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 2015

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Synopsis

Agricultural practices and water quality on farms registered for derogation in 2015

Dutch manure policy tries to limit the harmful environmental impact of agriculture. This is in line with international agreements on fertilizer use. The European Nitrates Directive prescribes Member States to limit the use of animal manure to 170 kg nitrogen per hectare. Farms with at least 80 percent of grassland may, under certain conditions, use more manure from grazing animals such as cows and sheep (derogation). Over the last 10 years, nitrate leaching from the manure to the upper groundwater has decreased or remained the same for these farms. By 2015, on average, the concentration is in all regions below the EU standard of 50 milligrams of nitrate per litre.

This is according to the annual report by RIVM and Wageningen Economic Research. They follow agricultural practices and the effects on water quality at 300 derogation farms and report their results to the EU annually. This report describes the situation in 2015 and the development between 2006 and 2016 (trend).

Management

The permissible amount of nitrogen from grazing manure is, depending on the soil and region, 250 kilograms per hectare (in the Clay region. Peat region and northern part of the Sand region) or 230 kilograms per hectare (in the Loess region and the rest of the Sand region). On average, derogation companies have used 238 kilograms of nitrogen from animal manure per hectare in 2015. The amount of nitrogen that can leached as nitrate to groundwater is determined, among others, by the so-called nitrogen soil surplus. This is the difference between the supply of nitrogen (such as fertilizers) and their discharge (including through grass and maize). The average nitrogen surplus over the regions has decreased over the period considered.

Groundwater quality

By 2015, the average nitrate concentration in the groundwater in Sand 250 was 26 milligrams per litre (mg/l). The highest concentration is measured in the Loess region (42 mg/l) and in Sand 230 (45 mg/l). On the average, farms in the Clay region and the Peat region had lower nitrate concentrations in leaching water (22 and 13 mg/l respectively). The difference between the regions can be explained by the proportion of soils prone to nitrate leaching. Especially in Sand 230 and in the Loess region there are grounds for which nitrate is degraded in a lesser extent, and therefore can leach more to groundwater.

Key words: derogation, agricultural practice, manure, Nitrates Directive, water quality.

Publiekssamenvatting

Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie in 2015

Het Nederlandse mestbeleid is er op gericht de schadelijke milieueffecten van de landbouw te beperken. Dit sluit aan bij internationale afspraken over het mestgebruik, die onder meer zijn vastgelegd in de Europese Nitraatrichtlijn. Die schrijft lidstaten voor om het gebruik van dierlijke mest te beperken tot 170 kg stikstof per hectare. Bedrijven met ten minste 80 procent grasland mogen onder bepaalde voorwaarden meer mest gebruiken, afkomstig van graasdieren zoals koeien en schapen (derogatie). Op deze bedrijven is in de periode 2006 tot en met 2016 de uitspoeling van nitraat uit de mest naar het grondwater gedaald of gelijk gebleven. In 2015 ligt op derogatiebedrijven de concentratie gemiddeld in alle regio’s onder de EU-norm van 50 milligram nitraat per liter.

Dit blijkt uit de jaarlijkse rapportage van het RIVM en Wageningen Economic Research. Zij volgen op 300 derogatiebedrijven de bedrijfsvoering en de effecten op de waterkwaliteit en zij rapporteren de resultaten hiervan jaarlijks aan de EU. In deze rapportage is de situatie in 2015 beschreven en de ontwikkeling tussen 2006 en 2016 (trend).

Bedrijfsvoering
De toegestane hoeveelheid stikstof uit graasdiermest is, afhankelijk van de bodemsoort en regio, 250 kilogram per hectare (in de Kleiregio, Veenregio en het noordelijke deel van de Zandregio) of 230 kilogram per hectare (in de Lössregio en het overige deel van de Zandregio). Gemiddeld hebben derogatiebedrijven in 2015 238 kilogram stikstof uit dierlijke mest per hectare gebruikt. De hoeveelheid stikstof die als nitraat kan uitspoelen naar het grondwater wordt onder andere bepaald door het zogenoemde stikstofbodemoverschot. Dit is het verschil tussen de aanvoer van stikstof (zoals meststoffen) en de afvoer ervan (waaronder via gras en maïs). Het stikstofbodemoverschot is gemiddeld over de regio’s tijdens de onderzochte periode gedaald met 16%.

Grondwaterkwaliteit
In 2015 was de gemiddelde nitraatconcentratie in het grondwater 26 milligram per liter (mg/l) in Zand 250. De hoogste concentratie wordt gemeten in de Lössregio (42 mg/l) en in Zand 230 (45 mg/l). Bedrijven in de Kleiregio en de Veenregio hadden gemiddeld een lagere nitraatconcentratie (respectievelijk 22 en 13 mg/l). Het verschil tussen de regio’s kan verklaard worden door het aandeel uitspoelingsgevoelige gronden. Vooral in Zand 230 en in de Lössregio komen gronden voor 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 and water quality in 2015 on the farms that registered for derogation in the derogation monitoring network. The agricultural practice data include data on fertiliser usage and actual nutrient surpluses. The report also includes the provisional data for the water quality in 2016.

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 Wageningen Economic Research. Wageningen Economic Research 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 derogation monitoring network was created in order to meet the conditions imposed by the European Commission when it granted a derogation to the Netherlands, permitting grassland farms to apply more nitrogen in the form of grazing livestock manure than the generally applicable standard of 170 kg of nitrogen per hectare. The purpose of the derogation monitoring network is to monitor the effects of this derogation on agricultural practices and water quality. 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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Arno Hooijboer, Tanja de Koeijer, Henri Prins, Astrid Vrijhoef, Leo Boumans and Co Daatselaar

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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 per hectare per year. The Netherlands has been granted an exemption from this obligation by the European Commission (hereinafter 'derogation'). This derogation has been granted to farms cultivating at least 80% of their total area as grassland. Farms on sandy and loessial soils in the provinces of Overijssel, Gelderland, Utrecht, Noord-Brabant and Limburg are permitted to apply up to 230 kg of nitrogen per hectare in the form of grazing livestock manure. Farms on other soils and on sandy soils in other provinces may apply up to 250 kg of nitrogen per hectare. The conditions attached to this derogation 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. This report describes the organisation of the monitoring network and the monitoring results for 2015.

Derogation monitoring network
The derogation monitoring network was set up by expanding the Minerals Policy Monitoring Programme (of RIVM and Wageningen Economic Research). A stratified random sampling method was used to select the 300 farms, distributed as evenly as possible according to soil type region (Sand Region, Loess Region, Clay Region and Peat Region), farm type (dairy farms and other grassland farms), and economic size. Of these 300 farms from the monitoring network, 288 actually made use of the derogation in 2015. On 273 farms, the nutrient flows were analysed in addition to collecting economic data. Apart from data on agricultural practices and water quality in 2015, this report also presents data on water quality in 2016, as this information relates to agricultural practices in 2015.

Agricultural practices in 2015
In 2015, the farms in the derogation monitoring network applied an average of 238 kg of nitrogen from livestock manure per hectare of cultivated land. Factoring in the statutory availability coefficients, the average quantity of plant-available nitrogen from livestock manure per hectare amounted to 116 kg of nitrogen. In addition, an average of 131 kg of nitrogen per hectare was applied in the form of inorganic fertilisers. At 248 kg per hectare, the total use of plant-available nitrogen was 26 kg below the total nitrogen application standard (274 kg per hectare on average).

At 80 kg per hectare, phosphate use was 4 kg below the average phosphate application standard for farms in the derogation monitoring network (84 kg per hectare).

The average nitrogen surplus on the soil surface balance (i.e. the net nitrogen input to the soil) in 2015 was calculated at 161 kg per hectare.

The Peat Region had the highest nitrogen surplus (as nitrogen mineralisation from peat is included in the surplus), followed by the Loess Region, the Clay Region, and the Sand Region in that order. On average, the phosphate surplus on the soil surface balance was 2 kg of phosphate per hectare.

Agricultural practices during the 2006-2015 period
The number of hectares of cultivated land per derogation farm increased over the 2006-2015 period. The quantity of milk produced per farm also increased over the same period, by 5% per year. This increase was due to an increase in the number of dairy cows; the milk production per dairy cow remained fairly constant.

Between 2006 and 2015, the proportion of intensive livestock farms (for example farms that keep pigs and poultry) granted derogation gradually decreased but remained stable over the last three years. This is also true for the phosphate production per hectare from intensive livestock. However, the total phosphate production per hectare in 2015 was higher than in previous years. These trends point to a steady increase in scale as well as intensification of milk production and specialisation in the dairy farming sector.

The average proportion of grassland on derogation farms increased from 83% in 2006 to 87% in 2015. During this period, the proportion of farms with grazing decreased from 89% to 76%.

Since 2006, the average quantity of nitrogen applied in the form of livestock manure has ranged from 232 kg to 242 kg of nitrogen per hectare. The statutory availability coefficient for nitrogen in livestock manure has gradually been increased, resulting in a rise in the total use made of the allowable plant-available nitrogen from livestock manure.

In 2014, the remaining margin available for the application of nitrogen (on average per farm) increased by 13 kg of nitrogen, and in 2015 it increased by an additional 2 kg of nitrogen per hectare due to an increase in the proportion of grassland, which is subject to a higher application standard than arable land, and a decrease in the proportion of farms with grazing. This additional resulting margin was not made use of. In 2015, the total release of plant-available nitrogen was 7 kg per hectare lower than in 2014, and it remained below the total application standard.

The application standard for phosphate decreased by more than 20% between 2006 and 2015. This resulted in an almost equally large decrease in the use of phosphate, particularly in the form of inorganic phosphate-containing fertilisers. Since 15 May 2014, derogation farms have been prohibited to put in inorganic phosphate-containing fertilisers.

In 2014, historically high yields of grass as well as silage maize were realised. The yields were also above-average in 2015. As a result, in 2014, the nitrogen surplus on the soil surface balance decreased by 30 kg per hectare compared to the 2006-2013 period. In 2015, the nitrogen soil surplus increased somewhat, but it was still below-average.

Over the entire period, the nitrogen soil surplus showed a decreasing trend.

In 2015, the phosphate soil surplus was 2 kg P2O5/ha, which is much lower than the average value over the 2006-2014 period.

Quality of water leaching from the root zone in 2015
In 2015, the nitrate concentrations in the water leaching from the root zone in all regions were, on average, lower than the nitrate standard of 50 mg/l (see Table 3.8).

There is a marked difference between the nitrate concentration in the water leaching from the root zone in the Sand Region with 230 kg N/ha (45 mg/l) and in the Sand Region with 250 kg N/ha (26 mg/l). This can be explained by the higher proportion of drier soils in the southern provinces (Sand-230) as well as the presence of reclaimed peat soils in the northern provinces (Sand-250). The nitrate concentration in the Loess Region (42 mg/l) is comparable to that in Sand-230.

The lowest nitrate concentrations in the water leaching from the root zone were measured in the Clay Region (22 mg/l) and the Peat Region (13 mg/l). This is due to the higher rate of nitrate decomposition in these regions as a result of soils that are wetter and richer in organic content.

Although the average nitrate concentration was below the EU standard of 50 mg/l, individual farms can exceed the standard. In Sand-230, 39% of the farms sampled had a nitrate concentration in the water leaching from the root zone that were higher than 50 mg/l; in Sand-250, this was true of 15% of the farms. In the Clay Region (14%) and the Peat Region (7%), there were also farms where the concentrations measured exceeded the EU standard.

The highest phosphorus concentrations in water leaching from the root zone were measured in the Peat Region (0.35 mg P/l), followed by the Clay Region (0.25 mg P/l). The phosphorus concentration in Sand-250 (0.19 mg P/l) was somewhat higher than in Sand-230 (0.11 mg P/l). The average phosphor concentration in the Loess Region was below the detection limit.

Water leaching from the root zone from 2007 up to and including 2016
The nitrate concentrations in the water leaching from the root zone in all the regions, with the exception of the Peat Region, decreased over the entire measuring period. The nitrate concentration in the Peat Region was stable and low throughout the entire measuring period.

The nitrate concentrations in the water leaching from the root zone in the Peat Region, Clay Region, and Sand-250 were lower than 50 mg/l throughout the entire measuring period. In 2014, the nitrate concentrations in the Loess Region and Sand-230 were approximately 50 mg/l; in 2015, nitrate concentrations below 50 mg/l were observed in both regions for the first time. In Sand-230, this decreasing trend continued into 2016; the results over 2016 for the Loess Region are not yet available.

During the measurement period, phosphorus concentrations in water leaching from the root zone decreased in the Clay Region and Peat Region, and remained stable in the other regions.

Relationship between agricultural practices and water quality
In the 2006-2015 period, the average nitrogen soil surpluses over all the regions showed a decreasing trend, with an average annual decrease of 3 kg N/ha. The nitrate concentration decreased in all regions, with the exception of the Peat Region (where the average nitrate concentration is well below 50 mg/l). This meets the expectation that a decrease in soil surpluses results in lower nitrate concentrations. The increasing proportion of grassland and the decrease in grazing intensity could also result in a small decrease in the nitrate concentration.

Due to the decreasing use of inorganic fertilisers, the phosphate surplus on the soil surface balance displayed a downward trend in the 2006-2015 period. The phosphorus concentrations in water leaching from the root zone in the Clay Region and Peat Region also decreased during the measurement period.

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 (hereinafter 'derogation'). In December 2005, the European Commission issued the Netherlands a derogation decision for the 2006-2009 period (EU, 2005). In February 2010, the derogation decision was extended until the end of 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 for the period until December 2017 (EU, 2014). Stricter derogation conditions apply during this period. 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. Farms on sandy and loessial soils in the provinces of Overijssel, Gelderland, Utrecht, Noord-Brabant and Limburg are permitted to apply up to 230 kg of nitrogen per hectare in the form of livestock manure originating from grazing livestock. As of 15 May 2014, farms participating in the derogation scheme are no longer permitted to import phosphate-containing fertilisers.

1.2 Fulfilment of obligations, approach, and scope

The present report compiled by RIVM and Wageningen Economic Research, together with the Netherlands Enterprise Agency report (2017), fulfils the following obligations under the latest derogation decision (2014):

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 up by the competent authority and shall be updated every year.

This obligation is fulfilled in the additional Netherlands Enterprise Agency report (2017).

8.2 A monitoring network for sampling of soil water, streams and shallow groundwater shall be established and maintained at derogation monitoring sites.

8.3 The monitoring network, corresponding to at least 300 farms benefiting from individual derogations, shall be representative of all soil types (clay, peat, sandy, and sandy loessial soils), fertilisation practices and crop rotations. The composition of the monitoring network shall not be modified during the period of applicability of this Decision.

This obligation is complied with as the derogation monitoring network has been incorporated into the Minerals Policy Monitoring Programme. The set-up of the derogation monitoring network is described in Chapter 2.

8.4 Surveys and continuous nutrient analyses 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 230 kg or up to 250 kg of nitrogen in the form of manure from grazing livestock is applied per hectare per year.

This obligation is complied with via this monitoring report, in which 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.

8.5 The monitoring network, including shallow groundwater, soil water, drainage water and streams on farms belonging to the monitoring network, shall provide data on nitrate and phosphorus concentrations in water leaving the root zone and entering the groundwater and surface water system.

This obligation is complied with via this monitoring report, in which 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.

8.6 Reinforced water monitoring shall address agricultural catchments in sandy soils.

This obligation is complied with as the geographical distribution of the derogation monitoring network is such that 160 of the 300 targeted 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 230 kg or 250 kg of nitrogen per hectare per year from grazing livestock manure on farms with at least 80% grassland, compliance with total nitrogen and phosphate application standards, and compliance with conditions on land use. Where the control carried out by the national authorities demonstrate that the conditions stated in Articles 5 and 6 are not fulfilled, the applicant shall be informed thereof. In this instance, the application shall be considered to be refused.

9.2 A programme of inspections shall be established on a risk basis and with appropriate frequency, taking account of results of controls in previous years, results of general random controls of *compliance with legislation implementing Directive 91/676/EEG, and any information that might indicate non-compliance. Administrative inspections with regard to land use, livestock numbers and manure production shall address at least 5% of farms benefiting from an individual derogation under this Decision. Field inspections shall be carried out on at least 7% of farms benefiting from an individual derogation under this Decision, in order to verify compliance with the conditions set out in Article 5 and 6 of this Decision.*

9.3 The competent authorities shall be granted the necessary powers and means to verify compliance with a derogation granted under this Decision.

The results of these controls are included in the Netherlands Enterprise Agency derogation report (2017).

Article 10 Reporting

10.1 The competent authorities shall submit to the Commission every year by March a report containing the following information:

- *(a) Data related to fertilisation on all farms which benefit from an individual derogation, including information on yields and on soil types;*
- *(b) Trends in livestock numbers for each livestock category in the Netherlands and on 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 the national level;*
- *(e) Maps showing the percentage of farms, percentage of livestock and percentage of agricultural land covered by individual derogation in each municipality, as referred to in Article 8 (1);*
- *(f) The results of water quality monitoring, including information on water quality trends for ground and surface water, as well as the impact of derogation on water quality*
- *(g) Information on nitrate and phosphorus concentrations in water leaving the root zone and entering the groundwater and surface water system as referred to in Article 8 (5) and the results of reinforced water quality monitoring in agricultural catchments on sandy soils as referred to in Article 8 (6);*
- (*h) The results of surveys on local land use, crop rotations and agricultural practices, and the results of model-based calculations of the magnitude of nitrate and phosphorus losses on farms benefiting from an individual derogation, as referred to in Article 8 (*4*);*
- *(i) An evaluation of the implementation of the derogation conditions, on the basis of controls at farm level and information on non-compliant farms, on the basis of the results of the administrative controls and field inspections, as referred to in Article 9.*

The present report may be regarded as the report referred to in Article 10 as cited above. Details of controls and instances of non-compliance are presented in the Netherlands Enterprise Agency derogation report

(2017). In consultation with the European Commission, these reports are submitted in June, as was the case for previous years.

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 information on the average use of fertiliser on all derogation farms in the Netherlands according to data from the LMM and Netherlands Enterprise Agency. Differences between both these sources can occur as a result of differences in their underlying goal and the specific population of farms involved. The obligation referred to in Article 10 (1) (d) is fulfilled in the Netherlands Enterprise Agency report (2017). Section 3.1.1 specifies the use of nitrogen in manure and fertilisers by crop and soil type.

10.2 The spatial data contained in the report shall, where applicable, fulfil the provisions of Directive 2007/2/EC. In collecting the necessary data, the Netherlands makes use, where appropriate, of the information generated under the Integrated Administration and Control System established pursuant to Chapter II of Title V of Regulation (EU) no. 1306/2013.

The Commission asked an additional question regarding the number of farms that have been granted a once-only exemption from the condition that at least 20% of the farmland must consist of grassland in connection with serious damage caused by mice. This question is answered in Appendix 6.

1.3 Previously published reports and contents of this report

This is the 11th annual report setting out the results of the derogation monitoring network. This report presents information on the use of fertiliser, 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 from 2008 up to and including 2010. 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; Lukács *et al.*, 2015 and 2016). 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 (see 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 2015. This chapter also contains the provisional water quality monitoring results for 2016 (see section 3.2.4).

Chapter 4 describes developments related to agricultural practices and water quality. This includes a discussion of trend-based changes since the start of the derogation scheme as well as an analysis of the extent to which the last year 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, the extension of the derogation granted in 2010, and the new derogation decision of May 2014 (refer to section 1.2). Previous reports provided extensive information 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 the LMM 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 usage 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, 2014). The acreage of agricultural land in the Loess Region accounts for approx. 1.5% of all agricultural land in the Netherlands, while the acreage in the Clay Region accounts for approx. 41% and the Peat Region for approx. 10.5%.

As of 2014, the data reported about agricultural practices in the Sand Region makes a distinction according to the maximum derogation which may be applied for by farms. Farms on sandy soils and loess soils in the provinces of Overijssel, Gelderland, Utrecht, Noord Brabant and Limburg may apply up to 230 kg of nitrogen per hectare in the form of grazing livestock manure. Farms on other soils and on sandy soils in other provinces may apply up to 250 kg of nitrogen per hectare per year in the form of grazing livestock manure. In this report, the Sand Region is further divided into two sub-regions called 'Sand-230' and 'Sand-250'. The Sand-230 sub-region is defined as the part of the Sand Region located in the provinces mentioned above. The Sand-250 sub-region is defined as the other part of the Sand Region (also see Figure A1.1 in Appendix 1). Consequently, farms in the Sand-230 sub-region are permitted to apply up to 230 kg N/ha in the form of grazing livestock manure. If a farm also has one or more fields on peat or clay soil, it can apply up to 250 kg N/ha in the form of grazing livestock manure on these fields.

In addition, farms participating in the derogation monitoring network that also participate in the 'Koeien en Kansen' (Cows and Opportunities) project are treated differently. 'Koeien en Kansen' (K&K) is a research project in which the effects of the future manure policy are investigated. A total of 15 K&K farms also participate in the derogation monitoring network. K&K farms that are located in the Loess Region or in Sand-230 may also apply 250 kg/ha of grazing livestock manure on plots with sand and loess soils. A total of 7 K&K farms located in the 230 kg/ha area have been given an additional increase in the grazing livestock manure standard to a maximum of 250 kg N/ha. One K&K farm is located in the Loess Region.

2.2 Statistical method used to determine deviations and trends

Determination of deviations in the measurement year under consideration

A statistical analysis was carried out to determine whether the values measured in the year under consideration deviated significantly from the average values measured in previous 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 Linear Mixed Effect Procedure within R.

Calculations were made using unweighted annual farm averages. In other words, 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 subsequently estimated as a so-called 'fixed effect', taking into account the fact that some data were 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). How estimates are made with such models is explained by Welham *et al*. (2004).

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. see 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 occurring during the measurement period. The REML method with annual groups was used for this purpose as well. In the descriptive text, only significant trend changes (p <0.05) will be discussed.

2.3 Water quality and agricultural practices

The water quality levels measured on the basis of nitrate concentration 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 the size and fluctuation of the precipitation surplus during that year. The local hydrological circumstances also have an effect. 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. 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 drains. The 'High Netherlands' comprises the other parts of the Sand Region, and the Loess Region. This difference in hydrological conditions (rate of leaching) also explains the different sampling methods and sampling periods employed in the Low Netherlands and High Netherlands (see Appendix 3).

In the Low Netherlands, water quality is determined in the winter season (November until April) following the year (the growing season) in which the agricultural practices were determined. 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 2015 can be related to agricultural practices in 2014 (see Table 2.1). Water quality samples for measurement year 2015 were taken during the winter of 2014/2015 in the Low Netherlands, and during the summer and autumn of 2015 in the High Netherlands.

The present report also includes water quality sampling results for measurement year 2016, which can be related to agricultural practices in 2015 (see Table 2.1). These water samples were taken in the winter of 2015-2016 in the Low Netherlands, and in the summer of 2016 in the High Netherlands. The results for the Loess Region from sampling carried out in the autumn of 2016 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 in 2016. The final figures will be reported in 2018, at which time the 2016 data for the Loess Region will also be available and finalised.

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

Reporting	Agricultural practices	Water quality[2]		
		Clay and Peat	**Sand**	**Loess**
Lukács *et al*., 2016	2014	2013/2014 final, 2014/2015 provisional	2014 final, 2015 provisional	2014/2015 final, 2015/2016 not available
Hooijboer *et al*., 2017[1]	2015	2014/2015 final, 2015/2016 provisional	2015 final, 2016 provisional	2015/2016 final, 2016/2017 not 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.

The nitrate concentrations are compared to the EU standard of 50 mg/l. This standard applies to groundwater and, strictly speaking, not to soil moisture, i.e. to water present in soil that is not saturated. Almost all measurements of water leaching from the root zone in the Loess Region and a limited number of measurements in the Sand region apply to nitrate concentrations in soil moisture. This is because the groundwater (i.e. the water-saturated zone) at these locations is found at great depths, often tens of metres below surface level. This groundwater is therefore not representative of the water leaching from the root zone in farms.

2.4 Number of farms in 2015

2.4.1 Number of farms where agricultural practices were determined

The derogation monitoring network is a fixed monitoring network. Nevertheless, 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 due to the presence on the farm of animals owned by third 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. In these cases, however, water quality samples have been taken.

Agricultural practices were successfully registered at 292 of the 300 planned farms (see Table 2.2). Of these 292 farms, 288 actually participated in the derogation scheme. Eighteen farms that participated in the derogation monitoring network in 2014 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 2015 (agricultural practices)

Farm type	**Planned/Actual**	**Sand 250**	**Sand 230**	**Loess**	**Clay**	**Peat**	**Total**
Dairy farms	Planned	140		17	52	52	261
	Actual:						
	- Of which were processed	50	87	18	53	53	261
	- Of which participated in the derogation scheme	50	85	17	53	53	258
	- Of which submitted complete nutrient flow data	50	82	17	53	52	254
Other grassland farms	Planned	20		3	8	8	39
	Actual:						
	- Of which were processed	1	17	2	5	6	31
	- Of which participated in the derogation scheme	0	17	2	5	6	30
	- Of which submitted complete nutrient flow data	0	8	2	4	5	19
Total	Planned	160		20	60	60	300
	Actual:						
	- Of which were processed	51	104	20	58	59	292
	- Of which participated in the derogation scheme	50	102	19	58	59	288
	- Of which submitted complete nutrient flow data	50	90	19	57	57	273

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

- The description of general farm characteristics (see section 2.6) concerns all farms that could be fully processed in FADN in 2015 and that participated in the derogation scheme (288 farms).
- The description of agricultural practices in 2015 (see section 3.1) concerns all farms for which a full picture of nutrient flows could be obtained from FADN data (273 farms).
- The comparison of agricultural practices in the 2006-2015 period (see 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 2015, the water quality was sampled on 301 farms (see Table 2.3). Of these 301 farms, 283 participated in the derogation monitoring network in 2015. The difference in 18 farms is caused by changes in the derogation monitoring network. As a result, samples were taken at a number of farms that later dropped out for measurement year 2015. The farms that dropped out were, however, used to determine trends in water quality. Furthermore, 4 farms out of the 283 farms in the derogation monitoring network that were sampled did not make use of the derogation or were not granted derogation. The water quality sampling results of the remaining 279 sampled farms are presented in this report.

Table 2.3: Planned and actual number of analysed dairy and other grassland farms per region in 2015 (water quality)

Farm type	Planned/Actual	Sand 230	Sand 250	Loess	Clay	Peat	Total
Dairy farms	Planned	140		17	52	52	261
	Actual:						
	- Sampled	92	50	17	54	52	265
	- Derogation monitoring network 2015[1]	83	48	16	52	51	250
	- Participated in derogation scheme	81	47	15	52	51	246
Other grassland farms	Planned	20		3	8	8	39
	Actual:						
	- sampled	17	1	4	8	6	36
	- Derogation monitoring network 2015[1]	16	1	3	7	6	33
	- Participated in derogation scheme	16	1	3	7	6	33
Total	Planned	160					
	Actual:						
	- sampled	109	51	21	62	58	301
	- Derogation monitoring network 2015[1]	99	49	19	59	57	283
	- Participated in derogation scheme	97	48	18	59	57	279

[1] Samples are often taken at farms before the composition of the derogation monitoring network is known (and 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 2015 (see section 3.2) concerns all farms where water quality samples were taken in 2015 and that were granted derogation in 2015 (279 farms).
- The description of the water quality results for measurement year 2016 (see section 3.2.4) concerns all farms participating in the derogation monitoring network in 2015 (except farms in the Loess Region) where water quality samples were taken in measurement year 2016 (277 farms).

- The analysis of water quality levels during the period from 2007 up to and including 2016 (see 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 were granted derogation in that previous year. This number varies from year to year (see Table 2.4).

Table 2.4: Number of farms per year that was used for determining trends in water quality; these farms were granted derogation in the year preceding the relevant measurement year

Year	Number of farms
2007	279
2008	280
2009	281
2010	280
2011	282
2012	278
2013	297
2014	289
2015	288
2016	277

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

Table 2.5: Number of farms that were sampled and reported on per sub-programme and per region for 2015 and 2016, and the sampling frequency of the leaching water and ditch water rounds; the targeted sampling frequency is shown between parentheses

Year		Sand		Loess	Clay	Pea	Total
		250	230				
2015	Number of farms	97	48	18	59	57	279
	Number of farms – Leaching water	97	48	18	59	57	279
	Number of rounds - Leaching water	1.0	1.0	1.0	3.4	1.0	
		(1)	(1)	(1)	(2-4)[1]	(1)	
	Number of farms – Ditch water	16	12	-	58	56	
	Number of rounds - Ditch water	4.2	4.2	-	4.0	4.0	
		(4)	(4)		(4)	(4)	
2016	Number of farms	108	52	-[2]	60	60	280
	Number of farms – Leaching water	108	52	-	60	59	279
	Number of rounds - Leaching water	1.0	1.0	-	3.4	1.0	
		(1)	(1)		(2-4)	(1)	
	Number of farms – Ditch water	17	12	-	59	59	
	Number of rounds - Ditch water	3.9	4.0	-	4.0	4.0	
		(4)	(4)		(4)	(4)	

[1] In the Clay Region, groundwater is sampled up to two times, and drain water is sampled 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.
[2] The autumn 2016 data for the derogation farms in the Loess Region were not yet available when this report was being prepared.

2.5 Representativeness of the sample of farms

In 2015, 288 farms participating in the derogation monitoring network were known to have registered for derogation. These farms had a combined total acreage of 16,718 hectares (accounting for 2.1% of all agricultural land on grassland farms in the Netherlands; see Table 2.6). The sample represents 88% of the farms and 98% of the acreage of all farms that registered for derogation in 2015 and that satisfied the LMM selection criteria (refer to Appendix 1). Farms not included in the sample population which did register for derogation were mainly other grassland farms with a size of less than 25,000 Standard Output (SO) units.

Section 2.1 explains that the Sand Region has been subdivided into the 'Sand-250' and 'Sand-230' sub-regions starting in 2014. Although this distinction has not been taken into account in the selection of farms, Table 2.6 shows that the representativeness of the sample in both sand regions is not jeopardised. In 2015, in both regions, 3.0% and 1.8%, respectively, of the area of cultivated land covered by the derogation was included in the sample. That percentage amounts to 2.1% for the entire derogation monitoring network.

Furthermore, in all regions the proportion of sampled to total acreage is greater on dairy farms than on other grassland farms. This is because, 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 it contains relatively few farms compared to the larger regions. Because the study requires a minimum number of observations per region, a relatively large number of farms from the Loess Region (20.4%) has been included in the derogation 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 2015 in the sample population, according to the 2015 Agricultural Census

Region	Farm type	Sample population [1]	Derogation monitoring network	
		area (hectares)	area (hectares)	Percentage of acreage of total sample population
Sand 250	Dairy farms	113074	3708	3.3%
	Other grassland farms	8723	0	0.0%
	Total	121797	3708	3.0%
Sand 230	Dairy farms	225442	4116	1.8%
	Other grassland farms	33629	476	1.4%
	Total	259071	4591	1.8%
Loess	Dairy farms	4024	893	22.2%
	Other grassland farms	531	35	6.6%
	Total	4555	928	20.4%
Clay	Dairy farms	242308	3256	1.3%
	Other grassland farms	25198	154	0.6%
	Total	267506	3410	1.3%
Peat	Dairy farms	137548	3858	2.8%
	Other grassland farms	13742	223	1.6%
	Total	151290	4081	2.7%
Total	Dairy farms	722396	15830	2.2%
	Other grassland farms	81823	888	1.1%
	Total	804218	16718	2.1%

[1] Estimate based on the 2015 Agricultural Census performed by Statistics Netherlands, (data processed by Wageningen Economic Research). 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 registered for derogation in 2015 had an average of 58 hectares of cultivated land, of which 87% consisted of grassland. The average livestock density was 2.5 Phosphate Livestock Units (LSUs) per hectare (see Table 2.7). Farm data derived from the 2015 Agricultural Census have been included for purposes of comparison, in so far as these farms are 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 (see 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 farm characteristics in 2015 of farms participating in the derogation monitoring network (DMN), compared to average values for the Agricultural Census (AC) sample population

Farm characteristics[1]	Population	Sand 250	Sand 230	Loess	Clay	Peat	Total
Number of farms in DMN	DMN	50	102	19	58	59	288
Grassland area (hectares)	DMN	61	37	40	52	62	50
	AC	50	33	34	49	46	42
Area used to cultivate silage maize (hectares)	DMN	11	7.9	8.0	6.2	7.0	8.0
	AC	7.4	5.8	5.6	4.3	3.2	5.1
Other arable land (hectares)	DMN	1.5	0.3	0.9	0.5	0.4	0.6
	AC	0.3	0.3	0.8	0.6	0.2	0.4
Total area of cultivated land (hectares)	DMN	74	45	49	59	69	58
	AC	58	39	41	54	50	48
Percentage of grassland	DMN	84	83	83	90	92	87
	AC	88	85	85	92	95	89
Natural habitats (hectares)	DMN	2.3	0.5	1.3	3.3	1.0	1.5
	AC	1.7	0.9	2.2	1.8	1.8	1.5
Grazing livestock density (Phosphate LSUs/ per hectare) [2]	DMN	2.2	2.7	2.6	2.4	2.2	2.5
	AC	2.0	2.6	2.5	2.2	2.1	2.3
Percentage of intensive livestock farms	DMN	0	12	5	2	5	6
	AC	2	10	2	3	3	6
Grazing livestock density (Phosphate LSUs/ha)[2]							
Dairy cattle (including young livestock) (Phosphate LSUs/ per hectare)[2]	DMN	2.2	2.6	2.4	2.3	2.1	2.4
Other grazing livestock (Phosphate LSUs/ per hectare)[2]	DMN	0.02	0.1	0.2	0.1	0.1	0.1
Intensive livestock (total) Phosphate LSUs/ per hectare)[2]	DMN	0.00	1.4	0.0	0.1	0.2	0.5
All animals (Phosphate LSUs/ per hectare)[2]	DMN	2.2	4.1	2.6	2.5	2.4	3.0

Source: Statistics Netherlands Agricultural Census 2015, data processed by Wageningen Economic Research 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, as 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 compared to the FADN. It is not clear whether this is actually the case, as the average for the farms participating in the derogation monitoring network is not a weighted average as opposed to the average for the FADN, which means that the comparison is not all that clear-cut. A similar comparison could not be carried out for the Loess Region due to an insufficient number of FADN-registered farms.

The monitoring results are generally calculated per unit of surface area. It is therefore likely that a farm's size has little or no influence on the results. The average milk production per hectare 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 2015, compared to the weighted average for dairy farms in the national FADN sample

Farm characteristics	**Population**	**Sand**		**Loess**	**Clay**	**Peat**	**Total**
		250	**230**				
Number of farms in DMN	DMN	50	85	17	53	53	258
kg FPCM[1]/farm (x1,000 kg)	DMN	1,123	989	910	1,022	1,172	1,054
	FADN	892	790		984	808	837
FPCM production in kg [1]per hectare of fodder crop	DMN	15,900	20,100	17,700	17,000	15,700	17,600
	FADN	14,800	19,000		16,300	14,400	16,700
FPCM production in kg[1] per dairy cow	DMN	8,800	8,900	8,600	8,600	8,500	8,700
	FADN	8,800	8,900		8,600	8,500	8,700
Percentage of farms with grazing in May-October period	DMN	90	69	76	77	72	76
	FADN	79	72		75	79	76
Percentage of farms	DMN	90	68	76	77	72	76
with grazing in May-June period	FADN	79	70		75	79	75
Percentage of farms	DMN	90	68	76	77	72	76
with grazing in July-August period	FADN	79	72		75	79	75
Percentage of farms	DMN	90	67	76	75	68	74
with grazing in September-October period	FADN	79	70		72	75	73

[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 further divided into districts (see Appendix B1.6). Table 9 makes a distinction between dairy farms and other grassland farms.

Table 2.9: Distribution of the 283 grassland farms where water quality samples were taken in 2015 and that were selected for the derogation monitoring network in that year, over the different soil type regions and the districts for policy-making purposes

Soil type regions and districts for policy-making purposes	Dairy farms	Other grassland farms	Total
Sand-230	**83**	**16**	**99**
• Sand Region – Central	60	13	73
• Sand Region – South	23	3	26
Sand-250	**48**	**1**	**49**
• Sand Region – North	41	1	42
• Sand Region – Central	2[1]	0	2
• Sand Region – South	4[1]	0	4
• Sand Region – West	1	0	1
Clay Region	**52**	**7**	**59**
• Marine Clay – North	23	4	27
• Marine Clay – Central	10	0	10
• Marine Clay – South-West	4	0	4
• River Clay	15	3	18
Peat Region	**51**	**6**	**57**
• Peatland Pastures – West	27	3	30
• Peatland Pastures – North	24	3	27
Loess Region	**16**	**3**	**19**

[1]These are farms that participate in the 'Cows and Opportunities' (K&K) project. Regardless of the region or soil type, these farms are allowed to apply up to 250 kg N/ha from grazing livestock manure.

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 Sand Region consists mostly of soils with good drainage, but the derogation farms are located on relatively less well-drained soils in the Sand Region. Traditionally, the best soils (with favourable drainage conditions and nutrient status) were used for arable farming, while poorer (e.g.

wetter) soils were used for dairy farming. In addition, the driest soils in the Sand Region are generally not used for agriculture. Wetter sandy soils are therefore over-represented in the derogation monitoring network.

On average, the farms in Sand-230 are located more on sandy soil (86%) than the farms in Sand-250 (81%). The farms in Sand-230 are on average also located more on clay soil. The farms in Sand-250 are located somewhat more on peat soil and wetland soil. The farms in Sand-230 are located more on well-drained soils as well as on poorly drained soils. Compared to the farms in Sand-230, the farms in Sand-250 are found more frequently on moderately drained soils.
The differences with respect to soil type and drainage class between 2015 and the provisional figures for 2016 are minimal (see Table 2.10 and Table 2.11). The figures for 2016 are provisional, as it was not yet known which farms actually made use of the derogation when this report was released.

Table 2.10: Soil type and drainage class (%) per region on the derogation farms sampled in 2015

Region	Soil types				Drainage class[1]		
	Sand	Loess	Clay	Peat	Poor	Moderate	Good
Sand-250	81	0	4	16	38	57	4
Sand-230	86	0	10	4	44	43	13
Loess Region	0	77	23	0	1	3	96
Clay Region	7	0	91	3	45	49	6
Peat Region	15	0	24	61	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: Soil type and drainage class (%) per region on farms from the derogation monitoring network sampled in 2016

Region	Soil types				Drainage class[1]		
	Sand	Loess	Clay	Peat	Poor	Moderate	Good
Sand-250	81	0	3	16	38	57	5
Sand-230	87	0	9	4	44	42	13
Loess Region	*	*	*	*	*	*	*
Clay Region	7	0	91	3	45	49	6
Peat Region	15	0	24	61	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.
* Results from the Loess Region were not yet available at the time the present report was being prepared.

3 Results

3.1 Agricultural characteristics

3.1.1 Nitrogen use in livestock manure

In 2015, the average use of nitrogen in livestock manure on derogation farms amounted to 238 kg/ha (including manure excreted during grazing). In Sand-250, the average amount of nitrogen used from livestock manure was less than in the other regions, namely 231 kg N/ha. The average amount of nitrogen used from livestock manure was highest in the Clay Region: 250 kg N/ha (see Table 3.1). In all regions, less nitrogen from livestock manure was applied on arable land (mainly land used for cultivation of silage maize) than on grassland. The farms in the derogation monitoring network both put in and put out livestock manure. As average manure production exceeded the permitted use, the average manure output exceeded the input (including stock changes). This was true of all regions (see Table 3.1).

Table 3.1: Average nitrogen use in livestock manure in the different regions (in kg of nitrogen per hectare) in 2015 on farms participating in the derogation monitoring network

Description	**Sand**		**Loess**	**Clay**	**Peat**	**Total**
	250	**230**				
Number of farms	50	90	19	57	57	273
Produced on farm[1]	260	332	287	297	274	296
+ Inputs	7	4	3	8	6	6
+ stock changes[2]	-6	-14	6	-6	-3	-7
– Outputs	31	89	56	49	39	57
Total amount used on farm	231	234	240	250	237	238
Use on arable land[3, 4]	185	197	192	167	216	192
Use on arable land[3, 5]	240	243	251	261	241	246

[1] Calculated on the basis of standard quantities (*N*=117) with the exception of dairy farms that stated they were using the guidance document on farm-specific excretion by dairy cattle (*N*=156) (see Appendix 2).
[2] A negative change in stocks is a stock increase.
[3] The average use data for grassland and arable land is based on 265 farms and 198 farms, respectively, instead of on 273 farms. This is because on 8 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 67 farms had no arable land.
[4] The figures concerning 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.

The average quantity of nitrogen in livestock manure produced in the Sand-230 sub-region exceeded the average quantity in the Sand-250 sub-region by 72 kg of nitrogen per hectare. This difference was largely compensated by a higher net nitrogen output in manure. The average quantities of nitrogen applied on arable land and on grassland differed little between both sub-regions. Approximately one out of every six farms in the derogation monitoring network did not put in or put out livestock manure (see Table 3.2). A similar number of farms only put in livestock manure, but did not put it out. These farmers probably put in nutrients in livestock manure because this offered economic benefits compared to using inorganic fertilisers. This may also apply to the farmers who both put in and put out livestock manure (9%). The percentage of derogation farms that only put out manure increased from 55% in 2014 to 61% in 2015. This rise is due to the fact that the nitrogen production increased as a result of a higher milk production per hectare, which in turn led to more farms with a surplus of manure.

Table 3.2: Average percentage of farms participating in the derogation monitoring network with livestock manure inputs and/or outputs in 2015

Description	**Sand**		**Loess**	**Clay**	**Peat**	**Total**
	250	**230**				
No inputs or outputs	11	11	25	18	25	16
Only outputs	53	73	65	60	47	61
Only inputs	26	11	5	14	12	14
Inputs and outputs	9	4	5	9	16	9

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 2015. In Sand-250, Sand-230, and the Loess Region, the average use of nitrogen-containing fertilisers was closer to the nitrogen application standard than in the Clay Region and the Peat Region (see Table 3.3).

Table 3.3: Average use of nitrogen in fertilisers (in kg of plant-available N/ha)[1] on farms participating in the derogation monitoring network in 2015

Description	**Item**	**Sand**		**Loess**	**Clay**	**Peat**	**Total**
		250	**230**				
Number of farms		50	90	19	57	57	273
Average statutory availability coefficient for livestock manure (%)[1]		47	49	48	49	50	49
fertiliser usage	Livestock manure	109	113	116	123	120	116
	Other organic fertilisers	0	0	0	2	1	0
	Inorganic fertilisers	118	129	115	155	127	131
	Total quantity of nitrogen	228	242	231	280	248	248
Nitrogen application standard		247	252	251	328	287	274
Use of plant-available nitrogen on arable land[2,3]		120	128	132	137	143	130
Application standard for arable land[2]		149	136	121	158	161	145
Use of plant-available nitrogen on arable land[2,4]		250	265	259	298	259	268
Application standard for arable land[2]		266	276	280	348	298	294

[1] Calculated on the basis of the applicable statutory availability coefficients (see Appendix 2).
[2] The average use data for grassland and arable land is based on 265 farms and 198 farms, respectively, instead of on 273 farms. This is because on 8 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 67 farms had no arable land.
[3] The figures concerning 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 2015, the average total use of phosphate on farms participating in the derogation monitoring network was lower than the application standard of 84 kg of phosphate per hectare (see Table 3.4). On average, 80 kg of phosphate was applied per hectare, of which 79 kg via livestock manure. Since 15 May 2014, it has been prohibited to put in inorganic phosphate-containing fertilisers to derogation farms. Consequently, any inorganic phosphate-containing fertilisers used in 2015 were purchased before 15 May 2014.

Table 3.4: Average use of phosphate in fertilisers (in kg of P_2O_5//ha) in 2015 on farms participating in the derogation monitoring network in 2015

Description	**Item**	**Sand**		**Loess**	**Clay**	**Peat**	**Total**
		250	**230**				
Number of farms		50	90	19	57	57	273
fertiliser usage	Livestock manure	77	76	80	85	79	79
	Other organic fertilisers	0	0	1	1	0	1
	Inorganic fertilisers	0	0	3	0	0	0
	Average total	78	77	83	86	79	80
Phosphate application standard		84	82	83	85	88	84
Use of phosphate on arable land[1,2]		63	70	75	60	75	68
Application standard for arable land[1]		59	57	56	61	64	59
Use of phosphate on arable land[1,3]		81	78	87	90	80	82
Application standard for arable land[1]		89	86	88	88	90	88

[1] The average use data for grassland and arable land is based on 265 farms and 198 farms, respectively, instead of on 273 farms. This is because on 8 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 67 farms had no arable land.
[2] The figures concerning 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 2015, the farms participating in the derogation monitoring network had an estimated average dry-matter yield of silage maize of 17,700 kg per hectare. This resulted in an estimated average yield of 192 kg of nitrogen and 32 kg of phosphorus (73 kg P_2O_5). Yields in the Clay Region, the Sand-230 sub-region and the Loess Region were slightly above the national average, while yields in the Sand-250 sub-region and the Peat Region were below the national average (see Table 3.5).

The calculated grassland yield amounted to 10,500 kg of dry matter per hectare on average. However, both the nitrogen and phosphorus yields per hectare were higher for grassland than for silage maize, due to higher nitrogen and phosphorus levels in grass. In 2015, the calculated grassland dry-matter yields were lowest in the Loess Region (see Table 3.5).

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 2015 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**
	250	**230**				
Silage maize yields						
Number of farms	44	73	14	30	27	188
kg of dry matter per hectare	17,000	17,800	19,400	18,100	17,000	17,700
kg N/ha	185	192	212	197	190	192
kg P/ha	31	32	34	33	30	32
kg P_2O_5/ha	71	73	79	76	70	73
Grassland yields						
Number of farms	49	83	15	49	50	246
kg of dry matter per hectare	10,200	10,700	9,100	10,900	10,800	10,500
kg N/ha	254	268	225	274	285	267
kg P/ha	37	39	32	39	36	37
kg P_2O_5/ha	84	89	74	88	82	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 161 kg per hectare in 2015 (see Table 3.6). 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 110 kg N/ha, whereas the surplus exceeded 200 kg N/ha on the 25% of farms with the highest surpluses (see Table 3.6).

Table 3.6: Nitrogen surpluses on the soil surface balance (in kg N/ha) on farms participating in the derogation monitoring network in 2015 (average values and 25th and 75th percentile values per region)

Description	**Item**	**Sand 250**	**Sand 230**	**Loess**	**Clay**	**Peat**	**Total**
Number of farms		50	90	19	57	57	273
Farm inputs	Inorganic fertilisers	118	129	115	155	127	131
	Livestock manure + other organic fertilisers	8	5	5	12	5	7
	Feedstuffs	172	297	220	191	182	223
	Animals	1	5	2	3	1	3
	Other	1	2	3	3	2	2
	Total	301	438	345	364	318	366
Farm outputs	Milk and other animal products	82	103	80	83	84	90
	Animals	11	38	16	19	13	22
	Livestock manure	37	103	52	56	41	64
	Other	18	19	8	21	28	20
	Total	149	263	156	179	165	197
Average nitrogen surplus per farm		152	175	189	185	153	169
+ Deposition, mineralisation and organic nitrogen fixation		45	37	36	38	120	56
- Gaseous emissions[2]		52	67	61	69	67	64
Nitrogen surplus on soil surface balance							
average[3]		145	145	164	154	206	161
25th percentile		99	102	125	110	171	110
75th percentile		176	181	196	195	243	205

[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 the method described in Appendix 2.

The average phosphate surplus on the soil surface balance was 2 kg per hectare (see Table 3.7). The 25% of farms with the lowest phosphate surpluses realised an average negative surplus of 13 kg per hectare, whereas the 25% of farms with the highest surpluses realised an average positive surplus of 17 kg per hectare.

Table 3.7: Phosphate surpluses on the soil surface balance (in kg P_2O_5 per hectare) on farms participating in the derogation monitoring network in 2015 (average values and 25th and 75th percentile values per region)

Description	Item	Sand 250	Sand 230	Loess	Clay	Peat	Total
Number of farms		50	90	19	57	57	273
Farm inputs	Inorganic fertilisers	0	0	3	0	0	0
	Organic fertilisers	4	2	2	5	2	3
	Feedstuffs	58	106	75	66	66	78
	Animals	1	3	1	2	1	2
	Other	0	1	1	1	1	1
	Total	63	111	82	74	70	84
Farm outputs	Milk and other animal products	33	41	32	33	33	36
	Animals	8	22	11	12	9	14
	Organic fertilisers	14	45	21	21	16	27
	Other	6	7	3	6	8	7
	Total	61	114	67	73	65	83
Phosphate surplus on soil surface balance:							
average[1]		2	-3	15	1	5	2
25th percentile		-14	-17	7	-10	-14	-13
75th percentile		15	10	26	20	18	17

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

3.2 Water quality

3.2.1 Water leaching from the root zone, measured in 2015 (NO_3, N and P)

In 2015, the nitrate concentration in all regions was, on average, lower than the nitrate standard of 50 mg/l (see Table 3.8).

There is a marked difference between the nitrate concentration in the water leaching from the root zone in Sand-230 (45 mg/l) and in Sand-250 (26 mg/l). This can be explained by the higher proportion of drier soils in the southern provinces. In addition, the northern provinces (Sand-250) contain more peat and reclaimed peat soils, which are associated with higher rates of denitrification.

However, strikingly, the groundwater levels measured during sampling were on average lower in Sand-250 than in Sand-230. This would seem to contradict the assumption that lower groundwater levels lead to higher rates of nitrate leaching. However, the distribution of the groundwater levels is not the same in both regions. Sand-230 has more dry soils as well as more wet soils (also see Tables 2.10 and 2.11). The quantity of dry soils in Sand-230 and the higher proportion of peat soils and wetland soils in Sand-250 probably have a greater impact on the nitrate leaching rates than do the average groundwater levels. Any differences that may exist with regard to the proportion of arable land (see section 2.7) or the nitrogen soil surplus (see section 3.7) do not play a role in explaining the higher nitrate concentrations in Sand-230.

Sand-230 contains many more of the sampled farms categorised as 'other grassland farms' (see Table 2.3) than does Sand-250. However, this does not have any consequences for the nitrate concentration beneath the root zone, as the average nitrate concentration on 'other farms' in Sand-230 does not differ from the concentration on dairy farms in Sand-230 (not presented in a figure).

The average nitrate concentration in the Peat Region was lower than in the Clay Region. The total nitrogen concentration, which also includes nitrate, was actually higher in the Peat Region than in the Clay Region. This is caused by higher ammonium concentrations in groundwater in the Peat Region. The higher ammonium concentrations are probably due to the decomposition of organic matter in peat, whereby nitrogen is released in the form of ammonium (Butterbach-Bahl and Gundersen, 2011, Van Beek *et al*., 2004).

Groundwater that is or has been in contact with nutrient-rich peat layers also 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 Sand-230, Sand-250, and the Loess Region. In addition, phosphate ions are easily adsorbed by iron and aluminium oxides and aluminium hydroxides and clay minerals, particularly under aerobic (oxygen-rich) conditions such as those occurring in the Sand Region, as a result of which these ions do not end up in the groundwater. Phosphate also readily precipitates under aerobic conditions in the form of poorly soluble aluminium, iron and calcium phosphates.

Table 3.8: Nutrient concentrations in 2015 (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 limit)

Characteristic	**Sand-250**	**Sand-230**	**Loess**	**Clay**	**Peat**
Number of farms	48	97	18	59	57
Nitrate (NO_3)	26	45	42	22	13
Nitrogen (N)	9.2	13	9.9	6.8	10
Phosphorus[1,2] (P)	0.19 (54)	0.11 (58)	<dl (83)	0.25 (19)	0.35 (12)

[1] The percentage of farms with average concentrations below the detection limit (dl) is stated in parentheses.
[2] The phosphorus concentration has been measured as the total amount of dissolved phosphorus.

In the Peat Region, the nitrate concentration in the water leaching from the root zone on 93% of the farms was lower than the nitrate standard of 50 mg/l (see Table 3.9). In Sand-250, this was true for 85% of the farms, and in the Clay Region for 86%.

The higher percentage of farms in Sand-230 and in the Loess Region with nitrate concentrations above the nitrate application standard, 39% and 28% respectively, 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 2015 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 class (mg/l)	Sand-250	Sand-230	Loess	Clay	Peat
Number of farms	48	97	18	59	57
<15	46	18	11	46	72
15-25	15	11	11	22	11
25-40	12	15	28	14	4
40-50	12	16	22	5	7
>50	15	39	28	14	7

In 2015, the farms in Sand-230 also had the highest median nitrogen concentration of all the regions; 50% of the farms in this region had a nitrogen concentration of 12 mg N/l or higher (see Table 3.10).

Table 3.10: Nitrogen concentrations in 2015 (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	Sand-250	Sand-230	Loess	Clay	Peat
Number of farms	48	97	18	59	57
First quartile (25th percentile)	5.7	8.3	6.7	3.8	7.3
Median (50th percentile)	7.6	12	9.5	5.8	8.3
Third quartile (75th percentile)	11	16	14	8.2	12

The highest median phosphorus concentration in the water leaching from the root zone was measured in the Clay Region; 50% of the farms in the Clay Region have a phosphorus concentration higher than 0.23 mg P/l (see Table 3.11).

Table 3.11: Phosphorus concentrations[1,2] (in mg P/l) in water leaching from the root zone on farms participating in the derogation monitoring network in 2015 (25th percentile, median and 75th percentile values per region)

Characteristic	Sand-250	Sand-230	Loess	Clay	Peat
Number of farms	48	97	18	59	57
First quartile (25th percentile)	<dl	<dl	<dl	0.11	0.10
Median (50th percentile)	<dl	<dl	<dl	0.23	0.20
Third quartile (75th percentile)	0.18	0.12	<dl	0.38	0.44

[1] Average values below the detection limit of 0.062 mg/l are indicated by the abbreviation <dl.

[2] The phosphorus concentration has been measured as the total amount of dissolved phosphorus.

3.2.2 *Ditch water quality measurements in 2014-2015*

Average nitrate concentrations in ditch water in the winter were highest in Sand-250 at 28 mg/l, and lowest in the Peat Region at 6.3 mg/l (see Table 3.12). Total nitrogen concentrations, too, were highest in Sand-250 (8.9 mg N/l). Similar to the results for water leaching from the root zone, the average nitrogen concentration in the Peat Region (5.2 mg N/l) was higher than in the Clay Region (4.3 mg N/l). Phosphorus concentrations in ditch water were highest in the Clay Region, and lowest in Sand-230

Table 3.12: Average ditch water nutrient concentrations (in mg/l) per region in the winter of 2014-2015 on farms participating in the derogation monitoring network

Characteristic	Sand-250	Sand-230	Loess[1]	Clay	Peat
Number of farms	12	16	*	58	56
Nitrate (NO_3)	28	24	*	11	6.3
Nitrogen (N)	8.9	8.0	*	4.3	5.2
Phosphorus[2] (P)	0.18 (33)	0.16 (56)	*	0.22 (28)	0.19 (27)

[1] There are no farms with ditches in the Loess Region.
[2] The phosphorus concentration has been measured as the total amount of dissolved phosphorus. The percentage of farms with average concentrations below the detection limit (dl) is stated in parentheses.

In Sand-230, 88% of the farms had ditch water nitrate concentrations equal to or less than 50 mg/l (see Table 3.13). All farms in the Peat Region had average ditch water nitrate concentrations below 50 mg/l.

Table 3.13: Frequency distribution (%) of farm-specific average nitrate concentrations (in mg/l) in ditch water on farms participating in the derogation monitoring network per region in the winter of 2014-2015, expressed as percentages per class

Concentration class nitrate (mg/l)	Sand-250	Sand-230	Loess	Clay	Peat
Number of farms	12	16	*	58	56
<15	42	38	*	78	88
15-25	0	19	*	12	5.4
25-40	33	25	*	8.6	7.1
40-50	17	6.2	*	0	0
>50	8.3	12	*	1.7	0

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

The highest median concentration of nitrogen was found in Sand-250. Fifty percent of the farms in Sand-250 had ditch water nitrogen concentrations equal to or higher than 8.4 mg N/l (see Table 3.14).

Table 3.14: Ditch water nitrogen concentrations (in mg N/l) on farms participating in the derogation monitoring network in the winter of 2014-2015 (25th percentile, median and 75th percentile values per region)

Characteristic	Sand-250	Sand-230	Loess *	Clay	Peat
Number of farms	12	16	*	58	56
First quartile (25th percentile)	5.1	5.0	*	2.2	3.3
Median (50th percentile)	8.4	7.8	*	3.7	4.5
Third quartile (75th percentile)	11	9.1	*	5.4	6.9

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

The highest median concentration of phosphorus was measured in Sand-250. In this region, the phosphorus concentration measured on 50% of the farms was higher than 0.15 mg P/l (see Table 3.15).

Table 3.15: Phosphorus concentrations[1,2] (in mg P/l) in ditch water in the winter of 2014-2015 on farms participating in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Characteristic	Sand-250	Sand-230	Loess*	Clay	Peat
Number of farms	12	16	*	58	56
First quartile (25th percentile)	<dl	<dl	*	<dl	<dl
Median (50th percentile)	0.15	<dl	*	0.14	0.10
Third quartile (75th percentile)	0.22	0.10	*	0.37	0.21

[1] Average values below the detection limit of 0.062 mg/l are indicated by the abbreviation <dl.
[2] The phosphorus concentration has been measured as the total amount of dissolved phosphorus.
* There are no farms with ditches in the Loess Region.

3.2.3 *Comparison of the final figures with the provisional figures for 2015*

The figures presented in this section hardly deviate from the provisional figures reported by Lukács *et al.* (2016). The minor differences are mainly caused by a number of farms having 'dropped out' because they did not make use of the derogation or were not granted derogation, or because the farms were replaced in the derogation monitoring network.

3.2.4 *Provisional figures for measurement year 2016*

At the time of writing, provisional results were available for 2016, with the exception of the Loess Region for which no results were yet available. The results are 'provisional' because it is unknown at this time which farms will be actually granted derogation for measurement year 2016. This could mean that some concentration data might be changed in the final report for 2016, which will be published in 2018.

In Sand-250, the average nitrate concentration in the water leaching from the root zone was 24 mg/l; in Sand-230, it was 37 mg/l (see Table 3.16). In Sand-230, 75% had concentrations lower than 50 mg/l; in Sand-250, that percentage was 88% (see Table 3.16).

In 2016, the average nitrate concentration in water leaching from the root zone in the Clay Region was 13 mg/l. Of the farms in the Clay Region, 97% had nitrate concentrations below 50 mg/l (see Table 3.16). The average nitrate concentration on farms in the Peat Region was 6.6 mg/l. In the Peat Region, with the exception of one farm (1.7%), all the farms had a nitrate concentration below 50 mg/l.

Table 3.16: Frequency distribution (%) 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 in 2016, expressed as percentages per class and average nitrate concentration per region

Nitrate concentration class (mg/l)	Sand-250	Sand-230	Loess*	Clay	Peat
Number of farms	52	108	*	60	59
Average concentration	24	37	*	13	6.6
<15	42	21	*	70	90
15-25	21	19	*	12	2
25-40	17	20	*	10	5
40-50	8	15	*	5	2
>50	12	25	*	3	2

* Results from the Loess Region were not yet available at the time the present report was being prepared.

In 2016, the average ditch water nitrate concentration in the Clay Region and the Peat Region amounted to 6.6 mg/l and 3.4 mg/l, respectively. These levels are well below the nitrate standard of 50 mg/l (see Table 3.17). In Sand-230, the nitrate concentration was 26 mg/l, and in Sand-250, it was 15 mg/l.

Table 3.17: Frequency distribution (%) of average ditch water nitrate concentrations (in mg/l) per farm, on farms participating in the derogation monitoring network per region in the winter of 2015-2016, expressed as percentages per class and average nitrate concentrations per region

Nitrate concentration class (mg/l)	Sand-250	Sand-230	Loess[1]	Clay	Peat
Number of farms	12	17		59	59
Average concentration	15	26		6.6	3.4
<15	67	35		90	97
15-25	17	24		2	2
25-40	8	18		7	2
40-50	8	12		2	0
>50	0	12		0	0

[1] There are no farms with ditches in the Loess Region.

The nitrogen concentration in the water leaching from the root zone was also the highest in Sand-230 (see Table 3.18). It should be noted, in this regard, that the nitrogen concentration in the water leaching from the root zone in the Peat Region was higher than in the Clay Region. This is caused by higher ammonium concentrations in groundwater in the Peat Region.

Table 3.18: Nitrogen concentrations (in mg N/l) in water leaching from the root zone, measured in 2016 on farms participating in the derogation monitoring network (average, 25th percentile, median and 75th percentile values per region)

Characteristic	Sand-250	Sand-230	Loess[1]	Clay	Peat
Number of farms	52	108	*	60	59
Average	9.0	11	*	4.9	8.4
First quartile (25th percentile)	5.5	6.9	*	2.9	6.3
Median (50th percentile)	8.1	10	*	3.8	8.3
Third quartile (75th percentile)	12	14	*	6.2	9.3

[1] Results from the Loess Region were not yet available at the time the present report was being prepared.

The ditch water nitrogen concentrations presented a similar picture to concentrations in water leaching from the root zone, but with lower concentration levels (see Table 3.19).

Table 3.19: Ditch water nitrogen concentrations (in mg N/l) measured in the winter of 2015-2016 on farms participating in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Characteristic	Sand-250	Sand-230	Loess*	Clay	Peat
Number of farms	12	17	*	59	59
Average	5.9	8.1	*	3.6	4.3
First quartile (25th percentile)	3.8	4.8	*	1.9	3.1
Median (50th percentile)	5.7	6.7	*	2.5	4.1
Third quartile (75th percentile)	6.9	10	*	4.0	5.5

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

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 3.20). In 2016, the ditch water phosphorus concentrations were highest in the Clay Region (see Table 3.21).

Table 3.20: Phosphorus concentrations[1,2] (in mg P/l) in water leaching from the root zone, measured in 2016 on farms participating in the derogation monitoring network (average, 25th percentile, median and 75th percentile values per region)

Characteristic	Sand-250	Sand-230	Loess*	Clay	Peat
Number of farms	52	108	*	60	59
Average	0.19	0.1	*	0.29	0.29
First quartile (25th percentile)	<dl	<dl	*	0.08	0.11
Median (50th percentile)	<dl	<dl	*	0.22	0.23
Third quartile (75th percentile)	0.12	0.10	*	0.41	0.42

[1] Average values below the detection limit of 0.062 mg/l are indicated by the abbreviation <dl.
[2] The phosphorus concentration has been measured as the total amount of dissolved phosphorus.
* Results from the Loess Region were not yet available at the time the present report was being prepared.

Table 3.21: phosphorus concentrations[1,2] (in mg P/l) in ditch water measured in the winter of 2015-2016 on farms participating in the derogation monitoring network (average, 25th percentile, median and 75th percentile values per region)

Characteristic	Sand-250	Sand-230	Loess[3]	Clay	Peat
Number of farms	12	17	*	59	59
Average	0.21	0.16	*	0.28	0.21
First quartile (25th percentile)	0.091	<dl	*	0.051	<dl
Median (50th percentile)	0.19	<dl	*	0.14	0.11
Third quartile (75th percentile)	0.29	0.12	*	0.39	0.28

[1] Average values below the detection limit of 0.062 mg/l are indicated by the abbreviation <dl.
[2] The phosphorus concentration has been measured as the total amount of dissolved phosphorus.
[3] 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[1]

The quantity of Fat and Protein Corrected Milk (FPCM) produced per farm increased continually during the 2006-2015 period by an average of almost 5% per year (see Figure 4.1). This rise was caused by the growing number of dairy cows per hectare. The area of cultivated land per farm also increased, but to a relatively lesser extent than the number of dairy cows. This resulted in an increase in milk production per hectare. Average FPCM production per dairy cow remained fairly stable. The proportion of intensive livestock farms (such as pigs and poultry) granted derogation gradually decreased during this period.

A Phosphate LSU is a unit that is used to express the phosphate production per Livestock Unit. This is a standard used to compare numbers of animals based on their standard phosphate production (Ministry of Agriculture, Nature & Food Quality, 2000: 1 phosphate LSU = the standard-based phosphate production of 1 dairy cow). Consequently, the use of LSUs enables the aggregation of all intensive livestock present on a farm (dairy cows, young livestock, pigs, chickens, sheep, etc.). The livestock density in phosphate LSUs per hectare showed a decreasing trend until 2013, but has remained fairly constant since (see Figure 4.2). Phosphate production by intensive livestock declined due to the decreasing number of farms with intensive livestock. However, this effect was largely compensated by the growth of 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 A4.1).

[1] This section only concerns dairy farms participating in the derogation monitoring network; other grassland farms have not been taken into consideration.

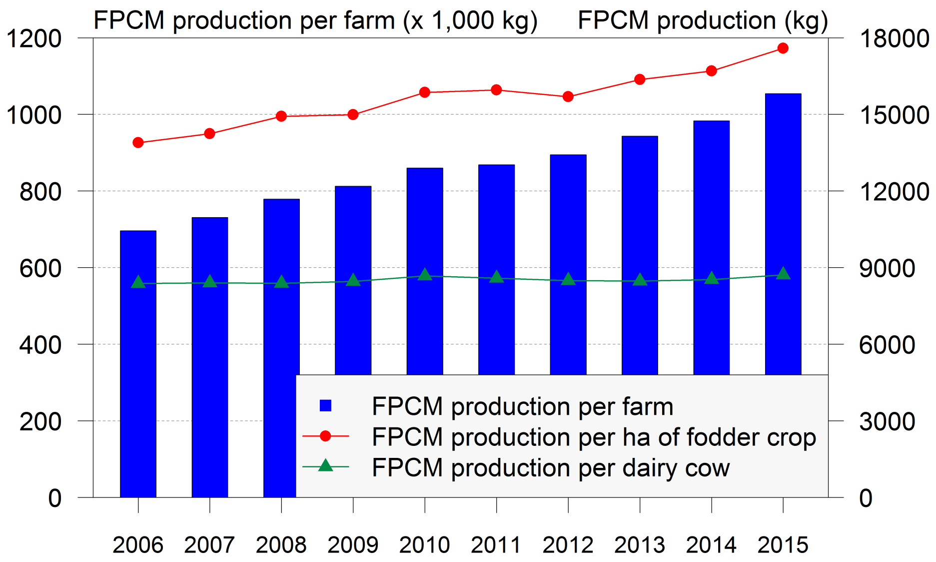

Figure 4.1: Average production of Fat and Protein Corrected Milk (FPCM) per farm (left y-axis), and per cow and per hectare of fodder crop (right y-axis) in the 2006-2015 period

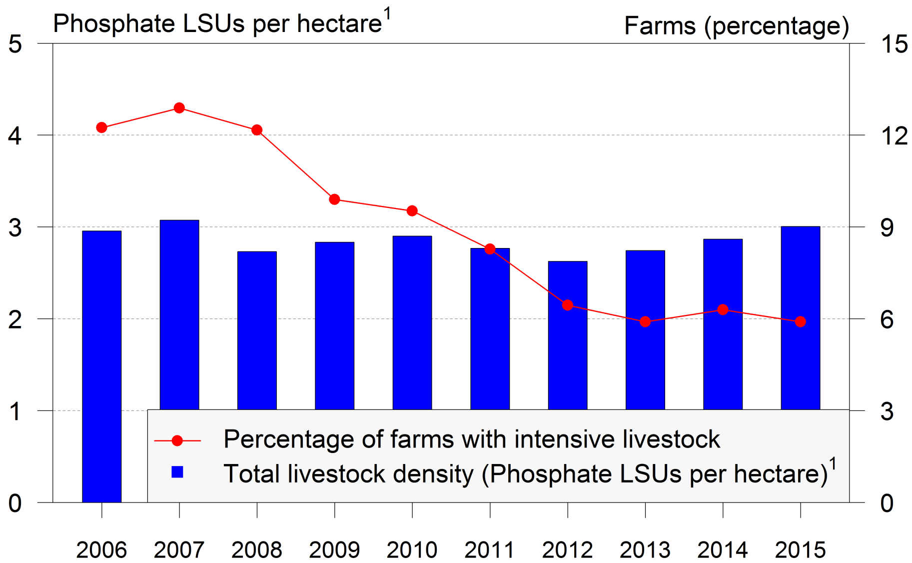

Figure 4.2: Average livestock density expressed in Phosphate Livestock Units per hectare, and percentage of dairy farms with intensive livestock (e.g. pigs and chickens) in the 2006-2015 period

The proportion of derogation farms with grazing continued to decrease in 2014 and 2015, after stabilising in 2012 and 2013 (see Figure 4.3; see Appendix 4, Table A4.1). Over the entire period from 2006 up to and including 2015, the percentage of dairy farms with grazing decreased from 89% to 76%.

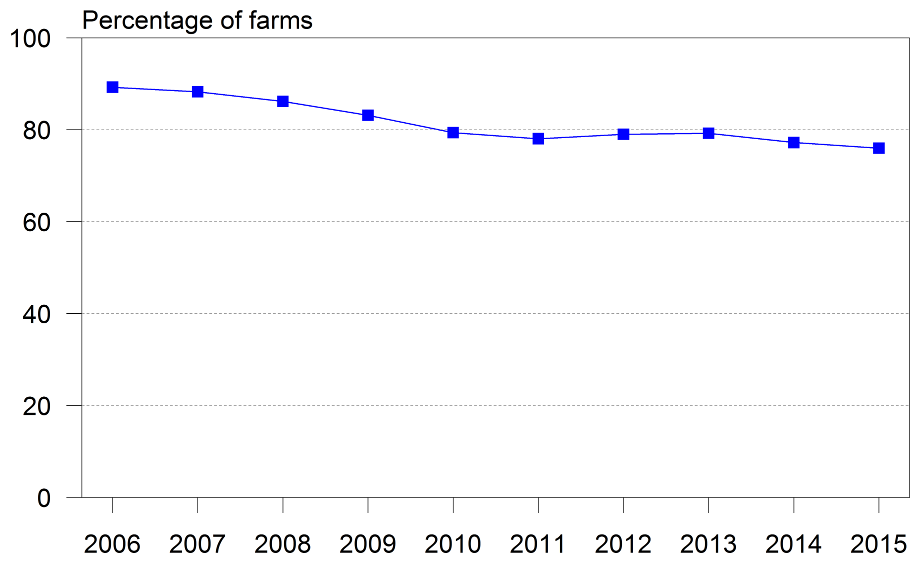

Figure 4.3: Proportion of dairy farms (%) where cows are grazed in the 2006-2015 period

4.1.2 *Use of livestock manure*

Since 2006, the average use of nitrogen in livestock manure has ranged from 232 kg to 242 kg of nitrogen per hectare (see Figure 4.4; see Appendix 4, Table 4.2).

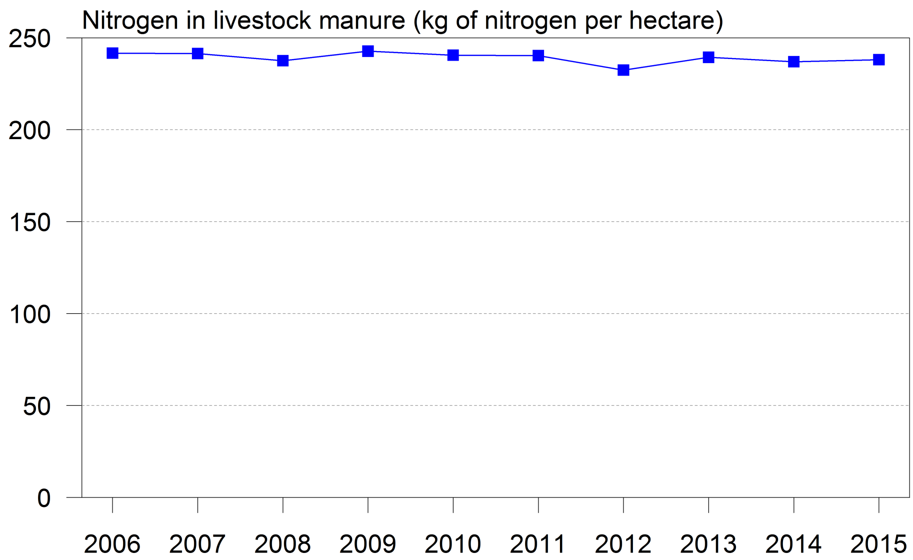

Figure 4.4: Use of nitrogen in livestock manure (in kg N/ha) in the 2006-2015 period

4.1.3 *Use of fertilisers compared to application standards*

The difference between the actual nitrogen usage and the nitrogen application standard decreased significantly in the past few years, particularly in the 2006-2009 period (see Appendix 4, Table A4.3). 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 17 kg per hectare in 2014 (see Figure 4.5; see Appendix 4, Table A4.3).

Strikingly, the average margin between the actual nitrogen usage and the nitrogen application standard increased again somewhat in 2015. This is due to a combination of decreased grazing and a higher proportion of grassland. Farmers who mow their grassland can apply more nitrogen-containing fertilisers than if the land is used for grazing. It should be noted that applicable legislation makes a distinction between the availability coefficient for nitrogen from grazing and nitrogen from the mechanical application of animal manure on the land. As a result of a different availability coefficient in combination with a different nitrogen application standard, the margin available for the application of inorganic nitrogen fertilisers diminishes somewhat on clay and peat soils and increases by approximately 20 to 25 kg of N/ha on sandy soils if the land is not used for grazing. A second reason for the higher average nitrogen application standard is that the nitrogen application standard for grassland is higher than for other crops. The proportion of grassland was roughly 83% between 2006 and 2013 and, as a result of the derogation conditions, increased to 86% and 87%, respectively, in 2014 and 2015. In 2015, the higher application standard did not result in a higher use of nitrogen-containing fertilisers in practice.

The use of inorganic nitrogen-containing fertilisers remained fairly stable during the 2006-2015 period (see Appendix 4, Table A4.3). The total quantity of plant-available nitrogen in 2015 was lower than in the previous year.

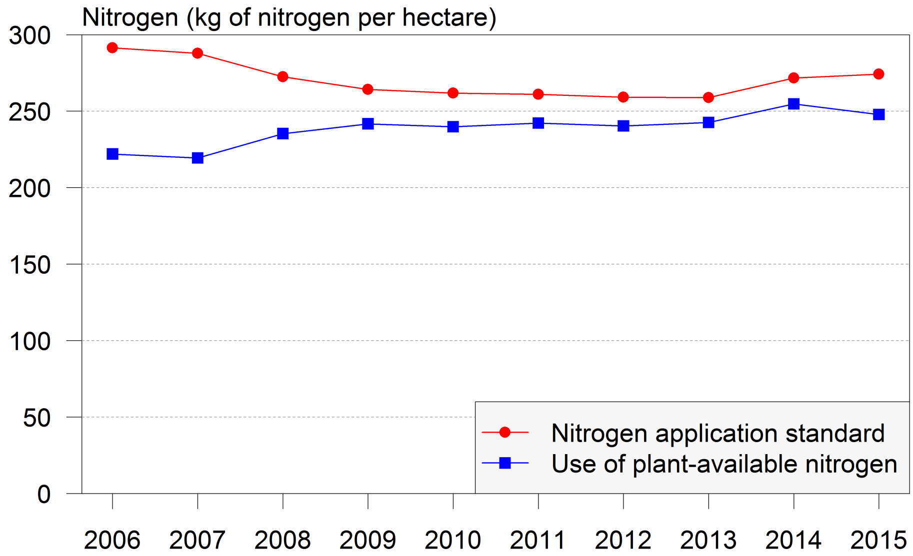

Figure 4.5: Use of plant-available nitrogen in livestock manure and inorganic fertilisers (kg N/ha) and total nitrogen application standard (kg N/ha) during the 2006-2015 period

During the 2006-2015 period, the use of phosphate-containing fertilisers on farms participating in the derogation monitoring network decreased by approx. 19%, while the phosphate application standard decreased by approx. 22% (see Figure 4.6). As a result, the difference between actual phosphate use and the phosphate application standard decreased from approx. 10 kg/ha in 2006 to 4 kg/ha in 2015. Between 2006 and 2015, the phosphate application standards were reduced from an average of 108 kg/ha to an average of 84 kg/ha. As a result, the initial margin between actual usage and the level prescribed by the standard was reduced. Between 2012 and 2014, the use of phosphate on derogation farms remained fairly constant, but it decreased in 2015 (see Appendix 4, Table A4.4). As of 15 May 2014, inorganic phosphate-containing fertilisers may no longer be supplied to derogation farms.

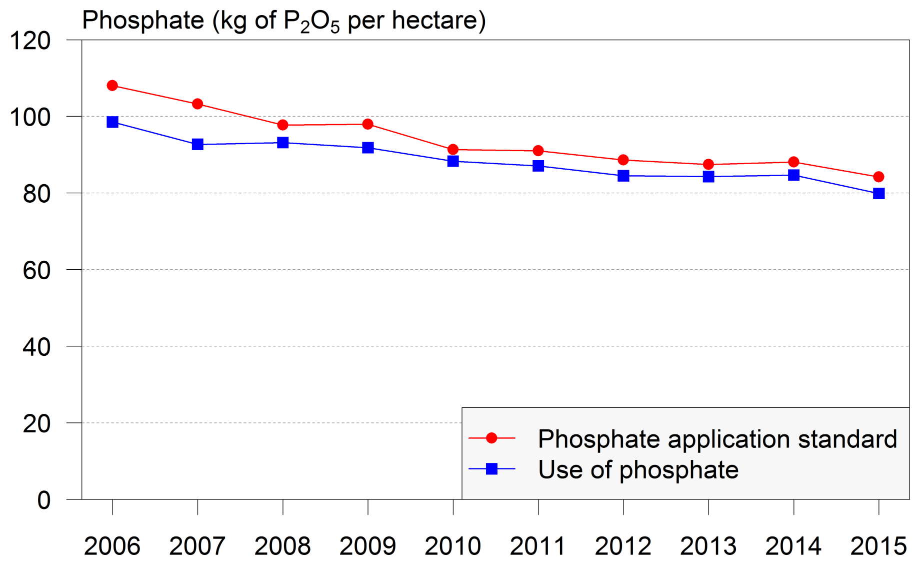

Figure 4.6: The use of phosphate via livestock manure and inorganic fertilisers (kg P2O5/ha) and the total phosphate application standard (kg P2O5/ha) in the 2006-2015 period

4.1.4 *Crop yields*

In 2014, the dry-matter yields for grass and silage maize were very high due to exceptional growing conditions. High yields were again realised in 2015, although the top yields of 2014 were not equalled (see Figure 4.7; see Appendix 4, Table A4.5A+B). In 2015, the dry-matter yields for both these crops were 6% and 2%, respectively, lower than in 2014. The yields of nitrogen and phosphate, in particular for grassland, were also a bit lower (see Figure 4.8 and Figure 4.9; see Appendix 4, Table A4.5).

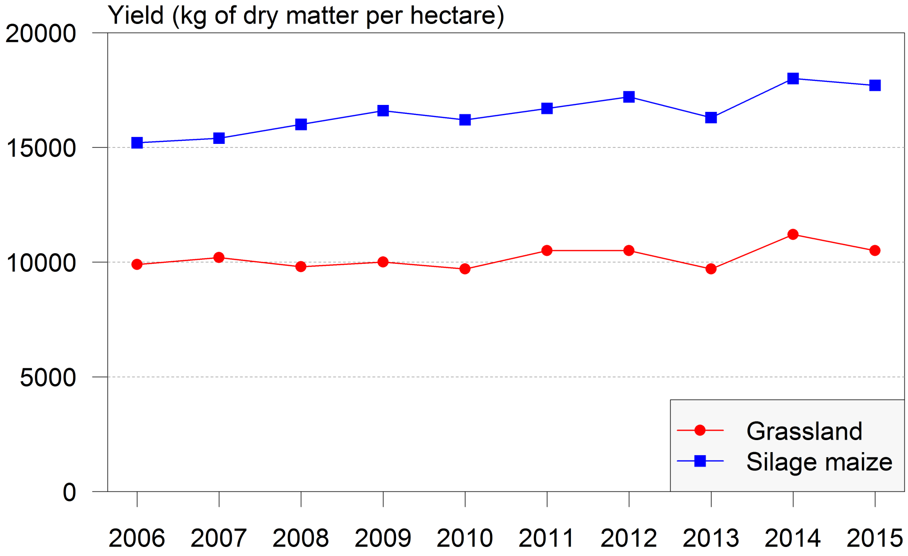

Figure 4.7: Average dry-matter yields for grassland and silage maize on derogation farms in the 2006-2015 period

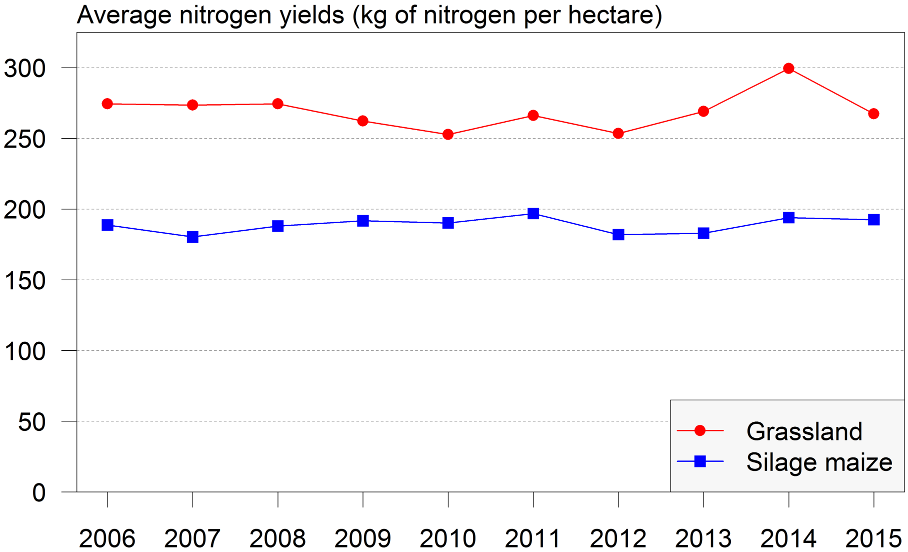

Figure 4.8: Average nitrogen yields (kg N/ha) for grassland and silage maize on derogation farms in the 2006-2015 period

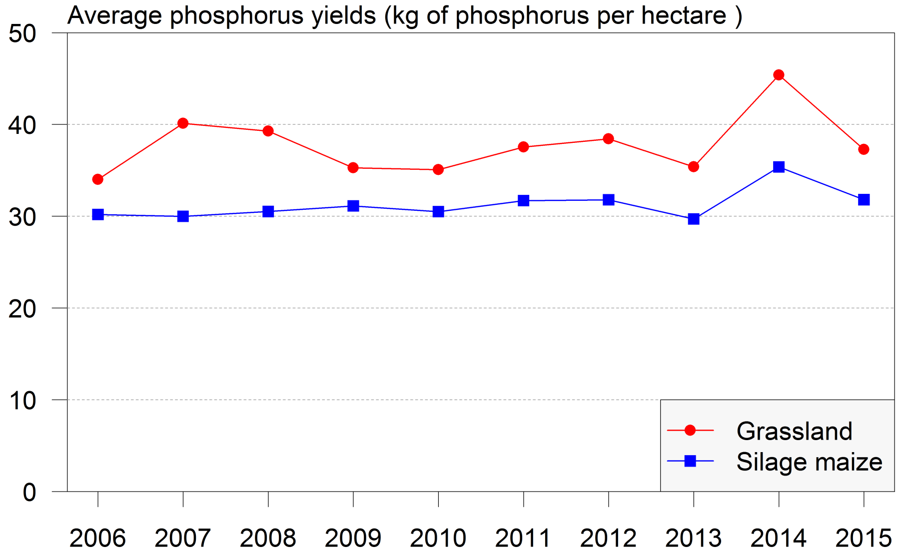

Figure 4.9: Average phosphorus yields (kg P/ha; 1 kg of phosphorus = 2.29 kg of P2O5) for grassland and silage maize on derogation farms in the 2006-2015 period

4.1.5 *Nutrient surpluses on the soil surface balance*

The average nitrogen surplus on the soil surface balance in 2015 was 12 kg/ha lower than the average for the 2006-2014 period. This was primarily due to the good growing season in 2015. As a result, high nitrogen yields were realised in 2015, as was the case in 2014, although the nitrogen yields in 2014 were even higher. From 2006 up to and including 2015, there was a decreasing trend in the average nitrogen soil surplus up until 2008, followed by a period of stabilisation, which was followed by another period of decreasing surpluses from 2013 onwards (see Figure 4.10; see Appendix 4, Table A4.6).

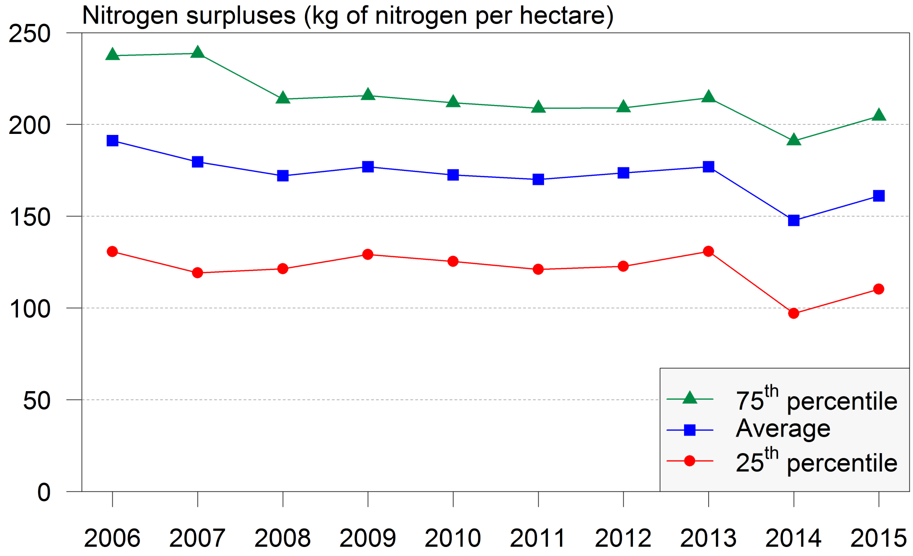

Figure 4.10: Average nitrogen surpluses (kg N/ha), and the nitrogen surpluses on the 25% of farms with the lowest surpluses (first quartile or 25th percentile), and nitrogen surpluses on the 25% of derogation farms with the highest surpluses (third quartile or 75th percentile) during the 2006-2015 period

The calculated 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 input side of the balance sheet (Appendix 2, Table A2.3). Until 2013, no clear trends were observable with respect to the different soil type regions. If the results for 2014 and 2015 are included in the analysis, then a decreasing trend is noticeable in some regions. This is due to the relatively low nitrogen soil surpluses in both these years (see Figure 4.11; see Appendix 4, Table A4.7).

Figure 4.11 shows that the nitrogen surplus in Sand-230 and Sand-250 is virtually the same, despite differences in farm characteristics. In 2015, the average input of nitrogen on farms in Sand-230 exceeded the average input on farms in Sand-250 by 136 kg of nitrogen per hectare, due to the fact that the farms in Sand-230 are generally characterised by more intensive farming practices. This was almost entirely compensated by the increased output of nitrogen via products and manure (increase of 112 kg N/ha) and by differences in deposition, biological nitrogen fixation and gaseous emissions. On average, farms in the two sub-regions comply with the fertiliser limitations that have been imposed. Other differences in nitrogen soil surpluses may arise as a result of minor adjustments at farm level or because some farms dropped out.

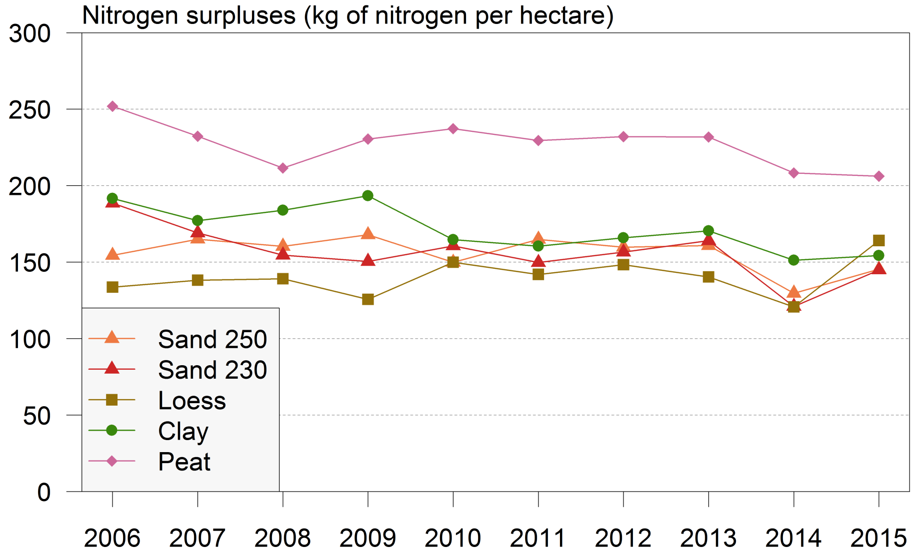

Figure 4.11: Average nitrogen surpluses per region (kg N/ha) on derogation farms in the 2006-2015 period

The phosphate soil surplus in 2015 was 16 kg/ha higher than in 2014, when the phosphate soil surplus was negative as a result of the relatively high crop yields. The increase in the phosphate soil surplus was mainly caused by a lower output of phosphate via the harvest of grass, maize and other crops. On average, the input of phosphate via fertilisers was also lower than in 2014 (see Table A4.8 in Appendix 4). As was the case in 2014, the phosphate surplus on the soil surface balance was significantly lower than the average value measured over the years 2006-2014 (see Figure 4.12; see Appendix 4, Table A4.8). This was caused primarily by a lower use of phosphate fertilisers (see Appendix 4, Table A4.4 and A4.8).

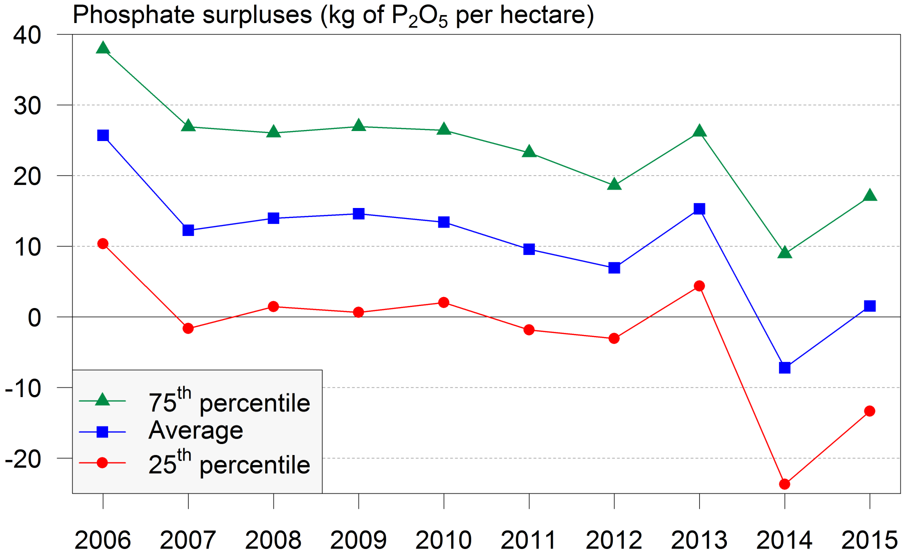

Figure 4.12: Average phosphate surpluses (kg P2O5/ha), and the phosphate surpluses on the 25% of farms with the lowest surpluses (first quartile or 25th percentile), and phosphate surpluses on the 25% of derogation farms with the highest surpluses (third quartile or 75th percentile) during the 2006-2015 period

4.2 Development of water quality

4.2.1 Development of average concentrations during the 2007-2016 period

In Sand-230 as well as in Sand-250, the average nitrate concentration in the water leaching from the root zone in the last measurement year was the lowest value of the entire series (see Figure 4.13). The nitrate concentration measured in the Loess Region in 2015 was also lower than in the previous years. In Sand-230, Sand-250, and the Loess Region, a decreasing trend can be seen over the entire measurement period (see Appendix 4, Table A4.9).

In the Clay Region and the Peat Region, the nitrate concentration in 2016 decreased again, after several years of increases, to a concentration below the value measured in 2014. In the Clay Region, the trend over the entire period is a decreasing one; in the Peat Region, no decreasing trend can be seen over the measurement period. The increase that was seen starting in 2013 does not seem to be continuing and was probably a natural variation caused by variations in the weather, similar to the peak that can also be seen in 2010 (see Appendix 4, Table A4.9). The effect of previous years with below-average precipitation was apparent in the 2010 results for the top metre of groundwater, so that we see higher nitrate concentrations in water leaching from the root zone in the Sand Region, Clay Region, and Peat Region in 2010 than in previous and subsequent years.

The average nitrate concentrations in water leaching from the root zone were the highest in the Loess Region and in Sand-230 but lower than 50 mg/l in 2015 and 2016 (for Sand-230). The trends in Sand-230 and the Loess Region are similar, although the variation in Sand-230 is higher than in the Loess Region. In 2014, the nitrate concentrations in the

Loess Region and Sand-230 were approximately 50 mg/l; in 2015, nitrate concentrations below 50 mg/l were observed in the water leaching from the root zone in both regions for the first time. In Sand-230, this decreasing trend continued into 2016; the results over 2016 for the Loess Region are not yet available.

The nitrate concentration in the Peat Region, Clay Region, and Sand-250 was less than 50 mg/l throughout the entire measuring period.

The higher nitrate concentrations in the Loess Region and Sand-230 compared to Sand-250 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.*, 2007a; Boumans and Fraters, 2011).

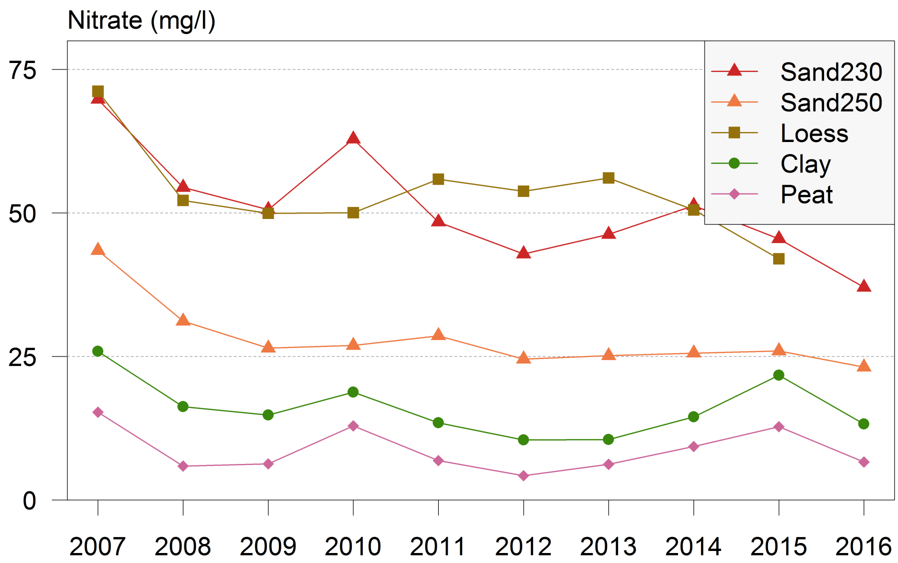

Figure 4.13: average nitrate concentrations in water leaching from the root zone on derogation farms in the four regions during the 2007-2016 period

Ditch water nitrate concentrations in Sand-230, Sand-250, and the Clay Region decreased during this period. There was no trend change in nitrate concentrations in the Peat Region. Strikingly, in 2016, the nitrate concentrations in Sand-250 as well as in the Peat Region, and Clay Region decreased again after an initial increase. The increase and decrease of the nitrate concentration in Sand-250 is strikingly large. We suspect that this is a natural fluctuation resulting from weather effects (see Figure 4.14; see Appendix 4, Table A4.9).

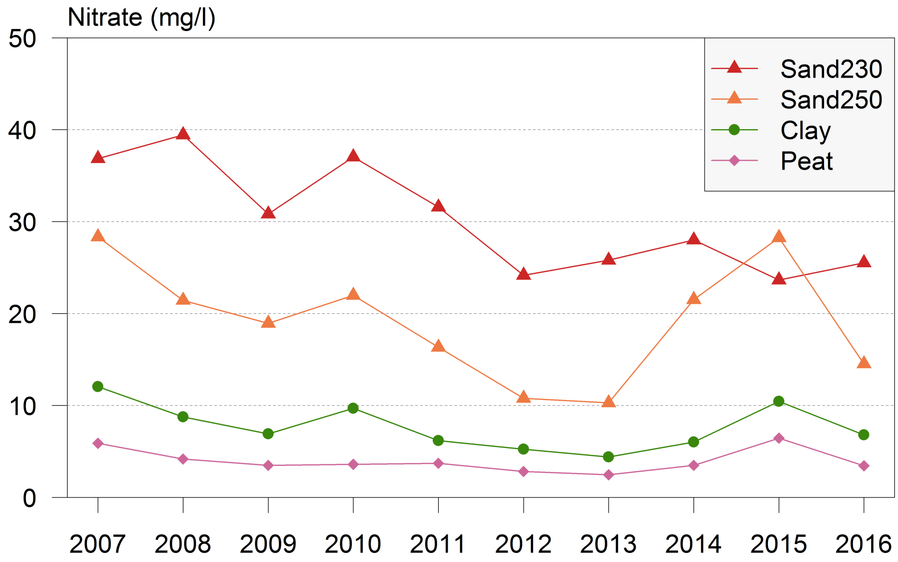

Figure 4.14: Average ditch water nitrate concentrations on derogation farms in the three regions during the 2007-2016 period

The phosphorus concentrations in water leaching from the root zone in the Clay Region and Peat Region also decreased during the measurement period. In Sand-230, Sand-250, and the Loess Region, the phosphorus concentration was stable (see Appendix 4, Table A4.9). The changes in ditch water phosphorus concentration in all regions with ditches did not follow any particular trend.

The nitrogen concentration in the water leaching from the root zone decreased in all regions with the exception of the Peat Region. The ditch water nitrate concentrations decreased in Sand-230 and Sand-250. The changes in ditch water nitrate concentration in the Clay Region did not follow any particular trend. The ditch water nitrate concentration in the Peat Region increased during the measurement period (see Appendix 4, Table A4.9 and A4.10).

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 input 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 nitrate 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 measure 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. For more information on the method, refer to Hooijboer *et al.* (2013; see Appendix 6). The method was further improved in 2016 by making use of detailed precipitation and evaporation data, by factoring in the sampling month, and by first indexing measured nitrate leaching instead of measured nitrate concentrations (Boumans and Fraters, in preparation). For this purpose, the measured nitrate concentrations are divided by the precipitation surplus in which the nitrate has dissolved. The precipitation surplus is calculated using the SWAP model (Van Dam *et al*., 2008). The indexed nitrate concentration is subsequently derived from the indexed nitrate leaching data. This method does not take all the processes into consideration that have an influence on the nitrate concentration, and is based only on correlations.

Using this method, it was found that the average, corrected nitrate concentrations in the water leaching from the root zone in Sand-230 during the 2007-2016 period decreased from 66 to 44 mg/l. In Sand-250, the nitrate concentration decreased from 37 to 27 mg/l. (see Table 4.1 and see Figure 4.15). Since 2011, 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 both subregions have displayed a downward trend. This decrease mainly occurred in the early period of the derogation monitoring network. Over the last few years, nitrate concentrations corrected for weather conditions and sample composition have fluctuated around 45 mg/l in Sand-230 and around 25 mg/l in Sand-250. In 2016, the indexed nitrate concentration in both subregions was higher than the measured concentration. We therefore suspect that the rather sharp decrease in 2016 was the result of natural fluctuations in weather and in the sample composition, and that it did not represent a decreasing trend caused by changes in agricultural practices.

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 and time of sampling; average relative evaporation, groundwater level, and average month of sampling are also shown

Year	Number of farms	Relative evaporation	Groundwater level[1]	Sampling month	Nitrate Measured	Nitrate Corrected
			Sand-250			
2007	55	1.4	150	3.0	43	37
2008	54	1.0	155	3.8	31	32
2009	56	1.0	173	4.1	26	29
2010	56	1.2	163	4.2	27	28
2011	58	1.4	157	5.1	29	26
2012	59	1.4	143	5.1	25	25
2013	59	1.2	153	4.8	25	25
2014	54	1.3	153	5.2	26	26
2015	49	1.2	159	5.0	26	27
2016	51	1.1	154	5.2	23	27
			Sand-230			
2007	88	1.5	130	3.5	70	66
2008	87	1.2	140	4.9	55	58
2009	86	1.2	153	4.6	51	52
2010	87	1.6	136	4.8	63	56
2011	84	1.7	142	5.1	49	46
2012	88	1.4	143	5.0	43	45
2013	95	1.3	152	4.9	46	45
2014	99	1.5	141	5.0	51	48
2015	103	1.4	134	5.1	46	47
2016	106	1.2	127	4.6	37	44

[1] Average groundwater level in centimetres below surface level.

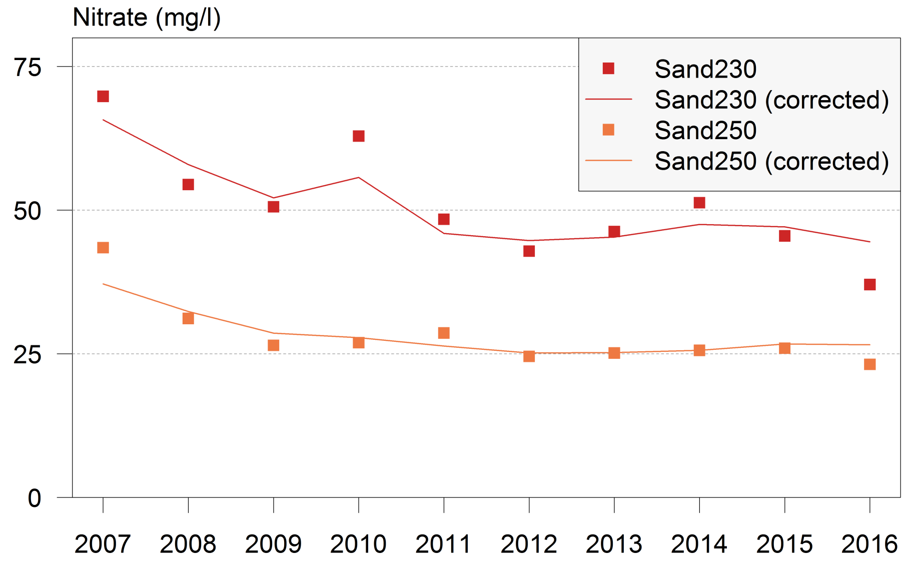

Figure 4.15: Development of the nitrate concentrations in water leaching from the root zone in the Sand Region in the successive measurement years, and the corrected nitrate concentrations

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. The improved correction method is currently being further developed so it can be applied to the Clay Region. 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
Between 2006 and 2015, the average nitrogen soil surpluses over all the regions showed a decreasing trend. The nitrate concentrations decreased in all the regions, with the exception of the Peat Region. This meets the expectation that a decrease in soil surpluses results in lower nitrate concentrations.

The results at the regional level sometimes differ from this general pattern. In the Loess Region, the nitrate concentration decreased whereas the nitrogen soil surplus did not do so. The decrease in nitrogen concentration in the Loess Region was largely due to the high nitrate concentration in 2007. This strong decrease at the beginning of the measurement series was possibly due to changes in farming operations before the derogation monitoring network was set up. 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. After-effects can remain noticeable for up to four years (Verloop, 2013).
In Sand-250 and Sand-230, the largest decrease also took place in the years leading up to 2010, in particular if corrections are made for weather and sampling variation. This may also be due to the above-

mentioned after-effects. The model used to correct for weather and sampling variation shows a higher nitrate concentration for 2016 in Sand-250 and Sand-230 than the measured trend line. We therefore suspect that the lower nitrate concentration in 2016 is in part due to favourable weather conditions and is not related to the lower soil surpluses, specifically in 2014.

Between 2012 and 2015, the nitrate concentration increased in the Peat Region and Clay Region. As the nitrate concentration in 2016 decreased again, and the above increase cannot be explained on the basis of the nitrogen soil surpluses, which actually decreased, this would also appear to be due to natural variations caused by the weather and not a trend-based change related to agricultural practices.

There are additional trends in the operations of the derogation farms that can influence the nitrate concentration but that do not change the nitrogen soil surplus:

- Since 2014, the derogation farms are required to have a minimum percentage of 80% grassland; in the period before that, the minimum was 70%. This resulted in an increase in the acreage of grassland in 2014 and 2015. The increasing proportion of grassland could also lead to a small decrease in the nitrate concentration, assuming that the soil surplus remained the same. The leaching fraction (i.e. the percentage of the nitrogen soil surplus that leaches out) is much higher on land used to cultivate maize than on grassland. However, the effect of this on the water quality cannot be determined independently of all the other developments on the farms and in the soil.
- The assumption is that the decrease in grazing on the derogation farms leads to lower nitrogen leaching. The nitrogen leaching that takes place during grazing in the second half of the growing season is relatively high, as the nitrogen in the urine released onto the surface cannot be completely absorbed by the grass (Corré *et al*., 2014). In Prins *et al*. (2015) However, no relation was found between the grazing intensity on grassland and the nitrate concentration in the groundwater on LMM farms on sandy soil.
- The ploughing-up of grassland has decreased (Van Bruggen *et al.,* 2015), among other reasons because this practice is no longer permitted in autumn on sandy and loessial soils since the introduction of application standards in 2006. In addition, the EU's agricultural policy as implemented in the Netherlands is also aimed at increasing the area of permanent grassland. This could result in lower nitrate concentrations in the uppermost groundwater. There are indications that the prohibition of ploughing-up grassland in the autumn has led to an increase in catch crops, often silage maize, on dairy farms. However, one cannot exclude the possibility that the targeted reduction of nitrate leaching by placing restrictions on the season when the ploughing of grassland is permitted has been masked by the increase in other types of catch crops (Velthof *et al*., 2017).

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 Peat Region also displayed a downward trend. This is in line with the expectation that a decrease in phosphate soil surpluses would lead to a decrease in phosphate concentration in the water leaching from the root zone.

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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 (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 subsequently 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. In doing so, the proportion of the total surface area of cultivated land in a given stratum was taken into account (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' (Cows and Opportunities) research project (see www.koeienenkansen.nl).

Replacements for farms that dropped out during the 2006-2015 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 (80% as of 2014) because the Netherlands Enterprise Agency (RVO.nl) and Wageningen Economic Research 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 the Netherlands Enterprise Agency. In addition, farmers may adjust the grassland percentage on their farms from year to year, so that the percentage may exceed the required 70% or 80% in a later year.

The consequences of these selection criteria are illustrated in Tables B1.1 and B1.2. Table A1.1 (farms) and Table A1.2 (acreages) specify how the sample population has been derived from the 2015 Agricultural Census data and a database maintained by the Netherlands Enterprise Agency. This database contains over 19,300 so-called ‘BRS numbers’ of farms that registered for derogation for 2015. BRS numbers are the registration numbers of farms registered with the Netherlands Enterprise Agency. As 683 BRS numbers did not appear in the 2015 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 more than 19,300 farms for which data were available in the 2015 Agricultural Census.

Table A1.1: Proportion of dairy and other grassland farms (%) represented in the sample population of the derogation monitoring network in 2015

	Distribution of farms		
	Dairy farms	**Other grassland farms**	**Total**
All farms registered for derogation in 2015	75%	25%	100%
Farms smaller than 25,000 SO units	0.1%	8.8%	8.9%
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	0.0%	0.0%	0.0%
Sample population	74%	15%	88%

Source: Statistics Netherlands Agricultural Census 2015, data processed by Wageningen Economic Research and FADN.

Table A1.2: Proportion of cultivated land (%) on dairy and other grassland farms represented in the sample population of the derogation monitoring network in 2015

	Distribution of acreage of cultivated land		
	Dairy farms	**Other grassland farms**	**Total**
All farms registered for derogation in 2015	88%	12%	100%
Farms smaller than 25,000 SO units	0.0%	1.5%	1.5%
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	0.0%	0.0%	0.0%
Sample population	88%	10%	98%

Source: Statistics Netherlands Agricultural Census 2015, data processed by Wageningen Economic Research and FADN.

Tables A1.1 and A1.2 show that specialised dairy farms account for 75% of all farms that registered for the 2014 derogation scheme, and account for 88% 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, 12% of all farms registered for derogation are excluded from the sample population. However, these farms account for just 2.3% of the total acreage for which farmers have requested derogation.

A1.3 Explanation of 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 (NGE) (Van der Veen *et al.*, 2012). Standard Output is a measure of the standard value of the production of a farm. 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 per 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 88% of the total acreage of cultivated land, as is apparent from Table A1.2; 12% of the acreage is found on other farms types. These farms were also included in the monitoring network in order to obtain a sample that is optimally representative of the different crop rotations and fertilisation practices. Non-dairy farms account for approx. 25% of all 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 representativeness 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: Peat Districts, Northern Sand Region I, Northern Sand Region II, Eastern Sand Region, Central Sand Region, Southern Sand Region, and Dune Areas and Wadden Sea Islands. The Loess Region has no further districts. The Peat Region is divided into two districts: Northern Peatland Pastures and Western Peatland Pastures. The Clay Region is divided into four districts: Northern Clay, Holland and IJsselmeer Polders, South-Western Marine Clay, and River Clay.

The classification of soil type regions for policy-making purposes is slightly different. The Sand Region is divided into four districts for policy-making purposes: Sand Region – North, Sand Region – Central, Sand Region – South, and Sand Region – West. For policy-making purposes, the Loess Region has not been subdivided. The Peat Region is divided into two districts for policy-making purposes: Peatland Pastures – North and Peatland Pastures – West. The Clay Region is divided into four districts for policy-making purposes: Marine Clay – North, Marine Clay – Central, Marine Clay – South-West, and River Clay (see Figure A1.1).

The distinction between the Sand-250 and Sand-230 districts as used in this report is based on the subdivision of the Sand Region for policy-making purposes. In the districts Sand Region – North and Sand Region – West, the maximum derogation amounts to 250 kg of nitrogen per hectare. In the districts Sand Region – Central and Sand Region – South, the maximum derogation on sandy soils is 230 kg of nitrogen per hectare.

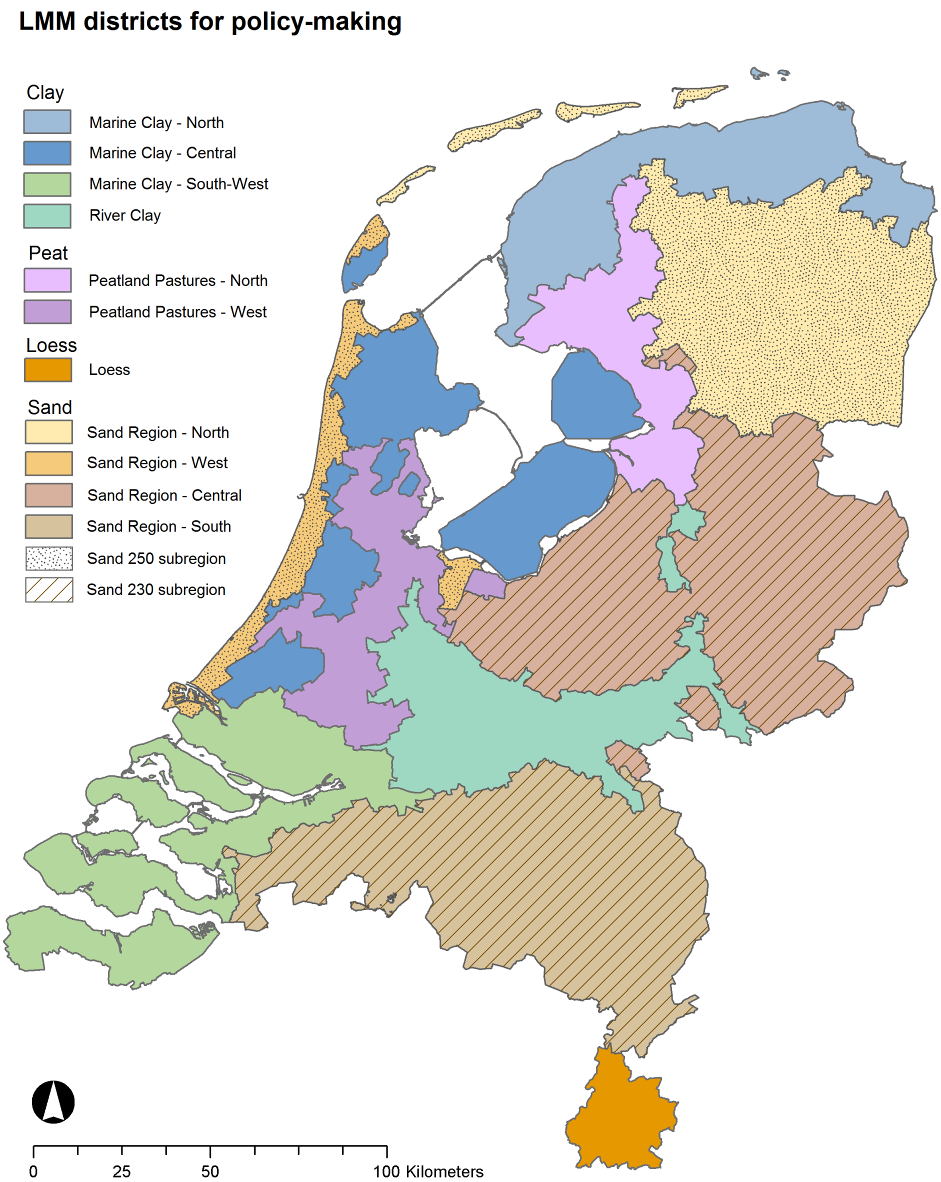

Figure A1.1: Soil type regions and districts for policy-making purposes in the Minerals Policy Monitoring Programme (LMM)

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 district 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 sub-region because it includes multiple groundwater bodies without one body being clearly dominant. In addition, three groundwater bodies were classified as a separate sub-region: 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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Websites

Agricultural Census data on Statistics Netherlands website:
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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 Wageningen Economic Research were monitored, and how these data were used to calculate fertiliser usage (section B2.2), grass and silage maize yields (section B2.3), and nutrient surpluses (section B2.4). Finally, the last section (B2.5) describes which significant changes were implemented in the calculation method and points of departure in comparison to the calculation method and points of departure of the derogation report released in 2016.

A2.1 General

Wageningen Economic Research 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; Binternet, 2013). Approx. 45 full-time Wageningen Economic Research 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. Wageningen Economic Research 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 subsequently 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. This is the land actually fertilised and used for crop cultivation on farms. 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 or camping sites).

A2.2 Calculation of fertiliser usage

The derogation decision (EU, 2014) stipulates that the report should include data on fertiliser usage and crop yields (Article 10 (1a)). This article states (in section 1.2):
'*The competent authorities shall submit to the Commission every year by March a report containing the following information: data related to*

fertilisation on all farms which benefit from an individual derogation, including information on yields and on soil types;'

Nutrient usage data are presented by region (Clay Region, Peat Region, Sand Region, and Loess Region). Fertiliser usage 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 usage*

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 (Netherlands Enterprise Agency, 2016, 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'). Manure production by intensive livestock is calculated based on the standard nitrogen quantities prescribed by law and the phosphate quantities 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 data on standard compositions (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 (Netherlands Enterprise Agency, 2016, Table 5). If no sampling results are available, the output of on-farm manure is calculated based on the farm-specific mineral content per m^3 of manure, provided that 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 subsequently 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). For these farms, the manure production is not calculated on the basis of standard quantities but on the basis of farm-specific data, if the farm indicates that it wishes to use the farm-specific excretion method. However, in some cases, the farm-specific calculation of manure production is nevertheless rejected, namely if the criteria mentioned in section B2.3.2 are not complied with. In these cases, the manure production is determined on the basis of standard quantities.

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 above); or, if this is not the case
- the applicable standard contents (Netherlands Enterprise Agency, 2016, Table 5).

The quantity of fertiliser applied on grassland is calculated as the closing entry:

Usage on grassland =
fertiliser usage at farm level - fertiliser usage on arable land

In the case of farms where grassland accounts for less than 25% of the total cultivated area[2], fertiliser usage on grassland is calculated based on allocations, and the fertiliser usage on arable land is calculated as the closing entry. The quantity of fertiliser used on grassland comprises fertilisers spread on the land 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.

[2] Not relevant for this report, as a minimum of 70% (80% as of 2014) grassland is required for derogation.

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 (Netherlands Enterprise Agency, 2016, 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 (Netherlands Enterprise Agency, 2016, 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 also applies to total fertilisation (i.e. inorganic fertilisers + livestock manure +
other organic fertilisers). Table A2.1 lists the confidence intervals for non-organic dairy farms.

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

Nutrient and type	Lower or upper limit	Kg N/ha
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 usage	Lower limit	50
Total fertiliser usage	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 usage	Lower limit	25
Total fertiliser usage	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 for the purpose of nutrient flow calculations.
[2] This table only states the lower and upper limits for fertiliser usage at farm level on non-organic dairy farms. Other limits are applied to other types of farms. Lower and upper limits are also applied 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 subsequently determined based on measurements and content data for silage supplies, insofar as these are available. The silage maize yield is subsequently 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 subsequently 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 subsequently 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 calculation procedure described above cannot be applied to all farms. On mixed farms, it is often difficult to clearly separate the product flows between different production units. The method is applied in accordance with Aarts *et al.* (2008).

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

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

These criteria were not taken into consideration because they were used in the study of Aarts *et al.* (2008) to make statements about the population of 'typical' dairy farms. These criteria can be ignored because the population data 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: 5,000 to 25,000 kg of dry matter per hectare
- grassland yield: 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 procedure described in 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. Mobility factor 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 mobility factor depends on the number of grazing days, among other things. Aarts *et al.* (2008) distinguish three grazing categories: no grazing (0 grazing days), less 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, 2010).

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]

Category	Conservation losses				Feed production losses
	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 put 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. In other words, 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 usage 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. 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 on reclaimed peat subsoils 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 bookkeeping 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 at farm level 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 at farm level is subsequently corrected to account for a number of input and output items on the soil surface balance. The phosphate surplus on the soil surface balance is equal to the surplus at farm level. 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 N/ha^{-1} year^{-1})

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 (Netherlands Enterprise Agency, 2016, Table 5). If farm-specific manure production is known, the output of on-farm manure is corrected accordingly (see section B2.2).
Feedstuffs	Balance of all inputs 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 farm. Standards for silage grass and silage maize are based on annual averages for the different soil type regions (data supplied by Eurofins).
Animals	Only imported animals	Standard quantities based on Ministry of Agriculture, Nature & Food Quality (2010), and Netherlands Enterprise Agency (2016, Table 7)
Plant products (sowing seeds, young plants and propagating material)	Only imported plant products	Data 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)	

Description of items	Calculation method	
	Quantity	**Contents**
Farm outputs		
Animal products (milk, wool, eggs)	Balance of all inputs, outputs and stock changes of all milk and other animal products	Netherlands Enterprise Agency (2016, Tables 7 and 8)
Animals	Balance of outputs and stock changes of animals and meat	Netherlands Enterprise Agency (2016, 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 (Netherlands Enterprise Agency, 2016, Table 5). If farm-specific manure production is known, the output of on-farm manure is corrected accordingly (see section B2.2).
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	Data based on Van Dijk, 2003 and CVB, 2012
Other	Balance of all inputs, outputs and stock changes of all other products in the case of net production (output)	
Nitrogen surplus at farm level	Farm input minus Farm output	
Input on soil surface balance		
+ Mineralisation	For grassland on peat soils: 160 kg of nitrogen per hectare per year (Van Kekem, 2004). 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 defined by the Netherlands Enterprise Agency (sand, clay, peat and loessial soils). Mineralisation in reclaimed peat subsoils was estimated based on the overall soil classifications of each farm (based on postcode), in accordance with the Alterra soil map, version of 2006 (2006).	
+ Atmospheric deposition	The basic data are derived from National Institute for Public Health and the Environment, 2016.	

Description of items	Calculation method	
	Quantity	**Contents**
+ Nitrogen fixation by leguminous plants	Clover on grassland (Kringloopwijzer, 2013): the quantity of nitrogen fixation depends on the proportion of clover (relationship between proportion of clover and clover density = 0.82; correction takes place) and the grassland yield, and is based on a nitrogen fixation per kg of dry-matter yield in the form of clover of (4.5/100). 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 emission 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 emitted is calculated as a percentage of the total ammonia nitrogen (TAN) excreted (based on the RAV emission factor). The TAN excreted is determined on the basis of the TAN percentages in the manure (Van Bruggen *et al*., 2015). The calculations take into account mineralisation and immobilisation of nitrogen in solid manure and slurry manure (Van Bruggen *et al*., 2015). Ammonia emission during grazing is calculated as a percentage (2.6%) of the TAN excreted during grazing (Van Bruggen *et al.,* 2015). 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-based emission factor to the net standard-based excretion (Groenestein *et al.,* 2005, Tamminga *et al*., 2014, Oenema *et al*., 2000). This factor depends on the type of animal (11.3% for dairy cows). The emission factor is preferably updated based on the data in Van Bruggen *et al.,* 2015. The emissions resulting from grazing are subsequently calculated by multiplying the quantity of nitrogen- excreted in grassland manure (net standard-based excretion for grassland fraction) by the emission percentage of the TAN excreted on grassland (Van Bruggen *et al.,* 2015) The emissions resulting from stabling and storage are calculated as the gross standard-based excretion minus the net standard-based excretion.	
Volatilisation resulting from	The ammonia emission factors for the application of livestock manure and inorganic fertilisers are based on Velthof *et al.* (2009) and Van Bruggen *et al*. (2015). Other	

Description of items	Calculation method	
	Quantity	Contents
application	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), an average percentage 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 TAN factor.	
Nitrogen surplus on the soil surface balance	Nitrogen surplus on farm + input on soil surface balance – output on soil surface balance	

A2.5 Changes in calculation method and points of departure

This section provides an overview of the most important changes that were implemented in the calculation method and points of departure in comparison to the calculation method and points of departure of the derogation report released in 2016. The changes are included in the descriptions provided in the previous sections. The changes in the calculation method and points of departure are as follows:

- The conditions for applying Farm-Specific Excretion (BEX) method and calculating grassland and silage maize yields have been broadened. The upper limit for silage maize yields has been raised from 22 to 25 tonnes of dry matter per hectare. An analysis made it clear that a relatively large number of farms had yields that were slightly above the upper limit, as a result of which the BEX calculation was rejected and replaced by the standard-based excretion calculation. An additional analysis also made it clear that the feedstuff flows on farms with several categories of animals (farms not of the NSO-type 4500 (specialised dairy cows), intensive livestock farms, and farms where the dairy herd accounts for less than 67% of the total quantity of phosphate LSUs for grazing livestock) are properly allocated to the animal categories concerned in the FADN database. When the derogation monitoring network was first set up, the registration of data in FADN was not able to effectively distinguish between feedstuff flows per animal category. As a result of both of the above changes, farms that indicate a wish to make use of the guidance document on farm-specific excretion apply the BEX calculation more frequently than was previously the case. In some cases, the BEX calculation is still rejected, for example due to very high crop yields. The above changes also had a relatively small effect on fertiliser usage (on average 1 kg of nitrogen per hectare lower). The effect on the nitrogen surplus and phosphate surplus on the soil surface balance is greater, as the ammonia emission is calculated for more farms on an individual farm-specific basis. This leads to a lower average emission and therefore to a higher nitrogen surplus on the soil surface balance.

- The calculation rule for calculating the nitrogen fixation of clover in grassland has been corrected. The calculation rule has been adjusted in accordance with the Kringloopwijzer (2013) calculation tool. As a result, the nitrogen fixation from clover is a factor 2 higher than in the calculation method of the previous year. This change results in higher calculated values for the nitrogen surplus on the soil surface balance (approximately +3 kg N/ha). This change has no effect on the phosphate surplus.
- The mineralisation and immobilisation processes in manure have been taken into account in the calculation method for farms that make use of the farm-specific excretion calculation method. In accordance with the calculation method of Van Bruggen *et al*. (2015), the TAN (total ammonia nitrogen) fraction in slurry manure changes due to mineralisation of nitrogen, resulting in a higher TAN fraction. The TAN fraction in solid manure also changes due to the immobilisation of nitrogen, resulting in a lower TAN fraction. Both processes have an effect on the ammonia emission (on balance, an average increase of approximately 1 kg/ha) and on the nitrogen surplus on the soil surface balance (on balance, an average decrease of approximately 1 kg/ha). This change has no effect on the phosphate surplus.
- The TAN fraction of the applied manure has been corrected. The TAN fraction was set at 37%, based on the TAN fraction of solid manure. However, the most important type of manure that is applied on derogation farms is slurry manure. Accordingly, the TAN fraction of the applied manure was changed in line with an average TAN fraction of slurry manure over the years and manure types of 62%, based on Van Bruggen et al., 2015. This applies only to farms where the manure production is calculated on the basis of standard quantities. The above change leads to an increase in the calculated ammonia emission associated with application of the manure, which in turn leads to a decrease in the nitrogen surplus on the soil surface balance (on average, approximately -10 kg N/ha). This change has no effect on the phosphate surplus.

The total effect of all the changes on the nitrogen surplus on the soil surface balance for the 2006-2014 series is, on average, approximately -7 kg N/ha. The total effect is the sum of the separate effects of the changes with regard to nitrogen-fixation by clover in grassland (+3 kg N/ha), mineralisation and immobilisation (-1 kg N/ha), and the TAN fraction (-10 kg N/ha). Finally, the change in the BEX conditions in combination with changes in the number of samples taken led to an increase in the calculated nitrogen surplus on the soil surface balance of +1 kg N/ha.

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Appendix 3 Sampling of water on farms in2015

A3.1 Introduction

The derogation decision (EU 2014, 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(f) and 1(g)). The monitoring of the quality of shallow groundwater, soil water, and streams on farms belonging to the monitoring network yields data about the nitrate and phosphorus concentrations in water leaving the root zone and ending up in the groundwater and surface water system (Article 8 (5)).

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 is sampled below the root zone. 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 concentrations in surface water are 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 loessial 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 the agricultural practices of the previous year as accurately as possible. Due to weather conditions, sampling campaigns may need to be extended or started at a later time.

Month	Jan-Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Agricultural data	■	■	■	■											
Soil moisture in Loess Region													■	■	■
Total groundwater in Sand Region								■	■	■	■	■	■		
Groundwater in Sand Region in Low Netherlands		■	■	■	■	■	■								
Groundwater Clay Region[1]			■	■		■	■								
Groundwater Peat Region[1]			■	■	■	■	■								
Drain water and ditch water in all regions		■	■	■	■	■	■	■							

[1] The exact date on which sampling is started depends on the amount of precipitation. Sufficient precipitation must have fallen before leaching into groundwater occurs. Sampling never starts later than 1 December.

Figure A3.1: Relationship between data on agricultural practices in a specific year and the water sampling period that has provided the data linked to these agricultural data, for all regions defined in the Minerals Policy Monitoring Programme (LMM)

In the High Netherlands, groundwater and soil moisture are sampled once a year on each farm. The average precipitation surplus in the Netherlands is approximately 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 expected to be 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 (the intended LMM sampling frequency). This higher sampling frequency allows for better 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 performed in accordance with the applicable work instructions. The text below refers to the applicable work instructions by stating the relevant document number. 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 2015 up to and including September 2015 (see

Figure A3.2). In the Loess Region, samples were taken from September 2015 up to and including November 2015 (see Figure A3.2). Each farm was sampled once during these periods.

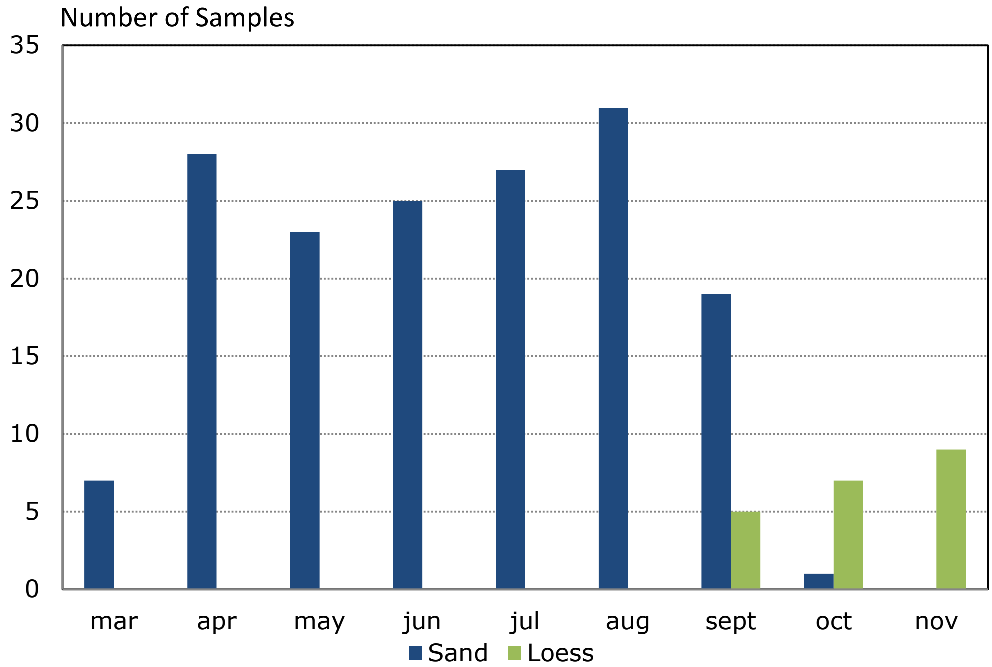

Figure A3.2: Number of samples taken of groundwater and soil moisture in the Sand Region and Loess Region per month in the period from April up to and including November 2015

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 subsequently 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. Bound phosphorus is filtered out when the water samples are filtered. Consequently, the phosphorus concentrations in the LMM programme only concern dissolved phosphorus. These concentrations are lower than the total phosphorus concentrations which include bound as well as dissolved phosphorus (Vrijhoef *et al.,* 2015).

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 2014 up to and including March 2015 (see Figure A3.3). Samples were taken 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 only 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.

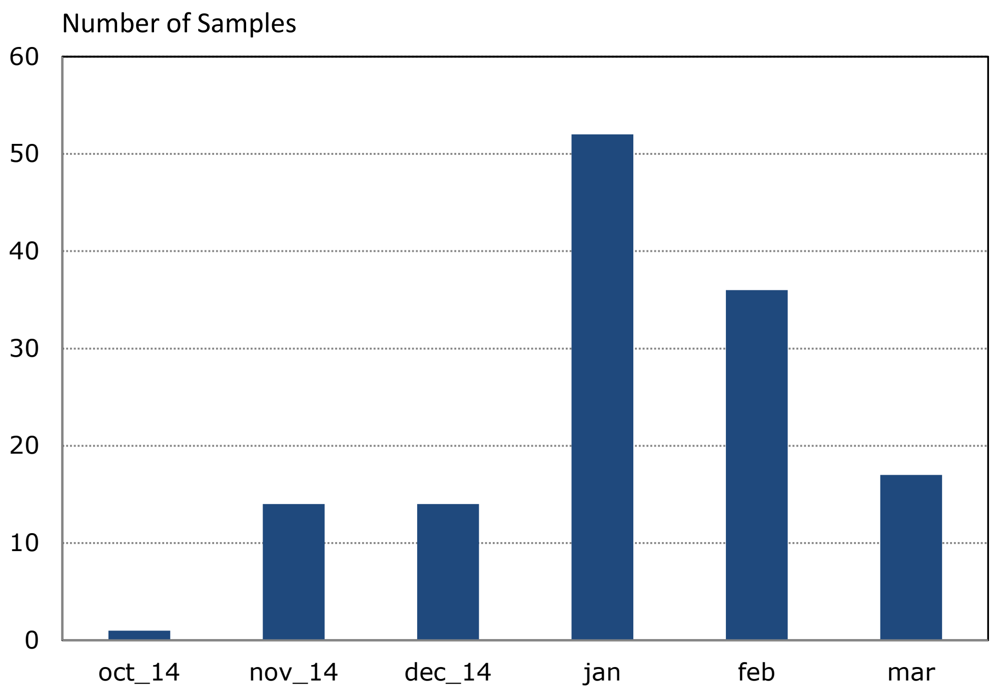

Figure A3.3: Number of ditch water samples in the Sand Region per month during the period from October 2014 up to and including March 2015

Three to four ditch water samples were taken on these farms in the winter of 2014-2015.

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. Bound phosphorus is filtered out when the water samples are filtered. Consequently, the phosphorus concentrations in the LMM programme only concern dissolved phosphorus. These concentrations are lower than the total phosphorus concentrations which include bound as well as dissolved phosphorus (Vrijhoef *et al.,* 2015).

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 2014 up to and including March 2015 (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.

During the winter of 2014-2015, 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, the samples were filtered in the laboratory and 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. Bound phosphorus is filtered out when the water samples are filtered. Consequently, the phosphorus concentrations in the LMM programme only concern dissolved phosphorus. These concentrations are lower than the total phosphorus concentrations which include bound as well as dissolved phosphorus (Vrijhoef *et al.,* 2015).

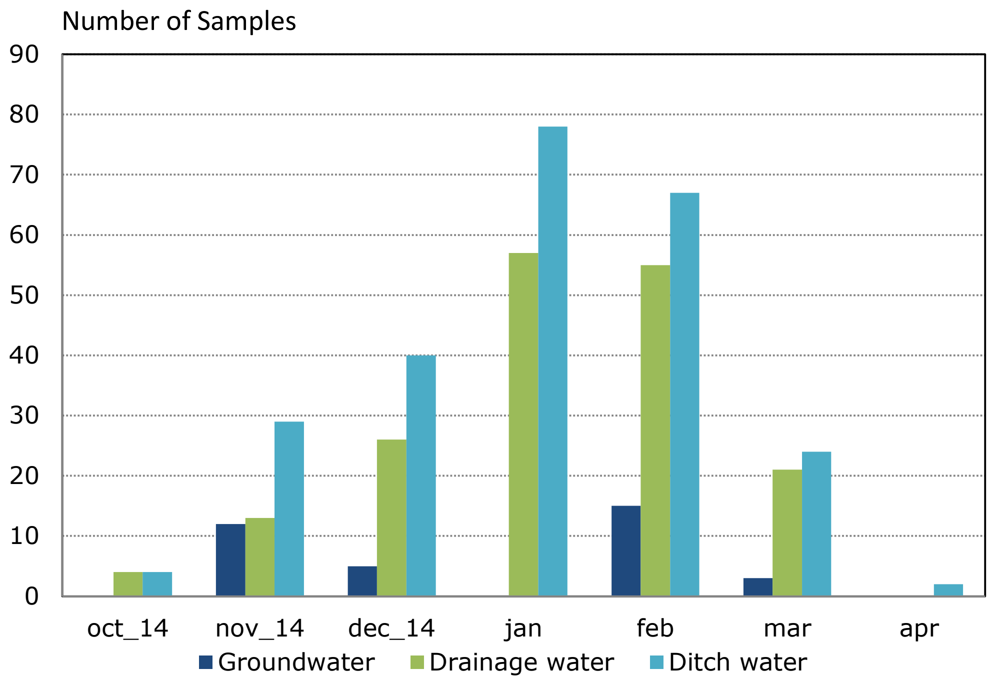

Figure A3.4: Number of groundwater, drain water, and ditch water samples in the Clay Region per month during the period from October 2014 up to and including April 2015

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 November 2014 up to and including March 2015 (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. Bound phosphorus is filtered out when the water samples are filtered. Consequently, the phosphorus concentrations in the LMM programme only concern dissolved phosphorus. These concentrations are lower than the total phosphorus concentrations which include bound as well as dissolved phosphorus (Vrijhoef *et al.*, 2015). 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.

A3.4 Peat Region

In the Peat Region, the top metre of groundwater was sampled once on all farms during the period from October 2014 up to and including April 2015 (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. Bound phosphorus is filtered out when the water samples are filtered. Consequently, the phosphorus concentrations in the LMM programme only concern dissolved phosphorus. These concentrations are lower than the total phosphorus concentrations which include bound as well as dissolved phosphorus (Vrijhoef *et al.,* 2015).

The ditch water was sampled using a method similar to the one employed in the Sand Region and Clay Region. 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. Bound phosphorus is filtered out when the water samples are filtered. Consequently, the phosphorus concentrations in the LMM programme only concern dissolved phosphorus. These concentrations are lower than the total phosphorus concentrations which include bound as well as dissolved phosphorus (Vrijhoef *et al.,* 2015).

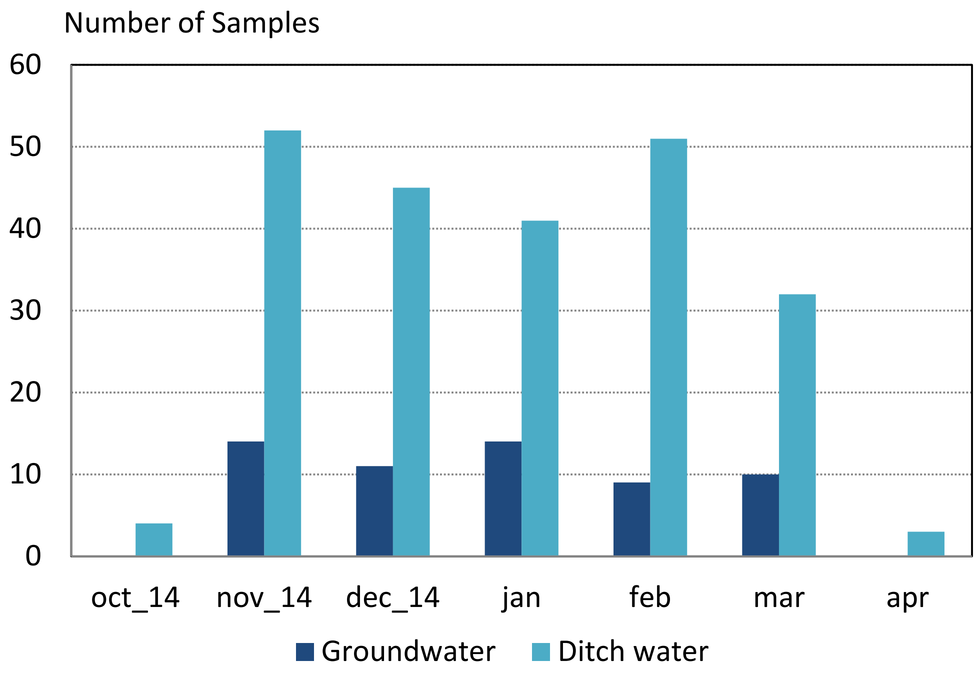

Figure A3.5: Number of groundwater and ditch water samples in the Peat Region per month during the period from October 2014 up to and including April 2015

The following RIVM work instructions were used

MIL-W-4001	Measuring nitrate concentrations in aqueous solutions using a Nitracheck 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

Table A4.1: Some general characteristics of farms participating in the derogation monitoring network (DMN) in the 2006-2015 period: average values for the 2006-2014 period, differences between 2015 results and the average values for the 2006-2014 period, and trends identified for the 2006-2015 period

Farm characteristic	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2006-2014	Difference	Trend
Number of dairy farms	251	247	253	249	252	255	262	255	250	258	253		
Number of other grassland farms	43	48	47	44	42	35	33	33	36	30	39		
Total area of cultivated land (hectares)	49	50	51	52	52	53	55	56	56	58	53	+	+
Proportion of grassland (%)	83	83	82	82	83	83	83	83	86	87	83	+	+
Proportion of farms with intensive livestock (%)	12	13	12	10	10	8	6	6	6	6	9	-	-
Total livestock density (LSUs/ha) [1]	3.0	3.1	2.7	2.8	2.9	2.8	2.6	2.7	2.9	3.0	2.8	≈	≈
Kilogrammes of FPCM per dairy farm (x 1,000)	696	731	779	813	860	869	894	943	983	1,054	841	+	+
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	8.5	8.7	8.5	+	+
FPCM production per hectare of fodder crop (x 1,000 kg)	14	14	15	15	16	16	16	16	17	18	15	+	+
Percentage of dairy farms where dairy cows graze in:													
• May-October	89	88	86	83	79	78	79	79	77	76	82	-	-
• May-June	86	84	82	80	76	76	77	76	76	76	79	≈	-
• July-August	88	88	86	83	79	78	79	78	76	76	82	-	-
• September-October	87	87	84	80	74	71	75	76	75	74	79	-	-

[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 LSU. One young animal 0-1 years of age produces = 9 kg of phosphate = 0.22 Phosphate LSU (source: Ministry of Agriculture, Nature & Food Quality, 2000).
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 2006-2015 period. ≈: insignificant trend ($p > 0.05$), +/-: significant trend ($p < 0.05$).

Table A4.2: Average application of nitrogen in livestock manure (in kg N/ha) on farms participating in the derogation monitoring network (DMN) in the 2006-2015 period: average values for the 2006-2014 period, differences between 2015 results and the average values for the 2006-2014 period, and trends identified for the 2006-2015 period

Description	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2006-2014	Difference	Trend
Use of nitrogen in livestock manure													
Number of farms	274	279	276	272	280	276	280	276	272	273	276		
Produced on farm	264	271	262	262	284	272	255	269	286	296	269	+	+
+ Inputs	8	10	10	10	8	11	11	10	8	6	10	-	≈
+ stock changes[1]	-4	-8	-7	-1	-8	-6	-5	-6	-13	-7	-6	≈	+
– Outputs	25	32	28	28	44	36	29	33	45	57	33	+	+
Total use	242	241	237	243	240	240	232	239	237	238	239	≈	≈
Use on grassland[2]	254	256	256	256	258	256	248	254	250	246	254	-	-
Use on arable land[3]	186	182	171	170	171	178	172	183	185	192	178	+	≈

[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), 268 (2007), 265 (2008), 258 (2009), 266 (2010), 262 (2011), 262 (2012), 262 (2013), 263 (2014) and 265 (2015). 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: 196 (2006), 197 (2007), 206 (2008), 197 (2009), 195 (2010), 199 (2011), 196 (2012), 198 (2013), 194 (2014) and 198 (2015). 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: 11 (2006), 14 (2007), 11 (2008), 14 (2009), 14 (2010), 14 (2011), 18 (2012), 14 (2013), 9 (2014) and 8 (2015). The numbers of farms without arable land were as follows: 69 (2006), 71 (2007), 59 (2008), 61 (2009), 71 (2010), 63 (2011), 66 (2012), 64 (2013), 69 (2014) and 67 (2015).
Difference: direction and significance of difference between 2015 and average for previous years. ≈: insignificant difference ($p > 0.05$), +/-: significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2015 period. ≈: insignificant trend ($p > 0.05$), +/-: significant trend ($p < 0.05$).

Table A4.3: Average application of nitrogen (in kg N/ha) on farms participating in the derogation monitoring network (DMN) in the 2006-2015 period: average values for the 2006-2014 period, differences between 2015 results and the average values for the 2006-2014 period, and trends identified for the 2006-2015 period

Description	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2006-2014	Difference	Trend
Number of farms	276	278	275	268	278	277	281	276	271	273	276		
Livestock manure excluding availability coefficient	242	241	237	243	240	240	232	239	237	238	239	≈	≈
Availability coefficient	39	40	48	48	49	49	49	49	50	49	47	+	+
Animal manure based on statutory availability coefficient	94	93	113	116	116	118	114	117	117	116	111	+	+
+ Other organic fertilisers	0	0	0	0	0	1	0	0	1	0	0	≈	+
+ Inorganic fertilisers	128	126	122	126	123	123	126	125	136	131	126	+	+
Total use	222	219	235	242	240	242	240	243	255	248	238	+	+
Nitrogen application standard applicable to farm	291	288	272	264	262	261	259	259	272	274	270	+	-
Use on grassland[1]	249	249	267	269	267	270	267	271	279	268	265	≈	+
Nitrogen application standard for grassland	318	315	296	287	282	283	281	281	292	294	293	+	-
Use on arable land[2]	111	116	123	123	121	126	125	126	130	130	122	+	+
Nitrogen application standard for arable land	163	163	165	161	162	156	149	149	150	145	158	-	-

[1] The average use on grassland is based on the following numbers of farms: 265 (2006), 268 (2007), 265 (2008), 258 (2009), 266 (2010), 262 (2011), 262 (2012), 262 (2013), 263 (2014) and 265 (2015). 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: 196 (2006), 197 (2007), 206 (2008), 197 (2009), 195 (2010), 199 (2011), 196 (2012), 198 (2013), 194 (2014) and 198 (2015). 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: 11 (2006), 14 (2007), 11 (2008), 14 (2009), 14 (2010), 14 (2011), 18 (2012), 14 (2013), 9 (2014) and 8 (2015). The numbers of farms without arable land were as follows: 69 (2006), 71 (2007), 59 (2008), 61 (2009), 71 (2010), 63 (2011), 66 (2012), 64 (2013), 69 (2014) and 67 (2015).

Difference: direction and significance of difference between 2015 and average for previous years. ≈: insignificant difference ($p > 0.05$), +/-: significant difference ($p < 0.05$).

Trend: direction and significance of trend in 2006-2015 period. ≈: insignificant trend ($p > 0.05$), +/-: significant trend ($p < 0.05$).

Table A4.4: Average application of phosphate (in kg of P_2O_5/ha) on farms participating in the derogation monitoring network (DMN) in the 2006-2015 period: average values for the 2006-2014 period, differences between 2015 results and the average values for the 2006-2014 period, and trends identified for the 2006-2015 period

Description	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2006-2014**	**Difference**	**Trend**
Number of farms	274	279	276	272	280	276	280	276	272	273	276		
Livestock manure	88	85	87	88	85	84	82	81	81	79	85	-	-
+ Other organic fertilisers	0	0	0	0	0	0	0	1	1	1	0	≈	+
+ Inorganic fertilisers	10	7	6	3	3	3	3	3	2	0	4	-	-
Total use	99	93	93	92	88	87	84	84	85	80	89	-	-
Phosphate application standard applicable to farm	108	103	98	98	91	91	89	87	88	84	95	-	-
Use on grassland[1]	101	95	98	94	92	90	87	87	87	82	92	-	-
Phosphate application standard for grassland	111	106	100	101	94	94	92	92	92	88	98	-	-
Use on arable land[2]	90	88	82	78	75	78	75	77	79	68	80	-	-
Phosphate application standard for arable land	95	90	85	85	78	75	70	64	64	59	78	-	-

[1] The average use on grassland is based on the following numbers of farms: 265 (2006), 268 (2007), 265 (2008), 258 (2009), 266 (2010), 262 (2011), 262 (2012), 262 (2013), 263 (2014) and 265 (2015). 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: 196 (2006), 197 (2007), 206 (2008), 197 (2009), 195 (2010), 199 (2011), 196 (2012), 198 (2013), 194 (2014) and 198 (2015). 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: 11 (2006), 14 (2007), 11 (2008), 14 (2009), 14 (2010), 14 (2011), 18 (2012), 14 (2013), 9 (2014) and 8 (2015). The numbers of farms without arable land were as follows: 69 (2006), 71 (2007), 59 (2008), 61 (2009), 71 (2010), 63 (2011), 66 (2012), 64 (2013), 69 (2014) and 67 (2015).
Difference: direction and significance of difference between 2015 and average for previous years. ≈: insignificant difference ($p > 0.05$), +/-: significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2015 period. ≈: insignificant trend ($p > 0.05$), +/-: significant trend ($p < 0.05$).

Table A4.5: Calculated crop yields for grassland and estimated crop yields for silage maize (in kg of dry matter, nitrogen, phosphate and P_2O_5/ha) on farms participating in the derogation monitoring network that meet the criteria for application of the grassland yield calculation method (Aarts et al., 2008), for the 2006-2015 period: average values for the 2006-2014 period, differences between 2015 results and the average values for the 2006-2014 period, and trends identified for the 2006-2015 period

Description	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2006-2014**	**Difference**	**Trend**
Estimated silage maize yield													
Number of farms	174	166	173	183	180	181	182	192	176	188	179		
Tonnes of dry matter per hectare	15.2	15.4	16.0	16.6	16.2	16.7	17.2	16.3	18.0	17.7	16.4	+	+
kg N/ha	189	180	188	192	190	197	182	183	194	192	188	≈	≈
kg P/ha	30	30	31	31	30	32	32	30	35	32	31	≈	+
Kilogrammes of P_2O_5 per hectare	69	69	70	71	70	73	73	68	81	73	71	≈	+
Calculated grassland yield													
Number of farms	234	230	228	231	243	238	243	251	236	246	237		
Tonnes of dry matter per hectare	9.9	10.2	9.8	10.0	9.6	10.5	10.5	9.7	11.2	10.5	10.2	+	+
kg N/ha	274	273	274	262	253	266	253	269	299	267	269	≈	≈
kg P/ha	34	40	39	35	35	38	38	35	45	37	38	≈	+
kg P_2O_5/ha	78	92	90	81	80	86	88	81	104	85	87	≈	+

Difference: direction and significance of difference between 2015 and average for previous years. ≈: insignificant difference ($p > 0.05$), +/-: significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2015 period. ≈: insignificant trend ($p > 0.05$), +/-: significant trend ($p < 0.05$).

Table A4.6: Nitrogen surplus on the soil surface balance (in kg N/ha) on farms participating in the derogation monitoring network (DMN) in the 2006-2015 period: average values for the 2006-2014 period, differences between 2015 results and the average values for the 2006-2014 period, and trends identified for the 2006-2015 period

Description	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2006-2014**	**Difference**	**Trend**
Number of farms	277	279	276	273	280	276	280	276	272	273	277		
Inputs of (organic and inorganic) fertilisers, feedstuffs, animals and other products	330	339	324	324	365	342	326	335	343	366	336	+	+
Outputs of milk, animals, feedstuffs, manure and other products	144	157	152	146	178	169	151	152	189	197	160	+	+
Deposition, mineralisation and nitrogen fixation	62	61	65	60	55	62	59	56	59	56	60	-	-
Gaseous emissions resulting from stabling, storage, grazing and application	62	68	64	65	69	65	61	62	65	64	65	≈	≈
Surplus on soil surface balance													
Average	191	180	172	177	172	170	174	177	148	161	173	-	-
25th percentile[1]	131	119	121	129	125	121	123	131	97	110	122		
75th percentile[2]	237	239	214	216	212	209	209	215	191	205	216		

[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 2015 and average for previous years. ≈: insignificant difference ($p > 0.05$), +/-: significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2015 period. ≈: insignificant trend ($p > 0.05$), +/-: significant trend ($p < 0.05$).

Table A4.7: Nitrogen surplus on the soil surface balance (in kg N/ha) on farms participating in the derogation monitoring network (DMN) in the 2006-2015 period: average values for the 2006-2014 period, differences between 2015 results and the average values for the 2006-2014 period, and trends identified for the 2006-2015 period

Region	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2006-2014**	**Difference**	**Trend**
Sand-250 sub-region (n = 46-56)	154	165	160	168	150	165	160	161	130	145	157	≈	≈
Sand-230 sub-region (n = 83-95)	189	169	155	150	161	150	157	164	121	145	157	≈	-
Loess Region (n = 15-20)	134	138	139	126	150	142	148	140	121	164	138	≈	≈
Clay Region (n = 56-69)	192	177	184	193	165	160	166	171	151	154	173	-	-
Peat Region (n = 47-59)	252	232	211	231	237	229	232	232	208	206	229	-	-
All farms (n = 272-280)	191	180	172	177	172	170	174	177	148	161	173	-	-

Difference: direction and significance of difference between 2015 and average for previous years. ≈: insignificant difference ($p > 0.05$), +/-: significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2015 period. ≈: insignificant trend ($p > 0.05$), +/-: significant trend ($p < 0.05$).

Table A4.8: Phosphate surplus on the soil surface balance (in kg of P_2O_5/ha) on farms participating in the derogation monitoring network (DMN) in the 2006-2015 period: average values for the 2006-2014 period, differences between 2015 results and the average values for the 2006-2014 period, and trends identified for the 2006-2015 period

Description	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2006-2014	Difference	Trend
Number of farms	277	279	276	273	280	276	280	276	272	273	276		
Inputs of (organic and inorganic) fertilisers, feedstuffs, animals and other products	87	83	80	77	92	83	72	78	76	84	81	≈	-
Outputs of milk, animals, feedstuffs, manure and other products	62	71	66	63	79	73	65	63	83	83	69	+	+
Surplus on soil surface balance													
Average	26	12	14	15	13	10	7	15	-7	2	12	-	-
25th percentile[1]	10	-2	1	1	2	-2	-3	4	-24	-13	-1		
75th percentile[2]	38	27	26	27	26	23	19	26	9	17	25		

[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 2015 and average for previous years. ≈: insignificant difference ($p > 0.05$), +/-: significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2015 period. ≈: insignificant trend ($p > 0.05$), +/-: significant trend ($p < 0.05$).

Table A4.9: Average nutrient concentrations (in mg/l) in water leaching from the root zone in the 2007-2016 period: average values for the 2007-2014 period, differences between 2016 results and the average values for the 2007-2014 period, and trends identified for the period from 2007 up to and including May 2016

		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2007-2015	Difference	Trend
Sand-250	Number of farms	55	54	56	56	58	59	59	54	49	51			
	Nitrate	43	31	26	27	29	25	25	26	26	23	29	≈	-
	Phosphorus[1]	<dl	<dl	<dl	0.10	0.13	0.10	0.13	0.17	0.18	0.19	0.11	≈	≈
	Nitrogen (P)	12.8	10.3	8.8	9.2	9.7	9.3	8.9	9.1	9.2	8.8	9.7	≈	-
Sand-230	Number of farms	88	87	86	87	84	88	95	99	103	106			
	Nitrate	70	55	51	63	48	43	46	51	46	37	52	-	-
	Phosphorus	0.09	0.08	0.09	0.08	0.10	0.09	0.08	0.11	0.10	0.10	0.09	≈	≈
	Nitrogen (P)	19	16	14	16	14	13	13	14	13	11	14.6	-	-
Loess Region[1]	Number of farms	16	17	19	17	19	19	20	18	18				
	Nitrate	70	52	51	51	56	54	56	51	42		55	-	-
	Phosphorus[1]	<dl	<dl	<dl	<dl	-[2]	<dl	<dl	<dl	<dl		<dl	≈	≈
	Nitrogen (P)	17	13	12	12	14	14	13	12	10		13.3	-	-
Clay Region	Number of farms	60	63	64	64	64	60	65	60	60	60			
	Nitrate	25	16	15	19	13	10	11	14	22	13	16	-	-
	Phosphorus	0.35	0.40	0.32	0.25	0.27	0.33	0.26	0.28	0.24	0.29	0.30	≈	-
	Nitrogen (P)	8.9	6.2	5.5	6.3	5.2	4.7	4.5	5.4	6.6	4.9	5.9	-	-
Peat Region	Number of farms	49	49	48	48	49	51	57	57	58	59			
	Nitrate	15	6	6	13	7	4	6	9	13	7	9	≈	≈
	Phosphorus	0.51	0.39	0.32	0.44	0.37	0.42	0.43	0.30	0.35	0.29	0.39	-	-
	Nitrogen (P)	10.7	9.7	8.2	10.7	9.4	8.0	8.3	9.3	10.1	8.4	9.4	≈	≈

* The concentrations deviate from the final figures that are reported annually (see section 2.4.2 for the calculation method).
[1] Average phosphorus concentrations below the detection limit of 0.062 mg/l are indicated by the abbreviation <dl.
[2] Phosphorus data were rejected in that year (Hooijboer *et al.*, 2013).
Difference: direction and significance of difference between 2016 and average for previous years. ≈: insignificant difference ($p > 0.05$), +/-: significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2007-2016 period. ≈: insignificant trend ($p > 0.05$), +/-: significant trend ($p < 0.05$).

Table A4.10: Average ditch water[1] nutrient concentrations (in mg/l) in the 2007-2016 period: average values for the 2007-2015 period, differences between 2015 results and the average values for the 2007-2014 period, and trends identified for the 2007-2015 period*

		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2007-2015	Difference	Trend
Sand-250	Number of farms	11	12	13	14	16	13	13	13	12	12			
	Nitrate	28	21	19	22	16	11	10	22	28	15	20	-	-
	Phosphorus	0.35	0.24	0.42	0.22	0.13	0.17	0.16	0.15	0.18	0.21	0.22	≈	≈
	Nitrogen (P)	8.2	7.3	7.2	7.5	5.9	4.8	4.8	7.5	8.9	5.9	6.9	-	-
Sand-230	Number of farms	20	21	21	20	19	22	22	17	18	17			
	Nitrate	37	39	31	37	32	24	26	28	24	26	31	≈	-
	Phosphorus	<dl	0.061	0.071	<dl	0.063	0.072	0.108	0.086	0.147	0.162	0.078	≈	≈
	Nitrogen (P)	10.1	10.7	8.8	10.5	9.1	7.7	8.0	8.5	7.7	8.1	9.0	≈	-
Clay Region	Number of farms	59	59	63	63	63	59	64	59	59	59			
	Nitrate	12.0	8.8	6.9	9.7	6.2	5.3	4.4	6.0	10.5	6.8	7.8	≈	-
	Phosphorus	0.32	0.36	0.35	0.22	0.27	0.25	0.26	0.26	0.21	0.28	0.279	≈	≈
	Nitrogen (P)	4.3	4.0	3.7	4.1	3.5	3.1	3.4	3.4	4.2	3.6	3.8	≈	≈
Peat Region	Number of farms	49	48	47	47	48	50	56	56	57	59			
	Nitrate	5.9	4.2	3.5	3.6	3.7	2.8	2.5	3.5	6.5	3.4	4.0	≈	≈
	Phosphorus	0.21	0.13	0.15	0.14	0.15	0.16	0.20	0.18	0.19	0.21	0.17	+	≈
	Nitrogen (P)	3.7	4.2	4.3	4.1	4.6	4.0	4.1	4.3	5.2	4.3	4.3	≈	+

* The concentrations deviate from the final figures that are reported annually (see section 2.4.2 for the calculation method).
[1] There are no farms with ditches in the Loess Region.
Difference: direction and significance of difference between 2015 and average for previous years. ≈: insignificant difference ($p > 0.05$), +/-: significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2007-2015 period. ≈: insignificant trend ($p > 0.05$), +/-: significant trend ($p < 0.05$).

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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 (RVO.nl), formerly known as the National Service for the Implementation of Regulations (DR), as well as the Minerals Policy Monitoring Programme (LMM) have reported the calculated fertiliser usage on farms participating in the derogation scheme. Because the calculated data sometimes showed significant discrepancies in the past, Wageningen Economic Research has analysed these differences since 2010 at the request of the Ministry of Economic Affairs.

One important cause of the calculated differences between the LMM data and the RVO.nl data is related to the different purposes for which fertiliser usage on derogation farms is calculated. The LMM calculations are aimed at calculating the fertilisation rates as accurately as possible, using as much farm-specific information as possible. The fertiliser usage calculations performed by RVO.nl serve a different purpose, namely to discover 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 usage as calculated based on LMM data and stated in this report, with the fertiliser usage 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 usage in kg/ha on farms to which derogation has been granted according to RVO.nl data, fertiliser usage in kg/ha on farms according to LMM derogation monitoring results, and differences between these source data in 2015 for both nitrogen and phosphate in kg/ha and in percentages

Item	LMM (kg/ha)	RVO (kg/ha)	Difference between LLM and RVO (basis) (kg/ha)	(%)
Nitrogen				
Livestock manure	236	234	2	1%
Inorganic fertilisers	133	119	14	11%
Other organic fertilisers	1	3	-3	-84%
Total	369	356	13	4%
Phosphate				
Livestock manure	79	81	-3	-3%
Inorganic fertilisers	0	0	0	-
Other organic fertilisers	1	1	-1	-49%
Total	80	83	-3	-3%

Source: based on data from RVO and FADN processed by Wageningen Economic Research

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 also applies to total fertilisation (i.e. inorganic fertilisers + livestock manure +
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 derogation in the year concerned (4 farms in the derogation monitoring network did not do so in 2015).

The application of these exclusion criteria meant that the number of LMM farms usable for derogation monitoring purposes in 2015 decreased from 293 to 273.

To enable a comparison with the RVO.nl data, fertiliser usage on these 273 LMM farms was also calculated based on the relevant RVO.nl data. For this purpose, 281 BRS numbers were linked to the 273 LMM farms. Some LMM farms have two BRS numbers, and in those cases the data belonging to the two BRS numbers were combined. Based on their RVO.nl data, 29 LMM farms with 30 BRS numbers turned out to fall outside the confidence intervals specified in Appendix 2. Eventually, the comparison with the RVO.nl data was made for 244 LMM farms with 251 BRS numbers.

The following data sources were used to compare the RVO.nl and LMM figures for 2015:

- Farm Accountancy Data Network (FADN) of Wageningen Economic Research: this concerns the 293 farms that qualified for derogation monitoring (DM) in 2015. 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 19,242 registration numbers (BRS numbers) of farms that applied for derogation in 2015. Eight BRS numbers have been added which are included in the 293 LMM farms, but not in the 19,242 BRS numbers.
- Data from the 2015 Agricultural Census concerning the 19,242 BRS numbers. In the case of 172 BRS numbers, no number could be found in the 2015 Agricultural Census, leaving 19,070 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 approximately 2 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.

Differences between the two populations are an important cause of the discrepancies. 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 10 kg, from 234 to 244 kg N/ha (B in Table A5.2). For this purpose, farms smaller than 10 ha 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, the difference between the LMM figure and the RVO.nl figure changes from 2 kg (A in Table A5.2) to -8 kg (A-B in Table A5.2).

The remaining difference of -8 kg (A-B in Table A5.2) may be attributed to the following factors (expressed as percentages of the -8 kg difference (A-B) in Table A5.2, and listed as items a through h):

a. The 244 LMM observations may be regarded 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 the fertiliser usage on these 244 farms is calculated based on RVO.nl data, the result deviates by 4.2 kg from the result for this much larger RVO.nl population. This may be considered a sampling difference, and explains 49% of the 8 kg difference.
b. The area of cultivated land in use on the above-mentioned 244 LMM farms is about 0.6 ha less than the cultivated land area according to RVO.nl data. If the RVO.nl results are converted to the area of cultivated land according to LMM data, we get a difference of 1.5 kg of nitrogen per hectare, or 18% of the A-B difference in Table A5.2.
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 2015 was that the calculated LMM fertiliser quantities were 6.9 kg per hectare lower than the RVO.nl quantities. This is equal to 82% of the A-B difference in Table A5.2.
d. The remaining difference (-7.2 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 almost 14 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 set. There are various reasons for this. 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 selected 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 2015

	Nitrogen	
Item	**kg N/ha**	**Percentage**
Difference between LMM and RVO.nl data (A)	1.8	
Difference due to different populations (B)	-10.2	
Difference in comparable populations (A-B)	*-8.4*	*-100*
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	*4.2*	*49*
b. Difference in acreage of cultivated land	*1.5*	*18*
c. Stocks	*-4.3*	*-51*
d. Inputs and outputs	*-2.6*	*-31*
e. Use of BEX* method in LMM programme	*-13.7*	*-163*
f. Standard-based excretion by dairy cows	*-0.1*	*-1*
g. Standard-based excretion by other cattle	*5.4*	*64*
h. Standard-based excretion by other grazing animals	*0.8*	*9*
i. Standard-based excretion by intensive livestock	*0.4*	*5*

Source: based on data from RVO and FADN processed by Wageningen Economic Research.
* The abbreviation BEX stands for 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 ha 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, < 0.5 kg/ha. Derogation farms are not permitted to use phosphate from inorganic fertilisers. LMM farms with more than one BRS number will have at least one BRS number with derogation, whereas the other BRS number or numbers will not be part of the derogation network; on the latter numbers, the use of phosphate from inorganic fertilisers is permitted.

A5.4 Conclusion

The differences found do not give cause to adjust the LMM calculation method. This applies to nitrogen as well as phosphate.

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Appendix 6 Exemptions from derogation conditions in connection with serious damage caused by mice

Introduction
During the autumn and winter of 2014/2015, approximately 60,000 ha of grassland in the Netherlands suffered damage, to a greater or lesser extent, from a plague of field mice. By far, most of the damage was suffered in the province of Friesland, but other parts of the Netherlands were also affected, including the province of Limburg. In the spring of 2015, experts were commissioned by the Fauna Fund to assess the damage suffered by individual farms.

As a result of the plague, the livestock farmers affected had less meadow grass available and were therefore unexpectedly forced to make use of their stocks of roughage or import extra roughage into the farm from elsewhere. On some of these farms, the cultivation of silage maize was seen as a way to still realise yields in 2015 on the plots that were damaged. However, one of the derogation conditions is that a minimum of 80% of the land under cultivation at the farm must consist of grassland. For these farms, this stood in the way of their being able to produce sufficient roughage for their livestock in 2015.

Exemption scheme
In consultation with the agricultural organisations and with permission from the European Commission, the then-state secretary Sharon Dijksma implemented a once-only emergency measure. This emergency measure included an exemption in 2015 from the requirement that 80% of the land under cultivation at the farm must consist of grassland. Exemption from the requirement that a minimum of 80% of the land under cultivation must consist of grassland could be obtained subject to the following conditions:

1. at least 65% of the land under cultivation had to remain grassland;
2. for the extra silage maize cultivated, a maximum of 170 kg of nitrogen from livestock manure could be applied per hectare;
3. the extra silage maize cultivated would be undersown with grass.

In order to be eligible for this exemption, at least 25% of the grassland acreage that was part of the farm in 2014 had to have suffered serious damage from the field mice plague and the expected reduction in the yield of grass had to be at least 25%.

Number of farms that submitted an application for the exemption scheme
Although the expectation beforehand was that approximately 700 farms would make use of this exemption scheme, only 27 farms actually submitted an application. Two of the farms included in the sample population for the derogation monitoring network submitted an application. These two farms were located in the provinces of Friesland and Limburg.

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