Title: Water Quality and Agriculture: Basic Measures **IA No:** Defra1819 **Lead department or agency:** Department for Environment, Food and Rural Affairs **Other departments or agencies:** Environment Agency	**Impact Assessment (IA)** **Date:** 29 October 2014 **Stage:** Consultation **Source of intervention:** EU **Type of measure:** Secondary legislation **Contact for enquiries:** Matthew Hampshire (matthew.hampshire@defra.gsi.gov.uk, 0207 2386167)

Summary: Intervention and Options

RPC Opinion: RPC Opinion Status

Cost of Preferred (or more likely) Option				
Total Net Present Value	**Business Net Present Value**	**Net cost to business per year** (EANCB on 2009 prices)	**In scope of One-In, Two-Out?**	**Measure qualifies as**
£698.5m	£391.5m	-£35.8m	No	NA

What is the problem under consideration? Why is government intervention necessary?

Water pollution from agriculture is a significant external cost to third parties such as water companies, recreational users of watercourses and members of the public. This is a market failure; in a free market there are limited incentives for farming businesses to adopt practices which would reduce water pollution. Effectively tackling water pollution requires a mix of regulation, voluntary action and financial incentives. The Water Framework Directive (WFD) requires us to introduce basic regulatory measures to control or prevent pollution. We have evidence of widespread pollution from phosphorus and sediment but no mandatory controls in place to tackle them. Government intervention is necessary to correct this market failure.

What are the policy objectives and the intended effects?

Our aim is to establish a clear regulatory baseline which represents good practice actions to meet the requirements of the Water Framework Directive (WFD). If governments sets and enforces a clear baseline this will encourage others (such as water companies and NGOs) to contribute further funds to incentivise additional actions to reduce diffuse water pollution from agriculture. Our aim is to reduce diffuse water pollution from agriculture, focusing on phosphorus and sediment, in a way that minimises costs to the farming sector and maximises benefits to the economy and the environment.

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)

Three policy options have been considered:

1. Do nothing more - does not meet WFD requirements, no further improvements in water quality, no additional costs.
2. Basic regulatory measures - meets WFD requirements, has net benefits for industry due to net cost savings, modest water quality improvements; preferred option due to offering best value-for-money and implementing WFD with most beneficial impacts for agricultural industry.
3. Enhanced regulatory measures - meets WFD requirements, more measures and higher costs to industry but with greater water quality benefits.In addition, we considered but rejected an improved voluntary approach, assurance schemes, incentivised measures, targeted regulation and extending cross compliance (all of which would not implement the WFD), and a maximal regulatory approach which would place a disproportionate burden on the industry.

Will the policy be reviewed? It will be reviewed. **If applicable, set review date:**

Does implementation go beyond minimum EU requirements?			No		
Are any of these organisations in scope? If Micros not exempted set out reason in Evidence Base.	**Micro** Yes	**< 20** Yes	**Small** Yes	**Medium** Yes	**Large** Yes
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)			**Traded:** 0	**Non-traded:** -0.43	

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible SELECT SIGNATORY: ..... Date: _____

Summary: Analysis & Evidence

Policy Option 1

Description: Do Nothing

FULL ECONOMIC ASSESSMENT

Price Base Year 2014	PV Base Year 2014	Time Period Years 10	Net Benefit (Present Value (PV)) (£m)		
			Low: 0	**High:** 0	**Best Estimate:** 0

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low				
High				
Best Estimate	0		0	**0**

Description and scale of key monetised costs by 'main affected groups'

Please see key assumptions section.

Other key non-monetised costs by 'main affected groups'

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low				
High				
Best Estimate	0		0	**0**

Description and scale of key monetised benefits by 'main affected groups'

Other key non-monetised benefits by 'main affected groups'

Key assumptions/sensitivities/risks **Discount rate (%)** 3.5

This is the 'do nothing' option against which other options are assessed.

BUSINESS ASSESSMENT (Option 1)

Direct impact on business (Equivalent Annual) £m:			In scope of OITO?	Measure qualifies as
Costs: 0	**Benefits:** 0	**Net:** 0	No	NA

Summary: Analysis & Evidence

Policy Option 2

Description: Regulation - package of 7 measures with net benefits to farm income. Preferred Option

FULL ECONOMIC ASSESSMENT

Price Base Year 2014	PV Base Year 2014	Time Period Years 10	Net Benefit (Present Value (PV)) (£m)		
			Low: 418	**High:** 1599	**Best Estimate:** 699

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	12.1		6.1	**64.7**
High	12.1	1	6.7	**69.9**
Best Estimate	12.1		6.4	**67.3**

Description and scale of key monetised costs by 'main affected groups'

Farm Businesses: repayments from required capital investment to implement new measures (PV of £25.3m). In addition, also costs of administration and familiarisation to new regulatory measures (PV of £40.4m). Net operational cost savings (see benefits below)
Government: Costs of enforcing new regulation (PV of £1.6m)

Other key non-monetised costs by 'main affected groups'

None.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	0		56.6	**487.6**
High	0	-	193.2	**1663.3**
Best Estimate	0		89.0	**765.8**

Description and scale of key monetised benefits by 'main affected groups'

Farm Businesses: Overall Net operational cost savings from more efficient use of inputs, though there are increased operational costs from implementing some measures (PV of net benefit of £457m). Environmental: Improvements in water and air quality. Improvements in water quality benefit water companies and the leisure industry. Members of the public also benefit more from use and non-use of watercourses. Improvements in air quality have health benefits and contribute to climate change mitigation (PV of total enviornmental benefits: £309m).

Other key non-monetised benefits by 'main affected groups'

Environmental: additional environmental benefits of two measures have not been quantified due to a lack of available data; likely to lead to improvements in water quality from reduced losses of nitrate and phosphorus . In addition, there will be further improvements in biodiversity from all measures which we have been unable to quantify.

Key assumptions/sensitivities/risks **Discount rate (%)** 3.5

Uptake: Central assumption of 80% uptake of costly measures, 90% uptake of farm income beneficial measures. Analysis includes scenarios of different levels of uptake. Baseline uptake: Baseline is full compliance with existing regulation, sensitivity analysis on current uptake where different. Methodology: FARMSCOPER modelling tool analysis of average farms across sectors of English agriculture to estimate net impacts of measures on farm income and environment. Analysis includes ranges of costs and benefits to reflect uncertainty.

BUSINESS ASSESSMENT (Option 2)

Direct impact on business (Equivalent Annual) £m:			In scope of OITO?	Measure qualifies as
Costs: 6.0	**Benefits:** 41.8	**Net:** 35.8	No	NA

Summary: Analysis & Evidence

Policy Option 3

Description: Regulation - overall package of 11 measures with net costs to farm income

FULL ECONOMIC ASSESSMENT

Price Base Year 2014	PV Base Year 2014	Time Period Years 10	Net Benefit (Present Value (PV)) (£m)		
			Low: 33	**High:** 1509	**Best Estimate:** 397

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	23.7		19.2	**189.3**
High	23.7	1	23.6	**226.4**
Best Estimate	23.7		21.4	**207.9**

Description and scale of key monetised costs by 'main affected groups'

Farm Businesses: repayments from required capital investment to implement new measures (PV of £153.7m). In addition, also costs of administration and familiarisation to new regulatory measures (PV of £52.0m). Net operational cost savings (see benefits below)

Government: Costs of enforcing new regulation (PV of £2.2m)

Other key non-monetised costs by 'main affected groups'

None.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	0		30.1	**259.0**
High	0	-	197.4	**1698.8**
Best Estimate	0		70.3	**605.3**

Description and scale of key monetised benefits by 'main affected groups'

Farm Businesses: Overall net operational cost savings from more efficient use of inputs, though there are increased operational costs from implementing some measures (PV of net benefit of £121.7m). Environmental: Improvements in water and air quality. Improvements in water quality benefit water companies and the leisure industry. Members of the public also benefit more from use and non-use of watercourses. Improvements in air quality have health benefits and contribute to climate change mitigation (PV of £483.5m).

Other key non-monetised benefits by 'main affected groups'

Environmental: additional environmental benefits of two measures have not been quantified due to a lack of available data; likely to lead to improvements in water quality from reduced losses of nitrate and phosphorus . In addition, there will be further improvements in biodiversity from all measures which we have been unable to quantify.

Key assumptions/sensitivities/risks **Discount rate (%)** 3.5

Uptake: Central assumption of 80% uptake of costly measures, 90% uptake of farm income beneficial measures. Analysis includes scenarios of different levels of uptake. Baseline uptake: Baseline is full compliance with existing regulation, sensitivity analysis on current uptake where different. Methodology: FARMSCOPER modelling tool analysis of average farms across sectors of English agriculture to estimate net impacts of measures on farm income and environment. Analysis includes ranges of costs and benefits to reflect uncertainty.

BUSINESS ASSESSMENT (Option 3)

Direct impact on business (Equivalent Annual) £m:			In scope of OITO?	Measure qualifies as
Costs: 18.8	**Benefits:** 11.1	**Net:** -7.7	Yes	IN

Evidence Base

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1. Introduction

1a. Policy Background

Agriculture and water are both critical to life and livelihoods. We want to improve the water environment and support a thriving farming sector. The Water Framework Directive (WFD) requires the UK to have basic regulatory measures to prevent and control diffuse water pollution from agriculture. Failure to implement Directive requirements puts Member States at risk of infraction proceedings. At present in England, there is a mix of regulatory controls with no mandatory controls on phosphorus or sediment. This Impact Assessment considers options for introducing regulatory controls in order to meet the requirements of the WFD.

Farming has an impact on the water environment; its direct interaction with soil, water and air means that inevitably nutrients, sediment, pesticides and faeces are lost to the environment. However, the problem arises when the scale of the inputs to improve production results in negative impacts on the water environment and so become unsustainable. This impact assessment considers a small set of basic actions that farmers can carry out to help mitigate these impacts.

In England, 29% of water bodies (1,429 out of a total of 4,982) are currently at good or better overall WFD status[1]. The agriculture and rural land management sector is responsible for 30% of those water bodies failing to meet their WFD objectives[2] (see Figure 1).

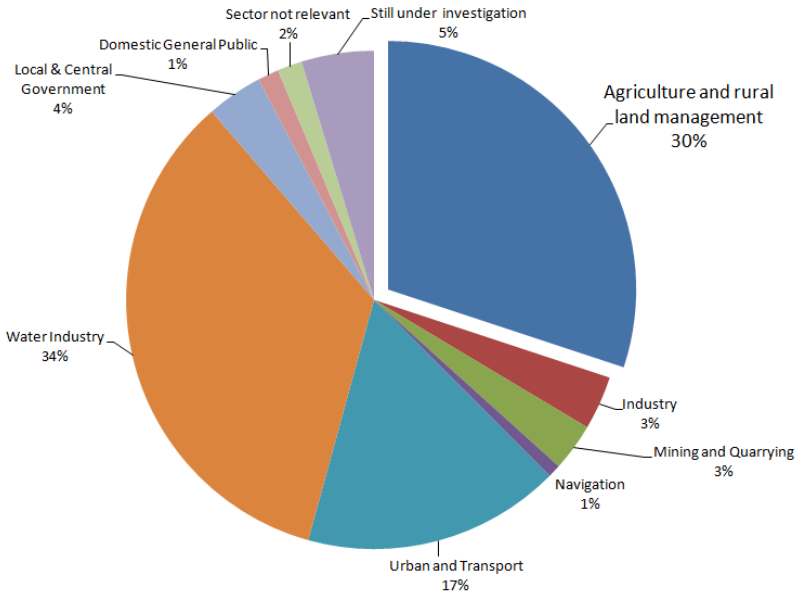


Figure 1: Sectors responsible for WFD Not Achieving Good Status (RNAGS). Based on number of individual counts, not number of water bodies.

Many farmers already take steps to safeguard the water environment and keep their soils and nutrients on the fields as it makes good economic and environmental sense. However, others don't for a variety of reasons, for example due to lack of skills, ability or awareness or where measures are costly, or simply because they do not wish to. In addition to meeting our legal requirements, these proposals are about communicating, advising and supporting all farmers to raise the baseline level of mandatory farming practice, to build the industry's future resilience (to challenges such as climate change) and to safeguard our natural environment.

[1] This figure covers all surface waters (rivers, canals, surface water transfers, lakes, estuaries and coastal waters) and ground waters, and is based on Cycle 2 water bodies and the New Building Block classification. These changes reflect: improvements to biological classification methods; improvements to environmental standards; refreshed designations of heavily modified water bodies; and adjustments to the number and shape of water bodies.

[2] WFD Reasons for Not Achieving Good Status (RNAGS) data, May 2014 i.e. reasons for water bodies predicted to be not achieving WFD good status objectives in England in 2015. Individual water bodies can have more than one reason for failure.

This impact assessment considers proposals to amend regulation to prevent and reduce diffuse water pollution from agriculture in a way that minimises costs to the farming sector and maximises benefits to the economy and the environment. In so doing, these proposals will implement relevant parts of the Water Framework Directive which requires us to have basic regulatory controls applicable to all to prevent pollution.

Two options have been shortlisted for consideration; our preferred option (2) is exempt from One-In-Two-Out requirements as it is required to complete transposition and implementation of the Water Framework Directive.

Subject to the outcome of this consultation, any regulation would be laid in early 2016 with a common commencement date of 1 October 2016. We propose to allow a transition period to give businesses sufficient time to familiarise themselves with the requirements and adapt their farming practices. The proposed implementation approach would be coupled with actions to improve compliance with existing rules to deliver the greatest benefits.

1b. The Water Framework Directive

The WFD established an integrated process for managing pressures on the water environment in order to safeguard our water resources. Article 11 specifies that Member States should establish a programme of measures (comprising basic regulatory measures and supplementary measures) to meet the environmental objectives of the Directive. Government has a choice on the balance between regulation, voluntary approaches and incentives; however their combined impact should deliver 'good status' for all water bodies. Failure to comply with WFD requirements and define our basic regulatory measures as required in article 11.3 would lead to the risk of infraction proceedings against the UK.

This impact assessment focuses on the requirement for 'basic measures' '*for diffuse sources liable to cause pollution, measures to prevent or control the input of pollutants'* (Article 11.3(h)) and the gaps in the existing regulatory framework.

The existing regulatory framework consists primarily of:

a. the Nitrate Pollution Prevention Regulations, which aim to reduce agricultural nitrate pollution and the risk of further such pollution occurring. The regulations implement the Nitrates Directive and only apply within designated Nitrate Vulnerable Zones (58% of England).

b. the Silage, Slurry and Agricultural Fuel Oil (SSAFO) Regulations, which set construction standards for storing silage, livestock slurry and agricultural fuel oil to minimise the risk of water pollution. These apply nationally, but are not relevant to silos, slurry storage systems or fuel storage tanks that were constructed before 1991 (about 40 to 50% of farmers).

c. cross-compliance requirements for those farmers claiming direct payments (94.6% of farmers).

The gaps identified both in terms of pollutants and geographic coverage were on **phosphorus** and **sediment** where no mandatory controls currently exist**.**

Phosphorus: The bulk of activity is either voluntary (e.g. through industry led initiatives such as Tried and Tested, which promotes nutrient management planning) or incentivised (e.g. through Rural Development Programme funds). On their own these will not achieve sufficient reductions on phosphorus nor do they meet the requirement for basic regulatory measures in the WFD.
Phosphorus is tackled in part indirectly through the Nitrates Regulations, the SSAFO Regulations[3] and through agri-environment baseline entry requirements (which have a

[3] Water Resources (Control of Pollution) (Silage, Slurry and Agricultural Fuel Oil) (England) Regulations

requirement for rules on phosphorus). However the Nitrates rules apply to only 58% of farmers and agri-environment schemes are limited and voluntary so coverage cannot be guaranteed.

Sediment: Sediment was also found to be a significant contributor to water bodies failing the WFD due to agriculture with no mandatory controls in place. Going forward this will be covered by new cross compliance requirements which fill the existing gap. However, as farmers do not have to claim the Basic Payment Scheme it does not have full coverage (currently approx. 94.6%). We are therefore proposing that farmers not claiming the Basic Payment Scheme should take good practice actions on soils.

Member States have some discretion in how they implement this requirement and as such this impact assessment considers two key options; the first, our recommended option (2), is 'light touch' with a short list of good practice actions which will become mandatory. It focuses on implementation that is cost beneficial for the industry with some water environment benefits. The second option (3) has additional actions for farmers that will become mandatory with some cost to the industry and delivers greater water environment benefits.

1c. Key Pollutants

Phosphorus

Phosphorus is a key nutrient, originating from organic (animal wastes) and inorganic (manufactured) fertilisers. It typically enters the water environment when applied on land in quantities exceeding plant uptake. Agricultural phosphorus is more predominantly transferred to the water environment by surface runoff, but also through leaching across the soil profile and through land drains. The most recent national source apportionment data indicates that agriculture contributes around 25%[4] of the total phosphorus load to rivers.

Phosphorus pollution can result in eutrophication (excessive plant growth due to the addition of large quantities of nutrients, mainly phosphorus in freshwater), killing aquatic organisms, affecting drinking water supplies, clogging waterways, blocking sluices, and disrupting flood defences. Defra analysis suggests that the damage caused by agricultural losses of phosphorus imposes costs of £16-134m each year on the natural environment[5].

Sediment

Sediment losses are indicative of soil degradation, which is a major concern for individual farms and for the future of productive farming across the country. The key activities contributing to sediment losses through soil erosion are agriculture and rural land management.

The most recent national source apportionment data indicates that 72-76%[6] of the sediment load to rivers in England is due to agriculture.

Soil erosion is a natural event, but rates of soil loss are hugely exacerbated by certain farming practices, in particular when bare soil is exposed to intense rainfall following planting or harvesting. Practices which commonly increase the risk of sediment pollution include the growing of high risk crops on sloping land, large numbers of livestock on wet fields causing compaction and bankside erosion, the wrong timing of farming operations such as cultivating and harvesting in wet conditions and poor post-harvest management of the soil.

The resulting sediment loss can have several key impacts. Firstly, it carries other pollutants with it, particularly phosphorus, generating multiple pollution pressures. Secondly, it has negative impacts on aquatic ecosystems by degrading habitat condition and smothering flora, fauna and

[4] Update to River Basin Management Plans, supporting information. Pressure Narrative. Phosphorus and freshwater eutrophication Environment Agency October 2014.

[5] Defra analysis of environmental benefits from improved water quality – see Annex C for more details.

[6] Ongoing Defra project WQ0223. Initial estimates not accounting for mitigation measure u

other life. It can also reduce navigability and lead to the infilling of dams and reservoirs. It can increase flood risk, through reduced flow in rivers affected by erosion and delivery of sediment from agriculture into water courses.

Consequently, sediment is a serious agricultural pollutant of the surface water environment. Defra analysis suggests that the damage caused by agricultural losses of sediment impose costs of £75-97m each year on the natural environment[7].

Other pollutants

Nitrogen

As with phosphorus, nitrogen is an important component of organic and inorganic fertilisers. It transfers to the water environment by leaching through the soil profile, surface runoff and losses through land drains.

58% of England is designated as Nitrate Vulnerable Zones due to the level of nitrates in water. In these areas, farmers must comply with requirements of the Nitrates Action Programme to reduce nitrate losses to the water environment. Nitrate can contribute to eutrophication and affect human health, imposing a significant treatment costs for water companies to reduce nitrate levels.

As separate regulations exist to tackle nitrate pollution, further rules on nitrate are not part of the proposed regulatory changes. However, reductions in nitrate pollution will be an important indirect benefit of these proposals.

Pesticides

Pressures from pesticide use occur primarily in areas for drinking water protection. Differences in the sources of these pressures, their spatial distribution, appropriate mitigation measures and the underlying legal framework mean that these issues are being considered through a separate but parallel impact assessment.

Faecal bacteria

Another important agricultural pollutant of the water environment is faecal bacteria. The presence of certain faecal bacteria (faecal indicator organisms, e.g. coliforms, Escherichia coli and enterococci) in water indicates that human health could be affected through ingestion when drinking, bathing (or other water based activity) or consuming shellfish. In rural catchments, agriculture is a key contributor to the presence of microbial pathogens in the environment. Around 33-44 bathing waters[8] and 23 shellfish waters[9] are at risk due to agriculture. The location of these pressures is much more spatially restricted and these are not the primary target of the proposed regulations. Nonetheless, reductions in faecal bacteria pollution will be an important indirect benefit of these proposals and help compliance with the Bathing Water Directive

Future pressures

The agricultural industry is under ever increasing pressure to increase food production to meet the needs of a growing global population. At the same time we will be increasingly feeling the impacts of climate change giving us hotter, drier summers and wetter winters with more extreme

[7] Defra analysis of environmental benefits from improved water quality – see Annex C for more details.

[8] The range in the number of bathing waters at risk from agriculture reflects two points of uncertainty:

- There are 7 bathing waters considered at risk based on 2012 data that had not been subject to a full assessment of likely sources and subject to further investigations. Statistical modelling indicates a significant contribution from agriculture but this needs further supporting evidence.
- Of the remaining 37 at risk bathing waters, all of them are at the bottom of catchments where agriculture contributes significantly to faecal indicator organism losses. Some catchments drain to multiple coastal sites and local investigations suggest that agriculture is not always a significant source of pollution in all of them. There are a further four sites (at the outlet of the Ribble) where local investigations and modelling disagree, but other sites at the outlet of the same catchment where the evidence agrees. We therefore reflect this in the range of sites at risk from agriculture.

[9] The contribution from agriculture to shellfish water failures is based on the results of local investigations, not detailed modelling.

weather events such as storms, flooding and droughts. These will increase the risk of soil erosion, water pollution and damage to farm infrastructure, stock and crops[10]. There will be less water available for crops and livestock, and with less water for dilution, pollution levels can be expected to rise. If not managed carefully these changes have the potential for significant negative impacts upon the natural environment and the farming sector. The proposed measures will support the resilience of the industry in the face of these future challenges.

[10] See The Climate Change Risk Assessment Summary: Agriculture for more details, available here: http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=15747

2. Policy objective

Our aim is to establish a clear set of regulatory baseline good practice actions that meet the requirements of the Water Framework Directive. These will provide a foundation for water companies, NGOs, voluntary actions and government incentives to build upon to deliver further reductions in pollution. Our aim is to reduce diffuse water pollution from agriculture, focusing on phosphorus and sediment, in a way that minimises costs to the farming sector and maximises benefits to the economy and the environment. These ambitions are reflected in the following objectives:

2a. A healthy water environment

Our policy objectives under the Water Framework Directive are to:

1. Avoid deterioration in our water bodies.
2. Focus action on our protected areas (such as bathing waters, shellfish waters, drinking water protected areas and Natura 2000 areas).
3. Aim for good status.

These proposals should provide basic actions to deliver the first objective, to avoid deterioration of our watercourses over the course of the next river basin management planning cycle (2015-21). In doing so, they should also facilitate progress towards achieving the protected area and 'good status' objectives under the Water Framework Directive. At present we do not have evidence on the effect of these proposals in contributing towards no deterioration, however more data should be available next year for the final impact assessment.

2b. A sustainable and competitive farming industry

Policy proposals will support a sustainable and competitive farming industry. This means an industry that increases its productivity and competitiveness, exploits market opportunities at home and abroad and enhances its long-term resilience. Specifically, policy proposals aim to increase the resource efficiency of farm businesses, increase their resilience, including to future challenges such as climate change, and boost its reputation at home and abroad. Government will do so in a way that minimises regulatory burdens on business. Section 5 examines the net benefits of these proposals to the farming industry.

2c. Wider environmental objectives

Within the scope of objectives (a) and (b), policy proposals seek to deliver multiple environmental benefits, including tackling air pollution, biodiversity loss, greenhouse gas emissions, soil loss and flooding. For example, reductions in water pollution help improve aquatic habitats. Measures relating to slurry and manure use can directly reduce ammonia emissions and improve air quality.

2d. Provide proportionate enforcement tools

The proposed new set of rules would equip the relevant enforcement agencies, with the appropriate and proportionate legal tools for tackling diffuse pollution which, by its very nature, is a series of small events. The current tools such as anti-pollution works notices and Environmental Permitting Regulations lend themselves much more to addressing large scale point source pollution events.

3. Rationale for intervention

Section 1 described the policy background and key agricultural pollutants, the impacts on the water environment and the gaps in the legislative framework for addressing them. These centre on phosphorus and sediment pollution. This section sets out the case for Government intervention and notes the wider benefits for agriculture and the environment.

3a. Market failure

Water pollution from agriculture can be considered as arising from a market failure due to "negative externalities". Agricultural losses of pollutants such as phosphorus and sediment to water impose a substantial cost on third parties. These spillover effects or negative externalities are not accounted for by producers, meaning that without government intervention producers would not implement socially beneficial measures which would reduce water pollution from agriculture. As a result, levels of water pollution are above the socially optimal level because of a market failure.

Water pollution from agriculture has a spillover effect on a number of third parties:

- Water companies must use costly processes to remove agricultural pollutants to produce safe drinking water
- Members of the public obtain reduced recreational value from use of watercourses, e.g. angling
- Members of the public suffer increased risk of illness when bathing
- Members of the public obtain reduced non-use benefits from watercourses due to ecosystem damage from agricultural water pollution and eutrophication of freshwater and marine water
- Commercial shellfisheries and fish farms[11] suffer an increased risk of contaminated produce from unclean water and therefore a loss of sales
- The tourism sector could suffer losses from beaches that are closed due to failing bathing water standards[12]
- Other farmers suffer loss of revenue due to potential health risks if polluted water is abstracted unknowingly and applied to sensitive crops, such as salad. Poor water quality may also prohibit the planting of certain crops

The value of economic benefit if agricultural water pollution was substantially reduced has been estimated in a Defra project (WT0706)[13]. These have been uprated to 2014 prices and are shown below in Table 1. This reviewed numerous other studies that valued the cost savings to the water industry and the public's willingness-to-pay for improvements in the water environment. It includes the first four spillover effects shown in the list above. By assuming symmetry between the benefits from mitigation and costs of pollution, these values can provide an estimate of the damage caused to third parties by agricultural water pollution. Indicative estimates of the damage caused by agricultural water pollution are shown in the table below.

[11] These sectors are worth c£14.8m and c£17m p.a. respectively (2011 figures).

[12] For example in the Northwest if all 33 bathing waters pass the minimum standard of the new Bathing Water Directive, the resulting increased visitor numbers might lead to an estimated additional £12.7m per year. However, should they fail, reduced visitor numbers could claim a cost of £1.3bn over 15 years. (source: Economic Impact of the Revised Bathing Water Directive: NW, URS, 2012)

[13] The report is available here - http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=13653&FromSearch=Y&Publisher=1&SearchText=wt0706&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description

Table 1: Spillover Costs of Agricultural Water Pollution (WT0706)

Spillover effect of agricultural water pollution	Annual cost to third parties (£m, 2014 prices)
Drinking water quality (surface and groundwater)	16-86
Lost recreational value due to worse water quality	18-46
Poorer fishing	18-45
Freshwater eutrophication	203-399
Marine eutrophication	Not available
Bathing water quality	30-54
River ecosystems and natural habitat impacts	447-626
Wetland ecosystems and natural habitat impacts	16-51

To reduce these costs of water pollution, it is necessary to increase the use of basic mitigation measures which are not adopted to a sufficient extent in a free market. Given the market failure, government intervention is needed to achieve the required level of take-up of basic mitigation measures. To tackle the wide issue of water pollution government will use all of the tools at its disposal, including incentives and voluntary approaches. However, regulation is an important component of the overall picture to establish a clear baseline. Moreover, to implement the relevant parts of the Water Framework Directive, gaps in the current regulatory framework need to be addressed.

3b. Barriers to uptake of beneficial practices

Some mitigation measures also have economic benefits for farmers. The benefits to a farmer of taking action can include:

- Greater efficiency of the farm business through reduced inputs (manufactured fertilisers/feed)
- Increased business resilience to future challenges such as climate change (by reducing soil erosion risk)
- Reduced business risks (from prosecution, loss of single farm payment, uninsured losses and claims)
- Improved legacy (soil losses may affect future productivity)
- Improved reputation (both locally and wider marketing benefits)

However, despite these benefits, take-up of good practice measures is far from universal in the farming sector. Annex D shows which methods have beneficial impacts on farm income and estimated rates of current uptake.

Neoclassical economic theory predicts that a rational profit maximising business with perfect information will make use of all possible opportunities to increase its net income. This implies that uptake of all business practices which increase farm income should be universal throughout the farming sector. However, not all of the above assumptions apply to all segments of the farming sector; the sections below discuss why farm businesses may not implement beneficial practices.

Profit Maximisation

Social research into segmentation within the agriculture industry found that there is a large degree of variation within the industry in the motivations and drivers of farm business activity[14]. Some parts of the farming industry have a clear focus on profit and investment, and lead take-up of innovative and beneficial practices within the industry. These businesses are closest to the rational profit-maximising model of classical economic theory, though they may also have other motives for business decisions. However, other segments are much more likely to aim for other objectives when making business decisions, including environmental, social, family and lifestyle factors. These businesses in effect aim to achieve a satisfactory level of profit instead of profit maximisation. For example, in the Farm Business Survey Business Management Practices module in 2011-12[15], farmers were asked why they did not carry out business planning, benchmarking or management accounting practices. Nearly half of farmers were 'not interested' despite evidence that these practices are linked with higher farm business performance. Analysis on segmentation shows that businesses associated with profit satisfaction were much less likely to pay for this advice[16]. If these businesses are already reaching their 'satisfactory' level of profit, then they will not be motivated to research different practices or strive to improve practices even if this would reduce costs.

Behavioural characteristics

There is also the potential for other behavioural characteristics to influence uptake of beneficial business practices. Previous Defra analysis has argued that behavioural characteristics could explain why businesses and individuals do not implement beneficial energy efficiency measures.[17] This could also apply to farm businesses and nutrient management; behavioural economics literature have identified characteristics such as loss aversion[18] and time inconsistency[19].These characteristics may mean that farm businesses place a large amount of emphasis on the initial investment (either in terms of capital spending or time and 'hassle') and excessively discount future benefits.

Informational Barriers

Information on the benefits of measures is imperfect because

- Farm income is highly variable due to the weather and other factors, so it's difficult to obtain clear information on the benefits of practices on the bottom line.
- Farm businesses are small and often geographically isolated, meaning that it's difficult to obtain information on business management.

Research on measures to reduce emissions of GHGs from agriculture included analysis of on-farm implementation of measures which both reduced emissions of GHGs and increased farm income[20]. In this analysis, even though these measures did show a benefit to farm income over several years, the authors commented that "measuring the direct economic and environmental effect of implementing a GHG mitigation plan on farm is not a straightforward task"[21]. This is because the economic effects of methods are often small relative to large changes in farm income between different years due to factors such as the weather, price movements and

[14] Source: Rural Business Research / University of Nottingham "Analysis of Farmer Segmentation across farms contributing to the Farm Business Survey: A Pilot Survey". Available here: http://www.fbspartnership.co.uk/documents/Analysis_of_Farmer_Segmentation_Research_within_the_Farm_Business_Survey.pdf

[15] https://www.gov.uk/government/statistics/farm-business-management-practices

[16] See above reference.

[17] Defra (2013): Behavioural Economics in Defra: Applying Theory to Policy

[18] Where an individual places less value on gaining new benefits than on not losing an equivalent amount which they already possess. See above reference.

[19] Where an individual places excessive weight on upfront costs and benefits, leading them to continually delay taking action they believe is beneficial. See above reference.

[20] http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17814

[21] See p xii of the above reference.

exchange rates. Where the effects of implementing good practice are difficult to identify, the lack of a 'feedback loop' acts as a barrier to the greater uptake of beneficial measures.

A further informational barrier exists because farm businesses are small and often geographically isolated. Many farm business managers are the sole employee of the business, meaning that their time is dominated by day-to-day management and that they have little time to consider changes to the farm business in detail. For example, when farm businesses were asked the reasons for not adopting a fertiliser recommendation system, 39% of farm businesses cited "needing more time" as a reason[22]. In addition, an industry structure made up almost entirely of small businesses means that it is difficult to achieve effective dissemination of good practice through the industry. As a result, the information available to farm businesses on good practice is often imperfect, which means that beneficial practices are adopted at a less than socially optimal rate of uptake.

Government Intervention

The factors listed above may explain why some businesses do not adopt beneficial business practices. Alone, these factors are not necessarily a rationale for Government intervention. However, in the presence of environmental externalities (as shown in Section 3a), there is a rationale for government to intervene to increase uptake of measures which are both environmentally and economically beneficial.

Annex D contains a more detailed discussion of the measures which have net beneficial impacts on farm income, including analysis on the effects of these measures on smaller farms. Where these measures are less beneficial or are costly for smaller farm holdings, the predicted impact on smaller farms has been used when modelling the value for money and cost impacts of measures. In addition, we have also conducted sensitivity analysis on the costs of measures. The analysis for this can be seen in section 5f.

[22] 2013 Farm Practices Survey.

4. Description of options considered (including do nothing)

This section reviews all the policy options that have been considered and explains the rationale for selecting the most viable options for a full cost-benefit analysis. The complete range of alternative policy mechanisms was explored and the proposed options selected on the basis of those standing the best chance of meeting the policy objectives. The complete policy development process has drawn on advice from agricultural industry representatives and wider stakeholders through workshops and expert groups. This transparency has achieved some consensus in the selection of proposed measures and mechanisms.

4a. Responsibility for addressing the issue

There are a number of sectors that contribute to water pollution although the most significant share comes from agriculture and rural land management (contributes to 30% of failures to reach good status) and from water companies (34% of failures)[23].

4b. Stakeholder engagement

Government has engaged the views of industry, water companies and environmental representatives throughout the development of these policy proposals, both in considering the evidence of the issue, resolving the most appropriate methods to address the problem and the most effective approach to implementation. In 2013 the Environment Agency (EA) commissioned consultants to develop a set of basic measures on their behalf. The measures were reviewed by industry representatives and considered those that might be applied nationally to reduce diffuse water pollution from agriculture. In parallel with this, Government drew on EA water quality data and sought evidence from other stakeholders, e.g. NFU and RSPB, to establish the extent of the problem and the specific pressures (sources) of the pollution. Two workshops were then held during late 2013 to discuss the evidence and preferences on how to tackle the problem. A technical group was convened in December 2013 to consider a refined set of basic measures.

At the workshops Defra agreed with stakeholders a broad set of guiding principles which should be followed if introducing new regulation. These included proportionate enforcement, establishing a level playing field at catchment scale, making sustainable land use decisions, recognising the importance of both food production and sustainable water management and improving resilience in the face of climate change. These issues have been closely considered in establishing the proposals set out in this IA. A detailed timeline of stakeholder engagement and those involved is set out in Annex G

4c. Developing the proposed basic measures

The proposed set of basic measures was developed from a strong evidence base of on-farm actions that reduce diffuse water pollution[24]. Following the stakeholder engagement mentioned above, the last filter was to select measures that focus on reducing phosphorus and sediment losses, identified as gaps in our Water Framework Directive implementation. The results of applying these measures were identified through a farm nutrient modelling tool, FARMSCOPER[25] and by agriculture industry experts.
Having determined a potential range of measures that would address key pollutants from agriculture, we sought to group them into measures that would be broadly cost beneficial to the farming industry and those that would impose some costs.

[23] Environment Agency data, May 2014.

[24] The ADAS Inventory of Mitigation Methods and Guide to their Effects on Diffuse Water Pollution, Greenhouse Gas Emissions and Ammonia Emissions from Agriculture formed a core part of this evidence http://www.adas.co.uk/LinkClick.aspx?fileticket=vUJ2vlDHBjc%3d&tabid=345

[25] See Annex C for more information on FARMSCOPER.

4d. Options considered

The options initially considered vary from a 'do nothing' baseline, for comparing the relative costs and benefits of all the other options, to a high impact set of measures that would deliver significant benefits for the water environment, although at significant cost to some farmers. Between the two are a set of regulatory measures that would present no overall net cost to the farming industry and an enhanced set of measures with greater potential costs for some farmers but greater water quality benefits. Both options 2 and 3 should close out the infraction risk on Article 11.3h of WFD. Options 4 – 9 (Annex A) were rejected as they did not meet the stated policy objectives. The section below expands on the recommended options and Annex B describes the measures involved in full detail.

Our proposed measures are focused on tackling phosphorus and sediment pollution. However, given the integrated nature of diffuse pollution they also tackle the other pollutants highlighted above and provide a clear baseline of good practice actions applicable to all.

The options considered, in increasing order of intervention, are:

- **Option 1. Do nothing more**

This would not implement Water Framework Directive requirements, but would impose no direct costs on the agricultural industry. The farming industry would suffer sub-optimal resource efficiency without action to promote uptake of cost-saving measures (given that some farmers do not take up resource efficient measures).

- **Option 2. Basic regulatory measures – the recommended option**

This option comprises mandatory measures to manage fertiliser use (a fertiliser recommendation system) and to reduce the risk of pollutant losses to watercourses. Livestock pollution risks are addressed through feed planning, locating feeding stations to avoid soil compaction and measures that address features allowing rapid transfer of pollutants to water courses such as tramlines. It would create net savings for the industry as a whole or for individual sectors, but some farms would bear net costs. It would secure modest water quality improvements and help prevent deterioration of the water environment in the face of future pressures such as climate change. It would implement the requirements of the Water Framework Directive.

- **Option 3. Enhanced regulatory measures**

In addition to the option 2 measures, this option includes mandatory restrictions on spreading fertilisers between mid-October and February and exclusion of livestock from watercourses. It would secure greater benefits for the water environment and society as a whole and promote greater future resilience e.g. from climate change impacts, but at increased cost to the industry. It would implement the requirements of the Water Framework Directive.

4e. Silage Slurry and Agricultural Fuel Oil Regulations

The proposed measures around storage and application of fertilisers (in option 3) include requirements to avoid spreading manures at high risk times. In order to meet this requirement, farmers will need to have arrangements in place for managing their slurry and manures when conditions are inappropriate for spreading. For most, this will mean having sufficient storage capacity for their manure.

At present the Water Resources (Control of Pollution) (Silage, Slurry and Agricultural Fuel Oil) (England) Regulations 2010 (or SSAFO regulations) require all farmers who upgrade their storage facilities to ensure that they have at least 4 months' capacity after the upgrade. Those who have not upgraded their facilities since 1991 do not have to comply with these rules unless served with a notice to do so by the Environment Agency.

The industry-led Slurry Working Group concluded that 5 months' storage was required to follow good practice guidelines and avoid spreading during inappropriate conditions. Whether regulation might be needed to ensure that all farmers have the recommended storage volume is under consideration. Any proposals for such regulations will form part of the nitrates consultation next year. For the purposes of this consultation, in line with the Slurry Working Group's recommendation we have assumed that 5 months' storage would be required for farmers to be able to comply with the proposed limitations on spreading that are included in option 3.

4f. Detailed description of measures

Developed through informal engagement with farming industry representatives, Government has sought to introduce basic good practice actions, or mitigation measures, which tackle agricultural pollution at source. The proposed measures have been refined by using a cost-effectiveness risk assessment framework, as demonstrated recently in Defra funded projects such as the Demonstration Test Catchments. This approach involves identifying the source of the pollutants (e.g. manure spreading), the water pathways through which pollutants move through a landscape (e.g. surface runoff from farm tracks) and the aquatic ecosystems (e.g. rivers or groundwater) on which they impact.

Mitigation measures targeting pollutant sources are often cost-effective at a farm level, in particular when they involve better matching nutrient inputs to crop needs by saving on the amount of inorganic fertilizer spread on land and hence reducing unwanted pollutant losses to air or water. Nevertheless, implementing mitigation measures at the pollutant source alone is not always enough to ensure good water quality in receiving water bodies. This is for example the case with certain farming practices such as cultivating along the slope which increases the risk of quick transfer of pollutants from a source to a receiving watercourse. In such cases, mitigation measures will usually aim to develop barriers to stop or slow down pollutant transfer in the landscape.

The proposed mitigation measures in this assessment can be grouped into the following three categories[26]:

1. **Inorganic and organic fertiliser management**
These measures rationalise the spreading of fertiliser to maximise crop uptake and minimise unwanted losses to air and water.
2. **Livestock management**
These measures control livestock to avoid degradation of soil (e.g. trampling of soil leading to increased losses of pollutant in surface runoff) or reducing nutrient and faecal indicator organisms input to land.
3. **Soil management**
These measures target agricultural practices that increase the risk of pollutant losses to surface water and groundwater (e.g. presence of bare ground subject to sediment losses in winter). Those farmers meeting the Good Agricultural and Environmental Conditions (GAEC) 4 and 5 as a requirement for receipt of the Basic Payment Scheme (94.6% of farmers) will be deemed to be complying with these rules.

Table 2 lists the two preferred options and details rules that farmers would have to comply with under the two options.

[26] S.P. Cuttle, C.J.A. Macleod, D.R. Chadwick, D. Scholefield & P. M. Haygarth, P. Newell-Price, D. Harris, M.A. Shepherd, B.J. Chambers & R. Humphrey. An Inventory of Methods to Control Diffuse Water Pollution from Agriculture (DWPA) USER MANUAL. September 2006. Defra Project ES0203

Table 2: Option 2 and 3 measures grouped according to farm activity

Option 2 measures (preferred option)				
Measure type	**Mitigation measure**	**Rationale and environmental impact**	**Target water pollutants**	**Source or Pathway**
1. Inorganic and organic fertilizer management	1a. Field manure storage is located at least 10m from a watercourse	Reducing the risk of pollutant losses in surface runoff by providing sufficient opportunities for pollutants to be incorporated in crops or retained or attenuated at the soil surface or through leaching in the area between manure storage and watercourses	N, P, FIOs, BOD[27]	Source
	1b. Use a recognized fertiliser recommendation system, taking soil reserves and organic manure supply into account	Reducing diffuse losses of pollutants to surface water and groundwater by avoiding spreading inorganic and organic fertilizer above crop (including grass) needs, when accounting for soil nutrient stocks, as well as pH and organic matter supplies	N, P	
	1c. Ensure that fertiliser and manures are spread accurately	Reducing diffuse pollutant losses and ensuring appropriate nutrient inputs to crops by controlling spreading so that target amounts of fertilizer are applied accurately in all areas	N, P	
2. Livestock management	2a. Use a feed planning system to match nutrient content of diets to livestock feeding requirements	Reducing diffuse pollutant losses by reducing N and P concentrations in livestock excreta and spread manure due to a reduction of nutrient inputs in feed when necessary	N, P	Source
	2b. Livestock feeders must not be positioned within 10m of any	Reducing diffuse pollutant losses in surface runoff at the vicinity of surface water or	N, P, Sediment, BOD, FIOs	

[27] Biological Oxygen Demand (BOD): amount of oxygen required by microorganisms to oxidize (i.e. degradate) organic matter present in an aquatic ecosystem. Fertilizer losses from agricultural fields can lead to an increase in BOD in surface water, through nutrient inputs which fuels plant growth and inputs of organic matter from materials such as manure.

	surface water or a wetland	wetlands by preventing poaching and increased excreta deposition typically occurring around feeders		
	2c. Avoid severe poaching [28]where likely to pollute a watercourse (compliance achieved if already meeting GAECs 4 & 5)	Reducing pollutant losses in surface runoff by preventing livestock to compact soil in areas highly connected to watercourses (i.e. areas where pollutant can be quickly transferred to surface water)	N, P, sediment, BOD, FIOs	Pathway
3. Soil management	3a. Action is taken to prevent run-off from tramlines, rows, irrigation and high risk sloping lands or those lands highly connected to surface water. (compliance achieved if already meeting GAECs 4 & 5)	Reducing pollutant losses in surface runoff by managing features which lead to quick transfer of pollutants from sources	P, sediment	Pathway
Option 3 measures (in addition the measures in Option 2)				
1. Inorganic and organic fertilizer management	1d. Do not spread more than 30m^3/ha of slurry or digestate or more than 8t/ha of poultry manure in a single application between 15th October and the end of February. No repeat spreading for 21 days.	Reducing diffuse pollutant losses to surface runoff and leaching by preventing application of large fertilizer amounts on land for short periods of time in those months when the risk of pollutant losses to water is the greatest	N, P, BOD, FIOs	Source
	1e. Do not spread manufactured fertiliser or manures at high-risk times or in high-risk areas.[29]	Reducing pollutant losses by preventing fertilizer application in areas where pollutants can easily and rapidly be transferred to surface water or groundwater, when weather conditions (e.g. high rainfall or frozen soils) favour quick transfer to surface runoff or drains, or when crops cannot uptake nutrients which are then more easily lost to water	N, P, BOD, FIOs	

[28] Poached soil is caused when livestock trample wet soil. Poaching causes compaction and ponding of water

[29] Note that for this measure (and for measure 1d), farmers with insufficient slurry storage will need to invest in increased slurry storage capacity or take other steps to manage their slurry in order to comply. The costs of this have been incorporated into the analysis based on the recommendation by the joint government and industry project on slurry management and storage 2013, that farmers will need 5 months of slurry storage to support compliance with these two methods. We expect to consider requirements on slurry storage capacity next year. This will look into whether minimum capacity rules should be altered, including for farms which are currently covered by the pre-1991 exemption on capacity in the Slurry, Silage and Fuel Oil regulations.

	1f. Incorporate manures into soil within 24 hours after application	Reducing pollutant losses to surface runoff and drains by increasing surface roughness of manure. Ammonia emissions are also reduced as a result of reduced contact of manure with air	P, BOD, FIOs	
2. Livestock Management	2d. Exclude livestock from watercourses[30] (excluding uplands and Common Land)	Reducing pollutant losses by preventing direct excreta inputs to watercourses or avoiding bank degradation leading to enhanced sediment losses	N, P, sediment, BOD, FIOs	Source

[30] Farms in less-favoured areas (LFAs) are exempt from this measure, which has been reflected in the FARMSCOPER analysis.

5. Monetised and non-monetised costs and benefits of each option

This section explains the analysis for estimating value for money of the policy options. Table 3 summarises the key results from this analysis, which are discussed further in Sections 5a-5e.

Table 3: Main results of analysis (rounded to the nearest £m)

	Option 2	Option 3
Present Value of Environmental Benefits	+£309m	+£484m
Present Value of Net Operational Cost Savings for Farm Businesses	+£457m	+£122m
Present Value of Capital Costs for Farm Businesses	-£25m	-£154m
Present Value of administration and familiarisation costs	-£40m	-£52m
Present Value of cost to Government of Enforcement	-£2m	-£2m
Net Present Value	**+£699m**	**+£397m**

5a. Methodology

The methodology for analysing the costs and benefits of the proposed options is based on a modelling framework called FARMSCOPER. FARMSCOPER uses model farms to assess the impact of mitigation methods on different farm types for given assumptions about the impact on pollution and on farm income after implementing the methods. For this analysis we've used average farms across 10 farm types in England as model farms; the average farms have been based on data from the 2010 June Agricultural Census. The tool can then upscale the results for individual model farms across England to present an overall net impact of the methods. Annex B shows individual assumptions about how a method affects farm income; these assumptions will be further scrutinised in the consultation and we hope to be able to further develop the evidence on these impacts for the final impact assessment.

FARMSCOPER presents results for a group of methods together, in order to capture interactions between different methods when they are applied together. The key outputs include overall reductions in losses of pollutants from the farm and the **net** impact of implementing the measures on net farm income, split into capital and operational costs. In this impact assessment the capital and operational costs have been considered separately, as both policy options require farm businesses to increase capital expenditure, but generally lead to net operational cost savings due to greater feed and fertiliser efficiency.

However, although both increases and reductions in operational costs are included in calculating net operational cost savings, FARMSCOPER does not separately identify these in the results of modelling. While it is possible to estimate increases and reductions in operational costs on individual model farms for individual methods (as in Annex B), it is not possible to robustly split out cost increases and reductions at a national scale from the outputs of the model. This is for two reasons:

- where there are interactions between the impacts on costs of different methods within a group, it is not possible to identify the costs of individual methods
- some methods will have both positive and negative impacts on operational costs; for example where implementing a measure means that a farm business reduces the

amount of inputs used, but this leads to lower production. In these cases the size of positive and negative impacts will depend on farm type and size and are difficult to robustly split out at a national level.

As a result, the operational cost savings presented in Section 5d of this impact assessment are a 'net' figure, taking into account where implementing a group of measures together has negative and positive impacts on operational costs.

At present not all of the proposed mitigation measures can be analysed in FARMSCOPER. Table C3 in Annex C shows the measures which have been analysed in FARMSCOPER. For those measures not modelled in FARMSCOPER, we have obtained expert judgement on the likely cost implications and environmental impacts of each measure. However, our evidence base on environmental impacts is not sufficient to quantify any national scale impacts of the measures not modelled in FARMSCOPER. This means that the environmental impact of some methods has not been included in the main analysis and that the estimate of environmental benefits is an under-estimate. We continue to develop the evidence on these measures and will draw on evidence from this consultation to inform modelling for the final impact assessment.

Table C1 in Annex C shows the positive and negative impacts we have been able to identify, quantify and monetise where possible using the best available evidence, while Annex F explains how we have ensured that this is a proportionate level of analysis. Preliminary discussion with relevant interested parties has been carried out in order to improve the estimates. In order to monetise environmental impacts, we have used established values for air pollutants and have estimated values for environmental benefits of unit reductions in water pollutants as part of this analysis; these are shown in Table 222 in Section 6b. The environmental benefits of options 2 and 3 are more uncertain than the impacts on farm businesses, and therefore there is a greater range in these benefits than other impacts. The current results are likely to undervalue the water and air quality benefits. However, with the help of additional evidence from this consultation, we hope to reduce uncertainties associated with the current evidence and where feasible monetise air quality and water quality impacts from both FARMSCOPER and non-FARMSCOPER measures for the final impact assessment. **Annex C** provides a detailed discussion of the analysis methodology used in this impact assessment. This includes a full description of the FARMSCOPER decision support tool, a discussion on the approach for valuing improvements in water quality and an explanation of the approach for analysing measures which cannot be analysed in FARMSCOPER.

5b. Uptake of measures

This section firstly explains the assumptions in the analysis on the baseline levels of uptake of mitigation methods and then discusses assumptions on final uptake of the methods after implementation of regulation.

Baseline of Uptake

In our analysis of these measures we have assumed a baseline of full compliance with existing regulation such as Nitrate Vulnerable Zones (NVZs) or Cross Compliance. This means that where a measure is already part of regulation in NVZs, we have assumed 100% adoption of this measure in NVZ areas. Furthermore, farm businesses in agri-environment schemes are also required to implement basic measures to reduce diffuse water pollution as part of their agreement, so we have assumed full implementation of these measures on these farms.[31] Where there are no regulations or current uptake exceeds the regulatory baseline, we have used our evidence of current levels of uptake as our baseline for the main scenario.

In some cases, our evidence base suggests that current levels of uptake are less than the regulatory baseline (i.e. some farmers don't comply with existing regulation or agri-environment obligations). However, we have assumed full compliance with existing regulation so that we can assess the impacts of an increase in regulation and extending regulation to new areas without

[31] It is expected that the proportion of agricultural area covered by agri-environment schemes will fall to about 40% by 2020 – we have used this as the baseline for estimating the proportion of farms which are already covered by these regulations as part of their agri-environment agreement.

confusing the picture by also assessing actions to improve compliance with existing regulation. There is no evidence to suggest that the introduction of new regulation on mitigation methods will increase compliance amongst farmers which are already required to implement these methods. As a result, adopting a baseline of current levels of uptake would over-estimate the number of farmers who would change practices. Furthermore, the impacts of existing regulation have already been assessed in previous impact assessments[32], and therefore to include the impacts of improving compliance with previous regulation would be 'double-counting' when assessing the overall burden of regulation on business.

In addition, where evidence suggests that some segments of the farming sector do not comply with existing regulation, we have undertaken sensitivity testing **(see section 5f)** in order to assess the impact on value for money of these measures when using different baseline assumptions.

Table C4 in Annex C shows the assumptions on uptake which have been used in the main scenario. This shows the proportion of farm businesses which are fully compliant with each measure. It may be that some businesses are partially compliant – for example on method 1b, evidence suggests that some farm businesses use a fertiliser recommendation system, but do not fully account for the organic manures applied to land. This has been taken into account in the analysis. Data on current uptake is sourced from Defra surveys and research projects, literature reviews by ADAS and expert opinion within Defra and ADAS[33].[34]

Adoption of measures under Options 2 and 3

We have analysed adoption of measures under options 2 and 3 in a range of scenarios from 60% to 100%, using 80% uptake as our central scenario. Where measures are cost-beneficial or cost-neutral we assume slightly higher uptake in the low- and central-uptake scenarios. We assume 80% compliance in the central scenario because there are cases where sections of the farming industry do not comply with existing regulation. However, rates of compliance with future regulation are uncertain, and therefore we analyse the impacts of regulation at both 60% and 100% compliance rates to assess whether this uncertainty affects the value for money of the options. These assumptions have been derived following discussions between Defra and the Environment Agency, and will be tested at consultation.

Table 4 below shows the assumed rates of compliance across the three scenarios above.

Table 4: Assumed uptake of measures in Options 2 and 3

Measure	Option (s)	Uptake in Options 2 and 3 (%)			Number of farm businesses affected in central uptake scenario
		Low	Central	High	
1a. Field manure storage is located at least 10m from a watercourse*	2 & 3	No Change	90	100	3000
1b. Use a fertiliser recommendation system, taking soil reserves and organic manure supply into account	2 & 3	75	90	100	24000
1c. Ensure that fertiliser and manures are spread evenly	2 & 3	60	80	100	42000

[32] See the impact assessment on nitrate vulnerable zones, which is available here: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/82417/20111220nitrates-directive-consult-ia.pdf

[33] UK-based private consultancy specialised in the environmental and rural sectors

[34] Defra sources include the Farm Practices Survey, British Survey of Fertiliser Practice and Defra project WT1508.

1d. Do not spread more than 30m^3/ha of liquid organic manure with high level of readily available N or more than 8t/ha of poultry manure in a single application between 15th October and the end of February. No repeat spreading for 21 days.*	3	No change	No change	100	0
1e. Do not spread manufactured fertiliser or manures at high-risk times or in high-risk areas.*	3	60	80	100	25000
1f. Incorporate manures into soil within 24 hours after application *	3	60	80	100	19000
2a. Use a feed planning system and match nutrient content of diets to livestock requirements	2 & 3	No Change	90	100	1000
2b. Livestock feeders must not be positioned within 10m of any surface water or a wetland	2 & 3	60	80	100	18000
2c. Avoid severe poaching where likely to pollute a watercourse (applicable to farmers not meeting GAECs 4 & 5)*	2 & 3	No Change	No change	100	0
2d. Exclude livestock from watercourses	3	60	80	100	15000
3a. Action is taken to prevent run-off from tramlines, rows, irrigation and high risk sloping lands or those lands highly connected to surface water. (applicable to farmers not meeting GAECs 4 & 5)*	2 & 3	No change	No change	100	0

*shows where a measure is part of existing regulation.

5c. Costs

This section discusses the costs of implementing each policy option. This includes the capital cost requirement for farm businesses to implement the mitigation measures. Any ongoing operational costs of implementing measures are considered in the net operational cost savings section in Section 5d.

In addition, there will also be a cost of administration and familiarisation to all farm businesses from implementing new measures on-farm. Finally, there are costs to government of implementing new interventions.

When estimating both the present value of costs and benefits of policy options, we have assumed a ten-year appraisal period, as the expected life of this policy is uncertain. In addition

we have also assumed a 3.5% discount rate, in line with Green Book appraisal guidance.[35] The price base year used is 2014.

Capital Costs of implementing Measures

Implementation of several of the mitigation methods will impose capital costs on farm businesses. Defra analysts used the FARMSCOPER tool to estimate the capital costs of implementing measures on farm businesses. This tool analysed the impacts on the individual model farms in different sectors of UK agriculture, and then upscaled these impacts to a national level. Where measures cannot be modelled in the FARMSCOPER tool, we used estimates of the impacts on individual model farms and upscaled these impacts to a national level based on an estimate of the number of farms affected. The assumptions which generated estimates of the impacts at an individual farm level are shown in Annex B. Table 5 below shows the estimated capital costs of implementing policy options 2 and 3 for different sectors. This includes measures which have been analysed within the FARMSCOPER tool and those which have been analysed separately. The range shown below captures uncertainty in the cost for a single farm of implementing measures and uncertainty in the final uptake of measures. The central value uses the central assumption on uptake and our best estimate of the capital cost for implementing a measure on an individual farm, as shown in Annex B.

Table 5: Required Capital Expenditure by Option (2014 prices, range in brackets)

Sector	Option 2	Option 3
Cereals	nil	nil
General Cropping	nil	nil
Horticulture	nil	nil
Mixed	£3.4m (£0.0m-£7.5m)	£18.0m (£4.3m-£34.9m)
Dairy	£17.2m (£0.0m-£37.9m)	£67.7m (£14.8m-£132.8m)
Lowland Grazing Livestock	nil	£37.1m (£10.9m-£69.3m)
LFA Grazing Livestock	nil	£1.7m (£0.5m-£3.2m)
Outdoor Pigs	nil	nil
Indoor Pigs	nil	£0.9m (£0.3m-£1.6m)
Poultry	nil	nil
Total	**£20.6m (£0.0m-£45.5m)**	**£125.4m (£30.7m-£241.9m)**

As shown above, Option 2 is estimated to have a relatively small capital cost. The capital cost will primarily affect dairy farmers, due to the cost of implementing a feed planning system for measure 2a. There are no capital costs in the low uptake scenario as there is no change in uptake of measure 2a in this scenario (see Table 4).

Option 3 has a much higher initial capital cost for livestock farms. This is due to the cost of constructing additional slurry storage capacity to comply with measures 1d and 1e on farms that are currently covered by the pre-1991 SSAFO exemption and the costs of additional fencing for farms where livestock currently have access to watercourses (2d).

In order to reflect that many farmers will borrow in order to spread the costs of capital items, in this analysis we have estimated the repayments of the expected capital costs over ten years using an interest rate of 7%. This shows the annual impacts on farm businesses of required capital expenditure and has been used when calculating the value for money of options 2 and 3. Table 6 shows the estimated annual costs to farm businesses from repayments on required

[35] See here - https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf

capital expenditure. The range and central values shown below are based on the range and central values in Table 5.

Table 6: Annual Costs of repayments for required capital expenditure (2014 prices range in brackets). Figures may not sum due to rounding.

Sector	Option 2	Option 3
Cereals	nil	nil
General Cropping	nil	nil
Horticulture	nil	nil
Mixed	£0.5m (£0m to £1.1m)	£2.6m (£0.6m to £5.0m)
Dairy	£2.4m (£0m to £5.4m)	£9.6m (£2.1m to £18.9m)
Lowland Grazing Livestock	nil	£5.3m (£1.5m to £9.9m)
LFA Grazing Livestock	nil	£0.2m (£0.1m to £0.5m)
Outdoor Pigs	nil	nil
Indoor Pigs	nil	£0.1m (£0.0m to £0.2m)
Poultry	nil	nil
Total	**£2.9m (£0m to £6.5m)**	**£17.9m (£4.4m to £34.4m)**

Table 7 below shows the Present Value of these repayments on capital expenditure for the central uptake scenario. The range in this table captures uncertainty in the capital cost for a single farm of implementing measures, but does not capture uncertainty in uptake – this means that the range is much narrower than in Table 5 and Table 6.

Table 7: Present Value of Repayments of Required Capital Expenditure (2014 prices, central uptake scenario, range in brackets)

Option 2	Option 3
£25.3m (£22.7m to £27.9m)	£153.7m (£135.1m to £172.2m)

Familiarisation and Administration Costs

As well as the cost of implementing the measures in each option, there will be costs in familiarising and adjusting to the new measures, monitoring farm implementation and dealing with the administrative burdens of compliance. These are difficult to quantify, and will vary for each farm depending on its size, the sector in which it operates, the extent to which it is already implementing measures and the expertise of farm staff.

For each option we identified the following potential initial costs of familiarisation and administration:

- Time involved in reading guidance and planning implementation of the methods
- Additional time spent planning on non-intensive livestock farms, as more measures (for example those on manures) apply to these farms
- Where relevant, time spent creating a feed planning regime

We also identified the following annual ongoing costs of implementation:

- Time spent monitoring compliance with and implementation of methods

- Where relevant, time spent monitoring and adjusting a feed plan.
- Where relevant, time spent creating and annually adjusting a nutrient management plan or a manure management plan (this is included in the method costs in the analysis in FARMSCOPER and not analysed here – see Annex B for more details)

Table 8: Assumptions on time requirements for farm managers and advisors (hours)

Option	Person	Initial				Annual	
		Guidance	Planning	Additional planning for livestock	Feed Planning	Monitoring	Feed Planning
2	Manager	2	4	2	4	2	2
2	Advisor	0	0	0	4	0	0
3	Manager	4	8	4	4	2	2
3	Advisor	0	0	0	4	0	0

It is expected that some of these familiarisation and administrative cost burdens will involve the time of a farm business advisor or consultant as well as the farm manager. Table 8 shows the assumptions made in calculating the time requirements. These are similar to the estimates made by Defra when appraising the impacts of changes to the NVZ rules[36], but will be additional to the administrative burden imposed by those regulations.

We have valued these time requirements using the Annual Survey of Hours and Earnings[37] for farm manager time and other sources[38] for the costs to farmers of advice from an advisor. The central assumptions are that a farm manager's time is valued at £20 per hour (including non-wage costs of employment) and the cost to farm businesses of an advisor's time is valued at £50 per hour. The full costs of implementation for each option are shown below in Table 9. These estimates have been discounted at the social time preference rate of 3.5% and summed over the ten year-period to show the present value of familiarisation and administrative costs in Table 10. The range shown in the tables below includes uncertainty in levels of uptake, while the central value is based on the central uptake scenario.

Table 9: Familiarisation and Administrative Costs of each option (2014 prices, range in brackets)

Option 2		Option 3	
Initial	Ongoing (pa)	Initial	Ongoing (pa)
£12.1m (£8.7m-£15.4m)	£3.3m (£2.4m-£4.2m)	£23.7m (£17.4m£30.0m)	£3.3m (£2.4m-£4.2m)

Table 10: Present value of familiarisation and administrative costs for each option (2014 prices, range in brackets)

Option 2	Option 3
£40.4m (£29.6m - £51.3m)	£52.0m (£38.3m - £65.8m)

[36] See here for the initial report to Defra for the NVZ rules: http://www.defra.gov.uk/consult/files/20111220nitrates-directive-consult-evid3.pdf

[37] Available in Table 14.5 here - http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-328216

[38] FARMSCOPER 3 Cost Tool.

Communications, surveillance and enforcement costs

As well as costs to industry, there will also be costs to government agencies of interventions. We describe the approach for implementation more broadly in Section 9.

A regulatory approach will place costs on government for communications, advice, surveillance and enforcement activities. The present value of costs to government for each option is shown in Table 11. These reflect both initial start-up costs and annual operation costs.

Table 11: Present Value of Total Costs to Government for each option (2014 prices). Figures may not sum due to rounding.

Cost	Option 2	Option 3
Communications	£0.4m	£0.5m
Surveillance	£0.4m	£0.6m
Enforcement	£0.8m	£1.2m
Total	**£1.6m**	**£2.2m**

The key assumptions underpinning these costs are shown in

Table 12.

Table 12: Key Assumptions in estimating costs to Government of implementing basic measures

Communications and advice	Based on integration of requirements to Farming Advice Service and Environment Agency advice and communications. Includes transitional communications plus ongoing provision of a national programme of events, helpline and website.
Surveillance	Based on integration of requirements into existing inspections, with 1.5-2 additional hours per inspection at £33 per hour. Training costs of £120 per staff member (80 staff in first year, then 30 staff pa thereafter). Negligible cost of integration of requirements into existing programme of catchment walkovers. Negligible increase in costs of incident reporting as diffuse pollution events can already be reported.
Enforcement	Based on achievement of projected compliance levels (Table 4) by Year 5 of implementation. Includes enforcement actions from all forms of surveillance (inspections, incident reporting, and catchment walkovers). Assumes that the average cost of enforcement actions (excluding letters) is £228 per farm in Year 1, arising primarily from advice and guidance. By Year 6, this rises to £435 as formal enforcement tools (e.g. cautions, works notices, prosecutions) are used as a last resort for the small number of businesses (<20 per annum) which do not undertake agreed measures.

Small and Micro Business Assessment

We have assessed the impact of each option on small and micro businesses. As almost all farming businesses are small businesses[39], this policy would not be viable and would not implement the Water Framework Directive if these businesses were deemed exempt. However, in recognition of the difficulties of adapting to new regulation as a small business, we are adopting a gradual implementation approach. This is described in Section 9. More detail on the Small and Micro Business Assessment can be found in Annex E.

5d. Benefits

There are two areas of benefits of the two policy options compared to the baseline: ongoing cost savings to farm businesses from implementing methods, and environmental benefits from implementation. These are discussed in turn below.

Net Operational Cost Savings to Farm Businesses

As well as the capital costs discussed in Section 5c, there will also be ongoing impacts from implementing the measures on farm. As discussed in Section 5a, the FARMSCOPER tool estimates a net ongoing impact from implementing measures which includes both positive and negative impacts on net farm income from implementing the measures. It is not possible to split out the positive and negative operational impacts on farm income from implementing the measures. As the ongoing positive impacts of implementing the measures outweigh the ongoing negative impacts for most farm types, we have considered these impacts in the benefits section as net operational cost savings to farm businesses. Where measures cannot be modelled in the FARMSCOPER tool, we used estimates of the impacts on individual model farms and upscaled these impacts to a national level based on an estimate of the number of farms affected. The assumptions which generated estimates of the impacts at an individual farm level are shown in Annex B.

Table 13 below shows the estimated net operational cost savings of implementing policy options 2 and 3 for different sectors. This includes measures which have been analysed within the FARMSCOPER tool and those which have been analysed separately. The range shown below captures uncertainty in the cost for a single farm of implementing measures and uncertainty in the final uptake of measures. The central value is based on the central uptake scenario and our best estimate of the operational cost impacts of implementing measures on a single farm, as shown in Annex B. Positive numbers refer to net cost savings, and negative numbers refer to implementing a group of measures is a net cost to the sector.

Table 13: Net Operational Cost Savings per year from policy options (2014 prices, range in brackets)

Sector	Option 2	Option 3
Cereals	+£10.7m (+£7.3m to +£18.0m)	+£4.3m (+£3.8m to +£8.0m)
General Cropping	+£7.7m (+£5.0m to +£12.3m)	+£0.1m (+0.1m to +£1.3m)
Horticulture	+£0.3m (+£0.2m to +£0.5m)	-£0.0m (-£0.0m to +£0.0m)
Mixed	+£8.9m (+£3.3m to +£13.3m)	+£3.1m (+£0.1m to +£4.4m)
Dairy	+£8.3m (-£1.5m to +£18.5m)	+£4.5m (-£4.0m to +£12.2m)
Lowland Grazing Livestock	+£4.3m (+£3.4m to +£4.8m)	-£1.6m (-£5.6m to +£0.4m)
LFA Grazing Livestock	+£3.5m (+£2.6m to +£3.9m)	+£0.8m (-£0.1m to +£1.4m)

[39] More than 99% of businesses in Agriculture, Fishing and Forestry in England employ fewer than 50 people. Source: UK Commission on Employment and Skills' Employer Skills Survey 2013.

Outdoor Pigs	+£0.1m (-£0.0m to +£0.1m)	+£0.0m (-£0.1m to +£0.0m)
Indoor Pigs	+£1.8m (+£0.8m to £2.1m)	+£0.4m (-£0.1m to +£0.4m)
Poultry	+£7.4m (+£3.4m to £8.2m)	+£2.4m (-£0.0m to +£2.7m)
Total	**+£53.1m (+£24.4m to +£81.6m)**	**+£14.1m (-£6.0m to +£30.9m)**

As shown above, option 2 has considerable net operational cost savings for farm businesses. These are generated from implementing income beneficial measures such as 1b, 1c and 2a in combination which means that businesses will use fertiliser and feed more efficiently whilst more environmental friendly fertilizer would have higher costs?.

Option 3 also has net operational cost savings for the industry, but these are much smaller than for Option 2. Cost savings are generated from implementing measures 1b, 1c and 2a, but implementing the additional methods 1d, 1e, 1f and 2d would lead to additional costs for farm businesses. For some sectors (grazing livestock, horticulture), the costs of implementing option 3 outweigh the cost savings relative to the baseline.

Table 14 below shows the Present Value of the net operational cost savings for the central uptake scenario. The range in this table captures uncertainty in the operational costs or cost savings for a single farm of implementing measures, but does not capture uncertainty in uptake – this means that the range is much narrower than in Table 13.

Table 14: Present Value of Net Operational Cost savings (2014 prices, central uptake scenario, range in brackets)

Option 2	Option 3
£457.2m (£410.4m to £504.0m)	£121.7m (£103.7m to £139.7m)

Environmental Benefits

All of the options considered in this impact assessment have benefits to the environment, to relevant sectors of the economy, such as water companies and tourism, and to other groups within society such as anglers and other recreational users of watercourses. These are listed below:

- Improvements in water quality due to reductions in concentrations of nitrates, phosphorus, sediment and Faecal Indicator Organisms (FIOs)
- Improvements in air quality due to reductions in emissions of ammonia
- Reductions in emissions of greenhouse gases such as nitrous oxide and methane, as well as decreases in emissions of carbon dioxide due to lower energy use and increased levels of soil organic carbon.
- Improvements in biodiversity and the natural environment.

Defra analysts have been able to quantify and value the impacts of measures that can be modelled in FARMSCOPER. This provides us with an indication of the benefits which could be achieved by the full package of measures. Full details of the methodology used in quantifying and monetising these impacts can be found in Annex C.

We have not been able to quantify the environmental benefits for those measures which cannot be modelled in the FARMSCOPER program. These environmental benefits have been identified by expert judgement and are discussed below. With input from this consultation we hope to develop our evidence base such that the benefits from these measures can be estimated and valued.

Some of the benefits identified above cannot be valued due to a lack of reliable values for monetising the impacts. This is the case for improvements in biodiversity and changes in soil organic carbon.

Table 15 below shows the estimated range of reductions in losses of pollutants for each option from the measures modelled in FARMSCOPER. This is based on current levels of agricultural activity; if agriculture were to intensify in the future then the reductions in losses of pollutants would be greater.

Table 15: Estimated percentage reduction in annual losses of pollutants from agriculture

Option	Uptake Level	Nitrogen	Phosphorus	Sediment	Ammonia	Methane	Nitrous Oxide	FIOs
2	**Central**	**0.8**	**2.4**	**0.3**	**0.7**	**0.5**	**0.8**	**0.9**
	Low	0.4	1.7	0.1	0.3	0.3	0.3	0.3
	High	1.6	3.2	0.5	1.4	0.8	1.3	1.5
3	**Central**	**1.6**	**6.6**	**0.3**	**1.2**	**0.5**	**1.5**	**12.6**
	Low	0.7	3.7	0.1	0.6	0.3	0.7	4.3
	High	2.8	9.5	0.5	2.0	0.8	2.3	21.1

As might be expected, the environmental benefits of basic measures increase with greater levels of uptake and government intervention. The most significant impact of the measures is on losses of phosphorus. The reductions in losses of sediment and nitrate to water are comparatively low, but environmental benefits on a national scale can be significant even with small percentage reductions. Reductions in losses of FIOs are much greater under Option 3 due to the inclusion of measure 2d, which greatly reduces losses of FIOs due to livestock excretion directly into watercourses. The implementation of basic measures also generates reductions in air pollution and greenhouse gas emissions at all levels.

Section 5a and Annex C discuss the methodology for monetising these impacts[40]. In addition, we have also valued changes in energy use, as these impacts will affect emissions of carbon dioxide (for example due to reduced use of machinery for applications of fertiliser). This has enabled us to calculate the annual value of environmental benefits from these measures. This is shown below in Table 16. A large proportion of the environmental benefits occur due to reductions in air pollution and greenhouse gas emissions, while the most significant impacts on water pollution are due to reductions in pollutants of phosphorus and FIOs.

Table 16: Annual Monetised Benefits from Pollutant Reduction for Option 2 and 3 (£m, central estimates, 2014 prices)

Option	Nitrogen	Phosphorus	Sediment	FIOs	Ammonia	Methane	Nitrous Oxide	Carbon Dioxide (lower energy use)	Total
2	£0.8m	£1.9m	£0.2m	£0.4m	£2.2m	£3.5m	£11.2m	£15.7m	£35.9m
3	£1.4m	£5.1m	£0.2m	£5.8m	£3.7m	£3.5m	£20.6m	£15.8m	£56.2m

[40] The benefits from reductions in water pollution have been monetised as explained in Annex C. The benefits from air pollution have been monetised using established sources – see Table 222

The benefits shown in Table 16 for include estimates for benefits to water companies from reduced pollution leading to less processing for clean drinking water. These are only related to reduction in losses of nitrogen to water. Defra analysis of benefits from reductions in water pollution suggests that cost savings to water companies are worth 46% of the benefit from reductions in levels of nitrate pollution. This is equal to £0.4m pa for option 2 and £0.7m pa for option 3.

We have discounted these values across a ten year time period to provide the present value of these benefits for each option, which is shown in Table 17. The analysis shows that the value of environmental benefits increase sharply as uptake or the number of methods implemented increases. The central values are based on our best estimates of the impact on pollution of implementing an individual method on an individual farm.

The assumptions underlying our valuation of environmental benefits are discussed in Annex C and will be tested at consultation. In addition, as shown in Table 3, even if environmental benefits were considered negligible, then the preferred option would still represent value-for-money.

Table 17: Present Value of Environmental Benefits for each option (£m, 2014 prices)

Level of Uptake	Option 2	Option 3
Low	£182m (£44m - £656m)	£270m (£83m - £874m)
Medium	£308m (£77m - £1159m)	£484m (£155m - £1559m)
High	£442m (£116m - £1701m)	£706m (£235m - £2275m)

Environmental Benefits from non-modelled measures

In order to identify the environmental benefits from measures which cannot be modelled in FARMSCOPER, Defra engaged expert opinion from stakeholders and the Environment Agency, as well as experts from ADAS and Rothamsted Research[41].This enabled us to identify the potential environmental benefits from implementing each on-farm measure. This is shown in Annex B for the measures contained in each policy option.

Implementation of the non-modelled measure (2c) in option 2 will achieve only negligible benefits in terms of reductions in losses of most water and air pollutants (whilst high financial benefits in term of cost savings), as this measure already applies to 95% of English farms through Cross-Compliance, and many of those not already covered are intensive livestock farms which do not have any arable or grassland. However, the non-modelled measure 1d in Option 3 will achieve reductions in nitrate and phosphorus water pollution as well as nitrous oxide, but will slightly increase CO_2 emissions due to more trips spreading slurry.

5e. Assessment of Value for Money

Net Present Values (NPV) for each of the policy options are presented below in Table 18. This shows the present values (PV) of environmental benefits, measure impacts on farm income, administration and familiarisation costs and the cost to Government of implementation. These have been combined to show the Net Present Value of each policy option.

The NPV analysis shows that Option 2 offers the best value for money, with a central estimate of +£699m over ten years.

Figure 2 below shows a range of Net Present Values capturing uncertainty in:

- Uptake of measures
- Impact of measures on farm businesses
- Reduction of pollution by measures

[41] UK-based agricultural research station targeting productive and sustainable agricultural systems

- Value of pollution reductions

It shows separately the minimum and maximum estimates of value for money for both the central uptake scenario and across all levels of uptake.

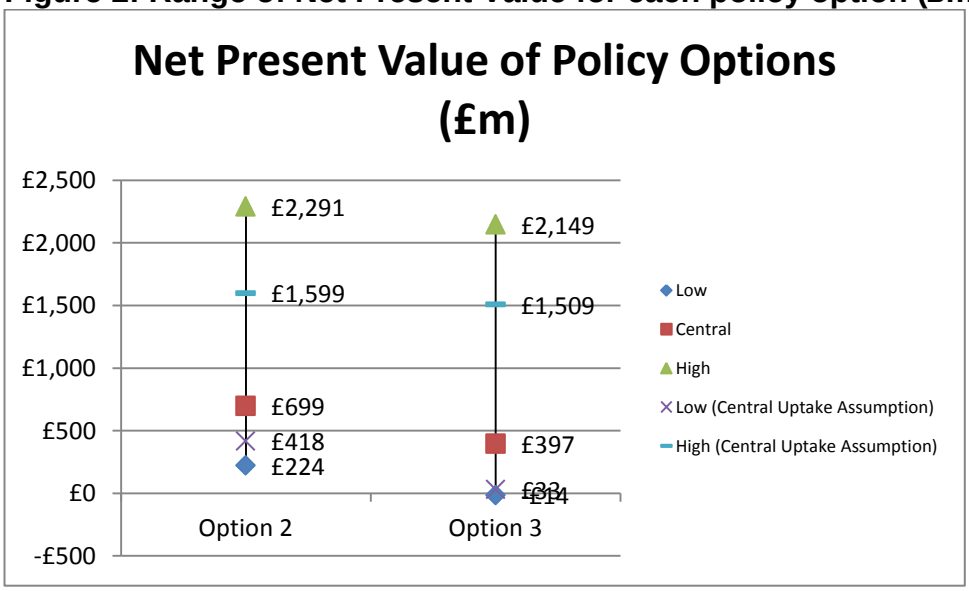
Note that this shows a wider range than in the impact assessment cover sheets due to including uncertainty in levels of uptake. The IA cover sheets only show the range of impacts in the central scenario of 80% uptake.

The range of NPVs covers a large amount of uncertainty; as suggested by Table 20, a large degree of this is due to the uncertainty in environmental benefits and levels of adoption of the measures. Note that these estimates of value-for-money are likely to be an underestimate, as there are some environmental benefits from the policy options which we have not been able to quantify or monetise. These are discussed in Section 8a.

Table 18: Net Present Value of each option (£m, 2014 prices, central uptake)

	Option 2	**Option 3**
Present Value of Environmental Benefits	+£309m	+£484m
Present Value of Net Operational Cost Savings for Farm Businesses	+£457m	+£122m
Present Value of Capital Costs for Farm Businesses	-£25m	-£154m
Present Value of administration and familiarisation costs	-£40m	-£52m
Present Value of cost to Government of Enforcement	-£2m	-£2m
Net Present Value	**+£699m**	**+£397m**

Figure 2: Range of Net Present Value for each policy option (£m, 2014 prices)



5f. Sensitivity Testing

We have conducted sensitivity analysis in two areas. Firstly, we looked at the impact of different assumptions on the baseline of current uptake on estimates of the value-for-money of options. Secondly, we conducted sensitivity analysis on the impacts of the policy options on the farming sector.

Baseline Levels of Uptake

In the main analysis we assumed a baseline of full regulatory compliance, i.e. farm businesses comply with all relevant existing regulation such as NVZ rules and scheme requirements for

agri-environment schemes. This is because we aimed for our analysis to capture the impacts of an increase in regulatory burden on the farming sector and the environment, as opposed to also capturing the impacts of increased compliance with existing regulation.

However, rates of compliance can vary across the farming sector. Estimates from ADAS used in FARMSCOPER suggest that compliance with rules such as positioning field manure storage away from watercourses and limits on spreading organic manure are widely adopted by farmers. However, rules preventing spreading of fertiliser at high risk times are only adopted by half of farmers and many farmers find it difficult to incorporate manures within 24 hours of application, sometimes due to poor soil conditions.

In order to assess whether the assumption of a lower level of baseline compliance affects the value-for money of the policy options, we also conducted analysis of the policy options with our current estimates of uptake as the baseline. Under this baseline, the number of farmers who have to implement basic measures is higher than in the main analysis, due to non-compliance with existing regulation in some areas. The results for value-for money in the central uptake scenario are shown in

Table 19.

Table 19: Value-for-money under baseline of current estimate of compliance

Option	Net Present Value	Change from main analysis	Change from main analysis (%)
2	+£666m	-£32m	-4.6%
3	-£344m	-£742m	-186.6%

For the preferred option (Option 2), the change in baseline assumption results in a slight decrease in value-for-money. This is because the baseline of lower practice means that more farmers have to implement measures which have negative impacts on farm income.

For Option 3, the change in baseline assumption results in a substantial reduction in value-for-money, and under this assumption the option would offer very poor value for money. Compared to the main analysis, there is a large increase in cost for the farming industry and a smaller increase in environmental benefits from adopting these measures. This is mostly due to the additional cost of complying with measure 1d on not spreading manures or fertilisers at high-risk times or in high-risk areas, and associated costs of increased slurry storage capacity. However, it should also be noted that the figure above is biased downwards to a degree, as some environmental benefits (such as improvements in biodiversity or from measures not modelled in the FARMSCOPER tool) have not been monetised and are therefore not included in the value-for-money assessment above.

This assessment effectively includes the impacts of raising compliance in areas which are already covered by existing regulation. Unless new regulation on basic measures could drive greater compliance through a significantly more effective enforcement or incentives regime, then it is unrealistic to assume that the introduction of new regulation would incentivise greater compliance from those already covered by existing regulation. We therefore believe that the main analysis is a more realistic assessment of the impacts of introducing new regulation.

Impact of Measures on Farm Businesses

In order to assess the extent to which estimates of value-for-money are vulnerable to uncertainty in the impacts on farm businesses, we also conducted sensitivity testing on the impacts of implementing measures on farm businesses.

We firstly estimated the change in the central estimate of NPV across the range of estimated impacts on farm business income. Table 20 below shows how NPV changes when we assume the most beneficial and the least beneficial values in the range of impacts on Farm Business

Income. Figure 2 above shows the full range of uncertainty in the value for money of the policy options; comparing this with Table 20 shows that only a small portion of the uncertainty in estimates of Value for Money is due to uncertainty in impacts on farm income. Levels of uptake and the value of environmental benefits are much more variable and contribute to the large range of NPV estimates shown in Figure 2.

Table 20: Net Present Value estimates for the projected range of impacts on farm income from implementing measures (central estimates, central uptake, 2014 prices)

Range of impact of measures on farm business income	Net Present Value	
	Option 2	Option 3
Least Beneficial	+£649m	+£360m
Central	+£699m	+£397m
Most Beneficial	+£748m	+£434m

We also estimated the impact on the average farm business which would have to occur for the costs of the policy options to outweigh the benefits in our central scenario. This analysis is shown below in Table 21.

Table 21: Sensitivity Analysis on Impacts on farm businesses (2014 prices)

Policy Option	Estimated average annual impact on farm income	Estimated worst impact* on farm income	Break even value for average annual impact on farm income
2	+£490	+£240	-£300
3	-£40	-£200	-£490

* i.e. the most costly or least beneficial impact on farm income in our range of estimated impacts on farm income.

This analysis shows that in our central scenario both policy options represent good value-for-money (i.e. benefits outweigh costs) even in our most pessimistic estimates of the impacts on farm businesses. This means that the impact on farm income of implementing the policy option would have to be very different from that suggested by the evidence for the policy option to be poor value-for-money for society.

6. Risks and assumptions

6a. Uptake and compliance

The assumptions in this impact assessment about uptake and compliance carry a degree of uncertainty. Because the farming industry has many small and geographically isolated businesses, it can be difficult to spread information effectively and change practices either through voluntary or regulatory mechanisms. Managers of farm businesses often operate as the farm's only employee and their time can be stretched in managing the day-to-day running of the business. Therefore even when changes are good practice or cost beneficial, it can be challenging to find the time to assess and implement them.

In order to ensure high rates of uptake of basic measures, subject to this consultation, we propose to implement any new regulations through a collaborative communications plan with an advice led approach. A transition period is proposed with enforcement and prosecution used as a last resort where advice and guidance has not been acted upon. This is described in more detail in Section 9.

There remains a risk that compliance may fall below or is above the levels expected. To address this, we have analysed the impacts of the regulatory policy options in three different scenarios with compliance rates of 60%, 80% and 100%. The approach for these scenarios is discussed in Section 5b.

It should be noted that intensive pig and poultry farms are likely to have already adopted many of the proposed measures as they are subject to strict controls to reduce pollution risk to water. Such farms are subject to farming permits under the Industrial Emissions Directive, which require various measures to address potential water pollution such as slurry and manure storage, land spreading, and bunded fuel storage. Intensive farming has a good level of compliance – 95% are in the higher compliance Bands A and B. This existing regulation has been included in the regulatory baseline used in the main analysis.

6b. Assumptions in methodology

Modelled Farms

A significant assumption in the modelling is the use of 'model' farm enterprises, which are based on the average farm in each sector of agriculture. These are generated from June 2010 Agricultural Census data covering all of England's farming businesses. However, farm businesses are not homogenous within any one individual sector of agriculture, and there is a risk that such variation is not captured within the model farm approach. This may mean that the modelled impact of mitigation measures is inaccurate. For example, this may be the case if a particular segment of agriculture is not currently implementing a practice because this practice would have no environmental impact or because it is less compatible with their farming system. In this case this may mean that the benefits to the environment or the farming industry of increasing uptake of this measure would be overstated by the central estimate of value-for-money.

In order to address this, we have presented ranges for the modelled impacts of uptake of mitigation measures on farm income and losses of pollutants which have informed the estimates of value-for-money. The process for dealing with uncertainty in pollutant impacts and farm income impacts is described in greater detail in Annex C.

Environmental Benefits

An important assumption in the methodology is the how the environmental benefits have been monetised. The value of environmental benefits for unit reductions in pollutants are shown below in Table 22. For the damage costs of ammonia and GHGs, we have used standard established sources.

For the environmental benefits of reductions in water pollution, we have developed our estimates for this piece of analysis. We used willingness to pay (WTP) estimates generated by independent consultant Paul Metcalfe as part of an update to the National Water Environment Benefits Survey in partnership with the Environment Agency to value improvements in the river environment.[42] This assessment does not include the value of improvements in drinking water and bathing waters as a result of pollutant reductions, which have been sourced from Defra project WT0706. We used preliminary working analysis of the Metcalfe WTP values disaggregated by pressure to generate the total cost of agricultural losses of each water-based pollutant, and were compared to annual losses under the baseline of current practice to obtain the unit environmental benefits shown in Table 22. More details on this method can be found in Annex C.

This average environmental benefit approach for water-based pollutants covers a large degree of variation, as levels and concentrations of water pollutants vary substantially over different geographical areas and time periods. In addition, the damage caused by an additional unit of water pollution is the result of a complex process which will depend on the size of the water catchment, the degree to which it is used by humans or supports wildlife and the baseline concentration of pollution in the water. Furthermore, the existence of tipping points and non-linear relationships between the level of water pollution and the condition of an ecosystem means that there may be sharp variations in the marginal impact of additional water pollution even within the same water catchment. In this impact assessment, we have used a range of unit environmental benefits shown below to attempt to capture this uncertainty.

Table 22: Average Environmental Benefits for reductions of each pollutant (£/kg unless otherwise stated, 2014 prices, range in brackets)

Pollutant Area	Pollutant	Value	Source
Water	Nitrate	£0.43 (£0.24 - £0.62)	Defra analysis – see Annex C
	Phosphorus	£12.79 (£2.77 - £22.66)	
	Sediment	£0.054 (£0.047-£0.061)	
	FIOs (£ per billion CFU)	£0.060 (£0.043-£0.077)	
Air	Ammonia[43]	£2.14 (£1.67-£2.43)	Defra ammonia value[44]
GHG	CO^2	£0.07 (£0.03-£0.10)	Average DECC non-traded cost of carbon across 2017-2027[45]
	Methane[46]	£1.50 (£0.75 – £2.25)	
	Nitrous Oxide	£22.18 (£11.09 - £33.28	

We are currently working to improve our understanding of how the damage caused by water pollution varies spatially and temporally as well as the marginal impact of water pollution at different pollutant concentrations. This improved evidence will hopefully be available to feed into the final impact assessment of this policy and any relevant assumptions will be validated during the consultation process.

[42] Paul Metcalfe. "Update of CRP WFD Benefit Values – Economic Component", 2012.

[43] Note that this value only includes health impacts of ammonia, and not biodiversity impacts. Biodiversity impacts of ammonia are discussed in Section 8a as unmonetised environmental impacts.

[44] See http://www.defra.gov.uk/environment/quality/air/air-quality/economic/damage/

[45] See https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisa

[46] Methane and Nitrous Oxide damage costs have been estimated by comparing the global warming potential to carbon dioxide, as outlined in the DECC guide to valuing greenhouse gas impacts.

Wider environmental impacts

As some of the impacts of this policy cannot be quantified or monetised[47], there is a risk that estimates of value-for-money of the different policy options understate the environmental benefits which can be achieved. In this impact assessment we have quantified and monetised impacts where possible and will aim to develop and improve the evidence for the final impact assessment for these policies. Where it has not been possible to quantify or monetise impacts, then we have identified impacts and have added appropriate caveats to the assessments of value for money.

6c. Costs to the Farming Industry

There is a generic risk within any estimates of the impact on businesses of new regulation that the impact is under- or over-estimated. We have carried out additional work to mitigate this risk in this impact assessment by consulting with agricultural experts within Defra and other stakeholders and then amending both the assumptions for our analysis and the measures included in each option following their feedback. We have used a range for costs to the farming sector to reflect that there may still be factors which we have not considered. These factors will be explored further in the consultation.

For modelling impacts on farm income, we have focussed on major impacts such as large changes in nutrient use efficiency. There may be smaller second-order impacts on farm income which have not been considered in the analysis. These impacts could be beneficial if a measure promotes small increases in nutrient use efficiency. For example, measure 1d in Option 3 on restricting spreading of manures and fertilisers at high-risk times and in high-risk areas will have a considerable cost for farmers not already implementing this measure. However, greater capacity will also allow the farmer to apply manures at more suitable times, reducing losses to watercourses and improving take-up of nutrients by crops, which could lead to improved plant growth or savings from reduced use of manufactured fertiliser. These small second-order impacts have not been modelled due to their complexity.

[47] See Table C1 in Annex C.

7 Direct costs and benefits to business calculations (following OITO methodology)

Option 2 is exempt from One-in, Two-out (OITO) as it is required to complete transposition and implementation of the Water Framework Directive. Article 11 requires Member States to establish a programme of measures to achieve the required improvements in water quality. Article 11.3 requires Member States to implement a set of basic measures as a minimum requirement and Article 11.3h sets specific requirements for diffuse sources of pollution including regulation.

The recommended option is what we expect to be the minimum required to meet the objectives of article 11.3h. Option 3 goes beyond what we expect to be the minimum required for meeting Article 11.3h. However, it does improve England's prospect of complying with the requirement in the WFD for all water bodies to reach good ecological status by 2027 and reduces reliance on voluntary and incentive-based approaches to achieve this. Based on our current interpretation of the WFD, Option 3 would still be in scope of OITO, but it is not our recommended policy option.

In order to provide greater clarity on the impacts of the policy, we have calculated the Equivalent Annual Net Cost to Business (EANCB) for the options in the central scenario below. Note that this includes direct cost savings to farmers from implementing cost-beneficial measures, but does not include any cost savings to water companies from better drinking water quality as this is an indirect cost saving.

Table 23: Equivalent Annual Net Cost to Business (EANCB) (2009 prices, central scenario)

Preferred Option	**EANCB**
Option 2	-£35.81m
Option 3	+£7.68m

NB Negative numbers indicate an increase in business net income.

8. Wider impacts

8a. Unquantified and Unmonetised Environmental Impacts

There are some environmental impacts of policy options which have not been monetised or quantified. One significant benefit will be improvements in biodiversity from reducing the risk of further damage or extending the scale of negative impacts, with the potential for habitat and species recovery in some locations. Improvements in aquatic biodiversity resulting from reductions in water pollution have already been included in our valuation of environmental benefits. However, improvements in biodiversity from reducing ammonia and nitrogen losses have not been quantified. This is potentially a significant biodiversity benefit given the widespread geographical scale of ammonia and nitrogen impacts; 97% of sensitive habitats in England are considered to exceed the critical loads for the protection of ecosystems from atmospheric deposition. Every six years, Member States of the European Union are required (by Article 17 of the Habitats Directive Directive) to report on implementation. In 2013 the UK reported that air pollution was a high threat to future prospects of 31 out of 77 Annex 1 (presently occurring) habitats.

Measures leading to a reduction in diffuse nutrient losses to air will also have potential benefits for terrestrial biodiversity. This includes reductions of ammonia emissions to air which can impact natural or semi-natural vegetation. Indeed, large nutrient supplies to semi-natural or natural vegetation have been shown to decrease plant species richness in these areas. In addition, measures leading to an exclusion of livestock from specific areas, such as river banks or wet patches, will protect specific ecosystems from habitat degradation. These benefits will therefore be greater in Option 3 than Option 2, as this option leads to greater reductions in losses of ammonia (see Table 15 in Section 5d) and includes measures which will protect some areas from trampling by livestock. These impacts are not quantifiable, but should be considered when assessing the value for money of the proposals especially as there are existing domestic, EU and international policy commitments on biodiversity. In addition we have obligations under the European directives on nature conservation, which, amongst other things, requires Member States to take preventative steps to avoid deterioration within European sites and failure to achieve this risks infraction proceedings and ultimately financial sanction and remedial action.

There may also be changes in soil organic carbon. The only measure likely to affect soil organic carbon is measure 3a in options 2 and 3. Measure 3a could have a positive impact on organic carbon by preventing losses of soil organic carbon when there is soil erosion. However, as this measure already covers almost all of England's farm businesses through cross-compliance, we expect that any impact will be negligible.

8b. Wider impacts on the Farming Sector

The most significant impact of the policy options on the economy will be in the agriculture sector. The increased uptake of cost-beneficial measures would improve the productivity of the farming sector.

Table 24 below shows the average capital expenditure requirement and the average annual net operational cost saving per farm in each sector for the preferred option. These are calculated from the values in Table 5 and Table 13 divided by the number of farm businesses in each sector based on the June Agricultural Census. It contrasts this with the percentage of businesses earning low Farm Business Income in 2011/12 (a good year for weather) with 2012/3 (a poor year for weather). It shows that there are considerable benefits to farm businesses for implementing these measures, and that the benefits to implementing these measures may help to reduce the number of farms making losses.

Where farm businesses are forced by regulation to implement costly measures, this may lead to some businesses exiting the industry. This is particularly the case where some farm businesses

are already reporting a low or negative net income and will therefore struggle to meet extra cost burdens placed upon them. In addition, even though for most farmers there are few barriers to borrowing to spread the cost of new capital equipment required by regulation[48], a requirement to purchase expensive capital equipment may provide an additional impetus for some businesses to exit the industry.

Table 24: Capital Expenditure Requirements for Farm Businesses under Option 2 and % of farming businesses with negative net income (central estimate, 2014 prices)[49]

Sector	Average Capital Expenditure Requirement	Average annual net operational cost saving	% of farms with Farm Business Income (FBI) <£0	
			2011/12	2012/13
Cereals	£0	+£600	2	7
General Cropping	£0	+£500	7	10
Horticulture	£0	+£50	17	27
Dairy	£2,200	+£1,100	7	16
Lowland Grazing	£0	+£100	10	22
LFA Grazing	£0	+£300	12	22
Mixed	£400	+£1,100	12	22
Indoor Pigs	£0	+£1,600	22	27
Outdoor Pigs	£0	+£200	22	27
Poultry	£0	+£3,500	29	15
All-sector average	**£200**	**+£500**	**9**	**16**

Implementation of the measures in the preferred policy option are likely to benefit most farm businesses, meaning that it is unlikely that regulation will lead to exit from the market. However, this may occur for struggling businesses in the dairy and mixed sectors, where regulation imposes an initial capital cost requirement. If some producers do exit the market, this could lead to a collective loss of experience in the sector and a small drop in overall employment. On the other hand, it could also provide an opportunity for entry by new businesses with innovative new ideas or for industry consolidation led by larger and more efficient businesses, therefore leading to a more efficient industry overall. In conclusion, the implications of new regulation on market structure are uncertain, and it is difficult to forecast how this would affect the sector as a whole.

8c. Wider Impacts on the rest of the economy

There are a number of areas in which implementing the Water Framework Directive on basic measures could impact on the wider economy:

- Where regulation leads to cost savings, producers may pass some of the reduction in costs onto market participants further down the supply chain, including consumers. However, the extent to which this is possible is uncertain and is probably unlikely to significantly impact on consumer prices.

[48] Farm businesses have low levels of indebtedness compared to other sectors of the economy, suggesting that they can accommodate additional borrowing if necessary. Over the period 2009-2013 liabilities for the average farm were worth 11% of assets and interest payments represented only 6% of Farm Business Income. Sources: Defra Farm Balance Sheet Analysis – available here: https://www.gov.uk/government/publications/balance-sheet-analysis-and-farming-performance-england-201011-20122013

[49] Data on Farm Business Income 2013/4 available here - https://www.gov.uk/government/publications/farm-accounts-in-england-201213 . Data for 2011/12 available here - http://webarchive.nationalarchives.gov.uk/20130315143000/http:/www.defra.gov.uk/statistics/foodfarm/farmmanage/fbs/publications/farmaccounts/farm-accounts-in-england-2012/

- Similarly, where regulation promotes reduced use of inputs such as fertiliser, this may negatively affect agricultural suppliers. On other hand, businesses may require additional advice in order to comply with the regulation, leading to a benefit for farm advisors.
- The impact on the farming sector of regulation will not have a serious knock-on effect on the rest of the economy as agriculture is only a small proportion of the whole economy.[50]
- There will be economic benefits for the water industry from the reduced cost of removing water pollution which may be passed on as savings to water bill payers. This is included in the estimates of environmental benefits from policy options.
- There will also be economic benefits for businesses in the outdoor recreation and tourism sectors from an improved water environment as more people choose to use watercourses during their leisure time due to an improved natural environment[51]. Some of these have also been included in the amenity value which the public places on better water quality in our estimates of the environmental benefits from policy options, but where improvements relate to reductions in concentrations of FIOs, these have not been valued.
- There will also be economic benefits to businesses in the shellfisheries sector due to cleaner water. These have not been included in valuations of the environmental benefits.

[50] In 2012 agricultural GVA was worth 0.6% of total GVA in England. Source: Agriculture in the UK 2013.

[51] It has been estimated that tourism generates around £14.3bn per year in the Northwest. If all 33 bathing water pass the minimum standard of the new Directive, it is estimated that an increased visitor numbers would lead to an additional £12.7m per year for the North West economy. However should they all fail, the reduced visitor numbers could come at a cost of £1.3bn to the local economy over 15 years.

9. Summary and preferred option with description of implementation plan

9a. Summary and Preferred Option

This impact assessment has reviewed the evidence of water pollution from agriculture and has identified phosphorus and sediment loss as the key pressures that need to be addressed both to improve the water environment and to implement relevant parts of the Water Framework Directive.

Section three described our policy objective which is to **establish a clear set of regulatory baseline good practice actions that meet the requirements of the Water Framework Directive**. In doing so we will reduce diffuse water pollution from agriculture in a way that minimises costs to the farming sector and maximises benefits to the economy and the environment. In aiming to achieve this objective we also seek to:

a) Support a healthy water environment – a measurable reduction in phosphorus and other pollutant losses over the next River Basin Management Plan cycle (2015-2021)

b) Promote a sustainable and competitive farming industry – by implementing policy proposals that increase resource efficiency, improve resilience and boost reputation, minimising regulatory burdens.

c) Secure wider environmental benefits – objectives (a) to (c) should deliver multiple environmental benefits including air quality, protecting soils, biodiversity, greenhouse gas emissions and flood risk.

d) Provide enforcement tools to the Environment Agency that are effective at addressing diffuse water pollution; i.e. a series of small events.

We considered the full range of mechanisms and measures for addressing these water quality issues and consulted informally with agricultural industry stakeholders, water companies and environmental NGOs whilst developing our proposals. This resulted in a refined list of basic measures that whilst targeted primarily at phosphorus and sediment losses delivered for all diffuse pollutants. Whilst non-regulatory mechanisms such as voluntary initiatives and guidance were considered, it was recognised that whilst these form an important and complementary part of the delivery of WDF, they would not implement the WFD requirement for national binding rules or deliver the scale of change required.

The set of basic measures were grouped into two possible options; option 2 would provide some environmental benefits and would be cost beneficial to the agricultural industry and option 3 would secure greater improvements in water quality but at an overall cost to farmers. Both options should close out the infraction risk.

Given that option 2 secures reductions in phosphorus and sediment losses but without placing significant additional burdens on the farming sector, this has been selected as the preferred option for consultation.

9b. Implementation plan

Subject to the outcome of this consultation, any regulation would be laid in early 2016 with a common commencement date of 1 October 2016. We propose to allow a transition period to give businesses sufficient time to familiarise themselves with the requirements and adapt their farming practices.

Communications

As well as the core objective of implementing the Water Framework Directive, the aim of the proposed regulations is to bring about an increase in the standard of farm practice and therefore

a reduction in water pollution. As such, communications and advice are central to delivering behaviour change.

Communications to explain the new regulatory requirements will be provided throughout the transition period, both directly and in partnership with leading industry bodies. These will be targeted towards farmers and land managers but also those that work with them (e.g. agronomists, suppliers, contractors), to maximise awareness and understanding of the requirements. Messages will be tailored to different industry sectors and take account of existing levels of awareness and uptake.

During and beyond this transition period, farmers will also have access to qualified and trained advisors who are at arms' length from the regulator. These will be provided as part of a single channel for farm advice across a number of regulatory regimes, including those under the Common Agricultural Policy. For farms in priority catchments, on-farm advice will be available.

Surveillance and enforcement

The Environment Agency is the competent authority for implementation of the Water Framework Directive and the regulator for domestic legislation on agricultural water pollution. It will act as the enforcement agency for any new regulations, adopting an advice-led approach to help farmers meet their legal requirements:

- It will use evidence to help identify where the priority areas, activities and farm businesses are for action and engage farmers to explain how the evidence relates to their farm.
- It will educate farmers on how the activities on farm are contributing to water pollution and enable farmers to take action by identifying the changes required in an action plan and, if needed, signpost them to where they can seek help to implement the changes.
- It will enforce where the actions are not implemented to agreed timescales by using the most appropriate and proportionate enforcement tool.
- It will then evaluate the action taken including behavioural changes, and record and monitor it to show success.

In using these tools, the regulator's approach will be proportionate and outcome-focused, with the aim of bringing businesses up to compliance.

To minimise burdens on businesses, the regulator will limit record-keeping requirements and focus inspection effort on the highest risk activities, areas and farm businesses. Within this, it will use data from wider regulatory regimes and external sources (e.g. farm assurance schemes) to target poor performance, such that farmers with a strong track record of good environmental performance are able to 'earn recognition' and benefit from a reduced probability of inspection. Inspection activity will be complemented by incident reporting and catchment walkovers.

The Rural Payments Agency also carries out inspections on farmers to ensure compliance with Cross compliance and baseline entry requirements for agri-environment schemes. In relation to these rules the RPA will check compliance with the GAECs 4 and 5 on soils as required under cross compliance. The baseline entry requirements for agri-environment are likely to include some of these measures and, where this applies, they will be inspected by the RPA.

Monitoring and evaluation

The Environment Agency will monitor implementation of the policy. Through its surveillance programme, it will collect compliance data to help assess the impact of the policy on farm practices. It will also monitor environmental outcomes through its programme of data collection under the Water Framework Directive (WFD). This includes ongoing measurement of the number of water bodies not achieving WFD objectives due to different agricultural pollutants.

Post implementation Review

The proposed intervention will be evaluated within five years of implementation to confirm that it has had its intended effect and has not incurred unintended consequences. This review will seek the views of stakeholders and draw on evidence collected from a number of test catchments during the implementation period. Policy recommendations arising from this evaluation will be considered as part of the six-year cycle of river basin management planning.

Annex A - Rejected options

The following options have been rejected on the basis that they would not meet the stated policy objectives.

- **Option 4. An improved voluntary approach**

Option 4 would involve enhancing the existing range of voluntary measures with the aim of securing improvements in water quality. Existing voluntary initiatives such as Tried & Tested and the Campaign for the Farmed Environment have been effective in securing good practice on many farms. However, relying on voluntary action alone would not meet the requirements of, or deliver the pace of change required by the WFD. We have therefore rejected this option.

- **Option 5. Maximal Regulatory Measures**

This option would apply Nitrate Vulnerable Zone standards everywhere and would introduce a robust set of mandatory new rules on all agricultural diffuse pollutants (phosphorus, sediment, faecal indicator organisms and pesticides) applied everywhere. It would therefore place significant impacts on the industry, delivering the maximum benefit to society. However, given the extra benefit does not exceed the higher costs imposed on the industry, it has not been pursued.

- **Option 6. Farm assurance schemes**

Farm assurance schemes such as the Red Tractor and Linking Environment and Farming (LEAF) have secured welcome improvements in environmental protection and form an important part of the overall action to tackle diffuse water pollution from agriculture. However, their voluntary status and incomplete coverage would not fulfil WFD requirements, so this option is also rejected.

- **Option 7. Incentivised measures**

Incentivising farmers to act rather than requiring them to act through regulation will achieve significant benefits for water quality. Incentives from government are provided through the Rural Development Programme for England for targeted high cost actions. However, to incentivise even the most basic of actions would be too costly and inequitable; many farmers already carry out these actions voluntarily or as a result of targeted regulation (in NVZs). In addition, it would not comply with WFD, so on this basis, this option is rejected.

- **Option 8. Targeted regulation**

The extent of phosphorus and sediment losses varies across the country due to differing farming practices, soils and rainfall amongst other variables. However, since the WFD requires us to ‘prevent or control the input of pollutants’ it would not be appropriate to target regulations for these widespread pollution issues. This option is therefore rejected.

- **Option 9. Extend cross compliance rules**

Government has considered whether to include these measures within cross compliance which would align with the existing baseline measures for farmers, potentially providing simplification. However, cross compliance alone does not have full geographic coverage and is not sufficiently binding and as a result we would not meet the WFD requirements. As cross compliance rules are negotiated with the European Commission there was limited scope to add to the existing rules. Therefore reliance on this option was rejected, but it could be an important element of a future approach.

Annex B – Measures

This annex contains detailed information on the measures, including analysis of the impact on farm income of the measures in each option for different farm types.

Impacts of Measures on Farm Income

Table B1 shows the assumptions which have been used to generate estimates of the impact on farm income, while Table B2 shows additional assumptions which have been used to estimate savings due to accounting for organic manure nutrient supply when using a fertiliser recommendation system. Where implementing a measure imposes capital costs on a farm business, this is shown in italics. Estimates of the time costs for administration and familiarisation are discussed separately in section 5c of the main document.

Table B1: Assumptions used in estimating farm income impacts of measures for Option 2. Sources: FARMSCOPER 3 Cost Tool, Nix Farm Management Pocketbook (44th edition)

Key: Green = positive impact on farm net income, red = negative impact, black = no impact, *italics = capital cost*	
Measure	**Assumptions for generating estimates of impacts on farm income**
1a. Field manure storage is located at least 10m from a watercourse	No additional costs to farm businesses of directly implementing this measure.
1b. Use a fertiliser recommendation system, taking soil reserves and organic manure supply into account	Costs of fertiliser applications to arable land are reduced by 5% due to more efficient use of fertiliser. Output of grassland increased by 10% due to more efficient use of fertiliser. In addition, there are savings due to not applying manufactured phosphorus fertiliser to soil with a high phosphorus index 4 or above), as recommended by fertiliser recommendation systems.[52] Around 20% of agricultural land is at P index 4 or above[53], and for this land there are savings are in the form of reduced use of phosphorus fertiliser (see table B2) and one less fertiliser application per annum (saving of £9 per ha which no longer has phosphorus fertiliser applied). There are no yield effects from no longer applying phosphorus to high-P soils. Where a farm has organic manure, there are additional savings from accounting for the nutrient value of manure applied to land. Table B2 separately shows the assumptions used to estimate the benefits to farm income of correctly accounting for the nutrient content of manure.[54] There will be additional costs of soil testing in order to implement a fertiliser recommendation system. It is assumed that a farmer will need to test each field every 5 years at a cost of £11.50 per test.
1c. Ensure that fertiliser and manures are spread evenly	A 1% increase in yield for arable crops due to more accurate spreading of manufactured fertiliser following calibration of a fertiliser spreader. No increase in yield on grassland due to fertiliser spreader calibration. No increase in arable or grassland yield due to manure or slurry spreader maintenance. An annual cost of £215 of calibrating a fertiliser spreader. An annual cost of £205 of maintaining a manure or slurry spreader.

[52] See p4, http://www.nutrientmanagement.org/2-nutrient-management-plan/

[53] See here: http://www.nutrientmanagement.org/paag-2013-final-dec-2013/

[54] Where the potential supply of a nutrient from organic manure is greater than total crop demand across the farm, then we assume no further cost savings beyond the total amount of manufactured fertiliser required to cater for total crop demand. This is because high transportation costs mean that it is unlikely that a farmer could sell excess organic manure to another farmer.

2a. Use a feed planning system and match nutrient content of diets to livestock requirements	*This will impose capital costs on farm businesses through purchasing additional transponder collars (£26 per cow) and feed dispensers (£2100 for every 20 cows).* More efficient use of feed due to feed planning and tailoring rations to individual animal demand leads to a 10% reduction in dairy input costs. Reducing the amount of nutrients in dairy, indoor pig and poultry diets leads to a 2% increase in input costs for these farms.
2b. Livestock feeders must not be positioned within 10m of any surface water or a wetland	This will impose costs on farmers for moving livestock feeders, estimated at 15 minutes per feeder, with a cost of £34 per hour for a tractor and a driver.
2c. Avoid severe poaching where likely to pollute a watercourse (applicable to farmers not meeting GAECs 4 & 5)	Costs based on fencing 1% of the grazing area at £5.50 per metre of electric fencing.
3a. Action is taken to prevent run-off from tramlines, rows, irrigation and high risk sloping lands or those lands highly connected to surface water. (applicable to farmers not meeting GAECs 4 & 5)	Costs based on additional tine cultivation of tramlines (on 30% of land area), at a rate of £46 per ha.
Additional Costs of Nutrient Management Planning	Where a business does not already have a nutrient management plan, it will need to create one to implement measure 1b. The costs of this are included in the FARMSCOPER analysis and is assumed to occupy 8 hours of farm manager time at £21 per hour.
Additional Costs of Manure Management Planning	For farms with livestock, where a business does not already have a manure management plan, it will need to create one to implement measures 1a and 1b. The costs of this are included in the FARMSCOPER analysis and is assumed to occupy 8 hours of farm manager time at £20 per hour.

Table B2: Assumptions used for estimating farm income impacts of accounting for organic manure nutrient supply when using a fertiliser recommendation system. Source: FARMSCOPER 3 Cost Tool.

Nutrient	**Nitrogen**	**Phosphorus**	**Potash**
Cost of manufactured fertiliser (£/kg)	£0.90	£0.85	£0.57
Nutrient content (kg nutrient/tonne animal waste)[55]			
Slurry	0.9	1.2	3.2
Farmyard Manure	0.6	3.2	8
Poultry Muck	6.3	25	18
Saving of manufactured fertiliser (£/tonne of animal waste)			
Slurry	£0.81	£1.02	£1.82
Farmyard Manure	£0.54	£2.72	£4.56

[55] For nitrogen, this measures available nitrogen within animal waste as opposed to total nitrogen, as a large portion of the nutrient content of animal waste is not immediately available for plant uptake.

Poultry Muck	£5.67	£21.25	£10.26

Table B3 shows the assumptions which have been used to estimate impacts on farm income of the additional methods in Option 3. This is in addition to the methods shown in Table B1.

Table B3: Assumptions used in estimating farm income impacts of measures for additional methods in Option 3. Sources: FARMSCOPER 3 Cost Tool, Nix Farm Management Pocketbook (44th edition)

Measure	Assumptions for generating estimates of impacts on farm income
1d. Do not spread more than 30m3/ha of liquid organic manure with high level of readily available N or more than 8t/ha of poultry manure in a single application between 15th October and the end of February. No repeat spreading for 21 days.	Cost based on additional slurry and poultry manure application costs, at £48/hr of spreading.
1e. Do not spread manufactured fertiliser or manures at high-risk times or in high-risk areas.	It is assumed that high-risk areas make up 5% of total farmland. Not applying fertiliser to these areas leads to 30% yield reductions in high-risk grassland areas and 50% yield reductions in high-risk arable areas. Not applying fertiliser to high-risk areas does save on fertiliser costs of manufactured nitrogen and phosphorus fertiliser (see Table B2) and on fertiliser applications (£9 per ha of high-risk area). Not applying fertiliser at high-risk times will lead to a 10% chance of yield reductions of 10% in any field in any year on both grassland and arable land for winter-sown crops. There are assumed to be no direct costs of not applying organic manures at high risk times and in high risk areas. *However, the industry-led Slurry Working Group estimated that farmers who manage their manures as slurry will require at least 5 months of slurry storage capacity in order to avoid applying slurry at high-risk times. We have therefore included the costs of upgrading slurry storage capacity to 5 months in this analysis. It is assumed that as part of the baseline farmers who do not currently 5 months storage have an average of 3 months' worth of storage, and upgrading storage has an initial capital cost of £62 per m^3 of storage required.*
1f. Incorporate manures into soil within 24 hours after application	It is assumed that 50% of organic manures are applied to bare arable land, and therefore need to be incorporated after application. This is costed at £61 per ha of bare arable land receiving manures.
2d. Exclude livestock from watercourses	*Costs based on 20% of farm grazing area having access to a watercourse. Capital costs will include the costs of fencing (£5.50 per metre) and installing pasture pumps as alternative sources of drinking water for livestock (£260 each, assumed 3 per field).*
Additional Costs of Manure Management Planning	For farms with livestock, where a business does not already have a manure management plan, it will need to create one to implement measures 1d, 1e and 1f. The costs of this are included in the FARMSCOPER analysis and is assumed to occupy 8 hours of farm manager time at £20 per hour.
Key: Green = positive impact on farm net income, red = negative impact, black = no impact, *italics = capital cost*	

The assumptions in tables B1, B2 and B3 will be further scrutinised in the consultation and we hope to be able to further develop the evidence on these impacts for the final impact assessment.

Table B4 below shows our central estimate of the capital cost requirement of each of the individual measures in the policy options on the average lowland grazing, dairy and cereals farm assuming that the farm was not previously enacting this measure. The impact of any of the measures is likely to vary according to the characteristics of each farm such as size, intensity of production, geographical characteristics and adoption of other practices. As the baseline adoption of each of these measures varies substantially, summing the values below will not give an accurate representation of the total capital cost requirement of each option on each farm type; this can be found in Section 5c.

Table B4: Capital Cost Impact of measures on Farm Income

Measure	User Guide Coding	Option	Impact on Average Farm Income		
			Lowland Grazing	Dairy	Cereals
1e. Do not spread manufactured fertiliser or manures at high-risk times or in high-risk areas. [56]	25, 26, 52, 68, 69, 72	3	£900[57]	£18000	N/A
2a. Use a feed planning system and match nutrient content of diets to livestock requirements	33,34	2 & 3	N/A	£24000	N/A
2d. Exclude livestock from watercourses	76	3	£3000	£3700	N/A
None of the other measures require capital expenditure					

Table B5 below shows our central estimate of the net operational cost impact of each of the individual measures in the policy options on the average lowland grazing, dairy and cereals farm assuming that the farm was not previously enacting this measure. The impact of any of the measures is likely to vary according to the characteristics of each farm such as size, intensity of production, geographical characteristics and adoption of other practices. The estimates shown in the table are based on the assumptions shown above and the data on average farms from the June Agricultural Census. As discussed in Section 5a, while it is possible to estimate this for individual measures at an individual farm level, it is not possible to separately identify these impacts at a national level for each group of measures. In addition, as the baseline adoption of each of these measures varies substantially, summing the values below will not give an accurate representation of the total net impact of each option on each farm type; this can be found in Section 5d.

Table B5: Operational Cost Impact of measures on Farm Income

Measure	User Guide Coding	Option	Impact on Average Farm Income		
			Lowland Grazing	Dairy	Cereals
1a. Field manure storage is located at least 10m from a watercourse	60	2 & 3	£0	£0	N/A
1b. Use a fertiliser recommendation system, taking soil reserves and organic manure supply into account	22, 23, 32	2 & 3	+£2600	+£6700	+£1500[58]

[56] The capital costs for this measure are costs of upgrading the capacity of slurry storage in order for livestock farms to have sufficient capacity to avoid spreading at high-risk times. See Table B3.

[57] Note that this is an average cost across lowland grazing farms which manage their organic manure as farmyard manure and as slurry. Farms which manage their manure as slurry and do not have adequate slurry storage will face much higher capital costs of implementing this measure.

[58] Even though the average cereals farm uses more fertiliser than the average dairy farm, the benefits from using a fertiliser recommendation system are greater for the dairy farm where it can utilise the nutrient content of manures more efficiently to reduce fertiliser use by a greater amount.

1c. Ensure that fertiliser and manures are spread evenly	21, 67	2 & 3	-£400	-£200	+£900
1d. Do not spread more than 30m^3/ha of liquid organic manure with high level of readily available N or more than 8t/ha of poultry manure in a single application between 15th October and the end of February. No repeat spreading for 21 days.	Not in user guide	3	N/A	-£630	N/A
1e. Do not spread manufactured fertiliser or manures at high-risk times or in high-risk areas.	25, 26, 52, 68, 69, 72	3	-£1200	-£2300	-£2400
1f. Incorporate manures into soil within 24 hours after application	73	3	-£400	-£2600	N/A[59]
2a. Use a feed planning system and match nutrient content of diets to livestock requirements	33, 34	2 & 3	N/A	+£11100	N/A
2b. Livestock feeders must not be positioned within 10m of any surface water or a wetland	38	2 & 3	-£100	-£100	N/A
2c. Avoid severe poaching where likely to pollute a watercourse (applicable to farmers not meeting GAECs 4 & 5)	Not in user guide, see method 2 below	2 & 3	-£300	-£310	N/A
2d. Exclude livestock from watercourses	76, also method 3 below[60]	3	-£50	-£50	N/A
3a. Action is taken to prevent run-off from tramlines, rows, irrigation and high risk sloping lands or those lands highly connected to surface water. (applicable to farmers not meeting GAECs 4 & 5)	Not in User guide, see method 7 below	2 & 3	£0	£0	-£750

Description of Measures

For most of the measures, detailed descriptions can be found in the ”Mitigation Methods User Guide”, which was developed in conjunction with an iteration of the FARMSCOPER decision support tool as part of Defra project WQ0106. The user guide is based on a mix of scientific studies and expert judgement and provides a detailed definition of the mitigation methods, as well as likely directions of changes in pollutant losses to air and water following implementation of the measures. The user guide also estimated the impacts on farm income of each of the measures. However, these estimates are now outdated, and should be ignored in favour of the updated estimates shown in Table B4.

Table B4 shows which mitigation method in the user guide corresponds to each basic measure. Note that in some cases a basic measure encompasses more than one mitigation method, so more than one mitigation method in the user guide should be referred to.

The full user guide can be found here - http://www.adas.co.uk/LinkClick.aspx?fileticket=vUJ2vlDHBjc%3d&tabid=345[61]

[59] Where a cereals farm imports manure, then this will lead to additional costs of implementing this measure on cereal farms not shown here. However, if a livestock farm exports manure, then the costs of implementing this measure will be lower for these farms than shown here.

[60] Method 3 below provides a full description of the impacts of this method. However, this method was modelled in FARMSCOPER using method 76 in the user guide, as the method described in the user guide was sufficiently close to Method 3 below for analysis on a national scale to be robust.

Some of the basic measures are not included in the User Guide. In order to understand more about the impacts of each of these individual measures, we asked ADAS to provide detailed definitions in a similar manner. These are included below for the relevant measures.

[61] Last accessed 14/08/2014.

2c. Avoid severe poaching where likely to pollute a watercourse

Method 2: Avoid severe poaching where likely to pollute a watercourse

Direction of change for target pollutants on the area where poaching is avoided:

Nitrogen			Phosphorus		Sediment	BOD	FIOs	Ammonia	Nitrous Oxide	Methane	Carbon Dioxide
Nitrate	Nitrite	Ammonium	Part	Sol							
↓	↓	↓	↓	↓	↓	↓	↓	~	↓	~	↑

Farm typologies applicable:

Dairy	Grazing LFA	Grazing Low	Mixed	Combinable Crops	Combinable Roots	In Pigs	Out Pigs	Poultry	Horticulture
✓	✓	✓	✓	×	×	×	✓	×	×

Description: Erect stock-proof fencing or exclude livestock when soils are 'wet' to prevent severe poaching (i.e. soil compaction and sward damage) in areas where there is a risk of direct surface runoff and pollutant transfer to watercourses**.**

Rationale: Poaching usually occurs when livestock are stocked on soils that are 'wet' and not strong enough to support the weight of grazing animals. This method aims to exclude livestock from 'wet' areas close to watercourses, either temporarily during high risk times or permanently, to reduce the risks of pollutant transfer to surface waters.

Mechanism for action: Poaching reduces vegetation cover and soil water infiltration rates, and increases the risk of surface runoff and associated nutrient, microbial pathogen and sediment losses to watercourses, particularly where there is direct connectivity or preferential flow pathways to surface waters. Excluding animals from 'wet' areas close to watercourses by installing temporary or permanent fencing, or excluding animals from these fields will help maintain good soil structure and vegetative cover. Also, reducing the amount of excreta deposited where there are preferential flow pathways to surface waters will reduce nutrient and microbial pathogen losses.

Potential for applying the method: This method is applicable to livestock farms where animals are kept outside in fields with good connectivity to surface waters. The risk of severe poaching is greatest when livestock are kept at high stocking densities on soils which are most likely to become waterlogged (i.e. medium/heavy soils).

Practicality: This method is applicable to most livestock farms that have areas of 'wet' land, which is particularly vulnerable to poaching. The method is less applicable to upland beef/sheep farms, with extensive areas of rough grazing and considerable areas of poorly drained soils that are susceptible to poaching and are difficult to fence off/exclude animals from.

Likely uptake: Moderate due to fencing costs.

Costs:

	Dairy	Grazing LFA	Grazing Low	Mixed	Pigs out	Costs based on fencing 1% of the grazing area and are amortised over 10 years
Annual cost for farm (£/farm)	310	470	300	310	60	

Effectiveness:

N: NO_3 (plus ammonium and nitrite) losses would be reduced and direct and indirect N_2O emissions by a small amount (<2%).

P and sediment: Particulate/soluble P and associated sediment losses would be reduced by up to 10%, as a result of lower amounts of poaching damage and reductions in surface runoff and erosion.

FIOs and BOD: Losses would be reduced by a small amount (<2%) as less excreta will be deposited close to or on poached areas with good connectivity to watercourses.

Other pollutants: CO_2 emissions would be increased by a very small amount as a result of the fencing operations. Impacts on other pollutants are likely to be minimal.

Key references:

Bilotta, G.S., Brazier, R.E. and Haygarth, P.M. (2007). The impacts of grazing animals on the quality of soils, vegetation and surface waters in intensively managed grasslands. *Advances in Agronomy*, 94, 238-280.

Collins, A.L., Zhang, Y., Walling, D.E. and Black, K. (2010). Apportioning sediment sources in a grassland dominated agricultural catchment in the UK using a new tracing framework. In: *Sediment Dynamics for a Changing Future* (pp. 68-75). International Association of Hydrological Sciences Publication No. 337, Wallingford, UK.

Cournane, F.C., McDowell, R., Littlejohn, R. and Condron, L. (2011). Effects of cattle, sheep and deer grazing on soil physical quality and losses of phosphorus and suspended sediment losses in surface runoff. *Agriculture, Ecosystems and Environment*, 140, 264-272.

Defra project ES0106 - Integrated catchment management at Whittle Dene: Phase II.

Defra project NT1005 - Phosphorus loss from grassland soils.

Defra project NT1013 - Phosphorus loss in surface runoff from different land uses.

Defra project PE0102 - Rationalising risk and scaling-up of on-farm practices to classify rates of phosphorus transfer to grassland catchments.

Doody, D.G., Archbold, M., Foy, R.H. and Flynn, R. (2012). Approaches to the implementation of the Water Framework Directive: targeting mitigation measures at critical source areas of diffuse phosphorus in Irish catchments. *Journal of Environmental Management*, 93, 225-234.

Evans, R. (1997). Soil erosion in the UK initiated by grazing animals. A need for a national survey. *Applied Geography*, 17, 127-141.

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Oliver, D.M., Clegg, C.D., Haygarth, P.M. and Heathwaite, A.L. (2005). Assessing the potential for pathogen transfer from grassland soils to surface waters. *Advances in Agronomy*, 85, 125-180.

Page, T., Haygarth, P.M., Beven, K., Joynes, A., Butler, T., Keeler, C., Freer, J., Owens, P.N. and Wood, G.A. (2005). Spatial variability of soil phosphorus in relation to the topographic index and critical source areas: sampling for assessing risk to water quality. *Journal of Environmental Quality*, 34, 2263-2277.

Thompson, J., Cassidy, R., Doody, D.G. and Flynn, R. (2013). Predicting critical source areas of sediment in headwater catchments. *Agriculture, Ecosystems and Environment*, 179, 41-52.

2d. Exclude livestock from watercourses

Method 3: Exclude livestock from watercourses within fields and provide alternative means of water provision

Direction of change for target pollutants in grazed fields with watercourses:

Nitrogen			Phosphorus		Sediment	BOD	FIOs	Ammonia	Nitrous Oxide	Methane	Carbon Dioxide
Nitrate	Nitrite	Ammonium	Part	Sol							
↓	↓	↓	↓↓	↓	↓↓	↓	↓	~	~	~	↑

Farm typologies applicable:

Dairy	Grazing LFA	Grazing Low	Mixed	Combinable Crops	Combinable Roots	In Pigs	Out Pigs	Poultry	Horticulture
✓	✓	✓	✓	×	×	×	×	×	×

Description: Erect stock-proof fences in grazing fields and on trackways adjoining rivers and streams.

Rationale: Trampling by livestock can erode river/stream banks and increase sediment inputs to watercourses. Livestock can also add pollutants directly by urinating and defecating into the water. Preventing access eliminates this source of direct pollution.

Mechanism of action: Livestock can cause severe damage to river and stream banks when attempting to gain access to drinking water. The vegetative cover is destroyed and the soil badly poached, leading to erosion of the bank and increased transport of soil particles and associated nutrients into watercourses. Livestock also add nutrients and FIOs by defecating and urinating directly into the water. Preventing bank access to livestock (e.g. by the erection of permanent or temporary fencing or other means) during stocking eliminates this source of pollution.

Potential for applying the method: This method is applicable to all farms with grazing livestock and river/stream banks. Benefits will be greatest on farms with high cattle or sheep numbers. The method is not applicable to outdoor pigs, as these are securely fenced and would not have direct access to rivers or streams.

Practicability: The method is less applicable to upland beef/sheep farms with extensive areas of rough grazing and considerable lengths of unfenced river/stream banks where it is impractical to fence off/exclude animals from direct access. There is likely to be a need to provide an alternative source of drinking water. Fencing watercourses may not be appropriate where flooding occurs on a regular basis.

Likely Uptake: Moderate. Capital grants schemes (typically 50% of cost) are available within Catchment Sensitive Farming priority catchments. Some management of the vegetation between the watercourse and the fences may be necessary to control weeds, etc.

Costs:

	Dairy	Grazing LFA	Grazing Low	Mixed	Costs are based on provision of standard fencing and water troughs and are amortised over 10 years.
Annual cost for farm (£/farm)	2,000	1,000	1,300	2,000	

Effectiveness:

N: NO_3 (plus ammonium and nitrite) losses would be decreased by a small (<2%) amount.

P: Particulate/soluble P and associated sediment losses would be reduced by up to 50%

FIOs and BOD: Losses would be reduced by a small (up to 5%) amount.

Other Pollutants: CO_2 emissions would be increased by a very small amount through fencing/water trough installation. Impacts on other pollutants are likely to be minimal.

Key references:

Collins, A.L., Walling, D.E., McMellin, G.K., Zhang, Y., Gray, J., McGonigle, D. and Cherrington, R. (2010). A preliminary investigation of the efficacy of riparian fencing schemes for reducing contributions from eroding channel banks to the siltation of salmonid spawning gravels across the south west UK. *Journal of Environmental Management*, 91, 1341-1349.

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Kay, D., Aitken, M., Crowther, J., Dickson, I., Edwards, A.C., Francis, C., Hopkins, M., Jeffrey, W., Kay, C., McDonald, A.T., McDonald, D., Stapleton, C.M., Watkins, J., Wilkinson, J. and Wyer, M.D. (2007). Reducing fluxes of faecal indicator compliance parameters to bathing waters from diffuse agricultural sources: The Brighouse Bay study, Scotland. *Environmental Pollution,* 147, 138-149.

Line, D.E. (2003). Changes in a stream's physical and biological conditions following livestock exclusion. *Transactions of the ASAE*, 46, 287-293.

Thorne, C.R. (1990). Effects of vegetation on riverbank erosion and stability. In: Thornes, J.B. (ed.), *Vegetation and Erosion: Processes and Environments*. Wiley, New York, pp. 125-144.

2c. Do not spread more than 30m^3/ha of slurry or digestate or more than 8t/ha of poultry manure in a single application between 15th October and the end of February. No repeat spreading for 21 days.

Method 5: Outside Nitrate Vulnerable Zones, restrict application rates of high readily available N organic manures between 15 October and end of February and do not apply to high-risk areas

Direction of change for target pollutants where manure is applied:

Nitrogen			Phosphorus		Sediment	BOD	FIOs	Ammonia	Nitrous Oxide	Methane	Carbon Dioxide
Nitrate	Nitrite	Ammonum	Part	Sol							
↓	↓	↓	↓	↓	~	↓	↓	~	↓	~	↑

Farm typologies applicable:

Dairy	Grazing LFA	Grazing Low	Mixed	Combinable Crops	Combinable Roots	In Pigs	Out Pigs	Poultry	Horticulture
✓	×	×	✓	✓	✓	×	×	×	×

Description: On farms outside Nitrate Vulnerable Zones (NVZs):

- Restrict application rates of high readily available nitrogen (RAN) organic manures to 30 m^3/ha for livestock slurries and anaerobic digestate, and 8 t/ha of poultry manure between 15 October and the end of February; with no repeat applications for 21 days.
- Do not surface broadcast high RAN manures within 10m of a watercourse.
- Do not apply slurry or digestate within 6m of a watercourse if using precision equipment.
- Do not spread high RAN manures within 50 m of a spring or borehole.
- Do not spread high RAN manures to land with a slope of more than 12°

Rationale: Limiting application rates of high RAN manures when soils are most likely to be 'wet', and not applying manures to areas close to watercourses or groundwater sources, will reduce the potential for nutrient pollution via leaching, surface runoff and drainage water contamination. The current maximum recommended application rate of high RAN manures detailed in the Code of Good Agricultural Practice is 50 m^3/ha for liquid manures, 8 t/ha for poultry litter and 13 t/ha for layer manure. Also, the Code of Good Agricultural Practice advises that organic manures should not be spread within 10 m of a watercourse or within 50 m of a spring, well or borehole (used to supply water for human consumption or use in farm dairies). In NVZs, these rules are mandatory. Closed periods for spreading high RAN manures already exist for farmers in NVZs.

Mechanism for action: This method reduces nutrient additions and hydraulic loading rates from liquid organic manure applications during periods when the risks of water pollution following application are highest. Limiting application rates will reduce the likelihood of high RAN manures causing water pollution, via surface runoff, leaching or rapid preferential flow through cracks/mole channels in soil to field drains. The method also reduces the risk of pollutant transfer from areas where there is good hydrological connectivity between fields and watercourses. A Farm Manure Management Plan should be prepared to manage pollution risks following application.

Potential for applying the method: This method is applicable to all farms either producing or importing high RAN organic manures.

Practicality: This method will be most applicable to farms that do not have sufficient storage capacity to store high RAN organic manures over the winter period, and have well drained soils that can be trafficked without causing compaction or where runoff risks are low.

Likely uptake: Moderate to high as there are many farms outside NVZs that do not have sufficient over-winter storage capacity for high RAN organic manures.

Cost:

Total cost for farm system (£/farm)	Dairy	Mixed	Comb Crops (In Pigs)	Comb Roots (Poultry)	Cost based on additional slurry and poultry manure application costs.
Annual	630	90	220	100	

Effectiveness:

N: NO_3 (plus ammonium and nitrite) leaching losses would be reduced by up to 10% and associated indirect N_2O emissions. *Overall* manure N use efficiency would be increased and manufactured fertiliser N use reduced by a small amount.

P, FIOs and BOD: Losses would be reduced by a small amount (<2%) due to a reduction in pollutant loadings and lower risks of surface water runoff and drainflow contamination.

Other pollutants: CO_2 emissions are likely to increase due to more frequent (lower application rate) manure applications. Impacts on other pollutant losses are likely to be minimal.

Key References:

Defra. (2009). Protecting our Water, Soil and Air. *A Code of Good Agricultural Practice for Farmers, Growers and Land Managers*. TSO, Norwich.

Defra (2013). *Guidance on Complying with the Rules for Nitrate Vulnerable Zones in England for 2013 to 2016*. www.gov.uk/nitrate-vulnerable-zones.

Defra/RPA (2014). *The Guide to Cross Compliance in England 2014*.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/320833/The_Guide_to_Cross_Compliance_in_England_2014_complete_edition.pdf.

Defra project ES0106 - Developing integrated land use and manure management systems to control diffuse nutrient loss from drained clay soils: BRIMSTONE-*NPS*.

Defra project ES0115 - Optimising slurry application timings to minimise nitrogen losses: OPTI-*N*.

Defra project WA1508 - Slurry storage and management.

Sagoo, E., Newell Price, J.P., Williams, J.R., Hodgkinson, R.A. and Chambers, B.J. (2014). Managing cattle slurry application timings to mitigate diffuse water pollution. In: *Proceedings of International Conference on Realistic Expectations for Improving European Waters*. I. Sisak (ed.). Final Conference of COST Action 869 - Mitigation Options for Nutrient Reduction in Surface and Ground Waters; pp. 77-90. Published at www.aton.hu.

Thorman, R. E., Sagoo, E., Williams, J. R., Chambers, B. J., Chadwick, D. R., Laws, J.A. and Yamulki, S. (2007). The effect of slurry application timings on direct and indirect N_2O emissions from free draining grassland soils. In: *Proceedings of the 15th Nitrogen Workshop*, Spain, pp. 297-299.

3a. Action is taken to prevent run-off from tramlines, rows, irrigation and high risk sloping lands or those lands highly connected to surface water. (applicable to farmers not meeting GAECs 4 & 5)

Method 7: Minimise runoff from tramlines or other compacted wheeled areas

Direction of change for target pollutants on tillage land area with tramlines:

Nitrogen			Phosphorus		Sediment	BOD	FIOs	Ammonia	Nitrous Oxide	Methane	Carbon Dioxide
Nitrate	Nitrite	Ammonium	Part	Sol							
~	~	~	↓↓	↓	↓↓	~	~	~	~	~	↑

Farm typologies applicable:

Dairy	Grazing LFA	Grazing Low	Mixed	Combinable Crops	Combinable Roots	In Pigs	Out Pigs	Poultry	Horticulture
✓	×	✓	✓	✓	✓	×	×	×	×

Description: Use tines to disrupt tramlines/compacted wheeled areas, drill future tramlines with a crop, or delay tramline establishment until the spring.

Rationale: Tramlines are generally established in autumn sown combinable crops at the time of drilling; they can result in the channelling of surface water and the development of rills and gullies particularly on sloping erosion susceptible soils. Tramline/wheeled area management to improve soil water infiltration rates can help to reduce accelerated surface runoff and the loss of particulate P and sediment.

Mechanism of action: Surface runoff and associated sediment mobilisation, can occur from 'compacted' tramlines/wheeled areas which act as concentrated flow pathways. The risk of runoff is greatest when soils are 'wet' during the winter. If tramlines are present, for example, as a result of the need to apply plant protection products during the autumn period, then tines can be used to disrupt the tramlines, which encourages water to infiltrate into the soil. Also, future tramlines can be drilled with the crop and then either wheeled over or sprayed off in spring. Using low ground-pressure vehicles also helps to limit soil compaction and maintain water infiltration rates.

Potential for applying the method: This method (either avoiding, drilling or disrupting tramlines/wheeled areas) is applicable to winter cereal cropped land and oilseed rape crops with poor ground cover, particularly on light/medium textured soils on sloping land in higher rainfall areas.

Practicability: Not establishing over-winter tramlines is potentially applicable to all winter sown combinable crop land, but will be less applicable where there is a need to apply plant protection products in the autumn/winter; drilling future tramlines or tramline loosening would be more applicable. Tramline/wheeled area loosening should not be carried when soils are 'wet' as tine cultivation can cause smearing, which will reduce soil water infiltration and increase runoff risks.

Likely uptake: Low-moderate.

Cost:

Total cost for farm system (£/farm)	Dairy	Grazing Low	Mixed	Comb Crops	Comb Roots	Costs based on additional tine cultivation of tramlines (on 30% of land area)
Annual	10	20	150	750	400	

Effectiveness:

P and sediment: Field evidence indicates that tramline disruption can reduce particulate P and associated sediment losses by 30-50% on winter cereal cropped land.

Other pollutants: CO_2 emissions would be increased by a small amount from the additional tine cultivation or need to apply a herbicide. Impacts on other pollutants are likely to be minimal.

Key references:

Bailey, A., Deasy, C., Quinton, J., Silgram, M., Jackson, B. and Stevens, C. (2013). Determining the cost of in-field mitigation options to reduce sediment and phosphorus loss. *Land Use Policy*, 30, 234-242.

Catt, J.A., Howse, K.R., Farina, R., Brockie, D., Todd, A., Chambers, B.J., Hodgkinson, R., Harris, G.L. and Quinton, J.N. (1998). Phosphorus losses from arable land in England. *Soil Use and Management*, 14, 168-174.

Chambers, B.J., Davies, D.B. and Holmes, S. (1992). Monitoring of soil water erosion on arable farms in England and Wales, 1989/90. *Soil Use and Management*, 8, 163-170.

Chambers, B.J., Garwood, T.W.D. and Unwin, R.J. (2000). Controlling soil water erosion and phosphorus losses from arable land in England and Wales. *Journal of Environmental Quality*, 29, 145-150.

Collins, A.L. and Davison, P.S. (2009). Mitigating sediment delivery to watercourses during the salmonid spawning season: potential effects of delayed wheelings and cover crops in a chalk catchment, southern England. *International Journal of River Basin Management,* 7, 209-220.

Collins, A.L., Jones, J.I., Sear, D.A., Naden, P.S., Skirvin, D., Zhang, Y.S., Gooday, R., Murphy, J., Lee, D., Pattison, I., Foster, I.D.L., Williams, L.J., Arnold, A., Blackburn, J.H., Duerdoth, C.P., Hawczak, A., Pretty, J.L., Hulin, A., Marius, M.S.T., Smallman, D., Stringfellow, A., Kemp, P., Hornby, D., Hill, C.T., Naura, M. and Brassington, J. (2012). *Extending the Evidence Base on the Ecological Impacts of Fine Sediment and Developing a Framework for Targeting Mitigation of Agricultural Sediment Losses*. Final report to Defra, August 2012.

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Fullen, M.A. (1985). Compaction, soil hydrological process and soil-erosion on loamy sands in east Shropshire, England. *Soil Tillage and Research*, 6, 17-29.

Silgram, M., Jackson, D.R., Bailey, A., Quinton, J.N. and Stevens, C. (2010). Hill slope scale surface runoff, sediment and nutrient losses associated with tramline wheelings. *Earth Surface Processes and Landforms*, 35, 699-706.

Skinner, R.J. and Chambers, B.J. (1996). A survey to assess the extent of soil water erosion in lowland England and Wales. *Soil Use and Management*, 12, 214-220.

Stevens, C.J. and Quinton, J. (2008). Investigating source areas of eroded sediments transported on concentrated overland flow using rare earth element tracers. *Catena*, 74*, 31-36.*

Withers, P.J.A., Hodgkinson, R.A., Bates, A. and Withers C. (2006). Some effects of tramlines on surface runoff, sediment and phosphorus mobilization on an erosion-prone soil. *Soil Use and Management,* 22, 245-255.

Annex C – Methodology

Table C1 below shows which impacts we have been able to identify, quantify and monetise in this impact assessment. The analysis has focussed on use of the FARMSCOPER modelling framework. This tool is described in more detail below. This section also considers the method for monetising environmental benefits and the method used to analyse measures which cannot be modelled in the FARMSCOPER tool.

Table C1: Level of analysis for different impacts of Options 2 and 3 in Consultation Stage Impact Assessment

Impact	Example Impacts	Measures	Identified?	Quantified?	Monetised?
Farm Business Impacts	Impacts on farm income, costs, cost savings	FARMSCOPER Measures	Y	Y	Y
		Non-FARMSCOPER measures	Y	Y	Y
Water Quality and Air Quality	Nitrates, Phosphorus, Sediment, Faecal Indicator Organisms, Ammonia, GHGs	FARMSCOPER Measures	Y	Y	Y
		Non-FARMSCOPER measures	Y	N	N
Wider Environmental Impacts	Biodiversity, soil organic carbon	FARMSCOPER Measures	Y	N	N
		Non-FARMSCOPER measures	Y	N	N

Introduction to FARMSCOPER

The FARMSCOPER (FARM SCale Optimisation of Pollutant Emissions Reduction) modelling tool was developed from 2006 as part of Defra project WQ0106 as a means to model on-farm losses of pollutants from agriculture to surface water and the atmosphere, and to model the effects of various mitigation methods in reducing such losses.[62] This includes modelling reductions in losses of phosphorus and sediment to water.

For the analysis in this Impact Assessment, Defra analysts have used the latest of version of the tool, version three. This version contains updated information on the cost of mitigation methods and baseline of current uptake of methods. FARMSCOPER uses Microsoft Excel as the user interface, and consists of three principal tools. The first is the ability to 'create' a model farm. This involves specifying the geographical conditions of the farm, details of the enterprises carried out on-farm and the practices used on-farm. The outputs of this tool are details of the annual losses of pollutants to air and water from the model farm based on evidence about the drivers on agricultural losses of pollutants from a suite of existing models. For this analysis, we have used model farms based on 2010 June Agricultural Census data, which provides data for the average farms across 10 farm types and a range of different soil types and rainfall levels.

[62] FARMSCOPER has previously been used for analysis in other contexts. This includes work on prioritising method selection in Demonstration Test Catchments and a Defra 2012 review of the voluntary approach in tackling agricultural emissions of GHGs. It is also currently being used as part of the modelling in the ongoing Defra project WQ0223. It has also been used in academic research; see: Zhang, Y., et al., Application of the FARMSCOPER tool for assessing agricultural diffuse pollution mitigation methods across the Hampshire Avon Demonstration Test Catchment, UK. Environ. Sci. Policy (2012), http://dx.doi.org/10.1016/j.envsci.2012.08.003

Table C2: The 10 Farm Types considered in FARMSCOPER

Cereals	Dairy
General Cropping	LFA Grazing Livestock
Indoor Pigs	Lowland Grazing Livestock
Outdoor Pigs	Mixed
Horticulture	Poultry

The second tool is used to model the impact of different mitigation methods on losses of pollutants from a given model farm. The program now contains 110 mitigation methods, but a user can add further methods if they have sufficient data. The tool allows a user to specify a level of current practice as prior implementation of different methods, and also to vary the extent to which a method is adopted. It then compares the losses of pollutants after the implementation of a single method or a group of methods with losses of pollutants under current practice. This is based on a series of evidence-based assumptions as to the efficacy of on-farm mitigation methods[63]. In addition, the tool also shows the impacts on farm income by modelling the likely cost and revenue implications of each of the mitigation methods[64]. Results are presented in terms of the loads (i.e. the mass) of pollutants lost from the farm, as opposed to concentrations (the mass of a specific pollutant for a given volume of water) in watercourses. Details of the methods which have been modelled in this analysis and the levels of prior and post implementation assumed can be found in Section 5b.

The final tool combines the outputs of the first two tools to estimate the effects of implementing a single method or a group of methods across a given geographical area. As such, it estimates the impact of the methods across each model farm and upscales the results according to the number of farms of each farm type, soil type and rainfall level. This means that the tool can be used to assess the impact across a geographical area if methods are implemented universally.

FARMSCOPER is a powerful modelling tool which can estimate the impact of a large number of mitigation methods across a wide area. However, while the use of average farms across the different sectors of agriculture is necessary in order to keep the data and resource requirements of analysis proportionate, it means that the final results of analysis are an average figure and hide a significant level of variation between different farm businesses and in different geographical areas with different conditions. Our approach to modelling uncertainty in outputs is discussed below.

Measures modelled in FARMSCOPER

Table C3 below shows which of the basic measures have been modelled in FARMSCOPER and which mitigation methods they correspond to. In some cases a basic measure encompasses more than one mitigation method in FARMSCOPER.

Table C3 also highlights where the fit between basic measures and mitigation methods in FARMSCOPER is not exact and explains where this may result in bias in the modelling results. We have used expert opinion from within Defra and outside bodies to check that the mitigation methods in FARMSCOPER correspond sufficiently to the basic measures.

Table C3: Mitigation Methods in FARMSCOPER

Basic Measure	Option(s)	FARMSCOPER Method(s)
1a. Field manure storage is located at least 10m from a	2 and 3	60 - Site solid manure heaps away from watercourses/field drains

[63] More detail on these assumptions can be found in the 'Mitigation Methods User Guide', which is available here - http://www.adas.co.uk/LinkClick.aspx?fileticket=vUJ2vlDHBjc%3d&tabid=345

[64] The relevant assumptions regarding the impacts of mitigation methods on net farm income are shown in Annex B for the methods in Options 2 and 3.

watercourse		
1b. Use a fertiliser recommendation system, taking soil reserves and organic manure supply into account	2 and 3	22 – Use a fertiliser recommendation system
		23 – Integrate fertiliser and manure nutrient supply
		32 – Do not apply P fertiliser to high-P soils
1c. Ensure that fertiliser and manures are spread evenly	2 and 3	21 – Fertiliser spreader calibration
		67 – Manure spreader calibration
1d. Do not spread more than 30m^3/ha of liquid organic manure with high level of readily available N or more than 8t/ha of poultry manure in a single application between 15th October and the end of February. No repeat spreading for 21 days.	3	Not modelled in FARMSCOPER
1e. Do not spread manufactured fertiliser or manures at high-risk times or in high-risk areas.	3	25 - Do not apply fertiliser to high-risk areas
		26 - Do not spread manufactured fertiliser to fields at high-risk times
		52 - Increase the capacity of farm slurry stores to improve timing of slurry applications
		68 - Do not apply manure to high-risk areas
		69 - Do not spread slurry or poultry manure at high-risk times
		72 - Do not spread FYM to fields at high-risk times
1f. Incorporate manures into soil within 24 hours after application	3	73 – Incorporate manure into the soil
2a. Use a feed planning system and match nutrient content of diets to livestock requirements	2 and 3	33 – Reduce dietary N and P intakes
		34 – Adopt phase feeding of livestock
2b. Livestock feeders must not be positioned within 10m of any surface water or a wetland	2 and 3	38 – Move feeders at regular intervals[65]
2c. Avoid severe poaching where likely to pollute a watercourse (applicable to	2 and 3	Not modelled in FARMSCOPER[66]

[65] This measure includes the impacts of keeping feeders away from watercourses and moving them frequently. The analysis is therefore likely to overstate both the costs and benefits of the basic measure, which only includes keeping feeders away from watercourses. The bias will be more serious for the environmental benefits than the costs to farm businesses, which have been downscaled to reflect the costs of moving feeders annually as opposed to more frequently.

[66] This measure only applies to the 6% of farm businesses which are not covered by cross-compliance, many of which are intensive livestock farms and do not have any arable or grassland. Therefore, in the analysis we have assumed that this measure will have no impact, though is essential to ensure that we are fully implementing Water Framework Directive requirements on national coverage of measures.

farmers not meeting GAECs 4 & 5)		
2d. Exclude livestock from watercourses[67]	3	76 - Fence off rivers and streams from livestock[68]
3a. Action is taken to prevent run-off from tramlines, rows, irrigation and high risk sloping lands or those lands highly connected to surface water. (applicable to farmers not meeting GAECs 4 & 5)	3	Not modelled in FARMSCOPER[69]

Table C4 shows the baseline levels of uptake which were assumed for each method in the main scenario. The final rates of implementation of the measures under regulation are shown in Table 4.

Table C4: Baseline of uptake of measures in main scenario

Measure	**Existing regulatory mechanism**	**Percentage of farmers adopting each measure**	
		NVZ	**Non-NVZ**
1a. Field manure storage is located at least 10m from a watercourse	NVZ	100	80
1b. Use a fertiliser recommendation system, taking soil reserves and organic manure supply into account	None	80	50
1c. Ensure that fertiliser and manures are spread evenly	None	50	25
1d. Do not spread more than 30m^3/ha of liquid organic manure with high level of readily available N or more than 8t/ha of poultry manure in a single application between 15th October and the end of February. No repeat spreading for 21 days.	NVZ	100	80
1e. Do not spread manufactured fertiliser or manures at high-risk times or in high-risk areas.	NVZ	100	50 (high-risk areas), 25 (high-risk times)
1f. Incorporate manures into soil within 24 hours after application	NVZ	100	25
2a. Use a feed planning system and match nutrient content of diets to livestock requirements	None	80	80

[67] Farms in less-favoured areas (LFAs) are exempt from this measure, which has been reflected in the FARMSCOPER analysis.

[68] This FARMSCOPER measure only includes the effects of preventing livestock from excreting in a watercourse and ignores any impacts from preventing bank erosion and poaching close to a watercourse where livestock regularly cross from a field to a watercourse to drink. As a result, it understates the impact of this measure, in particular on losses of sediment and phosphorus. We have used expert opinion to attempt to appraise the added impact of avoiding bank erosion and poaching close to a watercourse due to implementing this measure, but we have not been able to quantify this impact and therefore it has not been included in estimates of value-for-money.

[69] This measure only applies to the 6% of farm businesses which are not covered by cross-compliance, many of which are intensive livestock farms and do not have any arable or grassland. Therefore, in the analysis we have assumed that this measure will have no impact, though is essential to ensure that we are fully implementing Water Framework Directive requirements on national coverage of measures.

2b. Livestock feeders must not be positioned within 10m of any surface water or a wetland	None	50	50
2c. Avoid severe poaching where likely to pollute a watercourse (applicable to farmers not meeting GAECs 4 & 5)	Cross-Compliance	95	95
2d. Exclude livestock from watercourses	None	50	50
3a. Action is taken to prevent run-off from tramlines, rows, irrigation and high risk sloping lands or those lands highly connected to surface water. (applicable to farmers not meeting GAECs 4 & 5)	Cross-compliance	95	95

Uncertainty

Impacts on the environment and on farm businesses of adopting mitigation measures are subject to a large degree of uncertainty and depend on a wide range of factors. Central estimates of the value for money of the policy options reflect our current understanding of these impacts, but we have estimated ranges for these values to reflect both the inherent uncertainty of these impacts and gaps in our current understanding.

For uncertainty in farm costs, the results from core modelling in the FARMSCOPER tool only include a central estimate of the costs of measures. However, the tool does estimate a minimum and maximum impact on the farm business for each individual mitigation method. These are based on expert judgement from ADAS as to the uncertainty of the impact of a measure on the farm business – for example uncertainty in the unit cost of an item which must be purchased. When estimating the impacts on farm economics of groups of measures within the policy options, Defra economists have combined the FARMSCOPER estimates of minimum and maximum value for the measures within a group to produce a scaling factor. The central estimates of cost have then been adjusted using this scaling factor to present estimates for the minimum and maximum impact on farm businesses of a measure.

The FARMSCOPER modelling tool does present a distribution of expected impacts on pollutants from implementing a group of measures, but this is obtained at an individual farm level as opposed to at a national level. We have used a number of 'typical' farms from each farming sector to generate estimates of the minimum and maximum impact on pollutants for each sector from implementing each group of measures. The minimum and maximum points were estimated at the fifth and ninety-fifth percentile points along the cumulative probability distribution of expected pollutant reductions. These maximum and minimum values for the typical farms in the sector were then used to generate scaling factors for the pollutant reductions for each sector. We used 'typical' farms from each sector in order to reduce resource time spent running the model and in adherence to the principle of proportionality in analysis. However, this may lead to small biases in the range of expected pollutant reductions where the range of pollutant reductions varies between different geographical conditions such as soil type or levels of rainfall.

Valuation

In order to monetise the impact of policy options on the water environment, we have used estimates for environmental benefits for improvements in water quality. The main source for these estimates is analysis of the total willingness to pay for improvements to river environments generated through updates to the National Water Environment Benefits Survey (NWEBS) by independent consultant Paul Metcalfe. [70] As Metcalfe's study did not capture the value of benefits to drinking water and bathing waters, we used separate sources which are

[70] Paul Metcalfe. "Update of CRP WFD Benefit Values – Economic Component", 2012.

summarised in Defra project WT0706[71] to supplement the Metcalfe estimates. By assuming symmetry between the benefits from mitigation and the damage caused by pollution, these estimates are used as a proxy for the damage cost from all agricultural pollution; this assumption will be tested during consultation. The total contribution from agriculture across benefits to the river environment, drinking water and bathing waters and different pressures were then estimated using preliminary working analysis of WTP values disaggregated by pressure. The results for the total damage caused by agricultural losses of each pollutant are shown below in Table C5.

Table C5: Total Annual Environmental benefits from elimination of all agricultural losses of water-based pollutants (range in brackets)

Pollutant	**Total damage cost**
Nitrate	£89m (£50m - £130m)
Phosphorus	£76m (£16m - £134m)
Sediment	£86m (£75m - £97m)
FIOs	£43m (£31m - £55m)

In order to find a unit environmental benefits, the total damage caused by emissions of each pollutant were then divided by the total annual losses of that pollutant from agriculture as sourced from estimates of losses modelled in FARMSCOPER using a baseline of current practice. The unit environmental benefits (with appropriate allowances for uncertainty) are shown in Table 22.

The use of the update to the National Water Environment Benefits Survey means that this approach is consistent with that used by the Environment Agency in the next cycle of the River Basin Management Plans. As that analysis is concerned with valuing step changes in river quality in order to achieve targets under the Water Framework Directive, the NWEBS values can be used directly. In this case, as improvements in the water environment are more marginal and focussed on specific pollutants, we have estimated unit environmental benefits based on the willingness to pay for improvements to the river environment (through NWEBS) and to drinking and bathing waters (WT0706).

These damage cost estimates have a serious limitation where they do not sufficiently capture the degree of variation in the damage caused by an additional unit of pollution. The damage caused by an extra unit of pollutant in a watercourse will vary significantly depending on the amount of water in the watercourse, the existing concentration of pollutants, the extent to which humans or wildlife use the watercourse and a large number of other factors. These factors will vary spatially, temporally and even within different points of the same watercourse at the same time. In particular, due to the existence of tipping points and non-linear relationships between the level of pollution and the damage caused the pollution, it is likely that an additional unit of pollutant added to an already heavily polluted watercourse will have a larger impact than in a watercourse that has small concentrations of pollution. Furthermore, there are significant time lags between the loss of pollutants from a farm and the pollutant causing damage in a watercourse if the pollutant is lost to groundwater.

As the environmental benefits are an average value across England, they do not allow for this high degree of variation. We are developing the evidence on the damage caused by water pollution with a view to being able to model the impacts of reducing water pollution in a more sophisticated manner in the future. However, for this analysis we are using a range of values in order to capture the uncertainty in the environmental benefits of improved water quality, as shown in Table 2.

[71] The report is available here - http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=13653&FromSearch=Y&Publisher=1&SearchText=wt0706&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description

For valuing improvements in air quality and the value of mitigation of greenhouse gases, we used established damage costs. These are also shown in Table 2.

Methodology for non-FARMSCOPER measures

For the measures which cannot be modelled in FARMSCOPER, we have asked experts from ADAS to consider their likely impact on farm economics and the environment, as well as provide estimates as to baseline levels of uptake of these measures. For impacts on farm businesses, we have been able to use these estimates of baseline uptake and impacts on farm income to estimate a national cost to the industry for implementing these measures in each of the policy options. This has been added to the results from FARMSCOPER analysis in order to obtain an estimate of the net impact on the industry for implementing the full set of measures in each policy option.

While the results of expert judgement from ADAS have helped us to identify the impacts of implementing the measures on the environment, these impacts cannot be quantified on a national scale. This is because of the complex interactions between different farm practices which affect on-farm losses of pollutants to water. With the help of evidence raised during the consultation, we will continue to develop our understanding of this area so that these impacts can be quantified and monetised for the final impact assessment stage.

Annex D – Analysis on income beneficial Measures

Analysis of income-beneficial measures

We initially identified the following four measures shown in Table D1 as having beneficial or neutral impacts on farm income.

Table D1: Measures identified as having beneficial impacts on farm income

Measure	Beneficial Impacts on Farm Income
1a. Field manure storage is located at least 10m from a watercourse	This is of no cost to a farm business beyond planning time (covered in admin costs in Section 5c).
1b. Use a fertiliser recommendation system, taking soil reserves and organic manure supply into account	Using a recommendation system leads to fewer over- and under-applications of manufactured fertiliser, leading to cost savings due to lower fertiliser use, and improvements in yield where under-application is avoided.
1c. Ensure that fertiliser and manures are spread evenly	Ensuring even and accurate spread of fertiliser and manures leads to yield improvements in arable crops.
2a. Use a feed planning system and match nutrient content of diets to livestock requirements	Tailoring feed allocations to animal requirements leads to less wastage in feed and therefore has input cost savings. Reducing nutrient content in feed can also have animal health and welfare benefits.

One possible reason for a lack of uptake of these measures is that larger farms can benefit from economies of scale in implementing these measures, meaning that it is possible that implementing these measures is uneconomic on larger farms. Evidence also suggests that smaller farms are less likely to implement beneficial nutrient management practices[72]. We conducted analysis on these measures to estimate whether implementing these measures was cost-beneficial on smaller farms – the results of this for cereals and dairy farms are shown in Table D2.

Table D2: Annual Impact on Farm Income of implementing income-beneficial measures (2014 prices)

Measure	Impact on dairy farm income		Impact on cereals farm income	
	Average	Small	Average	Small
1a. Field manure storage is located at least 10m from a watercourse	£0	£0	£0	£0
1b. Use a fertiliser recommendation system, taking soil reserves and organic manure supply into account	+£5100[73]	+£3400	+£1500	+£800
1c. Ensure that fertiliser and manures are spread evenly	-£200	-£300	+£900	+£200

[72] For example, 41% of small farms did not have a nutrient management plan, compared to only 18% of large farms. In addition, 63% of small farms never calibrate their manure spreaders, compared to 46% of large farms. Source: Farm Practices Survey 2013 (greenhouse gas mitigation module)

[73] Even though the average cereals farm uses more fertiliser than the average dairy farm, the benefits from using a fertiliser recommendation system are greater for the dairy farm where it can utilise the nutrient content of manures more efficiently to reduce fertiliser use by a greater amount.

2a. Use a feed planning system and match nutrient content of diets to livestock requirements	+£7700	+£3900	N/A	N/A

The results show that most measures remain income beneficial for small farms, though there are some economies of scale in the measure on feed planning. The analysis does shows that it is uneconomic for dairy farms to calibrate fertiliser and manure spreaders (measure 3c) – this is because the benefits from this measures are realised on arable land, and that the average dairy farm has insufficient arable land for the benefits of calibrating a fertiliser spreader to cover the one-off costs of calibration. In the main analysis of value-for-money, we have used estimates of the effects on income for small farms to generate overall estimates of the impact on the farming sector; this includes using the result that measure 3c is costly for dairy farms.

In addition to analysing the impacts of these measures on small farms, we also consulted widely with industry and other experts on the impact of these measures in order to ensure that our analysis was robust. This process began with an in depth report by external consultants the Halcrow group[74] commissioned by the Environment Agency, which used workshops with farmers to assess the practicability and acceptability of a large number of mitigation methods. Stakeholders rated all of the income-beneficial measures shown in Table D2 as measures which 'all farmers should be doing', with the exception of 3c on fertiliser spreader calibration (rated as 'acceptable without industry support') and 2a on using a feed planning system (not assessed in the report). After the publication of the Environment Agency / Halcrow report, we have had several subsequent meetings with industry and environmental stakeholder groups in an effort to further refine the wider list of basic measures and consider the most appropriate approach to implementation. This stakeholder engagement has further informed our analysis and increased the robustness and confidence which can be placed in the results of the analysis.

[74] ADAS UK Ltd and Halcrow Group Limited. Report to the Environment Agency: "Identification of basic measures to address agriculture's impact on water", 2013. See Appendix I "Outputs of Stakeholder Workshop on Delivery Potential".

Annex E – Small and Micro Business Assessment

The vast majority of farm businesses are either small or micro businesses. Table E1 below shows the proportion of employers and employment in agriculture, fishing and forestry[75] with low levels of employment.

Table E1: Structure of Agriculture, Fishing and Forestry in England (2013)[76]. Figures may not sum due to rounding.

Number of employees	% of firms	% of employment
2-4	80.4%	46.7%
5-24	18.5%	34.3%
25-49	0.7%	5.6%
>50	0.5%	13.4%

Table E1 demonstrates that providing an exemption from basic measures for small and micro businesses would mean that the policy would only cover a small portion of the agriculture sector. This would mean that there would be a substantial reduction in the environmental benefits achieved by the policy, and that we would also breach our obligations under the Water Framework Directive to establish controls to address diffuse pollution from agriculture. Therefore, this policy would not be viable with an exemption for small and micro businesses.

In addition, as outlined in **Section 5d** evidence suggests that our preferred option has significant benefits to farm businesses, including when costs of familiarisation and administration have been taken into account. As shown in Table in **Section 7**, we estimate that our preferred policy option has an equivalent annual net benefit to business of £35.8m. This accounts for impacts on smaller farming businesses where there may be reduced economies of scale – **Annex D** shows how we have accounted for this in the analysis. Indeed, evidence suggests that smaller farm businesses have more to gain from the introduction of the preferred option, as baseline level of uptake of income beneficial measures is lower for small businesses than large businesses.[77] If an exemption were included for small and micro businesses, then they would not be able to benefit from the implementation of the income beneficial practices contained in the preferred policy option.

However, there are also barriers which prevent small farm businesses from implementing these measures. For small farm businesses, the farm manager is often the sole employee of the business, meaning that their time is dominated by day-to-day management and that they have little time to consider changes to the farm business in detail. A lack of time is therefore a frequently cited reason for a lack of uptake of income beneficial business practices[78]. This will act as a barrier to a small farm business being able to implement new measures quickly. In addition, due to a lack of economies of scale small farm businesses will also be disproportionately affected by the administration and familiarisation costs explained in **Section 5c**.

In order to minimise the immediate impact on small businesses covered by the preferred policy option and to help overcome the barriers described above, we have incorporated the following aspects into our proposed implementation approach. This will help Small and Micro Businesses

[75] Employment in forestry and fishing is small relative to agriculture and unlikely to mean that these results are not a reasonable proxy for the structure of the agricultural sector.

[76] Source: UK Commission for Employment and Skills' Employer Skills Survey 2013.

[77] For example, 41% of small farms did not have a nutrient management plan, compared to only 18% of large farms. In addition, 63% of small farms never calibrate their manure spreaders, compared to 46% of large farms. Source: Farm Practices Survey 2013 (greenhouse gas mitigation module)

[78] For example, when farm businesses were asked the reasons for not adopting a fertiliser recommendation system, 39% of farm businesses cited "needing more time" as a reason. Source: 2013 Farm Practices Survey.

to comply with the regulation, hence ensuring full benefits for the farming sector and the natural environment.

- **Transition Period:** In order to allow time for farm businesses to digest proposed regulation and to consider implementation, there will be a one year transition period after the regulation has been enacted.
- **Information and Advice:** During and after this transition period information, guidance and advice will be provided for farmers regarding the practical details of how to implement the new measures in order to aid adjustment. This will be conducted through existing channels such as the Farming Advice Service and Catchment Sensitive Farming.
- **Emphasis on Guidance and Warnings:** Enforcement actions will be focussed on providing guidance and later warnings where farm businesses are non-compliant with the new regulations. This is in order to avoid placing a disproportionate burden on farm businesses.
- **Focussed enforcement:** Enforcement will be focussed around areas with severe water pollution, such as water bodies which are failing under the Water Framework Directive or Protected Areas. This will ensure that enforcement is targeted at areas where uptake of measures can have the most environmental benefit and where farm businesses will have received greater advice on compliance.

Our approach to implementation and enforcement is described in more detail in **Section 9**.

Annex F - Rationale and evidence that justify the level of analysis used in the IA

There are several reasons which mean that it is proportionate to use extensive analysis to fully identify and partially quantify and monetise the impacts of the policy options presented here. Firstly, the environmental benefits and potential cost impacts or cost savings to industry of the policy options described are considerable and are valued in excess of £100m over a ten year time period. As some of the policy options could have a significant impact on the natural environment and the agriculture industry, it's important to ensure that the impacts can be quantified as accurately as possible.

Secondly, Defra's key priorities are to improve the environment and grow the rural economy. To that end, we have analysed the impact of these policy options in detail in order to ensure that the policy options presented create the best possible environment for the English agriculture sector to thrive and improve the health of water bodies in the future.

Finally, the evidence on some of the measures analysed has already been developed to a high standard. The FARMSCOPER modelling framework is a sophisticated decision support tool which synthesises the evidence on the impacts on water pollution mitigation measures and is able to present national estimates of the impact of different policy options. In addition, we have been able to leverage other already existing evidence on the impacts of measures not included in this tool.

As a result of these drivers, we have completed extensive analysis in order to assess the impacts of these policies. This includes modelling work, consultation with stakeholders and experts and the input of expert opinion across Defra and from academia into the analysis. This has allowed us to monetise a significant proportion of the impacts of these policy options and present an indicative estimate of value for money of the options. We are confident that the evidence presented in this Impact Assessment is the best that could have been brought together at the current stage of policy development. However there are also several areas where we are planning to further develop the evidence base for a final impact assessment with the help of evidence raised during the consultation.

Annex G - **Stakeholder Engagement Timeline**

Jan 2013 EA commissioned **Report** to develop set of basic measures.

March 2013 **Stakeholder workshop** as part of report to consider a short list of basic measures and get views on uptake, acceptability, practicability and applicability.

July 2013 Final report published.[79]

July 2013 **Stakeholder workshop** – developed guiding principles for any potential list of basic measures.

Nov 2013 **Stakeholder workshop** – covered the drivers for an increased regulatory baseline and considered which regulatory mechanisms would work best and how to make them more effective.

Feb 2014 **Technical Working group** - measures and approach to implementation discussed with smaller core group of stakeholders.

June 2014 **Technical Working group** - ran through detail of the proposed shortlist of measures.

July 2015 **Internal peer review** – Environment Agency, Natural England, Catchment Sensitive Farming, wider Defra.

Stakeholders included in the above conversations:

Sector	**Organisation (Division)**
ENGOs	Angling Trust
	Wildlife Trust
	The Rivers Trust
	West Country Rivers Trust
	Soil Association
	WWF UK
	RSPB
	Farming and Wildlife Advisory Group South West
Water companies	Northumbrian and Essex and Suffolk Water
	Thames Water
	South West Water
	Anglian Water
	South West Water
	Wessex Water

[79] ADAS UK Ltd and Halcrow Group Limited. Report to the Environment Agency: "Identification of basic measures to address agriculture's impact on water", 2013. See Appendix I "Outputs of Stakeholder Workshop on Delivery Potential".

	South East Water
	Essex and Suffolk Water
Research and educational establishments	ADAS UK Ltd
	Ricardo-AEA
	SOAS, University of London
	Rothamstead Research
Farming industry representatives	National Farmers' Union
	CLA
	Agricultural Industries Confederation
	National Pig Association
	Central Association of Agricultural Valuers
	Agriculture and Horticulture Development Board
	BPEX, Agriculture and Horticulture Development Board
	Red Tractor
	Linking Environment and Farming (LEAF)
	Pesticides Voluntary Initiative
	Metaldehyde Stewardship Group
	GrowHow UK Ltd
Government, NDPBs	Defra (water quality in agriculture)
	Defra (soils)
	Defra Water Quality Farmers' Panel
	Environment Agency
	Natural England
	Forestry Commission