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Results for 2007 in the derogation monitoring network

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Rapport in het kort

Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie
Resultaten meetjaar 2007 in het derogatiemeetnet

Dit rapport geeft een overzicht van de bemestingspraktijk en de waterkwaliteit in 2007 op graslandbedrijven in Nederland die meer dierlijke mest mogen gebruiken dan in Europese regelgeving is aangegeven (derogatie). De gegevens uit dit onderzoek kunnen worden gebruikt om de gevolgen voor de waterkwaliteit te bepalen. De waterkwaliteit gemeten in 2007 geeft de gevolgen weer van de landbouwpraktijk in 2006, het eerste jaar dat de derogatie in de praktijk werd toegepast.

De Europese Nitraatrichtlijn verplicht lidstaten het gebruik van dierlijke mest te beperken tot een bepaald maximum. Een lidstaat kan de Europese Commissie vragen om onder voorwaarden van deze beperking af te wijken. Nederland heeft toestemming gekregen om van 2006 tot en met 2009 af te mogen wijken van de gestelde norm. Een van de voorwaarden is dat de Nederlandse overheid een monitoringnetwerk inricht en aan de Commissie jaarlijks rapporteert over de resultaten daarvan.

Het RIVM en het LEI hebben in 2006 Nederland een monitoringnetwerk opgezet. Dit zogenoemde derogatiemeetnet meet de gevolgen voor de landbouwpraktijk en de waterkwaliteit als landbouwbedrijven afwijken van de Europese gebruiksnorm voor dierlijke mest. Het meetnet omvat driehonderd graslandbedrijven. Het derogatiemeetnet is een onderdeel van het Landelijk Meetnet effecten Mestbeleid (LMM). Van iets minder dan driehonderd bedrijven is gerapporteerd doordat sommige achteraf geen derogatie toepasten of kregen.

Trefwoorden: Nitraatrichtlijn, derogatiebeschikking, landbouwpraktijk, waterkwaliteit, mest

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Abstract

Agricultural practice and water quality at grassland farms under derogation
Results for 2007 within the framework of the derogation monitoring network

This report provides an overview of fertilisation practices and water quality in 2007 on grassland farms that are allowed to use more livestock manure than the limit set in European legislation (derogation). Data in this report can be used to study the consequences of this derogation on the water quality. The water quality values measured in 2007 reflect agricultural practices in 2006, which was the first year in which the derogation was applied.

The European Nitrates Directive obliges Member States to limit the use of livestock manure to a specified maximum. A Member State may seek permission from the European Commission to deviate from this obligation under specific conditions. In December 2005, the Commission granted the Netherlands the right to derogate from the obligation from 2006 up to and including 2009. One of the underlying conditions of the derogation is that the Netherlands establishes a monitoring network and reports the results to the European Commission.

In 2006, the National Institute for Public Health and the Environment (RIVM) and the Agricultural Economics Research Institute (LEI) set up a derogation monitoring network aimed at determining the effects of allowing farmers to deviate from the European application standard for livestock manure. The monitoring network comprises 300 grassland farms and is part of the Minerals Policy Monitoring Programme. Slightly less than 300 farms in the network are reported on as ultimately some of the farms did not make use of the derogation option.

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

Foreword

On behalf of the Ministry of Housing, Spatial Planning and the Environment (VROM) and the Ministry of Agriculture, Nature and Food Quality (LNV), the National Institute for Public Health and the Environment (RIVM) and the Agricultural Economics Research Institute (LEI) have compiled this report. LEI is responsible for the information about agricultural practice and RIVM for the water quality data. RIVM is also the official secretary within this project. This report is a direct translation of "Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie, Resultaten meetjaar 2007 in het derogatiemeetnet", Zwart et al, RIVM report 680717008, March 2009.

The Ministry of LNV asked the Expert Committee Fertilisers Act (CDM)[1] to assess the contents of the report and to ensure consistency with the methodology used to present the scientific basis for derogation.

In 2006, the Dutch government appointed the project group EU Monitoring to satisfy its reporting obligations to the European Commission with respect to the derogation decision of 8 December 2005. This project group, in which the Ministries of VROM and LNV are represented, has drawn up a project plan (26 October 2006). This details the obligations with respect to monitoring and reporting and describes how these ought to be realised. Five aspects must be included in the reports to the European Commission:

A. Percentages of grassland farms, animals and agricultural land, in each municipality that falls under an individual derogation (Article 8 of the derogation decision);
B. Monitoring data from soil water, watercourses and shallow groundwater (Article 10, para 1);
C. Results of inspection and enforcement (Article 10, para 1);
D. Synthesis of trends (Article 10, para 2);
E. Report about fertilisation and yield per soil type and crop (Article 10, para 4).

This report provides an overview of the results of the water quality monitoring in 2007 on a sample of farms registered for derogation (part B). The water quality monitoring 2007 covered most of the 300 farms participating in the monitoring network for the sampling of water quality on derogation farms (the derogation monitoring network). Due to changes in the sample population, such as relocations, variations between the participating farms occur across the years measured. Consequently the numbers of farms in the different regions and water types can change each year. The 300 farms were already participating in the Minerals Policy Monitoring Programme (LMM) or were recruited and sampled during the sampling campaign. The results of the water quality monitoring 2007 are related to the agricultural practices of 2006, the first derogation year. Furthermore, information is provided about the agricultural practices in 2007 for all farms in the derogation monitoring network that made use of the derogation. This includes data about the fertilisation, yields and the nutrient surpluses realised (part E).

Parts A (June 2009), C and D (March 2009) will be reported on separately. The Ministry of Housing, Spatial Planning and the Environment (VROM) and the Ministry of Agriculture, Nature and Food Quality (LNV) are responsible for the reports submitted to the European Commission. In June 2008, Zwart et al. (2008) reported on the results from the Dutch Nitrates Directive Action Programme 2002-2006 as part of the four-yearly Member State reports.

[1] The CDM is an independent scientific committee that advises the Ministry of LNV about the provision of scientific evidence for the regulations, standards and forfeits arising from the Fertilisers Act.

The authors would like to thank Oene Oenema, Jaap Schroder and Gerard Velthof who, on behalf of CDM[1], reviewed earlier versions of this report and made valuable suggestions. We would also like to thank Martin van Rietschoten (LNV) and Kaj Locher (VROM) for their critical comments. Finally we would like to thank our colleagues from LEI and RIVM who, each in their own way, have contributed to the development of this report.

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Summary and conclusions

Background
The Nitrates Directive obliges Member States to limit the use of livestock manure to a maximum of 170 kg of nitrogen per ha per year. A Member State can, under certain conditions, ask the European Commission if it may deviate from this obligation (derogation). In December 2005, the Commission granted the Netherlands derogation for the period 2006-2009. Grassland farms with 70% or more grassland may, under narrowly prescribed conditions, apply 250 kg nitrogen (N) per ha to their land in the form of manure from grazing livestock. In return the Dutch government is obliged to set up a monitoring network in accordance with the requirements stipulated in the derogation decision of the European Commission. Each year the Netherlands must also provide the European Commission with information – based on monitoring and model-based calculations – about the quantities of fertilisers applied to each crop per soil type and about the evolution of water quality.

The derogation monitoring network
In 2006, a new monitoring network was designed and established to monitor the evolution in agricultural practices and water quality as a consequence of the requested derogation. This network comprises 300 farms that applied for derogation. The derogation monitoring network was set up by expanding the National Programme for Monitoring the Effectiveness of the Minerals Policy (LMM). This means that all 300 selected farms also participate in the Farm Accountancy Data Network (FADN) of the Netherlands Agricultural Economics Research Institute (LEI). The National Institute for Public Health and the Environment (RIVM) is the designated authority responsible for monitoring the quality of water that leaches from the root zone and the quality of surface waters. By using a stratified random sampling method, the 300 farms are distributed as evenly as possible throughout the Netherlands in terms of region (sand, loess, clay and peat), farm type (dairy farms and other grassland farms) and economic size class, and with this the emphasis is on the sand region. This approach fulfils the condition that the sample should be representative for all soil types (clay, peat, sand and loess soils), fertilisation practices and crop rotations and that the focus is on the sand region.

Report for the measurement year 2007
This report describes the data on the agricultural practices of 283 of the derogation farms in 2007. In retrospect, 4 farms did not make use of the derogation, 1 farm could not be processed in the FADN and for 12 farms the nutrient flows could not be completely described.

In this report, unweighted means are reported. Data on water quality are provided for the 295 derogation farms that were sampled in 2007 (period November 2006 - January 2008). Of the 300 farms, 5 were not included (4 no derogation, 1 not in FADN). The water quality data reported for 2007 relate to farm practices in 2006 and the years preceding this. Therefore the effects of agricultural practices on water quality in the first derogation year (2006) can be observed. For the clay and peat regions the provisional water quality measurements for 2008 have been included in this report.

Characteristics of the area and the farms in the derogation monitoring network
The agricultural area in the derogation monitoring network is 1.8% of the total area used by all derogation farms that fulfilled the criteria for inclusion in the network (sample population). The sample population covers 85.6% of the farms and 96.6% of the acreage of all farms that registered for derogation in 2007. In the loess region, the percentage of the sample acreage included in the monitoring network was 13.9% and therefore considerably higher compared to other regions. At 49.8 ha (see Table S1), the average acreage of farms in the derogation monitoring network is larger than that of the

sample population (41.4 ha). Furthermore, the dairy farms in the monitoring network produced more milk per ha than the average dairy farm in the sample population, especially in the clay and peat regions. The percentage of acreage used as grassland in the derogation monitoring network (83%) is virtually the same as the average percentage of grassland in the sample population (84%).

Table S1 Characteristics of farms included in the derogation monitoring network for 2007, per region.

Characteristics	Region				
	Sand	Loess	Clay	Peat	All
Number of farms in the monitoring network	160	20	60	60	300
Total number of farms with derogation and fully processed in FADN	158	18	59	60	295
- of which specialised dairy farms	138	15	51	53	257
- of which other grassland farms	20	3	8	7	38
General characteristics of farms (mean data)					
Acreage of cultivated land (ha)	44.9	50.4	56.9	55.3	49.8
Percentage grassland	81	75	82	93	83
Milk production (kg FPCM1[1]) per ha fodder crop	14,749	13,059	14,532	13,319	14,312

[1] FPCM = Fat and Protein Corrected Milk. This is a standard used for comparing milk with different fat and protein contents (1 kg milk with 4.00% fat and 3.32% protein = 1 kg FPCM). The means reported only refer to the 257 specialised dairy farms.

Use of fertilisers

In 2007, farms in the derogation monitoring network used on average 238 kg nitrogen from livestock manure per ha of cultivated land (see Table S.2) and with this remained under the application standard for livestock manure at farm level. On arable land an average of 184 kg per ha was used, whereas on grassland 251 kg nitrogen from livestock manure was applied. Unlike the previous report, the manure production on some of the farms was calculated using a farm-specific method instead of forfeits.

The use of plant-available nitrogen from livestock manure and inorganic fertiliser (calculated with the prevailing statutory coefficients for plant-availability of nitrogen) was 251 kg per ha on grassland and 110 kg per ha on arable land (mainly silage maize) (see Table S.2). On both grassland and arable land the nitrogen use was lower than the nitrogen application standards in force in 2007. The average use of phosphate, from livestock manure and inorganic fertiliser, on arable land (101 kg P_2O_5 per ha) exceeded the phosphate application standard in force in 2007, while on grassland the average application of fertiliser (92 kg $_2O_5$ per ha) was lower in all regions than the phosphate application standard. In all regions the phosphate application at farm level was also below the application standard.

Table S2 Mean use of fertiliser on farms in the derogation monitoring network in 2007, per region.

		Region				
Characteristics		Sand	Loess	Clay	Peat	All
Use of fertiliser						
Nitrogen from livestock manure	Farm level	238	232	234	242	238
(kg N per ha)	Arable land[2]	182	190	175	207	184
	Grassland	254	260	246	246	251
Total plant-available nitrogen[1]	Arable land[2]	103	119	122	117	110
(kg N per ha)	Grassland	257	240	267	224	251
Total phosphate[1]	Arable land[2]	96	96	109	115	101
(kg P_2O_5 per ha)	Grassland	93	91	89	92	92

[1] From livestock manure, other organic fertiliser and inorganic fertiliser. The quantity of plant-available nitrogen from livestock manure and other organic fertiliser was calculated using the statutory availability coefficients determined for 2007.
[2] Arable land on grassland farms is mainly used for the production of silage maize (average 86%).

Crop yield and nutrient surpluses at farm level
For a fraction of the farms in the monitoring network, the grassland and silage maize yields were calculated according to the method described by Aarts et al. (2008). On average, a yield of 175 kg nitrogen and 71 kg phosphate were estimated for silage maize and a yield of 288 kg nitrogen and 90 kg phosphate were calculated for grassland.

The average nitrogen surplus on the soil surface balance in 2007 was calculated to be 186 kg per ha (see Table S3). This surplus decreases in the sequence peat >clay >sand >loess. The high surplus in the peat region was partly caused by an average of 76 kg net nitrogen mineralisation per ha being included in the calculation, whereas in the other regions the net nitrogen mineralisation was negligible. The average phosphate surplus on the soil surface balance is 16 kg P_2O_5 per ha. At 6 kg, this surplus is considerably lower in the loess region than in the other regions.

Table S.3 Mean estimated silage maize yield and calculated grassland yield on all farms that satisfied the selection criteria for applying the calculation method (Aarts et al., 2008) and nutrient surpluses on the soil surface balance on the farms in the derogation monitoring network in 2007, per region.

Characteristics	Sand	Loess	Clay	Peat	All
Estimated yield silage maize[1]					
kg N per ha	172	191	177	174	175
kg P_2O_5 per ha	69	76	76	71	71
Calculated yield grassland[1]					
kg N per ha	281	293	294	299	288
kg P_2O_5 per ha	88	94	93	94	90
Nutrient surpluses per ha cultivated land					
Nitrogen surplus on the soil surface balance (kg N per ha)	172	152	187	230	186
Phosphate surplus on the soil surface balance (kg P_2O_5 per ha)	15	6	18	18	16

[1] The silage maize and grassland yields are based on 181 of the 283 farms. The other farms did not satisfy the selection criteria.

Agricultural practice 2007 compared to 2006

A comparison of the results for 2007 with those from 2006 reveals that, on average, the participating farms applied 4 kg less nitrogen from livestock manure. The use of plant-available nitrogen (calculated with the prevailing statutory coefficients) remained virtually the same, whereas the use of phosphate was 5 kg less in 2007 than in 2006. The estimated silage maize yield (kg N and P_2O_5 per ha) was lower in 2007 compared to 2006, whereas the calculated grassland yield (kg N and P_2O_5 per ha) was higher. Due to these differences in fertilisation and yield, the surpluses of N and P_2O_5 on the soil surface balance were lower in 2007 than in 2006, especially for phosphate.

Water quality

The water quality measured in 2007 partly reflects the agricultural practices in the first year of derogation. In 2006, the average nitrate concentration in water leaching from the root zone was 51 mg NO_3 per litre in the sand region and 88 mg per litre in the loess region. In 2007, this was on average 56 mg NO_3 per litre in the sand region and 68 mg per litre in the loess region (see Table S.4). The average nitrate concentration was higher in the sand and loess regions than in the other two regions, where the average nitrate concentration was below 50 mg per litre.

Table S4 Quality of water leaching from the root zone on farms in the derogation monitoring network in 2007; average concentration of nitrate, total nitrogen and phosphorus (in mg per litre) and the percentage of farms with an average nitrate concentration above 50 mg per litre.

Characteristic	Region			
	Sand	Loess	Clay	Peat
Total number of farms	159	18	59	59
Nitrate (NO_3) (mg per litre)	56	68	30	14[1]
Nitrate >50 mg per litre,%	46	83	22	14[1]
Nitrogen (N) (mg per litre)	15.8	17.0	10.4	11.1
Phosphorus (P) (mg per litre)	0.12	<0.06	0.28	0.53

[1] For one farm in the peat region no nitrate data are available.

In the sand, clay and peat regions, the nitrate and total nitrogen concentrations in the ditch water were on average lower than in water leaching from the root zone (see Table S.5). In the sand and clay regions, the phosphorous concentrations in the ditch water were comparable to those in the water leaching from the root zone. In the peat region, the phosphorous concentrations in the ditch water were lower than in the water leaching from the root zone.

Table S.5 Quality of the ditch water on farms in the derogation monitoring network in 2007, expressed as average nitrate concentration, total nitrogen and phosphorous (in mg per litre) and the percentage of farms with an average nitrate concentration higher than 50 mg per litre.

Characteristic	Region		
	Sand	Clay	Peat
Number of farms	24	58[1]	59
Nitrate (NO_3) (mg per litre)	41	14	6
Nitrate %>50 mg per litre	33	4	2
Nitrogen (N) (mg per litre)	11	4.7	3.5
Phosphorus (P) (mg per litre)	0.14	0.32	0.23

[1] For one farm in the clay region no ditch water data are available.

Limited comparison of results from 2006 with 2007
This is the first year in which results from two consecutive sampling years are available. Some preliminary conclusions can be drawn from these results. On derogation farms in the sand region, the nitrate concentrations in the water leaching from the root zone were 7-9 mg per litre higher in 2007 than in 2006. This can be partly or fully attributed to a lower precipitation surplus in 2007 compared to 2006. In 2007, the average precipitation surplus over the Netherlands was 7% lower than in 2006. Without this difference in the precipitation surplus, the calculated increase is not significant (1.4 mg per litre with a standard error of 2.6 mg per litre). For the sand and clay regions, the nutrient concentrations in the ditch water of derogation farms in 2007 did not significantly differ from those in 2006. Only in the peat region did the nitrate concentration in the ditch water increase. However, at an average of 5-6 mg per litre, the nitrate concentration in 2007 clearly remained under the standard of 50 mg per litre.

The report due in 2010 will present the results of the first complete analysis of the evolution in water quality, based on measurements from the 2006-2008 period, and include model calculations.

1 Introduction

1.1 Background

The Nitrates Directive obliges Member States to limit the use of livestock manure to a maximum of 170 kg of nitrogen per ha per year. A Member State can, under certain conditions, ask the European Commission if it may deviate from this obligation (derogation). In December 2005, the European Commission issued the Netherlands with a definitive derogation decision under which grassland farms, cultivating at least 70% of their total area as grassland, were allowed to apply up to 250 kg of nitrogen per ha in the form of livestock manure that originates from grazing livestock (EU, 2005). The derogation decision applies to the period 2006 to and including 2009. In return for this, the Dutch government is obliged to collect a wide range of data regarding the effects of the derogation and to report these annually to the European Commission.

One of the obligations of the derogation decision, see Appendix 1, concerns 'the formation of a monitoring network for the sampling of groundwater, soil water, drainage water and ditches on farms for which an individual derogation is permitted' (Article 8 of the decision, para 2). The monitoring network must 'provide data on the nitrate and phosphorus concentrations in the water leaving the root zone and ending up in the groundwater and surface water system' (Article 8, para 4). This monitoring network, which covers at least 300 farms, should be 'representative for all types of soil (clay, peat, sandy, and loess), fertilisation practices and crop rotations' (Article 8, para 2). However, within the monitoring network, the monitoring of water quality on farms on sandy soils (including loess) should be improved (Article 8, para 5). The composition of the monitoring network should remain unchanged (Article 8, para 2) during the period in which the decision applies (2006-2009). During the negotiations with the European Commission it was agreed that the design of this monitoring network would tie in with the existing Minerals Policy Monitoring Programme (LMM), under which the water quality and operational management of farms selected for this purpose has been monitored since 1992 (Fraters and Boumans, 2005). It was also agreed that participants in the LMM, who satisfy the conditions, could be regarded as participants in the monitoring network for the derogation. Accordingly, the monitoring network for the derogation (the derogation monitoring network) has become part of the LMM. For the LMM the top metre of the phreatic groundwater, the soil moisture and/or the drainage water are sampled, as this is considered to sample the water leaving the root zone (see Appendix 4).

Aside from the obligation to monitor, there is the requirement to report the evolution in the water quality. The report should be based on 'the monitoring of leaching from the root zone, the surface water quality and the groundwater quality, as well as model-based calculations' (Article 10, para 1). Furthermore, an annual report must be submitted for the different soil types and crops regarding the fertilisation and yield on grassland farms on which derogation is permitted, to provide the European Commission with an understanding of the management on these farms and the degree to which this has been optimised (Article 10, para 4). This report is intended to meet the aforementioned reporting requirements.

1.2 Previous reports

The first report (Fraters et al., 2007) was limited to a description of the monitoring network, the progress made in 2006 in terms of setting this up, the design and content of the reports for the years 2008 to 2010, as well as a general description of the measurement and calculation methods to be used, and the models to be applied.

In 2008, the second report was published. This contained the first results from the derogation monitoring network (Fraters et al., 2008). The first year of derogation was 2006. The figures about agricultural practice concerned farm practice under derogation. The water quality data from 2006 relate to the agricultural practice from 2005 and therefore are not yet related to farm practice under derogation.

1.3 Content of this report

This is the third annual report about the results of the derogation monitoring network. Here we report on fertilisation with nitrogen and phosphate that is related to the acreage actually used and thus is registered as such in the FADN (Farm Accountancy Data Network of the Agricultural Economics Research Institute). This acreage may deviate from the acreage recorded in the land registration system of the National Service for the Implementation of Regulations of LNV[2]. Relating the fertilisation to the actual acreage in use allows a better understanding of the relationship between agricultural practices and water quality. However, these data cannot be used to assess compliance with the legislation, since this requires the acreages as recorded by the National Service for the Implementation of Regulations. Further information about these acreages can be obtained from VROM and LNV (2009). Furthermore this third report, unlike previous years, also provides information about the crop yields.

Apart from water quality, fertilisation and crop yields, the nutrient surpluses of the farms in the derogation monitoring network are also reported, since these surpluses determine, to a large extent, the quantity of nutrients that could potentially leach from the soil.

The annual mean measured nitrate concentration per region and outcomes from the model calculations will only be included in the reports from 2010 onwards. The calculations quantify the influence of confounding factors on the measured nitrate concentrations. In particular, the nitrate concentration in water leaching from the root zone is affected not only by fertilisation but also by variations in the precipitation surplus (Boumans et al., 1997). A statistical model has been developed to analyse the effect of variations in the precipitation surplus on the nitrate concentration in the uppermost layer of groundwater (Boumans et al., 2001, 1997). This method also corrects for changes in the composition of the group of participating farms, the sample (Fraters et al., 2004)[3]. Further details can be found under the description of the weather correction in Appendix 5.

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[2] In other words, ground that administratively speaking belongs to a farm but in practice is not used for fertilisation is not registered in the FADN but is, however, registered in the plot registration system of National Service for the Implementation of Regulations of LNV.

[3] Participants sometimes have to be replaced during the course of the programme (see Chapter 2) or changes in the acreage of the participating farms occur. As a result of this, the ratio between the soil types and/or drainage classes on the farms in the derogation monitoring network can change during the course of the programme. The soil type (sand, loess, clay, peat) and the drainage class (poor, moderate, well drained) affect the relationship between the nitrogen surplus and the nitrate concentration

Chapter 2 contains a brief description of the design and realisation of the derogation monitoring network. It also details the agricultural characteristics of the participating farms and provides a description of how the water quality is sampled. An explanation of the modelling work and analyses performed is also given. Chapter 3 presents and discusses the measurement results of the monitoring in 2007. In chapter 4 the changes since the implementation of the derogation are presented and discussed.

The relevant articles from the derogation decision granted to the Netherlands by the European Commission (EU, 2005) have been included in Appendix 1. Appendix 2 provides further details about the set-up of the derogation monitoring network. The other appendices provide a detailed justification concerning the registration of data for agricultural practice and the calculation of the fertilisation and the nitrogen and phosphate surpluses (Appendix 3) and how the quality of the water was measured (Appendix 4). Appendix 5 details the methodology applied for weather and sample correction. Finally, Appendix 6 describes the methodology for calculating the evolution of water quality.

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measured. A change in the nitrate concentration measured could therefore be caused by a change in the composition of the group of participating farms or changes in the acreage within this group.

2 Design of the derogation monitoring network

2.1 Introduction

The design of the monitoring network must satisfy the requirements of the European Commission, as stipulated in the derogation decision of December 2005, see Appendix 1. Previous reports provided extensive details about the composition of the sample and the choices this entailed (Fraters et al., 2007; Fraters and Boumans, 2005).

The setting up of the network and the reporting of the results is based on segmenting the Netherlands into regions, in line with the Nitrate Directive Action Programme and the fertilisation legislation. Four regions are distinguished for this purpose: the sand region, the loess region, the clay region and the peat region. The acreage of agricultural land in the sand region constitutes about 47% of the approximately 1.95 million hectares of total agricultural land in the Netherlands. The acreage of agricultural land in the loess region constitutes approximately 1.5%, in the clay region 39% and in the peat region 12% of the total agricultural acreage.

The sampling of the water quality for the measurement year 2007 was carried out during the winter of 2006/2007 in the Low Netherlands[4] and in the summer and the rest of 2007 in the High Netherlands.[4]. Water sampling took place on 300 farms in the derogation monitoring network. Farms that submitted an application for derogation but did not use this were not included in this report so as to ensure that the results concerning the effects of using derogation were not confounded.

The measured water quality in 2007 is in part related to the agricultural practice of 2006 and the preceding years. To what extent agricultural practice in a previous year affects the water quality measured depends, amongst other things, on the level of and variation in the precipitation surplus in that year. The difference between the Low and High Netherlands is caused by the difference in hydrology. This difference in hydrology also explains the different sampling methods used in the Low and High Netherlands.

As previously stated, all data about agricultural practices relevant for the derogation were registered, for all 300 derogation farms, according to the FADN system (Poppe, 2004). This report only includes data about the agricultural practices of farms that actually made use of the derogation. A description of the monitoring of the agricultural characteristics and the calculation of the fertilisation and the nutrient surpluses can be found in Appendix 3. The water sampling on the farms was carried out in accordance with the standard LMM procedures (Fraters et al., 2004). This sampling method is explained in Appendix 4.

[4] The Low Netherlands covers the clay and peat regions, and those soils in the sand region that are drained via ditches, whether or not in combination with drainage pipes or channels. The High Netherlands covers the other sand and loess soils.

2.2 Design and realisation of the sample

2.2.1 Number of farms in 2007

The derogation monitoring network is, as far as possible, a permanent monitoring network. However, the loss of a number of farms is unavoidable. Farms can drop out because:

- at the end of the year they indicate that they do not wish to make use of the derogation;
- they no longer participate in the LMM because 1) the farm has been sold or 2) the farm is no longer of a suitable type or 3) because cultivated land is no longer used or 4) because of administrative problems;
- the registration in FADN for the year concerned failed (farm was not fully processed).

Moreover, although a farm might have been processed in the FADN, it might have proved impossible to fully describe the nutrient flows. This could have been due to the presence of animals from other owners, as a result of which the supply and removal of feed, animals and manure could, by definition, not be complete or because of administrative errors in the registration of inputs, outputs and stock supplies.

Table 2.1 shows the planned and actual number of farms in the derogation monitoring network for 2007, per region (sand, loess, clay and peat) and farm type (dairy farms versus other grassland farms).

Table 2.1 Planned (design) and realised (realisation) number of dairy and other grassland farms per region.

Farm type	Design/realisation	Sand	Loess	Clay	Peat	All
Dairy farms	Design	140	17	52	52	261
	Realisation water quality	140	15	52	53	260
	Realisation FADN monitoring	139	15	52	53	259
	- for which derogation used	138	15	51	53	257
	- for which nutrient flows complete	133	15	50	53	251
Other grassland farms	Design	20	3	8	8	39
	Realisation water quality	20	5	8	7	40
	Realisation FADN monitoring	20	5	8	7	40
	- for which derogation used	20	3	8	7	38
	- for which nutrient flows complete	16	3	7	6	32
Total	Design	160	20	60	60	300
	Realisation water quality	160	20	60	60	300
	Realisation FADN monitoring	159	20	60	60	299
	- for which derogation used	158	18	59	60	295
	- for which nutrient flows complete	149	18	57	59	283

Eleven of the farms that had participated in FADN in 2006, no longer did so in 2007. These farms were therefore replaced.

In the various sections of this report the following numbers of farms are reported on:

- The description of general farm characteristics (section 2.3) and water quality (section 3.2) concerns all farms that could be processed in FADN in 2007 and that made use of the derogation (= 295).
- The description of agricultural practices in 2007 (section 3.1) concerns all farms for which the nutrient flows in 2007 could be fully completed in FADN (= 283).

The comparison of agricultural practice between 2006 and 2007 (section 4.2) concerns all farms that participated in the monitoring network in both 2006 and 2007 (273 farms). For 270 of these farms the nutrient flows could be fully completed in FADN for both years.

2.2.2 Representativeness of the sample

Table 2.2 describes which percentage of the acreage of all farms in the Netherlands, which both applied for derogation and satisfy the LMM selection criteria (the sample population, Appendix 2), is covered by the farms in the monitoring network. The sample population covers 85.6% of the farms and 96.6% of the acreage of all farms that registered for derogation in 2007.

Table 2.2 Area cultivated land (in ha) in the derogation monitoring network compared to the total area of cultivated land of farms with derogation in 2007 in the sample population, according to the Agricultural Census 2007.

Region	Farm type	Sample population[1]	Derogation monitoring network	
		Acreage in ha	Acreage in ha	% of acreage sample population
Sand	Dairy farms	367,553	6437	1.8%
	Other grassland farms	54,385	661	1.2%
	Total	421,938	7098	1.7%
Loess	Dairy farms	5226	756	14.5%
	Other grassland farms	1292	151	11.7%
	Total	6518	907	13.9%
Clay	Dairy farms	194,767	3030	1.6%
	Other grassland farms	31,965	326	1.0%
	Total	226,731	3356	1.5%
Peat	Dairy farms	159,652	3171	2.0%
	Other grassland farms	18,032	147	0.8%
	Total	177,684	3318	1.9%
All	Dairy farms	727,197	13,394	1.8%
	Other grassland farms	105,673	1285	1.2%
	Total	832,870	14,679	1.8%

[1] Estimate based on Agricultural Census 2007. Further information about how the sample population was defined can be found in Appendix 2.

With an area of 14,679 ha, 1.8% of the national acreage of the total sample population has been included in the sample (see Table 2.2). The loess region is strongly overrepresented (13.9%) for policy-related reasons. Furthermore, the dairy farms in all regions are more strongly represented in the acreage than the other grassland farms. This is because the desired number of farms for the sample per farm type is derived during the selection and acquisition process from the share in the total acreage of cultivated ground, whereas the other grassland farms included were on average smaller than the dairy farms in terms of the acreage of cultivated ground.

2.3 Description of the farms in the sample

Table 2.3 describes a number of characteristics of the farms in the derogation monitoring network. This table contains data from all farms in the derogation monitoring network for which the registration in FADN has been fully processed. For comparative purposes, the data from farms in the Agricultural Census 2007 (sample population) have also been included.

Table 2.3 Description of a number of general farm characteristics of the farms in the derogation monitoring network (DM) compared to the mean of the sample population (LBT)[1].

Farm characteristic	Population	Sand	Loess	Clay	Peat	All
Total number of farms :		158	18	59	60	295
Area grassland (ha)	DM	35.7	36.1	45.5	49.7	40.5
	LBT	29.8	29.0	41.0	40.3	34.5
Area silage maize (ha)	DM	8.2	10.7	9.3	5.2	8.0
	LBT	7.2	7.2	5.0	3.6	6.0
Area other arable land (ha)	DM	1.1	3.6	2.1	0.3	1.3
	LBT	0.8	2.4	1.4	0.3	0.8
Total area cultivated land (ha)	DM	44.9	50.4	56.9	55.3	49.8
	LBT	37.8	38.6	47.2	44.2	41.4
Percentage grassland	DM	81	75	82	93	83
	LBT	80	77	88	93	84
Area natural habitat (ha)	DM	0.4	2.5	0.5	0.4	0.5
	LBT	0.3	0.3	0.6	0.3	0.4
Stocking density grazing livestock (GVE per ha)	DM	2.11	2.00	2.04	1.96	2.06
	LBT	2.25	2.17	2.03	1.92	2.13
Percentage farms with housed animals	DM	19	11	15	13	17
	LBT	17	4	5	8	12
Specification livestock density derogation monitoring network (GVE[2] per ha)						
Dairy cattle (including young stock)	DM	2.00	1.81	1.87	1.81	1.92
Other grazing livestock	DM	0.11	0.19	0.18	0.15	0.14
Total housed animals	DM	1.58	0.08	0.52	0.36	1.03
Total all animals	DM	3.69	2.08	2.56	2.31	3.09

[1] DM = Farms in the derogation monitoring network 2007, LBT = Sample population based on Agricultural Census 2007 (Data Statistics Netherlands (CBS), processed by LEI).
[2] GVE = Livestock Unit, this is a comparative standard for animal numbers based on the phosphate production forfeit (phosphate production forfeit dairy cow = 1 GVE).

The following conclusions can be drawn from Table 2.3:

- The mean acreage of cultivated land of the sampled farms is greater than that of the farms in the sample population (49.8 versus 41.4 hectares). This applies to all regions.
- Besides the area of cultivated land, a mean of 0.5 hectares of nature conservation land is managed. This area is not included in the calculation of the environmental pressure per ha (fertilisation, surpluses and the like).
- For the farms sampled, 83% of the acreage is grassland and this is comparable to the mean of the sample population. On the farms sampled in the clay region, the percentage of grassland is slightly lower than in the sample population.
- On the farms sampled, an average of 86% (8.0 ha silage maize divided by 9.3 ha total arable land) of the arable land is used for silage maize.
- The livestock density of grazing livestock on the farms sampled in the sand and loess regions is lower than the mean of the sample population, whereas in the clay and peat regions the livestock density of grazing livestock per ha is more or less the same as in the sample population.
- On 17% of the farms in the derogation monitoring network, housed animals as well as grazing livestock are present. In all regions, the percentage of farms in the derogation monitoring network with housed animals is clearly higher than in the sample population. The presence of housed animals was not a criterion during the stratification process.
- Dairy cattle and the associated young stock constitute almost 93% of the grazing livestock present. The group other grazing livestock consists of beef cattle, sheep, goats, horses and ponies.
- The presence of large numbers of housed animals gives rise to a considerably higher mean total livestock density in the sand region compared to the other regions.

Table 2.4 provides a more detailed description of dairy farms in the derogation monitoring network. As the correct comparative material was not present in the Agricultural Census, for comparative purposes this table contains the weighted mean of the national sample from the Farm Accountancy Data Network (FADN).

Table 2.4 Mean milk production and grazing on dairy farms in the derogation monitoring network (DM) compared to the weighted mean of dairy farms in the national sample (FADN)[5].

Farm characteristic	Population	Sand	Loess	Clay	Peat	All
Total number of farms in DM:		138	15	51	53	257
	DM	663,061	605,495	816,985	826,449	723,941
kg FPCM[6] farm	FADN	567,407	356,622	669,211	638,373	595,364
kg FPCM per ha forage	DM	14,749	13,059	14,532	13,319	14,312
crop	FADN	14,502	12,621	13,089	12,614	13,762
	DM	8486	8250	8646	8128	8430
kg FPCM per dairy cow	FADN	8477	7555	8419	8138	8388
Percentage farms with	DM	88	93	82	89	88
grazing	FADN	84	100	90	92	87

The following additional conclusions can be drawn from Table 2.4:

[5] DM = dairy farms in the derogation monitoring network, FADN = weighted mean of the national sample of dairy farms in the FADN

[6] FPCM = Fat and Protein Corrected Milk, this is a comparative standard for milk with different fat and protein contents (1 kg milk with 4.00% fat and 3.32% protein = 1 kg FPCM).

- Just as for acreage, the dairy farms in the derogation monitoring network are also larger than the weighted national mean with respect to milk production. This applies to all regions.
- With more than 14,000 kg FPCM, the mean milk production per ha of forage crop is slightly higher than the national average. This applies to all regions.
- On the farms sampled, the average milk production per dairy cow present is slightly higher than the national average.
- On 88% of the farms, grazing is applied and therefore lower application standards and a low coefficient for plant-availability of nitrogen from grazing livestock manure are used in the calculations (see Appendix 3). For farms in the derogation monitoring network this percentage is of a similar level to the national average.

2.4 Monitoring of water quality

2.4.1 Sampling at farms

In the measurement year 2007, water quality was sampled at 295 derogation farms participating in the derogation monitoring network (see Table 2.5 and Figure 2.1). This concerned the sampling of groundwater, drain water or soil moisture. On the participating farms in the Low Netherlands[4] the ditch water on the farms was also sampled. The number of farms sampled per region in this period is stated in Table 2.5. The mean sampling frequency is also indicated. The average sampling frequency was lower than intended due to drought (drains gave no water) and problems in the realisation. The realisation problems have since been tackled by means of new contracts.

Table 2.5 Number of sampled farms registered for derogation per subprogramme and per region for 2007 and the sampling frequency of the leaching (L) and ditch water (DW). The desired sampling frequency is stated between parentheses.

Year	Sand region		Loess region	Clay region	Peat region
	All farms	Drained			
2007	159	24	18	59	59
L rounds	1 (1)	- (-)	1	2	1
DW rounds	0 (0)	2.2 (4)	0	2.3 (4)	3.5 (4)

The water quality sampling in 2007 took place in the period November 2006 to January 2008. The sampling period per region is stated in Table 2.6. In addition to this, the sampling in the loess region was continued in January 2008 as frost there had caused delays to the sampling. A detailed description of the sampling method per region is provided in Appendix 4.

Table 2.6 Sampling periods[1] for the water quality 2007, per region and programme, in the period November 2006 to January 2007. Samples are related to the agricultural practice data of 2006.

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Sand region Total																
Sand region Low NL																
Loess																
Clay																
Peat																

[1] Dark blue means that sampling took place. The light blue colour indicates that sampling only took place during part of the month.

This report also includes the provisional figures for the water quality sampling in 2008. It concerns the water quality data from the Low Netherlands, where sampling took place between November 2007 and April 2008.

Figure 2.1 shows the distribution of the sampled farms over the main soil type regions. A distinction is also made between dairy farms and other grassland farms. The distribution clearly shows that the focus of the derogation monitoring network lies in the sand region.

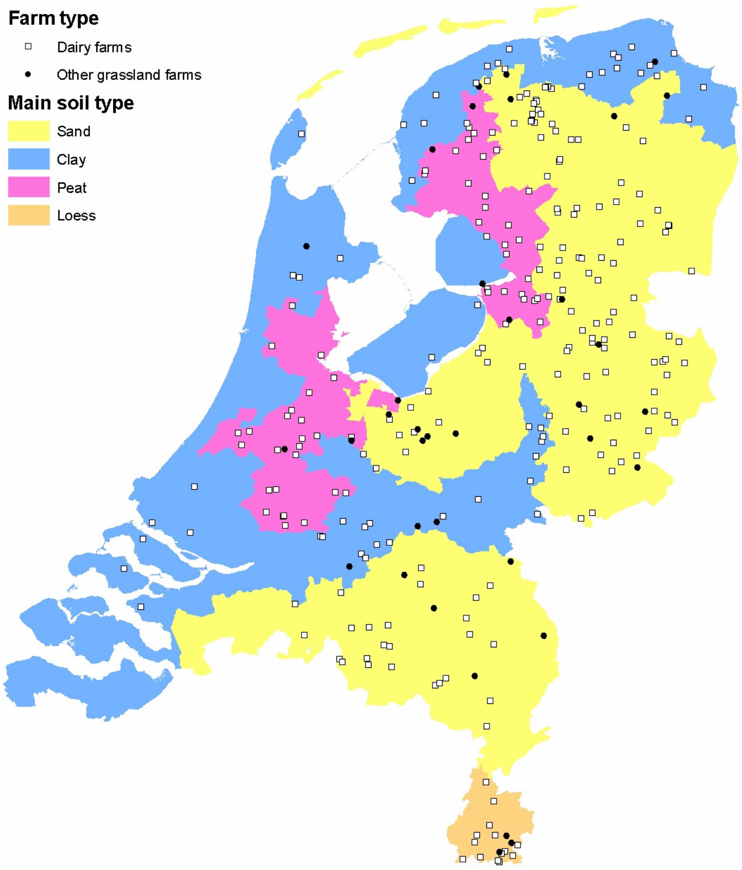

Figure 2.1 Location of the 295 grassland farms that participated in the water sampling for the purpose of the derogation monitoring network in 2007.

The soil and drainage characteristics of the farms concerned are given per region in Table 2.7. The table reveals that within a region, other soil types occur in addition to the main soil type after which the region is named. The loess region primarily consists of naturally good-draining soils and the peat region chiefly contains naturally poor-draining soils.

Table 2.7 Percentages of the acreage per soil type and drainage class on derogation farms sampled in 2007.

Region	Soil types				Drainage class[1]		
	Sand	Loess	Clay	Peat	Poor	Moderate	Good
Sand region	79	0	12	8	42	48	10
Loess region	1	70	30	0	2	3	95
Clay region	14	0	83	3	40	55	5
Peat region	12	0	37	51	90	10	0

[1] The drainage classes are linked to the groundwater regime classes. In total, 11 groundwater regime classes are distinguished on the basis of average highest groundwater level (AHG) and average lowest groundwater level (ALG) in a hydrological year (April–April). The three highest (lowest) values in a hydrological year are averaged. The class of naturally poor draining contains Gt I to Gt IV, the class moderately draining Gt V, V* and VI, and the class good draining Gt VII and Gt VIII.

2.4.2 Chemical analyses and calculations

The chemical analyses of the water samples were carried out in an accredited laboratory of RIVM. Table 2.8 provides an overview of the methods used for the different components. Further details can be found in Wattel-Koekoek et al. (2008).

Table 2.8 Components analysed with analysis method and detection limit.

Component	Analysis method[1]	Detection limit
Nitrate (NO_3-N)	IC	0.31 mg l^{-1}
Ammonium (NH_4-N)	CFA	0.064 mg l^{-1}
Total nitrogen (N)	CFA	0.2 mg l^{-1}
Total phosphorus (P)	Q-ICP-MS	0.06 mg l^{-1}

[1]
Q-ICP-MS : Quadruple inductively coupled plasma mass spectrometry.
IC : Ion chromatography.
CFA : Continuous flow analyser.

For each farm an annual mean concentration per component was calculated. For this calculation, observations with a concentration lower than the detection limit were assigned a value of 0. Consequently, farm mean concentrations lower than the detection limit can be calculated.

3 Results for 2007

3.1 Agricultural characteristics

3.1.1 Nitrogen use via livestock manure

Table 3.1 details the use of nitrogen from livestock manure on farms in the derogation monitoring network in 2007. For most of the farms, the manure production was calculated by means of forfeit standards. However, dairy farmers could choose to calculate a farm-specific manure production using the so-called Guidance (LNV, 2009b). This farm-specific manure production was adopted on dairy farms that indicated they were using the so-called Guidance (and who also benefited from this) and for which all of the necessary data were available (N = 23). On all other farms (N = 260) forfeits were used to determine the manure production. A more detailed explanation of the farm-specific and forfeit calculation methods for manure use is provided in Appendix 3.

Table 3.1 Mean nitrogen use via livestock manure (in kg N per ha) in 2007 on farms in the derogation monitoring network. Means per region.

Description	Sand	Loess	Clay	Peat	All
Total number of farms	149	18	57	59	283
Use livestock manure					
Produced on farm[1]	271	242	265	252	264
+ supply	10	10	10	15	11
+ stock mutation	-9	-2	-6	-5	-7
- removal	33	19	35	20	30
Total	238	232	234	242	238
Application standard livestock manure	243	246	244	244	244
Use on arable land[2]	182	190	175	207	184
Use on grassland[2]	254	260	246	246	251

[1]Calculated on the basis of forfeit standards with the exception of dairy farms that indicated they were using the Guidance farm-specific excretion diary cattle (see Appendix 3).
[2] The average use on grassland and arable land is based on 278 and 203 farms respectively instead of 283 farms because on 5 farms the allocation of fertilisers on arable land and grassland was not within the confidence intervals and because 75 farms had no arable land.

The following conclusions can be drawn from Table 3.1:

- At 244 kg per ha, the average application standard for livestock manure was below the derogation standard of 250 kg N from grazing livestock manure because:
    - a number of farms had only applied for derogation on a part of their acreage;
    - a number of farms also applied livestock manure from housed animals for which a standard of 170 kg per ha applies.
- The average use of nitrogen from livestock manure (238 kg per ha) was several kilograms under the average application standard.
- The use of nitrogen from livestock manure decreased in the order peat >sand >clay >loess.

- The use of nitrogen from livestock manure on arable land (mainly silage maize) was considerably lower in all regions than the use on grassland.

Table 3.1 also reveals that on average, livestock manure is both input and output from the monitoring network farms. As the production is generally higher than the use permitted, the removal of manure is on average higher than the supply of manure. This applies to all regions. Table 3.2 provides a more detailed explanation of the import and export of livestock manure on the farms in the derogation monitoring network.

Table 3.2 Percentage of farms in the derogation monitoring network that supplied and/or removed livestock manure in 2007. Means per region.

Description	Sand	Loess	Clay	Peat	All
No supply and removal	23	33	35	31	28
Only removal	42	33	33	29	37
Only supply	26	17	28	27	26
Both supply and removal	9	17	4	14	10

Table 3.2 shows that on 28% of the farms there was no transfer of manure to or from other farms. On 37% of the farms manure was only exported, whereas on 26% of the farms manure was only imported. This manure import can be explained by the fact that the purchase of nutrients via livestock manure in 2007 had a clear economic advantage compared to inorganic fertiliser. On 10% of the farms, manure was both input and output.

3.1.2 Fertiliser use compared to the application standards

Tables 3.3 and 3.4 detail the calculated use of plant-available nitrogen and phosphate from fertilisers. The quantity of plant-available nitrogen from livestock manure is calculated by multiplying the quantity of nitrogen in the livestock manure used (produced on own farm or imported, see Table 3.1) by the prevailing statutory plant-availability coefficients relevant to the specific situation (see Appendix 3). These tables also contain the mean application standards per ha for arable land (mainly maize acreage) and grassland to allow a comparison of fertiliser use. These mean application standards are based on the acreage of cultivated crops and the soil type classifications as registered in the FADN and the statutory application standards determined for 2007 (Dienst Regelingen, 2006).

Table 3.3 Mean nitrogen use (in kg plant-available N per ha) [1] on farms in the derogation monitoring network in 2007. Means per region.

Description	Category	Sand	Loess	Clay	Peat	All
Total number of farms		149	18	57	59	283
Average statutory plant-availability coefficient of N from livestock manure		41.1%	39.0%	41.3%	39.7%	40.7%
Use of plant-available nitrogen on farm level:	Livestock manure	98	90	97	96	97
	Other organic fertiliser	0	0	0	0	0
	Inorganic fertiliser	124	111	146	119	127
	Total mean	222	202	242	214	223
Use plant-available nitrogen on arable land[2]		103	119	122	117	110
Application standard arable land[2]		155	152	164	162	158
Use plant-available nitrogen on grassland[2]		257	240	267	224	251
Application standard grassland[2]		305	298	341	320	315

[1] Calculated according to the prevailing statutory availability coefficients (see Appendix 3).
[2] The average use and the application standards on grassland and arable land are based on 278 and 203 farms respectively instead of 283 farms, as on 5 farms the allocation of fertilisers on arable land and grassland did not fall within the confidence intervals and because 75 farms had no arable land.

The following conclusions can be drawn from Table 3.3:

- The calculated total (plant-available) nitrogen use was lower than the application standard in all regions on both grassland and arable land. This was partly because 88% of the dairy farms used grazing, as a result of which a low statutory plant-availability coefficient (in 2007 still 35%) could be used.
- In the clay region, the total (plant-available) nitrogen use is higher than in the other regions due to a higher use of inorganic fertiliser. Also the nitrogen application standards are higher on the clay soils.
- In the loess region, the total (plant-available) nitrogen use is lower than in the other regions due to a lower use of both livestock manure and inorganic fertiliser.
- In all regions, the nitrogen fertilisation on arable land, which mostly consists of silage maize, is considerably lower than the nitrogen fertilisation on grassland. In the sand region the fertilisation on arable land is somewhat lower than in the other regions.

Table 3.4 Mean phosphate use (in kg P_2O_5 per ha) in 2007 on farms in the derogation monitoring network. Means per region.

Description	Category	Sand	Loess	Clay	Peat	All
Total number of farms		149	18	57	59	283
Use of fertiliser	Livestock manure	85	84	83	86	85
	Other organic fertiliser	0	0	0	0	0
	Inorganic fertiliser	7	4	9	6	7
	Total average	93	87	93	93	92
Use phosphate on arable land[1]		96	96	109	115	101
Application standard arable land[1,2]		92	95	91	90	92
Use phosphate on grassland[1]		93	91	89	92	92
Application standard on grassland[1,2]		106	107	106	105	106

[1] The average use and the application standards on grassland and arable land are based on 278 and 203 farms respectively instead of 283 farms, as on 5 farms the allocation of fertilisers on arable land and grassland did not fall within the confidence intervals and because 75 farms had no arable land.
[2] The average phosphate application standard on grassland is over 105 kg per ha and on arable land over 90 kg per ha because a small proportion of the plots are phosphate poor or phosphate fixating. On these plots a phosphate application standard of 160 kg per ha was used.

The following conclusions can be drawn from Table 3.4:

- With the exception of the loess region, the average phosphate use at farm level in all regions was 93 kg per ha. In the loess region an average of 87 kg phosphate from fertilisers was applied.
- At an average of 92 kg, the phosphate use on grassland was lower than the application standard of 106 kg on grassland. This is the case in all regions.
- However, at 101 kg per ha, the use of phosphate on arable land is considerably higher than the application standard of 92 kg phosphate per ha. This is the case in all regions.
- On average 7.5% of the phosphate is applied via inorganic fertiliser. In the clay region the quantity of phosphate applied as inorganic fertiliser was highest in both relative and absolute terms.
- Also on the farm level, phosphate application was below the application standard in all regions.

3.1.3 Crop yields

Table 3.5 shows the average crop yield, estimated for silage maize and calculated for grassland, on the farms in the derogation monitoring network that satisfied the criteria for applying the calculation method for crop yield. This calculation method is derived from Aarts et al. (2008). In this method the yield from silage maize is estimated by the entrepreneur and/or advisor. The grass yield is calculated as the difference between the energy requirement of the cattle herd on the one hand and the energy uptake from farm-grown silage maize (and forage crops other than grass) and purchased feed on the other hand. Further information about this method is provided in Appendix 3.

Table 3.5 Average crop yield (in kg dry matter, N, P and P_2O_5 per ha) for silage maize (estimated) and grassland (calculated) in 2007 on farms in the derogation monitoring network that satisfied the criteria for using the calculation method (Aarts et al., 2008). Means per region.

Category	Sand	Loess	Clay	Peat	All
Total number of farms	101	12	33	35	181
Estimated yield silage maize[1]					
kg dry matter per ha	14,956	16,269	15,189	15,120	15,125
kg N per ha	172	191	177	174	175
kg P per ha	30	33	33	31	31
kg P_2O_5 per ha	69	76	76	71	71
Calculated yield grassland					
kg dry matter per ha	10,520	10,878	11,103	11,413	10,823
kg N per ha	281	293	294	299	288
kg P per ha	38	41	41	41	39
kg P_2O_5 per ha	88	94	93	94	90

[1] The estimated silage maize yield on sand, loess, clay, peat and all farms is based on 82, 11, 22, 18 and 133 farms respectively, as some of the farms that satisfied the criteria for using the calculation method did not cultivate any silage maize.

Table 3.5 shows that:

- The average estimated dry matter yield of silage maize, with the exception of the loess region, was about 15,000 kg per ha. At 16,269 kg dry matter per ha, the yield in the loess region was higher than in the other regions.
- An estimated 175 kg N and 31 kg P (71 kg P_2O_5) per ha were harvested from silage maize.
- At 10,823 kg per ha, the calculated grassland yield of dry matter was considerably lower than the estimated silage maize yield. However, as grass products have higher N and P levels than silage maize, the N and P yields per ha were considerably higher on grassland.
- The calculated grassland yields are lowest in the sand region and highest in the peat region.

3.1.4 Nutrient surpluses

Tables 3.6 and 3.7 detail the nitrogen and phosphate surpluses on the soil surface balance for farms in the derogation monitoring network in 2007. The surpluses are calculated using the calculation method described in Appendix 3.

Table 3.6 Nitrogen surplus on the soil surface balance (in kg per ha) for farms in the derogation monitoring network in 2007. Means and 25% and 75% quartiles per region.

Description	Category	Sand	Loess	Clay	Peat	All
Total number of farms		149	18	57	59	283
Input farm	Inorganic fertiliser	124	111	146	119	127
	Organic fertiliser	14	17	14	20	15
	Feed	171	112	160	129	156
	Other	8	5	10	8	8
	Total	317	245	330	275	307
Output farm	Milk and other animal products	70	53	75	65	69
	Animals	27	16	18	17	23
	Organic fertiliser	46	27	45	30	41
	Other	7	15	6	10	8
	Total	150	111	145	123	141
Mean nitrogen surplus per farm		167	135	186	153	166
+ Deposition, mineralisation and fixation		54	55	51	122	67
- Gaseous emission[1]		49	38	50	45	48
Mean nitrogen surplus soil surface balance		172	152	187	230	186
Nitrogen surplus soil surface balance first quartile (25%)		125	123	146	163	132
Nitrogen surplus soil surface balance third quartile (75%)		228	183	232	296	238

[1] Gaseous emission from housing and storage, during application and grazing.

The following conclusions can be drawn from Table 3.6:

- The mean nitrogen surplus of the soil surface balance is 186 kg per ha.
- The nitrogen surplus increases in the order loess<sand<clay<peat.
- There is a considerable variation in the nitrogen surplus on the soil surface balance. The 25% of farms with the lowest surplus realised a surplus of less than 132 kg N per ha, whereas for the 25% of farms with the highest surplus, the surplus was in excess of 238 kg N per ha.
- There are considerable differences between the regions with respect to the composition of the nitrogen surplus:
    - In the clay region, the surplus on the farm gate balance is the highest because of the relatively high input compared to the other regions, which was not fully compensated by a high output.
    - The sand region has a lower nitrogen surplus on the farm gate balance compared to the clay region, mainly due to the lower input of nitrogen in the form of inorganic fertiliser. Since there are no large differences between the clay and sand regions in terms of the input and output of the soil surface balance, the nitrogen surplus on the soil surface balance is also considerably lower in the sand region than in the clay region.
    - In the peat region, less nitrogen is imported in the form of feed compared to the sand and clay regions. This lower input is partly caused by the lower number of intensive livestock in this region. Since removal of nitrogen via animal products and manure is also considerably lower, the nitrogen surplus on the farm gate balance is only 14 kg

per ha lower than in the sand region. In contrast, the nitrogen surplus on the soil surface balance is higher, mainly due to the assumption that the average net nitrogen mineralisation on peat is 76 kg per ha. This is included as input in the soil surface balance.
- The farms in the loess region are characterised by a low nitrogen surplus. Both input and output are lower on the farm gate balance than in the other regions.

Table 3.7 Phosphate surplus on the soil surface balance (in kg P_2O_5 per ha) on farms in the derogation monitoring network in 2007. Means and 25% and 75% quartiles per region.

Description	Category	Sand	Loess	Clay	Peat	All
Total number of farms		149	18	57	59	283
Input farm	Inorganic fertiliser	7	4	9	6	7
	Organic fertiliser	7	8	8	10	8
	Feed	65	41	63	53	61
	Other	4	3	5	4	4
	Total	84	56	85	73	80
Output farm	Milk and other animal products	28	21	29	25	27
	Animals	15	10	12	11	13
	Organic fertiliser	23	13	25	16	21
	Other	2	6	2	3	3
	Total	68	50	67	55	64
Average phosphate surplus soil surface balance		15	6	18	18	16
Phosphate surplus soil surface balance first quartile (25%)		5	-1	5	6	4
Phosphate surplus soil surface balance third quartile (75%)		27	17	33	31	27

The following conclusions can be drawn from Table 3.7:
- The average phosphate surplus on the soil surface balance is 16 kg per ha.
- The phosphate surplus on the soil surface balance is highest in the clay and peat regions. At 6 kg per ha, the phosphate surplus in the loess region was considerably lower than in the other regions, which was mainly due to a lower input of phosphate via feed.
- On the 25% of farms with the lowest phosphate surplus this surplus was less than 4 kg per ha, whereas for the 25% of farms with the highest surplus this surplus was over 27 kg per ha.

3.2 Water quality

3.2.1 Leaching from the root zone, measured in 2007

In 2007, the concentrations measured in water leaching from the root zone are related to the agricultural practices on the farms in 2006 and the years prior to this. The water quality reported here is therefore related to the agricultural practices during the first year in which derogation was applied (i.e. agricultural practice in 2006).

The nitrate (NO_3) concentrations in the sand and loess regions are on average higher than 50 mg per litre. In the clay and peat regions, the nitrate concentrations are on average lower than 50 mg per litre (see Table 3.8). Although the nitrate concentration in the peat region is lower than in the clay region, the total nitrogen concentration is higher. This is due to the higher ammonium concentrations in the groundwater. The average ammonium nitrogen concentration in the peat region is 4.5 mg per litre. In the clay, sand, and loess regions the concentration is on average lower than 1 mg per litre. The higher ammonium concentration is probably the consequence of nutrient rich peat layers (Van Beek et al., 2004). The groundwater that is, or has been, in contact with nutrient rich peat layers often has a similarly high phosphate concentration (Van Beek et al., 2004) and these nutrient rich peat layers are probably also the cause of the measured higher mean phosphorus concentration in the peat and clay regions compared with the sand and loess regions.

Table 3 8. Nutrient concentration (in mg per litre) in water that leached from the root zone in 2007 on farms in the derogation monitoring network. Mean concentrations per region.

Characteristic	Sand			
	Sand	Loess	Clay	Peat
Total number of farms	159	18	59	59
Nitrate (NO_3)	56	68	30	14[1]
Nitrogen (N)	15.8	17	10.4	11.1
Phosphorus (P)[2]	0.12 (48%)	<0.06 (61%)	0.28 (15%)	0.53 (3%)

[1] No nitrate value was available from one farm.
[2] The average percentage of farms with concentrations lower than the detection limit of 0.06 mg per litre is indicated between brackets.

In the sand region, 54% of the farms have a nitrogen concentration lower than 50 mg per litre and in the loess region this is 17% (see Table 3.9). In the clay and the peat regions, the percentage of farms with a concentration lower than 50 mg per litre is 78% and 86%, respectively.

Table 3.9 Frequency distribution of the mean farm nitrate concentrations (in mg per litre) in water that leached from the root zone on farms in the derogation monitoring network per region in 2007, expressed as percentages per class.

Concentration class	Region			
(mg NO_3 per litre)	Sand	Loess	Clay	Peat
<15	15	6	42	71
15-25	12	0	22	9
25-40	11	0	5	3
40-50	16	11	8	3
>50	46	83	22	14
Total number of farms	159	18	59	58[1]

[1] No nitrate value was available from one farm.

Fifty percent of the farms in the sand region have a nitrogen concentration of between 8.9 and 22.1 mg N per litre (see Table 3.10). For the loess region the figures are more or less the same. For the peat and clay region, the values are lower.

Table 3.10 Nitrogen concentrations (in mg per litre) in water that leached out from the root zone in 2007 on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	Region			
	Sand	Loess	Clay	Peat
Total number of farms	159	18	59	59
First quartile (25%)	8.9	13.8	3.5	4.8
Median (50%)	13.6	16.6	6.1	9.1
Third quartile (75%)	22.1	21.6	13.1	13.6

The phosphorus concentration in the leaching water on 75% of the farms is lower than the detection limit of 0.07 mg per litre in the loess region and is lower than 0.15 mg per litre in the sand region (see Table 3.11). In the clay region, the phosphorus concentrations for 50% of the farms lie between 0.11 and 0.41 mg per litre. In the peat region the concentrations are higher.

Table 3.11 Phosphorus concentrations (in mg per litre) in water leaching out of the root zone in 2007 on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	Region			
	Sand	Loess	Clay	Peat
Total number of farms	159	18	59	59
First quartile (25%)	<0.06	<0.06	0.11	0.11
Median (50%)	0.06	<0.06	0.21	0.36
Third quartile (75%)	0.15	0.07	0.41	0.78

3.2.2 Ditch water quality, measured in 2007

The quality of the ditch water in the winter of 2006-2007 reported here, reflects the agricultural practices in 2006 and the years prior to this and is related to the first year of the derogation. The provisional peat and clay figures for 2008 are already presented here (Fraters et al., 2008).

The nitrate concentration in the ditch water on farms in the derogation monitoring network clearly differs between regions. With a mean of 41 mg per litre the nitrate concentration is highest in the sand region and with a mean of less than 5.9 mg per litre, is lowest in the peat region (see Table 3.12). This also applies to the nitrogen concentration, although the difference between the clay and peat regions is not significant. The phosphorus concentration in the ditch water is highest in the clay region and lowest in the sand region. In the loess region no farms in the derogation monitoring network had ditches.

Table 3.12 Nutrient concentration (in mg per litre) in ditch water in the winter of 2006-2007 on farms in the derogation monitoring network. Mean concentrations per region.

Characteristic	Region			
	Sand	Loess	Clay	Peat
Total number of farms	24	0	58[1]	59
Nitrate (NO_3)	41	-	14	5.9
Nitrogen (N)	11.0	-	4.7	3.5
Phosphorus (P)	0.14	-	0.32	0.23

[1] For one farm no ditch water data were available.

In the sand region, 16 of the 24 farms (67%) have a nitrate concentration lower than 40 mg per litre (see Table 3.13). In the clay and peat regions, 2 farms and a single farm respectively have a ditch water nitrate concentration higher than 50 mg per litre.

Table 3.13 Frequency distributions of the farm mean nitrate concentrations (in mg NO_3 per litre) in ditch water on farms in the derogation monitoring network per region in the winter of 2006-2007, expressed in percentages per class.

Concentration class (mg NO_3 per litre)	Region			
	Sand	Loess	Clay	Peat
<15	17	-	67	95
15-25	17	-	16	2
25-40	33	-	10	2
40-50	0	-	3	0
>50	33	-	3	2
Total number of farms	24	0	58[1]	59

[1] For one farm no ditch water data were available.

Approximately half of the farms in the sand region have a ditch water nitrogen concentration of between 5.9 and 15.2 mg per litre (see Table 3.14). In the clay and peat regions at least 75% of the farms have a ditch water nitrogen concentration lower than 6.6 mg per litre.

Table 3.14 Ditch water nitrogen concentrations (in mg N per litre) in the winter of 2006-2007 on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	Region			
	Sand	Loess	Clay	Peat
Total number of farms	24	0	58[1]	59
First quartile (25%)	5.9	-	2.2	2.2
Median (50%)	8.4	-	3.4	2.9
Third quartile (75%)	15.2	-	6.6	4.2

[1] For one farm no ditch water data were available.

On 50% of the farms in the sand region, the ditch water phosphorus concentration is lower than the detection limit of 0.08 mg per litre (see Table 3.15). In the peat region, 50% of the farms have a phosphorus concentration between 0.09 and 0.28 mg per litre. The highest concentrations were found in the clay region; here, 50% of the farms have a phosphorus concentration between 0.07 and 0.53 mg per litre. In both the peat and the clay regions the concentrations are higher than in the sand region.

Table 3.15 Ditch water phosphorus concentrations (in mg P per litre) in the winter of 2006-2007 on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	Region			
	Sand	Loess	Clay	Peat
Total number of farms	24	0	58[1]	59
First quartile (25%)	<0.06	-	0.07	0.09
Median (50%)	0.08	-	0.16	0.16
Third quartile (75%)	0.15	-	0.53	0.28

[1] For one farm no ditch water data were available.

Comparison with the provisional figures for 2007 as reported in 2008
The provisional figures reported in 2008 concerning the nitrate and total nitrogen concentrations in 2007 on derogation farms in the clay and peat region were slightly higher than the final figures for 2007 stated above. The phosphorous figures were the same as the provisional figures reported in 2008.

3.2.3 Provisional figures for the measurement year 2008

For the third measurement year (2008), provisional results are only available for the measurements in the clay and peat regions (sampled in winter 2007/2008); 'provisional' means that for a limited number of farms the results have not been processed yet. Additional data such as precipitation surplus, soil type and drainage class distribution are not available yet either. Therefore the extent to which weather conditions influenced differences in nutrient concentrations between 2007 and 2008 cannot be quantified yet. Consequently, no conclusions can be drawn regarding possible differences in the measured water quality between the measurement years 2007 and 2008.

The mean nitrate concentration in 2008 for the clay region was 22.8 mg per litre in the water that leached from the root zone. This is slightly lower than the 30 mg per litre in 2006 and 2007. Of the participating farms, 86% had a nitrate concentration lower than 50 mg per litre (see Table 3.16). At 7.1 mg per litre, the average nitrate concentration on farms in the peat region is lower in 2008 than in 2007 (14 mg per litre).

For 2008, the mean nitrate concentration in the clay region's ditch water is 10.6 mg per litre and therefore lower than the measurements in 2007 (14 mg per litre) and 2006 (12 mg per litre). In the peat region, the average nitrate concentration was also lower in 2008 (4.2 mg per litre) than in 2007. Of the participating farms in the clay region, 98% had a nitrate concentration lower than 50 mg per litre and in the peat region this figure was 100% (see Table 3.16).

Table 3.16 Frequency distributions for the farm mean nitrate concentrations (in mg NO_3 per litre) in water leaching out of the root zone (left) and in the ditch water (right) on farms in the derogation monitoring network per region in 2008, expressed in percentages per class. The figures given are provisional (see text).

Concentration class (mg NO_3 per litre)	Water type			
	Leaching out of root zone		Ditch water	
	Clay region	Peat region	Clay region	Peat region
<15	55	86	75	95
15-25	14	5.2	12	5.2
25-40	10	5.2	7.0	0
40-50	7	1.8	3.5	0
>50	14	1.8	1.8	0
Overall mean	22.8	7.1	10.6	4.2
Total number of farms	58	58	57	58

The mean total nitrogen concentration in the leaching water for the clay region was 7.2 mg per litre in 2008 (Table 3.17) and therefore lower than in the previous year (10.4 mg per litre). In the peat region the average concentration in 2008 was 9.0 mg per litre; this is lower than the value in 2007 (11.1 mg per litre). The ditch water nitrogen concentrations were clearly lower than in leaching water but exhibit a similar decrease.

Table 3.17 Nitrogen concentrations (in mg per litre) in the water leaching from the root zone (left) and in the ditch water (right) in 2008 (provisional figures) on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	Water type: Leaching		Ditch water	
	Clay region	Peat region	Clay region	Peat region
Total number of farms	58	57	57	58
Mean	7.2	9.0	4.4	4.0
First quartile (25%)	2.9	6.0	2.0	2.5
Median (50%)	4.5	8.8	3.2	4.0
Third quartile (75%)	8.9	11	5.8	5.2

The average phosphorus concentration in leaching water in the clay region was 0.24 mg per litre in 2008 (Table 3.8) and therefore lower than the figure in 2007 (0.28 mg per litre) and 2006 (0.40 mg per litre). The same holds for the peat region, with a mean of 0.43 mg per litre in 2008, 0.52 mg per litre in 2007 and 0.88 mg per litre in 2006. Like nitrogen, the phosphorus concentrations in ditch water are lower than in leaching water. The ditch water nutrient concentrations exhibit a difference between 2007 and 2008 which is comparable to that of the concentrations in water leaching from the root zone.

Table 3.18 Phosphorus concentrations (in mg per litre) in the water leaching from the root zone (left) and in the ditch water (right) in 2008 (provisional figures) on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	Water type: Leaching		Ditch water	
	Clay region	Peat region	Clay region	Peat region
Total number of farms	58	58	57	58
Mean	0.24	0.43	0.31	0.17
First quartile (25%)	0.08	0,17	<0.06	0.07
Median (50%)	0.18	0.36	0.12	0.11
Third quartile (75%)	0.32	0.57	0.52	0.21

4 Changes since the derogation

4.1 Introduction

In this chapter, the results from 2006 (Fraters et al., 2008) shall be compared with the results from 2007, as described in the previous chapters. It should be noted, however, that only a limited comparison is made. The possible consequences of derogation on water quality can be seen for the first time in the measurement results for 2007. For agricultural practice two measurement years are available for the detection of possible trends.

4.2 Trends in agricultural practice

This section reports on all 273 farms that participated in the derogation monitoring network during both 2006 and 2007. Farms that failed to participate in one of the years have not been included. Therefore the numbers differ slightly from those reported in Section 3.1 and in Fraters et al. (2008). As the nutrient flow data were incomplete for three of the farms, Tables 4.2, 4.3 and 4.5 concern the results of 270 farms. Table 4.4 concerns 149 farms that participated in both years and which satisfied the conditions for calculating the crop yields.

4.2.1 Classification of the farms

Table 4.1 details several farm characteristics of the farms that participated in both 2006 and 2007. This data reveals the extent to which the farms changed during this period.

Table 4.1: Description of a number of general farm characteristics of the farms in the derogation monitoring network (DM) in 2007, compared to 2006 (N = 273).

Farm characteristic	2006	2007
Number of dairy farms	249	248
Number of other grassland farms	24	25
Total area cultivated land (ha)	49.7	50.1
Percentage grassland	84	83
Percentage farms with housed animals	14	12
Total livestock density (GVE per ha)	2.36	2.36
kg FPCM[1] farm	697,213	724,618
kg FPCM per dairy cow	8406	8428
kg FPCM per ha forage crop	13,985	14,312
Percentage of dairy farms on which dairy cows graze	90	88

[1] FPCM= Fat and Protein Corrected Milk. This is a standard used for comparing milk with different fat and protein contents (1 kg milk with 4.00% fat and 3.32% protein = 1 kg FPCM). The means reported only refer to the 257 specialised dairy farms.

The following conclusions can be drawn from Table 4.1:

- Changes in the general farm characteristics are relatively small.
- The quantity of FPCM per farm has increased by over 27,000 kg.
- The milk production in 2007 was on average 300 kg FPCM per ha forage crop higher than in 2006.

4.2.2 Use of livestock manure

Table 4.2 shows the use of livestock manure in 2007 compared to 2006 on the same farms.

Table 4.2 Mean nitrogen use via livestock manure (in kg N per ha) in 2007, compared to 2006, on farms in the derogation monitoring network (N = 270).

Description category	2006	2007
Use nitrogen in livestock manure		
Produced on farm	262	261
+ input	9	11
+ stock mutation	-5	-7
- output	-22	-25
Total	244	240
Use on arable land	179[1]	186[2]
Use on grassland	257[1]	253[2]

[1] The average use and the application standards on grassland and arable land in 2006 are based on 263 and 193 farms respectively instead of 270 farms, as the allocation for fertilisers on arable land was not within the confidence limits for 7 farms and because 70 farms had no arable land.

[2] The average use and the application standards on grassland and arable land in 2007 are based on 266 and 194 farms respectively instead of 270 farms, as the allocation for fertilisers on arable land was not within the confidence limits for 4 farms and because 72 farms had no arable land.

The following conclusions can be drawn from Table 4.2:

- The average production of livestock manure in 2007 was more or less the same as in 2006.
- Both the import and export of livestock manure were slightly higher in 2007 than in 2006. The net effect (export minus import) on the use in both years is more or less comparable.
- In both years there was an increase in the supply of livestock manure. This was slightly higher in 2007 than in 2006.
- Taken together, all of the aforementioned minimal changes resulted in the total use of nitrogen from livestock manure being 4 kg per ha lower in 2007 than in 2006.
- The use of nitrogen from livestock manure on arable land was 7 kg per ha higher in 2007 compared to 2006, whereas the use on grassland was 4 kg per ha lower.

4.2.3 Use of fertilisers compared to the application standards

Table 4.3 compares the use of fertilisers to the statutory application standards.

Table 4.3 Mean nitrogen and phosphate use (in kg plant-available N and P_2O_5 per ha) on farms in the derogation monitoring network in 2007, compared to 2006 (N = 270).

Description category		Nitrogen (kg plant-available N per ha)		Phosphate (kg P_2O_5 per ha)	
		2006	2007	2006	2007
Average statutory plant-availability coefficient of N from livestock manure		39.8%	40.2%		
Use on farm level:	Livestock manure	97	96	88	86
	Other organic fertiliser	0	0	0	0
	Inorganic fertiliser	127	126	10	7
	Total mean	224	223	98	93
Use on arable land		108[1]	111[2]	101[1]	101[2]
Application standard arable land		157[1]	158[2]	96[1]	92[2]
Use on grassland		248[1]	250[2]	98[1]	93[2]
Application standard grassland		316[1]	314[2]	111[1]	106[2]

[1] The average use and the application standards on grassland and arable land in 2006 are based on 263 and 193 farms respectively instead of 270 farms, as the allocation for fertilisers on arable land was not within the confidence limits for 7 farms and because 70 farms had no arable land.

[2] The average use and the application standards on grassland and arable land in 2007 are based on 266 and 194 farms respectively instead of 270 farms, as the allocation for fertilisers on arable land was not within the confidence limits for 4 farms and because 72 farms had no arable land.

The following conclusions can be drawn from Table 4.3:

- The use of plant-available N per ha in 2007 was more or less the same as in 2006.
- The slightly higher use on both arable land and grassland in 2007 compared to 2006 contrasts with the lower use at farm level. This is due to the difference in the number of farms on which these means are based.
- The use of phosphate per ha was 5 kg lower in 2007 because less phosphate was used from both livestock manure and inorganic fertiliser.
- The decrease in phosphate use took place solely on grassland. On arable land the use in 2007 was the same as in 2006.

4.2.4 Crop yields

Table 4.4 details the crop yields calculated according to the method described by Aarts et al. (2008). In this method the yield from silage maize is estimated by the entrepreneur and/or advisor. The grass yield is calculated as the difference between the energy requirement of the livestock on the one hand and the energy uptake from farm-grown silage maize (and forage crops other than grass) and feed purchased on the other hand. Appendix 3 provides further details about this calculation method.

Table 4.4: Estimated crop yield (in kg dry matter, N, P and P_2O_5 per ha) for silage maize and calculated yield for grassland on farms in the derogation monitoring network (DM) that satisfied the criteria for the calculation method for grassland yield (Aarts et al., 2008), in 2007 compared to 2006 (N = 149) and the results reported in Aarts et al. (2008) for 2006.

	Aarts et al. (2008) in 2006	DM 2006	DM 2007
Total number of farms	271	149	149
Estimated yield silage maize			
Tonnes dry matter per ha	15.5	15.5[1]	15.0[1]
kg N per ha	203	204[1]	174[1]
kg P per ha	33	33[1]	31[1]
kg P_2O_5 per ha	76	76[1]	71[1]
Calculated yield grassland			
Tonnes dry matter per ha	9.2	9.6	10.9
kg N per ha	265	276	289
kg P per ha	33	34	40
kg P_2O_5 per ha	75	78	91

[1] The silage maize yields are based on 109 farms for 2006 and 110 farms for 2007, instead of 149 farms; 30 farms in 2006 and 29 farms in 2007 did not cultivate any silage maize.

The following conclusions can be drawn from Table 4.4:

- The average silage maize yield (both dry matter, N, P and P_2O_5) of the 149 farms that participated in the derogation monitoring network in both years, and which satisfied the criteria, was more or less the same in 2006 as the average yield reported by Aarts et al. (2008) for 2006.
- The average calculated grassland yield of these 149 farms was slightly higher in 2006 than the average grassland yield reported by Aarts et al. (2008) for 2006.
- The average estimated silage maize yield in kg dry matter per ha on these farms from the derogation monitoring network was slightly lower in 2007 (almost 2%) when compared to 2006.
- As the average N content of silage maize in 2006 was higher than in 2007, the N yield exhibited a relatively larger decrease than the dry matter yield.
- The calculated grassland yields on these 149 farms from the derogation monitoring network were higher in 2007 than in 2006, for dry matter, N, P and P_2O_5.

4.2.5 Nutrient surpluses on the soil surface balance

Table 4.5 details the nitrogen and phosphate surplus on the soil surface balance.

Table 4.5 Nitrogen and phosphate surplus on the soil surface balance (in kg N and P_2O_5 per ha) on farms in the derogation monitoring network in 2007, compared to 2006 (N = 270).

	Nitrogen (kg N per ha)		Phosphate (kg P_2O_5 per ha)	
Description category	2006	2007	2006	2007
Supply of (inorganic) fertiliser, manure, animals and other products	290	294	79	74
Removal of milk, animals, feed, manure and other products	118	131	53	59
Deposition, mineralisation and N fixation	68	68	n.a.	n.a.
Gaseous emission from housing and storage, during grazing and application	46	45	n.a.	n.a.
Average surplus soil surface balance	194	186	25	16
Surplus soil surface balance first quarter	146	130	13	4
Surplus soil surface balance third quarter	238	239	36	27

The following conclusions can be drawn from Table 4.5:

- The nitrogen surplus on the soil surface balance in 2007 was 8 kg per ha lower than in 2006, as 13 kg more nitrogen per ha was removed (produced) via milk, animals, manure or other products, whereas the supply of nitrogen via manure and inorganic fertiliser, feed animals and other products was only 4 kg per ha higher. Both the calculated supply via deposition, mineralisation and nitrogen fixation as well as the calculated emission were more or less the same in both years.
- The phosphate surplus on the soil surface balance in 2007 was considerably lower than in 2006. On the one hand this is because 5 kg less per ha was supplied in the form of inorganic fertiliser, manure, animals, feed and other products and on the other hand because there was more removal (production) of phosphate via milk, animals, feed, manure and other products.

4.2.6 Summary

The comparison of the results from 2007 with those from 2006 reveals that on average the participating farms applied slightly less nitrogen from livestock manure in 2007. The total calculated use of plant-available nitrogen from fertilisers was more or less the same, partly because in 2007 a slightly higher statutory coefficient for plant-availability of nitrogen from applied livestock manure was used. For phosphate, a decrease in the use of fertilisers seems to have occurred, possibly as a consequence of the tightening of the application standards in 2007. This decrease in phosphate use can also be seen in the lower supply of phosphate on the farm-gate balance.

The estimated silage maize yield (kg N and P_2O_5 per ha) was slightly lower in 2007 compared to 2006, whereas the calculated grassland yield (kg N and P_2O_5 per ha) was slightly higher. At farm level this will on average have led to a higher yield because 83% of the acreage is made up of grassland. This higher yield is also reflected in the higher average removal (i.e. production) of N and P_2O_5 per ha on the farm-gate balance.

It can be concluded that the combination of a higher production and a lower fertilisation in 2007 compared to 2006 has led to an improved utilisation of the fertilisers, especially for phosphate. This can also be seen in the lower surpluses on the soil surface balance in 2007.

4.3 Evolution in the water quality

In this section the water qualities measured in 2006 and 2007 are compared. Just a limited number of derogation farms were sampled in both years, as many of the farms had yet to be recruited during the first year (2006). Consequently only a limited comparison can be made. Two approaches (statistical methods) were used for this. First of all the traditional statistical method in which a difference is determined per farm and then the mean is tested for deviation from the null hypothesis (Table 4.6). Subsequently a modern technique was used (REML method, REsidual Maximum Likelihood), in which all data are used and the difference in the size of the sample is taken into account (Table 4.7). This method takes both paired and unpaired observations into account. In the clay and peat regions in particular, there was a considerable difference in the number of farms in 2006 and in 2007 and therefore REML is the most suitable method in these cases. A detailed explanation of the method used is provided in Appendix 6.

On the derogation farms in the loess, clay and peat regions there was no significant increase or decrease in the nitrate leaching (the concentration in the water leaching from the root zone) between 2006 and 2007. The nitrate leaching in the sand region was clearly higher in 2007 than in 2006 (according to both methods, see Tables 4.6 and 4.7). The calculated increase in the nitrate concentration was 8.1 mg per litre (Table 4.6) and 7.3 mg per litre (Table 4.7). Additional calculations revealed that the precipitation surplus, with which the nitrate is leached, was 7% lower in 2007 than in 2006 (see Appendix 5). The REML method was also used to investigate whether the difference in precipitation surplus between the two years influenced the nitrate concentrations measured. This analysis revealed that if the difference in precipitation surplus is taken into account, the increase would have been just 1.4 mg per litre (with a standard error of 2.6 mg per litre). The difference in the precipitation surplus between 2006 and 2007 could therefore explain the difference in nitrate concentration found between the two years.

On the derogation farms in the sand region, the nitrogen leaching increased between 2006 and 2007. This is correlated with the increase in nitrate leaching in this region. The phosphorous leaching in the sand region scarcely changed between 2006 and 2007.

The nutrient concentrations in the ditch water of derogation farms in the sand and clay regions did not change significantly. The nitrate concentration in the ditch water only increased in the peat region (according to both methods) but, at an average level of 5-6 mg/ml in 2007, clearly remained below the standard of 50 mg per litre. In the peat region there was also a concomitant decrease in the phosphorous concentration in the ditch water. These changes were possibly caused by changes in the hydrological conditions; more supply to the ditch water from shallow flows through the soil with more nitrate-rich and phosphorous-poor (younger) groundwater.

Table 4.6 Average nutrient concentrations (mg per litre) in the water flushing from the root zone (leaching) and the ditch water in 2006 and 2007 and the average difference[1] with the standard error. The average difference is the average of the differences per farm for all farms that were sampled in both years.

Soil type parameter	Number of observations	Mean 2006	Mean 2007	Difference 2007-2006	SE
Clay leaching					
Nitrate	16	30.7	29.0	-1.7	3.3
Phosphorous	16	0.38	0.30	-0.09	0.04
Nitrogen (N)	16	9.3	13.4	4.0	4.8
Clay ditch water					
Nitrate	16	13.2	18.4	5.2*	2.3
Phosphorous	16	0.35	0.32	-0.03	0.04
Nitrogen (N)	16	5.0	5.8	0.8	0.5
Sand leaching					
Nitrate	143	51	59	8.1***	2.5
Phosphorous	143	0.10	0.11	0.005	0.02
Nitrogen (N)	139	15	16	1.5**	0.6
Sand ditch water					
Nitrate	11	62	53	-8.7	4.9
Phosphorous	11	0.08	0.11	0.03	0.02
Nitrogen (N)	11	16	14	-1.8	1.1
Peat leaching					
Nitrate	18	3.8	6.7	2.9	4.9
Phosphorous	18	0.88	0.81	-0.07	0.08
Nitrogen (N)	18	12.0	10.5	-1.5	1.8
Peat ditch water					
Nitrate	17	1.2	4.9	3.7**	1.1
Phosphorous	17	0.44	0.28	-0.16**	0.05
Nitrogen (N)	17	4.0	3.5	-0.5	0.5
Loess leaching					
Nitrate	16	82.1	68.5	-13.6	8.7
Phosphorous	16	0.030	0.036	0.006	0.015
Nitrogen (N)	16	19.2	17.2	-2.0	2.3

[1] An asterisk indicates that the probability (p) of a difference being due to chance alone is small.

*	prob <0.05
**	prob <0.01
***	prob <0.001
SE	standard error

Table 4.7 Average nutrient concentrations (mg per litre) in the water flushing from the root zone (leaching) and the ditch water in 2006 and 2007 and the difference[1] with the standard error. REML method.

Soil type Parameter & water type	Mean 2006	Mean 2007	Difference 2007-2006	SE
Clay leaching				
Number	18	59		
Nitrate	29	30	-1.2	3.1
Phosphorous	0.40	0.28	-0.09*	0.04
Nitrogen (N)	8.9	10.4	2.0	2.6
Clay ditch water				
Number	18	58		
Nitrate	12.2	13.8	3.9	2.9
Phosphorous	0.39	0.32	-0.07	0.07
Nitrogen (N)	4.8	4.7	0.5	0.7
Sand leaching				
Number	149	159		
Nitrate	51	56	7.3**	2.4
Phosphorous	0.09	0.12	0.01	0.02
Nitrogen (N)	14.8	15.8 (4 mv)	1.3*	0.6
Sand ditch water				
Number	11	24		
Nitrate	62	41	-18	9
Phosphorous	0.18	0.08	0.03	0.04
Nitrogen (N)	15.6	11.0	-3.8	2
Peat leaching				
Number	18	59		
Nitrate	3.8	14(1 mv)	8.2	6
Phosphorous	0.88	0.53	-0.14	0.07
Nitrogen (N)	12.0	11.1	-1.8	2.4
Peat ditch water				
Number	18	58		
Nitrate	1.2	5.9	3.5**	0.8
Phosphorous	0.44	0.23	-0.17**	0.04
Nitrogen (N)	4.1	3.5	-0.7	0.4
Loess leaching				
Number	19	18		
Nitrate	80	68	-13	8
Phosphorous	0.03	0.03	0	0.01
Nitrogen (N)	19	17	-1.9	2

mv = missing value

[1] An asterisk indicates that the probability (p) of a difference being due to chance alone is small.

* p <0.05

** p <0.01

*** p <0.001

SE standard error

4.3.1 Summary

The nitrate leaching on the sand region farms is clearly higher in 2007 than in 2006; the calculated increase is 8.7 or 7.3 mg per litre, depending on the calculation method used. The precipitation surplus across the Netherlands decreased by an average of 7%, between 2006 and 2007. Without this difference in the precipitation surplus, the increase in the nitrate concentration would have been only 1.4 mg/ml (standard error of 2.6 mg per litre). The difference in the precipitation surplus between the two years might therefore account for the difference in nitrate concentrations found. In the sand and clay regions there was no clear increase or decrease in the nutrient concentrations in the ditch water on derogations farms. The nitrate concentration in ditch water only exhibited a clear difference in the peat region but, at an average of 5-6 mg/ml in 2007, it clearly remained below the standard of 50 mg per litre. In the peat region there was a concomitant decrease in the phosphorous concentration in the ditch water.

In general it can be concluded that most of the concentrations did not change. Where changes were observed these were probably correlated with:

- a difference in the precipitation surplus (nitrate/total N in sand region);
- a difference in hydrological conditions (supply ditch water in peat region).

The measurement data for 2008 will demonstrate whether or not a weather effect indeed exists.

4.4 Effect of agricultural practice on water quality

This section provides a qualitative consideration of the relationship between agricultural practice and the water quality on derogation farms. This examination allows for the fact that there is not a long series of measurements to support such a relationship.

Of all outcomes, the nitrate concentration in the groundwater and surface water is the result most sensitive to changes in agricultural practice. The nitrogen surplus on the soil surface balance is the agricultural practice parameter that can be most directly linked to the nitrate concentration in the water leaching from the root zone. The nitrate concentration is also influenced by meteorological factors and the effects from agricultural practice in previous years. The results reveal that the nitrogen surplus decreased between 2006 and 2007, whereas the nitrate concentration in the sand region increased. The weather could provide a possible explanation for this, as less precipitation fell in 2006/2007 and this could have led to a delay in the leaching. The effect of agricultural practice on water quality would then only be observable in later years.

The peat region exhibited a decrease in the concentration of total phosphate and total nitrogen, and a doubling of the nitrate concentrations in both the groundwater (almost significant) and in the ditches (significant). The agricultural practice exhibited a decrease in the phosphate surplus. The change in the concentration of total nitrogen and nitrate cannot be accounted for by the change in agricultural practice. In the peat region, the total phosphate and nitrogen concentrations found are correlated with the groundwater level; the deeper the groundwater the greater the quantity of phosphate and nitrogen found. The year 2007 was dry, with an average deeper groundwater level. A possible cause could therefore be the oxidation of ammonium nitrogen to nitrate. The aforementioned observations are consistent. It is expected that this difference is greater than a difference due to a phosphate surplus.

In the next report on the derogation monitoring network it shall be possible for the first time, besides agricultural practice data, to compare water quality data influenced by the use of derogation over several years.

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Appendix 1 The derogation decision, relevant articles about monitoring and reporting

This appendix contains the literal texts of the articles from the derogation decision of the European Commission (EU, 2005) with respect to the monitoring and reporting.

Article 8 Monitoring

1. Maps showing the percentage of grassland farms, percentage of livestock and percentage of agricultural land covered by individual derogation in each municipality, shall be drawn by the competent authority and shall be updated every year. Those maps shall be submitted to the Commission annually and for the first time in the second quarter of 2006.
2. A monitoring network for sampling of soil water, streams and shallow groundwater shall be established and maintained as derogation monitoring sites. The monitoring network, corresponding to at least 300 farms to which individual derogation has been consented, shall be representative of each soil type (clay, peat, sandy and sandy loessial soils), fertilisation practice and crop rotation. The composition of the monitoring network shall not be modified during the period of applicability of this Decision.
3. Survey and continuous nutrient analysis shall provide data on local land use, crop rotations and agricultural practices on farms benefiting from individual derogation. Those data can be used for model-based calculations of the magnitude of nitrate leaching and phosphorus losses from fields where up to 250 kg nitrogen per ha per year in manure from grazing livestock is applied.
4. Shallow groundwater, soil water, drainage water and streams in 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.
5. A reinforced water monitoring shall address agricultural catchments in sandy soils.

Article 9 Controls

1. The competent national authority shall carry out administrative controls in respect of all farms benefiting from an individual derogation for the assessment of compliance with the maximum amount of 250 kg nitrogen per ha per year from grazing livestock manure, with total nitrogen and phosphate application standards and conditions on land use.
2. A programme of inspections shall be established based on risk analysis, results of controls of the previous years and results of general random controls of legislation implementing Directive 91/676/EEC. Specific inspections shall address at least 5% of farms benefiting from an individual derogation with regard to land use, livestock number and manure production. Field inspections shall be carried out in at least 3% of farms in respect to the conditions set out in Article 5 and 6.

Article 10 Reporting

1. The competent national authority shall submit the results of the monitoring, annually, to the Commission, together with a concise report on evaluation practice (controls at farm level, including information on non-compliant farms based on results of administrative and field inspections) and water quality evolution (based on root zone leaching monitoring, surface/groundwater quality and model-based calculations). The first report shall be submitted by March 2007 at the latest, and subsequently annually before the end of March 2008, 2009 and 2010.
2. In addition to the data referred to in paragraph 1 the report shall include the following:
   a. data related to fertilisation at all farms which benefit from an individual derogation;

b. trends in livestock numbers for each livestock category in the Netherlands and at derogation farms;

c. trends in national manure production as far as nitrogen and phosphate in manure are concerned;

d. a summary of the results of controls related to excretion coefficients for pig and poultry manure at country level.

3. Thus, results obtained will be taken into consideration by the Commission with regard to an eventual new request for derogation by the Dutch authorities.

4. In order to provide elements regarding management of grassland farms, for which a derogation applies, and the achieved level of optimisation of management, a report on fertilisation and yield shall be prepared annually for the different soil types and crops by the competent authority and submitted to the Commission.

Appendix 2 Selection and recruitment of participants for the derogation monitoring network

A2.1 Introduction

This appendix explains the selection and recruitment of the 300 farms in the derogation monitoring network in detail. As indicated previously in the main text, the derogation monitoring network has become part of the Minerals Policy Monitoring Programme (LMM). The selection and recruitment of farms for the derogation monitoring network is comparable to that of participants in other parts of the LMM. Based on the – then most recent – Agricultural Census data (2005), a sample population was defined for each of the four regions. The sample populations were then divided into groups of farms (the strata) having the same groundwater body, farm type and economic size. From this distribution, the desired number of farms for the sample was derived per stratum, which not only considered the proportion of the total surface area of cultivated land in a given stratum (the greater the area of cultivated land, the greater the number of farms required in the random sample) but also a minimum representation per groundwater body.

The recruitment of farms was initially targeted at farms in the Farm Accountancy Data Network (FADN; report year 2006). For this, all suitable FADN farms were approached that had applied for derogation in 2006. Once the recruitment under FADN farms had been completed, it was determined which strata needed additional farms. Additional farms were selected from a database, compiled by the National Service for the Implementation of Regulations of the Ministry of Agriculture, Nature and Food Quality, which contains all farms that had applied for derogation in 2006. Of the additional participants chosen, fifteen are also participating in the research project *Koeien & Kansen* [Cows and opportunities] (www.koeienenkansen.nl).

Replacements for farms that dropped out between 2006 and 2007 were preferably selected from farms that already participated in the LMM and FADN. With this approach, water quality samples from previous years were also available for farms newly admitted to the derogation monitoring network.

A2.2 Definition of the sample population

Just like the LMM, a limited number of farms from the Agricultural Census database that had registered for derogation were not considered for the sample. The first group of farms excluded from participation in the derogation monitoring network were either very small (economic size smaller than 16 NGE[7]), or extremely large (larger than 800 NGE in size). Farms using organic practices were also excluded as, by definition, organic farms (irrespective of the type of grassland or fertiliser) do not use more than 170 kg nitrogen livestock manure per ha. Also, a minimum farm size of 10 hectares of cultivated land was adhered to so as to safeguard ascertain level of representivity in the total area.

The consequences of the aforementioned selection criteria are illustrated in Tables A2.1 and A2.2. In these tables, the farms (Table A2.1) and the acreages (Table A2.2) in the sample population have been

[7] NGE is the Dutch acronym for Netherlands Unit of Measurement, further information is provided later in this appendix

obtained using data from the Agricultural Census 2007 and a database from the National Service for the Implementation of Regulations which contains more than 25,000 BRS[8] numbers of farms that applied for derogation in the year 2007. As 1590 BRS numbers were missing from the Agricultural Census 2007 it has been decided not to include absolute numbers of farms and hectares in the tables. Instead the numbers of excluded farms and hectares of cultivated land have been expressed as a percentage of the more than 23,000 farms for which data were available in the Agricultural Census 2007.

Table A2.1 Percentage derivation of the number of farms represented in the sample population of the derogation monitoring network in 2007.

	Distribution number of farms		
	Dairy farms	Other grassland farms	Total
All farms registered for derogation in 2007	71.6%	28.4%	100.0%
Farms <16 NGE	0.3%	11.2%	11.5%
Farms >800 NGE	0.0%	0.0%	0.0%
Organic farms	0.5%	0.2%	0.7%
Farms <10 ha	0.7%	1.5%	2.1%
Sample population	70.1%	15.5%	85.6%

Table A2.2 Percentage derivation of the acreage of cultivated land represented in the sample population of the derogation monitoring network in 2007.

	Distribution acreage cultivated land		
	Dairy farms	Other grassland farms	Total
All farms registered for derogation in 2007	85.3%	14.7%	100.0%
Farms <16 NGE	0.0%	2.1%	2.1%
Farms >800 NGE	0.1%	0.0%	0.1%
Organic farms	0.7%	0.2%	0.8%
Farms <10 ha	0.1%	0.3%	0.4%
Sample population	84.3%	12.3%	96.6%

Tables A2.1 and A2.2 reveal that more than 70% of the derogation farms registered in 2007 and 85% of the associated acreage of cultivated land concerned specialised dairy farms. Furthermore, most of the dairy farms also satisfied the selection criteria for the sample population for the derogation monitoring network. The farms excluded are mainly other grassland farms with a small size in terms of NGE and cultivated land. As a consequence of the selection criteria adopted, almost 15% of the farms registered for derogation (yet only 3.4% of the acreage on which derogation has been applied for) fell outside of the sample design.

[8] BRN is the Dutch acronym for Farm Relation Number, under which farms are registered at the National Service for the Implementation of Regulations (organisation responsible for implementing European and Dutch regulations and an executive branch of the Ministry of Agriculture, Nature and Food Quality).

A2.3 Explanation per stratification variable

The derogation decision demands a monitoring network that is not only representative for all soil types but also for all fertilisation practices and crop rotations (Article 8 of the derogation decision). Accordingly, the stratification took place not only per region but also per farm type, economic size (size class) and groundwater body. These variables are explained in this section.

Classification according to farm type
For the classification of farms according to farm type, use was made of the classification based on the NEG classification[9] (Poppe, 2004). The NEG profile of a farm is determined by the extent to which the farm produces specific types of crops and/or keeps certain types of animals. For this, all crop acreages and numbers of animals per animal species present are converted into so-called standard gross margins (SGM). A farm is characterised as 'specialised' when a significant proportion (often at least two-thirds) of the total farm volume comes from a certain type of production (for example, dairy, arable or pigs). Within the NEG profile, eight main farm types can be distinguished of which five are pure and three combined. The five pure, main farm types are:
- arable
- market gardening
- permanent cultivation (fruit growing and tree nurseries)
- grazing livestock and housed animals (intensive livestock farming).

Combined farms are classified as:
- crop combinations
- mixed husbandry
- arable and mixed husbandry

Each main farm type is further divided into several subtypes. For example, within the grazing animal farms, specialised dairy farms are distinguished.

Within the group of farms that applied for derogation, dairy farms form a large homogenous group (that use almost 85% of the acreage of cultivated land as can be seen from Table A2.2). A good 14% of the acreage is situated on farms of a different type. These farms were also included in the monitoring network so as to gain as representative a sample as possible in terms of crop rotations and fertilisation practices.

Classification according to economic size
Other than farm type, farms were also classified according to economic size, for which four size classes are distinguished. This prevents farms of a smaller or larger economic size from being overrepresented.

The economic size was also determined using the standard gross margins. The total standard gross margins at farm level were converted into Netherlands Magnitude Unit (NGEs) by means of a scaling factor (De Bont et al., 2003).

[9] The NEG classification is a slightly modified version of the EC classification of farms that was introduced by Statistics Netherlands (CBS) for the Netherlands. This classification has retained its name despite the EC having become the EU.

Classification according to groundwater body per main soil type region
For the Framework Directive Water, a total of twenty groundwater bodies are distinguished in the Netherlands (Verhagen et al., 2006). During the setting up of the derogation monitoring network, a fair distribution (and minimal representation) was strived for in each region to cover the most important groundwater bodies measured in terms of cultivated land area. The municipality in which the farm receives post formed the basis for determining the groundwater body per farm. In municipalities where several groundwater bodies are found, all farms were attributed to the largest groundwater body.

Within the sand region, five groundwater bodies were distinguished as subregions, namely: Eems, Maas, Rhine Central, Rhine North and Rhine East. The other farms (in other groundwater bodies within the region) were attributed to the sixth subregion termed 'other'. The loess region only contains the '*Krijt*' [Chalk] groundwater body and was therefore not classified further. The peat region was divided into four subregions, namely the groundwater bodies Rhine North, Rhine East, Rhine West and 'other'. Five subregions were eventually distinguished in the clay region. As several groundwater bodies are situated in the South-western sea clay area (without clear domination) this entire clay area was classified as a separate subregion. A further three groundwater bodies were distinguished as separate subregions: Eems, Rhine North and Rhine West (in so far as this is located outside of the South-western sea clay area). The fifth subregion concerned the farms in other, not further classified, municipalities.

In Tables A2.3 to A2.6, the numbers of dairy and other grassland farms recruited per main soil type region and the subregions within these, are stated. Figure A2.1 shows the farms and subregions.

Table A2.3 Number of farms realised in the sand region in 2007, per subregion.

Groundwater body	Total number of farms	Number of dairy farms	Number of other grassland farms
EEMS sand	8	6	2
MAAS sand	30	25	5
RHINE CENTRAL sand	16	11	5
RHINE NORTH sand	29	27	2
RHINE EAST sand	72	66	6
OTHER within sand region	4	4	0
TOTAL SAND REGION	159	139	20

Table A2.4 Number of farms realised in the clay region in 2007, per subregion.

Groundwater body	Total number of farms	Number of dairy farms	Number of other grassland farms
EEMS clay	5	4	1
RHINE NORTH clay	16	15	1
RHINE WEST clay[1]	19	15	4
Western sea clay area	6	6	0
OTHER within clay region	13	11	2
TOTAL CLAY REGION	59	51	8

[1] Concerns farms situated outside of the south-western sea clay area.

Table A2.5 Number of farms realised in the peat region in 2007, per subregion.

Groundwater body	Total number of farms	Number of dairy farms	Number of other grassland farms
RHINE NORTH peat	13	11	2
RHINE EAST peat	16	14	2
RHINE WEST peat	25	24	1
OTHER within peat region	6	4	2
TOTAL PEAT REGION	60	53	7

Table A2.6 Number of farms realised in the loess region in 2007.

Groundwater body	Total number of farms	Number of dairy farms	Number of other grassland farms
TOTAL LOESS REGION	18	15	3

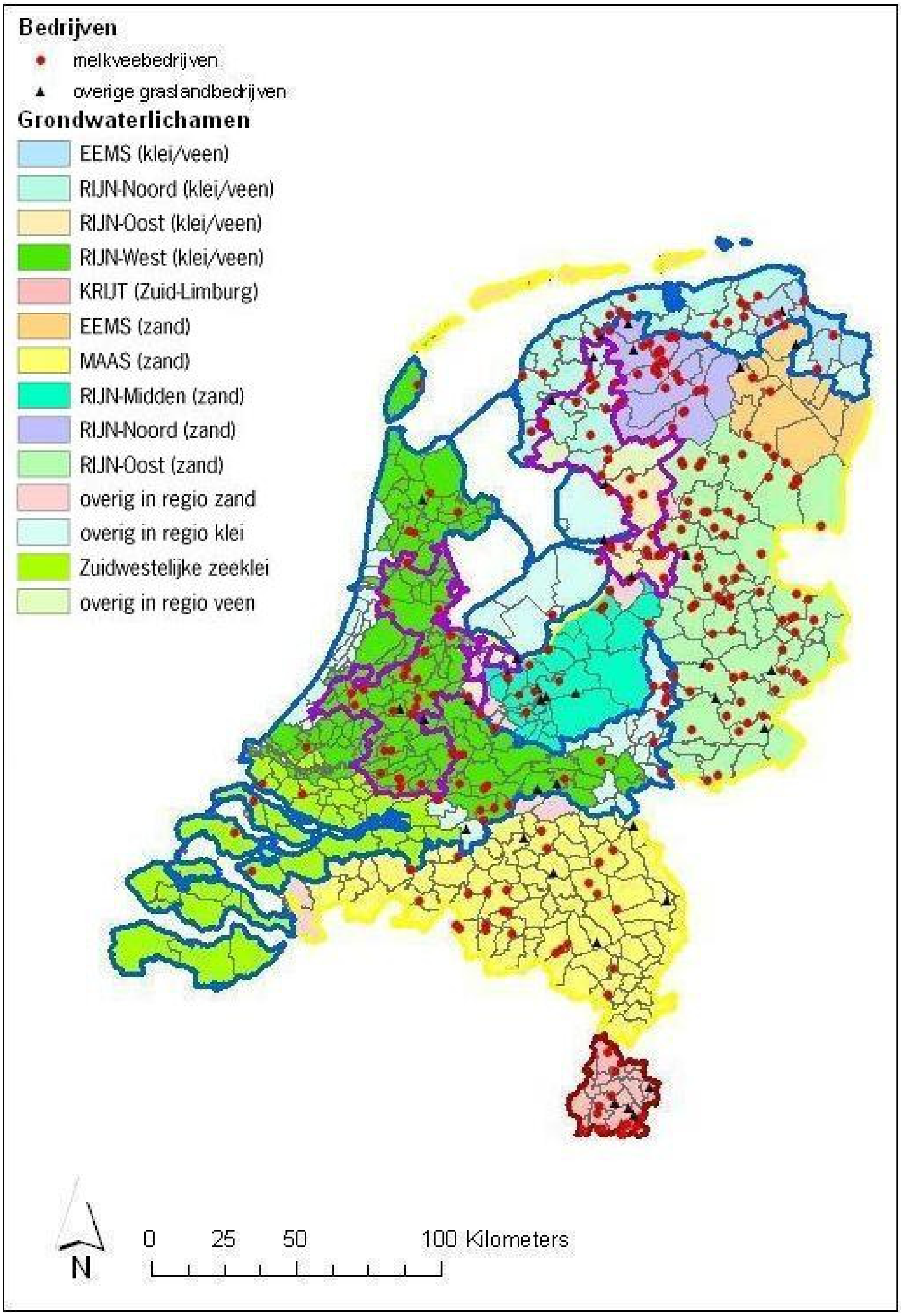


Figure A2.1 Location of dairy farms (●) and other grassland farms (▲) participating in the derogation monitoring network in 2007 per subregion.

Appendix 3 Monitoring of agricultural characteristics

This appendix provides an explanation of how the data about agricultural practice in the LEI-FADN were monitored and how the fertiliser usage, crop yields (section 2) and nutrient surpluses (section 3) were calculated from these data.

A3.1 Introduction

The LEI is responsible for monitoring the data on agricultural practices as part of the FADN. The FADN is a stratified sample of approximately 1500 farms and horticultural enterprises for which a detailed set of financial-economic and environmental data are maintained. The FADN represents almost 95% of the total agricultural production in the Netherlands (Poppe, 2004). Approximately 45 full-time LEI staff are responsible for collecting and recording the operational data in FADN. They process all the invoices of the participating farms. They also stock take initial and end supplies and additional data such as the crop rotation, grazing system and the composition of the livestock population. Participants receive a report from LEI, which largely contains annual totals (such as profit and loss accounts and a balance). Since apart from financial flows also many physical flows are registered data registration is complex and therefore, the outcomes are checked on inconsistencies resulting from data processing by researchers or participants.

Most of the data in FADN are converted into annual totals corrected for stock adjustments. The feed concentrate use per year therefore emerges from the sum of all purchases between two balance dates, minus all sales, plus the starting stock, minus the end stock. The use of fertilisers is known not just on an annual basis but also on a seasonal basis, running from the moment that the preceding crop is harvested until the harvest of the crop.

Fertilisation, yield and nutrient surpluses are expressed per surface unit. For this, the total acreage of the cultivated land is used. This is the acreage the farm actually fertilises and uses for crop production. Rented land, natural habitat, ditches and built-on land are not included in this acreage.

A3.2 Calculation of fertilisation and crop yields

According to the derogation decision (EU, 2005) the report should include details regarding the fertilisation and crop yield (Article 10, para 4). This article states (see Appendix 1): 'In order to provide elements regarding management in grassland farms, for which a derogation applies, and the achieved level of optimisation of management, a report on fertilisation and yield shall be prepared annually for the different soil types and crops by the competent authority and submitted to the Commission'.
For the presentation about fertiliser use, a distinction is made between the four regions (clay, peat, sand and loess). First fertilisation at farm level is reported, thereafter also a distinction is made between fertilisation on arable land and grassland.

Calculation of the fertiliser use

Nitrogen from livestock manure

For the calculation of fertiliser use from livestock manure, the production of manure on the farm is determined first. For nitrogen, this is the net production after subtraction of gaseous nitrogen losses from housing and storage. The manure production for grazing livestock is calculated by multiplying the mean number of animals present by the statutory excretion forfeits (Dienst Regelingen, 2006). An exception to this are those dairy farms that make use of the so-called Guidance (see header 'Farm-specific use of livestock manure' that follows in this appendix). For manure production from intensive livestock animals, the number of animals concerned is multiplied by the national excretion forfeits, as stipulated by the Working Group Uniformisation Manure Figures (Van Bruggen, 2007)[10].

Furthermore, the quantity of nutrients is registered for all fertilisers and stock (artificial fertiliser, livestock manure and other organic fertilisers) imported and exported. In principle, the quantity of nitrogen and phosphate in all imported and exported fertilisers is calculated by means of sampling. If sampling has not taken place, forfeit levels per fertiliser type are used (Dienst Regelingen, 2006). Nutrients in initial and final stocks are always calculated using forfeits (Dienst Regelingen, 2006).

The total quantity of fertiliser used at farm level is subsequently calculated as:

Fertiliser use farm = Manure production + Initial stock - Final stock + Input - Output

The quantities of fertilisers used on arable land are directly registered within FADN. Besides the type and quantity, the time of application is also recorded. The fertiliser use on grassland is subsequently calculated as:

Fertiliser use on grassland = Fertiliser use farm - Fertiliser use on arable land

This use on grassland consists of manure that is spread and manure that is directly excreted onto the grassland by grazing livestock (grassland manure). The quantity of nutrients directly excreted on grassland is calculated per type of animal by multiplying the percentage of time on an annual basis that the animals graze, by the excretion forfeits (Dienst Regelingen, 2006).

Farm-specific use of livestock manure

Since 2007, FADN has modified the calculation of the manure production for farms that make use of the Guidance farm-specific excretion dairy cattle. On these farms, manure production is not calculated on the basis of forfeits, but farm-specifically as long as the following criteria are satisfied:

- The farm is a specialised dairy farm (according to NEG classification).
- The dairy herd is at least 67% of the total GVE quantity of grazing livestock.
- No pigs and/or poultry are present on the farm.
- At least 80% of the acreage consists of fodder crops.
- The farm-specific calculation gives a real advantage (i.e. lower excretion) compared to the calculation using forfeits.

For the calculation of the farm-specific excretion of the dairy herd, the Guidance farm-specific excretion diary cattle before 1 January 2009 is used as the starting point (LNV, 2009a). All of the

[10] This is in contrast to the statutory calculation of manure production on intensive livestock farms. There the manure production is calculated as supply food and animals minus the removal of animals and animal products.

sections in this are followed, except for the calculation of the energy uptake (expressed in VEM which is the Dutch standard for the net energy content of feeds) from fresh grass (meadow grass and zero-grazing) and the empirical relationship between the uptake from grass silage and from fresh grass. For these exercises in the calculation the guidance effective from 1 January 2009 is used (LNV, 2009b), as this gives a more accurate representation[11].

Nitrogen use
The total nitrogen use is expressed in kg plant-available nitrogen. The quantity of plant-available nitrogen is calculated by multiplying the total quantity of nitrogen in organic fertilisers by the availability coefficient as stated in Table A3.1.

The plant-availability coefficient of nitrogen for all livestock manure produced and applied on the farm is lower if grazing is applied on the farm (35% instead of 60%). Also a lower plant-availability coefficient is calculated for the fertilisation of arable land during the autumn on clay and peat soil. In all other cases, the availability coefficient depends solely on the type of fertiliser.

Phosphate use
Phosphate use is expressed in kg phosphate. The calculation of the use includes all fertilisers with the exception of a part of the phosphate applied via compost and defecation scum.

Table A3.1 Applied availability coefficient (in%) for determination of nitrogen use (Dienst Regelingen, 2006).

Type fertiliser	Condition	Availability coefficient
Autumn application livestock manure on arable land on clay or peat soil	Liquid manure	30 (2006) 40 (2007)
	Solid manure	25
Manure produced by livestock on own farm	Farm with grazing	35
	Farm without grazing	60
Other fertilisers and conditions	Thin fraction and slurry	80
	Liquid manure	60
	Solid manure from pigs, poultry and minks	55
	Solid manure other animal species	40
	Mushroom compost	25
	Compost	10
	Sewage sludge	40
	Other organic fertilisers	50

[11] In the old guidance a distinction was only made between ‘more than' or 'less than' 138 days of grazing season. In the new guidance the actual number of days in the grazing season and zero-grazing are taken into account.

Calculation grass and silage maize yield

Design calculation module
The calculation module for determining the grass and silage maize yield in FADN has the same design as the procedure described in Aarts et al. (2005, 2008). The calculation module starts by determining the energy requirement of the dairy herd based on the milk production and growth realised. In FADN all transactions and stock mutations for feed products are registered. This clarifies what proportion of the energy requirement is covered by purchased feed. Then the energy uptake from farm-produced silage maize and other forage crops (other than grassland) is determined by multiplying yield estimates from the entrepreneur and/or advisor by the energy content (Dutch milk feed unit - VEM) of the crop. Finally it is assumed that the remaining energy requirement is satisfied by means of grass produced on the farm. The number of days in the grazing season registered in FADN is used to hypothesise a ratio between the energy uptake from fresh grass and that from grass silage.

The aforementioned procedure clarifies how much VEM is obtained by the herd from farm-produced feed. The nitrogen and phosphorous uptake are then calculated by multiplying this VEM uptake by the N:VEM and P:VEM ratios. Finally, the nitrogen and phosphorous yields for silage maize and grassland are calculated by multiplying the nitrogen and phosphorous uptake by the quantity of nitrogen and phosphorous lost on average during feed production and ensilaging.

Selection criteria
The calculation method used is not applicable for all farms. On mixed farms it is often difficult to clearly separate the product flows between different production units. Therefore, in accordance with Aarts et al. (2008) the method is only used on farms that satisfy the following criteria:

- It is a specialised dairy farm according to the NEG classification.
- The dairy herd is at least 67% of the total GVE quantity of grazing livestock.
- No pigs and/or poultry are present on the farm.
- At least 80% of the acreage consists of fodder crops.
- The countryside premium per ha grassland is no more than 100 euro.

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

- At least 15 ha fodder crops.
- At least 30 dairy cows.
- At least 4500 kg milk corrected for fat and protein (FPCM) per cow per year.
- Non-organic production method.

These criteria were not considered because in the study of Aarts et al. (2008) they were only used to allow statements to be made about the population of 'typical' dairy farms. In the Derogation Monitor the population has already been determined (permanent monitoring network of 300 farms) and therefore these criteria can be ignored.

Additionally, with respect to the outcomes the following confidence intervals for yields were used in accordance with Aarts et al. (2008):

Silage maize yield: 5000 - 22,000 kg dry matter per ha
Grassland yield: 4000 - 20,000 kg dry matter per ha

For yields that fall outside of this range it is assumed that this must have been caused by an error in the registration. The farms concerned are also excluded from the report.

Deviations from Aarts et al.
In several cases the procedure described by Aarts et al. (2005, 2008) is deviated from because more detailed information was available or because the procedure could not be incorporated in FADN in a comparable manner. It concerns the following items:
1. Composition of silage and silage maize.
2. Supplement for grazing based on the actual number of days in the grazing season.
3. Ratio of silage grass to fresh grass based on the actual number of days in the grazing season.
4. Conservation and feeds losses.

Ad 1)
In Aarts et al. (2008) the composition of grass and silage maize is based on provincial averages of the Netherlands Laboratory for Soil and Crop Research (BLGG). A slightly different method was used in FADN. Since 2006, the composition of the grass silage and silage maize silage has been recorded per farm in FADN. In the FADN calculation procedure, use is made of this farm-specific composition when all silage pits obtained have been fully sampled. If that is not the case (in one of the silage pits one of the parameters – dry matter, VEM, N or P – is missing) then the national average composition is used. This average composition of silage maize and grass is detailed in Table A3.2.

Table A3.2 National average composition of grass silage and silage maize in 2007 (website BLGG).

Silage type	Dry matter (gram per kg)	VEM (per kg dry matter)	N (gram per kg dry matter)	P (gram per kg dry matter)
Silage maize	339	963	11.7	2.1
Grass silage	514	898	28.0	4.1

Ad 2)
For the calculation of the energy requirement, a so-called mobilization charge has been incorporated. This mobilization charge is, for example, dependent on the grazing. In Aarts et al. (2008) a distinction was made between three types of grazing, namely 0 days, 138 days and more than 138 days. Since 2004, the exact number of days in the grazing season has been registered n FADN and so it was decided to use this data in the calculation. For every day of unlimited grazing, 533 VEM (16000/30) extra mobilization charge was incorporated per cow and for each day of limited grazing 400 VEM (12000/30), in accordance with Appendix 2 from the notes Guidance 2009 (LNV,2009b).

Ad 3)
In addition, the ratio of the energy uptake from fresh grass and silage grass is, in contrast to Aarts et al. (2008) based on the number of days in the grazing season and/or zero-grazing registered in FADN. For zero-grazing the percentage of fresh grass varies between 0 and 35%, in the case of unlimited grazing between 0 and 40% and in the case of limited grazing between 0 and 20%. This calculation is also performed in accordance with Appendix 2 from the note Guidance (LNV, 2009b).

Ad 4)
The information in appendix III in Aarts et al. (2008) is not complete with respect to the percentages adopted for conservation losses. To prevent misunderstandings, all percentages used in FADN for the calculation of conservation and feeds losses are shown in Table A3.3.

Table A3.3: Percentages used for conservation- en feeds losses.

	Conservation losses				Feed losses
Category	dry matter	VEM	N	P	dry matter, VEM, N and P
Wet by-products	4%	6%	1.5%	0%	3%
Additional roughage consumed	6%	8%	2%	0%	5%
Feed concentrate	0%	0%	0%	0%	2%
Milk products	0%	0%	0%	0%	2%
Silage maize	4%	4%	1%	0%	5%
Grass silage	10%	15%	3%	0%	5%
Meadow grass	0%	0%	0%	0%	0%

Demonstration calculation for grassland and silage maize yield

In Table A3.4 the yields for grassland and silage maize are calculated for a demonstration farm. The calculation of the VEM requirement is not explained further. This is described in detail in appendix III of the report by Aarts et al. (2008).

Table A3.4 Demonstration calculation for determination of yields for grassland and silage maize.

Demo calculation				
Grazing	183 days limited grazing			
Ha grassland	40			
Ha sil. maize	10			
	quantity	KVEM	N	
Total VEM uptake = 1.02 * VEM requirement		750000		
	quantity	KVEM	N	
Comp. Feed conc.	per kg	960	28.0	5.
Use feed conc. **(purchase-sale+bv-ev)**	200000	192000	5600	100
Feed losses	4000	3840	112	2
Net uptake feed conc.	196000	188160	5488	98
	quantity	KVEM	N	
Comp. wet by-products	per kg dm	1020	12.0	2.
Use wet by-products **(purchase-sale+bv-ev)**	20000	20400	240	4
Conservation losses	800	1224	4	
Fed	19200	19176	236	4
Feed losses	576	575	7	
Net uptake by-products	18624	18601	229	3
	quantity	KVEM	N	
Comp. additional roughage	per kg dm	700	10.2	2.
Use add. roughage **(purchase-sale+bv-ev)**	600	420	6.1	1.
Conservation losses	36	34	0.1	0.
Fed	564	386	6.0	1.
Feed losses	28	19	0.3	0.
Net uptake additional roughage	536	367	5.7	1.
		KVEM	N	
Total use feed purchased **(=sum feed conc. + wet by-products and additional roughage)**		207128	5723	102
	quantity	KVEM	N	
Comp. own silage maize	per kg dm	960	11.1	2.
Production own sil. maize **(= estimate yield by entrepreneur)**	140000	134400	1554	30
Conservation and feed losses	12600	12096	93.24	15.
Net uptake silage maize	127400	122304	1460.76	292.
	quantity	KVEM	N	
Net uptake from grass products **(=VEM total uptake - Use feed purchased - production own silage maize**		402780		
Factor fresh grass **(based on grazing system determined)**		20%		
Fresh grass composition	per kg dm	990	35	4.
Uptake from fresh grass **(=factor fresh grass * net uptake from grass products)**		80556	2848	39
	quantity	KVEM	N	
Grass silage composition	per kg dm	900	32	4.
Net uptale form grass silage **(=net uptake from grass products - uptake from fresh grass)**	358027	322224	11457	161
Feed losses	17901	16111	573	8
Grass silage feed	375928	306113	10884	153
Conservation losses	37593	45917	327	
Grass yield (over the dam)	413521	352030	11211	153
	kg dm	KVEM	N	P
Yield silage maize per ha	14000	13440	155	31
Yield grassland per ha	10338	8801	280	38

A3.3 Calculation of nutrient surpluses

In addition to fertilisation and crop yield the surplus of nitrogen and phosphate on the soil surface balance (in kg N per ha and phosphate in kg P_2O_5 per ha) is also reported on. These surpluses are calculated with the help of a method derived from the approach used and described by Schröder et al. (2004, 2007). This means that in addition to the quantities of nitrogen and phosphate in inorganic and artificial fertilisers, and the quantities of nitrogen and phosphate removed in crops, consideration is also given to other supply categories such as net mineralization of organic matter in the soil, nitrogen fixation by legumes and atmospheric deposition. The calculation of nutrient surpluses on the soil surface balance assumes an equilibrium situation. It is assumed that in the longer term, the import of organic nitrogen, in the form of crop residues and organic fertiliser, is equal to the annual breakdown. An exception is made to this rule for peat and reclaimed soils for which a supply from mineralization is used of 160 kg N per ha for grassland on peat and 20 kg N per ha for grassland on reclaimed soil and other crops on peat and reclaimed soil. For these soils it is known that net mineralization occurs as a consequence of the groundwater level management that is necessary to be able to use these soils for agricultural purposes. Schröder et al. (2004, 2007) calculated the surplus on the soil surface balance by using the release of nutrients as the starting point. In this study, a balance method is used to calculate the surplus on the soil surface balance from the farm data.

The calculation method used for the nitrogen surplus is summarised in Table A3.5. Initially, the surplus on the farm gate balance is calculated by adding the supply and removal of nutrients registered in the bookkeeping. This surplus is calculated with the inclusion of stock mutations. Regarding nitrogen, the surplus calculated on the farm gate balance is then corrected for input and output categories on the soil surface balance. Similarly, for phosphate the surplus on the soil surface balance is the same as the surplus on the farm gate balance. A more detailed explanation of the calculation methods can be found in the footnotes below the tables.

Table A3.5 Calculation method used for determining nitrogen surplus on the soil surface balance (kg N, per ha, per year).

Description categories		Calculation method
Input farm	Artificial fertiliser	Quantity[a] * level[e]
	Livestock manure and other organic fertiliser	Quantity[b] * levele[h]
	Feed	Quantity[a] * level[e,f]
	Animals	Quantity[b] * level[i]
	Plant products (sowing seed, young plants and seed potatoes)	Quantity[b] * level[g]
	Other	Quantity[b] * level
Removal farm	Animal products (milk, wool, eggs)	Quantity[c] * level[j]
	Animals	Quantity[d] * level[i]
	Livestock manure and other organic fertiliser	Quantity[d] * level[h]
	Crops and other plant products	Quantity[d] * level[g]
	Other	Quantity[d] * level
N surplus on the farm gate	Input farm - Output farm	
Input soil	+ Mineralisation	160 kg N for peat soil and 20 kg for reclaimed soil
	+ Atmospheric deposition	Differentiated per province
	+ N fixation by legumes	All legumes[m]
Output soil	- Volatilisation from housing and storage	Based on animal species, housing system and grazing
	- Volatilisation application and grazing	Artificial fertiliser and livestock manure, based on actual manure production, grazing and application method[o]
N surplus on the soil surface balance	N surplus farm + input soil surface balance - output soil surface balance	

a) Purchase - sale + initial stock - final stock.
b) Purchase + stock decrease.
c) Sale - purchase + final stock - initial stock.
d) Sale + stock increase.
e) N levels artificial fertiliser, feed concentrate and single feeds via annual reviews supplier. If these are not available then standards are used.
f) N levels for roughage via quarterly overviews or estimated standards (CVB, 2003).
g) N levels crops and plant products according to Van Dijk (2003).
h) N levels livestock manure and compost according to Dienst Regelingen (2006).
i) N levels animals according to Beukeboom (1996).
j) The N level of milk is calculated as the farm-specific protein level/6.38. Other N level animal products according to Beukeboom (1996).
k) For grass on peat: 160 kg N per ha per year, other crops on peat as equally reclaimed soil (irrespective of crop): 20 kg N per ha per year, all other soil types: 0 kg. For FADN farms the areas are established according to the four soil types used by the National Service for the Implementation of Regulations (sand/clay/peat/loess). For the estimation of the mineralisation of reclaimed land use was made of global soil classifications per farm (based on the postal code) according to De Vries and Denneboom (1992).

l) The atmospheric deposition is differentiated each year per province and varied in 2006 between 23 and 40 kg N per ha per year (MNP/CBS/WUR, 2007).

m) N fixation in kg N per ha per year (Schröder, 2006).
- for grass clover: in the case of clover proportion <5%: 10 kg, in the case of clover proportion between 5 and 15%: 50 kg, in the case of clover proportion >15% 100 kg, proportion of clover according to figures submitted by the participant;
- for lucerne: 160 kg;
- for peas, broad beans, kidney beans and snap peas 40 kg;
- for other legumes 80 kg.

n) Emissions from housing and storage are calculated as a function of the livestock species, housing system and grazing system according to Oenema et al. (2000).

o) Volatilisation in the case of grazing: 8% of the N total excreted on grassland (Schroder et al., 2005). In the case of mechanical application on grassland: trailing foot spreader, 10% of N total; trussed beam plough, 6.5% of N total; shallow grassland injector, 3% van N total; aboveground spreading of solid manure, 14.5% of N total. On arable land, incorporating 8.5% van N total; injection, 1% of N total; aboveground spreading of solid manure, 14.5% of N total (Van Dijk et al., 2004, Table 1).

Appendix 4 Sampling of water on farms

A4.1 Introduction

The derogation decision (EU, 2005) states that a report must be produced concerning the evolution of water quality based on, for example, regular monitoring of leaching from the root zone and checking of surface and groundwater quality (Article 10, para 1). For this, the monitoring of the quality of the 'shallow groundwater layers, soil water, drainage water and watercourses on farms that are part of the monitoring network' must provide data about the nitrate and phosphorus concentrations in the water leaving the root zone and ending up in the groundwater and surface water system (Article 8, para 4).

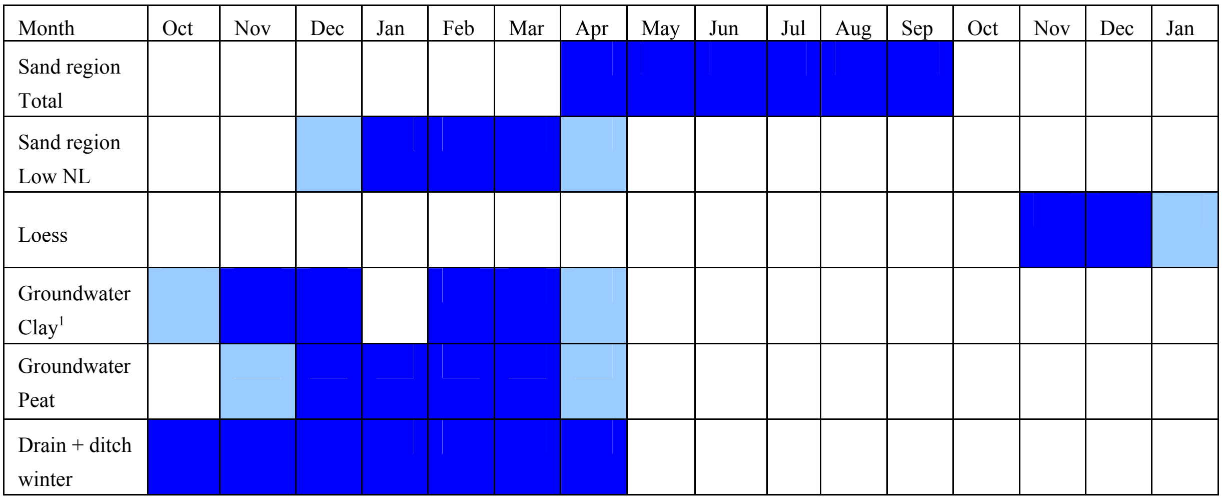
Water sampling
In the Netherlands, the groundwater level is often present just beneath the root zone; the mean groundwater level in the sand region is approximately 1.5 metres below the surface. In the clay and peat regions, the groundwater levels are, on average, even shallower. Only on the push moraines of the sand region and in the loess region is the groundwater level mostly deeper than 5 metres beneath the surface. Therefore, in the majority of situations, leaching from the root zone or leaching into groundwater can be measured by sampling the uppermost metre of groundwater. In situations where the groundwater level is deeper (more than five metres below the surface) and the soil retains sufficient moisture (loess region), the soil water below the root zone is sampled. There is little agriculture on the push moraines in the sand region. Where this does occur, the soil water below the root zone is also sampled if possible.

The loading of surface water with nitrogen (N) and phosphorus (P) takes place via run-off and groundwater, in which the travel times are usually long. In the High Netherlands, only leaching from the root zone is monitored by sampling the uppermost metre of groundwater or of soil water under the root zone. In the Low Netherlands, in areas drained via ditches, whether or not in combination with pipe drainage, the travel times are shorter. Here, the loading of surface water is visualised by sampling ditch water in combination with sampling of the uppermost metre of groundwater or water from the drainage pipes (drain water).

Number of measurements per farm
On each farm, groundwater is sampled at sixteen measurement locations, drain water at sixteen locations, soil moisture at sixteen locations and ditch water at eight locations. The number of measurement locations is 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, 1997, 1995; 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).

The measurement period and measurement frequency

Sampling takes place in the winter in the Low Netherlands. During the winter, the precipitation surplus here is largely transported via shallow groundwater flow to surface water. In the summer, especially in the peat region, water from the main rivers is often let into the ditches. Sampling from sand and loess soils in the High Netherlands can take place in both the summer and the winter. As the available sampling capacity must be spread over the year, the sand region is sampled in the summer and the loess region in the autumn. The measurement period (see Figure A 4.1) has been chosen in such a manner that the measurements represent leaching from the root zone and with this provide as good a picture as possible of the agricultural practices in the previous year. Weather conditions can, in practice, result in sampling taking longer or being delayed.



[1]: The exact starting date of the sampling depends on the quantity of precipitation. Sufficient precipitation must have fallen before leaching to the groundwater can take place. Under the current regulations sampling never starts later than 1 December.

Figure A4.1: Overview of standard sampling periods for determining the water quality per main soil type region.

Soil moisture and groundwater are measured at least once per year on each farm. The annual precipitation surplus in the Netherlands is approximately 300 mm per year. This quantity of water spreads throughout a soil with a porosity of 0.3 (typical for sandy soil) over a layer of around 1 metre in the soil (saturated soil). Therefore, the quality of the uppermost metre gives a good picture of the annual leaching from the root zone and the loading of groundwater. Other types of soil (clay, peat, loess) generally have a greater porosity. In other words, a sample from the uppermost metre will contain, on average, water from more than just the previous 1 year. A measuring frequency of once per year is therefore sufficient. Previous research has demonstrated that the variation in the nitrate concentration within one year, as well as the variation between previous years, disappears if dilution effects and variations in the groundwater level are taken into account (Fraters et al., 1997).

From the start of the first sampling season following granting of derogation (1 October 2006), the frequency of the sampling of drain water and ditch water was increased for the Low Netherlands, from two to three rounds per winter (current realised LMM sampling frequency) to approximately four rounds per winter (intended LMM sampling frequency) to achieve a better spread over the leaching season. The feasibility of the four rounds depends upon the climatological conditions. Too little precipitation or frost can lead to drains not being sampled. The intended LMM sampling frequency was based on research carried out by Meinardi and Van den Eertwegh in the early 1990s (Meinardi and Van den Eertwegh, 1997, 1995; Van den Eertwegh, 2002). Van den Eertwegh, 2002). The evaluation of the LMM programme in the clay areas, in the period 1996-2002, led to the conclusion that there was no reason to change the existing relationship between the number of sampling rounds per farm (realised sampling frequency) and year, and the number of drains sampled per farm and per sampling round (Rozemeijer et al., 2006). The intensification emerges from the European Commission's request for an increased sampling frequency. A frequency of four times per year is equivalent to the proposed sampling frequency for operational monitoring of vulnerable phreatic groundwater that has a relatively fast and shallow run-off (EU, 2006).

Besides the compulsory components of nitrate, total nitrogen and total phosphorus, the chemical analysis of the water samples also included the determination of other water characteristics. This was performed to clarify the data for the measurements of the compulsory components. These additional components were ammonium nitrogen, ortho-phosphorus and several general characteristics such as conductivity, pH and dissolved organic carbon. The results of these additional measurements have not been included in this report.

The following sections describe the sampling per region in greater detail.

A4.2 The sand and the loess regions

Standard sampling

Groundwater sampling of the derogation farms in the sand region took place in the period May 2007 to September 2007 (although farms were sampled for the LMM in April, these did not participate in the derogation monitoring network) and in the loess region in the period October 2007 to January 2008 (see Figure A4.2). In these periods, each farm was sampled once.

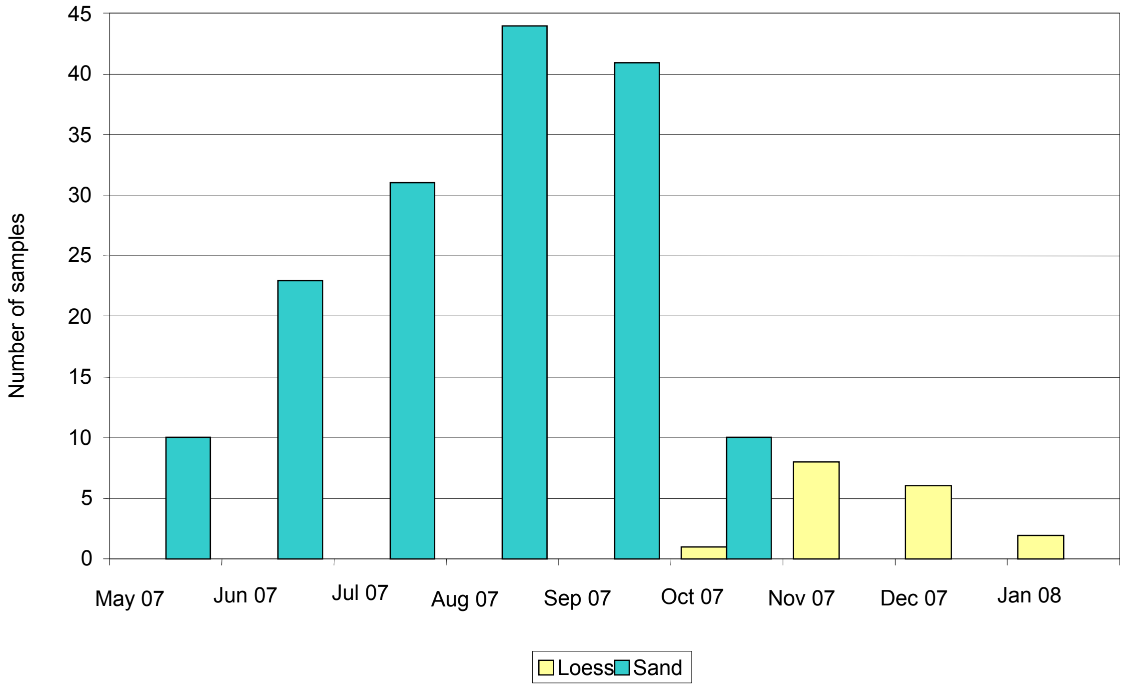


Figure A4.2 Number of samples for groundwater and soil moisture in the sand and loess region per month during the period May 2007 to January 2008.

The sampling was carried out according to the standard sampling method. This was as follows: on each farm, samples were taken from bore holes made at 16 locations. The number of locations per plot depended on the size of the plot and the number of plots on a farm. Within the plot the locations were chosen randomly. Selection and positioning took place according to a protocol[12]. The uppermost metre of groundwater was sampled using the open bore hole method[13]. In the field, the groundwater level and nitrate concentration (Nitrachek-method) were determined[14]. The water samples were filtered[15], conserved[16] and stored in a cool dark place for transport to the laboratory.[17] In the laboratory, two

[12] *Bepaling van de ligging van de bemonsteringspunten* [Determination of the location of the sampling points]. SOP number LVM-BW-P618. National Institute for Public Health and the Environment (RIVM)

[13] *Grondwaterbemonstering met een bemonsteringslans en slangenpomp op zand-, klei- of veengronden* [Groundwater sampling with a sampling lance and hose pump on sandy, clay or peat soils]. SOP number LVM-BW-P435. National Institute for Public Health and the Environment (RIVM)

[14] *Het meten van de nitraatconcentratie in een waterige oplossing m.b.v. een nitrachek-reflectometer (type 404)* [The measurement of the nitrate concentration in an aqueous solution with the aid of a nitracheck-reflectometer (type 404)]. SOP number LVM-BW-P110. National Institute for Public Health and the Environment (RIVM)

[15] *Filtreren van grond- of slootwater met behulp van een filterbedhouder en een 0,45 ìm membraanfilter* [Filtering of groundwater or ditch water using a filter bed holder and a 0.45 ìm membrane filter]. SOP number LVM-BW-P434. National Institute for Public Health and the Environment (RIVM)

[16] *Methode voor het conserveren van watermonsters door het toevoegen van een zuur* [Method for conserving water samples by adding an acid]. SOP number LVM-BW-P416. National Institute for Public Health and the Environment (RIVM)

[17] *Het tijdelijk opslaan en transporteren van monsters* [The temporary storage and transport of samples]. SOP number LVMBW-P414. National Institute for Public Health and the Environment (RIVM)

mixed samples were prepared (eight samples per mixed sample) and analysed for nitrate, total nitrogen and total phosphorus.

The additional sampling in the low-lying areas
Of those farms with drains and ditches in the sand region, additional drain and ditch water was sampled during the period November 2006 to March 2007 (see Figure A4.3). This was performed according to the standard method. On each farm two types of ditch sample were distinguished. In principle, there are two ditch types, farm ditches and local ditches. Farm ditches only discharge water originating from the farm. Local ditches carries water from elsewhere; the water leaving the farm is therefore a mixture.

If farm ditches are present, samples were taken downstream (where the water leaves the farm or the ditches) in four of these ditches. Furthermore, in four local ditches, samples were taken downstream to gain an impression of the local ditch water quality. If there were no farm ditches then samples were taken both upstream and downstream from four local ditches. This provided an impression of the local water quality and the effect of the farm on this. The ditch water sampling types were therefore farm ditch, local ditch upstream and local ditch downstream. The selection of locations for the ditch water sampling was protocolled[12]. The selection was aimed at gaining an impression of the effect of the farm on ditch water quality and excluding effects external to the farm as much as possible.

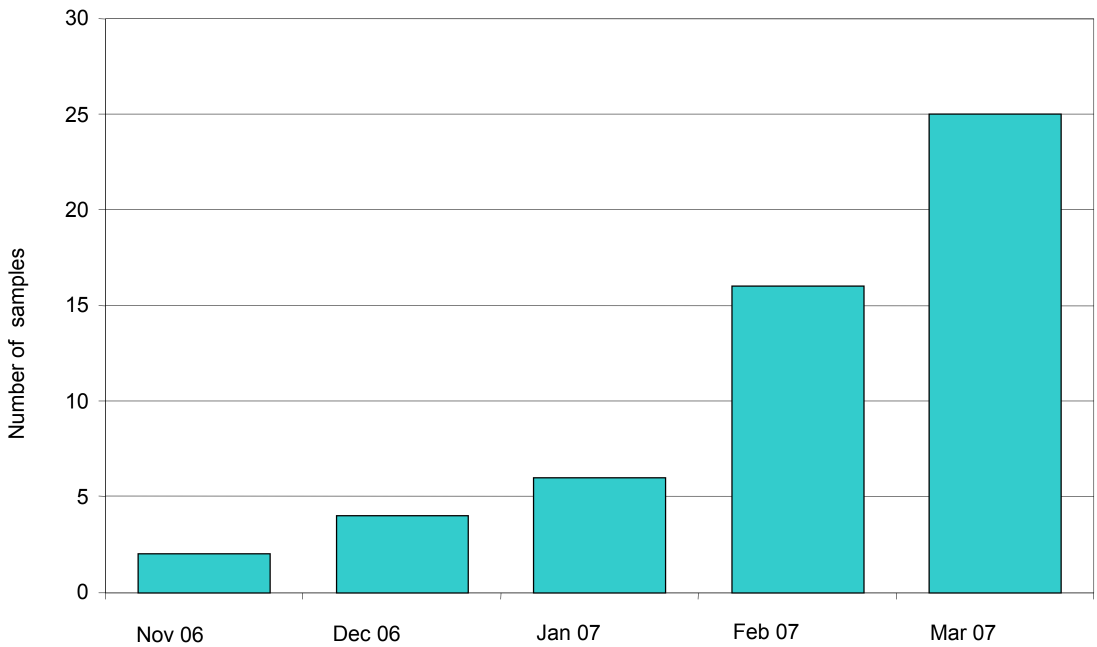


Figure A4.3 Number of samplings of drain water and ditch water in the sand region per month during the period November 2006 to March 2007.

During the winter of 2006-2007 drain and ditch water were sampled between one and four times on the farms.

The ditch water samples were taken with a measuring beaker attached to a stick or 'fishing rod' [17]. Water samples were stored in a cool, dry place for transport to the laboratory.[16]. In the laboratory, a mixed sample was prepared on the following day for the drain water samples, and two of the ditch water samples (one per type of ditch sampled). The individual drain water and ditch water samples were analysed for nitrate and the mixed samples were also analysed for total nitrogen and total phosphorus.

A4.3 The clay region

In the clay region, a distinction was made between farms on which the soil is drained with drainage pipes and farms where that is not the case. If less than 25% of a farm's acreage is drained with drainage pipes, or if less than 13 drains can be sampled, then the farm is considered not to be drained. The sampling strategy on drained farms differs from that on non-drained farms.

Drained farms
On the drained farms, drain water and ditch water were sampled in the period November 2006 to April 2007 (see Figure A4.4). On each farm, drainage pipes were selected for sampling. The number of drainage pipes to be sampled per plot depended on the size of the plot. Within the plot the drains were selected on the basis of a protocol[12]. On each farm two types of ditch sample were distinguished. For each type of ditch sample, four sampling locations were selected. The selection was protocolled[12] and was aimed at gaining an impression of the effect of the farm on ditch water quality and excluding effects external to the farm as much as possible.

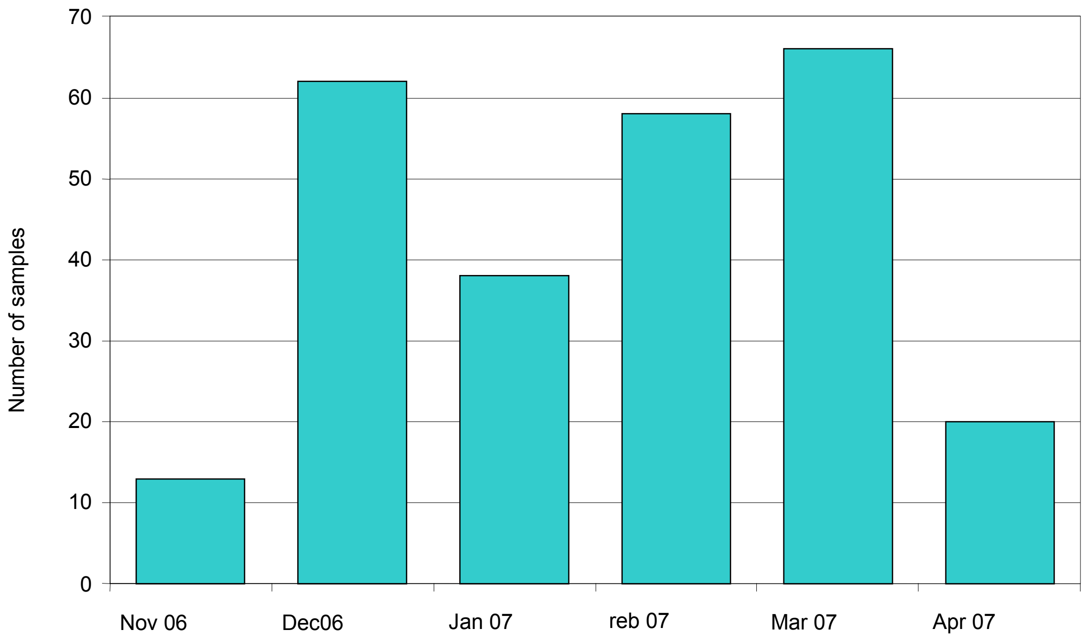


Figure A4.4 Number of samplings of drain and ditch water in the clay region per month during the period November 2006 to April 2007.

During this winter, the drain water and ditch water were sampled between one and four times as described in the previous section. The sampling was spread over the winter and the period between two samples was at least three weeks.

Water samples were stored in a cool, dry place for transport to the laboratory[16]. In the laboratory, a mixed sample was prepared on the following day for the drain water samples, and two of the ditch water samples (one per type of ditch sampled). The individual drain water and ditch water samples were analysed for nitrate and the mixed samples were also analysed for total nitrogen and total phosphorus.

Non-drained farms
On non-drained farms, the uppermost metre of the groundwater and ditch water were sampled in the period November 2006 to May 2007 [13,18] (see Figure A4.4).

The sampling of the groundwater was similar to that in the sand region. However, instead of the open bore hole method, the closed bore hole method was occasionally used[13]. In the field, the nitrate concentration (Nitrachek method) was determined at each of the 16 locations[14]. The water samples were filtered[15], conserved[16] and stored in a cool dark place for transport to the laboratory[17]. In the laboratory, two mixed samples were prepared (eight samples per mixed sample) and analysed for nitrate, total nitrogen and total phosphorus.

The ditch water sampling was similar to that of the drained farms, two types of ditch samples each with four locations. Sampling therefore took place with a filter lance[18] and water samples were filtered straightaway in the field[15] and analysed for nitrate (Nitrachek-method[14]). The individual samples were not only filtered but also conserved[16] and stored in a cool dark place for transport to the laboratory[17]. In the laboratory, two mixed samples were prepared from these ditch water samples (one per ditch sample type). The mixed samples were analysed for nitrate, total nitrogen and total phosphorus.

A4.4 The peat region

In the peat region the uppermost metre of groundwater was sampled once on all farms in the period November 2006 to April 2007 (see Figure A5.5). Ditch water was also sampled on three to four occasions in the period November 2006 to April 2007.

The sampling of groundwater was similar to that in the sand and clay regions. However, instead of an open or closed bore hole method, a reservoir tube method was usually used[13]. In the field, the nitrate concentration (Nitrachek method) was determined at each of the 16 locations[14]. The water samples were filtered[15], conserved[16] and stored in a cool dark place for transport to the laboratory[17]. In the laboratory, two mixed samples were prepared (eight samples per mixed sample) and analysed for nitrate, total nitrogen and total phosphorus.

Ditch water sampling, carried out at the same time as groundwater sampling, was similar to that of non-drained farms in the clay region. Sampling therefore took place with a filter lance.[18]. There were always two types of ditch samples, each with four locations. Water samples were analysed for nitrate

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[18] *Slootwater- of oppervlaktewaterbemonstering met een aangepaste bemonsteringslans en slangenpomp* [Sampling ditch water or surface water with a modified sampling lance or hose pump]. SOP number LVM-BW-P430. National Institute for Public Health and the Environment (RIVM)

straightaway in the field (Nitrachek method)[14]. The individual samples were filtered[15], conserved[16] and stored in a cool dark place for transport to the laboratory[17]. In the laboratory, two mixed samples were prepared from these ditch water samples (one per ditch sample type). The mixed samples were analysed for nitrate, total nitrogen and total phosphorus.

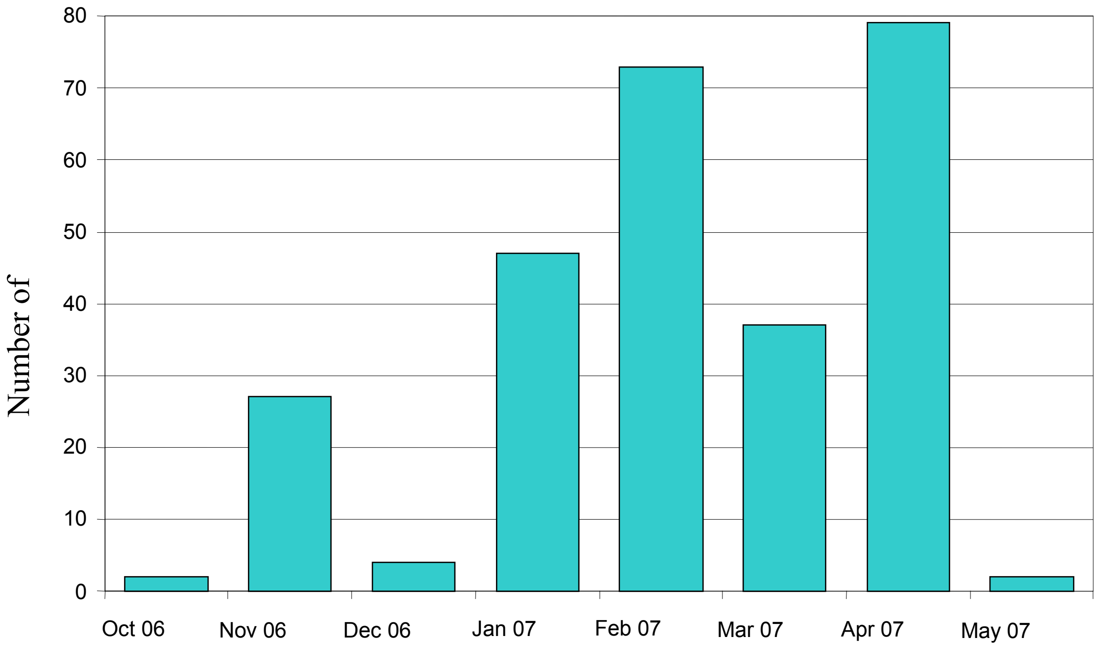


Figure A4.5 Number of samples from groundwater and ditch water in the peat region per month during the period October 2006 to May 2007.

The additional ditch water samples were taken at the same locations and at the same time as those for groundwater sampling. However, the sampling method was not the same, but rather the method used was that for drained farms in the clay region. Sampling was therefore done with a fishing rod and measuring beaker. No analyses took place in the field and the samples were stored in a cool, dry place for transport to the laboratory, but not filtered and conserved[17]. In the laboratory, two mixed samples were prepared on the following day (eight samples per mixed sample) and analysed for nitrate, total nitrogen and total phosphorus.

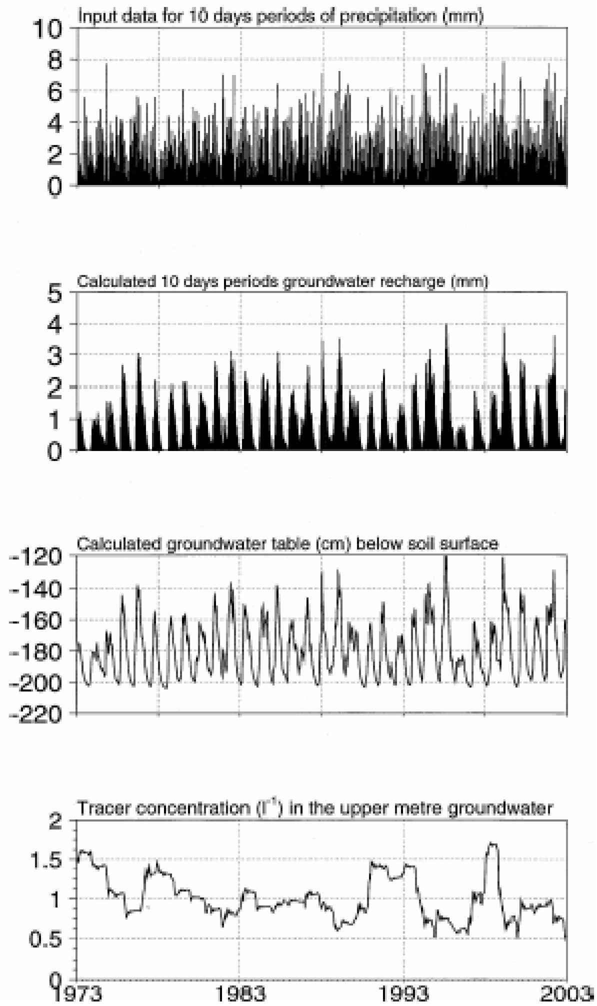
Appendix 5 Descriptions of methods for weather and sample correction

The nitrate concentration of the upper groundwater, which is sampled by the LMM, exhibits fluctuations that cannot be clarified by variations in the agricultural practice alone. Fraters et al. (1998) showed that fluctuations in the precipitation surplus caused fluctuations in the nitrate concentration. For example, it was demonstrated that the 50% reduction in the nitrate concentration between 1993 and 1994 was mostly caused by greater dilution arsing from a higher precipitation surplus. Below, a description of the method demonstrating the effect of the precipitation surplus is given.

The effect of a variable precipitation surplus on the nitrate concentration is determined by calculating a 'precipitation surplus' variable and then including this variable as a dependent variable in a statistical model.

The variable 'precipitation surplus' is calculated in two steps:

Step 1. First, the leaching from a virtual tracer was calculated by means of a soil simulation model ONZAT (OECD,1989) using nationally available data about precipitation and evaporation from 16 weather districts. The virtual tracer was applied each day to the soil surface of a standard soil profile with grass, for eight different drainage situations. The result is a trend in the groundwater level and a tracer concentration for 16 * 8 = 128 situations. The figure opposite shows the trend over a period of 30 years for a given situation, of the precipitation, groundwater suppletion, groundwater level and tracer concentration.



From the figure it can be concluded that variations in the precipitation surplus can cause a two-fold or three-fold variation in the tracer concentration between years. The tracer concentration is inversely proportional to the precipitation surplus.

Step 2. For each temporary drill hole, the weather district, sampling date and the groundwater level measured are used to find an associated tracer concentration in the simulation results (Boumans et al., 2001). Then the tracer concentrations are averaged per farm, so that a farm-averaged tracer concentration is obtained for the farm-average nitrate concentration that is measured in a mixed sample of groundwater from the same temporary drill hole.

Appendix 6 Description of the methodology for calculating the evolution in water quality

For all of the calculations in this report, the basic observation is the annual average concentration on a farm. The calculations that are subsequently performed are unweighted. This means that no corrections are performed for farm acreages, size, et cetera.

In chapter 4, two statistical techniques are used to investigate whether a change in water quality has taken place between two measurement years. The first technique is applicable if the same farms were investigated in both years. Then a difference for each farm can be determined and it can be investigated whether the average of these differences clearly deviates from the null hypothesis (Table 4.6). As farms have dropped out since 2006, fewer farms can be included in this analysis than the actual number of farms monitored in 2006.

For the clay and peat regions, the group of farms investigated differs significantly between the two years. Therefore a second method was used, REML (short for REsidual Maximum Likelihood). This method allows for the fact that the sample contains the same farms investigated in both years but also different farms investigated in either year. This REML method was also used to investigate whether a difference in the precipitation surplus could have affected the concentrations found (Table 4.7).

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