WHEN PROPFANS CRUISE, WILL LDN 65 FLY?

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INTRODUCTION

The question I would like to explore in this paper is the type and extent of response that may be expected from the persons exposed to the noise of propfans cruising overhead. The cruise mode is of particular interest because it appears that it is in this mode that the propfan airplane noise differs substantially from the noise of present jet-powered airplanes.

Early test data on propfan engines suggests that noise levels on the ground under the flight track of commercial propfan transports may approach 65 decibels. To explore the reaction of the exposed population to repeated noise levels of this magnitude, it may be helpful to review some of the pertinent literature on the effects of environmental noise.

TECHNICAL DETAILS

1. Protective Noise Levels

In EPA Report 550/9-74-004, the so-called Levels Document (ref.1) the Agency, as required by the Noise Control Act, identified the environmental noise levels (low enough) to protect the public health and welfare. Chart 1, from the Levels Document, shows that Ldn 55 is adequate to protect against outdoor activity interference and annoyance.

Chart 2, from Guidelines for Preparing Environmental Impact Statements on Noise (ref.2) shows the annoyance dose-response function that largely formed the basis for the selection of Ldn 55 as the "protective" level. Of interest also is Chart 3, from EPA's Protective Noise Levels (ref.3). These data, based on a number of community noise studies, show the level of community response to various levels of aircraft noise exposure.

Based on the foregoing findings, the Interagency Committee

on Noise in 1980 published the Guidelines for Considering Noise in Land Use Planning and Control (ref.4). Chart 4, from that document, shows that Ldn 65 was selected as the level at which "significant" noise exposure begins.

It should be noted that EPA's identification of Ldn 55 was made without consideration of the question of cost or practicality of achieving such a level of environmental noise. The Interagency Guidelines, appropriately enough, took into consideration matters of practicality and cost.

2. Sleep Disturbance due to Noise

What is the basis for judging sleep disturbance due to noise? The best data currently available to us is based on laboratory tests of the effects of noise on sleeping persons. Chart 5, from Fig. 8-2 of EPA's Desk Reference to Health and Welfare Effects of Noise (ref.5) shows the probability of noise-induced awakening as a function of A-weighted Sound Exposure Level (SEL).

From this figure, it can be seen that, for a noise event with SEL = 64 dB, the probability of a sleeping person awakening is 20 per cent. The probability of awakening ($P_{a)}$ is 10 per cent for SEL = 54 dB.

Since these data are based on the SEL at the sleeper's ear, the noise reduction between exterior and interior should be added to relate the probability of awakening to the exterior SEL. Taking 15 dB as typical for a single-family residence in the summer, and 20-25 db in the winter, the corresponding exterior SEL values for awakening are (see Chart 6):

* for Pa = 10 %, SELs(summer) = 69 dB and SELw(winter) = 74-79 dB;

* for Pa = 20 %, SELs = 79 dB and SELw = 84-89 dB.

3. Speech Interference due to Noise

It is well known that noise can interfere with speech communication. Chart 7, from Figure 10 of EPA's Protective Noise Levels, shows this effect quantitatively. From this figure, it is apparent that sentence intelligibility begins to degrade markedly at a sound level of 65 dB.

However, for consideration of interference with the educational process, a more stringent criterion may be necessary, particularly for the lower grades, where vocabulary is not well-developed in the pupils, and word intelligibility is crucial. In a US DOT/FAA Report to Congress, July 1977, on the Feasibility... of...Sound-Proofing Public Schools..., a level of 45 dB was

selected as the threshold of speech interference in classrooms (according to K.L.Kaufman (ref.6)).

Consider a "typical" airplane flyover, in which the sound level remains within 10 dB of the maximum for 10-20 seconds: if the maximum is 55 dB, the Single-event level (SEL) will be about 8 dB above the maximum sound level (Lamax) or about 63 dB. For a building with an outdoor-to-indoor attenuation of 20 dB, the corresponding outdoor SEL is about 83 dB.

4. Noise Exposure due to Cruising Propfans

Now, you may ask, what does all this have to do with cruising propfan airplanes? Well... let's look at the projected sound levels under the flight path of a propfan cruising at 35,000 feet. From NASA and other test data it is not unreasonable to anticipate maximal A-weighted sound levels (L_A max) around 65 dB, with corresponding SEL values possibly as high as 73 to 75 dB. It should be noted that these levels are 15 dB or more above those encountered from current transport airplanes at cruise altitude. Typical data from a propfan test bed aircraft are shown in Chart 8 (from ref.7).

Consequently, one may expect at least 10 per cent of the sleepers in a band a few miles wide under the flight path to be awakened by each overflight (nighttime.) It would be possible, given the population distribution data, to estimate the numbers of persons involved; for purposes of this discussion, we can reasonably infer that a comparatively large number of persons will be awakened by each overflight.

If a large fleet of propfans is operating, this will occur many times per night. Such a situation well may lead to a substantial volume of complaints. It should be added that, at the levels considered here, speech interference does not appear to be a significant factor.

5. Single-Event Levels vs DNL

It should be noted that, even with 100 overflights (at SEL = 75 dB) in 24 hours, 10 % of them at night, the DNL contribution would be less than Ldn 50 (see Chart 9.) So here we have a situation where the DNL is well below the level that requires mitigative action in the vicinity of an airport, but the number of awakenings is highly likely to generate many complaints.

A case in point is that of Westover Air Force Base near Chicopee, Mass. The Air Force was considering certain changes in operations of military aircraft, along with the optional introduction of commercial cargo aircraft activities. In the EIS for this proposed action (ref.8) the analysis disclosed that the anticipated nighttime operations of cargo aircraft could expose

some 40,000-plus local residents to exterior SEL values of 80 dB or higher, several times per night.

The next chart (10) shows that the SEL 80 boundary extends well beyond the Ldn 65 contour. Currently accepted dose-response data, indicating a probability of awakening of about 20 %, suggested that this exposure could cause multiple awakenings of 8,000 or more persons each night. Apparently largely as a result of these considerations, the Air Force decided to postpone indefinitely the introduction of the nighttime commercial cargo operations.

6. **EIS Reviews**

Under Section 309 of the Clean Air Act and the National Environmental Policy Act (NEPA), EPA is charged with reviewing and commenting on the environmental impact of (applicable) actions of any Federal department or agency. In accordance with this responsibility, the Office of Federal Activities (OFA) has reviewed a number of Environmental Impact Statements (EIS's) and Environmental Assessments (EA's) issued by the FAA concerning improvements, expansion, or construction of airports.

It is not uncommon, in the public comments section of these documents, to find complaints from individual citizens and community groups about the noise intrusions caused by the airport operations. In many instances, these complaints concern noise in areas outside the Ldn 65 contours. Partly as a result of these reviews, EPA and the FAA have been involved in correspondence and discussions concerning the question of supplementing the standard DNL analysis, either by extending the DNL analysis beyond the Ldn 65 contour, or by introducing certain single-event analyses.

CONCLUSION

The impending introduction of a new generation of commercial transport airplanes with propfan propulsion systems creates the apparent potential for repeated sleep disturbance and other annoyances due to the noise on the ground from these airplanes cruising overhead. Many complaints may emanate from the persons so exposed, even though the DNL is substantially below 65 dB, FAA's criterion for "significant" noise impact (exposure.)

Experience suggests that the earlier attention is devoted to consideration of mitigative approaches, the greater the probability of forestalling the impacts and resultant complaints, at reasonable cost.

REFERENCES

1. EPA Report 550/9-74-004, Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety. March 1974

2. Committee on Hearing, Bioacoustics, and Biomechanics National Research Council Guidelines for Preparing Environmental Impact Statements on Noise. National Academy of Science Washington, D.C. 1977

3. EPA Office of Scientific Assistant to DAA/Noise: Protective Noise Levels Condensed Version of EPA Levels Document. Environmental Protection Agency November 1978

4. Guidelines for Considering Noise in Land Use Planning and Control. Federal Interagency Committee on Urban Noise June 1980

5. EPA Office of Scientific Assistant: Desk Reference to Health and Welfare Effects of Noise. October 1979

6. Kaufman,K.L.: An Investigation of Teacher Voice Signal Amplification Treatment for Mediating Speech Communication Interference from Jet Aircraft Noise and from Minimal Hearing Loss in First and Second Grade Classrooms. Ph.D. Thesis Loyola University January 1985

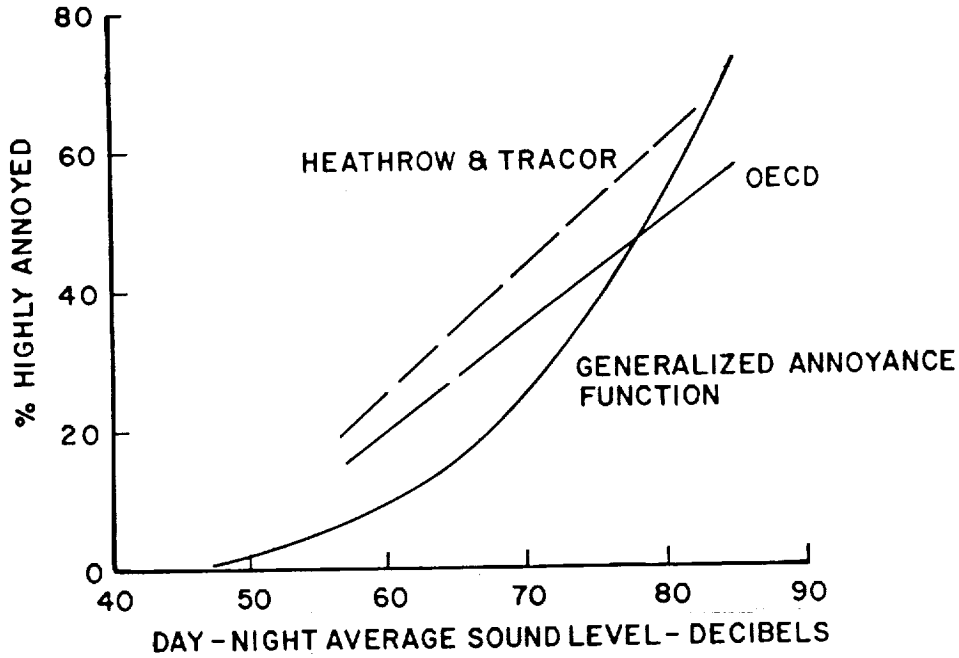
7. Rickley, E.J.: INFORMATION: En route Noise - Propfan Test Assessment Program. Letter Report DTS-48-FA853-LR1 US Department of Transportation Research and Special Programs Administration December 16,1987

8. US Air Force: Final Environmental Impact Statement - Proposal to Locate 16 C-5A Aircraft at Westover Air Force Base, Massachusetts. April 17,1987; Record of Decision. May 21,1987

Yearly L_{dn} Values That Protect Public Health and Welfare with a Margin of Safety

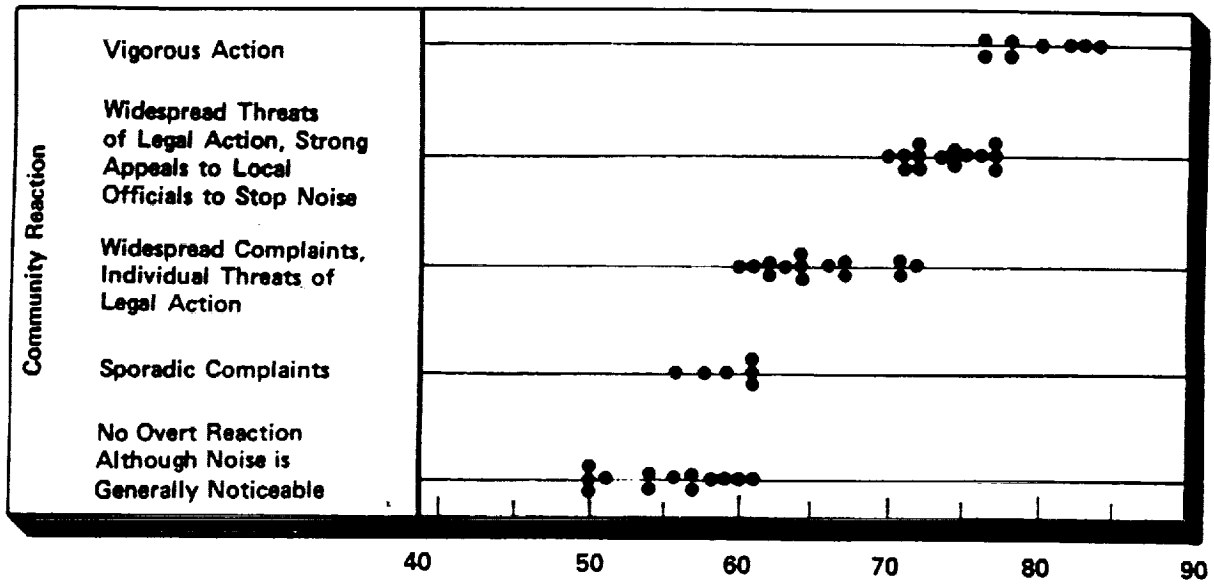
EFFECT	LEVEL	AREA
Hearing	$L_{eq(24)} \leq 70$ dB	All areas (at the ear)
Outdoor activity interference and annoyance	$L_{dn} \leq 55$ dB	Outdoors in residential areas and farms and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use.
	$L_{eq(24)} \leq 55$ dB	Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc.
Indoor activity interference and annoyance	$L_{dn} \leq 45$ dB	Indoor residential areas
	$L_{eq(24)} \leq 45$ dB	Other indoor areas with human activities such as schools, etc.

CHART 1



Comparison of Generalized Annoyance Function with Previously Published Functions Derived from Social Surveys Around Airports.

CHART 2



COMBINED DATA FROM COMMUNITY CASE STUDIES ADJUSTED FOR CONDITIONS OF EXPOSURE

CHART 3

NOISE ZONE CLASSIFICATION

Noise Zone	Noise Exposure Class	Noise Descriptor			HUD Noise Standards
		DNL[1] Day-Night Average Sound Level	L_{eq}(hour)[3] Equivalent Sound Level	NEF[4] Noise Exposure Forecast	
A	Minimal Exposure	Not Exceeding 55	Not Exceeding 55	Not Exceeding 20	"Acceptable"
B	Moderate Exposure	Above 55[2] But Not Exceeding 65	Above 55 But Not Exceeding 65	Above 25 But Not Exceeding 30	
C-1	Significant Exposure	Above 65 Not Exceeding 70	Above 65 Not Exceeding 70	Above 30 But Not Exceeding 35	"Normally Unacceptable"[5]
C-2		Above 70 But Not Exceeding 75	Above 70 But Not Exceeding 75	Above 35 But Not Exceeding 40	
D-1	Severe Exposure	Above 75 But Not Exceeding 80	Above 40 But Not Exceeding 80	Not Exceeding 45	"Unacceptable"
D-2		Above 80 But Not Exceeding 85	Above 80 But Not Exceeding 85	Above 45 But Not Exceeding 50	
D-3		Above 85	Above 85	Above 50	

CHART 4

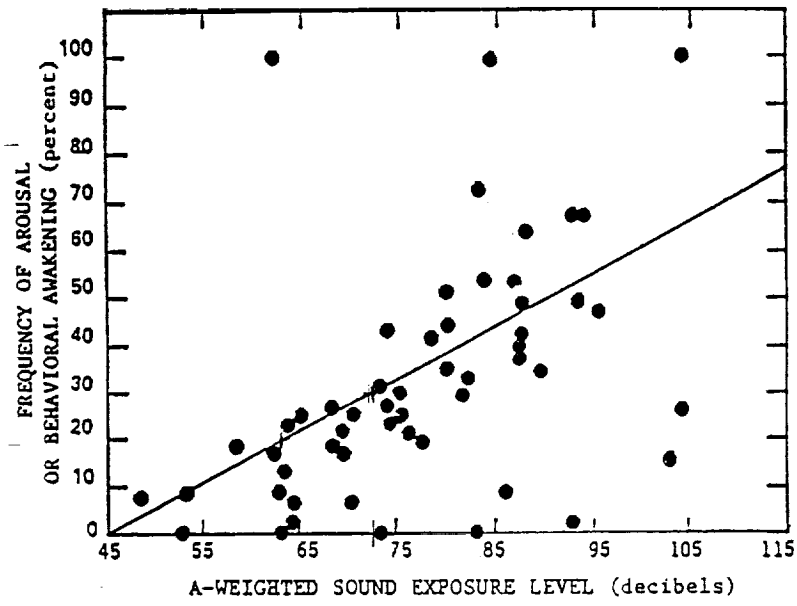


CHART 5

PROBABILITY OF A NOISE INDUCED AWAKENING

SOUND EXPOSURE LEVEL for SPECIFIED PROBABILITY 0F AWAKENING

Probability (Pa)	SEL (Summer)	SEL (Winter)
10%	69	74-79
20%	79	84-89

CHART 6

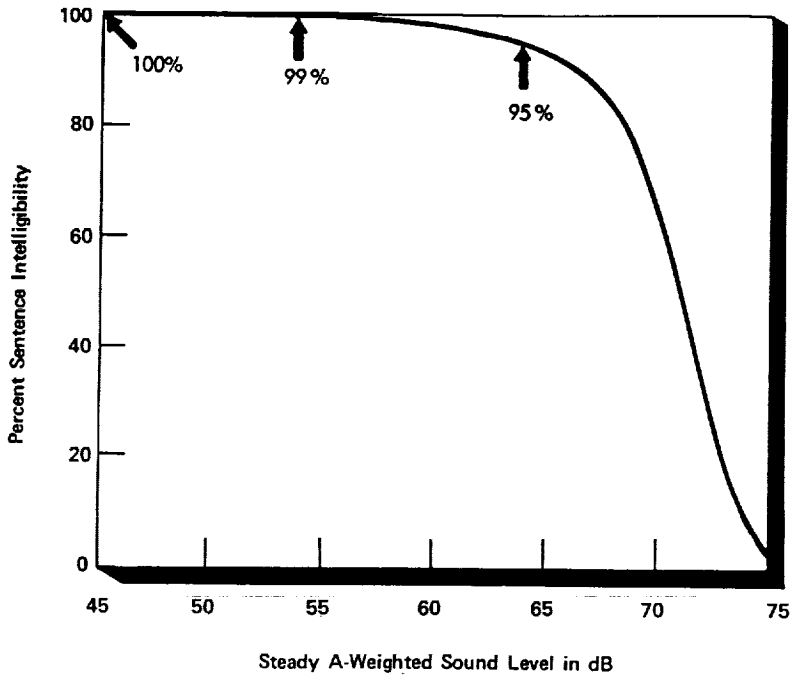


FIGURE 10. INDOOR SENTENCE INTELLIGIBILITY

CHART 7

PROPFAN NOISE DATA

Propfan Test Assessment (PTA)
En route Noise - 35000 ft

Location	SELmax	Lamax
On centerline	70.7	57.7
5 mi. West	60.7	53.9
5 mi. East	60.7	53.9
10 mi. West	57.4	49.1
10 mi. East	50.8	42.8

CHART 8

DNL CONTRIBUTION OF ONE EVENT

Assume event SEL = 75 dB

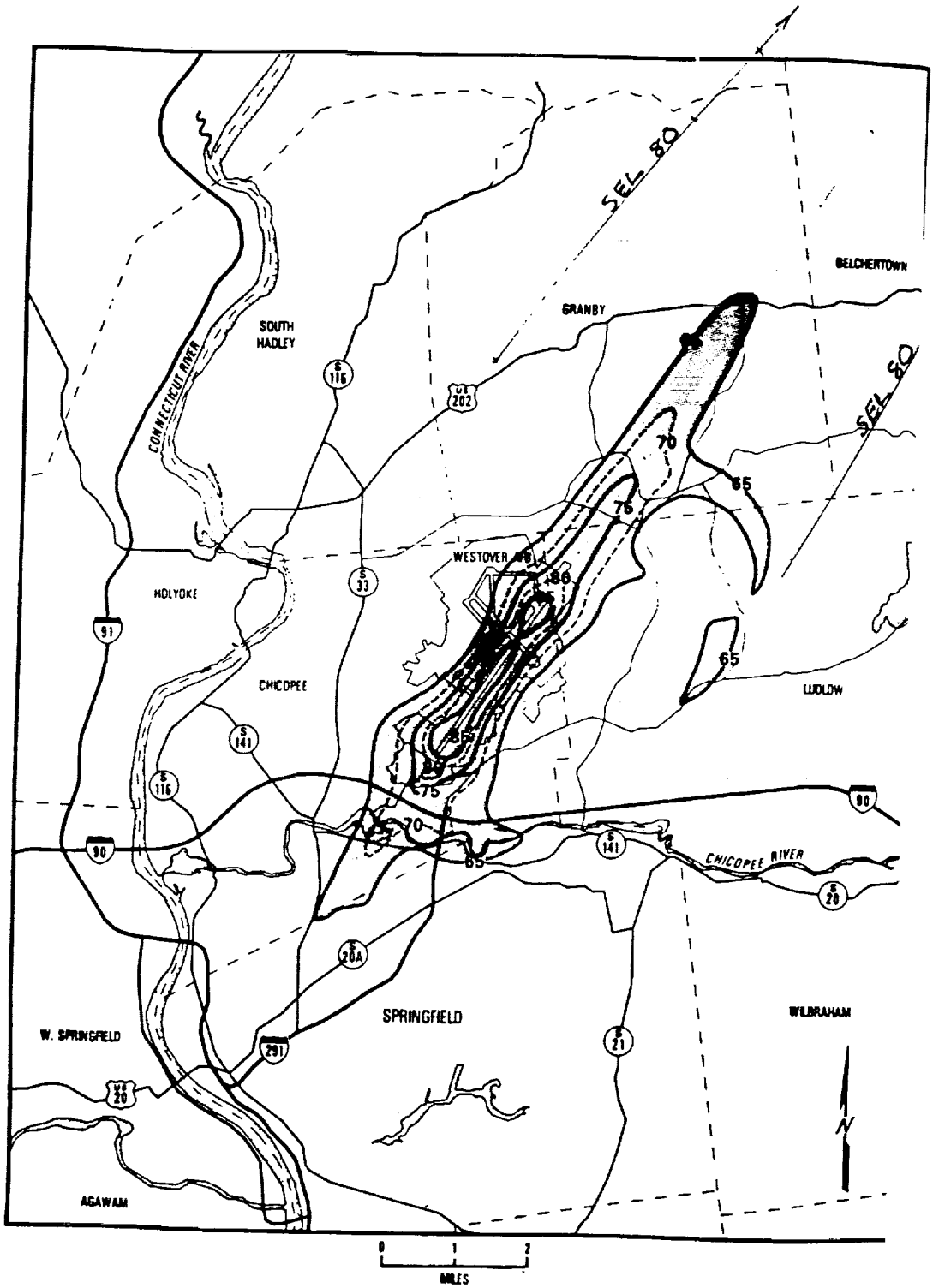
DNL contribution is

SEL - 10 log(86400) =
75 - 49.4 = 25.6 dB (daytime)
75 -49.4 + 10 = 35.6 (nighttime)

Assume 100 events, 10 at night
Daytime contribution is
25.6 + 10 log 90(=19.5) = 45.1 dB
Nighttime contribution is
35.6 + 10 log 10(=10) = 45.6 dB

Resultant DNL = 45.1 dB + 45.6 dB =
48.4 dB (Ldn 48.4)

CHART 9



Cumulative DNL for proposed (16 C-5A) military operations plus potential WMDC operations (with mitigation).

CHART 10

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OF POOR QUALITY