U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions

Appendix G: Agricultural Livestock Emission Activities and Sources

Version 1.1

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ICLEI – Local Governments for Sustainability USA

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Introduction

Agricultural livestock activities can be a significant source of greenhouse gas emissions for some communities. Many different types of livestock activities can produce emissions. This Protocol addresses agricultural livestock emission sources for which there are well-established quantification methods and for which mitigation measures are available to reduce emissions. Quantification methods and emission factors were taken from the US EPA. Currently, the Community Protocol covers emissions from the following sources:

Table A.0. Summary of Available Methods for Agricultural Emissions

GHG Source	GHG Types	Data Required	Available Methodologies
Methane Associated with Livestock Enteric Fermentation	CH_4	• Population and type of livestock	A.1
Methane Associated with Manure Management	CH_4	• Population and type of livestock • Manure Management Systems for each livestock population	A.2.1
Methane Associated with Anaerobic Digestion	CH_4	• Population and type of livestock • Manure Management Systems for each livestock population	A.2.2
Direct Nitrous Oxide Associated with Manure Management	N_2O	• Population and type of livestock • Manure Management Systems for each livestock population	A.2.3
Indirect Nitrous Oxide Associated with Manure Management	N_2O	• Population and type of livestock • Manure Management Systems for each livestock population	A.2.4

This Protocol does not address the potential clean energy benefits of anaerobic digestion (e.g., combustion of captured biogas methane in a gas-to-energy facility). GHG inventories are intended to take stock of all emissions that are occurring, even if the process produces additional climate protection benefits in the form of non-fossil fuel energy production. For anaerobic digestion, emissions generation from biogas combustion takes the form of non-combusted methane. Emissions reductions associated with anaerobic digestion should be accounted for elsewhere, such as in your climate action plan or other GHG mitigation initiatives.

This Protocol only addresses estimating emissions from agricultural livestock management. As this Protocol evolves over time, methods will be added. In the meantime, communities are encouraged to use valid accounting methods not covered in this Protocol to complete their agricultural emissions sources inventories.

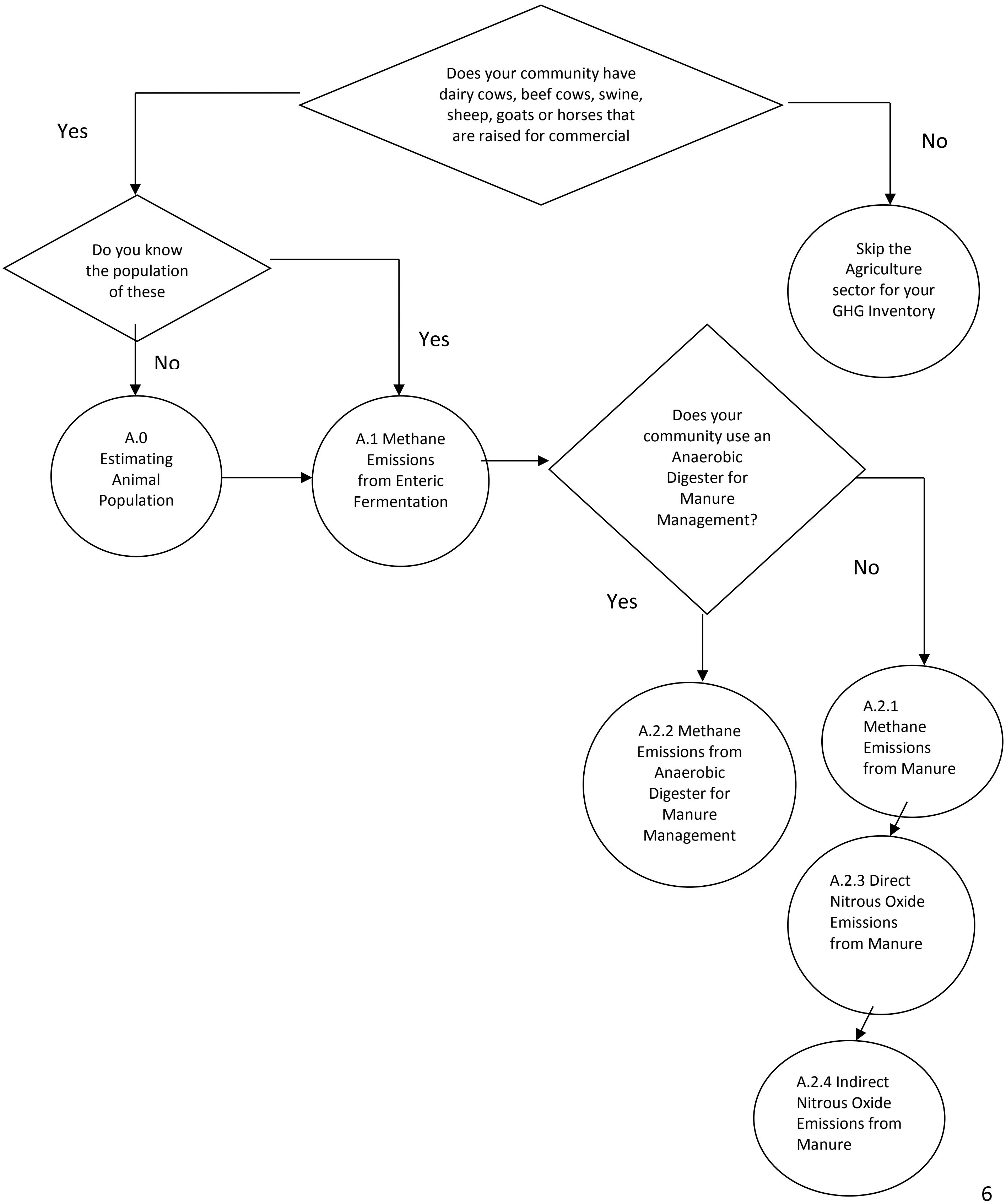
Other agricultural processes that produce greenhouse gas emissions not covered here include N_2O emissions related to soil management practices and CH_4 emissions from the cultivation of rice in submerged fields. The processes that govern the emissions generation from these sources, however, are highly dependent on local soil conditions and can vary widely from community to community and even within a single crop field. Larger scale GHG inventory methods such as those from IPCC and the US National Inventory utilize national averaged emissions factors to estimate emissions from these sources. Using national averaged emissions factors are likely to produce inaccurate results for any particular location. A local inventory that is based on national averaged emissions factors cannot provide policy relevant information that would instruct local officials how they might be able to manage those emissions sources, or to determine whether actions taken have made an impact from one inventory to the next. While emissions from soil management may be significant for some communities, these sources will not be covered in this Protocol until such time as methods to reliably calculate those emissions at the local level are developed.

In addition to agricultural practices not covered in this Protocol, a number of other land-use related sources of emissions are also not covered. Emissions from land conversion, forestry and other similar processes again are not covered here for similar reasons as cited above. National and international scale methods do not take into account local variation that can have significant impacts on emissions generation. While these emissions can be estimated, the procedures and depth of study required to do so are beyond the scope of this Protocol. If you have had local studies performed on additional agricultural and land use emissions sources, you may report those as line item direct emissions, citing the models and methods used in making the estimations.

Uncertainties

Uncertainties within the agriculture sector exist to the extent that the inputs used in any calculations are estimates of agricultural activity rather than direct measurements. From the size and characterization of animal populations, to the feeding regimes they are placed under, in most cases these inputs will need to be estimated. Estimation techniques generally rely on scaling down data available at higher levels of aggregation to the local level, and will not capture any specific local variation. As your community performs periodic re-inventories, estimation of the inputs again will not capture local variation from year to year, making it difficult to observe changes in these sources over time. Noting these limitations, the methods in this chapter are useful for acknowledging the emissions that result from agricultural activities and their relative contributions to the emissions profile of your community.

Chart A.1: Decision Tree for Reporting Emissions from Domestic Animal Production within your community



A.1 Enteric Fermentation from Domesticated Animal Production

What is Enteric Fermentation?
Enteric fermentation is the process of microbial fermentation through which methane is produced during animal digestion. Ruminants like cows and goats produce higher levels of methane because of their unique digestive systems. Enteric fermentation is one of the largest sources of methane. In the United States, CH_4 emissions from enteric fermentation represent about 25 percent of total CH_4 emissions from anthropogenic activities.

EPA *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 2010*

A.1 Methane Emissions from Enteric Fermentation

Recommended Approach

Methane emissions due to enteric fermentation from livestock production are derived from information on the population and emissions factors of each animal type (Equation A.1). Specific emission factors are provided for dairy and beef cattle, sheep, goats, swine, and horses. This method has been adapted from the US Environmental Protection Agency's *2011 Inventory of US Greenhouse Gas Emissions and Sinks.* Box A.1 at the end of this section presents an example calculation for domesticated animal production.

Cities with domestic sources of livestock production that qualify as Animal Feeding Operation (AFO) as defined by the US Environmental Protection Agency, must calculate emissions from enteric fermentation. An AFO includes any operation where animals are confined for at least 45 days out of any 12 month period and where there is no grass or vegetation in the confinement area during the normal growing seasons. Confined Animal Feeding Operations (CAFO) represent a special case. For the greatest accuracy, the Protocol recommends that local governments use community-specific data on livestock populations. Data on livestock populations, however, may only be available at the county level. If your community has domestic animal production, but no community-specific data on animal populations, use method A.0 to estimate the livestock population within your city and then follow method A.1 to estimate CH_4 emissions due to enteric fermentation.

Livestock population animal types that fall under the scope of a Protocol-compliant inventory include:

- dairy cows;
- beef cows;
- swine ;
- sheep;

- goats; and
- horses

Other livestock, such as poultry, produce insignificant volumes of emissions from enteric fermentation and would be de minimus for any particular community. The breakdown of poultry manure, however, is a much more significant source of emissions and is covered in methods A.2.1-A.2.4 in the Protocol.

A.0 Estimating Livestock Population in Your Community

If you don't know the livestock population in your community, this Protocol recommends the following way to estimate the number of livestock. If your community is a city or some other division of a county, the recommended method, A.0 uses the ratio of agricultural land in the community to agricultural land in the county as a proxy to estimate livestock population. While it is not likely that all land devoted to agriculture is being used for livestock population, this method assumes that livestock in the community are distributed comparably to agricultural land in the county. This assumption may not be true in many circumstances. Your local knowledge of agricultural practices in your community should help you decide if this method will produce realistic results. If that is not the case, the Protocol recommends that you either collect actual data on livestock in the community or forgo including this source in your inventory until accurate data is available. For county-wide inventories, you should be able to make use of the county scale data set directly.

A.0.1 Recommended Method Data Needs

Below are the data inputs that you will need to collect to estimate your community's livestock populations:

- Population of livestock in county by animal type
- Total agricultural land in county (acres)
- Total agricultural land in community (acres)

A.0.2 Recommended Calculation Method

The method presented consists of the following steps:

Step 1: Determine the ratio of the agricultural land area within your city to agricultural land area in the county. To do this, divide the total acres of agricultural land within your city by the total acres of agricultural land in the county. Agricultural land is considered land that is used for the commercial crop and or livestock production. Data on agricultural land can be accessed through your local planning department.

Step 2: Use Method A.1.3 to collect data on the population of livestock in your county by animal type. Multiply the fraction calculated in step one by the livestock population in the county.

Population of livestock in city = (Agricultural Land within city (acres)/Agricultural land in county (acres)) County Livestock population*

Step 3: Repeat this process for each type of livestock population applicable to your community
Step 4: After you have calculated the population of livestock in your city, follow Equation A.1 to calculate the CH_4 emissions associated with Enteric Fermentation.

A.1 CH_4 Emissions Due to Enteric Fermentation

A.1.1 Data Needs

Below are the data inputs that you will need to collect in order to estimate the CH_4 emitted due to enteric fermentation:

- Population for each animal type

A.1.2 Method Overview

The method presented consists of the following steps:

- Obtain data on animal populations
- Identify the geographic region and appropriate emissions factor
- Estimate methane emissions
- Convert to metric tons CO_2e
- Sum emissions from all animals

Equation A.1 **Methane Emissions due to Enteric Fermentation from Domesticated Animal Production**			
CH_4 Emissions =Σ (Animal Population x EF x (1/1000) x GWP)$_{animal\ type}$ Where:			
		Description	Value
CH_4 Emissions	=	Methane emissions due to enteric fermentation ($MTCO_2e$)	Product of equation A.1
Animal Population	=	Average annual animal population (head)	User input (or as calculated in A.0)
EF	=	Emissions Factor (kg CH_4/head/year)	Varies by animal type, see tables A.1.1 and A.1.2
1/1000	=	Conversion of kg CH_4 to metric tons	1/1000
GWP_{CH4}	=	Global Warming Potential; conversion from metric tons of methane into metric tons of CO_2 equivalents (CO_2e)	GWP[1]
Source: US Environmental Protection Agency's *2011 Inventory of US Greenhouse Gas Emissions and Sinks* Annex 3 Section 3.9 Methodology for Estimating CH_4 Emissions from Enteric Fermentation			

[1] See Appendix GWP for value.

A.1.3 Calculation Method

Step 1: *Obtain data on animal populations.*
Collect data on the animal populations in heads for each of the following animal types:

- dairy;
- cattle;
- beef cattle;
- sheep;
- goats;
- swine; and
- horses.

The Protocol strongly recommends using locally sourced data when possible. Localized data may be available from a state extension agency, university agricultural research center, or land grant college. If localized data is not available, countywide data can be obtained from the USDA National Agriculture Statistics Service. If this is the case, you can use method A.0 to estimate livestock population at the city level. Method A.0 should be used with caution, and only when you believe it will produce reliable results. If large scale confined animal feeding operations are present in your community, Method A.0 will be less likely to give an accurate account of livestock in your community. In this case, local data should be relied upon. It is important to use the same underlying data on livestock populations here that you will use in Section A.2 to determine emissions related to livestock manure production and management.

In some cases, livestock may cross a city or county border during their grazing patterns. However, emissions in these circumstances should be counted as in-boundary for the community where the animal primarily resides.

Step 2: *Choose appropriate emissions factor.*
Use Tables A.1.1 and A.1.2 to determine the appropriate emissions factors for each animal type. Table A.1.1 lists emission factors for different types of dairy and beef cattle. Table A.1.2 lists the emission factors for all other types of livestock.

Step 3: *Estimate methane emissions*
Multiply each animal population by the corresponding emission factors (determined in Step 2). Calculate the kilograms of emissions for each animal type separately.

Step 4: *Convert to metric tons CO_2e.*
Divide by 1000 to convert from kg to metric tons. Use a GWP of 21 to convert metric tons of methane into metric tons of CO_2e.

Step 5: *Sum all methane emissions from different livestock*
Sum methane emissions from all livestock types to ascertain total methane emissions from enteric fermentation.

Box A.1 below gives an example of how to calculate methane emissions from domesticated animal production.

Box A.1	Example Calculation of CH_4 emissions from Enteric Fermentation due to Domesticated Animal Production	
A community in California had 100,000 dairy cows and 50,000 beef cows in 2000. Determine methane emissions from enteric fermentation due to livestock production in this community. Based on this scenario, the inputs are as follows:		

		Description	Value
Animal Population (1)	=	Average annual animal population (head) for dairy cows	100,000
EF_1	=	Emissions Factor for dairy cows	132
Animal Population (2)	=	Average annual animal population (head) for beef cows	50,000
EF_2	=	Emissions Factor for beef cows	91
1/1000	=	Conversion of kg CH_4 to metric tons	1/1000
GWP_{CH4}	=	Global Warming Potential; conversion	GWP[2]
		from metric tons of methane into metric tons of CO_2 equivalents (CO_2e)	

Sample Calculation: Dairy Cow Emissions ($MTCO_2e$)	**= Animal Population x EF x (1/1000) x GWP** = 100,000 x 132 x (1/1000) x 21 = 277,200
Beef Cow Emissions ($MTCO_2e$)	**= Animal Population x EF x (1/1000) x GWP** = 50,000 x 91 x (1/1000) x 21 = 95,550
Total CH_4 emitted (MT CO_2e)	= Dairy Cow Emissions + Beef Cow Emissions = 277,200 + 95,550 = 372,750

[2] [2] See Appendix GWP for value.

A.2 Manure Management

Communities that rely on domestic animal production as part of their local economy will also need to calculate emissions from livestock manure. Manure, the natural byproduct of livestock, creates both methane (CH_4) and nitrous oxide (N_2O) gas emissions as it biodegrades. Note that this source also includes manure from poultry operations in addition to those operations that have been accounted for in method A.1. Enteric fermentation in poultry is an exceedingly small source of GHGs, however the breakdown of manure, which is often mixed with bedding materials can be a significant source of emissions. The following section addresses how to estimate CH_4 and N_2O emissions based on animal population and the type of manure management used. According to the US EPA, manure management refers to a system that stabilizes or stores livestock manure.

Different manure management systems include the following.

- Pasture, Range, and Paddock
- Drylot
- Solid Storage
- Liquid/Slurry
- Daily Spread
- Anaerobic Lagoon
- Deep Pit
- Anaerobic digester

Manure that is applied to soils is a common soil management technique, but emissions accounting methods for soil management are not addressed in this version of the Protocol.

How does manure produce greenhouse gases?
When manure decomposes in an anoxic (without oxygen) environment, methane is produced as a byproduct. Livestock manure is especially conducive to CH_4 generation because of its high organic content and large bacterial population. Nitrous oxide is also produced during the storage and treatment of animal manure through the nitrification and denitrification of nitrogen contained in ammonia that is present in the wastes. During nitrification, bacteria and other microorganisms oxidize the nitrogen within ammonia (NH_3) to create nitrites, which are further oxidized into nitrates. During denitrification, the nitrates are reduced by bacteria and become N_2O, which is released into the atmosphere.

A.2.1 Methane Emissions from Manure Management, Recommended Approach

Methane emissions estimates from manure are derived using data on animal populations, animal characteristics, and manure management practices. The amount of methane produced is dependent upon the animal's diet and the type of manure management system. Follow method A.2.1.1 for the following manure management systems.

- Pasture, Range and Paddock
- Drylot
- Solid Storage
- Liquid/Slurry
- Daily Spread
- Anaerobic Lagoon
- Deep Pit

Note that separate calculations are needed for the portion of waste managed in each system. If your community uses an anaerobic digester for some manure management, then follow Method A.2.2.1 for that portion of manure.

This method to estimate greenhouse gas emissions from domesticated animal manure has been adapted from the EPA's *US Inventory for Greenhouse Gas Emissions and Sinks 2011* and the 2006 IPCC *Guidelines for National Greenhouse Gas Inventories*. Boxes A.2.1 and A.2.2 at the end of this section present example calculations for both methane and nitrous oxide emissions from manure management.

If your city does not have community-specific data on livestock population, you will need to estimate livestock information using the method A.0 "Estimating Livestock Population in Your Community" (above) before proceeding on to Method A.2.1. however, local data is always preferred.

A.2.1.1 Data Needs

Below are the data inputs that you will need to collect in order to estimate the CH_4 emitted from manure management in your community for all manure management systems other than anaerobic digester:

- Average populations for each animal type
- Manure management system

A.2.1.2 Method Overview

The method presented consists of the following steps:

1. Obtain data on animal populations
2. Calculate the amount of volatile solids (VS) produced
    a. For all animals other than cattle (Equation A.2.1.1a)
    b. For cattle (Equation A.2.1.1b)

3. Estimate methane emissions for each type of manure management system
4. Convert to metric tons of carbon dioxide equivalent
5. Sum all methane emissions from different livestock populations

Equation A.2.1.1a	Volatile Solids (VS) Excreted by All Animals other than Cattle		
$VS\ Excreted_{animal,WMS} = Population_{animal} \times WMS \times TAM_i /1000 \times VS \times 365.25$ Where:			
		Description	Value
$VS\ Excreted_{animal,WMS}$	=	Amount of VS excreted in manure managed in each WMS for each animal type (kg/yr)	Product of Equation A.2.1.1
$Population_{animal}$	=	Annual average animal population by animal type animal population (head)	User input (or Method A.0)
WMS	=	Distribution of manure by waste management system for each animal type in a state (percent)	User input (or Table A.2.3.4)
TAM	=	Typical Animal Mass (kg)	See Table A.2.1.1
VS	=	Average daily volatile solid production rate per unit of animal mass (kg VS per 1,000 kg animal mass per day)	See Table A.2.1.1
365.25 1,000	= =	Days per year Kilograms animal mass	365 1,000
Source: US Environmental Protection Agency's *2011 Inventory of US Greenhouse Gas Emissions and Sinks1990-2009* Annex 3 page A-217			

Equation A.2.1.1b		Volatile Solids Excreted by Cattle	
VS Excreted$_{animal,WMS}$ = Population$_{animal}$ x VS x WMS Where:			
		Description	Value
VS Excreted$_{animal,WMS}$	=	Amount of VS excreted in manure managed in each WMS for each animal type (kg/yr)	Product of Equation A.2.1.1
Population$_{animal}$	=	Annual average state animal population by animal type animal population (head)	User input (or Method A.0)
VS	=	Average annual volatile solid production rate per animal (kg/animal/year)	See Table A.2.3.4
WMS	=	Distribution of manure by waste management system for each animal type (percent)	User input (or Table A.2.3.5)
Source: US Environmental Protection Agency's *2011 Inventory of US Greenhouse Gas Emissions and Sinks* Annex 3 page A-218			

Equation A.2.1.2		Methane Emissions from Manure Management for all animals (cattle and all other animals)	
CH_4 Emissions = VS Excreted$_{animal,WMS}$x B_o x MCF x 0.662 x (1/1000) x GWP Where:			
		Description	Value
CH_4 Emissions	=	Methane Emissions from manure management in metric tons carbon equivalent	Product of Equation A.2.1.2
VS Excreted$_{animal,WMS}$	=	Amount of VS excreted in manure managed in each WMS for each animal type (kg/yr)	Calculated in Equation A.2.1.1
B_o	=	Maximum CH_4 producing capacity per pound of manure (m^3/kg VS)	See Table A.2.1.1
MCF	=	Methane conversion factor based on manure management system	See Table A.2.1.2 or A.2.1.3
0.662	=	Density of CH_4, to convert from meters cubed to kg	0.662
1/1000	=	Conversion to metric tons	1/1000
GWP_{CH4}	=	Global Warming Potential; conversion from metric tons of methane into metric tons of CO_2 equivalents (CO_2e)	GWP[3]
Source: US Environmental Protection Agency's *2011 Inventory of US Greenhouse Gas Emissions and Sinks1990-2009* Annex 3 page A-218			

[3] [3] See Appendix GWP for value.

A.2.1.3 Calculation Method

Step 1: *Obtain data on animal populations.*
Collect data on poultry using the USDA National Agriculture Statistics Service or more localized data. For the remaining domestic animal populations, use the same underlying data here that you used in Section A.1 to determine emissions related to enteric fermentation.

Step 2: *Calculate the amount of volatile solids (*VS $Excreted_{animal,WMS}$*) produced.*
The calculation for VS excreted is different for cattle and all other animals. To calculate VS Excreted for all other animals use Equation A.2.1.1a. Note, you must calculate VS Excreted for each animal population separately. Refer to Table A.2.1.1 for the appropriate animal characteristic defaults for typical animal mass (TAM) and average daily volatile solid production rate per unit of animal mass (VS).

To calculate VS excreted for cattle use equation A.2.1.1b. Table A.2.3.4 has the VS for cattle by state.

The WMS value in both equations refers to the manure distribution for the different management systems. If you do not have local data on the how your community's animal manure is managed, you can refer to Table A.2.3.5 for the state defaults.

Step 3: *Estimate methane emissions for each type of manure management system.*
Calculate the kilograms of methane emissions from manure management for each animal population separately. Use table A.2.1.1 to determine the maximum CH_4 producing capacity per pound of manure (Bo) and tables A.2.1.2 (for dry systems) and A.2.1.3 (for liquid systems) to determine the methane conversion factor (MCF). Note there are different methane conversion factors for different types of management systems. Liquid systems include anaerobic lagoon and liquid/slurry and deep pit. The liquid systems have state-specific methane conversion factors so be sure to choose the appropriate factor for your city. Dry systems include aerobic treatment, cattle deep litter <1month, cattle deep litter >1 month, composting in vessel, composting static pile, composting extensive/passive, composting intensive, daily spread, dry lot, fuel, pasture, poultry with bedding, poultry without bedding, or solid storage. The conversion factors for these dry systems in table A.2.1.2 are contingent on the climatic conditions of your city (cool climate, temperate climate, and warm climate).

Determining your community's climatic conditions. The EPA relies up on the IPCC 2006 definition of cool, temperate, and warm. A cool climate has an average annual temperature of less than 15ºC (less than 59ºF). A temperate climate has an average annual temperature between 15 and 25ºC (about 59-77ºF). A warm climate has an average annual temperature of more than 25ºC (more than 77ºF). You can find out the average annual temperature in your community by going to http://www.climate.gov/#dataServices/pastPresent and looking at the 30-year normal annual temperature for your community.

Step 4:*Convert to metric tons CO_2e.*
Divide each animal population's emissions by 1000 to convert from kg to metric tons. Use a GWP of 21 to convert metric tons of methane into metric tons of CO_2e.

Step 5:*Sum all methane emissions from different livestock populations*
Finally, sum all methane emissions from each animal population to arrive at metric tons of CO_2e.

Box A.2.1.1	Example Calculation of Methane Emissions from Manure Management	
A community in California had 100,000 dairy cows in 2000. The manure from these dairy cattle is managed in an anaerobic lagoon. Determine methane emissions from manure in this community. Based on this scenario, the inputs are as follows:		
	Description	Value
	Volatile Solids Excreted by Cattle	
Animal Population =	Average animal population (head)	100,000
VS =	Average daily volatile solid production rate per unit of animal mass (kg VS/animal/year)	2,723.70
WMS =	Distribution of manure by waste management system for each animal type in a state (percent)	100%
	Methane Emissions from Manure Management	
$VS\ Excreted_{animal,WMS}$ =	Amount of VS excreted in manure managed in each WMS for each animal type (kg/yr)	Calculated in Equation A.2.1.1
B_o =	Maximum CH_4 producing capacity per pound of manure	0.24
MCF =	Methane conversion factor for anaerobic lagoon	0.75
0.662 =	Density of CH_4, to convert from meters cubed to kg	0.662
1/1000 =	Conversion to metric tons	1/1000
GWP_{CH4} =	Global Warming Potential; conversion from metric tons of methane into metric tons of CO_2 equivalents (CO_2e)	GWP[4]
Sample Calculation:		
$VS\ Excreted_{animal,WMS}$ (kg/year)	**= $Population_{animal}$ x VS x WMS** = (100,000 x 2723.70 x 1) = 272,370,000	
CH_4 Emissions (metric tons CO_2e)	= $VS\ Excreted_{animal,WMS}$ x B_o x MCF x 0.662 x (1/1000) x GWP = 272,370,000 x 0.24 x 0.75 x 0.662 x (1/1000) x 21 = 681,567 $MTCO_2e$	

[4] See Appendix GWP for value.

A.2.2 Methane Emissions from Anaerobic Digester for Manure Management

Follow method A.2.2.2 below if your community utilizes anaerobic digesters (AD) for manure management. If not, skip this and go on to Nitrous Oxide Emissions from Manure Management. Note that accuracy in this method depends on obtaining complete local data and will likely require field surveys of agricultural practices in your community if this information does not already exist.

A.2.2.1 Data Needs

- Number and types of animals on AD system
- Type of AD system (Covered Lagoon, Complete Mix, or Plug Flow)

Equation A.2.1		Methane Production from Manure in and Anaerobic Digester	
CH_4 Production$_{AD}$ = Population$_{AD}$ x TAM/1000 x VS x B_o x 0.662 x 365.25 x 0.9 Where:			
		Description	Value
CH_4 Production$_{AD}$	=	Methane production from a particular anaerobic digester (AD) system (kg/yr)	Result
Population$_{AD}$	=	Number of animals on AD system	User Input
TAM	=	Typical Animal Mass (kg/head)	See Table A.2.1.1
VS	=	Total volatile solid production rate (kg VS/1000 kg animal mass/day)	See Table A.2.1.1
B_o	=	Maximum CH_4 producing capacity per pound of manure (m^3/kg VS)	See Table A.2.1.1
0.662	=	Density of CH_4, to convert from meters cubed to kg (kg CH_4/m^3 CH_4)	0.662
1/1000	=	Conversion to metric tons	1/1000
365.25	=	Convert days to year	356.25
0.90	=	CH_4 production factor for AD systems	0.90*
*The EPA assumed that AD systems produce 90 percent of the maximum CH_4 producing capacity. This value is applied for all climate regions and AD system types. However, EPA realizes that the actual amount of CH_4 produced by each AD system is very variable and will change based on operational and climate conditions and an assumption of 90 percent is likely overestimating CH_4 production from some systems and underestimating CH_4 production in other systems. Source: US Environmental Protection Agency's *2011 Inventory of US Greenhouse Gas Emissions and Sinks1990-2009* Annex 3 page A-218			

Equation A.2.2		Methane Emissions from Manure in and Anaerobic Digester	
CH_4 Emissions$_{AD}$ = [CH_4 Production$_{AD}$ x CE_{AD} x (1-DE)] + [CH_4 Production$_{AD}$ x (1-CE_{AD})] x GWP/1000 Where:			
		Description	Value
CH_4 Emissions$_{AD}$	=	Total methane emissions from anaerobic digestion of manure (MT CO_2e/year)	Result
CH_4 Production$_{AD}$	=	Methane production from a particular anaerobic digester (AD) system (kg/yr)	From Equation A.2.1
CE_{AD}	=	Collection efficiency of the AD system, varies by system (percent)	Covered lagoon: 75% Complete Mix and Plug Flow: 99%
DE	=	Destruction efficiency of the AD system	0.98
GWP_{CH4}	=	Global Warming Potential of Methane (CO_2e)	GWP[5]
1/1000	=	Convert kg to metric tons	1/1000
Source: US Environmental Protection Agency's *2011 Inventory of US Greenhouse Gas Emissions and Sinks1990-2009* Annex 3 page A-219			

A.2.2.2 Calculation Method

The method presented consists of the following steps

Step 1: *Obtain data on animal populations.*

Collect data on poultry using the USDA National Agriculture Statistics Service or more localized data. For the remaining domestic animal populations, use the same underlying data here that you used in Section A.1 to determine emissions related to enteric fermentation

Step 2: *Calculate the Methane Produced*

Use Equation A.2.1 to determine the amount of methane produced per year. This is methane production potential due to the decomposition of the manure and not the total methane emissions from the anaerobic digester. For this equation you will use Table A.2.1.1 for TAM, VS, and B_o values. If you have multiple types of animal manure input into the digester, you will have to calculate the CH_4 production separately for each animal. Note that this equation assumes a 90% producing capacity for all climate regions and AD systems. This however may overestimate or underestimate emissions depending on the climate and the operational conditions.

Step 3: *Calculate the Methane Emissions*

Use Equation A.2.2 to calculate the methane emissions from the anaerobic digester. Note that covered lagoons have a 75% percent collection efficiency and Complete Mix and Plug & Flow digesters have a 99% efficiency. If you have manure input from different animals, you can sum the CH_4 production from each animal type and use that total sum as the input for CH_4 Production$_{AD}$

There are no nitrous oxide emissions associated with anaerobic digesters.

[5] See Appendix GWP for value.

A.2.3 Direct Nitrous Oxide Emissions from Manure Management

Nitrous oxide emissions from manure are estimated using data on animal populations, animal characteristics, and manure management practices. This method accounts for nitrous oxide emissions that are released directly from manure.

A.2.3.1 Data Needs

Below are the data inputs that you will need to collect in order to estimate the nitrous oxide emitted by manure management in your community:

- Average animal populations
- Manure management system

A.2.3.2 Method Overview

The method presented consists of the following steps:

- Obtain data on animal populations
- Calculate Kjeldahl[6] nitrogen excreted
  - For all animals other than cattle (A.2.3.1a)
  - For cattle (A.2.3.1b)
- Calculate nitrous oxide emissions from manure management
- Determine total annual emissions and convert to metric tons of carbon dioxide equivalent

[6] Kjedahl nitrogen refers to organic nitrogen in the form of either ammonia or ammonium

Equation A.2.3.1a	Kjeldahl Nitrogen Excreted from all animals other than cattle

$N\ Excreted_{animal,WMS}$ = $Population_{animal}$ x WMS x TAM / 1,000 x Nex x 365.25

Where:

		Description	Value
$N\ Excreted_{animal,WMS}$	=	Amount of N excreted in manure managed in each WMS for each animal type (kg/yr)	Product of Equation A.2.3.1
$Population_{animal}$	=	Annual average state animal population by animal type (head)	User input
WMS	=	Distribution of manure by waste management system for each animal type in a state (percent)	See Table A.2.3.5
TAM	=	Typical Animal Mass (kg)	See Table A.2.3.1
Nex	=	The daily rate of Kjeldahl nitrogen excreted (kg/day/1,000 kg animal mass)	See Table A.2.3.3
365.25	=	Number of days in a year	365.25

Equation A.2.3.1b	Kjeldahl Nitrogen Excreted from cattle

$N\ Excreted_{animal,WMS}$ = $Population_{animal}$ x WMS x Nex

Where:

		Description	Value
$N\ Excreted_{animal,WMS}$	=	Amount of N excreted in manure managed in each WMS for each animal type (kg/yr)	Product of Equation A.2.3.1
$Population_{animal}$	=	Annual average state animal population by animal type (head)	User input
WMS	=	Distribution of manure by waste management system for each animal type in a state (percent)	User input (or See Table A.2.3.5)
Nex	=	The daily rate of Kjeldahl nitrogen excreted (kg N/animal/year)	See Table A.2.3.4

Equation A.2.3.2	Direct Nitrous Oxide Emissions from Manure Management		
Direct N_2O Emissions = N excreted x EF_{WMS} x (44/28) x (1/1000) x GWP			
Where:			
		Description	Value
Direct N_2O Emissions	=	Direct Nitrous oxide emissions from manure management (MT CO_2e)	Result
NExcreted	=	Amount of N excreted in manure managed in each WMS for each animal type (kg/yr)	Calculated in Equation A.2.3.1
44/28	=	Ratio of molecular mass of nitrous oxide to nitrogen, conversion from kg of N_2O-N to kg of N_2O	44/28
1/1000	=	Conversion to metric tons	1/1000
GWP_{N_2O}	=	Global Warming Potential	GWP[7]

A.2.3.3 Calculation Method

Step 1: *Obtain data on animal populations.*

Use the same underlying data on livestock populations here that you used in Section A.1 and A.2 to determine emissions related to enteric fermentation.

Step 2:*Calculate Kjeldahl nitrogen excreted (Nex).*

The calculation for N_{ex} is different for cattle and all other animals. To calculate N_{ex} for all animals other than cattle use Equation A.2.3.1a. Note that you must calculate N_{ex} for each animal population separately. Defaults for typical animal mass (TAM) are found in table A.2.3.1. For nitrogen excreted (N_{ex}) by all livestock other than cattle please refer to Table A.2.3.3 and choose the factor under closest appropriate year.

To calculate N_{ex} for cattle use Equation A.2.3.1b. Table A.2.3.4 has the N_{ex} value for cattle by state.

The WMS value in both equations refers to the manure distribution for the different management systems. If you do not have local data on the how your community's animal manure is managed, you can refer to Table A.2.3.5 for the state defaults.

Sum the results across all animal types to obtain total Kjeldahl N excreted by managed manure. Kjeldahl nitrogen is the sum of the organic nitrogen, ammonia (NH_3) and ammonium (NH_4^+) in the manure.

Step 3: *Calculate nitrous oxide emissions from manure management.*

[7] See Appendix GWP for value.

Use Equation A.2.3.2 to convert the Kjeldahl N excreted by animal type (as determined in Step 2) to nitrous oxide emissions. Use the default emissions factor for the type of manure management system in Table A.2.3.2.

Step 4: *Convert to metric tons of CO_2e.*
Finally, sum all methane emissions from each animal population to arrive at metric tons of CO_2e. Use a GWP of 21 to convert metric tons of methane into metric tons of CO_2 equivalent.

A.2.4 Indirect Nitrous Oxide Emissions from Manure Management

Indirect nitrous oxide emissions from manure are associated with intermediary nitrous oxide released from the nitrification-denitrification process of nitrogen remaining in the soil and from nitrogen lost through runoff and leaching.

A.2.4.1 Data Needs

Below are the data inputs that you will need to collect in order to estimate the nitrous oxide emitted by manure management in your community:

- N excreted from equation A.2.3.1 (kg/year)
- Manure management system

Equation A.2.4.2	Indirect Nitrous Oxide Emissions from Manure Management		
Indirect N_2O Emissions = [(N excreted x $Frac_{gas, WMS}$/100 x $EF_{volatilization}$ (44/28)) + N excreted x $Frac_{runoff/leach, WMS}$/100 x $EF_{Runnoff/leach, WMS}$ (44/28)] x GWP/1000 Where:			
		Description	Value
Indirect N_2O Emissions	=	Indirect Nitrous oxide emissions from manure management (MT CO_2e/yr)	Result
NExcreted	=	Amount of N excreted in manure managed in each WMS for each animal type (kg/yr)	Calculated in Equation A.2.3.1 a or Equation A.2.3.1b
$Frac_{gas,WMS}$	=	**Nitrogen lost through volatilization in each WMS**	Table A.2.4
$Frac_{runoff/leach, WMS}$	=	**Nitrogen lost through runoff and leaching in each WMS; data were not available for leaching so the value reflects runoff only**	Table A.2.4
$EF_{volatilization}$	=	**Emission factor for volatilization (kg N_2O-N/kg N)**	0.010
$EF_{runoff/leach}$	=	**Emission factor for runoff/leaching (kg N_2O-N/kg N)**	0.0075
44/28	=	Ratio of molecular mass of nitrous oxide to nitrogen, conversion from kg of N_2O-N to kg of N_2O	44/28
1/1000	=	Conversion to metric tons	1/1000
GWP_{N_2O}	=	Global Warming Potential	GWP[8]

A.2.4.2 Calculation Method

The method presented consists of the following steps:

Step 1: *Determine N excreted*

N excreted is the amount of nitrogen excreted in manure managed in each WMA for each animal type. You have already calculated this in Equation A.2.3.1

Step 2: *Calculate Indirect N_2O Emissions for each Animal*

Use Equation A.2.4.2 to calculate indirect nitrous oxide emissions. You can refer to Table A.2.4 for the fraction of nitrogen lost through volatilization and runoff/leaching for each type of management system. You will have to calculate Equation A.2.4.2 separately for each animal type.

[8] See Appendix GWP for value.

Step 3: *Calculate Total Indirect N_2O Emissions*

Sum the indirect N_2O emissions you calculated in step 2 to get the total indirect N_2O emissions for your community.

Box A.2.1.1	Example Calculation of Direct Nitrous Oxide Emissions from Manure Management		
A community in California had 100,000 dairy cows in 2000. Their manure is stored in daily spread. Determine nitrous oxide emissions from manure in this community. Based on this scenario, the inputs are as follows:			
		Description	Value
		Direct Nitrous Oxide Emissions	
Population	=	Average animal population (head)	100,000
TAM	=	Typical Animal Mass (kg)	680
Kjedahl N	=	The daily rate of Kjeldahl nitrogen excreted (kg/day/1,000 kg animal mass)	0.1529
365	=	Number of days in a year	365
N excreted	=	Kjeldahl nitrogen excreted (kg)	Calculated in Equation A.2.3.1
EF	=	**Emission factor for manure management system type (kg N_2O-N/kg N excreted)**	0.002
44/28	=	Ratio of molecular mass of nitrous oxide to nitrogen, conversion from kg of N_2O-N to kg of N_2O	44/28
1/1000	=	Conversion to metric tons	1/1000
GWP_{N_2O}	=	Global Warming Potential	GWP[9]

Sample Calculation:

Kjeldahl N Excreted by $Animal_i$ (kg/yr) **= Population x TAM / 1000 x Kjeldahl N x 365**
= (100,000 x 680) / 1000 x 0.1529 x 365
= 3,794,978

N_2O Emissions (metric tons CO_2e) = N excreted x EF x (44/28) x (1/1000) x (12/44) x GWP
= 3,794,978 x 0.002 x (44/28) x (1/1000) x 310
= 3,694 MT CO_2e

[9] See Appendix GWP for value.

Box A.2.1.1 Cont.	Example Calculation of Indirect Nitrous Oxide Emissions from Manure Management		
		Indirect Nitrous Oxide Emissions	
Indirect N2O Emissions	=	Indirect Nitrous oxide emissions from manure management (MT CO_2e/yr)	Result
NExcreted	=	Amount of N excreted in manure managed in each WMS for each animal type (kg/yr)	3,794,978
$Frac_{gas,WMS}$	=	**Nitrogen lost through volatilization in each WMS**	10
$Frac_{runoff/leach, WMS}$	=	**Nitrogen lost through runoff and leaching in each WMS; data were not available for leaching so the value reflects runoff only**	0
$EF_{volatilization}$	=	**Emission factor for volatilization (kg N_2O-N/kg N)**	0.010
$EF_{runoff/leach}$	=	**Emission factor for runoff/leaching (kg N_2O-N/kg N)**	0.0075
44/28	=	Ratio of molecular mass of nitrous oxide to nitrogen, conversion from kg of N_2O-N to kg of N_2O	44/28
1/1000	=	Conversion to metric tons	1/1000
GWP_{N_2O}	=	Global Warming Potential	GWP[10]

Indirect N_2O Emissions = [(N excreted x $Frac_{gas, WMS}$/100 x $EF_{volatilization}$ x (44/28)) + N excreted x $Frac_{gas, WMS}$/100 x $EF_{Runnoff/leach, WMS}$ x (44/28)] x GWP/1000

= [(3794978 x 10/100 x 0.010 x 44/28) + (3794978 x 0/100 x 0.0075 x 44/28)] x 1/1000 x 310

= 1848.7 MT CO_2e

[10] See Appendix GWP for value.

Appendix AG: Agricultural Livestock Activities and Sources Emissions

Table A.1.1 Calculated National Emissions Factors for Cattle by Animal Type (kg CH_4/head/year)

Cattle Type	1990	1995	2000	2005	2006	2007	2008	2009
Dairy								
Cows	124	125	132	133	134	139	139	140
Replacements 7-11 months	48	46	46	45	45	46	46	46
Replacements 12-23 months	73	69	70	67	67	70	69	70
Beef								
Bulls	53	53	53	53	53	53	53	53
Cows	89	92	91	94	94	94	94	94
Replacements 7-11 months	54	57	57	59	60	60	60	60
Replacements 12-23 months	63	66	66	68	69	69	69	69
Steer Stockers	55	56	58	58	58	58	57	57
Heifer Stockers	51	56	60	59	59	59	59	59
Feedlot Cattle	39	38	39	39	39	42	42	43

Source: EPA 2011 Inventory of US Greenhouse Gas Emissions and Sinks Annex-3 Table A-178

Table A.1.2 Emission Factors for Animals Other than Cattle

Animal Type	*Emission Factor (kg CH_4/head/year)*
Sheep	8
Goats	5
Swine	1.5
Horses	18
Source: EPA 2011 Inventory of US Greenhouse Gas Emissions and Sinks Annex-3 Table A-180	

Table A.2.1.1 Recommended Animal Characteristic Defaults for Estimating Methane Emissions from Manure

Animal Type	***TAM (kg)***	***VS Rate (kg VS/1000 kg animal mass/day)***	***Bo (m^3 CH_4/kg VS)***
Dairy Cattle			
Dairy Cows	680	Table A.2.3.4	0.24
Dairy Heifers	406-408	Table A.2.3.4	0.17
Beef Cattle			
Feedlot Steer	419-157	Table A.2.3.4	0.33
Feedlot Heifers	384-430	Table A.2.3.4	0.33
NOF Bulls	750	Table A.2.3.3	0.17
NOF Calves	118	Table A.2.3.3	0.17
NOF Heifers	296-406	Table A.2.3.4	0.17
NOF Steers	314-335	Table A.2.3.4	0.17
NOF Cows	554-611	Table A.2.3.4	0.17
Swine			
Market Swine <50 lbs	13	Table A.2.3.3	0.48
Market Swine 50-119 lbs	39	Table A.2.3.3	0.48
Market Swine 120-179 lbs	68	Table A.2.3.3	0.48
Market Swine >180 lbs	91	Table A.2.3.3	0.48
Breeding Swine	198	Table A.2.3.3	0.48
Poultry			
Hens >/= 1 year	1.8	Table A.2.3.3	0.39
Pullets	1.8	Table A.2.3.3	0.39
Other Chickens	1.8	Table A.2.3.3	0.39
Broilers	0.9	Table A.2.3.3	0.36
Turkeys	6.8	Table A.2.3.3	0.36
Sheep			
Feedlot Sheep	25	Table A.2.3.4	0.36
NOF Sheep	80	-	0.19
Goats	64	Table A.2.3.3	0.17
Horses	450	Table A.2.3.3	0.33
NOF = Not on Feed			
Source: U.S. EPA. 2011. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. U.S. Environmental Protection Agency. EPA 430-R-04-003. Annex 3.9			

Table A.2.1.2 Methane Conversion Factors for Dry Systems (Percent)

Waste Management System	**Cool Climate MCF**	**Temperate Climate MCF**	**Warm Climate MCF**
Average Annual Temperature (ºC)	**(<15 ºC)**	**(15 to 25ºC)**	**(>25ºC)**
Aerobic Treatment	0	0	0
Cattle Deep Litter (<1 month)	0.03	0.03	0.3
Cattle Deep Litter (>1 month)	0.21	0.44	0.76
Composting- In Vessel	0.005	0.005	0.005
Composting- Static Pile	0.005	0.005	0.005
Composting- Extensive/ Passive	0.005	0.01	0.015
Composting- Intensive	0.005	0.01	0.015
Daily Spread	0.001	0.005	0.01
Dry Lot	0.01	0.015	0.05
Fuel	0.1	0.1	0.1
Pasture	0.01	0.015	0.02
Poultry with Bedding	0.015	0.015	0.015
Poultry without Bedding	0.015	0.015	0.015
Solid Storage	0.02	0.04	0.05

Sources: U.S. EPA. 2011. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. U.S. Environmental Protection Agency. EPA 430-R-04-003. Annex 3.9

Table A.2.1.3 Methane Conversion Factors (percent) by State for Liquid Systems for 2009

State	Dairy		Swine		Beef	Poultry
	Anaerobic Lagoon	Liquid/Slurry and Deep Pit	Anaerobic Lagoon	Liquid/Slurry and Deep Pit	Liquid/Slurry	Anaerobic Lagoon
Alabama	0.76	0.39	0.76	0.38	0.40	0.76
Alaska	0.46	0.14	0.46	0.14	0.14	0.46
Arizona	0.80	0.62	0.75	0.37	0.48	0.76
Arkansas	0.74	0.34	0.75	0.36	0.34	0.74
California	0.75	0.35	0.74	0.32	0.42	0.75
Colorado	0.63	0.21	0.67	0.24	0.22	0.63
Connecticut	0.68	0.24	0.68	0.24	0.25	0.69
Delaware	0.74	0.31	0.74	0.31	0.31	0.74
Florida	0.78	0.52	0.78	0.50	0.51	0.78
Georgia	0.76	0.39	0.76	0.38	0.38	0.75
Hawaii	0.77	0.58	0.77	0.58	0.58	0.77
Idaho	0.67	0.23	0.65	0.22	0.22	0.65
Illinois	0.71	0.28	0.71	0.28	0.27	0.71
Indiana	0.70	0.27	0.71	0.27	0.27	0.71
Iowa	0.68	0.24	0.69	0.25	0.25	0.69
Kansas	0.73	0.30	0.73	0.30	0.30	0.73
Kentucky	0.74	0.31	0.74	0.31	0.31	0.74
Louisiana	0.77	0.46	0.77	0.46	0.47	0.77
Maine	0.63	0.20	0.63	0.20	0.20	0.63
Maryland	0.72	0.29	0.73	0.30	0.30	0.73
Massachusetts	0.67	0.23	0.68	0.24	0.24	0.67
Michigan	0.67	0.23	0.68	0.24	0.23	0.68
Minnesota	0.66	0.23	0.67	0.23	0.23	0.66
Mississippi	0.76	0.41	0.76	0.39	0.41	0.76
Missouri	0.73	0.30	0.72	0.30	0.30	0.73
Montana	0.59	0.19	0.61	0.20	0.20	0.61
Nebraska	0.70	0.26	0.70	0.26	0.25	0.70
Nevada	0.71	0.26	0.71	0.27	0.26	0.71
New Hampshire	0.63	0.20	0.65	0.22	0.20	0.64
New Jersey	0.72	0.28	0.72	0.29	0.28	0.72
New Mexico	0.72	0.30	0.71	0.28	0.28	0.68
New York	0.65	0.22	0.66	0.22	0.22	0.67
North Carolina	0.73	0.31	0.75	0.37	0.32	0.73
North Dakota	0.65	0.21	0.65	0.21	0.21	0.64
Ohio	0.70	0.26	0.71	0.27	0.26	0.71
Oklahoma	0.75	0.37	0.74	0.35	0.34	0.75
Oregon	0.62	0.20	0.63	0.21	0.22	0.64
Pennsylvania	0.69	0.25	0.70	0.26	0.26	0.71
Rhode Island	0.69	0.26	0.69	0.26	0.26	0.69
South Carolina	0.76	0.38	0.76	0.39	0.39	0.76
South Dakota	0.68	0.24	0.68	0.24	0.24	0.68
Tennessee	0.74	0.31	0.75	0.34	0.32	0.74
Texas	0.76	0.44	0.76	0.43	0.37	0.77
Utah	0.67	0.23	0.66	0.22	0.23	0.66
Vermont	0.63	0.21	0.63	0.21	0.21	0.63
Virginia	0.71	0.28	0.73	0.31	0.28	0.72
Washington	0.62	0.20	0.64	0.21	0.22	0.63
West Virginia	0.69	0.26	0.70	0.26	0.26	0.69
Wisconsin	0.66	0.22	0.67	0.23	0.23	0.67
Wyoming	0.59	0.18	0.64	0.21	0.21	0.62

Sources: U.S. EPA. 2011. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. U.S. Environmental Protection Agency. EPA 430-R-04-003. Annex 3.9.

Table A.2.3.1 Recommended Animal Characteristic Defaults for Estimating Nitrous Oxide Emissions from Manure

Animal Type	*TAM (kg)*	*Kjeldahl Nitrogen (kg/1000 kg animal mass/day)*
Dairy Cattle		
Dairy Cows	680	Table A.2.3.4
Dairy Heifers	406-408	Table A.2.3.4
Beef Cattle		
Feedlot Steer	419-457	Table A.2.3.4
Feedlot Heifers	384-430	Table A.2.3.4
NOF Bulls	750	Table A.2.3.3
NOF Calves	118	Table A.2.3.3
NOF Heifers	296-406	Table A.2.3.4
NOF Steers	314-335	Table A.2.3.4
NOF Cows	554-661	Table A.2.3.4
Swine		
Market < 50 lbs	13	Table A.2.3.3
Market 50 – 119 lbs	39	Table A.2.3.3
Market 120 – 179 lbs	68	Table A.2.3.3
Market > 180 lbs	91	Table A.2.3.3
Breeding Swine	198	
Poultry		
Hens >/= 1 year	1.8	Table A.2.3.3
Pullets	1.8	Table A.2.3.3
Chickens	1.8	Table A.2.3.3
Broilers	0.9	Table A.2.3.3
Turkeys	6.8	Table A.2.3.3
Sheep		
Feedlot Sheep	25	Table A.2.3.3
NOF Sheep	80	Table A.2.3.3
Goats	64	Table A.2.3.3
Horses	450	Table A.2.3.3
NOF = Not on Feed		
Sources: U.S. EPA. 2011. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. U.S. Environmental Protection Agency. EPA 430-R-04-003. Annex 3.9		

Table A.2.3.2 Direct Nitrous Oxide Emissions Factors for 2009 (kg N_2O-N/kg Kjdl N)

Waste Management System	**Direct N_2O Emissions Factor**
Aerobic Treatment (force aeration)	0.005
Aerobic Treatment (natural aeration)	0.01
Anaerobic Digester	0
Anaerobic Lagoon	0
Cattle Deep Bed (active mix)	0.07
Cattle Deep Bed (no mix)	0.01
Composting in vessel	0.006
Composting intensive	0.1
Composting passive	0.01
Composting static	0.006
Daily Spread	0
Deep Pit	0.002
Dry Lot	0.02
Fuel	0
Liquid/Slurry	0.005
Pasture	0
Poultry with Bedding	0.001
Poultry without Bedding	0.001
Solid Storage	0.005

Sources: U.S. EPA. 2011. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. U.S. Environmental Protection Agency. EPA 430-R-04-003. Annex 3.9

Table A.2.3.3 — Estimated Volatile Solids and Nitrogen Excreted Production Rate by year for Animals Other than Cattle (kg/day/1000kg animal mass)

Table A-185: Estimated Volatile Solids and Nitrogen Excreted Production Rate by year for Animals Other Than Cattle (kg/day/1000 kg animal mass)

Animal Type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
VS																				
Market Swine <50 lb.	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8
Market Swine 50-119 lb.	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
Market Swine 120-179 lb.	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
Market Swine >180 lb.	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
Breeding Swine	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.611	2.623	2.634	2.645	2.656	2.668	2.679	2.69	2.701	2.713	2.724	2.735	2.735
NOF Bulls	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04	6.04
NOF Calves	6.41	6.41	6.41	6.41	6.41	6.41	6.41	6.5175	6.625	6.733	6.84	6.948	7.055	7.163	7.27	7.378	7.485	7.593	7.7	7.7
Sheep	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.11	9.02	8.93	8.84	8.75	8.66	8.57	8.48	8.39	8.3	8.3
Goats	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
Hens >1 yr.	10.091	10.091	10.091	10.091	10.091	10.091	10.091	10.097	10.103	10.109	10.115	10.121	10.1265	10.132	10.138	10.144	10.150	10.156	10.162	10.162
Pullets	10.091	10.091	10.091	10.091	10.091	10.091	10.091	10.097	10.103	10.109	10.115	10.121	10.1265	10.132	10.138	10.144	10.150	10.156	10.162	10.162
Chickens	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.817	10.833	10.85	10.867	10.883	10.9	10.917	10.933	10.95	10.967	10.983	11	11
Broilers	15	15	15	15	15	15	15	15.167	15.333	15.5	15.667	15.833	16	16.167	16.333	16.5	16.667	16.833	17	17
Turkeys	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.596	9.492	9.388	9.283	9.179	9.075	8.971	8.867	8.7625	8.658	8.554	8.45	8.45
Horses	10	10	10	10	10	10	10	10	10	9.61	9.22	8.83	8.44	8.05	7.66	7.27	6.88	6.49	6.1	6.1
Nex																				
Market Swine <50 lb.	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.627	0.653	0.68	0.707	0.733	0.76	0.787	0.813	0.84	0.867	0.893	0.92	0.92
Market Swine 50-119 lb.	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.43	0.44	0.45	0.46	0.47	0.48	0.49	0.5	0.51	0.52	0.53	0.54	0.54
Market Swine 120-179 lb.	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.43	0.44	0.45	0.46	0.47	0.48	0.49	0.5	0.51	0.52	0.53	0.54	0.54
Market Swine >180 lb.	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.43	0.44	0.45	0.46	0.47	0.48	0.49	0.5	0.51	0.52	0.53	0.54	0.54
Breeding Swine	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.232	0.230	0.227	0.224	0.221	0.219	0.216	0.213	0.211	0.208	0.205	0.203	0.203
NOF Bulls	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
NOF Calves	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.313	0.325	0.338	0.35	0.363	0.375	0.388	0.4	0.413	0.425	0.438	0.45	0.45
Sheep	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.423	0.426	0.429	0.432	0.435	0.438	0.441	0.444	0.447	0.45	0.45
Goats	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Hens >1 yr.	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.703	0.711	0.719	0.727	0.735	0.743	0.750	0.758	0.766	0.774	0.782	0.79	0.79
Pullets	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.703	0.711	0.719	0.727	0.735	0.743	0.750	0.758	0.766	0.774	0.782	0.79	0.79
Chickens	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.853	0.875	0.898	0.92	0.943	0.965	0.988	1.01	1.033	1.055	1.078	1.1	1.1
Broilers	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.088	1.077	1.065	1.053	1.042	1.03	1.018	1.007	0.995	0.983	0.972	0.96	0.96
Turkeys	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.730	0.721	0.711	0.702	0.692	0.683	0.673	0.663	0.654	0.644	0.635	0.625	0.625
Horses	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.295	0.289	0.284	0.278	0.273	0.267	0.262	0.256	0.251	0.245	0.245

Source: U.S. EPA. 2011. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. U.S. Environmental Protection Agency. EPA 430-R-04-003. Annex 3 Section 3.9 Table A-185.

Table A.2.3.4 Estimated Volatile Solids and Nitrogen Excreted Production Rate by State for Cattle for 2009 (kg/animal/year)

	Volatile Solids							Nitrogen Excreted						
State	Dairy Cow	Dairy Heifers	Beef NOF Cow	Beef NOF Heifers	Beef NOF Steer	Beef OF Heifers	Beef OF Steer	Dairy Cow	Dairy Heifers	Beef NOF Cow	Beef NOF Heifers	Beef NOF Steer	Beef OF Heifers	Beef OF Steer
Alabama	2,267.41	1,251.47	1,680.43	1,103.73	979.63	673.81	656.14	135.78	68.85	70.16	48.18	40.04	53.69	55.01
Alaska	1,846.07	1,251.47	2,158.74	1,475.35	1,287.98	758.17	723.58	115.86	68.85	84.14	60.31	49.59	61.06	61.25
Arizona	2,819.52	1,251.47	2,158.74	1,440.02	1,287.98	674.59	656.77	157.68	68.85	84.14	58.35	49.59	53.76	55.07
Arkansas	2,046.05	1,251.47	1,675.36	1,093.22	976.43	731.19	702.01	124.61	68.85	72.93	49.63	41.72	58.70	59.26
California	2,723.70	1,251.47	1,638.85	1,042.04	953.48	688.37	667.78	152.93	68.85	71.23	46.75	40.63	54.96	56.09
Colorado	2,824.09	1,251.47	1,546.94	951.51	896.01	685.35	665.37	157.87	68.85	71.65	44.97	40.74	54.70	55.87
Connecticut	2,494.94	1,251.47	1,652.50	1,093.00	962.06	674.37	656.59	143.73	68.85	68.93	47.85	39.24	53.74	55.06
Delaware	2,369.10	1,251.47	1,652.50	1,062.76	962.06	740.93	709.80	138.33	68.85	68.93	45.95	39.24	59.55	59.98
Florida	2,502.90	1,251.47	1,680.43	1,117.18	979.63	723.70	696.02	145.89	68.85	70.16	49.02	40.04	58.05	58.70
Georgia	2,543.18	1,251.47	1,680.43	1,103.56	979.63	706.46	682.24	147.62	68.85	70.16	48.17	40.04	56.54	57.43
Hawaii	2,159.89	1,251.47	2,158.74	1,450.79	1,287.98	706.46	682.24	129.34	68.85	84.14	58.95	49.59	56.54	57.43
Idaho	2,749.48	1,251.47	2,158.74	1,392.62	1,287.98	679.06	660.34	154.67	68.85	84.14	55.73	49.59	54.15	55.40
Illinois	2,509.01	1,251.47	1,653.05	1,037.84	962.40	664.58	648.76	144.34	68.85	70.73	45.55	40.34	52.88	54.33
Indiana	2,603.48	1,251.47	1,653.05	1,050.80	962.40	661.25	646.10	148.40	68.85	70.73	46.38	40.34	52.59	54.09
Iowa	2,620.71	1,251.47	1,653.05	1,022.85	962.40	675.86	657.78	149.14	68.85	70.73	44.59	40.34	53.87	55.17
Kansas	2,674.30	1,251.47	1,546.94	945.66	896.01	684.40	664.60	151.44	68.85	71.65	44.57	40.74	54.61	55.80
Kentucky	2,213.71	1,251.47	1,680.43	1,092.37	979.63	731.19	702.01	133.47	68.85	70.16	47.47	40.04	58.70	59.26
Louisiana	1,990.33	1,251.47	1,675.36	1,112.51	976.43	714.03	688.29	122.21	68.85	72.93	50.88	41.72	57.20	57.99
Maine	2,448.34	1,251.47	1,652.50	1,080.42	962.06	692.36	670.97	141.73	68.85	68.93	47.06	39.24	55.31	56.39
Maryland	2,462.83	1,251.47	1,652.50	1,066.48	962.06	641.27	630.13	142.36	68.85	68.93	46.18	39.24	50.85	52.61
Massachusetts	2,411.79	1,251.47	1,652.50	1,080.42	962.06	706.46	682.24	140.16	68.85	68.93	47.06	39.24	56.54	57.43
Michigan	2,775.94	1,251.47	1,653.05	1,045.14	962.40	674.88	656.99	155.80	68.85	70.73	46.02	40.34	53.78	55.09
Minnesota	2,535.74	1,251.47	1,653.05	1,047.02	962.40	690.51	669.49	145.49	68.85	70.73	46.14	40.34	55.15	56.25
Mississippi	2,191.18	1,251.47	1,680.43	1,103.12	979.63	680.89	661.80	132.50	68.85	70.16	48.14	40.04	54.31	55.54
Missouri	2,193.82	1,251.47	1,653.05	1,067.85	962.40	681.24	662.08	130.80	68.85	70.73	47.47	40.34	54.34	55.56
Montana	2,588.27	1,251.47	1,546.94	1,003.22	896.01	657.92	643.44	147.74	68.85	71.65	48.53	40.74	52.30	53.84
Nebraska	2,572.43	1,251.47	1,546.94	950.97	896.01	680.84	661.76	147.06	68.85	71.65	44.93	40.74	54.30	55.53
Nevada	2,729.35	1,251.47	2,158.74	1,428.01	1,287.98	691.23	670.06	153.80	68.85	84.14	57.69	49.59	55.21	56.30
New Hampshire	2,558.38	1,251.47	1,652.50	1,073.63	962.06	706.46	682.24	146.46	68.85	68.93	46.63	39.24	56.54	57.43
New Jersey	2,435.51	1,251.47	1,652.50	1,068.91	962.06	745.24	713.24	141.18	68.85	68.93	46.34	39.24	59.93	60.30
New Mexico	2,916.03	1,251.47	2,158.74	1,417.32	1,287.98	667.61	651.18	161.82	68.85	84.14	57.10	49.59	53.15	54.56
New York	2,598.56	1,251.47	1,652.50	1,050.97	962.06	675.38	657.39	148.18	68.85	68.93	45.21	39.24	53.83	55.13
North Carolina	2,621.22	1,251.47	1,680.43	1,103.07	979.63	731.19	702.01	150.97	68.85	70.16	48.14	40.04	58.70	59.26
North Dakota	2,349.60	1,251.47	1,546.94	985.19	896.01	671.24	654.09	137.49	68.85	71.65	47.29	40.74	53.46	54.83
Ohio	2,499.38	1,251.47	1,653.05	1,061.17	962.40	668.17	651.63	143.92	68.85	70.73	47.04	40.34	53.20	54.60
Oklahoma	2,372.40	1,251.47	1,675.36	1,066.91	976.43	672.96	655.46	138.62	68.85	72.93	47.94	41.72	53.61	54.95
Oregon	2,572.28	1,251.47	2,158.74	1,414.00	1,287.98	671.24	654.09	147.06	68.85	84.14	56.91	49.59	53.46	54.83
Pennsylvania	2,545.40	1,251.47	1,652.50	1,050.97	962.06	671.24	654.09	145.90	68.85	68.93	45.21	39.24	53.46	54.83
Rhode Island	2,430.23	1,251.47	1,652.50	1,095.96	962.06	675.44	657.44	140.95	68.85	68.93	48.03	39.24	53.83	55.14
South Carolina	2,555.49	1,251.47	1,680.43	1,107.64	979.63	688.56	667.94	148.15	68.85	70.16	48.42	40.04	54.98	56.11
South Dakota	2,602.79	1,251.47	1,546.94	970.02	896.01	674.32	656.55	148.37	68.85	71.65	46.25	40.74	53.73	55.05
Tennessee	2,366.26	1,251.47	1,680.43	1,100.05	979.63	671.24	654.09	140.02	68.85	70.16	47.95	40.04	53.46	54.83
Texas	2,664.94	1,251.47	1,675.36	1,058.67	976.43	678.95	660.25	151.19	68.85	72.93	47.41	41.72	54.14	55.40
Utah	2,667.08	1,251.47	2,158.74	1,424.78	1,287.98	719.20	692.43	151.13	68.85	84.14	57.51	49.59	57.66	58.37
Vermont	2,465.40	1,251.47	1,652.50	1,055.51	962.06	727.14	698.78	142.47	68.85	68.93	45.49	39.24	58.35	58.96
Virginia	2,504.58	1,251.47	1,680.43	1,097.87	979.63	675.38	657.39	145.96	68.85	70.16	47.81	40.04	53.83	55.13
Washington	2,830.17	1,251.47	2,158.74	1,401.02	1,287.98	674.99	657.08	158.13	68.85	84.14	56.19	49.59	53.79	55.10
West Virginia	2,199.28	1,251.47	1,652.50	1,071.08	962.06	617.96	611.49	131.04	68.85	68.93	46.47	39.24	48.81	50.89
Wisconsin	2,599.14	1,251.47	1,653.05	1,067.78	962.40	676.24	658.08	148.21	68.85	70.73	47.46	40.34	53.90	55.19
Wyoming	2,504.44	1,251.47	1,546.94	989.11	896.01	671.24	654.09	144.14	68.85	71.65	47.56	40.74	53.46	54.83

Source: U.S. EPA. 2011. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. U.S. Environmental Protection Agency. EPA 430-R-04-003. Annex 3 Section 3.9 Table A-186.

Table A.2.3.5 Manure Distribution Among Waste Management System by Operation (Percent)

Table A-187: 2009 Manure Distribution Among Waste Management Systems by Operation (Percent)

	Beef Feedlots		Dairies[1]						Dairy Heifer Facilities				Swine Operations[1]					Layer Operations		Broiler and Turkey Operations	
State	Dry Lot[2]	Liquid/ Slurry[2]	Pasture	Daily Spread	Solid Storage	Liquid/ Slurry	Anaerobic Lagoon	Deep Pit	Daily Spread[2]	Dry Lot[2]	Liquid/ Slurry[2]	Pasture[2]	Pasture	Solid Storage	Liquid/ Slurry	Anaerobic Lagoon	Deep Pit	Anaerobic Lagoon	Poultry without Litter	Pasture	Poultry with Litter
Alabama	100	1.3	45	17	11	10	17	0	17	38	0	45	5	4	8	51	32	41.9	58.1	1	99
Alaska	100	1.3	4	6	28	24	30	8	6	90	1	4	53	2	13	10	22	25	75	1	99
Arizona	100	0.4	0	10	9	20	61	0	10	90	0	0	14	3	5	50	27	60	40	1	99
Arkansas	100	1.3	57	15	11	7	10	1	15	28	0	57	4	4	12	46	35	0	100	1	99
California	100	1.3	1	11	9	21	58	0	11	88	1	1	13	3	8	47	29	12	88	1	99
Colorado	100	0.4	1	1	12	24	62	1	1	98	0	1	2	5	26	17	50	60	40	1	99
Connecticut	100	1	6	43	17	20	12	2	43	51	0	6	57	2	12	9	20	5	95	1	99
Delaware	100	1	6	44	19	19	10	2	44	50	0	6	12	4	24	18	42	5	95	1	99
Florida	100	1.3	17	22	8	15	39	0	22	61	1	17	71	1	8	6	14	41.9	58.1	1	99
Georgia	100	1.3	40	18	10	11	21	0	18	42	0	40	8	4	10	47	32	41.9	58.1	1	99
Hawaii	100	1.3	1	0	11	21	67	0	0	99	1	1	23	3	18	21	34	25	75	1	99
Idaho	100	0.4	0	1	12	23	63	1	1	99	0	0	46	3	15	10	26	60	40	1	99
Illinois	100	0.6	5	8	43	26	13	5	8	87	0	5	2	5	28	15	50	2	98	1	99
Indiana	100	0.6	8	13	35	24	16	3	13	79	0	8	3	5	28	15	50	0	100	1	99
Iowa	100	0.6	6	10	41	25	14	4	10	83	0	6	1	4	12	48	35	0	100	1	99
Kansas	100	0.6	3	5	28	33	29	3	5	92	0	3	2	5	28	13	51	2	98	1	99
Kentucky	100	1	61	14	14	6	2	2	14	24	0	61	5	4	12	45	34	5	95	1	99
Louisiana	100	1.3	60	14	10	6	9	1	14	26	0	60	54	2	13	10	22	60	40	1	99
Maine	100	1	7	45	20	17	9	2	45	48	0	7	73	1	7	6	13	5	95	1	99
Maryland	100	1	7	44	23	15	8	3	44	49	0	7	21	4	21	16	38	5	95	1	99
Massachusetts	100	1	7	45	24	15	6	3	45	47	0	7	31	3	19	14	32	5	95	1	99
Michigan	100	0.6	3	6	32	33	22	4	6	91	0	3	5	5	25	17	48	2	98	1	99
Minnesota	100	0.6	6	10	44	24	12	5	10	84	0	6	2	5	26	18	49	0	100	1	99
Mississippi	100	1.3	57	15	10	7	10	0	15	28	0	57	2	4	6	57	31	60	40	1	99
Missouri	100	0.6	8	14	48	18	6	5	14	77	0	8	3	5	28	14	51	0	100	1	99
Montana	100	0.4	3	4	25	26	36	6	4	93	0	3	6	5	25	17	47	60	40	1	99
Nebraska	100	0.6	4	6	35	30	21	4	6	90	0	4	3	5	28	15	50	2	98	1	99
Nevada	100	0.4	0	0	11	24	64	0	0	99	0	0	35	2	4	39	20	0	100	1	99
New Hampshire	100	1	7	44	21	16	9	3	44	49	0	7	57	2	12	9	20	5	95	1	99
New Jersey	100	1	8	45	24	14	6	3	45	47	0	8	31	3	19	14	33	5	95	1	99
New Mexico	100	0.4	0	10	9	19	61	0	10	90	0	0	92	0	2	2	4	60	40	1	99
New York	100	1	7	45	20	16	10	2	45	48	0	7	20	4	21	15	40	5	95	1	99
North Carolina	100	1	54	15	12	11	6	1	15	31	0	54	0	4	6	58	31	41.9	58.1	1	99
North Dakota	100	0.6	6	11	45	22	12	4	11	83	0	6	9	5	24	17	45	2	98	1	99
Ohio	100	0.6	8	14	41	23	11	4	14	78	0	8	7	4	27	15	47	0	100	1	99
Oklahoma	100	0.4	0	6	25	23	40	6	6	94	0	0	1	4	6	58	31	60	40	1	99
Oregon	100	1.3	20	0	13	21	44	2	0	80	1	20	58	2	12	9	20	25	75	1	99
Pennsylvania	100	1	9	47	25	12	5	2	47	44	0	9	5	5	25	18	47	0	100	1	99

	Beef Feedlots		Dairies[1]						Dairy Heifer Facilities				Swine Operations[1]					Layer Operations		Broiler and Turkey Operations	
State	Dry Lot[2]	Liquid/ Slurry[2]	Pasture	Daily Spread	Solid Storage	Liquid/ Slurry	Anaerobic Lagoon	Deep Pit	Daily Spread[2]	Dry Lot[2]	Liquid/ Slurry[2]	Pasture[2]	Pasture	Solid Storage	Liquid/ Slurry	Anaerobic Lagoon	Deep Pit	Anaerobic Lagoon	Poultry without Litter	Pasture	Poultry with Litter
Rhode Island	100	1	9	47	26	12	4	3	47	44	0	9	56	2	12	9	21	5	95	1	99
South Carolina	100	1.3	54	15	8	9	13	0	15	31	0	54	6	4	9	50	32	60	40	1	99
South Dakota	100	0.6	5	8	38	28	18	4	8	87	0	5	3	5	26	18	48	2	98	1	99
Tennessee	100	1	59	15	12	9	4	2	15	26	0	59	10	4	12	41	33	5	95	1	99
Texas	100	0.4	0	8	13	24	53	2	8	92	0	0	7	3	6	54	29	12	88	1	99
Utah	100	0.4	1	1	17	26	51	3	1	98	0	1	1	6	26	17	51	60	40	1	99
Vermont	100	1	7	44	19	17	10	2	44	49	0	7	86	1	4	3	7	5	95	1	99
Virginia	100	1	57	15	12	9	4	2	15	28	0	57	3	4	7	55	31	5	95	1	99
Washington	100	1.3	17	0	11	22	49	1	0	83	1	17	37	3	17	12	31	12	88	1	99
West Virginia	100	1	7	45	23	16	7	3	45	48	0	7	58	2	11	8	21	5	95	1	99
Wisconsin	100	0.6	7	12	42	24	12	4	12	82	0	7	13	4	24	17	42	2	98	1	99
Wyoming	100	0.4	7	12	22	23	30	6	12	81	0	7	3	5	26	17	49	60	40	1	99

[1] In the methane inventory for manure management, the percent of dairy cows and swine with anaerobic digestion systems is estimated using data from EPA's AgSTAR Program.
[2] Because manure from beef feedlots and dairy heifers may be managed for long periods of time in multiple systems (i.e., both drylot and runoff collection pond), the percent of manure that generates emissions is greater than 100 percent.

Source: U.S. EPA. 2011. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. U.S. Environmental Protection Agency. EPA 430-R-04-003. Annex 3 Section 3.9 Table A-187.

Table A.2.4Indirect Nitrous Oxide Loss Factors (percent)

Animal Type	Waste Management System	Volatilization Nitrogen Loss	Runoff/Leaching Nitrogen Loss* Central	Pacific	Mid Atlantic	Midwest	South
Beef Cattle	Dry Lot	23	1.1	3.9	3.6	1.9	4.3
Beef Cattle	Liquid/Slurry	26	0	0	0	0	0
Beef Cattle	Pasture	0	0	0	0	0	0
Dairy Cattle	Anaerobic Lagoon	43	0.2	0.8	0.7	0.4	0.9
Dairy Cattle	Daily Spread	10	0	0	0	0	0
Dairy Cattle	Deep Pit	24	0	0	0	0	0
Dairy Cattle	Dry Lot	15	0.6	2	1.8	0.9	2.2
Dairy Cattle	Liquid/Slurry	26	0.2	0.8	0.7	0.4	0.9
Dairy Cattle	Pasture	0	0	0	0	0	0
Dairy Cattle	Solid Storage	27	0.2	0	0	0	0
Goats	Dry	23	1.1	3.9	3.6	1.9	4.3
Goats	Pasture	0	0	0	0	0	0
Horses	Dry Lot	23	0	0	0	0	0
Horses	Pasture	0	0	0	0	0	0
Poultry	Anaerobic Lagoon	54	0.2	0.8	0.7	0.4	0.9
Poultry	Liquid/Slurry	26	0.2	0.8	0.7	0.4	0.9
Poultry	Pasture	0	0	0	0	0	0
Poultry	With bedding	26	0	0	0	0	0
Poultry	Without bedding	34	0	0	0	0	0
Poultry	Solid Storage	8	0	0	0	0	0
Sheep	Dry Lot	23	1.1	3.9	3.6	1.9	4.3
Sheep	Pasture	N/A	N/A	N/A	N/A	N/A	N/A
Swine	Anaerobic Lagoon	58	0.2	0.8	0.7	0.4	0.9
Swine	Deep Pit	34	0	0	0	0	0
Swine	Liquid/Slurry	26	0.2	0.8	0.7	0.4	0.9
Swine	Pasture	N/A	N/A	N/A	N/A	N/A	N/A
Swine	Solid Storage	45	0	0	0	0	0

* Data were not available for leaching so the value reflects runoff only

Source: U.S. EPA. 2011. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. U.S. Environmental Protection Agency. EPA 430-R-04-003. Annex 3 Section 3.9