



National Institute
for Public Health
and the Environment

Report 680717017/2010

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Agricultural practice and water quality on farms registered for derogation

Results for 2008 in the derogation monitoring network

RIVM report 680717017/2010

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This study was carried out on behalf of the Ministry of Agriculture, Nature and Food Quality and the Ministry of Housing, Spatial Planning and the Environment, under the auspices of project 680717, Minerals Policy Monitoring Programme

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Rapport in het kort

Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie

Resultaten meetjaar 2008 in het derogatiemeetnet

Dit rapport geeft een overzicht van de bemestingspraktijk in 2008 en de waterkwaliteit in 2008 en 2009 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 2008 geeft de gevolgen weer van de landbouwpraktijk in 2007, het tweede jaar dat de derogatie in de praktijk werd toegepast. De waterkwaliteit gemeten in 2009 geeft de gevolgen weer van de landbouwpraktijk in 2008.

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 in december 2005 toestemming gekregen om van 2006 tot en met 2013 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 Rijks Instituut voor Volksgezondheid en Milieu (RIVM) en het Landbouw Economisch Instituut (LEI) hebben in 2006 voor 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 284 graslandbedrijven is zowel de bedrijfsvoering als de waterkwaliteit gemonitord. Van iets minder dan driehonderd bedrijven is gerapporteerd doordat sommige achteraf geen derogatie toepasten of kregen en door bedrijfswisselingen in het meetnet.

Trefwoorden: nitraatrichtlijn, derogatiebeschikking, landbouwpraktijk, waterkwaliteit, mest

Abstract

Agricultural practice and water quality at grassland farms under derogation

Results for 2008 within the framework of the derogation monitoring network

This report provides an overview of fertilisation practices in 2008 and of water quality in 2008 and 2009 on grassland farms that are allowed to use more animal 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 2008 reflect agricultural practices in 2007, which was the second year in which the derogation was applied. The water quality values measured in 2009 reflect the consequences of agricultural practices in 2008.

The European Nitrates Directive obliges Member States to limit the use of animal manure to a specified maximum. A Member State may request the European Commission for permission 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; in 2009 derogation was extended to 2013. One of the underlying conditions of the derogation is that the Netherlands establish a monitoring network and report 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 use-standard for livestock manure. The monitoring network is part of the Minerals Policy Monitoring Programme. On 284 grassland farms the fertilisation practices as well as the water quality has been monitored. Fewer than 300 farms are reported in the network due to the fact that some farms ultimately did not make use of this option (derogation).

Keywords: Nitrates Directive, derogation decision, agricultural practice, water quality, manure

Foreword

On behalf of the Ministry of Agriculture, Nature and Food Quality (LNV) and the Ministry of Housing, Spatial Planning and the Environment (VROM), 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.

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 LNV and VROM 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. One of the reporting obligations is the monitoring of the water quality and agricultural practices. The Ministry of Agriculture, Nature and Food Quality (LNV) and the Ministry of Housing, Spatial Planning and the Environment (VROM) are responsible for all reports submitted to the European Commission.

This report provides an overview of the results of the water quality monitoring in 2008 and 2009 on a sample of farms registered for derogation. The water quality monitoring 2008 and 2009 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. Moreover, in retrospect, not each farm makes use of the derogation in practice. Consequently the numbers of farms in the different regions and water types can vary each year. The 300 farms were already participating in the National Programme for Monitoring the Effectiveness of the Minerals Policy (LMM) or were recruited and sampled during the sampling campaign. The results of the water quality monitoring 2008 and 2009 are related to the agricultural practices of 2007 and 2008, the second and third derogation years. Furthermore, information is provided about the agricultural practices in 2008 for all farms in the derogation monitoring network that made use of the derogation. This includes data about the fertilisation and the nutrient surpluses realised.

We would also like to thank Mr J. M. Dalhuizen (LNV), Mr K. Locher (VROM) and Mr G. Velthof (CDM) 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 this report.

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30 April 2010

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Summary

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 prescribed conditions, apply up to 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 – for example 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 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, putting emphasis 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.

Characteristics of the area and the farms in the derogation monitoring network

Table S.1 Characteristics per region of farms included in the derogation monitoring network for 2008.

Characteristics	Region				
	Sand	Loess	Clay	Peat	All
Number of farms in the monitoring network	159	22	59	60	300
Number of farms with derogation and fully processed in FADN	158	20	58	59	295
- of which specialised dairy farms	142	15	50	52	259
- of which other grassland farms	16	5	8	7	36
<i>Descriptive characteristics</i>					
Acreage of cultivated land (ha)	46.5	49.7	58.4	58.7	51.5
Percentage grassland	80	72	81	91	82
Milk production (kg FPCM ¹) per ha forage crop	15,400	13,200	15,500	14,000	15,000

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 259 specialised dairy farms.

In 2008, the total agricultural area covered by the derogation monitoring network was 1.8% of the total area of all derogation farms, meeting the criteria for inclusion in the network (the sample population). The sample population covers 86.7% of the farms and 96.7% of the acreage of all farms that registered for derogation in 2008. 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 51.5 ha (see Table S1), the mean acreage of farms in the derogation monitoring network is larger than that of the sample population (42.6 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 loess region. The percentage of acreage used as grassland in the derogation monitoring network (82%, Table S.1) is virtually the same as the mean percentage of grassland in the sample population (83%).

Use of fertilisers

In 2008, farms in the derogation monitoring network used on average 236 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 on average 175 kg per ha was used, whereas on grassland 250 kg nitrogen from livestock manure was applied. 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 availability coefficients) was 272 kg per ha on grassland and 124 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 2008. The mean use of phosphate, from livestock manure and inorganic fertiliser, on arable land (96 kg P₂O₅ per ha) exceeded the phosphate application standard in force in 2008, while on grassland the mean application of fertiliser (93 kg P₂O₅ per ha) was considerably lower in all regions than the phosphate application standard. Also on the farm level, phosphate application was below the phosphate application standards in all regions.

Table S2 Mean use of fertiliser on farms in the derogation monitoring network in 2008, per region.

Characteristics		Region				All
		Sand	Loess	Clay	Peat	
Fertiliser use:						
Nitrogen from livestock manure (kg N per ha)	Farm level	237	228	236	237	236
	Arable land ²	180	194	151	181	175
	Grassland	253	249	255	237	250
Total plant-available nitrogen ¹ (kg N per ha)	Arable land ²	121	129	131	120	124
	Grassland	272	264	303	243	272
Total phosphate ¹ (kg P ₂ O ₅ per ha)	Arable land ²	95	105	94	97	96
	Grassland	95	94	91	90	93

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 2008.

² Arable land on grassland farms is mainly used for the production of silage maize (mean 86%).

Crop yield and nutrient surpluses at farm level

For over 50% 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 180 kg nitrogen and 91 kg phosphate were estimated for silage maize and a yield of 262 kg nitrogen and 87 kg

phosphate were calculated for grassland (Table S.3). The mean nitrogen surplus on the soil surface balance in 2008 was calculated to be 196 kg per ha. This surplus decreases in the sequence peat >clay >sand >loess (Table S.3). The high surplus in the peat region was partly caused by a mean of 75 kg net nitrogen mineralisation per ha being included in the calculation, whereas in the other regions the net nitrogen mineralisation was negligible. The mean phosphate surplus on the soil surface balance is 16 kg P₂O₅ per ha.

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 2008, per region.

Characteristics	Region				
	Sand	Loess	Clay	Peat	All
Estimated yield silage maize ¹					
kg N per ha	182		180	173	180
kg P ₂ O ₅ per ha	73		73	65	72
Calculated yield grassland ¹					
kg N per ha	264		252	268	262
kg P ₂ O ₅ per ha	87		85	88	87
Nutrient surpluses per ha cultivated land					
Nitrogen surplus on the soil surface balance (kg N per ha)	174	157	216	246	196
Phosphate surplus on the soil surface balance (kg P ₂ O ₅ per ha)	15	14	16	18	16

¹ The silage maize and grassland yields are based on 148 of the 284 farms. The number of farms in the loess region that satisfied the selection criteria (6) was too low to be represented: these farms have therefore not been included in the mean. The other farms did not satisfy the selection criteria.

Comparison of agricultural practice for the years 2006, 2007 and 2008

The comparison of the results for the years 2006 to 2008 reveals that the milk productions per farm and per hectare have increased. There was also an associated increase in the production of livestock manure, yet due to a greater export of livestock manure in particular, the use of livestock manure remained more or less the same.

However, the use of inorganic nitrogen and phosphate fertilisers decreased in 2008, which was probably due to the increased availability coefficient forfeit for livestock manure for the grazing of dairy cattle and the slightly stricter nitrogen application standards. This had little effect on the nitrogen surplus on the soil surface balance, partly due to the moderate intensification (more milk and more animals per hectare).

The phosphate application standards also became stricter in the years 2006 to 2008, which mainly resulted in less use of inorganic phosphate fertiliser. The mean phosphate surplus on the soil surface balance therefore decreased.

The estimated silage maize yield (kg N and P₂O₅ per ha) was lower in 2007 and 2008 compared to 2006. This decrease was not expressed in the dry matter yield. The estimated grassland yield (kg N and P₂O₅ per ha) in 2007 and 2008 was also lower than in 2006. However, the yield of dry matter in 2008 was higher than in the other two years, although this difference was not significant.

In conclusion, it can be stated that the tightening of the application standards in the years 2006 to 2008 resulted in a reduced application of inorganic fertiliser. Apparently this resulted in lower nitrogen and phosphorous levels in silage maize and grass; the yield of dry matter is not affected by this. The surplus

for nitrogen on the soil surface balance has not really changed in the years 2006 to 2008. However, the surplus for phosphorous did decrease during this period.

Report water quality for the measurement year 2008

The water quality measured in 2008 partly reflects the agricultural practices in the second year of derogation. The mean nitrate concentration in water leaching from the root zone in the sand region was 51 mg NO₃ per litre in 2006 and 56 mg per litre in 2007. In the loess region the figures were 88 mg per litre in 2006 and 68 mg per litre in 2007. In 2008 the average values were 43 mg NO₃ per litre in the sand region and 54 mg per litre in the loess region (see Table S.4). The mean nitrate concentration was higher in the sand and loess regions than in the other two regions, where the mean nitrate concentration was lower, just as in previous years.

Table S.4 Quality of the water leaching from the root zone on farms in the derogation monitoring network in 2008, expressed as mean nitrate concentration, total nitrogen and phosphorous (in mg/l) and the percentage of farms with a mean nitrate concentration higher than 50 mg per litre.

Characteristic	Region			
	Sand	Loess	Clay	Peat
Number of farms	155	20	56	57
Nitrate (NO ₃) (mg/l)	43	54	23	7
% Nitrate >50 mg/l	37	55	14	2
Nitrogen (N) (mg/l)	13.2	13.3	7.2	8.8
Phosphorus (P) (mg/l)	0.17	0.03	0.24	0.44

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 2008; mean nitrate concentration, total nitrogen and phosphorous (in mg/l) and the percentage of farms with an mean nitrate concentration higher than 50 mg per litre.

Characteristic	Region		
	Sand	Clay	Peat
Number of farms	25	55	56
Nitrate (NO ₃) (mg/l)	39	11	4
% Nitrate >50 mg/l	28	2	0
Nitrogen (N) (mg/l)	10.7	4.4	3.9
Phosphorus (P) (mg/l)	0.13	0.31	0.17

Report water quality for the measurement year 2009, provisional results

The table below shows the provisional results for the water quality in 2009. These partly reflect agricultural practices in 2008 (third year of derogation). These can therefore be directly linked to the agricultural data that are also presented in this report. The final results for 2009 shall be included in the report for 2011 (it is not expected that these will strongly deviate from the provisional results).

Table S.6 Quality of the water leaching from the root zone on farms in the derogation monitoring network in 2009; mean nitrate concentration, total nitrogen and phosphorous (in mg/l) and the percentage of farms with a mean nitrate concentration higher than 50 mg per litre.

Characteristic	Region			
	Sand	Loess	Clay	Peat
Number of farms	154	0	58	58
Nitrate (NO_3) (mg/l)	39	*	20	6
%Nitrate >50 mg/l	31	*	12	2
Nitrogen (N) (mg/l)	11.6	*	6.5	7.7
Phosphorus (P) (mg/l)	0.15	*	0.28	0.39

* Results from the loess region were not yet available when this report was written.

Table S.7 Quality of the ditch water on farms in the derogation monitoring network in 2009; mean nitrate concentration, total nitrogen and phosphorous (in mg/l) and the percentage of farms with a mean nitrate concentration higher than 50 mg per litre.

Characteristic	Region		
	Sand	Clay	Peat
Number of farms	30	57	57
Nitrate (NO_3) (mg/l)	26	9	4
%Nitrate >50 mg/l	20	0	0
Nitrogen (N) (mg/l)	7.7	4.1	4.2
Phosphorus (P) (mg/l)	0.10	0.32	0.22

Comparison of results from 2007, 2008 and 2009 with respect to the water quality

This is the first report in which results are available from several successive sampling years. The graphs below shows the results for nitrate leaching from the root zone and ditch water. In these graphs the nitrate concentrations measured are given. The figures below do not show any statistical uncertainties as their purpose is to provide a visual impression of the trend in the concentrations.

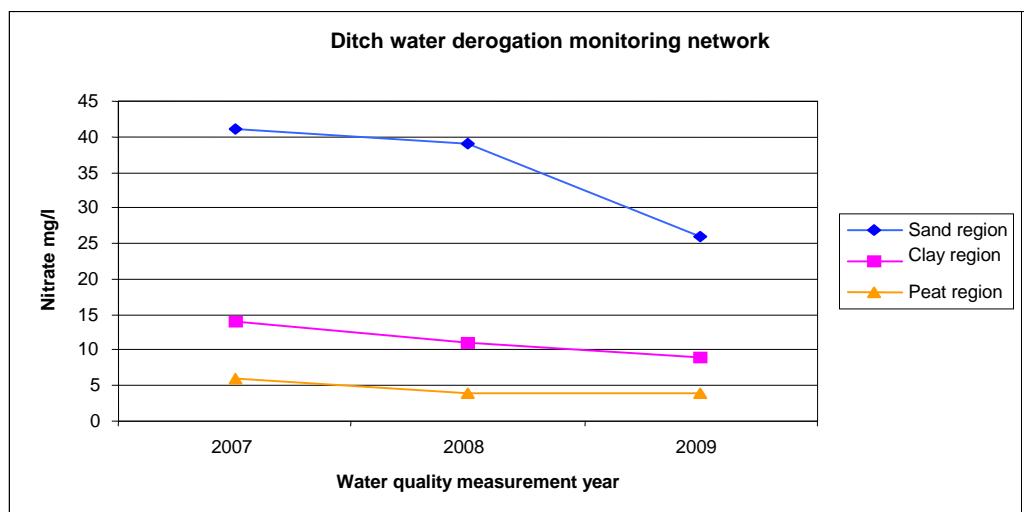


Figure S.1 Illustration of the nitrogen concentrations in the ditch water in successive measurement years

In the graph below for the leaching from the root zone, the result for the sand region is also given with a correction for the precipitation effect. In this graph a decrease in the concentrations can be observed.

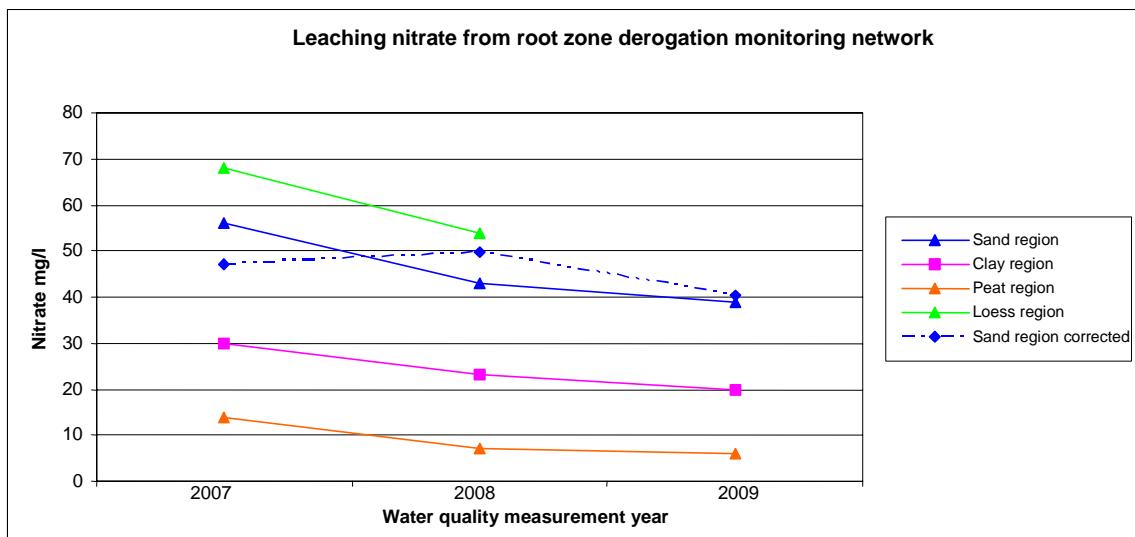


Figure S.2 Nitrogen concentrations in the ditch water in successive measurement years.

It is concluded that the majority of concentrations have not significantly changed. Where a decrease has been observed, this is probably associated with:

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

After correction for the precipitation effect, it was found that the concentrations in the sand region had decreased in 2009 compared to 2007 and 2008. However, it should be remembered that the results for 2009 are only provisional. In the report for 2011, the final concentrations shall be given and it will also be possible to see if this trend in the water quality has continued through 2010.

Effect of agricultural practice on water quality

Nitrogen

The water quality measured in 2007 was influenced by the agricultural practices of 2006 and earlier years, etc. After correcting for the effects of weather conditions, no significant decrease in nitrate concentration is observed in the sand region between 2007 and 2008. This concurs with the unchanged nitrogen use in agriculture. In agricultural practice little has changed with respect to both the use of nitrogen and its removal with the crop. The use of nitrogen from livestock manure has not changed and that for inorganic nitrogen fertiliser has decreased somewhat. The removal of nitrogen via silage maize exhibits no clear trend and varies considerably over time. The removal was highest in 2006 and lowest in 2007. For grass there is also no trend in the removal of nitrogen with the crop. The nitrogen soil surface surplus exhibits no trend over time and does not differ significantly between years.

The decrease in the nitrate concentration between 2008 and 2009 cannot be adequately explained in terms of the developments in agricultural practice. The decrease in the nitrogen surplus is small, not significant and has also not been observed in all regions. This is illustrated in Figure S.3 with a trend line for both the agricultural practice and the water quality.

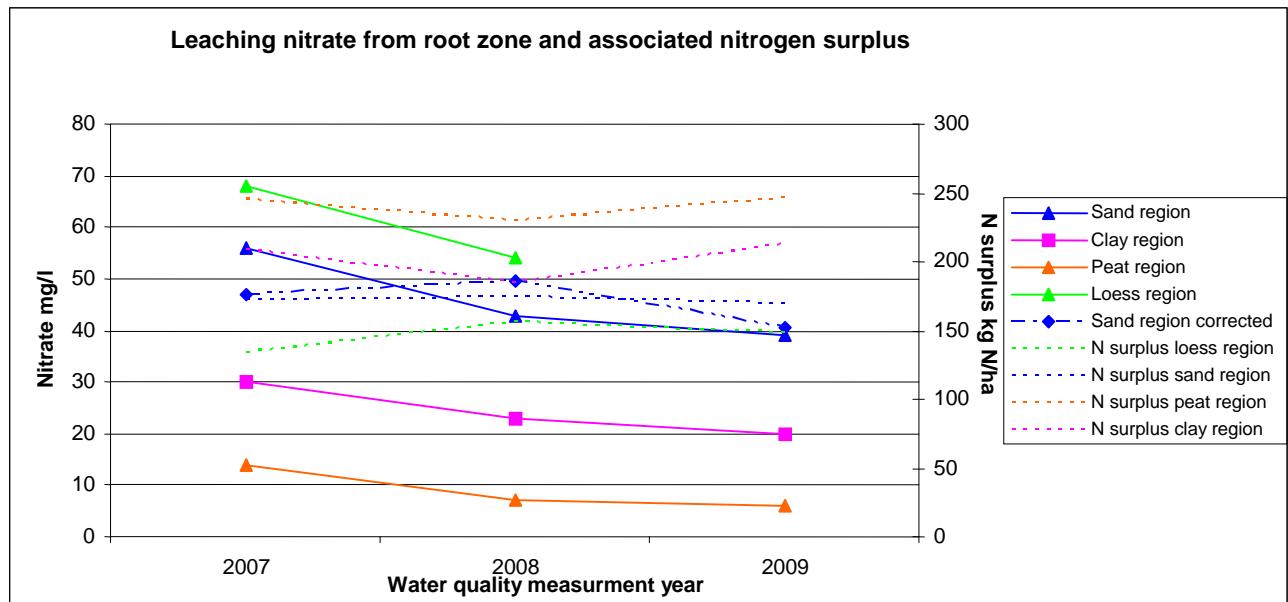


Figure S.3 Nitrate concentrations leaching from the root zone per soil type in successive measurement years combined with the nitrogen surplus from agricultural practice.

Phosphate

The phosphate surplus on the soil surface balance decreased in the measurement period. The effect of this decrease is not observed in the water quality. Here both small increases as well as decreases can be seen. The cause is possibly the strong binding of phosphate to the soil. The phosphorous concentration in the leaching water and the ditch water is therefore mainly determined by the hydrological conditions.

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, 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 setting-up of a monitoring network for the sampling of groundwater, soil moisture, drainage water and ditches on farms permitted an individual derogation' (Article 8 of the decision, para 2). The monitoring network must 'provide data on the nitrate and phosphorus concentrations in the water leaching from 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, sand, 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 should be intensified (Article 8, para 5). The composition of the monitoring network should remain unchanged during the period (2006-2009) in which the decision applies (Article 8, para 2). During the negotiations with the European Commission it was agreed that the design of this monitoring network would tie in with the existing National Programme for Monitoring the Effectiveness of the Minerals Policy (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 meet 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 leaching from the root zone (see Appendix 4).

Aside from the obligation to monitor, there is the requirement to report the evolution of 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 on 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 with derogation, 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 derogation monitoring network, the progress made in 2006 in terms of setting-up this network, 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 related to farm practice under derogation. The water quality data from 2006 relate to the agricultural practice during 2005 and therefore are not yet related to farm practice under derogation.

The third progress report was published in 2009; this contains the data from 2007 (Zwart et al, 2009). A brief comparison was also made between the results from 2006 and 2007, for which the caveat was made that 2006 was not a derogation year and so no series of measurements was available from which conclusions about trends could be drawn.

1.3 Content of this report

This is the fourth 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 as registered 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. In other words, land that administratively 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. 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. Furthermore, this fourth report reports on 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.

This is the first year in which both the annual mean measured nitrate concentrations per region and the outcomes of the limited model calculation are included. 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, 1997, 2001). This method also corrects for changes in the composition of the group of participating farms, the sample (Fraters et al, 2004). 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 may 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 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. Further details can be found under the description of the weather correction in Appendix 5 and the sample correction in Appendix 6.

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 and analyses performed is also given. Chapter 3 presents and discusses the measurement results of the monitoring in 2008. This chapter also contains the provisional results of the water quality monitoring for 2009. 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 is measured (Appendix 4). Appendix 5 details the methodology applied for weather correction. Finally, Appendix 6 describes the methodology for calculating the evolution of water quality (sampling correction).

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 and the extension of the derogation in 2009 (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 derogation monitoring network and the reporting of the results follows the subdivision of the Netherlands into regions, as made in the Nitrate Directive Action Programme and the fertilisation legislation. In this respect four regions are distinguished: the sand region, the loess region, the clay region and the peat region. The acreage of agricultural land in the sand region constitutes about 47% of the approximately 1.95 million hectares of 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 2008 was carried out during the winter of 2007/2008 in the Low Netherlands and in the summer and the rest of 2008 in the High Netherlands. 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 tile drainage or surface drains. The High Netherlands covers the other sand and loess soils. The sampling for determining the water quality for 2009 took place in the winter of 2008/2009 and in the summer of 2009 respectively. Water sampling took place on 300 farms in the derogation monitoring network. Farms that submitted an application for derogation but did not use it were not included in this report so as to ensure that the results concerning the effects of using derogation were not confounded. Consequently the number of farms reported on deviates from 300.

The water quality measured in 2008 partly reflects the agricultural practice of 2007 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 methods of 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.

2.2 Design and realisation of the sample

2.2.1 Number of farms in 2008

The derogation monitoring network is 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 use the derogation;
- they no longer participate in the LMM because the farm has been sold or because cultivated land is no longer used or because of administrative problems.

Furthermore, although a farm may have been processed in the FADN, it may 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 import and export of feed, animals and manure are, by definition, not complete or because of administrative errors in the registration of imports and/or, exports.

Table 2.1 shows the planned and actual number of farms in the derogation monitoring network for 2008, 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 in 2008.

Farm type	Design/realisation	Sand	Loess	Clay	Peat	All
Dairy farms	Design	143	15	51	52	261
	Realisation water quality	138	15	50	51	254
	Realisation FADN monitoring - for which nutrient flows complete	142	15	50	52	259
		138	15	49	52	254
Other grassland farms	Design	16	7	8	8	39
	Realisation water quality	16	5	8	7	36
	Realisation FADN monitoring - for which nutrient flows complete	16	5	8	7	36
		13	5	5	7	30
Total	Design	159	22	59	60	300
	Realisation water quality	154	20	58	58	290
	Realisation FADN monitoring - for which nutrient flows complete	158	20	58	59	295
		151	20	54	59	284

Eight of the farms that had participated in FADN in 2007, no longer did so in 2008. 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) concerns all farms that could be processed in FADN in 2008 and that made use of the derogation (= 295);
- the description of agricultural practices in 2008 (Section 3.1) concerns all farms for which the nutrient flows in 2008 could be fully completed in FADN (= 284).

The comparison of agricultural practice between 2006, 2007 and 2008 (Section 4.1) concerns all farms that participated in the monitoring network in all three years (274 farms). For 261 of these farms the nutrient flows could be fully recorded in FADN for all three years.

2.2.2 Representativeness of the sample

The sample population covers 86.7% of the farms and 96.7% of the acreage of all farms that registered for derogation in 2008 and which satisfied the LMM selection criteria (the sample population, Appendix 2). With an area of 15,184 ha, 1.8% of the national acreage of the total sample population has been included in the sample (see Table 2.2).

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 2008 in the sample population, according to the Agricultural Census 2008.

Region	Farm type	Sample population ¹		% of acreage sample population
		Acreage in ha	Acreage in ha	
Sand	Dairy farms	373,250	6820	1.8%
	Other grassland farms	51,318	523	1.0%
	Total	424,569	7342	1.7%
Loess	Dairy farms	4803	775	16.1%
	Other grassland farms	1432	220	15.4%
	Total	6235	995	16.0%
Clay	Dairy farms	204,800	3144	1.5%
	Other grassland farms	29,843	241	0.8%
	Total	234,642	3385	1.4%
Peat	Dairy farms	163,617	3298	2.0%
	Other grassland farms	17,835	165	0.9%
	Total	181,453	3462	1.9%
All	Dairy farms	746,470	14,036	1.9%
	Other grassland farms	100,428	1148	1.1%
	Total	846,898	15,184	1.8%

¹ Estimate based on Statistics Netherlands Agricultural Census 2008, processed by LEI. Further information about how the sample population was defined can be found in Appendix 2.

A minimum number of farms is needed to be able to make a well-founded statement per region. For loess that minimum has been set at fifteen. The loess region is relatively small and therefore it does not have many derogation farms in the sample population, as a result of which a relatively large number of farms are included in the monitoring network (16.0%). Furthermore, in all regions the dairy farms are more strongly represented in the acreage than the other grassland farms. This is because during the

selection and acquisition process the desired number of farms in the sample per farm type is derived 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 land.

2.3 Description of the farms in the sample

Table 2.3 provides a number of descriptive 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 2008 (sample population) have also been included.

Table 2.3 Description of a number of general farm characteristics in 2008 of the farms in the derogation monitoring network (DM) compared to the mean of the sample population (LBT)¹.

Farm characteristic ³	Population	Sand	Loess	Clay	Peat	All
Total number of farms:		158	20	58	59	295
Area grassland (ha)	DM	36.2	34.3	45.3	52.0	41.0
	LBT	30.2	28.8	41.6	41.0	35.1
Area silage maize (ha)	DM	9.3	12.4	9.6	6.4	9.0
	LBT	7.9	7.6	5.9	4.1	6.7
Area other arable land (ha)	DM	0.9	3.1	3.4	0.3	1.5
	LBT	0.7	2.1	1.4	0.4	0.8
Total area cultivated land (ha)	DM	46.5	49.7	58.4	58.7	51.5
	LBT	38.8	38.5	48.9	45.6	42.6
Percentage grassland	DM	80	72	81	91	82
	LBT	79	76	86	92	83
Area natural habitat (ha)	DM	0.5	2.8	1.7	0.5	0.9
	LBT	0.4	0.4	0.7	0.5	0.5
Stocking density grazing livestock (GVE ² /ha)	DM	2.22	1.99	2.24	2.02	2.17
	LBT	2.19	1.95	1.97	1.86	2.07
Percentage farms with intensive livestock farming	DM	16	20	14	14	15
	LBT	15	5	6	4	11
Specification livestock density derogation monitoring network (GVE per ha)						
Dairy cattle (including young stock)	DM	2.12	1.67	2.06	1.88	2.03
Other grazing livestock	DM	0.10	0.32	0.19	0.14	0.14
Total intensive livestock	DM	0.67	0.08	0.71	0.27	0.56
Total all animals	DM	2.89	2.07	2.95	2.29	2.73

Source: Statistics Netherlands Agricultural Census 2008, processed by LEI and Informatienet

¹ DM = Farms in the derogation monitoring network 2008, LBT = Sample population based on Agricultural Census 2008 (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).

³ Areas are given in hectares of cultivated land and the acreage of natural habitats is not included.

An examination of the agricultural characteristics of the sample population in comparison with the farms from the agricultural census (see Table 2.3) reveals the following differences:

- the mean acreage of cultivated land of the sampled farms is larger than that of the farms in the sample population (51.5 versus 42.6 hectares). This applies to all regions;
- on average an additional 0.9 ha of natural habitat is under farm management. This area is not included in the calculation of the environmental pressure per hectare of cultivated land (fertilisation, surpluses and the like);
- for the farms sampled, 82% of the acreage is grassland and this is comparable to the mean of the sample population. On the farms sampled in the loess and clay regions, the percentage of grassland is slightly lower than in the sample population;
- on the farms sampled, a mean of 86% of the arable land is used for silage maize (9.0ha silage maize divided by 10.5 ha of arable land in total);
- in all regions, the livestock density of grazing livestock on the farms sampled is higher than the mean of the sample population;
- on 15% of the farms in the derogation monitoring network, intensive livestock farming as well as grazing livestock are present. In all regions, the percentage of farms in the derogation monitoring network with intensive livestock farming is higher than in the sample population. The presence of intensive livestock farming 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 larger numbers of animals under intensive livestock farming on the sampled farms compared to the sample population gives rise to a considerably higher mean total stock density in all regions except for the loess region. The loess region has the lowest stock density in terms of dairy cattle and the associated young stock and the highest stock density for other grazing animals.

These differences between the agricultural census and the sample population are not such that the sample is disqualified.

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, this table contains for comparative purposes the weighted mean of the national sample from the Farm Accountancy Data Network (FADN). This table shows that in all regions the dairy farms have a higher acreage and higher milk production than the weighted national mean.

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).

Farm characteristic	Population	Sand	Loess	Clay	Peat	All
Total number of farms						
in DM:		142	15	50	52	259
kg FPCM ¹ per farm	DM	699,200	642,800	882,500	909,300	773,500
	FADN	600,600	354,000	756,800	710,400	643,300
kg FPCM per ha forage	DM	15,400	13,200	15,500	14,000	15,000
crop	FADN	14,700	12,700	14,200	13,400	14,300
kg FPCM per dairy	DM	8430	8100	8600	8200	8400
cow	FADN	8450	7500	8400	8200	8400
Percentage farms with	DM	85	100	82	87	86
grazing	FADN	79	100	88	87	83

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).

Table 2.4 specifically reveals the following:

- with more than 15,000 kg FPCM, the mean milk production per ha of forage crop is higher than the national mean. In each of the regions the milk production per hectare of forage crop on the farms sampled is higher than the weighted national mean;
- on the farms sampled, the mean milk production per dairy cow present is slightly higher than the national mean;
- grazing takes place on 86% of the dairy farms sampled. For farms in the derogation monitoring network this percentage is slightly higher than the national mean.

2.4 Monitoring of water quality

2.4.1 Sampling at farms

In the measurement year 2008, water quality was sampled at 288 farms participating in the derogation monitoring network that actually used derogation (see Table 2.5 and Figure 2.1). In 2009, 290 derogation farms were sampled. This concerned the sampling of groundwater, drain water or soil moisture. On the participating farms in the Low Netherlands, the ditch water on the farms was also sampled. The number of farms sampled per region in this period is listed in Tables 2.5 and 2.6. The mean sampling frequency is also indicated. This frequency was lower than intended due to drought (drains did not produce water) and problems in the realisation. These last-mentioned problems have now been dealt with by means of new contracts (2008) and a change in the contractor (2009); the result is demonstrated in the higher sampling frequency in 2008 and 2009 compared to 2007.

Table 2.5 Number of sampled farms registered for derogation per subprogramme and per region for 2008 and the sampling frequency of the leaching water (L) and ditch water (DW). The desired sampling frequency is stated between parentheses.

Year	Sand region				
	All farms	Of which drained	Loess region	Clay region	Peat region
2008	155	25	20	56	57
L rounds	1 (1)	(-)	1 (1)	2 (2)	1 (1)
DW rounds	- (-)	3.7 (4)	- (-)	2.9 (4)	3.9 (4)

Table 2.6 Number of sampled farms registered for derogation per subprogramme and per region for 2009 and the sampling frequency of the leaching water (L) and ditch water (DW). The desired sampling frequency is stated between parentheses.

Year	Sand region				
	All farms	Of which drained	Loess region	Clay region	Peat region
2009	154	30	20*	58	58
L rounds	1 (1)	- (-)	1 (1)	2 (2)	1 (1)
DW rounds	- (-)	3.8 (4)	- (-)	3.9 (4)	4.0 (4)

* In the loess region 20 farms were sampled in the period October 2009 to February 2010. The results of this sampling were not yet known when this report was compiled.

The water quality sampling in 2008 took place in the period November 2007 to February 2009. The water quality sampling in 2009 took place in the period October 2008 to February 2010. The figures for the water quality in the loess region, sampled from October 2009 to February 2010, are not yet available. The two new farms in this region were sampled in April 2010 as the addresses and consent for these farms were not available any earlier.

The sampling period per region is indicated in Table 2.7. In addition to this, the sampling in the loess region for 2008 and 2009 was continued in January and February of the following year, as the sampling there was delayed due to frost. A detailed description of the sampling method per region is provided in Appendix 4.

Table 2.7 Sampling periods for the water quality 2008 and 2009 per region and programme, in the period October 2007 to October 2009. Contains water quality data from the FADN collection 2007 (green) and FADN collection 2008 (yellow)

In this report the water quality data for FADN-year 2008 are still provisional. The final figures will be reported in 2011. Then the data from the loess region for 2009 will also be complete and final.

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 derogation monitoring network is focussed on the sand region.

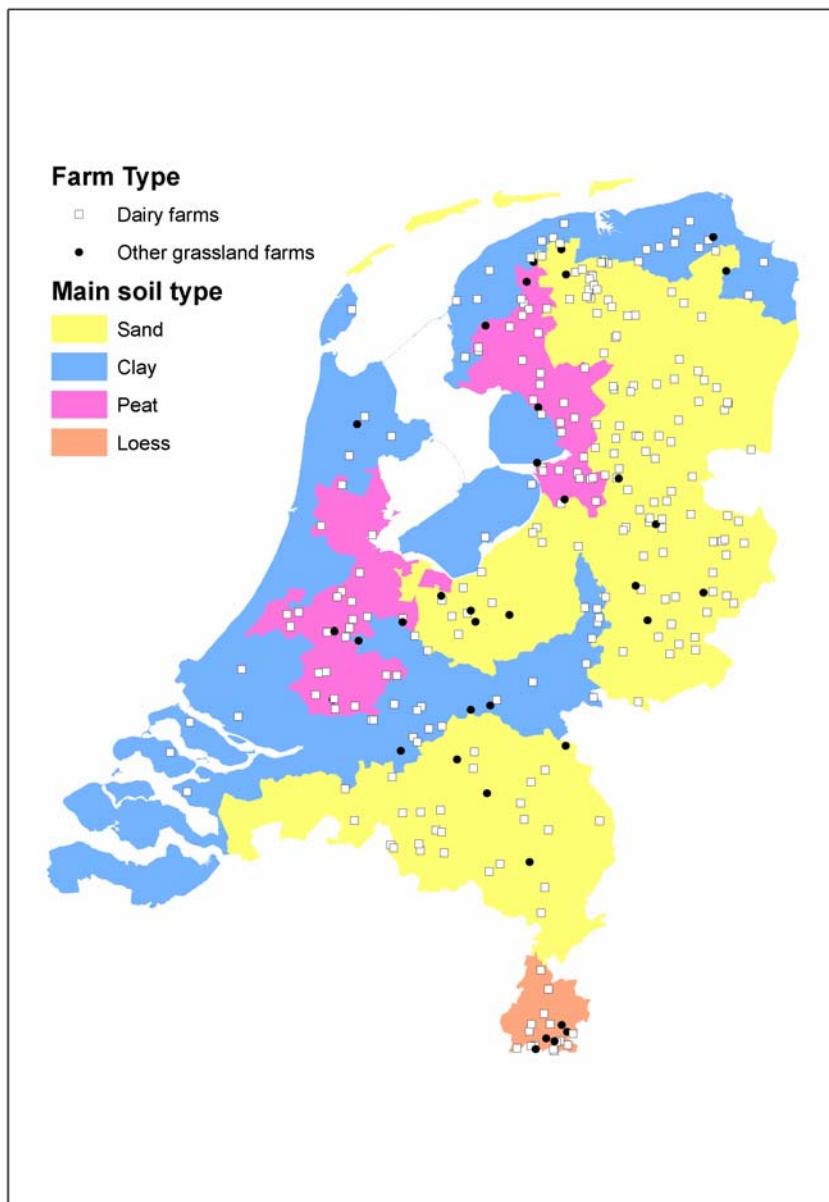


Figure 2.1 Location of the 288 grassland farms participating in the water sampling for the derogation monitoring network in 2008.

The soil and drainage characteristics of the farms concerned are given per region in Table 2.8 for 2008 and Table 2.9 for 2009. The tables reveal that within a region, other soil types occur in addition to the main soil type after which the region is named. By nature, the loess region primarily consists of well-drained soils and the peat region chiefly contains poorly-drained soils.

Table 2.8 Soil type and drainage class (in percentages) per main soil type region on derogation farms sampled in 2008

Region	Soil types				Drainage class ¹		
	Sand	Loess	Clay	Peat	Poor	Moderate	Good
Sand	81	0	11	8	41	48	10
Loess	1	71	28	0	2	3	96
Clay	15	0	82	3	41	53	6
Peat	12	0	37	51	89	10	0

Table 2.9 Soil type and drainage class (in percentages) per main soil type region on derogation farms sampled in 2009

Region	Soil types				Drainage class ¹		
	Sand	Loess	Clay	Peat	Poor	Moderate	Good
Sand	81	0	11	9	41	48	10
Loess	*	*	*	*	*	*	*
Clay	14	0	83	3	40	55	6
Peat	12	0	37	50	89	10	0

¹ The drainage classes are linked to the groundwater regime classes. The class of naturally poorly draining soils contains Gt I to Gt IV, the class of moderately draining soils Gt V, V* and VI, and the class well draining soils Gt VII and Gt VIII.

* Results from the loess region were not yet available when this report was prepared.

2.4.2 Chemical analyses and calculations

The chemical analyses of the water samples were carried out in the accredited analytical laboratory of RIVM. Table 2.10 provides an overview of the methods used for the different components. Further details can be found in Wattel-Koekoek et al (2008).

Table 2.10 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 : Quadrupole 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, calculated mean farm concentrations may result in values below the detection limit.

3 Results for 2008

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 2008. For most of the farms, the manure production was calculated by means of forfeit standards. However, dairy farmers could also choose to deviate from these standards and to calculate a farm-specific manure production using the so-called Guidance (LNV, 2009b). This farm-specific manure production was adopted for 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 = 41). On all other farms (N = 243) 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 2008 on farms in the derogation monitoring network. Means per region.

Description	Sand	Loess	Clay	Peat	All
Number of farms	151	20	54	59	284
Use livestock manure					
Produced on farm*	270	224	278	252	265
- export	37	14	42	23	34
- stock mutation	-8	-4	-6	-5	-7
+ import	12	22	7	14	12
Total	237	228	236	237	236
Application standard livestock manure	246	237	248	245	245
Use on arable land**	180	194	151	181	175
Use on grassland**	253	249	255	237	250

* 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).

** The mean use and the application standards on grassland and arable land are based on 275 farms and 208 farms respectively instead of 284 farms, as on 9 farms the allocation of fertilisers to arable land and grassland did not fall within the confidence intervals and because 68 farms had no arable land.

The following conclusions can be drawn from Table 3.1:

- at 245 kg per ha, the mean 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 intensive livestock farming for which a standard of 170 kg per ha applies;
- the mean use of nitrogen from livestock manure (236 kg per ha) was several kilograms under the mean application standard;

- the use of nitrogen from livestock manure decreased in the order clay > sand > peat > 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.

The farms in the monitoring network imported and exported livestock manure. As the production was generally higher than the use permitted, the export of manure was on average higher than the import of manure. This applied 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 imported and/or exported livestock manure in 2008. Means per region.

Description	Sand	Loess	Clay	Peat	All
No import and export	27	25	33	34	29
Only export	37	35	41	32	37
Only import	22	25	17	22	21
Both import and export	14	15	9	12	13

Table 3.2 shows that on 29% of the farms there was no import or export of manure. On 37% of the farms manure was only exported, whereas on 21% 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 2008 had a clear economic benefit compared to inorganic fertiliser. On 13% of the farms, manure was both imported and exported.

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 2008 (Dienst Regelingen, 2006).

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 86% of the dairy farms used grazing (Table 2.4) as a result of which a lower statutory nitrogen availability coefficient (45% in 2008) could be used.
- In the clay region, the total (plant-available) nitrogen use was 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 than on other soils.
- In the loess region, the total (plant-available) nitrogen use was 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, was considerably lower than the nitrogen fertilisation on grassland.
- In the peat region, the calculated nitrogen fertilisation on grassland was lower than on the other soil types. But from the perspective of the entire farm, the nitrogen fertilisation in the peat region was on average higher than for farms in the loess region and almost equal to farms in the sand region. This is explained by the fact that grassland in the peat region had a greater share of the crop

rotation (Table 2.3) and that the calculated nitrogen fertilisation on grassland was higher than on arable land.

Table 3.3 Mean nitrogen use from fertilisers (in kg plant-available N per ha)* on farms in the derogation monitoring network in 2008. Means per region.

Description	Category	Sand	Loess	Clay	Peat	All
Number of farms		151	20	54	59	284
Mean statutory availability coefficient from livestock manure		50.2%	50.1%	50.6%	49.7%	50.2%
Fertiliser use:	Livestock manure	119	114	119	117	118
	Other organic fertiliser	0	0	0	0	0
	Inorganic fertiliser	118	104	154	116	124
	Total mean	237	218	274	234	242
Use of plant-available nitrogen on arable land**		121	129	131	120	124
Application standard arable land**		156	163	165	157	158
Use of plant-available nitrogen on grassland**		272	264	303	243	272
Application standard on grassland**		290	280	324	297	298

* Calculated according to the prevailing statutory availability coefficients (see Appendix 3)

** The mean use and the application standards on grassland and arable land are based on 275 and 208 farms respectively instead of 284 farms, as on 9 farms the allocation of fertilisers to arable land and grassland did not fall within the confidence intervals and because 68 farms had no arable land.

The following conclusions can be drawn from Table 3.4:

- In the sand and loess regions more phosphate was applied in the form of fertiliser than in the clay and peat regions.
- At a mean of 93 kg, the phosphate use on grassland was lower than the application standard of 101 kg on grassland. This was the case in all regions.
- However, at 96 kg per ha, the use of phosphate on arable land was higher than the application standard of 88 kg phosphate per ha. This was the case in all regions.
- On average 95% of the phosphate was applied via livestock manure.

Table 3.4 Mean phosphate use from fertilisers (in kg P₂O₅ per ha) in 2008 on farms in the derogation monitoring network. Means per region.

Description	Category	Sand	Loess	Clay	Peat	All
Number of farms		151	20	54	59	284
Fertiliser use:	Livestock manure	88	88	85	86	87
	Other organic fertiliser	1	0	0	0	0
	Inorganic fertiliser	6	4	6	5	5
	Total mean	94	93	91	91	92
Use phosphate on arable land*		95	105	94	97	96
Application standard arable land**		88	90	91	85	88
Use phosphate on grassland*		95	94	91	90	93
Application standard on grassland**		100	102	101	100	101

- * The mean use and the application standards on grassland and arable land are based on 275 and 208 farms respectively instead of 284 farms, as on 9 farms the allocation of fertilisers to arable land and grassland did not fall within the confidence intervals and because 68 farms had no arable land.
- ** The mean phosphate application standard on grassland was over 100 kg per ha and on arable land over 85 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.

3.1.3

Crop yields

Table 3.5 shows the mean 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 measuring the quantity of ensilaged silage maize. 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.

The loess region is not included in Table 3.5 because the number of available farms in the loess region for crop yields was below the minimum required number of farms for which outcomes from FADN may be published. Therefore the loess farms have also been omitted from the total means in the last column of Table 3.5 Table 3.5 shows that:

- the mean estimated dry matter yield for silage maize was more than 15,000 kg per ha. The yield in the peat region was less than 15,000 kg dry matter per hectare and in the other regions it was higher than this;
- per hectare an estimated mean of 180 kg N and 40 kg P (91 kg P₂O₅) were harvested in the form of silage maize;
- at 9500 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 yield per ha was higher and the P yield per ha was about the same;
- the calculated grassland yields were highest in the peat region and lowest in the clay region.

Table 3.5 Mean crop yield (in kg dry matter, N, P and P₂O₅ per ha) for silage maize (estimated) and grassland (calculated) in 2008 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	Clay	Peat	All
Yields silage maize				
Number of farms	77	26	17	120
kg dry matter per ha	15,500	15,500	14,500	15,400
kg N per ha	182	180	173	180
kg P per ha	32	32	29	31
kg P ₂ O ₅ per ha	73	73	65	91
Yields grassland				
Number of farms	88	32	28	148
kg dry matter per ha	9500	9400	9700	9500
kg N per ha	264	252	268	262
kg P per ha	38	37	38	38
kg P ₂ O ₅ per ha	87	85	88	87

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 2008. The surpluses are calculated using the calculation method described in Appendix 3.

Table 3.6 Nitrogen surplus on the soil surface balance (in kg N per ha) on farms in the derogation monitoring network in 2008. Means and 25% and 75% percentiles per region.

Description	Category	Sand	Loess	Clay	Peat	All
Number of farms		151	20	54	59	284
Import to farm	Inorganic fertiliser	118	104	154	116	124
	Organic fertiliser	18	27	12	18	17
	Feed	180	104	205	150	173
	Other	9	8	10	6	9
	Total	326	243	380	290	323
Export from farm	Milk and other animal products	74	48	86	68	73
	Animals	28	15	16	17	22
	Organic fertiliser	50	23	54	33	46
	Other	6	21	8	0	6
	Total	158	108	163	118	147
Mean nitrogen surplus per farm		168	135	217	172	176
+ Deposition, mineralisation and fixation		53	56	48	120	66
- Gaseous emission*		47	34	49	46	46
Mean nitrogen surplus on soil surface balance		174	157	216	246	196
Nitrogen surplus on soil surface balance first quartile (25%)		136	142	183	170	148
Nitrogen surplus on soil surface balance third quartile (75%)		209	187	231	318	230

* Gaseous emission from housing and storage, during application and grazing.

The following conclusions can be drawn from Table 3.6:

- The mean nitrogen surplus on the farm gate balance was 176 kg per ha.
- The nitrogen surplus increased in the order loess<sand<peat<clay.
- There are considerable differences between the regions with respect to the composition of the nitrogen surplus on the soil surface balance:
 - In the clay region, the surplus on the farm gate balance was highest because of the relatively high import compared to the other regions, which was not fully compensated by a high export.
 - The sand region had a lower nitrogen surplus on the farm gate balance compared to the clay region, mainly due to a lower import. Since there were no large differences between the clay and sand regions in terms of the import via deposition, mineralisation and biological N-binding

and export via gaseous emissions, the nitrogen surplus on the soil surface balance was also considerably lower in the sand region than in the clay region.

- In the peat region, less nitrogen was imported in the form of feed compared to the sand and clay regions. This lower import was partly caused by the lower number of intensive livestock in this region. Since export of nitrogen via animals, animal products and manure was considerably lower in the peat region, the nitrogen surplus on the farm gate balance was still slightly higher than in the sand region. The nitrogen surplus on the soil surface balance was higher, mainly due to the assumption that the mean net nitrogen mineralisation on peat was 75 kg per ha. This was included as import in the soil surface balance.
- The farms in the loess region were characterised by a low nitrogen surplus. Both import and export were lower on the farm gate balance than in the other regions.
- 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 148 kg N per ha, whereas for the 25% of farms with the highest surplus, the surplus was in excess of 230 kg N per ha.

Table 3.7 Phosphate surplus on the soil surface balance (in kg P₂O₅ per ha) on farms in the derogation monitoring network in 2008. Means and 25% and 75% percentiles per region.

Description	Category	Sand	Loess	Clay	Peat	All
Number of farms		151	20	54	59	284
Import to farm	Inorganic fertiliser	6	4	6	5	5
	Organic fertiliser	9	14	6	10	9
	Feed	67	39	75	55	64
	Other	4	4	4	3	4
	Total	86	61	91	72	83
Export from farm	Milk and other animal products	29	19	32	26	28
	Animals	15	10	10	10	13
	Organic fertiliser	25	10	30	18	24
	Other	2	8	3	0	2
	Total	71	47	75	54	67
Mean phosphate surplus on soil surface balance		15	14	16	18	16
Phosphate surplus on soil surface balance first quartile (25%)		3	3	6	8	4
Phosphate surplus on soil surface balance third quartile (75%)		24	20	27	34	26

The following conclusions can be drawn from Table 3.7:

- The mean phosphate surplus on the soil surface balance was 16 kg per ha.
- The phosphate surplus on the soil surface balance was highest in the clay and peat regions. At 14 kg per ha, the phosphate surplus in the loess region was the lowest, which was mainly due to a lower import 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 26 kg per ha.

3.2 Water quality

3.2.1 Leaching from the root zone, measured in 2008

In 2008, the concentrations measured in water leaching from the root zone are related to the agricultural practices on the farms in 2007 and preceding years. The water quality reported here is therefore related to the agricultural practices during the second year in which derogation was applied.

The nitrate concentrations in the loess region were on average higher than 50 mg (NO₃) per litre. The nitrate concentrations in the other regions were on average lower than 50 mg (NO₃) per litre (see Table 3.8). Although the nitrate concentration in the peat region was lower than in the clay region, the total nitrogen concentration was higher. This was due to the higher ammonium concentrations in the groundwater. The mean ammonium nitrogen concentration in the peat region was 4.5 mg N per litre. In the clay and loess regions the concentration was on average lower than 1 mg per litre. In the sand region the mean concentration was 1.7 mg N 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/l) in water that leached from the root zone in 2008 on farms in the derogation monitoring network. Mean concentrations per region.

Characteristic	Region			
	Sand	Loess	Clay	Peat
Number of farms	155	20	56	57
Nitrate (NO ₃)	43	54	23	7
Nitrogen (N)	13.2	13.3	7.2	8.8
Phosphorous (P) ¹	0.17 (48)	<0.06 (65)	0.24 (12)	0.44 (5)

¹ The mean percentage of farms with concentrations lower than the detection limit of 0.06 mg per litre is indicated between brackets.

In the sand region, 64% of the farms had a nitrogen concentration lower than 50 mg per litre and in the loess region this was 45% (see Table 3.9). In the clay and the peat regions, the percentage of farms with a concentration lower than 50 mg per litre was 85% and 98% respectively.

Table 3.9 Frequency distribution of the mean farm nitrate concentrations (in mg NO₃/l) in water that leached from the root zone on farms in the derogation monitoring network per region in 2008, expressed as percentages per class.

Concentration class (mg NO ₃ /l)	Region			
	Sand	Loess	Clay	Peat
<15	23	5	55	86
15-25	11	0	14	5
25-40	20	20	11	5
40-50	10	20	5	2
>50	37	55	14	2
Number of farms	155	20	56	57

Fifty percent of the farms in the sand region had a nitrogen concentration between 7.9 and 17.3 mg N per litre (see Table 3.10). For the loess region the figures were more or less the same. For the peat and clay regions, the concentrations were lower.

Table 3.10 Nitrogen concentrations (in mg N per litre) in water that leached out from the root zone in 2008 on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	Region			
	Sand	Loess	Clay	Peat
Number of farms	155	20	56	56
First quartile (25%)	7.9	10.4	2.9	6.0
Median (50%)	12.1	14.0	4.5	8.8
Third quartile (75%)	17.3	15.6	8.9	11.3

The phosphorus concentration in the leaching water on 75% of the farms in the loess region was lower than the detection limit of 0.07 mg P per litre and in the sand region lower than 0.13 mg per litre (see Table 3.11). In the clay region, the phosphorus concentrations for 50% of the farms were between 0.08 and 0.31 mg per litre. In the peat region the concentrations were higher.

Table 3.11 Phosphorus concentrations (in mg P per litre) in water leaching from the root zone in 2008 on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	Region			
	Sand	Loess	Clay	Peat
Number of farms	155	20	56	57
First quartile (25%)	<0.06	<0.06	0.08	0.17
Median (50%)	0.06	<0.06	0.16	0.38
Third quartile (75%)	0.13	0.07	0.31	0.57

3.2.2 Ditch water quality, measured in 2007-2008

The quality of the ditch water in the winter of 2007-2008 reported here, reflects the agricultural practices in 2007 and the years prior to this and is related to the first year of the derogation. The provisional peat and clay figures have already been presented in 2009 (Zwart et al, 2009).

The loess region has no farms with ditches or drains and is therefore not included in the tables below.

The nitrate concentration in the ditch water on farms in the derogation monitoring network clearly differs between regions. With a mean of 39 mg NO₃ per litre the nitrate concentration was highest in the sand region and with a mean of less than 3.9 mg per litre, 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 was not significant. The phosphorus concentration in the ditch water was highest in the clay region and lowest in the sand region.

Table 3.12 Nutrient concentration (in mg/l) in ditch water in the winter of 2007-2008 on farms in the derogation monitoring network. Mean concentrations per region.

Characteristic	Region		
	Sand	Clay ¹	Peat ¹
Number of farms	25	55	56
Nitrate (NO ₃)	39	11	4
Nitrogen (N)	10.7	4.4	3.9
Phosphorus (P)	0.13	0.31	0.17

* The loess region has no farms with ditches.

¹ For clay and peat one farm had no ditches.

In the sand region, 16 of the 25 farms (64%) had a nitrate concentration lower than 40 mg per litre (see Table 3.13). In the clay and peat regions, 1 farm and 0 farms respectively had a ditch water nitrate concentration higher than 50 mg per litre.

Table 3.13 Frequency distributions of the farm mean nitrate concentrations (in mg NO₃/l) in ditch water on farms in the derogation monitoring network per region in the winter of 2007-2008, expressed in percentages per class.

Concentration class (mg NO ₃ /l)	Region		
	Sand	Clay	Peat
<15	24	76	95
15-25	20	11	5
25-40	20	7	0
40-50	8	4	0
>50	28	2	0
Number of farms	25	55	56

Approximately half of the farms in the sand region had a ditch water nitrogen concentration of between 5.1 and 15.3 mg N per litre (see Table 3.14). In the clay and peat regions 75% of the farms had a ditch water nitrogen concentration less than 5.8 mg per litre.

Table 3.14 Ditch water nitrogen concentrations (in mg N per litre) in the winter of 2007-2008 on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	Region		
	Sand	Clay ¹	Peat ¹
Number of farms	25	55	56
First quartile (25%)	5.1	2.0	2.5
Median (50%)	9.8	3.2	4.0
Third quartile (75%)	15.3	5.8	5.1

¹ For clay and peat one farm had no ditches.

On 50% of the farms in the sand region, the ditch water phosphorus concentration was lower than the detection limit of 0.08 mg P per litre (see Table 3.15). In the peat region, 50% of the farms had a phosphorus concentration between 0.07 and 0.22 mg per litre. The highest concentrations were found in the clay region. Here, 50% of the farms had a phosphorus concentration between 0.05 and 0.54 mg per litre. In both the peat and the clay regions the concentrations were higher than in the sand region.

Table 3.15 Ditch water phosphorus concentrations (in mg P per litre) in the winter of 2007-2008 on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	Region		
	Sand	Clay	Peat
Number of farms	25	55	56
First quartile (25%)	<0.06	<0.06	0.07
Median (50%)	0.08	0.12	0.11
Third quartile (75%)	0.16	0.54	0.22

Comparison with the provisional figures for 2008 as reported in 2009

The provisional figures reported in 2009 concerning the nitrate and total nitrogen concentrations in 2008 on derogation farms in the clay and peat region were slightly higher than the final figures stated above. The phosphorous figures are nearly the same as the provisional figures reported in 2008.

3.2.3 Provisional figures for the measurement year 2009

For the fourth measurement year (2009) only provisional results are available, with the exception of the loess region for which no results were yet available when this report was written. 'Provisional' indicates that the results are fairly reliable, but that various cross-checks have yet to be performed. This implies that in 2011 some concentrations in the final results may change.

In the sand region, the mean nitrate concentration in water leaching from the root zone was 39 mg per litre and 69% of the farms had a concentration lower than 50 mg per litre. The mean nitrate concentration in water leaching from the root zone in the clay region was 20 mg NO₃ per litre in 2009. Of the participating farms, 88% had a nitrate concentration lower than 50 mg per litre (see Table 3.13). The mean nitrate concentration on farms in the peat region was 4 mg per litre.

The mean nitrate concentration in the ditch water in 2009 in the clay and peat regions was 9 mg per litre and 4 mg per litre respectively for all participating farms (see Table 3.16) and was therefore far below the standard of 50 mg per litre.

Table 3.16 Frequency distributions for the farm mean nitrate concentrations (in mg NO₃ 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 2009, expressed in percentages per class. The figures given are provisional (see text).

Concentration class (mg NO ₃ /l)	Water type						
	Leaching out of root zone				Ditch water		
	Sand	Loess	Clay	Peat	Sand	Clay	Peat
<15	31	*	53	81	43	84	96
15-25	10	*	21	12	20	7	2
25-40	18	*	14	5	7	5	2
40-50	10	*	0	0	10	4	0
>50	31	*	12	2	20	0	0
Overall mean	39	*	20	6	26	9	4
Number of farms	154	0	58	58	30	57	57

* no data from the loess region were yet available at the time of reporting.

The mean total nitrogen concentration and the frequency distribution in the leaching water and ditch water for the three regions are given in Table 3.17. The nitrogen concentrations in the ditch water were lower than those in the leaching water.

Table 3.17 Nitrogen concentrations (in mg N per litre) in the water leaching from the root zone (left) and in the ditch water (right) in 2009 (provisional figures) on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	Leaching				Water type		
	Sand	Loess	Clay	Peat	Sand	Clay	Peat
Number of farms	153	0	58	58	30	57	57
Mean	11.6	*	6.5	7.7	7.7	4.1	4.2
First quartile (25%)	6.6	*	2.9	5.9	3.9	2.3	2.5
Median (50%)	10.2	*	4.4	7.3	6.1	3.2	3.8
Third quartile (75%)	15.3	*	7.9	9.5	12.1	4.7	5.4

* data from the loess region were not yet available at the time of reporting.

The table below details the mean phosphorous concentration and frequency distribution in the leaching water and in the ditch water for the three regions. Like nitrogen, the phosphorus concentrations in ditch water were lower than in leaching water, with the exception of the clay region where the phosphorous concentration in the ditch water was higher than in the leaching water.

Table 3.18 Phosphorus concentrations (in mg P per litre) in the water leaching from the root zone (left) and in the ditch water (right) in 2009 (provisional figures) on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	Leaching				Water type		
	Sand	Loess	Clay	Peat	Sand	Clay	Peat
Number of farms	154	0	58	58	30	57	57
Mean	0.15	*	0.28	0.39	0.10	0.32	0.22
First quartile (25%)	0.00	*	0.09	0.15	0.00	0.06	0.07
Median (50%)	0.06	*	0.20	0.30	0.07	0.13	0.12
Third quartile (75%)	0.13	*	0.39	0.42	0.13	0.50	0.20

4 Changes since the derogation

4.1 Introduction

In this chapter, the results of the agricultural practice during 2006 (Fraters et al, 2008) and 2007 (Zwart et al, 2009) shall be related to the and the water quality results of 2008 and 2009, as described in the previous chapters. It should be noted, however, that only a limited comparison is made. For both agricultural practice and water quality three measurement years are available. When making comparisons, it should be realised that a limited series of measurement data for three successive years does not provide sufficient basis for concrete statements about trends and developments. This chapter starts with describing the trends in agricultural practice and then presents the evolution of the water quality. Finally a link is made between the trends in agricultural practice and the evolution of the water quality.

4.2 Trends in agricultural practice

This section reports on all 274 farms that participated in the derogation monitoring network during 2006, 2007 and 2008 (see Figure 2.1). Farms that did not 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) and in Zwart et al (2009). As the nutrient flow data were incomplete for 13 of these farms in some of the years, Tables 4.3, 4.4, 4.5, 4.7 and 4.8 are based on the results from 261 farms. The calculated crop yields (Table 4.6) are based on the data of 81 farms that participated in all three years and satisfied the criteria for calculating crop yields in all years.

4.2.1 Change in assessment method

In the following overview tables of the agricultural practice characteristics, a letter code is used to indicate whether the annual mean values significantly differ from each other with a 95% confidence interval. For three years there are eight possibilities (see Table 4.1a), varying from 'no significant differences whatsoever (Result 1)' to 'All years differ significantly from each other (Result 8)'.

Table 4.1a Possible results for the three t-tests per variable. A ‘=’ indicates that the annual means do not significantly differ from each other whereas for ‘<>’ that there is a difference.

Result	Differences between years			Letter code		
	2006	2007	2008	2006	2007	2008
1	2006=2007	2006=2008	2007=2008	No letter coding in the table		
2	2006=2007	2006<>2008	2007=2008	a	ab	b
3	2006=2007	2006=2008	2007<>2008	ab	a	b
4	2006=2007	2006<>2008	2007<>2008	a	a	b
5	2006<>2007	2006=2008	2007=2008	a	b	ab
6	2006<>2007	2006<>2008	2007=2008	a	b	b
7	2006<>2007	2006=2008	2007<>2008	a	b	a
8	2006<>2007	2006<>2008	2007<>2008	a	b	c

a, b, c: a different letter indicates that there is a significant difference (95% confidence interval); for no letter or the same letter for two years there is no significant difference (95% confidence interval) between these two years.

Table 4.1b Example of the coding used in the tables below.

Description category	2006	2007	2008
Application standard on grassland	316 ^a	313 ^b	297 ^c
Number of dairy farms	247	246	247
Use on arable land	108 ^a	115 ^a	125 ^b
Import of (inorganic) fertiliser, feed, animals and other products	282 ^a	290 ^{ab}	297 ^b

The codes in the table should be read as follows:

- The application standard on grassland is significantly different between all three years and is indicated by three different letters.
- The number of dairy farms does not significantly differ between the years.
- The use on arable land exhibits no significant difference between 2006 and 2007 (same letter code); however, a significant difference was found between 2007 and 2008 and 2006 and 2008, the letter in the column 2008 differs from that in the columns 2006 and 2007.
- The import of inorganic fertiliser differs significantly between 2006 and 2008, the 290 in 2007 does not significantly differ from the 282 in 2006 nor the 297 in 2008 and therefore has the same letter code as each of these two years.

A period of three years only provides limited opportunities for finding trends. At most, a trend can only be indicated if the three years are all significantly different from each other (Result eight in Table 4.1a and application standard on grassland in Table 4.1b). And then there must also be an increase or decrease in the series of numbers.

4.2.2

Characterisation of the farms

Changes in the general farm characteristics over the course of time such as acreage of cultivated land, percentage of farms with grazing and the percentage of grassland are, in general, limited (see Table 4.2). The quantity of milk produced, expressed as FPCM per farm and per hectare has significantly increased. An important reason for this is the increases in the milk quota issued by the European Union of 0.5% in 2007 and 2.5% in 2008. The increase in the milk production was associated with an increase in the area of cultivated land and the stock density. There was a slight decrease in the proportion of grassland in 2008. The proportion of intensive livestock farming decreased significantly in the period 2006-2008.

Table 4.2 Description of a number of general farm characteristics of the farms in the derogation monitoring network (DM) in 2008, compared to 2006 and 2007 (N=274).

Farm characteristic	2006	2007	2008
Number of dairy farms	247	246	247
Number of other grassland farms	27	28	27
Total area cultivated land (ha)	49.4 ^a	49.7 ^a	51.6 ^b
Percentage grassland	83 ^a	83 ^a	82 ^b
Percentage farms with intensive livestock farming	16 ^a	14 ^b	14 ^c
Total stock density (GVE per ha)	2.45 ^a	2.49 ^a	2.62 ^b
kg FPCM farm	699,500 ^a	726,700 ^b	771,000 ^c
kg FPCM per dairy cow	14,100 ^a	14,500 ^b	15,000 ^b
kg FPCM per ha forage crop	8430	8450	8395
% dairy farms with grazing dairy cattle	85	85	85

^a, ^b, ^c: a different letter indicates that there is a significant difference (95% confidence interval); for no letter or the same letter for two years there is no significant difference (95% confidence interval) between these two years. See also Table 4.1a.

4.2.3 Use of livestock manure

The use of livestock manure expressed in nitrogen (N) did not change in the period 2006-2008 (Table 4.3). The use of farm-produced manure and imported manure was higher in 2008 but not significantly. The export of livestock manure increased significantly in the period 2006-2008. In all years there was an increase in the import of livestock manure. The use of nitrogen from livestock manure on grassland and arable land varied slightly in the period 2006-2008. When more manure was used on grassland, less appeared to be used on arable land but these differences are not significant.

Table 4.3 Mean nitrogen use from livestock manure (in kg N per ha) in 2008 on farms in the derogation monitoring network (DM) in 2008 compared to 2006 and 2007 (N=261).

Description category	2006	2007	2008
<i>Use nitrogen from livestock manure</i>			
Produced on farm	251	251	255
+ Import	9	11	12
+ Stock mutation	-5	-7	-6
- Export	19 ^a	22 ^b	25 ^c
<i>Total</i>	236	232	235
Number of farms with use on grassland**	252	252	252
Use on grassland	249	245	248
Number of farms with use on arable land**	179	179	179
Use on arable land	180	183	178

* The mean use and the application standards on grassland are based on 252 farms as the allocation of fertilisers to arable land at a number of farms did not fall within the confidence intervals.

** The mean use and the application standards on arable land are based on 179 farms as besides a number of farms falling outside of the confidence intervals for the allocation of fertilisers to arable land, a number of farms had no arable land.

^a, ^b, ^c: a different letter indicates that there is a significant difference (95% confidence); for no letter or the same letter for two years there is no significant difference (95% confidence interval) between these two years. See also Table 4.1a.

4.2.4 Use of fertilisers compared to the application standards

Table 4.4 compares the use of nitrogen fertilisers to the statutory nitrogen application standards. Table 4.4 shows several significant differences. However, these differences are nearly all the result of changes to the standard:

- the statutory availability coefficient for farm-produced grazing livestock manure in the case of grazing dairy cattle has been 45% since 2008, whereas this was 35% in 2006 and 2007. Therefore although the farms did not use more livestock manure in 2008, a higher use of available livestock manure was ascribed to them;
- also the nitrogen application standards on grassland in 2008, particularly in the clay and peat regions, have been tightened compared to 2007. The same happened in 2007 compared to 2006 but to a lesser extent.

As the application standards differ between years but very little between farms then the difference between years for the applications standards easily become significant.

The use of nitrogen fertiliser in 2008 was, however, a bit lower than in 2007 but not by much (6 kg/ha). The changes in the availability coefficient and the nitrogen application standards reduced the differences between the use and the nitrogen application standards:

- on grassland the difference in 2008 was just half of that between 2006 and 2007;
- on arable land the difference in 2008 was about two-thirds of the difference in 2006 and 2007.

Nevertheless, on both arable land and grassland about 30 kg/ha of the room in the nitrogen application standard is still not used. For a total use of 239 kg/ha that is just over 10%.

Table 4.4 Mean nitrogen use (in kg available N per ha) on farms in the derogation monitoring network (DM) in 2008 compared to 2006 and 2007 (N=261).

Description category	2006	2007	2008
Mean statutory availability coefficient	41 ^a	41 ^a	50 ^b
Livestock manure excl. availability coefficient	236	232	235
Livestock manure incl. availability coefficient	97 ^a	95 ^a	116 ^b
Fertiliser use:			
Other organic fertiliser	0	0	0
Inorganic fertiliser	127 ^{ab}	128 ^a	122 ^b
Total mean	223 ^a	223 ^a	239 ^b
Number of farms with use on grassland**	252	252	252
Use on grassland	247 ^a	248 ^a	267 ^b
Application standard grassland	316 ^a	313 ^b	297 ^c
Number of farms with use on arable land**	179	179	179
Use on arable land	108 ^a	115 ^a	125 ^b
Application standard arable land	157 ^a	160 ^b	159 ^b

* The mean use and the application standards on grassland are based on 252 farms as the allocation of fertilisers to arable land did not fall within the confidence intervals for a number of farms.

** The mean use and the application standards on arable land are based on 179 farms as besides a number of farms falling outside of the confidence intervals for the allocation of fertilisers to arable land, a number of farms had no arable land.

^a, ^b, ^c: a different letter indicates that there is a significant difference (95% confidence interval); for no letter or the same letter for two years there is no significant difference (95% confidence interval) between these two years. See also Table 4.1a.

Table 4.5 compares the use of phosphate fertilisers to the statutory phosphate application standards. Table 4.5 shows several significant differences. Just as for Table 4.4 adjustments to the application standards over the course of time, now for phosphate, play a large role.

From Table 4.5 it can be concluded that:

- The application standards for both grassland and arable land have been lowered each year (by 5 kg phosphate per ha). Some of the farms have requested a higher application standard for phosphate-poor or phosphate-fixing soils.
- The total use of phosphate via fertilisation has clearly fallen. This is almost entirely due to a reduction in the use of inorganic phosphate fertiliser.
- On arable land the phosphate application standard was exceeded but this was compensated for by fertilising less on grassland. Despite the higher phosphate application standard, grassland is fertilised less with phosphate than arable land.

Table 4.5 Mean phosphate use (in kg P₂O₅ per ha) on farms in the derogation monitoring network in 2008 compared to 2006 and 2007 (N=261).

Description category	2006	2007	2008	
Fertiliser use:	Livestock manure	87	86	87
	Other organic fertiliser	0	0	0
	Inorganic fertiliser	10 ^a	7 ^b	6 ^c
	<i>Total mean</i>	97 ^a	93 ^b	93 ^b
Number of farms with use on grassland**	252	252	252	
Use on grassland	97 ^a	93 ^b	93 ^b	
Application standard grassland	110 ^a	106 ^b	100 ^c	
Number of farms with use on arable land**	179	179	179	
Use on arable land	102	101	97	
Application standard arable land	96 ^a	92 ^b	88 ^c	

* The mean use and the application standards on grassland are based on 252 farms as the allocation of fertilisers to arable land did not fall within the confidence intervals for a number of farms.

** The mean use and the application standards on arable land are based on 179 farms as besides a number of farms falling outside of the confidence intervals for the allocation of fertilisers to arable land, a number of farms had no arable land.

^a, ^b, ^c: a different letter indicates that there is a significant difference (95% confidence interval); for no letter or the same letter for two years there is no significant difference (95% confidence interval) between these two years. See also Table 4.1a.

4.2.5 Crop yields

The crop yields were calculated according to the method described by Aarts et al (2008). A more detailed explanation of this calculation method is provided in Appendix 3.

Compared to the derogation report in 2009 (Zwart et al, 2009) the yields on grassland in 2007 are about 10% lower. Besides a slightly different population, changes in the calculations of the crop yields have also been implemented. Furthermore, 2007 was not a good year for grass yields and this is confirmed by the figures in Table 4.6.

The mean silage maize yield (dry matter, N and P) was significantly higher in 2006 than in later years (Table 4.6). The mean calculated grassland yield was, however, higher in 2008 than in the previous two years but the difference was not significant.

Table 4.6 Estimated crop yield (in kg dry matter, N, P and P₂O₅per ha) for silage maize and the calculated yield from grassland on farms in the derogation monitoring network that satisfy the criteria for the calculation method for grassland yield (Aarts et al, 2008) in 2008 compared to 2006 and 2007 (N=81).

	2006	2007	2008
Number of farms	81	81	81
<i>Estimated yield silage maize</i>			
Tonnes dry matter			
per ha	15.7 ^a	14.9 ^b	15.4 ^{ab}
kg N per ha	208 ^a	171 ^b	180 ^c
kg P per ha	35 ^a	30 ^b	31 ^b
kg P ₂ O ₅ per ha	80 ^a	69 ^b	71 ^b
<i>Calculated yield grassland</i>			
Tonnes dry matter			
per ha	9.4	9.4	9.8
kg N per ha	275	255	266
kg P per ha	37	36	39
kg P ₂ O ₅ per ha	85	82	89

“ The silage maize yields are based on 71 farms in the period 2006-2008 instead of 81 farms as 10 farms did not cultivate any silage maize.

^a, ^b, ^c: a different letter indicates that there is a significant difference (95% confidence interval); for no letter or the same letter for two years there is no significant difference (95% confidence interval) between these two years. See also Table 4.1a.

4.2.6 Nutrient surpluses on the soil surface balance

Table 4.7 details the nitrogen surplus on the soil surface balance.

Table 4.7 Nitrogen surplus on the soil surface balance (in kg N per ha) on farms in the derogation monitoring network in 2008 compared to 2006 and 2007 (N=261).

Description category	2006	2007	2008
Import of (inorganic) fertiliser, feed, animals and other products	282 ^a	290 ^{ab}	297 ^b
Export of milk, animals, feed, manure and other products	114 ^a	126 ^b	128 ^b
Deposition, mineralisation and N fixation	67	67	67
Gaseous emission from housing and storage, during grazing and application	44	43	43
Mean surplus on soil surface balance	192	187	193
Surplus on soil surface balance first quartile	143	136	146
Surplus on soil surface balance third quartile	232	239	230

^a, ^b, ^c: a different letter indicates that there is a significant difference (95% confidence interval); for no letter or the same letter for two years there is no significant difference (95% confidence interval) between these two years. See also Table 4.1a.

The following conclusions can be drawn from Table 4.7:

- The nitrogen surplus on the soil surface balance in the period 2006-2008 remained about the same. The import increased but so did the export. Both the calculated import via deposition, mineralization and nitrogen fixation as well as the calculated emission were more or less the same over the years reported on.
- The difference between the first and third quartiles was greater in 2007 than in the other years.

Table 4.8 reveals that the nitrogen surplus on the soil surface balance in de clay and peat regions differed significantly between 2007 and 2008. There were no significant differences in the nitrogen surplus on the soil surface balance between the other years. In the sand and loess regions there were no significant differences whatsoever in the nitrogen surplus on the soil surface balance between the years 2006, 2007 and 2008.

Table 4.8 Nitrogen surplus on the soil surface balance (in kg N per ha) on farms in the derogation monitoring network in 2008 compared to 2006 and 2007 (N=261): per region and total.

Region	2006	2007	2008
Sand N=140	172	175	169
Loess N=16	134	156	148
Clay N=48	208 ^{ab}	184 ^a	213 ^b
Peat N=57	245 ^{ab}	229 ^a	247 ^b
Mean surplus soil surface balance (Table 4.7)	192	187	193

^a, ^b, ^c: a different letter indicates that there is a significant difference (95% confidence interval); for no letter or the same letter for two years there is no significant difference (95% confidence interval) between these two years. See also Table 4.1a.

The nitrogen and phosphate yields of silage maize in 2006 were also significantly higher in each region than in 2007 and 2008. Between 2007 and 2008, no significant difference was found, with the exception of the sand region where these yields were significantly lower in 2007 than in 2008.

For the nitrogen yield on grassland no significant differences between years were seen in any region.

Table 4.9 details the phosphate surplus on the soil surface balance. In Table 4.9 it can be seen that the phosphate surplus on the soil surface balance in 2007 and 2008 was significantly lower than that in 2006. This was due to less import and more export.

Table 4.9 Phosphate surplus on the soil surface balance (in kg P₂O₅ per ha) on farms in the derogation monitoring network in 2008 compared to 2006 and 2007 (N=261).

Description category	2006	2007	2008
Import of (inorganic) fertiliser, feed, animals and other products	76 ^a	73 ^b	73 ^{ab}
Export of milk, animals, feed, manure and other products	51 ^a	55 ^b	56 ^b
Mean surplus on soil surface balance	25 ^a	17 ^b	16 ^b
Surplus on soil surface balance first quartile	12 ^a	5 ^b	4 ^b
Surplus on soil surface balance third quartile	36 ^a	30 ^b	26 ^c

^a, ^b, ^c: a different letter indicates that there is a significant difference (95% confidence interval); for no letter or the same letter for two years there is no significant difference (95% confidence interval) between these two years. See also Table 4.1a.

4.2.7

Summary

The comparison of the results for the years 2006 to 2008 reveals that the milk production per farm and per hectare has increased. There was also an associated increase in the production of livestock manure, yet due to a greater export of livestock manure in particular, the use remained more or less the same. However, the use of inorganic nitrogen fertilisers decreased in 2008, which was probably due to the increased availability coefficient forfeit for livestock manure for the grazing of dairy cattle and the slightly stricter nitrogen application standards. This had little effect on the nitrogen surplus on the soil surface balance, partly due to the moderate intensification (more milk and more animals per hectare). Also the phosphate application standards became tighter in the years 2006-2008, which mainly led to less use of inorganic phosphate fertiliser. The mean phosphate surplus on the soil surface balance therefore decreased.

The estimated silage maize yield (kg N and P₂O₅ per ha) was lower in 2007 and 2008 compared to 2006. This decrease was not expressed in the dry matter yield. The estimated grassland yield (kg N and P₂O₅ per ha) was also lower in 2007 and 2008 compared to 2006. However, the yield of dry matter in 2008 was slightly higher than in the other two years, though this difference was not significant.

In conclusion, it can be stated that the tightening of the application standards in the years 2006 to 2008 resulted in a reduced application of inorganic fertiliser. The yield of dry matter was not affected by this. The nitrogen surplus on the soil surface balance has not really changed in the years 2006 to 2008. However, the surplus for phosphorous did decrease during this period.

4.3

Evolution of the water quality

4.3.1

Introduction

In this section a comparison is made between the water quality measured in the different derogation years (2007-2009). First of all the traditional statistical method (paired comparison) was used in which a difference is determined per farm and then the mean of these differences is tested for a clear deviation from the null hypothesis to determine if there is a significant difference (Table 4.10). An explanation of the method used is provided in Appendix 6.

4.3.2 Evolution in the years 2006 and 2007

In the progress report for 2009 (Zwart et al, 2009) a comparison was made between 2006 and 2007, with 2007 being the first year in which the effects of derogation on the water quality were possibly visible. The water quality measured in 2006 is the result of agricultural practices from the period prior to derogation. This comparison revealed that 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 significantly higher in 2007 than in 2006. The calculated increase in the nitrate concentration was 8.1 or 7.3 mg per litre (dependent on the statistical method used). The difference in the precipitation surplus between 2006 and 2007 is a possible explanation for 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 did not change between 2006 and 2007 (Zwart et al, 2009). The nutrient concentrations in the ditch water of derogation farms in the sand and clay regions did not significantly change between 2006 and 2007 (Zwart et al, 2009).

4.3.3 Evolution during the derogation years 2007, 2008 and 2009

This is the first report with results available for several successive sampling years, although it should be noted that the results for 2009 are still provisional at this stage. From this limited series of results the following conclusions can be cautiously drawn. The graphs below provide an initial impression of the trend in concentrations. Whether the increases or decreases are also significantly different and whether there is a relationship with weather effects, is treated in Tables 4.10, 4.11 and 4.12.

The nitrate concentrations of the water leaching from the root zone were lower on the derogation farms in 2008 and 2009 than in 2007. This can be partly or fully attributed to a lower precipitation surplus in 2007. Over the past two years the mean level has only been above 50 mg per litre in the loess region.

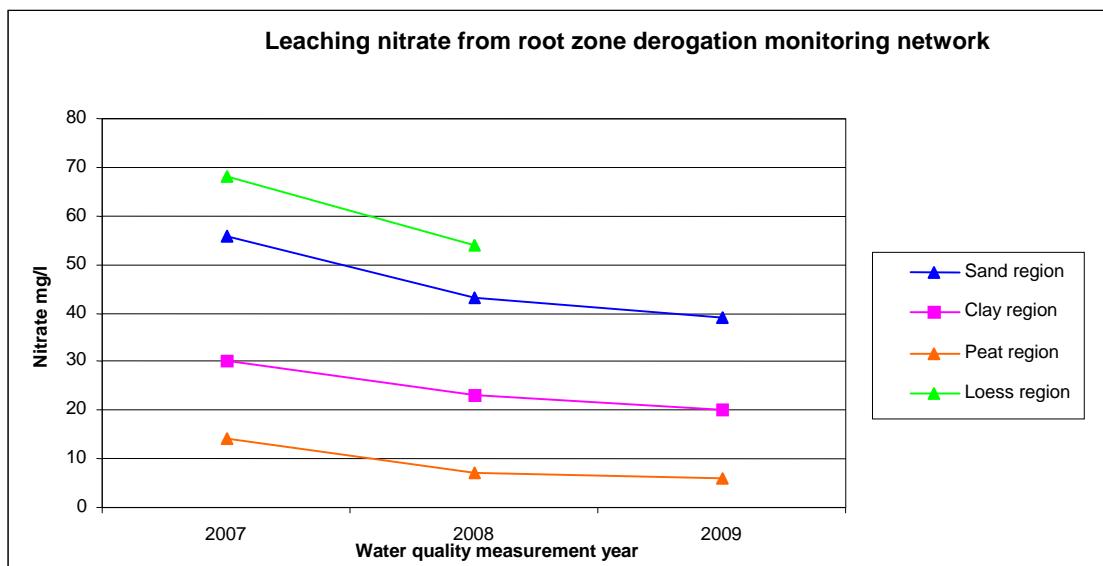


Figure 4.1 Nitrate concentration in water leaching from the root zone on derogation farms in the four regions during the period 2007-2009.

The nitrate concentrations in the ditch water on derogation farms in the peat and clay regions show the same picture as the results for leaching from the root zone (Figure 4.2). In 2009, the results from the sand region showed a marked decrease. The graph also reveals that in all regions and years the mean nitrate concentration was less than 50 mg per litre.

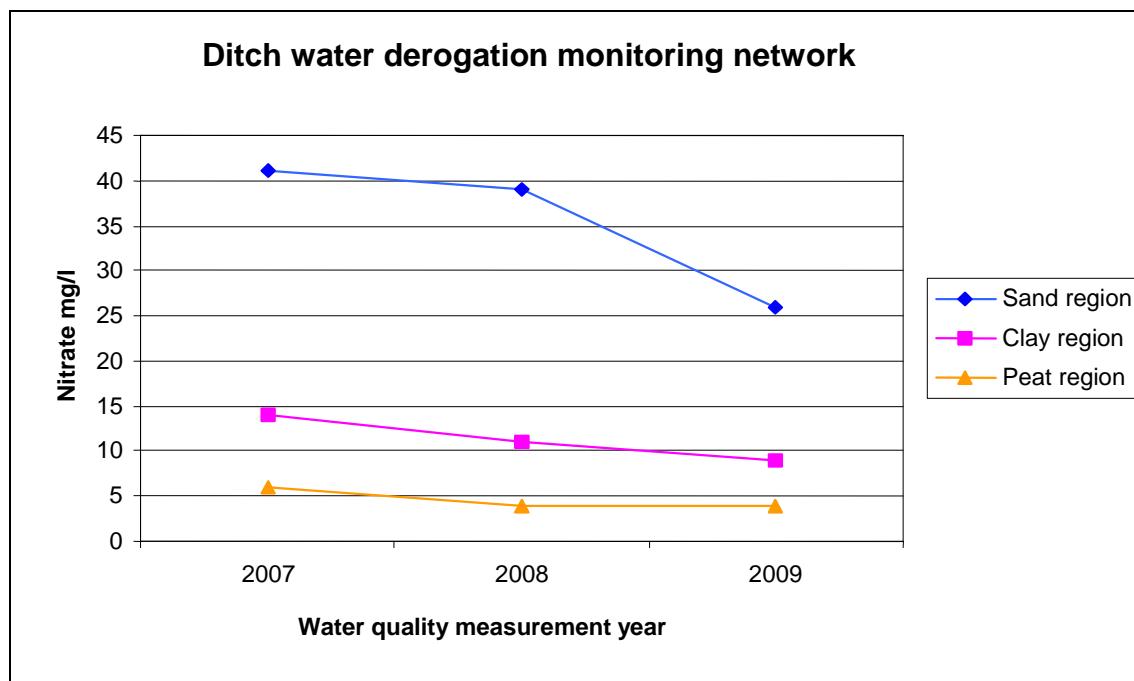


Figure 4.2 Nitrate concentration in ditch water on derogation farms in the four regions during the period 2007-2009.

In the tables below, the successive years are statistically compared to determine if the differences between years are significant. This is done by paired comparisons of farms that have participated in both years. In this comparison it is indicated to what extent a difference is significant.

Table 4.10 shows that the nitrogen and total nitrogen concentrations in both leaching water and the ditches decreased significantly between 2007 and 2008. Only for the ditches in the sand region is the decrease not significant. A significant increase or decrease for the phosphate concentration was not observed, with the exception of the decrease in the ditches in the peat region.

Table 4.10 Mean nutrient concentrations (mg/l) in the water leaching from the root zone (leaching) and in the ditch water in 2008 and 2007 and the mean difference with the standard error. The mean difference is the mean of the differences per farm for all farms that were sampled in both measurement years.

Soil type parameter	Number of observations	Mean 2007	Mean 2008	Difference 2008-2007	se ¹
Clay leaching					
Nitrate	56	29.7	22.9	-6.8	1.8
Phosphorous	56	0.26	0.24	-0.02	0.02
Nitrogen (N)	56	10.2	7.2	-3.1	1.4
Clay ditch water					
Nitrate	55	13.7	10.7	-3.0	1.3
Phosphorous	55	0.29	0.31	0.03	0.05
Nitrogen (N)	55	4.6	4.4	-0.3	0.3
Sand leaching					
Nitrate	155	55.9	42.9	-13.0	2.0
Phosphorous	155	0.12	0.17	0.05	0.04
Nitrogen (N)	155	15.6	13.2	-2.5	0.5
Sand ditch water					
Nitrate	25	41.4	38.5	-2.9	4.2
Phosphorous	25	0.14	0.13	-0.01	0.02
Nitrogen (N)	25	11.2	10.7	-0.5	1.0
Peat leaching					
Nitrate	55	14.7	6.3	-8.4	2.6
Phosphorous	56	0.54	0.44	-0.10	0.07
Nitrogen (N)	55	11.4	8.8	-2.6	1.5
Peat ditch					
Nitrate	55	6.0	4.2	-1.8	0.7
Phosphorous	55	0.22	0.17	-0.05	0.02
Nitrogen (N)	55	3.5	4.0	0.5	0.2
Loess leaching					
Nitrate	18	68.3	52.3	-16.0	2.7
Phosphorous	18	0.03	0.04	0.00	0.01
Nitrogen (N)	18	17.0	12.8	-4.2	0.9

¹ The asterisks indicate the degree of probability (p) that the calculated difference is due to chance and therefore that the difference is significant. The significant differences are shown in bold font.

* prob <0.05, 95% certainty

** prob <0.01, 99% certainty

*** prob <0.001, 99.9% certainty

se standard error.

From Table 4.11 it can be deduced that the observed decrease in the nitrate and nitrogen concentrations between 2007 and 2008 has continued between 2008 and 2009. However, the differences are only significant for the sand region.

A significant increase or decrease for the phosphate concentration was not observed between 2008 and 2009, with the exception of the decrease in the ditches in the sand region.

Based on Tables 4.10 and 4.11 it can be stated that there is a possible decreasing trend in nitrate and nitrogen concentrations in the sand region. Whether or not this trend continues will become apparent over the next few years.

Table 4.11 Mean nutrient concentrations (mg/l) in the water leaching from the root zone (leaching) and in the ditch water in 2008 and 2009 and the mean difference with the standard error. The mean difference is the mean of the differences per farm for all farms that were sampled in both measurement years.

Soil type parameter	Number of observations	Mean 2008	Mean 2009	Difference 2009-2008	se ¹
Clay Leaching					
Nitrate	56	22.9	21.0	-1.9	1.5
Phosphorous	56	0.24	0.26	0.02	0.03
Nitrogen (N)	56	7.2	6.6	-0.6	0.3
Clay ditch water					
Nitrate	55	10.7	9.4	-1.3	1.0
Phosphorous	55	0.31	0.32	0.01	0.03
Nitrogen (N)	55	4.4	4.2	-0.2	0.3
Sand leaching					
Nitrate	154	43.1	38.9	-4.2	1.7
Phosphorous	154	0.17	0.15	-0.02	0.03
Nitrogen (N)	153	13.2	11.6	-1.6	0.4
Sand ditch water					
Nitrate	25	38.5	29.7	-8.8	4.2
Phosphorous	25	0.13	0.10	-0.03	0.01
Nitrogen (N)	25	10.7	8.6	-2.1	1.0
Peat leaching					
Nitrate	57	7.2	6.5	-0.7	1.7
Phosphorous	57	0.44	0.38	-0.05	0.08
Nitrogen (N)	56	8.8	7.6	-1.2	0.5
Peat ditch					
Nitrate	56	4.3	3.6	-0.7	0.6
Phosphorous	56	0.17	0.22	0.06	0.06
Nitrogen (N)	56	3.9	4.2	0.3	0.3
Loess leaching					
Nitrate	0	-	-	-	-
Phosphorous	0	-	-	-	-
Nitrogen (N)	0	-	-	-	-

¹ The asterisks indicate the degree of probability (p) that the calculated difference is due to chance and therefore that the difference is significant. The significant differences are shown in bold font.

* prob <0.05, 95% certainty

** prob <0.01, 99% certainty

*** prob <0.001, 99.9% certainty

se standard error.

4.3.4 Influence of weather conditions

The nitrate concentration in the sand region decreased significantly in the period 2007-2009 (see previous section). The nitrate concentration in the leaching water is not only influenced by agricultural practice but also by environmental factors such as the groundwater level and the precipitation surplus

(see previous report; Zwart et al, 2009). For the sand and clay regions a correction method is available. If these factors are taken into account then the conclusion is that no significant decrease occurred between 2007 and 2008. However, compared to 2007 and 2008 there was a significant decrease in the nitrate concentration in 2009 (see Table 4.12). In 2008, the measured nitrate concentration was clearly lower than in 2007, but the precipitation surplus was more than 25% lower than in 2007; the relative precipitation surplus was 1.3 in 2007 and 0.93 in 2008. The groundwater level fell between 2007 and 2009 by about 23 cm. This also caused the nitrate concentration to be lower in 2008, if the other influencing factors did not change. The further decrease of the nitrate concentration in 2009 cannot be explained by climatological conditions, as the relative precipitation surplus did not decrease any further. An explanation of the method used is provided in Appendix 5.

Table 4.12 Mean nitrate concentrations (mg/l), measured¹ and corrected, in the leaching water in the sand region. The relative precipitation surplus and groundwater level are also given.

Year	number of farms	nitrate concentration ¹	Precipitation surplus (relative)	Groundwater level (m-surface)	Nitrate conc. corrected
2007	158	56	1.3	1.35	47
2008	154	43	0.93	1.45	50
2009	154	39	1.0	1.59	41

¹ nitrate concentrations deviate slightly from the concentrations in Tables 4.10 and 4.11 as now farms have been included that were not sampled in both years.

For leaching in the clay region, no clear relationship was found with the precipitation surplus and the groundwater level and so no corrected concentrations can be given.

4.3.5

Summary

The nitrate concentration decreased in the period 2007-2009. However, the differences are only significant for the sand region. The decrease in the sand region between 2007 and 2008 was probably caused by a difference in climatological conditions. From the results given above it can be seen that the increase in nitrate concentration in the sand region observed between 2006 and 2007 was not observed in subsequent years. This increase was probably caused by climatological differences between the years (Zwart et al, 2009).

The figure below gives the mean nitrate concentrations in the derogation years, as described in Sections 4.3.2 and 4.3.3, in a single figure. This figure does not show any statistical uncertainties. Instead, its purpose is to visualise how the concentrations change over time.

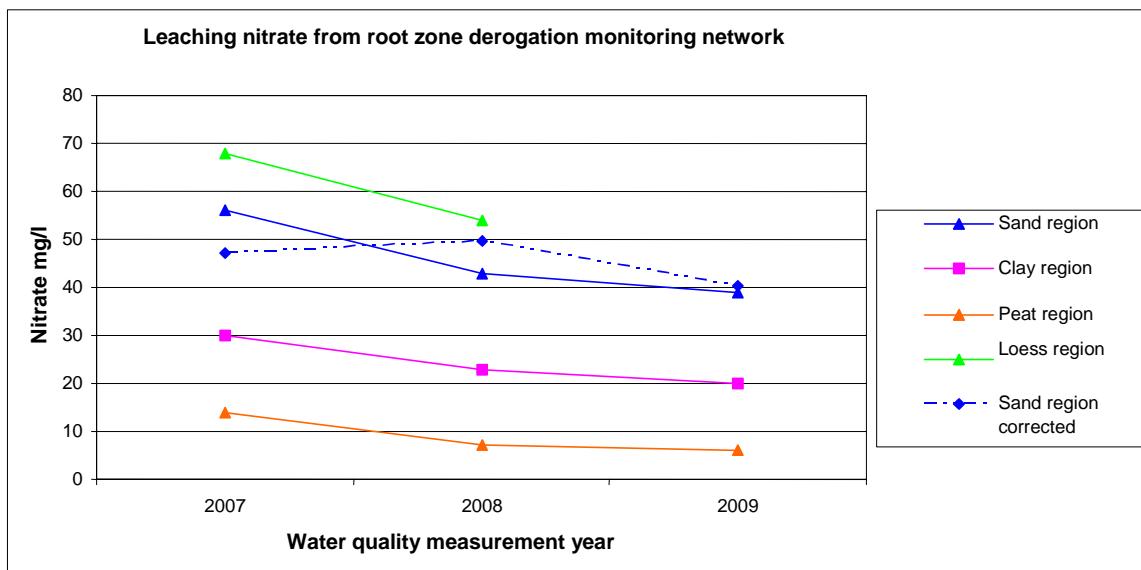


Figure 4.3 Nitrate concentrations leaching from the root zone per soil type region in successive measurement years.

It is concluded that the majority of concentrations have not significantly changed. Where changes were observed these were probably correlated with:

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

After correction for the precipitation effect, it was found that the concentrations in the sand region had decreased in 2009 compared to 2007 and 2008. However, it should be remembered that the results for 2009 are only provisional. In the progress report for 2011, the final concentrations shall be given and it will also be possible to see if this decreasing trend has continued in the water quality of 2010.

4.4 Effect of agricultural practice on water quality

This section provides a qualitative consideration of the trend in water quality on derogation farms in relation to developments in agricultural practice. Due consideration is given to the fact that a measurement series of three years is not enough to draw well-founded conclusions about trends. The following text is indicative in nature and should be assessed, and where necessary adapted, in subsequent years.

Nitrogen

The water quality measured in 2007 was influenced by the agricultural practices of 2006 and earlier years, et cetera. After correcting for the effects of weather conditions, no significant change in nitrate concentration is observed in the sand region between 2007 and 2008. This concurs with the unchanged nitrogen use in agriculture. In Figure 4.4, the trend lines for nitrate concentration in the leaching water and the nitrogen surplus from agricultural practice are shown. This figure does not show any statistical uncertainties. Instead, its purpose is to visualise how the concentrations change over time.

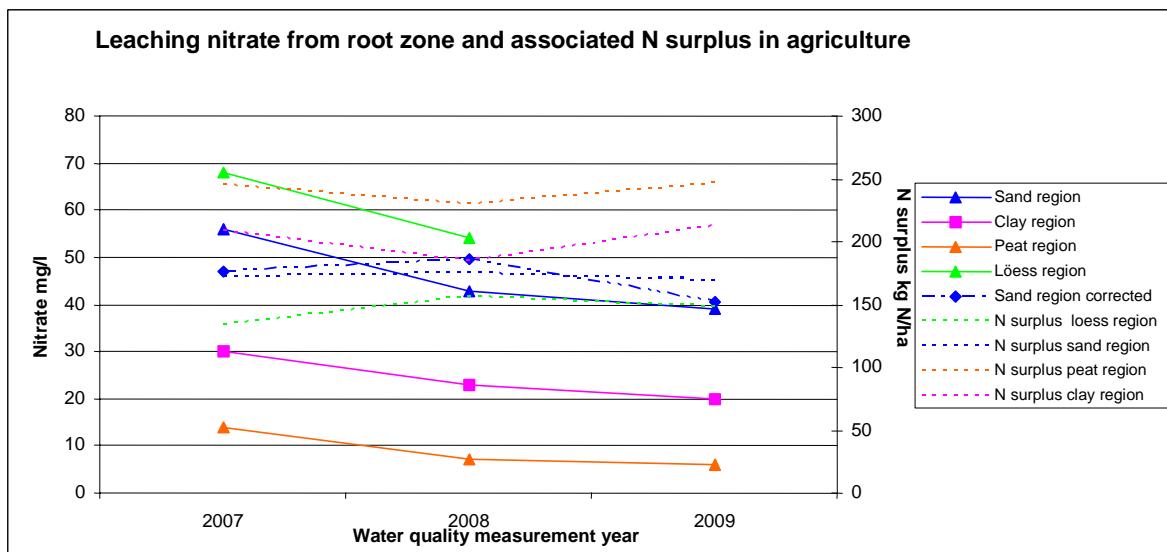


Figure 4.4 Nitrate concentrations leaching from the root zone per soil type region in successive measurement years with the nitrogen surplus from agricultural practice added.

The decrease in the nitrate concentration between 2008 and 2009 cannot be adequately explained, as the decrease in the nitrogen surplus is small and not significant. In agricultural practice little has changed with respect to both the use of nitrogen and its removal with the crop. The use of nitrogen from livestock manure has not changed and that for inorganic nitrogen fertiliser has decreased. The removal of nitrogen via silage maize exhibits no clear trend and varies considerably over time. The removal was highest in 2006 and lowest in 2007. For grass there is also no significant trend in the removal of nitrogen with the crop. The nitrogen soil surface surplus exhibits no trend and does not differ significantly between years.

Phosphate

The phosphate surplus on the soil surface balance decreased in the measurement period. The effect of this decrease is not observed in the water quality. Here both small increases as well as decreases can be seen. The cause is possibly the strong binding of phosphate to the soil. The phosphorous concentration in the leaching water and the ditch water is therefore mainly determined by the hydrological conditions.

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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 dairy and other grassland farms in the derogation monitoring network in detail. As indicated previously in the main text, the derogation monitoring network has become part of the National Programme for Monitoring the Effectiveness of the Minerals Policy (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 in a stratum, 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 (DR) 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 2008 were preferably selected from farms that already participate in the LMM and FADN. With this approach, water quality samples from previous years are also available for farms newly admitted to the derogation monitoring network.

A 2.2 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), or extremely large (larger than 800 NGE in size). NGE is the Dutch acronym for Netherlands Magnitude Unit – further information is provided later in this appendix. Farms using organic practices were also excluded as, by definition, organic farms (irrespective of the percentage of grassland or type of 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 a certain level of representativity in the total area. Finally, in the LMM the farm type without livestock contains only arable farms. Market garden enterprises, farms with permanent cultivations and farms with crop combinations are therefore not included in the LMM.

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 obtained using data from the Agricultural Census 2008 and a database from the National Service for the Implementation of Regulations which contains more than 24,000 farm relation numbers (BRS) of farms which applied for derogation for the year 2008. BRS 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). As 875 BRS numbers were missing from the Agricultural Census 2008, 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 nearly 23,000 farms for which data were available in the Agricultural Census 2008.

Table A2.1 Percentage derivation of the number of farms represented in the sample population of the derogation monitoring network in 2008.

	Distribution number of farms		
	Dairy farms	Other grassland farms	Total
All farms registered for derogation in 2008	73.0%	27.0%	100.0%
Farms <16 NGE	0.2%	10.4%	10.6%
Farms >800 NGE	0.0%	0.0%	0.0%
Organic farms	0.5%	0.2%	0.7%
Farms <10 hectare	0.6%	1.3%	1.9%
Farms outside LMM types		0.2%	0.2%
Sample population	71.8%	14.9%	86.7 %

Source: Statistics Netherlands Agricultural Census 2008, processed by LEI

Table A2.2 Percentage derivation of the acreage of cultivated land represented in the sample population of the derogation monitoring network in 2008.

	Distribution acreage cultivated land		
	Dairy farms	Other grassland farms	Total
All farms registered for derogation in 2008	86.1%	13.9%	100.0%
Farms <16 NGE	0.0%	1.9%	2.0%
Farms >800 NGE	0.2%	0.0%	0.2%
Organic farms	0.6%	0.1%	0.7%
Farms <10 hectare	0.1%	0.2%	0.3%
Farms outside LMM		0.1%	0.1%
Sample population	85.2%	11.5%	96.7%

Source: Statistics Netherlands Agricultural Census 2008, processed by LEI

Tables A2.1 and A2.2 reveal that more than 70% of the derogation farms registered in 2008 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 3.3% of the acreage for which derogation has been applied for) fell outside of the sample design.

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 (Poppe, 2004). 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. 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 intensive livestock (intensive livestock farming). Combined farms are classified as crop combinations, livestock combinations and crop and livestock combinations. Each main farm type is further divided into several subtypes. For example, within the grazing animal farms, specialised dairy farms are distinguished.

The main farm types market gardening, permanent cultivations and crop combinations are not represented in the LMM. A total of 0.2% of the farms with derogation (Table A2.1) with 0.1% of the cultivated land acreage do, however, belong to these main farm types. These farms (in total 40 with more than 1000 ha cultivated land) are therefore between 16 and 800 NGE in size, are not organic and have at least 10 ha cultivated land. Farms of these main farm types cannot per definition be dairy farms and therefore the relevant cells in Tables A2.1 and A2.2 are empty.

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. The roughly 27% non-dairy farms (Table A2.1) can be of various types, but in this publication are described as other grassland farms, as at least 70% of the cultivated land acreage must consist of grassland: otherwise the farm would not be eligible for derogation.

Classification according to economic size

Other than farm type, farms were also classified according to economic size, for which three 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 Units (NGEs) by means of a scaling factor (De Bont et al, 2003).

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 2008, per subregion.

Groundwater body	Total number of farms	Number of dairy farms	Number of other grassland farms
EEMS sand	9	8	1
MAAS sand	29	25	4
RHINE CENTRAL sand	14	10	4
RHINE NORTH sand	30	28	2
RHINE EAST sand	74	69	5
OTHER within sand region	2	2	0
TOTAL SAND REGION	158	142	16

Table A2.4 Number of farms realised in the clay region in 2008, per subregion.

Groundwater body	Total number of farms	Number of dairy farms	Number of other grassland farms
EEMS clay	6	5	1
RHINE NORTH clay	16	15	1
RIJN WEST clay *	19	15	4
South-western sea clay area	4	4	0
OTHER within clay region	13	11	2
TOTAL CLAY REGION	58	50	8

* Concerns farms situated outside of the south-western sea clay area

Table A2.5 Number of farms realised in the peat region in 2008, per subregion.

Groundwater body	Total number of farms	Number of dairy farms	Number of other grassland farms
RHINE NORTH peat	15	13	2
RHINE EAST peat	16	14	2
RHINE WEST peat	27	24	3
OTHER within peat region	2	1	0
TOTAL PEAT REGION	59	52	7

Table A2.6 Number of farms realised in the loess region in 2008.

Groundwater body	Total number of farms	Number of dairy farms	Number of other grassland farms
TOTAL LOESS REGION	20	15	5

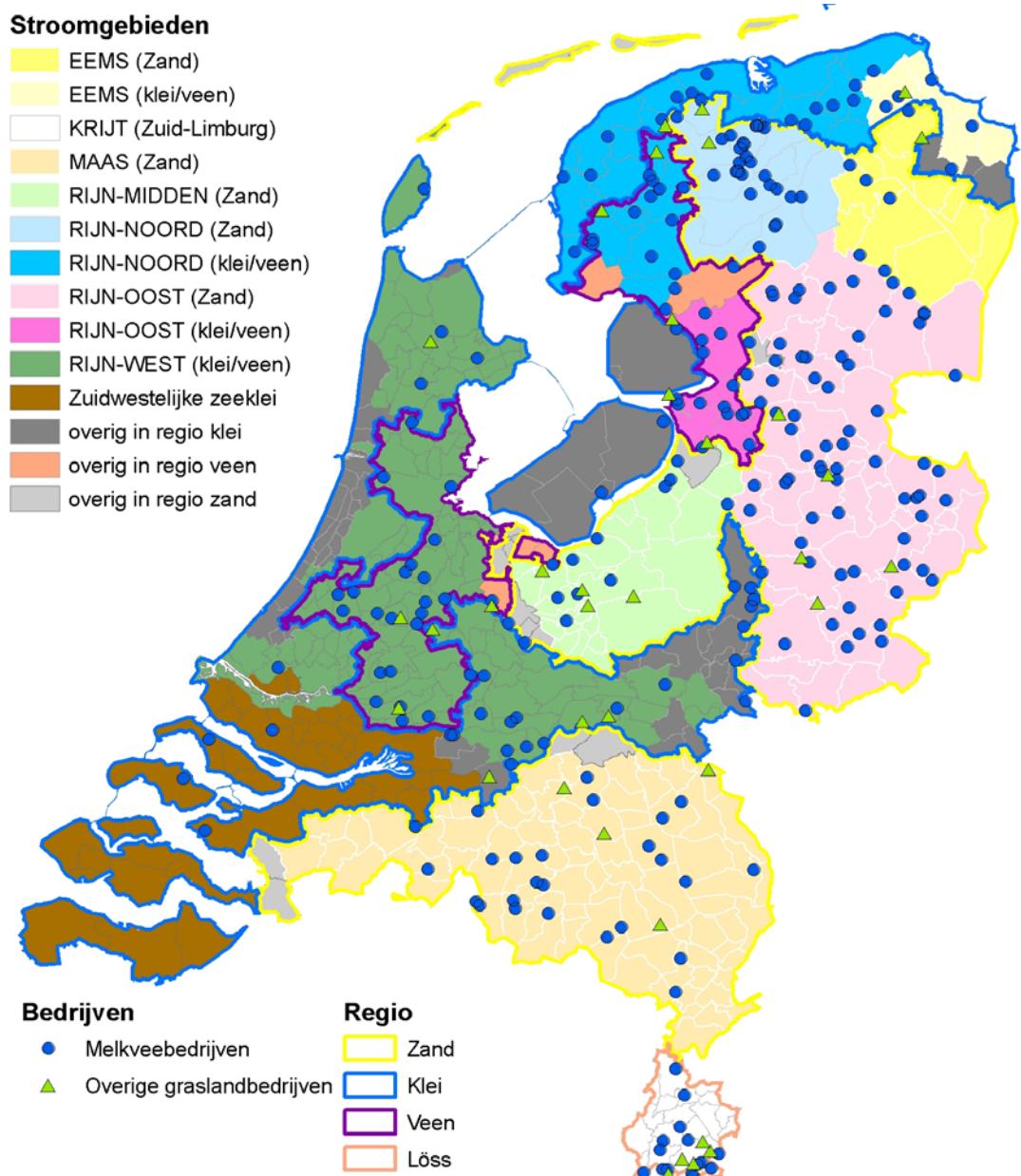


Figure A2.1 Location of dairy farms (o) and other grassland farms (Δ) participating in the derogation monitoring network in 2008 per subregion.

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 A 3.2) and nutrient surpluses (Section A3.3) 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 market garden 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). When the data are processed into information for participants or researchers, the outcomes are of course checked for inconsistencies, as in addition to financial flows, many physical flows are registered as well.

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 that the farm actually fertilises and uses for crop production. Rented land, natural habitat, ditches and built 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 on 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 a distinction is also made between fertilisation on arable land and grassland.

A3.2.1 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). This is in contrast to the statutory calculation of manure production on intensive livestock farms. There an intensive livestock balance method is used in which the manure production is calculated as the import of food and animals minus the export of animals and animal products.

Furthermore, the quantity of nutrients is registered for all fertilisers and stock (inorganic 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:

$$\text{Fertiliser use farm} = \text{Manure production} + \text{Initial stock} - \text{Final stock} + \text{Import} - \text{Export}.$$

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:

$$\text{Fertiliser use on grassland} = \text{Fertiliser use farm} - \text{Fertiliser use on arable land}.$$

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 forage 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 dairy cattle before 1 January 2009 is used as the starting point (LNV, 2009a). All of the

sections in this are adhered to, except for the calculation of the energy uptake (expressed in VEM which is the Dutch standard for the net energy content of feeds) from grass (grass silage and fresh grass) from fresh grass (meadow grass and zero-grazing) and the empirical relationship between the uptake from grass silage and from fresh grass. For the calculation of the uptake from grass, feed losses from purchased feed (feed concentrate, wet by-products, milk products) have been included in accordance with Aarts et al (2008). For the calculation of the energy uptake (expressed in VEM) from fresh grass the guidance effective from 1 January 2009 is used (LNV, 2009b), as this gives a more accurate representation. 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.

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 is lower (35% instead of 60% in 2006 and 2007, 45% instead of 60% since 2008) for all livestock manure produced and applied on the farm if grazing is applied on the farm. 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 coefficients (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)
	Solid manure	40 (2007) 50 (2008)
Manure produced by livestock on own farm		25 (2006/2007)
		30 (2008)
Other fertilisers and conditions	Farm with grazing	35 (2006/2007)
	Farm without grazing	45 (2008) 60
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

A3.2.2 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 first of all shows 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 measurements and levels of the silage supplies insofar as these are available. Otherwise for the farm-produced silage maize and other forage crops an estimate from the entrepreneur and/or their advisor is used. 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, phosphorous, energy uptake and dry matter yields for silage maize and grassland are calculated by multiplying the uptakes by the quantity of nitrogen, phosphorous, energy uptake and dry matter lost on average during feed production (only grass) 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 forage 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 forage crop;
- at least 30 dairy cattle;
- 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, 2008

In several cases the procedure described by Aarts et al (2008, 2005) 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 grass silage and silage maize;
2. supplement for grazing based on the actual number of days in the grazing season;
3. ratio of grass silage 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 silage and silage maize pits is based on provincial means 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 pits has been recorded per farm in FADN. In the FADN calculation procedure, use is made of this farm-specific composition if at least 80% of 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 mean composition is used. This mean composition of silage maize and grass is detailed in Table A3.2.

Table A3.2 National mean composition of grass silage and silage maize in 2008 (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 mobilisation charge has been incorporated. This mobilisation 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, less than 138 days and more than 138 days. Since 2004, the exact number of days in the grazing season has been registered in FADN and so it was decided to use these data in the calculation. For every day of unlimited grazing, 533 VEM (16,000/30) extra mobilisation charge was incorporated per cow and for each day of limited grazing 400 VEM (12,000/30), in accordance with Appendix 2 from the notes Guidance 2009 (LVN, 2009b).

Ad 3)

In addition, the ratio of the energy uptake from fresh grass and grass silage 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 (LVN, 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 and feed losses.

Category	Conservation losses				Feed losses
	Dry matter	VEM	N	P	
Wet by-products	4%	6%	1.5%	0%	3%
Additional forage crops 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).

A3.2 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 P₂O₅ 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 organic and inorganic fertilisers, and the quantities of nitrogen and phosphate removed in crops, consideration is also given to other import categories such as net mineralisation 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 an import from mineralisation 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 mineralisation 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 to the soil 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 import and export 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 import and export 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 A3.4 Demonstration calculation for determination of grassland and silage maize yields.

Demo calculation				
Grazing				183 days limited grazing
Ha grassland				40
Ha sil. Maize				10
Total VEM uptake = 1.02 * VEM requirement	quantity	kVEM	N	P
		750000		
Composition feed concentrates	quantity	kVEM	N	P
per kg	960	28.0	5.0	
Use feed concentrates (purchase - sale + sst. - est.)	200000	192000	5600	1000
Feed losses	4000	3840	112	20
Net uptake feed concentrates	196000	188160	5488	980
Comp. wet by-products	quantity	kVEM	N	P
per kg dm	1020	12.0	2.0	
Use wet by-products (purchase - sale + sst. - est.)	20000	20400	240	40
Conservation losses	0	0	0	0
Fed wet by-products	20000	20400	240	40
Feed losses	600	612	7	1
Net uptake wet by-products	19400	19788	233	39
Comp. additional roughage	quantity	kVEM	N	P
per kg dm	700	10.2	2.5	
Use additional roughage (purchase - sale + sst. - est.)	600	420	6	2
Conservation losses	0	0	0	0
Fed additional roughage	600	420	6	2
Feed losses	30	21	0	0
Net uptake additional roughage	570	399	6	1
Total use purchased feed (= sum feed concentrates + wet by-products + additional roughage)		kVEM	N	P
		208347	5727	1020
Comp. own silage maize	quantity	kVEM	N	P
per kg dm	960	11.1	2.2	
Production own silage maize (= estimate yield by entrepreneur)	150000	144000	1665	330
Conservation losses	0	0	0	0
Fed own maize silage	150000	144000	1665	330
Feed losses	7500	7200	83	17
Net uptake own silage maize	142500	136800	1582	314
Net uptake from grass products (= net total uptake - uptake purchased feed - uptake own maize silage)	per kg dm	kVEM	N	P
		404853		
Factor fresh grass (based on recorded grazing system)		20%		
Composition fresh grass	per kg dm	990	35	4.8
Net uptake from fresh grass (= factor fresh grass * net uptake from grass products)		80971	2910	399
Composition grass silage	quantity	kVEM	N	P
per kg dm	900	32	4.5	
Net uptake from grass silage (= net uptake from grass products - net uptake from fresh grass)	359869	323882	11706	1646
Conservation losses	17993	16194	585	82
Fed grass silage	377863	340077	12291	1728
Feed losses	0	0	0	0
Grass yield (passing the fence of the field)	377863	340077	12291	1728
Yield silage maize per ha	kg dm	kVEM	N	P
	15000	14400	167	33
Yield grassland per ha	9447	8502	307	43

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

<i>Description categories</i>		<i>Calculation method</i>
Import farm	Inorganic fertiliser	Quantity ^a * level ^e
	Livestock manure and other organic fertiliser	Quantity ^b * level ^h
	Feed	Quantity ^a * level ^{elf}
	Animals	Quantity ^b * level ⁱ
	Plant products (sowing seed, young plants and seed potatoes)	Quantity ^b * level ^g
	Other	Quantity ^b * level
Export 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
<i>N surplus on the farm gate balance</i>		Import farm - Export farm
Import soil	+ Mineralisation	160 kg N for peat soil and 20 kg for reclaimed soil ^k
	+ Atmospheric deposition	Differentiated per province ^l
	+ N fixation by legumes	All legumes ^m
	- Volatilisation from housing and storage	Based on animal species, housing system and grazing system ⁿ
Export soil	- Volatilisation application and grazing	Inorganic fertiliser and livestock manure, based on actual manure production, grazing and application method ^o
<i>N surplus on the soil surface balance</i>		N surplus farm + import soil surface balance - export 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 inorganic fertiliser, feed concentrate and single feeds via annual reviews supplier. If these are not available then standards are used.	
f)	N levels for forage crops 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 National Service for the Implementation of Regulations (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 40kg N per ha per year (MNP/CBS/WUR, 2007).
- m) N fixation in kg N per ha per year (Schröder, 2006):
 - 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 (Schröder 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, see Appendix 1) 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 moisture, 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 the phreatic 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 moisture below the root zone is sampled. There is little agriculture on the push moraines in the sand region with a deep groundwater level. Where this does occur, the soil moisture 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 longer. In the High Netherlands, only leaching from the root zone is monitored by sampling the uppermost metre of groundwater or of soil moisture 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, drain water and soil moisture are sampled 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 Eertwagh, 1997, 1995; Rozemeijer et al, 2006) and in the peat region (Van den Eertwagh 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 flows to the 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.

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																
Groundwater Clay ¹																
Groundwater Peat ¹																
Drain + ditch winter																

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 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 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 (LMM sampling frequency realised up until then) 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 Eertwagh, 1997, 1995; Van den Eertwagh, 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 quality characteristics. This was performed to explain 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. The activities were performed according to Standard Operating Procedures (SOPs). The text below refers to the SOPs used by stating the relevant SOP number (SOP Pxxx), and at the end of this appendix an overview of the SOPs concerned is provided.

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 March 2008 to September 2009 (1 farm was sampled in March on Monday 31 March) and in the loess region in the period October 2008 to January 2009 (see Figure A4.2). In these periods, each farm was sampled once.

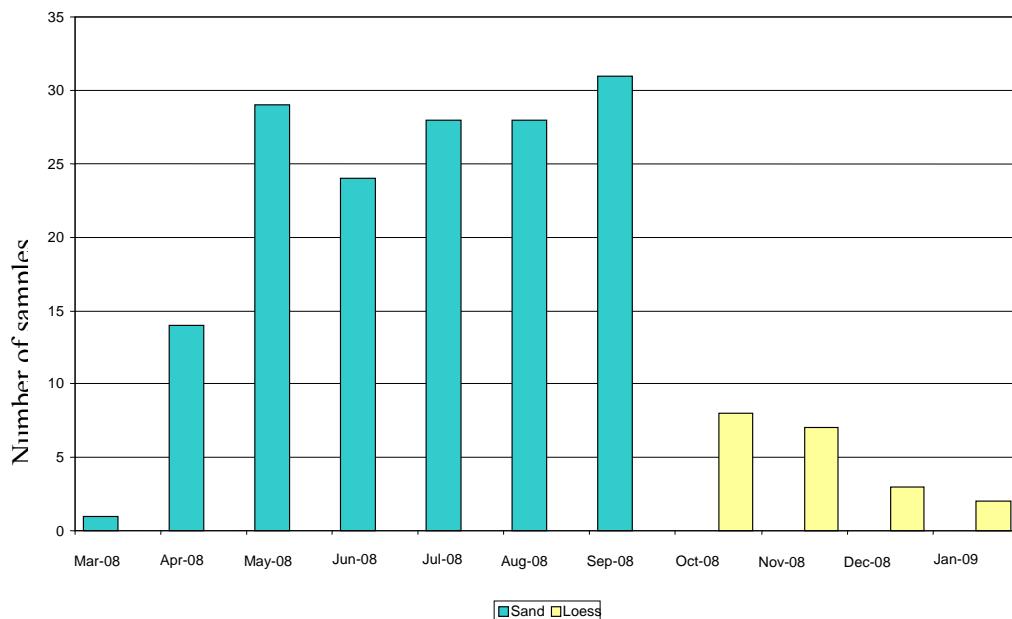


Figure A4.2 Number of samples for groundwater and soil moisture in the sand and loess region per month during the period May 2008 to January 2009.

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 (SOP P618). The uppermost metre of groundwater was sampled using the open bore hole method (SOP P213). In the field, the groundwater level and nitrate concentration (Nitratechek method) were determined (SOP P110). The water samples were filtered (SOP P434), conserved (SOP P416) and stored in a cool dark place for transport to the laboratory (SOP P414). In the laboratory, two 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

On farms in the sand region, additional ditch water samples were taken during the period October 2007 to April 2008 (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 carry 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 are therefore farm ditch, local ditch upstream and local ditch downstream. The selection of locations for the ditch water sampling was protocolled (SOP P618). The selection is 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.

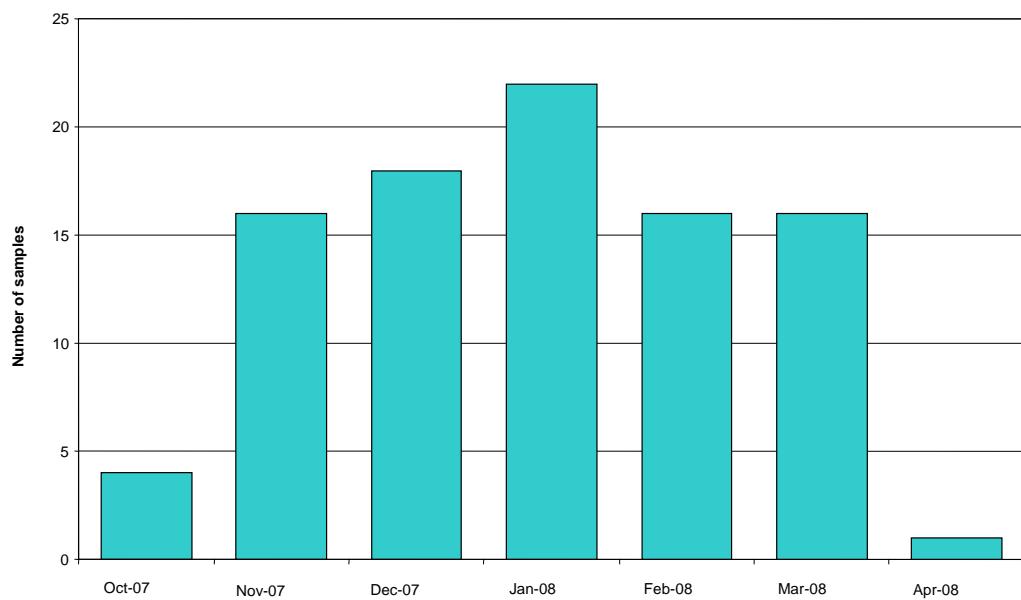


Figure A4.3 Number of samplings of ditch water in the sand region per month during the period October 2007 to April 2008.

During the winter of 2007-2008 ditch water was 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' (SOP P430). Water samples were stored in a cool, dark place for transport to the laboratory (SOP P414). In the laboratory, two mixed samples were prepared from these ditch water samples (one per ditch sample type). The individual 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 is 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 October 2007 to April 2008 (see Figure A4.4). On each farm, 16 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 (SOP P618). On each farm two types of ditch sample were distinguished. For each type of ditch sample, four sampling locations were selected. The selection was performed in accordance with the aforementioned protocol 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.

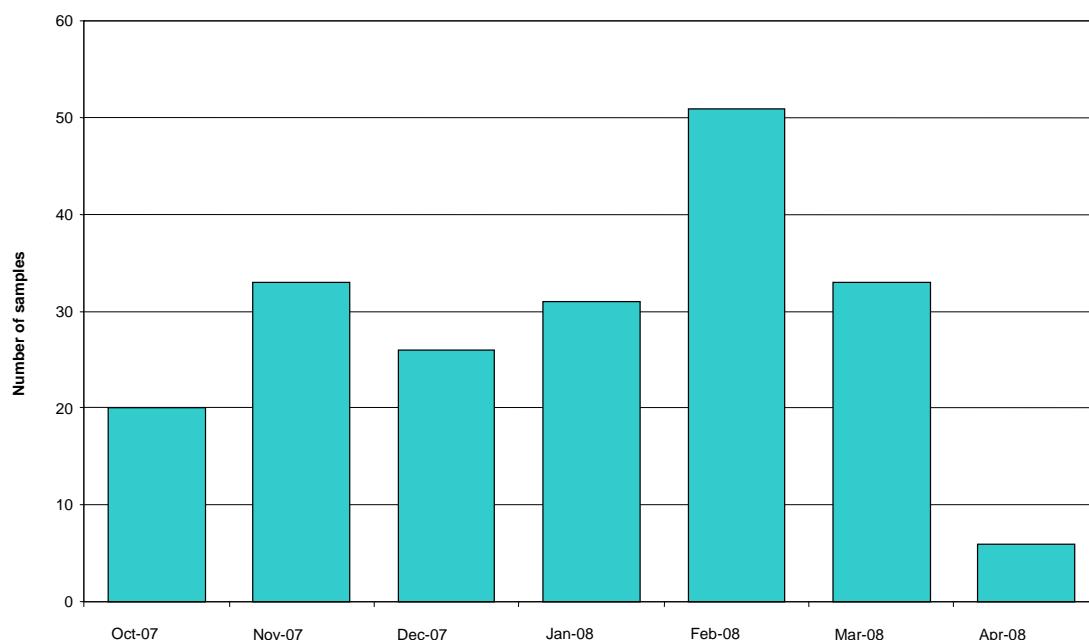


Figure A4.4 Number of samplings of ground-, drain and ditch water in the clay region per month during the period October 2007 to April 2008.

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 (SOP P414). In the laboratory, a single 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 2007 to May 2008 (SOP P618) (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 (SOP P435). In the field, the nitrate concentration (Nitratechek method (SOP P110)) was determined at each of the 16 locations. The water samples were filtered (SOP P434), conserved (SOP P416) and stored in a cool, dark place for transport to the laboratory (SOP P414). 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. However, an important difference was that sampling took place with a filter lance (SOP P430) and water samples were filtered straightaway in the field (SOP P434) and analysed for nitrate (Nitratechek-method SOP P110). As well as being filtered, the individual samples were also conserved (SOP P416) and stored in a cool dark place for transport to the laboratory (SOP P414). In the laboratory, two randomly composed 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 October 2007 and April 2008 (see Figure A4.5). And ditch water was sampled on three to four occasions in the period October 2007 to April 2008.

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 (SOP P435). In the field, the nitrate concentration (Nitratechek method (SOP P110)) was determined at each of the 16 locations. The water samples were filtered (SOP P434), conserved (SOP P416) and stored in a cool, dark place for transport to the laboratory (SOP P414). 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. The sampling therefore took place with a filter lance (SOP P430). There were always two types of ditch samples, each with four locations. Water samples were analysed for nitrate straightaway in the field (Nitratechek method (SOP P110)). The individual water samples were filtered (SOP P434), conserved (SOP P416) and stored in a cool dark place for transport to the laboratory (SOP P414). 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.

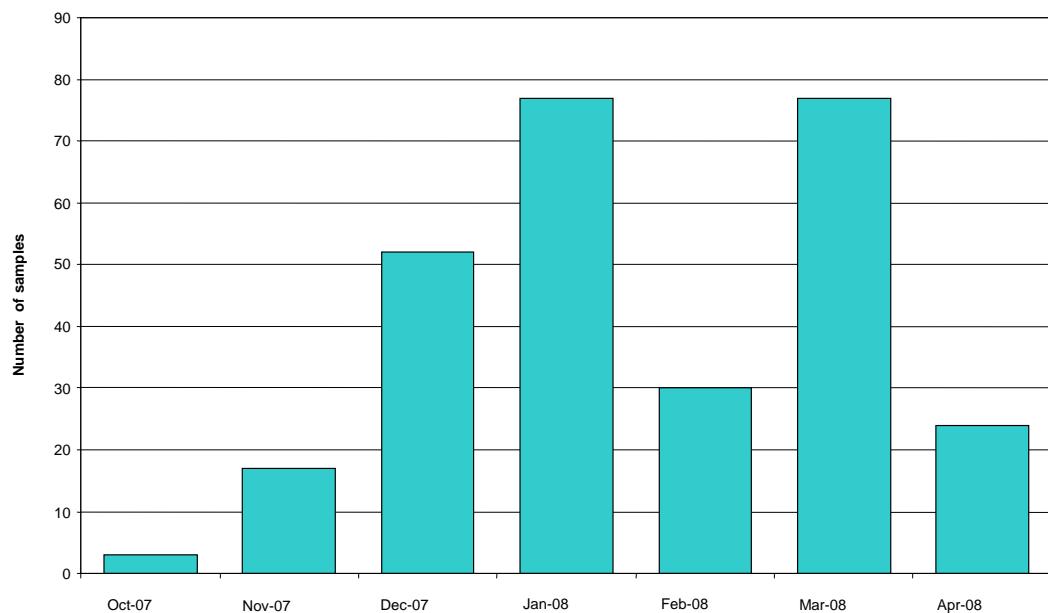


Figure A4.5 Number of samples from groundwater and ditch water in the peat region per month during the period October 2007 to May 2008.

The additional ditch water samples were taken at the same locations as the samples that were taken at the same time for the 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 therefore took place 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 [SOP P430], but not filtered and conserved. In the laboratory, two mixed samples were prepared on the following day (eight random samples per mixed sample) and analysed for nitrate, total nitrogen and total phosphorus.

Overview of the RIVM Standard Operating Procedures used:

- P618: Bepaling van de ligging van de bemonsteringspunten [Determination of the location of the sampling points]. SOP number LVM-BW-P618.
- P435: Grondwaterbemonstering met een bemonsteringslans en slangpomp 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.
- P110: 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 nitrachek reflectometer (type 404)]. SOP number LVM-BW-P110.
- P434: Filtreren van grond- of slootwater met behulp van een filterbedhouder en een 0,45 µm membraanfilter [Filtering of groundwater or ditch water using a filter bed holder and a 0.45 µm membrane filter]. SOP number LVM-BW-P434.
- P416: 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.
- P414: Het tijdelijk opslaan en transporteren van monsters [The temporary storage and transport of samples]. SOP number LVM-BW-P414.

P430: Slootwater- of oppervlaktewaterbemonstering met een aangepaste bemonsteringslans en slangpomp [Sampling ditch water or surface water with a modified sampling lance and hose pump]. SOP number LVM-BW-P430.

Appendix 5 Descriptions of methods for weather 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 cause 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 arising from a higher precipitation surplus. Below, a description of the method demonstrating the effect of the precipitation surplus is given.

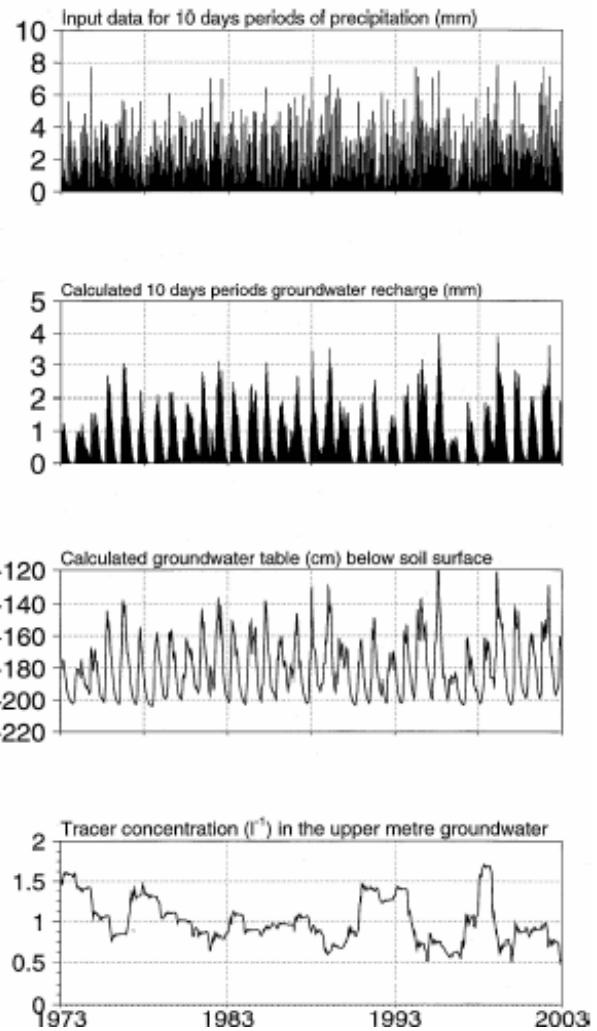
The effect of a variable precipitation surplus on the nitrate concentration is determined by calculating a 'precipitation surplus' variable and then including this variable as an explanatory variable in a statistical model, see Appendix 6.

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 even a 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 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 (= variable precipitation surplus) is obtained for the farm-average nitrate concentration that is measured in a mixed sample of groundwater from the same temporary drill holes.



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 mean concentration on a farm. The calculations 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. First of all the traditional statistical method in which a difference between two years is determined per farm and then it is tested whether the mean of these differences significantly differs from the null hypothesis. As farms continue to drop out, fewer farms can be included in this analysis than the actual number of farms monitored. This technique cannot be used to simultaneously compare three years. This first technique was therefore applied twice, namely on the differences between 2007 and 2008 and on the differences between 2008 and 2009, Table 4.10 and Table 4.11 respectively.

To correct for weather effects on the nitrate concentrations in the groundwater, all years must be simultaneously included in the analysis. Therefore a second method was used, REML (short for REsidual Maximum Likelihood) (Table 4.12). This method allows for the fact that the sample contains the same farms investigated in several years but also different farms investigated in several years. This REML method was also used to investigate whether a difference in the precipitation surplus or a difference in the groundwater level could have affected the concentrations found (Table 4.12). Such a method is only available for the sand region (and to a limited extent the clay region). Therefore, for the other regions no statements can be made about the extent to which the weather conditions have affected the results. The use of the REML method is described in greater detail in Fraters et al, (2004); annex 2.

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