NRA WATER QUALITY SERIES 6

THE INFLUENCE OF AGRICULTURE ON THE QUALITY OF NATURAL WATERS IN ENGLAND AND WALES

The Report of the
National Rivers Authority

NRA
National Rivers Authority

January 1992

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A report by the National Rivers Authority

NRA

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PREFACE

Degradation of river water quality occurs as a result of many activities; over the last two years the NRA has been addressing these in a systematic way. Many of the contaminants with a potential to pollute arise from point sources which are controlled through a system of setting of consents to discharge. This entire system has been reviewed and, subsequent to public consultation, is now being overhauled. Consent setting in the future will also be based primarily on the need to meet statutory objectives relating to water quality.

Many sources of contamination arise not from deliberate discharges, however, but from diffuse sources and from accidental releases. In this respect the agricultural industry is of major importance, not because it is less controlled or more careless than any other, but because of its immense size, the complexity of the tasks which it undertakes, and its virtual ubiquitous presence in all catchment areas. Thus it would not be feasible to embark upon a programme of environmental improvement without examining the impact which farming practices in particular can exert upon water quality. This report contains the result of such an examination; it makes many useful suggestions in order to help both farmers and regulating authorities minimise the risks and consequences of farm wastes polluting inland waters.

Because poor water quality often results from contaminants which enter the water in a diffuse manner, the view is sometimes taken that they must therefore be difficult to control. A lack of sufficient legislation and its enforcement is therefore cited as a contributing factor. Although there may well be cases to be answered with regard to contaminated land - which will be the subject of a subsequent NRA report - this is not the case for farm pollution. There is no shortage of legislation applying to farmers; rather, a simplification of existing dictate is called for, and this the report recommends.

It is clear that environmental concerns will continue to have an impact on the way in which all industries operate in the future. The NRA is committed to working together with such industries, particularly the farming industry with which such good relationships have been built up in the past. The NRA must, however, remain a firm regulator if environmental improvements are to be attained and it is to be hoped that, by producing reports such as this, the problems will be clearer such that both the NRA and the farming industry can work together to achieve the improvements which are sought.

R. J. Pentreath

Dr. R.J. Pentreath
Chief Scientist

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1 TERMS OF REFERENCE

This report was commissioned by the Chief Scientist of the NRA, who requested the Farm Waste Group to report on the effect of agriculture on the quality of natural waters and:

– provide a statement of relevant duties and powers, identifying any extra powers needed;

– make a clear statement of the scale and impact of agriculture on water quality and identify where additional data and information are needed;

– set out a strategy for achieving the NRA's aims and objectives and identify the role of other organisations; and

– draft relevant policies for adoption by the NRA.

2 NRA FARM WASTE GROUP MEMBERSHIP

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Environmental Protection Manager, South West Region.

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The Chairman of the NRA's Farm Waste Group acknowledges the exceptional contributions made by its members and expresses his personal appreciation for their help in the compilation of this report.

Particular thanks are due to R. M. Hamilton, who with his team, Mrs. H. Holland, Dr. J. A. D. Murray-Bligh, A. M. Burrows, Dr. R. P. Smith, A. G. Taylor, G. R. W Hawley, C. T. Martin, Mrs. S. A. Harris, Ms. A. Warburton, Mrs. J. Brown and Mrs. G. Gallard, all of NRA South West Region, has made significant contributions to this report.

The following persons also provided substantial contributions:

R. Buxton, Solicitor, Cambridge.
C. H. Mathias and P. A. Reaston of Robertson Gould Consultants, Warwick.
R. Thompson and T. Harrod of Soil Survey and Land Research Centre.
A. Burghes of Moonsoft, Exeter.

3. EXECUTIVE SUMMARY

Introduction

3.1 The legislation relating to water quality is extensive and complex. It is not surprising that many farmers are unaware of details of this legislation; nevertheless, the NRA relies on the public for co-operation in carrying out its legal duties. There is a good working relationship with organisations representing the industry and with individual farmers.

3.2 Agriculture is one of many activities which have an impact on water quality. Others include industry, sewage discharge and urban run-off. Agriculture accounts for about 12% of reported pollution incidents, but these are considered to be only a small proportion of what actually occurs.

3.3 Most human waste is treated, at considerable cost, before discharge to controlled waters. Farm livestock produce about three times the amount of waste and almost all of this is spread onto land. It is also considerably "stronger" in terms of its polluting potential, so if only 2% of it gets into water, it is equivalent to the load from all treated human waste.

3.4 Intensification of agriculture has led to greatly increased risks and occurrence of pollution by slurry, silage liquor, and a wide variety of agrochemicals. As a consequence, water quality has suffered. The Government has recognised the need for control and has introduced several regulations and codes of practice, and also provides grant aid to assist with the introduction of pollution control systems. These measures are welcome, but in the light of inevitable changes in agriculture, the NRA considers it necessary to have improved legislation, increased awareness by farmers of their responsibilities to the environment, and more effective measures to allow farmers to fulfil them.

3.5 For some time there has been increasing public and political concern about the effects of modern farming methods on the environment and, in some instances, on human health. A series of droughts in recent years has shown the precarious state of many water resources. Furthermore, the NRA has inherited an inadequate system of monitoring and reporting water quality, which is about to be improved. Detailed catchment investigations have exhibited chronic and diffuse pollution problems which are unrecognised by routine monitoring.

Pollutants from Agriculture

3.6 The majority of all reported farm pollution incidents are due to organic wastes (87%); oil represents 3%, pesticides less than 2%, nutrients less than 1% and all others about 7%. Most organic waste problems are caused by cow slurry (55%), with silage (20%), pig slurry (10%) and poultry (2%). The cause is usually inadequate storage, structural collapse or poor management. Examples of acute pollution incidents are given, showing wherever possible the cause, route to controlled waters, and effects. Chronic and diffuse problems are not so often reported but their effects can be equally severe. Examples are also given. Farm visit campaigns appear to be successful in reducing pollutions and the risk of these, but so far only about 5% of farms in England and Wales have been visited.

3.7 It is clear that when farmers increased their flock and herd sizes in response to government policies which promoted increased production, there was insufficient consideration of what to do with the huge amount of waste material so generated. There are no widely available cost-effective treatment systems so farmers have been forced to "store and spread". The new Farm Waste Regulations are seen as a significant step forward, but it will take many years for improvements in storage to have a widespread beneficial effect on water quality.

3.8 Most nutrient problems are chronic and diffuse. Evidence of rising trends of nitrate in both rivers and groundwater is well documented and further examples are given in this report. For some rivers it is clear that agriculture is the principal source of nitrate. The ploughing of old grassland releases enormous quantities of nitrate which migrates to the groundwater. In some cases where migration is slow, the impact of post-war ploughing is yet to be felt, but such impact is inevitable. For groundwaters with a rapid response time, there is some evidence that restrictions of fertiliser use and crop choice will limit, and occasionally reverse, the rise in nitrate levels.

3.9 Proposals from Europe to define vulnerable nitrate zones are being considered by the NRA, which has suggested a two-tier system of recommending careful practice over large areas, with intensive restrictions in sensitive areas around specific sources. It is felt that this concept could be extended to cover all "sensitive" waters for a wide variety of contaminants. Excess phosphate is one of the principal causes of unwelcome algal blooms, but control is more problematical than that of nitrate. It is likely that a comprehensive catchment approach will be necessary.

3.10 By their very nature, pesticides are likely to have an impact on animals and plants. Unfortunately, few are specific to their commercial target. Evidence of the effects of acute pollutions is presented but most problems are of a chronic or diffuse nature. Pesticides are commonly found in surface waters; they are less common in groundwaters. Whilst agriculture is a major source, it is recognised that there are many others. Although most persistent pesticides are no longer approved for use, their effect is likely to be observed for many years. Most modern pesticides are less persistent, but their sub-lethal impacts are largely unknown. Their seasonal use, and tendency to enter controlled waters with intense rainfall, has implications for the NRA's monitoring programme.

3.11 Problems with oil are relatively rare but when they occur, the effects can be severe. The new Regulations should assist in reducing these problems. Other contaminants include metals and acidic run-off, pharmaceutical products, disinfectants and suspended sediments. The impacts of some are obvious but for others are less well understood.

3.12 The main area of concern with regard to biological contaminants is that of pathogens from agricultural sources entering water supplies. However, pathogens occur everywhere but rarely have observable effects on plant, animal or human health. With genetically modified organisms, particularly micro-organisms, the risks are unknown; the Government's intention to issue regulations, and funding of research in this field, is welcome.

Discussion

3.13 It is clear from the evidence presented in this report that agriculture can, and often does, have a deleterious effect on natural water quality. The resolution of these problems will require all parties to appreciate the need for controls, and to work together to achieve improvements.

3.14 It is unlikely that the UK could reach and maintain self-sufficiency in the principal agricultural commodities. It does, therefore, seem sensible to balance the economics of self-sufficiency with those of protecting our vital water resources. A co-ordinated approach will be necessary.

3.15 Many land use and agricultural activities have impacts on water quality. The problems of water resources are inextricably linked with those of water quality. Again, it is necessary to have a co-ordinated approach to dealing with abstractions and discharges, and this is best done on a catchment basis. It is noted that the loss of wetlands also removes their important water quality functions, that is their ability to treat contaminated water by natural means. There is a strong argument for reinstating wetlands adjacent to particularly sensitive waters, although the administrative difficulties of this suggestion are recognised. These issues and those relating to lowland forestry, land drainage and abstraction, all of which impinge on both water resources and quality, need to be addressed separately.

The Way Forward

3.16 A clear strategy is presented, giving recommendations for NRA policies, practices and research requirements; this will enable it to meet the challenge of reducing the problems of pollution from an agricultural industry which is constantly changing. New or changed policies are recommended on discharge consents, protection zones, waste disposal and monitoring.

3.17 A large number of practical issues is dealt with, the key recommendation being liaison with MAFF to assess the feasibility of individual farm waste management plans. Other areas include farm inspections, prosecution, incident control, catchment management planning, sensitive areas, reducing the risk of pollution, use of buffer zones, co-operation with the farming community, monitoring progress, anticipating the effects of climatic change, additional powers required, and education.

3.18 The Farm Waste Group will continue to assess the effect of proposed policy and practice changes, and the outcome of the research and development programme, and in the light of these will make further recommendations as necessary.

4 INTRODUCTION

4.1 The 1989 Water Act created the National Rivers Authority (NRA) as the "guardian of the water environment" with specific statutory duties and wide regulatory powers. Foremost amongst the aims of the NRA is the necessity to control pollution and to achieve a progressive improvement in the quality of the rivers, groundwaters, estuaries and coastal waters of England and Wales, so that they and their uses are protected.

4.2 The NRA has a number of duties and powers relating to the protection of the aquatic environment; these include responsibilities relating to the setting of consents to discharge, enforcement powers, plus powers to prevent and mitigate the effects of pollution. These are all detailed in Appendix 1. There are several Acts, codes, regulations and EC Directives relating to aquatic environmental protection and these are also outlined in Appendix 1. Such is the range and complexity of this legislation, it is not surprising that many farmers are not even aware of the consequences of some of it, let alone of the detailed contents and potential impact on farming activities.

4.3 The NRA relies heavily on the public and other organisations for co-operation in carrying out these duties. It will be seeking to continue the good working relationship with the Ministry of Agriculture, Fisheries and Food (MAFF), the Agricultural Development and Advisory Service (ADAS), the Welsh Office Agriculture Department (WOAD), the National Farmers Union (NFU), the Farmers Union of Wales (FUW), the Country Landowners Association (CLA), individual farmers and other organisations representing the agricultural industry.

4.4 Agriculture, like other industries, is a source of aquatic pollution; it is also a water user. The extent to which water is abstracted also has an important effect on the quality of the water that remains. The bulk of abstracted water eventually returns to controlled waters, although not necessarily to the same ones; for example, pumped groundwater may, after use, be discharged to rivers. The quality of the returned water is also usually lower than that abstracted.

4.5 An important element of the NRA's role is to assist the Secretary of State with the setting of statutory Water Quality Objectives and the associated standards. These will be achieved by the control of potentially polluting inputs to, and the abstraction of water from rivers, groundwaters and estuaries. The control of consented discharges has been addressed in the NRA's first Water Quality Series report (NRA 1990). Agriculture is a source of both acute and chronic point source discharges, some of which have consents, and the more problematical diffuse inputs, including nitrate and phosphate. Nitrate inputs are specifically addressed by the recently adopted EC Nitrate Directive, the implementation of which is still being discussed. The scale of the problem should not be underestimated.

4.6 The natural waters of England and Wales are under a continuing threat of pollution and eutrophication through the activities of man, one of which is agriculture; others include industry, sewage, precipitation and urban run-off. This report addresses the threat from agricultural activity, and recommends a strategy for limiting and mitigating its effects now and in the future.

4.7 Agriculture in England and Wales is operated through about 186,000 individually managed units which are stocked with 40 million grazing animals, 6 million pigs and 96 million poultry and include over 5 million hectares of arable crops. More than 80% of the land available is used for agriculture.

4.8 In England and Wales, the human population is about 50 million. It produces a large amount of waste, most of which is discharged to the sewer. Biochemical oxygen demand (BOD) is used as a measure of the "polluting load" and about 1.5 million tonnes of BOD arrive at sewage treatment works every year. Most of this BOD is human excrement - about 0.9 million tonnes. Treatment removes about 95% and the remainder is discharged to rivers and estuarine waters. Billions of pounds have been spent in providing the infrastructure for treating human sewage and much more is to be spent over the next few years.

4.9 In comparison, farm livestock produces about 2.5 million tonnes of BOD every year - nearly three times that produced by humans. All of this is either deposited directly, or spread, onto the land. With few exceptions, no pretreatment is provided. Whilst it is not known precisely what fraction of such waste enters inland waters, if only 2% of it were to do so then it would be equivalent to that arising from the human population after treatment. Animal slurry is also about 100 times "stronger" per unit of volume in terms of BOD than the more dilute waste arising even from crude sewage outfalls. Thus its impact upon the receiving water, when introduced directly, can be very serious.

4.10 In 1979, the Royal Commission on Environmental Pollution expressed the view that :

> *"The need to provide sewage plants to treat human waste is commonly accepted; it seems paradoxical that most animal excreta in slurry form are applied to land without prior treatment"*

The same sentiments are just as relevant, thirteen years later. In comparison with the money spent on treating human waste, relatively little is available to reduce the impact or risks arising from the excreta of farm livestock.

4.11 Hundreds of chemicals, including pesticides, fertilisers, pharmaceutical products and disinfectants are stored, used or disposed of on farms. According to MAFF, for pesticides alone, there are some 450 active ingredients (biocides).

4.12 It is reasonable to suppose that intensification of agriculture over the past 50 years has led to the establishment of tens of thousands of slurry stores, silage clamps, sheep dippers and oil or chemical stores. These are widely distributed in river catchments used for potable water supply and other important purposes. The risk of a major pollution incident arising from these changes has been much increased in recent years. It is thus hardly surprising that the changes in land use practices and intensification of livestock farming have had an effect on the environment. At the same time, there has been a change in attitude by both the public and the farming community such that there is now widespread concern about environmental matters.

4.13 The issue, therefore, is not whether farming has an environmental impact, but whether it causes unacceptable environmental change and how this, through consideration of costs and benefits, may be brought to an acceptable level. The overall aim must be to ensure the use of sound and sustainable agricultural practices which will protect, care for, and maintain the land and associated waters.

4.14 The Government has recognised the need for measures to control potentially polluting activities on farms and has, over the past few years, introduced a number of regulations and codes of practice, described in detail in Appendix 1. In addition, the provision of grant aid has much assisted the introduction of pollution control systems on many farms. ADAS has carried out a number of useful advisory campaigns, and recently there has been an increase in the maximum fine which can be imposed by magistrates for pollution offences under the Water Resources Act 1991. The NRA welcomes these measures as significant steps in the right direction. It may be argued that enough has been done, but the view of the NRA is that much more needs to be done to improve the legislative framework within which it operates, the awareness and understanding of farmers of their responsibilities for environmental management, and provision of a practical means of carrying them out. It is recognised that attention has been paid to individual facets of the problem but these and new initiatives need to be focussed into a coherent plan; in this report, the attempt has been made to provide the focus.

4.15 It is inevitable that change in the agricultural industry will occur. How that change is made is critical both to the agricultural industry and the natural environment. This review is designed to help in the management of the transition by identifying the present scale of the problem, suggesting solutions, and drawing attention to areas where further research is needed. In this way the considerable investment required can be both soundly based and integrated with other measures, such as those proposed by the EC to meet objectives of controlling farm production, maintaining rural economies, and protecting the environment.

4.16 In producing this summary, full recognition is given to a number of sound reviews on agricultural pollution; for example, on nitrates and pesticides by the Water Research Centre, House of Commons Select Committee, Department of the Environment, and the DoE's Nitrate Co-ordination Group. There is no attempt to deal with matters already covered in some detail elsewhere. Rather, the intention is to bring together various conclusions with some new data and to identify areas where a lack of data or investigation makes sound judgements difficult.

5 BACKGROUND

5.1 Historical changes in land use and agricultural practices, which were primarily triggered by the advent of the Second World War, have had an important impact on water quality. They will continue to exert a significant influence on future water quality, particularly by serious incidents in rivers, and diffuse pollution to groundwaters which, even if reversed, will affect some aquifers for decades to come. A detailed analysis of trends in agricultural practices in the post-war period is given in Appendix 2. Regional variations are given in Appendix 3.

5.2 Water, with its many important uses, is vital to the fabric of our society. The seemingly secure supply of drinking water from natural waters and the perceived upward trend in quality has, until recently, been the source of much reassurance. However, a series of droughts in recent years, and signs of deterioration that are not accurately reflected in results from national monitoring programmes, have caused increasing concern. The agricultural industry, with its hitherto clean image, is now the subject of a number of environmental and public health concerns.

5.3 Surface and groundwaters are the source of over 21,000 Ml/d of raw water for public supply in England and Wales. This resource is drawn from more than 500 reservoirs, over 400 river intakes and more than 1,500 boreholes and springs. These, together with over 45,000 licensed and many legal but unlicensed private drinking, agricultural, and industrial supplies from natural waters, are vulnerable to both point source and diffuse pollution. This risk has grown in scale and complexity with the more intensive use of land and the increasing range of chemicals deployed.

5.4 It has long been recognised that the management of water resources involves setting objectives to protect designated uses, and then deriving an associated quality standard which must be met to achieve that protection. In turn, this will be reflected by the strictness of discharge consent conditions and the need for careful regulation of practices which cause pollution, or are at risk of doing so. This is highly pertinent to the future management of agriculture, because of the range and high pollution potential of wastes and by-products from the industry.

5.5 A wide range of substances has been assigned quality standards by the regulatory agencies. These standards should not be exceeded if the aquatic environment and its uses are to be protected. The chemistry of natural waters is complex and the impact of the contaminants arising from agriculture varies according to many factors, including the vulnerability of the organisms concerned. This makes setting standards difficult. There is often only rudimentary understanding of the effects of various contaminants and many of the standards are based on limited data. Standards for those considered to have high toxicity, which are persistent and which may accumulate in living organisms, have been given special status through EC Directives and the formulation of a 'Red List' in the UK.

5.6 Chemical monitoring of compliance with national and EC standards has, in the past, formed the basis of the assessment of whether or not natural water quality is satisfactory; however, only main rivers and their important tributaries have been monitored routinely by "spot" sampling, which is often inadequate. There is little information about many small watercourses and ditches which often provide important habitats, for example for the spawning of fish.

5.7 For the past fifteen years or so, river water quality in England and Wales has been assessed using the National Water Council (NWC) Classification Scheme. This was interpreted differently by the previous Water Authorities, which used a range of two to ten chemical tests to determine quality. Tests for nitrates, phosphates, pesticides and other substances which can affect water uses were not included in a systematic way. The retention of data and their statistical treatment were also different, and the use of biological information to improve the accuracy of results based on chemical data was extremely limited.

5.8 In short, in implementing the NWC Classification Scheme, the relevant Authorities used a limited range of chemical tests, carried out on a small number of occasions, usually without biological audit and were often confined to the larger watercourses. Assessments of trends in contamination were not routinely carried out. Such a crude system was not developed for, nor could hope to assess the impact of, point and diffuse discharges of a wide range of agricultural chemicals and wastes and other inputs. This explains, in part, why there have been confusing signals between the reported river water quality and the evidence from pollution incidents, specific investigations into contamination of natural waters, deterioration in fish stocks and changes to the ecology of many natural waters. The 1990 NWC Classification (NRA 1991 a), carried out for the DoE, has shown a significant decline in river water quality from that reported in 1985.

5.9 The NRA's approach is to ensure consistent methodology and interpretation in order to remove most of the problems associated with the use of the NWC Classification Scheme. Proposals for a new scheme for classifying water quality have been made in a recently published consulation document (NRA 1991 b).

5.10 The various types of potential farm pollutants and their sources have been categorised for descriptive purposes; these are set out in Table 5.1. Some of them, for example nitrates, have a range of sources both within agriculture - slurry and mineral fertilisers - as well as from industry. Other agricultural pollutants have, to varying degrees, been identified as having the capacity to cause serious impact on the quality of natural waters. They include some of the most polluting substances of their kind; for example, in terms of oxygen demand, milk is 400 times more polluting than crude human sewage.

5.11 The number of reported pollution incidents from agriculture has more than doubled in twelve years, as shown in Figure 5.1, and now represents 12% of all incidents. Part of this rise will be due to increased awareness by members of the public, and that the NRA now has more staff with pollution control responsibilities. Similar trends have been observed for pollutions from other sources. Irrespective of whether or not the trend is real, the present number of reported incidents gives cause for concern. Chronic problems are common and there is considerable evidence of diffuse pollution in some areas, as shown by declining river water quality. Examples of causes are given in this report.

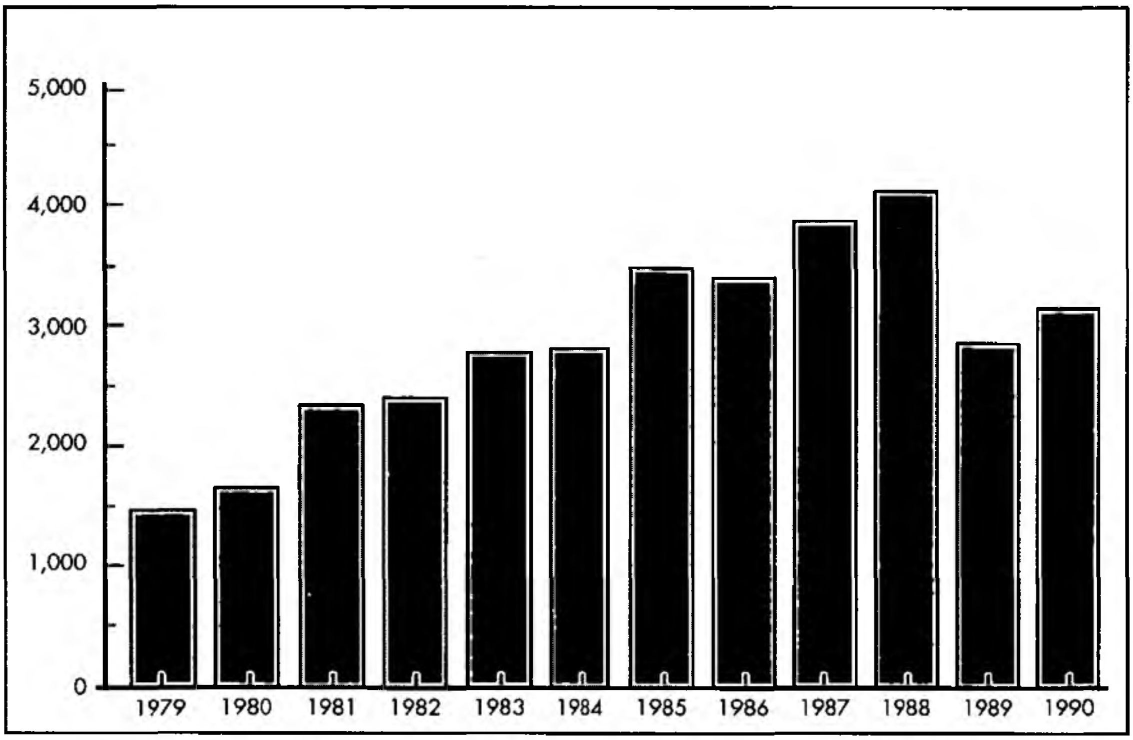
5.12 Almost all notified farm pollution incidents are reported by the general public. These tend to be incidents involving obvious visible changes in water quality or those associated with immediate loss of fish. Diffuse and chronic inputs are not seen. Such insidious contamination, which may follow quite subtle changes in land use practices, is often unrecognisable until monitoring is undertaken or secondary effects such as eutrophication become evident. Some catchment studies have shown chronic and diffuse pollution problems of this nature which were hitherto unrecognised.

5.13 Whilst reported incidents annually reflect problems at less than 2% of the estimated 186,000 farms in England and Wales, evidence from over 10,000 farm inspections by the NRA and

Table 5.1 - Sources of pollution from agriculture

Pollutant	Contaminants	Sources
Organic material	Carbohydrates Fats Proteins Ammonia Nutrients Metals	Slurry Silage Liquor Sewage Sludge Milk Related industry effluent Fish farm effluent
Nutrients	Nitrate Phosphate Potassium	Mineral fertilisers Organic wastes Land run-off
Pesticides	450 active ingredients available in UK	Herbicides Insecticides Fungicides Sheep dip
Biological Material	Large stock Bacteria Viruses Protozoa Fungi Genetically modified organisms	Escapes Sewage sludge Slurry Silage liquor Rendering plants Research
Oil	Fuel Lubricants	Storage
Metals	Cadmium Copper Zinc Iron Aluminium	Field drainage Slurry Sewage sludge Afforestation
Pharmaceutical products	Antibiotics Hormones Growth retardants	Veterinary products
Disinfectants	Chlorine Bromine Iodine Phosphorus	Cleansing agents
Physical effects	Temperature Silt Colour Acidity/alkalinity	Afforestation Land drainage Arable cultivation

Figure 5.1 Farm pollution incidents (1979-1990)



its predecessors shows that in many catchments the proportion of farms polluting, or at high risk of doing so, is about 40%. This does not mean that 40% of all farms are at high risk of polluting, but it is inferred that the real level of incidents is likely to be more than the reported 2%.

5.14 There is a problem in determining the seriousness of individual pollution events. Since 1985, strict criteria have been used to allow a consistent approach in the classification of pollution incidents. There is some concern over the comparability of these statistics as it is believed that, up until 1988, varying interpretations were made of what were serious incidents. Data from Farm Waste Reports (Water Authorities or NRA/MAFF, 1985, 86, 87, 88, 89) for all reported incidents have been used in the analyses described below. A common approach for defining serious pollutions is now being followed by the NRA. In 1990, 36% of all major incidents were from farms (NRA in press).

5.15 The combined effect of small, chronic or diffuse pollutions, in themselves not always serious, can be such that major changes occur in water quality, and the aquatic ecology and legitimate uses of water are damaged. In the event of an incident, a range of polluting mechanisms may occur: these include acute toxicity to aquatic animals and plants, asphyxiation of fish, smothering, bioaccumulation of toxins, aesthetic effects and microbiological or taste contamination of water abstracted for drinking. The contaminants act in different ways, to varying time-scales, with some causing damage to specific plants or animals and others acting on the whole ecosystem. Many of the complex inter-relationships and changes which occur are yet to be understood.

5.16 The impacts of water abstraction, land drainage, and upland afforestation are not dealt with in detail in this report. Each is a large subject in its own right. The effects of upland forestry practices on water quality have been reviewed by Swift et al (1990) and by others. Issues are being dealt with by a group with membership drawn from the NRA, the Forestry

Commission and the WRc. The issue of lowland forestry is equally important, because both government and private organisations are encouraging such planting. Newson (1989) summarised the sparse literature on the impacts of lowland forestry on water quality.

5.17 It was considered that research then being carried out would be inadequate as a working base for NRA policy; recommendations were made for further work. A research project to assess the hydrological and hydrochemical effects of small-scale hardwood plantations in lowland Britain is being part-funded by the NRA. Rosier et al (1990) summarise the results to date. It is clear that much remains to be investigated, particularly with regard to a wider range of tree species and ages, and soil types. Whilst this report deals with the effects of materials from farming which are added to water, account must be taken of the actual and predicted changes in water quantity caused by the activities mentioned above.

6. POLLUTANTS FROM AGRICULTURE - ORGANIC MATERIAL

Sources and Effects

6.1 The major sources of organic material arising from agricultural practices are animal slurry, silage liquor, and sludge from sewage treatment works that has been spread onto agricultural land. By-products from associated industries, such as abattoirs, dairies, meat and vegetable processing plants are also sources of organic materials.

6.2 Table 6.1 shows the estimated annual quantities of these substances. Almost all are disposed of, untreated, to agricultural land in England and Wales.

Table 6.1 - Estimated Amount of Wet Organic Material Spread on Land

Organic Material	Million Tonnes/Year
Animal Slurry*	200
Sewage Sludge	7.5
Silage Liquor	1.5
Milk, Abattoir and Vegetable effluents	Small quantities

**Includes excreta, yard and dairy washings, bedding and waste feed. Approximately half of the excreta is voided direct to land.*

6.3 Typical organic waste includes fats, carbohydrates, proteins, nitrates, phosphates, ammonia and microbiological organisms including pathogens. Where co-disposal takes place, slurry may also include silage liquor, pesticides, oils, veterinary products, disinfectants and their breakdown products.

6.4 When organic waste enters a watercourse, micro-organisms rapidly increase in number to take advantage of the food supply and during the breakdown process they use oxygen which is dissolved in surface waters. In extreme cases all the available oxygen may be removed. Examples of the BOD of some common organic materials are given in Table 6.2.

Table 6.2 - The Biochemical Oxygen Demand of some common organic materials

Organic Material	Typical BOD
Untreated human sewage	350 mg/l
Yard washings	2,000 mg/l
Animal slurry	30,000 mg/l
Silage liquor	60,000 mg/l
Milk	140,000 mg/l
Clean river water	<5 mg/l

6.5 Decomposition of proteins by bacteria can produce ammonia at levels which are toxic to many aquatic animals. Organic matter usually contains large quantities of suspended solids which increase turbidity and accumulate on the bed of slow flowing sections of watercourses.

6.6 When a pollution incident occurs, the biological breakdown of organic material will continue to have effects on water quality until the breakdown process is complete or there is sufficient additional dilution. The BOD of a clean river is 5 mg/l or less. When a waste such as human sewage pollutes natural waters it would need at least 70 dilutions, slurry 4000 dilutions and silage liquor 12,000 dilutions to avoid a significant deterioration in water quality. Where a continuous discharge occurs at a rate above the capacity of the water to deal with the organic matter, a large community of micro-organisms - known as sewage fungus - will often develop on the bed of a watercourse, sometimes for a distance of several kilometres.

6.7 The impact of excess organic materials on aquatic habitats depends on a number of factors, including the quantity of the material and its makeup, whether it is an intermittent or continuous discharge, the sensitivity of the species affected, and the dilution available in the receiving water. Sudden inputs of organic material may kill large numbers of fish and other animals. Chronic and diffuse inputs are often more subtle, causing slow but significant changes in habitats and biological communities. These long-term declines have been recorded on several rivers in England and Wales, such as in the River Torridge in Devon (Milford, 1986), and more recently, in some regions, the decline in river water quality between 1985 and 1990 is attributed partly to pollution from agriculture, much of which will have been caused by organic material (NRA 1991 a).

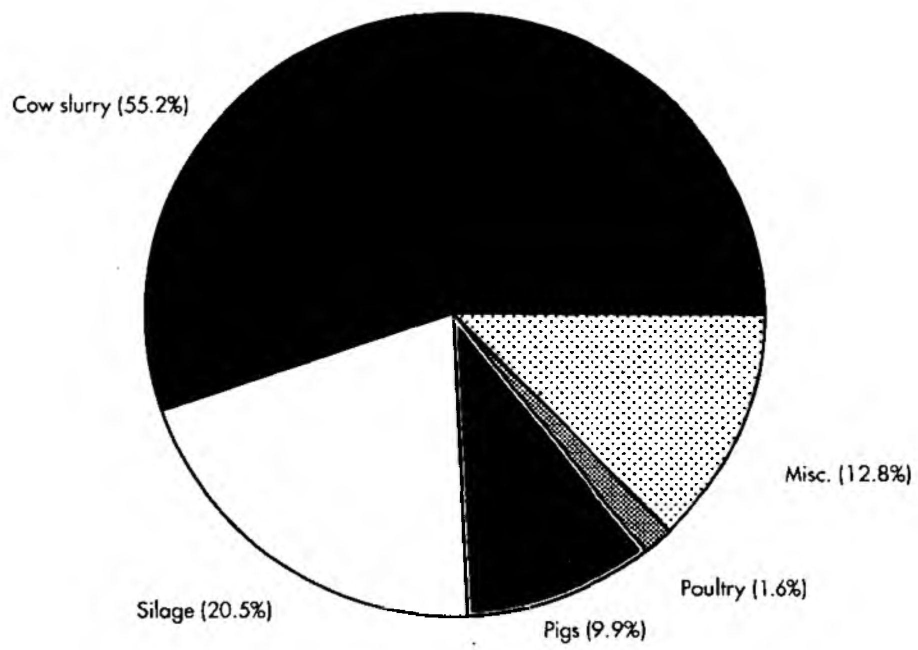
Pollution Incidents

6.8 Major incidents of pollution arising from organic waste from farms tend to be caused by poor containment of slurry or silage liquors and spillage when storage areas fail. Problems from land run-off occur when too much slurry is applied, where fields are underdrained or when adverse conditions obtain during or shortly after application. A common problem is caused by run-off from dirty yards, and overflow from storage and discharge of dairy washings. There is a range of other contributory factors, largely associated with poor planning and management of waste disposal. Examples of specific polluting events caused by organic farm waste are given in Appendix 4.

6.9 During the period 1985 to 1989, the majority (87%) of all reported farm pollution incidents were due to organic wastes: cow slurry accounted for 55%, silage for 20%, pig slurry for 10% and poultry for 2%, as shown in Figure 6.1. There are regional variations. Figures 6.2 and 6.3 show that the western half of the country had the majority of organic pollutions and that these were principally caused by cow slurry and silage. Problems with pig slurry occurred mostly in Anglian, Severn-Trent, Yorkshire and North West Regions. Incidents involving poultry occurred mostly in Severn-Trent, Anglian and the North West.

6.10 The majority of cow slurry problems were caused by inadequate storage in terms of capacity, structural soundness or management. Land run-off, and yard and parlour washings were also important. Almost all reported silage problems were due to inadequate storage capacity, poor structural soundness, or leaking drains. Pig slurry problems were principally due to inadequate storage capacity, structural collapse, poor management and over-application to land.

Figure 6.1 Percentage of all farm pollution incidents (1985-1989)



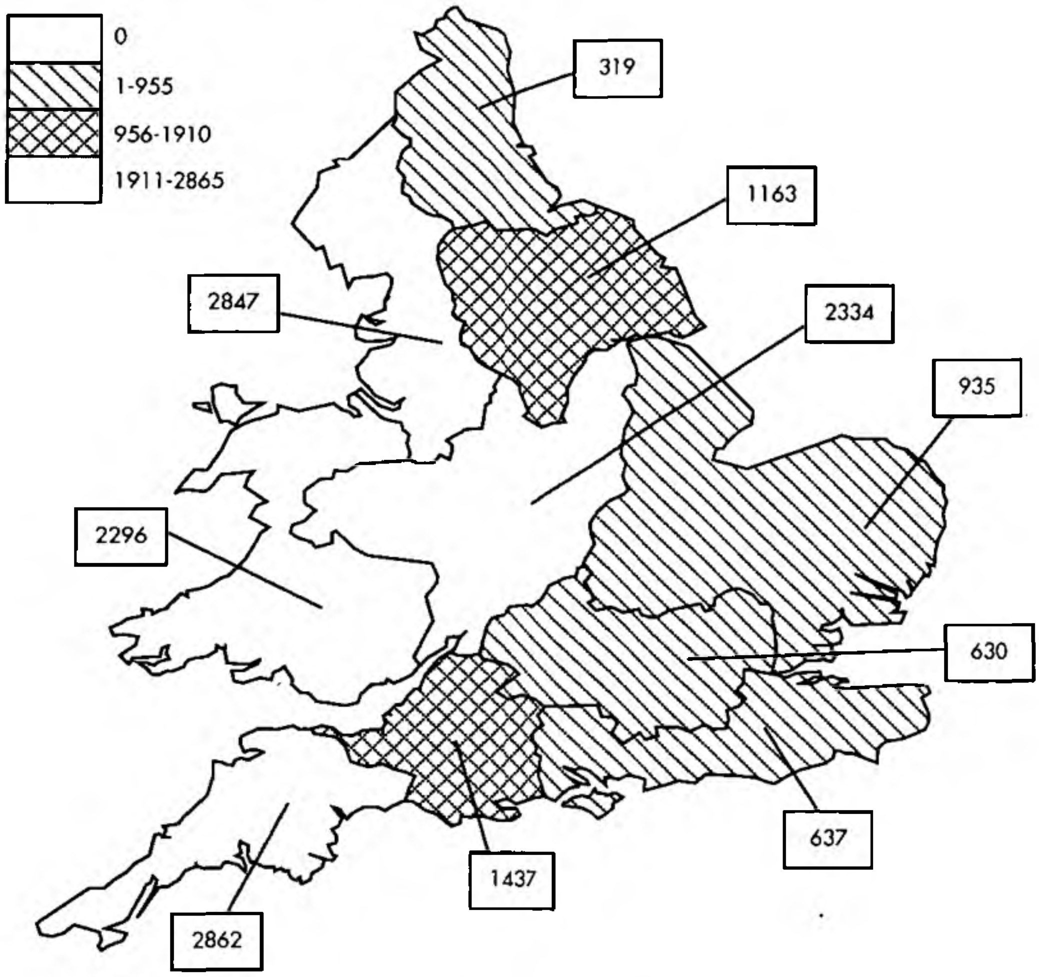
6.11 When land run-off problems are considered separately, it is clear that over the period 1985 to 1989 there has been a rising trend, as shown in Figure 6.4. Regional variations are also shown in Figure 6.4. Much of the land run-off occurs in rural areas after periods of heavy rainfall, when the ground is waterlogged or when it is frozen. These incidents tend not to be seen by the public and the reported figures are considered to be a significant under-estimate. It is acknowledged that the rising trend may be due, in part, to increased public awareness and the use of more pollution inspectors. Nevertheless, the present number of reported incidents is indicative of an unsatisfactory situation.

Chronic Effects

6.12 Acute pollution incidents have significant effects on environmental quality. Uses of water may be affected, but some of these may be only temporary, such as public water supply intake closure and stock watering. Chronic and diffuse pollutions, however, are more difficult to detect, as they require studies to be made over relatively long periods of time and over wide areas. Such detailed studies are few, and it is unwise to extrapolate from these to the whole of England and Wales. Nevertheless, those reported here all showed chronic and/or diffuse problems and are examples of the mechanism of water quality decline. The quinquennial surveys give national assessments of change.

6.13 Although arable farming is the dominant agricultural land use in East Anglia, pig production is an important activity (see Fig 6.3). The River Waveney catchment on the borders of Norfolk and Suffolk has a large number of pigs within it. Because much of the area is covered with impermeable boulder clay soils, organic waste frequently reaches the river through surface run-off and an extensive network of efficiently maintained drains. The rise

Figure 6.2 Distribution of total pollution incidents from organic waste (1985-1989)



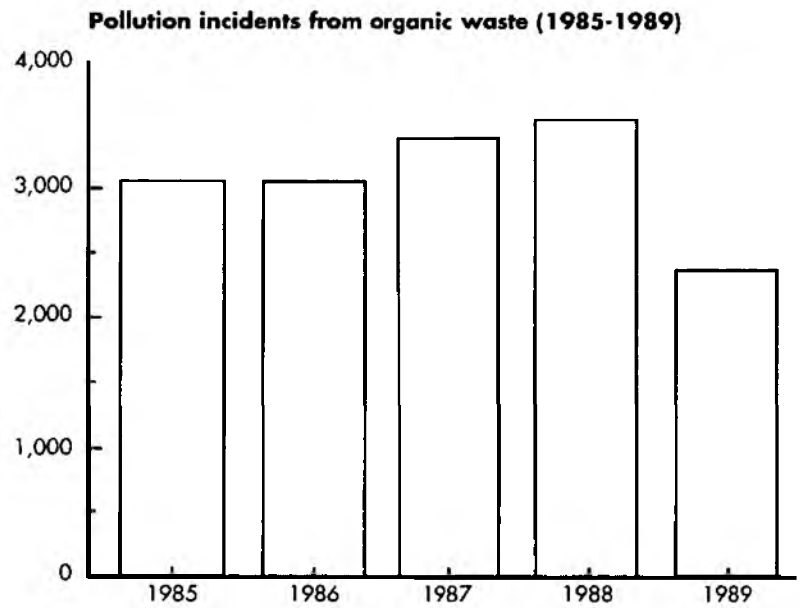
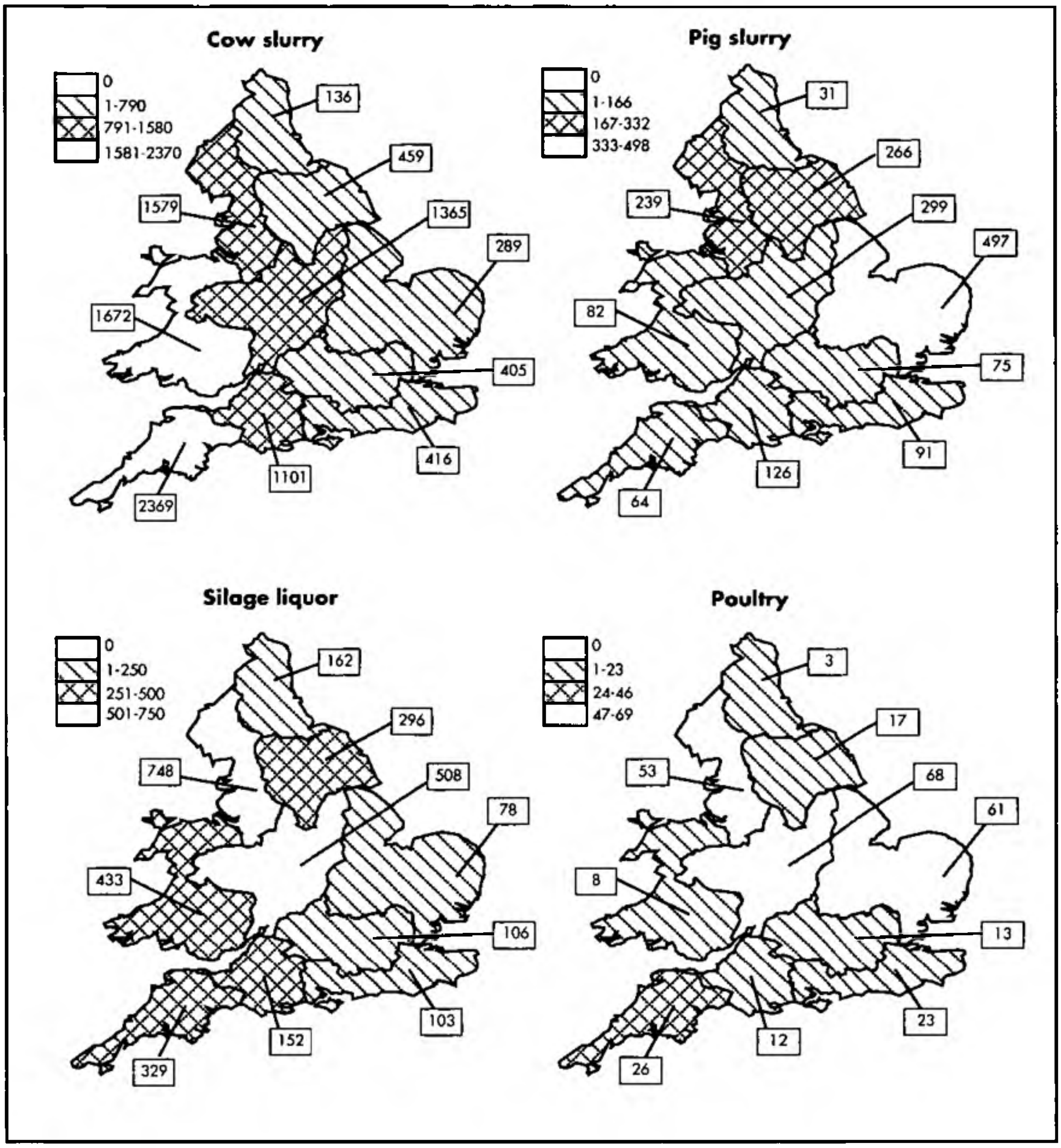


Figure 6.3 Distribution of total pollution incidents from organic waste (1985-1989)



in annual mean ammonia concentrations is indicative of increased and widespread pollution by pig slurry over the period 1965 to 1985, as shown in Fig 6.5. The number of pigs increased from 96,094 in 1964 to 208,913 in 1984, and their distribution became more uneven. Figure 6.5 masks the large seasonal variation which is associated with river flows; high concentrations of ammonia occurred at times of high rainfall. During 1984 the annual mean concentration of ammonia occurring in the tributaries was significantly correlated with the density of pigs occurring in those sub-catchments. Fish stocks were affected, with fish densities, biomass and, specifically, roach recruitment all declining between 1981 and 1985 (Anglian Water 1986).

Farm Campaigns

6.14 Since the mid 1980s, all Regions of the previous Water Authorities have undertaken farm visit campaigns and these have been continued by the NRA. Initially, the majority of

Figure 6.4 Distribution of total pollution incidents from land run-off (1985-1989)

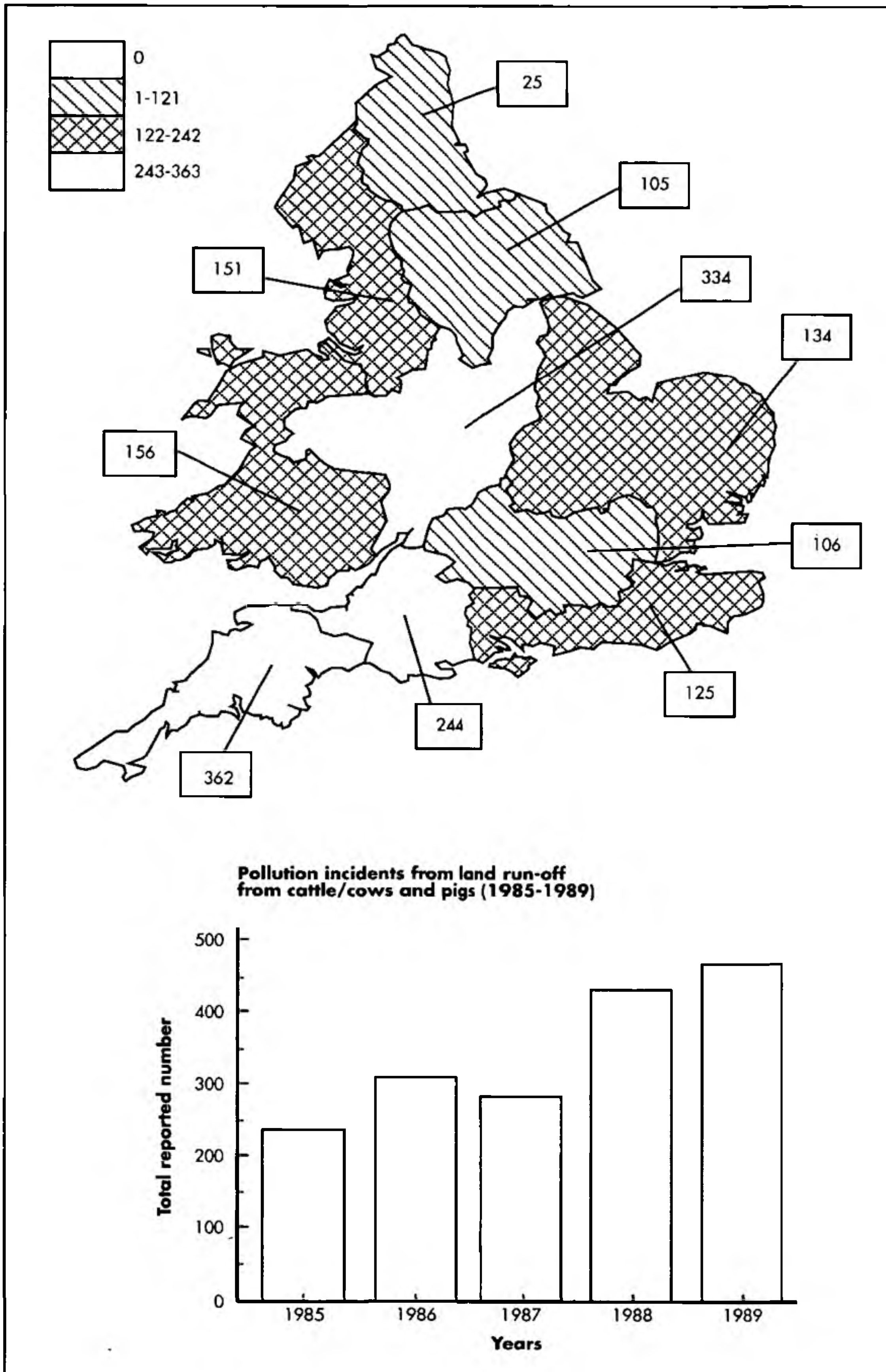
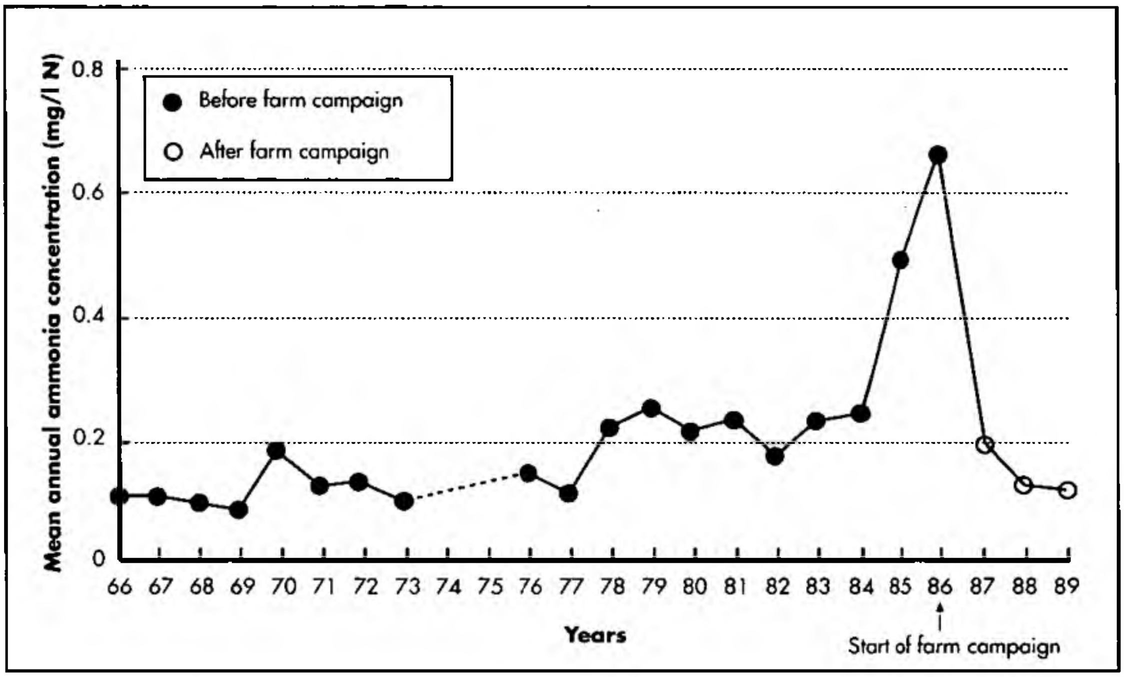


Figure 6.5 Trend in ammonia concentrations at Ellingham Mill, River Waveney



Regions identified single or few catchments where water quality problems were known to exist. Whilst all farms in these catchments were visited, the numbers were relatively low. The percentage found to be polluting or posing a significant risk, given different environmental circumstances such as season, weather or flow, was about 40% and varied regionally between 7% and 69%.

6.15 Some of these farm campaigns have had notable successes. Thus, for example, in the case of the River Waveney, between 1986 and 1988 a farm campaign was undertaken by the Anglian Water Authority. About 200 farms were visited and advice obtained from ADAS on remedial measures. Some fifteen prosecutions for pollution were also made during this period. In addition, over 40,000 fish were introduced in an effort to ensure recovery of the fishery. Since the farm campaign, there has been a noticeable reduction in ammonia concentrations in the main river (Figure 6.5). Some tributaries, however, continue to exhibit high ammonia concentrations. Whilst aquatic invertebrates are present in the upper reaches of the main river at levels consistent with the maintenance of breeding populations of coarse fish, biological quality in some tributaries remains poor as a consequence of continued organic enrichment. Fish densities and biomass have increased, as has recruitment for most species, but it is clear that full restoration of the fishery has not yet been achieved.

6.16 In the South West region the Water Authority, and subsequently the NRA, have operated farm campaigns for a long period, visiting a larger number of farms (over 6000). More recently these have been in catchments where water quality problems were not as significant as in the earlier areas of concern. Overall, the percentage of farms polluting or at high risk has fallen from 50% to 36%; this may reflect the impact of the publicity surrounding earlier parts of the campaign and the fact that recently visited areas have less intensive livestock.

6.17 In the Severn Trent Region the approach has been different, in that only dairy farms in particular catchments have been visited. Some 61% of these were polluting or posed a high risk at the time of the visit. Table 6.3 shows that nationally, so far, over 10,000 farms have been visited. This represents just over 5% of the total. Further examples of farm campaigns are given in Appendix 4.

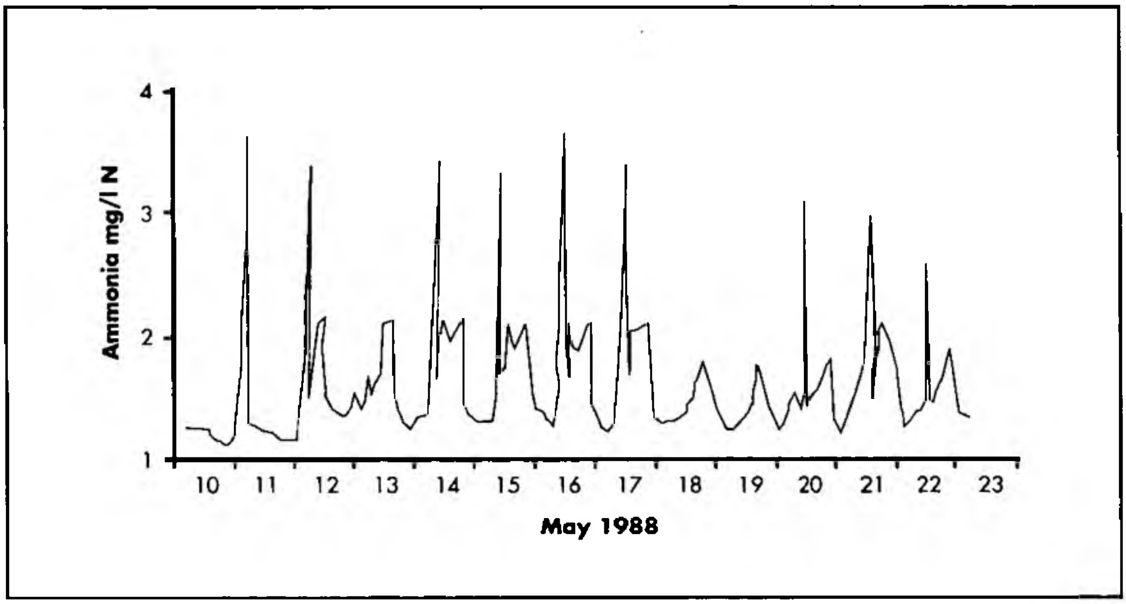
Relationships between farm organic waste and river quality

6.18 The relationship between land use, farm waste management and river quality has been investigated in some detail in the Eastern Cleddau, Wales (Schofield et al; 1990). It was found that water quality in the major rivers in the catchment was generally good, but high ammonia and BOD levels occurred in some tributaries draining land used for dairying. Intensive monitoring of one such tributary indicated that certain activities, such as the

Table 6.3 Farm Campaigns

Region	Catchment	Year	Number of farms visited	Number polluting or at high risk	% polluting or at high risk
Anglian	R. Waveney	1986-88	200	114	57%
Wessex	Lydden	1986-87	279	100	36%
Northumbria	Baydale Beck	1988	32	5	16%
Thames	Derry Brook	1987	78	20	26%
Southern	R. Arun	1989-90	331	26	8%
	R. Adur	1989-90	165	11	7%
	Chichester Rifes	1989-90	83	5	6%
Welsh	Various	1987-90	479	259	54%
North West	R. Gowy R. Weaver R. Brock R. Ribble Others	1987 1987 1987 1990 1987-88	1031	714	69%
Yorkshire	Whiske Wharfe Upper Dearne Washburne	1989 1989 1990 1990	297	148	50%
South West	Various	1984-90	6398	2279	36%
Severn Trent	Selected farms in Shropshire Staffordshire Warwickshire Leicestershire Montgomeryshire	1988-89	1068	657	61%
TOTAL			10,441	4,338	41.5%

Figure 6.6 Continuous chemical monitoring in the Clarbeston Stream



washing of yards and dairy parlours, caused a measurable deterioration in receiving water quality. Figure 6.6 shows how ammonia concentrations followed a marked diurnal variation associated with the daily cleaning of dairy parlours. Rainfall exerts a direct effect, probably by causing farm wastes to be washed off impermeable yard surfaces and from land which had received slurry applications. Benthic macroinvertebrate communities were characteristically dominated by pollution-tolerant taxa in streams affected by farm pollution.

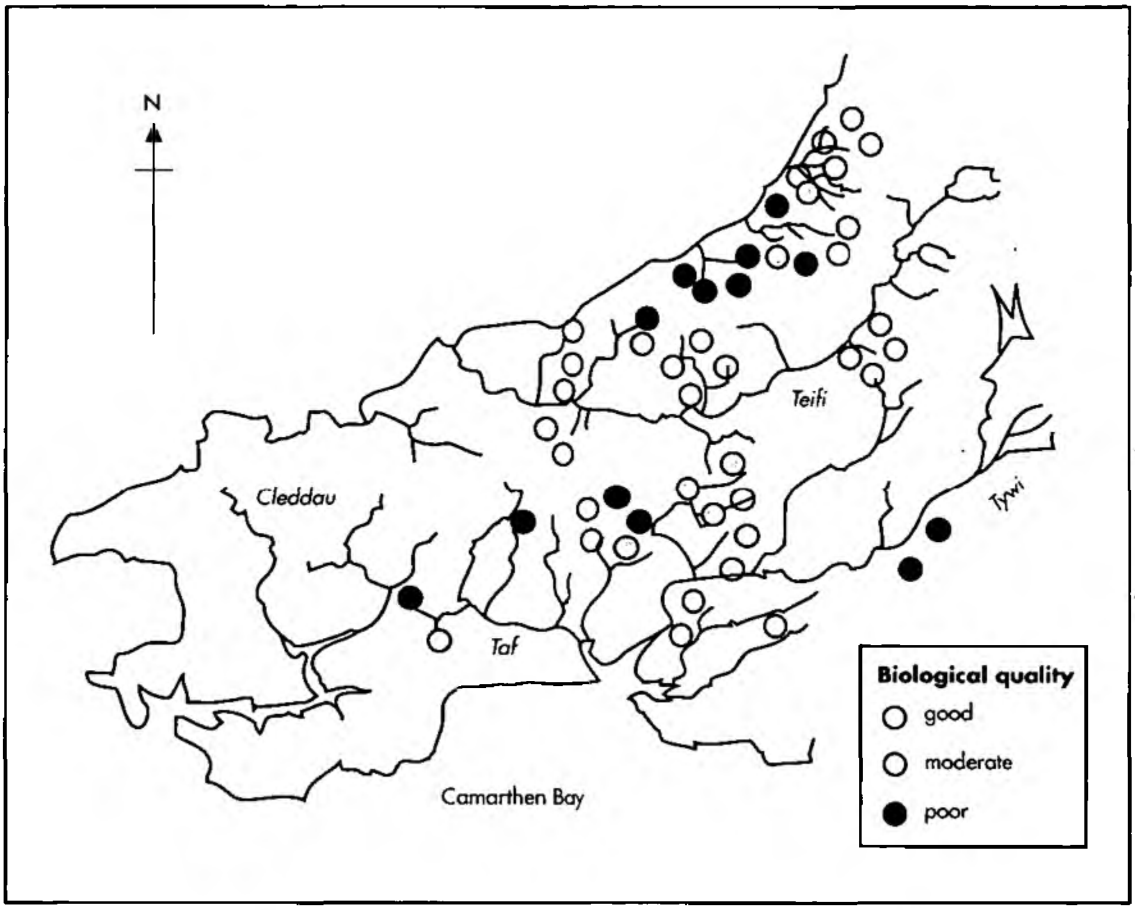
6.19 In a wider survey of streams in West Wales (Reynolds 1989), it has been demonstrated that wastes from agriculture can have a serious impact on the biology of headwater streams. Of the 50 sites shown in Figure 6.7, 22% were considered to be of poor biological quality and were generally located downstream of gross agricultural pollution. A further 30% were of moderate biological quality and indicated either mild or historical agricultural pollution. Agriculture-related industries may also contribute a polluting load of organic material. These include products from creameries, other food processing plants, and abattoirs. Three typical examples are given in Appendix 4.

Discussion

6.20 Over much of the past 50 years, government policies for agriculture have understandably placed emphasis on food production. In response, stock farmers intensified their practices, became dependent on imported feedstuffs, and increased their flock and herd sizes to a point where the associated land is often insufficient to cope with the slurry produced. It is clear that the implications of dealing with such a huge amount of material were not sufficiently considered. Whilst the use of the best available technology for dealing with such problems is usually advocated, in practice there is no suitable technology available on a wide scale at reasonable cost. Even if treatment could be made cost-effective, discharge consents are likely to be quite stringent and, therefore, difficult to comply with. There is little option but to collect, store and dispose of animal slurry to land.

6.21 Whilst new or substantially enlarged stores must be built to a recommended standard, there must be a large number of existing stores which are of doubtful quality. The risk of failure will depend on many factors but generally will be low for modern stores, and higher for older ones. There is also a separate risk dependent on the management of the slurry when it

Figure 6.7 Distribution of aquatic invertebrate sampling sites



leaves the store. Incidents such as those described in Appendix 4 will continue to occur until the problems of storage design and management have been solved. The new Farm Waste Storage Regulations, introduced under the 1989 Water Act, are seen as a significant step forward, although it will take many years for the improvements to have a general effect on water quality.

6.22 Farm campaign visits are seen as an effective method of assisting farmers to reduce the risk of acute pollution, and the occurrence of both chronic and diffuse pollution; however, only 10,000 of the 186,000 farms in England and Wales have been visited. Whilst the majority of these have been in areas of known water quality problems, it is likely that a substantial proportion of the rest are either polluting now or pose a high risk. Evidence from the South West Region suggests that this proportion may presently be about 30%. In England and Wales, the number of reported incidents is only about 3,500 each year. It is highly likely that pollutions are occurring at a rate considerably greater than that reported. In the future, it is clear that a standard approach and format to farm campaigns needs to be agreed. In this way, farmers will be encouraged, in an even-handed manner, to find acceptable solutions to their waste disposal problems.

7 POLLUTANTS FROM AGRICULTURE - NUTRIENTS

Sources and Effects

7.1 Nutrients are a group of substances which includes nitrogen, phosphorus and potassium; these are essential for plant growth. The major sources of nutrients are the soil itself, fertilisers, animal manures, rainfall, sewage, silage liquor, and a number of other minor inputs. Although soils contain large residues of nutrients, only a small fraction becomes available to plants. Thus nearly 2.5 million tonnes of mineral fertilisers as plant food are applied annually to land (Fertiliser Manufacturers Association, 1990), and smaller quantities of nutrients, in the form of animal slurry and sewage sludge, are spread annually onto agricultural land, to promote and sustain the growth of farm crops.

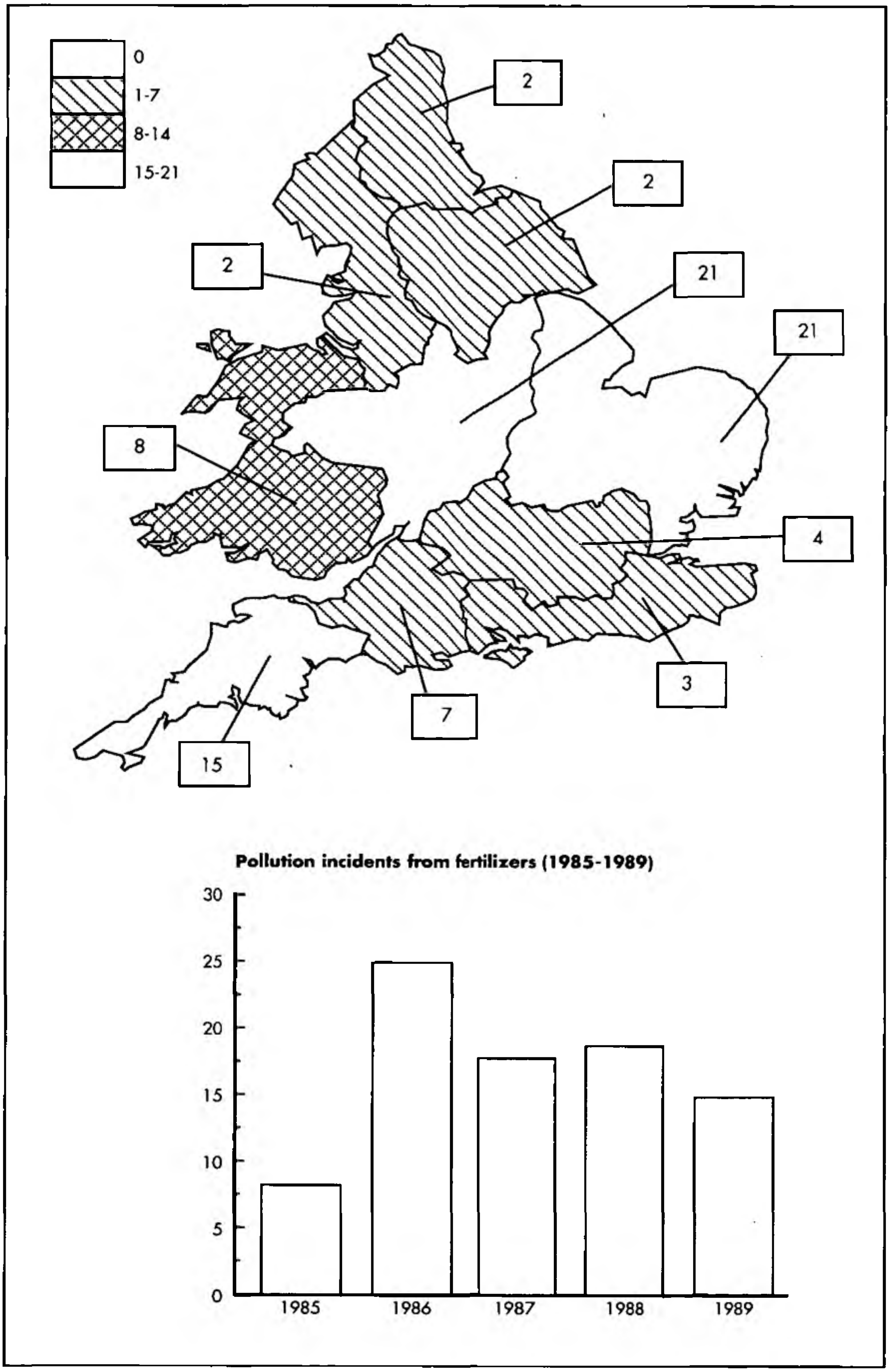
7.2 Nutrients from agriculture usually enter watercourses from drainage water percolating through the soil, from land run-off, from erosion of the soil, and by direct spillage. Nitrate is soluble and follows the movement of water in ground or surface waters, whereas phosphate may enter watercourses through soil erosion because it readily adheres to soil particles; little phosphate therefore enters groundwater. Other sources, especially sewage effluent, are important in some areas, but in rural areas the contribution is less significant. Calculations for the River Torridge in Devon showed that at low flows (Q95) up to 34% of the nitrogen in the river came from sewage treatment works whereas at average flows (adf) less than 3% was from this source, the remainder being from the land (Milford 1986).

7.3 An increase of nutrients in surface waters resulting in increased plant growth is commonly referred to as eutrophication. In freshwaters, phosphate is the principal limiting nutrient whereas in estuarine and coastal waters, it is nitrate. Blooms of algae are unsightly and can have an adverse effect on the environment. For example, large variations in dissolved oxygen and pH, caused by algae photosynthesising during the day and respiring at night, have been known to kill fish. Toxins may be produced by blue-green algae. (This was the subject of NRA Water Quality Series Report No. 2, 1990 b.)

7.4 The long-term subtle effects of eutrophication in watercourses is poorly documented, although it is likely that habitats and animal communities will be significantly altered. Eutrophication in lakes and reservoirs is better understood. Increasing and high levels of phosphates often result in the development of algal blooms. This has cost implications, because such water abstracted for potable supply has to be given extensive treatment to remove the algae. Decaying algae can also leave an unpleasant taste and odour in potable water. The ecological effects of high nitrate concentrations are unclear, but high concentrations in potable water are considered by some to represent a small potential health risk. Standards have been set in the Drinking Water Directive (11.3mg/l N or 50 mg/l as NO3) but these are to minimise the risks to human health, not to control the process of eutrophication. A large proportion of groundwaters in England and Wales, and surface waters in some areas, frequently have nitrate concentrations which exceed this standard.

7.5 The number of acute pollution incidents involving mineral fertilisers is generally low. In the period 1985 to 1989 there were 85 cases in England and Wales, which represent less than 0.5% of all reported farm incidents. Their distribution is shown in Figure 7.1. A number of detailed case studies are given in Appendix 4.

Figure 7.1 Distribution of total pollution incidents from fertilizers (1985-89)



Nitrate

7.6 There are many sources of nitrate; these include sewage treatment works and industrial discharges, and natural processes within the soil, as well as specific farm practices. There have been many reviews of the scale and extent of the problem of nitrate in water, the most important being that produced by the Department of the Environment (HMSO 1986). It is widely recognised that rising trends occur in many unconfined aquifers and surface waters throughout the country, and that these trends are associated with changed agricultural practices. Figure 7.2, adapted from the above document, indicates the groundwater areas vulnerable to nitrate contamination and also shows those aquifers which have been reported as having nitrate values exceeding 50 mg/l NO3 on one or more occasions in 1983 and 1984; the aquifers so identified do not represent the definitive list, but merely reflect the scale of the problem. In some areas, there has been a levelling, or a slight decline, in trends since about 1980, which has been related to changes in the management of winter cereals (Oakes 1989).

7.7 In 1986, the DoE's Nitrate Co-ordination Group reviewed long term data from 25 rivers and shorter term data from 149 sites. It concluded that nitrate concentrations had increased at varying rates, being generally higher in central and south eastern areas, although there were indications that trends were levelling off from the mid 1970s. Crude assessments of annual rates of increase are shown in Table 7.1

Table 7.1 - Geographical Variations in the Rates of Increase of Nitrate Concentrations in Rivers

Area	Increase in Nitrate Concentration
Scotland, Wales, North West	0.1 - 0.4 mg/l per year
North East	0.1 - 0.7 mg/l per year
Yorkshire, Severn Trent, Thames, Southern, Wessex	0.3 - 0.8 mg/l per year
Anglian	0.7 - 1.1 mg/l per year

7.8 Recently, the NRA has analysed data from twenty DoE Harmonised Monitoring sites to provide an up-to-date assessment of the situation in selected rivers. Two rivers were chosen from each region, on the basis of their being largely rural. Positive trends, significant at the 5% level of probability (or better), were observed on 13 rivers (65%); trends were not apparent on 6 rivers (30%) and one (5%), the River Esk in Yorkshire, had a significant negative trend. Results are shown in Figure 7.3 and examples of data and trends are shown in Figure 7.4. Many rivers exhibit winter peaks of nitrate, which are probably associated with surface run-off from the land and not from sewage effluents, which would be diluted in high river flows. An example is also shown in Figure 7.4. The implication is that rising nitrate trends in these rivers are due to agricultural practices, and it is clear from Figure 7.3 that rivers exhibiting positive trends are not restricted to principally arable areas.

7.9 The River Axe in Devon is such an example. It could be argued that changes in 'load' from a creamery discharge and a large sewage treatment works upstream were the principal causes. An assessment of data from points upstream of these influences has, however, shown positive trends in nitrate in areas where the only inputs are from agriculture, relatively few small sewage treatment works, and domestic properties. Annual mean concentrations of phosphate are low upstream of the creamery, and there is some indication of a decline with

Figure 7.2 Aquifers and the vulnerability of groundwater to nitrate pollution

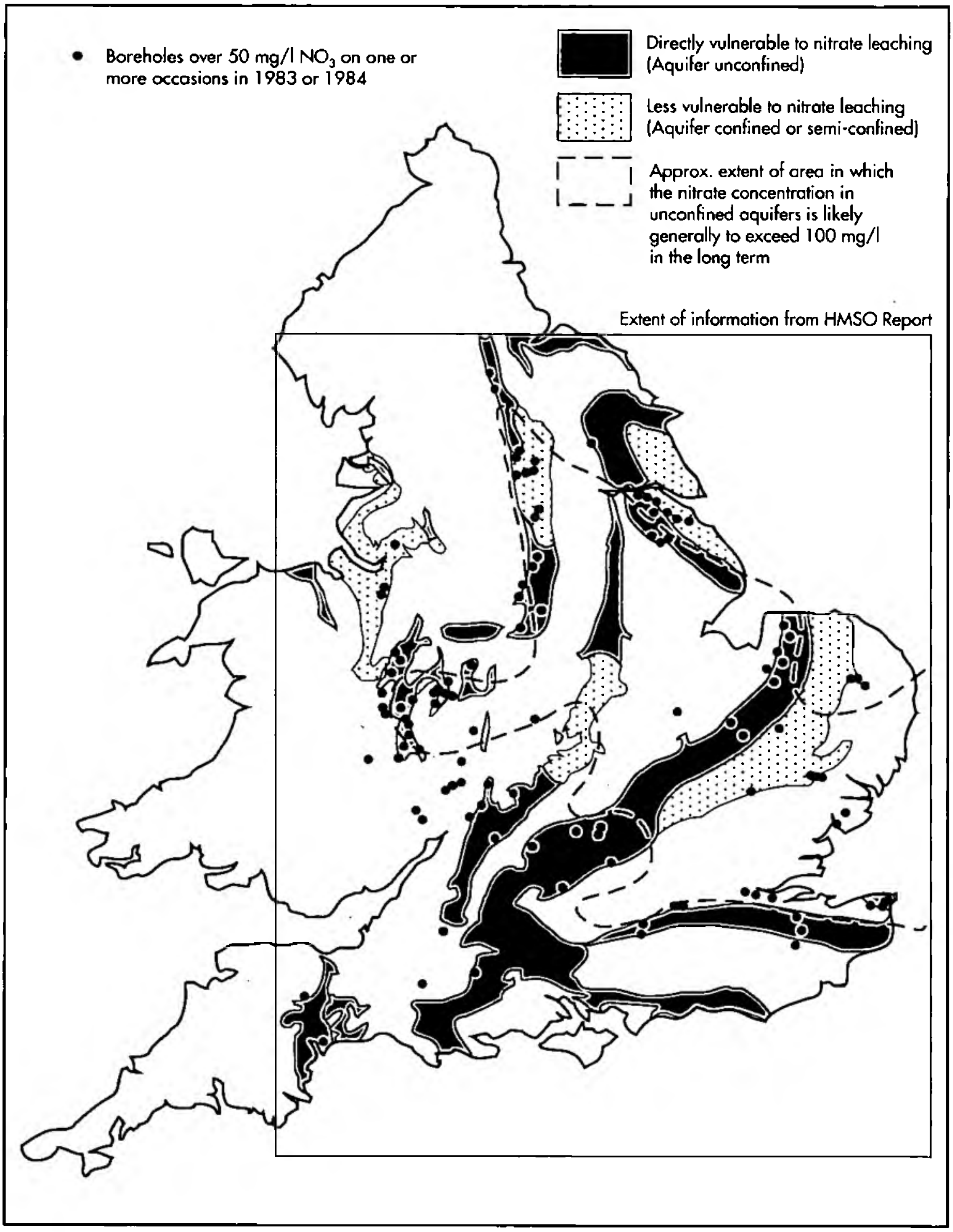


Figure 7.3 Nitrate trends in selected rivers in England & Wales

time. Downstream of the creamery, phosphate levels are higher with the suggestion of a recent increase. At these levels it is likely that phosphate is the limiting factor for algal production upstream, but there is also some indication of a rise in pH values, which may be a reflection of increased algal activity. Seasonal analysis shows that phosphate levels are higher in spring and summer, when nitrate levels tend to be falling and low. Hence at these times phosphate is not limiting, giving credence to the idea of increased algal production resulting in an upward trend in pH; Figures 7.4 and 7.5 show relevant data. Where Harmonised Monitoring data indicate trends in nitrate, it is clearly worth looking at all points upstream to see if trends remain, even when sewage and industrial influences are removed from the data set.

7.10 For the River Trent, (José 1989) it has been shown that in the main river, and two principally urban sub-catchments, nitrate concentrations have increased at a rate of up to 0.2 mg/l per year, doubling in about 20 years. Two principally rural sub-catchments have also exhibited increasing trends at rates of about 0.06 mg/l per year, doubling in about 30 years. Agriculture must, therefore, also be contributing to the observed nitrate increases in the main river.

7.11 Other examples exist; thus, for the River Thames, (Onstad and Blake 1980) modelling has been used to explain observed trends in nitrate concentrations as shown in Figure 7.6. Data on land use, inorganic fertiliser use, animal production and crop yields were used to generate estimates of the amount of nitrate available on the land over the period 1922 to 1975. Despite some gross assumptions, this accounted for 78% of the observed variance. The effects of a number of plausible options in agricultural trends were also assessed to the year 2000 and, regardless of the assumptions, river nitrate levels were still expected to rise.

7.12 Similarly, in the River Stour in Essex, it is known that a rising trend exists for nitrate concentrations, but it is more difficult to determine the causes. The river receives much sewage effluent and is also periodically the recipient of inter-catchment transfers from the River Ouse, which itself has high nitrate levels from agriculture and sewage.

Nitrate in Groundwaters

7.13 For groundwaters, long term data exist for many public supply boreholes; but these are imperfect indicators of trends in aquifer quality. Water from boreholes consists of a mixture from different depths and its quality is influenced by borehole construction, flow and pumping regime. Data from research boreholes are more reliable but are available for relatively short intervals. Of those sources with reliable data, some show little increase in nitrate since 1970, and a few have shown a decrease; but some display an overall rising trend, as the following examples illustrate.

7.14 Figure 7.7 shows nitrate concentrations observed over a period of more than 40 years from two supply boreholes in the West Cheshire aquifer (Lucey, 1991 pers. comm.). The Sandyford borehole intercepts relatively young groundwater (about 20 years) in an unconfined aquifer. The Eaton borehole, which does not show a trend, intercepts relatively old groundwater (at least several hundred and perhaps several thousand years old) in a confined aquifer. The observed trend at Sandyford is consistent with the predominant land use for dairying and the increasing use of nitrate fertilisers on grassland since the 1940s. Nitrate release following ploughing of long term grassland is not a significant factor in this area. Analysis of porewater from the unsaturated zone indicates that nitrate levels will continue to rise for some years, although predictions are difficult as there is a risk of recharge short-circuiting the unsaturated zone during wet weather.

Figure 7.4 Nitrate concentrations (mg/l N) in selected rivers in England & Wales

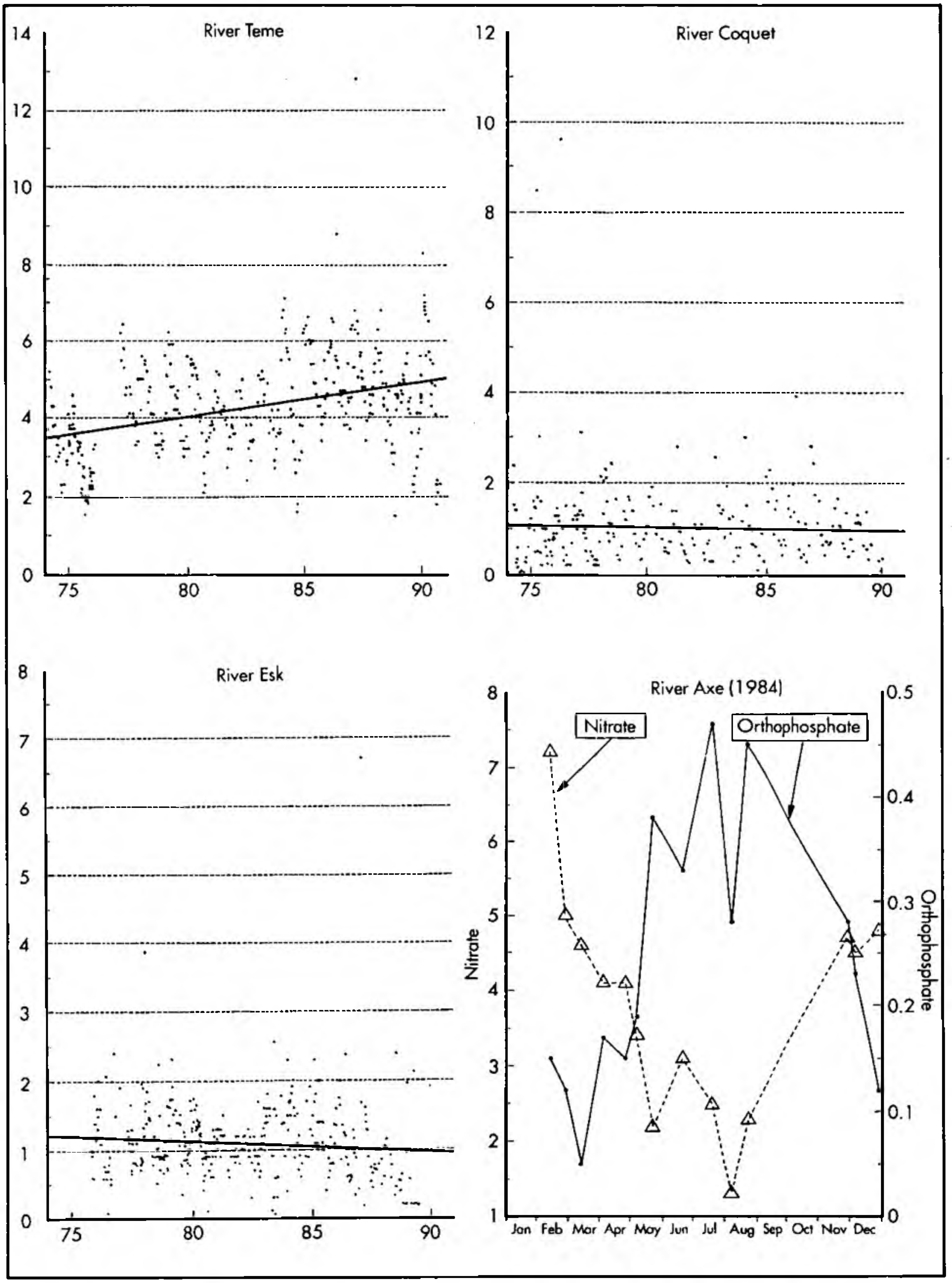


Figure 7.5 Nitrate, phosphate and pH trends in relation to discharges to the River Axe

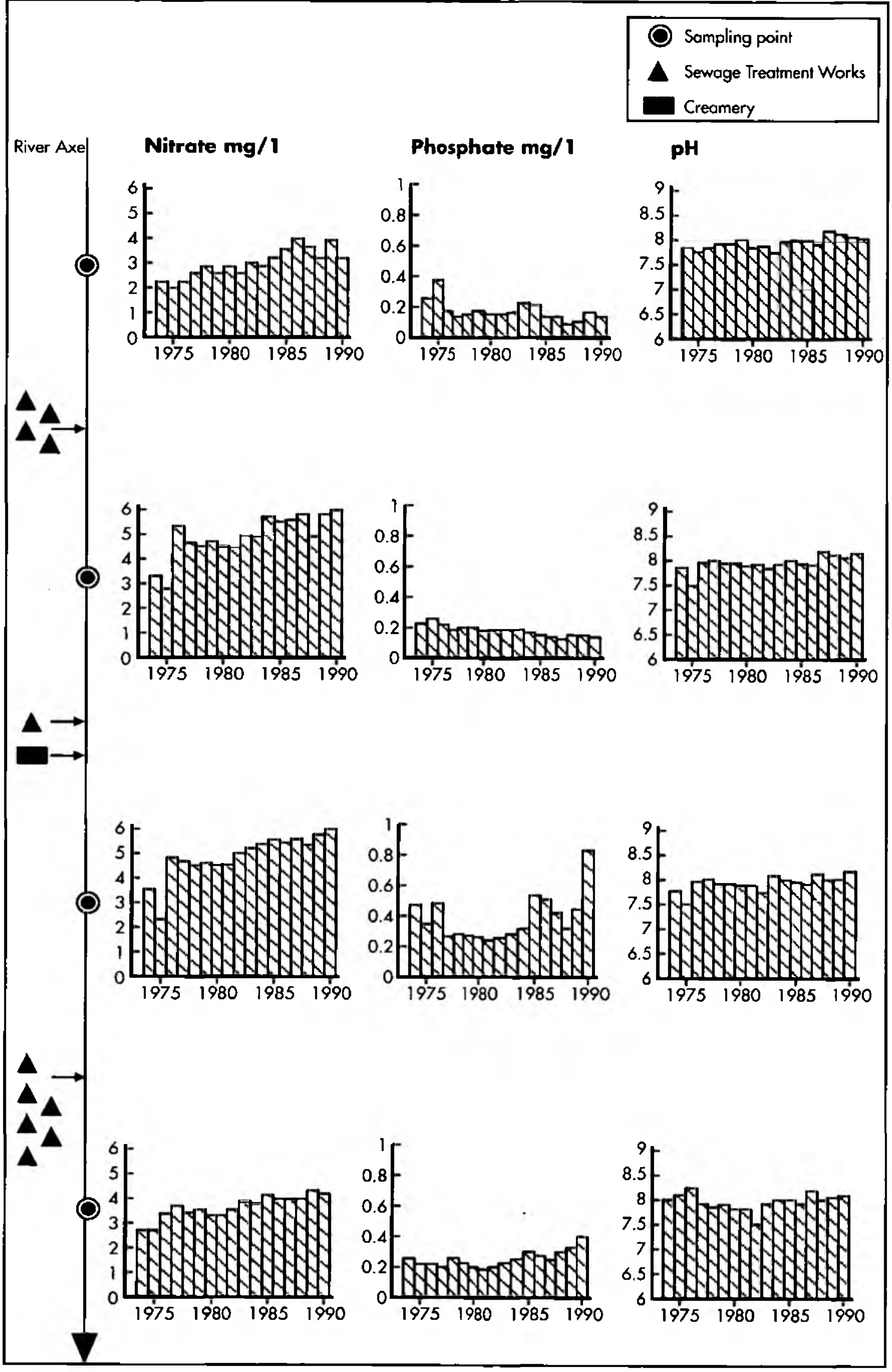


Figure 7.6 Mean quarterly nitrate concentrations, Walton intake on the River Thames (mg/l N) (1929-78)

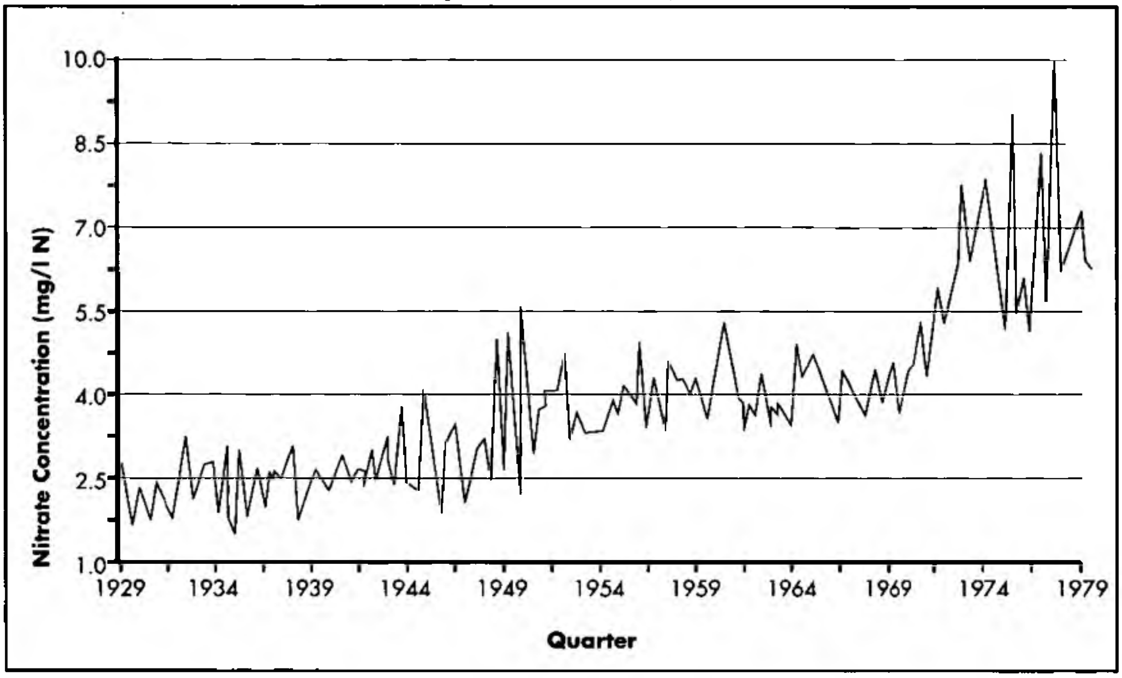
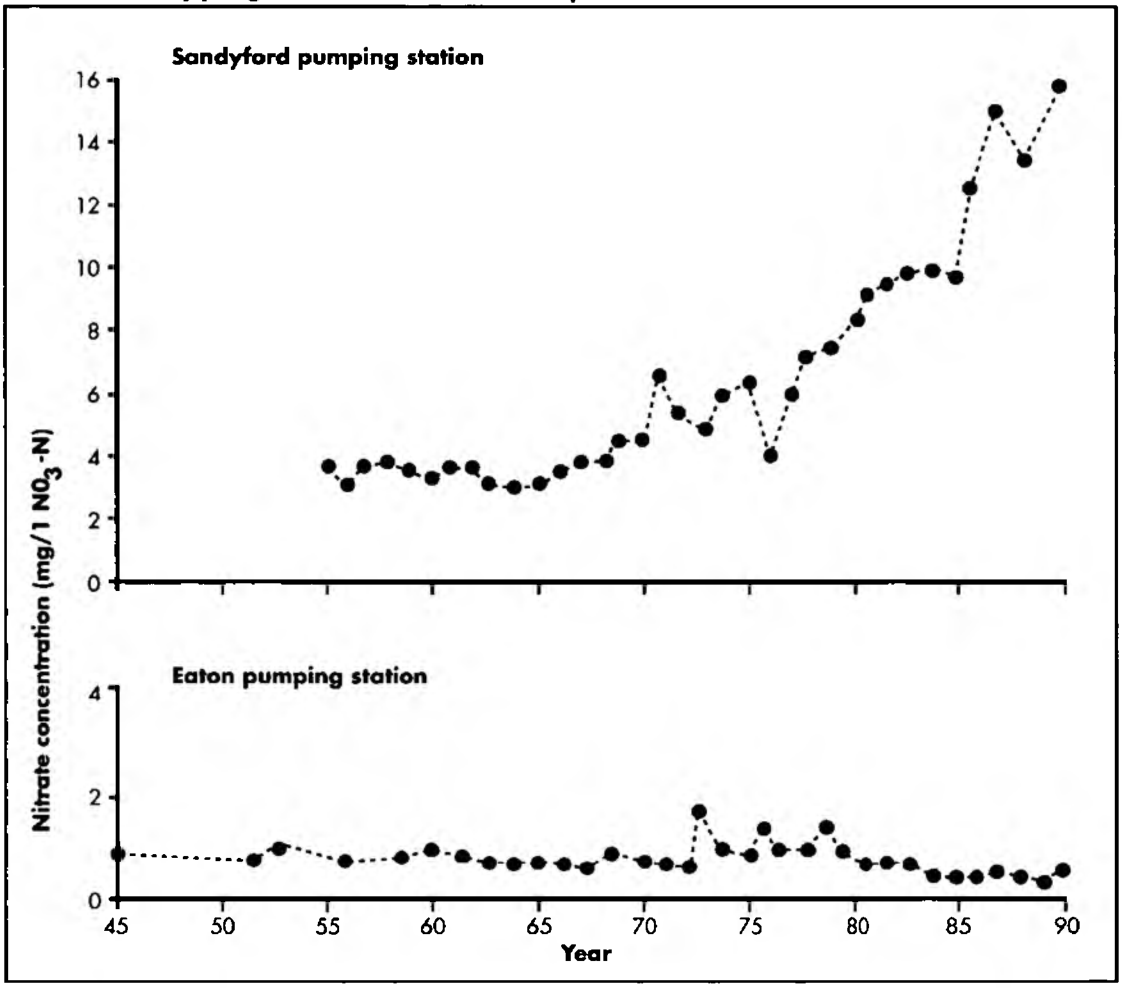


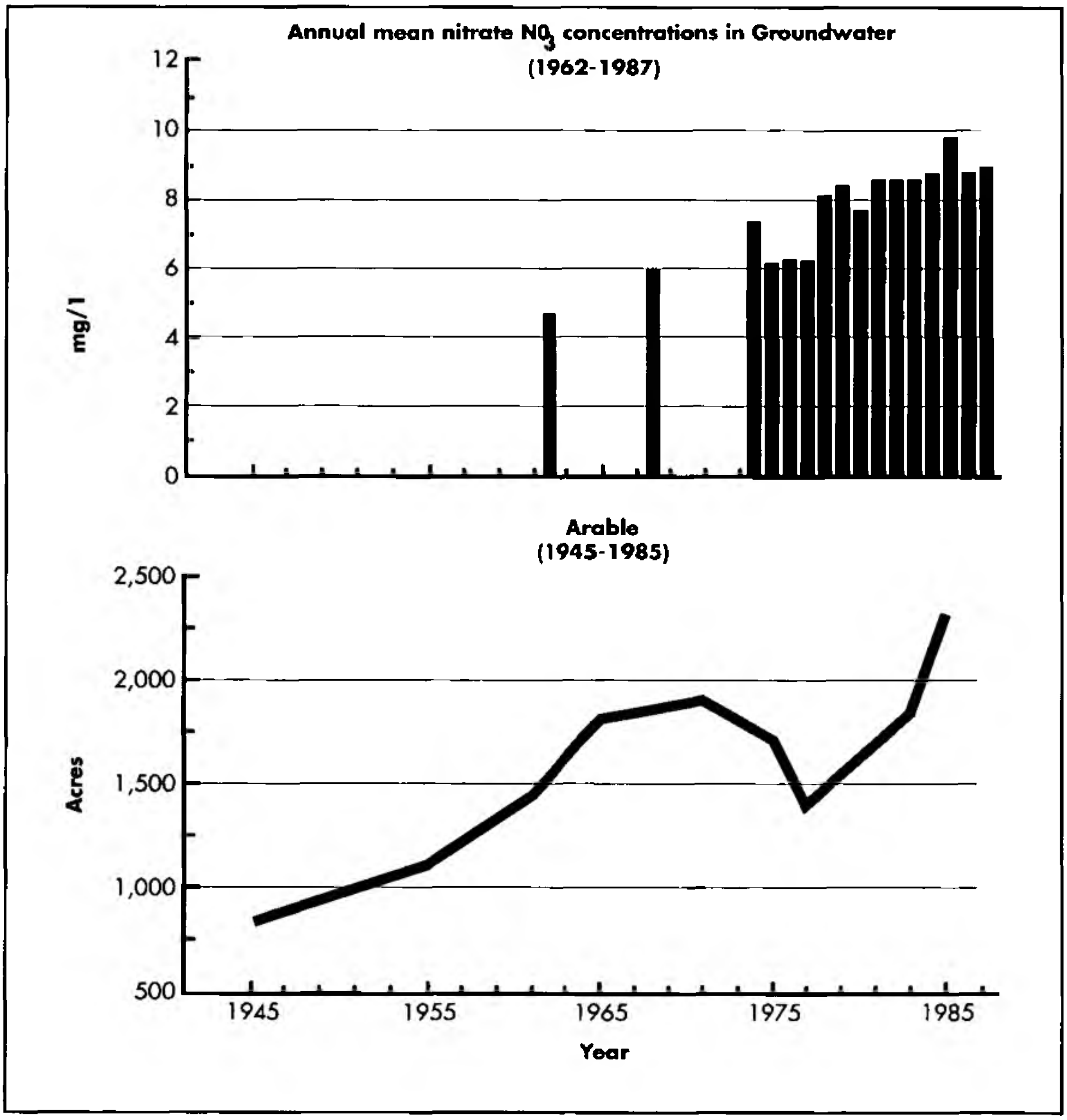
Figure 7.7 Nitrate trends observed in groundwater from two potable supply boreholes tapping the West Cheshire Aquifer



7.15 Another example is that at Swell, in Gloucestershire, where nitrate levels in the groundwater have been rising over the period 1962 to 1987, as shown in Figure 7.8. The hydrogeology of North Cotswolds limestones is difficult to define due to complex relationships between faulting, fissuring and continuity with surface water systems, but the Swell catchment area more or less coincides with the parish boundary, and parish statistics of arable land for various years between 1945 and 1985 are also shown. It was concluded that the rise in nitrate levels was related to the increase in the area under arable cultivation (Morgan-Jones 1988).

7.16 Land use over unconfined aquifers also affects the nitrate concentration in the unsaturated zone water. Between 60 and 80 kg N/ha may leach from land with spring sown cereals, whereas low productivity permanent grassland exhibits rates as low as 10 kg N/ha (Croll and Hayes 1988). However, permanent grass has a large storage capacity for mineralised nitrogen. Evidence for nitrate release from ploughing old grassland has been reviewed by Young (1986). He concluded that this practice releases between 200 and 400 kg N/ha for

Figure 7.8 Trends in Groundwater nitrate and arable land at Swell, Gloucestershire



leaching to groundwater. There was a significant national change from pasture and rough grazing to arable cropping during the period 1939 to 1946, mostly in the South of England and in East Anglia, and there has not been any substantial reversion to grassland since that time. It is therefore concluded that increased nitrate levels in groundwater, throughout England and Wales, first recognised in the early 1970s, are principally due to the ploughing of grassland in the 1940s.

7.17 Nitrate migration in groundwater appears to be highly variable, being non-systematic in Norfolk Chalk, where there is also evidence of dispersion. In the Isle of Thanet Chalk, downward migration is steady but slow and there is no evidence of lateral dispersion. Vertical stratification in the saturated zone is probably due to the aquifers not having reached an equilibrium with the 'recharge' water's quality. In many cases this is likely to take decades, or perhaps centuries.

7.18 A study on the Isle of Thanet, carried out by Southern Water Authority (1985), indicates that nitrate is moving vertically downwards at a rate of about 0.5 m/year. Because the chalk is largely sterile, it is unlikely that biological processes will significantly reduce the nitrate content. Its arrival at the saturated zone is thus irreversible and unavoidable. Concentrations of nitrate in the groundwater are about 30 mg/l beneath fertilised arable land, about 10 mg/l beneath fertilised permanent grass, and less than 3 mg/l beneath unfertilised permanent grass, although single ploughing events can cause peaks in excess of 50 mg/l. Trend analysis of the Thanet sources shows no clear upward or downward behaviour in the last thirty years. Nevertheless, future increases are expected as the effects of post-war ploughing and fertiliser usage eventually reaches the saturated zone.

7.19 Another example is that of the catchment above the Hatton groundwater source in the Severn Trent Region which occupies about 3000 ha (Oakes 1989). In almost half, dairying is the main agricultural enterprise, a quarter is used for arable production, and there is a significant area of forestry. The groundwater there exhibits a rising trend in nitrate concentration, as shown in Figure 7.9. What will happen in the future can only be predicted

Figure 7.9 Historic and future predictions for nitrate in groundwater in the Hatton Catchment

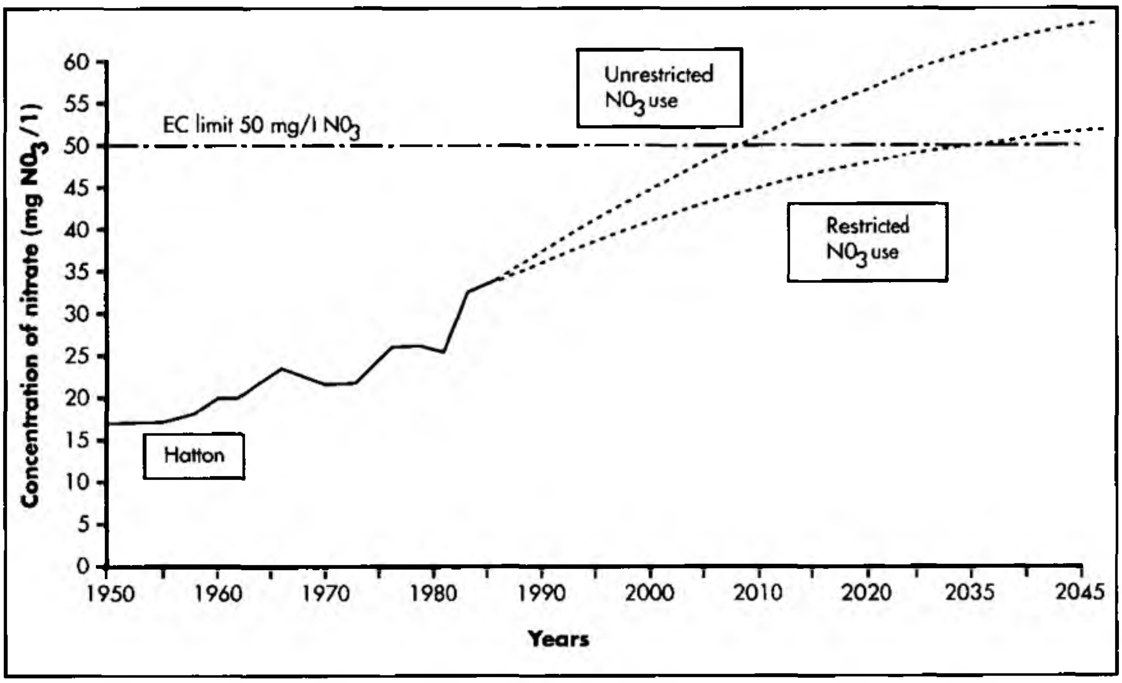
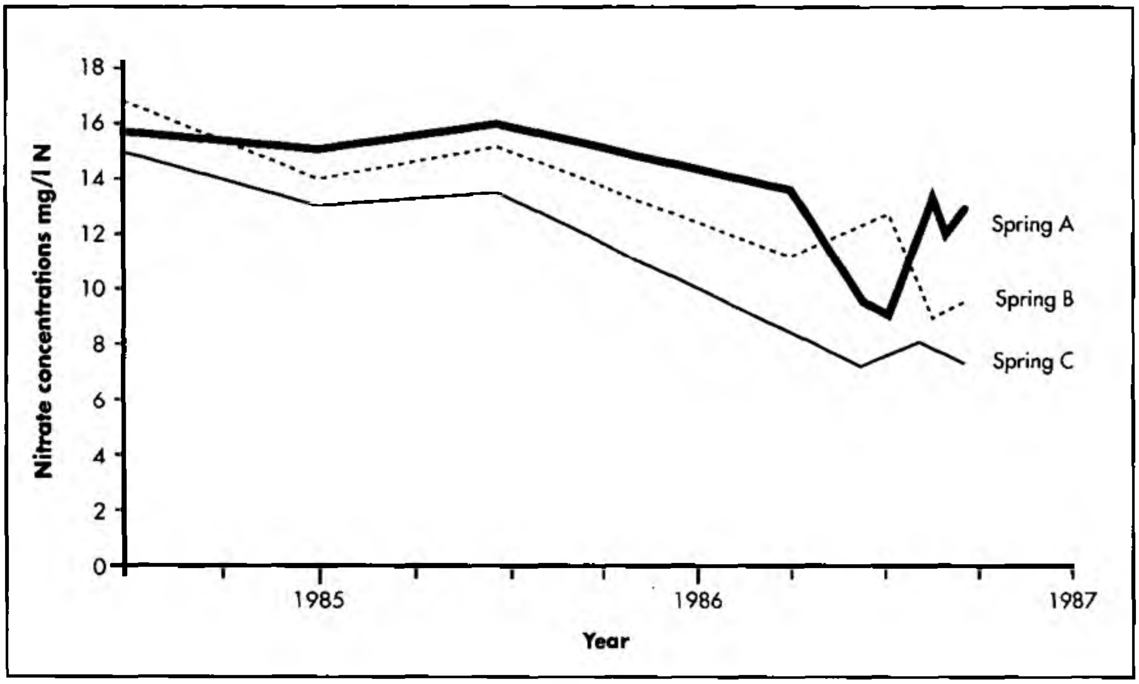


Figure 7.10 Nitrate concentration in springs draining to Batheaston Reservoir



by using a mathematical model. Using leaching rates known for different crops under different conditions, such a model has been constructed; this predicts exceedence of the EC Drinking Water standard early in the next century. It has been concluded that the necessary reduction in nitrate leaching cannot be achieved merely by improvements in the management of present land use, but that restrictions on land use are required which must involve a reduction in the intensity and area of arable cropping, and an extension of sympathetic grassland management practices.

7.20 There is evidence that groundwater nitrate concentrations can be reduced by the control of farming practices. Several years ago, increasing nitrate trends at Batheaston and Monkswood Reservoirs in the Wessex Region were causing concern, with predictions indicating exceedence of the EC limit within twenty years (Tuckwell and Knight 1988). Financial analysis indicated that, in this case, control of agricultural activities was the cheapest option. Between 1985 and 1987, 73% of Batheaston and 43% of the Monkswood catchments were therefore subjected to restrictive agreements: the main change was from cereal production to permanent grassland for sheep. Since then the winter maxima of nitrate concentrations in Batheaston have stabilised, and nitrate concentrations in springs feeding the reservoir are decreasing, as shown in Figure 7.10.

Phosphate

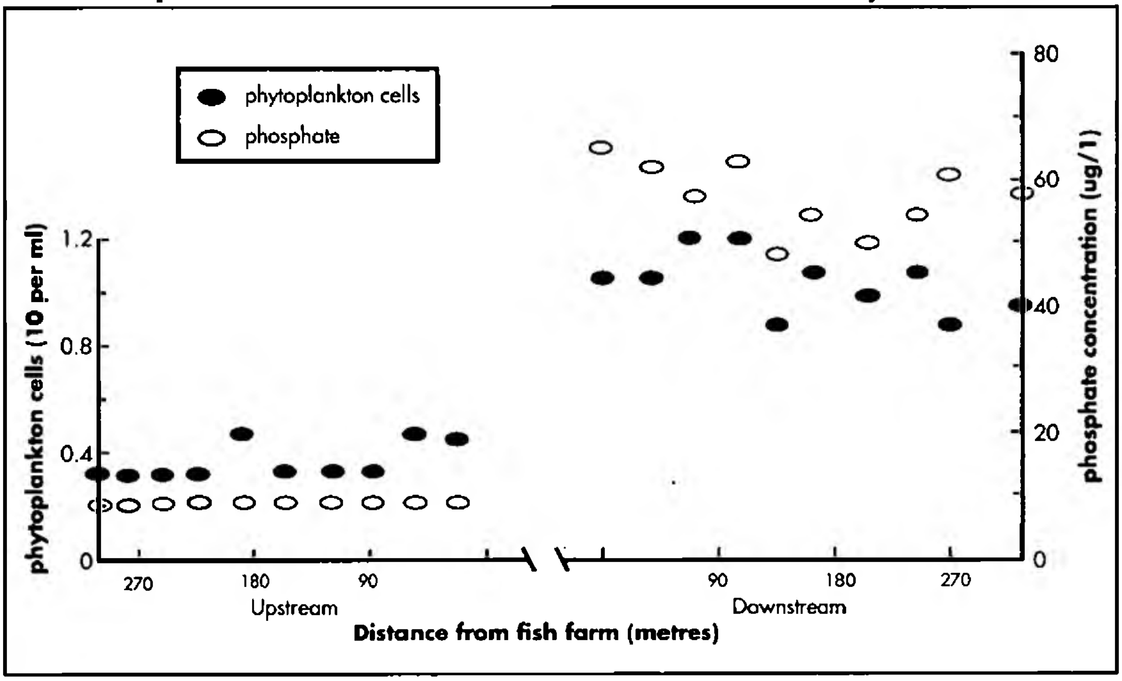
7.21 Phosphate is most often the limiting nutrient for algal growth in freshwater ecosystems. Much of the 'load' present in rivers and lakes comes from domestic sewage, but agricultural inputs may be significant. Using data for the River Torridge in Devon (Milford 1986), it has been calculated that about 35-45% of phosphate present in the river was from the land, the remainder being from sewage treatment works. To what extent this is representative of other rural catchments remains to be seen. Phosphates are readily bound by organic soils and sediments or by plants, but various activities can result in large fluxes. When phosphates become available, it is common for algal blooms to develop.

7.22 The relative roles of agriculture and other sources of phosphate input to waters has been studied at Slapton in Devon, (Johnes & O'Sullivan, 1989) where the applications of both nitrogen and phosphorus to the catchment of a natural lake have been calculated as 1219 and 146 tonnes/year respectively. Losses, and hence inputs to the lake, from agriculture are 148 and 2.5 tonnes/year respectively, and from sewage they are 7.9 and 2.3 tonnes respectively. Mean annual lake concentrations of 2.4 mg/l N and 62 µg/l P have been calculated from the hydrologically relevant loads. The value for phosphorus is well in excess of the limiting concentration of about 10 µg/l. Even if sewage inputs were excluded completely, the agricultural component is sufficient to cause eutrophication. Significant restrictions of agricultural and sewage treatment practices are therefore necessary to prevent the lake being overloaded with key nutrients.

7.23 Land-based farming practices are not the only source of input of excess phosphate to waters, as shown by the following examples. In the spring of 1984, algal blooms caused problems at a treatment works taking water from the Kennick Reservoir in Devon. Hamilton (1984) calculated that between 86 and 126 kg/year of phosphorus were added to the reservoir as a result of cage rearing of fish, which was considerably more than the 5 kg/year calculated to be entering naturally from streams. Mathematical models were used to predict the nutrient status of the reservoir. In theory, Kennick should be ultra-oligotrophic (very nutrient poor), but with fish cage-rearing there was a 72 to 98% chance of it becoming mesotrophic (moderately enriched). Cage rearing of fish was halted, and the facility was used only for holding fish. The recent introduction of low phosphate fish diets should minimise the extent of these problems. Nevertheless, it is sensible for assessments to be made of possible changes in trophic state before cage rearing in reservoirs is introduced.

7.24 There are also links between fish farm effluents and riverine eutrophication, as shown by studies at Hull University (Carr and Goulder, 1990 a, b). The conclusions were that there was a marked increase in organic and inorganic phosphate concentrations downstream of a fish farm, as shown in Figure 7.11. These increased phosphate concentrations enhanced phytoplankton growth in the laboratory, also shown in Figure 7.11. Benthic algae grew more

Figure 7.11 Concentration of algal cells achieved in water samples collected upstream & downstream of the fish farm on 25 July 1985



profusely in the river downstream of the fish farm, and aquatic macrophytes collected from downstream grew more when transferred to clean water than those collected from upstream because their tissues had a higher phosphorus content. Bacterial numbers in both water and sediments also increased downstream of the fish farm, which would enhance nutrient cycling and the availability of phosphorus for plants and algae, as well as reducing oxygen levels in the water. Phosphatase enzyme activity, which converts phosphorus from the unavailable organic form to the available inorganic form, was also shown to be greater in water downstream; this was attributed to enzyme excretion by rainbow trout and to uneaten fish food.

7.25 Another important source of phosphates is pig slurry. The best example is shown by Dodd and Champ (1983) who describe problems in Lough Sheelin, Eire, associated with increasing phosphate loads from expanding pig production in the catchment area. Pig numbers increased from just over 9,000 in 1968 to over 44,000 in 1982. At the same time the number of production units fell from 68 to 45. The volume of slurry produced increased from about 3.5 million gallons to over 30 million gallons. Lake water quality deteriorated during the 1970s, and it was predicted that it would cease to be a viable trout fishery within a few years, as shown in Fig 7.12. In 1975 a manure management plan was introduced, but this was not followed explicitly. Significant changes therefore occurred in the lake's biology; blue-green algal blooms developed, and water clarity was reduced. The lower margin of macrophyte growth receded by almost 1 metre, which represented a large reduction in the area of submerged vegetation and hence of the animals important in the diet of trout. Several species of mayfly and caddis flies suffered significant reductions in their populations and trout switched to feeding on chironomids. In 1980 an inter-departmental committee recommended various measures which needed to be taken, and by 1982 a large proportion of the pig slurry was being exported from the catchment for disposal elsewhere. However, water quality continued to deteriorate. Phosphorus in the lake sediment was remobilised and increased algal growth caused further die-back of macrophytes. There were indications of a gradual improvement from late 1982, but this has not been sustained (Champ 1990, pers. comm.). Similar recycling of phosphorus has been observed in 1987 and 1988.

Potassium

7.26 Although an essential nutrient, and one which is widely applied to the land in large quantities, potassium is not usually known to cause a problem in water, either environmentally or in terms of potable supply. This is largely due to the ability of plants to take up and retain potassium; any excess is easily absorbed and held by the soil. However, its importance in eutrophication has not been established, nor the relevance of soil erosion in its transport to watercourses.

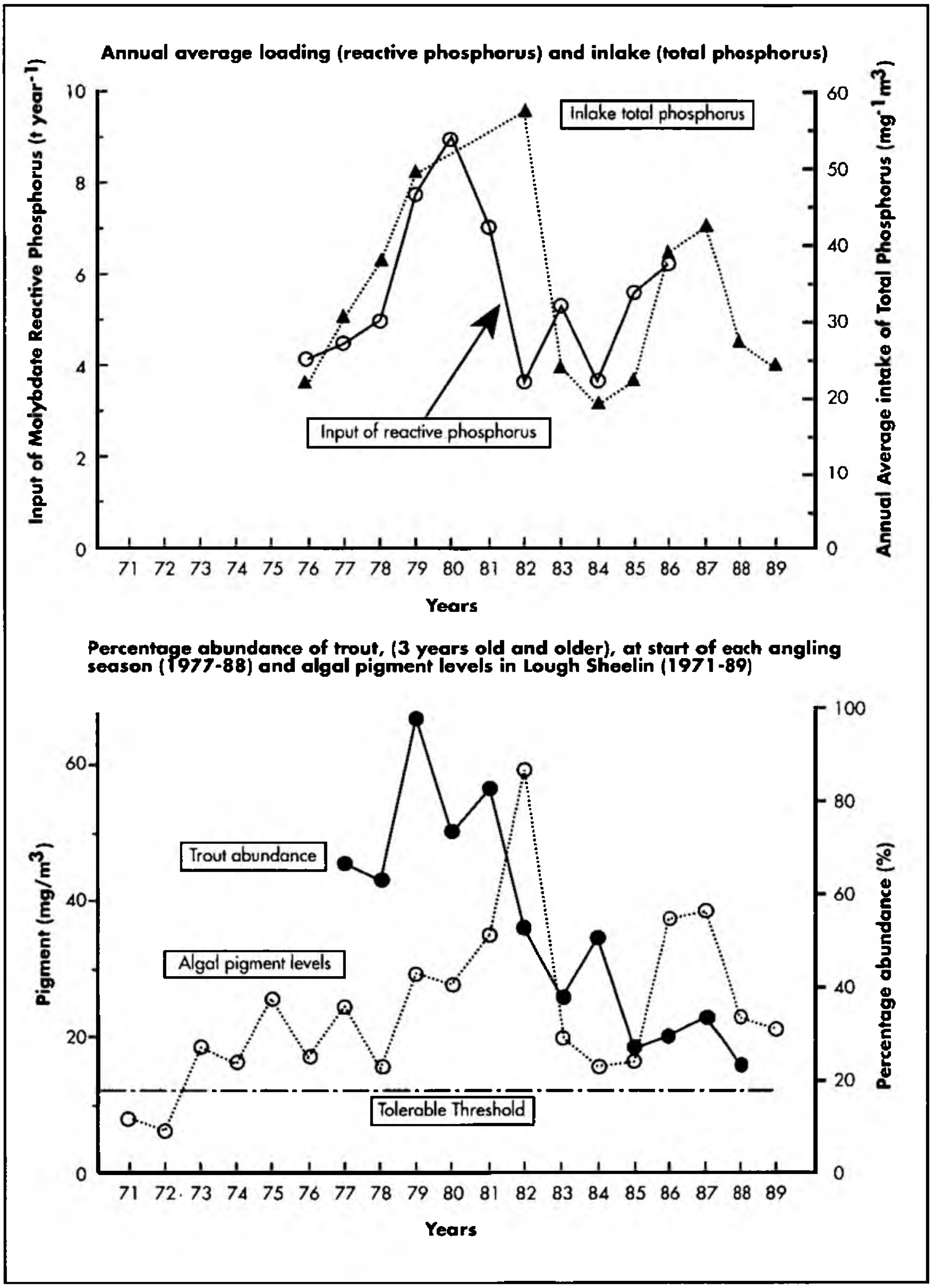
Discussion

7.27 It is clear that chronic and diffuse pollution is leading to nutrient enrichment of controlled waters. Evidence points to increasing trends in nitrate concentrations in both surface and groundwaters in some areas of England and Wales, and there is good evidence of a number of eutrophication problems caused by phosphate enrichment in surface freshwaters. To what extent this applies elsewhere is an open question.

7.28 The quality of many groundwaters will deteriorate as large amounts of nitrate migrate slowly into the saturated zone. For some groundwaters with a rapid response time, however, there is evidence that decline in water quality can be reversed. The NRA is thus working closely with MAFF on the effect of restrictions on groundwater quality in Nitrate Sensitive Areas.

7.29 Recently, the European Commission approved the new Nitrate Directive which requires

Figure 7.12 Phosphate concentrations, algal pigment levels and trout abundance Lough Sheelin



vulnerable nitrate zones to be defined and practices restricted within them. The initial response from the NRA was that vulnerable zones would occupy much of the land area of England and Wales and, for groundwaters, there would be too many to designate within the two year period allowed. Furthermore, it was argued that continued use of storage and blending by the Water Companies is likely to enable the majority of problems to be overcome within the foreseeable future. Nevertheless, there could be improved practice in the use of fertilisers and the NRA envisage a two-tier approach. Recommended nitrate practice would operate over large areas, and specific sources within designated Nitrate Sensitive Areas would be subject to detailed restrictions. Consideration is now being given on how to carry out the requirements of the Nitrate Directive.

7.30 There are compelling reasons for a wider consideration of the two-tier concept. Waters may be "sensitive" for a variety of reasons, not just with respect to nitrate contamination, or with respect to phosphate contamination, resulting in eutrophication. The two-tier approach could be adopted for a variety of contaminants or practices. It would be essential for the farmer to be aware of all "sensitive"areas on his land or there would be a risk of acceptable practices which protect one area causing damage to another.

7.31 In the UK it is normally phosphate which is the limiting nutrient for aquatic plant growth. Its principal sources are sewage discharges and the land. In phosphate enriched waters, even extremely efficient control of one or both of these is likely to leave adequate quantities to allow eutrophication to remain a problem. Furthermore, deposits in the mud of still and slow-flowing waters can be recycled for several years following the control of other sources. These issues have been debated by the NRA in its report on toxic blue-green algae (NRA 1990 b). On eutrophication control, its recommendation was that where it was considered necessary, full scheme evaluation should be carried out and that it may be necessary to develop a catchment management plan, so that controls can be exerted on significant nutrient sources which may be far removed from the affected waterbody.

8. POLLUTANTS FROM AGRICULTURE - PESTICIDES

Sources

8.1 Pesticides include insecticides, herbicides, fungicides and a number of others such as wood preservatives and other chemicals toxic to pest organisms. Sheep dipping is a veterinary medicinal practice, and carried out under statute. Nevertheless, the active ingredients in sheep dip are pesticides and are treated as such in this report. Few pesticides are 'target specific' and hence affect a range of organisms, but they are applied for specific reasons to protect livestock, plants or plant products from harmful organisms. The full extent of their toxicity to a range of aquatic life is usually unknown. At present some 450 active ingredients are available in England and Wales. The NRA routinely analyses for about 50 active ingredients in freshwaters, but could expand this list relatively easily and cost-effectively; however, there will remain some for which there are no routinely available methods of detection.

8.2 Pesticides are used not only by the agricultural industry; they are widely applied by other land users, local authorities and the general public. The introduction of novel pesticides is controlled by the Ministers in six Government Departments who are advised by the independant Advisory Committee on Pesticides. The Government can withdraw approval for use or seek a reassessment of any pesticide at any time. The risks to the aquatic environment arise from the storage of pesticides, as well as from their application to the land. Guidelines on storage, use and disposal are available within a number of codes of practise and also regulations made under the Food and Environmental Protection Act 1985 (see Appendix 1, paragraphs A1.45 - 49).

8.3 In a report on pesticides, chemicals and health by the British Medical Association (1990), evidence is quoted of 298 water sources or supplies exceeding the EC Drinking Water Directive Maximum Admissible Concentration (MAC) for single pesticides - 0.1 μg/l - and of 76 breaches of the MAC for total pesticides - 0.5 μg/l. These EC limits are not related to toxicology and the Government is pressing for them to be changed. The detected breaches occurred in six of the NRA regions. It was considered that absence of reported breaches elsewhere may reflect inadequate investigations of water in these areas. The most commonly detected pesticides which exceeded the MAC were the herbicides atrazine and simazine, which are widely used outside the agricultural sector.

8.4 Concern was expressed about the extent of water suppliers' monitoring programmes, and the shortage of suitable analytical techniques. It was noted that the inadequacy of existing data had been recognised by other bodies, including the 1979 Royal Commission on Environment Pollution and the 1987 Agriculture Committee. The announcement in March 1989 that the Government intended to review the safety of over 100 older pesticides was interpreted by some as an inability to guarantee that a large number of widely used pesticides are safe by today's standards. The NRA accepts that inevitably, pesticides approved some time ago will not have been assessed according to current standards which are constantly being refined and improved. The NRA believes that it does not follow that older pesticides are necessarily unsafe but the review programme must be welcomed because of the clear need to reassess older pesticides by today's standards.

8.5 In the first report on the quality of drinking water in England and Wales (DoE 1991), the Chief Inspector indicated that pesticide concentrations above the prescribed standard had been found in 2.1% of 540,007 determinations. Thirty-one pesticides had exceeded the standard in samples taken for compliance monitoring. The inclusion of operational sample results increased that number to 33 in 1989 and 34 in 1990. Atrazine, simazine, isoproturon, chlortoluron and mecoprop were the pesticides most frequently detected. On eight occasions an individual pesticide exceeded its advisory value, a concentration based on toxicological information and which includes a wide margin of safety. All were investigated and found to be transient. The overall conclusion was that pesticides detected in 1989 and 1990 were far smaller than amounts known to be harmful or likely to damage public health. Recognition was given to the Government's promotion of good practice in the use of pesticides, and action by water companies and the NRA in persuading some users to reduce application rates or switch to alternative pesticides. It was considered that these efforts were having some effect.

8.6 Typical agricultural application rates of pesticides are from less than 1 to 10 kg per hectare of active ingredient. Pesticides in surface and groundwaters arise from spraying crops, sheep dips, spillages and inappropriate storage and disposal. Pesticide contamination of watercourses largely depends on pesticide mobility, solubility, and rate of degradation. Examples are shown in Table 8.1. Although many pesticides decompose quickly in the soil, it is likely that they will be more persistent once in the groundwater because this tends to be less biologically active. Organochlorine pesticides - the approved use of which is now generally phased out in the UK - have low mobility and high persistence, and although they tend to bind to soil particles, during soil erosion significant movement can occur.

Acute Pollution Incidents

8.7 For the period 1985 to 1989, reported pollution incidents involving pesticides and sheep dip accounted for 1.8% of all farm incidents, although there are marked regional variations. Figure 8.1 shows that acute problems with sheep dip occur, as would be expected, mainly in the north and west of the country. The distribution of problems from pesticides, including

Table 8.1 - General Solubility, Mobility and Rate of Degradation of some Pesticides (in Headworth, 1989 after Steenvoorden, 1976)

Pesticide	Example	Mobility	Solubility	Rate of Degradation
Organo-chlorine	lindane	very low	very low	years
Organo-phosphorus	parathion*	low	low	weeks to months
Uracils	bromacil	low-high	low-high	months to years
Phenoxyalkanoic acids	MCPA	high	high	weeks to months
Triazines	atrazine	low	low	weeks to months
Carbamates	barban	low	low-high	days to weeks

** Parathion is not approved for use as a pesticide in the UK* herbicides and fungicides, are more generally spread (Figure 8.2), although more occur in East Anglia and the Midlands, reflecting the links with arable cropping in these areas. Some typical 'case histories' of pesticide pollution incidents are given in Appendix 4.

8.8 It can be seen from these examples that discharges from point sources characteristically result in fish and invertebrate mortalities. There are events where fish die but where there is no evidence as to cause. Pesticides are often implicated in these cases but not proved to have been involved.

8.9 The disposal of even small amounts of unused or surplus pesticide to foul sewers is another area of concern to the NRA. The pesticide may pass through the sewage treatment process unaltered and enter the river where it may kill aquatic life. In addition, the toxicity of some compounds is such that a relatively small amount could impair or incapacitate the biological sewage treatment process, and the discharge of inadequately treated sewage might then also pollute the river. A recent incident in the Northumbrian region, still sub judice, seems to confirm this concern.

Chronic Effects

8.10 Many pesticide problems are of a chronic or diffuse nature. There have been several reviews (Kenrick et al 1985, Croll 1988, 1990) which recognise the widespread occurrence of pesticides in surface waters over the last few years. They are not so commonly found in groundwaters and the most common, atrazine and simazine, are known to be used by non-agricultural agencies for weed control on industrial sites, railways (although British Rail intends to phase out their use) and roadsides, but they are also approved for some uses in agriculture.

8.11 Water Authority monitoring in the Anglian Region between 1985 and 1988 has shown that ten pesticides occurred in surface waters, as shown in Table 8.2 (Croll 1988). Table 8.3 shows similar information on five pesticides in groundwaters.

Table 8.2 - Pesticides Detected in Surface Waters (From Croll 1988)

Pesticide	Concentration		Occurrence
	Modal range µg/l	Max. µg/l	% of samples
Lindane	0.010 - 0.025	0.025	16
Dimethoate	0.02 - 0.1	0.27	14
Mecoprop	0.10 - 0.40	3.4	35
MCPA	0.10 - 0.22	0.22	1.5
2, 4 - D	0.20 - 1.7	1.7	1.5
Atrazine	0.02 - 0.6	9.0	58
Simazine	0.02 - 0.6	2.8	42
Dicamba	0.1 - 0.3	0.30	1.5
Dichloroprop	0.11 - 0.28	0.28	1.8
Diazinon	0.01 - 0.03	0.03	1.5

Figure 8.1 Distribution of total pollution incidents from sheep dips (1985-89)

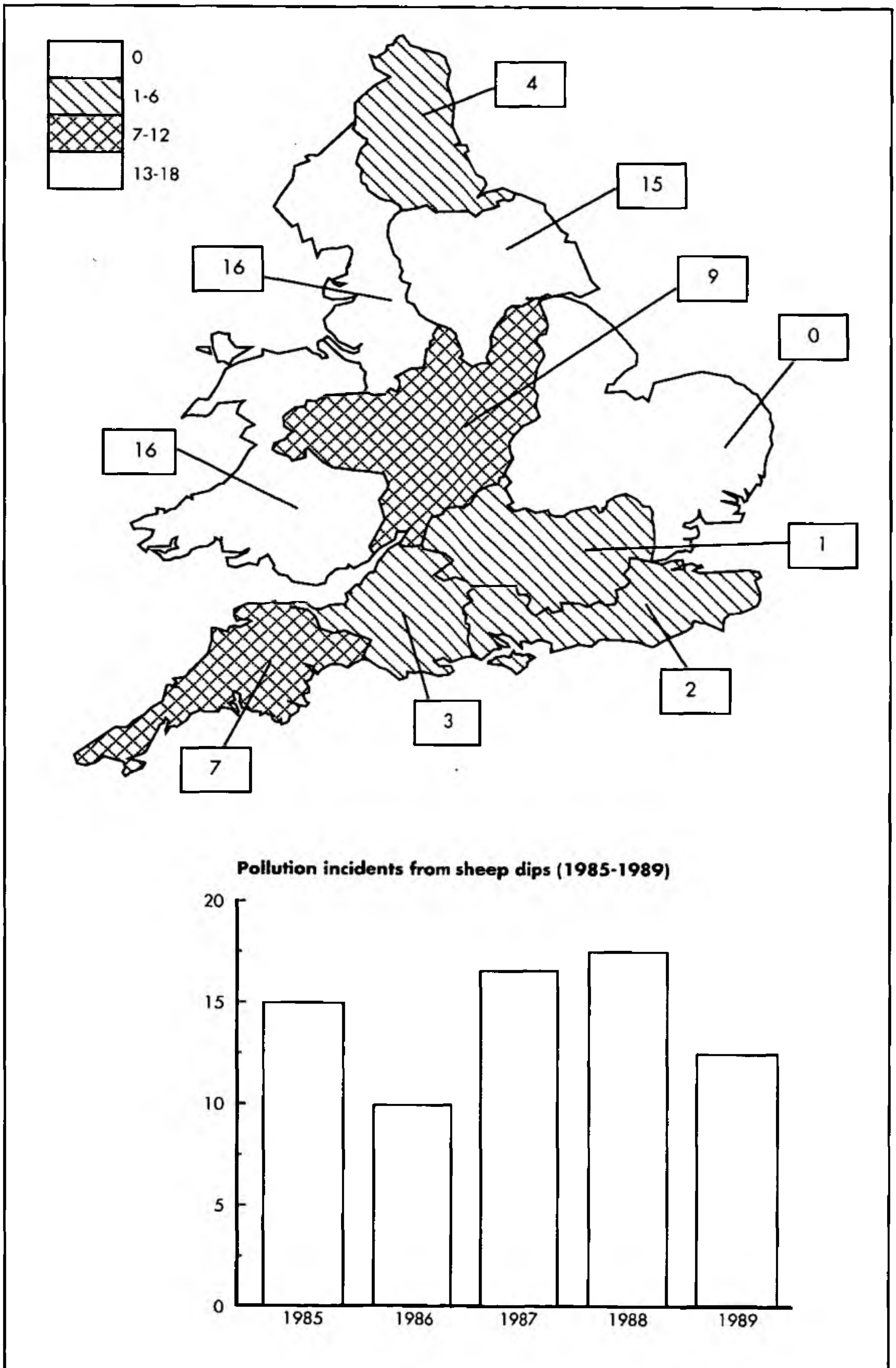
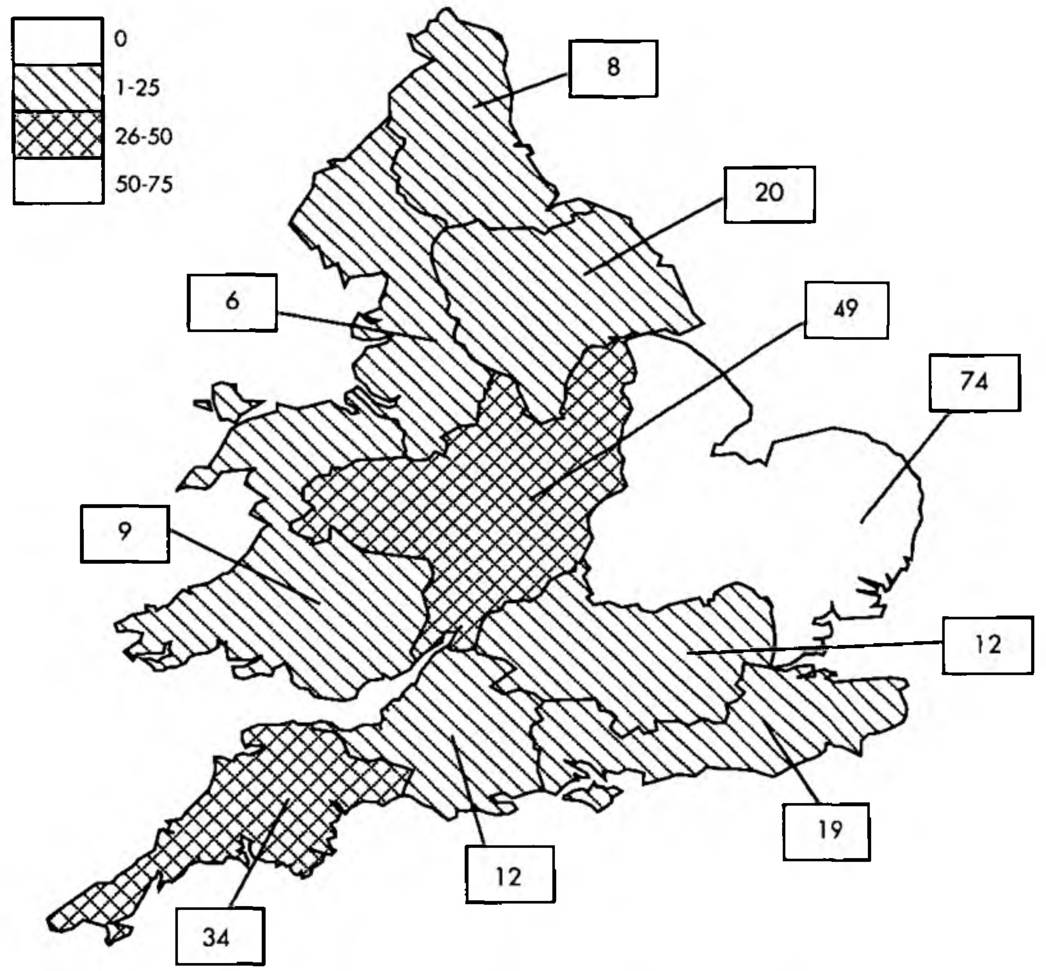


Figure 8.2 Distribution of total pollution incidents from pesticides (1985-89)



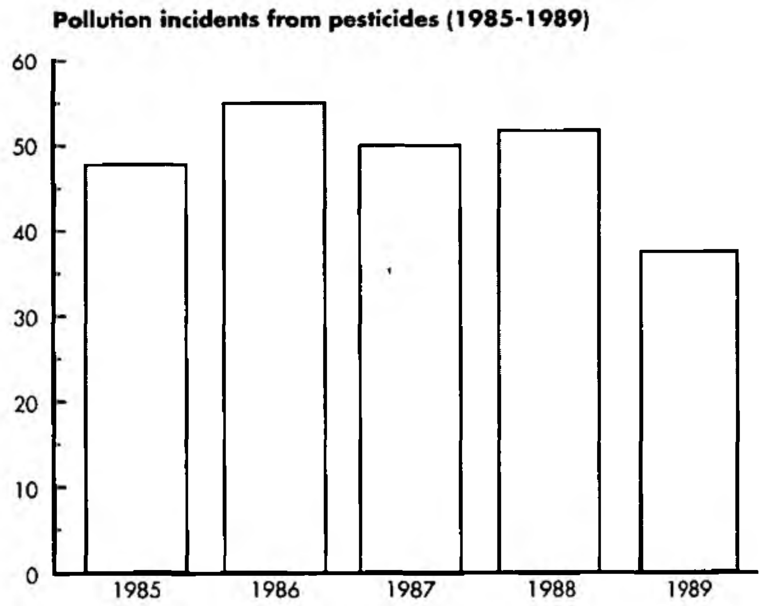


Table 8.3 - Pesticides detected in grounwater (from Croll 1988)

Pesticide	Concentration range µg/l	Occurrence % of samples
Mecoprop	0.1 - 0.38	3
MCPA	0.12	0.5
Atrazine	0.02 - 0.43	28
Simazine	0.02 - 0.26	9
2, 4 - D	0.11 - 0.2	1

8.12 Except for the triazines, the pesticides found in this exercise correspond more or less to those most commonly used in the UK and to those used in a part of the Anglian Region being studied in detail. In general, the frequency of occurrence is higher, often much higher, in surface waters than in groundwaters; presence in the latter was confined to younger groundwaters, particularly aquifer outcrops.

8.13 In a more recent detailed study of the Granta Catchment in the Anglian Region, early results (Hennings et al 1990) indicate that the number and concentrations of pesticides in surface waters are higher at times of high river flow, and that most of the annual pesticide load to the river is from surface run-off and not from groundwater.

8.14 Another detailed study has been carried out in West Cornwall (Smith 1990); this has shown that the pesticides aldrin and dieldrin are frequent contaminants in surface waters. Six of the nine monitored catchments had aldrin and/or dieldrin present in 5 to 42% of samples, as shown in Fig 8.3, and all catchments were contaminated by lindane, with 10-57% occurrence. Although most of the land is under grass and cereals, substantial areas are used for daffodil and other flower production, and for potatoes and brassicas. Historically, aldrin was applied to daffodil bulbs to control the large narcissus fly and on land converted from old grass to potatoes to control wireworm. Both aldrin and dieldrin were used on brassicas to control root fly. Dieldrin is a metabolite of aldrin but has also been applied separately. Approvals for the agricultural uses of dieldrin were withdrawn during the 1970s, and for all other uses in March 1989.

8.15 The route from land to water in this area has been identified. Both compounds adhere to organic soil particles which are flushed into the rivers during rainfall. Cultivation to a fine tilth, weed control, and a high level of both wheeled and foot traffic in daffodil fields, all encourage the formation of colluvium during rainfall, and the colluvium contains high levels of pesticide residues.

8.16 In the Newlyn River, peak values of aldrin in water coincided with rainfall events (Milford 1989); the Environmental Quality Standard (EQS) identified in the EC Dangerous Substances Directive was exceeded immediately downstream of the bulb fields. Aquatic invertebrate communities are also significantly affected. Pesticide concentrations in fish tissue were exceptionally high in November 1988 as shown in Figure 8.4.

8.17 Notification of these findings was made by the NRA to MAFF, DoE and the local District Council. Approvals for the three remaining agricultural uses of aldrin were withdrawn with immediate effect in May 1989, and the District Council imposed a ban on trout fishing in the Newlyn River. Since then, dieldrin levels in eels have declined, as have concentrations in both river water and sediments (Smith 1991). However, immediately downstream of the bulb fields the EQS continues to be exceeded, and the diversity of aquatic invertebrates has only increased at sites much further downstream of the bulb fields. In another part of West Cornwall, studies in the River Hayle catchment indicate that substantial residues of aldrin and dieldrin remain in the soil for many years after pesticide application, as shown in Figure 8.5.

8.18 It is surprising that aldrin is so persistent, as it has been generally believed to break down quickly to dieldrin. Unfortunately, however, it is now clear that the risk of chronic and diffuse pollution will remain for many years in this area, despite the ban on the use of aldrin. It is also clear that even regular weekly sampling is unlikely to be adequate to describe accurately the changes in the contamination of surface waters.

8.19 Another pesticide, lindane (gamma HCH), has also been found in all monitored catchments in West Cornwall. Although there are many non-agricultural uses of lindane, it is also used by farmers. The River Hayle study identified 21 insecticides, 37 herbicides and 28 fungicides (as active ingredients) in use by farmers at various times and in variable quantities in this small catchment; a detailed study of two of them indicates that the less soluble carbendazim tends to accumulate in colluvium in the same way as the "drins", whereas the soluble simazine does not.

Figure 8.3 Aldrin and dieldrin occurrence in West Cornwall rivers

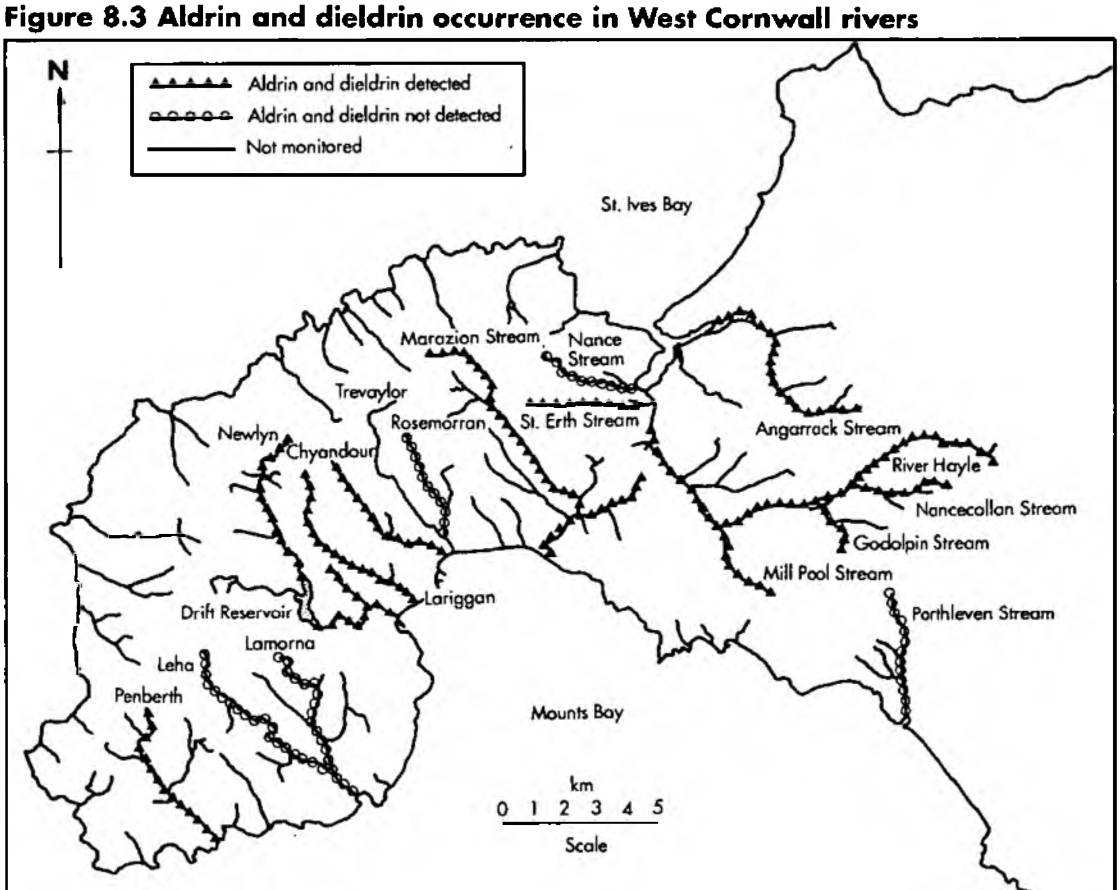


Figure 8.4 Dieldrin concentrations (ug/kg/wet wt.) in individual eels at Stable Hobba Bridge, West Cornwall

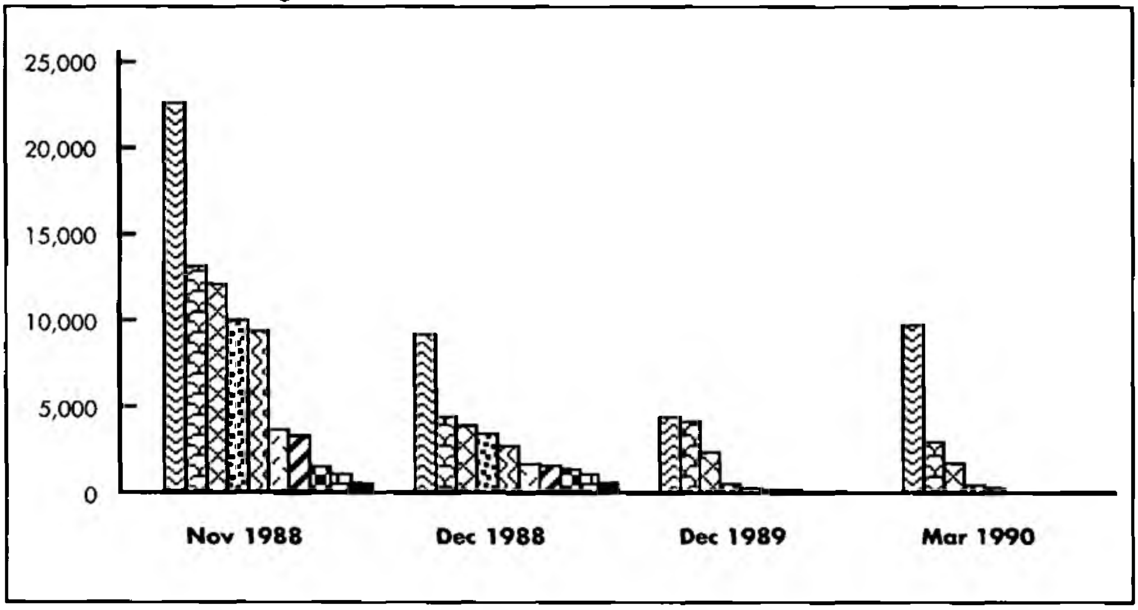
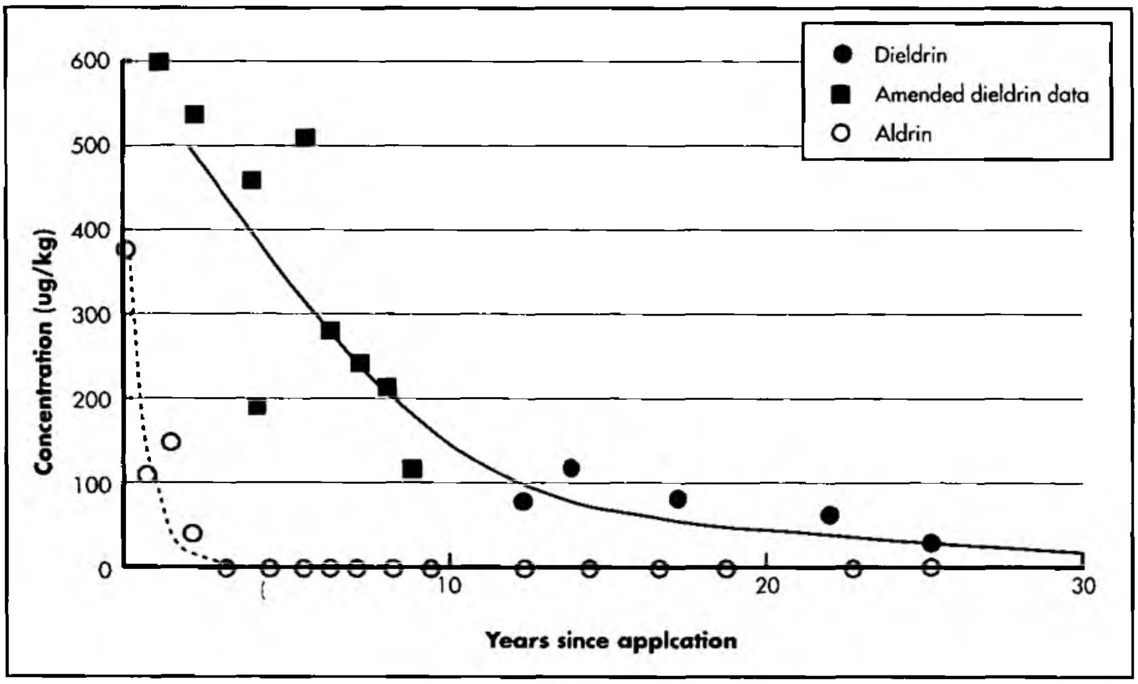


Figure 8.5 Degradation of aldrin and dieldrin in fields in West Cornwall (N.B Amended data allows for change in application rates of aldrin)



8.20 Some pesticide problems may not occur until the agricultural product is being processed, far removed from, and long after it has left, the farm. Such an example is that of tecnazene contamination of the Chyandour Brook in West Cornwall. Tecnazene is a fungicide used to control dry rot and inhibit sprouting in stored potatoes. It is also highly toxic to freshwater fish and invertebrates. The occurrence of a high concentration in January 1990 was traced to a discharge of potato wash water from a fish and chip shop. Similar problems are likely to be widespread throughout England andWales. Another example of tecnazene contamination was reported by MAFF (1991 a). Fish in the River Widd, Essex, were found to contain high levels of the compound, the presence of which was attributed to a discharge from a vegetable washing plant.

Risks to Catchments

8.21 All catchments are subject to risks arising from the storage and use of pesticides on farms; these aspects are thus usually part of the farm campaigns carried out by the NRA, as illustrated in the following example. A farm campaign was undertaken in the North West Region in May 1990 in the River Crossens catchment, where land use is primarily arable with cereals, root vegetables, and salad crops being grown (Thornett 1990). Pesticide use is widespread, and there is a possibility that numerous abstractions for irrigation of treated crops recycles a limited amount of water and concentrates the effect of any chemical run-off. Some 75 working farms were visited, of which 71 were arable and used some pesticides. The remainder were involved in beef, pig and poultry production and in vegetable washing. It was found that 52 farms required some remedial work, which represents 69% of the total. Some 34 needed construction or repair of pesticide stores, 17 required proper disposal of pesticides washings, 16 needed improved treatment or disposal of vegetable washings, and two had problems with slurry. A biological survey in April 1990 indicated that the majority of river sites were of poor or bad quality; three were in Class 2 (fair), 12 in Class 3 (poor) and 7 in Class 4 (bad), as shown in Figure 8.6. It is likely that much of this low quality was caused by factors such as organic inputs from farms, sewage treatment works and a wildfowl sanctuary. However, the absence of several pesticide-sensitive species from sites where they were expected led to the conclusion that toxic pollution had occurred at eight sites and possibly at a further two. A research project is now being developed to improve the understanding of pesticide behaviour and to establish control measures.

Seasonality

8.22 In 1988 a preliminary study by the Yorkshire Water Authority of the impact of sheep dipping highlighted a number of gaps in our knowledge. The location of sheep dippers is not readily available to the NRA. Further, modern sheep dips contain a wide variety of active ingredients but these are rarely included in routine water quality analyses. Figure 8.7 shows the distribution of sheep dippers in North Humberside, an area where groundwater sources are important for public and private supplies. Given the poor practice elsewhere in the disposal of spent sheep dip, the risks here are evident.

8.23 In the summer of 1988 an assessment was made of the effect of sheep dipping on the pesticide content of river water abstracted for potable supply at Carmarthen in Wales. An earlier catchment inventory had shown that sheep dip was the only source of diazinon. Fifty samples were taken, usually daily, starting eight days before the compulsory dipping period and continuing for 42 days. Six samples, ie. 12%, contained low concentrations of diazinon and no other pesticide. The maximum value was 0.019 µ/l, which is below the maximum admissable concentration of 0.1 µ/l indicated in the EC Drinking Water Directive. It was concluded that the presence of diazinon indicated incorrect disposal practices at farms, and that these incidents were likely to be in remote areas and, therefore, difficult to identify.

8.24 Mecoprop is a commonly and widely used post-emergence herbicide to control weeds in arable crops. Between January 1988 and December 1990, 68 samples of water from the Great Ouse at Bedford Water Treatment Works were analysed for mecoprop. Positive values were found on 78% of sampling occasions. It was found throughout the year with peak values occurring in spring, as shown in Figure 8.8. Peak concentrations in the water coincide with the recommended time of herbicide application. Six other compounds were analysed for. However, analyses for all seven were never done together. It is impossible to

Figure 8.6 The River Crossens drainage catchment

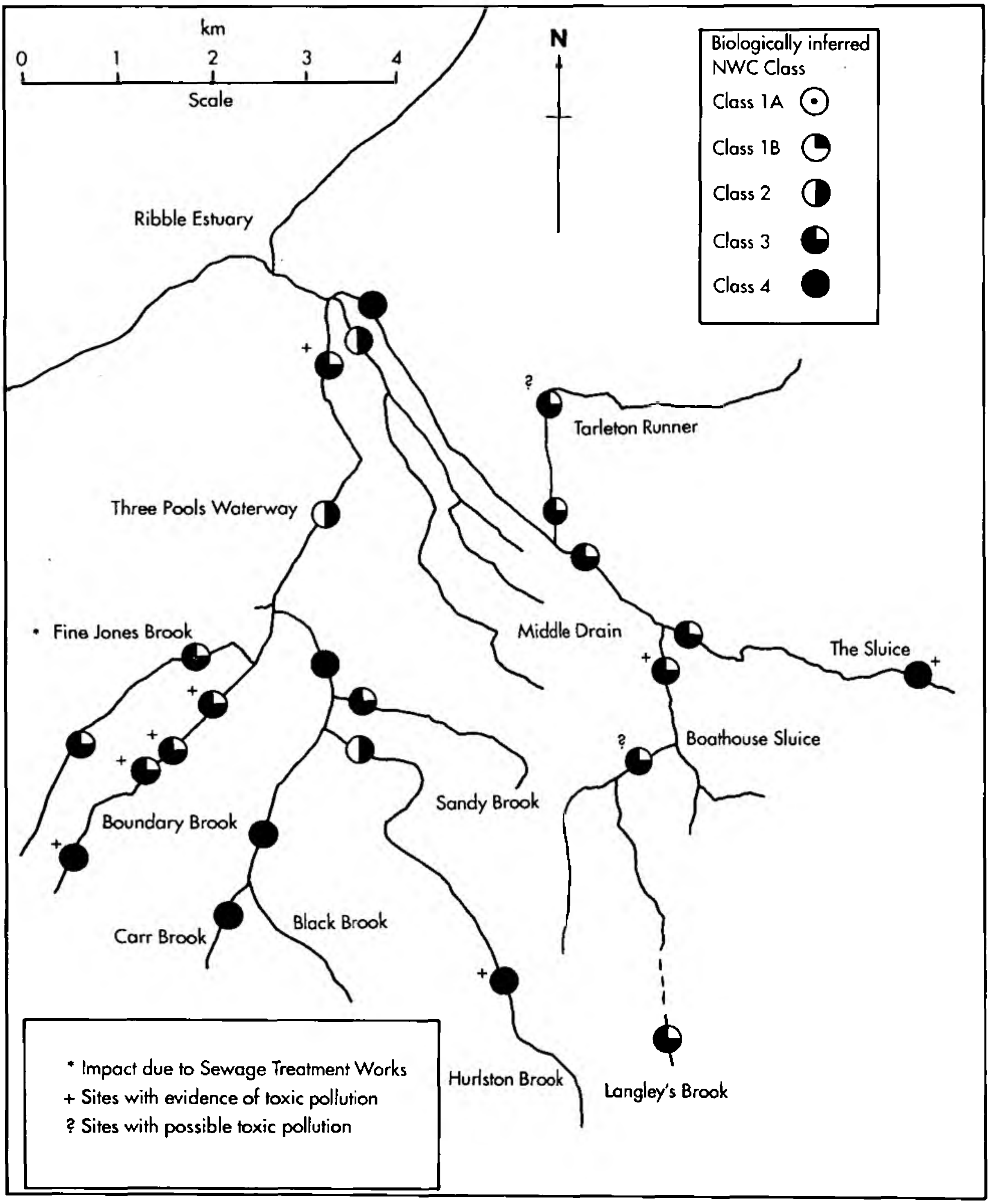


Figure 8.7 Sheep dip locations in North Humberside

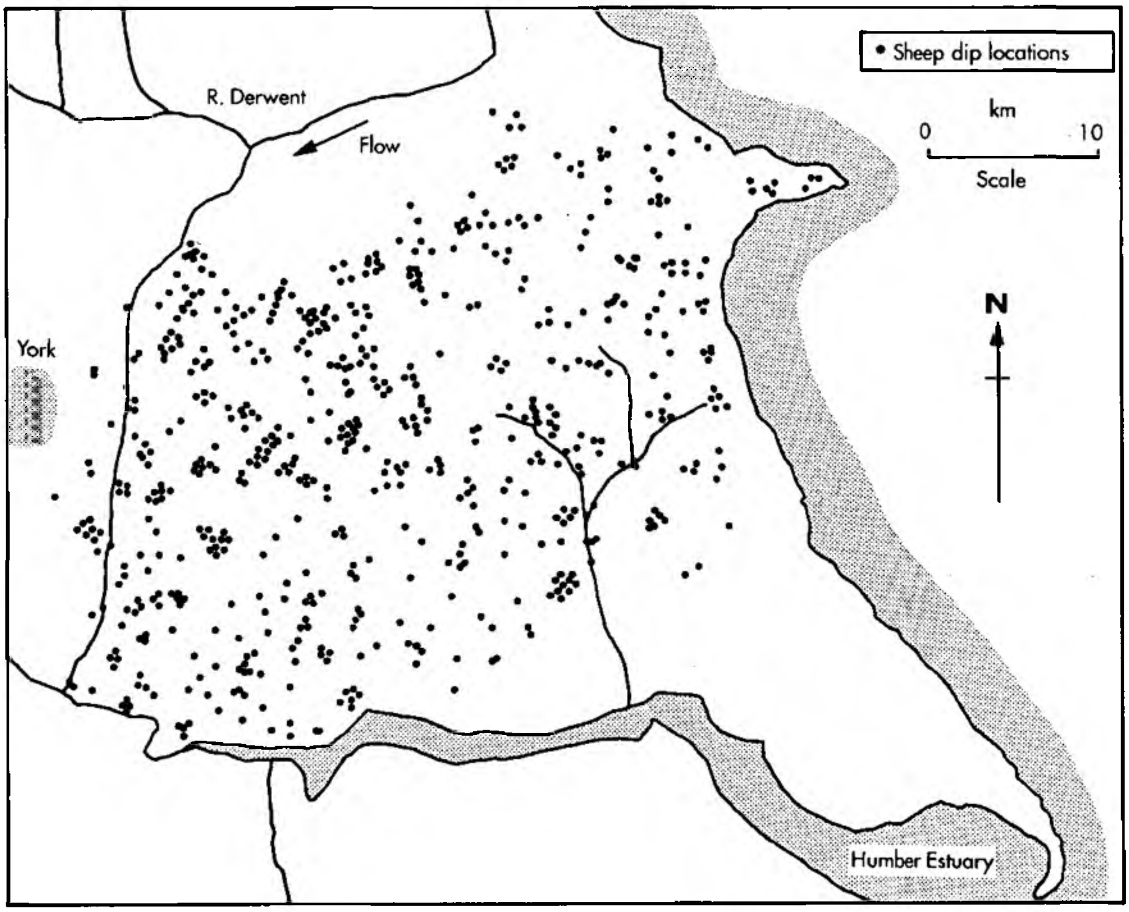
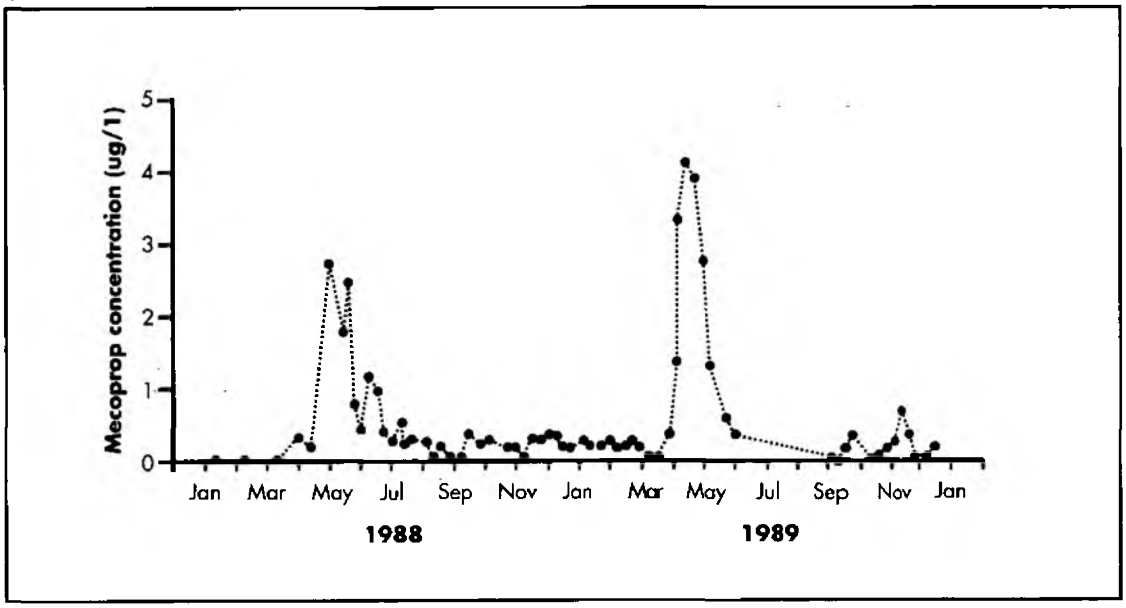


Figure 8.8 Concentration of Mecoprop in the Great Ouse at Bedford Water Works



say what levels occurred for all seven pesticides in total. It is clear that the EC Drinking Water Directive maximum admissable concentration (MAC) of 1 μg/l, for a single substance, was exceeded on several occasions, and it is likely that the MAC of 5 μg/l, for all pesticides in combination, was exceeded on some occasions. There is no environmental quality standard for mecoprop and the effects of these observed concentrations on aquatic flora and fauna are unknown. Even weekly sampling is likely to under-estimate peak concentrations, particularly if the critical period coincides with rainfall.

Discussion

8.25 Although some pesticides are widespread in surface waters and present in groundwaters, limitations to the extent of the NRA's monitoring programmes preclude a comprehensive assessment of the scale and extent of the problem. As analytical methods improve, it is also inevitable that more pesticides will be detected in environmental samples, although this is not to imply that their presence is necessarily harmful. Nevertheless, because of the lack of knowledge of sublethal effects on flora and fauna, their overall impact cannot be well-defined.

8.26 Even when approval for their use is withdrawn, some pesticides persist in the environment even though they may not be detectable in the water itself. This is particularly the case for organochlorine residues. Following surveys of the distribution of pesticides on Exmoor, Hamilton (1985) therefore advocated the use of all available materials (water, sediment, fish) to give an improved description of the extent and level of occurrence of organochlorines. He found pesticides to be widespread in the aquatic environment.

8.27 It is also considered that the increased use of pesticides associated with the intensification of agriculture is the cause of many being detected at low concentrations in rivers and groundwaters. Concentrations in raw waters sometimes exceed the stringent limits laid down in the EC Drinking Water Directive.

8.28 It would clearly be advantageous to develop better monitoring methods for pesticides. Milford (1987) described the experimental use of a pesticide monitor based on the accumulative properties of resin which, when installed in rivers and left for varying periods, trapped chemicals in the resin. Analysis for a wide variety of pesticides would give an indication of contamination by compounds not usually analysed for in present routine monitoring programmes. The development of this technique is being considered.

8.29 At the moment Water Companies are attempting to control the levels of pesticides in drinking water through improved water treatment methods which are likely to be of importance in the medium term. Farmers and others are incurring costs by using pesticides, but they also obtain significant benefits. The Water Companies incur costs, to the detriment of their customers and shareholders. A comprehensive economic analysis would be illuminating. Although subscribing to the view of the polluter paying, it would be better if less pesticides entered the aquatic environment. The problems of pesticide pollution could be reduced by encouraging farmers to use safer methods of pesticide storage, application and disposal. In the long term it may be that protection zones are required, similar to those being used to control nitrate.

8.30 Relevant pesticide users, including those in agriculture, are encouraged to receive training and to obtain appropriate certificates of competence from the National Proficiency Tests Council. Since 1988, about 44,000 full certificates have been issued to users throughout the British Isles, and a further 9,000 people have received certificates on successful completion of preliminary training. This is a welcome indicator of interest in achieving a high standard of use. A large proportion of these certificates will have been issued to people working in agriculture in England and Wales.

8.31 The recently announced National Pesticides Retrieval Scheme is a welcome step forward and could eliminate much of the potential for pollution from stored, unused material. Under this scheme, farmers are encouraged to dispose of unwanted and illegal chemicals and, providing they use the scheme, they will not be prosecuted for possessing illegal chemicals.

8.32 Other methods of pest control are being explored. Wratten & Thomas (1990) and Thomas & Wratten (1990) describe successful manipulations of the arable environment to encourage natural enemies of pests. As the numbers of predators such as beetles and spiders build up over winter in mid-field refuges, the pest populations are affected in the following spring and summer. In theory, farmers should be able to rationalise their use of pesticides. Again, an economic assessment would be valuable. Genetically induced disease resistance also has the potential to reduce the reliance placed on pesticides.

9 POLLUTANTS FROM AGRICULTURE - OIL AND OTHER CONTAMINANTS

9.1 A large number of other potential contaminants are used on farms or may be discharged to waters as a result of various farm practices. These include oils, acid discharges, metals, pharmaceutical products, disinfectants and suspended sediment. This category of pollutants represented less than 11% of the total reported incidents during 1985-1989.

Oil

9.2 Pollutions involving oil spillages represent 3% of all farm incidents in the period 1985-89. Figure 9.1 shows the regional differences. The majority of incidents are in the Anglian and Severn Trent regions. Only a small proportion are considered to be major incidents. They are usually caused by poor management during delivery and disposal. For the remainder, the scale of the problem and any impacts on environmental water quality are unknown. Regulations on oil storage have recently been introduced which should assist in reducing problems from spillage.

Other Contaminants

9.3 The sources of most other contaminants are obvious, although the quantities involved are unclear for many of them. Metals may be present in land drainage, slurry and human sewage sludge spread to land. The decision to halt human sludge disposal to sea may result in pressure to spread more on land although it is understood that a large proportion will be incinerated; this would increase slightly the risk of run-off of metals (as well as organic matter and pathogens) into watercourses.

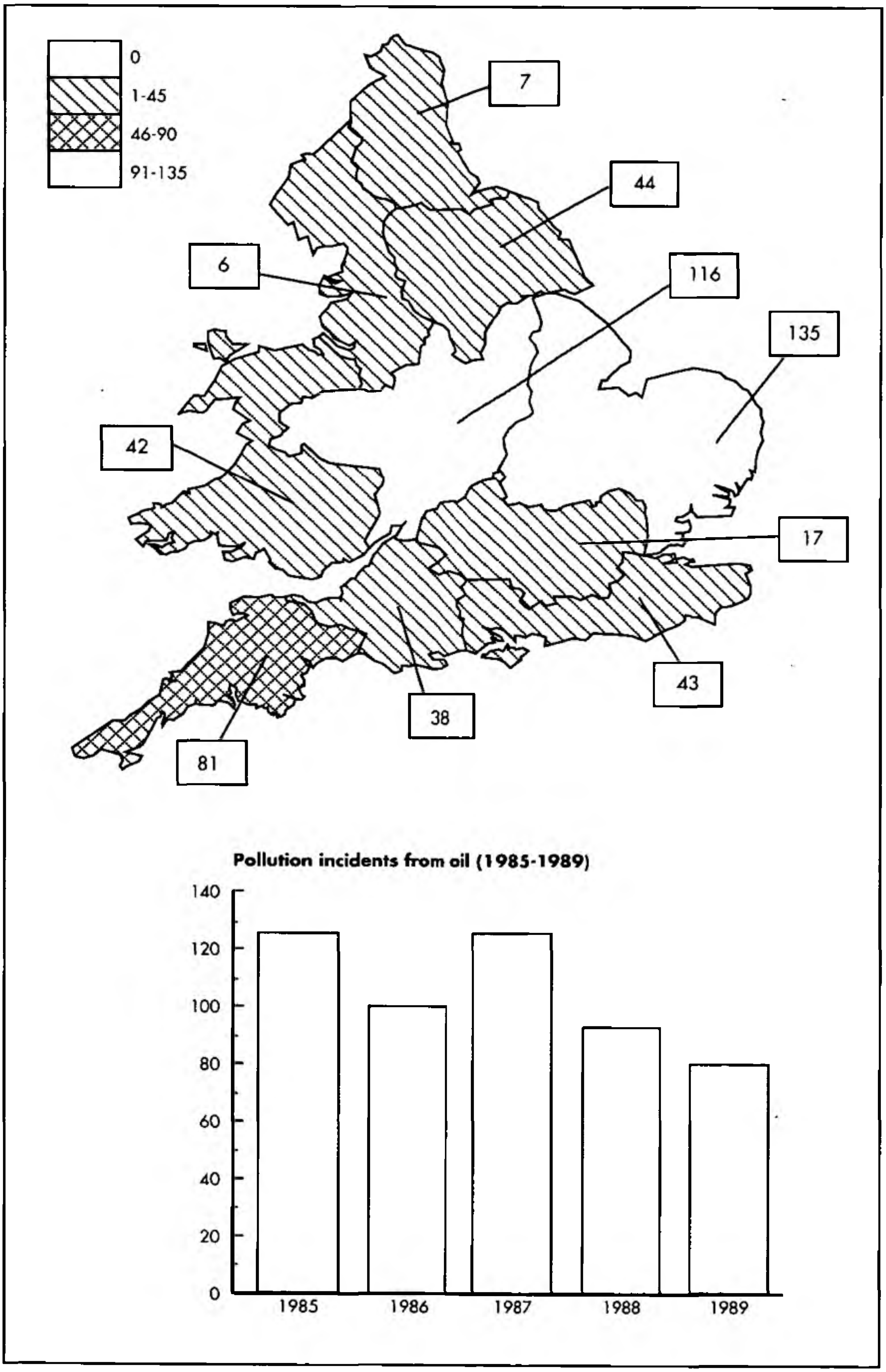
9.4 Incidents, the cause of which cannot be attributed to any of the categories already mentioned, represent less than 8% of the total during 1985 to 1989. Problems caused by vegetable washings and fish farms may be due to a variety of contaminants including organic material, nutrients and pesticides as discussed earlier, and suspended solids, pharmaceutical products and disinfectants.

pH and Metals

9.5 Pollution from acidic and metallic discharges can occur when soils containing iron sulphides are drained. Iron sulphides occur naturally in the form of mineral iron pyrites often found in peat and marine deposits. Drainage exposes sulphides to oxygen, subsequent rise in water tables produces sulphuric acid and ferric hydroxide, known as iron ochre. Some acidophilic bacteria thrive in these conditions and promote even further acidification and iron ochre.

9.6 Problems with iron ochre have occurred in the Upper Thurne Broads in Norfolk where soils contain peat (Madgwick et al 1990). The Internal Drainage Board installed electric pumps during the 1950s allowing much of the Brograve Level to be converted from grazing marsh to arable crops. The Rivers Commissioners, who were responsible for maintaining navigation, were obliged to remove accumulations of iron ochre from the Waxham Cut and Horsey Mere. Some 2,000 tons were removed in 1971 and 1975 and 1,440 tons in 1978. The ochre problem is unsightly and results in many public complaints. The aquatic flora have been adversely affected in areas subject to the worst siltation.

Figure 9.1 Distribution of total farm pollution incidents from oil (1985-89)



9.7 Drainage of soils in the Brightley Stream, atributary in the River Torridge catchment, has produced similar water quality problems. Exceptionally high levels of metals are mobilised from various mineral sulphides in the soil which gain easy access to the stream via land drains as shown in Table 9.1. The problem is particularly severe after long periods of dry weather. Acidophilic bacteria cause a build up of high metal concentrations and very acid conditions during dry weather. During the first flush of heavy rain, poor quality water is leached from the soil and this has lead to fish kills in 1976, 1978, 1984 and 1989. Environmental Quality Standards to protect abstraction for crop irrigation (equivalent to NWC Class 3) were exceeded. During 1990 recycling of contaminated stream water onto limed land reduced the effects.

Table 9.1 - Water Quality during heavy rainfall in October 1989 Brightly Stream

Determinand µg/l	Land drain	Brightley Stream d/s land drain	EQS for crop irrigation annual mean
pH	2.7	3.1	5.5
Dissolved sulphate	942,000	250,000	-
Total aluminium	26,700	6,510	-
Total nickel	2,360	338	150
Total copper	667	133	500
Total cadmium	106	21	20
Total zinc	33,000	4,970	1,000
Total iron	130,000	29,000	1,000

9.8 Another source of metals is pig slurry, which contains copper and zinc -additives of commercial pig food. A pollution incident of the River Madford, Devon, described in Appendix 4, resulted in copper and zinc in the sediment which remained for some months.

Pharmaceutical Products

9.9 A wide variety of pharmaceutical products is used in agriculture to prevent and to treat diseases. Sheep dip has been dealt with in Section 8. Dosing is either direct or, in the case of fish, for which only four medicines are licensed, also by dipping and through the food. Uneaten food, spent dip and excretory products may carry unassimilated chemicals into the environment.

9.10 The impact of fish farming has recently been reviewed (Mainstone et al 1989). Evidence of contamination of water from pharmacentical products does not exist, but concerns were expressed about a wide range of products. This includes canthaxanthin, a pigment which enhances salmon flesh colour and which is currently not a registered product in the US because of its potential carcinogenic properties. This pigment has now been largely replaced by astaxanthin, which is an EC approved pigment, a licensed human medicine and is not regarded as having carcinogenic properties.

9.11 Antibiotics tend to be used in small quantities and are unlikely to cause a problem; however, they may provoke allergic responses in a small proportion of the human population and could result in resistent strains of bacteria developing. This, in turn, may affect the composition of the bacterial flora. Some dips contain pesticides and fungicides. In Scotland the use of "Dichlorvos" on farmed salmon is of concern due to its high toxicity to marine arthropods other than the target species. It is not used in England and Wales although an application for its use in Wales is now being considered by the Welsh Office. Malachite Green is widely used but because of its suspected teratological effects on fish and rabbits, it is not a registered product in the US.

Disinfectants

9.12 Similar arguments apply to disinfectants used on farms. The review of the impact of fish farms (Mainstone et al 1989) indicates concern over formaldehyde, which may have carcinogenic properties. The main agricultural use of formaldehyde is in the production of silage.

Suspended Sediment

9.13 There is evidence that arable farming on sloping land can have an impact on suspended sediment loads, particularly when cross-contour ploughing occurs. The use of ridge and furrow techniques for potato and bulb growing in West Cornwall is known to result in fine soil particles migrating down slope and entering rivers (paragraphs 8.14 - 8.19).

9.14 This material has an obvious and immediate impact on gravel consolidation. In turn, this is likely to have an impact on macrophyte growth, and on the survival of animals which are dependent on a flow of water through the gravel. The reproductive success of salmonid fish may be severely compromised by the settlement of fine sediments. Because fine soil particles can act as a carrier of phosphates and some pesticides, problems of eutrophication, plus toxicological effects may also occur.

9.15 The close relationship between soil and water management has been recognised in many areas of the world. Forestry practices are well known to have significant impacts on soil and water quality. In New Zealand, comprehensive environmental policies incorporating soil and water management have been introduced. These also promote the concept of catchment management. It is likely that a significant proportion of water quality problems associated with particular compounds such as phosphates and pesticides could be controlled by the use of suitable soil management techniques.

Discussion

9.16 Although acute incidents from oil contamination are rare, when they occur they can have serious effects. Small quantities can have impacts over many kilometres of river and may severely limit downstream river uses.

9.17 The scale of both point source and diffuse pollutions caused by other contaminants is not well understood, although they are less obvious than organic material, nutrients and pesticides. For some, particularly pharmaceutical products, it would be sensible that risks of contamination are assessed, appropriate monitoring is undertaken and, where necessary, environmental quality standards are determined.

9.18 It is also sensible for farmers to minimise soil erosion. The use of soil conservation methods should be encouraged, not only to maintain a valuable resource but also to limit the contamination of surface waters by soil-associated compounds.

10. POLLUTANTS FROM AGRICULTURE - BIOLOGICAL MATERIAL

10.1 Biological materials which may be introduced to the aquatic environment range from domestic stock, such as escapes from fish and fur farms, to microbiological material, which may be 'domesticated', but generally is not. Potential contaminants include non-indigenous "large" stock, and a range of plant, animal and human pathogens such as bacteria, viruses, fungi, protozoa and parasitic worms. The sources of "large" domestic stock are insecure pens, with the risk of escape being exacerbated by inadequate management practices. Microbiological material is found in livestock slurry, silage effluent, animal feedstuffs, milk, processing wastes from vegetables and animal carcasses, fallen stock which are buried or disposed of near natural waters, sewage sludge and fish farm effluents. Any method whereby these materials or their effluents reach controlled waters will enable potential pathogens to contaminate those waters. In addition, sewage discharges which comply with their consent conditions often contain large numbers of pathogens.

10.2 Areas of concern are habitat degradation, competition with indigenous species, alteration of the genome and transmission of diseases to plants, animals and humans. Contamination of raw water for public supplies is the major concern, particularly in reservoirs, rivers and shallow groundwaters.

10.3 The accidental or wilful introduction of stock into the wild may have a variety of effects on the environment. The success of the introduced organism is dependent on a number of factors, including the size of initial or sequence of introductions, their timing, the availability of suitable habitat and meteorological conditions. Generally, the introduction of domestic fish, birds or mammals is unlikely to pose a significant threat, although an extreme example is that of the coypu.

10.4 During the 1930s, about 50 coypu farms were established in Britain to produce fur for the fashion clothing market. Many animals escaped and successfully colonised large parts of East Anglia. The population reached a maximum of about 200,000 in the late 1950s (Gosling 1989). Tunnel construction created an increased risk of flooding. Crop damage was widespread. Habitat degradation occurred in many broads and rivers and some plants, such as flowering rush *Butomus umbellatus* and cowbane *Cicuta virosa*, became extremely rare. Intermittent campaigns from 1962 to control coypu numbers were unsuccessful. Mathematical models were used to simulate the impact of trapping and cold winters on the population. This determined what trapping effort was needed to eradicate the pest. The final campaign was launched in 1981 when more than 5000 adults were alive. None were trapped after spring 1987 and early in 1989 it was decided to close the campaign. This is a rare example of successful reversal of an environmental mistake.

10.5 Competition with indigenous stock was considered in a recent review of the effects of fish farming (Mainstone et al 1989). The majority of fish farms using fresh water from rivers and groundwaters stock rainbow trout. Escapes are numerous and rainbow trout are found widely throughout the UK. Phillips et al (1985) considered that the feeding niches of native brown trout and introduced rainbows were similar, so it is inevitable that brown trout production would be reduced. However, the success of rainbow trout is limited by their inability to maintain significant breeding populations.

10.6 Some farms also produce brown trout and a number of these escape or are introduced into the wild. Intra-specific competition is considered to be less important, because farmed stock are less capable of long-term survival than wild strains.

10.7 Virtually all domestic stocks of animals or plants have been selectively bred and thus have been genetically manipulated. For example, disease resistance, nutrient assimilation and increases in yield have all been enhanced by carefully managed breeding programmes in a wide range of farm stock. However, part of the cost is a reduced ability to cope with natural conditions. Stahl (1983) has shown that hatchery reared Atlantic Salmon have lower genetic variability than do wild populations. Breeding programmes aimed at producing ideal domesticated salmon will result in fish with characteristics making them less able to survive in the wild. Interbreeding could introduce these characteristics into wild stocks, making them more vulnerable to disease and environmental change; but, with reduced potential for survival, it is unlikely that escaped fish would be successful at breeding.

10.8 The absolute incidence of waterborne disease in humans is difficult to assess because there are often several potential infection routes and there is believed to be much under-reporting of human illness (Kay et al in press). A large proportion of the waterborne problems that do occur will have human sewage as the principal source. Nevertheless, it is known that some bacteria, viruses, fungi, protozoan and parasitic worms can exist in farm livestock and hence there is the potential for natural waters to be contaminated. Bacterial genera of potential or actual concern include *Escherichia*, *Salmonella*, *Campylobacter*, *Leptospira* and *Listeria*; protozoan parasites include *Cryptosporidium* and *Giardia*; *Candida* is a fungus which may be of concern; most viruses are host-specific but adenoviruses from farm stock may have the ability to affect humans through the waterborne route.

Bacteria and Viruses

10.9 An example of bacterial contamination of water supplies is given in Appendix 4, paragraph A4.5. When water treatment works are subject to extremely high bacterial loading, it is likely that those species less susceptible to treatment processes will get into supply.

10.10 Kay et al (in press) refer to a paper by Geldreich (1972), who indicates that Salmonellae are often found in clinically healthy farm animals. The percentage of symptomless carriers was found to be between 7 and 22% in pigs, around 15% in cattle, and between 4 and 15% in sheep. It is reasonable to assume that wastes from farmyards, markets and abattoirs are likely to be sources of salmonellae in natural waters.

10.11 The Royal Commission on Environmental Pollution (1979) reviewed the transmission of disease from animal excreta to farm stock. It was reported that *Salmonella* had been found in 11% of cattle slurry samples, 22% of pig slurries and 42% of poultry manure. Because slurry is spread widely over pasture, the risk of infection arising from grazing on slurry spread land will be higher than for solid waste.

10.12 Human sewage sludge also contains *Salmonella* and, when spread on grass, its persistence varies from 18 days to 24 weeks; however, there is no evidence of animal diseases being linked with the spreading of sewage sludge on land.

10.13 The Royal Commission therefore considered that the main risk to human health was the consumption of raw foods which had been contaminated by raw human sewage or untreated sewage sludge (or by drinking unpasteurised milk); although there was no evidence of a link with the use of sludge, concern was expressed about the increased number of human deaths caused by *Salmonella*. The potential hazard to water supplies from viruses was also recognised, as was the necessity to establish links, if such links exist, between sewage sludge and water or shellfish contamination.

Parasites

10.14 Sewage sludge may contain the eggs of human parasitic worms and protozoan cysts. Eggs of the beef tapeworm are resistant to extreme environmental conditions and may survive on pasture for more than five months. Examples from Scotland were quoted by the Royal Commission in which 90% and 24% of carcasses were infected and linked to the application of sewage sludge to pasture.

10.15 *Cryptosporidium parvum* is a protozoan parasite which can cause cryptosporidiosis in humans. The parasite is probably endemic in both the domestic and wild animal populations in the UK and infected animals can excrete large numbers of oocysts. It causes a particular problem to water undertakers because of its extreme resistance to chlorination and because the minimum infective dose for humans is thought to be low, possibly as low as 10 oocysts.

10.16 Following outbreaks of cryptosporidiosis in Ayrshire, and in Swindon and parts of Oxfordshire in 1988 and 1989, the Government convened a group of experts to report on the organism concerned, its occurrence in the environment and its importance as a waterborne infection for man. The resulting "Badenoch Report" (DoE/DoH 1990) concluded that *Cryptosporidium* is widespread in livestock, making it likely that most oocysts in the environment derive from agricultural sources. All types of environmental water can become contaminated and the parasite may be present in low numbers in most waters from time to time. Waterborne cases represent only a proportion of the total, but this route is important in that large numbers of people can be affected. Because water treatment processes cannot easily cope with heavily contaminated raw water, much emphasis was placed on developing catchment control measures. Specific recommendations of relevance to the NRA, either directly or indirectly, included those to:

- improve methods of isolating, identifying and enumerating cryptosporidial oocysts in environmental samples;

- determine the numbers of oocysts occurring in different types of water and to determine their origin;

- review advice on the storage and disposal of animal manure (with MAFF);

- seek ways to reduce contamination of water sources (with MAFF and the water companies);

- make arrangements with water companies for the safe disposal of contaminated sludge and process waste water;

- work with the Water Companies, agricultural interests, health and local authorities in developing strategies for monitoring treated water supplies;

- contribute to the establishment of a communications network between interested parties; and

- liaise with Water Companies, MAFF, veterinary officers and farmers as appropriate in investigating sources of pollution.

10.17 Whilst the implementation of many of these is dependent on a solution to the first, a certain amount of planning can be done on theoretical grounds. There is certainly a lack of reliable data on the incidence of *Cryptosporidium* in the environment. Obtaining such information is rendered difficult and expensive by existing analytical techniques and these techniques require highly skilled and trained staff. The NRA welcomes and supports the national research programme and in particular the work being done to improve the methods of isolating, identifying and enumerating cryptosporidial oocysts in environmental samples.

10.18 To control inputs directly from animals and from yard run-off, the only practical option is likely to be the identification of protection zones within which direct access to streams and rivers would be restricted. Run-off from pasture, particularly at lambing and calving times, might be minimised by restricting stocking rates within a defined distance from a watercourse. Slurry known to be contaminated may need to be disposed of to landfill sites or arable land, providing that there is no risk of contaminating groundwaters. Although improvements to disposal of farm wastes would help, no practical means of achieving complete control are possible.

10.19 Similar arguments may apply to the disposal of contaminated backwash water and sludge from water treatment works and sewage treatment works. It should be noted, however, that backwash waters from sandfilters are a significant proportion of the volume treated. These are normally returned to controlled waters and it is difficult to envisage alternative methods of disposal. Each case would need to be treated on its merits.

10.20 Where pollution incidents occur involving *Cryptosporidium*, management of them will need to take into account the extra risks to potable supplies. Intake closure will need to be for longer, to allow attenuated plugs of an unseen pollutant to pass by.

10.21 The impact of cryptosporidia on tidal water quality is unknown.

Carcasses

10.22 The decline of the knackering industry has led to a situation where farmers, through no fault of their own, have to find other means of disposing of large numbers of animal carcasses. Whilst it is recognised that advice is given in the Code of Good Agricultural Practice, there is a strong likelihood of some material being disposed of in such a way as to affect water quality. As an example of the scale of the potential problem, for pigs alone, it has been calculated from data in the Meat and Livestock Commission Year Book, 1991 that more than 44,000 tonnes require disposal each year (Penny and Durrant, pers. comm.). There are no similar recording schemes for sheep and cattle, so equivalent figures cannot be calculated. Inadequate disposal practice must create a risk of contamination of water by organic material and potential pathogens.

Discussion

10.23 It is clear that the main area of concern is that of pathogens from agricultural sources contaminating potable water supplies. However, it is only when a large number of people are affected at the same time, in the same place, that an investigation is possible; in other circumstances data on human and animal health problems are poorly reported and not systematically investigated on a regional or national scale.

10.24 Pathogens occur everywhere, but this widespread occurrence rarely has an observable effect on the health of plant, animal or human populations. Where immunological competence is low, a relatively small contaminating load can have a significant effect on individual human health. Such contamination may be available from a variety of sources, of which agriculture is only one and water is only one route of transmission.

10.25 Some concern must be expressed about other microbiological materials which may contain genetically modified organisms. A number of claims are made about improved efficiency with regard to inocula for oxidation ditches and silage clamps. If microbiological material is being altered genetically for such purposes, it is likely that such organisms are being discharged to the environment. The risks to the environment are unknown. The disposal of unsuitable organisms will need to be controlled. The NRA welcomes the approach being made by the Government. It is intended to issue regulations under the Environmental Protection Act and the Health and Safety at Work Act. In addition, several research topics have current funding (1989/90) of almost £24 million.

11 DISCUSSION

11.1 Agriculture is only one among many industries which has an impact on water quality. The discharge of sewage effluent and trade wastes has a major impact in some waters; in the more densely populated parts of England and Wales, a greater proportion of the impact will be from sewage and industry, whereas in rural areas the emphasis is on agriculture. Many rural waters are, however, affected by sewage and trade wastes; similarly urban areas are often well downstream and river flow carries the impact of agricultural discharges to them. Although agriculture can, and often does, have a deleterious effect on natural water quality, and specific links between cause and effect are known for a large number of circumstances, due to the complexity of both the agricultural industry and the behaviour of natural waters, much is unknown. The resolution of water quality problems will, therefore, be difficult, unless all parties appreciate the need for investigation and controls, and work together.

11.2 Natural waters have the ability to cleanse themselves of discharges of some wastes, by a range of physical, chemical and biological processes, which are often seasonally and diurnally variable. The capacity of waters to receive and deal naturally with waste is limited and this is recognised when conditions are applied to consents to discharge. Although the NRA wishes to operate in a fair and equitable way towards all, it is relatively easy to control the material discharged from sewage treatment works and trade premises whereas it is difficult to control agricultural discharges which are extensive, variable and often diffuse.

11.3 Although field drainage is of benefit to the farmer in terms of the productivity of his land, there are impacts on water quality which, until relatively recently, have been unrecognised. In some cases, river flow regimes become altered, with peak flows being higher than previously and low flows being lower. Higher peak flows of shorter duration have increased scouring effects. The poor or bad water quality associated with rapid flushing of dirty yards, fields and ditches is exacerbated and this, in turn, is likely to have an increased deleterious effect on aquatic fauna and flora. At the other extreme, lower low flows provide less dilution for consented discharges. The inevitable result is that water quality suffers. However, experimental work by ADAS (MAFF 1991 b) has shown that for some soils, variations in loading and seasonal effects can result in differences in the quality of drainage water. Under the best conditions the soil acts as a filter, and drains may provide some storage. Soils with buffering capacity will have reduced the risks of deleterious impacts on river water quality.

11.4 When wetlands are drained, their beneficial effects on water quality are lost: these include the ability to change the nitrate levels in water and to absorb metals from solution. In their absence, surface run-off - rich in ammonia, nitrates or metals - is quickly discharged to controlled waters; water quality suffers and there is an increased impact on the ecosystem. There are thus strong arguments for the re-instatement of appropriately placed wetlands, which intercept silt, nutrients, pesticides and metals, adjacent to particularly sensitive waters. Overall this may be a cost-effective way of improving water quality and ensuring that designated uses are sustained. However, fragmented land ownership in England and Wales almost certainly implies that such re-instatements would need to be grant-aided or funded by detailed agreements.

11.5 The problems of water resources are inextricably linked with those of water quality, although quantity has not been discussed at length in this report. The majority of abstractions are returned but not at the same place, often not to the same type of water, and usually not of the same quality. Some abstractions are effectively a total loss. This applies to water abstracted for spray irrigation, usually in summer, and which is used by the crop, or evaporates, before it can return to the surface or groundwater. The effect of these geographical discontinuities and total loss abstractions is to reduce the dilution available for consented discharges and thus the quality of waters receiving those discharges.

11.6 It is clearly necessary to have a co-ordinated approach towards dealing with abstractions and discharges, and this is best done on a catchment basis; where groundwaters are involved, the catchment boundary will not necessarily coincide with the watershed indicated by surface topography.

11.7 There are also many water quality problems associated with upland forestry. Much research has been, and is being, done to assess the impact of specific practices; the resolution of such problems is being attempted by the NRA, the Forestry Commission, and the Water Research Centre. This work has not been discussed in this report; however, the promotion of various schemes and the introduction of proposals for lowland forestry plantations, in place of existing agriculture, requires consideration of the potential impacts on water quality before widespread introduction as an environmentally sound alternative.

11.8 It is likely that water use by deciduous trees is greater than that by agricultural crops. This may lead to reduced river flows and groundwater levels. In lowland Britain, the difference between rainfall and evaporation is small, so the amount of water available for river flow and aquifer recharge is sensitive to small changes in evaporation. It is also likely that deciduous trees will scavenge more pollutants from the atmosphere than do agricultural crops. When these processes are combined, the net result would be a deleterious change in water quality (Rosier et al, 1990).

11.9 Much of the future planting will be of deciduous hardwoods in small blocks scattered in a mosaic over the countryside. This may result in enhanced evaporation and scavenging due to the "edge" effect. Evaporation from ground vegetation will also be substantial, particularly in spring, and will be greater than that in a coniferous forest. It is likely that trees in lowland Britain will be water-stressed during summer.

11.10 Groundwaters which are vulnerable to nitrate pollution may also be vulnerable to pesticide pollution. A mixture of deciduous woodland and low-intensity land use ought to be particularly effective in controlling pollution of both types. Developments such as the proposed Midland forest, particularly when on land over unconfined aquifers which are important for public water supply, are likely to be encouraged. The use of conifers would almost certainly be opposed because of their impact on groundwater recharge.

11.11 The transfer from arable to forest will need to be controlled, with a grassland phase being necessary to immobilise the leachable nitrogen. Similarly, if contaminated land is to be planted, its preparation must be done in such a way as to prevent pollution.

11.12 A national policy is being developed for the control of fish farm effluents. Since the quality of effluents varies with the quality of abstracted water, consent conditions will be expressed in "relative" terms. The question of whether a minimum dilution is required on all fish farm effluents, irrespective of impact, is still being debated.

11.13 Cage rearing of fish in lakes, reservoirs and estuaries has the potential for increasing eutrophication. The rapid expansion of this industry in Scotland has led to considerable concern for the water quality of many sites. Whilst the same degree of expansion is unlikely in England and Wales, it would be sensible to learn from the Scottish experience and to be suitably cautious in the event of significant proposals.

11.14 Many thousands of numerical consents were issued for farm discharges in the early 1960s. Historically, they have never been regulated adequately and many are now inappropriate. The NRA does not want to maintain such an unworkable system but further regulation of agricultural discharges is not the answer; it would be better if these discharges were not made at all and that the waste material was disposed of to land. It is likely that the new charging scheme for discharges will trigger requests to revoke many of these consents. The NRA will welcome this.

11.15 Many of the recent changes in agriculture have implications for the quality of natural waters. The increase in part-time farming has increased the number of farms and hence, potentially, the number of problems. Intensification has led to farmers breaking out of the pattern of traditional agriculture, where self-sufficiency resulted in little being brought onto the farm, the land being capable of coping with its wastes. One of the reasons for the introduction of sewage treatment works was the pollution problems caused by the effluents arising from large concentrations of people. Modern farming practices, together with the greater "strength" of animal waste, and the risk of major spillages, has created similar problems. Large scale dairy, pig and poultry units are effectively factories. Whilst the general policy of the NRA is not to issue discharge consents for farms but to promote farm waste management plans, it may be necessary to treat factory farms, or those parts of farms operating in such a way, in the same way as other intensive industries are controlled. This would be considered only if waste management plans failed to achieve the desired objective. It is recognised that it would be difficult to designate farms or units to be controlled in this way.

11.16 Nevertheless, it is clear that water quality problems are numerous. The inevitable conclusion is that the present system is not working and that there is a need to modify the approaches taken by both farmers and the NRA.

11.17 Under the 1991 Water Resources Act, water quality objectives will be introduced on a statutory basis (NRA 1991 b). The objectives for individual stretches of water will be set by the Secretary of State, and prior to this, he will require assessments to be made of the benefits, and the costs, of meeting them. Diffuse sources of pollution, such as those arising from agriculture, as well as from industry, will need to be addressed on an equal footing with point sources, because control of both will be necessary. The reduction of potential risk is also important; one polluting event can negate the effects of many years' work, and the expenditure of enormous sums of money, in a matter of hours.

11.18 Conventional wisdom is that, from a short-term and individual perspective, pollution control is a cost to business with no return. What is undoubtedly true is that from the perspective of society as a whole, especially over the longer term, investment in pollution control is justified for the health, aesthetic, recreational and economic benefits it brings. This is recognised by the existence of pollution control legislation, including recent requirements for a precautionary approach in handling and storing slurry, silage, and oil on farms.

11.19 At a time when agriculture is not as prosperous as it has been, the NRA recognises that a policy initiative encouraging improved water quality control might be viewed with disquiet, as a thinly disguised call for farmers to spend more money when they can ill afford it. The NRA is acutely conscious of these concerns and, as reflected in the strategy of this report, proposes in particular to implement the requirements of the Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations 1991 in a sensitive way. Other measures proposed in this report - for example, improved monitoring and educational programmes - may have resource implications for the NRA and organisations such as ADAS, but will not involve direct costs to farmers.

11.20 In the longer term, however, the inescapable fact is that transforming agriculture to meet the modern requirements of environmental protection will cost money. Overall, the costs of investment in infrastructure and a change in practices will far exceed what can be had from grant aid and other currently available sources.

11.21 Over the coming years, billions of pounds are being invested in improved industrial waste and sewage disposal. The problems caused by agriculture are just as significant, yet the investment that will be required is hardly planned. Can, and should, the changes needed continue to be met by the agricultural industry on its own? What are the economic costs of water pollution by agriculture compared with that caused by industry or human sewage? How far will the existing levels of grant aid cope with the problem? What investments are being made in other countries? The NRA believes that the long-term aim to improve the effects of agriculture on water quality is far more likely to succeed if it is approached with some notion of how much it will cost and how it will be paid for, hence the recommendations in this report to examine the economic costs of water pollution and benefits of its control, and review the level and means of assisting the agricultural industry with the investment needed.

11.22 Water quality objectives have to strike a balance between the ideal of pristine waters (ie. where human activities have no impact) and the reality of the need for agriculture as an important part of the national economy and source of employment. No agriculture at all might result in a dramatic improvement in water quality. Conversely, if it were judged that food production and rural employment were paramount needs in society (perhaps in a drive to self sufficiency in food supplies), the necessary intensification would only be possible, or would at least be easier, at the expense of lower standards of water quality.

11.23 The reality, of course, lies between these two extremes. In the NRA's view it is possible to strike a proper balance which will not adversely affect present agricultural practices significantly, yet will result in improvement of water quality.

11.24 The proposals in this report are set out with this in mind. On the other hand, the NRA recognises the very important economic issues at stake and would encourage research which can justify in economic terms the balance which it is attempting to strike.

11.25 The NRA can take many actions which will improve the approach to water quality management taken hitherto. These include improved incident control, and the application of systematic approaches to pollution risk assessment and quality monitoring. These internal issues are dealt with more fully in the next chapter.

12. THE WAY FORWARD

Introduction

12.1 This section summarises how the issues raised earlier in this report should be dealt with. The NRA believes that the strategy presented will result in a significant long-term reduction in pollution from agriculture.

12.2 The first step is for farmers and interested organisations to consider the proposals and let the NRA have their constructive criticism. Only with their support for an agreed strategy can the problem be tackled. However, given that support, the NRA believes that very substantial improvements can be made. Some of it can be achieved at minimal cost to the industry, at least in the short term, by improved awareness of farmers of how to minimise the risk of polluting water, and the adoption of improved practices. Thus it may not be difficult for agriculture to improve its part in the national effort to clean up natural waters.

12.3 The central element of the NRA's recommended strategy is improved planning for disposal of wastes arising in agriculture. This should be implemented at an individual farm level, but in the context of the needs of river catchments. It is believed that the benefits of this work will compare very favourably with the costs of carrying it out. The effort must be supported with good monitoring and risk assessment programmes, and much improved education at all levels. Enhanced financial support and certain legal changes relating to waste disposal, water abstraction, and environmental assessment would give it the best chance of working.

12.4 The following is a summary of the main issues and the NRA's recommendations for dealing with them. Some recommendations are firm; the way to achieving them is straightforward and in many cases within the NRA's own remit. Others are suggestions which are put forward in the expectation that they will generate debate and ideas for refinement. Certain suggested legal changes would require parliamentary approval.

Catchment Management Planning

12.5 The quality and quantity of surface and groundwaters, and their general relationships with the well-being of wildlife, including fisheries, in river catchments, is well understood. These inter-relationships cannot be ignored if the NRA is to ensure that legitimate uses of controlled waters are to be protected in a balanced and even-handed way. The control of agricultural pollution, in parallel with other improvement programmes, can only be effectively carried out on a catchment by catchment basis. The NRA is already considering the catchment management approach, the use of modelling, and the need for Geographical Information Systems, which would be of much benefit in dealing with pollution from agriculture and other sources.

12.6 Environmental Impact Assessment (EIA) and planning are important aspects of protecting water resources from pollution in catchments. The Government has implemented the EC Directive on Environmental Impact Assessment by regulations, but as it stands, the EC Directive does not require EIA of policies; its scope is confined to projects. North American law and practice is presently moving towards EIA of policy initiatives as well as projects. The environmental impact of some agricultural policies in the 1970s and 1980s was severe, including their effects on water quality. Some of these problems might have been prevented by prior assessment. The same is true today, particularly in relation to policies which encourage afforestation.

12.7 * **It is RECOMMENDED that the NRA should encourage MAFF to apply EIA to policies as well as to practices.**

Waste Disposal

12.8 There is growing support for the view that waste disposal needs a structured approach. The House of Commons Select Committee report on Pollution of Beaches 1990 stated 'we cannot emphasise too strongly our support for the proposal by the Minister for the Environment and Countryside for a National Plan for waste'. Further, the EC, in its recent consultation paper on the review of the Common Agricultural Policy, indicated that a rural land use policy was a pre-requisite to substantial progress on local reforms. It also recognised that the basic building blocks of such a policy are the economic well-being and clear direction of individual farmers, and that support may have to be directed to localities where intensive farming is causing environmental impact. Careful examination of the causes and effects of agricultural pollution suggests that a more structured approach to storage and disposal of wastes is needed. Provided this is basically straightforward and practical, it is likely to be welcomed by many farmers who increasingly seek support and guidance.

12.9 * **It is therefore RECOMMENDED that the NRA promotes a structured approach to the planning and disposal of waste from farms, as a means of achieving improvements to water quality and minimising the risk of pollution.**

Discharge Consents

12.10 The NRA considers all applications to discharge effluent to controlled waters in an even-handed way. Consents to discharge are granted subject to conditions that will protect the quality of the receiving water.

12.11 Effluent from farms is potentially highly polluting or toxic and would require intensive and consistent treatment to meet the standards required for discharge to natural waters. For example, to treat effluent from a 100 cow dairy herd to a level of about 20 to 60 mg/l BOD, in a reliable manner, as required for human sewage, would probably cost more than £500k in capital and at least £20k/year in running costs. These running costs could exceed the annual profit on many farms. In many cases there is little dilution in available watercourses; this makes the standards for the effluent extremely stringent and, therefore, difficult to achieve in a sustained manner.

12.12 Other treatment options, such as reed beds or digestion, also require considerable capital outlay and careful management, and have yet to be proven for general application. It is not clear whether it is the cost, the management requirements, or the technical shortcomings of such systems which has so far restricted their use. Whatever the reasons, most farm waste cannot be treated satisfactorily before discharge, and so it has to be spread onto land.

12.13 * **It is RECOMMENDED that existing discharge consents for farm effluents are reviewed, and revoked where appropriate. In such cases, farmers may need guidance in formulating alternative disposal plans.**

12.14 **It is further RECOMMENDED that the relevant authorities assist appropriate commercial organisations in the research and development of effective treatment systems for farm wastes, and that MAFF progressively encourages their introduction by grant aid procedures.**

Pesticides

12.15 Limitations to the NRA's monitoring programmes and the absence of analytical techniques for many active ingredients preclude a comprehensive assessment of the scale and extent of pesticide contamination of water, and of their impact on flora and fauna. For those found to be important, a better understanding of how they gain access to water will be necessary for the development of control measures. An extension of the manufacturers' levy might be the most appropriate way of funding such work.

12.16 Alternative strategies should be explored to limit the use and abuse of pesticides, including the use of natural predators, and encouraging the development of disease and pest resistant strains. It is recognised that for the forseeable future, chemical means will remain predominant; a national policy on waste pesticide disposal is needed and this should incorporate an extension to the Pesticides Retrieval Scheme.

12.17 * **It is RECOMMENDED that the Government considers extending the manufacturers' levy to fund research and development of analytical techniques for all active ingredients, and assessments of impact on flora and fauna, as well as on pesticide behaviour and pathways to water as a pre-requisite to use in the environment.**

12.18 * **It is further RECOMMENDED that the NRA develops monitoring programmes which are capable of describing more accurately the occurence of pesticides in water, and also carries out catchment based pollution risk assessments which should incorporate comprehensive reviews of sheep dipper location.**

12.19 * **It is also RECOMMENDED that the Government considers the development of a national policy on pesticide disposal, identifies appropriate environmental quality standards, and further funds the research and development of alternative methods of pest control.**

Farm Waste Management Plans

12.20 The disposal of a whole range of agricultural waste and by-products to land is generally advocated as the soundest option. This is based on the principle that soil is a suitable medium for retaining, breaking down or releasing substances in a controlled manner within the capacity of the environment. The best example of this is the way that nutrients can be assimilated into plants during periods of active growth. The extent to which this process is successful in avoiding pollution is, however, dependant on many factors, with local management being the overriding one. This process is currently dependant on voluntary compliance with a series of detailed codes and guidelines, the results of which are still far from satisfactory to farmers and the NRA alike.

12.21 Farmers generally know their land well and, with some technical guidance, could develop simple, practical waste management plans which would ensure sound disposal regimes for all wastes and byproducts to land, or elsewhere, and hence prevent pollution. Indeed, for livestock wastes, the CoGAP identifies the requirement for a four stage plan, which could form the basis of a more widely applicable farm waste management plan.

12.22 Because incomes are not buoyant in many sectors of farming, funding arrangement will be needed for environmental improvements, separate from those for production, which have their own priority. On this basis, farm waste management plans should be grant aided and, to encourage rapid uptake, should be a pre-requisite for further grant support for pollution control measures. Alternatively, any application for grant aid to assist with the construction of waste management systems could be approved only if a waste management plan was produced; effectively, this would demonstrate an awareness of the best method of dealing with the waste. Once developed, they would form a logical basis for directing progress and ensuring value for grant aid support. An example of a farm waste plan, developed by ADAS, is at Appendix 5. It takes account of site-specific factors such as climate, soil type and topography to ensure disposal is within the environmental capacity of the farm.

12.23 * **It is therefore RECOMMENDED that the NRA enlists the support of MAFF to pursue the feasibility of using individual farm waste management plans to assist farmers in how best to cope with their waste and that, if shown to be feasible, the adoption of such plans be a pre-requisite for grant support for pollution prevention measures.**

Farm Visits

12.24 NRA staff in all regions have, to a greater or lesser extent, visited farms in catchments where water quality problems have been found. Experience has shown that such visits, 'face to face', are the most effective way of promoting action by farmers and gaining mutual understanding of the problems involved. Much valuable information is gained about the nature of the problems and of progress which is being made.

12.25 In the future it will be necessary to encourage farmers to provide, maintain and manage pollution control systems. Systematic visits to selected farms in all catchments is an effective way of doing this. ADAS also carries out farm visits. It is in the interests of the NRA, ADAS and farmers, for the NRA and ADAS to liaise and, where necessary, to co-ordinate their visits.

12.26 * **It is therefore RECOMMENDED that, to promote and direct change and to ensure that improvements are maintained, all NRA Regions carry out visits to representative farms on a routine basis. The results of such visits should be recorded in a systematic manner, so that trends can be identified and consistent national reporting is possible.**

12.27 * **It is further RECOMMENDED that the NRA seeks to improve the co-operation with ADAS on farm visits, to maximise benefit from this work.**

Co-operation with the farming community

12.28 It is essential that the NRA works closely with MAFF, ADAS, WOAD, the NFU, the FUW, the CLA, and the farmers themselves, to identify and reduce the risks of water pollution to mutual benefit. Without such close co-operation, little will be achieved. Some care is required, however, on the extent to which the NRA gives guidance direct to farmers, particularly where action resulting from such guidance could be used as a defence against any subsequent legal action. Nevertheless, the NRA should ensure that its policies are clearly stated and understood by all. Good contact is of course achieved via the NRA's farm visits in each region, but this is not always sufficient. It is particularly important to ensure that MAFF, ADAS, WOAD, NFU, FUW and CLA are advised well in advance of the implications of proposed changes in policy, and that general matters of concern are discussed.

12.29 * **It is RECOMMENDED that the NRA should foster and extend the already good relationship with MAFF and other organisations so that, wherever possible, a consensus on the approach to particular challenges is agreed and one message is sent to the EC about the special requirements of agriculture in England and Wales. National meetings where regular discussions can take place may be the most effective way of achieving this.**

12.30 * **It is also RECOMMENDED that, in order to assist farmers to find their way through the plethora of regulations, the NRA works with MAFF, ADAS, WOAD, the NFU, FUW and CLA to produce succinct, brief, yet clear guidance in the form of booklets, leaflets and video films, which will assist farmers in reducing farm pollution.**

Reducing the risk of pollution

12.31 To maintain and improve the quality of natural waters, it will be necessary to minimise the risk of pollution from farms and related industries. This will be particularly important in sensitive areas. A programme is therefore required which identifies target levels of reduction and time scales. It will be necessary to identify the risk, then develop the means to control it. Monitoring is also necessary to see if actions are effective. The risk from agriculture must be placed in the context of risks from other sources. The best strategy would be to carry out an overall risk assessment, on a catchment or sub-catchment basis, and tailor the controls accordingly. Elements of risk assessment would ideally include the following:

- the analysis of pollution and water quality records;
- the inspection of premises and storage structures;
- the establishment of a catchment inventory of key hazardous materials and related risks;
- clarification of the hydrology and time of travel of natural waters likely to be affected;
- the identification of uses and features needing protection;
- consideration of various pollution scenarios, their likely occurrence, and possible control measures.

Risks maps already developed by WRc, under contract to the NRA, go some way towards this ideal. An example is shown in Appendix 6.

12.32 Practical steps may then be taken to reduce pollution risks to natural waters by:

- controlling hazardous materials with regard to storage, use and disposal;
- the appropriate design and construction of storage and waste handling facilities, and provision of site plans;

– provision of contingency arrangements for emergencies;

– the rigorous enforcement of conditions attached to abstractions and discharges;

– ensuring sound disposal routes are used for wastes; and

– routine inspections.

12.33 * **Thus it is RECOMMENDED that the NRA develops and uses a consistent method of risk identification and planning for those catchments in which farming and other activities pose a major threat to sustaining good water quality, or are the current cause of poor water quality.**

The Use of 'Buffer Zones'

12.34 Intensification of agriculture has often led to removal of hedges, wetlands and river corridor vegetation, and cultivation right to the banks of watercourses. Research has shown that natural buffer zones have a beneficial effect on water quality and conservation value. This arises because the cultivation is removed some distance from the watercourse, and silt, nutrients and other substances are trapped, broken down or assimilated in biological material so that contamination of natural waters is minimised. There seems to be sufficient research evidence and practical experience elsewhere to support this approach, although there has been little uptake to date in the UK.

12.35 * **It is therefore RECOMMENDED that the NRA should seek support from MAFF for practical operational investigations to test the value of 'set aside' being devoted to 'buffer zones' in areas where intensive agriculture is having a deleterious impact on water quality.**

Financial Support for Agriculture

12.36 There is a widely held view that the transition of the agricultural industry to meet modern requirements of environmental protection should be given financial support. The costs of investment in infrastructure and change of practices will far exceed current grant aid and other payments available for environmental improvements.

12.37 Little has been done to establish the change which is necessary, and to compare the varying costs to agriculture in different countries which are making this change. The fact that the investment in industrial waste and sewage disposal in the next ten years will be billions of pounds is a sobering fact. It is therefore essential that the costs of achieving rural environmental objectives are identified. Much will depend on whether the current voluntary and largely unsupported changes can continue to be met by the agricultural industry at a rapid and consistent pace. It is equally important that the hidden costs of water pollution are established, so that the cost-benefit of further support for pollution prevention in agriculture can be shown. The NRA's aims will not be achieved until considerable investment in pollution control and changes in agricultural practices occur.

12.38 * **It is RECOMMENDED that the NRA should encourage MAFF to continue and, where possible, extend the grant aid system to incorporate other key aspects of pollution control, such as the separation of clean and dirty water, and to simplify the wide range of environmental incentives.**

Incident Control

12.39 The aquatic environment is extremely vulnerable to incidents of pollution from agriculture; in some cases the impact is transient; in others, as when there has been significant biotic loss, it may take many years to recover. Where there is contamination of groundwater, it may take much longer. It is quite clear that the policy of 'contain and dispose' of wastes from agriculture will continue to result in much higher risks of major incidents than hitherto; it will be many years before the basic infrastructure is sound enough to reduce the risk of these incidents.

12.40 * **It is therefore RECOMMENDED that the NRA is fully prepared and equipped to reduce the impact of the whole range of incidents which are likely to occur. Priority, in any incident, should be given to stopping or reducing its impact on legitimate water uses.**

12.41 * **It is further RECOMMENDED that farmers should have, as part of their individual farm waste management plans, a list of actions to follow in an emergency. The first of these would be to inform the NRA.**

Prosecution

12.42 Under Section 85 of the Water Resources Act 1991, it is an offence to cause or knowingly permit any poisonous, noxious or polluting matter or any solid waste to enter any controlled water. It is also an offence under Section 4 of the Salmon and Freshwater Fisheries Act (1975) to cause matter poisonous to fish, their food or spawn to enter water. Polluting materials and incidents are extremely diverse and it is impossible to define precisely all such poisonous materials. Hence, an NRA policy has been developed which enables decisions on appropriate actions to be made in a consistent manner. These actions include prosecution, issuing a formal caution, or sending a warning letter. The NRA is seeking to minimise the risk of pollution by co-operation with the agricultural industry. However, it will take formal action, where necessary, under the terms of the policy to ensure progress is made.

12.43 The Control of Pollution (Silage, Slurry, and Agricultural Fuel Oil) Regulations 1991 aim to prevent pollution by setting minimum standards for keeping and handling these substances. Most existing facilities will be exempt, though the NRA may require improvements if there is a risk of pollution. New or substantially enlarged or reconstructed facilities must comply with standards set out in the Regulations, and farmers must notify the NRA before bringing such facilities into use. Compliance with the Regulations is not a defence to a prosecution, but it may be a mitigating factor.

12.44 The aim of the Regulations has been to specify the level of performance required from the installations to minimise the risk of water pollution. To ensure support for this aim the NRA must be seen to administer the Regulations in a fair and consistent manner. Enforcement of the Regulations should follow if adequate warning has been given of the need for improvements within an appropriate timescale, and such a warning has been ignored.

12.45 * **It is therefore RECOMMENDED that the NRA provides a clear interpretation of what is required to comply with the Regulations.**

Additional Powers

12.46 Some of the NRA's aims can be achieved under existing powers. The achievement of others may, however, require changes in Government policies and legislation. Such changes are unlikely to be achieved in the short term, and certainly not until existing powers have been used to their full and substantial evidence provided for the need. The impact of agriculture on water quality is also only one component of the wider debate on environmental issues as a whole, and on the farmer's role in maintaining and enhancing the rural environment. Care will be needed with existing and future regulations to ensure that they are practical and do not affect the UK farming industry's ability to compete within and outside the EC. Nevertheless, there are several areas in which some additions to the legislation are worth examining, primarily in relation to the disposal of certain substances, and water use.

A duty of care

12.47 Present statutes and regulations made under them exclude controls over wastes arising from agriculture. There are practical advantages in not having agricultural wastes covered by the controls which affect most household, industrial and commercial wastes. To dispose of such waste legally requires a disposal licence. The NRA recognises that to expect farmers to have licences for the disposal of their own wastes on their own land would cause many difficulties.

12.48 However, there are several areas where further provision may be helpful. If the proposed EC Directive on hazardous waste is adopted, then there will need to be proper implementation mechanisms for that in so far as it will relate to farm wastes. In these circumstances it would be necessary to bring legal control over disposal of relevant wastes arising in agriculture.

12.49 The same issues apply to the disposal of animal carcasses. This is potentially a serious problem, because of the decline in the knackering industry. Thus farmers are inclined to dispose of more carcasses themselves. If knackering is not an option, disposal in a licensed site or authorised incinerator is preferred. Despite advice in the Code of Practice that "under no circumstances should carcasses be disposed of in or near watercourses", the NRA is finding that recent incidents are causing concern. Before the decline of the knackering industry, this was not the case.

12.50 The new Slurry, Silage, and Agricultural Fuel Oil Regulations 1991 do not cover the disposal of farm wastes on land. It is recognised that, in principle, disposal of slurries on land is a desirable, and indeed, essential practice.

12.51 * **It is therefore RECOMMENDED that, if rapid progress is not made with farm waste management plans, the NRA seeks new Regulations under Section 92 of the 1991 Water Resources Act, to the effect that persons with custody or control of defined wastes - including such material as pesticides and other chemicals and their containers, animal carcasses, and animal slurries - should take certain precautions in their disposal under a 'duty of care' system.**

Registration of Protected Rights

12.52 The existence of unrecorded but protected rights is a serious constraint on the NRA's ability to manage water resources properly. Thus, a licence to abstract water, or a right to abstract without the need for a licence, gives rise to a "protected right" under the Water Resources Act 1991. The NRA has a duty not to grant licences so as to derogate from protected rights of others. A significant proportion of these protected rights are held by farmers. Their locations and areas of effect will have an impact on where farm wastes can be disposed.

12.53 * **It is therefore RECOMMENDED that to ensure full protection of these rights, they should be registered with the NRA.**

Education

12.54 Education is vital to the effective prevention of water pollution from agricultural sources. Agriculture is too easily regarded as a natural activity that cannot cause pollution. Only by education will the need to prevent pollution be impressed on those people responsible for carrying out and managing agricultural activities. In the past there has been no nationally co-ordinated approach to education in this field, although a number of local initiatives have been taken. The advent of the NRA and the current interest in the environment provides an unprecedented opportunity for educational activity on a national scale. A variety of approaches is available, ranging from talks to "interested" groups, through publicity campaigns, to formal participation in the teaching programmes of the agricultural colleges. The time is right for the NRA to take a pro-active role in education, in addition to an on-going reactive response to requests for information and speakers.

12.55 The agricultural colleges and institutions providing similar courses are training and educating the farmers, landowners and land agents of tomorrow. It is essential that their students leave with an appreciation of environmental quality, and a knowledge of water pollution prevention. Until now, water pollution has not had a high profile in the curriculum at any of the major agricultural colleges or in the courses run by the Agricultural Training Board. Recent direct contact with a number of colleges has revealed an awareness of this deficiency. The opportunity exists for the NRA to provide teaching material in the form of data, case studies and visual aids and speakers to explain the Authority's role and its approach to water quality management.

12.56 * **It is therefore RECOMMENDED that the major agricultural colleges and the Agricultural Training Board be approached, requesting that water pollution is included in their curricula, and offering assistance in the provision of both teaching material and guest lecturers.**

12.57 There is an advantage in getting the message across at the earliest opportunity. The scale of effort needed in schools precludes an active involvement by the NRA, on any but a limited scale. There is, however, a requirement for information and teaching material for use in schools, particularly as part of GCSE courses. Work experience placements provide an additional opportunity to foster understanding of the NRA's role.

12.58 * **It is therefore RECOMMENDED that, after liaison with the Education Authorities, an information pack is produced for use in schools. The pack should include information on the influence of agriculture on water quality as part of more general information on water environmental quality. Speakers should be provided wherever resources allow.**

12.59 There is also a diversity of "interest" groups associated with agriculture, ranging from the NFU, FUW, CLA and the Royal Institute of Chartered Surveyors, to local farming groups that meet at intervals to discuss matters of mutual interest. All have a potential role to play in education and their co-operation should be fostered wherever there is the opportunity. Formal liaison meetings are already held between the NRA and some of these organisations, and should continue at both national and local levels.

12.60 * **It is RECOMMENDED that the opportunity should be taken to provide speakers and information to these groups where it is considered to be effective in communicating matters of mutual interest.**

Monitoring Progress

12.61 In order to measure the effectiveness of farm pollution control, risk reduction programmes, and education, the NRA needs to develop monitoring and surveillance programmes which reflect the sensitivity of the area, the likely sources of contamination, and the range of dependant plants and animals.

12.62 The use of point source monitoring, as for major discharges of largely known content, is inappropriate for the widely dispersed and often intermittent impact of agriculture. Similarly, relying on infrequent routine chemical monitoring of a small fraction of the potential pollutants is also unlikely to reflect the fitness for use of particular controlled waters.

12.63 The NRA needs a programme which includes real time data so that rapid action can be taken to trace pollution for a realistic number of pollutants. This must be matched by the ability to screen for a wider range of possible contaminants at key points where changes can be identified and followed up on a longer term basis. This would involve the integration of a wider range of techniques to screen for the 'health' of the water and its associated fauna and flora at a relatively small number of trigger sites. In parallel, the NRA should develop recognised, rapid multi-disciplinary survey techniques with known accuracy to check and follow up suspected pollution problems.

12.64 * **In view of the need to improve the surveillance of controlled waters in rural areas it is RECOMMENDED that a review be undertaken to identify a balance between remote sensing and routine chemical monitoring and biological and other techniques, both spatially and temporally, which will adequately screen water quality and provide real-time data. This should take into account resource implications, so that a balance is achieved between monitoring and action to reduce pollution.**

Sensitive Areas

12.65 There are some farming activities which, even when carried out in accordance with CoGAP, can affect legitimate uses of natural waters; for example, the ploughing of permanent pasture may release large quantities of nitrate to groundwater. For this reason, restrictions on certain practices may be necessary in these sensitive areas. The EC has identified criteria for sensitive and less sensitive areas in respect of the requirements of the Urban Waste Water Directive. These are designed to protect:

- freshwater lakes and other bodies such as estuaries and coastal waters where water exchange and nutrient input is such that they are, or may become, eutrophic if protective action is not taken;

- surface waters intended for the abstraction of drinking water which could exceed EC Directive nitrate levels; or to apply

- where further treatment of waste water is required to fulfil EC Council Directives.

12.66 This is a useful clarification, which is in contrast with current UK practice. These proposals do, however, increase an already potentially confusing number of statutory and voluntary environmental protection measures. They include Sites of Special Scientific Interest, Water Protection Zones (potential), Nitrate Sensitive Areas (pilot), Environmentally Sensitive Areas, Extensification schemes, Diversification schemes, Set Aside schemes, Farm and Conservation Grant schemes and many other environmental protection initiatives from other organisations, such as Countryside Stewardship and so on. It would be helpful for all concerned if these initiatives were reviewed, simplified and put into context in terms of their objectives, application and funding.

12.67 * **To meet its own aims, it is RECOMMENDED that the NRA should develop a system of identifying sensitive areas for controlled waters which can be applied generally using a two tier system with specific and precautionary measures to protect, as necessary, all vulnerable water uses.**

Anticipating the effects of climatic changes

12.68 Current discussions about major influences on agriculture such as the greenhouse effect are "theory rich and data poor". Nevertheless, after four droughts in 14 years in western regions and extreme problems with groundwater during the last two years, there can be no doubt that even a continuation of the recent pattern of weather will influence agriculture and the flow and quality of natural waters.

12.69 * **It is therefore RECOMMENDED that, as part of its watching brief on climatic trends, the NRA discusses with MAFF the possible changes in agricultural practices and patterns and the influence on water quality which may occur.**

Research and Development

12.70 An effective research and development (R&D) programme is essential to an organisation such as the NRA and this is recognised by a statutory duty laid down in the Water Resources Act 1991. The primary purpose of the NRA's R&D is to make the organisation more efficient and effective in its operation, and proactive with regard to both the problems it has to tackle and the changing statutory framework within which it operates. The NRA has well established links with DoE, MAFF and research institutes and co-operates with projects or sponsors a wide range of relevant research.

12.71 A number of recommendations on specific technical issues have arisen from the evidence presented on agricultural pollution. The main focus of these is in relation to pathways of contaminants to natural waters, monitoring, and assessing impact on legitimate uses, particularly fauna and flora, as follows:

- the environmental and economic impact of agriculture on natural waters;

- review of the impact of a range of chemicals (nutrients, pesticides, disinfectants and pharmaceutical products) on the ecology and well-being of aquatic plants and animals with a view to establishing whether control measures are needed to protect uses of natural waters;

- development of analytical techniques for chemical and microbiological contaminants where these are not currently available;

- development of monitoring techniques including rapid assay and use of artificial media e.g. resin for pesticides;

- assessment of the risk of impact from genetically modified organisms on uses of natural waters.

12.72 * **It is RECOMMENDED that these identified areas are included in the progressive review of the NRA's priorities for R&D.**

13. SUMMARY OF RECOMMENDATIONS

13.1 It is RECOMMENDED that the NRA should encourage MAFF to apply EIA to policies as well as to practices.

13.2 It is RECOMMENDED that the NRA promotes a structured approach to the planning and disposal of waste from farms, as a means of achieving improvements to water quality and minimising the risk of pollution.

13.3 It is RECOMMENDED that existing discharge consents for farm effluents are reviewed, and revoked where appropriate. In such cases, guidance should be given to farmers in formulating alternative disposal plans.

13.4 It is RECOMMENDED that the relevant authorities assist appropriate commercial organisations in the research and development of effective treatment systems for farm wastes, and that, once proven, MAFF progressively encourages their introduction by grant aid procedures.

13.5 It is RECOMMENDED that the Government considers extending the pesticide manufacturers' levy to fund research and development of analytical techniques for all active ingredients, and assessments of impact on flora and fauna, as well as on pesticide behaviour and pathways to water as a pre-requisite to use in the environment.

13.6 It is RECOMMENDED that the NRA develops monitoring programmes which are capable of describing more accurately the occurrence of pesticides in water, and also carries out catchment based pollution risk assessments which should incorporate comprehensive reviews of sheep dipper location.

13.7 It is RECOMMENDED that the Government considers the development of a national policy on pesticide disposal, identifies appropriate environmental quality standards, and further funds the research and development of alternative methods of pest control.

13.8 It is RECOMMENDED that the NRA enlists the support of MAFF to pursue the feasibility of using individual farm waste management plans to assist farmers in how best to cope with their waste and that, if shown to be feasible, the adoption of such plans be a pre-requisite for grant support for pollution prevention measures.

13.9 It is RECOMMENDED that, to promote and direct change and to ensure that improvements are maintained, all NRA Regions carry out visits to representative farms on a routine basis. The results of such visits should be recorded in a systematic manner, so that trends can be identified and consistent national reporting is possible.

13.10 It is further RECOMMENDED that the NRA seeks to improve the co-operation with ADAS on farm visits, to maximise benefit from this work.

13.11 It is RECOMMENDED that the NRA should foster and extend the already good relationship with MAFF and other organisations so that, wherever possible, a consensus on the approach to particular challenges is agreed and one message is sent to the EC about the special requirements for the control of pollution from agriculture in England and Wales. A national forum where regular discussions can take place may be the most effective way of achieving this.

13.12 It is also RECOMMENDED that, in order to assist farmers find their way through the plethora of regulations, the NRA works with MAFF, ADAS, WOAD, the NFU, FUW and CLA to produce succinct, brief, yet clear guidance in the form of booklets, leaflets and video films, which will assist farmers in reducing farm pollution.

13.13 It is RECOMMENDED that the NRA produces guidance on a consistent method of risk identification and planning for those catchments in which farming and other activities pose a major threat to sustaining good water quality, or are the current cause of poor water quality.

13.14 It is RECOMMENDED that the NRA should seek support from MAFF for practical operational investigations, particularly aimed at controlling soil erosion, to test the value of 'set aside' being devoted to 'buffer zones' in areas where intensive agriculture is having a deleterious impact on water quality.

13.15 It is RECOMMENDED that the Authority should encourage MAFF to continue and, where possible, extend the grant aid system to incorporate other key aspects of pollution control, such as the separation of clean and dirty water, and to simplify the wide range of environmental incentives.

13.16 It is RECOMMENDED that the NRA is fully prepared and equipped to reduce the impact of the whole range of incidents which are likely to occur. Priority, in any incident, should be given to stopping or reducing its impact on legitimate water uses.

13.17 It is further RECOMMENDED that farmers should have, as part of their individual farm waste management plans, a list of actions to follow in an emergency. The first of these would be to inform the NRA.

13.18 It is RECOMMENDED that the NRA provides a clear interpretation of what is required to comply with the Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations 1991.

13.19 It is RECOMMENDED that, if rapid progress is not made with farm waste management plans, the NRA seeks new Regulations, under Section 92 of the 1991 Water Resources Act, to the effect that persons with custody or control of defined wastes - including such material as pesticides and other chemicals and their containers, animal carcasses, and animal slurries - should take certain precautions in their disposal under a 'duty of care' system.

13.20 It is RECOMMENDED that to ensure full protection of unrecorded abstraction rights, they should be registered with the NRA.

13.21 It is RECOMMENDED that the major agricultural colleges and the Agricultural Training Board be approached, requesting that water pollution is explicitly included in their curricula, and offering assistance in the provision of both teaching material and guest lecturers.

13.22 It is RECOMMENDED that, after liaison with the Education Authorities, an information pack is produced for use in schools. The pack should include information on the influence of agriculture on water quality as part of more general information on water environmental quality. Speakers should be provided wherever resources allow.

13.23 It is RECOMMENDED that the opportunity should be taken to provide speakers and information to interested groups where it is considered to be effective in communicating matters of mutual interest.

13.24 In view of the need to improve the surveillance of controlled waters in rural areas it is RECOMMENDED that a review be undertaken to identify a balance between remote sensing and routine chemical monitoring and biological and other techniques, both spatially and temporally, which will adequately screen water quality and provide real-time data. This should take into account resource implications, so that a balance is achieved between monitoring and action to reduce pollution.

13.25 To meet its own aims, it is RECOMMENDED that the NRA should develop a system of identifying sensitive areas for controlled waters which can be applied generally using a two tier system with specific and precautionary measures to protect, as necessary, all vulnerable water uses.

13.26 It is RECOMMENDED that, as part of its watching brief on climatic trends, the NRA discusses with MAFF the possible changes in agricultural practices and patterns and the influence on water quality which may occur.

13.27 It is RECOMMENDED that identified areas are included in the progressive review of the NRA's priorities for R&D.

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15 GLOSSARY

Acidophilic	–	Refers to bacteria which are successful under acidic conditions.
ADAS	–	Agricultural Development and Advisory Service.
Anaerobic Digestion	–	A method used in sewage treatment in which bacteria reduce organic material under conditions of no oxygen.
Aquifers	–	Underground water.
Arthropods	–	A phylum of the animal kingdom, having segmented body and jointed limbs e.g. insects, spiders.
Bacteriophage	–	Virus which attacks bacteria.
Benthic	–	Pertaining to flora and fauna found in or on the sediments of water bodies.
Biocides	–	Poisons.
Biomass	–	Total quantity or weight of organisms in a given area or volume.
BOD	–	Biochemical Oxygen Demand, a standard test measuring the microbial uptake of oxygen, a measure of organic pollution.
CoGAP	–	Code of Good Agricultural Practice.
Colluvium	–	Extremely fine mobile soil.
Controlled Water	–	Definition under the Water Resources Act - natural waters which are not isolated.
Cryptosporidiosis	–	A disease caused by infection with *Cryptosporidia*, a protozoan parasite.
Cyprinids	–	A group of fish of the carp family.
Depuration	–	Removal of viruses from cells of shellfish.
Diurnal	–	Daily.
DoE	–	Department of the Environment.
EC	–	European Community.
Ecosystem	–	A biological community of interacting organisms and their physical environment.

Epidemiology	–	The study of the geographical and temporal pattern of disease.
EQS	–	Environmental Quality Standard.
ESA	–	Environmentally Sensitive Area.
Eutrophication	–	Nutrient enrichment typically leading to increased algal growth and periodic wide variations in e.g. dissolved oxygen.
Fauna	–	Animals.
Flora	–	Plants.
FUW	–	Farmers Union of Wales.
Inorganic Fertilisers	–	Fertilisers containing nitrogen, phosphorus and potassium.
Ley	–	A field temporarily under grass.
LFA	–	Less Favoured Area.
Macroinvertebrate	–	Large invertebrate animals such as insects, worms, snails.
Macrophytes	–	Large plants. In the aquatic situation e.g. lilies, reeds.
MAFF	–	Ministry of Agriculture, Fisheries and Food.
Micro-algae	–	Algae of microscopic size.
MMB	–	Milk Marketing Board.
Monoculture	–	The cultivation of a single species, type or cultivar.
NFU	–	National Farmers Union.
NIMEXE	–	Nomenclature Harmonisée pour les Statistiques du Commerce Extérieur des Pays de la CEE. (European Commercial Statistics)
Notifiable Disease	–	A disease, the occurrence of which has to be notified, by law, to the MAFF.
NPK	–	A fertiliser containing Nitrogen, Phosphorus, Potassium.
NRA	–	National Rivers Authority.
NSA	–	Nitrate Sensitive Area.
NWC	–	National Water Council.
Oocysts	–	Reproductive stage of protozoans.

Organic	–	Compounds based on the carbon atom.
Organochlorine	–	An organic compound containing chlorine.
Parameter	–	A measurable or quantifiable characteristic.
Pathogen	–	An organism which can cause disease.
PCP	–	Pentachlorophenol.
Photosynthesis	–	Production of carbohydrate from carbon dioxide and water by plants during daylight.
Potable	–	Drinkable.
Raceway	–	An artificial channel through which water flows rapidly.
Salmonid	–	A fish of the Salmon family.
Sheep Dip	–	Chemical used to eradicate pests from sheep.
Sheep Dippers	–	Structure containing bath of dip that sheep have to go through during dipping operations.
Silage	–	Mixture of conserved forage crops and a variety of materials.
Silage Clamp	–	Store for Silage.
Slurry	–	Animal waste in a liquid form.
Smolts	–	Young salmonid fish which are migrating to sea.
Taxa	–	Groups of similarly classified animals and plants.
Teratological	–	Adverse anatomical or biochemical effects exhibited by a developing foetus.
Weir	–	A low dam across a river.
WOAD	–	Welsh Office of Agricultural Development.
WRc	–	Water Research Centre.

APPENDIX 1

The Law, Agriculture and Water Management

The NRA's Statutory Duties

A1.1 The basic obligations of the NRA are fourfold.

A1.2 First are legal requirements to achieve and meet certain objectives for water quality, as may be required by the Government. For example, the Surface Waters (Dangerous Substances) (Classification) Regulations 1989, referred to below, form part of the water quality objectives scheme. Apart from pollution control, the NRA also has obligations to monitor water pollution.

A1.3 Second is a legal duty to conserve, redistribute, augment, and secure the proper use of water resources. This includes powers to determine minimum acceptable river flows.

A1.4 Third is a duty to exercise a general supervision over all matters relating to flood defence (previously known as land drainage).

A1.5 Fourth is an overriding environmental duty, which means that the NRA must generally exercise its powers so as to further certain environmental objectives, including the conservation of flora and fauna, and the beauty or amenity of any rural or urban area. It also has a duty to promote "the conservation and enhancement of the natural beauty and amenity of inland and coastal waters and of land associated with such waters, the conservation of flora and fauna which are dependent on an aquatic environment, and the use of such waters and land for recreational purposes" (Water Resources Act 1991, section 2).

Pollution Control in Agriculture

A1.6 Water pollution law applies universally: it does not discriminate between particular classes of users. A farmer can be as guilty of polluting a river as an industrial company. From that basic principle, however, farmers, in practice, enjoy both "advantages" and "disadvantages". For example, as discussed below, control on some farm wastes is less strict for farmers compared with others who have to dispose of waste. On the other hand, some water pollution legislation specifically targets agriculture - for example, measures to control the storage of silage, slurry and agricultural fuel oil, and nitrate sensitive area designations.

The Legal Framework

A1.7 Water pollution control is mainly governed by the Water Resources Act 1991. The Water Resources Act framework is relatively straightforward. However, there are a large number of other laws, originating both domestically and from the EC, which affect pollution control. Some of these affect farmers directly; mostly, they affect the way regulatory agencies, such as the NRA and MAFF, have to act in regulating farming activities.

A1.8 There are many further laws which affect farmers, but are not related to control of pollution or water use, such as stringent workplace safety regulations. These are outside the scope of this report.

THE WATER RESOURCES ACT 1991

A1.9 The Water Resources Act works in two ways. First, it allows people to be prosecuted if pollution occurs. Second, it contains measures designed to prevent pollution happening in the first place.

Pollution Offences

A1.10 Section 85 of the Water Resources Act 1991 makes it an offence to cause or knowingly to permit a discharge of poisonous, noxious or polluting matter or any solid waste matter to enter any controlled waters. It is also an offence to allow matter to enter water so as to obstruct flow and aggravate pollution. "Controlled waters" means all groundwater, coastal or inland waters including rivers, streams, ditches, land drains and most other passages through which water flows, and most lakes and ponds. One can "cause" pollution without acting intentionally or negligently.

A1.11 The definition of "controlled waters" is even wider than it may appear at first sight. "Groundwater" includes "any waters contained in underground strata" i.e. water subjacent to the surface of any land. It does not, therefore, have to be contained in an aquifer or some underground "body" of water. Similarly, the fact that land drains are classified as watercourses is of relevance to agriculture.

A1.12 A person does not, however, commit an offence under section 85 if he has proper authority to make the discharge. This usually means a consent to discharge issued by the NRA under section 88 of the Act. In practice, few farmers apply for discharge consents. The strengths of the wastes involved, the lack of dilution usually available, and the costs of treating the wastes to a form that might be acceptable to discharge, make it unlikely that an application for a discharge consent for most farm wastes would be acceptable to the NRA. Situations where wastes may be discharged to controlled waters under a discharge consent include factory-type farms, which may be able to justify the costs of treatment plant, and where the polluting effect of the waste is relatively weak, e.g. with vegetable washings.

A1.13 The detailed procedures for applying for and reviewing consents, etc., are set out in Schedule 10 of the Water Resources Act 1991. The NRA is in the process of streamlining its procedures for considering applications for consent, and standardising them between the regions.

A1.14 Consents to discharge can be reviewed. Indeed the NRA has a duty to review them from time to time. This may result from circumstances in e.g. an individual river or e.g. by the Government responding to European Directives on water quality. An important anomaly in the legislation is that although discharge consents may in any case be reviewed every two years, and without compensation being payable to the holder of the consent, the same is not true of licences to abstract water. Procedures for review in those cases are much more involved and are more likely to involve payment of compensation.

A1.15 Pollution offences are regarded very seriously and carry a penalty of up to £20,000 in the Magistrates Court and an unlimited fine in the Crown Court. It may also be necessary to pay for any damage caused by the pollution (e.g. fish killed, clean-up costs).

A1.16 Section 85 of the Water Resources Act 1991 does not automatically cover all types of discharge, including discharges to land and certain lakes or ponds. However, the NRA can prohibit such discharges in particular cases by issuing so-called "relevant prohibitions" under

Section 86. This power is limited to discharges "from a building or from any fixed plant" - a restrictive definition which raises complications in the case of certain farm waste disposal systems.

PREVENTATIVE LAW

A1.17 The Water Resources Act 1991 has several sections designed to prevent water pollution before it happens.

A1.18 Section 92 and the Control of Pollution (Silage, Slurry, and Agricultural Fuel Oil) Regulations 1991 made under section 110 of the Water Act 1989, aim to prevent pollution by silage effluent, slurry and oil spillages, by setting minimum standards for keeping and handling these substances. Most existing facilities will be exempt from these requirements, though the NRA may require improvements if there is a risk of pollution. New or substantially enlarged or reconstructed facilities must comply with standards set out in the Regulations. Farmers must notify the NRA before bringing such facilities into use. Compliance with these Regulations is not a defence to a prosecution, but it may be a mitigating factor if pollution occurs.

A1.19 Section 93 and Schedule 11 contain powers to designate water protection zones. Activities likely to result in water pollution can be restricted in these areas. As at the date of this report, no such zones have been designated. The NRA is responsible for proposing designations to the Secretary of State.

A1.20 Sections 94 and 95 and Schedule 12 contain powers to designate Nitrate Sensitive Areas. These are designed to prevent entry of nitrate into water. Again, the initiative for establishing these areas rests with the NRA. An experimental scheme is running under these powers for the period 1990 to 1995 in certain areas of the country. In some other areas farmers are encouraged to limit nitrate input, but these schemes are advisory only.

A1.21 Section 161 allows the NRA to carry out operations itself to prevent or clean up pollution if the circumstances warrant it, and recover the cost from the person responsible. This may, for example, happen if a farmer does not comply with requirements of the Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations. Potentially, section 161 is an extremely powerful weapon; the only check on what the NRA can do may be the practical problem of recovering its costs - apart from the identity and solvency of the person responsible. These must be "reasonably incurred", but they can include overhead expenses. The powers have not been used extensively in agriculture; the new Regulations make this more likely.

A1.22 Section 97 provides for ministers to approve codes of good agricultural practice. It is no longer a defence to prosecution for pollution for a farmer to say "I complied with the Code of Practice" - as used to be the case before the Water Act 1989 came into force. By the same token, non-compliance does not necessarily give rise to civil or criminal liability. A revised code of practice is in the course of being issued by MAFF. The NRA will need to take account of the code of practice in exercising its powers to prohibit particular discharges ("relevant prohibitions") and its powers under precautionary regulations made under section 92.

A1.23 Section 202 allows the NRA to ask e.g. farmers for information which will assist it in carrying out its job preventing water pollution.

A1.24 The NRA is in the process of finalising a system of charging for discharge consents. As the law stands, it is allowed to do this on the basis of its administrative costs in dealing with discharges. In other words, it can differentiate, for example, between the costs associated with discharging either into estuaries or fresh water, as one is more difficult to monitor than the other; similarly, the NRA can reasonably be expected to keep a closer eye on a large discharge compared with a small one. On the other hand, the NRA is not allowed to charge for discharges by direct reference to the degree of pollution caused, i.e. in effect by taxing pollution.

CONTROL OF USE OF WATER

A1.25 The following is a brief resumé of the law relating to water abstraction. The same law is also closely linked to impoundment - i.e. damming up or otherwise restricting water flow. This too can affect water quality; it is most relevant in agriculture where reservoirs are created to serve spray irrigation, and for fish farms.

Abstraction Law

A1.26 Water abstraction is governed by the Water Resources Act 1991. The basic structure of the Act remains the same as it was nearly 30 years ago, though over time it has been amended: most recently and substantially by the Water Act 1989.

A1.27 Most people who need to abstract water from a "source of supply" need an abstraction licence. A source of supply can be either an inland water (e.g. a river) or water in "underground strata" (i.e. groundwater). "Sources of supply" in the context of abstraction are thus similar, though not identical to "controlled waters" in the context of pollution control.

A1.28 To obtain a licence, one applies to the NRA with information about one's proposed use for the water; in the case of crop irrigation, one must include details of types of crop, areas to be irrigated etc. One must also explain how one has access to the source of supply e.g. that one occupies land next to the river from which one will abstract or that one has access to that land. The procedure usually involves publicity (though the NRA has a discretion not to require this in cases where the proposed abstraction will be less than 20 cubic metres a day).

A1.29 There are important exceptions to the normal requirement to have an abstraction licence. The key exception so far as agriculture is concerned is that abstractions of less than 20 cubic metres per day, which fulfil certain requirements as to location, do not need a licence, provided the water is used for agricultural purposes other than spray irrigation. Until the Water Act 1989, there was no 20 cubic metre limit to this exception; and pre-existing abstractions were preserved under transitional provisions in the Water Act 1989. Thus there is, in effect, a wide gap in the control of agricultural water use.

A1.30 Someone who has a licence to abstract, or may abstract without a licence under the above and other statutory exceptions, is said to have a 'protected right'. The NRA has a duty not to grant licences so as to derogate from protected rights of others. The existence of unrecorded but protected rights is a serious constraint on the NRA's ability to manage water resources properly. It also presents serious problems with effluent management, particularly in the case of fish farms and the need to attach appropriate conditions to their discharge consents.

A1.31 It is an offence to abstract water without a licence or not to comply with the terms of a licence. The penalties, compared with pollution offences, are modest - £2,000 maximum fine in the Magistrates Court although unlimited in the Crown Court. Prosecutions are extremely rare.

A1.32 Compared with a discharge consent, which is easily reviewable, the right to abstract water provided by an abstraction licence is treated differently by the law. Aside from the system of protected rights, there are elaborate rules governing the succession to licences when holders die, subdivide their land, etc. Revocation or variation of licences at the instance of e.g. the NRA is a complicated process which may involve payment of compensation and has hitherto seldom been used. There are now a number of proposals for review of licences.

A1.33 The NRA may, however, (without having to pay compensation) impose temporary restrictions on abstraction of water for use for spray irrigation, if an exceptional shortage of rain or other emergency makes that necessary. The power must be exercised fairly between holders of licences in the same area. Such restrictions can only relate to groundwater abstractions where that is in turn likely to affect the flow of an inland (i.e. surface) water.

A1.34 The NRA has power to charge for water abstraction licences. Unlike discharge consents, charging can and does relate to the amount of water abstracted and the purpose for which it is used. Spray irrigation falls into a particular (and expensive) category for this purpose. On the other hand no charges may be levied for abstraction for agricultural purposes (other than spray irrigation) of less than 20 cubic metres per day.

A1.35 As with pollution control, the NRA has broad powers to require information from people abstracting water, e.g. in relation to water flows.

FLOOD DEFENCE

A1.36 The land drainage aspects of flood defence are highly relevant to agriculture. The Water Resources Act 1991 and the Land Drainage Act 1991 preserve the structure of land drainage controls established under the Land Drainage Act 1976. These are tiered, with the NRA playing an overall supervisory role with its functions delegated in turn to Regional Flood Defence Committees (RFDCs) and Local Flood Defence Committees (LFDCs). Internal Drainage Boards (IDBs) liaise with the NRA Committees over drainage in their particular catchments.

A1.37 These bodies all enjoy considerable autonomy, although the legislation provides for their functions to be taken over by the NRA in appropriate circumstances. The issue here is whether the NRA's responsibilities towards water quality, water resources, or the environment can be prejudiced by land drainage activities carried out by these bodies.

A1.38 Briefly, the position is that the legislation does not contemplate the modern view that land drainage is anything but beneficial, whether to agriculture or otherwise. Thus, under the Land Drainage Act 1976, provisions for what might be called "environmental" considerations are confined to requirements to have regard for the interests of fisheries, ancient monuments, and ornamental ponds. The Water Resources Act 1991 has widened the qualifications for membership of RFDCs from persons with "knowledge of or capacity in land drainage or agriculture" to ability in "some matter relevant to the functions of the Committee": a small recognition, perhaps, of the wider implications of land drainage.

A1.39 There are provisions for environmental assessment of land drainage operations as a result of the EC Directive on Environmental Assessment. The Land Drainage Improvement Works (Assessment of Environmental Effects) Regulations 1988 prohibit land drainage works without the drainage body in question first considering whether the works are likely to have significant effects on the environment, and if that is the case then an environmental statement may be required.

A1.40 The land drainage legislation also provides for consultation and inquiries. Drainage authorities are also encouraged to follow a non-statutory set of conservation guidelines.

A1.41 Both the NRA and IDBs are subject to general environmental duties in the carrying out of their functions, under section 16 of the Water Resources Act 1991. Whilst the NRA exercises a general supervisory function in relation to land drainage and flood defence, its powers must be delegated to RFDCs. In doing so it may give directions to the RFDCs, but with the specific exception of doing so in relation to any internal drainage functions. However, although technically the NRA cannot give directions to RFDCs and LDFCs in relation to these functions, in practice these are NRA committees, or at least agents of the NRA so are similarly bound by the Section 16 duties.

CROWN IMMUNITY

A1.42 The Crown enjoys complete immunity from controls on abstraction. So far as pollution controls are concerned, the provisions of the Water Resources Act 1991 in principle apply to the Crown as they do to anyone else, subject to special provisions. The NRA finds that despite its privileges the Crown is generally a "good citizen", sometimes for example even paying for abstraction licences and consents where it is not obliged to. This is true both in the case of agriculture, and in other sectors where Crown interests are involved.

OTHER LAWS AND CODES OF PRACTICE AFFECTING FARMING AND WATER QUALITY

A1.43 The Scheme of control of pollution under the Water Resources Act 1991 is augmented, and complicated, by several other pieces of legislation and codes of practice. These have come into existence to control other types of environmental harm i.e. apart from pollution of water, or where control of pollution is only one objective. Objectives include standards of drinking water quality, pesticide control, safe bathing, fishing, control of toxic substances in the environment, protection of groundwater, public health, waste control, water supplies and river flows, less intensive agriculture, and ecology of natural waters.

A1.44 In the discussion below, these are divided into two parts:

* Other controls that farmers need to think about themselves; and,

* Other controls which the NRA needs to consider in carrying out its wider responsibilities, and which may therefore affect farmers in the end.

Other Water Controls Directly Affecting Farmers

FOOD AND ENVIRONMENTAL PROTECTION ACT (FEPA) 1985, WITH CONTROL OF PESTICIDE REGULATIONS 1986, AND CODE OF PRACTICE FOR THE SAFE USE OF PESTICIDES ON FARMS AND HOLDINGS

A1.45 FEPA Part III is the legislation which controls the supply and use of pesticides. It is principally enabling legislation i.e. it permits detailed rules to be specified in Regulations, and also contemplates issuing a Code of Practice.

A1.46 The Regulations that have been issued set out detailed rules on the approval, supply, storage and use of pesticides. One of the basic conditions laid down for the use of pesticides is that users take all reasonable precautions to protect the environment and "in particular to avoid the pollution of water". There are detailed rules designed to protect water in the case of aerial application of pesticides. People who use pesticides must be competent and have received proper instruction.

A1.47 The Code of Practice for the Safe Use of Pesticides on Farms and Holdings, issued in May 1990, gives guidance on pesticide use and precautions required to be taken to prevent water pollution. In particular - a matter not covered in the FEPA or the Regulations - the Code contains advice on possible routes for disposing dilute wastes and washings, highlighting the need to ask the NRA for advice where disposal is to land. Similar advice is contained in the 1991 Code of Good Agricultural Practice under Section 116 of the 1989 Water Act. FEPA contains powers to control the levels of pesticide which may be left in any crop, food or feeding stuff.

A1.48 Another code of practice - the Code of Practice for Suppliers of Pesticides to Agriculture, Horticulture and Forestry - provides guidance for people who sell, supply and store pesticides approved for agricultural use. The Code includes advice on pollution prevention at stores, highlights the need for all such stores to be inspected by the NRA and details matters which the NRA needs to consider. A scheme of regulation - or British Agrochemical Standards Inspection Scheme (BASIS) - exists which will not register a store as satisfactory unless it can be shown that an inspection by the NRA (and fire officers) has taken place.

A1.49 A major problem with pesticide regulation is that garden centres are exempt from controls. This is an unnecessary anomaly, and as the number of garden centres increases, the more dangerous the omission in the scheme of regulation becomes.

CONTROL OF POLLUTION ACT (COPA) 1974 PART I AND ENVIRONMENTAL PROTECTION ACT (EPA) 1990 PART II CONTROLS ON WASTE DISPOSAL

A1.50 Under the existing waste disposal legislation (the Control of Pollution Act 1974 Part I and the Collection and Disposal of Waste Regulations 1988) there are very few controls on agricultural wastes; these are not "controlled wastes" for the purposes of the legislation. The same scheme is carried over into the new Environmental Protection Act 1990, which (as regards waste) is only partially in force.

A1.51 Under the EPA 1990, the Secretary of State has wide powers to make Regulations defining particular wastes as "controlled", but this power is specifically limited so as to exclude wastes from agricultural premises. EPA 1990 S.63 will allow the Secretary of State to make Regulations which would have the effect of bringing agricultural wastes within the scheme of other wastes. However, such powers appear exercisable only in relation to "prescribed areas" and "subject to such modifications as may be prescribed". It is not yet known how these powers will be exercised. This restriction applies both to "normal" wastes and more hazardous wastes which could otherwise come into the more stringent regime applicable to special wastes.

A1.52 The NRA's interest in preventing pollution from farm wastes is to some extent served by the Control of Pollution (Silage, Slurry and Agricultural Fuel Oil Regulations) 1991 and reserve powers under Section 161 of the Water Resources Act 1991. Nevertheless, these powers are in practice only of limited use in controlling disposal of e.g. slurry, animal carcasses and used pesticide containers.

A1.53 One aspect of the EPA 1990 which may have considerable practical impact on farmers in some cases, concerns the use of their land for the deposit of other waste. Not only is this probably illegal (i.e. unless a waste disposal licence is in effect) but also, unless a landfill is properly sited and operated, it can pose serious pollution risks which can be extremely expensive to clean up. When the new Act comes into force, the authorities will have a duty to inspect such landfills, have power to clean them up if they appear likely to cause waste pollution, and can charge the owner of the land for doing so. This means that anyone who buys farmland is likely to take care to check that there is no such waste on it. From the point of view of someone who wishes to sell farmland, the presence of such waste may therefore have a serious effect on its value.

A1.54 The EPA 1990 also contains duties on Waste Collection Authorities to draw up re-cycling plans. The legal provisions relate to controlled waste and are therefore at first sight irrelevant to agriculture. On the other hand they may become relevant if and when e.g. plastic waste for re-cycling comes to have a value as a result of the development of the re-cycling industry.

EC DIRECTIVE ON SEWAGE SLUDGE IN AGRICULTURE (86/278/EEC) - IMPLEMENTED IN THE UK BY THE SLUDGE (USE IN AGRICULTURE) REGULATIONS 1989 (SI 1989/1263)

A1.55 These measures are designed to protect the environment, and particularly the soil, when sewage sludge is used in agriculture. The scheme of the regulations is that no-one - i.e. including the farmer or the supplier of the sludge - may permit the use of sewage sludge on agricultural land unless certain requirements are fulfilled. These include testing the sludge for the presence of specified substances and restricting the grazing of animals and harvesting of crops within specified periods of application. Although the NRA has no part in the administration of these controls, in practice they work towards improvement of water quality.

ENVIRONMENTAL ASSESSMENT DIRECTIVE (85/337/EEC) AND IMPLEMENTING REGULATIONS (PRINCIPALLY THE TOWN AND COUNTRY PLANNING (ASSESSMENT OF ENVIRONMENTAL EFFECTS) REGULATIONS 1988)

A1.56 Most agricultural projects are exempt from planning control and hence from the procedures established under the EC Directive requiring environmental assessment of projects likely significantly to affect the environment. Certain projects may however be subject to assessment: these include, for agriculture, projects which involve water management, poultry rearing, pig rearing, reclamation of land from the sea, and land drainage/flood defence.

A1.57 The EC Directive also requires assessment of projects for restructuring rural land holdings and for the use of uncultivated land or semi natural areas for intensive agricultural purposes. However, these aspects have not been implemented by the UK. By contrast, there are presently proposals before the European Commission to expand the ambit of EA in relation to agricultural projects.

A1.58 If a farmer plans a project which requires environmental assessment, he is responsible for carrying out the assessment. If a proposed project is likely to affect water quality or water resources, the NRA is interested to see that there are likely to be no adverse effects.

The Wider Remit of the NRA

A1.59 The NRA has very wide responsibilities towards improvement of water quality and water as a resource in England and Wales. Some of those responsibilities are directly set out in the Water Resources Act 1991. Others arise from different legislation, which the NRA then has to put into practice, usually by using powers which it has under the Water Resources Act 1991.

EC Legislation

A1.60 Much of the "other legislation" originates in the EC in the form of Directives. These are instructions to the UK Government, in common with other EC member states, to take steps in domestic law which will carry out the objectives of the Directive. Environmentally oriented directives tend to operate by setting standards (e.g. for drinking water quality). The Government, through the NRA, then has to meet these standards by taking whatever measures will achieve them. In the case of drinking water, one of the standards that has to be met relates to nitrate levels, hence the powers in the Water Resources Act 1991 to designate Nitrate Sensitive Areas in order to attempt to control nitrate levels. Similarly, particularly dangerous substances are "prescribed" by EC legislation: the NRA controls the entry of these into waters by issuing and reviewing discharge consents, and through the "relevant prohibition" mechanism.

A1.61 Some EC legislation appears in the form of Regulations rather than Directives. Essentially the difference between the two is that Regulations are effective in domestic law without the need for the member state to pass separate domestic legislation. The distinction between the two becomes blurred, however, because the courts have ruled that many Directives which have not been properly implemented by member states nevertheless do have direct effect in domestic law (though only to enable individuals to enforce rights against the state, and not the other way round).

A1.62 EC Regulations are very important in control of agriculture generally, particularly in implementation of the various subsidy and price schemes of the Common Agricultural Policy. They are relevant to this discussion in so far as some of those schemes aim to encourage less intensive or more environmentally friendly methods of farming.

A1.63 The following is a summary of EC legislation which the NRA has to deal with and hence may, indirectly, affect farmers. Some of it is still in draft (i.e. proposal) form. However, assuming that these proposals will eventually become law, the NRA has to begin to consider the implications of these proposals at an early stage in order to implement them efficiently when the time comes.

EC SURFACE WATER FOR DRINKING DIRECTIVE (75/440/EEC) AND EC SAMPLING SURFACE WATER FOR DRINKING DIRECTIVE (79/869/EEC)

A1.64 The object of the first of these Directives is to ensure that surface water abstracted for use as drinking water prior to treatment reaches certain standards and receives adequate treatment before being put into public supply; the second deals with quality measurements. The primary duty to ensure "wholesomeness" of supplies in England and Wales rests with the water undertakers under Part II of the Water Industry Act 1991. They are in turn supervised by the Director General of Water Services and the Secretary of State. The NRA's overall controls in relation to water are however in practice important for achieving the aims of this Directive.

EC DANGEROUS SUBSTANCES IN WATER DIRECTIVE (76/464/EEC)

A1.65 This is the framework Directive for establishing programmes for the elimination or reduction of particularly dangerous substances discharged to the aquatic environment. "Framework" means that it lays down few actual standards for the control of individual substances itself; these are laid down in "daughter" directives. The Directive contains two lists of substances, List I and List II; the object being to eradicate List I substances from the environment, and to reduce the levels of List II substances, the latter being considered less dangerous than the former.

A1.66 Of relevance to agriculture, daughter directives have been established for heavy metals and certain pesticide constituents, including lindane, dieldrin, aldrin, endrin, chlordane, and heptachlor, both by way of setting standards for levels in sewage sludge applied to the land, in water, and in food residues.

A1.67 In practice these substances are controlled in agriculture through farmers being expected to follow the codes of practice mentioned above (agriculture generally, and pesticides). The discharge consents system and "relevant prohibition" regime is in practice only indirectly relevant to the use of these substances in agriculture (as opposed to their production at chemical plants etc).

A1.68 The requirements of the daughter Directives are reflected in quality objectives set out in the Surface Water (Dangerous Substances) (Classification) Regulations 1989. Under section 84 of the Water Resources Act 1991 the NRA has a duty to ensure, so far as practicable, that these objectives are achieved at all times.

EC GROUNDWATER DIRECTIVE (80/68/EEC)

A1.69 The Directive on the protection of groundwater against pollution caused by certain dangerous substances requires member states to prevent the introduction into groundwaters of List I substances and to limit the introduction of List II substances. (The Lists are similar but not identical to the substances listed in the Dangerous Substances Directive, above.) The practical effect on farmers is similar to that described above in relation to the Dangerous Substances in Water Directive.

EC DRINKING WATER DIRECTIVE (80/778/EEC)

A1.70 The Directive sets maximum admissible concentrations for various substances in drinking water supplies. The prime responsibility for compliance rests with water undertakers. The control of pesticides and nitrates is of particular relevance to agriculture. Control of nitrates may be effected through Nitrate Sensitive Area designations (see above). Pesticide levels can be controlled through the Food and Environmental Protection Act 1985. The NRA could impose further controls e.g. by tighter restrictions on pesticide use in water protection zones.

EC DIRECTIVE ON WATER QUALITY FOR FRESHWATER FISH (78/659/EEC)

A1.71 This Directive sets water quality objectives for stretches of rivers and other freshwaters. Member states are required to designate freshwaters needing protection or improvement in order to support fish life. Waters are designated suitable for either salmonids (i.e. salmon and trout) or cyprinids (i.e. coarse fish). These objectives are to be achieved through pollution controls and reduction programmes.

PROPOSED EC DIRECTIVE ON HAZARDOUS WASTE (88/295/EEC)

A1.72 This proposed Directive is to list substances which render wastes hazardous. It includes pesticides among the wastes which are categorised as hazardous substances. If adopted, sheep dip effluents and residues from cleaning out tanks and equipment used for pesticide storage and spraying could be controlled. It is unclear how these might be controlled under the existing (Control of Pollution Act 1974 Part 1) or future (Environmental Protection Act 1990, Part II) legislation - for the reasons discussed above (A1.47-48).

PROPOSED EC DIRECTIVE TO CONTROL NITRATE FROM AGRICULTURAL SOURCES (COM(88)708 final)

A1.73 The object of this proposed Directive is to avoid (a) the concentration of nitrate in fresh water, both surface and ground, reaching a level at which it could interfere with the legitimate uses of these waters; and (b) eutrophication of surface, estuarial, coastal and marine waters. It will require Member States to designate vulnerable zones.

A1.74 Of relevance to agriculture, within these zones numbers of livestock animals would be restricted according to the land available for manure spreading. There would be codes of practice for manure spreading and for the storage of manure during prohibited periods. Limits would be set on the quantity of chemical fertilisers applied and for its method and timing of application.

A1.75 The NRA agrees with the objectives of this Directive.

A1.76 The Directive will probably have the significant effect of reducing pollution from agricultural activities by ensuring sound disposal of slurry and improving the storage facilities. A similar proposed Directive for controlling phosphate discharges from agricultural activities is currently in abeyance, as it is expected that this proposed nitrate Directive will itself lead to a reduction in phosphate loss from agricultural activities. When this Directive comes into effect, it will be implemented through the controls available under sections 93 to 96 of the Water Resources Act 1991.

PROPOSED REGULATION ON THE INTRODUCTION AND MAINTENANCE OF AGRICULTURAL PRODUCTION METHODS COMPATIBLE WITH PROTECTION OF THE ENVIRONMENT AND MAINTENANCE OF THE COUNTRYSIDE (COM(90)366)

A1.77 This Regulation would allow for payments to farmers for reducing the intensity of production, and for using farming practices which are designed to conserve the environment and maintain the countryside. It would be a development of existing schemes allowing for designation of environmentally sensitive areas and sectoral payments for less intensive farming methods (so-called "extensification") and thus a reduction of input of chemicals and other wastes to water. MAFF, rather than the NRA, is responsible for the administration of these grant programmes.

A1.78 The NRA's view is that these payments will be most effective if directed on a highly specific, farm-by-farm basis as part of individual plans to farm in a more environmentally sensitive fashion, and hopes to see the Regulation implemented on this basis.

POTENTIAL EC DIRECTIVE ON THE ECOLOGICAL QUALITY OF SURFACE WATERS

A1.79 The Commission is currently developing the framework for ecological classification systems for rivers, lakes, estuaries, deltaic waters and coastal waters which will facilitiate progress with ecological improvement schemes. Information would be produced about invertebrate communities, fish populations, algae, higher plants, and factors such as bioaccumulation of persistent toxins.

A1.80 Although, like others, such a Directive would not directly relate to agriculture, its impact may be extremely significant. The biological monitoring that it will involve will provide a better indicator than purely physical or chemical methods of the impacts of agriculture, enabling fine tuning controls to what the environment demands.

APPENDIX 2

Historical Trends in Agriculture, Afforestation and Fish Farming

Self-Sufficiency in the UK

A2.1 Trends in agricultural self-sufficiency between 1945 and 1989 are presented in Figure A2.1; this highlights the rapid increase in cereal production, particularly wheat, from 1970 onwards. Other significant changes are the rise to self-sufficiency in oilseed rape and a doubling of the percentage of self-sufficiency for beef, veal, mutton, lamb and sugar; self-sufficiency in milk production has also increased substantially from 54% to 86%.

Farm Size

A2.2 The economics of agricultural production have encouraged a steady growth in farm size. In 1960 the total number of holdings in England and Wales was 344,900 compared with 185,800 in 1987; thus, between 1960 and 1987, the average size of holding almost doubled - from 30 to 59 hectares. However, due to the recent increase in part-time farmers, the total number of holdings is currently increasing and leading to a downward trend in average farm size.

Cropping

A2.3 The overall change in cropping in England and Wales between 1930 and 1989 is presented in Figure A2.2. During this period the area devoted to arable crops and temporary grass increased by 36%. Figure A2.3 shows the trend in silage production over the period 1976 to 1989. Permanent pasture and rough grazing have declined steadily in area throughout this period.

A2.4 Until recently, agricultural policies encouraged the production of cereals; as a result, there has been a substantial increase to 3.3 million hectares, 60% of the cultivated area of England and Wales. In addition, wheat has been substituted for barley, and winter for spring cereal cropping. The overall increase in cereals has largely been at the expense of grassland. Details are shown in Figure A2.4.

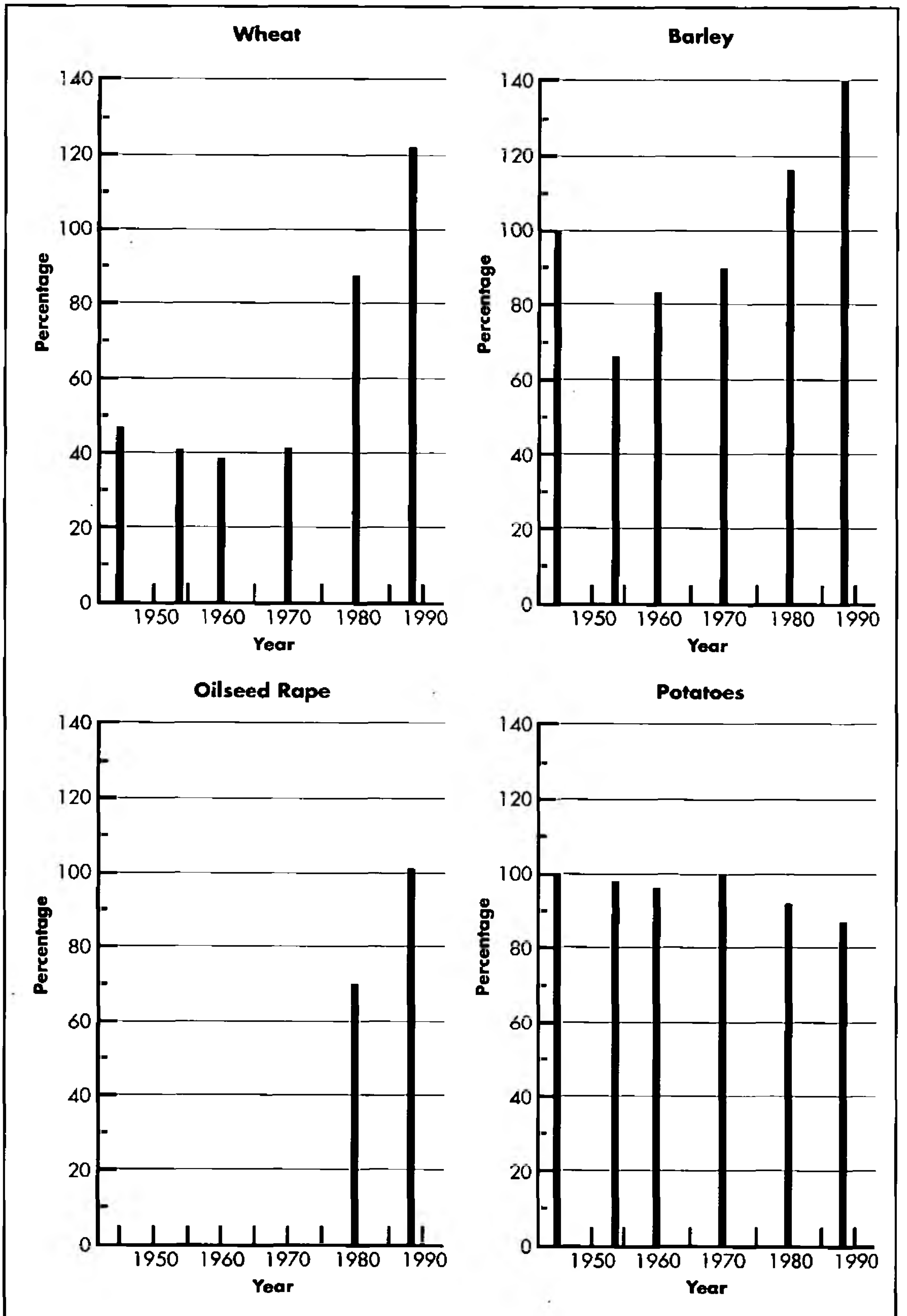
A2.5 Between 1930 and 1950 the area cropped with sugar beet and potatoes increased by 67 per cent, but has since declined. The area of sugar beet rose from 1970, but declined during the 1980s. This decline in area used for beet and potatoes is largely due to increased yields. The area devoted to horticultural crops is now only 3 per cent of the cultivated area in England and Wales.

A2.6 The area under root crops, which are primarily fed to livestock, has fallen consistently since 1930. Conversely, the area of rotational grass rose dramatically until 1960, mainly by ploughing up permanent pasture.

Grazing Livestock

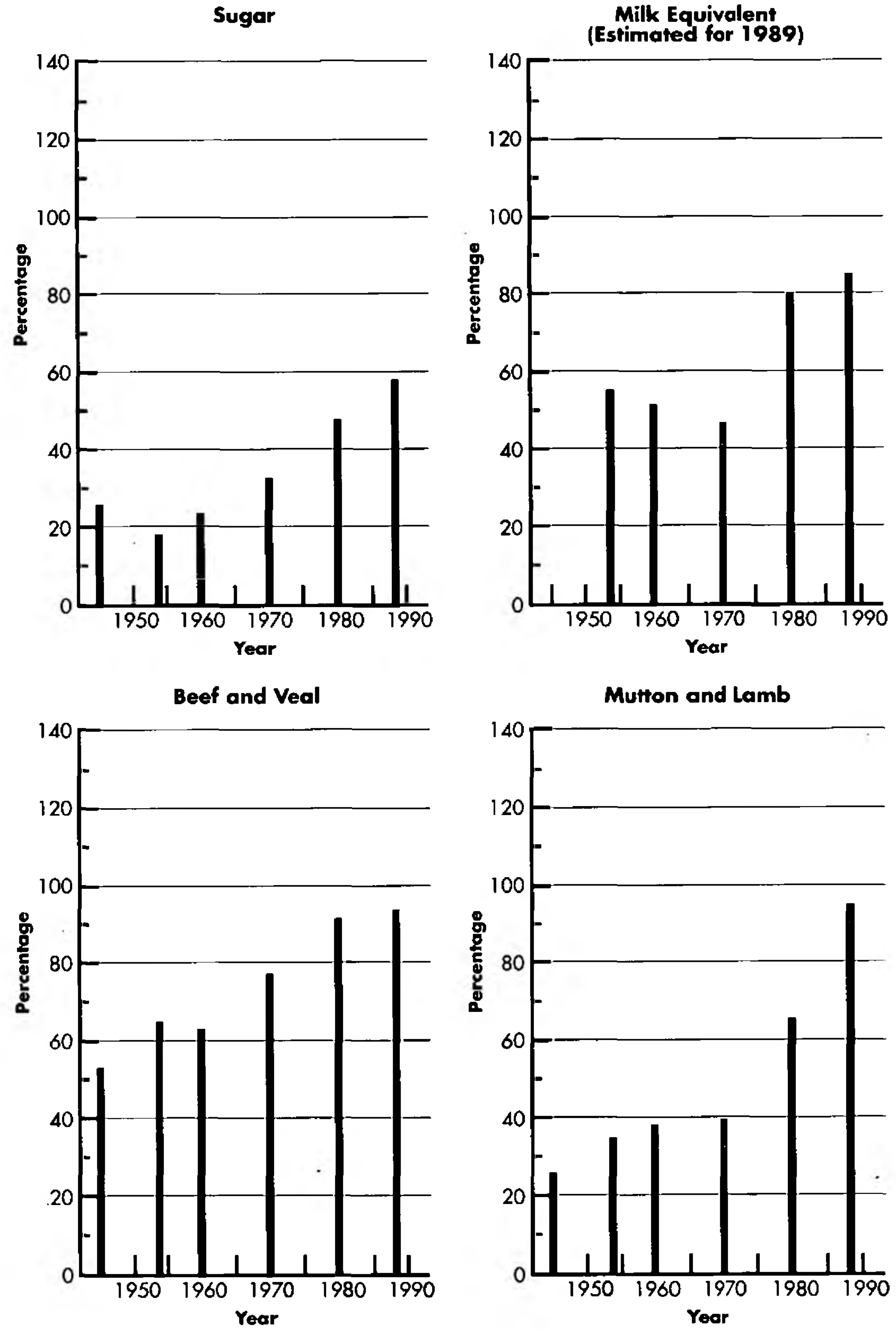
A2.7 Trends in total stock numbers in England and Wales are presented in Figure A2.5. Between 1930 and 1980 the total number of cattle rose by almost 70 per cent. The number of sheep, however, did not start to rise until the 1970s, and during the 1980s the number of breeding ewes in England and Wales rose by 37 per cent, to over 30 million. In contrast, in the 10

Figure A2.1 U.K Self Sufficiency (1945 - 1989)



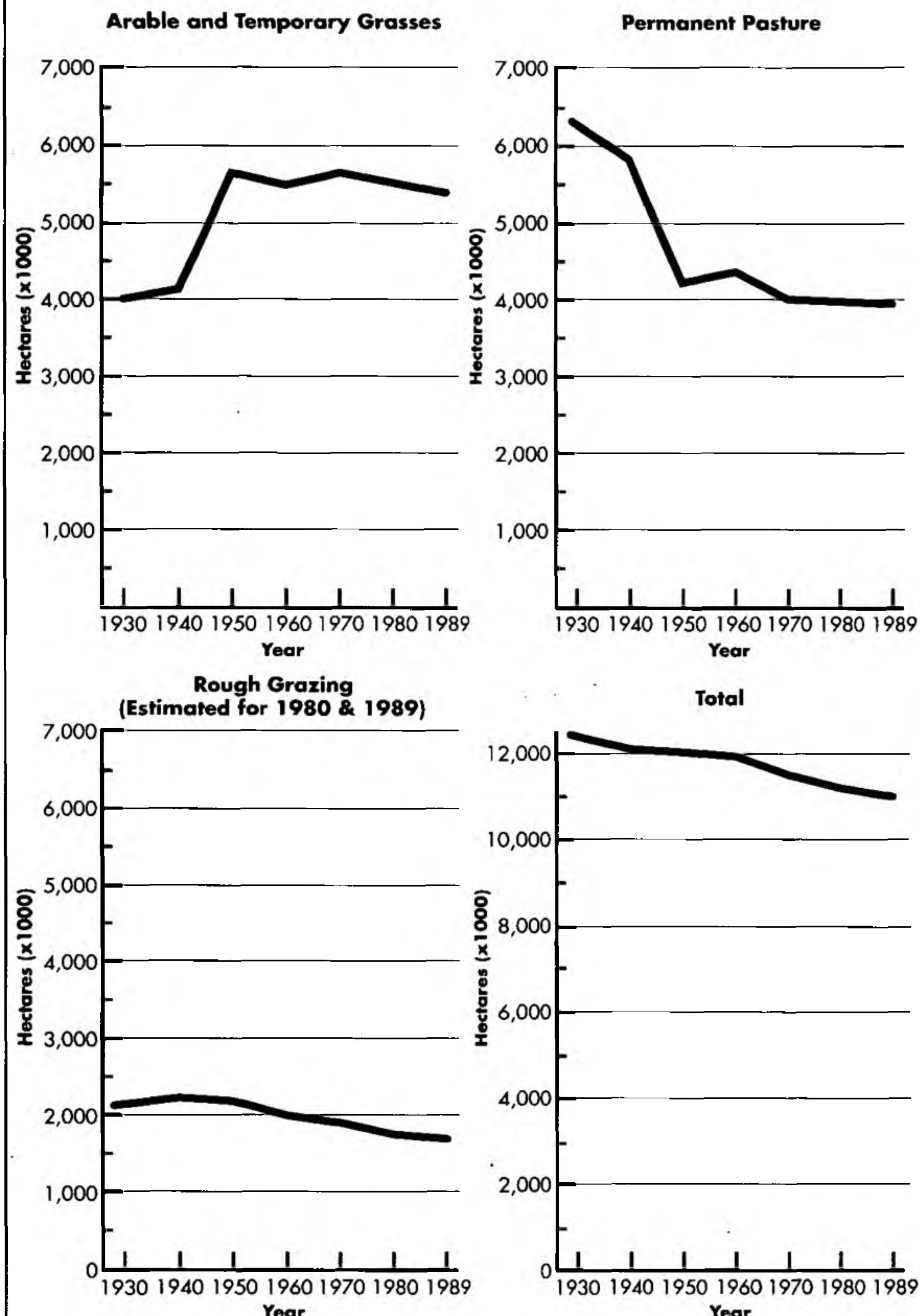
Data from MAFF June Agricultural Returns

Figure A2.1 U.K Self Sufficiency (1945 - 1989)



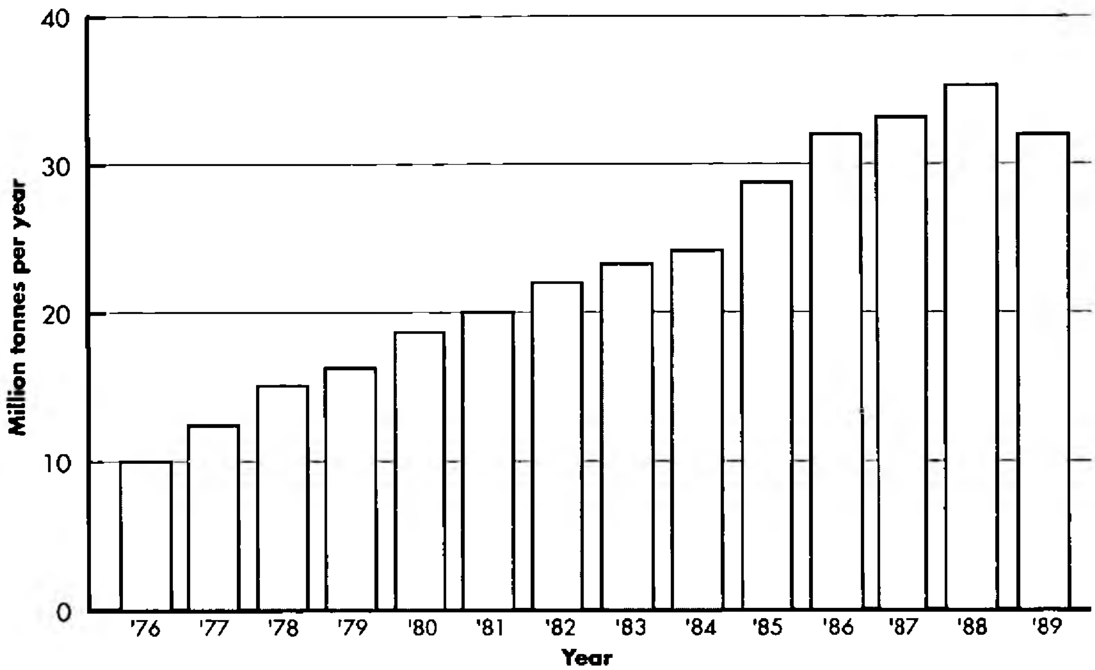
Data from MAFF June Agricultural Returns

Figure A2.2 Agricultural Area in England and Wales



Data from MAFF June Agricultural Returns

Figure A2.3 Silage Production in England & Wales (1976-89)



Source: MAFF NRA 1989 Farm Waste Report

years preceding the introduction of milk quotas in 1984, the number of dairy cows was fairly static but the average herd size had been progressively increasing as the number of milk producers declined. Since 1980, the number of dairy cows has fallen by almost 13 per cent, reflecting the impact of quotas and the increase in the average yield per cow. In fact, the trend towards larger herds has continued; in 1987 the average herd sizes in England and Wales were 63 and 49 cows respectively.

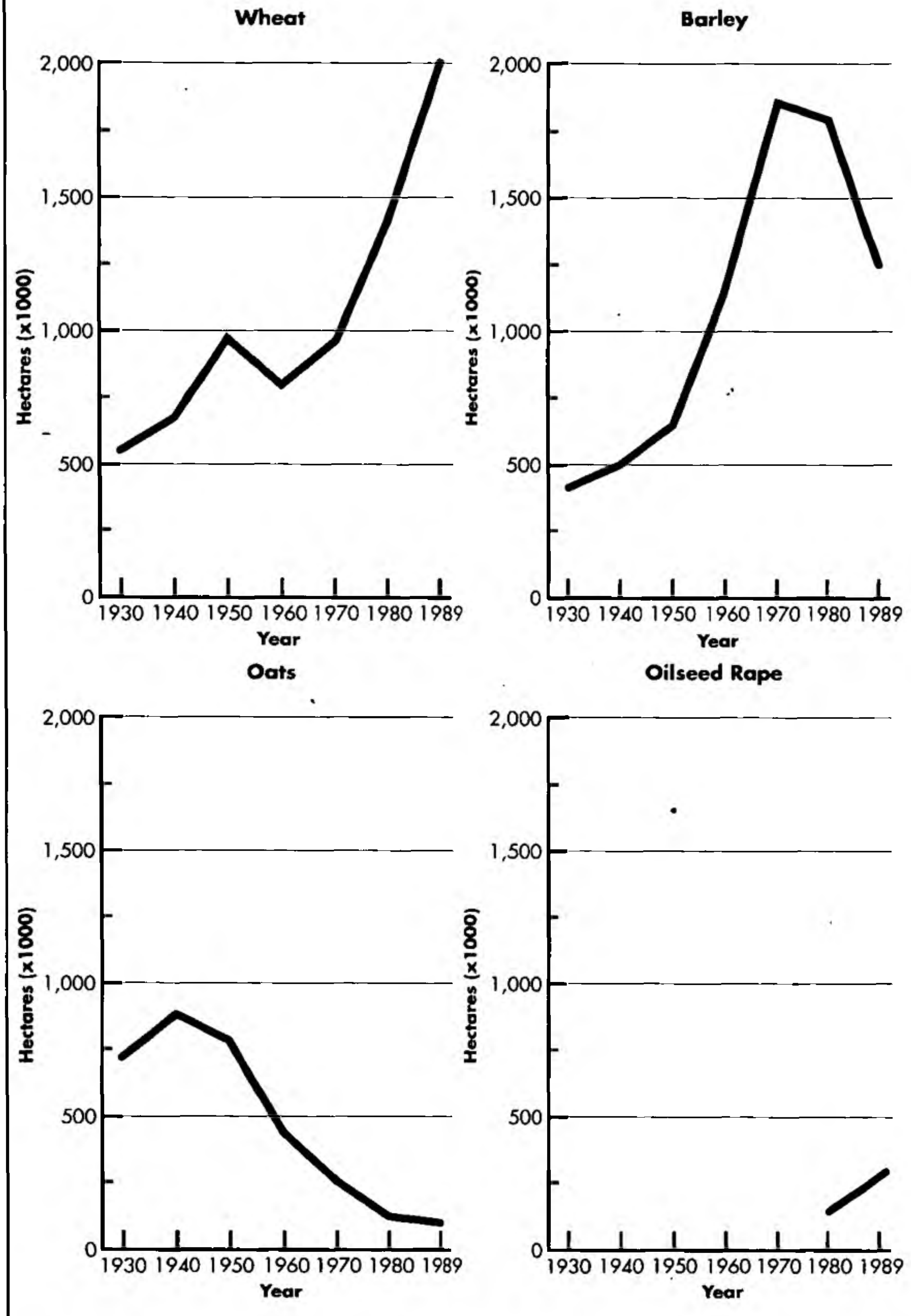
Intensive Livestock

A2.8 Between 1930 and 1960 the total number of pigs fluctuated, but showed a general upward trend. During the 1960s the number rose by 48 per cent, followed by a further small rise of 3 per cent in the 1970s, but since 1980 it has fallen back to the same level as in 1970. Fluctuations in the number of pigs is well known and normally follows a 3 to 4 year cycle. From 1940 to 1970, the total number of poultry rose by 104 per cent but has since declined by 12 per cent. Pig and poultry production has also become increasingly concentrated on fewer specialist holdings.

Fertiliser and Pesticide Usage

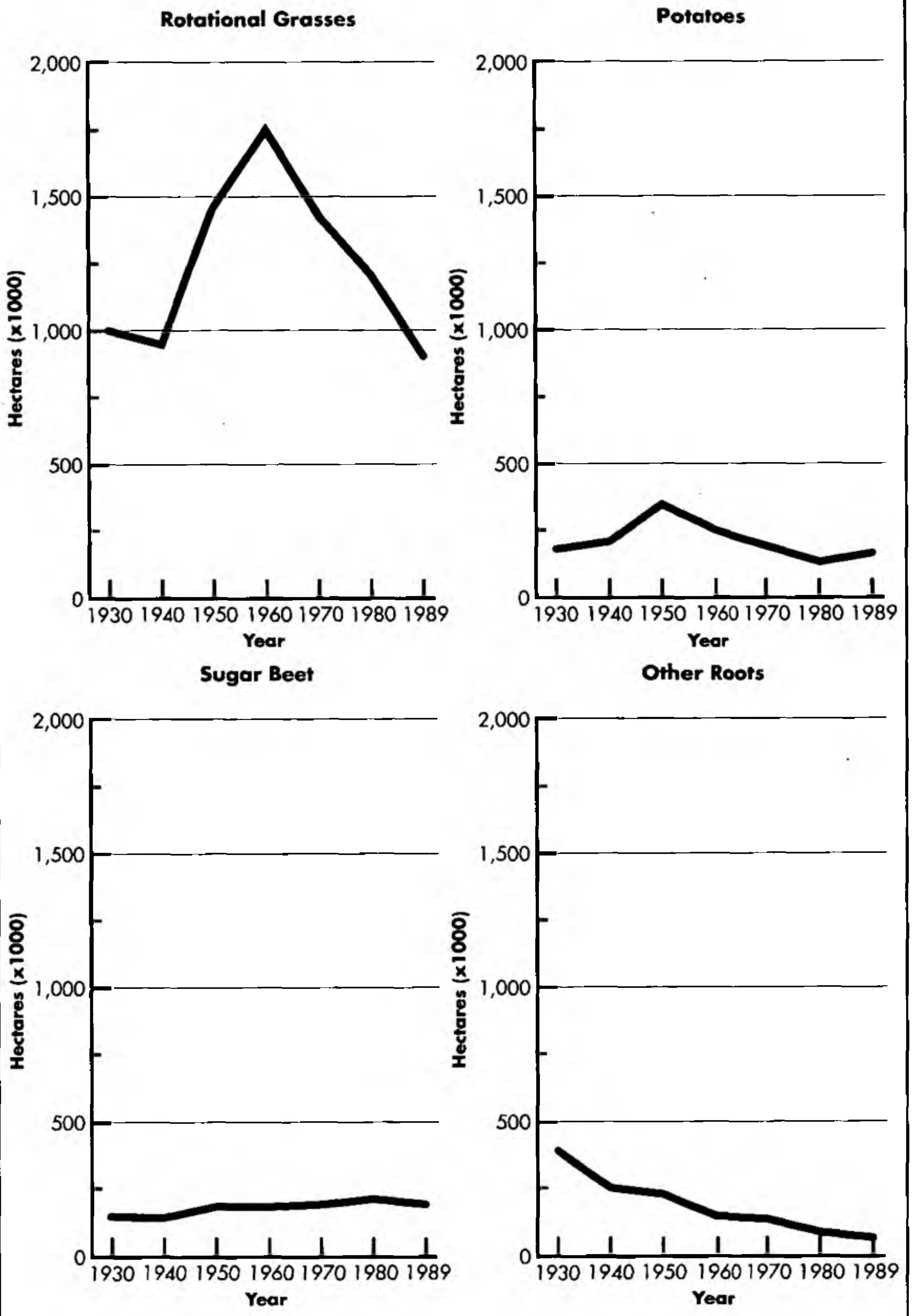
A2.9 New technology and breeding have raised crop yields, particularly over the last 20 years. The ability of crops to utilise greater quantities of plant food, especially nitrogen, together with the use of agrochemicals, and the efficiency and timeliness of cultivations achieved by greater mechanisation, have all contributed to higher yields.

Figure A2.4 Rotational cropping in England and Wales



Data from MAFF

Figure A2.4 Rotational cropping in England and Wales



Data from MAFF

Fertilisers

A2.10 Trends in the consumption of inorganic fertilisers in the United Kingdom from the late 1940s to the late 1980s are shown in Figure A2.6. The consumption of nitrogen fertilisers has risen from 210,000 tonnes in 1949/50 to 1.51 million tonnes in 1988/89; the increase in phosphates and potash use has been more modest, from the late 1950s, with overall consumption rising by 11 and 39 per cent respectively.

A2.11 Trends in fertiliser use on selected crops between 1970 and 1985 are shown in Table A2.1. During this period the application rate per hectare to winter wheat more than doubled, and to winter barley increased by almost two thirds. Nitrogen usage per hectare on spring barley and potatoes rose by about 20 per cent, but in the late 1970s and early 1980s usage on sugar beet declined as farmers responded to research advice, indicating that excessive use of nitrogen depressed sugar yields. Changes in the application rates of phosphate and potash have been relatively small, but in the case of sugar beet have fallen significantly.

A2.12 Nitrogen usage per hectare on all grassland has increased by nearly 80 per cent since 1970, but the overall usage of phosphate and potash has not changed. The usage of nitrogen on leys has consistently been about double that used on permanent pasture.

A2.13 Since the mid 1980s, fertiliser usage on arable crops has tended to decline. One of the main reasons for this is that farmers have reduced autumn nitrogen applications to winter cereals from about 60 per cent of the area in 1985 to under 20 per cent of the area in 1989. Nitrogen application rates to grassland have also declined.

Pesticides

A2.14 No single data source is available to provide current and historical usage of pesticide in agriculture and horticulture in England and Wales, although some general trends can be identified. The area treated, and the quantity of active ingredients applied, both increased considerably from the early 1970s to the early 1980s for almost all groups of pesticides. The notable exception is seed treatments, which have shown a steady downward trend; Table A2.2 summarises these changes for cereals, the largest group of arable crops.

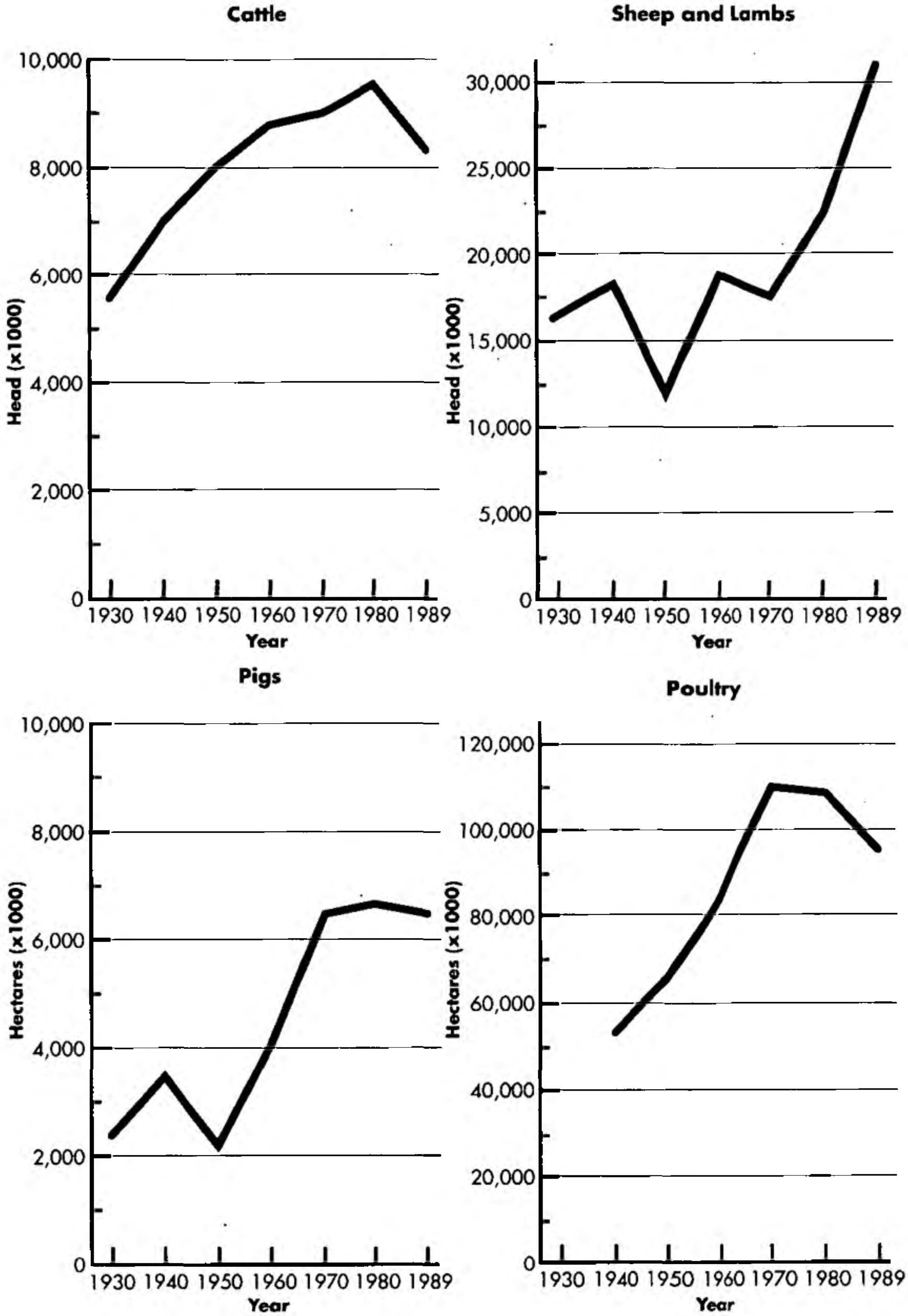
A2.15 Since the 1980s, the treated area has continued to increase slowly but the introduction of new active ingredients, effective at lower quantities per unit area, has led to a steady decline in total quantity of active ingredients applied - currently approximately 25,000 tonnes per year, of which 50% are herbicides and 25% fungicides.

Land Drainage

A2.16 In the 40 year period before the start of the last decade, farmers increasingly invested in land drainage to raise productivity. Drainage reduces the incidence of waterlogging, increases soil aeration and improves timeliness of operations. The annual rate of drainage was some 12,000 hectares in 1945, rising to around 100,000 hectares in 1979. This coincided with the application of increased quantities of fertilisers, pesticides and animal wastes. The recent cessation of grant aid by MAFF for land drainage has resulted in a reduction in investment by farmers.

A2.17 The effects of land drainage vary according to drain and soil types. In some cases, the rapid movement of surface and soil water to watercourses will have decreased the buffering capacity of the land, and will have contributed to the level of contamination of natural waters both directly and by effectively lowering dry weather flows and hence reducing

Figure A2.5 Total stock numbers in England and Wales



Data from MAFF

Figure A2.6 Inorganic Fertiliser Consumption in the United Kingdom (Thousands of tonnes of plant food)

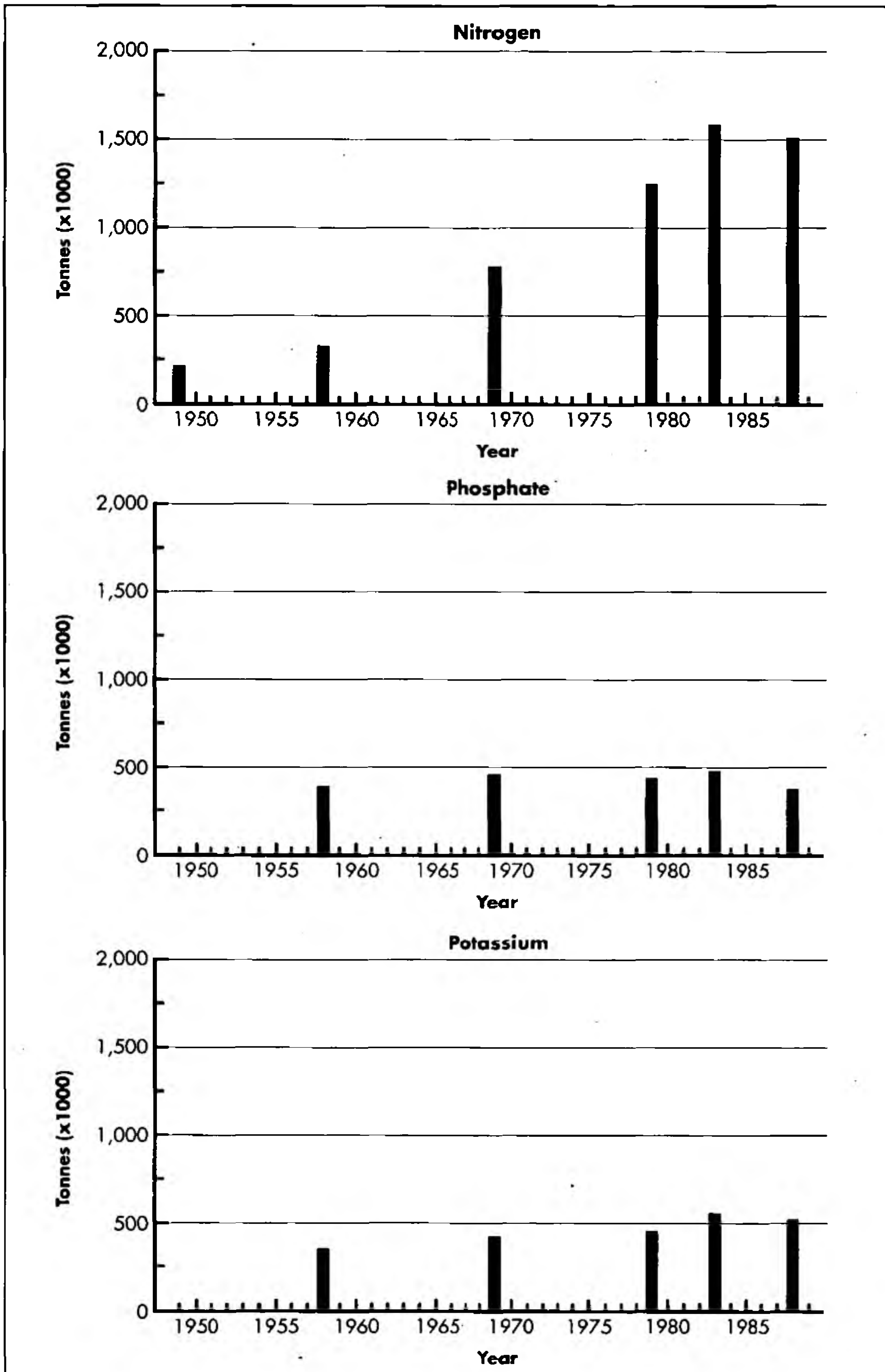


Table A2.1 - Trends in Fertiliser Usage on Selected Crops - Kg Plant Food per Ha

Crop	1970			1980			1985		
	N	P	K	N	P	K	N	P	K
Winter Wheat	92	45	36	145	46	39	192	54	52
Winter Barley	87	45	44	129	48	45	141	55	58
Spring Barley	83	43	44	87	37	40	102	38	44
Main Crop Potatoes	166	177	252	185	185	259	198	209	278
Sugar Beet	159	119	184	146	71	158	126	56	137
Oilseed Rape	-	-	-	254	51	38	272	58	55
All Grassland [1]	70	30	23	119	27	26	125	25	26

[1] *Excludes rough grazing*

Source : Survey of Fertiliser Practice in England and Wales - Agriculture Development and Advisory Service, Rothamstead Experimental Station, Fertiliser Manufacturers Association - 1970, 1980, 1985

dilution. In other cases, drainage of certain soils will have improved the buffering capacity of the land, and hence will have reduced the risk of deleterious impacts on surface water quality.

Farm Incomes

A2.18 Following entry into the EC in 1973 aggregate income increased, but since that year has tended to decline. Figure A2.7 shows the indices of net farm income in real terms by farm type in the United Kingdom over the last decade. As expected, incomes have fluctuated from year to year. Apart from dairying, net farm incomes have shown a general downward trend, particularly lowland livestock and cereal farms whose net income in 1989/90 is forecast to be only 15% of that achieved in 1982/83. Conversely, income from dairy farms in the same year is estimated to be 10% higher but is expected to fall in the current financial year (1990/91). Net income from pig and poultry farms has followed the normal cyclical pattern associated with holdings of this type. The ability of many holdings to invest in, or improve, facilities to solve pollution problems has been severely curtailed.

Forestry

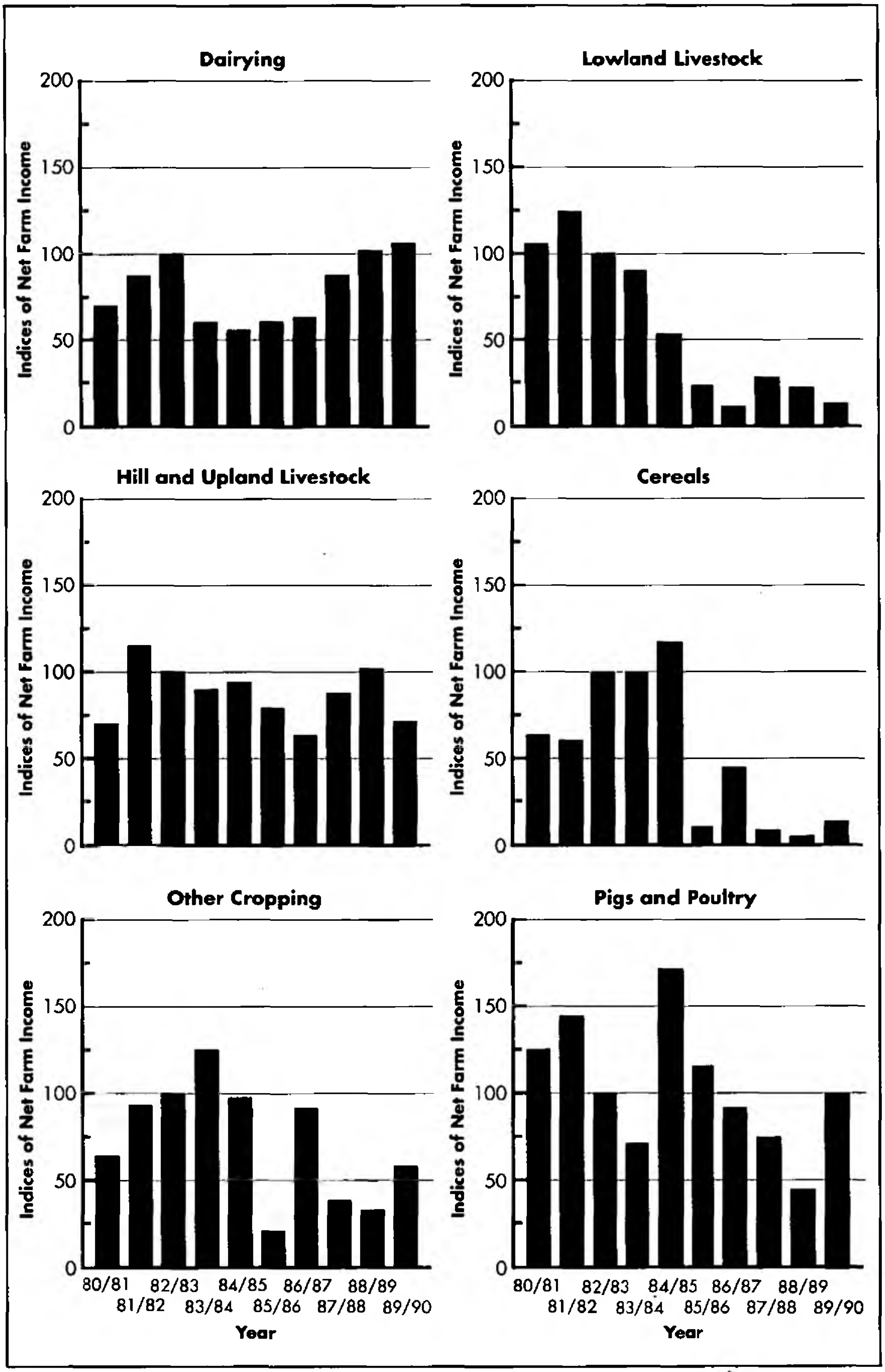
A2.19 Britain has less forest land than many other European countries, with 2.1 million hectares of productive and unproductive forest, covering 10% of the land area compared with the average EC forest area of 25%. Timber production has risen by nearly 50% over the past decade, and now meets just over 11% of Britain's estimated consumption of wood products. Supplies of domestic timber are expected to double in the period to 2000, as young commercial forests become productive.

Table A2.2 - Pesticide usage on cereals 1974 to 1988

	1974		1977		1982		1988	
	Treated Area '000 Ha	Tonnes Active Ingredient	Treated Area '000 Ha	Tonnes Active Ingredient	Treated Area '000 Ha	Tonnes Active Ingredient	Treated Area '000 Ha	Tonnes Active Ingredient
Herbicides	4472	8725	4577	7582.13	7395	12626.99	7150	9554.90
Fungicides	571	394.48	977	568.53	5247	2399.63	6901	3800.91
Insecticides	46	17.17	534	194.31	535	179.27	1227	288.26
Seed Treatments	3320	536.28	3273	496.88	3189	233.95	3106	141.93
Growth Regulators	42	71.00	188	238.93	770	1092.94	1603	1771.07
Molluscides	25	13.22	33	9.49	550	174.39	420	132.93
Other	-	-	-	-	64	?		
TOTAL ON CEREALS		9757.15		9090.24		16708.17		15690

Source - MAFF Pesticide Usage Surveys - Arable Farm Crops and Grass

Figure A2.7 Indices of net farm income in real terms by farm type (1982/83 = 100)



A2.20 The area of productive woodland in England and Wales identified in March 1989 is shown in Table A2.3.

Table A2.3 - Area of Productive Woodland in England and Wales 1989 - 1000 hectares

Country	High Forest		Coppice	Total
	Conifers	Broadleaves		
England	395	430	38	863
Wales	175	60	2	237
TOTAL	570	490	40	1100

Source : Forestry Facts and Figures 1988/89 - Forestry Commission

A2.21 During the 1980s the total area of new planting in Great Britain amounted to just under 250,000 hectares, of which about 11% was in England and Wales. The average annual planting rate was about 2,800 hectares. In the latter part of the decade, the proportion of broadleaved planting in both England and Wales increased significantly, as a result of the various government initiatives and incentives to encourage the establishment of hardwoods.

A2.22 However, major changes in the treatment of private forestry investment resulted from the 1988 Finance Act, which withdrew forestry from tax relief. Although improved planting grant incentives were introduced at the same time, there has been a marked reduction in the scale of new afforestation, particularly in respect of conifer schemes in the upland areas of Wales.

A2.23 In England, there is now a presumption against coniferous afforestation in upland areas as a result of detailed guidance from the Secretary of State for the Environment to the Forestry Commission (March 1988). In parallel with these changes has been the introduction of incentives and schemes designed to encourage the development of both conifer and broadleaved woodland creation in lowland areas.

A2.24 The introduction of the Farm Woodland Scheme for three years (1989-1991), with a target participation of 12,000 hectares per annum, indicates a potentially key alternative land use change; however, after the first year, the entry level is running at approximately 50% of the desired capacity.

Aquaculture

A2.25 The culture of fish has been practised in the UK for over two thousand years, yet it is only in the last two decades that fish farming has grown to become an economically significant industry. Within England and Wales, this growth has almost entirely been restricted to brown and rainbow trout, because salmon farming has been largely restricted to the deep water sea lochs of Scotland. Previous attempts to farm salmon in the warmer southern waters have failed due to a tendency for fish to mature at a young age, unfavourable water conditions and disease problems, although there are a number of operations producing salmon smolts in freshwater for the Scottish salmon farming industry.

A2.26 Apart from trout farming, there are a number of other forms of aquaculture practised in England and Wales, principally coarse fish species reared for stocking of private and public waters, shellfish production in estuarine and coastal margins and a very limited production of freshwater crayfish. These operations tend to be of an extensive nature and thus aquaculture's influence on the aquatic environment in England and Wales can be considered largely limited to freshwater trout culture.

Trout

A2.27 With the gradual refinement of breeding and growing-on techniques for trout, commercial trout farming rapidly established itself throughout the country and has proved to be a successful and adaptable industry. Despite problems due to uneven seasonality of supply during the early eighties, production in England and Wales has risen from 5,000 tonnes in 1980 and has now stabilised at a level of around 16,000 tonnes per year. This is principally due to a lack of suitable freshwater sites available for expansion, rather than market limitations. Production for the UK as a whole is given in Figure A2.8.

A2.28 Trout culture in England and Wales is practised almost exclusively in freshwater, although a small number of farmers operate cages in sea water. Normal practice is the use of 'off line' systems where water is abstracted from a watercourse by a weir and diverted through a number of holding ponds, tanks or raceways. Salmonids under intensive culture conditions demand high levels of oxygen, and thus require considerable volumes of water, generally around 5 litres per second for one tonne of fish held. Once the water leaves the holding facilities, it is often held in a settling pond to allow a reduction of suspended solids before being discharged back into the watercourse. Some farms, especially those with hatcheries, also use groundwater from bore holes to supplement surface water supplies, although some preliminary treatment is often required.

Other Forms of Aquaculture

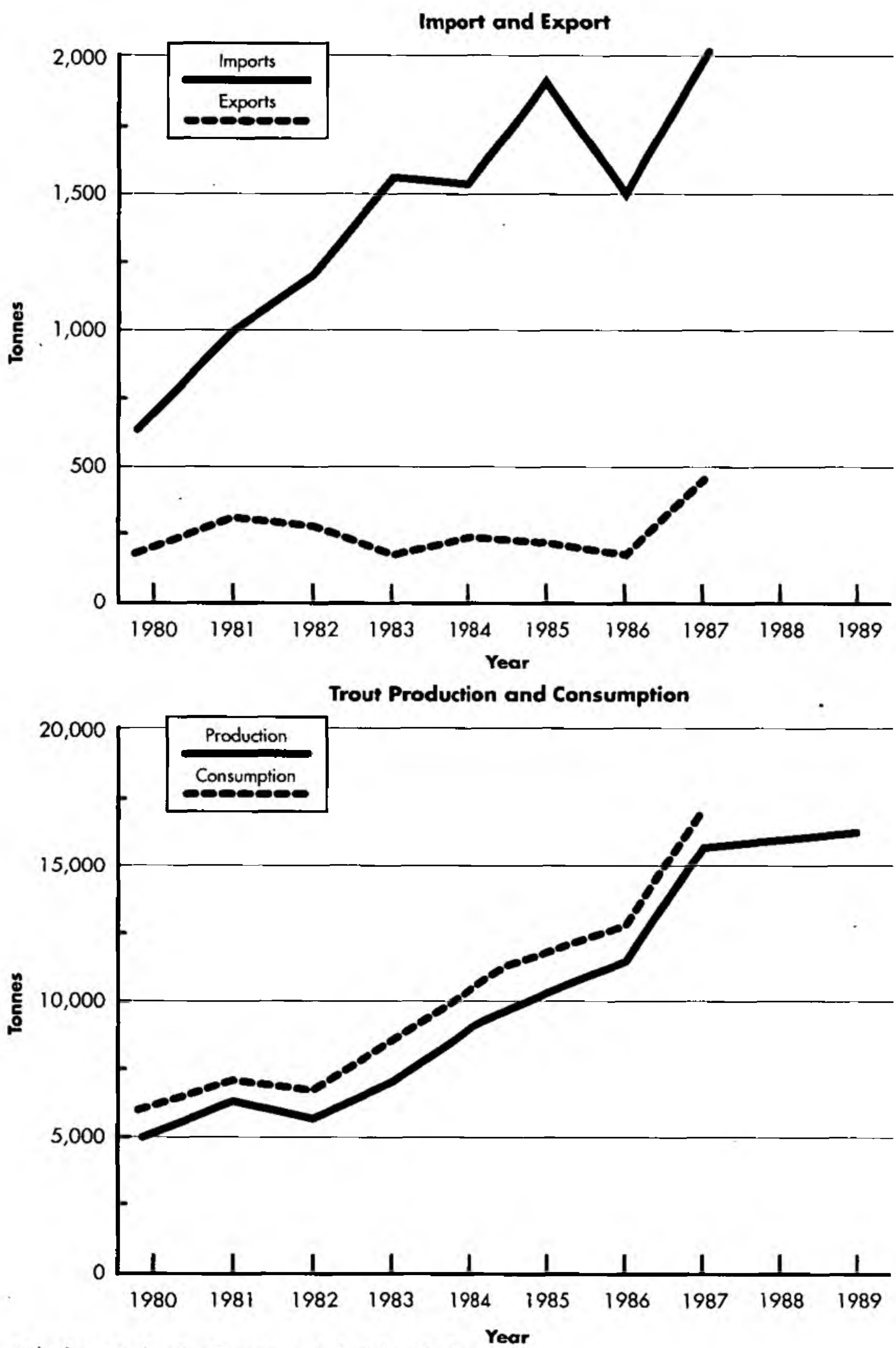
A2.29 As explained above, trout culture forms the major component of intensive aquaculture in England and Wales. Other forms of aquaculture are practised, but generally on an extensive scale and thus are considered to have a minimal effect on the aquatic environment, as indicated below.

A2.30 *Coarse fish culture* - A number of coarse fish species are reared, primarily for restocking of rivers and lakes, although a limited production of carp for human consumption exists. Some coarse fish hatcheries and nursery units are managed by the NRA, but there is increasing private sector involvement as the demand for stock fish increases.

A2.31 *Crayfish culture* - Farming of the American signal crayfish, *Pacifastacus lenisculus*, is not commonly practised. Despite problems of unusually high water temperatures and competition from foreign producers, production in the UK in 1989 exceeded 8 tonnes, almost double that in 1988. However, the extensive nature of crayfish culture (one animal per square metre) means that it is rarely economical to practice as monoculture. It is thus used as a secondary crop in ponds, gravel pits and shallow lakes in hard water areas. As such, despite the high demand and prices for this crustacean, expansion of production in the UK is likely to be slow in the medium term.

A2.32 *Others* - a number of marine finfish species, notably turbot and bass, can be cultured in the coastal waters of the UK. However, a number of factors, such as land costs, water conditions and temperatures are likely to prevent significant expansion of commercial farming of these species in the medium term.

Figure A2.8 Trout trade



Data from: Federation Europeene de la Salmoniculture
NIMEXE

APPENDIX 3

Variations in Agricultural Practice in the Ten NRA Regions

Agriculture

Holdings by Type

A3.1 The general nature of agricultural activity within the NRA regions is indicated in Figure A3.1. This details the percentage distribution of holdings by farm type between the regions. Because each regional boundary tends to follow catchment rather than county boundaries the figures are not exact but represent a close approximation. As expected, a large proportion of the arable holdings are located in the Anglian region, as are the highest percentage of pig and poultry holdings. The Welsh region contains a very high proportion of holdings with grazing livestock.

Land Use

A3.2 The area of agricultural land and land use within each NRA Region is shown in Figure A3.2. It should be noted that the areas of common rough grazing in each area are excluded. The Anglian NRA Region has the largest amount of agricultural land, followed by the Severn Trent and Welsh Regions, while Northumbria has the least.

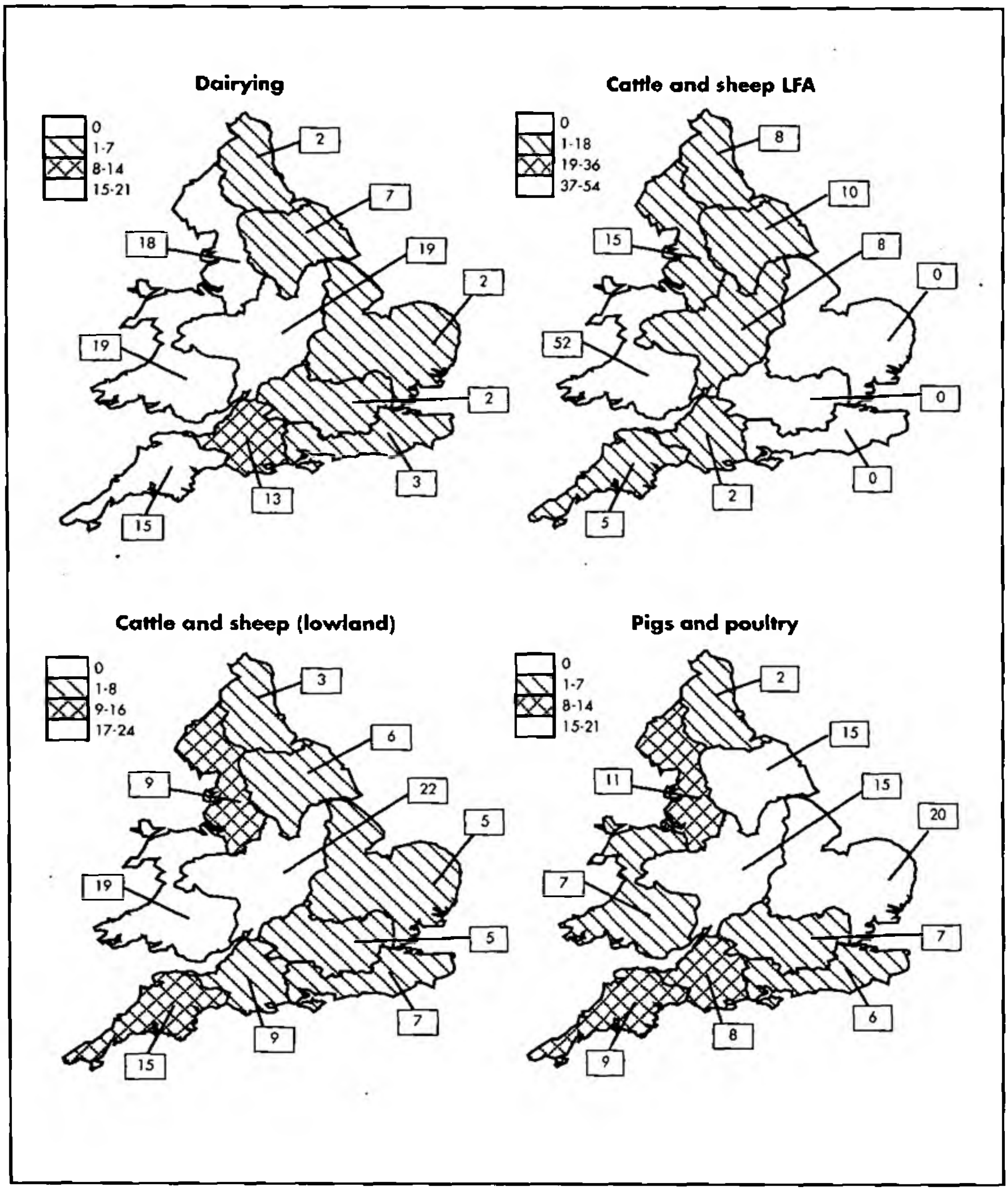
A3.3 Land use within the regions varies quite markedly. Those covering the uplands of England and Wales, which includes most of the Less Favoured Areas (LFA), are predominantly grassland. These include the North West, Northumbria, South West and Welsh regions. Severn Trent is equally divided between arable and grassland, the remaining regions being orientated towards arable cropping. Potatoes, sugar beet and oilseed rape, on which high levels of inorganic nitrogen are normally applied, are mostly to be found in the Anglian, Yorkshire, Thames and Severn Trent regions. Horticulture, most of which is intensive field scale vegetables, is mainly located in the Anglian and Southern regions.

Stocking

A3.4 The distribution of livestock is presented in Figure A3.3. Dairying is primarily located in the predominantly grassland regions and Severn Trent, North West, Welsh, Wessex and South West account for 79% of dairy cows in England and Wales. Apart from Severn Trent and Welsh, the regions with the highest proportion of dairy cows are those with the lowest land area. Beef cows are mostly found in the LFAs, with Wales, South West, North West and Northumbria accounting for almost 60% of the total population. Half the breeding ewes are to be found in the Welsh and Severn Trent regions; these, together with North West, South West and Yorkshire account for almost 80% of the total breeding flock.

A3.5 Over half the pigs are located in the Yorkshire and Anglian regions, but a significant number is also found in Severn Trent. Almost half the poultry flock is located in the Anglian and Severn Trent regions; these, together with North West, Yorkshire, Southern and Wessex account for over 80% of total numbers.

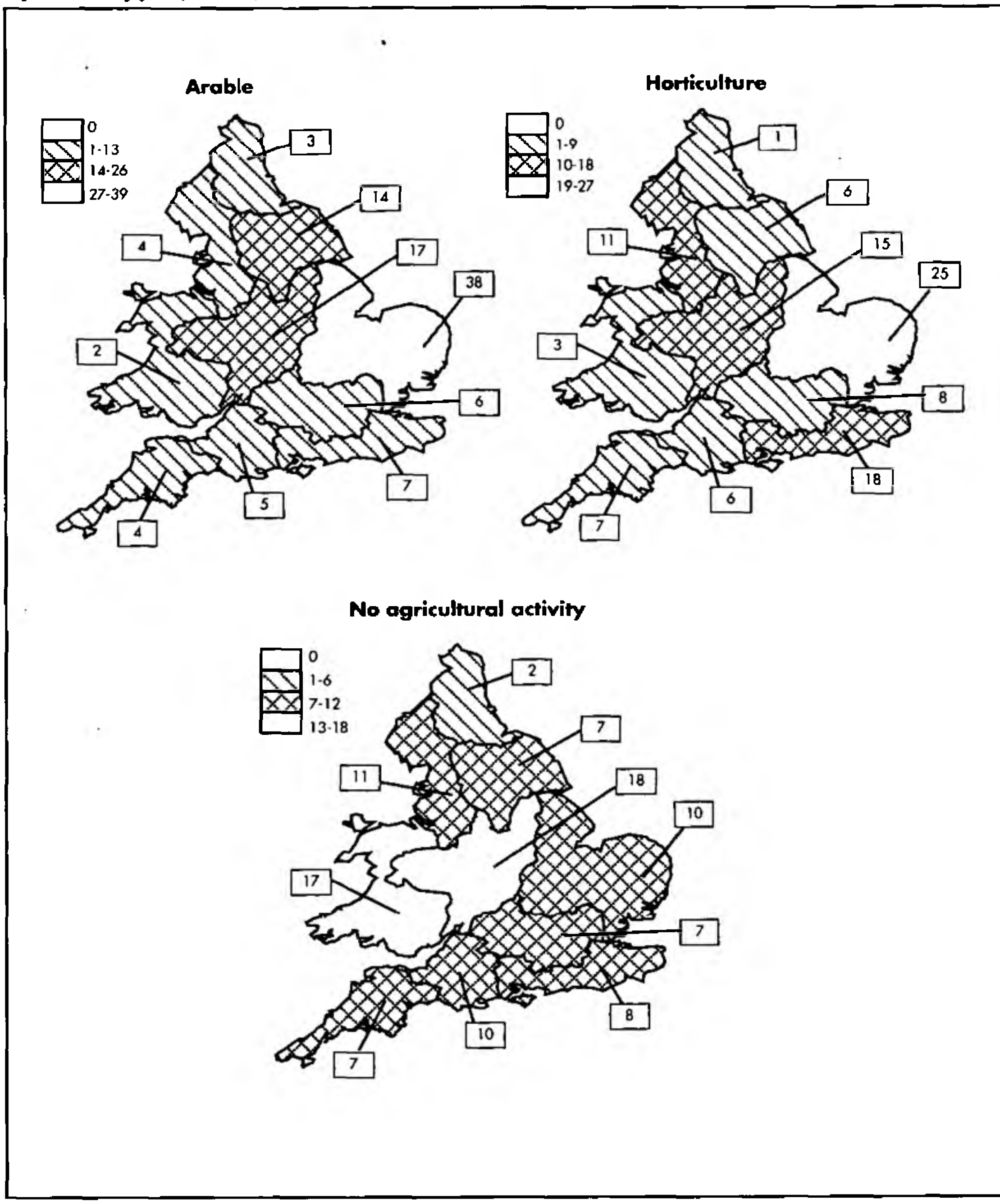
Figure A3.1 Approximate percentage distribution of holdings by farm type (1986)



Nitrogen

A3.6 Some evidence suggests that application rates of inorganic nitrogen to arable crops are lower in the West than in the East, but this has not been quantified. An analysis has been undertaken of the tonnage of inorganic nitrogen applied per annum by NRA region, based on published statistics. The results are presented in Figure A3.4. The tonnage of inorganic nitrogen applied will largely be a function of both the area of agricultural land and the intensity of cropping within each NRA region. The highest quantity of inorganic nitrogen is applied in the Anglian and Severn Trent regions, whereas the lowest tonnage is applied in the Northumbrian region. Most of the remaining regions receive between 6 and 8 per cent of the inorganic nitrogen applied in England and Wales, the exceptions being the Welsh and

Figure A3.1 Approximate percentage distribution of holdings by farm type (1986)



Yorkshire regions where, due to land area and cropping intensity, 12 and 10 per cent respectively of inorganic nitrogen is applied.

Pesticides

A3.7 As far as is known, no generally published county data exist for pesticide usage; consequently it is difficult to estimate the total application of active ingredients by NRA region.

A3.8 In general, relatively little pesticide is used on grassland except when reseeding or on permanent pasture where weed problems occur. Most pesticides are used on arable crops and it is to be expected that by far the greatest tonnage of active ingredients is applied in the Anglian, Severn Trent, Thames, Southern and Yorkshire regions.

Figure A3.2 Estimated area of agricultural land and land use within each NRA Region (1989)

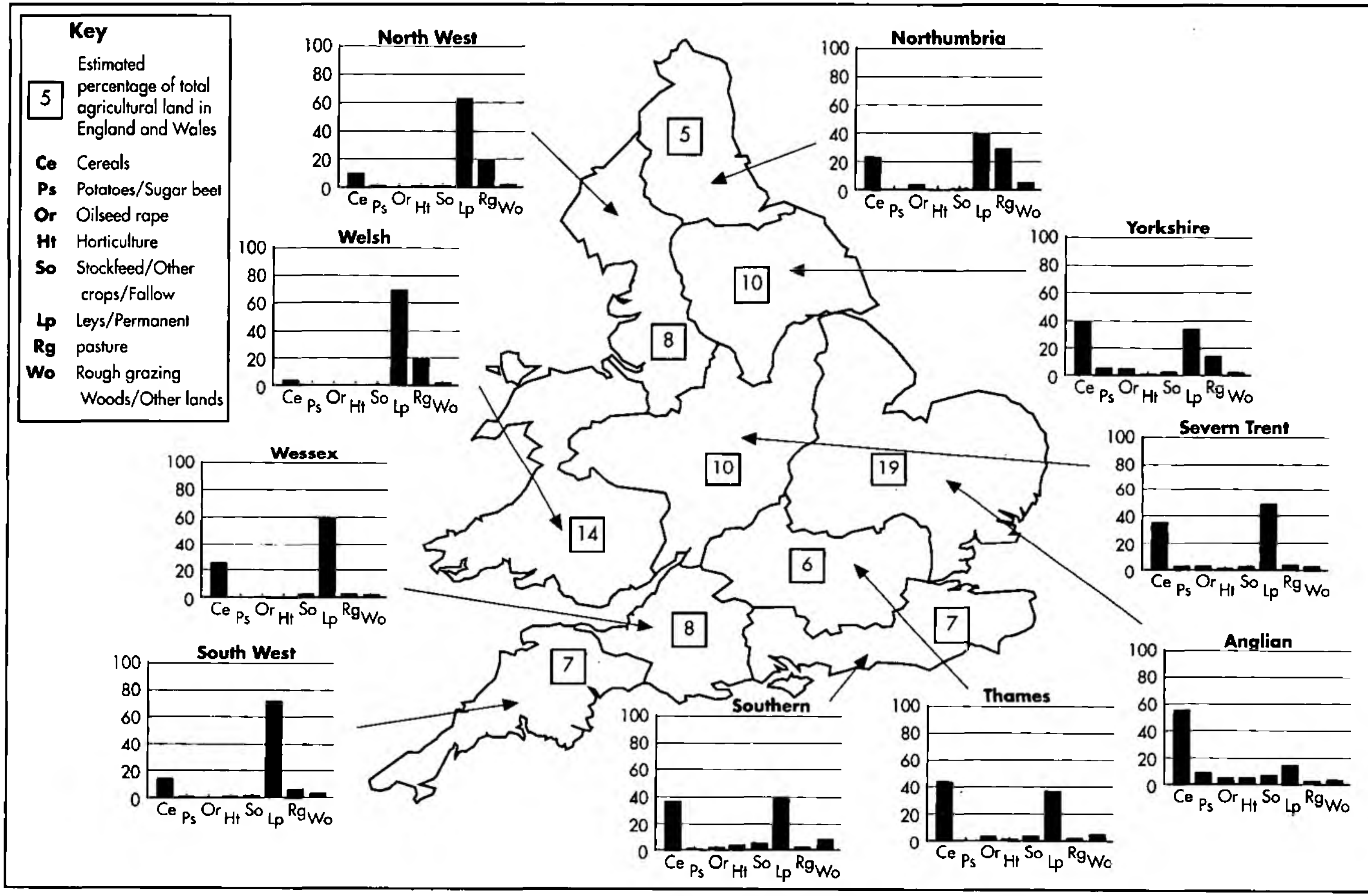
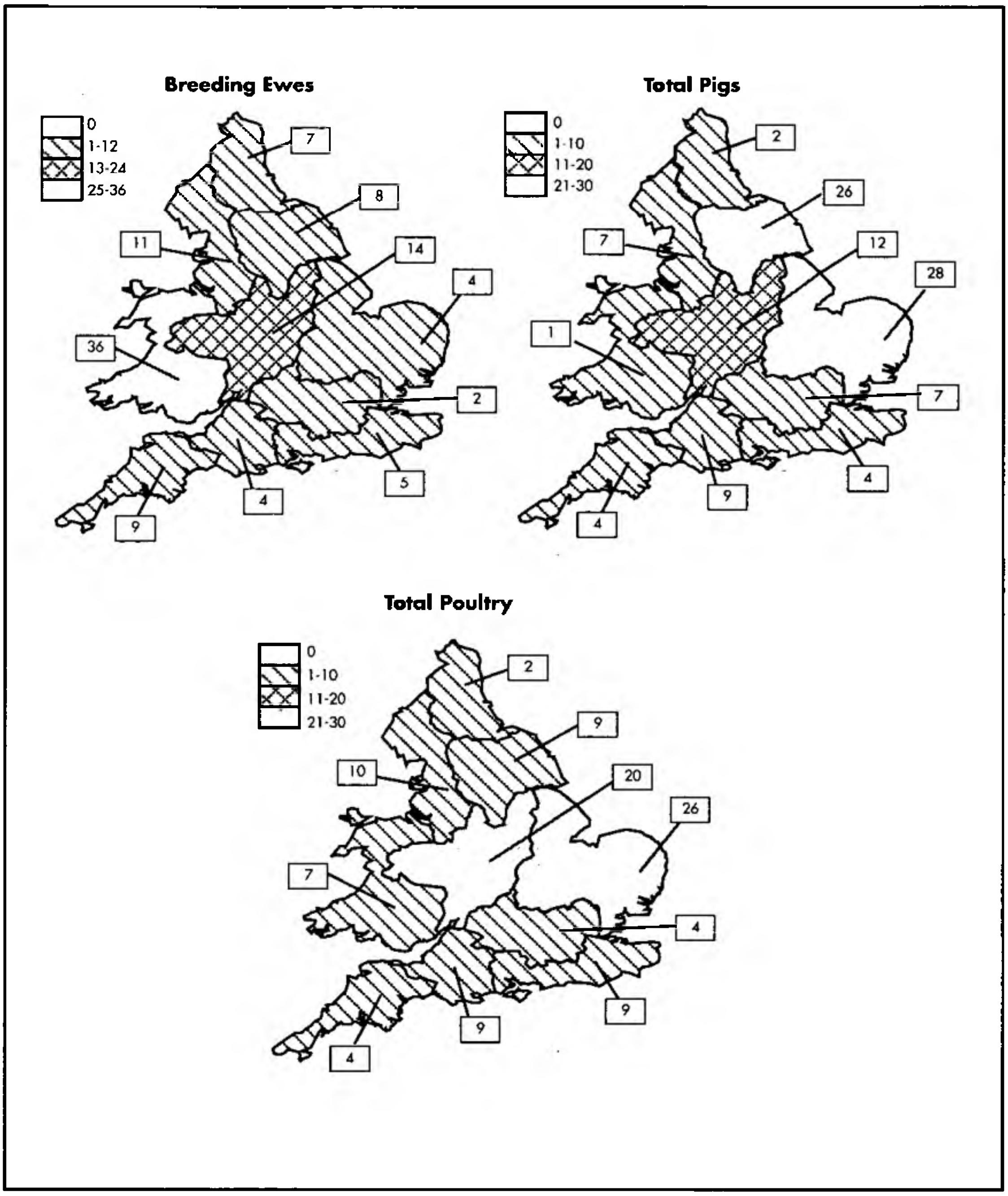
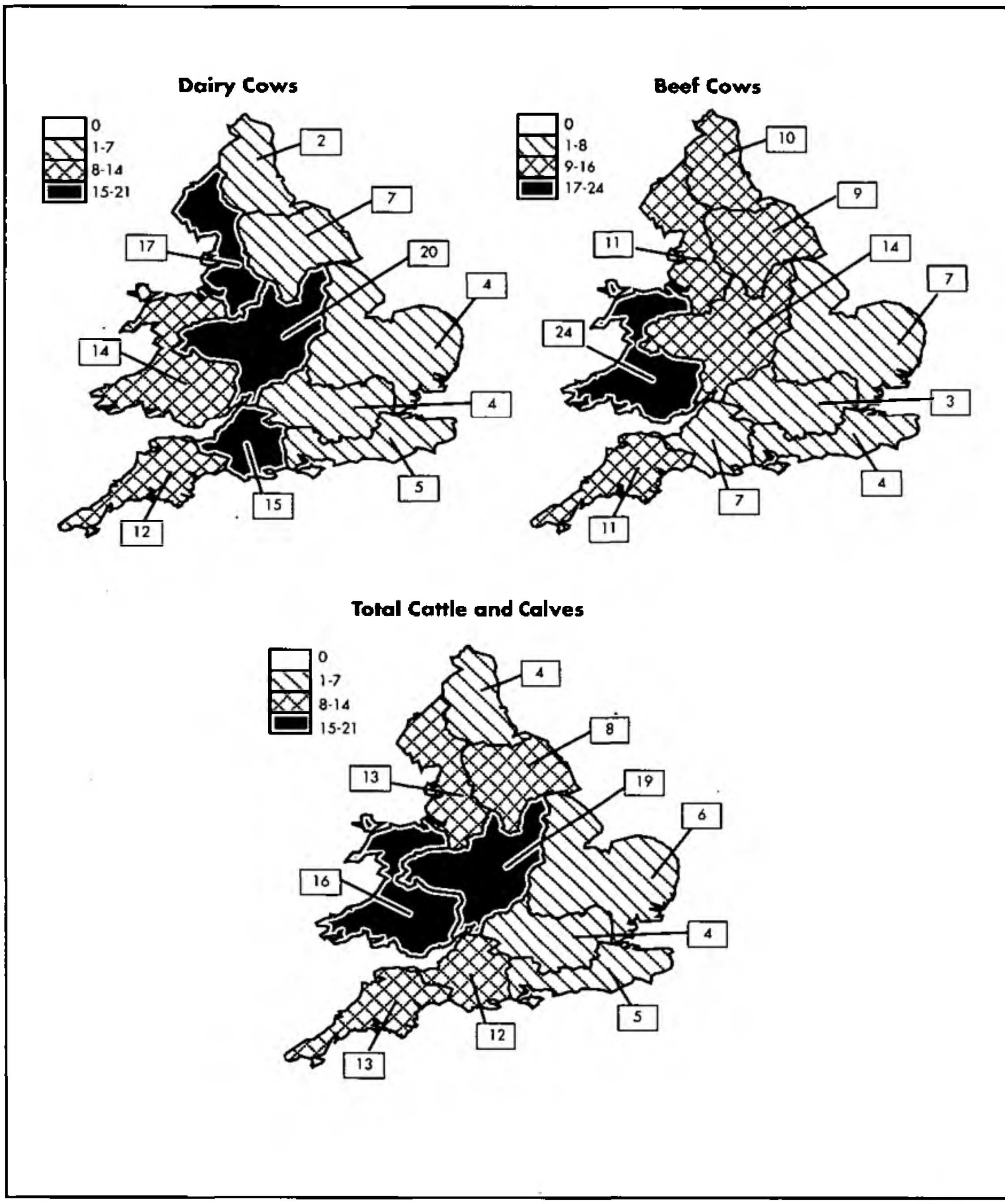


Figure A3.3 Approximate percentage distribution of livestock numbers by NRA Region (1989)



A3.9 Table A3.1 shows the top 50 pesticides by weight of active ingredient, in a survey of arable crops. Care must be exercised when interpreting these figures, as weight of active ingredient does not necessarily indicate widespread use. Many recently introduced formulations are extremely potent per unit weight of active ingredient, whilst some of the older chemicals such as sulphuric acid require higher applications of active ingredient per unit area to achieve the desired effect.

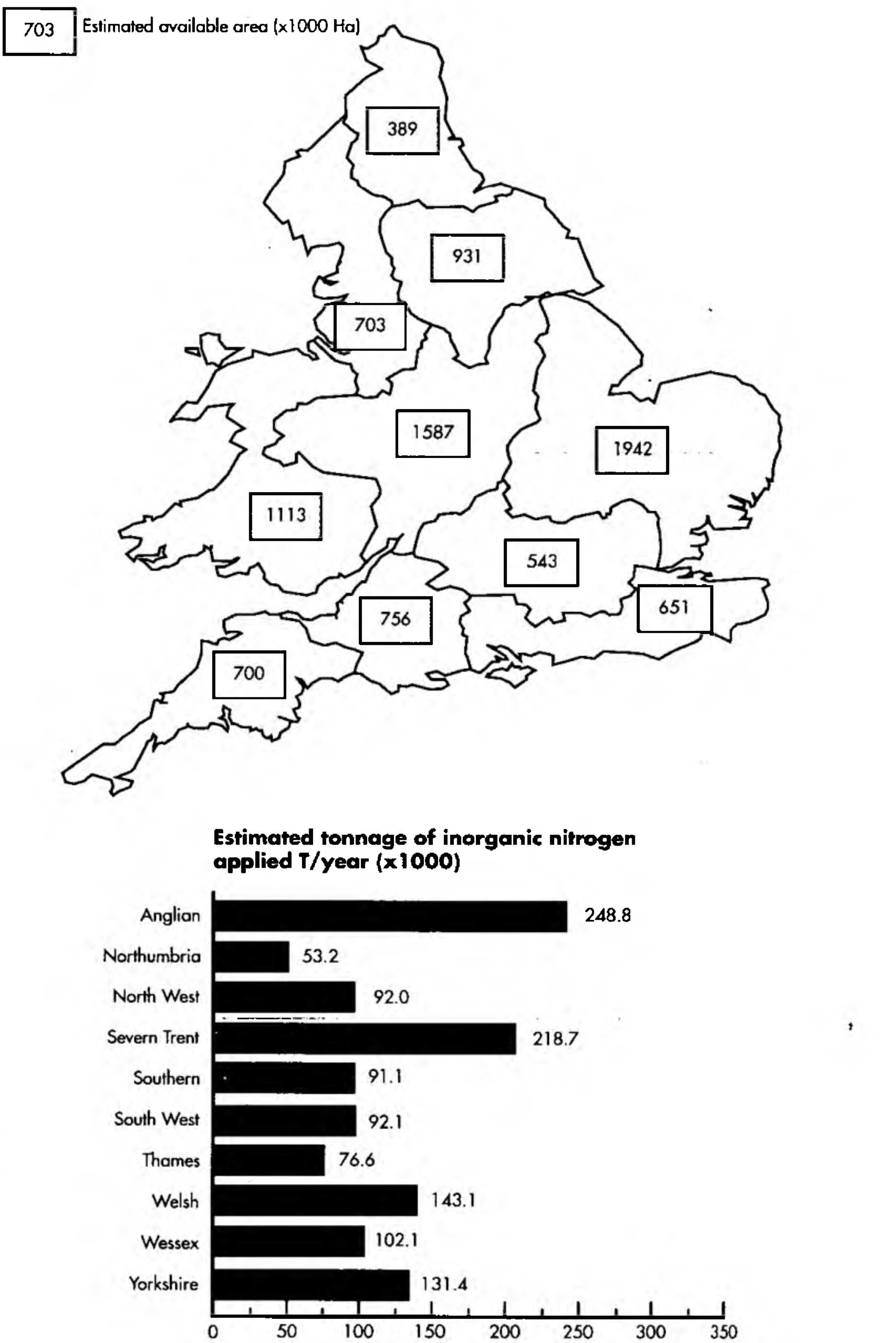
Figure A3.3 Approximate percentage distribution of livestock numbers by NRA Region (1989)



Livestock Effluent

A3.10 An assessment has been undertaken of the estimated average quantity of undiluted livestock effluent disposed of per hectare per annum on available land. This is shown for NRA Regions in Figure A3.5. It assumes that land cropped with winter cereals or horticultural crops receives no livestock effluent but conversely it assumes that all of the other land is flat or dry enough to be available for effluent disposal, or within reasonable distance for disposal of wastes from stock housing. It is recognised that this is a simplification because rough grazing and heavy land will receive reduced application rates per hectare, due to the lower stocking rates and the fact that most is likely to be too rough or waterlogged to spread effluent from housed livestock.

Figure A3.4 Inorganic nitrogen applied in each NRA Region



Using Fertilizer Manufacturers Association national averages of 150 kg/ha/yr for arable and 127 kg/ha/yr for grass

Table A3.1 - Estimated amount of the Fifty Active Ingredients, used most by weight, on all arable crops surveyed - Tonnes

Active Ingredient	Amount Used tonnes
1. Sulphuric acid	5466
2. Mecoprop	3099
3. Isoproturon	2720
4. Chlormequat	1446
5. Chlorotoluron	773
6. Mancozeb	673
7. Maneb	647
8. Fenpropimorph	560
9. Chlorothalonil	500
10. Prochloraz	436
11. Carbendazim	379
12. Sulphur	346
13. Tridemorph	323
14. MCPA	320
15. Trifluralin	318
16. Captafol	309
17. Pendimethalin	254
18. TCA	249
19. Glyphosate	246
20. Ioxynil	239
21. Choline Chloride	238
22. Bromoxynil	233
23. Tri-allate	189
24. Propiconazole	178
25. Terbutryn	177
26. Dimethoate	163
27. Fenpropidin	146
28. Linuron	143
29. Manganese, zinc ethylene bisdithiocarbamate	127
30. Diclofop-methyl	127
31. Propyzamide	119
32. Flamprop-M-isopropyl	113
33. Diquat	112
34. Metsulfuron-methyl	111
35. Methabenzthiazuron	98
36. Ethirimol	90
37. Metaldehyde	83
38. Methiocarb	81
39. Simazine	80
40. Demeton-S-methyl	78
41. Difenzoquat	76
42. Fluroxypyr	74
43. Paraquat	72
44. Mecoprop-P	72
45. Dichlorprop	70
46. Iprodione	69
47. Flutriafol	62
48. Triadimenol	62
49. Cyanazine	60
50. Carbetamide	59

A3.11 Even in regions such as Thames, with only 4% of the total undiluted livestock excreta production, the average disposal rates are not dissimilar to those in the North West which is a predominantly livestock area.

A3.12 These figures also mask the situation on farms. Significant quantities of rainwater and other liquid wastes such as parlour washings will be mixed with the livestock effluent, as will other solid matter such as bedding material. In addition, variations in stocking intensity between farms will result in some holdings needing to dispose of significantly greater quantities per unit area.

Silage Effluent

A3.13 Figure A3.6 shows the estimated rate of silage effluent applied per unit area of leys and permanent pasture, which is taken to be the area for disposal. This also assumes that total effluent production, estimated at 1.5 million tonnes, is distributed in the same proportion as the number of dairy cows, the main consumers of silage. Recent trends to making silage in "big bags" in some areas may have reduced the quantity of effluent produced.

Table A3.2 - Approximate distribution of fish farms by NRA Region

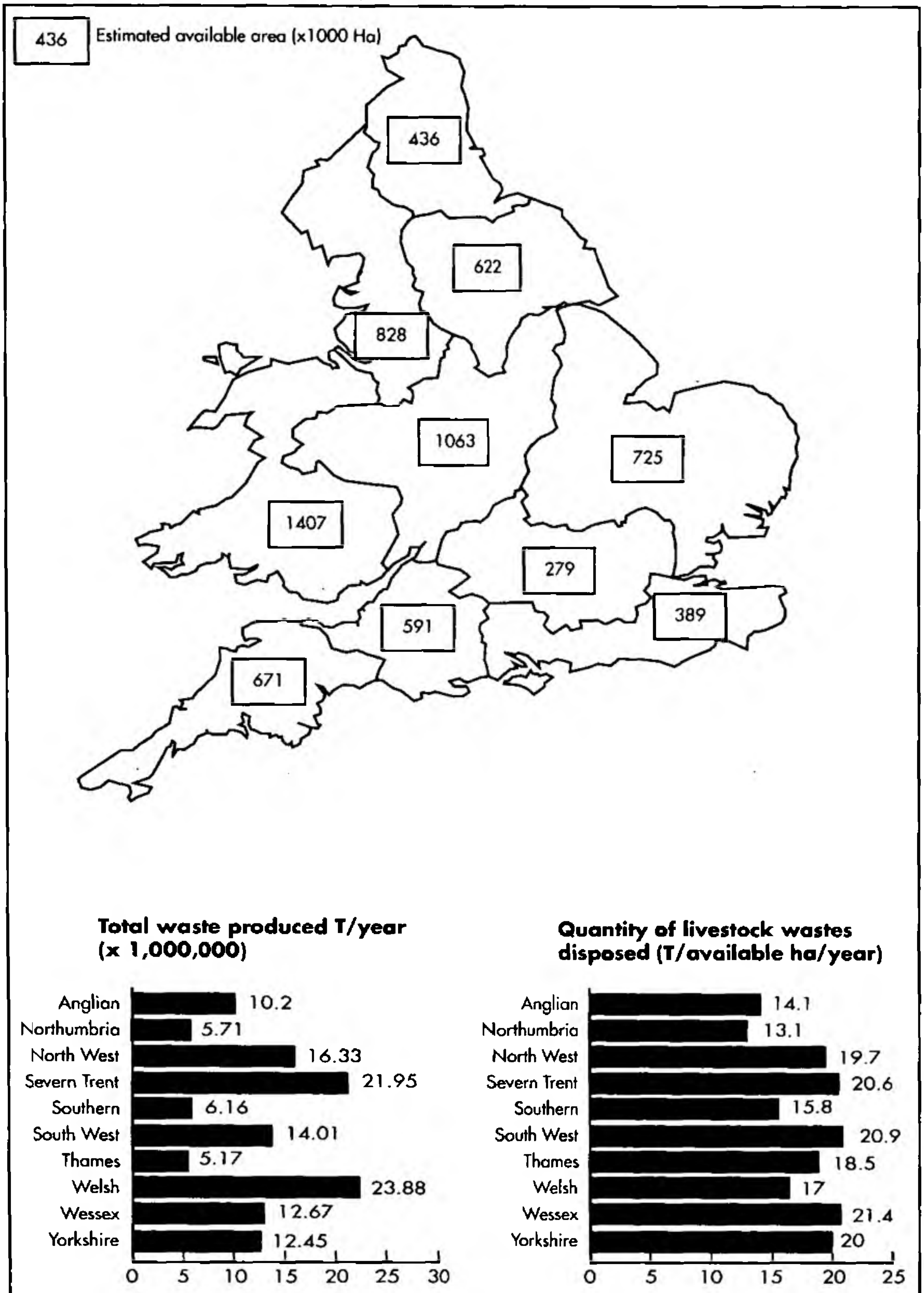
NRA Region	Land Based Fish Farms	
	No	%
Anglian	45	11
Northumbria	2	1
North West	20	5
Severn Trent	55	14
Southern	30	7
South West	66	17
Thames	44	11
Welsh	23	6
Wessex	50	13
Yorkshire	60	15
Total	395	100

Source : WRc

Fish Farms

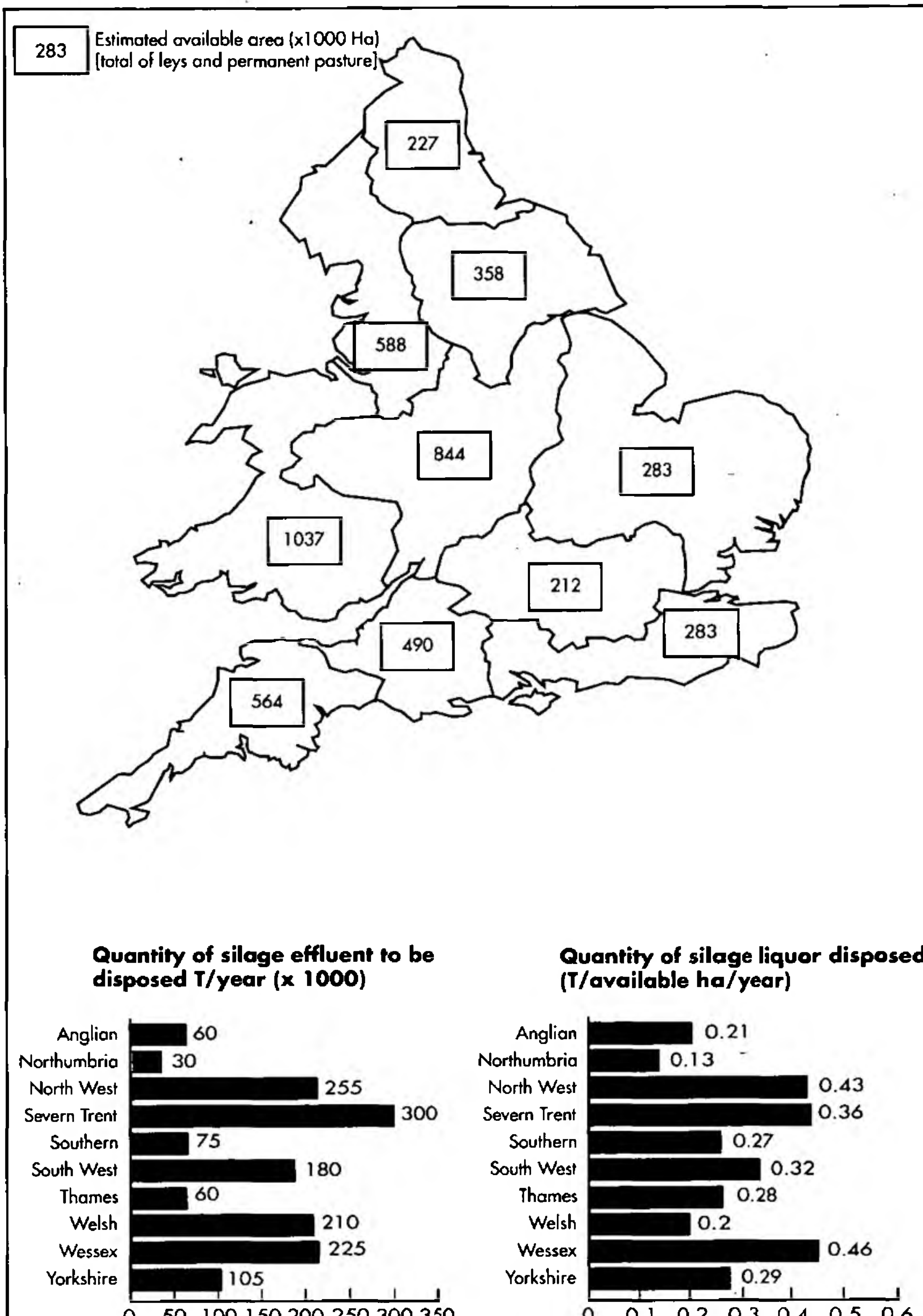
A3.14 The approximate distribution of land-based fish farms by NRA region is shown in Table A3.2. Most are classed as 'fish for the table', the remainder are mainly restocking farms or a combination of both. Not all fish farms have consents to discharge. The South West and Wessex regions account for 30% of fish farms, followed by the Yorkshire, Severn Trent, Anglian and Thames regions. Between them these regions have 81% of land based fish farms in England and Wales.

Figure A3.5 Undiluted livestock effluent applied per unit area in each NRA Region



Available area assumed to be used for Spring Barley, Potatoes, Sugar Beet, Stockfeed Crops, Leys, Permanent Pasture and Rough Grazing

Figure A3.6 Estimated silage effluent applied per unit area by NRA Region



Available area assumed to be that used for Leys and permanent pasture

Related Industries

A3.15 The size of organisations processing agricultural products varies greatly, ranging from small independent companies to large multinational organisations. It is, therefore, difficult to derive the regional distribution of related industries in terms of the number of organisations, size of plants or volumes processed. The following analyses should, therefore, be regarded as only indicative.

Abattoirs, Cutting Plants and Cold Stores

A3.16 The number of slaughterhouses, approved slaughterhouses, cutting plants and cold stores approved under the Fresh Meat Export Regulations (1987) by NRA region is shown in Figure A3.7. The greatest number of establishments is to be found in the Severn Trent region followed by the Yorkshire and Anglian regions. These three regions contain just over half the EC approved establishments.

Fruit, Vegetable and Potato Processors and Packers

A3.17 An analysis has been undertaken from data readily available from trade organisations; this is shown in Figure A3.8. Many processors and packers do not belong to these; consequently, the analysis should only be regarded as being in outline and for this reason has beenexpressed in percentage terms. However, in view of the distribution of these crops throughout England and Wales, and from knowledge of the industries concerned, it is considered probable that the analysis realistically reflects the likely distribution of the industry as a whole. As expected, most are to be found in the Anglian, Southern, Yorkshire and North Western regions; collectively, these contain about 80 per cent of the organisations processing and packing fruit, vegetables and potatoes.

Sugar Beet Factories

A3.18 There are twelve sugar beet factories in England, two of which are about to close; there are none in Wales. Nine plants - soon to be seven - are located in the Anglian region, the remainder being in the Severn Trent and Yorkshire areas.

Dairies and Creameries

A3.19 Five organisations and 44 establishments account for 77% and 89% respectively of milk processed or bottled. Table A3.3 shows the distribution of identified milk processing plants by NRA region. The location of plants is strongly influenced by the distribution of both the dairy cow and human population; consequently, 69% are to be found in the Severn Trent, Wessex, South West, Welsh and Thames regions.

Tanneries

A3.20 An outline analysis has been undertaken from data readily available from the principal trade organisation and is shown in Table A3.4. Since some manufacturers may not be represented, the analysis should only be regarded as being in outline and for this reason has been expressed in percentage terms. From the available information, the majority of tanneries are situated in the Anglian, Wessex and North West regions.

Figure A3.7 Slaughter houses, cutting plants and cold stores

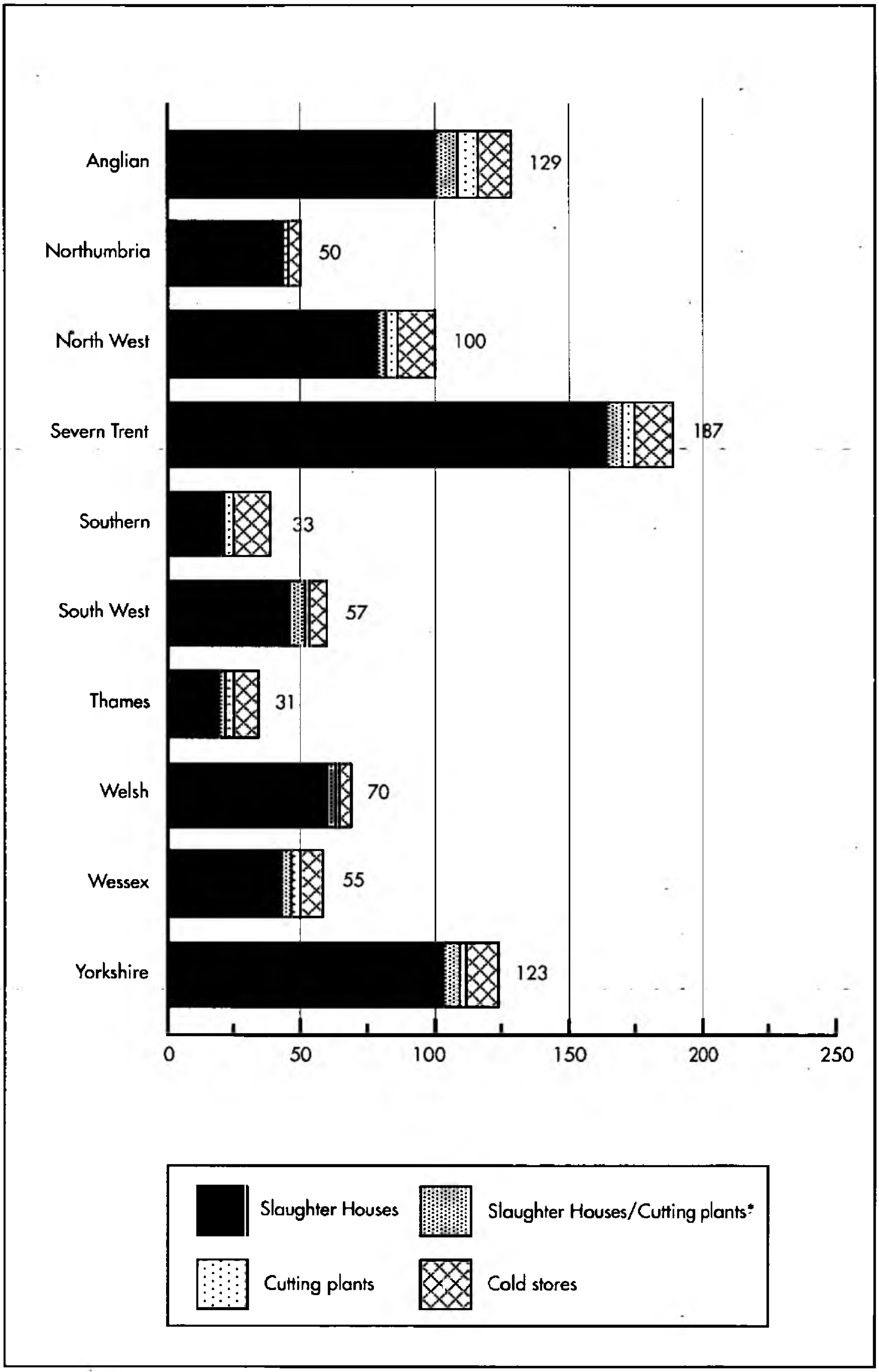
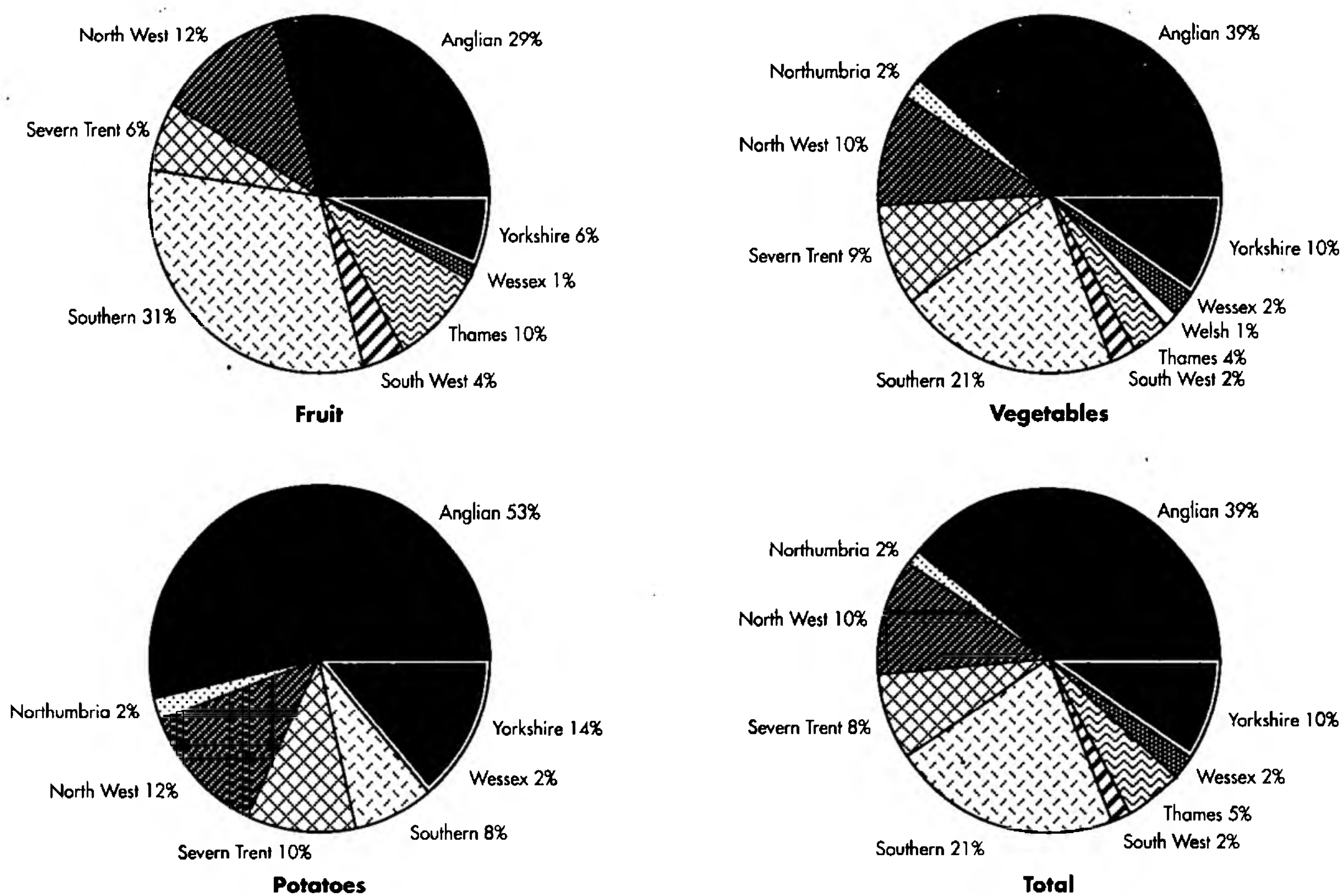


Figure A3.8 Outline distribution of fruit, vegetable and potato packers by NRA Region



Source: FFB/PPMA

Waste Disposal

A3.21 In some areas, particularly East Anglia, there is an increasing number of farms on which land is used, sacrificially, for the disposal of wastes arising from industries such as food and meat processing. Since the application rates are far greater than those required for agricultural purposes, it is clear that these are waste disposal operations. However, County Councils are unwilling to control these operations by the Waste Disposal Site Licensing procedures as farmers insist that wastes are being applied for agricultural purposes.

Table A3.3 - Distribution of milk processing plants by NRA Region

NRA Region	% of Identified Plants
Anglian	7
Northumbria	3
North West	9
Severn Trent	18
Southern	9
South West	14
Thames	10
Welsh	12
Wessex	15
Yorkshire	3

Source: MM3, Unigate, Grand Metropolitan

Table A3.4 - Outline distribution of tanneries by NRA Region

NRA Region	% of Identified Plants
Anglian	24
Northumbria	2
North West	13
Severn Trent	9
Southern	6
South West	6
Thames	9
Welsh	0
Wessex	22
Yorkshire	9

Source: British Leather Confederation

APPENDIX 4

Case Histories of Farm Pollution Events and Preventative Measures

Organic Farm Waste

A4.1 It is clear that a large number of incidents due to organic farm waste occur every year throughout England and Wales. A small number of typical examples has been carefully researched and these are presented as briefcase studies, indicating wherever possible the cause, route to controlled waters and effect.

A4.2 In August 1989 a large volume of cow slurry leaked from a lagoon into the River Fenni, a tributary of the River Taf. The cause was the collapse of an ineffective repair to a man-made breach in the lagoon wall. About 14,500 salmonid fish were killed over a distance of 9km.

A4.3 In September 1988, cow slurry escaped from a lagoon and entered the Nant Gurrey Fach, a tributary of the River Tywi. The escape was made through a hole which had probably existed since construction. More than 2,000 fish were killed.

A4.4 In May 1989, at least 200,000 gallons of cow slurry were spread on a 23 acre field over a period of three days. Previous dry weather had caused surface cracking and the slurry had percolated into land drains which discharged to the Ingleby Beck, a tributary of the River Leven (Tees). The application rate was at least 75 m3/hectare, which greatly exceeds the recommended rate of 50 m3/hectare (Code of Good Agricultural Practice). At least 1,300 trout were killed.

A4.5 During a prolonged period of cold weather early in 1986, large quantities of slurry were applied to land throughout West Wales. Heavy rain on 5 March washed much of the slurry into rivers in the area. Water abstracted from the Rivers Teifi, Tywi and Eastern Cleddau exhibited increased concentrations of ammonia. Conventional treatment resulted in the production of chloramines, which themselves resulted in over 100 consumer complaints about bad taste.

A4.6 A borehole at Pendine in West Wales abstracts water from a highly fissured limestone aquifer. There were no problems when the source was developed in 1971 but since then, intensification of farming in the catchment has led to slurry contaminating three streams which had direct contact with the aquifer. A scheme to divert two of the streams away from the aquifer brought about a significant improvement in quality of the abstracted water. Diversion of the third was planned.

A4.7 In the summer of 1986, discharges of silage liquor from two farms on the Mellingey Stream, a tributary of the River Camel, resulted in BOD concentrations rising from 7mg/l to 87mg/l. A short distance downstream, water was abstracted for use in a fishfarm. A small number of fish died.

A4.8 There are areas of carboniferous limestone in the catchments of the Rivers Kent and Eden in Cumbria. The use of bacteriophages as tracers has shown that silage liquor contaminates the groundwater which may emerge at springs several miles from the source. Increased

BOD, low dissolved oxygen, growth of sewage fungus, fish mortalities and problems with spawning have all been observed. The use of some private supplies has been affected.

A4.9 In September 1985, about 50,000 gallons of pig slurry escaped from a breach in a storage tank and entered the River Perry, a tributary of the River Severn. The cause was structural failure of a steel tank which had been damaged and repaired several years previously. In the river, BOD concentration rose from 2 mg/l to 1850 mg/l, solids concentration from 3 mg/l to 1000 mg/l and ammonia rose from 0.05 mg/l to 2.1 mg/l, resulting in the death of about 10,000 fish. As the polluted water moved downstream into the River Severn, peak concentrations of ammonia were lower, as shown in Figure A4.1. A potable water intake about 18 km downstream was closed temporarily.

A4.10 In July 1989, about 100,000 gallons of pig slurry escaped from a storage tank and entered the River Madford, a tributary of the River Culm. The cause was poor operation of the storage facility. In the River Madford ammonia concentrations increased to about 140mg/l and about 1500 fish were killed. Aquatic invertebrates were also affected. Water quality improved quickly after the event but river sediments were contaminated with copper and zinc. Three months later, sediment quality had improved but invertebrates exhibited only a partial recovery.

Farm Campaigns to Reduce Organic Pollution

A4.11 In February and March 1990 the Madford and Bolham sub-catchments of the River Culm in Devon were subject to a farm campaign. Farms were identified as either polluting, or posing a high or a low risk of pollution. Seventy two farms were visited of which 25 were polluting, ll were high risk and 36 were low risk as shown in Fig. A4.2. The majority of polluting and high risk farms were involved in dairying, the problems being caused by parlour washings and yard run-off. 64% of farms relied solely on a dungheap for waste storage, which were often unwalled. Mismanagement of storage facilities, including tanks and lagoons, was a major factor. During the period of this campaign only 6 pollution

Figure A4.1 Pollution of River Perry and River Severn (7th to 11th Sept 1985)

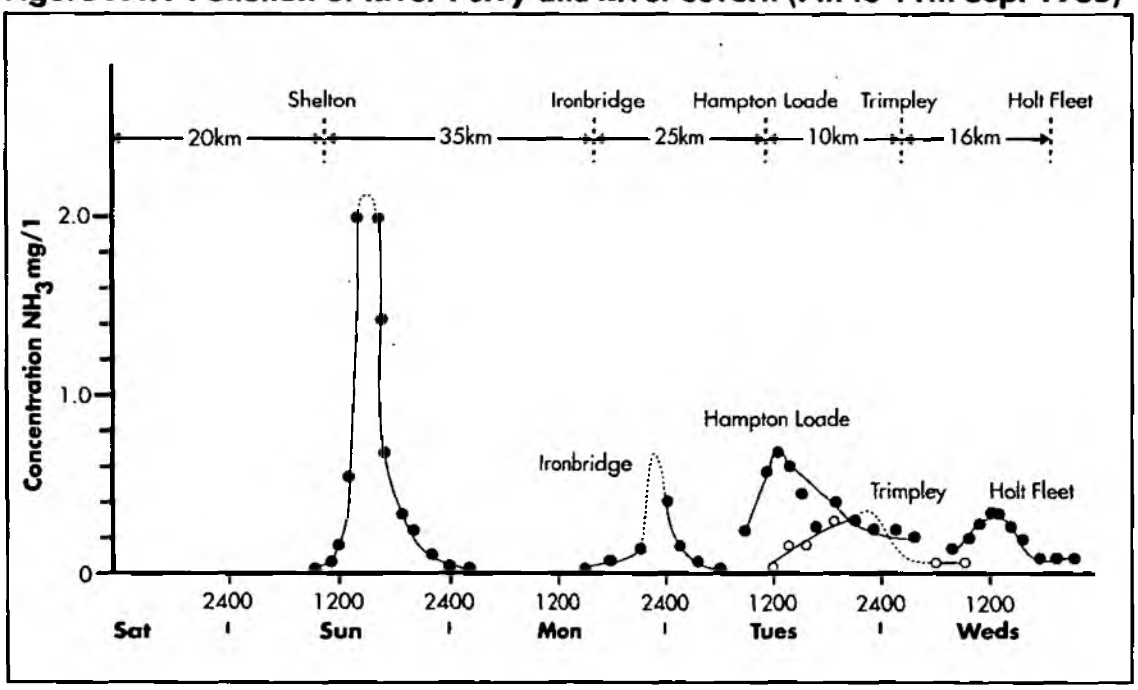
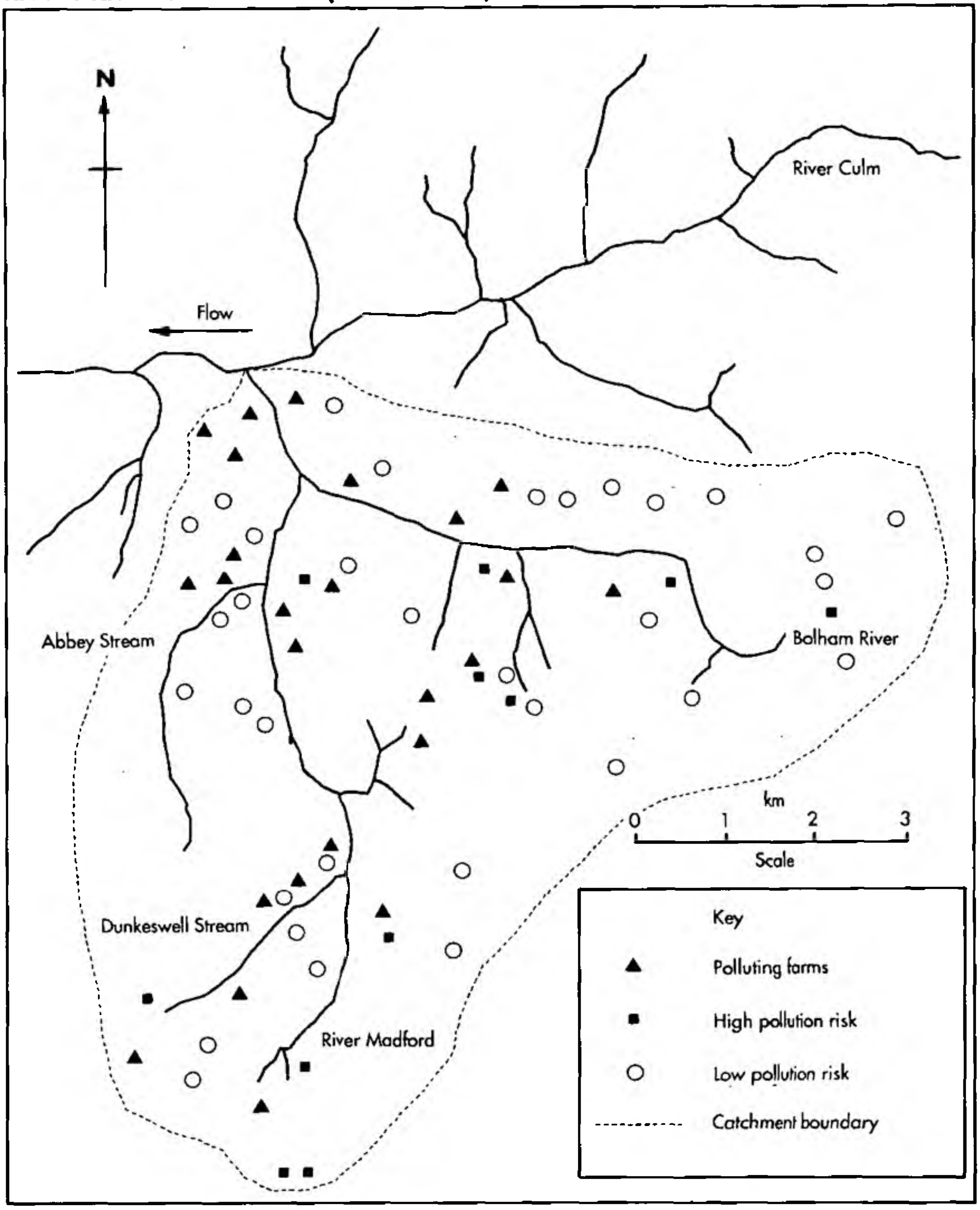


Figure A4.2 Pollution codes allocated to farms in the River Madford Catchment (March 1990)



incidents were reported by the public for this area. This represents 24% of the pollution incidents discovered by NRA staff. If this is representative of the whole region or country, the real impact on river water quality must be significantly underestimated.

A4.12 In July 1990 the River Loud catchment in the North West Region was the subject of a farm campaign. 35 of the 50 working farmers were asked to carry out remedial measures. 94% of these farmers responded in a positive manner. Problems associated with cattle waste were the most common (24) with silage the next most important (21). There were 13 problems of oil spillages, 4 associated with sheep dip and pesticides, 1 with pigs and 2 miscellaneous.

Food Processing

A4.13 In January 1986, at a creamery in Shropshire, a spillage of milk whey occurred during a transfer operation from silo to tanker. The whey caused failure of the on-site treatment works, resulting in an unsatisfactory effluent entering the Minsterley Brook, from which it was slow to clear. One month after the accident the BOD concentration 1.2km downstream of the discharge point was 19 mg/l compared with 4.4 mg/l upstream. A prolific growth of sewage fungus had developed and the invertebrate community was significantly reduced. A gradual improvement was evident during March, but on 10 April a second incident occurred as a result of a caustic spillage. A formal sample of the effluent on 23 April indicated a BOD of 320 mg/l, compared with the consent limit of 20 mg/l. The BOD level in the Minsterley Brook was raised from 1.7 mg/l to 12.5 mg/l.

A4.14 At an abattoir in North Devon, it has been the practice to spray irrigate fully treated effluent onto land. Tributaries within the catchment have been affected by direct run-off of treated effluent, the level of pollution in the watercourse being directly related to the quality of treatment plant effluent. Although there has been an improvement in effluent quality, chronic pollution continued with ammonia and sulphate concentrations in the receiving watercourse being particularly high. An aquatic invertebrate survey of one of the worst affected streams revealed gross organic pollution. An improvement was observed 3km downstream.

A4.15 In October 1986, 50 tonnes of concentrated sugar syrup were spilled at a sugar beet processing plant in Bury St Edmunds. The syrup was washed into a foul sewer and passed to a sewage treatment works. The discharge far exceeded the capacity of the sewage works and four days later 50 tonnes of chemical oxygen demand were present in 20km of the River Lark. River engineering works isolated the plug of pollution which was then treated to increase the oxygen content. Treated river water was then returned to the main flow. Although over 27,000 fish were rescued, almost 15,000 were killed. Over 100 staff were involved at a cost of £145,972.

Nutrients

A4.16 In April 1980 a fire at a farm in Sussex resulted in a mixture of fire-fighting foam, 1 ton of ammonium nitrate fertiliser and the combustion products of old vehicle tyres entering the River Lod, a tributary of the River Rother. This effluent had a BOD level of 3,250mg/l, an ammonia concentration of 1,390 mg/l and nitrate (as N) was 1,420 mg/l. 350 trout, dace and roach were killed. There are advantages in allowing fires to burn themselves out thereby preventing large volumes of contaminants from entering watercourses. It is recommended that, where agreements do not already exist, the NRA should discuss with relevant Fire Brigades this environmentally friendly option.

A4.17 In August 1986, 32,000 litres of NPK liquid fertiliser escaped from a ruptured storage tank and entered the River Iwerne in Dorset. The storage tank had become corroded and the butyl lining was unable to cope with pressures caused by bulk delivery. The tank manufacturer had previously sent two warnings of the risk of corrosion. At a short distance downstream a fish farm suffered almost total loss, with mortality of 360,000 fry and 10,000 growers. Fish deaths in the river were also reported. Aquatic invertebrates were significantly affected although some did survive. Contaminated riverwater was pumped to land and no wild fish were lost downstream of this point.

Pesticides

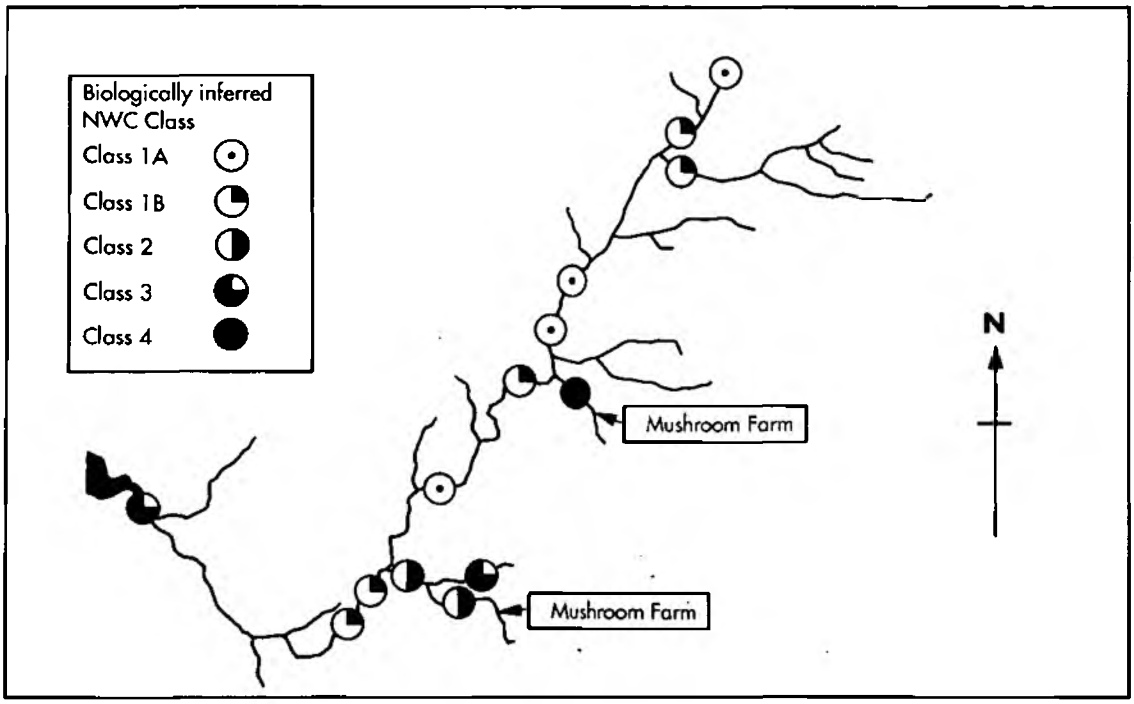
A4.18 In April 1990, the Soulton Brook, a tributary of the River Roden in Shropshire was polluted by run-off containing the pyrethroid insecticide, alpha cypermethrin. A field of oil seed rape had been sprayed on 5 April. It is believed that rainfall on 9 April washed the pesticide into the field drains. On 12 April it was evident that mayflies were dead and dying at a point about 10 km downstream. Investigations to identify the source of the pollution indicated that aquatic macro-invertebrates had been seriously affected throughout this length of river. The source was identified on 23 April when discussions with the farmer confirmed the previous use of cypermethrin. There is no routinely available method of analysis for this compound so a sequence of gc-ms and gc-ecd was used. A concentration of 3.5 μg/l was found in the discharge and one of 25.9 μg/l in a drain sump in the field. Cypermethrin is toxic to bees at 0.059 μg/l (24 hour LD50) and to fish at 2.8 μg/l (96 hour LC50). There was no evidence of fish being affected, probably because of dilution effects.

A4.19 In September 1979, the River Glaven in Norfolk was polluted by a discharge containing the insecticide triazophos. A quantity of this material had been used on a farm some days previously and it is believed that residues from the containers had contaminated surface water, which had entered a lagoon used to treat vegetable washings. Although dilution must have been considerable the discharge was toxic and both invertebrates and over 1000 fish were killed over a distance of about 3 km. It is believed that less than one litre of the pesticide had caused this mortality.

A4.20 In September 1989, the Melkridge Burn in Northumbria Region was contaminated by used sheep dip solution. When interviewed the farmer admitted that sheep dip liquor had entered the stream through a hole in the side wall of the sheep pen. Furthermore, the dipped sheep had waded through the watercourse and the spent dip liquor was being disposed of onto ground next to the stream. The farmer claimed that he had been dipping sheep and disposing of the liquor in the same way for over 25 years. Phenol, a major constituent of sheep dip, was found in the water downstream. Aquatic juvenile stages of mayflies were killed downstream as were about 20 fish. Post-mortems on these revealed damage to the gills and haemorrhaging of the livers which is consistent with deaths being caused by toxic poisoning.

A4.21 In July 1987, the Croyde Stream in North Devon was polluted by a discharge containing pentachlorophenol (PCP). The source was a mushroom farm where a large number of wooden crates had been dipped in a wood preservative containing PCP and stacked on site. Excess preservative had been tipped onto an adjacent earthbank. It was concluded that rainfall had caused leaching of PCP into road drains and hence to the watercourse. One sample of the effluent contained 7500 μg/l PCP. A large number of eels were killed over at least 2 km and at a bathing beach 3 km downstream, public access was restricted.

Figure A4.3 River Conder biological survey



A4.22 In May 1989, the Blockley Brook, a tributary of the River Stour in Warwickshire, was contaminated by run-off containing the insecticide, triazophos. The cause was inadequate storage resulting in yard drainage being contaminated. A concentration of 990,000 ng/l was recorded in the yard drainage and levels in excess of 300 ng/l were found in the River Stour 30 km downstream. Aquatic invertebrates were affected over a distance of 9 km, and many hundreds of fish were killed over more than 30 km. Despite restocking the trout population had not fully recovered after 18 months.

A4.23 Two mushroom farms on the River Conder in North West Region have been responsible for a number of fish kills since 1976. In 1979, 900 gallons of the disinfectant 'Santobrite' escaped from one farm. Aquatic invertebrates were affected and fish stocks were wiped out. Routine water quality monitoring has detected the presence of pentachlorophenol (PCP), a timber preservative implicated in other incidents involving mushroom farms. Biological monitoring has been undertaken routinely since another incident in 1984. This indicates no long term recovery suggesting that toxic discharges continue as shown in Figure A4.3. In September 1990, there were no live invertebrates in a sample taken immediately downstream of one of the farms. The discharges also cause nutrient enrichment and encourage excessive plant growth.

Oil

A4.24 In April 1990, 200 litres of diesel oil polluted the Eastern Cleddau in Wales. The cause was a spillage from a bulk delivery to tanks with insufficient capacity and no bunding. The oil entered a surface water drain and then the River Cleddau. At a fish farm about 1 km downstream, rainbow trout flesh was tainted and the fish rendered unfit for sale. A potable water supply intake about 10 km downstream was closed for several hours whilst the oil passed.

A4.25 In February 1990, 500 litres of diesel oil entered a tributary of the River Waveney in Suffolk, when a sight tube on a storage tank became dislodged. The valve on the sight tube had been left open and although the tank was bunded, the bund drain valve had also been left open. Oil was observed for a distance of 4 km, leading to public complaints.

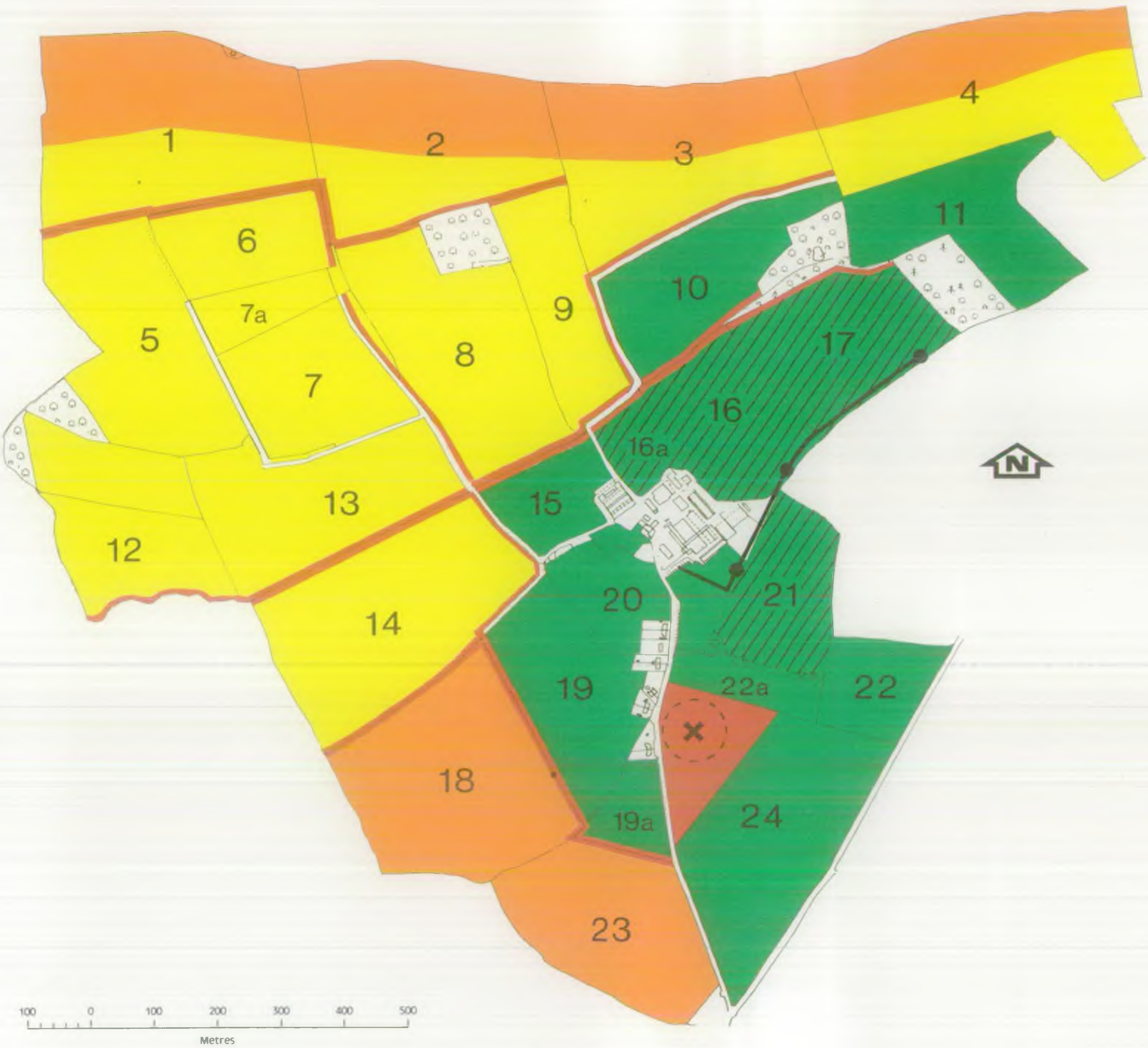
APPENDIX 5

A Farm Waste Management Plan

A5.1 Farm waste management plans will probably need to include a small amount of text and a map of the farm, indicating areas suitable for waste disposal. Factors which will need to be taken into account include topography, geology and soil type, land use, location of drains, watercourses and boreholes, season and rainfall.

A5.2 The attached example map has been produced by ADAS and is reproduced with permission.

EXAMPLE FARM WASTE MANAGEMENT PLAN



Job title:

HOME FARM

Storage and Application of Slurry and Dirty Water

Pollution Risk Classification

- Non spreading areas
- Very high risk
- High risk
- Lower risk
- Irrigated area
- Irrigation pipeline
- Borehole

Date: July 1991

Based upon the 1976 Ordnance Survey 1:10000 map with the permission of The Controller of Her Majesty's Stationery Office, Crown Copyright Reserved.

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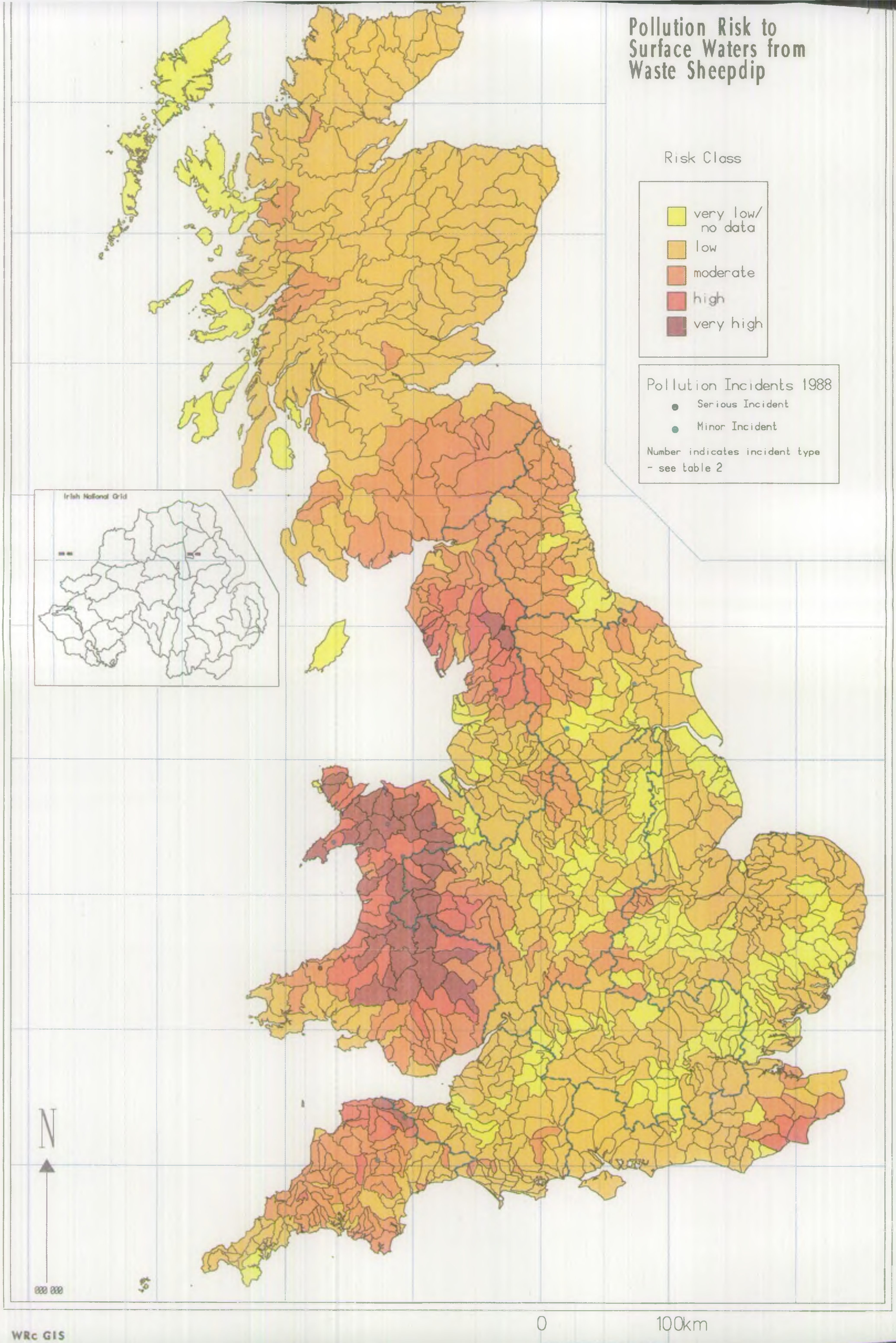
APPENDIX 6

Example Pollution Risk Assessment Map

A6.1 The pollution risk to surface waters from waste sheep dip was assessed using calculations of total waste dip, modified by factors for catchment area, slope, rainfall and winter rainfall acceptance potential. Similar assessments have been done for a number of other contaminants.

Source: Mainstone, C.P., Rutt, G., Pickering, T., Woodrow, D., Bascombe, A. D. & Turner, C., 1991. Sources of farm pollution and impact on river quality. WRc Interim Report, xi + 291 pp + annex.


Pollution Risk to Surface Waters from Waste Sheepdip
Risk Class
very low/ no data
low
moderate
high
very high
Pollution Incidents 1988
Serious Incident
Minor Incident
Number indicates incident type - see table 2
Irish National Grid
N
0
100km

WRc GIS

NRA

National Rivers Authority