550/9-74-009

POPULATION DISTRIBUTION OF THE UNITED STATES AS A FUNCTION OF OUTDOOR NOISE LEVEL

JUNE 1974

U.S. Environmental Protection Agency
Washington, D.C. 20460

Document is available to the public through the National Technical Information Service, Springfield, Virginia 22151

Document is available in limited quantities through the Environmental Protection Agency, Office of Noise Abatement and Control, Arlington, Virginia 20460

550/9-74-009

POPULATION DISTRIBUTION OF THE UNITED STATES AS A FUNCTION OF OUTDOOR NOISE LEVEL

June 1974

W. J. Galloway
K. McK. Eldred
M. A. Simpson

Prepared For:

U.S. Environmental Protection Agency
Office of Noise Abatement and Control
Washington, D. C. 20460

Under Contract No. 68-01-1886

ACKNOWLEDGMENTS

This report has profited from the contributions of many individuals. At Bolt Beranek and Newman, Andrew S. Harris was responsible for the noise measurements in the eastern half of the United States; processing of all field data was also performed under his direction. The organization, correlation, and further analysis of processed data was undertaken by Richard H. Muehlenbeck. In addition to these individuals, the authors would like to thank the BBN personnel who participated in the measurement and analysis phases of this project.

The authors are also grateful to Dr. Simone L. Yaniv, Project Officer in EPA's Office of Noise Abatement and Control, for her guidance and enthusiasm throughout the course of this study.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (CONT)

LIST OF TABLES

SECTION 1

INTRODUCTION

The Noise Control Act of 1972, in part, directs the Environmental Protection Agency (EPA) to develop criteria with respect to noise, to publish information on the levels of environmental noise requisite to protect the public health and welfare, and to identify major sources of noise. It also directs the EPA to propose noise emission standards, where feasible, for identified major sources of noise. The purpose of these actions is to bring about a containment and reduction of the noise to which the public is exposed in its overall environment.

A major consideration in judging the effectiveness of any emission standards is the degree to which such standards will contribute to the reduction of the general level of environmental noise in the country, and how many people will benefit from such reduction. In order to make such determinations it is essential to have knowledge of the present values of noise exposure experienced by the population so that the effect of noise control of a particular class of noise producers can be assessed.

Many modes of noise exposure are incurred by an individual as he moves through his normal activities. He receives various noise doses as he travels from place to place, at work or recreation, and at home. Each of these modes of exposure needs to be considered in terms of its effect on the individual's total noise dose, as is discussed in the EPA Report on Environmental Noise Levels.[1] However, most people spend more total time at their place of residence than at any other location. Thus, a basic information requirement is to describe the present noise exposure at home for the national population.

Specific estimates of the noise exposure due to airport operations and freeway traffic have been provided in the EPA Airport/Aircraft Noise Report[2] based on previously developed noise models for these two sources. While airports and freeways provide two of the most noisy environments in which people live, they impact only a small proportion of the total population. The largest part of the population is primarily impacted by noise from other sources. It is this noise exposure that needs to be defined.

While the noise exposures from airports and freeways have been studied extensively, little systematic knowledge exists on the general noise environment away from these two sources. Sample data on typical noise levels at different places ranging from wilderness to dense central city areas were reported in the EPA Report to Congress.[3] Representative noise level measurements at 20 different urban/suburban locations were reported under an Automobile Manufacturers Association program.[4] Some additional data of similar nature were available in the files of Bolt Beranek and Newman Inc. (BBN). These data serve to describe the range of noise levels to be expected in urban areas, but do not provide the bases for extrapolation to a general population.

A detailed description of the national noise environment would require an extensive noise survey over a wide variety of geographic locations, taking place over an extended time period. Such a survey should be performed. However, the urgency of having baseline information for use by EPA in meeting its immediate objectives required a carefully planned sample noise survey that could be used to derive a model for predicting a first order estimate of the national noise exposure.

This report summarizes the planning, conduct, and results of a noise survey of 100 sites in urban areas across the continental United States and the use of these results, coupled with other existing data, to provide an estimate of the outdoor noise levels experienced in residential areas by the national population. It concludes that more than 75 million people are exposed to Day/Night* sound levels in excess of 60 decibels, while 600,000 people are exposed to greater than 80 decibels.

---

* Day/Night sound level is the equivalent A-weighted sound level over a 24-hour period, with actual sound levels between 2200 and 0700 hours increased by 10 decibels. The symbol used for this measure is L_{dn}.

SECTION 2

SURVEY RATIONALE

The basic purpose of the survey was to assess the noise climate in residential areas primarily exposed to noise from other than airports or freeways. The results of the survey, when used with estimates of populations exposed to noise from airports and freeways derived from other models,[5,6] as reported in the EPA Aircraft/Airport Noise Study,[2] were to be used to estimate the outdoor noise exposure of the national population when at home.

Several factors seemed evident in planning the survey:

1. It was desirable to obtain data in areas where 1970 census data could be used in conjunction with any model derivations.
2. Measurements should be taken in the various geographic regions of the country.
3. Sites should be selected to obtain data over the widest possible range of living conditions.

A primary consideration in the planning was the evidence from community noise surveys that surface transportation noise is reported to be the most evident single contributor to environmental noise.[4,7] The predominant source of surface transportation noise is motor vehicles.[8,9] Over a wide range of population densities and of total populations, the number of automobiles per person is almost constant, the ration of trucks in service to automobiles in service is almost constant, and the usage of vehicles is directly proportional to population density.[10]

The above facts lead to the hypothesis that the number of motor vehicles in use per person, over a wide range of population densities, is essentially constant. Further, if non-freeway traffic is considered, the average speed of motor vehicles in urban areas is essentially constant.[9,10] Based on existing traffic noise models,[6] the noise produced by traffic is directly proportional to 10 times the logarithm of the number of vehicles flowing past a point (with constant speed). If this is the case, then a first order estimate of the space average noise level in a community should be proportional to 10 times the logarithm of the population density of the community. Variations from this space average would be expected to occur as a function of local street structure, homogeneity of population densities, type of building structures (e.g. single family residences as compared to high rise apartments).

This hypothesis was tested against 30 random samples of existing data where population density could be determined. Over a range of population densities from 1000 to 70,000 per square mile, it was found that the day/night sound level could be correlated with 10 times the logarithm of population density per square mile with an intercept at zero population of 22 decibels. For example, at a population density of 5000 per square mile, the approximate average for urban areas of the United States, the expected average day/night sound level would be 59 decibels.

Based on the above preliminary analysis, it was determined that the 100 sites to be selected for noise measurements would be chosen so that a maximum range of population densities could be explored, that data would be acquired only in urban areas so that census data could be employed in developing a national model, and that data would be acquired in each EPA region to ensure national coverage.

The measure selected for defining the noise environment was A-weighted sound level. It was determined that, due to time and budget constraints, measurements would be restricted to one 24-hour period per site, to be conducted during weekdays only (to avoid weekend variations in traffic). In order to provide a data base with sufficient detail for future analysis, it was decided to obtain a continuous statistical record of A-weighted sound level over the entire 24 hour period. The data were to be analyzed to provide a cumulative distribution of sound level for each hourly period. Based on these data, equivalent sound level, noise pollution level, traffic noise index, and day/night sound level were to be computed for each site.

Outside noise levels were chosen as being most characteristic of the noise environment produced in a residential area from sources beyond the control of the resident. Inside noise levels, while frequently affected by exterior noises, are generally dominated by the activities inside a home. Thus, inside noise levels are extremely dependent on the life styles of individuals and not on the external environment. In order to provide an indication of the relationships between inside and outside noise levels, 15 sites were chosen for which inside noise levels would be measured simultaneously with those outside. Comparison between the two sets of data at a site shows how little the interior noise levels are affected by exterior noise during waking hours.

In the following sections of this report we provide a description of the actual site selection, the results of the measurements, and the derivation of the model for urban noise.

SECTION 3

MEASUREMENT PROCEDURE

SITE SELECTION

One hundred measurement sites were chosen in fourteen cities located throughout the ten EPA regions. The various cities were selected so as to cover a wide range of population densities. Table 3-1 lists the cities in which measurements were obtained, the number of sites in each city, and the average central city population density. Within each city, specific sites were selected in census tracts with population densities ranging from a fraction of the average population density to several times this average density. Only census tracts with a homogeneous population distribution were utilized.

Note that no attempt was made to provide a systematic statistical description of noise in any particular city. The primary purpose was to obtain samples in as wide a range of population densities as possible, with the specific choice of sites in any geographical area being arbitrarily picked to maximize the difference in population densities.

Sites were also selected to provide a variation in proximity to streets of varying traffic density. Thus, for each population density, an attempt was made to select sites that varied between being adjacent to major traffic arteries to being located on only lightly traveled streets. Since the primary purpose of the survey was to obtain data in general urban residential areas away from freeways or airports, no site was selected closer than 300 meters from a freeway or an area where aircraft noise was significant, e.g. at an estimated L_{dn} of 70 or higher.

TABLE 3-1

CITIES IN WHICH NOISE MEASUREMENTS WERE OBTAINED

EPA Region	City	Central City Average Density (per sq. mile)	Number of Measurement Sites
1	Boston	13,900	8
2	New York	26,300	11
3	Washington, D. C.	12,300	6
	Pittsburgh	9,400	5
4	Atlanta	3,800	4
	Miami	9,800	6
5	Chicago	15,100	8
6	Dallas	3,200	6
7	Kansas City	2,100	4
	St. Louis	10,200	9
8	Denver	5,400	8
9	San Francisco	15,800	11
	Los Angeles	6,100	8
10	Seattle	6,400	6

NOISE DATA COLLECTION AND PROCESSING

At each measurement site, the microphone was located out-of-doors at an appropriate listener height. Thus, for single story residences, the microphone was typically positioned 1.5 meters above the ground. For multi-story residences, the microphone was placed at an elevation comparable to the height where occupants lived. In all instances, the microphone was located 1.8 meters from the building facade. Specific heights and microphone locations for each measurement are listed in Volume 2 of this report.

Noise levels were monitored continuously for a full 24-hour period at each site. The A-weighted noise level was automatically distributed into bins 1.25 dB wide spanning the range from 30 to 110 dBA. This discrimination width is an equipment limitation set by the selection of the wide dynamic range. Thus, a narrower bin width could have been used if a narrower dynamic range was employed. It was decided that the 1.25 dB bin width was perfectly narrow enough for this survey and that the dynamic range was a necessity.

At the end of each hour, the accumulated contents of each bin were recorded on magnetic tape in digital format. The data tapes were later processed by computer to yield various statistics and noise exposure levels for each hour, as well as for daytime and nighttime periods. Appendix A describes in greater detail the noise measurement instrumentation and data processing procedures. The computer output listings for each site are presented in Volume 2 (a sample listing for one site is given in Appendix B).

CENSUS DATA PROCESSING

Population densities in people per square mile were determined for each census tract in which noise measurements were made. Generally, this information, or data from which this information could be derived, was supplied by county or regional planning agencies.

As discussed above, measurements were to be obtained in homogenous census tracts. That is, it was desirable for modeling purposes to make noise measurements at sites having as uniform a population density as possible over an entire census tract. In a few instances, however, circumstances dictated acquiring measurements either on the border between two census tracts or in census tracts with a skewed population distribution, such as in an area in which a large portion of the tract is devoted to a park. In the former instance the two tract densities were averaged, while in the latter the population densities were adjusted to reflect the density of the actual inhabited area.

SECTION 4

SURVEY RESULTS

SUMMARY OF MEASURED DATA

The detailed results of the noise measurements at each site, and information on the site itself, are provided separately in Volume 2 of this report. A sample of the data format is provided, for one site, in Appendix B of this report. These data, all in A-weighted sound level, are presented in two formats. The first format lists, for each of the 24 hours, the values for maximum, minimum, L_{eq}, NPL, TNI, SIG, L_1, L_3, L_5, L_{10}, L_{20}, L_{30}, L_{40}, L_{50}, L_{60}, L_{70}, L_{80}, L_{90}, L_{95}, L_{97}, and L_{99} (see Appendix B for explanation of symbols).

The second format combines the hourly data into a daytime (0700-2200 hrs) period and a nighttime (2200-0700 hrs) period and lists the same measures as above for these two periods. A separate listing is provided for the combined 24 hour period with weightings of 0, 8, 10, and 12 decibels added to the nighttime noise levels. Note that L_{dn} is this 24-hour value using the 10 dB nighttime level weighting factor. Finally, cumulative distributions for the daytime and nighttime periods are also indicated on a probability scale. Recall that a straight line on this scale indicates a statistically normal distribution.

RELATIONSHIPS BETWEEN VARIOUS NOISE MEASURES

The data acquired in the survey were primarily intended for use in developing a model for estimating outdoor noise exposures for urban populations. Their use in developing such a model is discussed in Section 5 of this report. In addition to this use, the data provide an opportunity to explore the relationships between various noise measures. For example, how well does L_1 or L_{10} predict a maximum value or the relationships between L_{eq} and other measures. Further, it was hypothesized that noise environments should be proportional to the logarithm of population density ($\log \rho$), so it is of interest to examine how various measures are correlated to $\log \rho$.

The data for the 100 sites, separated by daytime and nighttime values per site, were used to compute a number of different Pearson product moment correlations. These results are listed in Table 4-1. These correlations show a number of interesting relationships:

1. L_1, L_{10}, L_{50} are highly correlated (i.e., of the order of 0.9 or higher) with L_{eq}.

2. The maximum value that occurs at any 1/8 second interval in the 9 hours of nighttime or 15 hours of daytime is not nearly as well correlated with the other measures, as might be expected.

3. L_{10}, L_{50}, L_{90} and L_{dn} are all correlated at greater than 0.7 with log ρ, and the slope of the accompanying regression line is 10 plus or minus less than 2. On the other hand NPL is considerably less predictable by log ρ, having a correlation coefficient of 0.458 during daytime and 0.642 at nighttime.

4. The addition of the 30 data points previously available to the data from the 100 sites does not significantly affect the correlation of the 100 sites alone with log ρ.

In addition to the correlation computations described above, it is of interest to examine the scattergrams for several of the measures. In Reference 1 the measure L_{dn} is used to define goals for environmental noise levels. The quantity NPL has also been advocated for this purpose. The scattergrams for L_{dn} and NPL, calculated separately for day and night periods, are plotted against population density on Figures 4-1 to 4-3. In Figure 4-4 the difference between L_d and L_n is plotted against L_{dn}.

TABLE 4-1

PEARSON PRODUCT MOMENT CORRELATIONS FOR VARIOUS MEASURES AT 100 SITES

$y = a_1x + a_2$ r = correlation coefficient S_e = standard error of estimate

y	x	Time Period	a_1	a_2	r	S_e	No. of Samples
L_{max}	L_1	day	.86	34.4	.637	5.6	100
		night	.97	23.7	.776	4.9	
L_{max}	L_{10}	day	.71	51.8	.588	5.9	100
		night	.75	44.6	.682	5.7	
L_1	L_{10}	day	.84	19.5	.936	1.9	100
		night	.80	20.4	.904	2.7	
L_{10}	L_{50}	day	.82	17.5	.937	2.1	100
		night	.92	10.6	.907	3.0	
L_{90}	L_{50}	day	.98	-3.9	.960	2.0	100
		night	.96	-2.5	.937	2.5	
L_{10}	L_{90}	day	.74	25.7	.860	3.1	100
		night	.77	21.4	.774	4.5	
L_{max}	L_{eq}	day	.93	39.3	.712	5.1	100
		night	1.00	31.4	.790	4.8	
L_1	L_{eq}	day	.92	15.3	.954	1.6	100
		night	.97	11.7	.951	1.9	
L_{10}	L_{eq}	day	1.02	-0.3	.947	1.9	100
		night	1.10	-5.0	.957	2.1	
L_{50}	L_{eq}	day	1.10	-13.2	.896	3.0	100
		night	.98	-5.1	.863	3.5	
L_1	$\log \rho$	day	7.53	40.7	.683	3.9	100
		night	9.38	26.6	.725	4.3	
L_{10}	$\log \rho$	day	9.12	25.0	.737	4.1	100
		night	10.44	12.8	.714	5.0	
L_{50}	$\log \rho$	day	11.16	8.8	.792	4.2	100
		night	9.12	11.5	.631	5.4	
L_{90}	$\log \rho$	day	11.22	3.6	.779	4.4	100
		night	8.13	11.0	.550	6.0	
L_{eq}	$\log \rho$	day	7.90	29.1	.687	4.1	100
		night	9.23	17.4	.724	4.3	
NPL	$\log \rho$	day	5.68	51.7	.458	5.3	100
		night	10.82	23.1	.642	6.3	

TABLE 4-1 (Cont'd)

$y = a_1 x + a_2$ $\quad$ r = correlation coefficient $\quad$ S_e = standard error of estimate

y	x	Time Period	a_1	a_2	r	S_e	No. of Samples
L_{dn}	$\log \rho$	24 hrs	8.33	29.4	.722	3.9	100
L_{dn}	$\log \rho$	24 hrs	9.00	25.8	.723	4.2	130 *
$L_d - L_n$	L_{dn}	24 hrs	-0.12	13.3	.188	3.2	100

*Includes 30 sites from previous studies

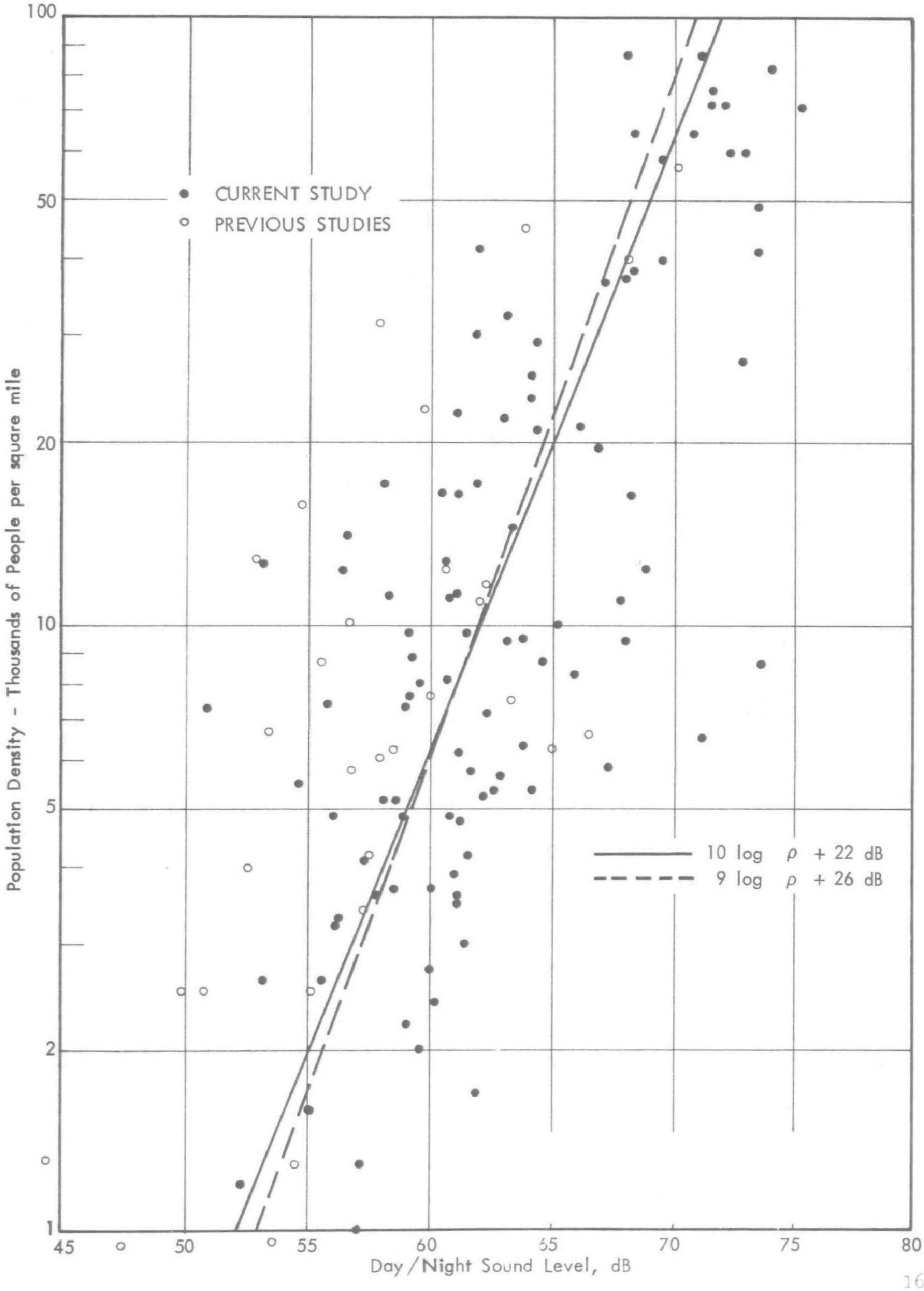


Figure 4-1. Day /Night Sound Level as a Function of Population Density

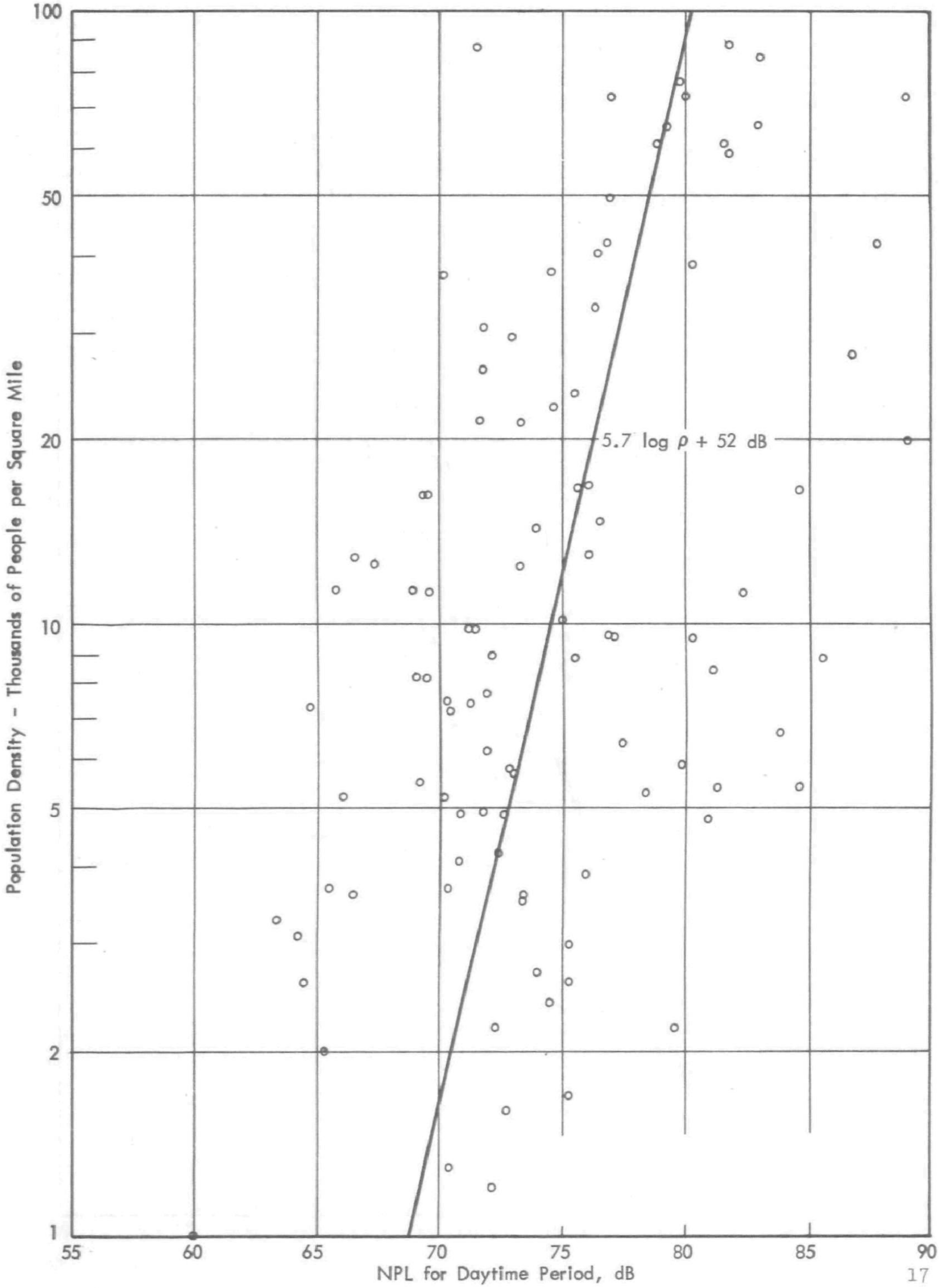


Figure 4-2. Daytime NPL as a Function of Population Density (100 EPA Sites)

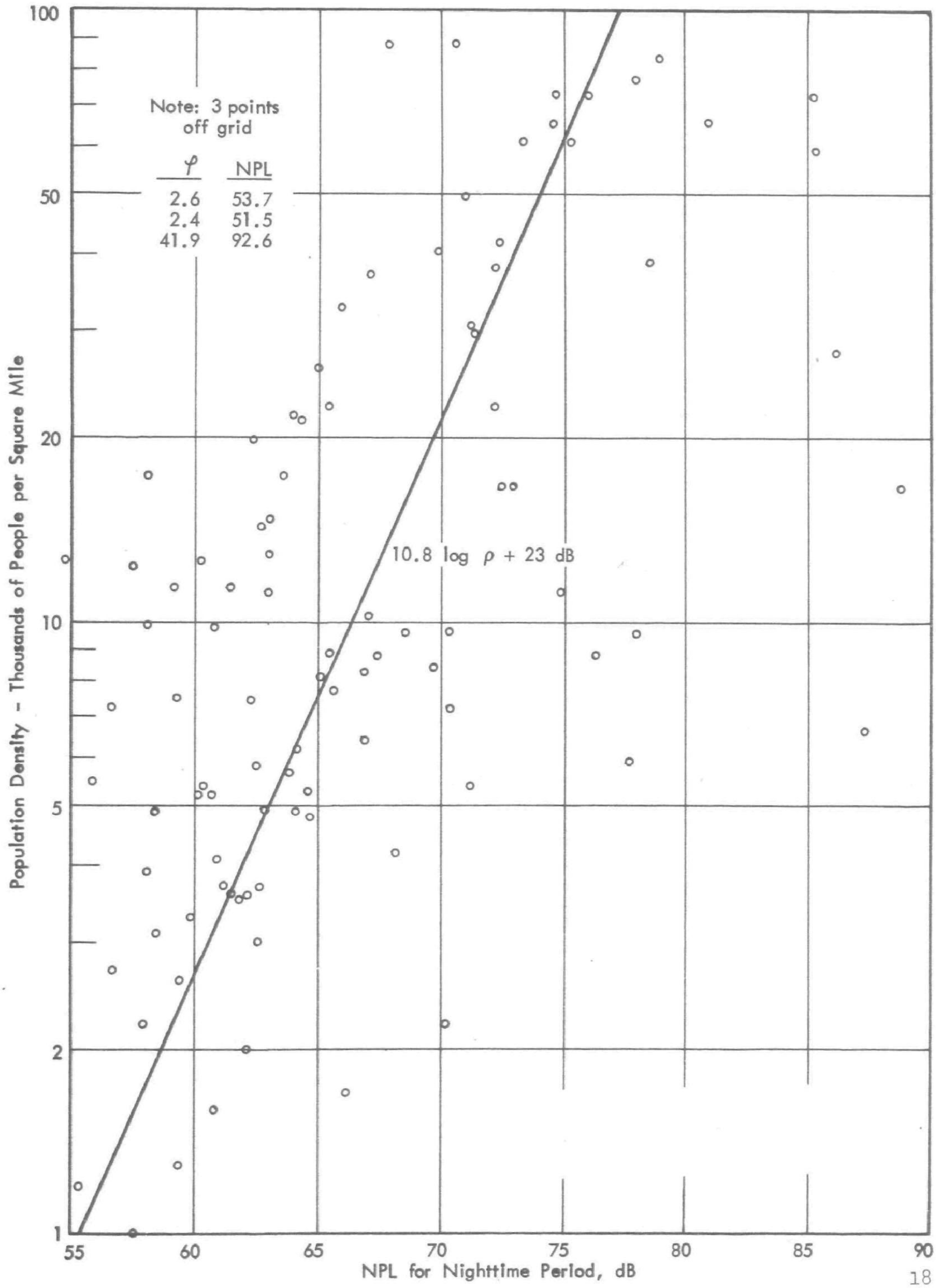


Figure 4-3. Nighttime NPL as a Function of Population Density (100 EPA Sites)

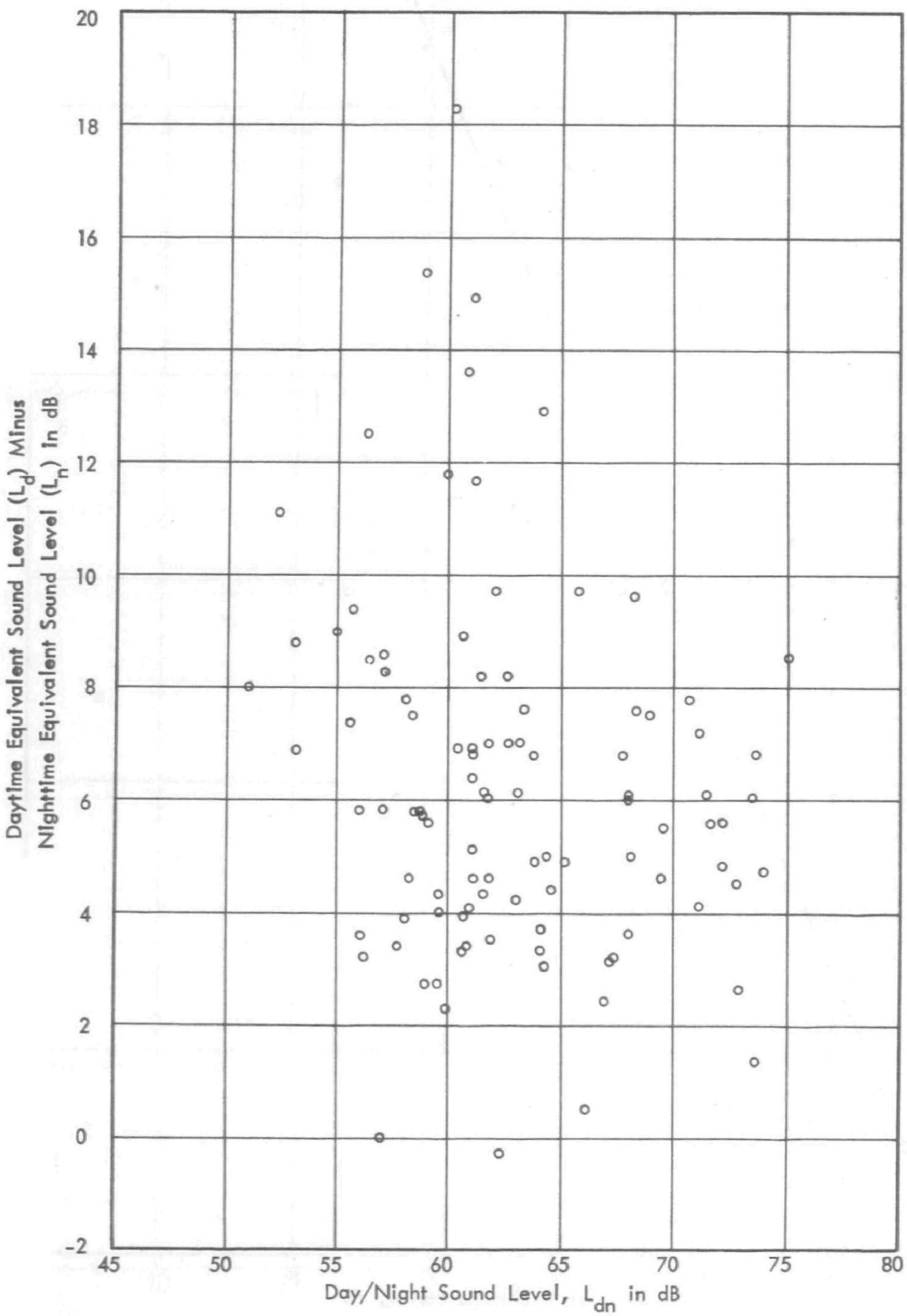


Figure 4-4. Comparison of the Difference Between L_d and L_n with the Day/Night Sound Level, L_{dn}

SECTION 5

DEVELOPMENT OF MODEL FOR URBAN NOISE AND ESTIMATE OF POPULATION EXPOSED TO NOISE AT VARIOUS LEVELS

MODEL FOR PREDICTING OUTDOOR NOISE LEVELS IN URBAN AREAS

In the previous section the results of the noise measurements were correlated with population densities. It was found that L_{max} and NPL were not nearly as well correlated with population density as L_{10}, L_{50}, L_{90} or L_{dn}. It was also found that these latter measures are between themselves highly correlated. Of these measures, L_{dn} was picked by EPA in Reference 1 as the measure most useful among these measures for relating environmental noise levels to human response. On these bases it seems reasonable to develop a model for predicting L_{dn} from population density.

It was shown in the previous section that, using the 100 EPA survey site data, plus the data from the 30 other sites available, a correlation of 0.723 was found with log ρ. The regression line computed for this relationship has the form:

$$L_{dn} = 9.00 \log_{10} \rho + 25.8 \text{ (decibels) for } \rho > 1.$$

The original hypothesis that urban noise levels would vary with population density was based on the assumptions that vehicular traffic density varies directly with population density, and further that average traffic speed for urban areas is relatively speed independent. Models for traffic noise[6] predict that average noise level varies as 10 $\log_{10}$ of the mean vehicle flow rate. A first order estimate of urban noise related to population density would thus expect average noise levels to vary as 10 $\log_{10} \rho$. Using a prediction equation for L_{dn} given by:

$$L_{dn} = 10 \log_{10} \rho + 22 \text{ (decibel) } \rho > 1$$

is statistically insignificant (at the 0.05 level) from the regression line found from the site measurements. For example, the difference between these two equations is less than one decibel for values of ρ between 1 and 100 thousand per square mile. This is shown on Figure 4-1 where the solid line is $10 \log_{10}\rho$ and the dashed line is $9 \log_{10} \rho$. For simplicity in analysis the $10 \log_{10}\rho$ relationship is used in the following development.

It was hoped in the initial planning for the survey that some information would be obtained to allow a systematic description of the deviations from the average correlation between noise level and population density to be derived in terms of city structure or roadway configuration. Evidence was obtained to indicate that such considerations do explain levels that are higher or lower than the average, but no systematic structure seemed developable from the data such that its use could be incorporated in a model at this time. Much more detailed exploration of individual community sites will be required before such refinements can be justified in any urban noise model.

Examination of the scatter in the data in Figure 4-1 indicates that the only reasonable estimate for variation of level at a fixed ρ is to assume that noise levels are normally distributed at each value of ρ, with the distribution being characterized by a standard deviation of the same order as the standard error obtained from the correlation computation. The standard error computed for the regression line is 4.19 decibels. The standard deviations of L_{dn} for a series of values at ρ vary from 3.56 to 5.12, with an average of 4.01. For model purposes, one can assume a standard deviation in L_{dn}, at any value of ρ, of 4 decibels.

With a means for predicting an average value of L_{dn} for any population density, and an assumption that the distribution of L_{dn} around the average is normal, with a standard deviation of 4 decibels, all the steps necessary to estimate outdoor day/night sound level are in hand. These factors can be combined by using the standard format for a normal probability distribution function to express a distribution function for L_{dn} as a function of ρ as:

$$L_{dn}(\rho) = \frac{1}{4\sqrt{2\pi}} e^{-\frac{(L_{dn} - \overline{L_{dn}})^2}{32}} \quad \text{(decibels)}$$

Where $\overline{L_{dn}} = 10 \log_{10} \rho + 22$, the standard deviation, σ , is 4 decibels, and ρ is in number of people per square mile.

ESTIMATING NATIONAL NOISE EXPOSURE

An estimate of the number of people exposed to different values of L_{dn} can be generated if the number of people at each value of ρ is known. The 1970 census provides the population by census tract for the more than 35,000 census tracts that account for the 134 million people living in areas defined as "urban" in the United States. The areas of these tracts, however, are not available directly in Census Bureau publications. It was learned that the basic data necessary to compute a distribution function of population as a function of population density was available in computer readable format at National Planning Data Corporation. Arrangements were made with this organization to generate the required distribution function. These data were provided as a cumulative population by census tract population density.

The distribution function of population was then stratified to provide the cumulative distribution of population in successive population density increments of one decibel on a 10 log ρ basis. That is, the total population in each successive increment from 100 or less people per square mile up to the maximum of greater than 200,000 people per square mile was determined with each increment being 1.26 times the previous increment. This stratified distribution is tabulated in Table 5-1.

The number of people exposed to different noise levels was determined for each increment in population density by assuming a distribution of noise levels according to the model previously described in this section as applied to the distribution of total population as a function of population density. The number of people at each level was assigned according to the approximation to a normal distribution listed in Table 5-2.

TABLE 5-1

POPULATION DISTRIBUTION IN URBAN AREAS BY

CENSUS TRACT POPULATION DENSITY - PEOPLE PER $(\text{MILE})^2$

CLASS INTERVALS ARE "UP TO" - E.G. 100 IS 0 TO 100

ρ	10 log ρ	% Pop.	Δ%
100	20	5.00	5.00
126	21	6.00	1.00
159	22	7.00	1.00
200	23	8.00	1.00
252	24	9.00	1.00
318	25	11.00	2.00
400	26	12.00	1.00
504	27	13.85	1.85
635	28	15.00	1.15
800	29	17.00	2.00
1,000	30	19.70	2.70
1,260	31	22.01	2.31
1,600	32	25.00	2.99
2,017	33	28.53	3.53
2,541	34	32.40	3.87
3,200	35	37.00	4.60
4,000	36	44.11	7.11
5,071	37	51.01	6.90
6,384	38	59.01	8.00
7,943	39	67.00	7.99
10,000	40	75.38	8.38
12,589	41	81.05	5.67
15,848	42	85.00	3.95
20,000	43	88.40	3.40
25,178	44	91.08	2.68
31,697	45	93.05	1.97
40,000	46	94.65	1.60
50,356	47	95.94	1.29
63,393	48	96.96	1.02
79,806	49	97.69	0.73
100,000	50	98.47	0.78
125,890	51	99.15	0.68
158,483	52	99.68	0.53
200,000	53	99.92	0.24
>200,000	54	100.00	0.08

Total Population Counted: 134,089,789

TABLE 5-2

FRACTIONAL DISTRIBUTION OF PEOPLE FOR DIFFERENT VALUES OF L_{dn} AROUND A MEAN $\overline{L_{dn}}$

dB re $\overline{L_{dn}}$	% of Population
-7	2.2
-6	2.3
-5	3.5
-4	5.5
-3	7
-2	8.5
-1	10
0	11
+1	11
+2	10
+3	8.5
+4	7
+5	5.5
+6	3.5
+7	2.3
+8	2.2

The population distribution of Table 5-1 was then used, at each increment in ρ, to generate the number of people exposed to different values of L_{dn} by applying the distribution of Table 5-2. For example, the increment in total population between population densities of 3200 to 4000 as listed in Table 5-1 is 7.11% of 134,089,789 people, or 9,533,720 people. Of these, 11%, or 1,048,000, were assigned the L_{dn} value for the mean,

$$(L_{dn} = 10 \log 4000 + 22 = 58),$$

11% were assigned to 59 dB, 10% to 60 dB, 8.5% to 61 dB, etc.

The final distribution of population at each noise level was then obtained by summing the fractional populations assigned to each noise level over all the values of ρ. The resulting values provide the incremental portion of the population exposed to various values of L_{dn}, and cumulative distributions of the total population either exposed to levels greater than some specific value of L_{dn} or exposed to less than a specified value of L_{dn}. Of primary interest is the total number of people exposed to day/night sound levels in excess of a specified value. This distribution is provided in Table 5-3.

TABLE 5-3

DISTRIBUTION OF URBAN POPULATION AT OR GREATER THAN A SPECIFIED L_{dn}

L_{dn}	Cum N (in millions of people)	L_{dn}	Cum N (in millions of people)
34	134.090	59	66.738
35	133.942	60	58.997
36	133.758	61	51.234
37	133.463	62	43.668
38	132.987	63	36.542
39	132.337	64	30.061
40	131.463	65	24.320
41	130.373	66	19.352
42	129.040	67	15.200
43	127.528	68	11.791
44	125.872	69	9.046
45	124.085	70	6.853
46	122.187	71	5.155
47	120.147	72	3.826
48	117.983	73	2.776
49	115.642	74	1.963
50	113.011	75	1.347
51	110.116	76	0.889
52	106.803	77	0.559
53	102.975	78	.332
54	98.544	79	.187
55	93.427	80	.093
56	87.665	81	.039
57	81.237	82	.012
58	74.222	83	.002
		84	.0

SECTION 6

CONCLUSIONS

The measurement program and subsequent analysis reported here provide a first order estimate of the urban population of the United States (not exposed to airport or freeway noise) exposed to different values of outdoor day/night sound level. In the previous report, EPA has provided an estimate of the number of people primarily exposed to various levels of airport and freeway noise. [2] The data from this report and that of Reference 2 can be combined to provide an estimate of the total outdoor environmental noise exposure for the urban residents of the country.

It is reasonable to assume that the rural population of the country is generally exposed to lower values of noise outdoors at home than the urban population. While no data are available to assess the noise environment of the rural population, extension of the model developed here would lead to the assumption that even at population densities of zero per square mile, the average noise level will be of the order of 22 decibels or greater due to wind, rain, and other natural sounds. Thus an extrapolation from the 134 million urban population to the slightly over 200 million total population would say that all people are exposed to average sound levels greater than 20 decibels.

These considerations lead to the distribution curves plotted in Figures 6-1 and 6-2. These figures show the estimate of the number of people in the country exposed to various values of L_{dn}, exclusive of those whose outdoor residential noise environment is dominated by freeway or airport noise. In Figure 6-1 these data are plotted on a linear scale of population. In order to more easily determine from the plotted data the number of people exposed to higher noise levels, the same data of Figure 6-1 have been replotted on a logarithmic scale of population on Figure 6-2.

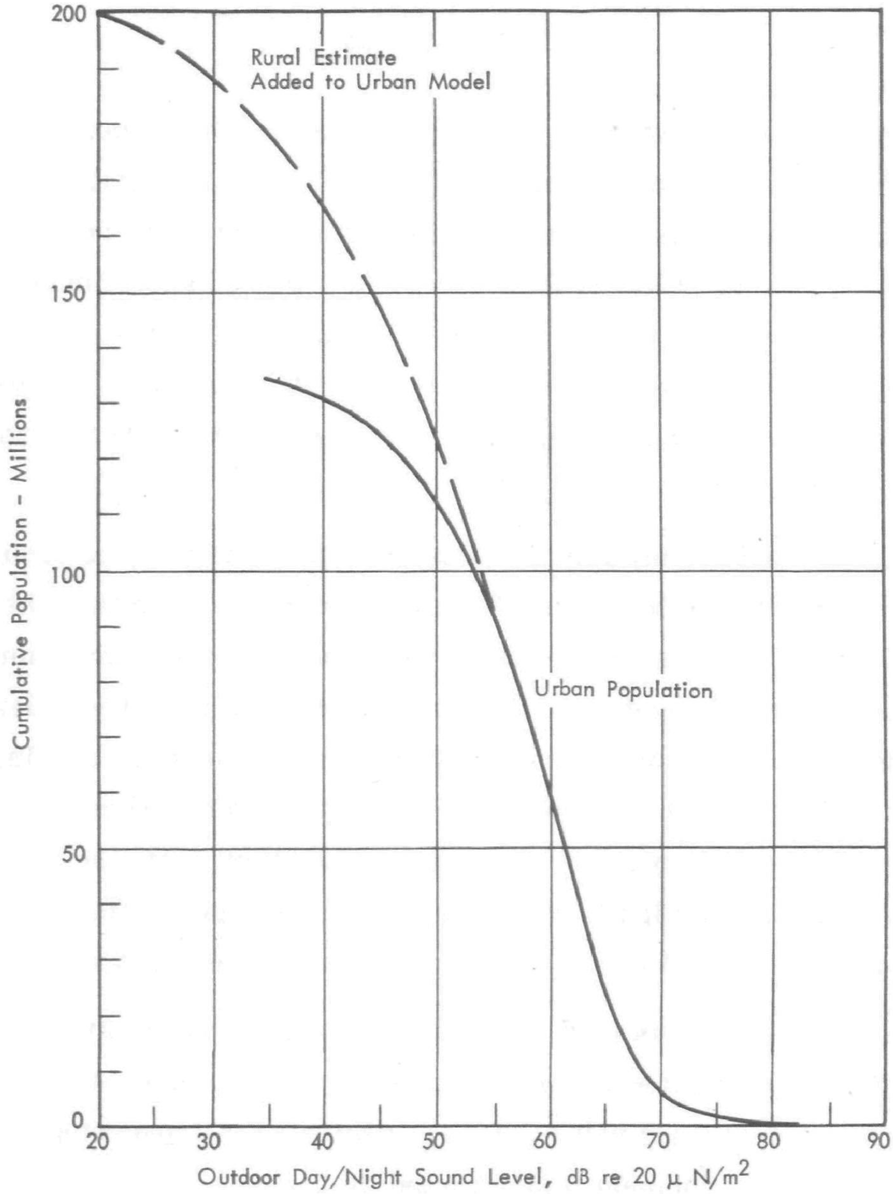


Figure 6-1. Population of the United States Exposed to Day/Night Sound Levels in Excess of a Specified Value (Excluding Freeway and Airport Noise)

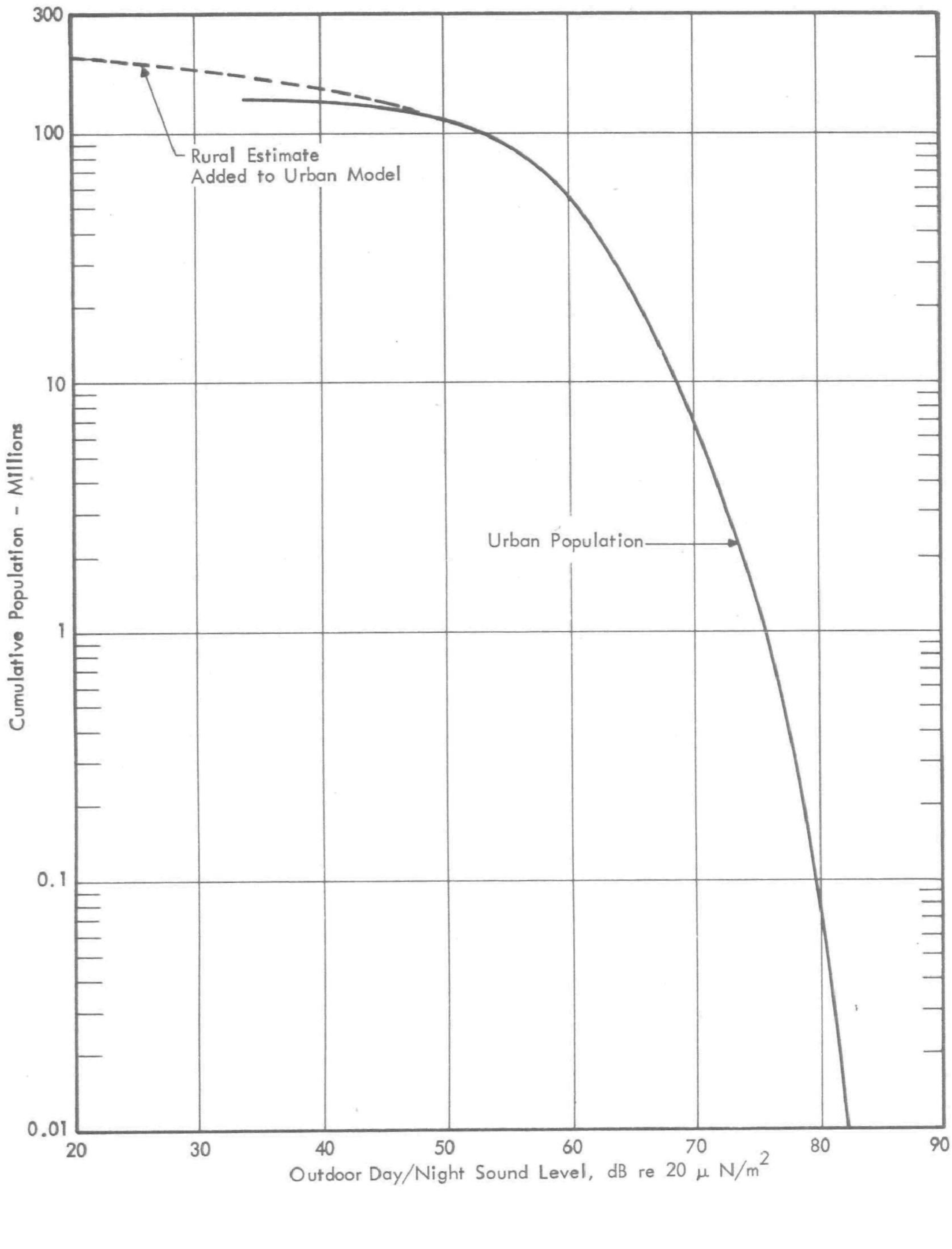


Figure 6-2. Population of the United States Exposed to Day/Night Sound Levels in Excess of a Specified Value (Excluding Freeway and Airport Noise)

A total estimate of residential population exposed to various values of outdoor noise levels must also include those people heavily affected by freeway and airport noise. Estimates of these populations were provided in Reference 2. These results are combined with the estimates developed in this report in Table 6-1. The reader should be aware that these estimates have been made on different bases with different assumptions on population densities, noise levels, and modeling methods. While the authors believe the estimates are as reasonable as can be provided with the information available, any policy decisions influenced by these data should take into account the adequacy of their derivation.

TABLE 6-1

SUMMARY OF THE NUMBER OF PEOPLE IN THE UNITED STATES EXPOSED TO VARIOUS LEVELS OF OUTDOOR DAY/NIGHT SOUND LEVEL

	Number of People in Millions			
L_{dn} Exceeds	Urban Traffic	Freeway Traffic	Aircraft Operations	Total
60	59.0	3.1	16.0	78.1
65	24.3	2.5	7.5	34.3
70	6.9	1.9	3.4	12.2
75	1.3	0.9	1.5	3.7
80	0.1	0.3	0.2	0.6

SECTION 7

RECOMMENDATIONS FOR FUTURE STUDY

The measurement program described in this report has provided a preliminary insight on the magnitude and variability of urban noise for a wide range of population densities. These data also provide a new basis for the design of a national noise survey. With this in mind, the following recommendations are made for future investigation.

1. The strong correlation of noise level with population density suggests that a random sampling of sites for urban noise measurements should be stratified in proportion to the population densities of the area to be studied.

2. A specific program should be conducted at several fixed levels of population density to determine if the assumed normality of noise level distribution is correct. This program should examine in detail the spatial variation in noise levels, for a fixed population density, in order to improve the knowledge of the effect of local variation in street structure and traffic flow on noise levels.

3. The variation in noise level over weekly periods should be examined to determine the difference, if any, in noise exposure on weekends as compared to week days.

4. The wide variation in noise levels throughout the urban population should engender quite different attitudes in residents exposed to these noises.

A social survey should be performed to investigate these differences for low, medium, and high population density environments.

REFERENCES

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

2. "Report on Aircraft/Airport Noise, Report of the Administrator of the Environmental Protection Agency to the Committee of Public Works, U.S. Senate," July 1973.

3. "Report to the President and Congress on Noise," EPA NRC500.1, December 31, 1971.

4. Galloway, W. J., "Motor Vehicle Noise: Identification and Analysis of Situations Contributing to Annoyance," BBN Report 2082, June 1971.

5. Galloway, W. J., "Predicting the Reduction in Noise Exposure Around Airports," Inter-Noise 72 Proceedings, Washington, D.C., October 4-6, 1972.

6. Gordon, C. G., Galloway, W. J., Kugler, B. A., and Nelson, D. L., "Highway Noise: A Design Guide for Highway Engineers," NCHRP 117, 1971.

7. OECD, "Urban Traffic Noise: Strategy for an Improved Environment," October 1969.

8. Wyle Laboratories, "Transportation Noise and Noise from Equipment Powered by Internal Combustion Engines," EPA NTID300.13, December 31, 1971.

9. Galloway, W. J., and Knapton, D. A., "Trends in Road Vehicle Noise," BBN Report 2081, June 1971.

10. Wilbur Smith and Associates, "Motor Trucks in the Metropolis," August 1969.

APPENDIX A

DATA ACQUISITION AND ANALYSIS DETAILS

APPENDIX A

DATA ACQUISITION AND ANALYSIS DETAILS

Measurement of the outdoor noise environment at each of the one hundred sites was accomplished using portable, unmanned monitoring systems developed by BBN. Each system consists, basically, of a microphone and preamplifier, a special noise monitoring unit, and a digital tape recorder. Figure A-1 shows a block diagram of this instrumentation. As can be seen in the diagram, the noise signal is A-weighted, converted to a digital format, and the output distributed to one of sixty-four counters, each 1.25 decibels wide. The noise environment is sampled at a rate of eight times per second. Once an hour, the contents of the sixty-four counters, as well as the time of day, are recorded onto the digital tape cassette. At the beginning and conclusion of each day's measurements, a calibration signal was recorded on the tape cassette. This signal was analyzed during data reduction as a check on system performance and as a calibration standard for the noise recordings.

Each tape cassette was processed by a time-shared computer (see Figure A-2), which produced an output listing tabulating hourly and daily statistics and noise exposure levels as indicated in Appendix B.

Noise data were acquired for a complete 24-hour period at each site. However, data for occasional hours were deleted due to the occurrence of adverse weather conditions (excessive wind, rain or thunder), non-typical noise intrusions (e.g. bulldozers, lawnmowers, garbage trucks very close to the microphone), or equipment malfunction. The omission of these data will not significantly influence the daily noise levels at a particular site.

As discussed in the report text, the microphone location was standardized at 1.8 meters from the facade of the building. In order to provide rationale for this distance, a series of measurements were performed in which simultaneous sets of ten minute noise samples were obtained with one microphone positioned 1.8 meters from a building facade and another microphone placed at various distances from the facade. These measurements were performed for a quiet residential situation as well as in an environment in which there were frequent passages of automobiles and trucks. Table A-1 shows the differences between the two microphones for both sets of measurements. Note that at the "noisy" site, as the microphone moves closer to the street, the noise levels are higher, as would be expected. Further, as the microphone is placed closer to the facade of the building, reflections result in higher levels as well. At the quiet site, microphone location is not significant. Thus, the choice of 1.8 meters as a measurement distance appears, from this limited set of measurements, to be quite appropriate.

TABLE A-1

DIFFERENCE IN L-EQUIVALENT VALUES OF 10 MINUTE SAMPLES FOR VARIABLE MICROPHONE-TO-BUILDING DISTANCES RELATIVE TO A DISTANCE OF 1.8 METERS

Distance d from Building Facade, in meters	L_e (d) - L_e (1.8 m.), in dB	
	Site A	Site B
0.9	1.6	-0.4
3.6	1.2	-0.8
5.4	2.2	-0.4
7.2	2.6	-0.4

Note: The noise environment at Site A was dominated by car and truck passages, while Site B was located in a "quiet" residential area.

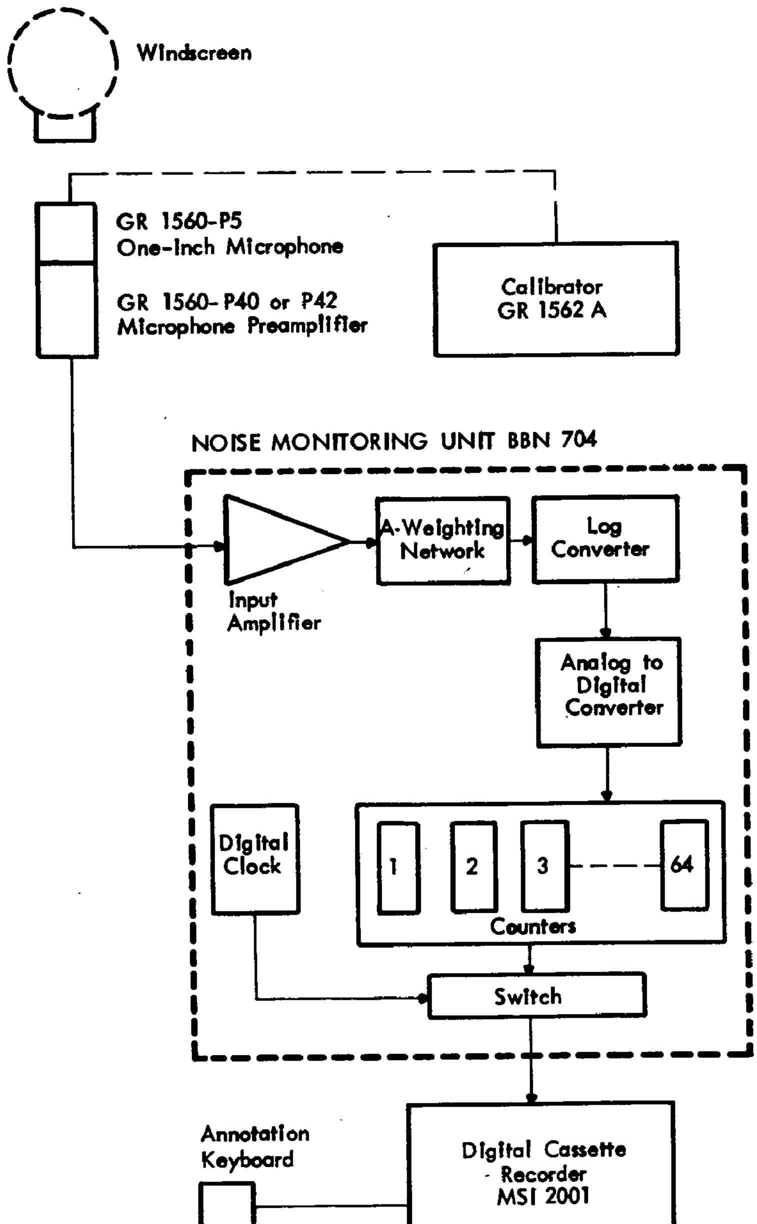


Figure A-1. Block Diagram of Noise Monitoring Instrumentation

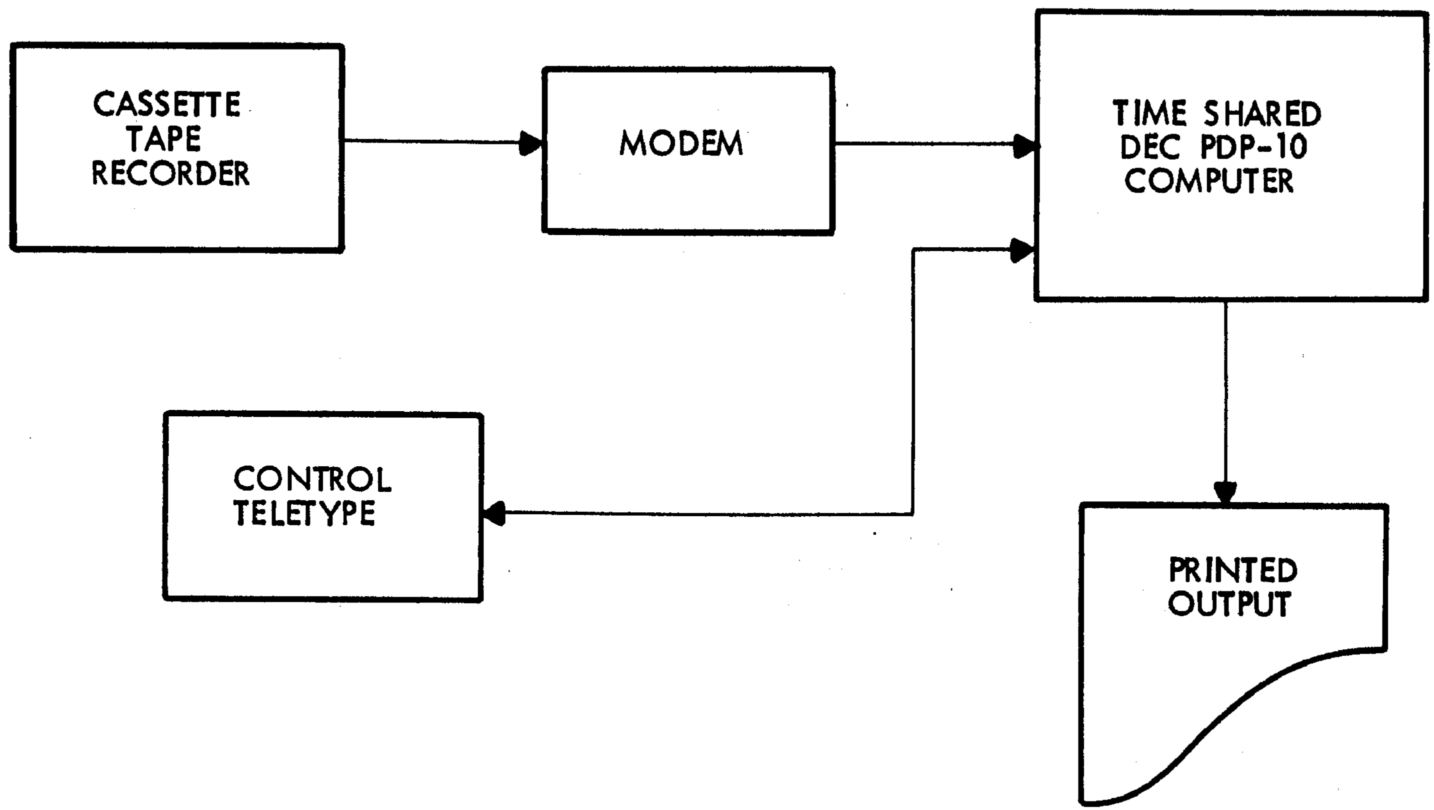


Figure A-2. Block Diagram of Data Analysis System

APPENDIX B

SITE DATA

APPENDIX B

SITE DATA

(Note: Appendix B is presented in full as a separate volume [Volume 2]. The text and a sample of the site descriptive data and computer output listings are reproduced here for reference.)

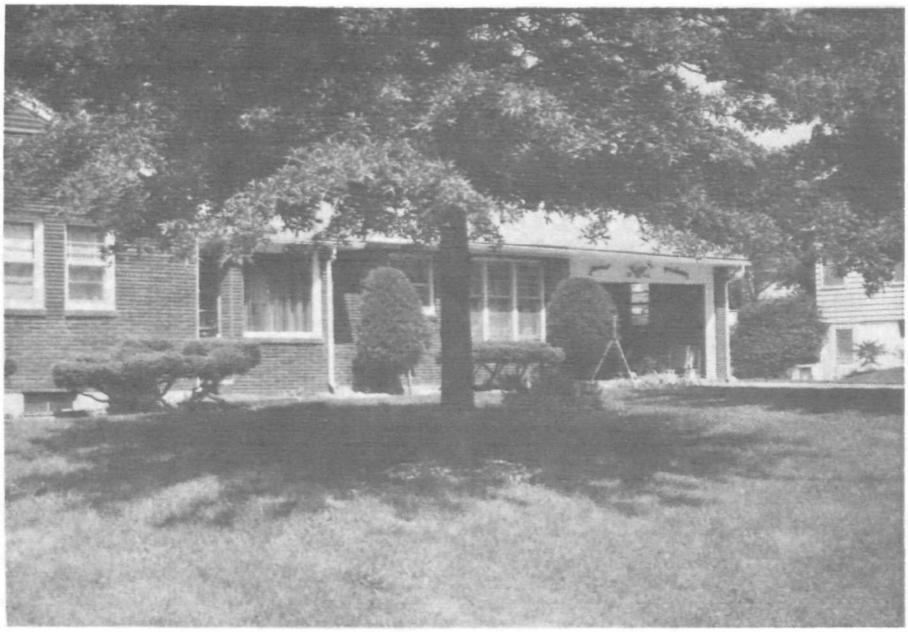
This appendix provides a description of each of the 100 measurement sites utilized during this project. The computer output listings for each of the sites are also presented. Data are presented by city, in alphabetical order.

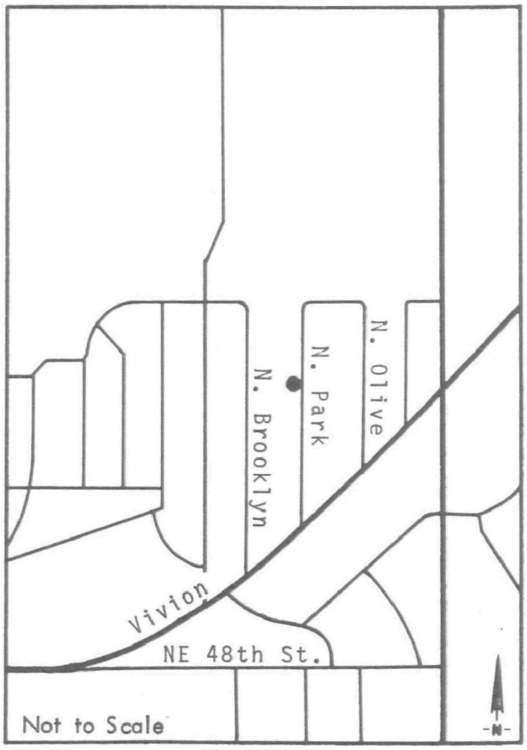
Figures B-1 through B-14 show maps of the fourteen cities in which noise measurements were obtained. On each map the specific measurement locations are indicated.

Figures B-15 through B-114 provide data for each of the sites. The first page of each figure, labeled Figure B-xx(a) provides a physical description of the site. A photo and vicinity map are shown, and the address, population density, and measured L_{dn} value are given. Also listed are various parameters of the traffic flow in the general vicinity of the site. The street on which the site is located and the street in the vicinity of the site which most contributes to the noise environment of the site are both classified into one of four categories: freeway, arterial, collector, and local. Also indicated are the types of vehicles that traverse these streets. Noise sources other than traffic that affect the noise environment at the site are also listed.

The second page of the figure, labeled Figure B-xx(b), lists various statistics and noise levels for each hour of the day. Tabulated are the maximum and minimum values occurring during the hour, the noise pollution level (NPL), the standard deviation (SIG) of the distribution of levels occurring during the hour, the L-equivalent level (L_{eq}), and the traffic noise index (TNI). Various percentile levels ranging from L_1 to L_{99} are also listed.

Similar noise measures are tabulated for the daytime (0700-2200 hrs.) and the nighttime (2200-0700 hrs.) periods on the final page, labeled Figure B-xx(c). Plotted at the top of this page is the distribution of levels for the daytime and nighttime periods. Also, the weighted 24-hour L-equivalent value, with weighting factors of 0, 8, 10, and 12 decibels for the nighttime periods, are listed. Note that the weighted L-equivalent value for a weighting factor of 10 decibels is the day/night sound level (L_{dn}).





L_{dn} :	60.0	dB
ρ :	2,700	people/sq.mi.

SITE: 1303

Address: 5030 North Park
Kansas City North, Mo.

Microphone Height: 1.5 m.

Distance to Curb: 14.0 m.

ROADWAY TYPE

At Site: Local

Vicinity: Arterial

TRAFFIC

At Site: Cars

Vicinity: Cars, Trucks

OTHER NOISE SOURCES:

Figure B-1. Description of Kansas City Site 1303 (Figure B-51(a) in Volume 2)

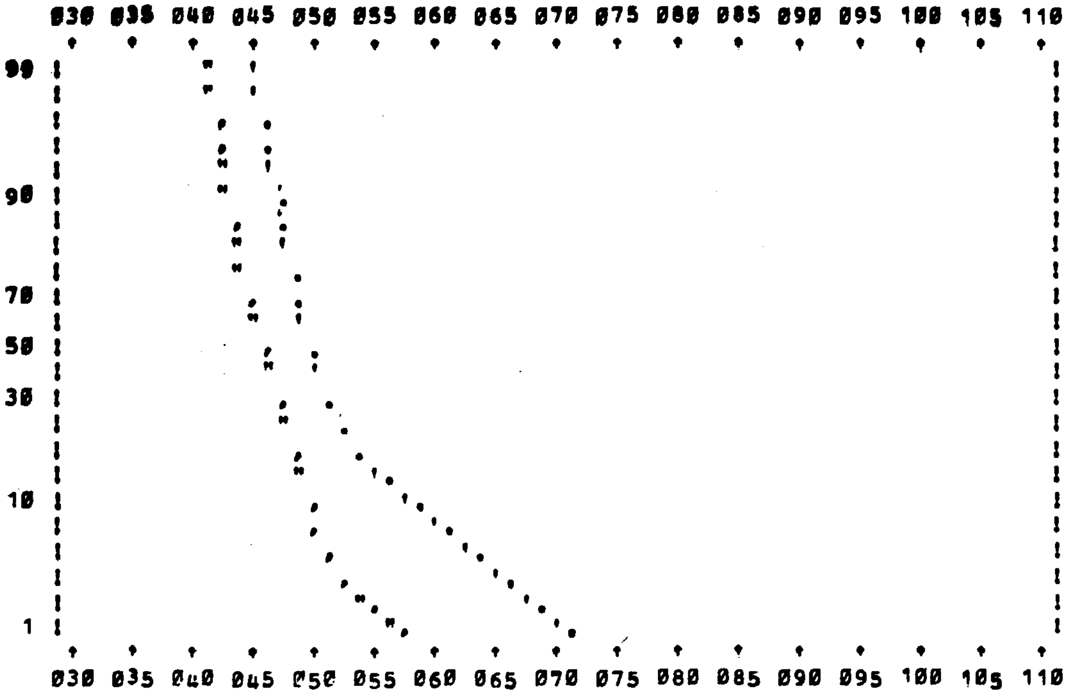
SITE # 1303

HR	MAX	MIN	NPL	SIG	LEQ	TNI	L1	L3	L5	L10	L20
1	68.8	42.5	55.0	2.4	48.9	29.4	58.0	54.8	52.2	48.9	48.3
2	68.8	42.5	50.5	1.6	46.4	26.3	51.2	48.4	47.5	47.2	46.4
3	71.3	41.3	54.8	2.8	47.7	28.5	60.6	51.4	48.4	46.8	45.9
4	62.5	40.0	50.0	1.8	45.3	26.9	52.8	48.2	47.0	46.1	45.6
5	76.3	40.0	54.0	2.7	47.0	25.9	58.7	49.6	46.6	45.3	44.6
6	68.8	40.0	54.0	2.8	46.8	34.3	56.9	51.1	49.6	47.7	46.0
7	76.3	42.5	62.3	3.7	52.9	37.0	65.6	58.6	53.5	50.6	48.7
8	70.0	42.5	56.7	2.7	49.9	37.1	59.7	55.2	53.3	51.2	49.7
9	71.3	42.5	57.8	2.8	50.6	36.1	60.8	56.2	54.0	51.3	49.8
10	81.3	45.0	67.5	4.2	56.9	40.8	70.0	64.9	59.7	53.7	51.3
11	70.0	43.8	56.7	2.4	50.7	33.0	60.9	53.6	52.0	50.9	49.9
12	83.8	43.8	63.5	3.5	54.6	46.3	63.8	58.8	56.9	54.9	53.4
13	82.5	43.8	65.5	3.9	55.6	40.1	65.4	59.4	55.9	51.7	49.9
14	77.5	45.0	63.3	3.7	53.9	43.2	66.1	62.0	58.7	54.1	50.7
15	76.3	43.8	57.8	2.6	51.0	36.1	58.6	52.4	51.4	50.8	49.9
16	75.0	43.8	60.0	2.9	52.5	34.2	64.0	58.7	55.3	51.9	50.4
17	81.3	43.8	60.9	3.2	52.7	39.6	63.2	57.0	54.3	52.2	50.9
18	86.3	47.5	70.1	4.4	58.9	51.6	70.8	65.5	62.3	57.4	53.6
19	98.8	45.0	84.5	7.0	66.6	84.9	77.6	72.4	69.6	65.3	60.3
20	92.5	46.3	79.0	5.9	63.9	72.3	75.9	69.4	66.3	62.5	58.6
21	93.8	46.3	86.0	7.2	67.6	92.2	79.5	75.4	73.0	69.0	64.6
22	90.0	46.3	66.6	3.7	57.2	43.5	68.3	62.2	59.2	55.2	52.4
23	65.0	46.3	53.7	1.4	50.1	29.1	55.9	53.8	52.6	51.1	50.1
24	67.5	43.8	52.8	1.6	48.7	28.9	55.6	51.5	50.4	49.7	48.9

HR	L30	L40	L50	L60	L70	L80	L90	L95	L97	L99
1	47.9	47.5	47.2	46.9	46.6	46.3	45.3	44.6	44.3	43.9
2	46.1	45.8	45.5	45.3	45.0	44.5	44.1	43.9	43.8	43.0
3	45.4	45.0	44.5	44.1	43.7	43.3	42.8	42.6	42.5	41.8
4	45.0	44.8	44.5	44.2	44.0	43.6	42.5	41.9	41.6	41.4
5	44.1	43.6	43.3	43.0	42.7	42.3	41.7	41.4	41.3	40.7
6	45.0	44.5	43.9	43.5	43.1	42.8	42.2	41.7	41.5	41.3
7	48.0	47.4	47.0	46.6	46.2	45.7	45.2	44.6	44.2	43.9
8	48.7	48.3	47.8	47.4	47.0	46.6	45.9	45.4	45.1	44.4
9	49.1	48.6	48.2	47.8	47.4	46.9	46.3	45.6	45.3	44.6
10	50.7	50.1	49.7	49.4	49.0	48.7	48.0	47.7	47.6	46.8
11	49.5	49.1	48.7	48.3	48.0	47.6	46.9	46.5	46.3	45.5
12	52.3	51.0	49.9	49.2	48.6	48.2	47.7	47.5	46.9	46.3
13	49.1	48.5	48.0	47.6	46.9	46.2	45.6	45.2	45.1	44.7
14	49.8	49.5	49.1	48.8	48.5	48.1	47.8	47.6	47.6	47.2
15	49.2	48.5	47.6	47.1	46.7	46.3	45.7	45.3	45.2	45.0
16	49.8	49.6	49.3	49.0	48.8	48.3	47.8	47.5	46.8	45.6
17	50.0	49.4	48.8	48.1	47.4	46.9	46.4	45.8	45.5	45.1
18	52.4	51.8	51.2	50.8	50.4	50.0	49.4	49.0	48.9	48.8
19	57.1	54.6	52.7	51.3	50.3	49.5	48.8	48.0	47.6	46.8
20	56.1	54.3	52.9	51.7	50.8	50.0	49.2	48.8	48.4	47.8
21	61.1	58.6	56.5	54.9	53.5	52.3	51.3	50.3	49.8	48.9
22	51.8	51.2	50.8	50.4	50.0	49.5	49.1	48.8	48.7	47.9
23	49.8	49.6	49.4	49.2	49.1	48.9	48.4	47.9	47.8	47.6
24	48.5	48.3	48.0	47.8	47.5	47.0	46.6	46.4	46.3	45.7

Figure B-2. Hourly Noise Data for Kansas City Site 1303 (Figure B-51(b) in Volume 2)

SITE # 1303



	DAY '.'.	NIGHT ".".	WEIGHTING	WEIGHTED L_{eq}
MAX	98.8	76.3	0.	58.7
MIN	42.5	40.0	8.	59.5
NPL	74.0	56.7	10.	60.0
SIG	5.2	3.1	12.	60.7
LEQ	60.6	48.8		
TNI	60.4	39.6		
L1	71.9	57.6		
L3	66.0	52.5		
L5	62.7	50.8		
L10	57.8	49.6		
L20	53.3	48.5		
L30	51.4	47.6		
L40	50.5	46.7		
L50	49.7	46.0		
L60	49.2	45.2		
L70	48.6	44.5		
L80	47.9	43.9		
L90	46.9	42.9		
L95	46.2	42.4		
L97	45.7	41.9		
L99	45.2	41.4		

Figure B-3. Day/Night Noise Data for Kansas City Site 1303
(Figure B-51(c) in Volume 2)

APPENDIX C

SUMMARY OF INFORMATION FROM OTHER SOURCES

APPENDIX C

SUMMARY OF INFORMATION FROM OTHER SOURCES

Data from noise measurements made at thirty sites during previous studies have been included in our analysis (see Figure 4-1). Figure C-1 provides a reference for each of these measurement points. The values of L_{dn} and population density for each of these sites are tabulated in Table C-1.

For the most part, noise data obtained at these sites were acquired by recording the noise level for ten minutes out of each hour on an analog tape recorder, with subsequent processing of the recorded signal through a distribution analyzer. The statistics resulting from this analysis were assumed to apply for the entire hour during which the ten minute sample occurred. Typically, the window size of the distribution analyzer was either 2.5 or 5 dB wide.

In order to evaluate whether this method of acquiring noise data for a 24-hour period would result in different L_{dn} values from the method which we utilized in this study, described in Appendix A, the recorded noise samples for two of the positions were played back through the BBN monitoring equipment and analyzed as though they were recorded in the field. Table C-2 compares the L-equivalent value determined by the monitoring instrumentation with the level determined originally using the analog system. While differences in individual hours range up to 3 dB, the average difference in hourly levels are 0.4 and 0.2 dB for the two sites, and in terms of L_{dn} comparisons, the differences are of the same magnitude.

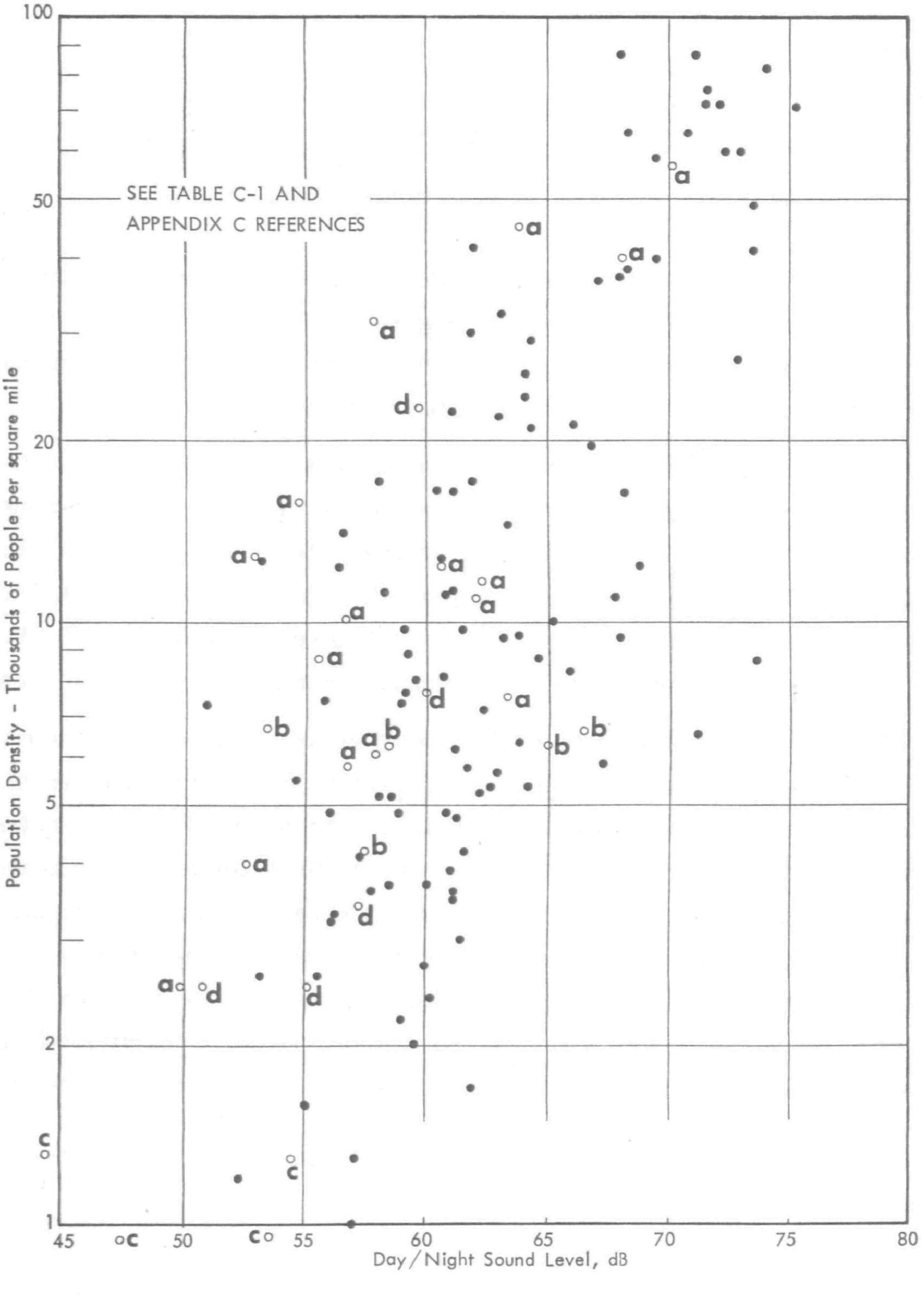


Figure C-1. Plot of L_{dn} vs. ρ Referencing Data from Previous Studies

TABLE C-1

DATA FROM PREVIOUS STUDIES

City	Reference	Site	L_{dn}, dB	ρ, people/sq. mile
Los Angeles	a	1	49.8	2,500
		3	52.7	4,000
		4	60.6	12,500
		6	54.8	15,900
		11	52.9	12,900
		18	56.7	10,200
		24	62.3	11,800
Boston	a	9	57.9	31,700
		14	68.1	40,600
		15	70.2	57,000
		17	63.9	45,400
		23	63.3	7,600
Detroit	a	1	57.9	6,100
		8	55.6	8,800
		9	56.8	5,800
Portland	b	1, 2, 3*	58.5	6,300
		4	65.0	6,300
		5, 6, 7*	57.5	4,200
		8, 9, 10*	53.5	6,700
		11	66.5	6,700
Hawaii	c	2	44.5	1,300
		3	54.5	1,300
		4	53.6	950
		9, 10*	47.5	950
Los Angeles	d	G	60.0	7,600
		J	62.0	11,000
		L	59.7	21,400
		M	57.3	3,400
		N	50.9	2,500
		O	55.2	2,500

*Note: L_{dn} values were averaged for these sites, which are located within a few blocks of each other and have similar noise environments.

TABLE C-2

COMPARISON OF L_{dn} AND HOURLY L-EQUIVALENT VALUES BETWEEN DIGITAL MONITORING SYSTEM AND ANALOG SYSTEM DATA PROCESSING

ΔL_e in dB

Hour	Los Angeles Site 4 (ref. a)	Los Angeles Site 6 (ref. a)
1	0.3	-0.3
2	-0.4	-1.2
3	-0.6	0.2
4	0.9	1.8
5	0.4	-0.3
6	-0.9	1.0
7	0.9	-1.2
8	0.3	-0.5
9	0.1	
10	0.6	-1.1
11	-0.3	0.8
12	1.5	1.0
13	1.7	-0.1
14	0.9	-0.1
15	1.1	-1.0
16	0.1	-1.0
17	-0.1	-1.2
18	-0.2	-0.3
19	-0.1	1.4
20	0.6	-0.2
21	3.0	
22	0.5	-1.1
23	-0.7	-0.8
24	0.5	0.7
Hourly Average	0.4	-0.2
ΔL_{dn}, dB	0.5	0.2

Note: Differences are monitoring system levels minus analog system levels.

APPENDIX C REFERENCES

a. "Community Noise Measurements in Los Angeles, Detroit and Boston," Bolt Beranek and Newman Report 2078, June 1971.

b. "I-205 Noise Impact Analysis," Bolt Beranek and Newman Report 2200, April 1972.

c. "Noise Assessment of Interstate Route H-3 from the Halawa Interchange to the Halekou Interchange," Bolt Beranek and Newman Report 2099, November 1971.

d. "Community Noise," EPA NTID300. 3, December 1971.

APPENDIX D

INSIDE NOISE DATA

APPENDIX D

INSIDE NOISE DATA

At fifteen of the one hundred sites at which outside measurements were obtained, measurements were simultaneously taken inside the residence. The inside measurement location was in the family or living room for fourteen of the sites, and in the bedroom for one site. The microphone was positioned at typical listener level, and for the family or living room situation was located where a resident might normally spend several hours sitting, relaxing, watching TV, etc.

The noise measurement instrumentation used for the inside measurements was slightly different from that utilized for outside measurements, in that the A-weighted noise level was continuously monitored and recorded on digital tape in the field, with distribution into various counters being performed by computer subsequently. The data were analyzed to yield the L-equivalent value for each hour of the day.

Figures D-1 through D-15 show patterns of L-equivalent values for each hour of the day both inside and outside of the various residences. Also indicated on each figure are the inside and outside values of the daytime (0700-2200 hrs) and nighttime (2200-0700 hrs) L-equivalent levels (indicated as L_d and L_n, respectively).

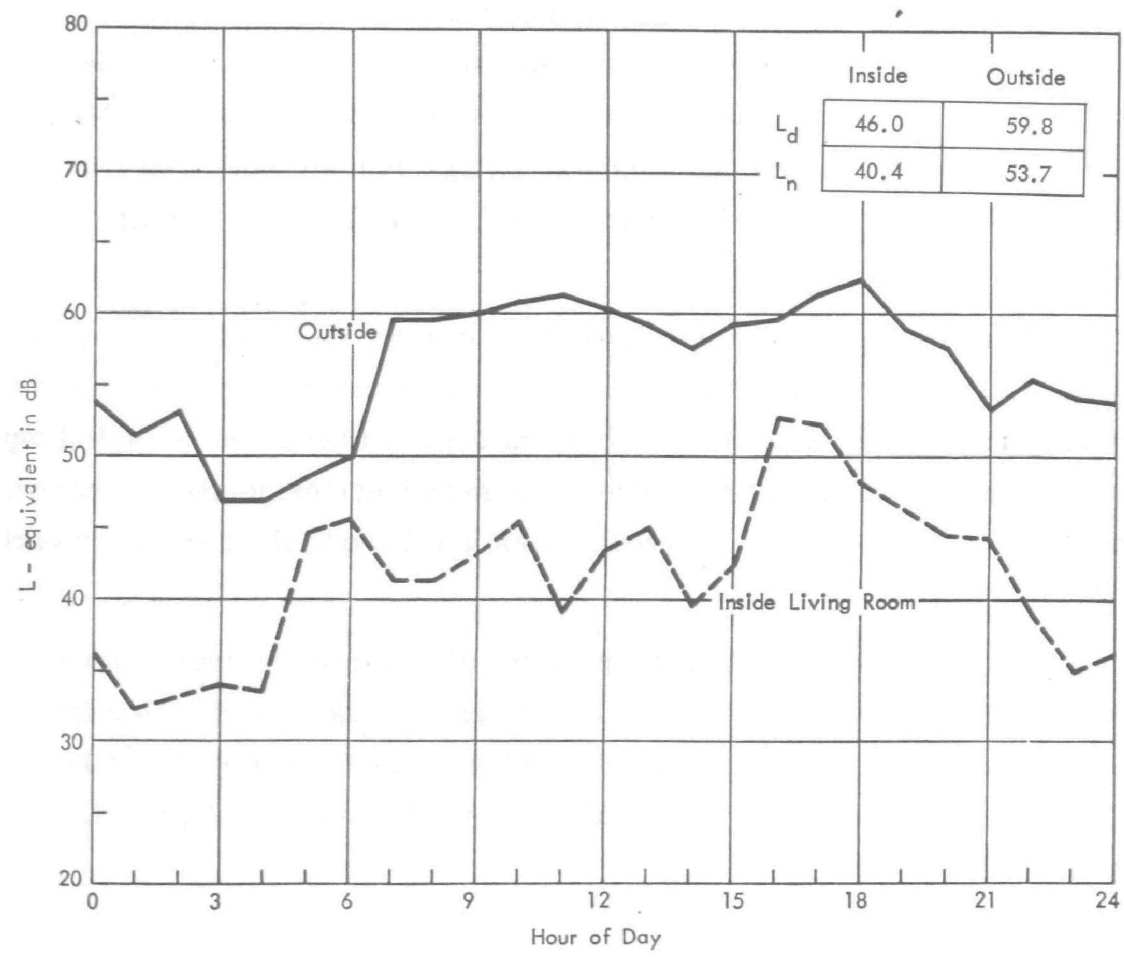


Figure D-1. Inside/Outside L-Equivalent Values at Boston Site 0007

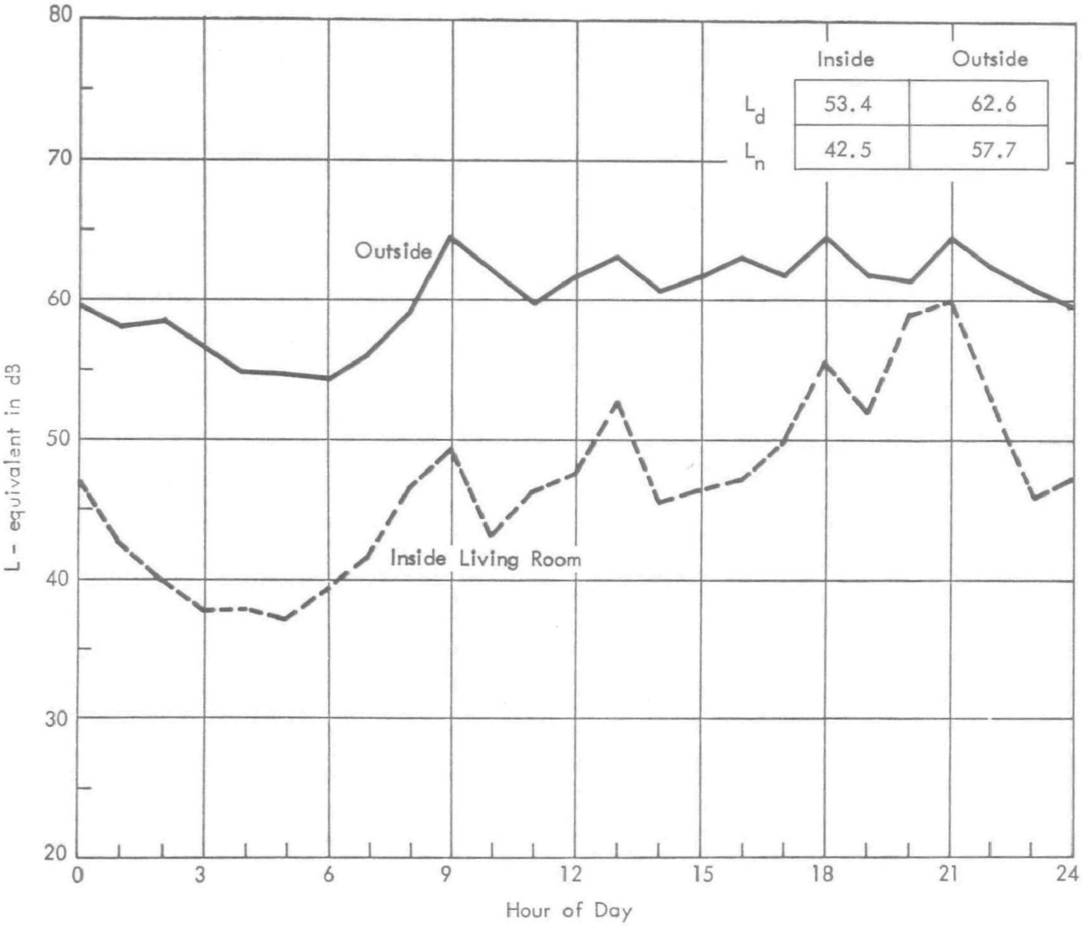


Figure D-2. Inside/Outside L-Equivalent Values at Boston Site 0008

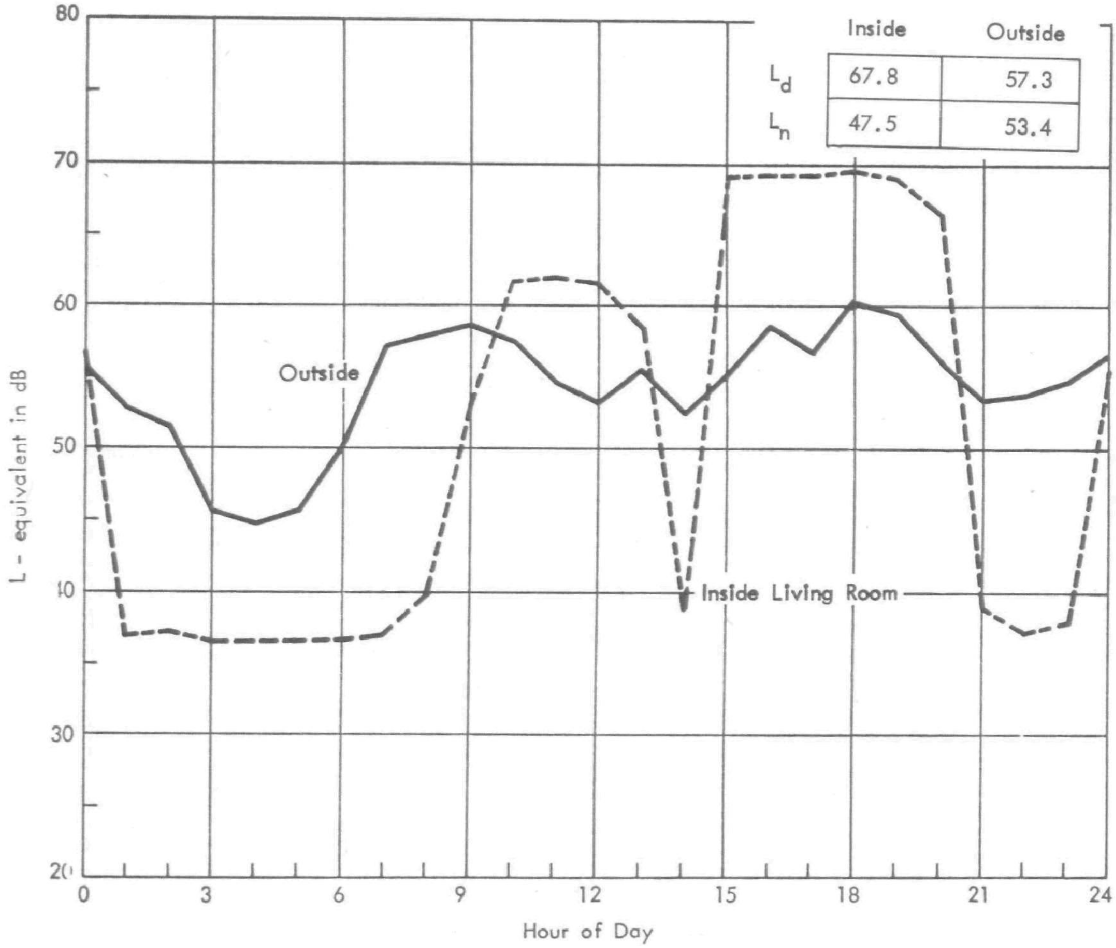


Figure D-3. Inside/Outside L-Equivalent Values at Denver Site 1104

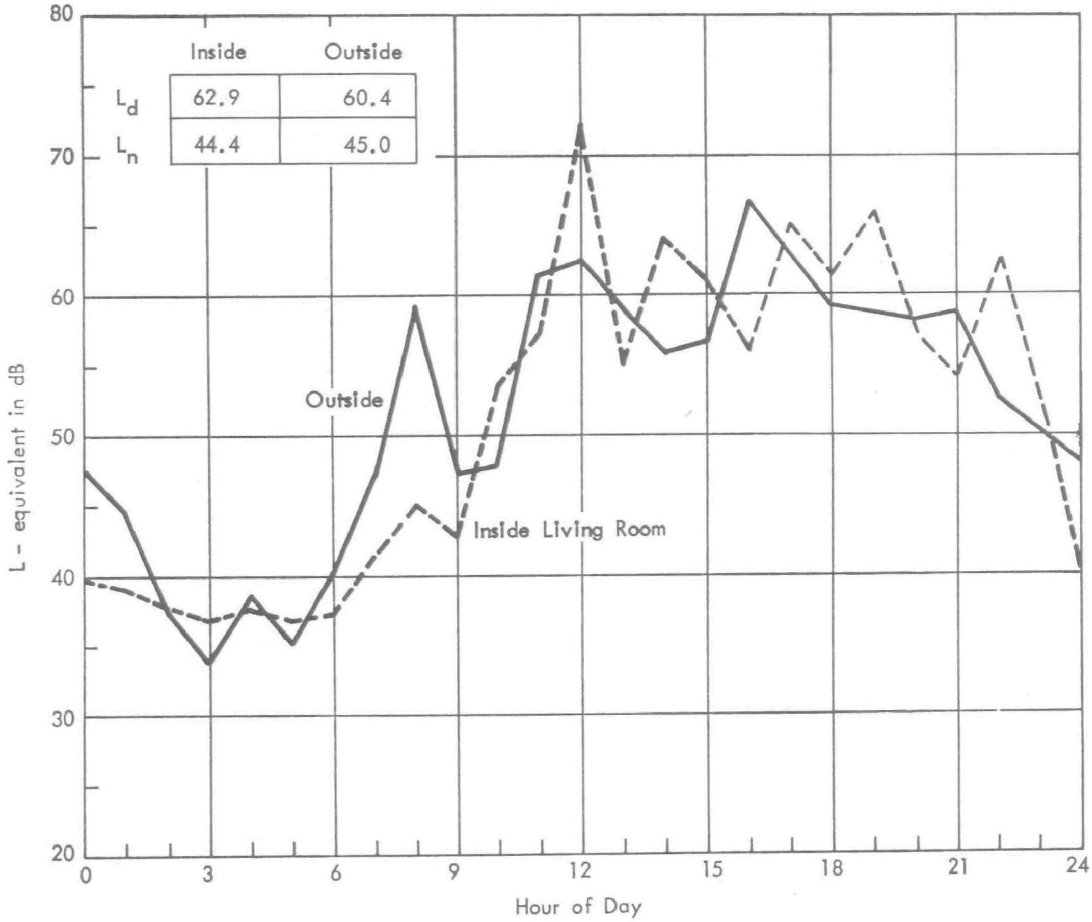


Figure D-4. Inside/Outside L-Equivalent Values at Denver Site 1107

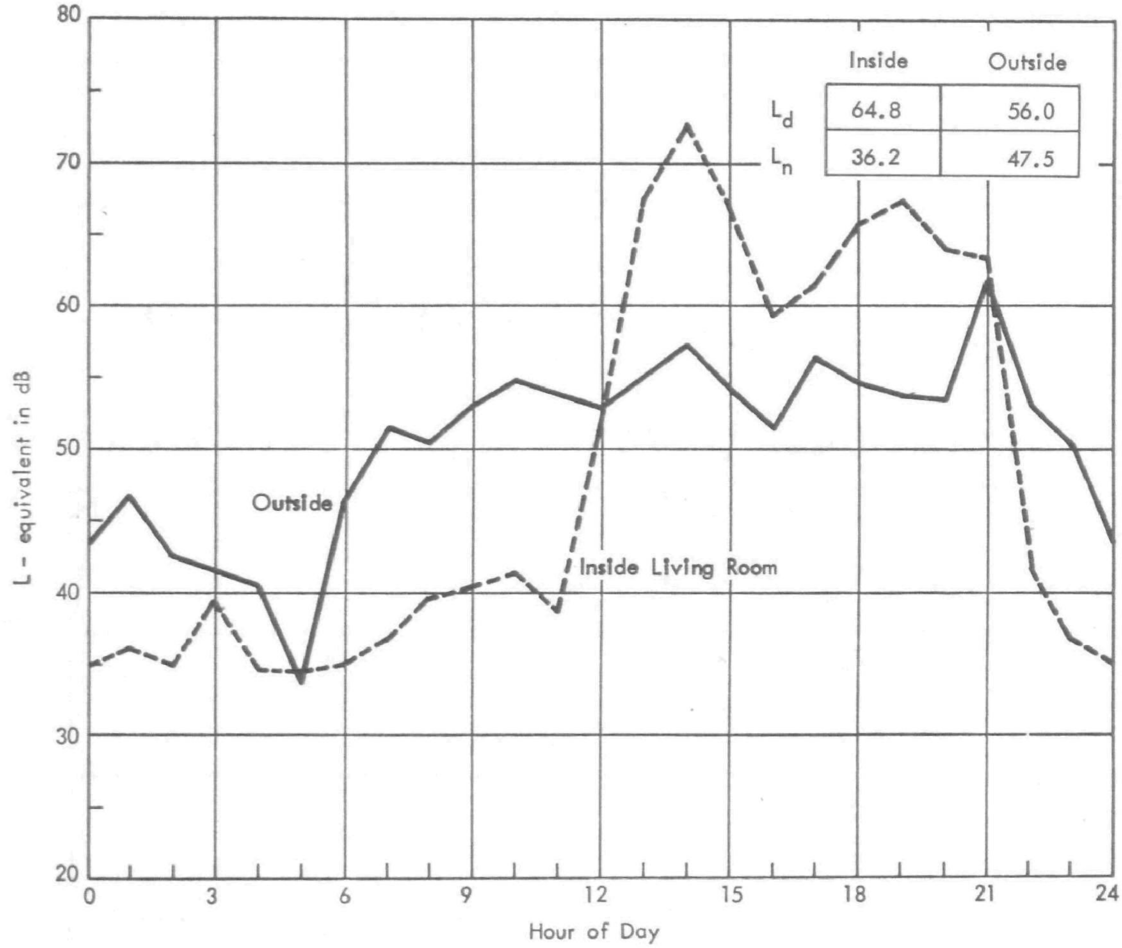


Figure D-5. Inside/Outside L-Equivalent Values at Denver Site 1110

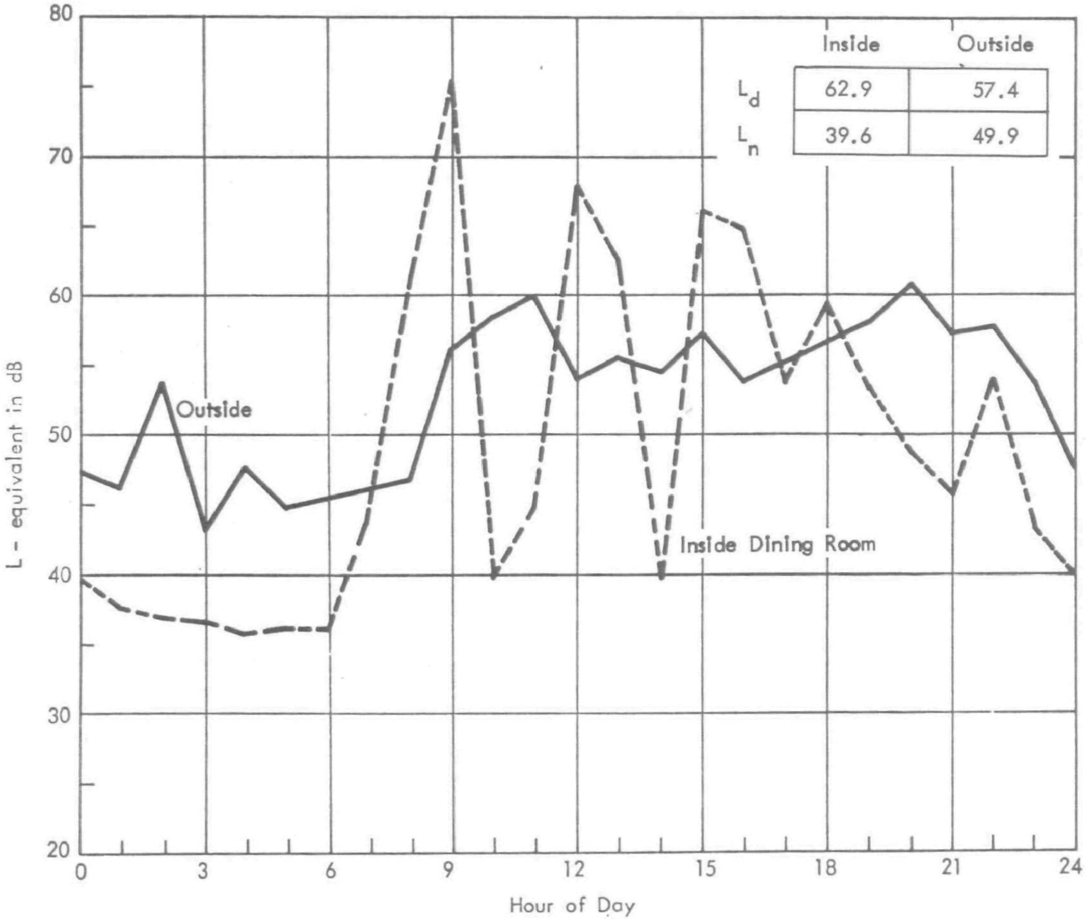


Figure D-6. Inside/Outside L-Equivalent Values at St. Louis Site 1201

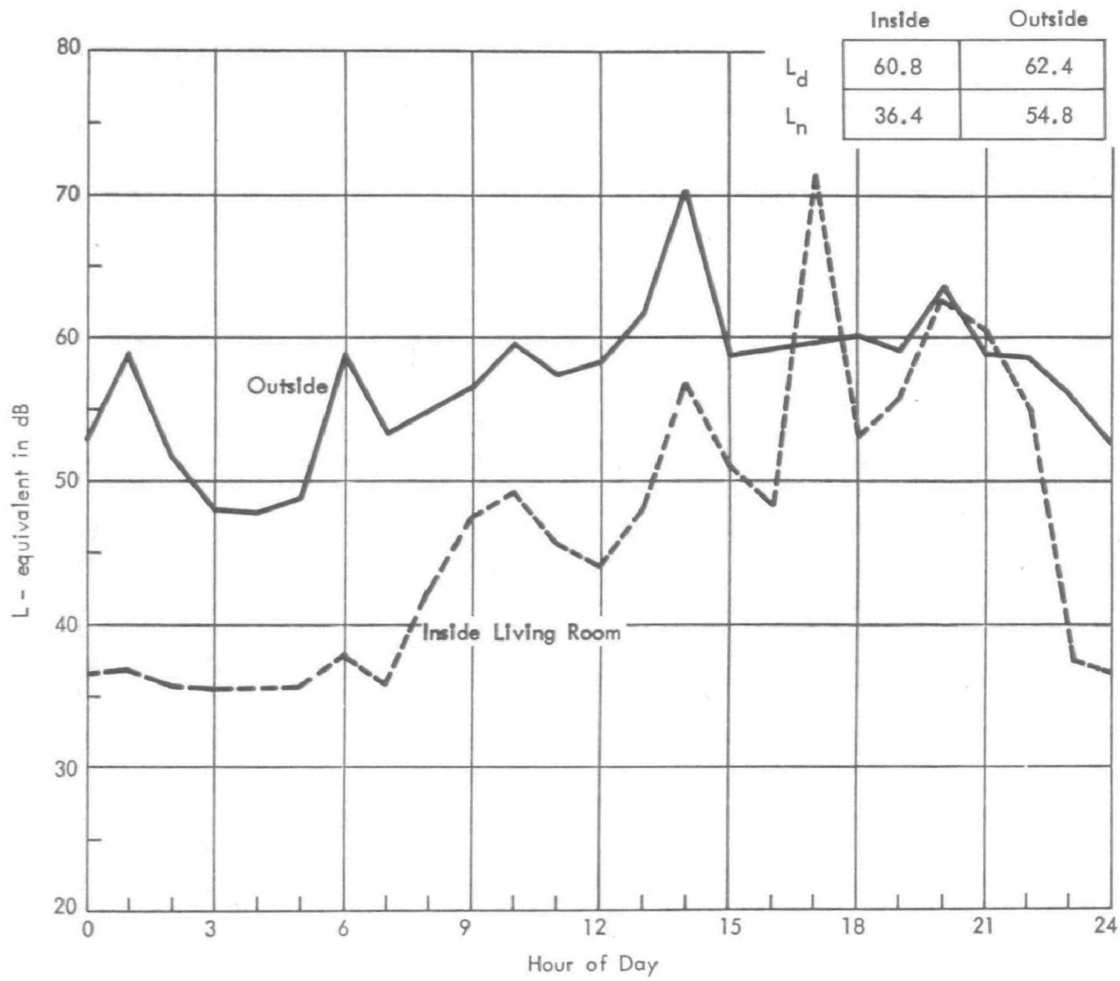


Figure D-7. Inside/Outside L-Equivalent Values at St. Louis Site 1211

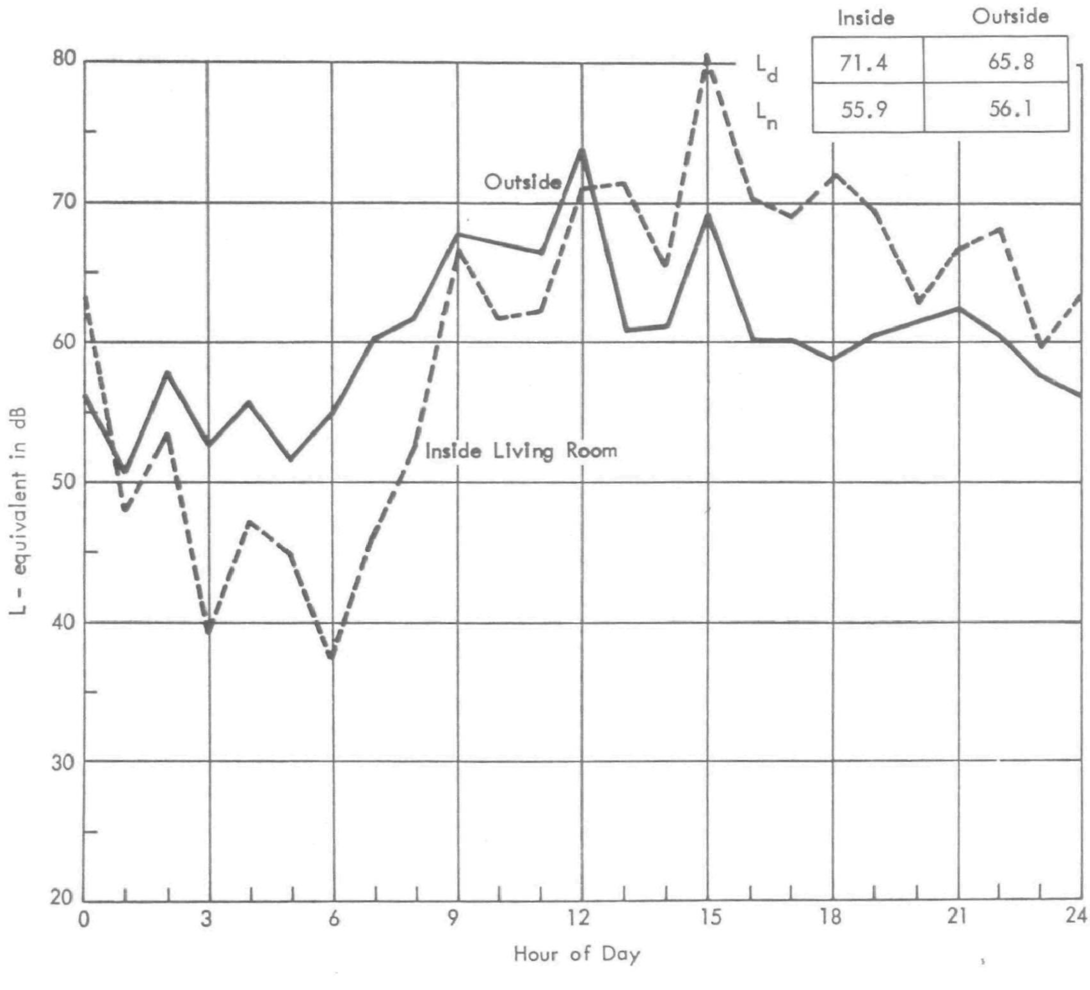


Figure D-8. Inside/Outside L-Equivalent Values at Dallas Site 1401

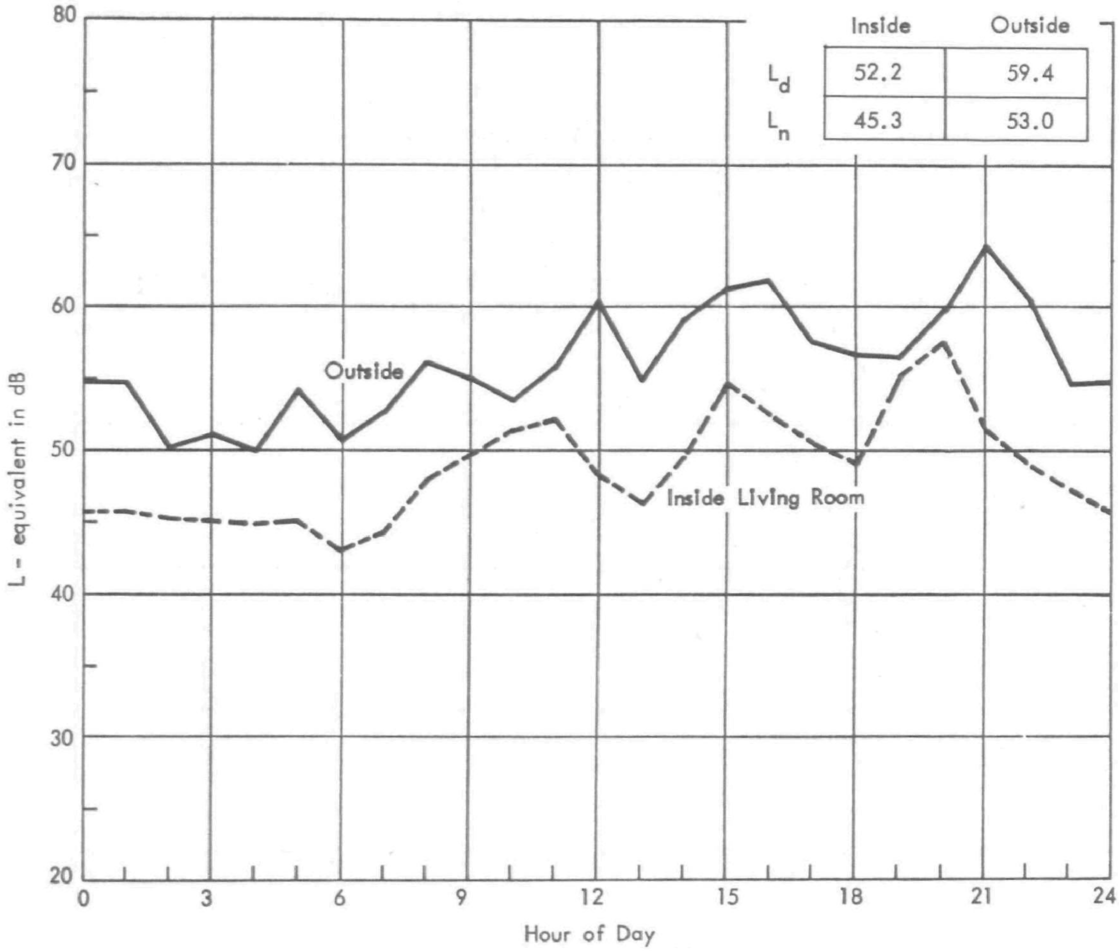


Figure D-9. Inside/Outside L-Equivalent Values at Dallas Site 1404

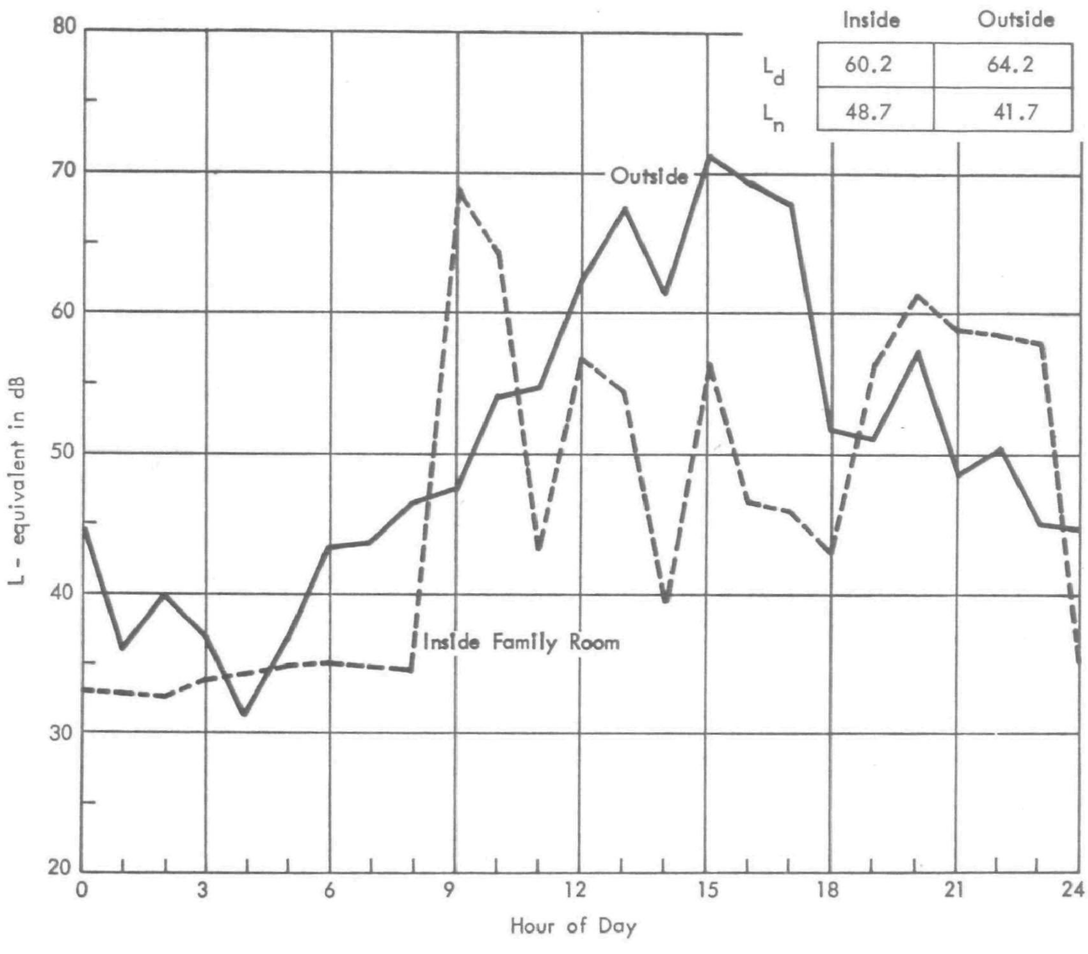


Figure D-10. Inside/Outside L-Equivalent Values at Seattle Site 15(

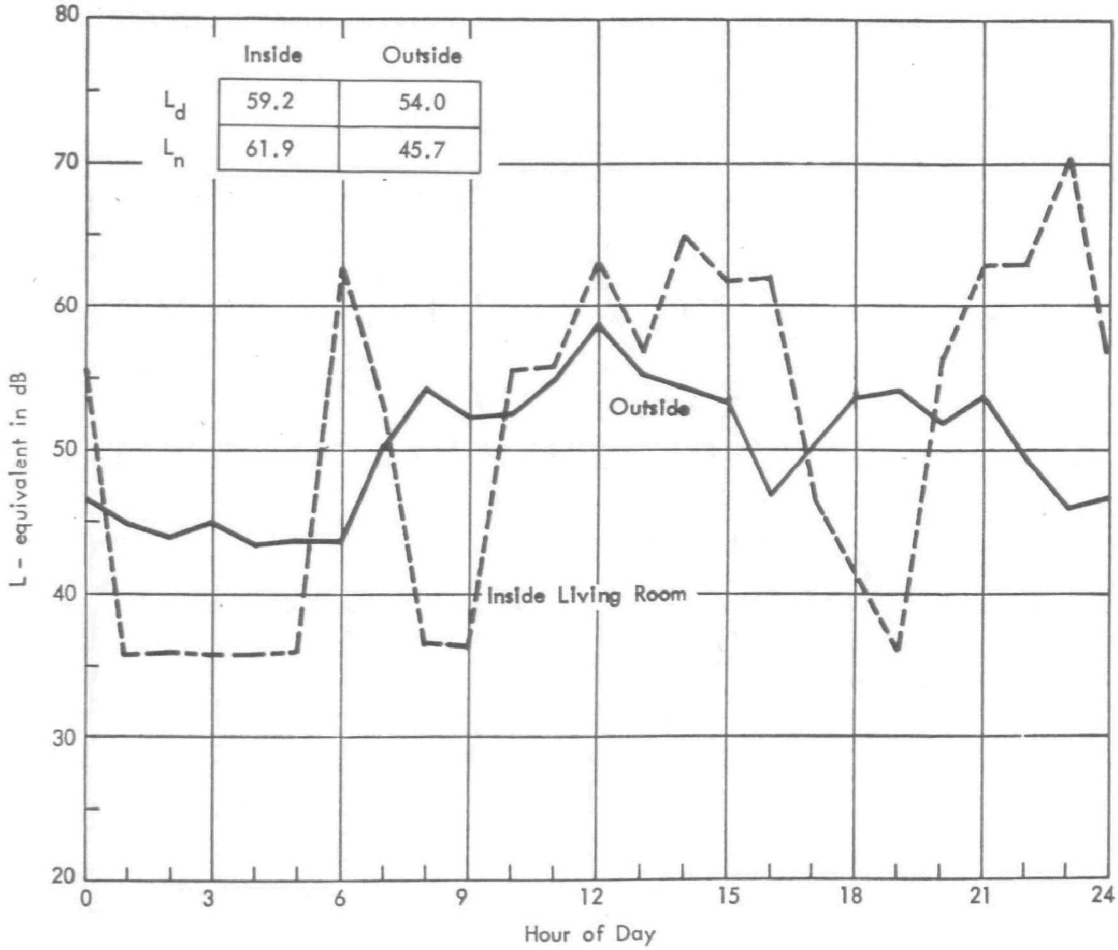


Figure D-11. Inside/Outside L-Equivalent Values at Seattle Site 1506

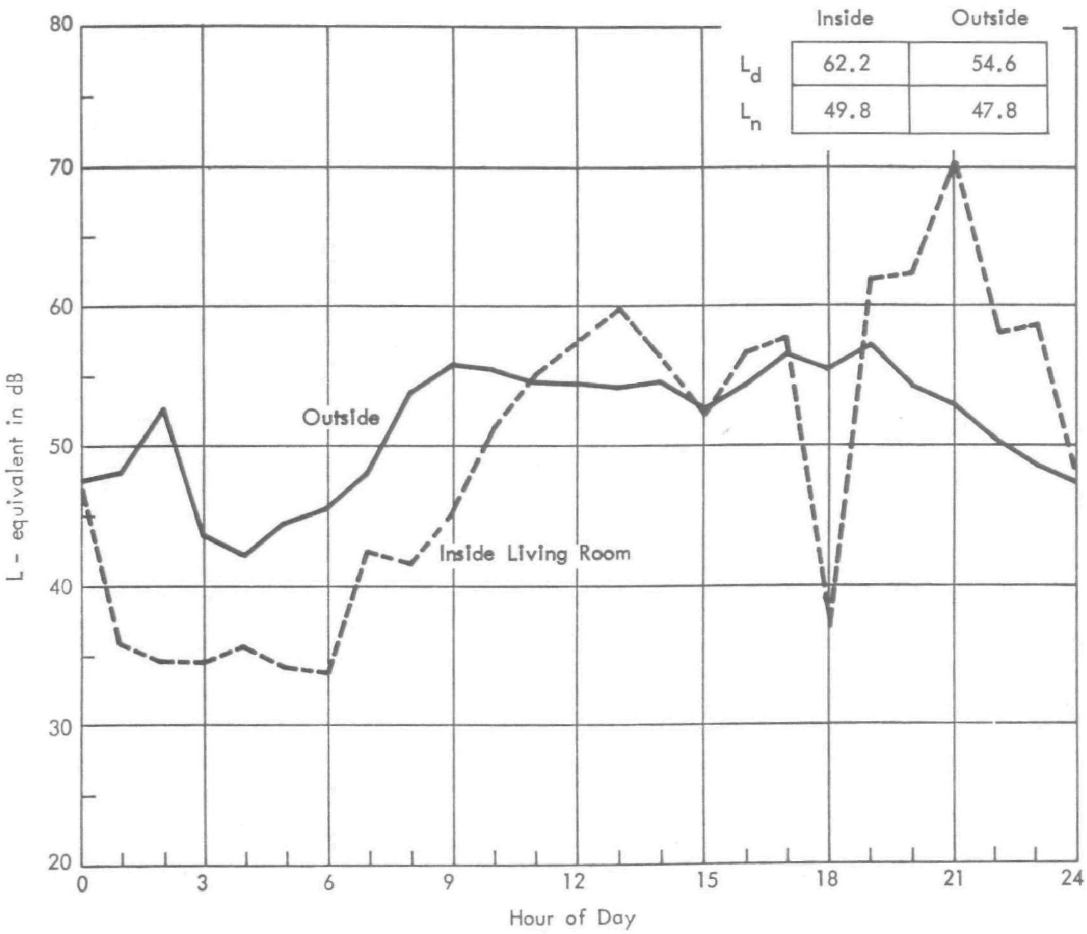


Figure D-12. Inside/Outside L-Equivalent Values at Los Angeles Site 1603

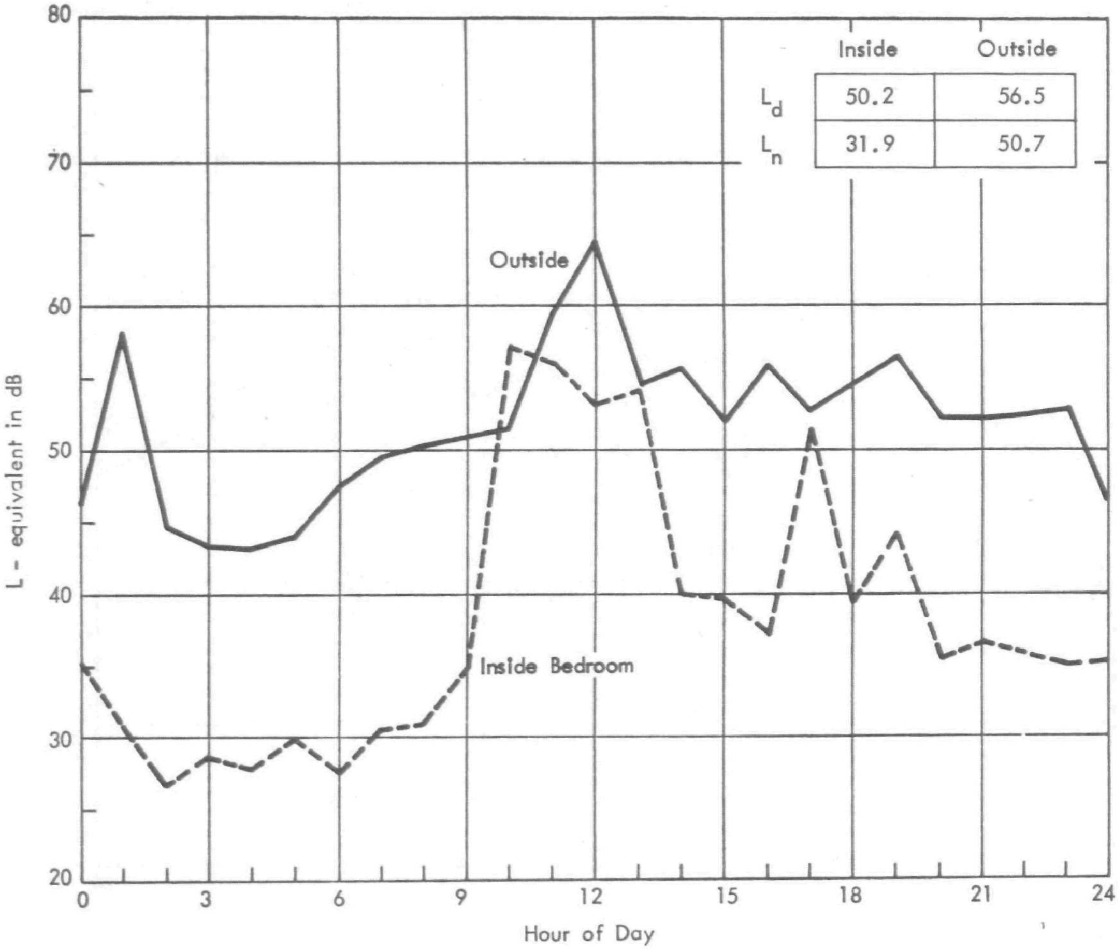


Figure D-13. Inside/Outside L-Equivalent Values at Los Angeles Site 1605

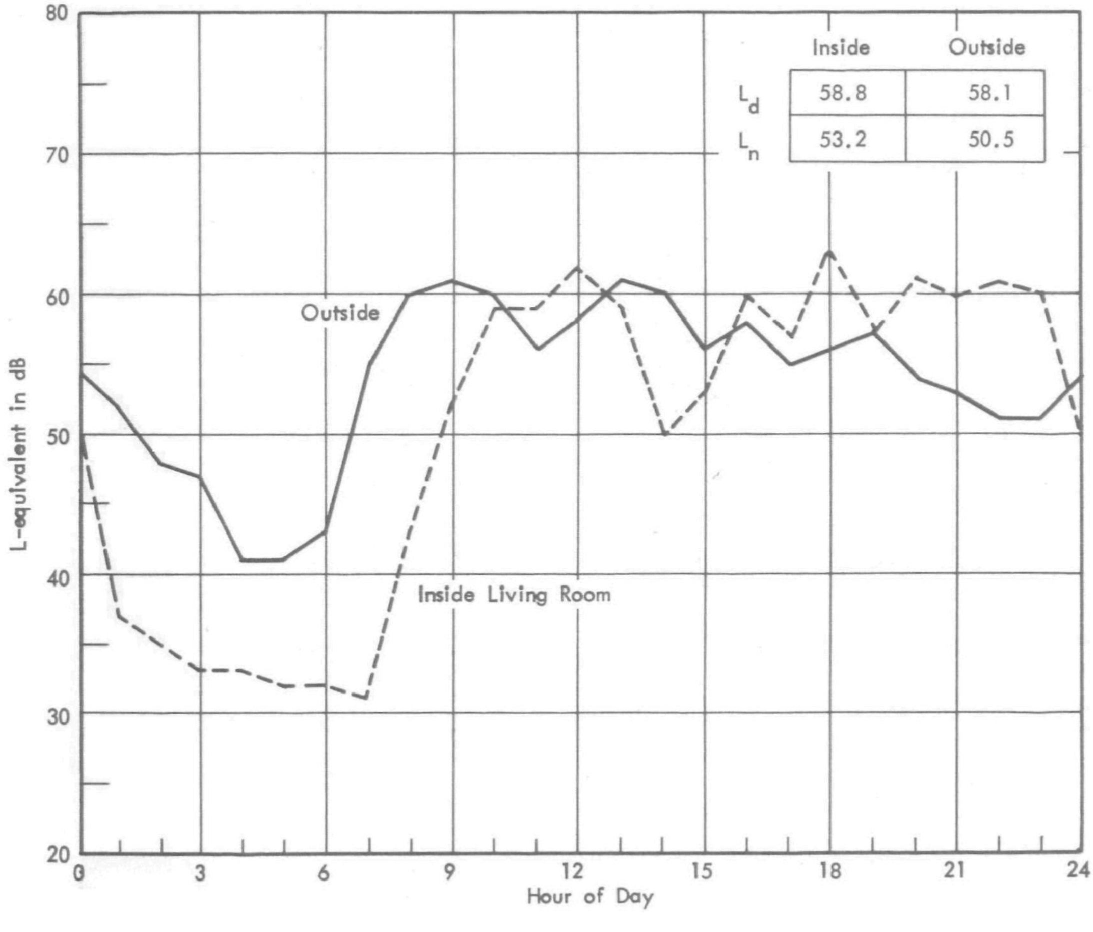


Figure D-14. Inside/Outside L-Equivalent Values at Los Angeles Site 1606

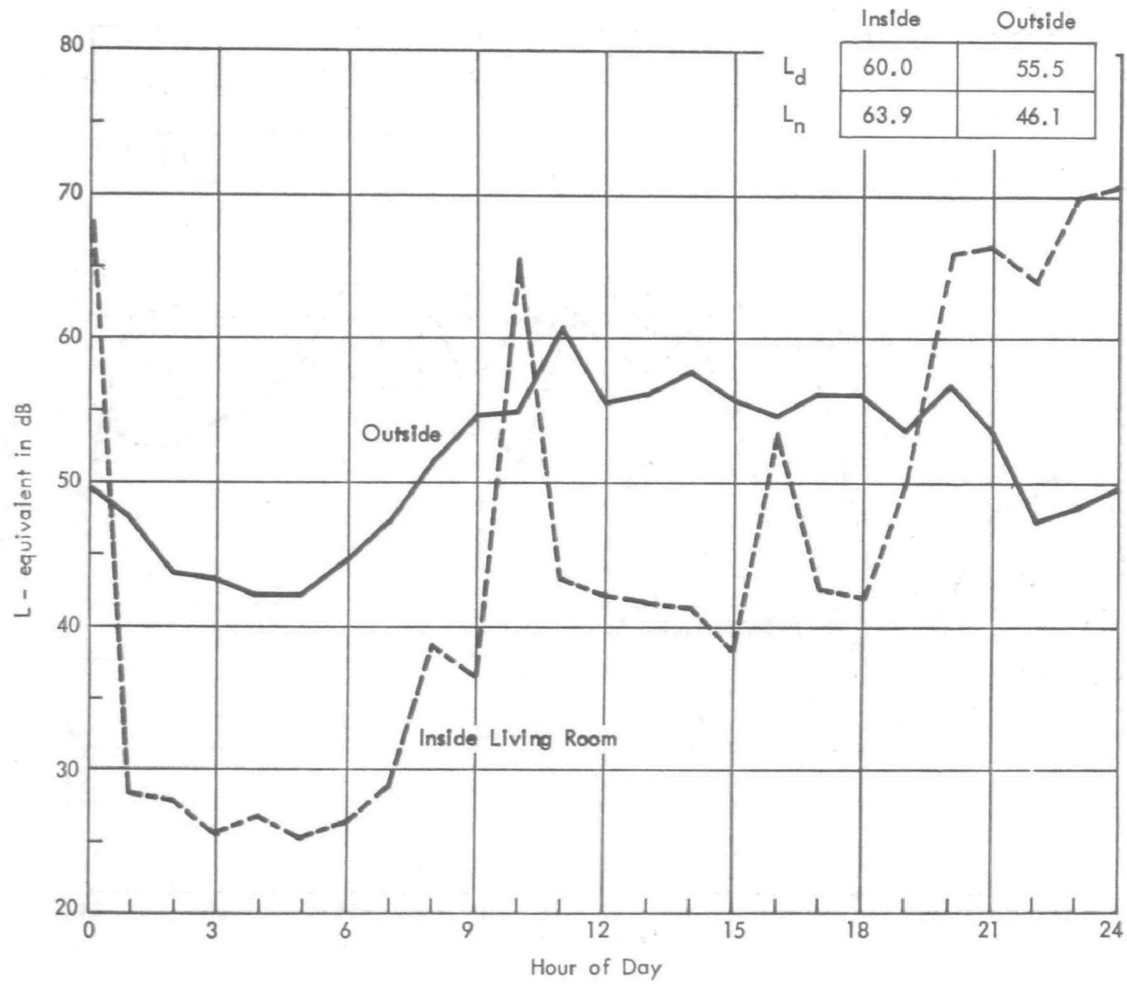


Figure D-15. Inside/Outside L-Equivalent Values at Los Angeles Site 1608

BIBLIOGRAPHIC DATA SHEET	1. Report No. 550/9-74-009	2.	3. Recipient's Accession No.
4. Title and Subtitle Population Distribution of the United States as a Function of Outdoor Noise Level			5. Report Date June 1974
			6.
7. Author(s) W.J. Galloway, K. McK. Eldred, & M.A. Simpson			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Bolt Beranek and Newman Inc.			10. Project/Task/Work Unit No.
			11. Contract/Grant No. 68-01-1886
12. Sponsoring Organization Name and Address Environmental Protection Agency Office of Noise Abatement and Control Crystal Mall #2 Arlington, Virginia 20460			13. Type of Report & Period Covered Final
			14.

15. Supplementary Notes

16. Abstracts

This report summarizes the planning, conduct and results of a noise survey in 100 sites in urban areas across the United States and the use of these results coupled with other existing data, to provide an estimate of the outdoor noise levels experienced in residential areas by the United States population. It concludes that there are more than 90 million people living in areas in excess of 55 L_{dn} and 1.3 million in areas in excess of 75 L_{dn}.

17. Key Words and Document Analysis. 17a. Descriptors

population density
day-night sound level Ldn
noise exposure
urban residential noise levels
noise measurement

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Limited number of copies from EPA,ONAC, Arlington, Virginia. Available from NTIS	X UNCLASSIFIED	
	20. Security Class (This Page) X UNCLASSIFIED	22. Price