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The role of economic instruments in managing diffuse nutrient pollution

A focus on phosphorus

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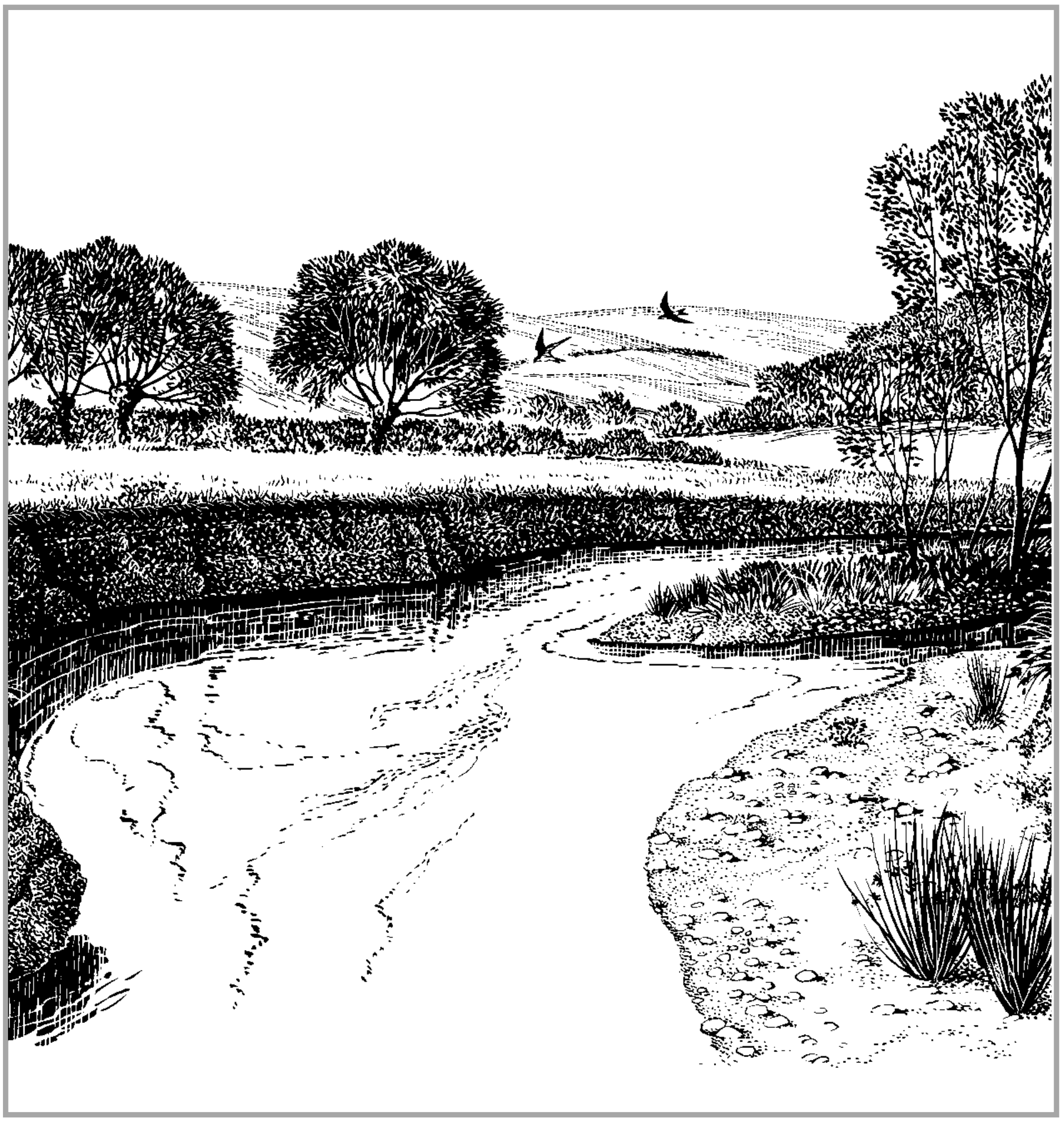

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The role of economic instruments in managing diffuse nutrient pollution: a focus on phosphorus

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Preface

This report was written for English Nature by Risk & Policy Analysts Ltd (RPA). It investigates the potential use of economic instruments to help tackle the effects of diffuse nutrient pollution on freshwater wildlife. It is an initial scoping study looking at a range of options. It is not intended to specify definitively the role of economic instruments relevant to this problem, nor the choice of option. This will require further detailed research in follow up to this study. English Nature sees economic instruments as having a possible long term role as part of a package of measures to tackle this problem. This study should be read alongside another report, published at the same time, which looks at a wide range of other possible policy mechanisms, including transitional grant aid (Policy mechanisms for the control of diffuse agricultural pollution, with particular reference to grant aid; English Nature Research Report 455; 2002).

English Nature
April 2002

Acknowledgements

RPA would like to acknowledge the advice and support provided by the Steering Group to this study. The Steering Group consisted of representatives from English Nature; the Environment Agency; the Department for Environment, Food and Rural Affairs; and the Royal Society for the Protection of Birds.

Executive summary

1. Introduction

The European Environment Agency has identified eutrophication (by nutrients) of inland and saline waters as a pan-European problem of major concern. This concern is re-iterated by the Environment Agency (EA), which has identified it as one of its top ten priorities in freshwaters; the Scottish Environmental Protection Agency (SEPA), which identifies eutrophication as its second and third most important priorities for lochs and rivers respectively; and English Nature (EN), which identifies it as being one of the largest problems facing the ecology of freshwaters in the UK and elsewhere.

As part of efforts to tackle the eutrophication problem, the EA published *Aquatic Eutrophication in England and* Wales: *A Management Strategy* in 2000. This strategy focuses on the macronutrients, phosphorus (P) and nitrogen (N). It highlights that, in freshwater situations, control measures should mainly be directed towards the control of P, which is generally the nutrient that is, or could most readily be made, the limiting nutrient to eutrophication. In saline waters, N is generally considered to be the limiting nutrient and hence the principle focus of control measures, although phosphorus is becoming more of a concern as new R&D comes to light.

2. Scope of the research

English Nature have commissioned this study to examine the ways in which economic instruments could be used to provide incentives for the reduction of diffuse nutrient inputs from agriculture. A focus on P was requested due to the current lack of any controls in this area - the Nitrates Directive provides some control over agricultural loads of N, though not to ecologically relevant levels.

The focus of the study has been on instruments that would discourage P emissions from farm sources. This work complements another study recently completed for English Nature by the Institute for European Environmental Policy (IEEP, 2002), which has examined the potential role of a wider set of possible policy measures for controlling diffuse pollution, with a particular focus on the use of grant-aid schemes. As the IEEP study considers the wider policy context, the focus of this study has been on analysis and not on a review of the literature on economic instruments. The work has included an analysis of the options and their appropriateness as a means of identifying and designing (at a preliminary level) likely candidates for further work.

3. Target actions for control of P

In order to address the nutrients problem, the study has identified the need for measures aimed at achieving general reductions in nutrient loads across all farms, and more stringent measures aimed at achieving more targeted reductions in priority areas. Such measures could be based on a range of different objectives:

- raising awareness of phosphate application;

- producing an incentive to reduce application rates and, therein to curb excessive emissions;
- promoting more targeted P inputs though better nutrient planning;
- addressing redistribution of P away from critical source areas (CSAs);
- encouraging the uptake of measures to reduce transport management (ground cover, avoiding winter manure applications, more effective incorporation); and
- reducing nutritive P values of manure.

4. Economic instruments for controlling phosphorous

Economic instruments provide an alternative approach to direct regulation or voluntary measures for achieving environmental quality improvements, with several different types of instruments being relevant to the management of nutrient emissions. These include emissions charges, product charges, simple fund raising levies, tradeable permit systems, and recycling credit schemes.

Based on a review of how each of the above types of instruments could be applied to reducing P emissions, a sub-set of the possible options were identified for further elaboration and this feasibility analysis. This targeting of a sub-set of the options does not mean that those not analysed further here would not provide feasible instruments, depending on the aim of the instrument and its detailed design. Instead, it reflects the fact that within the constraints of this study, we were able to concentrate on only a selected number of leading options.

The options considered here are:

- *Option 1: Nutrient Surplus Charge*. Three different forms of charge have been considered building on the requirements under NVZs, with the first (1a) involving simple minerals accounting requiring recording of P inputs and outputs and charging on the surplus P as a surrogate for emissions; the second (1b) is more stringent requiring that farmers also undertake more complete nutrient budgeting based on soil P testing; while the third (1c) is a combination of the first two approaches that allows farmers to decide whether or not to move to full nutrient budgeting.

- *Option 2: Tax on Feed Phosphorus Supplements and Content*. The introduction of a tax on feed P supplements and feed mixes may offer significant reductions in the nutritive value of manures. This, in turn, may provide a partial solution to P loadings and the disposal of 'waste' manures.

- *Option 3: Tradeable Permits Scheme for Application to Specific Problem Catchments*. Tradeable permits offer potential for reducing the environmental load of phosphorus at a reduced cost to farmers, compared with regulation or emission charges. The most appropriate method may be to base quotas on nutrient surpluses, to encourage farmers to reduce the amount of excess phosphorus on their farm.

- *Option 4: Measures to Address Management/Mitigation Issues*. A simple wise use levy (4a) could fund the encouragement of on-farm measures to reduce P loads or P transport may provide an important short-term and complementary measure to those described above. Alternatively, charge revenues could be used to provide rebates (4b) to farmers for undertaking particular activities on their farm. This could be supplemented by other sources of funding to encourage more innovative responses.

Table 3.3: Scoping of proposed instruments against mechanisms for reducing diffuse emissions of phosphorus

Mechanism	Simple Minerals Accounting (Option 1a)	Nutrient Mgmt. (Option 1b)	Options 1a & 1b Combined (Option 1c)	Tradeable Permits (Option 2)	Tax on Feed P (Option 3)	Wise Use Levy (Option 4a)	Charge Rebates (Option 4b)	Permit Charges (Option 5)*
Raising awareness of phosphate application	S	S	S	S	W	W	W	S
Reducing application rates/ curbing excessive emissions	W	S	W/S	S	W	W	W	S
More targeted P inputs though better nutrient planning	W	S	W/S	S		W	W	S
Redistribution of P away from CSAs	W	S	W/S	S		W	W	S
Reducing Soil P Indices		S	W/S	S			W	S
Encouraging the uptake of measures to reduce transport management	?	?	?	?		S	S	S
Reducing nutritive P values of manure (via feed)					S			

Key: S: strongly or directly addressed by instrument
W: weakly or indirectly addressed by instrument
? : could be incorporated as part of a rebate/wise use initiative
'blank': unlikely to be addressed by instrument

Note*: The impact of this option would be limited to its scope of application as targeted would be required to limit administrative costs. This makes rating in terms of 'weak' or 'strong' difficult.

- *Option 5: Permit Charges for Potentially Polluting Activities*. While probably not practical administratively as a universal approach across the country, a permit charging scheme might offer a more flexible alternative to traditional regulation in targeted areas – especially in circumstances where a permit trading system would not be practicable. The detailed work undertaken in the parallel report (IEEP) is relevant to this option.

- Table 1 sets out the scope of each of the instruments and their coverage in terms of the various mechanisms of action. As can be seen from the Table, none of the instruments in isolation is likely to give an incentive that is sufficient to cover all of the relevant mechanisms. Those measures that provide the strongest incentives to reduce P emissions are also those that are likely to have the highest compliance costs, thus creating the greatest incentives for farmers to respond. Those that may provide only a weak link to the various mechanisms for reducing environmental damages are also the lower cost measures. This suggests that it may be important to combine the instruments to create a cost-effective approach to addressing the nutrients problem.

5. The modelling approach

Given study resources, a 'top down' approach has been used to model the cost and effectiveness of the first three options set out above (with a more qualitative assessment provided on the Options 4 and 5). A consistent approach has been adopted across the options. As base data, the model uses national census data, published data on quantities of P produced and manurial P values to generate a detailed P budget. This is linked to a forecasting model that predicts changes under the various options. This model has permitted an analysis of the instruments in terms of their implications for different application levels of P to grassland and crop. It provides predictions on a national level for the variables of greatest concern and influence on the viability of the instruments, namely: the changes in the volume of farm 'waste' generated; its nutritive value; transport and spreading issues; changes to the national P budget; and associated surpluses and disposal issues.

The key independent variables that are addressed in the model include:

- application levels to grassland;
- maintenance application levels to crops;
- permissible application levels to crops under RB209;
- 'sustainable' application levels;
- areas available for spreading;
- distance travelled; and
- excretal P values.

A mode of operation for each of the instruments has been defined. Costs and environmental effectiveness of each instrument have been estimated using the modelling approach described above.

6. Summary of findings

Although it is not possible to make direct comparisons of all of the options in terms of overall environmental benefits and the cost-effectiveness with which they can be achieved, the 'best' options would appear to be the nutrient surplus charges (Options 1). Options 1a and 1c would offer a partial solution to reducing the current level of P loadings being spread on land, providing reductions in inputs of around 54,000 tonnes per annum. The costs to farmers are estimated to vary from £300 to £1,300 per holding depending on the transport distances required. The costs per unit of P reduced are higher for these options though than for Option 1b (based on the RB209 fertiliser recommendations (MAFF, 2000)), even though the latter has higher total annual costs. Under this option a potential 149,000 tonnes per annum of P are no longer spread on land, at estimated costs of between £1,000 to £2,800 per holding (again depending transport distances required).

The above costs relate to the full implementation of the option, but it would obviously be possible to bring in the same type of system with charge rates below those implied by the above figures to deliver a lower level of environmental gains at a lower cost to the nation.

Even a lower charge rate may have the potential to alter farm economics sufficiently by creating an increased demand for low P feed supplements and additives and an increased use of more innovative disposals methods. Both of these offer the potential for significantly reducing overall P loadings, with the up-take of low P feeds decreasing the level of P in manures by up to 57,000 tonnes per annum. Because these feeds are of the same or lower cost, this shift could be made at little to no cost to farmers – even in the absence of a product tax (Option 2). Similarly, some of the alternative disposal methods (including treatment and processing) may have relatively short pay-back periods.

Nutrient surplus charging may be politically unacceptable, however, as depending on the charge rates it could have implications for the competitiveness of farming (if applied at a national level). An alternative partial solution may then be the creation of Trading Zones (Option 3) in Critical Source Areas (CSAs). This option would seek to achieve reductions in quantities of P applied and in the areas to which P is applied by setting quotas at the field level. Where farmers have spare capacity for spreading P to land, this capacity could be sold to those who have to dispose of P off their land. The costs are of the same order of magnitude as those arising under the charging schemes, but the majority relate to regulatory set-up costs which may decrease in per unit terms through economies of scale should a number of zones be created. The creation of a trading system also provides a good basis for securing additional environmental benefits (in the form of reduced risk of diffuse P in the water column) through the development of management agreements, permit charges or other mechanisms (where this effectively constitutes Options 4b and 5).

It is more difficult to compare the measures to address management/mitigation issues (Options 4a and b), partly because it has not been possible to quantify the benefits and costs in the same manner. The creation of a wise use levy through the introduction of a tax on fertilisers or some other unit of production may be valuable in providing funding for education and the promotion of the types of actions highlighted in Section 4.5 and above. However, significant tax rates per unit may be required in order to produce the level of funding required finance the initiatives proposed by the study led by IEEP, although other public revenue sources could also contribute to the funding of these proposals. The alternative to the introduction of this type of levy would be to create a rebate system within the nutrient surplus charging schemes provided by Option 1. The revenues generated by the full options are significantly higher than those required to fund the IEEP proposals, suggesting that lower charges together with rebates on the adoption of the various management actions may prove highly cost-effective.

7. Recommendations on a combined approach

Based on the above findings, it would appear that a combined approach to the adoption of economic instruments may be the most appropriate. There are two possible combinations:

- Combination A: the introduction of nutrient surplus charges (Option 1) which builds on NVZ requirements, followed by the use of the revenues to fund wise use initiatives drawing on the types of management activities identified by the IEEP study. The nutrient surplus charging scheme would preferably be based on Option 1b, but with the rate set at one which does not result in the transport of manures over long distances. The rate could be set at a low level in the first years and increased over time in response to the need to generate the required level of funding and to provide the impetus for increased innovation in disposal methods and the shift to low P feeds.

- Combination B: the introduction of localised trading zones in CSAs. This could then be complemented by the creation of a wise use levy and/or funding provided by other public revenue sources, or through the introduction of permit charges to shift farmers away from the most damaging activities. This would ensure that the damages occurring in the most sensitive aquatic environments were being tackled, yet at lower costs to the nation as a whole (owing to the more limited coverage) than implied by the surplus charges. Education on the cost savings that could arise from the adoption of low P feeds should reduce the costs faced by individual farmers, with the grants/soft loans provided by the wise use levy/permit charge revenues further assisting the reduction in damages.

In both cases, further work is required to establish with more reliability the costs and benefits that would be involved and the best form that these combinations should take.

8. Further research

Clearly, the economic instruments examined here can provide a range of short to longer term strategic solutions for tackling diffuse P pollution issues. Further research is required to refine the estimates produced here for the charges and trading options. This could include:

- refining assumptions on transport and associated requirements using GIS data on livestock and crops to create a better understanding of how P surpluses would be spatially distributed;
- identifying the cost thresholds over which farmers would adopt other responses than transport;
- defining in more detail the administrative requirements associated with each option to provide a sounder basis for costing this aspect;

- assessing more fully the relative benefits associated with education and different in-soil P management methods so that the cost-effective of measures to be funded through a wise use initiative or charge rebates can be determined; and
- consideration of the impact of any charges to be levied nationally on the macro-economy.

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1. Introduction

1.1 Background

The European Environment Agency has identified eutrophication (by nutrients) of inland and saline waters as a pan-European problem of major concern. This concern is re-iterated by the Environment Agency (EA), which has identified it as one of its top ten priorities in freshwaters; the Scottish Environmental Protection Agency (SEPA), which identifies eutrophication as its second and third most important priorities for lochs and rivers respectively; and English Nature (EN), which identifies it as being one of the largest problems facing the ecology of freshwaters in the UK and elsewhere.

Eutrophication problems affect a range of priority species and habitats identified in the UK Biodiversity Action Plan, as well as nationally and internationally designated sites and other non-designated waters. As part of efforts to tackle the eutrophication problem, the EA published *Aquatic Eutrophication in England and Wales: A Management Strategy* in 2000. This strategy focuses on the macronutrients, phosphorus (P) and nitrogen (N). It highlights that, in freshwater situations, control measures should mainly be directed towards the control of P, which is generally the nutrient that is, or could most readily be made, the limiting nutrient to eutrophication. In saline waters, N is generally considered to be the limiting nutrient and hence the principle focus of control measures, although phosphorus is becoming more of a concern as new R&D comes to light.

For the past 40 years or so, most pollution control effort in the UK has been directed at point sources such as sewage and industrial effluent. Whilst this effort has reduced organic pollution considerably, and will in the future continue to help reduce nutrient levels, pollution loads from diffuse sources makes it increasingly difficult/impossible to restore and maintain the ecological integrity of receiving waters. Since agriculture is a very large contributor to diffuse nutrient loads, this sector is inevitably the major (but not the only) focus for diffuse source control.

There are various important drivers for tackling diffuse agricultural sources of nutrients, and diffuse pollution more generally. The policy mechanisms that could be applied to control the problem are also varied, from advice and awareness and grant schemes to conditions on payments and direct regulation. English Nature has commissioned this study to examine the ways in which economic instruments could be used to provide incentives for the reduction of diffuse nutrient inputs from agriculture. A focus on P was requested due to the current lack of any controls in this area - the Nitrates Directive provides some control over agricultural loads of N, though not to ecologically relevant levels.

This forms part of a wider initiative to generate an integrated framework for the complementary use of different policy mechanisms in controlling diffuse agricultural pollution. It is important to view economic instruments and other mechanisms as providing part of an overall solution to the problem, not a complete solution on their own. Assessing how different mechanisms might be combined to provide a workable package of measures is a key task.

Whilst the focus of this work is on the control of agricultural nutrient loads, the types of actions that farmers may take could have further benefits in reducing organic and microbial pollution (eg through improved organic waste management activities) and even in erosion control, depending upon the design of the economic instrument.

1.2 Aims and scope of the study

The aim of this study is to carry out feasibility research on policy options for economic instruments aimed at reducing diffuse source nutrient pollution from agriculture. Owing to the fact that P is the major limiting nutrient in freshwaters and there are currently few statutory or other controls on P emissions, the study's primary focus is the reduction of diffuse sources of P.

The objective is to consider instruments which discourage excessive P emissions and to evaluate their appropriateness as a means of identifying and designing (at a preliminary level) likely candidates for possible further work.

This work complements another study recently completed for English Nature by the Institute for European Environmental Policy (IEEP, 2002), which has examined the potential role of a wider set of possible policy measures for controlling diffuse pollution, with a particular focus on the use of grant-aid schemes. As the IEEP study considers the wider policy context, the focus of this study has been on analysis and not on a review of the literature on economic instruments.

1.3 Structure of the Report

This report presents the findings of the feasibility assessment of potential instruments for reducing diffuse nutrient pollution. The focus has been on a sub-set of possible measures for discouraging P emissions stemming from different agricultural activities. We have organised our discussion of these findings as follows:

- Section 2 provides a summary of the extent and principle sources of diffuse nutrient pollution and the key actions for reducing phosphorus pollution;
- Section 3 provides an introduction to the principles underlying economic instruments, the types of instruments available and the criteria for assessment of appropriateness; it also sets out the options that have been short-listed for more detailed examination and indicates why they were selected above other options;
- Section 4 provides an overview of the model used to analyse the short-listed options (with further details provided in Annex 1), and presents the results of our assessment concerning the appropriateness of each to controlling P emissions; while
- Section 5 summarises our conclusions and recommendations for further research.

2. Nutrients and the aquatic environment

2.1 Environmental effects and management targets

2.1.1 Mechanisms of impact

Elevated loads of essential plant nutrients to aquatic ecosystems give rise to a variety of direct and indirect impacts (collectively termed eutrophication) on plant and animal communities. Nutrient enrichment and associated eutrophication effects have a cost to society, including both damage costs (for example, from a reduction in recreational opportunities, increased costs of water treatment and additional maintenance of the water body) and non-use costs (incorporating the conservation and biodiversity losses).

The direct mechanism of impact caused by elevated nutrient levels is the stimulation of growth in certain plant species and subsequent alterations to the composition of the plant community. Varying degrees of severity in impact on plant communities can be recognised:

- increased growth rates of higher plants which re-grow rapidly following management;
- changes in species composition and balance within the higher plant community, as plants whose growth rates are optimised to high nutrient levels become more predominant; and
- excessive growth of algae (planktonic, epiphytic or benthic), which reduces the amount of light reaching the leaves and stems of higher plants and can change the species composition to one of shade-tolerant higher plants through to complete dominance of algae.

As a result of elevated nutrient levels in lakes, canals and sluggish lowland rivers, phytoplankton typically create the change from a healthy submerged higher plant community to algal dominance. This process is described by various authors with reference to case studies (eg Timms & Moss, 1984; Scheffer *et al,* 1992; Moss, 1997). In faster-flowing rivers, submerged plants have somewhat greater resistance to algal dominance but can be out-competed by epiphytic and benthic forms of algae that, unlike phytoplankton, can maintain high population densities in this type of habitat (Mainstone *et al*, 2000).

A range of indirect impacts also arise due to the effects on the plant community. These include:

- excessive standing crops of plants generating a large nocturnal oxygen demand, leading to severe stress and even death for fish and invertebrates;
- the loss of submerged higher plants (and some lower plants such as aquatic mosses) that provide essential habitat for many aquatic animals, afford shelter from predators, act as food sources and a substrate for laying eggs, resulting in the loss of this essential habitat; and
- excessive growth of benthic algae creating poor sediment conditions for a range of animal species. Oxygen exchange with the water column is reduced and, in rivers specifically, fine silt is deposited more readily, leading to further problems with oxygen exchange and a loss of interstitial habitat for invertebrates and young fish.

A wide range of environmental factors other than nutrient levels also influences the competitive balance between plant species. Some conditions, which may be transient or permanent, provide the higher plant community with greater resistance to competition from algae (eg strong flushing flows in rivers). In lakes, higher plants themselves create conditions that favour their continued dominance (eg by providing a refuge for large populations of phytoplanktiverous fish and invertebrates). This complex interaction of factors means that there is no simple dose-response relationship between nutrient levels and effects. The important implication of this is that environmental targets for phosphorus levels have to be set to control the risk of impact, rather than the inevitability of it.

2.1.2 Status of receiving waters

The concentrations of phosphorus and nitrogen in aquatic systems vary naturally according to catchment geology. The base-poor, hard geologies of the uplands generate very low nutrient levels (so-called 'oligotrophic' conditions), whereas the base-rich, soft geologies of many lowland areas generate higher nutrient levels (so-called 'eutrophic' conditions). The difference in nutrient concentrations between oligotrophy to natural eutrophy (perhaps from $<0.01mgl^{-1}$ to $0.03\ mgl^{-1}$ soluble phosphorus in rivers and lakes) is actually not that great when compared to the concentrations generated by artificial enrichment.

Pragmatic target levels of nutrients are in the process of being defined, based on those concentrations that would occur under conditions of relatively low human impact and that are deemed likely to avoid unacceptable ecological risk. They reflect the spatial pattern of natural levels and vary between 0.02 and $0.1\ mgl^{-1}$ soluble phosphorus (flowing rivers) or total phosphorus (lakes, canals, sluggish rivers and ditch systems). Many lakes, rivers and other freshwaters in England and Wales are heavily enriched with both phosphorus (and nitrogen), far exceeding these target levels. Associated wetland habitats such as fens and wet grasslands that are fed by such waters are also at risk.

Figure 2.1 shows the extent of phosphorus enrichment in rivers in England and Wales, indicating where natural and background levels lie. The scale of enrichment is clearly much greater in large lowland rivers, even though this must be interpreted in the light of the high sensitivity of upland oligotrophic rivers to small changes in nutrient status.

Similarly, Fox & Bailey-Watts (1998, in WRc, 1999) looked at more than 900 lakes in England, Scotland and Northern Ireland and found that 70% of English lakes had total P concentrations of $0.01mgl^{-1}$, compared with 35% in Northern Ireland. In a survey of 95 lake and other standing water SSSIs in England, Carvalho & Moss (1998) concluded that 80 of these were suffering from eutrophication.

The situation in estuarine and coastal waters in less clear since target levels have not been defined. Considering that N and P loads are so elevated in freshwaters entering these areas, the level of nutrient enrichment must be high.

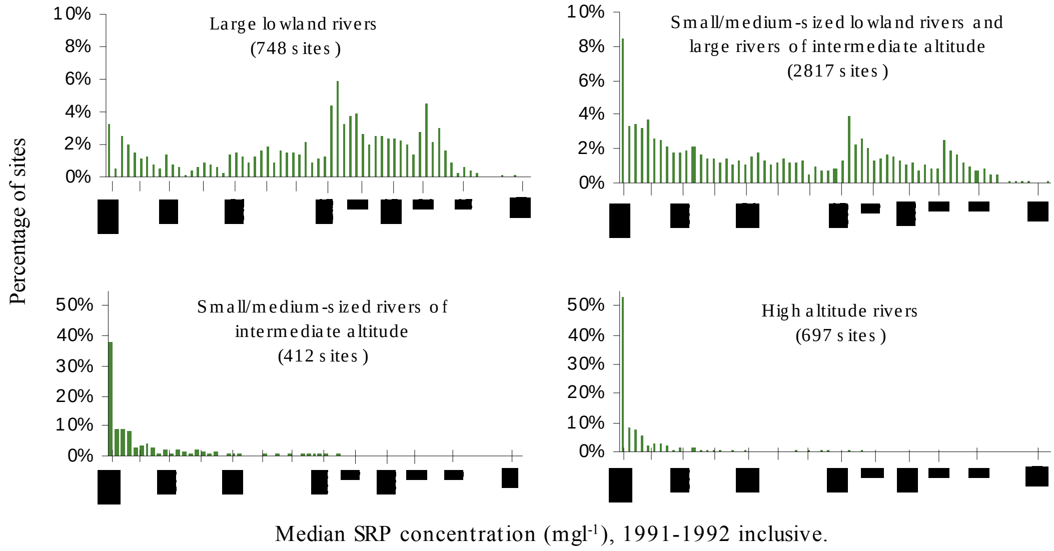

Figure 2.1 Ambient phosphorus concentrations (as Soluble Reactive Phosphorus) in different types of river in England and Wales

2.2 Sources of nutrients

2.2.1 Relative contributions from point and various diffuse sources

Nutrients come from both point sources (such as discharges from sewage treatment works (STWs) and industry) and from diffuse sources (including run-off from agricultural land and urban areas, groundwater and atmospheric deposition). Approximate national estimates of the main sources of P entering surface waters in the UK are shown in Figure 2.2.

This figure highlights the relative importance of diffuse agricultural sources (43%), with this likely to continue increasing due to reductions in phosphates in detergents and P-stripping in some larger STWs. For nitrogen, 70% of the total input to inland surface waters is estimated to come from diffuse sources, particularly agriculture (The Royal Society, 1983). The remaining 30% comes from sewage effluent and industrial discharges. Table 2.1 shows the main diffuse sources of P and N (in order of importance). For both nutrients, fertilisers (inorganic and organic) are the main sources.

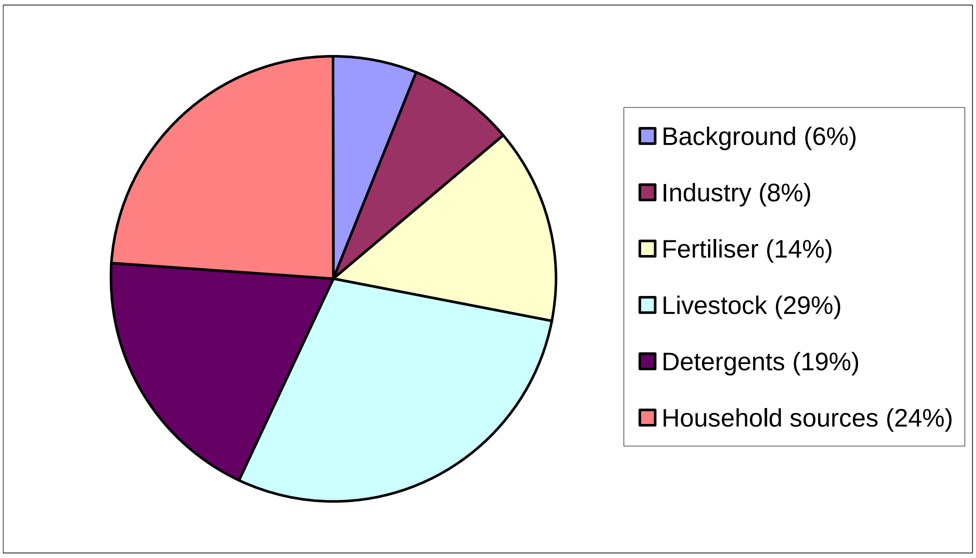

Figure 2.2 Sources of phosphorus entering surface waters in the UK

(Source: Morse *et al*, 1993)

Table 2.1 Contribution to national nutrient budget by diffuse sources (in order of importance)

Phosphorus	**Nitrogen**
Livestock manure and slurry	Inorganic fertilisers
Inorganic Fertilisers	Livestock manure and slurry
Natural export	Atmospheric deposition (itself sourced primarily from industry and agriculture)
Sewer leakage/septic tanks	Natural export
Sewage sludge	Sewer leakage
Atmospheric deposition (principally derived from adjacent areas)	Septic tanks
	Sewage sludge application to land
Source: WRc (1999)	

The relative importance of different nutrient sources can vary greatly between catchments, dependent upon population densities, land use and natural factors such as geology, soil type and hydrology. Table 2.2 illustrates the variation in P sources between four catchments in England. Contributions also change through time, both in the short-term, in response to climatic changes and land management activities, and in the longer-term in response to socio-economic and technological changes.

Table 2.2 Examples of annual P budgets (tonnes P per year)

	Upper reaches of Hampshire Avon (Parr *et al*. 1998)	**Warwickshire Avon (Iversen *et al*. 1997)**	**Pevensey Levels (Parr and Mainstone, 1997)**	**River Ant (Johnes *et al*. 1994)**
Atmospheric/natural	12.5 (14%)	57.9 (5.5%)	0.6 (1.6%)	0.08 (1.6%)
Inorganic fertiliser	19.9 (22.4%)	209.5 (20%)	2.5 (7.4%)	1.04 (21.3%)
Livestock	18.7 (21%)	99.5 (9.5%)	2.4 (7%)	2.89 (59.3%)
STWs	35.5 (39.9%)	654.3 (62.6%)	28.7 (84%)	0.86 (17.6%)
Unsewered population	23.8 (2.3%)	-	-	-
Industry (* = fish farm)	2.5* (2.8%)	-	-	-
Total	89.1	1045.0	34.2	4.87
Catchment area (km^2)	1249	2892	56	49.3
P load exported to river (kg/ha/yr)	0.7	3.6	6.1	1.0

2.2.2 Agricultural nutrient sources

'Sources' of phosphorus on farms come from (i) indigenous soil phosphorus, (ii) fertilisers (inorganic and organic) and (iii) imported livestock feed concentrates, which are returned to the land via direct excretion during grazing or as spread manure (Haygarth, 2000).

Farm nutrient balances

There is a large amount of evidence to show that the intensification of agriculture, and the associated long-term annual surplus of P, has led to the gradual build-up of soil P levels. An assessment of UK farms concluded that the average annual surplus of P is 16 kg/ha, averaged over the productive arable and grassland area (Edwards & Withers, 1998). Nutrient surpluses tend to be regionally diverse and localised depending on land use and management. Surpluses are most likely to lead to soil P build-up in areas with intense livestock production, especially pigs and poultry, and intense vegetable production. The mass balance of P within a typical English dairy farm (Table 2.3) illustrates the fragility of farm nutrient balances. For a 'typical' 57ha dairy farm in England, Haygarth *et al* (1998) calculated that in one year there was a surplus equivalent to 27 kg P per ha. If such management continues, the soil phosphorus reservoir will double in the next 30 years.

Table 2.3 Sources and balance of phosphorus in a 'typical' 57ha dairy farm in southwest England

	Tonnes P	Approx kg/ha
Inputs		
• Atmospheric	0.013	**0.2**
• Fertiliser	0.91	16
• Straw bedding	0.012	0.2
• Concentrates	**1.54**	27
Total inputs	**2.48**	**44**
P Cycling Through Farm		
• P consumed by herd:		
In silage	0.91	16
In fresh grass	0.94	16.5
In concentrates	1.54	27
Subtotal	*3.39*	*59*
• P recycled from herd:		
Excreta to pasture	0.55	9.6
Slurry & FYM	1.82	32
Subtotal	*2.37*	*42*
Outputs		
• Removed in calves	0.031	0.5
• Removed in milk	0.89	15.6
• Losses to water	0.057	1
Total Outputs	**0.978**	**17**
Balance (Inputs minus Outputs)	1.50 gain	27
Source: Haygarth *et al*, 1998		

Organic manures and livestock

Livestock manure, slurry and 'dirty water' (water used to wash down milking yards, equipment, etc.) are the main sources of organic P nationally, with an estimated 90 million tonnes of manure/slurry, plus 20 million m^3 of dirty water, produced each year in the UK. Nutrient losses from livestock farming come from sources around the farmyard (effectively small point sources) and from surface run-off and leaching from fields. Much of the manure/slurry is generated by over-wintered livestock and is stored and subsequently applied to fields. Once applied to fields, losses may occur rapidly, in response to immediate rainfall, or slowly, following incorporation of manure/slurry into the soil structure and subsequent soil erosion.

The level of nutrients in these livestock sources depends upon a number of factors, the most important being the time and life stage of livestock and nutrient levels in animal feeds. Table 2.4 shows the total amount of P and N produced by livestock in the UK in 1996 (from WRc, 1999). The Table shows that cows produce the most P per head, but sheep are responsible for the greatest total level of P production. Cows produce the most N per head and are also responsible for 61% of total N.

Table 2.4 Total phosphorus and nitrogen produced by livestock in the UK in 1996

Livestock	No. of livestock	P produced per head (kg)	Total P produced (tonnes)	N produced per head (kg)	Total N produced (tonnes)
Cattle	11,913,000	9	107,217	60	714,780
Pigs	7,496,000	4.5	33,732	15	112,440
Poultry[1]	125,981,000	0.2	25,196	0.5	62,991
Sheep	41,530,000	2.8	116,284	7	290,710
Total			282,429		1,180,921

Notes: [1] 1995 agricultural census data - no poultry data available for 1996
Source: WRc (1999)

The economic fertiliser value of livestock manure/slurry has been valued at £80 million per year (Chambers & Smith, 1996 in WRc, 1999). However, much of the manure/slurry production is located some distance from the main arable cropping areas, meaning that it may be necessary to transport it relatively long distances in order to realise this potential value. The cost of transporting manure/slurry is larger than the cost of transporting inorganic fertilisers such that manures/slurries are rarely transported more than 10 miles from where they were produced (Sharpley *et al*, 1999).

Spreading of manure/slurry as an organic fertiliser can cause additional problems in terms of P. This is because organic fertilisers are often applied to meet the N requirements of crops. However, the N:P ratio is typically 6.7:1 for cattle manure and 3.3:1 for pig manure (compared with 8:1 for inorganic fertilisers). There is also a difference in the availability of the nutrients, with only about 50% of N available as fertiliser N, whilst almost all of the P is available as fertiliser P. This means that more organic fertiliser is needed to give required levels of N, resulting in much higher concentrations of P being applied to land than are needed. Separation of the solid and liquid fractions can help to change these ratios as P moves preferentially into the solid fraction, while N goes mainly into the liquid fraction (Sharpley *et al*, 1999).

Table 2.5 shows the amount of land that is required to spread livestock manure/slurry (based on application rates of nitrogen at 250 kg/ha/year). However, as noted above, application based on N requirements is likely to result in providing P far in excess of requirements. For example, for one dairy cow, 0.19 ha of land is required based on N application rates of 250 kg/ha. This would result in P applications rates of 100 kg/ha. This is more than three times the average application rate of P inorganic fertilisers for arable land (32 kg/ha). For pig manure and poultry litter, P application rates could be even higher, with N and P output during the housing period (in kg) being very similar (Table 2.5).

Livestock feed

A large proportion of the build up of soil P in grassland areas is derived from feed concentrates. The main source of P for livestock comes from their feed. Phosphorus is an essential nutrient, with deficiencies of P believed to cause reproductive disorders.

Table 2.5 Land area needed for spreading wastes from different livestock

Type of Livestock[1]	Occupancy[2]	Land Area Required at 250 kg/ha 'total N' application rate[3]	Output during housing period (kg) [4]	
			N	P
1 dairy cow (550 kg)	6 month housed	0.19 ha	48	19
1 grower/fattener cow (400-500 kg)	-	0.06 - 0.12 ha	15-31	5.8-12
1 pig baconer (35-105 kg)	90%	0.05 ha	10.5	7.5
1 pig grower (18-35 kg)	90%	0.03 ha	6.1	4.5
1,000 laying hens	98%	2.6 ha	660	545
1,000 broilers	76%	2.0 ha	495	435
1,000 turkeys (male)	80%	5.6 ha	1,390	1,225
1,000 turkeys (female)	80%	2.6 ha	650	575
1 adult ewe (65 kg)	8%	0.003 ha	0.8	0.2

Notes: Typical figures to meet the recommended maximum loading of 250 kg/ha/yr of total N in applied organic manures. The amount of N excreted can vary according to weight, diet and other details of the production system.
Source: [1,2,3] MAFF (1998); [4] MAFF (2000).

This has led feed manufacturers to add in extra P to act as insurance against any such problems and also against reductions in milk yields and growth limitation. However, no research has shown there to be any benefits from feeding P levels above that required (Knowlton & Kohn, 1999).

It is estimated that around 70% to 80% of P in feed is excreted. A reduction in feed P could, therefore, have a significant effect on nutrient losses. Kohn *et al* (1997) state that 'improving the efficiency of animal production relative to feed nutrients is the most important mechanism for reducing nutrient losses from the farm'. These observations are based on US farms; in Europe, the digestibility of P is assumed to be 58% to 70% (compared with 50% in the US).

Feeding cows to meet their individual needs can also reduce the amount of P that is excreted. Dunlap (1997 in Kohn, 1999) showed that feeding all lactating cows together results in 7% more P (and N) being consumed. When all the cows are fed together 10% more nutrients end up in the manure than if the cows are fed according to their individual needs. Sharpley *et al* (1999) found that P excesses ranged from 16% to 70% when all cows were fed the same ration. This is important in herds with cows of different ages, as their ability to digest P decreases with age as well as by milk production rates (Knowlton & Kohn, 1999).

One of the ways of improving the digestibility of P in feed is to increase its bioavailability. This can be done by adding P in the form of phytase. However, this would mainly benefit non-ruminants (such as poultry and pigs – see Knowlton & Kohn, 1999) as ruminants (cows, sheep, etc.) have microbes in their guts which provide natural phytase activity, and which are responsible for making P in grains and forage more available.

Inorganic fertilisers

Inorganic fertilisers are used to raise nutrient levels in the soil to a point where they do not limit crop growth. Intensification of agriculture following the Second World War included a concerted effort to build up soil P levels to prevent growth limitation. Since P is rapidly sorbed onto soil particles and is progressively more tightly bound to the soil with time, this has resulted in much larger total P levels in agricultural soils, as well as higher soluble (or extractable) P levels. Application rates of inorganic P have fallen in recent years due to a reduction in maintenance dressings, but this is against a backdrop of large reservoirs of P in the soil.

The levels at which soil P is held to support different crops is a critical issue. The Fertiliser Recommendations (referred to as RB209 (MAFF, 2000)) are based on the quantities required to hold the soil at certain P levels, indicated by soil P index (0 = very low extractable P concentrations, 5 = very high extractable P levels). RB209 is based on the application levels that give the best financial return for the farmer. RB209 promotes soil index 2 as a target over a rotation, recommending a 'running down' or a 'building up' policy to achieve this target. Because of its rotational focus, RB209 'permits' application of P on soils over index 2 for some high value crops, the intention being that, in subsequent years in the rotation, applications should be reduced to account for these additions.

A few key points need to be made about fertiliser recommendations:

- they stress the need to maximise the nutritive value of manures/slurries – the largest over-applications of nutrients relative to recommended rates are due to treating manures/slurries as a waste requiring disposal rather than as an asset;
- all crops require far less N and P in well-aerated, well-structured soils compared to airless, compacted soils. The fertiliser recommendations do not account for this at present;
- multi-nutrient inorganic fertilisers (Nitrogen:Phosphorus:Potassium) do not necessarily provide the flexibility to apply P according to recommended rates; and
- the recommendations are based on economically optimal soil P levels, not environmentally sustainable levels. The definition of environmentally sustainable levels is the subject of on-going research.

Reducing P emissions to waterbodies is likely to require a reduction in the P index of many soils, with a target P index of 2 likely to be most appropriate for arable soils. Table 2.6 shows the proportion of soils that are below a P Index of 2 for a variety of land use types and how this proportion has changed between 1986 and 1997. The table shows that grassland has the highest proportion of soils that are currently at or below a P index of 2. However, the target P index for grassland may need to be lower than this. Potatoes and sugar beet have the lowest proportion of soils at or below the target P index, at around 25% and 28% respectively. This is because potatoes and sugar beet yields respond well to phosphate loads and have high associated recommended P application rates (ADAS-RSSS).

Table 2.6 Percent of soils at or below phosphorus index of 2

Land Use/Crop	Percent of Soils at or below P Index of 2			
	All years	1986-89	1990-93	1994-97
England and Wales - all soils	59.3	-	-	-
Arable crops only	48.5	45.2	51.0	49.2
All grassland types	70.6	70.6	72.3	68.7
Wheat (all)	50.7	47.3	53.6	50.8
Barley (all)	51.0	50.5	53.7	48.5
Oats (all)	64.9	58.6	66.7	68.5
Potatoes	25.2	17.4	30.0	28.9
Sugar Beet	28.3	23.0	36.4	25.3
Source: ADAS - Representative Soil Sampling Scheme (RSSS)				

2.2.3 Diffuse domestic sources

Diffuse nutrient loads from domestic sources originate from application of sewage sludge to land, from leaking sewers and septic tanks. Septic tanks and sewer leakage are believed to be minor sources of nutrients (WRc, 1999). Loads of sewage sludge to agricultural land have increased in importance since the prohibition of sludge dumping at sea, previously the major route for sludge disposal.

The *Code of Practice for Agricultural Use of Sewage Sludge* recommends maximum sludge applications rates based on N content, resulting in P applications at a rate of 125 kg of P per ha/yr (English Nature, 2000). This is around 2.5 times more than current application rates for tillage crops (47 kg/ha, see also Table 2.7) and twice as high as P uptake by cereal grains (59 kg P per ha, see also Table 2.7). The problem of N:P ratios in sewage sludge, and the link to P rules in the *Code of Good Agricultural Practice for the Protection of Water* (MAFF, 1998), is being addressed in the revision of the existing code.

Phosphorus can be recovered from STWs, or removed and recycled, potentially providing a sustainable source of P and reducing the need for imports of rock phosphate from outside of the UK. Sewage sludge also has advantages over rock phosphate in that it tends to have much lower concentrations of heavy metals (WRc, 1999). This area of work is receiving increasing attention from water industry experts, scientist and regulators, and has a dedicated webpage1. It has been the focus of two international conferences held in 1998 and 2001.

2.3 Delivery of agricultural nutrient loads to receiving waters

In terms of controlling loads of agricultural nutrients to receiving waters, it is equally important to tackle the pathways by which nutrients reach receiving waters as it is to tackle the scale of nutrient applications to agricultural land. This section provides a brief account of the key issues involved with respect to N and P.

1 See: http://www.nhm.ac.uk/mineralogy/phos/index.htm.

2.3.1 Phosphorus

Phosphorus sorbs strongly onto soil particulates such that the majority of diffuse agricultural loads of P are associated with particulate run-off during rainfall events – this makes soil erosion control a critical factor in controlling P losses from agricultural land. Where the soil is heavily overloaded with P, it may leach from the soil as soluble P and contribute to loads under dry weather conditions. Bearing this in mind, the initiation and subsequent transfer of P from agricultural soils to watercourses is dependent upon a number of factors:

- soil type, including clay and organic matter content (which increases the potential for P to sorb onto soil particles or be desorbed) and sensitivity to erosion (where soils that are less resistant tend to have higher rates of P loss);
- physical soil structure, since soil compaction (eg from the use of farm machinery when the soil is wet, excessive livestock densities) greatly increases surface run-off and hence soil erosion;
- soil P concentrations, as thresholds for retaining or releasing P to soil water, exist and vary according to soil type, management and site hydrology. Parcels of land that have high soil P concentrations and are highly susceptible to P loss (eg erosive or low adsoprtion capacity soils) are termed Critical Source Areas, and may be responsible for the majority of P leaving a farm;
- proximity to a watercourse, as much of the material that is mobilised as surface run-off is retained in nearby fields, particularly if there are run-off breaks such as hedgerows;
- intensity of rainfall, as this affects the potential for soil erosion. For example, storm events can account for the majority of P lost from agricultural fields;
- gradient of the land is also important, with steep slopes more prone to erosion than flatter land;
- ground cover is also an important control on the stability of the soil and hence its resistance to erosion. Some vegetation types, such as pasture and woodland, provide good ground cover and erosion resistance, whilst crops such as potatoes and oilseed rape provide a low degree of soil protection; and
- farm management, such as the time of year that ploughing or fertiliser application takes place, plus the rates of fertiliser application, can affect P losses, often being related to the factors given above.

Further details on the sources of P and the movement of P once it is in the watercourse are given in Annex 1.

2.3.2 Nitrogen

Unlike P, N tends to be leached out of soils mainly in the form of soluble nitrate, thus the dominant pathway is via subsurface flow (through soil and/or groundwater) (WRc, 1999). This makes nitrate very difficult to control. Indeed, in many areas, N reserves in soil are sufficient that even if N applications were stopped completely autumn flushes would still increase N in water to levels above those dictated by the Nitrate Directive.

2.4 Implications for the use of economic instruments

From the above discussion, the key points regarding P emissions and associated environmental damages can be summarised as follows:

1. Nutrient enrichment can be seen to be widespread in aquatic systems in England and Wales, even though the effects of that enrichment at any particular site may be difficult to predict due to the various complicating environmental factors.

2. Because upland oligotrophic rivers are highly sensitive to small changes in levels of nutrients, there is a need for greater prevention of nutrient inputs to these waters than to those lowland waters that are naturally eutrophic (see Section 2.1.2).

3. Targets for nutrient levels in receiving waters are in the process of being set, based on those concentrations that would occur under conditions of relatively low human impact and that are deemed likely to avoid unacceptable ecological risks.

4. Linking target concentrations of P in the aquatic environment to management actions at the catchment level is difficult, however. As a result, in the short term, it is more appropriate to link economic instruments to farming activities that are known to give rise to P emissions than to modelling of environmental processes. This requires that the targets for instruments are based on judgements concerning good or best practice.

5. A range of practical measures are needed to control diffuse agricultural loads of nutrients, including measures to control inputs and restrict movement of nutrients to receiving waters (as discussed in Section 2.3.1 above; see also IEEP, 2002).

6. The actions required to control the problem appear to include: 1) measures to achieve a basic level of farm performance across all farmed land that will help to reduce nutrient loads in a non-targeted way; and 2) further measures in priority areas to achieve more stringent and targeted control to meet particular wildlife objectives.

3. Economic instruments for controlling P

3.1 An introduction to economic instruments

3.1.1 Eutrophication as a market failure

In simple terms, agricultural production activities, whether through the application of inorganic fertilisers or through the spreading of livestock manures on crop land, are leading to excess loadings of P to the aquatic environment. Roughly 67% of agricultural land is estimated to have soil P levels higher than the target of index 2; the target level as discussed in Section 2. Thus, there is a need to reduce the intensity of P (and N) use in agriculture, so as to reduce both additional sources of P to the environment and to reduce the levels of P held in the soil. Furthermore, because P builds up in soil, acting as a stock pollutant, damages may continue for a long period following the control of new sources to agricultural land.

In economic terms, the environmental damages resulting from nutrient enrichment and eutrophication are referred to as 'externalities'. Externalities are impacts, positive or negative, that are 'external' to the price signals that are faced by farmers (or other polluters) in the markets in which they sell their products. In other words, because no price is readily placed on such environmental effects, farmers do not have to take them into account in their own decision making as to how to produce a good. Thus, we have what is called a market failure, as the environmental goods and services affected by production activities are not taken into account.

These market failures arise from the 'public good' nature of many environmental goods and services. Public goods have the characteristics of joint consumption and non-exclusivity. Consumption of the environment by one person does not diminish the quantity that another person can consume. Furthermore, one person cannot exclude another person from also consuming the resource, as there are no private (or only partial) property rights.

River systems and the ecological goods and services that they provide are essentially public goods. The property rights required to result in prices being placed on impacts to these goods and services are lacking. As a result, the impacts caused by excessive P inputs on plant communities and wildlife (described in Section 2) remain outside any markets and, thus, unpriced. If farmers are to be given signals as to the environmental damages arising from their actions, then some form of intervention is required.

3.1.2 Potential objectives of an economic instrument

As noted in the previous section, the actions required to control the eutrophication problem include measures aimed at reducing nutrient loads in a non-targeted way across all farmed land and additional measures in priority areas aimed at achieving more stringent and targeted control to meet particular wildlife objectives.

Such measures could be brought about through a range of different activities:

- raising awareness of phosphate application;
- reducing application rates of P and thereby curbing excessive emissions;
- promoting more targeted P inputs though better nutrient planning;

- addressing redistribution of P away from critical source areas (CSAs);
- encouraging measures either directly or by funding related policy interventions to reduce P loss from fields (improved soil structure, ground cover, avoiding winter manure applications, more effective incorporation); and
- reducing nutritive P values of manure through the use of low-P feed.

3.1.3 Economic instruments as a policy intervention

One way of implementing some of the above activities and correcting for the market failures is through the use of regulation. For example, regulation could be introduced that requires farmers to reduce application rates of P, to undertake nutrient planning or to force the adoption of measures aimed at transport management.

The key example of such an approach with regard to eutrophication problems is the EC Nitrate Directive and the designation of Nitrate Vulnerable Zones (Annex 1 provides further details on what is required under these). These set out a series of legal requirements which farmers must follow that restrict the quantity and timing of the application of N fertilisers and livestock manures to land. Future regulatory requirements such as those which will affect pig and poultry protection under the Integrated Pollution Prevention and Control Directive (IPPC) and the Water Framework Directive will also be important in this regard.

Other types of intervention which may be important as part of an overall solution include (see also IEEP, 2002):

- advice and awareness campaigns;
- grant aid, for example, related to management planning, capital works, or specific management measures;
- conditions on production subsidies; and
- quality assurance schemes.

Voluntary action can also help address such market failures and, in the context of farming, adherence to the UK Codes of Good Agricultural Practice (COGAPs) is important in this regard. For example the COGAPS, which relate to the protection of water, soil and air, promote the adoption of good environmental practice to prevent or reduce nutrient losses to water.

The focus of this study, however, is on correcting these market failures through the use of economic instruments that are consistent with the polluter pays principle. The aim of such instruments is to correct for the market failure by bringing the external social/environmental damage costs into the costs of production realised by the polluter - in this case the farmer. By so doing, the external costs are 'internalised' into the farmer's decision making processes. This, in turn, provides the incentive to polluters to change their behaviour in a manner that reduces the total costs of production that they face (where these include the external costs).

Economic instruments can be used on their own or to complement other policy interventions, in order to provide the signals required to polluters. Some of the reasons why they may be preferred to direct regulations and other forms of policy intervention are that they can:

- be more flexible, allowing regulators to respond to changes in the behaviour of polluters over time;
- be more efficient in that decisions on how to respond to the instrument are left to the polluter (in this case farmers), who should be able to respond in the most cost-effective way given the characteristics of his operations. Across all polluters within a given market, the most economically efficient outcome should result through this process;
- be less costly to implement in administrative terms, where there are ready mechanisms for monitoring behaviour and compliance;
- encourage innovation by giving polluters an incentive to develop new solutions for reducing pollution control costs. Such incentives may be aimed at achieving innovation in the short-term or may be longer-term in nature depending on the choice of instrument;
- in some cases, be used to raise revenues that can be used to: shift the tax burden from labour to environmental impacts and resource use (generating a 'double dividend' of social benefits); to create funds that can be used to assist polluters in meeting environmental objectives; or to fund other environmental actions.

This does not mean to say that the use of such instruments is always preferable to other forms of intervention. Indeed, a key issue with their use concerns their ability to deliver environmental objectives. The choice of economic instrument will affect the level of certainty that can be attached to achieving a particular environmental outcome. In theory, an appropriately-designed economic instrument can in itself ensure that environmental targets are met. In practice, polluters may not always respond to an economic instrument in the manner economic theory would suggest, as their behaviour will be influenced by a range of other factors. This may be particularly true for the agricultural sector, owing to the various other policy interventions that may affect a farmer's decision making, together with the range of other day to day factors affecting production activities.

Economic instruments are being applied though to a range of other environmental quality issues in the UK and elsewhere. Examples of the use of economic instruments in the UK include the climate change levy and greenhouse gas emissions trading scheme, the landfill tax, the aggregates levy and the forthcoming use of water abstractions trading schemes. Some of the key features of these instruments are summarised in Table 3.1. Economic instruments are also being used increasingly in the EU. According to the European Environment Agency, evidence of the effectiveness of environmental taxes in EU member States and Accession Countries is increasing. However, as the taxes are usually part of a policy package, it is often difficult to disentangle the contribution of each instrument to the overall environmental results[2].

[2] EEA(2000): Recent developments in the use of environmental taxes in the European Union, EEA.

Table 3.1 Examples of economic instruments for environmental protection in the UK

Name	Date Introduced	Aims	Key Features
Landfill Tax	1996	To ensure that the costs of landfill properly reflect environmental impact; promote a more sustainable approach to waste management	Differential tax rates for inert and active wastes; revenues may be recycled for environmental purposes via Environmental Trusts
Climate Change Levy	2001	To assist the UK in meeting its emission reduction requirements under the Kyoto Protocol	Tax on business use of energy (electricity, gas, solid fuels); energy intensive users eligible for reduced rates if they sign voluntary agreements to reduce emissions
Aggregates Levy	2002	To address the environmental costs of aggregates extraction; encourage use of recycled materials	Tax on sand, gravel and rock (including dredged aggregates); part of revenue used to finance Aggregates Levy Sustainability Fund
Emissions Trading Scheme	2002	Reduce the costs to business of reducing greenhouse gas emissions; provide early experience of the developing market for emissions trading	Participating companies bid for government incentives to meet five-year emissions reductions targets; targets can be met by reducing own emissions or buying surplus allowances from other participants
Water Abstractions Trading	Planned	To improve the efficiency of resource use across abstractors	Trading allowed between abstractors in line with strict rules to be established by the EA

3.1.4 The choice of instruments

This study is focused on the potential role of those economic instruments that adhere to the polluter pays principle, where this includes:

i. emissions charges/taxes;
ii. product charges/taxes;
iii. fund raising levies;
iv. tradeable permit systems;
v. rebate schemes;
vi. recycling credit based schemes;
vii. liability-based regimes, such as fines for non-compliance or the use of performance bonds; and
viii. risk-based charging systems aimed at providing an incentive for 'good' management of processes and activities (for example under IPPC).

Determining what type(s) of instrument is most applicable to a given environmental problem requires consideration of a range of issues and factors governing the effectiveness and technical feasibility of the various approaches. These are summarised in Table 3.2. Identification and evaluation of instruments should also consider the advantages of economic instruments over more 'traditional' approaches (such as direct regulation or voluntary agreements) and goodness of fit with existing approaches.

The first six of the instruments listed above appear to be the most relevant for managing P and N emissions, given the nature and scale of the problems. Liability-based regimes are more appropriate where damages are readily demonstrated at a site level; they are not as applicable to the eutrophication problem. Risk-based charging systems have been developed where administrative charges are payable in respect of operating permits (for example, they are planned under the IPPC system). Charges are higher for processes posing higher risks, reflecting the greater resources required to regulate these processes and providing polluters with an incentive to improve production processes, management systems and housekeeping in order to reduce the frequency of regulator inspections. In this regard, one could conceive of a creating a licensing scheme that imposes a lighter monitoring regime, and possibly lower charges, for farms that have conducted audits and instituted management plans. However, as this option is based on a regulatory instrument, it has not been considered further in this study.

Table 3.2 Key considerations for the appropriateness and feasibility of instrument options

Environmental effectiveness	- what are the features and extent of the environmental problem; - how is the problem currently addressed by policies and regulations; - how does the instrument fit within this context; - is the instrument likely to achieve the environmental objectives; - to what level of certainty; - is there likely to be a time lag between application and environmental benefit; - are there likely to be any 'knock-on' or perverse effects (for example, a shift to more damaging practices); and - will the instrument respect site or geographically specific issues.
Costs of compliance	- what financial burden will be placed on polluters, directly and indirectly; - how cost-effective is the instrument compared to other approaches; - is this likely to be sustainable; and - are the costs proportional to the damages.
Administration, Monitoring and Enforcement	- how costly is it to implement and then administer on an on-going basis, what systems are required, how compatible are these with existing systems; - what extent of monitoring and enforcement is required, is it technically viable, and cant it be achieved at reasonable cost; - are there any other administrative issues; and - what are the costs to the regulators of ensuring compliance with the instrument and how do these compare to other instruments.
Public revenues	- will the instrument be self financing or will it require public expenditure.
Innovation	- to what extent does the instrument respect local/regional factors; - does the instrument permit agents to make their own decisions regarding their response; and - are these likely to provide a long-term solution to the environmental problem.
Fairness	- does the balance of responsibility lie in particular industry sectors; - will the burden of an instrument rest unfairly on these sectors; and - what will be the end distribution of social costs and benefits and will it be fair.
Competition and competitiveness	- are there any competitiveness and solvency issues that may need addressing; - how will the need to comply with the instrument affect productivity.
Compatibility with other Policies	- how compatible is the instrument with other existing or future policies, in both environmental terms and more generally.
International Trade	- is the policy consistent with the EU single market; and - is it consistent with World Trade Organisation barrier to trade provisions.

The remainder of this section, therefore, provides a summary of how the first six of the instruments could be developed for the management of P. For further detailed discussions on how economic instruments have been used for the control of N see CLM *et al* (1999), which reviews the effectiveness of the schemes that have been applied in Europe.

3.2 Emissions charges/taxes

3.2.1 Introduction

Emissions charges and taxes have been introduced to meet a variety of objectives including:

- to change the behaviour of polluters, to reduce the environmental impact of their activities;
- to generate revenues, either to fund specific environment-related investment or to replace other forms of taxation; and
- to recover the administrative and other costs associated with regulation of pollution.

A charge is defined as a compulsory payment to either general government or a regulator in return for a particular service or set of benefits (OECD, 1999). A tax on the other hand is a compulsory, unrequited payment (ie not for a specific service or benefits). The OECD identifies a number of borderline cases within this classification, for example, where the charge greatly exceeds the cost of providing the service, where the payer is not the receiver of the benefit, where the benefits are only received by those paying the charge but are not necessarily in proportion to the level of payment. Given these definitions, both charges and taxes are relevant to this study.

Emissions charges/taxes are usually based on a payment per unit of pollutant emitted, with the aim generally being to link the charge/tax to environmental damage costs to provide a direct and continuing financial incentive to reduce emissions/damages. Thus, within the context of P management, they could theoretically be used to address market failures associated with both P emissions resulting from soil P (that already held in the soil) and from the on-going application of new sources of P (fertiliser or manure based). Examples of P and N emissions charges/taxes that have been applied in other cases are set out in Box 3.1.

The success of an emissions charge/tax is highly dependant on the selection of a suitable level of payment: too low and the economics are such that emissions may not be reduced sufficiently; too high and polluter who can only respond in the medium to longer-term may not have sufficient resources to adopt more innovative and strategic responses.

As the charge/tax is focussed on specific damaging pollutants (or activities), polluter specific data must either be collected by or submitted to the regulator for administration purposes. Where the number of polluters is relatively few and pollution is point source in nature, then the administrative cost burden may be reasonable and the approach cost-effective when compared with more regulatory-based measures. However, when targeting more diffuse sources of pollution from many polluters, the sheer extent of monitoring that may be required will raise the administrative cost burden significantly.

Box 3.1: Examples of P and N emission charges

Belgium: a tax has been applied to surplus manure since 1991 in the Flemish region. A base charge is levied on the nitrogen and phosphate content of surplus manure and a disposal charge is levied on waste quantities. The effects are reported to be negligible because the levies are too low (WRc, 1999).

France: an emissions charge has been in place since 1991, covering four substances in livestock farming: suspended solids, oxidisable matter, reduced nitrogen and reduced phosphate. It is calculated in a three-stepped process. First, emissions are calculated for each pollutant and each category of livestock. Coefficients are used to translate the number of animals into quantity of polluting substances and from this a gross charge is estimated. Second, farms are classified according to a number of parameters, eg storage capacity, location, run-off from buildings, etc, and the level of abatement performance calculated. Finally, a net charge is calculated according to a formulae (Gross Pollution Charge- Abatement Premium) (WRc, 1999). Effects are not reported.

The Netherlands: The introduction of a tax on manure in the Netherlands in 1998 needs to be seen within the broader policy on manure and ammonia which began in the early 1980s, involving manure production rights (see Box 3.3) and use standards for livestock manure. The tax is part of the National Environmental Policy Plan and was first applied to pig and poultry farms and dairy farms with >2.5 equivalent units per ha. From 2001, however, it has covered all agricultural farms. According to the scheme, registration of mineral losses is required through a mineral accounting system. The Minerals Accounting System (MINAS) involves the registration of mineral inputs (nitrogen and phosphate) used on a farm in fertiliser and animal feeds, and the mineral output in the form of products and manure. The mineral loss is calculated as follows:

Mineral loss = Input (fertiliser and feed)-output (product, manure).

Where the loss is larger than the allowable standard the farmer must pay a levy. Farmers are allowed to declare either an exact (measured) mineral loss or a standard amount. That part of mineral losses regarded as acceptable are termed the 'loss standard' and no levy is paid on this amount. Above the loss standard, however, a progressive taxation system is used. The levies have been set so that they are higher on average than the most expensive disposal option, to encourage farmers to invest in alternative disposal options (improved feed, manure application management and manure redistribution). In 2000, the rates on Nitrogen surplus are reported to be 1.50 NLG (EUR 0.68)/Kg and 5.00 NLG on P_2O_5 surplus (EUR 2.27)/kg (ECOTEC, 2001).

See also IEEP (2002) which provides a review of experience with different policy approaches in Europe and the USA.

In addition, by virtue of pollution being diffuse, it may be difficult or impossible to determine and monitor the quantity of emissions from each agent. In such circumstances it may be necessary to place the burden of proof on the agent. This, in turn, raises problems concerning charge evasion and equity.

3.2.2 Application to diffuse agricultural sources of P

The selection of the appropriate basis and administrative structure for applying a charge or tax to diffuse phosphorus pollution from agriculture is likely to be guided by the availability and reliability of polluter (farm) specific emissions data. There are two principal options for gathering such data:

- water pollution monitoring and predicted emissions; and
- data on nutrient surpluses.

In theory, a water pollution monitoring programme operated by the Agency could be used to deliver a charge based on predicted emissions that would penalise excessive use of P. However, the extent to which such a programme could be designed so that calculated charges specifically related to the emissions contribution of individual farms will be limited by logistical difficulties, cost and technical feasibility constraints (stemming from predictive uncertainty) constraints. These factors are likely to restrict the use of farm specific emissions charging to:

- a charge on per unit exceedance of target P concentrations; or
- charges on water quality predicted P emissions.

The remaining option for a water quality monitoring and prediction-based system is to charge groups of agents at a catchment or sub-catchment level. Clearly, this would require a less intensive monitoring effort by regulators and the lower resolution might bring predictive uncertainties within the bounds of acceptability. However, the charge would still need to be distributed between the polluting agents, which could be done at the farm level or across a cooperative group of farmers who determine compliance amongst themselves. As noted above, however, the use of *in situ* monitoring and prediction is limited by logistics and uncertainty.

The remaining options include distributing a charge on the basis of one or more of the following:

- the number of holdings;
- farming activity,
- farm management practices (including pollution control);
- farmed area; and
- geo-specific factors (such as soil, slope, etc.).

It is considered that, given the likely logistical and administrative costs, these options are no more likely to provide a feasible means of achieving a universally applicable (ie UK wide) charge than a predictive monitoring-based approach. However, such options could provide a means of achieving objectives in specific ‘problem’ catchments.

3.2.3 Minerals accounting, nutrient surpluses and nutrient planning

An alternative source of data on P emissions for a charge or tax is the calculation of farm P surpluses on a farm-by-farm basis. These could be calculated either from farm records on inputs (such as fertiliser and feed) and outputs (such as product and manure), or as part of a wider requirement for more precise nutrient planning and recording. Whether the instrument takes the form of a charge or tax depends on the level of regulator involvement, for example in monitoring and validating records and providing other support (eg advice).

In theory, a scheme attached to such data could, potentially, provide an incentive to curb excessive inputs, encourage better nutrient planning and, in so doing, reduce losses of P to water stemming from the on-going application of P to land (although it would not address the existing soil P loads and prevent transport of these to the aquatic environment). There is also scope for the inclusion of rebates for the uptake of management measures aimed at reducing transport of P, or for reducing any direct or indirect adverse effects stemming from the scheme (see also Section 3.5).

Preliminary work in this area suggests two principal options:

- a simple charge/tax based on minerals accounting; and
- a more complex charge/tax based on minerals accounting with additional incentive and price differentials to encourage uptake of more rigorous nutrient planning and soil analysis.

In terms of applying such a scheme in the UK, nutrient planning and, to a lesser extent, minerals accounting for phosphates is not widespread. The data that would be required to set up a charging scheme would require the expansion of current farm recording requirements to include more robust recording of inputs (c.f. Nitrate Vulnerable Zones.- NVZs). As the existing NVZ designations will be expanded to encompass upwards of 80% of farms in the UK, the basic data collection and recording processes for a minerals accounting system will soon be in place, reducing the additional burden of setting up a charge on P surpluses.

A simple minerals accounting charge/tax, which would be based on record keeping and reporting on inputs and outputs (off-take), could follow the Dutch model of submitting P accounts and charging on the basis of the nutrient surplus for a farm business unit. In this case, the level of nutrient surplus is used as a surrogate for emissions. Within this type of approach, however, there is no ready means of linking the instrument to spreading areas, soil P indices at a field level, P build up in soils at the field level, and other factors such as slopes, buffer zones, management practices, etc.

The key weakness of such a scheme is that it can only provide an incentive to curb applications of P over 'maintenance levels'. This is because the charge/tax would only apply to additions of P over these levels. As a result, an instrument based on simple minerals accounting may only be capable of maintaining current soil P indices rather than reducing them, unless general recommendations are revised downwards.

Theoretically, a better approach for the purposes of 'running down' soil P would be one based on nutrient planning according to soil P indices (see Section 2.2). If such methods were more widely applied, a charge/tax could be levied on quantities or P applied to soils above a target soil P index. In other words, applications over and above those recommended by the fertiliser recommendations (ie almost any P applied to soils of P index 3 and above – see RB 209 (MAFF, 2000)) would be penalised, with penalties rising for applications to soils of higher soil P index.

Although this type of scheme would fail to address directly the damages caused by the transport of P from the levels currently held in the soil in the near to mid-term, it does have several advantages:

- the charge/tax would provide a disincentive to spread P on soils of higher soil P index and would, therefore, provide an incentive to allow soil P in such areas to 'run down';
- given that suitable applications to soils of indices 0 to 2 would be permitted, a 'disposal pool' exists for the re-dispersal of (particularly manure) P;
- given that soil P changes slowly over time, submissions to the administering authority are verifiable over an extended time period (eg 4 years) contributing to efficient policing, administration and, hence, the effectiveness of the charge;

- farmers' yields will not be penalised (as the Fertiliser Recommendations are based on financial return for farmers rather than purely environmental grounds);
- there is an incentive to take greater consideration of where to spread manures on livestock units on the basis of sustainable P levels;
- the charge/tax would be consistent with the polluter pays principle. Those farmers who have historically raised P levels to excess and have insufficient land of low index to undertake spreading would have to find alternative locations for spreading; however, the level of charge would decrease as the pool of excess P is drawn down; and
- this may change the economics of manure use in farming - making the combination of soil fertilisation and improvement using manures and 'top-up' application of inorganic N more attractive, and, therefore, promoting the distribution of valuable P away from areas where it is in excess.

However, despite such advantages, the major obstacle to such a scheme is the fact that the use of more detailed nutrient planning and soil analysis is not widespread and new requirements to conduct soil testing and nutrient planning would be needed to put the charge/tax into effect. Although such testing and planning may take place for N as a result of a wider area being designated as Nitrate Vulnerable Zones (NVZs), it would have to also take place for P. As highlighted earlier, application based on N requirements can result in providing P far in excess of requirements (see Section 2.2.2). On its own, this approach also fails to take into account the CSA concept, ie risk of P loss is dependent on source and transport factors.

In light of the above, consideration has been given to how an economic instrument could be designed such that it promotes:

- a simple minerals accounting approach as a basic standard, with this helpin gto internalise environmental damage costs; and
- an incentive (in the form of stepped charge/tax rates) to graduate to more detailed nutrient planning and reporting (further internalising the environmental externalities).

The first aspect ties into the general trend for increased whole farm management planning, while the second would reward those farmers who undertake better management, by reducing their compliance costs (ie total payment due). Thus, in the interim, such an instrument would help to ensure that soil P does not increase and, in the longer-term, it would begin to 'run down' soil P indices where appropriate. With careful planning and consideration, it may be possible to encourage a general shift towards a reduction in soil P Indices and the distribution of nutrients away from CSAs.

3.3 Product charges/taxes

3.3.1 Introduction

Where the use of a particular input or raw material contributes to a pollution problem, a charge/tax can be placed on the use of the input to encourage producers to reduce its use or consumers to reduce consumption of the good containing that input.

Product charges/taxes differ from emissions charges in that they are focussed on inputs or activities (which then cause environmental damages) rather than the damages themselves. They assume that there are more environmentally friendly substitutes for the input or for the good. The level of charge/tax required to promote a change in behaviour is often difficult to gauge, however, since it is not possible to forecast exactly how the market will respond.

There are three basic options in terms of how such charges/taxes can be administered. They can be linked directly to an input (such as a particular substance), an output (such as a charge per unit production of a product) or on the carrying out of an activity that is part of the production process. They will be most effective when there is a strong and consistent link between a particular 'product' and a damaging environmental endpoint. However, the level of charge required to promote a change in behaviour is often difficult to gauge since it is not possible to forecast exactly how the market will respond. Where there are known and acceptable alternatives that are more expensive than the target material or process, a charge/tax designed to equalise these costs may often be the most appropriate starting point.

Box 3.2 provides an overview of the types of product taxes that have been used in other countries to help reduce emissions of P and N.

Box 3.2: Examples of P and N Related Product Charges

Austria: from 1986 to 1994, a tax on the retail price of fertiliser was established on the basis of N and P_2O_5 content, with a dual aim of raising funds to promote the grain production sector and soil conservation. In 1991, the charge rate was set up at 6.5 ATS (0.47 EUR)/kh on N and 3.5 ATS (0.25 EUR)/kg on P_2O_5. From 1987 to 1994, the use of fertiliser decreased by -0.8 per year partly due to price and partly to information from extension services. Price elasticity estimations are between -0.20 and -0.29 (ECOTEC, 2001). The direct effect of the taxes a reduction in nitrogen demand of about 2.5%, but the estimated change in fertiliser applications was between 18,000 and 20,000 tonnes (CLM, 1999). The tax was abolished in 1994 before joining the EU, with the result that N-use increased slightly again (Backman, 1999).

Finland: a tax on fertilisers based on nitrogen/phosphorus (N/P) of FIM 2.90 (EUR 0.44)/ kg N/P was repealed in 1994 owing harmonisation as part of EU membership. It is reported that the price increase of fertiliser was + 72% and the decrease of fertiliser use of 11-12% (price elasticity: -0.15 or less). No exemptions were applied. Currently, agricultural inputs are subject to the full VAT.

Norway: a fertiliser tax has been in force since 1988 on wholesalers and is based on the content of N and P. The tax was motivated mainly by fiscal reasons, with the revenue being used for information and extension (mainly about fertiliser planning) and to some extent research. The tax rates were raised gradually after their introduction and figures from 1999 indicate that these were at 24% and 21% for nitrogen and phosphorus respectively. The increases, however, have lagged behind general price inflation. In 1995, the tax represented approximately 20% of the product price (Van der Bijl et al., 1999). No data was provided on the degree to which the charge has reduced demand.

Sweden: charges on manufactured and imported fertilisers have been in place in Sweden since 1982 (WRc, 1999). No exemptions are applied and, since 1994, the revenue has been earmarked for environmental improvements in agriculture. In 1994, the tax on P was abolished and the tax on N was tripled and set to 0.19 EUR/kg. The price elasticity for fertilisers is reported to be between -0.12 and -0.51 (ECOTEC, 2001; CLM, 1999). The tax probably reduced the use of fertiliser-N by 15% to 20% in 1991/92 and appears to have encouraged greater use of manure, compost and leguminous crops in rotations. Nitrate use continues to fall but there is an issue with illegal imports for farmers' own use (ECOTEC, 2001).

Yugoslavia: in Serbia, fertilisers (and pesticides) are taxed at 7 %. No further information is available.

In terms of impacting on emissions of P, a scheme is most likely to take the form of a tax, which could be based on:

- levels of P in inorganic fertiliser;
- quantities of organic and inorganic P applied;
- levels of P in feed; and
- units of production such as (crop yields, headage, etc.) or stocking rates and number of livestock being produced.

As will be noted from the discussion that follows, product taxes are only applicable to reducing additional inputs of P to the environment. They do not provide a direct means for reducing the transport of P currently held in the soil.

3.3.2 Levels of phosphorus in fertiliser

It is possible to apply a tax on the quantities of P in inorganic fertilisers at the point of purchase, where the mode of operation would be to penalise use and thereby encourage better nutrient management.

In order to provide farmers with an incentive to alter their behaviour, the tax rate would need to be set at a level to ensure that potential savings from implementing nutrient reduction measures would neutralise or be slightly in excess of the tax payment. Such a could be used to fund wise use initiatives (see Section 3.4), with the option of increasing or decreasing charge levels over time to adjust effectiveness.

Owing to the simplicity of collection (point of purchase), this represents an administratively attractive ‘solution’ to diffuse sources of P pollution; although there may be problems in dealing with imported fertilisers. However, the extent to which the tax could (in isolation) actually deliver great enough changes in P use in agriculture may be limited for a number of reasons:

- data suggest that P usage is relatively unresponsive to prices and, as such, significant price increases may be required to instigate a sufficient shift towards reduced inputs and better nutrient management[3]; and
- a tax applied at point of purchase would only cover inorganic fertilisers and, as such, would provide only limited targeting towards the main user groups. The arable sector is the main user group of inorganic fertilisers and, though this sector constitutes part of the overall problem, more significant elements (eg diary, pig and poultry holdings) would escape the instrument;
- for those arable sectors that do represent significant problems (for example, elevated applications of P on root crops such as potatoes and sugar beet), the extremely high value of the crop means that any changes in demand stemming from price increases are likely to be very small for these crops. As such, a product tax on P will fail to impact on these problem areas.

3 For comparison purposes, it is interesting to note that CLM *et al* (1999) review modelling results that suggest that fertiliser taxes on nitrogen below 75% would yield between a 0 - 44% reduction in fertiliser inputs, with rates from 76 - 170% resulting in 0 – 81% reductions and from 171 – 300% yielding 10 -96% reductions. The associated reductions in farm incomes range from 2 to 23%.

A point of purchase tax on levels of P in inorganic fertilisers, therefore, could provide probably only a partial incentive to reduce P. However, such a tax might be important in complementing instruments aimed at reducing P emissions associated with manures, or in giving incentives to reduce excess spreading of manures on agricultural land.

3.3.3 Quantities of phosphorus applied

An alternative to the introduction of a tax on the P content of inorganic fertilisers is the expansion of a tax to cover the P content of all nutrient (inorganic and organic) inputs. This could theoretically be achieved by placing a tax on the quantities of P applied regardless of its source (fertiliser, manure or sludge).

Whilst this could potentially provide some incentive to farmers, the instrument is unlikely to be a cost-effective solution. Such a charge would have none of the benefits of administrative simplicity associated with, for example, a point of sale tax on P in fertilisers. It would have to depend on farmer returns of inputs. In administrative (and cost) terms this is comparable with, for example, an emissions charge based on nutrient surpluses (which shares the same data requirements). However, there are none of the high resolution and stronger incentives that are associated with the previous option.

3.3.4 Levels of phosphorus in feed

Evidence suggests that much of the phosphorus fed to livestock is excreted (eg 70% to 80% of P in feed), suggesting that phosphorus is being overfed (Kohn *et al,* 1997). This overfeeding may result from:

- uncertainty as to the phosphorus content of feeds;
- a lack of awareness of actual phosphorus requirements; and
- a belief that overfeeding phosphorus helps yields or fertility (Knowlton & Kohn, 1999).

As the elevated levels of P in feed contribute to the P nutritive value of manures, taxing levels of P in feed provides an opportunity for reducing loads to the environment. Such a reduction could be important given that livestock manure/slurry accounts for 34% of the additional diffuse sources of P to agricultural land (WRc, 1999).

For example, introducing a tax on phosphorus supplements and on the P content of mixed feeds could provide an incentive to farmers to reduce their P value. Owing to the fact that the evidence suggests excessive P inputs (over and above feeding requirements) has no demonstrable effect on yields or fertility (although there is some uncertainty over the latter with regard to ruminants – cow fertility), it is unlikely that the level of the tax would have to be high.

In designing such a tax, attention would have to be given to the differing feed requirements of livestock to ensure that P requirements are met (Knowlton & Kohn, 1999). This is particularly true for ruminants (cows and sheep) versus non-ruminants (pig and poultry), as the natural increased phytase activity in ruminant digestion means that their P requirements are lower. However, there is the option to increase phytase activity in non-ruminants to both compensate for this and/or provide further reductions in nutritive P values of, for example, pig and poultry manures.

This suggests that, for pig and poultry feed, a product tax could be applied to phytate-based phosphorus in order that phytase is used preferentially. For ruminants, the tax may need to relate to total phosphorus (although the use of protected amino acids could be included).

3.3.5 Crop production

An alternative to taxing inputs is to tax outputs. A tax on yields differentiated across the various crop-related farming activities according to estimated impact and contribution could theoretically be applied to target those activities deemed responsible for P pollution. To implement such a tax, it would be necessary to establish compartments for contribution to P loads and, for example, base the rates on units of production (crop yields, headage, etc.) for different types of compartments. For administrative simplicity and issues of competition, it would be necessary to apply such a tax uniformly.

However, this type of approach could potentially penalise those farms and farmers who are already operating nutrient management, providing little or no incentive to reduce P applications and improve application practices. This, in turn, would suggest the need for a performance based tax rebate, complicating the administrative simplicity of the tax by requiring the provision of a menu of management options for which rebate might be sought.

In addition to stifling innovation in farmers' response to nutrient management and control (one of the key advantages of economic instruments over other approaches), by being overly prescriptive the tax would also require farmer returns on productivity. As a result, this option would require much of the same data as to operate the (far more sensitive and focussed) nutrient surplus emissions charge. Thus, the setting up of this kind of output-based product tax is likely to present a much heavier administrative burden on the regulator and achieve less than the alternative tax.

3.3.6 Stocking rates and livestock production

A possible variation of an output based scheme would be to tax farmers on the basis of stocking rates or livestock production. For example, a tax could be levied where stocking rates per unit area would result in excess P per grazing area. Or, a tax could be levied per animal produced to encourage lower production rates, thus reducing the quantities of excess P generated.

There are issues associated with both approaches. A key concern in levying a tax on stocking rates is that the larger mixed farms could reduce the level of taxes that they faced by spreading their animals out across a wider area. Although this is desirable in theory, in the absence of any other controls, this may result in animals being grazed on land closer to sensitive watercourses. The outcome in terms of achieving target P levels in soils would therefore be uncertain, unless the reductions in stocking rates are linked to restrictions on where livestock can be grazed.

With regard to a simpler tax per animal produced, certainty of the environmental outcome would be low. However, given the administrative simplicity of such a measure, it may provide a way of generating revenue funds that could be used to finance wise use initiatives.

3.4 Wise use initiatives

In addition to direct incentives to curb use or promote farm-based solutions to P loading, there is the option to promote such solutions through 'wise use' initiatives. Many of the instruments considered here are focussed primarily on reducing inputs of P to the system or displacing inputs to areas where soil P build-up is non-existent or, at very least, less severe. Given the length of time it takes to 'run-down' soil P, such a strategy represents a medium to longer-term option for dealing with soil P build-up. The encouragement of on-farm measures through campaigns for reducing the loss of P from fields through advice and awareness campaigns and other initiatives could therefore provide this other crucial aspect of the control of diffuse pollution.

Such on-farm, wise use measures might best be encouraged through direct funding to farmers, with this funding met by:

- grant aid;
- the use of a simple levy aimed at generating funding; or
- the use of rebates as part of a product or emissions charging scheme, with these given for the implementation of transport minimisation strategies (see Section 3.5 below).

The IEEP study (2002) has focused on the use of grant aid for the encouragement of measures to reduce P loads and P emissions. As such, it has identified a series of actions that farmers can take and the costs associated with these, as a means to identifying how one might set about promoting uptake via a grant aid scheme.

A levy could also be used to fund a wise use initiative and, for administrative simplicity, could be charged on the basis of, for example, area farmed, livestock units, outputs, etc. Whilst this represents an administratively attractive solution, it may raise concern with regard to equity and fairness. Those farmers who have already adopted measures to reduce P loads (eg soil testing, buffer strips, etc.) at costs to themselves may argue that they should not be required to pay the costs of other farmers undertaking similar measures. Similarly, concern may arise over one sector (eg arable crop farmers) subsidising the activities of another (eg livestock farmers). This suggests that one may want to consider a levy system which targets not just one farming activity, but a range of activities so as to provide a more equitable outcome. Thus, a levy on farmed area may need to be linked with a charge on P in feeds or on livestock units.

3.5 Charge rebates

The revenues raised through an emissions charge or product tax could also be used to fund wise use initiatives or to generate funding for a wider grant aid scheme such as those proposed in the work carried out by IEEP (2002). There is the option, therefore, to attach wise use initiatives to any of these economic instruments in the form of, for example, a rebate for implementing on-farm measures to minimise losses of P from fields. The inclusion of such a rebate mechanism would greatly enhance the strategic effectiveness of the charges and taxes, allowing them to incorporate both input and loss minimisation. Alternatively, rebates could be linked to a farmer's ability to demonstrate sound environmental management of their farm (for example, adhering to management standards set by the Environment Agency).

Charging schemes could act as the sole source of funding for such a rebate, or be supplemented by additional sources in order to maximise the effectiveness and take-up of the schemes. Contributions form other sources may enable a scheme to fund a wider set of management activities than those that may be relevant to a specific farm's activities in relation to the original charge or tax (for example, investment in anaerobic digesters or collective responses by farmers).

3.6 Tradeable permits

3.6.1 Introduction

If acceptable levels of a given pollutant or the extent/frequency of a damaging activity can be established, then it should be possible to set quotas on the allowable level of that activity for individual polluters or groups of polluters. In turn, there is the opportunity to allow the trading of excess quotas between agents; for example, a farmer with land of sufficiently low soil P index for spreading of manures could sell the right to spread a quantity of manure on his/her land to a farmer with an excess of manure. This is counter to the way in which tradeable permit schemes are generally conceived, whereby a landowner would buy permits to keep manure on their own land. The difference arises because the aim here is to reduce total emissions of P to the environment by ensuring a better geographic spread over time (as the location of emissions matters greatly).

In an open market, the price for these rights to spread manure (ie a permit) will be flexible and will be a function of the pollution targets that have been set (as opposed to emissions and product charges where the level of emissions finally achieved is a function of the charge rate). This means that a well administered and policed scheme should have the potential to provide certainty about the outcome for the environment from the outset.

The initial method of allocating permits is important in this respect. The creation of permits and the ability to sell them should provide a dynamic incentive to reduce emissions (or damaging practices) and creates a property right of value where the polluter is able to sell (or lease) any spare quota to provide income. Thus, where permits are allocated free of charge on the basis of current discharges (grandfathering), this provides a potentially significant asset for existing polluters. It raises equity issues with regard to other polluters who may have already invested in pollution control and who would therefore receive a smaller quota. It also raises barrier to trade issues with regard to new entrants to farming.

Although there are many ways in which permits could be allocated on the basis of current practices and emission levels, the main alternative to grandfathering is the auctioning of emissions quotas. Auctioning would involve the regulator establishing the target pollutant load for a catchment (or other appropriate geographic scale) and then allowing farmers within that catchment to bid for permits. The highest bidders would be able to purchase the greatest number of permits.

In the context of eutrophication, there are obvious difficulties associated with the use of an auction-based allocation approach. It is likely to be important to set quotas at the individual farm (and potentially even field) level to ensure that 'hot spots' do not occur with regard to P and N concentrations. Thus, a system based on grandfathering which adjusts the initial allocation downward on the basis of a lack of past investment may be more appropriate.

There are also issues concerning the degree to which trading is restricted within a geographic area. By setting maximum quotas on the quantity of N and P permitted at any one farm (or for a series of fields), localised pollution problems should be avoided. However, where a catchment is at a high level of environmental stress, it may be appropriate to also 'discount' traded quantities. Discounting in this context is the process of adjusting downward the traded permit quantity in order to ensure that there are environmental gains. A related issue is the degree to which permit holders are allowed to 'bank' them. Many air quality trading schemes allow permit holders to bank the 'credits' which they earn in one year for reducing emission loads for use in a future period. In some cases, the ability to bank permits has been found to help smooth emissions reductions over time without affecting the dynamic incentives provided to polluters.

As with emissions charges (and product taxes), some monitoring is required to ensure compliance. Thus, there are similar administrative costs and issues associated with the burden of proof. The operation of a trading scheme, however, may incur additional costs associated with the initial allocation of quotas, the need to monitor fair trading, anti-competitiveness issues, etc.

Examples of quota and permit systems that have been applied to P and N control in Europe are given in Box 3.3.

Within the context of this study, three main options have been considered:

- establishing permit quotas so that phosphorus loads to nearby watercourses will decrease with the aim of reducing phosphorus concentrations in the water column;
- establishing permit quotas to allow for a specific phosphorus concentration on the farm (such as the soil P Index) or based on nutrient surpluses; or
- auctioning permits to undertake certain activities that lead to phosphorus losses, such as livestock production, autumn ploughing and sowing of winter cereals, ploughing of land above a certain gradient, or growing potatoes with high levels of P application.

Box 3.3: Examples of P and N Related Quota and Permit Trading Systems

UK: Hartley (1986) modelled the use of non-tradeable permits on farms in East Anglia and calculated that this would reduce nitrate concentrations in coastal waters of 6.2%, at a cost of around £6400 per annum per farm (as reported in CLM, 1999). However, no such scheme has been implemented in the UK.

Belgium: manure disposal quotas are set at a regional level. The region is divided into white, grey and black areas. In white and grey areas, where phosphate production is lower than 100 kg/ha, it is allowed to increase to 100 kg/ha. In black areas, where production is greater than 125 kg/ha, increases in P are only permitted if production is reduced elsewhere. Limited disposal routes have required intensive farms to transport manure long distances to receiving farms and from 1999 onwards to manure processing plants (WRc, 1999).

Denmark: the Action Plan on the Aquatic Environment II introduced non-tradable quotas at farm-level as a measure in Danish nitrogen policy from 1998. The required quota is set 10% below standard "economically optimal" norms for each crop. A reduction of N by 50% (one third the total effects derived from the Action Plan) is expected to be the result of non-tradable permits (Hasler *et al*, 1999). Non tradable quotas force the most intensive farms to reduce their fertiliser use to the same level as less intensive farms and give a higher overall income reduction with a high income distribution effect. The total income effect is reported to be in the range 0-7% (Backman, 1999).

The Netherlands (based on Vukina *et al*, 1998 and WRc,1999): Since the enactment of the Mestsoffenwet in January 1987, Dutch legislation allows a total manure production from all animal sources of up to 125 kg of phosphate (P_2O_5) per hectare of land. Farmers producing more manure in terms of phosphate need additional registered animal based manure production rights. The government aims to reduce manure production by 25% by 2002 through the gradual reduction in the rights available (estimated at 10,000 tonnes of P).

The system was introduced in two steps: in 1987 for the production of manure from cattle, swine and poultry, and in 1992 for the production of manure from sheep, goats, ducks, nutria and rabbits. Each farm was ascribed a "reference amount" based on an inventory of animals numbers and standards for the manure production for each specific animal category measured in Kg P_2O_5 per year. In 1986 all land for agricultural purposes was assessed too. The difference between the reference amount and the assessed acreage-based phosphate rights was used to identify manure surplus farms (with maximum levels for phosphate set at 85kg/ha in 2000 and falling to 80 kg/ha from 2002)(IEEP, 2002). A farm with production below its reference amount can increase animal production on the basis of unused (land based) manure production rights. For those farms with manure surpluses, an increase in production capacity is only possible with an increase in the reference quantity of manure production rights.

From 1986 until 1994, the transfer of manure production rights was restricted to guard against increases in manure related pollution problems. The only way to acquire additional manure production rights became the acquisition of land. Expansion of existing livestock farms in the South and East, where animal production has been traditionally concentrated, came to a standstill. As a result, the regulation indirectly constrained the agricultural sectors in these regions, affecting rates of adaptation and the ability to invest in the processes required to address the manure problem. Finally, permits became tradable again in 1994 under regionally differentiated sets of trading rules. For instance, trading of the animal-based manure quota is allowed within regions and from a surplus region into a deficit region, but prohibited from a deficit region into a surplus region. Moreover, trading is also restricted across certain animal species.

The tradable quota system has resulted in higher land prices (and quota prices) in the regions where the quota is binding and also in a reduction in the variations in land values between regions. Later developments in Dutch agricultural policy include the progressive retirement of rights for manure production, with this expected to reduce the emissions of phosphates by several millions of tonnes.

3.6.2 Quotas based on phosphorus concentrations in watercourses

Quotas for phosphorus emissions could be set according to the desired concentration of phosphorus in watercourses. This may vary according to the type of watercourse. The discussion set out in Section 2 suggests that as a minimum P concentrations may need to be reduced to 200 to 300 µg/l to result in ecological improvements.

However, such an approach would require a significant programme of surface water monitoring for phosphorus and, as already described for emissions charges, predictive uncertainties and administrative costs associated with establishing and monitoring quotas are likely to make such an option unrealistic.

3.6.3 Quotas based on phosphorus on the farm

An alternative option is to set quotas based on phosphorus inputs and nutrient surpluses, as given by soil P indices, with nutrient planning for key 'problem' catchments. Such a scheme could bear some similarity to the nutrient surplus emissions charge described earlier except that all farms in a catchment would be required to undertake nutrient planning and management. It would require the following:

- identification of the problem area (eg the boundaries of the CSA) and the geographic zone over which permit trading could take place;
- a soil test to identify baseline soil P index for all fields/farms in the catchment;
- apply the rule that no spreading is permitted on soils over index 2 (or perhaps 3); and
- farms with an insufficient area of suitable index soil for spreading generated manures (ie index 2 or below) would need to purchase the rights of others in the catchment with land of index 0 to 2/3 in order to dispose of excess nutrients.

The buying and selling of 'permits' or 'quotas' in this way would promote the distribution of nutrients away from CSAs and would follow a policy of 'running down' soil P. In addition, it would be in the interests of farms of low soil P index to adopt nutrient planning and soil testing requirements in order to be able to sell the rights so spread manure on their land and generate additional revenue.

Although one may want to start by restricting trading to a fairly localised area (eg catchment or more likely sub-catchment), it may be possible to open up the scheme to a wider geographic area. If farms outside identified problem areas were also permitted to enter the trading scheme (on condition that they undertake soil testing and nutrient planning to demonstrate these rights), this could also help increase the uptake of nutrient budgeting more generally.

3.6.4 Permits based on particular farming activities

As well as trading based on particular inputs or outputs, it may also be possible to buy and sell permits for certain activities. In terms of reducing phosphorus outputs, these may relate to farm practices that are known to increase phosphorus losses from the farm. Such activities could include:

- ploughing of land in autumn/winter for sowing of winter crops (this often leaves large areas of land with no ground cover, increasing the potential for soil erosion);
- ploughing of land that is more susceptible to erosion (including sloping land, riparian land and areas with erosion-sensitive soils);
- the cultivation of crops such as potatoes which are commonly accompanied by heavy applications of P; or
- livestock production where this could be based on the actual number of animals or on allowable stocking densities.

The first three types of activities would involve issuing permits which could be tradeable (or non-tradeable) as to the ability to undertake an activity in a given catchment, for example, where there is a need to deal with issues surrounding the losses of soil P from fields. As such, in isolation, such schemes may be able to help reduce future environmental damages associated with the gradual release of soil P. Care would be required though to ensure that trading if allowed would not lead to an exacerbation in problems. This suggests that permits would have to be grandfathered and indeed restricted to certain types of locations. This means that in priority catchments, such schemes would be more akin to direct regulation than an economic instrument based approach. However, outside priority catchments, it may be possible to allow trading of activity based permits where there is an aim to achieve non-targeted but more widespread reductions in the release of soil P.

It is unclear whether the use of such permits would be more cost-effective overall (in terms of costs to farmers and to regulators) than the more traditional licensing approaches. In particular, systems would have to be set up to monitor and enforce trading activities and these, together with the information and other transaction costs that a farmer would face, may be greater than the costs arising under direct regulation. Furthermore, there is likely to be a lower level of environmental certainty associated with trading in activities, given the stock pollutant nature of soil P. This is particularly true if such schemes were not complemented by measures aimed reducing new inputs of P to the system.

Tradeable livestock production rights have been used in the Netherlands to control the level of pig production. This system allows the Ministry of Agriculture to obtain on-going reductions in the number of pigs being produced in order to meet target reductions in the overall levels of manure being produced. In this case, setting permits at a national level (non-target reductions in P) would result in general reductions in nutrient loadings but may not deliver some of the site specific environmental gains desired for priority catchments. Thus, a two tier system may be required, with quotas on stocking densities set at the farm level and farmers able to move livestock from one farm to another in order to adhere to the quotas.

Again this type of approach would require the development of the trading system and rules for monitoring and enforcement of trades. Farmers would also face transaction costs in terms of their finding information on those who may have spare capacity within their quota and in establishing market clearing prices for this spare capacity. However, these costs may be lower than those associated with management activities as they relate to a more well-defined commodity.

3.7 Permit charges

A variation on the trading in the rights to undertake particular forms of activity is to create a permit-based charging or tax system. In this case, the economic incentive for farmers to reduce the level of potentially polluting activities would stem from requiring farmers to buy a permit if they wished to undertake a given activity, and to set the charge at a level that discouraged that activity.

Such an approach would act through similar economic levers as the alternative offering grants to farmers to change practices discussed in the parallel report by IEEP (2002). That report sets out the detail of practices that could be covered by such a scheme, and the level of charge (or grant) that would be required to influence farmers' decisions on whether it would be worthwhile to change particular practices. For this reason, such detail has not been included here.

The advantage over traditional regulatory approaches would be that individual farmers could continue to pursue a particular practice, if it was especially economically valuable to them to do so. The disadvantage is that under this option there would be no certainty that pollution would be controlled sufficiently in the particular places that it needs to be controlled – although this is an issue that arises with some of the other economic instruments considered in this report.

3.8 Recycling credit based schemes

3.8.1 Introduction

Within the UK, recycling credits have been used to stimulate the recycling of household waste and to reduce the amount of waste going to landfill by altering the relative economics of adopting more sustainable waste disposal options. Through the creation of these credits, those who collect or dispose of waste transfer the cost of avoided disposal to those who engage in incremental recycling (Pearce *et al*, 2000).

Recycling credits, which can act as a form of subsidy, may involve two types of payments:

- collection credits that are paid by the waste generator to third parties who collect waste; and
- disposal credits that are paid by the waste generator to a third party who runs local recycling schemes.

They provide signals to the market about the financial costs of waste collection and disposal, for comparison against the costs of recycling. Collection credits are calculated as a percentage of the costs of waste collection, including transport costs. Disposal credits are set in relation to the long-run marginal cost of the most expensive disposal method.

3.8.2 Application to diffuse agricultural sources of P

There has been an attempt to introduce manure recycling credits in other countries, where these take more the form of a subsidy than just a transfer as discussed above for the waste industry. Problems have arisen with such schemes, however. In particular, a scheme for manure processing in the Netherlands was put in place and operated (with EU funding) from

1989 to 1994. However, the manure processing facilities were not profitable and more aid than originally agreed was required to keep them operating. As a result, the scheme failed (ENDS Daily, 2000).

There are three scenarios that one can envisage for the use of such credits as part of a scheme to subsidise manure recycling in the UK. In the first, one could establish manure recycling plants at regional or more local levels depending on the volumes of manure surplus. To an extent, plants capable of handling such wastes may already be in existence in some parts of the country for the purposes of sludge processing[4] and might, in some cases, be capable of providing phosphate stripping or dilution to provide an organic alternative to inorganic fertilisers.

A second scenario is the use of such credits to provide an incentive to increase the quantity of manure, and in particular poultry wastes, that are being used as fuel sources in power plants. Poultry waste is already being used in a number of electricity generating plants operating in the UK, with such waste reportedly being transported over long distances. Waste from modern intensive rearing units is relatively dry and has both a high energy and phosphate content.

The third scenario involves the use of subsidies to encourage the development of on farm enterprises, where these could include composting or the use of manures for biogas production in order to meet farm energy requirements. Numerous examples exist of the use of livestock waste for such purposes in developing countries, and the concept is similar to the use of the gas generated in the treatment of sewage sludge providing the heat and power for the treatment plants. The creation of this type of system may provide sufficient incentive for such enterprises to be developed within the UK. A problem remains as to how to manage any biomass residues, which would still contain the P (and are traditionally used as a fertiliser).

However, the use of such recycling schemes should be viewed as part of a wider package of measures that may provide relief and a means of recycling and reusing nutrients from organic manure sources.

3.9 Options for detailed analysis

Based on the above discussion, a sub-set of the possible options were identified for further elaboration and the preliminary feasibility analysis. This targeting of a sub-set of the options reflects the fact that within the constraints of this study, we were able to concentrate on only a selected number of options. We were unable to carry out a more detailed analysis for all options. Those seemingly the most feasible options were therefore selected for the more detailed analysis.

The reasons for not examining some of the other options discussed above include that they appeared less feasible for technical reasons (ie related monitoring requirements or problems in levying a tax on imports of fertilisers) or there was insufficient time to study them in adequate detail (ie some of the other product charges). There may well be merit in examining some of the other options as part of any further work.

4 Southern Water, for example, already sell processed and graded sewage sludge as a soil conditioner and fertiliser.

Thus, the fact that we have not looked at some options does not mean that they would not provide feasible instruments and may, indeed, be preferable to some of those examined.

The sub-set of options that was carried forward for the feasibility analysis is as follows:

- *Option 1: Simple Minerals Accounting Nutrient Surplus Charge:* It is believed that a properly designed and implemented emissions charge based on farmer supplied nutrient surpluses could offer an opportunity to curb excessive P surpluses (and hence emissions) and potentially promote the uptake of better nutrient management practices. It may not, however provide an incentive for reducing soil P indices nationwide.
- *Option 1b: Nutrient Planning Phosphorus Surplus Charge:* The introduction of a graduated charge based on exceedance of P applications (according to recommendations) on soils of different soil P index could provide a means of both curbing excess applications of P (providing an incentive to divert excess P away from CSAs) and a means of 'running down' soil P levels where most appropriate.
- *Option 1c: Two Tiered Nutrient Surplus and Management Charge:* Options 1a and 1b in isolation have key disadvantages. Option 1a alone may only achieve maintenance levels at best and Option 1b alone would mean that all farms would have to adopt suitably robust nutrient management methods in order to supply the relevant information. The alternative is to integrate both options to form a two tier system which would require farmers to submit simple nutrient surpluses as a minimum, but would include a financial incentive (in the form of reduced charges) for submissions using nutrient planning. Additional incentives to move to nutrient planning may come from the avoidance of charges for application of P over maintenance rates on suitable soils of P index 0 and 1.
- *Option 2: Tax on Feed Phosphorus Supplements and Content:* The introduction of a tax on feed P supplements and feed mixes may offer significant reductions in the nutritive value of manures. This, in turn, may provide a partial solution to P loadings and the disposal of 'waste' manures.
- *Option 3: Tradeable Permit Scheme for Application to Specific Problem Catchments:* Tradeable permits offer potential for reducing the environmental load of phosphorus at a reduced cost to farmers, compared with regulation or emission charges. The most appropriate method may be to base quotas on nutrient surpluses, to encourage farmers to reduce the amount of excess phosphorus on their farm.
- *Option 4a: Wise Use Levy:* The use of a simple levy to fund the encouragement of on-farm measures to reduce P loads or P transport may provide an important short-term and complementary measure to those described above.
- *Option 4b: Charge Rebates:* Instead of using some simpler form of levy scheme, charge revenues could be used to provide rebates to farmers for undertaking particular activities on their farm. This could be supplemented by other sources of funding to encourage more innovative responses.
- *Option 5: Permit Charges for Potentially Polluting Activities*: While probably not practical administratively as a universal approach across the country, a permit charging scheme might offer a more flexible alternative to traditional regulation in targeted areas – especially in circumstances where a permit trading system would not be practicable. The detailed work undertaken in the parallel report (IEEP) is relevant to this option.

Table 3.3 provides a scoping of the above instruments and their coverage of the target issues identified earlier (Sections 2 and 3.1). As can be seen from the Table, none of the proposed instruments in isolation is likely to provide sufficient incentive to cover all of the relevant mechanisms. This suggests that a package approach may be required, combining different instruments into an overall scheme capable of addressing the problem comprehensively. This could include the types of measures identified by the IEEP study (IEEP, 2002).

Table 3.3 Scoping of proposed instruments against mechanisms for reducing diffuse emissions of phosphorus

Mechanism	Simple Minerals Accounting (Option 1a)	Nutrient Mgmt. (Option 1b)	Options 1a & 1b Combined (Option 1c)	Tradeable Permits (Option 2)	Tax on Feed P (Option 3)	Wise Use Levy (Option 4a)	Charge Rebates (Option 4b)	Permit Charges (Option 5)*
Raising awareness of phosphate application	S	S	S	S	W	W	W	S
Reducing application rates/ curbing excessive emissions	W	S	W/S	S	W	W	W	S
More targeted P inputs though better nutrient planning	W	S	W/S	S		W	W	S
Redistribution of P away from CSAs	W	S	W/S	S		W	W	S
Reducing Soil P Indices		S	W/S	S			W	S
Encouraging the uptake of measures to reduce losses from fields, etc.	?	?	?	?		S	S	S
Reducing nutritive P values of manure (via feed)					S			

Key: S: strongly or directly addressed by instrument
W: weakly or indirectly addressed by instrument
? : could be incorporated as part of a rebate/wise use initiative
'blank': unlikely to be addressed by instrument

Note*: The impact of this option would be limited to its scope of application as targeted would be required to limit administrative costs. This make rating in terms of 'weak' or 'strong' difficult.

4. Analysis of options

4.1 Introduction

As has been described in Section 3, the options selected for more detailed screening and analysis are as follows:

- Option 1a: Simple minerals accounting nutrient surplus charge;
- Option 1b: Nutrient planning phosphorous surplus charge;
- Option 1c: Two tiered nutrient surplus and management charge;
- Option 2: Tax on feed phosphorus supplements and content;
- Option 3: Tradeable permit scheme for application to specific problem catchments;
- Option 4a: Wise use levy;
- Option 4b: Wise use rebates; and
- Option 5: Permit charges for potentially polluting activities.

Clearly, owing to the fact that inputs of P provide the most tangible, measurable and common factor to underpin a charge or tax, the result is that most of the basic charge/tax instruments are focused on source issues. As noted in Section 3, however, this does not discount their potential for tackling transport issues as well, and these indirect benefits are discussed later.

For transparency and simplicity, in considering, describing and analysing the instruments, attention has been given to the basic structure of each so as to identify their principle cost components, implementation issues and environmental effectiveness.

4.2 Options 1a, 1b and 1c: Nutrient surplus charging

4.2.1 Underlying principle of nutrient surplus charging

Figure 4.1 provides published data on the UK's P budget. This budget is based on consideration of inputs of P in the form of animal feed and minerals, inorganic fertilisers, sewage sludge, and atmospheric sources. As can be seen from Figure 4.1, in theory there is sufficient P in the existing cycle to eliminate the need for the use of P in inorganic fertilisers. At least in principle, then, if a perfect re-distribution of nutrients from manures were achieved (substituting and eliminating inorganic P), within the tolerances of the data, there would appear to be little or no nutrient surplus at a national scale.

To promote this redistribution, charges could be levied at a farm level for every unit of P surplus produced and disposed of 'to farm' (ie spread on farmer occupied fields). More limits and associated charges could also be made on the basis of applications over and above the fertiliser recommendations (RB209 (MAFF, 2000)) or restricting any application of soils over Soil P Index 2.

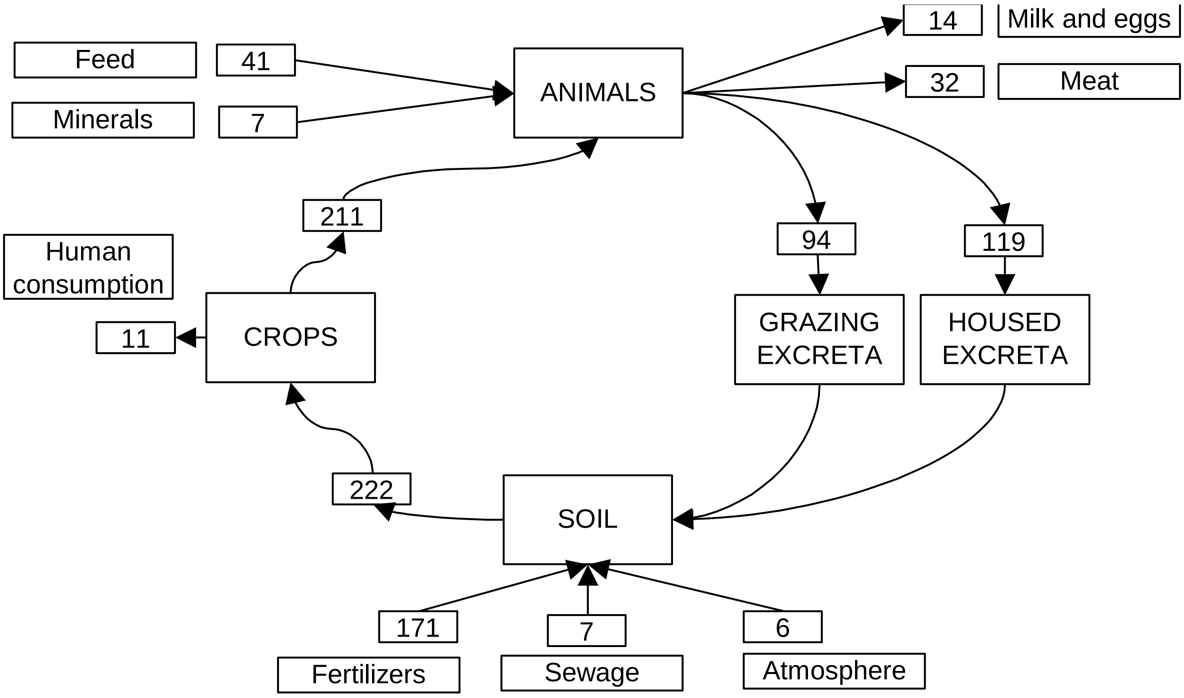

Figure 4.1 Cycling of P 000t in UK agriculture

(after Withers *et al* 2001)

4.2.2 The options

The three different nutrient surplus charges considered here can be described as follows, with Table 4.1 providing details on the objectives and operation of each:

- *Option 1a* - a nutrient surplus charge aimed at dissuading farmers from operating their farms with a net P surplus. The objective is to prevent further soil nutrient enrichment with P by ensuring that soil P levels do not increase over existing levels, ie all farms reduce inputs to equal to offtake.
- *Option 1b* - seeks to provide an incentive to 'run down' P enriched soils. Two scenarios have been applied. The first reflects the rules as set out in RB209 (which 'permit' applications on soils over index 2 for some crops) – hereafter referred to as the RB209 scenario. A second variation reflects no applications to soils over index 2 – hereafter referred to as the In2 scenario.
- *Option 1c* - Option 1c represents a combination of Options 1a and 1b. According to RB209 there is spare potential within safety margins to apply greater quantities for agronomic benefits. Option 1c would permit such applications by excluding from the charge those farmers who can demonstrate (through soil testing and analysis) that applications of P are within RB209 recommendations.

Table 4.1 Objectives and Operation of Charges

Option	Objectives	Operation
1a: Simple Nutrient Surplus Charge	The objective of a nutrient surplus charge would be to dissuade farmers from operating their farms with a net P surplus. A charge would encourage the export of surplus nutrients from the farm to an alternative location where they can be used as part of a balanced input programme (eg as a substitute for inorganic P on arable farms), or disposed of by alternative means (for example as fuel in poultry manure power stations, etc.).	The setting up of recording procedures on the farm for calculating annual inputs and outputs, and surpluses. Such a system would have to permit farmers to identify where there will be a need to find an alternative 'disposal route' to avoid a surplus. Calculations would have to be submitted to an administrative body which would then raise a charge against the level of surplus, and undertake any monitoring and validation work. The level of the charge would need to be set at a rate high enough to ensure that exporting surplus P from the farm is a financially more attractive option than disposing 'to farm' and incurring a charge. The optimum level of the charge would very much depend on the costs of transport and alternative disposal options.
1b: Charge Based on Soil Testing and Crop/Soil Requirements	Option 1b seeks to provide the incentive to 'run down' P enriched soils. The Representative Soil Survey provides data on the proportion of Soils of different P index by crop/grassland. Comparison of these data with the RB209 fertiliser recommendations reveals that around 2.3 million ha (≈39%) of agricultural soils in England and Wales are enriched with P to a level where little or no agronomic benefits can be gained from further enrichment and, indeed, where there would be no agronomic costs from running P down. Around 0.7 million ha (≈12%) of agricultural soils in England and Wales are enriched to Soil Index 4 and above and can be considered 'at risk'. Option 1b seeks to 'enforce' by means of charges, the RB209 fertiliser recommendations nationwide. This would involve charging on the basis of excess applications and soil P indexes.	Operation of the charge would require compulsory field specific soil testing nationwide (with the possible exception of extensive sheep farms) and submission of records to demonstrate applications. A charge based on soil measurement and testing would take account of existing soil P index and levels of P applied. It would therefore seek to penalise any applications on land above the target level (broadly index 2 in the recommendations). A graduated charge would apply such that the charge per kg P applied to a soil of, say, index 5 would be significantly higher than the same application on a lower index soil. Applications to soils below the target level or to maintain the target level would be permitted without charge as these soils are the only available (and relatively sustainable) 'sink' for livestock generated P.

Option	Objectives	Operation
1c: Combined Surplus and Soil Testing Approach	Option 1c represents a combination of Options 1a and 1b. Under 1a, according to RB209, there is spare potential within safety margins to apply greater quantities for agronomic benefits. Option 1c would permit such applications by excluding from the charge farmers who can demonstrate (through soil testing and analysis) that applications of P are within RB209 recommendations. The objectives of 1c are, then, to: • 'free up' this additional soil P capacity for use (and thus slightly reduce the total costs of transport and 'disposal'); • provide a simple means by which to derogate P applications that are within sustainable (taken to be RB209) limits (and thus reduce the unquantified costs associated with reduced future potential for increased output); and • promote the uptake of soil testing and analysis as a method of more effective nutrient planning.	Once granted, a derogated farm would no longer have to record and calculate surpluses using the methods set out for Option 1a, rather there would be a condition that the farmer demonstrates that s/he has not applied P at levels in excess of the recommendations. Any exceedance of these levels would result in a charge. The incentive to undertake soil testing would simply be the 'unlocking' of agronomic benefits associated with running up impoverished crop soils (which can be significant for low index soils) combined with the simpler (if slightly more expensive) recording and submission process. To maintain the momentum of the instrument towards the promotion of eventual uptake of soil testing and analysis, all derogated farms would have to continue in this capacity. In other words, there should be no option to return to simple minerals accounting once the process of soil testing and demonstration of inputs has been started. In addition, farms would have to register all land on the farm, not simply areas of land of lower soil index. This would mean that where a farm has several fields of low soil P index (say index 1) and several of higher soil P index (say index 3), the farmer would be unable to spread P on fields of higher index. Clearly, in this case, if the farmer had been operating the simple minerals accounting system, then 'maintenance' applications equal to off-take would be permitted.

4.2.3 Administration, monitoring and enforcement

It has been suggested that these options could be applied as an extension to requirements for Nitrate Vulnerable Zones which are soon to be extended to cover most of the study area.

Under NVZ rules all farms must keep adequate records relating to livestock numbers and the use of inorganic N fertiliser and organic manures. These are essential to monitor compliance and must be available for inspection by Environment Agency staff. The records need to include details of the following:

- the area of the farm and its individual fields, excluding areas of woodland, roads and hardstanding;
- the cropping of each field, including sowing dates;
- applications of manufactured N fertiliser, including quantities and application dates;
- any applications of organic manures, including type, quantity and application dates;
- any livestock kept on the farm, including type and length of time kept (ie normal stocking cycles); and
- any livestock manure moved off the farm, including quantities, dates and details of the recipient (MAFF, 2001).

Given the forthcoming expansion of NVZ rules to cover 80 percent or 100 percent of England, it has been suggested that the additional recording requirements to include P are likely to be small. Table 4.2 provides a description of the additional requirements that are likely to arise under each of the options.

In terms of administration and enforcement of the charges by a competent authority, however, additional resources would be required to monitor, cross-check compliance and raise charges based on returns. There would also be a need to undertake 'spot checks' on farms under some or all of the options. These additional 'national administration' requirements are discussed alongside the measurement and administration of the charges at farm level in Table 4.2. Overall costs of administration, monitoring, enforcement are provided in Table 4.3.

In terms of the operational costs of the instrument, it is assumed that these would be paid for by the charges raised. In this regard, it is reported by IEEP (2002) that there have been significant operational problems with collecting these charges in the Netherlands and that many court cases are outstanding on this issue. This suggests that resistance to paying charges could be anticipated in England and Wales. However, a number of ways of securing compliance without involving costly court cases could be developed alongside a charging scheme. For example, if non-compliance meant suspension from Farm Assurance Schemes (and hence the market), there would be a strong motivation to comply with both requirements to reduce P surpluses and associated charges for surplus P applications.

Table 4.2 Administration of nutrient surplus charges

Option	Farm Administration	National Administration
1a: Simple Nutrient Surplus Charge	To calculate a P balance accurately under Option 1a, farmers would need to collect the following additional data: o P fertiliser inputs; o straw exported/imported; o P in feed; and o ideally, crop yields (specifically crop exported from the farm). These data would have to be processed by the farmer. The application of this level of recording data may represent an increase in recording costs of approximately 50% over those required under NVZs. Applying this to the figure of £200 used in the Draft Regulatory Impact Assessment accompanying the NVZ consultation suggests an increase in recording costs of around **£100/farm** over the requirements under NVZs.	Cross-checking would require tracing P imported and exported from one farm to another or to other 'disposal' routes. In other words, where P has been exported/imported from one farm to another, the volume of 'waste' should appear on the minerals accounts of both. The import of minerals from countries not covered by the charge could be problematic, particularly in border areas, if the charge were not in place, for example, inScotland. However, being an island, these problems are considered to be far less than the problems faced in other countries where such a scheme has been tried (for example, the Netherlands). In terms of costs, the Levies Bureau in the Netherlands (in advance of the charge) calculated approximate costs of between €113 and €227 per farm for cross-checking (Ecotec, 2001). Using an exchange rate of 1.62, this equates to between £69 and £140 per farm. Additional per farm administration costs have been estimated at between £66 and £217. Using lower bound costs this equates to around £135 per farm. Assuming cross checking of 10% of farms per year (≈11,000) this provides an estimate of around £1.48 million per year.
1b: Charge Based on Soil Testing and Crop/Soil Requirements	The farm administration and record keeping requirements of this option would be greater than those under Option 1a because of the additional demands for soil testing* (which would have to occur every 4 years or so) and gathering field specific data. However, because the recommendations are based on additional inputs of P and the decay rate of P enriched soils is so slow, the spreading and fertilising rules are much more transparent than the calculation of inputs and outputs. Thus, at a simple level, if a farmer knows from initial soil testing that all of his/her fields are at Soil Index 4, then s/he knows that no spreading of P should occur on these fields for a number of years. This provides easier planning and calculation of what fertilisers to buy in and what proportion of livestock generated manure will have to be transported elsewhere, or be dealt with by other means (for example by reducing feed P or stocking rates). Thus additional costs of soil testing of, say £16 per ha every 4 years (£4 per ha/year) could be offset by less administration. In addition, on farms where P status is impoverished, there will be agronomic benefits to soil testing.	In terms of administration, there would be slightly different requirements than for Option 1a, where this administration is likely to be slightly simpler. Submissions of soil testing data and applications would be simpler to cross check and analyse than for simple minerals accounting submissions. Assuming cross-checking costs half of that for a surplus charge because of this simplification (≈£67 per farm) and 10% of farms are cross checked per year (≈11,000) provides cross-checking costs of approx £0.74 million per year. As reductions in soil P take a long time to occur, random testing would quickly identify falsifications in submitted data, whether initial soil P status or underestimation of applied P. That said, though the index is the only cheap, fairly reliable and widely used measure on which to base a charge, these spot checks would have to account for possible variations in initial samples and spot check samples before determining whether deliberate falsification has occurred and the farmer incurs a charge. It is assumed here that 5% are to be random tested over a ten year period (≈560 holdings per year) at a cost of £16 per ha. Assuming average farm size of approximately 60ha (≈£1000 per holding) gives a cost of around £0.56 million per year.

Option	Farm Administration	National Administration
1c: Combined Surplus and Soil Testing Approach	Farm administration and record keeping costs will vary slightly depending on whether a farmer decides to apply for a derogation from the charge (and undertake soil testing) or not. On balance, it is thought that the costs are likely to be similar to those under Option 1a (ie £100 per holding) even accounting for increased soil testing requirements for derogated farms. This is because it is believed that, to a large extent, it will be farmers who have already undertaken some level of soil testing (but may not be following RB209 guidelines 'to the letter') who will apply for a derogation. As such, these farmers will benefit from reduced complexity of submissions and associated costs. Where farmers have not and are found to have low soil P status, the agronomic benefits will compensate for any costs.	Depending on the uptake of derogations, administration is likely to be very slightly simpler than for Option 1a. Assuming cross checking of 10% of farms per year (≈11,000) this provides an estimate of around £1.48 million per year. However, there would be an additional need for policing, where this may require the administrative body to commission random independent soil tests on a proportion of derogated farms. Say 5% (≈5,600 holdings) are derogated and 5% (≈280) of these are randomly tested per year at a cost of £16 per ha. Assuming average farm size of approximately 60ha (≈£1000 per holding) gives a cost of around £0.28 million per year.
* It is interesting to note that most farm assurance schemes recommend or state that soil analysis is undertaken on a periodic basis. For example, the Assured Combinable Crops Scheme (ACCS) covers over 80% of the marketable crops and recommends soil sampling every 4-5 years. The Assured Produce Scheme (APS) on fruit now states that soil analysis is undertaken before planting.		

Table 4.3 Total annual costs per holding at the national level

	Farm Administration	National Administration* (average across all holdings)
Option 1a	£100 per farm (≈£11.1M)	Cross checking: £13 per farm (£1.48 M)
Option 1b	£100 per farm (≈£11.1M)	Cross checking: £6.6 per farm (£0.74 M) Random testing: £5 per farm (£0.56M) Total: £15.5 per farm (£2.04M)
Option 1c	£100 per farm (≈£11.1M)	Cross checking: £13 per farm (£1.48 M) Random testing: £2.50 per farm (£0.28M) Total: £15.5 per farm (£1.76M)
* These costs are averaged across all farms, rather than just the smaller percentage that would be checked or tested as described in Table 4.2		

4.2.4 Environmental effectiveness

The current situation

Table 4.4 provides data on the area and percentage area of crop and grassland of different soil P indexes. These data have been derived by combining Representative Soil Survey data (which provides sample data on the % area of soils under each crop/grass land type under each category of soil P index) and data on the area under each crop in the year of the sample (1997). This provides an indication of the baseline situation in England and Wales.

Table 4.4 Area and % area of England and Wales by Soil Index

		Soil P index					
		0	**1**	**2**	**3**	**4**	**5 +**
Thousand ha	**Crop**	101	461	1,078	1,344	659	264
	Grass	281	495	495	366	82	47
% Area Crop/grass	**Crop**	3%	12%	28%	34%	17%	7%
	Grass	16%	28%	28%	21%	5%	3%
% Total Area	**Crop**	2%	8%	19%	24%	12%	5%
	Grass	5%	9%	9%	6%	1%	1%

As can be seen from Table 4.4, if soils of index 3 and over are regarded as being over enriched with P, currently around 2,267 thousand ha (58%) of crop land and 495 thousand ha (29%) of grassland area are over enriched with P. This constitutes a total of around 2,700 thousand ha of land (around 49% of total area) that could be regarded as being over enriched with P. Of this land, around 1,052 thousand ha (39%) can be viewed as particularly at risk (being index 4 or above). As such, approximately 14% of total land area is at soil P index 4 or above and can be considered particularly at risk.

In terms of the effectiveness of the various options, Options 1a and 1c will result in no change to the data in Table 4.4. These options focus on ensuring that inputs of P match outputs (offtake) of P. Even where totally effective, then, these options would only stop further enrichment of soils, effectively ‘freezing’ soil P status at existing levels.

Option 1b, however, would result in significant changes to the areas at risk by preventing further applications of P on soils of higher soil P index (and/or limiting rotational P application rates to below maintenance levels for some crop/soil combinations according to the RB209 recommendations). Table 4.5 presents data on the areas of crop and grassland that would and would not be available for spreading of P under the application 'rules' of the two Option 1b scenarios (RB209 and In2). In this regard, the rules of In2 are that no applications of P should occur on soils of index 3 or above. Under the RB209 rules, some limited applications on soils of index 3 or above are permitted for some crop/soil index combinations.

Table 4.5 Spreading Area and Area for 'Running Down' of Soil P

		Area Available		Area Unavailable ('Run Down')	
		RB209	**In2**	**RB209**	**In2**
Thousand ha	**Crop**	2,455	1,640	1452	2268
	Grass	1,271	1,271	495	495
As % of Crop/grass area	**Crop**	63%	42%	37%	58%
	Grass	72%	72%	28%	28%
As % of Total Area	**Crop**	43%	29%	-	-
	Grass	22%	22%	-	-
Total		66%	51%	34%	49%

As can be seen from Table 4.5, the effect of Option 1b under the RB209 rules is to encourage the running down of P on 1,947 thousand ha (34%) of agricultural land (37% of cropped area and 28% of grassland area). Under In2 (where no applications are permitted on soils over index 3), running down of soil P is encouraged on 2,763 thousand ha (49%) of agricultural land (58% of crop area and 28% of grassland area).

If it is assumed that the universal application of the RB209 fertiliser recommendations represents sustainable use of P, this implies that no further applications of P should be permitted on 1,947 thousand ha of agricultural land. Options 1a and 1c would fail to make any impact on the achievement of such a sustainability objective (as no areas will be encouraged to run down). In contrast, In2 would go beyond such a sustainability objective. Options 1a and 1b would, however, stop the further degradation of the situation.

In terms of the reduction in the quantities of P applied under each of the options (and hence the reduction in the rate of further degradation that Options 1a and 1b could have), crop/grass specific data on the area of soils of different P index (aggregated into Table 4.4) have been combined with the recommended cop/grass P application rates given in the RB209 fertiliser recommendations. Once aggregated, these data suggest that in 1997 the maximum sustainable capacity for applied P (organic or inorganic) in England and Wales was around 132,000t.

Examination of data on actual application rates reveals that in 1997, 281,000t of P were applied as manure or fertiliser. In other words, assuming rates have not changed significantly since 1997, applications of P are currently running at 212% of sustainable capacity (i.e. P application rates are currently 112% over capacity).

Table 4.6 provides data on the changes in quantities of P applied as manure or fertiliser under the various options. As can be seen from Table 4.6, by definition, Option 1b (RB209) would reduce annual total applications rates down to sustainable levels. Options 1a and 1c each provide around 36% of the annual reduction required to meet the actual sustainable capacity of England and Wales.

Table 4.6 Table 4.6: Reductions in P applied under each option

	P Applied as Manure and Fertiliser (000's t)	Reduction (000's t)	% of Capacity	% Over Capacity	% Required Reduction
Present	281	-	212%	112%	-
Option 1a	228	54	172%	72%	36%
Option 1b - RB209	132	149	100%	0%	100%
Option 1b - IN2	111	169	84%	-16%	113%
Option 1c	228	52	173%	73%	35%

Whilst the key focus of the charges is clearly on the reduction of soil P and soil P application rates (so called source issues) as a means to reduce diffuse pollution risks (owing to that fact that this is the most amenable charging point), it is important to note that this does not mean that the charges would fail to address other factors responsible for diffuse P pollution from agriculture such as run-off and erosion (so called transport issues).

Although the effect of these charging options on the so called transport issues is difficult to quantify exactly within the study scale and time (and further consideration might be given to this in future), the fact that Option 1b reduces the available spreading area by 34% (for RB209 and 49% for In2) implies that there is a corresponding reduction in the risk of P loss from future applications in these areas (since these areas would no longer receive applications in the short to medium term).

4.2.5 Costs of compliance

The analytical approach

To allow comparison between the various instruments, a model has been developed to to provide consistent estimates of the costs of compliance. The modelling activities, base assumptions and the derivation of costs for all options are described in more detail in Annex 2.

Given the large range of possible farmer responses to instruments and the associated costs of meeting an appropriate balance in an individual farm situation, it is difficult to accurately model what the associated costs are likely to be. At present, the least cost option for disposal of manures is widely regarded to be the direct spreading to land. In modelling the costs associated with the proposed charging options, we have taken this to its logical conclusion, ie that manure is disposed of to land up to the recommended limits, the excess being disposed of by other means. Whilst this represents only a part of farmers' likely response to an instrument and is, as such, practically unrealistic, it does enable an examination of the changes in costs associated with the different options and estimation of the environmental effectiveness of each in terms of the quantities of P taken out of circulation.

The key cost variables examined in modelling, then, are associated with the transport, spreading or other disposal route for the surplus manures generated under each option. Given study resource, a 'top down' approach has been used to calculate total compliance costs.

In simple terms, the model calculates the volume of manure generated by existing flock/herd sizes and the capacity of livestock land to 'absorb' this at the rates implied by the different options. Any calculated excess manure must be disposed of elsewhere. As already noted, owing to the fact that spreading directly to land is broadly regarded as the least cost option (at present), the default 'disposal' route is loading, transport and spreading to land. As base data, the model uses national census data on crop areas and headage, published data on quantities of manure produced and manurial P values for different livestock to generate a detailed P budget. This is linked to a forecasting model that predicts changes under the various options in terms of generated 'wastes', spreading area required, and distances travelled.

From recent experience with the foot and mouth disease, it is unlikely to be considered good practice to increase trafficking between livestock farms unless very good disinfection systems were installed. However, given the restrictions that operating to a balanced P budget would create, it is unlikely that there would be any 'spare' capacity for spreading of slurry and farm yard manure from other livestock farms. In other words, the model has assumed that any surpluses are spread on crop land, whether that is crop land on a mixed farm (where it is assumed that the mixed farm will use this land to 'capacity') or arable land. No exchange between livestock farms occurs within the modelling.

It has been assumed that all crop land that is theoretically available for spreading under each of the options is used for this purpose, displacing the use of inorganic P where necessary (although, as discussed later, there are practical difficulties with this concept). As indicated above, any remaining excess must be disposed of by some other means.

Table 4.7 provides data on the total quantities of excess manure generated and transported/disposed under each of the options (where this data reflects the situation after implementation of NVZs to 80 – 100% of England). As can be seen from Table 4.7, the excess manure generated under Options 1a and 1c can be accommodated on [≈96% of] the available crop land and, as such, all of this material is transported to this land.

Under Option 1b (RB209 and In2), there is insufficient land to dispose of excess P within the limits discussed in Section 4.2.4. As such, 60% and 74% of volume (for RB209 and In2 respectively) must be disposed of by other means.

Table 4.7 Quantities of manure transported/disposed of under options

	Quantity transported (000 m^3)	Quantity disposed (000 m^3)	% Excess Transported	% Excess Disposed
Option 1a	20,348	0	100%	0%
Option 1b - RB209	8,499	12,705	40%	60%
Option 1b - IN2	5,592	15,822	26%	74%
Option 1c	20,326	0	100%	0%

Indicative compliance costs

As already noted, the key costs associated with these charging options relate to the transport, spreading and disposal of excess manures from livestock farming activities. Table 4.8 provides the total annual compliance costs of the options (in year 1) for each of the transport distance assumptions (low, medium and high) at both a national and per holding level. It is important to note that, as modelling revealed no manure excess (ie transportable manures), sheep holdings have been discounted from the costs (and by implication can be discounted from the charge altogether). The cost is averaged over all holdings, livestock (except sheep) and arable.

Table 4.8 Total indicative farmer compliance costs

	Total Annual Costs					
	Low		Middle		High	
	Per Holding (£'000s)	Total (£M)	Per Holding (£'000s)	Total (£M)	Per Holding (£'000s)	Total (£M)
Option 1a	0.9	*95*	1.4	*154*	2.9	*328*
Option 1b - RB209	1.3	*142*	1.7	*185*	2.8	*314*
Option 1b - IN2	1.4	*158*	1.8	*203*	3.0	*336*
Option 1c	0.9	*95*	1.4	*153*	2.9	*327*

As can be seen from Table 4.8, compliance costs range from between £900 to around £3,000 per holding per year depending on scenario and distance travelled assumptions (with the low assumption assuming transport of 5km or less depending on livestock type, the middle 10km or less and the high up to 25 km). It is important to note that these very much represent approximate indicative costs and the true costs may, in fact, be lower depending on the 'disposal' route chosen (transport verses alternative disposal). In this regard, it is interesting to compare the higher range costs for Options 1a and 1b, where it can be seen that total costs of Option 1b are lower than for Option 1a (which is less stringent from an environmental objective standpoint). The reason for this trend in the data is that, at the higher distances, the cost of disposing of manures by means other than transport becomes more economically efficient than what is (at present) the least cost option.

Whilst it is the assumptions and the cost data used that are responsible for these findings, it is also likely to hold in practice, especially given the large quantities of manure that are excess to sustainable requirements and thus the implications this has concerning the options available as alternative disposal methods. Although a full investigation into the costs of alternative disposal methods and the changes in the economics of manure disposal cannot be accommodated here, there are early indications that several options that may be/become feasible alternatives to the direct transport and spreading of manures.

For example, the current consensus appears to be that the economics of recovery of P (from manures or sewage sludges) are not determined, in the main, by the value of recovered phosphate. Rather the economic boundary considerations are defined by the cost of sludge disposal. In a situation where large excesses of manure require disposal (such as in the charging options under discussion here) and there is less available land on which to spread this, the costs of transport and spreading are likely to rise significantly. Coupled with this is the fact that, in reality, it is difficult to make a direct substitution of inorganic P with manurial P on arable crops. The timing window for application is extremely small (so as not to cause crop damage) and the additional storage capacity (and new storage units on arable farms) that would be required to provide similar levels of convenience (and timing) to compete with inorganic fertilisers pose problems to such direct substitution. P recycling would provide a solution to this by not only providing a disposal route for excess manurial P, but converting P to a more usable and transportable form for use in fertilisers.

Other, more local, solutions also already exist. Anaerobic digestion (AD), for example, has already been applied in a number of farm situations as a means of disposing of manures, or rather, converting their nutritive and organic value into more convenient or saleable forms. The British Biogen Good Practice Guidelines on AD (British Biogen, 2001) provides a case study of the application of AD to the Walford College farm in Shropshire. Here it was found that the initial investment costs (£134,000) for a farm digester could be paid off in less than four years by virtue of generated electricity (from burning of methane gas), more convenient spraying of nutrient liquor (and hence savings in spreading costs), savings in fertiliser and production of a peat substitute.

Given these preliminary indications, it is feasible that actual compliance costs of the charging options could be significantly less than those based on transport and spreading (as given in Table 4.8).

4.2.6 Summary and discussion

Implied charge rates

Table 4.6 gave figures on the estimated reduction in P applied that would take place under each of the options if they were fully implemented, while Table 4.8 presented the corresponding compliance costs that farmers would face. Combining these two sets of data provides an indication of the level at which the nutrient surplus charges would have to be set in order to provide farmers with sufficient incentive to bear the associated transport and disposal costs. These figures are set out in Table 4.9.

Table 4.9 Estimated annual nutrient surplus charge rates (farmers compliance costs only)

		Low		Middle		High	
	P Reduction (tonnes)	**Total Costs (£M)**	**Implied Charge per tonne**	**Total Costs (£M)**	**Implied Charge per tonne**	**Total Costs (£M)**	**Implied Charge per tonne**
Option 1a	54,000	95	*£1,760*	154	*£2,850*	328	*£6,070*
Option 1b- RB209	149,000	142	*£953*	185	*£1,240*	314	*£2,110*
Option 1b- IN2	169,000	158	*£930*	203	*£1,200*	336	*£1,990*
Option 1c	52,000	95	*£1,830*	153	*£2,940*	327	*£6,290*

As can be seen from the table, the charge rates are the lowest under Option 1b, with it being the most cost-effective in terms of achieving reductions in P applied to land. The charge rates should be taken as being indicative only of the actual rates. They suggest the average rate that would have to be set in order to encourage farmers to transport manure the distances assumed under each of the scenarios. If it is assumed that transport of only up to 5km is required to deliver the calculated reductions in P, then the low charge rate would come into effect. If it is assumed that transport of up to 10 km is required, then the rates set out under the middle scenario pertain, and similarly for high transport distances and the high scenario.

What becomes clear from these figures is that the higher the rate, the greater will be the incentive for farmers to transport manure longer distances or to find alternative disposal routes. Concerns over widescale transport of manure may, therefore, suggest that rates towards the lower end of those given above would be more appropriate. Although such lower rates may not fully deliver the estimated reductions in applied P, they should stimulate significant reductions, while not giving rise to the environmental issues surrounding high levels of transport.

Total implementation costs and public revenues

Table 4.10 provides estimates of the total annual costs of implementing Options 1a, 1b and 1c, where these include indicative compliance costs, farm administration costs and the costs to regulators of administration and monitoring.

Table 4.10 Total annual costs of implementing nutrient charging options

	Total Annual Costs					
	Low		Middle		High	
	Per Holding (£'000s)	Total (£M)	Per Holding (£'000s)	Total (£M)	Per Holding (£'000s)	Total (£M)
Option 1a	1.0	*108*	1.5	*167*	3.1	*341*
Option 1b - RB209	1.4	*155*	1.8	*198*	2.9	*327*
Option 1b - IN2	1.5	*171*	1.9	*216*	3.1	*350*
Option 1c	1.0	*108*	1.5	*167*	3.0	*340*

Of these total costs, only a small proportion of relate to the costs to regulators of administering and monitoring the charging schemes (less than 1.5% - see Table 4.3). This suggests that cost-recovery could easily be met (even at significantly lower charge rates), with there being significant levels of public revenues. As discussed later, these could be used to fund wise use initiatives, provide rebates for action taken on farm, or fund more strategic programmes such as the 'basic plan' and 'plan plus' proposed by the work undertaken by IEEP (2002).

Cost-effectiveness

As highlighted by the implied charge rates per tonne of P reduced, Option 1b is the most cost-effective in terms of the costs of delivering a unit reduction in P applied to fields. This relative cost-effectiveness is highlighted more clearly in Table 4.11, which indicates cost-effectiveness in terms of the total implementation costs per tonne reduction of phosphorous.

Table 4.11 Cost effectiveness (£ thousands per t reduction in P inputs)

	Low	Medium	High
Option 1a	2.0	3.1	6.3
Option 1b - RB209	1.0	1.3	2.2
Option 1b - IN2	1.0	1.3	2.1
Option 1c	2.1	3.2	6.5

As can be seen from Table 4.11, Option 1b is clearly the best option in terms of P inputs alone. In practice, Option 1b should provide a number of additional environmental benefits over Options 1a and 1c from, for example, letting soil P run down in a significant proportion of soils in England and Wales (as discussed in 4.2.4). This would tend to suggest that the additional investment in seeking a total solution (ie reducing P inputs to sustainable levels) is worth the extra expenditure compared to the partial solutions provided by Options 1a and 1c (which only reduce P inputs by 36% and provide no reduction in the spreading area).

Proportionality and fairness

In terms of the proportionality of the charge and environmental damages, it is clear from the P budget data that the UK is currently engaged in a growing environmental problem of soil P build up (on average), where, from soil survey data, this is being experienced on both crop land and livestock areas. As such, a failure to engage 'the problem' with a suitable policy instrument will result in a growing environmental problem and associated damage costs. The three nutrient surplus charging options offer either a partial or a total 'solution' and, from a cost effectiveness standpoint, the total solution (Option 1b) would appear to be more cost effective.

In terms of fairness, the data on the crop and grassland area at risk would tend to suggest that, on average, crop land is more enriched than grassland. In terms of soil P status alone, then, the distribution of this 'problem' would appear to lie more with arable farms than with livestock farmers.

However, compliance costs are likely to fall more on livestock farmers than arable farms since livestock farmers will have a 'transport and disposal' problem. However, the costs of disposal for livestock farmers are very much affected by the practicalities and resistance to the relative costs incurred by using livestock manures on the part of arable farmers. This is principally because farmers have an easy, convenient and cheap alternative to manures, namely inorganic fertilisers. In simple terms, then, the problem of soil P build up is as much to do with the use of inorganic P fertilisers 'taking up' the spare capacity for P generated from livestock farmers as it is the levels of P being produced from livestock farms.

As such, in response to a surplus charge, arable farmers can reduce their inputs of inorganic fertiliser (and potentially make a small saving), leaving livestock farmers to bear the burden of the compliance costs. This implies that the charge may have to be complemented by other measures to spread the costs more evenly and proportionately. A conclusion might be that a charge on the use of inorganic fertiliser P might be employed to address any imbalance, and this could be used to sponsor wise use initiatives (considered later).

Innovation

Whilst compliance costs may be, on the surface, fairly large and the innovation required to meet these challenges considerable, the charges (partial or total), offer the potential to arrive at a longer-term solution to diffuse pollution from agricultural P. The employment of alternative disposal methods such as anaerobic digestion and recycling offer the potential to arrive at a more strategic solution to the diffuse P problem by providing relatively low cost means of, for example:

- reducing P inputs to sustainable levels;
- reducing problems with the leaching and erosion of P from directly spread manures and poor incorporation (by virtue of sprayed liquors/recycled P fertilisers); and
- providing a safe, cheap and convenient means of disposing of excess manures.

At the same time, such solutions may provide additional benefits in the form of reducing methane emissions, electricity generation, and production of peat substitutes for horticultural use.

Competition issues and compatibility with other policies

At the full charge rates set out in Table 4.9, issues may arise over the ability of farmers to remain competitive at the EU and international levels. Although the estimated compliance costs per holding are relatively small (ranging from £1,300 to £2,800) for the preferred option 1b, even these levels of costs may pose problems for some of the farmers who have experienced low returns over the past few years.

However, as discussed above, it should be possible to minimise the additional costs arising from the charges through the increased up-take of more innovative disposal solutions. In this regard, it may be important to use charge revenues to act as finance for soft loans or grants aimed at investments in alternative disposal methods (although more research is obviously required on these issues).

In general though, a nutrient surplus charge should be compatible with other policies. It is consistent with the polluter pays principle in that it places the responsibility for environmental damages on those creating the damage. It also has advantages in that it builds on the requirements concerning N application rates under NVZs, which provide the administrative structure for implementing the charges.

Another key issue with regard to compatibility is likely to be the degree to which the likely response to these types of charges – the transport of manure from one farm to another – would raise issues with regard to hygiene and the transport of disease vectors.

4.3 Option 2: Tax on feed phosphorus supplements and content

4.3.1 Objective and principle of proposed instrument

As described in Section 2, there is an abundance of literature to suggest that livestock are overfed P to increase uptake and subsequent productivity. This, in turn, suggests that possible savings in P inputs to feed can be made and that this should affect excretal P values. The impact would be one of reducing the level of disposal required for excess P, for example, under the nutrient surplus charging schemes discussed above.

Discussions with feed suppliers has indicated that low P feeds exist already but that they are not in demand or actively marketed. The aim of this option then is to provide an incentive to feed producers and farmers to reduce feed P and, in so doing, decrease excretal P values as part of a solution to reducing the national P surplus. In considering this, and the potential reduction of excretal P that is possible, various data on feed requirements, feed additives, etc. has been compiled.

4.3.2 Administration, monitoring and enforcement

To instigate a shift to reduced P feeds using only feed P tax would require a tax at source (ie a sales tax). This would require research to identify and standardise measurement and classification of feed products, and the application of this to a very large range of feed products and feed producers.

Given the huge range of feeds and feed products, designing the tax base is likely to take considerable time and effort. It has not been possible to cost this aspect of implementation and administration for this study. However, systems would be required for verifying the tax rate that applied to different feeds, for tax collection and for enforcing tax evasion.

4.3.3 Environmental effectiveness

In terms of the minimum nutritional requirements of livestock, estimates vary widely and no consistent figure has been found. In the UK, the whole issue of feed and nutritional requirements is currently under review post-BSE and is being overseen by the Animal Nutrition Working Group. As the group is yet to report findings and no interim reports are available, it has not been possible to incorporate the UK's definitive estimates within this study.

Concerning the level of reduction in excretal P, the feed industry group has indicated that it is difficult to make exact estimates of the savings that are achievable, but suggests that a global 30 to 50% reduction in P inputs is possible without seriously affecting animal performance. Results of trial work also suggest that a reduction of 20% of P inputs is possible by the use of phytase enzymes without adversely affecting animal performance.

For the purposes of modelling, the lower (30%) reduction in feed P inputs has been combined with the 20% estimate for the addition of phytase to provide a 50% reduction in feed P inputs.

Table 4.12 provides estimates of the potential reduction in applied quantities of P achievable by the introduction of feed P reductions, where these are also expressed relative to the sustainable capacity of soils in England and Wales according to RB209. As can be seen from Table 4.12, the introduction of a feed P reductions would reduce total P spread by 57,000 tpa, representing 38% of the reductions required to meet sustainable application levels. It is interesting to note that this level of reduction is greater than that achieved by the charging options 1a and 1c.

Table 4.12 Reductions in P using feed reductions

	P Applied as Manure and Fertiliser (000's t)	Reduction (000's t)	% of Over Capacity	% Required Reduction
Present	281	-	112%	-
Feed Reductions	224	57	70%	38%
Target	132	149	0%	100%

4.3.4 Compliance costs

In terms of the costs of implementing feed reductions, we have consulted the feed industry group that is contributing to the technical Best Available Technology (BAT) notes for the forthcoming licensing of pig and poultry units. We are informed by this group that all of the necessary feeds and phytase additives are already in circulation and that there are no industry development costs associated with this option. In terms of the cost of these feeds and feed enzymes, they can often cheaper than comparative feeds that offer the same balance of nutrition. As such, there is no cost, in terms of feed prices, to moving to these alternatives and no compliance costs, assuming that the tax would not be set on levels of P that are recommended for sound nutritional purposes. Compliance costs (for the feed industry) would arise from the need to educate farmers on feed P issues and to promote these products more generally.

The effect of implementing feed savings on Options 1b and 1c provides some interesting results. The effect on Option 1b is to increase the quantity of manure that can be applied to both crop and grassland, increasing transport costs associated with the option, but compensating with reduced disposal costs. This provides net savings of around 14% at the shorter distances travelled. The levels of savings achievable by application to Option 1c are much greater, providing net cost savings of around £58 million (57%). These savings are made because greater quantities of manure can be spread to grassland and, hence, less requires transport and spreading on crop land. In area terms, the introduction of feed reduction under Option 1c would reduce the crop land required for spreading from 96% of total area to around 71% of total area.

4.3.5 Summary and discussion

Instigation of an economic instrument to encourage feed P reductions 'at the front end' by means of a product tax could be complex and costly. This is particularly true if the tax is aimed at driving the levels of P in feeds down to the levels which are deemed by experts to be required for nutritional purposes. In this case, one assumes that the tax would operate and generate revenues for only a short period of time, given that the low P feeds already exist and the issue appears to be more one of promotion and education. Furthermore, some change in demand for these lower P feeds may take place in any event as a result of the recommendations made by the Animal Nutrition Working Group.

However, the environmental benefits (in terms of reductions in quantities of P applied) may be significant. The best means of sponsoring this transition, however, is likely not to be through the introduction of a tax but by the use of limits placed upon the spreading of P (and therein manorial P content). This would make feed P reductions an attractive part of a farmer's suite of responses.

Proportionality and fairness

Given that the low P feeds and supplements exist, there are few issues concerning fairness and proportionality that would arise from the introduction of this type of tax. The key issue is likely to surround the level of resources required by industry and the regulators in deriving the appropriate tax rates for different feed products compared to the decline in revenues that might be expected to occur over the short term. Of course, revenues and total costs to farmers will also depend on whether the tax is levied on all P in feeds or only on the amount that is additional to nutritional requirements.

Providing incentives to livestock farmers to reduce feed P should also help alleviate the relative burden of the likely compliance costs that they would face under the other forms of instrument or direct regulations.

Innovation

A tax on P in feeds that is additional to nutritional requirements could be expected to lead to some level of innovation within the feed industry. However, as the lower P feeds already exist, the rate of innovation may not be high in the short-term (unless the tax is placed on total P in the feeds even though this may raise animal health issues).

Competition issues and compatibility with other policies

Given the dynamics discussed above, it is unlikely that the introduction of a feed P tax would raise significant competition issues. Indeed, the reverse could be true if the tax was also placed on all feed imports to the UK, as it may place UK producers who it is indicated already have lower feed P products available, at a competitive advantage.

This type of tax should be compatible with most other policies, particularly as it provides a very low cost (if not cost neutral due to the lower costs of the feeds) way of moving towards environmental objectives.

4.4 Option 3: Tradeable permit scheme for specific problem catchments

4.4.1 Principle and operation of proposed instrument

As discussed above, the application of soil testing and analysis and subsequent charges for applications in excess of RB209 (or In2) offers the potential to prevent further applications to soils of higher soil P index and permit them to run down, while ensuring that any applications to lower index soils are within sustainable or acceptable limits.

The objective of the tradeable permit scheme is to identify CSAs and produce the necessary leverage to enforce the operation of soil testing in specific problem catchments. The objective within these trading zones (TZs) would be to ensure compliance with RB209. As a result, any surplus P on farms within the TZ would have to be redistributed and applied at appropriate RB209 rates to soils of suitable soil P index (ie 0, 1, or 2). In cases where there remains a net TZ surplus of P, this surplus would have to be transported (in the form of manures) outside the boundaries of the TZ or be otherwise disposed.

The operation of the charge would require field level testing of all soils within the catchment and communication of the results to the appropriate farms or farmers by the regulator (or for the regulator).

For those fields of soil index 0 , 1, or 2, quantitative spreading rights could be awarded in units of kg/P per ha/year for a four year rotation using RB209 (on the basis of comparison of crop to be grown, existing soil P index and manurial P application rates). Depending on the crop/use of fields, soils of indexes 3 and above would generally not be allowed any further applications of P to permit the lengthy ‘running down’ process.

Farmers in TZs would be permitted to use their spreading rights for spreading of wastes generated on their own farms and, if there remains spare capacity, to charge other farms (that have no spare capacity) for accepting additional manures.

In all likelihood, operation of TZs within many CSA will create a situation where not all of the manurial P generated can be spread to land within the TZ. To deal with such situations, it may be important to allow farmers outside the trading zone to join for the purposes of expanding the land area available. Farmers inside the TZ could then 'buy' the rights awarded to those outside the TZ to permit them to export the manure from the TZ and dispose of it sustainably.

Clearly, in order to ensure that the problems in a CSA were not simply being shifted elsewhere, it would be necessary to ensure that farms outside the TZ accepting manure (ie in effect selling their spreading rights) were operating to the same robust procedures. As such, rights would be granted only to farmers who agreed to undertake the same soil testing and RB209 requirements – in effect, farmers outside (and even some distance from) the compulsory TZ could opt to join the TZ. The level of incentive for a farmer to do this would clearly depend on the status of his/her soils. For example, it is obvious that if a farmer just outside the TZ occupies 60 ha of crop land all of soil indexes 0 and 1, there may be significant financial benefits from joining the TZ because his low P soils have value to the farmers (traders) within the zone.

In terms of attributing value to the rights, the individual situation of the CSA, the surrounding area, and the number of farmers trading within the TZ (including those not geographically within it) will dictate the price of the rights and this should be left to the open market.

4.4.2 Administration, monitoring and enforcement

For the purpose of modelling, a scenario has been designed to reflect the situation in a fictitious CSA. The features of the CSA, in terms of area, number of different livestock holdings, and stocking levels are set out in Table 4.13.

Costs would be incurred by the regulator in delineating the trading zone, establishing trading rules for specific sites and in setting up systems for monitoring/approving trade activities. It has not been possible to develop detailed estimates of what these costs might be. One could expect, however, that soil testing would be required, a larger field study at the sub-catchment or CSA level would be undertaken, and internal systems for monitoring and approvals would be established. Soil testing alone would be likely to cost around £320,000, assuming a cost of £16 per ha for the first four years, with this initially borne by the regulator but recovered through charges. The costs of field studies are estimated at £150,000 (including any modelling work) and establishment of administrative systems at around £50,000. Assuming that these set-up costs are recovered over a ten year period, this equates to roughly £52,000 per annum to be recharged to farmers. Note though that while the field study and system set-up costs are one-off in nature, soil testing may need to be repeated at some point in the future.

Table 4.13 CSA scenario for application of TZ under Option 3

General Description			
Total grass area	10,000 ha (all of which is used to capacity with no exchange of manures for disease risk reasons)		
Total Tillage (excluding temp grass)	10,000 ha (3,000 ha of which has spreading rights awarded)		
Total Area	20,000 ha		
Stocking			
	Headage	**Holdings**	**Area**
Cattle	20,000	200	7100
Sheep	30,000	70	2800
Pigs	5,000	4	50
Poultry	20,000	3	20
Average Distance Travelled estimates (based on area radius of 8km)			
	Low	Mid	High
Cattle	4	7	10
Sheep	4	7	10
Pigs	4	7	10
Poultry	4	7	10

In addition to the above, the regulator would face some policing costs; based on the figures used for the charging schemes and assuming spot checks to cover 10% of the area over a period of four years, this equates to around £8,000 per year. In addition to this, there would need to be some cross checking of records to ensure that transported manure had been disposed of to legitimate traders. Assuming a cost of £100 per holding per year, and covering 10% of farms per year, this equates to a total annual cost of around £2,750 per year for cross-checking.

For farmers, it is assumed that they would have to undertake recording keeping of a similar nature to that required under Option 1b. Assuming £100 per holding in record keeping costs, the costs borne directly by farmers within the TZ are £27,000 per year.

Adding the various cost items together gives total annual costs of around £90,000 per year for the CSA, with most of this borne by the farmers either directly or through cost-recovery charges levied by the regulator. This equates to roughly £435 per non-sheep holding, or £4.5 per ha (grass and tillage). It is important to note that no incentive effect has been assumed to arise from these cost-recovery charges.

4.4.3 Environmental effectiveness

In considering the environmental effectiveness of the TZ, two scenarios have been adopted: one with the use of feed P reductions; and one without. Table 4.14 provides data on the volume of manure transported and spread to crop land within the TZ and the volume exported from the TZ under these two scenarios. As can be seen from Table 4.14, by introducing feed P reductions, all manures can be accommodated within the TZ itself. Without feed P reductions, some 23,400 m^3 manure would need to be transported to crop land within the TZ and 700 m^3 to area outside the TZ.

Table 4.14 Quantities of manure transported within and outside TZ annually

	Quantity transported Inside TZ (000 m^3)	Quantity Transported out of TZ (000 m^3)	% Excess Transported Inside TZ	% Excess Transported Outside TZ
TZ	23.4	0.7	97%	3%
TZ +Feed Reduction	0.3	0	100%	0%

In terms of the quantities of P reduced, if it is assumed that prior to the TZ, all manures were spread to grassland and all crop land received inorganic P, a total reduction of 57 t of P is made within the TZ, with nearly 2 t per year exported from the TZ. The introduction of feed reductions does not reduce this further since crop land will use P from inorganic sources to make up the difference.

4.4.4 Costs of compliance

The costs of complying with the TZ limits have been modelled using the same approach as for the nutrient surplus charges, with regard to the generation, transport, spreading, etc. of manures. This is described more fully in Annex 2.

Table 4.15 provides total annual compliance costs for the 207 holdings within the TZ, where this excludes sheep holdings. As can be seen from Table 4.15, whilst the introduction of feed P reductions does not reduce the quantity of P applied, it has the effect of considerably reducing the compliance costs of the TZ.

Table 4.15 Total annual compliance costs

	Total Annual Costs					
	Low		Middle		High	
	Per Holding (£s)	Total (£'000s)	Per Holding (£s)	Total (£'000s)	Per Holding (£s)	Total (£'000s)
TZ	464	*96*	638	*132*	801	*166*
TZ + Feed Reduction	22	*4.5*	34	*7.1*	36	*7.4*

4.4.5 Summary and dscussion

Total costs of implementation

The costs of system set-up and administration should be added to the compliance costs borne directly by farmers in order to estimate the total costs associated with this option. The resulting figures are provided in Table 4.16. These costs are slightly higher than those calculated for the nutrient surplus charges for the low and middle distance scenarios (although the differences are probably not significant given the uncertainties surrounding a number of the assumptions made). The costs under the high transport distance scenario are significantly less, however.In this regard, it is important to recognise that a higher proportion of the costs arising under this option stem from setting-up the trading system. These costs may be over-estimated (and likewise the costs of establishing nutrient surplus charges may be under-estimated). Again, the cost savings that could be achieved through shifting to low P feeds is evident, with the bulk of the total implementation costs comprised of those of setting up the trading system.

Table 4.16 Total annual costs of implementing trading within CSA

	Total Annual Costs					
	Low		Middle		High	
	Per Holding (£s)	Total (£'000s)	Per Holding (£s)	Total (£'000s)	Per Holding (£s)	Total (£'000s)
TZ	899	*186*	1,073	*222*	1,236	*256*
TZ + Feed Reduction	457	*95*	469	*147*	471	*97*

Cost-effectiveness

Table 4.17 provides an analysis of the cost-effectiveness of TZ in terms of total annual implementation costs per unit reduction of P within the TZ. As would be expected, the introduction of feed P reductions as a response to the TZ considerably increases the cost-effectiveness of the option.

Table 4.17 Cost effectiveness (£ thousands per t reduction in P inputs)

Table 4.17: Cost Effectiveness (£ thousands per t reduction in P inputs)			
	Low	Medium	High
TZ	3.3	3.9	4.5
TZ + Feed Reduction	1.66	1.70	1.71

Based on this analysis, it appears that tradeable permits would provide an effective means of reducing P inputs within CSAs and forcing the export and distribution of historical P from the CSA. As with the charging options discussed in Section 4.2, whilst the instrument does not specifically address P transport issues within CSAs, they are addressed indirectly by virtue of the fact that spreading activities will cease on a significant proportion of the land (thus reducing the risks associated with spreading and losses form fields in these areas).

However, as the setting up of a TZ involves closer administration monitoring and enforcement of limits and trading permits on participating farms than would occur with a charging option, there is the opportunity to encourage the implementation of a number of additional management measures on participating farms. The closer involvement of the administering authority in the day to day operation of a TZ would facilitate the regulation and monitoring of licences and management agreements. In this respect, the concept of a TZ combined with management agreements under the 'plan plus' in the IEEP report may provide added value and help reduce problems arising from existing soil P levels.

Proportionality and fairness

The arguments concerning proportionality and fairness regarding nutrient surplus charges are also relevant for the use of this type of tradeable permit. The burden of the costs will fall on livestock farmers who, if they are producing P in excess of sustainable requirements, will have to find either other fields for spreading or other means disposal. In this case, however, the potential fairness of the system may be less, as payments are most likely to transfer between livestock farmers and arable farmers in return for purchasing the right to spread manure on fields.

This is particularly true unless action is taken to make inorganic fertilisers less economically attractive than manure, for example, through the introduction of a fertiliser tax.

Innovation

Not only could a fertiliser tax help re-balance the distribution of costs, it could also provide a source of funding to assist livestock farmers in developing the more innovative alternative disposal methods discussed above. Because trading zones would only be established in CSAs, there may not be the same overall level of research and development effort put into alternative disposal methods than under the introduction of a nationwide charging scheme. This is particularly true if farmers respond to the introduction of trading by shifting to low P feeds.

Competition issues and compatibility with other policies

Competition issues may be more pronounced under this type of scheme than under a charge or tax. This is because only a sub-set of UK farmers would fall under the system and, thus, would be facing a change in their farming cost structures. This is likely to raise objections from those who are located in the CSA and would have to meet the permit requirements, particularly if a neighbouring farm falls outside the trading zone but is perceived to be an equal (or worse) offender in terms of P management practices.

However, this type of instrument does adhere to the polluter pays principle and is likely to be compatible with some of the direct forms of regulations such as IPPC. Indeed, design of the trading system could be developed so as to complement requirements under IPPC for livestock holdings, with record keeping linked to both IPPC requirements and the NVZ requirements.

Again though, issues surrounding the transport of manure from farm to farm will need to be addressed.

4.5 Option 4: Measures to address management/mitigation issues

4.5.1 Option 4a: Wise use levy

As an alternative to the nutrient surplus charges, it has been suggested that simpler forms of taxes be used to raise revenue which can fund education programmes and other management activities. A variety of possible taxable units were identified in Section 3.3, with these including taxes on crop production activities, stocking rates, livestock production and P in inorganic fertilisers. The latter is perhaps the most obvious form of tax for revenue raising purposes, given its use in other EU countries. The analysis presented above for both the nutrient surplus charges and the tradeable permit schemes also identified the potential value of a fertiliser tax as a means of ensuring that there is a demand for manurial P by arable farmers (reducing their use of inorganic P in its place) and as a potential mechanism for funding the adoption of more innovative disposal methods in the tradeable permit case.

Despite the relatively weak price elasticity of demand for fertilisers, a charge applied to fertiliser P would have the effect of both raising revenue for investment to fund wise use agreements and initiatives and, to an extent, alter the economics of P fertiliser use. For this reason, a tax on P inorganic fertilisers is considered here as a means of funding the types of wise use initiatives discussed in the IEEP report and elsewhere. However, the analysis that follows has had to remain simplistic, with a more detailed analysis required to model how farmers might react to different tax rates.

Administration, monitoring, enforcement and compliance costs

In terms of the level of tax that would be necessary to fund such initiatives, assuming an average price of £0.28 per kg P_2O_5 gives a price of £0.64 per kg P. When applied to the 138,200 t of inorganic P used in 2000 this suggests that farmers spent £88.7 million on inorganic P in 2000[5]. As such, a tax of around 1.12% on the value of P in inorganic fertilisers would be required to raise £1 million per year for investment in wise use initiatives. Using a price elasticity for phosphate of -0.25[6], a tax of 1.12% is likely to prove a reduction in use of -0.28%.

The IEEP report identifies a range of additional options for dealing with diffuse P from agricultural sources, which would rely on the provision of grant aid. A fertiliser tax could therefore provide one means of funding the 'basic plan' and the 'plan plus' proposed by that study. Based on figures provided in the IEEP report as to the possible budget profile for the basic plan, we have calculated that annual revenues of around £37.8million, £28.4 million and £18.8million would be required to fund 100%, 75% and 50% uptake of the 'basic plan'. The additional costs of the 'plan plus' are estimated to be in the order of £4.6 million per annum on average. As such (and by way of example only), a tax on the value of P in inorganic fertilisers of around 47.8%, 36.9% and 26.2% would be required to raise sufficient revenue to fund 100%, 75% and 50% uptake of the basic plan and plan plus schemes.

A tax such as one on the level of P in fertilisers would require the development of a point of sales system for collecting the tax and ensuring that there is no tax evasion. A key issue in this regard is likely to be the treatment of feed imports. Legal requirements would have to be placed on all feed producers and importers to comply with the tax system and to declare both the concentration of P in different fertilisers and quantities sold. Although enforcement of such a system on UK producers is not likely to be overly burdensome owing the relatively small number, it is likely to be much more difficult for Customs & Excise to enforce these requirements on all imports.

In this regard, placing a levy on livestock production and cropped area would not face the import related issues. However, tracking the movement of livestock from farm to farm for tax purposes may present other problems.

Effectiveness

The effectiveness of any simple level will depend on the rate at which the tax is set and, hence, the level of any incentive it gives to change polluting behaviour, and the uses of the revenues. In the absence of details of the benefits provided by the basic plan and plan plus

5 It is interesting to compare this figure to those for spreading costs of £33.5 million under Option 1c and applying feed reduction.

6 Denbaly & Vroomen (1993) reported in McCann, L & Easter, KW (1998) and WRc (1999).

programmes, it is not possible to compare the benefits which may derive from this type of instrument to the reductions in P applied as calculated for those considered above.

Proportionality and fairness

As discussed in Section 3, the key issue surrounding the creation of a wise use levy is with regard to proportionality and fairness is the degree to which those creating the environmental problem will also be those making the greatest contribution to the levy. A tax on fertilisers addresses the failure of farmers to use manurial P in preference to inorganic fertilisers. It does not, however, encourage livestock farmers to adopt low P feeds, nor to ensure that their own manure management activities are sustainable. This type of tax may not be viewed as fair, therefore, unless it is accompanied by similar taxes on, for example, units of livestock production.

Innovation

A tax on inorganic fertilisers which is set in order to raise a certain level of revenue may not have a significant impact on innovation, unless it is set at a high enough rate to stimulate the adoption of activities such as P recycling through the use of, for example, anaerobic digestion. Given that such disposal methods may have no net cost to the farmer (with the Walford College example indicating a four year pay-back period), the tax may not need to be high. However, the fact that they are not more widely in use suggests that farm economics have not provided sufficient incentive for their up-take.

Competition issues and compatibility with other policies

The magnitude of any competition issues arising from the introduction of a wise use levy will obviously depend on the rate at which the levy is set and the unit on which it is placed. A small tax on P in inorganic fertilisers, for example, is unlikely to give rise to significant concerns, although there may be attempts to circumvent the tax through the import of feeds.

The degree to which such a levy is compatible with other policies is unclear. There is an increasing use of environmental taxes within the UK, although the aim of such taxes is generally more incentive driven. This type of scheme would, however, provide a means of creating an incentive (even if limited) while generating the funding needed to sponsor education and other initiatives.

4.5.2 Option 4b: Charge rebates

As described in Section 3, the theoretical basis of an economic instrument is that the costs of certain activities are below their marginal social/environmental cost. As such, the private costs faced by a polluter do not take into account the environmental externalities associated with their activities. The aim of an economic instrument is to bring these externalities into a polluter's decision making process.

In the search for universally applicable, equitable and administratively simple instruments, the context of the problem promotes the linking of (the basic structure) of an instrument to levels of P applied/exceeded. However, in so doing, the basic structure of the instruments inevitably focuses more on source limitation of diffuse pollution than on transport issues[7]. Whilst the basic structure of an instrument (for example a charge) may be linked to the most convenient, measurable and tangible element of a given social/environmental problem, this does not exclude the possibility that additional elements can be used alongside the instrument to add resolution.

Identification of additional elements

Table 4.18 provides a scoping of all economic instrument options against the management methods to reduce diffuse pollution from P identified by the IEEP led study. As can be seen from the table, the instruments cover a range of the identified management methods either directly (ie explicitly), or indirectly by virtue of knock-on effects and changes to the economic context in which farmers operate. The extent and nature of the changes that are likely to take place under each of the options are difficult to predict with accuracy owing to the fact that instruments are flexible, permitting farmers to decide what is the best response in their business context.

Economic instruments tackle such issues such as reducing stocking rates and high risk crops by adjusting the economics of undertaking such operations. For example, faced with increasing problems with the transport of surplus manure, a farmer is likely to reduce stocking rates anyway as part of a wider package of measures to reduce costs and improve business performance. Equally, in the case of, for example, high risk crops, a farmer in a TZ with a potato field of soil index 4 may choose not to grow potatoes anymore as s/he is unlikely to obtain sufficient crop quality to sell the produce if s/he is unable to spread additional P. In addition, in (more extreme cases) farmers may take fields out of production, change farming system, move to forestry or let out land to permit other farmers to reduce stocking rates by expansion. All of which serve to reduce source and transport pollution problems.

The measures that would not be addressed directly or indirectly by the instruments considered here are as follows:

- Fertilizer and Manure Management
  - Restrict application timing
  - Placed starter fertiliser
  - Slow-release fertilisers
  - Incorporation of manures
  - Injection of manures

7 Though it is worth noting that a number of the other instruments would indirectly address localised transport issues by virtue of cessation of spreading activities on certain parcels of land.

Table 4.18 Scoping of management measures against instruments

Category of Measure	Measure	Option 1a – Minerals Surplus Charge	Option 1b – Nutrient Management Charge	Option 1c – Combined Instrument	Option 2 – Reduced Feed P	Option 3 - TZs
Nutrient Input Levels	Reduce dietary inputs	I	I	I	D	I
	Reduce fertilizer inputs	D	D	D	D	D
	Critical soil P levels	I	D	D (on derogated farms)		D
	Critical surplus loadings	D	D	D	I	D
Fertilizer and Manure Management	Restrict application timing					
	Placed starter fertilizer					
	Slow-release fertilizers					
	Incorporation of manures					
	Injection of manures					
	Manure composting	I	I	I		I
	Manure sharing schemes	D	D	D		D
	Manure incineration	I	I	I		I
	Manure nutrient recovery	I	I	I		I
	Nutrient immobilization	I	I	I	I	I
	No application zones		D	D (on derogated farms)		D
Farm Management	Collect farmyard run-off					
	Ditch barriers/management					
	Farm track impoundments					
	Move gateways/troughs					
Crop Management	Avoidance of high risk crops		I (depending on whether In2 option selected)			I (depending on whether In2 option selected)
	Early sowing of crops					
	Cover crops					
	Grassing down					

Category of Measure	Measure	Option 1a – Minerals Surplus Charge	Option 1b – Nutrient Management Charge	Option 1c – Combined Instrument	Option 2 – Reduced Feed P	Option 3 - TZs
Soil Management	Contour ploughing					
	Rough seedbeds					
	Change tramline direction					
	Reduce cultivation passes					
	Minimal cultivation					
	Novel cultivation practices					
	Green manuring					
Livestock Management	Reduce stocking density	I	I	I		I
	Restrict stock access					
Landscape management	Change farming system	I	I	I		I
	Reinstate hedges					
	Establish woodland	I	I	I		I
	Establish wetlands					
	Regulate groundwater level					
	Riparian buffer zones					
	Targeted buffer zones					
	Targeted impoundments					
	River bank stabilization					

- Farm Management
  - Collect farmyard run-off
  - Ditch barriers/management
  - Farm track impoundments
  - Move gateways/troughs
  - Early sowing of crops
  - Cover crops
  - Grassing down

- Soil Management
  - Contour ploughing
  - Rough seedbeds
  - Change tramline direction
  - Reduce cultivation passes
  - Minimal cultivation
  - Novel cultivation practices
  - Green manuring
  - Restrict stock access
  - Reinstate hedges
  - Establish wetlands
  - Regulate groundwater level
  - Riparian buffer zones
  - Targeted buffer zones
  - Targeted impoundments
  - River bank stabilisation

These measures could most easily be incorporated into the nutrient surplus charges or linked to the wise use levy discussed above, with charge rebates given where farmers can demonstrate that appropriate management actions have been undertaken, or that they have fulfilled particular management requirements.

Administration, monitoring, enforcement and compliance costs

Given that this option assumes that the activities would be funded out of charge revenues, the centre around the need for farmers and regulators to verify that a certain activity has been undertaken in order to claim the rebate. Regulators administering the system will need to verification and payment systems, with these likely to be similar to those that are already in place for the various agri-environment schemes. Similarly, farmers will need to be able to demonstrate that they have undertaken whatever works for which they are claiming a rebate.

As will be recalled from the above discussion, possible budget profiles for the basic plan are costs of around £37.8million, £28.4 million and £18.8million in order to fund 100%, 75% and 50% uptake, with an additional £4.6 million per annum required to fund the plan plus. These funding requirements could be met, at least in part, by a nutrient surplus charge set a rate lower than those presented in Table 4.9 (although voluntary shifts to low P feeds would be likely to impact on the revenues generated), with additional funding meeting any shortfall. Alternatively, the full rates given in Table 4.9 could be used to deliver the level of funding required; again though, account would have to be taken of the degree to which farmers would shift to low P feeds in order to reduce costs.

Effectiveness

As for the simple levy, it is not possible within this study to determine the likely environmental effectiveness of the use of charge rebates in this manner. Undoubtedly, additional benefits could be gained by reducing the potential for in-soil P to move to the aquatic environment. Given that such reserves are high and will provide on-going contributions to environmental damages, the environmental benefits could be considerable. However, in the absence of details of the benefits provided by the basic plan and plan plus programmes, it is not possible to compare them to the reductions achieved through the charges on their own.

Proportionality and fairness

As long as rebates are made available to all of those contributing to the charge/tax, then they should perform well in terms of their fairness. Issues may arise if disproportionate levels of rebate are given for particular activities, with one farm sector or holding type being able to take advantage of the rebates available. However, one would expect that a fairly equitable programme of distributions could be developed given the range of measures identified by IEEP and listed in the Table 4.18 above.

Innovation

The availability of funding (as a rebate) could be important in driving further innovation in both farm practices and in farm disposal methods. Thus, charges in association with rebates could provide the mechanism for stimulating significant changes in farm economics.

Competition issues and compatibility with other policies

If rebates are tied closely to the initial charging mechanism, significant competition issues should not arise nationally from rebates alone (although as indicated earlier they may arise from the charge). We have not been able to investigate the degree to which the provision of such rebates would raise issues at the EU or wider international levels.

4.6 Option 5: Permit charges for potentially polluting activities

A number of the activities highlighted in the previous section relate to particularly damaging activities. It has been suggested that, rather than provide aid to reduce the occurrence of these as part of a management packages, there is the option to licence and charge farmers to undertake such activities. This would in essence be a form of permit-based charge, which would provide farmers with a disincentive to continue with these activities.

The level and scope of applicability of such charges depends on the range of activities to be included or classified as 'potentially polluting activities' and the scope (national or focussed area) of application.

Unfortunately, there has been insufficient time and resources to consider these issues in detail as part of this study. We have not, therefore, been able to analyse what these charges may have to be set at and how they would be designed in the same manner as the previous instruments. However, this type of scheme is likely to be difficult to operate universally across the nation, owing to the logistical considerations for monitoring and enforcement. However, as part of focused efforts to target diffuse P pollution in CSAs or other target areas (for example within a trading zone), the greater administrative and operational involvement of the regulator may make the introduction of such charges attractive.

A number of other points are worth noting:

- with regard to proportionality and fairness, this type of approach directly targets those activities leading to damages and thus is likely to be considered fair; the degree to which it is proportional will depend on the level of charge and the extent of impact that can be attributed to the activity;
- this type of approach may not lead to significant levels of innovation on its own, although this will of course depend on the nature of the activities targeted; and
- one can expect competitiveness issues to arise if the cost of the permit makes high earning activities (such as growing potatoes) unprofitable, thereby putting UK farmers at a disadvantage.

Overall, though, further consideration should be given to this option as part of any further investigation into instruments targeted at diffuse P pollution.

4.7 Comparison of options

As has become clear from the above analysis and discussion, several of the options considered here show considerable promise as instruments for helping to reduce diffuse nutrient pollution associated with P emissions. Interestingly, it is also clear that the best strategy is likely to be one that draws on a combination of measures that can ensure the outcome is cost-effective, fair and does not give rise to concerns over the competitive position of UK farmers. This is highlighted by the summary provided in Table 4.19.

Table 4.19 Summary of option performance against key criteria

	Option 1a/1c: Nutrient Surplus Charge	Option 1b (RB209): Nutrient Surplus Charge	Option 2: Tax on P in Feeds	Option 3: Trading Zones	Option 4: Management/ Mitigation Measures	Options 5: Permit Charges
Environmental Effectiveness	Partial solution as leads to no reduction in area at risk/soil P index levels. Reduces National Inputs by 54,000t, equivalent to 36% of required reduction to reach sustainable levels (as defined by RB209).	Reduces spreading area by 34% and hence permits P to ‘run down’ on this area. Implied reduction of overall P transport risk by 34%. Reduces National Inputs by 149,000t to achieve sustainable levels of P inputs.	Theoretically capable of a reduction of 57,000t of P, equivalent to 38% of required reduction to meet sustainable levels. Would not reduce the area at risk.	Reductions in application rates and areas of application but only for key locations deemed at risk. Opportunity exists for permit charging and additional management measures targeted at transport issues. Benefits not quantified.	Benefits as yet unquantified, but could help reduce losses of soil P and provide reductions in P loadings	Benefits as yet unquantified, but could be significant depending on the types of activities targeted and the incentives/impact caused by the charges.
Costs of Compliance	When likely reductions in feed P are accounted for, compliance costs are of the order of £37 to £141 million/year nationally or £300 to £1,300 per holding/year. Under new economic conditions, compliance costs are likely to be reduced substantially as more innovative disposal options adopted.	If likely reductions in feed P are accounted for, compliance costs are of the order of £109 to £337 million/ year nationally or £1,000 - £2,800 per holding/year. Under new economic conditions, compliance costs are likely to be reduced substantially as mroe innovative disposal options adopted.	No net costs to farmers likely as the feeds are less expensive than those currently being purchased.	Of the order of £464 to £801 per holding or £96,000 to £166,000 per Trading Zone (20,000 ha, with this reducing to £22 to £36 per holding and £4,500 to £7,100 per Trading Zone, where savings from feed reductions included.	Some compliance costs will arise in demonstrating that activities undertaken in order to receive rebate or to gain grants from wise use levy.	Unquantified. Costs will mainly relate to paying the charge and any requirements by regulator to demonstrate adherence with permit conditions.

	Option 1a/1c: Nutrient Surplus Charge	Option 1b (RB209): Nutrient Surplus Charge	Option 2: Tax on P in Feeds	Option 3: Trading Zones	Option 4: Management/ Mitigation Measures	Options 5: Permit Charges
Administration, Monitoring and Enforcement	Would require the setting up of detailed monitoring, charging and policing. Estimated £13.14 million per year.	Would require the setting up of detailed monitoring, charging and policing. Estimated £13.14 million per year	Difficult to administer a charge to sponsor shift. Regulatory or charge based limits on P would sponsor a shift towards uptake.	Would require setting up of TZ, trading rules, testing, monitoring and enforcement. Estimated £90,000 per year total costs.	Design, collection and enforcement of levy/tax. For rebates, costs of agreeing and monitoring agreement conditions.	Design, collection and enforcement of charge. Costs of agreeing permits and monitoring adherence.
Public Revenues	Self financing.	Self financing.	Self financing/regulatory costs depending on approach taken.	Potentially self financing on a cost-recovery basis, but could also be financed from public revenues.	Wise use levy could be self financing or supplemented; rebates would be financed from linked charge revenues.	Self financing, with a cost-recovery basis most likely
Cost Effectiveness (all costs annual)	£1000 to £2,900 per t P reduction, not taking into account any reductions that might be achieved by moving to low P feeds.	£800 to £2,200 per t P reduction, not taking into account any reductions that might be achieved by moving to low P feeds.	Not a measure in itself, see Options 1 and 3 where these reductions have been included as part of farmer response to a charge.	Of the order of £1,650 per t P reduction	Not calculable for this study.	Not calculable for this study.
Innovation	Expected to drive innovation in disposal of manures and offer a range of ancillary environmental benefits (global warming, renewable energy, etc.).	Expected to drive innovation in disposal of manures and offer a range of ancillary environmental benefits (global warming, renewable energy, etc.).	Innovation of response in terms of the uptake of existing methods rather than new innovation most likely.	Unlikely to drive significantly levels of innovation as unlikely to change the least cost disposal method (ie spreading manures to land).	Depends on the flexibility of funding mechanisms.	Unknown as depends on nature of activities covered.
Fairness	Balance of costs felt more heavily in the livestock sector.	Balance of costs felt more heavily in the livestock sector.	No issues unless treatment of imported feed products is different (owing to problems of levying tax on imports).	Balance of costs felt more heavily in the livestock sector. All costs to be borne by farmers in CSAs. Debateable equitability.	A fertiliser tax in combination with other charging options would serve to increase equitability of these options.	Should be considered fair as only penalises those undertaking damaging activities.

	Option 1a/1c: Nutrient Surplus Charge	Option 1b (RB209): Nutrient Surplus Charge	Option 2: Tax on P in Feeds	Option 3: Trading Zones	Option 4: Management/ Mitigation Measures	Options 5: Permit Charges
Competition, Competitiveness and International Trade	Competitiveness issues from increased costs of P disposal. Assistance in the form of soft loans/rebates for alternative disposal methods could help.	Competitiveness issues from increased costs of P disposal. Assistance in the form of soft loans/rebates for alternative disposal methods could help.	No issues unless treatment of imported feed products is different.	Those in TZ may view the lack of controls on others as anti-competitive, but may not present major difficulty.	No issues unless there is a disproportionate level of funding given to certain activities/sectors, or funding approach does not conform with EU requirements.	If charges make some of the more profitable activities prohibitively expensive then maybe viewed as damaging ability of farmers to compete at EU and International levels.
Compatibility with other Policies	Compatible with NVZs.	Compatible with NVZs.	No issues likely.	Should be compatible with NVZs and IPPC	May be issues of international trade depending on funding	No issues likely.

5. Conclusions and recommendations

5.1 The problem

The application of P from inorganic fertilisers and manures to agricultural land in England and Wales is currently of the order of 281,000t P per year. This is more than twice the 132,000t P that is indicated as being the maximum sustainable capacity by the fertiliser recommendations RB209 (MAFF, 2000).

Around 2,267 thousand ha (58%) of crop land and 495 thousand ha (29%) of grassland area in England and Wales can be considered as being enriched with P over levels required for agronomic reasons, constituting around 43% of total agricultural area. Around 1,052 thousand ha of this P enriched land (39%) can be viewed as particularly at risk (being index 4 or above), representing some 14% of total agricultural land area.

Without regulation of some kind, soil P will continue to rise and aggravate an already significant environmental problem.

In light of this (and the historical context), any regulatory or policy instrument targeted at halting or reversing the increase in soil P levels will face difficulties of acceptance on economic and/or political grounds.

This study has considered:

- whether economic instruments based on the polluter pays principle could be applied to both source limitation and transport limitation of P as a diffuse source of pollution;
- which instruments these are likely to be and how might they operate; and
- what are the costs of each instrument and how appropriate overall are they likely to be in relation to the level of P reductions that they can deliver.

5.2 Applicability of instruments

A number of instruments could be successfully applied to diffuse P pollution from agriculture. Owing to the need for a measurable and tangible unit on which to base instruments, P application forms the target for most of the instruments.

Whilst the basis of many of the instruments is the quantity of P applied, they have the ability to influence other factors since, by definition, economic instruments will also affect a range of farm economic factors. By changing farm economics, these instruments provide the stimulus to adjust farm practices to maintain productivity at the highest levels possible. This will have the effect of making a range of what are currently ‘economically unattractive’ options more attractive, where these include:

- reducing dietary inputs;
- reducing fertiliser inputs;
- tackling critical soil P levels;
- addressing critical surplus loadings;

- manure composting;
- manure sharing schemes;
- manure incineration;
- manure nutrient recovery;
- nutrient immobilization;
- no application zones;
- avoiding high risk crops;
- reducing stocking density;
- changing farming systems; and
- establishing woodland.

However, other management based approaches targeted at areas of particular concern could not be addressed without additional arrangements. These approaches include fertilizer and manure management approaches (such as, application timing, incorporation of manures, etc.); farm management approaches (such as collecting farmyard run-off, early sowing of crops, cover crops, etc.); and soil management approaches (such as contour ploughing, rough seedbeds, minimal cultivation, targeted buffer zones, etc.). Economic instruments such as emissions charges and product taxes could, however, provide the necessary funding to operate initiatives in these areas in some cases, or provide 'incentives' in the form of permit charges to limit particularly polluting activities.

5.3 Assessment of the candidate instruments

Several options for economic instruments have been analysed for this study, with some examined in more detail than the others. The options considered in this preliminary feasibility analysis are:

- Option 1a: Simple minerals accounting nutrient surplus charge;
- Option 1b: Nutrient planning phosphorous surplus charge;
- Option 1c: Two tiered nutrient surplus and management charge;
- Option 2: Tax on feed phosphorus supplements and content;
- Option 3: Tradeable permit scheme for application to specific problem catchments;
- Option 4a: Wise use levy;
- Option 4b: Wise use rebates; and
- Option 5: Permit charges for potentially polluting activities.

Table 4.19 in the last section provided a summary of well each of the above instruments performed against a series of criteria, in order to highlight some of the advantages and disadvantages of each (to the degree possible within this study).

Although it is not possible to make direct comparisons of all of the options in terms of overall environmental benefits and the cost-effectiveness with which they can be achieved, the 'best' options would appear to be the nutrient surplus charges (Options 1). Options 1a and 1c would offer a partial solution to reducing the current level of P loadings being spread on land, providing reductions in inputs of around 54,000 tonnes per annum. The costs to farmers are estimated to vary from £300 to £1,300 per holding depending on the transport distances required. The costs per unit of P reduced are higher for these options though than for Option 1b (based on the RB209 fertiliser recommendations (MAFF, 2000), even though the latter has higher total annual costs. Under this option a potential 149,000 tonnes per annum of P are no longer spread on land, at estimated costs of between £1,000 to £2,800 per holding (again depending transport distances required).

The above costs relate to the full implementation of the option, but it would obviously be possible to bring in the same type of system with charge rates below those implied by the above figures to deliver a lower level of environmental gains at a lower cost to the nation. Even a lower charge rate may have the potential to alter farm economics sufficiently by creating an increased demand for low P feed supplements and additives and an increased use of more innovative disposals methods. Both of these offer the potential for significantly reducing overall P loadings, with the up-take of low P feeds decreasing the level of P in manures by up to 57,000 tonnes per annum. Because these feeds are of the same or lower cost, this shift could be made at little to no cost to farmers – even in the absence of a product tax (Option 2). Similarly, some of the alternative disposal methods (including treatment and processing) may have relatively short pay-back periods.

Nutrient surplus charging may be politically unacceptable, however, as depending on the charge rates it could have implications for the competitiveness of farming (if applied at a national level). An alternative partial solution may then be the creation of Trading Zones (Option 3) in Critical Source Areas (CSAs). This option would seek to achieve reductions in quantities of P applied and in the areas to which P is applied by setting quotas at the field level. Where farmers have spare capacity for spreading P to land, this capacity could be sold to those who have to dispose of P off their land. The costs are of the same order of magnitude as those arising under the charging schemes, but the majority relate to regulatory set-up costs which may decrease in per unit terms through economies of scale should a number of zones be created. The creation of a trading system also provides a good basis for securing additional environmental benefits (in the form of reduced risk of diffuse P in the water column) through the development of management agreements, permit charges or other mechanisms (where this effectively constitutes Options 4b and 5).

It is more difficult to compare the measures to address management/mitigation issues (Options 4a and b), partly because it has not been possible to quantify the benefits and costs in the same manner. The creation of a wise use levy through the introduction of a tax on fertilisers or some other unit of production may be valuable in providing funding for education and the promotion of the types of actions highlighted in Section 4.5 and above. However, significant tax rates per unit may be required in order to produce the level of funding required finance the initiatives proposed by the study led by IEEP, although other public revenue sources could also contribute to the funding of these proposals. The alternative to the introduction of this type of levy would be to create a rebate system within the nutrient surplus charging schemes provided by Option 1. The revenues generated by the full options are significantly higher than those required to fund the IEEP proposals, suggesting that lower charges together with rebates on the adoption of the various management actions may prove highly cost-effective.

5.4 Recommendations on a combined approach

Based on the above findings, it would appear that a combined approach to the adoption of economic instruments may be the most appropriate. There are two possible combinations:

- Combination A: the introduction of nutrient surplus charges (Option 1) which builds on NVZ requirements, followed by the use of the revenues to fund wise use initiatives drawing on the types of management activities identified by the IEEP study. The nutrient surplus charging scheme would preferably be based on Option 1b, but with the rate set at one which does not result in the transport of manures over long distances. The rate could be set at a low level in the first years and increased over time in response to the need to generate the required level of funding and to provide the impetus for increased innovation in disposal methods and the shift to low P feeds.

- Combination B: the introduction of localised trading zones in CSAs. This could then be complemented by the creation of a wise use levy and/or funding provided by other public revenue sources, or through the introduction of permit charges to shift farmers away from the most damaging activities. This would ensure that the damages occurring in the most sensitive aquatic environments were being tackled, yet at lower costs to the nation as a whole (owing to the more limited coverage) than implied by the surplus charges. Education on the cost savings that could arise from the adoption of low P feeds should reduce the costs faced by individual farmers, with the grants/soft loans provided by the wise use levy/permit charge revenues further assisting the reduction in damages.

In both cases, further work is required to establish with more reliability the costs and benefits that would be involved and the best form that these combinations should take.

5.5 Further work

Clearly, the economic instruments examined here can provide a range of short to longer term strategic solutions for tackling diffuse P pollution issues.

Further research is required to refine the estimates produced here for the charges and trading options. This could include:

- refining assumptions on transport and associated requirements using GIS data on livestock and crops to create a better understanding of how P surpluses would be spatially distributed;
- identifying the cost thresholds over which farmers would adopt other responses than transport;
- defining in more detail the administrative requirements associated with each option to provide a sounder basis for costing this aspect;
- assessing more fully the relative benefits associated with education and different in-soil P management methods so that the cost-effective of measures to be funded through a wise use initiative or charge rebates can be determined; and
- consideration of the impact of any charges to be levied nationally on the macro-economy.

Further research should also be directed at other ‘disposal’ options such as anaerobic digestion, their costs and wider environmental benefits in order to determine to what degree they should be supported by ‘soft loans’ or rebates linked to the charging instruments in order to achieve policy objectives.

Of equal importance is an investigation into the changes in environmental risks and benefits associated with any combined instrument proposals. Such work should attempt to give greater consideration to the indirect costs and benefits such as changes in water quality, pathogens, methane production, renewable energy, etc. that may come following the introduction of the combined interventions.

6. References

ADAS, 2001. *Alternative farming systems to reduce pollution impacts of nutrients – phosphorus*. Technical Report P126 prepared for the Environment Agency.

ADAS CONSULTING LTD, 2002. *Report on the 2001 Farm Practices Survey (England).* Report to DEFRA Farm Management Improvement Division, Woodthorne, ADAS.

BECKMAN, S., 1999. Literature review on levies and permits. *In*: van Zeijts, eds. *Economic instruments for nitrogen control in European agriculture.* Utrecht: CLM.

BEEGLE, D., 1999. Developing a comprehensive manure management plan, in *Mid-Atlantic Management Conference: systematic approach to dairying in the next Millennium*, 24 to 25 February 1999, Camp Hill, Pennsylvania, US.

BLANCHARD, P.J. *et al*, 2001. *Influence of Natuphos® Phytase and organic acids on the performance of growing/finishing pigs*, article downloaded from the British Society of Animal Science Internet Site (http://www.bsas.org.uk).

BRITISH BIOGEN, 2002. *Anaerobic digestion of farm and food processing residues: good practice guidelines*. British Biogen Internet Site (www.britishbiogen.co.uk).

CARVALHO, L. & MOSS, B., 1998. Lake SSSIs subject to eutrophication – an environmental audit. *English Nature Freshwater Series*, No. 3. Peterborough: English Nature.

CEEP, 1999. *Phosphate recycling: possibilities for P recovery from animal manure.* Article downloaded from Centre Europeen d'Etudes des Polyphosphates (CEEP) Internet site at (http://www.ceep-phosphates.org/scope.htm).

CIWEM, 2001. *Diffuse Pollution impacts, the environmental and economic impacts of diffuse pollution in the UK.* Lavenham: CIWEM.

CLM *et al*, 1999. *Economic instruments for nitrogen control in European agriculture*, H van Zeijts (ed.). Utrecht: Centre for Agriculture and Environment.

DALDORPH, P.W.G. *et al*, 2001. Integrated lake and catchment phosphorus model - a eutrophication management tool. I: Model Theory, *J.CIWEM*, Vol 15, July/August, pp174-181.

DANIEL, T.C. & MOORE, P.A. Jr, ed. *Managing phosphorus in manure: causes, concerns and BMPs*, article downloaded from the University of Arkansas Internet Site (http://www.engr.uga.edu/service/extension/publications/daniel.htm).

DE CLERCQ, M., 1996. *The implementation of green taxes, the Belgian experience.* University of Ghent.

DEFRA, 2001. *The British survey of fertiliser practice: fertiliser use on farm crops for crop year 2000.* Report produced by DEFRA, Fertiliser Manufacturers Association and the Scottish Executive.

DEFRA, 2002. The protection of waters against agricultural nitrate pollution in England – how should England implement the 1991 Nitrates Directive. Consultation paper.

ECOTEC, 1997. *Economic instruments for pesticide minimisation*. Final report by ECOTEC for the Department of the Environment.

ECOTEC, 2001. *Study on the economic and environmental implications of the use of environmental taxes and charges in the European Union and its Member States*. Final report to the European Commission.

ENDS Environmental Data Services, (14 December 2000). *Netherlands dealt blow over manure state aid,* article downloaded from *ENDS Daily* Internet site at (http://www.environmentdaily.com/articles/index.cfm?action=article&ref=8962...).

ENGLISH NATURE, 1997. *Wildlife and fresh water - an agenda for sustainable management*. Peterborough: English Nature.

ENGLISH NATURE, 2000. *Phosphorus and river ecology*. Report prepared on behalf of English Nature and the Environment Agency by Water Research Centre (WRc), March 2000.

ENTEC, 1998. E*conomic evaluation of the Nitrate Sensitive Areas scheme*. Report for the Ministry of Agriculture, Fisheries and Food, London.

ENVIRONMENT AGENCY, 1998. *Aquatic eutrophication in England and Wales: a proposed management strategy.* Consultative Report. Bristol: Environment Agency.

ENVIRONMENT AGENCY, 2000. Aquatic eutrophication in England and Wales – a management strategy. Bristol: Environment Agency.

ERM, 1998. *Economic instruments for water pollution charges***.** Revised draft final report for the Department of the Environment, Transport and the Regions (DETR), London.

FIBROPHOS LTD, 2001. *What is Fibrophos?* Article downloaded from Fibrophos Internet site at (http://www.fibrophos.co.uk/What_is_Fibrophos.htm).

FOSTER, S.S.D., 2000. Assessing and controlling the impacts of agriculture on groundwater - from barley barons to beef Bans. *Quarterly Journal of Engineering Geology and Hydrogeology*, **33**, pp 263-280.

Hasler, B and Schou, JS (1999): *The potential of tradable quotas in Danish agri-environmental policies*. Paper at the conference Regulatory Instruments and Approaches: Enforcement and Asymmetric Information, November 21-23, 1999, Copenhagen.

HEMINGWAY, 2000. The effect of reducing fertiliser nitrogen and phosphorus applications on the supplementary phosphorus requirements of ruminants. Paper presented at the Society of Chemical Industry (SCI) Agriculture and Environment Group Symposium *Control of Nitrogen and Phosphorus Excretion in Ruminants by Dietary Manipulation*, 22 February 2000, London.

HODGE, I., 1997. Applying land-use permits for the control of mineral emissions from agriculture. *In:* Romstad E *et al* (1997): *Economics, policies and the environment.* Wallingford: CAB International.

HOLDEN, P. & TIDMAN, M.J., 2001. *Phosphorus and swine feeding.* Article downloaded from the Integrated Crop Management Internet Site (http://www.ent.iastate.edu/ipm/icm/2001/4-16-2001/pswine.html).

IEEP (DWYER *et al*), 2002. Policy mechanisms for the control of diffuse agricultural pollution, with a particular reference to grant aid. Peterborough: *English Nature Research Reports*, No. 455.

IISD, 2001. *Recycling credits in the UK.* Article downloaded from The International Institute for Sustainable Development (IISD) Internet site at (http://iisd1.iisd.ca/greenbud/credits.htm).

JACOBSSON, C., 2000. *The Swedish Institute of Agricultural Engineering.* Paper presented at the second general meeting on Nutrient Management Legislation in European Countries (NUMALEC), 18-20 may 2000, Greece.

KEBREAB *et al,* 2001. *Phosphorus pollution by dairy cows and its mitigation by dietary manipulation.* Article downloaded from the British Society of Animal Science Internet site (http://www.bsas.org.uk).

KNOWLTON, K.F., (nd), *Reducing phosphorus losses through nutrition*. Article downloaded from the **US Jersey Cattle Association** Internet Site (http://www.usjersey.com/Reference/ Environment-3.pdf).

KNOWLTON, K.F. & KOHN, R., 1999. Feeding management to reduce phosphorus losses from dairy farms. In Mid-Atlantic Management Conference, *Systematic approach to dairying in the next Millennium*, 24 to 25 February 1999. Pennsylvania, US: Camp Hill.

KOHN, R. *et al,* 1997. A sensitivity analysis of nitrogen losses from dairy farms. *Journal of Environmental Management,* **50**, pp 417-428.

KOHN, R., 1999. *The impact of dairy herd management on nutrient losses to water resources*. Article downloaded from the University of Maryland Internet Site (www.inform.umd.edu/EdRes/Topic/AgrEnv/Manure/herdeffic.htm).

KOHN, R., 1999a. *Animal grouping strategies*. Article downloaded from the University of Maryland Internet site (www/inform/umd/edu/EdRes/Topic/AgrEnv/manure/ group.htm).

KOHN, R., 1999b. *Grazing for lactating dairy cattle*. Article downloaded from the University of Maryland Internet site (www/inform/umd/edu/EdRes/Topic/AgrEnv/manure/graze.htm).

MAFF, 1998. *Code of Good Agricultural Practice for the Protection of Water (The Water Code).* London: MAFF and Welsh Office.

MAFF, 2000. *Fertiliser recommendations for agricultural and horticultural crops*, 7th Edition (2000). London: The Stationery Office.

MAFF, 2001. *Guidelines for farmers in NVZs.* Booklet RB209. London: MAFF.

MAFF, 2001. *The draft soil strategy for England*. Consultation Paper. London: DETR.

McINERNEY, J., *et al,* 2000. *What's the damage - a study of the farm level costs of managing the countryside,* University of Exeter, Agricultural Economics Unit.

MORSE, G.K, LESTER, J.N. & PERRY, R., 1993. *The economic and environmental impact of phosphorus removal from wastewater in the European Community*. Selper Publications.

MOSS, B., 1997. The restoration of freshwater ecosystems – an overview. In: *River Restoration '96* – plenary lectures. Proceedings of an international conference arranged by the European Centre for River Restoration, National Environmental Research Institute, Denmark.

OECD, 1999. *Economic instruments for pollution control and natural resources management in OECD countries: A Survey*. Paris: OECD.

PEARCE, D., SECCOMBE-HETT, T. & TURNER, R.K., 2000. *Market-based instruments in the united kingdom: consultancy to support work on modernising the economy*. Final version by EFTEC and CSERGE for UK Round Table on Sustainable Development, April 2000.

PIMENTEL, D. *et al,* 1993. Environmental and economic effects of reducing pesticide in agriculture. *Agriculture, Ecosystems and Environment*, **46**, pp273-288.

ROUGOOR, C. & VAN DER WEIJDEN, W., 2001. *Towards a European levy on nitrogen, a new policy for reducing eutrophication, acidification and climate change*. Utrecht: Centre for Agriculture and Environment.

SHARPLEY, A.N. *et al,* 1999. *Phosphorus management on dairy farms*. In Mid-Atlantic Management Conference, *Systematic approach to dairying in the next Millennium*, 24 to 25 February 1999. Pennsylvania, US: Camp Hill.

SCHEFFER, M.., DE REDELIJKHEID, M.R. & NOPPERT, F., 1992. Distribution and dynamics of submerged vegetation in a chain of shallow eutrophic lakes. *Aquatic Botany*, **42**, pp199-216.

SCHIPPER, W. *et al,* 2002. *Phosphate recycling in the phosphorus industry*. Vlissingen: Thermphos International BV.

SPECK, S. & EKINS, P., 2000. *Recent trend in the application of economic instruments in EU Member States plus Norway and Switzerland and an overview of economic instruments in central and eastern Europe.* Update of database of environmental taxes and charges, by Speck, S. *et al*., Forum for the Future for DG Environment, July 2000.

STEEN, I. & AGRO, K., 2000. *Industrial view on agricultural environmental legislation in Europe*. Paper presented at the second general meeting on Nutrient Management Legislation in European Countries (NUMALEC), 18-20 may 2000, Greece.

THE REGIONAL ENVIRONMENTAL CENTRE FOR CENTRAL AND EASTERN EUROPE, 2000. *Sourcebook on economic instruments for environmental policy.* Hungary: The Regional Environmental Centre for Central and Eastern Europe.

TIMMS, R.M. & MOSS, B., 1984. Prevention of Growth of Potentially Dense Phytoplankton Populations by Zooplankton Grazing, in the Presence of Zooplanktivorous Fish, in a freshwater wetland ecosystem. *Limnology and Oceanography*, **29**, 472-486.

VAN DER BIJL, G. & VAN ZEIJTS, H., 1999. Nitrogen problems and current policies. *In: van Zeijts, ed. Economic instruments for nitrogen control in European agriculture.* Utrecht: CLM.

VUKINA, T. & WOSSINK, A., 1998. *Evolving environmental policies and asset values: nutrient trading schemes in The Netherlands*. Paper presented at the conference World Congress of Environmental and Resource Economist, 25-27 June 1998, Venice.

WATER RESEARCH CENTRE, 2000. P*hosphorus and river ecology – tackling sewage inputs.* Report for English Nature and the Environment Agency, Medmenham, WRc.

WEERSINK, A., 1998. Economic instruments and environmental policy in Agriculture. *Analyse de Politiques*, Vol. XXIV, No.3, pp309-326.

WHEATERUP, R.N. *et al*, 1999. *The effect of phosphorus concentration and the use of phytase enzyme in pig diets on growth performance and bone characteristics of finishing pigs.* Article downloaded from the British Society of Animal Science Internet site (http://www.bsas.org.uk).

WITHERS, P.J.F. et al, 2001. Phosphorus cycling in the UK agriculture and implications for phosphorous loss from soil. *Soil use and management*, Vol17, pp139-149.

WRc, 1999. *Diffuse pollution: sources of N and P.* Report for the Department of the Environment, Transport and the Regions, Report No. DETR 4755, June 1999.

Annex 1: Supporting information on nutrients in watercourses

A1.1 The phosphorus cycle

A1.1.1 Phosphorus movement from soils to watercourses

Phosphorus tends to sorb tightly to soil particles, particularly onto clay and organic matter. This means that phosphorus generally reaches surface waters via surface run-off, attached onto particulates. Phosphorus also has a higher affinity for finer particulates, resulting in phosphorus concentrations in run-off often being higher than in the parent soil. When soils are heavily enriched with phosphorus, concentrations of dissolved phosphorus leaching into sub-surface drainage and groundwater can be significant. The presence of macropores and fissures in soils (and the underlying geological deposits) can also increase the amount of phosphorus lost from the soil in this manner. However, not all of the phosphorus may be dissolved, much may be sorbed onto very fine particles (including colloids) which can be easily washed through macropores and fissures into sub-surface drainage and aquifers. An increase in phosphorus concentrations in drainage water and groundwater is important since it provides a continuous source of phosphorus to surface water bodies throughout the year (WRc, 1999).

Soil type is an important factor in determining how much phosphorus may be lost due to erosion and run-off. Erosion sensitive soils (sandy soils with low clay or organic matter content) can be eroded at very high rates, up to 30 kg/ha/yr. However, measurements made in the field show that loads tend to be distributed unevenly with much of the phosphorus being lost from limited areas (so-called ‘critical source areas’). Most of the material (estimated as 36% to 70%) mobilised as run-off is retained in nearby fields, with only the finer material often reaching watercourses. Run-off breaks can, therefore, have a significant impact on the amount of phosphorus reaching watercourses. For one catchment in Devon, 26% of particulates mobilised by surface run-off was retained within nearby fields, most in association with hedgerows (with sediment accumulation rates behind one hedgerow of 100 tonnes/ha/yr) (WRc, 1999).

The intensity of rainfall is also an important control on the amount of surface run-off that is generated. This is particularly true of storm events which can, in some catchments, account for the majority of phosphorus lost from agricultural fields. The importance of storm events may be increased due to a general lack of ground cover when heavy rainfall events are most likely, ie autumn and winter (WRc, 1999).

Ground cover, as noted above, is an important constraint on the amount of surface run-off that may be generated. Also important is the type of crop that is being grown. This is because different crops have a different ability to resist nutrient leaching. Permanent grassland has the lowest risk of leaching, while crops such as potatoes and oilseed rape lose nutrients by both erosion and surface/subsurface pathways. Row crops tend to lose most phosphorus via surface run-off, with particulate-bound phosphorus estimated to represent 90% of the total load. Management changes can also affect the amount of phosphorus being lost, with autumn ploughing and sowing of winter cereals associated with much higher erosion than spring sowing (WRc, 1999).

Other factors affecting the amount of phosphorus lost to watercourses include density of animals stocking and fertiliser application rates. These are discussed in detail in the sections on livestock and inorganic fertilisers, below.

A1.1.2 Phosphorus dynamics in watercourses

Most of the phosphorus from diffuse sources entering rivers is bound to sediments and particulates. For example, particulate-P contributions to total-P export has been measured at 66% to 88% while Bengston *et al* (1988) found that 73% of total phosphorus (variance) in streamwater could be accounted for by suspended soil concentrations (in WRc, 1999). As particulate-P is often sourced during autumn and winter, much of it can be quickly flushed downstream. This means that diffuse sources are most important where the retention of sediments is highest, or in years of lower than average flows (English Nature, 2000).

Phosphorus rich sediments that remain in the watercourse can supply phosphorus for subsequent growing seasons through nutrient cycling which results in phosphorus being released into the water column. Phosphorus can also be taken up from the sediment by plants, through root uptake, or by benthic algae (algae which live in or on the sediment) (WRc, 1999).

Phosphorus is released to the water column by resuspension, desorption and diffusion. Resuspension occurs where the sediment is disturbed, either by a change in flow conditions or disturbance by fish, boat propellers, etc. Desorption occurs when phosphorus attached to sediments is released. This may be because concentrations of phosphorus in the water are low or due to anoxic conditions in (or just above) the bed sediments. The presence of anoxic conditions can also affect the establishment and growth of macrophytes. Diffusion occurs from the matrix of particles, where phosphorus is more tightly bound. Again, the rate of diffusion is determined by the concentration of phosphorus in the overlying water. The movement of phosphorus from the sediment is dependent upon the concentration of phosphorus in the water column. This is important as it means that sediments can continue releasing phosphorus into the water column, potentially negating any efforts to reduce levels of dissolved phosphorus. It may, therefore, be more appropriate to set targets related to the concentration of phosphorus in sediments, rather than in the water column (WRc, 1999).

As well as being released into the water column, phosphorus can also be removed by precipitation with calcium (in areas of hardwater) and iron and aluminium (in areas of softwater). Algae can also assist co-precipitation with calcium onto bed sediments and plants. Colloids of calcium phosphate can also form, although these would tend to stay suspended in the water column rather than settle out onto the river bed (WRc, 1999).

The driving force for phosphorus dynamics in a surfacewater body is the concentration of phosphorus in the sediment and water column. This is of fundamental importance when looking to reduce levels of phosphorus since the sediment may provide a reservoir of phosphorus that can maintain elevated concentrations in the water column for many years. If the bioavailable phosphorus (ie phosphorus in the water column or available either directly or released from sediments) is not reduced to below 200 to 300 μg/l, no improvement in ecological quality can be expected (WRc, 1999).

The key factors in determining the potential for eutrophication as a result of increased phosphorus inputs is water turnover time and whether the water body is dominated by erosion and transportation, or by continuous sedimentation. Where erosion and transportation dominate, phosphorus in the sediments can be continually released, increasing (and prolonging) potential effects. If the water body is dominated by continuous sedimentation, much of the phosphorus will be buried and, hence, removed from the water column (however, erosion at a later date could allow for subsequent release into the water column) (Nordvarg, 2001).

A1.2 The nitrogen cycle

The main forms of nitrogen in surfacewaters are nitrate, nitrite and ammonia plus some organic forms, with nitrate the dominant. Nitrogen in these forms is highly soluble and the main pathway to surfacewaters is via subsurface flow (through soil and/or groundwater) (WRc, 1999). This makes nitrates very difficult to control. Indeed in many areas, N reserves in soil are sufficient that even if N applications were stopped completely, autumn flushes would still increase N in water to levels above those dictated by the Nitrates Directive.

The main source of nitrates in lowland catchments is from diffuse sources, mainly agriculture, with 70% of total N inputs estimated to come from these sources. The other 30% comes mainly from sewage and industrial effluents (The Royal Society, 1983 in Environment Agency, 2000). In upland catchments, natural inputs from atmospheric deposition is often the major source (DoE, 1994 in Environment Agency, 2000). However, most of the atmospheric N is derived from agriculture, from ammonia emissions from livestock rearing activities. Other sources include NO_x emissions from vehicles and power stations (The Royal Society, 1983 in Environment Agency, 2000).

The difficulties of controlling N (even if application was to cease) combined with the fact that most waterbodies are phosphorus limited indicates that the control of phosphorus may be more significant in terms of controlling eutrophication events.

A1.3 Other sources of nutrients

A1.3.1 Industrial discharges

Industrial discharges come mainly from food processing and the paper industry and are estimated to account for 2% to 10% of total phosphorus and N sources, with Morse *et al* (1993 in Environment Agency, 2000) estimating that industry as contributes 7% of phosphorus sources.

A1.3.2 Urban discharges

Urban sources come mainly from run-off including erosion, use of garden chemicals (particularly lawn fertilisers), animals and leachate from leaves and petrol additives (WRc, 1999). Nutrient loads via combined sewer overflows (CSOs) are estimated to be less than 5%, and in many cases would be much less than this as CSOs are only used during periods of high rainfall (Ellis, 1989; Funen County Council, 1991 in WRc, 1999). Typical phosphorus export coefficients for urban areas in Eastern England are 0.02 kg/ha/yr (Johnes *et al*, 1996 in Daldorph *et al*, 2001).

A1.3.3 Fish farms

Phosphorus emissions from fish farms in Europe account for around 1% to 4% of phosphorus emissions from agricultural activities. However, on the local scale the impact of a fish farm can be such that it is the dominant source of nutrients (INRA, 2001). Phosphorus pollution costs have also been estimated at 3% of the wholesale value of fish produced, with 12.5 kg of phosphorus released into the aquatic environment per tonne of trout produced. This can be compared with the phosphorus production of 680 people (before sewage treatment) (Foy, 1992).

Fish farms produce fast sinking particulate sources of phosphorus, comprised mainly of uneaten food pellets and faeces (Nordvarg, 2001). The rapid settling of these particulates means that the impact of fish farms is only usually detectable within 10m to 50m of the cages, thus only tend impact the local or intermediate scale. The sediments below the cages themselves are heavily enriched, often having phosphorus concentrations that are an order of magnitude higher than unaffected sediments (Hall *et al*, 1992; Holby and Hall, 1991; Kelly, 1993 in Johansson, 2001) and due to being reduced, have no benthic organisms living within them. This is an advantage as it prevents stirring up of the sediments and subsequent release of phosphorus into the water column. The eutrophication effects are, therefore, directly related to the size of the fish farm (Johansson, 2001).

Measurements taken in Swedish lakes have shown that phosphorus concentrations were higher in lakes where fish farms had been active for a number of years and that there is a time lag before there is a measurable response to increased phosphorus loads in lakes (Johansson, 2001).

Feeding fish with plant-based (rather than fish mean or fish-oil based) products can reduce nutrient emissions from fish farms as the amount of phosphorus released is less (INRA, 2001).

A1.3.4 Dosing of water supplies

Some water companies use phosphorus dosing of water to reduce plumbosolvency. Dosing rates are 0.5 to 1.0 mg/l, which means that the importance of this as a source of phosphorus is likely to be lower than that of leaking sewers (WRc, 1999).

A1.3.5 Natural Sources

Natural sources of phosphorus are estimated by Morse *et al* (1993 in Environment Agency, 2000) at 9%. In many catchments the importance of natural sources may be much lower. Atmospheric deposition is much more important for N, with most derived from industry and agriculture in the form of ammonia and N_2O and could be as high as 33% (Johnes *et al*, 1994 in WRc, 1999).

A1.4 Additional References

DALDORPH, P.W.G. *et al,* 2001. Integrated lake and catchment phosphorus model - a eutrophication management tool. I: Model Theory. *J. CIWEM*, Vol 15, July/August, pp174-181.

ENGLISH NATURE, 2000. *Phosphorus and river ecology.* Report prepared on behalf of English Nature and the Environment Agency by Water Research Centre (WRc), March 2000.

ENVIRONMENT AGENCY, 2000. Aquatic eutrophication in england and wales, a management strategy. *Environmental Issues Series*. Bristol: Environment Agency.

ENVIRONMENT AGENCY, 1998. *Aquatic eutrophication in England and Wales: a proposed management strategy.* Consultative Report, December 1998.

FOY, R.H., 1992. *Phosphorus from fish farms*. Report produced for the Aquatic Sciences Division, Department of Agriculture (Northern Ireland)

INRA, 2001. *Fish farming conditions aimed at minimal environmental impact.* Institut National de la Recherche Agronomique, article downloaded from the INRA Internet site (http://www.inra.fr/Internet/Directions/DIC/Presse/mai01/gd/nb5.htm).

JOHANSSON, T., 2001. *Phosphorus emissions from fish farms - observed and predicted effects.* Dissertation for the Degree of Doctor of Philosophy in Sedimentology, Uppsala University, Sweden.

NORDVARG, L., 2001. *Predictive models and eutrophication effects of fish farms*. Dissertation for the Degree of Doctor of Philosophy in Sedimentology, Uppsala University, Sweden.

WRc, 1999. *Diffuse pollution: Sources of N and P*. report for the Department of the Environment, Transport and the Regions, Report No. DETR 4755, June 1999.

Annex 2: Analysis of variable costs of options

A2.1 Introduction

As has been described in Section 3, the options selected for more detailed screening and analysis include the following:

- Option 1a: Simple minerals accounting nutrient surplus charge;
- Option 1b: Nutrient planning phosphorous surplus charge;
- Option 1c: Two tiered nutrient surplus and management charge;
- Option 2: Tax on feed phosphorus supplements and content; and
- Option 3: Tradeable permit scheme for application to specific problem catchments.

This Annex provides a brief description of the modelling activities undertaken to derive the key variable costs (transport, disposal, etc.) associated with each of these options.

A2.2 The analytical approach

A2.2.1 Overview

As highlighted in Section 4, the level of a charge required to ensure that excess P is exported from a given farm needs to be set at a level high enough to ensure that exporting surplus P is a financially more attractive option than disposing 'to farm' (and incurring a charge). As such, the optimum level of the charge very much depends on the costs of transport and alternative disposal options.

Given the large range of possible responses to a charge and the associated costs of meeting an appropriate balance in an individual farm situation, it is difficult to accurately model and pinpoint exactly what the associated costs are likely to be. At present, the least cost option for disposal of manures is widely regarded to be direct spreading to land. In modelling the costs associated with the individual options, we have taken this to its logical conclusion, ie that all manurial excess produced by placing limits on the quantities of manure that can be disposed of to land (on or off farm) are disposed of in this fashion, the excess being disposed of by other means. Whilst this represents only a part of a farmer's likely response to an instrument and is, as such, unrealistic, it does enable an examination of the changes in costs associated with the different options and estimation of the environmental effectiveness of each in terms of the quantities of P taken out of circulation.

The key cost variables examined in modelling, then, are associated with the transport, spreading or other disposal route of surplus manures generated under each option. A 'top down' approach has been used to model these.

A consistent approach has been adopted across the options. As base data, the model uses national census data, published data on quantities of P produced and manurial P values to generate a detailed P budget. This is linked to a forecasting model that predicts changes under the various options in terms of generated 'wastes', spreading area required, and distances travelled.

This model has permitted an analysis of the instruments in terms of their implications for different application levels of P to grassland and crop. The key independent variables that are addressed in the model include:

- application levels to grassland – where a range of values have been considered covering maintenance values (and increments above these), with these derived from published estimates of grassland P off-take;
- maintenance application levels to crops – where maintenance values have been derived by comparison of the area under each crop and recommendations given in RB209;
- permissible application levels to crops under RB209 – where application levels have been calculated by analysis of soil survey statistics, census data and recommendations under RB209 to provide areas of crops of different soil P status and associated recommendations;
- 'sustainable' application levels – where 'sustainable' has been modelled as no applications of P to crop land of soil P index 3 and above and values have been derived by consideration of soil survey statistics, census data and recommendations under RB209;
- areas available for spreading – where this data has been derived from census data and soil survey data;
- distance travelled – given time and resource constraints, it has not been possible to derive exact transport data as this would require consideration of regional and parish data. As such, to provide both an indication of the likely level of transport costs a range of values (low, medium and high) have been used to cover possible distances. To describe relative incremental changes in these costs under the various options, these have been increased in proportion to changes in available spreading area. Thus, the model provides a range of indicative values for the transport costs associated with each option, where these reflect the range of likely costs and permit direct comparison of cost changes between the various options; and
- excretal P values – where these have been derived per census head using published data and, in the case of the feed charge (Option 2), reductions using industry estimates have been applied to model how the use of reduced feed P inputs alters the costs associated with Options 1a and 1b.

A2.2.2 Base cost data

In simple terms, the model calculates the volume of manure generated by existing flock/herd sizes and the capacity of livestock land to 'absorb' this at the rates implied by the different options. Any calculated excess manure must then be disposed of elsewhere. As already noted, owing to the fact that spreading directly to land is broadly regarded as the least cost option (at present) the default 'disposal' route is loading, transport and spreading to land.

In transporting manures between farms, there is an inherent potential for spreading of diseases, as experienced in recent years with swine fever and foot and mouth disease (FMD). In light of FMD, DEFRA are currently reviewing this issue to prevent the spread of diseases. As yet, we are not aware of any new regulations except that codes on the treatment of slurry/manure to reduce potential pathogens may well be coming out this year.

From recent FMD experience, it is considered that it would not be good practice to increase trafficking between livestock farms unless very good disinfection systems were installed. However, given the restrictions that operating to a balanced P budget would create, it is considered unlikely that there would be any 'spare' capacity for spreading of slurry and manure from other livestock farms. In other words, the model has assumed that any surpluses are spread on crop land, whether that is crop land on a mixed farm (where it is assumed that the mixed farm will use this land to 'capacity') or arable land. No exchange between livestock farms occurs within the modelling.

It has been assumed that all crop land is available for spreading, although, as discussed in Section 4, there are practical difficulties with this concept which act to change the circumstances and hence recommendations for dealing with excess P. Any remaining excess must be disposed of by some other means and this is discussed further in Section 4.

Several cost items apply to the excess manures generated:

- transport and loading costs
- spreading costs; and
- disposal costs.

The level of these costs and how they have been derived is discussed below.

Transport costs

The cost of transporting FYM/slurry is, potentially, very expensive depending on the distances involved. Local deliveries could be undertaken by farm machinery, but if any distance is considered (say beyond adjacent farms) the use of farm vehicles will become a legal issue (use of rebate fuel, tax, etc.) and may require HGVs to undertake work. This would substantially increase costs, for example, a reasonable approximate cost for a 50 mile round trip could be around £4 per m^3 excluding loading costs. For the purposes of the model, the standard value of £0.47/m^3 used in the Draft Regulatory Impact Assessment accompanying the NVZ consultation has been applied. An additional £0.75/t loading costs has also been included in the model, providing a total cost of transport and loading of £1.22/m^3/ km distance travelled.

As noted earlier, the prediction of transport distances with any degree of accuracy would require considerably more time and resources than are available for this indicative study. It would involve relating a spatially distributed P surplus to spatially distributed manure production using GIS data on livestock and crops or, at the very least, several case study analyses at county level.

The baseline range of distances used for the purposes of modelling are provided in Table A2.1. These have been adjusted upwards or downwards depending on the changes in the availability of crop land under the various scenarios (since a reduction in available crop land under some of the options implies a greater average distance travelled).

Table A2.1: Distance Scenarios used to Calculate Transportation Costs for Option 1a			
	Distance Travelled (km)		
Livestock Type	**Low**	**Middle**	**High**
Cattle	5	10	25
Sheep	0	0	0
Pigs	2	5	10
Poultry	5	10	20

Spreading costs

In addition to the costs of transporting the material generated, there is the issue of getting lorries near fields during the wetter months of the year. If lorries cannot tip on the field, extra costs will be incurred at spreading to cover transport cost from storage heap to field. For liquid, this could also involve extra pumping equipment/storage. If solids are delivered, damage to farm tracks during winter becomes an issue of concern.

In terms of liquid wastes, non-livestock farms generally do not have storage facilities, so a delivery and spread service might have to operate. This, in turn, could lead to a tight operating window for autumn stubbles and through the winter months for spring sown crops which, in addition, raises issues for ground conditions and pollution risk.

Many farms now operate a very strict operational schedule for cultivations and it is possible that introducing FYM/slurry application could well upset this routine. As such, as is common with any policy to increase the use of farm wastes, many farms are likely to prefer to apply inorganic nutrients as they represent an easily stored, accessible and reliable source of nutrients.

Where slurry and FYM is not currently used on farms, specialist equipment or contractors may be required. However, many farmers are nervous about using contractors, since they may damage soil structure, not run to planned time and may not apply the material evenly.

In addition to the logistical problems associated with the increased use of organic manures, the removal of P from compound (NPK) fertiliser does not lead to operational savings for the farmer (only that of the nutrient in the fertiliser). It is only when applying straights (ie Triple Superphosphate) that operational savings of around £7.5/ha spread over 2-4 years can be made (ie £1.90 to £3.75/ha/year). With organic waste spreading, the cost might be approx £1.00-2.50/tonne based on cattle FYM, or £40-60/ha (contractor charges) based on 40 t/ha application. A spreading cost of £1.25 per m^3 has been used throughout modelling.

Disposal costs

As already discussed, in estimating costs of the various options, the model by default distributes excess manures to available crop land (where this implies the displacement of inorganic P where necessary). Where modelling reveals that there is insufficient crop land for disposing of all manure in this way, the remainder must be disposed via some alternative route.

For the purposes of modelling, a value of £7.50/m^3 disposal cost has been used, though, as discussed in more detail in Section 4, the large volumes of manurial excesses that would result from introducing the options are likely to change the economics of manure disposal such that significantly cheaper options are likely to be available to farmers through innovation. The value of £7.50 per m^3 provides a suitable value to examine the interplay between the costs of disposal versus transport.

Nitrate vulnerable zones

In terms of the timescale of the instruments examined in this study, the forthcoming expansion of NVZs to cover all (or most of) the agricultural area of England has been taken into account. As such, the costs of implementing the various measures take into account the costs of implementing NVZs and, indeed, the extent to which manures are already transported and spread to on crop land. To ensure direct compatibility with the costs calculated for reducing P burdens, the costs of NVZs have been calculated in the same way, ie all excess manures generated by the introduction of NVZs (calculated by consideration of existing herd sizes, spreading areas, rates of annual excreta and N content of manures) are transported to crop areas. The transport distances used have been taken from the regulatory impact assessment.

These costs have been subtracted from the cost estimates under each of the options such that **all costs estimated here reflect the incremental cost increase of moving from NVZs** to each option in turn. **All costs are annual costs**.

A2.3 Nutrient surplus charges: Options 1a, 1b and 1c

A2.3.1 Overview of options

Option 1a

The aim of a nutrient surplus charge would be to dissuade farmers from operating their farms with a net P surplus. The objective is to prevent further soil nutrient enrichment with P by ensuring that soil P levels do not increase over existing levels. Modelling assumes that all farms reduce inputs equal to offtake.

Option 1b

The objective of Option 1b is to provide an incentive to halt applications of P to soils which are already [over] enriched with P and to redistribute the P to soils of (currently) low soil P status where its addition may bring agronomic benefits.

As such, Option 1b seeks to provide an incentive to 'run down' P enriched soils. Two scenarios have been applied. The first reflects the rules as set out in RB209 (which 'permit' applications on soils over index 2 for some crops) – hereafter referred to as the RB209 scenario. The second reflects no applications to soils over index 2 – hereafter referred to as the In2 scenario.

Option 1c

Option 1c represents a combination of Options 1a and 1b. Under 1a, farmers with soils of index 1 and below would be unable to apply greater levels of P than maintenance values. According to RB209 there is spare potential within safety margins to apply greater quantities for agronomic benefits. Option 1c would permit such applications by excluding from the charge farmers who can demonstrate (through soil testing and analysis) that applications of P are within RB209 recommendations.

A2.3.2 Costs of options

Modelling tonnages of excess manures and applying the costs of transport and disposal described above provides the indicative costs for each of the options set out in Table A2.2 according to low, medium and high transport distance scenarios. Total costs are provided in Table A2.3.

Comparison of the costs across the different options reveals that, with increasing strictness of limits and reduction of spreading areas from the adoption of RB209 or In2 under Option 1b results in reductions in transport and loading costs relative to Option 1a. This is because the model assumes that all excess material is transported and spread to crop land wherever possible. Under Option 1a, there is sufficient crop land to absorb all P generated by the excess manures (although this implies displacing the use of inorganic P almost entirely). Under the scenarios investigated for Option 1b, there is insufficient crop land owing to existing areas that are already over enriched or approaching index 2 where only (small) maintenance applications can be sustained within the 'rules'. The result of this is that less manure requires transport to crop land - resulting in a reduction in costs relative to Option 1a.

However, these cost differences are compensated by corresponding increases in disposal costs relative to Option 1a as, even with the total displacement in the use of inorganic P, there is still insufficient land to dispose of manorial P generated within the safety margins implied by the introduction of RB209 and/or In2.

Table A2.2: Estimated Annual Costs

Livestock Type	Transport and Loading Costs (£ Millions)			Off-Farm Spreading Costs (£ Millions)	Disposal Costs (£ Millions)
	Low	Middle	High		
Option 1a					
Cattle	67.9	121.6	288.8	-	-
Sheep	0.0	0.0	0.0	-	-
Pigs	1.9	5.3	9.0	-	-
Poultry	1.5	3.0	6.1	-	-
TOTAL	71.4	130.0	303.8	24.1	0.0
Option 1b RB209					
Cattle	39.8	79.6	205.2	-	-
Sheep	0.0	0.0	0.0	-	-
Pigs	1.0	3.3	4.9	-	-
Poultry	0.8	1.7	3.3	-	-
TOTAL	41.6	84.5	213.5	10.3	82.9
Option 1b IN2					
Cattle	25.4	47.5	117.4	-	-
Sheep	0.0	0.0	0.0	-	-
Pigs	2.0	105.4	186.0	-	-
Poultry	89.4	186.2	379.8	-	-
TOTAL	10.3	19.8	48.3	6.9	103.2

Option 1c (Option 1a and Option 1b RB209)					
Cattle	67.7	121.1	287.7	-	-
Sheep	0.0	0.0	0.0	-	-
Pigs	1.9	5.3	8.9	-	-
Poultry	1.5	3.0	6.0	-	-
TOTAL	71.1	129.5	302.6	24.1	0

Table A2.3: Total Annual Costs			
	Total Costs (£millions)		
	Low	Middle	High
Option 1a	95.4	154.0	327.9
Option 1b - RB209	141.8	184.7	313.7
Option 1b - IN2	158.2	202.7	336.4
Option 1c	95.2	153.5	326.7

In terms of total annual costs, comparison of costs under the various options results in some interesting trends depending on the distance scenario that is applied.

Clearly, and as already noted, the model implies the extreme application of livestock manures to crop land. What this reveals is that, for the volumes and transport distances involved, the annual costs are likely to be very large, and, owing to practical consideration associated with timings of application, crop damage, etc., probably impractical as a long term option.

In this respect, it is interesting to compare the differences in the higher range costs for each of the options. Here it can be clearly seen that either of the Option 1b scenarios have lower total costs than the less 'strict' Option 1a. The reason for this simply comes down to the distances involved and the interplay between the costs of disposal versus the costs of transport. This, of course, implies that, where transport distances are likely to be at the longer end of the spectrum, alternative disposal routes may be more cost effective for the farmer. This issue and suitable responses to it are described in more detail in Section 4.

A2.4 Option 2: Charge on feed phosphorus supplements and content

A2.4.1 Objective and principle of proposed instrument

As described in Section 2, there is an abundance of literature to suggest that livestock are overfed P to increase uptake and subsequent productivity. This, in turn, suggests that possible savings in P inputs as feed can be made and that this should reduce excretal P values. The objective of Option 2 is to provide an incentive to reduce feed P and, in so doing, excretal P values as part of a solution to reduce the national P surplus.

Extent and Cost of Reducing Feed P

In terms of the minimum nutritional requirements of livestock, estimates vary widely and no consistent figure has been found. The whole issue of feed and nutritional requirements is currently under review by the Animal Nutrition Working Group.

In addition, Best Available Technology (BAT) reference notes for the forthcoming licensing of pig and poultry units (in 2007) under Integrated Pollution Prevention and Control (IPPC) legislation are currently being prepared. These notes will define what constitutes BAT under IPPC and are to include information on feed P reduction by the combined use of reduced feed

P supplements and addition of phytase enzymes to increase the availability of P from phytate in the plant material that makes up the bulk of feed.

These technical notes are yet to be released and will not cover cattle (as these units will not be covered by IPPC). However, we have consulted the feed industry group that is contributing to the technical notes. We are informed by this group that all of the necessary feeds and phytase additives are already in circulation and there are no industry development costs associated with this option. In terms of the cost of these feeds and feed enzymes, they can often be cheaper than comparative feeds that offer the same balance of nutrition. As such, there is no cost, in terms of feed prices, to moving to these alternatives.

In terms of the level of reduction in excretal P, the feed industry group believed it was difficult to make exact estimates of the savings that are achievable, but estimated that a global 30 to 50% reduction in P inputs was possible without seriously affecting animal performance. Results of trial work also suggest that a reduction of 20% of P inputs is possible by the use of phytase enzymes without adversely affecting animal performance.
As such, this option can be considered a zero cost option on balance, indicating that only a notional addition product charge (if any) should be required to shift farmers' demand to lower P feeds. What really appears to be required is education and promotion of these feeds.

As noted in Section 4, the levels of P reduction possible with feed reductions are broadly similar to the levels achieved by Options 1a and 1c but are difficult to sponsor without reference to limits on P applications.

This implies their appropriateness as part of a package of responses to limits on P applications. To examine this costs have been modelled with respect to the scenarios laid out in Options 1b and 1c for interest. As such, the costs calculated reflect a combination of Option 1b and Option 2 (reductions of feed P inputs). For the purposes of modelling, the lower (30%) reduction in feed P inputs has been combined with the 20% estimate for the addition of phytase to provide a 50% reduction in feed P inputs.

A2.4.2 Costs of options

The costs and cost savings of implementing changes to feed P concentrations in Option 1b are provided in Tables A2.4 and A2.5. The effect that this has on Option 1b – RB209 is effectively to increase the quantity of manure that can be disposed of to crop land (as opposed to being disposed of by other means). The result of this is an increase in transport costs (owing to the transport of greater quantities of manures), compensated by a reduction in costs of disposal by other means.

The net result is net decrease in total costs of around £19 million (representing a 14% reduction) for the shorter transport distances. For the longer transport distances the net cost actually increases by around £15 million (representing an increase of around 5%) owing to the interplay between the costs of transport versus disposal.

Table A2.4: Overall Variable Costs of Application of Feed Savings to Option 1b – RB209					
Livestock Type	**Transport and Loading Costs (£ Millions)**			**Off-Farm Spreading Costs (£ Millions)**	**Disposal Costs (£ Millions)**
	Low	**Middle**	**High**		
Option 1b – RB209					
Cattle	39.8	79.6	205.2	-	-
Sheep	0.0	0.0	0.0	-	-
Pigs	1.0	3.3	4.9	-	-
Poultry	0.8	1.7	3.3	-	-
TOTAL	41.6	84.5	213.5	10.3	82.9
Option 2 (with Feed reductions)					
Cattle	56.7	103.8	251.2		
Sheep	0.0	0.0	0.0		
Pigs	1.6	5.2	9.0		
Poultry	1.8	3.4	6.6		
TOTAL	60.2	112.4	266.8	14.2	34.9
Change in Costs					
Cattle	16.9	24.2	46	-	-
Sheep	0	0	0	-	-
Pigs	0.6	1.9	4.1	-	-
Poultry	1	1.7	3.3	-	-
TOTAL	18.6	27.9	53.3	3.9	-48

Table A2.5: Total Variable Costs of Application of Feed Savings to Option 1b – RB209			
	Total Costs (£millions)		
	Low	**Middle**	**High**
Option 1b – RB209	141.8	184.7	313.7
Option 2	122.4	174.6	329.0
Savings	19.4	10.1	-15.3

The effect on Option 1c is quite different in terms of the nature and level of changes in costs. The costs and cost savings of implementing changes to feed P concentrations in Option 1c are provided in Tables A2.6 and A2.7. These reveal that, depending on the transport distances involved, savings of between 57% and 61% are possible by the alteration in nutritional P. From a broader perspective, this reveals that, whatever policy option and target level of P reduction required, the implementation of a reduced feed P programme on the part of the farmer is likely to be the most cost effective ‘first line of defence’ for reducing costs of manure disposal.

In area terms, the introduction of feed reduction would reduce the crop land required for spreading from 96% of total area to around 71% of total area.

Table A2.6: Overall Variable Costs of Application of Feed Savings to Option 1c					
Livestock Type	**Transport and Loading Costs (£ Millions)**			**Off-Farm Spreading Costs (£ Millions)**	**Disposal Costs (£ Millions)**
	Low	**Middle**	**High**		
			Option 1c		
Cattle	67.7	121.1	287.7	-	-
Sheep	0.0	0.0	0.0	-	-
Pigs	1.9	5.3	8.9	-	-
Poultry	1.5	3.0	6.0	-	-
TOTAL	71.1	129.5	302.6	24.1	0
			Option 2 (with Feed reductions)		
Cattle	26.1	47.6	118.3	-	-
Sheep	0.0	0.0	0.0	-	-
Pigs	1.8	5.2	8.7	-	-
Poultry	1.5	3.0	6.0	-	-
TOTAL	29.4	55.8	133.0	7.9	0.0
			Changes in Costs		
Cattle	-41.6	-73.5	-169.3	-	-
Sheep	0.0	0.0	0.0	-	-
Pigs	-0.1	-0.1	-0.2	-	-
Poultry	0.0	0.0	0.0	-	-
TOTAL	-41.7	-73.7	-169.6	-16.2	0.0

Table A2.7: Total Variable Costs of Application of Feed Savings to Option 1c			
	Total Costs (£millions)		
	Low	**Middle**	**High**
Option 1c	95.2	153.5	326.7
Option 2	37.3	63.6	140.9
Savings	57.9	89.9	185.8

A2.5 Option 3: Tradeable permit scheme for specific problem catchments

A2.5.1 Objective and operation of proposed instrument

As has been discussed under Options 1b and 1c, the application of soil testing and analysis and subsequent charges for applications in excess of RB209 (or In2) offers the potential to prevent further applications to soils of higher soil P index and to permit them to run down, while ensuring that any applications to lower index soils are within sustainable or acceptable limits.

The aim of the tradeable permit scheme is to identify CSAs and produce the necessary leverage to enforce the operation of soil testing in specific problem catchments. The objective within these trading zones (TZs) would be to ensure compliance with RB209 with the effect that any surplus P on farms within the TZ would have to be redistributed and applied at appropriate RB209 rates to soils of suitable soil P index (eg 0, 1, or 2 depending on crop). In cases where there remains a net TZ surplus of P, this surplus would have to be transported (in the form of manures) outside the boundaries of the TZ to other farms.

For the purpose of modelling, a scenario has been designed to reflect the situation in a fictitious CSA. The features of the CSA are set out in Section 4.4.

A2.5.2 Variable costs of options

Total annual cost estimates for transport, loading, spreading and disposal for the TZ are provided in Table A2.8 (note all costs £'000s per year). In line with the results of Option 2 (feed reductions), results are also presented for the TZ where feed reductions have been enacted by farmers within the zone.

Under the TZ without feed reductions, the total costs equate to an average of between £463 to £800 per [affected] holding per year. Implementation of reduced P nutrition changes the total annual costs for farmers significantly by enabling all generated cattle manures to be spread on available grassland. Remaining costs are to the seven pig and poultry units only resulting in costs of £642 to £1000 per pig/poultry unit per year.

Owing to the fact that the TZ represents an isolated area surrounded by land outside TZ compliance rules, it is likely that both feed reductions and transport and disposal will represent the least cost disposal options and that these options are practicable because of the smaller volumes generated. As such, these costs probably reflect the actual costs of the TZ, where costs of applying the rules nationwide (Options 1a, b, and c) are likely to significantly change the economics of manure disposal and, hence, the opening of new disposal routes that currently do not exist.

Table A2.8: Total Variable Costs Option 3

Livestock Type	**Transport and Loading Costs (£'000s)**			**Off-Farm Spreading Costs (£'000s)**	**Disposal Costs (£'000s)**
	Low	**Middle**	**High**		
			Option 3		
Cattle	61.2	94.5	127.8	-	-
Sheep	0.0	0.0	0.0	-	-
Pigs	4.1	6.7	7.3	-	-
Poultry	0.2	0.4	0.3	-	-
TOTAL	65.5	101.6	135.4	25.3	5.1
			Option 3 (with Feed reductions)		
Cattle	0.0	0.0	0.0	-	-
Sheep	0.0	0.0	0.0	-	-
Pigs	3.9	6.4	6.8	-	-
Poultry	0.2	0.3	0.3	-	-
TOTAL	4.1	6.7	7.0	0.4	0.0

Table A2.9: Total Variable Costs Option 3

	Total Costs (£'000s)		
	Low	**Middle**	**High**
Option 3	95.9	132.0	165.8
Option 3+feed	4.5	7.1	7.4