended that it be implemented as an addendum to Airport Bulletin 2000-16 if determined to be feasible with regard to overall airport efficiency. The addition of markings and signs at designated run-up locations also are recommended to help obtain greater adherence to the desired procedures and headings. Prior to doing so, it is recommended that ANC staff discuss the proposed recommendation with aircraft operators to determine the potential impact on maintenance operations. In addition, the need for additional paving and/or blast deflectors to reduce the potential for jet-blast erosion and foreign object contamination of runways and taxiways should be explored with Airport Operations and Planning Staff.

7.5.3 New Run-up Location

Construction of a new run-up location would help to reduce the highest community run-up noise levels by moving run-ups farther from the closest residences. In addition, a new run-up location would provide the following potential benefits:

- Allow more options for aircraft orientations during run-ups, without concerns about foreign object contamination of taxiways or runways and jet blast on active runways and taxiways.
- Provide a more-central location for run-ups, reducing taxiing time.
- Allow future construction of a noise barrier, berm, or GRE (discussed in Sections 7.5.4 and 7.5.5 of this report) outside of Building Restriction Lines and in conformance with FAR Part 77 surfaces.

Potential new run-up locations include:

- West of Runway 14/32, potentially opposite Taxiway Uniform, adjacent to a proposed west-side north/south taxiway.
- North of the Building Restriction Line, near the existing Taxiway Juliet run-up location.
- At the northern end of North Airpark.
- East of the Building Restriction Line, near the existing Taxiway Quebec run-up location.

Of these options, the first one, west of Runway 14/32 is preferred because it would provide a central location and would be located farthest from all residential areas. The precise location of the run-up facility in the preferred area west of Runway 14/32 would have little effect on the acoustical benefit provided by the relocation. It is likely that the actual location (within this preferred area) would be determined by other factors such as constructability and operational considerations. Figure 7.5-2 shows maximum sound level contours for a B747-100 conducting a single-engine takeoff-power run-up at a potential location in the preferred area opposite Taxiway Uniform. The aircraft orientation shown in the figure (with the aircraft heading in an easterly direction) would be the preferred noise-abatement heading under calm wind conditions.

Any of the proposed locations (except for North Airpark) would require grading and paving of a run-up pad as well as new taxiway construction to provide access. The North Airpark location, although not requiring grading and paving, would be feasible only if sufficient unused space could be made available. In addition, the North Airpark location is least attractive acoustically because it is closest to residential areas.

Examples of airports with designated high-power run-up locations include: Seattle-Tacoma International Airport, Fort Lauderdale International Airport, Baltimore-Washington International Airport, San Jose International Airport, and Tampa International Airport.

Due to the range of possible run-up locations, it is not feasible within the scope and budget of this study to estimate the cost of relocating run-ups for specific locations at ANC. During a recent project at Portland (OR) International Airport, however, cost estimates for the construction of a run-up area for wide-body aircraft ranged from approximately $1 million to $2 million, depending upon site-specific factors. Actual costs could vary significantly depending upon local conditions at ANC.

Recommendation: New run-up locations should be considered in conjunction with planning for any proposed taxiway improvement projects, including a new north/south taxiway west of Runway 14/32. Based on its central location and distance from residential neighborhoods, the preferred area is on the west side of Runway 14/32. Airport operations, ATC, and tenants should review the feasibility and attractiveness of proposed locations with regard to such issues as taxiing time, providing taxi routes compatible with other taxiing aircraft, and, to the maximum extent practical, limiting runway crossings to access the facility. In addition, this measure should be considered within the context of the Master Plan process. Because the acoustical benefit of relocating run-ups to most locations west of Runway 14/32 would be similar, the precise location of the run-up facility should be determined based upon constructability issues and the operational considerations described above.

7.5.4 Noise Barriers or Berms

Since residential areas border ANC only to the east and to the south, it is not critical to mitigate noise in all directions around aircraft conducting run-ups. Because of this, a straight or L-shaped noise barrier or earth berm (as opposed to a more costly and complex three-sided GRE) may provide a substantial benefit. A noise barrier or berm could be constructed at any of the new run-up locations discussed in Section 7.5.3 including the preferred site west of Runway 14/32 (as shown in Figure 7.5-2), or, as alternatives, the areas outside of the Building Restriction Lines near the existing run-up locations on Taxiways Juliet and Quebec or at the northern end of the North Airpark.

Because noise barriers or berms are most effective when they are located close to either the noise source (the aircraft) or to the receiver (the residential area), the most effective location for a noise barrier or a berm in either of these areas would be as close as is possible to the designated run-up location. To be effective for a wide variety of aircraft, the barrier or berm should be approximately 30 to 45 feet in height with a minimum length of approximately four times (4x) the distance from the aircraft (i.e., if the barrier or berm were located 150 feet from the aircraft, it should have a minimum length of about 600 feet). In general, the farther the barrier or berm is located from the aircraft, the taller it would need to be. A barrier of these approximate dimensions may provide up to about 10 to 15 decibels of noise reduction in benefited directions (at locations without existing noise shielding) with performance depending upon the actual dimensions, aircraft type, aircraft location, listener location, and weather conditions. Depending on the location of the barrier or berm, a blast deflector may also be necessary to redirect jet exhaust upward away from the structure. In addition, because of the proximity to runways and taxiways, the location and the height of a barrier or berm may be constrained by FAR Part 77 requirements.

A wide variety of materials are available including concrete or metal panels, masonry block, wood, earth berms, or berm/barrier combinations. The majority of these materials provide similar acoustical benefits, but vary in durability, appearance, upkeep and cost. Because no noise-sensitive areas would be located on the aircraft side of the barrier or berm, a noise-absorptive surface would not be required, although an absorptive surface may provide marginally-better noise-reduction performance than a reflective surface (by perhaps one to two decibels).

If fill material is available, earth berms provide an attractive option because they require minimal upkeep. Because earth berms typically require at least a 2:1 (horizontal:vertical) slope, however, they require considerable space. For example, a 30-foot high berm would require at least a 120-foot wide corridor. The width of the berm may be reduced by using a berm/barrier combination. For example, a 15-foot high berm could be constructed with a 15-foot high wall running along the top. The barrier/berm combination would provide approximately the same benefit as a 30-foot high berm, but would require only a 60-foot wide corridor.

Based on a rough cost estimate of $20 per square foot, a 600-foot long, 30-foot high barrier would cost approximately $360,000. This unit cost includes materials, footings, and installation, but does not include engineering design, provision for relocation of utilities or drainage, landscaping, or a blast deflector (if required). Actual costs may vary considerably. Because of high variability in the cost of fill, we have not provided cost estimates for berm or berm/barrier combinations. In addition, this estimate does not include grading and paving that may be required for a run-up pad and taxiways.

The approximate noise-reduction values and costs provided here are preliminary estimates. A qualified acoustical consultant should perform a design study prior to construction to ensure that the barrier or berm provides the intended benefit.

- At Love Field (Dallas, Texas), a noise barrier was constructed to reduce noise from run-ups of aircraft ranging in size from small corporate jets up to narrow-body air-carrier jets.
- At Miami International Airport, an existing run-up area blast fence was improved by lengthening its sides, increasing its height, and adding sound-absorbing panels.
- At Barnstable/Hyannis (Massachusetts) Airport, an existing borrow pit was augmented by increasing the height of the berm walls for use as a run-up area.

Recommendation: Construction of noise barriers or berms to reduce noise from aircraft run-ups could provide a relatively low-cost alternative to a GRE. In addition, this option would not constrain the orientation of the aircraft, as would a GRE (potentially limiting use of a facility under various wind conditions). If operational measures are not deemed to be sufficient to mitigate run-up noise or are judged to be too restrictive to aircraft operators, it is recommended that construction of a run-up pad with a noise barrier or berm be considered. As described in Section 7.5.3, the area west of Runway 14/32 would be the preferred location.

7.5.5 Ground Run-up Enclosure (GRE)

A GRE would provide more comprehensive noise-reduction benefit than a straight or L-shaped barrier or berm by reducing noise levels in most directions around an aircraft conducting a run-up. In addition, because the walls of a GRE typically would be located closer to the aircraft than with a barrier or berm constructed near the existing run-up locations, a GRE may provide somewhat more consistent noise-reduction performance under a wider variety of weather conditions than a barrier or berm.

Typically, a GRE would be a three-sided, open-roofed enclosure, roughly rectangular in shape. The walls would typically be between 30 and 45 feet in height and would be constructed of noise-absorptive panels (typically perforated steel enclosing sound-absorptive fiber). A sloped blast deflector to re-direct the jet exhaust upward would be located at the rear of the enclosure. A GRE of this size would provide about 10 to 15 decibels of noise reduction with performance depending upon the actual dimensions, aircraft type, aircraft location, listener location, and weather conditions. Depending upon the size of the aircraft and the enclosure, use of the GRE may require the use of a tractor or tug to position an aircraft within the enclosure. In addition, because the orientation of the GRE would dictate the aircraft's heading during run-ups, use of the GRE may be limited by wind conditions. Depending upon the size of the aircraft that the GRE is intended to accommodate, the height of the walls, and the amount of site preparation necessary, the cost of a GRE may range between about $2 million and $8 million.

The approximate noise-reduction values and costs provided here are preliminary estimates. A qualified acoustical consultant should perform a design study prior to construction to ensure that a GRE provides the intended benefit.

GREs have been constructed at the following United States airports:

- Portland (Oregon) International Airport, accommodates up to MD-11 aircraft.
- Chicago's O'Hare International Airport, accommodates up to B-747 aircraft.
- Pease International Tradeport (Portsmouth, New Hampshire), accommodates up to B-727 aircraft.
- Indianapolis International Airport

Recommendation: If operational measures are not deemed to be sufficient to mitigate run-up noise or are judged to be too restrictive to aircraft operators, and if noise barriers or berms are determined not to be feasible or not to provide sufficient benefit, it is recommended that a GRE siting study be conducted to determine potential locations for the effective siting of a GRE at ANC. However, based upon the relatively low number of high-power nighttime run-ups conducted at ANC and the other less-expensive mitigation options available, a GRE does not appear to be warranted at this time.

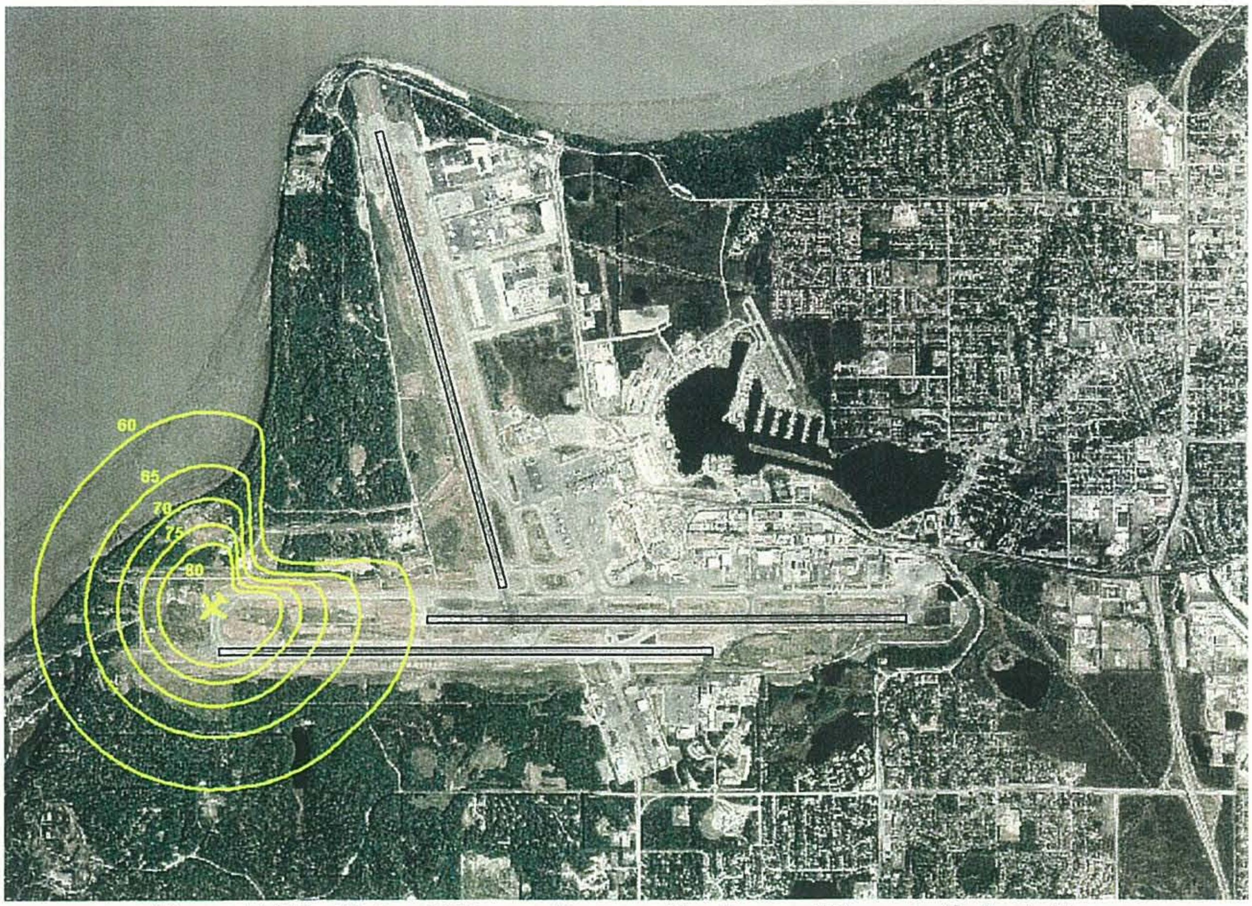


Figure 7-5.1. Takeoff Power Run-up Contours, Alternate Orientation
Taxiway J: 225 degrees true

B747-100: 60, 65, 70, 75, and 80 dBA, L_{max}

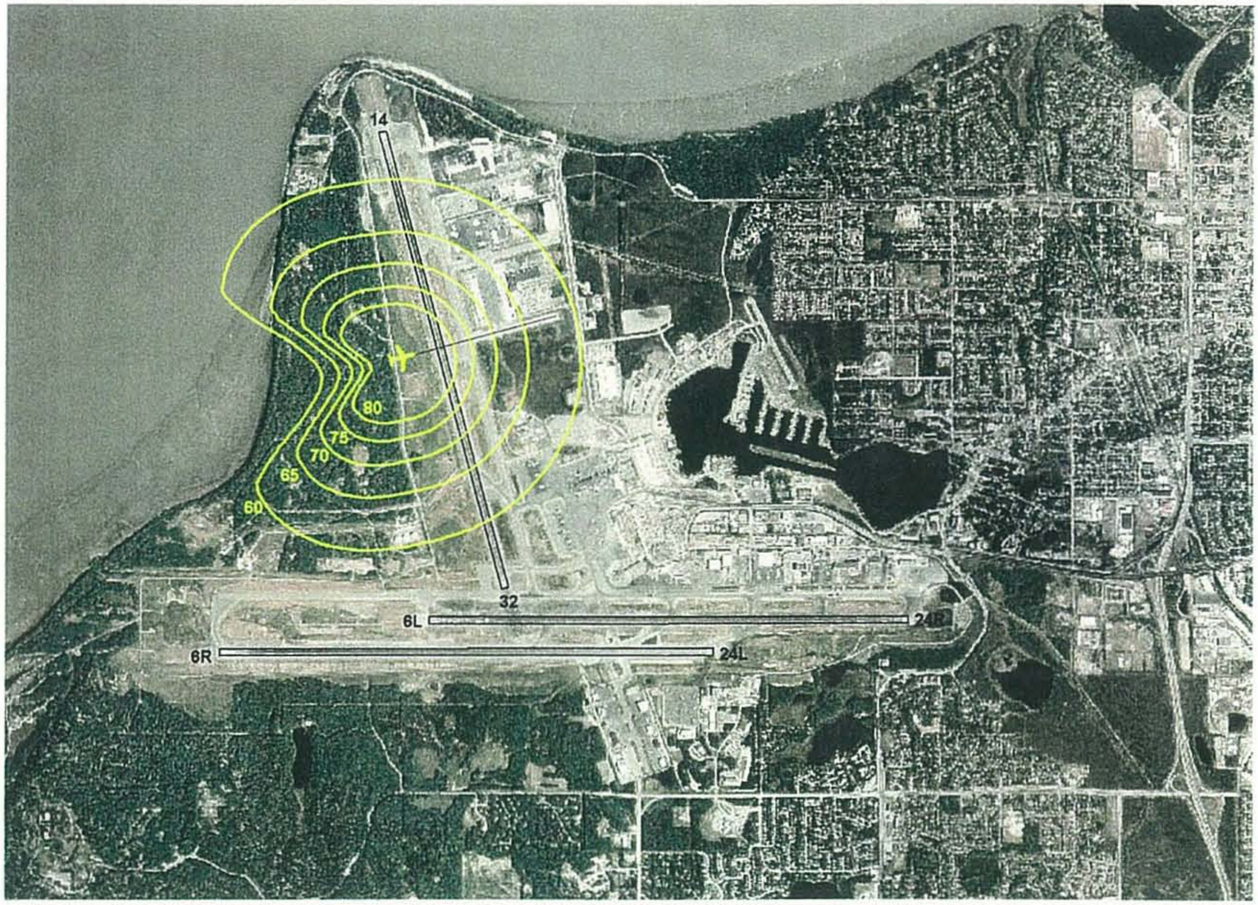


Figure 7-5.2. Takeoff Power Run-up Contours, Alternate Location West of Runway 14/32

B747-100: 60, 65, 70, 75, and 80 dBA, L_{max}

7.6 General Aviation Aircraft Start-up and Departure

The following measures would reduce noise levels in nearby residential areas from GA aircraft ground activities at the gravel strip and Lake Hood: pilot education to reduce takeoff noise levels, optimizing the orientation of parked aircraft to reduce engine start-up noise in community locations, and a noise barrier or berm east of the gravel strip.

7.6.1 Pilot Education to Reduce Takeoff Noise Levels

Measurements conducted at the gravel strip in September 2000 indicated a broad range of sound levels (approximately 25 dB) associated with GA aircraft departures. The range in sound levels depended upon aircraft type, power settings, and individual pilot technique. The loudest measured departures, which included a prominent tone as the plane of the propeller passed perpendicular to the noise monitor, were about 15 dB to 20 dB louder than the average measured departure. When the propeller diameter and rpm combine to move the propeller tips at or above the speed of sound, a strong tone is generated, raising the overall aircraft noise level by as much as 15 dB to 20 dB. Because this tone is most audible when the listener is aligned within roughly five degrees of the plane of the propeller disc, the sound level increases briefly as the aircraft passes directly abeam the observer (i.e. when the passing aircraft is closest to the observer).

This situation can be minimized by better pilot technique. Pilots typically use full throttle for takeoff, whether or not the aircraft load or runway length demands it. Many pilots are unaware that they are creating the tone since it is often not audible from the cockpit. Further, many pilots are not aware that available thrust is reduced when the propeller tips are supersonic.

Education for GA pilots in noise-sensitive departure procedures has been provided during many FAR Part 150 studies, including at ANC. Hanscom Field (Bedford, Massachusetts), Reid-Hillview Airport (San Jose, California), Fort Lauderdale Executive Airport, Boca Raton, and Naples, Florida all have on-airport signs regarding noise-abatement procedures.

The cost of educational signs can vary significantly from a few hundred to several thousand dollars depending on whether they are constructed by airport staff or purchased from a sign vendor and depending on whether they are lighted or not. Newsletters, posters, etc. directed at this issue would represent a small increment to the Airport's current marketing/public affairs budget.

Recommendation: It is recommended that the Airport provide education to GA pilots in noise-sensitive departure procedures. Several options are available including:

- Educational posters and/or signs posted at GA facilities.
- A newsletter targeted to tie-down and float-slip tenants.
- A discussion of noise reduction techniques added to the Anchorage Terminal Area Bulletin (which describes local airspace and standard arrival/departure procedures).
- Signage reminding pilots to "fly quiet - reduce rpm as soon as possible after lift off." The Airport should work with the FAA to determine the appropriate location for any signage.

7.6.2 Optimization of Aircraft Parking Orientation

Piston-engine aircraft are directional noise sources with the highest noise levels generally towards the front of the aircraft. For this reason, orienting tie-down locations with the rear of the aircraft towards residential areas could reduce annoyance. During pre-flight warm-up periods, the lowest noise levels, from the rear of the aircraft, would be directed towards the adjacent residential areas.

Incorporating this measure into the design of new tie-down locations could significantly reduce the cost of this measure.

Recommendation: In coordination with GA Operations and Planning personnel, it is recommended that the Airport consider orienting any new tie-down locations so that aircraft will be headed away from the nearest residences (generally southwestward as opposed to those that are currently oriented northeastward). The feasibility of parking orientations that would minimize community noise levels should be considered during the design of any new tie-down areas.

7.6.3 Noise Barrier or Berm

A noise barrier or earth berm to the east of the gravel strip could provide some benefit for the first few rows of homes during aircraft start-up, taxi, pre-flight run-ups, and at the start of takeoff roll. Because noise barriers or berms are most effective when they are located close to either the noise source (the aircraft) or to the receiver (the residential area), the most effective location for a noise barrier or a berm in this area would be along the airport property line, as close as is possible to affected residents. Because of its proximity to residences, however, a noise barrier in this location may have a significant visual impact. To some extent, the visual impact could be reduced through landscaping, use of a berm, or a berm/barrier combination. For example, a 10-foot high berm could be constructed with a 10-foot high wall running along the top. The barrier/berm combination would provide the same benefit as a 20-foot high wall, but would provide more landscaping possibilities and may be more acceptable to neighboring residents. Berms typically require at least a 2:1 (horizontal:vertical) slope, Therefore, a 10-foot high berm requires at least a 40-foot wide footprint. Figure 7.6-1 shows one concept for the location of such a noise barrier or berm. Although the figure shows the footprint for a berm, a noise barrier or barrier/berm combination could be located along a similar alignment.

A second location considered for a noise barrier or a berm would be roughly parallel to the gravel strip near the edge of the runway's building restriction line. This location would be farther from residents and, therefore, would have less visual impact than a barrier located along the property line. A barrier at this location would provide less benefit, however, than a barrier of similar height along the property line. Alternatively, a barrier or berm at this location could be made somewhat taller to provide additional benefit. Construction of a barrier or berm in this location would require a thorough review of the FAR Part 77 Surfaces for the gravel strip and other applicable regulations. Figure 7.6-2 shows a concept for the location of such a noise barrier or berm. Although the figure shows the footprint for a berm, a noise barrier or barrier/berm combination could be located along a similar alignment.

Table 7.6-1 compares the two potential noise barrier/berm locations. The table shows the approximate length of a barrier or berm at each location, the assumed height of 20 feet, and a rough cost estimate for a noise barrier based upon a unit cost of $20 per square foot. This unit cost includes materials, footings, and installation, but does not include engineering design, provision for relocation of utilities or drainage, or landscaping. Actual costs may vary considerably. A wide variety of noise barrier materials are available including concrete panels, masonry block, wood, earth berms, or berm/barrier combinations. The majority of the materials provide similar acoustical benefits, but vary in durability, appearance, upkeep and cost. We have not provided a cost estimate for a berm or berm/barrier combination because the cost would be strongly dependent upon the availability of fill.

The table also provides preliminary estimates of the noise reduction provided by a 20-foot barrier at either location. Different values of noise reduction are provided for first-row residences (those adjacent to the airport property line) and for second-row residences. In all cases, receptors are assumed to be located outdoors, standing at ground level. The noise-source spectrum used for the computations was from a Cessna 182 running at 50% power. The ranges of noise reduction were computed for several aircraft locations, including the existing tie-downs adjacent to the gravel strip and taxiways adjacent to the runway. Because of the significant distances from the tie-down areas to residences (1,500 to 2,000 feet), the performance of the noise barrier could be affected by weather conditions such as wind or temperature gradients (see Section 7.1.1). In addition to the different aircraft locations described above, the computed ranges of noise reductions take into account typical variations in weather conditions.

Table 7.6-1. Noise Barrier/Berm Alternatives for GA Aircraft Activities (Including Engine Start-up, Taxi, Pre-flight Run-ups, and Start of Takeoff) East of the Gravel Strip

Berm/Barrier Location	Approx. Length (feet)	Approx. Height (feet)	Approx. Barrier Cost (x 1,000)[1]	Approximate Reduction in A-weighted Noise Level (dB)	
				1st-row Homes	2nd-row Homes
Property Line	4,400	20	$1,760	10 to 16	4 to 10
Runway Building-Restriction Line	3,200	20	$1,280	4 to 11	3 to 10

[1]Cost estimates based upon unit cost of $20 per square foot for a noise barrier. No cost estimates are provided for berms.

At the closest homes to a property-line noise barrier, sound levels from ground noise may be reduced by approximately 10 to 16 decibels, depending primarily on the distance from the receiver to the barrier. This is a significant reduction that generally would be perceived as at least a halving of the sound level and could significantly reduce outdoor speech interference. At second-row homes that already receive some shielding from other homes and are located farther from the barrier, the expected noise reduction provided by a barrier may be approximately four to 10 decibels, depending on the aircraft location, the distance from the home to the barrier, existing shielding (from intervening homes) and weather conditions. The upper end of the range represents a significant reduction in noise levels, while the lower end of the range represents a perceptible but very modest reduction (reductions of less than three decibels in A-weighted sound levels are not generally noticeable).

At the closest homes to a noise barrier located along the runway building-restriction line, sound levels may be reduced by approximately four to 11 decibels, depending on the aircraft location, the distance from the home to the barrier, and weather conditions. The upper end of the range represents a significant reduction in noise levels, while the lower end of the range represents a perceptible but very modest reduction. At second-row homes, benefits would be similar, but slightly less because of increased distance to the barrier and existing shielding from intervening homes.

If constructed in either location, although the barrier or berm would provide substantial reductions in single-event noise levels from GA aircraft on the ground, it would not reduce noise from aircraft once they are airborne, and would have little effect on overall noise exposure.

The approximate noise-reduction values and costs provided here are preliminary estimates. A qualified acoustical consultant should perform a noise barrier design study prior to construction to ensure that the barrier provides the intended benefit.

In addition to the noise barrier examples provided in Section 7.4.5, noise barriers were constructed at the following airports primarily to provide shielding from start-of-takeoff noise:

- Based on the recommendation from the FAR Part 150 Study, a noise barrier was constructed to benefit a residential community near Syracuse (New York) Hancock International Airport in 1994.
- An earth berm was constructed at Hanscom Field (Bedford, Massachusetts) in 1986 to reduce noise from takeoff roll.
- Santa Monica, California.
- Palm Beach (Florida) International Airport

Recommendation: It is recommended that the Airport conduct a noise barrier/berm design study in conjunction with the affected community to evaluate alternative locations, ensure that the noise barrier, berm, or barrier/berm combination provides the intended benefit, and to determine the feasibility of locating a barrier or berm in this area with regard to FAR Part 77 surfaces and other site restrictions. The study should include a community-involvement component to (1) explain the purpose and expected benefits of the barrier or berm, (2) describe its location and appearance, and (3) permit the closest (abutting) residents to express concurrence or not with the Airport's recommendation.

Figure 7.6-1. Potential Gravel Strip Noise Barrier/Berm Location, Along Property Line (Source: DOWL Engineers)

Figure 7.6-2. Potential Gravel Strip Noise Barrier/Berm Location, Near Runway Building Restriction Line (Source: DOWL Engineers)

7.7 Airfield Maintenance Equipment

Because operation of airfield maintenance equipment, including snow-removal equipment, vacuum trucks, and runway rubber-removal machinery, is critical to safe operation of the Airport, options for operational restrictions are limited. In particular, nighttime maintenance operations generally are conducted only if the procedure must take place at that time.

The back-up alarms installed on all airport field maintenance equipment in accordance with federal law, sometimes are cited as a source of annoyance. The Occupational Safety and Health Standards for the Construction Industry (29CFR Part 1926.601) state that "No employer shall use any motor vehicle equipment having an obstructed view to the rear unless: (i) The vehicle has a reverse signal alarm audible above the surrounding noise level; or (ii) The vehicle is backed up only when an observer signals that it is safe to do so." To meet the requirement of being "audible above the surrounding noise level," backup alarms are designed to emit a distinct, tonal sound. Often, tonal noise sources are judged to be more intrusive and annoying than other noise sources with equivalent sound levels. Although backup alarms cannot be eliminated (without the presence of an observer), there are several alternatives to traditional backup alarms, including alarms that automatically adjust their output level based upon the ambient sound level, alarms with variable (i.e., "day" and "night") settings, and (less commonly) alarms that sound only if any object is detected directly behind the vehicle.

Ambient-sensitive, self-adjusting backup alarms increase or decrease their volume based on background sound levels to produce a tone that is readily noticeable over ambient levels[38]. The typical alarm adjusts between sound levels of 82 dBA and 107 dBA at four feet. Because noise from the vehicle's engine, cooling fans, etc. can interfere with the alarm's operation and negate its purpose, these alarms typically should be mounted as far to the rear of the vehicle as is possible. Self-adjusting backup alarms range in price from approximately $50 to $100. Manually-adjusting alarms eliminate the mounting-location problem, but their use requires that each alarm must be manually set at the beginning of each day and night period. Manually-adjustable backup alarms typically have settings for sound levels of 87 dBA and 107 dBA at four feet and range in price from about $50 to $100. Detector-type alarms use microwave doppler-shift radar to sense objects in the blind spots behind vehicles. Various types of these devices activate a buzzer and a red light in the cab of the vehicle in addition to sounding an external alarm if an object is sensed. Typical prices are approximately $500 to $700.

Variable-volume back-up alarms are used throughout the construction industry and are required for contractors performing nighttime construction on Boston's Central Artery/Tunnel project.

Recommendation: When feasible, conduct maintenance operations in areas closest to residential neighborhoods during daytime. Require the use of variable-volume back-up alarms on all new maintenance equipment purchased by ANC and on all equipment operated by contractors.

[38]Following discussion excerpted from: Schexnayder, Cliff J. and James Ernzen, *Mitigation of Nighttime Construction Noise, Vibrations, and Other Nuisances*, National Cooperative Highway Research Program, Synthesis of Highway Practice 218, Transportation Research Board, National Academy Press, 1999.

8. PUBLIC INVOLVEMENT

One of the important stated goals of the ground noise study was to provide opportunities for public input and involvement throughout the process. This goal was accomplished through a series of mailings, public meetings and workshops, postings on the Airport's web site, and opportunities for residents to participate in the September and February noise measurement programs by assisting in logging ground noise events and/or by having noise and vibration measurements conducted at their homes. This section of the report provides an overview of various aspects of the public involvement process.

8.1 August 2000 Questionnaire and Public Meeting

In August 2000, ANC's noise office mailed a newsletter and questionnaire to residents and community councils in neighborhoods around ANC, informing residents of the noise study and asking them to identify specific types of ground noise they found to be annoying, for inclusion in the study. The Airport's noise office received approximately 175 responses to the ground noise questionnaire.

On August 30, approximately 70 residents attended a public meeting held at the West Coast International Inn. Study-team members and ANC staff described the upcoming ground noise study and requested public input to ensure the proposed scope of work addressed the concerns of residents. Approximately 25 attendees submitted written comments at or following the meeting.

The comments received both through the questionnaire and the public meeting provided valuable guidance in planning and conducting the study. Representative comments both from the questionnaires and the public meeting were posted on the Airport's web site and are included here. The comments have been grouped into categories corresponding to issues of interest, and are preceded by a brief description of each category. The number of comments included for each issue provides a rough approximation of the relative number of comments that were received for each category.

1. Low-frequency Noise and Vibration

Many residents living near ANC identified low-frequency noise and vibration, especially when generated by departing aircraft during the start of takeoff roll, as a source of annoyance. Although vibration induced by low-frequency noise from commercial air carrier aircraft is not of sufficient magnitude to cause structural damage in standard residential construction, it can be annoying and can contribute to homeowners' concerns regarding potential damage to their property. Because of these concerns, specialized low-frequency noise and vibration measurements were conducted in residents' homes during the September 2000 measurements.

During the measurements, vibration levels were monitored inside homes by affixing vibration-detection instruments (accelerometers) to the walls and floors. Simultaneously, outdoor noise levels were monitored while an observer in the Airport's air traffic control tower logged aircraft operations. The measured vibration levels were then assessed based upon criteria for structural damage and annoyance. In addition, the simultaneous noise and vibration measurements allowed interior vibration levels to be correlated with measured noise levels.

Representative comments:

"My home is off Sand Lake and Raspberry Road near Kincaid Elementary School. The annoying noise I hear is a constant low rumble that can go on for hours at a time. I don't hear it much in the summer but it is especially noticeable during the winter on overcast days and at night."

"Loud, earth-rumbling, low-pitched [noise]. The first is heavy-jet take-off roll from the extension on Runway 32. The second is Lockheed cargo turboprop engine run-ups at night."

". . . since you extended Runway 14/32 we have been affected by noise from aircraft spooling up their jets prior to take-off to the north. The noise is very low frequency and it shakes the house. I presume we now feel it because the heavy planes are starting their roll closer to the houses in the Tanaina Hills subdivision."

"The warm-ups or run-ups are very noticeable in the morning . . . virtually a roar. Even the house vibrates at times."

"My house shakes – this happens before takeoff when there is a high-pitched whine before the plane takes off."

"I am awakened many times at night by the rumbling and loud noises. Since FedEx has come – cleared all that land and increased the number of flights. My bedroom is on the upper level of my three-story house. [. . .] The windows rattle and let in more noise. During the summer it is difficult to have windows open for fresh air because the noise is too much now."

"[I wait for the vibrations] to develop into a full-fledged earthquake (which it isn't) – but it's very unnerving."

"[There is] vibration in the house, noise all hours of night."

2. Auxiliary Power Units

APUs are small jet engines, often located near the tail of an aircraft, that are used to provide electrical power and heat to aircraft when they are on the ground with their main engines shut down. In addition, compressed air generated by APUs sometimes is used to start the aircraft's main engines. Although many of the cargo and passenger airlines at ANC use quieter alternative sources of power (typically, diesel ground power units, also known as GPUs) when aircraft will be on the ground for extended periods, APUs frequently are used during normal operations. Because they sometimes run for extended periods, APUs have the potential to be annoying despite being relatively quiet compared to other sources of ground noise such as start-of-takeoff roll or reverse thrust after landings. During the September 2000 measurements, 24-hour noise monitors were located near North Airpark and East Airpark specifically to track APU usage.

Representative comments:

"We have lived in Turnagain for 34 years . . . . During this time we have observed a significant increase in ground noise coming from ANC. [. . .] The differences between aircraft in flight and ground noise can be distinguished in particular by the constant rumble at ANC. This rumble seems to come from typical industrial noise sources such as generators, which we assume are auxiliary power units. These seem to run very often and create an annoying hum."

"We do not have jets flying over our home (just floatplanes), but airport noise is a growing and constant irritant. The noise characteristics range from deep rumbling sounds to high-pitched

whining. It is sufficient to rouse my family from sleep, sometimes as early as 4:30 AM. The noise continues without a break making it difficult to return to sleep. We hear airport noise at other times; in fact, the absence of noise is a rarity. We can hear the jets taxiing and taking off but the worst noise appears to be when they are just sitting on the ground."

"The noise is a constant roar. I've lived where I do for almost 30 years and the noise increases every year. [. . .] From 10 PM until 6 AM, I can hear ground-based operations when I am near a window. It is a constant sound for 10 to 30 minutes in duration."

". . . a high-pitched whine that goes on for hours, which we think are the auxiliary power units."

"We are on Aspen Drive, across from the Regal Hotel. We've lived here for 13 years and never heard airport noise until this past year. [. . .] Last year we began hearing the cargo jets warming up at the end of the runway, mostly at night."

"The ground noise that is very disturbing is when planes are sitting on the tarmac, without passengers, using their engines for power instead of [ground power] electricity."

"I am especially bothered by a constant low-pitched dull roar. I compare it to the sound made if a garbage truck sits on our street while compacting or . . . a carpet-cleaning truck running in a neighbor's driveway . . . . It does not change in pitch or start and stop. It goes on for several hours. It is loud enough to drown out the sound of my refrigerator running in the kitchen. [. . .] Last winter I had listened to the noise for more than an hour and then . . . drove by the Airport . . . and there was a plane sitting just inside the fence at Airpark Road off Raspberry Road (across the runway from ERA) with its engines running and aimed right at our neighborhood."

"I live adjacent to Connors Bog. I am not bothered by takeoffs and landings; however, I do hear a loud hum from the Airport. It is especially noticeable during summer evenings and nights when windows are open. It is not a high-decibel event but an annoying background hum for a lengthy period of time.

3. Run-ups

Maintenance run-ups are a necessary part of typical aircraft engine maintenance. During a maintenance run-up, an engine typically is brought up to and maintained at a certain power setting, ranging from idle-power to full takeoff-power, depending upon the particular maintenance check being performed. The power setting may be maintained anywhere from a few seconds to several minutes. The procedure may be repeated several times and potentially could last for 30 to 60 minutes, and go through several engine-run cycles. Although maintenance run-ups occur much less frequently than aircraft departures at ANC, they have the potential to be extremely annoying because they can generate high noise levels (especially high-power run-ups) for long periods of time. In addition, maintenance run-ups often are performed at night when the aircraft are not needed for regularly scheduled service.

Pre-flight run-ups are performed by propeller-driven aircraft, near the runway end, just prior to departure. During pre-flight run-ups, the throttles are increased to near takeoff levels while the pilot checks to see that certain aircraft systems are functioning properly. Pre-flight run-ups are relatively short in duration (approximately 30 to 60 seconds) and are not conducted by jet aircraft.

Representative Comments:

"Multiple engine run-ups [are annoying]. Landings and take-offs are not that bad. Early morning run-ups are."

"Low rumbling that increases in volume – sometimes so that it shakes the windows – then dies down lasts anywhere from two to five minutes. Sometimes it's continuous; as soon as one engine noise begins to subside, another one starts up."

"Particularly loud are the 737s while doing run-ups at the east end of the runway."

"Late-night maintenance run-up is sometimes quite bothersome. [. . .] The maintenance run-ups are the worst."

"Aircraft engine checks by the end of the north runway in the early AM hours (4:00 AM to 7:30 AM) are most annoying. I've woken up to the noise of run-ups many times. [It is] particularly distressing when the wind blows out of the west."

"I think it is the pre-flight run-ups. It's a very loud, continuous noise that seems to go on and on, usually in the middle of the night. [. . .] The noise prevents me from leaving bedroom windows open at night – sometimes the noise wakes me."

"We can especially hear rev-ups. They are deafening, lengthy roars. Ground run-ups interfere with sleep during early morning hours and indoor phone conversations and outdoor conversations are interrupted. During late afternoon hours, the house vibrates."

"Run-ups from turboprop planes such as Beech 1900s and South Airpark aircraft [are] very annoying -- can't sleep or wake up too early from noise and then can not get back to sleep because noise is constant. Run-ups should be done at Taxiway J or Taxiway Q only."

4. Kulis Air National Guard Base (ANGB)

Kulis ANGB, located near South Airpark, operates and performs maintenance on both C130 Hercules turboprop aircraft and helicopters. This maintenance activity includes aircraft maintenance run-ups, aircraft engine run-ups on test stands, and helicopter hovering for maintenance purposes. Although, due to the importance of its national security and rescue roles, the Guard is not subject to the same operating restrictions as other tenants, it has been proactive in efforts to reduce noise in residential areas. Working with ANC Planning and Noise Office staff, the Air National Guard sited their engine test stand in an area that would minimize annoyance to their neighbors. The Guard also participated in the operations data survey of all airport tenants and has been extremely cooperative throughout the study by meeting with the study team and providing operations data and access to the Base. In addition, during the September 2000 measurements, 24-hour monitors were located at residential and on-airport locations in the vicinity of Kulis ANGB.

Representative Comments:

"Primary noise is from Kulis Air Guard during weekend exercises. Planes are running on the ground for long periods of time."

"Kulis C-130 run-ups are particularly annoying; also, helicopter operations."

"Hold Kulis ANGB to the same standards and rules [as ANC] on engine run-ups."

5. *General Aviation (GA) Aircraft*

General aviation (GA) aircraft operate both off of Lake Hood and the adjacent gravel strip. During the September 2000 measurements, 24-hour noise monitors were located at the gravel strip and at residences adjacent to both Lake Hood and the gravel strip. Although GA flight operations are not included in this study, preflight run-ups, taxiing, and start-of-takeoff were evaluated.

FAA regulations make it illegal to operate an aircraft without an FAA-approved engine exhaust system. Airport operations personnel are not aware of any GA aircraft at ANC without an FAA-approved exhaust system.

Representative Comments:

"Ted Stevens AIA noises are acceptable. The small floatplanes with direct exhaust from the engine, no mufflers, are extremely noisy!"

"The scream from Cessna 206 and 185 (combination of high RPM noise and propeller noise) – and you know what I'm talking about!"

"I suspect the period of the noise study will miss most of the noise on Lake Spenard – May, June, July, August, September. [. . .] Could more activity be shifted to Lake Hood where there are fewer and sparser residences? I'm told that numerous aircraft owners remove the cones from mufflers in the belief it gives them more power. Is there a possibility of muffler inspections/enforcement?"

"Why are the little airplanes so loud when they take off? Some hurt our ears and rattle the dishes."

"Most of [the] noise comes from floatplanes during takeoff. . . ."

"Takeoffs from Lake Hood gravel strip and floatplanes operating to the north . . . [are] loud when abeam of propellers."

6. *Runway Maintenance and Snow Removal*

During the September 2000 measurements, with the assistance of ANC maintenance staff, controlled noise measurements were conducted of several types of runway maintenance and snow-removal equipment, including a runway sweeper, a snow-thrower, and a vacuum truck.

Representative Comments:

"Schedule airport runway maintenance during reasonable hours."

"The study may miss the snow removal equipment noise."

"[Annoyed by] construction equipment – motor noise, back-up alarm, etc."

7. *Reverse Thrust After Landing*

Aircraft utilize reverse thrust after landing to help slow down to a safe runway exit speed. Reverse thrust may range in duration anywhere from just a few seconds up to approximately 20 seconds and may vary greatly in terms of power. In community locations, it sometimes may be difficult to distinguish between noise from reverse thrust and from start-of-takeoff. Because of the high percentage of arrivals on Runways 6L and 6R at ANC (the east-west runways along the south side of the Airport), homes south of the runways are often exposed to noise from reverse thrust. To help evaluate this, during September 2000 and February 2001, measurements were conducted simultaneously at affected homes south of ANC in the Sand Lake area and at on-airport monitors located close to the runways.

Representative Comments:

"After 30 years living at our present address we know that any high level of noise is mostly from planes landing and employing reverse thrust . . . ."

". . . loud thrust reverses on landing . . . ."

"Most annoying is vibrating, window-rattling, reverse-thrust roar."

8. Taxiing Aircraft

During certain periods of heavy activity during both the day and night at ANC, several aircraft may be taxiing to a runway end to depart, resulting in nearly continuous taxi noise for an hour or more. Residents sometimes notice the high-pitched whine associated with the fan noise coming from the front of the engines on large turbofan aircraft, including many of the heavy cargo jets operating at ANC.

Representative Comments:

"As more jets taxi to the runway, the high-pitched whine of their engines are frequent interruptions during the night."

"Most of the ground noise I hear seems to be turboprop-related, especially when the pilot adjusts the pitch of the prop during taxiing"

"Heavy cargo aircraft taxi operations . . . ."

"Taxiing aircraft noise around 6:00 AM . . . ."

"The high-pitched whining of taxiing and planes sitting on the tarmac is awful . . . ."

9. General Comments

Representative Comments:

"Annoyance has occurred literally every hour in a 24-hour day at one time or another in the past year or so. Generally mornings seem worst. There are times when both ground and air noise are occurring simultaneously or overlap – then it's more difficult to discern individual sounds. There's a definite ongoing sound I attribute to vehicle traffic noise, but I don't know what roadways the noise is coming from -- this is a fairly new source of noise at my home. A lot of the other noise is difficult for me to identify the source – it's why the study is needed."

"I would like more attention paid to subjective sensitivity of people which is not an absolute measure, e.g., in decibels, but is important."

"Why would you tell the airport people when you are going to do the study? They would most likely make less noise at that time."

"What is decibel reading and long-term effect on children outside at Kincaid Elementary?"

"We are new homeowners in the Turnagain neighborhood. We love the neighborhood but are annoyed and concerned about the airport noise. It is hard to sleep in the night due to noise from

the jet engines. [. . .] We installed soundboard in our bedroom, but the sound enters via the window. [. . .] We find the noise worst from 12 AM to 2 AM and 4 AM to 6 AM, weekdays."

"Although it appears your study will not include my area behind Fred Meyer on Victor Road and Dimond Boulevard, I want it known that airport noise bothers my sleep. I'm awakened each morning at 2:30 AM by a plane taking off. The noise from aircraft taking off begins at 1:00 AM and continues to 3:00 AM."

"I am bothered especially at night by ground noise. It is to the point that I am on medication for it! I would like to participate in the study as much as possible."

10. Ground Noise Not a Problem

Many residents also took the time to respond to the questionnaire or attend the public meeting to let us know that they are not bothered by ground noise. Some residents found noise from flight operations to be more annoying than ground noise; others were not bothered at all by noise from the Airport.

Representative Comments:

"Ground (airplane) noise doesn't bother or annoy anyone in this household. [. . .] Tell the people that bought homes near the Airport that they will have to learn to live with it."

"[Ground noise] no problem. Never bothered [by ground noise]. When people purchase a home near an airport, the real estate agents should be required to inform them of possible noise from aircraft operations. After being informed, if they still decide to purchase, they do so with full knowledge of the noise situation and should not complain."

Ground noise is not that big of a problem, even at night compared to the little airplanes that fly over our house so low you can see the pilot's face!"

"It is much better now than a few years ago. Only rarely do I notice it now."

"Ground-based noise is not a problem, but in-flight noise is. My residential address is near Arctic and International."

"Sometimes (with low cloud cover) we will hear some engine sounds. Doesn't bother us. In fact, we like the sound. We have lived with 2.5 miles of the Airport since 1962. We do not have any complaints."

"Disallow any further homes or other residential areas near the Airport. I'm tired of tax dollars being wasted on a few individuals who complain about airport noise. Everyone who has moved near the Airport knew the Airport was there."

"I have lived near the Airport (one mile) for forty years – moved here in 1961. We knew the Airport was there – enjoy the convenience. Seldom is the noise annoying."

"Please no more money spent on study, study, study. [I] have lived within five minutes of the Airport since 1959 and I get so tired of people complaining. They should move."

8.2 Resident Involvement in Measurement Programs

In both the August 2000 questionnaire and public meeting, interested residents were presented with opportunities to assist the study team during the measurement programs in the following ways:

- Request that outdoor noise measurements be conducted at their home for a period of several days.
- Request that indoor vibration measurements be conducted in their home simultaneously with outdoor low-frequency noise measurements.
- Keep a log of ground noise events heard from their home during the measurement programs.

Many residents volunteered their homes for noise and vibration measurements. The actual measurement sites were selected by the study team from among the many that were offered based on technical issues and the desire for broad, representative coverage of the neighborhoods around ANC.

Many residents also assisted the study team during both the September 2000 and February 2001 measurement programs by providing supplemental logs of ground noise events that were audible and/or annoying at their homes. During the measurement programs, around-the-clock measurements were conducted in residential neighborhoods near ANC of noise levels associated with sources of ground noise at the Airport. In addition to noise monitors located in residential areas, several noise monitors were located at ANC, in close proximity to sources of ground noise, to help correlate measured community noise levels with specific sources at the Airport. To further assist in correlating measured noise levels with specific noise sources, observations were conducted at each monitoring site throughout much of the measurements. Residents' observations provided an additional resource in correlating measured noise levels with sources of annoyance. Approximately 45 residents filled-in and returned the logs that had been provided by ANC noise office staff; many of the events on these logs subsequently were correlated with particular noise events that occurred at ANC.

8.3 February 2001 Newsletter and Workshops

Prior to the February 2001 noise measurements, ANC mailed a newsletter to residents and community councils in neighborhoods around ANC describing the study's progress to-date and informing residents of the upcoming measurement program and a series of informal workshops. During the measurement week, study-team members and ANC staff held lunch-time workshops on three consecutive days to target specific concerns of residents from Turnagain, Spenard, and Sand Lake and to share preliminary results from the September 2000 measurements.

8.4 September 2001 Public Meeting

On September 27, 2001 approximately 35 residents attended a public meeting held at the West Coast International Inn. Study-team members and ANC staff described the results of the ground noise study and requested public comments on the results and the proposed noise mitigation measures. Approximately 20 attendees provided verbal comments at the meeting. In addition, five attendees submitted written comments at or following the meeting.

Comments and responses provided during the public meeting:

(The following comments and responses are paraphrased from notes taken during the public meeting. In some cases, when more than one comment concerned similar or related topics, the comments and questions have been combined here.)

Sleep Disturbance

1. What sound level was used to predict sleep disturbance?

Response to Comment 1: The results of studies on noise-induced sleep disturbance are somewhat ambiguous and the responses of individuals to intruding noise sources vary widely. For this project, however, we are using the following guidelines: awakening may occur for two percent of the population when the *outdoor* sound level associated with a single event exceeds:

- 70 to 75 dBA, L_{max} with windows open, or
- 80 to 85 dBA, L_{max} with windows closed.

FICAN has recommended slightly more conservative guidelines for assessing sleep disturbance.[39] The FICAN guidelines, which are intended to represent the *maximum* percent of the population expected to be awakened, would predict awakenings in about six percent of the population with the maximum sound levels provided above. Please note that the guidelines provided for speech interference and sleep disturbance in this study are intended only to serve as benchmarks to provide context for the sound levels discussed in the report and should not be interpreted as impact criteria.

Residential Sound Insulation

2. Is there an opportunity to receive federal funding for residential soundproofing?

Response to Comment 2: Federal funding for residential sound insulation is based upon the noise exposure contours developed during the FAR Part 150 Study. Typically, residences exposed to 125Day-Night Average Sound Levels (DNL or L_{dn}) of 65 dBA or greater may be eligible for federal funding for sound insulation. Because airport ground noise generally has only a minor effect on overall noise exposure, however, the ground noise study does not address DNL.

ANC's sound insulation pilot program is under development and will include 30 homes located within the DNL 69 dBA contour. Potential mitigation options include replacing windows and doors, installing insulation, and providing air circulation systems. The pilot program will determine the parameters for the entire program.

3. How may information on the sound insulation pilot program be obtained?

Response to Comment 3: Please contact Theresa Maser, Scott Eastepp, or Steve Ludwig at:
ANC Noise Program Office, P.O. Box 196960, Anchorage, Alaska 99519-6960, or by calling the Noise Information Line at 266-2648.

[39] "Effects of Aviation Noise on Awakenings from Sleep," FICAN, 1997.

Mitigation Measures Considered

4. Will the public have an opportunity to see the full list of mitigation options that were considered?

Response to Comment 4: Table 7-1 ("Summary of Mitigation Options") provides a full list of all mitigation options considered during the study. (This table also was displayed at the final public meeting on September 27, 2001.) In addition, Section 7 of the report provides a discussion of each mitigation option considered, including those not recommended for further consideration.

Health Effects of Low-frequency Noise and Vibration

5. The report does not adequately address health concerns related to low frequency noise and vibration.

Response to Comment 5: There are no known health risks associated with low-frequency aircraft noise and vibration. (Also see the response to Comment 27 for further discussion of health effects of noise.)

GA Aircraft Facilities

6. Are there any plans to move GA areas closer to the community as a mitigation measure?

Response to Comment 6: There are no plans to relocate GA aircraft facilities closer to the community as a mitigation measure. GA plans primarily are covered in the Lake Hood Seaplane Airport Layout Plan. A new GA parking area is being proposed near the Lake Hood gravel strip since there is a high demand for GA facilities in this area. More information on GA plans can be obtained by contacting the Airport Planning Department at: P.O. Box 196960, Anchorage, Alaska 99519-6960, or by calling 266-2544.

Methodology to Differentiate Ground-roll from Airborne Noise

7. How did the study differentiate ground-roll noise generated during start-of-takeoff from airborne noise after liftoff?

Response to Comment 7: During the noise measurement program, measurements were conducted simultaneously at reference locations on the Airport and at noise-sensitive community locations. The internal clocks in the noise monitors and the observers' watches all were synchronized. During periods of observation, observers at the airport measurement locations identified noise events that occurred at the Airport while observers at community locations logged audible airport noise events and other community noise events. By using the observers' logs and simultaneous measurement data, measured sound levels in the community were correlated with specific noise events occurring at ANC, including the precise time of liftoff for aircraft departures. Typically, the on-airport observers included one observer in the ATC tower and one at an outdoor location on the airfield.

Municipality of Anchorage Noise Monitoring

8. Is the Municipality of Anchorage conducting any noise monitoring independently?

Response to Comment 8: ANC is not aware of any ongoing noise monitoring being conducted by the Municipality.

Noise Barrier South of Runway 6R/24L

9. Would noise barriers on the south side of Runway 6R/24L reduce noise from thrust reversers in neighborhoods along Raspberry Road?

Response to Comment 9: Because of limitations imposed by the location of affected neighborhoods relative to potential noise barrier locations and local topography, it is unlikely that noise barriers would provide a noticeable reduction in reverse thrust noise for residential areas near ANC. In particular, the existing terrain south of Runway 6R/24L already blocks the direct sound propagation path from aircraft on the runway to most residential areas south of the Airport. In addition, operational requirements would not allow a noise barrier to be located close to the runway where it would be most effective. (Section 7.2.5 of this report provides additional information.)

APUs

10. What is the purpose of APUs and what have other airports done to minimize their use?

Response to Comment 10: APUs are small jet engines, often located near the tail of an aircraft, that are used to provide electrical power and heat to aircraft when they are on the ground with their main engines shut down. In addition, compressed air generated by APUs sometimes is used to start the aircraft's main engines. At many airports, including ANC, cargo and passenger airlines often use quieter alternative sources of power (typically, diesel ground power units, also known as GPUs) when aircraft will be on the ground for extended periods. Some airports also provide "plug-in" ground power for aircraft at passenger gates. Because running APUs is expensive in terms of both fuel and maintenance costs, airlines typically choose not to use APUs whenever possible. (Sections 5.1.4 and 7.4 of this report provide additional information.)

Departure and Arrival Flight Tracks

11. The Airport needs either to redevelop its runways so that aircraft will never takeoff or land over Anchorage or else move to Fire Island.

Response to Comment 11: The preferred operating configuration at ANC is for aircraft to land from the west and depart to the north, which minimizes direct overflights of residential areas in the Anchorage Bowl. Due to wind conditions and other operational considerations, it is not always possible to operate in this configuration, however, and aircraft sometimes must either takeoff or land over nearby residential areas. Relocating the Airport to Fire Island was considered during the Master Plan Study. It is currently not the preferred alternative.

Relocation of Runway 6R/24L

12. What would the effects be of moving Runway 6R/24L 1,500 feet to the west. In particular, what would the effects be for residences located on Air Guard Road?

Response to Comment 12: Residents in the Delong Lake area would realize a reduction in thrust reverser noise for landings on Runway 6R as well as a reduction in start-of-takeoff noise for departures on Runway 24L. The closest homes to the Airport along Air Guard Road may experience noticeable reductions in maximum sound levels during Runway 24L departures of up to five decibels. Those located farther to the west (e.g., in the Tanaina Hills neighborhood) would most likely not notice either an increase or decrease in noise levels from these events, except to the extent that overall use of thrust reverse may be reduced for aircraft exiting the runway on Taxiways Golf or Delta. (Sections 7.1.3 and 7.2.4 of this report provide additional information.)

Kulis Air National Guard Base

13. Was Kulis Air National Guard Base included in the study?

Response to Comment 13: Kulis was included in the study with measurements conducted at an on-airport location adjacent to Kulis (Site 2) and a nearby residential location on Air Guard Road (Site 17) during both the September 2000 and February 2001 measurement programs. In addition, the Air National Guard was included during the operations data survey of all airport tenants and has been extremely cooperative throughout the study by meeting with the study team and providing operations data and access to the Base. Although, due to the importance of its national security and rescue roles, the Guard is not subject to the same operating restrictions as other tenants, it has been proactive in working to reduce noise in residential areas due to run-up operations.

Comment Period

14. I know that I will not have time in one week to read and digest all of this information. Can the comment period be extended to 30 days?

Response to Comment 14: The comment period was extended to allow 30 days for comment.

Sources of Ground Noise Included

15. Has the study identified all of the sources of ground noise at the Airport including North Airpark?

Response to Comment 15: The project team has taken great care to ensure that the study has addressed all significant sources of ground noise at the Airport. Prior to the initial public meeting, discussions were held with airport staff and tenants and a questionnaire was sent to residents to identify potential sources of ground noise. At the first meeting and subsequently, residents were provided with opportunities to suggest any additional sources of airport ground noise to be addressed. During both the September 2000 and the February 2001 measurement programs, the study team spent extensive amounts of time both on the Airport and in nearby residential areas observing airport ground operations. Because of these efforts, we are confident that we have identified all significant sources of ground noise. Regarding North Airpark, during both measurement programs, a noise monitor was located just to the south of the FedEx ramp specifically for the purpose of monitoring north Airpark operations. In addition, an observer was stationed near the FedEx ramp for much of the measurement program.

Seasonal Differences in Sound Levels

16. *Was there any seasonal difference in the noise levels measured in September 2000 compared to the noise levels measured in February 2001?*

Response to Comment 16: The measurements indicated that, in general, sources of airport ground noise caused higher noise levels in community locations during February 2001 than during September 2000 due to specific weather conditions that occur more commonly during the winter than during non-winter months. On any given winter day, however, either higher or lower sound levels may occur at a particular location than during non-winter periods, because the variations in sound propagation are caused by specific weather conditions rather than the season. (Section 6 of this report provides additional information.)

Start-of-Takeoff Contours

17. *What does the indentation depicted in the start-of-takeoff contours directly behind the aircraft represent? (Figures 5.1-5 through 5.1-10)*

Response to Comment 17: Because turbulence caused by the jet exhaust interferes with sound propagation, the loudest sound levels during start-of-takeoff typically occur approximately 45 degrees from the rear of the aircraft, rather than directly behind. This effect can readily be measured and is incorporated in the FAA's Integrated Noise Model (INM), which was used to generate the start-of-takeoff contours depicted in the referenced figures.

Timeline for Recommendations

18. *Is there a timeline to move forward with the study's recommendations?*

Response to Comment 18: To the extent that various recommendations are related to other ongoing activities at the Airport, they will move forward in coordination with those activities. For example, some recommendations (such as the relocation of Runway 6R/24L, a new north/south taxiway, and a new run-up location) need to be planned in conjunction with the ongoing Master Plan Update. Required coordination with airport operations staff and tenants to implement other recommendations (such as revisions to airport bulletins and GA pilot education) currently is underway. Coordination with ATC personnel required for other recommendations (such as intersection departures and revised run-up procedures) also is in preliminary stages. Some recommendations (such as construction of noise barriers or berms and assessing the feasibility and costs associated with low-frequency treatments and standards for residential sound insulation) may require amending or updating the Airport's FAR Part 150 Program. These updates will be conducted as required.

The following responses are provided for written comments that were submitted during the comment period following the September 27, 2001 public meeting:

APUs

19. ". . . the contribution of noise from APUs is, according to the report, "not significant," yet the report recommends the extremely costly measure of providing ground power and pre-conditioned air throughout the Airport, including cargo facilities. While the use of airport-provided power may have other benefits (e.g., reducing fuel consumption and air emissions), these benefits must be assessed in relation to the cost of providing the infrastructure (e.g., addition of 400 Hz power grids) before determining the economic feasibility of this measure. Furthermore, as the report acknowledges, technical and operational limitations may prevent aircraft from fully using these power sources even where they are available, thereby reducing the potential effectiveness of this mitigation measure."

Response to Comment 19: Although Section 5.1.4 of the report acknowledges that "APUs do not make significant contributions to overall noise levels in most residential areas," it also points out that APUs "are audible under some conditions, particularly at night when background sound levels are lowest. Due to the extended nature of APU operations (lasting up to several hours), noise from APUs has the potential to be annoying despite relatively low sound levels . . . ." As noted in Section 2.3 of the report, "FICAN recognizes annoyance as the best indication of adverse community reaction to noise." The report also indicates that in portions of Turnagain and Spenard, APU noise may dominate the background sound level during some periods of the day or night and may cause outdoor speech interference during periods when several APUs are in use.

Section 7.4.2 of the report acknowledges that providing ground power outlets for cargo facilities is likely to be more costly than for passenger gates and recommends determining the feasibility of providing ground power at cargo facilities. The report recommends the use of alternative sources of ground power, such as GPUs, in locations where ground power outlets are determined not to be feasible.

Low-frequency Noise

20. ". . . in the absence of an approved standard or even an accepted metric for assessing low-frequency noise impacts, it is impossible to evaluate the effectiveness of any mitigation designed to address it. However, even if such a standard were identified and adopted by the FAA, the high incremental cost associated with additional sound insulation and the questionable scientific evidence for its effectiveness in mitigating low-frequency noise makes it unlikely that this would be an economically reasonable mitigation measure. Although the report suggests that these costs be evaluated in the future, it could go further by recommending that the Airport conduct a full cost-benefit analysis prior to considering the mitigation measure."

Response to Comment 20: Sections 7.1.5 and 7.2.6 of the report acknowledge that currently "there is no FAA standard to measure or assess the effects of low-frequency noise and there is still a debate on the effectiveness and benefit of any residential sound insulation that addresses low-frequency noise." The report recommends "once an FAA standard is in place regarding low-frequency noise, the Airport should assess the feasibility and costs associated with incorporating low-frequency treatments/standards during residential sound insulation" and request that the FAA approve an amendment to ANC's FAR Part 150 Noise Compatibility Program.

Outdoor Sound Levels

21. *"The report and mitigation options . . . seem to be aimed at reducing levels inside residential homes. What about sound levels outside my home or with doors and windows open? I expect that I should be able to live and use all of my property without intrusive noise. Soundproofing my home will not solve the problem."*

Response to Comment 21: Section 3 of the report provides guidelines for assessing speech interference at both outdoor and indoor locations. In addition, all measured and computed sound levels provided in the report are for outdoor locations (with the exception of measured indoor vibration levels). Section 3 provides guidelines for estimating indoor sound levels based upon measured outdoor levels. All recommended mitigation options (with the exception of assessing the feasibility and costs associated with low-frequency standards/treatments for residential sound insulation, pending an FAA standard) would provide benefit at both outdoor and indoor locations.

Relocation of Runway 6R/24L

22. *"Relocation of Runway 6R/24L to the west may reduce sound levels to the east of the runway, but what will it do for levels in the Tanaina Valley area?"*

Response to Comment 22: Residents in the Tanaina Valley area and other locations near the east end of Runway 6R/24L would most likely not notice either an increase or decrease in noise levels from either Runway 24L departures or Runway 6R arrivals, except to the extent that overall use of thrust reversers may be reduced for aircraft exiting the runway on Taxiways Golf or Delta. Figure 7.1-1 provides start-of-takeoff contours for departures on relocated Runway 24L and may be compared to Figure 5.1-7, which shows start-of-takeoff contours for the existing runway location. (Sections 7.1.3 and 7.2.4 of this report provide additional information.)

Measurement Locations

23. *"The noise measurements generated a great deal of useful data. My primary criticism in this regard is that measurements were not taken farther away from the Airport. [. . .] What is the ground noise footprint for Anchorage? For example, I live near Artic and International, and from indoors I can hear airplanes taking off and landing on all runways."*

Response to Comment 23: The community noise measurement sites were chosen to be representative of both the closest residential locations to the Airport, which generally are exposed to the highest levels of airport ground noise, and residential areas up to about one mile away. In addition, an effort was made to select sites away from other significant local noise sources (such as busy streets) to minimize interference with the measurements. Although ground noise events are audible in areas farther from the Airport (particularly during periods of the day or night when background sound levels are lowest), it is noise from airborne aircraft departing arriving ANC that typically produces the loudest airport-related sound levels in more distant areas. (The noise contours depicting the noise from airborne aircraft can be viewed at www.dot.state.ak.us/anc/1997nois.htm or by requesting a copy of the Noise Exposure Map from ANC's Noise Program Office.) Although ground noise measurements were not conducted in these areas, the majority of the recommended mitigation options would reduce sound levels from airport ground operations in these neighborhoods as well as in areas closer to the Airport.

Noise-related Stress

24. *"The impacts of noise disturbance are not confined to sleep interruption, loss of concentration, lack of productivity, and speech interference to mention a few of the effects. One of the major ones is stress partly because the affected population has no control over the source. The Final Report should cite relevant animal and human studies."*

Response to Comment 24: The guidelines for assessing speech interference and sleep disturbance provided in Section 3 of the report are intended to serve as benchmarks to provide context for the sound levels discussed in the report and should not be interpreted as impact criteria. Section 2.3 of the report acknowledges that "annoyance is not a trivial effect of aircraft noise exposure" and points out that "FICAN recognizes annoyance as the best indication of adverse community reaction to noise." The report further states that annoyance may be caused both by "relatively loud, short-duration events that may contribute to short-term speech interference and sleep interference . . ." and by "quieter, longer-duration events which may contribute to annoyance due to their persistent nature." The report provides mitigation recommendations for these quieter, longer-duration noise sources such as APUs and taxi/idle noise. (Also see the response to Comment 27 for further discussion of health effects of noise.)

Future Airport Expansion

25. *"A major failure of the Draft Report is that it confines itself to the current airport activity. If the Airport expands, which appears likely, ground noise impacts will increase at least proportionately."*

Response to Comment 25: The ANC Comprehensive Ground Noise Study is the result of a commitment made during the NCP update process to further investigate sources of ground noise at ANC and to pursue operational and structural abatement and mitigation measures to address ground noise, including low-frequency noise, created by aviation operations at the Airport. The recommended mitigation measures would be effective in reducing sound levels from future ground operations as well as existing operations. Although the Study's scope of work does not specifically include a forecast element, many of the mitigation recommendations address potential future development at the Airport (including new taxiways, Runway 6R/24L relocation, provision for ground power at new cargo and passenger facilities, a new run-up area, and recommendations for orientation of new GA aircraft tie-downs), and are recommended to be carried-out in coordination with the ongoing Master Plan process.

Effects of Noise Sources Other than Airport Ground Operations

26. *"The report does not address the cumulative impacts of noise. For example, when I hear a plane taking off at night I may not be able to get to or go back to sleep until I hear it takeoff. Airport noise is only part of the matrix. Although overflight noise is clearly the most overwhelming component, noise from International Airport road, the railroad, and the gravel plant are also major irritants."*

Response to Comment 26: Section 5.3 of the report provides information on the daily cycle of ground noise events at ANC and provides measurement data showing sound levels from combined events. In addition, when relevant, the report provides both quantitative and descriptive information on the effects of multiple simultaneous noise sources, such as taxiing/idling aircraft (Section 5.1.3) and multiple APUs (Section 5.1.4). Overflight noise is addressed in the FAR Part 150 Study and is not included in the Ground Noise Study. The Airport has no jurisdiction over International Airport Road, the railroad, or the gravel plant, and these noise sources are not included in the Ground Noise Study.

Health Effects

27. *"In order to comprehensively address ground noise and how important it is that ANC take serious measures to reduce it, the Final Report needs to include a much more extensive section discussing existing data on the potential negative health effects of cumulative, long-term exposure of ongoing, airport-generated noise to residential and school areas."*

Response to Comment 27: Despite considerable worldwide research, there is widespread disagreement regarding the effects of environmental noise on health. The World Health Organization (WHO) defines health as "A state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." This broad definition of health embraces the concept of well-being, and thereby renders noise impacts such as annoyance, interference with communication and deteriorated task performance as "health" issues. In 1992, a WHO task force identified the following specific health effects of noise: interference with communication; noise-induced hearing loss; annoyance responses; and effects on: sleep, the cardio-vascular and psycho-social systems, performance, productivity, and social behavior.[40] More recently, the WHO has published a document entitled, "Guidelines for Community Noise,"[41] which sets forth guidelines that, more accurately, are goals for achieving the WHO definition of well-being. These guidelines have not considered the practical and economic implications of achieving those goals.

At the aircraft ground noise levels experienced in the community locations around ANC, however, there is little solid evidence supporting a claim that noise affects human physical and mental health in the workplace or in communities. An article published in *Noise/News International*, the journal of the International Institute of Noise Control Engineering, noted

[40] World Health Organization, *The Environmental Health Criteria Document on Community Noise*, Report on the Task Force Meeting, Dusseldorf, Germany, 24-28 November 1992, WHO Regional Office for Europe, Report EUR/HFA Target 24, WHO, Copenhagen, Denmark,1993.

[41] WHO 2001. *Guidelines for Community Noise*. Report on the Task Force Meeting, London, UK, April 1999. World Health Organization, Geneva, Switzerland.

> . . . the claim is frequently made that noise affects human physical and mental health at the workplace as well as in communities. In spite of considerable research on this problem worldwide, there is little solid scientific evidence supporting many of these claims, and our scientific understanding is far from being able to demonstrate a reliable cause-effect relationship.[42]

The Federal Interagency Committee on Noise (FICON) also has found little evidence of health effects caused by community exposure to aircraft noise. In its 1992 *Federal Agency Review of Selected Airport Noise Analysis Issues*, FICON concluded that predictions of non-auditory health effects as a result of exposure to aircraft noise in a residential environment have not been conclusively demonstrated and that "no technical means are available for predicting extra-auditory health effects of noise exposure."[43]

For practical noise control considerations, the present status of our knowledge means that the criteria for evaluating noise impact, with respect to its direct and indirect effects on health, are the same criteria as those applied to prevent auditory effects. While

> . . . it appears that noise exposure can lead or contribute to [high blood pressure, as well as heart disease, gastric ulcers and other stress-related syndromes,] the cause for this is annoyance, emotion and attitude towards the noise, and not so much the physical stimulus *per se*. Studies in residential areas indicated that these psychological stress effects are caused by interference of the traffic or aircraft noise with communication and other daily activities, as well as interference with sleep behavior.[44]

In other words, by using criteria that prevent noise-induced hearing loss, minimize speech and sleep disruption, and minimize community reactions and annoyance, adverse effects on health also will be prevented.

Section 3 of the Ground Noise Study provides guidelines for assessing speech interference and sleep disturbance that are intended to provide context for the sound levels discussed in the report. In addition, Section 2.3 of the report acknowledges that "annoyance is not a trivial effect of aircraft noise exposure" and "FICAN recognizes annoyance as the best indication of adverse community reaction to noise." The report further states that annoyance may be caused both by "relatively loud, short-duration events that may contribute to short-term speech interference and sleep interference . . ." and by "quieter, longer-duration events, which may contribute to annoyance due to their persistent nature."

Cumulative Noise Effects of Ground and Flight Operations

28. *"[The Final Report] should address the cumulative effects of residents being subjected to both ground and air noise, since significant segments of this community are subjected to both, and at times, simultaneously."*

---

[42] Von Gierke, Henning E. and Kenneth McK. Eldred, "Effects of Noise on People," *Noise/News International*, June 1993, p. 85.

[43] *Federal Agency Review of Selected Airport Noise Analysis Issues*, Federal Interagency Committee on Noise, August 1992, pages 3-13 to 3-15.

[44] Von Gierke, p. 85.

Response to Comment 28: The FAA requires the use of the cumulative-exposure metric Day-Night Average Sound Level (DNL or L_{dn}), to determine noise exposure and land use compatibility. ANC's FAR Part 150 Noise Exposure Map provides DNL contours for ANC that are dominated, in most areas, by noise from aircraft in the air during either arrivals or departures. The noise exposure contours also include the contribution of noise generated by aircraft during start-of-takeoff roll. In nearly all locations in the vicinity of ANC, sound generated by airborne operations dominates the overall noise environment, and the additional contribution of ground-operations noise would have an insignificant effect on overall, or cumulative, noise exposure. For this reason, the Ground Noise Study relies upon single-event analysis (in terms of L_{max}) to help evaluate the intrusiveness of ground noise events that would be overshadowed by flight operations when considered only with cumulative-exposure analysis.

Public Outdoor Recreation Areas

29. *"The Final Report should include a discussion with regard to ground noise impacts on, and mitigation measures for, users of significant public amenities outside of residential areas in and around the Airport. A community is not only defined by the level of quality of life one experiences at one's own home, but also the level of quality of life in our parks, natural open spaces, recreational trails and other important public service facilities. [These] amenities are used and/or enjoyed by many residents and visitors on a daily basis year-round and evaluation of ground noise impacts on these areas should not be excluded from the ground noise study."*

30. *"The Final Report must comprehensively address the consequences of any proposed mitigation measure not only to residential areas, but also to public areas in and around the Airport."*

31. *"I take exception to the comment on page 101[of the Draft Report] that 'it is not critical to mitigate noise in all directions around aircraft conducting run-ups.' [. . .] The Final Report needs to acknowledge the heavy impacts of ground noise on the parks, recreational area and other public amenities surrounding the Airport and identify appropriate ground noise mitigation measures to these areas."*

Response to Comments 29, 30, and 31: It has been acknowledged that aircraft noise has the potential to affect the quality of recreational opportunities for users of parks and other public outdoor recreation areas. The National Park Service, for example, has issued a Director's Order (DO-47, December, 2000) that identifies the natural soundscape as a resource to be managed as are other park resources. The FAA, however, does not afford the same level of protection for parks as for residential areas. For example, while residential land use is considered to be compatible only with DNLs of 65 dBA or less, parks are considered to be compatible with DNLs of up to 75 dBA. In addition, the FAA does not provide funding for noise mitigation intended primarily to benefit public outdoor recreation areas, as it does for residential areas.

Daily Cycle Data for Turnagain

32. *"The Final Report should include daily cycle data for Site 10 in Turnagain of ground noise events and levels from combined events when Runway 32 is being used for departure (rather than Runway 14), to more accurately depict what actually occurs the majority of time in this area."*

Response to Comment 32: A figure providing the requested information has been included in Section 5.3 of the Final Report.

Vegetated Areas

33. *"The immediate next step in this Ground Noise Study process should be to complete a comprehensive inventory of all existing vegetated areas on airport land and work with the neighborhood residents, park and trail users, and the Clitheroe Center to evaluate their contributions in mitigating current airport ground noise as well as their contribution to mitigating other negative impacts associated with airport operations and activities, on the surrounding areas. The preservation of appropriate existing vegetated areas as impact mitigating measures should . . . be included in the overall ANC Master Plan Update as well as in the Ground Noise Final Report Mitigation Section."*

Response to Comment 33: Under some conditions, significant areas of vegetation (or acoustically "soft" ground) between a noise source and receiver may result in lower sound levels at the receiver than corresponding broad expanses of pavement. Measurements of taxiing aircraft conducted at ANC in the Postmark Bog area in 1999 have shown this effect.[45] Under certain weather conditions, however, such as temperature inversions or downwind conditions between the noise source and receiver, the ground type and/or the presence or lack of vegetation may have little effect on sound levels at the receiver. In addition, although intervening areas of pavement may increase sound levels under some conditions, newly constructed facilities (terminals, hangars, cargo facilities) may provide noise shielding, helping to reduce sound levels in community locations. As a result, the preservation of existing vegetated areas has not been proposed as a general noise mitigation measure. It is recommended, however, that the value of existing vegetated areas should be assessed for specific proposed facilities, with regard both to their function as buffer zones for non-compatible land uses and for their potential effect on sound propagation. In particular, it is recommended that the noise study report for proposed new facilities at ANC take into account the sound propagation conditions (including ground type) under both existing and proposed future conditions.

Construction of Additional Taxiways

34. *"Until the Airport provides much more specific information, including a map showing where additional high-speed taxiways might be built, the Final Report should be very reserved in its recommendation to implement building additional taxiways as ground noise mitigation*

[45] *Ted Stevens Anchorage International Airport Wetlands Permit Application Noise Assessment Report (Final),* HMMH Report No. 296690, Submitted to: State of Alaska DOT&PF, Submitted by: Harris Miller Miller & Hanson Inc., September 18, 2000, Page 13.

measures. Other negative impacts associated with additional construction of high-speed taxiways could outweigh any ground noise reduction."

Response to Comment 34: Sections 7.2.3 and 7.3.4 of the report recommend that construction of new taxiways, including high-speed runway exits, be considered in coordination with the Master Plan process. As such, specific information regarding any new taxiways proposed for construction would be available for public review and comment.

35. *"The Final Report needs to provide updated information with regard to the new North/South Taxiway and address whether planning for a new run-up location in the area recommended in the Draft Report was integrated into planning of the new taxiway."*

Response to Comment 35: Section 7.5.3 of the report recommends that "new run-up locations should be considered in conjunction with planning for any proposed taxiway improvement projects, including a new north/south taxiway west of Runway 14/32." Design for Phase 1 (approximately the southern one-third) of the new north/south taxiway on the west side of Runway 14/32 (Taxiway Y) was completed in June 2001 and construction began during the fall of 2002. Design for Phase 2 (approximately the northern two-thirds) will be completed during the winter of 2001/2002 with construction anticipated during 2002 and 2003. Although the Ground Noise Study Draft Report was not issued until August 2001, potential locations for new run-up areas, including the location near Taxiway Y, were discussed with ANC planning and operations staff during June of 2001. Provision for the recommended run-up area would be included under Phase 2 of the design of Taxiway Y.

Air Quality Emissions of GPUs

36. *"The Final Report should include information on the air quality emissions of APUs and GPUs as part of the discussion concerning the overall impact to the community of substituting GPUs as a ground noise mitigation measure."*

Response to Comment 36: For the criteria pollutants of concern in the Anchorage Bowl, the air-quality emission factors for diesel GPUs are lower than for APUs of typical cargo aircraft operating at ANC.

Gravel Strip Noise Barrier/Berm

37. *"Many factors associated with [a noise barrier or berm near the gravel strip] are not discussed in the Draft Report, but are very important in the evaluation of a berm in this area. These factors, including impacts to high-value wetlands, existing natural vegetation, Hood Creek, the hydrology of the area, aesthetics, sunlight blockage to homes, real estate value effects on homes, etc., all have to be factored in before any decisions on this potential mitigation measure are made. [. . .] After reviewing previously submitted public comment on the proposal of a trail/berm in the GA area of the Airport, appropriate language addressing the many impact factors associated with this mitigation measure proposal should be included in the Final Report."*

Response to Comment 37: Section 7.6.3 of the report recommends "that the Airport conduct a noise barrier/berm design study in conjunction with the affected community [near the gravel strip] to evaluate alternative locations, ensure that the noise barrier, berm, or barrier/berm combination provides the intended benefit, and to determine the feasibility of locating a barrier or berm in this area with regard to FAR Part 77 surfaces and other site restrictions." The recommendation further states that "the study should include a community-involvement component to (1) explain the purpose and expected benefits of the barrier or berm, (2) describe its location and appearance, and (3) permit the closest (abutting) residents to express concurrence or not with the Airport's recommendation." The design study should evaluate relevant siting issues, potentially including those listed by the commenter, for each noise barrier or berm alternative, including the no-action alternative.

Firing Range

38. *"I think that there is a firing range, which is operated by the Airport Security Department or others, . . . on Raspberry Road just before the entrance to Kincaid Park. [. . .] The noise is . . . very disturbing to my family. [. . .] It seems like this activity could be moved to a more appropriate location or coordinated with other agencies . . . ."*

Response to Comment 38: Approximately 65 ANC employees are trained in the use of 9-millimeter handguns at the range. Training typically is held in both the spring and the fall, although it does not necessarily occur only twice each year. Because the firing range was not in active use during either of the Ground Noise Study's two measurement periods, no measurements were made of this noise source. Based on previous data from other firing ranges however, maximum sound levels (L_{max}) for each shot fired (assuming no noise shielding) may be approximately 80 dBA at distances of 1,500 feet from the range. Because the "highly impulsive" nature of sound from small-arms gunfire is recognized to increase the potential for annoyance, it is appropriate to apply a penalty to the firing range noise when comparing it to noise from other sources, such as aircraft[46]. Based on assumptions of 65 users each firing approximately 30 rounds per day with no noise shielding from buildings, terrain, etc., the overall noise exposure from the range (including the "highly impulsive" penalty) would result in a DNL of approximately 65 dBA at a distance of 1,500 feet. Although the potential for short-term annoyance during the relatively infrequent training periods is recognized, activity at the range is unlikely to make a significant contribution to overall noise exposure at nearby residences.

[46] In this case, the appropriate penalty would be 12 decibels. American National Standards Institute (ANSI) Standard S12.9-1996-Part 4.

APPENDIX A: DESCRIPTION OF NOISE METRICS

To assist reviewers in interpreting the complex noise metrics used in evaluating airport noise, we present below an introduction to relevant fundamentals of acoustics and noise terminology.

A.1 Introduction to Acoustics and Noise Terminology

Five acoustical descriptors of noise are introduced here in increasing degree of complexity:

- Decibel, dB;
- A-weighted decibel, dBA;
- Sound Exposure Level, SEL;
- Equivalent Sound Level, Leq; and
- Day-Night Average Sound Level, DNL.

These noise metrics form the basis for the majority of noise analysis conducted at most airports throughout the U.S.

A.1.1 Decibel, dB

All sounds come from a sound source -- a musical instrument, a voice speaking, an airplane passing overhead. It takes energy to produce sound. The sound energy produced by any sound source is transmitted through the air in sound waves -- tiny, quick oscillations of pressure just above and just below atmospheric pressure. These oscillations, or sound pressures, impinge on the ear, creating the sound we hear.

Our ears are sensitive to a wide range of sound pressures. Although the loudest sounds that we hear without pain have about one million times more energy than the quietest sounds we hear, our ears are incapable of detecting small differences in these pressures. Thus, to better match how we hear this sound energy, we compress the total range of sound pressures to a more meaningful range by introducing the concept of sound pressure level.

Sound pressure levels are measured in decibels (or dB). Decibels are logarithmic quantities reflecting the ratio of the two pressures, the numerator being the pressure of the sound source of interest, and the denominator being a reference pressure (the quietest sound we can hear).

The logarithmic conversion of sound pressure to sound pressure *level* (SPL) means that the quietest sound that we can hear (the reference pressure) has a sound pressure level of about 0 dB, while the loudest sounds that we hear without pain have sound pressure levels of about 120 dB. Most sounds in our day-to-day environment have sound pressure levels on the order of 30 to 100 dB.

Because decibels are logarithmic quantities, combining decibels is unlike common arithmetic. For example, if two sound sources each produce 100 dB operating individually and they are then operated together, they produce 103 dB -- not the 200 decibels we might expect. Four equal sources operating simultaneously produce another three decibels of noise, resulting in a total sound pressure level of 106 dB. For every doubling of the number of equal sources, the sound pressure level goes up another three decibels. A tenfold increase in the number of sources makes the sound pressure level go up 10 dB. A hundredfold increase makes the level go up 20 dB, and it takes a thousand equal sources to increase the level 30 dB.

If one noise source is much louder than another, the two sources operating together will produce virtually the same sound pressure level (and sound to our ears) that the louder source would produce alone. For example, a 100 dB source plus an 80 dB source produce approximately 100 dB of noise when operating together (actually, 100.04 dB). The louder source "masks" the quieter one. But if the quieter source gets louder, it will have an increasing effect on the total sound pressure level such that, when the two sources are equal, as described above, they produce a level three decibels above the sound of either one by itself.

Conveniently, people also hear in a logarithmic fashion. Two useful rules of thumb to remember when comparing sound levels are: (1) a 6 to 10 dB increase in the sound pressure level is perceived by individuals as being a doubling of loudness, and (2) changes in sound pressure level of less than about three decibels are not readily detectable outside of a laboratory environment.

A.1.2 A-Weighted Decibel, dBA

Another important characteristic of sound is its frequency, or "pitch." This is the rate of repetition of the sound pressure oscillations as they reach our ear. When analyzing the total noise of any source, acousticians often break the noise into frequency components (or bands) to determine how much is low-frequency noise, how much is middle-frequency noise, and how much is high-frequency noise. This breakdown is important for two reasons:

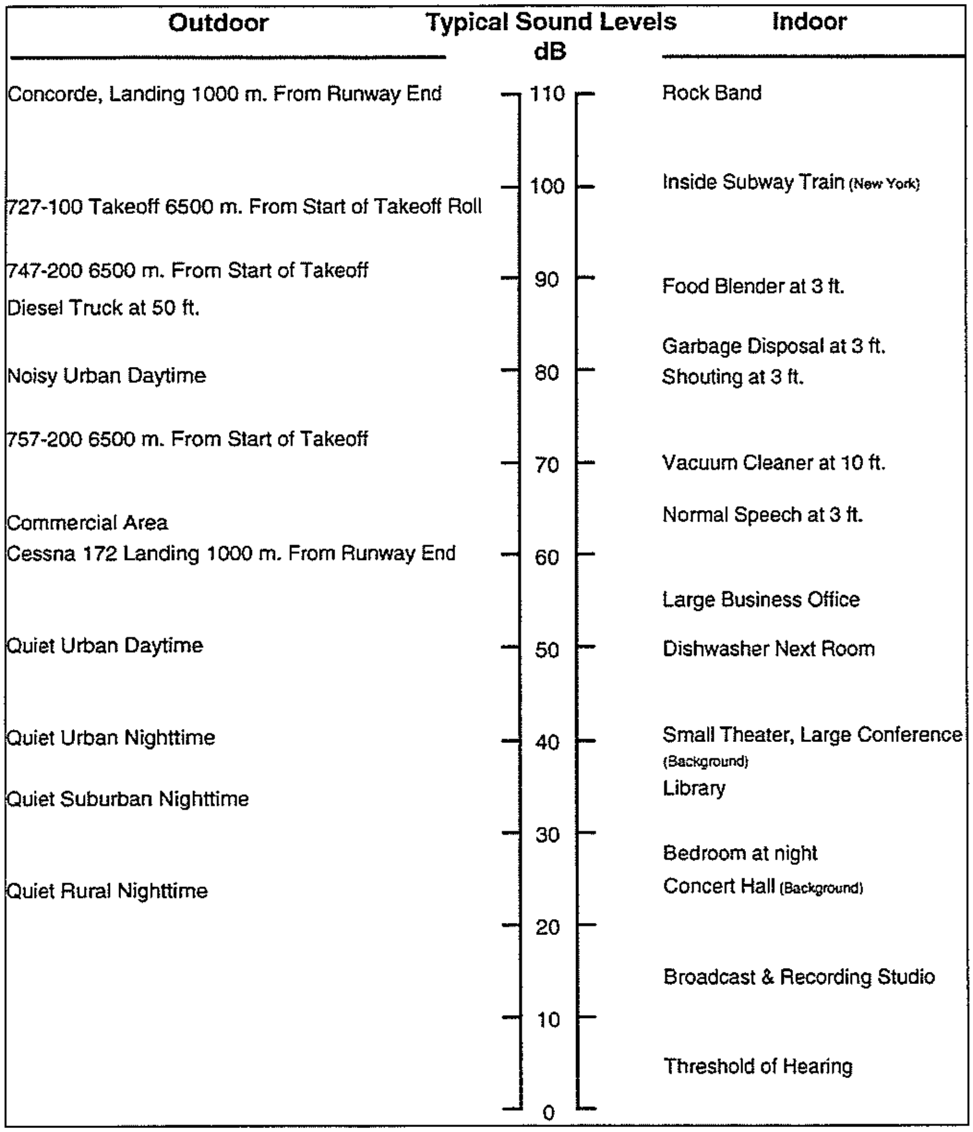
(1) People react differently to low-, mid-, and high-frequency noise levels. This is because our ear is better equipped to hear mid and high frequencies but is quite insensitive to lower frequencies. Thus, we find mid- and high-frequency noise to be more annoying.

(2) Engineering solutions to a noise problem are different for different frequency ranges. Low-frequency noise is generally harder to control.

The normal frequency range of hearing for most people extends from a low frequency of about 20 Hz to a high frequency of about 10,000 to 15,000 Hz. People respond to sound most readily when the predominant frequency is in the range of normal conversation, typically around 1,000 to 2,000 Hz. Acousticians have developed several filters which roughly match this sensitivity of our ear and thus help us to judge the relative loudness of various sounds made up of many different frequencies. The so-called A-weighting network, does this best for most environmental noise sources. Sound pressure levels measured through this filter are referred to as A-weighted sound levels (measured in A-weighted decibels, or dBA).

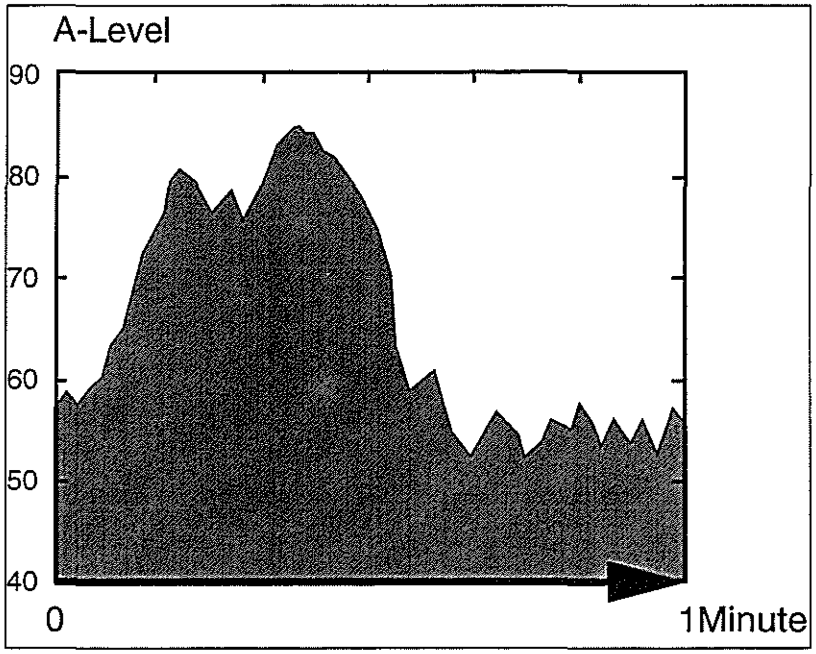
The A-weighting network significantly discounts those parts of the total noise that occur at lower frequencies (those below about 500 Hz) and also at very high frequencies (above 10,000 Hz) where we do not hear as well. The network has very little effect, or is nearly "flat," in the middle range of frequencies between 500 and 10,000 Hz where our hearing is most sensitive. Because this network generally matches our ears' sensitivity, sounds having higher A-weighted sound levels are judged to be louder than those with lower A-weighted sound levels, a relationship which otherwise might not be true. It is for this reason that A-weighted sound levels are normally used to evaluate environmental noise sources. Figure A.1 presents typical A-weighted sound levels of several common environmental sources.

Figure A.1 Common Environmental Sound Levels, in dBA



An additional dimension to environmental noise is that A-weighted levels vary with time. For example, the sound level increases as an aircraft approaches, then falls and blends into the background as the aircraft recedes into the distance (though even the background varies as birds chirp, the wind blows, or a vehicle passes by). This is illustrated in Figure A.2.

Figure A.2 Variation in the A-Weighted Sound Level over Time

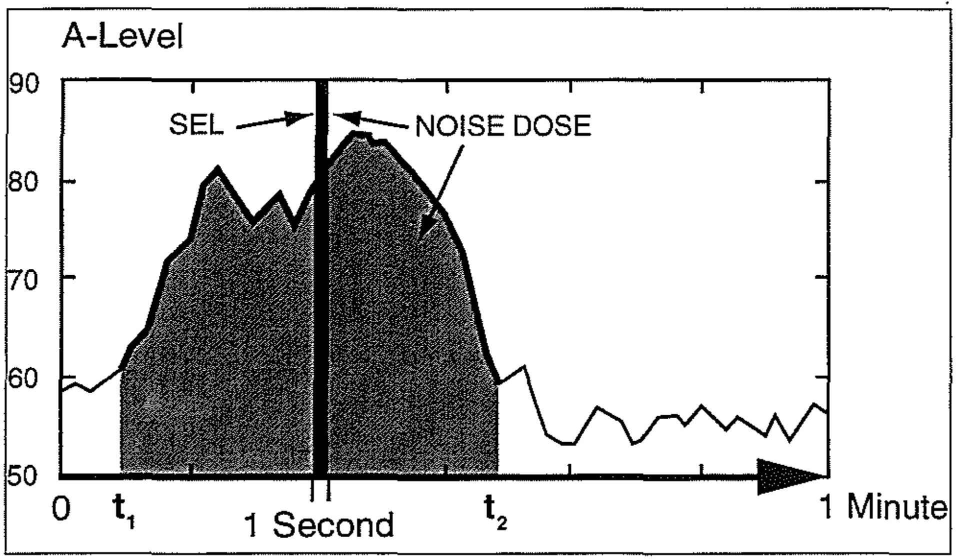


Because of this variation, it is often convenient to describe a particular noise "event" by its maximum sound level, abbreviated as L_{max}. In Figure A.2, the L_{max} is approximately 85 dBA. However, the maximum level describes only one dimension of an event; it provides no information on the cumulative noise exposure generated by a sound source. In fact, two events with identical maximum levels may produce very different total exposures. One may be of very short duration, while the other may continue for an extended period and be judged much more annoying. The next section introduces a measure that accounts for this concept of a noise "dose."

A.1.3 Sound Exposure Level, SEL

The most common measure of cumulative noise exposure for a single aircraft fly-over is the Sound Exposure Level, or SEL. SEL is an accumulation of the sound energy over the duration of a noise event. The lightly shaded area in Figure A.3 illustrates the portion of the sound energy included in this dose. To account for the variety of durations that occur among different noise events, the noise dose is normalized (standardized) to a one-second duration. This normalized dose is the SEL; it is shown as the darkly shaded area in Figure A.3. Mathematically, the SEL is the summation of all the noise energy compressed into one second.

Figure A.3 Sound Exposure Level



Note that because the SEL is normalized to one second, it will almost always be larger in magnitude than the maximum A-weighted level for the event. In fact, for most aircraft overflights, the SEL is on the order of 7 to 12 dBA higher than the L_{max}. Also, the fact that it is a cumulative measure means that not only do louder fly-overs have higher SEL than do quieter ones, but also fly-overs with longer durations have greater SEL than do shorter ones.

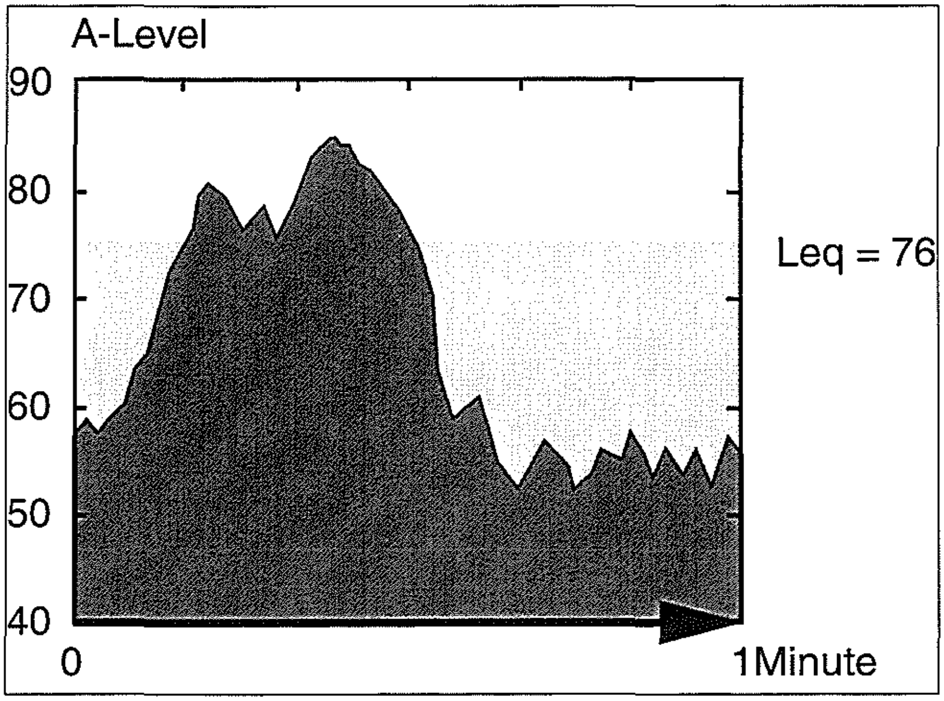
With this metric, we now have a basis for comparing noise events that generally matches our impression of the sound -- the higher the SEL, the more annoying it is likely to be. In addition, SEL provides a comprehensive way to describe a noise event for use in modeling noise exposure. Computer noise models base their computations on these SELs.

A.1.4 Equivalent Sound Level, Leq

The Equivalent Sound Level, abbreviated L_{eq}, is a measure of the exposure resulting from the accumulation of A-weighted sound levels over a particular period of interest -- for example, an hour, an eight-hour school day, nighttime, or a full 24-hour day. However, because the length of the period can be different depending on the time frame of interest, the applicable period should always be identified or clearly understood when discussing the metric.

L_{eq} may be thought of as a constant sound level over the period of interest that contains as much sound energy as the actual time-varying sound level. This is illustrated in Figure A.4. The equivalent level is, in a sense, the total sound energy that occurred during the time in question, but spread evenly over the time period. It is a way of assigning a single number to a time-varying sound level. Since L_{eq} includes all sound energy, it is strongly influenced by the louder events.

Figure A.4 Example of a 1-Minute Equivalent Sound Level



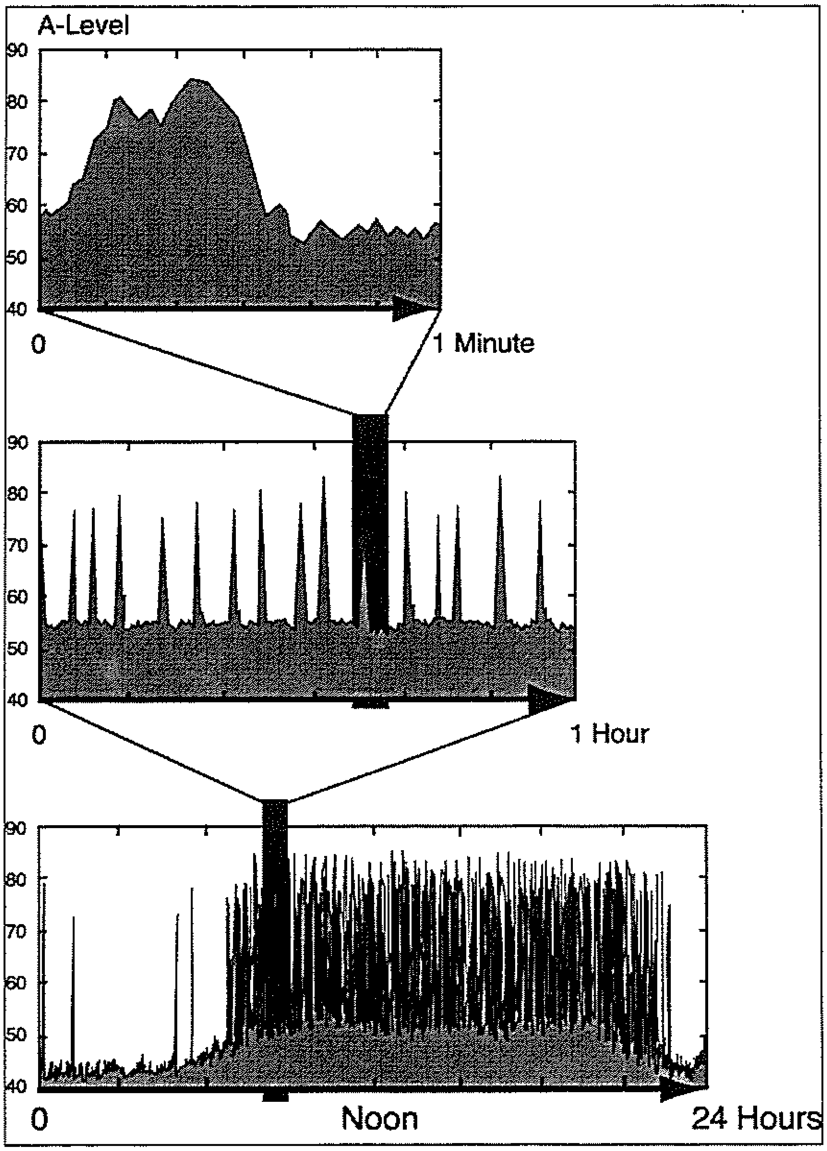
As for its application to airport noise issues, L_{eq} is often presented for consecutive one-hour periods to illustrate how the hourly noise dose rises and falls throughout a 24-hour period as well as how certain hours are significantly affected by a few loud aircraft.

A.1.5 Day-Night Average Sound Level, DNL

In the previous sections, we have been addressing noise measures that account for the moment-to-moment or short-term fluctuations in A-weighted levels as sound sources come and go affecting our overall noise environment. The Day-Night Average Sound Level (DNL) represents a concept of noise dose as it occurs over a 24-hour period. It is the same as a 24-hour L_{eq}, with one important exception; DNL treats nighttime noise differently from daytime noise. In determining DNL, it is assumed that the A-weighted levels occurring at night (10 p.m. to 7 a.m.) are 10 dB louder than they really are. This 10 dB penalty is applied to account for greater sensitivity to nighttime noise, and the fact that events at night are often perceived to be more intrusive because nighttime ambient noise is less than daytime ambient noise.

Earlier, we illustrated the A-weighted level due to an aircraft event. The example is repeated in the top frame of Figure A.5. The level increases as the aircraft approaches, reaching a maximum of 85 dBA, and then decreases as the aircraft passes by. The ambient A-weighted level around 55 dBA is due to the background sounds that dominate after the aircraft passes. The shaded area reflects the noise dose that a listener receives during the one-minute period of the sample.

Figure A.5 A-Weighted Level Fluctuations and Noise Dose



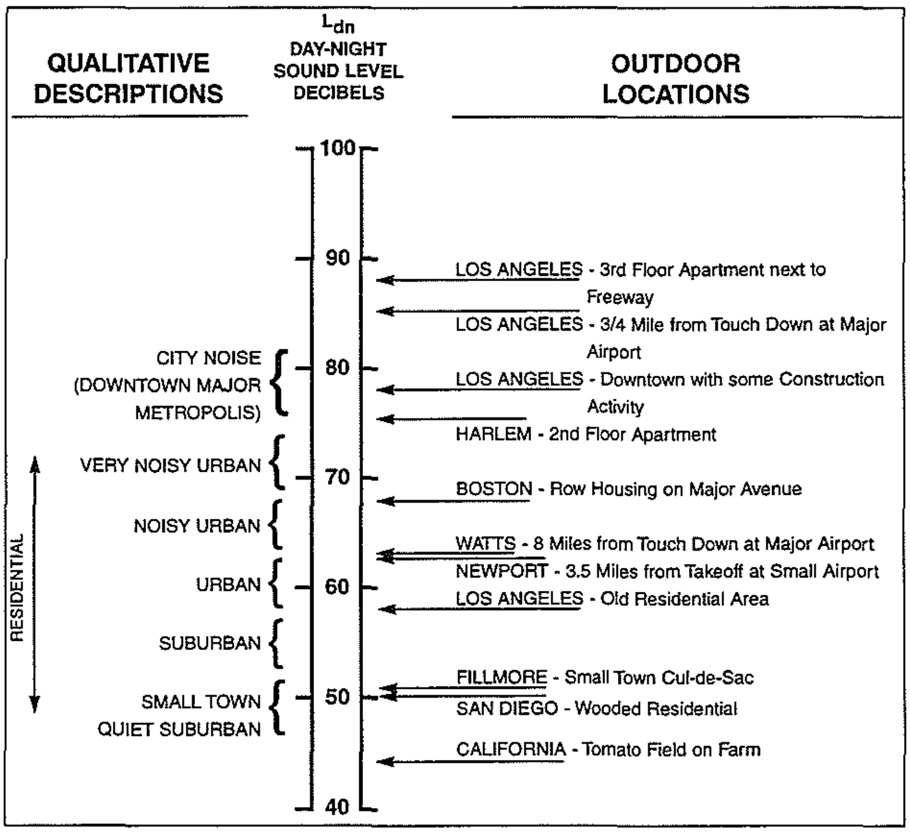
The center frame of Figure A.5 includes this one-minute interval within a full hour. Now the shaded area represents the noise dose during that hour when sixteen aircraft pass nearby, each producing a single event dose represented by an SEL. Similarly, the bottom frame includes the one-hour interval within a full 24 hours. Here the shaded area represents the noise dose over a complete day. Note that several overflights occur at night, when the background noise drops some 10 decibels, to approximately 45 dBA.

Values of DNL are normally measured with standard monitoring equipment or are predicted with computer models. Measurements are practical for obtaining DNL values for only relatively limited numbers of locations, and, in the absence of a permanently installed monitoring system, only for relatively short time periods. Thus, most airport noise studies utilize computer-generated estimates of DNL, determined by accounting for all of the SEL from individual aircraft operations that comprise the total noise dose at a given location on the ground. This principle is used in all airport noise modeling.

Computed values of DNL are usually depicted as noise contours that are lines of equal exposure around an airport (much as topographic maps have contour lines of equal elevation). The contours usually reflect long-term (annual average) operating conditions, taking into account the average flights per day, how often each runway is used throughout the year, and where over the surrounding communities the aircraft normally fly.

Figure A.6 presents a representative sample of DNL (denoted L_{dn} in the figure) measured at various locations in the U.S.

Figure A.6 Representative Examples of Day-Night Average Sound Levels



Source: United States Environmental Protection Agency, Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, March 1974, p.14

APPENDIX B. DAILY PROFILE OF GROUND NOISE EVENTS (SUPPLEMENTARY DATA)

This appendix provides the following additional information regarding the daily cycle of ANC ground noise events as a supplement to the data in Section Table 5.3 of the report:

- A table of all scheduled aircraft arrivals and departures at ANC on a typical mid-week day in January 2001. Table 5.3-1 in Section 5.3 provides a summary of this table with hourly totals. The table included in this appendix provides additional information including the scheduled arrival or departure time, the operator, and the aircraft type. This information allows an estimate of the approximate distribution of start-of-takeoff or thrust-reverser events that may be expected to occur throughout all hours of the day and night. In addition, the data may be used to develop estimates of the number of APUs that may be operating and the approximate number of taxiing aircraft at a particular time.
- A similar table providing all scheduled aircraft arrivals and departures at ANC on a typical mid-week day in July 2001.
- Additional detailed time-history plots (to supplement those in Section 5.3) for the hours starting at 6:00 AM or 7:00 PM at each of three representative sites located in Turnagain, Spenard, and Sand Lake. The graphs in this appendix provide time-history plots of actual and scheduled events for the hours not displayed in Section 5.3.

  The first graph of each pair provides the actual measured time-history trace at that site during the noted hour. The figure shows the time-varying A-weighted sound level as measured throughout the hour along with horizontal lines indicating the thresholds for the onset of indoor and outdoor speech interference. The actual measured sound levels include all types of ANC operations (including both airborne operations and ground noise) in addition to other noise sources such as local and distant street traffic.

  The second graph of each pair provides the same measured time-history trace as the first graph. In addition, the shaded areas superimposed in front of the *measured* levels indicate the approximate sound levels and durations of *scheduled* operations for that hour. The information on the scheduled events was derived from the preceding detailed tables of scheduled events. These figures are intended to show, in a schematic way, the approximate frequency of occurrence, duration, and sound-level contribution of each noise source during the representative hour. While an approximate correspondence should be expected between the numbers of scheduled and actual operations during a given hour, exact correspondence is not expected and no attempt was made to match the scheduled events to the actual measured events. In addition, the sound levels shown for the scheduled operations are based upon average measured or projected sound levels associated with the ground noise portion of each event. These average sound levels are not expected to correspond exactly with the measured sound level of each particular measured event.

ANC Scheduled Daily Ops, Mid-week, January 2001			
Time	**Operator**	**Plane**	**Operation**
0009	Alaska	B737-400	Arrival
0010	Alaska	B737-200	Arrival
0025	ERA	DHC-6	Arrival
0030	Alaska	MD80	Departure
0030	Tatonduk Flying Service	DC6	Arrival
0035	Singapore Airlines	B747-200	Departure
0035	Singapore Airlines	B747-400	Arrival
0036	Alaska	MD80	Arrival
0038	Alaska	MD80	Arrival
0040	ERA	DHC-8	Departure
0040	United	B737-300	Departure
0040	Delta	B767-300	Departure
0040	Evergreen	B747-200	Departure
0045	TWA	B757	Departure
0045	American	MD80	Departure
0055	Alaska	MD80	Departure
0100	Delta	B767-300	Departure
0100	Polar Air Cargo	B747-200	Arrival
0119	Delta	B757	Arrival
0120	Alaska	MD80	Departure
0122	Alaska	MD80	Arrival
0125	Alaska	B737	Departure
0126	Alaska	MD80	Arrival
0140	Alaska	MD80	Departure
0140	Singapore Airlines	B747-400	Departure
0145	ERA	DHC-8	Arrival
0145	America West	A319	Departure
0145	Continental	B757	Departure
0215	Cathay Pacific	A340-300	Arrival
0226	Alaska	B737-400	Arrival
0230	Korean Air	B747-400	Arrival
0230	Alaska Central Express	Beechcraft	Departure
0235	Korean Air	MD11	Arrival
0300	Asiana	B747-400	Arrival
0300	Alaska Central Express	Beechcraft	Departure
0300	Polar Air Cargo	B747-200	Departure
0335	Cathay Pacific	A340-300	Departure
0335	Korean Air	MD11	Departure
0335	China Southern	B747-200	Arrival
0400	Penair	Fairchild Metroliner	Departure
0400	Alaska Central Express	Beechcraft	Departure
0415	Alaska	B737	Arrival
0420	ERA	DHC-6	Departure
0420	Eva	MD11	Departure
0425	Korean Air	B747-400	Departure
0430	ERA	DHC-8	Departure
0430	Penair	Fairchild Metroliner	Departure
0430	Polar Air Cargo	B747-200	Arrival
0430	Nippon Cargo	B747-200	Arrival

ANC Scheduled Daily Ops, Mid-week, January 2001			
Time	**Operator**	**Plane**	**Operation**
0445	Alaska Central Express	Beechcraft	Departure
0445	Gemini	DC10	Arrival
0445	Alaska	B737	Arrival
0450	Asiana	B747-400	Departure
0455	Asiana	B747-200	Arrival
0500	Tatonduk Flying Service	DC6	Departure
0500	Penair	Fairchild Metroliner	Departure
0500	Alaska Central Express	Beechcraft	Departure
0500	Northern Air Cargo	B727	Departure
0500	Evergreen	B747-200	Arrival
0505	Mavial	Tupolov TU-154	Arrival
0517	UPS	B747-200	Arrival
0521	Alaska	B737	Arrival
0525	Northwest	B757	Departure
0525	Nippon Cargo	B747-200	Departure
0530	Frontier	Cessna	Departure
0535	ERA	DHC-8	Arrival
0545	Gemini	DC10	Departure
0550	Korean Air	MD11	Arrival
0555	ERA	DHC-8	Departure
0555	Asiana	B747-200	Departure
0600	Alaska	B737-200	Departure
0600	Northern Air Cargo	DC6	Departure
0600	Japan Airlines	B747-200	Arrival
0605	Alaska	B737-200	Departure
0610	Alaska	MD80	Departure
0615	ERA	DHC-6	Arrival
0620	Alaska Central Express	Beechcraft	Arrival
0620	Korean Air	B747-200	Arrival
0620	FEDEX	A300	Arrival
0625	Alaska	B737-400	Departure
0625	Delta	B757	Departure
0630	Alaska	B737-400	Departure
0630	Evergreen	B747-200	Departure
0630	Polar Air Cargo	B747-200	Departure
0630	Polar Air Cargo	B747-200	Arrival
0635	FEDEX	MD11	Arrival
0635	Korean Air	B747-200	Arrival
0635	Japan Airlines	B747-200	Arrival
0640	ERA	DHC-6	Departure
0640	United	B757	Departure
0640	Alaska	B737-200	Departure
0640	Northwest	B747-200	Arrival
0645	ERA	DHC-8	Departure
0650	Alaska	B737-400	Departure
0650	Korean Air	MD11	Departure
0650	FEDEX	DC10	Arrival
0654	United	DC10	Arrival
0655	ERA	DHC-8	Departure
0655	Frontier	Cessna	Arrival
0700	ERA	DHC-8	Arrival
0700	Alaska	B737-200	Departure

ANC Scheduled Daily Ops, Mid-week, January 2001			
Time	**Operator**	**Plane**	**Operation**
0700	Alaska Central Express	Beechcraft	Departure
0700	Artic Circle Air Service	Cessna	Departure
0700	Japan Airlines	B747-200	Departure
0700	Northern Air Cargo	DC6	Departure
0700	United	DC10	Arrival
0700	FEDEX	MD11	Arrival
0705	FEDEX	A300	Arrival
0710	Alaska	B737-400	Departure
0711	Alaska	MD80	Arrival
0720	ERA	DHC-8	Departure
0720	Korean Air	B747-200	Departure
0720	Eva	MD11	Arrival
0720	FEDEX	MD11	Arrival
0730	Frontier	Beechcraft	Arrival
0730	Delta	B757	Arrival
0730	Japan Airlines	B747-200	Departure
0735	Penair	Fairchild Metroliner	Departure
0735	Korean Air	B747-200	Departure
0740	ERA	Convair	Departure
0745	Penair	Saab SF340	Departure
0746	UPS	B747-200	Departure
0753	Alaska	B737-400	Departure
0755	ERA	DHC-8	Arrival
0755	Cathay Pacific	B747-200	Arrival
0800	Reeve	B727	Departure
0800	Penair	Fairchild Metroliner	Departure
0800	Alaska	MD80	Departure
0800	F.S. Air Service	Piper	Departure
0800	Northwest	B747-200	Departure
0810	Frontier	Beechcraft	Departure
0812	Nippon Cargo	B747-200	Departure
0815	Penair	Saab SF340	Departure
0815	ERA	Convair	Departure
0819	Alaska	B737-200	Arrival
0820	Penair	Fairchild Metroliner	Arrival
0820	United	DC10	Departure
0820	Eva	MD11	Departure
0825	ERA	DHC-8	Departure
0835	United	DC10	Departure
0840	ERA	DHC-6	Arrival
0840	Japan Airlines	B747-200	Arrival
0841	Alaska	B737-400	Arrival
0845	Delta	B757	Departure
0855	Cathay Pacific	B747-200	Departure
0855	Polar Air Cargo	B747-200	Departure
0855	Asiana	B747-200	Arrival
0900	Alaska	B737-400	Arrival
0900	Grant Aviation	Beechcraft	Departure
0900	ERA	DHC-6	Departure
0900	Frontier	Cessna	Departure
0902	Alaska	B737-200	Arrival
0910	China Airlines	B747-400	Arrival
0910	Northwest	DC-10	Departure

ANC Scheduled Daily Ops, Mid-week, January 2001			
Time	**Operator**	**Plane**	**Operation**
0910	FEDEX	DC10	Departure
0915	ERA	DHC-8	Arrival
0920	Penair	Fairchild Metroliner	Arrival
0920	ERA	Convair	Arrival
0920	Alaska	B737-200	Departure
0920	FEDEX	MD11	Departure
0926	Alaska	B737-400	Departure
0930	F.S. Air Service	Piper	Arrival
0930	FEDEX	MD11	Departure
0935	ERA	DHC-8	Arrival
0935	ERA	DHC-8	Arrival
0935	China Airlines	B747-200	Arrival
0940	Mavial	Tupolov TU-154	Departure
0940	Japan Airlines	B747-200	Departure
0942	Alaska	B737-400	Departure
0945	ERA	DHC-8	Departure
0945	China Airlines	B747-200	Arrival
0948	Alaska	B737-400	Arrival
0950	LTU	B767	Arrival
0950	Penair	Fairchild Metroliner	Departure
0955	ERA	DHC-8	Departure
0955	Asiana	B747-200	Departure
0955	Alitalia	B747-200	Arrival
1000	Korean Air	B747-400	Arrival
1000	ERA	DHC-8	Departure
1000	Empire Airlines	Fokker F27	Departure
1000	Nippon Cargo	B747-200	Arrival
1000	China Southern	B747-200	Arrival
1002	Alaska	B737-200	Departure
1005	Penair	Fairchild Metroliner	Arrival
1005	Alaska Central Express	Beechcraft	Arrival
1005	Northern Air Cargo	B727	Arrival
1010	Alaska	B737-200	Departure
1015	ERA	DHC-6	Arrival
1015	Alaska	B737-200	Arrival
1015	Frontier	Cessna	Arrival
1015	Northwest	B747-200	Arrival
1015	Nippon Cargo	B747-200	Arrival
1020	Korean Air	B747-200	Arrival
1020	Japan Airlines	B747-200	Arrival
1020	Nippon Cargo	B747-200	Arrival
1020	Airborne Express	DC9	Arrival
1026	Alaska	B737-400	Arrival
1030	Alaska Central Express	Beechcraft	Departure
1033	Alaska	B737-400	Departure
1035	Cathay Pacific	A340-300	Arrival
1035	China Airlines	B747-200	Departure
1039	Artic Circle Air Service	Cessna	Arrival
1040	United	DC10	Arrival
1042	Alaska	MD80	Arrival
1045	China Airlines	B747-200	Departure
1045	Alaska Central Express	Beechcraft	Arrival
1055	Penair	Saab SF340	Arrival

ANC Scheduled Daily Ops, Mid-week, January 2001			
Time	**Operator**	**Plane**	**Operation**
1100	ERA	Convair	Departure
1100	Air China	B747-200	Arrival
1105	ERA	DHC-8	Arrival
1110	Penair	Fairchild Metroliner	Arrival
1110	Reeve	L188	Departure
1110	China Airlines	B747-400	Departure
1110	Nippon Cargo	B747-200	Departure
1110	Northwest	B747-200	Arrival
1110	China Cargo Airlines	DC10	Arrival
1115	Alaska	B737-200	Departure
1120	Korean Air	B747-400	Departure
1120	Japan Airlines	B747-200	Departure
1120	Korean Air	B747-200	Departure
1120	Alaska Central Express	Beechcraft	Arrival
1123	Alaska	B737-400	Departure
1125	Penair	Saab SF340	Arrival
1125	ERA	DHC-6	Departure
1129	Alaska	MD80	Arrival
1130	Penair	Fairchild Metroliner	Departure
1130	Alaska	MD80	Departure
1130	ERA	DHC-8	Departure
1130	Japan Airlines	B747-200	Arrival
1140	Penair	Fairchild Metroliner	Departure
1140	United	DC10	Arrival
1140	Japan Airlines	B747-200	Arrival
1145	ERA	DHC-8	Arrival
1145	Northwest	B757	Arrival
1150	Cathay Pacific	A340-300	Departure
1155	Alitalia	B747-200	Departure
1155	Nippon Cargo	B747-200	Departure
1155	FEDEX	MD11	Arrival
1156	UPS	B747-200	Arrival
1156	Nippon Cargo	B747-200	Arrival
1159	Alaska	B737-400	Arrival
1200	Penair	Saab SF340	Departure
1200	LTU	B767	Departure
1200	Alaska Central Express	Beechcraft	Departure
1200	Northern Air Cargo	B727	Departure
1200	China Southern	B747-200	Departure
1200	Air China	B747-200	Departure
1200	China Cargo Airlines	DC10	Departure
1200	Alaska Central Express	Beechcraft	Departure
1200	Alaska Central Express	Beechcraft	Arrival
1201	Alaska	MD80	Arrival
1210	Alaska Central Express	Beechcraft	Arrival
1214	Alaska	MD80	Departure
1215	ERA	DHC-8	Departure
1215	Tatonduk Flying Service	DC6	Arrival
1219	ERA	DHC-8	Arrival
1220	Penair	Fairchild Metroliner	Arrival
1220	Frontier	Beechcraft	Arrival
1220	Nippon Cargo	B747-200	Arrival
1230	Penair	Fairchild Metroliner	Departure
1230	Northwest	B747-200	Departure

ANC Scheduled Daily Ops, Mid-week, January 2001			
Time	**Operator**	**Plane**	**Operation**
1230	Korean Air	B747-200	Arrival
1230	Asiana	B747-200	Arrival
1230	Air China	B747-200	Arrival
1235	Penair	Fairchild Metroliner	Departure
1235	Japan Airlines	B747-200	Departure
1235	Nippon Cargo	B747-200	Arrival
1239	Alaska	B737-200	Arrival
1240	ERA	DHC-6	Arrival
1240	Northwest	B747-200	Departure
1244	Alaska	B737-400	Departure
1245	Alaska	B737-700	Arrival
1245	Japan Airlines	B747-200	Departure
1245	China Airlines	B747-200	Arrival
1245	FEDEX	DC10	Arrival
1247	Alaska	MD80	Departure
1248	Alaska	MD80	Arrival
1250	Alaska	MD80	Arrival
1250	Northwest	B747-200	Departure
1250	United	DC10	Departure
1250	Nippon Cargo	B747-200	Arrival
1300	Penair	Fairchild Metroliner	Arrival
1300	ERA	Convair	Arrival
1300	Frontier	Beechcraft	Departure
1300	Northwest	B757	Departure
1300	Frontier	Cessna	Departure
1300	Korean Air	B747-200	Arrival
1305	Canada 3000	A320	Arrival
1306	United	B757	Arrival
1310	ERA	DHC-8	Arrival
1310	United	DC10	Departure
1315	Grant Aviation	Beechcraft	Arrival
1315	Nippon Cargo	B747-200	Departure
1316	Alaska	B737-200	Arrival
1324	Alaska	B737-200	Arrival
1325	ERA	DHC-8	Arrival
1325	FEDEX	MD11	Arrival
1325	FEDEX	MD11	Arrival
1330	ERA	Convair	Arrival
1330	ERA	DHC-6	Departure
1330	Korean Air	B747-200	Departure
1330	Asiana	B747-200	Departure
1330	Korean Air	B747-200	Departure
1330	Nippon Cargo	B747-200	Departure
1330	Northern Air Cargo	DC6	Arrival
1335	Alaska	B737-700	Departure
1335	Alaska	MD80	Departure
1345	Reeve	B727	Arrival
1345	ERA	DHC-8	Departure
1345	China Airlines	B747-200	Departure
1350	Nippon Cargo	B747-200	Departure
1355	Canada 3000	A320	Departure
1355	Nippon Cargo	B747-200	Arrival
1358	Alaska	B737-400	Arrival
1358	Alaska	B737-200	Departure

ANC Scheduled Daily Ops, Mid-week, January 2001			
Time	**Operator**	**Plane**	**Operation**
1359	Airborne Express	DC9	Departure
1400	Grant Aviation	Beechcraft	Departure
1400	Air China	B747-200	Departure
1400	Korean Air	B747-200	Departure
1400	FEDEX	A300	Departure
1400	KLM	B747-200	Arrival
1400	Alaska Central Express	Cessna	Arrival
1402	Alaska	B737-400	Arrival
1410	Penair	Saab SF340	Departure
1410	ERA	DHC-8	Departure
1415	Alaska	B737-200	Arrival
1415	Alaska	MD80	Departure
1416	Alaska	B737-200	Departure
1416	Empire Airlines	Fokker F27	Arrival
1418	Alaska	B737-200	Arrival
1424	Alaska	B737-200	Departure
1425	United	B757	Departure
1425	Frontier	Cessna	Arrival
1428	Northwest	B757	Arrival
1429	Alaska	B737-400	Arrival
1430	ERA	DHC-8	Departure
1440	Alaska	B737-400	Departure
1441	Alaska	B737-200	Arrival
1441	Delta	B767-300	Arrival
1445	ERA	DHC-6	Arrival
1445	FEDEX	MD11	Departure
1445	China Airlines	B747-200	Arrival
1447	Alaska	B737-400	Departure
1450	FEDEX	DC10	Departure
1450	Nippon Cargo	B747-200	Departure
1450	Nippon Cargo	B747-200	Departure
1454	Alaska	B737-400	Arrival
1500	KLM	B747-200	Departure
1500	Northern Air Cargo	DC6	Arrival
1510	Penair	Saab SF340	Arrival
1512	Alaska	B737-200	Arrival
1515	ERA	DHC-6	Departure
1518	ERA	DHC-8	Arrival
1518	Alaska	B737-200	Departure
1518	Alaska	B737-400	Departure
1523	Alaska	MD80	Arrival
1525	FEDEX	MD11	Departure
1525	FEDEX	A300	Departure
1528	Alaska	B737-400	Arrival
1530	Penair	Fairchild Metroliner	Arrival
1539	Alaska	B737-400	Departure
1540	Alaska Central Express	Beechcraft	Arrival
1545	Penair	Fairchild Metroliner	Arrival
1545	Alaska	B737-200	Departure
1545	China Airlines	B747-200	Departure
1545	China Airlines	B747-200	Departure
1545	China Airlines	B747-200	Departure
1545	China Airlines	B747-200	Arrival

ANC Scheduled Daily Ops, Mid-week, January 2001			
Time	**Operator**	**Plane**	**Operation**
1549	Alaska	B737-400	Arrival
1550	FEDEX	MD11	Departure
1550	FEDEX	MD11	Departure
1550	Japan Airlines	B747-200	Arrival
1553	Alaska	B737-200	Departure
1555	Alitalia	B747-200	Arrival
1555	Eva	MD11	Arrival
1600	ERA	DHC-8	Departure
1600	Tatonduk Flying Service	DC6	Departure
1600	Northern Air Cargo	B727	Arrival
1605	Frontier	Beechcraft	Arrival
1605	Alaska	MD80	Departure
1605	Nippon Cargo	B747-200	Arrival
1606	Alaska	B737-700	Arrival
1608	Alaska	B737-700	Arrival
1612	Alaska	B737-200	Departure
1615	ERA	DHC-8	Arrival
1615	Alaska	B737-400	Departure
1625	ERA	DHC-8	Arrival
1625	Cathay Pacific	B747-200	Arrival
1630	ERA	DHC-6	Arrival
1640	Alaska	B737-400	Departure
1640	Alaska Central Express	Beechcraft	Arrival
1645	Frontier	Cessna	Departure
1645	China Airlines	B747-200	Departure
1645	Singapore Airlines	B747-200	Arrival
1650	Alaska	B737-200	Arrival
1650	Penair	Fairchild Metroliner	Departure
1650	ERA	DHC-8	Departure
1650	Alaska	B737-700	Departure
1650	Japan Airlines	B747-200	Departure
1655	Alaska	B737-700	Departure
1655	Eva	MD11	Departure
1700	Penair	Fairchild Metroliner	Arrival
1700	Penair	Fairchild Metroliner	Arrival
1700	ERA	DHC-8	Departure
1700	Nippon Cargo	B747-200	Departure
1710	Frontier	Beechcraft	Departure
1715	ERA	DHC-8	Arrival
1715	Reeve	B727	Departure
1715	Penair	Saab SF340	Departure
1720	Penair	Saab SF340	Arrival
1730	Penair	Saab SF340	Departure
1735	ERA	DHC-8	Departure
1735	Cathay Pacific	B747-200	Departure
1735	China Airlines	B747-200	Arrival
1736	Nippon Cargo	B767	Departure
1745	Alaska	B737-200	Arrival
1745	ERA	DHC-6	Departure
1747	Alaska	B737-400	Arrival
1749	Northwest	B757	Arrival
1750	ERA	Convair	Departure
1750	Singapore Airlines	B747-200	Departure

ANC Scheduled Daily Ops, Mid-week, January 2001			
Time	**Operator**	**Plane**	**Operation**
1752	Alaska	B737-200	Departure
1754	Alaska	B737-400	Arrival
1755	ERA	DHC-8	Arrival
1755	Alitalia	B747-200	Departure
1800	F.S. Air Service	Piper	Departure
1810	Frontier	Cessna	Arrival
1815	Eva	MD11	Arrival
1816	TWA	B757	Arrival
1820	ERA	DHC-8	Departure
1830	Reeve	L188	Arrival
1836	Alaska	B737-400	Departure
1845	Alaska	B737-400	Departure
1845	Eva	MD11	Departure
1845	Eva	MD11	Departure
1850	Alaska	B737-200	Arrival
1854	Alaska	B737-200	Departure
1900	ERA	DHC-6	Arrival
1900	Northern Air Cargo	B727	Departure
1901	Alaska	B737-200	Arrival
1914	Alaska	B737-400	Arrival
1915	Grant Aviation	Beechcraft	Arrival
1925	Northwest	B757	Departure
1925	ERA	DHC-6	Departure
1929	UPS	B767	Arrival
1930	ERA	DHC-8	Arrival
1930	Alaska	B737-700	Arrival
1930	F.S. Air Service	Piper	Arrival
1930	ERA	Convair	Arrival
1930	Alaska Central Express	Beechcraft	Arrival
1936	United	B757	Arrival
1940	ERA	DHC-8	Arrival
1940	Northwest	DC-10	Arrival
1945	Continental	B757	Arrival
1945	Eva	MD11	Departure
1946	American	B757	Arrival
1952	Alaska	B737-700	Arrival
1955	ERA	DHC-8	Arrival
2000	Penair	Fairchild Metroliner	Arrival
2005	Alaska	B737-400	Departure
2005	Alaska	B737	Departure
2010	Reeve	B727	Arrival
2015	Delta	B767-300	Departure
2020	Alaska	B737-700	Departure
2025	Penair	Saab SF340	Arrival
2030	Alaska	B737-400	Arrival
2030	ERA	DHC-8	Departure
2040	Penair	Saab SF340	Arrival
2040	ERA	DHC-6	Arrival
2040	Alaska	B737-700	Departure
2045	ERA	DHC-6	Departure
2045	United	B757	Departure
2049	Alaska	B737-200	Arrival

ANC Scheduled Daily Ops, Mid-week, January 2001			
Time	**Operator**	**Plane**	**Operation**
2100	ERA	DHC-8	Departure
2100	Continental	B757	Departure
2105	TWA	B757	Departure
2115	Alaska	B737-400	Departure
2120	American	B757	Departure
2124	Alaska	MD80	Arrival
2135	Alaska	B737-400	Arrival
2136	Alaska	B737-400	Arrival
2139	American	MD80	Arrival
2140	ERA	DHC-8	Arrival
2144	Delta	B767-300	Arrival
2145	Northwest	B757	Departure
2145	Northern Air Cargo	B727	Arrival
2151	Delta	B757	Arrival
2201	Northwest	B757	Arrival
2205	ERA	DHC-8	Departure
2209	Alaska	B737-200	Arrival
2209	Alaska	MD80	Departure
2226	Alaska	MD80	Arrival
2230	UPS	B767	Departure
2238	Alaska	MD80	Arrival
2240	ERA	DHC-6	Arrival
2244	United	B757	Arrival
2255	TWA	B757	Arrival
2255	Delta	B757	Departure
2300	Korean Air	MD11	Departure
2310	ERA	DHC-6	Departure
2315	Delta	B767-300	Arrival
2316	Alaska	B737-400	Arrival
2323	Alaska	MD80	Departure
2325	ERA	DHC-8	Arrival
2325	Northwest	B757	Departure
2330	Alaska	MD80	Arrival
2330	Singapore Airlines	B747-200	Arrival
2339	United	B737-300	Arrival
2340	ERA	DHC-8	Arrival
2340	Northwest	B757	Arrival
2350	Alaska	B737-400	Arrival
2351	America West	A319	Arrival
2353	Continental	B757	Arrival

ANC Scheduled Daily Ops, Mid-week, July 2001			
Time	**Operator**	**Aircraft**	**Operation**
0009	Alaska	B737-400	Arrival
0010	Alaska	B737-200	Arrival
0025	ERA	DHC-6	Arrival
0030	Alaska	MD80	Departure
0030	Tatonduk Flying Service	DC6	Arrival
0035	Singapore Airlines	B747-200	Departure
0035	Singapore Airlines	B747-400	Arrival
0036	Alaska	MD80	Arrival
0038	Alaska	MD80	Arrival
0040	ERA	DHC-8	Departure
0040	United	B737-300	Departure
0040	Delta	B767-300	Departure
0040	Evergreen	B747-200	Departure
0045	TWA	B757	Departure
0045	American	MD80	Departure
0055	Alaska	MD80	Departure
0100	Delta	B767-300	Departure
0100	Polar Air Cargo	B747-200	Arrival
0119	Delta	B757	Arrival
0120	Alaska	MD80	Departure
0122	Alaska	MD80	Arrival
0125	Alaska	B737	Departure
0126	Alaska	MD80	Arrival
0140	Alaska	MD80	Departure
0140	Singapore Airlines	B747-400	Departure
0145	America West	A319	Departure
0145	Continental	B757	Departure
0145	ERA	DHC-8	Arrival
0215	Alaska	MD80	Departure
0215	Cathay Pacific	A340-300	Arrival
0226	Alaska	B737-400	Arrival
0230	Korean Air	B747-400	Arrival
0230	Alaska Central Express	Beechcraft	Departure
0235	Korean Air	MD11	Arrival
0300	Asiana	B747-400	Arrival
0300	Alaska Central Express	Beechcraft	Departure
0300	Polar Air Cargo	B747-200	Departure
0335	Cathay Pacific	A340-300	Departure
0335	Korean Air	MD11	Departure
0335	China Southern	B747-200	Arrival
0400	Penair	Fairchild Metroliner	Departure
0400	Alaska Central Express	Beechcraft	Departure
0415	Alaska	B737	Arrival
0420	ERA	DHC-6	Departure
0420	Eva	MD11	Departure
0425	Korean Air	B747-400	Departure
0430	ERA	DHC-8	Departure
0430	Penair	Fairchild Metroliner	Departure
0430	Polar Air Cargo	B747-200	Arrival

ANC Scheduled Daily Ops, Mid-week, July 2001			
Time	**Operator**	**Aircraft**	**Operation**
0445	Alaska Central Express	Beechcraft	Departure
0445	Gemini	DC10	Arrival
0445	Alaska	B737	Arrival
0450	Asiana	B747-400	Departure
0455	Asiana	B747-200	Arrival
0500	Tatonduk Flying Service	DC6	Departure
0500	Penair	Fairchild Metroliner	Departure
0500	Alaska Central Express	Beechcraft	Departure
0500	Northern Air Cargo	B727	Departure
0500	Evergreen	B747-200	Arrival
0505	Mavial	Tupolov TU-154	Arrival
0517	UPS	B747-200	Arrival
0521	Alaska	B737	Arrival
0525	Northwest	B757	Departure
0525	Nippon Cargo	B747-200	Departure
0530	Frontier	Cessna	Departure
0535	ERA	DHC-8	Arrival
0545	Gemini	DC10	Departure
0550	Korean Air	MD11	Arrival
0555	ERA	DHC-8	Departure
0555	Asiana	B747-200	Departure
0600	Alaska	B737-200	Departure
0600	Northern Air Cargo	DC6	Departure
0600	Japan Airlines	B747-200	Arrival
0605	Alaska	B737-200	Departure
0610	Alaska	MD80	Departure
0615	ERA	DHC-6	Arrival
0620	Alaska Central Express	Beechcraft	Arrival
0620	Korean Air	B747-200	Arrival
0620	FEDEX	A300	Arrival
0625	Alaska	B737-400	Departure
0625	Delta	B757	Departure
0630	Alaska	B737-400	Departure
0630	Evergreen	B747-200	Departure
0630	Polar Air Cargo	B747-200	Departure
0630	Polar Air Cargo	B747-200	Arrival
0635	FEDEX	MD11	Arrival
0635	Korean Air	B747-200	Arrival
0635	Japan Airlines	B747-200	Arrival
0640	ERA	DHC-6	Departure
0640	United	B757	Departure
0640	Alaska	B737-200	Departure
0640	Northwest	B747-200	Arrival
0645	ERA	DHC-8	Departure
0650	Alaska	B737-400	Departure
0650	Korean Air	MD11	Departure
0650	FEDEX	DC10	Arrival
0654	United	DC10	Arrival
0655	ERA	DHC-8	Departure
0655	Frontier	Cessna	Arrival
0700	Alaska	B737-200	Departure
0700	ERA	DHC-8	Arrival

ANC Scheduled Daily Ops, Mid-week, July 2001			
Time	**Operator**	**Aircraft**	**Operation**
0700	Alaska Central Express	Beechcraft	Departure
0700	Artic Circle Air Service	Cessna	Departure
0700	Japan Airlines	B747-200	Departure
0700	Northern Air Cargo	DC6	Departure
0700	United	DC10	Arrival
0700	FEDEX	MD11	Arrival
0705	FEDEX	A300	Arrival
0710	Alaska	B737-400	Departure
0711	Alaska	MD80	Arrival
0720	ERA	DHC-8	Departure
0720	Korean Air	B747-200	Departure
0720	Eva	MD11	Arrival
0720	FEDEX	MD11	Arrival
0730	Frontier	Beechcraft	Arrival
0730	Delta	B757	Arrival
0730	Japan Airlines	B747-200	Departure
0735	Penair	Fairchild Metroliner	Departure
0735	Korean Air	B747-200	Departure
0740	ERA	Convair	Departure
0745	Penair	Saab SF340	Departure
0746	UPS	B747-200	Departure
0753	Alaska	B737-400	Departure
0755	ERA	DHC-8	Arrival
0755	Cathay Pacific	B747-200	Arrival
0800	Reeve	B727	Departure
0800	Penair	Fairchild Metroliner	Departure
0800	Alaska	MD80	Departure
0800	F.S. Air Service	Piper	Departure
0800	Northwest	B747-200	Departure
0810	Frontier	Beechcraft	Departure
0812	Nippon Cargo	B747-200	Departure
0815	Penair	Saab SF340	Departure
0815	ERA	Convair	Departure
0819	Alaska	B737-200	Arrival
0820	Penair	Fairchild Metroliner	Arrival
0820	United	DC10	Departure
0820	Eva	MD11	Departure
0825	ERA	DHC-8	Departure
0835	United	DC10	Departure
0840	ERA	DHC-6	Arrival
0840	Japan Airlines	B747-200	Arrival
0841	Alaska	B737-400	Arrival
0845	Delta	B757	Departure
0855	Cathay Pacific	B747-200	Departure
0855	Polar Air Cargo	B747-200	Departure
0855	Asiana	B747-200	Arrival
0900	Grant Aviation	Beechcraft	Departure
0900	ERA	DHC-6	Departure
0900	Alaska	B737-400	Arrival
0900	Frontier	Cessna	Departure
0902	Alaska	B737-200	Arrival
0910	Northwest	DC-10	Departure
0910	China Airlines	B747-400	Arrival

ANC Scheduled Daily Ops, Mid-week, July 2001			
Time	**Operator**	**Aircraft**	**Operation**
1230	Asiana	B747-200	Arrival
1230	Air China	B747-200	Arrival
1235	Penair	Fairchild Metroliner	Departure
1235	Japan Airlines	B747-200	Departure
1235	Nippon Cargo	B747-200	Arrival
1239	Alaska	B737-200	Arrival
1240	ERA	DHC-6	Arrival
1240	Northwest	B747-200	Departure
1244	Alaska	B737-400	Departure
1245	Alaska	B737-700	Arrival
1245	Japan Airlines	B747-200	Departure
1245	China Airlines	B747-200	Arrival
1245	FEDEX	DC10	Arrival
1247	Alaska	MD80	Departure
1248	Alaska	MD80	Arrival
1250	Alaska	MD80	Arrival
1250	Northwest	B747-200	Departure
1250	United	DC10	Departure
1250	Nippon Cargo	B747-200	Arrival
1300	Frontier	Beechcraft	Departure
1300	Northwest	B757	Departure
1300	Penair	Fairchild Metroliner	Arrival
1300	ERA	Convair	Arrival
1300	Frontier	Cessna	Departure
1300	Korean Air	B747-200	Arrival
1305	Canada 3000	A320	Arrival
1306	United	B757	Arrival
1310	ERA	DHC-8	Arrival
1310	United	DC10	Departure
1315	Grant Aviation	Beechcraft	Arrival
1315	Nippon Cargo	B747-200	Departure
1316	Alaska	B737-200	Arrival
1324	Alaska	B737-200	Arrival
1325	ERA	DHC-8	Arrival
1325	FEDEX	MD11	Arrival
1325	FEDEX	MD11	Arrival
1330	ERA	DHC-6	Departure
1330	ERA	Convair	Arrival
1330	Korean Air	B747-200	Departure
1330	Asiana	B747-200	Departure
1330	Korean Air	B747-200	Departure
1330	Nippon Cargo	B747-200	Departure
1330	Northern Air Cargo	DC6	Arrival
1335	Alaska	B737-700	Departure
1335	Alaska	MD80	Departure
1345	ERA	DHC-8	Departure
1345	Reeve	B727	Arrival
1345	China Airlines	B747-200	Departure
1350	Nippon Cargo	B747-200	Departure
1355	Canada 3000	A320	Departure
1355	Nippon Cargo	B747-200	Arrival
1358	Alaska	B737-200	Departure
1358	Alaska	B737-400	Arrival
1359	Airborne Express	DC9	Departure

ANC Scheduled Daily Ops, Mid-week, July 2001			
Time	**Operator**	**Aircraft**	**Operation**
1400	Grant Aviation	Beechcraft	Departure
1400	Air China	B747-200	Departure
1400	Korean Air	B747-200	Departure
1400	FEDEX	A300	Departure
1400	KLM	B747-200	Arrival
1400	Alaska Central Express	Cessna	Arrival
1402	Alaska	B737-400	Arrival
1410	Penair	Saab SF340	Departure
1410	ERA	DHC-8	Departure
1415	Alaska	MD80	Departure
1415	Alaska	B737-200	Arrival
1416	Alaska	B737-200	Departure
1416	Empire Airlines	Fokker F27	Arrival
1418	Alaska	B737-200	Arrival
1424	Alaska	B737-200	Departure
1425	United	B757	Departure
1425	Frontier	Cessna	Arrival
1428	Northwest	B757	Arrival
1429	Alaska	B737-400	Arrival
1430	ERA	DHC-8	Departure
1440	Alaska	B737-400	Departure
1441	Alaska	B737-200	Arrival
1441	Delta	B767-300	Arrival
1445	ERA	DHC-6	Arrival
1445	FEDEX	MD11	Departure
1445	China Airlines	B747-200	Arrival
1447	Alaska	B737-400	Departure
1450	FEDEX	DC10	Departure
1450	Nippon Cargo	B747-200	Departure
1450	Nippon Cargo	B747-200	Departure
1454	Alaska	B737-400	Arrival
1500	KLM	B747-200	Departure
1500	Northern Air Cargo	DC6	Arrival
1510	Penair	Saab SF340	Arrival
1512	Alaska	B737-200	Arrival
1515	ERA	DHC-6	Departure
1518	Alaska	B737-200	Departure
1518	Alaska	B737-400	Departure
1518	ERA	DHC-8	Arrival
1523	Alaska	MD80	Arrival
1525	FEDEX	MD11	Departure
1525	FEDEX	A300	Departure
1528	Alaska	B737-400	Arrival
1530	Penair	Fairchild Metroliner	Arrival
1539	Alaska	B737-400	Departure
1540	Alaska Central Express	Beechcraft	Arrival
1545	Alaska	B737-200	Departure
1545	Penair	Fairchild Metroliner	Arrival
1545	China Airlines	B747-200	Departure
1545	China Airlines	B747-200	Departure
1545	China Airlines	B747-200	Departure
1545	China Airlines	B747-200	Arrival
1549	Alaska	B737-400	Arrival

ANC Scheduled Daily Ops, Mid-week, July 2001			
Time	**Operator**	**Aircraft**	**Operation**
1550	FEDEX	MD11	Departure
1550	FEDEX	MD11	Departure
1550	Japan Airlines	B747-200	Arrival
1553	Alaska	B737-200	Departure
1555	Alitalia	B747-200	Arrival
1555	Eva	MD11	Arrival
1600	ERA	DHC-8	Departure
1600	Tatonduk Flying Service	DC6	Departure
1600	Northern Air Cargo	B727	Arrival
1605	Alaska	MD80	Departure
1605	Frontier	Beechcraft	Arrival
1605	Nippon Cargo	B747-200	Arrival
1606	Alaska	B737-700	Arrival
1608	Alaska	B737-700	Arrival
1612	Alaska	B737-200	Departure
1615	Alaska	B737-400	Departure
1615	ERA	DHC-8	Arrival
1625	ERA	DHC-8	Arrival
1625	Cathay Pacific	B747-200	Arrival
1630	ERA	DHC-6	Arrival
1640	Alaska	B737-400	Departure
1640	Alaska Central Express	Beechcraft	Arrival
1645	Frontier	Cessna	Departure
1645	China Airlines	B747-200	Departure
1645	Singapore Airlines	B747-200	Arrival
1650	Penair	Fairchild Metroliner	Departure
1650	ERA	DHC-8	Departure
1650	Alaska	B737-700	Departure
1650	Alaska	B737-200	Arrival
1650	Japan Airlines	B747-200	Departure
1655	Alaska	B737-700	Departure
1655	Eva	MD11	Departure
1700	ERA	DHC-8	Departure
1700	Penair	Fairchild Metroliner	Arrival
1700	Penair	Fairchild Metroliner	Arrival
1700	Nippon Cargo	B747-200	Departure
1710	Frontier	Beechcraft	Departure
1715	Reeve	B727	Departure
1715	Penair	Saab SF340	Departure
1715	ERA	DHC-8	Arrival
1720	Penair	Saab SF340	Arrival
1730	Penair	Saab SF340	Departure
1735	ERA	DHC-8	Departure
1735	Cathay Pacific	B747-200	Departure
1735	China Airlines	B747-200	Arrival
1736	Nippon Cargo	B767	Departure
1745	ERA	DHC-6	Departure
1745	Alaska	B737-200	Arrival
1747	Alaska	B737-400	Arrival
1749	Northwest	B757	Arrival
1750	ERA	Convair	Departure
1750	Singapore Airlines	B747-200	Departure
1752	Alaska	B737-200	Departure

ANC Scheduled Daily Ops, Mid-week, July 2001			
Time	**Operator**	**Aircraft**	**Operation**
1754	Alaska	B737-400	Arrival
1755	ERA	DHC-8	Arrival
1755	Alitalia	B747-200	Departure
1800	F.S. Air Service	Piper	Departure
1810	Frontier	Cessna	Arrival
1815	Eva	MD11	Arrival
1816	TWA	B757	Arrival
1820	ERA	DHC-8	Departure
1830	Reeve	L188	Arrival
1836	Alaska	B737-400	Departure
1845	Alaska	B737-400	Departure
1845	Eva	MD11	Departure
1845	Eva	MD11	Departure
1850	Alaska	B737-200	Arrival
1854	Alaska	B737-200	Departure
1900	ERA	DHC-6	Arrival
1900	Northern Air Cargo	B727	Departure
1901	Alaska	B737-200	Arrival
1914	Alaska	B737-400	Arrival
1915	Grant Aviation	Beechcraft	Arrival
1925	Northwest	B757	Departure
1925	ERA	DHC-6	Departure
1929	UPS	B767	Arrival
1930	ERA	DHC-8	Arrival
1930	Alaska	B737-700	Arrival
1930	F.S. Air Service	Piper	Arrival
1930	ERA	Convair	Arrival
1930	Alaska Central Express	Beechcraft	Arrival
1936	United	B757	Arrival
1940	ERA	DHC-8	Arrival
1940	Northwest	DC-10	Arrival
1945	Continental	B757	Arrival
1945	Eva	MD11	Departure
1946	American	B757	Arrival
1952	Alaska	B737-700	Arrival
1955	ERA	DHC-8	Arrival
2000	Penair	Fairchild Metroliner	Arrival
2005	Alaska	B737-400	Departure
2005	Alaska	B737	Departure
2010	Reeve	B727	Arrival
2015	Delta	B767-300	Departure
2020	Alaska	B737-700	Departure
2025	Penair	Saab SF340	Arrival
2030	ERA	DHC-8	Departure
2030	Alaska	B737-400	Arrival
2040	Alaska	B737-700	Departure
2040	Penair	Saab SF340	Arrival
2040	ERA	DHC-6	Arrival
2045	ERA	DHC-6	Departure
2045	United	B757	Departure
2049	Alaska	B737-200	Arrival

ANC Scheduled Daily Ops, Mid-week, July 2001			
Time	**Operator**	**Aircraft**	**Operation**
2100	ERA	DHC-8	Departure
2100	Continental	B757	Departure
2105	TWA	B757	Departure
2115	Alaska	B737-400	Departure
2120	American	B757	Departure
2124	Alaska	MD80	Arrival
2135	Alaska	B737-400	Arrival
2136	Alaska	B737-400	Arrival
2139	American	MD80	Arrival
2140	ERA	DHC-8	Arrival
2144	Delta	B767-300	Arrival
2145	Northwest	B757	Departure
2145	Northern Air Cargo	B727	Arrival
2151	Delta	B757	Arrival
2201	Northwest	B757	Arrival
2205	ERA	DHC-8	Departure
2209	Alaska	MD80	Departure
2209	Alaska	B737-200	Arrival
2226	Alaska	MD80	Arrival
2230	UPS	B767	Departure
2238	Alaska	MD80	Arrival
2240	ERA	DHC-6	Arrival
2244	United	B757	Arrival
2255	Delta	B757	Departure
2255	TWA	B757	Arrival
2300	Korean Air	MD11	Departure
2310	ERA	DHC-6	Departure
2315	Delta	B767-300	Arrival
2316	Alaska	B737-400	Arrival
2323	Alaska	MD80	Departure
2325	Northwest	B757	Departure
2325	ERA	DHC-8	Arrival
2330	Alaska	MD80	Arrival
2330	Singapore Airlines	B747-200	Arrival
2339	United	B737-300	Arrival
2340	ERA	DHC-8	Arrival
2340	Northwest	B757	Arrival
2350	Alaska	B737-400	Arrival
2351	America West	A319	Arrival
2353	Continental	B757	Arrival

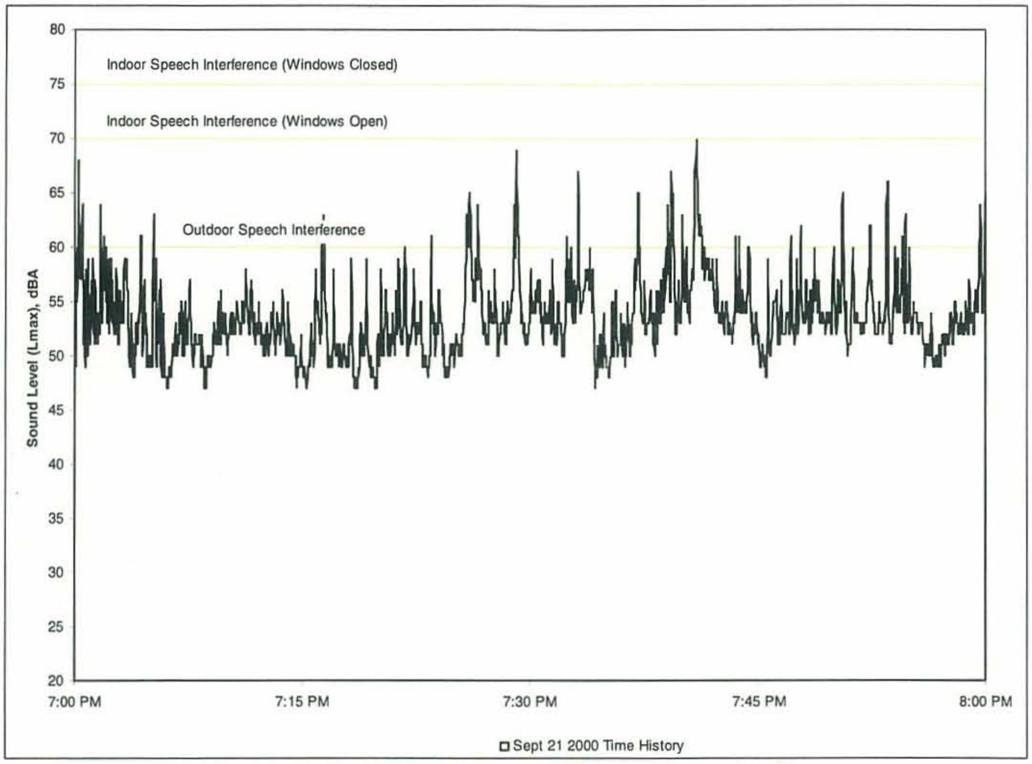


Figure B-1. Site 10 Time History, 7 pm to 8 pm

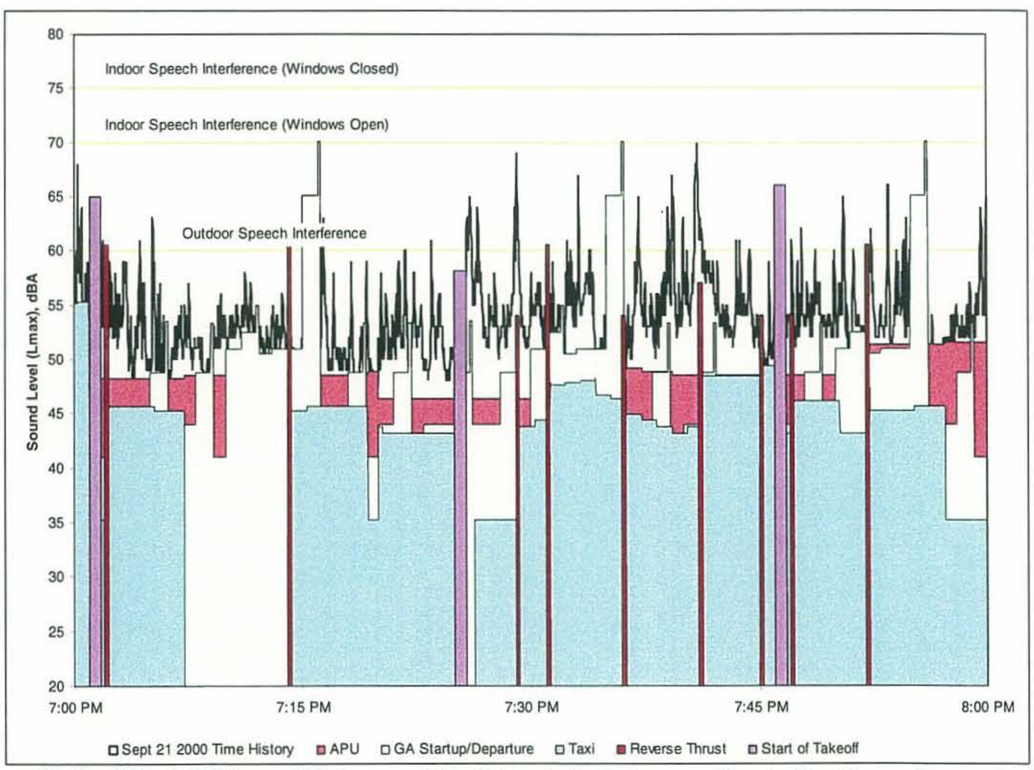


Figure B-2. Site 10 Time History with Scheduled Event Contributions, 7 pm to 8 pm

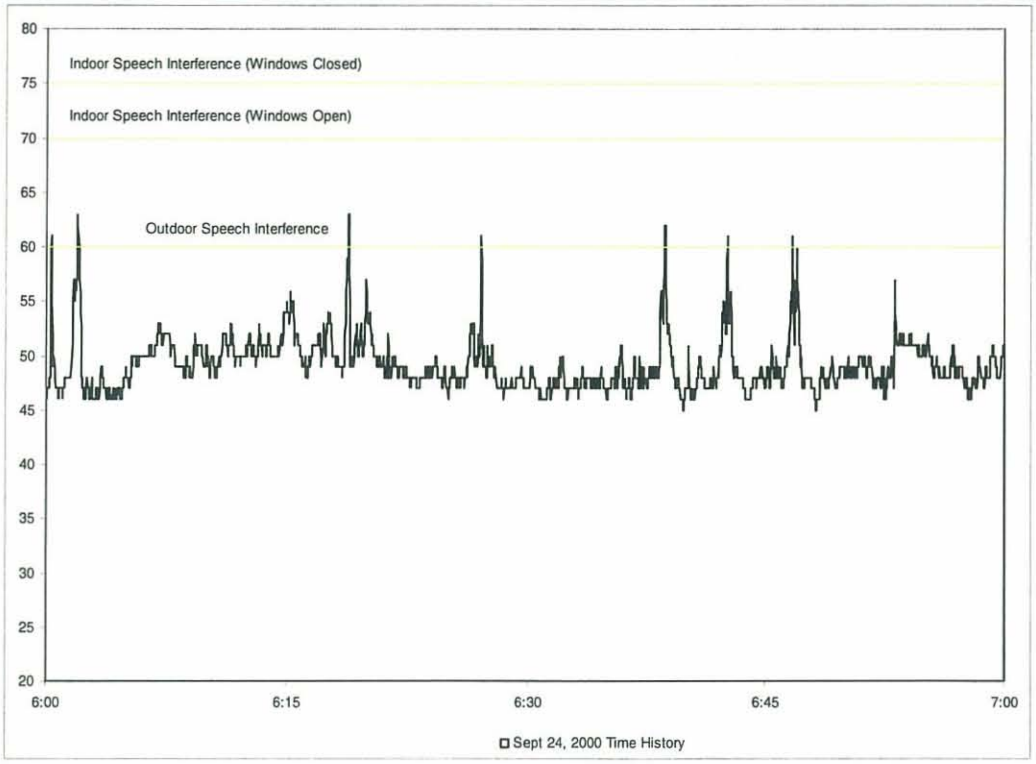


Figure B-3. Site 15 Time History, 6 am to 7 am

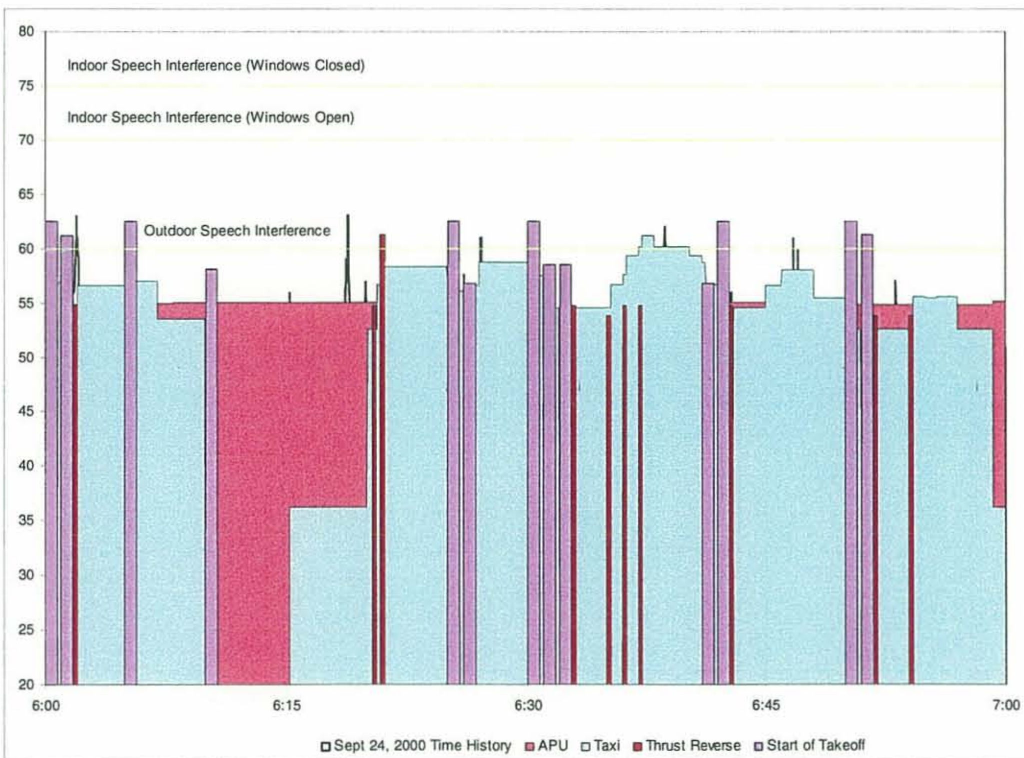


Figure B-4. Site 15 Time History with Scheduled Event Contributions, 6 am to 7 am

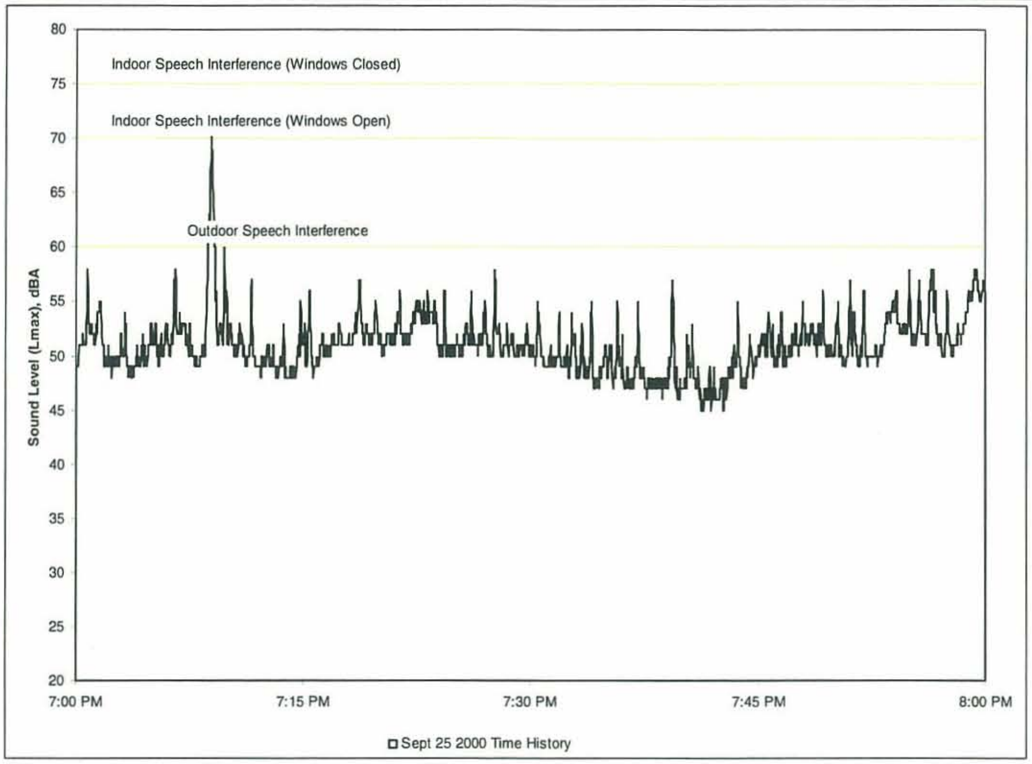


Figure B-5. Site 20 Time History, 7 pm to 8 pm

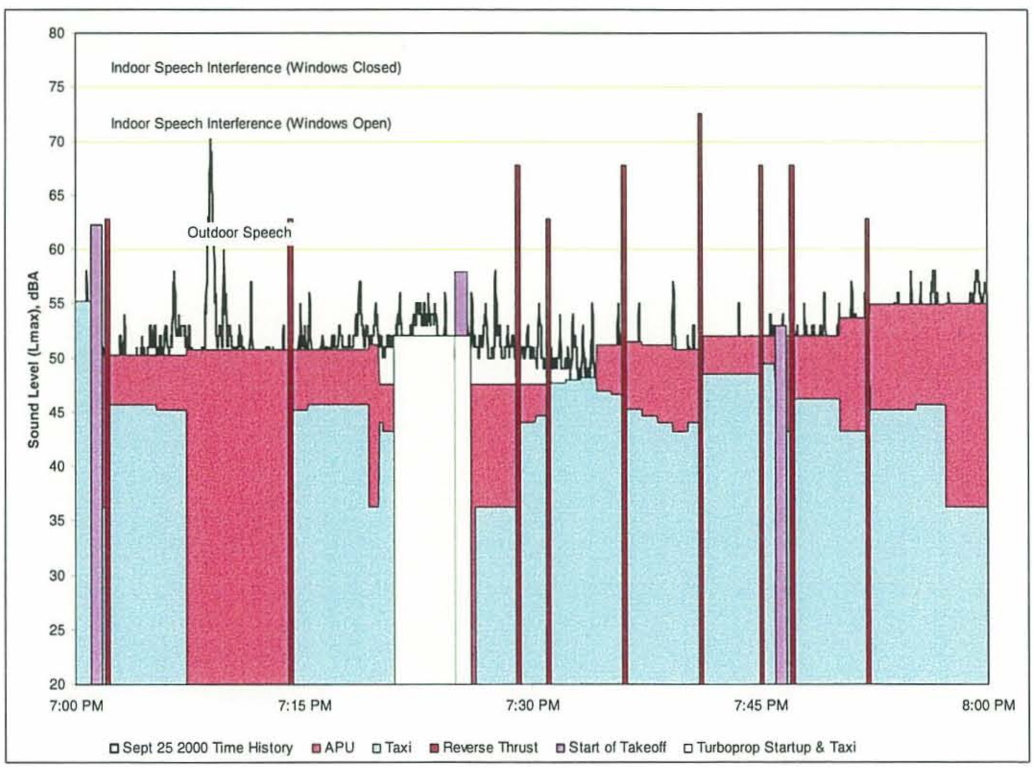


Figure B-6. Site 20 Time History with Scheduled Event Contributions, 7 pm to 8 pm

APPENDIX C. EFFECTS OF WEATHER ON LONG-DISTANCE SOUND PROPAGATION

Atmospheric effects that can influence the propagation of sound include (in roughly increasing order of importance) humidity and precipitation, temperature and wind gradients, and turbulence (or gustiness). The effects of wind, and in particular, of turbulence, generally are of more importance than other factors, however, the importance of temperature gradients is enhanced under calm wind conditions, and under unusual conditions can be extreme. Attenuation caused by humidity is generally of small relative importance to the other effects.

Influence of Humidity and Precipitation

In general, humidity and precipitation have little effect on the propagation of sound. Attenuation due to humidity only becomes important with high-frequency noise under fairly calm wind conditions. Rain, snow, and fog also have little, if any noticeable effect on sound propagation. A substantial body of empirical data supports these conclusions[47].

Influence of Temperature

The velocity of sound in the atmosphere is dependent upon the air temperature[48], and if the temperature varies at different heights above the ground, the sound will travel in curved paths rather than straight lines. Normally, during the daytime, the temperature decreases with increasing height; this condition, characterized by a negative temperature gradient, is known as temperature lapse. In temperature lapse conditions, sound waves are refracted upwards and an acoustical shadow zone may exist at some distance from the noise source.

Under certain weather conditions, a layer of cool air may be trapped beneath a layer of warmer air. This condition, know as a temperature inversion, is prevalent throughout many regions in the evening, at night, and early in the morning when heat absorbed by the ground during the day is released into the night sky through radiation[49]. The effect of an inversion is just the opposite of lapse conditions, sound propagating through the atmosphere refracts downward. Under inversion conditions, no shadow zones can be formed, and, barring effects due to terrain or other obstructions, sound levels at observer locations are not affected.

Often, however, the downward refraction caused by temperature inversions allows sound rays with originally upward-sloping paths to bypass obstructions and ground effects. As a result, audibility of distant sounds is often somewhat better at night (during the most common time for temperature inversions) than in the daytime[50]. Under extreme conditions, one study found that

---

[47] Ingard, Uno. "A Review of the Influence of Meteorological conditions on Sound Propagation," *Journal of the Acoustical Society of America*, Vol. 25, No. 3, May 1953, p. 407.

[48] In dry air, the approximate velocity of sound can be obtained from the relationship:

$c = 331 + 0.6T_c$

(c in meters per second, T_c in degrees Celsius). Pierce, Allan D., *Acoustics: An Introduction to its Physical Principles and Applications.* McGraw-Hill. 1981. p. 29.

[49] Embleton, T.F.W., G.J. Thiessen, and J.E. Piercy, "Propagation in an inversion and reflections at the ground," *Journal of the Acoustical Society of America*, Vol. 59, No. 2, February 1976, p. 278.

[50] Ingard, p. 407.

noise from ground-borne aircraft may be amplified 15 to 20 dB by a temperature inversion. In a similar study, noise caused by an aircraft on the ground registered a higher level at an observer location 1.8 miles away than at a second observer location only 0.2 miles from the aircraft[51].

Influence of Wind

Just as there is a temperature gradient in the atmosphere, there is also a wind gradient; typically, higher wind speeds exist at greater heights above the ground. The wind gradient affects sound propagation similarly to the temperature gradient by causing upward or downward refraction of sound. Because temperature is a scalar quantity (i.e., described by magnitude alone with no regard for direction), the refraction of sound caused by variations in the vertical gradient is the same in all horizontal (compass) directions[52]. Wind, on the other hand, is a vector quantity (described by both magnitude and direction) and affects sound propagation differently in various directions. Wind results in downward refraction downwind and upward refraction upwind with a shadow zone formed in the upwind direction. Receivers in a predominately downwind direction will experience higher sound levels, and those upwind will experience lower sound levels. Sound propagating perpendicular to the wind direction will not be affected.

The refraction caused by vertical gradients of wind is additive to the refraction due to temperature gradients[53]. One study suggests that for frequencies greater than 500 Hz, the combined effects of these gradients tends towards two extreme values: approximately 0 dB in conditions of downward refraction (inversion or downwind propagation) and -20 dB in upward refraction conditions (lapse or upwind propagation). At lower frequencies, the effects of refraction due to wind and temperature gradients are less pronounced[54].

The preceding discussion of the influence of wind is somewhat idealized due to the tacit assumption of laminar conditions (i.e., the assumption of no turbulence). In reality, a wind is generally "gusty," and sound levels heard at remote receiver locations will fluctuate with gustiness. In addition, gustiness can cause considerable attenuation of sound through the effects of eddies traveling with the wind. The attenuation due to eddies is essentially the same in all directions, with or against the flow of the wind, and can often mask the refractive effects discussed above[55].

---

[51]Dickinson, P.J., "Temperature Inversion Effects on Aircraft Noise Propagation," (Letters to the Editor) *Journal of Sound and Vibration.* Vol. 47, No. 3, 1976, p. 442.

[52]Piercy, J.E. and T.F.W. Embleton, "Review of noise propagation in the atmosphere," *Journal of the Acoustical Society of America,* Vol. 61, No. 6, June 1977, p. 141.

[53]Piercy and Embleton, p. 1412. Note, in addition, that as a result of the scalar nature of temperature and the vector nature of wind, the following is true: under lapse conditions, the refractive effects of wind and temperature add in the upwind direction and cancel each other in the downwind direction. Under inversion conditions, the opposite is true.

[54]Piercy and Embleton, p. 1413.

[55]Ingard, pp. 409-410.

APPENDIX D. SAMPLE NIGHTTIME MAINTENANCE RUN-UP RESTRICTIONS

This appendix provides the complete text of the four nighttime run-up policies summarized in Section 7.5.1 of the report. These policies, from four representative airports, are intended to provide examples of restrictions that have been implemented at other airports.

1. Fort Lauderdale-Hollywood International Airport

PURPOSE

To establish procedures for tenant airlines and ground handlers to perform aircraft idle power and full power engine runs for maintenance purposes such as fuel leak checks, oil and hydraulic filters, replaced components, engine overhaul, etc.

NOTE: The term "idle power," for purposes of this procedure, is defined as the lowest percentage of power that the engine will run at with throttles fully retarded (see attached sample power settings).

PROCEDURES -- FULL POWER ENGINE RUNS

A. In accordance with Broward County Code, Section 2-40(17) Engine Run Up (a) aircraft shall not be positioned for run-up so that the engine blast shall be directed at spectators, personnel, hangars, shops, or other vehicles. Aircraft shall not taxi behind other aircraft in the process of engine run-up. All persons are responsible for any damage from the effects of their engine blast incidental to flight or during ground run-ups and taxiing. All engine run-ups will be conducted in a designated run-up area.

B. In accordance with Broward County Code, Section 2-40(17) Engine Run Up (b) engine maintenance run-ups will be conducted at locations designated by the aviation division. Engine maintenance run-ups shall not be conducted between the hours of 11:00 pm and 7:00 am.

C. All full power engine maintenance run-ups will be conducted on runway 13/31, between taxiways Echo 2 and Echo 3, between the hours of 7:00 am and 11:00 pm local time. Full power engine runs are prohibited on all ramp areas.

PROCEDURES -- IDLE POWER ENGINE RUNS

A. Idle power engine runs will be allowed at all aircraft gates (on each concourse) and ramp areas between the hours of 7:00 am and 11:00 pm local time. Idle power engine runs at aircraft gates and ramp areas after 11:00 pm will be approved on a case-by-case basis.

1. Idle power engine runs necessary between the hours of 11:00 pm and 7:00 am will be coordinated and approved by the Broward County Aviation Department Operations Division (Duty Manager 359-1201).

2. **SCHEDULED** idle engine runs required to be performed between 11:00 pm and 7:00 am, in order to depart during these hours or shortly thereafter, must be approved in writing by the Manager, Airport Operations. Requests must be submitted in writing no later than three (3) working days prior to the event, specifying: the reason for the idle power engine run, estimated duration, and the justification for why it could not be accomplished during normally approved hours.

3. **UNSCHEDULED** idle engine runs required to be performed between 11:00 pm and 7:00 am, in order to depart during these hours or shortly thereafter, must be coordinated and approved by the Duty Manager or the Manager, Airport Operations prior to the event. In addition, a Letter of Justification must be forwarded to the Manager, Airport Operations within three (3) working days following the event. This letter must contain the reason for the idle power engine run, actual time of the run, duration, if known, and an explanation of why the idle power engine run could not be accomplished during normally approved hours.

4. Required idle power engine runs during these hours should be accomplished during flying activity periods to the maximum extent possible.

5. Required idle power engine runs will be made in areas coordinated with and approved by BCAD operations.

2. Portland (OR) International Airport Maintenance Engine Run-up Policy

Goal: The goal of this policy is to reduce noise impacts on communities in the vicinity of Portland International Airport caused by nighttime maintenance engine run-ups to comply with regulatory requirement. The Port of Portland will initiate this goal by instituting the interim measures and restrictions described below, effective July 1, 1996.

Definition: Maintenance engine run-ups include any aircraft engine operation not directly associated with an imminent (within 10 minutes of departure) aircraft flight.

Run-up Locations: All maintenance engine run-ups, regardless of when conducted, shall be at locations on the airfield approved by the Airport manager.

Prohibition: No non-emergency maintenance engine run-ups will be authorized between the hours of 2300 and 0700 Pacific Time. The following exemptions apply:

1. **Turboprop aircraft:** Turboprop aircraft, except direct drive turboprop aircraft (Metroliner and similar aircraft equipped with Garrett-type engines), may conduct ground maintenance engine run-up tests during the restricted hours with prior permission of the Duty Operations Supervisor. These types of run-ups must be conducted with the intent of producing the least noise necessary to meet the requirements of flight safety, and may only be conducted with in areas prescribed and approved by the Airport Manager. This specific exemption will be reviewed by the Maintenance Engine Run-up Working Group, a subcommittee of the Noise Abatement Advisory Committee (NAAC) by no later than September 30, 1996. If it is determined at that time that there are noise impacts related to run-ups by non-direct drive turboprop aircraft, then this exemption may be removed.

2. **Idle jet engine tests:** Aircraft engine checks conducted at idle settings, are authorized during the restricted period mentioned above.

3. **Emergency Operations:** Aircraft serving in an emergency status, such as Life Flight, aircraft diverted to PDX and requiring engine tests for the continuation of the flight, or other similar emergencies, approved by the Duty Operations Supervisor are exempt from this restriction.

4. **Unscheduled Maintenance Operations:** Aircraft which must conduct engine tests due to an unexpected abnormality that had been discovered on an inbound flight segment to PDX which requires further diagnosis, adjustment or replacement to assure a safe outbound flight in accordance with regulatory and manufacturer's requirements and in order to meet an early morning departure time may perform run-ups up to 2 hours prior to the scheduled departure, but not earlier than 0400, with prior approval from the Airport. For example, an aircraft scheduled to depart at 0600 may run-up no earlier than 0400; an aircraft scheduled to depart at 0700 may run-up no earlier than 0500. The aircraft operator must follow up with a written report to the Airport Manager no later than 2 business days after the event. This measure will be reviewed by the Maintenance Engine Run-up Working Group, a subcommittee of the Noise Abatement Advisory Committee (NAAC) by September 30, 1996 to evaluate its results.

5. **Noise Reduction Facility:** Maintenance engine run-ups are authorized if conducted within a Port of Portland approved facility which can attenuate the source engine noise to comply the requirements of regulatory statutes.

Regulatory Compliance: Final measures to assure full regulatory compliance will be implemented no later than January 1, 1999, after which time these interim measures become void. The Port of Portland reserves the right to institute additional measures at any time to meet City, State, or Federal statute.

3. Seattle-Tacoma International Airport, Port of Seattle Run-up Policy

Port of Seattle Rules and Regulations: Number 4 Section 7 – No aircraft engine run-ups shall be conducted between the hours of 2200 and 0700 except as follows: 1) Aircraft that are regularly scheduled to depart between the hours of 0700 and 0830 shall be allowed to run-up between 0600 and 0700 if prior approval of the POS Airport Supervisor is obtained. This exemption applies to run-ups necessary for engine checks at idle power, or if absolutely necessary and with the prior approval of the POS Supervisor, a one-time run-up at full power not to exceed a total of two (2) minutes duration during this designated quiet period shall be allowed. No aircraft shall conduct engine run-ups for maintenance purposes except at locations specified by the Director.

4. Baltimore-Washington International Airport Tenant Directive 501.1 (Excerpt)

Aircraft Engine Run-ups:

a. All engine run-ups of jet and turbo prop powered aircraft shall be conducted in the holding block for Runway 10 at the west end with the nose of the aircraft positioned on a magnetic heading of 190° -- 220° for the run-up. If an engine run-up cannot be conducted in the holding block for Runway 10, the alternate area for engine run-ups will be the holding block for Runway 33L with the nose of the aircraft pointed to a magnetic heading of 140° -- 160°. Any deviation from this procedure must receive prior approval from the BWI Airport Operations Center. Run-ups are authorized only during the time period 0600 to 2200 local time. Prior permission must be obtained from the Airport Operations Center for any run-ups conducted during the period 2200 to 0600 local. Permission shall be denied unless it can be shown that failure to conduct the run-up will delay departure of a scheduled passenger flight.

b. Multi-engined aircraft engine run-ups will be accomplished one engine at a time for all aircraft, i.e. jets, and turbo props. Engine power settings above idle will be maintained for a maximum of 60 seconds or less at a time.