NOISE, ODOUR AND ENVIRONMENTAL QUALITY

A summary

CONTENTS

1. INTRODUCTION

Environmental quality is determined by various factors, including exposure to noise and odour, industrial hazards and exposure to toxic and carcinogenic substances. This report concerns the relation between noise and odour exposures, and the environmental quality in residential areas. It is based on a noise and an odour study, a study of the comparability of data from noise and odour studies and a study of the appraisal of combined noise and odour exposure. For further information we refer to these studies, on which this summary report is based (see references).
In this introduction first the four studies will be sketched briefly, thereafter the organization of the rest of this report will be described.
Two studies established relation between noise and odour exposures, respectively, in residential areas and the annoyance they cause. The relations were based on a large amount of data from studies conducted both in the Netherlands and abroad. The results may be used to evaluate noise and odour from individual sources and can be used as a basis for environmental standards with respect to these sources. The database will most probably be updated in the future, with a view to producing regular reports.
The third study looked at the comparability of data from noise and odour surveys.
The final study on which this report is based is currently nearing completion. It concerns a method of evaluating exposure to noise from a number of sources and, possibly, to odour. Such a method is relevant with respect to the provisions of the section 157 of the Nuisance Act relating to combined noise sources, with respect to environmental impact studies and to integrated environmental zoning around industrial areas.

Chapter 2 gives a general outline of the study of the relation between exposure to noise or odour and nuisance. Chapter 3 looks at the noise study mentioned above in greater detail and presents results. Likewise the same applies to the odour study in chapter 4. Chapter 5 compares the annoyance caused by exposure to noise with that caused by exposure to odour. Chapters 6, 7 and 8 discuss the evaluation of combined exposures; chapter 6 focuses on the procedure for devising an evaluation method, chapter 7 describes the method itself, while in chapter 8 real situations are used to show how the outcome of such an integrated evaluation can be illustrated.

2. DOSE-RESPONSE STUDIES OF NOISE OR ODOUR

Dose-response studies of noise or odour are related to a chain of events which can be represented as follows:

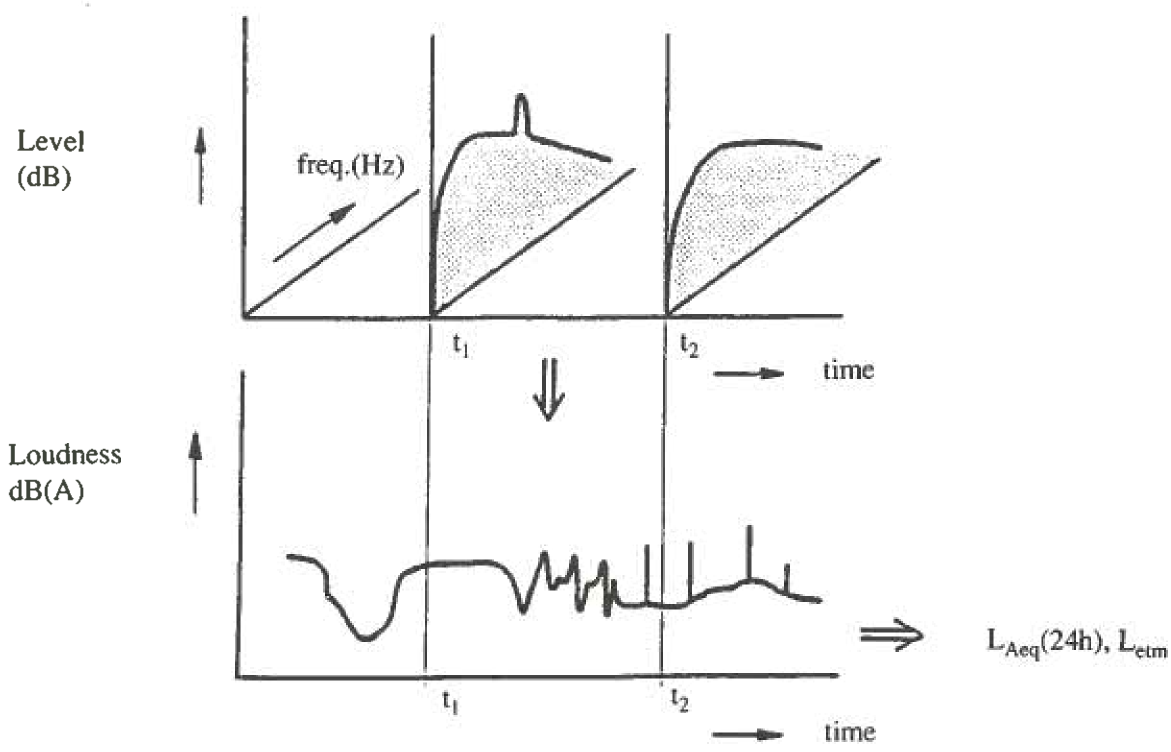
EMISSION → DISTRIBUTION → IMMISSION or DOSE → EFFECT/RESPONSE

An emission might, for instance, come from a road (traffic noise, odour of exhaust fumes) or an industrial site. Dispersal leads to dilution and possibly absorption may occur. The pollution which reaches a dwelling is referred to as the immission or dose to which its occupants are exposed. Their reaction to it is the effect or response.
Dose-response studies focus on the final link in the chain, with the aim of obtaining information which allows different effect levels to be translated into the corresponding immission or emission values. Having established what level of effect is acceptable, we can then set immission or emission standards. To facilitate the translation of effect levels into immission values, relations are often presented in the form of a curve which shows the response as a function of the dose.
This kind of study involves three stages: dose measurement, response measurement and analysis of the relationship between dose and response. Each of these three stages is examined in more detail below.

2.1 Dose

The immission is determined on the basis of a combination of emission measurements and dispersion calculations, or by immission measurements. Both approaches produce a great deal of data on the immission, which are summarized to produce one or more dose measurements, as illustrated in figure 1.

Figure 1. Summary of basic data on noise exposure. The frequency-time pattern (above) is first condensed into a time pattern (below), and then into one or several values such as L_{Aeq} (24h) or L_{etm}.



At any given moment sound intensities in different frequency ranges contribute to the total sound. Furthermore, the noise near a dwelling varies over time. Figure one shows how the whole frequency-time pattern can be summarized into a single dose measure. The first step is to condense the frequency spectrum at each point in time into one value. If the relation with noise annoyance is being studied, the A-weighted sound level, expressed in dB(A), is established. A time pattern of A-weighted noise levels is then produced. The second step is to condense this further, for instance to the 'average' over a 24-hour period, the L_{Aeq}(24h), or to a maximum of such a average for the daytime, for evening + 5dB(A) and for night + 10dB(A). This last dose measure, L_{etm}, is used in the Noise Nuisance Act.

For studies of odour, odour concentration is established by calculating the number of times an air sample has to be diluted with clean air before the odour is no longer detectable. The odour concentration near a dwelling also varies over time. C_{98} or $C_{99.5}$

might be determined for the distribution of odour concentration throughout a year. C_{98} is the concentration which is exceeded for 2% of the time (175 hours a year), while $C_{99.5}$ is the concentration which is exceeded for 0.5% of the time (44 hours a year).

2.2 Response

The effect on people exposed in their residential area is determined by surveys. The questionnaire used for this purpose starts usually with a brief introduction, followed by a number of questions about the dwelling and residential areas in general. Respondents are then asked to give a judgment on environmental factors such as noise from road traffic or odour from an industrial site. The questionnaire in general ends with questions about the respondents demographic and other relevant details.

The questions about noise and odour annoyance are the most important. A question might be worded as follows: "To what extent do you regard the noise of aircraft here as annoying?" The respondent might be given the choice of four answers: not annoyed, slightly annoyed, annoyed or severely annoyed.

To the different categories different scores are given. If 0 is taken as the bottom of the first category and 100 as the top of the last, the scores for the midpoints of the above four categories would be 12.5, 37.5, 62.5 and 87.5, respectively. In principle, the rule for assigning category scores is: (score for category i) = 100(i - 1/2)/m, where m is the number of categories and i=1,...,m is the rank number of a category (1 for no annoyance, m for severe annoyance).

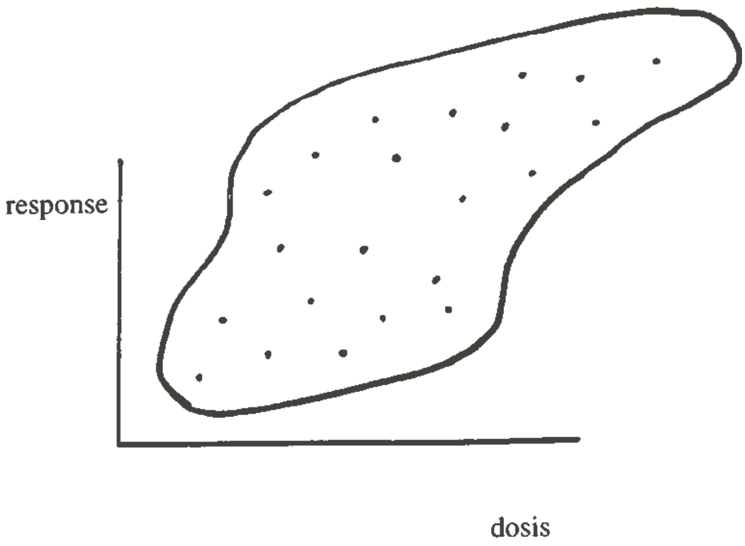
To the boundaries between categories also scores are given. In principle the rule for assigning these scores is: (inner boundary score i) = 100i/m, where m is the number of categories and i=1,...,m is the rank number of a boundary between two categories, beginning with a low level of annoyance.

2.3 Dose-response function

There are two methods of summarizing information on observed dose-response combinations. They are simply two different ways of processing the same data and either one may be used.

The first method takes as its basis the scores for the annoyance categories. The combination of a dose value and the score for the chosen annoyance category can be represented as a point on a plane. Plotting such a point for every respondent produces a scatter of points (figure 2). One might then seek a simple function, to which the position of the points is nearest on 'average'. A straight line, produced by linear regression, would be an example of such a function.

Figure 2. A scatter of points, in which each point represents a dose-response combination



The second method is based on the scores for the boundaries between annoyance categories. The dose values are combined into classes and the percentage of respondents for whom a certain level of annoyance is exceeded in each class is determined. Percentages obtained with 28, 50 and 72 as the boundary are regarded as the percentage which are 'at least a little annoyed', 'annoyed' and 'highly annoyed', respectively. These boundaries do not always correspond with the scores for the boundaries between the annoyance categories. Interpolations therefore have to be carried out in some cases between the percentages for adjoining lower and higher category boundaries. For example, if there are five annoyance categories the scores for the intermediate boundaries are 20, 40, 60 and 80 according to the rule set out in section 2.2. The percentage 'annoyed' (50 boundary) is then $(P_{40} + P_{60})/2$, where P_{40} and P_{60} are the percentages of respondents in the two and three highest annoyance categories, respectively.

3. NOISE FROM INDIVIDUAL SOURCES

Miedema (1992a) compiles and re-analyses the original data from a large number of European noise annoyance studies. Great care was taken that the dose and response measures were determined in a comparable way for different studies. Corrections and recalculations have been made where necessary. The dose measures determined include L_{Aeq}(24h), L_{dn} and L_{etm}. The effects measured for the purposes of the analyses were annoyance, disturbance of communication and sleep, startle and vibrations of the dwelling.

The studies contained over 13,000 assessments of the annoyance caused by noise which could be linked to an L_{etm} value for the noise. Figure 3 shows the percentage of people affected as a function of L_{etm}. The three different graphs were obtained by adopting different limits for the annoyance. On the left is the proportion 'at least a little annoyed', in the middle is the proportion 'annoyed' and, on the right, 'highly annoyed'.

Figure 4 gives the annoyance score as a function of L_{etm}. A score of 0 indicates that no annoyance is experienced by the exposed population, a score of 100 indicates that every individual in the exposed population experiences extreme annoyance.

The figures show that there is no annoyance from traffic at L_{etm} values below 40 dB(A). Above that, annoyance from all sources increases when the noise level increases, but increases more sharply in the case of air traffic and highway traffic than other road traffic, trains or trams. Impulse noise is a completely different matter. It causes more annoyance than any of the transport categories, particularly at low levels. Hearing impuls noise is almost equivalent to experiencing annoyance.

Figure 3. Noise annoyance percentages as a function of L_{etm}. (I = impulse noise, A = aircraft, H = highways, O = other road traffic, R = rail traffic)

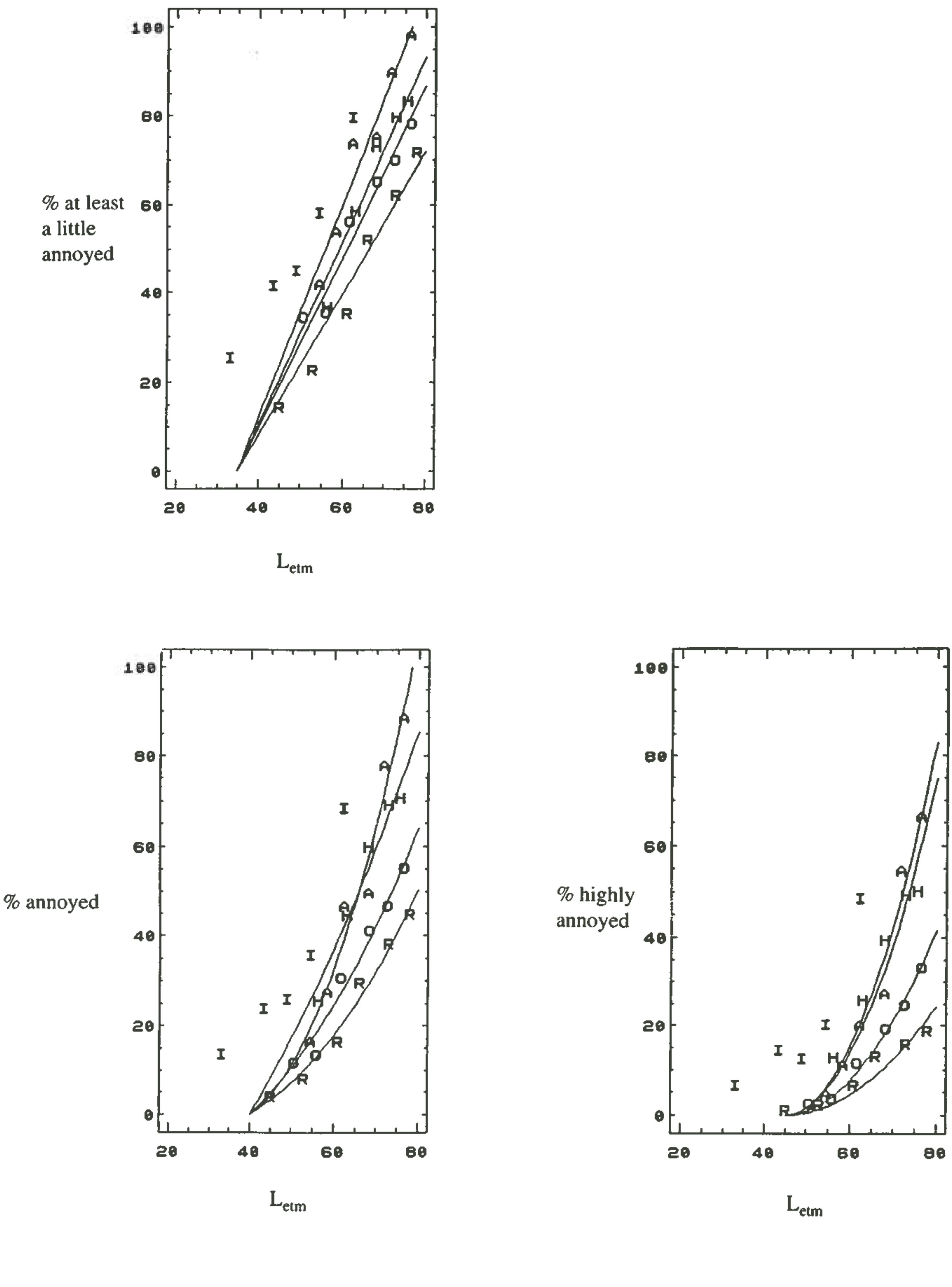
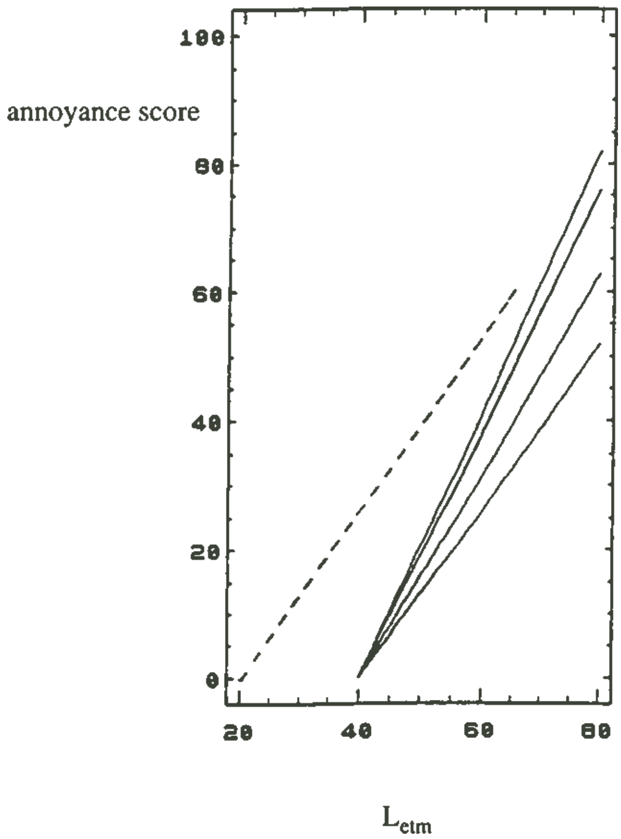


Figure 4. Noise annoyance score as a function of L_{etm} expressed in dB(A). The lines represent, from top to bottom, impulse noise (dotted), aircraft, highways, other road traffic and rail traffic.



4. ODOUR Annoyance FROM INDIVIDUAL SOURCES

Miedema (1992b) compiles and re-analyses the odour annoyance studies which determined both annoyance and exposure. All the studies were carried out in the Netherlands. They investigated six very different types of odour source. For all these sources the odour exposure was measured in the same way. Miedema scores the annoyance categories and boundaries between them in the same way as in his study on noise.

There were over 3,000 assessments of the annoyance caused by odour which could be linked to a $C_{99.5}$ value for the odour. The relation between annoyance and exposure was found to be the same for five of the six sources. Figure 5 shows the percentage of people affected as a function of $C_{99.5}$. The curves were determined using the boundaries 20, 28, 40, 50, 60, 72 and 80 (top to bottom). Thus, the top of the non-dotted curves refers to those who are 'at least a little annoyed', the middle to those who are 'annoyed' and the bottom to the 'highly annoyed'.

Figure 5. Odour annoyance percentages as a function of $C_{99.5}$ expressed in ge/m^3. The non-dotted curves represent, from top to bottom, 'at least a little annoyed', 'annoyed' and 'highly annoyed'.

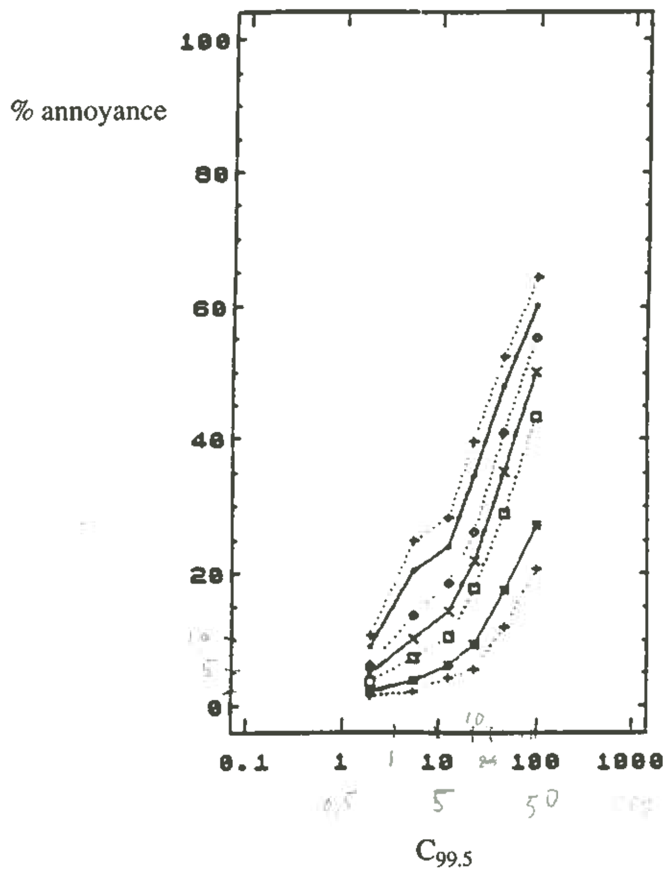


Figure 6. Odour annoyance score as a function of $C_{99.5}$ expressed in ge/m^3.

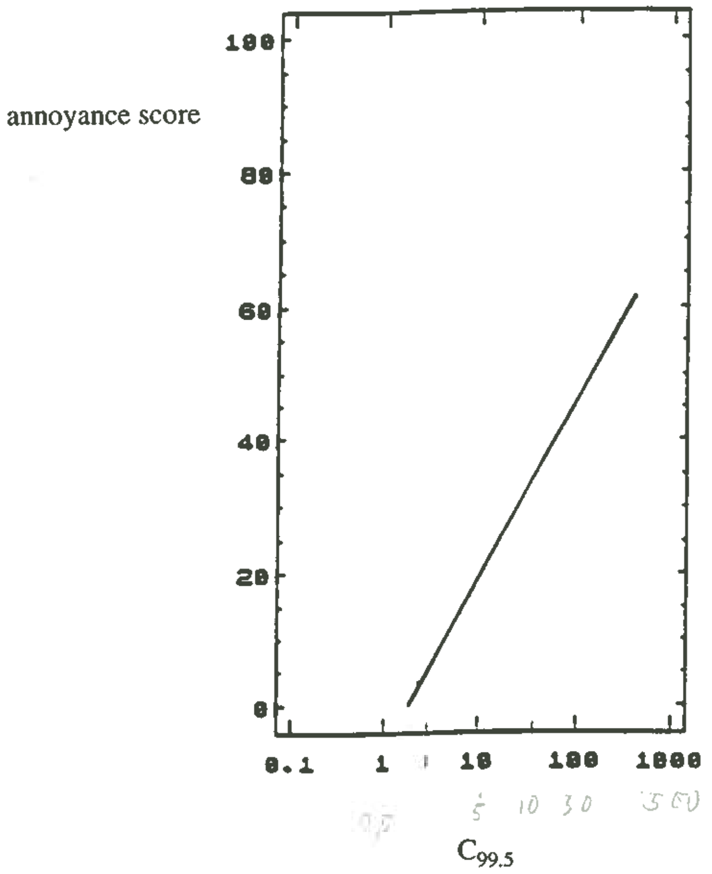


Figure 6 shows the annoyance score as a function of $C_{99.5}$. Again, a score of 0 indicates that no annoyance is experienced by the exposed population and a score of 100 indicates that every individual in the exposed population experiences extreme annoyance.
Figures 5 and 6 indicate that annoyance at $C_{99.5}$ values below 2 ge/m^3 is very low. Figure 5 shows that at those exposure levels a small percentage still states that they experience some annoyance. In figure 6 where, as it were, the curves from figure 5 are condensed, the fact that some annoyance responses are virtually always recorded, even below an annoyance threshold, has been taken into account. The straight line in figure 6 shows that the annoyance score is 0 for $C_{99.5}$ values below 2 ge/m^3.

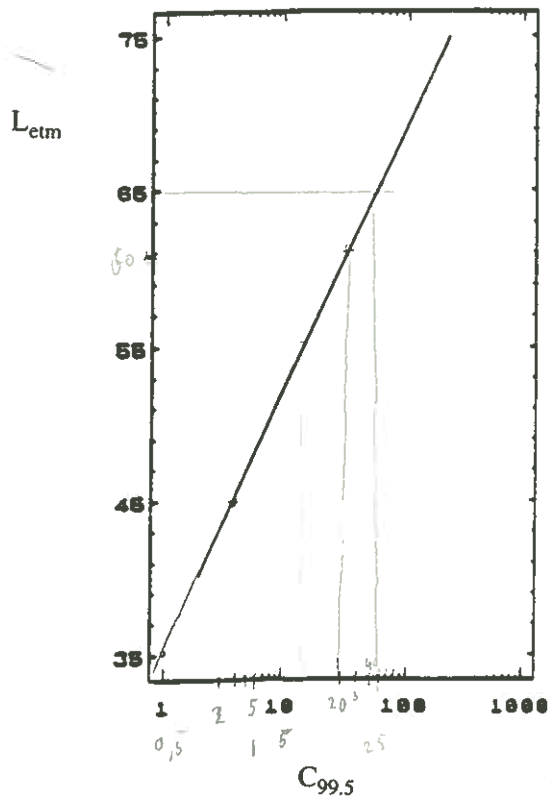
As has already been noted, the curves refer to five of the six sources studied. Annoyance from the sixth source was considerably higher than that from the others at the same level of exposure. This suggests that in certain cases the degree of annoyance may be underestimated on the basis of the curves.

5. COMPARISON OF NOISE AND ODOUR

In the noise and odour studies referred to in the previous section, respondents could specify the degree of noise or odour annoyance they experienced by choosing one of a limited number of categories. In order to be able to compare the results for noise and odour, one must know whether a category (e.g. 'annoyance') represents the same degree of aversion for both noise and odour.

Miedema (1993a) looked into this in a study of individuals who were exposed to noise and odour from industrial sites and, in most cases, from road traffic. They were asked to assess the degree of noise or odour annoyance caused by each source. They were also asked to compare, for example, the noise annoyance from one source and the odour annoyance from another and to indicate whether one causes more annoyance than the other, and to what extent. It appeared that, e.g., if an individual chose the same category for a noise source and an odour source, they were indeed equally annoying according to the comparison of the annoyance from both sources. It was therefore concluded that the same annoyance category expresses for noise and for odour the same degree of annoyance.

Figure 7. The L_{etm} value (in dB(A)) for road traffic (not highways) which causes the same degree of annoyance as a $C_{99.5}$ value (in ge/m^3) for an odour source.



Using this, it is easy to deduce from the results of the compilation studies on noise and odour which level of noise and odour produce the same degree of annoyance. Figure 7 shows which L_{etm} value for 'other road traffic' causes the same amount of annoyance as a $C_{99.5}$ value for an odour source.

The table below is based on similar comparisons. It shows which levels of exposure to certain noise and odour sources correspond with each other in terms of the annoyance they cause. Each 'exposure category' has been given a quality label, which is naturally open to discussion. The motivation for the classification used here is based on the relationship between L_{etm} and annoyance for other road traffic. A situation is regarded as good up to the level at which annoyance begins to occur (other road traffic L_{etm} = 40 dB(A)). If a third of the population is affected in the sense that they experience at least a little annoyed, ten per cent experience annoyed and some highly annoyed, the situation is no longer regarded as good or reasonable but as poor (other road traffic L_{etm} = 50 dB(A)). We begin to call the situation bad at the point at which the majority of the population experiences at least a little annoyed, a quarter annoyed and five to ten per cent, highly annoyed (other road traffic L_{etm} = 60 dB(A)). If a large majority (two-thirds) are affected (at least a little annoyed), the majority experience annoyed and a quarter experience highly annoyed, we regard the situation as extremely bad (other road traffic L_{etm} = 70 dB(A)). The final column of the table pertains to the evaluation of combined noise and odour sources, which is discussed in the following sections.

Table 1. Equal annoyance exposure categories for a number of individual noise sources, odour and combined exposure.

	L_{etm}						$C_{99.5}$	MKM
quality level	other road traffic	highways traffic	aircraft traffic	rail traffic	impulse	industry (non-impulse)	Odour	Combined
good	<40	<40	<40	<40	<20	<40	<1,9	<40
fairly good	40-45	40-44	40-44	40-46	20-26	40-44	1,9-3,8	40-45
reasonable	45-50	44-48	44-48	46-52	26-32	44-48	3,8-7,5	45-50
fair	50-55	48-52	48-51	52-58	32-38	48-52	7,5-15	50-55
fairly bad	55-60	52-57	51-55	58-64	38-44	52-57	15-29	55-60
bad	60-65	57-61	55-59	64-70	44-50	57-61	29-57	60-65
very bad	65-70	61-65	59-63	70-77	50-56	61-65	57-113	65-70
extremely bad	≥70	≥65	≥63	≥77	≥56	≥65	≥113	≥70

6. DERIVING THE ENVIRONMENTAL QUALITY MEASURE FOR NOISE AND ODOUR

The information set out above can be used for consistent appraisal of the annoyance from individual noise and odour sources. But any people experience annoyance not from one individual source but from a combination of sources. In fact, in the Netherlands, exposure to only one single source is more the exception than the rule. Tesink observes that it is not enough simply to look at individual sources within a combination: "The dilemma (...) is that, while it is difficult to provide scientific evidence to support such a composite total (...), anyone will intuitively say that where there are several sources of pollution, environmental quality is worse and that more stringent regulations for the building of houses as well as for the industry, among others, are appropriate". Miedema (1993b) discusses the problem of the "composite total" and suggests a method which reflects the impact of the different noise and odour sources on environmental quality. This method is described in the following chapter, and its application is demonstrated in the subsequent chapter. This chapter deals only with its foundation.

The principal requirement which an environmental quality measure must satisfy is as follows. An environmental quality measure must consistently assign or a higher or a lower number to a situation as the environmental quality is worse. In other words, there must be a strictly monotone relation between the measures and environmental quality.

In addition, it should also be suited to current practice. For many sources L_{etm} is used as the exposure measure for noise, while C_{98} and $C_{99.5}$ are used for odour. These measures are clearly related to the annoyance, as discussed in chapters 3 and 4. Certain conditions have to be satisfied in order to render the measure compatible with current practice. It must be possible to calculate it from the L_{Aeq} for each noise source in daytime, evening and at night (this is also the basis for the L_{etm}; see section 2.1) and from the $C_{99.5}$ for odour. In addition, where there is only one noise source, the environmental quality level must increase as the L_{etm} for that source increases. If there is only odour, the level must increase with the $C_{99.5}$ for the odour.

The measure can be seen as a rule which links one number to each combination of the L_{Aeq}'s per noise source and per period of the day and the $C_{99.5}$ for the odour. Certain empirical properties imply certain rules. Of particular importance is the ranking of situations according to the level of annoyance experienced. The result is based on a limited number of properties, not all of which can be described in simple terms. One property which can, however, be described effectively is transitivity. If situation A causes more annoyance than situation B, and B causes more than C, then it is assumed that A causes more annoyance than C. Another simple example is: if there are two situations, A and B, then A causes more annoyance than B, or B more than A, or A and B cause equal amounts of annoyance. These are examples of properties which are not open to dispute.

In our opinion, one of the assumed properties is critical. It is referred to as A^*-independence and Miedema (1993b) examines it in detail. We will restrict ourselves to giving a rough idea of what it entails.

A^*-independence is related to independence, but it is a weaker property, ie, less is assumed. Roughly speaking, A^*-independence means that (some of) the factors which contribute to annoyance can be divided into clusters in such a way that the factors within one cluster affect the level of annoyance independently of each other, but are not independent of factors outside the cluster. Straightforward independence would imply that there were only one 'cluster', encompassing all the factors that influence annoyance.

A^*-independence also means that clusters and not, previously, clustered factors can be clustered in a similar manner, until only one cluster remains.

The environmental quality measure was based on the properties mentioned above, and others, taking into account the condition that it should be compatible with current practice concerning individual sources. The measure can be described as follows. Per period of the day a 'weighted' combination is determined of the L_{Aeq}'s for different noise sources. The highest of the results for the three periods is taken, and a weighted combination with the $C_{99.5}$ for odour is determined. The weighing of this combination depends to a large extend on the relation on noise and odour discussed in chapters 3 and 4. In the following chapter a precise, stepwise description of the measure is given.

7. THE ENVIRONMENTAL QUALITY MEASURE FOR NOISE AND ODOUR

The L_{etm} value for road traffic (other than highways) which causes as much annoyance as a combination of noise sources is referred to here as MKM (the Dutch translation of environmental quality measure is 'Milieu Kwaliteits Maat') for noise. It is derived as follows:

1. Determine for highway traffic, other road traffic, rail traffic, aircraft, industrial noise without impulses and impulse noise $L_{Aeq,i}(07\text{-}19)$, $L_{Aeq,i}(19\text{-}23)$ and $L_{Aeq,i}(23\text{-}07)$, where i is the index for the type of source.
2. Calculate the sum of the noise coming from each of the individual sources for each of the three periods. For evening and night penalties of 5 and 10 dB(A), respectively, are applied:

$$Ynoise(07-19) = \sum_i [\ 10^{(L_{Aeq,i}(07-19)-b_i)/10}\ ]^{a_i}$$

$$Ynoise(19-23) = \sum_i [\ 10^{(L_{Aeq,i}(19-23)+5-PL_i)/10}\ ]^{a_i}$$

$$Ynoise(23-07) = \sum_i [\ 10^{(L_{Aeq,i}(23-07)+10-b_i)/10}\ ]^{a_i}$$

Use the following values for a_i and b_i:

		b_i	a_i
1	highway traffic	40	1,21
2	other road traffic	40	1,00
3	rail traffic	40	0,82
4	aircraft	40	1,31
5	industry (non-imp.)	40	1,21
6	impulse	20	0,84

These parameters are applicable to rail traffic if there are no special sounds such as squealing. The parameters for aircraft are based on surveys conducted around large civil airports, and are therefore not necessarily applicable to airfields which are used for military aircraft, light aircraft or helicopters, for instance.

3. Take the highest of the three values:

$Y_{noise} = \mathrm{Max}[Y_{noise}(07\text{-}19),\ Y_{noise}(19\text{-}23),\ Y_{noise}(23\text{-}07)]$

4. Determine the L_{etm} for road traffic (not highways) which would cause the same degree of annoyance as the combination of noise sources being evaluated:

$$MKM_{noise}=10logY_{noise}+40$$

The L_{etm} value for road traffic (not highways) which would cause the same degree of annoyance as a combination of noise sources is called the MKM(noise, odour). It is determined as follows (5 and 6 can be simplified to some extent):

5. Determine the following value for odour:

$$Y_{odour} = [\frac{C_{99.5}}{1.93}]^{1.7}$$

6. Using the result of steps 3 and 5, determine the following value:

$$Y = [\ (Y_{noise})^{\frac{1}{1.7}}+(Y_{odour})^{\frac{1}{1.7}}]^{1.7}$$

7. Determine the L_{etm} for road traffic (not highways) which would cause the same degree of annoyance as the combination of noise and odour sources being evaluated:

MKM(noise, odour) = 10log(Y) + 40

In our opinion, the exact value of the parameter in step 6 (which is deemed to be 1.7 here) is the most uncertain point in the entire procedure. Miedema (1993b) explains that the value is likely to be between 1 and 3, and explains the reason for taking 1.7 as the value.

8. APPLICATION OF THE ENVIRONMENTAL QUALITY MEASURE FOR NOISE AND ODOUR

Chapter 6 touches on the underpinning of the measure for environmental quality with respect to noise and odour. Chapter 7 sets out the 'recipe' for determining the values of the measure. Table 1 allows the measure to be compared with different levels of exposure to individual factors. This chapter illustrates how the result of investigations in which the measure is used can be presented in visual form, taking as an example a large industrial site in Arnhem.

The data used came from an industrial environmental zoning pilot project and have been collected by the research agencies DGMR (noise) and Projectresearch Amsterdam (odour). The data were provided by courtesy of the municipality of Arnhem and the province of Gelderland. DGMR carried out a number of extra calculations for the purposes of the present study. A number of contours have been drawn on figures 8 and 9 to help determine where the joint assessment indicated that extra measures are required in addition to the measures aimed at individual sources.

Figure 8 shows contours connecting points at which an equal level of annoyance is caused by noise from industry, 'other' road traffic and rail traffic. Each contour delineates an area (shaded) where the source in question causes more annoyance than road traffic (not highways) with an L_{etm} of 60dB(A).

This figure also shows the 'line of equal annoyance' obtained by a joint assessment of the load from these three noise sources. The area outside the contours for individual sources, but within the combined noise contour, is shaded evenly in yellow. In this area the annoyance level referred to above is exceeded as a result of the combination of noise sources which individually cause less annoyance. Some of the residential area to the northwest (upper left) falls within this area. The entire area studied falls within the combined contour for the three noise sources plus odour (not shown), with the exception of a very small area in the northwest. According to the classification given in table 1, this means that environmental quality in terms of noise and odour is 'bad' or worse in virtually the whole area.

Figure 8. Lines of equal annoyance from industrial noise, road traffic, rail traffic and the combined contour for these three sources. Annoyance along the contours is equal to the annoyance which would be caused by road traffic (not highways) with an L_{etm} of 60dB(A). The area within each of the individual contours is shaded (with straight lines). The area outside those contours but within the contour is shaded yellow. (The area studied, on which data were available, is outlined in black).

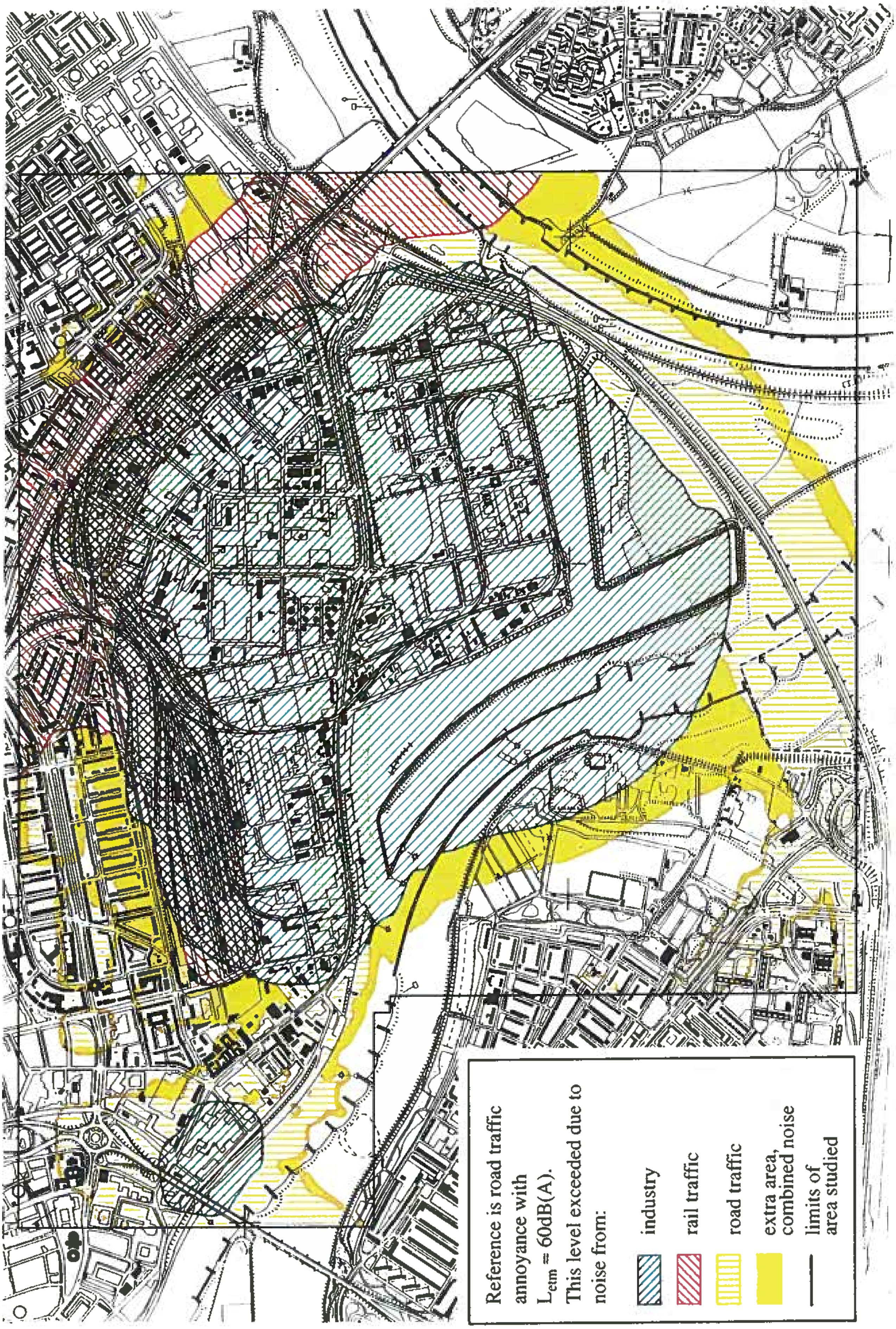
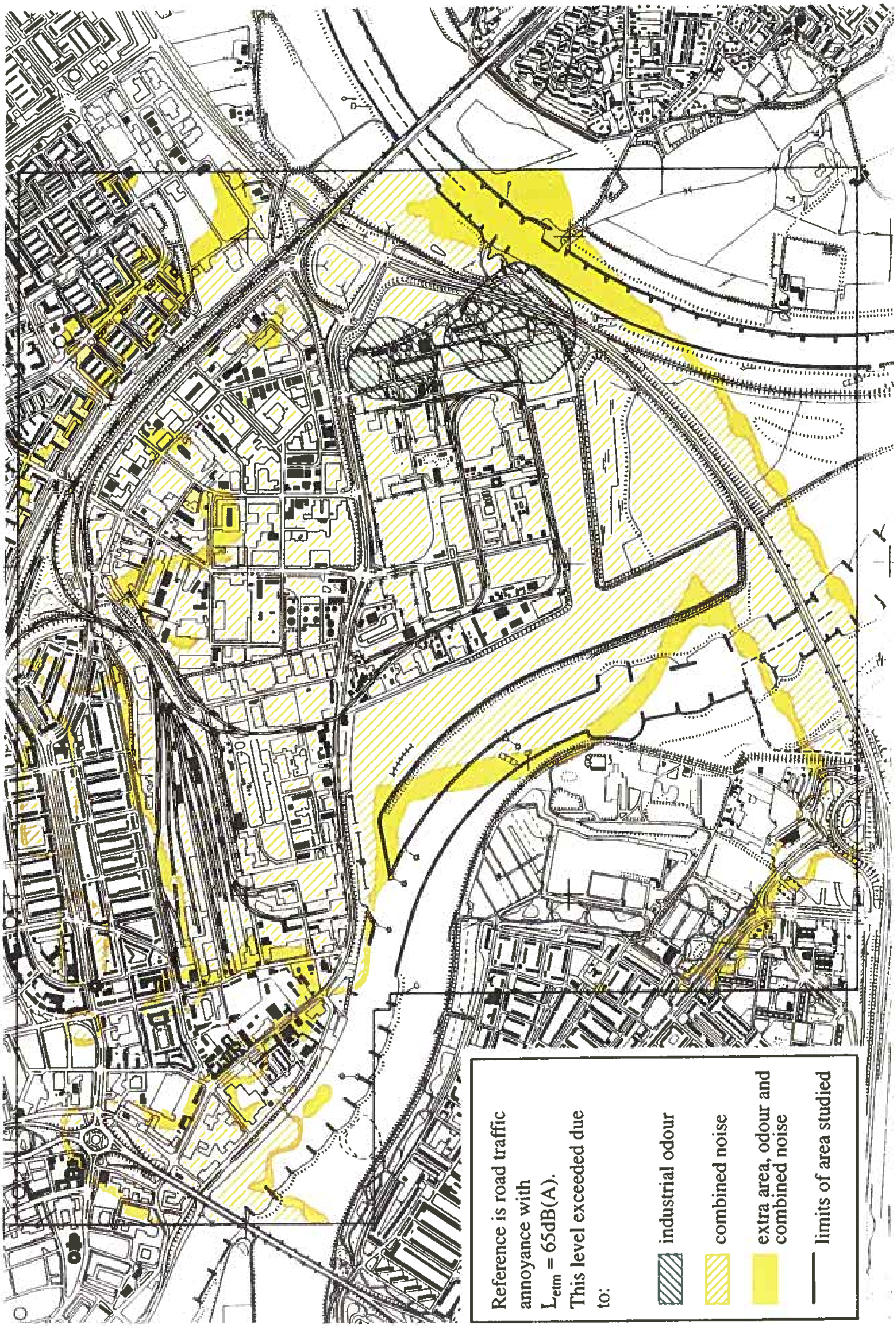


Figure 9. Lines of equal annoyance from industrial odour, the combination of the three noise sources and the combined contour for odour and noise. Annoyance along the contours is equal to the annoyance which would be caused by road traffic (not highways) with an L_{etm} of 65dB(A). The area outside the combined noise contour but within the contour for noise and odour combined is shaded yellow. (The area studied, on which data were available, is outlined in black).



The areas where the qualification 'very bad' applies are indicated in figure 9, which shows the lines of equal annoyance for odour alone, for the three noise sources and for odour and noise combined. The annoyance level along these contours corresponds to that caused by road traffic (not highways) with an L_{etm} of 65dB(A). The areas outside the odour contour and combined noise contour, but within the combined noise and odour contour, is shaded evenly in yellow. This shows that 'very bad' environmental quality in the northeast (in Bethaniënstraat for instance) is due to the cumulation of noise (from road and rail traffic) and odour.

The contours and assessments described above were based on the noise and odour sources for which exposure data were available. Factors or sources for which no data were available are not, of course, reflected in the contours. For the investigation area in Arnhem, especially highway traffic, which was not included here, appears to be an important factor.

REFERENCES

This report is a summary of the following publications:

MIEDEMA, H M E, Response functions for environmental noise in residential areas. Leiden: NIPG-TNO, 1992a. Report no. 92.021

MIEDEMA, H M E, Response functions for environmental odour in residential areas. Leiden: NIPG-TNO, 1992b. Report no. 92.006.

MIEDEMA, H M E, Matching noise and odour annoyance. Leiden: NIPG-TNO, 1993a (will appear as report no. 92.023)

MIEDEMA, H M E, Quantification of environmental quality: foundation and application with respect to noise and odour. Leiden: NIPG-TNO, 1993a (will appear as report no. 92.022).

In deze reeks zijn tot dusverre verschenen:

NUMMER	TITEL RAPPORT	
1	Response functions for environmental noise in residential areas	(1993/1)
2	Het aandeel van goederentransport in het treinverkeer en effecten van geluid en trillingen op omwonenden	(1993/2)
3	De rol van de aantallen passages bij gezondheidseffecten van nachtvluchten	(1993/3)
4a	Geluid, geur en milieukwaliteit	(1994/4a)