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C. LESLIE DAWSON
SECRETARY
AND
COMMISSIONER OF HIGHWAYS

MARTHA LAYNE COLLINS
GOVERNOR

November 25, 1985

Mr. R. E. Johnson
Division Administrator
Federal Highway Administration
330 West Broadway
Frankfort, Kentucky 40601

Dear Mr. Johnson:

Subject: Implementation Statement for UKTRP Report No. 85-15, "Effectiveness of Traffic Noise Barrier on I-471 in Campbell County, Kentucky"

The traffic noise measurements and data analyses summarized in the subject report show that the I-471 noise barrier has resulted in a substantial reduction in traffic noise for the affected homes. The success of this noise barrier in providing its predicted insertion loss proves that noise barriers provide an effective traffic noise abatement alternative.

The results of this study are now being used in public meetings to illustrate the potential effectiveness of proposed noise barriers.

The construction of additional barriers will be considered in the future as a viable noise abatement measure.

The funds allotted and used for this particular research study can well be justified.

Very truly yours,

R. K. Capito

R. K. Capito, P.E.
State Highway Engineer

Technical Report Documentation Page

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Prepared in cooperation with the U. S. Department of Transportation, Federal Highway Administration

16. Abstract

The objective of this study was to evaluate the effectiveness of the traffic noise barrier on I 471 in Campbell County, Kentucky. Since the barrier coincided with construction of I 471, it was necessary to predict noise levels that would exist if no barrier were present utilizing the FHWA STAMINA 2.0 computer model. This was compared to actual noise level measurements at the barrier site to determine the barrier insertion loss.

After calibration of the STAMINA 2.0 model, noise measurements were conducted at 39 receiver locations during off-peak and peak traffic conditions. The noise barrier reduced the noise level reaching adjacent residences substantially. Twenty-one residences (20 percent of the total in the study area) experienced a peak L10 insertion loss of 10 dBA or more, while another 63 residences (58 percent) were estimated as receiving an insertion loss of 5.0 to 9.9 dBA.

Comparison of insertion loss using levels predicted by the STAMINA 2.0 model with the barrier in place and measured levels were very close. Analyses indicated that insertion loss values predicted by the STAMINA 2.0 model will be achieved by the noise barrier.

A survey of community perception of the noise barrier was performed. Of 103 questionnaires delivered, 66 (64 percent) were returned. The community perception of the barrier was favorable, as 64 percent of the respondents generally liked the noise barrier and 95 percent felt it was effective in reducing traffic noise.

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Research Report
UKTRP-85-15

EFFECTIVENESS OF TRAFFIC NOISE BARRIER ON I 471 IN CAMPBELL COUNTY, KENTUCKY

by

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INTRODUCTION

Traffic noise may reach such excessive levels at locations near major highways that noise abatement measures are necessary. One noise abatement measure used frequently across the United States involves a noise barrier constructed along the highway. These barriers are vertical walls made of wood, metal, concrete, or earth berms. They are designed to reduce noise levels at sensitive receivers adjacent to the highway and to break the line of sight between vehicles on the highway and receivers adjacent to the highway.

Currently, only one noise barrier has been constructed in Kentucky. This barrier is located on Interstate 471 in Campbell County (Figure 1). This barrier is 15 feet high and is of metal construction. It is located adjacent to the shoulder of the interstate and has a total length of 2,550 feet. It was constructed in 1981, and its construction coincided with the construction of I 471. The cost of the metal noise barrier itself was $357,000 or $9.33 per square foot or $140.00 per linear foot. The total cost of the noise barrier construction project was $392,277.

The noise barrier was designed to shield traffic noise from a residential neighborhood adjacent to I 471. The objectives of this study were to determine the insertion loss provided by the barrier and to determine if noise reduction estimates were achieved. Since this barrier was the first to be constructed in Kentucky, a determination of barrier effectiveness will aid in future decisions regarding when and how additional noise barriers should be constructed. The construction of noise barriers is expensive, which means that the most efficient design must be used to minimize the amount of barrier area required while achieving the needed noise reduction. Any improvement in design would result in reduced construction costs as well as reductions in noise levels for the affected receivers.

Since the noise barrier was part of the construction of I 471, before-and-after data could not be obtained. This report describes the procedure used to determine the barrier field insertion loss. Modeling of the site is detailed along with the calibration procedure. Results of field measurements are presented. A survey developed to determine community perception of the noise barrier is also shown and results are presented.

DATA COLLECTION PROCEDURE

TECHNIQUE FOR DETERMINING INSERTION LOSS

Since construction of the noise barrier coincided with construction of I 471, before-and-after noise measurements could not be obtained. Also, there was not a similar site along the highway where there was no noise barrier where measurements could be taken and compared to those behind the barrier. Therefore, it was decided to use the procedure described in Section 5.5 of FHWA report FHWA-DP-45-1R (1). That procedure utilizes the FHWA STAMINA 2.0 model to determine insertion loss by comparing actual "after" sound level measurements to predicted "before" levels. The STAMINA

2.0 model considers highway traffic noise in relation to a roadway source, which is approximated by a series of straight-line segments, and estimates the acoustic intensity at receiver locations resulting from the roadway source. Source characteristics are defined by speed-dependent noise emission levels and by traffic density by vehicle type. Site geography is described by a three-dimensional coordinate system. Source-receiver path characteristics are then considered, taking into account effects of noise barriers, topography, vegetation, and atmospheric absorption.

Two locations (behind the noise barrier) were selected and measurements were taken to calibrate the model. Thirty-nine locations were then used in the data collection procedure. Once the calibration process was completed, "before" sound levels were predicted by the model. The insertion loss was determined by taking the difference between the calculated "before" and measured "after" noise levels.

MODEL DEVELOPMENT AND CALIBRATION

The first step in the model calibration process was the physical modeling of the study site. This was done by quantifying physical characteristics of the microphone or receiver locations, vehicles, the roadway, and the barrier. Using maps, an aerial photograph, and a preliminary field inspection, locations for the two microphones (study site and reference microphones) necessary to the calibration process were selected.

To locate the study site microphone, it was necessary to first establish a baseline perpendicular to the centerline of the near traffic lane, passing through the study site microphone location. The study site microphone had to be on the receiver side of the barrier (i.e. the barrier had to stand between the microphone and roadway) and had to be at least 10 feet from any vertical reflective surface. The geometry between the microphone and roadway was to be as simple as possible.

The reference microphone was located on the baseline in such a way that the noise barrier had no effect on it; it required an unobstructed view of the roadway through a subtended arc of at least 160 degrees. Due to the closeness of the noise barrier to the edge of the roadway, the only way to satisfy requirements for locating the reference microphone was to place it behind the noise barrier along the baseline and elevate it in such a manner that the barrier would have no effect (Figure 2). The reference microphone had to have a perpendicular clearance of 5 feet from a line originating at the near edge of the pavement and passing through the top front edge of the noise barrier. Using a tripod constructed of 1-inch diameter galvanized pipe, it was necessary to raise the microphone to a height of 28 feet to obtain the required perpendicular clearance (Figure 3). Locations of the microphones were expressed in terms of x, y, and z coordinates, with the z coordinate indicating the elevation of the microphone.

Vehicle types were grouped into four categories: automobiles (AUTOS), light trucks (LT), medium trucks (MT), and heavy trucks (HT). In terms of noise emission levels, all passenger cars, pickup trucks, and 12- or 15-passenger vans were grouped into the automobile category. The light truck category consisted of delivery-type trucks larger than a van in addition to pickup trucks having two axles and six tires. Single-unit trucks having two axles and six tires, as well as buses, were considered as medium trucks. Motorcycles were included in that category because they had similar noise emission levels. Single-unit trucks having three or more axles and all combination trucks were grouped into the heavy truck category. Corresponding source heights of 0.0, 0.0, 2.3 and 8.0 feet, respectively, were assigned to the categories and input into the STAMINA 2.0 model. Noise emission levels for cars, medium trucks and heavy trucks based on results from nationwide studies are incorporated into the STAMINA 2.0 model, but it was decided to use noise emission levels for different types of Kentucky vehicles derived in a previously issued report (2). The STAMINA 2.0 model allows for input of additional vehicle types; thus, parameters for Kentucky autos, light trucks, medium trucks and heavy trucks were added to the model as Vehicle Types 4, 5, 6, and 7, respectively. Traffic flow conditions for vehicle type, volume, and speed were then input into the model. The "Cars," "Medium Trucks," and "Heavy Trucks" vehicle types, based on nationwide emission levels, were all assigned traffic volumes of one vehicle per hour and speeds of 30 miles per hour (minimum values accepted by the model) so that they would effectively not be considered in the prediction process. Speeds and volumes were input for Vehicle Types 4, 5, 6, and 7 for prediction of traffic noise based on emission parameters for Kentucky automobiles, light trucks, medium trucks and heavy trucks, respectively. The STAMINA 2.0 User's Manual (1) did not specify what speeds were to be used. The 85th-percentile speed, which is the speed used to set speed limits, was used in this study.

A model of the roadway was constructed mathematically using a three-dimensional coordinate system to describe a string of sequentially connected straight-line segments. This presented a complex situation because the roadway running in each direction consisted of a mainline and an entrance or exit ramp, all within the study site location. It was decided to model the ramps, the mainline section before the ramp, and the mainline section after the ramps all as individual roadways with corresponding traffic volumes. For example, the southbound lanes of I 471, which are adjacent to the noise barrier, are comprised of the mainline section and an entrance ramp. The ramp was considered as one roadway and its traffic volumes recorded. The mainline section just prior to the entrance ramp was considered as a separate roadway and its traffic volumes recorded. Finally, the mainline section just past the entrance point of the ramp was considered as a roadway itself; the ramp traffic volumes and the previous mainline section volumes were added to obtain combined traffic volumes for the third roadway. A similar technique was used for the northbound lanes. The exit ramp and mainline section traffic volumes were added to obtain combined traffic volumes for the section just prior to the exit ramp. Thus, there were three individual roadways for each direction, or a total of six. The individual roadways making up the northbound or southbound roadways contained common terminal points in order to connect the individual sections. STAMINA 2.0 allows the user to adjust the emission levels for heavy trucks moving up grades, but does not allow the user to define traffic flow direction. However, a grade adjustment factor may be included in the roadway model and was taken into account in the prediction process for the upgrade southbound lanes.

The noise barrier was modeled physically in the same manner as the roadway, using a three-dimensional coordinate system to describe the barrier as a string of sequentially connected straight-line segments. The height of the top of the barrier was input into the model as well as its elevation at ground level. Barrier coordinates were inserted into the model during the calibration process for the purpose of predicting the present conditions and comparing those predicted noise levels to those actually measured. After calibration of the model, noise barrier coordinates are removed from the model to predict conditions that would exist if the barrier were not present.

A decision was made to model the concrete median barrier as a small noise barrier. Though it was not intended to be a noise barrier and its effect would be minimal, it was decided to include the concrete median barrier in the model to approximate the actual site as closely as possible. For the same reason, three hills in the study site considered to be sufficiently large to provide a significant amount of protection from traffic noise for some of the residences were included in the model. STAMINA 2.0 recognizes three types of barriers: absorptive, reflective, and structural. The noise barrier wall and the concrete median barrier were considered to be reflective barriers, while the three hills were modeled as absorptive earth barriers.

Other factors recognized by STAMINA 2.0 in the modeling process are alpha factors, which concern the effect of hard or soft ground on the noise propagation rate between the source and receiver, and shielding factors, which account for the additional attenuation of noise due to shielding by buildings, rows of houses, trees, or other terrain features. The hillside behind the noise barrier was covered with thick vegetation, leading to the use of the 4.5 dB per distance doubling propagation rate for soft ground between the roadway and the study site microphone. A propagation rate of 3 dB per distance doubling was used for the hard pavement surface between the roadway and the reference microphone. There were no shielding factors between the roadway and reference and study site microphones to cause additional noise attenuation in the model calibration process.

Noise measurements were taken at the reference microphone location by a microphone atop the 28-foot tripod and connected via cable to a B & K Model 4426 Noise Level Analyser. The microphone at the study site was supported on a smaller 5-foot tripod and was connected to another B & K Noise Level Analyser.

The final step in the calibration process was to obtain noise measurements at selected microphone reference and study site locations. During this time period, traffic volumes and speeds were recorded. Using this information, noise levels at the two receiver locations were predicted by the STAMINA 2.0 program. Those levels were then compared to the actual recorded levels at the receiver locations for the same time periods in order to test the validity of the model.

INSERTION LOSS MEASUREMENTS

After calibration of the STAMINA 2.0 model, noise data were collected for peak and off-peak traffic conditions to estimate the barrier insertion loss. Study site locations were selected throughout the neighborhood adjacent to the barrier and "after" noise level measurements were obtained at those locations using 1) a B & K Noise Level Analyser, and 2) a B & K Impulse Precision Sound Level Meter with a Portable Graphic Level Recorder. Measurements for peak traffic conditions were made between 3:55 p.m. and 6:05 p.m.; off-peak data were collected between 10:30 a.m. and 3:00 p.m. Noise data were collected on 21 different days with off-peak data collected on 10 days and peak data collected on 13 days. Noise level measurements were made at 10-minute intervals and corresponding traffic volumes were recorded. To obtain the "before" noise levels, the x, y, and z coordinates of the receiver locations were input into the STAMINA 2.0 model as described in the model calibration. A listing of those coordinates for the 39 receiver locations is in Appendix A. Receiver locations are noted on the map in Figure 4. The receiver locations varied from as close as 135 feet from the noise barrier to as far as 740 feet. Receiver elevations varied from 5 feet above the top of the barrier to 76 feet below the bottom of the barrier. Appropriate alpha and shielding factors were also input.

Coordinates of the noise barrier were excluded from the model to simulate the situation that would exist if no barrier were present. Corresponding traffic volumes and speeds were input into the model and the STAMINA 2.0 program was run to predict the noise levels that would exist for the study site receiver locations without the noise barrier. A sample output including noise barrier coordinates from calibration of the STAMINA 2.0 model is in Appendix B. The barrier insertion loss for each receiver location was calculated to be the difference between the "before" and "after" noise levels.

RESULTS

MODEL CALIBRATION

To calibrate the model, noise level measurements were obtained and corresponding traffic volumes and speeds were recorded for the reference location and the initial study site location. Data were collected over seven 10-minute intervals, resulting in seven separate "runs". For each run, the traffic volumes and speeds were entered into the STAMINA 2.0 model; the model used those volumes and speeds to predict the noise level. The predicted noise levels were then compared to measured traffic noise levels. For the reference microphone location, the allowable difference in Leq could not be more than 1.0 dBA. For seven runs, the average difference in Leq was 0.8 dBA. The difference ranged from 0.2 to 1.6 dBA. The average difference in L10 at the reference microphone was 0.2 dBA with a range of 0.0 to 0.5 dBA.

The allowable difference in Leq for the study site microphone location was 2.0 dBA. For seven runs, the average difference was 0.9 dBA, which also was acceptable. The differences ranged from 0.2 to 2.0 dBA. The average difference in L10 at the study site microphone was 0.9 dBA with a range of

0.0 to 2.3 dBA. Therefore, it was assumed that the STAMINA 2.0 model of the noise barrier site was calibrated properly and could be used to predict traffic noise levels for the situation where no noise barrier existed.

FIELD MEASUREMENTS

Traffic noise data were collected during off-peak and peak traffic conditions at 39 receiver locations. The receiver locations were selected to cover an area adjacent to I 471 which could be affected by the noise barrier. Maps and visual inspections were used to select this area. An attempt was made to select a sufficiently large area such that any residences that may have been impacted by the noise barrier would be included. The receiver locations covered an area that included 108 residences.

The data were summarized separately for off-peak and peak conditions. Traffic volumes were counted during each measurement period. The volumes are summarized in Appendix C. Volumes were counted by direction and by mainline and ramp. The measured noise levels were compared to noise levels predicted by the STAMINA 2.0 model for the situation that would exist if no barrier were present. The barrier insertion loss was calculated to be the difference between the measured existing noise levels and the predicted noise levels. The numbers of residences within certain noise level and insertion loss ranges were estimated. The measured noise data and corresponding traffic volumes for off-peak and peak traffic conditions are contained in Appendix D.

Off-Peak Conditions

Predicted and measured L10 and Leq average noise levels and insertion loss estimates for off-peak traffic conditions are summarized in Table 1. Average off-peak hourly volumes for I 471 are given in Table C-1. Over the data collection period, total off-peak volumes averaged 2,052 automobiles per hour, 7 light trucks per hour, 84 medium trucks per hour, and 64 heavy trucks per hour. Shown in Figures 5 and 6 are average predicted L10 and Leq noise levels, respectively, at each receiver location for the conditions that would exist if no barrier were present. Figures 7 and 8 show average measured L10 and Leq noise levels, respectively, at each receiver location, while insertion loss estimates for L10 and Leq noise levels are shown in Figures 9 and 10, respectively.

The effect of the noise barrier on traffic noise reaching residences (for off-peak traffic conditions) is shown in Table 2. For the situation with no noise barrier, 51 of the 108 residences (47 percent) were predicted to experience an L10 noise level of 60.0 dBA or greater; none of the residences were found to experience off-peak L10 noise levels of 60.0 dBA or more based on measured data for existing conditions. Similarly, 36 of 108 residences (36 percent) were predicted to experience an Leq noise level of 60.0 dBA or more with no barrier compared to no residences receiving Leq noise levels of 60.0 dBA or more for existing conditions with the barrier present.

Insertion loss estimates for residences throughout the study site for off-peak traffic conditions are given in Table 3. For L10 noise levels, 24 of 108 residences (22 percent) were found to have experienced an insertion loss of 10.0 dBA or more, while 61 of 108 residences (57 percent) had an insertion loss of 5.0 to 9.9 dBA. Similarly, 20 residences (18 percent) were estimated to receive an Leq insertion loss of 10.0 dBA or more, while 57 residences (53 percent) experienced an Leq insertion loss between 5.0 and 9.9 dBA.

Peak Conditions

Predicted and measured L10 and Leq average noise levels for peak traffic conditions are given in Table 4. Corresponding average hourly volumes for I 471 are given in Table C-2. Total peak traffic volumes over the data collection period averaged 4,592 automobiles per hour, 2 light trucks per hour, 68 medium trucks per hour, and 35 heavy trucks per hour. Figures 11 and 12 show average predicted L10 and Leq noise levels, respectively, if no barrier were present. Figures 13 and 14 show average measured L10 and Leq existing peak noise levels, respectively. Insertion loss estimates under peak traffic conditions for L10 and Leq noise levels are shown in Figures 15 and 16, respectively.

The effect of the noise barrier on traffic noise reaching residences for peak conditions is shown in Table 5. For noise levels predicted by the STAMINA 2.0 model if no barrier were present, 12 of 108 residences (11 percent) would experience an L10 noise level greater than or equal to 70.0 dBA, while another 46 residences (43 percent) would experience L10 levels from 60.0 to 69.9 dBA. For the existing situation with a barrier, no residences had peak-hour L10 levels measured at 70.0 dBA or more; only 5 residences (5 percent) had measured L10 levels between 60.0 and 69.9 dBA. Similarly, 46 residences (43 percent) had predicted Leq levels for peak conditions from 60.0 to 69.9 dBA, while there were no residences with measured Leq levels of 60.0 dBA or greater with the barrier present.

Peak hour insertion loss estimates for study site residences are given in Table 6. Twenty-one residences (20 percent) experienced a peak L10 insertion loss of 10.0 dBA or more, while another 63 residences (58 percent) were estimated to receive an L10 insertion loss of 5.0 to 9.9 dBA. Simalarly, 15 residences (14 percent) experienced an Leq insertion loss of 10.0 dBA or more, while 58 residences (54 percent) experienced a peak Leq insertion loss of 5.0 to 9.9 dBA.

MEASURED VERSUS PREDICTED INSERTION LOSS

One objective of this study was to determine whether computer estimates of insertion loss were being achieved. Field measurements were used to check the accuracy of predicted insertion losses. To compare predicted with measured insertion loss, the STAMINA 2.0 model was used to predict noise levels with the noise barrier in place.

A summary of insertion loss using both field measurements and STAMINA 2.0 to determine noise levels with the barrier is shown in Table 7. Comparisons are given for both L10 and Leq noise levels and for both peak and off-peak traffic conditions. Average insertion loss is given for each noise level and time period.

In three of four cases, the insertion loss using measured values was more than that using predicted values. However, there were only small differences between the compared values with the largest being 2.0 dBA.

There were only small differences between peak and off-peak and L10 and Leq insertion loss values. The L10 insertion loss values were slightly higher than the Leq values. The insertion loss for off-peak was slightly higher than peak using measured values while peak was slightly higher than off-peak using predicted values.

This analysis shows that insertion loss values predicted by the STAMINA 2.0 computer program will be achieved by the noise barrier.

SURVEY OF COMMUNITY PERCEPTION

A survey of community perception of the noise barrier was conducted among residents of the homes included in the analysis. A questionnaire and accompanying cover letter explaining the purpose of the survey, along with a postage-paid return envelope, were mailed to residents in the study area. Those were the same residences included in the area covered by the field measurements.

The questionnaire consisted of common questions asked of residents in similar noise-barrier evaluations (3, 4, 5, 6, 7, 8). Questionnaire topics included awareness of the barrier, highway-related problems with the barrier, activities affected by the barrier, and the general effectiveness of the noise barrier as perceived by residents of the neighborhood. The cover letter and questionnaire are contained in Appendix E.

Of 103 questionnaires delivered, 66 (64 percent) were returned; 49 (48 percent) were returned initially and 17 of 54 follow-up questionnaires (31 percent) were returned by residents who did not respond initially.

Responses showed that the affected homes were in an old and established neighborhood. The average length of residence was 18 years with an average of three persons per home. Ninety-eight percent of the respondents owned their homes.

Ninety-six percent of the respondents described the neighborhood as quiet or very quiet before the roadway and barrier were constructed, while only 34 percent felt it to be quiet or very quiet after construction of the roadway and barrier. Ninety-eight percent of the respondents were aware the barrier existed; of those, 63 percent learned about the barrier by observing its construction, while 19 percent learned of the barrier from the newspaper.

Concerning the effect of the noise barrier on highway-related problems, 78 percent of the respondents felt that the barrier made an overall improvement in reducing highway noise and 71 percent felt the barrier improved their privacy. In addition, 56 percent felt the barrier reduced highway dust and dirt accumulation and litter from vehicles, 54 percent felt it reduced headlight glare, 52 percent felt it reduced road vibrations, and 48 percent felt it reduced road fumes.

In relation to various activities, 57 percent thought relaxing outdoors was less difficult due to the presence of the barrier and 56 percent felt that conversation outdoors was less difficult. Also, 48 percent thought sleeping was less difficult, 46 percent thought conversation indoors was less difficult, 44 percent thought relaxing indoors was less difficult, and 42 percent thought telephone use was less difficult. Fifty-seven percent stated the barrier did not affect the amount they used their yards, but 40 percent felt they would have used their yards less if the barrier had not been constructed.

Thirty-three percent felt the barrier limited or restricted their view, 17 percent thought the barrier was unsightly, 15 percent felt it created a closed-in feeling, and 15 percent felt it had a detrimental effect on the environment. It should be noted that many respondents seemed to have difficulty discriminating the benefits of the noise barrier from the impact of the roadway, since their construction was coincidental. Thus, many of the negative answers and comments directed toward the noise barrier were actually directed toward construction of the roadway.

Seventy-eight percent of the residents who responded to the survey considered the appearance of the barrier to be acceptable; 12 percent thought it to be unsightly, while 10 percent thought it to be attractive. Compared to having no noise barrier, 50 percent felt the barrier was very effective in reducing traffic noise and 45 percent thought it was somewhat effective. In relation to property values, 57 percent felt the barrier had no effect, while 27 percent felt their property decreased in value and 16 percent felt that it increased. Overall, 64 percent of those responding generally liked the noise barrier, 13 percent disliked it, and 23 percent had no opinion.

SUMMARY

The STAMINA 2.0 computer program was calibrated using a model of the study site so that it could be used to predict noise levels assuming the noise barrier was not present. Noise measurements were then obtained at 39 receiver locations during both peak and off-peak traffic conditions. That allowed insertion loss estimates to be made.

The noise barrier reduced noise levels reaching the adjacent residences substantially. For example, 21 residences (20 percent of the total in the study area) experienced a peak L10 insertion loss of 10 dBA or more, while another 63 residences (58 percent) were estimated to receive an L10 insertion loss of 5.0 to 9.9 dBA. Also, the STAMINA 2.0 model predicted (with no barrier present) that 12 residences (11 percent) would experience peak L10 noise levels greater than or equal to 70 dBA while another 46 residences (43 percent) would experience levels from 60.0 to 69.9 dBA. Measurements found that no residences had peak L10 levels of 70 dBA or more and only 5 residences (5 percent) had levels between 60.0 and 69.9 dBA.

Noise levels with the barrier in place were predicted using the STAMINA 2.0 model. Comparisons of insertion loss using both measured levels and predicted values were close. The analysis indicated that insertion loss values predicted by the STAMINA 2.0 computer program will be achieved by the noise barrier.

Of 103 questionnaires mailed to residences to determine their perception of the barrier, 66 (64 percent) were returned. The community perception of the barrier was favorable. Overall, 64 percent of those responding to the survey generally liked the noise barrier, 13 percent disliked it and 23 percent had no opinion. Compared to having no noise barrier, 50 percent felt the barrier was very effective in reducing traffic noise and 45 percent thought it was somewhat effective.

IMPLEMENTATION

Traffic noise measurements and data analyses summarized in this report show that the I-471 noise barrier has resulted in a substantial reduction in traffic noise for the affected homes. The success of this noise barrier in providing its predicted insertion loss proves that noise barriers provide an effective traffic noise abatement alternative. The construction of additional barriers should be considered as a viable noise abatement measure. Results of this study may be used in future public hearings to illustrate the potential effectiveness of proposed noise barriers.

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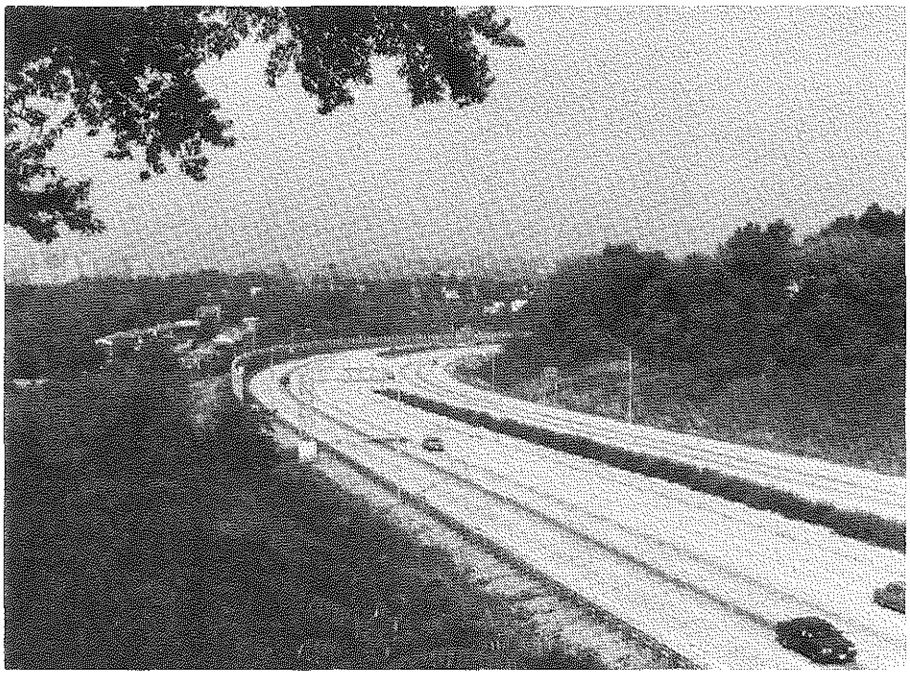

Figure 1. Noise Barrier, Interstate 471, Campbell County, Kentucky.

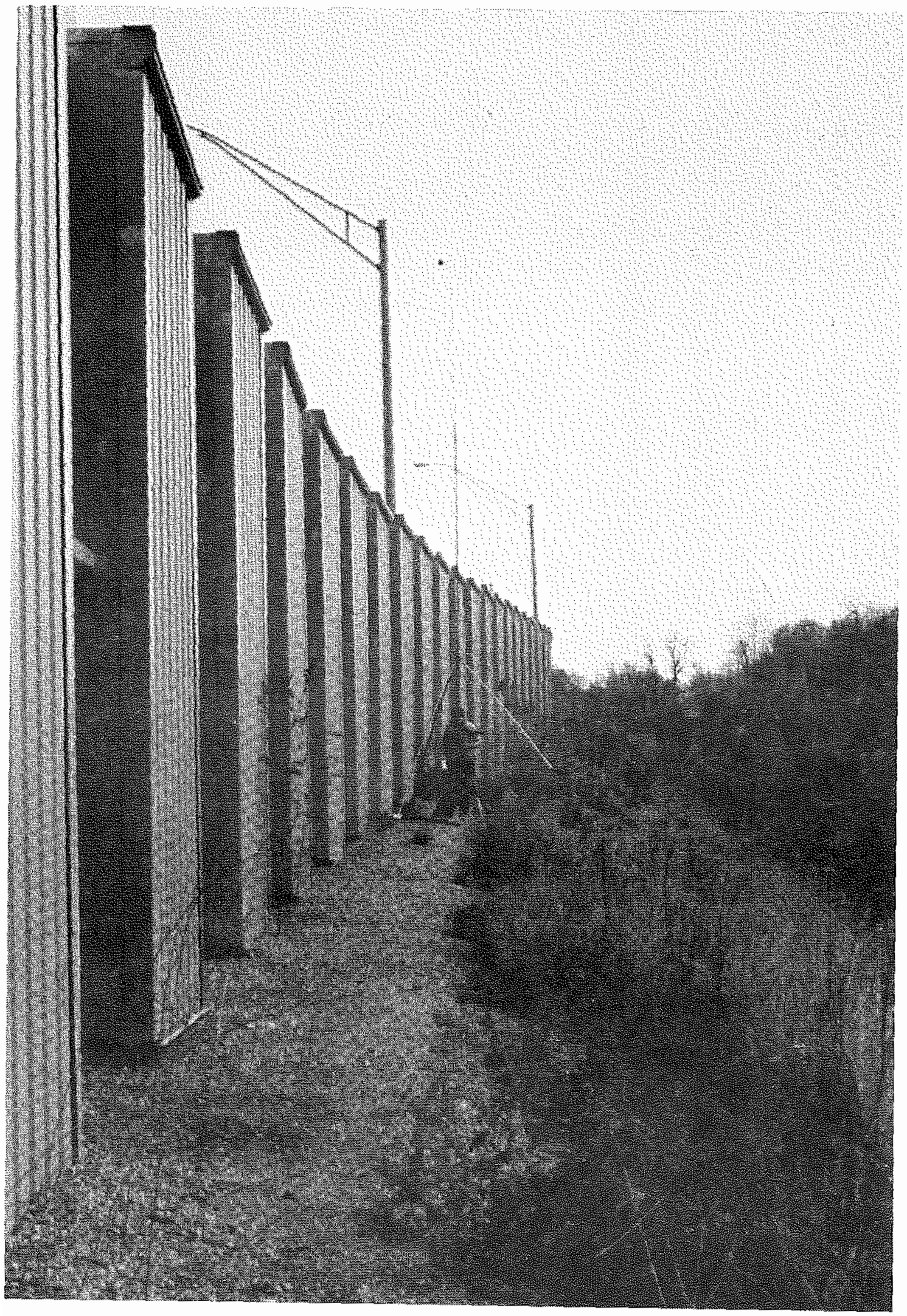

Figure 2. Elevated Reference Microphone.

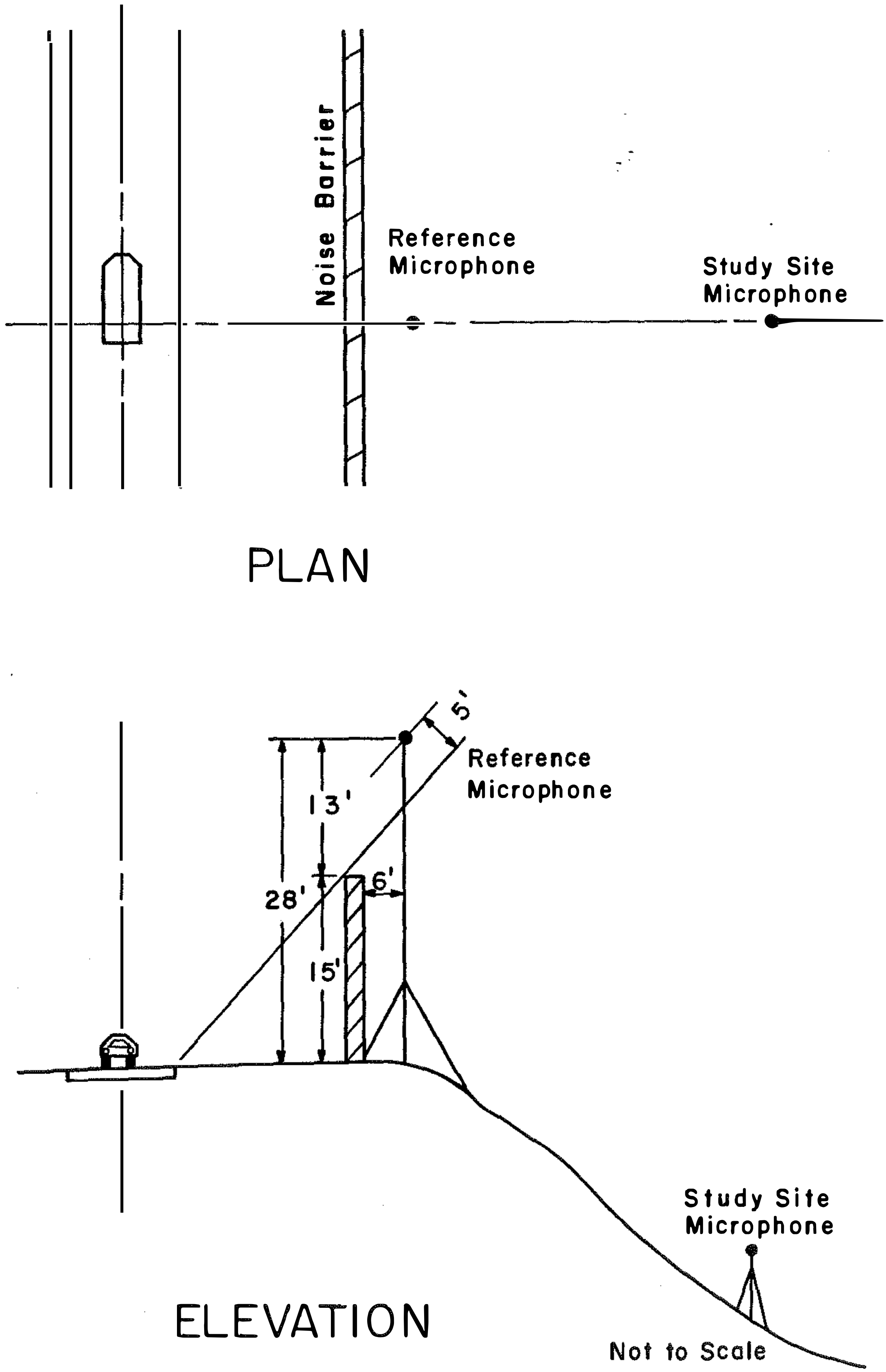

Figure 3. Reference Microphone Positioning.

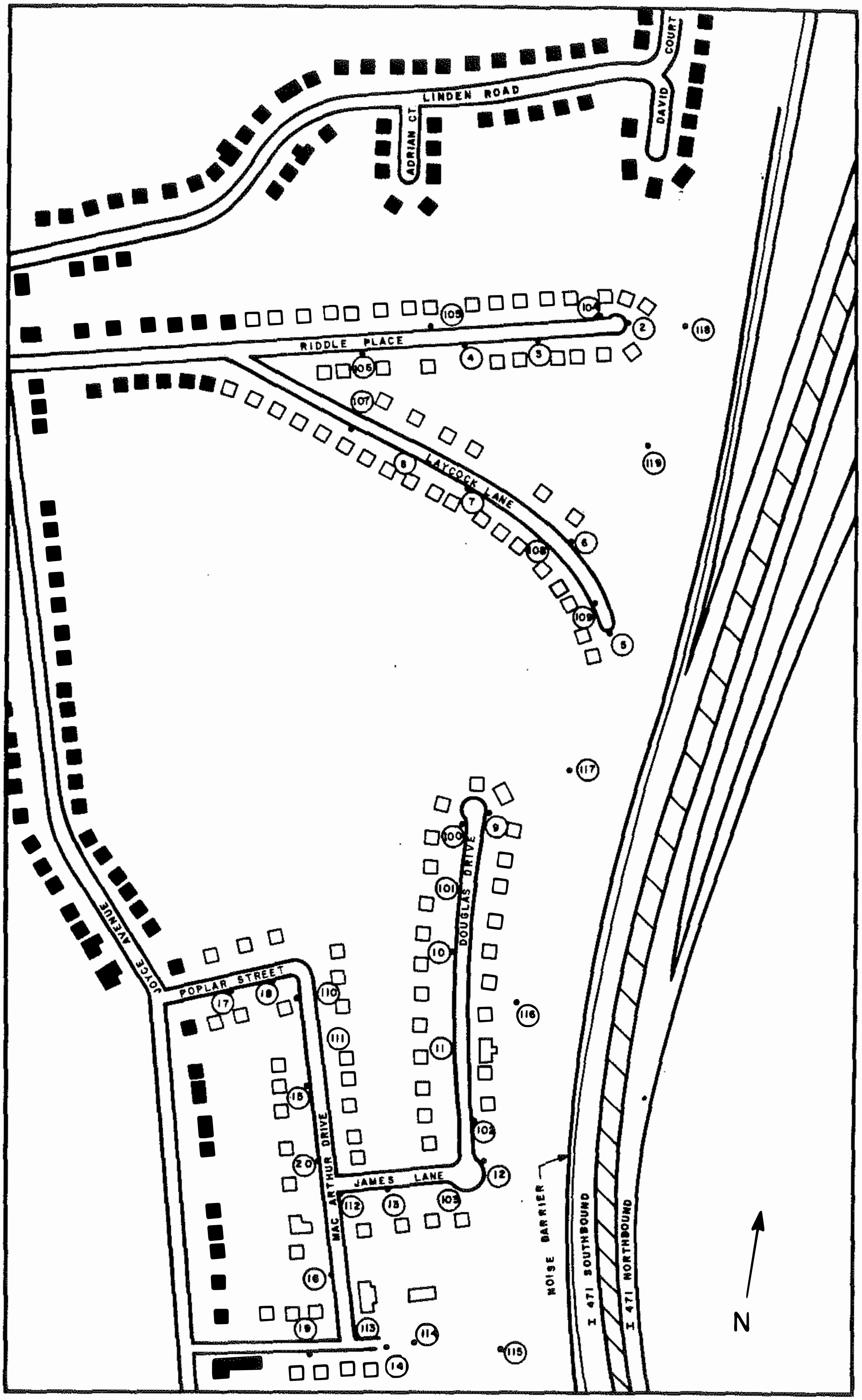

Figure 4. Field Measurment Receiver Locations.

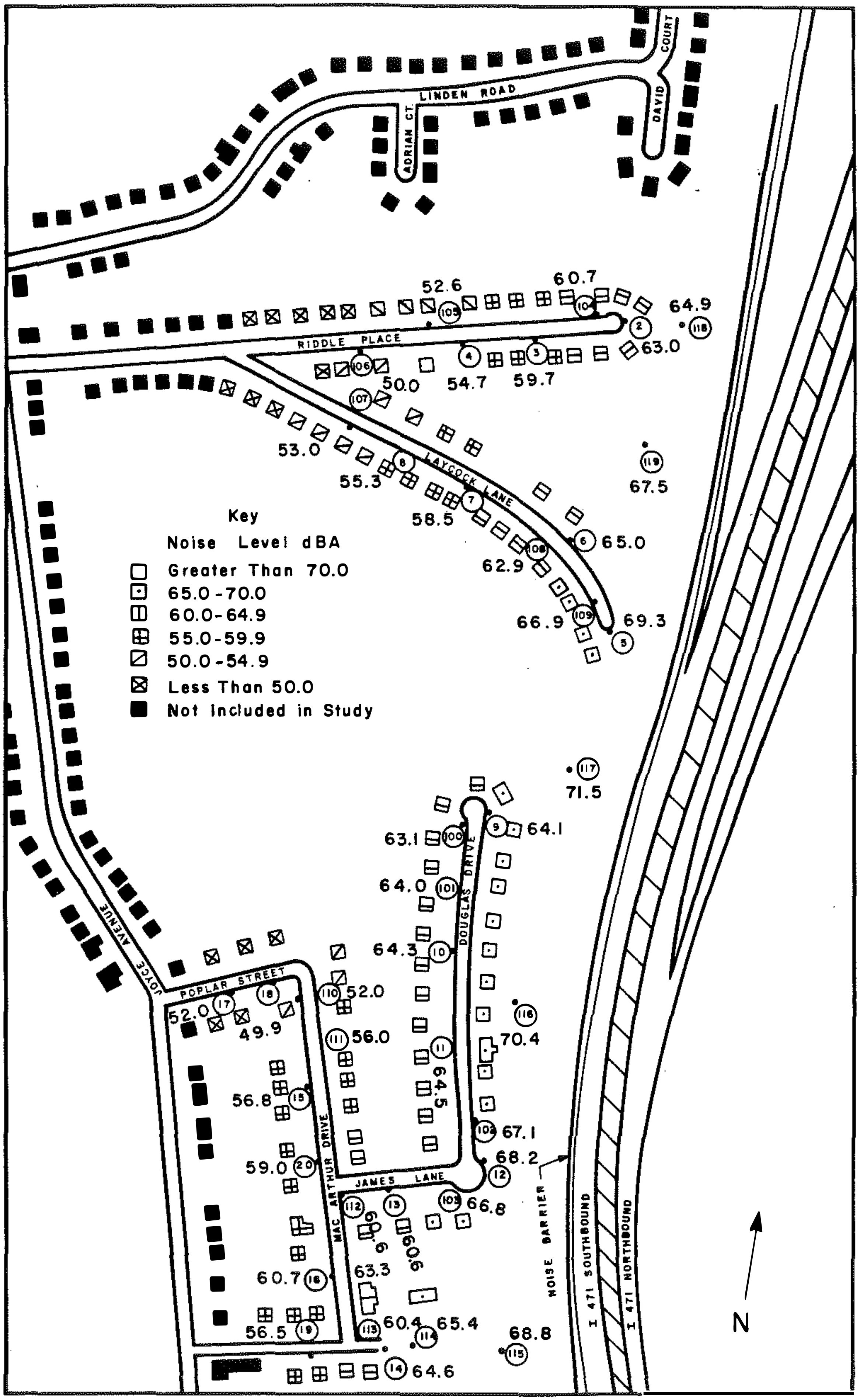

Figure 5. Average Predicted Off-Peak L10 (No Barrier).

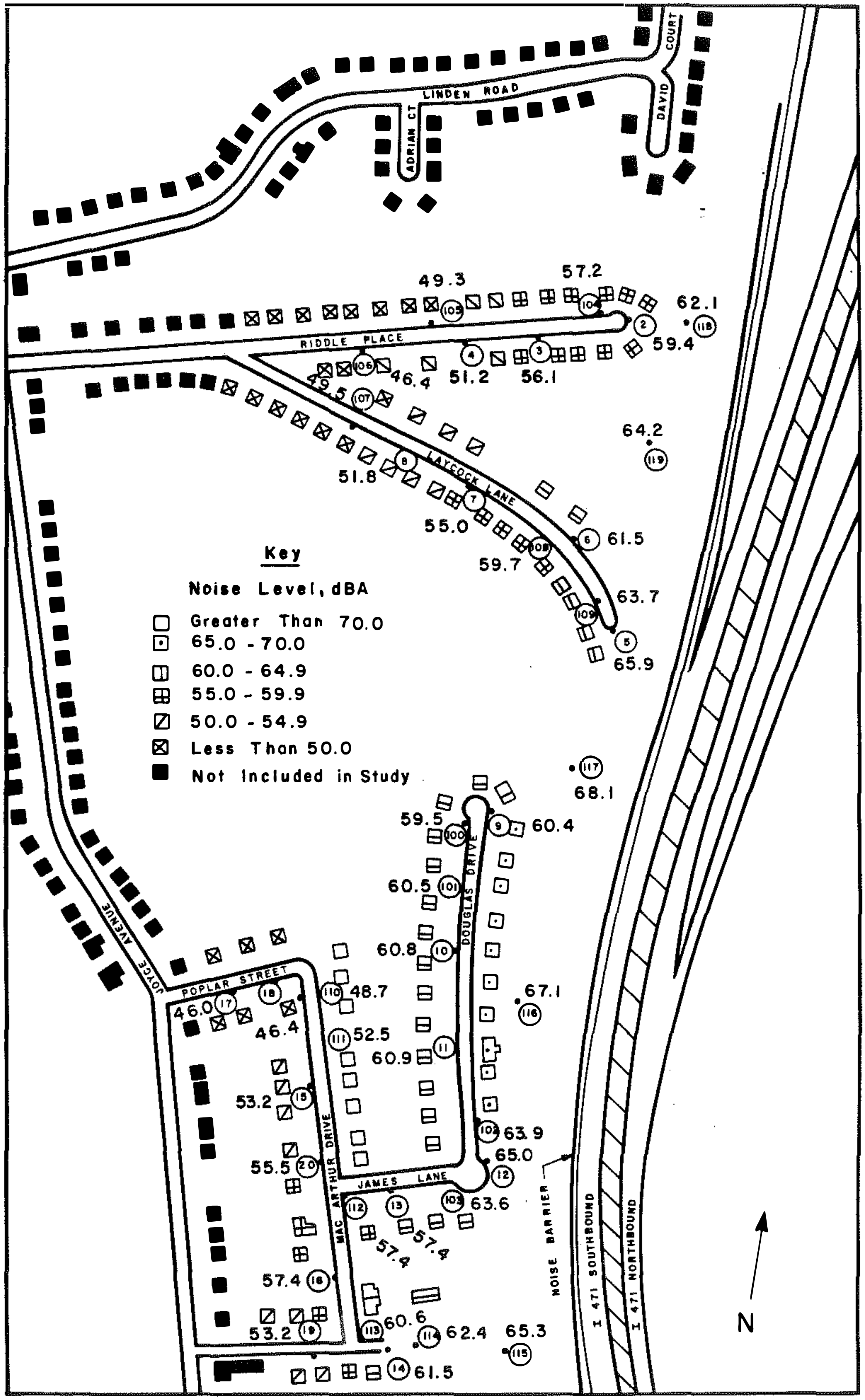

Figure 6. Average Predicted Off-Peak Leq (No Barriers)

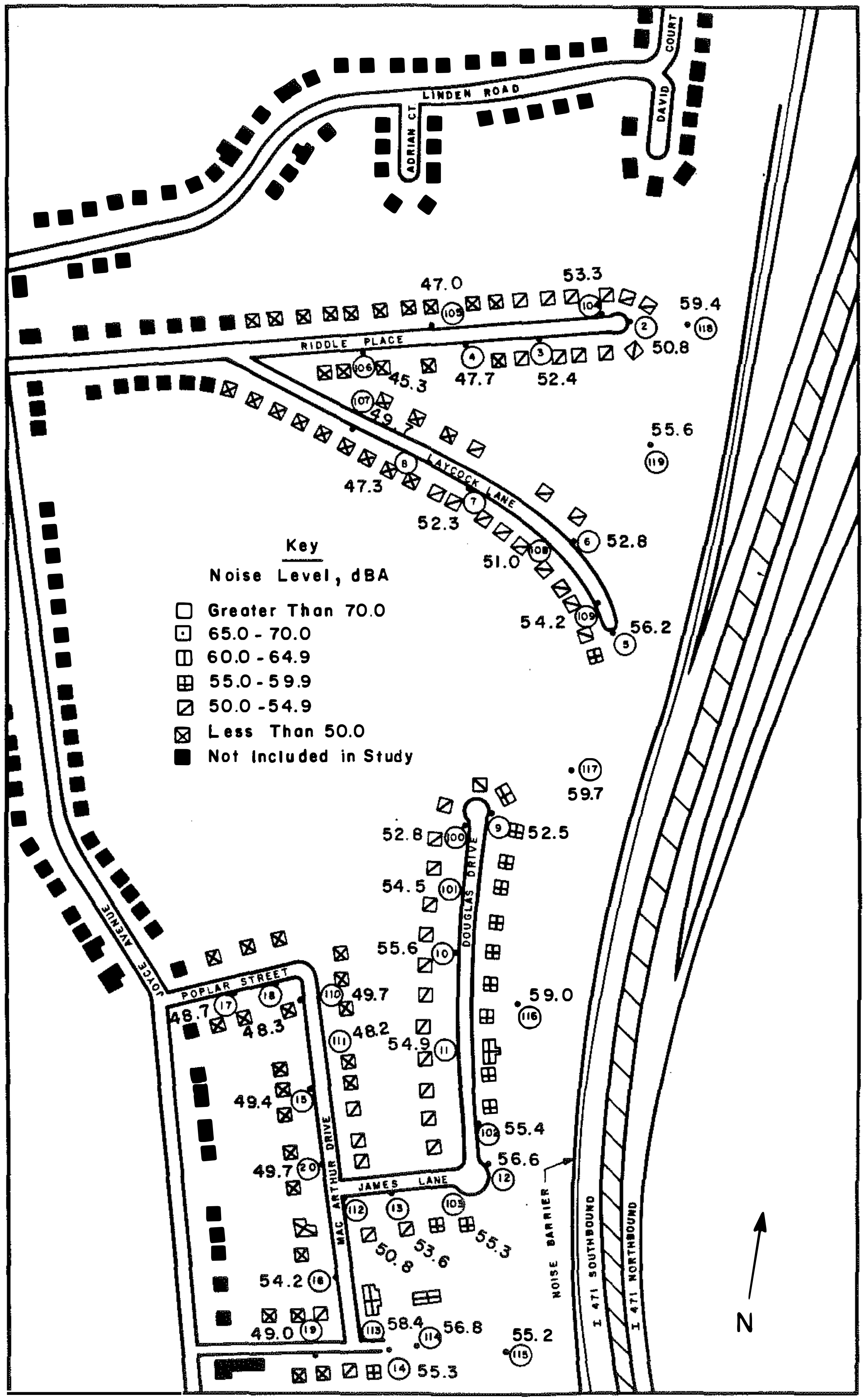

Figure 7 Average Measured Off-Peak L10 (Barrier Present).

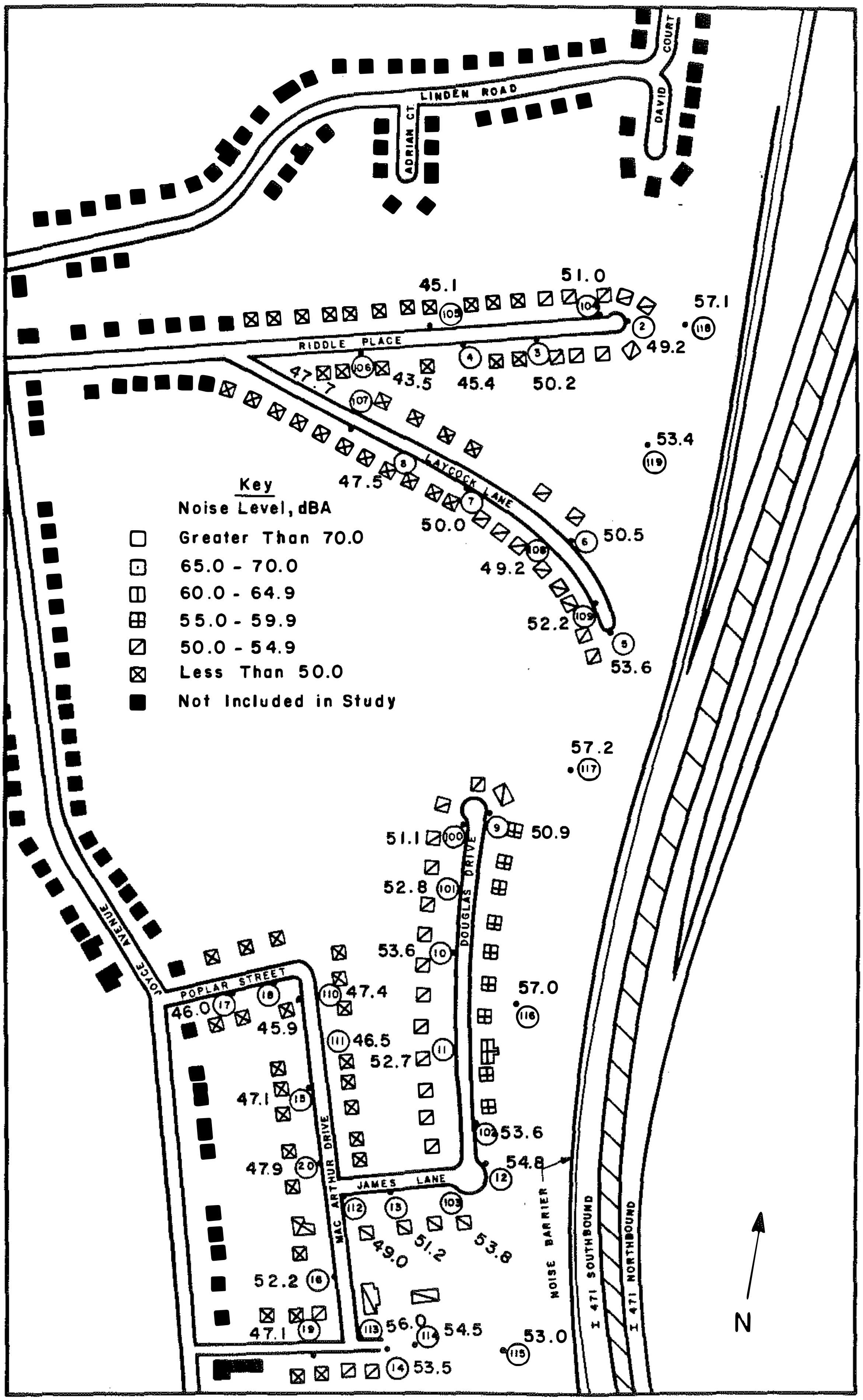

Figure 8. Average Measured Off-Peak Leq (Barrier Present).

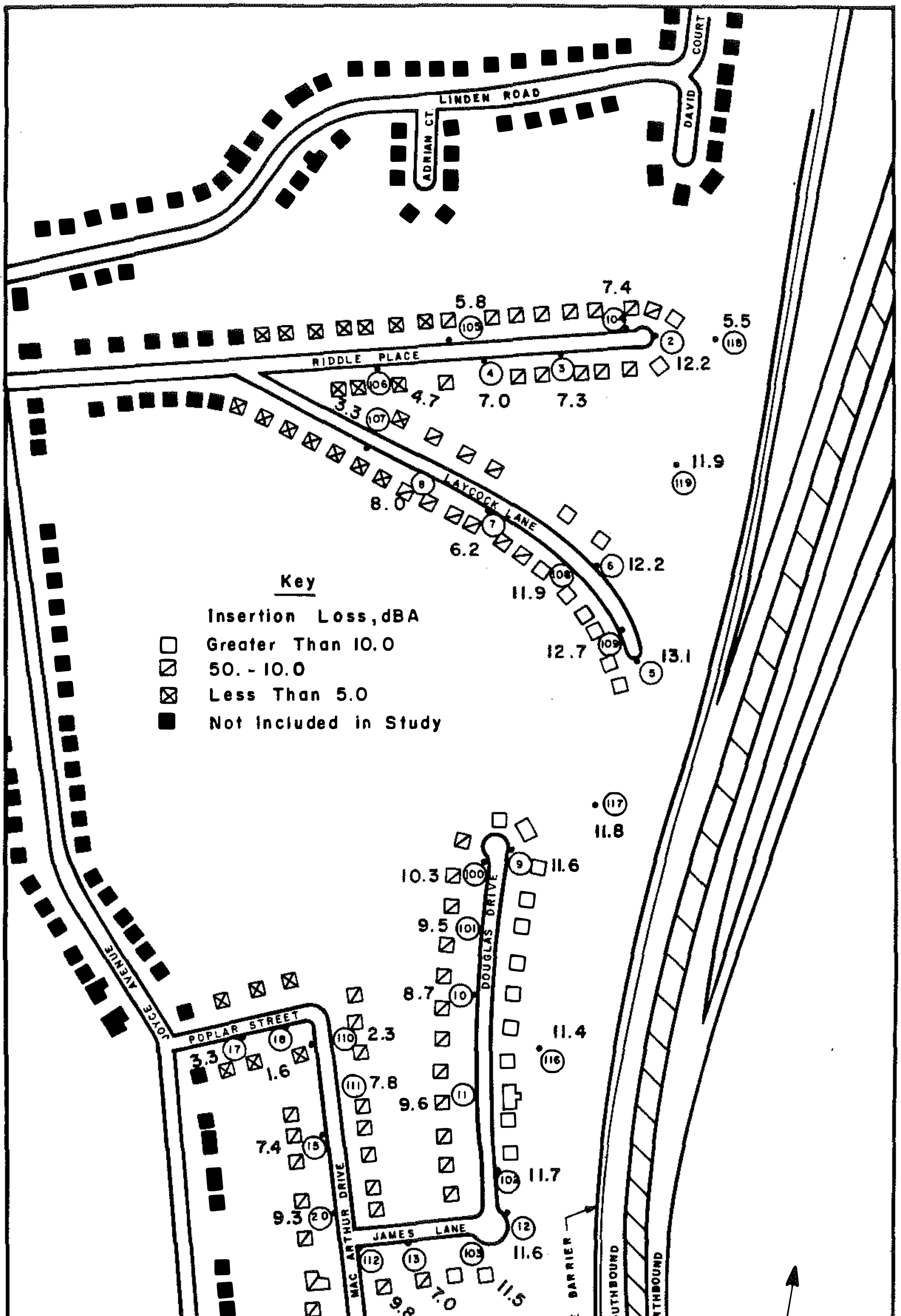

Figure 9. Average Off-Peak L10 Insertion Loss.

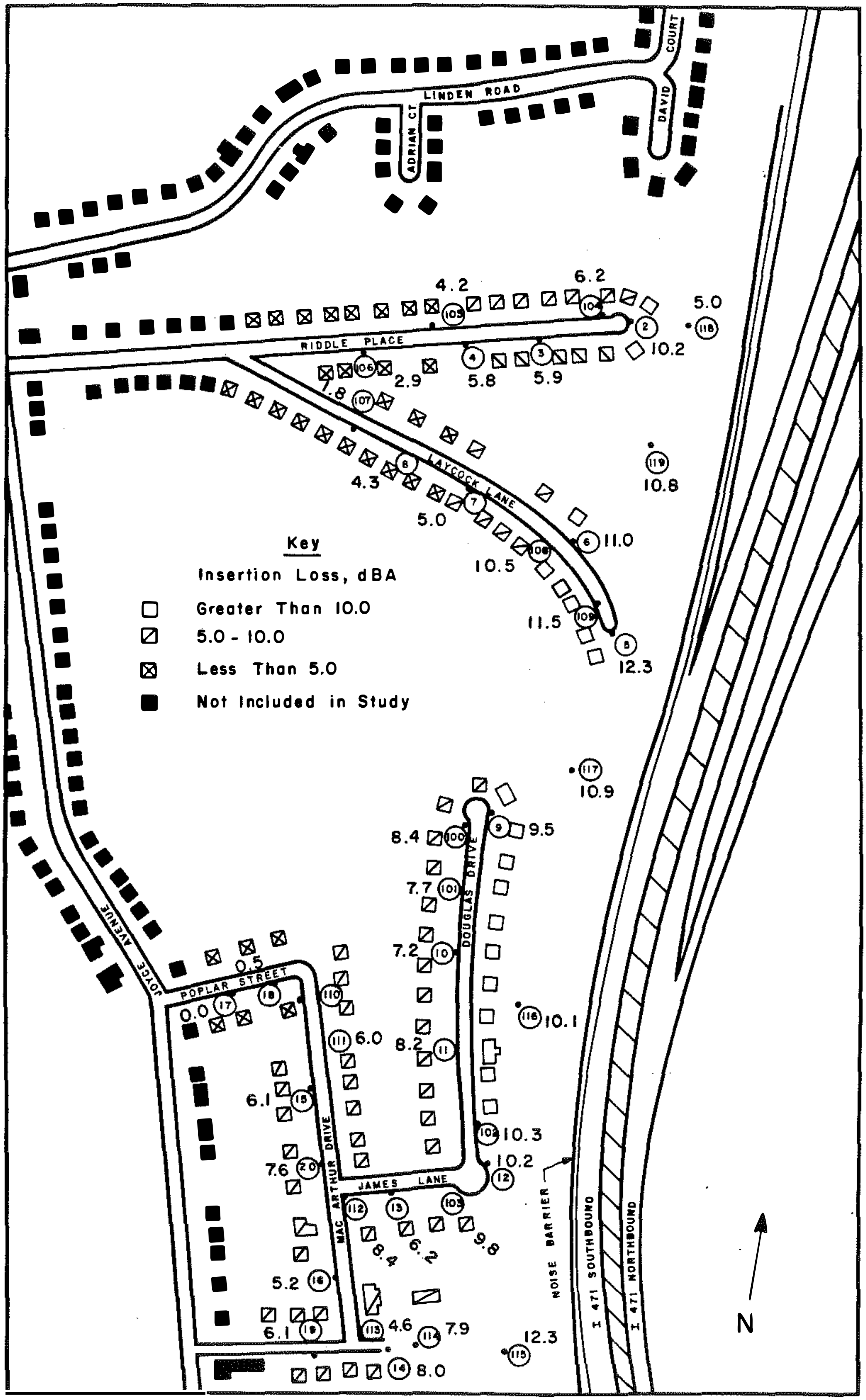

Figure 10. Average Off-Peak Leg Insertion Loss.

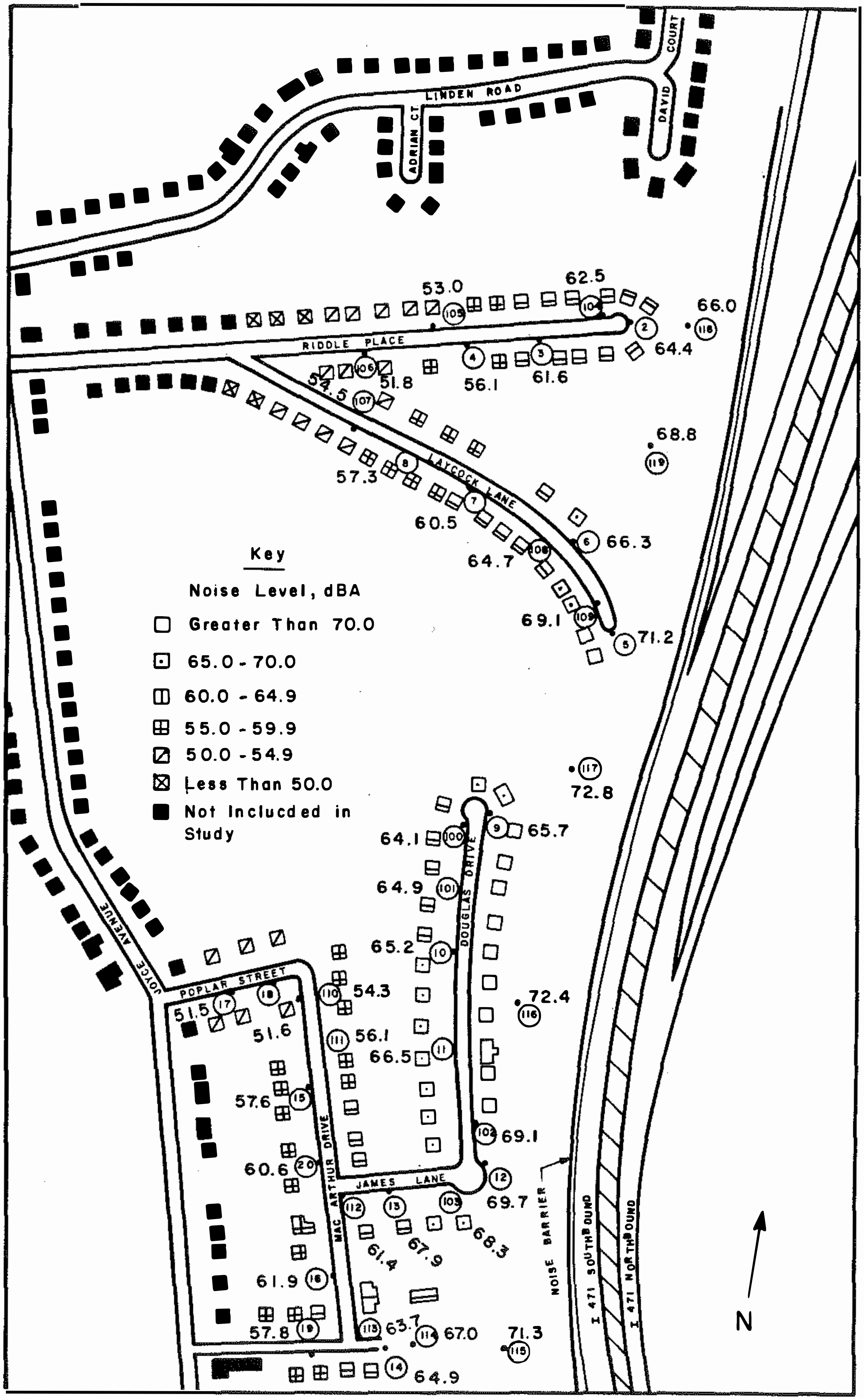

Figure II. Average Predicted Peak L10 (No Barrier).

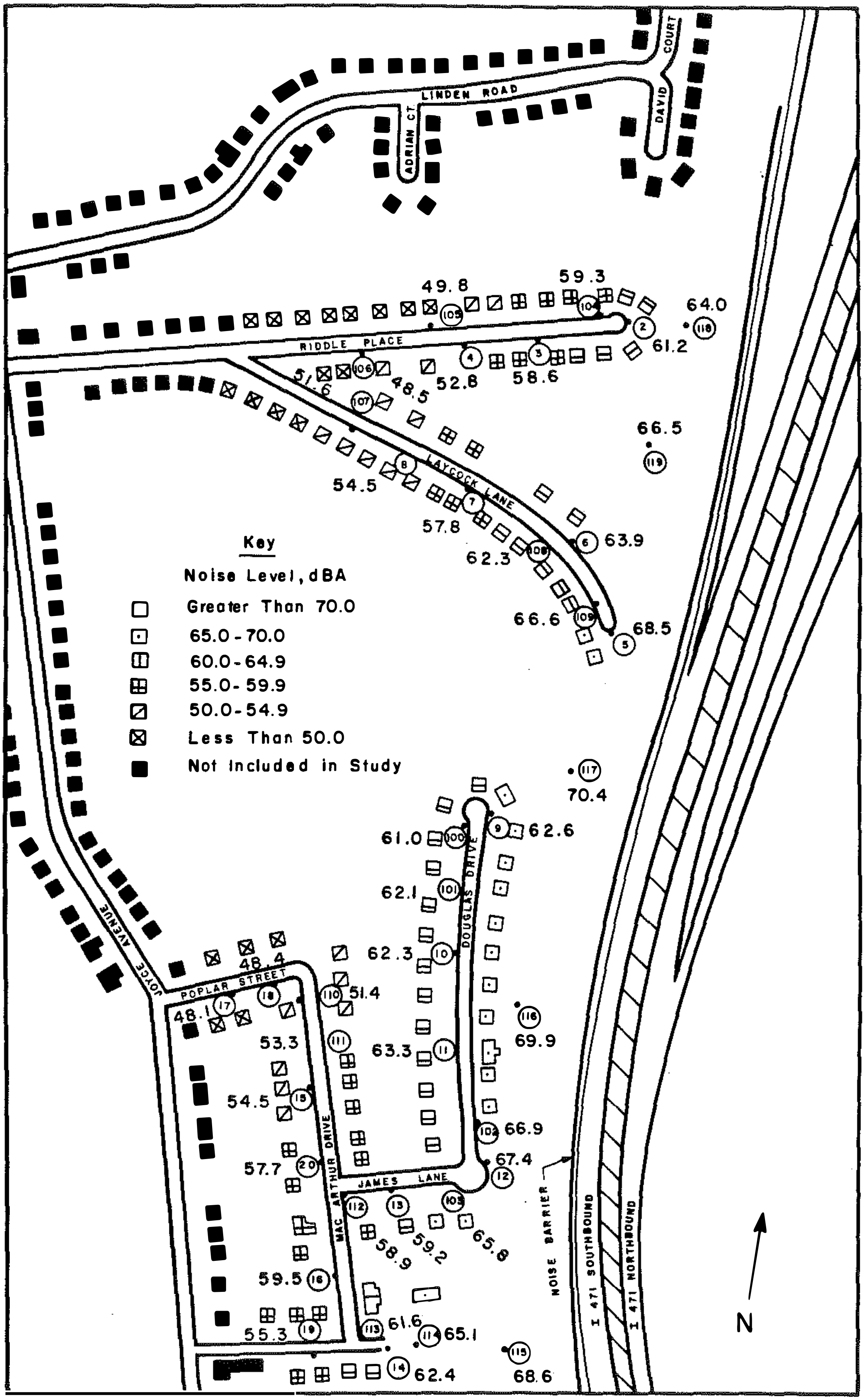

Figure 12. Average Predicted Peak Leq (No Barrier).

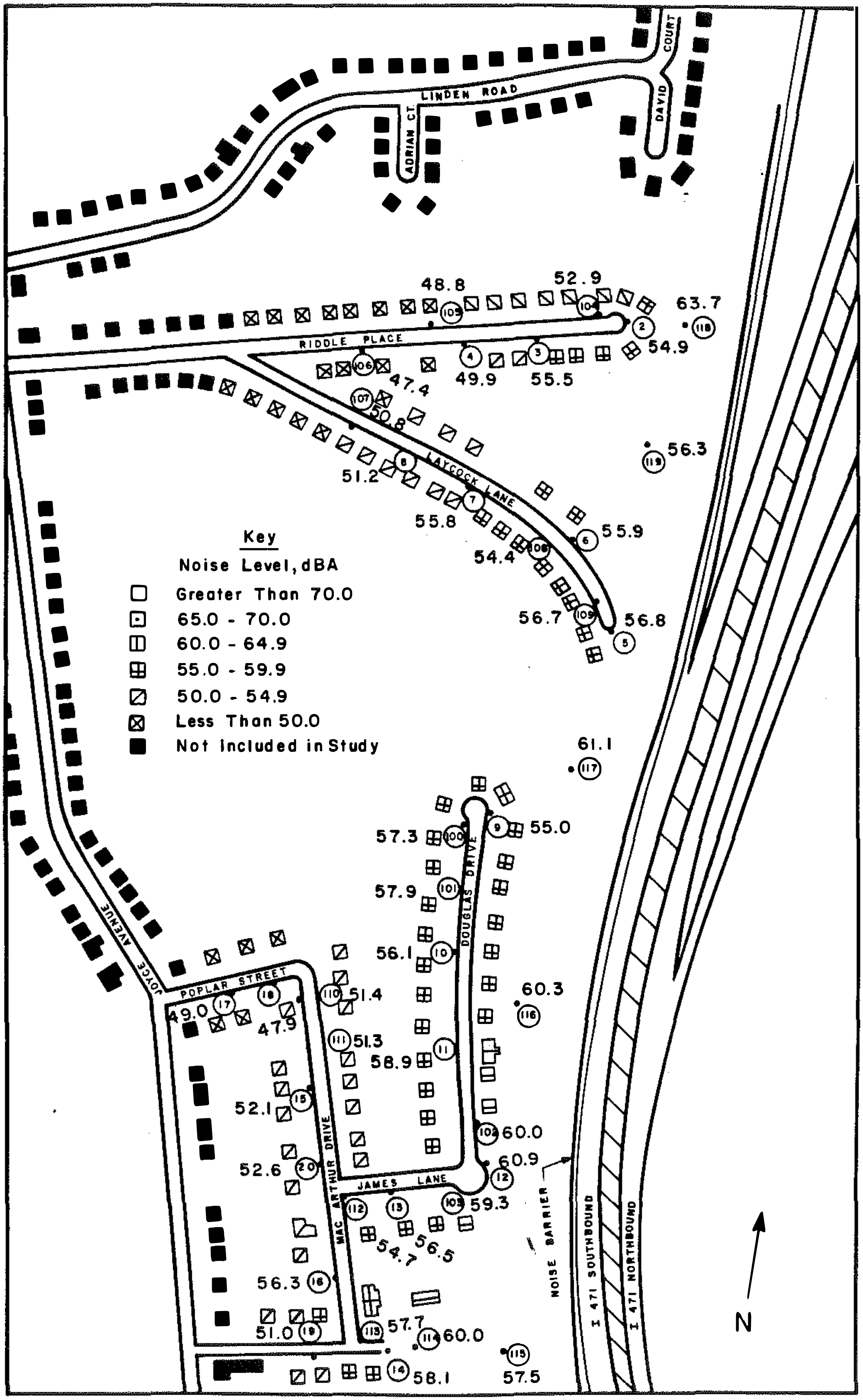

Figure 13. Average Measured Peak L10 (Barrier Present).

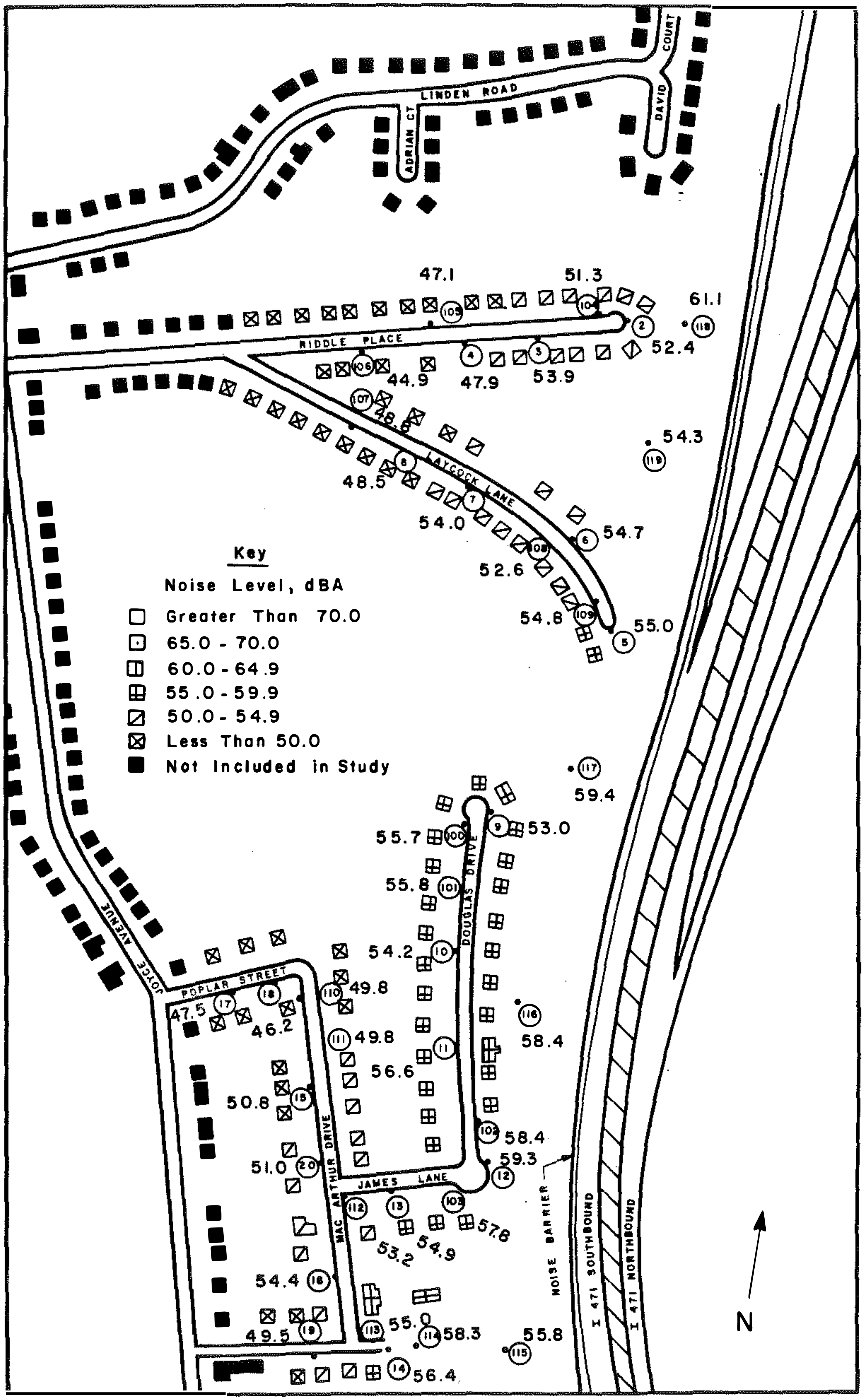

Figure 14. Average Measured Peak Leq (Barrier Present).

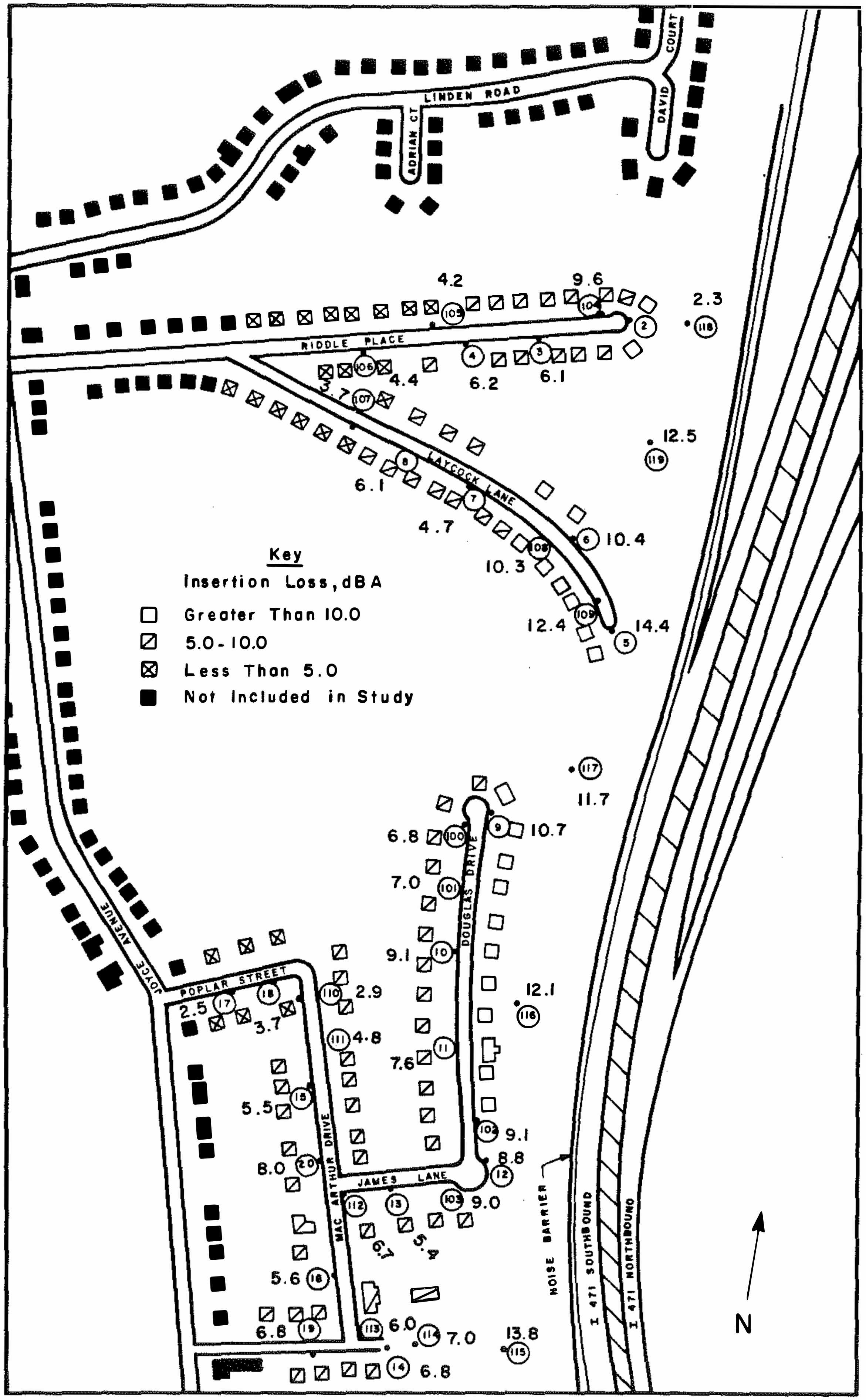

Figure 15. Average Peak L10 Insertion Loss.

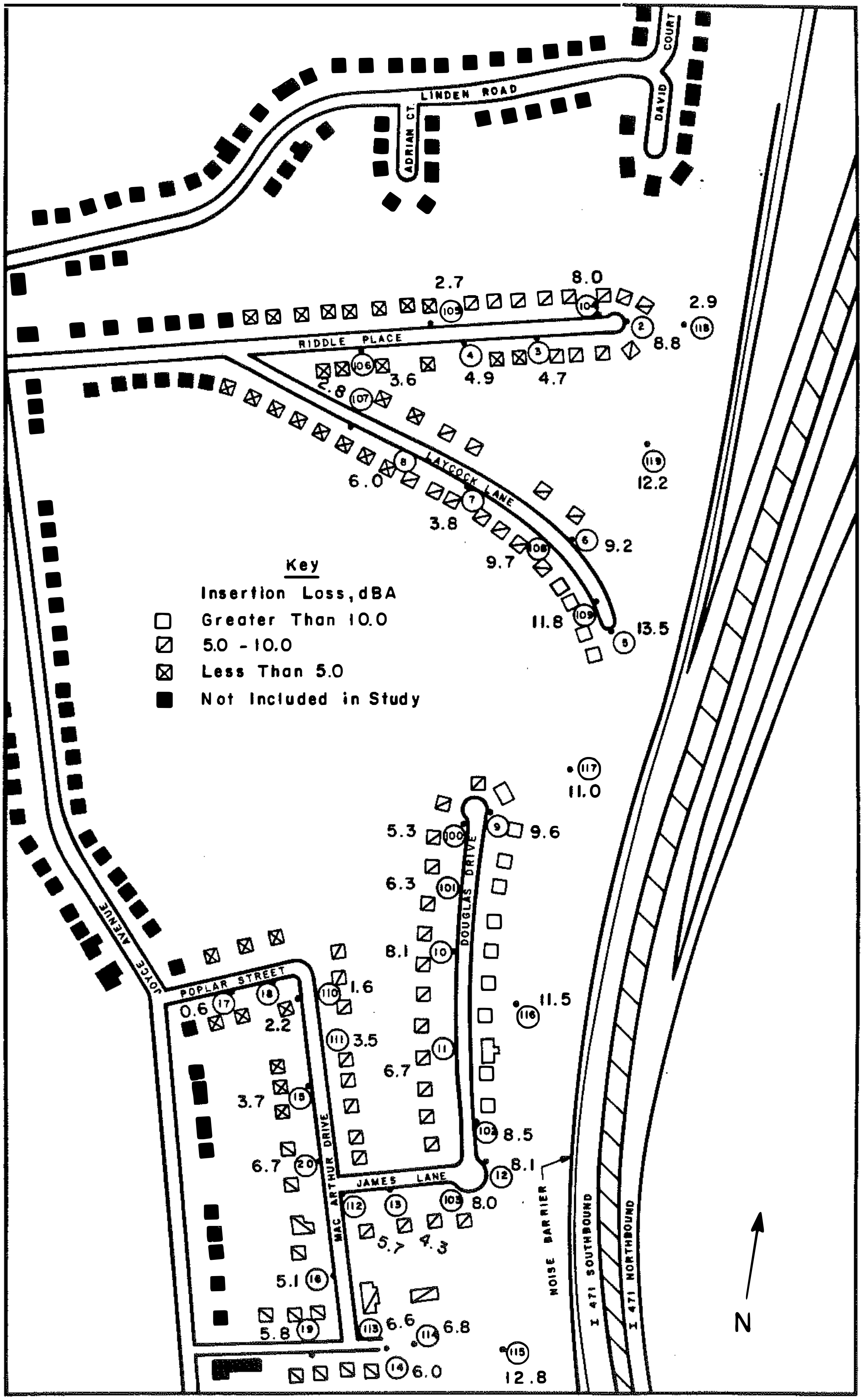

Figure 16. Average Peak Leg Insertion Loss.

TABLE 1. OFF-PEAK INSERTION LOSS MEASUREMENTS

RECEIVER LOCATION NUMBER	AVERAGE NOISE LEVEL (dBA)					
	MEASURED		PREDICTED		INSERTION LOSS	
	L10	Leq	L10	Leq	L10	Leq
002	63.0	59.4	50.8	49.2	12.1	10.2
003	59.7	56.1	52.4	50.2	7.3	5.9
004	54.7	51.2	47.7	45.4	7.0	5.8
005	69.3	65.9	56.2	53.6	13.1	12.3
006	65.0	61.5	52.8	50.5	12.2	11.0
007	58.5	55.0	52.3	50.0	6.2	5.0
008	55.3	51.8	47.3	47.5	8.0	4.3
009	64.1	60.4	52.5	50.9	11.6	9.5
010	64.3	60.8	55.6	53.6	8.7	7.2
011	64.5	60.9	54.9	52.7	9.6	8.2
012	68.2	65.0	56.6	54.8	11.6	10.2
013	60.6	57.4	53.6	51.2	7.0	6.2
014	64.6	61.5	55.3	53.5	9.3	8.0
015	56.8	53.2	49.4	47.1	7.4	6.1
016	60.7	57.4	54.2	52.2	6.5	5.2
017	52.0	46.0	48.7	46.0	3.3	0.0
018	49.9	46.4	48.3	45.9	1.6	0.5
019	56.5	53.2	49.0	47.1	7.5	6.1
020	59.0	55.5	49.7	47.9	9.3	7.6
100	63.1	59.5	52.8	51.1	10.3	8.4
101	64.0	60.5	54.5	52.8	9.5	7.7
102	67.1	63.9	55.4	53.6	11.7	10.3
103	66.8	63.6	55.3	53.8	11.5	9.8
104	60.7	57.2	53.3	51.0	7.4	6.2
105	52.8	49.3	47.0	45.1	5.8	4.2
106	50.0	46.4	45.3	43.5	4.7	2.9
107	53.0	49.5	49.7	47.7	3.3	1.8
108	62.9	59.7	51.0	49.2	11.9	10.5
109	66.9	63.7	54.2	52.2	12.7	11.5
110	52.0	48.7	49.7	47.4	2.3	1.3
111	56.0	52.5	48.2	46.5	7.8	6.0
112	60.6	57.4	50.8	49.0	9.8	8.4
113	63.3	60.6	58.4	56.0	4.9	4.6
114	65.4	62.4	56.8	54.5	8.6	7.9
115	68.8	65.3	55.2	53.0	13.6	12.3
116	70.4	67.1	59.0	57.0	11.4	10.1
117	71.5	68.1	59.7	57.2	11.8	10.9
118	64.9	62.1	59.4	57.1	5.5	5.0
119	67.5	64.2	55.6	53.4	11.9	10.8

TABLE 2. EFFECT OF NOISE BARRIER ON TRAFFIC NOISE REACHING RESIDENCES (OFF-PEAK)

NOISE LEVEL (dBA)		PREDICTED (NO BARRIER) NUMBER RESIDENCES	PREDICTED (NO BARRIER) PERCENT	MEASURED (BARRIER PRESENT) NUMBER RESIDENCES	MEASURED (BARRIER PRESENT) PERCENT
L10	70.0 or above	0	0	0	0
	65.0 - 69.9	18	17	0	0
	60.0 - 64.9	33	30	0	0
	55.0 - 59.9	28	26	17	16
	50.0 - 54.9	16	15	43	40
	Less than 50.0	13	12	48	44
Leq	70.0 or above	0	0	0	0
	65.0 - 69.9	10	9	0	0
	60.0 - 64.9	26	24	0	0
	55.0 - 59.9	27	25	10	9
	50.0 - 54.9	22	21	42	39
	Less than 50.0	23	21	56	52

TABLE 3. NUMBER OF RESIDENCES RECEIVING GIVEN INSERTION LOSS (OFF-PEAK)

AVERAGE INSERTION LOSS (dBA)	L10 NUMBER RESIDENCES	L10 PERCENT	Leq NUMBER RESIDENCES	Leq PERCENT
10 or above	24	22	20	18
5.0 - 9.9	61	57	57	53
Less than 5.0	23	21	31	29

TABLE 4. PEAK INSERTION LOSS MEASUREMENTS

RECEIVER LOCATION NUMBER	AVERAGE NOISE LEVEL (dBA) MEASURED		PREDICTED		INSERTION LOSS	
	L10	Leq	L10	Leq	L10	Leq
002	64.4	61.2	54.9	52.4	9.5	8.8
003	61.6	58.6	55.5	53.9	6.1	4.7
004	56.1	52.8	49.9	47.9	6.2	4.9
005	71.2	68.5	56.8	55.0	14.4	13.5
006	66.3	63.9	55.9	54.7	10.4	9.2
007	60.5	57.8	55.8	54.0	4.7	3.8
008	57.3	54.5	51.2	48.5	6.1	6.0
009	65.7	62.6	55.0	53.0	10.7	9.6
010	65.2	62.3	56.1	54.2	9.1	8.1
011	66.5	63.3	58.9	56.6	7.6	6.7
012	69.7	67.4	60.9	59.3	8.8	8.1
013	61.9	59.2	56.5	54.9	5.4	4.3
014	64.9	62.4	58.1	56.4	6.8	6.0
015	57.6	54.5	52.1	50.8	5.5	3.7
016	61.9	59.5	56.3	54.4	5.6	5.1
017	51.5	48.1	49.0	47.5	2.5	0.6
018	51.6	48.4	47.9	46.2	3.7	2.2
019	57.8	55.3	51.0	49.5	6.8	5.8
020	60.6	57.7	52.6	51.0	8.0	6.7
100	64.1	61.0	57.3	55.7	6.8	5.3
101	64.9	62.1	57.9	55.8	7.0	6.3
102	69.1	66.9	60.0	58.4	9.1	8.5
103	68.3	65.8	59.3	57.8	9.0	8.0
104	62.5	59.3	52.9	51.3	9.6	8.0
105	53.0	49.8	48.8	47.1	4.2	2.7
106	51.8	48.5	47.4	44.9	4.4	3.6
107	54.5	51.6	50.8	48.8	3.7	2.8
108	64.7	62.3	54.4	52.6	10.3	9.7
109	69.1	66.6	56.7	54.8	12.4	11.8
110	54.3	51.4	51.4	49.8	2.9	1.6
111	56.1	53.3	51.3	49.8	4.8	3.5
112	61.4	58.9	54.7	53.2	6.7	5.7
113	63.7	61.6	57.7	55.0	6.0	6.6
114	67.0	65.1	60.0	58.3	7.0	6.8
115	71.3	68.6	57.5	55.8	13.8	12.8
116	72.4	69.9	60.3	58.4	12.1	11.5
117	72.8	70.4	61.1	59.4	11.7	11.0
118	66.0	64.0	63.7	61.1	2.3	2.9
119	68.8	66.5	56.3	54.3	12.5	12.2

TABLE 5. EFFECT OF NOISE BARRIER ON TRAFFIC NOISE REACHING RESIDENCES (PEAK)

NOISE LEVEL (dBA)		PREDICTED (NO BARRIER) NUMBER RESIDENCES	PREDICTED (NO BARRIER) PERCENT	MEASURED (BARRIER PRESENT) NUMBER RESIDENCES	MEASURED (BARRIER PRESENT) PERCENT
L10	70.0 or above	12	11	0	0
	65.0 - 69.9	15	14	0	0
	60.0 - 64.9	31	29	5	5
	55.0 - 59.9	27	25	44	41
	50.0 - 54.9	18	16	37	34
	Less than 50.0	5	5	22	20
Leq	70.0 or above	0	0	0	0
	65.0 - 69.9	17	16	0	0
	60.0 - 64.9	29	27	0	0
	55.0 - 59.9	27	25	32	30
	50.0 - 54.9	16	15	36	33
	Less than 50.0	19	17	40	37

TABLE 6. NUMBER OF RESIDENCES RECEIVING GIVEN INSERTION LOSS (PEAK)

AVERAGE INSERTION LOSS (dBA)	L10 NUMBER RESIDENCES	L10 PERCENT	Leq NUMBER RESIDENCES	Leq PERCENT
10 or above	21	20	15	14
5.0 - 9.9	63	58	58	54
Less than 5.0	24	22	35	32

TABLE 7. MEASURED VERSUS PREDICTED INSERTION LOSS

	AVERAGE INSERTION LOSS (dBA)			
	L10		Leq	
	PEAK	OFF-PEAK	PEAK	OFF-PEAK
Measured	7.5	8.6	6.6	7.1
Predicted	7.2	6.6	7.2	6.4
Difference	0.3	2.0	0.6	0.7

APPENDIX A

RECEIVER COORDINATES

TABLE A-1. RECEIVER COORDINATES

RECEIVER LOCATION NUMBER	X COORD	Y COORD	Z COORD	SHIELDING FACTOR (dBA)
002	4327	1252	659	3.0
003	4302	1424	639	3.0
004	4287	1553	624	7.0
005	3723	1223	668	0.0
006	3895	1334	664	1.0
007	4006	1531	657	4.0
008	4068	1666	644	5.0
009	3350	1445	732	3.0
010	3078	1490	729	3.0
011	2917	1465	719	3.0
012	2671	1410	709	0.0
013	2613	1593	718	4.0
014	2286	1580	744	1.0
015	2808	1743	709	5.0
016	2440	1687	734	3.0
017	3038	1913	684	7.0
018	3048	1834	694	7.0
019	2266	1720	748	6.0
020	2665	1722	714	4.0
100	3330	1494	731	3.0
101	3204	1487	730	3.0
102	2771	1445	712	0.0
103	2616	1454	709	0.0
104	4333	1305	654	3.0
105	4302	1619	617	8.0
106	4264	1743	614	9.0
107	4119	1766	633	6.0
108	3891	1368	664	2.0
109	3783	1280	667	0.0
110	3011	1770	701	5.0
111	2919	1735	708	5.0
112	2593	1685	718	3.0
113	2303	1640	746	1.0
114	2289	1508	738	0.0
115	2326	1316	690	0.0
116	2986	1342	721	0.0
117	3467	1261	704	0.0
118	4346	1334	679	0.0
119	4052	1224	629	0.0

APPENDIX B

OUTPUT FROM STAMINA 2.0

```
                 STAMINA 2.0/BCR
            FHWA VERSION (MARCH 1982)
          TRAFFIC NOISE PREDICTION MODEL
         DEVELOPED UNDER CONTRACT BY BBN

  (INPUT UNITS- ENGLISH , OUTPUT UNITS- ENGLISH )


EVALUATION OF TRAFFIC NOISE BARRIER I-471 CAMPBELL CO.

PROGRAM INITIALIZATION PARAMETERS

     HEIGHT      CODE          DESCRIPTION
      0.0          1      RECEIVER HEIGHT ADJUSTMENT
      1.00         2      A-WEIGHTED SOUND LEVEL ONLY
      0.0          3      HEIGHT ADJUSTMENT FOR PASSENGER CARS (CARS)
      8.00         4      HEIGHT ADJUSTMENT FOR HEAVY TRUCKS   (HT)
      2.30         5      HEIGHT ADJUSTMENT FOR MEDIUM TRUCKS  (MT)
     0.0           6      HEIGHT ADJUSTMENT FOR TYPE4 VEHICLES (VEH4)       'AUTOS'
                          C0 =       20.44  C1 =       30.32  S0 =       3.11
     0.0           7      HEIGHT ADJUSTMENT FOR TYPE5 VEHICLES (VEH5)       'LT TRKS'
                          C0 =       21.86  C1 =       31.08  S0 =       3.41
     2.380         8      HEIGHT ADJUSTMENT FOR TYPE6 VEHICLES (VEH6)       'MED TRKS'
                          C0 =       26.98  C1 =       31.37  S0 =       3.89
     8.000         9      HEIGHT ADJUSTMENT FOR TYPE7 VEHICLES (VEH7)       'HEAV TRKS'
                          C0 =       36.52  C1 =       28.20  S0 =       3.44


ROADWAY    1      SOUTHBOUND I-471 MAINLINE (COMB)


                         VEHICLE TYPE   VEHICLES/HOUR     SPEED
                             CARS                1.         30.
                             HT                  1.         30.
                             MT                  1.         30.
                             VEH4             1170.         60.
                             VEH5                0.         55.
                             VEH6               30.         55.
                             VEH7               30.         55.

                           ------------COORDINATES-------------
                                X            Y            Z     GRADE
RS-1                          1179.         772.         779.     1
RS-2                          1551.         920.         768.     1
RS-3                          1834.        1027.         758.     1
RS-4                          2126.        1113.         749.     1
RS-5                          2428.        1169.         739.     1
RS-6                          2727.        1188.         730.     1
RS-7                          3037.        1174.         720.     1
RS-8                          3338.        1120.         710.     1
RS-8A                         3414.        1102.         707.     1


ROADWAY    2      SOUTHBOUND I-471 MAINLINE (SEP)


                         VEHICLE TYPE   VEHICLES/HOUR     SPEED
                             CARS                1.         30.
                             HT                  1.         30.
                             MT                  1.         30.
                             VEH4              990.         60.
                             VEH5                0.         55.
                             VEH6               30.         55.
                             VEH7               30.         55.

                           ------------COORDINATES-------------
                                X            Y            Z     GRADE
RS-8A                         3414.        1102.         707.     1
RS-9                          3827.        1004.         694.     1
RS-10                         4315.         882.         678.     1
RS-11                         4799.         763.         662.     1
RS-12                         5288.         662.         646.     1
```

Figure B-1. Output from STAMINA 2.0

ROADWAY 3 SOUTHBOUND I-471 ON-RAMP

VEHICLE TYPE	VEHICLES/HOUR	SPEED
CARS	1.	30.
HT	1.	30.
MT	1.	30.
VEH4	180.	55.
VEH5	0.	50.
VEH6	0.	50.
VEH7	0.	50.

	------------COORDINATES-------------			
	X	Y	Z	GRADE
RF-1	3419.	1130.	707.	1
RF-2	3523.	1109.	704.	1
RF-3	3719.	1062.	697.	1
RF-4	3919.	1036.	690.	1
RF-5	4117.	1010.	682.	1
RF-6	4315.	984.	672.	1
RF-7	4515.	961.	662.	1
RF-8	4713.	936.	653.	1
RF-9	4913.	912.	643.	1
RF-10	5111.	890.	633.	1
RF-11	5313.	886.	623.	1

ROADWAY 4 NORTHBOUND I-471 MAINLINE (COMB)

VEHICLE TYPE	VEHICLES/HOUR	SPEED
CARS	1.	30.
HT	1.	30.
MT	1.	30.
VEH4	990.	65.
VEH5	0.	65.
VEH6	36.	60.
VEH7	66.	60.

	------------COORDINATES-------------			
	X	Y	Z	GRADE
RN-1	1212.	689.	779.	0
RN-2	1585.	838.	768.	0
RN-3	1864.	944.	758.	0
RN-4	2147.	1027.	749.	0
RN-5	2440.	1081.	739.	0
RN-6	2728.	1100.	730.	0

ROADWAY 5 NORTHBOUND I-471 MAINLINE (SEP)

VEHICLE TYPE	VEHICLES/HOUR	SPEED
CARS	1.	30.
HT	1.	30.
MT	1.	30.
VEH4	774.	65.
VEH5	0.	65.
VEH6	36.	60.
VEH7	66.	60.

	------------COORDINATES-------------			
	X	Y	Z	GRADE
RN-6	2728.	1100.	730.	0
RN-7	3030.	1092.	720.	0
RN-8	3323.	1046.	710.	0
RN-9	3809.	929.	694.	0
RN-10	4296.	809.	678.	0
RN-11	4783.	688.	662.	0
RN-12	5276.	586.	646.	0

Figure B-1. Output from STAMINA 2.0 (Cont.)

ROADWAY 6 NORTHBOUND I-471 OFF-RAMP

VEHICLE TYPE	VEHICLES/HOUR	SPEED
CARS	1.	30.
HT	1.	30.
MT	1.	30.
VEH4	216.	60.
VEH5	0.	60.
VEH6	0.	55.
VEH7	0.	55.

	------------COORDINATES------------			
	X	Y	Z	GRADE
RE-1	2818.	1079.	725.	0
RE-2	3069.	1041.	716.	0
RE-3	3264.	993.	708.	0
RE-4	3457.	942.	701.	0
RE-5	3650.	889.	694.	0
RE-6	3843.	837.	687.	0
RE-7	4036.	785.	680.	0
RE-8	4229.	730.	675.	0

BARRIER 1 TYPE(R) TRAFFIC NOISE BARRIER

	---------COORDINATES----------					
	X	Y	Z	Z0	DELZ	P
B-1	1822.	1063.	774.	759.	0.	0
B-2	2117.	1149.	766.	751.		
B-3	2527.	1217.	753.	738.		
B-4	2939.	1219.	739.	724.		
B-5	3144.	1200.	733.	718.		
B-6	3351.	1165.	727.	712.		
B-7	3547.	1124.	719.	704.		
B-8	3698.	1090.	713.	698.		
B-9	3872.	1063.	705.	690.		
B-10	4343.	1007.	688.	673.		

BARRIER 2 TYPE(R) CONCRETE MEDIAN BARRIER

	---------COORDINATES----------					
	X	Y	Z	Z0	DELZ	P
BM-1	1196.	731.	781.	779.	0.	0
BM-2	1755.	951.	764.	762.		
BM-3	2136.	1071.	752.	750.		
BM-4	2434.	1126.	744.	742.		
BM-5	2728.	1144.	732.	730.		
BM-6	3033.	1129.	723.	720.		
BM-7	3331.	1083.	713.	710.		
BM-8	3818.	967.	697.	694.		
BM-9	4693.	749.	668.	666.		
BM-10	5282.	624.	649.	647.		

BARRIER 3 TYPE(A) EARTH BARRIER NO. 1

	---------COORDINATES----------					
	X	Y	Z	Z0	DELZ	P
EA-1	4525.	1113.	705.	689.	0.	0
EA-2	4586.	1105.	707.	686.		
EA-3	4637.	1098.	707.	683.		
EA-4	4738.	1087.	704.	678.		
EA-5	4837.	1075.	702.	673.		

BARRIER 4 TYPE(A) EARTH BARRIER NO. 2

	---------COORDINATES----------					
	X	Y	Z	Z0	DELZ	P
EB-1	4293.	1110.	678.	667.	0.	0
EB-2	4319.	1100.	680.	664.		
EB-3	4343.	1104.	680.	665.		
EB-4	4374.	1107.	680.	663.		
EB-5	4400.	1101.	680.	661.		

Figure B-1. Output from STAMINA 2.0 (Cont.)

BARRIER 5 TYPE(A) EARTH BARRIER NO. 3

	X	Y	Z	Z0	DELZ	P
EC-1	2631.	1576.	713.	711.	0.	0
EC-2	2724.	1600.	715.	707.		
EC-3	2815.	1620.	719.	705.		
EC-4	2993.	1608.	725.	699.		
EC-5	3078.	1580.	725.	698.		
EC-6	3180.	1571.	725.	695.		
EC-7	3257.	1573.	725.	690.		
EC-8	3391.	1549.	733.	684.		
EC-9	3626.	1503.	745.	677.		

RECEIVER DATA

	X	Y	Z
P107	4119.	1766.	633.

ALPHA FACTORS - ROADWAY ACROSS,RECEIVER DOWN

1 * 0.5 0.5 0.5 0.5 0.5 0.5

SHIELDING FACTORS - ROADWAY ACROSS,RECEIVER DOWN

1 * 3.0 3.0 3.0 3.0 3.0 3.0

EVALUATION OF TRAFFIC NOISE BARRIER I-471 CAMPBELL CO.

RECEIVER	LEQ(H)	SIG	L10	L50	L90
P107	48.1	5.5	51.6	44.6	37.6

Figure B-1. Output from STAMINA 2.0 (Cont.)

APPENDIX C

TRAFFIC VOLUME COUNT SUMMARIES

TABLE C-1. SUMMARY OF OFF-PEAK I-471 TRAFFIC VOLUMES

	TRAFFIC VOLUME (VPH)									
	MAINLINE					RAMP				
DIRECTION	AUTOS	LT	MT	HT	TOTAL	AUTOS	LT	MT	HT	TOTAL
Southbound	822	4	34	29	889	186	1	4	2	193
Northbound	829	2	39	31	901	215	0	7	2	224
Both	1,651	6	73	60	1,790	401	1	11	4	417

TABLE C-2. SUMMARY OF PEAK I-471 TRAFFIC VOLUMES

	TRAFFIC VOLUME (VPH)									
	MAINLINE					RAMP				
DIRECTION	AUTOS	LT	MT	HT	TOTAL	AUTOS	LT	MT	HT	TOTAL
Southbound	2,943	0	30	20	2,993	286	0	2	0	288
Northbound	1,122	2	32	15	1,171	241	0	4	0	245
Both	4,065	2	62	35	4,164	527	0	6	0	533

APPENDIX D

SUMMARY OF DATA BY LOCATION

TABLE D-1. SUMMARY OF OFF-PEAK DATA BY LOCATION

RECEIVER NUMBER	DATE	TIME	NOISE LEVEL L10	NOISE LEVEL Leq	TOTAL VOLUMES (VPH) AUTOS	LT	MT	HT
2	4-23-85	12:05-12:15	51.0	49.0	1896	36	54	120
		12:05-12:15	50.2	48.7	1896	36	54	120
	4-29-85	12:20-12:30	51.3	49.8	2310	0	66	192
3	6-06-84	12:25-12:35	51.5	49.6	1956	0	78	66
		12:40-12:50	53.0	50.5	1986	6	84	70
	2-21-85	1:15-1:25	53.5	51.2	1890	0	66	60
		1:30-1:40	51.5	49.6	2058	0	42	54
	4-29-85	12:35-12:45	52.5	50.1	2526	0	78	156
4	4-29-85	12:50-1:00	47.8	45.5	2200	6	78	108
		12:50-1:00	47.5	45.3	2200	6	78	108
5	6-11-84	10:55-11:05	51.8	54.9	1596	0	100	84
		11:10-11:00	54.5	52.3	1494	0	60	90
6	6-11-84	1:05-1:15	55.8	53.1	1960	18	84	54
	4-23-84	1:18-1:28*	52.0	49.8	1540	54	48	108
		1:18-1:28*	50.7	48.7	1540	54	48	108
7	6-11-84	1:25-1:35	52.0	49.6	1986	6	96	48
		1:40-1:50	50.5	50.4	2010	0	96	66
8	4-23-85	1:45-1:55	46.0	43.9	1416	18	78	78
	10-16-84	1:45-1:55	48.5	46.5	2112	0	132	84
9	6-18-84	11:10-11:20	52.0	50.8	1890	6	138	54
	7-09-84	11:05-11:15	54.0	52.3	1926	12	90	72
	12-17-84	11:00-11:10	51.5	49.9	1752	18	96	42
		11:15-11:25	52.5	50.5	1968	12	96	78
10	6-18-84	11:45-11:55	55.8	53.5	1890	0	108	48
	12-17-84	11:35-11:45	54.2	56.3	1986	0	84	103
	2-21-85	11:10-11:20	55.5	53.8	2046	0	72	78
		11:25-11:35	54.3	52.3	1866	6	54	84
	4-29-85	2:00-2:10	56.2	54.0	2370	0	90	90
11	6-18-84	12:05-12:15	55.0	52.6	1920	6	102	48
		12:20-12:30	55.8	53.4	2166	12	96	48
	12-17-84	1:05-1:15	54.2	52.3	2100	0	48	60
		1:20-1:30	54.5	52.5	2052	6	66	72
12	6-18-84	1:35-1:45	56.3	54.7	2286	12	60	42
		1:50-2:00	56.5	54.5	2172	6	78	54
	12-17-84	1:40-1:50	56.1	54.8	2376	6	72	48
		1:55-2:05	57.5	55.0	2154	12	132	72

TABLE D-1. SUMMARY OF OFF-PEAK DATA BY LOCATION (Cont.)

RECEIVER NUMBER	DATE	TIME	NOISE LEVEL L10	NOISE LEVEL Leq	TOTAL VOLUMES(VPH) AUTOS	LT	MT	HT
13	6-18-84	2:10-2:20	55.3	52.9	2154	6	84	30
		2:25-2:35	56.3	53.0	2280	12	54	60
	12-17-84	2:15-2:25	50.7	48.8	2376	6	54	48
		2:30-2:40	52.2	50.2	2934	18	78	72
14	6-18-84	3:00-3:10	57.3	55.2	2508	6	126	96
	4-25-85	10:45-10:55*	54.2	52.8	2214	30	102	108
		10:45-10:55*	54.2	52.6	2214	30	102	108
15	7-09-84	10:45-10:55	50.8	48.5	1866	6	54	66
	4-23-85	2:40-2:50*	50.3	47.4	2136	18	36	102
		2:40-2:50*	47.0	45.3	2136	18	36	102
16	6-21-84	11:25-11:35	54.3	52.2	2010	0	84	60
		11:40-11:50	54.0	52.1	2118	6	102	102
17	6-21-84	1:10-1:20	48.0	45.3	2334	6	54	60
		1:25-1:35	49.3	46.7	2190	6	66	78
18	6-21-84	1:45-1:55	49.5	46.6	2268	12	120	48
		2:00-2:05*	48.0	45.7	2118	0	114	48
		2:00-2:05*	47.5	45.3	2118	0	114	48
19	2-21-85	10:50-11:00	50.2	48.7	1848	12	90	48
	4-25-85	10:30-10:40*	47.5	45.9	1944	18	66	78
		10:30-10:40*	49.2	46.7	1944	18	66	78
20	7-09-84	1:55-2:05	49.8	47.8	1872	6	78	36
		2:10-2:20	47.9	47.9	2280	0	96	66
100	10-16-84	10:45-10:55	51.2	49.9	1968	24	48	30
		11:00-11:10	52.0	50.3	1836	12	78	102
	12-17-84	11:00-11:10	53.3	51.0	1752	18	96	42
		11:15-11:25	54.5	53.3	1968	12	96	78
101	10-16-84	10:45-10:55	53.8	52.2	1968	24	48	30
		11:00-11:10	54.8	53.0	1836	12	78	102
	12-17-84	11:35-11:45	54.2	52.6	1986	0	84	108
		11:50-12:00	55.2	53.4	2322	18	96	90
102	10-16-84	11:20-11:30	55.7	54.1	1938	6	102	48
		11:35-11:45	56.0	54.9	1794	12	78	66
	12-17-84	1:05-1:15	55.0	52.8	2100	0	48	60
		1:20-1:30	55.0	52.5	2052	6	66	72

TABLE D-1. SUMMARY OF OFF-PEAK DATA BY LOCATION (Cont.)

RECEIVER NUMBER	DATE	TIME	NOISE LEVEL L10	Leq	TOTAL VOLUMES(VPH) AUTOS	LT	MT	HT
103	10-16-84	11:20-11:30	57.3	55.8	1938	6	102	48
		11:35-11:45	56.8	55.3	1794	12	78	66
	12-17-84	1:40-1:50	53.2	51.6	2376	6	72	48
		1:55-2:05	53.8	52.4	2154	12	132	72
104	10-16-84	12:55-1:05	52.5	50.8	1602	12	90	60
	4-23-85	12:23-12:33*	54.3	51.5	1632	54	36	114
		12:12-12:33*	53.2	50.8	1632	54	36	114
105	4-29-85	1:05-1:15	47.8	45.7	2184	6	72	96
			46.2	44.5	2184	6	72	96
106	4-29-85	1:20-1:30	45.0	43.0	2070	6	90	78
107	10-16-84	1:30-1:40	49.5	48.2	1944	18	78	60
		1:45-1:55	51.0	48.5	2152	0	132	24
	4-29-85	1:40-1:50	48.5	46.4	2160	0	66	96
108	10-16-84	2:05-2:15	52.2	50.4	1482	0	126	54
		2:20-2:30	49.7	48.0	2340	0	90	36
	2-21-85	11:45-11:55	51.2	49.2	1812	6	42	48
		12:00-12:10	51.0	49.0	2256	6	84	42
109	10-16-84	2:05-2:15	57.0	54.6	2082	0	126	54
		2:20-2:30	54.0	52.1	2340	0	90	36
	2-21-85	11:45-11:55	52.8	50.3	1812	6	42	48
		12:00-12:10	52.8	51.8	2256	6	84	42
110	11-29-84	10:45-10:55	51.3	48.9	1902	24	78	70
		11:00-11:10	48.0	45.9	1728	30	72	18
111	11-29-84	11:20-11:30	48.3	45.9	2052	48	114	102
		11:35-11:45	48.0	47.0	2112	24	90	120
112	11-29-84	12:55-1:05	50.3	48.4	2040	36	96	84
		1:10-1:20	52.8	51.0	1980	18	90	90
	12-17-84	2:15-2:25	49.3	47.6	2376	6	54	48
113	11-29-84	1:30-1:40	58.3	55.5	2136	54	90	90
		1:45-1:55	57.3	54.7	2352	30	66	60
	4-29-85	2:15-2:25*	59.3	56.8	2958	0	126	84
		2:15-2:25*	58.7	56.8	2958	0	126	84
114	11-29-84	2:05-2:15	60.3	57.8	2220	42	66	96
		2:20-2:30	60.0	57.4	2670	30	120	60
		11:00-11:10*	53.0	51.2	1728	48	66	54
		11:00-11:10*	53.8	51.6	1728	48	66	54

TABLE D-1. SUMMARY OF OFF-PEAK DATA BY LOCATION (Cont.)

			NOISE LEVEL		TOTAL VOLUMES(VPH)			
RECEIVER NUMBER	DATE	TIME	L10	Leq	AUTOS	LT	MT	HT
115	3-27-85	12:30-12:40	56.2	54.2	1932	0	48	84
	4-25-85	11:40-11:50*	55.0	52.4	2004	42	78	30
		11:40-11:50*	54.5	52.3	2004	42	78	30
116	3-27-85	12:55-1:05	60.2	57.9	1938	6	96	72
		1:10-1:20	57.7	56.1	1914	12	84	36
117	3-27-85	1:35-1:45	62.5	60.0	2064	0	108	114
	4-25-85	12:00-12:10*	58.5	56.1	1770	24	102	114
		12:00-12:10*	58.2	55.7	1770	24	102	114

* Data taken simultaneously with analyzer and meter and recorder

TABLE D-2. SUMMMARY OF PEAK DATA BY LOCATION

RECEIVER NUMBER	DATE	TIME	NOISE LEVEL L_{10}	L_{eq}	TOTAL VOLUMES(VPH) AUTOS	LT	MT	HT
2	4-17-85	5:15-5:25	54.2	51.5	5352	0	102	66
	4-22-85	5:30-5:40	56.8	54.3	4830	6	36	72
	4-22-85	5:30-5:40	53.8	51.5	4830	6	96	72
3	4-02-85	5:11-5:21*	54.8	53.3	5380	0	56	54
		5:11-5:21*	56.2	54.5	5388	0	56	54
4	4-25-85	4:25-4:35*	49.5	48.1	3270	36	144	84
		4:25-4:35*	50.2	47.6	3270	36	144	84
5	3-20-85	3:55-4:05	56.5	54.9	3570	0	138	60
		4:10-4:20	57.0	55.1	5184	6	36	36
6	3-20-85	4:30-4:40	55.7	54.8	4110	0	84	36
		4:45-4:55	56.0	54.5	4932	0	66	30
7	3-20-85	5:05-5:15	56.0	54.4	5220	0	60	24
		5:20-5:30	55.5	53.6	5196	0	109	30
8	3-20-85	5:05-5:15	51.5	48.5	5220	0	60	24
		5:20-5:30	50.8	48.4	5196	0	109	30
9	2-27-85	3:55-4:05	55.0	52.6	3798	6	78	30
		4:10-4:20	55.0	53.4	5052	0	84	48
10	3-06-85	4:30-4:40	55.0	52.9	3990	0	72	36
		4:45-4:55	57.2	55.5	4914	12	36	6
11	3-06-85	3:55-4:05	59.3	56.9	3942	12	72	36
		4:10-4:20	58.5	56.3	4932	0	66	42
12	2-27-85	5:05-5:15	60.8	59.8	4956	12	60	30
		5:20-5:30	60.5	58.9	4710	12	72	48
	3-06-85	3:55-4:05	61.7	60.0	3942	12	72	36
		4:10-4:20	60.5	58.6	4932	0	66	42
13	2-27-85	5:40-5:50	56.2	54.9	4650	12	66	36
		5:55-6:05	56.7	54.8	3708	6	48	30
14	3-14-85	3:55-4:05	57.0	55.3	3510	6	78	66
		4:10-4:20	57.7	56.4	4848	0	96	54
	4-25-85	5:30-5:40	59.5	57.4	4068	12	108	18

TABLE D-2. SUMMMARY OF PEAK DATA BY LOCATION

RECEIVER NUMBER	DATE	TIME	NOISE LEVEL L_{10}	L_{eq}	TOTAL VOLUMES(VPH) AUTOS	LT	MT	HT
15	3-14-85	5:40-5:50	52.0	50.6	4668	0	66	42
		5:55-6:05	52.2	50.9	3666	0	42	30
16	3-06-85	5:05-5:15	55.8	53.9	4842	0	54	54
		5:20-5:30	56.8	54.8	5280	0	60	18
17	3-14-85	5:05-5:15	49.2	47.7	5184	6	60	30
		5:20-5:30	48.7	47.3	5034	6	72	42
18	3-14-85	5:05-5:15	47.5	46.6	5184	6	60	30
		5:20-5:30	47.3	45.6	5034	6	72	42
	4-25-85	5:15-5:25	49.0	46.4	4392	18	102	42
19	3-14-85	4:30-4:40	50.2	49.0	4074	6	60	36
		4:45-4:55	51.7	50.0	5142	0	72	24
20	3-06-85	4:30-4:40	51.7	50.3	4140	6	42	54
		4:45-4:55	53.5	51.6	4812	0	72	30
100	4-49-85	6:10-6:20*	58.0	56.8	3660	0	90	24
		6:10-6:20*	56.5	54.6	3660	0	90	24
101	2-27-85	4:30-4:40	57.0	54.6	3990	0	72	36
		4:45-4:55	58.8	57.0	4914	12	72	48
102	2-27-85	5:05-5:15	60.2	58.8	4956	12	60	30
		5:20-5:30	59.7	58.0	4710	12	72	48
103	2-27-85	5:40-5:50	59.0	57.6	4650	12	66	36
		5:55-6:05	59.5	58.0	3708	6	48	30
104	4-17-85	5:00-5:10*	53.2	51.4	4230	12	66	24
		5:00-5:10*	52.3	51.7	4230	12	66	24
	4-25-85	4:50-5:00*	52.3	51.2	4050	6	126	54
		4:50-5:00*	52.7	50.9	4050	6	126	54
105	4-25-85	4:10-4:20*	49.0	48.0	3762	36	54	48
		4:10-4:20*	48.5	46.1	3762	36	54	48
106	4-17-85	4:00-4:10	46.5	45.0	3870	0	138	108
	4-25-85	3:55-4:05*	48.3	44.9	4062	54	72	72
		3:55-4:05*	47.5	44.9	4062	54	72	72
107	3-20-85	5:55-6:05	51.5	49.5	3636	6	36	12
	4-22-85	4:30-4:40	51.2	48.7	5256	0	108	42
	4-29-85	5:15-5:25	49.7	48.1	5442	0	84	42

TABLE D-2. SUMMMARY OF PEAK DATA BY LOCATION

			NOISE LEVEL		TOTAL VOLUMES(VPH)			
RECEIVER NUMBER	DATE	TIME	L_{10}	L_{eq}	AUTOS	LT	MT	HT
108	3-20-85	4:30-4:40	54.3	52.6	4110	0	84	36
		4:45-4:55	54.5	52.5	4932	0	66	30
109	3-20-85	3:55-4:05	56.8	55.0	3570	0	138	60
		4:10-4:20	56.6	54.5	5184	6	36	36
110	4-10-85	3:55-4:05	52.7	51.2	3810	0	108	60
		4:10-4:20	52.5	51.2	4614	0	66	24
	4-29-85	5:35-5:45*	50.0	48.4	5340	6	78	84
		5:35-5:45*	50.2	48.4	5340	6	78	84
111	3-14-85	5:40-5:50	52.0	50.5	4668	0	66	42
	4-10-85	4:30-4:40	50.7	49.5	4332	0	90	6
		4:45-4:55	51.2	49.5	5046	0	48	42
112	3-06-85	4:30-4:40	55.3	53.4	4140	6	42	54
	4-29-85	5:50-6:00*	54.0	52.9	4506	0	84	24
		5:50-6:00*	54.7	53.2	4506	0	84	24
113	3-06-85	5:05-5:15	61.5	56.4	4842	0	54	54
	3-14-85	4:30-4:40	55.5	53.5	4074	6	60	36
		4:45-4:55	56.0	55.0	5142	0	72	24
114	4-10-85	5:05-5:15	59.5	58.1	5304	6	54	30
		5:20-5:30	60.5	58.5	5148	0	90	30
115	4-03-85	3:55-4:05	57.5	55.7	3828	0	72	48
		4:10-4:20	57.5	55.9	5172	0	84	30
116	4-03-85	4:30-4:40	60.0	58.1	4170	0	90	36
		4:45-4:55	60.5	58.6	5064	6	96	48
117	4-03-85	5:05-5:15	61.7	60.0	5418	0	78	42
		5:20-5:30	60.5	58.8	5232	0	42	36
118	4-17-85	5:30-5:40	62.5	60.3	5184	6	60	24
	4-29-85	4:00-4:10*	64.3	61.3	4716	0	192	66
		4:00-4:10*	64.2	61.7	4716	0	192	66
119	4-17-85	5:45-5:55*	56.0	53.7	4614	0	36	60
		5:45-5:55*	55.3	53.3	4674	0	36	60
	4-29-85	4:40-4:50*	56.8	54.9	5400	0	66	48
		4:40-4:50*	57.0	55.2	5400	0	66	48

*Data taken simultaneously with analyzer and meter and recorder

APPENDIX E

COVER LETTER AND QUESTIONNAIRE

KENTUCKY TRANSPORTATION RESEARCH PROGRAM

UNIVERSITY OF KENTUCKY

College of Engineering
Transportation Research Building
533 South Limestone
Lexington, Kentucky 40506-0043
Telephone: 606-257-4513

Dear Resident:

The University of Kentucky Transportation Research Program, in conjunction with the Kentucky Transportation Cabinet, is conducting a research study to evaluate the effectiveness of the traffic noise barrier located on Interstate 471 in Campbell County. As part of this study, it is important to obtain the opinion of the affected residents concerning the noise barrier.

Enclosed is a questionnaire and a self-addressed, postage-paid return envelope. Please fill out the questionnaire and return it at your earliest convenience. All information will be kept confidential. Information from the questionnaires will be used in determination of traffic noise barrier effectiveness and as an aid in future decisions regarding location and construction of noise barriers. Thank you for your assistance.

Sincerely,

Tom Creasey
Transportation Research Engineer

TRANSPORTATION RESEARCH PROGRAM

UNIVERSITY OF KENTUCKY

EFFECTIVENESS OF TRAFFIC NOISE BARRIERS QUESTIONNAIRE

Please complete and return this questionnaire in the enclosed self-addressed, postage-paid envelope. Thank you for your cooperation.

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1. How long have you lived at this address? ____Years ____Months

   What is your street address: ______________________________

2. How many persons live at this residence? ________

3. Do you own your residence, or do you rent? ___Own ___Rent

4. How would you describe your neighborhood before and after construction of I 471 and the accompanying traffic noise barriers?

	Before Construction (Check one)	After Construction (Check one)
Very quiet	_____	_____
Quiet	_____	_____
A little noisy	_____	_____
Noisy	_____	_____
Very Noisy	_____	_____

5. Are you aware that a noise barrier, which was constructed at the same time as I 471, stands between your residence and the interstate? ____Yes ____No

   (If you answered "No" to the above question, please stop here and return the questionnaire; if you answered "Yes", please continue).

6. How did you learn about the noise barrier?

__________Television/Radio
__________Newspaper
__________Public hearing notice
__________Letter from a political representative
__________Observed construction of barrier
__________Other________________________________

7. How do you feel that the presence of a noise barrier has affected these highway-related problems compared to the situation where no noise barrier was present?

	Worse	No Effect	Slight Improvement	Significant Improvement	No Opinion
Highway dust and dirt	______	______	______	______	______
Headlight glare	______	______	______	______	______
Litter from vehicles	______	______	______	______	______
Highway noise	______	______	______	______	______
Road vibration	______	______	______	______	______
Road fumes	______	______	______	______	______
Privacy	______	______	______	______	______
Other__________	______	______	______	______	______

8. How do you feel that the presence of a noise barrier affects the following activities compared to the situation where no noise barrier was present?

	More Difficult	No Effect	Less Difficult	Significantly Less Difficult	No Opinion
Conversation indoors	______	______	______	______	______
Conversation outdoors	______	______	______	______	______
Telephone use	______	______	______	______	______
Relaxing indoors	______	______	______	______	______
Relaxing outdoors	______	______	______	______	______
Sleeping	______	______	______	______	______
Leaving windows open	______	______	______	______	______
Other________	______	______	______	______	______

9. Indicate if you feel that the noise barrier has created any of the following disadvantages:

	Yes	No	No Opinion
Creates closed-in feeling	______	______	______
Hurts area environment	______	______	______
Limits or restricts view	______	______	______
Requires more yard maintenance	______	______	______
Visual eyesore; unsightly	______	______	______
Other____________________	______	______	______

10. How do you feel about the appearance of the barrier?

_____Attractive _____OK _____Unsightly

11. Compared to having no noise barrier at all, how effective do you feel the noise barrier has been in reducing the traffic noise?

_____Very Effective _____Somewhat Effective _____No Effect

12. How do you feel the presence of the noise barrier has affected the value of your property?

_____Decreased Significantly _____Decreased Somewhat _____No Effect _____Increased Somewhat

13. If the noise barrier had not been built, do you feel that you would use your yard more, less, or the same amount?

_____More _____Less _____Same Amount

14. How do you feel about the noise barrier in general?

_____Like _____Dislike _____No Opinion

Please feel free to submit any further comments about the noise barrier here. Thank you. Your help is sincerely appreciated.

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