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Abstract

Environmental problems, and human attempts to manage them, can be conceptualised as evolutionary complex systems, involving interlinked processes of physical, knowledge, technological, institutional, perceptual and behavioural change. Issues such as traffic pollution and asthma may be viewed as emergent systems, embedded within overlapping hierarchical systems.

A distinction may be made beween changes in physical systems ("physical emergence"), changes in human knowledge about those systems ("knowledge emergence") and changes in human perceptions ("perceptual emergence"). While processes of physical and knowledge emergence are important, it is through perceptual emergence that a phenomenon comes to be regarded as a "problem" or "issue", potentially leading to changes in policy, institutional arrangements or behaviour.

Physical changes may have impacts on human beings, which may be measurable and predictable in the mass. However, the outcome of such an impact, from the point of view of a particular individual, is mediated by that individual's perception, which is dictated by his or her personal experience, understanding and interests ("appreciative system"). These perceptions in turn will determine the individual's behaviour, which may feed back into the collective appreciative system, policy system, and the base physical system.

The distinction between policy based on measurement and control of impacts and individual perceptions and behaviour dependent on outcomes leads to incongruity between the "institutional" and "individual" views of an issue.

The thesis investigates this incongruity in the case of the "traffic pollution and asthma" emergent system. The perceptions of "institutional" and "individual" actors involved in the system were elicited by means of unstructured and semi-structured interviews, and analysed in terms of a number of key concepts (perceptions of measurement, risk and spatiality) across a number of dimensions (different actors in the same location, the same hierarchical position in different locations, and between a specific institution and individuals).

The empirical investigation demonstrates differences between multiple institutions managing different aspects of the problem and a lack of understanding and communication between institutions and individuals, despite the fact that an expressed aim of policy in this area is directed at communicating with individuals with the intention of changing individual behaviour.

Dedication

This thesis is dedicated to May and Les Rushby, in the hope that their youngest child can live up to some of their strength, courage and love of life.

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Becoming a Doctor of Philosophy, like life itself, is a complex evolutionary process, with many unforeseen emergent outcomes, not only intellectual and academic, but also emotional and personal. During the time in which I have engaged in that process, my personal appreciative system has overlapped with those of many other individuals, all of whom have contributed in some way to the pathway I have followed, and to the outcome of this thesis. While accepting that I can never hope to mention all those who have made a contribution, I would like to express my gratitude to the following:

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"How much more complicated life is than the attainment of a PhD would lead one to believe!"

Robertson Davies, "The Rebel Angels", 1981

"As no man fording a swift stream can dip his foot twice into the same water, so no man can, with exactness, affirm of anything in the sensible world that it is. As he utters the words, nay, as he thinks them, the predicate ceases to be applicable; the present has become the past; the 'is' should be 'was'. And the more we learn of the nature of things, the more evident is it that what we call rest is only unperceived activity; that seeming peace is silent but strenuous battle. In every part, at every moment, the state of the cosmos is the expression of a transitory adjustment of contending forces; a scene of strife, in which all the combatants fall in turn. What is true of each part, is true of the whole. Natural knowledge tends more and more to the conclusion that 'all the choir of heaven and furniture of the earth' are the transitory forms of parcels of cosmic substance wending along the road of evolution, from nebulous potentiality, through endless growths of sun and planet and satellite; through all varieties of matter; through infinite diversities of life and thought; possibly, through modes of being of which we neither have a conception, nor are competent to form any, back to the indefinable latency from which they arose. Thus the most obvious attribute of the cosmos is its impermanence. It assumes the aspect not so much of a permanent entity as of a changeful process, in which naught endures save the flow of energy and the rational order which pervades it."

Thomas Henry Huxley, "Evolution and Ethics", 1893

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1 Emergent Systems in the Real World

"Observe always that everything is the result of a change, and get used to thinking that there is nothing Nature loves so well as to change existing forms and to make new ones like them. "

Marcus Aurelius (121-180 AD)

1.1 Introduction

Environmental problems, such as the impact of traffic pollution on human health, rarely have simple, easily recognised causes. Rather, they are generated by complex sets of factors acting together, some physical, some relating to social, economic and/or technological conditions prevailing at the time, and some relating to human behaviour and perceptions.

Such issues may be characterised as emergent. The concept of emergence refers to the phenomenon whereby causes at one hierarchical level generate qualitatively new effects at a level of greater complexity (Lewes,1874; Mill,1904; Morgan,1933).

Many environmental problems are caused by the complex interactions of individual actions, each of which may be simple in itself, e.g. a single emission of volatile organic compounds (VOCs) to the atmosphere from a paint shop, but which in the aggregate combine with many other actions to produce an emergent outcome, e.g. a plume of ozone over a rural area downwind. The sum total of all the actions involved, and the processes by which they combine, may be considered as an emergent system.

The conventional model of scientific research, which concentrates on the identification and analysis of simple causal relationships, is of limited usefulness when applied to such complex, emergent systems (Allen, PM et al, 1994). While individual cause and effect relationships may be significant for tackling specific problems, an approach which concentrates exclusively on such relationships is in danger of providing only "technical fixes" for yesterday's problems. These technical relationships are embedded in a complex web of perception and meaning, consisting of multiple, nested, overlapping hierarchical relationships. When the overall issue or problem entails human involvement, either in terms of the source of the problem or the impact, any attempt to understand the issue or provide a solution must take that human interaction into account (van der Leeuw, 1995). However, as will be argued below, even policy approaches which explicitly attempt to modify behaviour, through modifying perceptions, also face major problems, firstly because the message which is being put over may not be heard and / or understood by the individuals to whom it is addressed, and secondly, because, even if the perceptual change is achieved, it may not translate into behavioural change.

The present thesis is situated within the emerging mode of scientific enquiry referred to as "issue based", "policy relevant" (Allen,PM et al, 1994), "integrative" (Seaton, 1996) and "interdisciplinary" (O'Riordan, 1995) research, which recognises that the nature of scientific evidence and the ways in which it is used in the formulation and implementation of policy are affected by institutional, cultural and political factors. The approach taken will employ concepts from the theory of complex systems in order to

investigate the interlinking processes of physical, technological, knowledge, perceptual, behavioural and institutional change which come together to produce an emergent system. The science of complex systems has been developed in response to the need to understand these separate processes in order to construct models which can capture the interactions between them, to provide decision support for the planning and implementation of development policies (Allen, PM, 1997). The approach taken here is not to attempt to construct models of the processes, but to develop a "soft" approach to complexity (Checkland, 1976), which emphasises the importance of the perceptions, or "appreciative systems" (Vickers, 1983), of those involved.

The thesis will be developed within the context of the substantive issue of "Traffic Pollution and Respiratory Health". It will demonstrate the implications of regarding the issue as an emergent system, which has arisen through the overlapping of a number of other hierarchical "systems", linking existing elements and relationships in qualitatively new ways.

1.2 Traffic Pollution and Respiratory Health: the Problem Context

Over recent years, widespread concern has arisen about the possible role of traffic pollution in contributing to increases in the prevalence of asthma (QUARG[1], 1993). Dramatic press and television reports, and reports by bodies such as the Royal Commission on Environmental Pollution (RCEP, 1994), have led to calls for "something to be done". However, to date, policy makers appear unable to provide a satisfactory "solution".

This thesis will argue that existing approaches to the problem, which are piecemeal, concentrating on limited aspects of the problem and dictated by the agendas of the various institutions involved, are inadequate for tackling the problem as a whole. It will be argued that greater insight may be achieved by conceptualising the issue of "traffic pollution and respiratory health" as an emergent system, and using the concepts of hierarchy, spatial scale and emergence to provide a more satisfactory analysis and understanding of the issue.

Conventional scientific approaches to the problem concentrate on the accumulation of evidence in order to establish the existence and nature of "cause and effect" relationships between the different elements of the problem. Asthma is seen as an important and increasing problem, and traffic pollution is seen as a plausible factor in contributing to the increase in asthma. However, the nature of the disease, and the complexity of the relationship with pollution, mean that it is not possible to state categorically that a causal relationship exists.

No single policy-making body has overall responsibility for traffic pollution and health, but rather the responsibilities and interests of several different bodies overlap. While transport planners have responsibility for transport infrastructure, environmental health departments have responsibility for air quality and public health departments for respiratory health. These different institutions have different perspectives on the problem, dictated by their own institutional responsibilities, and also different, though overlapping, geographical areas.

[1] Quality of Urban Air Review Group

The issue is also one in which individual members of the public are directly involved, both through the impact which pollution may have on their health and the effect which their behaviour may have on the problem. Traffic is generated from the accumulation of a large number of individual decisions, and while the benefits of a particular traffic movement accrue directly to the individual concerned, the negative consequences only become apparent in the aggregate. It is also an issue which arouses considerable controversy. Although the preferred option among policy makers in Oxford interviewed in the pilot study for this thesis is to reduce access to the city centre for private cars, it is recognised that some groups would not be happy with this approach, such as traders who feel that their businesses would suffer, and motorists who want to be able to get in to the centre. Continuing to allow access to buses and delivery vans is seen as a half-hearted approach to the problem, but closing the centre to buses would cause problems for people who depend on them, particularly elderly people and mothers of young children (see Chapter 5).

Approaches to tackling the problem have to date concentrated on changing technologies, e.g. through the development and introduction of catalytic converters, and / or changing behaviour. The approach adopted by the environmental health officers interviewed for this thesis, both in Oxford (Chapter 5) and in Bedfordshire and Hertfordshire (Chapters 6 and 9), is to try to change perceptions, and hence behaviour, by collecting and publicising information about air quality. However, evidence from the third element of field work, a public survey of households around Bedford, suggests both that the public are unaware of the information provided, and that, in any case, they are unwilling or unable to change their behaviour in response to it.

In summary, the issue of traffic pollution and respiratory health is one which is characterised by scientific uncertainty, multiple constituencies with potentially conflicting perceptions, and management by a plurality of institutions, none of which has overall ownership of the problem.

1.3 Emergent Systems Concepts

The thesis identifies three types of emergence: physical, knowledge and perceptual emergence. Of these, it is argued that the most significant for the management of emergent systems is perceptual emergence, which refers to the process by which a "problem", such as the relationship between traffic pollution and respiratory health, becomes recognised as such by the various constituencies involved, and the ways in which its perceived importance and relevance relative to other priorities changes, potentially leading to behavioural change in response.

The thesis will argue that the emergent system may be regarded as a "change of focus" in looking at elements and relationships which are situated within already existing overlapping hierarchies. These hierarchical relationships impose constraints on the elements which affect the ways in which changes, including changes imposed by institutions in attempting to manage the "problem", are received and responded to.

The management of emergent systems poses particular problems for policy-makers. Problems are recognised and described at the aggregate level, but may not be amenable to management at this level (Markus and Robey, 1988). Management may only be implementable at the individual level. However, those actions and components which may be regarded, relative to the aggregate level, as "simple", are

themselves determined by complex sets of factors and constraints. In addition, these components may be embedded in a number of overlapping hierarchies, and interact both vertically with other levels of the hierarchy and horizontally with other hierarchies (Park & Seaton, 1996) so that the "simple" relationships are engaged in constant and complex processes of change and mutual feedback (Allen PM, 1994).

The management of emergent problems takes place within an existing structure of institutions, some of which are in hierarchical relationships with each other, having both defined and implicit functions, and which may potentially be in conflict. Within a given institutional setting, the way in which an issue is defined and managed will depend not only on the responsibilities, constraints and priorities defined by the next higher level of the hierarchy, but also on constraints and priorities within the particular department or institution, and on the willingness and ability of individuals to implement policy (Hawkins, 1984).

The thesis will look at the differences in perceptions between the different constituencies involved, focusing particularly on the interface between the "individual" and "institutional" worlds. The discussion will be structured around three major dimensions of difference: spatiality, perception vs. objective measurement, and epidemiological vs. perceived risk. The spatial aspect is considered important because problems of air quality, such as global warming, acid rain and tropospheric ozone, have impacts over large geographical areas, often crossing administrative and even international boundaries. In order to be effective, management must be co-ordinated over these large geographical areas. However, the human activity which generates these problems occurs at the local level, and at the local level local conditions and considerations take priority in determining perceptions and behaviour.

1.4 Methodological Aspects of Emergence

A paradox lies at the heart of the study of emergent systems. On the one hand, because emergent effects occur at the aggregate level, large aggregations of data are required in order to understand them. Thus, patterns of disease in a population may be studied by means of epidemiological data, or of attitudes and perceptions by survey data. Such data must by its very nature be grouped and classified in order for the underlying patterns to become recognisable.

However, the action of classifying and aggregating data leads to a loss of detail and richness. Real world effects occur at an individual level, not in the aggregate. Epidemiological evidence may identify patterns and suggest causes, but does not have the precision of closely controlled, individual clinical tests. Clinical tests, on the other hand, may provide only a narrow, limited, artificial set of circumstances which do not reflect the complex environment within which individual cases occur. Similarly, while surveys may provide information about broad attitudes within society, only individual interviews and case studies can reflect the richness and complexity of individual experience.

The methodological paradox of emergence may be summed up in a pair of complementary questions:

How can we see the big picture without losing sight of the fine detail?

and

How can we see the fine detail without losing sight of the big picture?

1.5 Research Objectives

Because of the exploratory (and, indeed, "emergent") nature of the thesis, the research design was fluid in the early stages, and was modified as the work progressed. The initial focus was on recent growth in levels of concern about environmental issues, and the two way relationship between individual concerns and public policy.

The overall aim of the research was to contribute to developing better ways of understanding and dealing with emergent issues in general, rather than necessarily providing solutions to the substantive problem of traffic pollution and health. The case study can thus be seen as providing a context for the development of generic methods.

The objectives of the research were to:

- **Objective 1 :** Build a conceptual framework for the investigation of emergent systems, leading to a conceptual model of the process of emergence (Chapters 2, 3 and 4).
- **Objective 2 :** Develop and apply a method for research into emergent systems, leading to a taxonomy of dimensions of difference which can be used to investigate variations in perceptions between constituencies involved with an emergent issue (Chapters 4, 5, 6, 7 and 8).
- **Objective 3 :** Identify and explore the management issues resulting from emergent phenomena (Chapters 3,4 and 9).

1.6 Outline of the Thesis

The approach taken by this thesis is to investigate the complexity of these interactions by focusing on the perceptions of the different groups of actors involved. Perceptions were elicited using qualitative social science techniques, and comparisons made across the following dimensions:

- institutional (between groups of actors representing different hierarchies involved in the problem)
- spatially (between groups of actors in the same institutional position in different locations)
- hierarchically (between groups of actors at different positions in the hierarchy in the same location)

The third dimension is seen as crucial, in that it represents the relationship between "institutional actors" and "the public", and thus touches on issues of politics and representation.

The format of the thesis is as follows:

- Chapter Two provides a theoretical review of the use of complex systems concepts, including nested hierarchies, scale, multiple constituencies and perceptions, and emergence. It argues for the introduction of the idea of an "emergent system" as a way of conceptualising complex issues involving overlapping hierarchies which include and impact on human systems but have not been designed by human agency.
- Chapter Three looks at the historical development of air quality issues and management in the UK over the last two hundred years. It argues that present

approaches to the "issue" of traffic pollution and respiratory health should be seen within a complex context of co-evolving changes in physical, technological, knowledge, perceptual, behavioural and institutional systems. It draws parallels with the development of past "issues", and presents a "top-down" conceptual model of changes in air quality and air quality management as a complex system.

- Chapter Four addresses the problems of conducting research into emergent systems. It constructs a "bottom-up" conceptual model of specific change leading to "emergent" outcomes, which complements the top-down model presented in Chapter Three. It argues for the need to distinguish between "actors", "observers" and "recipients", and to recognise and investigate the perceptions of individuals and institutional actors at different levels, locations and positions within the nested over-lapping hierarchical systems which constitute the emergent system.
- Chapter Five introduces the fieldwork component of the thesis by describing the pilot study. This gives a "snapshot" of perceptions within the overlapping hierarchies involved in a single geographical location.
- Chapter Six investigates perceptions of institutional actors at a particular hierarchical level and institutional setting, in different specific locations over a wider geographical area.
- Chapter Seven investigates the perceptions of members of the public at different specific geographical locations within a limited area covered by one of the institutions discussed in Chapter Six.
- Chapter Eight investigates the relationships between sources of information and perceptions, and between perceptions and behaviour, using data from the public survey described in Chapter Seven.
- Chapter Nine looks at variations in perception across hierarchical levels within the same geographical location.
- Chapter Ten discusses the contribution to knowledge of the thesis, and the implications for policy, including the use of the top-down conceptual model as an explanatory device; problems of aggregation involved in research into emergent systems; and the effect of differences of perception between the individual and institutional worlds.

2 Complexity, Emergence and Emergent Systems

"I must Create a System, or be enslav'd by another Man's;
I will not Reason and Compare: my business is to Create."

William Blake, "Jerusalem, The Emanation of the Giant Albion", 1820

2.1 Introduction

Emergence, along with "system" and "complexity", is not easy to define. Meaning itself can be seen as emergent, arising from the juxtaposition of previously existing words and phrases with the perceptions and experience of the recipient. Although there is a core of concepts which seem critical to the idea of emergence, consideration of phenomena which appear to our intuition to embody "emergence" may reveal sets of characteristics which, while context-dependent and not necessary to a definition, may nevertheless contribute to our understanding.

This chapter will explore the ideas of complexity and emergence. The approach taken will be, firstly, to identify the core concepts of emergence by considering the historical use of the term and by introducing a distinction between physical and knowledge emergence (Sections 2.2 and 2.3). Section 2.4 will consider a number of concepts taken from systems thinking which may be used to derive a definition of an "emergent system". Section 2.5 will introduce the idea of complex systems, and the remainder of the chapter will show how aspects of complex systems theory: nested hierarchies (Section 2.5); multiple constituencies and perceptions (Section 2.7); evolutionary change (Section 2.8) and spatial and temporal variability (Section 2.9), can be applied to the study of the management of air quality, as described in Chapter 3, as a complex system, and that one aspect of that wider system, the "Traffic Pollution and Respiratory Health System", can usefully be conceptualised as an *emergent* system.

2.2 Theoretical Ideas of Emergence

Early ideas about emergence were concerned with achieving a better understanding of cause and effect relationships, and come strongly from a "scientific" perspective (see Section 4.1 for discussion of the difference between science perspective and issue-based perspective). Morgan (1933) attributes the first use of "emergent" as a technical term to Lewes (1874). Lewes is concerned with the relationships between groups and the parts which compose them, and states that

> *"We are not to conclude the properties of elements from the properties of the groups they form; nor vice versa".* (Lewes, 1874, p97).

He makes a series of distinctions: between component parts and constituent elements; between quantitative and qualitative relations; and between resultants and emergents. The term "components" refers to those parts whose properties do not change in the mass, and which may be combined quantitatively to produce resultants:

> *"A molecule of water has the properties of a gallon of water... a direction of movement is seen to be the line which would be occupied by the body if each of the incident forces had successively acted on it"* (Lewes, 1874, p98).

The combination of constituent elements, however, leads to qualitative change, and the production of "emergents", displaying qualitatively new properties, which cannot be seen in the elements, or deduced from them:

> *"No one commits the mistake of supposing that either of the elements of water has when separate the properties of water; no one supposes that the properties of each element combined in water could be deduced from the observed properties of the combination; no-one supposes that from the observed properties of oxygen and hydrogen, separately considered, the properties of water could be deduced. ... a chemical or vital product is a combination of elements which cannot be seen in the elements. It emerges from them as a new phenomenon."* (Lewes, 1874, pp97-98).

John Stuart Mill, in considering the processes of causation and induction, also distinguishes between combinations of causes whose joint effect is the sum of their separate effects, and those where the combination of several causes leads to effects which are qualitatively different. He refers to the first case as the principle of the "Composition of Causes", and to cases in which this principle is superseded as "heteropathic causation", and argues that:

> *"This difference between the case in which the joint effect of causes is the sum of their separate effects, and the case in which it is heterogeneous to them; between laws which work together without alteration, and laws which, when called upon to work together, cease and give place to others; is one of the fundamental distinctions in nature."* (Mill, 1904, p244).

To these ideas of causation and qualitative change, with their implicit time dimension, Morgan adds the concepts of hierarchy and process. Morgan is concerned with the evolution of more complex structures from simpler ones. Although at each level, the components may be characterised as "things" which take part in "processes", *"the trend of modern science is to resolve these things into processes"* (Morgan, 1933, p11). He argues that what is "new" at each new level of the hierarchy is the ways in which the components of the previous level relate to each other. This echoes Lewes' assertion that *"the significance of a phenomenon lies wholly in its relation to other phenomena"*(Lewes, 1874, p96) and that a thing cannot be divorced from its relations. Morgan asks:

> *"Is the pattern of molecular process different from that of atomic process, and the pattern of crystalline process different from that of molecular process? If so, may we speak of the pattern in each case as* ***new****, in the sense that its scientific interpretation requires a new formula? Some of those who believe, on empirical grounds, that this is so, name the novelty 'emergent.' And those who believe that novelty of this kind has occurred again and again in the course of natural advance, may speak of 'emergent evolution.'"* (Morgan, 1933, p12).

Morgan's discussion of emergent evolution leads to another core concept of emergence, that of unpredictability. He likens emergent evolution to a series of natural games, each with its own set of rules which can only be discovered by watching the game in play, i.e. through observation and experiment. At each new stage of the hierarchy, new games come into play, with new rules which cannot be predicted from the games which went before:

> *"One may liken the rules of the [atomic] game to the formula of an interpretative curve. As points within this curve the series of atoms which have thus far been disclosed to observation may be plotted. But in accordance with the formulated rules of the atomic game as a whole other points may be interpolated in the curve prior to the confirmation of their existence by experiment. So far prediction is nowise precluded.*
>
> *But when we pass from atoms to molecules, and thereafter to living organisms, it seems that there are new games, new rules of each game, new interpretative curves, with new formulas - i.e. new modes of substantial unity in the entities under consideration. If this be so, a molecular point cannot be extrapolated on an atomic curve; nor can a life-point be extrapolated on a molecular curve. Here prediction from one curve to the next, or to any later curve,* ***is*** *precluded. Such in brief is the emergent hypothesis."* (Morgan, 1933, p40).

These ideas have been reflected recently in the work of Allen, who argues that conventional approaches to modelling systems operate by identifying the components of the system and the interactions between them, and expressing these as a set of causal relationships, to give a mechanical representation of the system (Allen PM, 1995). However, the predictions generated by such a model can only be true as long as the qualitative structure of the system remains unchanged:

> *"The mechanical model of deterministic equations that we can construct at any given time has no way of producing 'new' types of objects, new variables, and so the 'predictions' that it generates will only be true until some moment, unpredictable within the model, when there is an adaptation or innovation, and new behaviour emerges"* (Allen PM, 1995).

For further discussion of Allen's work on complexity, see Section 2.8, below.

2.3 Physical Emergence and Knowledge Emergence

In his discussion of predictability, Morgan distinguishes between "primary" (or "original") and "secondary" (or "recurrent") novelty. He acknowledges the objection that in one sense the combination of oxygen and hydrogen atoms to produce a molecule of water cannot be regarded as "new" or unpredictable, because it has happened countless times in the history of the universe. This is an example of recurrent novelty. He justifies this somewhat paradoxical term by arguing that, although we can predict the outcome on the basis of prior knowledge, we can also imagine a hypothetical time before which the first combination of oxygen and hydrogen had occurred, at which time it would have been impossible to predict the nature of a molecule of water from knowledge of the properties of the constituent elements. Although prediction is possible in the case of recurrent novelty, he argues, it is not in the case of primary novelty:

> *"It may be said that what can be predicted is relative to some phase of scientific knowledge at the time-being. Let us frankly admit that this is so. Still I take it that what we are dealing with is knowledge of the course of events whatever that course may be apart from such knowledge"* (Morgan, 1933, p36).

Mill is confident of the ability of science to extend the boundaries of knowledge:

> *"The different actions of a chemical compound will never, undoubtedly, be found to be the sums of the actions of its several elements; but there may exist, between the properties of the compound and those of its elements, some constant relation, which, if discoverable by a sufficient induction, would enable us to foresee the sort of compound which will result from a new combination before we have actually tried it"* (Mill, 1904, p245).

Lewes, however, is less sanguine:

> *"In every question, from that presented by the growth of a blade of grass, to that presented in the evolution of a social organism, from the chemical union of two gases to the formation of ideal types, there must necessarily be certain transcendental elements, not determinable by us,* ***unexplored remainders*** *after the most exhaustive exploration"* (Lewes, 1874, p39).

Lewes' "unexplored remainders" may be likened to the residuals of statistical inference. The establishment of a statistical relationship between a group of supposed causal factors, e.g. a regression equation, is always to some extent arbitrary. According to Thurstone:

> *"It is the faith of all science that an unlimited number of phenomena can be comprehended in terms of a limited number of concepts or ideal constructs ... The constructs in terms of which natural phenomena are comprehended are man-made inventions. To discover a scientific law is merely to discover that a man-made scheme serves to unify, and thereby to simplify, comprehension of a certain class of natural phenomena ...*
>
> *Each generalization in the scientific description of nature results in a loss in the extent to which the ideal constructs of science match the individual events of experience. This is illustrated by simple experiments with a pendulum, in which the mass, the period, and the locus of the center of gravity with reference to a fulcrum are involved in the ideal construct that leads to experimental verification. But the construct matches only incompletely the corresponding experimental situation. The construct says nothing about the rusty setscrew and other extraneous details. From the viewpoint of immediate experience, scientific description is necessarily incomplete. The scientist always finds his constructs immersed in the irrelevancies of experience."* (Thurstone, 1947, pp51-53).

When a statistical model is constructed, assumptions about the significant factors involved in the relationships being modelled are implicit in the choice of variables. But the variables do not account for all the variation in the observations. Some variation (the residual variation) is always caused by extraneous, unrecognised, and perhaps unrecognisable factors. Among these factors, in addition to general "noise", may occur other factors which, if they were to be recognised, would contribute significantly to the explanation of the phenomenon under consideration.

Following Ehrenberg, this can be illustrated using the example of Boyle's Law (Ehrenberg, 1975). Boyle's Law states that the volume of a gas varies in a constant relationship with the pressure, i.e. PV = C, (where P=pressure, V=volume and C is constant.) The value of C for any particular gas may be estimated statistically from repeated experiments, even though the observed value for C will vary from

experiment to experiment. The variation in C may be due to a large number of extraneous factors, such as a chemical reaction, a leak in the apparatus, physical absorption or condensation of the gas. However, C also varies, regularly, with temperature, such that a more general relationship in three variables, known as the Gas Equation, exists, which states that PV=RT, where T is temperature and R is constant for any given amount of gas. An experimenter who was not aware of the significance of temperature, and who allowed it to vary in repeated trials, would produce a less accurate estimate for C than one who was aware of this and took it into account. (Ehrenberg, 1975).

The extension of understanding which led from Boyle's Law to the Gas Equation, the transfer of temperature from residual variation to significant variable, does not involve any change in the physical relationships between the gases. However, in terms of the recognition of the cause and effect relationships, a change has occurred, and the new relationship may seem to have "emerged". Although the physical relationships have not changed, a factor which was not previously taken into consideration has become recognised as significant. The impact on the total of human knowledge is similar to that which would have occurred if the relationship was genuinely "novel", and this process of discovery of new knowledge may be described as "knowledge emergence".

An example which displays both physical emergence and knowledge emergence occurred in the case of bovine spongiform encephalopathy (BSE, or "mad-cow disease"). Here social factors (demand for cheap meat, changes in the organisation of agriculture) and technological changes (in the processing of animal feeds), coupled with policy changes (deregulation) led to changes in natural systems (the transfer of disease from sheep - scrapie - to cattle - BSE). Emergent knowledge, arising from scientific research into the disease, was introduced into the public domain, where it became a subject for heated debate, leading to changes in public perception, policy responses (the EU ban on beef exports), and economic effects (fall in the demand for beef), threatening the livelihood of farmers and the relationship between the UK and its European partners (New Statesman, March 29th 1996; The Economist, April 6th-12th 1996). For further discussion of physical emergence and knowledge emergence, see Section 2.7.

2.4 Systems, Emergence and Emergent Systems

The idea of "knowledge emergence" can be seen as introducing a further level into Morgan's hierarchy (see Section 2.2) , that of human society and social relations. The application of ideas of emergence to the study of human organisations is a characteristic of the "systems movement". This section of the thesis will use concepts from conventional "system thinking" to explain the ideas of emergent properties, emergent outcomes and emergent systems.

Checkland identifies "emergence" as one of the fundamental ideas of systems thinking:

> *"It is the concept of organized complexity which became the subject matter of the new discipline 'systems'; and the general model of organized complexity is that there exists a hierarchy of levels of organizations, each more complex than the one below, a level being*

> *characterized by emergent properties which do not exist at the lower level"* (Checkland, 1981).

This use of "emergence" relates clearly to the argument which has gone before. However, it should be noted that the approach to "systems" and "emergence" expressed in this Section is still based on a "scientific", cause and effect perspective (see Section 2.2 above and 4.1 below). Section 2.8 will extend the discussion into the area of complexity and evolutionary change in systems.

The attempt to understand or manage complex situations as "systems" always involves a degree of simplification. The primary simplification occurs in the act of defining the "system of interest", by drawing a boundary between "the system" and that which lies outside the system, its "environment" (Beishon, 1971). Changes which occur in the "environment" are treated as being exogenous to the system. While simplification in the form of extracting and defining simple cause and effect relationships may be essential for understanding the situation in the short term, it also imposes limits on the understanding and ability to predict behaviour in the face of change and interactions both within the "system" and between the system and "environment". This will be returned to in the discussion of complex systems in Section 2.8, and of approaches to research into air pollution in Sections 4.2 and 4.3.

Checkland provides a clear and coherent picture of a "system" from the myriad of concepts which occur in the literature:

> *"The core notion is that of a whole in an environment which is delivering shocks to it. It may contain smaller wholes, and may itself be part of a larger whole. This gives us the idea of a layered or hierarchical structure. And if that whole has processes of communication and processes of control, then it might, in principle, adapt and survive in a changing environment ... Those are the four ideas you need to express the notion of the adaptive whole which is central in the systems literature"* (Checkland, 1992, pp1025-1026).

This concept of hierarchy is a unitary one: the whole "contains" smaller wholes, and is itself in a fixed relationship with its "environment", from which it can be isolated. This concept does not allow for the existence of "nested" or "overlapping" hierarchies, which will be returned to in Section 2.5.

Checkland argues elsewhere that we should not lose sight of the fact that the term "system" is an epistemological device, and that there is danger in assuming that it refers to actually existing phenomena in the "real world":

> *"it is useful to remember that ultimately the only possible source of these ideas is our perception of the world outside ourselves ... clarity demands that we be very careful about the difference between ontological statements of the form: the perceived world is something or other and epistemological statements which are not about the perceived world but are about knowing the perceived world".* (Checkland, 1992, p1026).

When a "system" is seen as a purely conceptual device in this way, questions arise over whether a property, outcome, or, indeed, a system, can ever be truly considered "emergent". A system is defined by the observer, and therefore includes all those properties, elements, and relationships which the observer deems relevant. In such circumstances, how can new properties and outcomes be said to "emerge"? How can

a "system" (i.e. model of something in the "real world"), which has been designed by people, ever generate, predict or cope with something which is truly "emergent", that is, genuinely novel? How can it take into account something which has not been built into its design?

Ackoff begins from a much more limited definition of a system as *"a set of interrelated elements"* (Ackoff, 1976, p106). He also stresses the conceptual nature of "systems", while implicitly recognising the relationship between systems and real-world phenomena:

> *"Although concrete systems and their environments are objective things, they are also subjective insofar as the particular combination of elements that form both is dictated by the interests of the researcher. Different observers of the same phenomena may conceptualize them into different systems and environments."* (Ackoff, 1976, p106).

This distinction between the "objective" and "subjective" nature of systems becomes crucial when looking at their properties. Ackoff also provides a series of definitions of systems terminology which may form a basis for the following discussion of emergent properties, emergent outcomes and emergent systems.

Ackoff argues that any particular system may have an unlimited set of properties, but that those properties which are considered relevant in any particular instance depends on the observer, and the purpose for which the system is being studied. An **emergent property** can be seen in these terms as a property which is added to the set of relevant properties as the result of a system (or environmental) event (see discussion on emergent knowledge, Section 2.3 above).

In this context, Ackoff does not give a definition of the **outcome** of a system. However, using his terminology, one may take the meaning of the term to be as follows:

> the **outcome** of a system event is the state of the system after the event has occurred, i.e. the set of values of the relevant properties

An emergent outcome may be defined as follows:

> an **emergent outcome** is a change in the set of relevant properties (as opposed to a change in the values of existing relevant properties).

Man-made, or designed, systems may frequently display emergent properties and/or outcomes. These may involve physical emergence of new properties which could not have been predicted, or knowledge emergence, of properties which were potentially inherent but not previously recognised. From a "systems design" perspective, these emergent properties and outcomes may be regarded as a sign of systems failure:

> *"A system can be said to have failed if it fulfils one or more of the following criteria.*
>
> *1 It has not met some of the objectives set for it by those involved with it, for example, designers, users, participants or researchers.*
>
> *2 It has produced outputs which are considered undesirable by those involved in it."* (Naughton & Peters, 1976, p60).

The "undesirable outputs" mentioned in the second criterion are, implicitly, unintended, and hence emergent outcomes.

However, the term "emergent system" refers, not to a designed system which has some emergent properties and/or outcomes, but to a system which, while it may have man-made, designed components or sub-systems, has not actually been designed / constructed as a system per se. (At this point, the question of epistemology re-enters the picture, and it is worth re-iterating that what is being discussed as a "system" is actually a convenient way of conceptualising a set of relationships occurring in the "real world").

In order to complete the definition of an emergent system, a further concept which must be added to those above is lack of intention, or purpose. Ackoff distinguishes between **purposive** and **purposeful** systems as follows:

> a **purposive system** is one which may have several different desired outcomes ("goals") but which does not choose which goal is to be pursued, although it is capable of choosing the means by which that goal may be achieved. The choice of goal is imposed from outside the system.
>
> a **purposeful** system is one which can change its goals: it can select ends as well as means, and thus displays will, or intentionality.

Ackoff uses this distinction between purposive and purposeful systems to explain the difference between organisations and organisms:

> *"An **organization** is a purposeful system that contains at least two purposeful elements which have a common purpose relative to which the system has a functional division of labour; its functionally distinct subsets can respond to each other's behaviour through observation or communication; and at least one subset has a system-control function."*
>
> *"Whereas both* [organisations and organisms] *are purposeful systems, organisms do not contain purposeful elements. The elements of an organism may be state-maintaining, goal-seeking, multi-goal-seeking or purposive; but not purposeful"* (Ackoff, 1976, p112).

Both organisms and organisations consist of multiple subsystems (which may be purposeful in the case of organisations, but not in the case of organisms), which come together to produce an overall system (the organization or organism) which is purposeful.

By an extension of this argument, an emergent system may be defined as follows:

> **an emergent system** is one which consists of multiple subsystems, which may or may not be purposeful, which jointly exhibit emergent properties, but which are not jointly purposeful.

2.5 Complex Systems and Overlapping Hierarchies

It will be recalled from Section 2.4 that Checkland's description of the hierarchical relationships between systems and sub-systems was described as "unitary", implying that each level of the hierarchy was completely contained by the one above (See also Checkland,1992). This may also be compared to Koestler's idea of the "holon", which is seen as an intermediate level between higher and lower hierarchical states (Koestler, 1975).

However, in the case of the "Traffic Pollution and Respiratory Health" system, described in Section 1.2, the lower levels of the hierarchy (subsystems and

components) can be seen as embedded within a number of different hierarchies, rather than a single, unified hierarchy. Each of the major aspects of the case study (traffic, air pollution and asthma), is embedded within other systems (see Chapter 5). Levels of traffic are determined by social factors such as the demand for transport and the design of cities and roads. Levels of pollution are affected not only by levels of traffic and technological factors such as fuel and engine characteristics, but also by natural systems such as climate and atmospheric chemical reactions. The relationship between pollution and the number of cases of asthma is affected by both natural factors involving physiological responses to pollution, and also social factors such as exposure and diagnosis rates.

Each of these aspects, as will be seen in Chapter 5, is treated "in the real world" as a system to be managed in its own right, within the context of specific institutions. Traffic is the responsibility of the land-use planning system, pollution of the environmental health system, and asthma of the public health system. All of these management systems are embedded within their own hierarchies, which exist within a spatial and temporal framework, and have a particular configuration at the present time, preceded by a particular history (see Chapter 3). Although the interactions between the systems may be recognised and acknowledged by actors within each system, the processes by which they may be related one to another are not necessarily expressed in existing institutional structures, which are limited by the constraints, agendas and remits imposed by their positions within the existing hierarchies.

The history of air quality management in the UK, as will be seen in Chapter Three, reveals a set of linked processes of co-evolving physical environmental change, perceptual change and policy change which may be compared to Allen's definition of complexity:

> *"the essence of complexity ... [is] the kinds of system that are about the co-evolution of a hierarchy of structures, with loops of positive and negative causalities linking the different scales as an integral whole."* (Allen, PM, 1997).

Allen considers the difficulty of modelling such a *"hierarchy of convoluted causality"*. For modelling to occur, a system must be defined at the so-called *"meso"* level, with links to both the macro level of environmental constraints, and the micro level of the internal structure of components and subsystems. For a particular model, constructed for a specific purpose, both the micro and macro levels may be treated as fixed, and exogenously determined. However, both the internal subsystems and the external environment of a complex system are changing over time, at different temporal and spatial scales (See Section 2.8).

Allen describes the different potential levels of interest in the formation of a transport model, depending on whether the intention is to understand overall traffic flows, an individual trip, or changing patterns of travel (Allen, 1997). Figure 2.1 shows a simplified depiction of the main sets of interactions involved in air quality and health, ranging from policy to manage the environment down to the specific toxic reactions induced by specific pollutants at molecular level (Bates and Watson,1978). If individual exposure is of interest, chemical reactions at the atmospheric ("macro") level may be taken as given, while the toxic impact of the pollutants at the molecular level ("micro") will be also be treated as a "black box" (Beishon, 1971), with no attention paid to the internal structure and interactions.

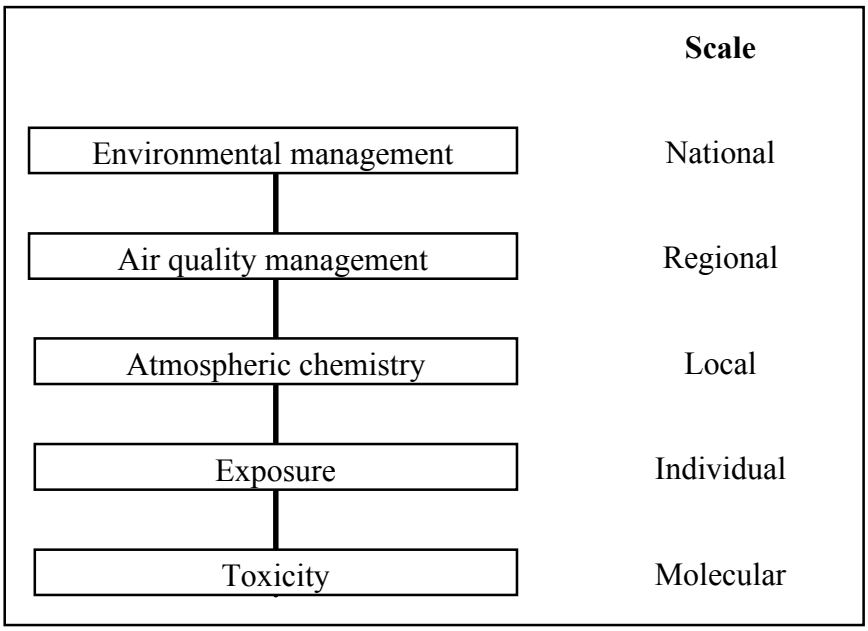


Figure 2.1: Nested Hierarchy of Air Pollution Systems

The choice of meso scale is in effect arbitrary, determined by the reason for which the system is being considered (Beishon, 1971). When the system of interest consists of fixed biological, physical or chemical relationships, such as the generation of tropospheric ozone, the choice of an appropriate "meso" level may be clear. The question becomes more problematic when human actors and decision-makers are involved. Identification of the "system" level will relate to the definition of the issue or problem of interest, but such definitions may be contentious (see Chapter 5). The point of interface between the technical, "scientific" subsystems and the human / decision making systems becomes crucial (Park, 1993).

Complex systems can be seen as consisting of nested hierarchies of systems, with interactions both upwards to the environment and downwards to the subsystems (vertical integration). In addition, interactions may occur between subsystems at the same level (horizontal integration) (Park and Seaton, 1996).

It will be recalled from Section 2.4 that the attempt to define clear cause and effect relationships when defining a "system" leads to simplification and a loss of richness in understanding. In Allen's words: *"models can be thought of in terms of a hierarchy, where increased 'simplicity' of understanding and predictive capability is obtained by making increasingly strong assumptions, which may be increasingly unbelievable."* (Allen,PM, 1997). An air quality management strategy which relies on managing traffic flows through an area to reduce pollution "hot-spots" may take fuel technology to be fixed; or, conversely, may fail, or be unable, to take account of the impact which diverting traffic will have on neighbouring areas.

The recognition of an emergent system involves a shift of focus, from the already existing systems of which the subsystems are part, to the emergent system which arises from the unanticipated interaction of certain subsystems or system components. Emergent systems can be seen as arising from the overlapping of existing systems. In

this context, it is worth noting that emergent systems often involve the interaction of natural/physical, technological and human systems (see Figure 2.2), and although this is not always the case, such a case may be taken as typical in demonstrating the existence of the overlapping systems.

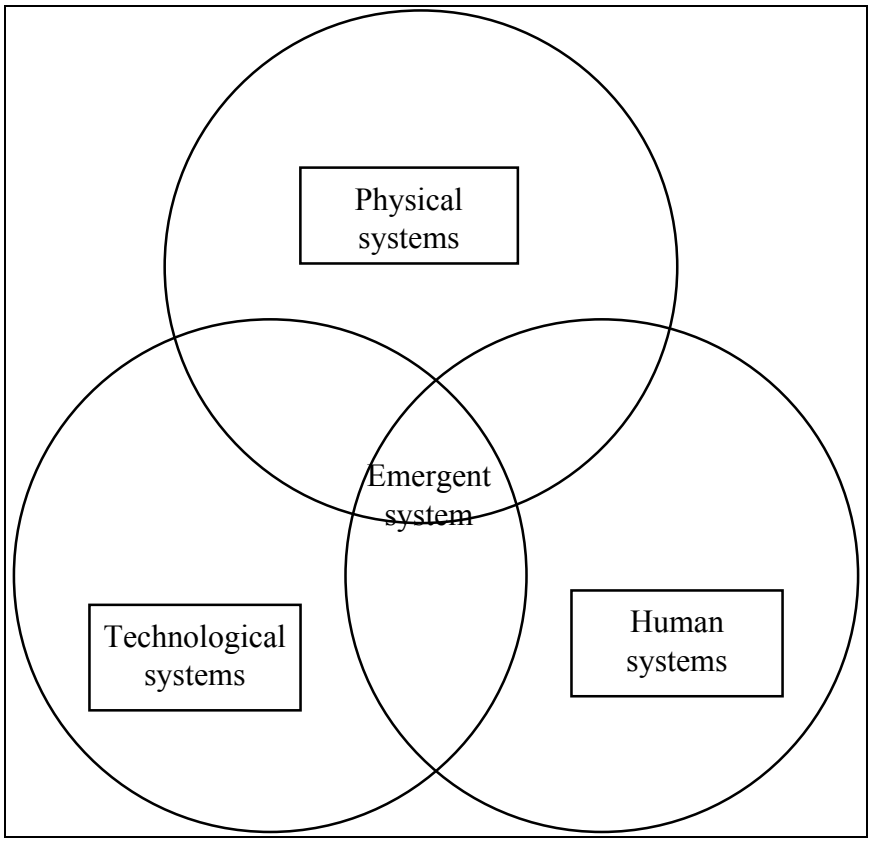


Figure 2.2: Systems Overlap to Create an Emergent System

Returning to Morgan's description of emergent evolution, it will be recalled that what is novel at each stage is the rules of combination of the underlying components (See Section 2.2). Similarly, an emergent system can be seen as a system which arises from the novel interactions produced by the overlapping of existing systems.

2.6 The Problem of Ownership

The characteristics of emergent systems described above present particular problems of management. The components and subsystems may be recognised within the context of the pre-existing base systems, rather than in terms of their significance within the emergent system. Consequently, management will be focused on the base systems, and there may be no ownership of, or attempts to manage, the emergent system. This will be reflected in the structure of managing institutions, and in the level on which policy instruments are focused.

Policy is generated and managed using pre-existing institutional structures. This can mean that, when emergent systems occur, there is no single body which has overall ownership of the problem. This is particularly clear in the case of traffic pollution and respiratory health, as is apparent from the interviews with institutional actors (See

Chapters 5 and 6). In the case of the Oxford pilot study, described in Chapter 5, different institutions had responsibility for each of the aspects of the problem, i.e. the county council was responsible for traffic, the city council for pollution and the health authority for asthma. Because no single body had overall responsibility, and each could only manage their own part of the problem, the partial solutions did not add up to a compete solution, and the problem "fell between the cracks".

However, the *possibility* of ownership, in a conceptual sense, is important for defining the type of emergent system of interest. The idea of ownership implies human involvement in the system, and although natural systems may display emergent properties, the systems of interest to the present thesis are those where it is human involvement which has generated emergence.

2.7 Multiple Constituencies, Perceptions, and Perceptual Emergence

Emergent systems such as the one described here are characterised by a plurality of actors, with different perceptions, agendas and constraints. Differences of perception occur between individuals involved, whether as contributors to the problem (drivers) or recipients (asthma sufferers.). Often the same individual may embody a number of contradictory roles, as in the case of the mother of an asthmatic child, living on a main road in a rural village, who is dependent on a car for transport.

Emergent physical effects come to be regarded as an "issue" or "problem" through the medium of perception. The process by which an emergent outcome becomes recognised as a "problem" is not necessarily straightforward, linear, or "one-to-one". The initial change, or "effect", may pass through a process of temporal and/or spatial dispersion, and combination with other factors, before affecting the recipient ("impact"). In order to be recognised as a "nuisance", the impact must be perceived, by the recipient and/or others, as undesirable. The low-level conceptual model to be developed in Chapter 4 will consider these issues in more depth.

Perception may or may not be directly affected by the physical effects, but it is also, and crucially, affected by understanding of those effects, by responses to those effects, i.e. policy, and by self-reinforcing positive feedback. Vickers talks about the process of **appreciation**, whereby an original "concern" becomes translated, potentially, into a "problem" for which a "solution" may be required in the form of action. In Vickers' words, an appreciative system is:

> *"a mental construct, partly subjective, largely intersubjective, that is, based on a shared subjective judgement, and constantly challenged or confirmed by experience"* (Vickers, 1983, p55).

Each individual bases his or her actions on his or her own personal appreciative system, but this is also related to the appreciative system of the culture to which he or she belongs:

> *"Every culture includes an appreciative system which must be at least sufficiently shared to guide collective action, to mediate communication, and to give the society which generates it enough self-confidence to survive. And this interpersonal artefact is sustained and changed by transmission through the series of personal appreciative systems which it develops and supports in succeeding generations"* (Vickers, 1983, p56).

Lewes speaks of "intellectual wealth" as "capitalised experience":

> *"If man is a social animal, which is undeniable, the unit in a living whole, just as any one organ is the unit of an organism, obviously his functions will be determined not only by his individual structure, but also by the structure of the Collective Organism. Man's individual functions arise in relations to the Cosmos; his general functions arise in relations to the Social Medium; thence Moral Life emerges...* (Lewes,1874, p159).

> *"The co-operation of the Medium is not less indispensable than that of the Organism; and, in the case of man, the Medium is constituted by the education of the race and of the individual"* (Lewes,1874, p161).

Each individual also encounters their own experience, which interacts with the "capitalised experience" inherited and acquired from the surrounding culture:

> *"Every organism has not only an inherited and gradually modified structure which is one of the determinants of its history, it has also a history of incident, that is of transient conditions, which may lead two similar organisms along divergent paths, and determine them to different manifestations."*

Individual perceptions interact and co-evolve with those of the surrounding culture:

> *"Our perceptions are evolutions; and, having necessarily a history at their back, it is clear that all perceptions are modified by pre-perceptions, all conceptions by preconceptions."*

The degree of congruence between the individual and collective appreciative systems will affect the response of the individual to policy change measures (Lemon,1991; Lemon, Hart & Seaton, 1992). Both individual and collective appreciative systems change over time, but not arbitrarily - many appreciative systems have built in inertia. Marmot observes that:

> *"When facts collide with theories, scientist are far more likely to discard or explain away the facts than the theory"* (Marmot, 1986).

citing as an example the case of a study conducted in the 1970s which appeared to show that levels of heart disease in the US were falling at a time when consumption of cholesterol was increasing. When the study was published, the data for cholesterol consumption were adjusted downwards, because of "changes in laboratory practice", so that the results were more in line with what would be expected. As Marmot comments:

> *"The facts did not fit the theory, so they were questioned and ultimately changed"* (Marmot,1986).

Changes within the collective appreciative system may be regarded as a third form of emergence, perceptual emergence, when, for example, some "effect" which was not previously conceptualised as a "threat" or "nuisance" becomes so perceived.

Although Vickers speaks of a single collective appreciative system, which allows a society to cohere, at a lower level it may be more accurate to speak of multiple collective appreciative systems, "multiple perspectives" (Linstone et al, 1981) or "plural rationalities" (Schwarz&Thompson,1990), which provide competing explanations of "real world" experience. The same issue may generate a multiplicity of perceptions of "the problem" of interest, some of which are more or less open to quantification and "scientific analysis" than others. Different definitions of "the

problem" may lead to conflict over policy, as will be seen in the discussion of the different definitions of "the problem" of traffic pollution and respiratory health in Oxford (Chapter 5). The perceived problem may differ from the "scientifically measured" problem; there may also be a multiplicity of "scientific" interpretations of the problem, and conflict over the definition of **the** scientific problem.

Perception and science both affect policy making, but at an earlier stage perception, in the form of the collective appreciative system, also sets the agenda for scientific research. This point will be returned to in Section 4.1, in which the impact of the "*traditional, rational, modernist view of science*" (Allen, PM et al, 1994) on setting the agenda for environmental / air quality research will be discussed in more detail. The generation of scientific evidence is not external to the system, and questions arise over the issue of which types of research should be funded, and who has responsibility for making those decisions (see Chapter 3). Science is "the art of the soluble" (Medawar, 1967); priority may be given to those definitions and aspects of the problem which are more quantifiable and amenable to scientific investigation, for example the transport and dispersal of pollutants, less to "softer" aspects such as driver behaviour, and least of all to interdisciplinary approaches which combine the two but are not able to provide clear unambiguous policy recommendations (O'Riordan, 1995).

In a pluralistic society, decisions are supposedly made on the basis of consensus between the parties involved. Consensus itself can be regarded as an emergent phenomenon, and as such, it is constantly changing, only reaching a steady state under special circumstances and for a limited period. Attempts to modify perceptions may be referred to as "constructing a consensus", but as an emergent outcome, consensus cannot be directly affected; rather, one must manage the components, i.e. the individual perceptions, of which the consensus is the result.

Policy measures may be directly aimed at changing perceptions, for example, health information campaigns (Davison, Smith and Frankel, 1991). A key component of policy related to air pollution and health is the provision of information to the public, on the assumption that this will lead them to modify their behaviour (See Section 5.7, Chapters 6, 7 and 9). However, any policy measures, by changing the context within which people live, may potentially have some impact on the appreciative systems, i.e. perceptions, of those affected.

2.8 Complexity and Evolutionary Change

An aspect of emergence which has not yet been considered directly is the question of temporality. Because emergent systems develop over time, and cannot be predicted, responses depend on existing institutions and roles. Emergent systems can only be recognised with hindsight, and structures must evolve to deal with them:

> *"... societies are presented with certain problems, and the tasks accomplished by political and administrative evolution are to devise ways of solving these problems. Partly under pressure of these solutions and partly in terms of their own logic, new problems establish the conditions for further evolutionary change"* (Weale,1992,p60).

The next chapter will consider this temporal aspect of emergence by looking at the historical development of air quality management in the UK over the last two centuries.

Allen's definition of complexity, mentioned in Section 2.5, recognises the importance of change over time. He defines an evolutionary complex system as one where the constituent components have internal structure which changes over time, and which can feed back and change structures at other levels of the hierarchy, so that the context of the original components changes, leading to evolutionary change (Allen, 1994).

Section 3.4 interprets the history of air quality management in the UK over the last two hundred years as an evolutionary complex system. Each of the major processes described - physical, knowledge, perceptual and institutional change - can be viewed as a separate dynamical system, with its own subsystems and internal structure. But overarching this, they are combined together in a further level of complexity and interaction, with complex feedbacks and interactions with their own environment(s), leading to a process of evolutionary change. In this context, contemporary concerns with traffic pollution may be seen as just an element within this wider process of change.

2.9 Spatial and Temporal Dispersion

A final aspect of emergent systems which will be considered in this thesis is the question of spatial and temporal dispersion of emergent effects.

It will be recalled from Section 2.5 that complex systems consist of nested hierarchies, different levels of which have impacts at different spatial and temporal scales. These differences of scale may lead to problems of integration between the levels of the hierarchy (see Chapters 5 and 8).

The three aspects of the Traffic Pollution and Respiratory Health system, as described in Section 2.5, are managed on different spatial scales, in terms of the geographical remit of the institutions responsible (see Chapter 5). Asthma induced by traffic pollution arises from the coming together of a large number of individual actions, and also affects people on an individual basis. The source of the problem may be regarded as lying in the individual decisions of drivers. However, pollution is generated and dispersed over a wide geographical area, from which the effect then feeds back to specific individuals (RCEP, 1994). Individual and institutional perceptions, as mentioned in Section 2.6, may also vary by location (See Chapters 6 and 7).

In addition, problems may be temporally dispersed, in that the accumulation of emissions may build up over time to produce an impact at a later time. Such effects may be distinguished from catastrophic events, such as the Chernobyl nuclear accident. However, cumulative emissions may lead to catastrophic effects when a threshold is crossed, for example, the 1952 London smog (see Section 3.2.2). Other problems may be chronic and non-cumulative, for example, land-fill gas odour (Longhurst & Cousins, 1993). The situation with asthma is both cumulative, in that the number of cases is rising, and chronic, but is not yet considered to be catastrophic, although this could arise if an epidemic were to occur at a time of high levels of traffic-generated pollution.

2.10 Conclusions

The discussion in this chapter has investigated ideas of emergence, to discover what are the crucial elements of the use of the term emergence; introduced the complex

systems concepts of hierarchy, scale, and perception; and has focused on several characteristics of emergent systems.

Emergence occurs within a context of hierarchical sets of relationships which change over time to generate new patterns of interaction (See Section 2.7 and Chapter 3). Three types of emergence have been identified (Table 2.1): physical emergence, in which novel patterns of relationship are generated (Section 2.3); knowledge emergence, in which the physical relationships may not change, but human understanding of them changes (Section 2.3); and perceptual emergence, in which, although the physical relationships and the overall sum of human knowledge about them may not change, nevertheless the perceptions of some observers and/or participants may change (Section 2.7).

Physical emergence is comparatively rare, referring as it does to the generation of qualitatively new phenomena. Far more significant from the point of view of this thesis are knowledge emergence and perceptual emergence. Knowledge emergence arises out of the field of scientific uncertainty; where all aspects of the physical relationships are not (or cannot be) fully understood, there is scope for change in human understanding. Similarly, perceptual emergence arises from the existence of multiple constituencies; the impacts which the emergent system has on the lives and perceptions of individuals and / or groups may change, leading to changes in perceptions on the part of individuals, groups or society as a whole, and changes in response, which may lead to further repercussions.

Table 2.1: The Three Types of Emergence

Source of variation	Changes occur in	Type of emergence
Spatial and temporal variability	Physical relationships	Physical emergence
Scientific uncertainty	Human understanding	Knowledge emergence
Multiple constituencies	Individual, group and social perceptions	Perceptual emergence

Complex systems ideas have also been explored, particularly the ideas of nested hierarchy (See Section 2.5), spatial and temporal dispersion (See Section 2.9), multiple constituencies and perceptions (See Section 2.7) and evolutionary change (See Section 2.8). The idea of emergent systems has been put forward as a special case of complex systems, typified by over-lapping sets of components and sub-systems which interact with one another and are related hierarchically to other systems (Section 2.5) and lack of ownership and intentionality (Sections 2.4 and 2.6)

An emergent system may be defined as:

Chapter Two

A co-evolving, hierarchically arranged set of relationships between components and subsystems, existing in overlapping hierarchical relationships with other systems; which can be recognised in combination as generating qualitatively new, unpredictable and unintended phenomena and relationships, and which has not overall been designed by human agency, although some of the components and subsystems may have been human-made.

3 The Co-Evolution of Issues and Institutions: the Emergence of Air Quality Management

"The process of interaction and mutual adaptation which we call history is an obscure, though familiar, mystery. Looking into the future, we see a widening vista of possibilities. Tomorrow is almost committed; but next year, ten, twenty years hence, what might not be possible? Yet looking into the past, the vista seems to narrow from past to present. We see a thin line of actualities detaching itself from all that might have been; and those who will some day look back over what is now our uncommitted future will see the same. Of all that competes for realisation, only a tiny fraction is realised, and in the process it excludes a host of alternatives. The eternal enigma of history is, 'Why from all these possibilities did these, rather than any of the others, come to birth?'"

Sir Geoffrey Vickers, "What Sets the Goals of Public Health?", 1958

3.1 Introduction

Worries about air pollution, and attempts to manage it, have a long and complicated history in Britain. Over the centuries, the issues of most concern have changed, as policy-makers have struggled to deal with each new problem effectively within a context dictated by pre-existing conditions and institutions. As technologies, knowledge, perceptions and social and economic conditions have all changed, yesterday's problems may have been solved (more or less satisfactorily) but new ones have always emerged to replace them.

Sperling has shown that technological change, far from following a clear and inevitable trajectory, moves along pathways in which the configuration of conditions at any particular point is dictated by the juxtaposition of a large number of disparate factors, not all of them obvious. Chief among these is the weight of the particular configuration which has emerged from the past course of history (Sperling, 1988). The same is also true of policy. At any time, the weight of past policies, and the inertia of the institutions, perceptions and expectations which they have created, will set the agendas and boundaries for potential future developments (Weale, 1992).

When the ideas of complex systems are applied to a study of the history of air quality management, it can be seen that the processes of atmospheric, technological, knowledge, behavioural and institutional change are intimately linked and co-evolving. In the context of Mediterranean land degradation, van der Leeuw has referred to this intimate linking as *"the true interactivity of past, present and future"* (van der Leeuw, 1995). As will be seen in Section 3.4, the interactions of all the other change processes provides the context for each, just as past changes dictate the context for the present situation.

This chapter will begin by reviewing the history and development of air quality issues and their management in the UK, concentrating on certain significant periods in the history of air quality management: the early Victorian attempts at smoke control; the Alkali Acts; reactions to the Great Smog of 1952 and recent attempts at integrated management (Section 3.2). The chapter will then continue with a review of current approaches to air quality (Section 3.3). This historical and contemporary material

will then be used in the development of a top down conceptual model of air quality management as a complex system, in order to show that many of the characteristics demonstrated by the contemporary concern with traffic pollution have also arisen previously (Section 3.4).

3.2 The Emergence of Air Quality Management

3.2.1 Victorian Approaches To Air Quality

Markham writes that: *"Air pollution has been a political issue in Britain for almost 800 years"* (Markham, 1994, p10). During the Middle Ages, numerous attempts were made to punish individual polluters, including a proclamation made in 1306 which threatened polluters with "grievous ransoms" (quoted in Markham, 1994, p5). During the seventeenth and eighteenth centuries, writers such as the diarist John Evelyn and the naturalist Gilbert White commented on the clouds of coal smoke which hung over London. However, such attempts at pollution control as existed were reliant on individual claimants bringing actions under the Common Law against individual polluters for specific nuisances (Ashby & Anderson, 1981). The idea of collective responsibility for, and collective management of, air quality is one which has developed slowly over the last two centuries.

By the early years of the nineteenth century, the industrial revolution, and particularly the burning of coal to produce steam power, was taking its toll on the quality of air over the major English industrial cities. The technology to enable steam engines to burn coal more efficiently, and hence reduce the amount of smoke produced, was already in existence, one of the earliest patents for such a device having been registered by James Watt in 1785 (Ashby & Anderson, 1981). However, in the absence of any regulation or incentives, the industrialists did not consider it worth their while to make any attempt at smoke control.

The issue was first raised in parliament in 1819, by Michael Angelo Taylor, MP for Durham city. Taylor was the first of many concerned individuals who would raise the profile of the issue of pollution over the next few decades, and was instrumental in the setting up of a select committee *'to inquire how far it may be practicable to compel persons using Steam Engines to erect them in a manner less prejudicial to public health and public comfort'* (Ashby & Anderson, 1981, p2). According to Ashby and Anderson,

> *"The evidence assembled by Taylor's committee in 1820 was enough to persuade any reasonable person that cleaning the air, like cleaning the streets, was a public responsibility and parliament could no longer be indifferent to it"*(Ashby & Anderson, 1981).

and Taylor's efforts led, in 1821, to the passing of a bill requiring furnaces of steam engines to consume their own smoke (Brimblecombe, 1987). The bill was a feeble affair, which had been severely weakened in debate, and it was never put to the test in the courts, but initiated the process of changing the climate of the opinion. To quote Ashby and Anderson again:

> *"The State had taken a first timid hesitant step toward a policy for clean air: and those whose interests were threatened by a clean air policy had put up their first defence"* (Ashby & Anderson, 1981, p5).

Those arguments were to be rehearsed again and again over the remainder of the century, particularly during the sustained campaign carried out by another MP, WA Mackinnon, from 1843 to 1850; and many of them have a familiar ring. First was the problem that it was not possible to provide conclusive evidence that smoke was a hazard to health; many other factors, such as malnutrition, poverty and long hours of work exacerbated the symptoms of respiratory disease, and although it was possible to demonstrate correlation between smoke and respiratory disease, correlation does not prove causality. Secondly, problems existed with the technology designed to improve fuel consumption, partly because it was not effective when the furnace was first started, and hence was unsuitable for furnaces which were used intermittently, but largely because it depended on the skill of the stoker and the maintenance of the boiler. Thirdly, but perhaps most significantly, were the objections of the industrialists (and their representatives in parliament) to any suggestion that the state might be permitted to interfere with the running of their businesses.

Smoke from steam furnaces was in fact only part of the problem of pollution, albeit a very significant part. Another source of smoke, and one which roused considerable passions, was the domestic hearth:

> *"By using smokeless fuel ... in closed stoves, or by adopting the traditional domestic stove to be found in Russia, Scandinavia and Germany, it would have been possible, technologically, to eliminate much of the smoke from domestic houses. Technologically, perhaps, but certainly not psychologically. The cheery open fire was the focus of family life. Quite apart from the enormous cost and trouble involved, the conversion of the open English fire would have precipitated a social revolution of the kind no politician would contemplate"* (Ashby & Anderson, 1981, p10).

Equivalent, perhaps, to depriving the average English person of his or her private car?

In addition to smoke from the industrial and domestic burning of coal, there was also the question of 'noxious vapours'. This was a blanket term used to describe pollution generated from a wide variety of industrial processes, and in 1862 a Select Committee on Injury from Noxious Vapours was set up in the House of Lords. Although many individual cities had some form of nuisance legislation by the middle of the nineteenth century, this was rarely effective, and in the absence of national legislation, industrialists needed only to move their factories outside the city boundaries - from where the pollution was able to drift back. (Wohl, 1983, p220).

The one industry for which significant legislation was achieved was the alkali industry. Wohl argues that one reason for the successful implementation of the Alkali Acts was that *"alkali pollution was subject to accurate chemical measurement and technological innovations that could result in industrial profits"* (Wohl, 1983, p230). Additionally, the main impact of alkali pollution was seen as being on the value of land in the vicinity, rather than the public health, so that two major vested interests, the industrialists and the landed gentry, were pitched against each other (Wohl, 1983).

The major progress in air quality management through the Victorian era can be seen as a glacially slow, but steady, shift in public opinion, amid fierce debate, towards the assumption that air quality is a public good which can, and should, be subject to legislative control. However:

> *"air pollution remained to the end of the century subject to the vagaries of a wide range of smoke abatement, public health and local nuisances acts, most of which were rendered inoperative by their "best practicable means" clauses and by the system of local inspection and high legal costs"* (Wohl, 1983, p231).

3.2.2 The Great Smog and the Clean Air Act of 1956

The issue of domestic smoke production did not go away. Although the problem of smoke from coal fires had been well recognised for some time, and potential solutions in the form of improved domestic stoves were technologically feasible, the introduction of legislation had to wait until the middle of the next century, when a combination of factors created a more suitable climate for change. Although the Simon committee of 1946 pressed for the introduction of smokeless zones, nothing was done at the time.

The dense fog which enveloped London from the 5th to the 9th December 1952, to which four thousand deaths were eventually attributed, is credited with being the trigger which precipitated the Clean Air Act. However, the official response was by no means immediate, partly perhaps, as Hall et al point out, because it took several weeks for mortality data to be analysed and for the extent of the catastrophic effects on public health to be recognised (Hall et al, 1975).

As is the case today with traffic pollution, responsibility for the issue was fragmentary. The epidemiological data which quantified the extent of the problem, were collected by the Ministry of Health, and the local authority medical officers of health, who had responsibility for public health. However, the responsibility for managing air pollution lay within another ministry entirely, and indeed:

> *"When the crisis broke, air pollution was only a part of the responsibilities of one civil servant in the Ministry of Housing and Local Government."* (Hall et al, p380).

Despite the fact that the main expertise and interest in the issue were located in the Ministry of Health, action in response could only come from the Minister for Housing and Local Government, who at the time was concerned with other priorities, not least the commitment to build 300,000 new houses. In addition, the technological aspects of the problem, including the supply of smokeless fuel, lay within the area of responsibility of the Ministry of Power.

Another factor was the perceived continuing unpopularity of measures to regulate domestic heating, which may explain the fact that the government's legislative response was delayed until after the General Election in May 1955.

Hall et al credit the maintenance of interest in the issue, which could have dropped from public sight, to the existence of a committed, authoritative and well prepared pressure group, the National Smoke Abatement Society, and the actions of individual backbenchers in raising questions.

Through the provisions of the 1956 Clean Air Act , local authorities were empowered to declare part or all of their district a 'smoke control area'. However, as with the situation of air quality management and ambient air quality monitoring forty years later, implementation varied greatly between different areas. While progress in Greater London was so significant that Hall could claim in 1975 that there had been

no smogs since 1962, local authorities in coal mining areas were, in the 1960s, more concerned with the mining interests and the future of the industry in their areas. Another theme which has contemporary echoes is the shortage of resources within local authorities, particularly of smoke control officers.

The management of domestic smoke production can thus be seen to have parallels with the traffic emissions case, being fragmented both institutionally and geographically, with local authorities having considerable discretion in implementation. Nevertheless, the 1956 Clean Air Act is regarded as having been successful in reducing smoke and smog. Perhaps some of the improvement in terms of air quality may, however, be attributable to technological changes which were taking place in parallel, such as the discovery of natural gas in the North Sea, the development of nuclear power, and the phasing out of steam locomotion. Ironically, this last has been overtaken by the growth in motor transport, leading to the current stage in the development of air quality issues.

3.2.3 Integrated Pollution Control

The Alkali Acts had led to the setting up of a central inspectorate, the Alkali Board, responsible for the management of pollution from industrial processes, while smoke pollution was managed on a local basis through nuisance legislation. Over the years, this split in responsibilities remained in place, although the responsibilities of the Alkali Board were slowly extended over the years, to cover other processes.

In 1976, the Royal Commission on Environmental Pollution recommended the introduction of an integrated approach to pollution control, with a unified inspectorate which could:

> *"ensure an integrated approach to difficult industrial problems at source, whether these affect air, water or land"* (Murley,1994, p5).

However, these recommendations were effectively ignored for over ten years (Bell and Ball, 1991). A major review of air pollution control began in 1986, which led to the establishment of a framework for a system of integrated pollution control under the Environmental Protection Act of 1990 (Murley,1994). Under Part I of the Act, all industrial processes were to be classified in terms of the nature and extent of emissions to all media, and methods for controlling those emissions. Working groups, involving representatives from industry and the local authorities, were set up to produce guidance notes (Best Practicable Means - BPM- Notes) for all processes, taking into account the current state of technology and scientific knowledge, together with EC legislation on industrial emissions.

The classes of processes were then divided into two groups: Part A, including emissions to water and land, with some particularly complex air emissions, which were to be controlled centrally by Her Majesty's Inspectorate of Pollution (HMIP); and Part B, consisting of the remaining air emissions from industrial processes, which were to be controlled by the local authorities.

The implementation of Part I of the Act thus extended local authority powers with respect to industrial air pollution, while Part III extended the powers of local authorities with respect to action to control smoke, dust, fumes and gases as a statutory nuisance (Murley, 1994)

3.3 Current Approaches to Air Quality

3.3.1 Air Quality Management

The involvement of the European Union in environmental legislation, together with a changing recognition of the nature of air pollution problems, has led during the 1980s and 1990s to a change in emphasis with regard to air quality in the UK, from control of emissions to control of ambient levels. The first EC Directive to define air quality standards (for sulphur dioxide and suspended particulates, ie smoke) (80/779/EEC) adopted in July 1980, was followed by directives for nitrogen oxides (85/203/EEC), lead (82/884/EEC) and implemented by the UK government in the Air Quality Regulations 1989. This introduced into the UK the first statutory air quality standards, and was followed by a directive for ozone (92/72/EEC, adopted under the ozone monitoring and information Regulations, 1994).

Concern over ambient air quality was also reflected in the setting up of bodies such as the Quality of Urban Air Review Group (QUARG), whose remit was to review current knowledge of urban air quality and how it is assessed in the UK, especially in relation to public exposure and information to the public; and the Expert Panel on Air Quality Standards (EPAQS), set up to recommend air quality standards for the UK.

The focus had increasingly shifted from the control of individual polluters and emissions to the management of ambient levels of pollutants. However, ambient levels are the emergent outcomes of the interactions of the underlying effects, and emergent outcomes cannot be managed directly (see Section 2.5).

In such a context, management takes on two roles. Firstly, there are attempts to control the lower level effects, for example through the control of prescribed processes, which have been relatively successful, or the phasing in of catalytic converters (the benefits of which are likely to be negated by increasing growth in motor transport - see RCEP,1994 - and which in any case actually contribute to another emergent problem, that of carbon dioxide production and the so-called "greenhouse effect" (Niewenhuis & Wells,1994)).

The second major role for management lies in the assessment of the scale of the problem, through measurement of pollution, identification of potential pollution incidents, spatial hotspots and trends over time. The imposition of limits and/or guidelines for ambient levels implies the ability to monitor those levels in order to evaluate compliance. The focus of government interest has therefore increasingly been on this aspect of management, as can be seen from the expansion of air quality monitoring.

3.3.2 Air Quality Monitoring

The first systematic monitoring of air quality in the UK was begun in 1914 by a voluntary group called the Committee for the Investigation of Air Pollution, and taken over officially under the auspices of the Meteorological Office in 1917 (Murley, 1994). In 1961, in the wake of the first Clean Air Act, The National Survey of Air Pollution was set up to monitor concentrations of smoke and sulphur dioxide in 1200 sites throughout the UK, carried out by local authorities and other bodies and co-ordinated by Warren Springs Laboratory. This was replaced in 1982 by the UK Smoke and Sulphur Dioxide Monitoring Network, involving 225 sites. The National

Nitrogen Dioxide Survey of 1200 sites, also operated by local authorities and administered by Warren Springs Laboratory, was begun in 1993. Since the closure of Warren Springs Laboratory in 1994, its co-ordinating function has been taken over by the National Environmental Technology Centre (NETCEN), part of AEA Technology, an agency of the Department of Trade and Industry (Murley, 1994).

In 1992, the Enhanced Urban Network (EUN) of monitoring sites became operational, in response to the need to monitor for compliance with the EC Directives. The EUN sites provide continuous monitoring of sulphur dioxide, nitrogen dioxide, carbon monoxide, ozone, particulates and hydrocarbons using automatic instruments at a number of sites around the country. Again, these sites are operated by trained local authority staff, and co-ordinated centrally. Ozone is monitored on the same basis by the Rural Air Quality Network of 15 sites (QUARG, 1993).

The existence of such high quality, centrally funded sites in certain locations has led local authorities in areas without an EUN site to implement their own monitoring schemes (see Chapter 5 and Hadfield, 1994(a)). Because of the trans-boundary and regional nature of air pollution issues, groups of authorities have also joined together to pool monitoring facilities, the first of these regional groupings being the London Air Quality Network of thirty three London authorities, established in 1993 (Beevers, 1993; see also Chapter 6 of the present thesis). In 1993, the Department of the Environment issued a consultation paper recognising the existence of local and regional monitoring, and considering the viability of incorporating data from local authority operated sites into nationally available data (DOE,1993).

However, monitoring of ambient pollution presents its own technological difficulties. In order to provide consistent and comparable data, equipment must be standardised and rigorous standards of quality assurance, quality control and calibration must be enforced (Beevers,1993; DOE,1993). The EUN has been criticised by local authority representatives as providing, in a limited number of locations, funding for equipment which is too expensive (because sophisticated) to be within the budgets of most local authorities (Hadfield,1994(a)). The availability of suitable monitoring methods at affordable costs varies between different pollutants. Some techniques, for example, diffusion tubes, provide only an average level for pollution over the period for which the tube is exposed. In order to record peak levels, necessary both for evaluating compliance with EU Directives and for providing real-time warnings, more sophisticated (and hence expensive) continuous monitoring equipment is required (Beevers,1994).

3.3.3 The Environment Act 1995

The culmination of the move towards management of ambient air quality rather than point sources is embodied in Part IV of the 1995 Environment Act . The Act requires local authorities to carry out a review of local air quality to assess whether air quality standards or objectives are being achieved, and if necessary, designate “air quality management areas” (AQMA), and to draw up management plans for policies to meet standards. However, the Act provides no guidance to local authorities as to how this is to be achieved, other than through the adoption of technical fixes such as the catalytic converter (Cannibal, Lemon & Longhurst, 1996). Moreover, as pointed out by the Royal Commission on Environmental Pollution, this is unlikely to be a viable solution in the long run:

> *"... the aim of future planning policies must be to reduce the need for movement (instead of stimulating ever more mobility, as has been for too long the case). This will involve a gradual shift away from lifestyles which depend on high mobility and intensive use of cars".* (RCEP, 1994).

At "ground level", the main emphasis of air quality management has thus come to centre on measurement. A concomitant of this approach is the use of such data as is collected to provide information to the public and influence individual behaviour (see Chapters 5 and 6). However, the means by which this can be achieved are fraught with difficulties (see Chapters 8 and 9).

3.4 The Evolution of Air Quality Management - Perceptions and Policy Making

3.4.1 Conceptual Model

When the concepts of emergence and complexity are applied to the past development of approaches to air quality management, it can be seen that many of the characteristics identified in Chapter 2, eg scientific uncertainty, multiple constituencies, emergent knowledge, spatial dispersion and the importance of public perceptions, have arisen before.

In order to understand the present situation and problems better, it may be helpful to interpret that history as a complex evolutionary process with recurring characteristics (see Section 2.8). The final part of this chapter presents a conceptual model of that process, illustrated with examples taken from that history.

The underlying model is shown in Figure 3.1 (note: Figure 3.1 is also repeated as Figure 4.4 in Section 4.5).

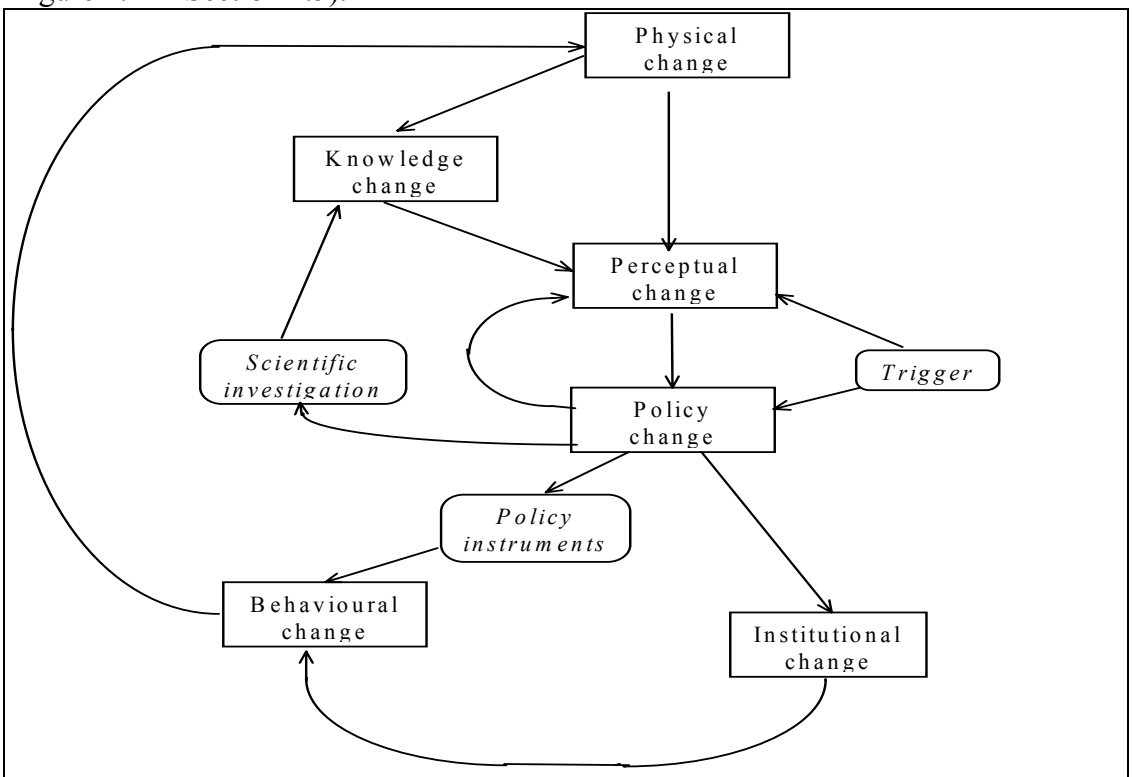


Figure 3.1: Top-down Conceptual Model of the Linked Processes of Change

Physical changes occur in the composition of the atmosphere, such as the London smogs of the 1950s (see Section 3.2.2) and statistically significant long-term upward trends in rural ozone concentrations over recent years (Bower et al, 1994).

Knowledge about the changes emerges, recognised by some individuals, but controversial - for example the findings of the Royal Commission on Environmental Pollution Eighteenth Report on Traffic Pollution (see Section 3.3.3 and RCEP, 1994).

Technology for measuring and responding to the changes also develops, for example, the development of the Enhanced Urban Network (see Section 3.3.2 - see also Wohl's comments about the suitability of alkali manufacture for technological measurement and control in Section 3.2.1).

Perceptions change amid controversy - concerned individuals and groups raise the profile of the issue, for example Michael Angelo Taylor and WA Mckinnon (see Section 3.2.1) and the National Smoke Abatement Society in the 1950s (see Section 3.2.2). The mass media also play a role in this - see discussion of the Times campaign on smoke control in the 1880s (Section 3.4.5, below).

a **Trigger** occurs, in the form of some kind of crisis, which may be catastrophic or merely recognition that a threshold level has been reached for example, the Great Smog of December 1952.

a **Response** is attempted by policy makers, within the context of existing institutional structures, for example, the Clean Air Act of 1956 (see Section 3.2.2).

eventually, **Institutions change** (perhaps) - for example, through the setting up of the Environment Agency (see Section 3.3.3).

3.4.2 Physical Change

The relationship between physical changes and changes in knowledge and/or perceptions is complex, and lies at the heart of the discussion of emergence (see Section 2.2). The physical composition of the atmosphere has been changing constantly throughout history (Markham, 1994). All the measures described in this chapter have occurred in response to such changes, whether caused by steam furnaces (section 3.2.1), industrial processes (Section 3.2.1), domestic fires (Section 3.2.2) or traffic (Section 3.3.1). These changes are occurring anyway, but acquire significance when they are recognised by people.

3.4.3 Knowledge Change

Scientific knowledge about the changes, and about underlying causal relationships, may advance, but not autonomously; it advances through the application of scientific investigation, the accumulation of data and the posing of questions, which will occur only when an issue has been recognised as being of interest (see Section 4.1 below). Even when science is applied to an issue, when the underlying relationships are complex, as in the case of traffic pollution and asthma, there is no single, unambiguous "scientific" answer (Section 4.3).

3.4.4 Technological Change

Technology also develops, both in response to its own imperatives and within its own constraints, (for example, as mentioned in Section 3.3.2, the nature of the specific

pollutant affects the type of monitoring technology which can be used), but also in response to other, external factors, usually economic, as in the case of James Watt's patent (see Section 3.2.1).

3.4.5 Perceptual Change

Scientific and technological change, while important, are thus in a sense always secondary to perceptual change (see Section 2.7. For further discussion of this issue, see Sections 4.1 and 10.2 below). However, perceptual change is always controversial, because of the existence of differences in perception between individuals and constituencies, as for example in the case of the controversy over smokeless fuel (see Section 3.2.1). But human activity occurs in response to perceptions, whether or not these are embodied in "scientific" evidence, or, to quote a contemporary politician referring to the "beef crisis" of March/April 1996 (see Section 2.3):

> *"The market doesn't run on science, it runs on human emotion"* (Paddy Ashdown MP, speaking on the BBC Radio 4 "Today" programme, 26/3/96).

When controversy exists, it is often concerned individuals and groups who work to increase the profile of an issue and to change general perceptions, as can be seen for example in the actions of MP Michael Angelo Taylor in the early 18th century (see Section 3.2.1) and the National Smoke Abatement Society (now the National Society for Clean Air) in the 1950s (see Section 3.2.2). The mass media have a role to play in this process of awareness-raising, and this is not purely a late twentieth century phenomenon, as the Times ran a campaign on smoke control in the 1880s, concluding:

> *"We must .. endeavour to stir up public opinion to the point of action by implanting a conviction in the public mind that civilisation itself is retarded by the toleration of nuisances that can be removed and of dirt that never ought to have been created ... we are not without hopes that the day is not far distant when public opinion will insist that London must somehow be relieved of its canopy of gloom and its hideous vesture of dirt"* (The Times, 23 May 1890, Quoted in Ashby and Anderson, 1981).

3.4.6 Triggers

Public opinion alone, however, is not always enough to invoke a response in terms of policy. This is usually brought about by the trigger of a dramatic event, such as the Great Smog (Section 3.2.2), or policy changes at a higher level, such as the adoption of the EU Directives on air quality limits in the 1980s (Section 3.3.1).

Referring to Figure 3.1, it may appear that "triggers" are exogenous to the model. However, at a higher level, it can be seen that such apparently "external" events have in fact been generated by the emergent effects of previous stages of the overall process - for example, the accumulation of chemicals in the atmosphere leading to the Great Smog (see Section 2.9), or by the imposition of new constraints from a higher level of the hierarchy, such as the EU Directives referred to above.

Thus, the model can be seen as applying at different hierarchical levels, with different temporal and spatial scales (see Section 2.5). This is a recognised feature of complex evolutionary systems (Section 2.8), as described by Allen :

> *"In reality, the interaction of the system within the larger one which is its environment will lead to a co-evolutionary dialogue involving the wider situation. This Co-Evolution of System and Environment means that, in reality, the changes in the environmental parameters* [ie, triggers], *will partially be related to the adaptations that occur within the system."* (Allen,PM 1997).

3.4.7 Policy Response

When an issue, however controversial, has been recognised as important, a first response of policy-makers is often to find out more about the problem, perhaps by setting up a committee or other body to investigate it, for example Taylor's select committee of 1820, or, more recently, QUARG and EPAQS. The general approach to monitoring air quality described in Section 3.3.2 can be seen as part of this information-gathering process. Thus the process of scientific investigation can be seen as internal to the system.

While collecting information and modifying perceptions may be seen as part of the policy process, ultimately, specific measures will be needed if change is to be effected. This, the final stage of the policy process, can be seen as exemplified by the imposition of smokeless zones. Often, policy is implemented within the context of existing institutional structures, for example, the use of local authorities to monitor air quality, although this may impose difficulties because of other constraints and priorities of those institutions (see Chapter 6). In some cases, the policy response may involve changing the institutions themselves, or creating new ones, as in the case of the Alkali board in the 19th century, or the Environment Agency in 1995.

3.4.8 Policy Change and Perceptions

Although the introduction of new policy instruments was referred to in the previous paragraph as the "final stage of the policy process", this is perhaps misleading. Policy continues to develop, for several reasons. Firstly, because its imposition, whether or not it fulfils the intended function, will change both the situation and perceptions of that situation, thus feeding back into the "physical" and "perceptual" change boxes of Figure 3.1. Secondly, the behaviour and responses of individuals, both those involved with the implementation and those on the receiving end, will affect how it is put into practice (Lemon and Naeem, 1990). Finally, the action may have unanticipated effects on the physical system; for example, in the 1970s, the catalytic converter was seen as a viable solution to the problem of atmospheric pollution from traffic, because carbon dioxide was not regarded as a pollutant, being already present in the atmosphere and not in itself toxic to humans. It is only with increasing knowledge about global warming and "the greenhouse effect" that this has come to be seen as a problem (von Schomberg, 1995).

3.5 Summary and Conclusions

Concern about the relationship between poor air quality and its impact on human health has grown rapidly in recent years, as indicated by the growth of legislation.

However, air pollution, and government attempts at regulating it, are not new phenomena, and consideration of the history of air pollution and its management in the UK over the last two centuries demonstrates the ways in which policy has evolved in response to changes not only in the chemical composition of the atmosphere, but also in knowledge about those changes and perceptions of their importance.

This chapter has presented a historical review of air quality policy in order to show the recurring importance of the major characteristics of environmental systems identified in Chapter Two, that is:

- that no single body has overall ownership, and hence management is fragmentary (Section 2.6);
- that management evolves within a context of pre-existing institutions which have been designed for other purposes (Sections 2.8, 3.4) ;
- that both the properties and the management of the system vary spatially, leading to different responses in different locations depending on the local context (Section 2.9);
- and that a significant component of that context lies in the perceptions and perspectives of members of the various constituencies involved (Section 2.7).

A conceptual model of the linked processes of physical, knowledge, technological, perceptual, policy and behavioural change has been presented, and illustrated using examples drawn from the history of air quality management. The next chapter will consider existing models of research into air quality, and suggest how the conceptual model developed here can provide new insights into the phenomenon of traffic pollution and respiratory health.

4 Current Approaches to Air Quality Research: the Need for an Issue-Based Approach

> *"The highest wisdom has but one science - the science of the whole - the science explaining the whole creation and man's place in it."*
>
> Leo Tolstoy, "War and Peace", 1868-1869

4.1 The Conventional Approach to Environmental Research

In 1990, the UK Government produced its first White Paper on the environment, "This Common Inheritance", in which it stated a number of principles:

> *"First, we must base our policies on fact not fantasy, and use the best evidence and analysis available. Second, given the environmental risks, we must act responsibly and be prepared to take precautionary action where it is justified. Third, we must inform public debate and public concern by ensuring publication of the facts. Fourth, we must work for progress in the international arena as we do at home. And fifth, we must take care to choose the best instruments to achieve our environmental goals."* (DOE, 1990a, p10).

Underlying these principles can be seen a set of assumptions: that environmental "risks" can be recognised and identified, and environmental "goals" established; that a set of "facts" can be obtained about those risks, which are distinguishable from "fantasy", by means of the "best evidence and analysis"; that public debate and concern can and should be "informed" by the publication of those "facts"; and that the achievement of those clearly specified "goals" depends on making the correct choice from among a clearly defined set of available instruments.

These assumptions reflect a view of the relationship between science and policy which has been described as the *"traditional, rational, modernist view of science"* (Allen et al, 1994). The approach assumes that a "problem" has been unambiguously identified and clearly defined by "decision-makers", and that the role of science is to investigate the problem in such a way as to provide an optimal solution. The overall "problem" will be broken down into its constituent elements, and an optimum solution found for each aspect of the problem. This assumes the existence of simple causal relations which can be discovered, so that appropriate action can be taken to modify the inputs to those relationships in order to produce the desired outcome (end-state). (Allen et al,1994).

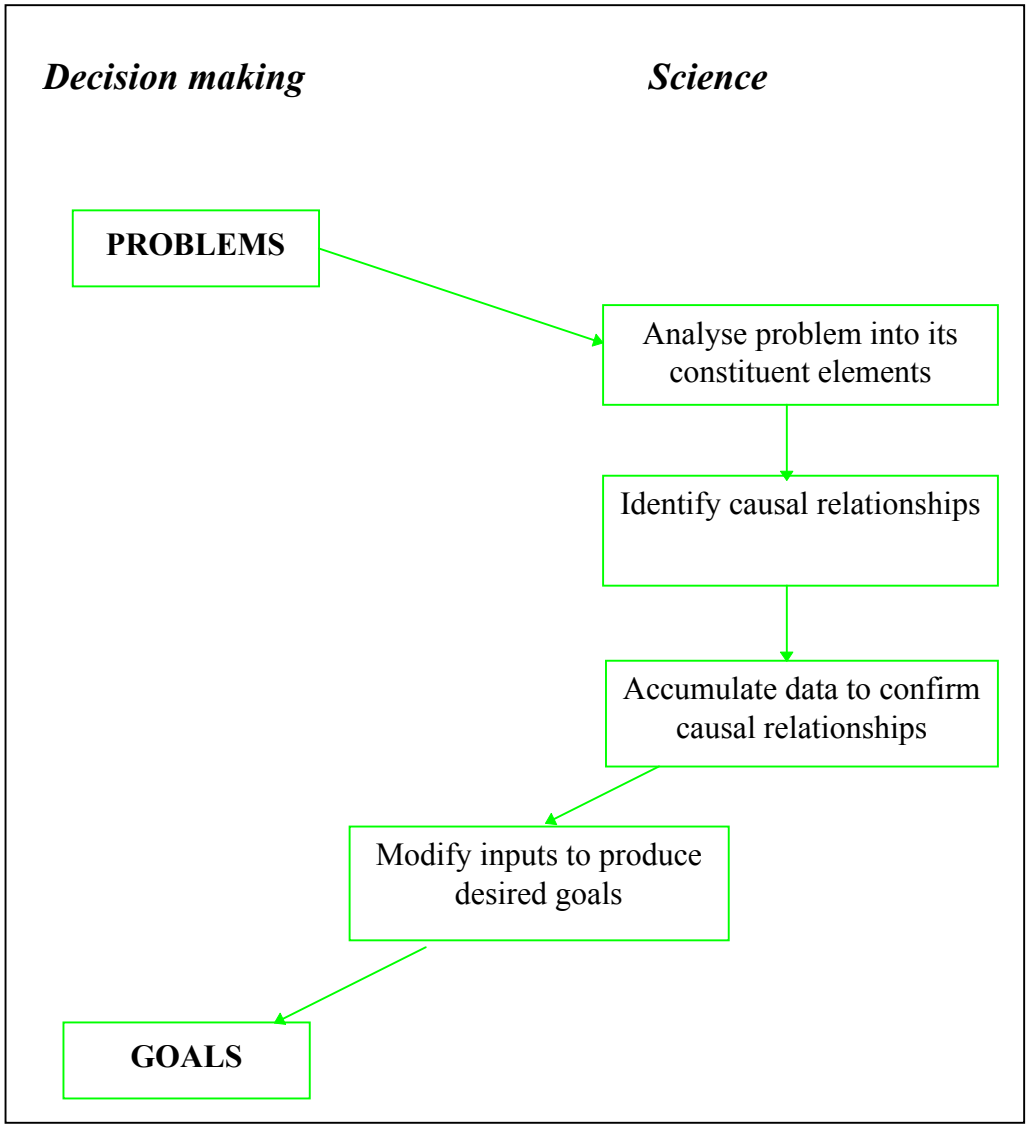


Figure 4.1: The Conventional View of the Relationship Between Science and Policy Making

This model of the relationship between science and decision making has been criticised for the assumption that science is external to the decision-making process, and available only to provide the best solution for tackling pre-defined problems which are identified by the "decision-makers" (see Allen et al, 1994). Although the model works well in terms of providing solutions once the problems have been defined, it cannot account for the difficulty of defining problems in the first place, or the possibility that the causal relationships involved will change in the future or generate new relationships and emergent outcomes (see Section 2.4) or "unintended consequences" (Allen et al, 1994).

4.2 Approaches to Research on Air Pollution

Existing research on air pollution has reflected the above model. This may be seen from the research priorities as set out in a number of official documents: the Environment White Paper, as mentioned above (Section 4.1); the first report of the Quality of Urban Air Review Group (QUARG) (see Section 3.3.1), and the report on

the possible links between pollution and asthma produced by the Committee on the Medical Effects of Air Pollution (COMEAP) (see Section 4.3.3).

The White Paper sets out the following approach to air quality:

> *"Research into air quality aims to establish the effects of possible pollutants on man and the natural environment."* (DOE, 1990).

The White Paper then continues to list a number of what it describes as "*examples of relevant public sector research problems"*(DOE, 1990). These are shown in Table 4.1, classified in terms of the type of causal relationships at which they are directed. Each of these sets of causal relationships then implies a particular type of research approach, as shown in Table 4.2 and described in more detail in Sections 4.3.1 - 4.3.4 below.

Table 4.1: Research Objectives for Air Quality Identified in the Environment White Paper (DOE, 1990a).

Research Objective (DOE, 1990).	**Relationships**
to monitor air quality to establish where the pollution comes from, how it can be controlled, reduced or treated, how it is transported through the air and how it changes chemically	Pollutant generation. Atmospheric chemistry and transformations
to assess and quantify the effects of air pollution on the natural and man-made environment and to derive 'critical loads'	Dose- response relationships, toxicity
to support a consortium of engine manufacturers in developing techniques to improve the design of vehicle engines and reduce emissions form them	Pollutant generation, fuel and engine technology
to provide accurate information on the contribution of vehicles to noise and pollution and assess and predict how this might change in response to legislative changes, as the basis for developing appropriate standards	Pollutant generation, fuel and engine technology
to improve prediction of local and regional dispersion of air pollutants, including radionuclides, and to extend knowledge of the atmospheric chemistry of air pollutants	Atmospheric chemistry and transformations
to improve understanding of the chemistry of the stratosphere and the troposphere in relation to air pollution problems near the ground; and to participate in the European Experiment on Transport and Transformation over Europe providing basic information on the transport of pollutants such as acidic substances and photo-oxidants like ozone	Atmospheric chemistry and transformations
to study the effects of nitrogen and sulphur-based acidic pollutants on sensitive organisms and ecosystems	Dose- response relationships, toxicity
to study the effects of atmospheric pollutants on natural vegetation, soils and surface waters	Dose- response relationships, toxicity
to develop new methods to quantify likely radon emissions in different areas	Pollutant generation
to investigate the release into the air of asbestos, man-made mineral fibres and chemicals from construction products and other materials used in homes	Pollutant generation
to monitor the levels of indoor pollutants in homes, particularly for families with babies	Population exposure, general and susceptible populations
to evaluate construction measures to reduce radon entry into houses" (DoE, 1990).	Pollutant generation

The Quality of Urban Air Review Group, set up in the wake of the environment White Paper with the aim of reviewing current knowledge of urban air quality and the ways in which it is assessed in the UK, defined its research aims as follows:

> *"The Group considers that it is not possible with current knowledge to establish a quantitative link between changes in national pollutant emissions and changes in urban air quality. The group recommends the establishment of a substantial programme of research aimed at understanding urban pollution emissions, chemistry and dispersion."* (QUARG, 1993).

The Committee on the Medical Effects of Air Pollution (COMEAP) was asked by the Department of Health (DH) to advise on the possible links between pollution and asthma, and given the following terms of reference:

> *"To advise on:*
> *a) The time trends and geographical pattern of asthma in the United Kingdom(UK) and the relationship of air pollution to such trends and patterns.*
> *b) The role of air pollution in aggravating existing asthma.*
> *c) The possible mechanisms by which air pollution might cause or aggravate asthma.*
> *d) Gaps in relevant information.*
> *e) Recommendations for further work."* (COMEAP, 1995).

These sets of research aims can be seen as being focused on elements of the above model: breaking down the problem into sub-problems in which the causal relationships can be identified and investigated.

"Alternative" approaches to the problem, while seeking to show that "official science" is inadequate, still subscribe to the same model, arguing that what is required is improved data collection leading to more thorough investigation of causal links:

> *"The long term effect of air pollution on children's health in the UK is largely unknown. There are two principal reasons for this. Firstly, there is significant shortage of air pollution monitoring equipment in population centres ... Secondly, there has been minimal research in the UK on the effects of the pollution that children experience. Since the dismantling of the Clean Air Council and the Medical Research council Air Pollution Research Unit more than 10 years ago, virtually no major work has been done in this country on the effects of air pollution on health."* (Read, 1991).

> *"DOE air quality information ... is only as good as the monitoring network can provide. The current size of the network is simply not up to the task of providing adequate local information for individuals to take personal decisions to protect their health."* (Weir,F, 1993).

The last extract reflects another aspect of the conventional approach, and one which will be returned to in Chapters Five, Six, Seven and Eight: that an aim of policy should be to provide individuals with information on which they can base personal decisions.

4.3 Recent Research on Air Pollution and Health

Throughout the history of air quality management, concern about air pollution has been linked to its potential for impact on health (Shrenk, et al,1949; Kennedy & Grumbly,1988; Wohl, 1983). However, a major difficulty has always been the

difficulty of establishing clear causal linkages between the two (Kennedy & Grumbly,1988; COMEAP,1995; IEH,1994). In recent years, significant increases in levels of asthma and other respiratory disease in developed countries such as the UK, occurring simultaneously with a growing awareness of air pollution, has led to an upsurge in interest in establishing a link between the two (Green,1994; Nitta et al,1993; Andrae et al, 1988). A simple indicator of this can be found in the growth in numbers of scientific papers investigating the subject. To demonstrate this, the author carried out a citation search of scientific papers with the keywords "pollution" and "asthma" in the title on the Bath Information and Data Service (BIDS) Science Citation Index, which revealed a sharp rise in the number of papers published annually since 1991 (see Figure 4.2).

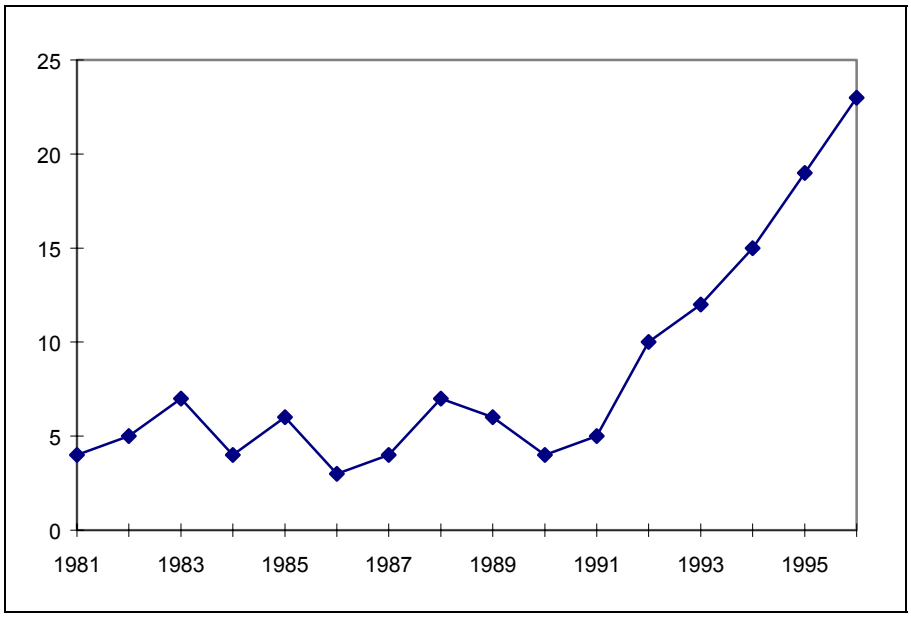


Figure 4.2 References to Air Pollution and Health in BIDS Science Citation Index

Concern over asthma has grown in recent years because of widespread evidence that the prevalence of asthma is increasing (POST, 1994). Studies have shown increases in hospitalisation for childhood asthma (Anderson, 1978), comparative studies of asthma prevalence over time (Burney,1988; Burr et al,1989), community based comparative studies (Yunginger et al,1992) and comparative studies involving both asthma and hay fever (Fleming& Crombie,1987). Other research suggests that these increases are not confined to the UK but occur in other countries, particularly the USA (Gergen&Weiss,1992; Sears,1991). However, consensus over the existence of an upward trend masks controversy over the extent of the increase (Storr, Barrel & Lenney 1988); reasons for the trend (Burney et al,1990; Sears,1991; Markowe,1986) and the reliability and consistency of the evidence (Fleming&Crombie,1987; Sears,1991; Ninan &Russell,1992).

Some of this controversy is attributable to the difficulties in defining the disease, (Yunginger et al,1992; Luyt et al,1993). Pride comments that *"the asthmatic disposition is probably a continuously distributed variable so that definition depends on selecting an arbitrary boundary between normal and asthma"* (Pride,1992). Similar symptoms may be caused by other conditions, and no clear dividing line exists between

“asthmatic” and “non-asthmatic” wheezing (Storr, Barrel & Lenney, 1988). Difficulties arise because the diagnosis of asthma is based on a collection of indicators of the asthmatic state, rather than a single, primary measurement. Methods of classifying diseases change over time, leading to the problem of "diagnostic transfer", the application of an asthma diagnosis to conditions which would previously have been diagnosed differently, for example, as "wheezy bronchitis" (Ninan & Russell,1992; Gergen & Weiss,1992).

The diagnosis of asthma is thus highly dependent on the perceptions of the diagnosing doctor. It has been suggested that the availability of effective treatments may have encouraged doctors to diagnose asthma more frequently (Storr, Barrel & Lenney, 1988; Yunginger et al,1992). Studies of asthma, particularly ones which suggest that asthma is underdiagnosed and undertreated, may raise the profile of the disease, leading to an increased awareness of the symptoms and willingness to diagnose it among doctors (Storr, Barrel & Lenney, 1988; Gergen & Weiss,1992). In addition, such publicity may increase awareness among the general public, encouraging previously undiagnosed asthmatics to seek medical help (Gergen & Weiss,1992).

Although the existence of an increasing trend in the prevalence of asthma is clear from many studies, the reasons for this trend are not. Several authors draw attention to the following question: if the trend is due to an increase in the "true" prevalence of respiratory disease, rather than changes in awareness and diagnostic fashion, is this caused by changes in the susceptibility of the population to developing asthma, in exposure to risk factors, or a combination of the two? (Gergen & Weiss,1992; Fleming & Crombie,1987). And what are these changes?

These questions are not easily answered, because the causality of asthma is very complex and not well understood (Gregg,I, 1986; POST, 1994). Distinctions must be made between factors affecting the "asthmatic disposition" (the tendency for a particular individual to develop asthma), and the factors which will trigger a specific attack. At a lower level, there is little understanding of the physiological mechanisms by which particular stimuli provoke a response which may be recognised as "asthmatic" (Lee,TH, 1992).

Several studies have attempted to relate levels of asthma specifically to the types of pollutant (principally nitrogen dioxide, carbon monoxide and ozone) generated by car exhausts. Speizer and Ferris investigated the prevalence of respiratory symptoms in a group of police officers exposed to car exhausts in the course of their work, and found no significant difference when compared with other occupational groups, although there was some evidence for an increase in the prevalence of disease in those men with a greater number of years of exposure to traffic (Speizer & Ferris,1973).

Nitta et al carried out cross-sectional studies on female adult subjects who lived near roadways subjected to very heavy traffic, and found a relationship between distance of residence from the roadside and the prevalence of symptoms (Nitta et al,1993).

Wjst et al carried out a cross-sectional study on children aged 9-11 years, involving both symptom questionnaires and pulmonary function tests, related to traffic density measured by means of traffic counts. They found a relationship between high rates of traffic density and both reduced pulmonary function and increased prevalence of symptoms (Wjst et al,1993).

The establishment of a causal link between traffic pollution and asthma, therefore, is fraught with difficulty and uncertainty, such that it seems unlikely that a connection could ever be established conclusively (Kennedy & Grumbly,1994; COMEAP,1995; IEH,1994).

Most research into asthma follows the model outlined in Section 4.1, of attempting to establish causal relationships between factors and effects. This approach is well exemplified by the work of the Health Effects Institute (HEI) in the USA, a multi-disciplinary [2] group of scientists brought together to investigate the relationship between transport pollution and health as a set of causal relationships (Bates & Watson,1988). The aim of the HEI was to formulate an integrated research strategy involving experts in the various stages of the relationship (see Figure 4.3), in order to assess the pattern and extent of population exposure to traffic pollution, and to assess the toxicity to humans, including particularly susceptible groups (Watson,1988).

Table 4.2 illustrates the main elements of such research. Sections 4.3.1 to 4.3.4 provide further description of these types of approach.

Table 4.2 Research Approaches to the Various Stages in the Relationship Between Traffic Pollution and Asthma

Sub-systems	Research approach
pollutant generation, fuel and engine technology	Technology, design
atmospheric chemistry and transformations	Monitoring, modelling
population exposure, general and susceptible populations	Epidemiological
dose-response relationships, toxicity	Clinical, laboratory tests on animals and humans

4.3.1 Technological / Design approaches

Attempts to reduce motor vehicle emissions concentrate on improvements to engine technology, the use of fuels which reduce mass emissions of vehicles or produce emissions which are less reactive, and vehicle inspection and maintenance programmes (Calvert et al, 1993). The introduction of emission standards for motor vehicles in the USA, originally in amendments to the Clean Air Act introduced in the 1970s and continuing in legislation since, most recently in 1990, have spurred research in this area (Kennedy & Grumbly, 1988; Calvert et al,1993).

[2] See Section 4.4 for discussion of the difference between "multi-disciplinary" and "inter-disciplinary"

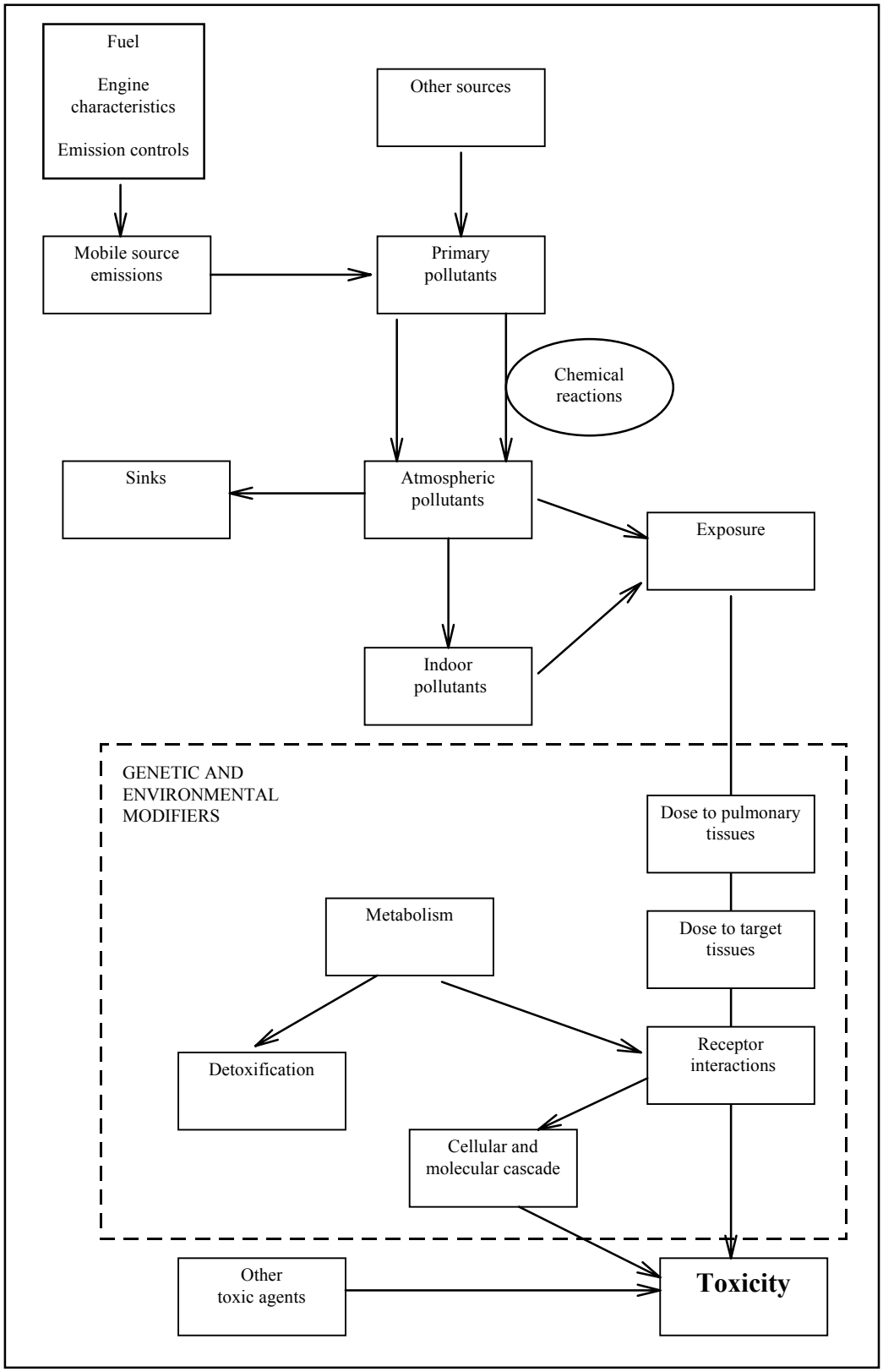


Figure 4.3: Causal Relationships Between Pollution Sources and Toxic Effects (Source: Bates & Watson, 1988)

The development and introduction of new technologies has disadvantages as a control strategy for emissions, firstly because new technologies apply to new vehicles, and innovations take time to be incorporated into the overall fleet (Calvert et al, 1993). A

further problem is that of tampering, malfunctioning of control technologies, and use of incorrect fuels for the engine type (Johnson, 1988). Also, the use of "technical fixes" may bring other emergent effects in its train, for example, attempts to promote diesel engines as a "green" technology because of their greater energy efficiency have led to increasingly high levels of carcinogenic hydrocarbons and particulates (Goodwin,1993; Kaufman, 1988, see also Section 4.5.2 below). Finally, any improvements to emission levels as a result of improved technology are likely to be overtaken by increases in the use of motor transport (RCEP, 1994; Ferguson,1993).

4.3.2 Monitoring and Modelling

Most monitoring concentrates on the monitoring of ambient pollution levels (Williams, 1994). Monitoring technologies are classified according to the time-frame of sampling into "passive" samplers (e.g. diffusion tubes) and continuous samplers (Beevers, 1993; QUARG, 1993). Passive samplers are exposed to the atmosphere for a period of time, and are then analysed to discover how much of the appropriate pollutant has been absorbed over that period, in order that the average concentration of that particular pollutant in the atmosphere above the tube over the period can be evaluated. Such techniques are "cheap and cheerful", but cannot be used for all types of pollutant (although the technology is still developing, e.g. diffusion tubes for ozone have only recently been available - Beevers, 1994). Continuous samplers are more sophisticated, and can give continuous values for concentrations of the relevant pollutant, but are also much more expensive (Beevers, 1993).

Problems occur with the choice of location for monitoring equipment, and the UK government networks in particular have been criticised for having insufficient numbers of monitors in the wrong locations (Weir,F, 1993; Holman, 1994). A balance must be struck between monitoring locations where the maximum levels are likely to occur, and those where most people are likely to be exposed (QUARG,1993; Williams, 1994). This point was also made by the Oxford environmental health staff interviewed in the pilot study (see Section 5.4), and a respondent to the survey of environmental health officers discussed in Chapter 6, who commented:

> *"One of our arguments, and the argument of the NSCA and other bodies, is that the UK government doesn't monitor at enough locations ... we are vastly under-represented population-wise, the number of monitoring stations that there are"* (EH6, 516-521).

Some progress has been made on the development of techniques for monitoring the exposure of specific individuals, but studies using such equipment are necessarily limited in scope due to the requirement for individual subjects to carry the equipment with them (Sexton and Ryan, 1988). A more practical approach to the measurement of individual exposure involves modelling techniques; however, the use of such measures, while having the benefits of increased simplicity and clarity, necessarily brings a reduction in accuracy (Sexton and Ryan, 1988; QUARG, 1993).

4.3.3 Epidemiological Approaches

Epidemiological studies look at the prevalence of disease in whole populations, and attempt to establish statistical relationships between occurrence of the disease and levels of factors such as air pollution (Gordis, 1988). Difficulties arise because of the large number of potential contributory factors, which may not be adequately

identified and controlled for, some of which, such as weather conditions, may be highly correlated with pollution levels (COMEAP,1995; Lancet,The (Editorial), 1985; Tseng et al, 1989; Gregg,I, 1986). Whitelegg et al carried out a questionnnaire based epidemiological study involving 1791 respondents, and found that exposure to traffic pollution was correlated with runny or blocked nose; red or sore eyes; sore throat; dry cough with phlegm and lack of energy, but not with breathing difficulties (Whitelegg et al, 1993).

It has been argued that epidemiological approaches are inferior to toxicological approaches because they indicate statistical associations but do not explain causal mechanisms:

> *"When the stakes are large, some scientists will not accept epidemiological evidence as proof of causation, no matter how elaborate it is. Second, most scientists accept a relationship as causal only when there is either laboratory evidence or a theory that specifies detailed functional mechanisms."* (Lave and Seskin, 1979).

Gordis suggests a number of criteria for evaluating the causal significance of an association between an attribute and a health effect, but argues:

> *"A basic question is what we mean by 'cause'. Rarely, if ever, do we have the clear situation of a necessary and sufficient cause. The tubercle bacillus, for example, is a necessary cause for tuberculosis but is not sufficient. Radiation is clearly not a necessary cause for leukemia because factors other than radiation may be leukemogenic. Indeed, with most chronic diseases of interest, we are dealing with complex situations in which a causal factor is neither necessary nor sufficient"* (Gordis, 1988).

The quality and accuracy of epidemiological research depends on the availability of an extensive body of good quality epidemiological data (Stallones, 1988). Recent increases in research and data collection mentioned in Sections 3.3.2 and 4.3.2) can thus be seen as an attempt to understand and manage the uncertainty inherent in the relationship between air pollution and asthma.

4.3.4 Experimental / Toxicological Approaches

Toxicological studies are experimental and laboratory-based, and typically involve exposing a limited number of subjects to measured levels of the factor under consideration, possibly asking them to perform specific exercise tasks, and then testing and measuring their bodies' response by carrying out tests of lung function (Bates &Watson, 1988, COMEAP,1995).

Recent studies have investigated the effects of nitrogen dioxide (Bauer et al, 1986; Rubinstein et al, 1990); ozone (Folinsbee, et al, 1984; Koren et al, 1989; Kulle et al, 1985; Holtzmann, et al, 1979; Linn, et al , 1978); sulphur dioxide (Linn et al, 1983); formaldehyde (Harving et al, 1986) and combinations of pollutants (Koenig, et al, 1990).

While being more controlled and specific than epidemiological tests, toxicological studies suffer from small and highly selected samples, an inability to control for individual differences between subjects, concentration on a limited number of factors

in a highly artificial environment, and an inability to consider possible synergistic effects (See Richards,1990, Stallones,1988).

Neither epidemiological nor toxicological studies can provide unequivocal "proof" of a connection between asthma and any particular factor (COMEAP, 1995; Erdreich, 1988). However,

> *"Difficult as it is to estimate scientifically the health effects of wide-reaching environmental factors, the alternative to careful analysis is public policy dictated by hunches, pressure groups, or charismatic individuals."* (Lave & Seskin, 1979).

4.4 Multidisciplinary and Interdisciplinary Approaches

A similar approach to that of the Health Effects Institute (see Section 4.3) has been taken in the UK by a group of seven medical, environmental and transport scientists, funded by the Ashden Trust, who organised a symposium on vehicle pollution and health in 1994 (Read, 1994). The main conclusions were as follows:

- that road traffic is the major source of air pollution in the UK, and that emissions have increased rapidly in recent years, despite the introduction of emission controls (Holman, 1994; see Section 4.3.1).
- that the relationship between vehicle pollution and respiratory problems is particularly complex, but, despite this, there is epidemiological evidence that three pollutants derived from vehicle exhaust (particulates, nitrogen dioxide and ozone) may have both short term and long term respiratory health effects (Walters, 1994; see Section 4.3.3).
- that the recent application of cell biology techniques has shown that even low levels of some vehicle pollutants can cause cell damage, inflammation and increase susceptibility to allergic conditions including asthma and rhinitis, as well as to infection (Davies, 1994; see Section 4.3.4).
- that certain vehicle generated pollutants (carbon monoxide and particulates) can also affect disorders of the heart (McMichael,1994), while others (benzene, 1,3-butadiene, PAHs[3], nitro-PAHs and asbestos) are known to induce cancer, particularly in association with particulate materials, also found in transport emissions, which can carry the carcinogenic materials directly into the lungs (Philips, 1994, see Section 4.3.4).
- that current trends in car use (forecast by the Department of Transport to expand to between 182 and 234% of its 1988 level by 2025) mean that any benefits from the use of catalytic converters (which in any case are ineffective in slow traffic and on short journeys, the majority of car use) will be outstripped, and that the increased market share of diesel cars is likely to lead to increased levels of particulates (Fergusson, 1994; see Section 4.3.1).

Such multi-disciplinary approaches, involving scientists from different specialisms, can be seen as providing an integrated approach, and thus an improvement on isolated, individual research (Kennedy & Grumbly,1988: Read,1994). However, the approach is still arguably concerned with the reductionist, cause and effect approach described in Section 4.1. O'Riordan (1995) has defined the difference between multi-disciplinary and interdisciplinary approaches as follows:

[3] polycyclic aromatic hydrocarbons

> *"Interdisciplinarity differs from multi-disciplinarity in that it draws upon common themes of process and evolution that embrace both physical and social systems"* (O'Riordan, 1995, pp7-8).

While multidisciplinary approaches may draw on different fields of expertise, often little attempt is made to integrate the results derived from the different disciplines, leading at best to a number of discrete, qualitatively different reports, and sometimes to conflict, as the "problem" is redefined in order to make it solvable within a particular discipline (Allen et al, 1995). This conflict of definitions is clear from the pilot study for the present thesis, where each of the institutions involved necessarily defined the problem of "traffic pollution and asthma" in terms of its own remit (Section 5.3). An interdisciplinary, integrative, or policy-relevant approach (Allen, et al, 1995) to research, on the other hand, is more concerned with stepping outside of existing structures of understanding, and looking at the interfaces and linkages, not only between disciplines but also between scientists, policy makers and recipients of the policy, i.e. the public. In O'Riordan's words:

> *"Interdisciplinarity means taking a more negotiated science into the policy realm and engaging with the public. This is because societal understanding is vital to the conduct of science under conditions of great uncertainty, value conflict and data ambiguity"* (O'Riordan, 1995, pp7-8).

4.5 Research Design

4.5.1 Background to the Research Design

Conventional approaches to research, based on the paradigms of the natural sciences and concentrating on quantification and hypothesis testing, have limited usefulness in tackling the problems of emergent systems. The complexity of such problems may lead to the use of reductive strategies aimed at limiting the complexity in order to construct simplified questions which may be researched within the scientific paradigm, whereas it is that very complexity which should be the main subject of the research (see Cobern,1991; Lawrence, 1982; Lemon,1991; Linstone et al,1981).

The approach taken here is to demonstrate how applying an emergent systems perspective to the real world phenomenon of traffic pollution and asthma can generate insights which a conventional approach would not provide. The underlying complexity is investigated by considering the problem from multiple viewpoints; eliciting the agendas and perceptions of individuals involved with the problem; drawing out common themes and contradictions within and between the various viewpoints and analysing the "system" using the key concepts of hierarchy, spatial scale and emergence.

Central to this approach are the ways in which the issues of hierarchy and perception interact in emergent systems, leading to a lack of congruity between the "institutional" and "individual" worlds, as manifested in terms of a series of dichotomies (see Chapters 5, 6 & 9):

- scientific uncertainty and perceptual risk
- spatiality defined in terms of institutional boundaries vs individual's sense of locality (also vs physical boundaries)
- observed / measured effects vs perceived outcomes

- the positions of observers (scientists, legislators, institutional actors) vs recipients / potential recipients

The sets of relationships which make up the emergent system are embedded within other hierarchical systems, and this affects how they are perceived both by the various constituencies affected / involved and by individuals within those constituencies (Section 2.4). These differences in perception, and in particular the predominance of a particular perspective centred on "objective" measurement, quantitative approaches to risk, predictive forecasting, technological solutions and information as a way of reducing uncertainty, lead to inappropriate policy responses and a failure to manage the emergent system in such a way as to solve the problem (Sections 2.5, 5.3 and 5.7).

4.5.2 Relationship between macro and micro levels

The conceptual model shown in Figure 3.1, and repeated here (Figure 4.4), depicts the processes of physical, knowledge, perceptual, policy, behavioural and institutional change as macro level movements.

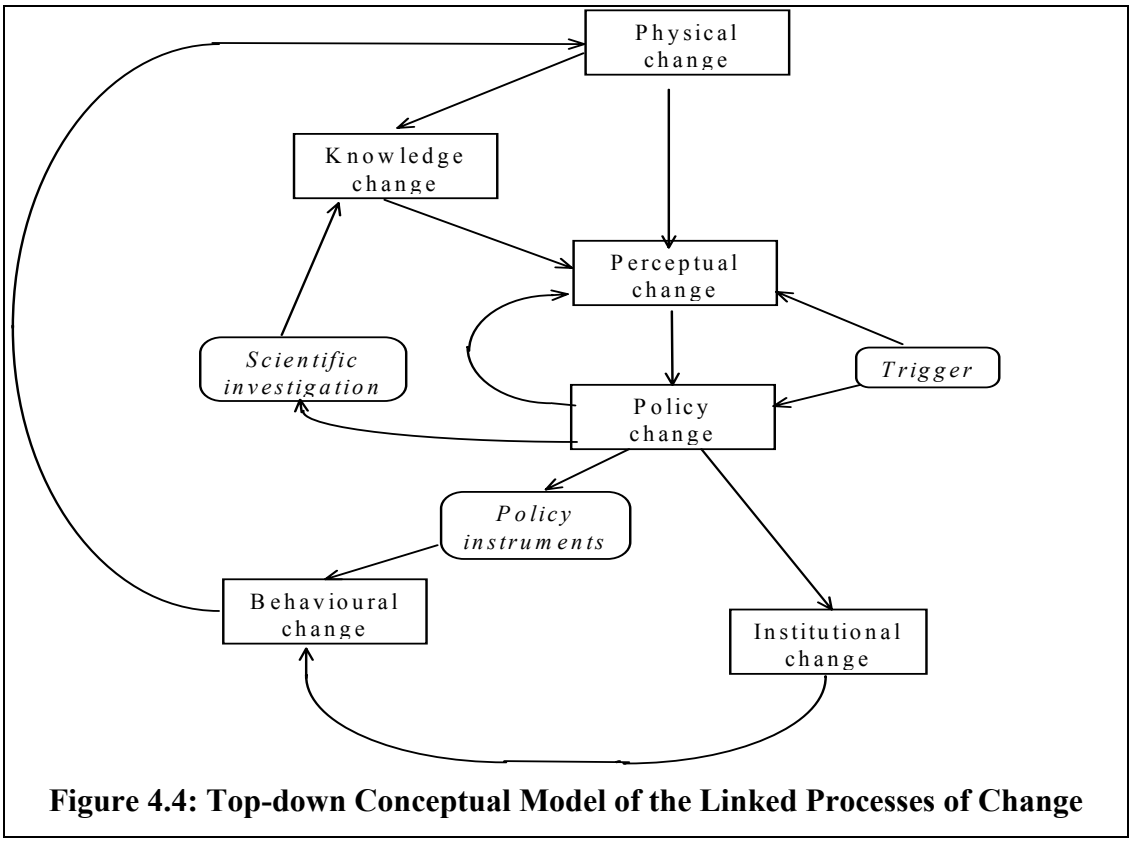


Figure 4.4: Top-down Conceptual Model of the Linked Processes of Change

However, change in the mass is the exception rather than the rule; changes take place in reality at the individual level: a specific group of molecules combine together in a chemical reaction; a research project produces a result which is written up in a scientific paper; a mother is told that her child has asthma; a driver decides to sell his car and cycle to work.

Difficulties in understanding complex systems arise from the attempt to aggregate such individual actions. While the resultant effects of mechanical systems may be

aggregated predictably, emergent effects, by definition, may not. This is particularly true when the micro-components involve human beings and human decision making:

> *"Planets, billiard balls, and point particles are helpless slaves to the force fields in which they move, but people are not! People can switch sources of energy on or off and can respond, react, learn and change according to their individual experience and personality."* (Allen,1994,).

Lee has made the same point from the field of organisational studies:

> *"The phenomenologist argues that human behaviour must be seen in its totality and must be experienced firsthand to be understood. If the researchers attempt an analysis, which almost by definition requires some effort to decompose a phenomenon, they miss the true essence of human life. The subjectivist claims that human behaviour can only be understood in terms of meaning and not in the causal relationships of natural sciences. The causal, mechanistic and measurement-oriented models of explanation, typical of the positivist approach, are inappropriate for the understanding of human behaviour".* (Lee, JSK 1992).

Management of emergent systems tends to be directed towards tackling symptoms, as part of the "problem solving and optimisation" approach to human governance criticised by Vickers (Vickers,1983). As will be discussed later in Chapter 6, it can be argued that regional emergent problems, such as the generation of tropospheric ozone, require strategic, regional based management (Chameides, 1994). However, at the same time, the causes of the problem lie with the behaviour of individuals, living individual lives with their own agendas, constraints and perceptions.

An emergent system cannot be "managed" directly", but only by managing its component subsystems - the processes which generate the outcomes. Management has to be directed at a different level from that at which the effect is observed. There is a conflict between the macro and micro levels of analysis, as described by Markus and Robey (Markus & Robey, 1988). Managing the problem at the level of emergence may not address the root causes, but attempting to tackle the causes at the individual level may be unsuccessful, and lead to other emergent, unintended, unanticipated consequences. This is typified by the "technical fix" approach, for instance the switch to unleaded petrol, which has reduced levels of lead pollution, but has also been implicated in increasing production of benzene, which is a carcinogen (Standeven et al, 1994); and the present concentration on the use of the three-way catalytic converter, which (when used effectively), may reduce the production of carbon monoxide, nitrogen oxides and hydrocarbons, but by increasing the production of carbon dioxide, a major "greenhouse" gas (Fergusson, 1994; Johnson, 1988).

A further difficulty with tackling emergent problems at the micro level is the fact that for one individual to change their own behaviour is not sufficient to solve the problem unless all other individuals also act, leading to the situation where no particular individual is prepared to act for the benefit of all, or at least, not enough to make a difference (Schofield, 1993.)

The management of emergent systems is always fragmentary, because the causes are fragmentary. In addition, management is always chasing after the unanticipated/able emergent consequences of attempts to manage the emergent outcomes of the last attempt at intervention (see Section 3.1).

4.5.3 Bottom-up Conceptual Model

Figure 4.4 can be regarded as a "top-down" conceptual model, looking at the interactions between high-level processes which are in fact the amalgamation of a large number of low level processes. However, in order to understand emergent systems fully, we also need a "bottom up" model, looking at those individual constituent processes.

The concept of emergence implies change in the attributes of some component, or the creation of a new component in response to a trigger event. An emergent system may be conceptualised as a set of process relationships of the form:

Figure 4.5 A Simple Causal Relationship

A change may take place wholly within one of the base systems or subsystems, within which context it may be predictable, measurable and well understood, producing, in Lewes' term, a "resultant effect" (e.g. the emission of NOx from an internal combustion engine - see Section 2.1). However, such effects may provide the triggers for other effects, potentially interacting with elements of the environment, or other systems, either cumulatively or through more complex interaction, to produce "emergent effects". The generation of tropospheric ozone through the interaction of NOx and VOCs in the presence of sunlight may be seen as such an emergent effect. Such sets of relationships may also include feedback loops, in which the effect of a change loops back to affect one or more triggers.

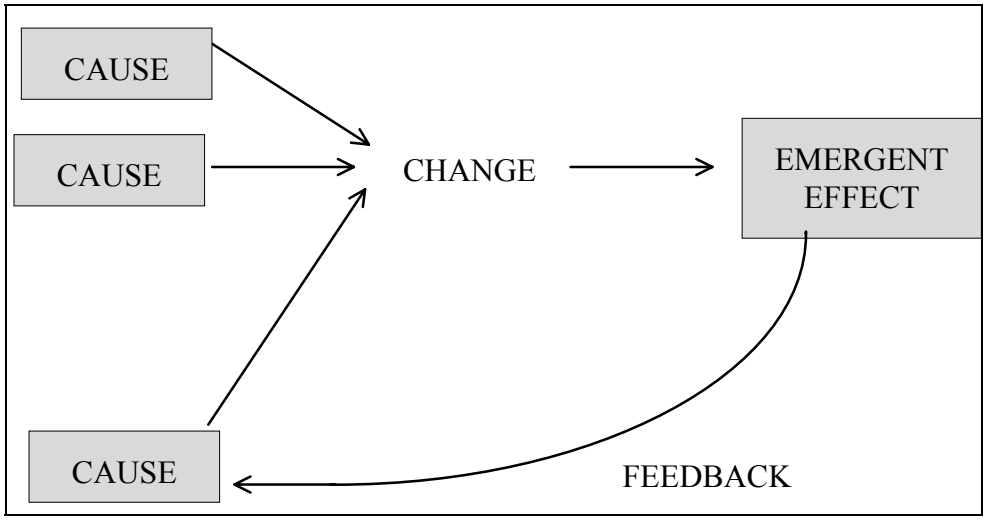


Figure 4.6: An Emergent Relationship with Feedback

Emergent effects may interact, accumulate or counteract each other without arousing any attention until they come into contact with a human individual, or recipient. The special type of effect which induces a change in some attribute of the recipient may be referred to as an "impact", in order to distinguish it from effects which do not affect people.

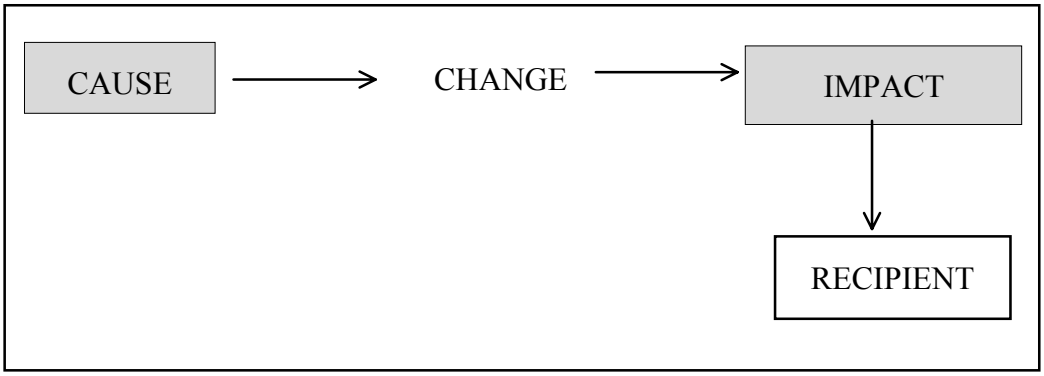


Figure 4.7: Causal Relationship with Human Recipient

The impact may be a physical change in some physiological function of the recipient, such as breathing or heart rate, and may or may not be measurable in some way. However, the significance of the impact lies in the extent to which it is recognised by the recipient (or others), and how it is perceived. An example of this process can be seen in Section 5.7, where an elected member of Oxford City Council describes the role of political representatives in "articulating issues" for their constituents. Impacts may be perceived as benign, neutral or adverse in terms of how they affect the health or quality of life of the recipient. Perceptions of the impact may be different for the recipient and for any observers, and will depend on the experience, priorities and circumstances (appreciative system - see Section 2.7) of the individual concerned. The term "outcome" is used to distinguish the impact as perceived from the initial impact.

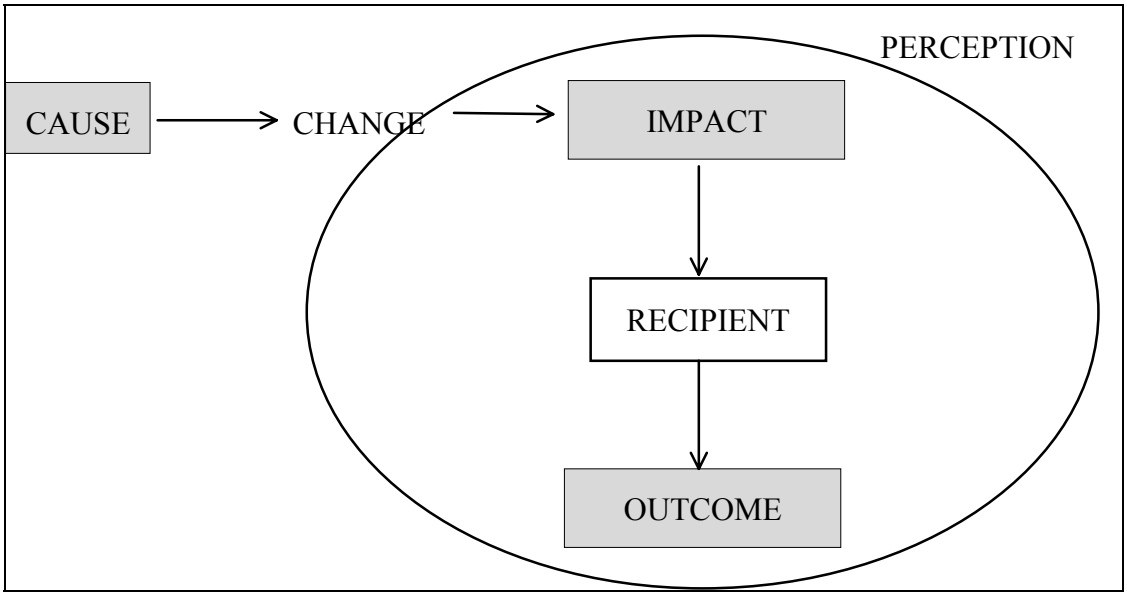


Figure 4.8: Bottom-up Conceptual Model of an Emergent Impact

This distinction between impact and outcome has important implications for policy. While policies may be directed at reducing the measurable impact, or contributory effects, this may not take into account the severity of the outcome as perceived by the recipient. For example, while Environmental Health Departments may be concerned with measuring ambient pollution levels (effects) and Public Health Departments with prevalence of respiratory disease (impacts), the recipients' perceptions of those impacts (outcomes) may be neglected (See Section 2.7 and Chapters 5, 6, 7 and 9).

Each individual's appreciative system (see Section 2.7) is affected by a complex set of factors, including individual experience, awareness of information, and other priorities, so that two recipients may view the same impact in very different ways, while even greater differences may exist between the perceptions of recipients and observers, including institutional actors.

For example, an individual may experience wheezing, brought on by exercise, potentiated by high ozone levels. As will be shown in Chapters 7 and 8, whether or not this experience is perceived as an "asthma attack" caused by "traffic pollution" will be affected by:

- whether the individual ("recipient") has had experience of asthma in the past
- whether members of the recipient's family or acquaintances have had experience of asthma in the past
- whether the individual seeks medical help
- whether the individual has read or seen any media reports about asthma or air pollution.

Conversely, the individual's awareness of media reports about asthma will be affected by his/her experience of asthma, either directly or via family and friends. If the individual visits the doctor, the doctor's perception will be affected by his/her experience and awareness, and this will colour the information given by the doctor to the individual.

The significance of perception, and understanding the distinction between "impacts" and "outcomes" lies in the final stage of the conceptual model. It is the outcome for the particular individual which will determine how that individual will respond, that is, change his or her behaviour (see Figure 4.9). Such behavioural change is the ultimate aim of policy. While most policies are targeted on measurable effects and impacts, policy makers may also try to change behaviour by changing perceptions - and any policy changes will affect perceptions anyway. However, the response in itself induces change, generating effects which may potentially feed back and affect the original problem in the desired way, or lead to new emergent problems.

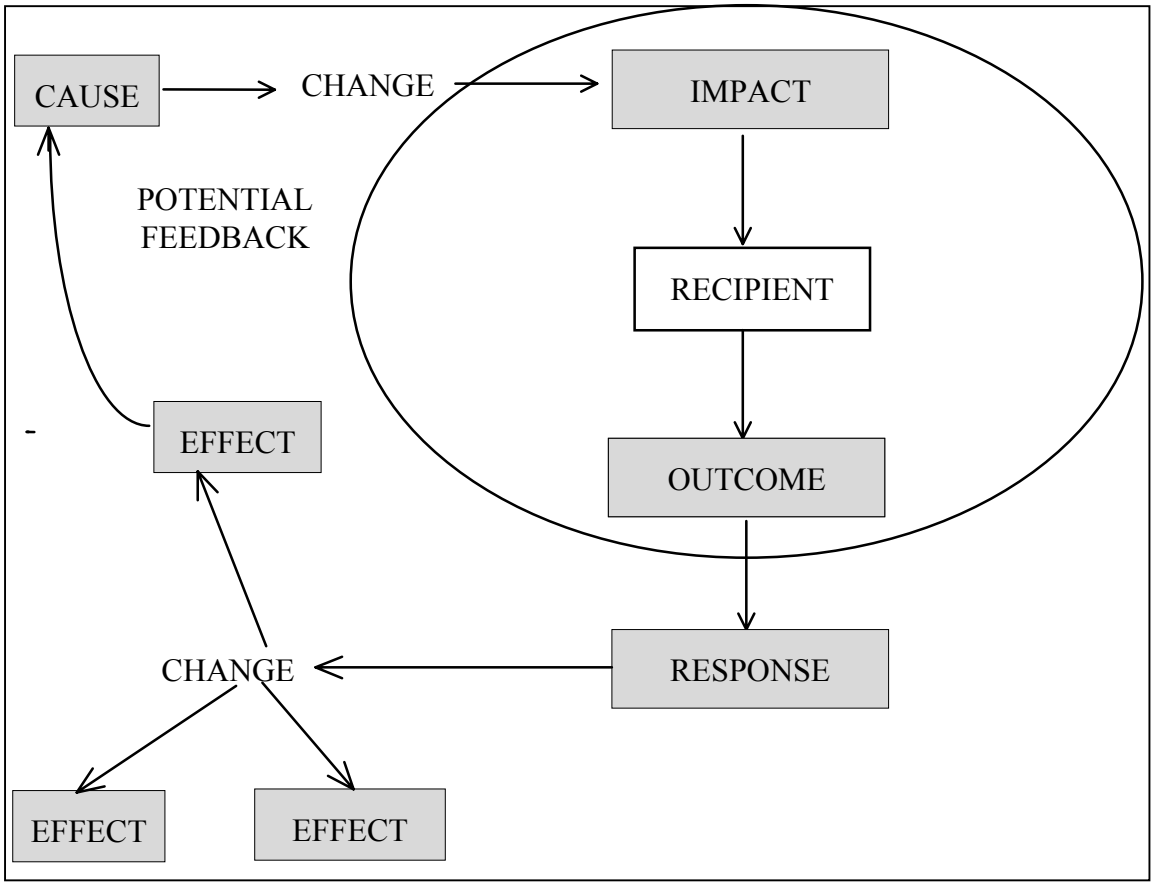


Figure 4.9: Bottom up Conceptual Model with Behavioural Response

Behavioural change, however, is not determined solely by perceptions. The individual recipient is not faced with an infinite range of behavioural options, but with a limited "decision space" of options among which he or she must choose (Seaton, 1996). These options will differ in their desirability, feasibility and response time, and the constraints to which they are subject, for example, while an asthmatic sufferer may be able to choose not to take a walk on a day when pollution is high, he or she may not be in a position to take a day off work, while the decision to move house to an area of lower pollution is one which may be completely impractical, at least in the short term. Indeed, the optimum behaviour for the individual may be one which actually contributes to the problem, e.g. if the individual decides to drive rather than walk to work because pollution is high.

In addition, the management of perception is inherently a blunt instrument. Although it may be possible to say, with a reasonable level of confidence:

> *"If we remove x% of traffic from the roads, we will reduce NOx emissions by y%, ozone levels by z% and cases of asthma by w%"* (although this is a gross oversimplification)

the following proposition:

> *"If we run this advertising campaign, we will persuade x% of drivers to leave their cars at home for y% of journeys, and hence reduce emissions by z%"*

seems inherently less acceptable.

The two propositions are fundamentally different, because the first is concerned with effects and impacts, while the second is concerned with outcomes. When perceptual factors enter, we move on to another stage in Morgan's hierarchy, and the rules of the game change. The techniques of analysis and prediction which are effective at lower levels are no longer suitable. Although prediction and modelling techniques may be used to predict behaviour in the mass (and, indeed, marketing, advertising, market research etc are based on the premise that human behaviour in the mass **is** predictable), the influence of perceptual factors means that individual behaviour can be significant and can induce unanticipated effects, which may have repercussions and emergent consequences. We cannot rely on being able to predict when humans are involved because of the sheer complexity of each individual's history (Van der Leeuw, 1995; Allen, 1997; Vickers, 1983).

4.5.4 Researching the Relationship Between the Hierarchical Levels

It will be recalled from Section 1.5 that the main objectives of the reserach were as follows:

- **Objective 1 :** To build a conceptual framework for the investigation of emergent systems, leading to a conceptual model of the process of emergence (Chapters 2, 3 and 4).
- **Objective 2 :** To develop and apply a method for research into emergent systems, leading to a taxonomy of dimensions of difference which can be used to investigate variations in perceptions between constituencies involved with an emergent issue (Chapters 4, 5, 6, 7 and 8).
- **Objective 3 :** To identify and explore the management issues resulting from emergent phenomena (Chapters 3,4 and 9).

So far, the discussion in Chapters 2, 3 and 4 has concentrated on the development of the conceptual framework (Objective 1), leading to:

- a top-down conceptual model of the macro processes of change
- a bottom-up conceptual model of the impacts of individual changes

The next stage of the research builds upon the conceptual framework in order to develop a method for the investigation of real-world emergent systems (Objective 2). A number of substantive research activities (to be described in the next Section), were undertaken in order to investigate the perceptions of constituencies involved in the Traffic Pollution and Respiratory Health System.

Because of the difficulty of tracing individual events / actions /effects / outcomes, the focus of the approach developed is instead on the perceptions of actors / observers /recipients, in order to establish similarities and contrasts between the perceptions of individuals at different positions in the hierarchy. In addition, although the processes involved are highly dynamic, the research must focus on a particular temporal snap-shot.

The approach taken here is to address the following questions:

- What are the significant components and sub-systems of the emergent system, and the other systems in which they are hierarchically embedded?
- What are the perceptions of actors at the institutional level, and how do they vary?
- What are the perceptions of actors at the individual level, and how do they vary?
- What are the similarities and differences between perceptions of actors at the institutional and individual levels?

The framework for analysis is based on the lack of congruity between the "institutional" and "individual" worlds, described in Section 4.5, manifested in a series of dichotomies, as shown in Table 4.3.

Table 4.3 Dimensions of Difference Between the Institutional and Individual Worlds

Institutional	**Individual**
Observers	Recipients
Focus on observed / measured effects and impacts	Focus on perceived outcomes
Scientific uncertainty and quantitative risk	Perceived risk
Spatiality defined in terms of institutional boundaries	Spatiality defined in terms of individual's sense of locality

4.6 Research Activities

The research can be divided into three main phases:

- a pilot study in Oxford
- a series of interviews with Environmental Health officers in thirteen district local authorities in Bedfordshire and Hertfordshire
- a questionnaire survey of 300 households in the Bedford district

The contribution to the thesis of the various components of the work is shown in Figure 4.10.

4.6.1 The Pilot Study

The term "emergent system" refers, not to a designed system which has some emergent properties and/or outcomes, but to a system which, while it may have man-made, designed components or sub-systems, has not actually been designed / constructed as a system per se (see Section 2.5). Additionally, the components or sub-systems involved can be seen as already embedded hierarchically within existing systems. The recognition of an emergent system involves a shift of focus, from the already existing systems of which the subsystems are part, to the emergent system

which arises from the unanticipated interaction of certain subsystems or system components.

A first step in the investigation of an emergent system is therefore the identification of the component systems and the responsible institutions. This was done by means of a pilot study, which took place in Oxford during April-October 1993 (Section 5.1).

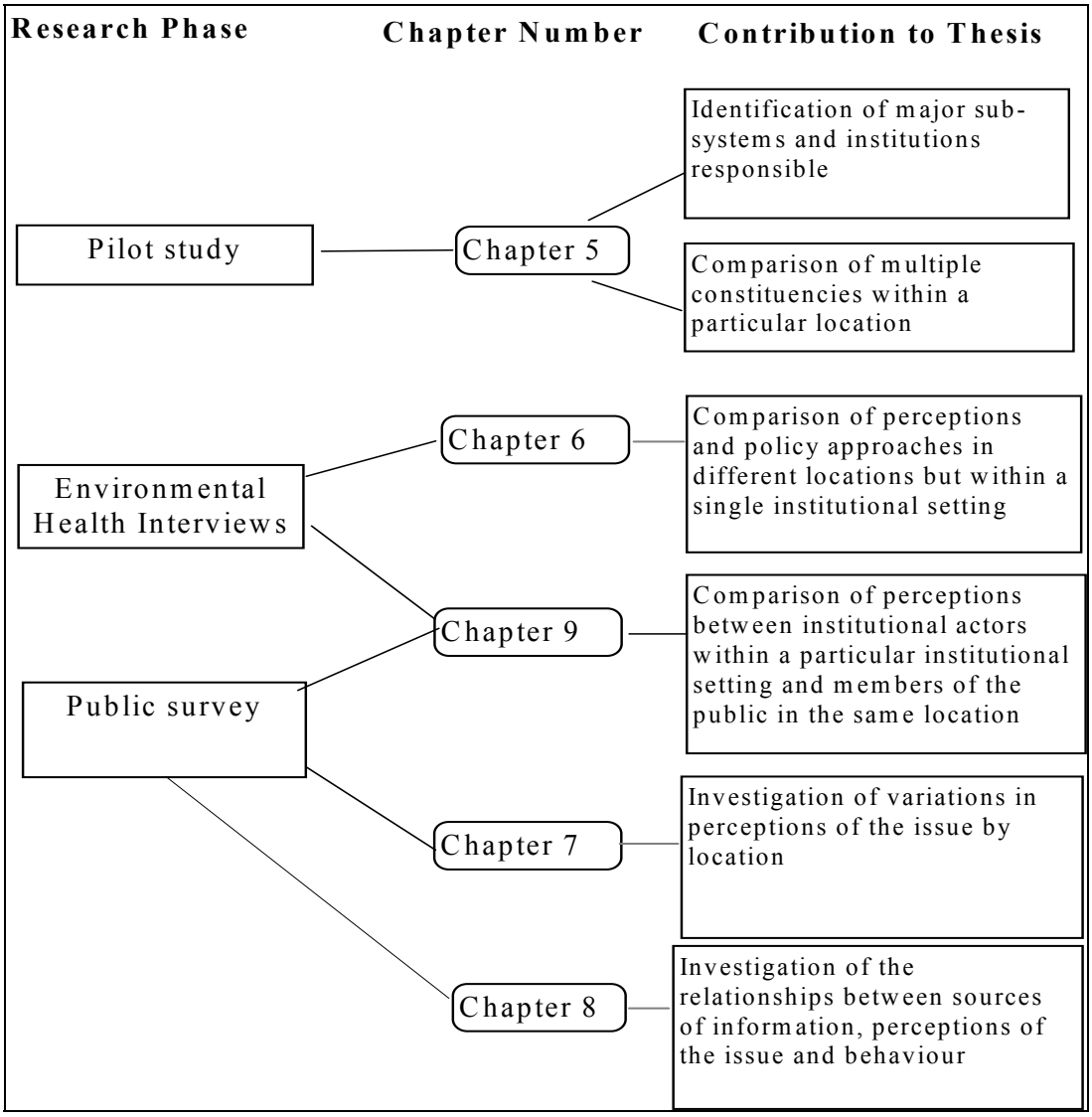


Figure 4.10: Phases of the Research

The pilot study was originally conceived as an application of a "multiple perspectives" approach. The multiple perspectives concept as developed by Linstone et al involves a set of three clearly defined perspectives, the technical (T) perspective, the organisational (O) perspective and the personal (P) perspective (Linstone et al, 1981). A true multiple perspectives study would consider the issue from each of these perspectives. The three areas originally covered by the three parts of the study, the scientific / medical perspective, the institutional perspective and the individual perspective, seemed to correspond well with these perspectives. However, what was revealed by the pilot study was the wide scope for variation and disagreement within each of these perspectives (see Section 5.4). It is therefore perhaps more accurate, in

order to avoid the suggestion that the study was a direct application of Linstone's concept, to eschew the use of the term "multiple perspectives" in favour of the broader and more flexible concept of "multiple constituencies".

Three main research techniques were employed in the project:
- Literature review of the available scientific knowledge about the relationship between air pollution and asthma.
- Semi-structured interviews with institutional actors
- Questionnaire-based interviews with members of the public

Information on current public policy approaches to traffic pollution within Oxford was obtained through interviews with various actors involved in policy making and implementation.

Interviews were conducted with representatives of the following institutions:
- Oxfordshire Health Authority, Dept of Public Health (DPH)
- Oxford City Council Environmental Health Department (EHD)
- Oxfordshire County Council, Dept of Planning and Property Services (DPPS)

In addition, the political dimension was recognised by including representatives of the ruling (Labour) group on the City council, specifically members who sit on the Health and Environmental Protection sub-committee (HEPS).

Questionnaire based interviews were conducted with a number of mothers of young children, in order to gauge their perceptions of the importance and relevance of the problem, and their awareness of existing policies.

The aims of the survey were twofold:
- to elicit the concerns and agendas of the respondents in terms of health, their personal experience of asthma, and the priority which they give to asthma relative to other health problems
- to elicit their perceptions of traffic as a threat to health, of traffic problems as they specifically affect Oxford, and their awareness and perceptions of current traffic policies in Oxford.

A more detailed discussion of the methods used in the pilot study is given in Section 5.2.

4.6.2 Interviews with Environmental Health Officers in Beds and Herts

The second strand of fieldwork in the present thesis was a series of interviews with staff in the environmental health departments of thirteen local authorities in the two adjacent counties of Hertfordshire and Bedfordshire. All fourteen local authorities in the two counties were invited to take part, but one (Broxbourne) declined to allow staff to be interviewed, although providing factual information about monitoring and pollution sources. Conversely, one of the authorities whose staff were interviewed (Hertsmere) failed to provide detailed information about pollution sources.

Environmental health departments were chosen for the survey in this part of the thesis because of their hierarchical position and role in current air quality management policy. The environmental health function of UK local authorities evolved from the concern with local management of public health which arose in the wake of the industrial revolution, a time at which the impact of conditions such as poor housing, diet, sanitation and working conditions on health came to be recognised (DOE, 1990),

and the responsibility of communities to strive to improve those conditions was acknowledged (Wohl,1988; see Section 3.2.1). Current responsibilities of environmental health departments include health and safety at work, food hygiene, litter, noise and pest control (DOE, 1990; Allen,P,1992).

Some local authorities have been involved in monitoring of local ambient air quality since 1917 (see Section 3.3.2), although statutory responsibilities with respect to air quality have only existed since the 1956 Clean Air Act for domestic smoke emissions, and the 1990 Environmental Protection Act for point-source industrial emissions. Local authority responsibilities with respect to air quality management have been extended since the survey, under the 1995 Environment Act, although the role still remains effectively largely one of monitoring and measurement, rather than control over sources (see Section 3.3.3).

In addition to being the sector of local government with responsibility for air quality, environmental health departments are responsible for answering complaints and queries from local residents, and thus are situated at the interface between the local authority and the public (Allen,P,1992). This aspect of their role also made them of particular interest to the research, because of the importance placed in the thesis on the relationship between the institutional and individual worlds.

The interviews were carried out over a two week period in July 1994. The aim of the survey was to elicit:

- the nature and extent of air quality monitoring in each district;
- the sources of air pollution which affect each district;
- reasons for air quality monitoring, influences on air quality monitoring and the perceived importance of monitoring in each district;
- constraints on air quality monitoring;
- the ways in which data collected from monitoring is used and disseminated.

A more detailed discussion of the methods used in the pilot study is given in Section 6.2.

4.6.3 Household Survey

The third major strand of fieldwork for the thesis consisted of a structured questionnaire survey of 300 households in 9 locations in and around Bedford. The survey was designed to build on the interview survey of mothers which was included in the Oxford pilot study, and on a previous survey of 280 households carried out in 1993 in the Marston Vale area, to the South of Bedford (Longhurst & Cousins, 1993).

The survey was conducted during June, July and August 1994, to overlap with the environmental health interviews, and run concurrently with ozone monitoring carried out by NETCEN[4] on behalf of Bedford Borough Council.

The aim of the survey was to elicit:

- the perceived importance of air pollution and/or asthma relative to other health issues
- the extent of experience of respiratory problems, relative to diagnosed "asthma"

[4] the National Environmental Technology Centre

- individuals' perceptions of local air quality, the way in which these perceptions vary spatially, and the relationship between these perceptions and objective measurement of air pollution
- individuals' perceptions of the main factors affecting local air quality
- individuals' awareness of sources of information about air quality and asthma

Data from the survey were analysed using a combination of quantitative and qualitative techniques. Further discussion on the analysis of the survey data can be found in Section 7.2.

4.7 Summary and Conclusions

Conventional research into air pollution, based on the rational, modernist paradigm, has tended to focus on identifying cause and effect relationships within single scientific disciplines, or at best employing multi-disciplinary approaches of a number of linked studies looking at separate aspects of the problem. This chapter has argued for the inadequacy of such an approach, and the need for a form of research, referred to as "interdisciplinary" (O'Riordan,1995), "integrative" or "policy relevant" (Allen et al,1995) research, which recognises the position of scientific knowledge and research within the complex evolutionary system of change processes described in the previous chapter (see Figure 4.4).

The research design for the present thesis is based on viewing the core issue of "traffic pollution and health" as an emergent system which exists at the interface of a number of overlapping, hierarchical systems, involving multiple constituencies and institutions. The importance of understanding the perceptions of the various constituencies is regarded as paramount, and a framework for research is developed in order to investigate the incongruities between the "institutional" and "individual" worlds around a series of issues: spatiality, measurement and perception and uncertainty.

The next three chapters will describe in detail the three research activities carried out for the thesis.

5 Variations in perspectives within a single locality: a case study of Oxford

"A very nice sort of place, Oxford, I should think, for people that like that sort of place."

George Bernard Shaw,"Man and Superman", 1909

5.1 Introduction

The pilot study for the present thesis was carried out in Oxford over the period April to October 1993. The aim of the study was to build up a composite picture of perceptions of the issue of traffic pollution and asthma within the city, and of the policy approaches of the relevant institutions, in order to investigate the relationships between the various institutions, and also between the institutional and individual worlds (see Section 4.5). A comprehensive list of constituencies might have included the following:

Agents / stakeholders

Drivers	Transport planners	Car manufacturers
Petrol companies	AA	RAC
Freight haulage companies	Road construction companies	Unions
Anti road campaigners	Greenpeace	Friends of the Earth
Transport 2000	Bus companies	Railtrack - rail companies
R&D companies	Universities	HMIP
Environmental Health depts	NSCA	Public Health depts
NHS	Asthma sufferers	residents
Joggers, sports people	schools	doctors
medical researchers	drug companies	Local authorities
Councillors	MPs	Central government
DoE	DTp	WHO
EU	Newspapers	Newspaper readers
TV companies	TV viewers	Radio companies
Radio listeners	Retail chains	Local shopkeepers

In the interests of practicality, it was obviously necessary to reduce the number of constituencies to be included in the study. The main constituencies were identified initially by considering the emergent system in terms of its major technical sub-systems, i.e. traffic, pollution and asthma. Each of these is embedded within a wider systemic context, subject to factors from outside, and producing effects other than those of interest in this particular case (See Figure 5.1).

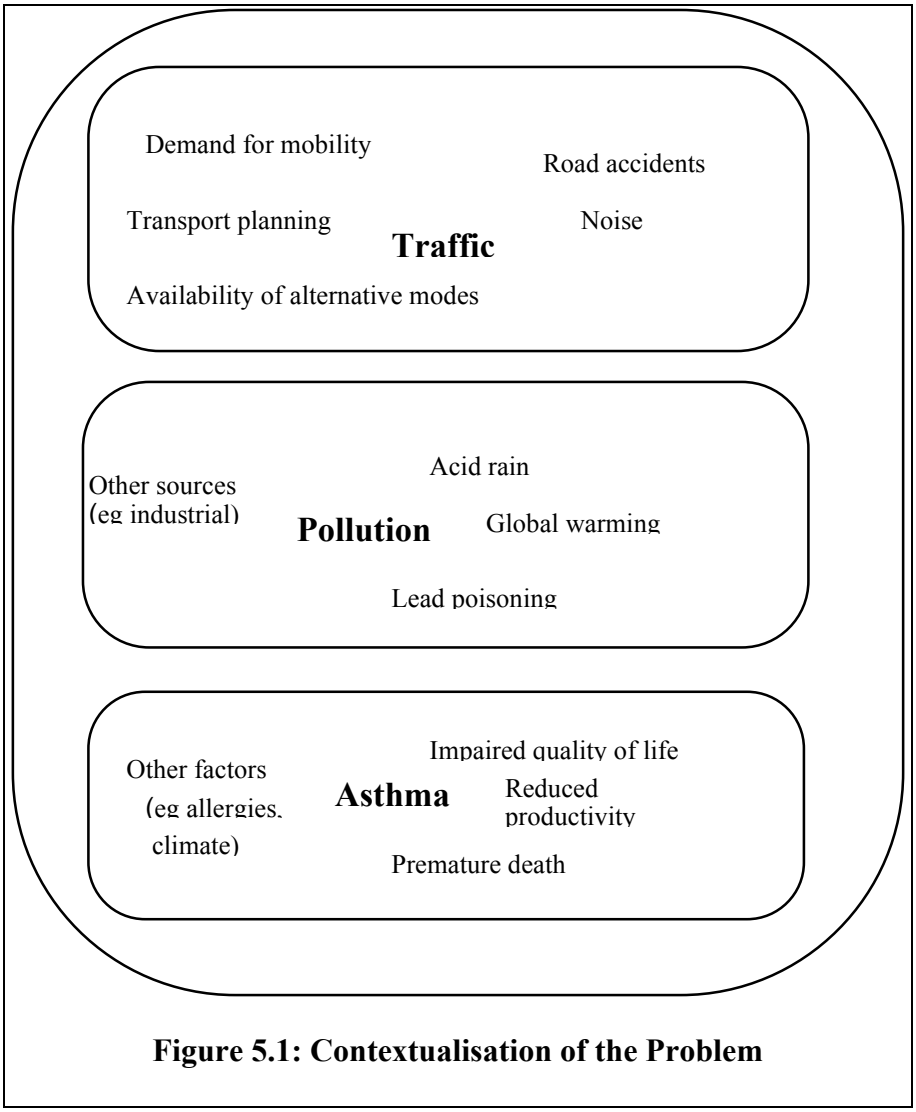


Figure 5.1: Contextualisation of the Problem

Within the specific geographical confines of the pilot study, i.e. the city of Oxford, each of these sub-systems is the responsibility of a specific agency, as follows:

Sub-system	Authority	Department
Traffic	Oxfordshire County Council	Department of Planning and Property Services.
Pollution	Oxford City Council.	Environmental Health Department
Asthma	Oxfordshire Health Authority.	Public Health Department

In addition to these three institutional constituencies, two other constituencies were included, in order to represent the recipients (or potential recipients) of the problem, and their political representatives. The public dimension was represented by visiting mother and toddler groups and administering questionnaires to the mothers present. This approach was considered suitable for both practical and research reasons, offering an accessible group of respondents with whom the researcher could establish a rapport, and who were likely to have given some consideration to health issues.

Interviews of the same format used for the institutional actors were also carried out with elected members of Oxford City Council Health and Environmental Protection Sub-committee.

Questions were designed to elicit the respondents' own views of the problem of traffic pollution and asthma in Oxford, the nature of current and proposed policy relevant to the problem, (or, in the case of the mothers, awareness of such policy), and the reasons for and expected results of the policy.

The study showed that the approaches, concerns and viewpoints of the various constituencies differed considerably, and did not easily lend themselves to a direct comparison (Hadfield, 1994a). Because the various actors and institutions are involved in different ways, the interviews tended to reflect different aspects of the overall problem area, and different perceptions of "the problem" (see Section 5.4, below).
It will be recalled from Section 4.5 that the interaction of the issues of hierarchy and perception in emergent systems leads to a lack of congruity between the "institutional" world of "observers" and the "individual" world of "recipients", which can be conceptualised as a series of dichotomies: spatiality defined in terms of institutional boundaries against the individual's sense of locality; quantified risk against perceived risk; and measured, "objective" impacts against perceived outcomes (see Section 4.5, Table 4.3). These differences are reflected in the pilot study, as expanded in Sections 5.5, 5.6 and 5.7.
The structure of the analysis of the pilot study is as follows:

- description of the institutional responsibilities of the three main institutions involved (Section 5.3);
- analysis of the different definitions of "the problem" as interpreted by the different constituencies (Section 5.4);
- differences in spatiality of concern between the different constituencies (Section 5.5);
- differences in attitude to objective measurement among the different constituencies (section 5.6);
- differences in perceptions of risk between the different constituencies (section 5.7);
- the relationship between the "institutional" and "individual" levels of the hierarchy ("policy makers" and "public"), and the importance of this relationship in the process of perceptual emergence (Section 5.8).

5.2 Research Method

5.2.1 Interviews With Institutional Actors

The interviews were semi-structured and open-ended. Because the various actors and institutions are involved in different ways, the interviews tended to reflect different aspects of the overall problem area.

Questions were oriented towards the particular area of policy with which the actors were involved. In general, the structure of the questioning was as follows:

- *"How do you see the problem of traffic pollution and asthma in Oxford?"*
- *"What policy are you involved with concerning traffic pollution and asthma?"*
- *"How and why was this policy adopted?"*
- *"What do you expect to be the outcome of this policy?".*

For each of the main areas, a specific policy emerged as being of most significance to the actors involved, and this was reflected in the questioning and responses. The main policies were as follows:

Transport	The Oxford Transport Study and recommendations
Pollution	The Oxford Air Pollution Monitoring System
Health	The East Oxford Paediatric Asthma Nurse

Three group and five individual interviews were conducted between April and July 1993, with a total of eight respondents: two from the Department of Public Health; three from the Environmental Health Department; one from the Department of Planning and Property Services and two elected members from the Health and Environmental Protection Sub-committee. An interview schedule is given in Table 5.1. Individual respondents from each department are identified by number within department in Table 5.1, and by department code and number in later text (e.g. speaker 1 from the department of Public Health attended interviews OX1, OX5 and OX6 and is referred to in the text as "DPH1").

Table 5.1: Schedule of Interviews With Institutional Actors

Group (G) or Individual (I)	Interview number	Date	Duration (Approx)	Respondents Present			
				DPH	EHD	DPPS	HEPS
G	OX1	20-Apr-93	45 mins	1	1 & 2		
I	OX2	27-Apr-93	45 mins	2			
G	OX3	27-Apr-93	2 hours		2 & 3		
I	OX4	19-May-93	45 mins		1		
I	OX5	26-May-93	45 mins	1			
I	OX6	08-Jun-93	30 mins	1			
G	OX7	21-Jun-93	1 hour		1		1 & 2
I	OX8	05-Jul-93	45 mins			1	

The interviews were tape recorded and transcribed verbatim into a Microsoft Access database. Each phrase was entered as a line in an Access table, and identified by interview code, group or individual interview (G/I), institution, respondent number, and line number within the interview. An example of data as held on the database is shown in Table 5.2.

Table 5.2: Example of Extract From an Interview as Held on the Database

Interview	G or I	Dept	Resp num	Line nu	Text
OX2	I	DPH	2	65	Asthma's a big problem,
OX2	I	DPH	2	66	10% of the population wheeze at some stage, maybe 20% of children -
OX2	I	DPH	2	67	those are high estimates, but it's a big problem.
OX2	I	DPH	2	68	It's certainly the commonest illness children take medication for at school,
OX2	I	DPH	2	69	so it's a well recognised problem,

Where quotations from the interviews are referred to in the body of the thesis, the source of the quotation is identified by interview number, institution, respondent

number, group or individual interview (G/I) and line number(s), for example, the extract shown in Table 5.2 is quoted as follows:

> *"asthma's a big problem, ten per cent of the population wheeze at some stage, maybe twenty per cent of children ... it's the commonest illness children take medication for at school, so it's a well recognised problem"* (OX2, DPH2,I, 65-69).

During the analysis, key concepts were allocated to each phrase (in some cases, a single phrase corresponded to several concepts). Table 5.3 shows the extract referred to in Table 5.2, with the concepts allocated to each phrase. The different interviews were compared by grouping together the themes or concepts into broader categories (e.g. "definition of the problem").

Table 5.3: Interview Extract with Allocated Concepts

Interview	Dept	Resp num	Line num	Text	Concept
OX2	DPH	2	65	Asthma's a big problem,	prevalence
OX2	DPH	2	65	Asthma's a big problem,	asthma
OX2	DPH	2	66	10% of the population wheeze at some stage, maybe 20% of children -	asthma
OX2	DPH	2	66	10% of the population wheeze at some stage, maybe 20% of children -	prevalence
OX2	DPH	2	67	those are high estimates, but it's a big problem.	asthma
OX2	DPH	2	67	those are high estimates, but it's a big problem.	prevalence
OX2	DPH	2	68	It's certainly the commonest illness children take medication for at school,	children
OX2	DPH	2	68	It's certainly the commonest illness children take medication for at school,	asthma
OX2	DPH	2	68	It's certainly the commonest illness children take medication for at school,	prevalence
OX2	DPH	2	69	so it's a well recognised problem,	asthma
OX2	DPH	2	69	so it's a well recognised problem,	perception
OX2	DPH	2	69	so it's a well recognised problem,	prevalence

5.2.2 Questionnaire Survey of Mothers

The scale of the survey was limited by time and resource constraints. The sample frame chosen was to visit mother and toddler groups and administer questionnaires to the mothers present. This approach was considered suitable for both practical and research reasons, offering an accessible group of respondents with whom the researcher could establish a rapport, and who were likely to have given some consideration to health issues.

Eleven groups in Oxford were approached, and positive responses were received from three, giving a total of twenty six respondents. In addition, a group from Turvey, a small Bedfordshire village, were surveyed as a control group (eight respondents). Table 5.4 gives a schedule of interviews with the mother and toddler groups.

The two main strands of the survey, health issues and traffic issues, were originally included in two separate questionnaires. The intention of this approach was to avoid suggesting a connection between the two issues, and thus biasing the results. However, time and resource constraints led to the two issues being combined in a

single questionnaire, as administering different questionnaires to different groups would have reduced the sample size for each questionnaire. In the event, only two respondents made a direct connection between asthma and traffic pollution, so there does not appear to have been a significant bias effect.

Table 5.4: Schedule of Interviews with Mothers

Group Code	Group Name	Location	Date	Number Of Respondents
T	Turvey Mothers and Toddlers	Turvey,Beds	13/10/93	8
O1	St Dominics Mother and Toddler Group	Cowley,Oxford	15/10/93	11
O2	New Marston Toddler Group	Marston,Oxford	19/10/93	9
O3	Bullingdon Mother and Toddler Group	Cowley,Oxford	21/10/93	6

For each of the two areas, the questionnaire was designed to lead the questioning from the most general level down to more specific issues (see Figure 5.2).

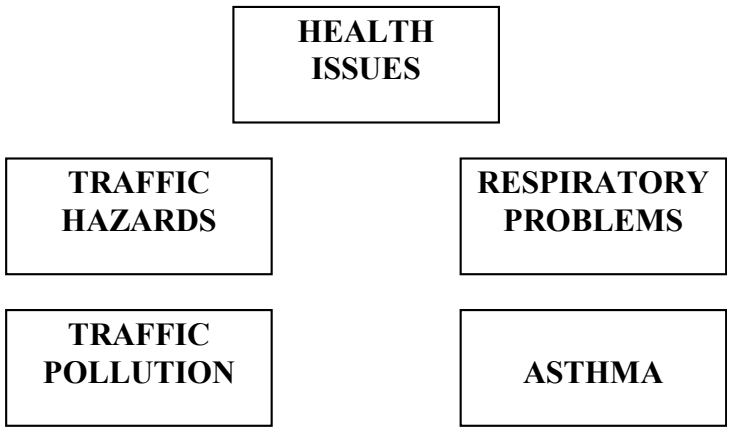


Figure 5.2: Outline of Questions

The possibility was considered of treating the "asthma" questions as a supplementary questionnaire, to be administered only to those respondents who mentioned respiratory problems in answer to the initial questions on health concerns. However, from the pre-pilot interviews it became apparent that not all respondents with experience of respiratory problems mentioned them as a major concern. It was therefore decided to administer this section of the questionnaire to all respondents.

A copy of the questionnaire is included in Appendix A.

In general, the questionnaire was not suitable for self-completion, but was used as a trigger for a brief (ten minute) interview. The interviews were not tape recorded because of objections from the respondents. Responses cannot, therefore, be considered completely verbatim, although great care was taken to record the responses in as much detail as possible. The responses were condensed and written directly onto the questionnaires during the interview, but were not coded at that stage, but rather later, when all the interviews had been conducted. Microsoft Excel was used for storage and analysis of the questionnaire data.

Each of the thirty two respondents (8 from the control group and 26 from the Oxford groups) was allocated a unique respondent number. Where quotations from the interviews are referred to in the body of the thesis, the source of the quotation is identified by group code, respondent number and question number.

5.3 Institutional Responsibilities

The starting point for the study was to investigate the stated objectives for each of the institutions involved, as dictated by their hierarchical position.

5.3.1 Transport Planning

Transport planning is the responsibility of the Oxfordshire County Council Department of Planning and Property Services.

The current structure plan for the county makes explicit recognition of the need to tackle the environmental impact of traffic, regarding the reduction of the need to travel by car as a main objective for transport policy, and containing a series of policies aimed at *"giving priority to travel by public transport and reducing the need for private vehicle use"* (Oxfordshire Structure Plan, 1992). These policies reflect the need to encourage the use of buses and bicycles as alternatives to the car and further restrain the use of cars by controlling the parking supply.

The county council has employed a team of consultants to conduct a study with the aim of securing environmental improvements in the centre of Oxford. The study commenced in 1991 and finished at the end of 1992.

On the basis of the package of measures recommended by the consultants, in July 1993 the county council applied to the Department of Transport for grant and credit approval support towards the implementation of the measures (the Oxford Integrated Transport Package).

5.3.2 Air Pollution

Air pollution is the responsibility of the Environmental Health Department of the Oxford City Council.

The city council corporate strategy includes the following explicit commitment:

> *"the extent and effects of pollution will be monitored and publicised and countervailing action taken to protect people and their environment"*
> (Oxford City Council Corporate Strategy, 1991-2).

Air quality standards are set by the EC for sulphur dioxide and suspended particulates (80/779/EEC), lead (82/884/EEC) and nitrogen dioxide (85/203/EEC). These EC Directives were implemented in the UK by the Air Quality Standards Regulations 1989, which came into force on 31 March 1989 (See Section 3.3.1).

A general requirement of the Directives is to identify, by suitable monitoring, areas which may be exceeding the limit values. To this end, the DOE has funded certain local authorities to purchase automatic, high quality monitoring stations for the four main urban pollutants: nitrogen dioxide, sulphur dioxide, ozone and carbon monoxide (the Enhanced Urban Air Quality Network) (See Section 3.3.2). However, the number of stations on the network is limited, and there is none near Oxford.

Accordingly, the city council has recently (1992) installed air pollution monitoring equipment in the city centre, to provide automatic continuous measurement of these pollutants.

5.3.3 Public Health

Responsibility for protecting and promoting public health lies with the Public Health Department of the Oxfordshire Health Authority.

> *"Health Authorities have a responsibility to measure the health of the population for which they are responsible, assess the scope for improving health, and identify steps that could be taken to close the gap between the present level of health and the actual level that could be attained."*
> (Annual Report of the Director of Public Health, Oxfordshire Health Authority, Gatherer, 1991).

In 1991, the Department of Health published a green paper entitled "The Health of the Nation", which put forward a range of health targets which might form part of a national health strategy (DH, 1991). This occurred within the wider context of the World Health Organisation's (WHO) strategy, "Health for All by the Year 2000", which also describes health targets and the means by which they can be achieved (WHO, 1985). The green paper was later followed by a white paper, also entitled "The Health of the Nation", which sets out the first governmental strategy for health in England. "The Health of the Nation" discusses environmental issues, but does not include them in its list of key areas, and does not define targets for such factors as air pollution, which are included in reports on the environment, rather than health (Gatherer, 1991).

Government policy, particularly since the late 1980s, has been to direct the health authorities to concentrate on more immediate, strictly medical aspects rather than broader environmental issues. In the absence of any specific responsibility to consider the possible impact of environmental degradation on health, the pressure of its other responsibilities, and the constraints of available time and resources, the authority is not in a position to be able to take an interest in the health effects of air pollution (Hadfield, 1994a; OX6, DPH1, I, 3-7).

The authority is, however, concerned about asthma. In the Annual Report for 1991, it is one of two public health issues (along with motor vehicle accidents) singled out as being of particular concern, because of the increasing rate of prevalence within the community (Gatherer,1991). Current approaches to managing asthma are based on the provision of the means and information for individual sufferers to control their own treatment, through regular monitoring of their peak flow [5], and adjusting medication accordingly.

This approach is demonstrated by the appointment of a Paediatric Asthma Nurse for East Oxford. The asthma nurse's role involves visiting schools, looking at children's experience of asthma, raising their awareness and promoting the use of self-treatment protocols, in order to help them to manage their asthma better. Oxford is the first health authority in the country to have made such an appointment, and at the time of the study one of the respondents was conducting a study to find out the effectiveness

[5] Peak flow is an indicator of the severity of asthma based on the rate of expiration of the patient, and can be measured using a simple meter into which the patient is required to blow.

of the approach, by means of comparing the symptoms of children at schools which had been visited by the asthma nurse with those who had not.

5.4 Definitions of the Problem

It will be recalled from Section 2.6 that the existence of multiple constituencies with different perceptions of "the problem" is a characteristic of emergent systems, and from Section 4.5 that the present approach to research will focus on those differences in perception. Therefore, in addition to identifying the formal responsibilities of the various institutions, the study was concerned with establishing the ways in which the different constituencies perceive the issue, and what their main concerns are with respect to it.

5.4.1 Transport Planning

Currently, the main area of concern for transport planning in Oxford is the problems caused by traffic in the city centre:

> *"the main problem in the centre of Oxford is we've got a lot of traffic, a lot of pedestrians, bicycle movements and bus movements all conflicting in the centre"* (OX8,DPPS1,I,5-8)

The problem is seen as having been exacerbated by deregulation of the buses, and is expected to get worse with the growth of car ownership and privatisation of the railways:

> *"The situation got much worse in the mid-80s when bus deregulation came along and the number of buses doubled"* (OX8, DPPS1,I,9-11).

However, although congestion is seen as a problem in itself, pollution per se was not mentioned by the respondents until prompted, when the following response was elicited:

> *"I'd certainly see [pollution] as an important issue, but how you actually weigh that against something else I'm not sure, we haven't done that in a formalised way"* (OX8,DPPS1,I,234-236).

5.4.2 Elected Members

The elected members echoed the views of the planners regarding congestion and problems caused by the deregulation of public transport:

> *"the political will is there for lots of reasons, not just pollution - it would be a better city if it wasn't for all the cars"* (OX7, HEPS1,G, 47-48).

> *"More and more people are getting cars ... and alongside that you've got the reduction of public transport ... in the country districts there's still a lot of people looking to Oxford"* (OX7, HEPS1,G, 498;509-511).

but were also explicitly concerned about pollution, which is seen as both an outcome and evidence of the underlying problem:

> *"the primary issue, I think, is the pollution one, because it's going to be unbearable"* (OX7, HEPS2, G, 143-144).

However, it is recognised that there is no simple solution to the problem:

"we're trying to get the traffic out of the city centre, but we recognise that there are people who won't be happy with that ... motorists who want to drive in the city, and the shopkeepers, who tend to ... dislike change, any change that will affect their business" (OX7, HEPS1,G, 37-41).

"I suppose we have a vision of a city with less traffic, more pedestrians, lower pollution, car parks around the outside and a public transport system that brings people in and takes them out again. What we don't have a vision of is where the residents are going to park their cars, and how much they're going to use them, and that may be the insoluble one" (OX7, HEPS1, G, 488-494).

5.4.3 Environmental Health

The Environmental Health Department are concerned with the health impacts of pollution, in line with their institutional responsibilities:

"there are potential health implications ... there's been quite a lot in the way of research done that's tended to show that levels of ... childhood asthma particularly ... has increased significantly, and research that seems to suggest that traffic pollution for one is a prime contributor to that and pollution generally is being seen as a detectable health effect" (OX3, EHD3, G, 7-14).

"this is where the whole pollution business becomes complicated ... if you're a hay fever or an asthmatic type of person, there are various things that can set you off ... you've got to look at them all to get the true picture, and that's another reason why pollution is coming to a lot more people's minds, because ... it's been seen as an additional effect on top of things like pollen that have been known for a long time" (OX3, EHD3,G, 518; 525-526; 531-535).

5.4.4 Public Health

For the Public Health Department, asthma is a major cause for concern:

"asthma's a big problem, ten per cent of the population wheeze at some stage, maybe twenty per cent of children ... it's the commonest illness children take medication for at school, so it's a well recognised problem" (OX2, DPH2, I, 65-69).

However, the connection between traffic pollution and asthma, taken as axiomatic by the Environmental Health Department, is questioned by a respondent in the Public Health Department:

"by and large I don't see cars as a cause of asthma, I'm not sure that there's any particularly convincing evidence that traffic pollution induces asthma" (OX2, DPH2, I, 132-134).

"I'm aware of new studies that have looked at ... general environmental pollution and asthma, and really haven't shown any convincing correlation ... I haven't looked at it extensively, but I'm not convinced that I need to, although ... there are certain ... occupational exposures that make asthma worse, and ... pollution levels earlier in this century ...

undoubtedly caused increased death in the cities" (OX2, DPH2, I, 228-236).

5.4.5 Mothers

The approach taken with the final constituency, the mothers, was to determine the relevance of asthma and/or traffic pollution as health issues by means of a general question about health concerns, as follows:

> *"Which problems related to your own or your family's health are you most concerned about? (Please list up to three, in order of importance, most important first)."*

The largest single category of responses (8 responses) mentioned asthma as the major worry (see Table 5.5). One might question whether respondents had guessed what was expected of them. However, care had been taken to avoid introducing bias in this way: the questionnaire was explained as being to do with general health worries, the interviewer's introduction made no mention of asthma, and only one of the respondents had seen the whole questionnaire prior to the interview (she did not mention asthma). For a copy of the questionnaire used in the interviews, see Appendix A.

Traffic was only mentioned once as a primary worry, linked with general child safety. However, among the secondary and tertiary worries it was mentioned four times in relation to road safety and six times in relation to pollution.

Among this limited sample, then, it would appear that asthma stands out as a cause for concern. Over half (eighteen) of the mothers have had direct experience of asthma in their immediate families, and only six have had no experience of asthma or related respiratory diseases. (See also Section 7.2).

Different hazards were seen as having different relevance at different stages in the child's life. Several respondents mentioned toddlers in buggies as being at particular risk from exhaust fumes. Mothers who had only toddlers and babies were not concerned about road safety because the children were never allowed out on their own, but said that this would become more of a worry when they were older.

Table 5.5 ***"Which problems related to your own or your family's health are you most concerned about?"***

Health concerns	Cited as main	Cited as other	Total no of times
Respiratory problems			
Asthma	**8**	**3**	**11**
Hay fever		1	1
Traffic			
Road safety		4	4
Pollution		6	6
Pollution/environmental (non-traffic)			
water	2	2	4
hygiene in public places		2	2
industrial pollution		2	2
food additives	1		1
Organisational/medical			
TB injections no longer given to 15-year olds	1		1
Shortage of kidney donors		1	1
Lifestyle			
Diet	4		4
Getting enough exercise		1	1
Smoking		1	1
Safety of children (Road safety, strangers etc.)	1		1
Specific problem in family	7	2	9
Specific but non-immediate			
AIDS	1	1	2
Meningitis	1	1	2
Cancer	1		1
Heart disease	1		1
Ear infections		1	1
No worries	6		6
Total number of concerns cited	34	28	62

Figure 5.3 gives a diagrammatical summary of the various definitions of the problem.

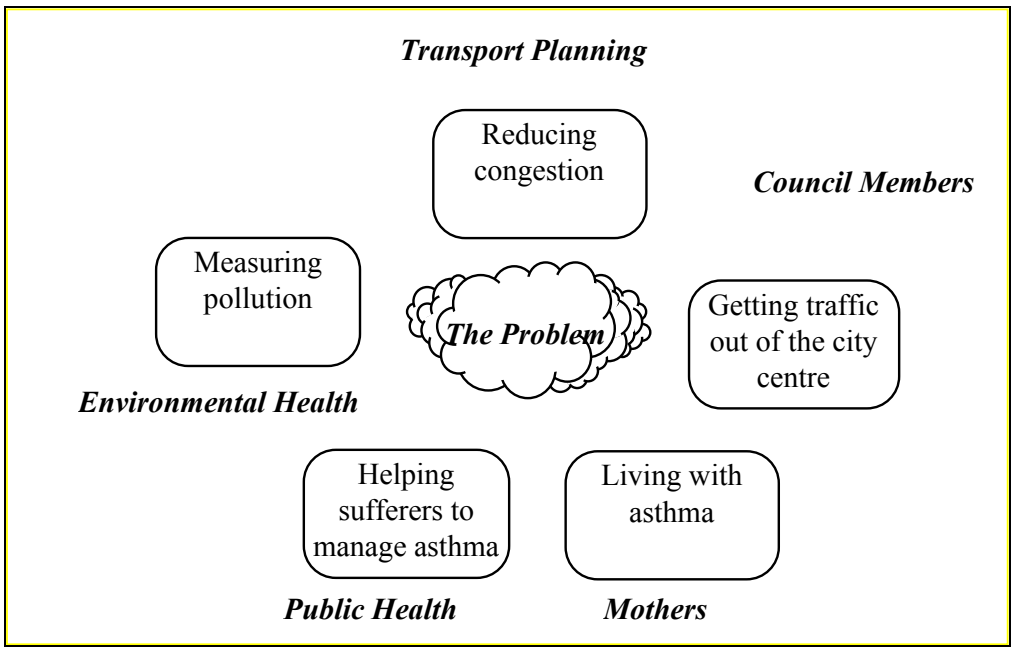


Figure 5.3: Definitions of the Problem

5.5 Spatiality

In addition to the functional split between different agencies described above, policy is formulated and administered within a geographical hierarchy of local, regional, national, European and international bodies (See Figure 5.4; Cannibal and Hadfield, 1995).

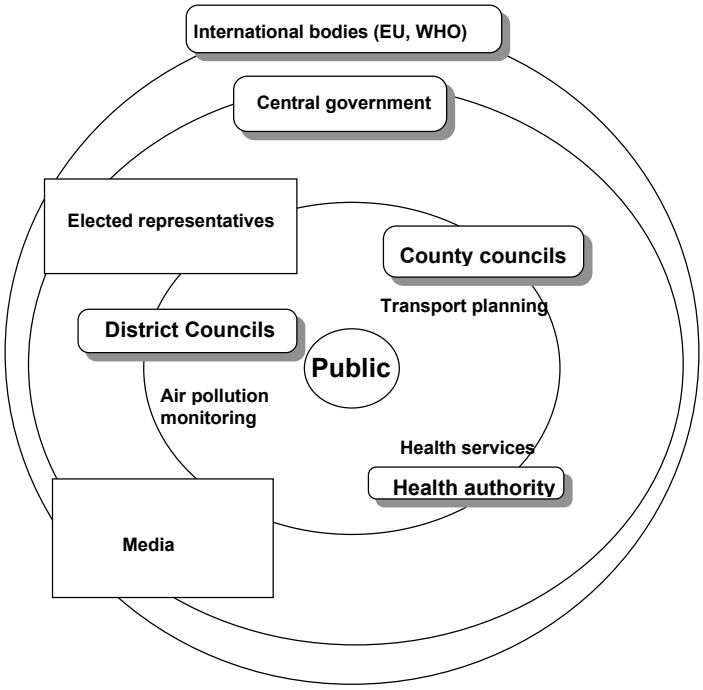


Figure 5.4 The Political Context

The three agencies involved in the survey were situated at different positions within this hierarchy, with responsibility for different geographical areas: transport planning at county level, in the Oxfordshire County Council Department of Planning and Property Services (Section 5.3.1); environmental health at city level, in the Oxford City Council Environmental Health Department (Section 5.3.2); and public health by the Oxfordshire Health Authority region (Section 5.3.3. See also Section 2.9 for discussion of spatial variations in emergent systems).

Figure 5.5 shows the relationship between the administrative boundaries of Oxfordshire Health Authority, Oxfordshire County Council and the five Oxfordshire District Councils (including Oxford City Council) at the time of the study. The area of the Oxfordshire District Health Authority did not correspond exactly with that of Oxfordshire County Council, as the area near Henley-on-Thames (the shaded area in the south-east corner of the map) was served at that time by the West Berkshire Health Authority. (source: Gatherer, 1991).

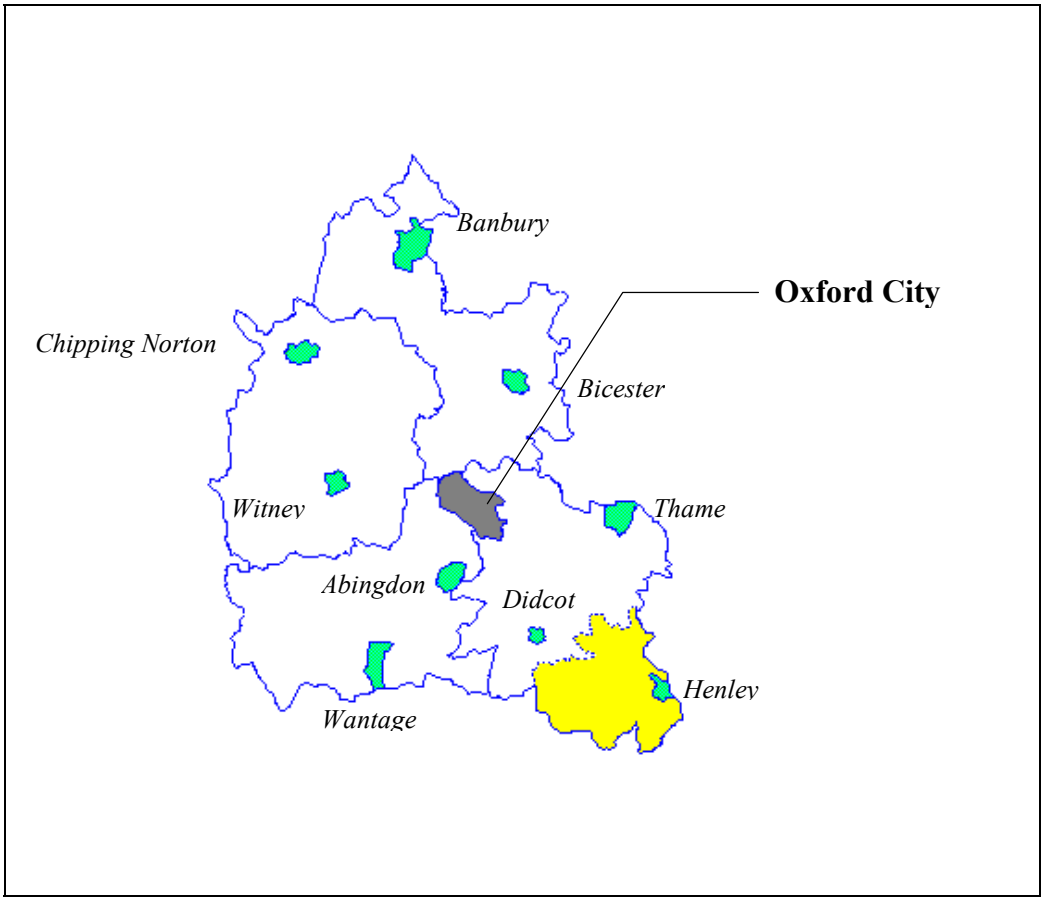


Figure 5.5 : Oxfordshire, Showing "Henley Overlap"

At national level, the health authority reports to the Department of Health, and both city and county councils report to the Department of the Environment, but there is no direct connection between the local authorities and the Department of Transport. (This issue will be returned to in Chapter 9).

In addition to these formally defined geographical boundaries, there were differences between the constituencies in the spatial concerns of respondents with regard to pollution. As will be recalled from Section 2.9, this variation in spatial concern is to be expected of an emergent system.

The Environmental Health department were concerned with the physical dispersion of various pollutants:

> *" Nitrogen dioxide is a secondary pollutant from nitrous oxide that comes out of car exhausts, and actually in the reaction from NO to NO_2 it gobbles up the ozone. You therefore don't have higher concentrations of ozone in city centres where you've got traffic pollution, you're more likely to have elevated ozone concentrations in the rural situation ... a lot of it comes over as an air mass from Europe anyway, quite a different situation from SO_2, NO_2 and CO which are where the pollution's created, where the major traffic problems are.* (OX3,674-679;689-692).

Their main interest was dictated by choosing the most suitable place for location of monitoring equipment:

> *"Our measurements in the city centre are there because that's where the traffic's worst. It's true to say that the exposure to persons is probably less as a whole, a lot of individuals for short periods of time. If you try and link pollution to health, I think you'd probably have to look at more an inner city area which also has traffic, where there are more people living and spending more time."* (OX3, 579-585).

As was mentioned in Section 4.3.2, a balance must be struck between monitoring locations where the maximum levels are likely to occur, and those where most people are likely to be exposed (QUARG,1993; Williams, 1994).

The Public Health view is more localised, concerned with the relationship between point sources and the location of recipients:

> *"Two of the schools who I've asked about respiratory symptoms are near to a factory about which there have been some complaints from the local residents, complaining that fumes are making everybody have wheeziness and chest symptoms. So, though the study's not primarily designed to look at that, just to add spice, I'm going to analyse the results from schools in the area - it's not actually going to be a particularly sensitive test, but just interesting."* (OX2, DPH2, I, 41-47).

Concern was also expressed about the relevance of monitoring in certain locations:

> *"How do people in Blackbird Leys, which is a housing estate just beyond the ringroad, view the value of monitoring data down in the town centre, when by and large they probably go down to the town centre no more often than the tourists?"* (OX1, DPH1, G, 94-97).

This approach to locality of pollution reflects the perceptions of the mothers, whose concerns are with their own immediate locality:

> *"I'm not a worrier ... I live on a cul-de-sac on an estate, so I'm not really affected"* (O1,19,4).

(For further discussion of the spatial dimension of individual's perceptions of concern, see Sections 7.4, 7.6 and 8.4.1).

Several respondents explicitly mentioned the difference between urban conditions and their own, suburban or rural, locality. Typical comments were:

> *"When I'm in the centre of Oxford I worry, with all the buses, but not when I'm at home"* (O1,11,4).

> *"I lived in North London for thirteen years, and it [traffic pollution] bothered me a lot then, but I don't see it as a problem now I live in the country"* (T,8,4)

The importance of locality is demonstrated by a comparison of responses from the Oxford groups and the control group to questions about traffic hazards. The main responses expected to the question:

> *".. please list up to three ways in which you believe traffic may be a threat to health, in order of importance"*

were road safety and pollution, the question being how these would be prioritised. The responses were noticeably (and predictably) different between the Oxford group and the control group (See Figure 5.6).

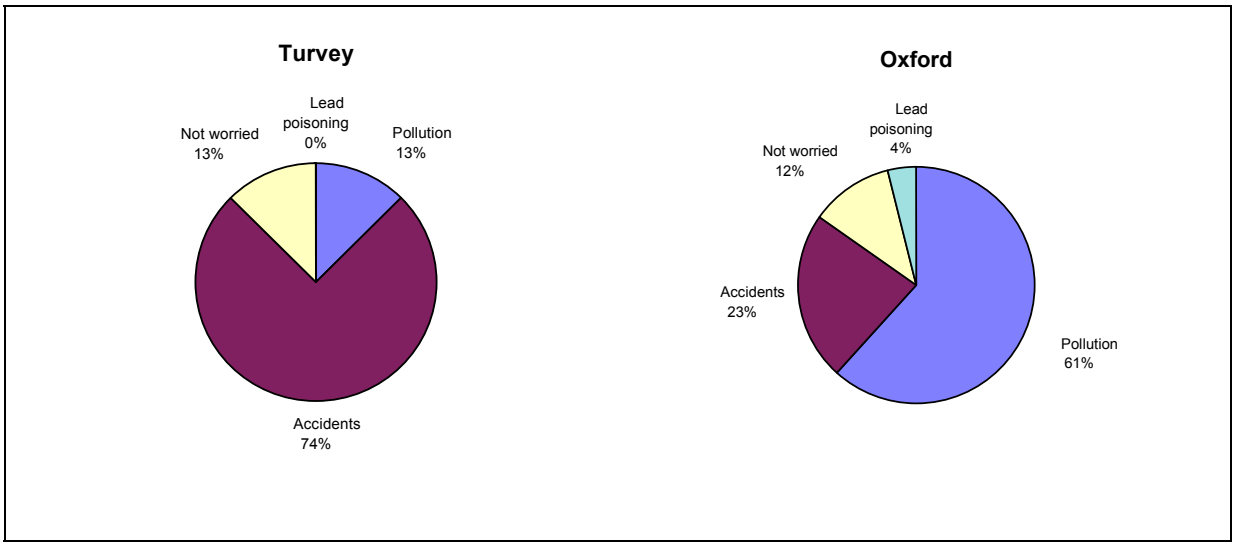


Figure 5.6: Concern about Traffic Hazards

Turvey is a small village situated directly on a busy trunk road. Six of the eight respondents mentioned being concerned about road safety, three of whom specifically referred to the main road. Of the other two, one said she was not particularly worried about the traffic, while the other specifically mentioned asthma in relation to road pollution.

Among the twenty six responses from the three Oxford groups, sixteen mentioned pollution, or fumes, as the most significant hazard, while six mentioned road safety. Of the other four, one mentioned lead pollution, while the other three were not worried about traffic hazards.

In summary, there are clear and noticeable differences between the constituencies in terms of the spatial concerns. For the policy makers, concerns are dictated largely by the geographical boundaries of their administrative areas, and also to some extent the physical properties of the pollutants in question. For most of the mothers, however, concern is centred around their immediate locality. While accepting the undesirability of the traffic conditions in the city centre, most do not regard it as an immediate concern to themselves, because they rarely go into the centre. This in itself might be seen as a result of the traffic problems, or in some cases of the success of traffic policies: *"I never go in because the parking is so expensive"* (O3,31).

This issue of variations in spatial concern between different hierarchical levels will be discussed in more detail in Chapter 9.

5.6 Objective Measurement and Perception

Within the Environmental Health department, the acquisition of "hard evidence" in the form of data from the air monitoring system is seen as a crucial factor in furthering the political aim of tackling traffic problems in the city centre:

> *"We need to prove to the shopowners that there is something which needs treating ...you have to sell it to everybody."* (OX7, HEPS1,G, 217-218; 223).

The Public Health Department are also concerned with establishing numbers of children in schools who are affected by asthma, in order to evaluate the effectiveness of the service provided by the Paediatric Asthma Nurse.

These approaches reflect a view of "real science" equivalent to the one described in Section 4.1, focused on quantification, measurement and the identification of causal relationships. In this view, a relationship between factors and outcomes may only be demonstrated "unequivocally" if both can be measured and a statistical relationship shown to exist. Even then, this is only a necessary, and not a sufficient, condition, as correlation does not prove causality.

The attitudes of the mothers, however, were less concerned with “objectively” measured levels of pollution, but with the impact on their own lives. As mentioned above, many perceived pollution as an issue which did not affect them because they avoided the city centre (Section 5.4). Although asthma was mentioned frequently as a health issue, it was not always seen as a major concern by comparison with other issues (Section 5.3.5). One respondent, who has suffered from asthma for about five years, was quick to say *"but it isn't a problem"* (O3,30,1).

On the subject of health worries, some felt that it was a good thing for children to be exposed to certain diseases, in order to build up their resistance:

> *"I'm not worried about childhood illnesses - I'd rather let them get them while they're young. They get all their vaccinations"* (O1,19,1).

> *"They get the normal childhood ailments, but I don't worry about them because they need to build up immunity ... you can't protect a child from everything ... they're immunised against diseases"* (O1,16,1).

One respondent felt, somewhat apologetically, that pollution was not high on her list of priorities:

> *"I'm not at all worried about pollution ... is that awful? I think there are so many other things to worry about: people starving, child abuse ..."* (T,5,1).

Monitoring is seen by the Environmental Health Department both as a means of contributing to scientific debate, establishing “the truth”, and as a way of both informing the public and persuading them of the need for change:

> *"If you're trying to make progress, you've got to inform perception, people's perception and other groups' perception, and that means you've got to communicate with them, because there's such a lot of misconceptions about ... you've got to talk to the Health Authority and get the Health Authority working with you, you've got to talk to your colleagues in the same local authority and get them working with you."* (OX4, EHD1, I, 326-334).

> *"All of that really leads on to thinking about campaigns about traffic, then you realise that you actually have quite a strong voice, to say that growing numbers of people who are susceptible are being affected by what they're being exposed to in larger cities, and traffic is a major source, all of which is true to a degree ... there is your reason for pressure to say, 'look, what about the traffic in large cities?' or to look at alternative means for controlling such. There's really where you get your*

> *thrust for change ... more research, more people doing research ... to give a growing picture of this type of information. All of it at the end of the day becomes part of a movement for establishing what the truth is."* (OX3, EHD3, G, 538-552).

The data was also seen as playing a role in the process of perceptual emergence and "consensus building". There was considerable emphasis on finding the best way to use the data to provide a service of informing the public:

> *"The big thing we've got to reconcile really is how we do more with the data, to make it more meaningful to members of the public".*(OX1, EHD2, G, 111-113).

> *"It's quite important how we make the findings public ... the public perception depends on how we do it."*(OX1, EHD1, G, 151-153).

However, the interviews with the mothers revealed little awareness of the availability of such data, and scepticism about its value. Respondents from the three Oxford groups (twenty six respondents) were asked *"Are you aware of anything the council is doing to try and reduce pollution from traffic?"*. Ten gave a "no" response to the question, but of these, four went on to mention speed bumps or other traffic-calming measures, and one the Park and Ride system, while two made the following comments:

> *"There was some talk of not allowing traffic into the city centre, but I don't know if anything came of it"* (O1,18,6).

> *"They keep talking about increasing pedestrianisation, reducing cars coming into the centre of Oxford"* (O2,24,6).

None of the respondents in the first Oxford group visited (Bullingdon, O1), mentioned the city council's air quality monitoring scheme, although one commented that *"They're always testing the fume levels"* (O1,10,7). As it was felt that this might be because they did not associate it with the question about "what the council is doing to try and stop pollution", a question asking specifically about it was included in the interviews for the other two groups (O2 and O3; fifteen respondents).

Four of the respondents were not aware of air quality monitoring of any kind. One mentioned that she thought the city centre air quality was sometimes monitored in the summer. The remainder had heard of air quality monitoring in general, and had sometimes noticed reports on the weather forecast or Ceefax. One commented:

> *"I suppose it's quite useful for people who've got asthma"* (O3,33,16).

Another added:

> *"It's useful to know, but there's not a lot you can do if it's high"* (O2,22,16).

None of the fifteen respondents was aware that there was a local monitoring system for Oxford. One said that she regularly listened to the local radio, but had never heard anything about it. (O2,28,16).

This issue of provision of information to the public was also raised in later parts of the research, and is discussed further in Chapters 8 and 9.

5.7 Scientific Uncertainty and Perceived Risk

From the scientific literature, the case for a direct and measurable relationship between traffic pollution and asthma is "not proven" (See Section 4.3). Among the institutional actors, particularly Environmental Health, the emphasis is on the collection of data as a way of establishing “the truth”. However, given the complexity of both asthma and air pollution, it seems unlikely that such incontrovertible proof of a relationship could ever be obtained.

Among the mothers, concern is less with the mathematical probability of contracting asthma, and the factors which might contribute to it, but rather with ways of living with and responding to health risks more generally. Several respondents appeared to see "worrying" in a negative light, and claimed not to be "worriers":

> *"I don't sit around worrying about things - I wait till things occur."* (T,8,1).
>
> *"I'm normally healthy, I don't let things worry me"* (O2,20,1).
>
> *"I don't worry all the time, but I try to be aware if things arise"* (O1,17,1).

Others made a distinction between immediate health concerns and the wider issues of pollution:

> *"On a day to day basis, I'm not concerned about [my family's] health suffering - though I am concerned as a wider issue"* (T,8,4).
>
> *"I'm worried about the long term detrimental effects [of air pollution] on respiratory problems"* (O2,1,1).

Some attributed concern to their lack of knowledge about the effects of pollution:

> *"I worry about pollution ... I don't know what effect it has"* (T,6,4).
>
> *"I don't know what it does to them, but it's not very healthy, is it?"* (O2,20,4).

Some were intimidated by the scale of the problems:

> *“It's such a big problem - there's nothing I can do about it"*(O2,27,3).
>
> *"I think the problems are so major, you couldn't do anything if you tried"*(O1,12,3).

Some felt that it was important for individuals to take responsibility for themselves, but not to worry about things for which they were unable to take responsibility:

> *"I worry about things I can control, but not about anything else ... ... a lot is within your own control as long as you're informed ... you can be as well informed as you want to be - go to the health clinic, library, watch documentaries ... so much information is there, but it's down to the individual to find out for yourself"* (O1,16,3).

A respondent who mentioned children's diet as first worry, hygiene in public places second, and car fumes third, commented:

> *"you can't get away from them [car fumes] - I don't feel it's something I can do anything about, so I don't really worry about it - I feel like I can control the diet, but not the fumes - there are cars everywhere these days - we use one too"* (O1,9,4).

5.8 Relationship Between The Policy Makers And The Public - The Role Of Perceptual Emergence

Sections 2.6 and 4.7 discussed the importance of perceptions, and the process by which an issue becomes recognised as a "problem" and enters into the collective appreciative system. This process was given the name "perceptual emergence" (Section 2.6).

The core issue of this thesis is that the relationship between the hierarchical levels in the complex of overlapping hierarchies referred to as the emergent "traffic pollution and asthma" system is crucial in understanding and managing the issue. This section will look at the interactions between the perceptions of traffic pollution and asthma held by the various constituencies researched in Oxford, and the way in which these perceptions illustrate the concept of perceptual emergence.

There is some evidence from this study of a consensus that traffic in Oxford city centre constitutes "a problem" (see Section 5.4). Among the policy makers, this is accepted as axiomatic, perhaps because they are involved in dealing with the negative effects of traffic on a daily basis. Among the mothers, however, there is less agreement. The main concerns for most of them centre around their immediate locality (see Section 5.5).

Concern was expressed by the policy makers about the involvement and perceptions of the public. Finding out about public opinion was considered an important part of the Oxford Transport Study:

> *"During the study, they [the consultants] had quite a detailed opinion research programme ... we also had public meetings which the County Council organised, and encouraged a lot of participation ... and all of the opinion research produced a very, very similar message, which was that people wanted less traffic in the middle of Oxford, and ... a pleasant environment for shopping."* (OX8,DPPS1,I,173-174; 178-179; 181-183).

The city council members are keen to stress the democratic nature of local politics:

> *"Every year there are elections in May ... you get a general view of what people think about what's going on, so it is quite close, much closer than the parliamentary system ... we go round each year knocking on doors persuading people to vote for us ... the votes would alter if we were thought to be going in a direction in which people didn't want to go"* (OX7, HEPS1, G, 58; 60-62; 67-68; 74-75).

"Giving a voice to people", articulating their needs and identifying problems, is seen as part of the council's role:

> *"If people think that traffic pollution is bad in the city centre, ... nobody says as they're walking down [the street] 'We need pollution equipment.' ... and I think that's where the council come in, you can see what the issues are."* (OX7, HEPS2,G, 435-438;442-443).

> *"I think, local politicians can look at a situation and say 'You shouldn't be having to put up with this sort of environment, let me give you a choice ... the choice is we spend money on clearing cars out of this area, or we continue to spend money on the priorities you've got at the moment.'"* (OX7, EHD1, G, 448-453).

The local media are seen as an important channel of communication:

> *"We've done several films and interviews about the [air pollution monitoring] service to give it more of a profile, so that hopefully people are aware that it's going on, also in the Oxford Mail there's been several articles."* (OX3, EHD3, G, 303-305).

In addition to informing the public, the media are seen as part of the political process of changing attitudes, in other words, changing the collective appreciative systems (see Section 2.6):

> *"That December* [1992] *episode was quite opportune, in that it enabled the whole system to be given a profile at that time, it was reported as a pollution episode ... when we've got good air quality, nobody wants to hear it, but when you've got bad news, it makes the headlines, and it made the newspapers, it was reported to the council meetings and so on, and the council decided to back it and provide the money to retain the system, whereas there were some doubts about that previously."* (OX3, EHD2, G, 356-358; 361-365).

Among the mothers, the media were most frequently cited as a source of information on policy and health issues. However, this seemed to be in the nature of a "catch-all" response. Responses to questions about sources of information tended to be either very specific ("the Alzheimer's society", "the asthma clinic") in the case of specific problems; very immediate ("I was watching a programme yesterday") or extremely vague and generalised. There was a sense that, although respondents became generally aware of policies and issues "through the media", it was not possible to pinpoint specific instances.

The "high profile" achieved by the pollution monitoring system in December 1992 may be seen as an example. By September 1993, none of the mothers questioned remembered this clearly enough to mention it in response to questioning about pollution monitoring, although the city council officers and members stressed the publicity it had received. One might speculate as to what responses would have been received if the survey had been conducted at the time of the episode (or, equally, what mention would be made of electric buses if the survey were to be repeated in July 1994). The inference could be made that issues which have a high profile in the short term may not retain their saliency unless they are seen to be specifically relevant (see also discussion of attitudes to air pollution in Bedford and the relationship with media reports, Section 8.3, Figure 8.4).

Despite an apparent strong commitment on the part of both councils to communicate their policies and activities to the public, and despite great efforts at communication, involving working with the local media, surveys, exhibitions etc., on present evidence, the message does not seem to be getting across.

None of the mothers seemed to be aware of the air pollution monitoring scheme, although some were aware of previous, ad hoc attempts at monitoring, and one commented: *"They're always testing the fumes"* (O1,10).

Although many respondents were aware of the "talk" about the plans to remove traffic from the city centre, there was widespread scepticism, and no appreciation of the details of the plan or the stage it had reached.

One respondent, who originally answered "no" to the question, *"Are you aware of anything the council is doing to try and stop pollution from traffic"*, later remembered that she had *"read something in the Oxford Mail, or maybe I had a questionnaire to fill in"* (O3,31,), and finally concluded that she had filled in a questionnaire, although she could not remember who the questionnaire was for, or what it had said. This is perhaps an indication of the perceived relevance of such activities in people's day to day lives.

The issue of asthma is also affected by perception. It will be recalled from Section 4.3 that asthma is considered within the medical literature to be an important and controversial health issue within western societies, a concern which is reflected among the respondents to the study (see Sections 5.4.3, 5.4.4 and 5.4.5). This consensus about asthma as a major and interesting problem is set within a wider context in which asthma is seen as a "trendy", high profile disease, frequently discussed in the media (OX2,13). The “problem” of asthma has entered into the collective appreciative system (see Section 2.3.3), interacting with personal experience to affect the perceptions of all the groups involved (for further discussion, see Section 7.3). It is both a function of and contributor to the growing rate of prevalence, by influencing diagnosis and the attachment of the "asthma" label to specific instances of respiratory disease (OX5, DPH1, I, 26-35); see also Gregg,1986; Burney, 1992; Gergen & Weiss, 1992). There is some recognition of this positive feedback mechanism on the part of respondents to the pilot study:

> *"They said he had asthma previously, now they say he hasn't got it. There's no history of asthma in the family, and he's been OK since Easter, so I hope it won't happen again ... There's such a prevalence of asthma diagnosis in this area ... I think maybe the doctor just needed an answer ... maybe I'm being naive, but I'm hoping he's grown out of it ... I read up articles and bits in books, but I just felt at the power of the doctor" (T,3,1).*

The existence of this consensus over the importance of asthma, while it may be justified, may be obscuring the debate within medical science about the prevalence, seriousness and causes of the disease.

5.9 Conclusions

The range of perceptions and attitudes towards the issue among the various constituencies is characteristic of emergent systems (see Section 2.6). Each institution has its own perspective on the issue and definition of the problem, dependent on its agendas, constraints and geographical boundaries, and focused on measurable effects and impacts such as ambient levels of nitrogen dioxide and numbers of hospital admissions for asthma. However, the perceptions of individuals, both within the institutions and in the “general public”, are affected by their own personal appreciative systems (Section 2.6), and centred on the meaning of these impacts on their own individual lives, that is, the perceived outcomes (Section 4.7).

Responsibility for transport, air pollution and health is split between different bodies at all geographical levels, and consequently, management of the emergent system of traffic pollution and health is fragmented between the different agencies (see Section 2.5). Despite the apparent consensus among the policy making bodies about the need to address the traffic problems in the city centre, the split in responsibilities (the city

council is responsible for environmental health, but has no responsibility for transport planning, while the county council is responsible for transport planning), seems to lead to a lack of co-ordination of effort.

The scientific evidence is characterised by a high degree of uncertainty (See Section 4.3). In spite, or perhaps because, of this, the collection of more data, particularly in terms of monitoring of ambient pollution, is seen as a key strategy, particularly by the Environmental Health Department (See Section 5.4). When air quality management is viewed as an evolving complex system, as in the top-down conceptual model developed in Section 3.4, this institutional response can be seen as a way of contributing to the processes of knowledge change and perceptual change (see Figure 4.4). Scientific data is recognised explicitly as a political tool by Environmental Health Officers, as a means of building consensus, and effecting perceptual, and ultimately political, change (see Section 5.4).

Within this process of perceptual emergence, "health" is seen as a key issue, because of its "non-political" nature. Thus, the establishment of a firm scientific connection between traffic via pollution to health is regarded as critical, although other motives for reducing levels of traffic in the city centre are also recognised.

Because the Environmental Health Department has no jurisdiction over traffic and transport planning, its contribution to "management" of the problem is regarded as essentially a strategy of educating, informing, and providing a service to "the public",. It is implicitly assumed that the collection and dissemination of data about ambient pollution will permit individuals to respond in ways which will assist them personally in managing their own health, as well as contributing to a wider process of modifying the collective appreciative system (Section 2.7). However, evidence from the public survey, on a sub-group of the population who were expected to, and indeed did, have high levels of experience and concern about asthma, showed a lack of awareness and cynicism about the value of "the council's" efforts, which raises doubts about the potential effectiveness of such a strategy. This is a theme which will be returned to in Chapters Six, Seven, Eight and Nine.

While the Transport Department are concerned with trying to control traffic ("causes"), and the Environmental Health Department with monitoring pollution levels in an attempt to use this data to change perceptions and thus affect outcomes, the Public Health Department are concerned with impacts. Like the Environmental Health Department, they are collecting more information, both in order to monitor levels of impacts and to assess the effectiveness of what they are trying to do in terms of improving the management of asthma. The emphasis of the approach is on providing the sufferers, or recipients with information, and with the necessary technology and medicines, in order for them to control their own treatment. The paediatric asthma nurse study is concerned with assessing how well this perceptual control can affect the physical impact. Through the paediatric asthma nurse, they are trying to affect perceptions, in order to change behaviour and hence feed back into the actual physical impacts.

In summary, the case study revealed a wide range of perspectives and perceptions of an issue characterised by scientific uncertainty and perceptual emergence, within a context of fragmented management and multiple institutions, each of which is only able to focus on its own part of the problem, within its own agendas and constraints.

The emphasis throughout is on trying to change individual behaviour; either of drivers, through physical means, in the case of the Transport department, or through perceptual means, in the case of the Environmental Health; or of asthma sufferers, through the provision of both actual medical treatment and information, on the part of Public Health. However, as will be recalled from Section 4.5.3, such measures rely for their effectiveness on the perceptions of the individuals whose behaviour is to be changed, and evidence from the survey of mothers suggests that their perceptions are not compatible with the requirements of the institutional actors.

6 Variations in Perspective Within a Single Institutional Framework - Differences Between Local Authorities

"The local authority feels squeezed: ground between the centre pressing from above and some "consumers" from below. Local elected members are trapped by these pressures, and by an additional, formidable pressure coming from their own workforces in the unions and professions. The space for action to promote their view of what is good for the local community is restricted. Indeed, they feel that they have no scope to meet the wishes of anyone locally since the centre is setting their levels of expenditure and taxation. They are becoming agents of the centre."

George Jones, "Between Centre and Locality", 1985

6.1 Introduction

It will be recalled from Chapter Two that major characteristics of the management of emergent environmental systems, such as the one considered in this thesis, are:

- that no single body has overall ownership, and hence management is fragmentary (Section 2.6);
- that management evolves within a context of pre-existing institutions which have been designed for other purposes (Sections 2.8, 3.4);
- that both the properties and the management of the system vary spatially, leading to different responses in different locations depending on the local context (Section 2.9);
- and that a significant component of that context lies in the perceptions and perspectives of members of the various constituencies involved (Section 2.7).

Chapter Three has shown that previous stages in the history of the management of air quality have demonstrated these characteristics. Chapter Five has shown that the management of the "Traffic Pollution and Respiratory Health" system within a particular geographical location is fragmented between different institutions.

The purpose of this chapter is to illustrate the variations which exist within a specific institutional setting (local authority environmental health departments) between a group of thirteen contiguous local authority areas, and the ways in which these variations relate to constraints imposed by the institutional position within the hierarchy, interacting with local contexts and perceptions.

The series of dichotomies between the institutional and individual perspectives identified in Section 4.5 will again be used to structure the analysis. The structure of the chapter is as follows:

- description of the locations of the authorities involved in the study (Section 6.3) and current approaches to air quality monitoring in the authorities at the time of the study (Section 6.4);
- differences in organisational structure within the different authorities, and the way in which these relate to locally defined priorities (Section 6.5);
- the spatiality of concern of the different authorities and the mismatch between the areas of responsibility of the individual authorities and the trans-boundary nature of air pollution (Section 6.6);
- the importance of the rationalist, "objective" attitude to measurement of pollution in determining the approach taken to monitoring among the different authorities (Section 6.7);
- attitudes to scientific uncertainty and perceptions of risk in the different authorities, and the relevance of this for monitoring (Section 6.8);
- the relationship between the environmental health function and other levels of the hierarchy (national government, elected councillors and "the public"), and the ways in which this relationship is reflected in the policy-making process (Section 6.9).

6.2 Research Method

This part of the work was carried out in conjunction with the Institute of Environmental Health Officers (IEHO), with a view to establishing the extent of air quality monitoring being carried out in the Beds and Herts region at that time, and was described in a report to the IEHO (Hadfield, 1994b). The thirteen local authorities taking part in the survey are located in the two adjacent counties of Hertfordshire and Bedfordshire (see Figures 6.1 and 6.2). All fourteen local authorities in the two counties were invited to take part, but one (Broxbourne) declined to allow staff to be interviewed, although providing factual information about monitoring and pollution sources. Conversely, one of the authorities whose staff were interviewed (Hertsmere) failed to provide detailed information about pollution sources.

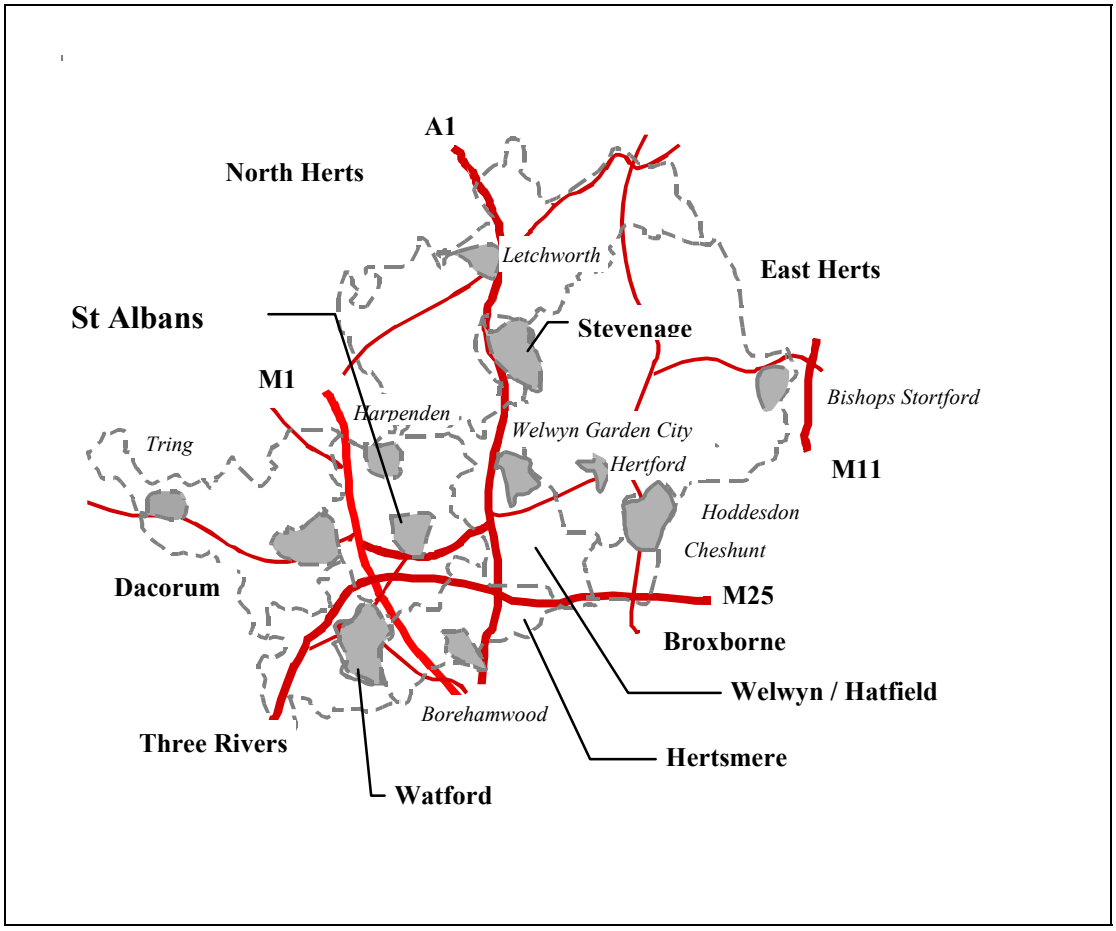


Figure 6.1: Local Authorities of Hertfordshire in 1994

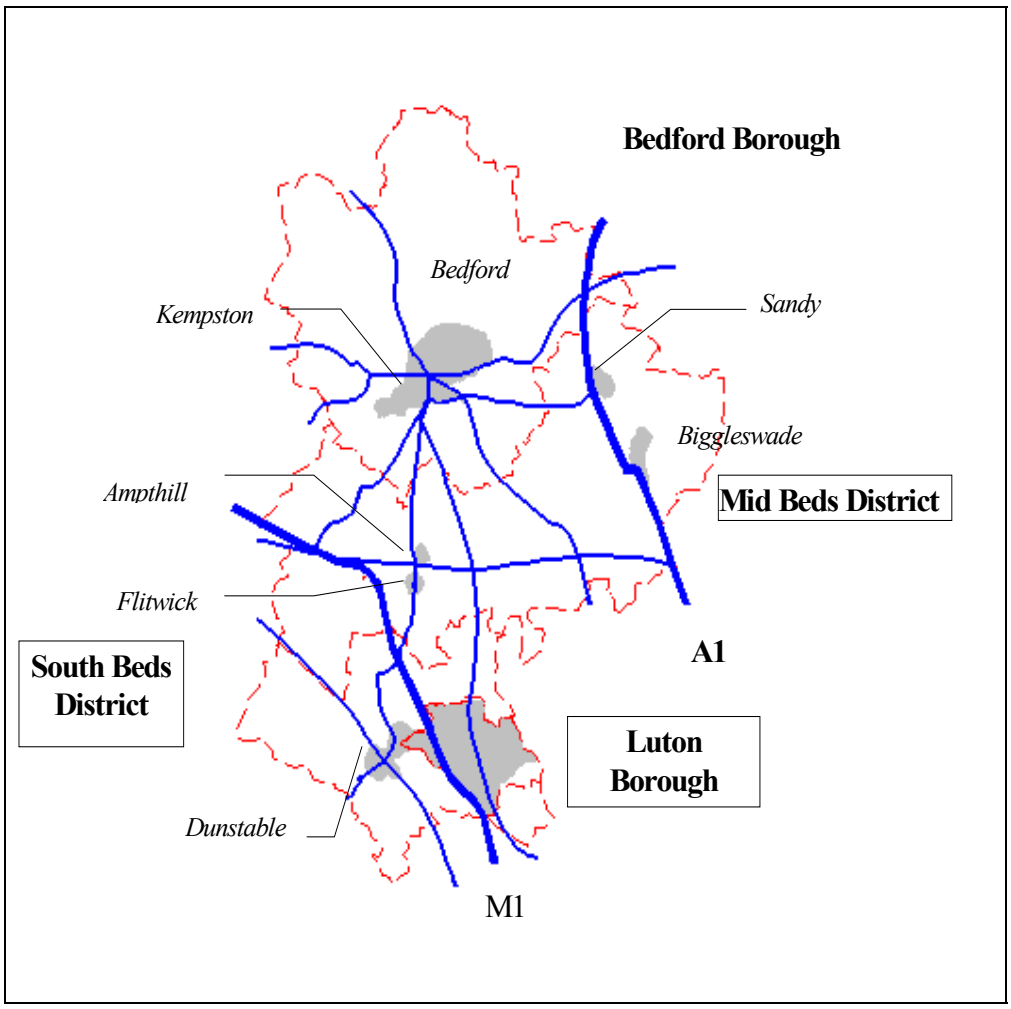


Figure 6.2: Local Authorities of Bedfordshire in 1994

Prior to the interviews, each of the fourteen authorities was sent a questionnaire to fill out giving details about the authority and current monitoring. A copy of the questionnaire is given in Appendix B. Information on monitoring sites and point sources was assembled in a Microsoft Access database, and included in the consultancy report to the IEHO (Hadfield, 1994b).

The interviews were carried out over a two week period in July 1994. A list of interview locations, times and dates is given in Table 6.1.

A copy of the interview schedule used to structure the interviews is given in Appendix C. The interviews were divided into seven main questions, with other sub questions, the main questions being listed in Table 6.2. The questions were related to the requirements of the consultancy work for the IEHO, and agreed with the client beforehand. The role of each of the questions with respect to the research designs are shown in Table 6.2. However, on the whole, the questions served as triggers to encourage the respondents to talk, rather than each fulfilling a specific role in the research design.

Table 6.1: Schedule of Interviews with Environmental Health Officers

LA code	Location	Date	Time	Duration	Number of phrases in interview
BED	Bedford	06/07/94	09:30:00	1 hour	291
DAC	Hemel Hempstead	04/07/94	14:00:00	1 hour	396
EHE	Hertford	12/07/94	14:00:00	45 mins	252
HER	Borehamwood	13/07/94	10:30:00	1.5 hours	674
LUT	Luton	08/07/94	10:30:00	1.5 hours	803
MBE	Biggleswade	14/07/94	10:30:00	1 hour	321
NHE	Letchworth	15/07/94	10:30:00	45 mins	207
SBE	Dunstable	13/07/94	14:00:00	1 hour	309
STA	St Albans	11/07/94	10:30:00	30 mins	76
STE	Stevenage	18/07/94	10:30:00	1 hour	305
THR	Rickmansworth	12/07/94	11:00:00	45 mins	255
WAT	Watford	04/07/94	11:00:00	1.5 hours	727
WEL	Welwyn Garden City	07/07/94	10:30:00	1 hour	471

Table 6.2: Questions Asked in Interviews of EHOs

1	*What monitoring of air pollution is carried out in your area?*	spatial variation in monitoring of ambient air quality
2	*What happens to the data which is collected from monitoring?*	role of monitoring data in processes of knowledge and perceptual emergence
3	*What are the sources of air pollution which affect your area?*	spatial variations in the physical "problem"
4	*What are the main influences on the monitoring you do?*	factors and constraints imposed by the perceptual and hierarchical context
5	*What is the name and address of your district health authority? Have you done or are you doing any work on air pollution in conjunction with the health authority?*	relationship between institutions
6	*Are you satisfied with your present monitoring, or would you like to extend it?*	perceptions of current policy, within the institution
7	*How important do you consider air pollution monitoring?*	perceptions of current policy, within the institution

The interviews were tape recorded and transcribed verbatim into a Microsoft Access database. Each phrase was entered as a line in an Access table, and identified by local authority code, speaker's initials and line number within the interview. Local authority code provided a unique identifier for each interview, as only one interview was conducted for each authority, although in some cases several individuals were present. However, in order to preserve anonymity, arbitrary interview numbers were assigned. An example of data as held on the database is shown in Table 6.3.

Table 6.3: Example of Extract from an Interview as Held on the Database

Interview	Line no	Speaker	Text
EH3	309	AA	we have all the new legislation coming in
EH3	310	AA	we don't really have time to study it
EH3	311	AA	we just have to do it!
EH3	312	AA	we can't work out how we're going to do these things, half the time
EH3	313	AA	they just happen
EH3	314	AA	so we have to do it as we go along

In general, where quotations from the interviews are referred to in the body of the thesis, the source of the quotation is identified by interview number, rather than local authority code, and line numbers, for example, the extract shown in Table 6.3 is quoted as follows:

> *"We have all the new legislation coming in, we don't really have time to study it, we just have to do it! We can't work out how we're going to do these things, half the time, they just happen, so we have to do it as we go along."* (EH3, 309-314).

However, where the location is evident from the content of the quotation, the local authority code has been retained

Because of the investigative nature of the study, and emphasis on perceptions, no pre-defined scheme for coding the interview responses was used. Instead, analytical categories and classification were developed during the process of data analysis, using an "open coding" approach (Strauss & Corbin, 1990). The interviews were carried out, and transcribed, by the author, allowing her to "live with the data". After transcription, the interviews as entered into Microsoft Access were inspected line by line, and key concepts allocated to each phrase (in some cases, a single phrase corresponded to several concepts). Table 6.4 shows the extract referred to in Table 6.3, with the concepts allocated to each phrase.

The set of concepts used in the analysis developed over time as new interviews were analysed and others were re-inspected. Periodically, the list of concepts was reviewed, and changes to the classifications made, for example, where two similar concepts had been used in different interviews, e.g. "constraints" and "limits", a single category would be chosen. Where possible ambiguities or conflicts in interpretation occurred, they were settled by re-inspecting the original data. Each interview was inspected several times in this way, and changes made in order to refine the list of concepts.

A final list of concepts used in the analysis, and the number of times they were referred to overall in the interviews, is given in Appendix D. The most frequently occurring concepts are shown in Table 6.5.

Table 6.4: Interview Extract with Allocated Concepts

LA Code	Line no	Speaker	Text	Note
EH3	309	AA	we have all the new legislation coming in	expertise
EH3	309	AA	we have all the new legislation coming in	constraints
EH3	309	AA	we have all the new legislation coming in	changes
EH3	310	AA	we don't really have time to study it	expertise
EH3	310	AA	we don't really have time to study it	constraints
EH3	310	AA	we don't really have time to study it	changes
EH3	311	AA	we just have to do it!	expertise
EH3	311	AA	we just have to do it!	constraints
EH3	312	AA	we can't work out how we're going to do these things, half the time	reactiveness
EH3	312	AA	we can't work out how we're going to do these things, half the time	constraints
EH3	313	AA	they just happen	reactiveness
EH3	313	AA	they just happen	constraints
EH3	314	AA	so we have to do it as we go along	constraints
EH3	314	AA	so we have to do it as we go along	reactiveness

Table 6.5: Most Frequently Occurring Concepts in Interviews

Concept	Times Mentioned
use of information	953
reasons for monitoring	683
constraints on monitoring	503
sources of pollution	471
public perceptions	386
change	367
priorities	365
local context	276
collaboration with other agencies	271
organisational structure	211
health effects of pollution	198
location of sites	192
limitations of monitoring	191
methods of monitoring	180
wider context	145
uncertainty	114
politics	106
extensions to current work	104
policy measures	86
regional strategy	85

6.3 Background and Context

In the wake of the Clean Air Acts, responsibility for monitoring of ambient levels of sulphur dioxide and black smoke devolved onto the local authorities. However, no clear lines of responsibility were established for monitoring of other pollutants (See Section 3.3.2).

During the 1980s and early 1990s, air quality once again began to cause concern, this time with respect to the impact of traffic. The Quality of Urban Air Review Group

(QUARG) was established by the DoE in response to the 1990 Environment White Paper, This Common Inheritance, which had made a commitment to increased air quality monitoring and wider dissemination of air quality data to the public (QUARG,1993). The QUARG recommended the establishment of the Enhanced Urban Network (EUN) of monitoring stations, in 24 locations. In these locations, responsibility for the implementation of ambient monitoring, together with support and funding from the DoE, were passed to the local authorities concerned (See Section 3.3.2).

In the interim, however, and in those locations not covered by the EUN, there existed no unified and statutory approach to ambient monitoring. The statutory requirements on local authorities with respect to air quality were limited to defining and supervising standards for the monitoring of those industrial processes in their areas prescribed for local authority supervision. (Responsibility for specific processes was shared between the local authorities and Her Majesty's Inspectorate of Pollution - see Sections 3.2.3, 3.3.2 and also, for experience in Oxford, Section 5.2.2).

In the absence of a statutory duty, approaches to ambient air quality monitoring evolved independently in each local authority area, reflected by the wide variety of approaches within the thirteen authorities involved in the survey. This chapter will look at the dimensions and extent of this variation, in order to show that the approach to monitoring in any particular authority is affected by:

- historical sources of pollution in the district (Section 6.4), i.e. physical emergence (see Section 3.4.2);
- local political factors and priorities (Section 6.5), i.e. perceptual and hierarchical factors (see Sections 3.4.5 and 2.4);
- the attitudes and concerns of individual staff members (Section 6.5), i.e. perceptual factors (see Section 3.4.5) working within
- financial and resource constraints dictated by the local electoral process (Section 6.5), i.e. hierarchical factors (see Section 2.4), and
- availability and cost of monitoring technology (Section 6.5), i.e. technological factors (see Section 4.3.2).

Table 6.6 gives some further factual information about the authorities involved for the time of the survey (June 1994). (Source: The Municipal Yearbook, 1995).

The authorities vary in the balance between rural and urban areas. The four southernmost authorities, Three Rivers, Watford, Hertsmere and Broxbourne may be considered the northern limits of Greater London. Luton is an urban / industrial borough, with a history of car manufacture. Bedford Borough, although dominated by the urban / industrial conurbation of Bedford and Kempston, also includes a large rural area. Stevenage is an exclusively urban area, although with no heavy industry. St Albans and Dacorum, while each based on a particular urban area (Hemel Hempstead in the case of Dacorum) also include more rural areas. Mid Beds and South Beds, while predominantly rural, are significantly affected by the brickworks and landfill areas in the Marston Vale (see below), while South Beds also contains the industrial area of Dunstable, as is reflected in the high number of prescribed processes (see Figure 6.5 below). The remaining districts, North Herts and East Herts, are predominantly rural with smaller towns and no heavy industry.

A significant feature is proximity to the major motorways and trunk roads. The combined corridors of the M1, A1, M25 and M11 motorways cover a considerable proportion of both the land area and the resident population of the region.

Table 6.6: The Local Authorities of Bedfordshire and Hertfordshire, 1994

LA Code	Authority	Population	Area (hectares)	Urban / rural	Political composition
BED	Bedford	133692	47575	Urban / rural mixed	HL
BRO	Broxbourne	88600	5225	Urban - Outer London	C
DAC	Dacorum	133000	21020	Urban / rural mixed	C
EHE	East Herts	120700	47662	Mainly rural	C
HER	Hertsmere	87800	9800	Urban - Outer London	C
LUT	Luton	171400	4336	Urban - industrial	L
MBE	Mid Beds	114800	50351	Mainly rural with some industry	C
NHE	North Herts	113300	37556	Mainly rural	HC
SBE	South Beds	110200	21183	Mainly rural with some industry	C
STA	St Albans	129600	16129	Urban / rural mixed	HD
STE	Stevenage	75000	2606	Urban - light industry	L
THR	Three Rivers	80500	8733	Urban - Outer London	HC/L
WAT	Watford	75800	2144	Urban - Outer London	L
WEL	Welwyn/Hatfield	91900	12765	Urban - light industry	HL

C = Conservative controlled

L = Labour controlled

HC = Hung council with Conservatives as largest party

HL = Hung council with Labour as largest party

HD = Hung council with Liberal Democrats as largest party

HC/L = Hung council with Conservatives and Labour as equal largest parties

6.4 Air Quality Monitoring and Pollution Sources Within Herts and Beds

6.4.1 Pollution Sources

Pollution sources mentioned by the respondents in the course of the interviews are shown in Figure 6.3. A more detailed breakdown of which sources were mentioned by authority is given in Table 6.7.

Questions about point sources of pollution were answered mainly in terms of prescribed processes (see Section 3.2.3), which were felt by all the authorities to be well controlled, or to constitute only localised nuisances.

> *"I don't think we've got anything air pollution wise, at all other than localised nuisance problems"* (EH3, 88-89).

> *"We do have specific problems in specific areas but those are more on the nuisance front, and hopefully most of those will be addressed once I get the authorisations* [for the prescribed processes] *out"* (EH2,363-365).

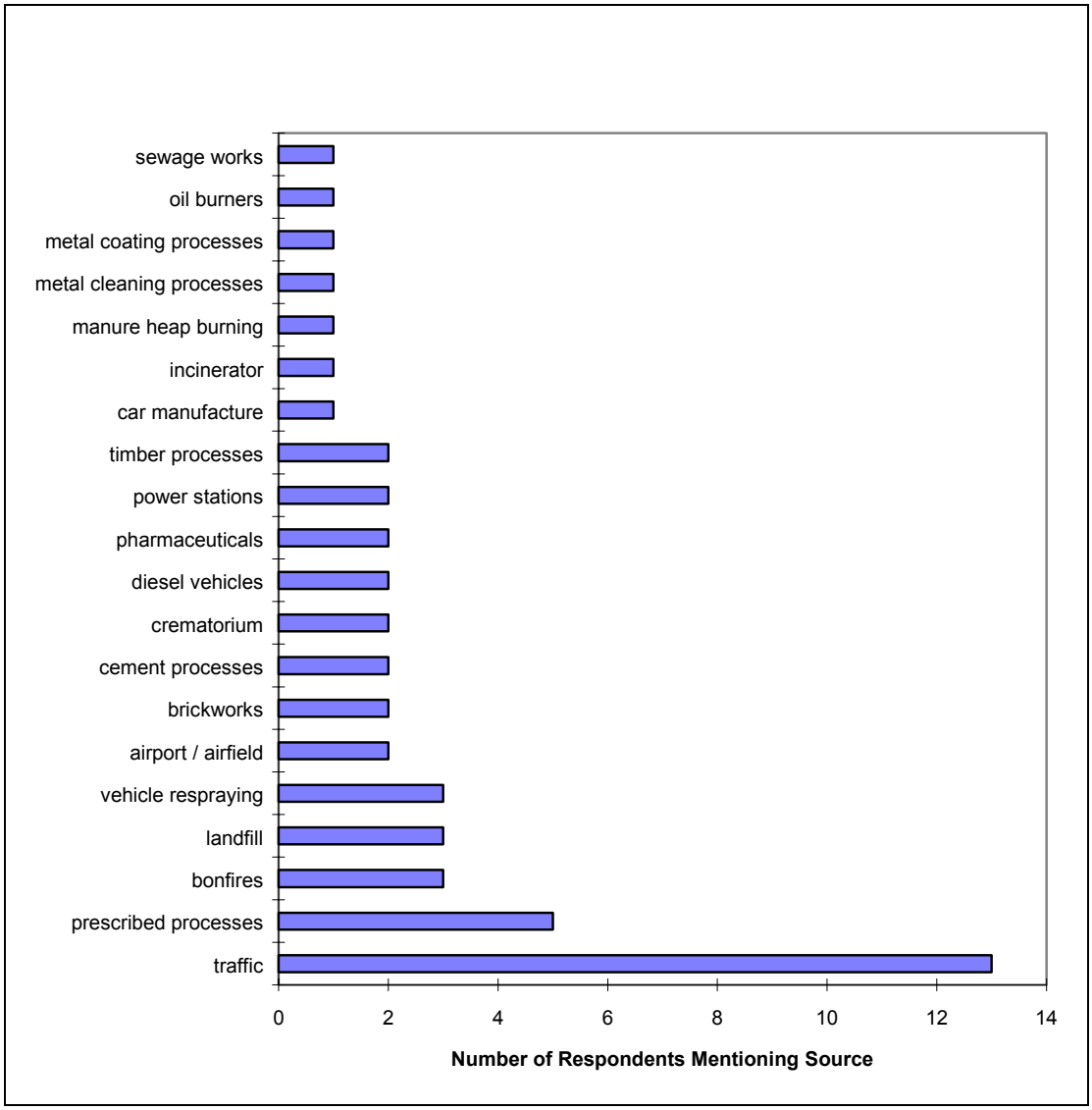


Figure 6.3: Pollution Sources Mentioned During Interviews

Table 6.7 shows which pollution sources were mentioned by which authorities during the course of the interviews. Figure 6.4 compares the number of pollution sources mentioned in the interviews and the number of prescribed processes for which each authority has responsibility. (Note: Data is not complete because no interview was carried out for Broxborne, and no information on prescribed processes was provided by Hertsmere.)

Interestingly, as can be seen from Figure 6.4, respondents in three authorities with relatively low numbers of prescribed processes (Three Rivers, Watford and Welwyn and Hatfield), mentioned a high number of individual point sources, suggesting that the individual respondents perceived those processes for which they had responsibility as important. In areas with a higher number of individual processes, such as Luton and South Beds, individual point sources were not identified to such an extent.

Table 6.7: Pollution Sources Mentioned by Local Authority

Source	BED	DAC	EHE	HER	LUT	MBE	NHE	SBE	STA	STE	THR	WAT	WEL	Total
airport / airfield					1							1		2
bonfires					1			1				1		3
brickworks	1					1								2
car manufacture					1									1
cement processes											1		1	2
crematorium					1						1			2
diesel vehicles					1							1		2
incinerator													1	1
landfill	1							1				1		3
manure heap burning								1						1
metal cleaning processes													1	1
metal coating processes													1	1
oil burners											1			1
pharmaceuticals			1										1	2
power stations	1		1											2
prescribed processes		1					1	1	1			1		5
sewage works								1						1
timber processes											1		1	2
traffic	1	1	1	1	1	1	1	1	1	1	1	1	1	13
vehicle respraying		1									1		1	3
Total sources mentioned	4	3	3	1	6	2	2	6	2	1	6	6	8	50

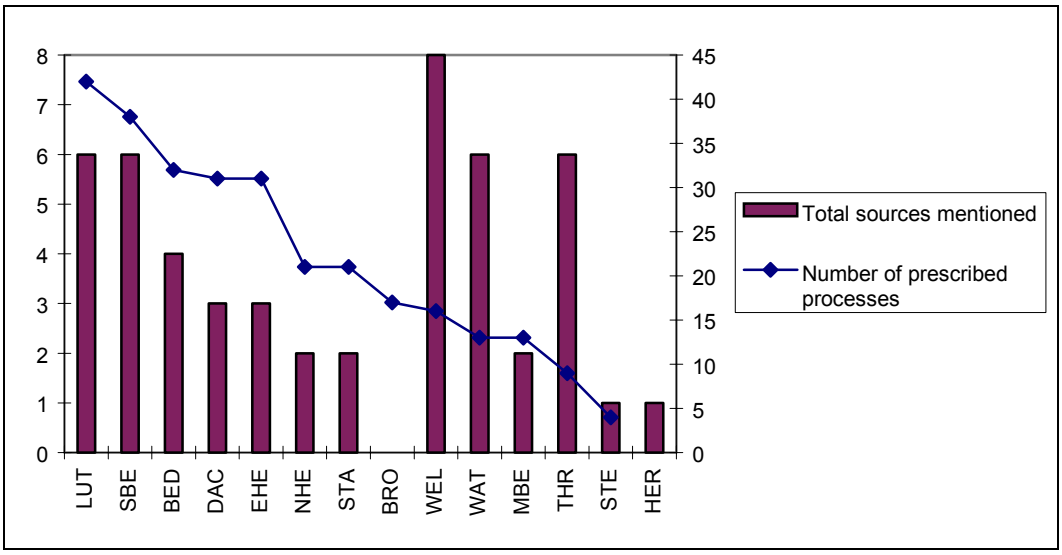


Figure 6.4: Prescribed Processes and Sources Mentioned by Local Authority

The most significant point source mentioned was the brickworks in the Marston Vale, affecting Bedford Borough and Mid Beds District (BED, 44-45; MBE, 104).

Current and former land fill sites give rise to methane and odour nuisance, and are monitored by Bedford, South Beds and Watford (BED, 141; SBE, 26; WAT, 628), although this is highly localised and not regarded as an ambient air quality problem, but as a contaminated land problem.

Unauthorised burning of rubbish, both in terms of domestic bonfires, and on a larger scale, as carried out by farmers, was mentioned by several authorities (HER, 353; LUT, 301; EH12, 35; NHE, 186; SBE, 85; STE, 264; THR, 186). While this may seem a relatively minor problem, it gives rise to a large proportion of nuisance

complaints from the public, and the health implications have not been fully explored. The possibility that garden bonfires might produce carcinogenic emissions such as polynuclear aromatic hydrocarbons (PAHs) was suggested by one respondent and the comment was made that far more complaints are received from the public about garden bonfires than about road vehicles (EH6, 300-314).

Traffic is overwhelmingly the main source of air pollution which concerns the authorities involved in the survey. It was mentioned by all authorities as the single most important source of ambient air pollution in their districts (see Figure 6.3).

The main routes through the region include the M1, the M25, the A1(M), the M11 (mainly in Essex, but having an impact on East Herts), and the A10. As is clear from the maps (see Figures 6.1 and 6.2), the combined corridors of these motorways cover a considerable proportion of both the land area and the resident population of the region. Proposals to widen the M1, M25 and A1(M) had recently caused concerns among the local authorities affected (see Section 6.10).

In Hertsmere, the opening of the M25 was identified as having changed the industrial base of the district, and hence the balance of industrial to traffic related sources of pollution:

> *"... the general trend has been to move out of this district to further afield, and to develop industrial sites into distribution depots here, because of the situation of Hertsmere in relation to the road network"* (HER, 97-101).

In addition to the main through routes, in Bedford, East Herts and North Herts concern was expressed about traffic pollution in the main urban centres, where levels are likely to be high because of traffic congestion, and large numbers of people are exposed. In Bedford, problems were attributed to the lack of a by pass (BED, 277), and in East Herts, NO_x monitoring data had been used by pressure groups of local residents campaigning for a by-pass for High Cross, where the A10 is at present single-lane (EHE, 134).

6.4.2 Air Quality Monitoring

Monitoring of different pollutants carried out by the authorities involved in the survey is shown in Table 6.8. As ambient air quality monitoring is not a statutory duty for local authorities, approaches have evolved independently in each district.

All fourteen districts are involved in a national ten-year nitrogen dioxide survey, involving diffusion tubes, organised by NETCEN[6] (formerly Warren Springs Laboratory). In some cases, as can be seen from the interviews (below), this was seen by the environmental health staff as a way of introducing monitoring to the council.

Bedford (and to a lesser extent Mid-Beds) have a history of monitoring sulphur dioxide and fluorine in relation to the brickworks. However, as the industry has been declining, it is no longer considered to be a major problem, a view reinforced by the results of monitoring for SO_2 and fluorine by the two authorities affected. Sulphur dioxide and smoke are monitored by St Albans as part of the National Smoke and Sulphur Dioxide Survey.

[6] The National Environmental Technology Centre

Table 6.8: Monitoring Carried Out By the Authorities at the Time of the Survey (June 1994)

Authority	Ben[7]	CH_4[8]	CO[9]	Fl[10]	NO_2[11]	NO_x[12]	O_3[13]	S&S[14]	SO_2[15]	VOC[16]
Bedford				2	8		10	2		5
Broxbourne					4					
Dacorum					26		1			
East Herts					10					
Hertsmere					9					
Luton	6		1		37		6	1		
Mid Beds					5			1	4	
North Herts					4					
South Beds		4			7					
St Albans					12			1		
Stevenage					10					
Three Rivers					4					
Watford					7	1				
Welwyn/Hatfield					9					

At the time of the survey, the only authority using continuous real-time monitoring equipment (for NO_x and ozone) was Dacorum, although Watford were in the process of selecting and purchasing continuous monitoring equipment for NO_2, and expected to have a system in place by January 1995.

Ozone monitoring was carried out in Bedford in association with NETCEN over the summers of 1992, 1993 and 1994. At the time of the survey, a fixed term (12 week) survey of ozone, using diffusion tubes at six locations, was being carried out by Luton.

Both Luton and Bedford councils were involved in pilot studies to monitor VOCs (volatile organic compounds). Luton had initiated an extensive programme of monitoring including nitrogen dioxide diffusion tubes, carbon monoxide, benzene and smoke and SO_2 as well as ozone and VOCs, in relation to the widening of the M1.

Bedford Borough have commissioned studies of ambient air methane levels in the Marston Vale, carried out by Cranfield University, and identification of methane emitting sites is continuing. South Beds District monitor for methane at four

[7] Benzene
[8] Methane
[9] Carbon monoxide
[10] Fluorine
[11] Nitrogen dioxide
[12] Nitrogen oxides
[13] Ozone
[14] Smoke and sulphur dioxide
[15] Sulphur dioxide
[16] Volatile organic compounds

locations, in relation to land-fill sites. Watford Borough monitor for methane and CO_2 at seven former landfill sites

6.5 Variations in Organisational Structure and Priorities

6.5.1 Commitment to Monitoring

Although environmental health is a statutory function of local authorities, the precise way in which it is handled is at the discretion of the individual authority (Allen, P, 1992; Municipal Year Book, 1995). Consequently, there is no consistent pattern of organisation for environmental health departments between the different districts. The way in which air quality monitoring is handled within environmental health, and the proportion of staff time allocated to it, reflects the priority accorded to ambient air quality within the authority, and dictates the ability of staff to fulfil this function.

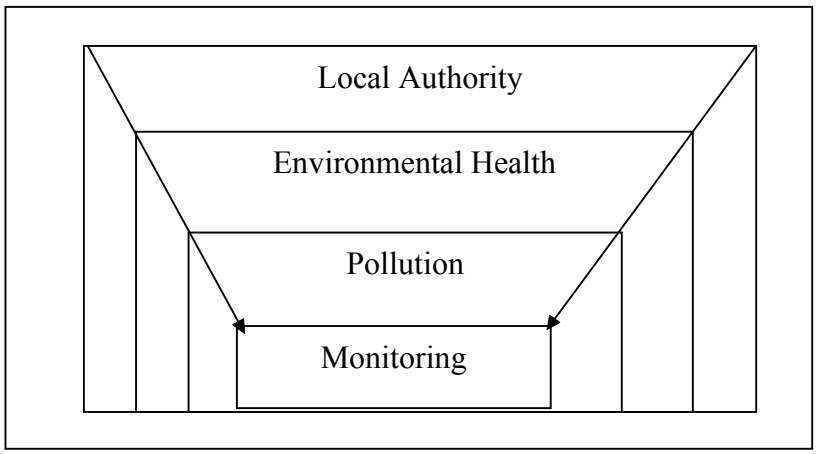


Figure 6.5: The Hierarchical Position of Air Quality Monitoring

In one authority, commitment to air quality monitoring is shown by the existence of a specific role, within a special "Environment Unit", under an environmental strategy officer, with a dedicated officer to deal with all the pollution issues, but not with complaints as EHOs are required to in other authorities (EH2, 596-606*)*.

This is in complete contrast with the situation at a neighbouring authority, where:

> *"[the authority] has cut the staffing to an absolute minimum, and most of that time is taken up with complaints. There hasn't been the sort of motivation ... it's been mainly doing what you have to do, which is dealing with complaints."* (EH3, 236-243).

The problem of having to spend time on other responsibilities, and the impact this has on monitoring work, was also mentioned at another authority:

> *"The problem with this council is that I don't only do this, I do every aspect of a district EHO's work as well ... [you have] to actually sit down and put your air pollution hat on instead of being able to concentrate on it all the time."* (EH5, 441-442; 447-448).

This difference in commitment has an impact on the effectiveness with which monitoring work is carried out:

"even if the members wanted something, they wouldn't be able to have it, because if you go out and do some monitoring, or whatever, then you come back and there's a stack of complaints and angry people because you haven't responded.." (EH3, 276-281).

"we don't have anybody, say, in my position [Principal Environmental Health Officer]*, who's looking to see how we're going to do these things. I have to be out there doing these things as well."* (EH3, 315-316).

"It's not a case of not being a priority, it's just a case of, there are a lot of reactive things that you just have to do. If somebody's drain blocks ... then everything else gets left and that's what you have to go and do." (EH5, 465-468).

6.5.2 Constraints on Monitoring

Respondents were asked what prevented them from doing more monitoring. The frequencies of phrases mentioning different types of constraint on monitoring are shown in Table 6.9 and Figure 6.6.

Table 6.9: Constraints Mentioned by Local Authority

Constraint	BED	DAC	EHE	HER	LUT	MBE	NHE	SBE	STE	THR	WAT	WEL	Total
staff time	17	6	5	56	2	6	4	1			6	13	116
financial	8	3	4	14	34		2	23	1	8	11	6	114
availability of technology		3		5	38								46
expertise		1		16	3		1					10	31
other priorities				18								12	30
usefulness			1	11			3	1	7		3		26
attitudes of councillors				7	4			11					22
attitudes of senior staff								9					9
availability of related data					4								4
manageability		2											2

Financial constraints relate both to costs of equipment and to the cost of employing staff to carry out the work involved. The different types of constraint are thus inter-related, as financial constraints, and the pressure of other priorities, lead to understating and an inability to carry out effective monitoring and make best use of the data generated.

The constraints on some authorities lead to a vicious circle of low staff morale, high turnover and lack of continuity:

"that was part of the purpose of Paul's post originally, was the fact that we'd be able to do some monitoring, but the trouble is that the complaints have risen to such an extent that he's not been able to do that either. So, they're going to have to really rethink if they want monitoring." (EH3, 454-459).

"the thing is, if you have a science graduate coming in their expectations will be, 'oh I'm going to do this and that monitoring' but in actuality they'll be doing complaint work with garden bonfires and noise complaints with barking dogs!" (EH3, 473-476).

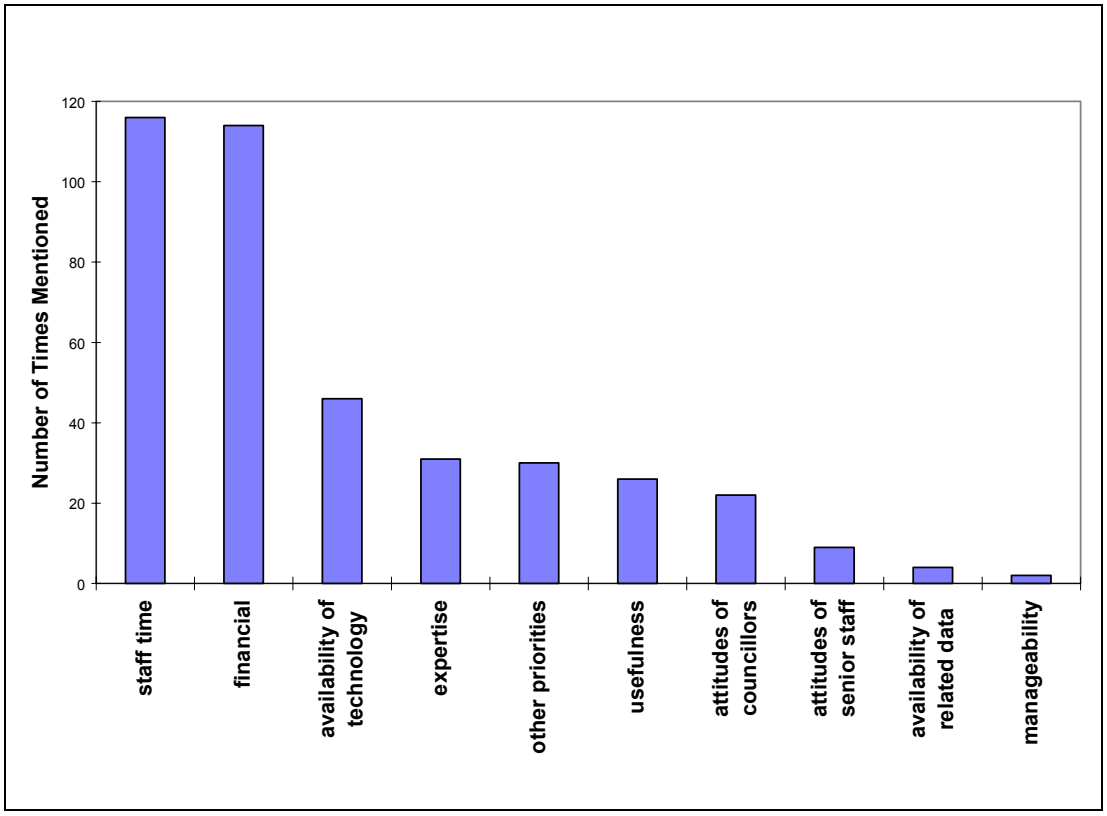


Figure 6.6: Frequencies of Constraints Mentioned in Interviews

Cost and resource constraints were universally seen as the most significant factors limiting the amount and type of monitoring carried out (Table 6.9 and Figure 6.6). The importance of getting maximum value for the money and time invested was frequently stressed:

> *"If we're going to extend it, we want to make sure that what we do gets the most information for the effort put into it, if you like."* (EH7, 160-161).

> *" ... and I would be quite happy to devote more time than that, but I would need to be satisfied that the monitoring we're carrying out is valid and meaningful."* (EH9, 123-125).

6.5.3 Technological Constraints

A further constraint on monitoring is the availability of suitable technology at an affordable price (see Section 4.3.2):

> *"That's the other thing that you've got to take account of, that there's actually a method. That's one reason why people do a lot of NO2 tubes, because they're available, lots of people do the supply and analysis of them."* (EH6, 415-418).

6.5.4 Financial Constraints

Provision of funding for monitoring must be seen within a wider context of each council as a whole, and the political process of setting priorities for the council:

> *" if we come up with something, it's just trying to find somebody that'll put up the money ... If we can get the councillors to think it's necessary and worthwhile, ie) it's worth the cost, then we may get to do it, but until we overcome ... the councillors, we haven't got a hope."* (EH13, 196-199;139-140).

Although, from an environmental health perspective, council finances may be seen as a constraint on monitoring work there is also recognition of the wider context in which the council as a whole must operate. In one authority, a recent improvement in finances for the authority as a whole had enabled them to join the WSL NOx monitoring network in its second year although conditions had prevented them from joining when it was first started (EH1, 60-69). Another issue mentioned by some authorities was that the sums involved are not particularly large in terms of overall council budgets, and that a monitoring system, once in place, is perhaps less likely to suffer from funding cuts than other schemes (EH11, 239-240; EH6, 713-728). Despite the emphasis on financial constraints, political will is also important, and the greatest commitment to monitoring is not necessarily to be found in the richest authorities:

> *"I have to bear in mind the budgetary constraints that I have and the budgetary constraints that ... the council as a whole have. ... [This] was one of only something like four authorities in the whole country that were capped last year, we had something like a 4% cut in our SSA*[17]*, and our neighbours ... had a 26% increase.* (EH2, 448-453*)."Many things in the council were actually cut ... and AQM has kept the same budget. It's obviously seen as important by the members and officers and hence that reflects how important it is to the citizens of Watford."* (EH2, 492-495).

6.5.5 Hierarchical Context

The wider context is one in which ambient air quality monitoring, as a non-statutory duty, may be squeezed out by other environmental health functions which have a statutory requirement, or are reactive to the public:

> *"Although we don't all like to be told what to do, at the same time, if there was a statutory duty to monitor, it would help committee-wise to get time and money to do things."* (EH7, 170-172).

> *"I think, the thing is, local government for years has got to monitor things, but they've done nothing with it, have they? It hasn't served any purpose."* (EH3, 612-615).

> *"I think it's probably understandable, because their primary function is statutory, and they've never made any bones that they're environmental scientists. They've been given those extra functions, so I think it's been difficult for a lot of local authorities, and now they're changing, taking on scientific personnel for that purpose, but to date it's been difficult."* (EH3, 619-626).

[17] Standard Spending Assessment, the basis on which the amount of central government funds allocated to the local authority is calculated

6.6 Spatiality - The Need For, And Difficulties Of, Regional Management Of Air Quality

Because of the trans-boundary nature of air pollution, all districts are subject to influences from outside their own area and there is little value in individual districts monitoring in isolation. Pollution may be regarded as a regional, national or even international problem, rather than one which an individual local authority has the power to do something about. A regional strategy is needed in order to take account of, and to measure, the geographical dispersal of pollutants.

This is particularly true in the case of tropospheric ozone. Ozone (O_3) is a naturally occurring gas produced from the interaction of two groups of gases, nitrous oxides (NO_x), and volatile organic compounds (VOCs), in the presence of sunlight. The detailed chemical reactions involved are extremely complex. However, in simple terms, NO_x is involved in both the generation of ozone, and also in the absorption of ozone and conversion back into nitrogen dioxide, dependent on various factors, including sunlight, wind conditions, and levels of VOCs (Chameides, 1994). This has implications for the local management of ozone. Although high levels of ozone may occur in heavily trafficked areas in the short-term, in the longer term ozone tends either to be absorbed and converted back to NO_x, or transported downwind to areas of lower nitrogen dioxide, where levels may be expected to be higher. The implication of this for air quality management is that strategies which are successful at curbing pollution in the immediate area may create problems for locations downwind (Chameides, 1994).

The survey showed that there was widespread recognition of this problem, and of the consequent need for local authorities to develop a regional air quality management strategy. Nine of the thirteen authorities mentioned regional, national, global or trans-boundary issues (see Table 6.10).

Table 6.10: References to Regional, National and Global Impacts

Note	BED	DAC	EHE	HER	LUT	EH12	NHE	SBE	STA	STE	THR	WAT	WEL
global impacts												14	
national policy				7	26					16		19	
regional strategy		7	39	3	4	22	13					5	6
trans-boundary pollution		3	6	3	1	18							

> *"I feel that that's important, that we look at it not just as East Herts, but as an area, and pool the resources... rather than us going our own way ... you can waste an awful lot of money going off and monitoring ... on NO2, we're very similar to other towns, ozone would be more relevant"* (EH10, 163-166; 198-201).
>
> *"... because there's no point in .... Broxbourne or Dacorum or North Beds monitoring in isolation, because everywhere has influences from outside."* (EH12, 266-268).
>
> *"if it could be justified as part of a regional survey, it would be a good bargaining tool to get more resources."* (EH7, 194-195).

However, despite this, the survey also revealed considerable cynicism about the political viability of authorities pooling resources for a regional benefit:

> *"One of the things people have been talking about in the last year, ozone would be monitored in one area, and would be paid for by some neighbouring areas. The thing is, that would be extremely difficult to sell to councillors, because councillors , if you're talking about monitoring in a local authority area, they want it doing in their ward, they want to know why you're not doing it in their ward rather than someone else's ...so to get councillors to agree to pay for monitoring to be done in another local authority's area would be incredibly difficult, even if there were very good scientific reasons for doing it."* EH6, 531-538; 540-543).

Each authority faces its own set of constraints and priorities (See Section 6.5.2). In some authorities, air quality was seen as basically good, so that there was no perceived need for monitoring. Differences in priorities between districts, dictated partly by variations in perceptions of the nature of the problem locally, lead to differences in willingness to commit resources. This is exacerbated by the fact that pollution generated in one district may only become a problem elsewhere, so that the authority in the originating district has no incentive to tackle the problem, while the authority in the receiving district is powerless to do anything about it. Local priorities are affected by factors outside of those directly related to air quality management, e.g. media representation of the problem, and local politics.

In summary, despite the existence of sound scientific and management reasons for strategic regional management of air quality, differences in perception between the constituent authorities suggest the potential for considerable difficulties in developing and implementing such a strategy. This issue of a mismatch between organisational boundaries and the trans-boundary nature of the pollution issue will be returned to in Chapter Nine.

6.7 Objective Measurement and Perception

Emphasis within environmental health is on measurement of ambient pollution levels and accumulation of data. The acquisition and accumulation of data becomes an end in itself, dictating that the main factors to be considered are technical considerations concerning the best way of handling the data, ensuring calibration and comparability, deciding on the most appropriate locations for monitoring sites etc.

"Use of data" was the concept most frequently mentioned in the interviews (see Table 6.5), mentioned 953 times in 5087 responses (18.7%). Concern about the best way to use the data focuses on two aspects, the use of the data to establish causal relationships (see Section 6.8), and provision of information to the public. As in the Oxford pilot study (see Section 5.5), this second aspect is widely seen as the most important reason for collecting the data (see Figure 6.7).

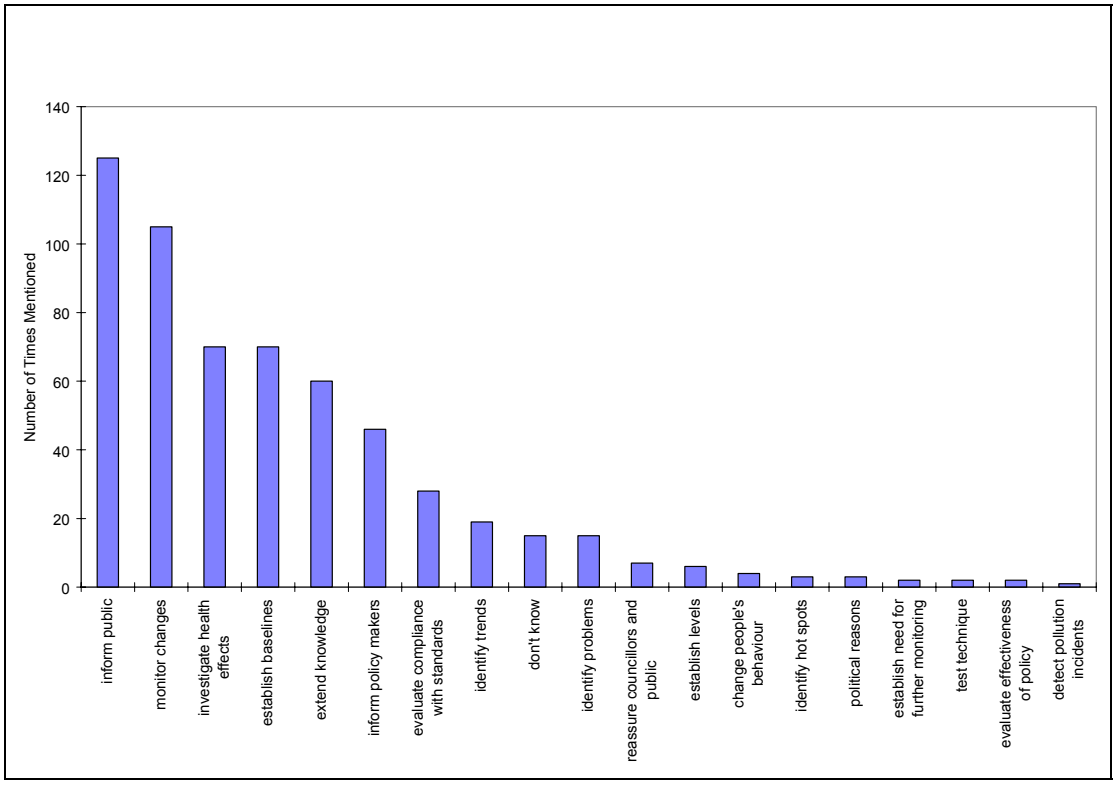


Figure 6.7: Reasons for Monitoring

The government's White Paper, "Air Quality: Meeting the Challenge", published in 1995, stated that:

> *"The Government has .. reviewed its public information arrangements in the light of its proposals for a new framework of air quality standards... The key aims of the proposals are to make air quality information as accessible as possible to the public; to provide a consistent framework for describing levels of air pollution, related directly to the new standards, and to action which members of the public may be advised to take;* ***and to promote provision of local air quality information to reinforce local air quality management****.*
>
> *An important part of the Government information service is provision of advice at different levels of pollution, and in particular, when air quality becomes 'poor' or 'very poor' according to the current system. ...* ***The Government will be considering how to improve the effectiveness of information, to target advice and to encourage more people to take appropriate action in episodes."*** (DOE, 1995, Part Six: Monitoring and Public Information, p30, emphasis added.)

Recent legislation also recognises the importance of disseminating air quality information. The 1995 Environment Act (see Section 3.3.3) refers to the need for regulations to make provision:

> *"for or in connection with the communication to the public of information relating to quality for the time being, or likely future quality, of the air."* (Environment Act, 1995, Part IV, Section 87.2(k), p111).

The importance attached to passing on monitoring information in the above official statements is reflected in the responses of environmental health staff :

> *"we're trying to get over, to get it outside more, because I really don't see the value of doing the work if we're not going to ... there's a lot of public concern about air pollution, and we haven't got the answers to give... the public [about] what is happening here."* (EH11, 263-266).

> *"I think ... probably a lot of what's being done at the moment [is that] people are sitting back and saying well, we're doing monitoring, and that's it, because they don't know where to take it beyond that."* (EH3, 530-534).

> *"it seems important, doesn't it, if you are going to monitor, to actually use the data at the end of it ... and also we would like to be able to pass that on to the public. I think it's important to have local information because then people can relate it to their situation."* (EH7,142-143; 162; 49-50).

However, this was also widely seen as a weakness in present systems, since the information is not timely enough, and also because of the scientific uncertainties involved in relating pollution data and health data, and the time and effort involved in providing meaningful information to the public:

> *"Because it's historic and it's a long-term average, you can't use it for any real-time warning of the population"* (EH6, 88-89).

> *"We would like someone to give us an idea of a bit more research into health effects and actually what the consequence of that amount of NOx is or can be"* (EH5, 411-413).

> *"... when WSL was approached, they said we could use the data, but you couldn't relate it to anything, so you're left wondering why you're doing it"* (EH7, 18-20).

> *"[we hardly] have time to do the monitoring, let alone finding the time to do the other end of it"* (EH11, 120-121).

Efforts are concentrated on the most effective ways of measuring concentrations, the best technological equipment, the best locations for monitors, etc. With regard to informing the public, efforts are devoted to the best ways of making the information available, again with an emphasis on technology:

> *"there is at the moment a monitor ready for installation in the foyer ... and the public will be able to look at the real-time data and see which DOE banding the air quality falls within"* (EH7, 170-174).

> *"the ultimate aim ... is to make the data as freely accessible as possible, and we might be able to achieve this by utilising the lines at the bottom of the screen on [the local cable TV channel], where Ceefax operates on ordinary TV ... we hope to have an interactive VDU in the One Stop Shop, so that people who are computer literate, unfortunately at the moment, will be able to access the info"* (EH2, 269-277).

In general, official and local authority concern has been concentrated on the provision of the information, with little attention paid to the potential uptake, relevance and impact on individual behaviour. Some of the environmental health staff were aware

both of this difficulty and of the dangers of providing data and raising levels of awareness without being able to give any further advice:

> *"It's all very well ... giving people the figures and let them make their own minds up, [they're then] asking [us]what they should do ... When you don't get convincing advice, then the public start getting worried and the whole thing snowballs, and you get people with fears that perhaps they shouldn't have."* (EH5, 362-369).

> *"you've got to be careful raising profiles, though, members aren't necessarily wanting to hear that the air quality in their town is poor"* (EH9, 143-146).

> *"Originally we had one or two quite high up politicians who were saying 'What if you show that the traffic pollution is serious, you'll stop people coming into the city centre, and spending their money in the shops.'"* (OX1, EHD2, 47-49).

One respondent identified the danger of a perceptual backlash:

> *"We would like someone to give us an idea of a bit more research into health effects ... otherwise, once the air pollution bubble bursts, everybody's perhaps not going to take it very seriously"* (EH5, 411-415).

This issue will be returned to in Chapters 8 and 9.

6.8 Scientific Uncertainty and Perceived Risk

The second major reason for monitoring revealed by the survey was the use of data to monitor changes occurring in the district, in order to reduce uncertainty (see Figure 6.7). In several districts, monitoring had been introduced in response to a specific change which it was anticipated could have an impact on air quality, for example, new road schemes, retail developments, or power station.

> *"I think it's very important in relation to particular processes or particular events, for example, the M1 widening, I think it's important to get some background levels, before it all starts, and then during, and then after. I think long-term monitoring, once you've identified the need ... is important ... so that you can see trends in the influence or effect of a process on an area, in order to detect whether the situation's changed."* (EH12, 238-245).

Where multiple perceptions of a particular issue co-exist with scientific uncertainty (see Section 2.6), data may be used as ammunition in arguing a particular case. Monitoring data had been used in this way by campaigners for a by-pass (EH10 134-135; 138-139). Another example of monitoring data being used to contribute to a debate of this kind is illustrated by the disputes between the Department of Transport Motorway Widening Unit and several district authorities about the widening of motorways in the region.

In Luton, Mid Beds and South Beds, concern centred on the M1 and plans for widening it. Luton had installed nitrogen dioxide diffusion tubes in an attempt to establish what the impact of the widening would be:

> *"the Motorway Widening Unit have had work carried out, both modelling and also monitoring, which they say indicates that there isn't a problem,*

> *and in the future the level of air pollution associated with the motorway will decrease ... in the past, predictions about traffic flows and environmental effects associated with traffic have been shown to be wildly inaccurate, that's from figures put out by the DTp over the years, they keep having to reassess their estimates of traffic flows upwards. The DTp are saying that, because of the improvements in vehicle technology, the total emissions will reduce with time, but we're saying, well, they might reduce from a particular vehicle, but if the total number of vehicle miles travelled increases, then the total emissions might increase. So basically, if they're so confident there isn't a problem, or won't be a problem from the motorway, why don't they implement real-time monitoring now and during and after the motorway's widened, and then ... we'll all know whether the air pollution aspects are something to worry about or not. The widening unit, though, don't seem to agree with our argument"* (LUT 100-124)

These concerns were also echoed by Mid Beds:

> *"What we'd like is to have one continuous monitoring station in Luton and one in rural Mid Beds, so that they could actually see what contribution the motorway makes to the Luton air quality, because the consultants for the DTP are always saying there are other sources in Luton which are just as polluting as the M1, which is perfectly true, but nobody's in a position to say what contribution the M1 makes now, let alone whether the widening's going to make it better in future and we reckon unless they have one in Luton and one in a rural area, they're not going to be able to do that"* (MBE, 123-133)

Similar disputes had also taken place between the Motorway Widening Unit and Three Rivers District, who were trying to persuade the DTp to put a continuous monitoring station at Junction 19 on the M25, to monitor the effects of widening. The proximity of the M25 was also a cause of concern for Watford, Dacorum and Hertsmere.

In Mid Beds, North Herts, Stevenage and Welwyn and Hatfield, the A1 was mentioned as a major source, although plans to widen the A1(M) had previously been abandoned by the DTp. In Welwyn and Hatfield, an alternative perspective on the issue of widening was put forward:

> *" ... probably the greatest pollution problem with the A1(M) is with it there at the moment, having two lanes with loads of idling cars, whereas you could have greater throughput of traffic and cars going at higher speeds giving out less pollutants if you had four lanes"* (WEL 371-375).

6.9 Relationships with Other Levels of the Hierarchy and Other Constituencies: the Formulation and Implementation of Policy

6.9.1 Relationship with Central Government

The discussion in the previous Section about the role of air quality monitoring as a means of generating "objective" evidence about the impact of motorway traffic, for use as ammunition in disputes with the Department of Transport Motorway Widening Unit illustrates difficulties in the relationship between the local authorities and central

government. In general, the nature or, rather, the perceived lack, of national transport policy, was seen as a major problem in the management of air quality:

> *"... we need to look at a national strategy for transportation, rather than leaving it to individual local authorities to deal with it"* (EH10, 225-226).
>
> *"...the government's lack of an integrated transport policy impacts on us quite heavily"* (EH2, 378-379).

However, as will be discussed further in Chapter 9, the local authorities are not directly responsible to the Department of Transport, but to the Department of the Environment. The central government's ambivalent attitude towards air quality management - effectively passing responsibility for local air quality to local authorities, without providing adequate guidance or finance (see Section 3.3.3 and Cannibal, Lemon and Longhurst, 1996) - is also a cause for concern:

> *"What we do has to be tailored within our existing staff allocation and the budget. Priority would be given to work with a strict legislative requirement ... There is no legal requirement as yet that we do any environmental monitoring other under than the Clean Air Act"* (EH11, 170-172; 178-180).
>
> *"although we don't all like to be told what to do, at the same time, if there was a statutory duty to monitor it would help committee-wise to get time and money to do things"* (EH7, 170-172).

6.9.2 The Local Context

The last comment in the previous section draws attention to the fact that the local authorities are not only responsible to central government, but also exist within a local political context, and are subject to pressures from both sides (Jones, 1985). As will be discussed further in Chapter 9, local authority officers are involved in a complex web of relationships with both elected members and residents, particularly in the case of the environmental health department, whose role in reacting to complaints brings them into direct contact with the public:

> *"We are very much the face of the council that a lot of our residents see, apart from the poll tax department, or the housing department, we're the other section that's always out there, at committees or public meetings or gatherings or whatever, in the schools and so on."* (EH2, 612-615).
>
> *"because it's like the public relations aspect as well, we have a duty to investigate complaints, but also the complainers can see that the council is working for them"* (EH7, 187-189).

Given the variation in levels of monitoring between different districts, the survey investigated the reasons why monitoring had been introduced in each case (Figure 6.7). When the respondents were asked why monitoring had originally been started in their district, in several cases they were uncertain, because staff changes had occurred since monitoring had been introduced, and they had merely inherited an existing situation (see references to staff morale and turnover in Section 6.5.2).

In general, monitoring had been introduced at the initiative of the officers, sometimes in response to queries from the public, elected members or pressure groups, although in one case, where the officer involved was clear in his belief that the air quality in his

area was good, and there was no need for monitoring, the initiative had come solely from the councillors. However, although the initiative came mainly from officers, rising levels of concern among both councillors and members of the public were frequently cited as justification for the higher profile monitoring has received in recent years:

> *"There's a lot of public concern about air pollution and we haven't got the answers to give them, members of the public, [about] what is happening here."* (EH11, 263-266).

> *"FOE*[18] *came to us and said 'Can you do some monitoring for the by pass?' and if people continue to come to us we'll certainly listen to what they've got to say."* (EH7, 54-58).

> *"A lot of this is in response to what goes on in the papers ... there's lots of people phoning and asking if we're doing such and such."* (EH13, 56-58).

> *"If a councillor gets a bee in his bonnet about something - the general public, there's very few complaints, apart from nuisance complaints."* (EH13, 99-101).

> *"I think we have a fair say, let's put it that way, certainly the Chief EHO has a fair say in what we do, but again it will take the members' involvement to say something like 'we would like you to look into air pollution' and we would sort out the nuts and bolts."* (EH5, 220-224).

Bedford was the only authority with a long history of ambient air quality monitoring (in relation to the brickworks - see Section 6.4.1). In most cases, the national NO2 diffusion tube survey, initiated by WSL in 1993 (see Section 3.3.2), had been seen by the officers as a "cheap and cheerful" introduction to monitoring, a way of persuading the members that it was worth initiating monitoring, and often this was still the only monitoring being carried out:

> *"We felt we ought to do something, and as we hadn't got any money to do anything, that was the cheap option."* (EH3, 39-41).

> *"I think it was because they didn't have any information at all, and because it was a national survey, the information was going to be useful."* (EH7, 90-92).

> *"Committee and council were against doing sampling, but fortunately it coincided with Bedfordshire Environment Week, and all the Beds councils were sticking out NOx tubes ... so we jumped on the bandwagon, and said 'if they're doing it, we've got to do it', and we just carried it on from there, really, until the DTI stuff [WSL NOx survey] came in".* (EH13, 122-128).

Comments such as *"We felt we ought to do something"* and *"so we jumped on the bandwagon"* suggest an atmosphere in which the value of air quality monitoring was entering the collective appreciative system and becoming accepted as a recognised function of local authorities. However, the precise implementation of this was subject to a process of individual negotiation in the separate local authorities. In some

[18] Friends of the Earth, an environmental pressure group

locations, changing attitudes towards monitoring were seen as having evolved from changes in policy towards the environment in general initiated some years earlier:

> *"In 1991, the council decided to have an environmental audit, which was done by Friends of the Earth. They established that we weren't doing any monitoring, [so] we went to WSL to see what they suggested."* (EH10, 102-105).

> *"About a year ago we were asked about environmental improvements, and started weighing up the cost of further monitoring, and what we might like to do, and it's likely that's going to be brought back out on the agenda again."* (EH5, 211-213).

In those cases where the political complexion of the council had recently changed, this was reflected in changes of attitude towards monitoring:

> *"We've now had a change in colour of leadership, which means we've got what is called an Environmental Strategy Committee which has just had its first meeting, so it's a bit difficult to tell where it's going to go."* (EH5, 207-210).

> *"There's never been any involvement of the members in that [monitoring] at all, they've never even shown any interest until recently. There's a glimmer of slightly more now ... there's been a political change here, as there has with a lot of authorities, and there's been more interest over the last few weeks, I would say, than there has been for years"* (EH3, 45-51).

Within an existing situation, individual members of environmental health staff may seek to introduce or increase commitment to monitoring. The extent to which they do this may be related to their own particular background, training and personal experience. One officer commented:

> *"I've got two asthmatic children, and I moved ... because of the pollution levels from quite a polluted area in Dagenham to Kent, because I knew that that's what caused it. My son was in hospital at less than two years of age, so I had to take some form of action."* (EH3, 506-511).

Historically, air quality monitoring has not been regarded as a significant environmental health function, and this is reflected in the training of environmental health officers, and the attitudes of some more senior members of the profession. Within the hierarchy, more senior officers may actively discourage functions which they do not regard as having high priority:

> *"To some extent the Assistant Director* [of Environmental Health] *puts a block on quite a few things that we try ... he tried to put a block on the Agenda 21 thing as well ... but we're under Community Services, so the Director of Community Services has overall responsibility."* (EH13, 149-155).

Within the council context, officers are expected to fulfil their duties within the remit and resources dictated by the political situation by elected members who are accountable to the public (see comments in Sections 6.5.1, 6.5.2 and 6.5.4). Statutory duties and finances are set by central government, constraining the ability of councils to set priorities (Jones,1985; Cannibal, Lemon and Longhurst, 1996). Resources are allocated to ambient air quality monitoring within a budgeting process within which

environmental health in turn must compete with other functions of the council (Section 6.5.1). In theory, the council officers are the professionals employed by the members and expected to provide expertise (Allen,P, 1992). However, air quality monitoring is not one of the traditional functions of environmental health, and hence in many cases the staff responsible do not have that expertise, and readily admit that this is so (see comments in Section 6.5.5, above). In some districts, officers have tried to take the initiative over monitoring, but have been constrained by lack of resources, which forces them to be reactive to public complaints and give priority to statutory functions (see comments in Section 6.5.1, above). In other cases, particularly where political changes have occurred, members have taken the initiative and have asked officers to look into monitoring (see comments above). In their role as "experts", officers may put proposals to the members, with varying degrees of success. Particularly in districts where senior officers are committed to monitoring, officers may not only influence members' decisions by provision of reports and information, but also indirectly through public opinion and the media, by issuing press releases, as has occurred, for example, in Bedford (Bedford on Sunday, 22/1/95 and 25/8/96. See also discussion of press releases by Oxford City Council in Section 5.7).

6.10 Conclusions

Emergent environmental systems arise in a context of overlapping hierarchical systems (Section 2.4), when changes in the physical environment (Section 3.4.2) lead to emergent, unpredictable impacts on human beings (Section 4.5.3), which are perceived variously as outcomes by individuals in multiple constituencies (Section 2.6 and Section 5.3), and which existing management structures and institutions are not able to deal with adequately (Section 2.5, Section 5.3).

Two main elements of this model are illustrated by the position of local authority air quality monitoring, as investigated in this chapter:

- air quality monitoring exists within a context of over-lapping hierarchies
- the role of air quality monitoring lies within the macro process of perceptual (and to a lesser extent) knowledge emergence

6.10.1 Over-lapping Hierarchies

The policy context in which this particular group of actors (environmental health officers) operate is one in which they are subject to pressures from both central government, which has chosen to rely substantially on local authorities to monitor local air quality, but without providing significant assistance or additional funding to permit them to do so, and the local residents (whose concerns will be considered in the next chapter) and their elected representatives.

Ambient air quality monitoring is a sub-function within a function (environmental health) of local authorities enmeshed within a hierarchical policy system (see Section 6.5). In any particular district the commitment to monitoring is dictated by priorities set through negotiation between officers and members (see Section 6.9), within constraints set by overall levels of resources and finances (Sections 6.5.2 and 6.5.4), and technical constraints set by the conditions of the district (Section 6.4), the availability of suitable technology (6.5.3) and the expertise of the officers (6.5.5).

6.10.2 Perceptual and Knowledge Emergence

The role of air quality monitoring may be located within the process of knowledge change and perceptual change described in Section 3.4. Monitoring is seen as a way of accumulating "hard" scientific evidence as a contribution to the process of identifying and understanding causal relationships. It is also integral to the process of perceptual emergence, both in the sense that changes in the collective appreciative system have led to its recognition as an issue of concern, as well as in contributing further to "raising the profile" of the issue of air quality.

However, the environmental health departments currently have no way of directly affecting the underlying physical system. Although they have some control over industrial sources of pollution, through the system of prescribed processes, the production of traffic pollution lies outside their jurisdiction . Their role is therefore confined to that of collecting information and passing it on to those who may be in a position to change the physical system, i.e. the transport planners, central government and local residents, whose concerns will be considered in the next chapter.

7 Spatial variations in public perceptions of air quality

"Never hope to find wisdom at the high colleges alone - consult old women, Gypsies, magicians, wanderers and all manner of peasant folk, and learn from them, for these have more knowledge about such things than all the high colleges."

Paracelsus (1493 - 1541).

7.1 Introduction

From Chapters 5 and 6, it is clear that the local authorities are concerned about air quality, and see traffic as the major influence on it (Section 6.4.1). Improving air quality is seen as dependent on modifying the behaviour of individual drivers and asthma sufferers, and providing air quality information is seen as crucial in achieving this:

> *"If you're trying to make progress, you've got to inform perception, people's perception and other groups' perception, and that means you've got to communicate with them, because there's such a lot of misconceptions about."* (OX4, EHD1, I, 326-330).

This reflects the role ascribed to perception in both the top-down conceptual model, described in Section 3.4, and the bottom-up conceptual model described in Section 4.5. The emergent system, as described in Chapter 2, has impacts which are characteristically diffuse, spread over many recipients in widely spread locations. In addition, these impacts are in part constructed by the perceptions of the individual recipients. Behaviour is influenced by perception, and so, in order to change behaviour (and consequently the physical system), it is thought necessary to change those perceptions, by accumulating information, investigating and demonstrating causal links between behaviours and outcomes, and making that information available to "the public".

However, as was pointed out in Section 4.5.3, although changing perceptions may be a necessary precondition for changing behaviour, it is by no means a precise instrument. The effectiveness of policies aimed at changing perceptions will depend on the receptivity of the individual to that change, the degree of congruence between the change and the recipient's appreciative system, and the ability of the recipient to change his or her behaviour in response to that change (Lemon and Naeem, 1990).

As was seen in Section 5.8, the pilot study revealed significant differences between the perceptions of the mothers and of the institutional actors in Oxford. The third major strand of fieldwork for the thesis was designed to investigate public perceptions of air quality and asthma, the ways in which those perceptions vary, the sources of information on which they are based, and the ways in which they affect behaviour. It consisted of a structured questionnaire survey of 300 households in 9 locations in and around Bedford. The survey was designed to build on both the interview survey of mothers which was included in the Oxford pilot study (see Chapter 5), and a previous survey of 280 households carried out in 1993 in the Marston Vale area, to the South of Bedford (Longhurst & Cousins, 1993). It was conducted during June July and August 1994, to overlap with the environmental health interviews (see Chapter 6),

and run concurrently with ozone monitoring carried out by NETCEN on behalf of Bedford Borough Council.

Questionnaire design and analysis were carried out by the author, but, because of the scale of the survey, a professional market research agency was employed to administer the survey. The survey was funded by Bedford Borough Council, through the Environmental Health Department.

Following the bottom-up conceptual model described in Section 4.5.3, the emphasis within the analysis is on the variation of perceptions within the survey, particularly with respect to spatiality (see Section 2.9), but also in relation to other factors which might affect individual appreciative systems, such as awareness of media reports and experience of respiratory problems (see Section 2.7). The overall aim of the analysis is to investigate what factors affect this variation in perception. In relation to the top-down conceptual model described in Section 4.5.2, the survey, like the survey of Environmental Health staff described in Chapter 6, provides a "snap-shot" of perceptions at a particular point in time. The two surveys together illustrate the lack of congruity between the perceptions of institutional actors and the public, ie the "institutional" and "individual" worlds, as described in Section 4.5.4.

The present chapter will describe the conduct of the survey, the "snap-shot" of perceptions in the different locations which it provides, and the ways in which those perceptions vary between the different locations. Chapter 8 will combine data from the survey of mothers in Oxford with data from the household survey in order to investigate the relationships between: personal experience and perceptions; sources of information and perceptions; and perceptions and behaviour. Chapter 9 will combine data from the survey of environmental health staff and the household survey in order to investigate the relationships between different hierarchical levels, and provide a comparison between the perceptions of the "institutional" and "individual" worlds.

The aims of the survey were to investigate:

- the importance of air pollution and/or asthma relative to other health worries, and the ways in which this varies, spatially and with respect to other factors (Section 7.3),
- individuals' perceptions of local air quality, and the ways in which this varies, spatially and with respect to other factors (Sections 7.4 and 7.5)
- the extent of experience of respiratory problems, relative to diagnosed "asthma" (Section 7.5)
- individuals' perceptions of the main factors affecting local air quality and the ways in which this varies spatially (Sections 7.6)
- the sources of information on which individuals' perceptions of the main factors affecting local air quality are based (Section 8.4)
- individuals' perceptions of the main factors affecting asthma, and the sources of information on which these perceptions are based (Sections 8.4, 8.5)
- the ways in which individuals' perceptions of air quality affect behaviour (Section 8.6)

7.2 Research Method

The survey was conducted in nine different locations, six within the Bedford / Kempston urban area, and three outlying villages: Sharnbrook, Harrold and Willington (see Figure 7.1.) Ozone diffusion tubes were also located in each of the

survey areas for the three months of June, July and August 1994, covering the survey period.

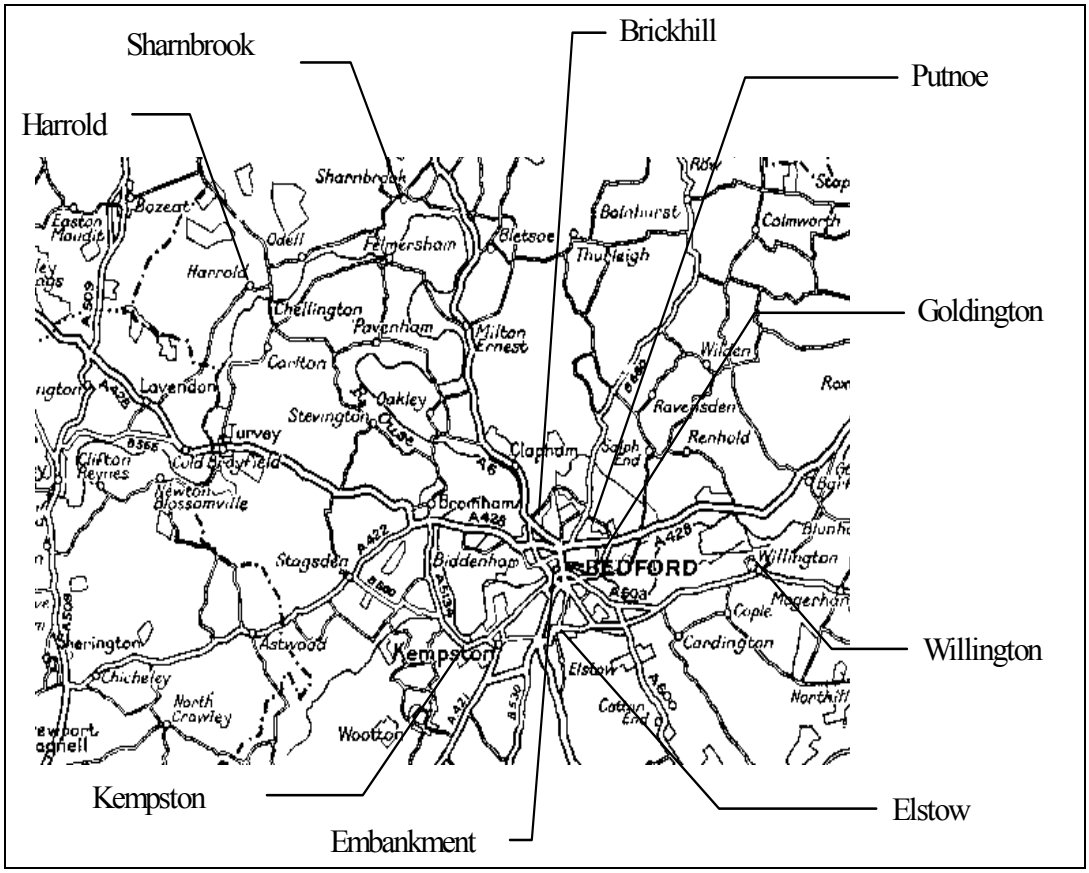


Figure 7.1: Map of the Bedford Area Showing Survey Locations

The survey locations were defined by selecting a block of streets downwind from each of the ozone diffusion tube sites, within which the interviewer was instructed to select a certain number of households for interview (approximately thirty in each urban location, and thirty five in each rural location, in order to give an overall total of 300 households, in approximate proportions of two thirds urban to one third rural). A list of locations showing the number of interviews in each is given in Table 7.1.

Table 7.1: Survey Locations

Area Code	Location	No of Respondents
b	Manton Heights / Brickhill	35
e	Embankment	34
g	Goldington Rd / Barkers Lane	35
h	Harrold	31
k	Kempston	34
l	Mile Rd / Elstow	35
p	Wentworth Drive / Putnoe	35
s	Sharnbrook	32
w	Willington	30

The questionnaire was designed to be suitable for self completion (for copy of questionnaire, see Appendix E). However, it was administered in interview form because the order of questioning was significant (see below).

The questionnaire consisted of four sections:

- an initial elicitation section on health issues, to establish which issues respondents perceived as being most important, and hence the relative importance of air pollution and respiratory disease. This was derived from the initial section of the questionnaire used in the pilot study for the interviews with mothers of young children
- a general section on understanding of asthma, perceptions of possible causes of asthma, and sources of information about asthma. This was administered to all respondents.
- a particular section relating to personal experience of asthma, administered to respondents who were found to have had experience of asthma or respiratory disease in their immediate family
- a general section on perceptions of local air quality and influences on air quality, based on a previous survey of 280 households carried out in 1993 in the Marston Vale area, to the South of Bedford (Longhurst & Cousins, 1993). Questions on air quality were duplicated exactly, in order to make the data comparable.

Order of questioning was important because, in order to establish the salience of the issues central to the survey (air pollution and respiratory disease), the questionnaire was based on an elicitation approach (see Sections 4.6.3 and 5.2.2). Instead of asking:

> *"How concerned are you about air pollution?"*

respondents were asked:

> *"Which problems related to your own or your family's health are you most concerned about? (Please list up to three, in order of importance, most important first)."*

This question was asked before any mention of respiratory disease or pollution had been made. Similarly, questions about the causes of asthma were asked before questions about air quality, to avoid suggesting a link to the respondents.

The analysis of the air quality section also incorporated data from the previous survey, giving a total of 582 respondents. A list of locations and numbers of respondents for the 1993 survey is given in Table 7.2. Survey locations are shown in Figure 7.2.

Table 7.2: Survey Locations for 1993 Marston Vale Survey (Source: Longhurst and Cousins, 1993).

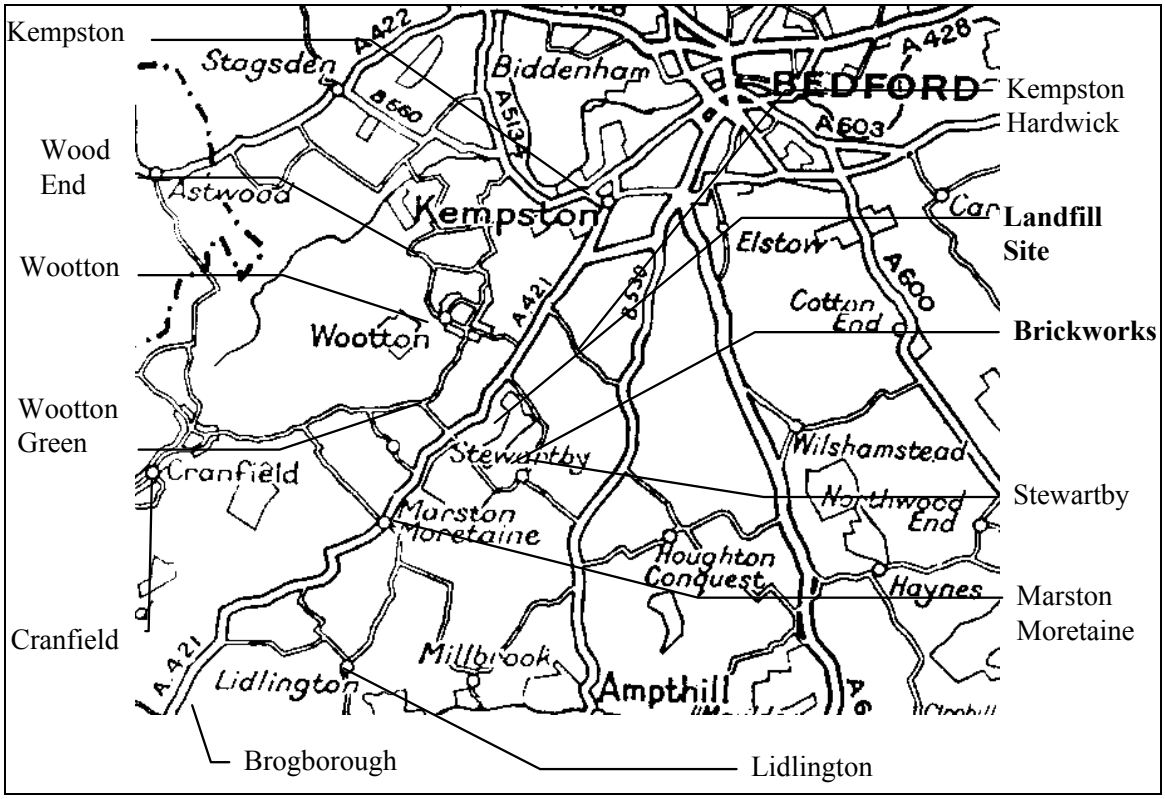


Figure 7.2: Map of the Marston Vale Area, Showing Locations for the 1993 Survey

The data were stored on a Microsoft Access database. This permitted multiple responses to some questions, eg health concerns, to be entered for a single respondent. It also allowed great flexibility in retaining the precise wording of responses (see Section 7.6.3 and Section 10.3). For cross tabulation and charting, selected data were extracted into Microsoft Excel, and for more detailed statistical analysis into SPSS.

Multiple regression analysis was used in order to investigate the relative significance of various factors in explaining variations in responses (see Section 7.3.2).

7.3 Perceptions of Health Issues

7.3.1 Most Frequently Mentioned Health Issues

Respondents were asked to give up to three answers to the question:

> *"Which problems related to your own or your family's health are you most concerned about? (Please list up to three, in order of importance, most important first)."*

When the first answer given was "none" (128 respondents), the respondent was prompted by the question:

> *"What is the first thing you think of when I mention 'Health'?"*

and any response given was then coded as a secondary issue (66 issues). In all, 168 valid primary issues (other than "none") were mentioned, 137 valid secondary issues and 21 valid tertiary issues. Coding categories were developed and allocated through inspection of the data (see description of procedure for developing analytical

categories and classification scheme for the EHO survey in Section 6.2), and the issues were classified into a total of 58 categories (see Table 7.3). Of these categories, 34 were only mentioned by one or two respondents. Figure 7.3 shows the frequencies of those categories which were mentioned more than twice, excluding "none".

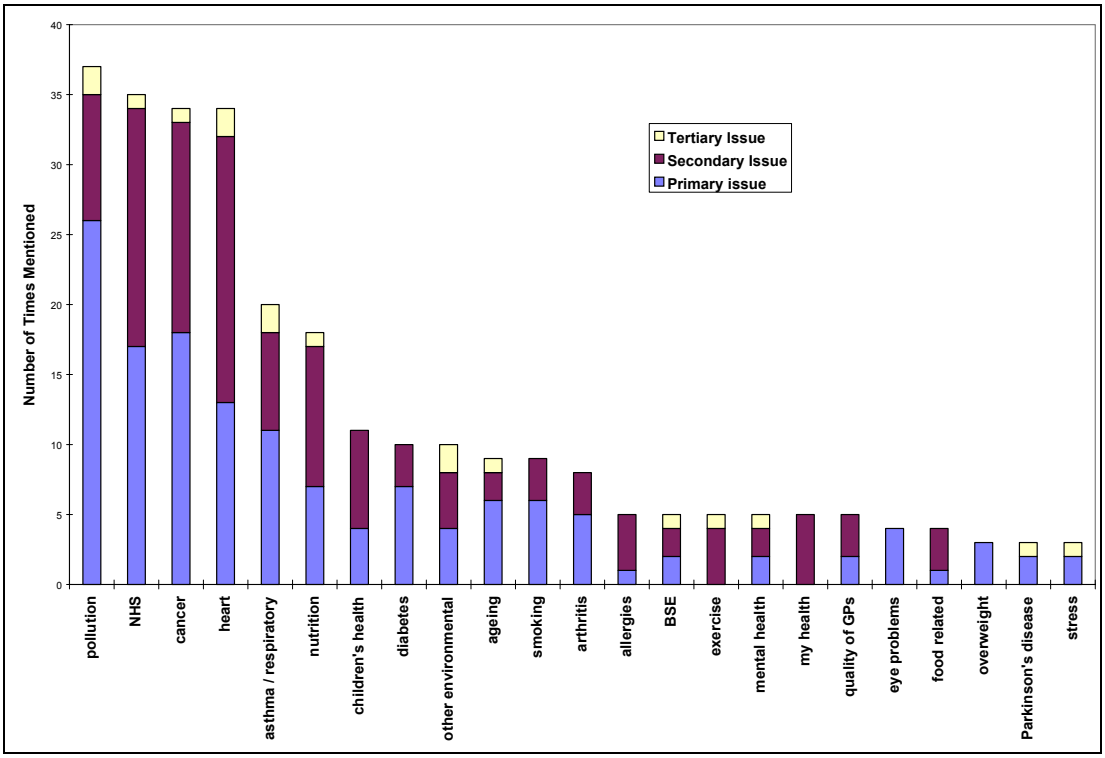


Figure 7.3 Issues Mentioned More Than Twice

As is clear from Figure 7.3, the most frequently mentioned issue was air pollution, mentioned by 26 (9%) respondents as their most important concern, and by 37 (12.5%) respondents when secondary and tertiary concerns are taken into account. This is in contrast with the result for the pilot survey of mothers in Oxford (see Section 5.3.5), for whom asthma was the major worry. This difference will be discussed further in Section 8.2.

7.3.2 Factors Affecting Health Concerns of the Public

In order to investigate what factors influence the public's health concerns, a number of regression models were constructed in SPSS.

For each respondent, a dummy variable of 1 or 0 was created to indicate whether asthma was one of the three issues mentioned, and another similar variable for whether air pollution was mentioned. These two variables were then taken as dependent variables and regressed on a number of independent variables taken from the questionnaires (for a full list, see Table 7.4). In addition, the respondent's numerical evaluation of air quality, on a scale of 1-5, was also taken as a dependent variable.

Table 7.3: Health Issues Mentioned, by Priority

Category	Priority			Total
	1	2	3	
none	128			128
pollution	26	9	2	37
NHS	17	17	1	35
cancer	18	15	1	34
heart	13	19	2	34
asthma / respiratory	11	7	2	20
nutrition	7	10	1	18
children's health	4	7		11
diabetes	7	3		10
other environmental	4	4	2	10
ageing	6	2	1	9
smoking	6	3		9
arthritis	5	3		8
allergies	1	4		5
BSE	2	2	1	5
exercise		4	1	5
mental health	2	2	1	5
my health		5		5
quality of GPs	2	3		5
eye problems	4			4
food related	1	3		4
overweight	3			3
Parkinson's disease	2		1	3
stress	2		1	3
Aids		2		2
back problems	1	1		2
colds	1	1		2
dental service	1	1		2
disability	2			2
drug/alcohol abuse	1	1		2
epilepsy	2			2
foot problems	1	1		2
hygiene	1	1		2
wife's health	1		1	2
angina		1		1
children's safety	1			1
circulation		1		1
emphysema	1			1
gall bladder	1			1
hearing problems	1			1
hydrocephalus		1		1
kidney problems	1			1
leg problems		1		1
ME	1			1
measles		1		1
meningitis	1			1
MS			1	1
muscular problems	1			1
parents' health	1			1
psoriasis			1	1
rheumatism		1		1
rheumatoid arthritis	1			1
sinus problems	1			1
stomach problems	1			1
stroke		1		1
TB			1	1
violence	1			1
women's problems	1			1
Total	296	137	21	454

Stepwise multiple regression was carried out for each of the dependent variables on all independent variables. In general, the goodness of fit of the regressions was very poor. When "ASTHMA" was the dependent variable, R-squared was .13666, and the only independent variable with a significant t-value was "RESPEXP". When stepwise regression was tried with "ASTHMA" as the dependent variable, all independent variables were removed.

Table 7.4 Variables Used in SPSS Regressions

SPSS Variable name	Description	Possible values
QNO	Questionnaire number	1-301
ASTHMA	Asthma mentioned as an issue	0 = no, 1=yes
POLL	Air pollution mentioned as an issue	0 = no, 1=yes
POLLUTIO	Subjective evaluation of local air quality	1= very good, 5= very bad
RESPEXP	Experience of respiratory problems in family	0 = no, 1=yes
AGE	Age group	1=18-25, 2=26-35, ..., 9=>86
CHILDREN	Children under 18 in family	0 = no, 1=yes
SEX	Sex of respondent	0=male, 1=female
POLL_AWA	Awareness of media reports on air pollution	0 = no, 1=yes
POLL_MED	Number of media reports on air pollution	0-3
ASTHMA_A	Awareness of media reports on asthma	0 = no, 1=yes
ASTHMA_M	Number of media reports on asthma mentioned	0-3
AREA_NUM	Number of survey area	1-9

When "POLL" was the dependent variable, the value for R-squared was .11530, and in the stepwise regression, the only variable left in was "AREA-NUM", with an R-squared of .01365. For "POLLUTIO", the R-squared was .01627, and "RESPEXP" was the only variable not rejected in the stepwise procedure.

In general, therefore, the statistical analyses were not successful. This is perhaps not surprising, given the nature of the data. However, insofar as any conclusions, however tentative, may be drawn from the analysis, it would appear that the most significant factor affecting concern about asthma as an issue is experience of respiratory disease in the family, while the most significant factor affecting whether air pollution is mentioned as an issue is location. It is this question which forms the basis for the next part of the analysis.

7.4 Spatial Variations in Perceptions of Local Air Quality

The survey data provides two measures of perception of air pollution within each local area:

- the number of respondents in the area mentioning air pollution as a concern in response to the initial elicitation question ("Which issues related to your own or your family's health are you most concerned about?")
- an index giving the average value for all respondents in the area in response to the question "How good or bad do you believe the air quality to be in this area?" on a scale of 1-5 (1=very good, 5=very bad).

The values of these two measures for the various locations are shown in Figure 7.4.

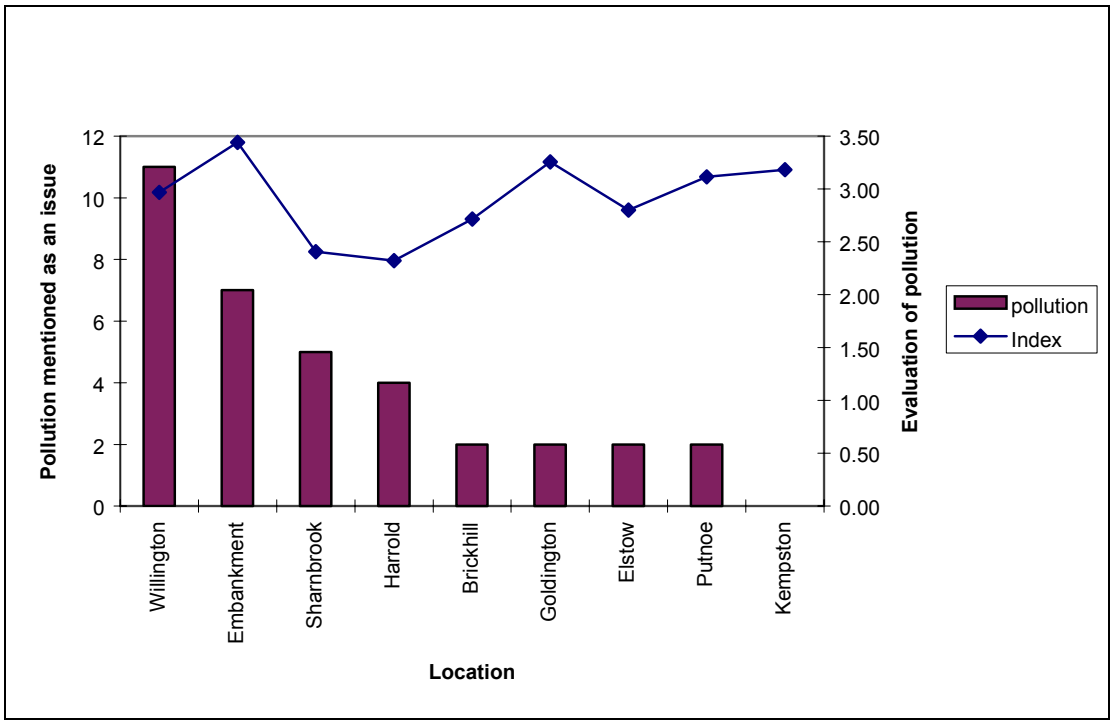


Figure 7.4: Pollution Mentioned and Assessment of Pollution, by Location

The location with the most people expressing concern about pollution as an issue was in the village of Willington, to the East of the town, although the evaluation of pollution was higher in the urban areas of Embankment, Goldington, Putnoe and Kempston. Although Kempston had the third highest value for the index, at 3.18, none of the respondents mentioned air pollution as an issue about which they were concerned. Generally, the value of the index for those respondents expressing concern about pollution was greater than for those who did not in all locations except for the villages of Harrold and Sharnbrook. However, as mentioned in Section 7.3, evaluation of pollution did not appear from the regression analyses as a significant indicator of concern about pollution. This suggests that other factors than subjective evaluation of local air quality affect the salience of air quality as an issue for the individual, the presence or absence of other competing concerns being perhaps likely candidates.

7.5 The Relationship Between Perceptions and Objective Measurement

It will be recalled from Section 4.5.4 that one of the dimensions of difference posited between the "institutional" and "individual" worlds is the distinction between an emphasis on objective measurement and on perception, or between measured impacts and perceived outcomes. The survey addressed this distinction in two contexts:

- perceptions of air quality vs measured levels of pollutant (ozone)
- experience of respiratory problems vs diagnosis of asthma

7.5.1 Perceptions of Air Quality and Objective Measurement of Pollution

As mentioned above (Section 7.2), average data for ozone in the nine locations is available for the survey period (see Table 7.5).

Table 7.5 Average Ozone Levels for the Survey Period in the Survey Locations (Source: Hitchin, 1994).

Location	Ave ozone (ppb[19])
Brickhill	67.1
Kempston	66.83
Sharnbrook	66.4
Putnoe	64.98
Elstow	64.61
Goldington	63.73
Willington	62.91
Harrold	58.8
Embankment	50.73

The lowest average level of ozone was found in the Embankment area, in the centre of Bedford town, a result which could be predicted from the scavenging effects of traffic on ozone, as mentioned above (Section 6.6; Chameides, 1994). The highest average concentration was measured in Brickhill, located on a hill in the northern part of Bedford, overlooking the rest of the town. Results from the remaining locations did not, on the whole, support the expectation that higher concentrations of ozone would be found in rural areas, with two of the villages, Willington and Harrold, having lower levels than the suburban areas of Putnoe and Goldington, and the urban area of Kempston being the second highest. However, most of the urban locations were actually located on the edges of the town. Also, the precise locations of the tubes may be significant, the Embankment tube being at a busy town centre intersection, while the Brickhill tube was located in the town cemetery, an open area next to a park.

[19] parts per billion

There is difficulty, therefore, in interpreting such results. Further difficulties present themselves in trying to relate these data to the perceptions data (See Figures 7.5 and 7.6). Ozone is a single pollutant, one which behaves in counter-intuitive ways, and not one which is evident to casual observation, unlike, for example, black smoke, or unburnt hydrocarbons from diesel fuel. Thus, the location in which ozone is lowest (Embankment) is also the one in which the assessment of pollution index is highest - a not unreasonable assessment, given the town centre location. Despite ozone's significance as a health risk and cause for concern from the council's perspective, it does not have an immediate and obvious impact on individuals' lives and perceptions.

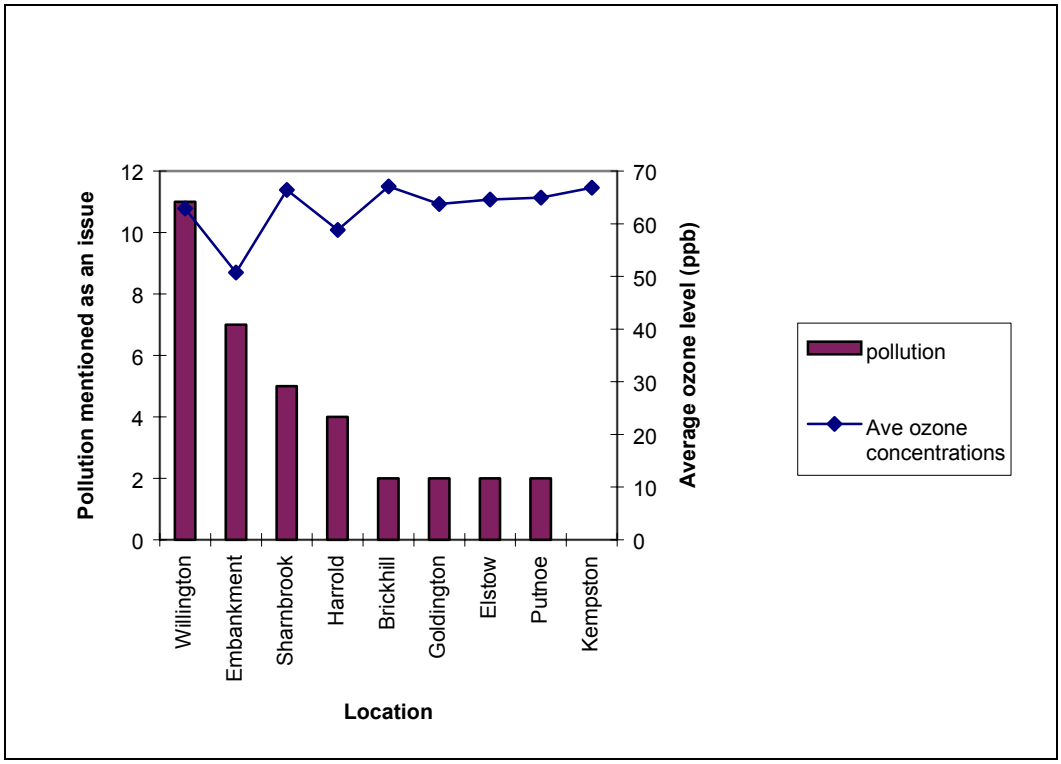


Figure 7.5: Pollution Mentioned and Average Ozone Levels, by Location

In addition to the point data on ozone for the different locations, time series ozone data is also available for the duration of the survey, for a single location (Elstow). Taking this as an indicator of ozone levels over the period for the area as a whole, and comparing with data on the numbers of respondents mentioning air pollution as an issue each day, produced the results shown in Figure 7.7.

Again, there appears to be little relationship between the level of concern expressed about pollution, as measured by the percentage of respondents each day mentioning pollution as a health issue, and average daily levels of ozone.

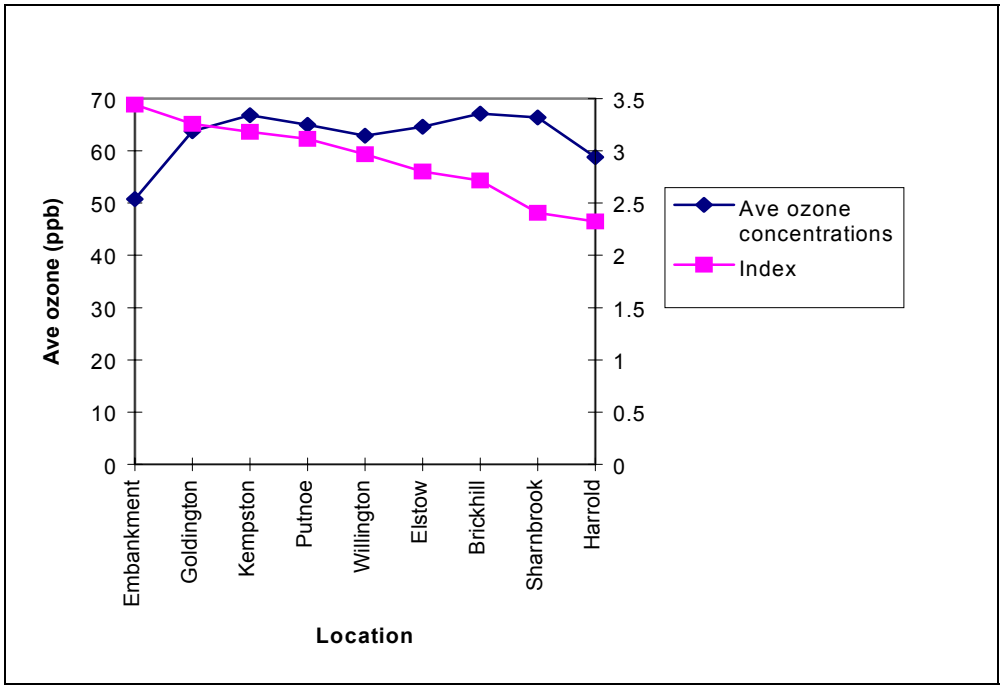


Figure 7.6: Assessment of Pollution, and Average Ozone Levels, by Location

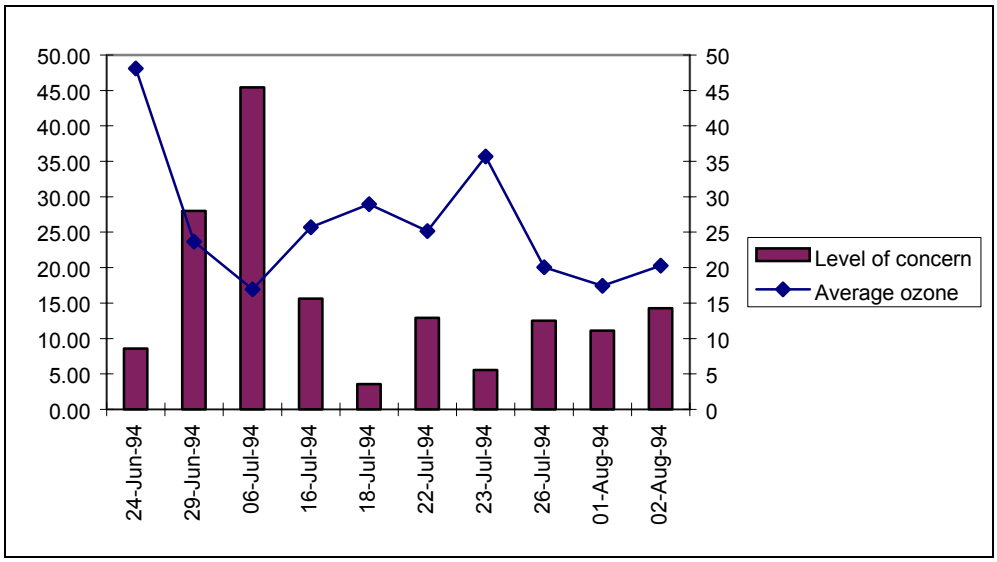


Figure 7.7: Level of Concern, and Average Ozone Levels, Over Time

7.5.2 Experience of Respiratory Disease and Diagnosis of Asthma

As will be recalled from Section 4.3, the diagnosis of "asthma" is not always straightforward, and may be affected by perceptual as well as physical factors. Instead of asking specifically about experience of asthma, therefore, the questionnaire included the following question:

> *"Have you or any member of your household ever experienced asthma or any other persistent difficulty with your breathing?"*

Sixty (20%) of respondents had experienced asthma or other respiratory problems with current members of the household. Responses to other questions suggested that respondents with experience of hay fever or rhinitis did not always respond positively to this question, therefore this is likely to be a low estimate of overall levels of respiratory problems. Twenty five respondents who did not have experience with current household members said they had received information about asthma from friends or relatives not currently in the household, including late husband, parents, grown up children, grandparents, grandchildren etc, suggesting that at least eighty five respondents (28%) had had direct, immediate contact with respiratory sufferers at some stage.

The questionnaire was designed to allow respondents to give information about several family members affected by respiratory problems, and information was given on a total of 68 sufferers. Fifteen of the 68 sufferers had not been diagnosed as having asthma, suggesting that diagnosis rates for asthma may underestimate the full extent of respiratory problems.

7.6 Perceptions of Local Sources of Pollution

Another focus of the questionnaire survey was to investigate what individuals perceive as the main sources of pollution affecting their locality. In this, the survey builds on a previous survey of 280 households carried out in 1993 in the Marston Vale area, to the South of Bedford (Longhurst & Cousins, 1993). The earlier survey was concerned with perceptions of odour nuisance; however, it included questions on air quality which were duplicated exactly in the present study, in order to make the data comparable. These additional responses have therefore been used in part of the analysis.

Respondents were asked to mention up to three influences: 179 respondents gave a valid second response, 44 gave a valid third response, and 1 gave a valid fourth response (overall total of valid responses: 494). The most frequently mentioned "first influences" were : traffic (118 respondents), brickworks (59 respondents) and "agricultural" (eg pollen, crop spraying) 19 respondents.

The influences which respondents were concerned about varied between the different locations. "Agriculture" was the most frequently mentioned first influence in Sharnbrook, "brickworks" in Willington and "traffic" in all other locations. However, particularly when second and third influences were taken into account, more highly localised influences became significant, with respondents on the Embankment mentioning "the river" and in Brickhill "the crematorium" (see Table 7.6).

7.6.1 Analysis of Influences Mentioned By Distance From Location

The variations in influences mentioned by location suggest that nearby sources are regarded as more significant. The sources were therefore analysed in terms of distance from the respondent's home. The questionnaire information included postcode, from which grid references were derived and used to calculate distances from the point sources mentioned. When traffic was mentioned, distance from the nearest main road was measured. For "parkland" and "agricultural", distance from the nearest open space was estimated from the OS map. For ambient and diffuse sources, such as domestic heating, the distance was taken to be .01km, ie 10 metres, or approximately the width of a house.

Table 7.6: Most Frequently Mentioned Influences By Location

Location	Main influence	Second most frequent	Third most frequent
Brickhill	Traffic	Brickworks	Crematorium
Elstow	Traffic	Open area / parkland	Brickworks
Embankment	Traffic	Brickworks	Topography
Goldington	Traffic	Brickworks	Topography
Harrold	Agricultural	Traffic	Open area /parkland
Kempston	Traffic	Brickworks	Landfill
Putnoe	Traffic	Brickworks	Landfill
Sharnbrook	Agricultural	Traffic	Open area / parkland
Willington	Brickworks	Traffic	Agricultural

Initial analyses showed a similar pattern of concern related to distance from source for each location, with three main clusters: a large number of responses mentioning diffuse / immediate sources; a small cluster of local point sources; and a third cluster further away (See examples of Brickhill, Embankment and Goldington in Figures 7.8.1, 7.8.2 and 7.8.3 respectively).

On inspection, in each case the most distant cluster was found to correspond to the brickworks and landfill in the Marston Vale. This pattern was repeated for all locations, and combining data from several locations showed clusters of "Marston Vale" influences corresponding to the distance from the various locations, although this clustering is smoothed out when all locations are combined (See Figure 7.9). Overall, 195 (48.5%) influences were within .5 kms, 238 (59.2%) within 1 km and 247 (61.4%) within 1.5 kms.

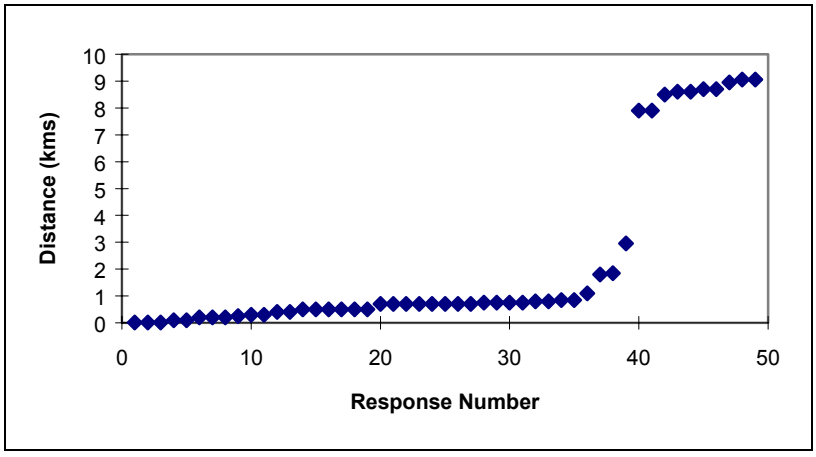


Figure 7.8.1: Distance from Sources: Brickhill

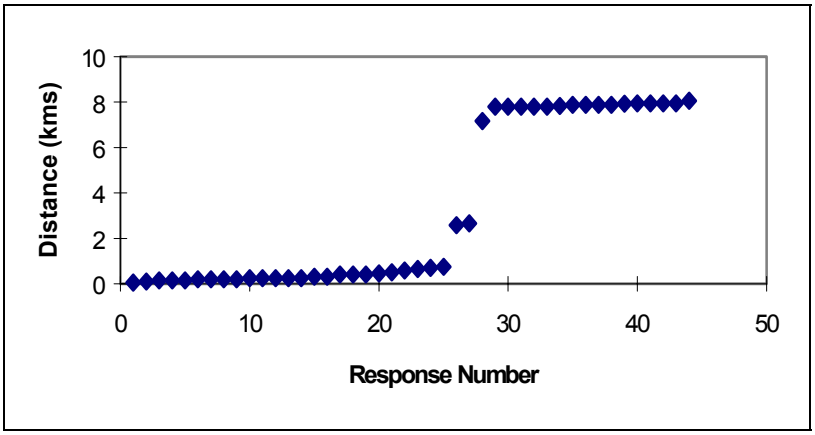


Figure 7.8.2 : Distance from Sources: Embankment

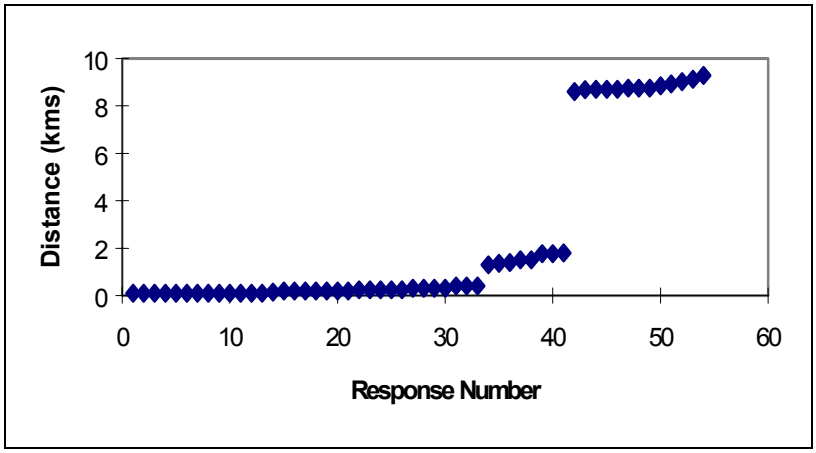


Figure 7.8.3: Distance from Sources: Goldington

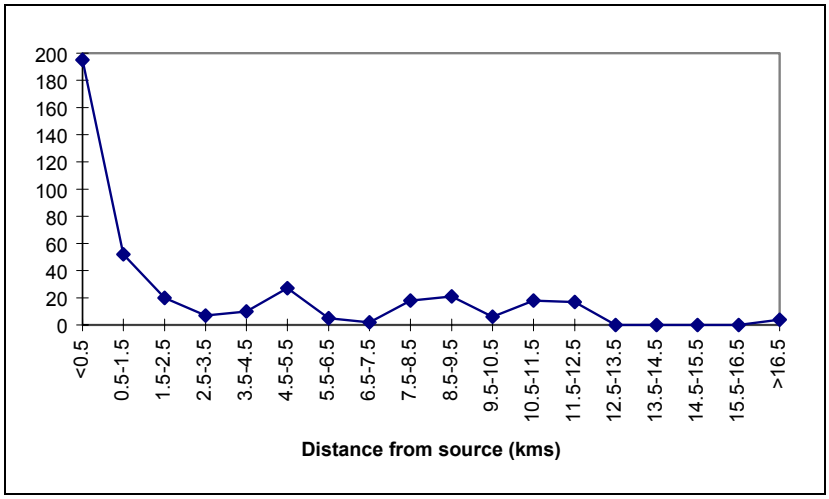


Figure 7.9: Frequencies of Response by Distance

7.6.2 Perceptions of the Major Regional Point Sources

The next stage of the analysis concentrated on the impact of the major regional point sources (the brickworks and landfill sites in the Marston Vale) on perceptions of influences on air quality in the various locations. The focus switched to the sources themselves, investigating the extent to which they were seen as significant in the various locations. For this stage of the analysis, data from the 1993 survey (see Section7.2 above) was combined with data from the 1994 survey.

Table 7.7: Locations and Distance from Brickworks for the Two Surveys

survey	area	location	No of respondents	Range of distance from brickworks		ave distance
m	wg	Wootton Green	15	0.28	3.06	2.26
m	st	Stewartby	13	0.45	0.98	0.76
m	kh	Kempston Hardwick	2	1.77	1.86	1.81
m	mm	Marston Moretaine	41	2.06	3.96	2.82
m	wo	Wootton	62	2.28	4.12	2.99
m	we	Wood End	9	3.29	4.78	3.95
m	km	Kempston	39	3.73	4.35	4.05
m	li	Lidlington	22	3.92	6.13	4.9
m	cr	Cranfield	73	4.28	8.3	6.44
b	k	Kempston	34	4.9	5.2	5.06
b	l	Mile Rd / Elstow	35	5.5	5.9	5.77
m	br	Brogborough	4	7.17	7.87	7.44
b	e	Embankment	34	7.72	8.05	7.87
b	b	Manton Heights / Brickhill	35	8.2	9.06	8.72
b	g	Goldington Rd / Barkers Lane	35	8.6	9.29	8.84
b	p	Wentworth Drive / Putnoe	35	10.5	10.9	10.73
b	w	Willington	30	11.46	11.78	11.65
b	h	Harrold	31	15.12	16.53	15.55
b	s	Sharnbrook	32	16.82	17.24	17.03

Figure 7.10 shows the number of respondents at each distance who mentioned the brickworks as the main influence on air quality.

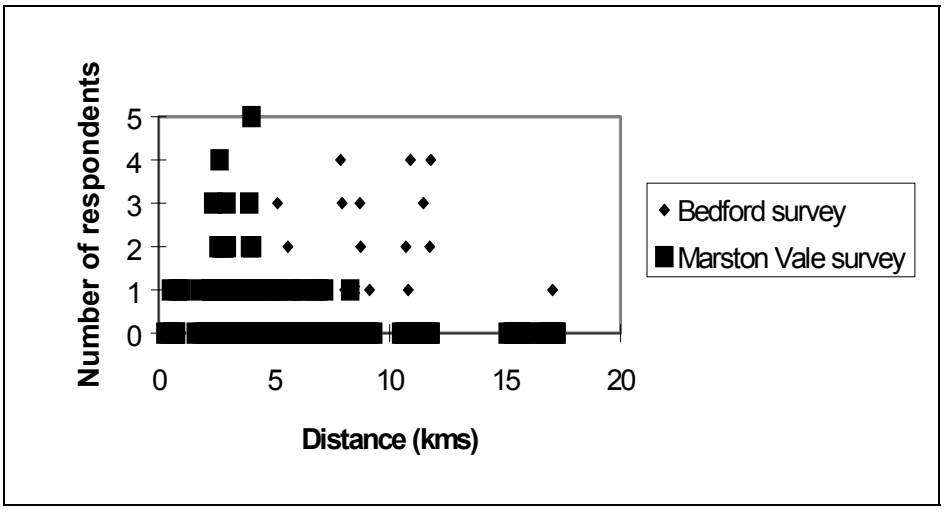


Figure 7.10: No of Respondents Mentioning Brickworks, by Distance from Brickworks

Again, the responses are clustered at distances corresponding to the survey locations. However, the data do not provide a very clear picture, firstly because the distances depend on the postcodes at which respondents live and are not evenly spread, and secondly because the frequencies of respondents depend on the number of people surveyed at each postcode.

Figures 7.11 and 7.12 show the responses grouped into ranges, starting with less than .5 kms, then .5 - 1.5 kms, 1.5 - 2.5 kms etc. The peak at 2.5-3.5 kms is striking (Marston Moreteyne / Wootton / Wood End), and subsequent peaks, at 8.5 - 9.5 kms (Embankment / Brickhill) and 11.5 - 12.5 kms (Willington), again correspond to specific survey locations.

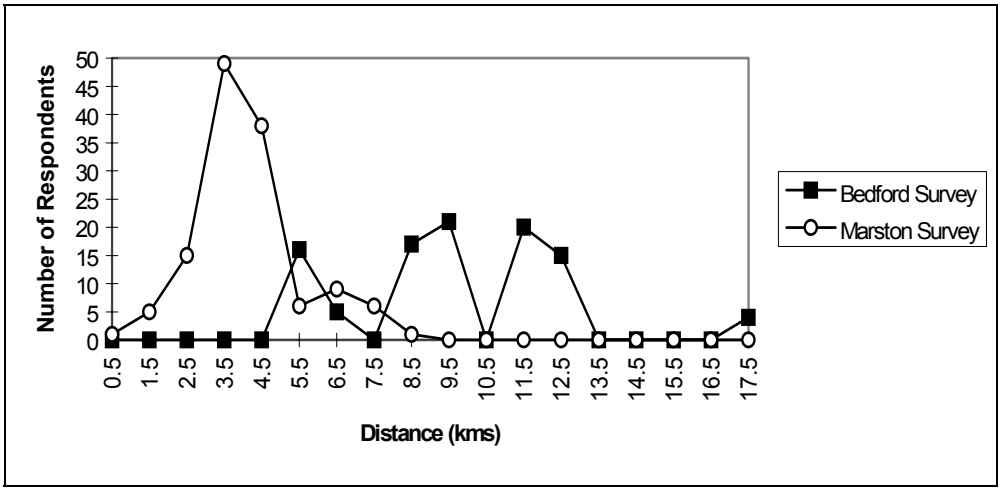


Figure 7.11: Brickworks Mentioned by Distance (Grouped)

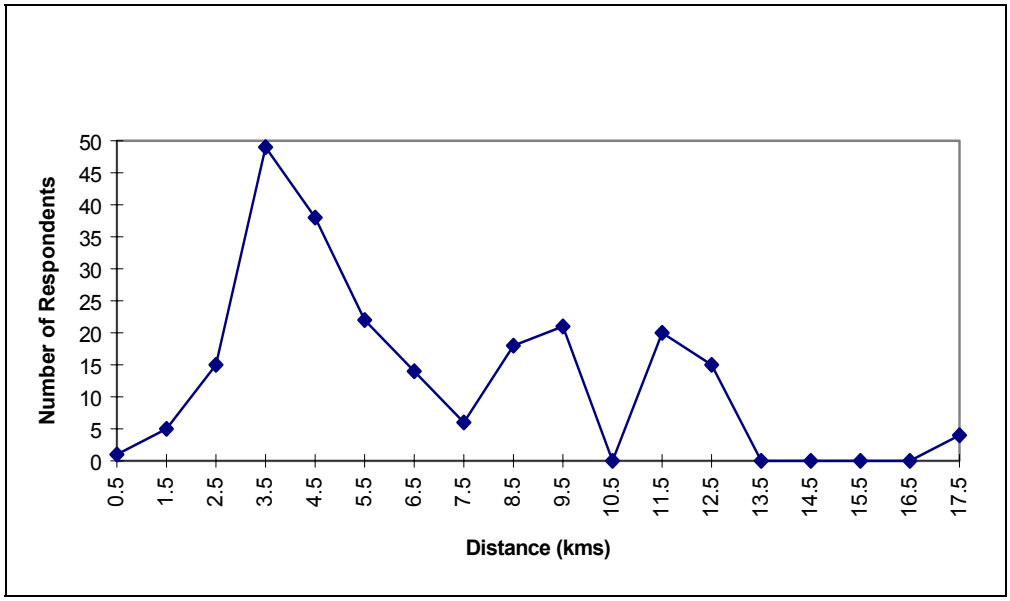


Figure 7.12: Brickworks Mentioned by Distance - Both Surveys

However, the results still do not take into account the different numbers of respondents interviewed in different locations, and Figure 7.13 accordingly shows the

number of respondents mentioning brickworks as the main influence within each distance range expressed as a percentage of the total number of respondents interviewed at that distance.

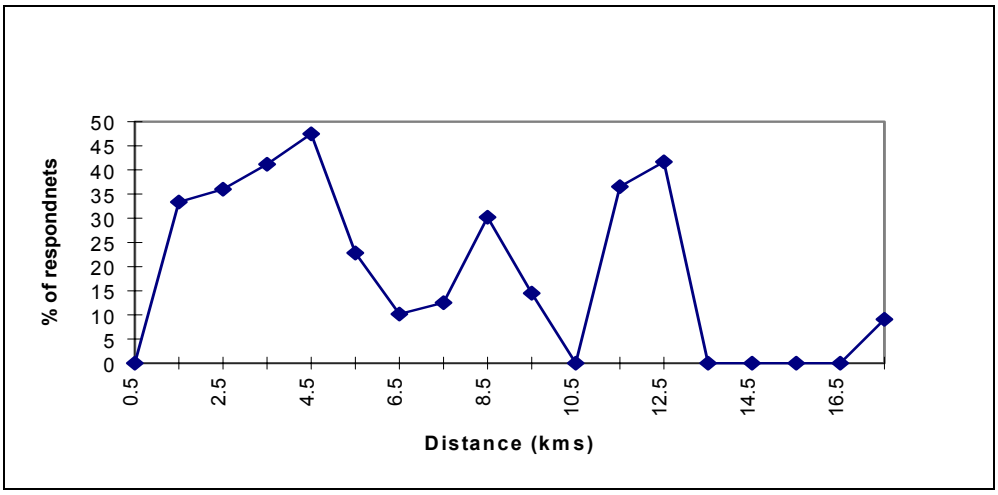


Figure 7.13: Percentage of Respondents Mentioning Brickworks as Main Influence (Both Surveys)

Ignoring those distance ranges in which no respondents were surveyed (9.5-10.5 kms and 13-16 kms), it is clear that concern over the brickworks as a major source of pollution does not, as might be anticipated, start at a high level and decline smoothly with distance. In fact, neither of the two respondents who live within .5 kms of the brickworks mentioned them as the main influence, and only 4 out of the 12 respondents who live between .5 and 1.5 kms away did so.

Modifying the data to include all those respondents who mentioned the brickworks as a secondary or tertiary influence changes the picture somewhat, particularly as regards those respondents living closest to the brickworks, but does not substantially affect the overall pattern of peaks (see Figures 7.14 and 7.15).

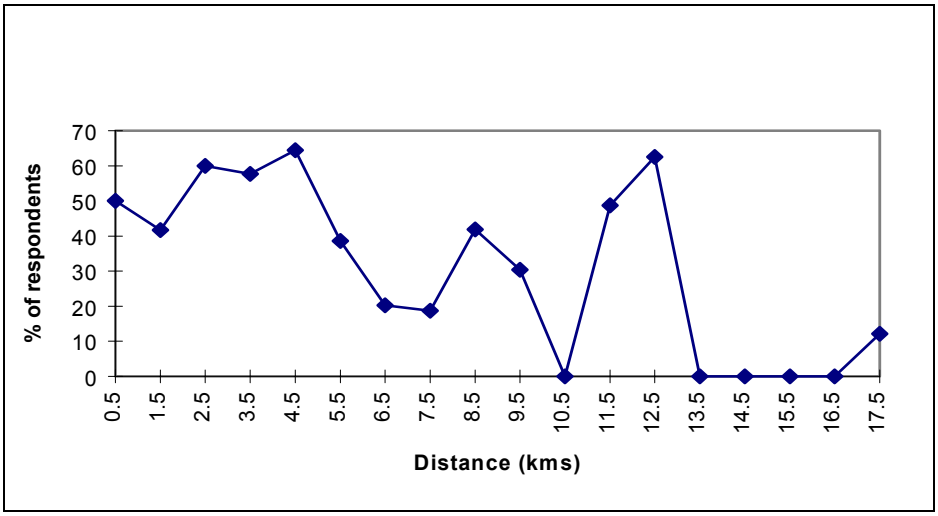


Figure 7.14: Percentage Mentioning Brickworks as an Influence (Both Surveys)

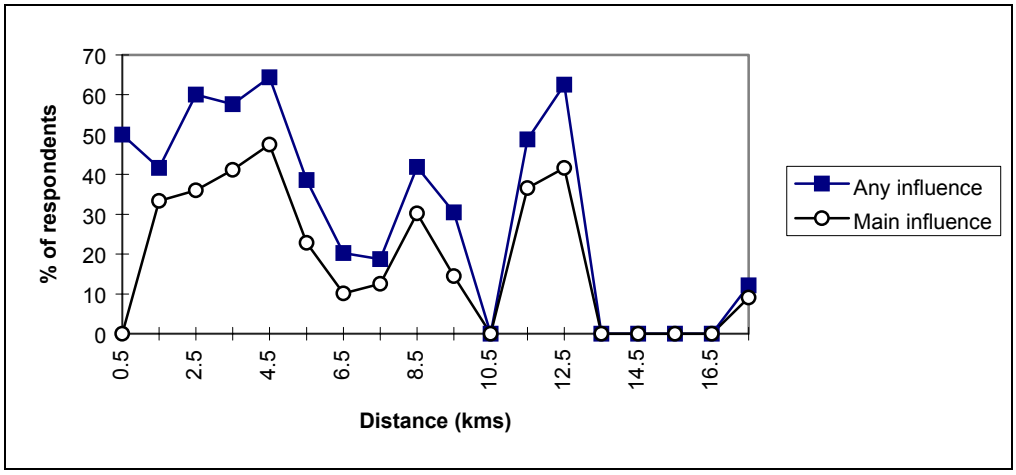


Figure 7.15: Percentage Mentioning Brickworks as an Influence (Both Surveys)

Switching the focus of the analysis to the landfill sites (see Table 7.8) reveals a pattern which corresponds more closely to what might be expected (Figures 7.16-7.18), with a high proportion (67%) of respondents closest to the sites displaying concern, which then declines steeply after 6.5 kms. (The "blip" at 12.5 kms is caused by a single respondent in Willington who mentioned the landfill site).

Table 7.8: Locations and Distance from Landfill for the Two Surveys

Survey	Area	Location	No of respondents	Range of distance from landfill		Ave distance from landfill
m	wg	Wootton Green	15	1.03	2.55	1.45
m	wo	Wootton	62	1.08	2.94	1.81
m	st	Stewartby	13	1.63	2.19	1.95
m	kh	Kempston Hardwick	2	1.65	1.71	1.68
b	l	Mile Rd / Elstow	35	1.65	2.1	1.94
b	k	Kempston	34	1.9	2.25	2.05
m	we	Wood End	9	2.09	4.83	2.89
m	mm	Marston Moretaine	41	2.19	4.57	3.15
m	km	Kempston	39	2.79	3.64	3.18
m	cr	Cranfield	73	4.16	7.89	6.13
m	li	Lidlington	22	4.61	6.84	5.57
b	p	Wentworth Drive / Putnoe	35	6.5	7	6.79
b	e	Embankment	34	7.07	7.36	7.18
b	b	Manton Heights / Brickhill	35	7.3	7.9	7.78
m	br	Brogborough	4	7.58	8.29	7.84
b	g	Goldington Rd / Barkers Lane	35	8.02	8.77	8.28
b	w	Willington	30	11.24	11.58	11.45
b	h	Harrold	31	13.94	15.33	14.34
b	s	Sharnbrook	32	15.66	16.07	15.87

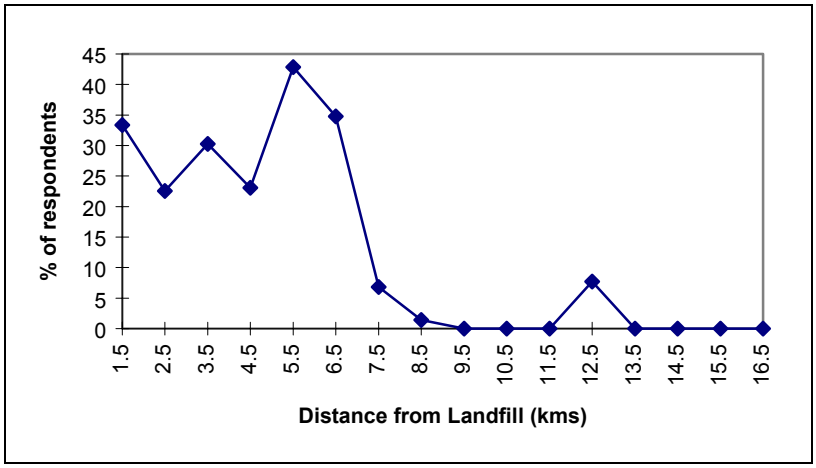


Figure 7.16: Percentage of Respondents Mentioning Landfill as Main Influence (Both Surveys)

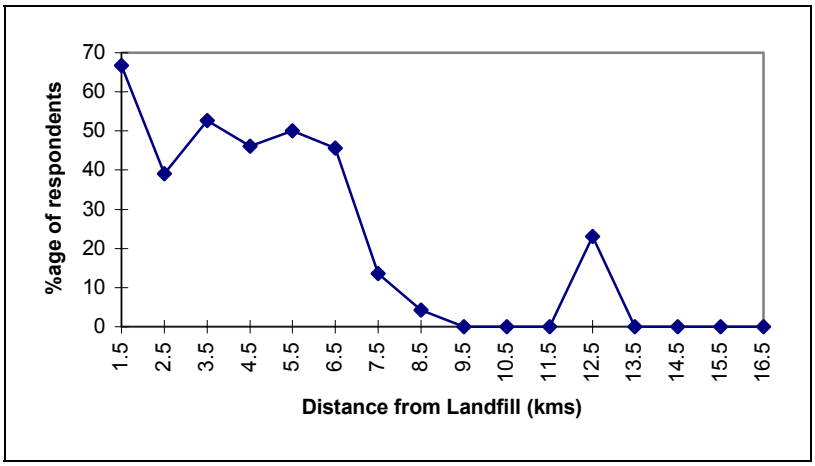


Figure 7.17:Percentage Mentioning Landfill as an Influence (Both Surveys)

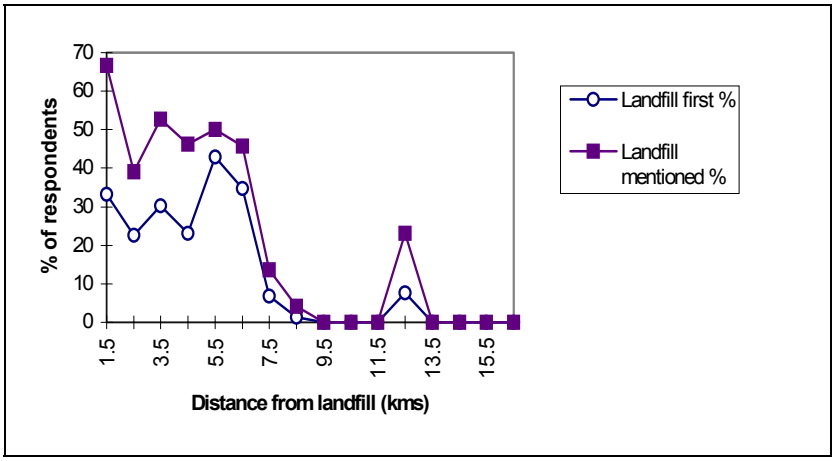


Figure 7.18: Percentage Mentioning Landfill (Both Surveys)

A possible explanation for the differences in response to the two regional point sources may lie in their proximity to each other, and a more realistic assessment of

their relative impacts among local residents. Those respondents who live in close proximity to both attribute local problems with air quality to the landfill, regarding the brickworks as a secondary problem by comparison. Those living further away, however, while aware that the Marston Vale has a generally bad reputation for air pollution, may tend to attribute this to the historical effects of the brickworks, which have historically been notorious locally, and be less aware of the existence and potential impact of the landfill sites.

7.6.3 Relationships Between Perceptions of Different Air Quality Influences

It appears that perceptions of which factors have the most significant effects on local air quality are not simply determined, but vary greatly between individuals and locations. Some of the variation in perception may be attributable to individual factors, the state of individual appreciative systems, awareness of and concern about pollution issues and personal experience. However, it is clear that significant variation is also attributable to locational factors.

The factors influencing air quality which were mentioned by respondents to the survey may be broadly classified as follows:

- major regional point sources (brick works, landfill)
- locally significant point sources (eg cemetery, sewage works)
- traffic
- landscape features, eg in a basin, on a hill, open area
- immediate / diffuse sources, eg domestic heating, smoking

Attempting to investigate these factors in isolation may risk ignoring complex interrelationships between the factors, eg perceptions of traffic may be affected by the proximity to a local point source. Statistical analysis of the data for the different locations, though crude, revealed significant differences in perception between the locations.

While the analysis reveals patterns of concern for each location, for a particular individual, other factors as well as location may be significant in determining perceptions. Responses to the question:

> *“"What do you consider to be the main influences on air quality locally?"*

suggested other dimensions of analysis in addition to the identified source. "Influences" were frequently mentioned in a positive way, for example:

> *"lots of fields and trees giving oxygen"*
> *"the countryside air"*
> *"openness of the area"*
> *"the open fresh air of countryside"*
> *"the Park"*

Among these “positive” influences can be included the lack of “negative influences, for example:

> *"not a built up area"*
> *"not much traffic"*
> *"not near any industry".*

"Agriculture" and living in a "rural" area was seen as both a positive and negative influence by different respondents. Problems attributable to agriculture included both chemicals applied by farmers and the crops themselves:

"farmers growing rape seed, it gives off a lot of pollen"
"farming sprays"
"farms nearby and crop spraying"
"farms, their general harvesting"
"rape crop, high pollen from it"

This again reflects the importance of immediate locality. Understandably, in the absence of nearby industrial sources in the form of factories, other types of local source acquire greater significance.

Some responses suggest that relative perception is important, comparing the immediate locality with other locations, or other times:

"away from M1 is better"
"this side of village does get smells from Shanks and McEwan [a landfill site]*"*
"brickworks not as bad as they were"
"improved since brickworks closed"
"much better than it used to be"

It will be recalled from Chapter 5 that respondents in the pilot study also compared air quality in their immediate locality to that in other places (Section 5.5). This relativity of perception suggests that respondents who have recently moved from more built up to more "open" and rural areas are likely to have a more positive perception of their local air quality, and may account for the observation that even relatively small areas of open space were considered important by some respondents:

"the Park"
"open area, the school"

In some cases, the general topology of the area was mentioned in preference to specific sources of pollution:

"we're in a valley, don't get as much fresh air"
"we're near to big fields, and lots of trees"
"we are in a low lying river basin / muggy area"
"we are on a hill"
"we get all the gunge that settles here"

Indoor sources of pollution were also mentioned by some respondents:

"people smoking"
"dust, house mites"
"fumes from gas fires in homes"
"food smells"

Seasonal variations, and variations attributable to changes in weather conditions, were mentioned by some respondents:

"Brogborough landfill occasionally"
"the brickworks (depending on wind direction)"
"some smells from time to time"
"sometimes there is a haze which hangs over the area"
"rape when in full flower"
"harvesting the crops"

"except when the smoke stacks blow"

Some responses were concerned with looking behind the immediate problems, and attributing blame and responsibility:

"bad governmental planning, allowing these emissions"
"rubbish people dump any old where"
"Shanks and McEwen - they manage the dumping"
"Unilever and their crop spraying"

One response in particular suggested that, in the absence of a specific reason to consider the question, the respondent did not feel able to comment about the issue of local air quality:

"no reason to ask"

In summary, asking the public about the determinants of "local air quality" produces a wide range of responses, which do not fit neatly into categories of management which would be recognised by the institutional actors.

7.7 Conclusions

The focus of this chapter has been on using the survey data to establish a "snap-shot" of perceptions of air quality in a number of locations in a particular geographical area at a particular time (June-August 1994).

From a wide range of health issues which caused concern, air pollution was most frequently cited, suggesting a significant level of awareness and concern about air pollution as a threat to health. However, the spatial spread of those sources of pollution regarded as most significant suggests that this perception is highly localised.

The sources mentioned also reveal a very broad understanding of the concept of "air quality", including not only traffic and industrial pollution but issues such as landfill and agricultural pollution. This is in contrast with the perceptions of the environmental health officers interviewed in Chapter 6, an issue which will be discussed in more detail in Chapter 9.

Public concerns about air quality are determined by a complex interaction of factors and potential sources. Pockets of concern in specific locations, such as Willington, are not easily explained away by the proximity of a recognised source, when the same concern is not shown closer to the source. Objectively measured levels of ambient pollutants in fixed locations do not necessarily relate to residents' perceptions. For an individual, perception of air quality in the current location must be placed in the context of past experience of air quality in other places.

8 The Relationship Between Information, Perception and Behaviour

"Where is the Life we have lost in living?
Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?"

TS Eliot, "The Rock", 1934

8.1 Introduction

The top-down and bottom-up conceptual models suggest that individual perceptions of emergent environmental issues are important in influencing individual behaviour and hence affecting the implementation of policy and effecting change in the underlying physical system (Sections 3.4.8 and 4.5.3). If the role of individual perception is extracted from the top-down model (Figure 4.3), it can crudely be seen as in Figure 8.1.

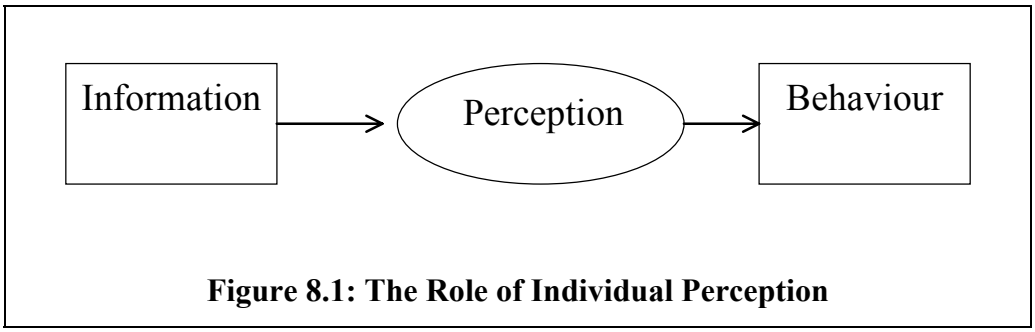


Figure 8.1: The Role of Individual Perception

The focus of this chapter will be to build on the data on perceptions of mothers in Oxford described in Chapter 5 and the "snap-shot" of perceptions of air quality in a number of locations in the Bedford area at a particular time (June-August 1994) established in Chapter 7 to investigate the interfaces between information / perception and perception / behaviour by investigating:

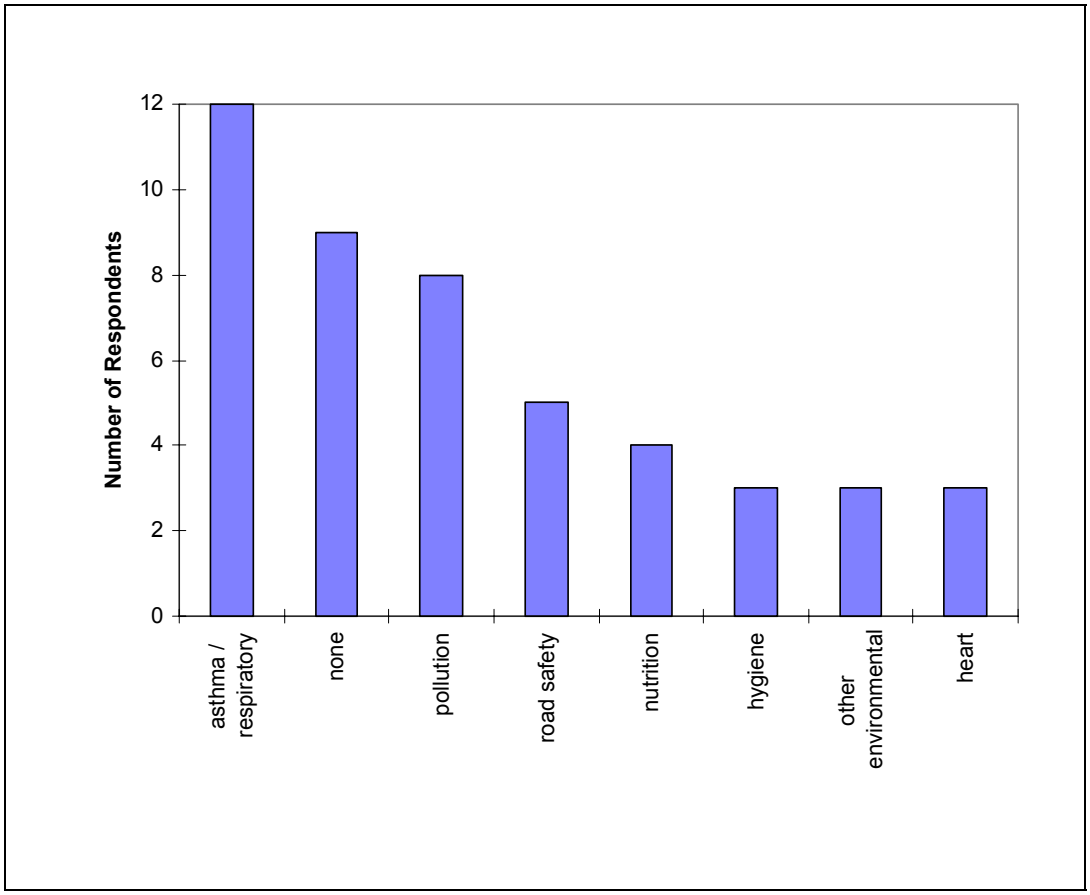
- levels of concern about air pollution and asthma, and the ways in which these vary between the two surveys and with respect to personal experience (Section 8.2)
- the sources of information on which individuals' perceptions of the main factors affecting local air quality are based (Section 8.4)
- individuals' perceptions of the main factors affecting asthma, and the sources of information on which these perceptions are based (Section 8.5)
- the ways in which individuals' perceptions of air quality affect behaviour (Section 8.6).

8.2 Differences in Perceptions of Health Issues Between Oxford Study and Household Survey

Responses to the question on health issues from the household survey (Section 7.3) were compared with those from the pilot study (Section 5.4.5), and were found to differ noticeably between the two surveys. In the pilot study, the largest single category of responses (8 responses) mentioned asthma as the major worry (see Figure

8.2). None of the remaining responses occurred more than four times, and air pollution was not mentioned at all. Respondents were asked to list up to three worries, and twenty four secondary and four tertiary problems were mentioned. Asthma was mentioned three times as a secondary worry, and hay fever once. Traffic pollution was mentioned six times among the secondary and tertiary worries, and industrial air pollution twice.

Figure 8.2: Issues Mentioned More Than Twice - Pilot Study



In the second survey, by contrast, 26 (9%) respondents mentioned pollution as their most important concern, while 11 (4%) respondents mentioned asthma or respiratory problems as their most important concern. When secondary and tertiary concerns are taken into account, air pollution was the most frequent response (other than "none"), mentioned by 37 (12.5%) respondents. Asthma or respiratory problems were mentioned by 20 (7%) respondents, of whom 14 have had experience of respiratory problems with current members of the household.

This higher degree of concern over respiratory disease may be attributable to the large proportion of the pilot study who have experience of respiratory disease among immediate family members (26 out of 34, or 78%, as against 60 out of 299, or 20%). However, even when this was taken into account, respondents in the pilot group were still more likely to mention asthma than those in the full survey (see Table 8.1). These differences suggest that concern over asthma and respiratory disease is not only related to experience within the family, but also has greater salience for those respondents who have close relatives likely to be in higher risk groups, e.g. small children and babies.

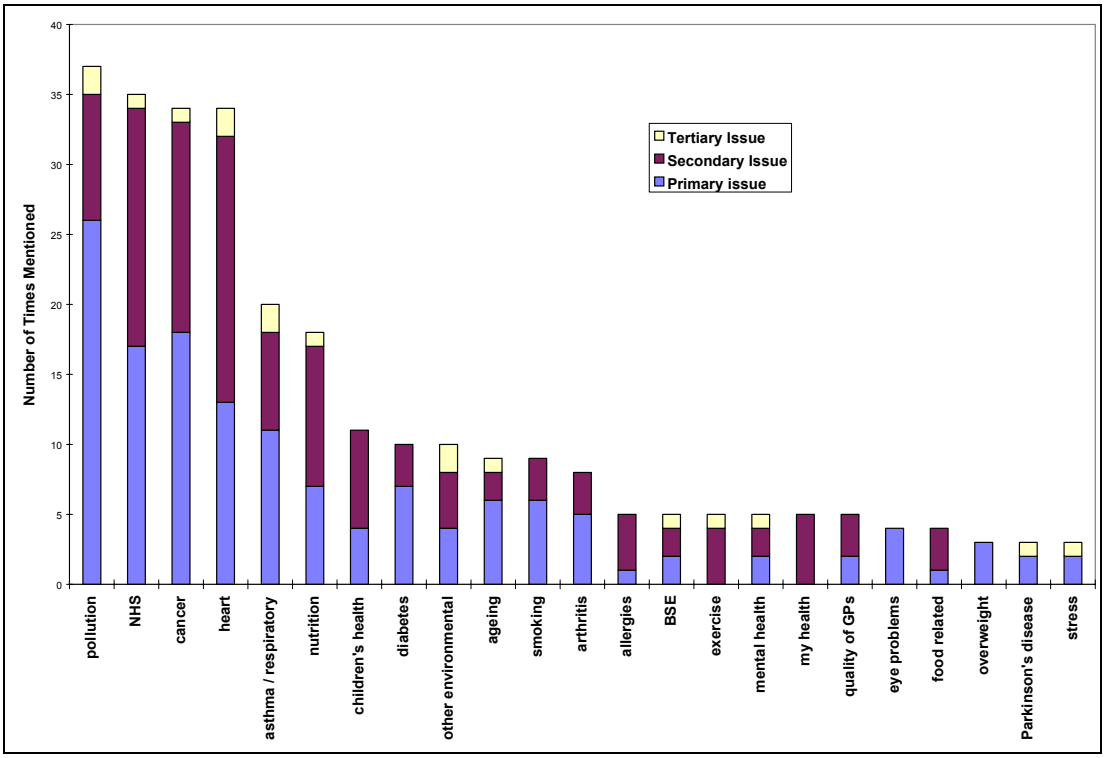


Figure 8.3: Issues Mentioned More Than Twice - Main Survey

Table 8.1 Experience Of Respiratory Problems For The Two Surveys

Pilot study	Asthma mentioned		No of		
	Yes	No	respondents	Yes %	No %
Respiratory problems in family	10	16	26	38.46	61.54
None in family	2	6	8	25.00	75.00
Total	12	23	34	35.29	67.65
Full survey	Asthma mentioned		No of		
	Yes	No	respondents	Yes %	No %
Respiratory problems in family	14	46	60	23.3	76.7
None in family	6	233	239	2.5	97.5
Total	20	279	299	6.7	93.3

8.3 Concern About Air Pollution and Awareness of Media Reports

The high salience of air pollution as a health issue may be due in part to considerable publicity in the media about ozone pollution during the period of the survey. This was investigated by means of the following question:

> *"Can you remember any programmes, articles etc. in the following media which have mentioned air quality? National press, Local press, National radio, Local radio, Magazines, Television."*

Respondents who could recall at least one report were coded with a 1, and those who could not with a 0. The percentage of respondents each day who were aware of media reports is shown in Figure 8.4.

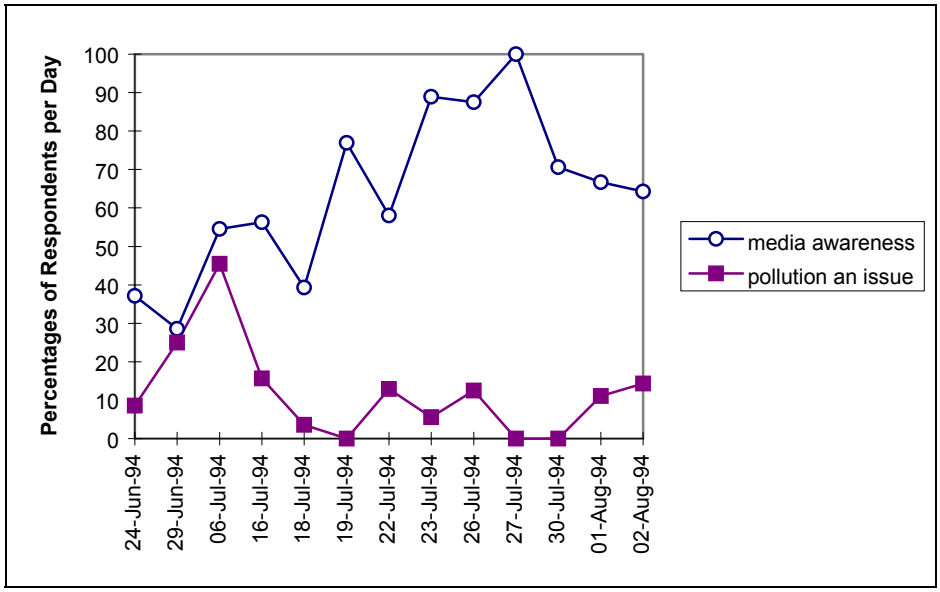


Figure 8.4: Level of Concern and Awareness of Media Reports Over Time

The evidence suggests that, while awareness of air quality issues continued to rise over the period, the main impact on health concerns was caused by coverage of pollution incidents at the start of the period, and that over time, other issues came back into the forefront of concern (see Figure 8.4). The implication of this for a policy which requires the interest and co-operation of the public is that, although air quality is clearly regarded as a "hot" issue, its salience may vary with the existence of other, competing concerns.
It will be recalled from Section 5.7 that this question about the long-term salience of media reports was also raised with respect to the Oxford mothers' awareness (or lack of it) of the air pollution monitoring system.

8.4 Sources of Information

As described in Chapters 5 and 6, the main policy strategy with regard to air pollution is to provide the public with information, in order to enable them to modify their behaviour appropriately. In this, the media, particularly the local media, are seen as an important route for putting information across and thus changing perceptions (see Sections 5.8 and 6.9).

Respondents to the survey of mothers in Oxford were asked whether they had tried to find out any more information about the health issues which they were concerned about, and if so, where from (see Question 3 of questionnaire in Appendix E). As mentioned in Section 5.8, the most frequent source mentioned was "the media", but this seemed to be a "catch-all" response.

The household survey attempted to investigate information sources in a more systematic way. Respondents were asked whether they had received any information about asthma and, separately, about air pollution:

"Have you ever tried to find out any information about asthma? If yes, where did you look/ask? Why did you ask for this information?"

"Can you remember any programmes, articles etc. in the following media which have mentioned asthma? National press, Local press, National radio, Local radio, Magazines, Television."

"Have you ever received any information about asthma from the following sources? Your doctor or other health professionals. Friends or relatives. Books. School or college? Other."

Of the 301 respondents, 32 had actively sought information about asthma, of whom 27 had experienced respiratory problems with current members of household, 3 had had experience with family members in the past (though not current members), 1 was a teacher, and 1 worked in a hospital. Thirty three respondents who had had experience of respiratory problems with current family members had not actively sought information.

One hundred and eighty respondents had received information about asthma from outside sources, or could remember seeing information about asthma in the media. The most commonly cited sources were television (27% of respondents), national press, (23%), magazines (16%), doctor or other health professionals (13%) and friends or relatives (13%) (Figure 8.5).

Similar questions were asked about air quality:

"Have you ever tried to find out any information about air quality? If yes, where did you look/ask? Why did you ask for this information?"

"Would you like to have more information about air quality? What would you do if you wanted to find out more?"

"Can you remember any programmes, articles etc. in the following media which have mentioned air quality? National press, Local press, National radio, Local radio, Magazines, Television."

Ten respondents (3%) said they had tried to find out more, but none had asked the Environmental Health Department. One hundred and sixty respondents (53%) said they would like more information, of whom 14 (5%) said they would ask the Environmental Health Department, and another 15 (5%) said they would ask "the Council".

One hundred and thirty two respondents (44%) were aware of at least one item in the media concerning air quality, of which 48% referred to TV, 22% to national press, 12% to national radio, 6% local radio, 5% magazines and 4% local press.

Figure 8.5 shows the breakdown of media reports mentioned for asthma and air quality. The main difference between the two types of report is that television, the main medium for each subject, is more significant for air quality than for asthma, with 49% of reports. National press is slightly more significant for asthma (28% as against 23%) and magazines are also more significant for asthma (19% against 5%) but all other media are consistent between the two topics.

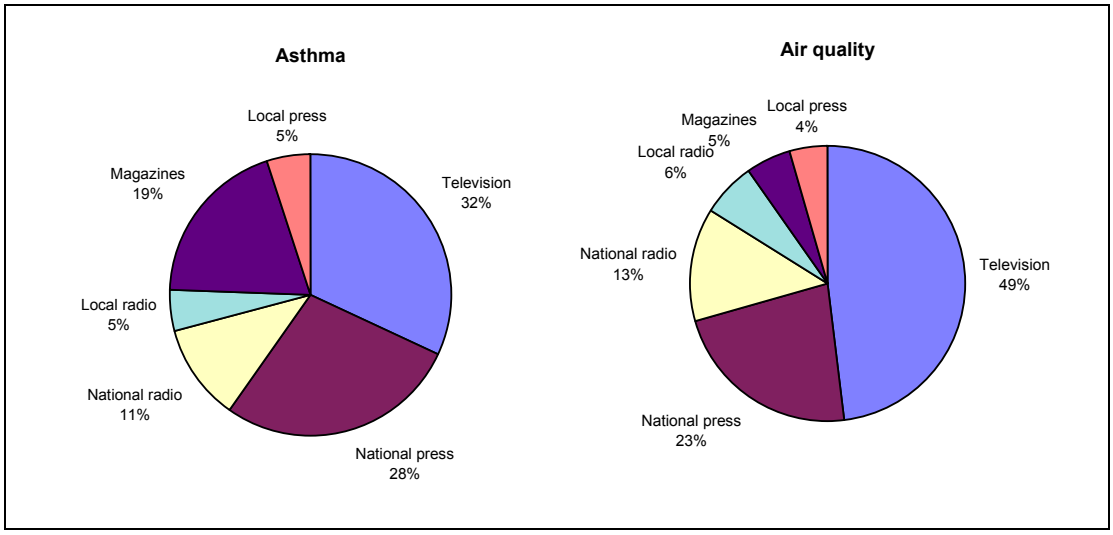


Figure 8.5: Breakdown Of Media Reports Remembered

For the broadcast media (television, national and local radio), reports on air pollution were split further between "news" items and regular bulletins. For local radio, 80% of reports mentioned were regular bulletins, and for television 75%, although for national radio reports only 40% were bulletins.

The results therefore indicate some differences of information sources between the two topics, with regular bulletins important for awareness of air pollution.

8.5 Perceptions and Experience of Asthma

It will be recalled from the bottom-up conceptual model in Section 4.5.3 that it is an individual recipient's perception which determines how a physical "impact" becomes constructed as an "outcome", and hence may or may not lead to a "response", i.e. a change in behaviour (see Figure 4.9). One aim of the survey was to investigate the respondents' perceptions of "asthma", and the ways in which those perceptions related to personal experience and information from outside sources.

One issue which arose from the Oxford study was a disparity between those factors which respondents identified as triggering asthma when asked the question:

> *"Are you aware of any factors which are thought to cause asthma or make it worse?"*

and the triggers which those who had experience of respiratory problems in the family mentioned as making the problem worse. Figures 8.6 and 8.7 show the observed triggers and perceived factors mentioned by those respondents who had experience respiratory problems. Although colds were mentioned as the trigger which most frequently brought on asthma (7 out of 26 respondents), the factors most often mentioned as potentially affecting asthma were pollution and dust (10 out of 26 respondents).

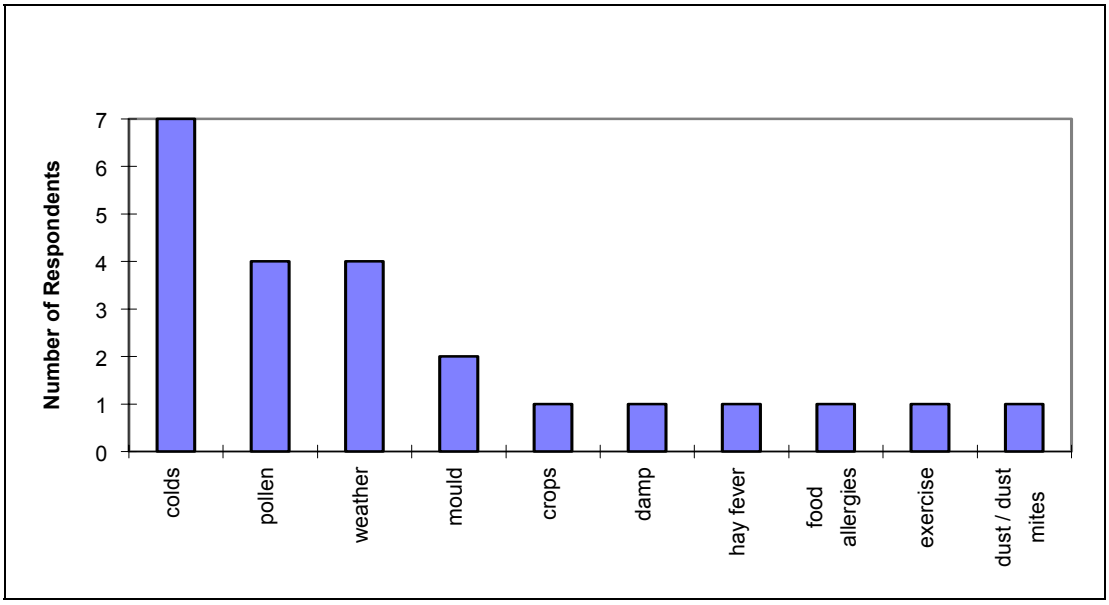


Figure 8.6: Observed Triggers (Pilot Study)

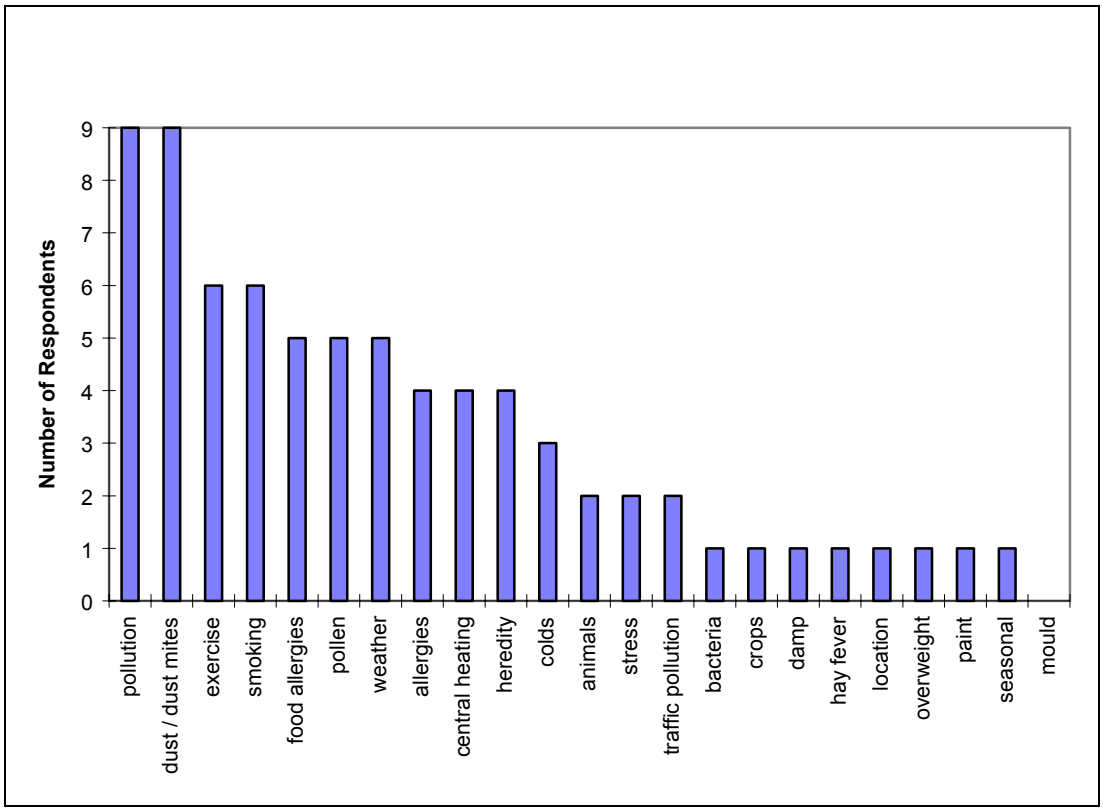


Figure 8.7: Perceived Factors (Pilot Study - Respondents with Respiratory Experience Only)

When the pilot study data were analysed, this disparity between the perception of triggers which may bring on asthma in a general sense and the specific factors which respondents have observed from personal experience was a surprising result which it was thought might repay further investigation. However, it seemed possible that this result might be an outcome of the order of questioning, in that respondents might not

wish to repeat any factors which they had already mentioned, and thus would try to think of different ones. The questionnaire for the main study tried to avoid this problem by asking general questions about asthma first, and then moving on to asking sufferers specifically about their experience.

All respondents, whether or not they had experience of asthma, were asked to mention any factors which they were aware of as potentially triggering asthma (see Table 8.8):

> *"Do you know of any specific factors which may bring on an asthma attack?"*

In addition, those who had experience of asthma were asked to say what factors they had observed to make it worse (see Table 8.9):

> *"Have you noticed any particular activities, weather conditions, times of day etc. which seem to make the problem worse?"*

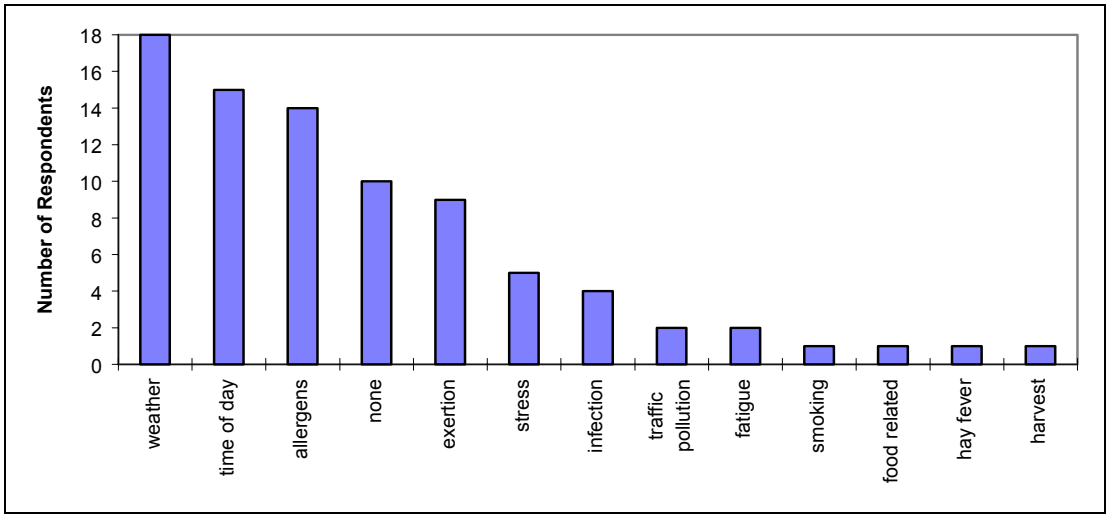


Figure 8.8: Observed Triggers (Household Survey)

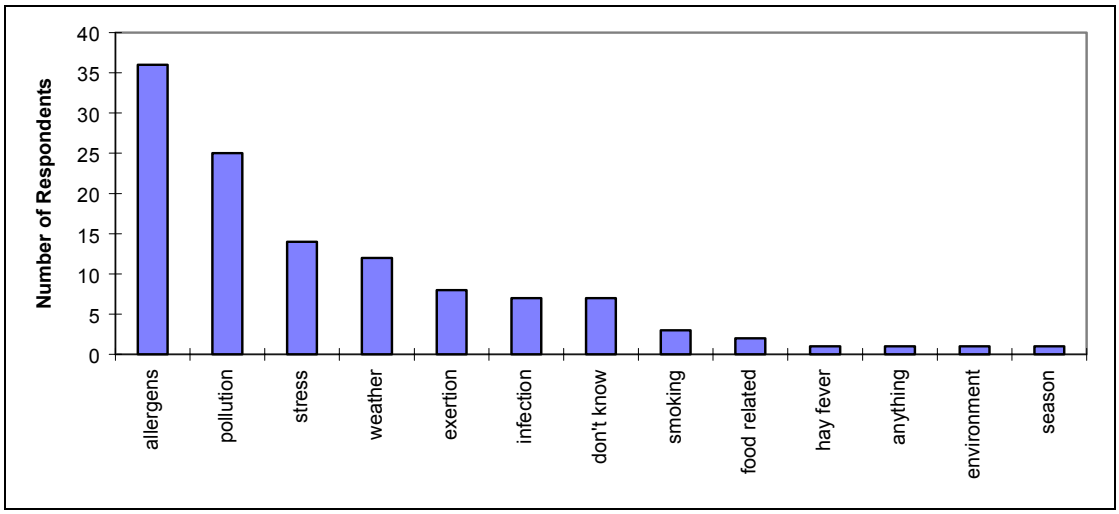


Figure 8.9: Perceived Factors (Household Survey - Respondents with Respiratory Experience Only)

The two main factors perceived as affecting asthma were allergens (29%) and pollution (23%). This was consistent over all respondents, whether or not they had direct experience of respiratory problems.

However, when respondents with experience were asked which factors made the problems worse, "weather" was most frequently cited (27%), while pollution was only mentioned by 3%. Types of weather mentioned include hot weather (7%), very cold or very hot (3%), humidity, and heavy conditions (6%), damp and changes in the weather.

The failure to mention pollution as an observed factor may be due to its "invisibility" (i.e. sufferers may not be aware of it). On the other hand, the significance of the weather in triggering attacks may be due to increased levels of pollutants associated with certain weather conditions.

Respondents with experience of respiratory problems were also asked at which, if any, time of year the problem was worst. For 37% of sufferers, the problem is not worse at any particular season, but for the rest, the most significant season is summer (32% affected) as against 13% affected for winter.

This association of respiratory problems with summer and hot weather may be due to either agricultural / natural sources of allergens (i.e. pollen), or photochemical pollution.

8.6 Perceptions and Behaviour

The household survey looked at the relationship between perception and behaviour on a number of levels:

- the number of respondents who were planning to move house in relation to air pollution
- the number of respondents who had changed their behaviour in response to perceived air pollution problems
- the number of respondents who had complained about air pollution

8.6.1 Moving House

This issue was addressed through the following questions:

> *"Do you expect to stay at this address for the next 2/3 years?"*
>
> *"If no, why do you expect to move?"*

No respondents from the sample of 300 were planning to move in response to air pollution.

8.6.2 Avoiding Certain Behaviours

The question:

> *"Have you ever refrained from any outdoor activity because you were worried about air quality? Please describe."*

received a positive response from seven respondents (see Table 8.2).

Table 8.2: Respondents Who Had Refrained From Outdoor Activity

Location	Comment
Embankment	When we moved here I wouldn't go out because of the smell in the area
Goldington	Six weeks in the year, June-July, I have to be careful because of hay fever
Goldington	I walk more slowly in London
Kempston	In London, I avoid going there now, partly because of the air
Kempston	Too much farm smells in Wootton
Sharnbrook	If I see a plane spraying crops, or smell it, I steer clear of it
Willington	We cycle and will not cycle into Sandy because of the traffic fumes, there is no cycle track

Two of the responses referred to London rather than the local area, while two referred to odour. Of the remaining three responses, one specifically linked the air quality issue with hay fever, while the other two mentioned particular pollution sources, i.e. crop spraying and traffic.

8.6.3 Complaining About Air Quality

The following questions were asked:

"Have you complained to anyone about air quality? If yes, who to?"

Four respondents replied positively, three of whom lived in the Goldington Rd area, and one in the Embankment area, (See Table 8.3).

Two of the complaints were concerned with sewage smells. All the complaints were made either to local authorities (county or district) or to the water authority. Interestingly, when asked to give their assessment of local air quality on a scale of 1 to 5, two of the complainants assessed it as "average" (3), and one thought it was "good" (2). Out of 77 respondents who said they thought local air quality was "bad" (4), only one had actually complained, while none of the 7 respondents who thought it was "very bad" (5) had done so. These results raise questions about the effectiveness of environmental health complaints procedures in reflecting public concerns about air quality and addressing potential problems.

Table 8.3: Respondents Who Had Complained About Air Quality

Location	Complained To	Evaluation of Pollution
Embankment	County Council	4
Goldington	Anglian Water Authority	3
Goldington	the planning authority	3
Goldington	council about sewage smells	2

These results therefore suggest that, despite the apparently high levels of concern about air quality, these perceptions do not strongly influence behaviour. This issue will be returned to in Section 10.4.

8.7 Conclusions

This chapter has looked at individual perceptions of air pollution and asthma, the ways in which they vary, the sources of information on which they are based and the ways in which they relate to behaviour.

The comparison of the most frequently mentioned health issues showed significant differences between the two surveys (see Section 8.2), raising questions about the factors contributing to individual appreciative systems with respect to health issues. Possible sources of variation might be:

- geographical (Oxford vs North Bedfordshire)
- temporal (October 1993 vs July 1994)
- demographic (mothers of small children vs general population)

It is not possible to say from the data which (if any) of these factors is responsible for the difference, although it seems likely that all are in some way involved.

Public awareness, or lack of awareness, of sources of information about asthma and air pollution raises questions about the effectiveness of information provision as a strategy. Although awareness of air quality bulletins on the television and radio in the household survey was fairly high, there was little awareness that more local information could be obtained from Environmental Health (see Section 8.4), even though information provision is seen by both national and local government as a major strategy for managing air quality. This issue will be returned to in Chapter 9.

Turning to asthma, measured levels of prevalence of the disease do not necessarily reflect the impact which it has on individuals' lives. The difference identified in Section 8.5 between responses to questions about factors which trigger asthma as opposed to those which the sufferer has observed to be significant raises intriguing questions about the role of personal experience relative to "common knowledge".

In addition, the evidence discussed in Section 8.6 suggests that high levels of concern about air quality do not at present induce individuals to change their behaviour. As was discussed in Chapter 4, it seems likely that this is because of the pressure of other constraints affecting the decision spaces of the individuals concerned. This is an area where further investigation is needed, and will be returned to in Chapter 10.

Chapter Nine

9 Hierarchical Aspects Of Emergence - Scale, Hierarchy And Perceptual Difference

"...he who wishes to see a Vision; a perfect Whole
Must see it in its Minute Particulars ...
For Art and Science cannot exist but in minutely organized Particulars."

William Blake, "Jerusalem, The Emanation of the Giant Albion", 1820

9.1 Introduction

An emergent system, as described in Chapter 2, can be defined as:

> *"A co-evolving, hierarchically arranged set of relationships between components and subsystems, existing in overlapping hierarchical relationships with other systems; which can be recognised in combination as generating qualitatively new, unpredictable and unintended phenomena and relationships, and which has not overall been designed by human agency, although some of the components and subsystems may have been human-made"* (Section 2.10).

It will be recalled from Section 4.5.2 that the interlinked processes of change which compose the top-down conceptual model described in Chapter 3 and depicted in Figure 4.4 operate at the macro level, but arise from the aggregation of large numbers of low-level changes. While the aims of management may be to control the high level emergent impacts, for example through setting targets for air quality, change can only be implemented at the individual level.

In Section 4.5.4, it was proposed that the present thesis would address the relationship between hierarchical levels, focusing on the perceptions of actors / observers / recipients, in order to establish similarities and contrasts between the perceptions of individuals at different positions in the hierarchy. A series of questions to be addressed in the research was identified:

- What are the significant components and sub-systems of the emergent system, and the other systems in which they are hierarchically embedded?
- What are the perceptions of actors at the institutional level, and how do they vary?
- What are the perceptions of actors at the individual level, and how do they vary?
- What are the similarities and differences between perceptions of actors at the institutional and individual levels?

The first three questions have been considered in Chapters 5, 6, 7 and 8. The aim of the present chapter is to describe the hierarchical positions of the actors and individuals involved in the field work, and investigate the relationships between the hierarchical levels by looking at the lack of congruity between the "institutional" world, as described in Chapter 6, and the "individual" world, as described in Chapter 7.

The structure of the chapter, which reflects that used in Chapter 5 for analysis of the pilot study, is as follows:

- description of the hierarchical position of the main institutions and the public, and the relationships between them (Section 9.2);

- analysis of the different definitions of "the problem" as interpreted by the environmental health officers and the public (Section 9.3)
- differences in spatiality of concern between the hierarchical levels (Section 9.4);
- differences in attitude to objective measurement, perception and the use of data between the hierarchical levels (Section 9.5)
- the issue of communication between the "institutional" and "individual" levels of the hierarchy ("policy makers" and "public"), and the importance of this relationship in the process of perceptual emergence (Section 9.6).

9.2 Hierarchical Position of the Relevant Institutions

It will be recalled from Chapter 5 that, in the case of the "traffic pollution and respiratory health" system, different sub-systems (the "traffic", "air pollution" and "respiratory health" subsystems) are the responsibility of different institutional bodies ("transport planning", "environmental health" and "public health" respectively.) Each of these agencies is in turn embedded in a different hierarchy of functional institutions, leading to fragmentation of efforts at managing the system. Figure 9.1 illustrates the main lines of responsibility for these three major subsystems.

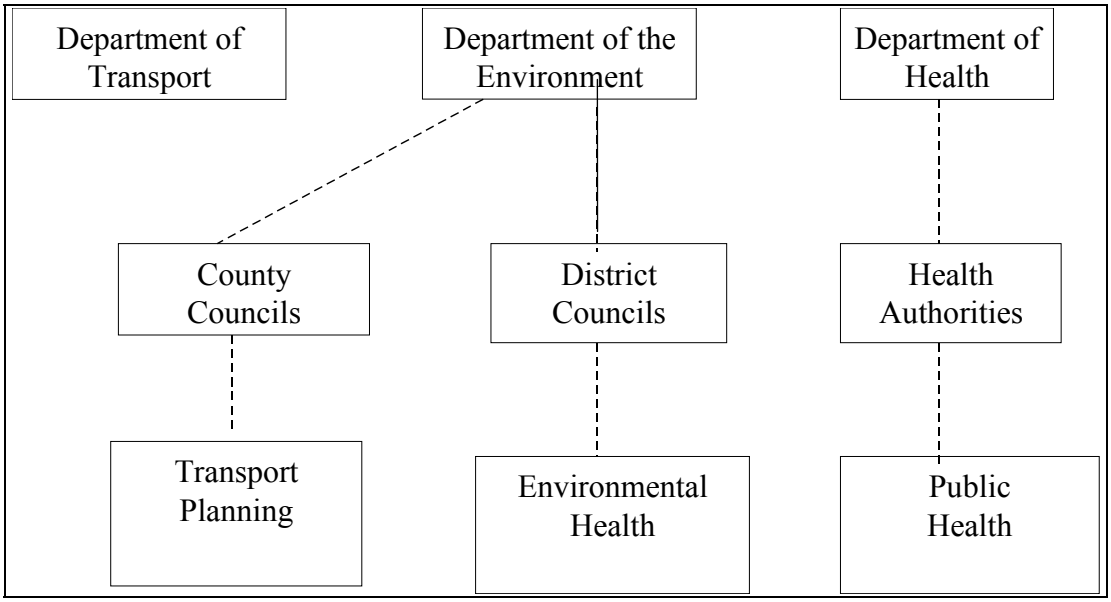


Figure 9.1: Institutional Responsibilities for Traffic, Air Pollution and Respiratory Health

One significant point which is clear from the diagram is the lack of a direct connection between the Department of Transport and the county councils - in other words, the body responsible for national transport policy does not have a direct relationship with those bodies responsible for local implementation of transport policy. It will be recalled from Chapter 6 that the nature or, rather, the perceived lack, of national transport policy, was seen as a major problem in the management of air quality (Section 6.9). However, as mentioned above, the local authorities are not directly responsible to the Department of Transport, but to the Department of the Environment. The central government's ambivalent attitude towards air quality management - effectively passing responsibility for local air quality to local

authorities, without providing adequate guidance or finance (see Section 3.3.3 and Cannibal, Lemon & Longhurst, 1996) is also a cause for concern.

In addition, the local authorities are not only responsible to central government, but also exist within a local political context, and are subject to pressures from both sides (Jones, 1985). Local authority officers are involved in a complex web of relationships with both elected members and residents (see Figure 9.2 and Sections 5.8 and 6.9), particularly, as was noted in Chapter 6, in the case of the environmental health department, whose role in reacting to complaints brings them into direct contact with the public.

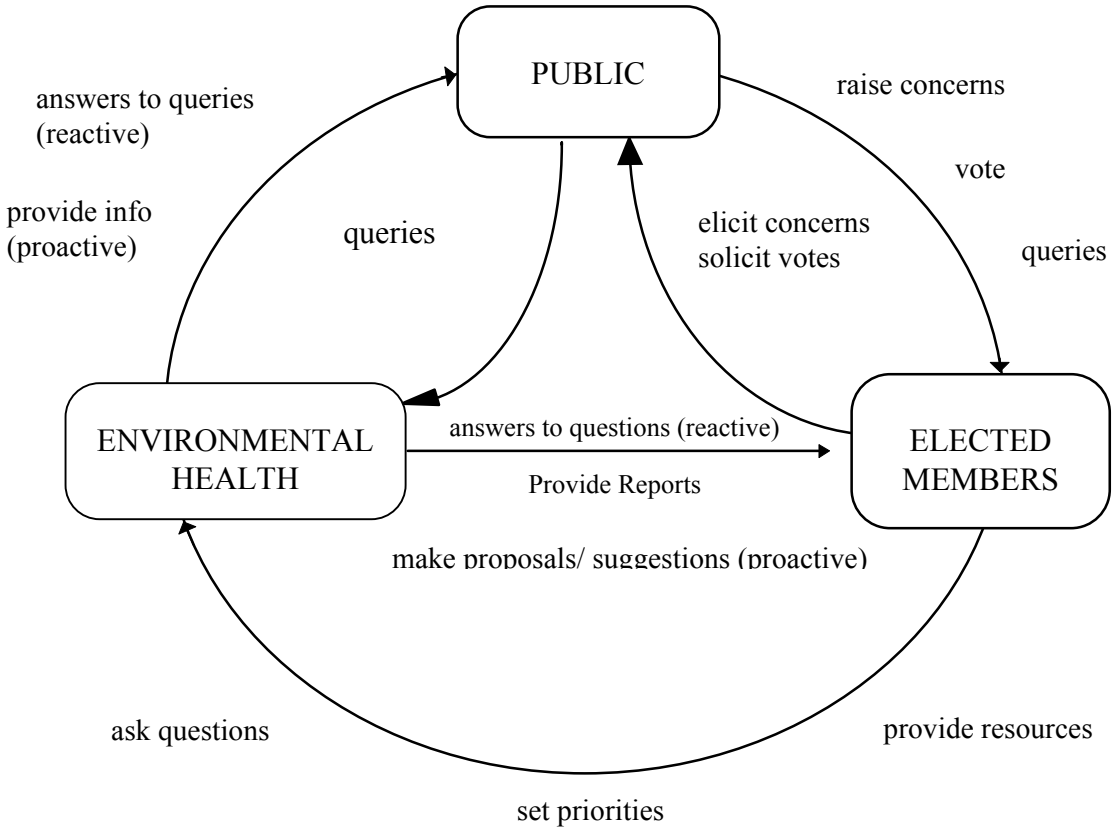


Figure 9.2 : Relationships Between Environmental Health Officers, the Public and Elected Members

In general, the environmental health departments have no control or remit over the main causes of pollution, even in their own area. While individual local authorities may have some control over traffic management in their own town centres, there is no regional body which has responsibility for the motorways and trunk roads which pass through Bedfordshire and Hertfordshire, not to mention the migration of traffic pollution from outside the region.

National transport policy, particularly with respect to road building and motorway widening, is crucial to air quality. Local government re-organisation is also likely to have an impact on the region, changing the status and the balance of urban and rural areas within some districts, and producing an atmosphere of uncertainty about the future.

The remainder of this chapter will look in more depth at the perceptual differences between the environmental health staff, as discussed in Chapter 6, and members of the public, as discussed in Chapter 7.

9.3 Definitions Of Air Quality

In the household survey, questions about influences on air quality revealed a very broad range of perceptions of the meaning of "air quality". As mentioned in Section 7.6, responses to the question:

> *"What do you feel are the major influences on air quality locally?"*

were not necessarily expressed in terms of recognisable sources of pollution. Topographical features, such as: *"we're on a hill",* or, alternatively, *"we're in a dip",* were mentioned, as well as distance from the sea and the proximity of both built-up areas and fields and open spaces.

When more conventional sources of "pollution" were identified, as well as major point sources such as the brick works, and the problem of traffic, landfill odour, agricultural sprays and pollen were all mentioned as significant.

However, questions directed at the EHOs about sources of pollution in their districts revealed a far more limited view. Apart from the ubiquitous traffic, concern was focused heavily on those point sources which lay within local authority control, the "prescribed process". Even here, distinctions were made between those controlled by the local authorities and those controlled by HMIP. Definitions of the problem and of impacts on air quality were dictated by institutional responsibility. Although landfill was mentioned by some respondents, for example Watford and South Beds (See Section 6.4), this was within a context in which the landfill was seen as a contaminated land problem, another responsibility of the environmental health department, but not related directly to ambient air quality. Agricultural emissions and pollens were not mentioned by any respondents, in contrast with the public survey.

The role of traffic pollution within the perceptions of the EHOs is interesting. While seen as something which they are not able to control within their own districts, and hence something which they do not have institutional responsibility for, it is universally recognised as the most significant source of pollution in the region. Here the temporal aspects of emergence enter into the situation. Those factors which were regarded as being most significant in the past, i.e. industrial point sources, are well managed within present institutional structures, and no longer seen as causing significant problems. However, the issue which does cause the most significant problems from the point of view of the EHOs, i.e. traffic, is the one over which they have at present no jurisdiction (see Section 9.2).

9.4 Perceptions of Spatial Scale

As will be recalled from Section 6.6, the physical characteristics of air pollution dictate the need for the problem to be managed at a larger scale than the local authority districts. The natural system which is being "managed" has boundaries which are dictated not only by anthropogenic factors such as patterns of settlement and traffic flows, but also by natural processes such as climate, dispersal of pollutants and atmospheric chemistry.

Over half (8 out of 13) of the respondents involved in the survey of environmental health staff were conscious of this and keen to be involved in development of a regional strategy for air quality management (see Table 6.8).

However, it was also noted that such an approach would require the pooling of resources by individual authorities for a regional benefit. The resources available for monitoring and managing air quality within each district are determined by a process of political negotiation involving officers, members and residents, dictated partly by the perceptions of the individual participants and collective perceptions of the nature of the problem locally, local media representation of the problem, and local politics (see Sections 6.5 and 9.2). As was discussed in Section 6.6, it was suggested that the spatial concerns of councillors are unlikely to extend beyond the administrative boundaries of the district.

There is thus a conflict between the scale dictated by the physical system, and that dictated by the political and administrative system in which the environmental health departments are also hierarchically embedded. However, when the scale of concern of individual members of the public is investigated, a far more immediate scale is apparent. It will be recalled from Chapter 7 that when questioned about local air quality, members of the public define their area of concern in highly localised ways.

Air quality is not seen as a district problem, let alone a regional problem, but as a neighbourhood problem. Consideration of perceptions of significant influences on local pollution are significant in this regard. As mentioned in Section 7.6.3, even small areas of open space, such as parks and school playing fields, are regarded as having a positive impact on air quality.

Analysis of the responses by location revealed “hot spots” of concern, such as Willington, where 11 respondents out of 30 identified air pollution as a health issue, the highest for any location in the survey, and 20 respondents mentioned the brickworks as an influence on local air quality. From the survey results, it is not possible to tell whether this localisation of concerns is attributable to physical factors affecting the concentration of pollutants in the area; the existence or otherwise of competing concerns; or the effects of shared perceptions due to proximity, social interaction and the exchange of information, experience, hearsay and village gossip. However, one might speculate that all these factors could have a part to play.

9.5 Measurement, Perception and the Use of Information

As will be recalled from Sections 5.6 and 6.7, growing levels of public awareness and concern, and the need to be able to provide both real-time health warnings and general information about local conditions, (even if only to reassure residents that conditions are good) were cited most frequently by the environmental health staff as reasons for monitoring. However, this was also widely seen as a weakness in present systems, since the information is not timely enough, and also because of the scientific uncertainties involved in relating pollution data and health data, and the time and effort involved in providing meaningful information to the public:

Monitoring of ambient pollutants is seen by the EHOs as the central approach to management of the traffic pollution problem. The accumulation of data is seen both as a way of increasing understanding of the problem in order to reduce scientific uncertainty, and providing a service to the public, with the ultimate aim of encouraging people to change their behaviour.

The study described in Chapter 5 highlighted the gap in the relationship between the local authorities and the public. The environmental health department see collecting and disseminating air quality data as a crucial part of their role in managing the system. However, the mothers were unaware of the information available, and sceptical about its value.

These findings are reinforced by the later studies. "Getting the message across" to the public is seen by the Environmental Health Officers as a major concern and justification for monitoring work. However, the public survey showed low levels of awareness of local authority provision of air quality information, despite the high level of concern about air pollution as a health issue (see Section 8.4). Although over half the respondents said they would be interested in receiving more information about air quality, only 5% were aware that it could be obtained from the environmental health department, and of the ten respondents who had actually tried to find out more information, none had consulted environmental health.

9.6 Communication Between the Local Authorities and the Public

The government's White Paper, "Air Quality: Meeting the Challenge", published in 1995, stated that:

> *"The Government has .. reviewed its public information arrangements in the light of its proposals for a new framework of air quality standards... The key aims of the proposals are to make air quality information as accessible as possible to the public; to provide a consistent framework for describing levels of air pollution, related directly to the new standards, and to action which members of the public may be advised to take;* ***and to promote provision of local air quality information to reinforce local air quality management****.*
>
> *An important part of the Government information service is provision of advice at different levels of pollution, and in particular, when air quality becomes 'poor' or 'very poor' according to the current system. ...* ***The Government will be considering how to improve the effectiveness of information, to target advice and to encourage more people to take appropriate action in episodes."*** (DoE, 1995, Part Six: Monitoring and Public Information, p30, emphasis added.)

Recent legislation also recognises the importance of disseminating air quality information. The 1995 Environment Act (see Section 3.3.3) refers to the need for regulations to make provision:

> *"for or in connection with the communication to the public of information relating to quality for the time being, or likely future quality, of the air."* (Environment Act, 1995, Part IV, Section 87.2(k), p111).

However, the meaning of the information when (or if) it reaches an individual member of the public, is often neglected. As discussed in the previous section, evidence from both the pilot study (see Section 5.6) and household survey (see Section 8.4) suggests that the public are often unaware of the information which is available, and unable, or unwilling, to modify their behaviour in response.

A gap exists between the perceptions of the local authorities, who recognise that they have a duty to collect and disseminate information on air quality, and the general

public. Individuals may wish to know more, but find the information available confusing, or may simply be unaware of it.

> *"You can look at Teletext and see that the air quality's poor, but nobody tells you what the hell to do about it. So, what do you do? Do you go to work wearing a mask, what?"* (EH5, 352-355).

The existence of the "information gap" has been officially recognised for some time. In 1993, the Quality of Urban Air Review Group reported:

> *"Although the DOE has increased the dissemination of air quality data to the public through the provision of a freephone line; through CEEFAX; and through the printed and broadcast media, no study has been carried out as to the effectiveness of the current presentation. Research should be undertaken to establish the effectiveness with which the data are being communicated."* (QUARG, 1993, p27, Section 2.15).

> *"Public alert systems allow sensitive individuals to avoid exposure to outdoor air pollution. There is, however, a need to assess the effectiveness with which the data are being communicated and the impact on driving behaviour of requests to curtail unnecessary journeys."* (QUARG, 1993, Executive Summary and Principal Recommendations, page vi).

Official and local authority concern in this area has been concentrated on the provision of the information, with little attention paid to the potential uptake, relevance and impact on individual behaviour. The process of disseminating information can be regarded as having three major elements: the source of the information, the transfer process (message / medium) and the audience. As described above, much attention has been focused on the first two elements, at the expense of the third. In parallel with the process of technological innovation, this can be seen as a "supply push" rather than "demand-pull" approach (Rothwell, 1992), with little attention paid to the receptivity of the audience (Seaton & Cordey-Hayes, 1993). An evaluation of international environmental technology databases found that initiatives to supply information on clean technologies suffer from lack of demand for the information, and commented: "*... current practice ... has seen information provision initiatives established in isolation because they are a relatively easy and high profile option."* (Hooper & Jenkins, 1995).

Research on public perceptions of sustainability indicators in Lancashire has demonstrated the gap between individuals' concerns and decision-makers' attempts at delivering the message of sustainability (Macnaghten et al, 1995). Current research with both local authorities and commercial companies identifies the need to develop a "sense of audience" in the provision of environmental information (Stubbs & Lemon, 1996).

9.7 Conclusions

Comparison of the different aspects of the field work reveals significant differences in perspective between the institutional actors within the local authorities and the public.

The environmental health officers define air quality problems according to their institutional definitions, relating to those aspects of the problem for which they are

responsible. The public, on the other hand, have a far broader perception of air quality.

A significant difference between the two groups lies in perception of the scale of the problem. The local authorities are concerned with institutional boundaries, and air quality as it affects their district as a whole. This concern with institutional boundaries was also apparent in the differences between the institutions in Chapter 5.

In addition, because the physical boundaries of the system of pollution generation lie outside those of the individual district, the EHOs are concerned with extending the boundaries and looking to regional control of air quality. The public, on the other hand, are more concerned about their immediate locality.

The sources of pollution which are mentioned also reveal a different set of definitions and understanding of air quality between the public and the EHOs. The definitions used by the EHOs tend to be limited by their responsibilities, with concerns centred initially on prescribed processes, although the interest in traffic as a source of pollution suggests a change of emphasis in response to the emergent problem.

This conflict between perspectives is fundamental. The success of a strategy of providing health warnings depends crucially on the public's awareness of sources of information, on their perceived relevance, and on the ability of the individuals to respond by changing their behaviour. Public perceptions of air quality are therefore of great importance, in addition to the question of providing a democratic mandate to the local authority to act on the public's behalf. While institutional priorities and the nature of the physical system dictate the need for local authorities to adopt a district or even regional perspective, at the same time, the individuals are right to look at things in their own personal terms, because their priorities and agendas are dictated by what affects their lives directly.

Finally, the emphasis on information provision as a means of modifying behaviour and hence tackling the generation of pollution is in danger of concentrating on the technical means of accumulating and disseminating information without considering the receptivity of the public to such information. Approaches which concentrate on the provision of information may be patronising, or manipulative, and based on assumptions of a single rationality, while ignoring the realities of individual experience, priorities and agendas.

10 Investigating Emergence: Insights, Methodological Difficulties and Implications

"There is something between the gross specialised values of the mere practical man, and the thin specialised values of the mere scholar. Both types have missed something; and if you add together the two sets of values, you do not obtain the missing elements. What is wanted is an appreciation of the infinite variety of vivid values achieved by an organism in its proper environment. When you understand all about the atmosphere and all about the rotation of the earth, you may still miss the radiance of the sunset. There is no substitute for the direct perception of the concrete achievement of a thing in its actuality. We want concrete fact with a high light thrown on what is relevant to its preciousness."

Alfred North Whitehead, "Science and the Modern World", 1926

10.1 Introduction

This thesis has been concerned with processes of change in those aspects of physical systems which impinge on human existence and are frequently referred to as "the environment". It has argued that such changes do not exist in isolation, but in complex, co-evolutionary relationships with other change processes, in human knowledge, perception, institutions and behaviour (Chapters 3 and 4). These processes may be moving at different temporal and spatial scales, (van der Leeuw, 1995), but change exists, and the changes are interlinked. While some of the repercussions of a particular change may appear predictable, perhaps even inevitable, when viewed from the perspective of one "change process", e.g. that providing additional lanes on a motorway will reduce congestion and increase the rate of flow-through, thus reducing pollution, it may in turn produce other changes which act as triggers in other systems, generating further changes and repercussions.

Conventional approaches to such problems focus on breaking them down into solvable sub-problems, identifying cause and effect relationships, and solving the sub-problems (Chapter 4), but without regard to what responses or outcomes might be generated. In order to create solvable problems, the "system of interest" must be isolated from its "environment". But if the individual processes or components which make up the system of interest are also embedded within other hierarchical systems, pressures from within those hierarchies will impose limits and imperatives on what can / cannot / must be done.

This thesis has introduced the expression "overlapping hierarchies", in preference to "nested hierarchies", as used by complex systems scientists. The idea of "nesting" holds the implication that each level of the hierarchy is completely contained within the one above. It has been argued here that what is of interest is the sub-systems which may be contained in, and subject to pressures from, a number of separate hierarchies, which are not necessarily related or subsumed under any higher level hierarchy. Emergent systems arise in situations where one sub-system of interest may be of high significance within one hierarchy, but low within another.

Within a context of overlapping hierarchies, while processes of physical and knowledge emergence are important, the driving force behind change is perception

and perceptual emergence. The physical effects may accumulate, but unless and until a trigger occurs which stimulates a major shift in collective perceptions, it will not lead to changes in policy, institutional arrangements or behaviour (other than on an individual and eccentric scale).

Perceptual emergence is concerned with dynamic processes of learning, and with the tension and mutual interaction between individual and aggregate appreciative systems. However, perceptual emergence does not necessarily and inevitably imply the attainment of a "consensus", as multiple constituencies and multiple appreciative systems cannot always be reconciled. Rather, the occurrence of a trigger event may bring conflicting views and discourse to the point where the phenomenon becomes an "issue", and hence a stimulus for debate and policy change.

The approach in this chapter will be to assess the extent to which the three reserach objectives identified in Section 1.5 have been met (see Table 10.1). The thesis will then conclude by suggesting some areas for further research (Section 10.6).

Table 10.1: Structure of Chapter Ten, and Relationship to Research Objectives

	Objective	Discussion	Section
1	Build a conceptual framework for the investigation of emergent systems, leading to a conceptual model of the process of emergence .	Apply the top-down conceptual model described in Section 3.4 to the issue of traffic pollution and respiratory health	10.2
		Show how the concepts of overlapping hierarchies, multiple perceptions and perceptual emergence have contributed to the understanding of the issue	10.3
2	Develop and apply a method for research into emergent systems,	Discuss the strengths and weaknesses of the method used, and methodological difficulties of investigating emergent systems.	10.4
3	Identify and explore the management issues resulting from emergent phenomena.	Discuss some implications for management and policy making.	10.5

10.2 Applying the Top Down Model to Traffic Pollution and Respiratory Health

This section will look at the issue of traffic pollution and respiratory health in terms of the top-down conceptual model described in Section 3.4.

The existence of physical changes to the atmosphere attributable to motor vehicle emissions, particularly in the form of increased levels of tropospheric ozone, are well recognised and documented (Chameides, 1994; Seinfeld, 1989). This recognition and documentation is part of the process of knowledge emergence. While the potential for health effects of vehicle pollution has long been recognised, the accumulation of knowledge about the issue has accelerated in recent years, as indicated by Figure 4.2 in Section 4.3. The process of knowledge emergence has not occurred in direct response to the physical changes, but because of increased perception of the issue leading to increased levels of investment in research, as indicated by the creation of research bodies, networks and initiatives such as the Health Effects Institute, IEH, EPAQS and COMEAP. High levels of perception are illustrated by results from the household survey, and media campaigns and reports (e.g. The Times, 10-11/1/94,

12/2/94, 18/2/94, 21/8/96; Bedfordshire on Sunday, 22/1/95, 25/8/96; BBC Horizon Programme, 10/5/93), which in turn feed back into the perceptions of individuals, both institutional actors and recipients.

Increasing levels of perception have led to some policy responses, mainly in the form of increasing research to add to emergent knowledge, as outlined in the environment White Paper. Technological change is also co-evolving with policy change, as emission controls provide a stimulus for the development of new engine and fuel technologies (CEST,1993; Calvert et al, 1993).

At present, management of air quality is centred on environmental health departments, whose role is confined to the accumulation of monitoring data, which is used to contribute to the processes of knowledge emergence and perceptual emergence. The successful existing policies of smokeless zones and integrated pollution control (prescribed processes) were devised to cope with the issues of domestic smoke and industrial pollution respectively. Traffic pollution, however, has emerged as an issue since these institutional responsibilities were defined, and although it is widely recognised within the environmental health departments, present institutional arrangements are not well suited to cope with it.

It will be recalled from the conceptual model that major institutional and behavioural change normally occurs only in response to some form of trigger, such as the Great Smog. To date, despite widespread and controversial recognition of the issue, it can be argued that such a trigger has yet to occur. From observing history, it seems likely that such a trigger will occur at some point in the future, although the exact form it will take and the time when it will occur cannot be predicted. One might speculate that a major asthma epidemic, coinciding with high levels of ozone pollution, might perform such a function and stimulate major policy changes, providing it received high levels of publicity and a sympathetic political climate.

10.3 Traffic Pollution and Respiratory Health as an Illustration of Emergent Systems Concepts.

10.3.1 Perception, Policy and Behavioural Change

As was pointed out in Sections 5.8 and 9.6, changing individual behaviours is seen as a major thrust of policy. This is because it is the aggregation of individual behaviour which is responsible for the problem, and without a change in that behaviour, the situation cannot improve.

However, several major difficulties present themselves:

- perceptual differences between the generators of the message and the recipients
- the impact of other hierarchical constraints
- disjunction between the initiators and recipients of the problem

The main contribution of the field work to this issue is identifying clearly the existence of different perceptions / perspectives between the different constituencies.

As is clear from Chapter 9, the messages generated by the institutional actors are not received by the public. There is no clarity in the messages given out, because the understanding does not yet exist .

From the public health viewpoint, the messages to individuals about taking responsibility for their own asthma and managing their own treatment may be

relatively successful. However, when this is linked in with air quality information, this becomes more problematic. As was pointed out in Section 4.3, at present, it is not possible to give clear advice on what to do because of the uncertainties in science.

Also, even if that advice was available, it would be taken by individuals within the constraints of their own lives and priorities, i.e. their decision spaces. As was pointed out in Section 8.2, even among those respondents to the survey who had experience of respiratory problems, although asthma was the main concern, it was actually only mentioned by 23%, leaving a majority (77%) who had more pressing concerns, either in terms of other health issues or other issues generally, while air pollution was mentioned by 17%. An even smaller proportion of respondents (2%) had actually taken any action in response to perceived poor air quality. Behaviour is affected by so many other considerations, constraints and motivations that the position of "action to avoid asthma", for the majority of people (though not perhaps for severe sufferers) is analogous to the position of air quality monitoring within local authorities, described in Figure 6.5, Section 6.5. It is one issue among many, which must take its place within a life full of conflicting pressures and requirements.

A final point concerns the disjunction between the behaviour causing the problem and response to it. As mentioned above, the provision of information is directed at respiratory suffers, and encouraging them to change their behaviour. However, the behaviour which is causing the problem is not that of the sufferers (although they may be the same people) but of the drivers. In a classic control loop, the negative outcomes would lead to a change of behaviour, provided they were recognised (Ashby WR, 1956). If a sufferer's asthma is brought on by smoking, then if information is provided to the sufferer about the effects of smoking on asthma, the individual sufferer can assess the information so received, decide for him or herself whether the satisfaction derived from smoking is sufficient to compensate for the health impacts, and change his or her behaviour accordingly - a feedback loop exists.

However, in the case of traffic pollution, the individual who is suffering from the ill effects, while possibly also a driver, is unable to affect the outcome simply by changing their own behaviour. There is thus no longer a direct feedback loop. On the other hand, as the majority of drivers are not themselves sufferers, there is no direct incentive for them to change their own behaviour. Indeed, as was suggested in Chapter 4, it may be that for an individual driver who is also a sufferer the most suitable response to information that air pollution is high on a particular day may be to drive, rather than walking, to work, thus contributing to the problem.

This thesis has not been able to address the relationship between perceptions and driver behaviour directly. This is an area where potentially further work is required.

10.3.2 Overlapping Hierarchies

A further issue raised in the theoretical development is that emergent systems occur within a context of overlapping hierarchies. This is demonstrated clearly in the Oxford study (Chapter 5). Responsibilities for transport, air quality and health were split between different institutions embedded in different hierarchies. This had two effects:

- For each institution, priorities were set at a higher hierarchical level, which imposed constraints on the ability of the institution to deal with the problem, and the methods which could be used. For example, the environmental health

department had no jurisdiction over transport, therefore their approach to the problem was limited to generating information, through monitoring, which they then hoped to use in a process of perceptual change in order to put pressure on the bodies which were in a position to do something about the traffic problem (Section 5.6).

- For each institution, the boundaries of "the system of interest" were dictated by its responsibilities (geographical and hierarchical) such that elements which were part of "the system" for other institutions were part of the "environment", for the system concerned. For example, in Oxford, from the point of view of the Transport Department, traffic pollution was an effect of traffic, though not necessarily the most significant one, while for the Environmental Health Department it was an input to be measured. Although the actual elements, and some of the low-level interactions between them, may be the same, they perform different roles within the different sub-systems and are perceived in different ways.

If behaviour is viewed hierarchically, in the sense that actions are subject to sets of constraints imposed by the next level up, then when an element exists within overlapping hierarchies, it may be subject to multiple sets of pressures, leading to contradictory responses. The question then becomes: which pressure takes priority? This point may be illustrated by the situation of the environmental health officers described in Section 6.9 and 9.2, who are subject to multiple sets of constraints and requirements, imposed by both central government, and the local political context.

The existence of multiple pressures may add to the unpredictability of behaviour. Prediction must be based on a particular set of assumptions about the determinants of behaviour, when in reality those may not be the most significant.

10.3.3 Institutional and Individual Worlds

It will be recalled that in Section 4.5 it was posited that the way in which the issues of hierarchy and perception interact in emergent systems leads to a lack of congruity between the "institutional" and "individual" worlds, and that this can be conceptualised as a series of dichotomies, as shown in Table 4.3, and repeated below as Table 10.2.

Chapters 5 and 9 have used examples from the fieldwork to illustrate these dimensions of difference. While the institutional actors are concerned with problems affecting their physical area of responsibility, individuals are concerned with their immediate locality. Institutional concern with measurement and quantification of effects, including quantifying epidemiological risks, may disregard the reality for particular individuals of dealing with air pollution and / or asthma within their own lives.

The interface between the "worlds" is a critical point for the successful implementation of policy. The concentration of effort on collection, generation and transmission of information to the public assumes strong causal relationships between the provision of that information, the recipients' understanding of that information, and changes to the recipients' behaviour, and hence is of questionable value when these relationships appear to be tenuous (See Chapter 8).

Table 10.2 Dimensions of Difference Between the Institutional and Individual Worlds

Institutional	Individual
Observers	Recipients
Focus on observed / measured effects and impacts	Focus on perceived outcomes
Scientific uncertainty and quantitative risk	Perceived risk
Spatiality defined in terms of institutional boundaries	Spatiality defined in terms of individual's sense of locality

Although this approach provided a clear framework for analysis of the fieldwork data, there is a danger of over-simplifying the situation by suggesting the existence of two discrete worlds. As will be recalled from Chapter 5, the different institutions do not all have a single unified approach, and individuals within institutions do not necessarily conform to the stereotypical perspectives, as can be seen from some of the comments of Environmental Health Officers in Chapter 6. Even more dangerous is the suggestion that "the public" has a single, unified perspective, when the clearest evidence from the household survey demonstrates how much variation exists in public perceptions (see Chapters 7 and 8).

10.4 Methodological Issues of Investigating Emergence

The core aim of this thesis has been to develop a method of enquiry suitable for the investigation of emergent systems. This process has presented a number of difficulties and issues which, in keeping with the emergent nature of the method, have only become apparent with hindsight, but which need to be taken into account in future studies of this type.

10.4.1 Temporal Aspects

As described in Chapter 2, emergence is a process which, by definition, takes place over time. There is therefore difficulty in designing fieldwork which is able to take into account this temporal nature, and the present research has been based on "snapshots". Although it might be possible to design longitudinal studies which could track changes in perceptions over time, the inherent unpredictability of triggers, as currently understood, suggests difficulty in selecting an appropriate time-frame.

10.4.2 The Problem of Causality

A further difficulty with emergent phenomena is that they are inherently the outcomes of multiple, mutually interacting causes. Multi-causal problems present practical difficulties for research, leading to a tendency to break them down into sub-problems, and tackle those which are most amenable to practical solution - described by Marmot as "the art of the soluble" (Marmot,1986).

10.4.3 Causality and Correlation

The analysis of the survey data suggested a number of relationships between perceptions and contributory factors, for example, that location is an important determinant of concern over pollution, and that experience of respiratory disease, or the presence of family members in high risk groups, is a determinant of concern about respiratory disease. To continue the analogy with epidemiology referred to in the

introduction to this section, these might be seen as "risk factors" increasing the likelihood for an individual of interest in these issues.

However, the existence of a pattern of relationship between factors cannot logically be taken to imply a causal relationship. Epidemiological methods have been criticised for being incapable of describing causal mechanisms:

> *"When the stakes are large, some scientists will not accept epidemiological evidence as proof of causation, no matter how elaborate it is. Second, most scientists accept a relationship as causal only when there is either laboratory evidence or a theory that specifies detailed functional mechanisms."* (Lave and Seskin, 1979; quoted in Stallones, 1988).

Gordis suggests a number of criteria for evaluating the causal significance of an association between an attribute and a health effect, but argues:

> *"A basic question is what we mean by 'cause'. Rarely, if ever, do we have the clear situation of a necessary and sufficient cause. The tubercle bacillus, for example, is a necessary cause for tuberculosis but is not sufficient. Radiation is clearly not a necessary cause for leukemia because factors other than radiation may be leukemogenic. Indeed, with most chronic diseases of interest, we are dealing with complex situations in which a causal factor is neither necessary nor sufficient"* (Gordis, 1988).

In the case of such health risk factors, such causal relationships may at least be postulated, and alternative methods of research, for example clinical studies, may be employed. However, as was observed in Section 4.5.3, this is not the case with perception data.

10.4.4 Problems with the Enquiry Techniques

The problem of coping with the potentially extremely large number of constituencies led to a need for selectivity in the choice of constituencies studied (governed partly by practical issues of access). This led in turn to severe limitations in the sizes of samples available for analysis, which were therefore too small for formal statistical analysis. The approach used therefore relied on demonstrating regularities and variations in responses, and building up the weight of demonstration, rather than on evidence which could be tested for statistical significance

The process of enquiry into the data relied on developing an "intuitive feel" for the data, and using this to construct a story line which was then justified by reference back to the original data. Although this approach offered insights into the perceptions of actors, it presents difficulties of reproducibility of the analysis, in that the mental mapping processes involved and the criteria for selectivity in handling the data were not made explicit.

With hindsight, the robustness of the method could be strengthened by the use, within the same broad framework, of more formalised techniques, such as conceptual mapping or formalised content analysis.

10.4.5 Hierarchical Aspects

A main theme of this thesis has been that emergent environmental problems, such as traffic pollution and health, can usefully be conceptualised as overlapping, hierarchically arranged systems of components which interact to generate emergent effects at the next level of the hierarchy.

It follows that, in order to investigate phenomena in the "real world" in terms of such systems, it is necessary to look both at the low level components and emergent effects. In Chapter 1, two questions were raised about the difficulty of taking both of these hierarchical levels into account:

> *"How can we see the big picture without losing sight of the fine detail?"*

and

> *"How can we see the fine detail without losing sight of the big picture?"*

The problem is one of aggregating large numbers of individual elements in order to establish patterns of relationships between those elements. Conventionally, statistical analysis is used to search large volumes of data for patterns which are unlikely to have occurred by chance. This approach is typified by the use of epidemiological approaches to the study of the distribution of disease in populations.

> *"The basis of epidemiology is the fact that disease and disability distribute predictably in human populations. The methods of epidemiology are designed to measure variations in risk and to identify the characteristics of people and their environments that are predictive of those variations."* (Stallones, 1988).

Through the accumulation and interpretation of epidemiological data, it may be possible to approach some estimation of the numbers and likely characteristics of individuals who will be affected.

The approach taken to the analysis of the survey data in Chapter 7 may be seen as analogous to an epidemiological approach. Data on the perceptions of a sample of the population of Bedford and the surrounding villages were investigated with a view to establishing patterns of variation in those perceptions, and identifying possible contributory factors to those variations.

10.4.6 Issues of Classification

The problem of identifying patterns in large amounts of data implies a need to break the data down into manageable categories. Such classification is inevitably, to a certain extent, arbitrary.

Conventionally in social science surveys, this classification is carried out in advance, by providing a number of options from which the respondent is required to choose the most appropriate. For many types of analysis, this is a satisfactory approach, and was used in the survey, for example, in the questions concerned with the type of information source / media recalled by the respondent. However, a disadvantage in using this approach when investigating individual perceptions is that it requires the imposition of the researcher's perceptual categories onto the analysis before the collection of data (Shipman, 1988).

As will be recalled from Sections 5.2 and 7.2, the approach taken in the present study was to avoid this problem by asking open, elicitation type questions such as:

> *"Which issues related to your own or your family's health are you most concerned about? (Please list up to three, in order of importance, most important first)."*
>
> *"What do you consider to be the main influences on air quality locally?"*

While avoiding the imposition of the researcher's perceptions on the responses given during the interviews, this approach presented difficulties in classification when the data were analysed. For example, as mentioned in Section 7.6.3, one distinction which had not been anticipated and which became apparent from the survey responses was that "influences" could be viewed in a positive light, for example:

> *"lots of fields and trees giving oxygen"*

rather than sources of pollution.

Some of these more general categories presented difficulties in evaluating distances from pollution sources (or "influences"). Where responses were classified as "open space", distance was measured from the nearest non-built up area, for example, a school playing field. Similar problems occurred with indoor sources, such as:

> *"people smoking"*
>
> *"fumes from gas fires in homes"*

which were allocated an arbitrary distance of .01kms.

It might perhaps be argued that the provision of fixed categories before the questionnaires were administered would have simplified the procedure for both respondents and researcher, and that the imposition of the researcher's own categories was merely deferred to the analysis stage. (In fact, if, for example, a postal questionnaire had been used, this would have been an important consideration, as ease of completion for the respondents could have a significant impact on the rate of response.)

However, despite presenting these additional difficulties for the numerical analysis of the data, this more open approach to questioning permitted useful insights into the perceptions of respondents. By retaining the full richness of the original responses, it was possible to identify some of the less predictable dimensions of response identified in Section 7.6.3, such as the relative nature of perceptions of air quality, the attribution of responsibility in some responses, and the fact that the same "influence" (e.g. *"rural location"* could be perceived both positively and negatively by different respondents).

10.4.7 Dangers in the Evaluation of Epidemiological Data

A danger which arises with the use of epidemiological data to suggest causal relationships is the fallacy of the converse. Where a relationship may not be "proved" to be statistically significant, the result may be interpreted as implying that the relationship is "proved" to be non-existent. This may in part be due, as Haynes suggests, to differences in perspective between scientists investigating the prevalence of disease and policy makers charged with attempting to manage potential causes. Haynes argues that the scientist's responsibility is never to claim more than the

evidence allows, and if there is a probability of more than 5 per cent that a result could have been caused by chance, the scientist will reject the evidence as not being sufficiently strong. The environmental manager, on the other hand, has a different responsibility: to protect the public from a potential hazard. Where scientific uncertainty exists, both scientist and policy maker may feel that their responsibility lies in erring on the side of caution, but while for the scientist the cautious approach means assuming that the risk does not exist because it has not been proved, for the policy maker the cautious approach is to act as though it does exist (Haynes, 1995). Such a simplistic division of attitudes along institutional lines may, however, be modified by individual perceptual circumstances, for example, the policy maker may have an interest in minimising public concern about an issue (a point illustrated by the UK government's response to the BSE crisis), while a particular scientist may see him or herself as a "whistle-blower", with a responsibility to bring the hazard to public notice.

The accumulation and interpretation of ever more, and more detailed, epidemiological data, offers the possibility of identifying risk factors and estimating numbers and characteristics of individuals likely to be affected. However, a further danger with the use of epidemiological data to identify risk factors is that estimates of the numbers likely to be affected within a population acquire an air of spurious accuracy. Stallones points out that the final outcome of an epidemiological approach to risk assessment is to predict that a certain number of people in the population will suffer from the impact of the hazard, a number which, given the uncertainties involved, cannot be correct except by accident, and whose confidence limits must extend from zero to infinity. Nevertheless:

> *"the presentation of a number that looks real and is supported by some arcane mathematics gives an illusion of reality which seems a firm enough basis for governmental regulatory action"*(Stallones, 1988).

10.4.8 The Integration of Quantitative and Qualitative Data

This section has tended to concentrate on some of the pitfalls and problems of the use of quantitative data analysis, both specifically in terms of the survey content of the present thesis, and more generally in terms of the use of epidemiological approaches to identifying risk factors for disease. Nevertheless, it cannot be stressed too strongly that such analyses have an important role in the investigation of emergent problems. An emergent effect, by definition, arises from the interactions of a large number of components, and any thorough investigation of such an effect requires large volumes of data, which in practical terms must rely on some form of quantitative, numerical analysis:

> *"An essential requirement of any scientific answer to a question is an adequate empirical database, which includes statistical adequacy, representativeness, random selection, and so on"* (Lee,JSK 1992).

However, it has been the intention of this study in general, and the present chapter in particular, to demonstrate that such a quantified approach alone is not sufficient to provide a full explanation of issues where human perceptions and behaviour are as intimately involved as in the present case. A fundamental distinction between the institutional and individual perspectives, as discussed in Chapter 9 and Section

10.3.3, is the assumption that epidemiological and quantitative approaches are sufficient to achieve an understanding of emergent problems.

10.5 Implications for Management and Policy

As is clear from the study, existing institutions do not map onto emergent problems, either geographically or functionally. There is a need to be alert to the fact that existing agencies are unlikely to be able to cope with emergent issues, because they have not been designed to do so. Within the management / governmental system, adaptive capacity is required, in order to deal with novelty rather than recurrence and to assist the development of institutional forms and management measures appropriate to the issues.

From a top down perspective, there is a need to speed up response times in identifying emergent phenomena. It is important to develop a recognition within the higher levels of the hierarchy that emergent phenomena are a normal part of evolutionary processes, and that the policy horizon of government must begin to take into account this need for adaptive capacity.

From a bottom up perspective, there is a need to find more effective and routinised ways of identifying the agendas of individuals in communities. Emergent problems are always experienced by individuals within the population before they can be perceived in the aggregate, and hence increasing sensitivity to public concerns and fine-tuning of political agenda setting may lead to earlier recognition of emergent problems.

There are also implications for the role of science. Since emergent phenomena are novel, when one arises it is unlikely that substantial prior scientific investigation will have been directed towards it (particularly if science research is directed on assumptions of simple causality). This issue suggests a need for diversity in the research activities of the science base, and a greater recognition of the value of autonomous research.

10.6 Implications for Further Research

The generality of the method should be tested by application in other contexts. The overall method could be strengthened by use of more robust low level techniques, which would make the mental mapping processes involved more explicit. Further work on the method should concentrate on this aspect.

There is scope for more theoretical development which would concentrate on developing links between Vickers' theory of appreciation and more recent work on policy-relevant research (such as issues of perceptual congruence, receptivity and decision spaces), while also taking account of other areas of theory, such as the sociology of innovation. In this context, it may be interesting to note that appreciative systems in themselves can be seen as emergent, formed from overlapping nested hierarchies, and that this might offer a fruitful line for study.

Understanding the dynamics of appreciative systems is crucial. More focused research is required into the relationships between individual experience, information, behaviour, and the hierarchical relationships between individual and aggregate appreciative systems

The inherent temporality of emergence constrains which issues can be researched, but it is to be hoped that, through the accumulation of knowledge of emergent systems which could be gained from a number of studies (particularly if, opportunistically, it were possible to observe the occurrence of and reactions to a "trigger" event), ultimately it might be possible to discover regularities in the type of factors interacting to produce emergent systems, or trigger events, which would increase the possibility for prediction.

10.7 Conclusions

The original insight of the thesis, that "Traffic Pollution and Respiratory Health" can be conceptualised as an emergent system, has led to the exploration of the issue in terms of the overlapping hierarchies from which it is composed. Given the scale of the change processes involved in the top-down conceptual model, and the long temporal scale at which they operate, the substantive research has only been able to investigate a small subset of the issue, focusing on the perceptions of actors involved with the problem at a particular point in time,

Investigation of the perceptions of the various constituencies has led to the recognition of significant differences between them. It has been suggested here that the most significant differences arise between those actors whose decision spaces are dictated by their institutional role and those who are loosely defined as "individuals", or "the public", although this should not be regarded as a hard and fast division.

Within the problem context, "individuals" are regarded not as powerless recipients, but as major contributors to the "problem", through their actions as drivers of motor vehicles. Two major control strategies have been adopted by policy makers: technological approaches and perceptual approaches, which attempt to change the behaviour of individuals by changing their perceptions through the provision of information about air quality.

However, as the field work has demonstrated, perceptual differences between the institutional actors and the public suggest that the information provided is not absorbed by the intended recipients. Further, when individuals are aware of the information, this may not be sufficient to change their behaviour, which can only be changed within the context of their own individual decision space and priorities.

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APPENDICES

APPENDIX A

Sample Questionnaire from Pilot Study

HEALTH CONCERNS QUESTIONNAIRE

Thank you for agreeing to help me with this survey.

Please remember that there are no "right" or "wrong" answers: I am interested in finding out your views and opinions.

If you have any problems answering the questions, please ask.

GROUP NAME _____

DATE _____

1 Which problems related to your own or your family's health are you most concerned about? (Please list up to three, in order of importance, most important first).

HEALTH PROBLEMS	**MOST IMPORTANT PROBLEM**	**NEXT MOST IMPORTANT**	**THIRD MOST IMPORTANT**
Nature of the problem			
Person affected (e.g. self, partner, child, mother, father)			

2 For each of the problems mentioned in response to question 1, what do you think are the main factors affecting the problem? (Please list up to three, in order of importance).

FACTORS	**MOST IMPORTANT PROBLEM**	**NEXT MOST IMPORTANT**	**THIRD MOST IMPORTANT**
Most important factor			
Next most important factor			
Third most important factor			

3 For each of the problems, have you tried to find out any more information about the problem? If so, where have you found information from?

SOURCES OF INFORMATION	***MOST IMPORTANT PROBLEM***	***NEXT MOST IMPORTANT***	***THIRD MOST IMPORTANT***
TRIED TO FIND OUT MORE	***YES / NO***	***YES / NO***	***YES / NO***
ABLE TO FIND OUT MORE	***YES / NO***	***YES / NO***	***YES / NO***
Sources of information (e.g. doctors, friends, newspapers, television, personal experience)			

4 Are you concerned that traffic may affect your health or that of your family?

YES / NO

If so, please list up to three ways in which you believe traffic may be a threat to health, in order of importance (most important first), and say which members of your family might be affected.

TRAFFIC HAZARDS	**MOST IMPORTANT HAZARD**	**NEXT MOST IMPORTANT**	**THIRD MOST IMPORTANT**
Nature of hazard			
Person(s) affected, e.g. self, children, elderly parents, everyone			

5 Are you aware of anything the council is doing to try and reduce pollution from traffic?

YES / NO

IF YOU ANSWERED "YES" TO QUESTION 5:

6 Please describe in your own words what the council is doing to reduce pollution from traffic:

7 What do you think the council hopes to achieve by taking this action?

8 How likely do you think it is that the council's action will do what the council intends? (Please circle one number below, where 1 is "not at all likely" and 5 is "almost certain").

not at all likely		***unlikely***	***possible***	***likely***	***almost certain***
1		***2***	***3***	***4***	***5***

9 What do you personally think will be the most likely result of this action?

10 How likely do you think it is that the council's action will be good for your health or that of your family? (Please circle one number below, where 1 is "not at all likely" and 5 is "almost certain").

not at all likely		***unlikely***	***possible***	***likely***	***almost certain***
1		***2***	***3***	***4***	***5***

SUPPLEMENTARY QUESTIONNAIRE ON BREATHING PROBLEMS

If breathing-related difficulties were mentioned in answer to question 1:

11 Have you noticed any particular times of year, activities, weather conditions etc. which seem to make the problem worse?

12 Does the person affected do anything in particular when the problem is bad? (e.g. take medication, have time off work or school, stay indoors)?

13 Has the person affected ever been diagnosed as having asthma?

YES / NO

14 What do you understand by the term "asthma"?

15 Are you aware of any factors which are thought to cause asthma or make it worse?

APPENDIX B

Sample Questionnaire from Survey of Environmental Health Officers

Chief Environmental Health Officer,
Broxbourne Borough Council,
Bishops' College,
Churchgate,
Cheshunt
EN8 9NF

23rd June 1994

Dear Sir/Madam,

I am a researcher at the International Ecotechnology Research Centre, Cranfield University, engaged in an ESRC-funded programme on perceptions of traffic pollution and implications for policy. Barry Williams, Principal EHO of Bedford Borough, has commissioned me to conduct a study of air pollution monitoring on behalf of the Herts and Beds branch of the Institution of Environmental Health Officers.

The study involves a survey of air pollution monitoring currently carried out by local authorities in the Bedfordshire and Hertfordshire area , the results of which will contribute towards developing a joint air pollution monitoring strategy for the area.

I understand that you have been asked by Barry Williams to take part in this study, and I would be grateful if you would provide some details about your authority and the monitoring you do on the enclosed sheets and return them to me.

I will also be contacting you within the next week to ten days with a view to arranging to come and talk to you or your staff. The scope of the interview, as agreed with Barry, will be as follows:

- What monitoring of air pollution is carried out in your area?
- What happens to the data which is collected from monitoring?
- What are the sources of air pollution which affect your area, and how do they relate to the main population areas?
- What are the main influences on the monitoring you do? Which policies most influence what to monitor, how does your monitoring relate to legislation and do you collaborate with any other agencies in monitoring activities?
- Are you satisfied with your present monitoring, or would you like to extend it?
- How important do you consider air pollution monitoring, and how does it relate to other work within your department?
- What do you see as the main reasons for the monitoring you are doing? What do you see as the major problems attributable to air pollution, and what would you say are the main benefits of monitoring?

I look forward to hearing from you.

Yours sincerely,

Linda Hadfield

Herts and Beds Local Authorities Air Pollution Monitoring Survey

This survey is being conducted by Cranfield University in conjunction with the Herts and Beds branch of the Institution of Environmental Health Officers, as the first stage of an audit of existing local authority air pollution monitoring in the Herts and Beds area.

Please provide the following information for your authority:

Name:

Broxbourne Borough Council

Address:

Bishops' College,
Churchgate,
Cheshunt

Postcode

EN8 9NF

Phone no:

Fax no:

Name of CEHO:

Name of officer to contact:

Phone no:

How many air pollution monitoring sites are there in your area?

Please enter as much information as possible for each monitoring site on next sheet.

Herts and Beds Local Authorities Air Pollution Monitoring Survey **Page 2**

	Number of each type of monitoring equipment at site								Is the site currently on a
	NO2 Diffusion	SO2/smoke	Continuous monitoring - Pollutants monitored					Other	network? If so, please specify.
Name and Address of Site	Tubes	Bubblers	NOx	SO2	O3	CO	PM10	(Please describe)	(eg WSL SO2)
		7							

Thank you for your co-operation. Please return survey forms (by post or fax), and direct any queries about the survey, to: Linda Hadfield, INTA/IERC, Cranfield University, Cranfield, Bedford, MK43 0AL Tel: (0234) 750111 ext 2655 Fax: (0234) 750163

APPENDIX C

Interview Schedule for Survey of Environmental Health Officers

APPENDIX C

Interview Schedule for EHOs 3rd May 1994

1. What monitoring of air pollution is carried out in your area?
   - How many sites? Where are they?
   - What equipment?
   - What pollutants?
   - How frequently is data collected?
   - What calibration/QA procedures are there on the equipment?

2. What happens to the data which is collected from monitoring?
   - How is it stored/collated?
   - How is it presented? Do you have any examples of reports etc. generated?
   - How often?
   - Who to?

3. What are the sources of air pollution which affect your area?
   - For specific sources (both local authority and HMIP controlled):
     - what type of source?
     - what pollutants?
     - who is responsible?
     - what monitoring action have you taken/ are you taking?
   - Which ones are you particularly concerned about?
   - Are there any potential sources which are likely to cause problems in the future?
   - Where are the main population areas?

4. What are the main influences on the monitoring you do?
   - which policies most influence what to monitor?
   - how does your monitoring realest to legislation?
   - do you collaborate with any other agencies in monitoring activities?
   - what, if any, organisational problems have you come up against in relation to air pollution monitoring?

5. Links with health authorities
   - what is the name and address of your district health authority?
   - have you done or are you doing any work on air pollution in conjunction with the health authority?
   - to what extent have your monitoring practices been influenced by consultation with health professionals, and/or any epidemiological data?

6 Are you satisfied with your present monitoring, or would you like to extend it?
   - if so, in what way?
   - why?
   - what is preventing you?

7. How important do you consider air pollution monitoring?
   - how does it relate to other work within your department?
   - what do you see as the major problems attributable to air pollution?
   - what do you see as the main reasons for the monitoring you are doing?
   - what would you say are the main benefits of monitoring?

1 Basic Site Information

Authority: Site code:

Address of nearest building:

Postcode

Site phone:

Type of site (eg kerbside, urban background, suburban, rural)

How often is the site inspected?

Type of monitoring and equipment:

Why is monitoring carried out at the site?

Distance from nearest road? Traffic flow on nearest road?

Potential sources of pollution?

Any problems with access or vandalism?

Other comments

Tube Details

Authority: Site code:

Tube ref no:

Pollutant

Lab used for analysis:

Accredited lab?

Height above ground .....
Distance from road.....
Altitude.....

Position on building:

Network?

Other comments

2 What happens to the data which is collected from monitoring?

How is it stored/collated?

How is it presented? Do you have any examples of reports etc. generated?

How often?

Who to?

3. What are the sources of air pollution which affect your area?

For specific sources (both local authority and HMIP controlled):

what type of source?	what pollutants?	who is responsible?	what monitoring action have you taken/ are you taking?

- Which ones are you particularly concerned about?

- Are there any potential sources which are likely to cause problems in the future?

- Where are the main population areas?

4. What are the main influences on the monitoring you do?
   - which policies most influence what to monitor?

   - how does your monitoring relate to legislation?

   - do you collaborate with any other agencies in monitoring activities?

   - what, if any, organisational problems have you come up against in relation to air pollution monitoring?

   - to what extent have your monitoring practices been influenced by consultation with health professionals, and/or any epidemiological data?

5. Links with health authority

- what is the name and address of your district health authority?

- have you done or are you doing any work on air pollution in conjunction with the health authority?

- to what extent have your monitoring practices been influenced by consultation with health professionals, and/or any epidemiological data?

6. Are you satisfied with your present monitoring, or would you like to extend it?
   - if so, in what way?

   - why?

   - what is preventing you?

7. How important do you consider air pollution monitoring?
   - how does it relate to other work within your department?

   - what do you see as the major problems attributable to air pollution?

   - what do you see as the main reasons for the monitoring you are doing?

- what would you say are the main benefits of monitoring?

APPENDIX D

List of Concepts Used for Coding Interviews With Environmental Health Officers

Concept	Times Mentioned
use of information	953
reasons for monitoring	683
constraints on monitoring	503
sources of pollution	471
public perceptions	386
change	367
priorities	365
local context	276
collaboration with other agencies	268
organisational structure	211
health effects of pollution	198
location of sites	192
limitations of monitoring	191
methods of monitoring	180
wider context	131
uncertainty	114
politics	106
extensions to current work	104
regional strategy	99
policy measures	86
staffing	72
legislation	71
national policy	68
operational problems	58
previous work	52
asthma	48
lack of expertise	46
influences on monitoring	45
staff turnover	43
relationship with health authority	38
traffic	35

Concept	Times Mentioned
responses to monitoring	34
trans-boundary pollution	31
media reports	31
training	29
expertise	28
monitoring networks	26
multiple perceptions	23
vandalism	22
health studies	22
political changes	20
public relations	18
benefits of monitoring	18
transport policy	18
importance of monitoring	17
history	16
queries from the public	15
external work	15
global impacts	14
methods of monitoring	14
differences between authorities	14
reactiveness	13
types of pollution	12
location of population areas	11
extent of area	10
complacency	10
practical considerations	9
access	8
emissions balancing	8
comparability of results	7
pressure groups	7

APPENDIX E

Sample Questionnaire from Household Survey

Cranfield

Local community health survey

Cranfield University are carrying out a study to investigate the concerns of people in the North Beds area about issues related to their health.
This work includes a survey of local households, selected by postcode. We would appreciate your help with this study by answering the following questions.

All your answers are recorded anonymously and are strictly **CONFIDENTIAL**

Information about yourself

How long approximately have you lived at this address? .....
If you have lived here for less than two years, where did you move from?
.....

Do you expect to stay at this address for the next 2/3 years? ❍ yes ❍ no

❍ don't know

If no, why do you expect to move?

.....

Sex ❍ male ❍ female

Do you have any children under the age of 18? ❍ yes ❍ no

Which of the following age groups do you belong to? (Please circle one)

18-25 26-35 36-45 46-55 56-65 66-75 76 or older

General health concerns

Which issues related to your own or your family's health are you most concerned about? Please list up to three, most important first.
(If no response, write "NONE" on line 1, then prompt as follows:
"What is the first thing that springs to mind when I mention health?"
and enter any response on line 2.)

health issue
1.
2.
3.

We would now like to ask about asthma

Please describe, in your own words, what you understand by the term "asthma"?

.....

Asthma only affects some people, and it does not affect them all the time. We would like to ask whether you know of any factors which are thought to bring on specific asthma attacks, and also if you know of anything which is thought to make people more likely to develop asthma.

Do you know of any specific factors which may bring on an asthma attack?

.....

Do you know of anything which may make people more sensitive to having asthma?

.....

Have you ever tried to find out any information about asthma ? ❍ yes

❍ no

If yes, where did you look/ask?

.....

Why did you ask for this information?

.....

Can you remember any programmes, articles etc in the following media which have mentioned asthma?

National Press Local Press National radio Local radio Magazines Television

NP/LP/NR/LR/M/TV	Paper/Programme	Details	Approx

Have you ever received any information about asthma from the following sources?

	Yes	No	Details
Your doctor or other health professionals?			
Friends or relatives?			
Books?			
School or college?			
Others? Please			

Are you aware of any organisations associated with asthma? ❍ yes ❍ no

Please specify .....

Have you or any member of your household ever experienced asthma or any other persistent difficulty with your breathing?

❍ yes ❍ no

If no, go to page 4

For each person who has been affected by breathing difficulties:

Sex ○ male ○ female

Which of the following age groups does the person belong to? (Circle one)

0-5 6-15 16-25 26-35 36-45 46-55 56-65 66-75 76 or older

What is the nature of the problem? .....

Approx age when the problem began ○

0-5 6-15 16-25 26-35 36-45 46-55 56-65 66-75 76 or older

Has the person been affected in the last two years?

○ yes ○ no

If no, approximately how old was the person the last time the problem occurred?

0-5 6-15 16-25 26-35 36-45 46-55 56-65 66-75 76 or older

Is the problem worse at any particular times of year? (Please specify).

.....

Have you noticed any particular activities, weather conditions, times of day etc which seem to make the problem worse?

.....

Does the person affected take any medication for the problem? (Please specify).

.....

Has the person affected had any time off work or school in the last two years because of the problem? ○ yes ○ no ○ don't know

Would you say that in your opinion the problem is:

GETTING BETTER	GETTING WORSE	STAYING THE SAME	DON'T KNOW

(Circle one)

If you think the problem is getting better / worse, Have you any idea why?

.....

Does the person affected do anything in particular when the problem is bad?

.....

Has the person affected ever been diagnosed as having asthma?

○ yes ○ no ○ don't know

Finally: We would now like to ask about air quality locally

How good or bad do you believe the air quality to be in this area ?

VERY GOOD GOOD AVERAGE BAD VERY BAD

(please circle)

What do you think are the main reasons for this?

.....

.....

What do you feel are the major influences on air quality locally ?

1. .....
2. .....
3. .....

Have you ever tried to find out any information about air quality ? ❍ yes ❍ no

If yes, where did you look/ask?

.....

Why did you ask for this information?

.....

Have you complained to anyone about air quality? ❍ yes ❍ no

If yes, who to ?.....

Would you like to see more information about air quality ? ❍ yes ❍ no

Where would you go/look if you wanted to find out more?

.....

.....

Have you ever refrained from any outdoor activity because you were worried about air quality?

❍ yes ❍ no Please describe

.....

Can you remember any programmes, articles etc in the following media which have mentioned air quality?

National Press Local Press National radio Local radio Magazines Television

NP/LP/NR/LR/M/TV	Paper/Programme	Details	Approx

□□□□ □□□

time:_____:_____hrs date:_____/_____ 94

THANK YOU FOR YOUR HELP WITH THIS SURVEY