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# THE NUISANCE DUE TO THE NOISE OF AUTOMOBILE TRAFFIC. AN INVESTIGATION IN THE NEIGHBORHOODS OF FREEWAYS

Claude Lamure and Michel Bacelon

Translation of "La Gêne Due au Bruit de la Circulation Automobile - une Enquête auprès de Riverains d'Autoroutes", Cahiers du Centre Scientifique et Technique du Batiment, No. 88, October 1967 - Cahier 762, pp 0-12.



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16. Abstract An inquiry has been held among 400 people living near freeways in an attempt to determine the characteristics of traffic noise nuisance.

A nuisance-index has been compiled, based on the answers to a questionnaire. Nuisance expressed in these terms was then compared with the noise level measured on the most exposed side of each building.

The correlation between the nuisance indices and the average noise levels is quite good for dwellings with facades parallel to the freeway. At equal noise levels on the most exposed side, the nuisance given for these latter dwellings is lower than for others.

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## I. Preliminary Remarks

by Claude Lamure, Chief of the "Human Requirements" Division of the C.S.T.B.

How do we define requirement levels for traffic noise?

Defining levels of traffic noise levels which should not be exceeded in residential areas poses problems of doctrine and method for town planners and builders.

The two extreme positions which can be taken with respect to requirements for air-borne chemicals are well-known--they are presented clearly in the text cited in Reference [1], for example.

The dogmatic approach defines the requirement levels only by use of physiological or medical considerations which can be summarized rather shortly by stating that the surroundings must not produce any detectable physiological disturbance.

The pragmatic approach implicitly takes account of the cost of preventing a nuisance and the social cost of this nuisance, and sets the requirement level so that the best overall economic trade-off is obtained. For noise, another form of this pragmatic attitude which is frequently called on consists of predicting the intensity of the reactions of people living in the neighborhood, ranging from total absence of complaint to demonstrations in the streets (cf., for example, [2] Chapter 36, Community Reaction to Noise, and [3](1).

In general, and for traffic noise in particular, the dogmatic position cannot be held in full rigor because it is inevitable that the surroundings will produce detectable physiological disturbances.

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*Numbers in margin indicate pagination in original foreign text.

By substituting the idea of well-defined limited disturbances for that of detectable disturbances, it may be possible to define uniform limits which would be applicable, for example, to all bedrooms, to every hospital, etc., whatever the site and the cost of the land. Studies such as these carried out by the Center for Bioclimatic Studies at Strasbourg under the direction of Professor Metz are contributing to the definition of such levels [4]. At the present time, acoustics experts recommend noise-level limits of the order of 30 db (A) in bedrooms; these recommendations, based on experience, will have to be sharpened because they do not take account of the nature and significance of the noise. It is also necessary to specify whether one is speaking of the peak levels or of the noise level above these limits during a given fraction of the time, which can be very different.

For places other than those reserved for sleep (rooms lived in during the day, offices, etc.), unless the harm from very low frequency sounds is characterized better [5], the dogmatic attitude seems unrealistic. In particular, application of a single requirement level independent of economic considerations runs the risk of being too burdensome in the noisiest areas, which are most often precisely the ones with the highest occupation density and the highest land cost.

We, thus, have to come back to more realism, implicitly taking account of economic facts and providing a range of different limits depending on density of urbanization and land cost.

No one can pretend to apply monetary values to nuisance or to the physiological disturbance of the population, or to give an exactly equal value to the various limits which are adopted; but more modestly, an econometric approach [6] could allow these various levels to be mutually consistent.

Investigations among the residents.

Along with physiological or econometric studies, it is desirable to make inquiries among the residents so that their responses can be compared to the noise levels to which they are exposed. These investigations, such as the one we made for the Region of Paris District, have two main values:

1. In some cases curves giving percentages of dissatisfied persons have distinct changes in slope and it can be expected that at certain noise levels the annoyance of people nearby will increase more rapidly.

For some things it is above an average noise level of the order of 60 to 64 db (A) that this increase becomes evident.

2. Comparing expressed annoyance with the lay-out of buildings, and then analyzing correlations between the attitude of persons living near freeways and the various acoustic variables allow the most favorable lay-outs to be found and the most important acoustic quantities to be defined.

It will be seen that no particular importance attaches to the absolute values of the percentages of dissatisfied neighbors: This value depends to a great degree on the way the questionnaire is administered, on the type of question and on the nuisance index used. In addition, it is well-known that for any noise level there are always some dissatisfied people just as there is found to be a part of the population which has especially low sensitivity. Thus, in the investigation presented below, the percentage of dissatisfied responses is almost never zero, even for very low noise levels.

The hard problem of choosing the acoustic quantity to use in studying nuisance is pretty much avoided here because for dense traffic, such as that of freeways, the various acoustic quantities of a given traffic are interrelated [7]. The investigation also shows that correlations between the nuisance index and the average noise level are of the same order, whether one is considering real traffic or traffic arbitrarily fixed at 2000 vehicles per hour.

In the general case, it is known that consideration of the average noise level is completely insufficient for making a correlation between noise and annoyance or physiological disturbance [1], [8], [9]. The acoustic indices, proposed in great number, generally take account of peak levels and the number of these peaks [8], [9]. For the noise of automobile traffic, it appears from the work of the Building Research Station that in looking for a compromise one can use the level exceeded 10% of the time; for very low night traffic it would be preferable to use the level of the extreme peak or the difference between this level and the background noise. /2

## II. Results of an Investigation in Neighborhoods Bordering Freeways (Autoroute du Sud (South Freeway) and Boulevard Peripherique (Peripheral Boulevard), Paris),

by Michel Bacelon, psychologist

### 1. Introduction

In 1964, the Region of Paris District asked the C.S.T.B. for a study of the reactions of people living near freeways to the noise of automobile traffic. Measurements of these noises had previously led to a relation between the sound level at a point near the highway, the cross-section and the traffic volume at this point [7].

### 2. The sound levels and the sample

Knowledge of the traffic is necessary for determining the sound level. In the following report, we shall be talking of traffic observed in the spring of 1965 on a weekday between 11:00 A.M. and noon. Two types of vehicular traffic could be compared on the Autoroute du Sud: 2000 to 2500 vehicles per hour on the Fontainebleau section (the part of the freeway between the Orleans-Lyon junction and the Lyon-Fontainebleau junction), and 3500 to 4000 vehicles per hour on the common trunk (the part between the Orleans-Italy on-ramps and the Orly-Fontainebleau junction). On the Paris peripheral boulevard, traffic of 5000 to 5500 vehicles per hour was recorded.

The sample of families used in the investigation was selected primarily on the basis of acoustic consideration (note 1).

The sound levels used in choosing the sample were the average sound levels (exceeded during 50% of the observation time). While the data were being processed, consideration was also given to average sound levels for a base traffic of 2000 vehicles per hour. The sound levels shown are those which would prevail at the location of the front of the building if it were not there; consequently, they depend only on the site. We recall that the levels observed inside dwellings are lower than the levels outside by 10 to 15 db on the average when the windows are closed and by 0 to 5 db when the windows are open.

There is only a limited number of sites with characteristics simple enough that acoustic pressures are well-defined by the average levels. Our choice was finally 9 residential towns along the Autoroute du Sud and along the peripheral boulevard at the southern part of Paris. All housing in the sample (total of 420 units) had at least one face in direct view of the freeway. The farthest was 150 m from the edge of the freeway, the nearest was 10 m. The distribution of the sample among the sound levels was not uniform, as the following table shows:

| Decibels (A) | No. of sites | Decibels (A) | No. of sites |
|---|---|---|---|
| 53 | 9 | 68 | 21 |
| 54 | 8 | 69 | 24 |
| 55 | 14 | 70 | 6 |
| 56 | 9 | 71 | 7 |
| 57 | 22 | 72 | 7 |
| 58 | 23 | 73 | 7 |
| 59 | 20 | 74 | 3 |
| 60 | 18 | 75 | 3 |
| 61 | 20 | 76 | 3 |
| 62 | 16 | 77 | 3 |
| 63 | 20 | 78 | 3 |
| 64 | 26 | 79 | 14 |
| 65 | 23 | 80 | 6 |
| 66 | 34 | 81 | 3 |
| 67 | 20 | | |

## 3. The questionnaire and the nuisance index

### 3.1. The pre-inquiry

A pre-inquiry consisting of 25 non-directive interviews was made for three types of neighborhoods of the Autoroute du Sud: 8 stay-at-home owners of individual dwellings exposed to average noise levels of the order of 63 to 67 db (A), 10 tenants of apartments exposed to sound levels of the order of 70 db (A), and 7 co-owners subjected to noise levels of the order of 63 db (A).

It appeared for the most part that the attitudes of the owners of private dwellings were quite different from those of the other people in the neighborhood of the freeways; they tried to convince themselves that the noise did not bother them very much.

### 3.2. The questionnaire

The questionnaire contained 66 questions which could be classified in the following way:

- 10 questions of identity (name, age, work of head of family, etc.)
- 3 questions about possibilities for leisure time activities, transportation, contact with people, etc.
- 15 questions about the behavior of the family in the dwelling in relation to the noise level. (Do the children sleep in the freeway side or on the other side? Where does the family like best to gather together?, etc.). The corresponding responses could not be used because the diversity of house plans (sometimes within the same town) meant that the small numbers of sites were not distributed continuously in the range of sound levels determined.
- 38 questions about the reactions of the people to the freeway noise which did lead to usable responses. /3

The test used in the continuous region from 53 to 71 db (A) was the $\chi^2$ test of the median.

### 3.3. Construction of the index

Of the 38 questions about reactions caused by the freeway, 14 for the tenants and 15 for the co-owners gave a $\chi^2$ such that there was less than one chance in a hundred that the correlation observed between the type of response and the noise level was chance. These 14 and 15 questions served to determine an index for each person examined. The responses to these questions could be only "yes", "no" or "don't know". An unfavorable reaction to the freeway was counted 1; the opposite, 0. In this way a certain total was obtained for each person, a number out of 14 (or 15 for the co-owners). Converted to a scale of 10, this number gave the index for the person considered. An index value of 0 indicated that the person did not have a single response showing an unfavorable response toward the freeway; a value of 10 indicated that he had only responses showing an unfavorable reaction.

### 3.4. Elimination of 38 apartments

By calculating the median indices and the median average noise levels for each town (or apartment building), Figure 1 was obtained. The noise levels in each town were quite widely scattered, so this graph is useful only for finding possible peculiarities. Thus, two towns (22 people questioned) which gave very different results from the others have been eliminated from the calculations which follow. Such aberrant results can be explained by the fact that it was very difficult to find "quiet" urban sites on the Paris peripheral boulevard. At the two locations in question, the cross-section of the urban freeway was complicated and the freeway noise was superposed on the noise of heavy local traffic controlled by lights. In addition, quite a large number of apartments had only one room exposed to the noise.

Of the two apartment buildings along the Paris peripheral boulevard which remained usable, one was very close to the freeway (10 m), occupying the median of the boulevard, and the other was located in a very quiet street paralleling it. But we had to resort to the

Paris peripheral boulevard to find noise levels of the order of 80 db (A).

It also seemed necessary to eliminate 16 persons whose indices were excessively far from the medians: for example, an index of 10 at 53 db (A) or an index of 2.5 at 81 db (A).

Out of the 420 questionnaires collected, 38 (22 + 16) were thus eliminated from consideration of annoyance index. In addition, 12 cases were eliminated because of errors or omissions. Finally, out of 420 persons questioned, a sample group of only 370 persons was used.

3.5. The questions from which the nuisance index was calculated

The percentages of responses to the questions from which the nuisance index was calculated are shown in 15 figures (Figures 2a, 2b and 2c). For each of them there is a legend giving the question and in a box $\chi^2$ and the significance level for the median, and the number of responses.

These graphs were constructed from the raw data with a moving average over 3 db (A) (Note 2); the 53-, 54- and 55-db (A) sample sets are shown at 54 db (A); the sample sets at 54, 55 and 56 db (A) are shown at 55 db (A), etc. /6

Then the totals at 54, 55 and 56, etc., were plotted as percentages of the total number of responses.

The curves are interrupted at 70 db (A)--the set 69, 70 and 71 db (A)--and the last determinable point of the curve is joined by a dashed line to the 80 db (A) point (the set 79, 80, 81 db (A)) which is again calculable.

## 4. The principal results

### 4.1. Correlation of nuisance index with sound level (Note 3).

a) Sound level for real traffic

The sound level of real traffic was the basis of our calculations and is shown for the curves.

The correlation between nuisance index and sound level shows a strong relationship (r = 0.605) between the two variables.

b) Sound level for traffic of 2000 vehicles per hour

For average traffic of 2000 vehicles per hour, the relationship is just as strong (r = 0.61) as the one found with the real traffic. It would have been possible to make the calculations on the basis of 2000 vehicles per hour but it was simpler to use real traffic which gave the real sound levels directly.

### 4.2. The median nuisance indices by 1-decibel bands

When median annoyance indices by 1-decibel bands are used, as shown in Figure 3, a more evident increase in nuisance can be seen, starting at 62-64 db (A).

This result is even clearer in Figure 4, drawn from the moving average over 3 db (A) (Note 4). A more readable curve is obtained in this way. Examination of the graph shows that nuisance level 2.5 lies at about 63.5 db (A), that nuisance level 5 is at about 67.5 db (A) and that nuisance level 7.5 can be assumed to be around 75 db (A).

### 4.3. The scatter in nuisance indices

The nuisance indices obtained for each noise level are quite few in number and scarcely form a Gaussian distribution. We have preferred to illustrate the scatter in these indices at each noise level by interquartile deviation rather than by standard devia- /9 tion. The interquartile deviation is the difference in the indices exceeded by 25% and 75% of each sub-population. These deviations are:

| dB (A) | deviation interquartile | dB (A) | deviation interquartile |
|---|---|---|---|
| 54 | 1,20 | 64 | 5,45 |
| 55 | 2,10 | 65 | 4,60 |
| 56 | 2,10 | 66 | 3,80 |
| 57 | 2,15 | 67 | 4,10 |
| 58 | 2,15 | 68 | 2,95 |
| 59 | 2,80 | 69 | 3,00 |
| 60 | 3,60 | 70 | 2,75 |
| 61 | 4,30 | .. | ... |
| 62 | 4,65 | 80 | 1,00 |
| 63 | 4,70 | | |

The deviations are especially high for noise levels above 59 db (A); by separating buildings parallel to the freeway from those which are oriented other than parallel (towers, apartment buildings perpendicular to it, detached housing units, oblique orientations), the semi-interquartile deviations shown in the table below are obtained:

Semi-interquartile deviations as a function of building orientation

| dB (A) | buildings parallel | other than parallel |
|---|---|---|
| 56 | 2,00 | 2,10 |
| 57 | 2,25 | 3,25 |
| 58 | 2,00 | 4,00 |
| 59 | 2,25 | 4,10 |
| 60 | 2,30 | 4,00 |
| 61 | 3,30 | 4,50 |
| 62 | 2,60 | 5,00 |
| 63 | 3,00 | 6,00 |
| 64 | 2,50 | 5,20 |
| 65 | 1,50 | 5,50 |
| 66 | 3,60 | 4,75 |
| 67 | 3,50 | 4,80 |

Scatter seems to be distinctly lower for buildings parallel to the freeway and is about what would be expected from the scatter in individual sensitivities.

Likewise, in the range from 56 db (A) to 67 db (A), one finds correlation coefficients between nuisance indices and average noise levels to be 0.35 for apartments which are other than parallel and 0.53 for parallel ones (Note 5). These correlation coefficients are smaller than the ones given in Section 4.1. because they are for a part of the sample limited to noise levels between 54 and 67 db (A).

Figures 5 and 6 show the nuisance indices exceeded by 25, 50 and 75% of the population at each noise level.

### 4.4. The effect of building orientation

Figure 7 shows the median nuisance indices for people living /10
in apartments parallel to the freeway and for other neighbors of the freeway. It is seen that for the same median nuisance index, the people living in apartments parallel to the freeway accept an average noise level at the exposed building front which is 2 to 5 db (A) higher than the average noise level to which other neighbors are subjected at their most exposed frontage. This is not a chance result because significance calculation made by simple comparison of the nuisance indices of the two sub-populations gives a $\chi^2$ of 8.30, or a difference significant between px.01 and px.001. The correlations between the nuisance indices for the two sub-populations and the noise levels are $r = 0.35$ for other than parallel orientations and $r = 0.53$ for parallel ones, which is a significant difference at px.001.

It can thus be considered that at equal noise levels, the nuisance indices for parallel apartments are significantly lower than nuisance indices for the other cases. Unfortunately, the small size of the sample did not allow us to make a curve of the variation of nuisance level as a function of inclination of the building to the freeway. The 2- to 5-db difference for buildings at all angles would certainly be greater for perpendicular dwelling units.

### 4.5. An attempt at explanation

Various explanations of these results are possible.

They could be attributed to the fact that determination of the sound level, a function of distance and height, is more difficult for apartments not parallel to the freeway, but this would not explain the systematic character of the differences found--the expected effect would be mainly a wide scatter in the results.

Another explanation would start from the common notion that rapidly-changing noise is more annoying than noise which increases and decreases regularly. But it is for the apartments perpendicular to the freeway that the noise changes most abruptly when a vehicle passes.

The explanation which seems most satisfactory, however, is that for apartments perpendicular to the freeway (an extreme case, but one which best allows understanding of what we wish to say), the residents are bothered on two sides and this double exposure to noise is not conveyed by the sound levels which are attributed to them. It should be pointed out here that all dwelling units visited had double exposure if they had more than two rooms.

### 4.6. The most often cited sound sources

Question 21, also used in constructing the nuisance index, asked in a second part what were the noticeable noises from the freeway. These sound sources are compared in the table below:

| | No. of mentions | percentage |
|---|---|---|
| horns | 169 | 42.60 |
| heavy weights | 80 | 20.15 |
| sports cars | 46 | 11.60 |
| ambulances, police vehicles | 39 | 9.80 |
| brake squeals, accident sounds | 37 | 9.35 |
| general traffic sounds | 10 | 2 50 |
| effect of ribbing (Note 6) | 10 | 2.50 |
| week-end | 6 | 1.50 |
| total | 397 (Note 7) | 100 |

It can be seen that it is the horns which people living beside freeways notice most often.

5. Conclusion

The nuisance index as we have calculated it has led to meaningful results for doubly-exposed apartments located in buildings parallel to a freeway.

In the other cases, the indices are not really usable because of the excessively greater scatter in the results due to the diversity in the orientations of the apartments.

A subsequent study taking this orientation problem into account is required.

There is a significant difference in nuisance at equal noise levels on the most exposed side, depending on whether or not the apartments have a side which is not exposed--in other words, the nuisance is the same in an apartment with a non-exposed side as in an apartment without such a side (i.e., with two exposed sides), and subjected to noise 2 to 5 db (A) lower.

If one wished to use the results obtained in this investigation to suggest an average noise level which should not be exceeded in front of rooms lived in during the day, from the shapes of the response curves, one could take it that the critical value for measuring nuisance lies between 60 and 65 db (A), this average level being the one exceeded 50% of the time for mid-season daytime traffic, excluding rush hours.

## APPENDIX

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### THE POPULATION EXAMINED

The population examined was representative only from the standpoint of the sound levels. Nevertheless, here are its main characteristics.

1. Accommodations

The towns investigated are new. The oldest three are only eight years old. The occupation times are very nearly the time which has passed since the apartment buildings were opened and the towns built. The following table gives the occupation times, the "service time" of the apartments and the number of persons interviewed per town (Note A-1):

| | occupation time | service time | number of persons interviewed |
|---|---|---|---|
| ORA | 8 yrs | 8 yrs | 5 |
| VAN | 7 " 11 mos | 8 " | 23 |
| CHE | 7 " 4 " | 8 " | 12 |
| PAV | 6 " 11 " | 7 " | 31 |
| CER | 1 " 10 " | 2 " | 62 |
| MOR | 3 " 5 " | 3 " 8 mos | 22 |
| ROS | 3 " | 3 " 3 " | 68 |
| SGE | 2 " 7 " | 2 " 10" | 57 |
| GVA | 2 " | 2 " 2 " | 90 |

These are thus recent constructions of good quality, generally occupied by the same people over their service lives.

The following table shows the number of children, the number of rooms and the number of persons per apartment:

| | Median no. of children per apartment, by town | Median no. of persons per apartment, by town | Median no. of rooms per apartment, by town |
|---|---|---|---|
| ORA | 1.75 | 4 | 4 |
| VAN | 3.75 | 5.80 | 4 |
| CHE | 2 | 4 | 3.50 |
| PAV | 2.50 | 4.85 | 4.65 |
| CER | 1.30 | 3.40 | 3.50 |
| MOR | 1.90 | 4.30 | 3.50 |
| ROS | 2 | 4 | 3.90 |
| SGE | 2.20 | 4.30 | 3.30 |

It can be seen that the apartments are not over-crowded. The exterior walls, as well as the interior appointments, are of the H.L.M. (medium-rent housing) type.

In support of the table above, the responses to question 49: "Aside from the freeway, are you satisfied with your apartment?" gave the following percentages of YES responses:

| | |
|---|---|
| ORA | 80% |
| VAN | 100% |
| CHE | 100% |
| PAV | 92.50% |
| CER | 87.30% |
| MOR | 91.30% |
| ROS | 94.65% |
| SGE | 71.90% |
| GVA | 94.40% |

All the towns had better than 70% YES responses to this question. The people examined were well-housed and felt satisfied with their housing. The status of occupation (renter or co-owner) seemed to have no effect on this feeling.

2. Age of family head

As the table shows, age is related to distance from Paris; statistical calculations for these age differences show a significant difference of better than px.001 among the ages of different sections of the freeway.

But, above all, it turns out that the population seen was young.

| | median age | Set (no. of responses recd.) |
|---|---|---|
| peripheral | 41 yrs 2 mos | 28 |
| common trunk | 33 " 10 " | 95 |
| Fontainebleau | 31 " 2 " | 220 |
| Total: | 32 " 7 " | 343 |

3. Previous residences

The question asked was "where did you live before you came here?". In many cases, the responses did not give a previous residence but a geographic origin. However, the following table was made from them in which the line headings show the geographic location given and the column headings the current residence of the persons asked:

| | peripheral | common trunk | Fontainebleau | Total |
|---|---|---|---|---|
| Paris | 20 | 40 | 52 | 113 |
| Banlieue | 2 | 42 | 102 | 147 |
| Province | 3 | 12 | 41 | 57 |
| French North Africa | | 4 | 33 | 37 |
| Foreign | 1 | 1 | 7 | 9 |
| Total: | 26 | 99 | 245 | 370 |

4. Socio-professional classes

The socio-professional classes used here combine some I.N.S.E.E. (French National Institute for Statistics and Economic Studies) classes as follows:

A. upper management, professional

B. middle management, merchants, artisans

C. employees

D. skilled workers

E. semi-skilled workers

The table giving the distribution of our sets among the socio-professional classes by town is as follows:

| | A | B | C | D | E | Total |
|---|---|---|---|---|---|---|
| ORA | 2 | 2 | 1 | | | 5 |
| VAN | 2 | 3 | 10 | 6 | 2 | 23 |
| CHE | | | 10 | 2 | | 12 |
| PAV | | 1 | 21 | 5 | | 27 |
| CER | | 19 | 38 | 4 | | 61 |
| MOR | | 3 | 12 | 4 | | 19 |
| ROS | 2 | 22 | 22 | 10 | | 56 |
| SGE | 1 | 14 | 32 | 9 | 2 | 56 |
| GVA | | 15 | 58 | 11 | 2 | 86 |
| TOTAL | 7 | 79 | 204 | 51 | 4 | 345 |

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## FOOTNOTES

Note 1 - The principal characteristics of the population examined are given in the Appendix (page 2).

Note 2 - This procedure makes allowance for the uncertainty in measuring the mean noise levels, which can be estimated to be ± 1.5 db (A) at most (page 6).

Note 3 - Sound level determined from tables [7] or measured in difficult cases (page 6).

Note 4 - Discontinuities in the curve are accentuated because of grouping by class (page 6).

Note 5 - The coefficients of the correlation between nuisance index and the various acoustic variables as found in the study of Reference 10 are of the order of 0.4 (page 9).

Note A-1 - The towns are indicated by their initials (page 11).

Note 6 - These responses are for a city built along a relatively steep coast. It seems as though all the other noise sources would have been mentioned by population along rivers.

Note 7 - The total exceeds 370, even though most persons did not respond to the first question, and several noise sources can be mentioned by the same person.

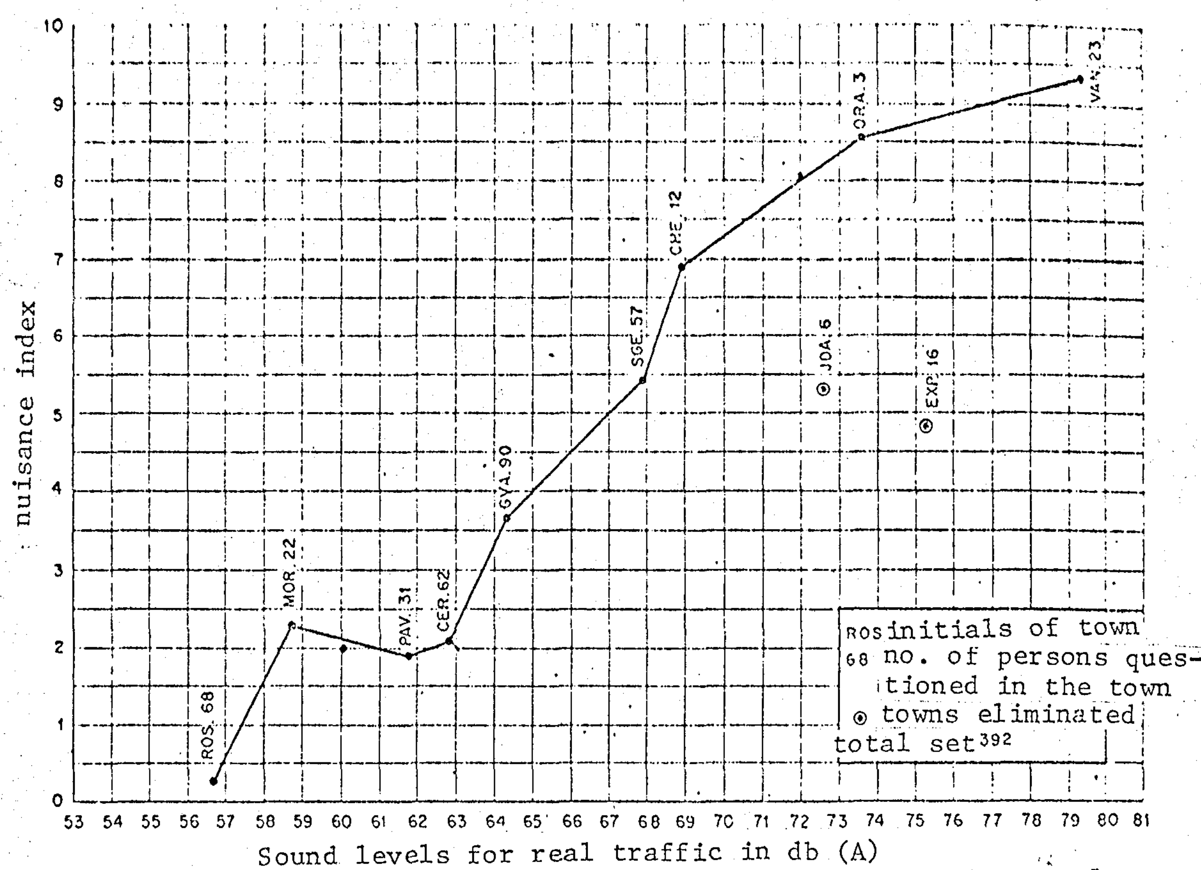
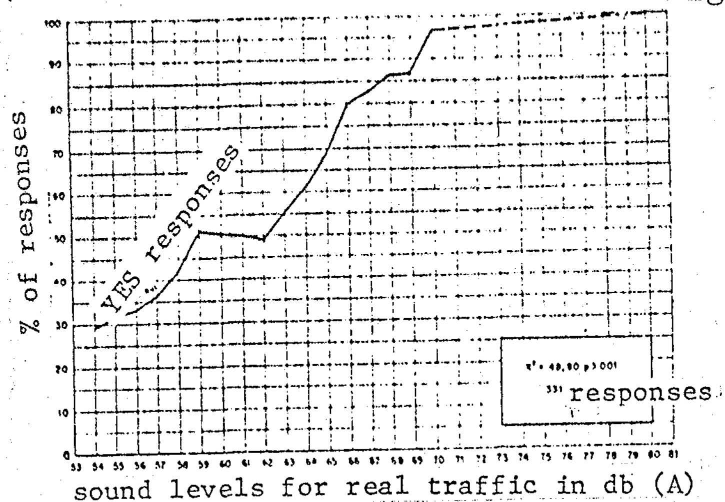
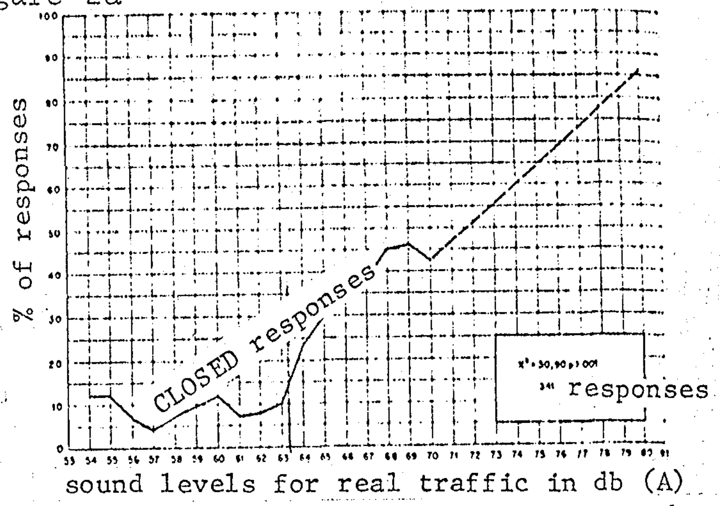



Figure 1 - Median nuisance indices and average sound levels, by town.

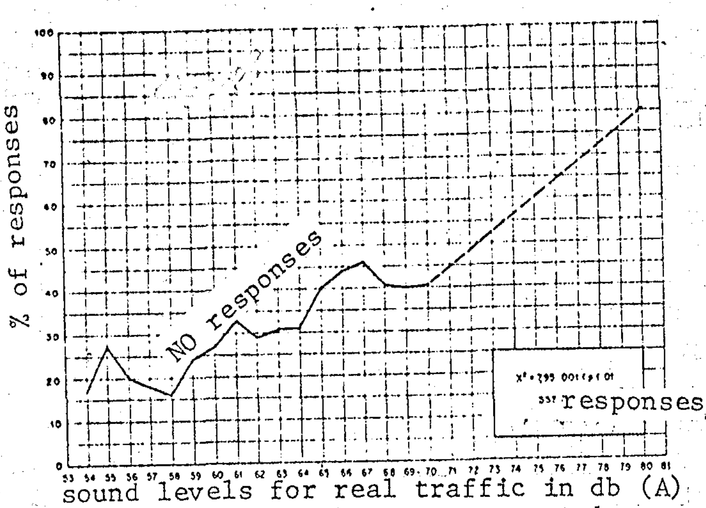
Figure 2a



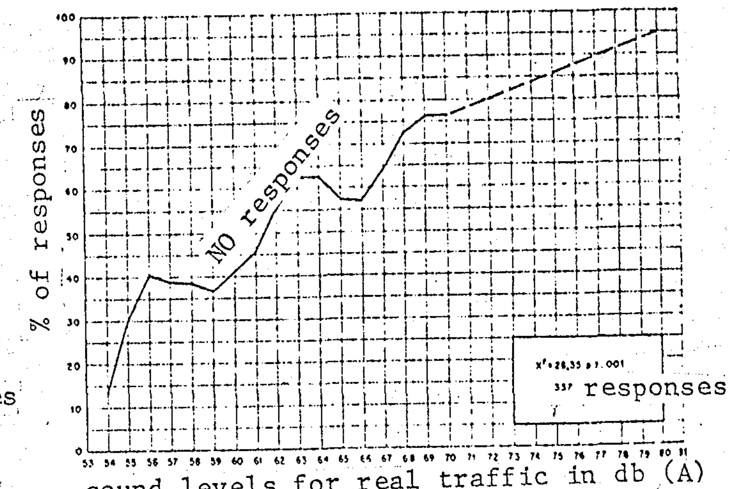

**Question 1.** Do you think you are too close to the freeway?



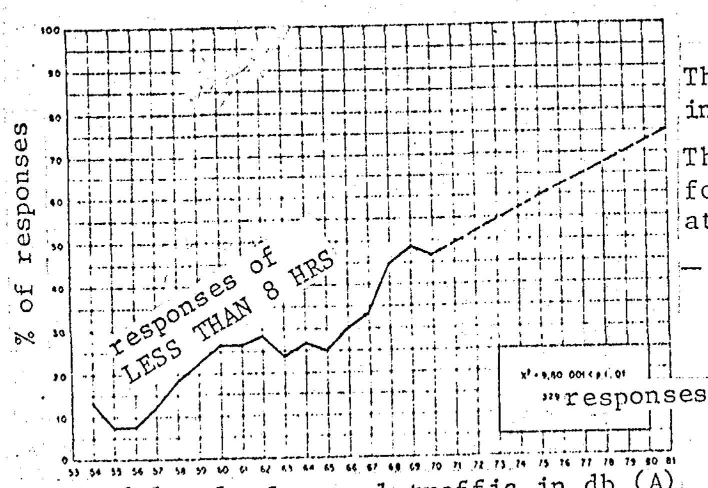

**Question 3.** – In the rooms on the freeway side, do you leave the windows open, partially open or closed in summer?




**Question 8.** Do you sleep with the window open in summer?




**Question 9.** In the building or in the neighborhood, are there any noises more annoying than those from the freeway?




**Question 10.** – How many hours of sleep do you think you get at night?

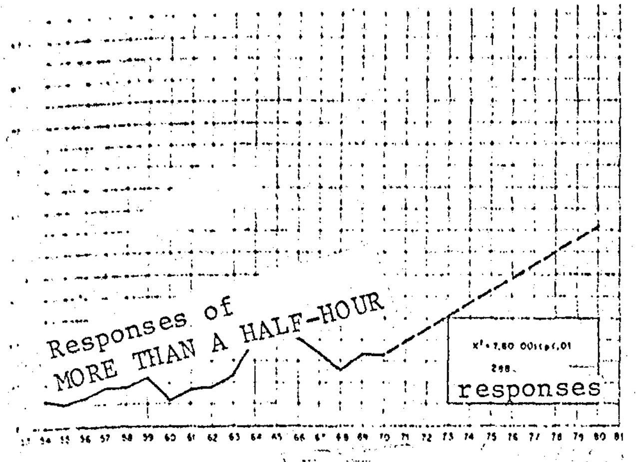
Légend. figures 2 a – 2 c.

The ordinates show the % of responses of the type indicated, out of the total no. of responses given.

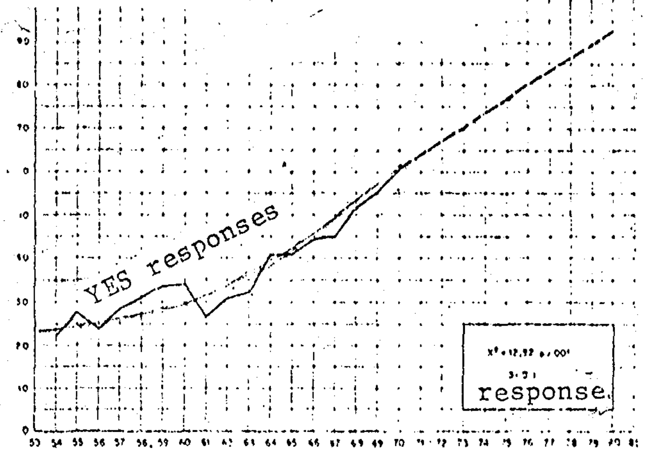
The abscissas give the average sound levels in db (A) for real traffic between 11 AM and Noon of week days at the period in question.

– – –Assumed curve between the last point of the solid curve and the known point at 80 db (A).

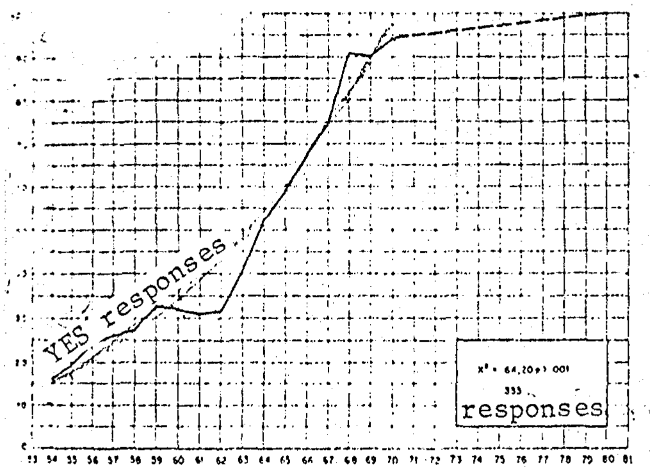
Figure 2b



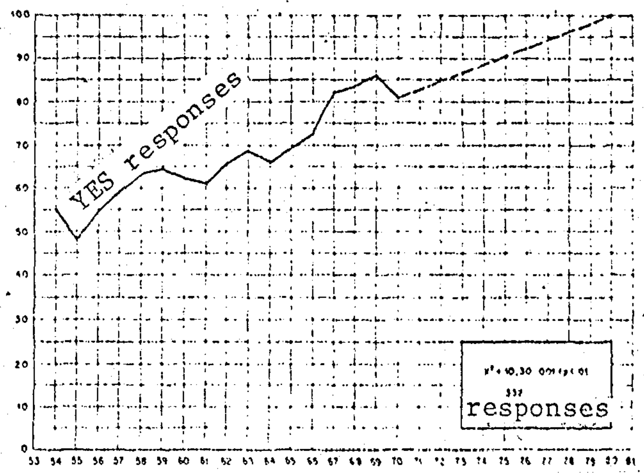

Question 11. How long do you think it takes you to go to sleep?



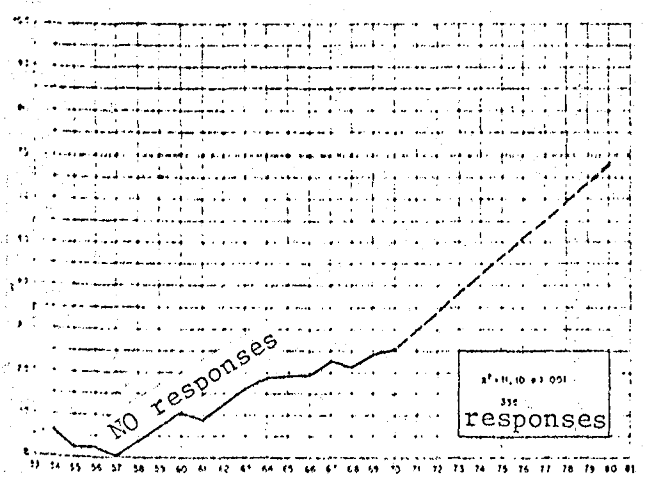

Question 16. — Does the freeway wake you at night?



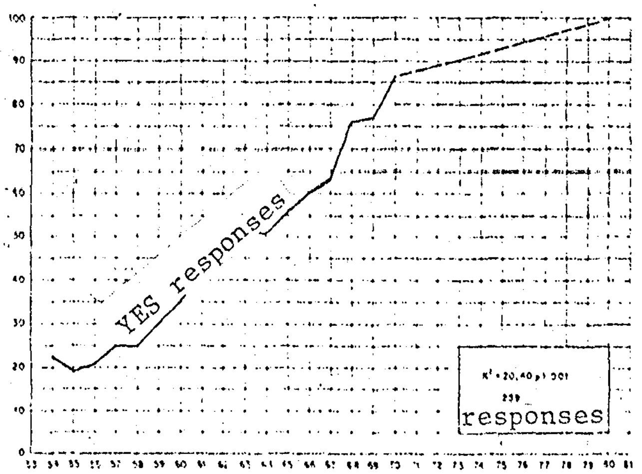

Question 20. Do you have to close the windows when friends or parents visit you?




Question 21. In the general freeway noise, are there ordinary or unusual noises that you recognize?

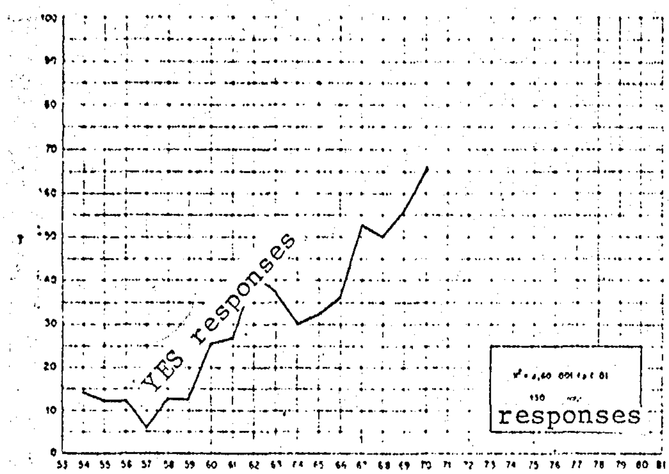



Question 35. Are you used to the noise?

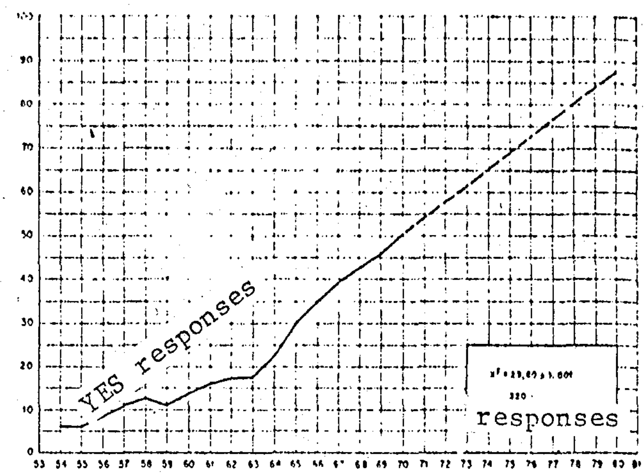



Question 37 If you could, would you move to an equivalent apartment farther from the freeway?

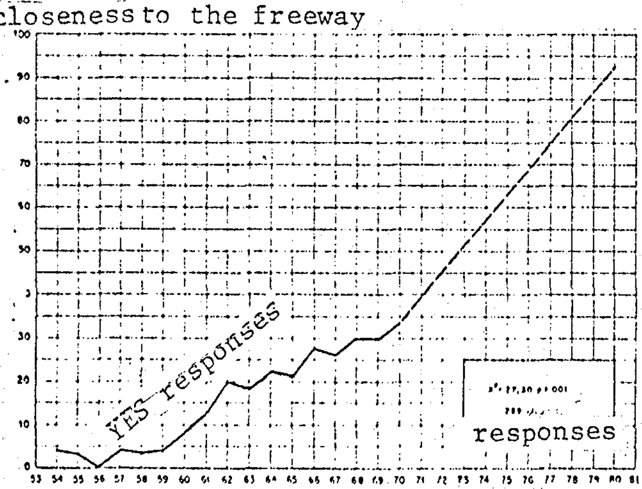
Figure 2c



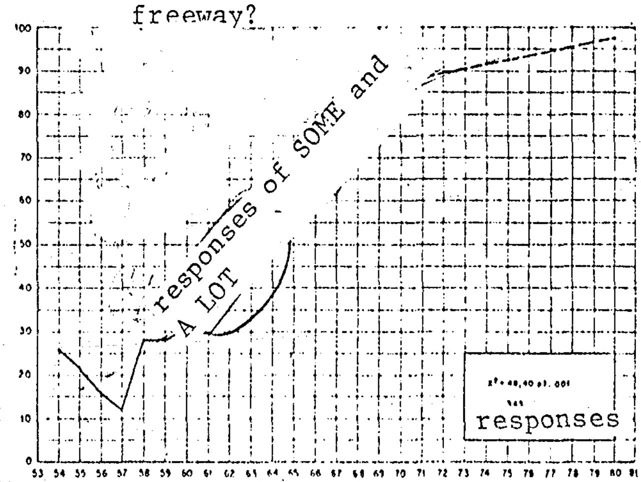

Question 50 Do you think that your home has lost some of its value because of its closeness to the freeway




Question 53. Do you have the impression that you are more nervous since you have been living near the freeway?




Question 54 Do you have the impression that your children are more nervous since you have been living near the freeway?




Question 57. Finally, are you bothered by the freeway: not at all, a little, some, a lot?

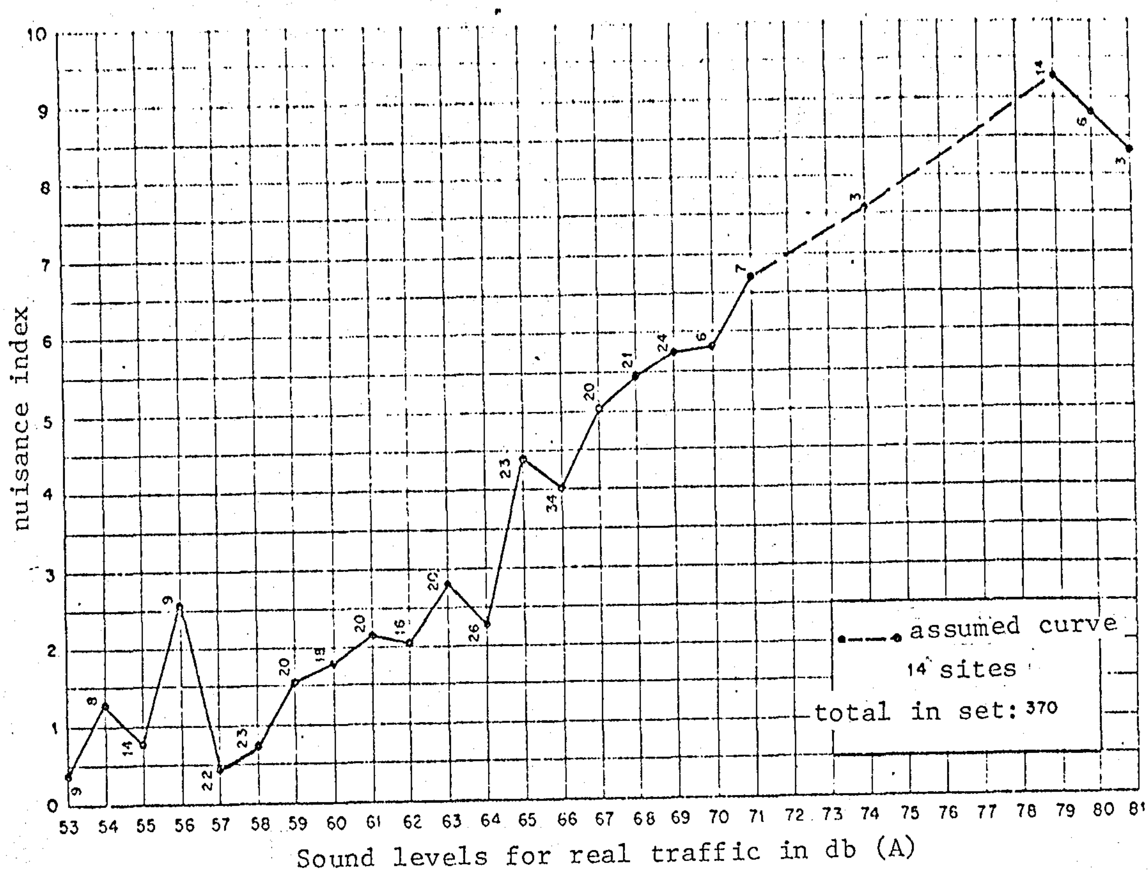



Figure 3. Median nuisance indices per db (A).

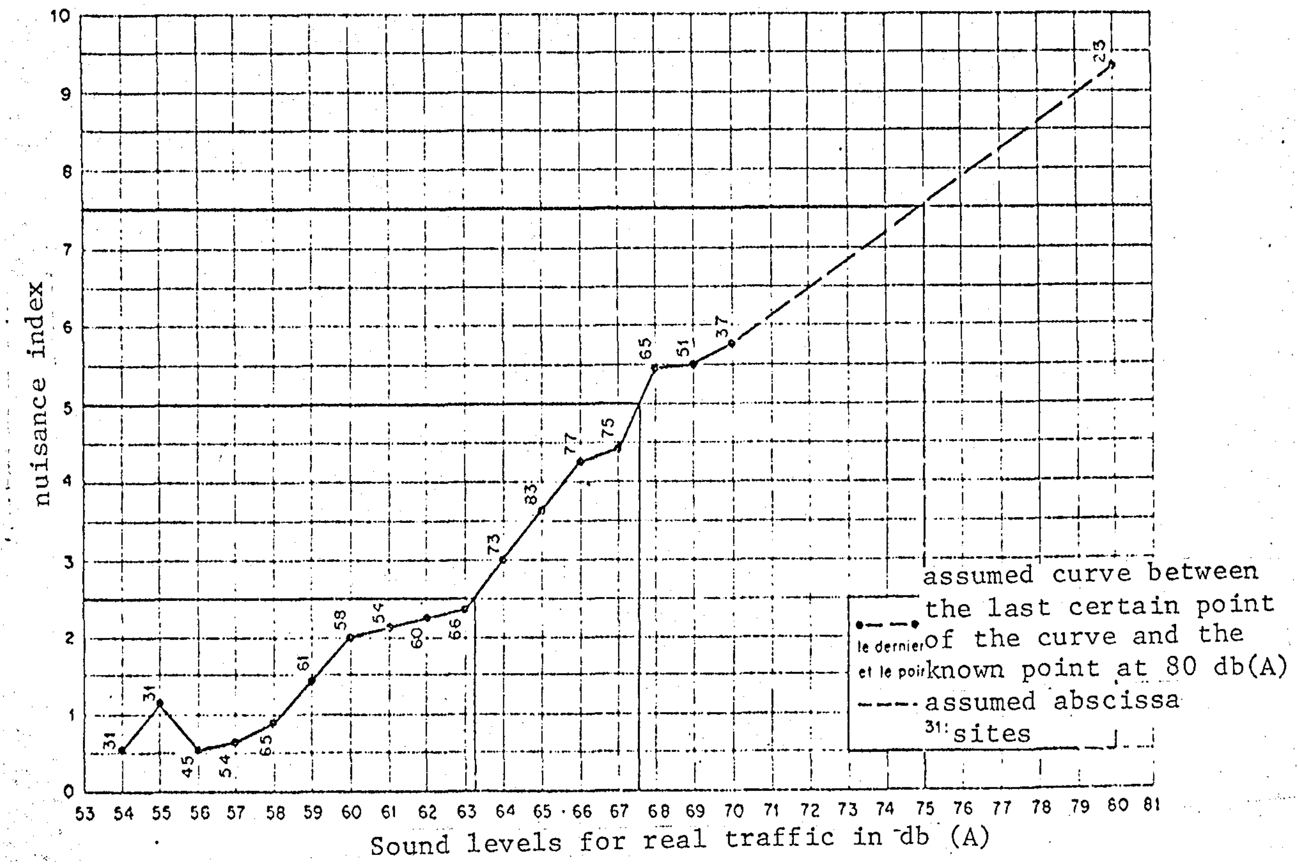



Figure 4. Curve for moving average over 3 db (A) and for the whole population.

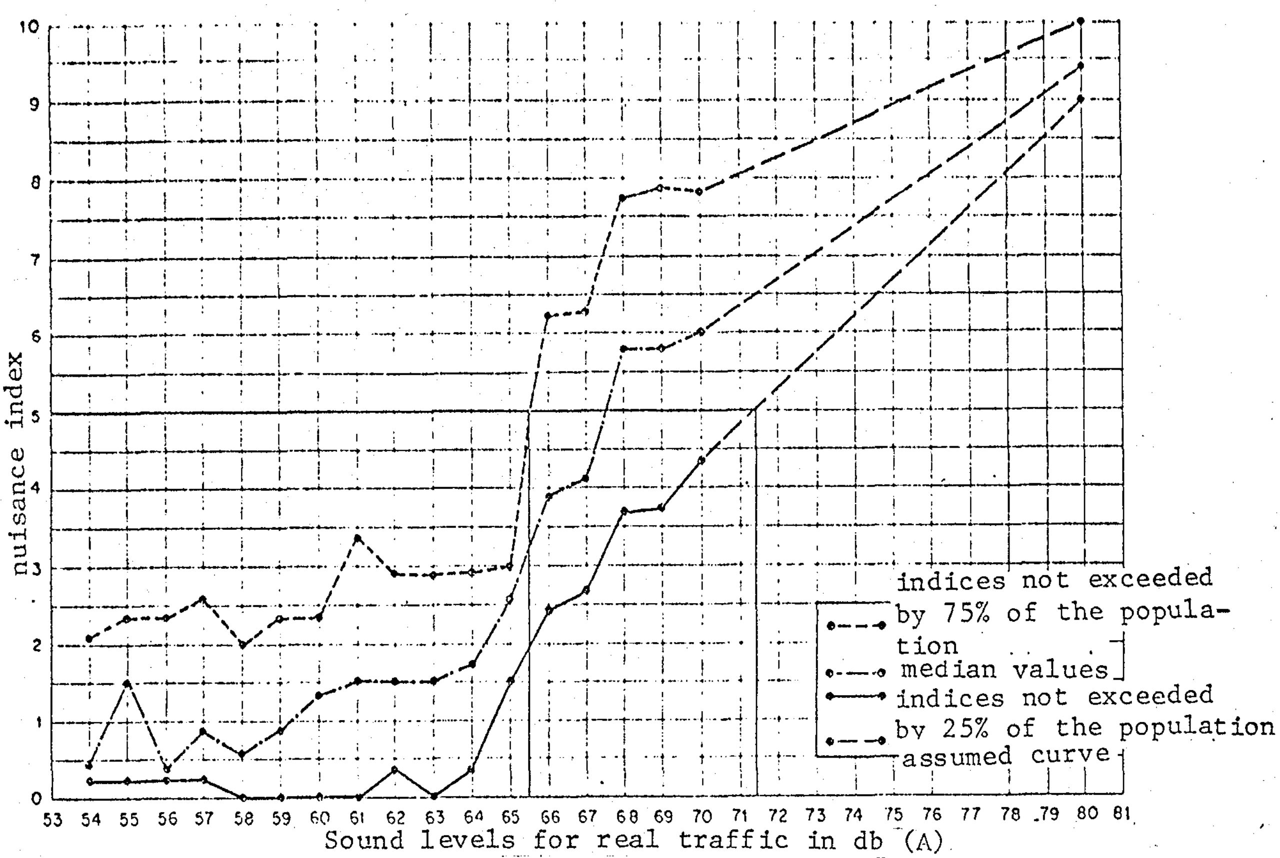



Figure 5. Scatter of nuisance indices around the median for apartments parallel to the freeway.

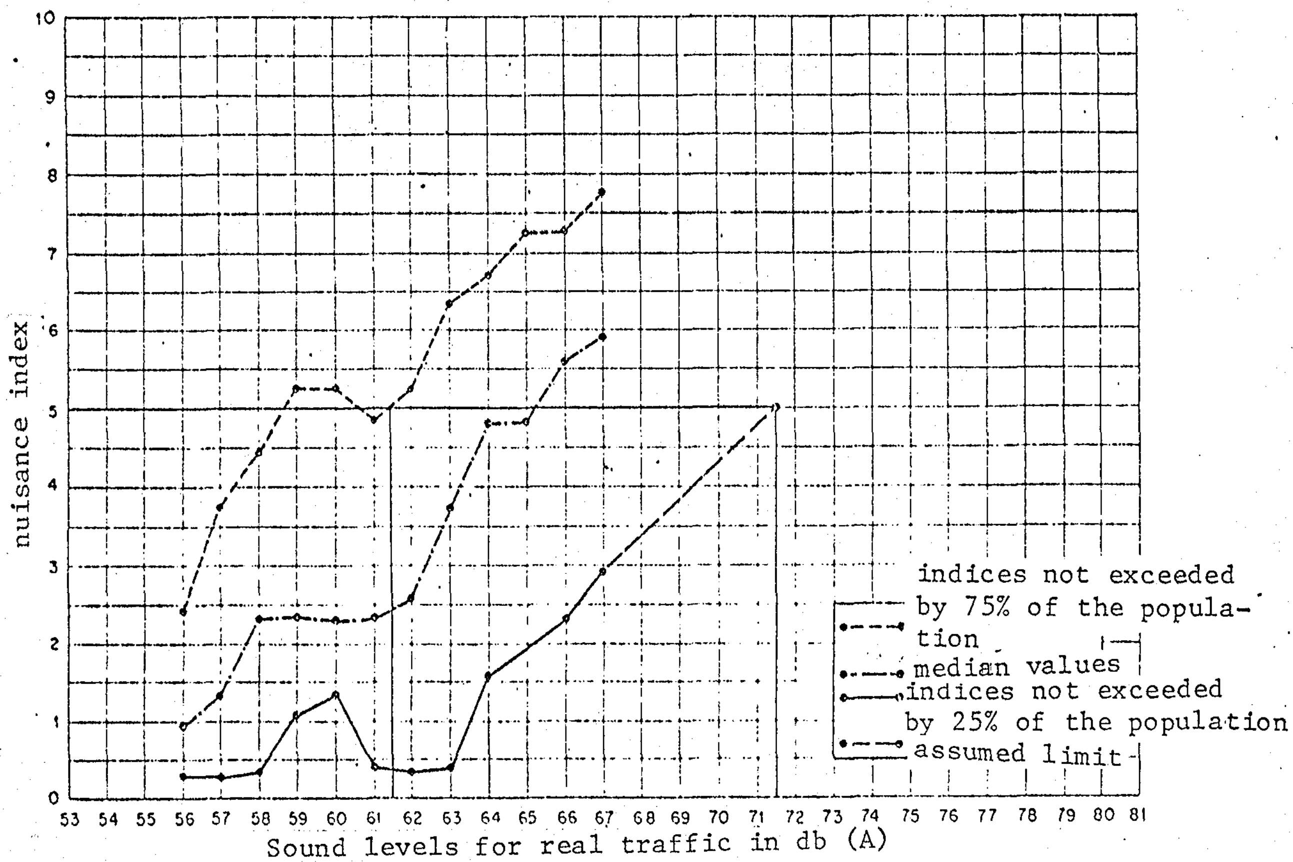



Figure 6. Scatter of nuisance indices around the median for apartments other than parallel to the freeway.

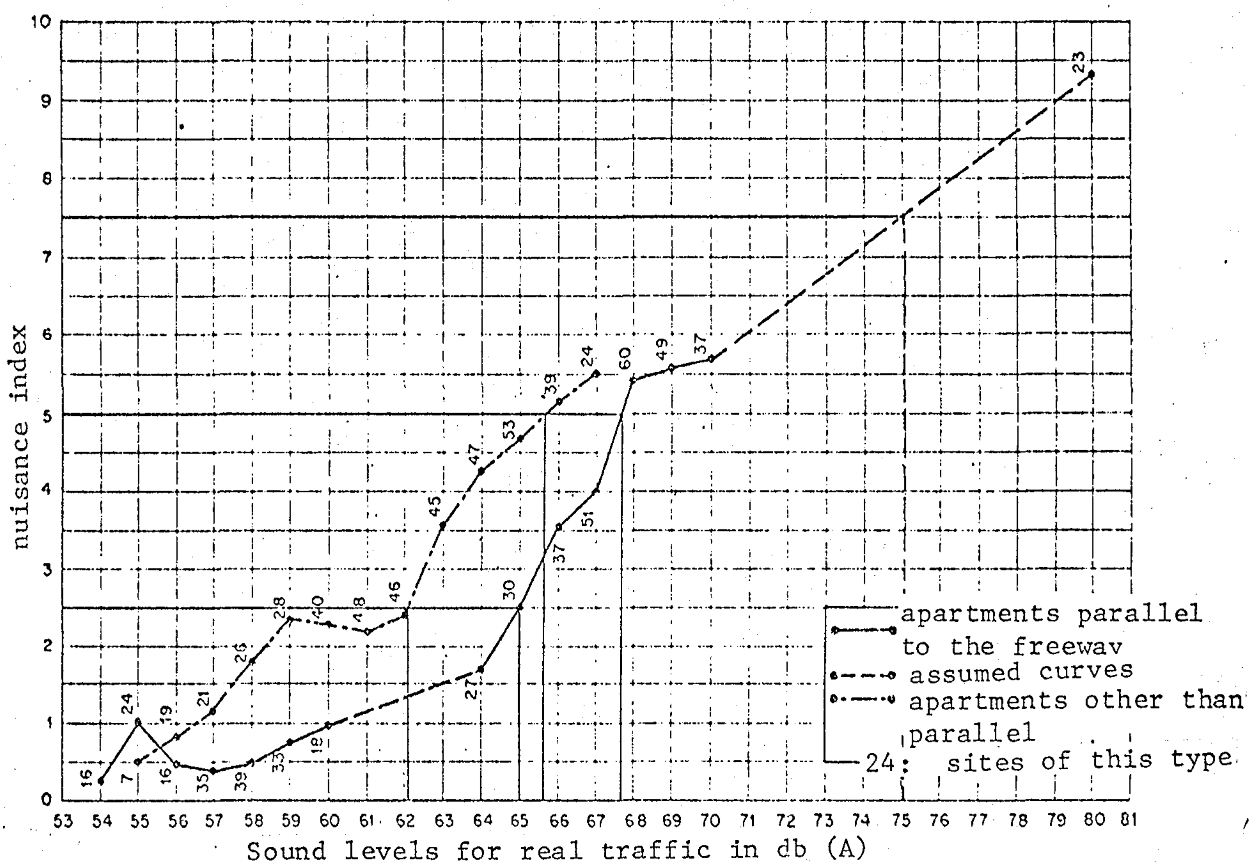



Figure 7. Moving averages of the indices for apartments parallel to the freeway and for apartments other than parallel to the freeway, per db (A).