Wyle Report

WR 03-13

(J/N 47871)

June 2004

Executive Summary

LAND USE PLANNING GUIDELINES FOR NEW NON-URBAN AIRPORTS

Prepared for

Greater Toronto Airports Authority
Lester B. Pearson International Airport
3111 Convair Drive
Toronto AMF, Ontario, Canada L5P 1B2

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1.0 Introduction and Purpose

Planning for land uses around airports has been and continues to be one of the more challenging aspects of airport planning. This is because airports attract growth, and to protect citizen quality of life, local land use authorities must discourage the development of land uses nearby that are considered incompatible with the environmental consequences of aviation activity. Where an airport is already surrounded by residential or other noise sensitive land uses, the intent of land use planning guidelines is to hold the line and prevent any increases in incompatible land use. However, where a new airport is planned in a less urbanized environment, a unique opportunity exists to establish appropriate land use planning guidelines at the outset to preserve the balance between the integrity of the airport and the quality of life of the community that it serves.

The purpose of this study was to determine appropriate land use planning guidelines for residential and other sensitive land uses for specific application to new airports in non-urban settings. This was accomplished by gaining an understanding of the existing land use guidelines that apply in Canada and undertaking a thorough literature review of acoustics research and noise level criteria, the historical basis for aircraft noise land use guidelines, and the results of more recent studies regarding speech interference and sleep disturbance. This information was compiled and assessed to derive the most suitable, practical, and defensible land use guideline for new non-urban airports. It is intended that Transport Canada's current land use planning guidelines would continue to apply to existing Canadian airports.

2.0 Noise Metric Terminology

A number of different aircraft noise related terms have been developed to quantify environmental noise and its effects on human activities. It is important to understand several of them in order to make the best use of the technical results discussed.

2.1 A-weighted Sound Level

The loudest sounds that can comfortably be detected by the human ear have intensities 1,000,000,000,000 times greater than sounds that can just be detected. Because of this vast range, any attempt to represent the intensity of sound using a linear scale becomes very unwieldy. As a result, a logarithmic unit known as the decibel (abbreviated dB) is used to represent the intensity of a sound. Such a representation is called a sound level. A sound level of 0 dB is approximately the threshold of human hearing under extremely quiet listening conditions. Sound levels above about 120 dB (1,000,000,000,000 times greater) begin to cause discomfort in the human ear and trigger pain at still higher levels. Normal speech has a sound level of approximately 60 dB.

In measuring community noise, frequency dependence is taken into account by adjusting the level of sounds in the very high and very low frequency ranges to approximate the human ear's lower sensitivity to sounds in those frequency ranges. This is called "A-weighting". In this document all sound levels are A-weighted sound levels and the adjective "A-weighted" has been omitted.

2.2 Maximum Sound Level

The Maximum Sound Level from an event, or L_{max}, in decibels (where A-weighting is assumed) is a single event metric used to describe the noise associated with a single aircraft over-flight. L_{max} is the highest level measured during a single noise event, but does not take into account the duration of the event. An event with a relatively low L_{max} but a longer duration can be just as intrusive as a short duration event with a higher L_{max}. In order to accurately describe a noise environment, both the L_{max} and the duration of the events must be considered. The single-event metric that combines both of these characteristics, the Sound Exposure Level, is discussed next.

2.3 Sound Exposure Level

Sound Exposure Level, or SEL, is another commonly used single-event metric, and unlike L_{max}, takes into consideration both the highest level and the duration of the event. SEL is a logarithmic measure of the total acoustic energy during the noise event. It does not directly represent the sound level heard at any instant in time, but rather provides a measure of the net sound energy of the entire acoustic event. A general rule of thumb is that the SEL of an event is approximately 10 dB higher than the L_{max} (e.g. an L_{max} of 80 dB is equivalent to an SEL of 90 dB).

2.4 Effective Perceived Noise Level

The third single event metric is the Effective Perceived Noise Level (EPNL), which forms the basis for airport noise analysis in Canada. EPNL is based on the Maximum Perceived Noise Level PNL (a basic single event descriptor reflecting the maximum sound level heard by a receiver that includes a correction factor for the pure tones heard in aircraft noise) plus a correction for the duration of the noise. PNL and EPNL are the equivalents to L_{max} and SEL respectively but with different frequency weighting factors. In addition to being used widely throughout Canada, the U.S. Federal Aviation Administration (USFAA) requires that certification noise levels be measured in terms of EPNL.

2.5 Equivalent Sound Level

The equivalent sound level (L_{eq}) is the most straightforward and flexible time averaged metric used to enable analysts and planners to evaluate the cumulative effects on people of a number of noise events. The time-average sound level is dominated by the louder levels that occur during the averaging period. As a simple example, consider a sound level of 100 dB that lasts for 30 seconds, immediately followed by a sound level of 50 dB which also lasts for 30 seconds. The time-average sound level over the total 60-second period is 97 dB, not 75 dB.

In essence, L_{eq} represents the average noise energy of all events occurring over a specified period of time. The time period in hours is denoted in parenthesis. For example $L_{eq(1)}$, $L_{eq(8)}$, and $L_{eq(24)}$ represent the average noise energy over a 1-hour, 8-hour, and 1-day (24 hour) time period, respectively. For analysis of daytime noise impacts, $L_{eq(15)}$ is sometimes used, while for analysis of nighttime noise exposure $L_{eq(9)}$ may be used. For analysis of noise impacts at school, $L_{eq(7)}$ might be used, corresponding to the typical school day. The L_{eq} is the basis for the Day-Night Average Sound Level, discussed below.

2.6 Day-Night Average Sound Level

In the U.S. and a few other countries, the cumulative 24-hour noise exposure is expressed in terms of the Day-Night Average Sound Level (abbreviated by DNL). DNL is a cumulative measure of the acoustic energy received during an average 24-hour calendar day, with a 10 dB penalty added to noise events occurring between 22:00 and 07:00 to reflect their greater intrusiveness and potential for disturbing sleep.

2.7 Noise Exposure Forecast

The Noise Exposure Forecast (abbreviated by NEF) is the noise metric used for land use planning purposes in Canada, and represents the cumulative 24-hour noise exposure based on EPNL single-event levels for individual aircraft flights, with a 12 dB penalty added to noise events occurring between 22:00 and 07:00 to reflect their greater intrusiveness and potential for disturbing sleep. All references to the NEF metric in this Executive Summary relate to NEF contours generated by Transport Canada's Noise Exposure Forecast Model (currently Version 1.8). Inputs required to produce an NEF contour include: the traffic volume, aircraft fleet mix, runway utilization, operational procedures, and day/night traffic distribution representative of a 24-hour "peak planning day" defined as the 95^{th} percentile day in terms of traffic volume.

2.8 Number-of-events Above

Number-of-events Above (NA) is a noise metric that reflects the average number of times the noise level exceeds a chosen threshold level during a specified time period. NA contours can be depicted at any noise threshold level (x) and any user defined number of events (z), using the notation 'NAx(z),' meaning 'z' events above noise level 'x'. The selected analysis parameters (x and z) may differ in each affected community, based on specific circumstances.

3.0 Current Federal Land Use Guidelines

At the Federal level, Transport Canada's publication TP1247E, *"Land Use in the Vicinity of Airports"* addresses airport noise and its implications for development on lands surrounding airports. This publication, describes the operational characteristics of airports which may influence land uses outside the airport property boundary and recommends, where applicable, guidelines for land use in the vicinity of airports. The objective of this publication is to assist planners and legislators at all levels of government in becoming familiar with problems related to land use associated with airport development. As jurisdiction of land use is provincial matter, the Federal guidelines are advisory in nature. The TP1247E guidelines document has been revised and updated a number of times since its inception. The latest edition (7th) was issued in May of 1996 and clarified Transport Canada's position that residential uses are incompatible at and above NEF 30 and should not be permitted.

4.0 Factors Considered for Aircraft Noise Impact Assessment and Management

The effect of noise on human activity is often described in terms of annoyance, which is defined as any negative subjective reaction on the part of an individual or group. However, various non-noise related factors, such as attitude towards the noise source and local conditions, may influence an individual's reaction to activity interference and are difficult to quantify. The assessment of aircraft noise impacts can be further strengthened by examining the most recent research available on the impact of aircraft noise on the specific activities most directly affected by environmental noise, such as speech interference and sleep disturbance. A summary of the sleep and speech research has been used to derive recommended criterion for use in the compilation of land use guidelines for a new non-urban airport. These criteria in terms of NA contours were then compared to the NEF contours to assess whether the NEF 30 guideline is valid for the various noise effects.

Human response to noise is an extremely complex phenomenon, influenced by many variables in addition to the activity interference effects as measured by speech interference and sleep disturbance. Those that have been the subject of scientific research include habituation to noise, the type of environment (non-urban/rural vs. urban), community attitudes toward the noise source, the extent of prior exposure to the noise source, and the type of flight operation causing the noise. These factors, and other more qualitative considerations relevant to the determination of land use planning guidelines for new, non-urban airports are discussed below.

4.1 Annoyance

In the early 1960s and 1970s a number of social surveys were conducted to document the magnitude of noise pollution and community reactions to environmental noise. The results from eleven surveys were combined to develop what is commonly referred to as the 'Schultz Curve' (Schultz, 1978), which defines the percentage of the population that is expected to be highly annoyed at different levels of noise (in terms of DNL). At the time, the Shultz Curve was considered the best available instrument to predict community annoyance due to all types of transportation noise and is to date widely used for land use planning criteria in the U.S. According to this curve, approximately 15% of the community will be Highly Annoyed at a DNL of 65 dB, as illustrated in Figure 1. The NEF 30 criteria that is in use in Canada for land use planning, is also based on a similar level of annoyance.

Similar to the social surveys conducted by Shultz, Hall conducted a survey in the vicinity of Pearson Airport in the late 1970s (Miller 1991). His study results showed (1) a greater percentage of the study sample was Highly Annoyed by aircraft noise than road traffic noise, and (2) more than twice the percentage of Highly Annoyed people at a given DNL compared to the percentage predicted using Schultz's Curve. The primary explanation for these findings is that the Schultz Curve rates the entire noise environment, whereas Hall's Curve specifically focused on aircraft noise. Further research indicated that people are about 5 dB more sensitive to noise generated by aircraft than road traffic (Miller 1991). Due in part to the significantly higher percent Highly Annoyed due to aircraft generated noise at Pearson Airport, the Schultz curve shifted by 5 dB has been applied in studies at Pearson Airport. The results of a 1991 social survey in the communities around Pearson Airport have also been used to generate an aircraft noise annoyance curve (labeled in Figure 1 as the Pearson Airport Survey). This curve is fairly consistent with the shifted Schultz curve (Miller, 1991 and GTAA).

One of the variables that has been studied more recently is the degree of annoyance associated with the source of the noise. Miedema & Vos (1998) present synthesis curves for the relationship between DNL and percentage 'Annoyed' and percentage 'Highly Annoyed' for three transportation-noise sources. Separate, non-identical curves were found for aircraft, road traffic, and railway noise.

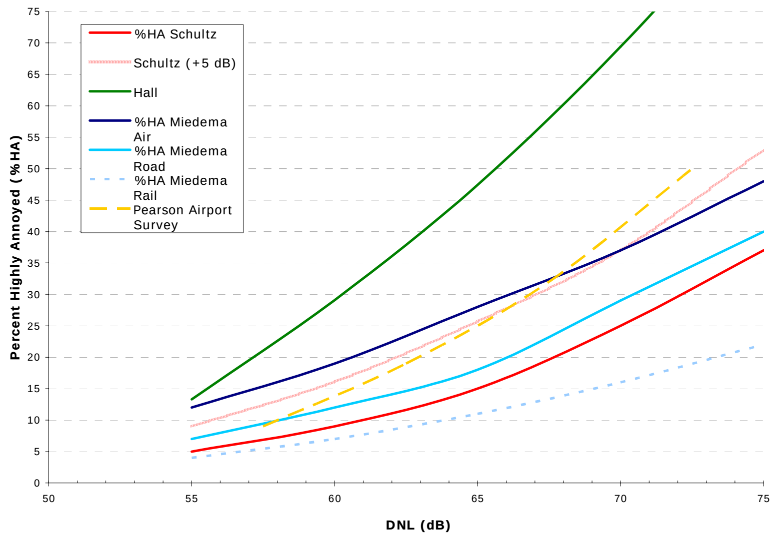

Figure 1. Comparison of %HA Curves

These curves show a higher percentage of the exposed population to be Annoyed or Highly Annoyed when the source of the noise is aircraft than when it is railways or roads (Miedema, 2002). Comparing the levels on Miedema's curve (1998) to those on the Schultz curve (1978) indicates that the percentage of Highly Annoyed people is higher than previously thought when the noise is solely generated by aircraft activity. It can be deduced from Figure 1 that Miedema's Highly Annoyed versus DNL values due to aircraft activity compare well with the shifted Schultz Curve adapted by Pearson Airport as well as the social survey results from Pearson Airport.

There is general agreement on a relationship between DNL and noise annoyance. However, as was mentioned earlier, annoyance is not necessarily the best descriptor of the effects of noise on human activity because it contains so many factors that are unrelated to noise itself. It is therefore necessary to examine the individual human activities that are most directly affected by noise, namely speech interference and sleep disturbance.

4.2 Speech Interference

Speech interference is the most readily quantified adverse effect of noise, and speech is the activity most often affected by environmental noise. Several studies have been conducted over the last 30 years resulting in various noise level criteria for speech interference. In *"Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety,"* known as the "Levels Document", the US Environmental Protection Agency (1974) identified a goal of an indoor 24-hour average sound level of 45 dB based on the intelligibility of sentences during steady noise. In this case, intelligibility pertains to the percentage of sentences correctly understood out of those transmitted according to the American National Standards Institute (ANSI 1994). The curve displayed in Figure 2 shows the effects of steady indoor background sound levels on sentence intelligibility.

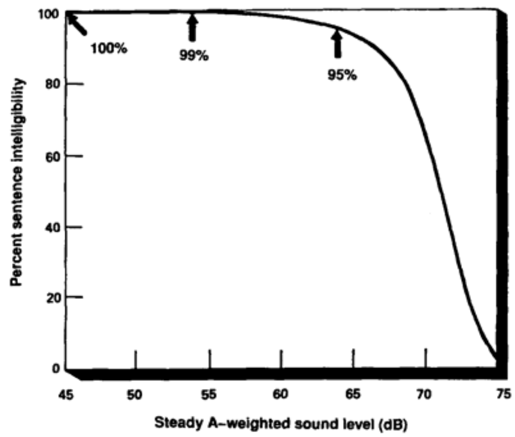

Figure 2. Speech Intelligibility Curve *(Source: EPA 1974)*

The most important application of speech interference criteria is in the classroom where the percent of words (rather than whole sentences) transmitted and received, commonly referred to as 'word intelligibility', is critical. For teachers to be clearly understood by their students, it is important that regular voice communication is clear and uninterrupted. It is therefore important to evaluate the steady background level, the level of voice communication, and the single event level due to aircraft over-flights that might interfere with speech.

Both the American National Standards Institute (ANSI) (2002) and the American Speech-Language-Hearing Association (1995) recommend at least a 15 dB signal-to-noise ratio in classrooms to ensure that children with hearing impairments and language disabilities are able to enjoy high word intelligibility. Thus, if the average adult voice registers a minimum of L_{max} 50 dB in the rear of the classroom, the ANSI (2002) standard requires that the continuous background noise level indoors must not exceed a L_{eq} of 35 dB (assumed to apply for the duration of school hours). The World Health Organization (WHO 1999) also recommends an indoor L_{eq} of 35 dB for overall background noise in schools.

However, the noise from aircraft events is not continuous, but consists of individual events where the noise level can greatly exceed the background level for a limited time period as the aircraft flies over. Thus, single event criteria, which account for those sporadic intermittent noisy events, are also essential to specifying speech interference criteria. In the presence of intermittent noise events, such as aircraft overflights, ANSI states that the criteria for allowable background noise level can be relaxed by 5 dB to 40 dB since speech is impaired only for the short time when the aircraft noise is close to its maximum value. Various researchers indicated that if an aircraft noise event's maximum indoor noise level, (L_{max}), does not exceed the speech level of L_{max} 50 dB, 90 percent of the words would be understood by students seated throughout the classroom. The WHO (1999) also recommends an indoor L_{max} criterion of 50 dB for intermittent noise. Note that an L_{max} of 50 dB is equivalent to an SEL of 60 dB for an aircraft flyover.

The impact of aircraft events on speech intelligibility is also determined by the frequency of the noise events. To account for the single event noise level in conjunction with the frequency of those events, the Number-of-events Above (NA) metric may be more suitable for determining criteria for minimal speech interference. Furthermore, different speech intelligibility criteria are generally appropriate for different environments, such as educational facilities (classrooms, libraries, auditoria, etc.) or residences. The criteria for classrooms are more restrictive due to the necessity of achieving higher percentages of word intelligibility for clear and effective communication between teacher and students. In rooms other than classrooms, auditoria, libraries, and other educational facilities, the required percent sentence intelligibility is more crucial, as conversations are more social in nature. As such two different criteria were compiled to assess the level of speech interference in the different environments.

4.2.1 Classroom Criterion

The Classroom criterion is proposed in terms of an outdoor NA contour, delineating the area beyond which no significant speech interference in the classroom is predicted due to aircraft events. The noise level component of the criterion is derived by taking several factors into account; 90% word intelligibility (indoor SEL 60 dB), a windows closed situation (+25 dB for noise attenuation), and a +5 dB correction to account for the normal tendency to raise one's voice during a noise event. The result is an outdoor criterion of SEL 90 dB. Since there are no existing standards for number of exceedances, let it be assumed that this level should be exceeded only once during a teaching session. Taking into account both the single event level and the number of aircraft events within a teaching session, it is concluded that a classroom criterion of NA90(1) per teaching session is appropriate. Normalizing this over a 15 hour daytime period, which for noise modeling purposes is defined as 0700-2200, the classroom criterion can be represented by the NA90(15) noise contour, encompassing the area in which 15 or more events above SEL 90 dB will occur during the daytime period.

4.2.2 Residential Criterion

The residential criterion is also proposed in terms of an outdoor NA contour. For residential areas the level of word intelligibility is not as critical as in the classroom, rather, a high sentence intelligibility level should be considered. Additionally, since it is likely windows will be open when weather permits, the residential criterion is based on a windows open rather than windows closed assumption. Thus the noise level components of the residential criterion is comprised of; 97 percent sentence intelligibility during an aircraft over-flights (indoor L_{max} 60 dB from Figure 2, equivalent to SEL 70 dB)), and open windows (+15 dB for noise attenuation). The result is an outdoor SEL of 85 dB. As was the case for the classroom criterion it can be assumed that the outdoor 85 dB SEL be exceeded only once per hour. As such the residential criterion is NA85(1). Normalizing this over a 15 hour daytime period, which for noise modeling purposes is defined as 0700-2200, the residential criterion can be represented by the NA85(15) noise contour, encompassing the area in which 15 or more events above SEL 85 dB will occur during the daytime period.

4.2.3 Application of Speech Criteria

The above proposed speech criteria are expressed in terms of the NA metric, but land use planning guidelines/policies in Canada are based on the NEF metric. For practical implementation, it was necessary to undertake a modeling exercise to assess the relationship between the recommended school and residential criteria as expressed in the NA metric and the more conventional NEF metric. To illustrate this relationship, case airport examples across a range of airport sizes/roles were modeled, generating NEF and NA contours for the recommended speech criteria. Table 1 below illustrates the range of relationships between the speech criteria and the NEF contours for the noise impact generated by arrival and departure operations separately. The relationships for areas impacted by a blend of arrivals and departures would fall between the arrival and departure range provided in the table.

Table 1. NEF Level Comparison to Speech NA Criteria for Airport Case Studies

Criteria	Equivalent NEF Level	
	Departure	Arrival
Speech – Residences (NA85(15))	23-28	25-30
Speech - Schools (NA90(15))	31-35	33-40

The results of this exercise indicated that:

- The residential speech criterion is the more restrictive, resulting in lower NEF values, and
- The residential speech criterion equates to NEF levels, across a variety of airports roles, in the range of 23-28 for departures and 25-30 for arrivals suggesting that a NEF threshold lower than 30 is recommended.

4.3 Sleep Disturbance

Disturbance of sleep is a major concern in the assessment of environmental noise levels, since a good night's sleep is essential to a person's physiological and psychological health and well-being. A number of studies conducted since the early 1960s have attempted to quantify the noise levels that interfere with sleep. In the early years of aircraft noise research, field studies conducted with people in their normal living situations were rare, and consequently much of the data on the impact of noise exposure on sleep originated primarily from experimental research in controlled laboratory environments. In 1992, the U.S. Federal Interagency Committee on Noise (FICON) recommended a dose-response curve which predicted the percent of the exposed population expected to be awakened (% awakening) as a function of the exposure to single event noise levels expressed in terms of SEL. This curve incorporated most of the research performed up to that point, and indicated that 10% of the population was predicted to be awakened when exposed to an interior SEL of approximately 58 dB (FICON, 1992).

In the early 1990s, field studies were conducted to validate the earlier laboratory work. The most significant finding from these studies was that there was a distinctly lower effect of noise on sleep in real-life conditions than had been previously reported from laboratory studies (Pearsons, 1995). A study performed in 1992 by the Civil Aviation Policy Directorate of the Department of Transportation in the United Kingdom concluded that average sleep disturbance rates (those that are unrelated to outdoor noise) are unlikely to be affected by aircraft noise at outdoor levels below an L_{max} of 80 dB (Ollerhead, 1992). Based on such field studies, the U.S. Federal Interagency Committee on Aviation Noise (FICAN) updated its recommended dose-response curve in 1997. The new relationship represents the higher end, or upper envelope, of the latest field data and should be interpreted as the maximum percent awakened. According to this relationship, a maximum of 3 percent of people would be awakened at an indoor SEL of 58 dB (compared to 10 percent using the 1992 curve).

Fidell et al. (2000) also developed a relationship to identify the sound levels that cause awakenings based on several field studies. The results suggest that even fewer people are awakened than the FICAN 1997 curve indicates. An indoor SEL of 58 dB using Fidell's curve corresponds to approximately 1 percent of the population who will be awakened, versus 3 and 10 percent for the same level on the FICAN 1997, and 1992 curves respectively. Figure 3 provides a comparison of these three curves for indoor SEL.

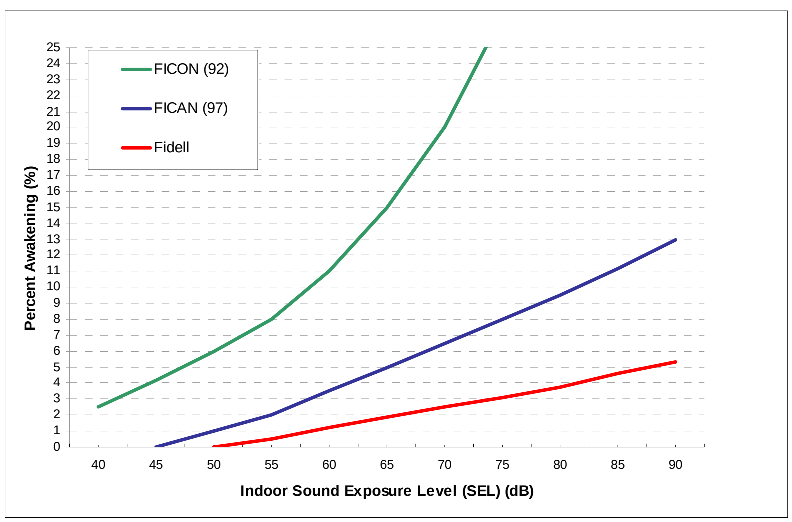

Figure 3. Comparison of FICON 1992, FICAN 1997, Fidell et al. Awakening Curves

Other studies indicate that for a good night's sleep, the number of noise occurrences plays a role almost as important as the level of the noise. The results of Miedema's work, for example, suggest a limit of one noise event per night.

4.3.1 Sleep Criterion and Application

Based on a review of the sleep disturbance literature, the Number-of-events Above (NA) metric has been used to identify noise levels and the number of events that correlate well with sleep disturbance research findings. The sleep criterion is defined by the NA90(1) contour line, and encompasses the area in which one or more events above SEL 90 dB will occur during an average night. This criterion is derived primarily from the extensive field study in the U.K. by Ollerhead, who found that there is a 3 percent chance of some level of arousal and a 1 percent chance of brief awakenings when aircraft flyovers exceed SEL 90 dB outdoors. In addition to Ollerhead's findings, Fidell's relationship shows a 3 percent chance of some level of sleep disturbance with noise events at an indoor SEL of 75 dB, equivalent to an outdoor SEL of 90 dB with open windows. With closed windows this outdoor SEL would equate to a 2.5 percent chance of some level of sleep disturbance.

Similarly to the application of the speech criteria, the relationship between the proposed sleep criterion and the standard NEF metric was assessed through the modeling of case airport examples across a range of airport sizes/roles. Table 2 below shows the range of relationships between the sleep criterion and the NEF contours.

Table 2. NEF Level Comparison to Sleep NA Criterion

Criterion	Equivalent NEF Level	
	Departure	Arrival
Sleep (NA90(1))	25-29	30-40

The NEF 30 standard currently in use is higher than the sleep disturbance criterion suggested by this NA analysis for departure, providing support for extending the sleep disturbance protection area beyond the NEF 30 contour.

4.4 Habituation

Research shows that the time it takes to become habituated (accustomed to airport operations) depends on the frequency and intensity of noise events and that habituation, or lack thereof, is an important factor that should be considered when determining threshold levels of annoyance and activity interference from aircraft noise. Case studies indicate that no matter how large the protection area around a new or expanding airport, there will be considerable noise complaints until the majority of the newly impacted population becomes habituated, as well as continuing complaints from the impacted population on an ongoing basis. Therefore, the development of land use planning guidelines for new, non-urban airports should recognize that a portion of the population is likely to be un-habituated in the early years of airport operation, and an appropriate level of protection should be built in.

4.5 Non-urban Versus Urban Environment

Urban and suburban populations generally experience outdoor background sound levels 10 to 20 dB higher than non-urban populations, and it seems intuitive that the average person will be more aware of aircraft noise (or any other noise) if it stands out clearly above the general background noise level. When considered with the habituation findings, there is some justification for defining a new land use planning threshold for noise sensitive development, based on an NEF level lower than 30 to compensate for low background noise levels at a new, non-urban airport site where habituation has not yet occurred.

4.6 Community Attitudes and Experience

Studies show that fewer noise complaints occur when there is a history of cooperation between the community and the airport. Where noise has been recently introduced or increased, there is usually an initial perception that the noise is very intrusive, and the rate and level of habituation is closely related to the level of effort and sincerity of responsible officials to abate the noise level and mitigate the impacts. A related study showed that the public will tolerate higher noise levels if they are generated by military, air ambulance, and law enforcement flight activity, rather than operations that are perceived as less essential, such as General Aviation. Researchers concluded that diverse community attitudes towards different types of operations suggest that a single noise exposure level is not suitable for predicting citizen response to different types of airports or operations. In planning for a new, non-urban airport that may include many types of operations over time, community tolerance for the various types of operations should be a factor in determining the appropriate criteria for the definition of land use planning threshold for noise sensitive development.

4.7 Buffer Zone

Most of the world's airports were developed without a buffer zone between the area where national guidelines or local standards limit noise-sensitive development and the area where noise-sensitive development should occur "without restriction." Case studies show that those airports that are protected by a buffer zone that allows noise sensitive development "with restrictions" between the "no noise-sensitive development" area close to the airport and the "build without restriction" area, have the least controversy associated with capacity expansion projects over time. Transport Canada's NEF guideline was clarified in the 1990s to preclude noise sensitive development in the NEF 35 to NEF 30 zone. The only buffer zone considerations in the current NEF 30 guideline are in footnote (A) of Table 3 "Transport Canada – Land Use in the Vicinity of Airports," which recommends that developers inform prospective tenants or purchasers of residential units that annoyance caused by aircraft may begin as low as NEF 25 and in Section 4.2.1, which states that "Transport Canada does not support or advocate incompatible land use (especially residential housing) in areas affected by aircraft noise. These areas may begin as low as NEF 25". If a single land use planning criterion for noise sensitive development is established for new, non-urban airports in Canada, it should include the buffer considerations and be set at a threshold below which all noise-sensitive development is permitted without restrictions or limitations. This buffer would also offer protection against the long term planning uncertainties inherent in airport planning.

4.8 Opportunity

The best opportunity to establish a cooperative relationship with nearby communities and to incorporate a sufficient buffer zone to control noise sensitive development around a new airport is in the initial planning stage. This opportunity diminishes quickly as the airport develops and community land use patterns become established.

4.9 Encroachment

Most airports are eventually surrounded by uses that are incompatible, such as residences, noise sensitive businesses, schools, and public gathering facilities. Such encroachment is largely driven by the overriding draw of potential or perceived dollars for tax base or profit, and by the lack of understanding or sensitivity by cities and developers of the value of, and need for, long-term noise mitigation zoning. Encroachment potential is clearly a vital factor in planning and establishing appropriate protection criteria for new, non-urban airports.

5.0 Recommendations

The goal of this project was to recommend noise exposure thresholds for noise-sensitive land uses in the vicinity of new non-urban airports in terms of the NEF metric. For the purpose of this study, noise-sensitive uses include schools, day-care centers, nursing homes, residences, hospitals, and other similar uses where airport noise might significantly disrupt human activity, more specifically speech and sleep.

Based on a thorough analysis of national and international aviation noise standards, policies and guidelines, criteria to protect from excessive speech interference and sleep disturbance were established. Pertinent factors considered in compiling the final recommendation, included not only the speech interference and sleep disturbance research and criteria, but also habituation, non-urban vs. urban environment, community attitudes toward the noise source, prior experience with the noise source, the purpose of flight operations causing the noise, encroachment potential, and unique opportunities available at the planning stage of airport development in a non-urban location. Finally, an airport noise modeling exercise was undertaken to apply the established criteria for speech interference and sleep disturbance and compare them to the corresponding NEF contours resulting in the following recommendations:

- Establish a single NEF criterion, above which no noise sensitive development is permitted to occur around a new non-urban airport site. A single criterion is most practical for reasons of simplicity, implementation and administration.
- Establish NEF 25 as the single criterion, which is the most practical and defensible single criterion to meet the stated project goal, which also fully considers all of the pertinent factors discussed in this report.

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