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

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LEI WAGENINGEN UR

# Colophon



S. Lukács (author), RIVM
T.J. de Koeijer (author), LEI
H. Prins (author), LEI
A. Vrijhoef (author), RIVM
L.J.M. Boumans (author), RIVM
C.H.G. Daatselaar (author), LEI

Contact person:
Saskia Lukács
Centre for Environmental Monitoring
saskia.lukacs@rivm.nl

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# Publiekssamenvatting


## Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie in 2014

De Nederlandse landbouw is wereldwijd gezien een zeer productieve en efficiënte sector. Het gebruik van mest is noodzakelijk voor de efficiënte productie van gewassen. Mestgebruik heeft echter ook ongewenste (milieu)effecten. Het Nederlandse mestbeleid tracht schadelijke milieueffecten te beperken; monitoring is hierbij een essentieel onderdeel. Dit sluit aan bij internationale afspraken over het mestgebruik en over het volgen van het effect van beleidsmaatregelen.

De Europese Nitraatrichtlijn schrijft lidstaten voor om het gebruik van dierlijke mest te beperken tot 170 kg stikstof per hectare. Landbouwbedrijven in Nederland met ten minste 80 procent grasland mochten in 2014 onder bepaalde voorwaarden van deze norm afwijken en meer mest, afkomstig van graasdieren zoals koeien en schapen, gebruiken (derogatie). LEI Wageningen UR en het RIVM volgen op 300 derogatiebedrijven de bedrijfsvoering en de effecten op de waterkwaliteit en rapporteren de resultaten hiervan jaarlijks aan de EU. In deze rapportage zijn de situatie in 2014 beschreven en de trends tussen 2006 en 2015. De nitraatconcentratie in het grondwater is in deze periode, afhankelijk van de regio, gedaald of gelijk gebleven.

### Bedrijfsvoering
Gemiddeld hebben derogatiebedrijven in 2014 237 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 stikstofbodemoverschot. Dit is het verschil tussen de aanvoer van stikstof (zoals meststoffen) en de afvoer ervan (waaronder via gras en maïs). Het gemiddelde Nederlandse stikstofbodemoverschot is gedurende de onderzochte periode niet significant veranderd, maar vertoonde in 2014 wel een sterke daling als gevolg van het goede groeiseizoen voor gras en maïs.

### Grondwaterkwaliteit
In 2014 was de gemiddelde nitraatconcentratie in het grondwater in de Zandregio 40 milligram per liter (mg/l). Dit was 10 mg/l onder de nitraatnorm van 50 mg/l. Bedrijven in de Kleiregio en de Veenregio hadden gemiddeld een lagere nitraatconcentratie (respectievelijk 15 en 9,5 mg/l). De nitraatconcentratie op de derogatiebedrijven in de Lössregio was gemiddeld 51 mg/l. Het verschil tussen de regio's wordt vooral veroorzaakt door een hoger percentage uitspoelingsgevoelige gronden in de Zand- en Lössregio; dit zijn gronden waar nitraat in mindere mate in de bodem wordt afgebroken en daardoor meer kan uitspoelen naar het grondwater.


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

# Synopsis


## Agricultural practices and water quality on farms registered for derogation in 2014

Dutch agriculture is highly productive and efficient. The use of minerals is necessary for efficient production of crops, but also has undesirable (environmental) effects. The Dutch minerals policy seeks to minimise adverse environmental impacts, whereby monitoring is an essential component. This consists with international agreements on the use of minerals and monitoring the impact of policies.

Conform the EU Nitrates Directive, the member states are required to limit the use of livestock manure to a maximum of 170 kg of nitrogen per hectare per year. Dutch farms growing grass on at least 80 per cent of their total agricultural area were in 2014 allowed to deviate from this requirement under certain conditions. This exemption from the standard of 170 kg nitrogen is referred to as ‘derogation’. LEI Wageningen UR and RIVM monitor agricultural practices and water quality at 300 farms, which have been granted derogation and annually report the results to the EU. This study shows the results in 2014 and trends between 2006 and 2015. The report concludes that the average nitrate concentration in groundwater on these farms has stabilized or decreased in this period.

### Agricultural practice

This report shows that, on average, derogation farms in 2014 applied 237 kg of nitrogen per hectare in the form of livestock manure. The quantity of nitrogen that can potentially leach into groundwater in the form of nitrate is partly determined by the nitrogen soil surplus. This surplus is defined as the difference between nitrogen input (e.g. in the form of fertilisers) and output (e.g. via harvested grass and maize). The average nitrogen soil surplus in the Netherlands has not changed substantially during the period studied, but in 2014 it decreased considerably due to the good growing season for grass and maize.

### Groundwater quality

In 2014, the average nitrate concentration in groundwater on derogation farms in the Sand Region amounted to 40 milligrammes per litre (mg/l), and was therefore below the nitrate standard of 50 mg/l. On average, farms in the Clay Region and Peat Region had lower nitrate concentrations (15 and 9.5 mg/l, respectively). Derogation farms in the Loess Region had an average nitrate concentration in groundwater of 51 mg/l. The differences between the regions are mainly caused by a higher percentage of soils prone to nitrogen leaching in the Sand Region and Loess Region. Less denitrification (microbial decomposition of nitrate) occurs on these soils, and more nitrate can therefore leach into the groundwater.


Keywords: derogation, agricultural practices, manure, Nitrate Directive, water quality

# Preface

This report provides an overview of agricultural practices in 2014 on all farms that registered for derogation in the derogation monitoring network. The agricultural practice data include data on fertiliser use and actual nutrient surpluses. Information is also provided about the results of water quality monitoring conducted in 2014 and 2015 on farms in the derogation monitoring network.

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

The derogation monitoring network was created in order to meet the conditions imposed by the European Commission when it granted an exemption 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 the derogation scheme 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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Saskia Lukács, Tanja de Koeijer, Henri Prins, Astrid Vrijhoef,
Leo Boumans and Co Daatselaar

3 June 2016

# Contents

# Summary


**Introduction**
The EU Nitrates Directive obligates member states to limit the use of nitrogen in livestock manure to a maximum of 170 kg of nitrogen per hectare per year. The Netherlands has requested the European Commission to grant an exemption from this obligation (this exemption is referred to as 'derogation' throughout this report). 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, North 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 exemption arrangement include an obligation for the Dutch government to set up a monitoring network comprising 300 farms that have registered for derogation ('derogation farms'), and to submit annual reports to the European Commission.

**Derogation monitoring network**
The derogation monitoring network was set up by expanding the Minerals Policy Monitoring Programme (*Landelijk Meetnet effecten Mestbeleid*, LMM) of RIVM and LEI. A stratified random sampling method was used to select 300 farms, distributed as evenly as possible according to soil type 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, 286 actually participated in the derogation scheme in 2014. In addition to collecting economic data, nutrient flows were also analysed on 271 farms. In addition to data on agricultural practices and water quality in 2014, this report also presents data on water quality in 2015, as this information relates to agricultural practices in 2014.

**Agricultural practices in 2014**
In 2014, the farms in the derogation monitoring network applied an average of 237 kg of nitrogen from livestock manure per hectare of cultivated land. Factoring in the statutory availability coefficients, the average quantity of plant-available nitrogen amounted to 117 kg of nitrogen per hectare. In addition, an average of 136 kg of nitrogen per hectare was applied in the form of inorganic fertilisers and 2 kg of plant-available nitrogen per hectare was applied in the form of other organic fertilisers. At 255 kg per hectare, the total use of plant-available nitrogen was 16 kg less than the total nitrogen application standard (271 kg per hectare on average).

At 85 kg per hectare, phosphate use was 3 kg below the average phosphate application standard for farms in the derogation monitoring network (88 kg per hectare).

The average nitrogen surplus on the soil surface balance (i.e. the net nitrogen input to the soil) in 2014 was calculated at 153 kg per hectare.

The Peat Region[1] had the highest nitrogen surplus, followed by the Clay Region, the Sand Region and the Loess Region. On average, the phosphate surplus on the soil surface balance was negative, namely -7 kg of phosphate per hectare.

**Agricultural practices during the 2006-2014 period**
Milk production per farm increased continually during the 2006-2014 period by 4.5% per year on average. This rise was caused by the growing number of dairy cows per hectare and the increase in the average area of cultivated land per farm. Average milk production per dairy cow was fairly stable. The proportion of derogation farms with animals in stables (such as pigs and poultry) decreased gradually during this period. As a result, phosphate production by animals in stables declined, although total phosphate production in 2014 was higher than in previous years. These trends point to a steady increase in scale, intensification of milk production, and specialisation in the dairy farming sector.

The average proportion of grassland on derogation farms increased from 83% in 2013 to 86% in 2014. In 2014, dairy cows were put out to pasture on 77% of all dairy farms, down from 79% in 2012 and 2013.

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 was gradually increased, resulting in a rise in the total use of plant-available nitrogen.

In 2014, the remaining margin available for the application of nitrogen increased due to an increase in the proportion of grassland, which is subject to a higher application standard than arable land. This additional margin was used to apply greater quantities of inorganic fertilisers. The use of inorganic fertilisers remained virtually constant until 2013, but increased in 2014. In 2014 the total release of plant-available nitrogen was 12 kg per hectare higher than in 2013, although the total application standard was not exceeded.

The application standard for phosphate decreased by nearly 20% between 2006 and 2014. This resulted in an almost equally large decrease in the use of phosphate, particularly in the form of inorganic phosphate-containing fertilisers. As of 15 May 2014, inorganic phosphate-containing fertilisers may no longer be supplied to derogation farms.

The dry-matter yields for grass and silage maize were below average in 2013, whereas historically high yields were recorded in 2014. The dry-matter yield for grass was 9% higher than in 2013, and the dry-matter yield for silage maize was 14% higher. The nitrogen and phosphate yields were also considerably higher for both crops.

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

In 2014, the nitrogen surplus on the soil surface balance decreased by 30 kg per hectare compared to the 2006-2013 period. This decrease was mainly caused by the exceptional growing season of 2014, which resulted in an increased output of nitrogen via the harvest of grass, maize and other crops. The output of nitrogen via manure also increased. No trend change could be observed in the average nitrogen soil surplus during the 2006-2013 period. As indicated above, the nitrogen soil surplus decreased in 2014. In 2014 the phosphate soil surplus was negative and considerably lower than the average surplus in the 2006-2013 period, due to the increase in phosphate output via crops.

**Water quality in 2014**

At 40 mg/l, the average nitrate concentration in water leaching from the root zone in the Sand Region was below the nitrate standard of 50 mg/l. At 51 mg/l, the average nitrate concentration on farms in the Loess Region slightly exceeded the standard. Nitrate concentrations in the Clay Region (15 mg/l) and the Peat Region (9.5 mg/l) were far below the nitrate standard. In the Sand Region, nitrate concentrations were below the nitrate standard on 66% of all farms. In the Loess Region, this was the case on 71% of all farms. The percentage of farms with below-standard average nitrate concentrations was 95% in the Peat Region and 91% in the Clay Region. In all soil type regions, the nitrate and nitrogen concentrations measured in ditch water were lower than the concentrations measured in water leaching from the root zone and into groundwater.

The highest phosphorus concentrations in water leaching from the root zone were measured in the Peat Region (0.30 mg P/l), followed by the Clay Region (0.27 mg P/l). The average phosphorus concentration in the Sand Region was 0.14 mg P/l, and fell below the detection threshold in the Loess Region.

**Water quality in the 2007-2015 period**

The average nitrate concentration in water leaching from the root zone in the Sand Region and Loess Region was lower in the most recent measurement year than in the previous year. Nitrate concentrations in the Sand Region and Clay Region displayed a downward trend during the entire measurement period. There was no trend change in nitrate concentrations in the Loess Region and Peat Region. A decrease in nitrate concentrations in ditch water was observed in the Sand Region and Clay Region. There was no trend change in ditch water nitrate concentrations in the Peat Region.

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

**Relationship between agricultural practices and water quality**

The nitrogen soil surpluses showed no upward or downward trend during the 2006-2013 period. However, the nitrate concentrations in water leaching from the root zone did decrease during this period. This decrease may be caused by after-effects of higher soil surpluses in the past. Nitrogen soil surpluses decreased substantially in all regions in 2014 by an average of 17%. This recent development is not yet reflected in decreasing nitrate concentrations in ditch water or in water leaching from the root zone.

Due to the decreasing use of inorganic fertilisers, the phosphate surplus on the soil surface balance displayed a downward trend in the 2006-2014 period. Possibly as a result of this, phosphorus concentrations in water leaching from the root zone decreased in the Clay Region and Peat Region 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 (this exemption is referred to as 'derogation' throughout this report). In December 2005, the European Commission issued the Netherlands with a derogation decision for the 2006-2009 period (EU, 2005). In February 2010, the derogation decision was extended until 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. From 2014 onward, farms cultivating at least 80% of their total area as grassland are 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, North 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, scope

The present report compiled by RIVM and LEI, together with the Netherlands Enterprise Agency report (2016), 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 (2016).

*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.*

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.*

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.*

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.*

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

**Article 9 Controls**

9.1 *The competent national authority shall carry out administrative controls in respect of all farms benefiting from an individual derogation for the assessment of compliance with the maximum amount of 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. If the controls 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/EEC,* *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 (2016).

**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 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 the 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 (2016). In consultation with the European Commission, these reports are submitted in June, as was the case in 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 the data for all derogation farms in the Netherlands, and discusses the differences between the two sets of results arising from a difference in approach. The obligation referred to in Article 10(1)(d) is fulfilled in the Netherlands Enterprise Agency report (2015). 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 shall make 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.*

## 1.3 Previously published reports and contents of this report

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

The first report (Fraters *et al*., 2007b) was limited to a description of the derogation monitoring network, the progress made in 2006, and the design and content of the reports for the years 2008 to 2010 inclusive. The derogation monitoring network results have been published in the subsequent reports (Fraters *et al*., 2008; Zwart *et al*., 2009, 2010 and 2011; Buis *et al*., 2012; Hooijboer *et al*., 2013 and 2014; Lukács *et al.*, 2015). Once results for multiple measurement years became available, the reports devoted more attention to the examination of trends in agricultural practices and water quality.

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

Chapter 3 presents and discusses the measurement results of the monitoring of agricultural practices and water quality for 2014. This chapter also contains the provisional water quality monitoring results for 2015 (section 3.2.4).

Chapter 4 describes developments related to agricultural practices and water quality, including a discussion of trend-based changes since the start of the derogation scheme, and a statistical analysis of the extent to which agricultural practice year 2014 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 en 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 use and nutrient surpluses. Water samples on farms were taken in accordance with the standard LMM procedures ((Fraters *et al*., 2004)). This sampling method is explained in Appendix 3.

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

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

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 in the provinces of Overijssel, Gelderland, Utrecht, North Brabant and Limburg may apply up to 230 kg of nitrogen per hectare per year in the form of grazing livestock manure. The same requirement applies to farms on loessial soils. 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. See also Figure A1.1 in Appendix 1. Farms in the Sand-230 sub-region are permitted to apply up to 230 kg of nitrogen per hectare per year 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 of nitrogen per hectare per year in the form of grazing livestock manure on these fields.

With respect to water quality, the distinction between the Sand-230 and Sand-250 sub-regions has been applied to the provisional data for 2015, which are related to the agricultural practice data for 2014. The water quality data for 2014 are related to agricultural practices in 2013, when the same maximum quantity applied to all types of soils (namely 250 kg of nitrogen per hectare per year).

## 2.2 Statistical method used to determine deviations and trends

*Determining deviations in the measurement year under consideration*
The comparison aims to establish if there is a significant difference between the value measured in the measurement year and the average for the preceding years. The significance was determined using the Restricted Maximum Likelihood procedure (REML method). The REML method is suitable for unbalanced data sets and therefore takes account of farms which 'drop out' and are replaced. The agricultural practice data were processed using the REML method available as part of the 'linear mixed effects models procedure' (MIXED method) in IBM SPSS Statistics (version 22). The water quality data were processed using the REML method in GenStat (16th edition; VSN International Ltd.).

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

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

Table A4.1B). The main text of this report only mentions differences if they are significant.

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

## 2.3 Water quality and agricultural practices

The water quality levels measured in any year partly reflect agricultural practices in the year preceding the water quality monitoring and in previous years. The extent to which agricultural practices in previous years affect the water quality measurements depends on various factors, including (fluctuations in the) precipitation surplus during that year and local hydrological conditions. In the High Netherlands, it is assumed that agricultural practices affect water quality at least one year later. In the Low Netherlands, the impact of agricultural practices on water quality is quicker to materialise. The 'Low Netherlands' comprises the Clay Region, the Peat Region and those parts of the Sand Region that are drained by means of ditches, possibly in combination with drainage pipes or surface drainage. The 'High Netherlands' comprises the other parts of the Sand Region, and the Loess Region. 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 following the year in which the agricultural practices were determined. In the Sand Region, groundwater is sampled in the summer following the year in which agricultural practices are determined. In the Loess Region, soil moisture samples are taken in the autumn following following the year in which agricultural practices were determined (see Appendix 3).

This means that water quality samples for measurement year 2014 can be related to agricultural practices in 2013 (see Table 2.1). Water quality samples for measurement year 2014 were taken during the winter of 2013/2014 in the Low Netherlands, and during the summer and autumn of 2014 in the High Netherlands.

The present report also includes water quality sampling results for measurement year 2015, which can be related to agricultural practices in 2014 (see Table 2.1). These water samples were taken in the winter of 2014-2015 in the Low Netherlands, and in the summer of 2015 in the High Netherlands. The results for the Loess Region from sampling carried out in the autumn of 2015 are not yet available, and the other data are regarded as provisional because it is unknown at this time which farms will qualify for participation in the derogation scheme. The definitive figures will be reported in 2017, at which time the 2015 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*

| *Report* | *Agricultural practices* | *Water quality*[2] | | |
|---|---|---|---|---|
| | | *Clay and Peat* | *Sand* | *Loess* |
| Lukács *et al.*, 2015 | 2013 | 2012/2013 final, 2013/2014 provisional | 2013 final, 2014 provisional | 2013/2014 final, 2014/2015 not yet available |
| Lukács *et al.*, 2016[1] | 2014 | 2013/2014 final, 2014/2015 provisional | 2014 final, 2015 provisional | 2014/2015 final, 2015/2016 not yet available |

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

## 2.4 Number of farms in 2014

### *2.4.1 Number of farms where agricultural practices were determined*

Although the derogation monitoring network is a permanent network, a number of farms 'drop out' every year because they are no longer participating in the LMM programme. It is also possible that agricultural practices could not be reported due to incomplete data on nutrient flows. Incomplete nutrient flow data may be caused by the presence on the farm of animals owned by 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. However, water quality samples have been taken in these cases.

Agricultural practices were successfully registered at 298 of the 300 planned farms (see Table 2.2). Of these 298 farms, 286 actually participated in the derogation scheme. Thirty farms that participated in the derogation monitoring network in 2013 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 2014 (agricultural practices)*

| Farm type | Planned/actual | Sand | | Loess | Clay | Peat | Total |
|---|---|---|---|---|---|---|---|
| | | 250 | 230 | | | | |
| Dairy farms | Planned[1] | 140 | | 17 | 52 | 52 | 261 |
| | Actual: | | | | | | |
| | - Of which processed by LEI[2] | 47 | 91 | 16 | 52 | 54 | 260[3] |
| | - Of which participating in the derogation scheme | 45 | 86 | 15 | 50 | 54 | 250[3] |
| | - Of which submitted complete nutrient flow data | 45 | 83 | 15 | 50 | 54 | 247 |
| Other grassland farms | Planned[1] | 20 | | 3 | 8 | 8 | 39 |
| | Actual: | | | | | | |
| | - Of which processed by LEI[2] | 1 | 18 | 4 | 9 | 6 | 38 |
| | - Of which participating in the derogation scheme | 1 | 17 | 3 | 9 | 6 | 36 |
| | - Of which submitted complete nutrient flow data | 1 | 9 | 3 | 6 | 5 | 24 |
| Total | Planned[1] | 160 | | 20 | 60 | 60 | 300 |
| | Actual: | | | | | | |
| | - Of which processed by LEI[2] | 48 | 109 | 20 | 61 | 60 | 298 |
| | - Of which participating in the derogation scheme | 46 | 103 | 18 | 59 | 60 | 286 |
| | - Of which submitted complete nutrient flow data | 46 | 92 | 18 | 56 | 59 | 271 |

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

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

- The description of general farm characteristics (section 2.6) concerns all farms that could be fully processed in FADN in 2014, and that participated in the derogation scheme (286 farms).
- The description of agricultural practices in 2014 (section 3.1) concerns all farms for which a full picture of nutrient flows could be obtained from FADN data (271 farms).
- The comparison of agricultural practices in the 2006-2014 period (section 4.1) concerns all farms that participated in the derogation monitoring network in the respective years. This number varies from year to year (see Appendix 4, Table A4.2A).

### 2.4.2 *Number of farms where water quality was sampled*

In 2014, water quality was sampled on 304 farms (see Table 2.3). Of these 304 farms, 276 participated in the derogation monitoring network in 2014. The difference of 28 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 2014. However, the farms that dropped out have been used to determine trends in water quality. Furthermore, eleven farms out of a total of 276 did not qualify for participation or did not actually participate in the derogation scheme. The water quality sampling results of the remaining 265 sampled farms are presented in this report.

*Table 2.3 Planned and actual number of analysed dairy and other grassland farms per region in 2014 (water quality)*

| *Farm type* | *Planned/actual* | *Sand* | *Loess* | *Clay* | *Peat* | *Total* |
|---|---|---|---|---|---|---|
| Dairy farms | Planned[1] | 140 | 17 | 52 | 52 | 261 |
| | Actual: | | | | | |
| | - sampled[2] | 140 | 18 | 56 | 54 | 268 |
| | - Derogation monitoring network 2014[3] | 126 | 17 | 52 | 51 | 246 |
| | - Participated in derogation scheme | 120 | 16 | 50 | 51 | 237 |
| Other grassland farms | Planned[1] | 20 | 3 | 8 | 8 | 39 |
| | Actual: | | | | | |
| | - sampled[2] | 20 | 4 | 7 | 5 | 36 |
| | - Derogation monitoring network 2014[3] | 17 | 2 | 6 | 5 | 30 |
| | - Participated in derogation scheme | 16 | 1 | 6 | 5 | 28 |
| Total | Planned[1] | 160 | 20 | 60 | 60 | 300 |
| | Actual: | | | | | |
| | - sampled[2] | 160 | 22 | 63 | 59 | 304 |
| | - Derogation monitoring network 2014[3] | 143 | 19 | 58 | 56 | 276 |
| | - Participated in derogation scheme | 136 | 17 | 56 | 56 | 265 |

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

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

- The description of the water quality results for measurement year 2014 (section 3.2) concerns all farms where water quality samples were taken in 2014 and that qualified for participation in the derogation scheme in 2014 (265 farms).
- The description of the water quality results for measurement year 2015 (section 3.2.4) concerns all farms participating in the derogation monitoring network in 2014 (except farms in the Loess Region) where water quality samples were taken in measurement year 2015 (270 farms).

- The analysis of water quality levels during the 2007-2015 period (section 4.2) concerns all farms that participated in the derogation monitoring network in the agricultural practice year preceding the relevant measurement year, and that qualified for participation in the derogation scheme in that previous year. This number varies from year to year (see Table 2.4).

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

| *Year* | *Number of farms* |
|---|---|
| 2007 | 278 |
| 2008 | 279 |
| 2009 | 280 |
| 2010 | 279 |
| 2011 | 281 |
| 2012 | 277 |
| 2013 | 295* |
| 2014 | 285 |
| 2015 | 270 (excluding farms in Loess Region) |

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

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

*Table 2.5 Number of sampled and reported farms per sub-programme and per region in 2014 and 2015, and sampling frequency of leaching water (LW) and ditch water (DW) (the target sampling frequency is stated in parentheses)*

| *Year* | | *Sand* | | *Loess* | *Clay* | *Peat* | *Total* |
|---|---|---|---|---|---|---|---|
| 2014 | Number of farms | 136 | | 17 | 56 | 56 | 265 |
| | Number of farms – Leaching water | 135 | | 17 | 56 | 56 | 264 |
| | Number of farms – Ditch water | 25 | | - | 55 | 55 | 135 |
| | LW sampling frequency | 1.0 (1) | | 1.0 (1) | 3.4 (2-4)[2] | 1.0 (1) | |
| | DW sampling frequency | 4.0 (4) | | - | 4.0 (4) | 4.2 (4-5) | |
| *Year* | | *Sand*[1] | | *Loess* | *Clay* | *Peat* | *Total* |
| | | *250* | *230* | | | | |
| 2015 | Number of farms | 47 | 113 | - | 62 | 58 | 270 |
| | Number of farms – Leaching water | 47 | 113 | -* | 62 | 58 | 270 |
| | Number of farms – Ditch water | 10 | 21 | - | 61 | 57 | 146 |
| | LW sampling frequency | 1.0 (1) | 1.0 (1) | -* | 3.4 (2-4) | 1.0 (1) | |
| | DW sampling frequency | 4.3 (4) | 4.2 (4) | - | 4.0 (4) | 4.0 (4-5) | |

[1] Since 2014, farms in the Sand Region are permitted to apply up to 230 kg or up to 250 kg of nitrogen per hectare per year in the form of grazing livestock manure. Because the water quality data for 2015 are related to agricultural practice year 2014, the distinction between the Sand-250 and Sand-230 sub-regions has not been implemented with respect to water quality until measurement year 2015.

[2] 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.
* In the Loess Region, samples were taken at twenty derogation farms during the autumn of 2015. These sample results were not yet available when this report was compiled.

## 2.5 Representativeness of the sample of farms

In 2014, 286 farms participating in the derogation monitoring network are known to have registered for derogation. These farms had a combined total acreage of 16,113 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 2014 and that satisfied the LMM selection criteria (refer to Appendix 1). Farms not included in the sample population which did register for derogation are mainly other grassland farms with a size of less than 25,000 Standard Output (SO) units.

Section 2.1 explains that the Sand Region has been subdivided into the 'Sand-250' and 'Sand-230' sub-regions with effect from 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 sub-regions is not jeopardised. In 2014, in the two sub-regions, 2.8% and 1.9%, respectively, of the area of cultivated land covered by the derogation scheme was included in the sample. That percentage amounts to 1.9% 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. During the selection and recruitment process, the required number of farms to be sampled for each farm type is derived from the share in the total acreage of cultivated land. On average, the other grassland farms selected are slightly smaller than the dairy farms in terms of their acreage of cultivated land.

The Loess Region is relatively small and therefore does not have many derogation farms in the sample population. Because the study requires a minimum number of observations per region, a relatively large number of farms from the Loess Region (17.7%) 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 2014 in the sample population, according to the 2014 Agricultural Census*

| | | *Sample population*[1] | *Derogation monitoring network* | |
|---|---|---|---|---|
| *Region* | *Farm type* | *Area (hectares)* | *Area (hectares)* | *Percentage of acreage of total sample population* |
| Sand 250 | Dairy farms | 104,089 | 3,129 | 3.0% |
| | Other grassland farms | 8,187 | 68 | 0.8% |
| | Total | 112,275 | 3,197 | 2.8% |
| Sand 230 | Dairy farms | 216,180 | 4,233 | 2.0% |
| | Other grassland farms | 32,896 | 473 | 1.4% |
| | Total | 249,076 | 4,706 | 1.9% |
| Loess | Dairy farms | 4,046 | 742 | 18.3% |
| | Other grassland farms | 614 | 84 | 13.7% |
| | Total | 4,660 | 826 | 17.7% |
| Clay | Dairy farms | 237,316 | 3,170 | 1.3% |
| | Other grassland farms | 24,137 | 245 | 1.0% |
| | Total | 26,1453 | 3,415 | 1.3% |
| Peat | Dairy farms | 135,046 | 3,755 | 2.8% |
| | Other grassland farms | 13,346 | 214 | 1.6% |
| | Total | 148,392 | 3,969 | 2.7% |
| Total | Dairy farms | 696,678 | 15,028 | 2.2% |
| | Other grassland farms | 79,180 | 1,085 | 1.4% |
| | Total | 775,858 | 16,113 | 2.1% |

[1] Estimate based on the 2014 Agricultural Census performed by Statistics Netherlands, data processed by LEI. Refer to Appendix 1 for further information on how the sample population was defined.

## 2.6 Description of farms in the sample

The 286 farms which are known to have registered for derogation in 2014 had an average of 55 hectares of cultivated land, of which 83% was comprised of grassland. The average livestock density was 2.4 Phosphate Livestock Units (LSUs) per hectare (see Table 2.7). Farm data derived from the 2014 Agricultural Census have been included for purposes of comparison, in so far as these farms were included in the sample population (see Appendix 1).

A comparison of the structural characteristics of the population of farms in the derogation monitoring network with the Agricultural Census data (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 characteristics in 2014 of farms participating in the derogation monitoring network (DMN), compared to average values for the Agricultural Census (AC) sample population*

| *Farm characteristic*[1] | *Population* | *Sand 250* | *Sand 230* | *Loess* | *Clay* | *Peat* | *Total* |
|---|---|---|---|---|---|---|---|
| Number of farms in DMN | DMN | 46 | 103 | 18 | 59 | 60 | 286 |
| Grassland area (hectares) | DMN | 57 | 36 | 37 | 51 | 60 | 47 |
| | AC | 47 | 31 | 33 | 47 | 45 | 41 |
| Area used to cultivate silage maize (hectares) | DMN | 12 | 9.5 | 7.9 | 5.8 | 6.2 | 8.3 |
| | AC | 7.4 | 6.0 | 5.5 | 4.4 | 3.1 | 5.3 |
| Other arable land (hectares) | DMN | 0.7 | 0.7 | 1.4 | 0.7 | 0.5 | 0.7 |
| | AC | 0.4 | 0.4 | 1.1 | 0.8 | 0.2 | 0.5 |
| Total area of cultivated land (hectares) | DMN | 70 | 46 | 46 | 58 | 66 | 56 |
| | AC | 55 | 37 | 39 | 52 | 48 | 46 |
| Percentage of grassland | DMN | 84 | 81 | 81 | 90 | 92 | 86 |
| | AC | 87 | 84 | 84 | 91 | 95 | 88 |
| Natural habitats (hectares) | DMN | 1.8 | 0.3 | 1.3 | 3.4 | 1.2 | 1.4 |
| | AC | 1.4 | 0.8 | 1.9 | 1.5 | 1.4 | 1.2 |
| Grazing livestock density (Phosphate LSUs per hectare)[2] | DMN | 2.1 | 2.6 | 2.5 | 2.4 | 2.2 | 2.4 |
| | AC | 2.0 | 2.6 | 2.5 | 2.2 | 2.1 | 2.3 |
| Percentage of intensive livestock farms | DMN | 0 | 11 | 6 | 2 | 8 | 6 |
| | AC | 1 | 10 | 2 | 3 | 3 | 6 |
| Specification of livestock density on farms participating in derogation monitoring network (Phosphate LSUs per hectare)[2] | | | | | | | |
| Dairy cattle (including young livestock) (Phosphate LSUs per hectare)[2] | DMN | 2.0 | 2.5 | 2.3 | 2.2 | 2.1 | 2.3 |
| Other grazing livestock (Phosphate LSUs per hectare)[2] | DMN | 0.02 | 0.12 | 0.22 | 0.19 | 0.13 | 0.13 |
| Intensive livestock (total) (Phosphate LSUs per hectare)[2] | DMN | 0.00 | 1.2 | 0.02 | 0.09 | 0.14 | 0.48 |
| All animals (Phosphate LSUs per hectare)[2] | DMN | 2.1 | 3.8 | 2.5 | 2.5 | 2.4 | 2.9 |

Source: Statistics Netherlands Agricultural Census 2014 (data processed by LEI and FADN).

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

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

The weighted average of the national FADN sample has been used to determine the extent to which the characteristics of dairy farms participating in the derogation monitoring network deviate from those of other dairy farms. The Agricultural Census does not provide appropriate data for comparison. The comparison (see Table 2.8) shows that in all regions, the dairy farms participating in the derogation monitoring network have a larger acreage and produce more milk per farm than the weighted national average. This is caused by the calculation method used. In order to calculate the national average, all data are weighted based on the different sample densities within the population. This weighting procedure was not applied to the derogation monitoring network data. A similar comparison has not been performed for the Loess Region due to an insufficient number of FADN-registered farms. The monitoring results are generally related to the total area of the farm. It is therefore likely that a farm's size has little or no influence on the results. The average milk production per hectare and per dairy cow on dairy farms participating in the derogation monitoring network differed little from the national FADN average.

*Table 2.8 Average milk production and grazing periods on dairy farms participating in the derogation monitoring network (DMN) in 2014, compared to the weighted average for dairy farms in the national FADN sample*

| *Farm characteristic* | *Population* | *Sand* | | *Loess* | *Clay* | *Peat* | *Total* |
|---|---|---|---|---|---|---|---|
| | | *250* | *230* | | | | |
| Number of farms in DMN | DMN | 45 | 86 | 15 | 50 | 54 | 250 |
| FPCM[1] production per farm (kg) | DMN | 990,700 | 926200 | 786600 | 1029100 | 1079200 | 983100 |
| | FADN | 855,000 | 737,600 | | 981,500 | 803,400 | 807,500 |
| FPCM[1] production in kg per hectare of fodder crop | DMN | 14,700 | 18,800 | 16,200 | 16,300 | 15,300 | 16,700 |
| | FADN | 14,300 | 17,900 | | 16,100 | 14,400 | 16,100 |
| FPCM[1] production per dairy cow (kg) | DMN | 8,530 | 8,770 | 8,410 | 8,430 | 8,300 | 8,530 |
| | FADN | 8,570 | 8,730 | | 8,490 | 8,250 | 8,530 |
| Percentage of farms with grazing in May-October period | DMN | 89 | 71 | 80 | 76 | 78 | 77 |
| | FADN | 77 | 74 | | 78 | 85 | 78 |
| Percentage of farms with grazing in May-June period | DMN | 89 | 67 | 80 | 74 | 78 | 76 |
| | FADN | 77 | 70 | | 78 | 85 | 76 |
| Percentage of farms with grazing in July-August period | DMN | 89 | 69 | 80 | 74 | 78 | 76 |
| | FADN | 77 | 74 | | 78 | 85 | 78 |
| Percentage of farms with grazing in September-October period | DMN | 87 | 66 | 80 | 76 | 76 | 75 |
| | FADN | 77 | 69 | | 78 | 82 | 75 |

[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 A1.6). The table also makes a distinction between dairy farms and other grassland farms.

*Table 2.9 Distribution across soil type regions and districts of the 276 grassland farms where water samples were taken in 2014 for derogation monitoring purposes*

| *LMM soil type regions and districts* | *Dairy farms* | *Other grassland farms* | *Total* |
|---|---|---|---|
| Sand Region | 126 | 17 | 143 |
| • Sand Region – North | 44 | 1 | 41 |
| • Sand Region – Central | 53 | 11 | 61 |
| • Sand Region – South | 27 | 5 | 29 |
| • Sand Region – West | 2 | 0 | 2 |
| Clay Region | 52 | 6 | 58 |
| • Marine Clay – North | 23 | 4 | 27 |
| • Marine Clay – Central | 9 | 0 | 9 |
| • Marine Clay – South-West | 5 | 0 | 5 |
| • River Clay | 15 | 2 | 17 |
| Peat Region | 51 | 5 | 56 |
| • Peatland Pastures – West | 28 | 3 | 31 |
| • Peatland Pastures – North | 23 | 2 | 25 |
| Loess Region | 17 | 2 | 19 |

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

The Loess Region mainly consists of soils with good drainage, whereas the Peat Region mainly consists of soils with poor drainage. The well-drained soils in the Sand Region are under-represented in the derogation monitoring network. Traditionally, the best soils (with favourable drainage conditions and nutrient status) were used for arable farming, while poorer (i.e. wetter) soils were used for dairy farming. In addition, the driest soils in the Sand Region are generally not used for agriculture. Wetter sandy soils are therefore over-represented in the derogation monitoring network. There are only minimal differences between 2014 and 2015 with respect to soil type and drainage class in the derogation monitoring network (see Table 2.10 and Table 2.11).

*Table 2.10 Relative distribution (in percentages) of soil types and drainage classes in the different regions, for derogation farms where samples were taken in 2014*

| *Region* | *Soil type* | | | | *Drainage class*[1] | | |
|---|---|---|---|---|---|---|---|
| | *Sand* | *Loess* | *Clay* | *Peat* | *Poor* | *Moderate* | *Good* |
| Sand | 85 | 0 | 7 | 8 | 41 | 48 | 11 |
| Loess | 0 | 75 | 25 | 0 | 1 | 3 | 96 |
| Clay | 5 | 0 | 92 | 3 | 44 | 51 | 5 |
| Peat | 14 | 0 | 26 | 60 | 94 | 6 | 0 |

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

*Table 2.11 Relative distribution (in percentages) of soil types and drainage classes in the different regions, for derogation farms where samples were taken in 2015*

| *Region* | *Soil type* | | | | *Drainage class*[1] | | |
|---|---|---|---|---|---|---|---|
| | *Sand* | *Loess* | *Clay* | *Peat* | *Poor* | *Moderate* | *Good* |
| Sand-250 | 83 | 0 | 2 | 16 | 38 | 59 | 2 |
| Sand-230 | 86 | 0 | 9 | 4 | 43 | 43 | 14 |
| Loess | * | * | * | * | * | * | * |
| Clay | 6 | 0 | 91 | 3 | 43 | 50 | 6 |
| Peat | 15 | 0 | 25 | 60 | 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 when the present report was being prepared.

# 3 Results

## 3.1 Agricultural characteristics

### *3.1.1 Nitrogen use in livestock manure*

In 2014, the average use of nitrogen in livestock manure on derogation farms amounted to 237 kg per hectare (including manure excreted during grazing). Average nitrogen use was lowest in the Sand-230 sub-region at 228 kg of nitrogen per hectare. Average nitrogen use was highest in the Loess Region at 249 kg of nitrogen per hectare (see Table 3.1). Derogation farms in the Loess Region have about 25% of their fields on clay soils (see Table 2.10), therefor these farms were allowed to apply more than the 230 kg of nitrogen per hectare permitted for loessial soils. 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 import and export livestock manure. As average manure production exceeded the permitted use, the average manure output exceeded the input (including stock changes). This applied to all regions (see Table 3.1), although the average manure input and output were nearly balanced in the Sand-250 sub-region. The average use of livestock manure in 2014 was 3 kg of nitrogen per hectare less than in 2013 (see Appendix 4, Table A4.2).

*Table 3.1 Average nitrogen use in livestock manure in the different regions (in kg of nitrogen per hectare) in 2014 on farms participating in the derogation monitoring network*

| *Description* | *Sand* | | *Loess* | *Clay* | *Peat* | *Total* |
|---|---|---|---|---|---|---|
| | *250* | *230* | | | | |
| Number of farms | 46 | 92 | 18 | 56 | 59 | 271 |
| Produced on farm[1] | 246 | 307 | 293 | 287 | 280 | 286 |
| + Inputs | 13 | 6 | 6 | 11 | 7 | 8 |
| + Changes in stocks[2] | -9 | -18 | -7 | -15 | -7 | -12 |
| – Outputs | 16 | 67 | 42 | 40 | 37 | 45 |
| Total | 234 | 228 | 249 | 243 | 243 | 237 |
| Use on arable land[3, 4] | 183 | 184 | 198 | 175 | 199 | 186 |
| Use on grassland[3, 5] | 243 | 244 | 265 | 254 | 249 | 248 |

[1] Calculated on the basis of standard quantities (N=125), with the exception of dairy farms that stated they were using the guidance document on farm-specific excretion by dairy cattle (N=146) (see Appendix 2).
[2] A negative change in stocks is a stock increase and corresponds to output.
[3] The average use data for grassland and arable land are based on 265 farms and 197 farms, respectively, instead of on 271 farms. This is because on 10 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 68 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 61 kg of nitrogen per hectare. This difference was compensated by a higher net nitrogen output in manure. The average quantities of nitrogen applied on arable land and on grassland were virtually the same in both sub-regions. Nearly 20% of all farms in the derogation monitoring network did not import or export livestock manure (see Table 3.2). A similar number of farms only imported livestock manure, but did not export it. These farmers probably imported nutrients in livestock manure because this offered economic benefits compared to using inorganic fertilisers. This may also apply to the farmers who both imported and exported livestock manure (11%). The percentage of derogation farms that only exported manure increased from 44% in 2013 to 55% in 2014. This rise is due to the fact that nitrogen production showed a greater increase than the margin available for nitrogen application, resulting in a manure surplus at a larger number of farms.

*Table 3.2 Average percentage of farms participating in the derogation monitoring network with livestock manure inputs and/or outputs in 2014*

| *Description* | *Sand* | | *Loess* | *Clay* | *Peat* | *Total* |
|---|---|---|---|---|---|---|
| | *250* | *230* | | | | |
| No inputs or outputs | 11 | 12 | 17 | 27 | 24 | 18 |
| Only outputs | 39 | 65 | 61 | 54 | 51 | 55 |
| Only inputs | 39 | 13 | 6 | 13 | 10 | 16 |
| Inputs and outputs | 11 | 10 | 17 | 7 | 15 | 11 |

### 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 nearly all regions in 2014. The available margin for nitrogen application was almost completely utilised only in the Loess Region. In the Sand-230 sub-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 nitrogen per hectare)[1] on farms participating in the derogation monitoring network in 2014*

| *Description* | *Item* | *Sand 250* | *Sand 230* | *Loess* | *Clay* | *Peat* | *Total* |
|---|---|---|---|---|---|---|---|
| Number of farms | | 46 | 92 | 18 | 56 | 59 | 271 |
| Average statutory availability coefficient for livestock manure (%) | | 48 | 51 | 48 | 50 | 50 | 50 |
| Fertiliser use | Livestock manure | 111 | 114 | 120 | 122 | 121 | 117 |
| | Other organic fertilisers | 0 | 0 | 0 | 2 | 2 | 1 |
| | Inorganic fertilisers | 116 | 128 | 131 | 172 | 133 | 136 |
| | Total quantity of nitrogen | 228 | 242 | 251 | 296 | 256 | 255 |
| | Nitrogen application standard | 245 | 247 | 253 | 329 | 281 | 271 |
| Use of plant-available nitrogen on arable land[2,3] | | 131 | 123 | 150 | 145 | 124 | 130 |
| Application standard for arable land[2] | | 149 | 144 | 158 | 157 | 155 | 150 |
| Use of plant-available nitrogen on grassland[2,4] | | 249 | 278 | 278 | 316 | 269 | 279 |
| Application standard for grassland[2] | | 264 | 275 | 273 | 350 | 293 | 292 |

[1] Calculated on the basis of the applicable statutory availability coefficients (see Appendix 2).
[2] The average usage data and the application standards for grassland and arable land are based on 265 farms and 197 farms, respectively, instead of on 271 farms. This is because on 6 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 68 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 2014, the average total use of phosphate on farms participating in the derogation monitoring network was slightly lower than the application standard of 88 kg of phosphate per hectare (see Table 3.4). On average 85 kg of phosphate was applied per hectare, of which 81 kg via livestock manure. As of 15 May 2014, inorganic phosphate-containing fertilisers may no longer be supplied to derogation farms. Consequently, any inorganic phosphate-containing fertilisers used in 2014 were purchased before 15 May 2014.

*Table 3.4 Average use of phosphate in fertilisers (in kg of $P_2O_5$ per hectare) in 2014 on farms participating in the derogation monitoring network*

| *Description* | *Item* | *Sand* 250 | *Sand* 230 | *Loess* | *Clay* | *Peat* | *Total* |
|---|---|---|---|---|---|---|---|
| Number of farms | | 46 | 92 | 18 | 56 | 59 | 271 |
| Fertiliser use | Livestock manure | 82 | 75 | 89 | 84 | 83 | 81 |
| | Other organic fertilisers | 1 | 0 | 2 | 1 | 2 | 1 |
| | Inorganic fertilisers | 3 | 2 | 3 | 2 | 3 | 2 |
| | Total phosphate use | 87 | 78 | 94 | 88 | 88 | 85 |
| | Phosphate application standard | 89 | 85 | 87 | 89 | 91 | 88 |
| Use of phosphate on arable land[1,2] | | 85 | 73 | 88 | 74 | 83 | 78 |
| Application standard for arable land[1] | | 64 | 63 | 61 | 65 | 65 | 64 |
| Use of phosphate on grassland[1,3] | | 87 | 81 | 97 | 91 | 89 | 87 |
| Application standard for grassland[1] | | 94 | 91 | 93 | 92 | 94 | 92 |

[1] The average usage data and the application standards for grassland and arable land are based on 265 farms and 197 farms, respectively, instead of on 271 farms. This is because on 6 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 68 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 2014, farms participating in the derogation monitoring network had an estimated average dry-matter yield of silage maize of 17,700 kg per hectare, resulting in an estimated average yield of 190 kg of nitrogen and 35 kg of phosphorus (79 kg of $P_2O_5$). 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 11,100 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. The calculated grassland dry-matter yields were lowest in the Sand-250 sub-region.

*Table 3.5 Average crop yields (in kg of dry matter, nitrogen, phosphorus and $P_2O_5$ per hectare) for silage maize (estimated) and grassland (calculated) in 2014, 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 | 32 | 70 | 6 | 22 | 22 | 152 |
| Kg of dry matter per hectare | 16,600 | 18,000 | 19,600 | 18,100 | 17,300 | 17,700 |
| Kg of nitrogen per hectare | 179 | 193 | 229 | 189 | 188 | 190 |
| Kg of phosphorus per hectare | 32 | 35 | 40 | 37 | 34 | 35 |
| Kg of $P_2O_5$ per hectare | 72 | 81 | 91 | 84 | 77 | 79 |
| *Grassland yields* | | | | | | |
| Number of farms | 37 | 75 | 7 | 43 | 47 | 209 |
| Kg of dry matter per hectare | 10,600 | 11,000 | 11,200 | 11,600 | 11,100 | 11,100 |
| Kg of nitrogen per hectare | 271 | 298 | 299 | 302 | 314 | 298 |
| Kg of phosphorus per hectare | 42 | 46 | 45 | 47 | 43 | 45 |
| Kg of $P_2O_5$ per hectare | 97 | 106 | 103 | 107 | 98 | 103 |

### *3.1.4 Nutrient surpluses*

The average nitrogen surplus on the soil surface balance of farms participating in the derogation monitoring network amounted to 153 kg per hectare in 2014 (see Table 3.6). In 2014, inputs (nitrogen via feed products and manure) as well as outputs (nitrogen via animals, milk and manure) were higher than in 2013 (see Table A4.6 in Appendix 4). The nitrogen surpluses on the soil surface balance showed considerable variation. The 25% of farms with the lowest surpluses realised a surplus of less than 101 kg of nitrogen per hectare, whereas the surplus exceeded 200 kg of nitrogen per hectare on the 25% of farms with the highest surpluses.

*Table 3.6 Nitrogen surpluses on the soil surface balance (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network in 2014 (average values and 25th and 75th percentile values per region)*

| *Description* | *Item* | *Sand* 250 | *Sand* 230 | *Loess* | *Clay* | *Peat* | *Total* |
|---|---|---|---|---|---|---|---|
| Number of farms | | 46 | 92 | 18 | 56 | 18 | 271 |
| Farm inputs | Inorganic fertilisers | 116 | 128 | 131 | 172 | 133 | 128 |
| | Livestock manure and other organic fertilisers | 14 | 6 | 6 | 14 | 10 | 10 |
| | Feedstuffs | 148 | 249 | 164 | 171 | 167 | 192 |
| | Animals | 1 | 3 | 1 | 3 | 1 | 2 |
| | Other | 1 | 2 | 2 | 2 | 3 | 2 |
| | Total | 281 | 388 | 303 | 362 | 314 | 343 |
| Farm outputs | Milk and other animal products | 74 | 97 | 70 | 77 | 80 | 84 |
| | Animals | 11 | 23 | 14 | 19 | 13 | 17 |
| | Livestock manure | 24 | 84 | 48 | 55 | 43 | 57 |
| | Other | 30 | 34 | 35 | 29 | 28 | 31 |
| | Total | 140 | 239 | 167 | 180 | 164 | 189 |
| Average nitrogen surplus per farm | | 141 | 149 | 136 | 182 | 150 | 154 |
| + Deposition, mineralisation and organic nitrogen fixation | | 40 | 34 | 34 | 33 | 123[1] | 54 |
| - Gaseous emissions[2] | | 45 | 59 | 53 | 58 | 56 | 55 |
| Nitrogen surplus on soil surface balance | | | | | | | |
| Average[3] | | 136 | 125 | 117 | 157 | 217 | 153 |
| 25th percentile | | 104 | 79 | 53 | 107 | 166 | 101 |
| 75th percentile | | 177 | 169 | 186 | 202 | 259 | 200 |

[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 negative, namely -7 kg per hectare (see Table 3.7). This is a significant decrease compared to 2013, when the phosphate soil surplus amounted to 16 kg. This decrease was mainly caused by a higher output of phosphate via the harvest of grass, maize and other crops. On average, the supply of phosphate via fertilisers remained stable compared to 2013 (see Table A4.8 in Appendix 4). The 25% of farms with the lowest phosphate surpluses realised an average negative surplus of 23 kg per hectare, whereas the the 25% of farms with the highest surpluses realised an average positive surplus of nearly 10 kg per hectare.

*Table 3.7 Phosphate surpluses on the soil surface balance (in kg of $P_2O_5$ per hectare) on farms participating in the derogation monitoring network in 2014 (average values and 25th and 75th percentile values per region)*

| *Description* | *Item* | *Sand* | | *Loess* | *Clay* | *Peat* | *Total* |
|---|---|---|---|---|---|---|---|
| | | *250* | *230* | | | | |
| Number of farms | | 59 | 59 | 56 | 0 | 18 | 46 |
| Farm inputs | Inorganic fertilisers | 3 | 2 | 3 | 2 | 3 | 2 |
| | Organic fertilisers | 7 | 2 | 4 | 6 | 5 | 5 |
| | Feedstuffs | 50 | 86 | 53 | 60 | 60 | 67 |
| | Animals | 1 | 2 | 1 | 2 | 1 | 1 |
| | Other | 0 | 0 | 1 | 1 | 1 | 1 |
| | Total | 61 | 93 | 62 | 70 | 70 | 76 |
| Farm outputs | Milk and other animal products | 30 | 38 | 28 | 31 | 31 | 33 |
| | Animals | 8 | 14 | 10 | 13 | 9 | 11 |
| | Organic fertilisers | 10 | 40 | 19 | 23 | 19 | 25 |
| | Other | 14 | 15 | 14 | 12 | 11 | 13 |
| | Total | 61 | 108 | 71 | 78 | 70 | 83 |
| Phosphate surplus on soil surface balance: | | | | | | | |
| Average[1] | | 1 | -15 | -10 | -8 | 0 | -7 |
| 25th percentile | | -5 | -31 | -23 | -26 | -13 | -23 |
| 75th percentile | | 10 | 6 | 0 | 6 | 12 | 9 |

[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 2014 ($NO_3$, N and P)*

In contrast to the data on agricultural practices in 2014, the data on water quality in 2014 have not yet been subdivided into the ‘Sand-250’ and ‘Sand-230’ sub-regions, since the water quality in measurement year 2014 is related to the agricultural practices in 2013, when this distinction had not yet been introduced.

In 2014, the average nitrate concentrations in the Sand Region, Clay Region and Peat Region were below the nitrate standard of 50 mg/l (see Table 3.8). The average nitrate concentration in the Loess Region was 51 mg/l. Although nitrate concentrations in the Peat Region were lower than in the Clay Region, the total nitrogen concentration was higher. This is caused by higher ammonium concentrations in groundwater in the Peat Region. The higher ammonium concentrations are probably due to nutrient-rich peat layers ((Van Beek *et al*., 2004)) in which nitrogen is released in the form of ammonium due to the decomposition of organic matter (Butterbach-Bahl and Gundersen, 2011).

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

*Table 3.8: Nutrient concentrations in 2014 (in mg/l) in water leaching from the root zone on farms participating in the derogation monitoring network (average concentrations per region and percentage of observations below the phosphorus detection threshold)*

| *Characteristic* | *Sand* | *Loess* | *Clay* | *Peat* |
|---|---|---|---|---|
| Number of farms | 135 | 17 | 56 | 56 |
| Nitrate ($NO_3$) | 40 | 51 | 15 | 9.5 |
| Nitrogen (N) | 12 | 12 | 5.3 | 9.3 |
| Phosphorus[1,2] (P) | 0.14 (61) | <DT (82) | 0.27 (18) | 0.30 (3.6) |

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

In 2014, 66% of farms in the Sand Region had nitrate concentrations below the nitrate application standard of 50 mg/l. In the Loess Region, 71% of farms had below-standard nitrate concentrations (see Table 3.9). The percentage of farms with below-standard average nitrate concentrations was 95% in the Peat Region and 91% in the Clay Region. The higher percentage of farms in the Sand Region and Loess Region with nitrate concentrations above the nitrate application standard is due to a higher percentage of soils prone to leaching in these regions. These are soils where less denitrification occurs, partly due to lower groundwater levels and/or limited availability of organic material and pyrite (Biesheuvel, 2002; Fraters *et al.*, 2007a; Boumans and Fraters, 2011).

*Table 3.9 Frequency distribution (in percentages) in 2014 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* | *Loess* | *Clay* | *Peat* |
|---|---|---|---|---|
| Number of farms | 135 | 17 | 56 | 56 |
| <15 | 23 | 12 | 66 | 73 |
| 15-25 | 16 | 0 | 21 | 14 |
| 25-40 | 15 | 24 | 2 | 5 |
| 40-50 | 11 | 35 | 2 | 2 |
| >50 | 34 | 29 | 9 | 5 |

In 2014, 50% of all farms in the Sand Region had a nitrogen concentration of 11 mg N/l or lower (see Table 3.10). The median value for the Loess Region was also 11 mg N/l. Fifty percent of all farms in the Peat Region had a nitrogen concentration of 8.9 mg N/l or lower. The median value for the Clay Region was 4.4 mg N/l.

*Table 3.10 Nitrogen concentrations in 2014 (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* | *Loess* | *Clay* | *Peat* |
|---|---|---|---|---|
| Number of farms | 135 | 17 | 56 | 56 |
| First quartile (25th percentile) | 7.0 | 8.4 | 3.4 | 6.6 |
| Median (50th percentile) | 11 | 11 | 4.4 | 8.9 |
| Third quartile (75th percentile) | 16 | 12 | 5.7 | 11 |

Phosphorus concentrations on 75% of farms in the Sand Region were equal to or less than 0.11 mg P/l (see Table 3.11). Phosphorus concentrations on 50% of farms in the Clay Region were equal to or less than 0.22 mg P/l. The median value for farms in the Peat Region was 0.16 mg P/l. In the Loess Region, over 75% of farms had a phosphorus concentration below the detection threshold.

*Table 3.11 Phosphorus concentrations[1,2] in 2014 (in mg P/l) in water leaching from the root zone on farms participating in the derogation monitoring network (25th percentile, median and 75th percentile values per region)*

| *Characteristic* | *Sand* | *Loess* | *Clay* | *Peat* |
|---|---|---|---|---|
| Number of farms | 135 | 17 | 56 | 56 |
| First quartile (25th percentile) | <DT | <DT | 0.07 | 0.10 |
| Median (50th percentile) | <DT | <DT | 0.22 | 0.16 |
| Third quartile (75th percentile) | 0.11 | <DT | 0.39 | 0.52 |

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

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

### 3.2.2 *Ditch water quality measurements in 2013-2014*

Average nitrate concentrations were highest in the Sand Region at 26 mg/l, and lowest in the Peat Region at 3.5 mg/l (see Table 3.12). Nitrogen concentrations, too, were highest in the Sand Region (8.4 mg N/l). Similar to the results for water leaching from the root zone, the average nitrogen concentration in the Peat Region (4.3 mg N/l) was higher than in the Clay Region (3.4 mg N/l). Phosphorus concentrations in ditch water were highest in the Clay Region, and lowest in the Sand Region.

*Table 3.12 Average ditch water nutrient concentrations (in mg/l) per region in the winter of 2013-2014 on farms participating in the derogation monitoring network*

| *Characteristic* | *Sand* | *Loess* | *Clay* | *Peat* |
|---|---|---|---|---|
| Number of farms | 25 | * | 55 | 55 |
| Nitrate ($NO_3$) | 26 | * | 6.1 | 3.5 |
| Nitrogen (N) | 8.4 | * | 3.4 | 4.3 |
| Phosphorus[1] (P) | 0.14(52) | * | 0.26(29) | 0.18(29) |

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

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

Of the 25 farms in the Sand Region, 84% had ditch water nitrate concentrations equal to or less than 50 mg/l (see Table 3.13). All farms in the Clay Region and Peat Region had average ditch water nitrate concentrations below 50 mg/l. Fifty percent of the farms in the Sand Region had ditch water nitrogen concentrations equal to or less than 7.2 mg N/l (see Table 3.14). Fifty percent of all farms in the Clay Region and Peat Region had ditch water nitrogen concentrations equal to or less than 2.9 mg N/l and 4.3 mg N/l, respectively.

*Table 3.13 Frequency distribution (in percentages) of average ditch water nitrate concentrations (in mg/l) per farm, on farms participating in the derogation monitoring network in the winter of 2013-2014, expressed as percentages per class per region*

| *Nitrate concentration class (mg/l)* | *Sand* | *Loess* | *Clay* | *Peat* |
|---|---|---|---|---|
| Number of farms | 25 | * | 55 | 55 |
| <15 | 36 | * | 91 | 98 |
| 15-25 | 24 | * | 5.5 | 0 |
| 25-40 | 20 | * | 3.6 | 1.8 |
| 40-50 | 4.0 | * | 0 | 0 |
| >50 | 16 | * | 0 | 0 |

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

*Table 3.14 Ditch water nitrogen concentrations (in mg N/l) on farms participating in the derogation monitoring network in the winter of 2013-2014 (25th percentile, median and 75th percentile values per region)*

| *Characteristic* | *Sand* | *Loess* | *Clay* | *Peat* |
|---|---|---|---|---|
| Number of farms | 25 | * | 55 | 55 |
| First quartile (25th percentile) | 4.7 | * | 1.9 | 3.2 |
| Median (50th percentile) | 7.2 | * | 2.9 | 4.2 |
| Third quartile (75th percentile) | 10 | * | 4.4 | 5.4 |

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

Fifty percent of farms in the Sand Region had ditch water phosphorus concentrations below the detection threshold of 0.062 mg P/l (see Table 3.15). Fifty percent of farms in the Peat Region and the Clay Region had phosphorus concentrations equal to or less than 0.10 mg P/l.

*Table 3.15 Ditch water phosphorus concentrations[1,2] (in mg P/l) in the winter of 2013-2014 on farms participating in the derogation monitoring network (25th percentile, median and 75th percentile values per region)*

| *Characteristic* | *Sand* | *Loess* | *Clay* | *Peat* |
|---|---|---|---|---|
| Number of farms | 25 | * | 55 | 55 |
| First quartile (25th percentile) | <DT | * | <DT | <DT |
| Median (50th percentile) | <DT | * | 0.10 | 0.10 |
| Third quartile (75th percentile) | 0.17 | * | 0.44 | 0.20 |

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

[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 with provisional figures for 2014 as reported in 2015*

The figures presented in this section hardly deviate from the provisional figures reported by Lukács *et al.* (2015). The minor differences are mainly caused by a number of farms having ‘dropped out’ because they did not qualify for participation or did not actually participate in the derogation scheme, or because farms were replaced in the derogation monitoring network.

### 3.2.4 *Provisional figures for measurement year 2015*

At the time of writing, only provisional results were available for 2015. No results for the Loess Region were available when this report was being prepared. The results are ‘provisional’ because it is unknown at this time which farms will be actually granted derogation for measurement year 2015. This could mean that some concentration data might be changed in the final report for 2015, which will be published in 2017. The results for the Sand Region have been presented for the region as a whole, and specified for the Sand-250 and Sand-230 sub-regions.

In the Sand Region, the average nitrate concentration in water leaching from the root zone was 41 mg/l. The average nitrate concentration was 48 mg/l in the Sand-230 sub-region and 24 mg/l in the Sand-250 sub-region (see Table 3.16). Nitrate concentrations were below 50 mg/l at 67% of all farms in the Sand Region. This percentage is comparable to that of 2014 (see Table 3.9). Concentrations were below 50 mg/l at 58% of all farms in the Sand-230 sub-region and at 88% of all farms in the Sand-250 sub-region (see Table 3.16).

In 2015, the average nitrate concentration in water leaching from the root zone in the Clay Region was 22 mg/l. Eighty-seven percent of the participating farms in the Clay Region had nitrate concentrations below 50 mg/l (see Table 3.16). The average nitrate concentration on farms in the Peat Region was 13 mg/l. In the Peat Region, 93% of all farms had a nitrate concentration below 50 mg/l.

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

| *Nitrate concentration class (mg/l)* | *Sand* | *250* | *230* | *Loess* | *Clay* | *Peat* |
|---|---|---|---|---|---|---|
| Number of farms | 160 | 47 | 113 | | 62 | 58 |
| Average concentration | 41 | 24 | 48 | | 22 | 13 |
| <15 | 28 | 49 | 19 | * | 47 | 72 |
| 15-25 | 11 | 15 | 10 | * | 21 | 10 |
| 25-40 | 13 | 13 | 13 | * | 13 | 3 |
| 40-50 | 15 | 11 | 17 | * | 7 | 7 |
| >50 | 33 | 12 | 42 | * | 13 | 7 |

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

In 2015, the average ditch water nitrate concentration in the Clay Region and the Peat Region amounted to 10 mg/l and 6.5 mg/l, respectively. These levels are well below the nitrate standard of 50 mg/l (see Table 3.17). At 25 mg/l, the average ditch water nitrate concentration in the Sand Region exceeded the average concentration in the Clay Region and Peat Region.

*Table 3.17 Frequency distribution (in percentages) of average ditch water nitrate concentrations (in mg/l) per farm, on farms participating in the derogation monitoring network in the winter of 2014-2015, expressed as percentages per class and average nitrate concentrations per region*

| *Nitrate concentration class (mg/l)* | *Sand* | *250* | *230* | *Loess* | *Clay* | *Peat* |
|---|---|---|---|---|---|---|
| Number of farms | 31 | 10 | 21 | | 61 | 57 |
| Average concentration | 25 | 24 | 25 | | 10 | 6.5 |
| <15 | 42 | 40 | 43 | * | 79 | 88 |
| 15-25 | 10 | 0 | 14 | * | 11 | 5 |
| 25-40 | 29 | 40 | 24 | * | 8 | 7 |
| 40-50 | 10 | 20 | 5 | * | 0 | 0 |
| >50 | 10 | 0 | 14 | * | 2 | 0 |

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

Nitrogen concentrations in water leaching from the root zone were also higher in the Sand Region than in the Clay Region and Peat Region (see Table 3.18). It is also noteworthy that nitrogen concentrations in the Peat Region were higher than in the Clay Region, due to higher ammonium concentrations in the Peat Region. The ditch water nitrogen concentrations presented a similar picture to concentrations in water leaching from the root zone, but with lower concentration levels (see Table 3.19).

*Table 3.18 Nitrogen concentrations (in mg N/l) in water leaching from the root zone, measured in 2015 on farms participating in the derogation monitoring network (average, 25th percentile, median and 75th percentile values per region)*

| *Characteristic* | *Sand* | | | *Loess* | *Clay* | *Peat* |
|---|---|---|---|---|---|---|
| | | *250* | *230* | | | |
| Number of farms | 160 | 47 | 113 | * | 62 | 58 |
| Average | 12 | 8.9 | 13 | * | 6.7 | 10 |
| First quartile (25th percentile) | 6.7 | 5.6 | 8.3 | * | 3.5 | 7.2 |
| Median (50th percentile) | 11 | 7.2 | 12 | * | 5.8 | 8.3 |
| Third quartile (75th percentile) | 15 | 11 | 16 | * | 8.2 | 12 |

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

*Table 3.19 Ditch water nitrogen concentrations (in mg N/l) measured 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* | | | *Loess* | *Clay* | *Peat* |
|---|---|---|---|---|---|---|
| | | *250* | *230* | | | |
| Number of farms | 31 | 10 | 21 | * | 61 | 57 |
| Average | 8.0 | 8.0 | 8.0 | * | 4.2 | 5.2 |
| First quartile (25th percentile) | 4.5 | 5.4 | 4.1 | * | 2.1 | 3.3 |
| Median (50th percentile) | 7.8 | 8.4 | 7.1 | * | 3.6 | 4.7 |
| Third quartile (75th percentile) | 9.2 | 11 | 9.0 | * | 5.3 | 6.9 |

* 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 2015, 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 2015 on farms participating in the derogation monitoring network (average, 25th percentile, median and 75th percentile values per region)*

| *Characteristic* | *Sand* | | | *Loess* | *Clay* | *Peat* |
|---|---|---|---|---|---|---|
| | | *250* | *230* | | | |
| Number of farms | 160 | 47 | 113 | * | 62 | 58 |
| Average | 0.12 | 0.19 | 0.09 | * | 0.24 | 0.35 |
| First quartile (25th percentile) | <DT | <DT | <DT | * | 0.09 | 0.10 |
| Median (50th percentile) | <DT | <DT | <DT | * | 0.21 | 0.21 |
| Third quartile (75th percentile) | 0.13 | 0.17 | 0.11 | * | 0.38 | 0.44 |

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

*Table 3.21 Ditch water phosphorus[1,2] concentrations (in mg P/l) measured in the winter of 2014-2015 on farms participating in the derogation monitoring network (average, 25th percentile, median and 75th percentile values per region)*

| *Characteristic* | *Sand* | | | *Loess* | *Clay* | *Peat* |
|---|---|---|---|---|---|---|
| | | *250* | *230* | | | |
| Number of farms | 31 | 10 | 21 | * | 61 | 57 |
| | | | | | | |
| Average | 0.15 | 0.21 | 0.13 | * | 0.21 | 0.19 |
| First quartile (25th percentile) | <DT | 0.06 | <DT | * | <DT | <DT |
| Median (50th percentile) | <DT | 0.19 | <DT | * | 0.13 | 0.10 |
| Third quartile (75th percentile) | 0.20 | 0.22 | 0.07 | * | 0.37 | 0.20 |

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

# 4 Developments in monitoring results

## 4.1 Developments in agricultural practices

### *4.1.1 Developments in farm characteristics*[2]

The quantity of Fat and Protein Corrected Milk (FPCM) produced per farm increased continually during the 2006-2014 period (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 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 farms with animals in stables gradually decreased. The average livestock density expressed in Phosphate Livestock Units per hectare decreased until 2012, but increased slightly in 2013 and 2014 (see Figure 4.2). Phosphate production by animals in stables 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).

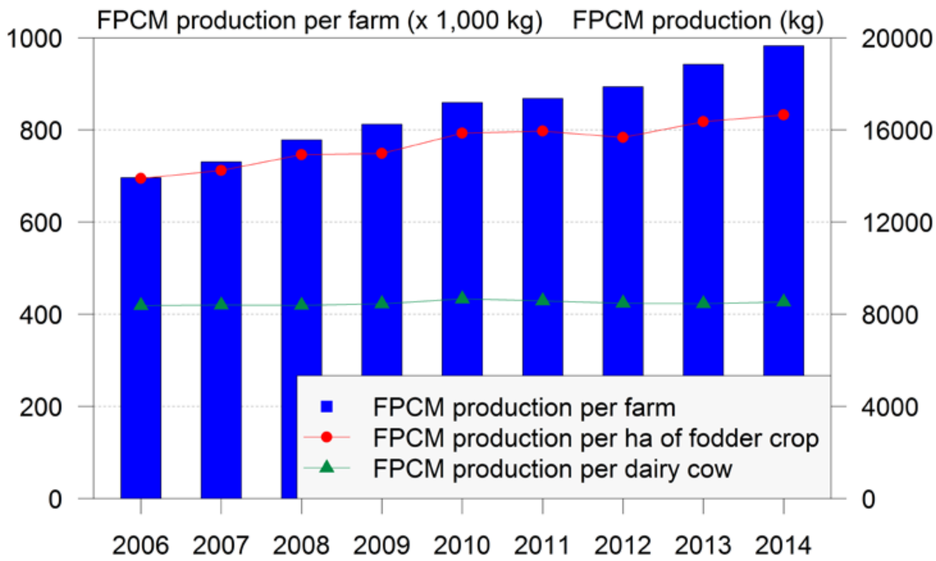
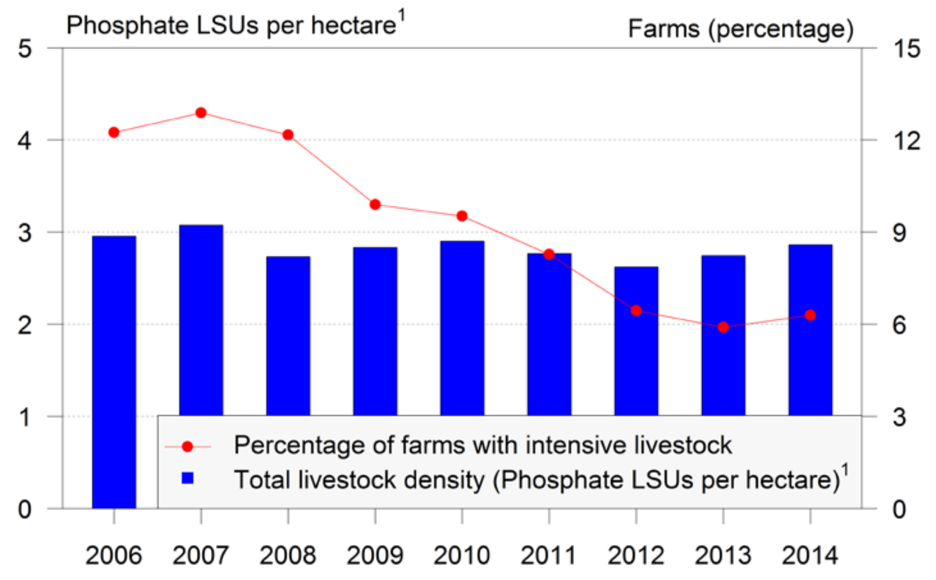



*Figure 4.1 Average production of Fat and Protein Corrected Milk (FPCM) per farm (left y-axis), and per cow and per hectare of fodder crop (right y-axis) in the 2006-2014 period*

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




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

*Figure 4.2 Average livestock density expressed in Phosphate Livestock Units per hectare, and percentage of dairy farms with intensive livestock (e.g. pigs, chickens, sheep) in the 2006-2014 period*

The percentage of derogation farms with grazing continued to decrease in 2014, after stabilising in 2012 and 2013 (see Figure 4.3; Appendix 4, Table A4.1).

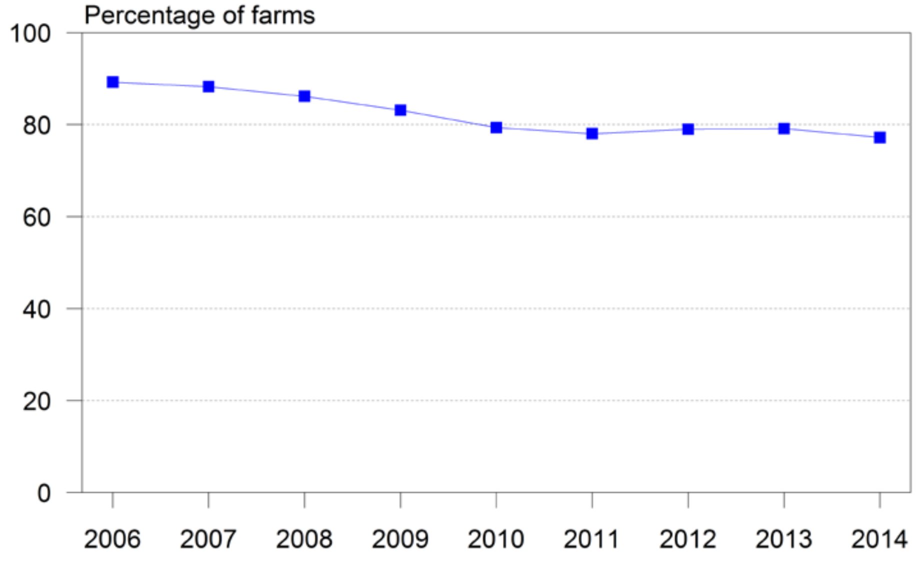



*Figure 4.3 Percentage of dairy farms where cows are grazed in the 2006-2014 period*

### 4.1.2 *Use of livestock manure*

Since 2006, the average use of nitrogen in the form of livestock manure has ranged from 232 kg to 242 kg of nitrogen per hectare. In 2014, the average use of nitrogen in the form of livestock manure amounted to 237 kg per hectare (see Figure 4.4; Appendix 4, Table A4.2).

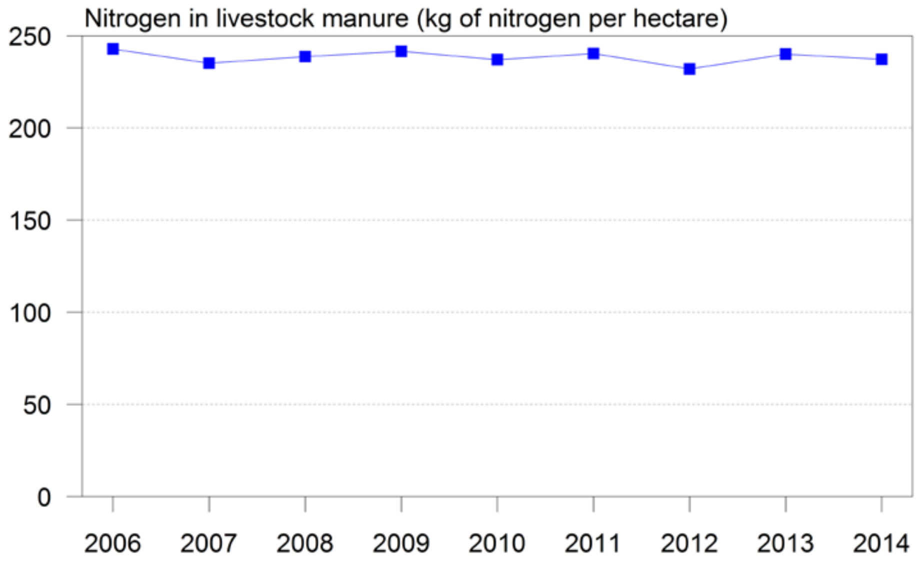



*Figure 4.4 Use of nitrogen in livestock manure (in kg of nitrogen per hectare) in the 2006-2014 period*

### 4.1.3 *Use of fertilisers compared to application standards*

In 2014, the total use of plant-available nitrogen remained below the nitrogen application standard. 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 16 kg per hectare in 2014. This is partly due to higher statutory availability coefficients for manure on dairy farms with grazing livestock, and partly due to more stringent nitrogen application standards (Figure 4.5; see also Appendix 4, Table A4.3). The total use of nitrogen-containing fertilisers remained stable during this period.

The available margin for nitrogen application increased in 2014, for reasons including a decrease in grazing and a higher proportion of grassland. The nitrogen application standard is higher for grassland than for other crops. Farmers who only mow their grassland can apply more nitrogen-containing fertilisers than if the land is used for grazing. The higher application standard was utilised in 2014 by using larger quantities of nitrogen-containing fertilisers. In addition, a higher availability coefficient applies to grassland that is only mown and not used for grazing (60% instead of 45%).

The use of inorganic nitrogen-containing fertilisers remained fairly stable during the 2006-2013 period, but increased by 11 kg of nitrogen per hectare in 2014 (see Appendix 4, Table A4.3). The total quantity of plant-available nitrogen in 2014 was higher than in the previous year.

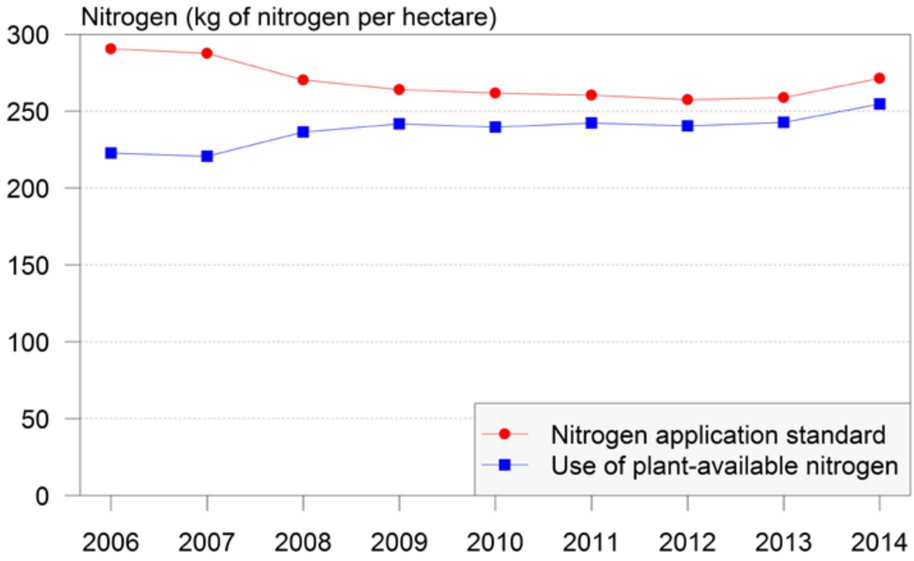



*Figure 4.5 Total nitrogen application standard (in kg of nitrogen per hectare) and use of plant-available nitrogen in livestock manure and inorganic fertilisers (in kg of nitrogen per hectare) during the 2006-2014 period*

During the 2006-2014 period, the use of phosphate-containing fertilisers on farms participating in the derogation monitoring network decreased by approx. 14%, while the phosphate application standard decreased by approx. 19% (see Figure 4.6). As a result, the difference between actual phosphate use and the phosphate application standard decreased from approx. 10 kg per hectare in 2006 to 3 kg per hectare in 2014. Between 2006 and 2014, the phosphate application standards were reduced from an average of 108 kg per hectare to an average of 88 kg per hectare. As a result, the initial margin between actual usage and the level prescribed by the standard was reduced. The lower application standards also resulted in a reduction in the use of inorganic phosphate-containing fertilisers. The use of phosphate on derogation farms has remained stable since 2012 (see Appendix 4, Table A4.4). As of 15 May 2014, inorganic phosphate-containing fertilisers may no longer be supplied to derogation farms.

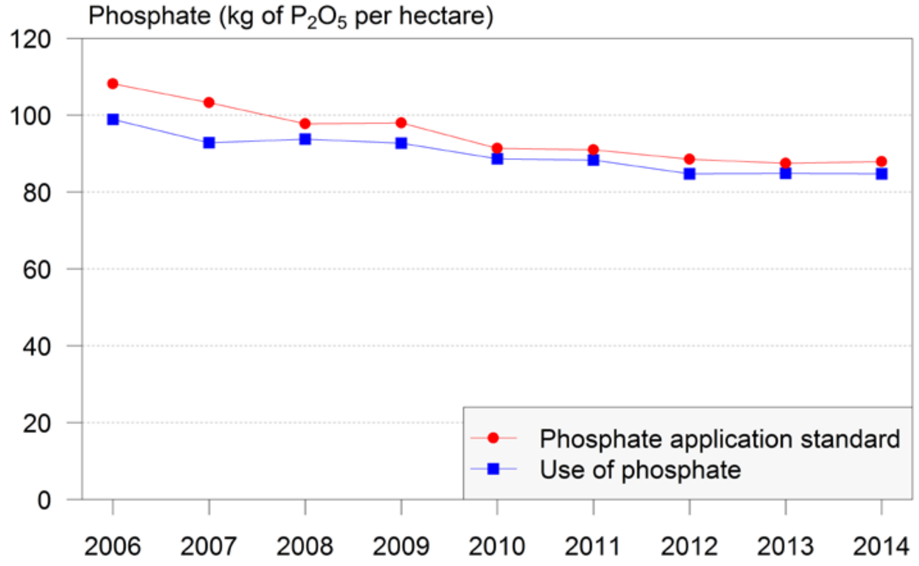



*Figure 4.6 Total phosphate application standard (in kg of $P_2O_5$ per hectare) and use of phosphate in livestock manure and inorganic fertilisers (in kg of $P_2O_5$ per hectare) during the 2006-2014 period*

### 4.1.4 Crop yields

The dry-matter yields for grass and silage maize were below average in 2013, whereas historically high yields were recorded in 2014 (see Figure 4.7; Appendix 4, Tables A4.5A and A4.5B). The dry-matter yield for grass was 9% higher than in 2013, and the dry-matter yield for silage maize was 14% higher than in 2013. The nitrogen yields (Figure 4.8; Appendix 4, Table A4.5) and phosphate yields (Figure 4.9; Appendix 4, Table A4.5) were also considerably higher for both crops.

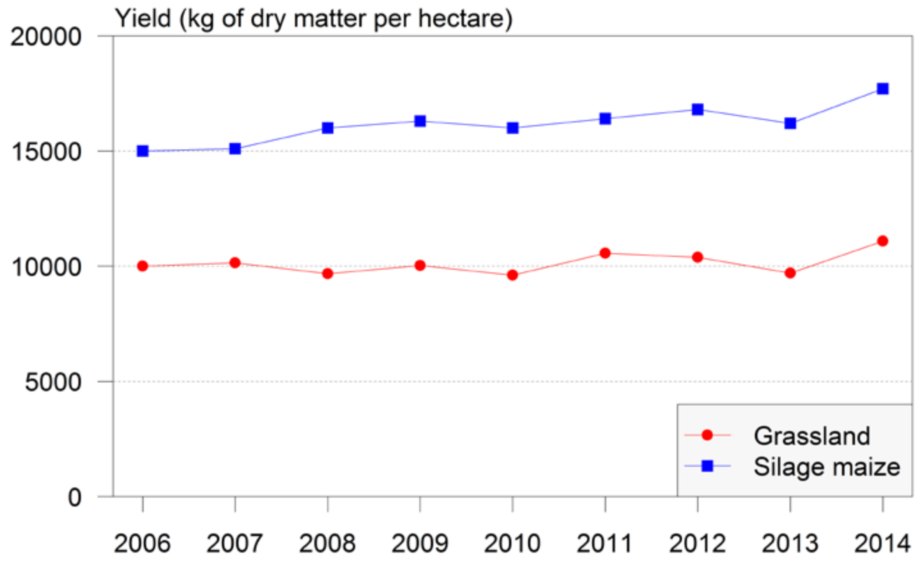



*Figure 4.7 Average dry-matter yields for grassland and silage maize on derogation farms in the 2006-2014 period*

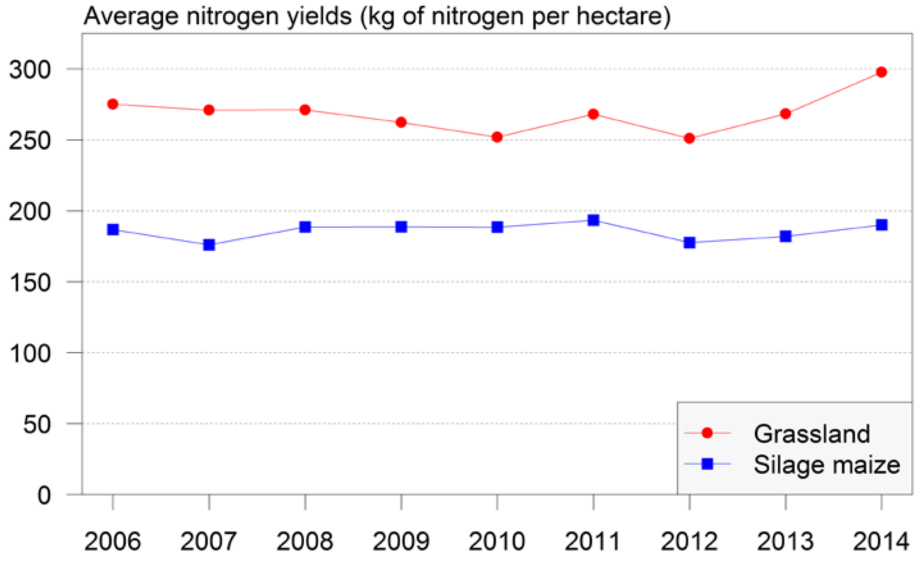



*Figure 4.8 Average nitrogen yields (in kg of nitrogen per hectare) for grassland and silage maize on derogation farms in the 2006-2014 period*

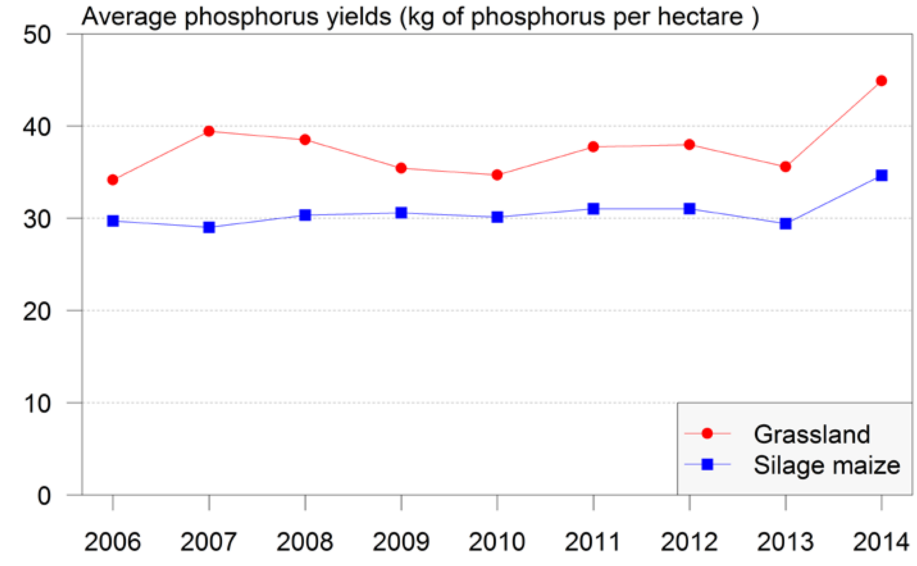



*Figure 4.9 Average phosphorus yields (in kg of phosphorus per hectare; 1 kg of phosphorus = 2.29 kg of $P_2O_5$) for grassland and silage maize on derogation farms in the 2006-2014 period*

### *4.1.5 Nutrient surpluses on the soil surface balance*

The average nitrogen surplus on the soil surface balance in 2014 was 30 kg per hectare lower than the average for the 2006-2013 period. This was mainly due to the exceptional growing season of 2014, which resulted in an increased output of nitrogen via the sale of feed products. The output of nitrogen via manure also increased. No trend change could be observed in the average nitrogen soil surplus during the 2006-2013 period (see Figure 4.10; Appendix 4, Table A4.6). As indicated above, the nitrogen soil surplus decreased in 2014.

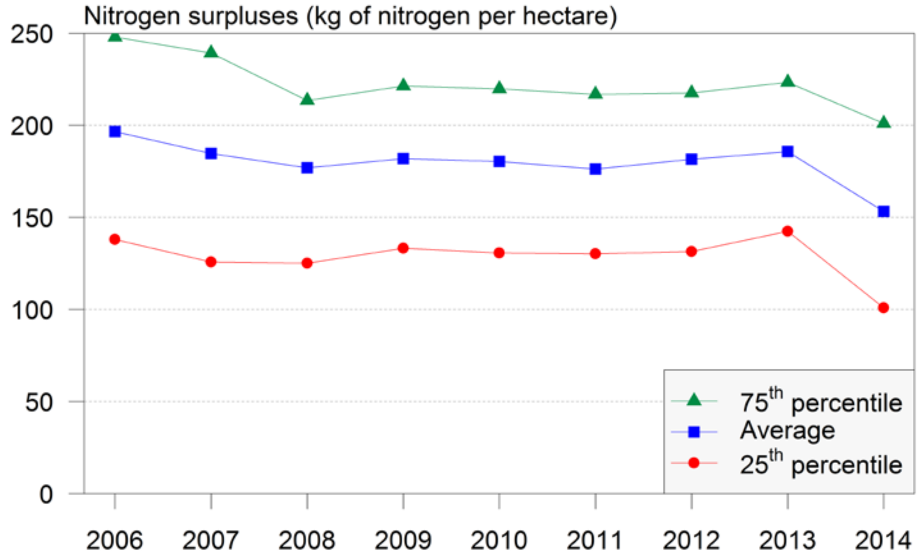



*Figure 4.10 Average nitrogen surpluses, nitrogen surpluses on the 25% of derogation farms with the lowest surpluses (first quartile or 25th percentile), and nitrogen surpluses on the 25% of derogation farms with the highest surpluses (third quartile or 75th percentile) during the 2006-2014 period-*

The nitrogen surplus on the soil surface balance was consistently higher in the Peat Region than in the other regions. This is mainly due to additional mineralisation on peat soils, which has been estimated and included on the supply side of the balance sheet (see Appendix 2, Table A2.3). Until 2013, no clear trends were observable with respect to the different soil type regions. If the year 2014 is included in the analysis, a significant downward trend emerges in a number of regions due to the very small nitrogen soil surpluses in 2014 (see Figure 4.11; Appendix 4, Table A4.7).

This is the first derogation report to draw a distinction between the 'Sand-250' and 'Sand-230' sub-regions. Figure 4.11 shows that the nitrogen surplus in both sub-regions is virtually the same, despite differences in farm characteristics. The average input of nitrogen on farms in the Sand-230 sub-region exceeded the average input on farms in the Sand-250 sub-region by 107 kg of nitrogen per hectare, due to the fact that the former sub-region is generally characterised by more intensive farming practices. This was almost entirely compensated by the increased output of nitrogen via products and manure (increase of 99 kg of nitrogen per hectare) and by differences in deposition, organic 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. As a result, differences in nitrogen soil surpluses of more than 10 kg of nitrogen per hectare per year may arise for small groups of farms like those in the Peat Region and Loess Region.

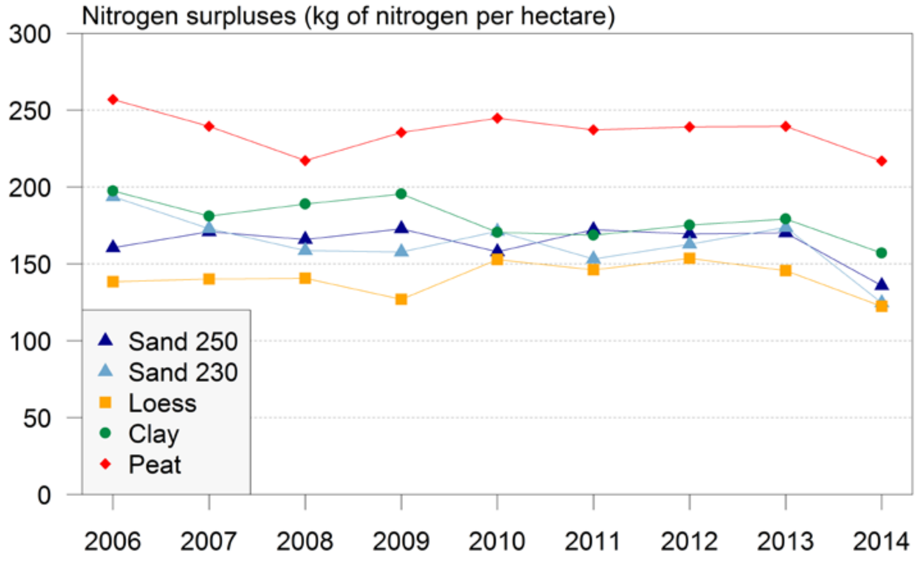



*Figure 4.11 Average nitrogen surpluses per region (in kg of nitrogen per hectare) on derogation farms in the 2006-2014 period*

In 2014, the phosphate surplus on the soil surface balance was also considerably lower than the average for the 2006-2013 period (Figure 4.12; see also Appendix 4, Table A4.8) due to the increased output of phosphate via crops (see Appendix 4, Tables A4.4 and A4.8).

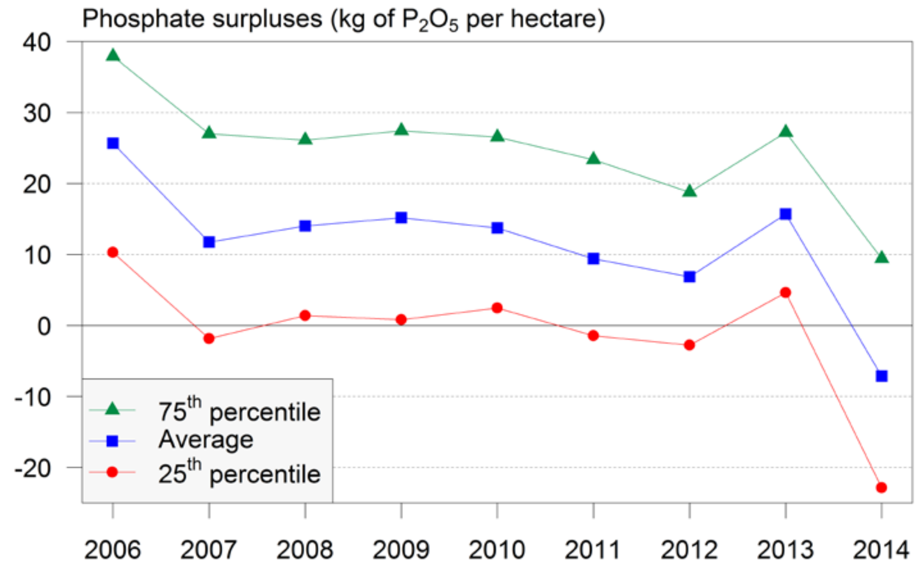



*Figure 4.12 Average phosphate surpluses, phosphate surpluses on the 25% of derogation farms with the lowest surpluses (first quartile or 25th percentile), and phosphate surpluses on the 25% of derogation farms with the highest surpluses (third quartile or 75th percentile) in the 2006-2014 period (expressed in kg of $P_2O_5$ per hectare)*

## 4.2 Development of water quality

### *4.2.1 Development of average concentrations during the 2007-2015 period*

The average nitrate concentrations in water leaching from the root zone in the Sand Region and Loess Region were lower in the most recent measurement year than in the previous year. Nitrate concentrations in the Sand Region also displayed a downward trend during the entire measurement period. There was no trend change in nitrate concentrations in the Loess Region (see Figure 4.13; Appendix 4, Table A4.9). In 2015, nitrate concentrations in the Clay Region and the Peat Region were higher than the average for the 2007-2014 period. In the next few years it will become clear whether this increase is the result of natural fluctuations or an upward trend. Concentrations in the Clay Region displayed a downward trend during the entire measurement period. Nitrate concentrations in the Peat Region no longer display a downward trend (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. These results revealed higher nitrate concentrations in the Sand Region, Clay Region and Peat Region than in previous and subsequent years.

The average nitrate concentrations were highest in the Loess Region, followed by the Sand Region, Clay Region and Peat Region. In the Clay Region and Peat Region, the average concentrations amounted to less than 50 mg of nitrate per litre in all years (see Figure 4.13). In the Sand Region, this has been the case since 2008. The average nitrate concentration in the Loess Region only reached the 50 mg/l standard in 2009 and 2010. In 2014, the average nitrate concentration amounted to 51 mg/l (see Appendix 4, Table A4.9). The higher nitrate concentrations in the Loess Region and Sand Region are caused mainly by a higher percentage of soils prone to leaching. These are soils where less denitrification occurs, partly due to lower groundwater levels (Fraters *et al.*, 2007; Boumans and Fraters, 2011).

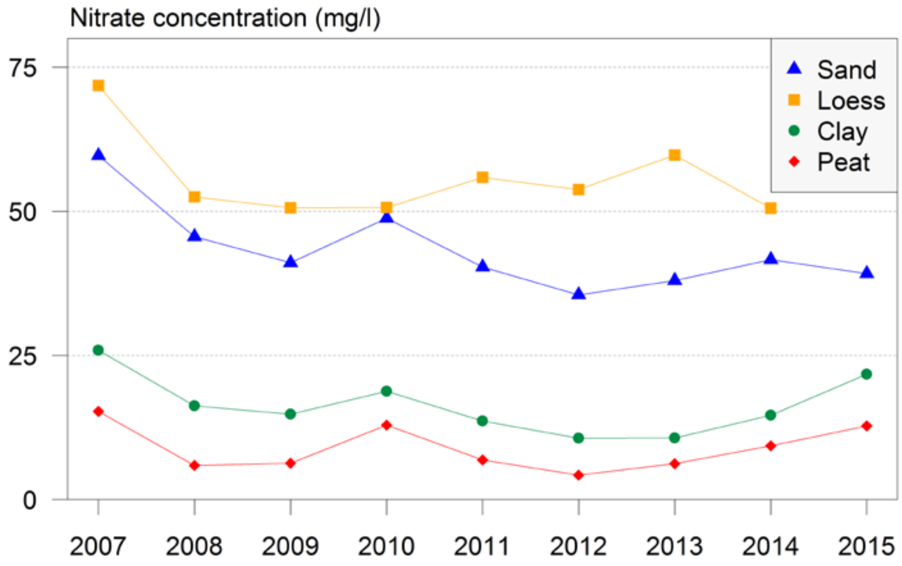



*Figure 4.13 Average nitrate concentrations in water leaching from the root zone on derogation farms in four regions during the 2007-2015 period*

Ditch water nitrate concentrations in the Sand Region and Clay Region decreased during the 2007-2015 period. No trend change could be observed in the Peat Region (see Figure 4.14; Appendix 4, Table A4.9).

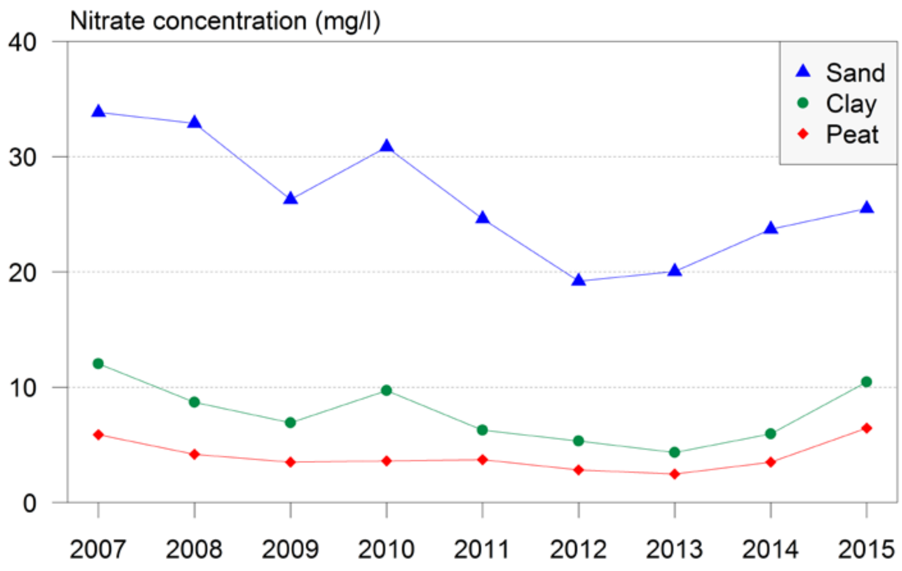



*Figure 4.14 Average ditch water nitrate concentrations on derogation farms in three regions during the 2007-2015 period*

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

Nitrogen concentrations in water leaching from the root zone decreased in the Sand Region and Clay Region, but remained stable in the Peat Region and Loess Region. Ditch water nitrogen concentrations decreased in the Sand Region, remained stable in the Clay Region, and increased slightly in the Peat Region (see Appendix 4, Tables 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 supply and decomposition of organic matter, mineralisation and immobilisation will not be perfectly balanced in each year. For instance, nitrate leaching may be significantly affected by the ploughing-up of grassland and grass-maize rotation (Velthof and Hummelink, 2012). As a result, there will be variations in soil surpluses and nitrogen leaching.

The nitrogen concentration is also affected by the precipitation surplus and changes in groundwater levels (Boumans *et al.*, 2005; Fraters *et al.*, 2005; Zwart *et al.*, 2009; Zwart *et al.*, 2010; Zwart *et al.*, 2011). Changes in the composition of the farm sample can also have an effect, since soil types and groundwater levels vary between farms (Boumans *et al.*, 1989).

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

If this method is applied, we find that the average corrected nitrate concentrations in the Sand Region decreased from approx. 55 mg/l in 2007 to approx. 40 mg/l in 2015, a reduction of approx. 15 mg/l (see Table 4.1 and Figure 4.15). Since 2009, both the measured and the corrected nitrate concentrations have been below the nitrate standard.

Over the entire measurement period, measured and corrected nitrate concentrations in the Sand Region have displayed a downward trend. This decrease mainly occurred in the early period of the derogation monitoring network. The nitrate concentrations corrected for weather conditions and sample composition have fluctuated around 40 mg/l in the past few years.

*Table 4.1 Average nitrate concentrations (in mg/l) in water leaching from the root zone in the Sand Region, measured and corrected for weather conditions and time of sampling; including average relative evaporation, groundwater level, and average month of sampling*

| Year | Number of farms | Relative evaporation | Groundwater level[1] | Month of sampling | Nitrate Measured | Nitrate Corrected |
|---|---|---|---|---|---|---|
| 2007 | 141 | 1.5 | 138 | 3.3 | 60 | 55 |
| 2008 | 141 | 1.1 | 146 | 4.5 | 46 | 50 |
| 2009 | 142 | 1.3 | 161 | 4.4 | 41 | 45 |
| 2010 | 143 | 1.5 | 147 | 4.6 | 49 | 45 |
| 2011 | 142 | 1.6 | 149 | 5.1 | 40 | 38 |
| 2012 | 147 | 1.4 | 144 | 5.1 | 36 | 38 |
| 2013 | 151 | 1.3 | 153 | 4.9 | 38 | 39 |
| 2014 | 152 | 1.4 | 146 | 5.1 | 42 | 40 |
| 2015 | 152 | 1.4 | 142 | 5.0 | 39 | 40 |

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

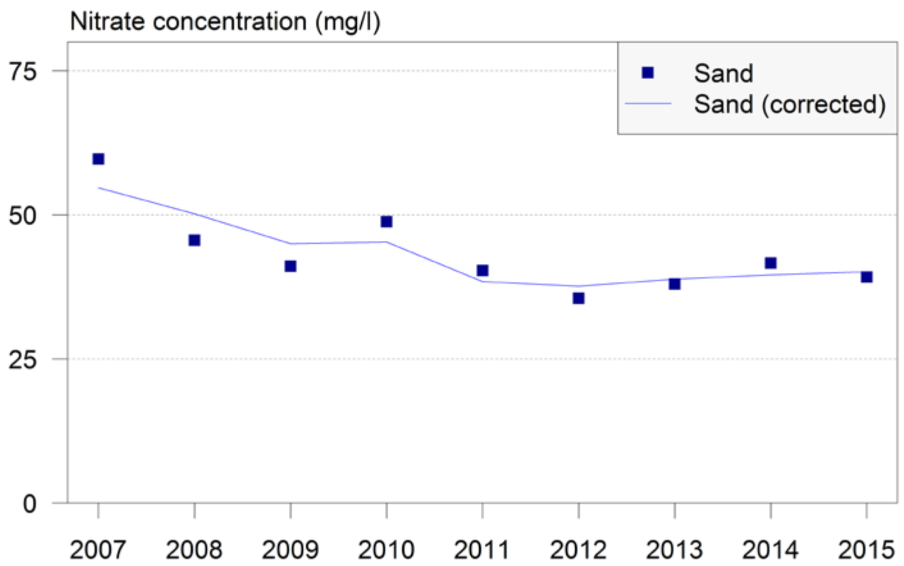



*Figure 4.15 Development of uncorrected and corrected nitrate concentrations in water leaching from the root zone in the Sand Region in successive measurement years*

With respect to nitrate concentrations in water leaching from the root zone in the Clay Region, no clear link has been found with the precipitation surplus using the correction method originally developed for the Sand Region. The fact that drain water or groundwater samples are taken in the Clay Region is a complicating factor. This means that no corrected concentration data can be provided. 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.

*Nitrate concentrations in water leaching from the root zone: distinction between Sand-230 and Sand-250 sub-regions*
The derogation decision of 2014 (EU, 2014) makes a distinction according to the maximum derogation which may be applied for by farms. Farms on sandy soils in the provinces of Overijssel, Gelderland, Utrecht, North Brabant and Limburg may apply up to 230 kg of nitrogen per hectare per year. The same requirement applies to farms on loessial soils. Farms on other soils and on sandy soils in other provinces may apply up to 250 kg of nitrogen per hectare per year.

Although this distinction only entered into effect in 2014, the development of the nitrate concentrations has been presented here by dividing the Sand Region into two sub-regions known as 'Sand-230' and 'Sand-250'. Farms in the Sand Region and located in the above-mentioned provinces have been selected and included in the Sand-230 sub-region.
The Sand-250 sub-region includes all other farms in the Sand Region that are located in other provinces.

During the entire measurement period, the farm-specific nitrate concentrations in the Sand-230 sub-region were significantly higher than in the Sand-250 sub-region (see Figure 4.16; Appendix 4, Table A4.11). This appears to be caused mainly by a higher percentage of soils prone to leaching, i.e. soils where less denitrification occurs due to lower groundwater levels and other factors (Table 2.11).

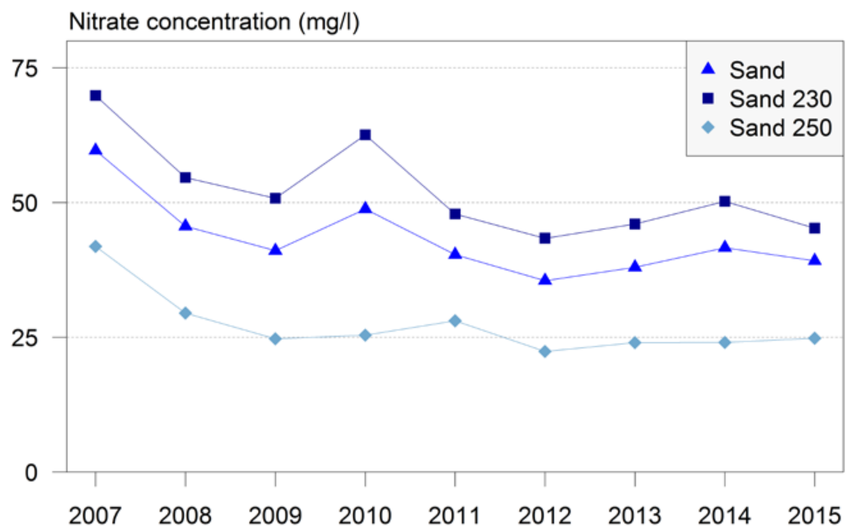



*Figure 4.16 Average nitrate concentrations in water leaching from the root zone on derogation farms in the Sand Region and in the Sand-230 and Sand-250 sub-regions in the 2007-2015 period*

## 4.3 Effects of agricultural practices on water quality

*Nitrogen*
The nitrogen soil surpluses in each region did not change during the 2006-2013 period, although the nitrate concentrations in water leaching from the root zone did decrease during this period. However, that decrease occurred mainly in the period up to and including 2011. The downward trend seems to be levelling out since 2012 in the Sand Region and Loess Region, while nitrate concentrations in the Clay Region and Peat Region appear to be increasing slightly once more. Nitrogen soil surpluses decreased substantially in all regions in 2014. This recent development is not yet reflected in decreasing nitrate concentrations in ditch water or in water leaching from the root zone. As the nitrogen soil surplus did not decrease in the 2006-2011 period, there must be other causes for the decline in nitrate concentrations during that period. Providing a conclusive explanation for a decrease in nitrate concentrations while the nitrogen surplus remains unchanged is not easy. Possible explanations include:

- After-effects. The soil surplus is based on a balance between input and output. Further nitrogen input from the soil is not included in the soil surplus. Because after-effects can remain noticeable for up to four years (Verloop, 2013), they are expected to occur only at the start of the measurement period. After-effects therefore offer a possible explanation for the decrease in nitrate concentrations during that period. In the coming years, it will become clear whether the substantial decrease in nitrogen soil surpluses in 2014 will have a delayed reducing effect on the nitrate concentrations.
- Decrease in grazing during the measurement period. The general trend in dairy farming is a steady increase in scale and intensification of milk production per hectare. In addition, more and more farmers are opting to keep their dairy cows in stables full-time, resulting in a decreasing proportion of farms with grazing dairy cows (see Figure 4.3 and section 4.1.1). This trend in grazing may partly explain the decreasing nitrate concentrations in the Sand Region (Boumans and Fraters, 2011). On the other hand, a study conducted by van Prins, Van Leeuwen and Boumans (2015) on sandy soils found that the extent of grazing on grassland has no effect on nitrate concentrations in groundwater.
- The extent of denitrification. A small relative decrease in the nitrogen surplus may result in a significant decrease in nitrate concentrations, since a larger portion of the surplus is denitrified while the soil's denitrification capacity remains the same.
- Decrease in the ploughing-up of grassland. 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.

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

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

# References


Aarts, H.F.M., C.H.G. Daatselaar and G. Holshof (2008). Bemesting, meststofbenutting en opbrengst van productiegrasland en snijmaïs op melkveebedrijven. Wageningen, Plant Research International, Report No. 208.

Beek, C.L. van, G.A.P.H. van den Eertwegh, F.H. van Schaik, G.L. Velthof and O. Oenema (2004). The contribution of agriculture to N and P loading of surface water in grassland on peat soil. Nutrient Cycling in Agroecosystems 70: 85-95.

Biesheuvel, A. (2002). Over het voorkomen en de afbraak van pyriet in de Nederlandse ondergrond. Deventer, Witteveen+Bos, Report No. SECI/KRUB/rap.003.

Boumans L.J.M., C.M. Meinardi and G.J.W. Krajenbrink (1989). Nitraatgehalten en kwaliteit van het grondwater onder grasland in de zandgebieden. Bilthoven, RIVM Report No. 728472013.

Boumans, L.J.M., B. Fraters and G. van Drecht (2005). Nitrate leaching in agriculture to upper groundwater in the sandy regions of the Netherlands during the 1992-1995 period. Environmental Monitoring and Assessment 102, 225-241.

Boumans, L.J.M. and B. Fraters (2011). Nitraatconcentraties in het bovenste grondwater van de zandregio en de invloed van het mestbeleid. Visualisatie afname in de periode 1992 tot 2009. Bilthoven, RIVM Report No. 680717020.

Bruggen, C. van, A. Bannink, C.M. Groenestein, J.F.M. Huijsmans, H.H. Luesink, S.M. van der Sluis, G.L. Velthof and J. Vonk (2015). Emissies naar lucht uit de landbouw, 1990-2013. Berekeningen van ammoniak, stikstofoxide, lachgas, methaan en fijn stof met het model NEMA. Wageningen, WOt Technical Report No. 46.

Buis, E., A. van den Ham, L.J.M. Boumans, C.H.G. Daatselaar and G.J. Doornewaard (2012). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie. Resultaten meetjaar 2010 in het derogatiemeetnet. Bilthoven, RIVM Report No. 68071028.

Butterbach-Bahl, K. and P. Gundersen (2011). Nitrogen processes in terrestrial ecosystems. The European Nitrogen Assessment. Sutton, M.A., C.M. Howard, J.W. Erisman, G. Billen, A. Bleeker, P. Grennfelt, H. van Grinsven and B. Grizzetti (eds). Cambridge, Cambridge University Press.

Dam, J.C. van, P. Groenendijk, R.F.A. Hendriks and J.G. Kroes (2008). Advances of modeling water flow in variably saturated soils with SWAP. Vadose Zone Journal, Volume 7, No. 2, May 2008.

EU (1991). Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Communities, No. L 375/1-8.

EU (2005). Commission decision of 8 December 2005 granting a derogation requested by the Netherlands pursuant to Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Union, No. L 324/89-93 (10 December 2005).

EU (2010). Commission decision of 5 February 2010 amending Decision 2005/880/EC granting a derogation requested by the Netherlands pursuant to Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources (2010/65/EU). Official Journal of the European Union, No. L 35/18 (6 February 2010).

EU (2014). Commission Implementing Decision of 16 May 2014 granting a derogation requested by the Netherlands pursuant to Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources (2014/291/EU). Official Journal of the European Union, No. L 148/88 (20 May 2014).

Fraters, B., P.H. Hotsma, V.T. Langenberg, T.C. van Leeuwen, A.P.A. Mol, C.S.M. Olsthoorn, C.G.J. Schotten and W.J. Willems (2004). Agricultural practice and water quality in the Netherlands in the 1992-2002 period. Background information for the third EU Nitrates Directive Member States report. Bilthoven, RIVM Report No. 500003002.

Fraters, B. and L.J.M. Boumans (2005). De opzet van het Landelijk Meetnet effecten Mestbeleid voor 2004 en daarna. Uitbreiding van LMM voor onderbouwing van Nederlands beleid en door Europese monitorverplichtingen. Bilthoven, RIVM Report No. 680100001.

Fraters D., L.J.M. Boumans, T.C. van Leeuwen and W.D. de Hoop (2005). Results of 10 years of monitoring nitrogen in the sandy region in The Netherlands. Water Science & Technology, 5 (3-4), 239-247.

Fraters, B., L.J.M. Boumans, T.C. Van Leeuwen and J.W. Reijs (2007a). De uitspoeling van het stikstofoverschot naar grond- en oppervlaktewater op landbouwbedrijven. Bilthoven, RIVM Report No. 680716002.

Fraters, B., T.C. Van Leeuwen, J.W. Reijs, L.J.M. Boumans, H.F.M. Aarts, C.H.G. Daatselaar, G.J. Doornewaard, D.W. de Hoop, J.J. Schröder, G.L. Velthof and M.H. Zwart (2007b). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie. Beschrijving van de meetnetopzet voor de periode 2006-2009 en de inhoud van de rapportages vanaf 2008. Bilthoven, RIVM Report No. 680717001.

Fraters, B., J.W. Reijs, T.C. van Leeuwen and L.J.M. Boumans (2008). Landelijk Meetnet effecten Mestbeleid. Resultaten van de monitoring van waterkwaliteit en bemesting in meetjaar 2006 in het derogatiemeetnet. Bilthoven, RIVM Report No. 680717004.

Ham, A. van den, N.W.T.H. van den Berkmortel, J.W. Reijs, G.J. Doornewaard, K. Hoogendam and C.H.G. Daatselaar (2010). Mineralenmanagement en economie op melkveebedrijven. Gegevens uit de praktijk. The Hague, Agricultural Economics Research Institute of Wageningen University & Research Centre, Brochure No. 09-066.

Hooijboer, A.E.J., A. van den Ham, L.J.M. Boumans, C.H.G. Daatselaar, G.J. Doornewaard and E. Buis (2013). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie. Resultaten meetjaar 2011 in het derogatiemeetnet. Bilthoven, RIVM Report No. 680717034.

Hooijboer, A.E.J., T.J. de Koeijer, A. van den Ham, L.J.M. Boumans, H. Prins, C.H.G. Daatselaar and E. Buis (2014). Landbouwpraktijk en

waterkwaliteit op landbouwbedrijven aangemeld voor derogatie in 2012. Bilthoven, RIVM Report No. 680717037.
Kleinbaum, D.G., L.L. Kupper and K.E. Muller (1997). Applied regression analysis and other multivariable methods. Boston, International Thomson Publishing Services.
Ministry of Agriculture, Nature & Food Quality (2000). 15505 MINAS Tables Brochure.
Lukács, S., T.J. de Koeijer, H. Prins, A. Vrijhoef, L.J.M. Boumans, C.H.G. Daatselaar and A.E.J. Hooijboer (2015). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie in 2013. Bilthoven, RIVM Report No. 2015-0071.
Payne, R.W. (2000). The guide to GenStat. Part 2: Statistics. (Chapter 5, REML analysis of mixed models). Rothamsted, Lawes Agricultural Trust (Rothamsted Experimental Station).
Poppe, K.J. (2004). Het Bedrijven-Informatienet van A tot Z. The Hague, Agricultural Economics Research Institute, Report No. 1.03.06.
Prins, H., T. van Leeuwen and L.J.M. Boumans (2015). Landbouwpraktijk en waterkwaliteit op melkveebedrijven ingedeeld naar beweidingsintensiteit. In: LMM digital newsletter, July 2015.
Netherlands Enterprise Agency (2015). Derogatierapportage.
Velthof, G.L. and E. Hummelink (2012). Risico op nitraatuitspoeling bij scheuren van grasland in het voorjaar. Wageningen, Alterra, Report No. 2292.
Verloop, K. (2013). Limits of effective nutrient management in dairy farming: analyses of experimental farm De Marke, PhD thesis, Wageningen University, Wageningen.
Welham, S., B. Cullis, B. Gogel, A. Gilmour and R. Thompson (2004). Prediction in linear mixed models. Australian and New Zealand Journal of Statistics 46(3): 325-347.
Zwart, M.H., G.J. Doornewaard, L.J.M. Boumans, T.C. van Leeuwen, B. Fraters and J.W. Reijs (2009). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie. Resultaten meetjaar 2007 in het derogatiemeetnet. Bilthoven, RIVM Report No. 680717008.
Zwart, M.H., C.H.G. Daatselaar, L.J.M. Boumans and G.J. Doornewaard (2010). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie. Resultaten meetjaar 2008 in het derogatiemeetnet. Bilthoven, RIVM Report No. 680717014.
Zwart, M.H., C.H.G. Daatselaar, L.J.M. Boumans and G.J. Doornewaard (2011). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie. Resultaten meetjaar 2009 in het derogatiemeetnet. Bilthoven, RIVM Report No. 680717022.

**Websites**

Statistics Netherlands, Agricultural Census data: http://statline.cbs.nl

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

## A1.1 Introduction

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

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

Replacements for farms that dropped out during the 2006-2014 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 the Agricultural Economics Research Institute of Wageningen University & Research Centre (LEI) use different operational methods and definitions when registering farm data. Due to these discrepancies, the FADN grassland percentages may differ from the data registered by 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 70% or 80% in a later year. The consequences of these selection criteria are illustrated in Tables A1.1 and A1.2. Table A1.1 (farms) and Table A1.2 (acreages) specify how the sample population has been derived from the 2014 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 2014. BRS numbers are the registration numbers of farms registered with the Netherlands Enterprise Agency. As 446 BRS numbers did not appear in the 2014 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 18,900 farms for which data were available in the 2014 Agricultural Census.

*Table A1.1 Proportion of dairy and other grassland farms (in percentages) represented in the sample population of the derogation monitoring network in 2014*

| | *Distribution of farms* | | |
|---|---|---|---|
| | *Dairy farms* | *Other grassland farms* | *Total* |
| All farms registered for derogation in 2014 | 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 2014, data processed by LEI.

*Table A1.2 Proportion of cultivated land (in percentages) on dairy and other grassland farms represented in the sample population of the derogation monitoring network in 2014*

| | *Distribution of acreage of cultivated land* | | |
|---|---|---|---|
| | *Dairy farms* | *Other grassland farms* | *Total* |
| All farms registered for derogation in 2014 | 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 2014, data processed by LEI.

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 (*Nederlandse Grootte-Eenheid*, NGE) (Van der Veen *et al.*, 2012). The Standard Output of a crop, animal product or other agricultural product is its average monetary value based on the prices received by the agricultural entrepreneur, expressed in euros per hectare or animal. A regional SO coefficient for each product has been defined as the average value during a specific reference period (five years). The Netherlands is regarded as a single region for this purpose. The total Standard Output of a farm (i.e. the sum of all SOs per hectare of cultivated crops and per animal) is a measure of its total economic size, expressed in euros. A farm is characterised as ‘specialised’ when a particular agricultural activity (e.g. dairy farming, arable farming or pig farming) accounts for a significant proportion (often at least two-thirds) of its total economic size. Eight main farm types can be distinguished. Five of these types concern one single activity, while three types concern a combination of activities. The five single-activity farm types are: arable farming, horticulture, permanent crops (fruit growing and tree nurseries), grazing livestock, and intensive livestock farming. The three combined-activity farm types are: crop combinations, livestock combinations, and crop-and-livestock combinations. Each main farm type is further divided into a number of subtypes. For instance, the subcategory of specialised dairy farms is part of the overall category of grazing livestock farms.

Within the group of farms that registered for derogation, dairy farms form a large and homogeneous group, which uses almost 88% of the total acreage of cultivated land, as is apparent from Table A1.2. Twelve percent of the acreage is located on farms of a different type. 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. The Loess Region has not been subdivided for policy-making purposes. 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, farmers may apply up to 250 kg of nitrogen per hectare (i.e. the 'maximum derogation' amounts to 250 kg of nitrogen per hectare per year). In the districts Sand Region – Central and Sand Region – South, farmers may apply up to 230 kg of nitrogen per hectare per year on sandy soils.

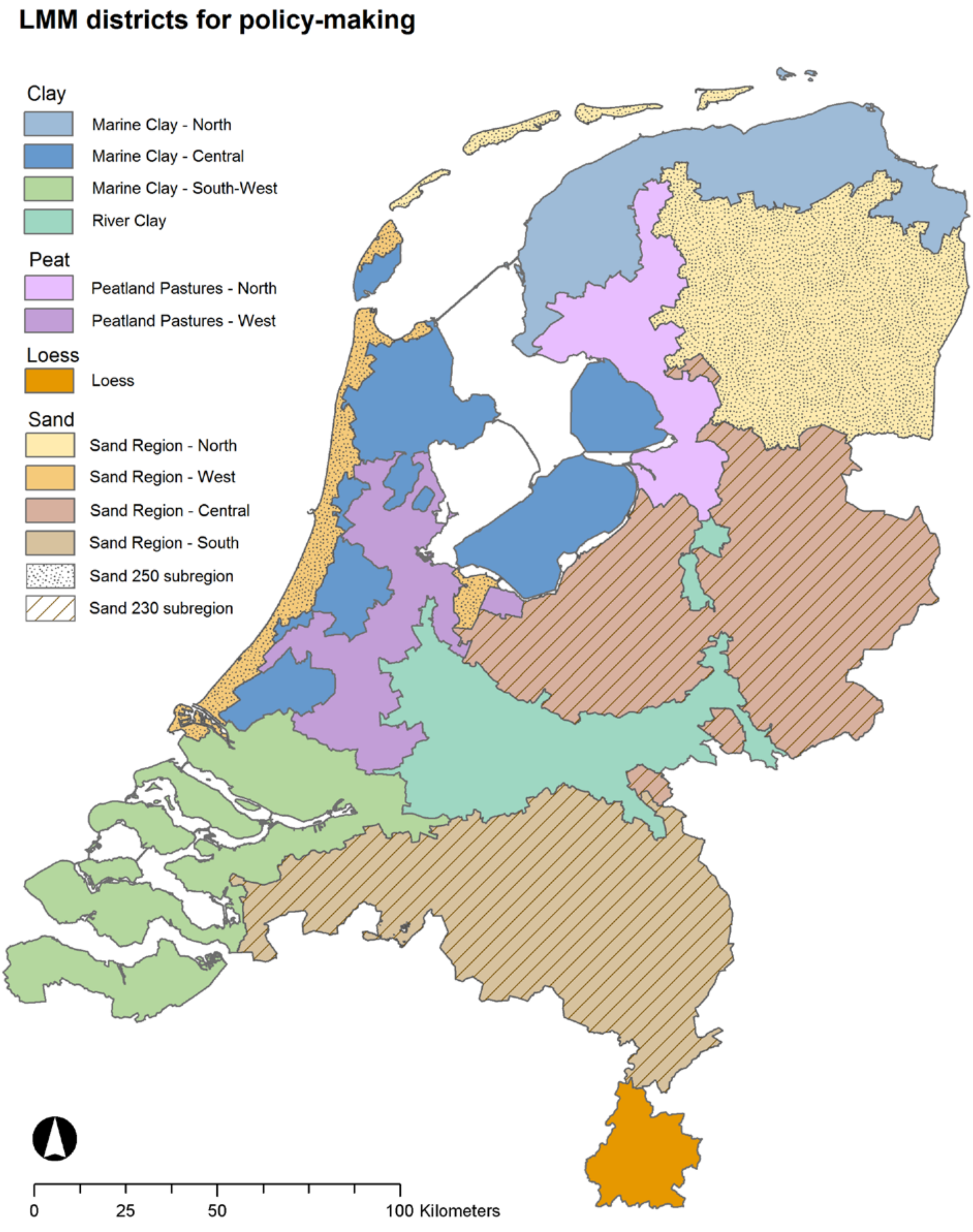



*Figure A1.1 Soil type regions and districts for policy-making purposes in the Minerals Policy Monitoring Programme (LMM)*

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. Three other groundwater bodies were distinguished as separate sub-regions: Eems, Rhine North and Rhine West (in so far as the latter is located outside the marine clay area in the south-west of the Netherlands). The fifth sub-region includes farms in other, unallocated municipalities.

## References

Veen, H.B. van der, I. Bezlepkina, P. de Hek, R. van der Meer and H.C.J. Vrolijk (2012). Sample of Dutch FADN 2009-2010: design principles and quality of the sample of agricultural and horticultural holdings. The Hague, Agricultural Economics Research Institute of Wageningen University & Research Centre, Report No. 2012-061.

Verhagen, F.Th., A. Krikken and H.P. Broers (2006). Draaiboek monitoring grondwater voor de Kaderrichtlijn Water. Den Bosch, Royal Haskoning, Report No. 9S1139/R00001/900642/DenB.

## Websites

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

# Appendix 2 Monitoring of agricultural characteristics

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

## A2.1 Introduction

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

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

Fertiliser usage, yields and nutrient surpluses are expressed per unit of surface area. The total acreage of cultivated land in the Netherlands is used for this purpose, i.e. the land actually fertilised and used for crop cultivation on 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, 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(1) states:
*'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;'*

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

### A2.2.1 Calculation of fertiliser 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 cubic metre of manure, provided the relevant farm uses the Farm-Specific Excretion (BEX) method or the stable balance method. Standard quantities are used for the other farms.

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

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

*Farm-specific use of livestock manure*

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

- The farm is a specialised dairy farm according to the Standard Output classification.

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

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

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

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

- the contents derived from sampling results (if available), or
- the farm-specific mineral content if the manure production is calculated separately for each farm (see below), or, if this is not the case,
- the applicable standard contents (Netherlands Enterprise Agency, 2016, Table 5).

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

Fertiliser use on grassland = Fertiliser use at farm level -/- Fertiliser use on arable land.

In the case of farms where grassland accounts for less than 25% of the total cultivated area[3], fertiliser use on grassland is calculated based on allocations, and the fertiliser use on arable land is calculated as the closing entry. The quantity of fertiliser used on grassland comprises 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.

[3] Not relevant for this report, as farms must consist of at least 70% grassland (80% as of 2014) to qualify for participation in the derogation scheme.

*Use of plant-available nitrogen*

The total nitrogen use is expressed in kilogrammes of plant-available nitrogen. The quantity of plant-available nitrogen is calculated by multiplying the total quantity of nitrogen in organic fertilisers by the availability coefficients as stated in Table 3 (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 applies to the separate nitrogen and phosphate quantities, as well as the total quantities of fertilisers applied (i.e. inorganic fertilisers, livestock manure, and other organic fertilisers). Table A2.1 lists the confidence intervals for non-organic dairy farms.

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

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

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

## A2.3 Calculation of grass and silage maize yields

### *A2.3.1 Calculation procedure*

The calculation procedure for determining grass and silage maize yields in FADN is largely identical to the procedure described in Aarts *et al.* (2005, 2008). First, the energy requirement of the dairy herd is determined based on milk production and growth achieved. All transactions and stock changes of feed products are registered in FADN. These data are used to determine the proportion of the energy requirement covered by purchased feedstuffs. The energy uptake from farm-produced silage maize and other fodder crops (other than grass) is then determined based on measurements and content data for silage supplies, insofar as these are available. The silage maize yield is 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 then assumed that the remaining energy requirement is covered by grass produced on the farm. The number of grazing days registered in

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

#### A2.3.2 *Selection criteria*

The 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. In accordance with Aarts *et al.* (2008), the method is therefore only used on farms that satisfy the following criteria:

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

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

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

These criteria were not considered because they were used in Aarts *et al.* (2008) to make statements about the population of ‘typical’ dairy farms. These criteria can be ignored because the population 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 of 5,000 to 22,000 kg of dry matter per hectare
- Grassland yield of 4,000 to 20,000 kg of dry matter per hectare

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

#### A2.3.3 *Deviations from 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. Supplement for grazing based on actual number of grazing days
3. Ratio of conserved grass to fresh grass, based on the actual number of grazing days

## 4 Conservation and feed production losses

*Re 1*
Aarts *et al.* (2008) base the composition of silage grass and silage maize pits on provincial averages supplied by the Netherlands Laboratory for Soil and Crop Research (BLGG). A slightly different method is used in the FADN network. Since 2006, the composition of silage grass and silage maize pits per farm is also registered in FADN. The FADN calculation procedure uses these farm-specific composition data if at least 80% of all silage pits have been fully sampled. The average pit composition for each soil type is used if less than 80% of pits have been sampled and/or if data are missing (i.e. dry-matter yields, VEM uptake, nitrogen or phosphate content). Data on average silage grass and silage maize pit composition are obtained annually from BLGG.

*Re 2*
A so-called 'mobility factor' is taken into account when calculating the energy requirement. This factor depends on the number of grazing days, among other things. Aarts *et al.* (2008) distinguish three grazing categories: no grazing (0 grazing days), 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, 2009).

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

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

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

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

## A2.4 Calculation of nutrient surpluses

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

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

| *Description of items* | | *Calculation method* | |
|---|---|---|---|
| | | *Quantity* | *Contents* |
| Farm inputs | Inorganic fertilisers | Balance of all inputs, outputs and stock changes of inorganic fertilisers | Data obtained from suppliers' annual overviews. If these are not available, standards are used (Nutrient Management Institute, 2013). |
| | Livestock manure and other organic fertilisers | Balance of all inputs, outputs and stock changes of livestock manure and other organic fertilisers in the case of net consumption (input) | Sampling results or standard quantities (Netherlands Enterprise Agency, 2016, Table 5). If farm-specific manure production is known, the output of on-farm manure is corrected accordingly (see section A3.2). |
| | Feedstuffs | Balance of all 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).<br>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.<br>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) | |
| Farm outputs | Animal products (milk, wool, | Balance of all inputs, outputs and stock changes of all milk and | Netherlands Enterprise Agency (2016, Tables 7 and 8) |

| *Description of items* | | *Calculation method* | |
|---|---|---|---|
| | | *Quantity* | *Contents* |
| | eggs) | other animal products | |
| | 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 A3.2). |
| | Crops and other plant products | Balance of outputs and stock changes of plant products (crops not intended for roughage), stock increases and sales of roughage | Data based on Van Dijk (2003) and Centraal Veevoederbureau (2012) |
| | Other | Balance of all inputs, outputs and stock changes of all other products in the case of net production (output) | |
| Nitrogen surplus at farm level | | Farm input -/- 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. | |
| | + Nitrogen fixation by leguminous plants | Clover on grassland (Kringloopwijzer, 2013): the quantity of nitrogen fixation depends on the proportion of clover and the grassland yield, and is based on a nitrogen fixation per kg of dry-matter yield in the form of clover of (4.5/100)/2.<br>Other crops (Schröder, 2006):<br>- Lucerne: 160 kg per hectare<br>- 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.<br>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:<br>- Ammonia emissions resulting from stabling and storage: the stable code under the Regulations on the Use of Ammonia in Livestock Farming (*Regeling Ammoniak en Veehouderij*, RAV) is used as a starting point. The total nitrogen emissions are calculated as a percentage of the emitted ammonia nitrogen (based on the RAV emission factor). The emitted ammonia nitrogen is determined on the basis of the TAN percentages in the manure (Van Bruggen *et al.*, 2015).<br>- Ammonia emissions resulting from grazing are calculated as a percentage (2.6%) of the total quantity of ammonia nitrogen excreted on grassland (Van Bruggen *et al.*, 2015).<br>If a farm calculates excretion based on standard quantities, the emissions resulting from grazing, stabling and storage are calculated as follows:<br>- 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.<br>- The emissions resulting from grazing are then calculated by multiplying the quantity of nitrogen excreted in grassland manure (net standard-based excretion * grassland fraction) by the emission percentage of the total quantity of ammonia nitrogen excreted on grassland (Van Bruggen *et al.*, 2015).<br>- The emissions resulting from stabling and storage are calculated as the gross standard-based excretion minus the net standard-based excretion. |
| | - Volatilisation resulting from application | The ammonia emission factors for the application of livestock manure and inorganic fertilisers are based on Velthof *et al.* (2009) and Van Bruggen *et al*. (2015). Other gaseous nitrogen emissions during application are not taken into consideration. Emissions resulting from application are calculated as a percentage of the applied ammonia nitrogen based on the emission factors as reported in Appendix 14 in Velthof *et al.* (2009). If no information on the application method is available (this has not been the case in the LMM framework since 2010), 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 Total Ammonia Nitrogen (TAN) factor. |
| Nitrogen surplus on the soil surface balance | | Nitrogen surplus on farm + input on soil surface balance – output on soil surface balance |

## References

Aarts, H.F.M., C.H.G. Daatselaar and G. Holshof (2005). Nutriëntengebruik en opbrengsten van productiegrasland in Nederland. Wageningen, Plant Research International, Report No. 102.

Aarts, H.F.M., C.H.G. Daatselaar and G. Holshof (2008). Bemesting, meststofbenutting en opbrengst van productiegrasland en snijmaïs op melkveebedrijven. Wageningen, Plant Research International, Report No. 208.

Alterra (2006). Soil map of the Netherlands on a scale of 1 : 50,000. Website: http://www.bodemdata.nl/ (visited on 18 July 2011).

Bruggen, C. van, A. Bannink, C.M. Groenestein, J.F.M. Huijsmans, H.H. Luesink, S.M. van der Sluis, G.L. Velthof and J. Vonk (2015). Emissies naar lucht uit de landbouw, 1990-2013. Berekeningen van ammoniak, stikstofoxide, lachgas, methaan en fijn stof met het model NEMA. Wageningen, WOT Natuur & Milieu, WOt Technical Report No. 46, 160 pages.

Statistics Netherlands (2010). Gestandaardiseerde berekeningsmethode voor dierlijke mest en mineralen. Standaardcijfers 1990-2008. The Hague, Statistics Netherlands.

Statistics Netherlands (2011). Dierlijke mest en mineralen 2009. http://www.cbs.nl/NR/rdonlyres/DAC00920-82AC-4E9F-8C01-122F5721D627/0/20110c72pub.pdf

Centraal Veevoederbureau (2012). Tabellenboek Veevoeding. Lelystad, Centraal Veevoederbureau.

Dijk, W. van (2003). Adviesbasis voor de bemesting van akkerbouw- en vollegrondsgroentegewassen. Lelystad, Applied Plant Research, Report No. 307.

EU (2014). Commission Implementing Decision of 16 May 2014 granting a derogation requested by the Netherlands pursuant to Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources (2014/291/EU). Official Journal of the European Union, No. L 148/88 (20 May 2014).

Groenestein, C.M., K.W. van der Hoek, G.J. Monteny and O. Oenema, (2005). Actualisering forfaitaire waarden voor gasvormige N-verliezen uit stallen en mestopslagen van varkens, pluimvee en overige dieren. Wageningen: Agrotechnology & Food Innovations (Report / Agrotechnology & Food Innovations 465), 33 pages.

Kekem, A.J. van, 2004. Veengronden en stikstofleverend vermogen. Alterra Report No. 965, Alterra, Wageningen, 52 pages.

Koeijer, T.J. de, G. Kruseman, P.W. Blokland, M.W. Hoogeveen and H.H. Luesink (2012). Mambo: visie en strategisch plan 2012-2015. Wettelijke Onderzoekstaken Natuur & Milieu. Working Document No. 308. Agricultural Economics Research Institute, Wageningen University & Research Centre.

Kringloopwijzer (2013). http://www.verantwoordeveehouderij.nl/index.asp?pzprojecten/projectkaart.asp?IDProject=503 (16 April 2013)

Ministry of Agriculture, Nature & Food Quality (2010). Handreiking bedrijfsspecifieke excretie melkvee, versie per 2010 van kracht. The Hague, Ministry of Agriculture, Nature & Food Quality, www.minlnv.nl (16 April 2013).

Nutrient Management Institute (2013). Fertiliser database. http://www.nmi-agro.nl/sites/nmi/nl/nmi.nsf/dx/databank-meststoffen.htm Nutrient Management Institute (16 April 2013).
Oenema, O., G.L. Velthof, N. Verdoes, P.W.G. Groot Koerkamp, G.J. Monteny, A. Bannink, H.G. van der Meer and K.W. van der Hoek (2000). Forfaitaire waarden voor gasvormige stikstofverliezen uit stallen en mestopslagen. Wageningen, Alterra, Report No. 107.
Poppe, K.J. (2004). Het Bedrijven-Informatienet van A tot Z. The Hague, Agricultural Economics Research Institute, Wageningen University & Research Centre, Report No. 1.03.06.
National Institute for Public Health and the Environment (2016). Grootschalige concentratie- en depositiekaarten. http://www.compendiumvoordeleefomgeving.nl/indicatoren/nl0189-Vermestende-depositie.html?i=3-17 (18 February 2016)
Netherlands Enterprise Agency (RVO.nl, 2016). Tabellen Mestbeleid 2014. http://www.rvo.nl/documenten-publicaties-archief?query-content=Tabel%20mest&page=1&f[0]=field_onderwerpen_tax%3A20173&f[1]=field_onderwerpen_tax%3A20179 (17 March 2016) Ministry of Economic Affairs (17 March 2016)
Schröder, J.J., H.F.M. Aarts, M.J.C. de Bode, W. van Dijk, J.C. van Middelkoop, M.H.A. de Haan, R.L.M. Schils, G.L. Velthof and W.J. Willems (2004). Gebruiksnormen bij verschillende landbouwkundige en milieukundige uitgangspunten. Wageningen, Plant Research International B.V., Report No. 79.
Schröder, J.J. (2006). Berekeningswijze N-bodemoverschot t.b.v. ABC en BIN2, respectievelijk WOD2. Werkgroep Onderbouwing Gebruiksnormen, Memorandum of 26 March 2006.
Schröder, J.J., H.F.M. Aarts, J.C. van Middelkoop, R.L.M. Schils, G.L. Velthof, B. Fraters and W.J. Willems (2007). Permissible manure and fertilizer use in dairy farming systems on sandy soils in The Netherlands to comply with the Nitrates Directive target. European Journal of Agronomy 27(1): 102-114.
Tamminga, S., F. Aarts, A. Bannink, O. Oenema and G.J. Monteny (2004). Actualisering van geschatte N en P excreties door rundvee. 'Environmental Policy in Rural Areas' series No. 25, Wageningen.
Velthof, G.L., C. van Bruggen, C.M. Groenestein, B.J. de Haan, M.W. Hoogeveen and J.F.M. Huijsmans (2009). Methodiek voor berekening van ammoniakemissie uit de landbouw in Nederland. WOT Report No. 70. WOT Natuur & Milieu, Wageningen.

# Appendix 3 Sampling of water on farms in 2014

## 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, paragraph 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 below the root zone is sampled. There is little agricultural activity on push moraines in the Sand Region where the water table is far below ground level. Where these agricultural activities do occur, the soil moisture below the root zone is also sampled if possible.

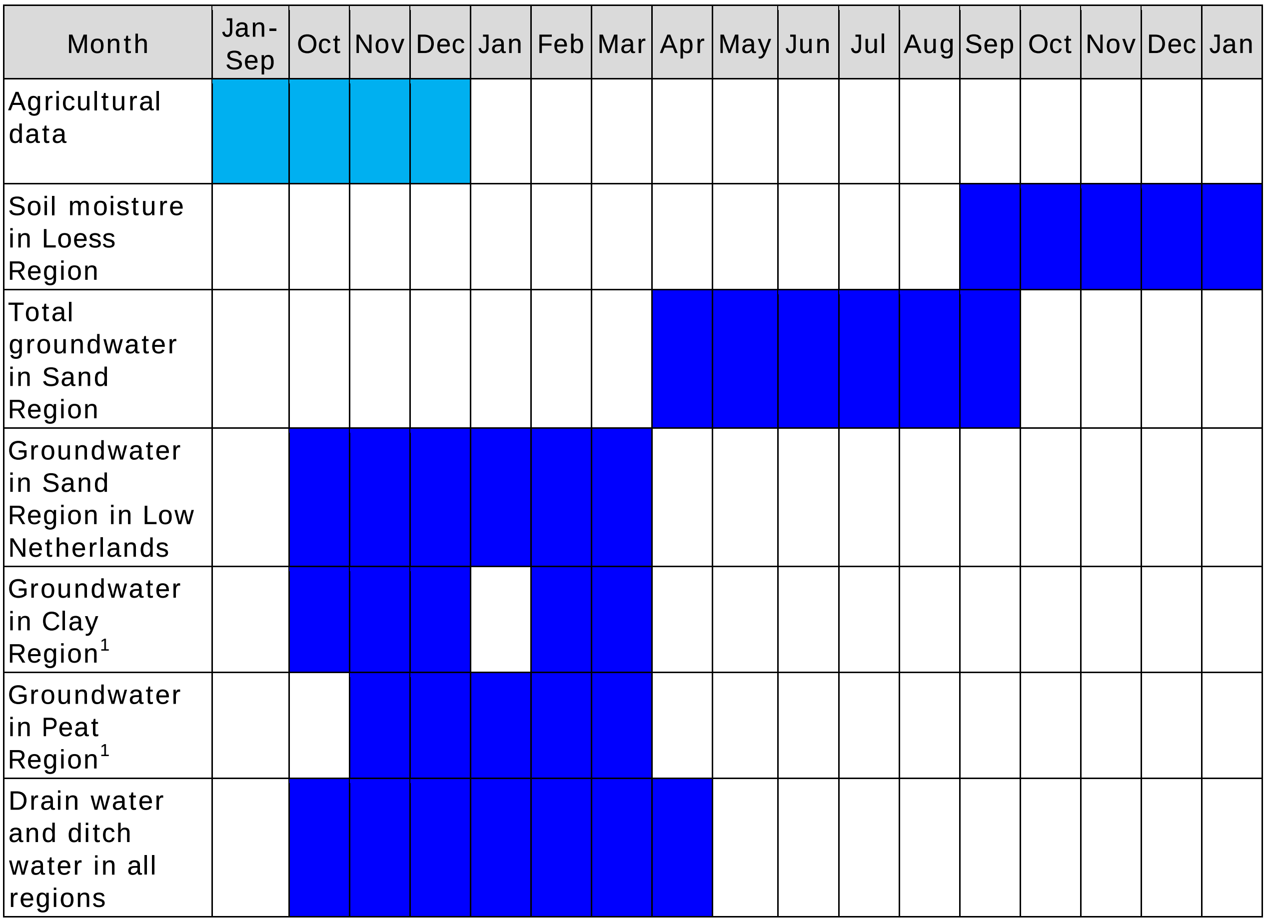
The surface water is loaded with nitrogen and phosphorus via run-off and groundwater. In the latter case, the travel times are usually longer. In the High Netherlands, only water leaching from the root zone is monitored by sampling the top metre of groundwater or by sampling soil moisture below the root zone. In areas drained by means of ditches in the Low Netherlands (possibly in combination with tile drainage), the travel times are shorter. Here, the 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 as accurately as possible the agricultural practices of the previous year. Due to weather conditions, sampling campaigns may need to be extended or started at a later time.




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

*Figure A3.1 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 annual precipitation surplus in the Netherlands amounts to approx. 300 mm. This quantity of water spreads throughout the soil with a porosity of 0.3 (typical for sandy soils) over a soil layer of approx. 1 metre (saturated soil). Therefore, the quality of the top metre of groundwater is 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 (e.g. BW-W-

021). An overview of the work instructions concerned is provided at the end of this appendix.

## A3.2 Sand Region and Loess Region

### *A3.2.1 Standard sampling procedure*

Groundwater sampling on derogation farms in the Sand Region was carried out from April 2014 through to September 2014 (see Figure A3.2). In the Loess Region, samples were taken from September 2014 through to November 2014 (see Figure A3.2) Each farm was sampled once during these periods.

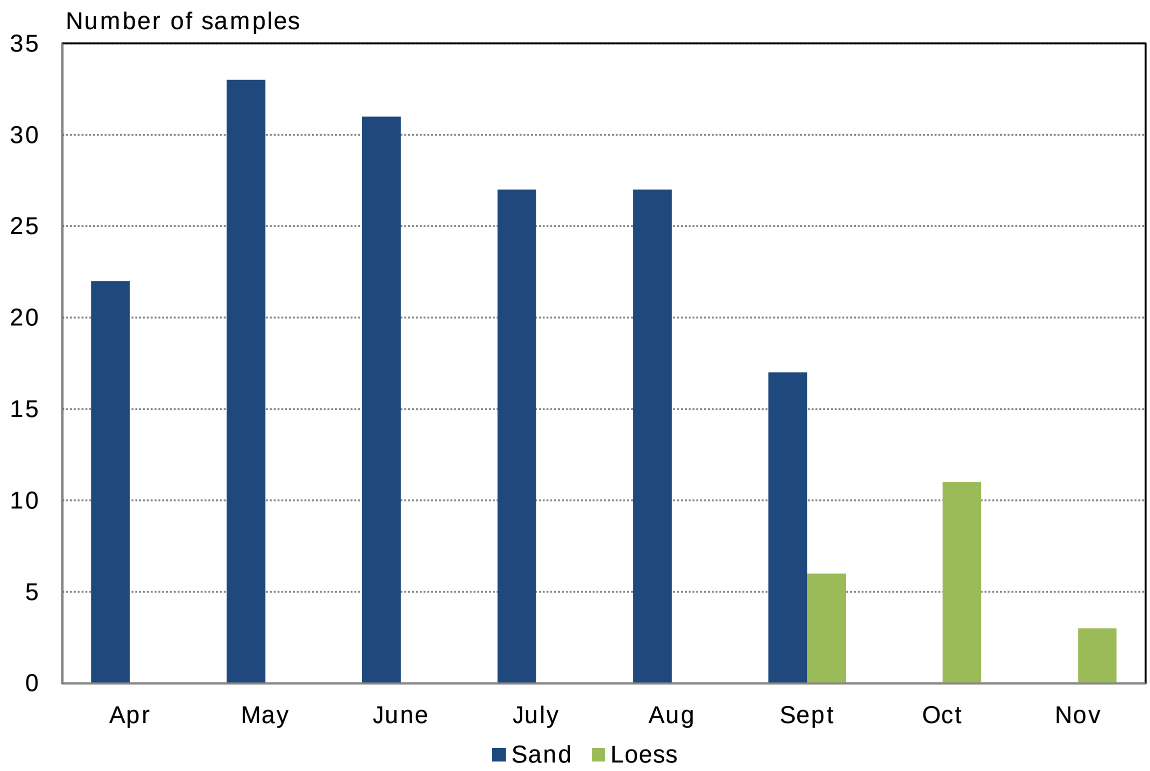



*Figure A3.2 Number of groundwater and soil moisture samples in the Sand Region and Loess Region per month during the period from April 2014 through to November 2014*

The samples were taken in accordance with the standard sampling method. On each farm, samples were taken from bore holes drilled at sixteen locations. The number of locations per plot depended on the size of the plot and the number of plots on each farm. The locations in the plot were selected at random. The locations were selected and positioned in accordance with the applicable protocol (MIL-W-4021). The top metre of groundwater was sampled using the open bore hole method (MIL-W-4015). The groundwater levels and nitrate concentrations were determined in situ at each location (Nitrachek method, MIL-W-4001). The water samples were filtered and stored in a cool dark place prior to transport to the laboratory (MIL-W-4008). Acidification has been deployed as a method of conservation since 1 November 2010, using sample bottles which have been previously acidified in the laboratory or by the manufacturer. Acidification was previously carried out in situ using sulphuric acid or nitric acid (MIL-W-4009). Soil moisture samples were taken by collecting drill cores at depths ranging from 150 to 300 cm, using an Edelman drill. The samples were then transported to the laboratory in untreated form and packed in tightly sealed containers (MIL-W-4014). In the laboratory the samples were centrifuged to collect the soil moisture. In the laboratory two compound samples were prepared (each consisting of eight separate samples) and analysed for nitrate content, total nitrogen content, and total phosphorus content. 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 2013 through to March 2014 (see Figure A3.3), in accordance with the standard method. On each farm, no more than two types of ditches were distinguished: farm ditches and local ditches. Farm ditches 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.

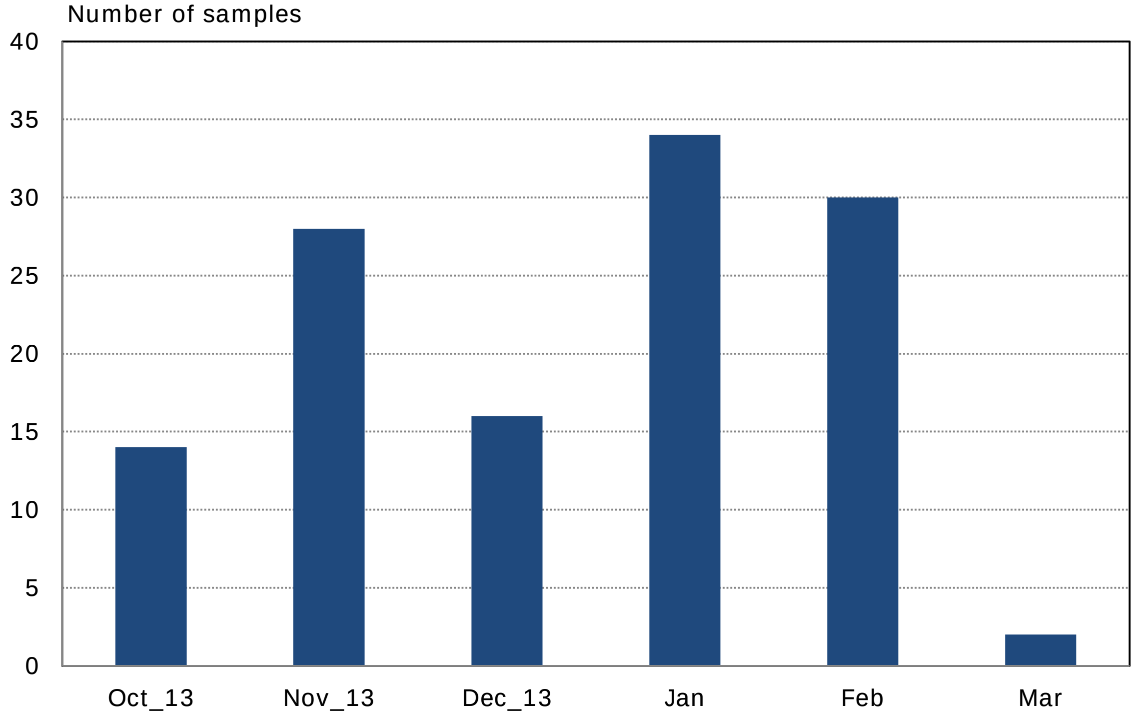



*Figure A3.3 Number of ditch water samples in the Sand Region per month during the period from October 2013 through to March 2014*

Three to four ditch water samples were taken on these farms in the winter of 2013-2014.

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 2013 through to March 2014 (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 2013-2014, 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).

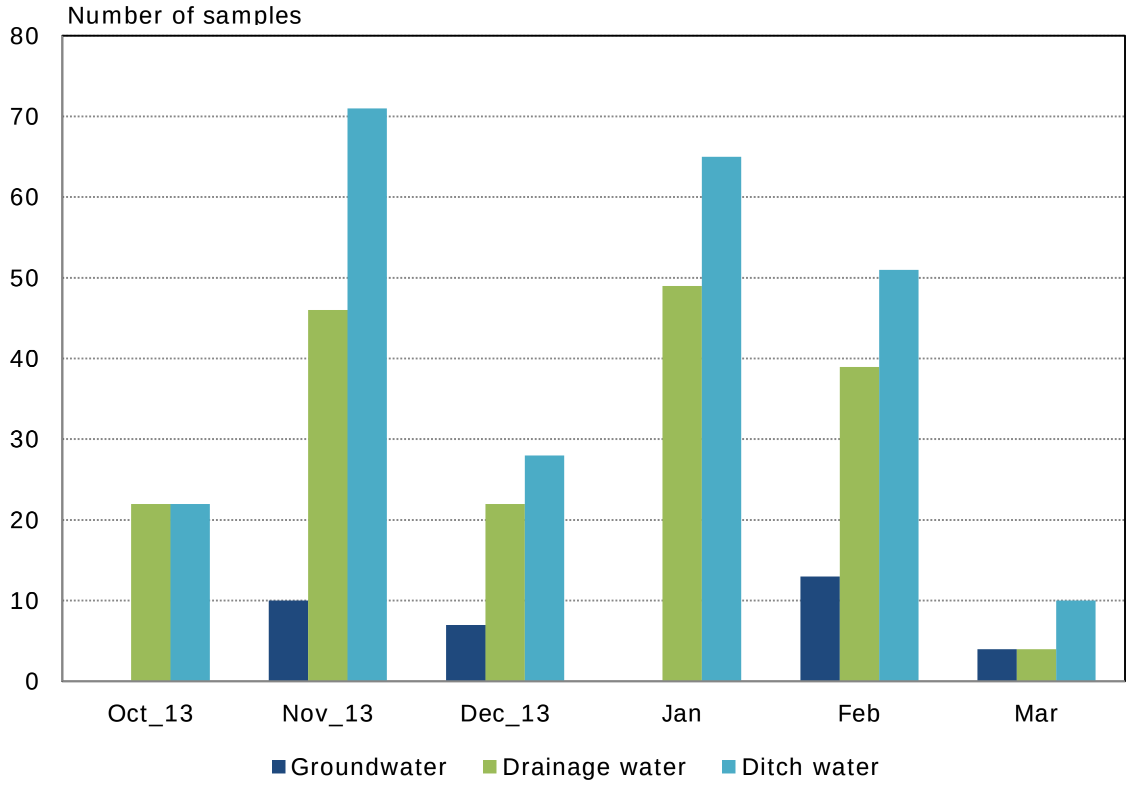



*Figure A3.4 Number of groundwater, drain water and ditch water samples in the Clay Region per month during the period from October 2013 through to March 2014*

### 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 2013 through to March 2014 (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 2013 through to March 2014 (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).

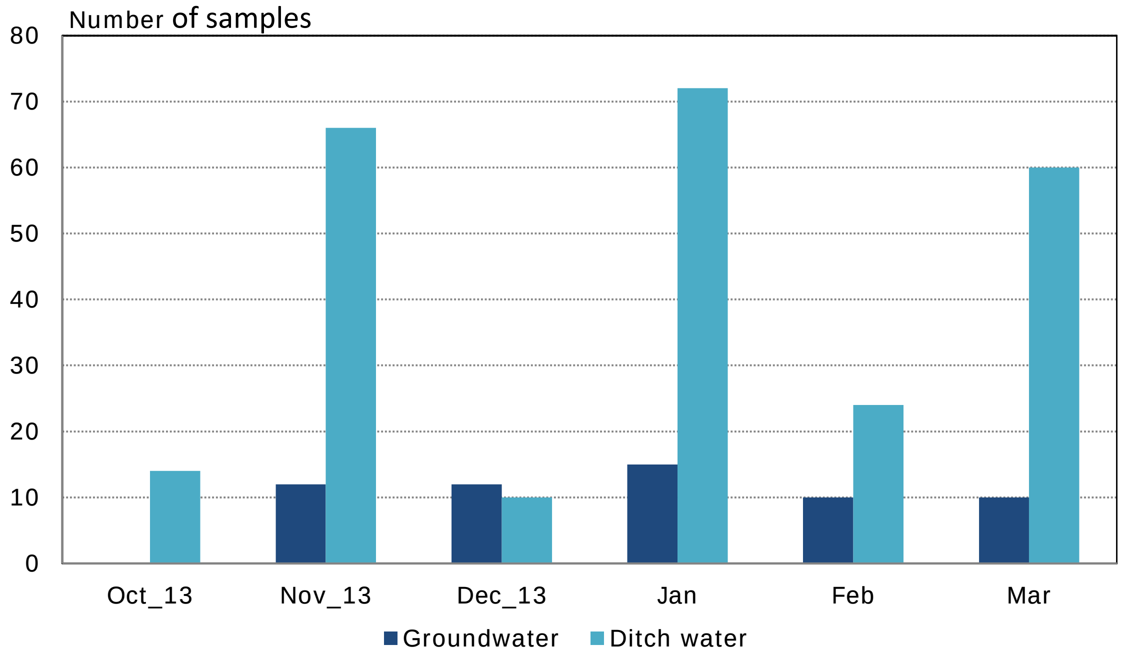



*Figure A3.5 Number of groundwater and ditch water samples in the Peat Region per month during the period from October 2013 through to March 2014*

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 |

## References

Beek, C.L. van, G.A.P.H. van den Eertwegh, F.H. van Schaik, G.L. Velthof and O. Oenema (2004). The contribution of agriculture to N and P loading of surface water in grassland on peat soil. Nutrient Cycling in Agroecosystems 70: 85-95.

Boumans, L.J.M., G. van Drecht, B. Fraters, T. de Haan and D.W. de Hoop (1997). Effect van neerslag op nitraat in het bovenste grondwater onder landbouwbedrijven in de zandgebieden; gevolgen voor de inrichting van het Monitoringnetwerk effecten mestbeleid op Landbouwbedrijven (MOL). Bilthoven, RIVM Report No. 714831002.

Eertwegh, G.A.P.H. van den (2002). Water and nutrient budgets at field and regional scale. Travel times of drain water and nutrient loads to surface water. Wageningen, Wageningen University. PhD thesis.

Eertwegh, G.A.P.H. van den, and C.L. van Beek (2004). Veen, Water en Vee; Water en nutriëntenhuishouding in een veenweidepolder. Eindrapport Veenweideproject fase 1 (Vlietpolder). Leiden, Rijnland District Water Control Board.

EU (2005). Commission decision of 8 December 2005 granting a derogation requested by the Netherlands pursuant to Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Union, No. L 324/89-93 (10 December 2005).

EU (2006). Monitoring Guidance for Groundwater. Final draft. Drafting group GW1 Groundwater Monitoring, Common Implementation Strategy of the WFD.

Fraters, B., H.A. Vissenberg, L.J.M. Boumans, T. de Haan and D.W. de Hoop (1997). Resultaten Meetprogramma Kwaliteit Bovenste Grondwater Landbouwbedrijven in het zandgebied (MKBGL-zand) 1992-1995. Bilthoven, RIVM Report No. 714801014.

Fraters, B., L.J.M. Boumans, G. van Drecht, T. de Haan and W.D. de Hoop (1998). Nitrogen monitoring in groundwater in the sandy regions of the Netherlands. Environmental Pollution 102 (Supplement 1): 479-485.

Fraters, B., L.J.M. Boumans, T.C. van Leeuwen and D.W. de Hoop (2002). Monitoring nitrogen and phosphorus in shallow groundwater and ditch water on farms in the peat regions of the Netherlands. Proceedings of the 6th International Conference on Diffuse Pollution. Amsterdam, the Netherlands, 30 September – 4 October 2002: 575-576.

Meinardi, C.R. and G.A.P.H. van den Eertwegh (1995). Onderzoek aan drainwater in de kleigebieden van Nederland. Deel 1: Resultaten van het veldonderzoek. Bilthoven, RIVM Report No. 714901007.

Meinardi, C.R. and G.A.P.H. van den Eertwegh (1997). Onderzoek aan drainwater in de kleigebieden van Nederland. Deel 2: Interpretatie van de gegevens. Bilthoven, RIVM Report No. 714801013.

Rozemeijer, J., L.J.M. Boumans and B. Fraters (2006). Drainwaterkwaliteit in de kleigebieden in de periode 1996-2001. Evaluatie van een meetprogramma voor de inrichting van een monitoringnetwerk. Bilthoven, RIVM Report No. 680100004.

Vrijhoef, A., E. Buis and B. Fraters (2015). Effecten van filtratie op stikstof- en fosforconcentraties in slootwater op landbouwbedrijven in het Landelijk Meetnet effecten Mestbeleid. Bilthoven, RIVM Report No. 2015-0065.

# 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 2006-2014 period: average values for the 2006-2013 period, differences between 2014 results and the average values for the 2006-2013 period, and trends identified for the 2006-2014 period*

| *Farm characteristic* | *2006* | *2007* | *2008* | *2009* | *2010* | *2011* | *2012* | *2013* | *2014* | *2006-2013* | *Difference* | *Trend* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of dairy farms | 251 | 247 | 253 | 249 | 252 | 255 | 262 | 254 | 250 | 253 | | |
| Number of other grassland farms | 43 | 48 | 47 | 44 | 42 | 35 | 33 | 34 | 36 | 40 | | |
| Total area of cultivated land (hectares) | 49 | 50 | 51 | 52 | 52 | 53 | 56 | 56 | 56 | 52 | + | + |
| Proportion of grassland (%) | 83 | 83 | 82 | 82 | 83 | 83 | 83 | 83 | 86 | 83 | + | + |
| Proportion of farms with intensive livestock (%) | 12 | 13 | 12 | 10 | 10 | 8 | 6 | 6 | 6 | 10 | - | - |
| Total livestock density (Phosphate Livestock Units per hectare)[1] | 3.0 | 3.1 | 2.7 | 2.8 | 2.9 | 2.8 | 2.6 | 2.7 | 2.9 | 2.8 | ≈ | ≈ |
| Kilogrammes of FPCM per dairy farm (x 1,000) | 697 | 731 | 779 | 813 | 860 | 869 | 894 | 942 | 993 | 823 | + | + |
| 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 | 8.5 | ≈ | + |
| FPCM production per hectare of fodder crop (x 1,000 kg) | 14 | 14 | 15 | 15 | 16 | 16 | 16 | 16 | 17 | 15 | + | + |
| Percentage of dairy farms where dairy cows graze in: | | | | | | | | | | | | |
| • May-October | 89 | 88 | 86 | 83 | 79 | 78 | 79 | 79 | 77 | 83 | - | - |
| • May-June | 86 | 84 | 82 | 80 | 76 | 76 | 77 | 75 | 76 | 80 | ≈ | - |
| • July-August | 88 | 88 | 86 | 83 | 79 | 78 | 79 | 78 | 76 | 82 | - | - |
| • September-October | 87 | 87 | 84 | 80 | 74 | 71 | 75 | 76 | 75 | 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 LSUs); one young animal 0-1 years of age produces 9 kg of phosphate (0.22 Phosphate LSUs) (source: Ministry of Agriculture, Nature & Food Quality, 2000). Difference: direction and significance of difference between 2014 and average for previous years. ≈ insignificant

difference ($p > 0.05$), +/- significant difference ($p < 0.05$). Trend: direction and significance of trend in 2006-2014 period. ≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

*Table A4.2 Average application of nitrogen in livestock manure (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2014 period: average values for the 2006-2013 period, differences between 2014 results and the average values for the 2006-2013 period, and trends identified for the 2006-2014 period*

| *Description* | *2006* | *2007* | *2008* | *2009* | *2010* | *2011* | *2012* | *2013* | *2014* | *2006-2013* | *Difference* | *Trend* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Use of nitrogen in livestock manure* | | | | | | | | | | | | |
| Number of farms | 273 | 278 | 275 | 268 | 278 | 277 | 281 | 276 | 271 | 276 | | |
| Produced on farm | 265 | 264 | 262 | 257 | 276 | 272 | 257 | 269 | 286 | 265 | + | + |
| + Inputs | 8 | 10 | 10 | 0 | 8 | 11 | 11 | 10 | 8 | 8 | ≈ | + |
| + Changes in stocks[1] | -4 | -8 | -7 | 0 | -8 | -5 | -5 | -6 | -12 | -6 | - | + |
| – Outputs | 26 | 30 | 26 | 0 | 39 | 37 | 31 | 33 | 45 | 28 | + | + |
| Total use | 243 | 235 | 239 | 242 | 237 | 240 | 232 | 240 | 237 | 238 | ≈ | ≈ |
| Use on grassland[2] | 254 | 249 | 256 | 259 | 250 | 252 | 245 | 255 | 249 | 252 | ≈ | - |
| Use on arable land[3] | 184 | 181 | 172 | 169 | 167 | 176 | 172 | 181 | 186 | 175 | + | ≈ |

[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: 263 (2006), 271 (2007), 263 (2008), 259 (2009), 266 (2010), 263 (2011), 268 (2012), 268 (2013) and 265 (2014). 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: 195 (2006), 200 (2007), 204 (2008), 198 (2009), 195 (2010), 199 (2011), 203 (2012), 204 (2013) and 197 (2014). On a number of farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit. In addition, some farms had no arable land. The allocation of fertilisers to arable land or grassland exceeded the upper limit or fell below the lower limit on the following numbers of farms: 8 (2006), 7 (2007), 12 (2008), 9 (2009), 12 (2010), 14 (2011), 13 (2012), 8 (2013) and 6 (2014). The numbers of farms without arable land were as follows: 68 (2006), 71 (2007), 59 (2008), 61 (2009), 71 (2010), 64 (2011), 65 (2012), 64 (2013) and 68 (2014).

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 2006-2014 period. ≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

*Table A4.3 Average application of nitrogen (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2014 period: average values for the 2006-2013 period, differences between 2014 results and the average values for the 2006-2013 period, and trends identified for the 2006-2014 period*

| *Description* | *2006* | *2007* | *2008* | *2009* | *2010* | *2011* | *2012* | *2013* | *2014* | *2006-2013* | *Difference* | *Trend* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of farms | 273 | 278 | 275 | 268 | 278 | 277 | 281 | 276 | 271 | 276 | | |
| Livestock manure excluding availability coefficient | 243 | 235 | 239 | 242 | 237 | 240 | 232 | 240 | 237 | 238 | ≈ | ≈ |
| Availability coefficient | 39 | 40 | 48 | 48 | 50 | 49 | 49 | 49 | 50 | 47 | + | + |
| Animal manure based on statutory availability coefficient | 94 | 94 | 114 | 117 | 116 | 119 | 114 | 117 | 117 | 111 | + | + |
| + Other organic fertilisers | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | + | + |
| + Inorganic fertilisers | 129 | 127 | 122 | 125 | 123 | 123 | 126 | 125 | 136 | 125 | + | + |
| Total use | 223 | 221 | 236 | 242 | 240 | 242 | 240 | 243 | 255 | 236 | + | + |
| Nitrogen application standard applicable to farm | 291 | 288 | 270 | 264 | 262 | 261 | 258 | 259 | 271 | 269 | + | - |
| Use on grassland[1] | 247 | 246 | 266 | 268 | 264 | 267 | 267 | 270 | 279 | 262 | + | + |
| Nitrogen application standard for grassland | 317 | 314 | 296 | 286 | 282 | 282 | 282 | 280 | 292 | 292 | ≈ | - |
| Use on arable land[2] | 110 | 114 | 123 | 123 | 118 | 125 | 124 | 124 | 130 | 120 | + | + |
| Nitrogen application standard for arable land | 163 | 162 | 165 | 161 | 161 | 155 | 148 | 149 | 150 | 158 | - | - |

[1] The average use on grassland is based on the following numbers of farms: 263 (2006), 271 (2007), 263 (2008), 259 (2009), 266 (2010), 263 (2011), 268 (2012), 268 (2013) and 265 (2014). 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: 195 (2006), 200 (2007), 204 (2008), 198 (2009), 195 (2010), 199 (2011), 203 (2012), 204 (2013) and 197 (2014). On a number of farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit. In addition, some farms had no arable land. The allocation of fertilisers to arable land or grassland exceeded the upper limit or fell below the lower limit on the following numbers of farms: 8 (2006), 7 (2007), 12 (2008), 9 (2009), 12 (2010), 14 (2011), 13 (2012), 8 (2013) and 6 (2014). The numbers of farms without arable land were as follows: 68 (2006), 71 (2007), 59 (2008), 61 (2009), 71 (2010), 64 (2011), 65 (2012), 64 (2013) and 68 (2014).

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 2006-2014 period. ≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

*Table A4.4 Average application of phosphate (in kg of $P_2O_5$ per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2014 period: average values for the 2006-2013 period, differences between 2014 results and the average values for the 2006-2013 period, and trends identified for the 2006-2014 period*

| *Description* | *2006* | *2007* | *2008* | *2009* | *2010* | *2011* | *2012* | *2013* | *2014* | *2006-2013* | *Difference* | *Trend* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of farms | 273 | 278 | 275 | 268 | 278 | 277 | 281 | 276 | 271 | 276 | | |
| Livestock manure | 88 | 85 | 88 | 89 | 85 | 85 | 81 | 82 | 81 | 85 | - | - |
| + Other organic fertilisers | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | + | + |
| + Inorganic fertilisers | 10 | 7 | 6 | 4 | 3 | 3 | 3 | 3 | 2 | 5 | - | - |
| Total use | 99 | 93 | 94 | 93 | 89 | 88 | 85 | 85 | 85 | 91 | - | - |
| Phosphate application standard applicable to farm | 108 | 103 | 98 | 98 | 91 | 91 | 89 | 88 | 88 | 96 | - | - |
| Use on grassland[1] | 101 | 95 | 97 | 96 | 91 | 90 | 88 | 87 | 87 | 93 | - | - |
| Phosphate application standard for grassland | 111 | 106 | 100 | 101 | 94 | 94 | 92 | 92 | 92 | 99 | - | - |
| Use on arable land[2] | 90 | 87 | 83 | 78 | 74 | 78 | 75 | 77 | 78 | 80 | ≈ | - |
| Phosphate application standard for arable land | 95 | 90 | 85 | 85 | 78 | 75 | 70 | 64 | 64 | 80 | - | - |

[1] The average use on grassland is based on the following numbers of farms: 263 (2006), 271 (2007), 263 (2008), 259 (2009), 266 (2010), 263 (2011), 268 (2012), 268 (2013) and 265 (2014). 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: 195 (2006), 200 (2007), 204 (2008), 198 (2009), 195 (2010), 199 (2011), 203 (2012), 204 (2013) and 197 (2014). On a number of farms, the allocation of fertilisers to arable land exceeded the upper limit or fell below the lower limit. In addition, some farms had no arable land. The allocation of fertilisers to arable land or grassland exceeded the upper limit or fell below the lower limit on the following numbers of farms: 8 (2006), 7 (2007), 12 (2008), 9 (2009), 12 (2010), 14 (2011), 13 (2012), 8 (2013) and 6 (2014). The numbers of farms without arable land were as follows: 68 (2006), 71 (2007), 59 (2008), 61 (2009), 71 (2010), 64 (2011), 65 (2012), 64 (2013) and 68 (2014).

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 2006-2014 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 $P_2O_5$ per hectare) on farms participating in the derogation monitoring network that meet the criteria for application of the grassland yield calculation method (Aarts* et al.*, 2008), for the 2006-2014 period: average values for the 2006-2013 period, differences between 2014 results and the average values for the 2006-2013 period, and trends identified for the 2006-2014 period*

| *Description* | *2006* | *2007* | *2008* | *2009* | *2010* | *2011* | *2012* | *2013* | *2014* | *2006-2013* | *Difference* | *Trend* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Estimated silage maize yield* | | | | | | | | | | | | |
| Number of farms | 149 | 136 | 149 | 161 | 159 | 160 | 159 | 176 | 152 | 172 | | |
| Tonnes of dry matter per hectare | 15.0 | 15.1 | 16.0 | 16.3 | 16.0 | 16.4 | 16.8 | 16.2 | 17.7 | 16 | + | + |
| Kilogrammes of nitrogen per hectare | 187 | 176 | 189 | 189 | 188 | 193 | 178 | 182 | 190 | 185 | ≈ | ≈ |
| Kilogrammes of phosphorus per hectare | 30 | 29 | 30 | 31 | 30 | 31 | 31 | 29 | 35 | 30 | + | + |
| Kilogrammes of $P_2O_5$ per hectare | 68 | 66 | 69 | 70 | 69 | 71 | 71 | 67 | 79 | 69 | + | + |
| *Calculated grassland yield* | | | | | | | | | | | | |
| Number of farms | 203 | 194 | 196 | 205 | 217 | 213 | 216 | 234 | 209 | 231 | | |
| Tonnes of dry matter per hectare | 10.0 | 10.1 | 9.7 | 10.0 | 9.6 | 10.6 | 10.4 | 9.7 | 11.1 | 10 | + | + |
| Kilogrammes of nitrogen per hectare | 275 | 271 | 271 | 262 | 252 | 268 | 251 | 268 | 298 | 265 | + | ≈ |
| Kilogrammes of phosphorus per hectare | 34 | 39 | 39 | 35 | 35 | 38 | 38 | 36 | 45 | 37 | + | + |
| Kilogrammes of $P_2O_5$ per hectare | 78 | 90 | 88 | 81 | 79 | 86 | 87 | 81 | 103 | 84 | ≈ | + |

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 2006-2014 period. ≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

*Table A4.6 Nitrogen surplus on the soil surface balance (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2014 period: average values for the 2006-2013 period, differences between 2014 results and the average values for the 2006-2013 period, and trends identified for the 2006-2014 period*

| *Description* | *2006* | *2007* | *2008* | *2009* | *2010* | *2011* | *2012* | *2013* | *2014* | *2006-2013* | *Difference* | *Trend* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of farms | 273 | 278 | 275 | 268 | 278 | 277 | 281 | 276 | 271 | 276 | | |
| Inputs of (organic and inorganic) fertilisers, feedstuffs, animals and other products | 331 | 332 | 319 | 311 | 355 | 340 | 329 | 334 | 343 | 331 | ≈ | + |
| Outputs of milk, animals, feedstuffs, manure and other products | 144 | 153 | 147 | 136 | 170 | 169 | 154 | 151 | 189 | 153 | + | + |
| Deposition, mineralisation and nitrogen fixation | 58 | 57 | 60 | 55 | 52 | 58 | 56 | 53 | 54 | 56 | - | - |
| Gaseous emissions resulting from stabling, storage, grazing and application | 52 | 56 | 55 | 53 | 56 | 54 | 50 | 50 | 55 | 53 | + | ≈ |
| Surplus on soil surface balance | | | | | | | | | | | | |
| Average | 197 | 185 | 177 | 182 | 180 | 176 | 182 | 186 | 153 | 183 | - | ≈ |
| 25th percentile[1] | 138 | 126 | 125 | 133 | 131 | 130 | 131 | 142 | 101 | 132 | | |
| 75th percentile[2] | 248 | 239 | 213 | 221 | 220 | 217 | 218 | 223 | 201 | 225 | | |

[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 2014 and average for previous years. ≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2014 period. ≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

*Table A4.7 Nitrogen surplus on the soil surface balance (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2014 period: average values for the 2006-2013 period, differences between 2014 results and the average values for the 2006-2013 period, and trends identified for the 2006-2014 period*

| *Region* | *2006* | *2007* | *2008* | *2009* | *2010* | *2011* | *2012* | *2013* | *2014* | *2006-2013* | *Difference* | *Trend* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sand-250 sub-region (N = 54-56) | 161 | 171 | 166 | 173 | 158 | 172 | 170 | 170 | 136 | 168 | - | ≈ |
| Sand-230 sub-region (N = 81-91) | 194 | 173 | 159 | 158 | 171 | 153 | 163 | 174 | 125 | 168 | - | ≈ |
| Loess Region (N = 15-20) | 138 | 140 | 141 | 127 | 153 | 146 | 154 | 146 | 117 | 143 | - | - |
| Clay Region (N = 63-69) | 197 | 181 | 189 | 196 | 171 | 169 | 175 | 179 | 157 | 182 | - | - |
| Peat Region (N = 47-56) | 257 | 240 | 217 | 236 | 245 | 237 | 239 | 239 | 217 | 239 | - | ≈ |
| All farms (N = 268-281) | 197 | 185 | 177 | 182 | 180 | 176 | 182 | 186 | 153 | 183 | - | ≈ |

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

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 2006-2014 period. ≈ insignificant trend ($p > 0.05$), +/- significant trend ($p < 0.05$).

*Table A4.8 Phosphate surplus on the soil surface balance (in kg of $P_2O_5$ per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2014 period: average values for the 2006-2013 period, differences between 2014 results and the average values for the 2006-2013 period, and trends identified for the 2006-2014 period*

| *Description* | *2006* | *2007* | *2008* | *2009* | *2010* | *2011* | *2012* | *2013* | *2014* | *2006-2013* | *Difference* | *Trend* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of farms | 276 | 278 | 275 | 269 | 278 | 277 | 281 | 276 | 271 | 276 | | |
| Inputs of (organic and inorganic) fertilisers, feedstuffs, animals and other products | 87 | 81 | 78 | 73 | 88 | 82 | 74 | 79 | 76 | 80 | - | - |
| Outputs of milk, animals, feedstuffs, manure and other products | 62 | 69 | 64 | 58 | 74 | 73 | 67 | 63 | 83 | 66 | + | + |
| Surplus on soil surface balance | | | | | | | | | | | | |
| Average | 26 | 12 | 14 | 15 | 14 | 9 | 7 | 16 | -7 | 14 | - | - |
| 25th percentile[1] | 10 | -2 | 1 | 1 | 2 | -1 | -3 | 5 | -23 | 2 | | |
| 75th percentile[2] | 38 | 27 | 26 | 27 | 27 | 23 | 19 | 27 | 9 | 27 | | |

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

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

Difference: direction and significance of difference between 2014 and average for previous years. ≈ insignificant difference ($p > 0.05$), +/- significant difference ($p < 0.05$).

Trend: direction and significance of trend in 2006-2014 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 2007-2015 period: average values for the 2007-2014 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* | *2007-2014* | *Difference* | *Trend* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Water leaching from root zone in Clay Region* | | | | | | | | | | | | |
| Number of farms | 61 | 63 | 64 | 64 | 63 | 59 | 67 | 57 | 60 | | | |
| Nitrate | 26 | 16 | 15 | 19 | 14 | 11 | 11 | 15 | 22 | 16 | + | - |
| Phosphorus | 0.35 | 0.40 | 0.32 | 0.25 | 0.27 | 0.33 | 0.25 | 0.26 | 0.24 | 0.30 | ≈ | - |
| Nitrogen | 9.1 | 6.2 | 5.5 | 6.3 | 5.2 | 4.7 | 4.5 | 5.3 | 6.6 | 5.9 | ≈ | - |
| *Water leaching from root zone in Sand Region* | | | | | | | | | | | | |
| Number of farms | 143 | 142 | 142 | 143 | 142 | 147 | 151 | 152 | 152 | | | |
| Nitrate | 60 | 46 | 41 | 49 | 40 | 36 | 38 | 42 | 39 | 44 | - | - |
| Phosphorus | 0.07 | 0.07 | 0.07 | 0.09 | 0.11 | 0.10 | 0.10 | 0.13 | 0.12 | 0.09 | ≈ | + |
| Nitrogen (N) | 16 | 14 | 12 | 14 | 12 | 11 | 11 | 12 | 12 | 13 | - | - |
| *Water leaching from root zone in Peat Region* | | | | | | | | | | | | |
| Number of farms | 49 | 49 | 48 | 48 | 49 | 51 | 57 | 57 | 58 | | | |
| Nitrate | 15 | 6.0 | 6.3 | 13 | 6.9 | 4.2 | 6.2 | 9.3 | 13 | 8.4 | + | ≈ |
| Phosphorus | 0.51 | 0.39 | 0.32 | 0.44 | 0.37 | 0.42 | 0.43 | 0.30 | 0.35 | 0.40 | ≈ | - |
| Nitrogen | 11 | 9.7 | 8.2 | 11 | 9.4 | 8.0 | 8.3 | 9.3 | 10 | 9.3 | ≈ | ≈ |
| *Water from leaching from root zone in Loess Region*[1] | | | | | | | | | | | | |
| | *2007* | *2008* | *2009* | *2010* | *2011* | *2012* | *2013* | *2014* | | *2007-2013* | *Difference* | *Trend* |
| Number of farms | 18 | 18 | 20 | 18 | 19 | 19 | 19 | 18 | | | | |
| Nitrate | 71 | 52 | 50 | 50 | 56 | 54 | 57 | 51 | | 56 | ≈ | ≈ |
| Phosphorus[2] | <DT | <DT | <DT | <DT | *[2] | <DT | <DT | <DT | | <DT | ≈ | ≈ |
| Nitrogen | 18 | 13 | 12 | 12 | 14 | 14 | 13 | 12 | | 14 | ≈ | ≈ |

* The concentrations deviate from the final figures that are reported annually (see section 2.4.2 for the calculation method).
[1] The difference was determined based on a comparison of the data for 2014 with the data for the 2007-2013 period. The data for 2015 are not yet available.
[2] Average phosphorus concentrations below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT *[2] The phosphorus data for 2011 were rejected (Hooijboer *et al.*, 2013).
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 ($p < 0.05$).

*Table A4.10 Average ditch water[1] nutrient concentrations (in mg/l)* in the 2007-2015 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* | *2007-2014* | *Difference* | *Trend* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Ditch water in Clay Region* | | | | | | | | | | | | |
| Number of farms | 60 | 59 | 63 | 63 | 62 | 58 | 66 | 56 | 59 | | | |
| Nitrate | 12 | 8.7 | 6.9 | 9.7 | 6.3 | 5.3 | 4.3 | 6.0 | 10 | 7.4 | + | - |
| Phosphorus | 0.32 | 0.35 | 0.35 | 0.22 | 0.27 | 0.25 | 0.26 | 0.25 | 0.21 | 0.28 | ≈ | ≈ |
| Nitrogen | 4.3 | 4.0 | 3.7 | 4.2 | 3.5 | 3.2 | 3.3 | 3.4 | 4.2 | 3.7 | ≈ | ≈ |
| *Ditch water in Sand Region* | | | | | | | | | | | | |
| Number of farms | 31 | 33 | 34 | 34 | 35 | 35 | 35 | 29 | 30 | | | |
| Nitrate | 34 | 33 | 26 | 31 | 25 | 19 | 20 | 24 | 26 | 26 | ≈ | - |
| Phosphorus | 0.14 | 0.13 | 0.21 | 0.12 | 0.09 | 0.11 | 0.13 | 0.12 | 0.16 | 0.13 | ≈ | ≈ |
| Nitrogen | 9.4 | 9.5 | 8.2 | 9.2 | 7.7 | 6.6 | 6.9 | 7.8 | 8.2 | 8.2 | ≈ | - |
| *Ditch water in Peat Region* | | | | | | | | | | | | |
| Number of farms | 49 | 48 | 47 | 47 | 48 | 50 | 56 | 56 | 57 | | | |
| Nitrate | 5.9 | 4.2 | 3.5 | 3.7 | 3.7 | 2.8 | 2.5 | 3.5 | 6.5 | 3.7 | + | ≈ |
| Phosphorus | 0.21 | 0.13 | 0.15 | 0.14 | 0.15 | 0.16 | 0.20 | 0.18 | 0.19 | 0.16 | ≈ | ≈ |
| Nitrogen | 3.7 | 4.2 | 4.3 | 4.1 | 4.6 | 4.0 | 4.1 | 4.3 | 5.2 | 4.2 | + | + |

* 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 ($p < 0.05$).

*Table A4.11 Average nutrient concentrations (in mg/l) in water leaching from the root zone in the 2007-2015 period: average values for the 2007-2014 period, differences between 2015 results and the average values for the 2007-2014 period, and trends identified for the 2007-2015 period (data for Sand Region as a whole, and specified for Sand-230 and Sand-250 sub-regions)*

| | *2007* | *2008* | *2009* | *2010* | *2011* | *2012* | *2013* | *2014* | *2015* | *2007-2014* | *Difference* | *Trend* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Water leaching from root zone in Sand Region* | | | | | | | | | | | | |
| Number of farms | 143 | 142 | 142 | 143 | 142 | 147 | 151 | 152 | 152 | | | |
| Nitrate | 60 | 46 | 41 | 49 | 40 | 36 | 38 | 42 | 39 | 44 | - | - |
| Phosphorus | 0.07 | 0.07 | 0.07 | 0.09 | 0.11 | 0.10 | 0.10 | 0.13 | 0.12 | 0.09 | ≈ | + |
| Nitrogen | 16 | 14 | 12 | 14 | 12 | 11 | 11 | 12 | 12 | 13 | - | - |
| *Water leaching from root zone in Sand-230 sub-region* | | | | | | | | | | | | |
| Number of farms | 92 | 92 | 90 | 91 | 90 | 94 | 99 | 105 | 110 | | | |
| Nitrate | 70 | 55 | 51 | 62 | 47 | 43 | 45 | 50 | 45 | 53 | - | - |
| Phosphorus | 0.07 | 0.07 | 0.07 | 0.10 | 0.07 | 0.07 | 0.11 | 0.09 | 0.13 | 0.09 | ≈ | ≈ |
| Nitrogen | 19 | 15 | 14 | 16 | 14 | 13 | 13 | 14 | 13 | 15 | - | - |
| *Water leaching from root zone in Sand-250 sub-region* | | | | | | | | | | | | |
| Number of farms | 51 | 50 | 52 | 52 | 52 | 53 | 52 | 47 | 42 | | | |
| Nitrate | 42 | 29 | 24 | 25 | 28 | 22 | 24 | 24 | 25 | 27 | ≈ | - |
| Phosphorus[1] | <DT | <DT | 0.06 | 0.10 | 0.13 | 0.10 | 0.12 | 0.16 | 0.16 | 0.10 | ≈ | + |
| Nitrogen | 12 | 10 | 8.4 | 8.9 | 9.5 | 8.7 | 8.6 | 8.7 | 8.9 | 9.4 | ≈ | - |

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 ($p < 0.05$).
[1] Average phosphorus concentrations below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT.

## References

Aarts, H.F.M., C.H.G. Daatselaar and G. Holshof (2008). Bemesting, meststofbenutting en opbrengst van productiegrasland en snijmaïs op melkveebedrijven. Wageningen, Plant Research International, Report No. 208.

Hooijboer, A.E.J., A. van den Ham, L.J.M. Boumans, C.H.G. Daatselaar, G.J. Doornewaard and E. Buis (2013). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie. Resultaten meetjaar 2011 in het derogatiemeetnet. Bilthoven, RIVM Report No. 680717034.

Ministry of Agriculture, Nature & Food Quality (2000). 15505 MINAS Tables Brochure.

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

## A5.1 Introduction

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

*Table A5.1 Fertiliser use in kg per hectare on farms to which derogation has been granted according to RVO.nl data, fertiliser use in kg per hectare on farms according to LMM derogation monitoring results, and differences between these source data in 2014 for both nitrogen and phosphate in kg per hectare and in percentages*

| *Item* | *LMM data (kg per hectare)* | *RVO.nl data (kg per hectare)* | *Difference between LMM and RVO.nl data (kg per hectare)* | *(%)* |
|---|---|---|---|---|
| Nitrogen | | | | |
| Livestock manure | 238 | 247 | -8 | -3% |
| Inorganic fertilisers | 137 | 126 | 11 | 8% |
| Other organic fertilisers | 1 | 3 | -2 | -71% |
| Total | 376 | 376 | 0 | 0% |
| Phosphate | | | | |
| Livestock manure | 82 | 89 | -7 | -8% |
| Inorganic fertilisers | 2 | 2 | 1 | 48% |
| Other organic fertilisers | 1 | 1 | 0 | -8% |
| Total | 85 | 92 | -7 | -7% |

## A5.2 Approach

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

- Fertilisation with inorganic fertilisers, livestock manure and other organic fertilisers must fall within the LMM confidence intervals. This applies to the separate quantities of nitrogen and phosphate, as well as the total quantities of fertilisers applied (i.e. inorganic fertilisers, livestock manure, and other organic fertilisers). The relevant criteria are specified in Appendix 2 (Table A2.1).
- Farms may not have an anaerobic digestion plant.
- Farms must actually make use of the exemption in the year concerned (twelve farms in the derogation monitoring network did not do so in 2014).

The application of these exclusion criteria meant that the number of LMM farms usable for derogation monitoring purposes in 2014 decreased from 298 to 271.

To enable a comparison with the RVO.nl data, fertiliser use on these 271 LMM farms was also calculated based on the relevant RVO.nl data. For this purpose, 283 BRS numbers were linked to the 271 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, 22 LMM farms with 28 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 249 LMM farms with 255 BRS numbers.

The following data sources were used to compare the RVO.nl and LMM figures for 2014:

- Farm Accountancy Data Network (FADN) of the Agricultural Economics Research Institute (LEI): this concerns the 298 farms that qualified for derogation monitoring (DM) in 2014. 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 19,367 registration numbers (BRS numbers) of farms that applied for derogation in 2014. Twelve BRS numbers have been added which are included in the 298 LMM farms, but not in the 19,367 BRS numbers.
- Data from the 2014 Agricultural Census concerning the 19,367 BRS numbers. In the case of 446 BRS numbers, no number could be found in the 2014 Agricultural Census, leaving 18,925 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 8 kg per hectare lower 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 decrease by 2 kg, from 247 to 245 kg of nitrogen per hectare (B in Table A5.2). For this purpose, farms smaller than 10 hectares and/or 25,000 SO units have been excluded from the RVO.nl data set in accordance with the LMM population. In addition, the same confidence intervals have been used for the fertiliser quantities as in the LMM data set (see Appendix 2, Table A2.1). By rendering the populations comparable, 2 kg (21%) (B in Table A5.2) of the observed difference of 8 kg of nitrogen per hectare (A in Table A5.2) can be explained.

The remaining difference of 6.5 kg (79%) (A-B in Table A5.2) may be attributed to the following factors (expressed as percentages of the 8 kg difference (A) in Table A5.2, and listed as items a. through i.):

a. The 249 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 use on these 249 farms is calculated based on RVO.nl data, then the result deviates by 1.8 kg from the result for this much larger RVO.nl population. This may be considered a sampling difference, and explains 21% of the 8 kg difference.
b. The area of cultivated land in use on the above-mentioned 249 LMM farms exceeds the cultivated land area according to RVO.nl data by almost 2 hectares. If the RVO.nl results are converted to the area of cultivated land according to LMM data, we get a difference of 8.2 kg of nitrogen per hectare, or 99% compared to the A – B difference in Table A5.2.
c. and d. 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 2014 was that the calculated LMM fertiliser quantities were 1.2 kg per hectare higher than the RVO.nl quantities. This amounts to a difference of 14% compared to the A – B difference in Table A5.2.
e. The remaining difference (-1.2 kg per hectare; items e. through i.) can be accounted for by differences in the method used to calculate excretion quantities. The BEX method is used at approx. half of all farms participating in the LMM programme. As a result, the use of livestock manure according to the LMM data is more than 12 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.
f. The standard-based excretion in the LMM programme is determined with greater accuracy than in the RVO.nl data set, for a number of reasons. RVO.nl is not always able to calculate excretion by dairy cows due to insufficient data on milk supplies or urea levels.
g. 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.

h. In addition, RVO.nl does not classify excretion by hobby animals as 'Excretion', but as 'Other organic fertilisers'.
i. 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 2014*

| Item | *Nitrogen* | |
|---|---|---|
| | *Kg of nitrogen per hectare* | *Percentage* |
| Difference between LMM and RVO.nl data (A) | -8.2 | -100 |
| Difference due to differences between populations (B) | -1.7 | -21 |
| Difference when populations are rendered comparable (A – B) | *-6.5* | *-79* |
| 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 | *1.8* | *21* |
| b. Difference in acreage of cultivated land | *-8.2* | *-99* |
| c. Stocks | *1.4* | *17* |
| d. Inputs and outputs | *-0.2* | *-3* |
| e. Use of BEX* method in LMM programme | *-12.3* | *-149* |
| f. Standard-based excretion by dairy cows | *1.8* | *21* |
| g. Standard-based excretion by other cattle | *10.2* | *124* |
| h. Standard-based excretion by other grazing animals | *0.98* | *10* |
| i. Standard-based excretion by intensive livestock | *-1.8* | *-21* |

Source: RVO.nl and FADN data processed by LEI.
* The abbreviation BEX stands for *Bedrijfsspecifieke Excretie* (Farm-Specific Excretion) (National Service for the Implementation of Regulations, 2010)

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

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

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

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

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

## A5.4 Conclusion

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

## References

National Service for the Implementation of Regulations (*Dienst Regelingen*, DR) (2010). Handreiking bedrijfsspecifieke excretie melkvee. Version effective as of January 2010. Assen, National Service for the Implementation of Regulations, Ministry of Agriculture, Nature & Food Quality.

National Service for the Implementation of Regulations (DR) and Netherlands Food and Consumer Product Safety Authority (NVWA) (2011). Resultaten van controles op en kengetallen van landbouwbedrijven aangemeld voor derogatie alsmede kengetallen van de Nederlandse veehouderij. Ministry of Infrastructure and the Environment; Ministry of Economic Affairs, Agriculture and Innovation; National Service for the Implementation of Regulations, Ministry of Economic Affairs, Agriculture and Innovation; Netherlands Food and Consumer Product Safety Authority, Ministry of Economic Affairs, Agriculture and Innovation; The Hague.

**S. Lukács | T.J. de Koeijer | H. Prins | A. Vrijhoef**
**L.J.M. Boumans | C.H.G. Daatselaar**

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