Institute of Occupational Medicine

Research Report TM/01/06
November 2001

An evaluation of the likely future cancer risks from asbestos contamination in Wider Armley and other areas of West Leeds

JW Cherrie, HA Cowie, EM Sneddon and AGMcK Nicholl

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Previous studies have shown that homes in the Aviary's housing estate of West Leeds, close to the site of a former asbestos factory, are contaminated loose asbestos fibres. This research makes an assessment of the probable future asbestos-related risks to health for the residents of the area of West Leeds, in which the factory site and the Aviary's estate are located, excluding the Aviary's estate. The main aim of the work was to help define any actions that should be taken by Leeds City Council to manage the risk to the local population. Lifetime risks of death from mesothelioma were estimated using a mathematical model of the relationship between the estimated quantity of asbestos that might be inhaled in the future and details of the population. There are approximately 34,000 people living within the area, although because of the age of the houses only about 8,000 live in homes that may be contaminated with loose asbestos. The study concludes that there will probably be no cancer deaths from the asbestos contamination if the people in this area continue to live in their homes for a further 20 years. We consider that the risks are so small that the Council should not take any action to manage the situation.

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SUMMARY

Many urban communities in the UK live with the legacy of past asbestos manufacturing and local environmental contamination from these activities. In these areas the relevant public authorities are responsible for managing the risks to people living in homes contaminated by asbestos emissions. However, there is often only very limited information about the exposure to asbestos for people in such situations and so the problem is managed on the basis of the potential hazard rather than the probable risks to health, i.e. the homes are "decontaminated" in preference to other intervention strategies.

Previous studies have identified the presence of loose asbestos fibres in homes in the Aviary's housing estate of West Leeds, close to the site of a former asbestos factory. This factory has been recognised as the primary potential source of environmental asbestos contamination in this area, although other possible industrial sources of environmental asbestos contamination have been identified as part of the present work. In this report we describe the results of a research study to investigate the probable future asbestos-related risks to health for the residents of the area of West Leeds, in which the factory and the Aviary's estate are located (including Armley and parts of Burley and Kirkstall). In the report we refer to this part of the city as the "Wider Area" and consider that it extends up to 1,600 metres from the primary source, excluding the Aviary's estate. The research was specifically focused on the Wider Area and does not seek to revise the historical estimates of risk for the Aviary's area or review the current policy in respect of this area. The primary aim of the present study was to identify the best way of managing any asbestos contamination in the Wider Area so that the future risks to the residents and people working in the area are minimised.

We identified the extent of asbestos contamination around the old asbestos factory from samples of loose dust collected in houses and a computer dispersion model. Estimates of the population at possible risk were obtained from Census information and knowledge of the housing stock. A small number of measurements of airborne asbestos concentration were made in homes under normal occupation and during simulation of home improvement activities likely to disperse the asbestos contamination. Future lifetime risks of death from mesothelioma were estimated using a mathematical model of the relationship between the estimated quantity of asbestos that might be inhaled in the future and the mesothelioma risk, the most significant type of cancer caused by exposure to asbestos. The lifetime risk was estimated for 20 years of exposure in the future, assuming either no change in the way that people live or with an appropriate management plan designed to reduce the likely risk to the occupants. Detailed estimates of possible lung cancer deaths from the asbestos contamination were not made, although we consider that they are likely to be of a similar magnitude to those for mesothelioma.

Approximately one-third of houses in the Wider Area, excluding the Aviary estate, appear to have minute traces of asbestos in them. This contamination is generally found within roof voids, sub-floor areas and box-sash window cavities. The houses that have been identified with this trace contamination are located throughout the wider area. From the dispersion modelling we had expected a relatively uniform pattern of contamination around the former factory site, decreasing away from the primary source. For the purposes of this investigation we have assumed that the area of contaminated houses could extend up to 1,600 metres from the primary source of the contamination and the area under investigation was divided into three sections reflecting the likely decrease in contamination away from the primary source. Also, since we know that the factory ceased trading in the 1950's we have assumed that the whole of the housing stock built prior to 1960 could have some asbestos contamination.

Most of the past evidence for asbestos contamination within homes has been obtained by a local analyst working closely with Leeds City Council. This analyst has developed a considerable level of expertise of the local situation and has worked with the Council to develop a local protocol for sampling to take account of the nature of the contamination and context of samples found in this area. This, together with diligent analysis in accordance with the methodology recommended by the Health and Safety Executive (MDHS77), has resulted in highly sensitive detection of the presence of asbestos more frequently than might otherwise have been expected. Detailed investigation by the authors of this report failed to show asbestos contamination in homes where it was previously found using the more sensitive methodology. However, we have assumed that the original results are accurate.

We estimate there are 34,277 people living within the area under investigation, although because of the age profile of the housing stock only about 8,000 were judged to be at possible risk from any asbestos contamination. There are approximately equal numbers of males and females in the area selected for investigation, of whom about 13% are thought to be less than ten years of age. Based on our measurements the background exposure levels were judged to be 0.00001 fibres/ml or less, averaged over a 24-hour period. Exposure during home improvements is likely to be higher than this figure, but it was considered unlikely that anyone would be exposed to more than 0.1 fibres/ml. For comparison, the typical asbestos levels in UK buildings with asbestos products as part of the building components are probably ten times higher than the background level in houses in the Wider Area area. The concentrations we measured in activities designed to simulate home improvements in the Wider Area were lower than the corresponding levels found in the Aviary estate, which remains an unexplained phenomenon outside the scope of this research.

Because of the limited information available to us there are some uncertainties in our estimate of risk of death from mesothelioma. However, taking this uncertainty into account we have been able to predict with some degree of certainty the maximum likely risk. We consider if no action is taken and people in this area continue to live in their homes for a further 20 years, then there will no mesothelioma deaths from the asbestos contamination (the risk of death from mesothelioma is estimated to be 2.4 per million people exposed rising to 51 per million, with 90% confidence, i.e. in this population this corresponds to less than one death predicted). If residents were required to use professional asbestos contractors when undertaking home improvements that could disturb possible loose asbestos contamination then the predicted risk of mesothelioma deaths would be even lower (0.4 per million exposed rising to 7 per million, with 90% confidence). However, we consider that all of these risks are so small that no proactive intervention action on the part of the Council is warranted in the future.

Up to this time the asbestos contamination in the Wider Area has been managed on the basis of the presence of trace asbestos in buildings rather than the likely risks to individuals living in these homes. This is a common practice, but because of the particularly sensitive methods used by the Leeds City Council's analyst when analysing bulk samples, this has, in our opinion, resulted in some homes being wrongly identified as presenting a risk from the asbestos contamination. We therefore recommend that the Health and Safety Executive, the Department of Transport, Local Government and the Regions, the Environment Agency and other interested parties should review the sampling and analytical methods used to identify asbestos in loose dust bulk samples from buildings to ensure that they are appropriate given the likely level of risk to occupants and others in an environmental context.

In this research we have not considered asbestos containing products such as insulation boards or asbestos cement pipes that may be installed in houses in the Wider Area. Such products, when they are disturbed may contribute an additional risk to workmen and occupants. For this reason, tradesmen working in these homes will still be required to check there are no asbestos containing products that could be disturbed during work and give rise to asbestos exposure. If asbestos is present then they must comply with the appropriate health and safety legislation.

The research has sought to address issues of environmental asbestos exposure that has arisen from an old industrial site and to make recommendations regarding the risks to the resident population. Whilst we have drawn specific conclusions for this area of West Leeds, the situation is not likely to be unique. Our conclusions in this case should assist with the management of similar problems in other urban conurbations and, in particular, provide a better understanding of the relationship between asbestos hazards and risks.

1. INTRODUCTION

Asbestos is the name given to a group of six naturally occurring fibrous minerals that were used to manufacture products for industrial applications and been used in construction. In the past, asbestos was widely used in the UK for its thermal insulation properties, its mechanical strength and its chemical resistance. The most common variety used was chrysotile (or white) asbestos, with amosite (brown) and crocidolite (blue) asbestos also being used in significant quantities. Several hundred thousand tonnes of asbestos were imported into the UK and subsequently processed in factories around the country. The demand for asbestos began to increase at the end of the 19th Century and around this time several factories were established in Leeds, including the United Asbestos Company (1897), J.W. Roberts (1899), The North of England Asbestos Company (1904) and Bell's Asbestos and Engineering Supplies Ltd (1929). The Roberts factory, which was located in the Armley area of Leeds, continued to operate until 1958. The map shown in Figure 1.1 identifies the Roberts factory site, also referred to in this report as the primary source, the Aviary's housing estate and the Wider Area, which is the subject of this research.

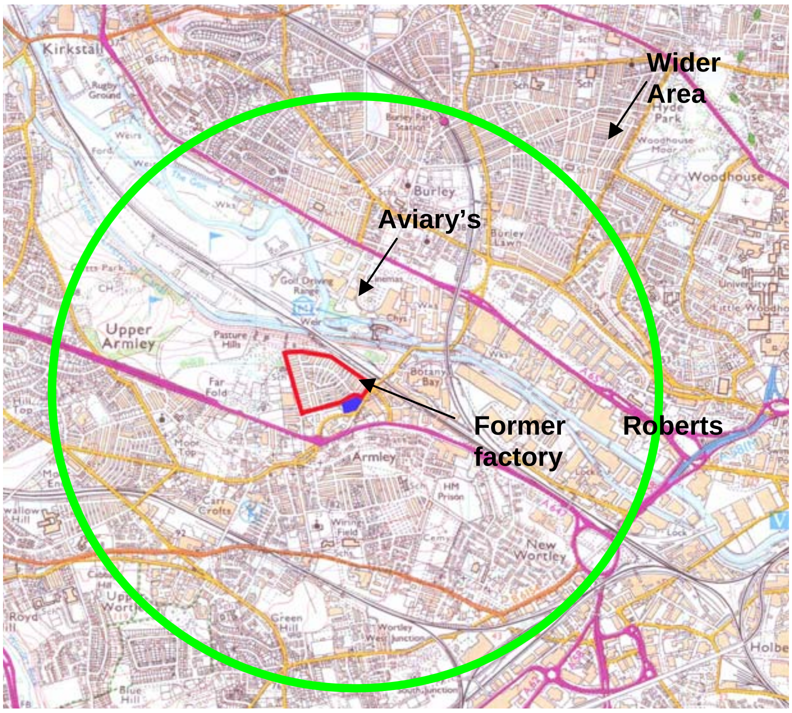

Figure 1.1 Map showing the Roberts factory site, the Aviary's estate and the Wider Area

When asbestos was used in an uncontrolled way in factories it caused *asbestosis*, which is a result of scarring of the tissue in the lung or, more properly, *fibrosis* in the lung. Asbestos can also cause cancer in the lung, the same type of cancer caused by cigarette smoking, and cancer of the lining of the lung or bowel known as *mesothelioma*. Relatively low level or short-term exposure to asbestos may cause both types of cancer, with occupations such as plumbers, carpenters and building workers having a high risk. There is scientific evidence to suggest that chrysotile (white) asbestos does not cause mesothelioma, although this is not fully accepted within the scientific community. Furthermore, the link between chrysotile and lung cancer should not be discounted.

In 1990 a number of physicians from the Leeds Health Authority published a report describing deaths from mesothelioma for the years between 1971 and 1987, for people living in Leeds or amongst people who were born in Leeds (Arblaster *et al*, 1990). This study found that fifty out of 210 mesothelioma cases identified (24%) had either a direct or indirect occupational link with the former

J.W. Roberts asbestos factory. In thirty-six of these cases, either the coroner or the local media had suggested that it was “environmental” exposure to asbestos that had caused the person's disease. The study found that in 19 of these cases the individual had either worked in the Roberts factory or had a relative or close contact who had worked in the factory. Of the remainder, a large proportion had lived close to the Roberts factory (seven out of eight next-of-kin interviewed said their relative had lived within about 250 metres of the factory). The report, however, concluded, amongst other matters, that there was no increased risk of developing mesothelioma for those currently living in the Armley area. They also recommended health professions improve the recording of cases of mesothelioma and have increased alertness to its potential incidence.

In the late 1980’s there was concern about environmental asbestos contamination in houses in the Aviary’s estate in Armley. As Figure 1.1 shows, the Aviary's area is a distinctly identifiable area of houses adjoining the primary source, and is largely surrounded by non-residential developments or open land. The asbestos found in cavities and voids in these homes was considered to have arisen from emissions from the Roberts asbestos factory, possibly because of poor controls on emissions into the air from the premises. Between 1990 and 1992 Leeds City Council undertook initial research to evaluate the extent of the contamination and to attempt to quantify the possible problem. In 1994, the Council commissioned Professor Roger Willey from the University of Paisley to review the available scientific information and make recommendations for managing the asbestos contamination to minimise future risks. Professor Willey concluded that there were “small traces” of asbestos in dusts within inaccessible parts of the houses in the Aviary’s estate and that “in normal living conditions… the risk to health from exposure to asbestos … is negligible”. (Willey, 1994). However, he also identified that exposure to asbestos during certain home improvement works, such as removing floorboards, removing windows etc., could give rise to higher levels of airborne asbestos that “would be unacceptable”. Professor Willey recommended an asbestos management programme within the Aviary’s involving the use of experienced competent contractors when undertaking certain refurbishment work and in the removal of asbestos contaminated dust and debris so as to minimise the risks to house occupants.

Subsequently, Professor Julian Peto from the Institute of Cancer Research was asked by a group of residents from the Aviary’s estate to comment on the likely risk to health and the proposed remedial measures. He wrote to the Council agreeing with the views of Professor Willey saying that “the risks to residents must be very low” and “the only people who might suffer non-trivial risks are the workers involved in repairs, not the residents” (Peto, 1994). Further consultation by the Council with the Department of the Environment, who were responsible for government housing policy, and the Health and Safety Executive, who enforce the health and safety law for people at work, showed general agreement about the risks involved. The Council then introduced a scheme to provide assistance to householders in the Aviary’s area to identify the presence of asbestos in their property, with financial compensation or grant assistance being available in certain circumstances to assist with the removal of asbestos from specified void spaces and renovation of the property.

All houses in the Aviary’s estate are located not more than 400 metres from the original asbestos factory, referred to elsewhere in this report as the primary source. The nearest houses in the Aviary's estate are directly adjacent to the original factory buildings. Since January 1998 up to beginning of 2001 the Council had surveyed 364 houses in the Aviary's estate. In all but one of these homes, asbestos contamination was found. Opportunistic samples obtained from a random selection of homes in the Wider Area since 1992 were also found to contain asbestos, although the proportion of houses contaminated (about 38%) was lower than in the Aviary’s estate. These findings prompted the Council to seek expert opinion on the possible risks, if any, associated with loose asbestos fibre contamination in houses in the Wider Area.

On the 21st March 2000 Leeds City Council wrote to the Institute of Occupational Medicine requesting they undertake a research project to investigate the possible future risks to health from environmental and occupational exposure to asbestos from contamination in loose dust and make recommendations for managing the situation. This report summarises these investigations.

2. AIMS OF THE STUDY

The main aim of the project was to evaluate information held by the Council holds concerning loose asbestos contamination in the area of West Leeds around the former Roberts asbestos factory (referred to as the Wider Area in this report) and undertake appropriate additional research to enable a reliable assessment of the possible future risks to health of the population in the area. These risk estimates were to incorporate possible asbestos management options open to the Council.

The research was to be limited to the area within 1,600 metres (approximately one mile) of the site of the former Roberts asbestos factory, but excluding the Aviary's estate for which management plans had already been agreed. The work was also to encompass both occupational and non-occupational exposure to asbestos, although the primary focus of the work was the environmental (i.e. residential) exposure.

It was not the intention of this study to include possible risks from exposure to asbestos products installed in the homes of the residents in the Wider Area, nor to investigate risks to people working with asbestos products in the area. The sole focus was on exposure to possible loose asbestos contamination in the community that had arisen as a result of any previous environmental contamination.

Finally, the project was designed to investigate the likely future risks to health from cancer caused by loose asbestos in homes in the wider area, rather than ill health caused by asbestos exposure during the time when the factory operated or in the time since the factory closed to the present. This was because the main purpose of the work was to help the Council decide how best to manage any asbestos contamination in the Wider Area so as to minimise future risks. This approach recognises that it is only the future risks that can be addressed by introducing an asbestos management policy.

To achieve our aims we identified the following specific objectives:

- review historical research carried out in the Aviary's estate;
- evaluate the data from samples of loose dust collected in homes in the Wider Area;
- evaluate airborne fibre concentration data from controlled experiments in houses in the Aviary's estate;
- evaluate the likely spread of asbestos contamination throughout the area;
- obtain information about the likely activities undertaken by residents that may result in exposure to asbestos fibres;
- undertake further sampling to refine the estimates of exposure during certain activities carried out by residents in the area;
- estimate the likely future health risks to people in the community, for one or more proactive management options compared with no intervention, taking account of the uncertainty in some of the risk determinants.

This work has been undertaken with the active involvement of a Steering Group comprising members of Leeds City Council, the local residents (through the Armley Asbestos Campaign), the Health and Safety Executive and the local analyst (Wharfedale Environmental Services) who has been actively involved over a number of years in the sampling and analysis of asbestos in support of the Council.

3. EVALUATION OF PREVIOUS HISTORICAL INFORMATION CONCERNING ASBESTOS EXPOSURE IN THE AVIARY'S ESTATE IN ARMLEY, LEEDS

Testing of airborne fibre concentrations in houses in the Aviary's estate, which is located within the Armley area of Leeds, began in 1992. These sampling exercises fell into two categories: normal occupancy, where the air sampled was considered representative of that inhaled by the occupants on a day-to-day basis, and disturbed conditions, where the airborne fibre concentrations were likely to be elevated because of building work or some other activity. Initial results from samples collected from 300 houses under normal occupancy were reassuring and no individual measurement exceeded 0.01 fibres/ml[①]. This level is the lowest reliable detection limit for the method used and does not really reflect the likely fibre concentration in the buildings, which were probably much less than this figure.

3.1 MEASUREMENTS MADE FOR THE REPORT PREPARED BY PROFESSOR WILLEY

The first comprehensive programme of measurements relating to disturbance conditions was undertaken during 1994 for inclusion in a report prepared by Professor Willey. These data were mostly obtained using the standard methodology to assess the concentration of airborne fibres in situations where people were either occupationally exposed to asbestos or to ensure that areas where asbestos had been disturbed are "clean" and suitable for reoccupation. The method has been fully described by the Health and Safety Executive in their publication *Asbestos Fibres in Air* (HSE, 1995). It is based on collecting a sample of the particles in the air onto a membrane filter, which is then analysed using a phase contrast optical microscope. This technique is limited to assessing all fibres in the air and cannot specifically confirm whether they are asbestos. However, where the majority of the airborne fibres are likely to be asbestos it is an appropriate technique to use.

Professor Willey reported concentrations in four homes under normal occupation. In all of these the concentration was less than 0.01 fibres/ml, which is the level at which buildings are considered clear for reoccupation after remedial work. The report also contained data obtained during remedial work, such as ceiling collapses, removing floorboards and removing windows. These data are summarised in Table 3.1.

Table 3.1 Summary of airborne fibre concentrations reported by Professor Willey

Activity	Number of measurements	Mean airborne fibre concentration (fibres/ml)	Range (fibres/ml)
Ceiling collapse	8	0.4	<0.2 – 0.7
Removal of floorboards	3	<0.01	<0.01 – 0.01
Removal of windows	7	0.03	0.02 – 0.04

The highest concentrations were seen during the ceiling collapse, where the average fibre concentration was 0.4 fibres/ml, with the maximum concentration being 0.7 fibres/ml. Some of these levels exceed the legal limit for asbestos in the air where people work with asbestos (i.e. 0.2 fibres/ml for amosite and crocidolite asbestos) and Professor Willey considered such levels unacceptable.

[①] Fibres per milliliter of air, where the fibres were longer than 5µm, thinner than 3µm with the ratio of the length to the diameter being less than 3.

3.2 OTHER MEASUREMENTS MADE DURING 1994 AND 1995

In addition to the work undertaken with Professor Willey, a range of other measurements of airborne fibre concentration was made in the Aviary's estate, both under normal occupancy and in disturbance situations. The majority of these tests were carried out by Wharfedale Environmental Services, who acted throughout for Leeds City Council, or the Health and Safety Executive. A feature of a number of these tests was the analysis of some of the samples by transmission electron microscopy, in an attempt to establish the actual concentration of asbestos in the air rather than the total fibre concentration obtained from optical microscope analysis.

The Institute of Occupational Medicine collected and analysed air samples from a house in Nunnington View in the Aviary's estate in 1994. They carried out this work at the request of a solicitor acting on behalf of the occupant. In this case the client specifically requested analysis by transmission electron microscopy. Asbestos fibres were detected on two of the four samples collected (one in the bedroom and the second from the bathroom). The asbestos fibre concentrations were <0.001 fibres/ml and 0.0045 fibres/ml, respectively. The exact conditions under which these tests were undertaken was not described in the report although we have presumed that it was while the occupants were going about their normal daily routine. No special disturbance of settled dust was carried out.

As we have indicated, transmission electron microscopy is a more powerful analytical procedure than optical microscopy, and it enables lower concentrations of fibres to be detected and the fibres to be specifically identified as asbestos or otherwise. The lowest concentration detectable on the samples analysed in this case was 0.001 fibres/ml, i.e. the technique was ten times more sensitive than the optical microscope analysis. Also, the fibres were mostly either amosite or crocidolite. Interestingly, no asbestos was detected in any of the separate bulk samples of loose dust collected from within the house (10 samples analysed).

During October 1994, Wharfedale Environmental Services carried out an assessment of the exposure to asbestos during the removal of sash windows at a house in Aviary Terrace. The samples were analysed using the phase contrast optical microscope technique and the results showed similar levels to those found previously. Samples collected by personal monitors worn by people carrying out the work showed levels of 0.02 fibres/ml, with the concentrations in the home during the work being equal to or less than 0.01 fibres/ml. In the debris from the window removal the analyst found traces of crocidolite asbestos.

In August 1995 the Health and Safety Executive completed a number of measurements in two houses in the Aviary estate where ceilings were collapsed. This work was undertaken in conjunction with Leeds City Council (via Wharfedale Environmental Services) to determine whether proposed cleaning procedures for roof voids in the Aviary's estate were adequate. The measurements were carried out during the cleaning of the ceiling void spaces, while the ceilings were being dropped and while the workers were cleaning up afterwards. The samples were again analysed using the phase contrast optical microscope techniques, although in this case non-standard procedures were used because of the presence of large quantities of non-fibrous dust and/or man-made mineral fibres on the sample filters. The results are summarised in Table 3.2.

Table 3.2 Summary of measurements made as part of ceiling removal

Activity	Number of samples	Average short-term fibre exposure levels (fibres/ml)
Bagging roof void debris	12	0.8
Vacuuming roof space	6	0.05
Dropping ceiling	9	0.6
Clean-up after ceiling dropped	3	0.2

The duration of each activity varied from 10 minutes (dropping ceiling) to 120 minutes (bagging roof void debris in one house). Two of the situations where high concentrations were obtained while bagging debris from roof voids were additionally anaysed by transmission electron microscopy. No asbestos fibres were identified on either of these samples, which corresponded to the asbestos fibre concentration being less than 0.2 fibres/ml.

In 1994 and 1996 the Health and Safety Executive measured airborne fibre levels in houses in the Aviary estate where sash window boxes contaminated with asbestos were being removed. Both exercises used optical microscope analysis methods, although some analysis was also carried out using transmission electron microscopy. In the first house six samples were collected giving an average airborne fibre concentration of 0.1 fibres/ml analysed by phase contrast optical microscopy. The average asbestos fibre concentration from the three of these samples analysed by transmission electron microscopy was 0.03 fibres/ml. The asbestos fibres were mostly crocidolite with some chrysotile. On the second occasion, in 1996, four samples were collected and analysed using optical microscopy giving an average airborne fibre concentration of 0.03 fibres/ml. No asbestos fibres were detected when samples from this house were analysed by transmission electron microscopy. The asbestos fibre concentrations were typically quoted as less than 0.005 fibres/ml.

3.3 DISCUSSION OF THE HISTORICAL EXPOSURE DATA

All of the information described here originates from samples collected in the Aviary's estate within the Armley area. This is the area that is probably representative of the very worst conditions that might exist in houses in Armley. Nevertheless, the data are reassuring. In the air samples that were collected during normal occupation of homes there was no indication of high exposure to asbestos. The data reported by Professor Willey did not suggest any elevated airborne fibre levels, although as we have discussed the optical microscope technique has limited capability in this respect. Measurements made by the Institute of Occupational Medicine using transmission electron microscopy, which overcomes this problem, support the likely low airborne concentrations with the maximum measured asbestos concentration being 0.0045 fibres/ml and the other measurements all being less than 0.001 fibres/ml.

However, these concentrations are relatively high compared with other houses in the UK that have asbestos products installed within them. Burdett and Jaffrey (1986) reported mean asbestos fibre levels in buildings with sprayed asbestos installed of 0.0004 fibres/ml and for buildings with amosite insulated warm air heaters the mean was 0.0002 fibres/ml, both analysed by transmission electron microscopy. Gazzi and Crockford (1987) found that flats with amosite insulation boards had a mean asbestos fibre level analysed by transmission electron microscopy of 0.0003 fibres/ml, with the highest individual concentration being 0.0025 fibres/ml. A recent report from the Medical Research Council Institute for Environment and Health identified that in buildings which contain asbestos in good condition the airborne fibre concentration is generally less than 0.0005 fibres/ml (IEH, 1997).

Airborne fibre levels during refurbishment of homes in the Aviary's estate were higher than during normal occupation. The highest levels were found when contaminated ceilings were pulled down. Exposure levels up to 1.3 fibres/ml were recorded, although more typically the airborne fibre concentrations were around 0.5 fibres/ml. These situations presented a number of measurement problems because of the large quantities of airborne non-fibrous dust generated during the work. However, there seems to be a fair amount of consistency in the data and they are probably representative of conditions when contaminated ceilings are dropped. The more important concern with these data is the fact that they were obtained from optical microscope analysis, which cannot differentiate between asbestos and non-asbestos fibres. In situations where there are data from both optical and transmission microscopy, where the latter technique can positively identify asbestos, the proportion of asbestos fibres was much less than 100% Therefore, using optical microscopic analysis will overestimate the asbestos fibre concentrations from disturbance samples.

Other remedial work, such as removing windows or lifting floorboards, appears to generate lesser airborne fibre concentrations, with the highest measurement being around 0.1 fibres/ml and more typical measured levels were around 0.03 fibres/ml, when old window sash boxes were removed and settled dust was disturbed. Analysis by electron microscopy again confirmed that many of the fibres measured during this activity were not asbestos. Lifting floorboards did not appear to raise exposure levels measured by phase contrast optical microscopy above 0.01 fibres/ml.

4. ESTIMATION OF THE LIKELY ASBESTOS CONTAMINATION IN HOMES IN THE WIDER AREA FROM INDUSTRIAL SOURCES

4.1 RESULTS FROM BULK SAMPLES OF LOOSE DUST COLLECTED FROM WITHIN HOUSES

In the Aviary's estate almost all of the 364 properties tested by bulk sampling by Leeds City Council for the presence of asbestos in loose dust were positive. Elsewhere within 400 metres of the former Roberts factory site, i.e. out side the Aviary's estate, there have been 15 properties sampled of which seven (47%) had detectable quantities of asbestos found in them. In the wider area, excluding the central 400-metre circle around the primary source, there have been 116 properties investigated and in 43 (37%) cases asbestos was found in loose dust. Notably, crocidolite asbestos was not generally found in these samples although it was said to have been extensively used in the Roberts factory.

There is little information about the pattern of contamination within the Wider Area because of the limited number of measurements available and the limited area investigated. Almost all of the houses studied were located in the area South West of the Wider Area. To investigate further the likely pattern of asbestos contamination in the Wider Area we have used computer air dispersion modeling, as described in the following section.

4.2 MODELLING THE DISPERSION IN AIR

Asbestos fibre escaping into the air around the Roberts factory will have settled inside nearby houses in locations with low air movement, such as the roof voids, under the floors and within window sash weight boxes. We have assumed that, where the estimated air concentration around the house was higher, the level of contamination in the house would also be greater. A dispersion modelling exercise was therefore carried out to examine the likelihood of houses in different areas being contaminated with asbestos fibre from the factory. This estimation was based on dispersion patterns due to the wind and topographical features in the area, as calculated using a standard air dispersion model.

4.2.1 The model and parameters used

The dispersion model used was *Aermod*, which is a development of the US Environmental Protection Agency regulatory model called ISCST3 (Industrial Source, Complex, Short Term, 3rd revision). This model was written and developed in the computer language FORTRAN, but has been compiled and given a "user-friendly" interface by Lakes Environmental Software Inc. of Canada. Lakes Environmental Software also provides other facilities, including modules that draw concentration contours on maps. This software is endorsed by the Meteorological Office for use in Britain.

The model requires a number of inputs:
- information about the source of the emissions;
- the area for which the air concentration estimates are to be produced;
- local meteorological data;
- data about the local terrain and
- the format of the required output.

The model of the dispersion from the primary source in Armley was based on a ground area approximately 1600 metres (or one mile) around the former factory. This distance was chosen to represent a reasonable area around this prime source of asbestos for assessment of the likely risks to the local population.

Source parameters

If the actual average concentration of asbestos at a point had been required, it would have been necessary to know the release rate of asbestos from the factory, and any variation in that release rate with time of day, week or year, or variation due to factors such as wind strength. However, this information was not available and it was therefore assumed that the asbestos fibre was released from the factory at a steady rate, with no seasonal variation or wind affecting the release rate. Because the actual release rate was not known a nominal rate was selected in order to give a range of contours in a suitable scale. This process therefore provides a relative estimate of the asbestos concentration around the factory while it was operating.

The boundaries of the model calculations

The computer model calculates average concentrations at a number of points, as defined in the setup program. These may be arranged in a number of ways, including a simple mesh of points (a Cartesian grid), a complex grid or using polar co-ordinates. In this case we selected a uniform Cartesian grid of 71 x 74 points at 50 metre intervals (3500m x 3650m), with the factory located 1600 metres north of the southern edge and 1600 metres east of the western edge of the defined area. This grid was fine enough to allow a good set of contours to be drawn between the points, while at the same time not causing excessive computing time to be used in calculating concentrations at too many points.

Meteorological data

The meteorological data used in this model was from a randomly selected year, in this case 1995, and was taken from the Meteorological Office weather station in Leeds, which was the nearest to the factory site. The data therefore already had taken into account the particular topography of Leeds (i.e. the valley and the hills). The Meteorological Office provided hourly wind speed and direction data, together with other parameters such as urban and rural mixing heights, in a format specifically designed for use in this dispersion model. The effect of buildings is accounted for in the urban model parameters.

Terrain grid

In addition to the location of the grid points, the model allows for the variation in terrain height around the source. In this case, the factory is situated on the southern side of a valley through which run the river Aire, the Leeds and Liverpool canal and a railway line. The floor of the valley is approximately 50 metres below the level of the factory, and runs in a north-west to south-east direction.

The terrain grid was set up on a coarser scale than the receptor grid, using a 11 x 10 grid of points at 400 metre intervals in both directions. Heights were estimated from the Ordnance Survey map for each of the 110 intersection points, and the computer program was then used to calculate the height of each of the receptor positions. The model was run with and without the terrain grid included to identify whether this affected the final average concentrations.

Model output

As the long-term occurrence of airborne asbestos was of interest for this study, the output from the model was the annual average concentration. Other output periods, such as the highest hourly or daily average, were not as relevant to this application, and were therefore not calculated.

At the end of the calculation of concentrations, the contours of equal concentrations (isopleths) based on the annual average concentrations were calculated with all the variables, such as wind speed and direction, taken into account. These contours can be overlain on a copy of a map for the area, and examples of this are shown in the following sections.

4.2.2 Results of the modelling exercise

Meteorological data

The meteorological data was analysed for the occurrence of wind speeds in the different directions over the year (1995 data). The results of this analysis are shown in the wind rose in Figure 4.1 below, and the occurrences in each category are summarised in Table 4.1.

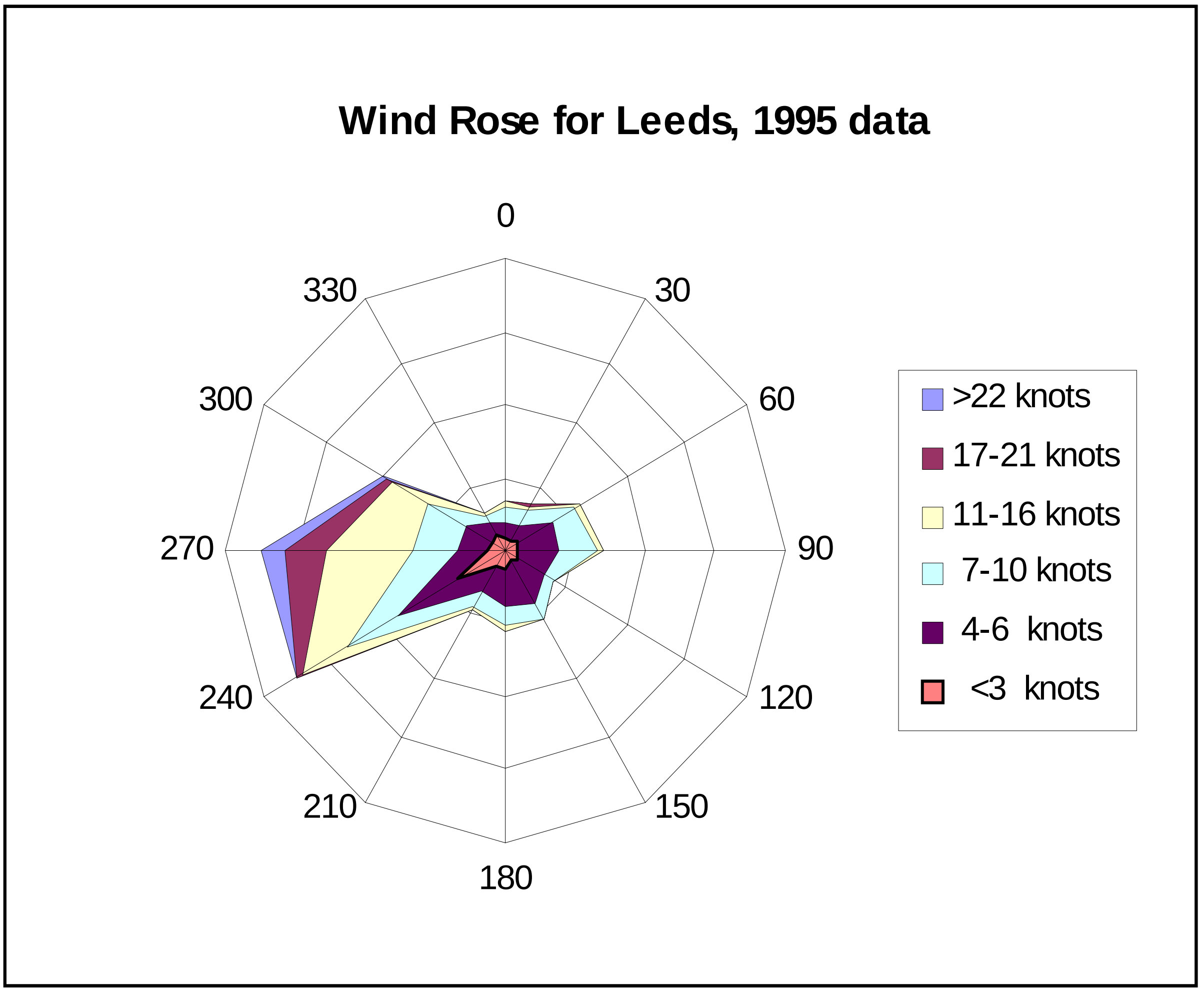

Figure 4.1 Wind rose diagram of wind speeds and directions at Leeds for 1995. The diagram shows the directions from which the winds come (i.e. mainly westerly).

Table 4.1 Summary of wind directions and speed categories for Leeds in 1995, from which the wind rose in Figure 4.1 above is drawn. Each cell shows the number of hours during 1995 (total 8760 hours).

	Direction (°):	**0**	**30**	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**270**	**300**	**330**
1:	<3 knots	90	61	117	79	98	88	118	127	379	131	108	119
2:	***4-6 knots***	103	132	271	307	229	346	259	195	485	201	211	100
3:	7-10 knots	114	126	193	273	83	91	132	116	437	329	323	67
4:	11-16 knots	31	28	42	40	3	10	36	24	370	612	293	19
5:	17-21 knots	0	8	3	0	0	0	1	0	51	311	51	0
6:	>=22 knots	0	1	1	0	0	0	0	0	4	170	13	0
Total		338	356	627	699	413	535	546	462	1726	1754	999	305

Figure 4.1 and Table 4.1 show that the largest proportion of winds at all speeds came from the west (51% from 240° to 300°), and the smallest component from the north. Note that relevant meteorological data are not available for years when the Roberts factory operated and so we have had to assume that the data from 1995 is a reasonable approximation to the weather in the earlier part of the 20th Century.

Dispersion model results - no terrain grid

The output from the model without the inclusion of terrain heights is shown in Figure 4.2. It is clear that the pattern of isopleths is roughly symmetrical around the line running from north-west to south-east, being slightly elongated in the southerly direction. This is mainly as a result of the prevailing wind direction. The area of the Aviary's estate is mostly contained within the contour line labelled "1". Towards the boundary of the map we would expect that the concentration of airborne asbestos would have been approximately a tenth of that at the edge of the Aviary estate and approximately a hundredth of that close to the factory (the innermost contour represents a relative asbestos exposure level of 10).

Figure 4.2 Contour plot of annual average concentrations around the primary source. No terrain heights are taken into account in this model. The concentrations are nominal values and not absolute levels experienced.

See Figure 1.1 for the location of the former Roberts factory and the Aviary's estate

Dispersion model results - with terrain grid

The concentrations with the terrain grid added, but with all other factors the same, are shown in Figure 4.3. below. There is qualitatively little difference between this and the previous figure.

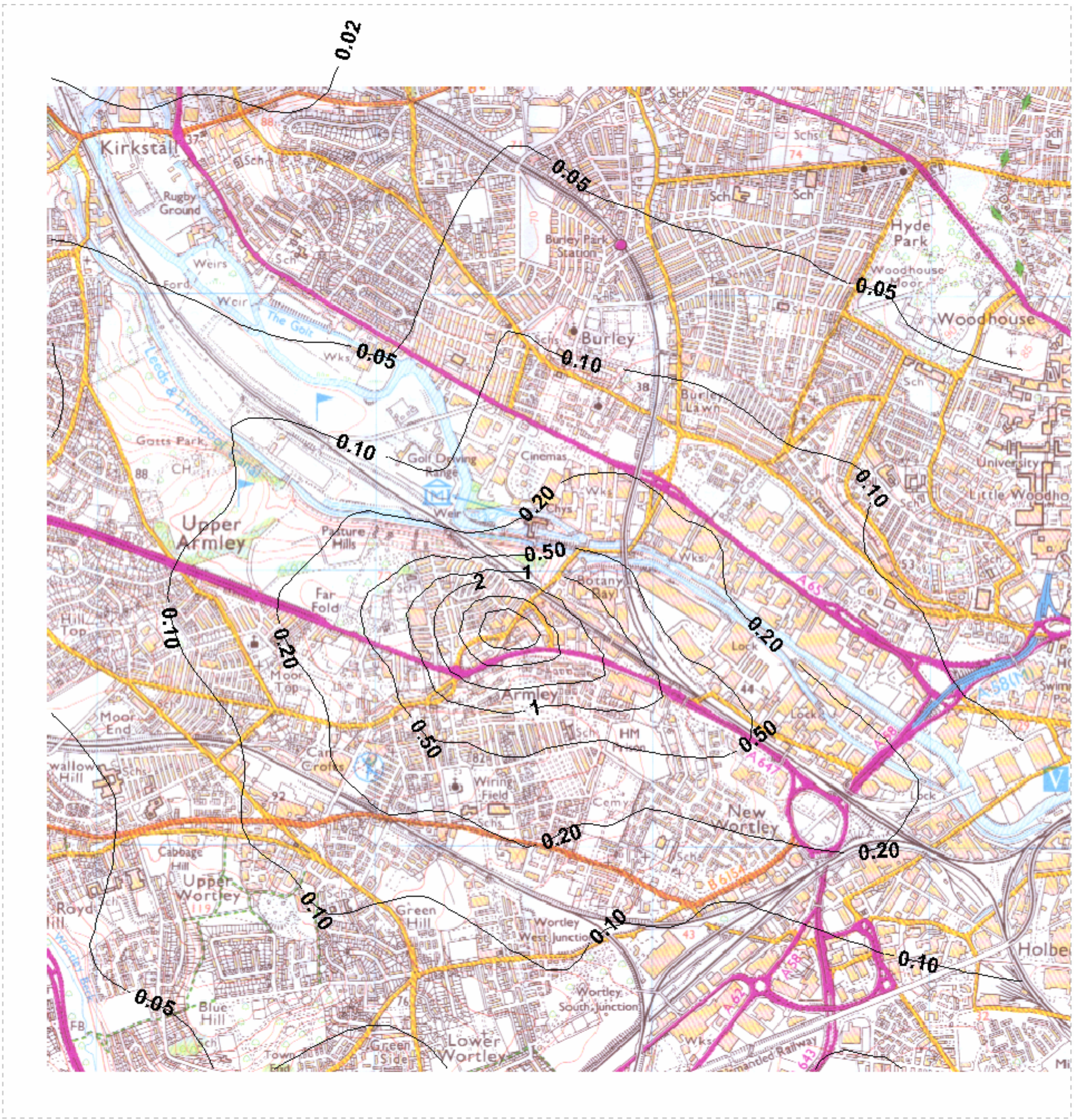

Figure 4.3 Contour plot of annual average concentrations around the primary source, taking terrain heights into consideration.

4.2.3 Conclusions from the modelling

By comparing Figures 4.2 and 4.3 the differences in concentration contours can be seen to be very small, indicating that the ground-level concentrations were not strongly affected by the deep valley running through the centre of the area, which in part may be because this is already accounted for in the wind direction data. The contours show a lengthening from the factory towards the south-east, which is in line with the valley rather than being obviously related to prevailing wind direction. From the pattern of the contours we expect that the contamination in the areas of Armley further away from the factory would be much less than in the area within 400 metres of the Roberts factory site. The concentrations at 1 km from the old factory site are estimated to have been about one fiftieth of those within 100 metres of the factory. In addition, we expect the contamination to be approximately distributed in an even pattern around the factory, with the exception that the asbestos may have travelled further in the south-easterly direction towards New Wortley because of the prevailing wind.

4.3 OTHER INDUSTRIAL SITES IN LEEDS

Howell and Arblaster (2000) have attempted to identify all of the industrial sites with potential to cause residential exposure in West Yorkshire. They found information on 269 asbestos factories that had operated between 1900 and 1979, although many had operated for only a short time. About 45% of these factories were located in an area with a Leeds postcode. Some of the key locations are shown in Figure 4.4 on the following page.

There were three factories located within about 400 metres of the old Roberts factory and a further six within 1600 metres. All of these factories could have potentially contributed to the contamination found within the Wider Area and this may complicate the pattern of contamination identified within the community.

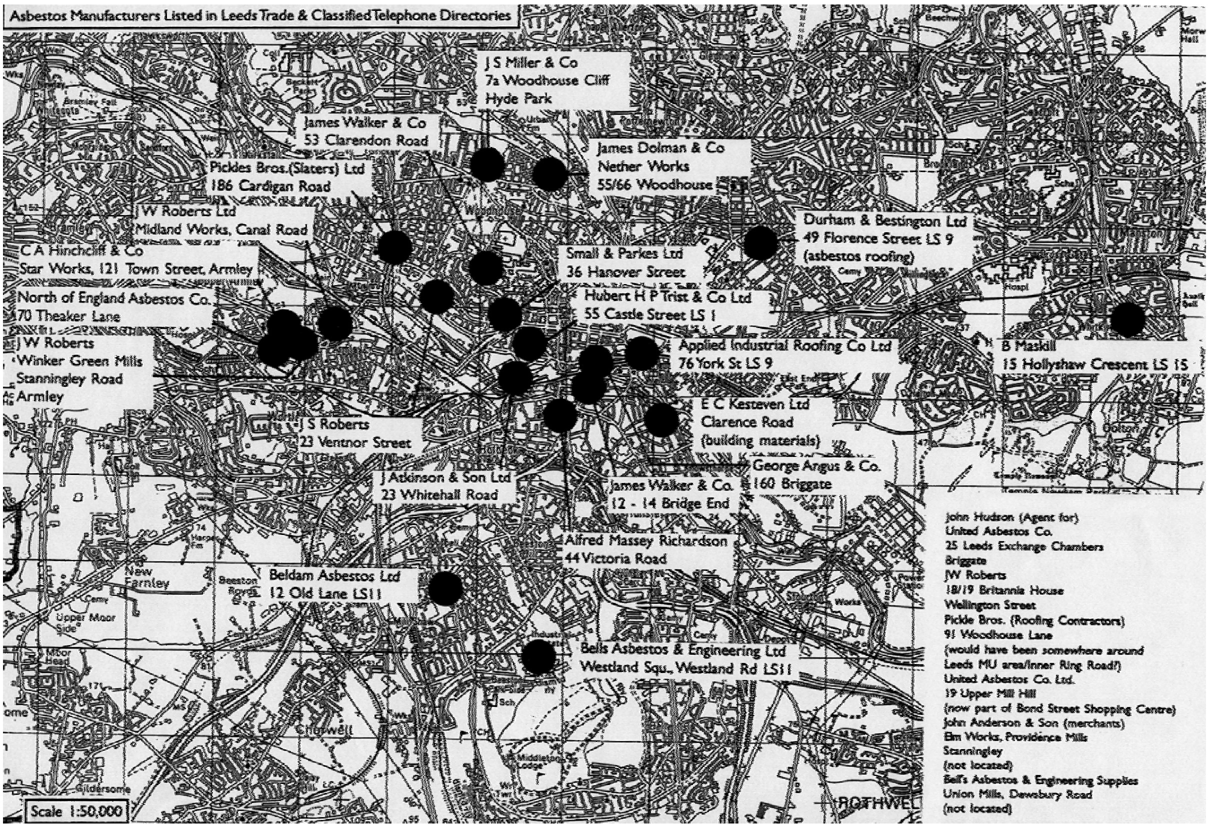

Figure 4.4 Asbestos manufacturers as obtained from the Leeds Trade and Classified telephone directories

4.4. CONCLUSIONS REGARDING SPREAD OF ASBESTOS FIBRE FROM THE ROBERTS FACTORY

From the information obtained from our dispersion model we expect the spread of asbestos contamination to be fairly symmetrically distributed around the former Roberts factory site. It is also expected that the amount of contamination would decrease further away from the site with the contamination within the 400 metre radius circle being about ten times greater that that which might be found near the edge of the 1600 metre radius circle. This assumption may be modified by other factors such as the age of the property, because older properties would have had longer to accumulate contamination, and the exact design of the house. However, within the smaller circle the contamination found in the Aviary's estate was apparently different from the remainder of this area (100% of houses contaminated versus 47%[②]). It should be noted that only a relatively small number of houses elsewhere in the 400 metre radius have been tested, but the difference is strongly suggestive of a different pattern of contamination. The dispersion model assumes that the only way for asbestos contamination to get into the houses is through the outside air, whereas it is expected that many of the workers in the Roberts factory would have lived in the houses in the Aviary estate. If this were the case then they would have carried home some asbestos fibres on their clothing and this contamination may have become airborne again in their house and then preferentially accumulated in the stagnant air spaces within the homes, i.e. in window sash boxes etc. However, it should also be noted that the testing of homes has been carried out in the Aviary's since 1988 and there have been a number of protocols used. In many cases there have been multiple tests made on some houses, particularly houses where previous test results were negative and this may explain the higher proportion of positive results in the Aviary's estate. From the present research we are not in a position to say why there is apparently greater level of loose asbestos contamination in the Aviary's estate and additional investigations would be needed to try to resolve this issue.

The methodology used by the Council analyst to test for asbestos contamination in houses does not allow an assessment of the magnitude of the contamination; houses are either identified as positive for the presence of asbestos or not. Because we expect the level of contamination to decrease as we go away from the factory site it would therefore also be expected that all houses should be identified as contaminated out to some (unknown) distance. However, moving still further away the level of contamination should decrease so that there will be some houses that are contaminated with such low levels that they are not detectable in the samples collected. This is seen in the test results from within the Wider Area, excluding the Aviary's, where some houses in a block may show contamination while others do not. For the purposes of the risk assessment we have assumed that where asbestos is not detected it is either not present or is present at such a low level that it does not represent a hazard.

Also, for the risk assessment we have chosen to divide the area around the Roberts factory into three regions based on concentric rings at 400, 800 and 1600 metres (approximately ¼, ½ and 1 mile). The proportion of houses assumed to be contaminated was chosen to reflect the bulk sample results obtained in the survey of houses undertaken by the Council.

[②] Since this report was originally drafted the Council have reviewed their data and on the basis of this work it has been suggested that part of the difference between these two areas may be due to differences in the sampling protocol used. However, we consider that this change will not materially affect the conclusions of our work.

5. THE PROBABLE PATTERNS OF EXPOSURE TO ASBESTOS AMONGST THE RESIDENTIAL POPULATION

5.1 IDENTIFICATION OF ACTIVITIES LIKELY TO RESULT IN ASBESTOS EXPOSURE

The main locations of asbestos contamination in homes in this area of Leeds are roof voids above upper floor ceilings and, to a lesser extent, within window sash weight boxes. The main reasons for someone in the community disturbing asbestos in the roof voids would be to store materials or to repair that part of the house or its fittings. The main reason for disturbing windows and other areas where asbestos could have accumulated would be as part of some form of do-it-yourself (DIY) work or where a tradesman was employed to do such work. It is necessary for the estimation of the risk for the population that we have an estimate of the amount of time residents may spend in such activities. We therefore devised a short questionnaire for residents, which the Council agreed to distribute to a number of local people. A copy of the questionnaire is shown in Appendix 1.

5.2 ESTIMATION OF TIME PER YEAR SPENT DOING LOFT WORK AND DIY

Estimation of the time spent doing loft work and DIY work was calculated from information supplied by questionnaires completed by residents of Leeds. Thirty questionnaires were completed: 11 by females and 19 by males. Fourteen respondents were aged 20-39, twelve aged 40-59; and four were aged 60 or more. Information was collected on the frequency and lengths of time the respondent spent doing loft and DIY work. Similar information was requested for the respondent's partner. The results here are based only on the self-reports because it was not possible to distinguish between those whose partner did no loft or DIY work and those who did not live with a partner. It is however notable that estimates for partners of both sexes tended to be lower in both frequency and length of time spent doing loft or DIY work, than for respondents themselves.

Loft work

Fourteen men (74%) reported visiting the loft during each year. The majority - eleven men (aged up to 81) - spent a total of one hour or less on loft work per year. The average time spent on loft work among these men was 32 minutes. Three of the men (aged 35 to 53) spent more than one hour per year on loft work. On average these three men estimated they spent 223 minutes per year working in their loft. We have therefore assumed for the risk assessment that 60% of men aged 18 to 70 carry out loft work for, on average, 30 minutes per year, and 15% of men aged 18 to 70 carry out loft work for, on average, 3.5 hours per year.

Two women (18%), aged 25 and 63, reported visiting the loft during each year for an average visit length of 16 minutes. Mean total time spent on loft work was 21 minutes per year (ranging from 12 to 30 minutes). In the current study we have assumed that 20% of women aged 18 to 70 carry out loft work for, on average, 20 minutes per year.

DIY work

Twelve men (63%) reported carrying out relevant DIY work over a five year period, none of whom was over 60. Most spent less than two hours per year on this DIY work (9 men, mean time 47minutes) while three spent an average of 17 hours per year doing DIY. For the calculation of mesothelioma risks, therefore, we have assumed that 45% of men aged 18 to 70 carry out DIY work for, on average, 45 minutes per year, and 15% of men aged 18 to 70 carry out DIY work for, on average, 17 hours per year.

The two women who had reported carrying out loft work also reported doing DIY, for an hour at a time. One did so once a year and the other did so once every five years. Based on these figures, we have assumed that 10% of women aged 18 to 70 carry out DIY work for, on average, one hour per year.

6. MEASUREMENT OF ASBESTOS EXPOSURE IN SELECTED HOMES AND EXPOSURE ESTIMATES FOR THE RISK ASSESSMENT

6.1. INTRODUCTION

Preliminary estimates of the possible future risk suggested that it was most important to have a reliable estimate of the background asbestos concentration in homes during normal occupation. In addition, because it was expected that the degree of asbestos contamination in homes outside the Aviary's estate would be lower than in the Aviary's, it was also important to have additional information about possible exposures during activities that might disturb settled asbestos contamination. A programme of monitoring was planned to provide information to support the risk assessment. To ensure sufficient sensitivity to detect the very low airborne fibre concentrations that were to be expected (based on the experience in the previous monitoring in the Aviary's estate) it was decided to analyse most samples using transmission electron microscopy. However, a number of samples were also collected for analysis by phase contrast optical microscopy for comparability with the historical local research data.

6.2. MONITORING AND ANALYSIS METHODS

Sampling in occupied homes

Suitable premises for monitoring were identified by Leeds City Council. Houses for background sampling were occupied and the work was explained to the residents and their permission was sought. Previous investigations had shown by bulk sample analysis that each selected house was contaminated with traces of asbestos in loose dust, mostly in the roof voids. Measurements were made in one room where the operation of the sampler would be relatively unobtrusive. The samples were collected over a 24-hour period. While the samples were collected the residents went about their normal routines.

Samples were collected using electrically conductive cowl filter holder loaded with 0.4 µm pore polycarbonate filters. The filter holder was connected to a high flowrate sampling pump with a length of polythene tubing. The sampling head was located approximately 1.5 metres above the floor facing downwards. The pumps were switched on and the flowrate through the filter was measured using a calibrated flowmeter. The initial flowrate was set at approximately 8 litres per minute. The duration of sampling was noted and at the end of the period the flowrate was measured again.

Transmission microscope analysis

The samples were analysed at either the Institute of Occupational Medicine or the Health and Safety Laboratory in Sheffield, using the methods described in the International Standards Organisation method 10312 (BSI, 1995). The filters were coated with a thin layer of carbon and a small portion was cut and mounted on a 200 mesh Transmission electron microscope grid. The filter was then dissolved using chloroform in a washing system. The samples were examined on a transmission electron microscope at a magnification of approximately 11,000 times. A minimum of 50 grid openings were examined. All structures (i.e. fibres) longer than 5µm with the ratio of length to diameter greater than 3 were counted and identified as either asbestos or non-asbestos.

Sampling and analysis methods for disturbance activities

We attempted to acquire additional measurements for activities representative of home improvement work and loft access. Suitable situations for measurement were identified by the Council where it was known there was asbestos contamination in the home and remedial work was planned. Measurements were obtained either from the workers undertaking this work (personal samples) or from within the room where the activities were undertaken (static samples). The samples were collected using medium flowrate, battery-operated sampling pumps connected to a cowl sampling head. The filter used was either a polycarbonate membrane filter, where the sample was to be analysed by transmission electron microscopy, or a cellulose-ester membrane filter where analysis was to be by phase contrast optical microscopy. Samples were collected at a flowrate of 2 litres per minute over the duration of the activity. The electron microscopic analysis was carried out as previously described. The optical microscopic analysis was carried out at the Institute of Occupational Medicine using the standard method published by the Health and Safety Executive (HSE, 1995).

6.3 RESULTS FROM THE MONITORING

Thirteen samples were obtained from houses under normal occupancy in the Wider Area outside the Aviary estate. The results from these samples are shown in Appendix Table 2.1. No asbestos fibres were found on any of these samples – the estimated concentrations were all less than 0.0008 fibres/ml (Samples WA1 to WA13 in Appendix Table 2.1). However, because no asbestos fibres were detected we have confidence that the actual airborne asbestos fibre concentrations were much lower. We have pooled all of the data together to give a better estimate of the likely maximum concentration in houses in this area. This pooled estimate of the fibre concentration suggests that there was less than 0.00001 fibres/ml of asbestos present in the air in these homes. We have used this value as our estimate of the background exposure of people living in the Wider Area for the purposes of the risk assessment.

Five static samples were obtained within the Wider Area during disturbance activities representative of home improvement work and were analysed by transmission electron microscopy. The results from these samples are shown in Table 6.1 and Appendix Table 2.2.

Table 6.1 Results from electron microscope analysis of samples collected during disturbance

Activity	Location within property	Area	Concentration of asbestos (fibres/ml)	Comments
Removal of Windows	***Work on the first floor***	400m [3]	<0.0009	Sample WA14. One amosite asbestos fibre <5µm long found
	Work on the ground floor	400m	<0.0009	Sample WA15. Three amosite asbestos fibres <5µm long found
After major disturbance	Inside enclosure in attic dormer	400m	<0.0003	Sample WA16. No asbestos detected
	Inside enclosure by end terrace wall	400m	<0.0003	Sample WA17. No asbestos detected
Loft access	Constructing enclosure	800m	<0.004	Sample WA19. No asbestos detected

[3] Two personal samples collected alongside this sample gave concentration estimates <0.2 and <0.3 fibres/ml, respectively. One amosite fibre was detected on one of these samples.

Two samples were collected during the removal of windows (WA14 and WA15), two after more major disturbance (WA16 and WA17) and, finally, there was one sample collected while constructing an enclosed space within an attic to prevent the escape of any asbestos fibres during major disturbance (WA19). This latter situation we consider representative of loft access by residents. All samples were characteristic of the exposure that would have been received by someone undertaking the activity.

Asbestos fibres were found on only two of the five samples and in both of these the fibres were shorter than 5μm and were therefore excluded from the calculation of airborne fibre concentration. In contrast we have also measured the airborne fibre concentration during cleaning up after a ceiling had been dropped in a house in the Aviary's estate (WA18). The result from this sample was 0.17 fibres/ml (based on three amosite asbestos fibres being identified), while on all of the samples from the Wider Area the estimated asbestos fibre concentrations were between less than 0.004 fibres/ml and less than 0.0003 fibres/ml. Note, the relatively wide range in these detection limits arises because the work may only have lasted for a relatively short time and so it is difficult to ensure sufficient air has been sampled to obtain the lower detection level.

Data from personal samples collected during disturbance work and analysed by optical microscopy are also shown in Appendix Table 2.3 and these data are summarised in Table 6.2. Only one of these samples could be analysed because of difficulties with non-fibrous particles obscuring the filter (and any fibres that may have been present on the sample). The measurement provided concentration estimates that were below the limit of detection. These samples confirm that the concentrations were not high, but add little to our understanding of the possible risks for people undertaking such activities. Data from similar measurements made in the Aviary's estate are also shown in the Appendix, although these are also uninformative.

Table 6.2 Results from optical microscope analysis of samples collected during disturbance activities

Activity	Location within premises	Area	Fibre concentration (fibres/ml)	Comments
Removal of Windows	***Work on the first floor***	400m	<0.02	Sample WA20
	Work on the ground floor	400m	-	Sample WA21 could not be analysed because of large quantities of non-fibrous dust
Loft access	General disturbance	800m	N/A	No suitable samples collected

We also collected a small number of samples representative of background exposure conditions and analysed these using optical microscopy (WA22, 26, 27 and 28). These data, which are also shown in Appendix Table 2.3, provide estimates of fibre concentration that are either comparable or higher than the corresponding data from the electron microscope analysis. Where the concentration estimates are higher by the optical microscope analysis it is probably because this technique cannot distinguish between asbestos and non-asbestos fibres and some of the latter contribute to the measurements. Two personal samples were collected during disturbance activity and analysed by electron microscopy (Samples WA29 and 30, shown in Appendix Table 2.4). The results from these samples were both below the detection limit (<0.2 and <0.3 fibres/ml) and these were comparable with the results from the other personal samples collected at this time (WA24 and 25, both of which were <0.4 fibres/ml).

In two of the properties we collected a number of bulk samples of fine dust that had settled out in roof voids, in sash window boxes etc. The results of these tests are given in Appendix Tables 2.5 and 2.6. Sixteen samples were collected and in all cases we were unable to detect asbestos in these samples, even though prior testing had confirmed the presence of asbestos in these houses.

The measured fibre concentration data presented in this section are all lower than the corresponding levels found in the earlier work in the Aviary's estate. The historical measured concentrations obtained in the Aviary's estate while removing window sash boxes were around 0.1 fibres/ml measured by optical microscopy and from limited electron microscope analysis the asbestos fibre concentration was 0.03 fibres/ml. In the Wider Area the results were <0.0009 fibres/ml of asbestos fibres detected by electron microscopy. After major disturbance the historical levels from the Aviary's were typically around 0.5 fibres/ml with the maximum around 1.3 fibres/ml, all using optical microscope analysis. In the current measurements asbestos was not detectable on the air samples collected in the Wider Area, excluding the Aviary's estate, while major disturbance activities were taking place. The one occasion when a concentration of 0.17 fibres/ml was measured was from a property in the Aviary's estate. We feel this supports the view that asbestos exposure levels in the Wider Area, even where the homes are contaminated with asbestos, are much lower than in the Aviary's estate.

6.4 EXPOSURE ESTIMATES USED IN THE RISK ASSESSMENT

There is insufficient information from the present monitoring programme to unconditionally use the measured values in the risk assessment. For example, we have only a single measurement that might be relevant to residents entering the loft of a house contaminated with asbestos and only three that are relevant to major disturbance arising from home improvement work. Realistically we had always known that our measurements would "inform the study" rather than provide definitive estimates of actual exposure. We have therefore used the available data and our knowledge of the extent of the asbestos contamination in the Wider Area to devise a set of assumptions for the estimation of exposures to be used in the risk estimation. We have deliberately chosen to overestimate rather than underestimate the likely exposure so that the risk estimates are conservative.

For the background exposure we have chosen to set the level at 0.00001 fibres/ml for the two inner areas, i.e. the 400 metre and 800 metre circles. For the area out to 1600 metres we have chosen a background exposure level in houses of 0.000005 fibres/ml. These figures compare with the measured asbestos fibre concentrations of less than 0.00001 fibres/ml. When residents require to access the loft area in a home that is contaminated with asbestos we have chosen to set the exposure level for the risk calculations at 0.001 fibres/ml for the inner areas (zero to 400 metres and 400 to 800 metres) and 0.0005 fibres/ml for the area between 800 and 1600 metres. The comparable measurement data was less than 0.004 fibres/ml for someone working in a loft space, although because of the relatively short duration of the work we consider this sample does not have sufficient sensitivity to reflect the likely true level in the loft. Finally, for DIY work (and similar work carried out by joiners, builders and other tradsemen) in the home we have chosen an exposure estimate of 0.1 fibres/ml for the inner circles and 0.05 fibres/ml for the outer ring (800 to 1600 metres). The highest measurement for what would be very extreme activity for a householder was 0.17 fibres/ml (and this was from a house within the Aviary's estate), and the other exposure measurements were all much lower than this.

We have also devised exposure estimates for an intervention strategy that could be available to the Council to develop an asbestos awareness and advice strategy for the Wider Area. We outlined a number of possible intervention scenarios, but ultimately decided to investigate only one. This was based on a campaign to alert residents to the presence of possible contamination and advise that they either did not undertake major home improvements or employed a specially trained workman experienced in dealing with asbestos to do this, with appropriate precautions to minimise the disturbance of any asbestos. In this scenario we assumed that the background asbestos fibre concentrations were as we have described earlier. However, there would be no exposure to the residents from home improvement work because this would be undertaken by a professional using appropriate precautions. However, at the end of the improvement work we assume that the background fibre concentration in the home would be increased to 0.005 fibres/ml.

After all of the DIY activities we have assumed that the asbestos contamination in the home would remain elevated for one year. We further assumed that the concentration would decline rapidly over the first few days after the work was complete and then more slowly over the following months. At the end of one year the concentration we assume would have returned to the background level. This pattern is based on data published by Burdett *et al* (1989), summarised in Figure 6.1 on the following page. During the period investigated by Burdett and his co-workers the asbestos concentration rose periodically because of dust disturbance activities such as sweeping or vacuuming and general housework.

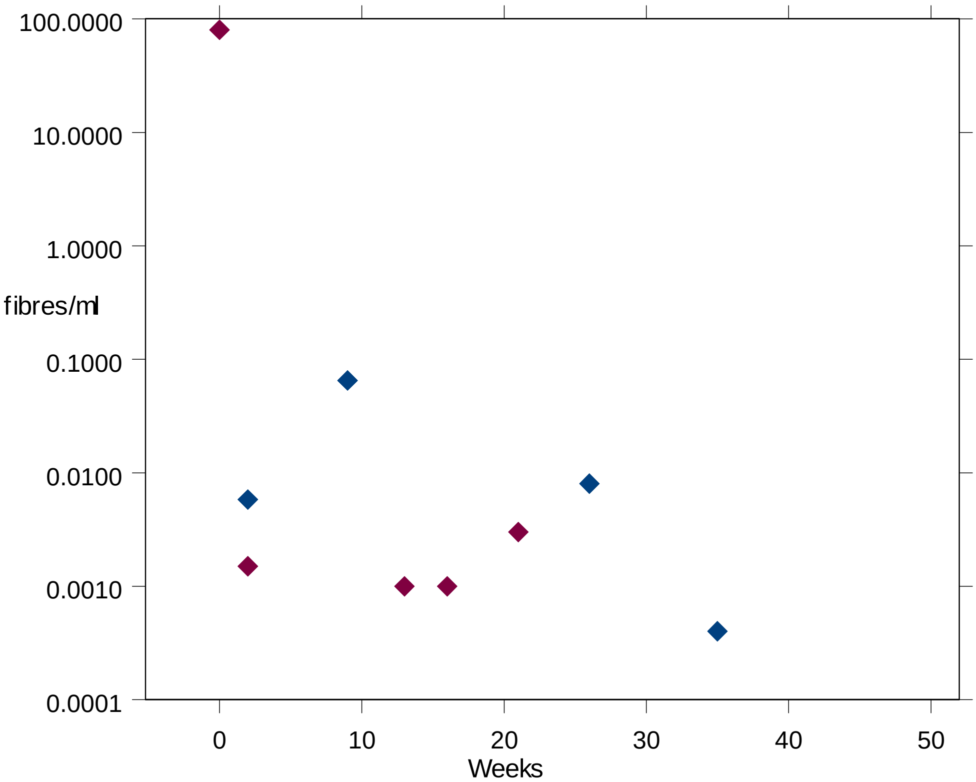

Figure 6.2 Decline of asbestos concentration measured by Burdett *et al* (1985)

This type of decline in exposure level is plausible. The rapid decline reflecting the removal of asbestos from the house air by fresh air being drawn from outside. The long slow decline most probably results from the sequestration of some fibres within the room furnishings and fittings. These fibres may be resuspended by cleaning or movement within the room, retaining the contamination in the room for a long time.

7. ESTIMATION OF THE LIKELY FUTURE CANCER RISKS FROM ASBESTOS CONTAMINATION IN HOMES IN THE WIDER AREA

7.1 BACKGROUND

We have acknowledged that the exposure to asbestos fibres can potentially cause the development of lung cancer along with mesothelioma. Lung cancer is a difficult disease to attribute to asbestos exposure as over 90% of cases are due to cigarette smoking. Almost all lung cancer patients with asbestos exposure also have a history of cigarette smoking. It is not straightforward to determine the cause of their disease, although lung cancer rates among asbestos workers who smoke are higher than those predicted by simply adding up the lung cancer rates for smoking and for asbestos exposure. Most of the studies of asbestos exposure and lung cancer were undertaken on people who worked with asbestos during the early and middle part of the 20th century. Asbestos exposure levels were often well above current occupational exposure levels and greater than any of the situations investigated in this research. For this reason our knowledge of lung cancer risks associated with low levels of asbestos exposure is limited. Lung cancer is a relatively common disease among the general population. Because of this, the uncertainty of attribution to asbestos exposure rather than smoking and the lack of information on smoking habits in the study population, we have concentrated our assessment of the likely future cancer risks on the risks of malignant mesothelioma, and have provided only approximate estimates of future risks of lung cancer. We are confident, however, that excluding detailed consideration of lung cancer would not bias our conclusions about the risks from asbestos nor the selection of the best approach to manage the situation.

Mesothelioma is a malignant nodular-type cancer of the membranes that line the lung or bowel cavity. Malignant mesothelioma of these membranes is extremely rare in individuals without exposure to asbestos. It is an incurable cancer and is usually fatal within about a year of diagnosis. Mesothelioma has been associated with short-term exposure to asbestos, and among those non-occupationally exposed (e.g. cases among women who washed the clothes of men who worked with asbestos). There is no evidence of a relationship between mesothelioma risk and cigarette smoking.

It is generally accepted that mesothelioma is almost exclusively associated with exposure to the crocidolite (blue), amosite (brown) and other similar varieties of asbestos rather than chrysotile (white) asbestos. Also, the time between first being exposed to asbestos and the detection of the disease is normally more than 30 or 40 years (IEH, 1997).

7.2 POPULATION POSSIBLY AT RISK

Possible future exposures and cancer risks have been estimated for individuals who currently reside within 1600 metres (approximately one mile) of the former JW Roberts asbestos works; subdivided into three areas:

- ‘400 metre area’ - those living up to 400 metres (approximately 0.25 miles) from the works;
- ‘800 metre area’ - those living between 400 and 800 metres (about 0.25 and 0.5 miles) from the works;
- ‘1600 metre area’ - those living more than 800 metres from the works, but within the 1600 metre circle (0.5 miles to one-mile).

Population figures were provided by Leeds City Council using the 1991 Census small area statistics, for the 400m and 800m areas combined and for the 1600m area, and were verified by examination of detailed maps of the area of interest. Separate population estimates for the 400 metre and 800 metre areas were subsequently calculated from the maps, which indicated that 45% of the population in the combined area resided within the 400 metre area, with 55% in the 800 metre area. Table 7.1 shows the number of residents within each of these areas classified by age group and sex.

Table 7.1 Distribution of total study population by age group, sex and residential area

Age Group	Males			Females		
	400 metre	800 metre	1600 metre	400 metre	800 metre	1600 metre
<10	183	223	1906	157	192	1829
10-19	131	159	1601	117	142	1561
20-29	255	312	3483	265	325	3521
30-39	173	211	2064	156	191	1957
40-49	128	156	1415	120	146	1413
50-59	132	162	1278	119	145	1296
60-69	122	150	1191	134	163	1240
70-79	91	111	700	167	205	1116
80+	32	40	273	77	95	746
Total	1247	1524	13911	1312	1604	14679

Significant asbestos contamination was only considered possible in housing built prior to 1960, by which time the primary source had ceased production. Calculations based on the detailed maps of the area estimated that 27.6% of houses in the 400 metre area were built prior to 1960, 52.1% of houses in the 800 metre area and 67.2% of houses in the 1600 metre area. In addition, results from the asbestos sampling programme suggested that only a proportion of the pre-1960 houses in each of the areas were likely to contain any asbestos fibres. It was estimated that 47% of residents of the pre-1960 housing in the 400 metre area, excluding the Aviary's estate, and 37% of residents of pre-1960 housing in the 800 metre and 1600 metre areas may live in houses with some traces of asbestos contamination. Dispersion modelling of the geographical spread of potential asbestos exposure showed that any risks were likely to be similar throughout each of the identified areas.

Based on these proportions, Table 7.2 shows the estimated population with potential residential exposure to asbestos in each of the three areas, classified by age and sex. For example, in the 400m area 27.6% of houses were built prior to 1960 and 47% of these houses were judged to have potential asbestos contamination. The population at risk in the 400m area was therefore calculated as 0.276 x 0.47 = 0.129 (i.e. 13%) of the total population in that area.

Table 7.2 Distribution of potentially exposed study population by age group, sex and residential area

Age Group	Males 400 metre	800 metre	1600 metre	Females 400 metre	800 metre	1600 metre
<10	24	43	474	20	37	455
10-19	17	31	398	15	27	388
20-29	33	60	866	34	63	875
30-39	22	41	513	20	37	487
40-49	17	30	352	16	28	351
50-59	17	31	318	15	28	322
60-69	16	29	296	17	31	308
70-79	12	21	174	22	40	277
80+	4	8	68	10	18	185
Total	162	294	3459	169	309	3648

7.3 EXPOSURE ESTIMATION

Exposure to asbestos fibres was estimated by age, sex and residential area (400 metre, 800 metre, 1600 metre). Average annual exposure concentration comprised four separate sources:

- background asbestos exposure;
- exposure due to work in roof voids, i.e. loft areas;
- exposure due to carrying out DIY work ('active' DIY exposure) and
- exposure due to living in a house in which DIY work was carried out ('passive' DIY exposure).

The effect of the different sources of exposure is additive so that, for each age and sex, risk of mesothelioma from relevant sources was added together to estimate total mesothelioma risk.

Time-weighted exposures were calculated to provide estimates of the concentrations of asbestos experienced from each source on average over each calendar year. For example, it was estimated that someone carrying out frequent loft work would do so for a total of 3.5 hours per year, and would be exposed to a concentration of 0.0005 fibres/ml (in the 1600 metre area). Average total number of hours in a year (adjusted for leap years) is 8766 hours. The time-weighted annual average concentration for these individuals would therefore be 3.5/8766 * 0.0005 fibres/ml = 1.996 x 10^{-7} fibres/ml.

Annual average concentrations are summarised in Table 7.3 by residential area and source, separately for men and women. These average annual concentrations are based on the concentrations of asbestos estimated for each source in each residential area as described earlier, and the average amounts of time spent exposed to each source during each year (summarised in Table 7.4, below). Exposure levels for men and women, and between different age groups differed due to lifestyle differences; whereby children and older individuals were not actively exposed due to carrying out loft and DIY work and women tended to carry out less loft and DIY work than men. Background and passive asbestos exposure due to DIY work was assumed to be the same for men and women of all ages.

Table 7.3 Annual average concentration (fibres/ml) by source of exposure and residential area

Source of exposure	Residential Area 400 metre	800 metre	1600 metre
Background	1.000×10^{-5}	1.000×10^{-5}	5.000×10^{-6}
Loft work (occasional)			
Males	5.704×10^{-8}	5.704×10^{-8}	2.852×10^{-8}
Females	3.765×10^{-8}	3.765×10^{-8}	1.882×10^{-8}
Loft work (frequent)			
Males	3.993×10^{-7}	3.993×10^{-7}	1.996×10^{-7}
DIY work (occasional)			
Males	8.556×10^{-6}	8.556×10^{-6}	4.278×10^{-6}
Females	1.141×10^{-5}	1.141×10^{-5}	5.704×10^{-6}
DIY work (frequent)			
Males	1.939×10^{-4}	1.939×10^{-4}	9.697×10^{-5}
DIY work ('passive')			
By householder	1.678×10^{-3}	1.678×10^{-3}	9.043×10^{-4}
By tradesman	1.253×10^{-4}	1.253×10^{-4}	1.253×10^{-4}

'Passive' exposure to asbestos from relevant DIY work was calculated assuming that the occurrence of major DIY would generate dust throughout the property, with exposure to all in the household. The level of dust would decline rapidly in the few days following DIY work, and then gradually return to background levels over the following months. In the calculation of annual average exposures, we have assumed that the levels of dust generated decrease exponentially to a tenth of their original level three days after the DIY work took place, and then decrease exponentially from 10% of the original level to the background level over the next year. Two types of 'passive' DIY have been estimated, that caused by the householder carrying out the DIY work, and that caused by a tradesman specially trained to deal with asbestos contaminated houses carrying out the work. It has been assumed that the level of exposure caused by a tradesman would be much lower than that caused by the householder, due to his expertise and tendency to work more cleanly. It can be seen from Table 7.3 that 'passive' DIY exposure is the largest contributor to total exposure and hence to the estimation of mesothelioma risk.

Table 7.4 Estimates of the proportion of individuals by age group and sex carrying out loft work and 'active' DIY work, plus number of hours per year spent carrying out such work

	Loft work				'Active' DIY work			
	Occasional		Frequent		Occasional		Frequent	
	%	hours	%	hours	%	hours	%	hours
Males: 0-17	0	-	0	-	0	-	0	-
Males: 18-70	60	0.5	15	3.5	45	0.75	15	17
Males: 71+	0	-	0	-	0	-	0	-
Females: 0-17	0	-	0	-	0	-	0	-
Females: 18-70	20	0.33	0	-	10	1.00	0	-
Females: 71+	0	-	0	-	0	-	0	-

7.4 METHODS USED TO ESTIMATE THE RISK OF MESOTHELIOMA

7.4.1 Association between mesothelioma risk, time and dose

Research into the risks of mesothelioma associated with exposure to asbestos fibres has concentrated almost exclusively on occupational rather than environmental asbestos exposure. A comprehensive review of the most important studies has been published by Hodgson and Darnton (2000). Most researchers agree that there is a positive exposure-response curve for mesothelioma (Hillerdal, 1999) with the risk of mesothelioma increasing as asbestos exposure increases. The risks of mesothelioma incidence are considered to be equivalent to those for mesothelioma mortality, as the disease is incurable and usually fatal within months of diagnosis.

Peto *et al* (1982) showed that the incidence of mesothelioma was dependent on time since first exposure, but did not depend on age at first exposure nor on smoking habit or sex; the same relationship being noted by others including Schneiderman *et al* (1981). Incidence of mesothelioma was found to be proportional to a power of time since first exposure, in the form:

$$I_M(t,f) = k \cdot f \cdot (t - t_1)^n \qquad \text{equation 7.1}$$

where: $I_M(t,f)$ = mesothelioma incidence at time 't' and concentration 'f'

k = constant: reflecting the mesothelioma risk per unit of exposure

f = asbestos exposure level (measured in fibres per unit volume of air)

$(t - t_1)$ = time since first exposure

n = constant: reflecting the power to which $(t - t_1)$ is raised

The equation contains two constants 'k' and 'n' which vary across epidemiological studies and between exposures to asbestos of different types (see below).

Equation 7.1 is a reasonable representation of the cumulative incidence of mesothelioma for continuous exposure to a constant concentration of asbestos. However, for the case where exposure is not continuous, equation 7.1 can be modified as follows:

$$I_M(t,f) = k \cdot f \cdot [(t - t_1)^n - (t - t_2)^n] \qquad \text{equation 7.2}$$

where $(t - t_2)$ is time since exposure stopped. This model implies that the risk of mesothelioma will continue to increase after exposure ends. It has also been suggested that the model should be fitted with a lag of around 10 years, to allow for the latency of disease development after exposure. This results in a revised form of equation 7.2:

$$I_M(t,f) = k \cdot f \cdot [(t - t_1 - 10)^n - (t - t_2 - 10)^n] \qquad \text{equation 7.3}$$

This formula has been used in the estimation of possible future mesothelioma risks in the current study.

As we have noted the estimated values of ‘k’ and ‘n’ vary between epidemiological studies. Results from four occupational studies, summarised by the Health Effects Institute (1991) gave three similar values of ‘k’ ranging from 1.0×10^{-8} to 3×10^{-8}, with the fourth study much higher at 1.2×10^{-7}; although Health Effects Institute report notes that there were weaknesses in all four studies reported (particularly for assessing the effects of chrysotile) due mainly to limited or unreliable exposure data. A study of the environmental effects of chrysotile asbestos used $k = 0.04 \times 10^{-8}$ (Chang *et al*, 1999), with $n = 3.2$. In the current study we have chosen $k = 1.5 \times 10^{-8}$, which is at the lower end of the ranges reported, as we consider it better reflects the types of asbestos fibre found in the Wider Area; we have also examined the effect on our estimates of using different values of k (section 7.6).

Values of ‘n’ fall typically between 2 and 4, and are generally lower (between 2 and 3) for models including adjustment for latency. Many studies of mesothelioma risk have used values of n of 3.0 or 3.2, while Peto (1982) recommended using an n-value of 3.5 for risk assessment purposes. Because we are adjusting for latency in the current study we have chosen to use $n = 3.0$. Although neither existing data nor biological theory provide very much guidance on the value of ‘n’, its value is very important in the estimation of lifetime mesothelioma risks; therefore we have also examined the effect on our estimates of using different values of ‘n’.

7.4.2 Estimation of possible mesothelioma risks in the study population

The possible future risk of mesothelioma in the study population was calculated on a yearly basis. The potentially exposed population of the area of interest (Table 7.2) was subdivided into single year age groups for men and women, based on information on the age distribution of the area in 5-year age groups from the 1991 Census data provided by the Council. Single year of age and sex-specific all-cause death rates for England and Wales were used to estimate the total numbers of deaths per year for each age and for each sex. Risk of death from mesothelioma was estimated using the formula 7.3, with individual exposure levels for residents of each age and sex (‘f’ in equation 7.3) calculated as described in section 7.4 below. In calculation of the mesothelioma risks it was assumed that exposure started in 2000 and lasted for 20 years. In other words, we were concerned with investigating how best to manage any risk over the next 20 years, up to 2020.

Results from the analysis of the study population in the starting year of 2000 provided total numbers of deaths from all-causes for each age and sex during 2000, and the estimated total number of deaths from mesothelioma for each age and sex. These figures were then used to estimate the study population at the start of 2001. For example, the number of men aged 41 at the start of year 2001 was calculated as the number of men aged 40 in 2000 minus the number of expected deaths (from all causes and from mesothelioma) among men aged 40 during 2000. This process was then repeated to follow the study population through time.

The output from the analyses comprised the estimated expected number of deaths from mesothelioma for each single year of age in each calendar year, following the study population for 100 years. This was done to follow the group through its lifetime, i.e. until the death of all those aged less than 1 at the start of the follow-up in 2000. We therefore have estimated the lifetime risk from the 20-year exposure period we have investigated.

Possible future risks of mesothelioma in the study population were calculated under two scenarios. The first scenario assumed normal occupation with no intervention or additional precautionary measures. This implied that, within each year, all individuals in contaminated houses were exposed to the background concentration of asbestos. In addition among those aged 18-70, 60% of men and 20% of women were exposed to occasional loft work; 15% of men to frequent loft work; 45% of men and 10% of women to occasional DIY work and 15% of men to frequent DIY work. Finally all residents in the 15% of houses where frequent DIY work was done, were exposed to 'passive' DIY concentrations (by householder) over the year. We consider that people such as joiners, builders and other trades employed to do work comparable to the DIY activities would experience the same exposure and hence risks as the householders.

The second scenario involved an intervention strategy whereby householders were advised against carrying out loft and DIY work. It was assumed that there would be no active exposure from loft or DIY work, but that a specially trained tradesman experienced in dealing with asbestos would carry out some 'DIY' work in the 15% of houses where frequent DIY work was usually carried out. All residents of contaminated houses were therefore exposed to background levels of asbestos and 15% were also exposed to 'passive' DIY exposure (by tradesman).

Risks of mesothelioma were calculated separately for residents of the '400 metre', '800 metre' and '1600 metre' areas for each of the two scenarios

7.4.3 Sensitivity analysis

The estimation of risks of mesothelioma depends on a number of assumptions. Levels of exposure to asbestos were estimated from a limited number of samples, values of 'k' and 'n' in the risk equation vary between studies, and estimates of latency time can be as high as 40 or 50 years. The influence of these assumptions on the estimation of mesothelioma risks was examined in two ways. Firstly, the mesothelioma risk equation was re-applied using values of 'k', 'n' at the extremes of those found in previous studies; and the resulting changes in the estimated risks examined. Secondly, a Monte-Carlo simulation procedure was used which examined the effects of varying simultaneously the values of 'k', 'n' and estimated exposure levels and showed which of these had the greatest effect on the outcome value. In these simulations, the parameters were assumed to be from specified statistical distributions (see section 7.6.3 for details).

7.5 ESTIMATION OF POSSIBLE RISK OF MESOTHELIOMA - RESULTS

7.5.1 Presentation of results

Risks of mesothelioma, calculated separately for residents of the '400 metre', '800 metre' and '1600 metre' areas, for each of the two scenarios described in section 7.4 are summarised in Tables 7.5 to 7.10. Each table contains the estimated population in contaminated houses for each age group at the start of the follow-up period (the year 2000), the expected number of deaths from mesothelioma in that population over their lifetime, after adjustment for deaths from other causes, and the lifetime rate of mesothelioma deaths (per thousand).

In interpreting these data it may be helpful to consider the concepts of "acceptable" and "tolerable" risks, which were originally developed for interpreting risks within the nuclear industry (HSE, 1994b) but has also been considered for use with hazardous substances (Topping, 2001). In this scheme a "tolerable" risk of death for a worker is one where, after public consultation, the risk is 1 per 1,000 per year or less. Such risks may be tolerated because of the benefits that accrue from the activity. Tolerable risks for the general public from large industrial sites are consider to be less than 1 per 10,000 per year. Risks are considered to be negligible or "acceptable" at 1 per million per year. In such situations it is generally considered that putting effort into further reducing the risks would be grossly disproportionate to the benefit achieved.

7.5.2 Results - scenario one, no intervention

Tables 7.5 and 7.6 show that lifetime death rates from mesothelioma in the 400 metre and 800 metre areas, excluding the Aviary's estate, were the same (except for small rounding errors), as the estimated exposure levels in these two areas were identical. Overall expected death rates from mesothelioma in these areas, under current exposure conditions, were 3.7 deaths per million for men and 4.1 deaths per million for women. The slightly higher rates for women were due to the age structure of the population, with women living on average longer than men and so having longer to accrue the risk from their asbestos exposure. As expected, the highest death rates were among the under-10 age group, who were exposed earliest in their lives. This is because in the model we have used the risk of mesothelioma increases with time since first exposure and the youngest members of the community therefore have the longest time to accumulate the risk.

Table 7.5 400 metre area: population, expected number of deaths from mesothelioma and rate per 1000 by sex and age group. No intervention.

	Males			Females		
Age Group	**Popn**	**Exp deaths (x 10^3)**	**Rate/'000**	**Popn**	**Exp deaths (x 10^3)**	**Rate/'000**
<10	24	0.311	0.0130	20	0.320	0.0160
10-19	17	0.122	0.0072	15	0.140	0.0093
20-29	33	0.118	0.0036	34	0.169	0.0050
30-39	22	0.036	0.0016	20	0.048	0.0024
40-49	17	0.009	0.0005	16	0.014	0.0009
50-59	17	0.002	0.0001	15	0.004	0.0003
60-69	16	0.0003	0.00002	17	0.0009	0.00005
70-79	12	0.00002	0.000002	22	0.0001	0.000005
80+	4	0	0	10	0	0
Total	162	0.598	0.0037	169	0.696	0.0041

Table 7.6 800 metre area: population, expected number of deaths from mesothelioma and rate per 1000 by sex and age group. No intervention.

Age Group	Males Popn	Males Exp deaths (x 10^3)	Males Rate/'000	Females Popn	Females Exp deaths (x 10^3)	Females Rate/'000
<10	43	0.565	0.0131	37	0.582	0.0157
10-19	31	0.222	0.0072	27	0.253	0.0094
20-29	60	0.214	0.0036	63	0.307	0.0049
30-39	41	0.066	0.0016	37	0.087	0.0024
40-49	30	0.017	0.0006	28	0.026	0.0009
50-59	31	0.004	0.0001	28	0.007	0.0003
60-69	29	0.0006	0.00002	31	0.002	0.00006
70-79	21	0.00004	0.000002	40	0.0002	0.000005
80+	8	0	0	18	0	0
Total	294	1.089	0.0037	309	1.264	0.0041

Estimated lifetime death rates from mesothelioma under current conditions in the 1600 metre area (Table 7.7) were approximately half those in the 400 metre and 800 metre areas, as estimated exposures levels were half as high. Overall mesothelioma death rates were 2 deaths per million for men, and 2.4 deaths per million for women.

Table 7.7 1600 metre area: population, expected number of deaths from mesothelioma and rate per 1000 by sex and age group. No intervention.

Age Group	Males Popn	Males Exp deaths (x 10^{-3})	Males Rate/'000	Females Popn	Females Exp deaths (x 10^{-3})	Females Rate/'000
<10	474	3.295	0.0070	455	3.807	0.0084
10-19	398	1.522	0.0038	388	1.892	0.0049
20-29	866	1.688	0.0019	875	2.337	0.0027
30-39	513	0.434	0.0008	487	0.617	0.0013
40-49	352	0.103	0.0003	351	0.172	0.0005
50-59	318	0.022	0.00007	322	0.044	0.0001
60-69	296	0.003	0.00001	308	0.009	0.00003
70-79	174	0.0002	0.000001	277	0.0009	0.000003
80+	68	0	0	185	0.00002	0.0000001
Total	3459	7.067	0.0020	3648	8.879	0.0024

7.5.3 Results - scenario two, DIY intervention

Under the second scenario whereby residents did not carry out any loft or DIY work themselves, the lifetime risks of death from mesothelioma, in the 400 metre and 800 metre areas, were around a tenth of those estimated under current exposure conditions. The estimated overall death rate was 0.4 per million for men and 0.5 per million for women (Tables 7.8 and 7.9).

Table 7.8 400 metre area: population, expected number of deaths from mesothelioma and rate per 1000 by sex and age group. DIY intervention.

	Males			Females		
Age Group	**Popn**	**Exp deaths (x 10^{-3})**	**Rate/'000**	**Popn**	**Exp deaths (x 10^{-3})**	**Rate/'000**
<10	24	0.032	0.0013	20	0.035	0.0018
10-19	17	0.013	0.0008	15	0.015	0.0010
20-29	33	0.012	0.0004	34	0.019	0.0006
30-39	22	0.004	0.0002	20	0.005	0.0003
40-49	17	0.001	0.00006	16	0.002	0.0001
50-59	17	0.0002	0.00001	15	0.0004	0.00003
60-69	16	0.00004	0.000002	17	0.0001	0.000006
70-79	12	0	0	22	0.00001	0.0000005
80+	4	0	0	10	0	0
Total	162	0.062	0.0004	169	0.077	0.0005

Table 7.9 800 metre area: population, expected number of deaths from mesothelioma and rate per 1000 by sex and age group. DIY intervention.

	Males			Females		
Age Group	**Popn**	**Exp deaths (x 10^{-3})**	**Rate/'000**	**Popn**	**Exp deaths (x 10^{-3})**	**Rate/'000**
<10	43	0.058	0.0013	37	0.064	0.0017
10-19	31	0.023	0.0007	27	0.028	0.0010
20-29	60	0.022	0.0004	63	0.034	0.0005
30-39	41	0.007	0.0002	37	0.010	0.0003
40-49	30	0.002	0.00007	28	0.003	0.0001
50-59	31	0.0004	0.00001	28	0.0008	0.00003
60-69	29	0.00007	0.000002	31	0.0002	0.000006
70-79	21	0	0	40	0.00002	0.0000005
80+	8	0	0	18	0	0
Total	294	0.112	0.0004	309	0.140	0.0005

In the 1600 metre area, rates were also reduced under the intervention scenario, though by a smaller factor than in the 400 metre and 800 metre areas. The reduction in exposure caused by having a tradesman carry out the DIY work was less in this area than for the other areas, resulting in the smaller (though still substantial) reduction in death rates, to around a sixth of those under current exposure conditions. Overall lifetime mesothelioma death rates were 0.3 per million men and 0.4 per million women (Table 7.10).

Table 7.10 1600 metre area: population, expected number of deaths from mesothelioma and rate per 1000 by sex and age group. DIY intervention.

	Males			Females		
Age Group	**Popn**	**Exp deaths (x 10^{-3})**	**Rate/'000**	**Popn**	**Exp deaths (x 10^{-3})**	**Rate/'000**
<10	474	0.522	0.0011	455	0.643	0.0014
10-19	398	0.243	0.0006	388	0.320	0.0008
20-29	866	0.273	0.0003	875	0.395	0.0005
30-39	513	0.071	0.0001	487	0.104	0.0002
40-49	352	0.017	0.00005	351	0.029	0.00008
50-59	318	0.004	0.00001	322	0.008	0.00002
60-69	296	0.0006	0.000002	308	0.001	0.000003
70-79	174	0.00003	0.0000002	277	0.0001	0.0000004
80+	68	0	0	185	0	0
Total	3459	1.131	0.0003	3648	1.500	0.0004

7.6 SENSITIVITY ANALYSIS

7.6.1 Background

The equation used for the calculation of mesothelioma risks (equation 7.3) contained two constants 'k' and 'n':

$$I_M(t,f) = k \cdot f \cdot [(t - t_1 - 10)^n - (t - t_2 - 10)^n]$$

and included an estimate of the annual average exposure to asbestos ('f'). As described in section 7.3.1, estimates of the constants vary across epidemiological studies, and there will be variation in the exposure estimation. In the main analyses for the current study reported above, we have used the values for these variables which were most relevant to the current conditions in the study area.

We now consider the effects on the risk estimates of using different values of 'k' and 'n' and adjusting for variation in exposure levels - firstly by re-calculating the risk estimates substituting specific values for the constants (section 7.6.2), and secondly using Monte-Carlo simulation methods to examine the effects of simultaneously varying both 'k' and 'n' and also investigating the effects of variation in the exposures (section 7.6.3).

7.6.2 Effect of changes in the values of 'k' and 'n'

The constant 'k' in equation 7.3 is a multiplicative factor representing the risk per unit of asbestos exposure. Changes in the value of 'k' therefore have the effect of multiplying the risk estimates by a constant amount (e.g. a doubling of the value of 'k' results in a doubling of the resulting mesothelioma risk estimates). Results from epidemiological studies suggest that the value of 'k' is likely to lie between 1.0×10^{-8} and 3.0×10^{-8}. Use of the higher of these values in the current study would imply possible mesothelioma risks, under current conditions, of 7.4 deaths per million men and 8.2 deaths per million women in the 400 metre and 800 metre areas; and 4 deaths per million men and 4.8 deaths per million women in the 1600 metre area. The total number of expected deaths from mesothelioma in the study area would be less than 0.04.

Changes in the value of 'n' have a greater effect on the estimation of the risk of mesothelioma. Results from epidemiological studies have suggested that for models including adjustment for latency, values of 'n' typically lie between 2 and 3; for models without adjustment for latency 'n' lies between 3 and 4. In the current study we have used set the value of 'n' equal to 3; Table 7.11 summarises the effects on the risk estimates if 'n' was as high as 3.5. Results are reported for individuals who were first exposed to asbestos before the age of 40, as it is among these that most deaths are likely to occur.

It can be seen from this table that increasing the value of 'n' from 3.0 to 3.5 results in an increase in the expected number of deaths from mesothelioma by a factor of around seven. Even with an increase of this magnitude, the total number of expected deaths in the study group, across all ages and areas, would be less than one (i.e. we expect 0.15 additional deaths). If we assume high values for both 'n' (= 3.5) and 'k' (= 3.0×10^{-8}), the total number of expected deaths from mesothelioma in the area, assuming no intervention, would be less than 0.3.

Table 7.11 Expected lifetime number of deaths (x 10^3) from mesothelioma by age at first exposure, sex and residential area for n = 3.0 and n = 3.5. No intervention.

		Expected number of deaths (x 10^3)				
Area: sex	**n**	**<10**	**10-19**	**20-29**	**30-39**	**Total**
400m: men	3.0	0.311	0.122	0.118	0.036	0.587
	3.5	2.369	0.855	0.750	0.209	4.183
400m: women	3.0	0.320	0.140	0.169	0.048	0.677
	3.5	2.543	1.026	1.139	0.295	5.003
800m: men	3.0	0.565	0.222	0.214	0.066	1.067
	3.5	4.302	1.553	1.363	0.380	7.598
800m: women	3.0	0.582	0.253	0.307	0.087	1.229
	3.5	4.618	1.863	2.069	0.535	9.085
1600m: men	3.0	3.295	1.522	1.688	0.434	6.939
	3.5	25.070	10.660	10.810	2.508	49.048
1600m: women	3.0	3.807	1.892	2.337	0.617	8.653
	3.5	30.180	13.880	15.770	3.776	63.606

7.6.3 Monte-Carlo sensitivity analysis

The previous section showed the effect of setting ‘n’ and of ‘k’ to specified values and examining their effect on the risk estimates for mesothelioma. A more general methodology has also been used which assumes that the values of ‘n’, ‘k’ and of the exposure levels are from specified statistical distributions. A simulation programme has been performed, which calculates the mesothelioma risk many times, each time taking values of ‘n’, ‘k’ and exposure level randomly generated from the specified distributions. The result of the simulation programme is a distribution of estimated values for the possible risk of mesothelioma, calculated using the different values of ‘n’, ‘k’ and exposure. By examining the effect on our study population of mesothelioma risks towards the upper end of this resulting distribution, we can estimate ‘worst-case’ numbers of mesothelioma deaths.

In the results given below, we have assumed that ‘n’ and ‘k’ are from a triangular distribution centred around the values 3 and 1.5 x 10^{-8} respectively (the ‘best’ estimate values used in our main analysis). Exposures have been assumed to be log-normally distributed, around a geometric mean value of the exposures given in Table 7.3. Five thousand simulations were run, and the 90th percentile of the resulting distribution of estimated mesothelioma risks (the value below which 90% of the estimates lie) was used to calculate expected numbers of mesothelioma deaths in the study population.

Results from this analysis provided results higher than those reported in Tables 7.5 to 7.10 by a factor of around 20. Assuming no change to current practices, the estimated total number of mesothelioma deaths in the study area was 0.41, a rate of 51.3 per million. As before around half the deaths (0.193) were expected to occur among those aged less than 10 at first exposure to asbestos. If the council implement an intervention policy, and home improvements are carried out by a professional tradesman rather than the householder, then the expected number of deaths under this 'worst-case' scenario would be 0.056, a rate of 7.03 per million exposed.

7.7 LUNG CANCER RISKS

We have estimated in detail the risks of mesothelioma arising from environmental exposure to asbestos, using mesothelioma as a sentinel health outcome that is almost exclusively associated with asbestos exposure. However, exposure to asbestos can also increase the risk of lung cancer among an exposed population. In this section, for comparison, we have made some approximate estimates of the increase in lifetime risk of lung cancer associated with 20 years of exposure to asbestos at levels typical of those experienced by the study population.

These estimates are less precise than those for mesothelioma for a number of reasons, outlined in section 7.1. In particular, statistical models for the association between asbestos exposure and lung cancer are expressed in terms of relative risk (i.e. the risk of lung cancer among a population exposed to asbestos is expressed as a proportional increase of the risk among a similar unexposed population). It can be difficult to find suitable data on lung cancer risk among such an unexposed population, which ideally would have similar smoking and lifestyle habits to the study population.

In the calculations below, we have used estimates of the lifetime risk of lung cancer that are based on the 1996 estimated lifetime risks for males (8%) and females (4.3%) in the UK. However, because lung cancer rates in the Northern and Yorkshire area are higher than elsewhere in England and Wales, we have used estimated lifetime risks of death from lung cancer of 9% for males and 5% for females.

Lifetime risks of lung cancer are not available separately for smokers and non-smokers. However, we have assumed that the lifetime risk in 1996 was based on a population where 75% of adults aged 16 or over were smokers. The risk of lung cancer is substantially higher among smokers than non-smokers. If we assume that smokers are 10 times as likely as non-smokers to be diagnosed with lung cancer, then we can estimate that for men, the lifetime risk of lung cancer among smokers is approximately 12% and among non-smokers is 1.2%. For women the lifetime risk among smokers is estimated to be 6.5% and among non-smokers to be 0.6%

It is normally assumed that the lifetime risk of lung cancer for an asbestos exposed population increases in proportion to the cumulative exposure to asbestos (calculated as average concentration of asbestos multiplied by duration of exposure), using an equation of the form:

$$I_A = I_U \,.\, (1 + K_L \,.\, f \,.\, d) \qquad \text{equation 7.4}$$

where I_A = mortality risk in asbestos exposed population

I_U = mortality risk in non-exposed population

K_L = constant

f = average concentration of asbestos (fibres/ml)

d = duration of exposure (years)

The constant K_L represents the increase in risk per unit asbestos exposure and typically ranges from around 0.0005 to 0.05, with an average value of around 0.01. As an example, if we take a population exposed to asbestos at a concentration of 0.1 fibres/ml for 10 years, with K_L = 0.01, then equation 7.4 becomes:

$$I_A = I_U.(1 + 0.01 \times 0.1 \times 10)$$

$$I_A = I_U.(1.01)$$

This shows that the lung cancer risk in the exposed population is 1% higher than in the unexposed population. Clearly the magnitude of such an increase in terms of additional numbers of deaths depends on the underlying risk of lung cancer in the unexposed population.

Equation 7.4 assumes that the relative risk for lung cancer among individuals exposed to asbestos is independent of age at first exposure, gender and smoking habit. Recent studies (Liddell, 2001) suggest that the relative risk may be higher among non-smokers than among smokers, by a factor of around two (i.e. the relative risk for non-smokers may be twice as high as that for smokers), although because of the very low risk of lung cancer in non-smokers the difference in the number of expected cases of lung cancer would be small (HEI, 1991). The calculations below assume that the risks are the same in the two smoking groups.

Table 7.12 shows the estimated increase in lifetime lung cancer risk for non-smokers and for smokers, and for comparison estimated lifetime risks for mesothelioma. Risks for mesothelioma are presented for individuals aged 0, 10, 20, 30 and 50 at first exposure. Lifetime risks are calculated for exposure to asbestos at a concentration of 0.00001 fibres/ml for 20 years. The risks are directly proportional to the concentration of asbestos (e.g. exposure to asbestos at a concentration of 0.0001 fibres/ml for 20 years would result in a lifetime risk increased by a factor of 10).

Table 7.12 Estimated increase in lifetime risk (x 10^6) of lung cancer and mesothelioma due to asbestos exposure at 0.00001 f/ml for 20 years duration.

		Males	Females
Lung cancer			
	non-smokers	0.024	0.013
	Smokers	0.240	0.130
Mesothelioma			
age	0 yrs	0.571	0.725
at	10 yrs	0.337	0.441
first	20 yrs	0.179	0.286
exposure	30 yrs	0.083	0.109
	50 yrs	0.009	0.014

These estimates show that the mesothelioma risk exceeds the lung cancer risk, even among smokers, for childhood exposure to asbestos. For smokers (around 30% of the current population) lung cancer risk is higher than mesothelioma risk for individuals whose age at first exposure was above 20 (for men) or above 30 (for women). For the 70% of the population who are non-smokers the risk of mesothelioma exceeds that of lung cancer for all except those first exposed to asbestos aged around 50 or more, where the risks of mesothelioma are very small.

8. REVIEW OF THE LEEDS CITY COUNCIL ASBESTOS MANAGEMENT PROCEDURES FOR DOMESTIC PROPERTIES IN THE WIDER AREA

8.1 LEGISLATION

There is extensive legislation to ensure that people who are exposed to asbestos as part of their work are protected and that the risks to members of the general public or householders in premises where workmen are disturbing asbestos contamination are controlled. However, none of this legislation affects people being exposed in their own homes, either as part of their normal routine or in doing home improvement work. The following sections outline the key points of the relevant legislation.

8.1.1 Health and Safety at Work etc. Act 1974

Under health and safety legislation (Health and Safety at Work etc. Act 1974, Sections 2 and 3), employers are responsible for the activities of all persons on their premises, whether they are employees or not. In the context of asbestos, it is our opinion that this implies that commercial and industrial property owners are required to identify areas where asbestos is present and advise contractors working in these premises accordingly. There is no obligation on domestic property owners to provide such advice to contractors. In this context, the term “contractor” includes any tradesman working on the premises and not just someone undertaking work where they are expected to encounter asbestos contamination. Any contractor working on the site will also have duties towards themselves and their staff under Sections 2 and 3 of the Health and Safety at Work Act.

8.1.2 Management of Health and Safety at Work Regulations 1999

Under Regulation 3 of the Management of Health and Safety at Work Regulations, every employer shall make a suitable and sufficient assessment of the risks to the health and safety of his employees to which they are exposed whilst they are at work. This obligation is imposed on the Council and contractors who may have employees working in homes where there is any type of occupational hazard present, including the presence of asbestos contamination within the building.

8.1.3 Control of Asbestos at Work Regulations 1987

The Control of Asbestos at Work Regulations apply to all situations where work is carried out on asbestos containing materials that may expose an employer's workers or people not in his employ to asbestos. Under Regulation 8 of these regulations, every employer shall prevent the exposure of his employees to asbestos. Where it is not reasonably practicable to prevent such exposure, the level of asbestos in air must be reduced to the lowest level reasonably practicable by measures other than the use of respiratory protective equipment.

There is a requirement that before work commences where someone may be exposed to asbestos an employer must identify the type of asbestos involved with the work, or assume that there is asbestos present and that it is not chrysotile asbestos (Regulation 4). Employers whose employees may carry out work that could expose them to asbestos must also identify the magnitude of exposure and set out steps to prevent or reduce that exposure to the lowest level reasonably practicable (Regulation 5). These steps should be set out in a written plan (Regulation 5A) and must be followed (Regulations 8, 9 and 10).

The regulations also require that where asbestos is disturbed as part of work that the employer takes steps to prevent or, if this is not possible, minimise to the lowest level reasonably practicable, the spread of asbestos away from the work activity. If the exposure to asbestos is likely to exceed half the relevant occupational limit for fibres in air[4], averaged over a 12-week period, the area must be designated as an “asbestos area”. If the asbestos exposure could exceed the limit value than the area must be designated as a “respirator zone” and anyone entering that area must wear adequate respiratory protection.

8.1.4 Proposed changes to the Control of Asbestos at Work Regulations

The Health and Safety Commission have published proposals to amend the Control of Asbestos at Work Regulations, focusing on requirements on employers to identify and record the location of asbestos in non-domestic premises. Nothing in these proposed amendments applies to domestic premises, although there will be further public consultation on this matter.

8.2 LEEDS CITY COUNCIL POLICY AND PROCEDURES FOR HOUSES IN THE WIDER AREA, EXCLUDING THE AVIARY ESTATE

The current Council policy, developed from the Aviary's estate, covers property owners who apply for grants, planning permission subject to a legal notice requiring remedial building works to be monitored or who seek Council advice generally. After an application has been made, the current Testing Protocol, also developed from the Aviary's estate, is implemented to determine the presence of asbestos. This approach has been extended to include houses in the Wider Area. Copies of both the policy and the testing protocol are included in the Appendix 3.

The Testing Protocol gives guidance on the sampling strategy to be adopted in the various parts of the property including roof/ceiling voids, sub-floor voids and sash windows. In the roof voids, dust and debris samples are to be collected from the eaves wall area, the top of the wall between the roof and the wall, and immediately below the wall on the floor/ceiling. It is advised that a number of small samples around each area are collected, with a minimum of two, but preferably three samples. In the weight boxes associated with original sash windows or replacement casement insert windows, a dust and debris sample should be collected from both sides of the window. In sub-floor voids, samples of dust and debris should be collected in close proximity to the outside walls, i.e. up to 300mm. No indication is given as to the number of samples to be collected as a minimum, but it is inferred that a number of samples are collected in preference to one combined sample. Where a dormer window has been fitted, the renovation work may have resulted in the spread of asbestos or sealed it in. According to the protocol the area involved should be sampled representatively. Where the property has a cellar, dust and debris samples should be collected from windows, former coal chutes, air grates and original ceilings. The samples should be collected as close as possible to the external walls. Any sub-floor void areas filled with rubble should also be sampled. Where there are deposits of “black” dust on walls or ledges these should be sampled as a combined sample. Having regard to the particular local circumstances and history of asbestos manufacturing and processing, which predominantly ceased approximately 50 years ago, care is taken to ensure that samples are taken from below the surface of any dust layer in order that they are representative of the period when environmental contamination would have been at its most active.

The technique recommended for analysis of samples is the standard method developed by the Health and Safety Executive (HSE, 1994a). This method uses low power optical microscopy to identify fibres in the material collected and then higher magnification polarised light microscopy to identify the type of asbestos. We understand that the method is applied in a very diligent manner by the analyst used by the Council, making the technique very sensitive.

[4] For amosite and crocidolite 0.2 fibres/ml and for chrysotile 0.3 fibres/ml, both averaged over a four-hour period. There are also short-term limits for 10-minute periods of 0.6 fibres /ml and 0.9 fibres/ml for amosite or crocidolite and chrysotile, respectively.

If asbestos is detected, the property owner is required to obtain estimates for the subsequent removal of the asbestos under controlled conditions by an asbestos removal contractor licensed by the Health and Safety Executive.

8.3 EVALUATION OF THE COUNCIL POLICY IN RELATION TO LEGAL REQUIREMENTS AND BEST PRACTICE

We consider that Council policy should reflect the likely degree of risk in respect of the amount of asbestos present and, as necessary, include a Code of Practice for working in the different areas within Armley. Although the current and proposed asbestos health and safety legislation does not cover people in their own homes, it does affect any contractor and his employees working on their property. The precautions to be taken should take into account what is reasonably practicable in terms of cost and the resultant benefit in respect of the reduction of the risk.

To that extent, a contractor planning work in peoples' houses is required to make an assessment of the risks in a property before undertaking any work where their staff were likely to be exposed to asbestos. The assessment should take in to account:

- the type of work and its location;
- expected exposures;
- number of operatives;
- frequency and duration of exposure;
- control of exposure;
- waste removal/disposal and
- any other occupational hazards.

Given that the sampling survey has shown the presence of only trace amounts of asbestos in the properties in the Wider Area and low fibre concentrations in the air samples collected, we consider it is unlikely that either the asbestos Control Limits or Action Levels would be exceeded. The presence of other hazards such as soot, pigeon droppings or other hazardous substances may present a greater risk to health.

Although personal protective equipment should be regarded as the last line of defence, it would be generally advised as accepted good practice that respiratory protection be worn during any alteration work where exposure to hazardous materials or high airborne dust concentrations are to be expected. This would afford protection from all airborne particulate material, not just asbestos and particularly for contractors who more routinely undertake this type of “dirty” work and who have obligations under health and safety legislation.

We consider that the techniques used to analyse samples collected from houses in the Wider Area, which are based on the method recommended by the Health and Safety Executive, are overly sensitive and identify asbestos in situations where it is very unlikely to represent a risk to the occupants or others working within the house. We recommend that the Health and Safety Executive, the Department of Transport, Local Government and the Regions, the Environment Agency and other interested parties should review these procedures with the objective of making the detection of asbestos in loose dust in buildings better reflect the likely risks to people in these properties.

In view of the very low additional risk associated with the historical environmental contamination, and the obligations on contractors to ensure that they comply with the general duties under health and safety legislation whenever undertaking building work, we have concluded that there is no reason for any additional proactive action specifically in the Wider Area. There is no justification, therefore, that properties within this area of Leeds should be subject to routine bulk sampling and analysis to detect the presence of asbestos fibres in building voids, nor that disturbance work or refurbishment involving void areas is undertaken under controlled conditions. It is our view that any waste material incorporating settled dust from building voids in the Wider Area would not normally be subject to any special waste disposal procedures, particularly as in this study we have not been able to identify any asbestos in samples of settled dust. Contractors will, however, remain under a general legal duty to consider the particular circumstances in each individual case and should develop appropriate work plans to minimise the risks to workers and others who may be affected by the work. This also applies to building materials or installed products that may contain asbestos.

9. GENERAL DISCUSSION

This study has focused on the area of West Leeds around the former Roberts asbestos factory, excluding the Aviary's estate where it has been recognised for some time that there is a problem with loose asbestos contamination in the houses (we refer to this are as the “Wider Area”). In our work we have drawn upon the experience from the Aviary's to inform the decisions we have made about the likely exposure to asbestos when contamination is disturbed. However, in the course of this work it has become clear that the degree and extent of asbestos contamination is greater in the Aviary's than in other areas within Armley that are similarly close to the old JW Roberts asbestos factory. We cannot explain why there is a difference between these areas but we are sure that the potential for exposure to asbestos are greater for most people living in the Aviary's compared to someone in the Wider Area. Based on this study we cannot say whether the risks for people living in the Aviary’s are significant and we suggest that further investigation of these issues should be considered.

The background asbestos exposure levels measured in homes in the Wider Area were all below the detection limit of the very sensitive electron microscope technique we used. Combining together all of the measurements we estimate that the maximum possible asbestos exposure level in such circumstances would be 0.00001 fibres/ml. A recent report from the Medical Research Council Institute for Environment and Health suggested that in buildings where there was asbestos containing products in good condition the exposure levels were generally less than 0.0005 fibres/ml and outdoors in the centre of cities the concentration may be up to 0.0001 fibres/ml (IEH, 1997). The levels in the homes in the Wider Area are therefore much lower than may be found in many other buildings in the UK containing asbestos products.

Results from the estimation of risk of mesothelioma, using our best estimates for the exposure and risk model parameters, show that for a further 20 years exposure to current conditions a total of 0.02 deaths would be expected in the study population over their lifetime, assuming no intervention from the Council. This is equivalent to an overall lifetime death rate of 2.5 deaths per million, with the rate slightly higher among women than men and higher among those first exposed to asbestos at an early age. Risks of this magnitude are insignificant, probably more than a thousand times less than the threshold of one death per ten thousand per year that is considered as “tolerable” in the context of other non-occupational risk assessments and about twenty times lower than the level often considered “acceptable”. Even the highest lifetime risk estimates of 16 deaths per million (for female children currently under 10 years of age living in houses within 400 metres and where renovation works are undertaken on a DIY basis or using non-specialist tradespeople) are less than the “acceptable” level of risk of 1 death per million per year. If residents were advised against carrying out work in their lofts and doing home improvement work, the total number of deaths expected would reduce to 0.003; an overall lifetime death rate of 0.4 deaths per million. Again, the highest risk estimates (for female children under age 10) are less than the “acceptable” level of risk.

Asbestos is also know to cause lung cancer, although in this research we have not chosen to predict in detail the likely number of deaths from this cause. Mesothelioma is almost always caused by asbestos exposure, whereas cigarette smoking almost always causes lung cancer. Even when someone is exposed to asbestos, the lung cancer risk associated with the asbestos exposure is still much greater for someone who smokes compared with a non-smoker. We have shown that for non-smokers the estimated mesothelioma risks are almost always greater than the lung cancer risks due to asbestos. For cigarette smokers the asbestos-related lung cancer risks are smaller for young people but greater for older individuals. Overall, we consider that the risk of lung cancer from loose asbestos contamination in the Wider Area is likely to be of a similar order of magnitude to the mesothelioma risks. Therefore we are confident that making decisions about how best to manage the future risks on the basis of the mesothelioma risk calculations will not be misleading and the combined risk from mesothelioma and lung cancer would still be insignificant.

To try to place the predicted mesothelioma risks in perspective we have estimated the number of deaths that might be expected amongst the residents of Armley over the next 20 years from a variety of causes, assuming there is no change from current rates. In this period there could be about 260 deaths from lung cancer, which as we have noted will mostly be due to cigarette smoking and some from inhalation of cigarette smoke from others. There could be about twelve deaths from malignant melanoma of which much will be due to ultraviolet radiation in sunlight. About 140 people in Armley will probably die from accidents in the coming 20 years: perhaps 60 from road accidents with five from fires and a further five from accidental poisonings. Set against these common causes of death the predicted deaths (0.02) from mesothelioma from loose asbestos dust contamination in the Wider Area are clearly not important.

Expected death rates from mesothelioma are higher among residents first exposed to asbestos as children, than among those first exposed at a later age. In the 400 metre and 800 metre areas, expected lifetime death rates for those aged under 10 at first exposure are 13 per million for males and 16 per million for females, assuming no intervention, with rates in the 1600 metre area around half as high. The expected number of deaths in this age group was 0.009, about half of the total number of deaths expected. Under the home improvement intervention scenario, death rates in those first exposed under age 10 reduce to 1.3 per million for men and 1.8 per million for women, with total expected deaths of 0.0014. These risks are still very small and we consider there is no reason to be particularly concerned about the risks to young people in this situation. Also, as we have already indicated, there is only a very remote chance of anyone in the Wider Area dying from an asbestos-related mesothelioma due to fine asbestos contamination in roof voids and other inaccessible area of their homes.

It should be remembered that the main cause of mesothelioma is asbestos exposure amongst those who have worked with asbestos containing materials. It is not just people who have worked in the asbestos manufacturing industry that are at risk but it is those who have worked as plumbers, carpenters, electricians, builders and many other construction or industrial jobs who have an increased risk of death from this form of cancer (Peto *et al*, 1995). Many of those who currently live in the Wider Area will have previously have worked with asbestos, and using the estimates of risk provided by Professor Peto and his co-workers it seems likely that about 50 men who are currently living in the Wider Area will at sometime during the remainder of their life die from mesothelioma as a result of past occupational exposure. The risks are lower for women, but it is possible that a further ten women resident in the Wider Area may die from mesothelioma associated with work activities. These figures far outweigh any possible risks from any future residential exposure in this part of Leeds.

Estimation of mesothelioma risk is based on a formula containing a number of variables, many of which vary between studies. There is also some uncertainty about the level of exposure that residents might actually experience. It is therefore important to consider the effects of the estimates used for these variables on the resulting mesothelioma risk estimates. The three principal factors are the constants 'k', 'n' and exposure level ('f'). The effects of changes in the exposure level and of 'k' on the resulting risk estimates are multiplicative, with the risk of mesothelioma increasing by a constant factor. For example, if the actual exposure levels were three times as high as our estimates, then the resulting mesothelioma risks would also be three times as high.

In the current study, the estimates of the exposure levels for the risk estimates were intentionally set at the higher end of the likely range of actual exposures. This was done as a 'worst-case' scenario such that the estimated risks of mesothelioma should also be at the top end of the possible range. It is very unlikely therefore that the effect of exposure is underestimated in the current study and it is more likely that it is overestimated, thereby presenting a 'worst-case' evaluation to provide a degree of caution. Estimates of 'k' and 'n' in this study were made after review of the literature and were based on the results of occupational epidemiological studies. Values were chosen which were most relevant to the current conditions in the study area, although a sensitivity analysis was carried out to examine the effects of using more extreme values. If both 'k' and 'n' were replaced with values from the top end of their likely range the reported risks of mesothelioma would be increased by a factor of around 15, leading to total expected deaths in the study population of around 0.3. This estimate is based on a very extreme set of assumptions and we are therefore reassured that the predicted number of deaths is still less than one. A less subjective "worst case" estimate of risk is provided by the Monte-Carlo modelling we have undertaken. This showed that allowing the three factors, i.e. 'k', 'n' and 'f', to vary simultaneously over a realistic range of values gave a maximum number of mesothelioma deaths in Armley from exposure to loose asbestos in houses of less than one death after 20 years of exposure, with 90% confidence.

We believe that these risks are sufficiently low that they do not warrant any intervention on the part of Leeds City Council. Further, we are of the opinion that the current policy of the Council is overly cautious in seeking to protect health. It is unnecessary to provide any incentive to residents in the Wider Area to identify asbestos since the vast majority of home improvement work where loose asbestos might be present carries a negligible risk to health. Whenever major refurbishment of a property is to be undertaken, irrespective of location and not confined to the area considered in this research, there could be significant exposure to asbestos from asbestos containing materials installed in the home or other hazardous substances for a short period of time. Work on this scale is normally undertaken by competent workmen, who already have a legal obligation to identify the presence of asbestos or asbestos containing materials and take steps to control exposure from any work activities. This obligation is no different to that applying in any other part of the UK and we suggest that it is sufficient to ensure health risks are appropriately managed. No additional intervention by the Council is considered necessary or appropriate.

In this work we have collected a limited amount of new data about the likely levels of asbestos fibre exposure in homes during disturbance activities and during normal occupation. Where possible, we used transmission electron microscopy to evaluate the samples and we collected the samples over several hours. In every case when we measured in homes where there was no deliberate disturbance of dust that could be contaminated with asbestos we were unable to identify the presence of any asbestos fibres. This gives a great deal of confidence that if there is asbestos present in the air of homes in the Wider Area then the concentration must be very low. This conclusion is only possible using the electron microscope analytical technique; optical microscope analysis, which is satisfactory when there are higher levels of asbestos present, cannot discriminate between asbestos and other fibrous dusts that may be present in the home.

It is well known that the electron microscope tends to produce higher asbestos exposure estimates than optical microscope analysis on comparable samples where only asbestos fibres are present (Cherrie *et al*, 1989). This is because this technique can detect very thin fibres that are invisible on the optical microscope. However, the risk model we have used assumes that the fibre concentrations were measured using optical microscopy. We have not attempted to correct the measurements we have made using transmission electron microscopy to account for this difference. However, if we had made an adjustment it would have further reduced the estimated risks.

Based on expertise built up over a number of years, and following a locally agreed protocol for sampling complemented by diligent analysis in accordance with the method recommended by the Health and Safety Executive (Method MDHS77), the Council's analyst has been able to identify the presence of asbestos more frequently than might otherwise have been expected. In two homes, where previous samples analysed using these methods had identified asbestos we collected further samples of loose dust from locations where we expected to find asbestos contamination. In all cases, no asbestos was found. Most importantly, a methodology whereby highly sensitive detection has the consequence of labelling homes as contaminated with asbestos and triggers decontamination activity, when the houses do not actually present a significant risk to the occupants, is inappropriate. We suggest that the Health and Safety Executive, the Department of Transport, Local Government and the Regions, the Environment Agency and other interested parties should review the procedures and guidance that are used in such circumstances, with the purpose of making the identification of asbestos and resultant action more accurately reflect the risk to building occupants.

In the time since this research was completed the Health and Safety Executive published a mew method for surveying, sampling and assessment of asbestos-containing materials in buildings (known as MDHS100). We recommend that any future review of this method includes reference to the importance of appropriate sampling protocols in such situations where indiscriminate environmental pollution may have contaminated buildings, either recently or historically.

An important conclusion of this report, as suggested above, is that there is no justification in routinely undertaking bulk sampling and analysis for the detection of loose asbestos as a precursor to any works in this area, because of the negligible risk to health posed by any contamination.

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APPENDIX 1 QUESTIONNAIRE TO OBTAIN INFORMATION ABOUT ACTIVITIES THAT MAY HAVE CAUSED DUST TO BE RELEASED INTO THE AIR

Institute of Occupational Medicine

8 Roxburgh Place, Edinburgh EH8 9SU

INFORMATION ABOUT ACTIVITIES THAT MAY CAUSE DUST TO BE RELEASED INTO THE AIR OF YOUR HOME

The Institute of Occupational Medicine is an independent research organisation that has been commissioned by Leeds City Council to investigate the potential risks from fibrous dust exposure. As part of this research we would like to obtain some information about activities you may carry out in your home that could give rise to airborne dust.

1. How often do you or your partner go into the loft in your home to move stored items or do some other activity?

   YOU_________________ each year. PARTNER________________ each year.

2. On average how long would you or your partner spend in your loft on any one occasion?

   YOU_________________ minutes. PARTNER________________ minutes.

3. How often do you or your partner carry out DIY work on your home where you would lift floorboards, remove external windows or doors etc?

   YOU_______________ each 5 years. PARTNER_____________ each 5 years.

4. On average how long would you or your partner spend carrying out such DIY work on any one occasion?

   YOU_________________ minutes. PARTNER________________ minutes.

5. How often would you employ a builder or some other tradesman to undertake the sort of work described in Question 3?

   _________________________ every 5 years.

6. How old is your house?

   _________________________ years.

7. How long have you lived in this house?

   _________________________ years.

8. What is your age?

   _________________________ years.

9. Are you male or female?

   ____

Thank you for your assistance.

JOHN CHERRIE, HEAD OF HUMAN EXPOSURE RESEARCH

APPENDIX 2 SUMMARY OF MEASUREMENTS MADE DURING THIS STUDY

Appendix Table 2.1 Summary of data from high volume background samples analysed by TEM

Type of sample	Address	Location	Date	Concentration of asbestos (fibres/ml)	Comments	Sample Code
Background	Brentwood Grove	Spare bedroom	26/7/00	<0.0005	Normal occupancy	WA1
	Eyres Avenue	Front room	26/7/00	<0.0005	Normal occupancy	WA2
	Wesley Road	Front room	26/7/00	<0.0005	Normal occupancy	WA3
	Christchurch Road	Dining room	26/7/00	<0.0005	Normal occupancy	WA4
	Eyres Avenue	Staircase to attic dormer	15/10/00	<0.0002	Normal occupancy	WA5
	Eyres Avenue	Front room	15/10/00	<0.0003	Normal occupancy	WA6
	Brentwood Grove	Bedroom	28/11/00	<0.0004	Normal occupancy	WA7
	Churchview Terrace	Dormer bedroom – right	28/11/00	<0.0008	Normal occupancy, Calcium sulphate fibres detected	WA8
	Churchview Terrace	Dormer bedroom – left	28/11/00	<0.0006	Normal occupancy, Calcium sulphate fibres detected	WA9
	Laurel Grove	Bedroom	16/1/01	<0.0003	Normal occupancy	WA10
	Laurel Grove	Upstairs bedroom	22/1/01	<0.0004	Normal occupancy	WA11
	Nancroft Mount	Attic	23/1/01	<0.0004	Normal occupancy	WA12
	Oriental Street		23/1/01	<0.0003	Normal occupancy	WA13

Appendix Table 2.2 Summary of data from high volume samples analysed by TEM collected during activities

Type of sample	Address	Location	Date	Concentration of asbestos (fibres/ml)	Comments	Sample code
Removal of Windows	Eyres Avenue	First floor	3/11/00	<0.0009	One amosite asbestos fibre <5 m long found	WA14
	Eyres Avenue	Ground floor	3/11/00	<0.0009	Three amosite asbestos fibres <5 m long found	WA15
After major disturbance	Eyres Avenue	Inside enclosure in attic dormer	19/10/00	<0.0003		WA16
	Eyres Avenue	Inside enclosure by end terrace wall	19/10/00	<0.0003		WA17
	Arley Terrace	Inside enclosure during clean-up	16/1/01	0.17	Three amosite and three chrysotile fibres longer than 5 m were found on this sample	WA18
Constructing enclosure	Churchview Terrace	In enclosure	28/11/00	<0.004		WA19

Appendix Table 2.3 Summary of data from samples analysed by PCOM

Address	Activity	Date	Fibre concentration (fibres/ml)	Analysis method	Comments	Sample code
Eyres Avenue	Personal sample - Removing windows	3/11/00	<0.02	PCOM		WA20
Eyres Avenue	Personal sample - Removing windows	3/11/00	-	PCOM	Uncountable because of non-fibrous dust	WA21
Laurel Grove	Static in upstairs bedroom	16/1/01	0.0002	PCOM *		WA22
Arley Terrace	Static sample - during clean-up	16/1/01	-	PCOM	Uncountable because of non-fibrous dust	WA23
Arley Terrace	Personal sample – during clean-up	16/1/01	<0.4	PCOM		WA24
Arley Terrace	Personal sample – during clean-up	16/1/01	<0.4	PCOM		WA25
Laurel Grove	Static in upstairs bedroom	22/1/01	0.0003	PCOM *		WA26
Nancroft Mount	Static in attic	23/1/01	0.001	PCOM *		WA27
Oriental Street	Static	23/1/01	0.001	PCOM *		WA28

* Note, the method requires concentrations less than 0.01fibres/ml to be reported as this value, although here we quote the calculated fibre concentration

Appendix Table 2.4 Summary of data from personal samples analysed by TEM

Address	Activity	Date	Fibre concentration (fibres/ml)	Analysis method	Comments	Sample code
Arley Terrace	Personal sample - Clean-up after ceiling dropped	12/1/01	<0.2	TEM		WA29
Arley Terrace	Personal sample - Clean-up after ceiling dropped	12/1/01	<0.3	TEM	One amosite asbestos fibre longer than 5 m found on this sample	WA30

Appendix Table 2.5 Summary of results from bulk samples taken in a house in Eyres Avenue

Location	Date	Asbestos types present	Comments	Sample code
Debris from attic loft to dormer bedroom	19/10/00	None detected		WA31
Debris from cavity, interior end wall	19/10/00	None detected		WA32
Debris from cavity, end terrace wall	19/10/00	None detected		WA33
Debris on roof joist inside cavity, end terrace wall	19/10/00	None detected		WA34
Window recess after sash removed	3/11/00	None detected		WA35
Window recess between brick and wood	3/11/00	None detected		WA36
Within first floor vent	3/11/00	None detected		WA37
Within first floor vent	3/11/00	None detected		WA38
Under floor boards in small attic room	3/11/00	None detected		WA39
Under floor boards in large attic room	3/11/00	None detected		WA40

Appendix Table 2.6 Summary of results from bulk samples taken a house in Christchurch View

Location	Date	Asbestos types present	Comments	Sample code
Beneath floor in right dormer bedroom	4/12/00	Non detected		WA41
Dust and debris from behind wall in right dormer bedroom	4/12/00	None detected		WA42
Dust and debris in ceiling void of right dormer bedroom	4/12/00	None detected		WA43
Beneath floor in left dormer bedroom	4/12/00	Non detected		WA44
Dust and debris from behind wall in left dormer bedroom	4/12/00	None detected		WA45
Dust and debris in ceiling void of left dormer bedroom	4/12/00	None detected		WA46

APPENDIX 3 LEEDS CITY COUNCIL PROTOCOL FOR TESTING FOR THE PRESENCE OF ASBESTOS CONTAMINATED DUST IN HOUSING AT THE AVIARY'S AREA, ARMLEY, LEEDS

LEEDS
CITY COUNCIL

DEPARTMENT OF HOUSING SERVICES

PROTOCOL FOR TESTING FOR THE PRESENCE OF ASBESTOS CONTAMINATED DUST IN HOUSING

AT

THE AVIARY'S AREA, ARMLEY, LEEDS

2001 EDITION

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BACKGROUND INFORMATION

The following outlines the history of the contamination found in the houses within the Aviary's area at Armley, Leeds.

A survey was conducted by Leeds City Council, during 1991 and 1992, to try to establish the extent of the contamination found in a small number of houses on the estate during a previous exercise.

The survey consisted of taking dust samples from the houses, particularly from voids, such as the roof voids, sash window weight boxes, cellar coal chutes and underfloor voids. It was found that the most frequently detected asbestos contamination was in the roof voids and sash windows.

The detection of asbestos fibres depends on careful scrutiny of the whole of the sample taken, and not just an aliquot of that sample. The asbestos fibres might be coated with dust or other materials and thus be difficult to isolate from the matrix. A positive result is obtained on detection and confirmation of the first asbestos type.

The location from which the samples are taken is critical, bearing in mind that the contamination was wind-borne, and any suspended materials will tend to drop out of suspension as wind speed falls and be deposited near an obstruction which has caused the wind speed to drop significantly. It is also very important to recognise that the suspected source of contamination ceased to function over 40 years ago and therefore contamination is unlikely to be found on the surface of dust deposits.

The following pages outline the basic methodology to be adopted in carrying out the preliminary bulk testing as well as air testing following decontamination and clearance. Additionally the procedure to be adopted during emergency incidents is given to the rear of this document.

For further information regarding working methods and practices refer to the document 'MINIMUM SPECIFICATION FOR THE REMOVAL OF ASBESTOS CONTAINING MATERIAL FROM PROPERTIES WITHIN THE AVIARYS AREA, 2000 Edition'.

BULK SAMPLING STRATEGY

The sampling of dust/debris should only be undertaken by a laboratory with experience in sampling, with accreditation for sampling by UKAS, and should not be undertaken by contractors or other unqualified organisations.

ROOF SPACE VOIDS

The collection of dust/debris samples should be taken from the eaves wall area, both from on top of the wall between the roof and the wall itself, and immediately below the wall on the floor/ceiling. It is suggested that a minimum of two, but preferably three, samples are taken from the eaves void (Left-Hand Side, Right-Hand Side and Centre). It is preferable to collect a number of small samples around each area (ie. Left-Hand Side, Right-Hand Side and Centre) than to collect one large sample. The smaller samples can then be incorporated into one compound sample. This technique will help to minimise the chance of sampling in a 'non-productive' area.

A note should be made as to whether or not the roof slates are back-pointed, as this could explain the non-detection of asbestos in the dust. It is always useful to note whether or not the joists in the roof space floor run parallel or at right-angles to the front wall.

The roof apex void can usually be accessed by means of a hatch present on the upstairs landing, and at least one sample should be taken from this area if accessible.

The samples collected from each separate roof void area **MUST** be treated as separate samples and **NOT** mixed to form a compound sample. The reason for this is that mixing individual samples may cause dilution of any asbestos present, making it more difficult to identify and increasing the analysis time.

SASH WINDOWS / INSERT WINDOWS

Asbestos dust has been found within weight boxes of the original double sash windows typical of pre-1919 properties. Consequently it is necessary to gain access to these spaces to take samples.

'Insert windows' exist where 'modern' casement windows have been fixed into the external frame of the original sash window following removal of the sashes.

The sampling of sash window weight boxes is fairly straightforward, but removing the sample from the box is difficult. It is almost impossible not to cause damage to the existing internal window surround during this operation, and this should be minimised and made good to an acceptable degree. A joiner is a useful aid in these cases, particularly where the frame is in poor condition. There is always the risk of glass being broken or falling out of the frame if the putty has deteriorated. It is preferable to take a sample from both sides of the weight box, but these can be combined into one compound sample.

SUB-FLOOR VOIDS

The sampling of sub-floor voids requires the lifting of floor boards, which often presents problems as most are tongued and grooved. It is usually necessary to employ the services of professional joiners, and occasionally carpet fitters, to gain access to the test areas whilst ensuring satisfactory re-instatement on completion.

The areas of particular interest for sampling are along the outside walls in the sub-floor voids, where material may be confined to the space within an area supported by the first two joists where these run parallel to the front exterior wall. Where the joists run at right-angles to the exterior wall, then dust from the area at a distance of up to 300mm should be sampled. There is thought to be little asbestos contamination further away from the exterior walls towards the centre or back of the rooms.

Each sampled area should be treated as an individual sample on each floor, and the samples should not be combined to form one compound sub-floor sample from the whole property.

Houses with a 'modern' dormer window present a problem, particularly where the dormer window is in line (or flush) with the face wall.

The debris from disturbance of the roof when the dormer window was constructed may have fallen into the space between the ceiling joists and may have since been boarded over when the floor was extended. This area will also require sampling.

CELLARS

Asbestos fibres may have blown into cellar areas when the factory was operating. It is therefore best to sample cellars in the areas of windows, former coal chutes, air grates and any original ceilings. Samples should generally be taken from as close to the external walls as possible. It is sometimes necessary to obtain cellar samples via the ground floor rooms by lifting floorboards. Void areas filled with rubble (known as 'dumplings') have to be sampled in this way. Any deposits of 'black' dust on walls and ledges should also be sampled and could be compounded into one 'wall' sample.

GENERAL POINTS

The samples should be adequately labelled at the time of collection , as to the sampling location, property address and any other relevant details. The samples should then be analysed in accordance with MDHS 77, Asbestos in Bulk Materials -

Sampling and Identification by Polarised Light Microscopy (PLM), June 1994. Any departure from the method should be recorded on the report issued.

The quantity of asbestos seen can vary from single thin fibres to fairly large clumps, and adequate time for analysis should be allowed.

It is also recommended that the collected sample is not subject to a sub-sampling procedure, where there is a high chance of the asbestos remaining undetected, because of the heterogeneous nature of the contamination. The whole sample should be worked through until either a positive or negative result is obtained. It is unnecessary to look and detect all six types of asbestos in the sample and it would be acceptable to cease analysis on identification of the first species detected.

It would be advisable to retain the samples for a minimum period of six months, in case there is need to re-examine the samples for a particular property.

AIR SAMPLING

CLEARANCE TESTING

This procedure is carried out following decontamination works, and serves to indicate that the contaminated dust has been effectively removed from the property as far as is reasonably practicable. The testing should only be undertaken by a laboratory with experience in sampling, with accreditation for sampling by UKAS, and should not be undertaken by contractors or other unqualified organisations.

The 'Clearance Testing' should be carried out in accordance with MDHS 39/4 and the current edition of EH 10.

The visual examination of the cleaned area should be in accordance with the current edition of both MDHS 39 and EH 10. The area which has been cleaned **MUST** be disturbed for a satisfactory period of time before the taking of air samples, to ensure that all residual dust becomes airborne.

If sealant is applied following the Clearance Test, it has been found that a certain amount of inaccessible dust is released into the property by the use of airless spraying equipment, and it is therefore preferable to apply the sealant prior to the air sampling taking place. A thorough visual examination must be undertaken **prior to** the application of sealant to ensure the area is free of any residual deposits of excessive loose dust or debris. Approved sealant should be applied to all exposed brickwork and joist ends, following thorough cleaning. Sealant must not be applied to roof slates, laths and exposed joists in the roof areas, nor should it be used to seal the lath and plaster top surface of the ceilings, as excess weight can cause the ceiling to collapse.

AIR TESTS

The number of samples required will be in accordance with MDHS 39/4 and EH 10, and should be single samples of 480-litre minimum volume each. It is anticipated that in a roof space two 480-litre samples will be required. In other areas, such as an enclosure around a window, for example, where the total enclosure volume will be less than 10 cubic metres, a total of two 240-litre samples would be acceptable or one 480-litre sample. **If sample volumes are less than a total of 480 litres**, then the results **MUST** be quoted to a detection level of 0.01 fibres/ml of ambient air by counting an appropriate increased number of graticule areas.

If the whole of a property is decontaminated, then we would expect a total number of air samples to be within 7-12 individual samples, with at least one sample per room of less than 25 square metres.

The results of air samples should be less than 0.010 fibres per millilitre of ambient air, in accordance with MDHS 39/4. The allowance of 20% of the total results to be between 0.010 and 0.015 fibres/ml is acceptable.

PROCEDURE FOR EMERGENCY CONTAMINATION TESTING IN THE AVIARYS AREA, ARMLEY

Occasionally uncontrolled works are carried out in the Aviarys which may result in contamination of the habitable areas of a property or of a public area. In such circumstances the following procedure should be adopted:

1) It is necessary to establish the degree of contamination prior to carrying out any disturbed air sampling. The degree of contamination can be assessed by the taking of 'swab/wipe' samples from flat surfaces within the suspected contaminated area and carrying out examination under phase contrast microscopy. This requires the filter to be mounted by the Acetone/Triacetin method to give a permanently mounted sample, using the method based on the MDHS 39/4.

   The sample is then examined by the microscopist for the presence of asbestos form fibres. The whole filter should be scanned at random to give an overall impression of the fibre loading and the ease of detection of asbestiform fibres. The results obtained from this method will provide a rapid indication of the likely dangers of carrying out a disturbed air sample/test.

   If possible, a bulk sample of dust/debris should be collected from the contaminated area and analysed for the presence of asbestos.

2) A disturbed air sample should then be collected from the areas where it is suspected that contamination may exist. This should be carried out as detailed in MDHS 39/4. Due care should be taken not to damage fixtures and fittings within the areas tested during disturbance and not to spread any dust from the 'incident area' to other unprotected areas.

REPORTING OF RESULTS

The reports from any tests - bulk samples, swab tests or air samples - should be forwarded at the earliest opportunity, and in any case within 3 working days of the incident to **Department of Housing and Environmental Health Services, Dewsbury Road One Stop Centre, 190 Dewsbury Road, Leeds LS11 6PF**. Reports should be marked for the attention of the **Asbestos Project Co-Ordinator**.

Institute of Occupational Medicine

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Applying science for a better working environment

The Institute of Occupational Medicine

The IOM is a major independent centre of scientific excellence in the fields of occupational and environmental health, hygiene and safety. We aim to provide quality research, consultancy and training to help to ensure that people's health is not damaged by conditions at work or in the environment. Our principal research disciplines are exposure assessment, epidemiology, toxicology, ergonomics and behavioural and social sciences, with a strong focus on multi-disciplinary approaches to problem solving.

Our beginnings

Our first major research programme began in the 1950s, on respiratory health problems in the coal mining industry. Major themes were quantification of airborne dust concentrations in different jobs, characterisation of types and constituents of the dusts, measurement of health effects, relationships between exposure and disease, and proposals for prevention. This research became an international benchmark for epidemiological studies of occupational health, and was the primary influence on dust standards in mines in the UK, US and other countries.

Current themes

Our current work spans many other industries including asbestos, MMMF, pesticides, chemicals, energy, telecoms, metals, textiles, construction, agriculture as well as the environment. While diseases of the respiratory tract remain a major interest, our scope now extends to many other health outcomes such as mortality, cardiovascular effects, cancer, back pain, upper-limb disorders, hearing loss, skin diseases, thermal stress and psychological stress. Related work includes the development and application of measurement and control systems, mathematical models and survey methods.

Who we work for

Our work in these areas is conducted for a wide range of organisations in the UK, the EU, and the US, including Government departments, international agencies, industry associations, local authorities, charitable organisations, and industrial and commercial companies. The IOM is a World Heath Organisation (WHO) collaborating centre and is an approved institute of the Universities of Edinburgh and Aberdeen, enjoying collaborative research links with NIOSH, IARC, and many other institutes throughout the world.

Publication

We believe that our research findings should be publicly available and subject to the scrutiny of the international scientific community. We publish our findings in the peer reviewed scientific literature and through our own series of Research Reports.

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