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Methane and nitrous oxide emissions from animal manure management, 1990 - 2003
Background document on the calculation method for the Dutch National Inventory Report

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Abstract

Methane and nitrous oxide emissions from animal manure management, 1990 - 2003
Background document on the calculation method for the Dutch National Inventory Report

Since 2005 the Netherlands has used a new country-specific method to calculate the methane and nitrous oxide emissions from animal manure management. Compared to the default methods provided by the Intergovernmental Panel on Climate Change, this method has led to a more realistic estimate of the emissions. Manure management in the Netherlands comprises manure storage, manure production in the meadow and manure processing. Methane and nitrous oxide contribute to the greenhouse effect and, in order to meet the commitments of the Kyoto protocol, have to be reported annually in the Dutch National Inventory Report. This protocol encourages countries to use country-specific methods rather than the default methods provided by the Intergovernmental Panel on Climate Change. The report describes the calculation schemes and data sources used for methane and nitrous oxide emissions from animal manure management in the Netherlands. The elaborate explanation will facilitate expert reviewing. Finally, the report also presents an overview of the methane and nitrous oxide emissions from animal manure management and the underlying data used in the 1990 - 2003 period.

Key words: methane, nitrous oxide, greenhouse gases, emissions, animal manure, Kyoto protocol, climate change, IPCC

Het rapport in het kort

Methaan en lachgas emissies bij opslag en behandeling van dierlijke mest, 1990 - 2003
Achtergronddocument van de berekeningsmethode voor het Nederlandse National Inventory Report

Nederland berekent vanaf 2005 met een nieuwe methode de uitstoot van methaan en lachgas die optreedt bij mestopslag en -behandeling. Hierdoor wordt een betere schatting van de uitstoot verkregen dan wanneer de standaard berekeningsmethode van het Kyoto protocol gebruikt wordt. In Nederland omvat mestbehandeling naast mestbewerking ook mestproductie in de weide. Methaan en lachgas dragen bij aan het broeikaseffect. In het Kyoto protocol is afgesproken dat Nederland een emissiereductie tot stand brengt en jaarlijks rapporteert over de broeikasgasemissies in het National Inventory Report. Het Kyoto protocol moedigt landen aan een landspecifieke methode te gebruiken in plaats van de standaard berekeningsmethode die het Intergovernmental Panel on Climate Change aanbiedt. Het rapport geeft een transparante beschrijving van de rekenregels en de gebruikte databronnen voor de Nederlandse methaan en lachgas uitstoot ten gevolge van mestbehandeling. De uitvoerige toelichting maakt beoordeling door experts mogelijk. Het rapport omvat tenslotte een overzicht van de methaan- en lachgasemissies bij mestbehandeling en van alle onderliggende data voor de periode 1990 – 2003.

Trefwoorden: methaan, lachgas, broeikas, emissies, dierlijke mest, Kyoto protocol, klimaatverandering, IPCC

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Summary

The countries that have ratified the Kyoto protocol are obliged to provide an annual National Inventory Report (NIR) on the relevant greenhouse gas (GHG) emissions. To facilitate the production of national emission inventories, the Intergovernmental Panel on Climate Change (IPCC) has issued Guidelines. At the same time the IPCC encourages countries to use country-specific methods and data if these give a more realistic picture of the emission of greenhouse gases. However, if a country uses country-specific methods and data, it has to provide a transparent description of the emission calculation method and data sources used.

This report describes the calculation schemes and data sources used for methane and nitrous oxides emissions from animal manure management in the Netherlands. Manure management comprises manure storage, manure production in the meadow and manure processing.
The Netherlands is characterised by a high animal density, allowing the use of considerable statistical data on animal manure to comply with environmental protection and manure legislation. The availability of these data in the Netherlands means that country- and year-specific manure and nitrogen excretion data for specific animal categories in the Netherlands can be used as well as country-specific data on manure characteristics.

In facilitating expert reviewing, this report clearly indicates the Dutch approach and also provides an overview of the Dutch data which have been used for the calculations. The main advantage of this approach is the use of a common national database with data on animal numbers and manure excretion to calculate the agricultural methane, nitrous oxide and ammonia emissions in the Netherlands.

This report not only provides the calculation schemes but also presents an overview of both the methane and nitrous oxide emissions from animal manure management and all underlying data used in the 1990 – 2003 period.

1. Introduction

The United Nations Framework Convention on Climate Change (UNFCCC), agreed on in Rio de Janeiro in 1992, is aimed at stabilizing emissions of greenhouse gases to levels that prevent a negative impact of human activities on climate. It was ratified by the Netherlands and came into force in March 1994. One of the commitments for Parties under the Convention is to develop, publish and regularly update national emission inventories of greenhouse gases.

The awareness that further steps were needed led in 1997 to the Kyoto Protocol, in which Annex 1 Parties agree to reduce greenhouse gas emissions by some 5% in the 2008-2012 period relative to 1990. Reduction commitments differ per country. The agreements reached in Kyoto and, subsequently, in the European Union have resulted in a 6% emission reduction commitment for the Netherlands. This target pertains to the most important greenhouse gases: carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and a number of fluorinated (F) gases.

The Netherlands has implemented a series of policies and measures to achieve a reduction in greenhouse gas emissions. Emissions and emission reductions have to be monitored, registered and reported in compliance with international (IPCC) standards.

The monitoring process in the Netherlands
The Netherlands has, for many years, had a system for the registration and reporting of relevant emissions to air, water and soil. This system, the Pollutant Emission Register (PER), was implemented under responsibility of the Ministry of Housing, Spatial Planning and the Environment (VROM). Since April 2004, the Netherlands Environmental Assessment Agency (MNP in Dutch) coordinates the PER on behalf of the ministry. The MNP acts as the interface between science and policy. It assesses the quality of the environment for people and ecosystems so to advise national and international policy-makers.
Several institutes are involved in the process of compiling the national greenhouse gas inventory. Actual data collection and elaboration is done by institutes such as CBS, MNP/RIVM, LEI and TNO, on the basis of the annual environmental reports from companies, questionnaires and studies. Agricultural data are collected and reported by LEI (Agricultural Economics Research Institute) and CBS (Statistics Netherlands). MNP calculates the methane and nitrous oxide emissions on the basis of the annual agricultural census data.

In December 2005 SenterNovem was designated by law as National Inventory Entity. In addition to co-ordinating the establishment of a national system for greenhouse gas emissions, the tasks of SenterNovem include the overall co-ordination of (improved) quality control and quality assurance activities as part of the National System and co-ordination of the support/response to the UNFCCC review process. In that context, SenterNovem was involved in development of monitoring protocols for greenhouse gas emissions and also commissioned the development of this background document.

The Monitoring Improvement Programme
The Kyoto Protocol under the UNFCCC prescribes Parties to implement a national system for greenhouse gas emissions. In the Netherlands such a programme has been implemented

under responsibility of VROM. This has led to the establishment of the National System, required by the end of 2005. Practical co-ordination of this programme was assigned to SenterNovem.

The most important projects included:
● Adapting the monitoring procedures (where needed) to new international requirements, with methods, instructions, working processes, tasks and responsibilities described in protocols. Where necessary, agreements with sectors and institutes were made on adaptations of the present methods, to comply with new international standards.
● Updating and elaborating the quality assurance and control process of greenhouse gas monitoring.
● Improving the uncertainty assessment and management in emission data. Many data necessarily imply estimates or rough assessments; the climate convention requires an assessment of related uncertainties.
● Studies into more accurate and detailed emission factors and/or methodologies.

This background document
This report is the result of a study carried out as part of the improvement programme. It provides background information for four agricultural protocols which are available via www.greenhousegases.nl and include:
● methane emissions from manure management: cattle;
● methane emissions from manure management: swine;
● methane emissions from manure management: other;
● nitrous oxide emissions from manure management.
It also provides an overview of emissions and underlying statistical data used.

This report starts with a brief overview of animal manure production in the Netherlands, followed by a description of the Dutch procedures for calculating methane and nitrous oxide emissions from manure management in the two subsequent chapters. These two chapters may be read independently.

2. Animal manure production in the Netherlands

The Netherlands with a total agricultural area of 20,000 km^2 has a high animal density. The animal categories used in this report are the same as in the annual Dutch agricultural census (available via www.cbs.nl, select Statline). For reasons of transparency these distinct categories will be used throughout this report; in some tables categories are aggregated to IPCC categories. Table 2.1 overviews the Dutch animal categories with the type of manure management: liquid, solid or meadow, given per category.

For sheep, goats, rabbits, mink and foxes only the numbers of mother animals are presented. The offsprings' manure production is already included in the mothers' manure production. This also holds for sows. Although the number of piglets is presented in the Dutch agricultural census, their manure production has already been included in the manure production of the sows, so the manure production of the piglets is not registered separately.

Most of the animal manure in the Netherlands is in liquid form. From the ruminants, only suckling cows, sheep, goats, horses and ponies have solid manure. With the exception of laying hens, poultry produces only solid manure. Both laying hens under 18 weeks, and 18 weeks and over have, during the last 25 years, switched from almost 100% liquid manure to >90% solid manure systems. Nearly 100% of the pigs are held on liquid manure systems. Ruminants spend some time in the meadow during the summer. Pigs and poultry are held in animal housing all year round.

Table 2.1 Animal categories in the Netherlands and types of manure management

CBS code	Animal category	Manure management			IPCC key source
		Stable		Meadow	
		Liquid	Solid		
Cattle					X
Cattle for breeding					
201	Female young stock under 1 yr	X		X	
203	Male young stock under 1 yr	X			
205	Female young stock, 1-2 yr	X		X	
207	Male young stock, 1-2 yr	X			
209	Female young stock, 2 yr and over	X		X	
211	Cows in milk and in calf	X		X	
213	Bulls for service 2 yr and over	X			
Cattle for fattening					
216	Meat calves, for rosé veal production	X			
214	Meat calves, for white veal production	X			
217	Female young stock < 1 yr	X		X	
219	Male young stock (incl. young bullocks) < 1 yr	X			
221	Female young stock, 1-2 yr	X		X	
223	Male young stock (incl. young bullocks), 1-2 yr	X			
225	Female young stock, 2 yr and over	X		X	
227	Male young stock (incl. young bullocks) ≥ 2 yr	X			
228/229	Suckling cows (incl. fattening + grazing cows, ≥ 2 yr)		X	X	
Ruminants, not cattle					
265/266/268	Sheep (ewes)		X	X	
282/284	Goats (mother animals)		X		
260/261	Horses		X	X	
285/286	Ponies		X	X	
Pigs					X
235/237	Piglets	X			
239/241	Fattening pigs	X			
243/245	Gilts not yet in pig	X			
247/249/251	Sows	X			
243/253	Young boars not yet in service	X			
255	Boars for service	X			
Poultry					
269	Broilers		X		
271	Broilers parent animals under 18 weeks		X		
273	Broilers parent animals 18 weeks and over		X		
275	Laying hens under 18 weeks	X	X		
276/278	Laying hens 18 weeks and over	X	X		
287	Ducks for slaughter		X		
291	Turkeys for slaughter		X		
293	Turkeys parent animals under 7 months		X		
295	Turkeys parent animals 7 months and over		X		
233	Rabbits (mother animals)		X		
290	Minks (mother animals)		X		
292	Foxes (mother animals)		X		

Table 2.2 overviews the Dutch manure production for aggregated animal categories. The manure production has decreased from 87.7 to 69.5 * 10^9 kg in the 1990 - 2003 period. This is mainly a result of the Dutch manure policy, especially for pigs, poultry and cattle for fattening. The EU policy on milk quotas resulted in declining manure production for cattle for breeding. Milk production per cow increased as a result of genetic changes in cattle due to breeding programmes and the changing composition of feed intake. With the national milk quota remaining unchanged during the 1990 - 2003 period, dairy cattle numbers for female cows decreased by the same order of magnitude. Manure production per cow increased, but to a smaller extent than the decrease in total cow numbers, causing an overall decrease in total manure production by breeding cattle.

The animal numbers have declined and for most animal categories the manure production per animal also declined. For cattle for breeding, the sharp decline in manure production in the meadow is the result of the shorter period of time spent in the meadow. The poultry values for the year 2003 are exceptionally low due to the outbreak of fowl plague in that year.

Table 2.2 Animal manure production in the Netherlands, classified into main animal categories and type of manure management, with production figures given in 10^9 kg

Animal category	Type of manure	1990	1995	2000	2003
Cattle for breeding	Total manure production	57.83	52.75	49.06	47.08
	Liquid stable manure	38.64	35.24	33.84	34.80
	Solid stable manure				
	Meadow	19.19	17.51	15.22	12.28
Cattle for fattening	Total manure production	8.40	8.92	7.68	6.77
	Liquid stable manure	5.98	6.01	4.83	4.22
	Solid stable manure	0.84	1.02	1.14	1.01
	Meadow	1.58	1.89	1.71	1.54
Ruminants, not cattle*	Total manure production	2.47	2.70	2.72	2.66
	Liquid stable manure				
	Solid stable manure	0.65	0.81	0.94	1.03
	Meadow	1.82	1.89	1.78	1.63
Pigs	Total manure production	16.36	16.15	14.13	11.72
	Liquid stable manure	16.36	16.15	14.13	11.72
	Solid stable manure				
	Meadow				
Poultry	Total manure production	2.59	2.17	2.19	1.23
	Liquid stable manure	1.45	0.90	0.53	0.16
	Solid stable manure	1.14	1.27	1.66	1.07
	Meadow				
Total liquid stable manure		62.4	58.3	53.3	50.9
Total solid stable manure		2.6	3.1	3.7	3.1
Total manure in meadow		22.6	21.3	18.7	15.4
Total manure production		87.7	82.7	75.8	69.5

* These figures are not identical to the figures used in the NIR2005 calculations, where manure production by horses and ponies in the stable and in the meadow was estimated as being too low for 1990 - 2003 (see also Table 3.3). The adjusted figures, as shown in Table 2.2, will be used in the methane emission calculations in NIR2006.

3. Methane emissions from animal manure management

This chapter focuses on methane emissions from animal manure stored in liquid form, manure stored in solid form and manure excreted during pasture time. Manure is normally stored inside the animal housing and for a certain period of time also in storage facilities outside the animal housing.

3.1 Contribution of agricultural methane emissions to total Dutch GHG emissions

Total Dutch greenhouse gas emissions amounted to about 215 * 10^9 kg CO_2 equivalent in 2003 (Klein Goldewijk et al., 2005). Roughly 10% is CH_4-based and the share of agriculture in CH_4 emissions is roughly 50% (Table 3.1). Enteric fermentation is animal based and accounts for circa 70% of the agricultural methane emissions. Manure management comprises methane emissions from animal manure stored in the animal housing and in storage facilities outside the animal housing. These emissions account for circa 30% of the agricultural methane emissions.

Table 3.1 Relevance of agricultural methane emissions in the Netherlands

		1990	1995	2000	2003
Total GHG emissions	10^9 kg CO_2 equivalents	211.7	224.0	214.0	214.8
Total CH_4 emissions	10^9 kg CO_2 equivalents	25.6	23.8	19.5	17.5
Total CH_4 emissions	10^6 kg CH_4	1220	1135	929	831
Total agricultural emissions	10^6 kg CH_4	490	479	434	404
Enteric fermentation	10^6 kg CH_4	349	334	307	289
Manure management	10^6 kg CH_4	141	145	127	115

Source: Klein Goldewijk et al., 2005

3.2 Scientific background of methane emissions from animal manure management

Once excreted by the animal, the organic matter in animal manure is subject to aerobic and anaerobic breakdown. Liquid animal manure storage is characterised by strict anaerobic conditions due to the high BOD (Biochemical Oxygen Demand) content of manure and the slow diffusion of oxygen into the liquid manure. Normally the organic matter is hydrolysed and converted into volatile fatty acids. The initial number of methane-producing bacteria is too small to produce a significant amount of methane. The presence of ammonia in liquid manure also inhibits the methane production. Only when the manure is stored for a long time, does the multiplication of the methane producers result in a substantial release of methane. The required number of methane bacteria is reached sooner at higher temperatures during storage of animal manure or when the initial number of methane bacteria is high. The latter occurs when the manure storage facility is not fully emptied when land spreading takes place, leaving part of the manure in the storage facility.

A breakdown of organic matter occurs during storage of liquid manure. The first two processes, hydrolysis and acidification, normally occur during storage of manure and volatile acids are produced. The conversion of volatile fatty acids into methane and carbon dioxide depends on storage conditions.

The effect of storage time and temperature on methane production is presented in Table 3.2 and in Figure 3.1. The methane production is represented as a MCF, Methane Conversion Factor, meaning that the actual methane production is expressed as the ratio between the actual and the ultimate methane production; the latter occurs with very long storage times. The IPCC default MCF value is also plotted. This default value is considered by IPCC as representative for a storage time of longer than 30 days and a temperature of 15 ºC (Zeeman and Gerbens, 2002). However, this is a very crude approach. Figure 3.1 shows this IPCC default value to be more representative for pig manure with a storage time longer than 3 months at 20 ^{o}C or for pig manure with a storage time longer than 5 months at 15 ºC. This is discussed in more detail in Section 3.3.

Table 3.2 Effect of storage time and temperature on methane emission from stored liquid manure

Storage time in days	100	120	150	180
Pig manure, 10 ºC	0	0	0	0.269
Pig manure, 15 ºC	0	0.151	0.349	0.393
Pig manure, 20 ºC	0.357	0.393	0.437	0.491
Cattle manure 10 ºC	0	0	0	0.143
Cattle manure 15 ºC	0	0.116	0.245	0.284
Cattle manure 20 ºC	0.296	0.335	0.373	0.412
IPCC default value	0.39	0.39	0.39	0.39

Emissions are expressed as MCF, the ratio between actual emission and ultimate methane production under ideal circumstances.
Source: Zeeman, 1994

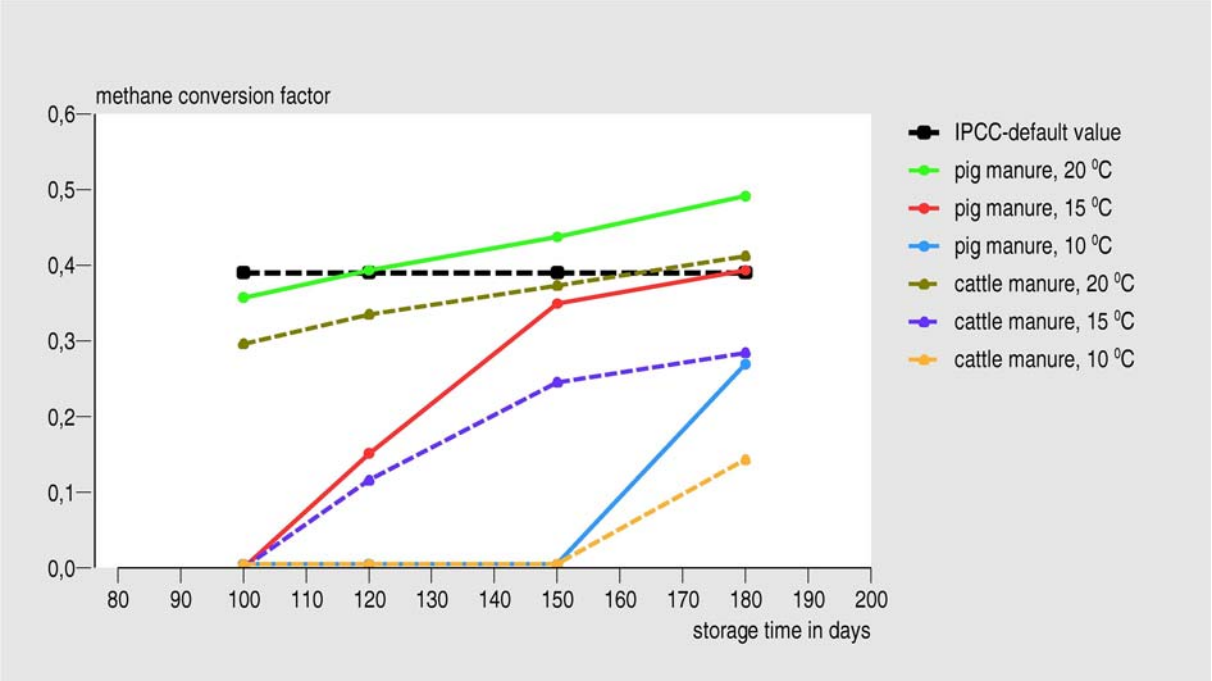

Figure 3.1. The Methane Conversion Factor (MCF) increases with an increase in temperature and storage time of liquid animal manure. Note the difference between cattle and pig manure: this is due to the difference in organic matter characteristics in both manure types. Source: Zeeman, 1994.

Biogas production from liquid animal manure is aimed at maximum production of methane. This is achieved by choosing the appropriate process conditions in terms of temperature and residence time in the anaerobic fermentor. A prerequisite is to use fresh manure in order to conserve the methane that would be emitted during storage inside or outside the animal house. So the use of fresh manure will lower the methane emissions. On the other hand, digested animal manure in an open storage could emit methane. Covering the storage of digested manure with a balloon will prevent methane emissions to the environment and in this way contribute to an enhanced biogas yield (Angelidaki et al., 2004).

Storage of solid manure can be characterised by both anaerobic and aerobic conditions. When the structure of the pile is open there is ample supply of oxygen and aerobic conditions prevail. If there is less access for oxygen, anaerobic processes dominate, but to a certain extent the emitted methane is oxidised in the outer layers of the pile. Solid manure is nowadays commonly found in Dutch poultry houses. For low emission rates of ammonia, the solid manure should be kept dry, a condition which also offers a very low potential for methane emissions. Excretion of manure in the meadow is also expected to offer a very low potential for methane emission; this is due to the aerobic conditions in the topsoil.

3.3 Method of calculating methane emissions from animal manure management

Until recently the methane emissions from animal manure management were calculated using precursor IPCC Guidelines and country-specific emission factors established in the early nineties (Van Amstel et al., 1993). Later on, the calculation methods were summarized in Spakman et al. (1997, 2003). In 2005 the calculation methods were brought in line with the IPCC Guidelines (1997, 2001); the country-specific emission factors used were also reviewed. This report describes the new calculation methods, activity data, and emission factors as used for calculating methane emissions from animal manure management in the Netherlands from 2005 on. The report also provides background information for three agricultural protocols which are available via www.greenhousegases.nl. These include:

- methane emissions from manure management: cattle (VROM, 2005a);
- methane emissions from manure management: swine (VROM, 2005b);
- methane emissions from manure management: other (VROM, 2005c).

Equation (1) from the IPCC Guidelines is used to estimate methane emissions from animal manure management. In this equation for a specific animal category (i), the emission factor is expressed as the amount of methane (in kg) emitted per animal per year.

$$\text{Total Emission} = \sum \text{Number of animals}_i * \text{Emission factor per animal}_i \quad (1)$$

Since the Netherlands is characterised by a high animal density a lot of statistical data on animal manure is available in this country to comply with environmental protection and manure legislation. Therefore the Netherlands does not use the IPCC emission factor but, instead, a country-specific emission factor for a specific animal category, which is expressed as amount of methane emitted per kg animal manure. This emission factor is calculated using equation (2).

$$EF = OM * Bo * MCF * 0.662 \quad (2)$$

where:

EF	=	Emission Factor, kg CH_4 per kg animal manure
OM	=	Organic Matter, kg OM per kg animal manure
Bo	=	ultimate CH_4 production, m^3 CH_4 per kg OM
MCF	=	Methane Conversion Factor, the actual methane conversion rate as percentage of the ultimate conversion rate
0.662	=	specific weight of methane, kg per m^3

The Dutch approach differs from the IPCC method in that the Dutch use the organic matter (OM) content instead of volatile solids (VS) content in the calculation equations. However, in general terms there is no difference in outcome between methane calculations based on OM (Organic Matter) values, as used by the Netherlands, and methane calculations based on VS (Volatile Solids) values used in calculation equations provided by IPCC. The reason is that the Dutch maximum potential of CH_4 production (Bo) is also expressed in terms of organic matter content.

The total Dutch emission is calculated with equation (3):

$$\text{Total Emission} = \sum \text{Number of animals}_i * \text{manure production per animal}_i * \text{emission factor per kg animal manure}_i \quad (3)$$

In fact there is no difference between this method and the default IPCC method. Both approaches produce the same national emissions.

Because there are different CH_4 emission factors for manure produced in the meadow and also for liquid and solid manure production in animal housing, there are three calculations: one for manure produced in the meadow, one for liquid stable manure and one for solid stable manure. Note that CH_4 emissions from manure excreted in the meadow are also accounted for in this calculation. In accordance with IPCC Guidelines two different approaches are used for reporting CH_4 and N_2O emissions from animal waste produced in the meadow during grazing. CH_4 emissions from animal waste produced in the meadow are included in source category *Manure management.* N_2O emissions from animal waste produced in the meadow are included in source category *Agricultural soil* (see also Section 4.3).

In the case that biogas production from animal manure increases in the Netherlands in the near future, the method for calculating methane emissions from manure management has to be extended to include the effects of biogas production. Focus should also be placed on N_2O emissions when digested manure is applied to the soil.

3.4 Relevant statistical data necessary for calculating methane emissions

Statistical data on the following is needed for calculating the national methane emissions from manure management (see also equations 2 and 3):

- the number of animals in each animal category as indicated in Table 2.1
- the amount of manure produced by each animal per year for each animal category, distribution of manure type over the animal housing (liquid, solid) and the meadow
- the content of organic matter per kg manure for each animal category.

The ***animal numbers*** in each animal category are taken from the annual agricultural census. These data are reported in Agricultural Data (Landbouwcijfers), issued by LEI (Agricultural Economics Research Institute) and CBS (Statistics Netherlands). These data are also available on www.cbs.nl (select Statline). See Appendix 1 for a presentation of these data.

The ***amount of manure per animal*** is calculated by the WUM (Working Group on Uniform Data for Animal Excretion) on a yearly basis for all animal categories except horses and ponies. The first WUM reports describe the methodology in detail (WUM, 1994a, b and c); an annual publication is available for subsequent years (Van Eerdt, 1995a, b, 1996, 1997, 1998, 1999; Van Eerdt et al., 2003; Van Bruggen, 2003, 2004, 2005). The annual manure production data are collected in Table 3.3. The shares of liquid and solid manure, along with the amount of manure produced in the meadow, are also published by WUM. The annual excretion data for horses and ponies are taken from the Belgian legislation, where the excretion values used represent the average for horses and ponies (VLM, 2000). It is assumed that 70% of the manure is produced in the stable and 30% in the meadow. If Dutch figures for manure composition of stable horse manure and average figures for cattle manure in the meadow are used, the annual manure production in stable and meadow can be calculated as follows:

	Amount of manure	kg N	kg P_2O_5
Stable	5,000	35	15
Meadow	3,500	15	6
Total	8,500	50	21

The ***content of organic matter*** in the different types of animal manure is taken from the tables in the Guidelines for Fertilization of Grassland and Arable Crops. These Guidelines, used by the Agricultural Advisory Services in the Netherlands, are available for general use. The content of organic matter and minerals in animal manure (including horses) is based on the BLGG analyses (BLGG = Laboratory for Soil and Crop Testing). Data for 1990 - 1994 are taken from Anonymous (1988), and data for 1995 - 1999 from Van Dijk (1999); data from 2000 onward are found in Anonymous (2002). Table 3.4 presents the organic matter content of the different types of manure collected.

Table 3.3 Animal manure production per animal type for the 1990 – 2003 period. Values are given in kg per animal per year and reflect the total manure production, including cleaning water

Animal category		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Manure production in animal houses															
Cattle for breeding															
Female young stock under 1 yr	L	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500
Male young stock under 1 yr	L	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	5,000	5,000	5,000	5,000	5,000
Female young stock, 1-2 yr	L	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Male young stock, 1-2 yr	L	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500
Female young stock, 2 yr and over	L	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Cows in milk and in calf	L	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	18,000	18,000	19,500	19,500
Bulls for service 2 yr and over	L	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500	11,500
Cattle for fattening															
Meat calves, for rosé veal production	L	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Meat calves, for white veal production	L	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500
Female young stock < 1 yr	L	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500
Male young stock (incl. young bullocks) < 1 yr	L	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500
Female young stock, 1-2 yr	L	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Male young stock (incl. young bullocks), 1-2 yr	L	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Female young stock, 2 yr and over	L	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Male young stock (incl. young bullocks) ≥ 2 yr	L	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Suckling cows (incl. fattening/grazing ≥ 2 yr)	S	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000
Manure production in meadow															
Cattle for breeding															
Female young stock under 1 yr	M	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Male young stock under 1 yr	M	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	-	-	-	-	-
Female young stock, 1-2 yr	M	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500
Male young stock, 1-2 yr															
Female young stock, 2 yr and over	M	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500
Cows in milk and in calf	M	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	5,500	5,500
Bulls for service 2 yr and over															
Cattle for fattening															
Meat calves, for rosé veal production															
Meat calves, for white veal production															
Female young stock < 1 yr	M	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Male young stock (incl. young bullocks) < 1 yr															
Female young stock, 1-2 yr	M	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500
Male young stock (incl. young bullocks), 1-2 yr															
Female young stock, 2 yr and over	M	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500
Male young stock (incl. young bullocks) ≥ 2 yr															
Suckling cows (incl. fattening/grazing ≥ 2 yr)	M	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000

Table 3.3 continued. Animal manure production per animal type for the 1990 – 2003 period. Values are given in kg per animal per year and reflect the total manure production, including cleaning water

Animal category		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Manure production in animal houses															
Ruminants, not cattle															
Sheep (ewes)	S	325	325	325	325	325	325	325	325	325	325	325	325	325	325
Goats (mother animals)	S	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300
Horses*	S	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Ponies*	S	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Pigs															
Piglets															
Fattening pigs	L	1,300	1,300	1,250	1,250	1,250	1,250	1,250	1,250	1,200	1,200	1,200	1,200	1,200	1,200
Gilts not yet in pig	L	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300
Sows	L	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,100	5,100	5,100	5,100
Young boars not yet in service	L	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300
Boars for service	L	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200
Poultry															
Broilers	S	10	10	10	10	10	11	11	11	11	11	11	11	11	10.9
Broilers parent animals under 18 weeks	S	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	13.4	13.4	8.2
Broilers parent animals 18 weeks and over	S	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3	23.0	23.0	20.6
Laying hens under 18 weeks, liquid manure	L	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	22.5
Laying hens under 18 weeks, solid manure	S	10	10	10	10	10	10	10	10	10	10	9	9.1	9.1	7.6
Laying hens 18 weeks and over, liquid manure	L	63.5	63.5	63.5	63.5	63.5	63.5	63.5	63.5	63.5	63.5	63.5	63.5	63.5	53.4
Laying hens 18 weeks and over, solid manure	S	22.5	22.5	22.5	22.5	22.5	23.5	23.5	23.5	23.5	23.5	24.0	25.4	25.4	18.9
Ducks for slaughter	S	86.3	86.3	86.3	86.3	86.3	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
Turkeys for slaughter	S	37.9	37.9	37.9	37.9	37.9	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Turkeys parent animals under 7 months**	S	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	-	-	-	-
Turkeys parent animals 7 months and over**	S	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	-	-	-	-
Rabbits (mother animals)***	S	377	377	377	377	377	377	377	377	377	377	377	377	377	377
Minks (mother animals)***	S	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.7	104.0
Foxes (mother animals)***	S	272.2	272.2	272.2	272.2	272.2	272.2	272.2	272.2	272.2	272.2	272.2	272.2	272.2	272.0
Manure production in meadow															
Ruminants, not cattle															
Sheep (ewes)	M	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Goats (mother animals)															
Horses*	M	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500
Ponies*	M	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500

L and S refer to liquid and solid manure production in animal housing, M refers to manure produced in the meadow

*These figures are not identical to the figures used in the NIR2005 calculations, where the solid stable manure production and manure production in the meadow by horses and ponies was incorrectly estimated as 4,670 and 2,330 kg, respectively (see also Table 2.2). In NIR2006 the adjusted figures as shown in Table 3.3 will be used in the methane emission calculation

**These figures are not identical to the figures used in the NIR2005 calculations, where the solid stable manure production by turkeys' parent animals was incorrectly estimated as 37.9 between 1990 and 1995, as 45.0 between 1995 and 1998 and was not accounted for in 1999. In NIR2006 the adjusted figures as shown in Table 3.3 will be used in the methane emission calculation

*** Figures for 1990 and 1991 are not available; the 1992 figures were used in order to develop a consistent time series for the emission calculation

Source: WUM and VLM (horses and ponies)

Table 3.4 Organic matter content of the different types of animal manure for the 1990 - 2003 period. Values are given in kg organic matter per 1000 kg animal manure and reflect the total manure production, including cleaning water

Animal category		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Manure production in animal houses															
Cattle for breeding															
Female young stock under 1 yr	L	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Male young stock under 1 yr	L	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Female young stock, 1-2 yr	L	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Male young stock, 1-2 yr	L	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Female young stock, 2 yr and over	L	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Cows in milk and in calf	L	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Bulls for service 2 yr and over	L	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Cattle for fattening															
Meat calves, for rosé veal production	L	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5
Meat calves, for white veal production	L	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Female young stock < 1 yr	L	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Male young stock (incl. young bullocks) < 1 yr	L	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Female young stock, 1-2 yr	L	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Male young stock (incl. young bullocks), 1-2 yr	L	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Female young stock, 2 yr and over	L	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Male young stock (incl. young bullocks) ≥ 2 yr	L	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Suckling cows (incl. fattening/grazing ≥ 2 yr)	S	140	140	140	140	140	153	153	153	153	153	150	150	150	150
Manure production in meadow															
Cattle for breeding															
Female young stock under 1 yr	M	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Male young stock under 1 yr	M	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Female young stock, 1-2 yr	M	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Male young stock, 1-2 yr															
Female young stock, 2 yr and over	M	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Cows in milk and in calf	M	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Bulls for service 2 yr and over															
Cattle for fattening															
Meat calves, for rosé veal production															
Meat calves, for white veal production															
Female young stock < 1 yr	M	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Male young stock (incl. young bullocks) < 1 yr															
Female young stock, 1-2 yr	M	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Male young stock (incl. young bullocks), 1-2 yr															
Female young stock, 2 yr and over	M	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Male young stock (incl. young bullocks) ≥ 2 yr															
Suckling cows (incl. fattening/grazing ≥ 2 yr)	M	60	60	60	60	60	66	66	66	66	66	64	64	64	64

Table 3.4 continued. Organic matter content of the different types of animal manure for the 1990 - 2003 period. Values are given in kg organic matter per 1000 kg animal manure and reflect the total manure production, including cleaning water

Animal category		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Manure production in animal houses															
Ruminants, not cattle															
Sheep (ewes)	S	205	205	205	205	205	205	205	205	205	205	205	205	205	205
Goats (mother animals)	S	182	182	182	182	182	182	182	182	182	182	182	182	182	182
Horses	S	250	250	250	250	250	250	250	250	250	250	250	250	250	250
Ponies	S	250	250	250	250	250	250	250	250	250	250	250	250	250	250
Pigs															
Piglets															
Fattening pigs	L	50	50	50	50	50	60	60	60	60	60	60	60	60	60
Gilts not yet in pig	L	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Sows	L	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Young boars not yet in service	L	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Boars for service	L	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Poultry															
Broilers	S	508	508	508	508	508	508	508	508	508	508	508	508	508	508
Broilers parent animals under 18 weeks	S	427	427	427	427	427	427	427	427	427	427	427	427	427	427
Broilers parent animals 18 weeks and over	S	427	427	427	427	427	427	427	427	427	427	427	427	427	427
Laying hens under 18 weeks, liquid manure	L	90	90	90	90	90	93	93	93	93	93	93	93	93	93
Laying hens under 18 weeks, solid manure	S	350	350	350	350	350	350	350	350	350	350	350	350	350	350
Laying hens 18 weeks and over, liquid manure	L	90	90	90	90	90	93	93	93	93	93	93	93	93	93
Laying hens 18 weeks and over, solid manure	S	350	350	350	350	350	350	350	350	350	350	350	350	350	350
Ducks for slaughter	S	209	209	209	209	209	209	209	209	209	209	209	209	209	209
Turkeys for slaughter	S	464	464	464	464	464	464	464	464	464	464	464	464	464	464
Turkeys parent animals under 7 months	S	464	464	464	464	464	464	464	464	464	464	-	-	-	-
Turkeys parent animals 7 months and over	S	464	464	464	464	464	464	464	464	464	464	-	-	-	-
Rabbits (mother animals)	S	367	367	367	367	367	367	367	367	367	367	367	367	367	367
Minks (mother animals)	S	185	185	185	185	185	185	185	185	185	185	185	185	185	185
Foxes (mother animals)	S	185	185	185	185	185	185	185	185	185	185	185	185	185	185
Manure production in meadow															
Ruminants, not cattle															
Sheep (ewes)	M	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Goats (mother animals)															
Horses*	M	60	60	60	60	60	66	66	66	66	66	64	64	64	64
Ponies*	M	60	60	60	60	60	66	66	66	66	66	64	64	64	64

L and S refer to liquid and solid manure production in animal housing, M refers to manure produced in the meadow

*These figures are not identical to the figures used in the NIR2005 calculations, where the organic matter content for horse manure produced in the meadow was incorrectly estimated as 250 for 1990 - 2003. In NIR2006 the adjusted figures, as shown in Table 3.4 will be used in methane emission calculations.
Source: see text in Section 3.4

3.5 Emission factors for methane emissions from animal manure management

As described in Section 3.3 the Netherlands does not use the IPCC proposed emission factor per animal but, instead, a country-specific emission factor per kg animal manure. Multiplying the Dutch emission factor by the amount of manure produced by an animal gives the methane emission per animal. The following equation is used (see also Section 3.3):

$$EF = OM * Bo * MCF * 0.662 \quad (2)$$

where:

EF	=	Emission Factor, kg CH_4 per kg animal manure
OM	=	Organic Matter, kg OM per kg animal manure
Bo	=	ultimate CH_4 production, m^3 CH_4 per kg OM
MCF	=	Methane Conversion Factor, the actual methane conversion rate as percentage of the ultimate conversion rate
0.662	=	specific weight of methane, kg per m^3

The Dutch approach differs from the IPCC method in that the Dutch use the organic matter (OM) content instead of volatile solids (VS) content in the calculation equations. However, in general terms there is no difference in outcome between methane calculations based on OM (Organic Matter) values, as used by the Netherlands, and methane calculations based on VS (Volatile Solids) values used in calculation equations provided by IPCC. The reason is that the Dutch maximum potential of CH_4 production (Bo) is also expressed in terms of organic matter content.

Data sources for the OM content of animal manure are described in Section 3.4, and data sources for Bo and MCF in this Section (3.5). The Netherlands also uses country-specific values for Bo and MCF in association with the OM contents.

Based on results of Dutch research on animal manure digestion, we use Bo = 0.25 for all cattle manure and Bo = 0.34 m^3 CH_4 per kg OM for all pig and poultry manure (Zeeman, 1994; Zeeman and Gerbens, 2002). These Bo values are presented in Table 3.7. The IPCC Guidelines use slightly different values for Western Europe: for dairy cattle 0.24, for non-dairy cattle 0.17 and for pigs 0.45 m^3 CH_4 per kg VS.

The IPCC Guidelines use the following default MCF values for storage of liquid manure: MCF = 0 for storage time less than 1 month and MCF = 0.39 for storage time exceeding 1 month. This is a very crude approach, since the MCF value of 0.39 is based on a storage time of 6 months with a manure temperature of 15 °C (Zeeman and Gerbens, 2002).

In the Netherlands animal manure is stored in cellars under the slatted floors in the animal house and if that storage is full the manure is pumped into a storage facility outside the animal housing. Storage times are different because in spring and summer animal manure is applied to the field and temperature during storage changes over the year and temperature is also different inside and outside the animal house.

A survey in the early 1990s showed that storage capacity inside the animal house was about 4 months and outside the animal house about 2 months (Van der Hoek, 1994; CBS, 1997). Information about temperature profiles in manure storages is scarce and mostly based on models (De Mol and Hilhorst, 2003, 2004).

The following assumptions are made for the calculation of the MCF values for liquid cattle and pig/poultry manure:

- all manure storage facilities are empty per 1 September;
- the storage inside the animal house is filled up first;
- the animal house per 1 January is filled to capacity with manure, and subsequently, half of its content is transferred to a storage facility outside the animal house;
- all manure storage facilities are empty per 1 March.

This cycle is repeated from March 1 to September 1 with the exception of the storage facilities being partly emptied before September 1; furthermore part of the cattle manure is produced in the meadow (and not stored). Tables 3.5 and 3.6 give all the details on the calculation of MCF values for liquid cattle and pig/poultry manure.

The IPCC Guidelines recommend MCF = 0.01 for stored solid cattle manure and MCF = 0.015 for stored solid poultry manure. However, the literature shows methane emissions from stored solid cattle manure to be possibly higher (Amon et al., 2001). For this reason we set the MCF value for stored solid cattle manure equal to the MCF for stored solid poultry manure. The IPCC Guidelines recommend MCF = 0.01 for manure produced in the meadow This value is also used in the Dutch methane emission inventory.

Table 3.5 Scheme for calculating the year-round MCF value for liquid cattle manure

Liquid cattle manure	Period	Temperature of manure	MCF at 6 months	Share of liquid manure in storage (in terms of total manure production, including production in meadow)	MCF correction factor for land spreading***due to in between emptying	Contribution to annual MCF****
Storage inside building	1 Sept – 1 March	10	0.143	= 4/12	1.00	0.064
Storage outside building*	1 Jan – 1 March	10	0.143	= 2/12	1.00	0.032
Storage inside building**	1 March – 1 Sept	15	0.284	= 3/12	0.75	0.071
Storage outside building*	1 March – 1 Sept	10	0.200	= 0/12		0.000
Total	1 Sept – 1 Sept			= 9/12		0.17

* This 2 month storage concerns manure that has been stored 4 months previously inside the building; in the case the temperature of the manure in the outside storage is 5 °C lower than in the inside storage, we used 70% of the original MCF.
** 25% of the annual manure production is deposited in the meadow (= 3 months or 3/12). The remaining 75% is collected in the storage, of which 50% in wintertime (= 6 months or 6/12, divided into 4/12 in storage inside and 2/12 in storage outside) and 25% in summertime (= 3 months or 3/12).
The full summertime manure is collected in the animal housing because dairy cattle are milked inside the animal house; secondly, male cattle is in the stable all year round.
*** For 1 March – 1 September a correction factor 0.75 is used because part of the manure is spread on the land beforehand.
**** The contribution to the annual MCF is calculated as:
(MCF at 6 months * share of liquid manure in storage) / (4/12 + 2/12 + 3/12 + 0/12).

Table 3.6 Scheme for calculating the year-round MCF value for liquid pig and poultry manure

Liquid pig and poultry manure	Period	Temperature Manure	MCF at 6 months	Share of liquid manure in storage (in terms of total manure production)	MCF correction factor due to emptying in between for land spreading**	Contribution to annual MCF***
Storage inside building	1 Sept – 1 March	15	0.393	= 4/12	1.00	0.131
Storage outside building*	1 Jan – 1 March	10	0.275	= 2/12	1.00	0.046
Storage inside building	1 March – 1 Sept	15	0.393	= 4/12	0.90	0.118
Storage outside building*	1 March – 1 Sept	10	0.275	= 2/12	0.90	0.041
Total	1 Sept – 1 Sept			= 12/12		0.34

* This 2 month storage is for manure that has been stored 4 months previously inside the building; in the case the temperature of the manure in the outside storage is 5 °C lower than in the inside storage, we used 70% of the original MCF.
** For 1 March – 1 September a correction factor 0.90 is used because part of the manure is spread on the land beforehand.
*** The contribution to the annual MCF is calculated as:
(MCF at 6 months * share of liquid manure in storage) / (4/12 + 2/12 + 4/12 + 2/12).

Table 3.7 Overview of the Bo and MCF as used in the Dutch calculations. Bo is given as m^3 CH_4 per kg organic matter; MCF is the actual methane emission as a fraction of the ultimate methane production under ideal circumstances

Animal category	Liquid manure		Solid manure		Meadow	
	Bo	MCF	Bo	MCF	Bo	MCF
Cattle for breeding						
Female young stock under 1 yr	0.25	0.17			0.25	0.01
Male young stock under 1 yr	0.25	0.17			0.25	0.01
Female young stock, 1-2 yr	0.25	0.17			0.25	0.01
Male young stock, 1-2 yr	0.25	0.17				
Female young stock, 2 yr and over	0.25	0.17			0.25	0.01
Cows in milk and in calf	0.25	0.17			0.25	0.01
Bulls for service 2 yr and over	0.25	0.17				
Cattle for fattening						
Meat calves, for rosé veal production	0.25	0.14				
Meat calves, for white veal production	0.25	0.14				
Female young stock < 1 yr	0.25	0.17			0.25	0.01
Male young stock (incl. young bullocks) < 1 yr	0.25	0.17				
Female young stock, 1-2 yr	0.25	0.17			0.25	0.01
Male young stock (incl. young bullocks), 1-2 yr	0.25	0.17				
Female young stock, 2 yr and over	0.25	0.17			0.25	0.01
Male young stock (incl. young bullocks) ≥ 2 yr	0.25	0.17				
Suckling cows (incl. fattening/grazing cows, ≥ 2 yr)			0.25	0.015	0.25	0.01
Ruminants, not cattle						
Sheep (ewes)			0.25	0.015	0.25	0.01
Goats (mother animals)			0.25	0.015	0.25	0.01
Horses			0.25	0.015	0.25	0.01
Ponies			0.25	0.015	0.25	0.01
Pigs						
Piglets						
Fattening pigs	0.34	0.34				
Gilts not yet in pig	0.34	0.34				
Sows	0.34	0.34				
Young boars not yet in service	0.34	0.34				
Boars for service	0.34	0.34				
Poultry						
Broilers			0.34	0.015		
Broilers parent animals under 18 weeks			0.34	0.015		
Broilers parent animals 18 weeks and over			0.34	0.015		
Laying hens under 18 weeks	0.34	0.34	0.34	0.015		
Laying hens 18 weeks and over	0.34	0.34	0.34	0.015		
Ducks for slaughter			0.34	0.015		
Turkeys for slaughter			0.34	0.015		
Turkeys parent animals under 7 months			0.34	0.015		
Turkeys parent animals 7 months and over			0.34	0.015		
Rabbits (mother animals)			0.34	0.015		
Minks (mother animals)			0.34	0.015		
Foxes (mother animals)			0.34	0.015		

Table 3.8 Overview of the emission factors for methane emissions from animal manure management as used in the Dutch calculations. The emission factor is given as kg CH_4 per kg animal manure

Animal category		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Manure production in animal houses															
Cattle for breeding															
Female young stock under 1 yr	L	0.00169	0.00169	0.00169	0.00169	0.00169	0.00186	0.00186	0.00186	0.00186	0.00186	0.00180	0.00180	0.00180	0.00180
Male young stock under 1 yr	L	0.00169	0.00169	0.00169	0.00169	0.00169	0.00186	0.00186	0.00186	0.00186	0.00186	0.00180	0.00180	0.00180	0.00180
Female young stock, 1-2 yr	L	0.00169	0.00169	0.00169	0.00169	0.00169	0.00186	0.00186	0.00186	0.00186	0.00186	0.00180	0.00180	0.00180	0.00180
Male young stock, 1-2 yr	L	0.00169	0.00169	0.00169	0.00169	0.00169	0.00186	0.00186	0.00186	0.00186	0.00186	0.00180	0.00180	0.00180	0.00180
Female young stock, 2 yr and over	L	0.00169	0.00169	0.00169	0.00169	0.00169	0.00186	0.00186	0.00186	0.00186	0.00186	0.00180	0.00180	0.00180	0.00180
Cows in milk and in calf	L	0.00169	0.00169	0.00169	0.00169	0.00169	0.00186	0.00186	0.00186	0.00186	0.00186	0.00180	0.00180	0.00180	0.00180
Bulls for service 2 yr and over	L	0.00169	0.00169	0.00169	0.00169	0.00169	0.00186	0.00186	0.00186	0.00186	0.00186	0.00180	0.00180	0.00180	0.00180
Cattle for fattening															
Meat calves, for rosé veal production	L	0.00052	0.00052	0.00052	0.00052	0.00052	0.00052	0.00052	0.00052	0.00052	0.00052	0.00052	0.00052	0.00052	0.00052
Meat calves, for white veal production	L	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035
Female young stock < 1 yr	L	0.00169	0.00169	0.00169	0.00169	0.00169	0.00186	0.00186	0.00186	0.00186	0.00186	0.00180	0.00180	0.00180	0.00180
Male young stock (incl. young bullocks) < 1 yr	L	0.00169	0.00169	0.00169	0.00169	0.00169	0.00186	0.00186	0.00186	0.00186	0.00186	0.00180	0.00180	0.00180	0.00180
Female young stock, 1-2 yr	L	0.00169	0.00169	0.00169	0.00169	0.00169	0.00186	0.00186	0.00186	0.00186	0.00186	0.00180	0.00180	0.00180	0.00180
Male young stock (incl. young bullock), 1-2 yr	L	0.00169	0.00169	0.00169	0.00169	0.00169	0.00186	0.00186	0.00186	0.00186	0.00186	0.00180	0.00180	0.00180	0.00180
Female young stock, 2 yr and over	L	0.00169	0.00169	0.00169	0.00169	0.00169	0.00186	0.00186	0.00186	0.00186	0.00186	0.00180	0.00180	0.00180	0.00180
Male young stock (incl. young bullocks) ≥ 2 yr	L	0.00169	0.00169	0.00169	0.00169	0.00169	0.00186	0.00186	0.00186	0.00186	0.00186	0.00180	0.00180	0.00180	0.00180
Suckling cows (incl. fattening/grazing ≥ 2 yr)	S	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00035	0.00037	0.00037	0.00037	0.00037
Manure production in meadow															
Cattle for breeding															
Female young stock under 1 yr	M	0.00010	0.00010	0.00010	0.00010	0.00010	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011
Male young stock under 1 yr	M	0.00010	0.00010	0.00010	0.00010	0.00010	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011
Female young stock, 1-2 yr	M	0.00010	0.00010	0.00010	0.00010	0.00010	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011
Male young stock, 1-2 yr															
Female young stock, 2 yr and over	M	0.00010	0.00010	0.00010	0.00010	0.00010	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011
Cows in milk and in calf	M	0.00010	0.00010	0.00010	0.00010	0.00010	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011
Bulls for service 2 yr and over															
Cattle for fattening															
Meat calves, for rosé veal production															
Meat calves, for white veal production															
Female young stock < 1 yr	M	0.00010	0.00010	0.00010	0.00010	0.00010	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011
Male young stock (incl. young bullocks) < 1 yr															
Female young stock, 1-2 yr	M	0.00010	0.00010	0.00010	0.00010	0.00010	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011
Male young stock (incl. young bullock), 1-2 yr															
Female young stock, 2 yr and over	M	0.00010	0.00010	0.00010	0.00010	0.00010	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011
Male young stock (incl. young bullocks) ≥ 2 yr															
Suckling cows (incl. fattening/grazing ≥ 2 yr)	M	0.00010	0.00010	0.00010	0.00010	0.00010	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011

Table 3.8 continued. Overview of the emission factors for methane emissions from animal manure management as used in the Dutch calculations. The emission factor is given as kg CH_4 per kg animal manure

Animal category		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Manure production in animal houses															
Ruminants, not cattle															
Sheep (ewes)	S	0.00051	0.00051	0.00051	0.00051	0.00051	0.00051	0.00051	0.00051	0.00051	0.00051	0.00051	0.00051	0.00051	0.00051
Goats (mother animals)	S	0.00045	0.00045	0.00045	0.00045	0.00045	0.00045	0.00045	0.00045	0.00045	0.00045	0.00045	0.00045	0.00045	0.00045
Horses	S	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062
Ponies	S	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062
Pigs															
Piglets															
Fattening pigs	L	0.00383	0.00383	0.00383	0.00383	0.00383	0.00459	0.00459	0.00459	0.00459	0.00459	0.00459	0.00459	0.00459	0.00459
Gilts not yet in pig	L	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268
Sows	L	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268
Young boars not yet in service	L	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268
Boars for service	L	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268	0.00268
Poultry															
Broilers	S	0.00172	0.00172	0.00172	0.00172	0.00172	0.00172	0.00172	0.00172	0.00172	0.00172	0.00172	0.00172	0.00172	0.00172
Broilers parent animals under 18 weeks	S	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144
Broilers parent animals 18 weeks and over	S	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144	0.00144
Laying hens under 18 weeks, liquid manure	L	0.00689	0.00689	0.00689	0.00689	0.00689	0.00712	0.00712	0.00712	0.00712	0.00712	0.00712	0.00712	0.00712	0.00712
Laying hens under 18 weeks, solid manure	S	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118
Laying hens 18 weeks and over, liquid manure	L	0.00689	0.00689	0.00689	0.00689	0.00689	0.00712	0.00712	0.00712	0.00712	0.00712	0.00712	0.00712	0.00712	0.00712
Laying hens 18 weeks and over, solid manure	S	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118	0.00118
Ducks for slaughter	S	0.00071	0.00071	0.00071	0.00071	0.00071	0.00071	0.00071	0.00071	0.00071	0.00071	0.00071	0.00071	0.00071	0.00071
Turkeys for slaughter	S	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157
Turkeys parent animals under 7 months	S	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	-	-	-	-
Turkeys parent animals 7 months and over	S	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	0.00157	-	-	-	-
Rabbits (mother animals)	S	0.00124	0.00124	0.00124	0.00124	0.00124	0.00124	0.00124	0.00124	0.00124	0.00124	0.00124	0.00124	0.00124	0.00124
Minks (mother animals)	S	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062
Foxes (mother animals)	S	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062
Manure production in meadow															
Ruminants, not cattle															
Sheep (ewes)	M	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
Goats (mother animals)															
Horses*	M	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
Ponies*	M	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010

L and S refer to liquid and solid manure production in animal housing, M refers to manure produced in the meadow

*These figures are not identical to the figures used in the NIR2005 calculations, where the organic matter content for horse manure produced in the meadow was incorrectly estimated as 250 for 1990 - 2003 (see also Table 3.4). In NIR2006 the adjusted figures as shown in Table 3.8 will be used in methane emission calculations.

3.6 Overview of methane emissions from animal manure management 1990 - 2003

An overview of the aggregated animal categories is presented in Table 3.9.
The total methane emissions from animal manure management have decreased from 141.4 to 115.3 * 10^6 kg CH_4 in the period 1990 - 2003.

Information for all individual animal categories is presented in Appendix 2.

Table 3.9 Overview of methane emissions from animal manure management during 1990 - 2003. Values are given as 10^6 kg CH_4 per year

Animal category		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Cattle for breeding	Total	67.22	66.98	64.42	62.65	60.94	67.48	66.36	63.74	63.23	61.99	62.59	63.80	65.21	63.99
	Liquid	65.30	65.06	62.57	60.86	59.20	65.55	64.47	61.90	61.43	60.24	60.92	62.12	63.83	62.64
	Solid														
	Meadow	1.92	1.92	1.85	1.79	1.74	1.93	1.89	1.84	1.81	1.75	1.67	1.68	1.38	1.35
Cattle for fattening	Total	7.71	8.63	8.51	8.29	8.07	8.09	7.01	6.65	6.13	5.71	5.14	4.94	4.48	4.20
	Liquid	7.26	8.10	7.96	7.70	7.52	7.53	6.45	6.12	5.60	5.16	4.53	4.33	3.91	3.66
	Solid	0.29	0.34	0.36	0.38	0.36	0.36	0.36	0.35	0.36	0.37	0.42	0.42	0.39	0.37
	Meadow	0.16	0.19	0.20	0.21	0.19	0.21	0.20	0.18	0.18	0.18	0.19	0.19	0.17	0.17
Ruminants, not cattle*	Total	0.55	0.60	0.64	0.66	0.65	0.65	0.69	0.69	0.69	0.71	0.71	0.72	0.72	0.74
	Liquid														
	Solid	0.37	0.41	0.43	0.45	0.46	0.46	0.49	0.50	0.51	0.53	0.54	0.55	0.56	0.58
	Meadow	0.18	0.20	0.21	0.21	0.19	0.19	0.19	0.18	0.18	0.18	0.18	0.17	0.16	0.16
Pigs	Total	54.34	54.45	54.09	56.26	54.35	60.28	60.24	62.71	56.09	55.13	52.77	50.13	45.70	43.71
	Liquid	54.34	54.45	54.09	56.26	54.35	60.28	60.24	62.71	56.09	55.13	52.77	50.13	45.70	43.71
	Solid														
	Meadow														
Poultry**	Total	11.55	11.65	11.74	11.23	9.38	8.21	8.43	8.51	5.72	5.91	6.03	5.86	4.26	2.64
	Liquid	10.00	10.07	10.07	9.61	7.75	6.44	6.63	6.67	3.55	3.62	3.76	3.66	1.96	1.16
	Solid	1.55	1.58	1.68	1.62	1.63	1.77	1.80	1.84	2.17	2.29	2.27	2.20	2.30	1.48
	Meadow														
Total liquid manure		136.90	137.69	134.68	134.43	128.82	139.80	137.79	137.39	126.66	124.15	121.98	120.24	115.41	111.17
Total solid manure		2.21	2.32	2.47	2.45	2.45	2.59	2.65	2.70	3.03	3.19	3.23	3.17	3.25	2.43
Total manure in meadow		2.26	2.31	2.25	2.21	2.13	2.32	2.29	2.20	2.16	2.12	2.04	2.04	1.71	1.68
Total Dutch manure production		141.36	142.31	139.40	139.08	133.39	144.72	142.73	142.29	131.86	129.45	127.25	125.44	120.37	115.28

*These figures are not identical to the figures presented in the NIR2005 for the 1990 - 2003 period. In NIR2005 the manure production by horses and ponies – both in the animal housing and in the meadow – was incorrectly estimated as being lower and the organic matter content of manure produced in the meadow by horses and ponies was incorrectly estimated as being much higher. Overall, in NIR2005 figures on emissions from horses and ponies were higher than the figures on emissions presented in Table 3.9. The adjusted figures as shown in Table 3.9 will be presented in NIR2006.

**Although the differences are very small, these figures are not always identical to the figures presented in NIR2005. In NIR2005 the solid stable manure production by turkeys' parent animals was incorrectly estimated as being lower in the 1990 - 1999 period. The adjusted figures as shown in Table 3.9 will be presented in NIR2006.

4. Nitrous oxide emissions from animal manure management

This chapter focuses on nitrous oxide emissions from animal manure management, a source comprising emissions from stored animal manure in the animal house and from storage facilities outside the animal house. Nitrous oxide emissions from animal manure excreted in the meadow or applied to agricultural soils are discussed in another background document (Van der Hoek et al., 2006).

4.1 Contribution of agricultural nitrous oxide emissions to total Dutch GHG emissions

Total Dutch greenhouse gas emissions are about 215 * 10^9 kg CO_2 equivalent in 2003 (Klein Goldewijk et al., 2005). Roughly 10% is N_2O based and the share of agriculture in N_2O is roughly 50% (Table 4.1). Manure management comprises nitrous oxide emissions from animal manure stored in the animal housing and in storage facilities outside the animal housing. Direct and indirect nitrous oxide emissions from agriculture are discussed in another background document (Van der Hoek et al., 2006).

Table 4.1 Relevance of agricultural nitrous oxide emissions in the Netherlands

		1990	1995	2000	2003
Total GHG emissions	10^9 kg CO_2 equivalents	211.7	224.0	214.0	214.8
Total N_2O emissions	10^9 kg CO_2 equivalents	21.3	22.4	19.9	17.3
Total N_2O emissions	10^6 kg N_2O	68.7	72.3	64.2	55.9
Total agricultural emissions	10^6 kg N_2O	37.3	40.8	34.4	30.2
Manure management	10^6 kg N_2O	2.2	2.4	2.4	1.9
Direct soil emissions	10^6 kg N_2O	19.1	23.7	20.2	17.9
Indirect soil emissions	10^6 kg N_2O	15.7	14.6	11.9	10.4

Source: Klein Goldewijk et al., 2005

4.2 Scientific background of nitrous oxide emissions from animal manure management

Nitrous oxide can be produced as a by-product from manure because of nitrification and denitrification processes. Nitrification is an aerobic process which oxidizes ammonium into nitrate and denitrification is an anaerobic process which denitrifies nitrate into nitrogen gas. When the conditions are insufficiently aerobic (nitrification) or insufficiently anaerobic (denitrification) nitrous oxide is likely to be formed.

Liquid animal manure is a strict anaerobic substrate. This is due to its very low redox potential, its high biochemical oxygen demand and the slow oxygen diffusion into animal manure. Nitrification therefore does not occur in liquid animal manure. Furthermore, animal manure does not contain nitrate, so denitrification is also absent in liquid animal manure. Solid animal manure is accessible for diffusion of oxygen, so nitrification will occur. The percentage of FAS (free air space) of the stored solid animal manure determines the aerobic/anaerobic status and hence the emission rate of nitrous oxide.

4.3 Method of calculating nitrous oxide emissions from animal manure management

Until recently the nitrous oxide emissions from animal manure management were calculated using a country-specific approach established in the early nineties (Kroeze, 1994). At that time the assumption was made that not only liquid manure but also most of the solid manure was stored under anaerobic conditions. Therefore the default IPCC emission factor for nitrous oxide emissions from liquid manure was applied for both types of manure management. Later on the calculation method was summarized in Spakman et al. (1997, 2003). In 2005 the calculation methods were brought in line with the IPCC Guidelines (1997, 2001). A distinction was made between nitrous oxide emissions from liquid and solid manure by applying the default IPCC emission factors provided for the two different manure management systems. This report describes the new calculation method, activity data, and emission factors as used for calculating nitrous oxide emissions from animal manure management in the Netherlands from 2005 on. It also provides background information for an agricultural protocol that is available via www.greenhousegases.nl:

- nitrous oxide emissions from manure management (VROM, 2005d).

Equation (4) is taken from the IPCC Guidelines to estimate nitrous oxide emissions from animal manure management. In this equation for a specific animal category ($animal_i$) the nitrogen excretion is expressed as the amount of nitrogen (in kg) excreted per animal per year. IPCC Guidelines also offer default values for nitrogen excretion.

$$\text{Total } N_2O \text{ Emission} = \sum 44/28 * (\text{Number of animals}_i * \text{nitrogen excretion per animal}_i * \text{Emission factor per kg nitrogen per animal}_i) \quad (4)$$

The factor 44/28 is used for converting N_2O-N into N_2O

Since the Netherlands is characterised by a high animal density, a lot of statistical data on animal manure is available in this country to comply with environmental protection and manure legislation. Therefore the Netherlands does not use default IPCC nitrogen excretion figures but, instead, country- and year-specific nitrogen excretion data for specific animal categories. These country- and year-specific data are expressed as the amount of nitrogen excreted per animal per year.

Another difference with the IPCC method is that the Netherlands subtracts the ammonia-nitrogen figures from the nitrogen excretion figures. This is also done in the calculation of direct N_2O emissions from soils. For direct soil nitrous oxide emissions this is in line with IPCC Guidelines. Country- and year-specific values for ammonia emissions from animal housing are used.

The Netherlands uses the default IPCC emission factors for nitrous oxide emissions from animal manure management in the Dutch calculations.

Total Dutch N_2O emission by manure management is calculated with equation (5):

$$\text{Total } N_2O \text{ Emission} = \sum 44/28 * ((\text{Number of animals}_i * \text{nitrogen excretion per animal}_i) - NH_3\text{-N emission}) * \text{Emission factor per kg nitrogen in animal manure}_i) \quad (5)$$

The factor 44/28 is used for converting N_2O-N into N_2O

Because there are different N_2O emission factors for liquid and solid manure production in animal housing, there are two calculations: one for liquid stable manure and one for solid stable manure. Note that N_2O emissions from nitrogen excreted in the meadow are not accounted for in this calculation. In accordance with IPCC Guidelines these emissions are reported as part of the N_2O agricultural soil emissions, more precisely as N_2O emissions from animal production (see also Van der Hoek et al., 2006).

4.4 Relevant data necessary for calculating nitrous oxide emissions

For the calculation of the national nitrous oxide emissions from manure management statistical data are necessary on (see also Equations 4 and 5):

- the number of animals in each animal category as indicated in Table 2.1
- the amount of nitrogen produced per animal per year for every animal category, distributed over 3 different waste management systems: liquid stable manure, solid stable manure and manure produced in the meadow
- the total ammonia emissions from animal houses and manure storage facilities outside the animal houses.

The numbers of animals in each animal category are taken from the annual agricultural census. This data are reported in Agricultural Data (Landbouwcijfers), issued by the LEI (Agricultural Economics Research Institute) and CBS (Statistics Netherlands). These data are also available on Internet www.cbs.nl (select Statline). See Appendix 1 for a collection of the data.

The amount of excreted nitrogen per animal is calculated by the WUM (Working Group on Uniform Data for Animal Excretion) on a yearly basis for all categories, except horses and ponies. The first WUM reports describe the methodology in detail (WUM, 1994a, b and c); for subsequent years an annual publication is available (Van Eerdt, 1995a, b, 1996, 1997, 1998, 1999, Van Eerdt et al., 2003, Van Bruggen, 2003, 2004, 2005). The data for the annual nitrogen excretion are collected in Table 4.2. The shares of liquid and solid manure, and the amount of manure produced in the meadow, are also published by WUM. Data on nitrogen excretion are derived from Belgian legislation for horses and ponies (VLM, 2000).

The total ammonia emissions from animal houses and manure storage facilities outside the animal houses are taken from the annual emission inventories in the PER (Pollutant Emission Register). The calculation method for these ammonia emissions is described in full detail in Van der Hoek (1994, 2002). Emission data are available via www.mnp.nl and also in the Milieucompendium. It is assumed that liquid and solid manure management systems have the same ammonia emission factor per kg nitrogen (see also Table 4.3). Ammonia emissions from solid manure production by horses in stables are not accounted for by the PER. Instead we used an average emission factor of 3.6 kg NH_3 per animal per year. This value is derived from the emission factors for horses and ponies used in the Dutch ammonia legislation (RAV, 2005). The average emission factor is calculated by multiplying the relative share of the animal type times the emission factor per animal type: 16/36 * 5.0 (horses over 3 year) + 8/36 * 2.1 (horses under 3 year) + 9/36 * 3.1 (ponies over 3 year) + 3/36 * 1.3 (ponies under 3 year) = 3.6 kg NH_3.

Table 4.2 Nitrogen excretion per animal type for the 1990 – 2003 period. Values are given in kg nitrogen per animal per year

Animal category		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Nitrogen excretion in animal houses															
Cattle for breeding															
Female young stock under 1 yr	L	29.2	31.5	31.1	31.6	32.8	32.5	30.5	34.0	29.6	28.2	27.0	26.9	25.6	23.4
Male young stock under 1 yr	L	29.3	31.7	31.2	31.6	32.8	32.5	30.4	33.8	29.5	39.9	38.9	39.1	38.4	39.1
Female young stock, 1-2 yr	L	45.2	49.2	48.3	48.9	51.5	50.4	47.2	53.7	48.4	46.9	44.9	44.8	42.2	43.6
Male young stock, 1-2 yr	L	90.7	99.1	97.1	98.2	103.8	101.3	94.7	108.5	105.8	101.1	96.7	96.6	90.6	92.2
Female young stock, 2 yr and over	L	45.0	49.1	48.2	48.8	51.4	50.3	47.1	53.7	48.4	46.8	44.8	44.8	42.2	43.6
Cows in milk and in calf	L	89.0	87.1	81.2	94.4	94.7	96.5	94.2	92.6	97.1	93.1	91.6	94.0	99.6	103.7
Bulls for service 2 yr and over	L	90.7	99.1	97.1	98.2	103.8	101.3	94.7	108.5	105.8	101.1	96.7	96.6	90.6	92.2
Cattle for fattening															
Meat calves, for rosé veal production	L	29.9	29.9	29.9	29.9	29.9	29.9	30.3	28.8	28.7	35.6	35.3	36.1	31.0	31.3
Meat calves, for white veal production	L	10.6	10.6	10.6	10.6	10.6	11.6	11.4	10.3	11.6	10.9	11.9	11.9	12.1	12.2
Female young stock < 1 yr	L	29.0	31.3	30.9	31.3	32.5	32.3	30.2	33.6	29.2	27.8	26.6	26.5	25.3	23.2
Male young stock (incl. young bullocks) < 1 yr	L	24.9	23.3	21.9	28.6	30.4	29.5	28.4	28.0	27.3	27.6	27.3	28.2	27.0	27.4
Female young stock, 1-2 yr	L	45.0	49.0	48.2	48.7	51.2	50.2	46.9	53.2	48.0	46.5	44.5	44.4	41.9	43.3
Male young stock (incl. young bullocks), 1-2 yr	L	52.8	48.8	48.1	88.6	71.5	64.6	63.4	58.8	58.0	58.5	56.8	59.7	57.4	57.8
Female young stock, 2 yr and over	L	45.2	49.2	48.4	48.9	51.4	50.4	47.1	53.5	48.1	46.5	44.5	44.4	41.8	43.3
Male young stock (incl. young bullocks) ≥ 2 yr	L	52.8	48.8	48.1	88.6	71.5	64.6	63.4	58.8	58.0	58.5	56.8	59.7	57.4	57.8
Suckling cows (incl. fattening/grazing ≥ 2 yr)	S	42.4	46.4	45.6	46.2	48.4	47.7	44.5	50.5	48.5	41.4	41.0	40.9	41.2	40.5
Nitrogen excretion in meadow															
Cattle for breeding															
Female young stock under 1 yr	M	13.4	12.9	11.9	12.7	12.5	12.6	13.2	13.1	15.2	13.4	13.9	13.8	13.8	17.8
Male young stock under 1 yr	M	13.4	13.0	11.9	12.7	12.5	12.6	13.1	13.0	15.1					
Female young stock, 1-2 yr	M	46.9	45.1	41.5	44.1	43.9	43.5	45.9	45.7	41.8	36.4	37.9	37.8	37.5	36.1
Male young stock, 1-2 yr															
Female young stock, 2 yr and over	M	46.9	45.1	41.5	44.1	43.9	43.5	45.9	45.7	41.8	36.4	37.9	37.8	37.5	36.1
Cows in milk and in calf	M	46.6	55.7	56.7	48.8	44.9	46.8	49.6	46.9	36.9	37.4	34.6	37.0	26.4	27.4
Bulls for service 2 yr and over															
Cattle for fattening															
Meat calves, for rosé veal production															
Meat calves, for white veal production															
Female young stock < 1 yr	M	13.3	12.8	11.8	12.6	12.4	12.5	13.0	12.9	15.0	13.2	13.7	13.6	13.6	17.7
Male young stock (incl. young bullocks) < 1 yr															
Female young stock, 1-2 yr	M	46.9	45.1	41.5	44.1	43.9	43.5	45.9	45.7	41.8	36.4	37.9	37.8	37.5	36.1
Male young stock (incl. young bullocks), 1-2 yr															
Female young stock, 2 yr and over	M	46.9	45.1	41.5	44.1	43.9	43.5	45.9	45.7	41.8	36.4	37.9	37.8	37.5	36.1
Male young stock (incl. young bullocks) ≥ 2 yr															
Suckling cows (incl. fattening/grazing ≥ 2 yr)	M	68.3	65.4	60.1	64.1	63.6	63.1	66.7	66.4	62.8	53.4	54.0	54.1	52.4	51.4

Table 4.2 continued. Nitrogen excretion per animal type for the 1990 – 2003 period. Values are given in kg nitrogen per animal per year

Animal category		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Nitrogen excretion in animal houses															
Ruminants, not cattle															
Sheep (ewes)	S	3.9	4.0	3.8	4.0	4.2	4.0	3.9	4.4	4.4	3.9	3.9	3.9	3.7	3.7
Goats (mother animals)	S	19.9	20.9	20.3	21.1	21.6	21.5	20.6	22.0	22.4	19.4	19.4	20.6	20.1	20.1
Horses	S	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Ponies	S	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Pigs															
Piglets															
Fattening pigs	L	14.3	13.7	14.4	14.5	14.9	14.5	14.3	13.0	13.8	13.3	12.1	12.1	11.7	11.9
Gilts not yet in pig	L	14.0	14.1	14.0	13.7	13.6	14.4	13.9	13.8	13.4	13.9	14.0	13.1	13.2	14.2
Sows	L	33.8	30.9	31.8	31.9	30.1	31.4	31.3	29.9	29.9	30.6	30.3	31.0	30.0	29.9
Young boars not yet in service	L	14.0	14.1	14.0	13.7	13.6	14.4	13.9	13.8	13.4	13.9	14.0	13.1	13.2	14.2
Boars for service	L	25.0	24.5	25.4	24.6	23.0	24.6	23.7	22.8	22.4	22.4	22.6	23.5	23.3	23.8
Poultry															
Broilers	S	0.61	0.64	0.64	0.62	0.57	0.63	0.61	0.59	0.57	0.57	0.54	0.52	0.54	0.53
Broilers parent animals under 18 weeks	S	0.56	0.57	0.62	0.57	0.56	0.55	0.52	0.56	0.51	0.44	0.42	0.35	0.35	0.32
Broilers parent animals 18 weeks and over	S	1.32	1.41	1.47	1.54	1.40	1.42	1.42	1.30	1.30	1.28	1.21	1.11	1.09	1.05
Laying hens under 18 weeks, liquid manure	L	0.38	0.39	0.43	0.39	0.38	0.36	0.34	0.36	0.33	0.33	0.31	0.30	0.30	0.30
Laying hens under 18 weeks, solid manure	S	0.38	0.39	0.43	0.39	0.38	0.36	0.34	0.36	0.33	0.33	0.31	0.30	0.30	0.30
Laying hens 18 weeks and over, liquid manure	L	0.75	0.82	0.87	0.91	0.81	0.81	0.80	0.70	0.69	0.71	0.67	0.68	0.67	0.70
Laying hens 18 weeks and over, solid manure	S	0.75	0.82	0.87	0.91	0.81	0.81	0.80	0.70	0.69	0.71	0.67	0.68	0.67	0.70
Ducks for slaughter	S	1.12	1.12	1.12	1.12	1.12	1.09	1.09	1.09	1.09	1.00	0.99	0.95	0.95	0.90
Turkeys for slaughter	S	1.98	1.98	1.98	2.08	2.08	1.97	1.97	1.97	1.97	1.84	1.85	1.70	1.68	1.76
Turkeys parent animals under 7 months	S	2.38	2.38	2.38	2.38	2.38	2.78	2.52	2.52	2.52	2.52	-	-	-	-
Turkeys parent animals 7 months and over	S	3.17	3.17	3.17	3.17	3.17	3.04	3.04	3.04	3.04	3.04	-	-	-	-
Rabbits (mother animals)*	S	8.70	8.70	8.70	8.70	8.70	8.10	8.10	8.10	8.1	7.9	7.6	7.6	7.7	7.8
Minks (mother animals)*	S	4.08	4.08	4.08	4.08	4.08	4.08	3.50	3.50	3.5	4.2	3.5	3.3	3.0	2.9
Foxes (mother animals)*	S	13.90	13.90	13.90	13.90	13.90	13.90	9.00	9.00	9.0	9.9	8.3	7.7	7.0	6.6
Nitrogen excretion in meadow															
Ruminants, not cattle															
Sheep (ewes)	M	21.1	20.7	19.7	20.2	20.3	20.3	21.9	21.0	21.6	18.8	19.5	19.1	18.9	18.8
Goats (mother animals)															
Horses	M	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Ponies	M	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0

L and S refer to liquid and solid manure production in animal housing, M refers to manure produced in the meadow

* Figures for 1990 and 1991 are not available; the 1992 figures are used in order to develop a consistent time series for emission calculation.
Source: WUM and VLM (horses and ponies)

Table 4.3 Nitrogen excretion in liquid and solid manure for the 1990 – 2003 period. Values are given in 10^6 kg nitrogen per year

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total Dutch nitrogen excretion by animals*	663,815	686,809	672,202	690,645	657,344	656,948	645,786	622,303	591,891	566,244	528,079	527,335	489,353	470,690
Total nitrogen excretion in animal houses*	493,016	497,741	491,934	523,626	503,672	500,462	482,504	470,515	461,425	446,581	414,945	411,816	394,918	375,644
Total NH_3-N emission from animal houses + manure storage**	73,462	75,633	75,251	78,236	75,456	73,819	70,874	67,682	63,822	65,716	60,712	52,889	52,085	48,709
NH_3-N as share of nitrogen excretion in animal houses	0.149	0.152	0.153	0.149	0.150	0.148	0.147	0.144	0.138	0.147	0.146	0.128	0.132	0.130
Total nitrogen excretion in liquid manure	431,157	430,177	418,926	451,757	435,811	429,254	411,572	400,147	383,689	365,765	338,011	338,797	318,740	316,066
NH_3-N as share of nitrogen excretion in animal houses	0.149	0.152	0.153	0.149	0.150	0.148	0.147	0.144	0.138	0.147	0.146	0.128	0.132	0,130
Total nitrogen in liquid manure	366,912	364,811	354,843	384,259	370,522	365,938	351,117	342,587	330,620	311,942	288,555	295,286	276,702	275,083
Total nitrogen excretion in solid manure*	61,859	67,564	73,008	71,868	67,861	71,208	70,932	70,368	77,736	80,816	76,934	73,020	76,178	59,578
NH_3-N as share of nitrogen excretion in animal houses**	0.149	0.152	0.153	0.149	0.150	0.148	0.147	0.144	0.138	0.147	0.146	0.128	0.132	0,130
Total nitrogen in solid manure	52,642	57,297	61,840	61,130	57,695	60,705	60,513	60,246	66,984	68,923	65,677	63,642	66,131	51,853

*These figures are not identical to the figures presented in NIR2005 for the 1990 - 2003 period. The nitrogen excretion by horses and ponies in the animal housing was not included in NIR2005. The adjusted figures, as shown in Table 4.3, will be presented in NIR2006.

**These figures are not identical to the figures presented in NIR2005 for the 1990 - 2003 period. The ammonia emission from manure produced by horses and ponies in the animal housing was not included in NIR2005. The adjusted figures, as shown in Table 4.3, will be presented in NIR2006.

Combining the nitrogen excretion rates per animal in Table 4.2 and the animal numbers in Appendix 1 results in total nitrogen excretion per animal category as presented in Appendix 3.

Table 4.3 presents the Dutch data for total nitrogen excretion in liquid and solid manure and the corresponding ammonia emissions.

4.5 Emission factors for nitrous oxide emissions from animal manure management

The default IPCC emission factors are used for nitrous oxide emissions from animal manure management in the Dutch calculations.
● For liquid animal manure systems: emission factor = 0.001 kg N_2O-N per kg N in liquid animal manure.
● For solid animal manure systems: emission factor = 0.02 kg N_2O-N per kg N in solid animal manure.

4.6 Overview of nitrous oxide emissions from animal manure management 1990 - 2003

An overview of the total nitrous oxide emissions from liquid and solid manure is presented in Table 4.4. The total nitrous oxide emissions from animal manure management have decreased from 2.23 to 2.06 * 10^6 kg N_2O in the period 1990 - 2003. When we skip the year 2003 with less (solid) poultry manure due to the fowl plague (see Chapter 2), the conclusion is that the nitrous oxide emissions from animal manure management steadily increases during the period 1990 - 2002.

Table 4.4 Overview of nitrous oxide emissions from animal manure management during the 1990 – 2003 period. Values are given as 10^6 kg N_2O-N and N_2O per year

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total emission liquid manure	N_2O-N	0,367	0,365	0,355	0,384	0,371	0,366	0,351	0,343	0,331	0,312	0,289	0,295	0,277	0,275
Total emission solid manure*	N_2O-N	1,053	1,146	1,237	1,223	1,154	1,214	1,210	1,205	1,340	1,378	1,314	1,273	1,323	1,037
Total emission manure in animal houses*	N_2O-N	1,420	1,511	1,592	1,607	1,524	1,580	1,561	1,548	1,670	1,690	1,602	1,568	1,599	1,312
Total emission liquid manure	N_2O	0,577	0,573	0,558	0,604	0,582	0,575	0,552	0,538	0,520	0,490	0,453	0,464	0,435	0,432
Total emission solid manure*	N_2O	1,654	1,801	1,944	1,921	1,813	1,908	1,902	1,893	2,105	2,166	2,064	2,000	2,078	1,630
Total emission manure in animal houses*	N_2O	2,231	2,374	2,501	2,525	2,396	2,483	2,454	2,432	2,625	2,656	2,518	2,464	2,513	2,062

*These figures are not identical to the figures presented in the NIR2005 for the 1990 - 2003 period. In NIR2005 the N_2O-emissions from manure produced by horses and ponies in the animal housing was not included The adjusted figures as shown in Table 4.5, will be presented in NIR2006.

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Appendix 1. Animal numbers in the Netherlands 1990 – 2003

Animal category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Cattle for breeding														
Female young stock under 1 yr	752,658	760,636	720,342	687,326	687,442	696,063	703,237	651,019	615,834	596,635	562,563	552,595	529,127	503,703
Male young stock under 1 yr	53,229	59,044	53,905	49,753	47,841	44,163	57,182	46,785	41,830	37,653	37,440	88,001	44,692	31,213
Female young stock, 1-2 yr	734,078	754,860	748,325	696,243	678,960	682,888	679,796	684,011	639,875	607,670	594,100	559,089	551,716	528,133
Male young stock, 1-2 yr	34,635	37,628	39,297	31,957	33,034	33,118	37,203	31,632	27,586	25,331	26,328	26,819	31,543	19,650
Female young stock, 2 yr and over	145,648	152,994	144,542	139,866	123,924	124,970	125,153	137,880	117,120	106,348	104,633	106,908	96,781	89,162
Cows in milk and in calf	1,877,684	1,852,165	1,775,259	1,746,733	1,697,868	1,707,875	1,664,648	1,590,571	1,610,630	1,588,489	1,504,097	1,539,180	1,485,531	1,477,766
Bulls for service 2 yr and over	8,762	9,899	8,547	8,551	7,975	8,674	9,229	8,198	8,141	10,278	10,410	10,982	14,132	11,755
Cattle for fattening														
Meat calves, for rosé veal production	28,876	39,784	51,018	62,996	77,226	85,803	100,394	100,948	101,267	118,397	145,828	150,950	152,033	171,501
Meat calves, for white veal production	572,709	581,834	586,713	593,214	612,290	583,516	577,196	603,171	609,724	634,257	636,907	556,780	561,300	560,027
Female young stock < 1 yr	53,021	65,551	61,436	63,009	63,144	57,218	55,575	47,669	42,362	45,977	41,300	42,911	38,887	38,016
Male young stock (incl. young bullocks) < 1 yr	255,375	275,383	244,178	233,479	226,539	188,193	147,553	137,053	115,106	97,465	83,447	76,861	62,988	59,682
Female young stock, 1-2 yr	56,934	70,367	76,980	78,906	70,340	66,653	60,061	54,137	50,169	46,462	44,807	42,950	42,337	44,081
Male young stock (incl. young bullocks), 1-2 yr	178,257	198,533	199,261	186,821	179,714	169,546	139,452	142,050	130,080	112,198	88,669	82,234	68,759	53,705
Female young stock, 2 yr and over	42,555	51,515	50,843	49,859	50,791	48,365	37,084	22,345	20,208	17,528	16,917	18,097	16,228	16,595
Male young stock (incl. young bullocks) ≥ 2 yr	12,073	12,503	13,253	11,596	12,161	10,969	11,170	8,664	7,790	8,421	9,397	12,668	11,368	10,197
Suckling cows (incl. fattening/grazing ≥ 2 yr)	119,529	139,375	145,708	156,459	146,462	146,181	146,384	144,502	145,362	152,581	163,397	160,802	150,972	144,004

The Agricultural Census provides the numbers of rosé veal calves from 1995. The rosé veal breeding farming started in the second half of the 80-ies. In 1995 the share of rosé veal calves was 12.8% of the total number of veal calves. It is assumed that over the period from 1987 to 1995 the share of rosé veal calves annually increased by 1.6%. Therefore, the share for 1990 was calculated to be 4.8%.

Continued. Appendix 1

Animal category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Ruminants, not cattle														
Sheep (ewes)	789,691	858,779	876,293	874,674	794,317	770,730	784,976	719,190	693,897	715,776	681,441	647,668	589,315	592,806
Goats (mothers)	37,472	43,706	38,123	34,607	37,554	43,231	55,251	61,448	71,152	85,764	98,077	115,573	142,879	157,848
Horses	49,931	55,438	62,231	65,089	68,333	70,101	73,397	75,468	76,639	76,619	78,892	77,587	79,084	83,002
Ponies	19,661	21,278	24,021	26,639	28,990	29,903	33,308	36,868	36,969	38,547	39,352	42,899	42,383	43,290
Pigs														
Piglets	5,190,749	4,465,911	5,270,428	5,672,918	5,599,760	5,596,117	5,626,233	5,996,140	5,094,466	5,238,755	5,102,434	5,418,427	4,744,505	4,541,673
Fattening pigs	7,025,102	7,040,888	7,144,732	7,525,935	7,270,868	7,123,923	7,094,533	7,432,558	6,591,246	6,774,085	6,504,540	6,216,252	5,591,044	5,367,450
Gilts not yet in pig	385,502	396,132	398,868	392,432	367,675	357,520	375,251	393,745	421,101	343,620	339,570	312,990	282,510	289,355
Sows	1,272,215	1,272,559	1,307,710	1,334,880	1,293,910	1,287,224	1,292,402	1,318,003	1,293,619	1,171,016	1,129,174	1,071,504	1,007,154	950,449
Young boars*	13,893	14,312	12,901	13,061	10,530	11,382	8,623	18,759	19,343	7,057	6,917	7,405	6,625	5,487
Boars for service	27,587	26,812	25,763	25,219	22,268	21,297	21,631	29,859	26,091	32,284	35,182	15,072	15,839	14,681
Poultry														
Broilers	41,172,110	41,639,370	46,524,971	45,780,901	43,055,802	43,827,286	44,142,119	44,986,833	48,537,027	53,246,552	50,936,625	50,127,029	54,660,302	39,319,158
Broilers parents < 18 weeks	2,882,250	3,088,160	3,007,100	3,003,660	3,166,090	3,065,170	2,688,180	3,090,370	3,482,870	3,254,710	3,644,120	2,932,780	2,553,650	2,328,749
Broilers parents ≥ 18 weeks	4,389,830	4,359,760	4,837,300	4,900,600	4,811,560	4,506,840	5,032,380	4,951,550	5,237,950	5,804,260	5,397,520	4,548,120	4,949,320	3,723,907
Laying hens < 18 weeks, L**	7,339,708	7,230,010	7,821,924	6,635,699	6,258,132	4,889,555	5,381,525	5,713,747	2,646,390	2,760,770	2,865,850	2,722,013	1,527,888	896,730
Laying hens < 18 weeks, S**	3,781,062	3,724,550	4,029,476	3,418,391	4,172,088	4,000,545	4,403,066	4,674,884	7,939,170	8,282,310	8,597,550	8,166,038	8,658,032	6,001,196
Laying hens ≥ 18 weeks, L**	19,919,466	20,132,292	19,882,788	19,307,928	15,218,915	12,294,122	12,513,392	12,469,090	6,786,734	6,911,947	7,166,060	7,004,301	3,731,346	2.672,492
Laying hens ≥ 18 weeks, S**	13,279,644	13,421,528	13,255,192	12,871,952	15,218,915	16,977,598	17,280,398	17,219,220	24,062,056	24,505,993	25,406,940	24,833,429	24,971,314	17,885,137
Ducks for slaughter	1,085,510	1,151,710	1,035,968	843,875	756,128	868,965	861,064	906,225	970,279	1,076,737	958,466	866,945	852,420	655,259
Turkeys for slaughter	1,003,350	1,184,920	1,310,348	1,257,402	1,252,965	1,175,527	1,205,705	1,218,055	1,461,973	1,386,608	1,543,830	1,523,250	1,450,590	796,032
Turkeys parents < 7 months	28,550	31,050	29,700	45,650	18,050	13,930	27,000	102,800	20,600	38,600	-	-	-	-
Turkeys parents ≥ 7 months	20,460	20,160	24,110	19,610	23,890	17,290	17,150	36,220	17,650	13,200	-	-	-	-
Rabbits (mother animals)***	105,246	105,246	105,249	89,373	73,719	64,234	61,492	64,372	61,323	54,666	52,252	49,386	50,391	44,634
Minks (mother animals)***	543,969	543,969	563,054	465,735	476,337	456,104	485,357	525,088	565,564	575,830	584,806	611,368	617,472	613,296
Foxes (mother animals)***	10,029	10,029	7,933	7,320	7,079	7,102	6,748	6,744	7,644	5,290	3,816	4,648	4,851	4,179

* = not yet in service

** = L = liquid manure, S = solid manure

*** = no figures available in 1990, for consistency in time series figures for 1991 are used for 1990

Appendix 2. Overview of methane emissions from animal manure management 1990 - 2003

Values are given as 10^6 kg CH_4 per year per animal category

Animal category		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Methane emission from manure in animal houses															
Cattle for breeding															
Female young stock under 1 yr	L	4.452	4.499	4.261	4.066	4.066	4.531	4.578	4.238	4.009	3.884	3.544	3.481	3.334	3.173
Male young stock under 1 yr	L	0.315	0.349	0.319	0.294	0.283	0.288	0.372	0.305	0.272	0.350	0.337	0.792	0.402	0.281
Female young stock, 1-2 yr	L	7.444	7.654	7.588	7.060	6.885	7.621	7.587	7.634	7.141	6.782	6.416	6.038	5.959	5.704
Male young stock, 1-2 yr	L	0.673	0.731	0.764	0.621	0.642	0.708	0.796	0.677	0.590	0.542	0.545	0.555	0.653	0.407
Female young stock, 2 yr and over	L	1.477	1.551	1.466	1.418	1.257	1.395	1.397	1.539	1.307	1.187	1.130	1.155	1.045	0.963
Cows in milk and in calf	L	50.773	50.083	48.003	47.232	45.910	50.826	49.540	47.335	47.932	47.273	48.733	49.869	52.142	51.870
Bulls for service 2 yr and over	L	0.170	0.192	0.166	0.166	0.155	0.186	0.197	0.175	0.174	0.220	0.215	0.227	0.293	0.243
Cattle for fattening															
Meat calves, for rosé veal production	L	0.075	0.103	0.133	0.164	0.201	0.223	0.261	0.262	0.263	0.308	0.379	0.392	0.395	0.446
Meat calves, for white veal production	L	0.702	0.713	0.719	0.727	0.750	0.715	0.707	0.739	0.747	0.777	0.780	0.682	0.688	0.686
Female young stock < 1 yr	L	0.314	0.388	0.363	0.373	0.373	0.372	0.362	0.310	0.276	0.299	0.260	0.270	0.245	0.240
Male young stock (incl. young bullocks) < 1 yr	L	1.942	2.094	1.857	1.776	1.723	1.575	1.235	1.147	0.963	0.816	0.676	0.623	0.510	0.483
Female young stock, 1-2 yr	L	0.577	0.714	0.781	0.800	0.713	0.744	0.670	0.604	0.560	0.519	0.484	0.464	0.457	0.476
Male young stock (incl. young bullocks), 1-2 yr	L	3.013	3.355	3.368	3.157	3.037	3.154	2.594	2.642	2.419	2.087	1.596	1.480	1.238	0.967
Female young stock, 2 yr and over	L	0.432	0.522	0.516	0.506	0.515	0.540	0.414	0.249	0.226	0.196	0.183	0.195	0.175	0.179
Male young stock (incl. young bullocks) ≥ 2 yr	L	0.204	0.211	0.224	0.196	0.206	0.204	0.208	0.161	0.145	0.157	0.169	0.228	0.205	0.184
Suckling cows (incl. fattening/grazing ≥ 2 yr)	S	0.293	0.341	0.357	0.383	0.359	0.358	0.359	0.354	0.356	0.374	0.423	0.416	0.391	0.373
Methane emission from manure in meadow															
Cattle for breeding															
Female young stock under 1 yr	M	0.113	0.114	0.108	0.103	0.103	0.115	0.116	0.107	0.102	0.098	0.093	0.091	0.087	0.083
Male young stock under 1 yr	M	0.008	0.009	0.008	0.007	0.007	0.007	0.009	0.008	0.007					
Female young stock, 1-2 yr	M	0.404	0.415	0.412	0.383	0.373	0.413	0.411	0.414	0.387	0.368	0.359	0.338	0.334	0.320
Male young stock, 1-2 yr															
Female young stock, 2 yr and over	M	0.080	0.084	0.079	0.077	0.068	0.076	0.076	0.083	0.071	0.064	0.063	0.065	0.059	0.054
Cows in milk and in calf	M	1.314	1.297	1.243	1.223	1.189	1.315	1.282	1.225	1.240	1.223	1.158	1.185	0.899	0.894
Bulls for service 2 yr and over															
Cattle for fattening															
Meat calves, for rosé veal production															
Meat calves, for white veal production															
Female young stock < 1 yr	M	0.008	0.010	0.009	0.009	0.009	0.009	0.009	0.008	0.007	0.008	0.007	0.007	0.006	0.006
Male young stock (incl. young bullocks) < 1 yr															
Female young stock, 1-2 yr	M	0.031	0.039	0.042	0.043	0.039	0.040	0.036	0.033	0.030	0.028	0.027	0.026	0.026	0.027
Male young stock (incl. young bullocks), 1-2 yr															
Female young stock, 2 yr and over	M	0.023	0.028	0.028	0.027	0.028	0.029	0.022	0.014	0.012	0.011	0.010	0.011	0.010	0.010
Male young stock (incl. young bullocks) ≥ 2 yr															
Suckling cows (incl. fattening/grazing ≥ 2 yr)	M	0.096	0.112	0.117	0.125	0.117	0.129	0.129	0.127	0.128	0.134	0.144	0.142	0.133	0.127

Continued. Appendix 2

Values are given as 10^6 kg CH_4 per year per animal category

Animal category		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Methane emission from manure in animal houses															
Ruminants, not cattle															
Sheep (ewes)	S	0.131	0.142	0.145	0.145	0.132	0.128	0.130	0.119	0.115	0.119	0.113	0.107	0.098	0.098
Goats (mothers)	S	0.022	0.026	0.022	0.020	0.022	0.025	0.032	0.036	0.042	0.050	0.057	0.068	0.084	0.092
Horses*	S	0.155	0.172	0.193	0.202	0.212	0.217	0.228	0.234	0.238	0.238	0.245	0.241	0.245	0.257
Ponies*	S	0.061	0.066	0.074	0.083	0.090	0.093	0.103	0.114	0.115	0.119	0.122	0.133	0.131	0.134
Pigs															
Piglets															
Fattening pigs	L	34.978	35.057	34.205	36.030	34.809	40.874	40.705	42.644	36.305	37.312	35.827	34.239	30.795	29.564
Gilts not yet in pig	L	1.343	1.380	1.390	1.367	1.281	1.246	1.307	1.372	1.467	1.197	1.183	1.090	0.984	1.008
Sows	L	17.730	17.734	18.224	18.603	18.032	17.939	18.011	18.368	18.028	16.319	15.434	14.645	13.766	12.991
Young boars 1	L	0.048	0.050	0.045	0.046	0.037	0.040	0.030	0.065	0.067	0.025	0.024	0.026	0.023	0.019
Boars for service	L	0.237	0.230	0.221	0.216	0.191	0.183	0.186	0.256	0.224	0.277	0.302	0.129	0.136	0.126
Poultry															
Broilers	S	0.708	0.716	0.800	0.787	0.741	0.829	0.835	0.851	0.918	1.007	0.964	0.948	1.034	0.737
Broilers parents under 18 weeks	S	0.064	0.068	0.067	0.067	0.070	0.068	0.060	0.069	0.077	0.072	0.081	0.057	0.049	0.027
Broilers parents 18 weeks and over	S	0.160	0.159	0.176	0.179	0.175	0.164	0.183	0.180	0.191	0.211	0.197	0.151	0.164	0.110
Laying hens < 18 weeks, liquid manure	L	1.284	1.265	1.369	1.161	1.095	0.884	0.973	1.033	0.479	0.499	0.518	0.492	0.276	0.144
Laying hens < 18 weeks, solid manure	S	0.045	0.044	0.048	0.040	0.049	0.047	0.052	0.055	0.094	0.098	0.091	0.088	0.093	0.054
Laying hens ≥ 18 weeks, liquid manure	L	8.715	8.808	8.699	8.448	6.659	5.558	5.658	5.638	3.068	3.125	3.240	3.167	1.687	1.016
Laying hens ≥ 18 weeks, solid manure	S	0.353	0.356	0.352	0.342	0.404	0.471	0.479	0.477	0.667	0.680	0.720	0.744	0.748	0.399
Ducks for slaughter	S	0.067	0.071	0.063	0.052	0.046	0.043	0.043	0.045	0.048	0.054	0.048	0.043	0.042	0.033
Turkeys for slaughter**	S	0.060	0.071	0.078	0.075	0.075	0.083	0.085	0.086	0.103	0.098	0.109	0.108	0.102	0.056
Turkeys parents under 7 months**	S	0.002	0.002	0.002	0.004	0.001	0.001	0.002	0.008	0.002	0.003				
Turkeys parents 7 months and over**	S	0.003	0.002	0.003	0.002	0.003	0.002	0.002	0.004	0.002	0.002				
Rabbits (mother animals)	S	0.049	0.049	0.049	0.042	0.034	0.030	0.029	0.030	0.029	0.026	0.024	0.023	0.024	0.021
Minks (mother animals)	S	0.035	0.035	0.036	0.030	0.031	0.029	0.031	0.034	0.036	0.037	0.038	0.039	0.040	0.040
Foxes (mother animals)	S	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Methane emission from manure in meadow															
Ruminants, not cattle															
Sheep (ewes)	M	0.158	0.172	0.175	0.175	0.159	0.154	0.157	0.144	0.139	0.143	0.136	0.130	0.118	0.119
Goats (mothers)															
Horses*	M	0.017	0.019	0.022	0.023	0.024	0.025	0.026	0.026	0.027	0.027	0.028	0.027	0.028	0.029
Ponies*	M	0.007	0.007	0.008	0.009	0.010	0.010	0.012	0.013	0.013	0.013	0.014	0.015	0.015	0.015

L and S refer to liquid and solid manure production in animal housing, M refers to manure produced in the meadow

*These figures are not identical to the figures presented in NIR2005 for the 1990 - 2003 period. In NIR2005 the manure production by horses and ponies, both in the animal housing and in the meadow, was incorrectly estimated as being too low. Also, the organic matter content of manure produced in the meadow by horses and ponies was incorrectly estimated as being much higher in NIR2005. Overall figures on emissions by horses and ponies in NIR2005 were higher than the figures on emissions presented in Table 3.9. The adjusted figures, as shown in the table above, will be presented in NIR2006.

**Although the differences are very small, these figures are not always identical to the figures presented in NIR2005. In NIR2005 the solid stable manure production by turkeys' parent animals was incorrectly estimated as being lower in the 1990 - 1999 period. The adjusted figures, as shown in the table above, will be presented in NIR2006.

Appendix 3. Overview of nitrogen excretion per animal category 1990 - 2003

Values are given as 10^6 kg nitrogen per year per animal category

Animal category		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Nitrogen excretion in animal houses															
Cattle for breeding															
Female young stock under 1 yr	L	21.978	23.960	22.403	21.720	22.548	22.622	21.449	22.135	18.229	16.825	15.189	14.865	13.546	11.787
Male young stock under 1 yr	L	1.560	1.872	1.682	1.572	1.569	1.435	1.738	1.581	1.234	1.502	1.456	3.441	1.716	1.220
Female young stock, 1-2 yr	L	33.180	37.139	36.144	34.046	34.966	34.418	32.086	36.731	30.970	28.500	26.675	25.047	23.282	23.027
Male young stock, 1-2 yr	L	3.141	3.729	3.816	3.138	3.429	3.355	3.523	3.432	2.919	2.561	2.546	2.591	2.858	1.812
Female young stock, 2 yr and over	L	6.554	7.512	6.967	6.825	6.370	6.286	5.895	7.404	5.669	4.977	4.688	4.789	4.084	3.887
Cows in milk and in calf	L	167.114	161.324	144.151	164.892	160.788	164.810	156.810	147.287	156.392	147.888	137.775	144.683	147.959	153.24
Bulls for service 2 yr and over	L	0.795	0.981	0.830	0.840	0.828	0.879	0.874	0.889	0.861	1.039	1.007	1.061	1.280	1.084
Cattle for fattening															
Meat calves, for rosé veal production	L	0.863	1.190	1.525	1.884	2.309	2.566	3.042	2.907	2.906	4.215	5.148	5.449	4.713	5.368
Meat calves, for white veal production	L	6.071	6.167	6.219	6.288	6.490	6.769	6.580	6.213	7.073	6.913	7.579	6.626	6.792	6.832
Female young stock < 1 yr	L	1.538	2.052	1.898	1.972	2.052	1.848	1.678	1.602	1.237	1.278	1.099	1.137	0.984	0.882
Male young stock (incl. young bullocks) < 1 yr	L	6.359	6.416	5.347	6.677	6.887	5.552	4.191	3.837	3.142	2.690	2.278	2.167	1.701	1.635
Female young stock, 1-2 yr	L	2.562	3.448	3.710	3.843	3.601	3.346	2.817	2.880	2.408	2.160	1.994	1.907	1.774	1.909
Male young stock (incl. young bullocks), 1-2	L	9.412	9.688	9.584	16.552	12.850	10.953	8.841	8.353	7.545	6.564	5.036	4.909	3.947	3.104
Female young stock, 2 yr and over	L	1.923	2.535	2.461	2.438	2.611	2.438	1.747	1.195	0.972	0.815	0.753	0.804	0.678	0.719
Male young stock (incl. young bullocks) ≥ 2 yr	L	0.637	0.610	0.637	1.027	0.870	0.709	0.708	0.509	0.452	0.493	0.534	0.756	0.653	0.589
Suckling cows (incl. fattening/grazing ≥ 2 yr)	S	5.068	6.467	6.644	7.228	7.089	6.973	6.514	7.297	7.050	6.317	6.699	6.577	6.220	5.832
Nitrogen excretion in meadow															
Cattle for breeding															
Female young stock under 1 yr	M	10.086	9.812	8.572	8.729	8.593	8.770	9.283	8.528	9.361	7.995	7.820	7.626	7.302	8.966
Male young stock under 1 yr	M	0.713	0.768	0.641	0.632	0.598	0.556	0.749	0.608	0.632	0.000	0.000	0.000	0.000	0.000
Female young stock, 1-2 yr	M	34.428	34.044	31.055	30.704	29.806	29.706	31.203	31.259	26.747	22.119	22.516	21.134	20.689	19.066
Male young stock, 1-2 yr															
Female young stock, 2 yr and over	M	6.831	6.900	5.998	6.168	5.440	5.436	5.745	6.301	4.896	3.871	3.966	4.041	3.629	3.219
Cows in milk and in calf	M	87.500	103.166	100.657	85.241	76.234	79.929	82.567	74.598	59.432	59.409	52.042	56.950	39.218	40.491
Bulls for service 2 yr and over															
Cattle for fattening															
Meat calves, for rosé veal production															
Meat calves, for white veal production															
Female young stock < 1 yr	M	0.705	0.839	0.725	0.794	0.783	0.715	0.722	0.615	0.635	0.607	0.566	0.584	0.529	0.673
Male young stock (incl. young bullocks) < 1 yr															
Female young stock, 1-2 yr	M	2.670	3.174	3.195	3.480	3.088	2.899	2.757	2.474	2.097	1.691	1.698	1.624	1.588	1.591
Male young stock (incl. young bullocks), 1-2															
Female young stock, 2 yr and over	M	1.996	2.323	2.110	2.199	2.230	2.104	1.702	1.021	0.845	0.638	0.641	0.684	0.609	0.599
Male young stock (incl. young bullocks) ≥ 2 yr															
Suckling cows (incl. fattening/grazing ≥ 2 yr)	M	8.164	9.115	8.757	10.029	9.315	9.224	9.764	9.595	9.129	8.148	8.823	8.699	7.911	7.402

Continued. Appendix 3

Values are given as 10^6 kg nitrogen per year per animal category

Animal category		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Nitrogen excretion in animal houses															
Ruminants, not cattle															
Sheep (ewes)	S	3.080	3.435	3.330	3.499	3.336	3.083	3.061	3.164	3.053	2.792	2.658	2.526	2.180	2.193
Goats (mothers)	S	0.746	0.913	0.774	0.730	0.811	0.929	1.138	1.352	1.594	1.664	1.903	2.381	2.872	3.173
Horses*	S	1.748	1.940	2.178	2.278	2.392	2.454	2.569	2.641	2.682	2.682	2.761	2.716	2.768	2.905
Ponies*	S	0.688	0.745	0.841	0.932	1.015	1.047	1.166	1.290	1.294	1.349	1.377	1.501	1.483	1.515
Pigs															
Piglets															
Fattening pigs	L	100.459	96.460	102.884	109.126	108.336	103.297	101.452	96.623	90.959	90.095	78.705	75.217	65.415	63.873
Gilts not yet in pig	L	5.397	5.585	5.584	5.376	5.000	5.148	5.216	5.434	5.643	4.776	4.754	4.100	3.729	4.109
Sows	L	43.001	39.322	41.585	42.583	38.947	40.419	40.452	39.408	38.679	35.833	34.214	33.217	30.215	28.418
Young boars 1	L	0.195	0.202	0.181	0.179	0.143	0.164	0.120	0.259	0.259	0.098	0.097	0.097	0.087	0.078
Boars for service	L	0.690	0.657	0.654	0.620	0.512	0.524	0.513	0.681	0.584	0.723	0.795	0.354	0.369	0.349
Poultry															
Broilers	S	25.115	26.649	29.776	28.384	24.542	27.611	26.927	26.542	27.666	30.351	27.506	26.066	29.517	20.839
Broilers parents under 18 weeks	S	1.614	1.760	1.864	1.712	1.773	1.686	1.398	1.731	1.776	1.432	1.531	1.026	0.894	0.745
Broilers parents 18 weeks and over	S	5.795	6.147	7.111	7.547	6.736	6.400	7.146	6.437	6.809	7.429	6.531	5.048	5.395	3.910
Laying hens < 18 weeks, liquid manure	L	2.789	2.820	3.363	2.588	2.378	1.760	1.830	2.057	0.873	0.911	0.888	0.817	0.458	0.269
Laying hens < 18 weeks, solid manure	S	1.437	1.453	1.733	1.333	1.585	1.440	1.497	1.683	2.620	2.733	2.665	2.450	2.597	1.800
Laying hens ≥ 18 weeks, liquid manure	L	14.940	16.508	17.298	17.570	12.327	9.958	10.011	8.728	4.683	4.907	4.801	4.763	2.500	1.871
Laying hens ≥ 18 weeks, solid manure	S	9.960	11.006	11.532	11.713	12.327	13.752	13.824	12.053	16.603	17.399	17.023	16.887	16.731	12.520
Ducks for slaughter	S	1.216	1.290	1.160	0.945	0.847	0.947	0.939	0.988	1.058	1.077	0.949	0.824	0.810	0.590
Turkeys for slaughter	S	1.987	2.346	2.594	2.615	2.606	2.316	2.375	2.400	2.880	2.551	2.856	2.590	2.437	1.401
Turkeys parents under 7 months	S	0.068	0.074	0.071	0.109	0.043	0.039	0.068	0.259	0.052	0.097	0.000	0.000	0.000	0.000
Turkeys parents 7 months and over	S	0.065	0.064	0.076	0.062	0.076	0.053	0.052	0.110	0.054	0.040	0.000	0.000	0.000	0.000
Rabbits (mother animals)	S	0.916	0.916	0.916	0.778	0.641	0.520	0.498	0.521	0.497	0.432	0.397	0.375	0.388	0.348
Minks (mother animals)	S	2.219	2.219	2.297	1.900	1.943	1.861	1.699	1.838	1.979	2.418	2.047	2.018	1.852	1.779
Foxes (mother animals)	S	0.139	0.139	0.110	0.102	0.098	0.099	0.061	0.061	0.069	0.052	0.032	0.036	0.034	0.028
Nitrogen excretion in meadow															
Ruminants, not cattle															
Sheep (ewes)	M	16.662	17.777	17.263	17.668	16.125	15.646	17.191	15.103	14.988	13.457	13.288	12.370	11.138	11.145
Goats (mothers)															
Horses**	M	0.749	0.832	0.933	0.976	1.025	1.052	1.101	1.132	1.150	1.149	1.183	1.164	1.186	1.245
Ponies**	M	0.295	0.319	0.360	0.400	0.435	0.449	0.500	0.553	0.555	0.578	0.590	0.643	0.636	0.649
Total N excretion in solid manure*	S	61.859	67.564	73.008	71.868	67.861	71.208	70.932	70.368	77.736	80.816	76.934	73.020	76.178	59.578
Total N excretion in liquid manure	L	431.157	430.177	418.926	451.757	435.811	429.254	411.572	400.147	383.689	365.765	338.011	338.797	318.740	316.066
Total N excretion in meadow**	M	170.800	189.068	180.268	167.020	153.672	156.486	163.282	151.788	130.465	119.663	113.134	115.518	94.435	95.045
Total nitrogen excretion		663.815	686.809	672.202	690.645	657.344	656.948	645.786	622.303	591.891	566.244	528.079	527.335	489.353	470.690

L and S refer to liquid and solid manure production in animal housing, M refers to manure produced in the meadow

*These figures are not identical to the figures presented in NIR2005 for the 1990 - 2003 period. The nitrogen excretion by horses and ponies in the animal housing was not included. The adjusted figures as shown in the table above will be presented in NIR2006.

** These figures are not identical to the figures presented in NIR2005 for the 1990 - 2003 period. The nitrogen excretion by horses and ponies in the meadow was not included. The adjusted figures as shown in the table above will be presented in NIR2005. Note, however, that in accordance with IPCC Guidelines, data on N_2O emissions from nitrogen excretion in the meadow are not accounted for in source category manure production but, instead, under source category agricultural soils (and more specific under animal production).