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Summary.

The failure of some water supplies to meet the standards set by the EC's 1980 Drinking Water Directive has highlighted several deficiencies within the current system of pesticide regulation. The prevailing regulatory philosophy relies on the screening of new products before they come onto the market, and so pesticides that would pose undue risks to people and the environment should not pass this first and most important hurdle. This style of regulation, in principle, has many merits. However, the way in which it has been mobilized to control the harmful effects of agricultural pesticides in Britain, through the prior approval system, reveals a number of weaknesses. An underlying problem is the agricultural orientation of the approach. The Ministry of Agriculture, Fisheries and Food (MAFF) exercises overall control of the regulatory system, and the interests of agriculture and agribusiness seem sometimes to be favoured at the expense of water consumers and the general water environment.

Specific weaknesses internal to the approval system itself are discussed in this report. These weaknesses have so far failed to undermine official confidence in the security of the approval system and its complacency towards those pesticides actually in use.

One assumption of the approval system is that the proper application of pesticides on the farm can be left to self-regulation, with emphasis on the farmer using pesticides responsibly and safely. This assumption allows commercial advisors to have a large influence over spraying decisions. The Agricultural Inspectors of the Health and Safety Executive (HSE), who have responsibility for regulating pesticides on the farm, pay only infrequent visits and then tend to concentrate on worker health and safety. As a result, examination of how pesticides are stored is far from comprehensive, while scrutiny of how they are **used** is negligible. Environmental regulators such as the National Rivers Authority (NRA) play only a marginal role.

Currently, the Government's preferred solution to the water pollution problems uncovered by monitoring for pesticides under the Drinking Water Directive is to revise the maximum admissible concentrations (MACs) for pesticides in water, stipulated in the Directive. Up to now such action has been outside the government's control, but operationalising the principle of

subsidiarity within the EC may change this. The UK government has pressed for some areas of regulation, including water quality, to be reviewed in this context. A possibility is that the current EC standards for pesticides in drinking water could be replaced by limits for individual substances determined according to toxicological information. However, although such individual tailoring of limits has a logical appeal, in practice there are large variations between countries and scientists in what counts as 'acceptable' concentrations for drinking water.

In this report[1], we document the problems of monitoring pesticides in the environment. Systematic monitoring for approved products has not been deemed necessary under the British system which has tended to wait until a pesticide in use has had demonstrably adverse effects before taking action, rather than relying on a further layer of precautionary monitoring. In fact, current concerns over pesticides and official reviews of the herbicides Atrazine and Simazine have been stimulated by the results of monitoring under an EC Directive rather than a specifically British scheme. Even now, very little detailed information is available on the geographical distribution of pesticide use.

Action on pesticides which have breached the EC standards has been confined to the treatment of contaminated drinking water by water companies and the banning of some pesticides with acknowledged problems. Commercial interests have contributed to the improvement of spraying technology, but this has been as much to reduce costs and the hazards to operators as to protect the environment. Measures to reduce the amount of agrochemicals applied to land, such as those being tried for nitrates, have so far not been pursued in Britain.

Our analysis of agricultural pesticides draws on research carried out in the upper catchment of the Great Ouse (in Bedfordshire and Buckinghamshire), where rising levels of agricultural pesticides, particularly herbicides used on cereals, have been detected in water supplies. Intensive interviews were conducted with cereal producers; in-depth interviews, with private companies and public organizations that influence farmers' pesticide use and management; and public sector advisors from the Agricultural Development and Advisory Service (ADAS) and regulators (NRA and HSE) were accompanied and observed in the field.

In the report we argue that the EC standards for pesticides in drinking water should not be relaxed on the grounds that there is uncertainty over toxicity levels and merit in the precautionary principle which informs the existing standards. However, the issue must not be confined to drinking water standards and the impact on human health alone. Debate should be broadened to address the impact and regulation of pesticides in the environment as a whole. The current regulatory system, and the philosophy underlying it, fails to adopt this holistic approach. Furthermore, it is complex, bureaucratic, expensive, unco-ordinated and difficult to police. A more effective regulatory system would ***proceed from*** environmental standards as over-riding criteria. It would focus on control over usage and direct monitoring and policing efforts to achieve and maintain environmental quality.

Part One: The Problem of Agricultural Pesticides in Water.

Opinions sharply differ on the significance of the problem of agricultural pesticides in water. In this section we explore how the 'problem' has emerged and been framed. The EC Drinking Water Directive (80/778/EEC) has brought pesticide contamination of water to public attention and thus most of the discussion has centred around the dangers to human health. Conversely, the impact on the water environment in general has received little attention.

1.1 Trends in Pesticide Use in Britain.

It was not until after 1945 that agrochemicals became the mainstay of pest control in British agriculture. The shift in emphasis in agricultural policy in the early 1950s - away from simply increasing output to encouraging improvements in efficiency and containing the costs of price support - was the most important stimulus to the use of pesticides. The cost-price squeeze after 1951 meant that farmers had to increase their efficiency to maintain or improve their incomes, and the adoption of agrochemical technologies helped to achieve this.

Advances in the development of agrochemicals and the promotion of cost-reducing and yield-boosting technologies meant that, by the mid-1960s, about 200 pesticides were in common use in Britain. Herbicides were a particularly important innovation and were first used on a widespread scale in the 1950s and 1960s as cereal production expanded and rising labour costs made hand hoeing unviable (Tait, 1981). The use of selective herbicides enabled farmers to move from the traditional system of crop rotation to continuous cereal cropping and was thus instrumental in transforming arable crop production methods.

Between 1948 and 1982, total home and export sales of pesticides rose from £107 million to £828 million (both at 1991 prices), and by 1991, over 500 different products were available under 1300 different brand names, and total sales were up to £1.17 billion (at 1991 prices) (DoE, 1983, p.3; BAA, 1992, p24). Against the availability of such market information since the 1940s, comprehensive data on pesticide **usage** in Britain has only been available since 1974, from ADAS's Pesticide Usage Surveys of a random sample of farmers. Between 1974 and 1982, the quantity of pesticides used in Britain (in terms of tonnes of active ingredient) more than doubled (see Table 1), but has fallen since the mid-1980s, with a decline of more than 17% between 1980 and 1989 in England and Wales (Foulkes, 1991, p.25). This decline is sometimes taken by agricultural interests to imply diminishing cause for concern (see Maclean quoted in Foulkes, 1991, p.25; Madden, 1992, p.54), but the decline in weight of active ingredient applied has been due, in part, to a gradual shift towards more potent products. Moreover, in terms of tonnes per km^2 the use of pesticides in the UK is higher than in most other OECD countries (see Table 2). By 1988, herbicides accounted for 61% of all pesticides and were applied to 97% of arable crops. Currently, the most extensively used active ingredients (in terms of both area sprayed and tonnes applied) are Mecoprop, Isoproturon, Ioxynil and Bromoxynil (Davis et al., 1989; 1990).

1.2 The Emergence of a Pesticides in Water Problem.

The pollution of surface and groundwaters by agricultural pesticides only began to emerge as an issue of public and political concern in the 1980s. The Royal Commission on Environmental Pollution, in its 1979 study of agriculture and pollution, devoted over a quarter of its report to looking at pesticides but the pollution of water was not specifically dealt with. Rather, the main areas of concern were the risks to human health from pesticide residues in food, risks to farm workers from contact with sprays, and to wildlife from cumulative effects in the food chain (RCEP, 1979). The only threat to watercourses from pesticides was perceived as coming from the careless disposal of containers or spray tank washings which, it was felt, could cause acute, but transient incidents (Tait, 1981). Indeed, it has been suggested, with respect to pesticides in water, that;

> "*the phasing out of the organochlorine pesticides, together with an absence of good monitoring data, and few cause and effect relationships seems to have generated an atmosphere of complacency*" (Otter, 1992, p.1).

Events during the 1980s challenged this complacency, and there is now a greater effort to clarify the means by which agricultural pesticides contaminate ground and surface waters (see, for example, Walker, 1991;

RASE/ADAS, 1992; Gomme *et al.*, 1991; 1992; Greig-Smith *et al.*, 1992).

The EC's Drinking Water Directive, agreed in 1980, has been instrumental in bringing pesticide contamination of surface and groundwaters to the attention of scientists, policy-makers and pressure groups, and thus to the wider public in Britain. The Directive established a very low maximum admissible concentration (MAC) of 0.1μg/l for any individual pesticide and 0.5μg/l for total pesticides.

These were the first legally enforceable numerical standards for pesticide pollution of water. Not only did they establish a definite regulatory threshold, but also an authoritative norm which framed the very definition of pesticide contamination as a public problem. Previously, little information on the problem existed. Friends of the Earth (FoE) had attempted to monitor the environmental impacts and health hazards of pesticide use (see FoE, 1985; Rose, 1990), and incidents reported by members of the public and local FoE groups were collated in an effort to "show that a major problem of pesticide pollution exists" (FoE, 1985, p.ii). Many of the reported incidents involved people in the countryside suffering from contact with pesticides, but a few cases referred to pesticides having entered watercourses. However, the dearth of information on the extent of the threat to water was evident.

The introduction of the MACs meant the provision of both a yardstick against which the extent of pesticide pollution in water could be measured, and of an EC-mandated requirement to monitor drinking water sources in order to demonstrate compliance. This provided, for the first time, an opportunity to quantify the problem, and the public availability of the data enabled environmental groups to 'get a handle' on the issue. Thus, after the enactment of the Directive in Britain, FoE was able to collate monitoring data collected as a requirement of the Directive. Data from 10 Water Authorities and 28 Statutory Water Companies revealed that, between July 1985 and June 1987, the EC's MAC for any single pesticide had been exceeded in 298 water supplies and the MAC for total pesticides had been exceeded 70 times (FoE, 1988). The worst affected regions were East Anglia and Thames (see Table 3). FoE's report and the publicity it attracted brought the now measurable problem of pesticide pollution of water to wider public attention.

More recently, FoE have been able to use the data which water companies are obliged to submit to the Drinking Water Inspectorate to calculate that at least 14.5 million customers in England and Wales were supplied with drinking water which breached the standard for pesticides in 1992 (FoE, 1993). Such calculations are only made possible by the monitoring required by the Directive.

Compliance monitoring demonstrated the geographical spread of water pollution from pesticides, showed that pesticides were being detected more frequently, and at higher levels, in surface waters than in groundwaters, and pointed to herbicides as the most common cause of contamination. This evidence was supported by scientific studies which had considered the risks to water from pesticides (Lawrence and Foster, 1987; Croll, 1986; 1991). One such study by the British Geological Survey in 1986 recognised that accidental spillages or the disposal of containers were not the only threat to water quality, and concluded that the greatest threat "from the normal use of agricultural pesticides" was being posed by "the relatively soluble herbicides that are very widely and regularly applied for weed control in cereal production" (Lawrence and Foster, 1987, p.26).

Figure 1 shows the variety of routes by which pesticides may reach watercourses. The ignorant or deliberate discharge of pesticides into watercourses, via, for example, leaky stores, careless disposal of containers and direct spraying, is generally characterised as point source pollution. Concentrations rise rapidly over a short period of time and the source can often be unambiguously assigned. In constrast, diffuse pollution tends to arise from normal agricultural practices as pesticides make their way from their target to surface and groundwaters over longer periods of time, and it is difficult, if not impossible, to assign this type of contamination to a specific farmer.

The threat from run-off has been assessed as part of the 'Granta Catchment Pesticide Study' in Cambridgeshire, one of the most detailed investigations of the movement of pesticides in the water environment (see Hennings et al., 1988; Clark et al., 1991; Gomme et al., 1991; 1992). Findings suggested that much of the pesticide detected in rivers was washed from the land, often via field drains. This has two important implications. First, most pollution would be expected to occur during and immediately after periods of rainfall as the pesticide gets washed in 'pulses' into rivers. Secondly, routine monitoring of pollution needs to recognise that the threat is related to rainfall in order to pick up these pulses.

Groundwaters tend to be at risk chiefly from the normal spraying of pesticides on land. Generally, only between 10% and 40% of pesticides applied reach their target (weeds or pests). A significant proportion remains in the soil, and this is greater for those pesticides aimed at plant roots rather than leaves. Herbicides pose the greatest risks, not only because they are are applied in by far the greatest quantities (Table 1), but also because they are often applied directly onto soil to kill weeds as they emerge (Foster et al., 1991), leaving them more prone to being washed away in rain.

However, scientific knowledge concerning the movement of pesticides in water is far from complete, as is knowledge of the impact of very small but frequent doses on public health. Indeed, given the profound difficulties of tracing the fate of small molecules in large and complex biological systems, it may never be. The problem is compounded by analytical difficulties when small amounts are being measured. Although the measurements may appear precise, their accuracy is much less certain. The levels of error - up to 300% - mean that concentrations could be much higher, or much lower, than those recorded (Hance, 1990). These uncertainties have left the framing of the issue open to contestation between different groups.

1.3 Controversy over the Standards for Pesticides in Water.

Pesticides are biocides and are, by their very nature, specifically designed to kill living things. The very thought of weedkiller in drinking water causes public alarm and this is seldom tempered by scientific evidence of the scale of the problem. However, the science is itself partial and not beyond dispute. Ultimately, what is an acceptable level of risk is a matter for social choice. While effected commercial interests understandably stress the costs involved in implementing strict standards, they also seek to minimise any existing risks. However, although it is important to keep such risks in perspective, pesticide contamination of water is a legitimate public concern.

The strength of public concern and the extent of scepticism about scientific assessments of health risks have been highlighted by a recent Gallup opinion poll. When asked 'would you accept more pesticides in your drinking water if you were told that the levels were not dangerous and water charges were lower as a result ?', 77% of respondents said 'No' (Clover, 1993).

It is generally agreed that the EC's MACs represent a strict standard, and some would argue too strict. When the individual MAC was established at 0.1μg/l, it was at the time equivalent to the detection level for pesticides like DDT, and was thus a surrogate zero (RCEP, 1992, p.126, para 7.142). In keeping with this position, a number of organisations have expressed the view that "pesticides have no place in drinking water", including FoE (Daily Telegraph, 26th July 1993, p.4) and the European Commission (see ENDS, 1993, p.37). In principle, this would mean progressive revisions to the MACs, because, as the British Agrochemical Association points out, improvements in monitoring mean that "zero", in terms of what can be technically measured, is becoming ever smaller (BAA, 1992, p.10).

The pressures, however, are operating in the other direction, to relax the existing standards. The main pressures come from the affected commercial interests, particularly the agrochemical industry and the water companies. In Britain they have won the support of the Government to press for a review of the MACs and the operation of the Drinking Water Directive. Their main challenges relate to the costs of implementation and the scientific basis of the MACs for protecting health.

The Government too has been unwilling to concede that a general health risk of any significance exists and there has been continuing contention with the European Commission over compliance with the Drinking Water Directive (see, for example, Seymour *et al.*, 1992; Wilkinson, 1993). Since the introduction of the pesticide MACs, the Department of the Environment has provided its own list of toxicologically derived maxima called advisory values (AVs) drawing on guide values adopted by the World Health Organisation in 1984 (DoE, 1989). Most of the DoE's AVs are higher than the EC MACs, but meeting the MACs must remain the formal long term policy objective in Britain while they remain the **legal** limits. Water companies are exempted from legal action when the pesticide MACs are exceeded providing that the following conditions are met: the DoE's AVs are not also exceeded; the water company gives an 'undertaking' under Section 19 (1) (b) of the Water Industry Act 1991 to meet the MACs by upgrading water treatment practices; and the Secretary of State for the Environment has published Notices of Satisfaction.

The British Government has been pressing the European Commission to review the MACs for some time, driven partly by the high cost of treating water to remove pesticides (Maddox, 1992). In order for water supplies to meet the MACs, "considerable additional treatment" is required at waterworks involving the use of activated carbon filters to remove pesticides (Croll, 1991, p.389). Improved water treatment entails substantial additional investment on the part of water suppliers, who can then pass on the costs to consumers. A survey by ENDS has found that those water companies committed to making early reductions in pesticide levels in drinking water will need to invest £800 million in improved water treatment, and annual operating costs will rise by £80 million (ENDS, 1992a, p.9).

As can be seen from Tables 4 and 5, a switch from the EC MACs to AVs similar to those proposed by the British Government would eliminate much of the problem at the stroke of a pen, for while breaches of the MACs are common, breaches of the AVs are rarer.

As well as supporting the efforts of the British Government, the water companies are acting with others through their European federation, Eureau, to urge relaxation of the MACs (Eureau, 1992). However, there has been a growing awareness among these groups that it may be politically unacceptable to change the MACs and a compromise has been suggested. Although the existing MAC value for individual pesticides would be retained, it would be downgraded to a 'trigger value' for "a range of preliminary and corrective measures" (Johnen, 1990, p.11), and its legal limit status transferred to a second toxicologically-based value. Likewise, Ofwat, the regulatory body charged with overseeing changes in water charges and protecting the interests of water customers, has pressed the Government to consider renegotiating EC standards where they "place an unmanageable burden on customers" (Ofwat, 1993, p.13).

In the UK, the costs of implementing the Directive have been very narrowly framed in the above terms, focusing solely on water treatment options. Since the privatisation of the water industry in 1989, such costs incurred in order to meet EC standards can be automatically passed on to the water consumer. A different approach, embodying the polluter pays principle, might encourage more cost effective solutions which would tackle the **causes** rather than the **symptoms** of the problem.

The agrochemical companies, through their trade association, the British Agrochemical Association (BAA), are also pressing for the MACs to be reviewed. The BAA also lobbies through its international association, GIFAP, based in Brussels (see GIFAP, 1990). The BAA (1992, p.10) points to the Drinking Water Inspectorate's (DWI) findings and associated medical evidence which suggests that the amounts of pesticide ingested with drinking water are unlikely to cause harm. The EC's MACs, indeed, have been widely criticised for having no toxicological basis (see, for example, GIFAP, 1990; Fawell, 1992). With this in mind, the Government has argued that the approach to pesticide residues in water "should be similar to that adopted for pesticides in food", and that they should be regulated according to human toxicology and the likelihood of their presence in water (UK Government, 1991, pp.18-19).

However, the assumptions underlying the toxicological basis of pesticide standards have been questioned recently because of concerns in the U.S. that they do not adequately protect vulnerable groups like infants and children, who differ both quantitatively and qualitatively from adults in their exposure to pesticides. A report by the National Academy of Sciences on pesticides in the diets of infants and children also highlighted the consumption of pesticides in water as "an important potential route of exposure" (National Research Council, 1993, p.11).

Not only are existing toxicological standards being questioned, but for many pesticides the toxicology has not yet been done, and synergistic relationships have been barely explored. In such a situation, the precautionary principle suggests the retention, not the loosening, of strict standards. The Royal Commission on Environmental Pollution has also cautioned against reliance solely on advisory values set at levels to protect human health, as "they may not be suitable for the protection of aquatic life.

Experience has shown this to be the case" (RCEP, 1992, p.126).

In these debates, it would be misguided to see strict quality standards as being 'imposed' on Britain by 'Brussels bureaucrats'. On the contrary, the Directive was agreed by all the Member States, who jointly share responsibility for its stipulations. It has sometimes been convenient for British politicians to overlook this fact, and as part of the 1992-1993 'backlash' against European integration, water standards were singled out for attacks on the EC's 'regulatory zeal'. It was argued, with reference to the principle of subsidiarity, that standards should be set by national governments. However, the EC has been reluctant to re-open this issue and consider relaxing the standards. The then Environment Commissioner, Carlo Ripa di Meana, said in 1989;

> *"To introduce a higher maximum admissible concentration for each pesticide in drinking water, simply to avoid the need for any alteration in current pesticide usage, would constitute a departure from [the EC's precautionary] policy, and one which consumers of drinking water would surely consider unacceptable"* (quoted in ENDS, 1990b, p.31).

More recently, it has been reported that the EC "does not envisage making a proposal to change [the MACs]" (quoted in ENDS, 1992c, p.37).

The rest of this report examines the regulatory framework for pesticide pollution and discusses how it works in practice. Particular attention is paid to the advice given about pesticides, their use by farmers and their detection in water. We then go on to examine current responses and explore possible future scenarios. These scenarios are based on fieldwork conducted in Bedfordshire and Buckinghamshire in a study area centred on the catchment of the River Ouse. This is part of the region of Britain most dominated by cereal production, East Anglia. Surface and groundwaters have been routinely monitored for certain pesticides since 1985, successively by the Anglian Water Authority and its privatised successor, Anglian Water Services Ltd. (see Croll, 1986; 1991). By 1990, 700 water samples had been analysed, and Isoproturon was found to be the most frequently detected pesticide in surface waters, followed by Atrazine, Simazine, Chlortoluron and Mecoprop (see Table 4). Isoproturon, Atrazine and MCPA at times exceeded not only the MAC, but also the British AVs. The detected frequency of pesticide pollution of groundwaters was much less although still provides an important cause of concern (Table 5), with Atrazine the most prevalent, followed by Simazine and Isoproturon.

Atrazine and Simazine are used widely outside agriculture for weed control on highway verges, railway land and industrial sites. This leaves Isoproturon as the most commonly detected **agricultural** pesticide in Anglian waters. Isoproturon (IPU) is a pre-emergent herbicide used to kill weeds such as black grass and wild oats in cereal crops. It is the third most commonly used pesticide on arable crops in terms of weight of active ingredient. Over 2700 tonnes are applied in Britain each year (NRA, 1992a, p.138). The use of IPU and the possible implications of future regulatory controls will, therefore, be examined in Part 6 of this report. In the next section, we review the way in which the current pesticide regulatory system operates.

Part Two: The Pesticide Regulatory System.

In this section we outline the structure and operation of the current system of regulating pesticides and highlight its weaknesses. We argue that the system has been largely geared to health and safety issues, with much less attention to the environmental impacts of pesticides. In particular, reliance on self-regulation is undermined by a number of unrealistic assumptions about the way in which pesticides are used, including the assumption that pesticides are only applied in suitable field conditions and that guidelines for use will be closely followed.

In Britain, a complex regulatory network covers the introduction, manufacture and application of pesticides. This is outlined in Figure 2, which, it should be noted, refers only to **agricultural** pesticides. (There are slight differences for non-agricultural pesticides such as those used in timber treatment). In addition, although agriculture is the most extensive user of pesticides, some of the same chemicals are also used by other industries.

Before a totally new pesticide intended for agricultural use can be sold on the market it has to be approved. (This aspect of the regulatory system is represented by Column I in Figure 2). The pesticide manufacturer has to satisfy the regulators that the product does not present an "unacceptable risk to the environment, consumer or operator" (Tooby and Marsden, 1991, p.3). The information required to do this comes from both field and laboratory research and usually includes toxicity, metabolism, residue and environmental studies. Field trials are used to determine the chemical's efficacy in protecting crops against the targeted weeds, pests or diseases, and environmental studies aim to evaluate the behaviour of the chemical in soil and water, including its mode of degradation. Studies typically cover the possibility of impacts on fish and other aquatic organisms, birds, mammals, insects, and soil organisms.

The manufacturer then submits a dossier on the product to MAFF's Pesticide Safety Division (PSD), which assesses the data and may ask the company to undertake additional studies. Advice from other scientific experts may also be sought. The PSD's evaluation report, the raw data, and any other relevant material are then passed to the Advisory Committee on

Pesticides (ACP) which advises the Minister (who is responsible for the final decision) on the granting of approval. The ACP also makes specific recommendations concerning the statutory conditions of use which will appear on the product label. These include: the pests, weeds or diseases against which the product can be used; the crops to which it can be applied; the maximum dose rate and number of treatments; the timing of applications; any special restrictions regarding temperature, wet weather, soil type and the like; operator and environmental protection requirements; and how the product should be stored and its container disposed of.

This system was set up under the Food and Environment Protection Act (FEPA) 1985 and implemented through the Control of Pesticides Regulations (COPR) 1986. Prior to this, assessment of new products was carried out under a voluntary scheme operated by the manufacturers, which was generally less thorough. COPR also provides for any pesticide to be recalled for review if new data comes to light and for all pesticides to be reviewed once every ten years. However, although these reviews are now proceeding (MAFF, 1990), many older active ingredients have not yet undergone the more stringent testing now required, especially concerning their fate and behaviour in the environment.

The usage of pesticides on the farm comes under both COPR and the Control of Substances Hazardous to Health (COSSH) Regulations, which cover any such substance and not just pesticides. (This aspect of the regulatory system is represented by Column II in Figure 2). COPR requires farmers to comply with conditions of approval as they appear on the pesticide label, including any conditions intended to protect the environment. These regulations also cover the certification of users (although many older farmers are exempt from obtaining a certificate of competence in spraying), the storage of pesticides on the farm, and the qualifications required by those who provide advice in the course of selling pesticides. Under the COSHH Regulations, the user is required to assess the risks before applying a particular pesticide, but here the emphasis is on the health risks to the user and the public. Written records have to be kept of 'COSSH assessments', and also of all pesticide applications. MAFF and the Health and Safety Executive (HSE) have jointly issued a Code of Practice costing £5 (MAFF/HSE, 1990), which is intended to help farmers and other users comply with both COPR and the COSSH Regulations. MAFF delegates its responsibility for policing COPR to HSE's Agricultural Inspectorate, which is also responsible for policing the COSSH Regulations.

The control of pollution of watercourses by pesticides comes under the 1989 Water Act (now consolidated by the 1991 Water Industry Act and Water Resources Act) and is the responsibility of the NRA (Column III in Figure 2). Point source incidents on farms tend to be rare (NRA, 1992b) and are dealt with by prosecution if appropriate. However, diffuse pollution presents much more intractable problems. As has been described above, the detection of low concentrations of pesticides in surface and groundwaters provides proof that contaimination occurs, but its extent is difficult to gauge and agriculture is not always the culprit. Detection relies on specific research projects and monitoring of river quality, both of which have been selective in terms of the localities observed. Some monitoring is carried out by NRA regions, but although some have now instigated systematic programmes, in general, monitoring schemes remain quite poorly developed and coverage is still patchy.

Drinking water and its sources are now subject to more extensive monitoring because there is a statutory duty to ensure that pesticides in drinking water do not exceed the EC MACs. This monitoring, which is carried out by the water companies or their agents, is regulated via the 1991 Water Industry Act and overseen by the Drinking Water Inspectorate (Column IV in Figure 2).

Finally, various standing committees exist to investigate certain impacts of pesticide use. In particular, incidents where public health may be affected (including cases where members of the public have been exposed through spraying) are considered by the Pesticides Incidents Appraisal Panel (PIAP) based at HSE(2), while incidents involving birds, mammals and honey bees are examined by MAFF's Wildlife Incidents Investigation Scheme (WIIS).

The regulation of agricultural pesticides is thus characterised by a complex and highly fragmented structure, with a variety of agencies having different responsibilities concerning approval, advice, usage and monitoring. The key element, however, is the approval system, the point at which regulatory powers are strongest. This is also the aspect of the system which has been particularly criticised by the agrochemical industry and agricultural interests, who have complained about the length of time taken for a pesticide to be approved, arguing that this can put British farmers at a competitive disadvantage (BMA, 1992, p.66). In an unusual alliance, they joined forces in 1989 with environmental groups and issued a joint letter proposing that reviews of older pesticides should be speeded up and the waiting time for approval of new products reduced to a year to enable new safer products to be brought onto the market more quickly.

However, in our view, the difficulties with relying on a strategy of prior approval extend beyond its bureaucratic deficiencies and lack of resources. The intention of the prior approval system is that pesticides likely to contaminate soil and water should not reach the market in the first place. This strategy relies heavily on the predictive powers of science including the skills of those involved in the development of new pesticides (company scientists) and in the assessment of environmental risk (regulatory scientists). However, current understanding of the movement of pesticides in the environment is patchy, and their behaviour is difficult to predict from laboratory tests (Tooby and Marsden, 1991; Carter 1991). This casts doubt on the extent to which problems can have been forestalled for those products introduced since 1986, or would be forestalled had all products been subject to the more rigorous testing now required. Although further research may improve understanding of the behaviour of pesticides in the environment and their impact on it, the complexity of both biological systems and the chemical and physical processes involved mitigates against predictive methods ever being able to provide absolute safeguards.

More than this, the corollary of allowing only 'safe' pesticides onto the market is that they **must** be used as directed. Yet the present system is characterised by a huge imbalance in regulatory effort, with intervention focussed primarily on the approval process, to the neglect of pesticides in use and their threat to water environments. The same alliance that called for the overhaul of the approval system has also recognised this weakness and argued that at least 100 extra HSE inspectors should be appointed to enable effective enforcement of the regulations (BMA, 1992, p.66).

To what extent such an increase in resources might redress the balance is arguable. On the part of the pesticide companies, at least, the call for a quickening of the prior approval system reflects the 'productivist' view of agriculture, within which pesticides are seen as an indispensible technology in the maximisation of agricultural productivity. Our examination, in the next three parts of this report on advice, use and monitoring, suggests that rather more thorough-going reform is required.

Part Three: Pesticide Advice.

3.1 Advising British Farmers on Pesticide Use.

Pesticide use is an aspect of agricultural practice where farmers are particularly dependent upon technical advice. The chemistry of crop protection has become increasingly complex and beyond the level of knowledge that many farmers feel comfortable with (Lever, 1990). The complexity of the science has been compounded by the fact that the number of different pesticide products and brands from which farmers must choose has dramatically increased. There has also been a considerable growth in mixtures of active ingredients and distributors' 'own label' products, thus potentially confusing farmers even more (Metcalfe, 1982). Moreover, the costs of pest control have risen. In the case of wheat, for example, the proportion of variable costs attributable to pesticides rose from 8% to 36% between 1974 and the mid-1980s (Nix, 1989). This has come at a time when the regulation of agriculture has increased and the number of farm-workers has steadily declined. Thus, the demand for help with pesticide decisions from off the farm has correspondingly increased (Walker, 1987). A large survey by a market research group found that over 50% of British farmers regularly turned to outside advisors for guidance on pesticide use, and 22% admitted to feeling out of touch with technical developments in agrochemicals, product suitability and choice (Produce Studies Group, 1990; Agricultural Supply Industry, 1990). In our survey of cereal producers in the Ouse catchment, only 19% insisted that it was on the basis of their own expertise that they decided which pesticide to use. However, **all** of them consulted external sources of advice at some stage.

Besides the general information that is available through the farming press, there are five main sources of advice for British farmers on using pesticides: the agrochemical manufacturer, the agrochemical merchant, ADAS, independent crop consultants and arable farming research centres. The major difference between them is that while the first two also sell the products required to implement their advice, the latter three do not.

On-farm advice about pesticide usage comes overwhelmingly from the private sector, particularly from representatives of chemical merchants. This is supported by our survey findings in the Ouse catchment (see Table

6). (The role of agrochemical manufacturers in delivering on-farm advice has diminished in recent years because of the increased competition in off-patent pesticide markets and the cost of maintaining an on-farm sales force, and now most manufacturers' advice comes in the form of recommendations on the product labels).

In our survey, over half of the farmers identified the merchant's representative as their most important source of advice, in deciding both what type of pesticide to use and how best to use it, and none of the farmers interviewed said that they completely avoided advice from this source. Likewise, in their recent study, Fearne and Ritson (1989) found that most of the farmers they surveyed (64.9%) chose to turn to commercial representatives for advice on crop husbandry problems. Since the late 1960s, agricultural merchants have developed specialist expertise in chemical crop protection and chemical distribution now tends to be carried out either as a separate business or as a specialist division of the main merchant business (Walker, 1987). Sales staff usually offer pesticides for sale at two price rates. The higher rate will include regular technical advice from the merchant's own specialist arable advisors who will visit the farm and walk fields to assess crop protection requirements and advise on product choices and dose rates.

In contrast, ADAS, once charged with delivering government policy but now a public sector agency, represent a neutral source of advice on pesticide use. Its arable crop consultants are supported by a system of experimental farms and regional centres. Fearne and Ritson (1989) revealed how ADAS advisors still tend to be regarded by farmers as 'the man from the Ministry', despite their new found commercial role, and still tend to be used more by larger and more highly qualified farmers leaving the rest to rely largely upon private advice. As well as personal advice from ADAS on a consultancy basis, farmers can subscribe to an ADAS group to obtain more general advice which is tailored to local or regional conditions. Weather reports and news of pest infestations are circulated, for example, and farmers are advised about the timing of spraying and so on.

Some farmers that value up-to-date but general crop husbandry advice have banded together to fund arable crop research centres. The number of these has risen to more than 60 in England in recent years, drawing in many of the most progressive and innovative farmers. According to Skinner (1992), more than 10% of farmers with more than 20 ha of cereals are now members of research centres. This demand stems in part from distrust of advice from merchants' reps and manufacturers.

Furthermore, evidence from our survey suggests that the role of the main pesticide regulatory bodies in advising farmers about pesticide usage is negligible. While 57% of the farmers we interviewed had received some advice from the NRA, the Government agency responsible for protecting the water environment, no farmer found the NRA an important source of advice for choosing and using pesticides (Table 6). In addition, although the vast majority of farmers had had some contact with the HSE's Agricultural Inspectorate, no farmer found them an important source of advice on these issues, despite the fact that the HSE have the main responsibility for regulating and advising farmers on safety in pesticide use.

3.2 Dependence on Advice.

Farming's greater reliance on private companies who manufacture and sell inputs for technical advice has been cited as an example of the increasing control suppliers are able to wield over farming practice (see Clunies-Ross and Hildyard, 1992). Advisory services provided by commercial interests are seen essentially as a means employed by private companies to encourage farmers to buy their inputs.

A small and declining number of large multi-national companies dominate the markets for most inputs to agriculture, including agrochemicals. At the same time, the decline in the numbers of local merchants has tended to strengthen the links between the manufacturers and the merchants that remain, particularly through franchising and exclusive agency policies. This, in turn, has led to more intense contact between the farmer and agribusiness companies, which;

> *"although still framed in technical terms, has extended for many farms from a purely 'trouble-shooting' technical level to a regular managerial one"* (Hawkins, 1991, p.139).

However, suppliers argue that their strategies are not necessarily to maximise the sales of the product in the short term, but to maintain a share in the market. If they were to give advice to farmers that was not the most cost-effective, farmers could transfer their custom to other companies. Instead, it is argued that technical advice is used to foster customer loyalty through strengthening the links between company and farmer.

Nevertheless, the imperatives of the manufacture and distribution system does affect what advice is given. Pesticides are usually manufactured in batches, often over a year before they will be used. Similarly, merchants order products for the following year immediately after the previous harvest. While planning for the quantities required can be related to what has been sold in previous years, the weather still has to be guessed at, and weather conditions can have a marked effect on what types and quantities of pesticides are demanded. Merchants do not want to be left with unsold stocks, so they may find themselves having to try to sell products that may not necessarily be required, or which are not the most appropriate and, as long as a plausible technical reason can be found, they are able to do this. Moreover, because some sales staff are paid wholly or in part on a commission basis, there is an implicit incentive to sell more. Finally, manufacturers may wish to promote new products, and may offer discounts to merchants on selected lines.

The different sources of advice on pesticide practices do not provide farmers with clear choices between independent and commercial or 'paid for' and free advice. The distinctions are often quite blurred. While advice from commercial specialists attached to merchants is often cited as 'free' advice (see, for example, Fearne and Ritson, 1989, pp.48-49), farmers who avail themselves of it usually have to buy their pesticides at higher price rates. Conversely, although farmers who avail themselves of independent sources of advice pay less for their supplies, they have to pay directly for the advice they receive.

When farmers in our survey were asked if they felt there were differences in the quality of the information between the various sources, 65% acknowledged that commercial advice could be biased (see Table 7). One of these farmers explained:

> *"Of course there is bias. An independent consultant has nothing to sell except his reputation. A commercial rep. has a product to sell. This must put them under pressure at times. There are some excellent chaps in the business but there must be pressure to sell sometimes."*

The view that there are some "*excellent chaps*" in the business of advising farmers on pesticides was shared by many of the farmers interviewed. Many respondents who acknowledged the risk of bias qualified their answers by arguing that the information they received from their own merchant's representative was not biased. As one farmer remarked;

> *"There can be bias but you have to chose your advisor. The general opinion on [my commercial advisor] is if he leaves, how on earth could we carry on. He's very well respected and works very hard. It's not the same with all of them. Some are set terrible [sales] targets by their firms."*

One farmer running a 70 ha farm was able to quantify what he saw as the difference between commercial and independent advice. In 1988 he had become suspicious about the amount of agrochemicals he was being advised to apply by the merchant's representative, and their high cost. After changing merchants several times, he decided to switch to ADAS and by employing their specialist advice found that he was able to cut his total agrochemicals bill by two-thirds and yet maintain the same level of pest control.

A quarter of the farmers we surveyed felt that there was no difference between independent and commercial advice, however. Most of these were familiar with the accusations of bias in advice and were able to respond to them. All relied on a merchant's representative, perhaps making it less likely that they would acknowledge potential bias in the advice they received, especially if they enjoyed a good working relationship with their advisor. The trust displayed by such farmers in commercial advice indicates the success of companies in developing farmer loyalty. Research by Hawkins (1991) found that a great deal of effort was spent by technical advisors trying to convince farmers of the coincidence of interests between farmer and company. Thus, for many farmers, their spray advisor is someone who is seen to be 'on their side' in the fight against pests in crops.

But perhaps one of the clearest insights into how some farmers view the advice they receive can be gained from a farmer belonging to a small group of five respondents who argued that there were discernable differences in the quality of independent and commercial advice, although it was not necessarily true to say that commercial advice was more biased. The farmer, who ran a 300 ha farm, explained:

> *"Since ADAS have gone commercial, they are just as biased as commercial reps. It's just that the bias will be different. Some commercial reps will be influenced by commercial factors such as higher margins or bonuses on certain chemicals. But ADAS have to justify their cost so they have to bias their advice to show that they're worth their salt. It would be difficult for them to visit a farm, charge for advice and then advise to do nothing. Most farmers are aware of the bias. It's like sailing a boat. You tend to steer to compensate for the bias."*

The 'sailing a boat' metaphor is a powerful one. It shows how pesticide practices can be **negotiated** through the advisory process, with more experienced farmers 'steering to compensate' when it comes to deciding what actually to do.

In practice, ADAS advisors work with the same ethos as merchants' representatives; that is, one which sees the chemical option as *the* method of crop protection, at least for arable crops. In principle, they could advocate other strategies, such as mechanical or biological control, but their remit is ***efficient*** crop protection and chemicals are percieved as the best means of achieving this. ADAS consultants are also bound by the same legal constraints as other advisors, in that if their advice is properly implemented and yet fails to work there may be a case for litigation. Training also helps to reinforce the chemical perspective. All spray advisors are required to possess a certificate of competence, and the certification scheme - BASIS (British Agrochemicals Standard Inspection Scheme) - is run by the British Agrochemicals Association.

Although ADAS consultants are not tied to the sales of specific chemicals, it does not necessarily follow that their advice will always involve lower usage. ADAS advice is backed up by public sector research into efficacy in real world situations, through research at experimental husbandry farms and trials on individual farmers' fields. Armed with this information and their past experience, ADAS advisors aim to provide advice which is cost-effective. This means that the cost of particular chemical protection strategies is evaluated in the light of the results expected. Strategies may involve targeting, less prophylactic spraying or lower dose rates, but only if it is felt that these will produce the required results.

While ADAS consultants are impeccable in sticking to specified label precautions, environmental issues are not generally a factor to be considered in deciding what to use. What matters is crop protection.

Farmers in our survey were asked what options they might consider in developing a strategy for cutting herbicide use. There was a marked reluctance on the part of most farmers to contradict the advice of their pesticide advisors on dose rates. Almost 90% of farmers said that they already undercut dose rates recommended on the product labels, but usually did so **only on the advice of their advisor**. When asked if they ever undercut the dose rates recommended by their advisor, less than 40% of farmers said they did so. Most of the rest justified their reluctance to over-ride the advice of their advisors by arguing that they did not have the necessary technical expertise themselves to take such (financial) risks. Some also argued that if the pesticide failed, their negotiating position with the merchant would be undermined and their opportunity to claim compensation for failure would be jeopardised.

The minority of farmers who were prepared to apply pesticides at dose rates lower than those recommended by their advisors stressed the preconditions for such action. It was not something that they would do routinely, but 'occasionally', or after 'some convincing', or 'under ideal weather conditions', they may take a chance. As one farmer explained;

> *"If you pick and choose the conditions carefully you can cut dose rates. I would only undercut my advisor if weather conditions are ideal. They give their advice to make sure you're covered, but with practice and experience, you can identify the weather conditions whereby you can go lower than they say."*

Much stronger convictions were expressed about why advisors' recommended dose rates should not be undercut. One farmer said:.

> *"I would never go lower than the advisor says. If I think he's going too high, I'd get another advisor."*

Another explained:

> *"Nobody gets rich doing half a job. I'd cut dose rates if my advisor recommends it but I'd never go lower than that. I wouldn't have any comeback on the firm if it failed."*

In issuing advice on dose rates, merchants and manufacturers share some of the responsibility for chemical crop protection. This sharing of responsibility is most reassuring for many farmers who do not feel confident about their own expertise in pesticide use. One farmer, for example, in explaining why he would not consider applying herbicides at dose rates lower than his (merchant's) advisor had recommended, said, "*I figure the advisor knows his job and I know mine.*" Such deference to the specialist expertise of advisors was widespread, and appeared to differ little between farmers who favoured commercial or independent advice. For example, one young farm manager, running a 300 ha arable farm, cited the merchant's representative as the most important source of advice on pesticides. When asked if he would consider using lower dose rates than those advised, he said;

> *"My advisor gives good advice. He's a trained agronomist. How can you argue with him ?"*

The evidence from the survey demonstrates how the role of advisors is crucial to understanding how pesticides are used. Not only is the merchant's representative by far the most important source of advice, but the extent to which farmers are prepared to moderate advice from advisors is severely limited. In particular, farmers assess the risk of pesticide failure and the prospect of compensation from the manufacturers or merchants against the possible savings from applying pesticides at lower dose rates. Some farmers feel there is scope to make savings on pesticide costs in spite of the risk, because the dose rates on product labels are set on the high side. Just how high these rates are set is unclear as the information is commercially sensitive. The willingness of farmers to exploit this potential area of savings depends on their confidence, knowledge and ability to risk financial losses. Those in the survey most confident about experimenting with dose rates tended to be younger and more highly educated and were often the larger specialist cereal producers who employed a wider range of sources of advice. The more conservative farmers, on average, were older, farmed smaller units and had mixed farms where cereal production formed only a part of the business.

These findings also illustrate the dominance of economic risk assessment over environmental risk. The greatest risk in cutting dose rates is that of the pesticide failing and the supplier not being liable to pay compensation for crop failure or yield reductions. Environmental risk seems not to bear directly on the farmers' decisions or the advisor's advice. This can be explained in part by two points. First, the pollution of surface and groundwaters by pesticides is an emerging issue amongst the farming population. During the survey farmers were asked what they thought were agriculture's main detrimental effects on the environment, before specific issues about pesticide usage were raised during the interview. Water pollution by pesticides was hardly mentioned. Second, there is an assumption amongst both farmers and advisors alike that once a pesticide has been licensed by the authorities it must be safe to use, provided they keep to the general instructions on the product label or from the manufacturers' advisors.

It is usually the personal relations between farmers and their commercial advisors that are crucial in determining which pesticides are used, and in what amounts. The process of negotiation between them can be a key factor in sealing the fate of the local water environment, but the environmental risks of pesticide use seem to have little impact on their decisions. The importance of such advice to decisions that farmers take has major implications for the regulation of agricultural production. It is dubious whether farmers, in general, could develop the necessary expertise in crop protection to enable them to modify to their financial advantage the pesticide advice they receive. It seems more likely that with the rapidity of technological change and product development they are becoming **more** dependent on technical expertise from advisors.

Part Four: Regulating Pesticide Use.

Reliance on the prior approval system for the regulation of pesticides has engendered complacency amongst regulators in that the policing of farmers' use of pesticides is neglected. This complacency is also fostered by the legislative emphasis on self-regulation by the farmer. The Control of Pesticides Regulations (COPR) 1986 set out detailed rules on the storage and use of pesticides on farms which farmers are expected, indeed obliged, to follow. However, environmental factors are covered in a more general way than those concerned with human health and safety. For example, farmers are required to take "all reasonable precautions" to protect the environment and "in particular to avoid the pollution of water", but with few specific regulations in terms of spraying and disposal disposal practices.

Although the recent Royal Commission on Environmental Pollution (1992) recognised that "In most cases the only practical way to control diffuse pollution is to regulate the activities which may give rise to the pollution"(p.20), neither the HSE's Agricultural Inspectorate nor the NRA, the two bodies concerned with the regulation of agricultural pesticides in the field, has yet developed a comprehensive regulatory strategy.

The HSE's Agricultural Inspectorate has the major responsibility for overseeing pesticide use in the field, but a number of factors compromise its effectiveness. There is every indication that the Inspectorate remains hopelessly understaffed for the task in hand. In 1991 there were only around 150 Inspectors in the field to deal with 280,000 agricultural holdings. Thus the great majority of farms are visited only infrequently. According to estimates by the Institution of Professional Civil Servants, the average farm is visited by the HSE once in every 9.8 years, and a self-employed farmer might not see an Inspector for 29 years (BMA, 1992, p.66). However, in 1992 there were plans to visit about 11% of holdings (Farmers Weekly, 19.7.91) and our fieldwork suggests that Inspectors try to give priority to farms judged to be posing greater health and safety risks. This highlights another problem - the Inspectorate's (understandable) concentration on worker safety rather than protection of the wider environment (despite its responsibility in both areas). Our fieldwork in the Ouse catchment found that Inspectors tend to focus on the human health and safety risks presented by farm machinery, electricity, grain stores, ladders and pesticide storage on farms, with a special emphasis on COSHH assessments, rather than the risks presented to the environment from routine pesticide use. Although Inspectors are more likely than the NRA to comment on the use of pesticide and to check machinery (for example, they keep an eye open for people who spray in unsuitable weather conditions), their main environmental concerns surround stores and the disposal of washings rather than diffuse pollution threats to the water environment.

The NRA's duty to protect the water environment engages its interest in the storage, use and disposal of dangerous substances such as agricultural pesticides. However, when it comes to regulating pollution from agriculture, its powers have been exercised selectively. It does not take more than the briefest of chats with a dairy farmer and an arable farmer to find that the preoccupation has been with regulating pollution from livestock effluents. This is primarily because acute pollution is caused by such effluents, resulting in 'incidents' which are more easily detected and recorded and which pose a much more immediate threat to the water environment (Lowe *et al.*, 1992; Ward *et al.*, 1993). However, gross pollution from pesticides does occur. Indeed, the NRA has identified pesticide pollution **incidents**, which are more easily quantified and graphically represented, alongside other types of gross pollution, but the more diffuse nature of the pesticide pollution highlighted by the EC Drinking Water Directive poses intractable difficulties for the NRA.

The NRA's role in 'regulating' pesticides is almost wholly confined to monitoring by scientific staff, which is itself far from comprehensive (as will be discussed in Part Five), along with some involvement by specialists in the preparation of legislation and guidance codes. It has been slow to ensure that this albeit limited monitoring of pesticides informs on-the-ground investigations and regulation. Thus, although the NRA has a strong network of field staff, they have little routinely to do with pesticides. Although pesticides are sometimes covered in farm campaigns, they are not normally a priority. They will also be addressed in response to the relatively rare acute point source pollutions, such as accidental spillages from stores and washings disposal into drains, which usually result in fish kills. However, despite numerous breaches of the MACs by agricultural pesticides, the Anglian region of the NRA, for example, has not adopted a preventative campaign of farm visits targeting pesticide use.

However, in other regions there is some evidence of increasing interest in the regulation of diffuse pesticide pollution where high concentrations have been found in water. For example, in Wessex, Northumbria and North West regions farm visit campaigns have been specifically targeted on pesticides after monitoring revealed pesticide pollution. However, even where these special initiatives have been instigated, they follow the pattern of routine visits where pesticides are addressed, and place the emphasis on stores and washings disposal rather than pesticide use in the field. One such example is the NRA's study of the River Crossens catchment in the North West region in 1990, where high levels of pesticides were found in watercourses. Intensive pesticide use on the local cereal and horticultural crops in the catchment is being exacerbated by a high degree of irrigation which is thought to concentrate the effects of chemical run-off. Of the 71 arable farms visited as part of the study, on almost half pesticide storage was found to be flawed, requiring either the construction or repair of pesticide stores. In addition, the disposal of pesticide washings was judged to be inadequate and proper means of disposal were requested on nearly a quarter of the farms (NRA, 1992a, p.59; Thornett, 1990). Application practices were not, however, investigated.

The prevailing belief within the NRA remains that the approval system is the most efficient means of controlling water pollution from pesticides. Nonetheless, it would like to see improvements in the system, particularly more rapid reviews of products, and has been active in seeking the reviews of Atrazine, Simazine and Isoproturon. So far there has been little evidence of the NRA pursuing other means to regulate pesticides. It appears daunted by the prospect of introducing water protection zone for pesticides, particularly because of the policing difficulties such selective bans would present, although it does recognise the value of reducing pesticide use and acknowedges that such zones may be necessary in the long term (NRA, 1992a, p.62). As a shorter term option, however, the NRA has promoted the incorporation of riverside buffer zones into agricultural land set-aside schemes, under which farmers receive compensation, in order to combat diffuse pollution and enhance the aquatic environment. In addition, while its designation of general groundwater protection zones has a bearing on pesticides, these are more likely to effect the location of pesticide manufacture and storage than actual pesticide use.

Although there is an overlap of responsibilities between the NRA and the HSE over the disposal of pesticide washings, regulation in this and other areas is weakened by a lack of communication and co-ordination between the two bodies. In part this may stem from the different policy backgrounds of the two organisations. While the NRA forms part of an environmental policy community, HSE loyalties are divided. Many of the longserving staff in the Agricultural Inspectorate were transferred there from ADAS's Farm Safety division when the HSE was established in the 1970s and continue to have an agricultural outlook. More recent recruits have to be graduates, a number of whom have degrees in environmental science, and tend to have weaker associations with the farming world and a greater sensitivity to environmental issues.

The differing allegiances of the two organisations are perhaps reflected in their treatment of public complaints about pollution. While the NRA has nurtured the public reporting of water pollution incidents and pursues a growing proportion of them in the courts, the Agricultural Inspectorate is more reticent about the value of public reporting. However, prosecutions related to pesticides have increased in recent years.

Although the sets of responsibilities described here can be seen to be fragmented and thinly resourced, it must be emphasised that simply increasing the extent of policing of COPR and the COSSH Regulations to improve the regulatory system would not necessarily lead to the elimination of diffuse pollution. The model embedded in the 'safe if used as directed' philosophy envisages the farmer as a **competent technician** and **responsible business manager**. It assumes that he or she will obediently follow the crop protection recipes provided by the advisor, and will be competent and able to observe all the constraints on the application of pesticides. However, while anecdotal evidence suggests that at least a few farmers are indifferent to, or even blatantly contravene, label directions, others undoubtedly feel unable to consistently comply with particular directions without putting effective crop protection in jeopardy. Moreover, as the HSE's large survey of sheep dipping practices has recently found, plenty of evidence can be uncovered of routine farming practices which show a "complete disregard" for health and environmental risks, despite numerous guides, leaflets, codes of practice and statutory regulations (HSE, 1993a), and this is reinforced by anecdotal evidence from our own research. A greater enforcement effort might conceivably deter 'rogue' farmers, but the 'naive sociology' (Wynne, 1989) implicit in the understandings of what farmers can be expected to deliver makes it less likely to deter others. More importantly, assuming that better compliance would lessen diffuse pollution assumes that failure to **comply** is the critical problem. But it is not known, and impossible to tell from monitoring data, whether diffuse pollution results simply from non-compliance with label directions, or also occurs despite pesticides being used as directed.

It is questionable whether the ideal of 'safe if used as directed' could ever be achieved, and this outcome is certainly unlikely in a system which aims to control the types of pesticides that are available for use, rather than to control the usage of pesticides. In this regard, regulatory strategy is in accord with the interests of pesticide manufacturers for it promotes the development of **theoretically** ever safer pesticide products as the solution to environmental problems, rather than the development of crop protection systems that rely less on chemical control and more on the use of resistant varieties, cultural suppression and biological agents. The oligopolistic structure of the pesticide sector, and its control of crop protection research, combined with the running down of public sector 'near market' agricultural research in the UK, also militate against such a change in strategy. Rather, although some public sector work such as the LIFE (Low Input Farming and the Environment) experiment at Long Ashton research station is proceeding, the emphasis remains very much on products for chemical control.

An overall reduction in pesticide usage represents an alternative strategy for alleviating diffuse pollution. Over the past decade, usage in terms of tonnes applied to the major arable crops has in fact decreased, but the the area treated has continued to increase for most arable crops (Davis *et al.*, 1990). Possible explanations include a reduction in the number of treatments per crop and changes in the mix of products used as newer more powerful pesticides which work at lower dose-rates replace older compounds. More recently, some farmers have begun to explore more cost-effective approaches whereby, for example, weeds or diseases are tolerated up to a certain threshhold and diminished yields are compensated for by the lower cost of inputs. Some sections of the farming press have also pushed the principle of 'don't spray if you don't need to', prompting one commentator, for example, to argue that "the traditional cost-benefit values for agrochemicals and other inputs are in the melting-pot" (Abel, 1992, p.3). Another initiative, LEAF (Linking Environment And Farming), aims to promote 'environmentally responsible' farming through the adoption of integrated crop management on demonstration farms. However, given that its guidelines on crop protection merely encourage farmers to follow mainstream 'best practice' in using crop protection chemicals, it would appear to do no more than echo the often ineffective exhortations of the regulatory system.

The promotion of such approaches may well be related to recent economic and image difficulties in arable farming and strategies could adjust to changes in anticipated profitability. Whether they presage any permanent change remains to be seen. However, although it encourages farmers to consider the necessity of pesticide applications in their COSHH assessments, ***the regulatory system itself provides no real incentives for farmers to reduce pesticide use.*** Rather, the reverse tends to be the case. For example, the granting of approval is also conditional on establishing efficacy at the recommended dose-rate. However, the effectiveness of an application of pesticide varies according to the local conditions of its use and pesticides may also work effectively at less than the recommended dose rates. Moreover, manufacturers tend to set dose-rates at the higher end of the range because farmers can claim compensation from them if spraying fails to work, provided, that is, the farmer did use the product as directed. By the same token, as we argued earlier, this mitigates against risk-averse farmers deciding to apply pesticides at rates different from the recommended ones.

Although everyone involved in the use of pesticides on farms is obliged by law to have aqdequate instruction and guidance, only those spray operators born after December 31st 1964 are required to gain certificates of competence. Recognised certificates are those issued by the National Proficiency Test Council (NPTC) for the pesticide foundation module and the pesticide application module. Operators undergo a test to gain such certificates, these being arranged by County Proficiency Test Committees (in England). Training for such certificates tends to be through courses held at agricultural colleges or through the Agricultural Training Board

(ATB). However, it is of concern that the test is regarded very much as 'a formality' if an operator has been through the training, and that so little supervisory input comes from outside the agricultural sector.

Given that the individual farmers' **usage** of pesticides is the point at which local environmental pollution originates, diffuse pollution is likely to remain endemic to UK farming as long as regulation relies on farmers acting responsibly, and assumes no untoward ecological outcome provided that they do so. In turn, the current regulatory strategy accords with the prevailing agricultural epistemology which equates efficient production with the optimium use of pesticides and other inputs, and with mainstream agricultural values which rate economically efficient production as paramount (except where payment is offered for doing otherwise). Thus, little priority is accorded to environmental issues where these collide directly with production interests. Within this perspective, agriculture and environment are seen as separate spheres, with impacts on the latter tackled as unfortunate consequences of the former, rather than as integral to technological farming systems.

Part Five: Water Monitoring.

The shortcomings of the prior approval system and the regulation of pesticide use are only exacerbated by the limited monitoring for pesticides in water. The monitoring system is geared to drinking water sources rather than the whole water environment and is hampered by poor knowledge of detailed pesticide use and a lack of analytical techniques. It has to be tailored to specific active ingredients, but only around 50 of the 450 or so approved active ingredients for use in agriculture (albeit the more widely used substances) are subject to any monitoring at all (NRA, 1992a, p.51).

The efforts of the Drinking Water Inspectorate (DWI), along with the realisation of the extent of breaches of the Drinking Water Directive, have at least meant that some of these shortcomings are beginning to be realised, if not rectified. However the preoccupation remains with **drinking water** quality, rooted in concerns about public health. Monitoring schemes for the wider water environment, including groundwaters, are rudimentary, and little is known about the extent or consequences of pesticide contamination. The Royal Commission on Environmental Pollution, for example, has highlighted the inadequacy of monitoring, arguing that:

> *"Apart from the analyses of water for public supply, and monitoring by the NRA and [the Scottish River Purification Authorities], for certain pesticides which are List I substances, there is no defined programme of monitoring, no established list of pesticides to be monitored, no statistically valid pattern of monitoring and no list of sites chosen for the likelihood of their contamination by pesticides"* (RCEP, 1992, p.127).

The collection and collation of data on pesticides in water has become more standardised since the establishment of the DWI in 1990. Annual reports are now compiled which contain the results of a technical audit of the quality of drinking water supplied by the 39 water companies in England and Wales (DWI, 1991; 1992a; 1993). The 1992 audit found that 33 different pesticides were detected above the 0.1µg/l MAC compared with 34 in 1991 and 31 in 1990; and that 3.0% of analyses exceeded 0.1µg/l compared with 2.8% in 1991 and 2.1% in 1990 (DWI, 1993, pp.241-242). It is unclear, however, whether this increase arises from increasing pollution or better detection rates.

The DWI argues that because water companies are obliged to sample at increased frequencies in supply zones where standards have been breached, monitoring is being concentrated in high risk zones and so more pollution is being detected. If increased detection of breaches is not indicative of rising pesticide pollution, however, then it must be the case that the extent of pesticide contamination has been significantly **under-recorded** in the past (ENDS, 1992d), and it is unlikely that this will be fully rectified for some time.

Monitoring schemes are, on the whole, quite poorly developed. Anglian Water, which covers the region most affected by pesticide pollution, now has the longest tradition in monitoring (see Croll, 1986; 1991), and other companies are having to develop and refine monitoring strategies and sample at increased frequencies (DWI, 1992a, p.x).

Each water company is required to develop a monitoring strategy based on the likely risk of particular pesticides being present, but their efforts are poorly scrutinised. The DWI, in its 1992 report on *Nitrate, Pesticides and Lead*, highlights the lack of monitoring of some of the 50 most extensively used pesticides (1992b, p.38), and reveals that a quarter of the companies monitor for fewer than 30 compounds. However, the Inspectorate has refrained from censure. Indeed, its regulations do not specify which pesticides a water company should monitor for. However, it has advised companies to cut down on monitoring for organochlorines and organophosphates which rarely appear in water, and has urged them to concentrate more on herbicides used extensively in agriculture as part of a strategy of targeting commonly occuring pesticides.

Given the large number of compounds and the usually very small concentrations involved, the key to effective targeting is to know as much as possible about what to look for and where. In this regard, a difficulty for the water companies is the lack of specific knowledge of pesticide use in their respective areas. There have been calls for publication of data on sales and level of use since 1977. For example, the Nature Conservancy Council made this case to the Royal Commission on Environmental Pollution (RCEP, 1979; see also FoE, 1985, p.8). MAFF's published Pesticide Usage Survey gives only a general picture and there are frequently delays in its publication. A number of water companies, having found the information inadequate for their purposes, have had to commission their own detailed surveys. So as well as financing the clean-up of contaminated water, water consumers are also paying the costs of identifying the level and extent of pesticide usage. The DWI has recognised the problems associated with this lack of knowledge and has outlined its aim "to press MAFF to collect and provide information on pesticide usage data on a regional basis or, if possible, by water company catchment areas" (DWI, 1992b, p.48). However, the continuation of even the existing usage survey is threatened by pressures on the resources necessary for its completion.

More carefully targeted monitoring is likely to pick up more traces of pollution, but may miss unanticipated pollutants, as an incident in Oxfordshire in 1991 revealed. Some lindane was dumped into a sewer, but broad spectrum analysis, carried out monthly, would have been too infrequent to pick up the incident, and it was only when dead fish were spotted that samples were taken. Results showed lindane present at 220 µg/l in the effluent discharge and 3 µg/l in the River Cherwell (ENDS, 1991).

More comprehensive monitoring is inhibited by the avalability not only of resources but also of dedicated analytical techniques. Although manufacturers of new pesticides are required to develop and make available analytical methods to detect their product in water, such techniques of sufficient sensitivity exist for only a minority of the products approved in the UK. Water companies are advised by the government to refer to methods published by the Standing Committee of Analysts (SCA) but these cover only a few pesticides. In many cases the best currently available methods are not capable of achieving the required performance of a limit of detection of one-tenth the standard (0.01µg) and a total error of less than 20% (DWI,1992b, pp.34-5). Indeed, the DWI accepts a limit of 0.02µg for pesticides because of "the difficulty of achieving the target limit of detection" (p.37) for many of them.

Most monitoring is carried out to fulfil the requirements of the EC Drinking Water Directive, a factor which has helped divert attention from monitoring and protecting water at source. However, the NRA has a broader duty to protect the aquatic environment from contamination, a duty which goes beyond a concern for just **drinking water** supply sources. Other monitoring for pesticides has to be carried out under the 1976 EC Dangerous Substances Directive, but this covers only the persistent organochlorines (such as DDT) which were creating obvious environmental problems during the 1970s (and which have subsequently been banned). It has not been upgraded to cover agricultural pesticides which have been developed subsequently, nor those which are now most frequently detected in rivers.

The NRA claims to carry out routine analysis for "about 50 active ingredients in freshwaters" (NRA,1992a, p.51), but not all are monitored in every region. Although there is no point in monitoring where a pesticide is not used, the NRA's coverage remains far from complete for those pesticides in use. This is due partly to a lack of analytical techniques, and partly to the cost of analysis. Biological monitoring may be of use here, through observation of species known to be pesticide sensitive.

Finally, the NRA's own recorded farm pollution incidents distinguishes those caused by pesticides (NRA, 1992b). These figures, however, reflect only observed cases of acute pollution (which "characteristically result in fish and invertebrate mortalities"). Other cases may go unobserved or unreported and, as the NRA itself notes, there are events where fish die and pesticides are implicated but there is no absolute proof (NRA,1992a, p.53). Unlike slurry and silage effluent, pesticide contamination rarely causes a change in the colour or smell of a watercourse and is thus more difficult to spot or diagnose. Detailed studies of pesticide pollution investigating the underlying **processes** are usually only undertaken where an intractable problem clearly exists.

The inadequacy of monitoring is compounded by uncertainties in assessing the implications. The lack of analytical techniques is matched by a lack of toxicological data, leaving the EC MACs regarded as too arbitrary. In response, the DoE has set its Advisory Values, but such values have not yet been developed for 21 pesticides which were detected at concentrations greater than 0.1µg/l during 1989 and 1990. An absence of environmental quality standards also makes it difficult to assess the implications for the water environment in general. For example, the NRA has explained that between January 1988 and December 1990, 68 samples of water from the

Great Ouse were analysed for the presence of Mecoprop. The pesticide was found on 78% of the sampling occasions, with peak values found in the spring (coinciding with recommended application times). The NRA reports exceedences of the EC Drinking Water Directive MAC on "several occasions" but was unable to assess the effects on the water environment. It noted that "there is no environmental quality standard for Mecoprop and the effects of these observed concentrations on the aquatic flora and fauna are unknown" (NRA, 1992a, pp.59-62).

Part Six: Responses to the Pesticides Problem.

In 1990, MAFF announced that, in line with commitments given in the Environment White Paper, 'This Common Inheritance', 38 pesticide active ingredients would be reviewed by the Advisory Committee on Pesticides (MAFF, 1990). Results of the review are not yet available. In April 1992, however, MAFF banned the use of Atrazine and Simazine, although only on non-cropped land. These are the two herbicides most frequently detected at levels breaching the MACs, and were widely used by British Rail and local authorities. The ban is viewed as a precedent because it is the first substantial regulatory decision to be influenced directly by the need to comply with the EC MAC's rather than by conventional toxicological considerations (ENDS, 1992b). It also brings restrictions closer for solely agricultural herbicides. Indeed, the next pesticide 'in line', in terms of it being the next most commonly detected in excess of the MAC, is the pre-emergent cereal herbicide, Isoproturon (IPU). Crucially, however, the move against Atrazine and Simazine did not involve MAFF acting against agricultural interests. Rather, it has been local government and transport interests who have had to change their practices.

Over the same period, the NRA has been emphasising the value of catchment management planning as a strategy for controlling pollution (see NRA, 1990; 1991; 1992a; RCEP, 1992). This involves the identification of vulnerable surface and groundwaters and could lead to the designation of Water Protection Zones (WPZs) under the 1989 Water Act. Restrictions on farming practices including the use of pesticides could then be imposed in particular catchments specifically for the purpose of protecting water from agricultural pollution. Similar schemes are already being piloted under MAFF's Nitrate Sensitive Areas, although restrictions on farming practice have so far been voluntary, accompanied by compensation payments and, crucially, administered by MAFF rather than the NRA (see Seymour *et al.*, 1992). Regulatory officials are, however, at least beginning to consider tougher controls on the **use** of polluting pesticides in specific catchments (ENDS, 1990a; Barnden *et al.*, 1990; Farmers Weekly, 1990).

A common complaint about a tougher regulatory stance on pesticide use is that we do not know how this would affect agriculture in the areas involved. This section of the report represents an attempt to begin to fill that gap in our understanding. In our detailed study of farmers in the catchment of the Bedford Ouse (Figure 3), where water quality has been affected in recent years by the intensification of agriculture (RCEP, 1992, p.208), farmers were asked how they might respond to different regulatory scenarios.

The quality of the Bedford Ouse is class 1B or 2 (lower good and fair) throughout its length, with the exception of a short reach downstream of Brackley which is class 3 (poor) (RCEP, 1992). Agricultural pollutants are cited by regulatory officials as an important contributory factor to poor river quality. Drainage waters from agricultural land bring nitrates, phosphates and other agrochemicals, such as herbicides, into the river and into groundwaters. According to a study conducted for the Royal Commission for Environmental Pollution in 1992

> "*Significant improvements in the Bedford Ouse will...be difficult in view of increasing demands for supply from a river with an already high degree of re-use. Nevertheless, pollution from pesticides and nitrate is likely to decline slowly as a result of constraints on their use in agriculture*" (RCEP, 1992, p.208).

Table 8 shows the Drinking Water Inspectorate's findings for Anglian Water Services Ltd, the water company which covers the Ouse catchment. In 1990 the most problematic pollutants were all herbicides - Atrazine, Simazine, IPU and Mecoprop. Between 1990 and 1991, the number of zones covered by undertakings under Section 19 of the Water Industry Act 1991 to secure compliance with standards for pesticides rose from 98 to 124, and the number of zones not complying with regulatory requirements for Atrazine, Simazine and IPU also rose.

The DoE's Advisory Values (AVs) for pesticides in water, which tend to be less stringent than the EC's MACs, have been breached in the Ouse catchment by levels of IPU ranging from 0.2 to 5.13μg/l (AV=4). Monitoring has found that concentrations vary considerably from month to month, which suggests that surface run-off of pesticides from farmland is significant.

IPU use is linked to changing agricultural practices in the region. During the post-war period there has been a gradual 'arable-isation' from the east. Statistics for the county level are shown in Table 9. For Bedfordshire and Buckinghamshire, the proportion of the total cropped area under wheat and barley more than doubled from 1959 to 1989 from 25.1% to 50.5%. The shift to cereal production took place earlier and was more marked in Bedfordshire than Buckinghamshire such that, by 1989, 63% of Bedfordshire's total cropped area was under wheat and barley compared with 42% in Buckinghamshire. These trends are reflected in the agricultural geography of the Bedford Ouse catchment. The eastern part of the catchment (in Bedfordshire) is dominated by cereal production, whereas to the west of Milton Keynes (in Buckinghamshire), the catchment has more mixed farms and a greater proportion of grass cropping. Here, the spread of cereal cropping has been relatively more recent. The area has heavy soils and it is the combination of improved drainage and the use of cereal herbicides that have made this arable-isation possible.

It is in the light of the increasing interest in controlling IPU use in certain catchments that we will consider three possible regulatory scenarios and their likely impact on agriculture in the Ouse catchment. These are: a ban on the use of IPU in the catchment; a ban on the use of IPU in the autumn months; and a ban on the use of all herbicides in the autumn.

6.1 Responses to an Autumn Ban on IPU Use.

First, farmers were asked what they might do if IPU was banned from autumn use (see Table 10). The most common response (44% of the farmers) would be to switch to another chemical such as Chlortoluron (Dicurane) or Fenoxaprop-ethyl (Cheetah). The former is also a pre-emergent herbicide (which means it lingers in the soil) whilst the latter is a contact herbicide. The farmers' responses show that IPU plays a very important role in local arable cropping. Most farmers felt a ban on its use in the autumn would hamper them because of the increased threat to cereal crops from blackgrass weeds in particular. One farmer explained;

> *"We wouldn't have a crop. IPU is very important. The blackgrass is unbelievable. It's very serious....We couldn't really farm without IPU."*

A switch to Dicurane from IPU seemed to be the least disruptive option for farmers. However, Dicurane's main active ingredient, Chlortoluron, is persistent and has also been detected in surface and groundwaters at levels above the EC's MAC (Croll, 1991), and so any future restrictions on IPU might also be applied to Chlortoluron. Moreover, it can only be used in conjunction with particular cereal varieties, and so a switch to Dicurane could also mean a change to less high-yielding varieties. No doubt because of such drawbacks, Dicurane was not the most favoured option. Instead, the most commonly cited alternative to using IPU in the autumn was the new contact herbicide Fenoxaprop-ethyl (Cheetah). However, the main problem, as the farmers perceived it, was its higher cost. Cheetah is a relatively new product which is still under patent, and the manufacturer has a monopoly on its production. Its cost at the time of our survey was about £22 per acre (£54 per hectare), compared with £10-£14 per acre (£25-£35 per hectare) for IPU(3). Furthermore, farmers were not clear how best to maximise the efficiency of Cheetah whilst not compromising its efficacy.

However, using fewer residual herbicides in the autumn would go against the strategy being promoted by ADAS and local merchants as the most cost-effective method of weed control in cereals - which is to concentrate on pre-emergent weed control in the autumn. Although some farmers had been cutting down on residual (pre-emergent) herbicides, even for them, an autumn ban on IPU would cause problems.

The second most common response to an autumn ban on IPU was to drill cereals later and then use IPU in the spring. Just under a quarter of the farmers said this would be their response. Again, this option seemed to be much less attractive than carrying on with IPU in the autumn. One farmer explained;

> *"No IPU in the autumn would be disastrous because of the blackgrass. Maybe not in the first year but in the second and third it would be dramatic. We tried it three years ago, using no IPU and the loss was 30% by the second year. It's taken us three years to get back to where we were.*

Spraying in the spring would involve greater dose rates and less effective control because weeds in the crop would be that much bigger. Moreover, crop yields would suffer because of the competition from the weeds in the early growth stages. By drilling later, these risks would be reduced, but also the spring workload would be increased at a time of year when weather conditions are variable and heavy land is often still wet. There could also be problems of finding the suitable time to spray.

6.2 Responses to a Total Ban on IPU Use.

The second scenario put to the farmers was a total withdrawal of IPU (Table 11). This then eliminates the option of continuing to use IPU outside the autumn restriction period. These responses shed more light on the nature of the farmers' dependence on IPU. Overall, the farmers seemed much more willing to consider changing chemicals than altering their cropping practices. As one farmer put it, "*Given the market conditions at the moment, a change of chemicals would be the solution*". Over half said that they would switch to Dicurane (Chlortoluron) or Cheetah. Again, the greater costs of adequately controlling the threat from blackgrass posed the biggest problem under this scenario.

One referred to the 'old methods' of rotations and cultivations as a possible solution but feared their high relative cost. He said;

> *"We'd be going back to the old traditional method. Wait for the weeds to grow then harrow then drill. That would break the farm. We couldn't grow corn in those conditions. It would be completely unviable. Cereals rely on that chemical to control the blackgrass.*

Cropping changes could follow under this scenario. There would probably be less emphasis on cereal production and a greater emphasis on arable break crops, a continuation of a trend already apparent in the catchment.

The responses show what problems such a restriction would cause the farmers. Their eventual action following an IPU ban would most probably be taken after consultation with their advisors. Indeed, almost a quarter of the farmers were unsure what to do. One said;

"It would be catastrophic if we couldn't use them at all. I don't think there would be any other products. I don't really know, I'd have to ask my spray man. I rely on him."

For some farmers, the current returns to cereal production were so tight that any further restrictions would lead to a re-evaluation of their whole farm strategy. Some 14% said that a total ban on IPU would force them to consider stopping cereal production, possibly by entering land into voluntary set-aside schemes. This is double the number of farmers who gave such as response to the autumn ban.

6.3 Responses to a Total Ban on Autumn Herbicide Spraying.

The final scenario put to the farmers was an autumn ban on the application of all herbicides. Responses were more evenly spread (Table 12), and again underline the fundamental importance of pre-emergent herbicides to cereal production in the catchment. The most common response (25%) would be to switch to Cheetah, followed by the spring use of IPU in combination with later drilling (23%). Some 19% said they might have to revert to spring cropping and withstand lower yields.

A number of interesting issues emerged in the discussions with farmers. Firstly, the crucial importance of pre-emergent herbicide spraying in the autumn to cereal production in the Ouse catchment became apparent. As one farmer explained, if this were to be restricted,

"It would make growing grain in North Bucks very difficult. It was mainly grass here and the grass weeds and seeds are deep seated. Marginal grain land would go out....I'd have to think again about grain."

Moreover, spraying in the spring would increase the pressures on the spring workload, and there were fears about weather conditions making spraying difficult in the spring months. One farmer interviewed in April 1991 noted *"there have only been 2 decent spraying days in the last 6 weeks due to the wind and frost."*

Some farmers wondered about what steps could be taken to minimise the risks to the crops. Four broad strategies were identified, although many of the suggestions were tentative. Rotational fallows were one option mentioned to reduce the build up of weeds. Since the survey was conducted, a rotational set aside scheme has been agreed under the Common Agricultural Policy reforms, and it is possible that rotational set aside could contribute to weed control under future autumn herbicide spraying restrictions. A second strategy suggested was to drill crops later in the autumn so that weeds do not become a problem until the spring. However, the later the drilling, the greater the risks to the crop and to future spraying programmes from the weather. Smaller crop plants are less able to withstand harsh winters, and there is also a risk of poorer yields. Switching to spring sown crops could be another option, but yields are lower. Most farmers thought that wheat and barley yields would fall by about 30%. Another option was to rely more on cultural and mechanical methods of weed control such as direct drilling, scratch cultivation and mechanical weeding. Many farmers, however, were suspicious of these methods. One farmer highlighted the problem of a ban:

> *"But for residual herbicides we couldn't continue to farm in the same way. We could maybe carry on for 3 years but then have to go back to spring cropping and change the rotation. We could use cultural methods of weed control but the yield penalty would be £100 per acre. Chemicals cost £10 per acre, so you can see why we use chemicals."*

Other farmers considered set aside as an alternative. Nine thought that an autumn ban on herbicide spraying would leave them unable to carry on producing cereals at all. However, a minority of farmers felt that, although costs would inevitably increase, they would still be able to continue. It depended on their current spraying systems and the amount of cereal land they had. One farmer suggested that a total ban on autumn spraying would not be as bad as the total withdrawal of IPU from the market. He said;

> *"IPU could be put on in the spring. You would get satisfactory control but would have to put on higher doses in the spring to get the same control. You'd need a 50% increase in dose rate to get a result with blackgrass in spring compared to autumn."*

Thus, such regulatory measures aimed at reducing pollution risks in the autumn could result in greater risks at other times of the year.

In summary, these discussions show how the farmers saw IPU as a highly effective, efficient and reliable chemical for weed control in cereals. Its use had, in effect, become routinized. There was a perceived dependence on IPU to the extent that farmers were unsure what they would do without it. MAFF's review of IPU has not been widely publicised and the farmers seemed unaware of the water pollution problems and regulatory scrutiny this was prompting. Therefore, for most farmers, our survey interviews were the first time that they had thought seriously about what they might do without IPU. The number of farmers who felt unable to say without first consulting their advisor only serves to underline the important role advisors play in influencing pesticide spraying decisions.

Part Seven: Conclusions.

1. We would argue that the principle for guiding the regulation of pesticides ought to be the ***precautionary approach***. This corresponds to the approach to environmental protection and pollution control adopted by the British Government, formally laid out in its White Paper on the environment, 'This Common Inheritance'. It states that:

> "*where there are significant risks of damage to the environment, the Government will be prepared to take precautionary action to limit the use of potentially dangerous materials or the spread of potentially dangerous pollutants, even where scientific knowledge is not conclusive, if the balance of likely costs and benefits justifies it*" (Secretary of State for the Environment, 1990, p.11)

It is important to realise that science can never provide us with definitive risk assessments, no matter how much information is available. Of course, it can alert us to problems and help indicate their probable extent and consequences, but scientific knowledge about the different risks to public health and to the environment associated with pesticides in water remains patchy and many gaps in our understanding still have to be filled in. Given the scientific uncertainties that surround the issue, it is particularly pertinent that the precautionary approach be applied.

The Government has also noted that the precautionary approach to environmental protection helps us realise that "*prevention is better and cheaper than cure*" (p.11). Thus, for pollution control, policy should seek "*to prevent pollution at source*" (p136). However, this principle has not yet been applied in the case of agricultural pesticides.

2. The present regulatory system for pesticides is partial and fragmented and fails to address the impacts of pesticides on the environment as a whole. The organizations which are in practice responsible for environmental protection in relation to pesticide use are part of the agricultural community and do not give sufficient weight to environmental considerations. The regulation of pesticides by approval has been geared more to the needs of agriculture (and the interests of agrochemical companies) than to those of the environment. Both the problems of fragmented responsibilities, and the agricultural orientation of the system could be overcome if a single organisation were to take over the approval system for pesticides from MAFF (and for non-agricultural pesticides from HSE). The most obvious candidate would be the proposed new Environmental Protection Agency (EPA). In addition, water pollution considerations could be given greater consideration if the NRA were given a statutory role in the approval system. The new EPA could also have responsibility for the in-field regulation of pesticide use under FEPA.

A unified regulatory agency would be better able to co-ordinate, monitor and police the use of pesticides. In part, this need stems from the nature of pesticides as pollutants: there are a wide variety of chemicals; their impacts are spatially and temporally diverse; and it is usually impossible to unambiguously link the polluter with the pollution.

3. The monitoring of agricultural pesticides in the (water) environment appears grossly inadequate. It could be greatly improved if those responsible for monitoring pesticide pollution were provided with adequate information on pesticide use. Finding pesticides in water is somewhat akin to finding a needle in a haystack, and better co-ordination between monitoring strategies and pesticide usage patterns would improve the efficiency with which monitoring is targeted. We recommend that a condition of use for an agricultural pesticide (whether or not newly approved) should be that the company develop and supply to the NRA analytical techniques so that it can be monitored in the (water) environment. If pesticide companies made up to date information - on which pesticides are being sold and where - available to regulators, monitoring could be more effectively targeted.

For example, tailored monitoring schemes could be established to cover ground and surface waters - regardless of whether they are drinking water supply sources - which correspond more closely to local patterns of pesticide usage. Monitoring could then be widened from the protection of **drinking** water to the protection of the whole water environment. In addition, more research is needed into the effects of agricultural pesticides on aquatic fauna and flora, and into the breakdown of pesticides in groundwaters. Action on groundwaters is urgently required as once contaminated they are virtually impossible to clean up.

4. The bulk of advice which farmers receive about pesticide application comes from the representatives of agrochemical suppliers. This situation may well have encouraged greater use of pesticides. One way of separating advice on crop protection requirements from the sale of pesticides would be through a prescription system, run by a body independent of the manufacturers or merchants, to regulate pesticide use. The system could, for example, work like that for the prescription of drugs in the NHS. The advisor (like the doctor) would respond to calls from the farmer (the patient) and upon assessment of the situation sanction the use of any necessary pesticides (drugs). This would entail a completely regulated market in pesticides (just as with most drugs in the NHS) and allow a better check on usage. Indeed, the scheme could be administered with no additional 'red tape' on the farm. Applications of pesticide could then be tailored in problem catchments to ensure that farming practices were carried out within the bounds of the local environment.

Such a system would mean advice on crop protection would be divorced from the selling of pesticides. The advisors, or 'crop doctors', would have to be licensed and be free from commercial links. They should be able to give advice on the whole range of crop protection strategies. Currently, as soon as an advisor is called onto the farm, non-chemical pest control strategies are almost inevitably closed off. The term 'crop protection' has been appropriated by the chemical industry, but there are a range of alternatives to 'chemical' crop protection, such as cultivations, mechanical weeding, biological control and integrated pest management.

Licensed crop doctors could also help in the collection of information on pesticide usage. Farmers are already obliged to keep records of pesticide applications by law. Crop doctors could keep a copy of any recommendations to spray, so that full and detailed information on the distribution of pesticide use could be easily collated and made available to environmental regulators like the NRA on request.

5. The application of pesticides in the field is only poorly regulated. Only younger farmers have to have spraying competence certificates and there are question marks over the rigour of the certification system. We are still some way from the point where all persons who apply agricultural pesticides should have passed a test of competence. Furthermore, the environmental aspect of these examinations could be strengthened. The responsibility for this training and certification could be given to the licensed crop doctors.

6. The 'Polluter Pays Principle' (PPP) is not being applied to agricultural pesticides. Instead, water companies are removing pesticides from drinking water supplies and passing the bill on to consumers. Thus, the public is paying for the clean-up of water and is ultimately bearing an unforeseen cost for the use of agricultural pesticides. If the PPP were to be applied to agricultural pesticides, farmers and/or the agrochemical industry would be made to bear the interim clean-up costs. One example of how this could be achieved is through a graduated levy imposed on pesticides sales, with the highest levies on those chemicals which are found in water in the largest amounts. This tax could then be used to fund clean-up operations, such as removing pesticides from water. The levy ought to be required for a transition period only, for if the crop doctor system tailored advice on pesticide applications in the light of local pollution risks, contamination should decrease over time and the levy would eventually become redundant.

7. It is difficult and expensive to identify users causing diffuse pesticide pollution. However, breaches of environmental quality standards anywhere in a catchment could be used to act as a trigger for local catchment restrictions. Such enforcement action could be more easily policed under a prescription system administered by the crop doctors and would encourage farmers (and other users) to behave responsibly. Usage could be monitored through the records collected by the crop doctors. This would make for a more flexible regulatory response to pesticide pollution, with feedback from monitoring forming an integral part, guiding future monitoring strategies and triggering review procedures. This would also make the approval procedure that much more provisional and open to subsequent amendment in the light of field experience.

Finally, let us consider as an example what would happen in our study area, the Bedford Ouse catchment, with its problem of pollution from IPU, under such a regulatory system. Local catchment-wide restrictions would indeed be triggered, and enforced through the prescription system. IPU use in the catchment would consequently only be permitted by crop doctors at levels falling within the environmental constraints of the catchment.

If, on the other hand, polluting pesticides were to be banned from use altogether, rather than relying on levies, taxes or prescriptions to control their use, farmers' costs would probably (although not certainly) rise. For example, for individual farmers, a total ban on the use of IPU would imply an additional average cost of about £25 per hectare in using an alternative, non-polluting pesticide.

Such bans of particular polluting pesticides, regionally or nationally, would, however, seem to be **economically** preferable to the treatment option which currently preoccupies policy makers and the water industry. For example, while water companies estimate that it will cost £800 million in capital equipment and £80 million each year in running costs, the immediate annual cost to British agriculture of even a national ban on the use of Isoproturon could be as little as £28million[4].

As the Government notes in 'This Common Inheritance', "prevention is better and cheaper than cure" (p.11). Tackling pesticide pollution at source would not only appear to be more effective in terms of regulatory control, but also, on the basis of these preliminary calculations, it would seem to incur much smaller costs.

Footnotes.

(1) Much of the research work that informs this report was carried out as part of the PATCH (Pollution, Agriculture and Technology Change) Programme. The PATCH Programme was funded by the Economic and Social Research Council under its Joint Agriculture and Environment Programme, and the ESRC's financial support is gratefully acknowledged. Research was carried out at University College London and Bath University between 1989 and 1992. Additional research has since been conducted as part of a research project entitled 'Conditions for the Integration of European Community Environmental Policy at the Local Level: A Social, Cultural and Political Analysis', funded by the European Commission under its Socio-Economic Environment Research (SEER) Programme, and the EC's financial support is also gratefully acknowledged.

(2) HSE investigated 226 pesticide incidents in the 1992/93 season - the highest number on record (HSE, 1993b).

(3) It should be noted that different farmers cite different prices for pesticides. This is because while prices tend to be set by companies at the highest rate that the market can bear, there is scope for negotiating lower prices if chemicals are bought in bulk. Therefore, in general, larger farm businesses can buy their sprays at lower prices. In addition, the costs of sprays vary according to whether the farmer chooses the accompanying advisory services or not. All prices cited in the text were quoted in 1991.

(4) The calculation is based on the assumption supported by farmers surveyed in the Ouse catchment that Fenoxaprop-ethyl would be the best alternative to IPU and could deliver the same degree of weed control. Its higher cost per hectare has been multiplied by the 1.5million hectares usually treated with IPU (but see also note 3).

Acronyms.

ACP	Advisory Committee on Pesticides
ADAS	Agricultural Development and Advisory Service
ATB	Agricultural Training Board
AV	Advisory Value (DoE)
BAA	British Agrochemicals Association
BMA	British Medical Association
COPR	Control of Pesticides Regulations
DoE	Department of Environment
DoH	Department of Health
DTI	Department of Trade and Industry
DWI	Drinking Water Inspectorate
EC	European Community
ENDS	Environmental Data Services
EPA	Environmental Protection Agency
FEPA	Food and Environment Protection Act
FoE	Friends of the Earth
GIFAP	Groupement International des Associations Nationales de Fabricants de Produits Agrochemiques (International Group of National Associations of Manufacturers of Agrochemical Products)
HSE	Health and Safety Executive
IPM	Integrated Pest Management
IPU	Isoproturon
µg/l	microgramme per litre
MAC	Maximum Admissible Concentrations
MAFF	Ministry of Agriculture, Fisheries and Food
NCC	Nature Conservancy Council
NHS	National Health Service
NPTC	National Proficiency Test Council
NRA	National Rivers Authority
NSA	Nitrate Sensitive Area
OECD	Organisation for Economic Co-operation and Development
OFWAT	Office of Water Services
PATCH	Pollution, Agriculture and Technology Change (Programme)
PPP	Polluter Pays Principle
PSD	Pesticide Safety Directorate
RASE	Royal Agricultural Society of England
RCEP	Royal Commission on Environmental Pollution
SCA	Standing Committee of Analysts
WHO	World Health Organisation
WPZ	Water Protection Zones

Table 1 - Pesticide usage on arable crops in England and Wales

Chemical Group	(Tonnes of active ingredient)			
	1974	1977	1982	1988
Insecticides*	(286.7)	520.4	591.8	490.3
Molluscicides*		19.3	203.3	164.7
Seed treatments	540.4	524.1	266.9	3388.0
Fungicides	1090.6	1402.1	3542.6	5099.9
Herbicides	13683.3	17275.2	24228.5	16294.5
Growth regulators	71.0	238.9	1109.3	1771.1
Total Pesticides	15672.1	20025.8	31390.4	27216.6
Area grown (000 ha)	3839.5	3765.8	3800.7	4025.4
Loading (kg/ha)	4.08	5.31	8.25	6.76

Notes

* - For 1974 the figure listed in parenthasis against insecticides is a combined total for insecticides and molluscicides.

Arable crops are defined as cereals, potatoes, peas and beans, oilseed rape and linseed.

Sources: Pitman, 1992; Sly, 1977; 1981; Davis *et al.*, 1990.

Table 2 - Pesticide use in OECD countries - 1988

	Area of agricultural land (000km^2)	Pesticides used on arable & crop land (t/km^2)
Canada	785	0.09
USA	4314	0.18
France	313	0.44
Former West Germany	119	0.42
Italy	171	n/a
UK	185	0.58
Japan	53	1.77
North America	5099	0.16
OECD Europe	1858	0.45
OECD	11872	0.25

Source: OECD data cited in Rae (1991, p. 31).

Table 3 - The regional distribution of pesticide contamination of drinking water supplies, 1985-1987

	No. of breaches of a single MAC	No. of breaches of total MAC
Anglian	113	58
North Trent	2	5
Severn	34	5
Thames	122	9
Wessex	26	1
Yorkshire	1	0

Source: FoE, 1988.

Table 4 - Pesticides detected in surface waters in the Anglian Region, 1985

Pesticide	Modal range μg/l Concentration	Max. μg/l	DoE's AV (μg/l)	Occurrence (% of samples)
Lindane	<0.010 to 0.025	0.055	-	16
Dimethoate	<0.02 to 0.2	0.94	3	14
Diazinon	<0.01 to 0.1	0.23	-	1
Mecoprop	<0.10 to 0.4	5.1	10	35
MCPA	<0.10 to 0.22	16.0	0.5	1
2,4-D	<0.20 to 0.3	2.1	1000	1
Dichloroprop	<0.1 to 0.2	0.5	40	1
Dicamba	<0.1 to 0.3	0.3	4	1
Atrazine	<0.02 to 0.6	9.0	2	58
Simazine	<0.02 to 0.6	7.1	10	42
Ioxynil	<0.04	0.1	10	2
Bromoxynil	<0.02	0.1	10	4
Chlotoluron	<0.1 to 0.3	2.6	80	38
Isoproturon	<0.05 to 1.0	11.5	4	84
Linuro	<0.2	<0.2	10	0
Propyzamide	<0.1 to 0.23	2.23	-	2

Source: Croll, 1991

Table 5 - Pesticides detected in groundwaters, 1985

Pesticide	Concentration range (μg/1)	DoE's AV (μg/1)	Occurrence (% of samples)
Mecoprop	0.1 - 0.38	10	3
MCPA	0.12	0.5	0.5
2,4-D	0.11 - 0.2	1000	1
Atrazine	0.02 - 0.43	2	28
Simazine	0.02 - 0.26	10	9
Isoproturon	0.1 - 0.41	4	6
Chlortoluron	0.1 - 0.12	80	3

Source: Croll, 1991.

Table 6 - Sources of advice for pesticide use (63 farms)

	Farmers that used this source for any advice (%)	Most important sources of advice (% of farmers)					
		Which product to use			How best to use it		
		1st	2nd	3rd	1st	2nd	3rd
Own expertise	100	19	16	6	16	10	2
Merchant's representative	100	57	22	6	56	10	5
Manufacture's representative	100	2	3	3	8	6	-
Independent consultant	60	6	2	-	5	-	2
Contractor	97	-	2	-	5	5	-
Employee's expertise	97	-	-	-	-	2	-
Neighbour	90	-	2	6	-	-	-
Family	92	-	-	2	-	-	-
NRA	57	-	-	-	-	-	-
HSE	94	-	-	-	-	-	-
ADAS (personal)	78	14	8	-	13	8	2
ADAS (group)	52	5	11	2	5	2	1
Farming research group	49	2	-	2	-	-	-
Farming press	97	-	5	5	-	2	2
Farming events & conferences	94	-	2	3	-	-	-
Other		2	2	-	3	2	-

1st = most important source of advice; 2nd = second most important source of advice;
3rd = third most important source of advice. Vertical columns do not total 100% because some farmers gave joint first choice of advice and some farmers did not give a second or third preference.
Source: Farm survey.

Table 7 - Do you think there is any difference between independent and commercial advice? (57 responses)

Response	No	%
Yes, commercial advice can be biased	37	65%
No, no difference	15	26%
Yes, different quality but not bias	5	9%

Source: Farm Survey.

Table 8 - Pesticides in Anglian Water Services' Supply Zones, 1990-91.

Pesticide	Determinants exceeding MACs		Zones not complying with the regulatory requirements	
	%	%	No.	No.
	1990	1991	1990	1991
Atrazine	34.0	21.9	73	94
Bromoxynil	0.0	0.1	0	2
Chlortoluron	0.8	1.1	16	54
Dichlorprop	1.0	0.6	26	12
Dichlorvos	<0.1	0.0	1	0
Dimethoate	0.0	0.3	0	14
Diuron	0.0	<0.1	0	1
Ioxunil	0.1	<0.1	1	1
Isoproturon	13.9	2.4	54	64
Linuron	0.1	0.0	2	0
MCPA	0.0	<0.1	0	1
MCPB	0.1	<0.1	4	1
Mecoprop	32.6	5.1	66	62
Propyzamide	1.3	2.3	26	50
Simazine	19.9	9.1	25	55

Source: Drinking Water Inspectorate, 1992a, p. 29

Table 9 - The changing proportion of the area of crops and grass under wheat and barley, 1959-89.

	1959	1969	1979	1989
Bedfordshire	35.5	53.5	63.4	63.0
Buckinghamshire	18.3	34.3	41.5	41.6
Beds & Bucks combined	25.1	41.9	50.4	50.5

Source: MAFF Country agricultural statistics.

Table 10 - Farm responses to an autumn ban on IPU use.

Response	No. of farmers	%
Don't know (I would have to ask my advisor	6	10.2
Use IPU in the spring and drill later	14	23.7
Switch to another chemical	26	44.1
Spring cropping	5	8.5
Change cropping pattern/rotation	2	3.4
Use cultural methods of weed control	2	3.4
No effect	8	13.6
Consider stopping cereal production or set aside	4	6.8
Total	59	100%

Source: Farm Survey

Table 11 - Farm responses to a total ban on IPU use.

Response	No. of farmers	%
Don't know (I would have to ask my advisor	14	24.1
Use IPU in the spring and drill later	-	0.0
Switch to another chemical	33	56.9
Spring cropping	2	3.4
Change cropping pattern/rotation	2	3.4
Use cultural methods of weed control	3	5.2
No effect	2	3.4
Consider stopping cereal production or set aside	8	13.8
Total	58	100%

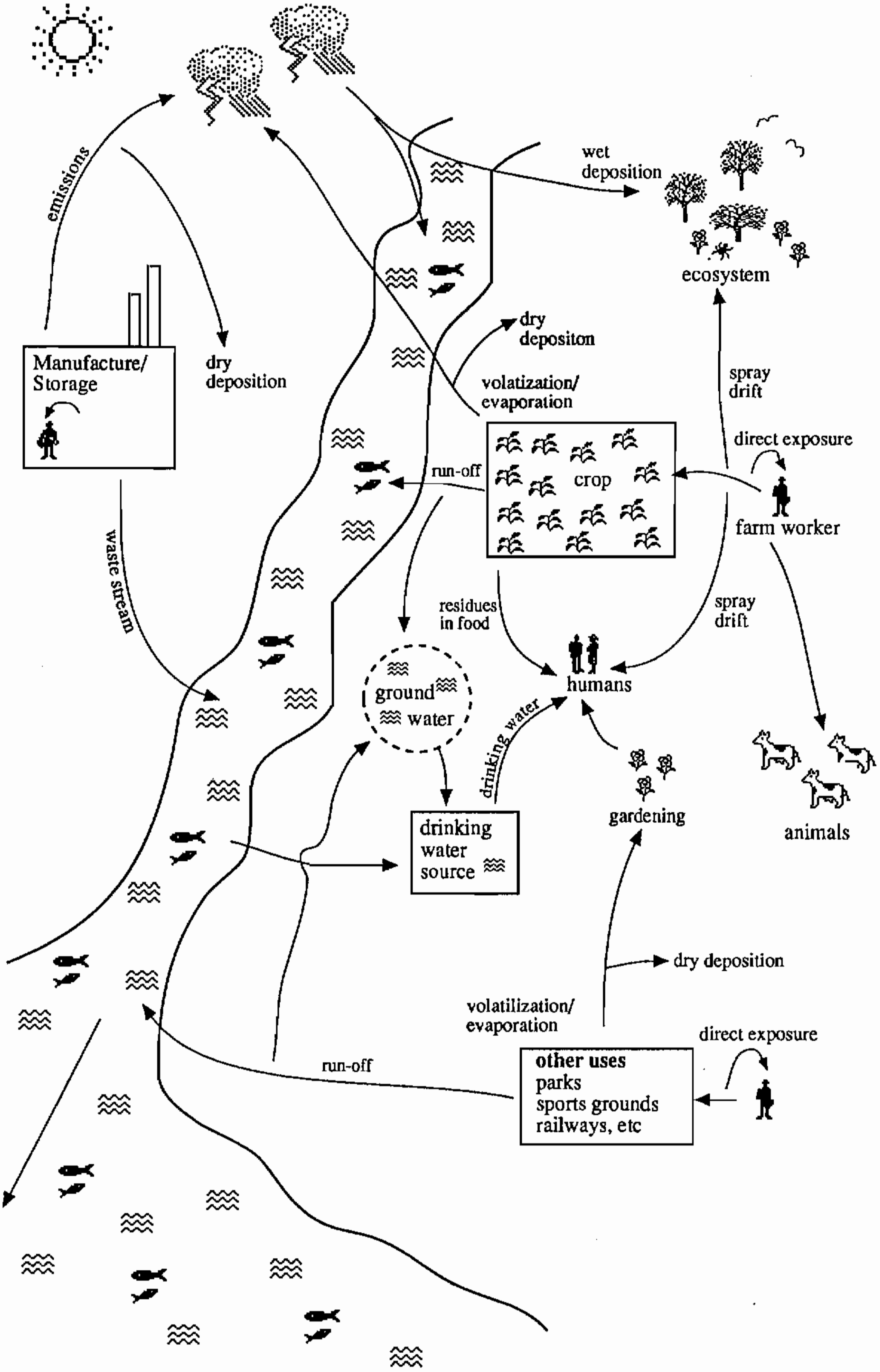
Source: Farm survey.

Table 12 - Farm responses to an autumn ban on all herbicides.

Response	No. of farmers	%
Don't know (I would have to ask my advisor	10	16.9
Use IPU in the spring and drill later	14	23.4
Switch to another chemical	15	25.4
Spring cropping	11	18.6
Change cropping pattern/rotation	6	10.2
Use cultural methods of weed control	8	13.6
No effect	6	10.2
Consider stopping cereal production or set aside	9	15.3
Total	59	100%

Source: Farm survey.

Figure 1 - Pesticides in the Environment: A Schematic Diagram of Pathways.



Legislative framework	FEPA 1985 & COPR 1986	HSW 1974 COSHH 1988	Water Act 1989 (+ COPA 1974) (Water Resources Act 1991) (Water Industry Act 1991)	
	COLUMN I	COLUMN II	COLUMN III	COLUMN IV

Notes:
– – –► movement of pesticides between compartments (does not show pathways)
- - - ► liaison with

* PIAP Pesticides Incidents Appraisal Panel
Considers incidents where normal usage of pesticides may have affected other people or property.

Abbreviations

MAFF	Ministry of Agriculture, Fisheries and Food
DoE	Department of the Environment
HSC	Health and Safety Commission
HSE	Health and Safety Executive
NRA	National Rivers Authority
ADAS	Agricultural Development Advisory Service
PSD	Pesticides Safety Divsion
ACP	Advisory Committee on Pesticides
WIIS	Wildlife Incidents Investigation Scheme
WPPR	Working Party on Pesticide Residues
EP	Environmental Panel
EPD	Environment Protection Division
FEPA	Food and Environment Protection Act
COPR	Control of Pesticides Regulatrions
HSW	Health and Safety at Work Act
COSHH	Control of Substances Hazardous to Health Regulations
COPA	Control of Pollution Act
ACOP	Advisory Code of Practice
COGAP	Code of Good Agricultural Practice
AV	Advisory Value
µg/l	micrograms per litre

Figure 2 : ENVIRONMENTAL REGULATION OF AGRICULTURAL PESTICIDES

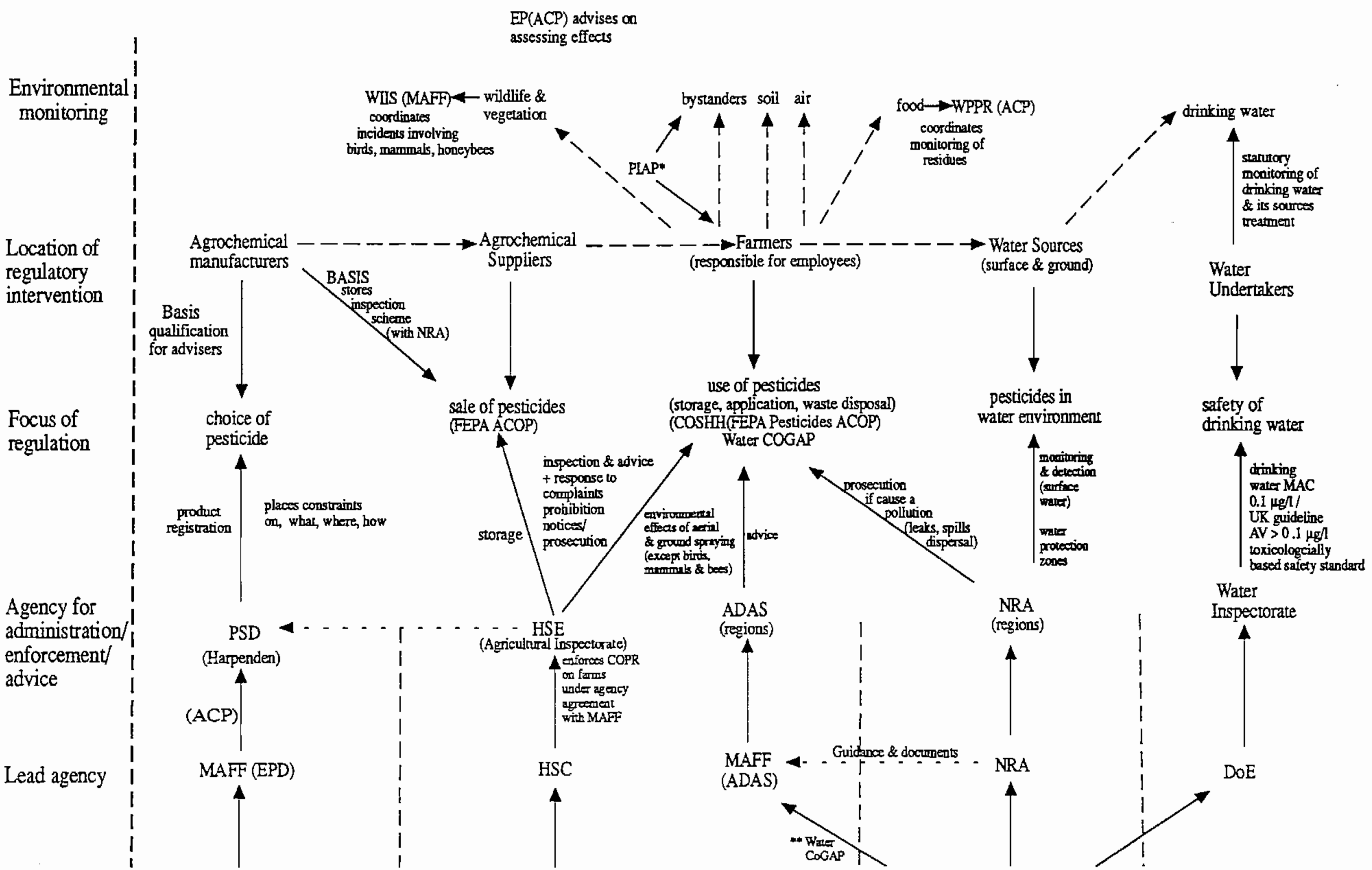
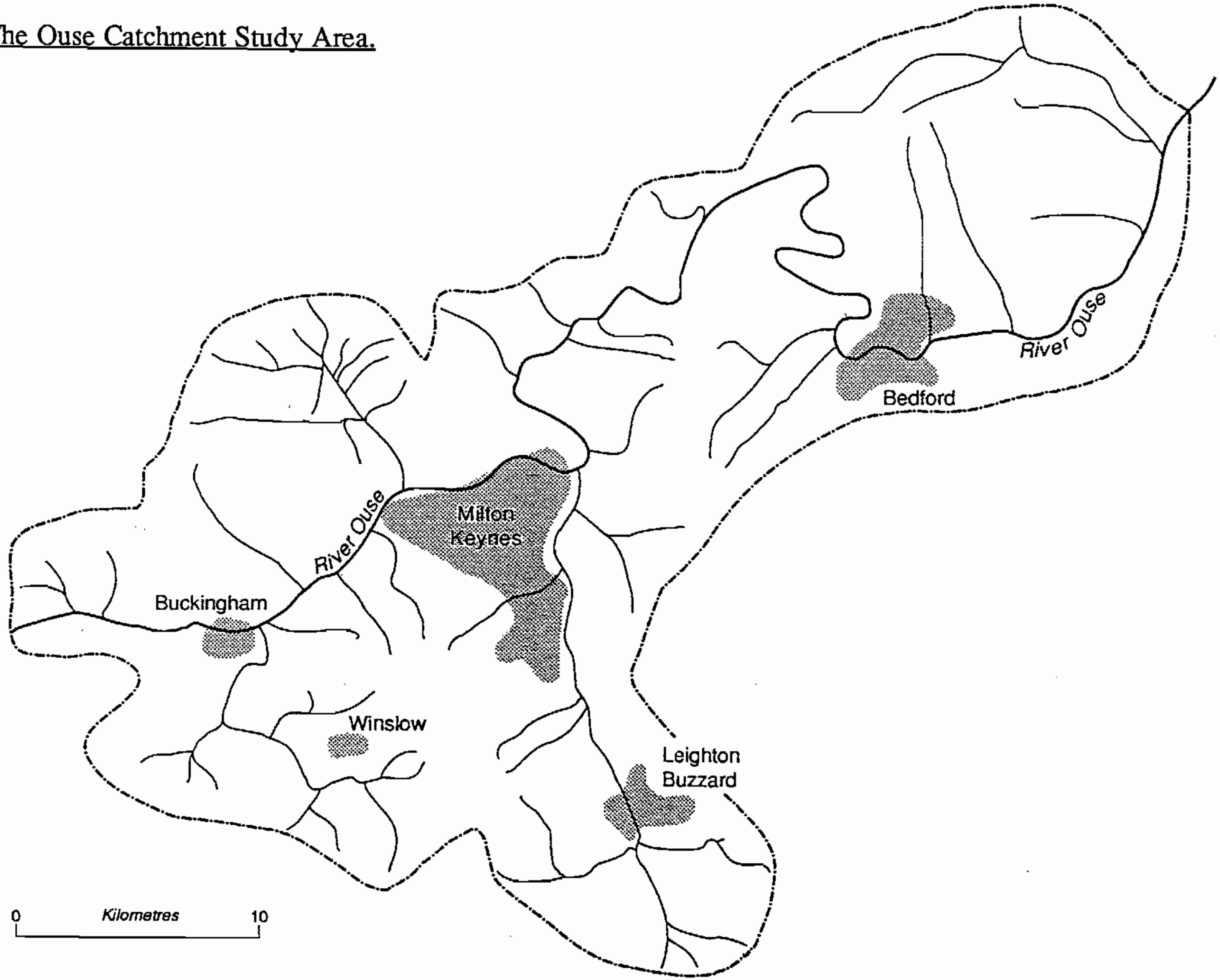


Figure 3 - The Ouse Catchment Study Area.



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