National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Agricultural practices *and water quality on farms* registered for derogation in 2013

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LEI WAGENINGEN UR

Colophon

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Synopsis

Agricultural practices and water quality on farms registered for derogation in 2013

The EU Nitrates Directive obligates member states to limit the use of livestock manure to a maximum of 170 kg of nitrogen per hectare per year. In 2013, Dutch farms cultivating at least 70% of their total area as grassland were allowed to deviate from this requirement under certain conditions, and apply up to 250 kg of nitrogen per hectare (this partial exemption is referred to as 'derogation' throughout this report, and farms participating in the derogation scheme are referred to as 'derogation farms'). The Netherlands is obligated to monitor agricultural practices and water quality at 300 farms to which derogation has been granted, and to submit an annual report on the results to the EU. This annual report is compiled by the Agricultural Economics Research Institute (LEI) of Wageningen University & Research Centre, and the Dutch National Institute for Public Health and the Environment (RIVM). This study examines farms that registered for derogation in 2013, and shows trends between 2006 and 2014. The report concludes that the average nitrate concentration in groundwater on these farms remained stable or decreased during this period.

Agricultural practices
The report also shows that, on average, derogation farms in 2013 used approx. 4 kg less nitrogen per hectare in the form of livestock manure than the prescribed maximum of 250 kg of nitrogen per hectare per year. The quantity of nitrogen that can potentially leach into groundwater in the form of nitrate is partly determined by the nitrogen soil surplus. This surplus is defined as the difference between nitrogen input (e.g. in the form of fertilisers) and nitrogen output (e.g. via milk). On average, the nitrogen soil surplus has not changed substantially during the period studied.

Groundwater quality
In 2013, the average groundwater nitrate concentration on derogation farms in the Sand region amounted to 37 milligrammes per litre (mg/l), and was therefore below the nitrate standard of 50 mg/l. On average, farms in the Clay region and Peat region had even lower nitrate concentrations (11 and 6 mg/l, respectively). With an average groundwater nitrate concentration of 56 mg/l, only derogation farms in the Loess region exceed the standard. The difference between the regions is mainly caused by a higher percentage of soils prone to nitrogen leaching in the Sand region and Loess region. Less denitrification occurs on these soils, and more nitrate can therefore leach into the groundwater.

Keywords: derogation, agricultural practices, manure, Nitrates Directive, water quality.

Publiekssamenvatting

Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie in 2013

De Europese Nitraatrichtlijn verplicht lidstaten om het gebruik van dierlijke mest te beperken tot 170 kg stikstof per hectare. Landbouwbedrijven in Nederland met ten minste 70 procent grasland mochten onder bepaalde voorwaarden van deze norm afwijken en in 2013 250 kilogram per hectare gebruiken (derogatie). Nederland is verplicht om op 300 bedrijven die derogatie inzetten de bedrijfsvoering en waterkwaliteit te meten en deze resultaten jaarlijks aan de EU te rapporteren. LEI Wageningen UR en het RIVM stellen jaarlijks deze rapportage op. Dit rapport beschrijft de situatie in 2013 en de trends voor de periode tussen 2006 en 2014. Uit de resultaten blijkt dat de nitraatconcentratie in het grondwater in deze periode, afhankelijk van de regio, is gedaald of gelijk is gebleven.

Bedrijfsvoering
Ook blijkt dat het stikstofgebruik uit dierlijke mest op de derogatiebedrijven in 2013 gemiddeld circa 4 kilogram per hectare lager was dan de maximaal toegestane 250 kilogram stikstof per hectare. De hoeveelheid stikstof die als nitraat kan uitspoelen naar het grondwater wordt onder andere bepaald door het stikstofbodemoverschot. Dit is het verschil tussen de aanvoer van stikstof (zoals meststoffen) en de afvoer ervan (waaronder via melk). Het gemiddelde Nederlandse stikstofbodemoverschot is gedurende de onderzochte periode niet significant veranderd.

Grondwaterkwaliteit
In 2013 lag de nitraatconcentratie in het grondwater in de Zandregio (gemiddeld 37 milligram per liter (mg/l)) onder de nitraatnorm van 50 mg/l. Bedrijven in de Kleiregio en de Veenregio hadden gemiddeld een lagere nitraatconcentratie (respectievelijk 11 en 6 mg/l). Alleen de derogatiebedrijven in de Lössregio lagen gemiddeld boven de norm (56 mg/l). Het verschil tussen de regio's wordt vooral veroorzaakt door een hoger percentage uitspoelingsgevoelige gronden in de Zand- en Lössregio; dit zijn gronden waar nitraat in mindere mate in de bodem wordt afgebroken en daardoor meer kan uitspoelen naar het grondwater.

Kernwoorden: derogatie, landbouwpraktijk, mest, Nitraatrichtlijn, waterkwaliteit.

Preface

This report provides an overview of agricultural practices in 2013 on all farms that registered for derogation in the derogation monitoring network. The agricultural practice data include data on fertiliser use and actual nutrient surpluses. Information is also provided about the results of water quality monitoring conducted in 2013 and 2014 on farms in the derogation monitoring network.

This report was commissioned by the Dutch Ministry of Economic Affairs, and prepared by the Dutch National Institute for Public Health and the Environment (RIVM) in collaboration with the Agricultural Economics Research Institute (LEI) of Wageningen University & Research Centre. LEI is responsible for the information about agricultural practices, while RIVM is responsible for the water quality data. RIVM also served as the official secretary for this project.

The monitoring network covers 300 farms. The farms in the derogation monitoring network were either already participating in the Minerals Policy Monitoring Programme (*Landelijk Meetnet effecten Mestbeleid*, LMM), or were recruited and sampled during sampling campaigns.

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4 June 2015

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Summary

Introduction
The EU Nitrates Directive obligates member states to limit the use of nitrogen in livestock manure to a maximum of 170 kg of nitrogen per hectare per year. The Netherlands has requested the European Commission to issue an exemption from this obligation (this exemption is referred to as 'derogation' throughout this report). In 2013, Dutch farms cultivating at least 70% of their total area as grassland were allowed to apply up to 250 kg of nitrogen per hectare in the form of manure from grazing livestock. The conditions attached to this exemption arrangement include an obligation for the Dutch government to set up a monitoring network comprising 300 farms that have registered for derogation ('derogation farms'), and to submit annual reports to the European Commission.

Derogation monitoring network
The derogation monitoring network was set up by expanding the Minerals Policy Monitoring Programme (*Landelijk Meetnet effecten Mestbeleid*, LMM) of RIVM and LEI. A stratified random sampling method was used to select 300 farms, distributed as evenly as possible according to soil type (sand, loess, clay and peat), farm type (dairy farms and other grassland farms), and economic size. Of these 300 farms, 288 actually participated in the derogation scheme in 2013. In addition to data on agricultural practices and water quality in 2013, this report also presents data on water quality in 2014, as this information relates to agricultural practices in 2013.

Agricultural practices in 2013
In 2013, the farms in the derogation monitoring network used an average of 246 kg of nitrogen from livestock manure per hectare of cultivated land. This is 4 kg less than the maximum permitted nitrogen application standard for livestock manure (250 kg per hectare). The average statutory availability coefficient amounted to 49%, resulting in a quantity of plant-available nitrogen of 120 kg per hectare. In addition, an average of 126 kg of nitrogen per hectare was applied in the form of inorganic fetilisers. At 246 kg per hectare, the total use of plant-available nitrogen was 12 kg less than the total nitrogen application standard (258 kg per hectare on average).
At 87 kg per hectare, phosphate use was slightly below the average phosphate application standard for farms in the derogation monitoring network (88 kg per hectare). The phosphate application standard depends on the phosphate status of the soil.

The average nitrogen surplus on the soil surface balance in 2013 was calculated at 190 kg per hectare. The Peat region[1] had the highest nitrogen surplus, followed by the Clay region, the Sand region and the Loess region. The phosphate surplus on the soil surface balance amounted to 16 kg of phosphate per hectare on average.

[1] Mineralisation on peat soils has been taken into account in the calculation of the nitrogen surplus.

Agricultural practices during the 2006-2013 period
Milk production per farm increased continually during the 2006-2013 period. This rise is caused by an increase in the average area of cultivated land per farm and the growing number of dairy cows per hectare. Average milk production per dairy cow was fairly stable. The proportion of derogation farms with pigs and poultry decreased substantially during this period. As a result, phosphate production by pigs and poultry declined significantly. However, this effect was largely compensated by intensification in the dairy farming sector. These trends point to a steady increase in scale, intensification of milk production, and specialisation in the dairy farming sector.

The proportion of grassland has remained stable, while the proportion of farms with grazing dairy cows slowly declined until 2011. The decrease in grazing in the September-October period was greater than the decrease in grazing throughout the entire May-October grazing period. The percentage of dairy farms with grazing animals has remained stable over the past three years.

In 2013, the quantity of nitrogen produced in livestock manure was 18 kg per hectare higher than in 2012. The use of nitrogen in livestock manure showed a slight upward trend in the 2006-2013 period. The use of inorganic fertilisers remained virtually constant. The statutory availability coefficient for nitrogen in livestock manure was gradually increased, resulting in a rise in the total use of plant-available nitrogen. Nevertheless, the use of (plant-available) nitrogen remained below the total application standard for nitrogen. In 2013, the total release of plant-available nitrogen was a few kilogrammes above the level of 2012.

The application standard for phosphate decreased between 2006 and 2013. This resulted in a decrease in the use of phosphate, particularly in the form of inorganic phosphate-containing fertilisers.

The grass and silage maize crop yields (expressed in tonnes of dry matter per hectare) increased during the 2006-2012 period. Due to the cold spring, grassland production in 2013 fell below the multi-year average. However, the nitrogen yield for grassland was above average in 2013. Yields measured in kilogrammes of phosphate per hectare were at an average level in 2013 for both grassland and maize acreage.

The nitrogen surpluses on the soil surface balance fluctuated somewhat from year to year, but no overall increase or decrease took place during the 2006-2013 period. In 2013, both the nitrogen input (via feed products) and the nitrogen output (via milk and livestock manure) increased compared to 2012. As a result, the surplus remained virtually unchanged. The phosphate soil surplus decreased from 2006 to 2012, but exceeded the multi-year average in 2013. Both nitrogen input and phosphate input (via feed products) increased in 2013. However, phosphate output (via animals and manure) remained stable. The decrease in the use of inorganic phosphate-containing fertilisers mainly took place in the 2006-2010 period. Both the nitrogen soil surpluses and the phosphate soil surpluses differ significantly between farms.

Water quality in 2013
At 37 mg/l, the average nitrate concentration in water leaching from the root zone in the Sand region was below the nitrate standard of 50 mg/l. At 56 mg/l, the average nitrate concentration on farms in the Loess region exceeded the standard. Nitrate concentrations in the Clay region (11 mg/l) and the Peat region (6 mg/l) were lower. In the Sand region, nitrate concentrations were below the nitrate standard on 69% of all farms. In the Loess region, this was the case on 44% of all farms. The percentage of farms with below-standard average nitrate concentrations was 100% in the Peat region and 97% in the Clay region. In all soil type regions, the nitrate and nitrogen concentrations measured in ditch water were lower than the concentrations measured in water leaching from the root zone and into groundwater.

The highest phosphorus concentrations in water leaching from the root zone were measured in the Peat region (0.44 mg P/l), followed by the Clay region (0.24 mg P/l). The average phosphorus concentration in the Sand region was 0.10 mg P/l, and fell below the detection threshold in the Loess region.

Water quality in the 2007-2014 period
In 2014, the nitrate concentrations measured in water leaching from the root zone were comparable to the average levels in previous years. This was the case in all regions. Nitrate concentrations in the Sand region, Clay region and Peat region decreased during the entire measurement period. There was no trend change in nitrate concentrations in the Loess region. The decrease in nitrate concentrations was also observed in ditch water.

During the measurement period, phosphorus concentrations in water leaching from the root zone decreased in the Clay region and Peat region, and increased in the Sand region. During the measurement period, no trend change could be observed in the phosphorus concentrations in the Loess region.

Relationship between agricultural practices and water quality
The nitrogen soil surpluses showed no upward or downward trend during the 2006-2013 period. However, the nitrate concentrations in water leaching from the root zone did decrease during this period. Possible causes of this decrease may include after-effects of higher soil surpluses in the past and a decrease in grazing.

As a result of a decrease in the use of inorganic fertilisers in the 2006-2013 period, the phosphate surplus on the soil surface balance displayed a downward trend. Phosphorus concentrations in groundwater declined during the measurement period in the Clay region and the Peat region. It is unclear if this is caused by the downward trend of the phosphorus surpluses.

1 Introduction

1.1 Background

The EU Nitrates Directive obligates member states to limit the use of nitrogen in livestock manure to a maximum of 170 kg of nitrogen per hectare per year (EU, 1991). A member state can request the European Commission for exemption from this obligation under certain conditions (this exemption is referred to as 'derogation' throughout this report). In December 2005, the European Commission issued the Netherlands with a derogation decision for the 2006-2009 period (EU, 2005). In February 2010, the derogation decision was extended until December 2013 (EU, 2010). During this period, grassland farms cultivating at least 70% of their total area as grassland were allowed to apply on their total area up to 250 kg of nitrogen per hectare in the form of livestock manure originating from grazing livestock. In May 2014, a new derogation decision was issued under new conditions for the period until December 2017 (EU, 2014).

1.2 Fulfilment of obligations, approach, scope

The present report compiled by RIVM and LEI, together with the RVO.nl report (2015), fulfils the following obligations under the original derogation decision (2005) and its extension (2010):

Article 8 Monitoring

8.1 Maps showing the percentage of grassland farms, percentage of livestock and percentage of agricultural land covered by individual derogation in each municipality, shall be drawn by the competent authority and shall be updated every year. Those maps shall be submitted to the Commission annually and for the first time in the second quarter of 2006.

This obligation is fulfilled in RVO.nl *et al.* (2015).

8.2 A monitoring network for sampling of soil water, streams and shallow groundwater shall be established and maintained as derogation monitoring sites. The monitoring network, corresponding to at least 300 farms benefiting from individual derogations, shall be representative of each soil type (clay, peat, sandy and sandy loessial soils), fertilisation practices and crop rotation. The composition of the monitoring network shall not be modified during the period of applicability of this Decision.

Chapter 2 describes the set-up of the derogation monitoring network.

8.3 Survey and continuous nutrient analysis shall provide data on local land use, crop rotations and agricultural practices on farms benefiting from individual derogations. Those data can be used for model-based calculations of the magnitude of nitrate leaching and phosphorus losses from fields where up to 250 kg nitrogen per hectare per year in manure from grazing livestock is applied.

Section 3.1 (situation) and section 4.1 (trends) summarise the results of the 300 farms that participate in the derogation monitoring network. Appendix 5 presents the data of all derogation farms in the Netherlands, and discusses the differences arising from a number of factors, including a difference in approach.

8.4 Shallow groundwater, soil water, drain water and streams in farms belonging to the monitoring network shall provide data on nitrate and phosphorus concentration in water leaving the root zone and entering the groundwater and surface water system.

Section 3.2 (situation) and section 4.2 (trends) provide data on the quality of ditch water and water leaching from the root zone on the 300 farms that participate in the derogation monitoring network.

8.5 A reinforced water monitoring shall address agricultural catchments in sandy soils.

Of the 300 farms in the planned sample, 160 farms are located in the Sand region (see section 2.4).

Article 9 Controls

9.1 The competent national authority shall carry out administrative controls in respect of all farms benefiting from an individual derogation for the assessment of compliance with the maximum amount of 250 kg nitrogen per hectare per year from grazing livestock manure, with total nitrogen and phosphate application standards and conditions on land use.

9.2 A programme of inspections shall be established based on risk analysis, results of controls of the previous years and results of general random controls of legislation implementing Directive 91/676/EEC. Specific inspections shall address at least 5% of farms benefiting from an individual derogation with regard to land use, livestock number and manure production. Field inspections shall be carried out in at least 3% of farms in respect to the conditions set out in Article 5 and 6.

The results of these controls are included in RVO.nl *et al.* (2015).

Article 10 Reporting

10.1 The competent authority shall submit the results of the monitoring, every year, to the Commission, with a concise report on evaluation practice (controls at farm level, including information on non compliant farms based on results of administrative and field inspections) and water quality evolution (based on root zone leaching monitoring, surface/groundwater quality and model-based calculations). The report shall be transmitted to the Commission annually in the second quarter of the year following the year of activity. (Additional provision in the extension of the derogation decision, EU, 2010).

The present report is the report referred to in the above article. Details of controls and instances of non-compliance are presented in RVO.nl *et al.* (2015).

10.2 In addition to the data referred to in paragraph 1 the report shall include the following:

(a) data related to fertilisation in all farms which benefit from an individual derogation;
(b) trends in livestock numbers for each livestock category in the Netherlands and in derogation farms;
(c) trends in national manure production as far as nitrogen and phosphate in manure are concerned;
(d) a summary of the results of controls related to excretion coefficients for pig and poultry manure at country level.

Section 3.1 (situation) and section 4.1 (trends) summarise the agricultural practice results of the 300 farms that participate in the derogation monitoring network. Appendix 5 presents the data for all derogation farms in the Netherlands, and discusses the differences between the two sets of results arising from a difference in approach. The obligation referred to in Article 10(2)(d) is fulfilled in RVO.nl *et al.* (2015).

10.3 The results thus obtained will be taken into consideration by the Commission with regard to an eventual new request for derogation by the Dutch authorities.
10.4 In order to provide elements regarding management in grassland farms, for which a derogation applies, and the achieved level of optimisation of management, a report on fertilisation and yield shall be prepared annually for the different soil types and crops by the competent authority and submitted to the Commission.

Section 3.1.3 specifies the grass and silage maize yields per hectare for the different soil types on the 300 derogation farms. Section 3.1.1 specifies the use of nitrogen in manure and fertilisers per crop and soil type.

1.3 Previously published reports and contents of this report

This is the ninth annual report setting out the results of the derogation monitoring network. It contains data on fertilisation, crop yields, nutrient surpluses, and water quality.

The first report (Fraters *et al*., 2007b) was limited to a description of the derogation monitoring network, the progress made in 2006, and the design and content of the reports for the years 2008 to 2010 inclusive. The derogation monitoring network results have been published in the subsequent reports (Fraters *et al*., 2008; Zwart *et al*., 2009, 2010 and 2011; Buis *et al.*, 2012; Hooijboer *et al.*, 2013 and 2014). Once results for multiple measurement years became available, the reports devoted more attention to the examination of trends in agricultural practices and water quality.

Chapter 2 describes the design and implementation of the derogation monitoring network. It also provides the agricultural characteristics of the participating farms (section 2.6). Section 2.7 describes the soil characteristics of the farms where water quality samples were taken.

Chapter 3 presents and discusses the measurement results of the monitoring of agricultural practices and water quality for 2013. This chapter also contains the provisional water quality monitoring results for 2014 (section 3.2.4).

Chapter 4 describes developments related to agricultural practices and water quality, including a discussion of trend-based changes since the start of the derogation scheme, and a statistical analysis of the extent to which agricultural practice year 2013 differed from previous years. In addition, an assessment is provided of the effects of agricultural practices on water quality.

2 Design of the derogation monitoring network

2.1 Introduction

The design of the derogation monitoring network must satisfy the requirements of the European Commission, as stipulated in the derogation decision of December 2005 and the extension of the derogation granted in 2010 (section 1.2). Previous reports provided extensive details about the composition of the sample and the choices this entailed (Fraters and Boumans, 2005; Fraters *et al*., 2007b).

During negotiations with the European Commission, it was agreed that the design of this monitoring network would tie in with the existing national network for monitoring the effectiveness of minerals policy, i.e. the Minerals Policy Monitoring Programme (LMM). Water quality and agricultural practices at farms selected for this purpose have been monitored under this programme since 1992 (Fraters and Boumans, 2005). Additionally, it was agreed that all LMM participants that satisfy the relevant conditions would be regarded as participants in the derogation monitoring network.

All agricultural practice data relevant to the derogation scheme were registered in the Farm Accountancy Data Network (FADN) (Poppe, 2004). Appendix 2 provides a description of the monitoring of the agricultural characteristics and the calculation methods for fertiliser use and nutrient surpluses. Water samples on farms were taken in accordance with the standard LMM procedures (Fraters *et al*., 2004). This sampling method is explained in Appendix 3.

The set-up of the derogation monitoring network and the reporting of results are based on the division of the Netherlands into regions as used in the action programmes of the Nitrate Directive (EU, 1991). Four regions are distinguished: the Sand region, the Loess region, the Clay region, and the Peat region. The acreage of agricultural land in the Sand region accounts for about 47% of the approx. 1.85 million hectares of agricultural land in the Netherlands (Statistics Netherlands Agricultural Census, data processed by LEI, 2013). The acreage of agricultural land in the Loess region accounts for approx. 1.5%, in the Clay region for approx. 41%, and in the Peat region for approx. 10.5% of all agricultural land.

With effect from measurement year 2011, there have been some changes to the boundaries of the four regions. In 2011, the FADN calculation system used by LEI to determine soil surpluses was also adjusted. The effects of these changes are explained in Hooijboer *et al.* (2013 and 2014).

2.2 Statistical method used to determine deviations and trends

Determining deviations in the measurement year under consideration
The comparison aims to establish if there is a significant difference between the value measured in the measurement year and the average

for the preceding years. The significance was determined using the Restricted Maximum Likelihood procedure (REML method). The REML method is suitable for unbalanced data sets and therefore takes account of farms which 'drop out' and are replaced. The agricultural practice data were processed using the REML method available as part of the 'linear mixed effects models procedure' (MIXED method) in IBM SPSS Statistics (version 22). The water quality data were processed using the REML method in GenStat (16th edition; VSN International Ltd.).

The calculations were based on unweighted annual farm averages, i.e. the data were not corrected for farm acreage, intensity, etc. All available annual farm averages were divided into two groups, with Group 1 comprising all the figures for the measurement year concerned, and Group 2 comprising all averages for the preceding years. The difference between Group 1 and Group 2 was then estimated as a so-called 'fixed effect', taking into account the fact that some data are not derived from the same farms ('random effect'). A discussion of fixed and random effects may be found in standard statistical manuals on variance analysis, e.g. Kleinbaum *et al.* (1997) and Payne (2000). Welham *et al.* (2004) explain how to produce estimations with such models.

If the results for the most recent measurement year deviate significantly from the average of the preceding years ($p < 0.05$), the direction of the deviation compared to previous years is indicated by a plus sign (+) or a minus sign (-). If there is no significant difference ($p > 0.05$), this is indicated by the 'approximately equal' sign (≈). These symbols may be found in the 'Difference' column in the overview tables (e.g. Appendix 4, Table A4.1B). The main text of this report only mentions differences if they are significant.

Determination of trends
The data were also analysed to identify any trends during the measurement period. The REML method with annual groups was used for this purpose as well. Only significant trend changes ($p < 0.05$) will be discussed.

2.3 Water quality and agricultural practices

The water quality levels measured in any year partly reflect agricultural practices in the year preceding the water quality monitoring and in previous years. The extent to which agricultural practices in previous years affect the water quality measurements depends on various factors, including (fluctuations in the) precipitation surplus during that year and local hydrological conditions. In the High Netherlands, it is assumed that agricultural practices affect water quality at least one year later. In the Low Netherlands, the impact of agricultural practices on water quality is quicker to materialise. This difference in hydrological conditions (rate of leaching) also explains the different sampling methods and sampling periods employed in the Low and the High Netherlands (see Appendix 3).
In the Low Netherlands, water quality is determined in the winter following the year in which the agricultural practices were determined. The 'Low Netherlands' comprises the Clay region, the Peat region and those parts of the Sand region that are drained by means of ditches,

possibly in combination with drainage pipes or surface drainage. The 'High Netherlands' comprises the other parts of the Sand region, and the Loess region. In the Sand region, groundwater is sampled in the summer following the year in which agricultural practices were determined. In the Loess region, soil moisture samples are taken in the autumn following the year in which agricultural practices were determined (see Appendix 3).

This means that water quality samples for measurement year 2013 can be related to agricultural practices in 2012 (see Table 2.1). Water quality samples for measurement year 2013 were taken during the winter of 2012/2013 in the Low Netherlands, and during the summer and autumn of 2013 in the High Netherlands.

The present report also includes water quality sampling results for measurement year 2014, which can be related to agricultural practices in 2013 (see Table 2.1). These water samples were taken in the winter of 2013-2014 in the Low Netherlands, and in the summer of 2014 in the High Netherlands. The results for the Loess region from sampling carried out in the autumn of 2014 are not yet available, and the other data are regarded as provisional because it is unknown at this time which farms will qualify for participation in the derogation scheme. The definitive figures will be reported in 2016, at which time the 2014 data for the Loess region will also be available and finalised.

Table 2.1 Overview of data collection periods and presented monitoring results on agricultural practices and water quality

Report	Agricultural practices	Water quality[2]		
		Clay and Peat	Sand	Loess
Hooijboer *et al.*, 2014	2012	2011/2012 final, 2012/2013 provisional	2012 final, 2013 provisional	2012/2013 final, 2013/2014 not yet available
Lukács *et al.*, 2015[1]	2013	2012/2013 final, 2013/2014 provisional	2013 final, 2014 provisional	2013/2014 final, 2014/2015 not yet available

[1] Present report
[2] The provisional figures can be related to the agricultural practice data presented in the same report. The definitive figures can be related to the agricultural practice data presented in the previous report.

2.4 Number of farms in 2013

2.4.1 Number of farms where agricultural practices were determined

Although the derogation monitoring network is a permanent network, a number of farms 'drop out' every year because they are no longer participating in the LMM programme. It is also possible that agricultural practices could not be reported due to incomplete data on nutrient flows. Incomplete nutrient flow data may be caused by the presence on the farm of animals owned by other parties, so that data on the input and output of feedstuffs, animals and manure is by definition incomplete. In addition, other administrative errors may have been made when registering inputs and/or outputs. However, water quality samples have been taken in these cases.
Agricultural practices were successfully registered at 297 of the 300 planned farms (see Table 2.2). Of these 297 farms, 288 actually

participated in the derogation scheme. Sixteen farms that participated in the derogation monitoring network in 2012 have since dropped out. These farms have therefore been replaced.

Table 2.2. Planned and actual number of analysed dairy and other grassland farms per region in 2013 (agricultural practices)

Farm type	*Planned/actual*	*Sand*	*Loess*	*Clay*	*Peat*	*Total*
Dairy farms	Planned[1]	140	17	52	52	261
	Actual					
	- Of which processed by LEI[2]	139	17	51	54	261[3]
	- Of which participating in the derogation scheme	136	16	51	52	255[3]
	- Of which submitted complete nutrient flow data	136	16	51	52	255
Other grassland farms	Planned[1]	20	3	8	8	39
	Actual					
	- Of which processed by LEI[2]	20	4	7	5	36
	- Of which participating in the derogation scheme	19	2	7	5	33
	- Of which submitted complete nutrient flow data	11	2	5	4	22
Total	Planned[1]	160	20	60	60	300
	Actual					
	- Of which processed by LEI[2]	159	21	58	59	297
	- Of which participating in the derogation scheme	155	18	58	57	288
	- Of which submitted complete nutrient flow data	147	18	56	56	277

[1] As determined based on old regional boundaries
[2] As determined based on new regional boundaries
[3] The actual sample differs from the planned sample due to changes in regional boundaries and developments on the farms

The various sections of this report describe agricultural practices based on the following numbers of farms:

- The description of general farm characteristics (section 2.6) concerns all farms that could be fully processed in FADN in 2013, and that participated in the derogation scheme (288 farms).
- The description of agricultural practices in 2013 (section 3.1) concerns all farms for which a full picture of nutrient flows could be obtained from FADN data (277 farms).
- The comparison of agricultural practices in the 2006-2013 period (section 4.1) concerns all farms that participated in the derogation monitoring network in the respective years. This number varies from year to year (see Appendix 4, Table A4.2A).

2.4.2 *Number of farms where water quality was sampled*

In 2013, water quality was sampled on 302 farms (see Table 2.3). Of these 302 farms, 283 participated in the derogation monitoring network in 2013. The difference of nineteen farms is caused by the fact that no samples could be taken at some new farms in 2013, due to changes in the derogation monitoring network. However, the farms that dropped out have been used to determine trends in water quality. Furthermore, nine farms out of a total of 283 did not qualify for participation or did not actually participate in the derogation scheme. The water quality sampling results of the remaining 274 sampled farms are presented in this report.

Table 2.3 Planned and actual number of analysed dairy and other grassland farms per region in 2013 (water quality)

Farm type	*Planned/actual*	*Sand*	*Loess*	*Clay*	*Peat*	*Total*
Dairy farms	Planned[1]	140	17	52	52	261
	Actual					
	- Sampled[2]	133	19	61	53	266
	- Derogation monitoring network 2013[3]	129	19	52	52	252
	- Participated in derogation scheme	126	17	52	50	245
Other grassland farms	Planned[1]	20	3	8	8	39
	Actual					
	- Sampled[2]	22	2	7	5	36
	- Derogation monitoring network 2013[3]	18	2	6	5	31
	- Participated in derogation scheme	17	1	6	5	29
Total	Planned[1]	160	20	60	60	300
	Actual					
	- Sampled[2]	155	21	68	58	302
	- Derogation monitoring network 2013[3]	147	21	58	57	283
	- Participated in derogation scheme	143	18	58	55	274

[1] As determined based on old regional boundaries
[2] As determined based on new regional boundaries
[3] Samples are often taken at farms before the composition of the monitoring network is known (i.e. after certain farms have dropped out). However, the farms that have dropped out are used to determine trends.

This report details the water quality on the following numbers of farms:

- The description of the water quality results for measurement year 2013 (section 3.2) concerns all farms where water quality samples were taken in 2013 and that qualified for participation in the derogation scheme in 2013 (274 farms).
- The description of the water quality results for measurement year 2014 (section 3.2.4) concerns all farms participating in the derogation monitoring network in 2013 (except farms in the Loess region) where water quality samples were taken in measurement year 2014 (277 farms).
- The analysis of water quality levels during the 2007-2014 period (section 4.2) concerns all farms that participated in the derogation monitoring network in the agricultural practice year preceding the relevant measurement year, and that qualified for participation in the derogation scheme in that previous year. This number varies from year to year (see Table 2.4).

Table 2.4 Number of farms per year used to determine water quality trends (the farms qualified for participation in the derogation scheme prior to the year when samples were taken)

Year	Number of farms
2007	278
2008	279
2009	280
2010	279
2011	281
2012	277
2013	295*
2014	267 (excluding farms in Loess region)

* In 2013, the sampling procedure was adjusted to the new regional boundaries to ensure that farms switching regions would no longer 'drop out'. The number of farms in 2013 is much larger caused by farms changing regions than in previous years (see Table 2.3).

Depending on the soil type region, water leaching from the root zone (groundwater, drain water or soil moisture) and/or ditch water is sampled (see Table 2.5).

Table 2.5 Number of sampled and reported farms per sub-programme and per region in 2013 and 2014, and sampling frequency of leaching water (LW) and ditch water (DW) (the target sampling frequency is stated in parentheses)

Year		Sand	Loess	Clay	Peat	Total
2013	Number of farms	143	18	58	55	274
	Number of farms – Leaching water	142	18	58	55	273
	Number of farms – Ditch water	31	-	57	54	142
	LW sampling frequency	1.0 (1)	1.0 (1)	3.4 (2-4)[1]	1.0 (1)	
	DW sampling frequency	3.8 (4)	-	4.0 (4)	4.1 (4-5)	
2014	Number of farms	158	-	60	59	277
	Number of farms – Leaching water	157	-*	60	59	276
	Number of farms – Ditch water	31	-	59	58	148
	LW sampling frequency	1.0 (1)	-*	3.4 (2-4)	1.0 (1)	
	DW sampling frequency	4.0 (4)	-	4.0 (4)	4.2 (4-5)	

[1] In the Clay region, groundwater is sampled up to two times and drain water up to four times, depending on the type of farm. Therefore, the average total number of samples will always be between two and four, depending on the proportion of farms with groundwater sampling versus farms with drain water sampling.
* In the Loess region, samples were taken at twenty derogation farms during the autumn of 2014. These sample results were not yet available when this report was compiled.

2.5 Representativeness of the sample of farms

In 2013, 288 farms participating in the derogation monitoring network are known to have registered for derogation. These farms had a combined total acreage of 15,958 hectares (accounting for 2.0% of all agricultural land on grassland farms in the Netherlands, see Table 2.6). The sample represents 87% of the farms and 97% of the acreage of all farms that registered for derogation in 2013 and that satisfied the LMM selection criteria (refer to Appendix 1). Farms not included in the sample population which did register for derogation are mainly other grassland farms with a size of less than 25,000 Standard Output (SO) units.

Furthermore, it is noteworthy that in all regions the proportion of sampled to total acreage is greater on dairy farms than on other grassland farms. During the selection and recruitment process, the required number of farms to be sampled for each farm type is derived from the share in the total acreage of cultivated land. On average, the other grassland farms selected are slightly smaller than the dairy farms in terms of their acreage of cultivated land.

The Loess region is relatively small and therefore does not have many derogation farms in the sample population. Because the study requires a minimum number of observations per region, a relatively large number of farms from the Loess region (15.9%) is included in the monitoring network.

Table 2.6 Area of cultivated land (in hectares) included in the derogation monitoring network compared to the total area of cultivated land on derogation farms in 2013 in the sample population, according to the 2013 Agricultural Census

		Sample population[1]	Derogation monitoring network	
Region	Farm type	Area (hectares)	Area (hectares)	Percentage of acreage of total sample population
Sand	Dairy farms	341,564	7,528	2.2%
	Other grassland farms	48,585	549	1.1%
	Total	390,149	8,077	2.1%
Loess	Dairy farms	4,287	739	17.2%
	Other grassland farms	673	52	7.7%
	Total	4,960	791	15.9%
Clay	Dairy farms	237,200	3,214	1.4%
	Other grassland farms	28,109	144	0.5%
	Total	265,309	3,358	1.3%
Peat	Dairy farms	134,910	3,535	2.6%
	Other grassland farms	14,007	197	1.4%
	Total	148,917	3,732	2.5%
All types	Dairy farms	717,960	15,016	2.1%
	Other grassland farms	91,375	942	1.0%
	Total	809,334	15,958	2.0%

[1] Estimate based on the 2013 Agricultural Census performed by Statistics Netherlands, data processed by LEI. Refer to Appendix 1 for further information on how the sample population was defined.

2.6 Description of farms in the sample

The 288 farms which are known to have registered for derogation in 2013 had an average of 55 hectares of cultivated land, of which 83% was comprised of grassland. The average livestock density was 2.4 Phosphate Livestock Units (LSUs) per hectare (see Table 2.7). Farm data derived from the 2013 Agricultural Census have been included for purposes of comparison, in so far as these farms were included in the sample population (see Appendix 1).

A comparison of the structural characteristics of the population of farms in the derogation monitoring network with the Agricultural Census data (Table 2.8) shows that the population of farms in the derogation monitoring network is representative of the Agricultural Census sample population, despite some minor differences.

Table 2.7 Overview of a number of general characteristics in 2013 of farms participating in the derogation monitoring network (DMN), compared to average values for the Agricultural Census (AC) sample population

Farm characteristic[1]	Population	Sand	Loess	Clay	Peat	Total
Number of farms in DMN	DMN	155	18	58	57	288
Grassland area (hectares)	DMN	41	33	50	58	45
	AC	33	30	45	44	39
Area used to cultivate silage maize (hectares)	DMN	11	9.5	6.4	7.6	9.1
	AC	7.8	7.6	5.0	3.4	6.2
Other arable land (hectares)	DMN	0.8	1.2	1.5	0.1	0.8
	AC	0.6	1.4	1.1	0.3	0.7
Total area of cultivated land (hectares)	DMN	52	44	58	66	55
	AC	42	39	51	48	45
Percentage of grassland	DMN	80	77	88	91	83
	AC	81	78	89	94	86
Natural habitat (hectares)	DMN	0.8	2.4	2.8	1.4	1.4
	AC	0.9	1.7	1.5	1.3	1.1
Grazing livestock density (Phosphate Livestock Units per hectare)[2]	DMN	2.4	2.6	2.4	2.3	2.4
	AC	2.4	2.4	2.1	2.0	2.2
Percentage of intensive livestock farms	DMN	6	6	2	9	6
	AC	9	2	4	3	6
Dairy cattle (including young livestock) (Phosphate Livestock Units per hectare)[2]	DMN	2.3	2.3	2.2	2.1	2.3
Other grazing livestock (Phosphate Livestock Units per hectare)[2]	DMN	0.11	0.27	0.20	0.11	0.14
Intensive livestock (total) (Phosphate Livestock Units per hectare)[2]	DMN	0.62	0.02	0.00	0.15	0.36
All animals (Phosphate Livestock Units per hectare)[2]	DMN	3.0	2.6	2.4	2.4	2.8

Source: Statistics Netherlands Agricultural Census 2013 (data processed by LEI and FADN).

[1] Surface areas are expressed in hectares of cultivated land; natural habitats have not been included.

[2] Phosphate Livestock Unit (LSU) is a standard used to compare numbers of animals based on their standard phosphate production (Ministry of Agriculture, Nature & Food Quality, 2000). The standard phosphate production of one dairy cow is equivalent to one Phosphate Livestock Unit.

The weighted average of the national FADN sample has been used to determine the extent to which the characteristics of dairy farms participating in the derogation monitoring network deviate from those of other dairy farms. The Agricultural Census does not provide appropriate data for comparison. The comparison (see Table 2.8) shows that in all regions, the dairy farms participating in the derogation monitoring network have a larger acreage and produce more milk per farm than the weighted national average. This is caused by the calculation method used. In order to calculate the national average, all data are weighted based on the different sample densities within the population. This weighting procedure was not applied to the derogation monitoring network data. A similar comparison has not been performed for the Loess region due to an insufficient number of FADN-registered farms. The average milk production per hectare and per dairy cow on dairy farms participating in the derogation monitoring network differed little from the national FADN average.

Table 2.8 Average milk production and grazing periods on dairy farms participating in the derogation monitoring network (DMN) in 2013, compared to the weighted average for dairy farms in the national FADN sample

Farm characteristic	*Population*	*Sand*	*Loess*	*Clay*	*Peat*	*Total*
Number of farms in DMN	DMN	136	16	51	52	255
FPCM[1] production per farm (kg)	DMN	908,700	722,200	980,500	1,058,800	942,000
	FADN	769,600		880,300	736,900	781,700
FPCM[1] production in kg per hectare of fodder crop	DMN	17,000	16,000	16,100	15,300	16,400
	FADN	16,900		15,200	14,000	15,800
FPCM[1] production per dairy cow (kg)	DMN	8,610	8,150	8,400	8,210	8,460
	FADN	8,680		8,340	8,170	8,470
Percentage of farms with grazing in May-October period	DMN	80	81	73	81	79
	FADN	76		77	86	78
Percentage of farms with grazing in May-June period	DMN	76	81	69	79	75
	FADN	70		74	83	74
Percentage of farms with grazing in July-August period	DMN	79	81	71	81	78
	FADN	76		76	86	78
Percentage of farms with grazing in September-October period	DMN	76	81	69	81	76
	FADN	73		73	86	76

[1] FPCM = Fat and Protein Corrected Milk, a standard used to compare milk with different fat and protein contents (1 kg of FPCM is defined as 1 kg of milk with 4.00% fat content and 3.32% protein content).

2.7 Characteristics of farms where water quality samples were taken

The sampled farms are distributed across the four soil type regions (see Table 2.9). The soil type regions are divided into districts (see Appendix B1.6). The table also makes a distinction between dairy farms and other grassland farms.

Table 2.9 Distribution across soil type regions and districts of the 283 grassland farms where water samples were taken in 2013 for derogation monitoring purposes

LMM soil type regions and districts	*Dairy farms*	*Other grassland farms*	*Total*
Sand region	129	18	147
• Reclaimed moor district	5	0	5
• Northern sand district I	17	1	18
• Northern sand district II	29	0	29
• Eastern sand district	39	7	46
• Central sand district	12	4	16
• Southern sand district	25	6	31
• Dunes and islands	2	0	2
Clay region	52	6	58
• Northern marine clay district	24	4	28
• Polder marine clay district	9	0	9
• Southwestern marine clay district	3	0	3
• River clay district	16	2	18
Peat region	52	5	57
• Western peat district	28	3	31
• Northern peat district	24	2	26
Loess region	19	2	21
• Loess region	19	2	21

Within a particular region, other soil types occur in addition to the main soil type for which the region is named (see Tables 2.10 and 2.11).

The Loess region mainly consists of soils with good drainage, whereas the Peat region mainly consists of soils with poor drainage. The well-drained soils in the Sand region are under-represented in the derogation monitoring network. Traditionally, the best soils (with favourable drainage conditions and nutrient status) were used for arable farming, while poorer (i.e. wetter) soils were used for dairy farming. In addition, the driest soils in the Sand region are often not used for agriculture. Wetter sandy soils are therefore over-represented in the derogation monitoring network. The differences in soil type and drainage class in the derogation monitoring network between 2013 and 2014 are minimal (see Table 2.10 and Table 2.11).

Table 2.10 Relative distribution (in percentages) of soil types and drainage classes in the different regions, for derogation farms where samples were taken in 2013

Region	*Soil type*				*Drainage class*[1]		
	Sand	*Loess*	*Clay*	*Peat*	*Poor*	*Moderate*	*Good*
Sand	86	0	6	8	39	50	10
Loess	0	79	21	0	1	3	96
Clay	5	0	92	3	46	49	5
Peat	15	0	27	58	94	6	0

[1] The drainage class is linked to the water table class (*Grondwatertrap*, Gt). The 'Poor natural drainage' class comprises water table classes Gt I through Gt IV, the 'Moderate drainage' class comprises water table classes Gt V, Gt V* and Gt VI, and the 'Good drainage' class comprises water table classes Gt VII and Gt VIII.

Table 2.11 Relative distribution (in percentages) of soil types and drainage classes in the different regions, for derogation farms where samples were taken in 2014

Region	*Soil type*				*Drainage class*[1]		
	Sand	*Loess*	*Clay*	*Peat*	*Poor*	*Moderate*	*Good*
Sand	86	0	6	7	40	50	11
Loess	*	*	*	*	*	*	*
Clay	5	0	92	3	46	48	5
Peat	13	0	26	60	94	5	0

[1] The drainage class is linked to the water table class (*Grondwatertrap*, Gt). The 'Poor natural drainage' class comprises water table classes Gt I through Gt IV, the 'Moderate drainage' class comprises water table classes Gt V, Gt V* and Gt VI, and the 'Good drainage' class comprises water table classes Gt VII and Gt VIII.

* Results from the Loess region were not yet available when the present report was being prepared.

3 Results

3.1 Agricultural characteristics

3.1.1 Nitrogen use in livestock manure

In 2013, the average use of nitrogen in livestock manure on derogation farms amounted to 246 kg per hectare (including manure excreted during grazing). In all regions, less nitrogen in livestock manure was applied on arable land (mainly land used for cultivation of silage maize) than on grassland. The farms in the monitoring network both import and export livestock manure. As average production exceeded the permitted use, the average manure output exceeded the input (including stock changes). This applied to all regions (see Table 3.1). On average, the use of livestock manure in 2013 exceeded the 2012 levels by 11 kg of nitrogen per hectare (see Appendix 4, Table A4.2).

Table 3.1 Average nitrogen use in livestock manure in the different regions (in kg of nitrogen per hectare) in 2013 on farms participating in the derogation monitoring network

Description	*Sand*	*Loess*	*Clay*	*Peat*	*Total*
Number of farms	147	18	56	56	277
Produced on farm[1]	282	280	270	272	278
+ Inputs	11	10	12	7	10
+ Changes in stocks[2]	-7	-6	-8	-2	-6
– Outputs	43	25	25	29	36
Total	243	260	248	248	246
Use on arable land[3, 4]	185	204	169	191	185
Use on grassland[3, 5]	261	274	263	255	261

[1] Calculated on the basis of standard quantities (N=142), with the exception of dairy farms that stated they were using the guidance document on farm-specific excretion by dairy cattle (N=135) (see Appendix 2).
[2] A negative change in stocks is a stock increase and corresponds to output.
[3] The average use data for grassland and arable land are based on 267 farms and 203 farms, respectively, instead of on 277 farms. This is because on 10 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 66 farms had no arable land.
[4] The figures for use on arable land are reported by the dairy farmer.
[5] Grassland usage levels are calculated by deducting the quantity applied on arable land from the total quantity applied.

Approx. 20% of all farms in the monitoring network did not import or export livestock manure (see Table 3.2). A similar number of farms only imported livestock manure, but did not export it. These farmers probably imported nutrients in livestock manure because this offered economic benefits compared to using inorganic fertilisers. This may also apply to the farmers who both imported and exported livestock manure (13%).

Table 3.2 Average percentage of farms participating in the derogation monitoring network with livestock manure inputs and/or outputs in 2013

Description	*Sand*	*Loess*	*Clay*	*Peat*	*Total*
No inputs or outputs	15	33	32	25	22
Only outputs	45	33	45	46	44
Only inputs	23	22	16	18	21
Inputs and outputs	17	11	7	11	13

3.1.2 Nitrogen and phosphate use compared to nitrogen and phosphate application standards

On average, the calculated total use of plant-available nitrogen at farm level on farms participating in the derogation monitoring network was lower than the nitrogen application standard in all regions in 2013. In the Sand region and Loess region, the average use of nitrogen fertilisers was closer to the nitrogen application standard than in the Clay region and Peat region (see Table 3.3).

Table 3.3 Average use of nitrogen in fertilisers (in kg of plant-available nitrogen per hectare)[1] on farms participating in the derogation monitoring network in 2013

Description	*Item*	*Sand*	*Loess*	*Clay*	*Peat*	*Total*
Number of farms		147	18	56	56	277
Average statutory availability coefficient for livestock manure (%)		49	48	50	49	49
Fertiliser use	Livestock manure	118	127	124	121	120
	Other organic fertilisers	0	0	1	0	0
	Inorganic fertilisers	119	107	151	123	126
	Total average fertiliser use	237	234	276	244	246
	Nitrogen application standard	241	239	296	271	258
Use of plant-available nitrogen on arable land[2, 3]		123	137	135	125	126
Application standard for arable land[2]		137	139	150	147	141
Use of plant-available nitrogen on grassland[2, 4]		271	261	300	261	274
Application standard for grassland[2]		267	264	317	284	280

[1] Calculated on the basis of the applicable statutory availability coefficients (see Appendix 2).
[2] The average use data and the application standards for grassland and arable land are based on 267 farms and 203 farms, respectively, instead of on 277 farms. This is because on 10 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 64 farms had no arable land.
[3] The figures for use on arable land are reported by the dairy farmer.
[4] Grassland usage levels are calculated by deducting the quantity applied on arable land from the total quantity applied.

In 2013, the average total use of phosphate on farms participating in the derogation monitoring network was slightly lower than the application standard of 88 kg of phosphate per hectare (see Table 3.4). On average 96% of phosphate was applied in the form of livestock manure.

Table 3.4 Average use of phosphate in fertilisers (in kg of P_2O_5 per hectare) in 2013 on farms participating in the derogation monitoring network

Description	*Item*	*Sand*	*Loess*	*Clay*	*Peat*	*Total*
Number of farms		147	18	56	56	277
Fertiliser use	Livestock manure	81	91	85	84	83
	Other organic fertilisers	0	0	2	1	1
	Inorganic fertilisers	3	2	2	3	3
	Total average fertiliser use	85	92	89	88	87
	Phosphate application standard	85	87	91	90	88
Use of phosphate on arable land[1, 2]		77	82	70	83	77
Application standard for arable land[1]		62	61	69	66	64
Use of phosphate on grassland[1, 3]		87	96	92	88	89
Application standard for grassland[1]		91	94	94	92	92

[1] The average use data and the application standards for grassland and arable land are based on 267 farms and 203 farms, respectively, instead of on 277 farms. This is because on 10 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 64 farms had no arable land.
[2] The figures for use on arable land are reported by the dairy farmer.
[3] Grassland usage levels are calculated by deducting the quantity applied on arable land from the total quantity applied.

3.1.3 *Crop yields*

In 2013, farms participating in the derogation monitoring network had an estimated average dry-matter yield of silage maize of 16,200 kg per hectare, resulting in an estimated average yield of 187 kg of nitrogen and 30 kg of phosphorus (69 kg of P_2O_5). Yields in the Clay region and Loess region were slightly above the national average, while yields in the Sand region and Peat region were below the national average (see Table 3.5). The calculated grassland yield amounted to 9,800 kg of dry matter per hectare on average. However, both the nitrogen and phosphorus yields per hectare were higher due to higher nitrogen and phosphorus content of grass. The calculated grassland dry-matter yields were lowest in the Sand region.

Table 3.5 Average crop yields (in kg of dry matter, nitrogen, phosphorus and P_2O_5 per hectare) for silage maize (estimated) and grassland (calculated) in 2013, on farms participating in the derogation monitoring network that meet the criteria for application of the calculation method (Aarts et al.*, 2008)*

Description	*Sand*	*Loess*	*Clay*	*Peat*	*Total*
Silage maize yields					
Number of farms	115	12	26	25	178
Kilogrammes of dry matter per hectare	16,200	17,000	16,400	15,700	16,200
Kilogrammes of nitrogen per hectare	187	204	190	177	187
Kilogrammes of phosphorus per hectare	29	33	33	29	30
Kilogrammes of P_2O_5 per hectare	67	75	75	67	69
Grassland yields					
Number of farms	132	13	46	46	237
Kilogrammes of dry matter per hectare	9,300	10,400	10,900	10,000	9,800
Kilogrammes of nitrogen per hectare	264	303	290	286	275
Kilogrammes of phosphorus per hectare	35	45	40	37	37
Kilogrammes of P_2O_5 per hectare	81	103	92	84	85

3.1.4 Nutrient surpluses

The average nitrogen surplus on the soil surface balance of farms participating in the derogation monitoring network amounted to 190 kg per hectare in 2013 (see Table 3.6). In 2013, inputs (nitrogen via feed products and manure) as well as outputs (nitrogen via animals and manure) were higher than in 2012 (see Table A4.6A in Appendix 4). The nitrogen surpluses on the soil surface balance showed considerable variation. The 25% of farms with the lowest surpluses realised a surplus of less than 147 kg of nitrogen per hectare, whereas the surplus exceeded 229 kg of nitrogen per hectare on the 25% of farms with the highest surpluses.

Table 3.6 Nitrogen surpluses on the soil surface balance (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network in 2013 (average values and 25th and 75th percentile values per region)

Description	*Item*	*Sand*	*Loess*	*Clay*	*Peat*	*Total*
Number of farms		147	18	56	56	277
Farm inputs	Inorganic fertilisers	119	107	151	123	126
	Livestock manure and other organic fertilisers	10	8	16	9	11
	Feedstuffs	226	179	166	184	202
	Animals	4	1	3	2	3
	Other	2	2	2	2	2
	Total	361	298	338	320	344
Farm outputs	Milk and other animal products	86	72	75	82	82
	Animals	22	14	13	12	17
	Livestock manure	49	29	35	32	42
	Other	15	23	16	14	16
	Total	173	137	140	141	157
Average nitrogen surplus per farm		188	163	198	179	187
+ Deposition, mineralisation and organic nitrogen fixation		36	36	34	120[1]	53
- Gaseous emissions[2]		47	45	51	54	49
Average nitrogen surplus on soil surface balance[3]		177	153	181	245	190
Nitrogen surplus on soil surface balance, 25th percentile		144	124	153	158	147
Nitrogen surplus on soil surface balance, 75th percentile		211	229	237	250	229

[1] Based on the assumption of higher nitrogen mineralisation from organic matter on peat soil (see Appendix 2)
[2] Gaseous emissions resulting from stabling, storage, application and grazing
[3] Calculated in accordance with method described in Appendix 2

The average phosphate surplus on the soil surface balance was 16 kg per hectare (see Table 3.7). This is an increase compared to 2012, when the phosphate soil surplus amounted to 10 kg. This increase was mainly caused by an increased supply of phosphate in purchased feed products. Phosphate output (via animals and manure) remained unchanged in 2013 (see Table A4.8 in Appendix 4). In contrast to the previous year, the 25% of farms with the lowest phosphate surpluses realised a surplus above 0 kg per hectare, while the 25% of farms with the highest surpluses realised an average surplus of nearly 30 kg per hectare. As in the case of nitrogen soil surpluses, these differences could be explained by the assumption that farmers with a low phosphate soil surplus are able to effectively integrate environmental aims into their farm management practices (Van den Ham *et al.*, 2010). Additionally, some of these farms may have relatively high crop yields, while farms with a high surplus may have soils producing relatively low yields.

Table 3.7 Phosphate surpluses on the soil surface balance (in kg of P_2O_5 per hectare) on farms participating in the derogation monitoring network in 2013 (average values and 25th and 75th percentile values per region)

Description	*Item*	*Sand*	*Loess*	*Clay*	*Peat*	*Total*
Number of farms		147	18	56	56	277
Farm inputs	Inorganic fertilisers	3	2	2	3	3
	Organic fertilisers	5	4	8	4	5
	Feedstuffs	79	61	60	65	71
	Animals	2	1	2	1	2
	Other	1	0	1	0	1
	Total	90	68	72	74	81
Farm outputs	Milk and other animal products	34	29	30	32	33
	Animals	13	9	9	8	11
	Organic fertilisers	21	11	14	14	18
	Other	4	8	4	3	4
	Total	73	58	58	58	66
Average phosphate surplus on soil surface balance[1]		17	11	14	16	16
Phosphate surplus on soil surface balance, 25th percentile		5	0	6	7	5
Phosphate surplus on soil surface balance, 75th percentile		29	22	25	26	27

[1] Calculated in accordance with method described in Appendix 2

3.2 Water quality

3.2.1 Water leaching from the root zone, measured in 2013 (NO_3, N and P)

In 2013, the average nitrate concentrations in the Sand region, Clay region and Peat region were below the nitrate standard of 50 mg/l (see Table 3.8). The average nitrate concentration in the Loess region was 56 mg/l. Although nitrate concentrations in the Peat region were lower than in the Clay region, the total nitrogen concentration was higher. This is caused by higher ammonium concentrations in groundwater in the Peat region. The higher ammonium concentrations are probably due to nutrient-rich peat layers (Van Beek *et al*., 2004) in which nitrogen is released in the form of ammonium due to the decomposition of organic matter (Butterbach-Bahl and Gundersen, 2011).

Groundwater that is or has been in contact with nutrient-rich peat layers often has high phosphorus concentrations (Van Beek *et al*., 2004). These nutrient-rich peat layers may also partly cause the higher average phosphorus concentrations measured in the Peat region and Clay region compared to the concentrations measured in the Sand region. In addition, phosphate ions are easily adsorbed by iron and aluminium (hydr)oxides and clay minerals, particularly under aerobic (oxygen-rich) conditions such as those occurring in the Sand region. Phosphate also readily precipitates in the form of poorly soluble aluminium, iron and calcium phosphates.

Table 3.8 Nutrient concentrations in 2013 (in mg/l) in water leaching from the root zone on farms participating in the derogation monitoring network (average concentrations per region and percentage of observations below the phosphorus detection threshold)

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	142	18	58	55
Nitrate (NO_3)	37	56	11	6
Nitrogen (N)	11	13	4.6	8.3
Phosphorus[1] (P)	0.10 (61)	<DT (83)	0.24 (21)	0.44 (7)

[1] The percentage of farms with average concentrations below the Detection Threshold (DT) is stated in parentheses.

In 2013, 69% of farms in the Sand region had nitrate concentrations below the nitrate application standard of 50 mg/l. In the Loess region, 44% of farms had below-standard nitrate concentrations (see Table 3.9). In the Peat region, all farms had below-standard nitrate concentrations. In the Clay region, nearly all farms (97%) had below-standard nitrate concentrations. The higher percentage of farms in the Sand region and Loess region with nitrate concentrations above the nitrate standard is due to a higher percentage of soils prone to leaching in these regions. These are soils where less denitrification occurs, partly due to lower groundwater levels and/or limited availability of organic material and pyrite (Biesheuvel, 2002; Fraters *et al.*, 2007a; Boumans and Fraters, 2011).

Table 3.9 Frequency distribution in 2013 of farm-specific average nitrate concentrations (in mg/l) in water leaching from the root zone on farms participating in the derogation monitoring network per region, expressed as percentages per class

Nitrate concentration classes (mg/l)	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	142	18	58	55
<15	29	0	76	85
15-25	16	6	12	5
25-40	15	28	7	5
40-50	9	11	2	4
>50	31	56	3	0

In 2013, 50% of all farms in the Sand region had a nitrogen concentration of 9.3 mg N/l or lower (see Table 3.10). The median value for the Loess region was 12 mg N/l. Fifty percent of all farms in the Peat region had a nitrogen concentration of 7.2 mg N/l or lower. The median value for the Clay region was 3.4 mg N/l.

Table 3.10 Nitrogen concentrations in 2013 (in mg N/l) in water leaching from the root zone on farms participating in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	142	18	58	55
First quartile (25th percentile)	6.5	9.2	2.4	5.5
Median (50th percentile)	9.3	12	3.4	7.2
Third quartile (75th percentile)	14	16	5.3	9.9

Phosphorus concentrations on 75% of farms in the Sand region were equal to or less than 0.10 mg P/l (see Table 3.11). Phosphorus concentrations on 50% of farms in the Clay region were equal to or less than 0.22 mg P/l. The median value for farms in the Peat region was 0.31 mg P/l. In the Loess region, over 75% of farms had a phosphorus concentration below the detection threshold.

Table 3.11 Phosphorus concentrations[1] in 2013 (in mg P/l) in water leaching from the root zone on farms participating in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	142	18	58	55
First quartile (25th percentile)	<DT	<DT	0.07	0.13
Median (50th percentile)	<DT	<DT	0.22	0.31
Third quartile (75th percentile)	0.10	<DT	0.33	0.47

[1] Average values below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT

3.2.2 *Ditch water quality measurements in 2012-2013*

Average nitrate concentrations were highest in the Sand region at 19 mg/l, and lowest in the Peat region at 2.5 mg/l (see Table 3.12). Nitrogen concentrations, too, were highest in the Sand region (6.7 mg N/l). Similar to the results for water leaching from the root zone, the average nitrogen concentration in the Peat region (4.1 mg N/l) was higher than in the Clay region (3.5 mg N/l). Phosphorus concentrations in ditch water were highest in the Clay region, and lowest in the Sand region.

Table 3.12 Average ditch water nutrient concentrations (in mg/l) per region in the winter of 2012-2013 on farms participating in the derogation monitoring network

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	31	*	57	54
Nitrate (NO_3)	19	*	4.6	2.5
Nitrogen (N)	6.7	*	3.5	4.1
Phosphorus (P)	0.14	*	0.24	0.20

* There are no farms with ditches in the Loess region.

Of the 31 farms in the Sand region, 29 farms (94%) had ditch water nitrate concentrations equal to or less than 50 mg/l (see Table 3.13). All farms in the Clay region and Peat region had average ditch water nitrate concentrations below 50 mg/l. Fifty percent of the farms in the Sand region had ditch water nitrogen concentrations equal to or less than 5.2 mg N/l (see Table 3.14). Fifty percent of all farms in the Clay region and Peat region had ditch water nitrogen concentrations equal to or less than 2.6 mg N/l and 3.9 mg N/l, respectively.

Table 3.13 Frequency distribution of average ditch water nitrate concentrations (in mg/l) per farm, on farms participating in the derogation monitoring network in the winter of 2012-2013, expressed as percentages per class per region

Nitrate concentration class (mg/l)	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	31	*	57	54
<15	58	*	93	98
15-25	13	*	5	2
25-40	13	*	2	0
40-50	10	*	0	0
>50	6	*	0	0

* There are no farms with ditches in the Loess region.

Table 3.14 Ditch water nitrogen concentrations (in mg N/l) on farms participating in the derogation monitoring network in the winter of 2012-2013 (25th percentile, median and 75th percentile values per region)

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	31	*	57	54
First quartile (25th percentile)	3.8	*	1.8	2.8
Median (50th percentile)	5.2	*	2.6	3.9
Third quartile (75th percentile)	9.8	*	3.6	5.1

* There are no farms with ditches in the Loess region.

Fifty percent of farms in the Sand region had ditch water phosphorus concentrations below the detection threshold of 0.062 mg P/l (see Table 3.15). Fifty percent of farms in the Peat region had phosphorus concentrations equal to or less than 0.14 mg P/l. Phosphorus concentrations on half of all farms in the Clay region were equal to or less than 0.13 mg P/l.

Table 3.15 Ditch water phosphorus concentrations[1] (in mg P/l) in the winter of 2012-2013 on farms participating in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	31	*	57	54
First quartile (25th percentile)	<DT	*	<DT	0.05
Median (50th percentile)	<DT	*	0.13	0.14
Third quartile (75th percentile)	0.18	*	0.34	0.29

[1] Average values below the detection threshold of 0.062 mg P/l are indicated by the abbreviation <DT.
* There are no farms with ditches in the Loess region.

3.2.3 *Comparison with reported provisional figures for 2013*

The figures presented in this section hardly deviate from the provisional figures reported by Hooijboer *et al.* (2014). The minor differences are mainly caused by a number of farms having 'dropped out' because they did not qualify for participation or did not actually participate in the derogation scheme, or because farms were replaced in the derogation monitoring network.

3.2.4 *Provisional figures for measurement year 2014*

At the time of writing, only provisional results were available for 2014. No results for the Loess region were available when this report was being prepared. The results are 'provisional' because it is unknown at this time which farms will be granted derogation for measurement year 2014. This could mean that some concentration data might be changed in the final report for 2014, which will be published in 2016.

In the Sand region, the average nitrate concentration in water leaching from the root zone was 43 mg/l (see Table 3.16). Nitrate concentrations at 63% of farms were below 50 mg/l. This is a lower percentage than in 2013 (see Table 3.9). In 2014, the average nitrate concentration in water leaching from the root zone in the Clay region was 14 mg/l. Ninety-two percent of the participating farms in the Clay region had nitrate concentrations below 50 mg/l (see Table 3.16). The average nitrate concentration on farms in the Peat region was 9 mg/l. In the Peat region, 95% of all farms had a nitrate concentration below 50 mg/l.

In 2014, the average ditch water nitrate concentration in the Clay region and Peat region amounted to 6.0 mg/l and 3.5 mg/l, respectively. These levels are well below the nitrate standard of 50 mg/l (see Table 3.16). At 25 mg/l, the average ditch water nitrate concentration in the Sand region exceeded the average concentration in the Clay region and Peat region.

Table 3.16 Frequency distribution of average nitrate concentrations (in mg/l) in water leaching from the root zone (left section of table) and in ditch water (right section) per region in 2014, expressed in percentages per concentration class and average nitrate concentrations for all farms

Nitrate concentration class (mg/l)	*Water type*						
	Water leaching from root zone				*Ditch water*		
	Sand	*Loess*	*Clay*	*Peat*	*Sand*	*Clay*	*Peat*
Number of farms	157	*	60	59	31	59	58
Average concentration for all farms	43	*	14	9.2	25	6.0	3.5
<15	23	*	67	75	39	92	98
15-25	14	*	20	14	26	5	0
25-40	15	*	3	5	16	3	2
40-50	11	*	2	2	3	0	0
>50	37	*	8	5	16	0	0

* Results from the Loess region were not yet available at the time of preparation of the present report.

Nitrogen concentrations in water leaching from the root zone were also higher in the Sand region than in the Clay region and Peat region (see Table 3.17). It is also noteworthy that nitrogen concentrations in the Peat region were higher than in the Clay region, due to higher ammonium concentrations in the Peat region. The ditch water nitrogen concentrations presented a similar picture to concentrations in water leaching from the root zone, but with lower concentration levels.

Table 3.17 Nitrogen concentrations (in mg N/l) in water leaching from the root zone (left section of table) and in ditch water (right section) in 2014 on farms participating in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Characteristic	*Water type*						
	Water leaching from root zone				*Ditch water*		
	Sand	*Loess*	*Clay*	*Peat*	*Sand*	*Clay*	*Peat*
Number of farms	157	*	60	59	31	59	58
Average	12	*	5.4	9.2	8.0	3.4	4.2
First quartile (25th percentile)	7.2	*	3.2	6.6	4.2	2.0	3.1
Median (50th percentile)	11	*	4.5	8.7	6.3	2.9	4.2
Third quartile (75th percentile)	16	*	5.8	11	9.8	4.4	5.3

* Results from the Loess region were not yet available at the time of preparation of the present report.

Unlike the nitrogen concentrations, the phosphorus concentrations in water leaching from the root zone were higher in the Peat region and the Clay region than in the Sand region (see Table 3.18). In 2014, the ditch water phosphorus concentrations were highest in the Clay region.

Table 3.18 Phosphorus concentrations[1] (in mg P/l) in water leaching from the root zone (left section of table) and in ditch water (right section) in 2014 on farms participating in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Characteristic	*Water type*						
	Water leaching from root zone				*Ditch water*		
	Sand	*Loess*	*Clay*	*Peat*	*Sand*	*Clay*	*Peat*
Number of farms	157	*	60	59	31	59	58
Average	0.13	*	0.28	0.30	0.11	0.26	0.18
First quartile (25th percentile)	<DT	*	0.09	0.10	<DT	<DT	<DT
Median (50th percentile)	<DT	*	0.23	0.16	<DT	0.10	0.11
Third quartile (75th percentile)	0.11	*	0.41	0.50	0.15	0.45	0.20

[1] Average values below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT.
* There are no farms with ditches in the Loess region.

4 Developments in monitoring results

4.1 Developments in agricultural practices

4.1.1 Developments in farm characteristics[2]

The quantity of Fat and Protein Corrected Milk (FPCM) produced per farm increased continually during the 2006-2013 period (see Figure 4.1). This rise was caused by an increase in the average area of cultivated land per farm and the growing number of dairy cows per hectare. Average FPCM production per dairy cow remained fairly stable. The proportion of farms with intensive livestock and the average livestock density expressed in Phosphate Livestock Units per hectare have decreased (see Figure 4.2). As a result, phosphate production by pigs and poultry declined significantly. However, this effect was largely compensated by intensification in the dairy farming sector. This trend points to a steady increase in scale and specialisation in the dairy farming sector, as well as intensification resulting in higher milk production per hectare of fodder crop (see Appendix 4, Table A4.1A +B). The increase in nitrogen production in livestock manure per hectare was less than the increase in milk production per hectare of fodder crop, particularly after 2010 (see Appendix 4, Table A4.2A).

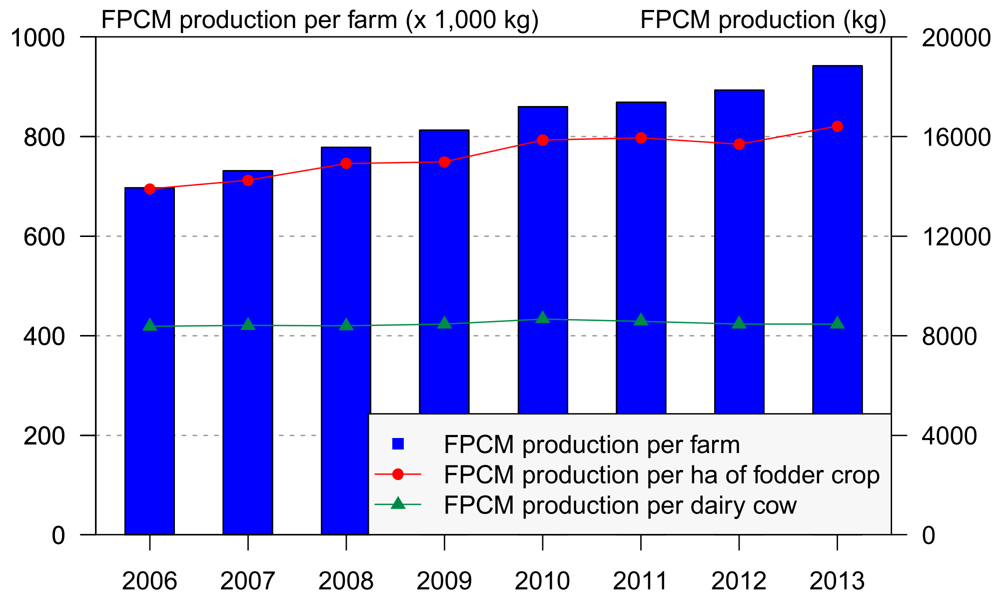

Figure 4.1 Average production of Fat and Protein Corrected Milk (FPCM) per farm (left y-axis), and per cow and per hectare of fodder crop (right y-axis) in the 2006-2013 period

[2] This section only concerns dairy farms participating in the derogation monitoring network, i.e. without other grassland farms.

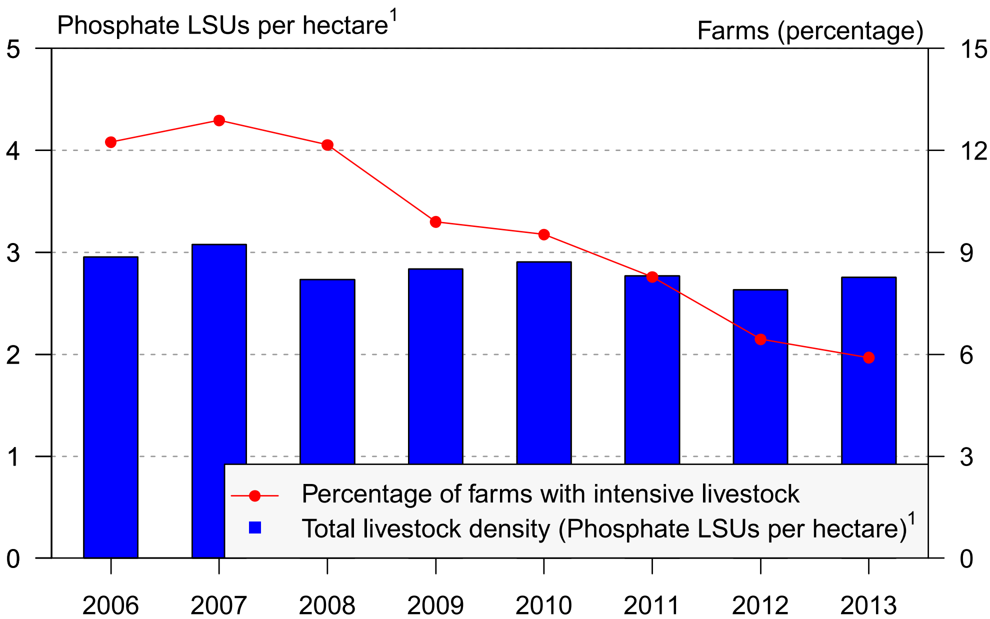

Figure 4.2 Average livestock density expressed in Phosphate Livestock Units per hectare, and percentage of dairy farms with intensive livestock (e.g. pigs, chickens, sheep) in the 2006-2013 period

[1] Phosphate Livestock Unit (LSU) is a standard used to compare numbers of animals based on their standard phosphate production (Ministry of Agriculture, Nature & Food Quality, 2000). The standard phosphate production of one dairy cow is equivalent to one Phosphate Livestock Unit. The use of LSUs enables the aggregation of all intensive livestock present on a farm (dairy cows, young livestock, pigs, chickens, sheep, etc.).

The percentage of farms with grazing decreased until 2011 and stabilised in 2012 and 2013 (Figure 4.3; see also Appendix 4, Tables A4.1A and A4.1B).

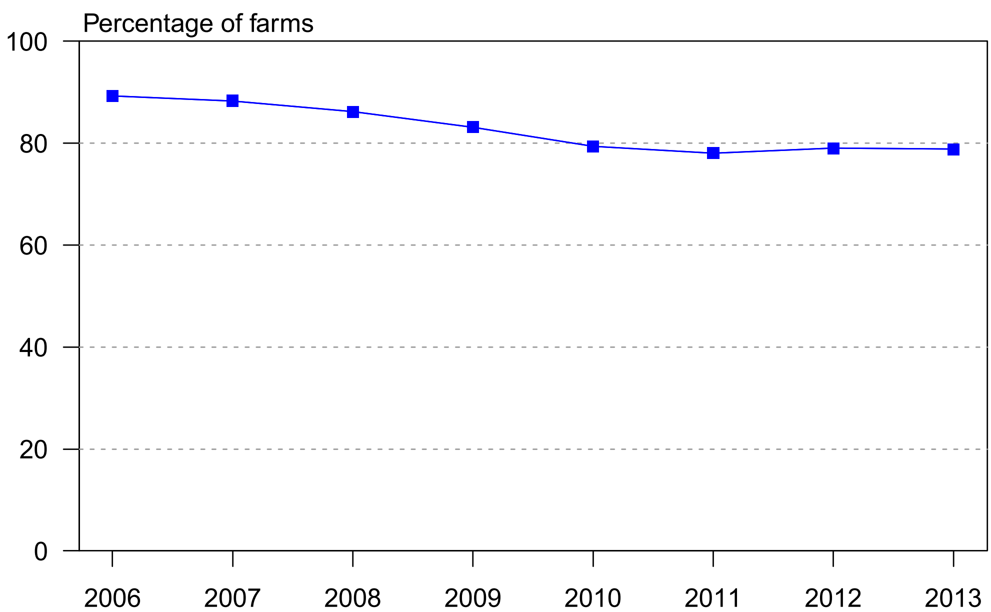

Figure 4.3 Percentage of dairy farms where cows grazed in summer in the 2006-2013 period

4.1.2 *Use of livestock manure*

In 2013, the use of nitrogen in livestock manure was slightly higher than the average for the 2006-2012 period (Figure 4.4; see also Appendix 4, Tables A4.2A and A4.2B).

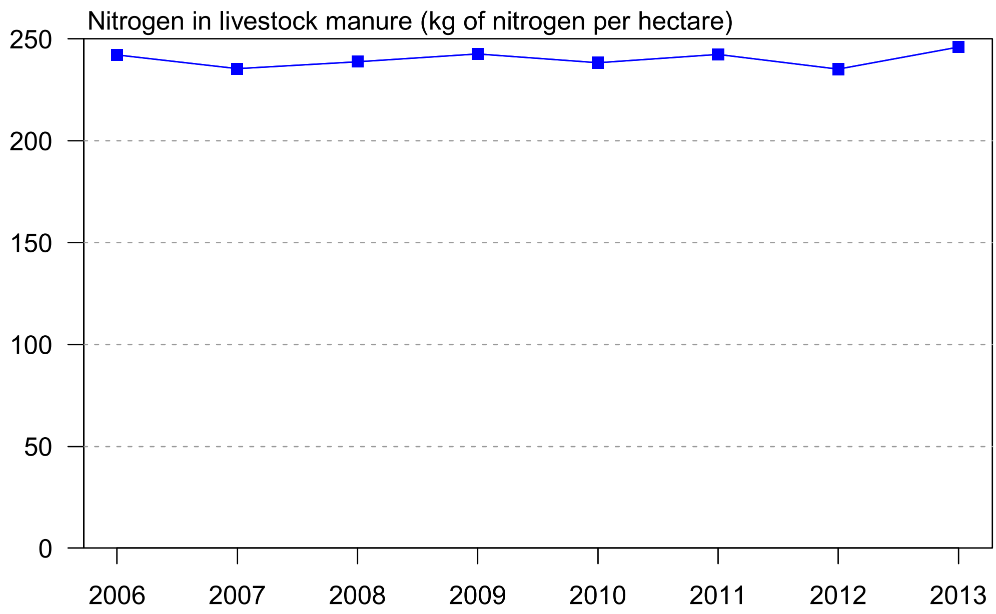

Figure 4.4 Application of nitrogen in livestock manure (in kg of nitrogen per hectare) in the 2006-2013 period

4.1.3 *Use of fertilisers compared to application standards*

In 2013, the total use of plant-available nitrogen remained below the nitrogen application standard, but the difference is decreasing (see Appendix 4, Table A4.3B). Whereas the difference between actual usage and the application standard for plant-available nitrogen amounted to approx. 60 kg per hectare in 2006, this difference had decreased to 12 kg per hectare in 2013. This is partly due to higher statutory availability coefficients for manure on dairy farms with grazing, and partly due to more stringent nitrogen application standards (Figure 4.5; see also Appendix 4, Tables A4.3A and A4.3B).

The use of inorganic nitrogen-containing fertilisers was fairly stable during the 2006-2013 period (see Appendix 4, Table A4.3A). The total applied quantity of plant-available nitrogen in 2013 was slightly higher than the average for the seven preceding years.

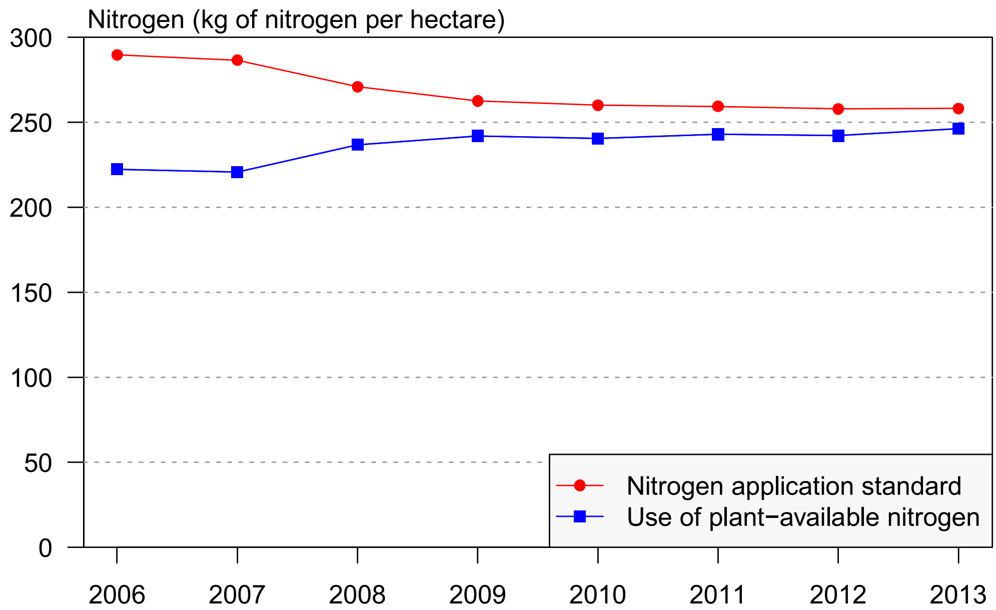

Figure 4.5 Total nitrogen application standard (in kg of nitrogen per hectare) and use of plant-available nitrogen in livestock manure and inorganic fertilisers (in kg of nitrogen per hectare) during the 2006-2013 period

During the 2006-2013 period, the use of phosphate-containing fertilisers on farms participating in the derogation monitoring network decreased by approx. 12%, while the phosphate application standard decreased by approx. 19% (see Figure 4.6). As a result, the difference between actual phosphate use and the phosphate application standard decreased from approx. 10 kg per hectare in 2006 to 1 kg per hectare in 2013. Between 2006 and 2013, the phosphate application standards were reduced from an average of 108 kg per hectare to an average of 88 kg per hectare. As a result, the initial difference between actual usage and the level prescribed by the standard was reduced. The lower application standards also resulted in a reduction in the use of inorganic phosphate-containing fertilisers (see Appendix 4, Tables A4.4 and A4.4B).

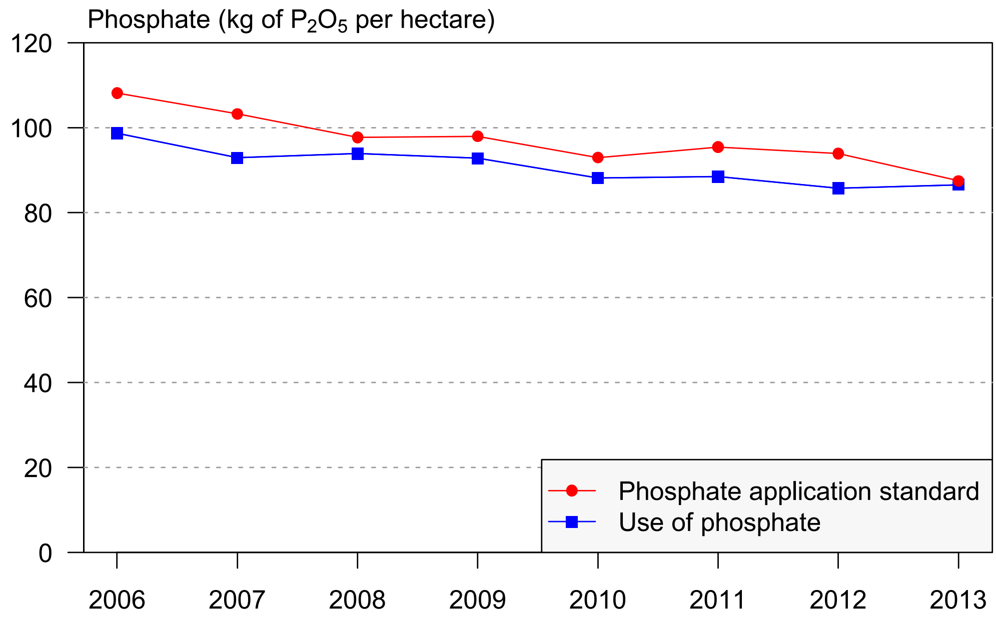

Figure 4.6 Total phosphate application standard (in kg of P_2O_5 per hectare) and use of phosphate in livestock manure and inorganic fertilisers (in kg of P_2O_5 per hectare) during the 2006-2013 period

4.1.4 Crop yields

The average dry-matter yields for grass and silage maize grew slightly in the 2006-2012 period (see Figure 4.7; Appendix 4, Tables A4.5A and A4.5B). However, the dry-matter yields for both crops were 5% lower in 2013 than in 2012. Yields expressed in kilogrammes of nitrogen do not show a clear trend for silage maize, nor for grassland in the period up to and including 2011 (see Figure 4.8; Appendix 4, Tables A4.5A and A4.5B). The nitrogen yield of silage maize in 2013 was normal compared to the average for the preceding years, and the yield for grassland was above average. Yields measured in kilogrammes of phosphate showed little difference from the previous years for silage maize as well as grassland (Figure 4.9; Appendix 4, Tables A4.5A and A4.5B).

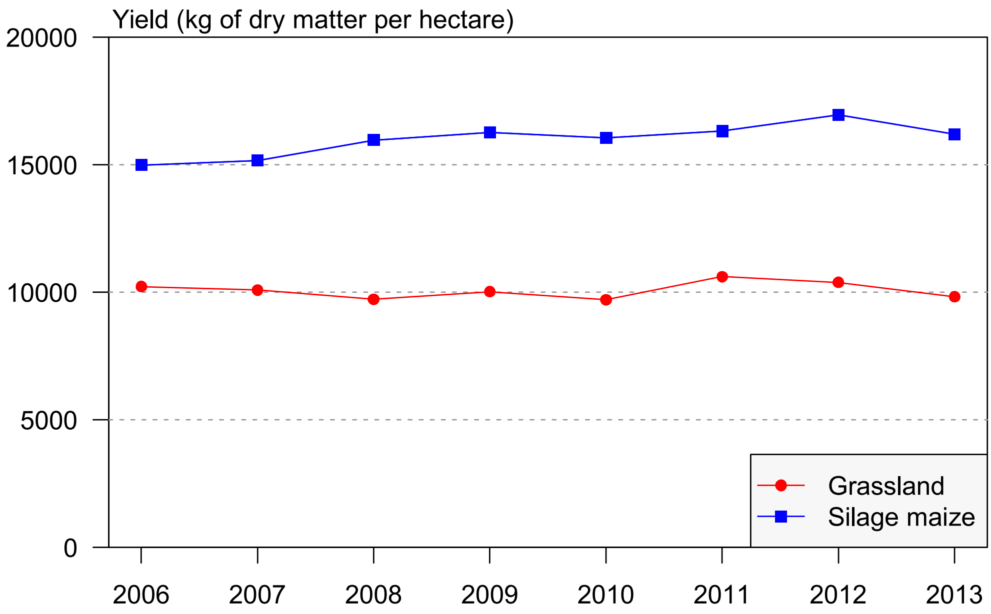

Figure 4.7 Average dry-matter yields for grassland and silage maize on derogation farms in the 2006-2013 period

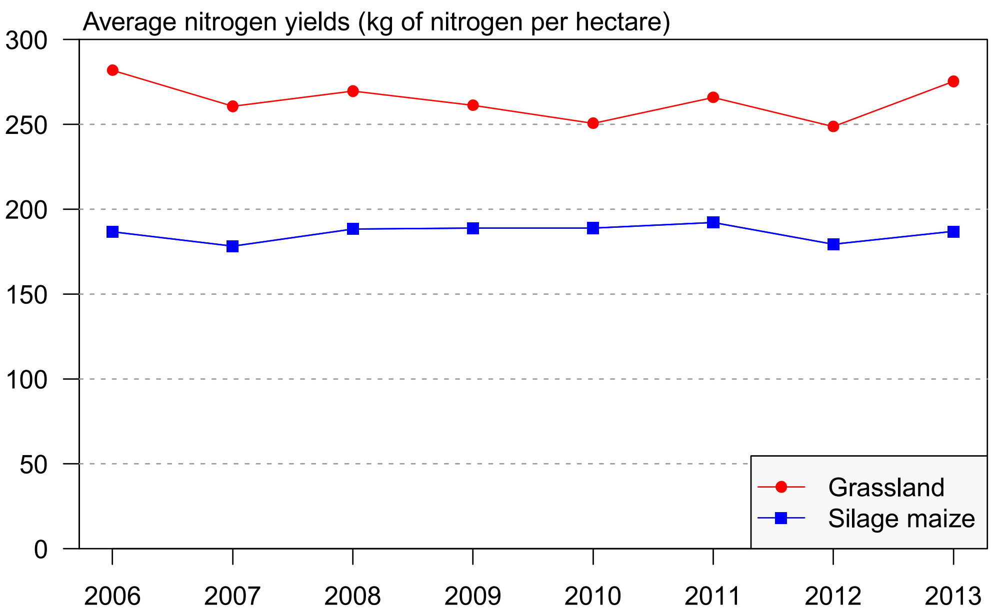

Figure 4.8 Average nitrogen yields (in kg of nitrogen per hectare) for grassland and silage maize on derogation farms in the 2006-2013 period

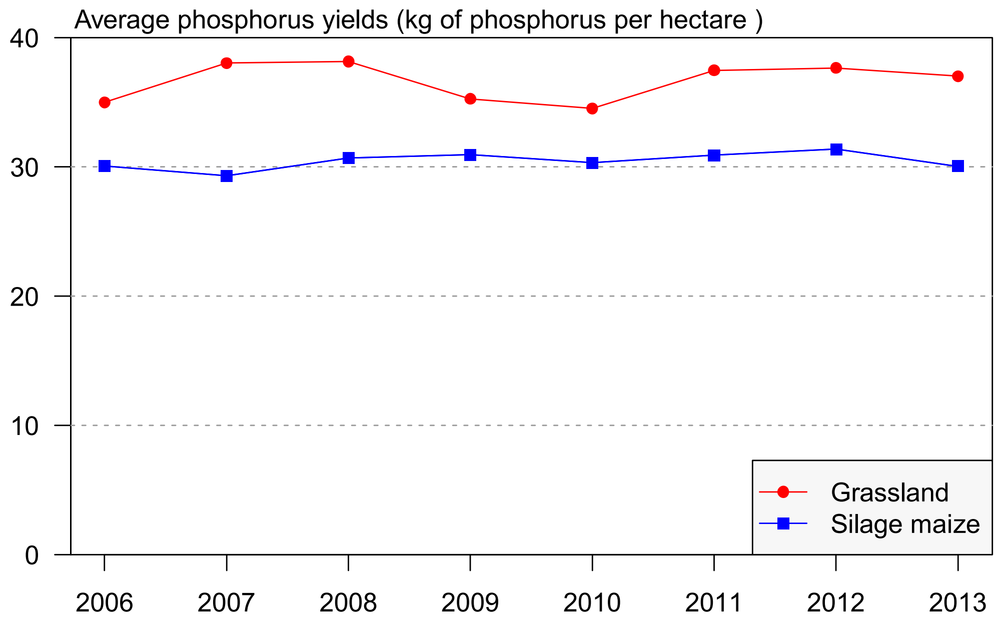

Figure 4.9 Average phosphorus yields (in kg of phosphorus per hectare; 1 kg of phosphorus = 2.29 kg of P_2O_5) for grassland and silage maize on derogation farms in the 2006-2013 period

4.1.5 Nutrient surpluses on the soil surface balance

The average nitrogen surplus on the soil surface balance in 2013 was approx. 5 kg per hectare higher than the average for the 2006-2012 period. This was mainly due to the poor growing season of 2013, which resulted in an increased supply of nitrogen in purchased feed products. No trend change could be observed in the average nitrogen soil surplus during the 2006-2013 period (see Figure 4.10; Appendix 4, Tables A4.6A and A4.6B). The nitrogen surplus on the soil surface balance was consistently higher in the Peat region than in the other regions. This is mainly due to additional mineralisation on peat soils, which has been estimated and included on the supply side of the balance (see Appendix 2, Table A2.3). No clear differences or trends were observable with respect to the different soil type regions during the surveyed period (see Figure 4.11; Appendix 4, Table A4.7A+B).

Other differences in nitrogen soil surpluses may arise as a result of minor adjustments at farm level or because some farms dropped out. As a result, differences in nitrogen soil surpluses of more than 10 kg of nitrogen per hectare per year may arise for small groups of farms like those in the Peat region and Loess region.

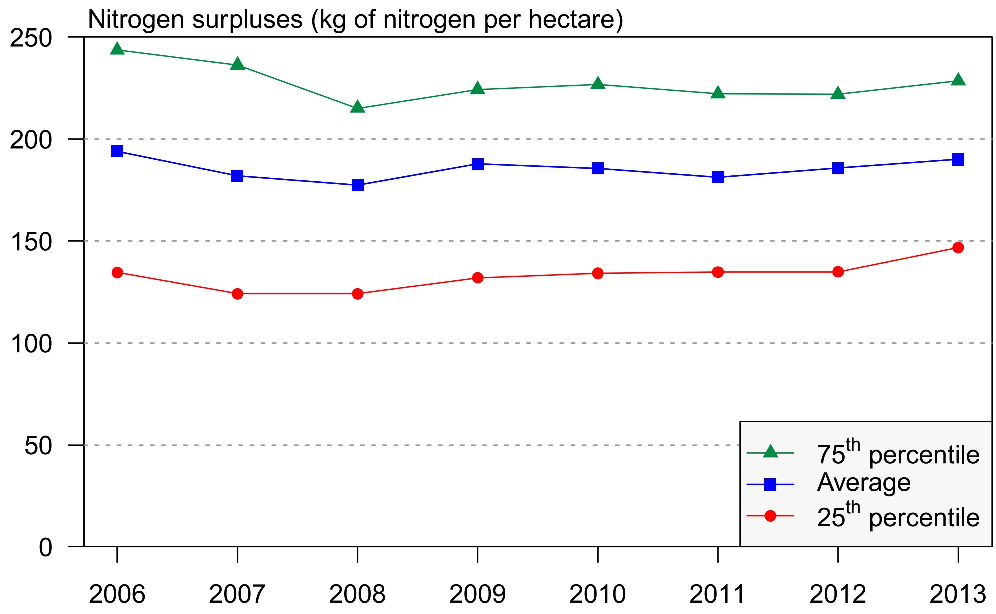

Figure 4.10 Average nitrogen surpluses, nitrogen surpluses on the 25% of derogation farms with the lowest surpluses (first quartile or 25th percentile), and nitrogen surpluses on the 25% of derogation farms with the highest surpluses (third quartile or 75th percentile) during the 2006-2013 period (expressed in kg of nitrogen per hectare)

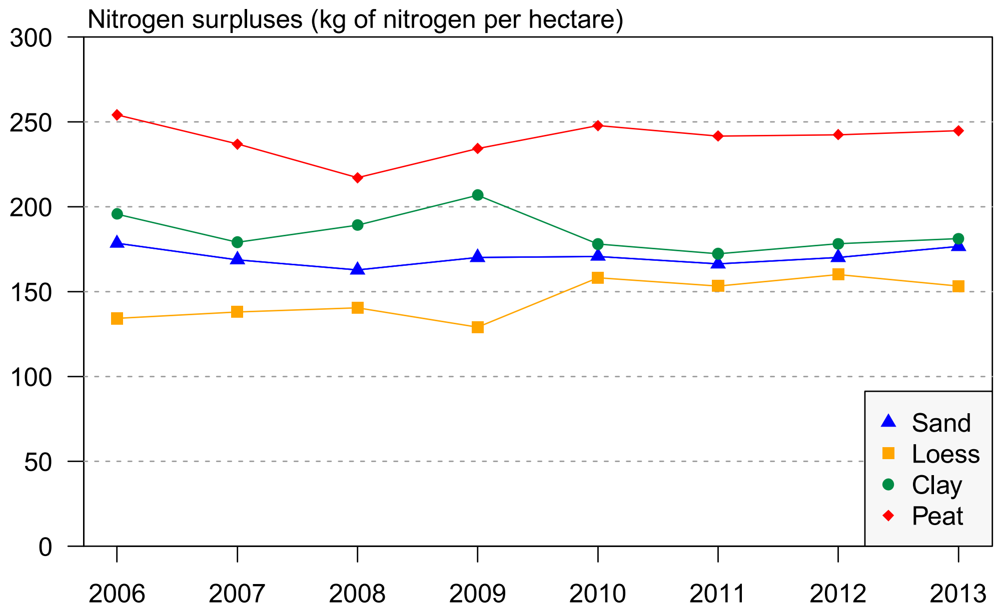

Figure 4.11 Average nitrogen surpluses per region (in kg of nitrogen per hectare) on derogation farms in the 2006-2013 period

In 2013, the phosphate surplus on the soil surface balance was also higher than the average for the 2006-2012 period (Figure 4.12; see also Appendix 4, Tables A4.8A and A4.8B) due to the increased phosphate supply via feed products (Appendix 4, Tables A4.4A, A4.4B, A4.8A, and A4.8B).

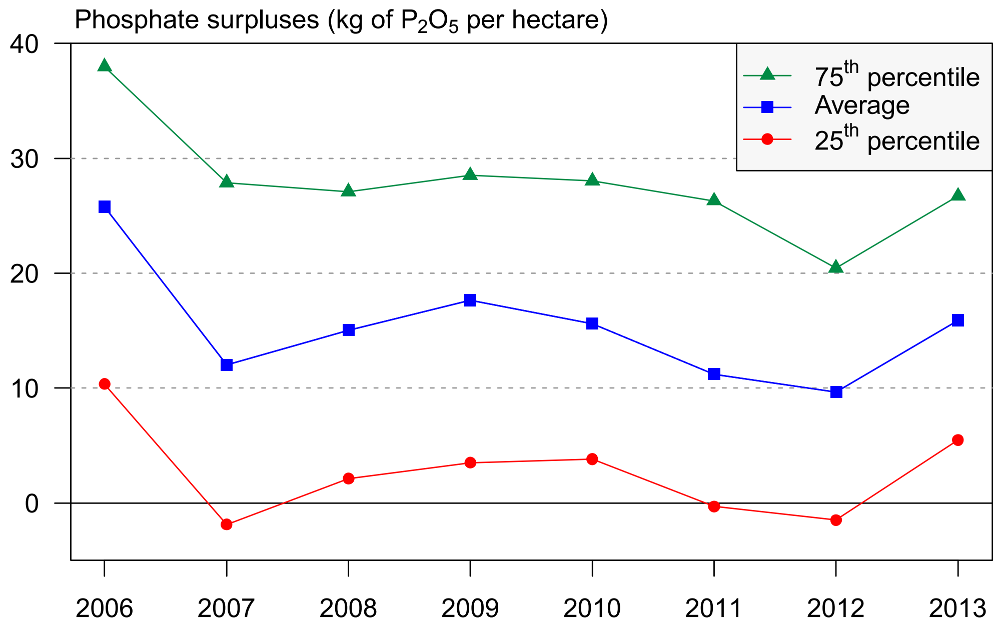

Figure 4.12 Average phosphate surpluses, phosphate surpluses on the 25% of derogation farms with the lowest surpluses (first quartile or 25th percentile), and phosphate surpluses on the 25% of derogation farms with the highest surpluses (third quartile or 75th percentile) in the 2006-2013 period (expressed in kg of P_2O_5 per hectare)

4.2 Development of water quality

4.2.1 Development of average concentrations during the 2007-2014 period

Nitrate concentrations in water leaching from the root zone decreased in all regions except the Loess region (see Figure 4.13; Appendix 4, Tables A4.9A and A4.9B). Nitrate concentrations in 2014 were higher than in the immediately preceding years. In the next few years it will become clear whether this increase is the result of natural fluctuations or an upward trend. Nitrate concentrations in 2014 were at the level of the average for the 2007-2013 period (Appendix 4, Table A4.9B).

The effect of previous years with below-average precipitation was apparent in the 2010 results for the top metre of groundwater. These results revealed higher nitrate concentrations in the Sand region, Clay region and Peat region than in previous and subsequent years.

The average nitrate concentrations were highest in the Loess region, followed by the Sand region, Clay region and Peat region. In the Clay region and Peat region, the average concentrations amounted to less than 50 mg of nitrate per litre in all years (see Figure 4.13). In the Sand region, this has been the case since 2008. The average nitrate concentration in the Loess region only reached the 50 mg/l standard in 2009 and 2010.

The higher nitrate concentrations in the Loess region and Sand region are caused mainly by a higher percentage of soils prone to leaching. These are soils where less denitrification occurs, partly due to lower groundwater levels (Fraters *et al.*, 2007; Boumans and Fraters, 2011).

Ditch water nitrate concentrations also decreased in all regions during the 2007-2014 period (see Figure 4.14; Appendix 4, Tables A4.9A and A4.9B)

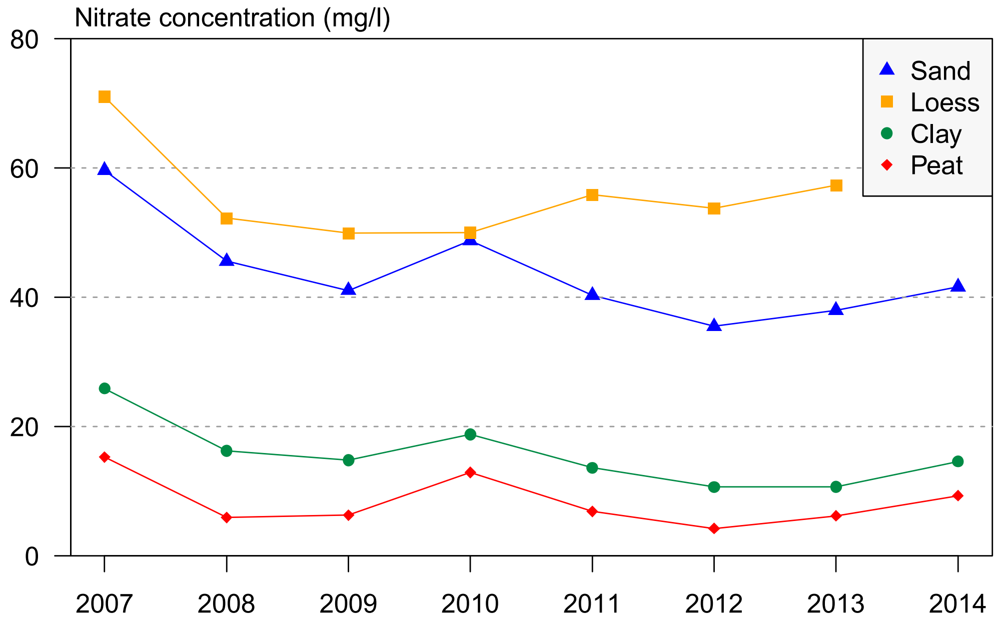

Figure 4.13 Average nitrate concentration in water leaching from the root zone on derogation farms in four regions during the 2007-2014 period

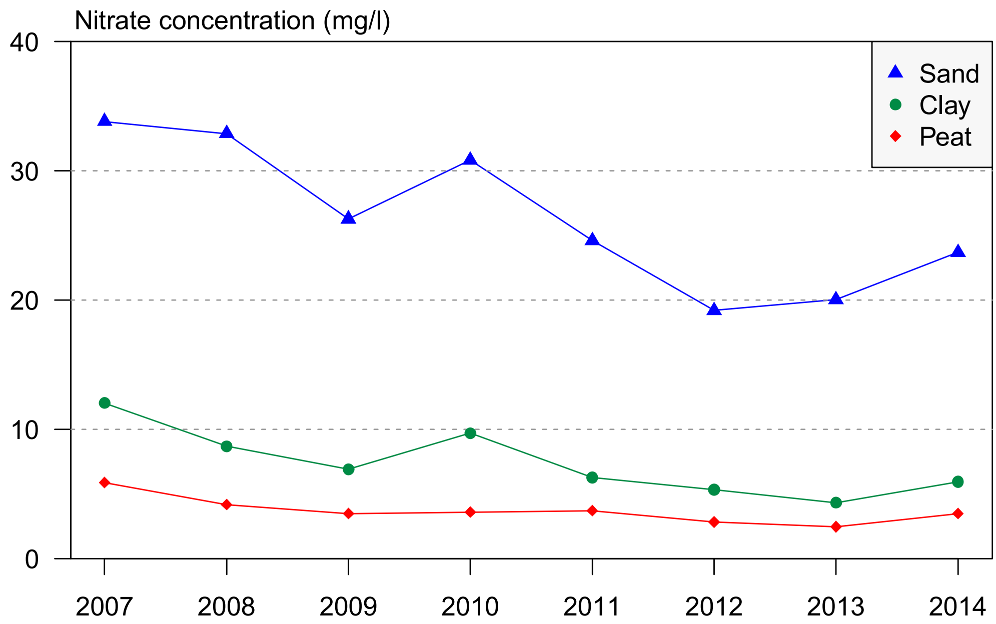

Figure 4.14 Average ditch water nitrate concentration on derogation farms in three regions during the 2007-2014 period

During the measurement period, phosphorus concentrations in water leaching from the root zone decreased in the Clay region and Peat region, and increased in the Sand region but remained very low (Appendix 4, Table A4.9B). During the measurement period, no trend change could be observed in the phosphorus concentrations in the Loess region.

Average nitrogen concentrations decreased everywhere, except in ditch water in the Peat region and in water leaching from the root zone in the Loess region (see Appendix 4, Tables A4.9A and A4.9B). In the Loess region, Peat region and Clay region, the concentrations in the most recent measurement year did not differ significantly from the average for the preceding years. In the Sand region, nitrogen concentrations in water leaching from the root zone were lower.

4.2.2 Effects of environmental factors and sample composition on nitrate concentrations

Nitrate concentrations in water leaching from the root zone are not only affected by agricultural practices, but also by environmental factors. Particularly precipitation and temperature have an effect on crop yields, and consequently also on nitrogen output, soil surpluses and nitrogen leaching. Even if a long-term balance is achieved between the annual supply and decomposition of organic matter, mineralisation and immobilisation will not be perfectly balanced in each year. For instance, nitrate leaching may be significantly affected by the ploughing-up of grassland and grass-maize rotation (Velthof and Hummelink, 2012). As a result, there will be variations in soil surpluses and nitrogen leaching. The final nitrogen concentration is also affected by the precipitation surplus and changes in groundwater levels (Boumans *et al.*, 2005; Fraters *et al.*, 2005; Zwart *et al.*, 2009; Zwart *et al.*, 2010; Zwart *et al.*, 2011). Changes in the composition of the farm sample can also have an effect, since soil types and groundwater levels vary between farms (Boumans *et al.*, 1989).

A statistical method has been developed for the Sand region in order to correct the measured nitrate concentrations for the effects of weather conditions, groundwater levels and changes in the composition of the sample (Boumans and Fraters, 2011). This method uses relative evaporation as a yardstick for the impact of annual fluctuations in the precipitation surplus (see Table 4.1). Nitrate concentrations will rise as evaporation increases and groundwater levels decrease, provided other factors do not change. Refer to Hooijboer *et al.* (2013, Appendix 6) for a further explanation of the statistical method used. This method does not take all processes into consideration and is based only on correlations.

If this method is applied, we find that the average corrected nitrate concentrations in the Sand region decreased from approx. 60 mg/l in 2007 to approx. 39 mg/l in 2014, a reduction of approx. 20 mg/l (see Table 4.1 and Figure 4.15). Since 2009, both the measured and the corrected nitrate concentrations have been below the nitrate standard. Over the entire measurement period, measured and corrected nitrate concentrations in the Sand region have displayed a downward trend. This decrease mainly occurred in the early period of the derogation monitoring network. The nitrate concentrations corrected for weather conditions and sample composition have fluctuated around 40 mg/l in the past few years.

Table 4.1 Average nitrate concentrations (in mg/l) in water leaching from the root zone in the Sand region, measured and corrected for weather conditions, including average relative evaporation and groundwater levels

Year	Number of farms	Relative evaporation	Ground water level[1]	Measured nitrate concentration	Corrected nitrate concentration
2007	141	1.3	137	60	60
2008	141	0.9	146	46	54
2009	142	1.0	161	41	46
2010	143	1.4	147	49	44
2011	142	1.3	149	40	39
2012	147	1.0	144	36	41
2013	151	1.0	153	38	41
2014	152	1.3	146	42	39

[1] Average groundwater level in centimetres below surface level

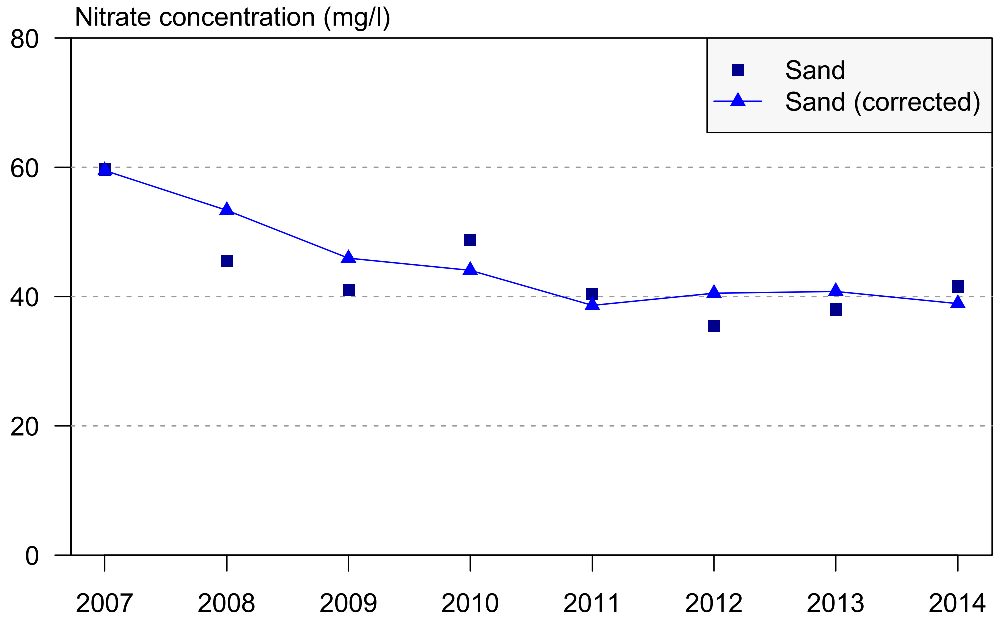

Figure 4.15 Development of uncorrected and corrected nitrate concentrations in water leaching from the root zone in the Sand region in successive measurement years

With respect to nitrate concentrations in water leaching from the root zone in the Clay region, no clear link has been found with the precipitation surplus using the correction method originally developed for the Sand region. The fact that drain water or groundwater samples are taken in the Clay region is a complicating factor. This means that no corrected concentration data can be provided. In addition, such a correction cannot be performed (yet) in the Peat region or the Loess region.

4.3 Effects of agricultural practices on water quality

Nitrogen

The nitrogen soil surpluses in each region did not change during the measurement period, although the nitrate concentrations in water leaching from the root zone did decrease during the entire measurement period. However, that decrease occurred mainly in the period up to and including 2011. As the nitrogen soil surplus did not decrease even in the 2006-2011 period, there must be other causes for the declining nitrate concentrations.

One possible explanation is a decrease in grazing during the measurement period. The trend in dairy farming points to a steady increase in scale and intensification of milk production per hectare. In addition, more and more farmers are opting to keep their dairy cows in stables full-time, resulting in a decreasing proportion of farms with grazing dairy cows (see Figure 4.3 and section 4.1.1). This trend in grazing may partly explain the decreasing nitrate concentrations in the Sand region (Boumans and Fraters, 2011). It is noteworthy that the decrease in nitrate concentrations as well as the decrease in grazing occurred during the 2006-2011 period. After this period, both parameters stabilised. The percentage of dairy farms where dairy cows are kept in stables during the September-October period has shown a notable increase, from 13% in 2006 to 24% in 2013. The risk of nitrate leaching is particularly high in autumn due to the higher precipitation surplus and lower nitrogen absorption by crops.

After-effects may offer another explanation for decreasing nitrate concentrations when the soil surplus remains the same. The soil surplus is based on a balance between input and output. Further nitrogen input from the soil is not included in the soil surplus. Because after-effects can remain noticeable for up to four years (Verloop, 2013), they are expected to occur only at the start of the measurement period. After-effects therefore offer a possible explanation for the decrease in nitrate concentrations during that period.

Phosphate

The phosphate surplus on the soil surface balance displayed a downward trend during the entire measurement period. The phosphorus concentrations in water leaching from the root zone in the Clay region and the Peat region also displayed a significant downward trend. It is unclear if this is caused by decreasing phosphate surpluses.

The link between the decreasing phosphate soil surplus and the phosphorus concentrations is unclear because phosphate bonds strongly to the soil, so that any changes in the phosphate surplus have less effect on phosphorus concentrations. Changes in groundwater levels and increased surface run-off may also affect phosphorus concentrations in water leaching from the root zone and in ditch water.

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Appendix 1 Selection and recruitment of participants in the derogation monitoring network

A1.1 Introduction

This appendix explains the selection and recruitment of the 300 dairy and other grassland farms participating in the derogation monitoring network. As stated in the main text, the derogation monitoring network has been incorporated into the Minerals Policy Monitoring Programme (*Landelijk Meetnet effecten Mestbeleid*, LMM). The selection and recruitment of farms for the derogation monitoring network is comparable to the selection and recruitment of participants in other parts of the LMM programme. Based on the most recent Agricultural Census data at the time (2005), a sample population was defined for each of the four regions. These sample populations were then subdivided into groups of farms (‘strata’) belonging to the same groundwater body and of the same farm type and economic size. Based on this distribution, the required number of sampled farms was derived for each stratum, taking into account the proportion of the total surface area of cultivated land in a given stratum (the greater the proportion of cultivated land in a stratum, the larger the number of farms to be included in the sample), as well as a minimum representation for each groundwater body.

Recruitment was initially targeted at farms participating in the Farm Accountancy Data Network (FADN; reporting year 2006). All suitable FADN farms that had registered for derogation in 2006 were approached. After the FADN farms had been recruited, it was determined which strata required additional farms. Additional farms were selected from a database maintained by the National Service for the Implementation of Regulations of the Ministry of Agriculture, Nature & Food Quality. This database included all farms that registered for derogation in 2006. Fifteen of the additional participants thus selected also participate in the ‘Koeien & Kansen’ research project (see www.koeienenkansen.nl).

Replacements for farms that dropped out during the 2006-2013 period were preferably selected from farms that already participated in the LMM programme and the FADN network. The advantage of this approach is that water quality samples and/or agricultural practice data from previous years are also available for farms newly admitted to the derogation monitoring network.

A1.2 Definition of the sample populations

As with the LMM programme, the sample excludes a small number of farms that had registered for derogation and were included in the Agricultural Census database. The first group of farms excluded from participation in the derogation monitoring network comprises very small farms with an economic size of less than 25,000 Standard Output (SO) units. Farms using organic production methods were also excluded. By definition, these organic farms may not use more than 170 kg of nitrogen from livestock manure per hectare (irrespective of the

percentage of grassland or the type of fertiliser). Also, a minimum farm size of 10 hectares of cultivated land was adopted to ensure representativeness with respect to surface area. Finally, only farms where grassland makes up at least 60% of the total area of cultivated land were included in the selection for derogation monitoring purposes. We have opted for a selection requirement that falls short of the 70% minimum prescribed by law because RVO.nl and LEI use different operational methods and definitions when registering farm data. Due to these discrepancies, the FADN grassland percentages may differ from the data registered by RVO.nl. In addition, farmers may adjust the grassland percentage on their farms from year to year, so that the percentage may exceed 70% in a later year.
The consequences of these selection criteria are illustrated in Tables A1.1 and A1.2. Table A1.1 (farms) and Table A1.2 (acreages) specify how the sample population has been derived from the 2013 Agricultural Census data and a database maintained by RVO.nl. This database contains over 20,900 so-called 'BRS numbers' of farms that registered for derogation for 2013. BRS numbers are the registration numbers of farms registered with RVO.nl. As 445 BRS numbers did not appear in the 2013 Agricultural Census, it was decided not to include absolute numbers of farms and hectares in the tables. Instead, the numbers of excluded farms and hectares of cultivated land are expressed as a percentage of the nearly 21,000 farms for which data were available in the 2013 Agricultural Census.

Table A1.1 Proportion of dairy and other grassland farms (in percentages) represented in the sample population of the derogation monitoring network in 2013

	Distribution of farms		
	Dairy farms	*Other grassland farms*	*Total*
All farms registered for derogation in 2013	72%	28%	100.0%
Farms smaller than 25,000 SO units	0.1%	10.0%	10.1%
Organic farms	0.2%	0.2%	0.4%
Farms smaller than 10 hectares	0.7%	1.6%	2.3%
Farms where grassland makes up less than 60% of cultivated land	0.2%	0.1%	0.2%
Sample population	71%	16%	87%

Source: Statistics Netherlands Agricultural Census 2013, data processed by LEI

Table A1.2 Proportion of cultivated land (in percentages) on dairy and other grassland farms represented in the sample population of the derogation monitoring network in 2013

	Distribution of acreage of cultivated land		
	Dairy farms	*Other grassland farms*	*Total*
All farms registered for derogation in 2013	87%	13%	100.0%
Farms smaller than 25,000 SO units	0.0%	1.7%	1.7%
Organic farms	0.3%	0.1%	0.4%
Farms smaller than 10 hectares	0.1%	0.3%	0.4%
Farms where grassland makes up less than 60% of cultivated land	0.1%	0.1%	0.2%
Sample population	86%	11%	97%

Source: Statistics Netherlands Agricultural Census 2013, data processed by LEI

Tables A1.1 and A1.2 show that specialised dairy farms account for 72% of all farms that registered for the 2013 derogation scheme, and account for 87% of the total acreage of cultivated land. Almost all dairy farms also met the selection criteria used to define the sample population for the derogation monitoring network. The excluded farms are mainly other grassland farms with a small economic size (as expressed in SO units) and a small area of cultivated land. Under the adopted selection criteria, 13% of all farms registered for derogation are excluded from the sample population. However, these farms account for just 2.8% of the total acreage for which farmers have requested derogation.

A1.3 Notes on individual stratification variables

The derogation decision calls for a monitoring network that is representative of all soil types, fertilisation practices and crop rotations (see Article 8 of the derogation decision). When the derogation monitoring network was designed, the stratification was therefore based on region, as well as farm type, economic size (size class) and groundwater body. With effect from 2012, stratification based on groundwater body was replaced by stratification based on district. These stratification variables are explained below.

A1.4 Classification according to farm type

Since 2011, the LMM programme has used Standard Output (SO) units as a measure of the economic size of farms. This unit replaces the previously used Dutch Size Unit (*Nederlandse Grootte-Eenheid*, NGE) (Van der Veen *et al.*, 2012). The Standard Output of a crop, animal product or other agricultural product is its average monetary value based on the prices received by the agricultural entrepreneur, expressed in euros per hectare or animal. A regional SO coefficient for each product has been defined as the average value during a specific reference period (five years). The Netherlands is regarded as a single region for this purpose. The total Standard Output of a farm (i.e. the

sum of all SOs per hectare of cultivated crops and per animal) is a measure of its total economic size, expressed in euros.
A farm is characterised as 'specialised' when a particular agricultural activity (e.g. dairy farming, arable farming or pig farming) accounts for a significant proportion (often at least two-thirds) of its total economic size. Eight main farm types can be distinguished. Five of these types concern one single activity, while three types concern a combination of activities. The five single-activity farm types are: arable farming, horticulture, permanent crops (fruit growing and tree nurseries), grazing livestock, and intensive livestock farming. The three combined-activity farm types are: crop combinations, livestock combinations, and crop-and-livestock combinations. Each main farm type is further divided into a number of subtypes. For instance, the subcategory of specialised dairy farms is part of the overall category of grazing livestock farms.

Within the group of farms that registered for derogation, dairy farms form a large and homogeneous group, which uses almost 87% of the total acreage of cultivated land, as is apparent from Table A1.2. Thirteen percent of the acreage is situated on farms of a different type. These farms were also included in the monitoring network in order to obtain a sample with maximum representativeness for the different crop rotations and fertilisation practices. Non-dairy farms account for approx. 28% of the total number of farms (see Table A1.1). These farms can be of various types, but are described in this report as 'Other grassland farms', as most of the cultivated land consists of grassland.

A1.5 Classification according to economic size

Farms are not only classified by type but also according to economic size, with four size classes being distinguished. This prevents over-representation of farms of below-average or above-average economic size. Economic size is also expressed in SO units.

A1.6 Classification according to soil type region and district

The Netherlands has been divided into four soil type regions as part of the Minerals Policy Monitoring Programme. The regions are further subdivided into a number of districts. Fourteen districts were defined in total, based on four-digit postcode districts. The participants in the derogation monitoring network have been selected with a view to achieving optimal distribution and representation in each region, in order to cover the most important districts in terms of the area of cultivated land.

In the Sand region, seven districts were distinguished: Reclaimed moor ditrict, Northern sand district I, Northern sand district II, Eastern sand district, Central sand district, Southern sand district, and Dunes and islands. The Loess region has no further districts. The Peat region is divided into two districts: Northern peat district and Western peat district. The Clay region is divided into four districts: Northern marine clay district, Polder marine clay district, Southwestern marine clay district, and River clay district (see Figure A1.1).

Figure A1.1 Soil type regions and districts in the Minerals Policy Monitoring Programme (LMM)

In the 2006-2013 period, stratification within the regions was based on groundwater body (Verhagen *et al.*, 2006). In this period, geographical stratifications (e.g. according to groundwater body) were still based on municipal boundaries. The transition to stratification according to districts coincided with the transition from classification based on municipal boundaries to a (more accurate and stable) classification of regions and districts based on postcode districts (from FADN 2013 onward).

The Water Framework Directive distinguishes a total of twenty groundwater bodies in the Netherlands (Verhagen *et al.*, 2006). The derogation monitoring network has been designed with a view to achieving optimal distribution and representativeness in each region, in order to cover the most important groundwater bodies measured in terms of the area of cultivated land. Each farm was assigned to a groundwater body based on the municipality where the farm receives post. In municipalities with multiple groundwater bodies, all farms were assigned to the largest groundwater body.

In the Sand region, five groundwater bodies were distinguished as sub-regions: Eems, Maas, Rhine Central, Rhine North, and Rhine East. Other farms belonging to other groundwater bodies within the region were assigned to a sixth sub-region termed 'Other'. The Loess region only contains the 'Cretaceous' groundwater body, and was therefore not subjected to further subdivision. The Peat region was divided into four sub-regions, namely the groundwater bodies Rhine North, Rhine East, Rhine West, and 'Other'. The Clay region was divided into five sub-regions. The entire marine clay area in the south-west of the Netherlands was classified as a separate district because it includes multiple groundwater bodies without one body being clearly dominant. Three other groundwater bodies were distinguished as separate sub-regions: Eems, Rhine North and Rhine West (in so far as the latter is located outside the marine clay area in the south-west of the Netherlands). The fifth sub-region includes farms in other, unallocated municipalities.

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Agricultural Census data on Statistics Netherlands website: http://statline.cbs.nl
Koeien & Kansen website: http://www.koeienenkansen.nl

Appendix 2 Monitoring of agricultural characteristics

This appendix explains how the agricultural practice data in the FADN network maintained by the Agricultural Economics Research Institute (LEI) were monitored, and how these data were used to calculate fertiliser usage (section A2.2), grass and silage maize yields (section A2.3), and nutrient surpluses (section A2.4).

A2.1 Introduction

LEI is responsible for monitoring the agricultural practice data registered in the FADN network. It does so on the basis of a stratified sample of approx. 1500 farms and horticultural enterprises, maintaining a set of detailed financial, economic and environmental data. The FADN represents nearly 95% of total agricultural production in the Netherlands (Poppe, 2004; FADN, 2013). Approx. 45 full-time LEI employees are tasked with collecting and registering farm data in FADN. They process all the invoices of the participating farms. They also produce inventories of initial and final stocks and gather additional data on crop rotations, grazing systems, and the composition of the livestock population. LEI sends participants a so-called ‘participant’s report’ containing mainly annual totals (e.g. a profit-and-loss account and balance sheet). When data are processed to produce information for participants or researchers, the results are of course checked for inconsistencies. This is possible because the system also records physical flows in addition to financial flows.

Most FADN data are converted into annual totals, which are then corrected for stock mutations. For example, the annual consumption of feed concentrate is derived from the sum of all purchases made during the period between two balance sheet dates, minus all sales, plus initial stocks, minus final stocks. Fertiliser usage is registered for each crop, and the data allow for calculations of usage per year and per growing season. The growing season extends from the harvesting of the previous crop to the harvesting of the current crop.

Fertiliser usage, yields and nutrient surpluses are expressed per unit of surface area. The total acreage of cultivated land in the Netherlands is used for this purpose, i.e. the land actually fertilised and used for crop cultivation on the farm. This acreage does not include rented land, nature areas, ditches, built-up land, paved surfaces, and grassland not used for the production of fodder (e.g. yards, camping sites).

A2.2 Calculation of fertiliser usage

The derogation decision (EU, 2005) stipulates that the report should include details of fertiliser usage and crop yields (Article 10, paragraph 4). This Article states (see section 1.3): “In order to provide elements regarding management in grassland farms, for which a derogation applies, and the achieved level of optimisation of management, a report on fertilisation and yield shall be prepared annually for the different soil types and crops by the competent authority and submitted to the Commission.”

Nutrient usage data are presented by region (Clay region, Peat region, Sand region and Loess region). Fertiliser use at farm level is reported, and a distinction is made between the use of fertilisers on arable land and on grassland.

A2.2.1 Calculation of fertiliser use

On-farm use of livestock manure
In order to calculate the use of nutrients in livestock manure, on-farm production of manure is calculated first. In the case of nitrogen, this concerns net production after deducting gaseous emissions resulting from stabling and storage. Manure production by grazing livestock is calculated by multiplying the average number of animals present by the applicable statutory excretion standards (National Service for the Implementation of Regulations, 2013, Tables 4 and 6). This method does not apply to farms that use the guidance document issued for this purpose (see the section below headed 'Farm-specific use of livestock manure'). Calculations of manure production by intensive livestock are based on two different sources: the nitrogen quantities on the standards prescribed by law and the phosphate quantities as reported by the Working Group on Uniform Mineral and Manure Excretions (WUM).

In addition, the quantities are registered for all fertiliser inputs and outputs and all fertiliser stocks (inorganic fertilisers, livestock manure and other organic fertilisers). The nitrogen and phosphate quantities in inorganic fertilisers and other organic fertilisers are derived from the annual overviews of suppliers. If no specific delivery details are known, the quantities are multiplied by factors derived from a standard composition (Nutrient Management Institute, 2013).

In principle, the nitrogen and phosphate quantities in inputs and outputs of organic fertilisers are determined by means of sampling. If sampling has not been performed, standard contents for each type of fertiliser are used (National Service for the Implementation of Regulations, 2013, Table 5). If no sampling results are available, the output of on-farm manure is calculated based on the farm-specific mineral content per cubic metre of manure, provided the relevant farm uses the Farm-Specific Excretion (BEX) method or the stable balance method. Standard quantities are used for the other farms.

The total quantity of fertiliser used at farm level is then calculated using the following formula:

Quantity of fertiliser used on farm = Production + Opening stock level – Closing stock level + Input – Output

Farm-specific use of livestock manure
As of agricultural practice year 2007, the calculation method for manure production has been modified for farms that make use of the guidance document on farm-specific excretion by dairy cattle (Ministry of Agriculture, Nature & Food Quality, 2010). Manure production on these farms is not calculated on the basis of standard quantities but separately for each farm, provided the following criteria are fulfilled:

- The farm is a specialised dairy farm according to the Standard Output classification.
- The dairy herd accounts for at least 67% of the total quantity of phosphate LSUs for grazing livestock.
- No pigs or poultry are present on the farm.
- The farm itself has reported that it uses the BEX method.

As of 1 January 2009, the guidance document on farm-specific excretion by dairy cattle is used to calculate the farm-specific excretion of the dairy herd (Ministry of Agriculture, Nature & Food Quality, 2010). The calculation method used deviates from the guidance document in two respects (Ministry of Agriculture, Nature & Food Quality, 2010):

- The uptake from silage maize expressed in fodder units (*Voedereenheden Melkvee*, VEM) is derived directly from the silage maize yields reported by the farmer, corrected for stocks (the same method used in Aarts *et al.*, 2008). In the guidance document, the uptake is calculated using a correction method.
- The allocation of fodder units to fresh and conserved grass is calculated based on the net number of grazing hours reported by the farmer, whereas the guidance document (Ministry of Agriculture, Nature & Food Quality, 2010) and Aarts *et al.* (2008) define three classes based on reported grazing hours.

Use of fertilisers on arable land and grassland
The quantities of fertilisers used on arable land are registered directly in the Farm Accountancy Data Network (FADN). The type of fertiliser, the quantities applied, and the time of application are all documented.
The quantities of nitrogen and phosphate applied on arable land are calculated by multiplying the quantity of manure (in tonnes or cubic metres) by:

- the contents derived from sampling results (if available), or
- the farm-specific mineral content if the manure production is calculated separately for each farm (see below), or, if this is not the case,
- the applicable standard contents (National Service for the Implementation of Regulations, 2013, Table 5).

The quantity of fertiliser applied on grassland is calculated as the closing entry: Fertiliser use on grassland = Fertiliser use at farm level -/- Fertiliser use on arable land. In the case of farms where grassland accounts for less than 25% of the total cultivated area[3], fertiliser use on grassland is calculated based on allocations, and the fertiliser use on arable land is calculated as the closing entry. The quantity of fertiliser used on grassland comprises spread fertilisers and manure excreted directly by grazing animals on grassland (grassland manure). The quantity of nutrients in grassland manure is calculated for each animal category by multiplying the calculated excretion by the percentage of the year that the animals spend grazing.

[3] Not relevant for this report, as farms must be comprised of at least 70% grassland to qualify for participation in the derogation scheme.

Use of plant-available nitrogen
The total nitrogen use is expressed in kilogrammes of plant-available nitrogen. The quantity of plant-available nitrogen is calculated by multiplying the total quantity of nitrogen in organic fertilisers by the availability coefficients as stated in Table 3 (National Service for the Implementation of Regulations, 2013, Table 3). The quantity of nitrogen from inorganic fertilisers with an availability coefficient of 100% is added to the outcome.

If dairy cows graze on the farm, the availability coefficient is lower (45% instead of 60% since 2008) for all grazing livestock manure produced and applied on the farm. A lower statutory availability coefficient is used if arable land on clay and peat soils is fertilised in autumn using solid manure. In all other cases, the availability coefficient depends solely on the type of fertiliser or manure.

Phosphate use
Phosphate use is expressed in kilogrammes of phosphate. All fertilisers (inorganic fertilisers, livestock manure and other organic fertilisers) are included in the calculation.

Application standards
The average application standards for grassland and arable land are calculated by multiplying the crop areas registered in FADN by the application standards stated in Tables 1 and 2 (National Service for the Implementation of Regulations, 2013, Tables 1 and 2). Phosphate differentiation has been applicable since 2010 (depending on the phosphate status of the soil). Soil test results are registered in FADN in order to determine the phosphate status of the soil. If the phosphate status is unknown, a high phosphate status is assumed by default.

A2.2.2 Lower and upper limits
On LMM farms, fertilisation with inorganic fertilisers, livestock manure and other organic fertilisers must fall within the LMM confidence intervals in order to eliminate any data registration errors. This applies to the separate nitrogen and phosphate quantities, as well as the total quantities of fertilisers applied (i.e. inorganic fertilisers, livestock manure, and other organic fertilisers). Table A2.1 lists the confidence intervals for non-organic dairy farms.

Table A2.1 Lower and upper limits for applied quantities of inorganic fertilisers, livestock manure and other organic fertilisers on non-organic dairy farms, and total quantities of fertilisers applied (inorganic fertilisers, livestock manure and other organic fertilisers), expressed in kilogrammes of nitrogen and phosphate per hectare[1, 2]

Nutrient and type	*Lower or upper limit*	*Kg per hectare*
Nitrogen		
Inorganic fertilisers	Lower limit	0
Inorganic fertilisers	Upper limit	400
Livestock manure	Lower limit	0
Livestock manure	Upper limit	500
Other organic fertilisers	Lower limit	0
Other organic fertilisers	Upper limit	400
Total fertiliser use	Lower limit	50
Total fertiliser use	Upper limit	700
Phosphate		
Inorganic fertilisers	Lower limit	0
Inorganic fertilisers	Upper limit	160
Livestock manure	Lower limit	0
Livestock manure	Upper limit	250
Other organic fertilisers	Lower limit	0
Other organic fertilisers	Upper limit	200
Total fertiliser use	Lower limit	25
Total fertiliser use	Upper limit	350

[1] If a value falls outside the upper and lower limits listed in Table A2.1, the nutrient flows of the relevant farm are considered incomplete and the farm is not included in the calculation of nutrient flows.
[2] This table only states the lower and upper limits for fertiliser use at farm level on non-organic dairy farms. Other limits are applicable to other types of farms. Lower and upper limits are also applicable to other quantities and indicators.

A2.3 Calculation of grass and silage maize yields

A2.3.1 Calculation procedure

The calculation procedure for determining grass and silage maize yields in FADN is largely identical to the procedure described in Aarts *et al.* (2005, 2008). First, the energy requirement of the dairy herd is determined based on milk production and growth achieved. All transactions and stock changes of feed products are registered in FADN. These data are used to determine the proportion of the energy requirement covered by purchased feedstuffs. The energy uptake from farm-produced silage maize and other fodder crops (other than grass) is then determined based on measurements and content data for silage supplies, insofar as these are available. The silage maize yield is determined by adding conservation losses to the ensilaged quantity of silage maize. If no reliable silage supply measurements can be obtained, the farmer and/or a consultant is asked to provide an estimate of the yields of farm-produced silage maize and other fodder crops.

It is then assumed that the remaining energy requirement is covered by grass produced on the farm. The number of grazing days registered in FADN is used to calculate a ratio between the energy uptake from fresh grass and the uptake from conserved grass. This procedure can be used to determine the quantity of energy (expressed in fodder units) obtained by the animals from farm-produced feed. The nitrogen (N) and phosphate (P) uptake are then calculated by multiplying the uptake in fodder units (VEMs) by the N:VEM and P:VEM ratios. Finally, the N, P, kVEM and dry-matter yields (in kilogrammes) for grassland are calculated by adding to the uptake the average quantities of N, P, kVEMs and dry matter lost during feed production and conservation.

A2.3.2 *Selection criteria*

The above calculation procedure cannot be applied to all farms. On mixed farms, it is often difficult to clearly separate the product flows between different production units. In accordance with Aarts *et al.* (2008), the method is therefore only used on farms that satisfy the following criteria:

- The farm is a specialised dairy farm according to the Standard Output classification.
- The dairy herd accounts for at least 67% of the total quantity of phosphate LSUs for grazing livestock.
- No pigs or poultry are present on the farm.

The following selection criteria for application of the method were <u>not</u> adopted from Aarts *et al.* (2008):

- At least 15 hectares used for cultivation of fodder crops
- At least 30 dairy cows
- Annual milk production of at least 4500 kg of Fat and Protein Corrected Milk (FPCM) per cow

These criteria were not considered because they were used in Aarts *et al.* (2008) to make statements about the population of 'typical' dairy farms. These criteria can be ignored because the population details have already been registered in the permanent derogation monitoring network (comprising 300 farms). In line with Aarts *et al.* (2008), the following additional confidence intervals for yields were applied with respect to the outcomes:

- Silage maize yield of 5,000 to 22,000 kg of dry matter per hectare
- Grassland yield of 4,000 to 20,000 kg of dry matter per hectare

If the yield falls outside this range, it is assumed that this must be caused by a book-keeping error. In that case, the grass and silage maize yields of the farms concerned are also excluded from the report.

A2.3.3 *Deviations from Aarts et al. (2008)*

In a few cases, we deviated from the procedure described in Aarts *et al.* (2005, 2008) because more detailed information was available, or because the procedure could not be properly incorporated into the LMM model. This concerns the following data:

1. Composition of silage grass and silage maize pits
2. Supplement for grazing based on actual number of grazing days
3. Ratio of conserved grass to fresh grass, based on the actual number of grazing days
4. Conservation and feed production losses

Re 1

Aarts *et al.* (2008) base the composition of silage grass and silage maize pits on provincial averages supplied by the Netherlands Laboratory for Soil and Crop Research (BLGG). A slightly different method is used in the FADN network. Since 2006, the composition of silage grass and silage maize pits per farm is also registered in FADN. The FADN calculation procedure uses these farm-specific composition data if at least 80% of all silage pits have been fully sampled. The average pit composition for each soil type is used if less than 80% of pits have been sampled and/or if data are missing (i.e. dry-matter yields, VEM uptake, nitrogen or phosphate content). Data on average silage grass and silage maize pit composition are obtained annually from BLGG.

Re 2
A so-called 'mobility factor' is taken into account when calculating the energy requirement. This factor depends on the number of grazing days, among other things. Aarts *et al.* (2008) distinguish three grazing categories: no grazing (0 grazing days), fewer than 138 grazing days, and more than 138 grazing days. The numbers of grazing days have been registered in FADN since 2004 and it was decided to use these data for the calculation, in accordance with Appendix 2 to the guidance document (Ministry of Agriculture, Nature & Food Quality, 2010).

Re 3
Deviating from Aarts *et al.* (2008), the ratio of energy uptake from fresh grass vs. uptake from silage grass was calculated based on the number of grazing days and/or 'zero grazing' days registered in FADN. The percentage of fresh grass varies between 0 and 35% for zero grazing, between 0 and 40% for unlimited grazing, and between 0 and 20% for limited grazing. This calculation is also performed in accordance with the method described in Appendix 2 to the guidance document (Ministry of Agriculture, Nature & Food Quality, 2009).

Re 4
The information in Appendix III in Aarts *et al.* (2008) is not complete with respect to the percentages adopted for conservation losses. To avoid any misunderstandings, all percentages used in FADN to calculate conservation and feed production losses are stated in Table A2.2.

Table A2.2 Percentages used to calculate conservation losses and feed production losses[1]

	Conservation losses				*Feed production losses*
Category	*Dry matter*	*VEM*	*N*	*P*	*Dry matter, VEM, N and P*
Wet by-products	4	6	1.5	0	2
Additional roughage consumed	10	9.5	2	0	5
Feed concentrate	0	0	0	0	2
Milk products	0	0	0	0	2
Silage maize	4	4	1	0	5
Silage grass	10	15	3	0	5
Meadow grass	0	0	0	0	0
Minerals	0	0	0	0	2

[1] The percentage for conservation losses is a percentage of the quantity supplied to or in the feed storage facility. The percentage for feed production losses is a percentage of the same quantities after deducting the conservation losses, i.e. 100 kg (dry matter) of silage grass in the silage pit corresponds to 90 kg of dry matter after conservation and 85.5 kg of dry matter consumed by the animal.

A2.4 Calculation of nutrient surpluses

In addition to fertiliser use and crop yields, the report also states the nitrogen and phosphate surpluses on the soil surface balance (in kg of nitrogen and P_2O_5 per hectare). These surpluses are calculated by applying a method derived from the approach used and described by Schröder *et al.* (2004, 2007). This means that, alongside the input quantities of nitrogen and phosphate in organic and inorganic fertilisers and the output quantities in crops, allowance is also made for other sources of input, such as net mineralisation of organic substances in the soil, nitrogen fixation by leguminous plants, and atmospheric deposition.

A state of equilibrium is assumed when calculating nutrient surpluses on the soil surface balance. It is assumed that, in the long term, the input of organic nitrogen and phosphate in the form of crop residues and organic manure is equal to the annual decomposition. An exception to this rule is made for peat soils and reclaimed peat subsoils (*'dalgronden'*). With these soil types, an input due to mineralisation is taken into account: 160 kg of nitrogen per hectare for grassland on peat soils, and 20 kg of nitrogen per hectare for grassland or other crops on peat soils and reclaimed peat subsoils. It is known that net mineralisation occurs on these soils as a result of groundwater level management, which is necessary in order to use the land for agriculture. Schröder *et al.* (2004, 2007) calculate the surplus on the soil surface balance by using the release of nutrients to the soil as a starting point. In this study, a method was employed that uses farm data to calculate the surplus on the soil surface balance.

The calculation method used to determine the nitrogen surplus is summarised in Table A2.3. The surplus on the farm gate balance is first calculated by determining the total input and output of nutrients as registered in the farm records. Stock changes are taken into account when calculating this surplus.

The calculated nitrogen surplus on the farm gate balance is then corrected to account for input and output items on the soil surface balance. The phosphate surplus on the soil surface balance is equal to the surplus on the farm gate balance. A more detailed explanation of the calculation methods can be found in Table A2.3 below.

Table A2.3 Calculation methods used to determine the nitrogen surplus on the soil surface balance (kg of nitrogen per hectare per year)

Description of items		*Calculation method*	
		Quantity	*Contents*
Farm inputs	Inorganic fertilisers	Balance of all inputs, outputs and stock changes of inorganic fertilisers	Data obtained from suppliers' annual overviews. If these are not available, standards are used (Nutrient Management Institute, 2013).
	Livestock manure and other organic fertilisers	Balance of all inputs, outputs and stock changes of livestock manure and other organic fertilisers in the case of net consumption (input)	Sampling results or standard quantities (National Service for the Implementation of Regulations, 2013, Table 5). If farm-specific manure production is known, the output of on-farm manure is corrected accordingly (see section A3.2).
	Feedstuffs	Balance of all input and stock decreases of all feed products (feed concentrate, roughage, etc.)	Data obtained from suppliers' annual overviews. If these are not available, standards are used (Centraal Veevoederbureau, 2012). Standards for compound feed in 2006-2009 based on data compiled by Statistics Netherlands (2010, 2011). As of 2010, all compound feed data are calculated for each separate farm. Standards for silage grass and silage maize are based on annual averages for the different soil type regions (data supplied by the Netherlands Laboratory for Soil and Crop Research).
	Animals	Only imported animals	Standard quantities based on Ministry of Agriculture, Nature & Food Quality (2010), and National Service for the Implementation of Regulations (2013, Table 7)
	Plant products (sowing seeds, young plants and propagating material)	Only imported plant products	Standard quantities based on Van Dijk, 2003
	Other	Balance of all inputs, outputs and stock changes of all other products in the case of net consumption (input)	Standards based on Internet search queries
Farm outputs	Animal products (milk, wool, eggs)	Balance of all inputs, outputs and stock changes of all milk and other animal products	National Service for the Implementation of Regulations (2013, Tables 7 and 8)
	Animals	Balance of outputs and stock changes of animals and meat	National Service for the Implementation of Regulations (2013, Tables 7 and 8)
	Livestock manure and other organic fertilisers	Balance of all inputs, outputs and stock changes of livestock manure and other organic fertilisers in the case of net production (output)	Sampling results or standard quantities (National Service for the Implementation of Regulations, 2013, Table 5). If farm-specific manure production is known, the output of on-farm manure is corrected accordingly

Description of items		*Calculation method*	
		Quantity	*Contents*
			(see section A3.2).
	Crops and other plant products	Balance of outputs and stock changes of plant products (crops not intended for roughage), stock increases and sales of roughage	Standard quantities based on Van Dijk (2003) and Centraal Veevoederbureau (2012)
	Other	Balance of all inputs, outputs and stock changes of all other products in the case of net production (output)	Standards based on Internet search queries
Nitrogen surplus on farm gate balance		Farm input -/- Farm output	
Input on soil surface balance	+ Mineralisation	For grassland on peat soils: 160 kg of nitrogen per hectare per year. Other crops on peat soils and reclaimed peat subsoils (irrespective of crop): 20 kg of nitrogen per hectare per year. All other soil types: 0 kg. In the case of FADN farms, the surface areas are registered according to the four soil types used by the National Service for the Implementation of Regulations (sand, clay, peat and loess soils). Mineralisation in reclaimed peat subsoils was estimated based on the overall soil classifications of each farm (based on postcode), in accordance with De Vries and Denneboom (1992).	
	+ Atmospheric deposition	The basic data are derived from National Institute for Public Health and the Environment, 2013.	
	+ Nitrogen fixation by leguminous plants	Clover on grassland (Kringloopwijzer, 2013): the quantity of nitrogen fixation depends on the proportion of clover and the grassland yield, and is expressed per kg of dry matter: 0 to 1% clover: 0 kg; 1 to 5% clover: 0.03 kg; 5 to 15% clover: 0.1 kg; more than 15% clover: 0.2 kg. Other crops (Schröder, 2006): - Lucerne: 160 kg per hectare - Peas, broad beans, kidney beans and French beans: 40 kg per hectare	
Output on soil surface balance	- Volatilisation resulting from stabling, storage and grazing	The calculation method is based on Velthof *et al.* (2009). Calculations are based on the Total Ammonia Nitrogen (TAN) percentage. If the farm uses a farm-specific calculation method to calculate manure production, the emissions resulting from grazing, stabling and storage are calculated as follows: - Ammonia emissions resulting from stabling and storage: the stable code under the Regulations on the Use of Ammonia in Livestock Farming (*Regeling Ammoniak en Veehouderij*, RAV) is used as a starting point. The total nitrogen emissions are calculated as a percentage of the emitted ammonia nitrogen (based on the RAV emission factor). - Ammonia emissions resulting from grazing are calculated as a percentage (3.5%) of the total quantity of ammonia nitrogen excreted on grassland. If a farm calculates excretion based on standard quantities, the emissions resulting from grazing, stabling and storage are calculated as follows: - The gross standard-based excretion is calculated by adding the standard-	

Description of items		Calculation method	
		Quantity	*Contents*
		based emission factor to the net standard-based excretion (Oenema *et al.*, 2000). This factor depends on the type of animal (11.3% for dairy cows). - The emissions resulting from grazing are then calculated by multiplying the nitrogen excreted in grassland manure (net standard-based excretion * grassland fraction) by 3.5%, and then by the fraction of the total quantity of ammonia nitrogen in manure. - The emissions resulting from stabling and storage are calculated as the gross standard-based excretion minus the net standard-based excretion.	
	- Volatilisation resulting from application	The ammonia emission factors for the application of livestock manure and inorganic fertilisers are based on Velthof *et al.* (2009). Other gaseous nitrogen emissions during application are not taken into consideration. Emissions resulting from application are calculated as a percentage of the applied ammonia nitrogen based on the emission factors as reported in Appendix 14 in Velthof *et al.* (2009). If no information on the application method is available (this has not been the case in the LMM framework since 2010), a standard for each soil type is applied. This standard is derived using the MAMBO method (De Koeijer *et al.*, 2012). Agricultural Census data on application methods are used for this purpose. The methods are classified according to soil type and land use type, and linked to an emission factor and a Total Ammonia Nitrogen (TAN) factor.	
Nitrogen surplus on the soil surface balance		Nitrogen surplus on farm + input on soil surface balance – output on soil surface balance	

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Appendix 3 Sampling of water on farms in 2013

A3.1 Introduction

The derogation decision (EU 2005, see section 1.3) states that a report must be produced on the development of water quality, and that this report must be based, among other things, on regular monitoring of water leaching from the root zone as well as surface and groundwater quality (Article 10, paragraph 1). The monitoring of the quality of the 'shallow groundwater layers, soil moisture, drain water and watercourses on farms that are part of the monitoring network' must yield information about the nitrate and phosphorus concentrations in water leaving the root zone and ending up in the groundwater and surface water system (Article 8, paragraph 4).

A3.1.1 Water sampling

In the Netherlands, the groundwater level is often located just below the root zone. The average groundwater level in the Sand region is approximately 1.5 metres below surface level. The average groundwater level in the Clay region and Peat region is shallower. The average groundwater level is more than five metres below surface level only in the Loess region and on the push moraines in the Sand region. In most situations, therefore, water leaching from the root zone or leaching into groundwater can be analysed by sampling the top metre of phreatic groundwater. In situations where the water table is more than five metres below surface level and the soil retains sufficient moisture (in the Loess region), the soil moisture below the root zone is sampled. There is little agricultural activity on push moraines in the Sand region where the water table is far below ground level. Where these agricultural activities do occur, the soil moisture below the root zone is also sampled if possible.

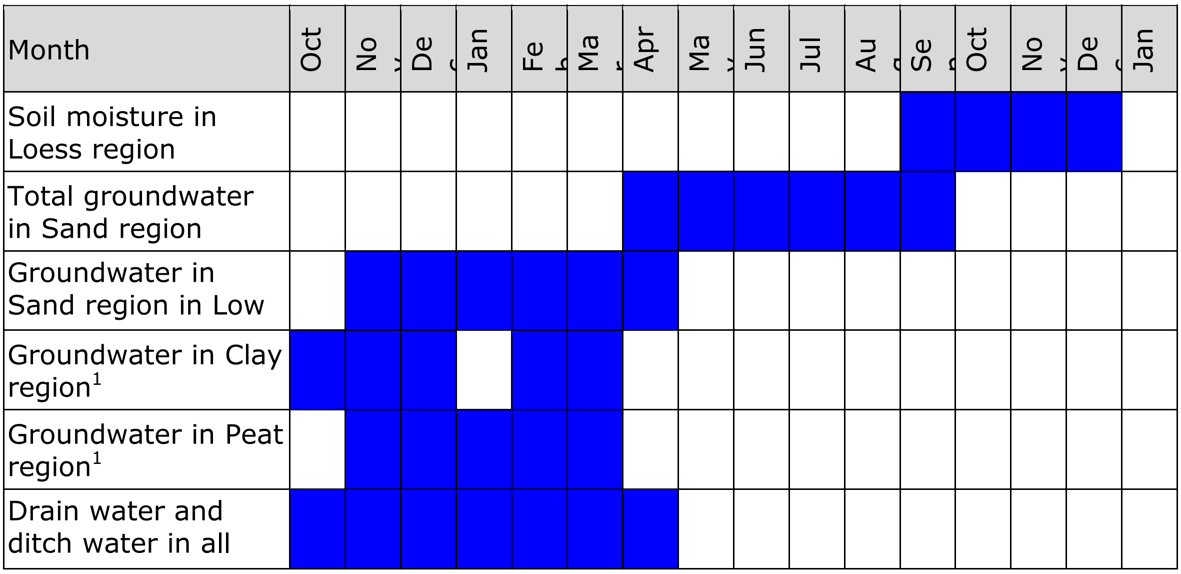
The surface water is loaded with nitrogen and phosphorus via run-off and groundwater. In the latter case, the travel times are usually longer. In the High Netherlands, only water leaching from the root zone is monitored by sampling the top metre of groundwater or by sampling soil moisture below the root zone. In areas drained by means of ditches in the Low Netherlands (possibly in combination with tile drainage), the travel times are shorter. Here, the loading of surface water is analysed by sampling ditch water, the top metre of groundwater, and/or water from tile drainage (drain water).

A3.1.2 Number of measurements per farm

On each farm, groundwater, soil moisture and drain water were sampled at sixteen locations, while ditch water was sampled at up to eight locations. The number of measurement locations was based on the results of previous research carried out in the Sand region (Fraters *et al.*, 1998; Boumans *et al.*, 1997), in the Clay region (Meinardi and Van den Eertwegh, 1995, 1997; Rozemeijer *et al.*, 2006), and in the Peat region (Van den Eertwegh and Van Beek, 2004; Van Beek *et al.*, 2004; Fraters *et al.*, 2002).

A3.1.3 *Measurement period and measurement frequency*

In the Low Netherlands, samples are taken in winter. In this region of the country, shallow groundwater flows in winter transport a significant portion of the precipitation surplus to the surface water. In polders in the dry season, water from outside the polder is often let in to maintain groundwater levels and water levels in ditches. Samples can be taken in summer as well as winter on sand and loess soils in the High Netherlands. As the available sampling capacity must be utilised throughout the year, sampling in the Sand region is carried out in summer and sampling in the Loess region in autumn. The measurement period (see Figure A3.1) has been chosen in such a manner that the measurements are properly representative of water leaching from the root zone, and thus reflect as accurately as possible the agricultural practices of the previous year. Due to weather conditions, sampling campaigns may need to be extended or started at a later time.



[1] The date when sampling starts depends on the quantity of precipitation, as sufficient precipitation must have fallen before leaching into groundwater occurs. Sampling never starts later than 1 December.

Figure A3.1 Overview of standard sampling periods for determining water quality in each region

In the High Netherlands, groundwater and soil moisture are sampled once a year on each farm. The annual precipitation surplus in the Netherlands amounts to approx. 300 mm. This quantity of water spreads throughout the soil with a porosity of 0.3 (typical for sandy soils) over a soil layer of approx. 1 metre (saturated soil). Therefore, the quality of the top metre of groundwater is representative of the water leaching from the root zone every year, and of the loading of the groundwater. Other types of soil (clay, peat, loess) generally have higher porosity. In other words, a sample from the top metre will contain, on average, water from more than just the previous year. A measuring frequency of once every year is therefore sufficient. Previous research has shown that variations in nitrate concentrations in a single year and between years can be eliminated when dilution effects and

groundwater level variations are taken into account (Fraters *et al.*, 1997).
From the start of the first sampling period in the Low Netherlands after the granting of derogation (1 October 2006), the sampling frequency for drain water and ditch water was increased from two to three rounds per winter period (the LMM sampling frequency until then) to approximately four rounds per winter (intended LMM sampling frequency). This higher sampling frequency allows for improved distribution during the leaching season. The feasibility of four sampling rounds depends on the weather conditions. It may be impossible to sample drains during periods of frost or insufficient precipitation. The intended LMM sampling frequency was based on research carried out in the early 1990s (Meinardi and Van den Eertwegh, 1995, 1997; Van den Eertwegh, 2002). A review of the LMM programme in the Clay region in the 1996-2002 period produced the conclusion that there was no reason to change the existing relationship between the number of sampling rounds per farm and per year (actual sampling frequency) and the number of drains sampled on each farm and during each sampling round (Rozemeijer *et al.*, 2006). The sampling frequency was increased in response to a request from the European Commission. A frequency of four times a year corresponds to the proposed sampling frequency for operational monitoring of vulnerable phreatic groundwater with a relatively fast and shallow run-off (EU, 2006).

In addition to the compulsory components of nitrate content, total nitrogen content and total phosphorus content, other water quality characteristics were also determined as part of the chemical analysis of water samples. This was done to explain the results of the measurements of the compulsory components. These additional components include ammonium nitrogen, orthophosphate and a number of general characteristics such as conductivity, pH value, and dissolved organic carbon concentration. The results of these additional measurements have not been included in this report.

The sections below describe the sampling procedure for each region in greater detail. Sampling was conducted were performed in accordance with the applicable work instructions. The text below refers to the applicable work instructions by stating the relevant document number (e.g. BW-W-021). An overview of the work instructions concerned is provided at the end of this appendix.

A3.2 Sand region and Loess region

A3.2.1 Standard sampling procedure

Groundwater sampling on derogation farms in the Sand region was carried out from April 2012 through to October 2013 (see Figure A3.2). In the Loess region, samples were taken from September 2013 through to November 2013 (see Figure A3.2). Each farm was sampled once during these periods.

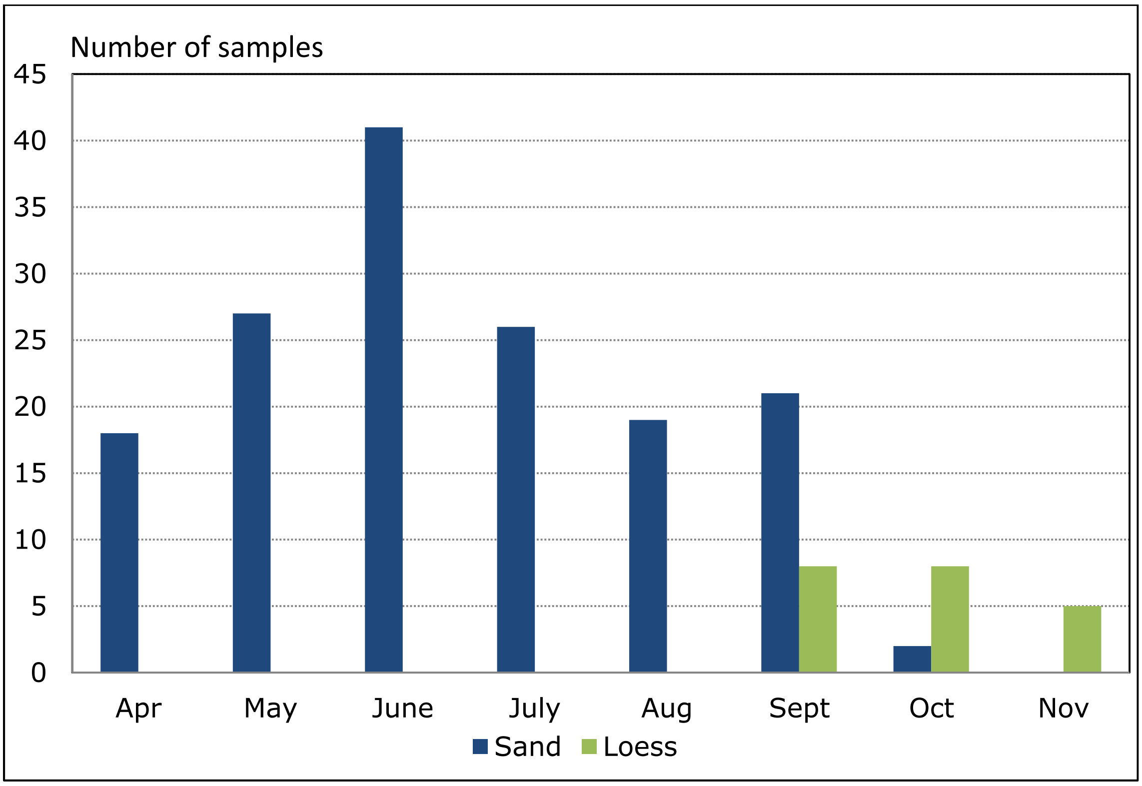


Figure A3.2 Number of groundwater and soil moisture samples in the Sand region and Loess region per month during the period from April 2013 through to November 2013

The samples were taken in accordance with the standard sampling method. On each farm, samples were taken from bore holes drilled at sixteen locations. The number of locations per plot depended on the size of the plot and the number of plots on each farm. The locations in the plot were selected at random. The locations were selected and positioned in accordance with the applicable protocol (MIL-W-4021). The top metre of groundwater was sampled using the open bore hole method (MIL-W-4015). The groundwater levels and nitrate concentrations were determined in situ at each location (Nitrachek method, MIL-W-4001). The water samples were filtered and stored in a cool dark place prior to transport to the laboratory (MIL-W-4008). Acidification has been deployed as a method of conservation since 1 November 2010, using sample bottles which have been previously acidified in the laboratory or by the manufacturer. Acidification was previously carried out in situ using sulphuric acid or nitric acid (MIL-W-4009). Soil moisture samples were taken by collecting drill cores at depths ranging from 150 to 300 cm, using an Edelman drill. The samples were then transported to the laboratory in untreated form and packed in tightly sealed containers (MIL-W-4014). In the laboratory the samples were centrifuged to collect the soil moisture. In the laboratory two compound samples were prepared (each consisting of eight separate samples) and analysed for nitrate content, total nitrogen content, and total phosphorus content.

A3.2.2 *Additional sampling in low-lying areas*

On farms in the Sand region, additional ditch water samples were taken during the period from October 2012 through to April 2013 (see Figure A3.3), in accordance with the standard method. On each farm, no more than two types of ditches were distinguished: farm ditches and local ditches. Farm ditches transport water originating on the farm itself. Local ditches carry water from elsewhere, so that the water leaving the farm is a mixture.

If farm ditches were present, samples were taken downstream (i.e. where the water leaves the farm or ditch) in up to four of these ditches. Furthermore, samples were taken downstream in up to four local ditches to gain insight into the local ditch water quality. If there were no farm ditches, samples were taken both upstream and downstream in four local ditches. This method provides insight into the local water quality and the impact of the farm's activities on water quality. Three types of samples may therefore be distinguished: farm ditch, local ditch (upstream), and local ditch (downstream). The locations for ditch water sampling were selected in accordance with the applicable protocol (MIL-W-4021). The selection was aimed at gaining insight into the impact of the farm's activities on ditch water quality, and excluding as far as possible any effects external to the farm.

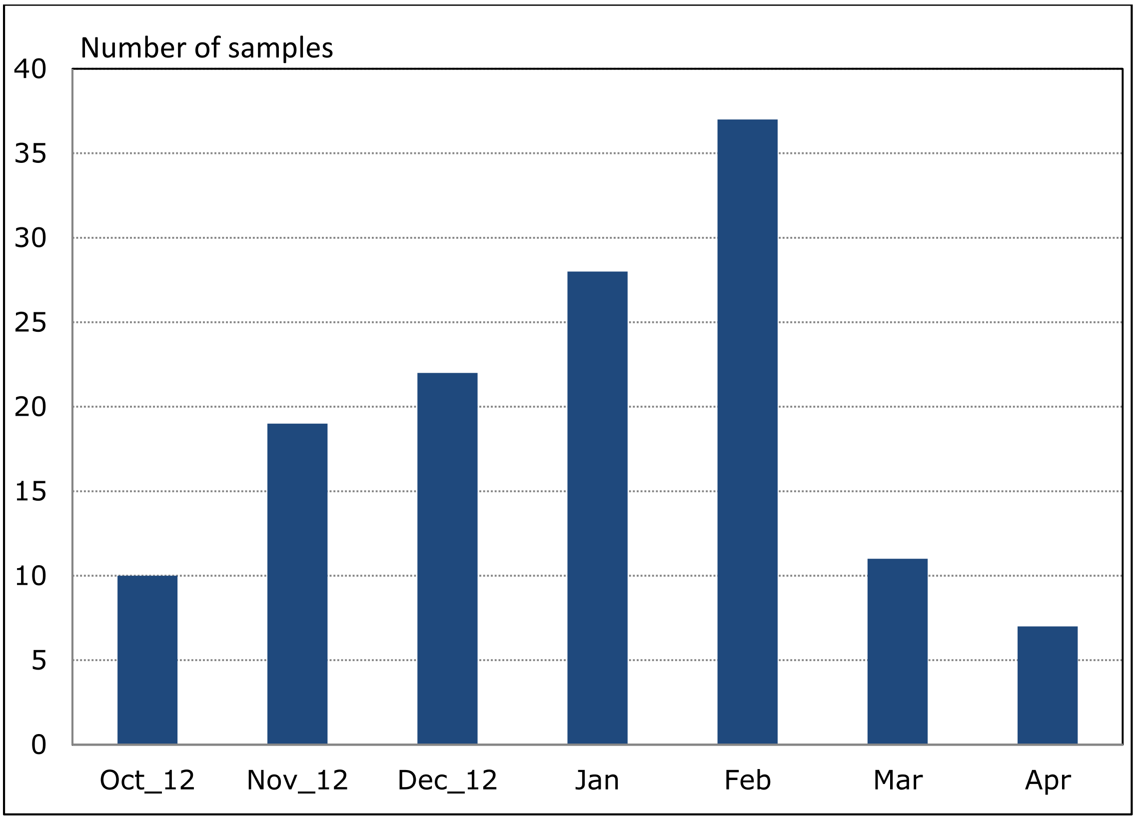


Figure A3.3 Number of ditch water samples in the Sand region per month during the period from October 2012 through to April 2013

Three to four ditch water samples were taken on these farms in the winter of 2012-2013.

The ditch water samples were taken using a measuring beaker attached to a stick or 'fishing rod' (MIL-W-4011). Water samples were stored in a cool, dark place prior to transport to the laboratory (MIL-W-4008). The ditch water samples were filtered in the laboratory on the next day, and two compound samples were prepared (one for each ditch type). The individual ditch water samples were analysed for nitrate content, and the compound samples were also analysed for total nitrogen and total phosphorus content.

A3.3 Clay region

In the Clay region, a distinction is made between farms where the soil is drained using drainage pipes and farms where this is not the case. A farm is considered to lack drainage if less than 25% of its acreage is drained using drainage pipes, or if less than 13 drains can be sampled. Different sampling strategies are used on farms with drainage and farms without drainage.

A3.3.1 Farms with drainage

On farms with drainage, drain water and ditch water were sampled during the period from October 2012 through to April 2013 (see Figure A3.4). On each farm, 16 drainage pipes were selected for sampling. The number of drainage pipes to be sampled on each plot depended on the size of the plot. Within one plot, the drains were selected in accordance with the relevant protocol (MIL-W-4021). On each farm, two ditch types were distinguished. For each ditch type, up to four sampling locations were selected (see section A3.2). The selection was performed in accordance with the aforementioned protocol, and was aimed at gaining insight into the impact of the farm's activities on ditch water quality, and excluding as far as possible any effects external to the farm.

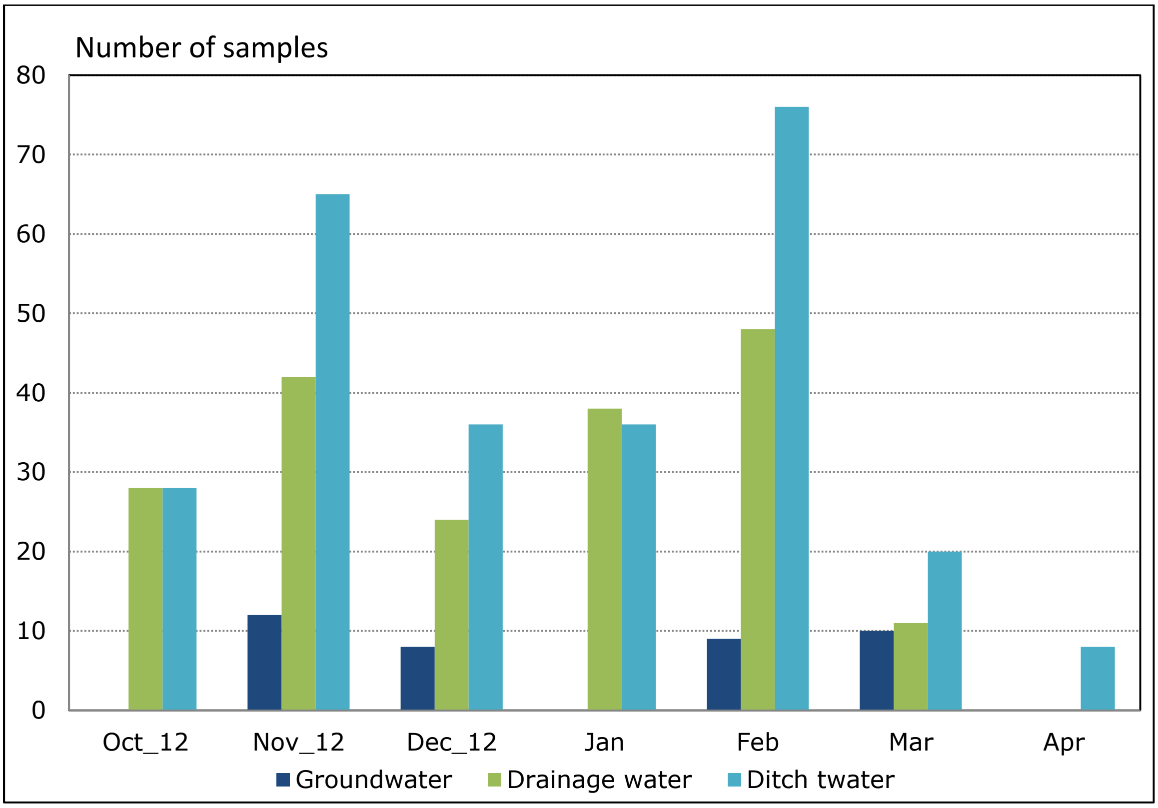


Figure A3.4 Number of groundwater, drain water and ditch water samples in the Clay region per month during the period from October 2012 through to April 2013

During the winter of 2012/2013, drain water and ditch water were sampled between one and four times using the method described in the previous section. The samples were taken throughout the winter, with a period of at least three weeks elapsing between two samples.

Water samples were stored in a cool, dark place prior to transport to the laboratory (MIL-W-4008). The next day, one compound sample was prepared from the drain water samples in the laboratory, and two compound samples were prepared from the ditch water samples (one for each ditch type). The individual drain water and ditch water samples were analysed for nitrate content, and the compound samples were also analysed for total nitrogen content and total phosphorus content.

A3.3.2 Farms without drainage

On farms without drainage, samples were taken of the top metre of groundwater and ditch water during the period from October 2012 through to March 2013 (MIL-W-4021) (see Figure A3.4). On these farms, the groundwater was sampled one or two times, while the ditch water was sampled one to four times.

The groundwater was sampled using a method comparable to the one used in the Sand region, with the exception that the groundwater was sampled twice in the Clay region. However, the closed bore hole method (MIL-W-4015) was occasionally used instead of the open bore hole method. The nitrate concentration was determined in situ at each of the

16 locations (Nitrachek method, MIL-W-4001). The water samples were filtered and stored in a cool, dark place prior to transport to the laboratory (MIL-W-4008). Acidification has been deployed as a method of conservation since 1 November 2010, using sample bottles which have been previously acidified in the laboratory or by the manufacturer. Acidification was previously carried out in situ using sulphuric acid or nitric acid (MIL-W-4009). In the laboratory, two compound samples were prepared (each consisting of eight individual samples) and analysed for nitrate content, total nitrogen content, and total phosphorus content.

The ditch water samples were taken in a manner similar to the method used on farms with drainage, i.e. two ditch types were defined, with up to four sampling locations per ditch type. However, samples were taken using a filter lance (MIL-W-4011), and water samples were immediately filtered in situ and analysed for nitrate content (Nitrachek method, MIL-W-4001). The individual samples were not only filtered, but also conserved (MIL-W-4009) and stored in a cool, dark place prior to transport to the laboratory (MIL-W-4008). In the laboratory, one compound sample was prepared for each ditch type. The compound samples were analysed for nitrate content, total nitrogen content, and total phosphorus content.

A3.4 Peat region

In the Peat region, the top metre of groundwater was sampled once on all farms during the period from October 2012 through to April 2013 (see Figure A3.5). In the same period, three to four ditch water samples were taken on these farms.

The groundwater was sampled using a method similar to the one employed in the Sand region and Clay region. However, the reservoir tube method (MIL-W-4015) was generally used instead of the open or closed bore hole method. The nitrate concentration was determined in situ at each of the 16 locations (Nitrachek method, MIL-W-4001). The water samples were filtered and stored in a cool, dark place prior to transport to the laboratory (MIL-W-4008). Acidification has been deployed as a method of conservation since 1 November 2010, using sample bottles which have been previously acidified in the laboratory or by the manufacturer. Acidification was previously carried out in situ using sulphuric acid or nitric acid (MIL-W-4009). In the laboratory, two compound samples were prepared (each consisting of eight individual samples) and analysed for nitrate content, total nitrogen content, and total phosphorus content.

The ditch water samples were taken together with the groundwater samples, using a method similar to that used on farms without drainage in the Clay region. The samples were taken using a filter lance (MIL-W-4011). Samples were taken at four locations for each of the two ditch types. Water samples were immediately analysed in situ for nitrate content (Nitrachek method, MIL-W-4001). The individual water samples were filtered and stored in a cool, dark place prior to transport to the laboratory (MIL-W-4008). Acidification has been deployed as a method of conservation since 1 November 2010, using sample bottles which have been previously acidified in the laboratory or by the manufacturer. Acidification was previously carried out in situ using sulphuric acid or nitric acid (MIL-W-4009). In the laboratory, two compound samples were prepared from these ditch water samples (one for each ditch type). The compound samples were analysed for nitrate content, total nitrogen content, and total phosphorus content.

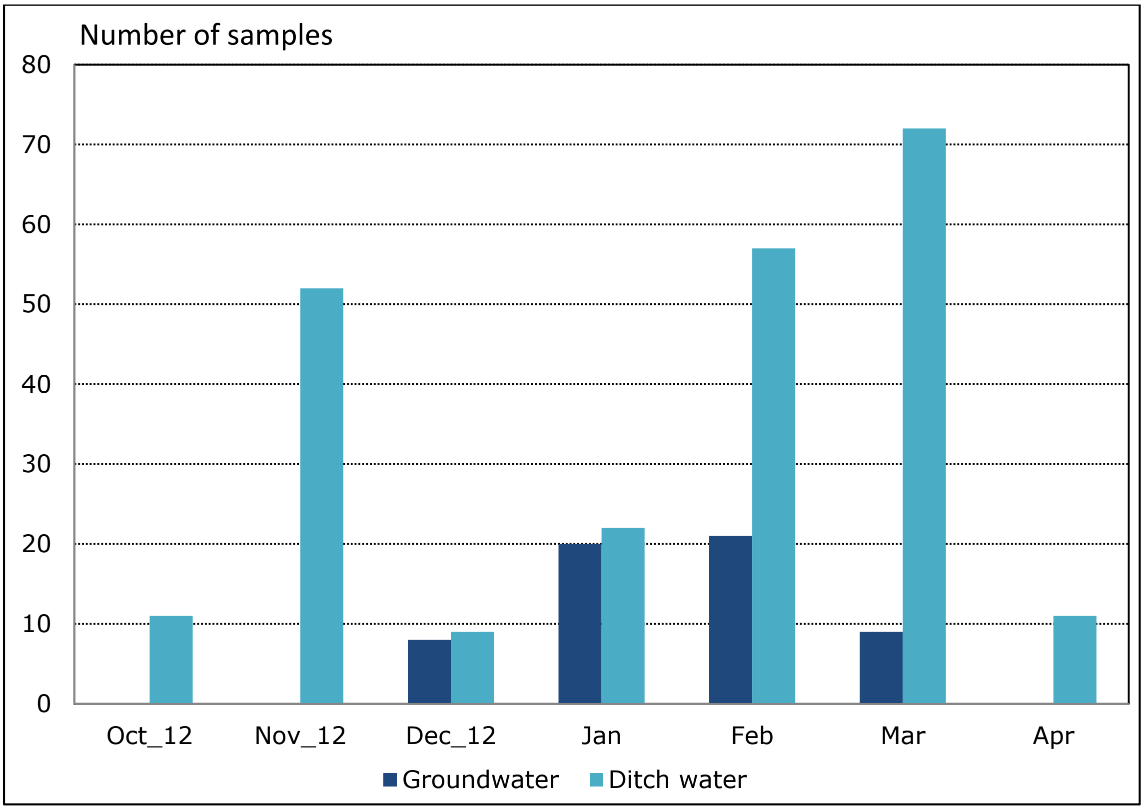


Figure A3.5 Number of groundwater and ditch water samples in the Peat region per month during the period from October 2012 through to April 2013

The additional ditch water samples were taken at the same locations as the samples that were taken together with the groundwater samples. However, a different sampling method was used, namely the method used on farms with drainage in the Clay region. Samples were taken using a 'fishing rod' and measuring beaker. No analyses were performed in situ and the samples were stored in a cool, dark place prior to transport to the laboratory (MIL-W-4011), but not filtered or conserved. On the next day, one compound sample for each ditch type was prepared in the laboratory and analysed for nitrate content, total nitrogen content, and total phosphorus content. Up to four separate samples were combined to prepare a compound sample for each ditch type.

The following RIVM work instructions were used:

MIL-W-4001	Measuring nitrate concentrations in aqueous solutions using a Nitrachek reflectometer (type 404)
MIL-W-4008	Temporary storage and transportation of samples
MIL-W-4009	Method for conserving water samples by adding acid
MIL-W-4011	Sampling ditch water or surface water using a modified sampling lance and peristaltic pump
MIL-W-4014	Soil sampling using an Edelman drill for soil moisture analysis purposes
MIL-W-4015	Groundwater sampling using a sampling lance and peristaltic pump on sand, clay or peat soils
MIL-W-4021	Determining sampling locations

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Appendix 4 Derogation monitoring network results by year

Compared to the reports published in the years up to 2012, some changes have occurred in the data for the 2006-2010 period. In the reports published from 2013 onwards, the number of dairy farms has decreased by 5 to 12 farms and the number of other grassland farms has increased by 5 to 12 farms. The proportion of farms with intensive livestock has decreased by 4 to 6 percentage points in the reports published from 2013 onwards. This is caused by the fact that in 2011 (report published in 2013), the LMM programme started using Standard Output (SO) units instead of Dutch Size Units (*Nederlandse Grootte-Eenheid*, NGE) as the unit of economic size. The new units are applied with retroactive effect (see Appendix 1, section A1.4).

Table A4.1A Some general characteristics of farms participating in the derogation monitoring network (DMN) in the 2006-2013 period

Farm characteristic	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
Number of dairy farms	251	247	249	249	252	255	262	255
Number of other grassland farms	43	48	47	44	42	35	33	33
Total area of cultivated land (hectares)	49	50	51	52	52	53	55	55
Proportion of grassland (%)	83	83	82	82	83	83	83	83
Proportion of farms with intensive livestock (%)	12	13	12	10	10	8	6	6
Total livestock density (Phosphate Livestock Units per hectare)[1]	3.0	3.1	2.7	2.8	2.9	2.8	2.6	2.7
Kilogrammes of FPCM per dairy farm (x 1,000)	697	731	779	813	860	869	893	942
Kilogrammes of FPCM per dairy cow (x 1,000)	8.4	8.4	8.4	8.5	8.7	8.6	8.5	8.5
FPCM production per hectare of fodder crop (x 1,000 kg)	14	14	15	15	16	16	16	16
Percentage of dairy farms where dairy cows graze in:								
• May-October period	89	88	86	83	79	78	79	79
• May-June	86	84	82	80	76	76	77	75
• July-August	88	88	86	83	79	78	79	78
• September-October	87	87	84	80	74	71	75	76

[1] Phosphate Livestock Unit (LSU) is a unit used to compare numbers of animals based on their standard phosphate production. One adult dairy cow produces 41 kg of phosphate on average, which is equivalent to 1 LSU. One young animal 1-2 years of age produces 18 kg of phosphate (0.44 Phosphate LSUs); one young animal 0-1 years of age produces 9 kg of phosphate (0.22 Phosphate LSUs) (source: Ministry of Agriculture, Nature & Food Quality, 2000).

Table A4.1B Some general characteristics of farms participating in the derogation monitoring network (DMN): average values for the 2006-2012 period, results for 2013, differences between 2013 results and the average values for the 2006-2012 period, and trends identified for the 2006-2013 period

Farm characteristic	*Average 2006-2012*	*2013*	*Difference*	*Trend*
Number of dairy farms	253	255		
Number of other grassland farms	41	33		
Total area of cultivated land (hectares)	52	55	+	+
Proportion of grassland (%)	83	83	≈	≈
Proportion of farms with intensive livestock (%)	10	6	-	-
Total livestock density (Phosphate Livestock Units per hectare)[1]	2.8	2.7	≈	≈
Kilogrammes of FPCM per farm (x 1,000)	806	942	+	+
Kilogrammes of FPCM per dairy cow (x 1,000)	8.5	8.5	≈	+
FPCM production per hectare of fodder crop (x 1,000 kg)	15	16	+	+
Percentage of dairy farms where dairy cows graze in:				
• May-October period	83	79	-	-
• May-June	80	75	-	-
• July-August	83	78	-	-
• September-October	80	76	-	-

[1] Phosphate Livestock Unit (LSU) is a unit used to compare numbers of animals based on their standard phosphate production. One adult dairy cow produces 41 kg of phosphate on average, which is equivalent to 1 LSU. One young animal 1-2 years of age produces 18 kg of phosphate (0.44 Phosphate LSUs); one young animal 0-1 years of age produces 9 kg of phosphate (0.22 Phosphate LSUs) (source: Ministry of Agriculture, Nature & Food Quality, 2000).
Difference: direction and significance of difference between 2013 and average for previous years. ≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$). Trend: direction and significance of trend in 2006-2013 period.
≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table A4.2A Average nitrogen usage in livestock manure (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2013 period

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
Number of farms	273	278	276	270	277	277	282	277
Use of nitrogen in livestock manure								
Produced on farm	264	263	267	266	277	273	260	278
+ Inputs	8	10	10	10	8	11	11	10
+ Changes in stocks[1]	-4	-8	-7	-1	-8	-5	-5	-6
– Outputs	25	29	31	32	38	36	31	36
Total use	242	235	239	243	238	242	235	246
Use on grassland[2]	253	248	256	260	252	254	249	261
Use on arable land[3]	183	180	172	169	168	177	173	185

[1] A negative change in stocks is a stock increase and corresponds to output of manure.
[2] The average use on grassland is based on the following numbers of farms: 265 (2006), 272 (2007), 264 (2008), 260 (2009), 265 (2010), 263 (2011), 270 (2012) and 268 (2013). On a number of farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit.
[3] The average use on arable land is based on the following numbers of farms: 197 (2006), 201 (2007), 205 (2008), 199 (2009), 195 (2010), 199 (2011), 2015 (2012) and 204 (2013). On a number of farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit. In addition, some farms had no arable land. The allocation of fertilisers to arable land or grassland exceeded the upper limit or fell below the lower limit on the following numbers of farms: 8 (2006), 6 (2007), 12 (2008), 10 (2009), 12 (2010), 14 (2011), 12 (2012) and 9 (2013). The numbers of farms without arable land were as follows: 68 (2006), 71 (2007), 59 (2008), 61 (2009), 70 (2010), 64 (2011), 65 (2012) and 64 (2013).

Table A4.2B Application of nitrogen in livestock manure (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN): average values for the 2006-2012 period, results for 2013, differences between 2013 results and the average values for the 2006-2012 period, and trends identified for the 2006-2013 period

Description	*Average 2006-2012*	*2013*	*Difference*	*Trend*
Number of farms	276	277		
Use of nitrogen in livestock manure				
Produced on farm	267	278	+	+
+ Inputs	10	10	≈	+
+ Changes in stocks[1]	-6	-6	≈	≈
– Outputs	32	36	≈	+
Total use	239	246	+	≈
Use on grassland	253	261	+	≈
Use on arable land	175	185	+	≈

1 A negative change in stocks is a stock increase and corresponds to output of manure.
Difference: direction and significance of difference between 2013 and average for previous years. ≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$). Trend: direction and significance of trend in 2006-2013 period.
≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table A4.3A Average nitrogen usage (in kg of plant-available nitrogen per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2013 period

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
Number of farms	273	278	276	270	277	277	282	277
Livestock manure excluding availability coefficient	242	235	239	243	238	242	235	246
Availability coefficient	39	40	48	48	49	49	49	49
Livestock manure including availability coefficient	94	94	114	117	116	120	116	120
+ Other organic fertilisers	0	0	0	0	0	0	0	
+ Inorganic fertilisers	129	127	123	125	124	123	126	126
Total use	222	221	237	242	241	243	242	246
Nitrogen application standard applicable to farm	290	287	271	263	260	259	258	258
Use on grassland[1]	246	246	267	269	265	268	269	274
Nitrogen application standard for grassland	317	314	295	286	282	281	281	280
Use on arable land[2]	110	113	123	123	119	126	124	126
Nitrogen application standard for arable land	156	154	157	153	153	150	143	141

[1] The average use on grassland is based on the following numbers of farms: 265 (2006), 272 (2007), 264 (2008), 260 (2009), 265 (2010), 263 (2011), 270 (2012) and 268 (2013). On a number of farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit.

[2] The average use on arable land is based on the following numbers of farms: 197 (2006), 201 (2007), 205 (2008), 199 (2009), 195 (2010), 199 (2011), 205 (2012) and 204 (2013). On a number of farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit. In addition, some farms had no arable land. The allocation of fertilisers to arable land or grassland exceeded the upper limit or fell below the lower limit on the following numbers of farms: 8 (2006), 6 (2007), 12 (2008), 10 (2009), 12 (2010), 14 (2011), 12 (2012) and 9 (2013). The numbers of farms without arable land were as follows: 68 (2006), 71 (2007), 59 (2008), 61 (2009), 70 (2010), 64 (2011), 65 (2012) and 64 (2013).

Table A4.3B Nitrogen usage (in kg of plant-available nitrogen per hectare) on farms participating in the derogation monitoring network (DMN): average values for the 2006-2012 period, results for 2013, differences between 2013 results and the average values for the 2006-2012 period, and trends identified for the 2006-2013 period

Description	*Average 2006-2012*	*2013*	*Difference*	*Trend*
Number of farms	276	277		
Livestock manure excluding availability coefficient	239	246	+	≈
Availability coefficient	46	49	+	+
Livestock manure including availability coefficient	110	120	+	+
+ Other organic fertilisers	0	0	+	+
+ Inorganic fertilisers	125	126	≈	≈
Total use	235	246	+	+
Nitrogen application standard applicable to farm	270	258	-	-
Use on grassland	261	274	+	+
Nitrogen application standard for grassland	294	280	-	-
Use on arable land	120	126	+	+
Nitrogen application standard for arable land	152	141	-	-

Difference: direction and significance of difference between 2013 and average for previous years. ≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$). Trend: direction and significance of trend in 2006-2012 period. ≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table A4.4A Average phosphate usage (in kg of P_2O_5 per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2013 period

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
Number of farms	273	278	276	270	277	277	282	277
Livestock manure	88	85	88	89	85	85	82	83
+ Other organic fertilisers	0	0	0	0	0	0	0	1
+ Inorganic fertilisers	10	7	6	4	3	3	3	3
Total use	99	93	94	93	88	89	86	87
Phosphate application standard applicable to farm	108	103	98	98	93	95	94	88
Use on grassland[1]	100	95	98	96	91	91	89	89
Phosphate application standard for grassland	111	106	100	101	96	99	97	92
Use on arable land[2]	90	87	83	78	74	78	75	77
Phosphate application standard for arable land	95	90	85	85	79	77	73	64

[1] The average use on grassland is based on the following numbers of farms: 265 (2006), 272 (2007), 264 (2008), 260 (2009), 265 (2010), 263 (2011), 270 (2012) and 268 (2013). On a number of farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit.

[2] The average use on arable land is based on the following numbers of farms: 197 (2006), 201 (2007), 205 (2008), 199 (2009), 195 (2010), 199 (2011), 205 (2012) and 204 (2013). On a number of farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit. In addition, some farms had no arable land. The allocation of fertilisers to arable land or grassland exceeded the upper limit or fell below the lower limit on the following numbers of farms: 8 (2006), 6 (2007), 12 (2008), 10 (2009), 12 (2010), 14 (2011), 12 (2012) and 9 (2013). The numbers of farms without arable land were as follows: 68 (2006), 71 (2007), 59 (2008), 61 (2009), 70 (2010), 64 (2011), 65 (2012) and 64 (2013).

Table A4.4B Phosphate usage (in kg of P_2O_5 per hectare) on farms participating in the derogation monitoring network (DMN): average values for the 2006-2012 period, results for 2013, differences between 2013 results and the average values for the 2006-2012 period, and trends identified for the 2006-2013 period

Description	*Average 2006-2012*	*2013*	*Difference*	*Trend*
Number of farms	276	277		
Livestock manure	86	83	-	-
+ Other organic fertilisers	0	1	≈	+
+ Inorganic fertilisers	5	3	-	-
Total use	92	87	-	-
Phosphate application standard applicable to farm	99	88	-	-
Use on grassland	94	89	-	-
Phosphate application standard for grassland	101	92	-	-
Use on arable land	81	77	≈	-
Phosphate application standard for arable land	84	64	-	-

Difference: direction and significance of difference between 2013 and average for previous years. ≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$). Trend: direction and significance of trend in 2006-2013 period.
≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table A4.5A Calculated crop yields for grassland and estimated crop yields for silage maize (in kg of dry matter, nitrogen, phosphorus and P_2O_5 per hectare) on farms participating in the derogation monitoring network that meet the criteria for application of the grassland yield calculation method (Aarts et al.*, 2008), during the 2006-2013 period*

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
Estimated silage maize yield								
Number of farms	152	142	154	164	164	164	162	178
Tonnes of dry matter per hectare	15.0	15.2	16.0	16.3	16.1	16.3	17.0	16.2
Kilogrammes of nitrogen per hectare	187	178	189	189	189	192	179	187
Kilogrammes of phosphorus per hectare	30	29	31	31	30	31	31	30
Kilogrammes of P_2O_5 per hectare	69	67	70	71	69	71	72	69
Calculated grassland yield								
Number of farms	206	201	201	209	221	218	220	237
Tonnes of dry matter per hectare	10.2	10.1	9.7	10.0	9.7	10.6	10.4	9.8
Kilogrammes of nitrogen per hectare	282	261	270	261	251	266	249	275
Kilogrammes of phosphorus per hectare	35	38	38	35	35	37	38	37
Kilogrammes of P_2O_5 per hectare	80	87	87	81	79	86	86	85

Table A4.5B Calculated crop yields for grassland and estimated crop yields for silage maize (in kg of dry matter, nitrogen, phosphate and P_2O_5 per hectare) on farms participating in the derogation monitoring network that meet the criteria for application of the grassland yield calculation method (Aarts et al.*, 2008): average values for the 2006-2012 period, results for 2013, differences between 2013 results and the average values for the 2006-2012 period, and trends identified for the 2006-2013 period*

Description	*Average 2006-2012*	*2013*	*Difference*	*Trend*
Estimated silage maize yield				
Number of farms	157	178		
Tonnes of dry matter per hectare	16	16	+	+
Kilogrammes of nitrogen per hectare	186	187	-	≈
Kilogrammes of phosphorus per hectare	31	30	≈	+
Kilogrammes of P_2O_5 per hectare	70	69	≈	+
Calculated grassland yield				
Number of farms	211	237		
Tonnes of dry matter per hectare	10	9.8	+	+
Kilogrammes of nitrogen per hectare	263	275	≈	-
Kilogrammes of phosphorus per hectare	37	37	+	+
Kilogrammes of P_2O_5 per hectare	84	85	+	+

Difference: direction and significance of difference between 2013 and average for previous years. ≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$). Trend: direction and significance of trend in 2006-2013 period.
≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table A4.6A Nitrogen surpluses on the soil surface balance (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2013 period

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
Number of farms	273	278	276	270	277	277	282	277
Inputs of (inorganic) fertilisers, feedstuffs, animals and other products	331	332	333	336	355	341	332	344
Outputs of milk, animals, feedstuffs, manure and other products	143	152	156	149	167	165	153	157
Deposition, mineralisation and nitrogen fixation	58	57	57	55	52	58	56	53
Gaseous emissions resulting from stabling, storage, grazing and application	52	56	56	54	54	52	49	49
Average surplus on soil surface balance	194	182	177	188	186	181	186	190
Surplus on soil surface balance (25th percentile)[1]	134	124	124	132	134	135	135	147
Surplus on soil surface balance (75th percentile)[2]	244	236	215	224	227	222	222	229

[1] Upper limit of the 25% of farms with the lowest surplus on the soil surface balance
[2] Lower limit of the 25% of farms with the highest surplus on the soil surface balance

Table A4.6B Nitrogen surpluses on the soil surface balance (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN): average values for the 2006-2012 period, results for 2013, differences between 2013 results and the average values for the 2006-2012 period, and trends identified for the 2006-2013 period

Description	*Average 2006-2012*	*2013*	*Difference*	*Trend*
Number of farms	276	277		
Inputs of (inorganic) fertilisers, feedstuffs, animals and other products	337	344	≈	≈
Outputs of milk, animals, feedstuffs, manure and other products	155	157	≈	+
Deposition, mineralisation and nitrogen fixation	56	53	-	-
Gaseous emissions resulting from stabling, storage, grazing and application	53	49	-	-
Average surplus on soil surface balance	185	190	≈	≈
Surplus on soil surface balance (25th percentile)[1]	131	147		
Surplus on soil surface balance (75th percentile)[2]	227	229		

[1] Upper limit of the 25% of farms with the lowest surplus on the soil surface balance
[2] Lower limit of the 25% of farms with the highest surplus on the soil surface balance
Difference: direction and significance of difference between 2013 and average for previous years. ≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$). Trend: direction and significance of trend in 2006-2012 period.
≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table A4.7A Nitrogen surpluses on the soil surface balance (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2013 period

Region	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
Sand (N = 138-145)	179	169	163	170	171	166	170	177
Loess (N = 15-20)	134	138	141	129	158	153	160	153
Clay (N = 63-69)[1]	196	179	189	207	178	172	178	181
Peat (N = 47-56)	254	237	217	234	248	242	243	245
All farms (N = 270-282)	194	182	177	188	186	181	186	190

[1] The figures presented here differ from previously published figures due to a correction to the nitrogen contents of the roughage stocks in 2007. This correction mainly affects the results for clay areas in 2007 and 2008.

Table A4.7B Nitrogen surpluses on the soil surface balance (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN): average values for the 2006-2012 period, results for 2013, differences between 2013 results and the average values for the 2006-2012 period, and trends identified for the 2006-2013 period

Region	*Average 2006-2012*	*2013*	*Difference*	*Trend*
Sand (N = 138-145)	170	177	≈	≈
Loess (N = 15-19)	145	153	≈	≈
Clay (N = 63-69)	186	181	≈	≈
Peat (N = 47-55)	239	245	≈	≈
All farms (N = 270-281)	185	190	≈	≈

Difference: direction and significance of difference between 2013 and average for previous years. ≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$). Trend: direction and significance of trend in 2006-2013 period.
≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table A4.8A Phosphate surpluses on the soil surface balance (in kg of P_2O_5 per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2013 period

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
Number of farms	273	278	276	270	277	277	282	277
Inputs of (organic and inorganic) fertilisers, feedstuffs, animals and other products	87	80	83	82	88	82	76	81
Outputs of milk, animals, feedstuffs, manure and other products	62	68	68	65	72	71	66	66
Average surplus on soil surface balance	26	12	15	18	16	11	10	16
Surplus on soil surface balance (25th percentile)[1]	10	-2	2	4	4	0	-1	5
Surplus on soil surface balance (75th percentile)[2]	38	28	27	29	28	26	20	27

[1] Upper limit of the 25% of farms with the lowest surplus on the soil surface balance
[2] Lower limit of the 25% of farms with the highest surplus on the soil surface balance

Table A4.8B Phosphate surpluses on the soil surface balance (in kg of P_2O_5 per hectare) on farms participating in the derogation monitoring network (DMN): average values for the 2006-2012 period, results for 2013, differences between 2013 results and the average values for the 2006-2012 period, and trends identified for the 2006-2013 period

Description	*Average 2006-2012*	*2013*	*Difference*	*Trend*
Number of farms	276	277		
Inputs of (organic and inorganic) fertilisers, feedstuffs, animals and other products	83	81	≈	-
Outputs of milk, animals, feedstuffs, manure and other products	68	66	≈	≈
Average surplus on soil surface balance	15	16	≈	-
Surplus on soil surface balance (25th percentile)[1]	2	5		
Surplus on soil surface balance (75th percentile)[2]	28	27		

[1] Upper limit of the 25% of farms with the lowest surplus on the soil surface balance
[2] Lower limit of the 25% of farms with the highest surplus on the soil surface balance
Difference: direction and significance of difference between 2013 and average for previous years. ≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$). Trend: direction and significance of trend in 2006-2013 period.
≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

Table A4.9A Average nutrient concentrations (in mg/l) in water leaching from the root zone and ditch water in the 2007-2014 period

	2007	2008	2009	2010	2011	2012	2013	2014
	Water leaching from root zone in the Clay region							
Number	61	63	64	64	63	59	67	57
Nitrate	26	16	15	19	14	11	11	15
Phosphorus	0.35	0.40	0.32	0.25	0.27	0.33	0.25	0.26
Nitrogen	9.1	6.2	5.5	6.3	5.2	4.7	4.5	5.3
	Ditch water in the Clay region							
Number	60	59	63	63	62	58	66	56
Nitrate	12	8.7	6.9	9.7	6.3	5.3	4.3	6.0
Phosphorus	0.32	0.35	0.35	0.22	0.27	0.25	0.26	0.25
Nitrogen	4.3	4.0	3.7	4.2	3.5	3.2	3.3	3.4
	Water leaching from root zone in the Sand region							
Number	143	142	142	143	142	147	151	152
Nitrate	60	46	41	49	40	36	38	42
Phosphorus	0.07	0.07	0.07	0.09	0.11	0.10	0.10	0.13
Nitrogen	16	14	12	14	12	11	11	12
	Ditch water in the Sand region							
Number	31	33	34	34	35	35	35	29
Nitrate	34	33	26	31	25	19	20	24
Phosphorus	0.14	0.13	0.21	0.12	0.09	0.11	0.13	0.12
Nitrogen	9.4	9.5	8.2	9.2	7.7	6.6	6.9	7.8
	Water leaching from root zone in the Peat region							
Number	49	49	48	48	49	51	57	57
Nitrate	15	6.0	6.3	13	6.9	4.2	6.2	9.3
Phosphorus	0.51	0.39	0.32	0.44	0.37	0.42	0.43	0.30
Nitrogen	11	9.7	8.2	11	9.4	8.0	8.3	9.3
	Ditch water in the Peat region							
Number	49	48	47	47	48	50	56	56
Nitrate	5.9	4.2	3.5	3.7	3.7	2.8	2.5	3.5
Phosphorus	0.21	0.13	0.15	0.14	0.15	0.16	0.20	0.18
Nitrogen	3.7	4.2	4.3	4.1	4.6	4.0	4.1	4.3
	Water leaching from root zone in the Loess region							
Number of farms	18	18	20	18	19	19	19	
Nitrate	71	52	50	50	56	54	57	
Phosphorus [1]	<DT	<DT	<DT	<DT	*	<DT	<DT	
Nitrogen	18	13	12	12	14	14	13	

[1] Average phosphorus concentrations below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT

* The phosphorus measurements for this year were rejected (Hooijboer *et al.*, 2013)

Table A4.9B Average nutrient concentrations (in mg/l) in water leaching from the root zone and ditch water: average values for the 2007-2013 period, differences between 2014 results and the average values for the 2007-2013 period, and trends identified for the 2007-2014 period

	Average 2007-2013	2014	Difference	Trend
	Water leaching from root zone in the Clay region			
Nitrate	16	15	≈	-
Phosphorus	0.31	0.26	≈	-
Nitrogen	5.9	5.3	≈	-
	Ditch water in the Clay region			
Nitrate	7.6	6.0	≈	-
Phosphorus	0.29	0.25	≈	≈
Nitrogen	3.7	3.4	≈	-
	Water leaching from root zone in the Sand region			
Nitrate	44	42	≈	-
Phosphorus	0.09	0.13	≈	+
Nitrogen	13	12	-	-
	Ditch water in the Sand region			
Nitrate	27	24	≈	-
Phosphorus	0.13	0.12	≈	≈
Nitrogen	8.2	7.8	≈	-
	Water leaching from root zone in the Peat region			
Nitrate	8.3	9.3	≈	-
Phosphorus	0.41	0.30	-	-
Nitrogen	9.3	9.3	≈	-
	Ditch water in thePeat region			
Nitrate	3.8	3.5	≈	-
Phosphorus	0.16	0.18	≈	≈
Nitrogen	4.1	4.3	≈	≈
	Water leaching from root zone in the Loess region[1]			
	Average 2007-2012	2013	Difference	Trend
Nitrate	55	57	≈	≈
Phosphorus[2]	<DT	<DT	≈	≈
Nitrogen	14	13	≈	≈

Difference: direction and significance of difference between 2014 and average for previous years. ≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$). Trend: direction and significance of trend in 2007-2013 period.
≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).
[1] The difference was determined based on a comparison of the data for 2013 with the data for the 2007-2012 period. The data for 2014 are not yet available.
[2] Average phosphorus concentrations below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT.

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Appendix 5 Comparison of data on fertiliser usage at derogation farms as calculated by RVO.nl and LMM

A5.1 Introduction

Since 2006, the Netherlands Enterprise Agency (*Rijksdienst voor Ondernemend Nederland* or RVO.nl, formerly the National Service for the Implementation of Regulations) as well as the Minerals Policy Monitoring Programme (*Landelijk Meetnet effecten Mestbeleid*, LMM) have reported the calculated fertiliser use on farms participating in the derogation scheme. Because the calculated data sometimes showed significant discrepancies in the past, LEI has analysed these differences since 2010 at the request of the Ministry of Economic Affairs.
One important cause of the differences between the LMM and RVO.nl data concerns the different purposes of calculating fertiliser and manure use on derogation farms. The LMM calculations are aimed at calculating the fertilisation rates as accurately as possible, using as much farm-specific information as possible. The fertiliser use calculations performed by RVO.nl serve a different purpose, namely discovering possible offenders.
There are also differences in the population. The LMM population is a sample of the Agricultural Census data that excludes very small farms. The RVO.nl data concern all farms included in the Agricultural Census that have applied for derogation.
This Appendix compares the fertiliser use as calculated based on LMM data and stated in this report, with the fertiliser use as calculated by RVO.nl (see Table A5.1). In addition, an explanation is provided of any differences that were found.

Table A5.1 Fertiliser use in kg per hectare on farms to which derogation has been granted according to RVO.nl data, fertiliser use in kg per hectare on farms according to LMM derogation monitoring results, and differences between these source data in 2013 for both nitrogen and phosphate in kg per hectare and percentages

Item	*LMM data (kg per hectare)*	*RVO.nl data (kg per hectare)*	*Difference between LMM and RVO.nl data (kg per hectare)*	*(%)*
Nitrogen				
Livestock manure	244	228	16	7%
Inorganic fertilisers	125	114	11	10%
Other organic fertilisers	0	4	-3	-89%
Total	369	345	24	7%
Phosphate				
Livestock manure	82	83	-1	-1%
Inorganic fertilisers	3	2	1	39%
Other organic fertilisers	1	2	-1	-59%
Total	85	86	-1	-1%

A5.2 Approach

The LMM population includes only farms that meet the following criteria:

- Fertilisation with inorganic fertilisers, livestock manure and other organic fertilisers must fall within the LMM confidence intervals. This applies to the separate quantities of nitrogen and phosphate, as well as the total quantities of fertilisers applied (i.e. inorganic fertilisers, livestock manure, and other organic fertilisers). The relevant criteria are specified in Appendix 2 (Table A2.1).
- Farms may not have an anaerobic digestion plant.
- Farms must actually make use of the exemption in the year concerned (four farms in the derogation monitoring network did not do so in 2013).

The application of these exclusion criteria meant that the number of LMM farms usable for derogation monitoring purposes in 2013 decreased from 297 to 277.

To enable a comparison with the RVO.nl data, fertiliser use on these 277 LMM farms was also calculated based on the relevant RVO.nl data. For this purpose, 287 BRS numbers were linked to the 277 LMM farms. Some LMM farms have two BRS numbers, and in those cases the data belonging to the two BRS numbers were combined. Twenty LMM farms with 20 BRS numbers turned out to fall outside the confidence interval specified in Appendix 2 based on their RVO.nl data, among other things because their milk production and urea level data were missing from the RVO.nl data. Eventually, the comparison with the RVO.nl data was made for 257 LMM farms with 267 BRS numbers.

The following data sources were used to compare the RVO.nl and LMM figures for 2013:

- Farm Accountancy Data Network (FADN) of the Agricultural Economics Research Institute (LEI): this concerns the 297 farms that qualified for derogation monitoring (DM) in 2013. We mainly analysed the fertilisation data, but also used other FADN data pertaining to these farms where necessary. These farms are all participants in the LMM programme and will therefore be referred to below as ‘LMM farms’, and the data provided as ‘LMM data’.
- Data provided by the Netherlands Enterprise Agency (RVO.nl): this concerns 21,151 registration numbers (BRS numbers) of farms that applied for derogation in 2013. Ten BRS numbers have been added which are included in the 297 LMM farms, but not in the 21,151 BRS numbers.
- Data from the 2013 Agricultural Census concerning the 21,151 BRS numbers. In the case of 760 BRS numbers, no number could be found in the 2013 Agricultural Census, leaving 20,391 BRS numbers with Agricultural Census data.

A5.3 Analysis of differences

A5.3.1 Nitrogen in livestock manure

The calculated quantity of nitrogen in livestock manure is 16 kg per hectare higher according to the LMM data than according to the RVO.nl data (see Table A5.1). Table A5.2 summarises the reasons for these differences.

The main difference is due to differences between the two populations. If the RVO.nl population were to be rendered comparable to the LMM population, the nitrogen use in livestock manure calculated by RVO.nl would increase by 9 kg, from 228 to 237 kg of nitrogen per hectare (B in Table A5.2). For this purpose, farms smaller than 10 hectares and/or 25,000 SO units have been excluded from the RVO.nl data set in accordance with the LMM population. In addition, the same confidence intervals have been used for the fertiliser quantities as in the LMM data set (see Appendix 2, Table A2.1). By rendering the populations comparable, 9 kg (58%) (B in Table A5.2) of the observed difference of 16 kg of nitrogen per hectare (A in Table A5.2) can be explained.

The remaining difference of 7 kg (42%) (A-B in Table A5.2) may be attributed to the following factors (expressed as percentages of the 16 kg difference (A) in Table A5.2, and listed as items a through h).

a. The 257 LMM observations may be considered as a sample from the much larger RVO.nl population of farms with a size of 10 hectares or more, an economic size of 25,000 SO units or more, and falling within the LMM confidence intervals (i.e. the sample population). If fertiliser use on these 257 farms is calculated based on RVO.nl data, then the result deviates by 5.2 kg from the result for this much larger RVO.nl population. This may be considered a sampling difference, and explains 32% of the 16 kg difference.
b. and c. In addition, the stocks, inputs and outputs registered in the LMM programme sometimes differ from the RVO.nl data. FADN participants are requested to report the actual situation, which may differ from the RVO.nl data. The net effect of these discrepancies in 2013 was that the calculated LMM fertiliser quantities were 1.7 kg per hectare higher than the RVO.nl quantities. This amounts to a difference of 10% compared to the A-B difference in Table A5.2.
d. The remaining difference (-0.2 kg per hectare; items d through h) can be accounted for by differences in the method used to calculate excretion quantities. The BEX method is used at approx. half of all farms participating in the LMM programme. As a result, the use of livestock manure according to the LMM data is more than 10 kg per hectare less than according to the RVO.nl data. The BEX method is applied in the LMM programme for all farms that report that they use the BEX method, provided that sufficient reliable data are available.
e. The standard-based excretion in the LMM programme is determined with greater accuracy than in the RVO.nl data, for a number of reasons. RVO.nl is not always able to calculate excretion by dairy cows due to insufficient data on milk supplies or urea levels.
f. Furthermore, the LMM programme takes the stable system into account when determining the standard quantities. Stable system data are not included in the RVO.nl data set, so the lower standard quantities for solid manure are chosen in the case of young livestock.
g. In addition, RVO.nl does not classify excretion by hobby animals as ‘Excretion’, but as ‘Other organic fertilisers’.
h. Furthermore, the excretion by intensive livestock is calculated differently, e.g. due to differences in the initial and closing stocks.

Table A5.2: Breakdown of differences in the use of nitrogen in livestock manure on derogation farms according to RVO.nl data and according to LMM data for the year 2013

Item	*Nitrogen*	
	Kilogrammes of nitrogen per hectare	*Percentage*
Difference between LMM and RVO.nl data (A)	16	100
Difference due to differences between populations (B)	9.3	58
Difference when populations are rendered comparable (A-B)	*6.7*	*42*
The difference (A-B) is caused by:		
a. RVO.nl population ≥ 10 hectares, ≥ 25,000 SO units and within LMM confidence intervals, versus LMM derogation farms with RVO.nl data	*5.2*	*32*
b. Stocks	*2.8*	*17*
c. Inputs and outputs	*-1.1*	*-7*
d. Use of BEX* method in LMM programme	*-10.3*	*-65*
e. Standard-based excretion by dairy cows	*-0.7*	*-4*
f. Standard-based excretion by other cattle	*9.4*	*59*
g. Standard-based excretion by other grazing animals	*0.8*	*5*
h. Standard-based excretion by intensive livestock	*0.5*	*3*

Source: RVO.nl and FADN data processed by LEI

* The abbreviation BEX stands for *Bedrijfsspecifieke Excretie* (Farm-Specific Excretion) (National Service for the Implementation of Regulations, 2010)

A5.3.2 *Nitrogen in inorganic fertilisers and other organic fertilisers*

The differences in the use of nitrogen in other organic fertilisers and inorganic fertilisers are minor compared to the differences in the use of nitrogen in livestock manure. They can largely be explained by the following factors:

- The farms that were excluded (because of sampling limitations and because they fell outside the confidence intervals) use less fertilisers. The RVO.nl data in Table A5.1 still include farms smaller than 10 hectares or 25,000 SO units.
- RVO.nl classifies excretion by hobby animals as ‘Other organic fertilisers’.

A5.3.3 *Phosphate in livestock manure, inorganic fertilisers and other organic fertilisers*

The nitrogen-phosphate ratio in cattle manure is reasonably stable. This also applies to other organic fertilisers. The differences in Table A5.1 for phosphate in livestock manure and other organic fertilisers are caused by the same factors as for nitrogen. In the case of phosphate in inorganic fertilisers, the difference in kilogrammes stated in Table A5.1 is small.

A5.4 Conclusion

The differences do not give cause to adjust the LMM calculation method, either for nitrogen or for phosphate.

References

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