NASA Contractor Report 3490



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# I. INTRODUCTION

## A. Rationale for Current Study

Most quantitative information about community reaction to noise exposure (for example, that summarized by Schultz, 1978) concerns steady state circumstances of both exposure and attitudes. Studies of community reactions to noise exposure usually assume tacitly that the community is thoroughly familiar with prevailing static exposure conditions, and that any transient changes in opinions about exposure have long since turned into a stable, long term set of attitudes. One may wonder if the relationship of annoyance to noise level derived from these conditions is applicable for predicting changes in community response from sudden changes of noise exposure in the community. The current study explores the changes of prevalence of annoyances associated with a series of shifts in aircraft noise exposure in the vicinity of an airport with appreciable air carrier traffic.

The objective of the study was simply to determine if a change in annoyance was associated with a change in noise exposure. Another cause for interest in a study of reaction to changes in exposure is its potential for producing information about the time course and degree of adaptation to noise exposure. Such information could have important implications for regulatory and policy decisions.

Support for the commonsensical observation that people "get used to" noise is mostly anecdotal at present. Adaptation is nonetheless believed to be as an influence on community reaction to noise exposure, as may be inferred from inclusion of a correction factor for "familiarity" or "history of exposure" (EPA, 1979) in the earliest indices of community reaction to noise (cf. Stevens et al., 1955).

Reliable information about community adaptation to changes in noise exposure is sparse not only because research has historically concentrated on other aspects of community reaction to noise exposure, but also because systematic study of the problem poses several procedural problems. Major changes in exposure conditions of the sort likely to produce measurable changes in community reaction rarely arise. Those that do occur are frequently unidirectional and irreversible. Longitudinal experimental designs suitable for collecting the desired sort of information require successive re-interviewing of respondents, careful monitoring of physical exposure conditions, and other potentially costly measures.

The current study took advantage of an unusual set of exposure conditions associated with runway repairs at a major airport. People in one neighborhood in which the noise environment had been dominated by local street traffic were abruptly exposed to an increase in aircraft noise exposure. Several months later, these same people were exposed to a sudden decrease in aircraft noise exposure. At the same time, people in two other neighborhoods long exposed to aircraft noise experienced the complementary pattern of changes in noise exposure. Residents of a fourth nearby neighborhood, which underwent smaller changes in noise exposure through the study period, were available for interviewing for purposes of experimental control. The general pattern of changes in exposure was a matter of public record in advance of the changes.

Thus, it was possible to use consistent survey techniques and repeated acoustic measurements: 1) to determine whether or not a change in prevalence of annoyance is associated with a change in aircraft noise exposure, and 2) to assess the time course of adaptation to changing aircraft noise exposure, and 3) to compare annoyance due to aircraft at Burbank Airport with similar information collected elsewhere.

## B. Anticipated Changes in Exposure and Annoyance

The three panels of Figure 1 suggest relationships between noise exposure and annoyance at Burbank Airport that might reasonably have been anticipated on the basis of general knowledge of human response to noise exposure*. The topmost plot shows a pattern of change in community noise exposure on axes of Day Night Level ($L_{dn}$) vs. time. Since aircraft activity and runway utilization at Burbank Airport are fairly stable from day to day, no large exposure fluctuations were expected. The step change in exposure occurred when aircraft traffic patterns changed suddenly as a result of the closure of the main runway.

Following the step change in exposure, people's attitudes toward aircraft noise could reasonably have been expected to change as suggested in the two lower panels of Figure 1. Annoyance with aircraft noise over the past week was expected to increase dramatically, with perhaps some overshoot due to overreaction to exposure change per se. It was expected, however, that short term annoyance would eventually stabilize at a new level predictable from the relationship derived by Schultz (1978) from a number of attitudinal surveys conducted world-wide.

In contrast, long term annoyance with aircraft noise (represented in the bottom panel in Figure 1) was expected to increase in a more gradual manner to a new higher level of annoyance,

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*The expected relationship for decreases in annoyance following decreases in exposure are simply the converse of those discussed here.

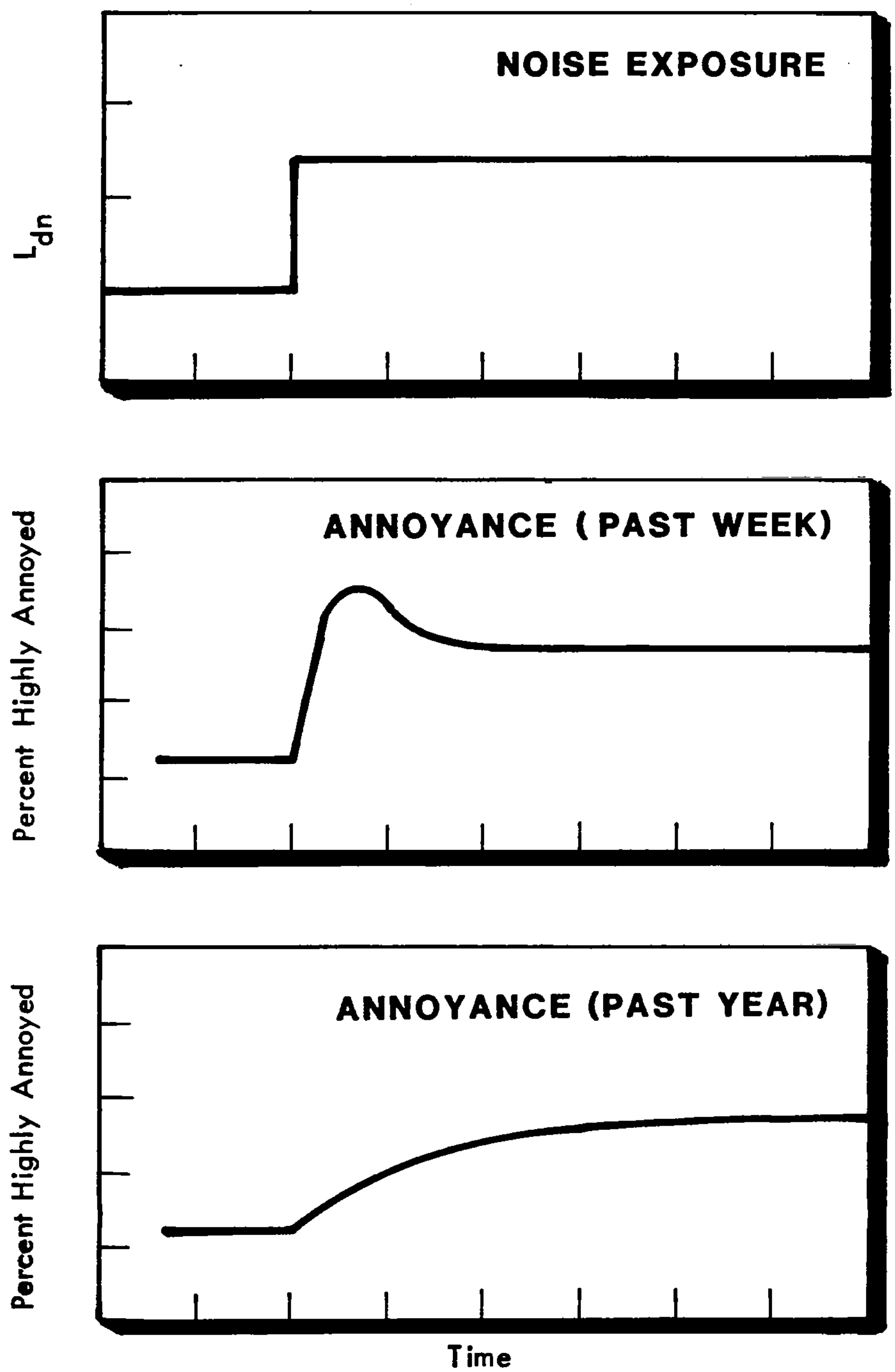


FIGURE 1. EXPECTED HISTORY OF DOSAGE AND RESPONSE.

with an exponential rate of increase. Short term and long term annoyance were expected to be close to identical before any exposure change, and ultimately to become asymptotic at the same level of annoyance after a long period of time following the step change.

The slopes of the functions relating the rise (and fall) of annoyance to increasing (and decreasing) exposure would not necessarily be identical. Common sense would suggest that annoyance would rise more rapidly following an increase in exposure than it would fall following a decrease in exposure.

## C. Acknowledgments

The authors thank Drs. David M. Green and Theodore Schultz for comments and discussions concerning analyses of the present data. We are especially grateful to residents of the Burbank Airport area for their repeated expressions of opinions about noise exposure.

## II. METHOD

### A. Study Design

A social survey was designed to take advantage of changes in noise exposure associated with runway repairs at Burbank Airport (BUR). In mid-September 1979, most of the main runway (15-33) was closed for repairs. Prior to the closure, Runway 15 supported virtually all scheduled air carrier departures (about 50 per day), half the arrivals (about 25 per day), and about 75% of the general aviation operations (about 450 out of approximately 600 combined arrivals and departures per day) at BUR. The remaining half of air carrier arrivals and the remaining 25% of general aviation operations used Runway 07. At the onset of repairs, all commercial and much general aviation air traffic at BUR was diverted to the cross runway (see Figure 2). The main runway was subsequently closed to all traffic until late December of 1979 (see Figure 3). Repairs to the cross runway began several months later, and were completed by late October, 1980.

Four rounds of interviewing were conducted in conjunction with the changes in noise exposure caused by repairs to the main runway: one immediately before the initial closure of the main runway, and three others before its reopening. A fifth round of interviews was conducted approximately three months after completion of all runway repairs (see Figure 4).

### B. Site Selection and Exposure Patterns

Four residential neighborhoods were identified in which aircraft noise exposure was expected to be homogeneous (plus or minus 3 decibels) from extensive prior measurements. Each

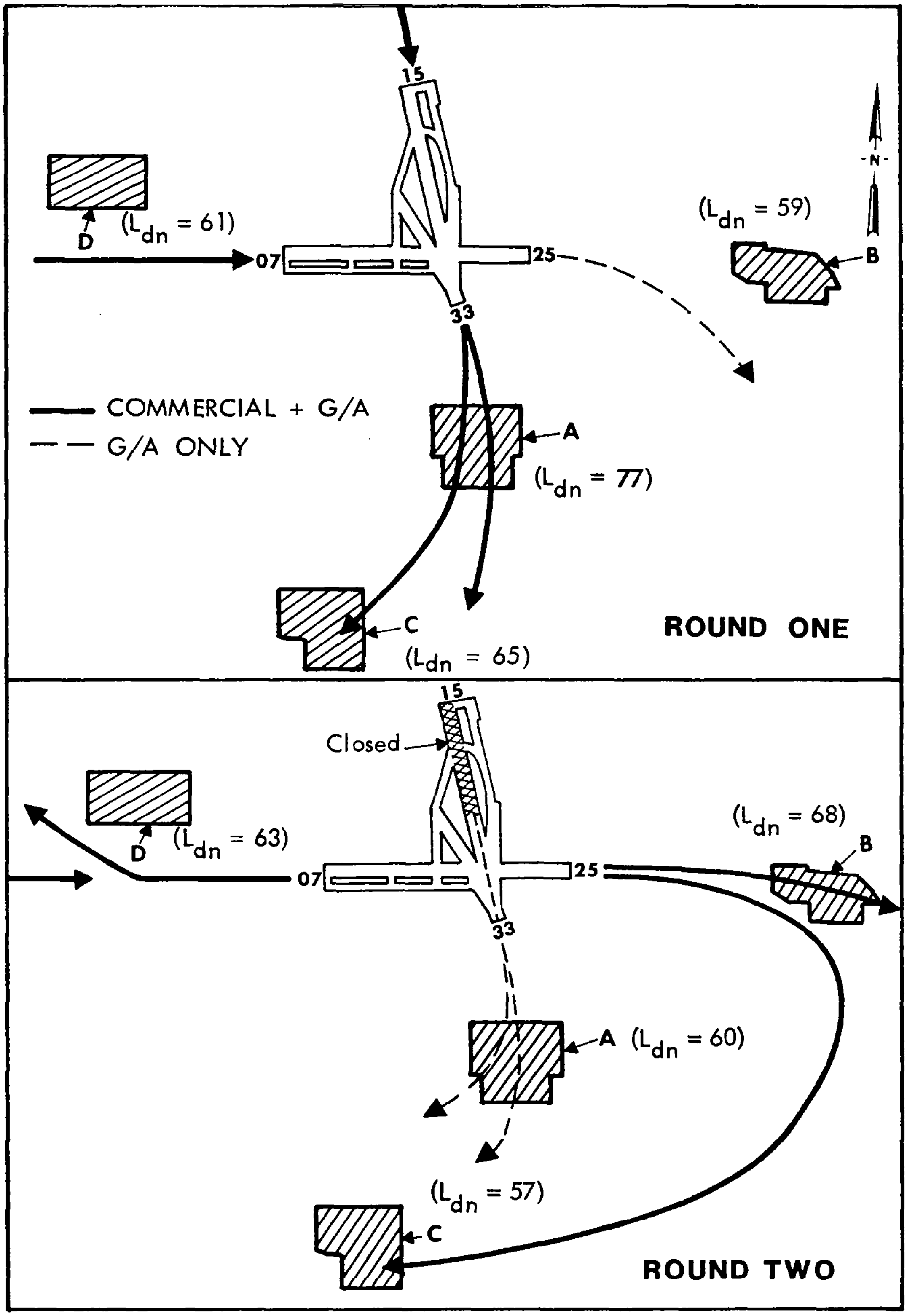


FIGURE 2. MAP OF INTERVIEWING SITES SHOWING PRINCIPAL FLIGHT PATHS - ROUNDS ONE AND TWO.

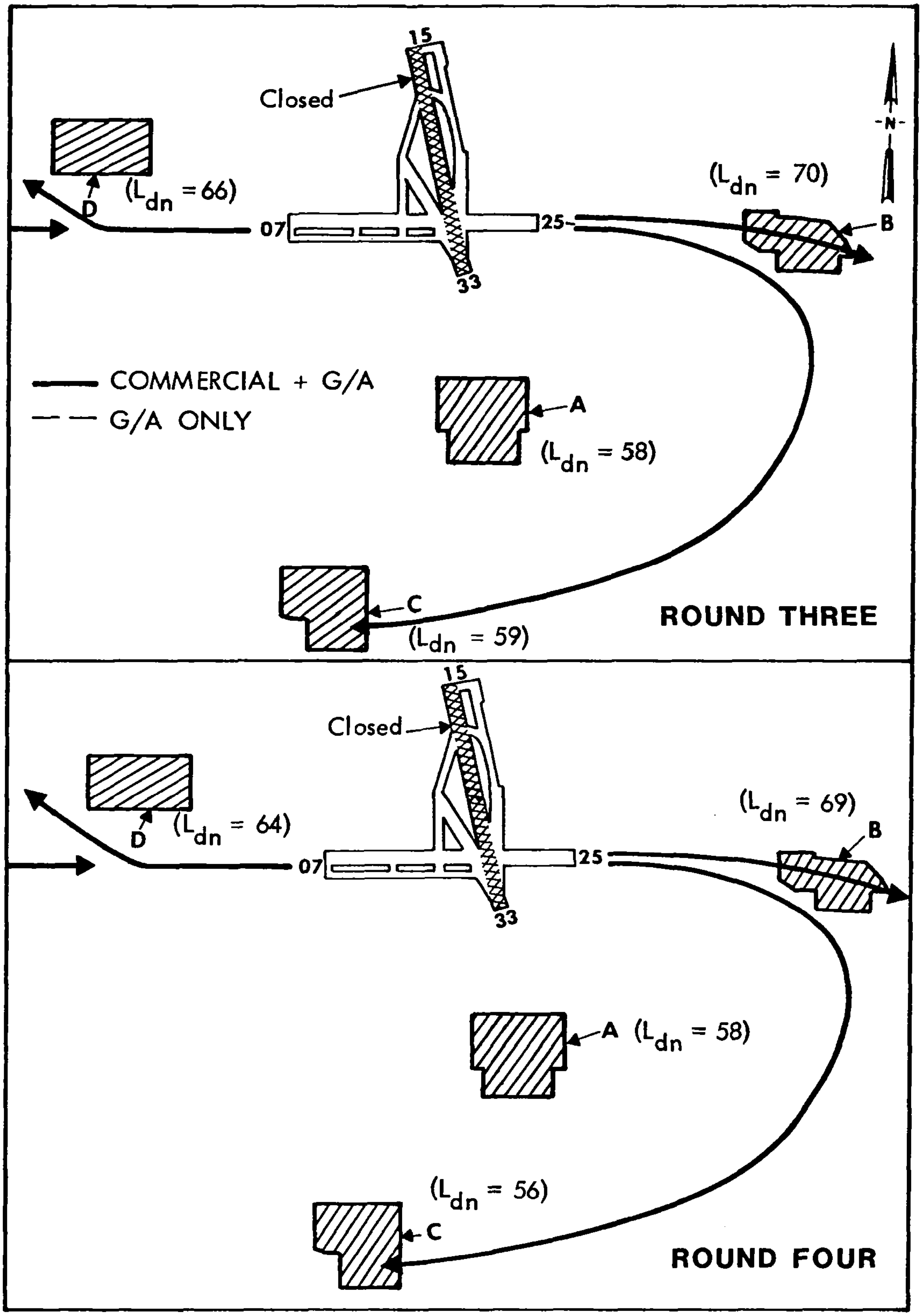


FIGURE 3. MAP OF INTERVIEWING SITES SHOWING PRINCIPAL FLIGHT PATHS - ROUNDS THREE AND FOUR.

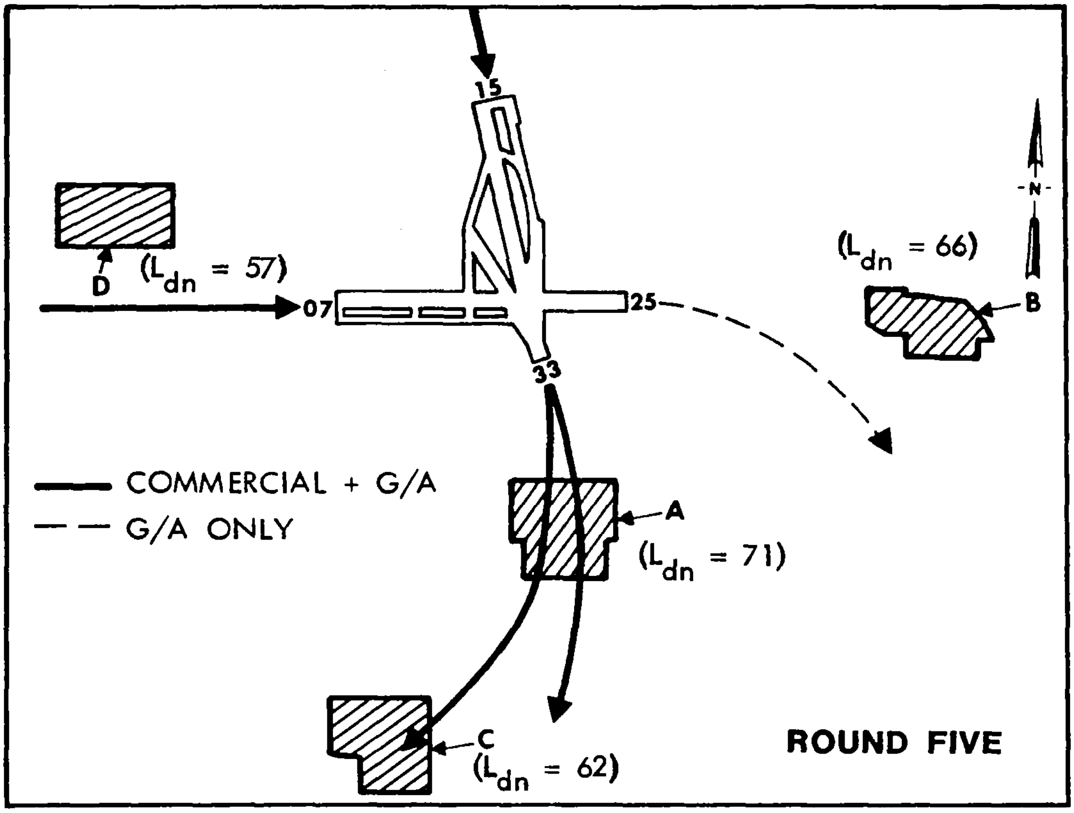


FIGURE 4. MAP OF INTERVIEWING SITES SHOWING PRINCIPAL FLIGHT PATHS - ROUND 5.

neighborhood contained approximately 200 households. Block by block decisions about the boundaries of each site were made on the basis of existing and projected noise exposure contours. Visits to the sites confirmed that they were unaffected by highway and other high level noise sources.

Residences in the four neighborhoods were primarily detached single family, one story wood frame buildings on a regular grid of two lane streets, with about twenty houses per block face. A few two story apartment buildings were present at some of the sites. For many years prior to closure of Runway 15-33, and also upon completion of all runway repairs, Neighborhood A was exposed to about 50 air transport departures daily at maximum A-levels averaging 105 dB, and to several hundred general aviation departures at maximum A-levels of about 85 dB. From mid-September 1979 to early October, 1979, Neighborhood A was relieved of all air transport overflights and subjected to smaller than customary numbers of daily general aviation departures. In early October, 1979, Neighborhood A was also relieved of all general aviation departures when Runway 15-33 was entirely closed for repairs. Neighborhood A was subjected to a modest number of general aviation aircraft in the downwind leg of a right hand traffic pattern on Runway 07.

Neighborhood B, under the departure path of Runway 07, experienced the complementary change in exposure. Prior to the closure of the main North-South Runway, Neighborhood B's noise exposure had been dominated by street traffic noise. Very few air transport operations overflew the neighborhood, and sideline noise from such operations was barely audible. From mid-September to mid-January, 1980, noise exposure in

Neighborhood B was dominated by aircraft noise, with average single event noise levels higher than those created by street traffic noise.

Neighborhood C, in the flight path of departures from Runway 07 but some distance from the airport, had for years prior to the runway closure been exposed to the same daily numbers of departures as Neighborhood A, but at lower levels. Maximum A-levels from jet aircraft departures in Neighborhood C prior to runway closure averaged 89 dB. Following the closure of the main runway, aircraft departing to the east on the cross runway made a sweeping right turn after takeoff to overfly Neighborhood C, but at a greater altitude than before the change in runways. General aviation operations were well dispersed before reaching this neighborhood.

Noise exposure in Neighborhood D prior to closure of the main runway at BUR was influenced by both aircraft overflights and local street traffic noise. Closure of Runway 15 doubled the number of landings on Runway 07 and increased the number of westerly departures on Runway 25. Maximum A-levels in this neighborhood averaged about 78 dB for approaches and 89 dB for departures.

## C. Measurements of Noise Exposure

Neighborhood noise levels were measured during the week preceding each round of interviews by a portable noise monitor installed in the rear yard of a single-story, one family residence centrally located within each neighborhood. These measurements were the basis for estimating noise exposure for individual neighborhoods in all rounds of interviewing.

Sites were selected on the basis of two major criteria: (1) absence of unusual acoustic barriers, and (2) freedom from unusual or high level sound sources in proximity to the microphone. The microphone was mounted on a tripod approximately 2.4 meters above ground level. Monitor units were calibrated every other day, but otherwise operated unattended. Details of the noise monitoring process may be found in Appendix A. For procedural reasons, other measurements (as described in Appendix E) were also made.

## D. Sampling

Since the four sites each contained only a few hundred households, attempts were made to exhaust rather than sample the adult, English speaking population with one face to face contact and four telephone callbacks during each round of interviewing. The sampling frame for each interviewer was a detailed street map showing block faces along which an interview was to be attempted at every residence.

As the identical procedure was followed in each round of interviewing, the resulting sample was tantamount to a panel sample, although respondents' names were not recorded. Names were not solicited to guarantee anonymity, thereby improving the likelihood of multiple re-interviews.

## E. Survey Instrument

Since it was anticipated that respondents might become increasingly unwilling to complete a long interview on successive rounds of interview, an extremely brief and direct questionnaire was developed. The first four questions seen in Figure 5 were asked during the first four rounds of interviews. The response scale for gauging intensity of

BURBANK V December 1980

| ITEM | QUESTION | RESPONSE CODE | CARD COL |
|---|---|---|---|
| 1 | What would you say is the major environmental problem in this (your) neighborhood at this time of year?<br>VERBATIM:________________ | Aircraft.............. 1<br>Air Quality........... 2<br>Other................. 3<br>Don't Know............ 6<br>Not Ascertained....... 7<br>Refused............... 8 | 23 |
| 2 | While you've been at home over the past WEEK (just since last ____________), would you say you've been not at all annoyed by street traffic noise, slightly annoyed by street traffic noise, moderately annoyed by street traffic noise, very annoyed by street traffic noise, or extremely annoyed by street traffic noise? | Not At All Annoyed.... 1<br>Slightly Annoyed...... 2<br>Moderately Annoyed.... 3<br>Very Annoyed.......... 4<br>Extremely Annoyed..... 5<br>Don't Know............ 6<br>Not Ascertained....... 7<br>Refused............... 8 | 24 |
| 3 | While you've been at home over the past WEEK (just since last ____________), would you say you've been not at all annoyed by aircraft noise, slightly annoyed by aircraft noise, moderately annoyed by aircraft noise, very annoyed by aircraft noise, or extremely annoyed by aircraft noise? | Not At All Annoyed.... 1<br>Slightly Annoyed...... 2<br>Moderately Annoyed.... 3<br>Very Annoyed.......... 4<br>Extremely Annoyed..... 5<br>Don't Know............ 6<br>Not Ascertained....... 7<br>Refused............... 8 | 25 |
| 4 | While you've been at home over the past YEAR (since this time last year), would you say that you've been not at all annoyed by aircraft noise, slightly annoyed by aircraft noise, moderately annoyed by aircraft noise, very annoyed by aircraft noise, or extremely annoyed by aircraft noise? | Not At All Annoyed.... 1<br>Slightly Annoyed...... 2<br>Moderately Annoyed.... 3<br>Very Annoyed.......... 4<br>Extremely Annoyed..... 5<br>Don't Know............ 6<br>Not Ascertained....... 7<br>Refused............... 8 | 26 |
| 5 | Some people think noise from some airplanes using Burbank Airport is more annoying than noise from others. Just on the basis of noise, how many small airplanes flying near your house would it take to annoy you as much as a single large jet? | Small Airplanes More Annoying..............000<br>Number of Small Airplanes=1 Large Jet....__<br>Don't Know.............666<br>Not Ascertained........777<br>Refused................888<br>VERBATIM:________________ | 27-29 |
| 6 | How concerned would you say the people who run the airport and the airplanes are about the feelings and comfort of people who live in this (your) neighborhood? | Not At All Concerned.. 1<br>Slightly Concerned.... 2<br>Moderately Concerned.. 3<br>Very Concerned........ 4<br>Extremely Concerned... 5<br>Don't Know............ 6<br>Not Ascertained....... 7<br>Refused............... 8 | 30 |

**FIGURE 5. QUESTIONNAIRE ITEMS.**

annoyance was the same closed category scale used in prior studies of annoyance associated with aircraft and other community noise sources (cf. Fidell and Jones, 1973; Fidell, 1978).

Question 1 was intended to direct respondents' attention to environmental matters; to elicit spontaneous mention of aircraft noise as a major environmental problem of local concern; and to place concern with aircraft noise into perspective with the other major environmental problem in the area (air pollution).

Question 2 was intended to further focus the respondents' attention on noise exposure, and on the time frame of the preceding week. It was also intended to provide perspective on the relative degree of annoyance associated with aircraft and street traffic noise exposure.

Question 3 dealt with the issue of greatest interest - opinions about the immediate effects of shifts in noise exposure. Question 4 was intended to aid interpretation of response to Question 3, and to determine how respondents' opinions about long term exposure were affected by recurring changes in exposure.

In the fifth and final round of interviews, the two final questions seen in Figure 5 were asked as well. Question 5 was included in an effort to determine whether the observed prevalence of annoyance in the first four rounds could be attributed in part to the use of the airport by both general aviation and scheduled air carrier aircraft. Question 6 was included to explore another potential non-acoustic source of annoyance in the airport area.

## F. Interviewing

About twenty interviewers were trained to administer the questionnaire both personally (face to face) and by telephone for each round of questioning. The initial interview attempt in each round was always in person. Crews of eight or more interviewers were assigned to canvass specific block faces within each site, as an initial attempt to obtain an interview with at least one adult per household. Subsequent callbacks to potential respondents who were not at home during the daylight personal interviewing hours were made by telephone at different times of day.

All personal contacts within a site were completed within half a day. Almost all telephone callbacks were completed within the next 48 hours. The first four rounds of interviews started with personal interviews during daylight hours on 30 August, 28 September, 10 November, and 8 December, 1979. The first round preceded runway closure by 18 days. The second, third, and fourth rounds followed runway closure by 11, 54, and 82 days. The final round of interviews started in the same manner on 20 December, 1980, two months after completion of repairs to the cross runway.

# III. RESULTS

Analyses of findings of the physical and social measurements are presented in the following order in this section. Measured noise exposure levels are summarized first, after which responses to the six substantive questionnaire items are analyzed. Appendix B contains information about the mechanics of interviewing and raw data

## A. Noise Exposure Information

### 1. Differences Among Neighborhoods

Table 1 summarizes the observed $L_{dn}$ values for both aircraft noise and ambient noise at each site in the week preceding each round of interviews. The patterns of changes in aircraft noise exposure in the four interviewing areas were generally as expected. In Neighborhoods A and C, levels were appreciably lower following the closure of the main runway than they had been for several years. Aircraft noise exposure levels increased considerably in Neighborhood B, but only slightly in Neighborhood D.

The pattern of aircraft noise exposure levels observed in the four neighborhoods in the week preceding the fifth round of interviews resembled the pattern observed in the week preceding the first round of interviews in general, but not in detail. Aircraft noise exposure in three of the four neighborhoods (A, C and D) was less intense in December 1980 than in August 1979 by three to six decibels, due primarily to reduced flight frequencies by commercial air carriers. Aircraft noise exposure in December 1980 was seven decibels higher in Neighborhood B than it had been in August 1979, due to increased use of the resurfaced cross runway.

TABLE I. DAY-NIGHT NOISE LEVELS OF AIRCRAFT AND AMBIENT EXPOSURE AT THE INTERVIEWING SITES, IN dB

Aircraft Noise Exposure

| Neighborhood | Round 1 | Round 2 | Round 3 | Round 4 | Round 5 |
|---|---|---|---|---|---|
| A | 77 | 60 | 58 | 58 | 71 |
| B | 59 | 68 | 70 | 69 | 66 |
| C | 65 | 57 | 59 | 56 | 62 |
| D | 61 | 63 | 66 | 64 | 57 |

Ambient Noise Exposure

| Neighborhood | Round 1 | Round 2 | Round 3 | Round 4 |
|---|---|---|---|---|
| A | -- | 50 | 49 | -- |
| B | 56 | 57 | 60 | 56 |
| C | -- | 50 | 51 | 53 |
| D | 56 | 51 | 52 | 52 |

## 2. Variability of Levels Within Neighborhoods

Figure 6 shows the NOISEMAP-generated $L_{dn}$ contours at 1 decibel intervals superimposed on each interview neighborhood and vicinity. The heavy broken line shows the interview neighborhood boundary, while the circled star within the boundary line indicates the position of the central noise monitoring site.

The $L_{dn}$ contours, intended to illustrate gradients only, were generated from detailed 1980 typical day information (without runway closures) concerning aircraft flight paths, flight path utilization, aircraft mix, and noise and performance information for these aircraft. Since interviewing areas were selected in part on the basis of their exposure to a single runway's operations, day-to-day and round-to-round variations in runway utilization could be expected to affect the absolute magnitude of the contour values, but would be unlikely to affect the exposure gradient appreciably. To minimize confusion, arbitrary absolute values have been assigned to the contours shown in the figures. Based on these contours, the exposure extremes across the interview neighborhoods (re the central monitoring site) are estimated as follows for Rounds 1 and 5:

| Neighborhood | Deviation from Central Monitoring Point |
|---|---|
| A | +2, -2½ dB |
| B | +2½, -3 |
| C | +1, -1½ |
| D | +2, -5 |

For Rounds 2-4 the shift in operations would change the shape of the contours in Figure 6. However the deviations in level from the central monitoring point should be no greater than those listed above for Rounds 1 and 5.

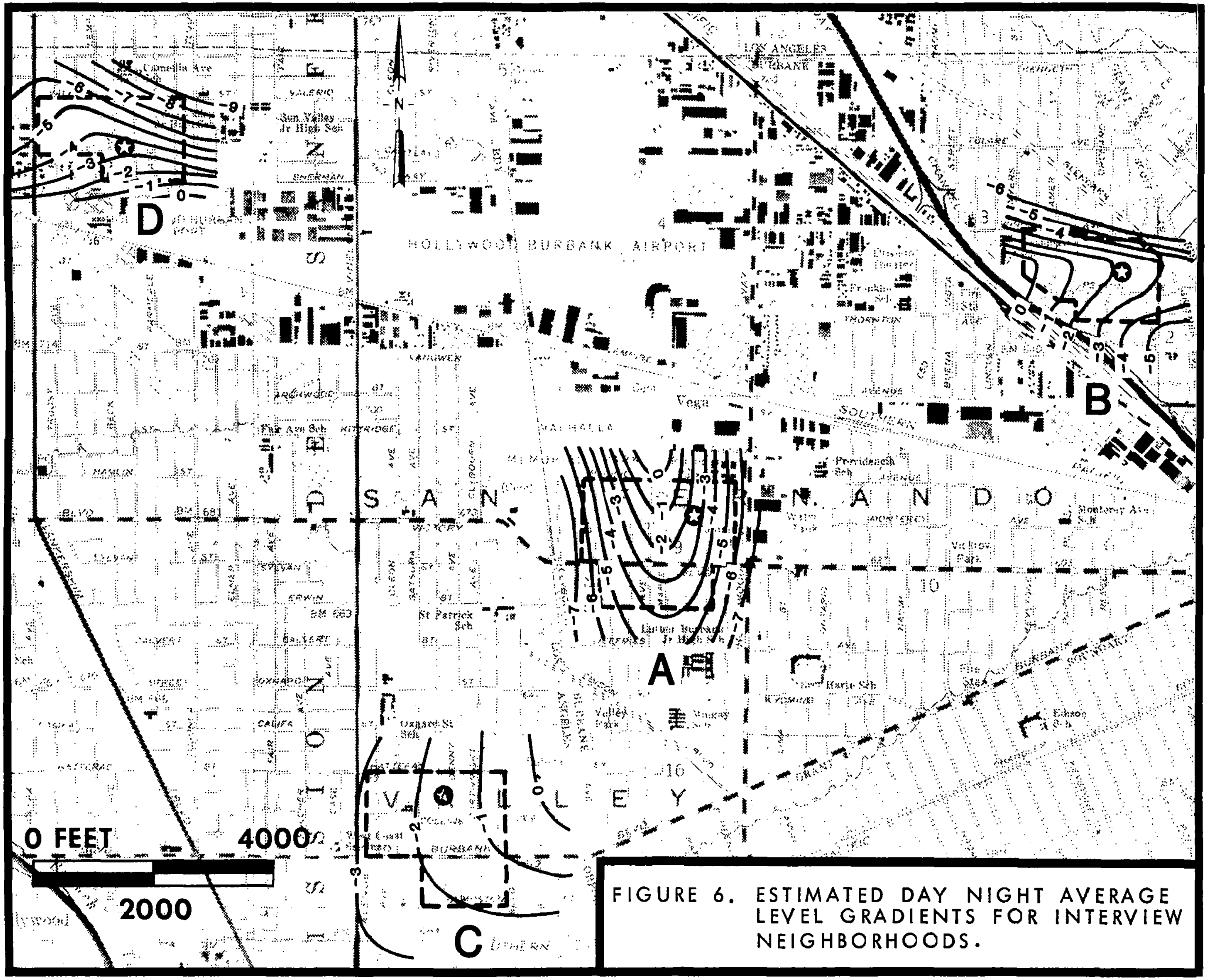


FIGURE 6. ESTIMATED DAY NIGHT AVERAGE LEVEL GRADIENTS FOR INTERVIEW NEIGHBORHOODS.

## B. Attitudinal Information

### 1. Analysis of Responses to Question 1

Question 1 elicited the respondent's opinion of the major environmental problem in his neighborhood. Responses were recorded as spontaneous mentions of aircraft, air quality or any other environmental concern.

Figure 7 summarizes the changes observed in proportions of respondents at each site who spontaneously cited aircraft noise as the major environmental problem at the current time of year. For purposes of comparison, aircraft noise exposure during the week preceding each round of interviews is also plotted on the same figure.

The trend in proportions of respondents citing aircraft noise as the major environmental problem reflected actual noise exposure. In fact the patterns throughout the four rounds of interviewing of aircraft noise exposure and proportions identifying aircraft noise as the major neighborhood environmental problem are similar for all neighborhoods as shown in Figure 7.

### 2. Analyses of Responses to Question 2

#### a. Dosage Response Relationships

Proportions of respondents annoyed by traffic noise in the preceding week are quite consistent and do not differ significantly within neighborhoods from round to round. In all cases, however, the percentage of respondents highly annoyed exceeds the percentage predicted by Schultz (1978) by about 7% on average. Figure 8 plots the

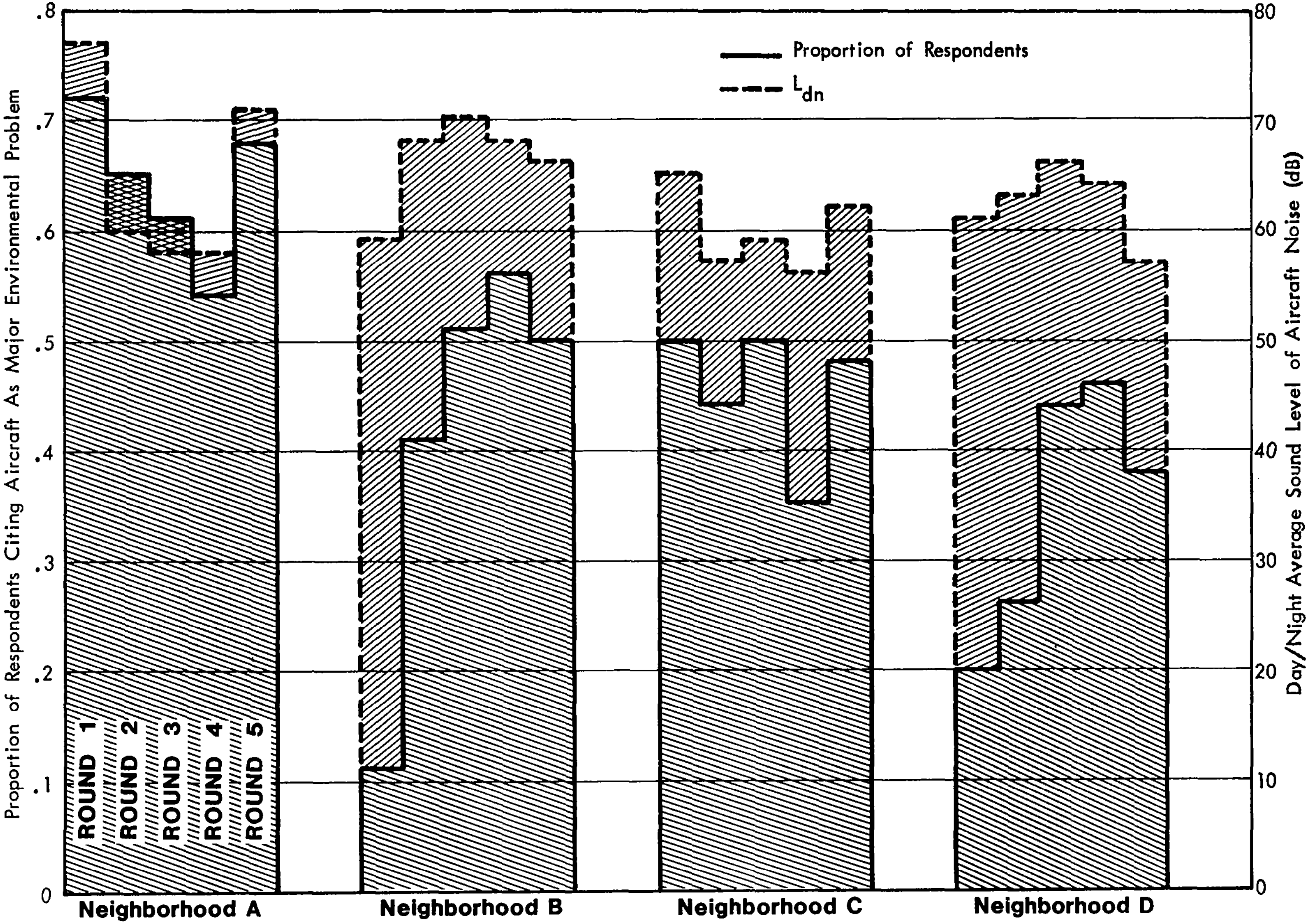


FIGURE 7. AIRCRAFT NOISE EXPOSURE AND PROPORTIONS OF RESPONDENTS CITING AIRCRAFT NOISE AS THE MAJOR NEIGHBORHOOD ENVIRONMENTAL PROBLEM AT THIS TIME OF YEAR FOR EACH ROUND OF INTERVIEWS.

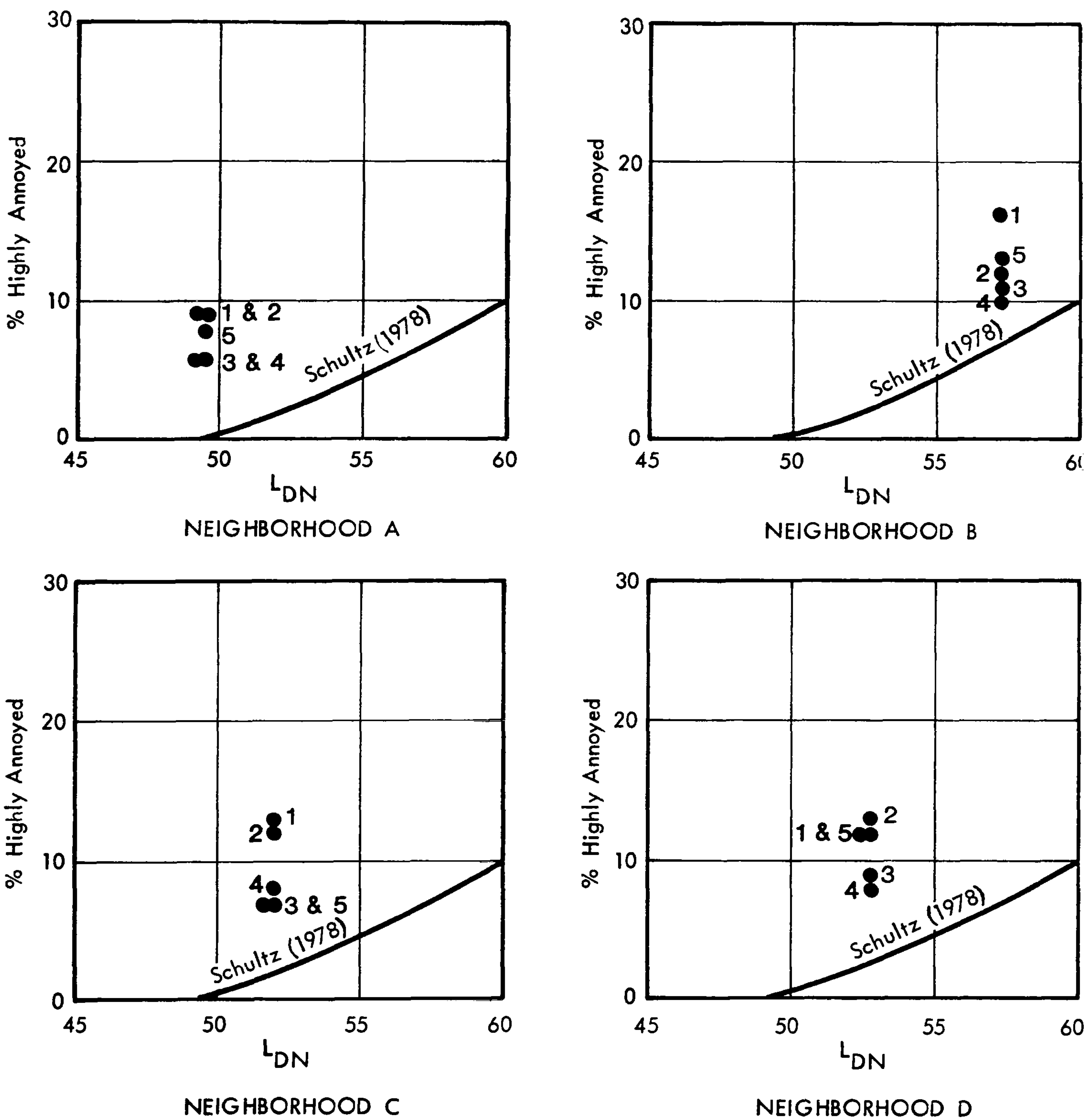


FIGURE 8. ANNOYANCE DUE TO STREET TRAFFIC NOISE OVER THE PAST WEEK FOR FIVE ROUNDS OF INTERVIEWING.

percentage of respondents highly annoyed during each round of interviewing against the mean ambient noise level measured in each neighborhood. The figure also shows the relationship of these data to the relationship of Schultz (1978). Further analysis of the variability of annoyance to traffic noise is provided in Appendix C.

## 3. Analyses of Responses to Question 3

### a. Effects of Exposure History on Immediate Annoyance

The top two panels of Figure 9 show the effects of changes in aircraft noise exposure on immediate annoyance. Note that exposure changes resembled those anticipated in Figure 1. Note also that the changes in annoyance reflected the observed changes in exposure (see Table I).

### b. Relationship of Current Findings About Immediate Annoyance of Aircraft Noise to Prior Findings

The prevalence of annoyance due to aircraft noise in the week preceding interviewing is consistent with changes in exposure within neighborhoods, but is in poor agreement with a well known dosage-response relationship (Schultz 1978), as illustrated in Figure 10. Also shown in Figure 10 is the least squares regression line, bounded by its 95% confidence limits.

## 4. Analyses of Responses to Question 4

### a. Effects of Exposure Change on Long Term Annoyance

The bottom panel of Figure 9 shows the effects of the step changes in exposure on long term attitudes toward aircraft

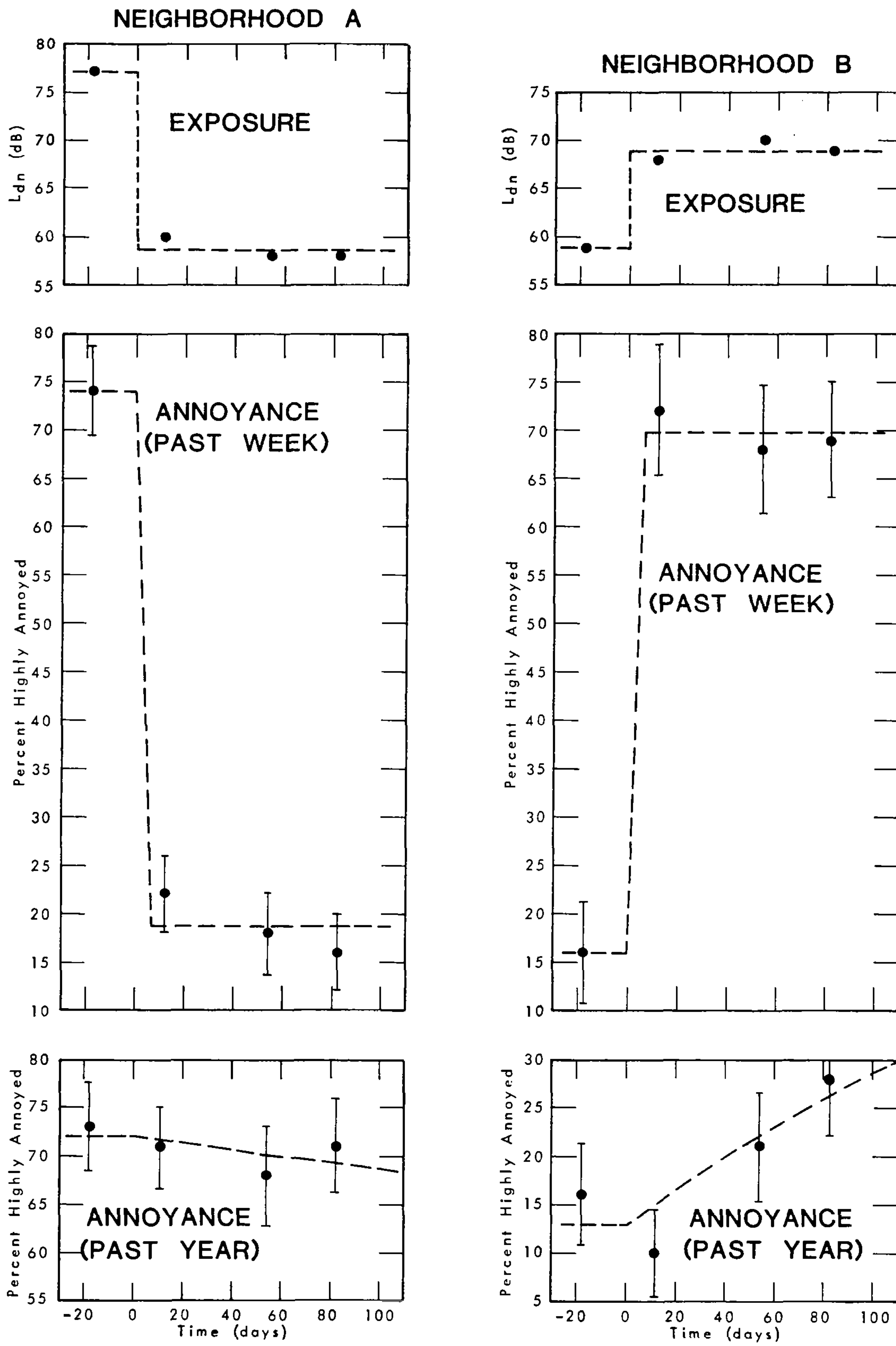


FIGURE 9. OBSERVED HISTORY OF EXPOSURE AND ANNOYANCE.

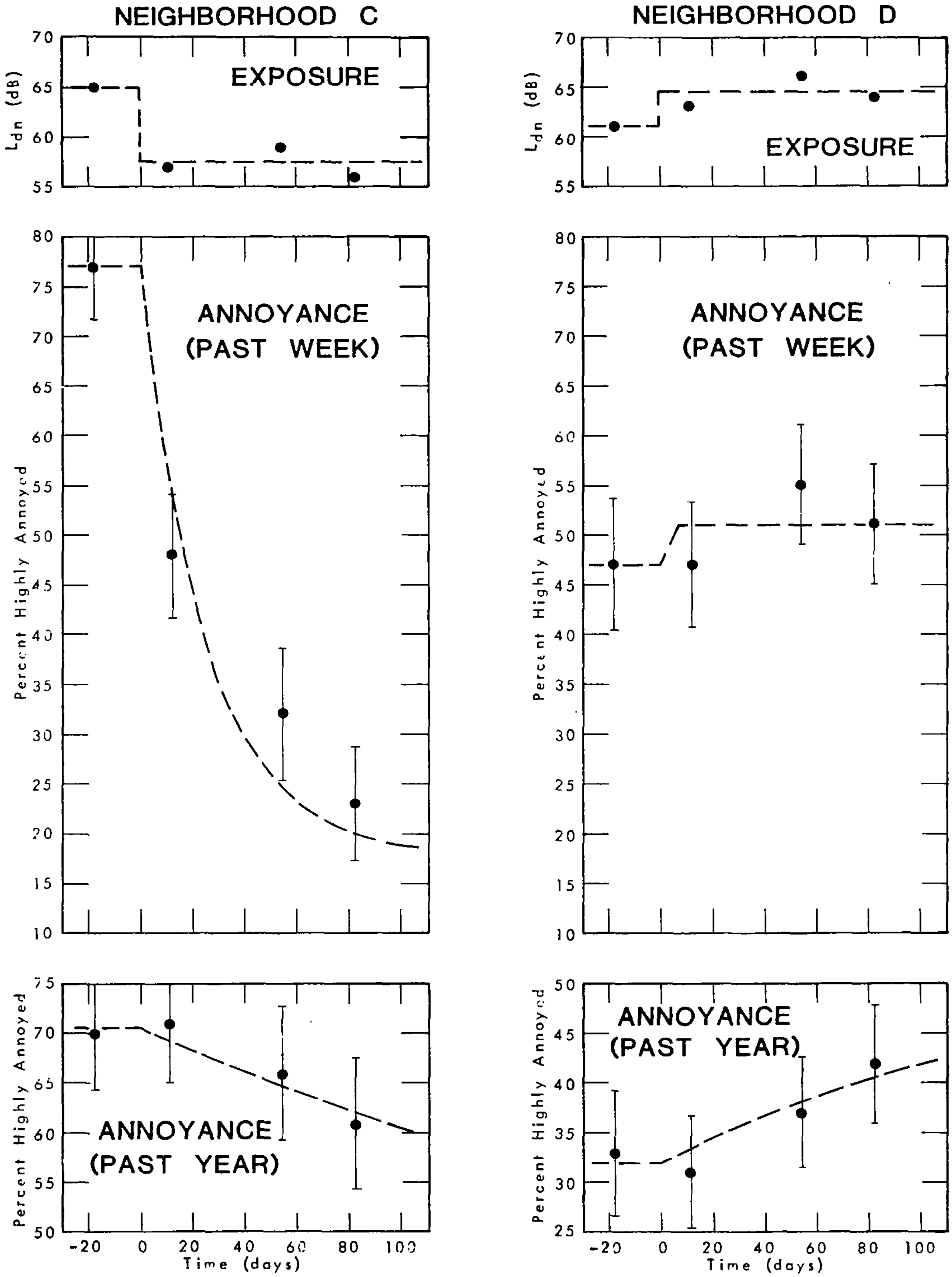


FIGURE 9. CONCLUDED.

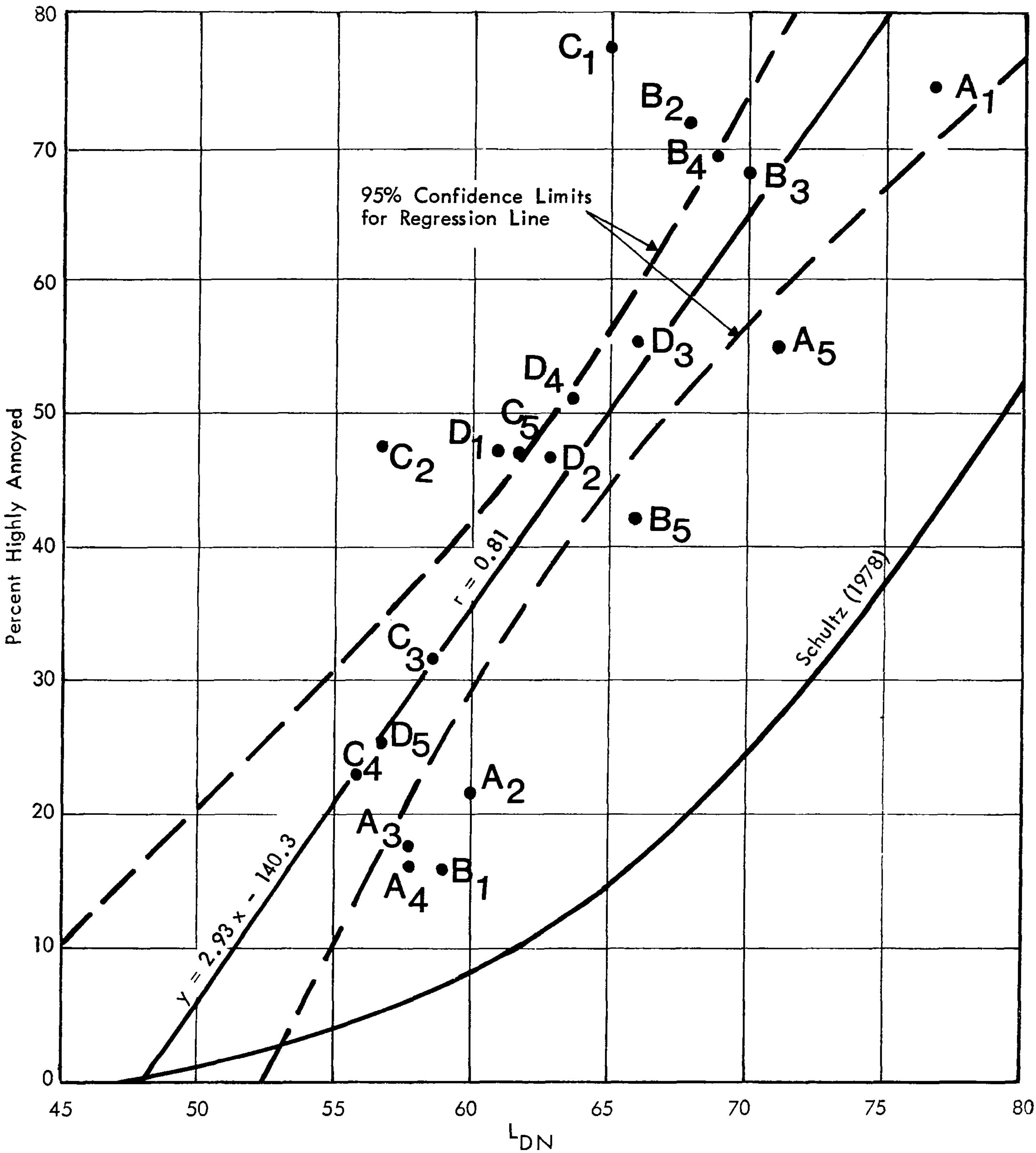


FIGURE 10. OBSERVED RELATIONSHIP OF IMMEDIATE ANNOYANCE AND NOISE EXPOSURE (QUESTION 3).

noise. Note that even though the changes are not as dramatic or immediate as the changes in short term annoyance, they nonetheless reflect the direction and magnitude of changes in exposure.

### b. Relationship Between Weekly and Yearly Annoyance Due to Aircraft Noise

Correlations between weekly and yearly distributions of annoyance due to aircraft noise were very strong in the first round of interviews. Indeed, in the two neighborhoods (A and C) most heavily exposed to aircraft noise before the closure of Runway 15-33, the figures for yearly and weekly annoyance were nearly identical ($r = 0.997$ and $0.991$, respectively). Slightly lower correlation was observed in Neighborhood B ($r = 0.908$), which had no significant exposure from air carrier operations prior to closure of Runway 15-33. These high correlations provide assurance that there was nothing peculiar about opinions during the week preceding the first round of interviews.

In Neighborhood D, which had no significant exposure from air carrier operations and even less exposure from general aviation traffic than Neighborhood B, the correlation was poor (0.206); the distribution of annoyance due to aircraft noise for the week preceding the first round of interviews was generally higher than for the year. In successive rounds of interviews, the relationships between weekly and yearly distributions of annoyance due to aircraft noise changed dramatically. In Neighborhood B, for example, the correlation changed from +0.908 for Round 1 to -0.73 in Round 2, -0.54 in Round 3, -0.49 in Round 4, and +0.49 in Round 5.

The fact that the correlations changed so greatly underscore the respondents' ability to distinguish between weekly and annual opinions.

## 5. Analyses of Responses to Question 5

Question 5 was included in the final round of interviews to explore the hypothesis that discrepancies in proportions of respondents highly annoyed by aircraft noise and similar proportions predictable from Schultz's (1978) relationship might be attributable to the presence of large numbers of general aviation operations at Burbank Airport. The question required respondents to estimate how many overflights of small general aviation aircraft in their neighborhoods were equally annoying as a single overflight by an air carrier aircraft. If people based their answers solely on single event exposure levels produced by the two types of aircraft flyovers, their answers would have been approximately 100:1, since overflights of transport aircraft produce single event noise exposure levels on the order of 20 dB greater than those of general aviation aircraft in the interviewing areas.

A sizeable proportion of respondents had difficulty either in understanding the question or in formulating a numerical response. Responses from 38% of all respondents were coded as "Don't Know" (i.e., unable to understand the question or provide an estimate). Another 11% of all respondents indicated that individual overflights by general aviation aircraft were either as annoying as or more annoying than individual overflights by air carrier aircraft. Figure 11 is a histogram of the numerical estimates of number of general aviation aircraft overflights made by the 43% of all respondents who were: (1) able to answer Question 5, and (2) who thought that a general aviation aircraft overflight was less annoying than an air carrier aircraft overflight.

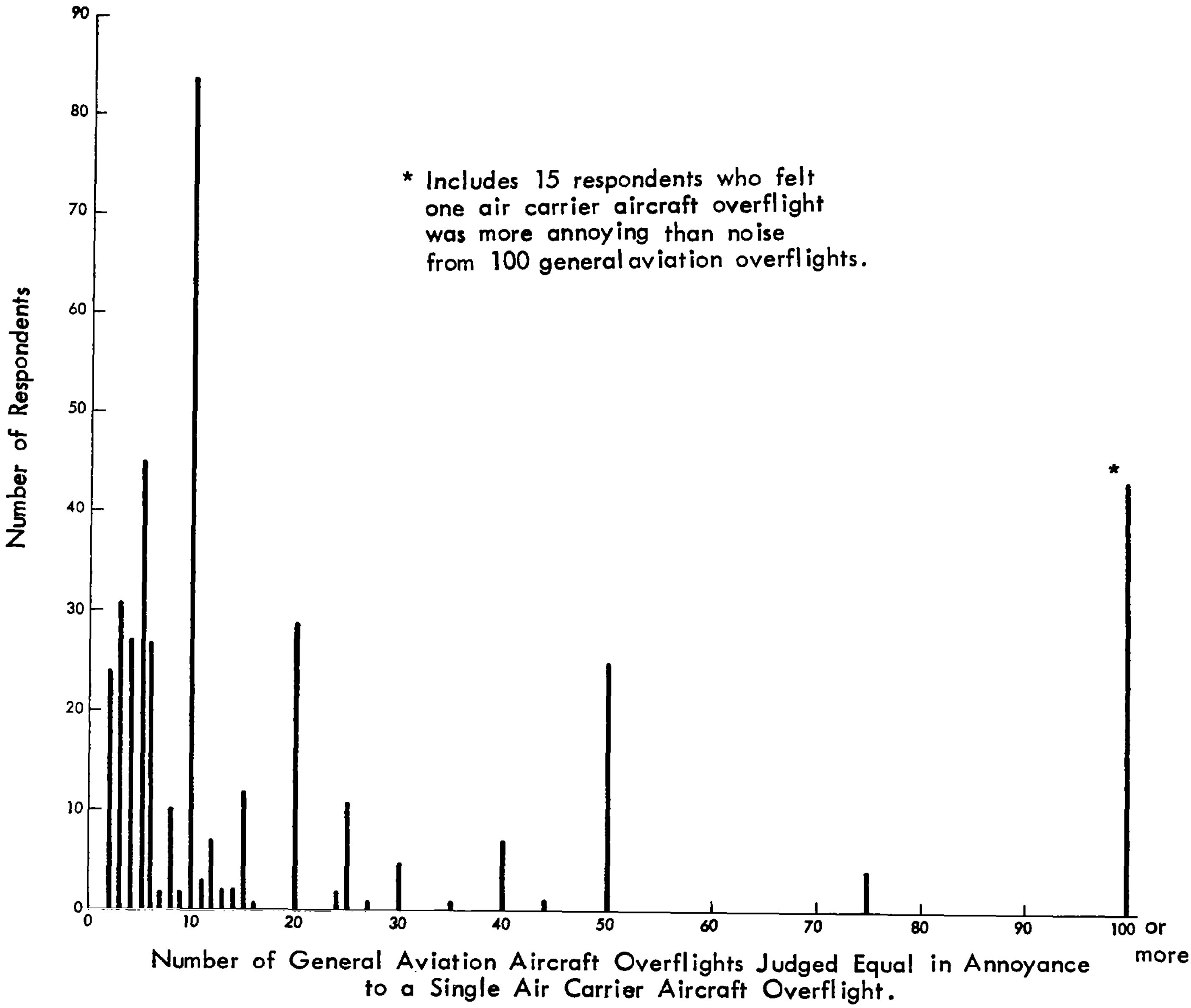


FIGURE 11. RELATIVE ANNOYANCE OF OVERFLIGHTS OF GENERAL AVIATION AIRCRAFT AND SINGLE AIR CARRIER AIRCRAFT.

## 6. Analysis of Responses to Question 6

Question 6 was included in the final round of interviews to explore the hypothesis that discrepancies between the currently observed proportions of respondents highly annoyed by aircraft noise and similar proportions predictable from Schultz's (1978) relationship might be attributable to strong negative attitudes toward airport and airline management rather than purely acoustic factors. Figure 12 displays histograms of responses to this question by neighborhood. In general, the prevalence of unfavorable attitudes toward aircraft and airport operators reflected noise exposure levels.

## 7. Analyses of Demographic Effects

Responses to the key question (concerning annoyance due to aircraft noise during the week preceding the interview) were examined for evidence of effects of age and sex of respondents. Chi square tests of association were performed first in data aggregated over all neighborhoods and rounds of interviews. No significant differences were observed between the distributions of responses of male and female respondents, nor among respondents with estimated ages under 30 years, 30-50 years, and over 50 years.

More detailed chi square tests on data for separate rounds of interviews and neighborhoods revealed no other noteworthy differences in response distributions attributable to age or sex.

## 8. Analyses of Effects of Mode of Interviewing

Analyses similar to those described above were also performed on response distributions for Question 3 determined by personal

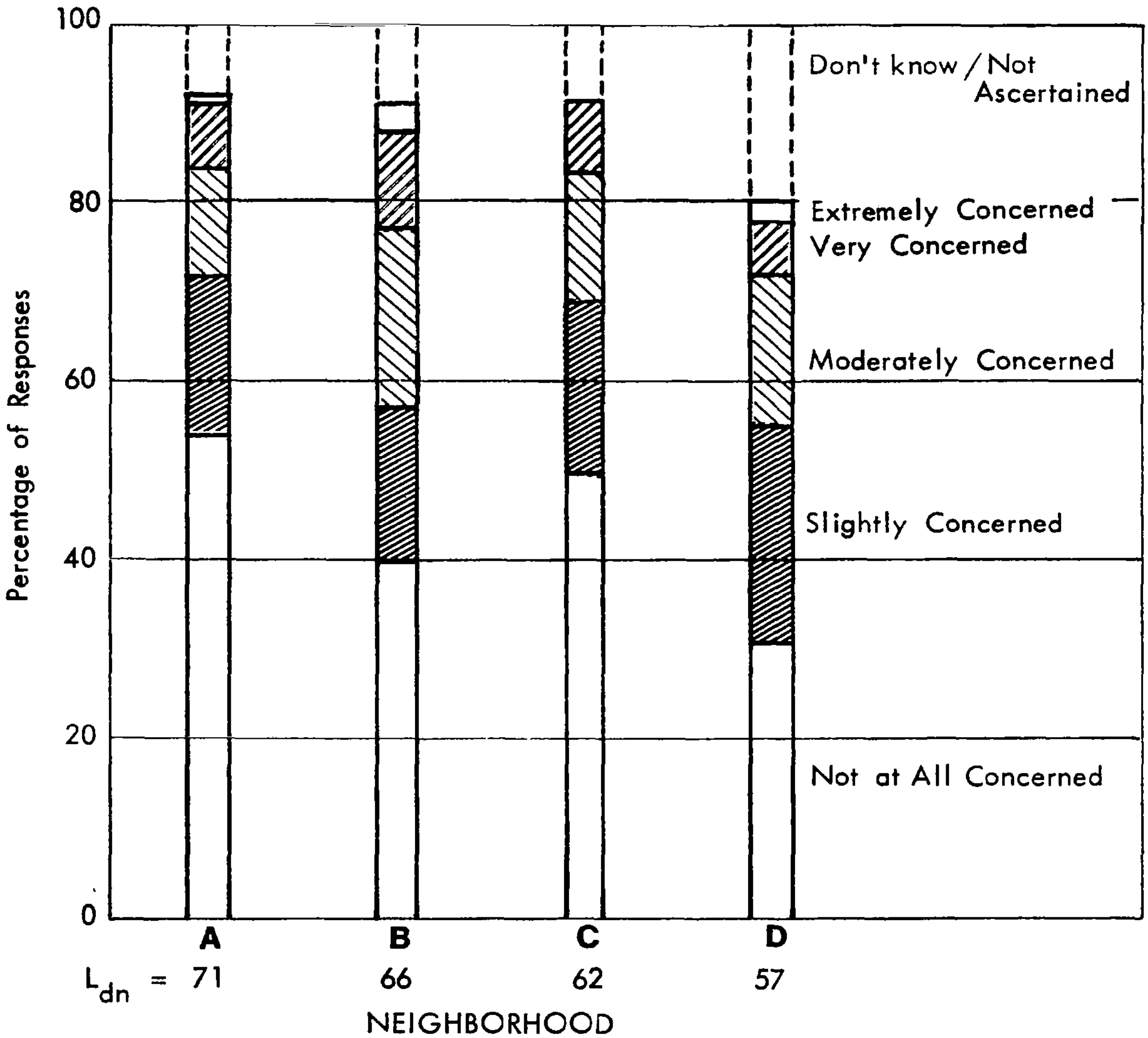


FIGURE 12. DISTRIBUTIONS OF REPORTED DEGRESS OF CONCERN OF AUTHORITIES FOR RESIDENTS' COMFORT.

(face-to-face) and telephone interviewing. No significant differences were observed between the response information derived from the two types of interviews.

## IV. DISCUSSION

Several aspects of the current findings are noteworthy, as are certain aspects of the study design that permit analyses not hitherto employed in social survey research on community reaction to noise exposure. Because these novel analyses may be unfamiliar, they are described in detail in Appendices C and F to supplement the following discussion.

### A. Direct Evidence of Sensitivity to Changes in Aircraft Noise Exposure

Although Figure 9 shows similar patterns of changes in exposure and annoyance, it is not clear from the figure what processes are responsible for these findings. Logically, a sudden change in numbers of aircraft overflights could increase the numbers of people reporting a high degree of annoyance, decrease the number reporting a low degree of annoyance, or perturb the distribution of degree of annoyance over neighborhood residents in some other non-linear fashion.

Responses to the question about annoyance due to aircraft noise in the week preceding the interview provided the clearest indication of sensitivity to physical exposure parameters. This sensitivity is explored further in Appendix C in the framework of the Theory of Signal Detectability. The results indicate that changes in exposure do indeed relate to changes in annoyance in the communities under study.

### B. Relationship to Prior Findings

The disagreement apparent in Figure 10 between the current data and the relationship of Schultz (1978) requires comment at some length. The disagreement is substantial, since the relationship of Schultz lies well outside the 95% confidence interval for the regression line of the current data. Both procedural and substantive sources for the disagreement are discussed below.

### 1. Procedural Explanations

Whenever research fails to produce an expected finding, the first possibility to be considered is faulty technique or error of measurement. These potential explanations for the discrepancy may be rejected for reasons noted below.

#### a. Error of Physical Measurement

Consider first the possibility of error in physical measurement of aircraft noise levels. This explanation may be dismissed out of hand for several reasons:

(1) The automatic noise monitoring equipment gave no indication of malfunction or calibration drift that could have had any noticeable effect on the estimated aircraft noise exposure levels at the four interviewing sites.

(2) The interviewing sites were sufficiently small in area and homogeneously exposed to aircraft noise that it is extremely doubtful that the observed aircraft noise levels failed to represent the actual exposure at all residences at each site (see Appendix E).

(3) The aircraft noise exposure estimates developed from the computer-based analyses of the monitoring data faithfully reflect the known pattern of changes in aircraft operations, and are consistent with other measurements independently made for other purposes during the same time periods.

It is, however, possible to speculate about the possibility of a systematic underestimation of several decibels in traffic noise levels, attributable to the placement of microphones in backyards. Measurements of traffic noise on streets immediately in front of residences tend to be lower when made in backyards than when made at curbside or front facade measurement points. Not all traffic noise to which neighborhood residents are exposed is generated on adjacent block faces, however. The lack of standardized measurement points in the survey research summarized by Schultz (1978) precludes direct estimates of the effects of a potential underestimation of traffic noise levels on the relationship between the current data on annoyance due to traffic noise and the information developed by Schultz.

b. Errors of Social Measurement

The next possibility that may be rejected is error in social measurement. Among the reasons that errors of this sort may be dismissed are the following:

(1) Bias due to systematic under- or over-representation of certain subpopulations in the interviewing areas is an unlikely explanation for the present findings because the sampling procedures nearly exhausted the population available for interviewing.

(2) Bias due to unknown random errors is also an unlikely explanation, because the disagreements between the current data and those of Schultz (1978) are consistent in direction and uniform across interviewing sites. It is difficult to conceive of a random error in the current study that could have produced such a consistent pattern of disagreement with Schultz (1978).

(3) The same survey organization, using very similar techniques, produced data on arcraft noise annoyance in good agreement with Schultz (1978) in a nearby airport community several years earlier (Fidell and Jones, 1973).

## 2. Substantive Explanations

The absence of compelling reasons to attribute the poor agreement between the current data and Schultz's (1978) synthesis to procedural matters forces consideration of substantive bases for the disagreement. It should be understood from the outset of this discussion, however, that the present data do not by themselves indicate which (if any) of the potential explanations offered is "best." Instead, the data support a variety of interpretations, of which the "best" may emerge only after general understanding of community response to noise exposure improves. Alternative interpretations of the data are discussed below in order of simplicity and plausibility.

### a. Differences in Background Noise at Burbank and at Synthesis Sites

In his discussion of the scatter in social survey data on the relationship between community noise exposure and prevalence of annoyance, Schultz (1978) explicitly suggests that the annoyance of aircraft noise exposure in a community may depend on the amount of traffic noise exposure. Schultz (1978, p. 384) shows in his Figure 9 the results of a Swiss aircraft noise survey, in which differences in percentages of the community highly annoyed by the same aircraft noise exposure as great as 40% were reported in neighborhoods with different traffic noise exposure.

Figure 13 shows the relationship between the current data and the relationship between annoyance and noise exposure for light

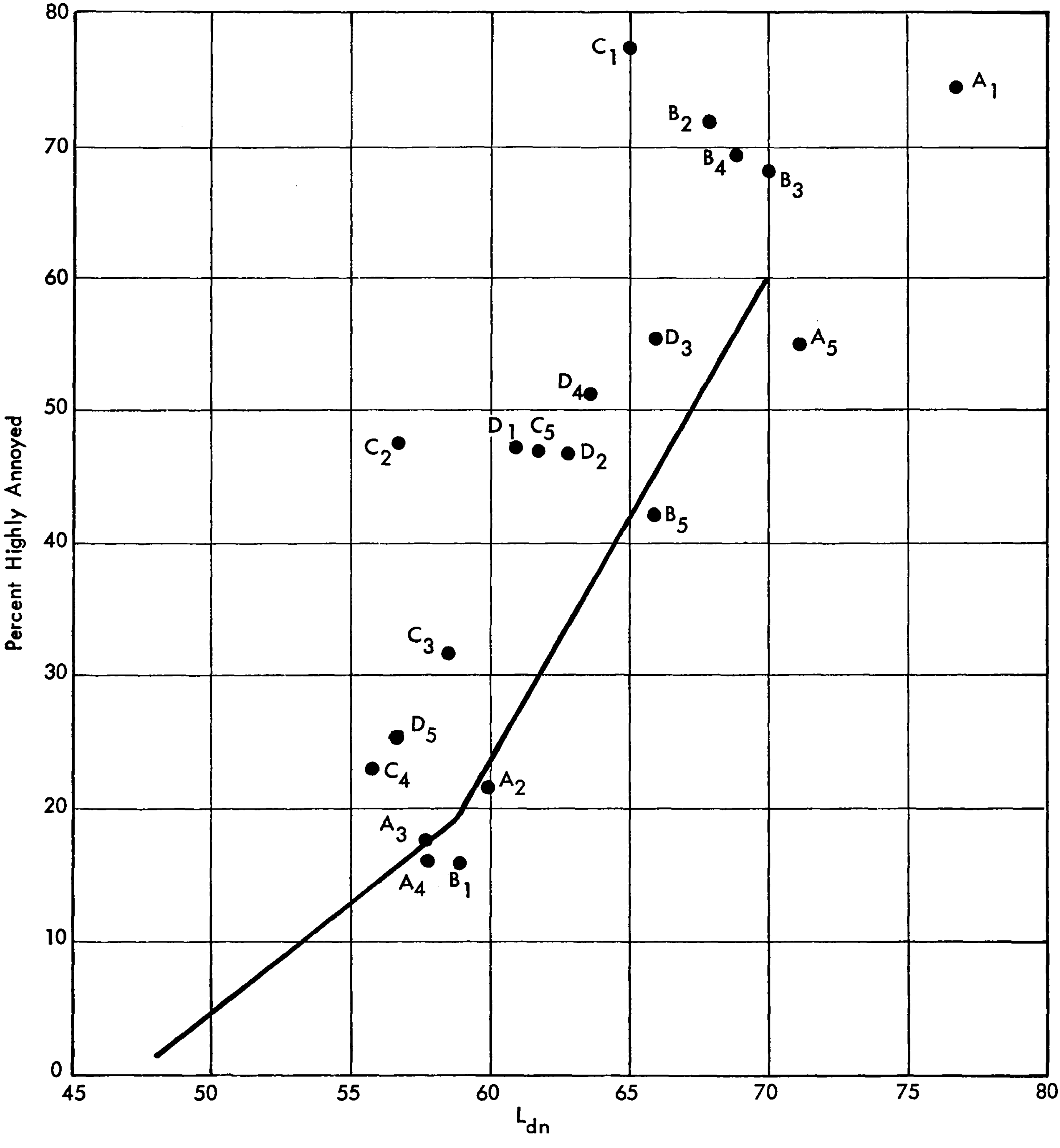


FIGURE 13. CURRENT DATA COMPARED WITH RELATIONSHIP INFERRED FROM SWISS AIRCRAFT NOISE SURVEY (LIGHT TRAFFIC).

traffic noise exposure observed in the Swiss study. The measured traffic noise levels at Burbank Airport ($L_{dn}$ on the order of 50-55 dB) appear fairly similar to those reported by the Swiss ($L_{50}$ between 40-52 dB).

Clearly, the relationship between exposure and annoyance for the light traffic noise exposure case seen in Figure 13 comes considerably closer to the present data than does the synthesis relationship. Attributing this closer agreement to the influence of traffic noise is not unreasonable, since the bulk of the aircraft annoyance data from the eleven clustering surveys in Schultz's synthesis was collected in neighborhoods surrounding major international airports, near which traffic noise levels considerably higher than those near Burbank Airport probably prevail.

Additional support for the plausibility of this background noise level hypothesis is provided by the observations of Waters and Bottom (1971), and the empirical evidence of Fidell, et al. (1979) on the relationship between detectability and annoyance of community noise. For the same $L_{dn}$, residents in neighborhoods near Burbank Airport may simply have heard more overflights than the people whose opinions are summarized in Schultz's synthesis.

b. Differences in Dosage-Response Relationships for Different Noise Sources

It is sometimes contended that the prevalence of annoyance due to noise exposure in a community may depend for a variety of reasons on the source of that exposure. These reasons range from the nature of the exposure to individual attitudes toward operation of noise sources. Hall et al. (1981) are proponents of the position that for the same integrated noise exposure, greater percentages of people will be highly annoyed by aircraft noise than by traffic noise.

Figure 14 shows a relationship between aircraft noise exposure and prevalence of high annoyance derived by Hall et al. (1981). As was the case in Figure 13, Schultz's (1978) synthesis curve does not agree with the present data as well as the alternative relationship plotted in the figure. It is not clear whether the fit of Hall's aircraft noise relationship to the present data is merely fortuitous, or whether it should be interpreted as support for the position that decibel for decibel, aircraft noise is more annoying than traffic noise. The scatter in the data from which Hall derived his relationship is considerable, and Hall's estimates of aircraft noise exposure responsible for observed annoyance may be in error by several decibels.

### c. Politicization of Community Response to Aircraft Noise Exposure

Airport noise-related issues have been prominent community concerns in the vicinity of Burbank Airport for many years. Litigation seeking redress for past exposure and limits to further exposure, disputes between the airport operating authority and airlines, and the terms of the recent sale of the airport from a private to a public agency, have all been extensively publicized. Intuitively, all of this attention seems likely to have a sensitizing influence on the prevalence of self-reported annoyance.

One interpretation of the greater prevalence of annoyance for the same exposure levels in the present data than in Schultz's synthesis might therefore be that the present data reflect a general increase in awareness of aircraft noise. Some support for this interpretation may be found in the observation that well over half of the respondents in all neighborhoods felt that airport and airplane operators cared not at all, or only slightly, for their comfort (see Figure 12). Such attitudes

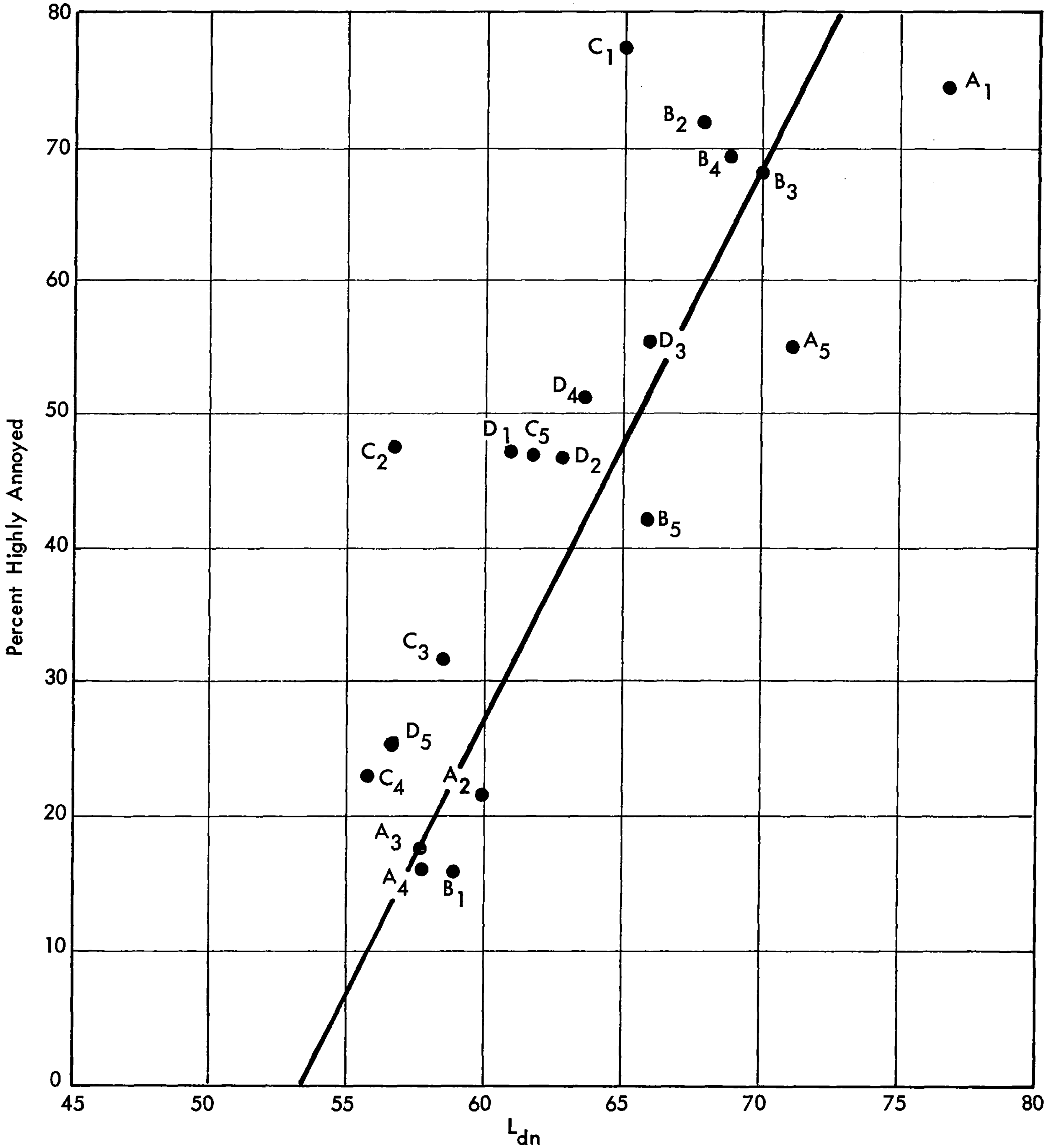


FIGURE 14. CURRENT DATA COMPARED WITH RELATIONSHIP INFERRED BY HALL (1981).

seem consistent with a general arousal of adverse opinion about aircraft noise. It might also be that the changes in exposure patterns themselves drew unusual attention to aircraft noise.

By similar reasoning, the greater prevalence of annoyance with aircraft noise in the present survey might also reflect the community's anticipatory reactions to feared increases in aircraft noise exposure. In this view, the community's reactions to traffic noise are similar to the views expressed in many other communities, because there is little realistic basis for fear of great increases in traffic noise in the vicinity of Burbank Airport. The community's reactions to aircraft noise exposure, however, may be more intense that those expressed in communities in which there is little prospect for future increases in aircraft noise exposure. Fears of increases in aircraft noise exposure may not have been as pressing in the communities in which the data summarized by Schultz (1978) were collected.

The difficulty with intuitive explanations of the sort discussed in this subsection is that they are essentially non-quantitative, and do not admit readily of empirical test. The validity of such explanations is thus likely to remain in doubt for the foreseeable future.

### d. Appropriateness of the Metric of Noise Exposure

The preceding discussion has sought explanations for the ill fit between Schultz's synthesis and the current data along the ordinate of Figure 10. The following discussion draws attention to the abscissa of the figure.

The first point to be made is that the quality of physical measurement in some earlier aircraft noise survey research is very uneven. It may be that some of the disagreement in dosage-effect relationships of the current study and of that derived by Schultz is due to errors of measurement in the prior work.

It is also possible, however, that integrated energy measures of aircraft noise exposure are ill suited to characterizing the aircraft noise dose of communities near mixed-use airports. $L_{dn}$ values in the interviewing areas were dominated by the small minority of flights by air carrier aircraft at Burbank Airport.

The majority of the flight activity at the airport by general aviation aircraft escaped quantification by $L_{dn}$ (because of its 20 dB lower single event level), even though such flights were clearly audible. The bimodality of the distributions of aircraft noise levels that may be seen in some of the figures of Appendix D demonstrates this effect.

If the intensity of community reaction to aircraft noise is even partially related to the number of aircraft noise intrusions experienced daily, then $L_{dn}$ may be a poor metric of noise exposure at Burbank Airport, even though it might be entirely adequate in an airport with more homogeneous flight operations. Thus, Schultz's (1978) synthesis may simply be inapplicable to the current data because of the inappropriateness of the metric of the abscissa. Rice (1980, Figure 6) has reported analyses that suggest that numbers of annual airport operations (and hence, perhaps, aircraft mix) may affect dosage response relationships reported in terms of $L_{dn}$.

## C. Changes in Long Term Assessment of Noise Exposure

An issue of concern to agencies responsible for policy decisions about aircraft noise exposure is the amount of time that must pass after a major change in a community's noise exposure before stable estimates of community reaction to the changed exposure can be made. Estimates of the rates at which respondents in the four neighborhoods changed their long term opinions about aircraft noise exposure were made by assuming that these opinions changed at an exponential rate.

The general form of the exponential relationship between change in output as a function of change in input for the assumed process is:

$$P(t) = P(\infty) + \Delta P . e^{-t/T}$$

where:

$t$ = elapsed time since noise exposure change, in days

$T$ = time constant of attitude change, in days

$P(t)$ = percent highly annoyed at time t

$P(\infty)$ = percent highly annoyed after long term adaptation to changed noise exposure

$\Delta P$ = difference between percent highly annoyed after exposure change and long after change.

Appendix F contains details of the application of this analysis to the current annoyance data. Several observations may be made about the time course of change of long term attitudes toward aircraft noise exposure despite the variability in estimates of the time constant documented in Appendix F.

First, the most likely value of the time constant is on the order of two to ten months. Second, in communities where the noise exposure has been particularly high (e.g., Neighborhood A) a saturation effect may occur, such that people do not soon forget their past environment, thus producing particularly long time constant estimates. The data of this study are too limited by themselves to make stronger statements about the dependence of T on direction of exposure change or absolute level (either daily average or individual event).

## D. Prevalence of Annoyance in Four Neighborhoods

Figure 10 shows the prevalence of high annoyance in all neighborhoods during all time periods. As noted earlier, these data do not correspond closely to the relationship synthesized by Schultz (1978). This does not imply that responses of communities to changes in aircraft noise exposure are inconsistent or unpredictable, however.

Replotting the data of Figure 10 in Figure 15 makes this point more clearly. Shading is used in Figure 15 to emphasize the regularity of the data in the four separate neighborhoods over the five rounds of interviewing. Within each shaded area, sizeable increases or decreases in exposure are accompanied by large changes in the prevalence of annoyance. The results for the first round of interviewing (before exposure changes) are highlighted by solid square symbols. Arrows point to the results of the second round (first interview after change).

Although Figure 15 shows consistency of responses *within* neighborhoods, it also shows differences *among* neighborhoods.

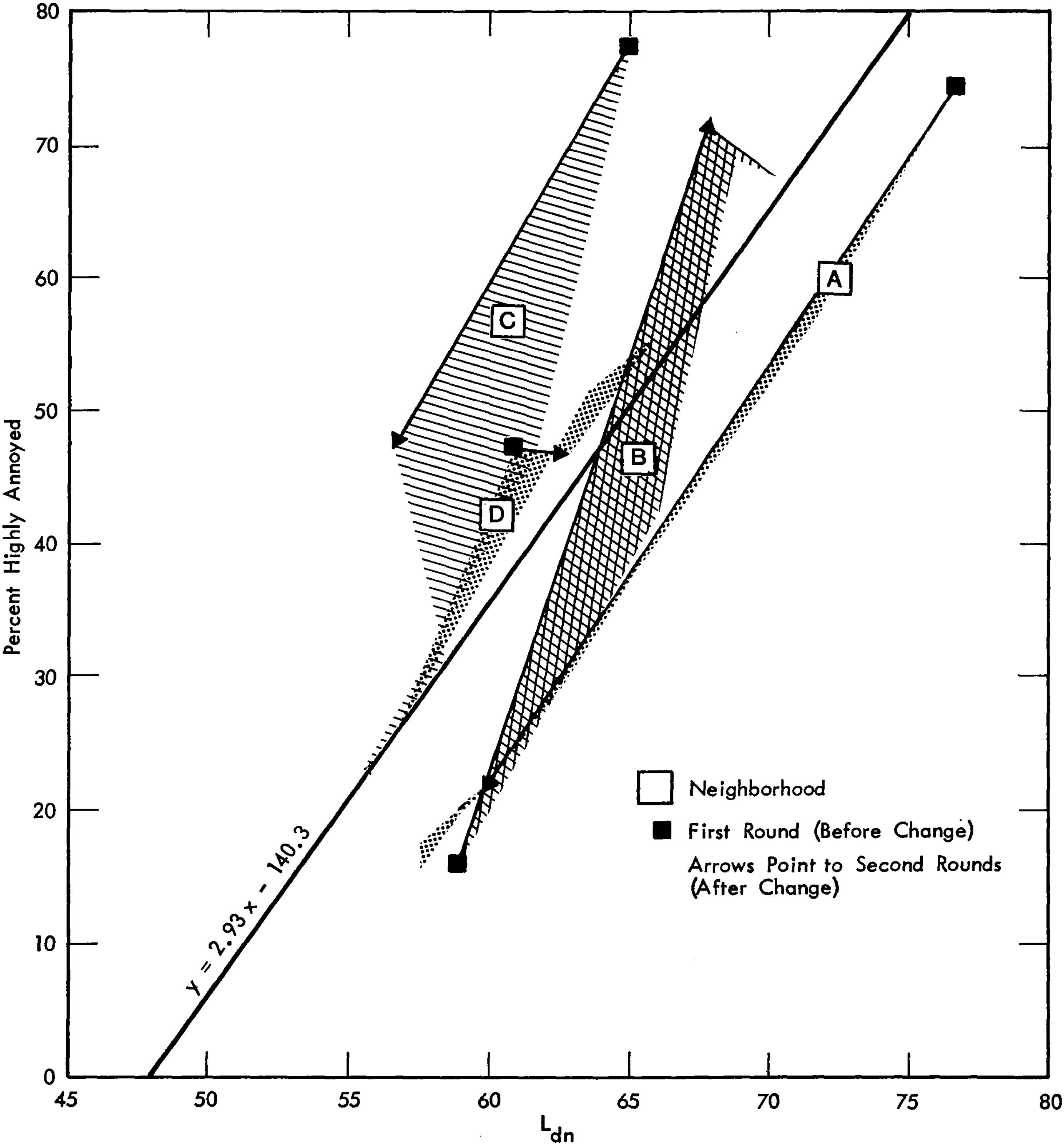


FIGURE 15. ANNOYANCE AND NOISE EXPOSURE FOR DIFFERENT NEIGHBORHOODS.

In the first round of interviews, for example, two neighborhoods (A and C), differed in exposure by about 12 dB, but did not differ meaningfully in prevalence of high annoyance. In fact, the proportion highly annoyed in Neighborhood A (0.74) lies well within the 95% confidence interval (0.70 to 0.84) for the proportion highly annoyed in Neighborhood C. Similarly, Neighborhoods B and D in Round 1 differed by only 2 dB in exposure, but by approximately 30% in pervasiveness of high annoyance. The proportion highly annoyed in Neighborhood D (0.47) lies well outside the 95% confidence interval for the proportion highly annoyed in Neighborhood B (0.09 to 0.23).

The results of the second round of interviewing compared to the first (arrowed lines for each neighborhood) certainly indicate that any substantial change in exposure level produces a change in the percentage of people reporting high annoyance. Further comparison of the first two rounds of interviewing suggests that a decrease in exposure (neighborhoods A and C) produces less change in annoyance than an increase in exposure (neighborhood B). However, this difference may be related to neighborhood or previous exposure conditions, especially since the increasing and decreasing annoyance/exposure slopes appear very much the same within neighborhoods.

The shaded areas in the figure are relatively narrow, indicating a small variation in response to exposure within each neighborhood. Exceptions do exist, especially in area C. However, the responses as a whole show less variability when grouped by neighborhood than when ungrouped.

The regression line for all of the data (shown originally in Figure 10) is presented again in Figure 15. Even though the difference in response between neighborhoods is apparent, the responses for each neighborhood are still reasonably represented by the regression line through all of the data.

## V. CONCLUSIONS

1. The magnitude and direction of change in proportions of the community highly annoyed by aircraft noise in the weeks preceding each of five rounds of interviewing were highly correlated with changes in physical exposure.

2. Observed percentages of respondents highly annoyed by traffic noise exposure were somewhat higher than those predicted by Schultz (1978).

3. Observed percentages of respondents highly annoyed by aircraft noise exposure were much greater than predicted by Schultz (1978).

4. Changes in the prevalence of annoyance following changes in aircraft noise exposure were attributable directly to exposure effects rather than to changes in criteria for reporting annoyance.

5. At least two months must elapse following changes in aircraft noise exposure of the magnitude observed in the current study before the proportion of the community highly annoyed by the changed exposure begins to stabilize.

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## APPENDIX A

## DETAILS OF NOISE MEASUREMENT PROCEDURES

## NOISE MONITOR INSTRUMENTATION

The noise monitor units used in this study are the BBN Model 704 and 614 systems designed especially for unattended monitoring of aircraft and community noise over long periods of time. The units are capable of operating for several days unattended; however, routine calibration is performed every other day to insure data accuracy. In this particular study the Model 704 monitored aircraft noise intrusions, while the Model 614 measured the ambient noise environment.

### A. Model 704

Figure A-1 shows the Model 704 in field service. The Model 704 unit consists of a General Radio, 1/2-inch electret microphone, monitor control unit and digital cassette tape recorder.

The unit also incorporates a small keyboard by which annotation (such as site location, date, instrumentation serial numbers, etc.) may be directly coded on the digital magnetic tape.

The monitor can operate in one of two user-selectable configurations, "time history mode" or "statistical mode", depending upon the particular application involved. In time history mode, the history of individual noise intrusions (such as aircraft flyovers) is retained. Statistical mode provides detailed statistics of

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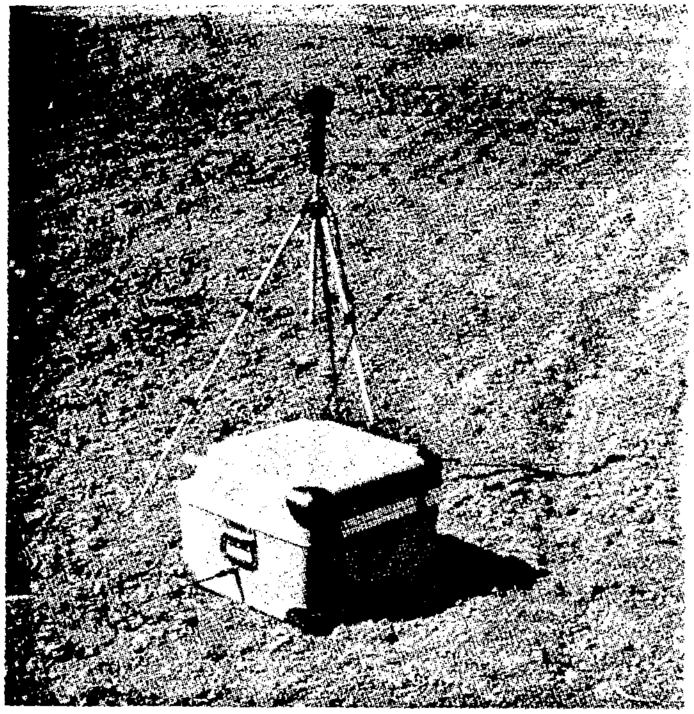


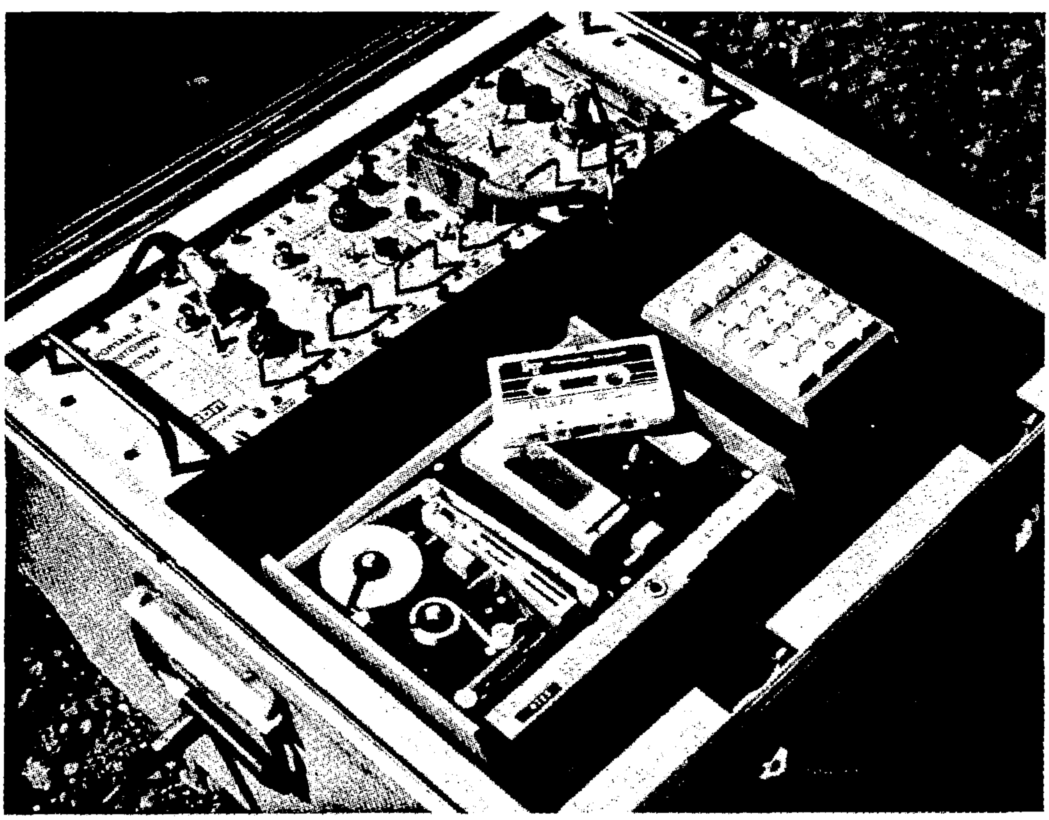


FIGURE A-1. MODEL 704 NOISE MONITOR.

hourly sound levels at the expense of losing the identity of individual events. "Time history" mode was used in this study.

The entire system meets Type 1 sound level meter specifications. All data were recorded using the A-weighting network and "slow" meter dynamics. The digital cassettes retrieved from the units were sent on a digital computer to our laboratory for analysis. The summary data provided by the computer forms the heart of the information gathered in this study.

A block diagram of the unit operating in "time history" mode is shown in Figure A-2. In this mode operation is controlled by a user-selectable sound level threshold. During periods when the sound level does not exceed the threshold, the monitor unit remains in a quiescent state. However, when an aircraft or other transient noise intrusion occurs and the sound level rises above the preset threshold value the sound level is digitized and recorded on digital tape. The monitor unit continues to digitize the recording at a one second rate as long as the threshold is exceeded. When the sound level drops below the threshold value, sound level recording ceases and the time-of-day is recorded on the tape (from an internal digital clock). The significant noise intrusions and their time of occurrence are recorded. This mode of operation is consistent with state airport noise regulations and provides a means for separating the lower level background noise environment from the higher aircraft noise levels. The dynamic range of the instrument is 100 decibels.

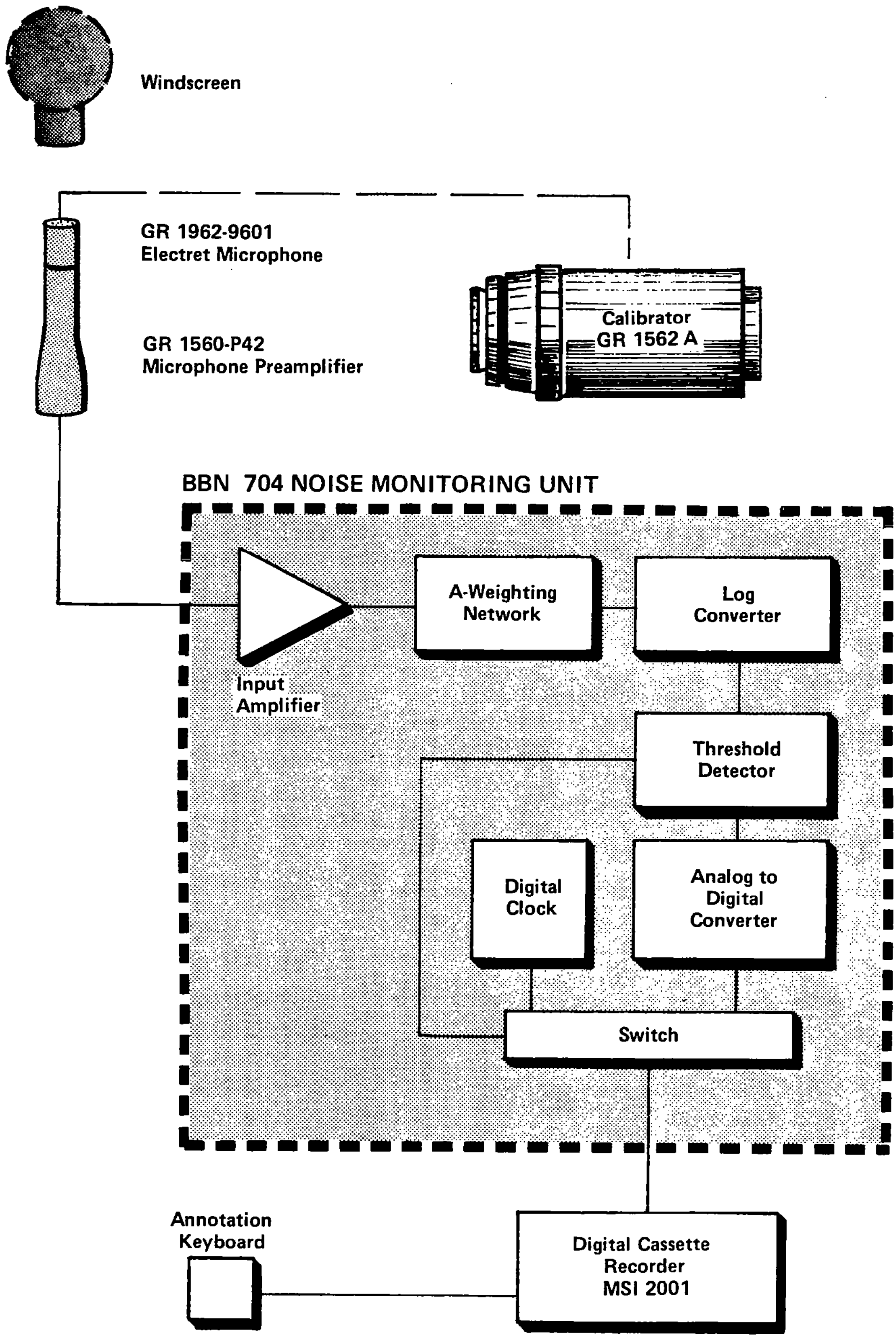



FIGURE A-2. BLOCK DIAGRAM OF MODEL 704 NOISE MONITOR LOGIC.

The digital tapes recorded by the monitor are processed by a Digital Equipment Corporation PDP-8 computer to provide single event, hourly, and daily statistics.

A typical computer printout is shown in Figure A-3. Note that for each noise intrusion, the time of day, the maximum level, the time duration for which the level is within 10 decibels of the maximum value, and the single event noise exposure level (SENEL) are tabulated. In addition the hourly noise level (HNL) is tabulated at the end of each hour. Finally, at the end of each day, the community noise equivalent level (CNEL) and day-night average level are listed.

The effect of the digitization process on computed sound exposure level (SEL) accuracy is shown in Figure A-4. Within the monitor, the output of the microphone is converted by analog circuitry to a time-varying DC voltage proportional to the A-weighted, slow-response sound level in decibels. At a fixed period rate (in this study once per second), the instantaneous DC voltage is digitzed (in this study to a resolution of 1 decibel) and recorded on digital tape. Later, the tape is processed by a digital computer which computes the sound exposure level of each noise event by an energy summation of these digitized levels. Figure A-4 shows the $\pm 95$ percent confidence interval on the computer SEL as a function of signal duration 10 dB down from the maximum value at 3 different digitization rates (the middle curve applies to this study. Basically, the graph ascribes numerical values to common sense expectations. At very long durations (e.g., 60 seconds or greater) the signal rises and decays slowly with time, and the probable error is

```
    TIME      MAX    DUR  SENEL
   20:14.5   77.0     6   82.0
  <20:33.1   72.0     4   77.3
   20:38.8   79.0     9   84.2
   20:51.9  102.0     7  107.5
  <20:52.2   75.0    14   84.1
$ HNL  (2000 TO 2059) =   72.0

    TIME      MAX    DUR  SENEL
   21:49.8  103.0     5  108.2
  <21:51.7   73.0     3   76.9
   21:56.3  102.0     7  108.1
$ HNL  (2100 TO 2159) =   75.6
$ HNL  (2200 TO 2259) =   41.1
$ CNEL (08 SEP  1979) =   76.1
$ LDN  (08 SEP  1979) =   75.2


$ DATE: 09 SEP  1979

    TIME      MAX    DUR  SENEL
  <02:00.8   76.0    10   84.0
$ HNL  (0200 TO 0259) =   48.4
$ HNL  (0600 TO 0659) =   29.4

    TIME      MAX    DUR  SENEL
  <07:09.9   76.0     8   82.9
   07:10.9  107.0    10  113.9
   07:14.7   98.0     9  105.3
  <07:22.5   75.0    12   81.6
   07:23.4  105.0     8  111.6
  <07:42.9   71.0     8   78.5
   07:43.5   99.0    11  106.8
$ HNL  (0700 TO 0759) =   81.2

    TIME      MAX    DUR  SENEL
   08:05.5   81.0    10   87.6
  <08:09.1   76.0    11   84.2
  <08:10.3   73.0     6   79.8
   08:16.3   98.0    10  105.5
  <08:20.9   72.0     1   73.0
  <08:29.8   77.0    12   84.4
   08:32.2   76.0     8   81.8
  <08:33.9   75.0     7   81.4
  <08:35.1   75.0     6   80.5
   08:40.8   94.0     7  100.5
```

FIGURE A-3. TYPICAL OUTPUT FROM MODEL 704 NOISE MONITOR.

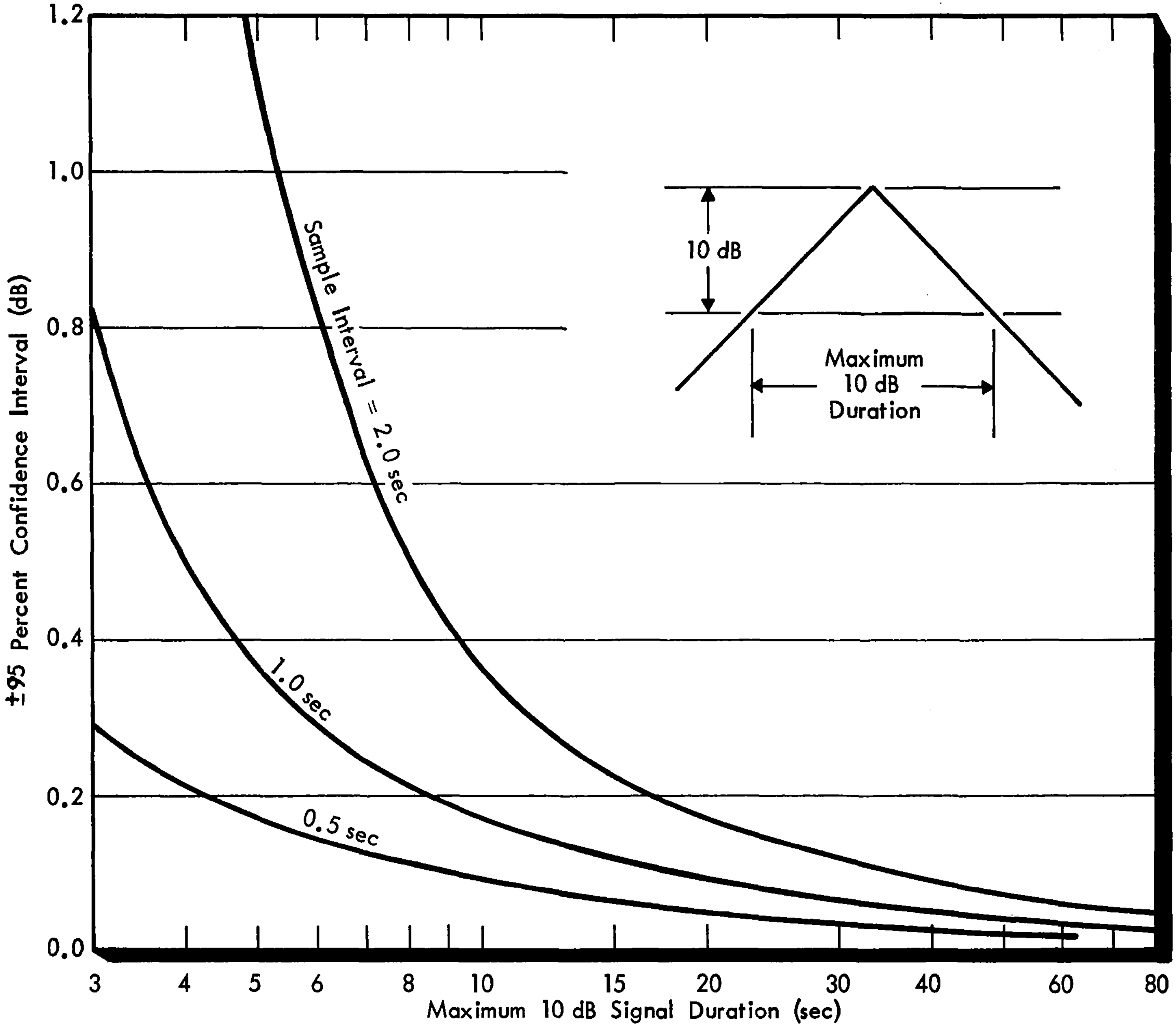



FIGURE A-4. SOUND EXPOSURE LEVEL COMPUTATIONAL ERROR BOUNDS DUE TO FINITE SAMPLING RATE (1 dB SPL RESOLUTION).

less than ±0.1 dB due to the large number of individual sound levels incorporated in the summation. In contrast, the probable error increases for short duration (fast rise/decay) signals since fewer digitized sound levels contribute to the sum. In this case the value of the sum becomes more sensitive to the precise instant at which the sound level was digitized by the monitor.

All things considered, however, the 95 percent confidence interval does not grow excessively large even for relatively short durations. For example, the interval is less than ±0.5 dB for all durations in excess of 4 seconds. By way of comparison, a review of the noise monitor data at sites nearest the airport reveals that durations less than 6 or 7 seconds are rarely observed.

### B. Model 614

Figure A-5 shows the Model 614 in field use. The Model 614 field unit consists of a General Radio, 1/2-inch electret microphone and monitor control units. The monitor contains a microprocessor computer and printer so that sound level information can be displayed directly in the field.

In the configuration used in this study, the unit records the total noise environment (i.e., there is no threshold discrimination). A-weighted sound levels are digitized to the nearest 0.2 dB twice per second by the processor and accumulated over a 1 hour period. At the end of the hour, the hourly noise level (HNL) is calculated and printed along with the $L_{99}$, $L_{90}$, $L_{50}$, $L_{10}$, and $L_5$ centile levels and the maximum sound level. The community noise equivalent level (CNEL) and day-night average level (DNL) are calculated and printed at the end of each day.

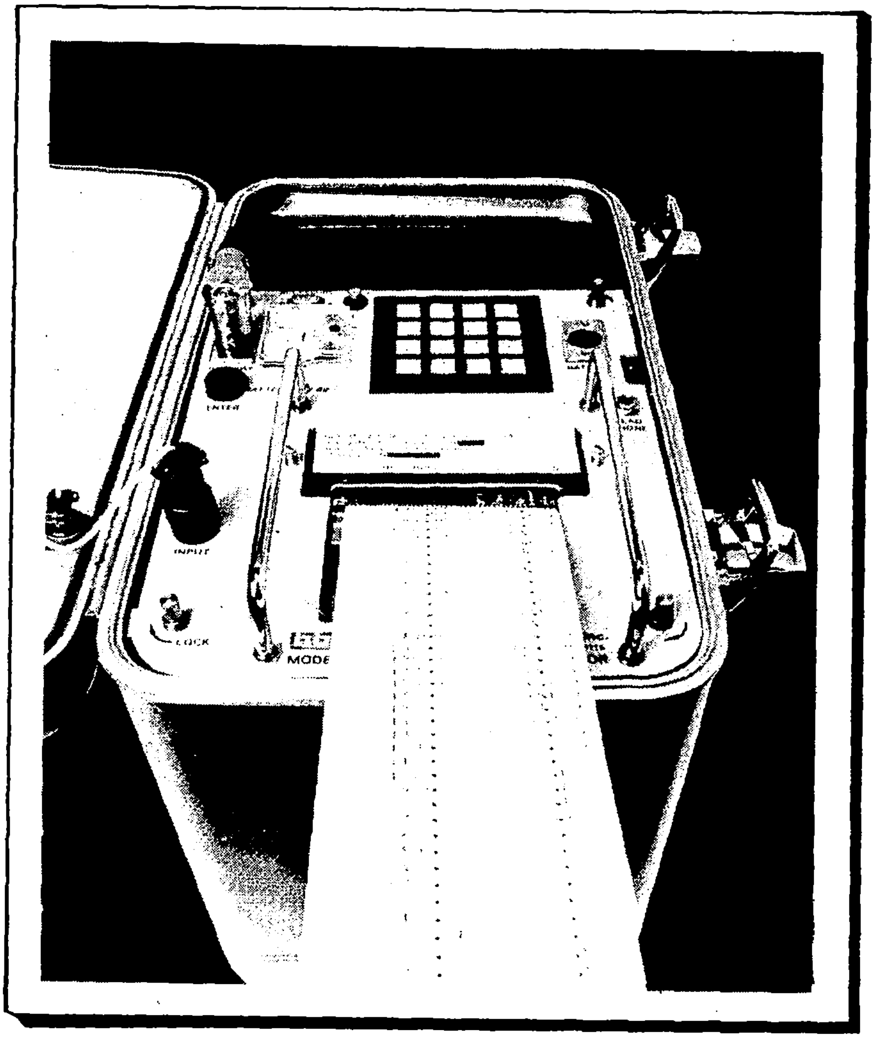



FIGURE A-5. MODEL 614 NOISE MONITOR.

Typical output for a one-day period is shown in Figure A-6. For ease of identification each HNL is followed by the letter "H", the CNEL followed by the letter "C", and the DNL followed by the letter "d". The indicated times are the end of the hour for which the HNL is reported.

```
42. 44. 47. 51. 58. 62.0 %
0000.03   04   000   049.3   F
0000.02   04   000   068.8   d
0000.01   04   000   069.5   C
0000.00   04   000   049.3   H
43. 44. 47. 50. 59. 68.0 %
2300.01   04   000   049.8   F
2300.00   04   000   049.8   H
43. 45. 49. 55. 74. 88.0 %
2200.01   04   000   063.3   F
2200.00   04   000   063.3   H
45. 47. 49. 52. 68. 87.0 %
2100.01   04   000   061.5   F
2100.00   04   000   061.5   H
46. 48. 50. 59. 86. 92.0 %
2000.01   04   000   070.8   F
2000.00   04   000   070.8   H
47. 49. 53. 58. 82.102.0 %
1900.01   04   000   074.6   F
1900.00   04   000   074.6   H
51. 52. 55. 59. 74. 89.0 %
1800.01   04   000   064.5   F
1800.00   04   000   064.5   H
51. 52. 55. 60. 87. 97.0 %
1700.01   04   000   073.5   F
1700.00   04   000   073.5   H
51. 52. 54. 57. 72. 91.0 %
1600.01   04   000   063.3   F
1600.00   04   000   063.3   H
50. 51. 53. 57. 72. 91.0 %
1500.01   04   000   065.0   F
1500.00   04   000   065.0   H
45. 47. 50. 60. 87. 97.0 %
1400.01   04   000   072.9   F
1400.00   04   000   072.9   H
46. 47. 49. 54. 72. 86.0 %
1300.01   04   000   062.4   F
1300.00   04   000   062.4   H
```



FIGURE A-6. TYPICAL OUTPUT FROM MODEL 614 NOISE MONITOR.

## APPENDIX B
## TABULATIONS OF DATA

Table B-1 accounts for all completed and attempted interviews in the manner suggested by Kish (1965). More than 5,000 interviews were completed all told, about 52 percent with female respondents, and 46 percent with male respondents. About three quarters of these interviews were conducted in person, and one quarter by telephone.

The major reason for non-completion of an interview was unavailability of a telephone listing following an initial attempted personal contact, listed as "unlisted" in Table B-1. Failure to reach a potential respondent after four callbacks, shown as "unreached" was the next most common reason for non-completion. Language problems precluded only 242 interviews. Refusals to complete an interview totalled only 816, only 12% of all contacts that could have led to a completed interview.

Questionnaire data were keypunched, proofread, edited, and submitted for tabulation to standard statistical software. Summaries of responses to each question for each round of interviews and each site are listed in Tables B-2 through B-7.

Table B-8 summarizes auxiliary information collected in the course of interviewing.

TABLE B-1

ACCOUNTING OF RESPONDENT CONTACTS
(All Figures are Percentages)

| Neighborhood | A | | | | | B | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Round | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Responses: F/F | 52 | 61 | 43 | 49 | 47 | 36 | 36 | 40 | 46 | 47 |
| Tel. | 17 | 12 | 21 | 17 | 13 | 19 | 13 | 24 | 10 | 8 |
| Total | 69 | 73 | 64 | 66 | 60 | 55 | 49 | 64 | 56 | 55 |
| Non-Responses: | | | | | | | | | | |
| Unlisted | 17 | 13 | 22 | 17 | 21 | 27 | 31 | 22 | 27 | 25 |
| Unreached | 2 | 5 | 3 | 4 | 5 | 1 | 4 | 3 | 5 | 11 |
| No English | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 2 | 1 |
| Other | 1 | 1 | | 1 | 1 | 1 | 1 | | 1 | 1 |
| Refusal | 9 | 8 | 9 | 11 | 13 | 13 | 12 | 7 | 9 | 7 |

| Neighborhood | C | | | | | D | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Round | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Responses: F/F | 46 | 45 | 35 | 43 | 41 | 33 | 40 | 28 | 34 | 40 |
| Tel. | 13 | 9 | 14 | 11 | 7 | 16 | 5 | 13 | 7 | 6 |
| Total | 59 | 54 | 49 | 54 | 48 | 49 | 45 | 41 | 41 | 46 |
| Non-Responses: | | | | | | | | | | |
| Unlisted | 26 | 26 | 33 | 25 | 28 | 36 | 39 | 43 | 41 | 39 |
| Unreached | 3 | 6 | 4 | 8 | 10 | 3 | 6 | 4 | 6 | 6 |
| No English | 5 | 5 | 5 | 4 | 4 | 4 | 2 | 3 | 3 | 3 |
| Other | | | 1 | | 1 | | 1 | | 3 | |
| Refusal | 7 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 6 | 6 |

| | ALL NEIGHBORHOODS | | | | | |
|---|---|---|---|---|---|---|
| Round | 1 | 2 | 3 | 4 | 5 | Σ/N |
| Responses: F/F | 42 | 46 | 36 | 42 | 44 | 42 |
| Tel. | 16 | 9 | 17 | 11 | 8 | 13 |
| Total | 58 | 55 | 53 | 53 | 52 | 55 |
| Non-Responses | | | | | | |
| Unlisted | 26 | 27 | 32 | 28 | 28 | 28 |
| Unreached | 2 | 6 | 4 | 6 | 8 | 5 |
| No English | 3 | 2 | 3 | 2 | 2 | 3 |
| Other | 1 | 1 | | 1 | 1 | 1 |
| Refusal | 9 | 9 | 8 | 9 | 9 | 9 |

# TABLE B-2

## MAJOR NEIGHBORHOOD ENVIRONMENTAL PROBLEM

| Neighborhood | A | | | | | B | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Round | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| $L_{dn}$ | 77 | 60 | 58 | 58 | 71 | 59 | 68 | 70 | 69 | 66 |
| MAJOR ENVIRONMENTAL PROBLEM | | | | | | | | | | |
| Aircraft | 0.72 | 0.65 | 0.61 | 0.54 | 0.68 | 0.11 | 0.41 | 0.51 | 0.56 | 0.50 |
| Air Quality | 0.15 | 0.15 | 0.12 | 0.10 | 0.09 | 0.45 | 0.32 | 0.09 | 0.16 | 0.24 |
| Other | 0.07 | 0.09 | 0.12 | 0.16 | 0.08 | 0.15 | 0.14 | 0.19 | 0.16 | 0.14 |
| DK | 0.04 | 0.09 | 0.09 | 0.17 | 0.13 | 0.09 | 0.10 | 0.19 | 0.08 | 0.11 |
| NA | 0.02 | 0.02 | 0.05 | 0.03 | 0.02 | 0.20 | 0.03 | 0.03 | 0.05 | 0.01 |

| Neighborhood | C | | | | | D | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Round | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| $L_{dn}$ | 65 | 57 | 59 | 56 | 62 | 61 | 63 | 66 | 64 | 57 |
| MAJOR ENVIRONMENTAL PROBLEM | | | | | | | | | | |
| Aircraft | 0.50 | 0.44 | 0.50 | 0.35 | 0.48 | 0.20 | 0.26 | 0.44 | 0.46 | 0.38 |
| Air Quality | 0.19 | 0.25 | 0.19 | 0.10 | 0.20 | 0.39 | 0.41 | 0.19 | 0.23 | 0.24 |
| Other | 0.18 | 0.17 | 0.18 | 0.19 | 0.14 | 0.20 | 0.19 | 0.22 | 0.16 | 0.22 |
| DK | 0.06 | 0.11 | 0.08 | 0.31 | 0.16 | 0.07 | 0.10 | 0.12 | 0.07 | 0.11 |
| NA | 0.06 | 0.04 | 0.05 | 0.05 | 0.01 | 0.14 | 0.04 | 0.04 | 0.08 | 0.05 |

TABLE B-3

SUMMARY OF ANNOYANCE AND NOISE DATA FOR FIVE ROUNDS

| Neighborhood | A | | | | | B | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Round | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| $L_{dn}$ | 77 | 60 | 58 | 58 | 71 | 59 | 68 | 70 | 69 | 66 |
| TRAFFIC OVER THE PAST WEEK | | | | | | | | | | |
| NAA | 0.50 | 0.58 | 0.57 | 0.52 | 0.54 | 0.48 | 0.60 | 0.47 | 0.53 | 0.51 |
| SLI | 0.23 | 0.16 | 0.20 | 0.25 | 0.18 | 0.18 | 0.12 | 0.22 | 0.20 | 0.22 |
| MOD | 0.17 | 0.15 | 0.16 | 0.16 | 0.18 | 0.18 | 0.15 | 0.17 | 0.15 | 0.13 |
| VERY | 0.05 | 0.03 | 0.03 | 0.04 | 0.04 | 0.11 | 0.05 | 0.07 | 0.06 | 0.06 |
| EXT | 0.04 | 0.06 | 0.03 | 0.02 | 0.04 | 0.05 | 0.07 | 0.04 | 0.04 | 0.07 |
| UNK | 0.01 | 0.02 | 0.01 | 0.01 | 0.02 | | 0.01 | 0.06 | 0.02 | 0.01 |
| *HIGHLY | 0.09 | 0.09 | 0.06 | 0.06 | 0.08 | 0.16 | 0.12 | 0.11 | 0.10 | 0.13 |
| Neighborhood | C | | | | | D | | | | |
| Round | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| $L_{dn}$ | 65 | 57 | 59 | 56 | 62 | 61 | 63 | 66 | 64 | 57 |
| TRAFFIC OVER THE PAST WEEK | | | | | | | | | | |
| NAA | 0.41 | 0.54 | 0.52 | 0.51 | 0.49 | 0.49 | 0.48 | 0.54 | 0.56 | 0.49 |
| SLI | 0.22 | 0.21 | 0.23 | 0.20 | 0.24 | 0.15 | 0.22 | 0.19 | 0.17 | 0.19 |
| MOD | 0.21 | 0.12 | 0.18 | 0.20 | 0.19 | 0.22 | 0.17 | 0.14 | 0.17 | 0.17 |
| VERY | 0.07 | 0.06 | 0.05 | 0.06 | 0.05 | 0.08 | 0.08 | 0.04 | 0.06 | 0.08 |
| EXT | 0.06 | 0.06 | 0.02 | 0.02 | 0.02 | 0.04 | 0.05 | 0.05 | 0.02 | 0.04 |
| UNK | 0.03 | 0.01 | | 0.01 | 0.01 | 0.02 | | 0.04 | 0.02 | 0.02 |
| *HIGHLY | 0.13 | 0.12 | 0.07 | 0.08 | 0.07 | 0.12 | 0.13 | 0.09 | 0.08 | 0.12 |

*Highly = Very + Extremely.

## TABLE B-4

## SUMMARY OF ANNOYANCE AND NOISE DATA FOR FIVE ROUNDS

| Neighborhood | A | | | | | B | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Round | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| $L_{dn}$ | 77 | 60 | 58 | 58 | 71 | 59 | 68 | 70 | 69 | 66 |
| AIRCRAFT OVER THE PAST WEEK | | | | | | | | | | |
| NAA | 0.05 | 0.40 | 0.38 | 0.40 | 0.14 | 0.46 | 0.09 | 0.06 | 0.06 | 0.20 |
| SLI | 0.06 | 0.22 | 0.25 | 0.25 | 0.13 | 0.26 | 0.10 | 0.10 | 0.13 | 0.22 |
| MOD | 0.13 | 0.14 | 0.17 | 0.17 | 0.17 | 0.12 | 0.08 | 0.15 | 0.11 | 0.15 |
| VERY | 0.16 | 0.08 | 0.08 | 0.07 | 0.23 | 0.08 | 0.18 | 0.19 | 0.21 | 0.17 |
| EXT | 0.58 | 0.14 | 0.10 | 0.09 | 0.32 | 0.08 | 0.54 | 0.49 | 0.48 | 0.25 |
| UNK | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | | 0.01 | 0.01 | 0.01 | 0.01 |
| *HIGHLY | 0.74 | 0.22 | 0.18 | 0.16 | 0.55 | 0.16 | 0.72 | 0.68 | 0.69 | 0.42 |

| Neighborhood | C | | | | | D | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Round | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| $L_{dn}$ | 65 | 57 | 59 | 56 | 62 | 61 | 63 | 66 | 64 | 57 |
| AIRCRAFT OVER THE PAST WEEK | | | | | | | | | | |
| NAA | 0.03 | 0.15 | 0.20 | 0.26 | 0.15 | 0.22 | 0.13 | 0.10 | 0.10 | 0.31 |
| SLI | 0.08 | 0.17 | 0.22 | 0.30 | 0.15 | 0.10 | 0.18 | 0.13 | 0.20 | 0.21 |
| MOD | 0.09 | 0.18 | 0.26 | 0.18 | 0.22 | 0.19 | 0.21 | 0.20 | 0.18 | 0.21 |
| VERY | 0.21 | 0.17 | 0.18 | 0.14 | 0.22 | 0.19 | 0.17 | 0.15 | 0.21 | 0.08 |
| EXT | 0.56 | 0.31 | 0.14 | 0.09 | 0.25 | 0.28 | 0.30 | 0.40 | 0.30 | 0.17 |
| UNK | 0.03 | 0.02 | | 0.03 | 0.01 | 0.02 | 0.01 | 0.02 | 0.01 | 0.02 |
| *HIGHLY | 0.77 | 0.48 | 0.32 | 0.23 | 0.47 | 0.47 | 0.47 | 0.55 | 0.51 | 0.25 |

*Highly = Very + Extremely.

TABLE B-5

SUMMARY OF ANNOYANCE AND NOISE DATA FOR FIVE ROUNDS

| Neighborhood | | | A | | | | | B | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Round | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| $L_{dn}$ | 77 | 60 | 58 | 58 | 71 | 59 | 68 | 70 | 69 | 66 |
| AIRCRAFT OVER THE PAST YEAR | | | | | | | | | | |
| NAA | 0.05 | 0.10 | 0.08 | 0.07 | 0.11 | 0.30 | 0.28 | 0.20 | 0.17 | 0.10 |
| SLI | 0.06 | 0.10 | 0.07 | 0.06 | 0.06 | 0.28 | 0.32 | 0.26 | 0.24 | 0.19 |
| MOD | 0.14 | 0.07 | 0.14 | 0.12 | 0.14 | 0.16 | 0.23 | 0.30 | 0.26 | 0.18 |
| VERY | 0.19 | 0.17 | 0.22 | 0.15 | 0.24 | 0.07 | 0.05 | 0.09 | 0.13 | 0.19 |
| EXT | 0.54 | 0.54 | 0.46 | 0.56 | 0.42 | 0.09 | 0.05 | 0.12 | 0.15 | 0.28 |
| UNK | 0.02 | 0.02 | 0.03 | 0.04 | 0.03 | 0.10 | 0.07 | 0.03 | 0.05 | 0.05 |
| *HIGHLY | 0.73 | 0.71 | 0.68 | 0.71 | 0.66 | 0.16 | 0.10 | 0.21 | 0.28 | 0.47 |
| Neighborhood | | | C | | | | | D | | |
| Round | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| $L_{dn}$ | 65 | 57 | 59 | 56 | 62 | 61 | 63 | 66 | 64 | 57 |
| AIRCRAFT OVER THE PAST YEAR | | | | | | | | | | |
| NAA | 0.04 | 0.07 | 0.07 | 0.08 | 0.08 | 0.20 | 0.14 | 0.12 | 0.09 | 0.18 |
| SLI | 0.07 | 0.07 | 0.07 | 0.09 | 0.10 | 0.16 | 0.20 | 0.18 | 0.15 | 0.22 |
| MOD | 0.14 | 0.12 | 0.15 | 0.17 | 0.16 | 0.22 | 0.26 | 0.24 | 0.24 | 0.25 |
| VERY | 0.21 | 0.20 | 0.20 | 0.18 | 0.25 | 0.16 | 0.17 | 0.14 | 0.22 | 0.11 |
| EXT | 0.49 | 0.51 | 0.46 | 0.43 | 0.37 | 0.17 | 0.14 | 0.23 | 0.20 | 0.17 |
| UNK | 0.05 | 0.03 | 0.05 | 0.05 | 0.04 | 0.09 | 0.09 | 0.09 | 0.10 | 0.06 |
| *HIGHLY | 0.70 | 0.71 | 0.66 | 0.61 | 0.62 | 0.33 | 0.31 | 0.37 | 0.42 | 0.28 |

*Highly = Very + Extremely.

## TABLE B-6
## NUMBER OF SMALL AIRPLANES AS ANNOYING AS ONE AIR CARRIER AIRCRAFT

(RAW DATA)

| Neighborhood | A | B | C | D | A |
|---|---|---|---|---|---|
| $L_{dn}$ | 71 | 66 | 2 | 57 | |
| Not Annoyed by Either Small and Large Aircraft | 14 | 1 | 2 | 2 | 19 |
| Equally Annoying | 28 | 4 | 10 | 10 | 52 |
| Small Aircraft More Annoying | 23 | 11 | 5 | 17 | 56 |
| Not Annoyed by Small | 16 | 10 | 14 | 5 | 45 |
| DK | 53 | 53 | 59 | 70 | 235 |
| NA | 16 | 40 | 37 | 31 | 124 |
| Refused | 2 | 1 | 1 | 1 | 5 |
| | | | | | 536 |
| # Remaining | 134 | 120 | 80 | 77 | 411 |
| $\overline{X}$ | 44 | 65 | 15 | 35 | 43 |
| Median | 10 | 10 | 6 | 10 | 10 |
| Mode | 10 | 10 | 10 | 10 | 10 |

(% DATA)

| Neighborhood | A | B | C | D | A |
|---|---|---|---|---|---|
| $L_{dn}$ | 71 | 66 | 62 | 57 | |
| Not Annoyed by Either | 0.05 | | 0.01 | 0.01 | 0.02 |
| Equally Annoying | 0.10 | 0.02 | 0.05 | 0.05 | 0.05 |
| Small More Annoying | 0.08 | 0.05 | 0.02 | 0.08 | 0.06 |
| Not Annoyed by Small | 0.06 | 0.04 | 0.07 | 0.02 | 0.05 |
| DK | 0.19 | 0.22 | 0.28 | 0.33 | 0.25 |
| NA | 0.06 | 0.17 | 0.18 | 0.15 | 0.12 |
| Refused | 0.01 | | | | 0.01 |
| | 0.55 | 0.50 | 0.61 | 0.64 | 0.57 |
| | | | | | 0.43 |

able to make a judgment

TABLE B-7

SUMMARY OF ANNOYANCE AND NOISE DATA FOR ROUND 5

| Neighborhood | A | B | C | D |
|---|---|---|---|---|
| $L_{dn}$ | 71 | 66 | 62 | 57 |
| Concern of People Who Run Airports and Airplanes | | | | |
| NAA | 0.54 | 0.40 | 0.50 | 0.31 |
| SLI | 0.18 | 0.17 | 0.19 | 0.34 |
| MOD | 0.12 | 0.20 | 0.14 | 0.17 |
| VERY | 0.07 | 0.11 | 0.08 | 0.06 |
| EXT | 0.01 | 0.03 | | 0.02 |
| UNK | 0.08 | 0.09 | 0.09 | 0.20 |
| *HIGHLY | 0.08 | 0.14 | 0.08 | 0.08 |

*Highly = Very + Extremely.

TABLE B-8

SUMMARY OF AUXILIARY INFORMATION FOR FIVE ROUNDS

| Neighborhood | A | | B | | C | | D | | ALL | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % |
| Type of Interview | | | | | | | | | | |
| F/F | 1292 | 76 | 760 | 75 | 881 | 80 | 963 | 79 | 3896 | 77 |
| Tel. | 411 | 24 | 255 | 25 | 218 | 20 | 261 | 21 | 1145 | 23 |
| | 1703 | | 1015 | | 1099 | | 1224 | | 5041 | |
| Sex: | | | | | | | | | | |
| Female | 943 | 55 | 578 | 57 | 606 | 55 | 508 | 42 | 2635 | 52 |
| Male | 736 | 43 | 428 | 42 | 481 | 44 | 694 | 57 | 2339 | 46 |
| Unknown | 24 | 1 | 9 | 1 | 12 | 1 | 22 | 2 | 67 | 1 |
| Age: | | | | | | | | | | |
| <30 | 391 | 23 | 279 | 27 | 322 | 29 | 511 | 42 | 1503 | 30 |
| 30-50 | 785 | 46 | 424 | 42 | 445 | 40 | 479 | 39 | 2133 | 42 |
| >50 | 463 | 27 | 235 | 23 | 290 | 26 | 184 | 15 | 1172 | 23 |
| Unknown | 64 | 4 | 77 | 8 | 42 | 4 | 50 | 4 | 233 | 5 |

## APPENDIX C

## APPLICATION OF THE PSYCHOPHYSICAL THEORY OF SIGNAL DETECTABILITY TO ANALYSES OF CHANGES IN COMMUNITY RESPONSE TO NOISE EXPOSURE

### I. BACKGROUND INFORMATION

The psychophysical theory of signal detectability (Green and Swets, 1966) provides another perspective on the data collected in this study. The theory employs plots known as Receiver Operating Characteristics (ROC curves) to summarize the entire range of decision making performance possible for a decision maker of fixed sensitivity. The types of problems most often addressed within this theoretical framework involve perceptual decision making under conditions of uncertainty and risk. The area of uncertainty concerns the presence or absence of some physical condition, while the risk is associated with real-world decision outcomes.

The ROC curve distinguishes the fundamental sensitivity of the decision maker to physical conditions from the obscuring influences on his decisions of the costs and payoffs of the outcomes of his decisions ("response bias"). The ROC curve makes explicit the relationship between two forms of "correct" and "incorrect" decisions: decisions that some condition is present when in fact it actually is present ("hits"); and decisions that some condition is present when in fact it is not ("false alarms").

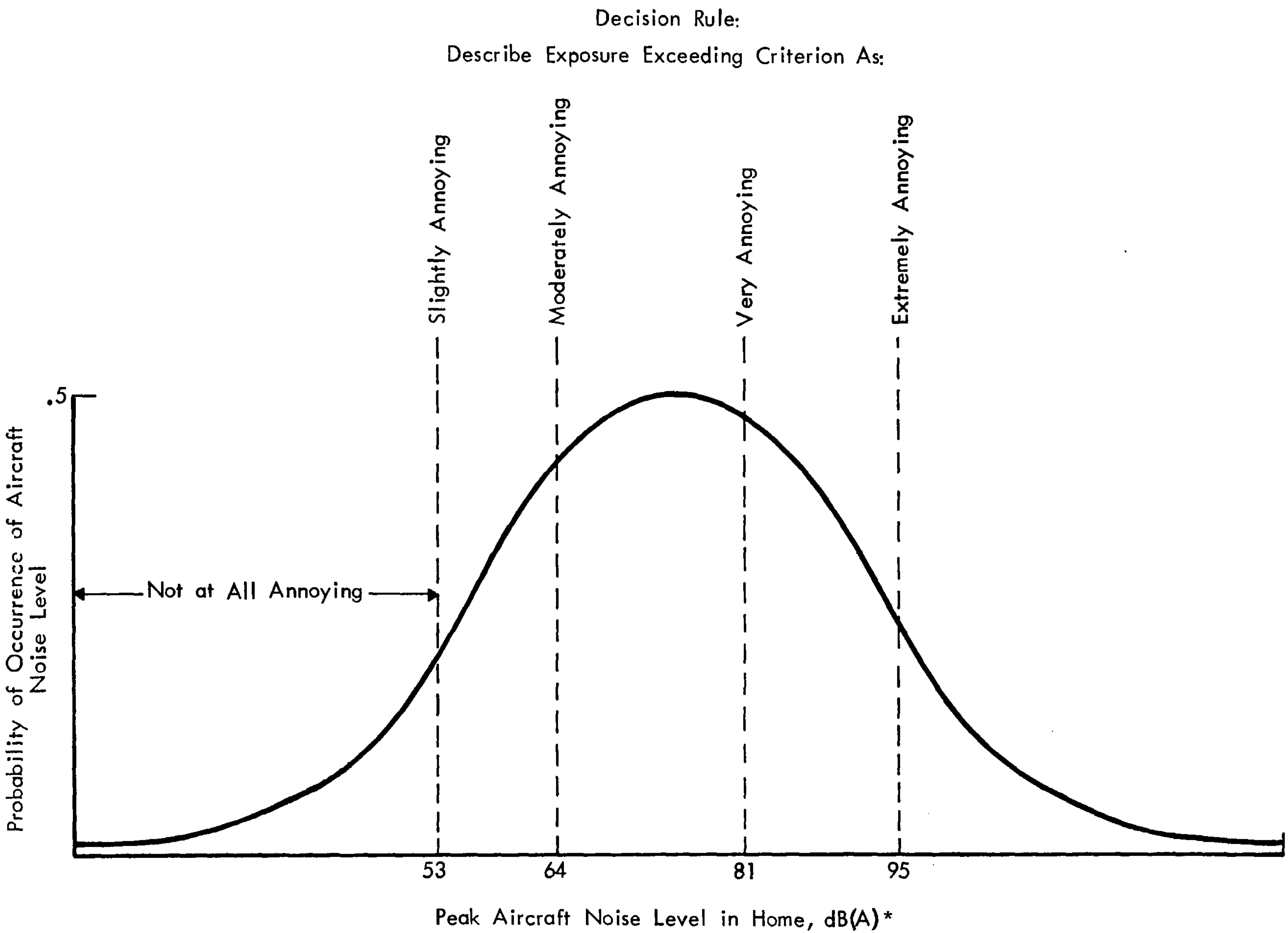
The relationship is curvilinear on linear axes, but linear on normal probability axes. The shape of the relationship is a consequence of the manner in which the areas under each of two distributions to the left and right of a fixed decision criterion vary as the criterion is shifted to take account of the costs and payoffs of decision outcomes (see below). The decision making process itself is quite similar to that of a parametric statistical inferential test, such as a t-test.

The theoretical framework of the Theory of Signal Detectability is sufficiently general that it readily accommodates the present problem of assessing the effects of changes in aircraft noise exposure on changes in the prevalence of annoyance in communities. In this application, the "decision maker" is not an individual, but a group of people; the "decision" concerns which degree of annoyance to report to an interviewer; and the "sensitivity" involved is that summarized by the dosage-response relationship (transfer function) between noise exposure and annoyance.

Application of the model of decision making under conditions of uncertainty and risk may be understood by considering the exemplary set of personal decision criteria for a resident of an airport neighborhood seen in Figure C-1. The shape of the exposure distribution is assumed for reasons of convenience to be Gaussian, although this assumption is clearly not critical.

When an interviewer asks a respondent "How annoyed are you by aircraft noise... ", the respondent is assumed to decide how to describe his annoyance by evaluating exposure with regard to these personal decision criteria, as illustrated in Figure C-1. Proportions of the community expressing common degrees of annoyance may therefore be regarded as composed of people whose exposure or criteria for judging it correspond.

Suppose now that the exposure distribution changes (shifts to the left or right on the abscissa of Figure C-1) due to

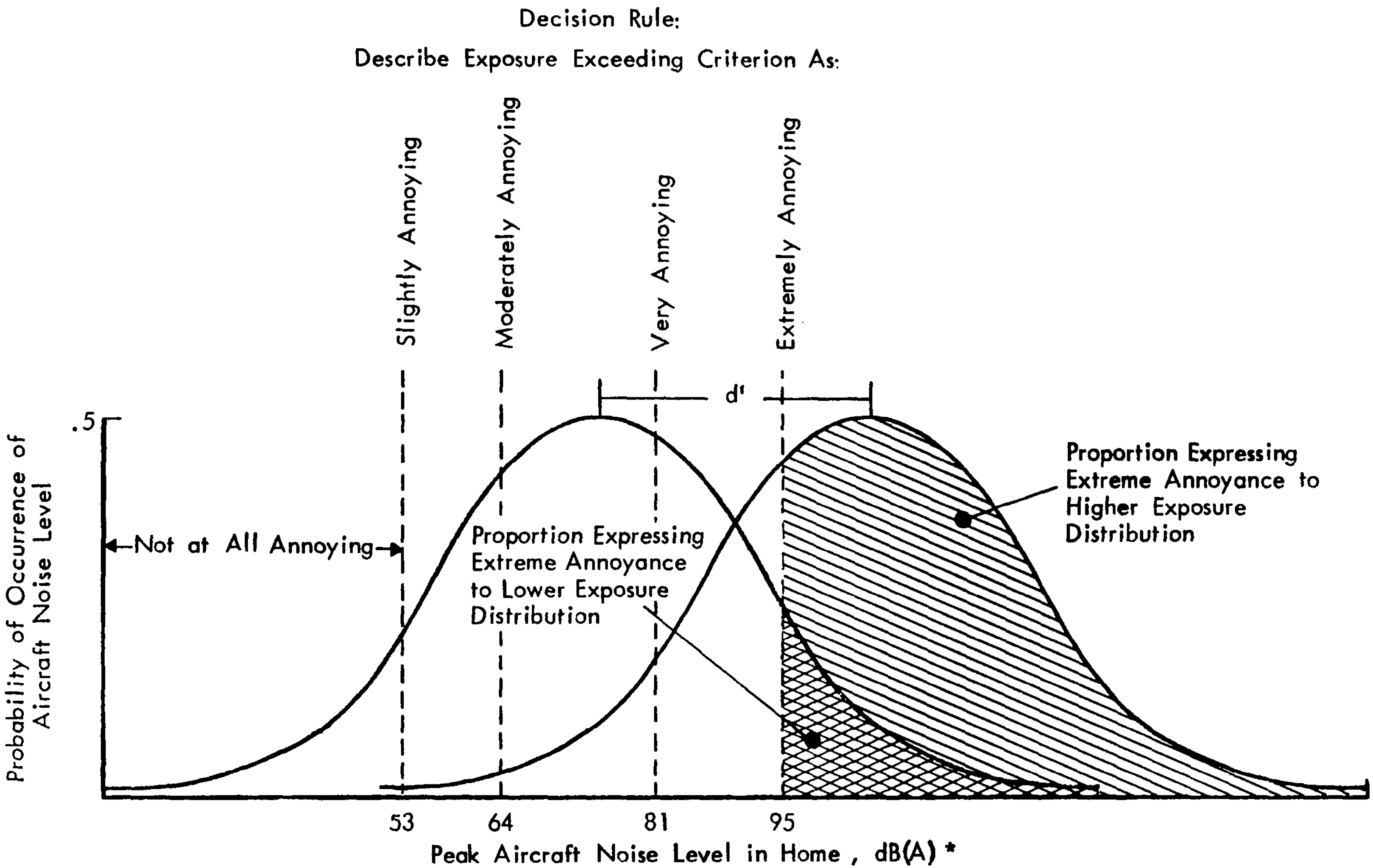



* Hypothetical values based on data of Fidell and Teffeteller, 1981

FIGURE C-1. EXAMPLE OF HYPOTHETICAL INTERNAL CRITERIA FOR SELF REPORTED ANNOYANCE TO AIRCRAFT NOISE.

decreases or increases in numbers of aircraft overflights. If the personal decision criteria remain constant, different proportions of the community will express varying degrees of annoyance, as shown in Figure C-2. For example, more people will describe themselves as "very" or "extremely" annoyed and fewer people will describe themselves as "not at all" or "slightly annoyed", as the distribution of aircraft noise exposure shifts to the right.

A metric known as d', based on the distance between the means of the two distributions (normalized by dividing the standard deviation of the leftmost distribution), yields a single parameter that can be used to characterize the entire ROC curve.




* Hypothetical values based on data of Fidell and Teffeteller, 1981

FIGURE C-2. ILLUSTRATION OF DIFFERENCE IN PROPORTIONS OF PEOPLE REPORTING EXTREME ANNOYANCE AS A FUNCTION OF CHANGE IN EXPOSURE RATHER THAN CHANGE IN CRITERIA FOR ANNOYANCE.

## II. APPLICATION TO CURRENT DATA

### A. Invariance of Annoyance Due to Traffic Noise

Distributions of respondents reporting varying degrees of annoyance to the local traffic noise during the preceding week may be examined using the techniques outlined above. Figure C-3 (plotted from the data in Table B-3) shows the cumulative proportions of respondents in each category of annoyance observed in the first round of interviews versus the same figures averaged over the next four rounds of interviews. In this presentation, points lying along the positive diagonal represent a lack of discriminable difference between the variables plotted on the abscissa and the ordinate.

The proximity of the points of Figure C-3 to the positive diagonal therefore illustrate the lack of change in the respondent's reaction to traffic noise exposure throughout the course of this study. Thus, distributions of respondents reporting varying degrees of annoyance due to local street traffic noise during the preceding week were stable and consistent over rounds of interviewing. This finding is hardly surprising, considering the negligible changes in ambient noise levels (see Table 1) in the weeks preceding each round of interviews.

### B. Sensitivity to Changes in Aircraft Noise Exposure

The dependence of annoyance upon aircraft noise exposure is demonstrated in Figure C-4, in which responses to Question 3 are plotted in the fashion described for Figure C-3. The abscissa quantifies normalized cumu-

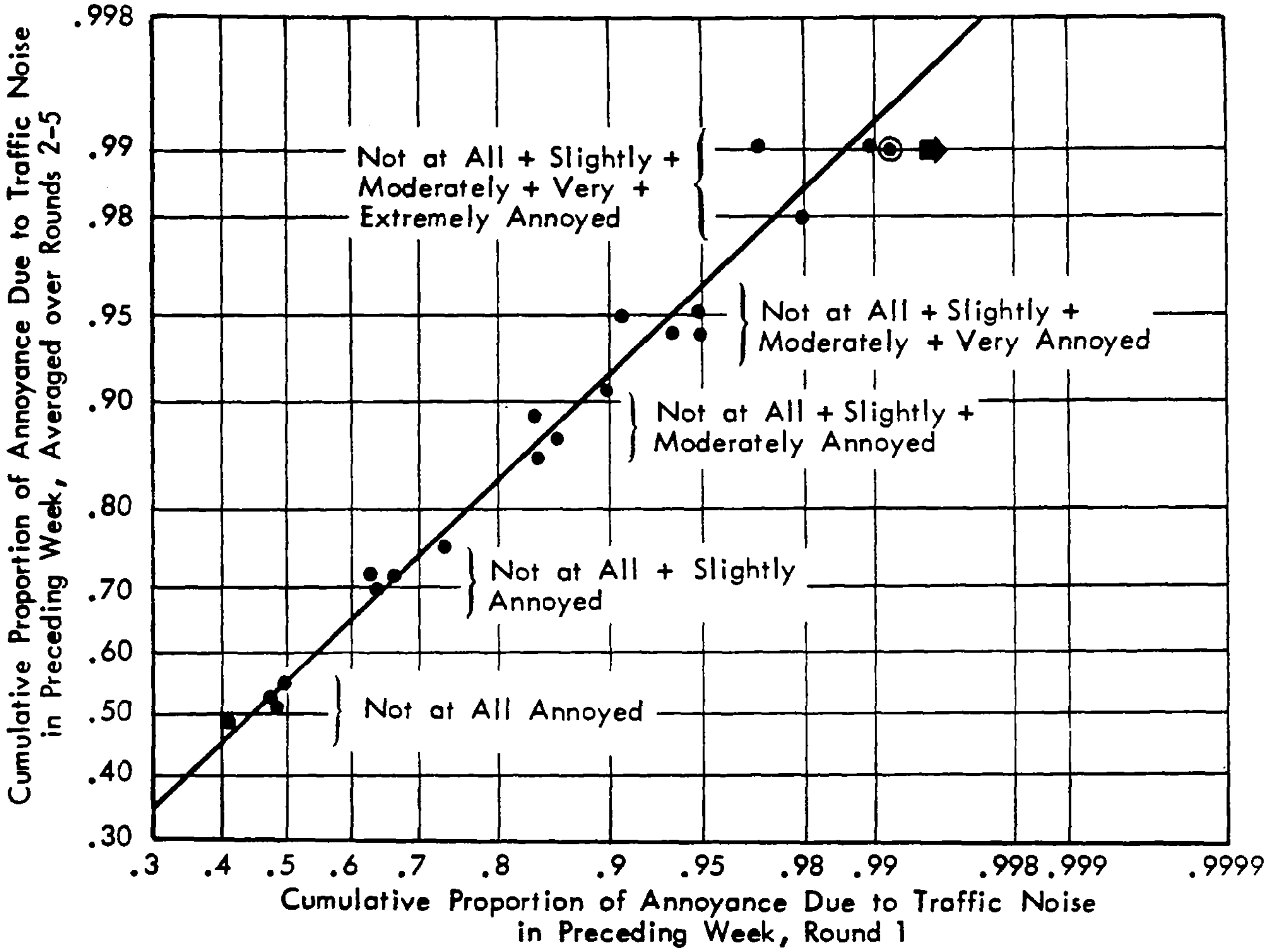



FIGURE C-3. COMPARISON OF DISTRIBUTIONS OF ANNOYANCE TO TRAFFIC NOISE BETWEEN INTERVIEW ROUNDS. EACH POINT REPRESENTS ONE NEIGHBORHOOD.

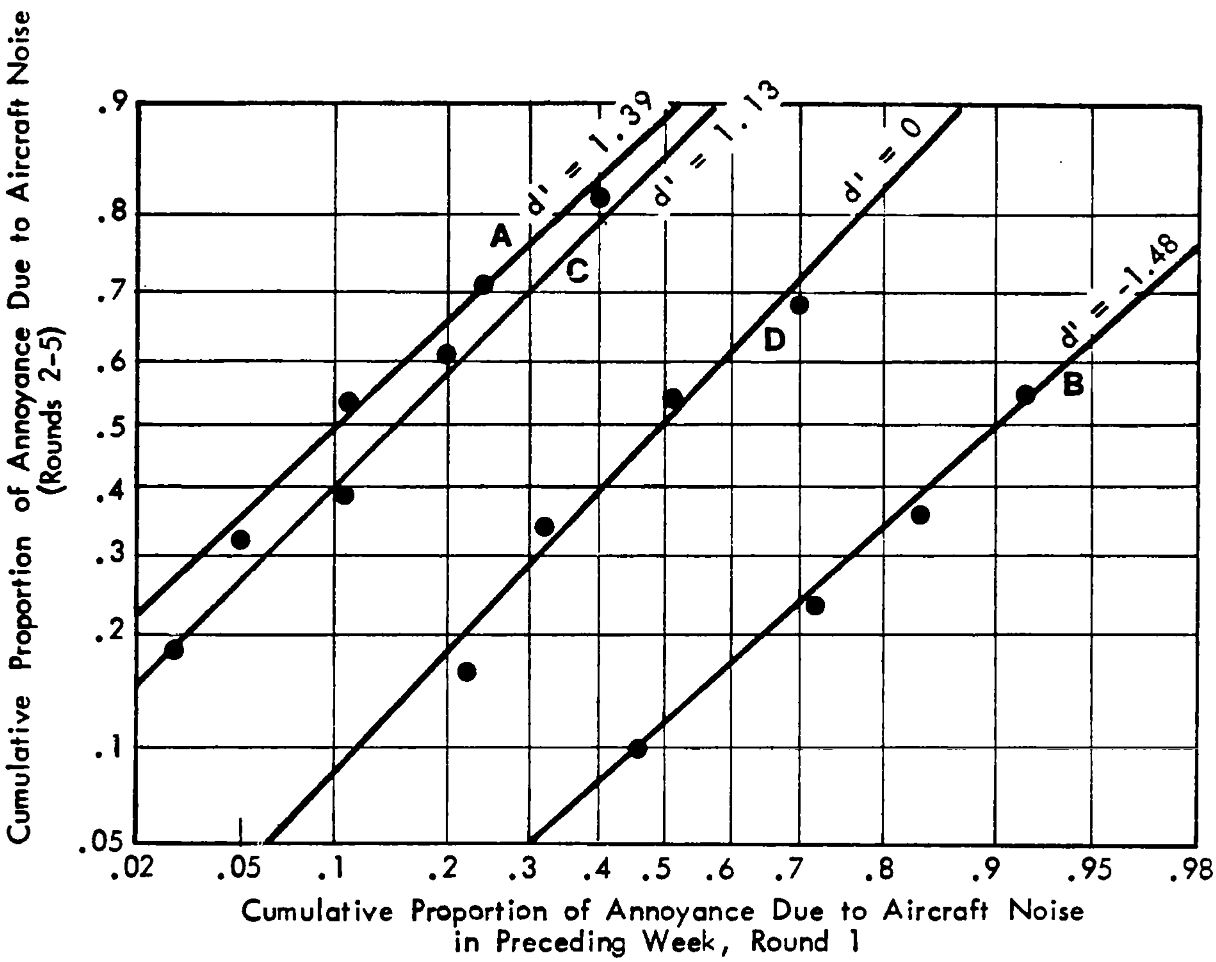



FIGURE C-4. COMPARISON OF DISTRIBUTIONS OF ANNOYANCE TO AIRCRAFT NOISE (OVER PAST WEEK) AMONG INTERVIEW ROUNDS.

lative proportions of respondents expressing varying degrees of annoyance with aircraft noise in the week preceding the first round of interviews. The ordinate quantifies the distribution of annoyance averaged over the following four rounds of interviews.

Several aspects of the relationships revealed in Figure C-4 are noteworthy. First, notice that data for the different neighborhoods are regularly displaced from the positive diagonal by an amount related to the change in exposure. The points for Neighborhoods A and B which underwent the greatest changes in aircraft noise exposure are displaced farthest from the positive diagonal.

The data points for Neighborhood C, which experienced an intermediate change in exposure, are proportionally closer to the positive diagonal. The data points for Neighborhood D, which experienced only slight increases in exposure in rounds 2-4, and a small decrease in round 5, are indistinguishably close to the positive diagonal, as were the annoyance data for street traffic noise in all neighborhoods in Figure C-3.

The values of d' shown in Figure C-4 are indices of how detectable the changes in noise environment were to the respondents in each neighborhood. Given that the variance of annoyance responses (across categories) did not change appreciably with changes in exposure levels (evidenced by the alignment of data points nominally parallel to a unit slope diagonal), d' is the number of standard deviations the mean value of the distribution shifted as a result of the exposure change.

In Figure C-4, the position of the data points for Neighborhood B, below the positive diagonal, results from an observed increase in annoyance from the first round to successive rounds of interviews due to an increase in aircraft noise exposure. The positions of the data points for Neighborhood A and C, above the positive diagonal, result from an observed decrease in annoyance from the first round to successive rounds of interviews due to a decrease in aircraft noise exposure.

Pairs of data points plotted as in Figures C-3 and C-4 lie along a straight line ROC curve (on normal probability axes) only if the underlying assumptions of the signal detection analysis are valid. The straight line ROC curves so plotted will only be parallel to the positive diagonal if the decision criteria remain in the same relative positions in the different exposure conditions. The interested reader is encouraged to consult Green and Swets (1966) for a fuller and more formal background in these types of analyses.

The major implications of the excellent account of the present data given by a detection-theoretical analysis is that changes in community annoyance with changes in aircraft noise exposure are orderly and lawfully governed, and that considerable insight into the processes governing such changes in reaction may be understood in systematic detail.

# APPENDIX D

## DISTRIBUTIONS OF AIRCRAFT NOISE EXPOSURE

A more detailed picture of the noise exposure at the various measurement sites is indicated by the distribution of noise levels over some time period. Therefore, distributions are presented of maximum A-weighted sound levels from individual aircraft noise intrusions compiled from the aircraft noise monitor data acquired in each neighborhood. Figure D-1 through D-12 present a compilation over a one-week period immediately prior to an interview round. The data presented in these figures have been screened on the basis of event duration (top 10 dB). Noise events of unreasonably short or long duration (less than 5 seconds or greater than 45 seconds), and thus unlikely to have arisen from aircraft flyovers, are excluded.

The distributions shown are not exhaustive (i.e., they are not shown for every neighborhood and every interview round). They do, however, present a representative picture of the aircraft noise climate in each neighborhood over the course of the study.

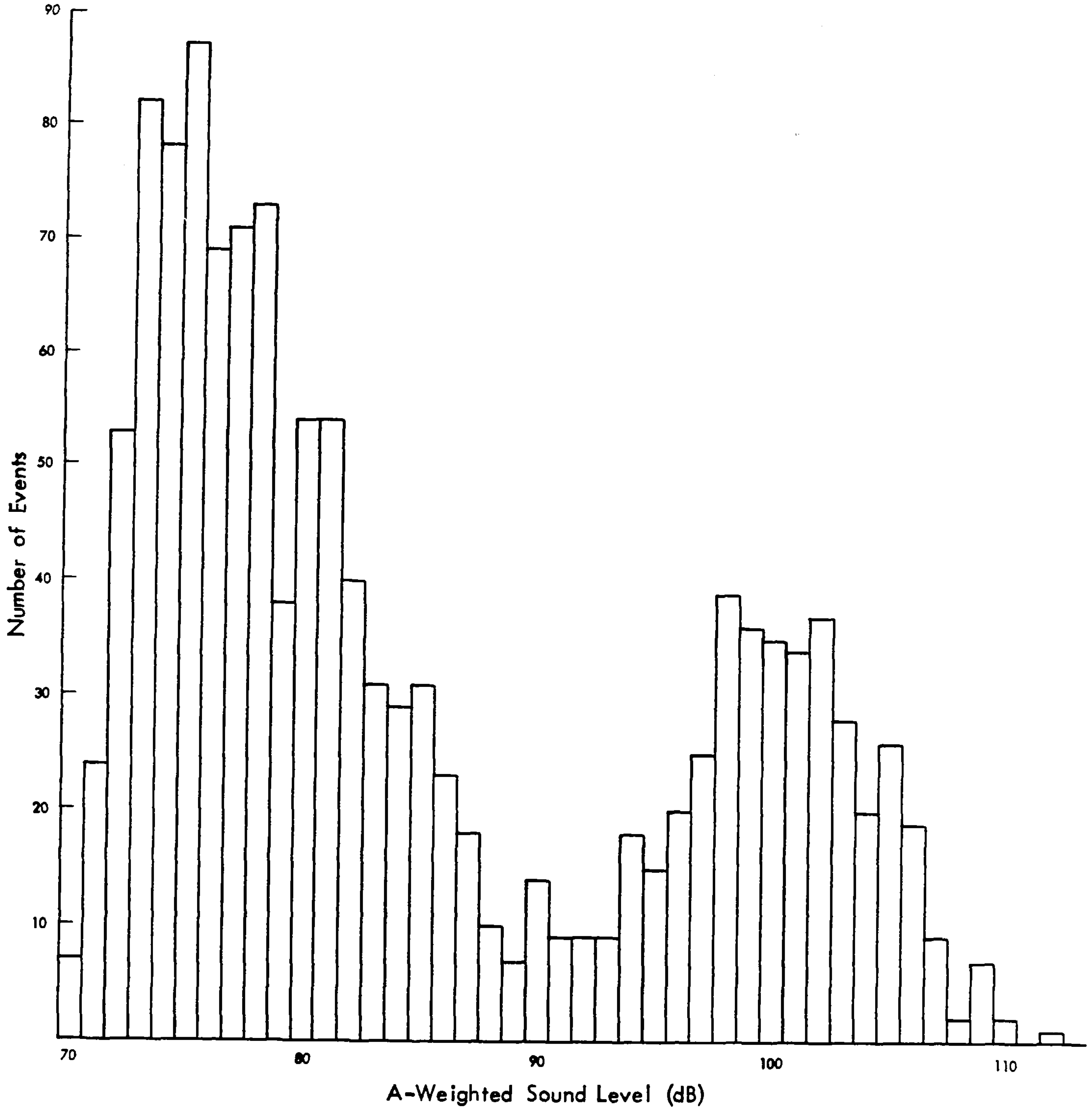



FIGURE D-1. DISTRIBUTION OF MAXIMUM A-WEIGHTED SOUND LEVELS FOR NEIGHBORHOOD A (Week prior to round 1).

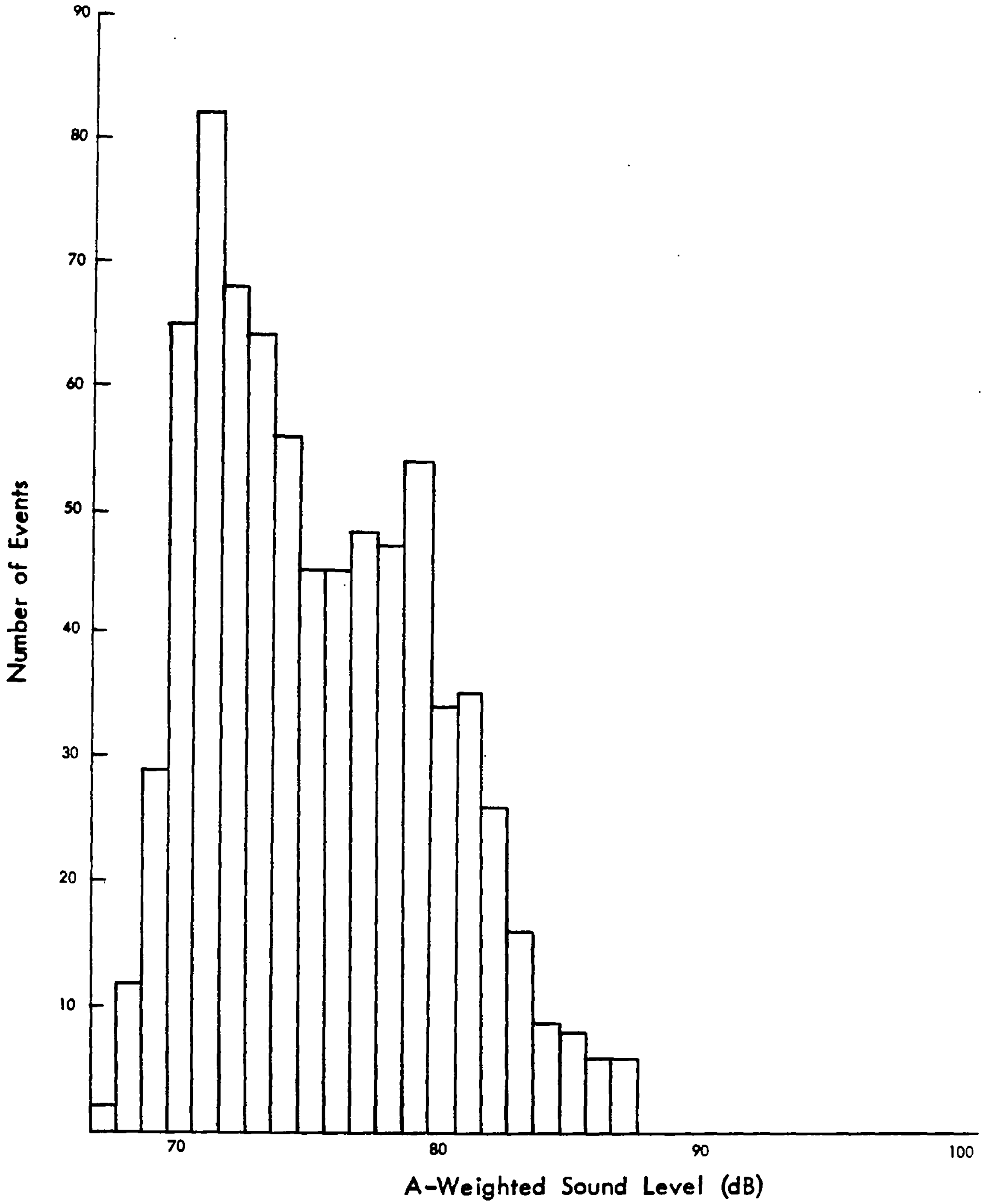



FIGURE D-2. DISTRIBUTION OF MAXIMUM A-WEIGHTED SOUND LEVELS FOR NEIGHBORHOOD A (Week prior to round 4).

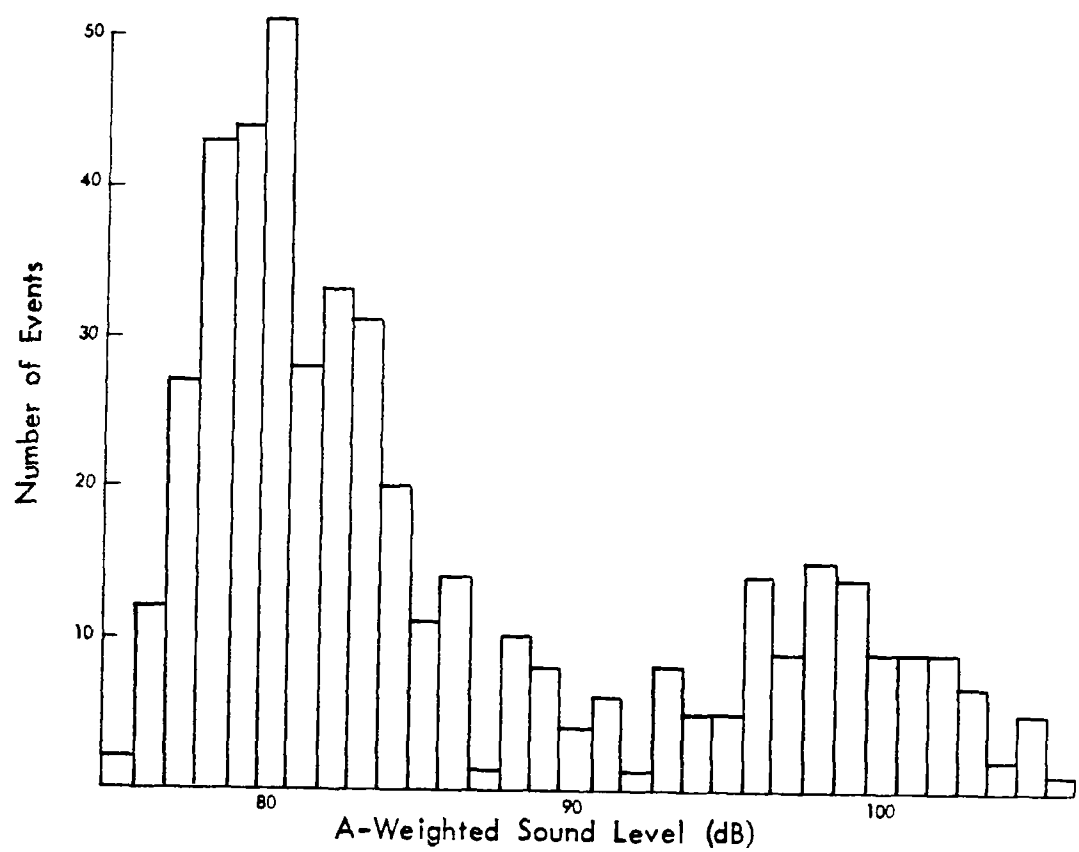



FIGURE D-3. DISTRIBUTION OF MAXIMUM A-WEIGHTED SOUND LEVELS FOR NEIGHBORHOOD A (Week prior to round 5).

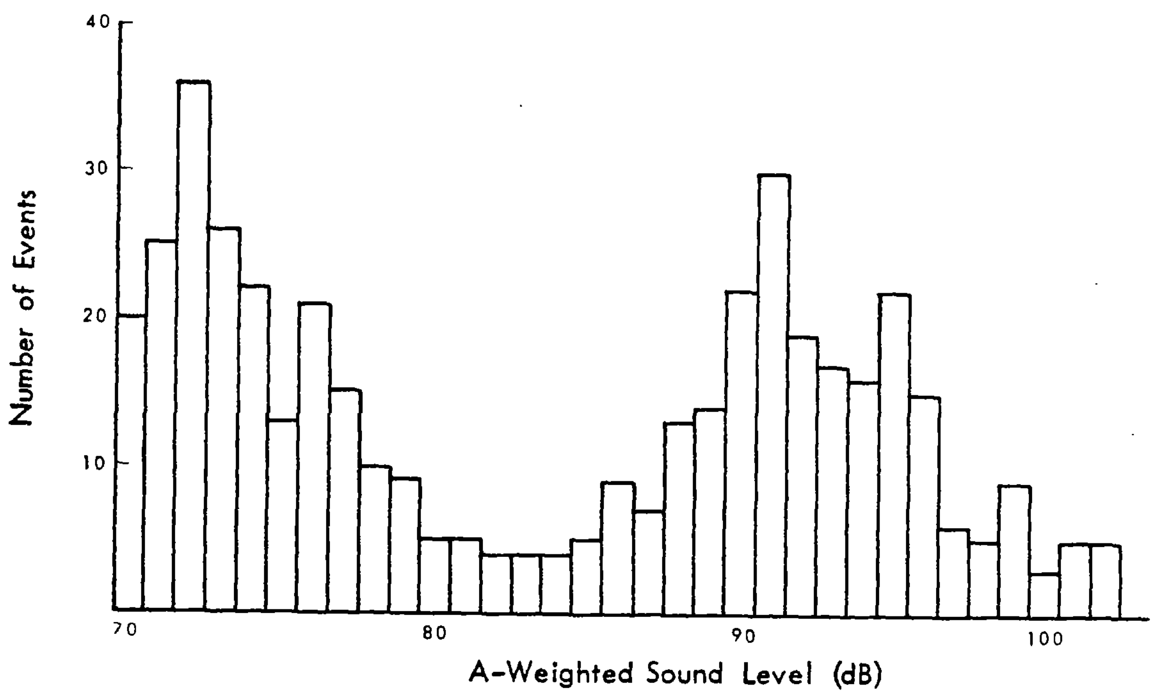



FIGURE D-4. DISTRIBUTION OF MAXIMUM A-WEIGHTED SOUND LEVELS FOR NEIGHBORHOOD B (Week prior to round 2).

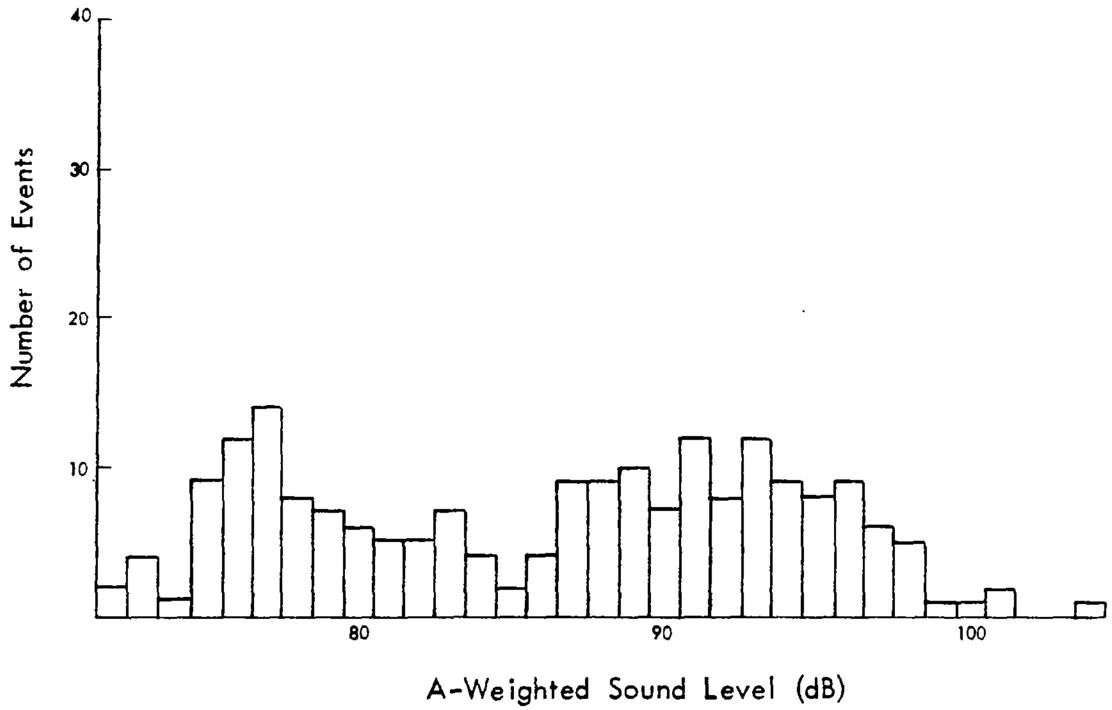



FIGURE D-5. DISTRIBUTION OF MAXIMUM A-WEIGHTED SOUND LEVELS FOR NEIGHBORHOOD B (Week prior to round 5).

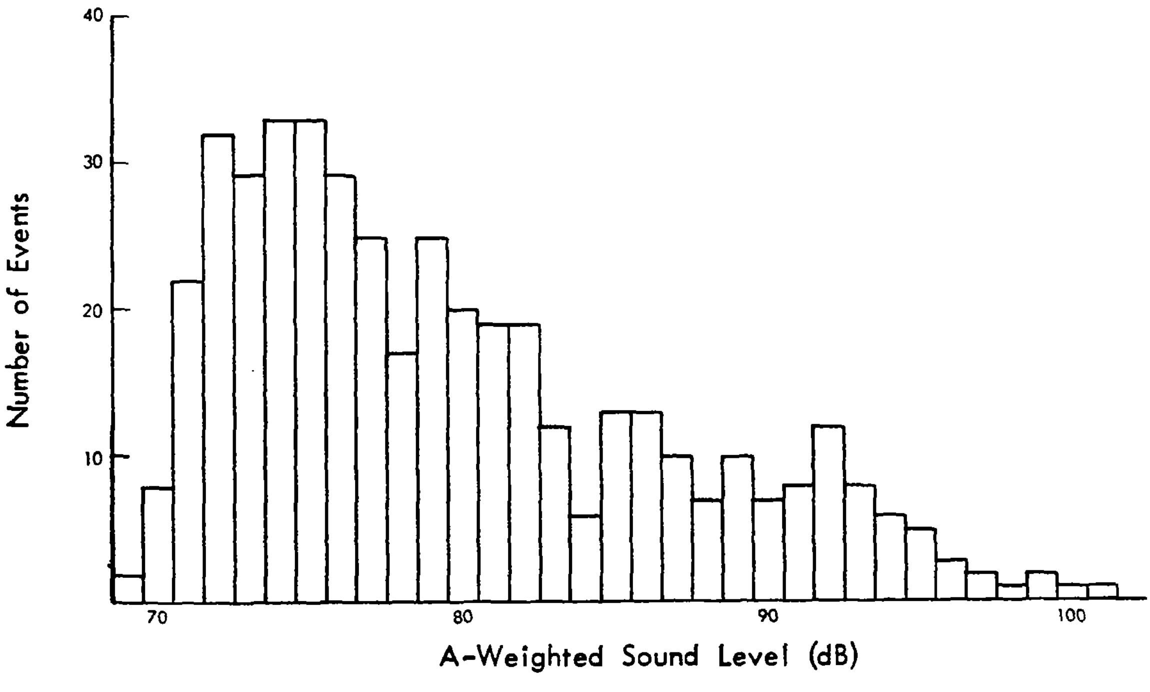



FIGURE D-6. DISTRIBUTION OF MAXIMUM A-WEIGHTED SOUND LEVELS FOR NEIGHBORHOOD C (Week prior to round 1).

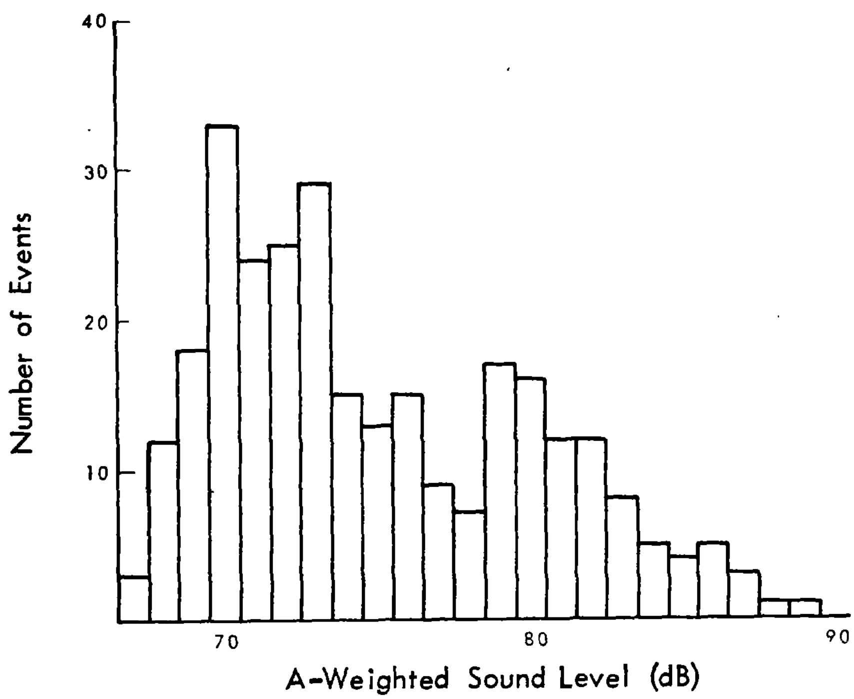



FIGURE D-7. DISTRIBUTION OF MAXIMUM A-WEIGHTED SOUND LEVELS FOR NEIGHBORHOOD C (Week prior to round 2).

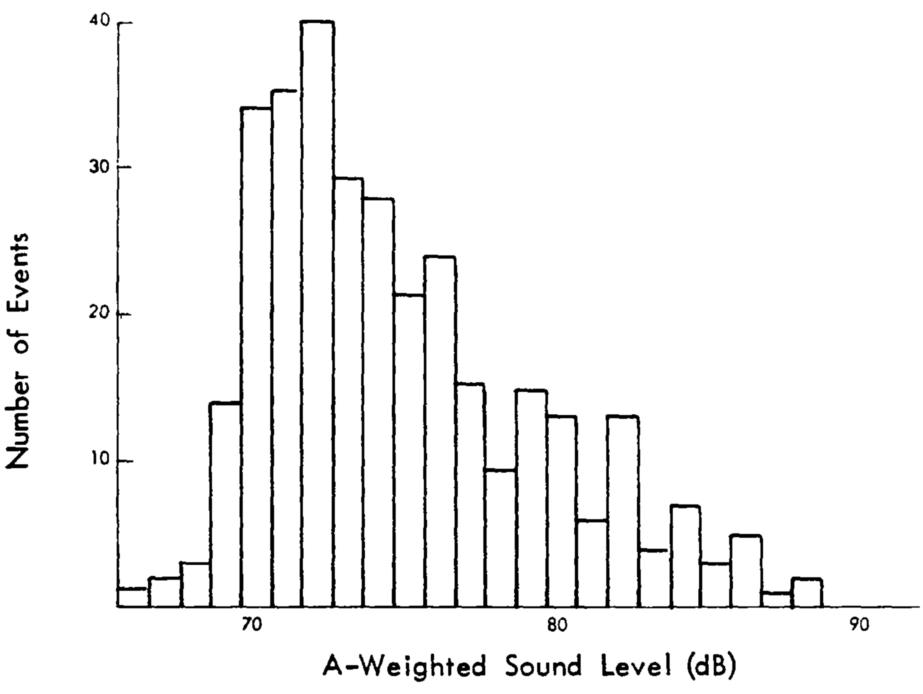



FIGURE D-8. DISTRIBUTION OF MAXIMUM A-WEIGHTED SOUND LEVELS FOR NEIGHBORHOOD C (Week prior to round 4).

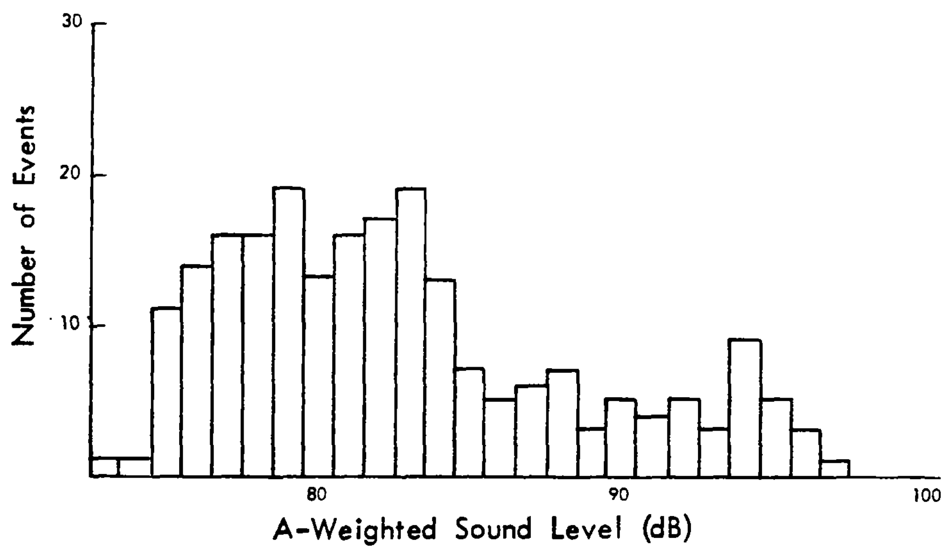



FIGURE D-9. DISTRIBUTION OF MAXIMUM A-WEIGHTED SOUND LEVELS FOR NEIGHBORHOOD C (Week prior to round 5).

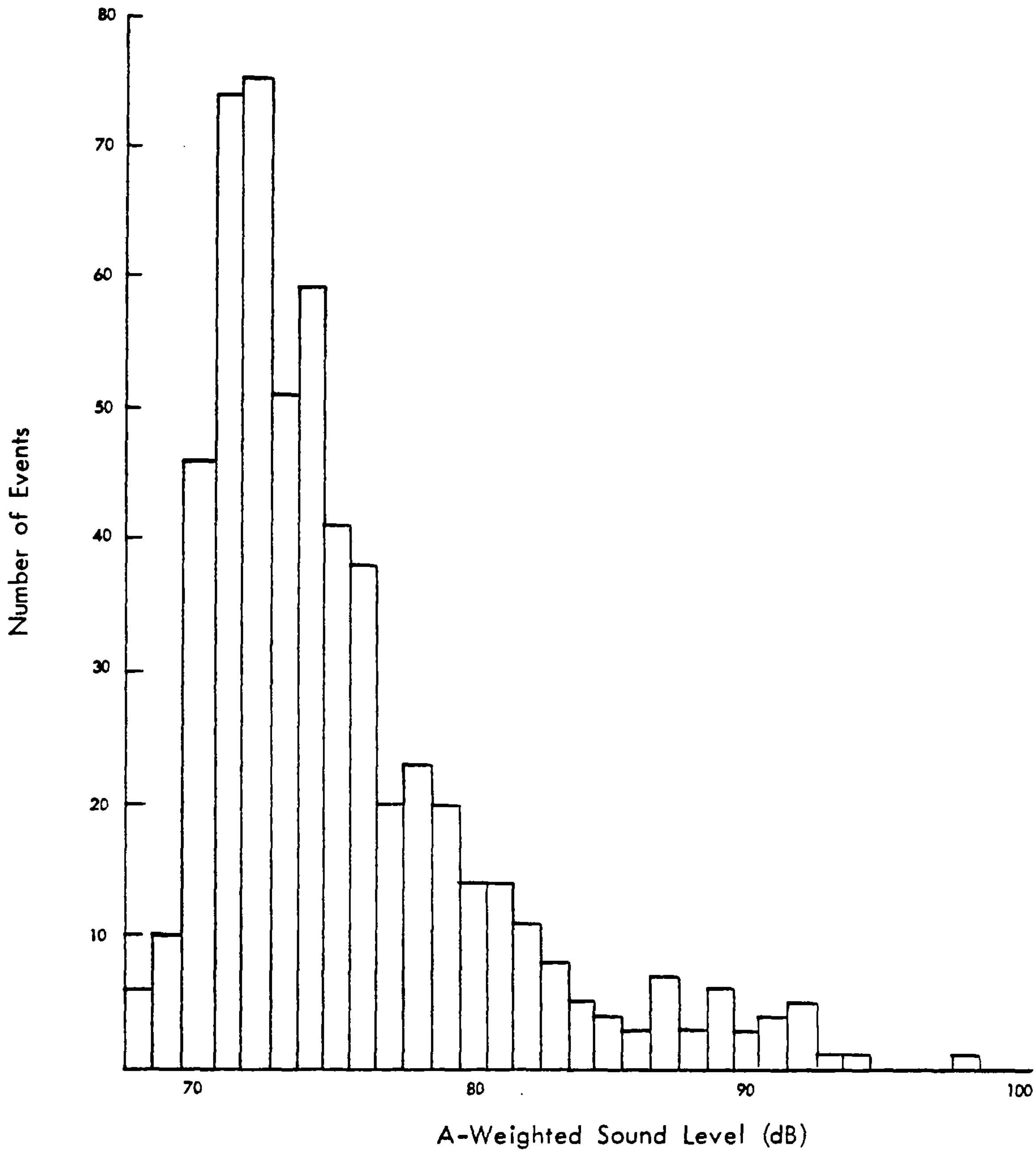



FIGURE D-10. DISTRIBUTION OF MAXIMUM A-WEIGHTED SOUND LEVELS FOR NEIGHBORHOOD D (Week prior to round 2).

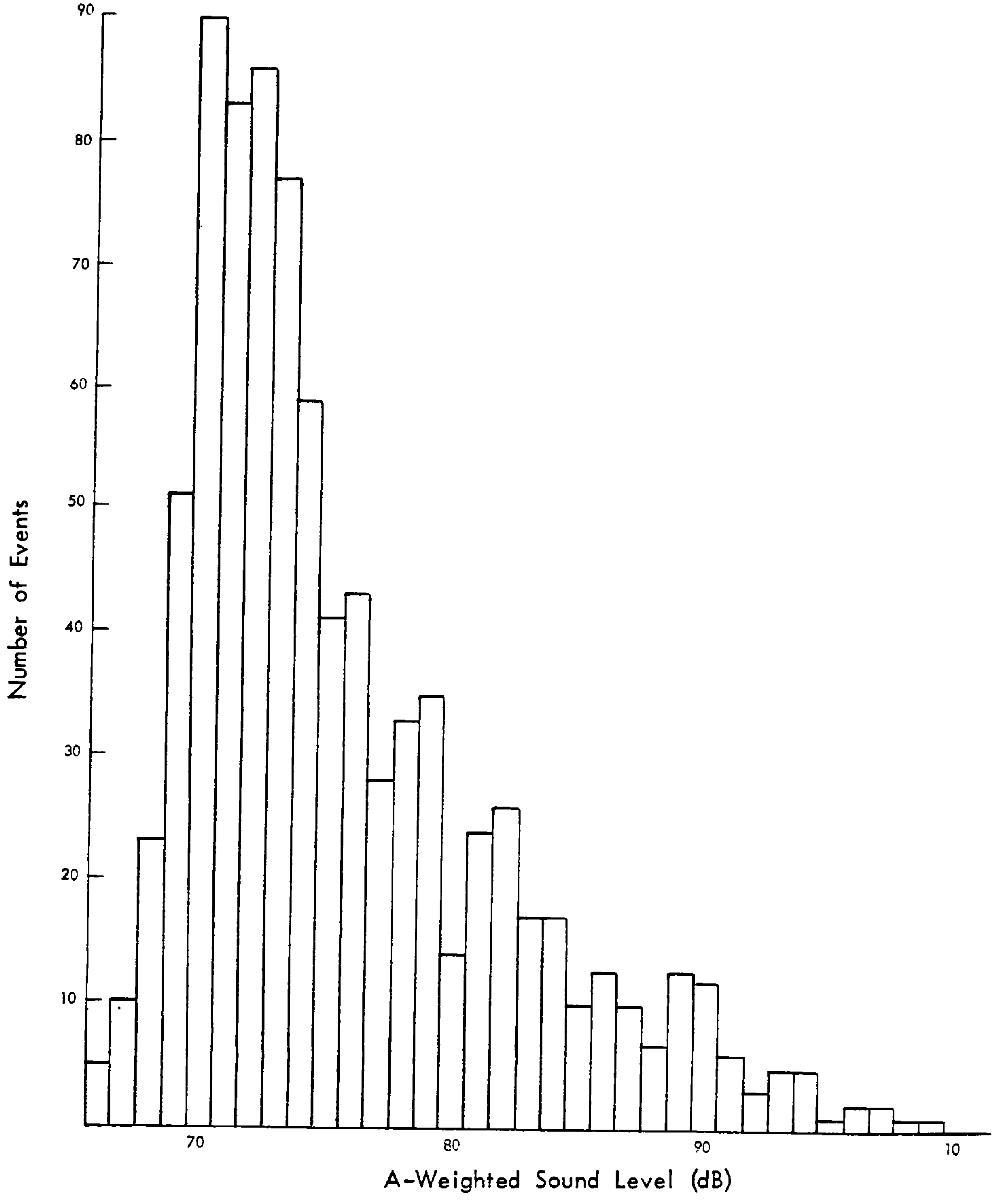



FIGURE D-11. DISTRIBUTION OF MAXIMUM A-WEIGHTED SOUND LEVELS FOR NEIGHBORHOOD D (Week prior to round 4).

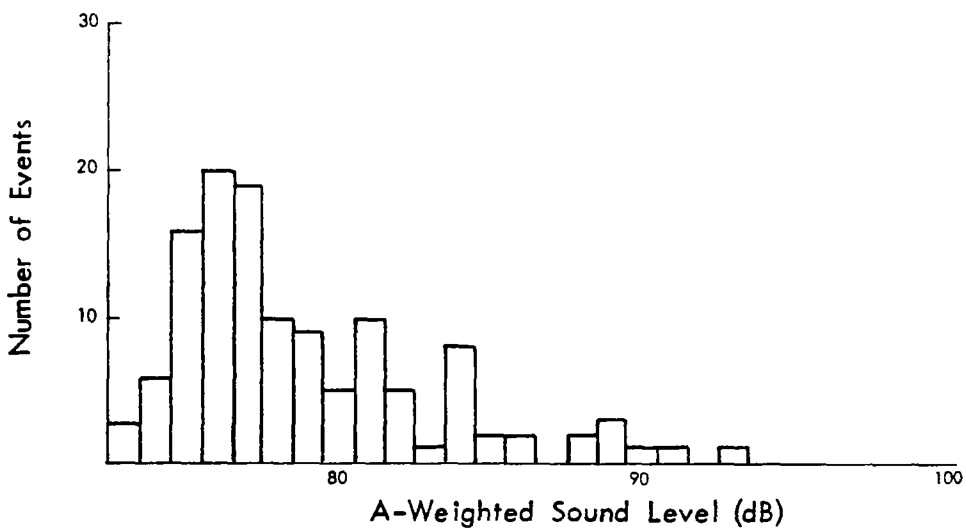



FIGURE D-12. DISTRIBUTION OF MAXIMUM A-WEIGHTED SOUND LEVELS FOR NEIGHBORHOOD D (Week prior to round 5).

## APPENDIX E

## SPATIAL SOUND EXPOSURE DIFFERENTIALS IN NEIGHBORHOOD A

This appendix describes simultaneous sound level monitoring at five sites in Neighborhood A undertaken to quantify the means and extremes of the daily noise exposure range. Neighborhood A is immediately south of the airport, approximately 2 miles from brake release. The predominant noise source is jet aircraft departures on runway 15. Maximum A-weighted sound levels from departing jet aircraft are on the order of 95 to 105 dBA.

Figure E-1 shows the interview area (bounded by the heavy broken line), computer generated noise contours, and the location of the noise monitors. Monitor site 0001 is a remote monitor station (RMS) of the permanent Burbank noise monitor system with a microphone atop a 6-meter high pole along a lightly traveled residential street. Site 0001 is actually outside the interview neighborhood boundary, but provides useful information for establishing gradients. The remaining four sites are in rear yards of single story, single family residences. The microphones at these sites were located atop a 2.4-meter high pole and connected to BBN Model 704 noise monitors described in Appendix A.

Site 2036 is the central site where measurements were acquired in this neighborhood prior to each of the five interview rounds. Site 2141 is typical of the highest noise exposure to be found in the neighborhood, while site 1910 is typical of the lowest. Like site 2036, site 2029 was chosen to be

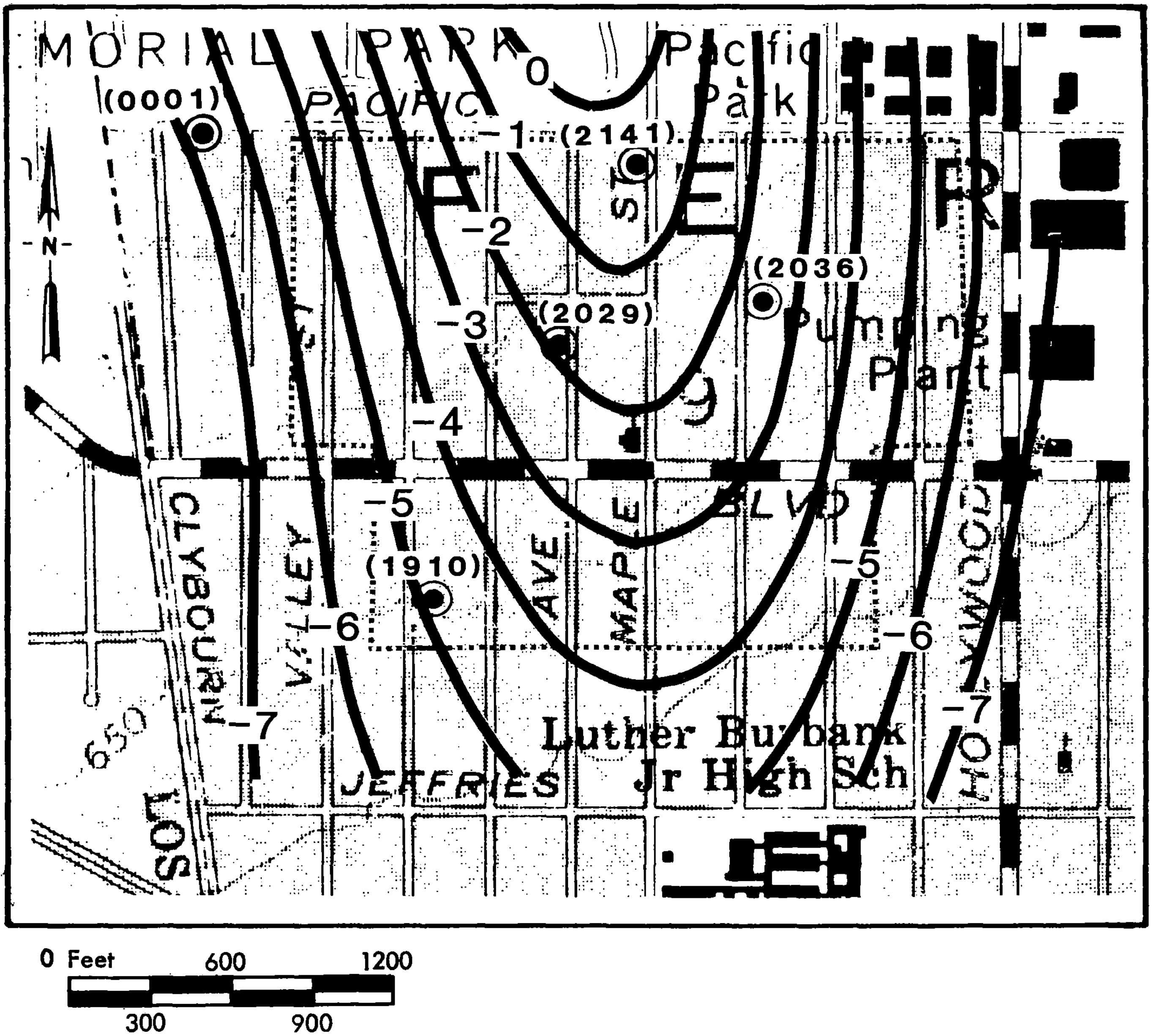



FIGURE E-1. AUXILIARY NOISE MONITOR SITES - NEIGHBORHOOD A.

representative of a neighborhood average. This site was selected by personnel different from those who originally selected site 2036. Noise monitoring equipment was also installed and serviced by different personnel. The period during which these special purpose measurements were made lasted eight calendar days (12-19 January 1981) following interview round 5.

All monitors operated in a threshold detecting mode to distinguish transient noise intrusions from the general background noise in the community. Only those intrusions whose maximum sound level exceeded a preset threshold (approximately 68 dB[A]) were recorded and subsequently tabulated by time of day, maximum A-level, upper 10 dB duration, and SEL (integrated over the time between threshold crossings). Individual SEL's were subsequently energy summed to obtain hourly noise levels (HNL) and Day/Night average levels ($L_{dn}$).

The choice of microphone locations substantially reduced the chance that non-aircraft noise intrusions would be recorded by the noise monitor because ground based noise sources, attenuated by a row of houses, would only rarely produce jet aircraft magnitude sound levels at the microphones. Those non-aircraft intrusions that were recorded were likely to be of sufficiently low level as to effect computed HNL and $L_{dn}$ values only negligibly. Nonetheless, noise monitor records were screened for events of high maximum sound level, but unusually long or short duration. These events (which were extremely rare) were then cross checked against the records of a nearby monitor to see whether or not the same event occurred there simultaneously. If it did not, the event was discarded.

Table E-1 shows the measured $L_{dn}$ at the five measurement sites, along with the deviations from the central site (2036). Only a partial day's data was acquired on the 12th and the 19th since these were equipment installation and removal days. Thus, no $L_{dn}$ values are shown for these calendar days. On the 17th a 2:00 am departure of a C-5A controlled the $L_{dn}$ for the whole day. Hence, the measured $L_{dn}$ on this date was atypical: it did not represent an average over many equally contributing events. The remaining five calendar days were more typical of aircraft operations. $L_{dn}$ comparison statistics are computed over these days only.

An energy average $L_{dn}$ over the five calendar days is also shown in Table E-1 for each site, along with the difference in this energy average from that of the central site. Also shown is the arithmetic average and standard deviation of the daily deviations from the central site. The close agreement (less than 0.1 dB) between the energy and arithmetic average is not surprising, considering the small daily variations. The 95% confidence interval for the arithmetic average is also shown as an aid to interpreting inter-site differences, and differences between measured and predicted exposure.

In addition to the $L_{dn}$ analyses, inter-site comparisons were also made at a more microscopic level. Figures E-2 through E-9 show the hourly noise levels measured at each site and the differences between these and the central site levels (labeled DELTA). Data are incomplete for the 12th and the 19th for reasons discussed earlier. The goal of this fine grained analysis was to reduce the effects of non-aircraft intrusions and nighttime anomalies on the inter-site comparisons.

# TABLE E-1. DAY NIGHT AVERAGE LEVEL COMPARISONS BETWEEN MEASUREMENT SITES IN NEIGHBORHOOD A

| SITE / DATE | 2036 | 2141 | RE: 2036 | 2029 | RE: 2036 | 1910 | RE: 2036 | 0001 | RE: 2036 |
|---|---|---|---|---|---|---|---|---|---|
| 1-13-81 | 76.9 | 78.8 | 1.9 | 76.4 | -0.5 | 72.9 | -4.0 | 71.4 | -5.5 |
| 1-14-81 | 75.5 | 78.2 | 2.7 | 75.5 | 0.0 | 71.9 | -3.6 | 70.0 | -5.5 |
| 1-15-81 | 73.7 | 76.0 | 2.3 | 73.6 | -0.1 | 69.9 | -3.8 | 67.9 | -5.8 |
| 1-16-81 | 73.7 | 76.1 | 2.4 | 73.5 | -0.2 | 70.3 | -3.4 | 68.4 | -5.3 |
| 1-17-81* | 77.9 | 77.0 | | 77.0 | | 69.3 | | 71.0 | |
| 1-18-81 | 71.3 | 73.8 | 2.5 | 71.5 | 0.2 | 67.8 | -3.5 | 65.6 | -5.7 |
| Energy Average | 74.62 | 76.93 | 2.31 | 74.43 | -0.19 | 70.90 | -3.72 | 69.09 | -5.53 |
| Arithmetic Average | | | 2.36 | | -0.12 | | -3.66 | | -5.56 |
| Arithmetic Std. Dev. | | | 0.30 | | 0.26 | | 0.24 | | 0.20 |
| Arithmetic 95% C.I. | | | 0.27 | | 0.23 | | 0.22 | | 0.17 |

* Early morning C-5A departure controls $L_{dn}$ for the day.

S I T E   C O M P A R I S O N   A N A L Y S I S

DATE 01-12-81

REFERENCE SITE = 2036
REFERENCE HNL ACCEPTANCE THRESHOLD = 55.0
COMPARISON HNL ACCEPTANCE THRESHOLD = 55.0

| | 2036 | | 2141 | | 2029 | | 1910 | | 0001 | |
|---|---|---|---|---|---|---|---|---|---|---|
| HOUR | HNL | DELTA | HNL | DELTA | HNL | DELTA | HNL | DELTA | HNL | DELTA |
| ----- NIGHT ----- | | | | | | | | | | |
| 00-01 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 01-02 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 02-03 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 03-04 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 04-05 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 05-06 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 52.0 | 0.0 |
| 06-07 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ----- DAY ----- | | | | | | | | | | |
| 07-08 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 76.0 | 0.0 |
| 08-09 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 74.4 | 0.0 |
| 09-10 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 64.0 | 0.0 |
| 10-11 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 71.7 | 0.0 |
| 11-12 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 74.3 | 0.0 |
| 12-13 | 76.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 72.5 | -3.5* |
| 13-14 | 80.6 | 0.0 | 82.9 | 2.3* | 0.0 | 0.0 | 0.0 | 0.0 | 76.9 | -3.7* |
| 14-15 | 79.0 | 0.0 | 81.3 | 2.3* | 75.6 | -3.4* | 68.6 | -10.4* | 72.8 | -6.2* |
| 15-16 | 77.8 | 0.0 | 78.4 | .6* | 79.0 | 1.2* | 76.9 | -.9* | 72.3 | -5.5* |
| 15-17 | 80.4 | 0.0 | 83.0 | 2.6* | 80.1 | -.3* | 75.8 | -4.6* | 73.2 | -7.2* |
| 17-18 | 78.9 | 0.0 | 81.3 | 2.4* | 78.2 | -.7* | 73.9 | -5.0* | 72.0 | -6.9* |
| 18-19 | 70.9 | 0.0 | 73.4 | 2.5* | 71.2 | .3* | 67.3 | -3.6* | 67.8 | -3.1* |
| ----- EVENING ----- | | | | | | | | | | |
| 19-20 | 79.2 | 0.0 | 82.9 | 3.7* | 81.1 | 1.9* | 78.3 | -.9* | 74.3 | -4.9* |
| 20-21 | 50.3 | 0.0 | 53.1 | 0.0 | 48.7 | 0.0 | 44.7 | 0.0 | 60.0 | 0.0 |
| 21-22 | 49.3 | 0.0 | 48.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 55.8 | 0.0 |
| ----- NIGHT ----- | | | | | | | | | | |
| 22-23 | 58.8 | 0.0 | 60.6 | 1.8* | 59.2 | .4* | 56.5 | -2.3* | 56.9 | -1.9* |
| 23-00 | 50.9 | 0.0 | 56.6 | 0.0 | 54.3 | 0.0 | 54.9 | 0.0 | 53.2 | 0.0 |

FIGURE E-2. HOURLY AIRCRAFT NOISE LEVEL COMPARISON AT 5 SITES IN INTERVIEW NEIGHBORHOOD A, 12 JANUARY 1981.

S I T E   C O M P A R I S O N   A N A L Y S I S

DATE 01-13-81

REFERENCE SITE = 2036
REFERENCE HNL ACCEPTANCE THRESHOLD = 55.0
COMPARISON HNL ACCEPTANCE THRESHOLD = 55.0

| | 2036 | | 2141 | | 2029 | | 1910 | | 0001 | |
|---|---|---|---|---|---|---|---|---|---|---|
| HOUR | HNL | DELTA | HNL | DELTA | HNL | DELTA | HNL | DELTA | HNL | DELTA |
| ----- NIGHT ----- | | | | | | | | | | |
| 00-01 | 50.7 | 0.0 | 48.7 | 0.0 | 45.7 | 0.0 | 41.0 | 0.0 | 0.0 | 0.0 |
| 01-02 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 02-03 | 47.3 | 0.0 | 53.2 | 0.0 | 49.2 | 0.0 | 50.2 | 0.0 | 52.1 | 0.0 |
| 03-04 | 56.6 | 0.0 | 59.5 | 2.9* | 54.3 | -2.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| 04-05 | 33.4 | 0.0 | 42.5 | 0.0 | 34.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 05-06 | 0.0 | 0.0 | 0.0 | 0.0 | 35.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 06-07 | 57.1 | 0.0 | 58.4 | 1.3* | 55.4 | -1.7* | 45.1 | -12.0 | 61.5 | 4.4* |
| ----- DAY ----- | | | | | | | | | | |
| 07-08 | 82.0 | 0.0 | 84.3 | 2.3* | 80.5 | -1.5* | 77.0 | -5.0* | 77.6 | -4.4* |
| 08-09 | 82.6 | 0.0 | 85.8 | 3.2* | 82.5 | -.1* | 77.9 | -4.7* | 74.7 | -7.9* |
| 09-10 | 57.7 | 0.0 | 59.3 | 1.6* | 56.7 | -1.0* | 51.4 | -6.3 | 0.0 | 0.0 |
| 10-11 | 78.3 | 0.0 | 80.2 | 1.9* | 78.6 | .3* | 75.5 | -2.8* | 71.2 | -7.1* |
| 11-12 | 75.6 | 0.0 | 77.3 | 1.7* | 74.6 | -1.0* | 71.6 | -4.0* | 67.4 | -8.2* |
| 12-13 | 75.2 | 0.0 | 76.8 | 1.6* | 74.4 | -.8* | 70.1 | -5.1* | 74.8 | -.4* |
| 13-14 | 78.8 | 0.0 | 80.4 | 1.6* | 79.1 | .3* | 76.5 | -2.3* | 75.1 | -3.7* |
| 14-15 | 72.5 | 0.0 | 75.3 | 2.8* | 72.8 | .3* | 71.2 | -1.3* | 68.4 | -4.1* |
| 15-16 | 76.2 | 0.0 | 76.4 | .2* | 73.1 | -3.1* | 67.5 | -8.7* | 67.7 | -8.5* |
| 16-17 | 77.1 | 0.0 | 80.6 | 3.5* | 79.1 | 2.0* | 77.6 | .5* | 72.1 | -5.0* |
| 17-18 | 76.0 | 0.0 | 78.8 | 2.8* | 76.8 | .3* | 74.3 | -1.7* | 70.4 | -5.6* |
| 18-19 | 72.4 | 0.0 | 74.3 | 1.9* | 71.7 | -.7* | 68.1 | -4.3* | 68.6 | -3.8* |
| ----- EVENING ----- | | | | | | | | | | |
| 19-20 | 79.6 | 0.0 | 82.6 | 3.0* | 81.0 | 1.4* | 78.9 | -.7* | 73.9 | -5.7* |
| 20-21 | 51.9 | 0.0 | 55.5 | 0.0 | 52.0 | 0.0 | 45.4 | 0.0 | 55.8 | 0.0 |
| 21-22 | 40.9 | 0.0 | 44.4 | 0.0 | 33.4 | 0.0 | 35.4 | 0.0 | 56.2 | 0.0 |
| ----- NIGHT ----- | | | | | | | | | | |
| 22-23 | 75.5 | 0.0 | 75.4 | -.1* | 73.3 | -2.2* | 67.4 | -8.1* | 68.6 | -6.9* |
| 23-00 | 56.0 | 0.0 | 58.3 | 2.3* | 58.5 | 2.5* | 58.6 | 2.6* | 57.3 | 1.3* |

FIGURE E-3. HOURLY AIRCRAFT NOISE LEVEL COMPARISON AT 5 SITES IN INTERVIEW NEIGHBORHOOD A, 13 JANUARY 1981.

S I T E   C O M P A R I S O N   A N A L Y S I S

DATE 01-14-81

REFERENCE SITE = 2036
REFERENCE HNL ACCEPTANCE THRESHOLD = 55.0
COMPARISON HNL ACCEPTANCE THRESHOLD = 55.0

| | 2036 | | 2141 | | 2029 | | 1910 | | 0001 | |
|---|---|---|---|---|---|---|---|---|---|---|
| HOUR | HNL | DELTA | HNL | DELTA | HNL | DELTA | HNL | DELTA | HNL | DELTA |
| ----- NIGHT ----- | | | | | | | | | | |
| 00-01 | 50.7 | 0.0 | 51.6 | 0.0 | 50.5 | 0.0 | 51.6 | 0.0 | 0.0 | 0.0 |
| 01-02 | 50.9 | 0.0 | 55.5 | 0.0 | 50.6 | 0.0 | 44.2 | 0.0 | 0.0 | 0.0 |
| 02-03 | 52.8 | 0.0 | 54.8 | 0.0 | 51.6 | 0.0 | 50.5 | 0.0 | 56.6 | 0.0 |
| 03-04 | 38.0 | 0.0 | 48.4 | 0.0 | 35.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 04-05 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 05-06 | 0.0 | 0.0 | 48.0 | 0.0 | 47.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 05-07 | 61.2 | 0.0 | 64.7 | 3.5* | 60.5 | -.7* | 58.8 | -2.4* | 60.6 | -.6* |
| ----- DAY ----- | | | | | | | | | | |
| 07-08 | 80.9 | 0.0 | 83.6 | 2.7* | 80.7 | -.2* | 77.2 | -3.7* | 75.2 | -5.7* |
| 08-09 | 80.3 | 0.0 | 82.9 | 2.6* | 78.8 | -1.5* | 74.7 | -5.6* | 74.2 | -6.1* |
| 09-10 | 79.8 | 0.0 | 82.0 | 2.2* | 78.0 | -1.8* | 72.5 | -7.3* | 72.2 | -7.6* |
| 10-11 | 73.3 | 0.0 | 75.8 | 2.5* | 75.2 | 1.9* | 73.4 | .1* | 67.4 | -5.9* |
| 11-12 | 78.7 | 0.0 | 81.1 | 2.4* | 78.7 | 0.0* | 75.7 | -3.0* | 72.4 | -6.3* |
| 12-13 | 76.8 | 0.0 | 79.4 | 2.6* | 77.5 | .7* | 73.8 | -3.0* | 72.8 | -4.0* |
| 13-14 | 79.7 | 0.0 | 81.2 | 1.5* | 79.3 | -.4* | 75.6 | -4.1* | 75.1 | -4.6* |
| 14-15 | 75.2 | 0.0 | 77.5 | 2.3* | 75.1 | -.1* | 71.9 | -3.3* | 70.8 | -4.4* |
| 15-16 | 62.5 | 0.0 | 64.4 | 1.9* | 62.9 | .4* | 57.6 | -4.9* | 60.2 | -2.3* |
| 16-17 | 78.2 | 0.0 | 81.3 | 3.1* | 77.9 | -.3* | 73.8 | -4.4* | 71.5 | -6.7* |
| 17-18 | 74.8 | 0.0 | 78.5 | 3.7* | 77.1 | 2.3* | 74.1 | -.7* | 70.8 | -4.0* |
| 18-19 | 76.3 | 0.0 | 79.9 | 3.6* | 78.5 | 2.2* | 75.8 | -.5* | 70.4 | -5.9* |
| ----- EVENING ----- | | | | | | | | | | |
| 19-20 | 79.8 | 0.0 | 82.7 | 2.9* | 80.3 | .5* | 75.1 | -4.7* | 71.7 | -8.1* |
| 20-21 | 52.6 | 0.0 | 54.1 | 0.0 | 50.9 | 0.0 | 43.7 | 0.0 | 55.8 | 0.0 |
| 21-22 | 54.4 | 0.0 | 56.2 | 0.0 | 55.2 | 0.0 | 51.9 | 0.0 | 0.0 | 0.0 |
| ----- NIGHT ----- | | | | | | | | | | |
| 22-23 | 57.3 | 0.0 | 61.1 | 3.8* | 59.3 | 2.0* | 57.6 | .3* | 57.3 | 0.0* |
| 23-00 | 51.9 | 0.0 | 52.0 | 0.0 | 54.2 | 0.0 | 56.0 | 0.0 | 57.2 | 0.0 |

FIGURE E-4. HOURLY AIRCRAFT NOISE LEVEL COMPARISON AT 5 SITES IN INTERVIEW NEIGHBORHOOD A, 14 JANUARY 1981.

S I T E   C O M P A R I S O N   A N A L Y S I S

DATE 01-15-81

REFERENCE SITE = 2036
REFERENCE HNL ACCEPTANCE THRESHOLD = 55.0
COMPARISON HNL ACCEPTANCE THRESHOLD = 55.0

| | 2036 | | 2141 | | 2029 | | 1910 | | 0001 | |
|---|---|---|---|---|---|---|---|---|---|---|
| HOUR | HNL | DELTA | HNL | DELTA | HNL | DELTA | HNL | DELTA | HNL | DELTA |
| ----- NIGHT ----- | | | | | | | | | | |
| 00-01 | 50.6 | 0.0 | 51.0 | 0.0 | 50.5 | 0.0 | 40.2 | 0.0 | 0.0 | 0.0 |
| 01-02 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 02-03 | 49.1 | 0.0 | 53.4 | 0.0 | 51.6 | 0.0 | 48.9 | 0.0 | 59.0 | 0.0 |
| 03-04 | 47.2 | 0.0 | 48.5 | 0.0 | 45.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 04-05 | 52.7 | 0.0 | 52.1 | 0.0 | 34.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 05-06 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 06-07 | 62.2 | 0.0 | 65.1 | 2.9* | 60.8 | -1.4* | 53.9 | -8.3 | 60.0 | -2.2* |
| ----- DAY ----- | | | | | | | | | | |
| 07-08 | 75.7 | 0.0 | 78.7 | 3.0* | 74.7 | -1.0* | 70.0 | -5.7* | 73.6 | -2.1* |
| 08-09 | 80.5 | 0.0 | 83.0 | 2.5* | 81.2 | .7* | 77.3 | -3.2* | 73.0 | -7.5* |
| 09-10 | 73.1 | 0.0 | 76.2 | 3.1* | 75.4 | 2.3* | 73.9 | .8* | 69.1 | -4.0* |
| 10-11 | 77.8 | 0.0 | 80.6 | 2.8* | 77.6 | -.2* | 72.8 | -5.0* | 72.0 | -5.8* |
| 11-12 | 73.0 | 0.0 | 76.5 | 3.5* | 75.4 | 2.4* | 75.0 | 2.0* | 67.2 | -5.8* |
| 12-13 | 76.4 | 0.0 | 79.4 | 3.0* | 77.5 | 1.1* | 71.3 | -5.1* | 68.6 | -7.8* |
| 13-14 | 70.6 | 0.0 | 74.5 | 3.9* | 73.5 | 2.9* | 68.9 | -1.7* | 67.6 | -3.0* |
| 14-15 | 77.9 | 0.0 | 79.0 | 1.1* | 75.2 | -2.7* | 71.0 | -6.9* | 67.7 | -10.2* |
| 15-16 | 68.3 | 0.0 | 69.6 | 1.3* | 68.7 | .4* | 64.8 | -3.5* | 62.1 | -6.2* |
| 16-17 | 73.9 | 0.0 | 75.9 | 2.0* | 70.7 | -3.2* | 64.9 | -9.0* | 66.8 | -7.1* |
| 17-18 | 78.2 | 0.0 | 79.0 | .8* | 76.7 | -1.5* | 71.0 | -7.2* | 70.1 | -8.1* |
| 18-19 | 67.7 | 0.0 | 69.9 | 2.2* | 69.0 | 1.3* | 65.0 | -2.7* | 67.6 | -.1* |
| ----- EVENING ----- | | | | | | | | | | |
| 19-20 | 76.1 | 0.0 | 78.0 | 1.9* | 74.2 | -1.9* | 68.4 | -7.7* | 68.3 | -7.8* |
| 20-21 | 72.1 | 0.0 | 74.8 | 2.7* | 73.9 | 1.8* | 72.8 | .7* | 64.3 | -7.8* |
| 21-22 | 58.3 | 0.0 | 61.3 | 3.0* | 59.0 | .7* | 57.2 | -1.1* | 56.7 | -1.6* |
| ----- NIGHT ----- | | | | | | | | | | |
| 22-23 | 58.2 | 0.0 | 59.3 | 1.1* | 58.7 | .5* | 54.6 | -3.6 | 55.1 | -3.1* |
| 23-00 | 52.9 | 0.0 | 55.8 | 0.0 | 55.3 | 0.0 | 57.9 | 0.0 | 53.1 | 0.0 |

FIGURE E-5. HOURLY AIRCRAFT NOISE LEVEL COMPARISON AT 5 SITES IN INTERVIEW NEIGHBORHOOD A, 15 JANUARY 1981.

S I T E   C O M P A R I S O N   A N A L Y S I S

DATE 01-16-81

REFERENCE SITE = 2036
REFERENCE HNL ACCEPTANCE THRESHOLD = 55.0
COMPARISON HNL ACCEPTANCE THRESHOLD = 55.0

| | 2036 | | 2141 | | 2029 | | 1910 | | 0001 | |
|---|---|---|---|---|---|---|---|---|---|---|
| HOUR | HNL | DELTA | HNL | DELTA | HNL | DELTA | HNL | DELTA | HNL | DELTA |
| ----- NIGHT ----- | | | | | | | | | | |
| 00-01 | 48.6 | 0.0 | 48.9 | 0.0 | 37.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 01-02 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 02-03 | 47.2 | 0.0 | 39.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 03-04 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 04-05 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 05-06 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 06-07 | 60.5 | 0.0 | 62.2 | 1.7* | 59.5 | -1.0* | 57.4 | -3.1* | 60.8 | .3* |
| ----- DAY ----- | | | | | | | | | | |
| 07-08 | 77.5 | 0.0 | 80.3 | 2.8* | 79.0 | 1.5* | 76.9 | -.6* | 75.0 | -2.5* |
| 08-09 | 81.1 | 0.0 | 84.0 | 2.9* | 82.4 | 1.3* | 79.7 | -1.4* | 76.8 | -4.3* |
| 09-10 | 62.3 | 0.0 | 63.9 | 1.6* | 61.1 | -1.2* | 59.1 | -3.2* | 61.1 | -1.2* |
| 10-11 | 62.0 | 0.0 | 62.0 | 0.0* | 59.0 | -3.0* | 65.6 | 3.6* | 62.6 | .6* |
| 11-12 | 60.7 | 0.0 | 62.6 | 1.9* | 59.1 | -1.5* | 56.8 | -3.9* | 62.9 | 2.2* |
| 12-13 | 73.2 | 0.0 | 75.4 | 2.2* | 72.6 | -.5* | 65.1 | -8.1* | 65.6 | -7.6* |
| 13-14 | 60.3 | 0.0 | 60.8 | .5* | 56.3 | -4.0* | 54.6 | -5.7 | 63.3 | 3.0* |
| 14-15 | 57.2 | 0.0 | 60.1 | 2.9* | 55.0 | -2.2* | 52.3 | -4.9 | 63.7 | 6.5* |
| 15-16 | 54.0 | 0.0 | 57.8 | 0.0 | 54.9 | 0.0 | 50.4 | 0.0 | 62.4 | 0.0 |
| 15-17 | 80.9 | 0.0 | 82.3 | 1.4* | 76.3 | -4.5* | 69.6 | -11.3* | 70.1 | -10.8* |
| 17-18 | 78.1 | 0.0 | 80.2 | 2.1* | 77.7 | -.4* | 74.8 | -3.3* | 74.0 | -4.1* |
| 18-19 | 61.1 | 0.0 | 64.1 | 3.0* | 61.6 | .5* | 60.1 | -1.0* | 62.1 | 1.0* |
| ----- EVENING ----- | | | | | | | | | | |
| 19-20 | 80.2 | 0.0 | 82.7 | 2.5* | 79.0 | -1.2* | 73.3 | -6.9* | 70.9 | -9.3* |
| 20-21 | 76.7 | 0.0 | 79.4 | 2.7* | 78.6 | 1.9* | 75.1 | -1.6* | 68.9 | -7.8* |
| 21-22 | 56.1 | 0.0 | 59.5 | 3.4* | 55.6 | .5* | 55.6 | -.5* | 61.9 | 5.8* |
| ----- NIGHT ----- | | | | | | | | | | |
| 22-23 | 52.3 | 0.0 | 51.4 | 0.0 | 51.4 | 0.0 | 54.6 | 0.0 | 49.9 | 0.0 |
| 23-00 | 50.2 | 0.0 | 51.4 | 0.0 | 47.3 | 0.0 | 46.7 | 0.0 | 0.0 | 0.0 |

FIGURE E-6. HOURLY AIRCRAFT NOISE LEVEL COMPARISON AT 5 SITES IN INTERVIEW NEIGHBORHOOD A, 16 JANUARY 1981.

S I T E   C O M P A R I S O N   A N A L Y S I S

DATE 01-17-81

REFERENCE SITE = 2036
REFERENCE HNL ACCEPTANCE THRESHOLD = 55.0
COMPARISON HNL ACCEPTANCE THRESHOLD = 55.0

| | 2036 | | 2141 | | 2029 | | 1910 | | 0001 | |
|---|---|---|---|---|---|---|---|---|---|---|
| HOUR | HNL | DELTA | HNL | DELTA | HNL | DELTA | HNL | DELTA | HNL | DELTA |
| ----- NIGHT ----- | | | | | | | | | | |
| 00-01 | 0.0 | 0.0 | 53.7 | 0.0 | 34.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 01-02 | 43.3 | 0.0 | 43.2 | 0.0 | 45.9 | 0.0 | 46.9 | 0.0 | 0.0 | 0.0 |
| 02-03 | 81.4 | 0.0 | 80.2 | -1.2* | 80.4 | -1.0* | 71.5 | -9.9* | 73.6 | -7.8* |
| 03-04 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 04-05 | 0.0 | 0.0 | 0.0 | 0.0 | 39.7 | 0.0 | 33.4 | 0.0 | 0.0 | 0.0 |
| 05-06 | 41.6 | 0.0 | 50.5 | 0.0 | 31.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 05-07 | 51.8 | 0.0 | 52.7 | 0.0 | 47.0 | 0.0 | 41.3 | 0.0 | 51.8 | 0.0 |
| ----- DAY ----- | | | | | | | | | | |
| 07-08 | 67.4 | 0.0 | 70.2 | 2.8* | 69.0 | 1.5* | 66.5 | -.9* | 70.0 | 2.6* |
| 08-09 | 67.5 | 0.0 | 69.0 | 1.5* | 67.7 | .2* | 65.8 | -1.7* | 72.2 | 4.7* |
| 09-10 | 57.1 | 0.0 | 58.7 | 1.6* | 55.8 | -1.3* | 53.6 | -3.5 | 59.9 | 2.8* |
| 10-11 | 60.5 | 0.0 | 61.4 | .9* | 57.3 | -3.2* | 55.6 | -4.9* | 64.9 | 4.4* |
| 11-12 | 58.7 | 0.0 | 60.0 | 1.3* | 56.3 | -2.4* | 53.5 | -5.2 | 63.4 | 4.7* |
| 12-13 | 61.6 | 0.0 | 62.9 | 1.3* | 59.3 | -2.3* | 56.9 | -4.7* | 65.5 | 3.9* |
| 13-14 | 63.0 | 0.0 | 62.4 | -.6* | 62.4 | -.5* | 61.9 | -1.1* | 65.9 | 2.9* |
| 14-15 | 43.4 | 0.0 | 50.0 | 0.0 | 34.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 15-16 | 60.1 | 0.0 | 62.3 | 2.2* | 58.1 | -2.0* | 51.9 | -8.2 | 61.6 | 1.5* |
| 15-17 | 66.9 | 0.0 | 70.4 | 3.5* | 69.7 | 2.3* | 68.8 | 1.9* | 67.4 | .5* |
| 17-18 | 73.3 | 0.0 | 76.2 | 2.9* | 74.4 | 1.1* | 71.9 | -1.4* | 69.2 | -4.1* |
| 18-19 | 74.2 | 0.0 | 75.8 | 1.6* | 74.1 | -.1* | 70.9 | -3.3* | 69.8 | -4.4* |
| ----- EVENING ----- | | | | | | | | | | |
| 19-20 | 74.4 | 0.0 | 76.2 | 1.8* | 74.9 | .5* | 72.4 | -2.0* | 67.5 | -6.9* |
| 20-21 | 40.4 | 0.0 | 54.7 | 0.0 | 40.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 21-22 | 43.0 | 0.0 | 51.2 | 0.0 | 47.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ----- NIGHT ----- | | | | | | | | | | |
| 22-23 | 0.0 | 0.0 | 31.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 23-00 | 48.6 | 0.0 | 48.0 | 0.0 | 50.2 | 0.0 | 43.0 | 0.0 | 0.0 | 0.0 |

FIGURE E-7. HOURLY AIRCRAFT NOISE LEVEL COMPARISON AT 5 SITES IN INTERVIEW NEIGHBORHOOD A, 17 JANUARY 1981.

S I T E   C O M P A R I S O N   A N A L Y S I S

DATE 01-18-81

REFERENCE SITE = 2036
REFERENCE HNL ACCEPTANCE THRESHOLD = 55.0
COMPARISON HNL ACCEPTANCE THRESHOLD = 55.0

| | 2036 | | 2141 | | 2029 | | 1910 | | 0001 | |
|---|---|---|---|---|---|---|---|---|---|---|
| HOUR | HNL | DELTA | HNL | DELTA | HNL | DELTA | HNL | DELTA | HNL | DELTA |
| ----- NIGHT ----- | | | | | | | | | | |
| 00-01 | 50.1 | 0.0 | 51.1 | 0.0 | 49.5 | 0.0 | 44.6 | 0.0 | 0.0 | 0.0 |
| 01-02 | 49.6 | 0.0 | 52.5 | 0.0 | 49.6 | 0.0 | 47.2 | 0.0 | 0.0 | 0.0 |
| 02-03 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 03-04 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 04-05 | 48.1 | 0.0 | 56.5 | 0.0 | 49.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 05-06 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 06-07 | 0.0 | 0.0 | 33.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ----- DAY ----- | | | | | | | | | | |
| 07-08 | 67.7 | 0.0 | 70.3 | 2.6* | 69.6 | 1.9* | 69.1 | 1.4* | 59.8 | 2.1* |
| 08-09 | 73.8 | 0.0 | 75.8 | 2.0* | 73.1 | -.7* | 68.9 | -4.9* | 65.5 | -8.3* |
| 09-10 | 59.4 | 0.0 | 59.9 | .5* | 59.2 | -.2* | 57.4 | -2.0* | 60.3 | .9* |
| 10-11 | 68.7 | 0.0 | 71.6 | 2.9* | 72.8 | 4.1* | 72.7 | 4.0* | 69.5 | .8* |
| 11-12 | 75.0 | 0.0 | 76.8 | 1.8* | 75.2 | .2* | 69.4 | -5.6* | 67.3 | -7.7* |
| 12-13 | 75.5 | 0.0 | 77.5 | 2.0* | 75.4 | -.1* | 69.5 | -6.0* | 68.8 | -6.7* |
| 13-14 | 69.4 | 0.0 | 73.1 | 3.7* | 72.4 | 3.0* | 70.4 | 1.0* | 66.9 | -2.5* |
| 14-15 | 60.5 | 0.0 | 63.5 | 3.0* | 60.3 | -.2* | 55.1 | -5.4* | 61.5 | 1.0* |
| 15-16 | 72.8 | 0.0 | 75.5 | 2.7* | 74.8 | 2.0* | 72.4 | -.4* | 66.2 | -6.6* |
| 16-17 | 70.2 | 0.0 | 70.8 | .6* | 69.8 | -.4* | 66.9 | -3.3* | 66.3 | -3.9* |
| 17-18 | 75.3 | 0.0 | 77.4 | 2.1* | 75.9 | .5* | 73.2 | -2.1* | 70.0 | -5.3* |
| 18-19 | 72.3 | 0.0 | 73.8 | 1.5* | 71.1 | -1.2* | 65.2 | -7.1* | 67.7 | -4.6* |
| ----- EVENING ----- | | | | | | | | | | |
| 19-20 | 80.0 | 0.0 | 82.9 | 2.9* | 78.9 | -1.1* | 73.7 | -6.3* | 72.1 | -7.9* |
| 20-21 | 73.3 | 0.0 | 77.3 | 4.0* | 75.3 | 2.0* | 69.8 | -3.5* | 66.6 | -6.7* |
| 21-22 | 58.0 | 0.0 | 63.7 | 5.7* | 56.4 | -1.5* | 49.3 | -8.7 | 58.1 | .1* |
| ----- NIGHT ----- | | | | | | | | | | |
| 22-23 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 23-00 | 44.3 | 0.0 | 47.9 | 0.0 | 48.7 | 0.0 | 46.9 | 0.0 | 0.0 | 0.0 |

FIGURE E-8. HOURLY AIRCRAFT NOISE LEVEL COMPARISON AT 5 SITES IN INTERVIEW NEIGHBORHOOD A, 18 JANUARY 1981.

SITE COMPARISON ANALYSIS

DATE 01-19-81

REFERENCE SITE = 2036
REFERENCE HNL ACCEPTANCE THRESHOLD = 55.0
COMPARISON HNL ACCEPTANCE THRESHOLD = 55.0

| | 2036 | | 2141 | | 2029 | | 1910 | | 0001 | |
|---|---|---|---|---|---|---|---|---|---|---|
| HOUR | HNL | DELTA | HNL | DELTA | HNL | DELTA | HNL | DELTA | HNL | DELTA |
| ----- NIGHT ----- | | | | | | | | | | |
| 00-01 | 46.3 | 0.0 | 49.8 | 0.0 | 50.5 | 0.0 | 49.8 | 0.0 | 0.0 | 0.0 |
| 01-02 | 40.4 | 0.0 | 39.3 | 0.0 | 37.2 | 0.0 | 40.6 | 0.0 | 0.0 | 0.0 |
| 03-04 | 0.0 | 0.0 | 49.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 04-05 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 05-06 | 62.9 | 0.0 | 64.5 | 1.6* | 61.7 | -1.2* | 56.9 | -6.0* | 55.9 | -7.0* |
| 06-07 | 49.8 | 0.0 | 48.8 | 0.0 | 48.3 | 0.0 | 46.8 | 0.0 | 51.7 | 0.0 |
| ----- DAY ----- | | | | | | | | | | |
| 07-08 | 81.2 | 0.0 | 82.4 | 1.2* | 80.1 | -1.1* | 78.5 | -2.7* | 77.4 | -3.8* |
| 08-09 | 79.7 | 0.0 | 81.4 | 1.7* | 75.8 | -3.9* | 69.6 | -10.1* | 70.4 | -9.3* |
| 09-10 | 71.2 | 0.0 | 72.3 | 1.1* | 70.6 | -.5* | 68.1 | -3.1* | 70.0 | -1.2* |
| 10-11 | 72.0 | 0.0 | 72.8 | .8* | 70.5 | -1.5* | 66.2 | -5.8* | 65.6 | -6.4* |
| 11-12 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 65.4 | 0.0 |
| 12-13 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 67.7 | 0.0 |
| 13-14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 70.9 | 0.0 |
| 14-15 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 67.0 | 0.0 |
| 15-16 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 58.5 | 0.0 |
| 16-17 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 66.6 | 0.0 |
| 17-18 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 69.0 | 0.0 |
| 18-19 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 62.6 | 0.0 |
| ----- EVENING ----- | | | | | | | | | | |
| 19-20 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 72.9 | 0.0 |
| 20-21 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 64.7 | 0.0 |
| 21-22 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ----- NIGHT ----- | | | | | | | | | | |
| 22-23 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 53.4 | 0.0 |
| 23-00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 54.9 | 0.0 |

FIGURE E-9. HOURLY AIRCRAFT NOISE LEVEL COMPARISON AT 5 SITES IN INTERVIEW NEIGHBORHOOD A, 19 JANUARY 1981.

Selecting one auxiliary site at a time, hourly sound levels were compared with the central site on an hour-by-hour basis. To be included in the analysis, hourly levels at both sites had to exceed a value of 55 dB, the lowest probable value for a single jet overflight during the hour. The results are shown in Figure E-10, comparing the four auxiliary sites (2141, 2029, 1910, and 0001) individually with the central site (2036). Analyses are shown for daytime hours (0700 to 1859), evening hours (1900 to 2159), nighttime hours (2200 to 0659), and the entire 24 hour day. Shown in the first column (labeled "N") is the sample size (i.e., the number of hours satisfying the aforementioned 55 dB criterion. In the next two columns are the energy average sound levels for the auxiliary and central sites, respectively, with the "DIFF" column showing the energy difference between the two sites. The remaining two columns (labeled "MEAN" and "DEV") show the arithmetic mean and standard deviation of the individual hourly differences shown in the "DELTA" columns of Figures E-2 through E-9.

Although the differences for the individual periods of the day show some weak trends, the sample size is too small to draw firm conclusions. The trends that do exist (the lesser difference at night than during the day and evening) are probably the result of subtle differences in departure procedures after dark. The small number of night departures contribute negligibly, however, to overall daily exposure.

Both the energy and arithmetic differences of the 24 hour statistics agree extremely well, except at auxiliary site 0001 (outside the interviewing area). This agreement strongly suggests that the differences are level

## SITE COMPARISON ANALYSIS
## (SUMMARY)

| | | ENERGY AVG HNL | | | HNL DIFFERENCE | |
|---|---|---|---|---|---|---|
| | N | SITE 2141 | SITE 2036 | DIFF | MEAN | DEV |
| DAY | 80 | 78.5 | 76.2 | 2.3 | 2.1 | .9 |
| EVENING | 13 | 79.7 | 76.8 | 2.9 | 3.1 | 1.0 |
| NIGHT | 12 | 71.1 | 71.8 | -.7 | 1.8 | 1.4 |
| 24 HOUR | 105 | 78.2 | 75.9 | 2.3 | 2.2 | 1.1 |

| | | ENERGY AVG HNL | | | HNL DIFFERENCE | |
|---|---|---|---|---|---|---|
| | N | SITE 2029 | SITE 2036 | DIFF | MEAN | DEV |
| DAY | 79 | 75.8 | 76.1 | -.2 | -.3 | 1.8 |
| EVENING | 13 | 77.4 | 76.8 | .5 | .4 | 1.4 |
| NIGHT | 11 | 71.0 | 72.2 | -1.2 | -.3 | 1.5 |
| 24 HOUR | 103 | 75.8 | 75.9 | -.1 | -.2 | 1.7 |

| | | ENERGY AVG HNL | | | HNL DIFFERENCE | |
|---|---|---|---|---|---|---|
| | N | SITE 1910 | SITE 2036 | DIFF | MEAN | DEV |
| DAY | 73 | 72.8 | 76.4 | -3.6 | -3.4 | 3.1 |
| EVENING | 12 | 74.1 | 77.2 | -3.1 | -2.9 | 2.8 |
| NIGHT | 8 | 64.6 | 73.5 | -8.9 | -3.6 | 4.2 |
| 24 HOUR | 93 | 72.7 | 76.3 | -3.6 | -3.4 | 3.1 |

| | | ENERGY AVG HNL | | | HNL DIFFERENCE | |
|---|---|---|---|---|---|---|
| | N | SITE 0001 | SITE 2036 | DIFF | MEAN | DEV |
| DAY | 80 | 71.0 | 76.2 | -5.2 | -3.6 | 4.0 |
| EVENING | 13 | 69.8 | 76.8 | -7.0 | -5.3 | 4.3 |
| NIGHT | 11 | 65.3 | 72.2 | -6.9 | -2.1 | 3.8 |
| 24 HOUR | 104 | 70.5 | 76.0 | -5.5 | -3.5 | 4.0 |

FIGURE E-10. SUMMARY AIRCRAFT NOISE LEVEL COMPARISON AT 5 SITES IN INTERVIEW NEIGHBORHOOD A.

independent; that is, HNL's at the auxiliary sites tend to differ from those of the central site by roughly constant amounts, regardless of absolute level. This observation is based on the greater sensitivity of the energy comparison to the higher levels, and the equal sensitivity of the arithmetic comparison to all levels. The 2 dB discrepancy observed at site 0001 suggests that the HNL difference is smaller at lower levels than at high levels. This may be the result of higher sound level jet aircraft making straight out departures and lower level general aviation aircraft turning right shortly after takeoff.

Comparison of the 24 hour energy average HNL differences in Figure E-10 with the energy average $L_{dn}$ differences in Table E-1 reveals agreement within $\pm$ 0.1 dB. It is therefore concluded that the values shown in Table E-1 are free of any unusual anomalies and can be used with confidence in further comparisons with the noise contours shown in Figure E-1.

Table E-2 compares the measured inter-site $L_{dn}$ differences (shown in Table E-1) with the estimated inter-site differences from the $L_{dn}$ contours of Figure E-1. Note that the measurements confirm the contour estimates to within $\pm 1$ decibel. Thus, the contours of Figure 6 can be used as a means for estimating the noise exposure gradient across interview neighborhoods with a high accuracy.

Table E-2 also shows that monitor site 2029, selected to provide a second central tendency measurement, is in very close agreement with the original central site. Varying the personnel involved in site selection and instrument deployment had little effect on the measurement results.

TABLE E-2. VARIATION IN NOISE EXPOSURE ACROSS NEIGHBORHOOD A

| Monitoring Site | $L_{dn}$, re: Central Site (2036) | |
|---|---|---|
| | Measured Values* | Estimated Values from Contours |
| 2141 | +2.3 dB | +2.0 |
| 2029 | -0.2 | -0.5 |
| 1910 | -3.7 | -2.5 |
| 0001** | -5.5 | -4.4 |

* From Table E-1

** Immediately west of Neighborhood A

# APPENDIX F

## BACKGROUND INFORMATION FOR ESTIMATION OF TIME COURSE OF CHANGES IN COMMUNITY ANNOYANCE DUE TO CHANGES IN AIRCRAFT NOISE EXPOSURE

As noted in the Discussion Section of this report, the general form of the exponential relationship between change in annoyance as a function of change in exposure is assumed to be

$$P(t) = P(\infty) + \Delta P \cdot e^{-t/T}$$

where:
- $t$ = elapsed time since noise exposure change, in days
- $T$ = time constant of attitude change, in days
- $P(t)$ = percent highly annoyed at time t
- $P(\infty)$ = percent highly annoyed after long term adaptation to changed noise exposure
- $\Delta P$ = difference between percent highly annoyed before exposure change and long after change.

The strategy for determining T, given only four rounds of interviews (and thus four $(t, P(t))$ data points) was to estimate values of $P(\infty)$ and $\Delta P$ and then iteratively select the value of T which generated the smallest mean square error between the observed and predicted percent highly annoyed.

Values of $P(\infty)$ and $\Delta P$ were derived in two different ways to permit assessment of the sensitivity of the prediction to the estimated values. It was observed first that before a change in exposure had occurred (Interview Round 1) peoples' attitudes regarding annoyance due to aircraft over the past year (Question 4) and past week (Question 3) were virtually identical. That is, after a long period of habituation to an unchanging noise environment one could infer attitudes about the past year from those stated for the past week. If the assumption is made that people have habituated after 2 months of exposure to the new environment, a reasonable estimate of $P(\infty)$ may be made by averaging the percent highly annoyed to aircraft over the past week from Interview Rounds 3 and 4.

A second method for estimating $P(\infty)$ uses the relationship of Schultz (1978) to extrapolate existing attitudes before the exposure change to those a long time after the change. Figure F-1 shows graphically how this was accomplished. First a data point corresponding to $L_{dn}$ and percent highly annoyed from Question 4 of Round 1 is plotted. A more stable estimate of percent highly annoyed before the change was obtained by averaging the values from both Rounds 1 and 2. Round 2 took place only two weeks after the change in noise exposure and there is no significant difference in responses to Question 4 between these rounds.

Next, Schultz's curve is made to pass through this data point by moving the curve horizontally until agreement is reached. Finally, an estimate of the long term average noise exposure after the change is obtained by averaging the measured $L_{dn}$'s over Interview Rounds 2, 3, and 4. Entering the curve with this $L_{dn}$ value, the percent highly annoyed is read from the shifted curve and used as the estimated value of $P(\infty)$.

Values of $\Delta P$ were obtained by taking the difference between the average percent highly annoyed to aircraft over the past year from interview Rounds 1 and 2 and the previously determined values of $P(\infty)$.

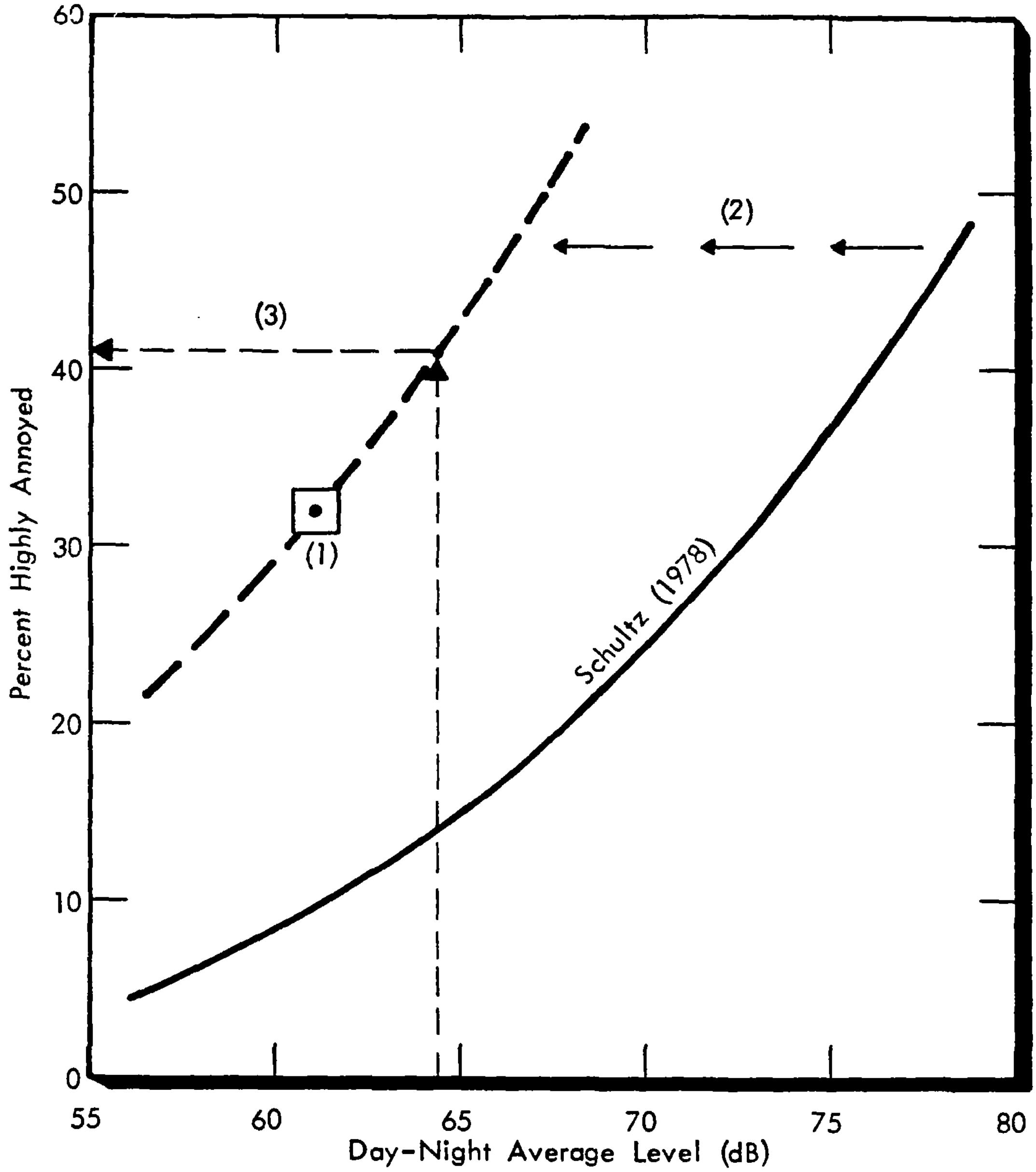



FIGURE F-1. GRAPHICAL METHOD FOR ESTIMATING ATTITUDINAL CHANGE TO A CHANGE IN NOISE ENVIRONMENT.

Table F-I lists the observed values of $L_{dn}$ and percent highly annoyed to aircraft over the past year. Table F-II shows the estimated values of $P(\infty)$, $\Delta P$ and T under the various assumptions stated above. In addition, selected values of $P(\infty)$ were perturbed $\pm 10$ percent to examine the sensitivity of the estimated value of T to changes in $P(\infty)$.

Finally, the constants of Table F-II were used in the equation such that the best fitting exponential curves and the raw data points could be plotted, as shown in Figure F-2. These figures also show the step change in noise exposure for each neighborhood. The two graphs shown for each community are, in fact, the input and output functions analogous to those of Figure 1.

It may be seen from Table F-II that the estimated value of the time constant, T, is in most cases quite sensitive to the estimated value of $P(\infty)$ (the asymptotic level of annoyance).

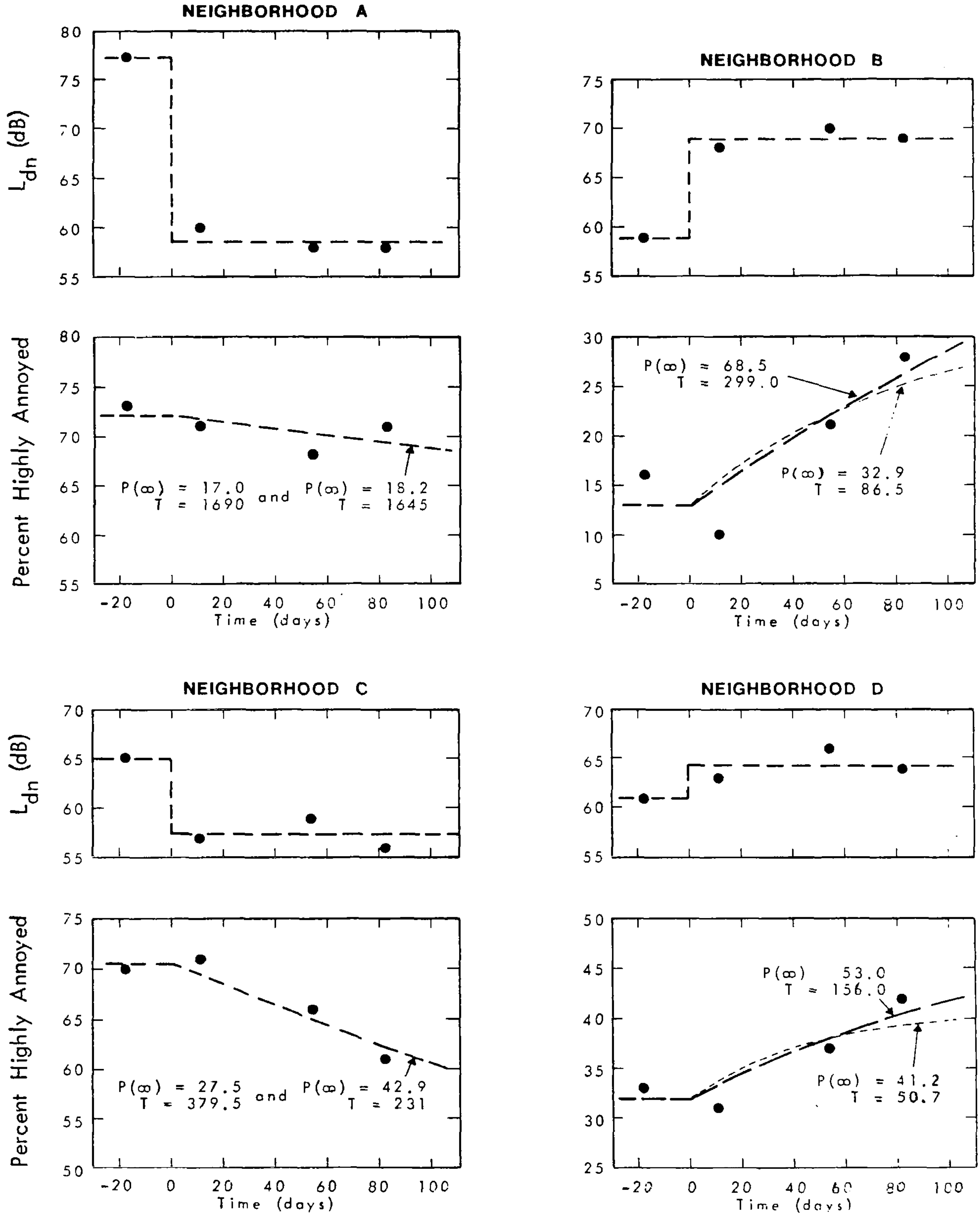



FIGURE F-2. OBSERVED HISTORY OF EXPOSURE AND ANNOYANCE TO PAST YEAR.

TABLE F-I. $L_{dn}$ AND PERCENT HIGHLY ANNOYED (AIRCRAFT OVER PAST YEAR) AS A FUNCTION OF TIME

| Days After Runway Closure (t) | Neighborhood A | | Neighborhood B | | Neighborhood C | | Neighborhood D | |
|---|---|---|---|---|---|---|---|---|
| | $L_{dn}$ | %HA (P[t]) | $L_{dn}$ | %HA (P[t]) | $L_{dn}$ | %HA (P[t]) | $L_{dn}$ | %HA (P[t]) |
| -13 (0) | 77 dB | 73 | 59 dB | 16 | 65 dB | 70 | 61 dB | 33 |
| 11 | 60 | 71 | 68 | 10 | 57 | 71 | 63 | 31 |
| 54 | 58 | 68 | 70 | 21 | 59 | 66 | 66 | 37 |
| 82 | 58 | 71 | 69 | 28 | 56 | 61 | 64 | 42 |

TABLE F-II. ESTIMATED TIME CONSTANTS FOR VARIOUS ASSUMED ASYMPTOTIC VALUES OF PERCENT HIGHLY ANNOYED

| | NEIGHBORHOOD A | | | NEIGHBORHOOD B | | | NEIGHBORHOOD C | | | NEIGHBORHOOD D | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P(∞) Assumption | %HA (P[∞]) | Change in %HA (ΔP) | Estimated Time Constant (T) | %HA (P[∞]) | Change in %HA (ΔP) | Estimated Time Constant (T) | %HA (P[∞]) | Change in %HA (ΔP) | Estimated Time Constant (T) | %HA (P[∞]) | Change in %HA (ΔP) | Esti-mated Time Constant (T) |
| (1) | 17.0 | 55.0 | 1690 | 68.5 | -55.5 | 299.0 | 27.5 | 43.0 | 379.5 | 53.0 | -21.0 | 156.0 |
| (2) | 18.2 | 53.8 | 1645 | 32.9 | -19.7 | 86.5 | 42.9 | 27.6 | 231.0 | 41.2 | - 9.2 | 50.7 |
| (3) | 16.4 | 55.6 | 1710 | 29.6 | -16.6 | 67.5 | 38.6 | 31.9 | 272.5 | 37.1 | - 5.1 | 25.2 |
| (4) | 20.0 | 52.0 | 1590 | 36.2 | -23.2 | 106.0 | 47.2 | 23.3 | 190.0 | 45.3 | -13.3 | 86.5 |

(1) Average of "aircraft over past week", interview rounds 3 & 4

(2) Estimated from Shultz (1978) curve (see text for details)

(3) Same as (2) plus 10%

(4) Same as (2) minus 10%.

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15. Supplementary Notes

Langley Technical Monitor: David G. Stephens
Final Report for TASK 33

16. Abstract

Four rounds of interviews were conducted in the vicinity of Burbank Airport during a four-month period during which a counterbalanced series of changes in aircraft noise exposure occurred due to runway repairs. A fifth round of interviewing was undertaken approximately one year after completion of the initial runway repairs. Noise measurements were made in conjunction with administration of a brief questionnaire to a near-exhaustive sample of residents in four airport neighborhoods. The magnitude and direction of change of annoyance with aircraft noise exposure corresponded closely to the actual changes in physical exposure. Estimates were made of time constants for the rate of change of attitudes toward aircraft noise.

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