ECONOMICS REPORT

FOR NIT18 NVZ ACTION PROGRAMME IMPACT ASSESSMENT.

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Date: December 2011

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1 INTRODUCTION

1.1 Objectives of the report

The Nitrates Directive aims to reduce or prevent the pollution of waters due to nitrates from agricultural sources. It sets down criteria for identifying waters which are polluted or likely to become polluted with nitrate and requires:

1. all land draining to such waters to be designated as NVZs (Article 3);
2. an Action Programme (AP) of measures to be applied within NVZs and certain prescribed;
3. measures to be included in any such Programme (Article 5); and
4. the extent of NVZ designations and the effectiveness of AP measures to be reviewed at least every four years.

In line with this fourth requirement, Defra is currently undertaking a review of both the NVZ designations and the AP in England. This report provides the underpinning economic assessment of the 2009-2013 AP. It also provides an economic assessment of a number of possible additions to the current AP that are being considered either for the 2013 review or for later reviews.

1.2 Approach to estimating the costs of measures at farm scale

This document estimates the total cost of the measures within the 2009-2013 NVZ AP (including those already present in previous APs) and the cost of potential additional measures.

The costs are calculated at farm scale, for typical farms likely to be affected. The description of these farms is taken from the Defra Robust Farm Types and survey data, as developed within the Mitigation Methods User Guide (Defra project WQ0106)

The costs of certain measures have been calculated for three farm sizes, small, medium and large. Defra statistics use the Farm Business Survey (FBS) definition of farm size in terms of the number of standard labour requirements (SLR) in annual full-time equivalents such that one SLR roughly corresponds to:

- 95 hectares of cereals or
- 50 dairy cows

The SLR of any individual farm is derived from the labour required for all of its enterprises, but in the following calculations, farm size would be in terms of:

- small = farms of less than 2 SLR
- medium = 2 to 3 SLR
- large = more than 3 SLR.

Table 1.1: Definitions of farm sizes

Farm size	SLRs	Dairy cows (typical)	Dairy farm size ha (typical)	Arable farm size ha (typical)
Small	< 2	75	40	100
Medium	2 – 3	125	70	200
Large	> 3	>150	100	400

Upscaling calculations are based on the total numbers of livestock and land areas in NVZs. However, the burden of regulation may be deemed disproportionate on very small farms. These are large in number, but comprise a small proportion of land area and stock numbers. (Table 6.2). The issue is explored in more detail in Section 6.

1.3 Scaling up costs for the whole NVZ area

Costs were calculated for the whole of the 2008 NVZ area within England (62% of England; Figure 1). Equivalent methods can be applied to obtain costs for the much smaller area of NVZs in Wales, although the results are likely to have a lower relative precision because of the small and widely separated areas involved.

In order to estimate costs for the whole NVZ area, the costs at farm level are first expressed in appropriate terms (units) for which statistics are available or can be deduced.

In order to determine statistics for agricultural activities within NVZs, the mapped extent of the 2009-12 NVZ area was overlaid on spatially distributed mapping of agricultural survey data (cropping, livestock numbers) within the ADAS agri-environmental spatial database. Quantities and types of manure applied, and associated nutrients, were calculated by spatial overlay of the NVZ boundary onto the mapped output of Manures-GIS (Defra project WQ0103; Figure 2). The most recent mapped data are for 2004, and statistics were updated to 2009 on a pro rata basis by comparison of the national totals for 2004 and 2009. Data on soil types were derived in the same way using the NATMAP1-000 soil map and associated database. The NVZs in England cover approximately 3.4 million ha of arable and 1.8 million ha of managed grassland.

Upscaling calculations given here are based on the total numbers of livestock and land areas in NVZs. However, the burden of regulation may be deemed disproportionate on very small farms. These are large in number, but comprise a small proportion of land area and stock numbers. A limit on farm size for implementation of measures would entail a small downward adjustment of the results.

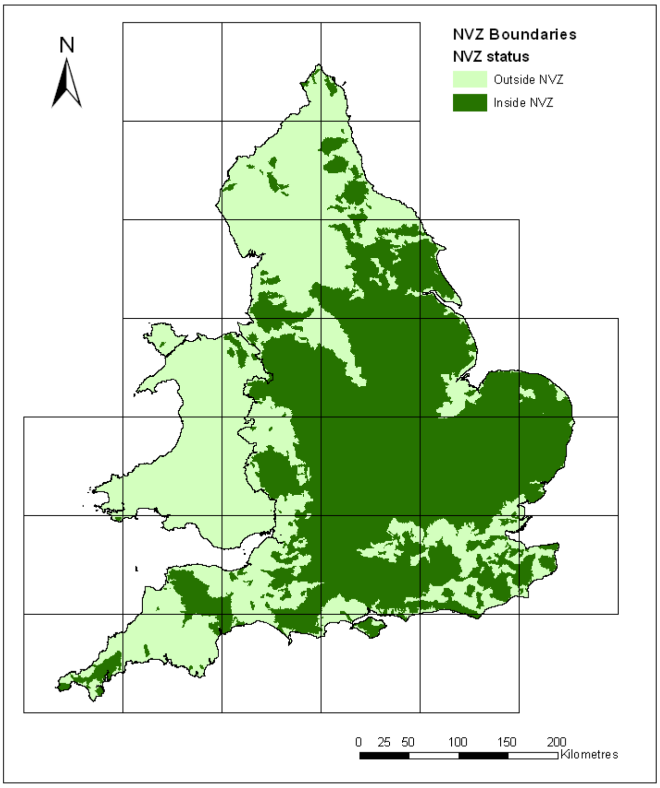

Figure 1. Spatial extent of the current NVZ areas in England and Wales (2009-12).

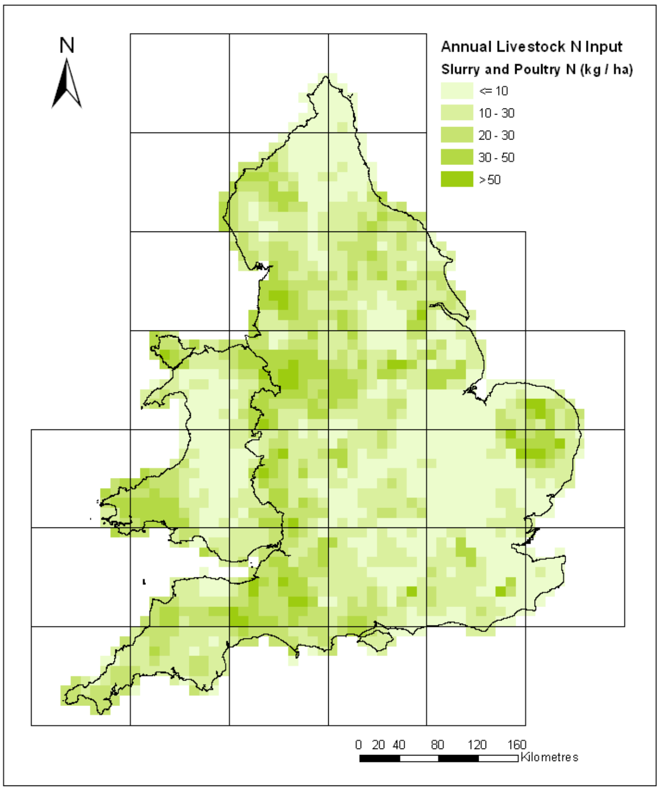

Figure 2. Total nitrogen loadings in slurry and poultry manures (kg/ha of agricultural land).

2 COST OF THE CURRENT (2009-2013) NVZ ACTION PROGRAMME

The costs are discussed in turn in this section, and a summary is presented in Section 6.

2.1 Administrative costs - record keeping and calculations

This section includes the costs of administration, carrying out the required calculations and record keeping incurred by all farms within NVZs (for example, in relation to fertiliser and manure planning) but does not include costs relating to for example slurry storage construction, which affect only certain farms.

The completion of records required by the NVZ AP is a formal process and bringing together accurate figures can be a challenge. In addition, there will be the time taken to read and absorb the documentation. Many arable farms will already have established relatively complete recording systems which are largely fit for purpose for compliance with the NVZ AP. However, on many grassland farms, particularly the more extensive farms, this may not be the case. The Farm Practice Survey 2007 (Defra, 2007) indicates that more than 70% of arable farms had a recognised nutrient management plan, about 50% of dairy farms, and less than 20% of non-dairy lowland livestock and LFA farms. More than half of all lowland livestock farms (mainly beef/sheep farms) reported using no manufactured fertiliser. Where nutrient management plans exist, they may not all be adequate for NVZ AP purposes. For example, the commonest method cited for assessing the nutrients supplied by manure was “own knowledge and experience” (c.75% of grassland and 50% of arable farms that spread manure).

The following assumptions were made for calculating costs:

- The figures below are based on the farmer’s time costed at £20/hr.
- For the initial NVZ planning, it was assumed that it would take around a day to read the relevant leaflets for all farmers, that is, 8 hours at £20/hour (first year only).
- Time taken to calculate the manure storage requirement and compliance with the Farm-level livestock manure N limit (170 kg N/ha) would be for livestock farmers. Farm-scale risk mapping would also be required for those who apply organic manures to land. For a medium sized dairy farm, this activity has been budgeted at 11 hours (first year only)
- Further time each year is needed for recording and calculating field-level cropping and nutrient management information. However, on grass farms this is simplified by the limited number of crops and most data calculated in year 1 and many arable farms are already recording this information as computerised records for crop assurance schemes.
- Costs on dairy and arable farms are based on reasonable time estimates for the work. Estimates for pig and poultry farms assume they are associated with arable farms. The estimates are average values since all farms will vary in soil type, topography, field size and number, and management approach.

- Farm sizes were based on Farm Business Survey definitions using the Standard Labour Requirement (SLR) for small, 1 to less than 2 SLRs, medium, 2 to 3 SLRs and large more than 3 SLRs. Production units used were for arable, 95ha per SLR and dairy 50 cows/SLR. For dairy, a stocking rate of 2.15 cows/ha was used.

Table 2.1 summarises the estimated costs for carrying out the required calculations and record keeping. Thus for a medium sized dairy farm, there is an initial cost of £500 per farm, with subsequent annual costs of £200.

Table 2.1 Preparation of initial NVZ plans and compliance calculations

(cost averaged over ten year period)

Farm type	Read leaflets	Calculate capacity of manure stores, farm N/limit etc	Nitrogen management plan	Total Initial Year Cost	Annual cost	Cost £/ha
Arable	£	£	£	£	£	£
Small	160	0	20	180	40	0.40
Medium	160	0	40	200	60	0.30
Large	160	0	80	240	80	0.20
Dairy						
Small	160	150	90	400	140	4.00
Medium	160	220	120	500	200	3.45
Large	160	300	165	610	260	3.00
Pigs						
Small	160	150	90	400	140	4.00
Medium	160	220	120	500	200	3.45
Large	160	300	165	610	260	3.00
Poultry						
Small	160	40	90	290	140	4.00
Medium	160	60	120	340	200	3.45
Large	160	80	165	405	260	3.00

For small and large dairy farms, whilst the background reading should take the same amount of time, a factor of 0.6 and 1.4 has been applied to the calculations, making the initial year cost £390 and £625, respectively. Annual costs should be £140 on the small farm and £260 on the larger farm. These figures should apply to pig and poultry farms the same way as for dairy or beef farms.

For arable farms, again the initial reading will take as long, but with no livestock-related calculations to do, and assuming cropping and nutrient management records already exist, the total cost in year 1 would be £200, with smaller farms at £180 and larger farms at £240. Annual updates would take less time than for livestock farms, so the average cost over ten years would be £40, £60 and £80 for small, medium and large farms, respectively.

2.1.1 Summary of costs

Taking into account the costs for the first year and second and subsequent years and assuming relative weightings of 20%, 50% and 30% for farms in the small, medium and large categories, the average cost of administration over a ten year period is estimated as:

- Around £ 1.10 per ha on arable, £8.70 on livestock farms in the first year; and

- £0.30 per ha per annum on arable farms, and £3.45 per ha per annum on livestock farms for subsequent years.

2.1.2 Cost for the whole NVZ area

Based on an arable area of 3.4 million ha and a grassland area of 1.8 million ha (based on 62% England designated), these figures indicate the following estimated administration costs for the whole NVZ area in England:

- £19.1 million in the first year
- £ 7.1 million per year in subsequent years.

A range of +/- 25% is suggested on these values.

2.2 Fertiliser quantity: Nmax and manure N efficiency coefficients

Nitrogen planning
Farmers are required to plan nitrogen applications for each crop using a 4 stage process. The main cost of this measure is administrative (nitrogen management plan), and has been included in the section above on administrative costs.

Nmax and manure N efficiencies
For the whole area of specified crop types across the farm, nitrogen inputs from livestock manures and manufactured fertilisers must not exceed the Nmax limit, allowing for the crop available N from livestock manures using the standard manure N efficiency coefficients. The main cost of this rule is calculation and administrative, and has been included in the section above on administrative costs.

This requirement is not expected to constrain N use on crops and is not expected to impact on crop production outputs (crop yield and quality). Since most grassland receives much less than the Nmax limit of 340 kg N/ha or 380 kg N/ha if 3 cuts or more are taken (reducing to 300 and 340 from January 2012), it is assumed that crop and livestock production is not affected by this measure. If there is any constraint on N inputs below standard recommended rates, it is likely to be small and nitrogen use will be close to the economic optimum. This is defined as the point where the marginal cost of additional inputs is balanced by the marginal value of additional yield. That is, at this point any small reduction in yield due to reduced N fertiliser use will approximately balance, or be very little greater than, the saving in fertiliser cost.

2.2.1 Summary of costs

This measure results in zero cost (other than administration). Savings on fertiliser inputs are likely to occur on some farms due to greater awareness of recommendations and the value of manures. These savings are most likely where the crop-available N from manures is allowed for in a reduction in fertiliser N. The price of fertiliser N has fluctuated in recent years between about £0.43 and £1 per kg N.

2.2.2 Cost and benefit for the whole NVZ area

Earlier research had shown that the main area where compliance with recommendations was poor was in adjustment for the N applied by manures (Lord *et al* 2007). The total N applied within NVZs in manures with high crop-available N (slurries and poultry manures) is 93 kT, based on Manures GIS. Defra project WT0932 calculated, using MANNER with appropriately weighted spatial data, that these manures provided 31 kT of crop-available N under the current NVZ AP (Table 12, final report, Defra project WT0932) . The value of this in terms of fertiliser N replaced, at prices of 0.43 to 1 £/kg N, would be a saving of £14 million to £31 million per annum assuming no reduction was made previously. There are no costs other than administrative costs already accounted for.

2.3 Closed spreading periods for manufactured nitrogen fertiliser

This measure has no deemed costs because inputs are permitted where there is an economic case (i.e. the crop has a nitrogen requirement). There may be a small saving on autumn-applied N fertiliser which is not applied due to this measure, but this saving will apply to a very limited area. The British Survey of Fertiliser Practice (BSFP) shows that the amount of autumn applied N fertiliser for cereals is extremely small and has been reducing for many years.

The BSFP shows that in 2002, prior to introduction of the NVZ AP measure prohibiting autumn N applications about 5% of cereals in England received some autumn N. The typical application rate would be low, probably as part of a low-N compound, but is not stated. Data since then are consistent with restrictions on this use of N in NVZs. In contrast, oilseed rape has a recognised crop N requirement in the autumn at which time N application is permitted. In 2010, 29% of oilseed rape crops received autumn N with an average application rate of 33 kg N/ha (BSFP, 2010).

2.3.1 Summary of costs

A reduction in fertiliser N of 15 kg/ha in autumn would save £6 to £15 per ha for ammonium nitrate prices of £150 to £345 per tonne.

2.3.2 Cost and benefit for the whole NVZ area

This measure is expected to result in zero cost other than administrative costs already accounted for.
Assuming a saving of 15 kg/ha N on 5% of the winter cereal area (ca 1.5 million ha in NVZs, the reduction in fertiliser N input of 1.2 kT N would save £ 0.5 million to £1.2 million per annum.

2.4 Closed period for spreading livestock manures; and slurry storage

These two measures are closely linked and therefore considered together. The major cost of these measures relates to provision of additional slurry storage, but the benefit is accrued by enabling compliance with the closed spreading period rules.

Closed spreading periods
Organic manures with a high readily available nitrogen content (i.e. more than 30% of total N; e.g. slurry and poultry manure) must *not* be applied to land during the following periods (inclusive dates).

Grassland		**Tillage land**	
Sandy or shallow soils	**All other soils**	**Sandy or shallow soils**	**All other soils**
1 Sept – 31 Dec	15 Oct – 15 Jan	1 Aug – 31 Dec*	10 Oct – 15 Jan

*On sandy or shallow soils under tillage, application is permitted between 1 August and 15 September inclusive, provided a crop is sown on or before 15 September.

Organic manure storage
By 1st January 2012, there must be at least 6 months storage capacity for poultry manures and pig slurry, and at least 5 months storage for slurry from other types of livestock (e.g. cattle). Poultry manure and other types of solid manure must be stored on an impermeable base, in a roofed building, or in an appropriately located temporary field heap.

2.4.1 Cost of compliance with the minimum slurry storage requirements

The cost of compliance with the NVZ AP slurry storage regulations is the dominant cost to farmers of the Action Programme. The approaches available are illustrated for a case study farm, and then scaled up to NVZ level.

In this section we have not dealt with storage costs for FYM. Potential future measures are discussed in a separate section.

The case study farm
This measure applies particularly to dairy farms and we have based the calculations on the dairy farm typology from the Mitigation Methods – User Guide (Defra project WQ0106) which had 110 dairy cows and the majority of the manure managed as slurry. In this case, we have assumed that the farm uses a slurry-based system. Other stock were included in the DP-All typology, but on most farms, they would produce FYM, so not adding to the slurry produced.

Based on the Farm Practice Survey 2007, just over half of all farms had less than 5 months' storage and the average storage on those farms was about 3 months. We have assumed in this case study that the farm requirement is for an additional 2 months capacity. (The up-scaling to NVZ level takes account of the range of actual storage capacities, see below).

Assuming a baseline of 3 months storage, the farm has just under 1,100 m^3 of storage. This volume is sufficient for the slurry as produced, plus parlour washings of half the rainfall falling on the cow housing and collecting yard and via gutters – (assuming 1050 mm annual rainfall). The calculated storage requirement for this farm is 368 m^3 per winter cow month (Table 2.4).

Options available to farmers

The Farm Practice Survey for 2004 identified that the main alternative to increased storage was to divert clean or dirty water away from the slurry store. The three options open to farmers that have been costed are:

Option 1) Diverting/capturing clean water and dirty water to reduce the volume to the slurry store. This breaks down into:

- ensuring all clean water (rainfall) is diverted to drains
- clean water is captured for re-use (optional)
- dirty water is captured for separate spreading to land, requiring less storage because dirty water is not subject to the closed spreading periods.

Option 2) Using a slurry separator to reduce the volume of slurry liquids for storage, and where the solids can be stored in temporary field heaps. Slurry separators typically remove 15 - 20% of the volume from cattle slurry, and 5 - 10% from pig slurry.

Option 3) Increasing the storage capacity.

Note that options 1, and particularly 2, are only capable of providing a limited increase in the effective storage capacity, and are therefore suitable only for those farms where the storage deficit is fairly small.

Assumptions

For option 1, we have assumed that half of the rainwater is currently piped away to clean water drains, but the other half ends up in the slurry store either directly from yard runoff, or through damaged gutters and downpipes allowing it to run on to yard areas. Re-use of rainwater (e.g. for milk cooling and livestock drinking which saves on mains water costs) may provide limited security of supply in times of summer drought. However the cost of installing a re-use system is greater than that of simple rainfall capture and diversion to a soak-away or drain. For dirty water capture, we have assumed that the farmer installs a dirty water tank with sufficient capacity to store two weeks of parlour washings.

For option 2, the slurry separator will remove solids from the slurry and these can be stored in temporary field heaps, leaving a liquid that is easy to pump and spread.

For option 3, we have assumed that the slurry store is enlarged, with no change to the quantities of rainwater and parlour washings entering the store. Many farmers prefer slurry to be dilute because it is easier to handle for spreading, so this situation is the most common.

Administration costs associated with option 3

When new slurry storage is being considered, planning regulations need to be taken into account. Additional costs associated with planning issues can vary. For any capital expenditure project, there can be considerable time-related costs incurred by the farmer's input for obtaining quotations, and also liaising and project managing the work. This may range from two days (costing £320) for a small project to perhaps ten days (costing £1600) for a new slurry store, plus any professional fees. A typical average would be 3 days (costing £480).

Professional fees for providing drawings and liaising with the planning authority would vary depending on the individual provider, along with the size and difficulty of the job. The cost range would be from around £2,000 to £4,000, but a typical average cost would be around £2,500 (pers. comm. Gary Owen, ADAS).

Tenancy issues

In the case of tenanted farms, a landlord may be unwilling to either fund or even to permit the building of new slurry stores because he will be liable for capital improvements carried out by the tenant at the end of the tenancy. This is a real issue for older tenants on small farms with no successors. On these farms it is not uncommon for older tenants to cease dairying, and a larger farm nearby to take on either the herd or sometimes just the land, as a means of avoiding the need to apply for a derogation.

Other issues

At the outset, the farmer has to finance the whole capital cost, which generally means using a loan. This could be refused if the profit from the livestock enterprise has been at or below zero, which has been the case for a number of years for many dairy farmers. It will usually mean the bank taking a charge over a substantial proportion of assets, which in turn means they cannot be used as collateral for other purposes. The bank may charge a higher interest rate if the business is not profitable.

The loan may limit the farmer's ability to finance the day to day costs of trading. This is a particular issue when input prices (e.g. fertiliser and feed) are increasing. In recent years, many farmers have had to extend their overdrafts to cover these increasing costs.

The costs may have knock-on effects on the farm viability, for example, farmers may have to sell some land or not replace the milking parlour as planned.

The costs and issues listed above may lead to those farmers on smaller farms in need of investment preferring to leave dairying earlier than they might otherwise have done.

The costs identified for additional slurry storage assume that location is not an issue. However, on many farms there may be limited space which in turn may mean additional concrete roadways and other infrastructure costs.

Illustrative examples

Option 1: Diverting/capturing clean water and dirty water
Diverting the other half of the yard water and roof water from the farm buildings away from the slurry store would, on average, save some 75m^3 per month, and collecting the parlour washings separately would save a further 99m^3 per month, a total of 157m^3 per month. This is sufficient to make a 3 month store capable of storing 5 months slurry. For farms at the limit of their capacity, it may be a less costly method of staying within the regulations, depending on the disposition and state of the yard and buildings.

Diverting clean water
Avoiding clean (roof) water going to the slurry store will entail repairing gutters and providing additional drainage to ensure rainwater is directed to a clean water drain. This could cost around £1,000. In this example, the volume of water collected and diverted away from the slurry store would be about 47m^3/month.

Setting up a system for re-use of clean water on farm
Alternatively, the rainwater could be captured for use on the farm. The water collected from roofs net of evaporation would typically be 90% of the rain falling (pers. comm. Phil Metcalfe, ADAS). In an area of 1050mm rainfall, the average monthly rainfall collected would be 79mm, which (if 50% recovery) would result in 47m^3/month rainfall collected, or 567m^3 per annum. A typical system might use a 30m^3 tank to collect enough rainwater for 3 days supply. In an area of 700mm rainfall, the amount collected would be 378m^3 per annum. For the two rainfall areas the volume is approximately 1.5 and 1 month of the herd's water requirement, respectively (for a 110 cow herd, the monthly water requirement for drinking and parlour washing is about 380 m^3).

The cost of equipment to provide a 30m^3 system for rainwater re-use on the farm is around £5,500 (pers. comm. OCMIS and Silverline), but if a new roof is needed, for example over 25% (300 sq. m) of the area, there will be an additional cost of £27,000 (£90/sq m, Nix 2010).

Table 2.2 Costs of rainwater capture system

Rainwater capture system	**£**
Galv. steel tank 30 cu m	2,700
Pipes & gutters to roof	250
Filter	80
Pumps	250
Pipes	1,000
Header tank	150
uv filters	1,000
New bulbs	62
Total investment cost	**£5,492**
Amortisation cost £/£1,000	94
Annual amortised cost	**£516**
Electricity £/yr	100
Repairs @ 2%	110
Annual cost	**£726**
Annual benefit*	£404-567
Annual net cost	£159 - 321

* mains water assumed to cost £1/m^3

A storage period of no more than three days is appropriate for collected rainwater that is intended for cattle drinking water. Longer storage would require more expensive treatment than a simple filter and ultra violet light. Any rainfall in excess of this requirement (in this case more than 35mm over three days) would be diverted to clean water drains. The volume of water available at any one time will be a function of the amount and timing of rainfall. At times of heavy rain, some rainfall will be lost to drainage, whereas in dry periods the collected water will all be used up and mains water will be required. The extent of storage will depend on local rainfall and the cost of storage. In this example, a standard tank size has been used as one unit of storage.

These costs appear reasonable, but depend on all roofs being in a good state. Any rebuilding or repair of the roof, or other works, could greatly increase the cost.

Diverting dirty water / parlour washings

Using the same case study farm, separate dirty water storage would reduce additions to the slurry tank. Dirty water can be spread to land at any time during the year. Parlour washings generate 25 litres/day/cow (2.75 m^3 per day on this farm) and rainfall on uncovered yard areas generate a further average of 0.924 m^3 per day (if half is already captured to another store). A 60 m^3 tank would allow for 14 days storage. The cost of this unit would be £2,226 (£49.50 per m^3, Nix 2010).

There may be an issue of separating slurry and dirty water due to the direction of falls on the floors, but where yards are scraped clean of slurry, runoff and parlour washings may be deemed to be dirty water if they can be directed to a separate store.

Table 2.3 Costs of dirty water storage

	Per cow	Per farm
Parlour washings l/day	25	2.75
Uncovered yard area run off	6.4	704
Tank size for two weeks storage m^3	0.55	60
Capital cost of tank plus ancillary works £	25.10	2,751
Amortised cost £ pa*	2.85	314
Repairs @ 2%	0.50	55.02

* 20 years @7%

Total system costs for clean and dirty water management
The total cost of diverting clean water would be around £1,000 to route the clean water to a drain, and a further £2,751 to divert and store dirty water - a total of £3,751. On an amortised basis, this would be £353 per annum. The additional storage capacity generated would, on average, be equivalent to converting a 3 month store to a 5 month store on this farm – though the exact benefit is very dependent on individual farm layout, area and conditions.

If the rainwater were to be collected for re-use, the cost would be £5,492 (from Table 2.2), making a total cost of £8,243. On an amortised basis, this would be £775 per annum.

Although diverting clean and dirty water is less expensive than providing increased slurry storage, many farmers may not adopt it because they prefer slurry to be diluted with rainfall and parlour washings, as this makes the slurry easier to handle and spread. On some farms the lie of the yards may make this option very difficult to implement. This option is mainly suitable for farms where the slurry storage is almost adequate (> 4 months).

Slurry store covers
A further option to overcome storage limitations by reducing rainwater accumulation is to install a permanent cover on the slurry store to reduce rainwater capture. The cover would normally be constructed from a self supporting impermeable membrane on a vertical stainless steel centre tube. The cost of this has been estimated at £1.08/m^3 (Ryan, 2003). If a cover was added to the slurry store on the case study farm, assuming a height of 3.5m, the cover would avoid the capture of approximately two weeks rainfall over the 5 month storage period (based on 1050mm annual rainfall). For those at the margin of capacity, this may be a viable option, although the rainfall avoided would be less in areas of less than 1050mm.

However, covers can be difficult to retro-fit and may infringe warranties on the existing tank, as well as suffering from weather damage which can tear the fabric over a period of time.

On the case study farm, the total capital cost of such a cover would be £15,759, compared with the cost of an additional month of storage of £18,432. Whilst farmers tend to replace the whole store, the cost of additional storage is not far above the cost of a cover as well as ensuring that the slurry is more easily pumped for spreading. Given the small increment in storage capacity (2 weeks or less) and the high cost, this measure is not considered further.

Option 2: Slurry separators

The cost of a slurry separator is typically around £10,500 plus the cost of installation, which can bring the total up to £23,000 for a unit to service the case study farm of110 cows.

Separation would typically save 15% or 165m^3 of the 1,106 m^3 slurry production to be stored, or approximately two weeks' input.

The benefits of increased nitrogen availability in the liquid fraction for crop uptake, the ability to pump the dilute liquid for land application, and being able to store the solid fraction in temporary field heaps, make a slurry separator an attractive option for some (particularly large) farmer. The slurry separator would cost around £40 /m^3 per annum including repairs on an amortised basis, assuming 1,106 tonnes were separated. This compares well with exporting manures, see 2.5 below. However it is only suitable as a solution to meeting the storage requirement where the shortfall in storage capacity is small, i.e. under 2 weeks.

Option 3: Additional slurry storage

For the case study herd being considered, the current slurry storage capacity was estimated to be 3 months (the approximate mean value for farms with insufficient storage). If this were to be extended by 2 months, the capital costs would include the additional tank or lagoon capacity, the administration time of the farmer (£480) and professional fees (£2,500).

Current storage is used for slurry, parlour washings, rainfall falling onto yard areas that drain to the slurry collection area and rainfall from damaged or blocked roof-water goods. In the latter case, we have assumed that this is equivalent to half of the rainwater on 1,200m^2 of roof.

Table 2.4 Volume of slurry storage required

	m^3 per cow per day	m^3 per cow per month	m^3 per farm per month
Slurry volume per day	0.064	1.92	211.2
Rainfall from roof to store (50% of total on 1,200m^2)		0.43	47.21
Parlour washings	0.025	0.75	82.5
Rainfall run off from yard		0.25	27.12
Total monthly requirement m^3		3.35	368.63

Table 2.5 Cost of additional slurry storage

Total for additional 2 months storage	Capital	Annual
Tank		
Capital – construction of tank, £50/m^3	£36,863	
Farmer cost plus professional fees	£2,980	
Total cost	£39,843	
Amortised*		£3,745
Running costs		£737
Total annual cost		£4,483
Lagoon		
Capital – construction of tank, £40/m^3	£29,490	
Farmer cost plus professional fees	£2,980	
Total cost		£32,470
Amortised*		£3,052
Running costs		£650
Total annual cost		£3,702

* 20 years @7%

The cost of extending tank storage to 5 months slurry capacity would be £39,843. Where this cost is financed by borrowing, the bank is likely to impose a higher rate of interest if the business is at or near its borrowing limit, and schedule the loan over a shorter period than would otherwise have been the case. Both of these conditions will have an adverse effect on the business.

A lagoon would be slightly cheaper than a tank. The cost quoted of £40/m^3 (Nix, 2010) is for a lined lagoon, with a base designed to enable access for emptying. In some cases farmers may be able to use earth-bank lagoons without a liner, which can be substantially cheaper, but this depends on availability of suitable impermeable clay sites, and risks leakage if the clay seal is breached e.g. due to drying out. It is therefore not a universally suitable option.

2.4.2 Summary of slurry storage costs

Table 2.6 below summarises the costs of each of the options open to farmers to comply with the storage requirements of the current AP.

Table 2.6 Summary capital and annual costs of compliance for a 110 cow herd with 3 months slurry storage:

Investment	Months storage provided	Capital cost £/farm	Annual cost £/farm	Capital cost £/cow	Annual cost £/cow*
Divert clean roof water	1	1,000	114	9.09	1.04
Separate dirty water	1	2,751	314	25.10	3.35
Capture clean roof water and re-use	1	5,492	726	49.93	1.45**
Capture clean roof water and separate dirty water	2	8,243	775	74.94	8.54
Install slurry separator	0.5	23,000	3,266	209.09	40.15
Extend slurry store by 2 months capacity					
Tank:	2@	39,843+	4,483	362.21	40.75
Lagoon:	2@	32,470	3,702	295.19	33.65

*Annual cost includes repairs
+ Capital includes whole initial capital cost including management and fees
**Net cost after allowing for the value of water collected @ £1/m^3
@ These new-build measures could provide as much storage as required.

For the case study farm, the capital cost per additional cow month of slurry storage varies from about £10 (divert clean roof water) to £210 (slurry separator). The cheapest option by far is diversion of roof water, where this is contributing to slurry storage volumes. However, this is not applicable on all farms (e.g. roof-water may already be diverted) or may not provide sufficient extra slurry storage capacity. The options with lower costs are often only suitable on farms with a relatively small shortfall in storage capacity – certainly less than 2 months – or as part of a composite solution. Not all types of solution will be practicable on all farms.

With the 1st January 2012 deadline approaching, those farmers who have not yet upgraded their slurry storage are facing a significant financial challenge. Dairy farms, in common with many other farm types, have been operating on a very low profit margin for much of the past ten years. A recent improvement in profitability occurred in 2008 when milk prices rose, but this was quickly offset by the rise in fertiliser prices and, since the autumn of 2010, a large rise in purchased feed prices. This means that many dairy farms are running at a loss or at very low margins (e.g. Farmers Weekly, February 2011).

For older farmers without successors, the prospect of a £39,000 investment over a 20 year period is unlikely to appeal and they will tend to seek cheaper short term fixes, for example, capturing rainfall from an existing roof to reduce inflow into the slurry store.

Types of farms more likely to increase the capacity of slurry stores

Those farmers who can afford the capital outlay will need to have:
1. The capital available to spend, or
2. The capital to borrow against in the case of a loan in order to give the bank security, and
3. The cash flow to save for other capital expenditure or to make loan repayments out of profit.

Farmers who may increase slurry store capacity are likely to be owner occupiers of larger family farms, mixed farms or large dairy farms with relatively low borrowings.

Types of farms less likely to increase the capacity of slurry stores

Many small and medium dairy farms and tenant farms would struggle to find the capital either as cash or to borrow against to build additional capacity. Low or non-existent profits also mean that they do not have the cash to make the repayments on the loan.

Many small and medium sized dairy farms have had to extend their borrowings in recent years, particularly in response to rising fertiliser and feed costs. These farms are at or near their limit and the banks may be unwilling to lend on capital expenditure that earns no money.

Many farms have used up their capital reserves and would have to sell land to find the money to increase the capacity of slurry stores if the bank is unwilling to arrange a loan. Farm finances are individual to each business and depend on many factors, but it is likely that such problems are more prevalent on small and medium farms especially if they are tenanted.

The farmer's age may be relevant - older farmers without successors are unlikely to be interested in a 20 year investment.

2.4.3 Calculation of slurry storage costs for the whole NVZ area

In scaling up, we have assumed that farmers will in practice decide to build additional storage, and that in most cases this will be a new storage tank. The other options are generally applicable only to special circumstances (e.g. small shortfall in storage) (Table 2.6).

The national cost depends on the total shortfall in storage (months), the quantity of slurry produced per month, and the cost per m3 of storage.

How much slurry storage was already present on farms?

The 2007 Farm Practice Survey (FPS) was used to estimate the slurry storage capacity that was in place prior to the 2009-2013 NVZ AP. This survey was carried out before the current (2009-12) NVZ AP slurry storage requirement came into force for most farmers. Although there was a requirement for farms on sandy and shallow soils to meet closed spreading period requirements for slurry (and poultry manure) spreading, this was less stringent and only affected around 10% of the NVZ area. It therefore gives the best available baseline position. Other survey data both earlier and later have also been examined, and give a picture that is broadly consistent with the 2007 survey (see below). Average slurry storage reported has increased slowly over the past 10 years, and the proportion of farms with less than 1 month's storage has fallen, but there remains a considerable shortfall.

Farm Practice Survey 2011 data on slurry storage

This survey states that on dairy farms, 26% had less than 4 months storage, and 61% had 4 to 6 months storage, the remaining 13% having more than 6 months storage. The NVZ AP requirement is 5 months storage. This suggests that about 26-77%, mean 56%, have insufficient storage. This figure is in reasonable agreement with the more detailed data from the 2007 survey cited below.

The average age of stores reported was 15 years, and on dairy farms only 8% were under 5 years old. On a 20 year build cycle, one would expect 25% to be under 5 years old. On dairy farms, 33% were planning to upgrade their slurry storage facilities within the next 3 years. These figures suggest that there has been little increase in storage in recent years, but that a substantial change is imminent, presumably to achieve compliance with the NVZ AP.

Farm Practice Survey 2007 data on slurry storage
The 2007 FPS showed that 56% of all farms had the less than 5 months' storage as required for compliance by cattle farmers with the NVZ AP. (Figure 2.1).

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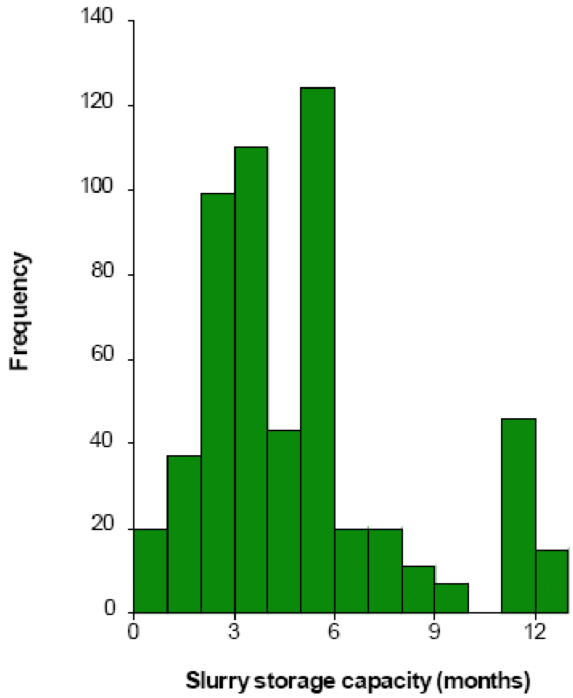

Figure 2.1 Slurry storage capacity in England, FPS 2007.

Although the FPS survey was national, these data were assumed to represent the 'prior' situation within NVZs. The data appears to show some small relative improvement in storage capacity in NVZs since designation though the rate of change of storage capacity suggests any such effect was not very great.

Using the FPS data, Table 2.7 summarises the storage deficit in NVZs. These deficits were weighted by the proportion of farms in each class, to give an average deficit. For example, a farm with 3-4 months' storage was assumed to require a minimum of 1.5 months of additional storage to comply with the NVZ AP, and so on.

Table 2.7 Calculation of storage deficit with respect to the 5 months requirement

Storage capacity (months)	<1	1-2	2-3	3-4	4-5	Total
% in class, from FPS 2007	4	7	18	20	8	56%
Assigned storage deficit for farms in class (m)	4.5	3.5	2.5	1.5	0.5	
Weighted mean storage deficit with respect to 5 months	0.16	0.24	0.45	0.30	0.04	1.19

Using this method, it was calculated that the mean storage deficit was 1.19 months across all farms, or 2.13 months on those 56% of farms with less than 5 months' storage.

Other surveys:
Given the uncertainty in the survey estimates, and the large costs associated with increasing storage, data from other surveys were also reviewed to give some understanding of the uncertainty around the need for additional storage.

The NFU survey 2010

The National Farmers Union undertook a survey to gain a better understanding of the measures being adopted by dairy farmers in England and Wales to comply with the requirements of the NVZ AP. Over 150 farmers within NVZs completed the questionnaire between September and November 2010. Sufficient storage must be in place by 1st January 2012, and it might therefore be expected that the results would reflect that some changes had already been undertaken. However, the responses were largely framed as intentions rather than completed actions.

The results showed that 45% of the farmers surveyed did not have enough slurry storage to comply with the five month storage requirement, but this included 5% who planned to achieve compliance by a change in management.

These figures are consistent with those from the FPS 2007, and in line with the statement within FPS that storage capacity within NVZs was greater on average than on farms outside NVZs. They are also the most recent data, so some farms are likely to have already acted to achieve compliance.

2001 Farm Practice Survey
The FPS 2001 found that, of respondents reporting more than 1 month's slurry storage, the average slurry storage on cattle farms was 4.9 months. The corresponding figure from the FPS 2007 distribution (i.e. calculated ignoring the cases with <1 month's storage) was similar at 5.1 months.

Smith et al. 2001 (1997 survey)
Smith *et al*. (2001) carried out a detailed survey in 1997 and found that 16% of dairy slurry and 25% of beef slurry was on farms that had less than 1 month's storage, *c*.10% was on farms with 1 or 2 months' storage and 35% on farms with 3 or 4 months storage. Thus, a total of about 61% of slurry was on farms with less than 5 months storage. These data are slightly worse than those reported for 2007 (4% of slurry on farms with <1 month storage, 56% on farms with < 5 months). However, the 1997 results are broadly consistent with those from 2007, particularly with regard to the proportion of farmers with little or no storage.

Renewal of stores and pressures to improve storage
The FPS surveys in 2004 and 2006 indicated that about 10% of stores were modified annually. The new build rate was about 2-3% per annum. About 6-8% of changes were to increase storage capacity, either by diverting water or by enlarging the store. Thus, there is a small but steady pressure towards increased storage capacity due to required rebuilds of stores and reorganisation of farms. In 2001, half of all stores were built prior to 1991 and were therefore not subject to the Control of Pollution 1991 regulations.

Conclusion:
The distribution of storage presented in the 2007 FPS survey and used here is broadly consistent with the other surveys both before and after this date. The data used for scaling up to the whole NVZ area up are as follows:

- Percentage of farms with insufficient storage: 56%
- Average storage deficit (months) on these farms: 2.13 months.
- Percentage of annual slurry production for which additional storage is required: 14.5% (cattle); 10.0% (pig).

How much slurry is produced from dairy and pig systems in NVZs in England?
Annual slurry production by cattle in NVZs in England is 13.11 million m^3 and by pigs 2.98 million m^3. These figures were derived from spatially mapped livestock numbers within the MANURES - GIS system for 2004 (Defra project WQ0103), cut to the NVZ area, and adjusted on a pro-rata basis for changes in stock numbers nationally between 2004 and 2009. MANURES - GIS takes account of other sources of the slurry volume to be stored, including rain water and parlour washings, and integrates all processes of N loss and transfer up to the point of spreading to land.

The total number of dairy cows within the NVZ area (based on mapped data from the 2009 June Survey), was estimated as 606,800 or 52% of the England total, and this was taken as the proportion of England's cattle slurry within the NVZ area. The proportion of pigs within the NVZ area was estimated as 80%. The number of dairy cows in England and Wales has fallen by 16% between 2004 and 2009, the number of beef cattle by 3% and pigs by 5%.
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What is the cost per m^3 of additional slurry storage?

In practice, the most effective method of achieving compliance for most farmers is to build a slurry tank. The case study figures are for 110 cows, requiring 2 months' additional slurry storage, and producing 3.75 m^3 (diluted) slurry per month each. Scaled per m^3 of slurry storage, the cost for a slurry tank is £53.61 per m^3 (Table 2.8) for capital including planning etc, and £6.04 per m^3 for annual costs including repairs and servicing of the loan.

Total costs of increased storage

Table 2.8 shows the total cost of providing increased storage on farms in NVZs in England in order to meet the current NVZ slurry storage requirement (5 months for cattle slurry, 6 months for pig slurry). The costs were based on installation of a metal tank store as other options considered were either relatively more expensive, or did not provide sufficient additional storage to solve the problem for most farmers. Installation of lined earth-bank lagoons would cost about 20% less than this @ £40/m^3 (Nix, 2010), although some farmers on suitable impermeable clay subsoils can achieve costs as low as £10 - £15/m^3. Because this is not a universal solution, we have used the figure from Nix, 2010. We have also provided a new build cost if all farms with less than 5 months storage were to build a new store (as many on farm stores are now 'old').

Economic benefits from increased manure storage capacity and more efficient use of manure N

Once sufficient storage is in place, the costs of a change in manure application timing to comply with the closed spreading periods are minor. The minimum storage capacity required exceeds the length of the closed periods to allow for adverse weather and other constraints.

On some farms there may be an issue of a peak labour requirement when stores are full and it is essential to spread as soon as conditions are suitable. However, many farmers now use contractors for slurry spreading, since the cost of contractor spreading at £46/hr (Nix 2010) is often more economic than purchasing the machinery. We have assumed no additional cost to the farmer beyond that of storage.

On those fields where manure was previously applied in autumn/winter, but is now applied in spring, the saving in nitrate leaching (and thus purchased N fertiliser) could typically be up to 50 kg/ha N (depending on the type of manure, quantity applied, soil type and the delay before soil incorporation). Thus on individual fields, there are substantial savings to be made. However, the proportion of fields affected by this change in any one year is small, which limits the overall impact.

2.4.3 Slurry storage cost for the whole NVZ area

The total annual quantity of slurry produced within the NVZ area of England was estimated to be 13.1 million m3 of cattle slurry and 3 million m3 of pig slurry, based on Manures-GIS 2004 values updated to 2009. These values are in good agreement with those used in Defra project WT0932 allowing for the fact that the present project deals with England only (Wales adds ca 1%), and that WT0932 used 2004 values directly.

Table 2.8 Cost of increasing storage capacity: farms in NVZs in England

Summary data	**England**				
		Cattle		**Pigs**	
Total annual slurry output	Million m^3	13.11		2.98	
		Capital	**Annual**	**Capital**	**Annual**
Cost of storage per m^3	£/ m^3	53.61	6.04	53.61	6.04
Target: 5 months cattle, 6 months pigs					
Volume for which additional storage is required	Million m^3	1.92		0.30	
Additional cost	£million	**103.9**	**11.7**	**16.1**	**1.8**
Maximum additional cost if full new storage built	£million	244.7	27.5	45.2	5.1
Minimum additional cost if 50% of storage was provided by lined earth-bank lagoons.	£million	90.3	10.2	14.0	1.6

The estimates are *highly uncertain*, because costs and options available on individual farms will vary greatly, and because of imprecision in the underlying data. Storage data are as reported by farmers, and may not be calculated according to the NVZ methodology which includes all water, as well as slurry entering the store. Reported storage was greater on NVZ farms and it is noticeable that there was a 'dip' in the number of farms reporting storage of between 4 and 5 months between 2004 and 2006. The assumed volume of additional storage constructed is smaller in the present calculations than in Defra project WT0932 , because we have taken account of the significant number of farms which recorded more than 5 months' slurry storage in previous surveys, and we have assumed (as in Manures-GIS) that only about 12% of the annual total cattle slurry is produced in each of the winter months (rather than ca 17%), since a significant proportion of slurry is produced during milking, which occurs all year round.

The estimated net saving of nitrate-N loss due to the Closed Period within the 2001-12 NVZ AP, after adjustment for the effect of rapid incorporation of applied manures, was 1.0Kt N. (this is consistent with estimates in Defra project WT0932).The price of ammonium nitrate fertiliser has fluctuated widely recently, from around £150 per tonne (0.43 £/kg N) to ca £345 per tonne (1 £/kg N), and continues to fluctuate on a rising trend. Taking account of this range, the savings were estimated to be in the range £0.4 million to £1.0 million per annum across the NVZ area.

The P and K value of manure is not affected by the date of application since these nutrients are retained by the soil.

The total cost of increasing cattle and pig slurry storage to meet the current requirements of the NVZ AP was estimated in the range:

- Capital cost
  £104 to £290 million

- Annual cost amortised over 20 years, offset by annual savings in nitrogen fertiliser:
  £11 to £32 million

2.5 Livestock manure N farm limit – 170 kg N per ha of agricultural land

This measure sets an annual limit (170N) for the total loading of nitrogen from livestock manures whether deposited at grazing or in houses. Farms with more than 80% of their land in grassland may apply annually for a derogation to this limit which, if successful, allows the permitted loading to be increased to 250 kg N/ha (250N). Further conditions apply on derogated farms.

The limit largely relates to the stocking density of the farm and in particular affects dairy farms (c.1,500 dairy farms in England have been estimated to have a loading that is over 170N). Most pig and poultry farms have adjusted to this restriction by exporting manures.

The case study farm
This measure applies particularly to dairy farms, and the calculations are based on the dairy farm typology from the Mitigation Methods - User Guide, which had 110 dairy cows. We have assumed a stocking rate of 2.15 cows/ha (217 kg/ha N loading), as the estimated average for those farms which exceed the 170N limit. Other small numbers of livestock were included in the User Guide typology, but for simplicity the calculations are given only in terms of milking dairy cows.

2.5.1 Costs of compliance

There are four options open to farmers who are above the 170N limit as summarised in Figure 2.9. The fact that very few farmers have applied for a derogation (c.450 in 2010, c.400 in 2011) suggests that many farmers have identified and are already taking these options, or are ‘ignoring’ the requirement.

Costs are illustrated in terms of a typical farm exceeding the 170N limit, with 110 cows stocked at 2.25 cows/ha (for simplicity, we assume no other livestock).

Option 1: Exporting slurry to other local farms which are below the 170N limit

Exporting slurry to other *local* farms incurs the same costs as spreading slurry on the home farm, plus transport costs. As many farmers now use contractors, the cost would be £40-50/hr working at an average rate of 2 loads per hour. Assuming the work rate falls by 50% to account for the additional travel, this would double the cost per cubic metre of slurry from approximately £1.75 to £3.50. If we assume the manure is moved between farms within an NVZ, the cost accrues to the NVZ regardless of whether the donor or receiving farmer pays.

From NVZ guidance leaflet 3 (Defra / EA, 2008) the average N production per dairy cow (6000-9000 litres milk yield) is 101kg N/year, which for the stocking rate of 2.15 cows/ha is 217 kg N/ha/year, of which some would be as handled manure and the rest deposited at grazing. To achieve compliance with the 170N limit, the farmer would need to export 47kg N/ha i.e. 2,400 kg total N or 948m^3 of slurry. Using the costs above, this adds £1.75 per m^3 to the farm's slurry spreading costs, or £1,658 for the farm. This calculation applies to the typical production of slurry which includes dilution with yard, roof and washing water as described in Section 2.4.2.

For farms with FYM, the standard figure for the N content of cattle FYM is 6 kg N/t - export of 2,400 kg N would thus need the export of 400 t FYM. At an additional £1.75 per tonne, this would increase the annual FYM export costs to a local farm by about £700.

Option 2: Reduced stock numbers

The gross margin per cow from 110 cows stocked at 2.15 cows/ha at an average yield of 7,000 litres milk/cow would be £916/cow (Nix, 2010), a total of £100,760 for the farm. To reduce the stocking density from 217 to 170 kg/ha N, stock numbers would have to be reduced by 21.7%, or 24 cows, producing a gross margin loss of £21,984. Reducing stock numbers would therefore be very unlikely to be acceptable to most farmers. Note: some may take the option of rearing their young stock off farm which would reduce N loadings by a small amount.

This is not a straightforward calculation because it involves a complete change of farm system, and in all but extreme cases is likely to be avoided. Since the option exists to apply for a derogation, we have taken the view that reducing stock numbers would occur only in rare cases where other factors make this an option that is economically no worse than the alternatives outlined below, including application for a derogation.

Option 3: Rent additional land to reduce stocking density

Farmers could rent additional land which carries few or no livestock. Farm rents in England in 2009 were about £150/ha. The additional land required to reduce the N loading on the case farm from 217 to 170 kg N/ha is 14ha, assuming that the rented land is available with a zero manure N loading (i.e. no livestock). The additional annual rental for this land would therefore be approximately £2,100 per year. The additional land would be used to increase the land area used in the N loading calculation and hence achieve compliance. Whilst there will be a cost in terms of rent, the additional land may be used either to reduce costs or to increase production of grass (hay or silage) or arable cropping e.g. cereals. The value from these uses will offset the rental, administrative and finance costs, so that the net effect in some cases may be cost neutral. There will be issues of availability, location and ease of access of any additional land and indeed, if the outcome is likely to positive, it should be assumed that the farmer would have already taken such action.

Renting additional land with zero or low N loadings (i.e.. stocking rates) is likely to be reasonably easy in mixed or arable dominated catchments (where the additional land can be used to grow maize or other fodder crops, or continue in normal arable cropping), or in areas with significant extensive grassland systems (beef and sheep). However, it is likely to be more difficult in intensive dairy areas like the South West, West Midlands or North West. Although in intensive dairying areas, the trend for small dairy farms to close, allowing neighbouring farms to increase herd size and farm area, may enable these farms to achieve suitable stocking densities.

Option 4: Apply for a derogation
Application for a derogation is required annually and involves both an administrative cost and compliance with additional measures. We have assumed that the additional administrative costs of applying for a derogation would be of the order of five days of the farmer's time, which would cost around £800 per farm. This is an annual cost.

In addition, on derogated farms farmers must:
• Prepare a nitrogen and phosphate application plan for each field. Sampling and analysis for soil extractable P MUST be done at least once every four years
• Plant a crop with a high nitrogen demand immediately after ploughing grassland
• NOT plough up temporary grassland on sandy soils between 1 July and 31 December.
• NOT plough up an area of grass before 16 January if livestock manure was applied to that area between the following dates:
  – Sandy soils 1 Sept to 31 Dec
  – All other soils 15 Oct to 15 Jan
• NOT include leguminous or other atmospheric nitrogen-fixing plants in the crop rotation (except grass with less than 50% clover or legumes under-sown with grass)
• Keep relevant records of calculations showing compliance with the various conditions of the derogation, and submit specified records to the Environment Agency annually.

We have counted no additional costs for these conditions, other than the administrative/planning costs above, on the grounds that

- nitrogen planning is part of the main NVZ AP
- phosphate planning is likely to be cost neutral or beneficial to farmers, since given the P surplus on most dairy farms there are potential savings in fertiliser use
- The remaining restrictions are not considered to be financially onerous

2.5.2 Summary of costs of the options for 170N limit compliance

An analysis of options open to farmers to achieve compliance with the 170N limit (Marks & Ryan, 2005) concluded that alternative methods would be available to the majority of farmers. The fact that relatively few farmers have applied for a derogation suggests that most farmers are indeed finding other ways to comply with the 170N limit, or are ignoring the requirement.

Table 2.9 Summary of annual costs for the four options

Option	Annual costs for a 110 cow farm £
1 a) Export slurry	1,700
1 b) Export FYM	700
2) Reduce stocking rates	22,000
3) Rent additional land	0 to 2,100
4) Apply for a derogation	800

2.5.3 Upscaling costs

In order to scale up these estimates, we have re-expressed them in terms of cost per 'surplus cow'. On the case study farm, there were originally 110 cows stocked at 2.15 cows/ha. The Nitrates Directive limit is 170 kg N/ha, or 1.68 cows per ha (cows yielding 6000-9000 litres of milk/year producing 101 kg N/ha/year). The farm therefore has to reduce cow numbers by 24 and the farm costs are therefore per 24 'surplus' cows.

How many cows are on farms which exceed the 170 limit?
A statistical analysis of June Survey data on dairy farms in NVZs for 2006 (by Natural England) was used to determine the distribution of stocking densities. The results were then scaled to the 2009 estimate of numbers of dairy cows within NVZs. More recent data (e.g. 2009) could not be used directly to arrive at the stocking densities because the upscaling method used to link the June Survey and the last full census resulted in too great a loss of precision and under-reporting of the areas of land assigned to individual farms (Hester Lyons, ADAS, pers. comm. confirmed by Defra statisticians).

Table 2.10 Percentage of cows and grass by stocking density, within NVZs

England NVZ 2006

N loading Bands (kg N/ha)	**<170**	**170 – 189**	**190 - 209**	**210 - 229**	**230 - 250**	**>250**	Total
% of all cows in NVZ	*58*	*10*	*8*	*6*	*5*	*12*	*100*
% of grass on stock farms in NVZ	*88*	*4*	*3*	*2*	*1*	*3*	*100*

The statistics indicate that 42% of cows on NVZs were on farms which exceeded the 170N limit. About 17% were on farms which exceeded 230 kg N/ha, and 12% on farms which exceeded 250 kg N/ha. These farms represent about 12% of the grassland area within NVZs.

By interpolation of these numbers, it was estimated that the number of 'surplus' cows above the 170N limit was 19% of the total. Note: other livestock may be involved on the farm, but the calculation is simplified by discussion in terms of dairy cow equivalents.

These detailed calculations were available for 2006 for an NVZ area of 70% of agricultural land. The number of dairy cows within the current NVZ (62% of agricultural land) in 2009 was calculated to be 606,833. The total number of dairy cow equivalents which require action of some kind was therefore 19% of this, pro rata, or 115,141.

Choice of options to achieve compliance

Table 2.11 Cost of options for complying with 170kg N/ha loading limit

Option	Cost per 'surplus' cow £	Cost for whole NVZ area £ million
1) a)Export slurry	69	8.0
1 b)Export FYM	29	3.4
2) Reduce stocking rates	916	105.5
3) Rent additional land	0 to 88	Up to 10.2
4) Apply for a derogation	38	4.3

Most options are more expensive than applying for a derogation. Export of FYM could be less expensive, but rather few dairy farmers are on FYM systems. We have assumed that where the cost of compliance is greater than the cost of applying for a derogation, the latter would be preferred. The effective cost of compliance is therefore taken as £38 per surplus cow per annum (as the application has to be renewed annually).

2.5.4 Costs for the whole NVZ area

At an effective cost of compliance of £38 per surplus cow per annum, the total cost of the 170 limit to the NVZ farming industry is estimated as £4.3 million annually. A range of +/- 25% is suggested.

2.6 Organic manure N field limit – 250 kg/ha of total N per ha per 12 months

This measure sets a limit of 250 kg of total organic manure N per ha that is spread to land in any 12 month period. The impact of this measure needs to be assessed along with the Nmax/Crop N limitation measure (see section 2.2). These other measures will ensure inputs are already below 250 kg/ha N in most cases. The exception is most likely to relate to manures with a low proportion of crop-available N. The impact of the 250N field limit will be to ensure that this manure is spread on a greater number of fields, probably within the same farm and will avoid 'disposal' on a small number of sacrifice fields. The additional cost of this measure is considered to be small even on affected farms, and negligible overall.

The administrative costs of manure application planning are included in Section 2.1. There would be no savings in fertiliser input beyond those already accounted for by other measures considered above.

2.7 Prompt incorporation of slurry/ poultry manures applied to bare soil and stubble

This rule requires that slurry or poultry manures applied to bare soil (or stubble) should be incorporated as soon as possible (24 hours at the latest), or be injected or band spread. The purpose is to reduce ammonia emissions.

It was assumed that an extra pass of cultivators was required for incorporation of the manure on the same day, requiring 1.5 hours at £27 per hour (£18 per ha). Manure application rates were assumed to be 40m^3/ha for pig slurry, 8t/ha for broiler litter and 13 t/ha for layer manure.

2.7.1 Summary of costs

The cost of the extra cultivation was taken to be £18/ha where slurry or poultry manure is applied to arable land.

2.7.2 Cost for the whole NVZ area

Assuming that 58% of pig slurry and 90% of poultry manure are applied to arable land, the additional operational cost of this measure under the current (2008-12) NVZ AP has been calculated to be £4.0 million per annum . (Defra project WT0932).

The reduction in fertiliser requirement due to reduced ammonia emissions under the current (2008-12) NVZ AP has been estimated to be 1.4 kT N per annum. (Defra project WT0932). The value of the fertiliser saved at 0.43 to 1 £/kg N is £ 0.6 to £1.4 million per annum.

The net annual cost to the industry within NVZs is therefore £2.6 to £3.4 million.

2.8 Other measures controlling how nitrogen is applied

These measures are focused on good practice, avoiding localised pollution and nuisance. They include:

- Prohibition on spreading manufactured fertiliser and manure N on steep slopes or near a water course
- Prohibition of the use of high trajectory slurry spreaders.
- Manufactured N fertiliser and organic manures to be applied in a uniform and accurate manner.

These measures do not markedly affect the profitability of a farm nor require new machinery. The management/ administration cost is covered under the additional administration costs detailed in Section 2.1.

2.9 Summary

The most costly measure by far, at both national and farm scale, is the requirement for additional slurry storage. This affects rather few farms, most of them dairy, but incurs a very large localised cost. The Derogation has reduced the impact of the 170N stocking density limit on individual farms, and the total cost.

The administrative costs are smaller, but affect all farms.

Remaining measures are either low cost or in some cases likely to have a positive economic impact.

A summary of the net costs is given in section 5.

3 COSTS OF POTENTIAL MEASURES NOT CURRENTLY IN THE AP

3.1 Increasing the values of the livestock manure N efficiency standard values.

The livestock manure N efficiency standard values apply when calculating compliance with whole farm fertiliser N inputs. The proposed increases in these values are of 5-10% of the total N content of the manure (Table 2.12). The values are intended for compliance testing at whole farm level. The requirement is that the total fertiliser input on the farm each year shall not exceed the Nmax allowance for each of the crops on the farm, minus the Manure N efficiency adjustment for manures applied on the farm.

Table 2.12. Estimated manure N efficiencies compared with values stipulated in the current NVZ AP and recommended for adoption in the next NVZ AP.

Manure type	Current NVZ AP	Suggested values in the next NVZ AP 2013-2016
Cattle slurry	35	40
Pig slurry	45	50
Poultry manures	30	30

Increasing the values of manure N efficiency used in the calculation should theoretically result in a reduction in the amount of manufactured N fertiliser to be applied, because a greater quantity of crop-available N is deemed to be derived from the manure. The reduction should be of the order of 5% of the N applied as slurry or poultry manure, or 4.5 kT N within the NVZ area of England. However the Nmax values for crops are generally set to encompass the range of recommendations, and on most farms, there is sufficient flexibility to absorb some change in the Manure N calculation. That is, on most farms, farmers could apply the economically optimum quantities of N fertiliser under the current NVZ AP, and a moderate change to the manure N efficiency values will have rather little effect on this. Defra project WT0932 calculated the difference in 'Manure N available to crops' as a result of changing from manure N efficiency values for slurries and poultry manures under the 2009-12 NVZ AP to be 5 kT N within England and Wales, equivalent to a 1% reduction in N fertiliser inputs.

The actual change on the ground is likely to be very much smaller than this. At such small changes, inputs will still be close to the economic optimum, and any economic saving in fertiliser inputs will be roughly balanced by a change in production of equivalent value.

No economic burden or benefit is therefore assigned to the magnitude of change in N efficiency values under consideration..

3.2 Storing solid manures on an impermeable base

If solid manures had to be stored on an impermeable base, and field heaps were no longer allowed, there would be a large requirement to construct impermeable (e.g. concrete) pads with leachate collection sumps.

3.2.1 Summary of costs

Estimates made as part of Defra project WT0932 (Nitrates Action Program: Impacts of Greenhouse Gas emissions) conclude that the capital cost would be £256 million (or £23.5 million per annum amortised over 20 years) in England and Wales.

A saving of 3% of N in solid manures due to collection of leachate was assumed. This would be applied to land and would increase crop-available N.

It was assumed that 40% of FYM and 30% of poultry manure was currently stored in field heaps (the remainder being spread directly to land).

3.2.2 Cost for the whole NVZ area

The total cost of storing all solid manures on an impermeable base was estimated as £256 across the NVZ area of England and Wales. Stock numbers on Wales NVZs are ca 1.3% of those in England and Wales, so the cost for England is estimated as £253 million or £23.2 million per annum amortised over 20 years. The increase in crop N uptake due to the collection of leachate from heaps was estimated by Defra project WT0932 to be 0.4 kT N across the NVZ area, at a fertiliser value of £0.2 to 0.4million per annum. The net annual cost is then £22.8 to £23.0 million amortised.

3.3 Cover crops

Cover crops in the context of NVZs mean green cover over-winter, in situations where the land would otherwise be fallow and bare. This green cover reduces nitrate loss because the plants take up N during autumn, which is then released slowly following destruction of the green cover in winter/spring. The greatest benefits are likely to be on nitrate 'leaky' sandy and shallow soils.

For a cover crop to be effective, the main requirement is for substantial growth of green cover in the autumn (e.g. a green leaf area index at least 1) - this requires early and rapid establishment. The most cost-effective, and therefore preferred, approach is to carry out a light (scratch) cultivation followed by broadcasting tail corn, oilseed rape or other cheap seed – natural regeneration without seeding can be successful, but is unreliable. It can be detrimental to plough, because weeds and volunteers are killed, drilling is delayed and seedbeds are often too dry, resulting in further delay to establishment. Purchase of specialist cleaned seed is not necessary and indeed may also delay establishment if the seed is not be ready immediately after harvest. The cost of the cheapest and preferred approach would be around £20/ha (with tail corn at no cost) or £40 to £60 for fodder rape or mustard compared with £80-100//ha for ploughing and use of purchased seed.

Destruction of the cover crop in late winter or early spring may either be by ploughing down or through using a herbicide. To prevent the cover crop acting as a 'green bridge' for pests and weeds, a single spray of paraquat may be used by some farmers, at a cost of £15/ha. This would increase the range of costs attributable to the cover crop from £35/ha to £115/ha, excluding the ploughing which is counted as an operation for the spring crop.
Specific situations may incur additional problems and costs. These include:

- There are potential problems with cover crops on medium/heavy soils, where they could delay cultivations for spring crops. This would make the use of cover crops economically untenable on many farms.

- Use of a herbicide and/or other agrochemicals to avoid weed, pest or disease transfer to subsequent crops. This is often not required if the cover is destroyed sufficiently early.

Cover crops are most effective on sandy or shallow soils typical of groundwater catchments. Spring cropping (e.g. potatoes, sugar beet, spring cereals) where cover crops would be required, is also most prevalent on these soils.

3.3.1 Summary of costs

Costs of between £20-70/ha were considered to be a reasonable range to cover most cases for cover crop establishment.

3.3.2 Cost for the whole NVZ area

The area of land within NVZs where cover crop establishment may be practised is estimated as 0.68 million ha assuming 20% of arable land within NVZs in England. At a cost per ha of £20 to £70 per annum, the cost of implementation of this measure is therefore estimated as £13.7 million to £47.9 million if implemented across the whole NVZ area.

3.4 Extending the Closed Period for slurry and poultry manure by 1 month

Any extension of the Closed Period for manures will increase manure storage capacity requirements and it has been assumed the increase is *pro rata*.

Storage costs

A 1 month increase to the storage capacity requirement (assumed to be in spring) would affect dairy farms and pig farms on slurry systems. Costs per m^3 are likely to be greater than those incurred under the current NVZ AP, as farmers will already have taken the most cost-effective strategy to achieve compliance, and will be faced with an additional storage requirement of 1 month or more. On some farms, there may be difficulties in finding new suitable sites, as the best options may have been taken to achieve compliance with the original storage requirements. There may also be greater difficulty in acquiring finance for such additional storage.

The estimated additional cost was up to £135 million (taken from Defra project WT0932 Option 1b) on the assumption that all farms would require one additional month of storage. The actual cost may be smaller than this as some farms already recorded more than 6 months' storage capacity in 2007.

Other economic effects of an extension to the Closed Spreading Period for organic manures

The measure may have costs related to delays in field and/or livestock operations. For grass production, early application of slurry 6-8 weeks before first cut helps avoid contamination of grass silage which can have an adverse effect on silage quality. Slurry application at 1 month (and preferably 8 weeks) before grazing is recommended to avoid herbage rejection and the risk of pathogens transfer.

Difficulties are expected on arable farms, especially on medium/heavy soils, under winter cropping because the number of days suitable for spreading are limited and there may be some issues as fieldwork is compressed into a short period. For spring arable crops, timeliness of operations is critical, since the soil can dry out or operations can be held up due to prolonged wet weather.

3.4.1 Summary of costs

Costs of storage per cubic metre were the same as for the 2009-12 Closed Period (see above).

3.4.2 Cost for the whole NVZ area

While it is estimated that 44% of dairy farmers have at least 5 months' storage, only about 21% were reported by the 2007 Farm Practice Survey to have more than 6 month's storage. An extension of the storage requirement will therefore affect the great majority of farms with slurry. It was estimated, using the same data sources and method as for the 2009-12 Closed Period, that slurry storage requirement would be increased by 1.08 million m3 cattle slurry and 0.17 m3 pig slurry, an increase of 56% over and above the new storage requirement for the 2009-12 Closed Period, at a cost of £59 million for cattle and £9 million for pigs (total £68 million). If all farmers added 1 month of storage to the storage already in place under the 2009-12 NVZ AP, the cost would be £98 million. The minimum cost assuming 25% of farmers could construct the somewhat cheaper earth lagoons was £59 million.

The additional saving in fertiliser N would be small or nil, in agreement with the conclusions of Defra project WT0972.

The total cost for the additional month of storage was therefore estimated as £59 to £98 million, or an annual amortised cost over 20 years of £6.6 to 11.0 million.

3.5 Increase the storage capacity requirement over the whole territory to the same as in NVZs (i.e. align the SSAFO and NVZ AP regulations)

The SSAFO regulations apply to the whole country, whereas the NVZ AP measures apply to c.62% of the agricultural land area. SSAFO comes into force on farms with new, substantially modified or enlarged stores, and requires a minimum of 4 months storage (calculated by a different method to that for NVZs). The difference in the storage requirement calculated according to the SSAFO regulations and that calculated according to the NVZ AP is taken as two weeks additional storage on NVZs for cattle and 6 weeks of additional storage for pigs.

Introducing this measure would entail additional capital costs for storage on all relevant farms outside the NVZs. These costs would be incurred when manure stores are built or renewed.

We assume therefore that this measure entails updating the SSAFO requirement on farms currently with less than the NVZ requirement of 5 months' storage calculated by the NVZ AP method. By analogy with the calculations within NVZs (section 2.5), we assume:

- 56% of slurry is on farms without sufficient storage
- The average deficit on these farms relative to the NVZ AP requirement is 2.1 months
- Under SSAFO, the average deficit would have been 0.5 months less (and a few of the farms would not have been required to increase their storage).
- Therefore compliance with NVZ rules accounts for 24% of the total cost

Since 44% of all slurry is estimated to be produced outside NVZs, the total cost of this measure is estimated as 19% of the total cost calculated within NVZs, or about £20-40 million. This cost will be incurred gradually on farms as they renew storage (i.e. over a period of c.20 years).

(If SSAFO rules were fully aligned with the NVZ AP with immediate effect this could incur a major cost. About 56% of slurry is estimated to be produced within NVZs. The imposition of

NVZ storage requirements to the rest of England on the same timescale as within NVZs would incur an additional cost outside NVZs of c.80% of that calculated for within NVZs).

3.6 Summary

Of the potential future NVZ measures considered here, a requirement for storage of solid manures on hard surface with collection of leachate is the most expensive, followed in terms of capital cost by the extension of Closed Period with associated increased slurry storage requirement. For both of these the cost falls mainly on cattle and pig farms. Implementation of cover crops is also relatively costly overall, and this is one of the few measures where the sector most affected in terms of both cost and environmental benefit is the arable sector.

The net costs are summarised in Section 5.

4 OTHER POSSIBLE LONGER-TERM MEASURES ON WHICH COMMENTS REQUESTED BY DEFRA

4.1 Move towards phosphorus based targets (including full nutrient planning).

The cost of this measure will depend on the severity of the target – a modest target could probably be achieved at little cost (or even with a modest saving) especially given the high cost of fertiliser. Phosphorus (P) inputs have been falling on both arable and grassland farms for many years, and recent increases in price have resulted in a further sharp downturn in fertiliser use. Farmers will be relatively receptive to measures that increase phosphorus use efficiency, and these savings are simpler to achieve than savings in nitrogen because phosphorus remains in the soil for future years.

There are two types of approach to reducing phosphorus inputs:

1. Define measures to minimise P inputs and surplus
2. Define a farm P balance (surplus) target

Restrictions on P inputs to land: fertiliser and manure

Phosphorus can be stored in soils (unlike nitrate) and therefore the aim of good P management is to ensure that soil P reserves are at an adequate level for crop growth, and then to maintain this level by, on average over a rotation, replacing the P removed in crops. The method of achieving this involves periodic soil analysis (recommended every 4 years) coupled with simple recording of inputs and yields. It is much simpler than the assessment of crop N requirements.

Arable farmers are already a long way towards good phosphate practice. Most farmers routinely sample soils for nutrients, including P, and are well aware of the soil P Indices of their fields. On average, current fertiliser plus manure P inputs to arable land are only slightly greater than off-takes in crop produce. Most arable farmers include P planning as part of their routine farm management practices, though this has in the past been much less commonly practised on grassland farms. A formal requirement would increase administrative costs, but could reduce fertiliser costs, especially on grassland farms using livestock manures, where the manure P content may not be fully accounted for.

Annual inputs of manure up to the total N limits permitted within the NVZ AP would usually provide excess inputs of P, sufficient for 2-4 years of the rotation. This measure would therefore not entirely remove the arable phosphate surplus unless an additional P restriction was placed on manure inputs per field per rotation.

Despite the fall in P inputs to grassland in recent years, most dairy farms are in P surplus because the P supply in purchased feeds exceeds the P removed in crop and livestock products. A requirement for P fertiliser planning (and not to apply P where the soil P Index is high) would incur a cost for analysis of soil P at intervals (e.g. 4-5 years) and an administrative cost. These costs would usually be balanced by savings in phosphate fertiliser.

Full nutrient management planning would mean both increased administration costs and soil sampling costs (at £5/ha averaged across whole farm area), see Section 5.1. However, many arable farmers will already be doing this and with current phosphate fertiliser costing c.80p/kg P_2O_5, savings of 40kg/ha (equivalent to £32/ha) are possible on fields with a soil P index over 2. This would mean little or no change on most arable farms, but would be a new cost on many grassland farms. Net costs could range from minus £25/ha (i.e. a saving) to £5/ha if no fertiliser savings, costed across the farm (not per ha analysed), assuming a third party takes the samples.

Restrictions on the farm P surplus

Within arable cropping, a farm P surplus of zero or close to zero is theoretically achievable, based on applying sufficient phosphate fertiliser on each field to balance off-take in crops. Indeed the national arable P balance taking account of manures applied is already close to zero, and dipped below zero in 2008 when fertiliser prices were exceptionally high. On some arable farms using livestock manures, a farm P surplus restriction would restrict the rates of manure application to less than those currently applied as permitted by the NVZ AP. Additional farms would need to take up the surplus manure. There is sufficient arable land in total to accommodate all the P from manure. (An exception to the surplus rule might be required for soils with very low P status to allow the soil P content to be built up).

On cattle (particularly dairy) farms, P purchased in feeds often exceeds P removed in products. Thus even if no chemical fertiliser is used, these farms often have a P surplus. While some reduction in feed P is possible, there are economic and practical limitations. Therefore, if a P surplus target is set, it needs to be sufficiently high to allow for the feeding of an adequate diet under current technology. The appropriate level for a farm will depend on a number of factors including stocking density and availability of arable land to allow more extensive spreading of manure and hence more effective use of the manure phosphate content.

Annual calculation of the farm phosphate balance would be an additional cost, similar to that of fertiliser planning and Nmax.

This approach is administratively more difficult because the appropriate ‘best practice’ target varies between farms depending on land use and stocking densities.

The PLANET software (www.planet4farmers.co.uk) can calculate a farm gate P balance based on nutrient imports and exports, and contains ‘benchmark’ values.

4.2 Encouraging the use of low protein animal feeding (LNF) and low phosphorus (P) feed to reduce the N and P content of manures.

The composition of diets fed to livestock varies widely, depending largely on the price and availability of feeds. Feeds which exceed the protein (i.e. N) or P requirements of stock result in greater N or P excretion.

For non-ruminant livestock, reductions in protein content will require supplementation with specific synthetic amino acids, which will increase feed costs. The cost effectiveness of this will depend on the relative prices of the amino acids and the protein feeds they are replacing. The recent marked increase in soybean meal prices has made the use of these more competitive, although their use is not yet cost neutral by moving to an appropriate protein level, a farmer may save £10 to £15 per cow per annum, but this may already have been achieved to a large extent due to recent increases in commodity costs. For ruminant livestock, total N consumed has declined markedly in the last decade or so, as a result of reduced levels of N fertiliser applied to grassland, which in turn has resulted in lower N silages. (The average N content of 1st cut silages in England and Wales in 1998-1999 was 25.9 g/kg DM; for 2006-2008 it was 21.1 g/kg DM.) This has been compensated to some extent by increasing the use of high protein feeds, but overall feed protein levels are lower.

Reducing the P content of non-ruminant diets requires supplementation with phytase enzymes. Levels of P in pig and poultry diets have declined in recent years as a result of using phytase additives, although reliable industry data on total use are not available. Ruminants produce their own phytase and therefore don't require enzyme supplementation, but reductions in P can be achieved from careful management of inputs (Cottrill *et al.* 2005). It is widely believed that dairy producers feed in excess of apparent dietary requirements (i.e. apply a safety margin) due to uncertainty over the amounts and availability of P in different feeds and the perceived need for additional P to maintain dairy cow fertility, but reliable data to support this are not available. High P intakes may also occur as a result of using high P forages (e.g. maize silage) and feeds (e.g. cereal by-products), but using alternative low-P feeds may be cost-negative. Further research on ways of measuring the availability of dietary P, or the development of a simple diagnostic tool to assess the P status of a herd, could allow dietary levels to be reduced without compromising health, welfare and productivity. Availability of comprehensive feed composition statistics from the industry would allow better assessment of progress and of potential further reductions that might be achievable.

Currently, dairy farmers get feed advice form feed suppliers, independent consultants and veterinarians. Many of these are aware of the environmental and economic costs associated with feeding excess P, but there is likely to be scope for further progress through better knowledge transfer.

5 SUMMARY AND DISCUSSION: TOTAL NVZ COSTS OF MEASURES

In this section the total costs of the measures within the current NVZ AP and some possible future measures are summarised. They are discussed in the context of the farming system and the sectors or farm types affected.

5.1 Costs of NVZ AP 2009 -12 measures

Table 5.1 Upper and lower cost estimates for measures from the current NVZ AP (£M)

Measure	Capital/ first year cost £ million Min	Capital/ first year cost £ million Max	Annual cost * £ million Min	#	Annual cost * £ million Max	#	Sectors most affected
General administration/ Record keeping	14	24	5		9		All
Crop N requirement (i.e. Nmax)	0	0		-31		-14	All
Closed spreading period for manufactured nitrogen fertiliser	0	0		-1		0	Arable
Closed period for spreading livestock manures; and slurry storage	104	290	11		32		Dairy; pig
Organic manure N farm limit – 170 kg N per ha of agricultural land	0	0	3		5		Dairy
Organic manure N field limit – 250 kg N per ha	0	0	v small		v small		Livestock
Prompt incorporation of slurry/ poultry manures applied to bare soil or stubble	0	0	3		3		Arable with manures
Other measures.	0	0	v small		v small		Livestock

***** includes amortised capital costs and any cost savings
# negative cost in this column = financial benefit

5.2 Costs of potential future measures

Table 5.2 Summary of the unit costs for the three potential future Action Programme measures

Measure	Capital/ first year cost £ million Min	Capital/ first year cost £ million Max	Annual cost * £ million Min	Annual cost * £ million Max	Sectors most affected
Increasing the values of the Manure N efficiency coefficients	0	0	0	0	Livestock
Storing solid manures on an impermeable base #	253	253	23	23	Livestock, especially beef
Cover crops	0	0	14	48	Arable (spring crops)
Extending the Closed Period for manures by 1 month	59	98	7	11	Dairy and pigs
Aligning SSAFO with NVZ calculation of storage ##	20	40			Dairy and pigs

***** includes amortised capital costs and any cost savings
# taken direct from Defra project WT0932
Note on SSAFO; this cost looks small because it only applies to the two extra weeks of storage on top of what would have been required for SSAFO only.

5.3 Cost of measures in the context of farm economics

The major cost of the NVZ AP is slurry storage. Any economic benefit from this in terms of increased efficiency of manure N use is relatively small compared to the cost. This measure poses a major economic challenge to dairy farmers and some pig farms. Many dairy farms (in particular) have limited access to finance and low income, compounded by an ageing work force, and succession concerns.

The 170 manure N loading limit could represent a significant cost on some farms and again impinges mainly on the dairy industry. The ability to apply for a derogation (allowing an increase in the limit to 250N) serves as a safety net for affected farmers where other less expensive options are not available.

Measures relating to N fertiliser use (and to P planning under the derogation) encourage farmers towards better planning, but do not in general restrict their inputs relative to economic best practice. Recent years have seen consistent reductions in phosphate inputs on arable land and grassland, and in N inputs to grassland. These trends are largely independent of the NVZ AP, but work in the same direction.

A major burden on farmers is change and uncertainty around regulation, compounded by changing and uncertain economic conditions. Anon (2011).

5.4 Costs by farming sector

Dairy farmers are by far the most affected by NVZ AP measures, mainly due to the capital cost of slurry storage and associated works. Pig farms on slurry will also be affected, although many of the larger farms are likely to have achieved most of the necessary compliance under IPPC regulations. Since dairy farming is located dominantly in the wetter western, it is these areas where the financial burden will be greatest. A major issue is that dairy margins have been poor for many years, which is not conducive to capital investment. A second issue is the average age of farmers, which discourages long-term investment, where there are no successors to pass the business on to.

The financial burden from the current NVZ AP on arable farmers is small, consisting chiefly of administrative costs. Arable farmers who use livestock manures will be affected by some of the measures, including the closed spreading periods for manures; and limits on total quantities of manure N applied.

Of measures under consideration for the future, most again affect mainly livestock farms or land receiving manures. The use of cover crops is the only potential measure considered which has its primary impact on arable farms. Arable cropping is the majority land use within NVZs occupying 2/3 of the area.

5.5 Farm size: should small farms be excluded from the NVZ AP?

Defra have asked whether it might be reasonable to set a farm size limit for implementation of the NVZ AP. Environmental benefit is proportional to the area or number of stock affected, while the administrative and some other costs do not reduce pro rata with farm size. This is also true of governmental costs of information dissemination and compliance assessment. On very small farms, the burden of regulation may be excessive compared to the environmental benefit that is achieved. Small farms are large in number, but represent a small fraction of the total agricultural industry or land area.

It may also be noted that many of the smaller farms will be relatively extensive in their management, and are unlikely to have, for example, slurry-based systems for their livestock.

5.5.1 Farm size statistics

The Farm Business Survey defines a 'spare time farm' as one which has a standard labour requirement (SLR) of less than 0.5. That is, it requires a work force of less than half a full time person. This threshold is also translated as:

- Less than 50 ha cereals, or
- Less than 25 dairy cows, or
- Less than 200 ewes

Of the 130,000 recorded farms in England (within NVZs), around 50% are below the 0.5 (SLR) threshold. Published Defra statistics show that farms of less than 1 SLR account for 78% of holdings in England in 2008, but only 17% of the labour force (http://www.defra.gov.uk/evidence/statistics/foodfarm/general/auk/latest/excel/documents/Table-3-5.xls). The data confirm that there are a very large number of small farms which account for rather little of the total agricultural industry.

However some of the 0.5 SLR thresholds used by the Farm Business Survey may be too high if the objective is to involve, say, at least 95% of the agricultural land area and livestock numbers within NVZ legislation. For example farms with less than 50 ha of cereals account for 22% of the cereal area.

The EU has defined thresholds for 'viable holdings' which are somewhat lower. Viable holdings should have at least:

5 ha cereals
10 dairy cows
10 beef animals
10 pigs or
1000 poultry.

While the Defra published statistics do not exactly match these criteria, the closest matches are given below (for the UK in 2008). The EU criteria do not include sheep. A relatively high criterion has been selected for sheep numbers, as the majority of NVZ AP measures would have little impact on sheep farming. It may be worth assessing the beef criterion in more detail, as it is likely that many of the smallest beef enterprises are on farms where another enterprise is dominant (e.g. Dairying) so some farms which fall below the beef threshold may nevertheless be caught by other thresholds. Some provision may also have to be made for 'minority' activities such as specialist vegetable farms.

Table 5.3 Selected data on proportions of holdings and land area by size groupings Source: Defra

EU criterion		Defra statistics			
Enterprise	Minimum ha or head		Maximum Closest match	Percentage on holdings <= criterion holdings	ha or head
Cereals	5		15	35	4
Dairy cows	10		9	34	1
Beef	10		9	42	7
Sheep	n/a	Breeding sheep	49	39	4
Pigs	10	Breeding sows	4	44	2
		Fattening pigs	9	42	1
Poultry	1000	Broilers	9999	65	1
		Layers	999	95	3

Use of the EU criteria as a threshold for requiring implementation of the NVZ AP would exclude more than one third of holdings across all enterprises, but substantially less than 5 percent of the land area and livestock number.

5.5.2 Conclusion

Overall, these data confirm that a threshold farm size for implementation of the NVZ AP would greatly reduce the number of farms involved in NVZ legislation, while having very little impact on the area of land or number of livestock falling under the legislation. Thus the administrative burden on both farmers and government would be greatly reduced while the environmental impact would be little affected. This would improve the ratio between cost and environmental benefit.

Potential thresholds are indicated above, for consideration.

5.6 Overall conclusions on the costs of measures

The main points arising from the economic analysis are:
Current 2009-12 NVZ AP

- The dairy sector is shouldering the majority of the cost of the NVZ AP, via slurry storage requirements and the 170 limit for excretal returns. This industry is in recurrent economic difficulty, with most farmers have concerns over capital cost and obtaining finance for slurry storage, on a background of low profitability and increased costs, and an ageing workforce.
- Western England is being hit the hardest in terms of NVZ AP costs due to the high proportion of dairying (and beef) farming
- The administrative burden to farmers and government is disproportionate on very small farms, and consideration should be given to a threshold farm size for full regulation.

Potential further measures

- Introduction of a requirement for hard standings and leachate collection from FYM would be extremely expensive, for rather little benefit

ADAS

- Extension of the Closed Period and storage requirement for slurries by one month would also be very expensive, and the burden would fall once again largely on the dairy industry. Provision of additional storage may be even more burdensome than the current requirement as farmers will already have employed the optimal solution for their own situation.
- Cover crops are one of the few measures which target and have a significant environmental benefit on arable land. They have little capital cost but a moderate ongoing cost.
- In terms of achieving maximum return per unit of cost, measures targeted to specific locations and nutrients may be more effective than the blanket approach of the Nitrates Directive. For example, cover crops would be most effective in reducing nitrate in areas of spring cropping such as are found in groundwater areas; and would have greatest economic benefit (to the water industry and consumer) in groundwater aquifers used for water supply.

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Annex 1: Questions from the 'Consultation on Implementation of the Nitrates Directive in England' and the supporting evidence that can be found in this document.

Question 3: Do you agree that crop available nitrogen from all types of organic manures should count towards the Nmax limits?

- Section 3.1. Livestock manure N efficiency standard values.
- Section 5.2. Cost of potential measures.

Question 8: Which of the 3 closed spreading period options do you prefer?

- Section 3.4. Extending the closed period.
- Section 2.4.3. Cost of existing storage.
- Section 5.2. Cost of potential measures.

Question 13: Do you agree that the Action Programme does not require any amendments with respect to the storage of solid livestock manures?

- Section 3.2. Cost of replacing field heaps with impermeable bases.

Question 14: Do you have ideas that will reduce the burden but maintain the environmental benefits of the Nitrates Directive?

- Section 5.5. Discussion about farm size and the impact of excluding small farms from regulation.

Question 16: Do you think cover crops should be included in the Action Programme?

- Section 3.3 Cover crops.
- Section 5.2. Potential cost of measures.