



Australian Government

Department of Climate Change, Energy,
the Environment and Water

DRAFT Greenhouse Gas Emissions Estimation and Reporting Guidelines for Agriculture, Fisheries and Forestry

Methodological Guidance

Chapter 4: Manure Management



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Cataloguing data

This publication (and any material sourced from it) should be attributed as: DCCEEW 2025, DRAFT Greenhouse Gas Emissions Estimation and Reporting Guidelines for Agriculture, Fisheries and Forestry - Methodological Guidance, Department of Climate Change, Energy, the Environment and Water, Canberra, February. CC BY 4.0.

This publication is available at dcceew.gov.au.

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Acknowledgements

We thank Environmental Accounting Services for drafting this document, and the Voluntary Greenhouse Gas Estimation and Reporting Standards Reference Group for their valued contributions.

Acknowledgement of Country

We acknowledge the Traditional Owners of Country throughout Australia and recognise their continuing connection to land, waters and culture. We pay our respects to their Elders past and present.

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4 Scope 1 – Manure Management

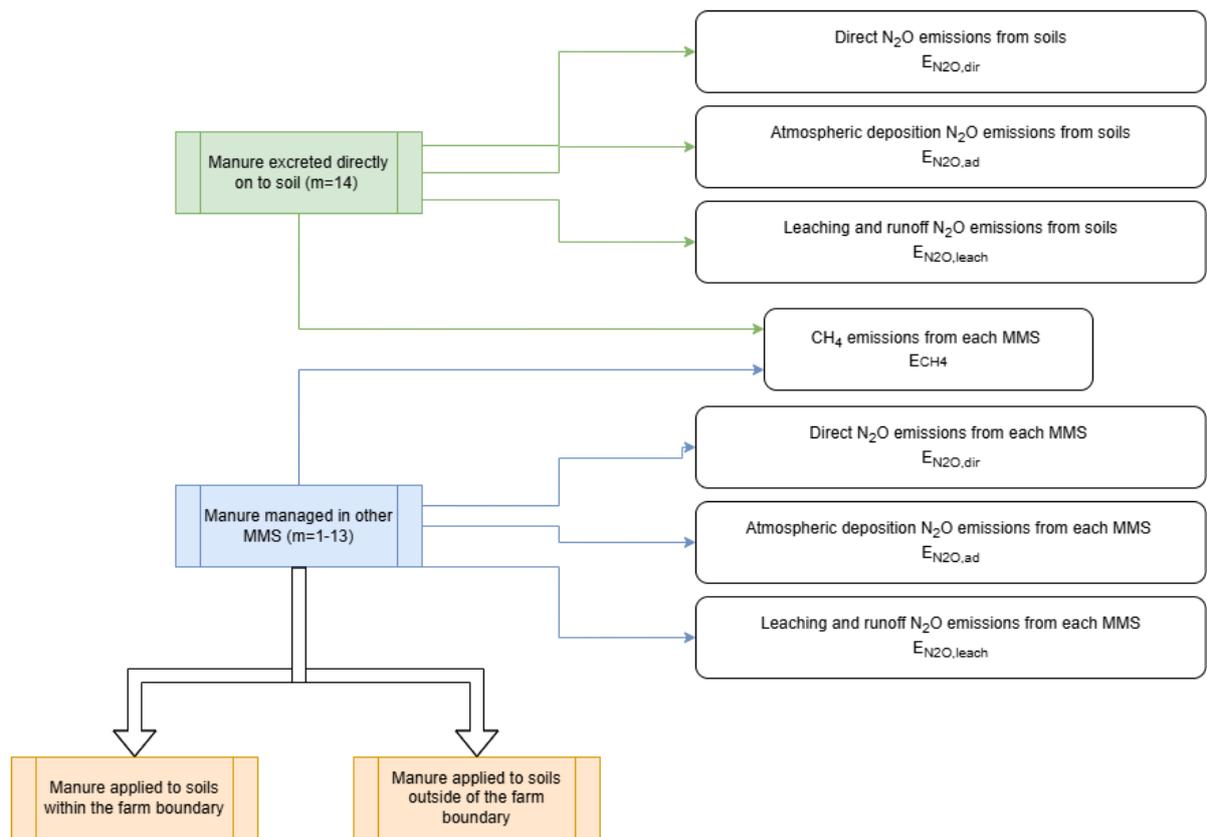
1 Where appropriate, for each sector this chapter covers the following manure management
2 systems:

3 **Manure Management Systems (MMS)**

Subscript (m)	MMS
1	Anaerobic lagoon
2	Liquid systems
3	Daily spread
3a	Sump and dispersal
3b	Drains to paddock
4	Solid Storage
5	Drylot
6	Composting (passive windrow)
7	Digestor/Covered Lagoon
8	Deep Litter
9	Pit storage (<1 month)
10	Poultry manure with bedding
11	Poultry manure without bedding
12	Direct Processing
13	Direct Application
14	Pasture range and paddock

4

5 Figure 4.1 demonstrates the relevant emissions calculations outlined in this chapter to each
6 of these MMS. There two main components to methane emission estimates – manure
7 excreted directly onto pasture, and managed manure through systems for housed animals.
8 Managed manure also results in direct and indirect nitrous oxide emissions. For manure
9 excreted to pasture there are no nitrous oxide emissions from manure management,
10 however emissions from the soil occur from the metabolism of the deposited urine and
11 faeces, and indirectly through atmospheric deposition and leaching and runoff. Note that
12 emissions associated with manure from management systems that is subsequently applied
13 to soils are covered in the organic fertiliser section in Chapter 5 Section 5.1 Fertiliser
14 module.



15

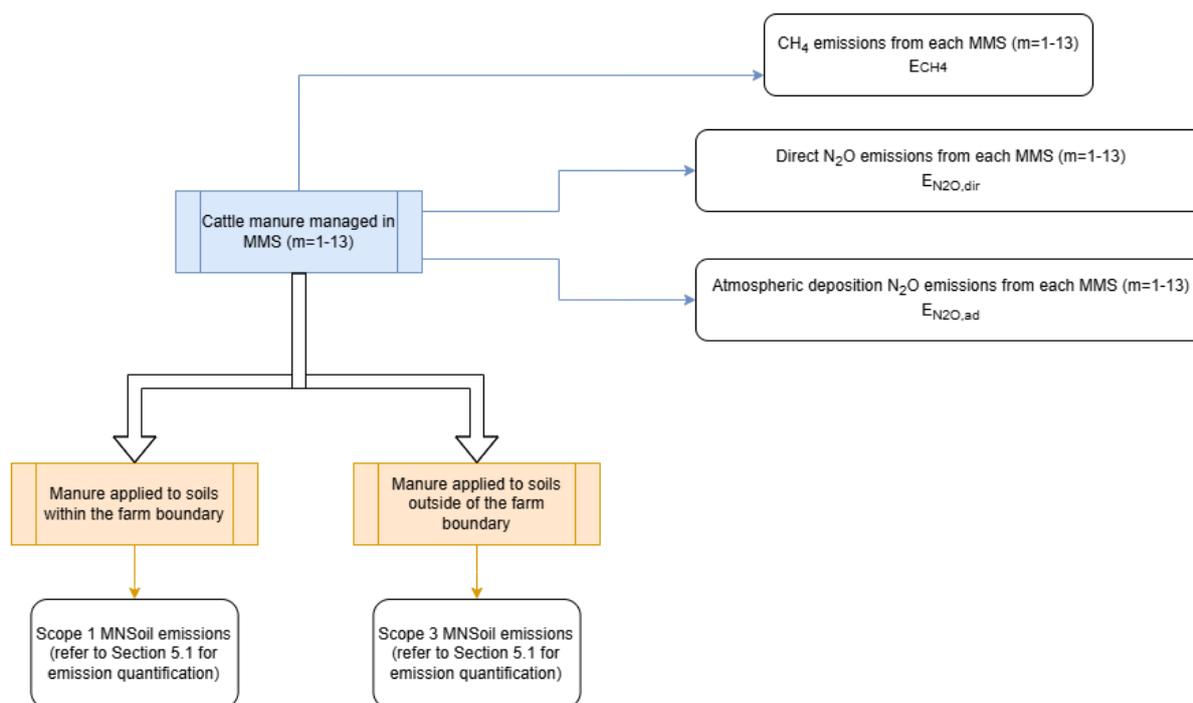
16 Figure 4.1: Example possible emissions sources from manure for livestock enterprises

17

18

19 4.1 Beef - Feedlot

20 This module covers the estimation of methane and nitrous oxide that results from beef
 21 feedlot cattle manure management. Figure 4.2 summarises the emission sources associated
 22 with the manure from beef feedlot cattle. As cattle are housed the pasture, range and
 23 paddock MMS is not applicable in this chapter. However, emissions associated with manure
 24 from management systems that is subsequently applied to soils are covered in the organic
 25 fertiliser section in Chapter 5 Section 5.1 Fertiliser module.



26
 27 Figure 4.2: Summary of emissions sources associated with manure management in beef
 28 feedlot systems

29 The following subscripts are used in this module:

Subscript	Meaning
<i>i</i>	Climate zone
<i>j</i>	Cattle group
<i>m</i>	Manure Management System (MMS)
<i>T</i>	Treatment Stage

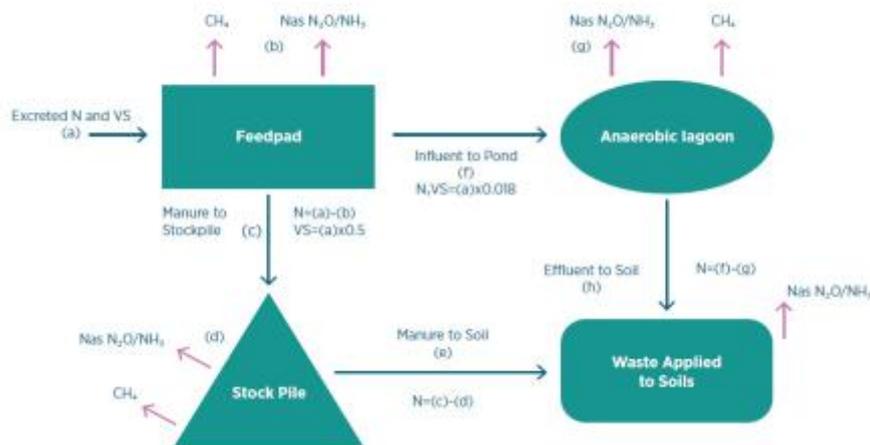
30
 31 Emissions are estimated based on groups of cattle with similar intake requirements and
 32 lengths of stay on the feed pad and the different stages and systems of manure treatment.
 33 The climate zone will affect the selection of appropriate emission factors. The emissions are
 34 summed across each group and manure management system within the feedlot operation
 35 during the reporting period.

36 The number of groups per farm within the reporting period will depend on the size of the
 37 feedlot operation and the diversity of the intake and length of stay of the groups of cattle on
 38 the feed pad. Groups can be labelled as numbers e.g. Group 1, Group 2, Group 3 or given
 39 relevant names based on age or breed of group e.g. R2 Wagyu, R3 Angus, R3 Mixed for
 40 data entry purposes.

41 Manure from feedlot cattle may pass through multiple treatment stages. Therefore, volatile
 42 solid and nitrogen inputs and losses are estimated at each treatment stage (see Figure 4.3).
 43 It is assumed that the primary treatment stage (T=1) of all manure is the feedpad
 44 (considered to a drylot system). Manure may then be transferred to a secondary treatment
 45 stage (T=2), such as a stock pile, after which all waste is assumed to be applied to soils
 46 (either on-site or sold as an organic fertiliser). A fixed amount (2%) of manure is assumed to
 47 runoff from the feedpad into an anerobic lagoon, the tertiary treatment stage (T=3), before
 48 also being applied to soils.

49 The manure management system (m) for secondary treatment stage (T=2) will need to be
 50 input so that the appropriate constants and emissions factors can be applied. Additionally,
 51 the climate zone (i) the feedlot is operating in is needed to inform the methane conversion
 52 factor applied.

Figure 5.6 Mass flow method of estimating manure management emissions - feedlot cattle example



53

54 Figure 4.3 Example of the possible different stages of manure management in beef feedlot
 55 systems from the Australian National Inventory Report [1].

56 **Question Reference 4.1.**

57 The Guidance currently assumes that the feed pad (T2), stockpiles, passive windrows and
 58 direct application to soils (T2) and uncovered anaerobic lagoons (T3) are the only manure
 59 management system (MMS) options aligned with the NIR options.

60 Are there other MMS in use in the feedlot industry, is so what systems and at what treatment
 61 stage do they occur?

62

63

64 **4.1.1 Estimation methodology**65 **4.1.1.1 METHOD 1 — MANURE METHANE BEEF FEEDLOT**

66 (1) Total annual methane emissions from manure management E_{CH_4} (t CH₄) is
67 calculated as:

$$68 \quad E_{CH_4} = \sum_j (D_j \times Mm_j \times N_j) \times 10^{-3}$$

69 Where D_j = length of stay of each cattle group (days)

70 Mm_j = methane production from manure in each group (kg CH₄/head/day)

71 N_j = numbers of beef cattle in each group (head)

72

73 (2) Methane production from the manure of each group of feedlot beef cattle Mm_{ij}
74 (kg CH₄/head/day) is calculated as:

$$75 \quad Mm_j = \sum_m \sum_T M_{jmT}$$

76 Where: M_{jmT} = methane production from manure per cattle group, MMS, and
77 treatment stage (kg CH₄/head/day)

78

79 **Treatment stage 1 (primary system)**

80 (3) Production of methane in treatment stage 1 MMS $M_{ijm=5 T=1}$ (kg CH₄/head/day) is
81 calculated as:

$$82 \quad M_{ijm=5 T=1} = VS_j \times B_O \times MMS_{m=5 T=1} \times MCF_{im=5} \times \rho$$

83 Where VS_j = volatile solid production from feedlot cattle in each group (kg/head/day)

84 B_O = emissions potential (m³ CH₄/kg VS)

85 $MMS_{m=5 T=1}$ = the fraction of manure in each primary system. Assumed to be
86 1 for the drylot MMS

87 $MCF_{im=5}$ = methane conversion factor for climate zone and system. Under
88 Method 1, the default state climate zone is applied

89 ρ = density of methane (kg/m³)

90

91 **Treatment stage 2 (secondary system)**

92 (4) Production of methane in each treatment stage 2 MMS $M_{ijmT=2}$ (kg CH₄/head/day) is
93 calculated as:

$$94 \quad M_{ijmT=2} = VS_j \times 0.5 \times B_O \times MMS_{mT=2} \times MCF_{im} \times \rho$$

95 Where 0.5 = fraction of volatile solids lost during storage in the primary system,
96 (based on McGahan, et al. (2004) [2] and Wiedemann et al. (2014) [3])

97 $MMS_{mT=2}$ = the fraction of manure in each secondary system

98 MCF_{im} = methane conversion factor for climate zone and MMS. Under
99 Method 1, the default state climate zone is applied

100 Note: if all manure is directly applied to soils after it is scraped from the feed pad then
101 methane emissions from the secondary stage is assumed to be zero i.e. if $MMS_{jm=13T=2} = 1$
102 then $M_{ijm=13T=2} = 0$.

103

104 Treatment stage 3 (tertiary system)

105 (5) Production of methane in treatment stage 3 MMS $M_{ijm=1T=3}$ (kg CH₄/head/day) is
106 calculated as:

$$107 \quad M_{ijm=1T=3} = VS_j \times B_0 \times MMS_{m=1T=3} \times MCF_{im=1} \times \rho$$

108 Where $MMS_{m=1T=3}$ = the fraction of manure to the tertiary system. Assumed to be
109 0.02 to an anaerobic lagoon MMS

110 $MCF_{im=1}$ = methane conversion factor for climate zone and anaerobic lagoon
111 system. Under Method 1, the default state climate zone is applied

112

113 (6) Volatile solid production VS_j (kg/head/day) based on the BeefBal model (McGahan et
114 al. (2004)) [2] is calculated as:

$$115 \quad VS_j = I_j \times (1 - DMD_j) \times (1 - A)$$

116 Where I_j = dry matter intake for each group (kg DM/head/day)

117 DMD_j = dry matter digestibility for each group (fraction)

118 A = ash content of manure (fraction)

119 4.1.1.2 METHOD 2 — MANURE METHANE BEEF FEEDLOT

120 Method 2 is the same as Method 1 except that under equations 4.1.1.1 (3) – (5) farm specific
121 climate zone is required for $MCF_{im=1}$.

122

123 4.1.1.3 METHOD 1 — MANURE DIRECT N₂O BEEF FEEDLOT

124 (1) The total annual direct nitrous oxide emissions from manure management systems
125 $E_{N_2O,dir}$ (t N₂O) is calculated as:

$$126 \quad E_{N_2O,dir} = \sum_j \sum_m \sum_T (MN_{jmT} \times EF_{jm} \times C_{g,N_2O}) \times 10^{-3}$$

127 Where: MN_{jmT} = nitrogen per cattle group, MMS and treatment stage (kg N₂O)
 128 EF_{jm} = nitrous oxide emission factor for MMS (kg N₂O-N/kg N)
 129 C_{g,N_2O} = 44/28 factor to convert elemental mass of nitrous oxide to molecular
 130 mass

131 Note: exclude $MN_{jm=13T=2}$ which moves directly to MN_{soil} calculation (equation 4.1.1.7(1))

132 **Treatment stage 1 (primary system)**

133 (2) Nitrogen in the treatment stage 1 MMS $MN_{jm=5 T=1}$ (kg N₂O) is calculated as:

134
$$MN_{jm=5 T=1} = AE_j \times MMS_{jm=5 T=1}$$

135 Where: AE_j = total nitrogen excreted by each cattle group (kg N)
 136 $MMS_{jm=5 T=1}$ = fraction of manure in primary system. Assumed to be 1 for the
 137 drylot MMS

138

139 (3) Annual nitrogen excretion AE_j (kg N) from each feedlot cattle group is calculated as:

140
$$AE_j = N_j \times NE_j \times L_j$$

141 Where N_j = number of cattle in each group (head)
 142 NE_j = nitrogen excretion (kg N/head/day)
 143 L_j = length of stay of cattle group (days)

144

145 (4) Nitrogen excretion NE_j (kg/head/day) is calculated by:

146
$$NE_j = NI_j \times (1 - NR_j)$$

147 Where NI_j = nitrogen intake (kg/head/day)
 148 NR_j = nitrogen retention expressed as a fraction of intake (per cent).
 149 Under Method 1, default I_j and NR_j values are applied.

150

151 (5) Nitrogen intake NI_j (kg/head/day) of feedlot cattle is calculated by:

152
$$NI_j = I_j \times CP_j \div 6.25$$

153 Where I_j = dry matter intake as calculated for enteric methane (kg DM/head/day)
 154 CP_j = crude protein content of feed (fraction)

155 6.25 = factor for converting crude protein into nitrogen

156 Under Method 1, CP_j values are applied.

157

158 Treatment stage 2 (secondary system)

159 (6) Nitrogen in each treatment stage 2 MMS $MN_{jmT=2}$ (kg N₂O) is calculated as:

$$160 \quad MN_{jmT=2} = NT_{jmT=2} \times MMS_{jmT=2}$$

161 Where $NT_{jmT=2}$ = nitrogen transferred to secondary treatment MMS (kg N)

162 $MMS_{jmT=2}$ = fraction of manure in each to secondary system.

163 Note: if direct application occurs at treatment stage 2 the nitrogen ($MN_{jm=13T=2}$) moves
164 directly to MN_{soil} calculation (equation 4.1.1.7(1)) and is not included in direct nitrous oxide
165 from manure management equation (Equation 4.1.1.3 (1)).

166 (7) Nitrogen transferred to treatment stage 2 MMS $NT_{jmT=2}$ (kg N) is calculated as:

$$167 \quad NT_{jmT=2} = \left(MN_{jm=5T=1} \times (1 - FracGASM_{m=5} - EF_{m=5}) \right) - MN_{jmT=3}$$

168 Where $MN_{jmT=1}$ = nitrogen in MMS treatment stage 1 (kg N)

169 $FracGASM_{m=5}$ = fraction of N volatilised from drylot MMS

170 $MN_{jmT=3}$ = nitrogen in MMS treatment stage 3 (kg N)

171

172 Treatment stage 3 (tertiary system)

173 (8) Nitrogen in treatment stage 3 MMS $MN_{jm=1T=3}$ (kg N) is calculated as:

$$174 \quad MN_{jm=1T=3} = AE_j \times MMS_{jm=1T=3}$$

175 Where AE_j = total nitrogen excreted by each cattle group (kg N)

176 $MMS_{m=1T=3}$ = fraction of manure to tertiary system. Assumed to be 0.02 to
177 anaerobic lagoon MMS

178

179 4.1.1.4 METHOD 2 — MANURE DIRECT N₂O BEEF FEEDLOT

180 Method 2 is the same as Method 1 except that under equation 4.1.1.3 (4) - (5) farm specific
181 data for NR_j , I_j , and CP_j is required.

182

183

184 4.1.1.5 METHOD 1 — MANURE DEPOSITION N₂O BEEF FEEDLOT

185

186 (1) Total annual atmospheric deposition emissions from manure management $E_{N_2O,ad}$ (t
187 N₂O) is calculated as:

$$188 E_{N_2O,ad} = (MMS_{ATMOS} \times EF_{ad} \times C_{g,N_2O}) \times 10^{-3}$$

189 Where MMS_{ATMOS} = mass of N volatilised from MMS (kg N)

190 EF_{ad} = emission factor for atmospheric deposition (kg N₂O-N/kg N)

191

192 (2) Volatilised nitrogen from MMS MMS_{ATMOS} (kg N) is calculated as:

$$193 MMS_{ATMOS} = \sum_j \sum_m \sum_T MN_{jmT} \times FracGASM_{mT}$$

194 Where MN_{jmT} = nitrogen in each treatment stage MMS (kg N) (excluding
195 $MN_{jm=13T=2}$)

196 $FracGASM_{mT}$ = fraction of N volatilised in each MMS ((kg NH₃-N + NO_x-N)/kg
197 N)

198 Note: in the case of direct application at treatment stage 2 the nitrogen ($MN_{jm=13T=2}$) moves
199 directly to $MNSoil$ calculation (equation 4.1.1.7 (1)) and is not included in the atmospheric
200 deposition from manure management calculation.

201

202 4.1.1.6 METHOD 2 — MANURE DEPOSITION N₂O BEEF GRAZING

203 There is no Method 2 quantification option for this emission source.

204

205 4.1.1.7 METHOD 1 — MANURE LEACHING AND RUNOFF N₂O BEEF FEEDLOT

206 Due to strict environmental controls leaching from feedlot MMS are assumed to be zero.

207 Run-off from MMS is included in the treatment stage 3 of the direct MMS estimates.

208

209 4.1.1.8 MANURE APPLIED TO SOILS

210 It is assumed that all manure managed through MMS (m=1-13) will eventually be applied to
211 soils. The mass of nitrogen applied to soils is calculated here and then this $MNSoil$ value is
212 transferred to Chapter 5 Section 5.1 to estimate emissions associated with the application of
213 organic fertilisers, including the associated atmospheric deposition, and leaching and run-off
214 emissions.

215 This manure may be applied to soils within the boundary of the feedlot or may be sent off-
216 site and applied to another farming system or enterprise. Where manure is applied to soils
217 within the boundary of the farming enterprise $MNSoil_{scope1}$, the emissions from shall be
218 estimated and reported as Scope 1 emissions. Where the manure is used on other farming

219 enterprises $MNSoil_{scope3}$, the emissions from shall be estimated and reported as Scope 3
 220 emissions under Scope 3 Category 5 – waste generated in operations (see Chapter 7
 221 Section 7.10).

222 (1) The mass of nitrogen applied to soils for scope 1 emissions $MNSoil_{scope1}$ (kg N) is
 223 calculated as:

$$224 \quad MNSoil_{scope1} = \sum_j \sum_m \sum_T MN_{jmT=2,3} \times (1 - EF_{mT=2,3} - FracGASM_{mT=2,3}) \times PF$$

225 Where $MN_{jmT=2,3}$ = mass of N in secondary and tertiary treatment MMS stages as
 226 calculated for manure management (kg N)

227 $EF_{mT=2,3}$ = nitrous oxide emission factor for each MMS (kg N₂O-N/kg N)

228 $FracGASM_{mT=2,3}$ = fraction of animal waste N volatilised in each MMS for
 229 each cattle group ((kg NH₃-N + NO_x-N)/kg N)

230 PF = fraction of manure applied to soil within the feedlot boundary

231

232 Note: where direct application occurs at treatment stage 2 ($MN_{jm=13T=2,3}$), $EF_{jm=13T=2}$ and
 233 $FracGASM_{jm=13T=2}$ are set to zero.

234 (2) The mass of nitrogen applied to soils for scope 3 emissions $MNSoil_{scope3}$ (kg N) is
 235 calculated as:

$$236 \quad MNSoil_{scope3} = \sum_j \sum_m \sum_T MN_{jmT=2,3} \times (1 - EF_{mT=2,3} - FracGASM_{mT=2,3}) \times (1 - PF)$$

237 This approach assumes that the manure used off-site within a different farm enterprise is
 238 considered a “waste product” from the farm, rather than a co-product.

239 If the manure is sold for use as an organic fertiliser elsewhere, under the GHG Protocol the
 240 manure would be considered a co-product and thus would require some of the total farm
 241 emissions allocated to it.

242 Furthermore, the emissions from the application of manure to soils would then fall into a use-
 243 of-sold-products emissions category, which is outside of the cradle-to-gate boundary.

244 The exact wording used in this section is therefore subject to review and non-specific until
 245 the Common Reporting Framework provides guidance on emission allocation between co-
 246 products; and whether manure sold off-site is considered a co-product or waste stream.

247

248

249 **4.1.2 Data/Parameters**250 **4.1.2.1 INPUT DATA (REQUIRED)**

Data / Parameter	D_j
Data unit	days
Description	Duration of stay for each cattle group
Data source	Farm stock records; system type records or purchase and sales can be evaluated to determine average length of stay
Quality assurance / quality control considerations	Ensure average length of stay aligns with duration of stay expected for feedlot cattle class in the National Inventory Report.

251

Data / Parameter	N_j
Data unit	head
Description	Number of beef cattle in each group
Data source	Farm stock records e.g. head counts, diary entries, purchase, and sales records
Quality assurance / quality control considerations	All animals purchased or sold in the reporting period are assumed to be reported. Number of cattle reported can be cross checked with stocking density allowances for system size. If value is significantly higher or lower than expected stocking density, flagged as possibly erroneous. Check the class of animals on farm align with reported products from farm.

252

Data / Parameter	I_j
Data unit	kgDM/head/day
Description	Average dry matter intake per head of each group of cattle within feedlot system per day. National default data based on length of stay is available if intake of a group is not known.
Data source	Farm records relating to dry matter assessment of total mixed ration (TMR), and daily feed and feed waste weights for each group
Quality assurance / quality control considerations	Intake can be compared to inventory defaults for the relevant cattle class. If significantly higher or lower than inventory defaults check farm records to ensure correct data entry.

253

254

255

256
257
258
259
260

Question Reference 4.2:

If a feedlot has more than one manure management system (MMS), should specific guidance be provided for calculating the percentage of manure allocated to each system?
Are there existing tools or methodologies available to support this calculation?

Data / Parameter	MMS _{mT=2}
Data unit	fraction
Description	Fraction of manure at treatment stage 2 for each manure management system i.e. what fraction of manure goes to what MMS once it has been removed from the feed pad. If there is only one available MMS then this should be equal to 1. This may be different for different cattle groups.
Data source	Farmer records as to what fraction of manure flows to each system based on the available MMS options (m). This fraction should be based on either weight or volume of manure. If treatment is different for different cattle groups this can also be recorded per cattle group.
Quality assurance / quality control considerations	Only those specific MMS options (m) addressed by the guidance should be included as options to assign fractions to. The fraction of manure to each manure management system should sum to one. If only one MMS used to treat manure, then fraction equal to 1. Note: if manure is directly applied to soils after it is scraped from the feedlot then methane and nitrous oxide emissions will be zero for this secondary treatment stage MMS. The nitrogen in the manure (MN _{jm=13T=2}) moves directly to MN _{soil_{jm}} calculation (equation 4.1.17(1)) (see also Chapter 5 Section 5.1). It is excluded from equation 4.1.1.3 (1) and 4.1.1.4 (2)

261

Data / Parameter	PF
Data unit	fraction
Description	Fraction of manure applied to soil within the feedlot boundary
Data source	Farmer records of manure sales or transport weights compared to total manure treated on farm.
Quality assurance / quality control considerations	If all of manure is not applied to soil within the feedlot boundary ensure it is appropriately tracked what proportion is sent off-site to other entities. If it is not known what proportion is sent off-site to other entities assume all manure is applied within in the feed lot boundary until better data can be collected.

262
263

264 4.1.2.2 DATA (METHOD 1 AND 2 OPTIONS)

265

Data / Parameter	DMD _i
Data unit	fraction
Description	Dry matter digestibility of diet used within feedlot system
Method 1 data source	Table A5.5.3.2, National Inventory Report, Volume 2 [4]
Method 1 value	See Appendix Table 12.1.2.3 in Chapter 12 Apply the dry matter digestibility that best represents the duration of stay of each cattle class.
Method 2 data source	Farm records or feed receipt stating dry matter digestibility of TMR
Quality assurance / quality control considerations	If Method 2 data is used compare this input to inventory defaults for the relevant cattle class. If significantly higher or lower than inventory defaults check farm records to ensure correct data entry.

266

267 **Question Reference 4.3:**

268 Is farm-specific data on the crude protein content (CP) of the ration readily available? If so
269 should farm-specific data for CP be required under Method 1?

270 Are there specific tools or industry guidance that could be referenced to support feedlot
271 producers to calculate CP?

272

Data / Parameter	CP _j
Data unit	fraction
Description	Average crude protein content of the feed given to each cattle group. National default data based on length of stay is available if crude protein content of TMR for a group is not known.
Source of data (T1)	Table A5.5.3.2, National Inventory Report, Volume 2 [4]
Default (T1) Value	See Appendix Table 12.1.2.3 in Chapter 12 Apply the crude protein per cent that best represents the duration of stay of each cattle class.
Source of optional data (T2)	Farm records or feed receipt stating crude protein of TMR
Quality assurance / quality control considerations	If T2 data is used compare this input to inventory defaults for the relevant cattle class. If significantly higher or lower than inventory defaults check farm records to ensure correct data entry.

273

274

275 4.1.2.3 CONSTANTS

276

Data / Parameter	B_0
Data unit	m ³ CH ₄ /kg VS
Description	Emissions potential.
Data source	IPCC (2019), Chapter 10 [5]
Value	0.19
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report.

277

Data / Parameter	$MMS_{m=5T=1}$
Data unit	fraction
Description	Fraction of volatile solids to each primary system, assumed all primary systems are drylot.
Data source	Table A5.5.3.4, National Inventory Report, Volume 2 [4]
Value	1
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report.

278

279

Data / Parameter	ρ
Data unit	kg/m ³
Description	Density of methane.
Data source	National Greenhouse and Energy Reporting (Measurement) Determination 2008 [6]
Value	0.6784
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

280

281

282 A Method 2 option for methane conversion factors (MCF) is currently under consideration.
 283 This approach would require selection of MCF base on site-specific climate zone. This will
 284 be further developed in Tranche 2 as it is also relevant for piggeries and poultry production.
 285 The climate zone specific methane conversion factors for feedlot cattle are also under review
 286 and may change in future revisions.

287

Data / Parameter	MCF_{imT}
Data unit	fraction
Description	Methane conversion factor based on State, and system at each treatment stage
Data source	Table A5.5.3.5, National Inventory Report, Volume 2 [4]
Value	See Appendix Table 12.1.2.5 in Chapter 12 Apply the methane conversion factor that best represents the MMS in each treatment stage.
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

288

Data / Parameter	$MMS_{m=1T=3}$
Data unit	fraction
Description	Fraction of volatile solids to each tertiary system assumed that 2 per cent is run-off from the feed pad.
Data source	Table A5.5.3.4, National Inventory Report, Volume 2 [4]
Value	0.02
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

289

Data / Parameter	A
Data unit	per cent
Description	Ash content of manure.
Data source	National Greenhouse Gas Inventory Report Vol 1. (2023) [1]
Value	0.16
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report.

290

291

292

Data / Parameter	C_{g,N_2O}
Data unit	fraction
Description	Factor to convert elemental mass of nitrous oxide to molecular mass.
Data source	IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Chapter 5: Agriculture [7]
Value	44/28
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report.

293

294 **Question Reference 4.4:**

295 Is farm-specific data on nitrogen retention (NR) readily available? If so should farm-specific
296 data for NR be required under Method 1?

297 Are there specific tools or industry guidance that could be referenced to support feedlot
298 producers to calculate NR?

299

Data / Parameter	NR_j
Data unit	per cent
Description	Nitrogen retention expressed as a per cent of intake based on length of stay of each cattle group on the feed pad.
Data source	Table A5.5.3.1, National Inventory Report, Volume 2 [4]
Value	See Appendix Table 12.1.2.2 in Chapter 12 Apply the nitrogen retention that best represents the duration of stay of each cattle class.
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

300

Data / Parameter	EF_{mT}
Data unit	kg N_2O -N/kg N
Description	Nitrous oxide emission factor for each MMS.
Data source	Table A5.5.3.6, National Inventory Report, Volume 2 [4]
Value	See Appendix Table 12.1.2.6 in Chapter 12 Apply the EF that best represents the MMS in each treatment stage.
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

301

302

Data / Parameter	FracGASM _{mT}
Data unit	(kg NH ₃ -N + NO _x -N)/kg N
Description	Fraction of N volatilized in each MMS.
Data source	Table A5.5.3.7, National Inventory Report, Volume 2 [4]
Value	See Appendix Table 12.1.2.7 in Chapter 12 Apply the FracGASM that best represents the MMS in each treatment stage.
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

303

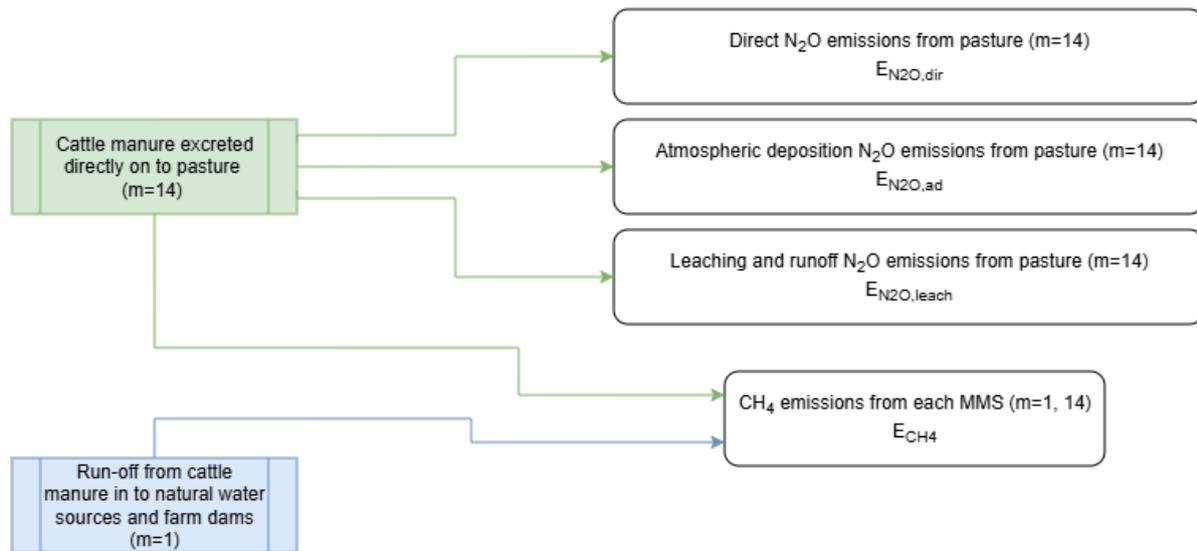
Data / Parameter	EF _{ad}
Data unit	kg N ₂ O-N/kg N
Description	Emission factor for atmospheric deposition
Data source	Table 5.21, National Inventory Report, Volume 1 [1]
Value	See Appendix Table 12.2.2.3 in Chapter 12 Apply the atmospheric deposition EF that best represent the production systems immediately surrounding the feedlot. For non-irrigated cropping systems, the emission factor varies depending on whether the agricultural system is in a high rainfall or low rainfall zone. Refer to Chapter 1 Section 1.8 for guidance on determining the relevant rainfall zone.
Quality assurance / quality control considerations	Ensure the most recently available emissions factors is used in alignment with the Australian NIR. If farm rainfall records are not available for the reporting year ensure rainfall records from the Australian Bureau of Meteorology are used to ensure rainfall is taken from a credible source.

304

305

306 4.2 Beef - Pasture, Rangeland and Paddock

307 This module covers the estimation of methane and nitrous oxide emission that results from
 308 grazing beef cattle manure management. Figure 4.4 summarises the emission sources
 309 associated with the manure of beef cattle on pasture, rangeland and paddock (PRP). There
 310 are two components to methane emission estimates –manure excreted directly onto PRP,
 311 and manure that runs-off into natural water sources and farm dams. There are no nitrous
 312 oxide emissions from manure management for manure excreted to PRP, however emissions
 313 from the soil occur from the metabolism of the deposited urine and faeces, and indirectly
 314 through atmospheric deposition and leaching and runoff.



315

316 Figure 4.4: Emissions that result from manure of beef cattle on pasture, rangeland and
 317 paddock

318 The following subscripts are used in this module:

Subscript	Meaning
<i>i</i>	Climate zone
<i>j</i>	Time-period (e.g season or month)
<i>k</i>	Beef cattle class
<i>l</i>	Beef cattle subclass
<i>m</i>	Manure management system

319

320 Emissions are estimated based on age and sex classes of cattle, time of the year and
 321 manure management system. The climate zone will affect the selection of appropriate
 322 emissions factors. The emissions are summed across each class (and subclass), manure
 323 management system and time-period spent on farm during the reporting period.

324 The classes of cattle on the farm ('Beef cattle input class') will depend on the diversity of the
 325 farming operation. These classes need to be mapped back to default categories ('Beef
 326 Cattle Classes (l) and Subclass (n)') to allow the use of default values under Method 1.

327 The time-period selected will depend on availability of stock numbers and liveweight and
 328 liveweight gain data (see Herd Flow modelling guidance in Section 1.3.7).

329

Beef Cattle Classes (l)	Beef Cattle Subclass (n) ^(a)	Beef Cattle input classes
1 = Bulls < 1 year	1 = Bulls < 1 year	Bulls < 1 year
2 = Bulls > 1 year	2 = Bulls > 1 year	Bulls > 1 year
3 = Cows < 1 year	3 = Cows < 1 year	Cows < 1 year
4 = Cows 1-2 years	4 = Cows 1-2 years	Cows 1-2 years
5 = Cows > 2 years	5a = Cows 2-3 years	Cows 2-3 years
	5b = Cows > 3 years	Cows > 3 years
6 = Steers < 1 year	6 = Steers < 1 year	Steers < 1 year
7 = Steers > 1 year	7a = Steers 1-2 years	Steers 1-2 years
	7b = Steers 2-3 years	Steers 2-3 years
	7c = Steers >3 years	Steers >3 years

330 (a) Only available for cattle in QLD and NT

331 The only relevant manure management systems (m) for grazing beef are PRP (m=14) and
 332 anaerobic lagoons (m=1). Where farmers have unfenced natural water sources and farm
 333 dams, anaerobic lagoons are used as a proxy to estimate the runoff of manure into these
 334 water sources .

335

336

337 **4.2.1 Estimation methodology**338 **4.2.1.1 METHOD 1 — MANURE METHANE BEEF GRAZING**

339

340 (1) Total annual methane production from manure management E_{CH_4} (t CH₄) for grazing
341 beef cattle is calculated as:

$$342 \quad E_{CH_4} = \sum_j \sum_k \sum_l \sum_m (N_{jkl} \times Mm_{jklm} \times D_j) \times 10^{-3}$$

343 Where N_{jkl} = number of beef cattle in each time-period, class and sub class (head)

344 Mm_{jklm} = methane production from manure in each time-period, class, sub
345 class and MMS (kg/head/day)

346 D_j = number of days in each time-period for each input class (days). This is
347 91.25 days under Method 1 as the default time-period is a season

348 (2) Methane production from the manure of grazing beef cattle Mm_{jkl} (kg/head/day) is
349 calculated as:

$$350 \quad Mm_{jklm} = VS_{jkl} \times B_o \times MMS_m \times MCF_{im} \times \rho$$

351 Where VS_{jkl} = volatile solid production (kg/day)

352 B_o = emissions potential (m³ CH₄/kg VS)

353 MMS_m = fraction of waste in each manure management system

354 MCF_{im} = Methane conversion factor for climate zone and MMS. Under
355 Method 1, the default state climate zone is applied

356 ρ = density of methane (kg/m³)

357

358 The primary manure management system (MMS) for pasture-fed beef is pasture range and
359 paddock (m=14). Where natural water sources and farm dams are present the anaerobic
360 lagoon (m=1) MMS is used to estimate the run-off of manure into these water sources.
361 Where farmers can demonstrate animals are on bore or reticulated water systems, where
362 water is provided in troughs (i.e., no unfenced natural water sources or farm dams), then the
363 only relevant MMS to be considered shall be pasture range and paddock (m=14).

364 The assumption regarding % run-off into farm dams is under review and may change. Until
365 new assumptions are confirmed the allocation to MMS for unfenced water sources is aligned
366 with the current NIR approach.

367 A new method for estimating VS production will be implemented in the next NIR and has
368 been reflected here.

369 (3) Volatile solid production from grazing beef VS_{jkl} (kg/head/day) is calculated by:

$$370 \quad VS_{jkl} = (I_{jkl} \times (1 - DMD_{jkl}) + (0.04 \times I_{jkl})) \times (1 - A)$$

371 Where I_{jkl} = dry matter intake as calculated in Chapter 3 Section 3.2 (kg/head/day)
Draft Greenhouse Gas Emissions Estimation and Reporting Guidelines for Agriculture, Fisheries and Forestry

372 DMD_{ijk} = dry matter digestibility expressed as a fraction. Default values
 373 applied under Method 1

374 A = ash content of feed intake expressed as fraction

375 **4.2.1.2 METHOD 2 — MANURE METHANE BEEF GRAZING**

376 Method 2 is the same as Method 1 except that under equations 4.2.1.1 (3) feed intake I_{jkl} is
 377 estimated as per section 3.2.1.2 and farm specific data is applied for DMD_{jk} for the selected
 378 time-period (i.e. seasonal, monthly or other) and for MCF_{im}

379 Under Method 2 the selected time-period and associated D_j used in equation 4.2.1.1 (1) may
 380 be a season ($D_j = 91.25$ days), month ($D_j = 28-31$ day depending on month) or a specific
 381 number of days in a month or season if the entry and exit from farm of a specific cohort of
 382 animals is being estimated

383 **4.2.1.3 METHOD 1 — SOIL DIRECT N₂O BEEF GRAZING**

384 (1) Total annual direct nitrous oxide emissions from agricultural soils from deposition of
 385 urine and dung $E_{N_2O,dir}$ (t N₂O) is calculated as:

386
$$E_{N_2O,dir} = \{(AF \times EF_{PRP} \times C_{g,N_2O}) + (AU \times EF_{PRP} \times C_{g,N_2O})\} \times 10^{-3}$$

387 Where AF = total mass of faecal nitrogen excreted on PRP for beef cattle (kg N)

388 AU = total mass of urinary nitrogen excreted on PRP for beef cattle (kg N)

389 EF_{PRP} = emission factor for nitrous oxide from urine and dung deposited to soil
 390 (kg N₂O-N/kg N deposited)

391 C_{g,N_2O} = factor to convert elemental mass of nitrous oxide to molecular mass

392

393 (2) Total faecal nitrogen excreted to pasture, range and paddock AF (kg N) is calculated
 394 as:

395
$$AF = \sum_j \sum_k \sum_l (N_{jkl} \times F_{jkl} \times D_j)$$

396 Where N_{jkl} = number of beef cattle by time-period, class and sub class (head)

397 F_{jkl} = nitrogen excreted in faeces in each time-period, class and subclass (kg
 398 N/head/day)

399 D_j = number of days in each time-period (days). This is 91.25 days under
 400 Method 1 as the default time-period is a season

401 (3) Nitrogen excreted in faeces F_{jkl} (kg N/head/day) is calculated based on the approach
 402 developed by the SCA (1990) [8] and Freer et al. (1997) [9] as:

403
$$F_{jkl} = \left[\left\{ 0.3 \times I_{jkl} \times CP_j \times \left(1 - (DMD_{ijk} + 0.1) \right) + (0.105 \times ME_{jkl} \times I_{jkl} \times 0.008) \right. \right.$$

 404
$$\left. \left. + (0.0152 \times I_{jkl}) \right\} \div 6.25 \right] + (0.08 \times 0.032 \times MC_{jk=1,3,6} \div 6.38)$$

405 Where I_{jkl} = dry matter intake (as calculated in Section 3.2) (kgDM/head/day)

406 CP_j = crude protein content of dry matter intake (fraction)

407 DMD_{jk} = dry matter digestibility (fraction)

408 ME_{jkl} = metabolizable energy (MJ/kgDM)

409 $MC_{jk=1,3,6}$ = milk intake (kg/head/day)

410 Under Method 1, default CP_j and DMD_j values are applied.

411

412 (4) Metabolizable energy ME_{jkl} (MJ/kgDM) is calculated by Minson and McDonald
413 (1987) [10] as:

$$414 \quad ME_{jkl} = 0.1604 \times (DMD_j \times 100) - 1.037$$

415 Where DMD_j = dry matter digestibility (fraction)

416

417 (5) Total urinary nitrogen excreted to pasture, range and paddock AU is calculated as:

$$418 \quad AU = \sum_j \sum_k \sum_l (N_{jkl} \times U_{jkl} \times D_j)$$

419 Where U_{jkl} = nitrogen excreted in urine in each time-period, class and sub class (kg
420 N/head/day)

421 D_j = number of days in each time-period (days). This is 91.25 days under
422 Method 1 as the default time-period is a season

423 (6) Nitrogen excreted in urine U_{jkl} (kg N/head/day) is calculated as:

$$424 \quad U_{jkl} = (I_{jkl} \times CP_j \div 6.25) + (0.032 \times MC_{jk=1,3,6} \div 6.38) - NR_{jkl} - F_{jkl}$$

$$425 \quad - [(1.1 \times 10^{-4} \times W_{jkl}^{0.75}) \div 6.25]$$

426 Where NR_{jkl} = the amount of nitrogen retained by the body (kg N/head/day)

427 W_{jkl} = liveweight (kg/head)

428 Under Method 1, default W_{jkl} values are applied.

429

430 (7) The amount of nitrogen retained by the body NR_{jkl} (kg N/head/day) is calculated as:

$$431 \quad NR_{jkl} = (0.032 \times MP_{jk=5} \div 6.38) + \left\{ \left\{ 0.212 - 0.008 \times (L_{jkl} - 2) - \right. \right.$$

$$432 \quad \left. \left. \left[\frac{0.140 - 0.008 \times (L_{jkl} - 2)}{1 + e^{(-6 \times (L_{jkl} - 0.4))}} \right] \right\} \times (LWG_{ijkln} \times 0.92) \right\} \div 6.25$$

433 Where $MP_{jk=5}$ = milk production (kg/head/day)

434 L_{jkl} = intake relative to that needed for maintenance

435 Z_{jkl} = relative size
 436 LWG_{jkl} = liveweight gain (kg/head/day). Under Method 1, default LWG_{jkl}
 437 values are applied.

438

439 (8) Milk production for the season of calving and season after calving $MP_{jk=5}$
 440 (kg/head/day) is calculated as:

$$441 \quad MP_{jk=5} = LC_{jk=5} \times DMP_{jk=5}$$

442 Where $LC_{jk=5}$ = proportion of cows > 2 years (k=5) lactating for the season of calving
 443 and season after calving noting that for all other seasons $LC_{jk=5} = 0$

444 $DMP_{jk=5}$ = daily milk production (kg/head/day)

445 For farms with multiple calving seasons, the proportion of cows > 2 years in calf ($LC_{jk=5}$)
 446 should be reported separately for each season.

447

448 (9) Intake relative to that needed for maintenance L_{ijkln} is calculated as:

$$449 \quad L_{ijkln} = \frac{I_{ijkln}}{(1.185 + 0.00454 \times W_{ijkln} - 0.0000026 \times W_{ijkln}^2)^2}$$

450

451 (10) The relative size of the cattle Z_{ijkln} , is calculated as:

$$452 \quad Z_{jkl} = \frac{W_{jkl}}{SRW_k}$$

453 Where SRW_k = standard reference weight (kg)

454 4.2.1.4 METHOD 2 — SOIL DIRECT N₂O BEEF GRAZING

455 Method 2 is the same as Method 1 except that under equations 4.2.1.3 (3), (6) and (9) feed
 456 intake I_{jkl} is estimated as per section 3.2.1.2 and farm specific data is applied for the
 457 selected time-period (i.e. seasonal, monthly or other) for CP_{jkl} (Eq 4.2.1.3 (3) and (6)),
 458 DMD_{ijk} (Eq 4.2.1.3 (3) and (4)), W_{jkl} (Eq 4.2.1.3 (6), (9) and (10)), LWG_{jkl} (Eq 4.2.1.3 (7)).

459 Under Method 2 the selected time-period and associated L_j used in equation 4.2.1.3 (2) may
 460 be a season ($L_j = 91.25$ days), month ($L_j = 28-31$ day depending on month) or a specific
 461 number of days in a month or season if the entry and exit from farm of a specific cohort of
 462 animals is being estimated

463 4.2.1.5 METHOD 1 — SOIL DEPOSITION N₂O BEEF GRAZING

464 (1) Atmospheric deposition emissions from urine and dung deposited on pasture $E_{N2O,ad}$
 465 (t N₂O) are calculated as:

$$466 \quad E_{N2O,ad} = M_{vol} \times EF_{ad} \times C_{g,N2O} \times 10^{-3}$$

467 Where M_{vol} = mass of nitrogen volatilised from urine and faeces deposited on
 468 pasture (kg N)

469 EF_{ad} = emission factor for atmospheric deposition (kg N₂O-N/kg N)

470

471 (2) The mass of nitrogen volatilised M_{vol} (kg N) is calculated as:

$$472 \quad M_{vol} = (AU + AF) \times FracGASMsoil$$

473 Where $FracGASMsoil$ = fraction of nitrogen volatilised from urine and faeces
 474 deposited on pasture ((kg NH₃-N + NO_x-N)/kg N)

475 4.2.1.6 METHOD 2 — SOIL DEPOSITION N₂O BEEF GRAZING

476 There is no Method 2 quantification option for this emission source.

477 4.2.1.7 METHOD 1 — SOIL LEACHING AND RUNOFF N₂O BEEF GRAZING

478 (1) Leaching and runoff emissions from urine and dung deposited on pasture $E_{N_2O,leach}$
 479 (t N₂O) are calculated as:

$$480 \quad E_{N_2O,leach} = M_{leach} \times EF_{leach} \times C_{g,N_2O} \times 10^{-3}$$

481 Where M_{leach} = mass of nitrogen lost to leaching and runoff (kg N)

482 EF_{leach} = emission factor for leaching and runoff (kg N₂O-N/kg N)

483

484 (2) The mass of nitrogen lost to leaching and runoff M_{leach} is calculated as:

$$485 \quad M_{leach} = (AU + AF) \times FracWet \times FracLEACH$$

486 Where $FracWet$ = fraction of N available for leaching and runoff in each climate
 487 zone.

488 $FracLEACH$ = fraction of all N that is lost through leaching and runoff

489

490 4.2.1.8 METHOD 2 — SOIL LEACHING AND RUNOFF N₂O BEEF GRAZING

491 There is no Method 2 quantification option for this emission source

492

493 **4.2.2 Data/Parameter tables**494 **4.2.2.1 INPUT DATA (REQUIRED)**

Data / Parameter	N_{jkl}
Data unit	head
Description	Number of pasture beef cattle per time-period, class and sub class
Data source	Farm stock records and herd flow model see Chapter 1 Section 1.9
Quality assurance / quality control considerations	All animals purchased, sold or born in the reporting period are assumed to be reported. Number of cattle reported can be cross checked with stocking density allowances for farm size. If value is significantly higher or lower than expected stocking density, flag as possibly erroneous.

495

Data / Parameter	$LC_{jk=5}$
Data unit	fraction
Data source	Proportion of cows > 2 years in calf in the season of calving. This is used as a proxy for cows >2 lactating
Value	Farm records: Proportion of cows > 2 can be based on scanning numbers where available. If scanning results are not available weaning numbers can also be used to approximate the proportion of cows > 2 years lactating. For farms with multiple calving seasons, the proportion of cows > 2 years in calf $LC_{jk=5}$ should be reported separately for each season or time period. Noting that the calving season should be considered 3 months from the calving month if Method 2 herd flow data is used (see Chapter 1 Section 1.9) and that for all other time periods $L_{jk=5} = 0$
Quality assurance / quality control considerations	Scanning records can be used to check input data. If scanning or weaning results are not recorded proportion of cows > 2 years can be cross checked from number of cows and calves in the reporting period.

496

497

498 4.2.2.2 DATA (METHOD 1 AND 2 OPTIONS)

Data / Parameter	D_j
Data unit	days
Description	Duration of stay for each cattle, class and sub class
Method 1 data source	National Inventory Report Volume 1 [1]
Method 1 value	91.25
Method 2 data source	Farm stock records; system type records or purchase and sales can be evaluated to determine average duration of each cattle input class (see Chapter 1 Section 1.9 for more details on herd flow modelling)
Quality assurance / quality control considerations	<p>Ensure that if animals are on the farm all year round the duration of stay is 365 days</p> <p>Ensure that if animals are only born part way through the reporting period their duration of stay reflect this.</p> <p>If Method 1 is used inputs must be completed seasonally throughout the calculations.</p>

499

Data / Parameter	DMD_j
Data unit	fraction
Description	Dry matter digestibility
Method 1 data source	Table A5.5.2.3, National Inventory Report, Volume 2 [4]
Method 1 value	<p>See Table 12.1.1.5 in Chapter 12 Appendix</p> <p>Select the appropriate default value for location of cattle and season</p>
Method 2 data source	Farm source records for seasonally dry matter digestibility of feed.
Quality assurance / quality control considerations	<p>If Method 2 data is used compare this input to inventory defaults for the relevant cattle class.</p> <p>If significantly higher or lower than inventory defaults check farm records to ensure correct data entry.</p> <p>If farm data is only available for one (or more) seasons, use data available for season(s) and supplement missing data with inventory data.</p>

500

501

502

Data / Parameter	CP_j
Data unit	fraction
Description	Crude protein content of feed dry matter
Method 1 data source	Table A5.5.2.4, National Inventory Report, Volume 2 [4]
Method 1 value	See Table 12.1.1.5 in Chapter 12 Appendix Select the appropriate default value for location of cattle and season
Method 2 data source	Farm source records for seasonally crude protein of feed.
Quality assurance / quality control considerations	If Method 2 data is used compare this input to inventory defaults for the relevant cattle class. If significantly higher or lower than inventory defaults check farm records to ensure correct data entry. If farm data is only available for one (or more) seasons, use data available for season(s) and supplement missing data with inventory data.

503

Data / Parameter	W_{jkl}
Data unit	kg
Description	Average liveweight of beef pasture cattle per time-period, class and subclass
Method 1 data source	Table A5.5.2.1 National Inventory Report Volume 2 [4]
Method 1 value	See Table 12.1.1.1 & 12.1.1.2 in Chapter 12 Appendix Select the appropriate default value for location of cattle, class/subclass and season
Method 2 data source	Farm stock records and herd flow model (see Chapter 1 Section 1.9)
Quality assurance / quality control considerations	Purchase and sale weight records (invoices) can be used for data assurance and control of entered values. Dated print out, screen shot, or photo of scale unit records can also be used for quality assurance of entered values. It is recommended Method 1 default values are sense checked against production data and system to ensure they are appropriate e.g. if autumn calving ensure default weights reflect this with lowest weigh value applied in autumn for stock <1 year and/or that default weights reflect when stock are expected to be at the lightest and heaviest.

504

Data / Parameter	LWG_{jkl}
Data unit	kg/head/day
Description	Average liveweight gain of beef pasture cattle per time-period, class and sub class
Method 1 data source	Table A5.5.2.2 National Inventory Report Volume 2 [4]
Method 1 value	See Table 12.1.1.3 & 12.1.1.4 in Chapter 12 Appendix

	Select the appropriate default value for location of cattle, class/subclass and season
Method 2 data source	Farm stock records and herd flow model (see Chapter 1 Section 1.9)
Quality assurance / quality control considerations	<p>Purchase and sale weight records (invoices) can be used for data assurance and control of entered values.</p> <p>Dated print out, screen shot, or photo of scale unit records can also be used for quality assurance of entered values.</p> <p>It is recommended Method 1 default values are sense checked against production data and system to ensure they are appropriate e.g. that default liveweight gain reflects when stock are expected to be growing more due to feed quality and availability.</p>

505

Data / Parameter	EF _{PRP}
Data unit	kg N ₂ O-N/kg N
Description	Emission factor for urine and dung deposited on pasture, range or paddock
Method 1 data source	IPCC 2019, Volume 4, Chapter 11, Table 11.1 [11]
Method 1 value	0.004
Method 2 data source	<p>A farm-specific approach to EF_{PRP} can be employed by using the IPCC values for EF_{PRP} specific to the climate zone (wet vs dry) in which the farm is located. See Table 12.2.2.4 in Chapter 12 Appendix for these values.</p> <p>Refer to Chapter 1 Section 1.8 for guidance on how to determine the climate zone the enterprise is located in. Wet and dry climates used in this classification are a subset of the temperate and tropical climate zones – this is not to be confused with rainfall zones.</p>
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

506

507

508 4.2.2.3 CONSTANTS

509

Data / Parameter	B_0
Data unit	$m^3 CH_4/kg VS$
Description	Emissions potential
Data source	IPCC (2019), Chapter 10 [5]
Value	0.19
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report.

510

Data / Parameter	MMS_m
Data unit	fraction
Description	Fraction of waste in each MMS
Data source	National Inventory Report, Volume 1 [1]
Value	If the farm has unfenced water sources inventory defaults of $MMS_{m=14} = 0.95$ and $MMS_{m=1} = 0.05$ If animals are on bore or reticulated water systems where water is provided in troughs (i.e. no unfenced natural water sources) then all waste should be allocated to pasture range and paddock and $MMS_{m=14} = 1$ and $MMS_{m=1} = 0$.
Quality assurance / quality control considerations	Ensure the most recently available published data is used in alignment with the Australian NIR. High resolution aerial imagery can be used to cross check that water sources are stock excluded.

511

Data / Parameter	MCF_{im}
Data unit	fraction
Description	Methane conversion factor
Data source	M14 = National Inventory Report, Volume 1 [1] M1 = IPCC 2019, Volume 4, Chapter 10, Table 10.17 [12]
Value	Methane conversion factor is dependent on climate zone. See Table 12.1.1.9 in Chapter 12 Appendix for these climate zone dependent values. Refer to Chapter 1 Section 1.8 on guidance for determining which climate zone the enterprise is located in.
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

512

513

514

Data / Parameter	ρ
Data unit	kg/m ³
Description	Density of methane
Data source	National Greenhouse and Energy Reporting (Measurement) Determination 2008 [6]
Value	0.6784
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

515

Data / Parameter	A
Data unit	fraction
Description	Ash content of feed intake
Data source	National Greenhouse Gas Inventory Report Vol 1. (2023)
Value	0.08
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

516

Data / Parameter	$MC_{jk=1,3,6}$
Data unit	kg/head/day
Description	Milk intake
Method 1 data source	Table A5.5.2.5, National Inventory Report, Volume 2 [4]
Method 1 value	See Table 12.1.1.7 in Chapter 12 Appendix Select the appropriate default value based on the cattle breed. Noting that the calving season should be considered 3 months from the calving month if Method 2 herd flow data is provided (see Chapter 1 Section 1.9) and the season after calving the 3 months after this period.
Quality assurance / quality control considerations	Ensure all other stock classes other than cattle <1 year old are defaulted to zero. Ensure alignment with the latest version of the Australian National Inventory Report

517

518

Data / Parameter	$DMP_{jk=5}$
Data unit	kg/head/day
Description	Daily milk production
Method 1 data source	Table A5.5.2.5
Method 1 value	See Table 12.1.1.7 in Chapter 12 Appendix Select the appropriate default value based on the cattle breed. Noting that the calving season should be considered 3 months from the calving month if Method 2 herd flow data is provided (see Chapter 1 Section 1.9) and the season after calving the 3 months after this period.
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report.

519

Data / Parameter	SRW_k
Data unit	kg
Description	Standard reference weight
Method 1 data source	Table A5.5.2.6, National Inventory Report, Volume 2 [4]
Method 1 value	See Table 12.1.1.8 in Chapter 12 Appendix. Select the appropriate default value based on cattle class.
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report.

520

521

522 **Question Reference 4.5.**

523 Current guidance provides the option to select the most appropriate emission factor for
524 atmospheric deposition based on grazing system.

525 Is this necessary? Should this just be assumed to be constant as non-irrigated pasture? Will
526 producers want the option of a weighted average approach?

Data / Parameter	EF_{ad}
Data unit	kg N ₂ O-N/kg N
Description	Emission factor for atmospheric deposition.
Data source	National Inventory Report Volume 1, Table 5.21 [1]
Value	See Table 12.2.2.3 in Chapter 12 Appendix This is the same emissions factor as used for direct nitrous oxide emissions from inorganic fertilisers. Apply the EF that best represent the production system In some farm systems animals may graze on crops. Apply the inorganic fertiliser EF that best representing how the cattle are grazed for the majority of the year or calculate a weighted average if the number of days on each grazing system is known. For non-irrigated cropping systems, the emission factor varies depending on whether the agricultural system is in a high rainfall or low rainfall zone. Refer to Chapter 1 Section 1.8 for guidance on determining the relevant rainfall zone.
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

527

Data / Parameter	FracGASMsoil
Data unit	(kg NH ₃ -N + NO _x -N)/kg N
Description	Fraction of nitrogen volatilised from urine and faeces deposited on pasture
Method 1 data source	IPCC 2019, Volume 4, Chapter 11, Table 11.3 [11]
Method 1 value	0.21
Quality assurance / quality control considerations	Ensure the most recently available published data is used in alignment with the Australian NIR.

528

529

530

Data / Parameter	FracWET
Data unit	Fraction
Description	Fraction of nitrogen that is available for leaching and runoff
Data source	National Inventory Report Volume 1 [1]
Value	To determine whether the entity is located in an area where leaching occurs refer to Chapter 1 Section 1.8 on how to determine whether the enterprise is located in a leaching zone. Where it is determined that leaching does occur, FracWET = 1 Where it is determined that leaching does not occur, FracWET = 0
Quality assurance / quality control considerations	Farm title data can be checked to ensure spatial farm boundaries used to define climate zone are correct. Other inputs such as electricity or fuel of irrigation purposes can be used to highlight if pastures are irrigated and therefore leaching will be occurring.

531

Data / Parameter	FracLEACH
Data unit	fraction
Description	Default fraction of N that is lost through leaching and runoff
Method 1 data source	National Greenhouse Gas Inventory Volume 1 [13, p. 1]
Method 1 value	0.24
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

532

Data / Parameter	EF_{leach}
Data unit	kg N ₂ O-N/kg N
Description	Emission factor for leaching and runoff
Method 1 data source	National Greenhouse Gas Inventory Volume 1 [13, p. 1]
Method 1 value	0.011
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

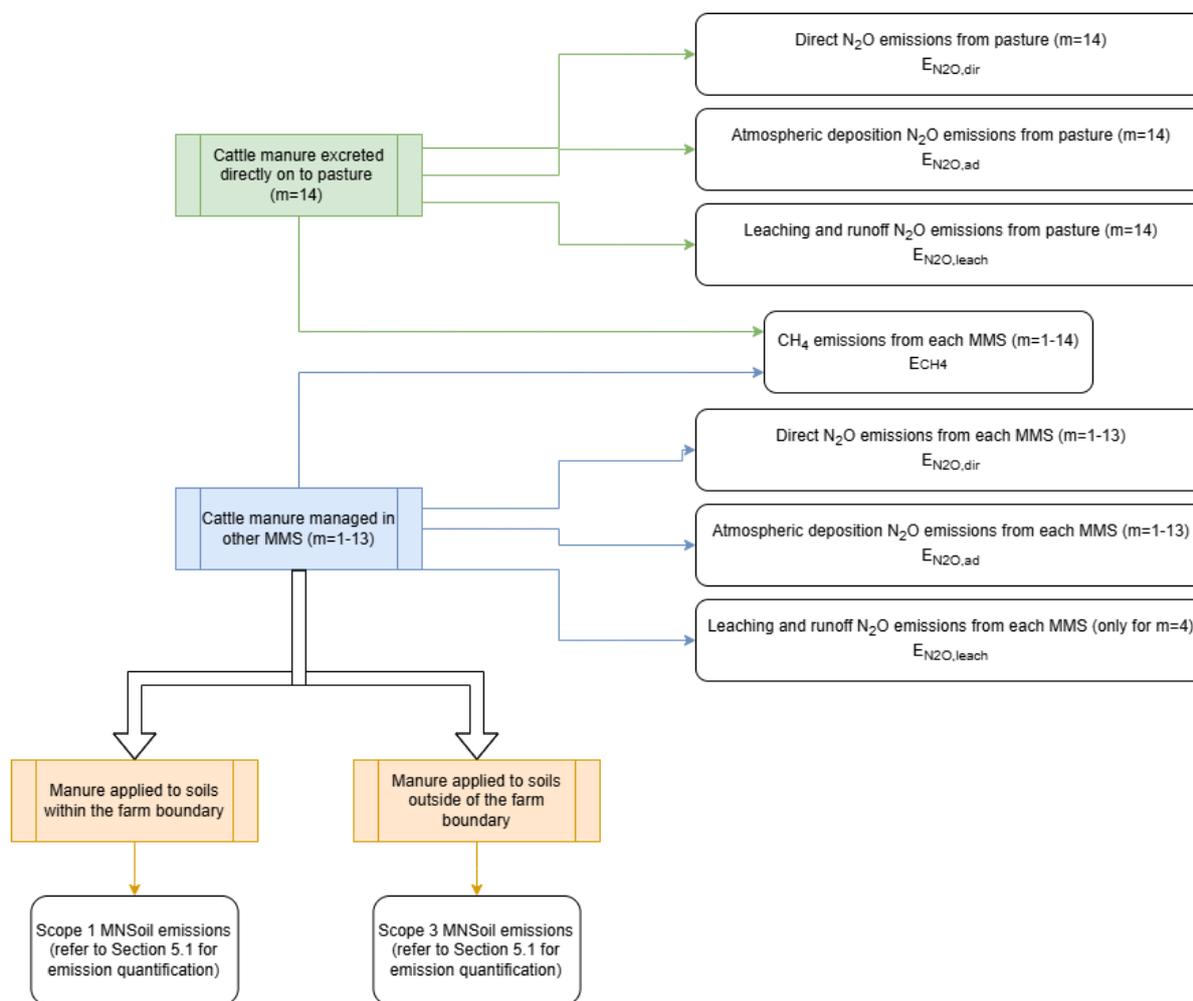
533

534

535 4.3 Dairy

536 This module covers the estimation of methane and nitrous oxide emission that results from
 537 dairy cattle manure management. Figure 4.5 summarises the emission sources associated
 538 with the manure from dairy cattle. There are two components to methane emission estimates
 539 – manure excreted directly onto pasture, and managed manure from the milking shed or and
 540 feedpad. Managed manure also results in direct and indirect nitrous oxide emissions. For
 541 manure excreted to pasture there are no nitrous oxide emissions from manure management,
 542 however emissions from the soil occur from the metabolism of the deposited urine and
 543 faeces, and indirectly through atmospheric deposition and leaching and runoff. Note that
 544 emissions associated with manure from management systems that is subsequently applied
 545 to soils are covered in the organic fertiliser section in Chapter 5 Section 5.1 Fertiliser
 546 module.

547



548

549 Figure 4.5: Emissions that result from dairy cattle manure

550

551

552

553 The following subscripts are used in this module:

Subscript	Meaning
<i>i</i>	Climate zone
<i>j</i>	Livestock class
<i>m</i>	Manure management system

554
 555 Emissions are estimated based on age and sex classes of cattle and the manure
 556 management system. The climate zone will affect the selection of appropriate emissions
 557 factors. The emissions are summed across each class, manure management system and
 558 time-period spent on farm during the reporting period.

559 The classes of cattle on the farm ('dairy input class') will depend on the diversity of the
 560 farming operation. The number of heifer and bull calves should be reported separately to
 561 weaned stock less than 12 months in age to capture emissions from calves sold at weaning.
 562 These classes need to be mapped back to default categories ('dairy cattle class j') to allow
 563 the use of default inventory values under Method 1.

Dairy Cattle Class j	Possible Dairy Input Class
1 = Milking cows	Milking cows
2 = Heifers > 1 year	Heifers > 1 year
3 = Heifers < 1 year	Replacement heifers < 1 year, weaned
	Heifer Calves, <1 year, preweaning
4 = Bulls > 1 year	Mature bulls
5 = Bulls < 1 year	Other weaned stock < 1 (non-replacement heifers, steers or bulls)
	Bull Calves, <1 year, preweaning

564
 565 The National Inventory Report and Method 1 defaults for dairy assume that all "other stock"
 566 will be sold from the dairy at 12 months or less. In cases where other stock such as steers or
 567 bulls are retained beyond 12 months Method 1 default values for liveweight and liveweight
 568 gain can be taken from the appropriate beef pasture, range and paddock defaults (see
 569 Section 4.2 for more detail).

570 Nitrous oxide emissions from managed manure are only relevant for milking cows (j=1). The
 571 manure management systems (m) will differ for manure excreted while animals are grazing
 572 or in the milking shed or feedpad. Manure from other dairy cattle classes (j=2-5) is all
 573 assumed to be excreted to pasture (m=14)

574 Guidance is currently provided for the manure management systems (MMS) aligned with the
 575 NIR options. These include pasture, anaerobic lagoons, drains to paddock, sump and
 576 dispersal systems, and associated solid separation (considered solid storage). The MMS
 577 options available for dairy cattle are under review

578

579 4.3.1 Estimation methodology

580 4.3.1.1 METHOD 1 — MANURE METHANE DAIRY

581 (1) Total annual methane production from manure management E_{CH_4} (t CH₄) is
 582 calculated as the sum of methane from manure from dairy cows, bulls, young stock
 583 and pre-weaned calves:

$$584 \quad E_{CH_4} = \sum_j \sum_m \left((N_{j=1,2,4} \times Mm_{j=1,2,4,m} \times D_{j=1,2,4}) + (N_{j=3,5} \times Mm_{j=3,5,m} \times D_{j=3,5}) \right. \\ 585 \quad \left. + (N_{j=3,5} \times MPW_{manure,j=3,5} \times D_{j=3,5}) \right) \times 10^{-3}$$

586 Where N_j = number of dairy cattle in each class

587 M_{jm} = methane production from manure of weaned dairy cattle in each class
 588 in each MMS (kgCH₄/head/day)

589 $MPW_{manure,j=3,5}$ = methane production from manure of pre-weaned heifer and
 590 bulls calves (<1 year) (kg CH₄/head/day)

591 D_j = Duration of stay on the farm (days). Method 1 default values for these
 592 time periods are provided in data tables.

593 (2) Methane from manure production M_{ijm} (kgCH₄/head/day) from weaned dairy cattle is
 594 calculated by:

$$595 \quad Mm_{jm} = VS_j \times B_o \times MMS_{jm} \times MCF_{im} \times \rho$$

596 Where: VS_j = daily volatile solids production per head for dairy cattle (kg/head/day)

597 B_o = emissions potential (m³ CH₄/kgVS)

598 MMS_{jm} = fraction of waste from each class in each management system

599 MCF_{im} = methane conversion factor for climate zone and MMS. Under
 600 Method 1, the default state climate zone is applied

601 ρ = density of methane (kg/m³)

602 Guidance for calculating MMS_m has been provided in the data tables below based on default
 603 times spent on pasture, in the milking shed and on a feedpad including both Method 1 and 2
 604 options.

605 For weaned dairy cattle volatile solids VS_j (kg/head/day) are calculated as:

$$606 \quad VS_j = \left(I_j \times (1 - DMD_j) + (0.04 \times I_j) \right) \times (1 - A)$$

607 Where I_j = dry matter feed intake as calculated in Chapter 3 Section 3.3)
 608 (kgDM/head/day)
 609 DMD_j = dry matter digestibility. Default values applied under Method 1
 610 A = ash content of feed intake

611 4.3.1.2 METHOD 2 — MANURE METHANE DAIRY

612 Method 2 is the same as Method 1 except that under equations 4.3.1.1 (3) feed intake I_{jkl} is
 613 estimated as per section 3.3.1.2 and farm specific data is applied for DMD_k for and for MCF_{im}

614 Under Method 2 the selected time-period and associated D_j used in equation 4.2.1.1 (1) may
 615 be a year, $D_{j=1,2,4}$ = 365 days, or $D_{j=3,5}$ = 284 or 84 days depending on pre or post weaning or
 616 a specific number of days if the entry and exit from farm of a specific cohort of animals is
 617 being estimated

618 4.3.1.3 METHOD 1 — MANURE DIRECT N₂O DAIRY

619 (1) The total annual direct nitrous oxide emissions from manure management systems
 620 $E_{N_2O,dir}$ (t N₂O) is calculated as:

$$621 \quad E_{N_2O,dir} = \left\{ \sum_j \sum_m (FN_{jm} \times EF_m \times C_{g,N_2O}) + \sum_j \sum_m (UN_{jm} \times EF_m \times C_{g,N_2O}) \right\} \times 10^{-3}$$

622 Where FN_{jm} = total faecal nitrogen in each MMS for dairy cattle classes (kg N)
 623 UN_{jm} = total urinary nitrogen in each MMS for dairy cattle classes (kg N)
 624 EF_m = nitrous oxide emission factor for each MMS (kg N₂O-N/kg N deposited)

625 (2) Total faecal nitrogen in each MMS FN_{jm} (kg N) is calculated as:

$$626 \quad FN_{jm} = AF_j \times MMS_{jm}$$

627 Where AF_j = total annual faecal nitrogen excreted by each dairy class (kg N)
 628 MMS_{jm} = fraction of waste in each MMS for each dairy class (kg N)

629

630 (3a) Total annual faecal nitrogen excreted by dairy cattle >1 year old, $AF_{j=1,2,4}$ (kg N) is
 631 calculated as:

$$632 \quad AF_{j=1,2,4} = (N_{j=1,2,4} \times F_{j=1,2,4} \times 365)$$

633

634 Where: $F_{j=1,2,4}$ = nitrogen excreted in faeces in dairy cattle >1 year old (kg
 635 N/head/day)

636 (3b) Total annual faecal nitrogen excreted by dairy cattle <1 year old, $AF_{j=3,5}$ (kg N) is
 637 calculated as:

$$638 \quad AF_{j=3,5} = (N_{j=3,5} \times F_{j=3,5} \times 281) + (N_{j=3,5} \times FPW_{j=3,5} \times 84)$$

639
 640 Where: $F_{j=3,5}$ = nitrogen excreted in faeces in weaned dairy cattle <1 year old (kg
 641 N/head/day)

642 $FPW_{j=3,5}$ = nitrogen excreted in faeces in pre-weaned calves (kg N/head/day)

643

644 (4) Nitrogen excreted in faeces of dairy cattle >1 year old and weaned cattle <1 year old
 645 F_j is calculated using equations developed by the SCA (1990) [8] and Freer et al.
 646 (1997) [9] as:

$$647 \quad F_j = \left\{ 0.3 \times \left(CPI_j \times \left(1 - (DMD_j + 0.1) \right) \right) + 0.105 \times (ME_j \times I_j \times 0.008) + (0.0152 \times I_j) \right\}$$

$$648 \quad \quad \quad \times \frac{1}{6.25}$$

649 Where CPI_j = crude protein intake (kg/head/day)

650 ME_j = metabolizable energy (MJ/kgDM)

651 DMD_j = dry matter digestibility (fraction). Default values applied under Method
 652 1

653

654 (5) Metabolizable energy ME_j is calculated by Minson and McDonald (1987) [10] as:

$$655 \quad ME_j = 0.1604 \times (DMD_j \times 100) - 1.037$$

656 Where DMD_j = dry matter digestibility (fraction). Default values applied under Method
 657 1

658

659 (6) The crude protein intake CPI_j (kg/head/day) of dairy cattle is calculated as:

$$660 \quad CPI_j = I_j \times CP_j$$

661 Where CP_j = crude protein content of feed intake (fraction). Default values applied
 662 under Method 1

663

664 (8) Total urinary nitrogen in each MMS UN_{jm} (kg N) is calculated as:

$$665 \quad UN_{jm} = AU_j \times MMS_{jm}$$

666 Where AU_j = total annual urinary nitrogen excreted by each dairy class (kg N)

667 MMS_{jm} = fraction of waste in each MMS for each dairy class (kg N)

668

669 (9a) Total annual urinary nitrogen excreted by dairy cattle >1 year old, $AU_{j=1,2,4}$ (kg N) is
 670 calculated as:

671 $AU_{j=1,2,4} = (N_{j=1,2,4} \times U_{j=1,2,4} \times 365)$

672

673 Where: $U_{j=1,2,4}$ = nitrogen excreted in urine in dairy cattle >1 year old (kg N/head/day)

674 (9b) Total annual urinary nitrogen excreted by dairy cattle <1 year old, $AU_{j=3,5}$ (kg N) is
675 calculated as:

676 $AU_{j=3,5} = (N_{j=3,5} \times U_{j=3,5} \times 281) + (N_{j=3,5} \times UPW_{j=3,5} \times 84)$

677

678 Where: $U_{j=3,5}$ = nitrogen excreted in urine in weaned dairy cattle <1 year old (kg
679 N/head/day)

680 $UPW_{j=3,5}$ = nitrogen excreted in urine in pre-weaned calves (kg N/head/day)

681

682 (10) Nitrogen excreted in urine for of dairy cattle >1 year old and weaned cattle <1 year
683 old U_j (kg N/head/day) is calculated as:

684
$$U_j = \left(\frac{CPI_j}{6.25} \right) - NR_j - F_j - \left[\frac{1.1 \times 10^{-4} \times W_j^{0.75}}{6.25} \right]$$

685 Where NR_j = amount of nitrogen retained by the body (kg N/head/day)

686 W_j = liveweight (kg). Default values applied under Method 1

687 (11) The amount of nitrogen retained by the body NR_j is calculated as:

688
$$NR_j = \left(\frac{0.032 \times MP_j \times 1.03}{6.38} \right)$$

689
$$+ \left\{ \left\{ 0.212 - 0.008 \times (L_j - 2) - \left[\frac{0.140 - 0.008 \times (L_j - 2)}{1 + e^{-6 \times (Z_j - 0.4)}} \right] \right\} \times (LWG_j \right.$$

690
$$\left. \times 0.92) \right\} \times \frac{1}{6.25}$$

691 Where MP_j = milk production (L/head/day)

692 L_j = intake relative to that needed for maintenance

693 Z_j = relative size

694 LWG_j = liveweight gain (kg/day). Default values applied under Method 1

695 1.03 = conversion factor for milk in litres to kg

696 Where daily milk production data is collected in quantities of milk solids rather than litres of
697 milk, refer to Chapter 3 Section 3.3 for converting milk solids to litres.

698 (12) Intake relative to maintenance L_j is calculated as:

699
$$L_j = \frac{I_j}{(1.185 + 0.00454 \times W_j - 0.0000026 \times W_j^2)^2 \times MR_j + MI_j}$$

700 Where MR_j = increase in metabolic rate when producing milk (kgDM/head/day)
 701 MI_j = additional intake required for milk production, as calculated in Chapter 3
 702 Section 3.3 (kgDM/head/day)

703

704 (13) The relative size Z_j is calculated as;

$$705 \quad Z_j = \frac{W_j}{SRW_j}$$

706 Where SRW_j = standard reference weight (kg)

707

708 4.3.1.4 METHOD 2 — MANURE DIRECT N2O DAIRY

709 Method 2 is the same as Method 1 except that under equations 4.3.1.3 (4), (6) and (12) feed
 710 intake I_{jkl} is estimated as per section 3.2.1.2 and farm specific data is applied for the
 711 selected time-period (i.e. seasonal, monthly or other) for CP_{jkl} (Eq 4.2.1.3 (6)), DMD_{ijk} (Eq
 712 4.3.1.3 (4) and (5)), W_{jkl} (Eq 4.3.1.3 (10), (12) and (13)), LWG_{jkl} (Eq 4.3.1.3 (11)).

713

714 4.3.1.5 METHOD 1 — MANURE DEPOSITION N2O DAIRY

715 (1) Annual atmospheric deposition emissions from MMS $E_{N2O,MMS,ad}$ is calculated as:

$$716 \quad E_{N2O,MMS,ad} = MN_{ATMOS} \times EF_{N2O} \times C_g \times GWP_{N2O} \times 10^{-3}$$

717 Where MN_{ATMOS} = mass of N volatilised from MMS (kg N)

718 EF_{N2O} = inorganic fertiliser emission factor for irrigated pasture (kg N₂O-N/kg
 719 N)

720

721 (2) Total of nitrogen volatilised from MMS MN_{ATMOS} (kg N) is calculated as:

$$722 \quad MN_{ATMOS} = \sum_j \sum_m (FN_{jm} \times FracGASM_m + UN_{jm} \times FracGASM_m)$$

723 Where $FracGASM_m$ = fraction of N volatilised from MMS (fraction)

724

725 4.3.1.6 METHOD 1 — MANURE LEACHING AND RUNOFF N2O DAIRY

726 (1) Annual emissions from leaching and run off from each MMS $E_{N2O,leach}$ (t N₂O) is
 727 calculated as:

$$728 \quad E_{N2O,leach} = \sum_j \sum_{m=1-13} (MNLeach_{jm} \times EF_{leach} \times C_g) \times 10^{-3}$$

729 Where $MNLeach_{jm}$ = mass of N lost through leaching and runoff from each MMS (kg
730 N)

731 $MNLeach_m$ is assumed to be zero for anaerobic lagoons (m=1), and for daily spread
732 treatments (sump and dispersal m=3a, and drains to paddock m=3b) is nitrogen is
733 transferred directly to manure applied to soils (see section 4.3.1.8 Manure applied to Soil)

734 Emissions from leaching and run off are only estimated for the solid storage MMS (m=4).
735 This simplifies the equation to:

$$736 \quad E_{N2O,leach} = MNLeach_{jm=4} \times EF_{leach} \times C_g \times 10^{-3}$$

737 This assumption may need to be reconsidered if other MMS are incorporated based on
738 stakeholder feedback.

739 (2) The mass of nitrogen lost to leaching and runoff from solid storage
740 systems $MNLeach_{jm=4}$ (kg N) is calculated as:

$$741 \quad MNLeach_{jm=4} = (FN_{jm=4} + UN_{jm=4}) \times FracWET_i \times FracLEACH_{MS}$$

742 Where $FracWET_i$ = fraction of N available for leaching and runoff in climate zone.
743 Under Method 1, the default state climate zone is applied

744 $FracLEACH_{MS}$ = fraction of N lost through leaching and runoff

745 4.3.1.7 METHOD 2 — MANURE LEACHING AND RUNOFF N2O DAIRY

746 Method 2 is the same as Method 1 except that under equations 4.6.1.6 (2) farm specific
747 climate zone is required for $FracWET_i$.

748

749 4.3.1.8 MANURE APPLIED TO SOILS

750 It is assumed that all manure managed through an MMS (m=1-13) will eventually be applied
751 to soils. The mass of nitrogen applied to soils is calculated here and then this $MNSoil$ value
752 is transferred to Chapter 5 Section 5.1 to estimate emissions associated with the application
753 of manure to soils as organic fertilisers, including associated atmospheric deposition and
754 leaching and run-off emissions.

755 The manure may be applied to soils within the boundary of the farm or may be sent off-site
756 and applied to another farming enterprise. Where manure is applied to soils within the
757 boundary of the farming enterprise $MNSoil_{scope1}$, the emissions from shall be estimated and
758 reported as Scope 1 emissions. Where the manure is used on other farming enterprises
759 $MNSoil_{scope3}$, the emissions from shall be estimated and reported as Scope 3 emissions
760 under Scope 3 Category 5 – waste generated in operations (see Chapter 7 Section 7.10).

761 (1) The mass of nitrogen from manure that is applied to soils for scope 1 emissions
762 $MNSoil_{scope1}$ (kg N) is calculated as:

$$MNSoil_{scope1} = \sum_j \sum_m (UN_{jm=1-13} + FN_{jm=1-13}) \times (1 - EF_{m=1-13} - FracGASM_{m=1-13}) - MNLeach_{jM}) \times PF$$

Where PF_{scope} = fraction of manure applied to soil within the farm boundary

(2) The mass of nitrogen from manure that is applied to soils for scope 3 $MNSoil_{scope3}$ (kg N) is calculated as:

$$MNSoil_{scope3} = \sum_j \sum_m (UN_{jm=1-13} + FN_{jm=1-13}) \times (1 - EF_{m=1-13} - FracGASM_{m=1-13}) - MNLeach_{jM}) \times (1 - PF)$$

This approach assumes that the manure used off-site within a different farm enterprise is considered a “waste product” from the farm, rather than a co-product.

If the manure is sold for use as an organic fertiliser elsewhere, under the GHG Protocol the manure would be considered a co-product and thus would require some of the total farm emissions allocated to it. Furthermore, the emissions from the application of manure to soils would then fall into a use-of-sold-products emissions category, which is outside of the cradle-to-farm gate boundary.

The wording used in this section is therefore still subject to review and non-specific until the Common Reporting Framework provides guidance on emission allocation between co-products, and whether manure sold off-site is considered a co-product or waste stream.

781

4.3.1.9 METHOD 1 — SOIL DIRECT N₂O DAIRY

(1) Direct nitrous oxide emissions $E_{N2O,dir}$ (t N₂O) on to pasture are calculated as:

$$E_{N2O,dir} = \sum_j \{ (FN_{jm=14} \times EF_{PRP} \times C_{g,N2O}) + (AU_{jm=14} \times EF_{PRP} \times C_{g,N2O}) \} \times 10^{-3}$$

Where $FN_{jm=14}$ = mass of faecal nitrogen excreted on pasture, range and paddock for each dairy cattle class (kg N)

EF_{PRP} = emission factor for nitrous oxide emissions for urine and dung deposited on PRP (kg N₂O-N/kg N deposited)

$C_{g,N2O}$ = factor to convert elemental mass of N₂O to molecular mass

$UN_{jm=14}$ = mass of urine nitrogen excreted pasture, range and paddock for each dairy cattle class (kg N)

792

4.3.1.10 METHOD 1 — SOIL DEPOSITION N₂O DAIRY

(1) Atmospheric deposition emissions from urine and dung deposited on pasture $E_{N2O,ad}$ (t N₂O) are calculated as:

796
$$E_{N2O,ad} = M_{vol,m=14} \times EF_{ad} \times C_{g,N2O} \times 10^{-3}$$

797 Where $M_{vol,m=14}$ = mass of nitrogen volatilised from urine and faeces deposited on
798 pasture (kg N)

799 EF_{ad} = emission factor for atmospheric deposition (kg N₂O-N/kg N)

800

801 (2) The mass of nitrogen volatilised $M_{vol,PRP}$ (kg N) is calculated as:

802
$$M_{vol,m=14} = \sum_j (UN_{jm=14} + FN_{jm=14}) \times FracGASMsoil$$

803 Where $FracGASMsoil$ = fraction of nitrogen volatilised from urine and faeces
804 deposited on pasture ((kg NH₃-N + NO_x-N)/kg N)

805

806 4.3.1.11 METHOD 2 — SOIL DEPOSITION N₂O DAIRY

807 There is no Method 2 quantification option for this emission source

808

809 4.3.1.12 METHOD 1 — SOIL LEACHING AND RUNOFF N₂O DAIRY

810 (1) Leaching and runoff emissions from urine and dung deposited on pasture $ES_{N2O,leach}$
811 (t N₂O) are calculated as:

812
$$E_{N2O,leach} = M_{leach,m=14} \times EF_{leach} \times C_{g,N2O} \times 10^{-3}$$

813 Where $M_{leach,m=14}$ = mass of nitrogen lost to leaching and runoff from urine and
814 faeces deposited on pasture (kg N)

815 EF_{leach} = emission factor for leaching and runoff (kg N₂O-N/kg N)

816

817 (2) The mass of nitrogen lost to leaching and runoff $M_{leach,PRP}$ is calculated as:

818
$$M_{leach,m=14} = \sum_j (UN_{jm=14} + FN_{jm=14}) \times FracWet \times FracLEACH$$

819 Where $FracWet$ = fraction of N available for leaching and runoff in the climate zone
820 of the entity. Under Method 1, it is assumed the entity is in a leaching climate
821 zone.

822 $FracLEACH$ = fraction of N that is lost through leaching and runoff

823 Where $FracGASM_{m=1-13}$ = fraction of N volatilised in each MMS ((kg NH₃-N + NO_x-N)/kg N)

824

825 4.3.1.13 METHOD 2 — SOIL LEACHING AND RUNOFF N₂O DAIRY

826 Method 2 is the same as Method 1 except that under equations 4.3.1.11 (2) farm specific
827 climate zone is can be calculated $FracWet$.

828

829 **4.3.2 Data/Parameters**830 **4.3.2.1 INPUT DATA (REQUIRED)**

Data / Parameter	N_j
Data unit	head
Description	Number of dairy cattle in each class j
Data source	Farm stock records and herd flow model see Chapter 1 Section 1.9 Noting that the number of heifer and bull calves should be reported separately to weaned stock less than 12 months in age to capture emissions from calves sold at weaning.
Quality assurance / quality control considerations	All animals purchased or sold in the reporting period are assumed to be reported. The number of heifer and bull calves should be reported separately to weaned stock less than 12 months in age to capture emissions from calves sold at weaning. Number of cattle reported can be cross checked with stocking density allowances for system size. If value is significantly higher or lower than expected stocking density, flagged as possibly erroneous. Check the class of animals on farm align with expected enterprise on farm: for example, self-replacing systems vs purchased breeder or trading systems.

831

Data / Parameter	MP_j
Data unit	L/head/day
Description	Daily milk production per milking cow
Data source	Farm milk sales records and number of milking cows. The average amount of milk sold per day (in litres) can be divided by the average number of milking cows on the farm to calculate the daily milk production per milking cow. If milk production records are in terms of milk solids rather than litres of milk, refer to the section 3.3 for converting milk solids (MS_j) into litres (MP_j).
Quality assurance / quality control considerations	Ensure farm source data isn't significantly different when compared to NIR state-based values indicating potential data entry error. State-based values can be found in Table 12.1.3.9 in Chapter 12 Appendix If milk production can be verified through milking parlour software and corroborated via milk collection receipts.

832

Data / Parameter	PF
Data unit	fraction
Description	Fraction of manure from MMS applied to soil within the farm boundary
Data source	Farm source data When all manure treated in MMS is applied within the farm boundary and none is sold off-site to be used in a different enterprise, then PF = 1.
Quality assurance / quality control considerations	Ensure farm source data isn't significantly different when compared to NIR state-based values indicating potential data entry error.

833

834 4.3.2.2 DATA (METHOD 1 AND 2 OPTIONS)

Data / Parameter	D_j
Data unit	days
Description	Duration of stay for each dairy cattle input class
Method 1 data source	National Inventory Report Volume 1 [1]
Method 1 value	For all manure stock ($j = 1,2,4$) $D_j = 365$ For pre-weaned young stock ($j=3,5$) $D_j = 84$ For weaned stock <1 year ($j = 3,5$) $D_j = 281$
Method 2 data source	Farm stock records; system type records or purchase and sales can be evaluated to determine average duration of each cattle input class (see Chapter 1 Section 1.9 for more details on herd flow modelling).
Quality assurance / quality control considerations	Ensure that if animals are on the farm all year round the duration of stay is 365 days Ensure that if animals are only born part way through the reporting period their duration of stay reflect this.

835

Data / Parameter	MMS_{jm}
Data unit	fraction
Description	Fraction of volatile solids voided to each manure management system m
Method 1 data source	Annual fraction of time spent on pasture, in the milking shed or on a feedpad is based on the assumptions underlying the defaults for f_m used in the National Greenhouse Gas Inventory MMS calculations. User-defined data for fraction of waste from the milking shed and feedpad that goes to each MMS may be based on farm records of MMS quantities (where available), or estimates based on experience and observations made throughout the year.
Method 1 value	MMS_{jm} is determined based on the fraction of time dairy cows or heifers spend on pasture, in the milking shed, or on feedpad.

	<p>The user must select which the feeding system most representative of the dairy operation, to then determine the fraction of time the cows spend in each area. See Table 12.1.3.10 in Chapter 12 Appendix.</p> <p>The fraction of volatile solids voided to pasture ($f_{m=14}$) is equal to the annual fraction of time spent on pasture in the provided table. For example, for a grazing-only system, $f_{m=14} = 0.89$</p> <p>The annual fraction of time spent in the milking shed and on the feedpad are used to allocate manure to different MMS.</p> <p>The user must indicate what percentage of waste is allocated to each MMS that is used to manage waste from the feedpad and from the milking shed respectively. The following MMS options are available:</p> <ul style="list-style-type: none"> • Anaerobic lagoon (m = 1) • Sump and dispersal system (m = 3a) • Drains to paddocks (m = 3b) • Solid storage (m = 4) <p>f_m is calculated as the percentage of waste allocated to the MMS from that area multiplied by the time spent in that area.</p> <p>For example, for a grazing-only system where 50% of the waste from the milking shed is drained to paddocks and the remaining 50% is spread a through sump and dispersal system:</p> $f_{m=3a} = 0.11 * 0.50 = 0.055$ $f_{m=3b} = 0.11 * 0.50 = 0.055$ <p>The user must also indicate if the waste is pre-treated (solid separation) before entering in to sump system of lagoon.</p> <p>The user must specify the percentage of solid waste removed by the pre-treatment process and transferred to solid storage.</p> <p>For example, if the previous example included pre-treatment before sump and dispersal and the use specified that 20% of the waste is removed my pre-treatment, then:</p> $f_{m=3a} = 0.055 * 0.8 = 0.044$ $f_{m=4} = 0.055 * 0.2 = 0.011$
<p>Method 2 data source</p>	<p>If the time spent between pasture, milking shed and feedpad is different to the systems 1-4 offered in the Method 1 option, then the annual fraction of time spent in each area can be estimated from farm records for time split between paddock and housed for each livestock class.</p> <p>Alternatively, the ADCC tool provides a questionnaire-based approach to these calculations, which can be utilised to calculate f_m [14].</p>
<p>Quality assurance / quality control considerations</p>	<p>Ensure MMS and time spent in each system align with dairy system recorded on farm, i.e., housed or pasture-based system.</p>

836

	If Method 1 is used ensure the most recent estimate for annual fraction of time spent per area is used.
Data / Parameter	DMD _j
Data unit	fraction
Description	Dry matter digestibility
Data source	Table A5.5.1.4, National Inventory Report, Volume 2 [4].
Method 1 value	0.75
Method 2 data source	If average DMD for the reporting period of different livestock classes is known based on farm records of feed sources and quality, a farm specific DMD value can be used. The ADCC, 2025 [14] provides support on how to calculate DMD from feed sources. For any stock classes where farm records of feed sources and quality are not available, the NIR default shall be applied.
Quality assurance / quality control considerations	Compare to inventory defaults, if values are significantly higher or lower data entry error is possible. Where Method 2 data is used conduct checks of farm source data are within expected ranges. The ADCC, 2025 [14] provides ranges of DMD for different forage of non-forage supplements.

837

Data / Parameter	CP _j
Data unit	fraction
Description	Crude protein content of feed intake
Method 1 data source	Table 5.5.1.4, National Inventory Report, Volume 2 [4]
Method 1 value	0.20
Method 2 data source	Farm records or feed receipt stating crude protein of TMR (total mixed ration) for different livestock classes. The ADCC, 2025 [14] provides support on how to calculate CP from feed sources. For any stock classes where farm records of feed sources and quality are not available, the NIR default shall be applied.
Quality assurance / quality control considerations	Compare to inventory defaults, if values are significantly higher or lower data entry error is possible. Where Method 2 data is used conduct checks of farm source data are within expected ranges. The ADCC, 2025 [14] provides ranges of CP for different forage of non-forage supplements

838

Data / Parameter	W _j
Data unit	kg
Description	Liveweight
Method 1 data source	Table A5.5.1.1 National Inventory Report, Volume 2 [4] and the ADCC 2025 [14]

839

Method 1 value	See Table 12.1.3.1 and Table 12.1.3.2 in Chapter 12 Appendix Select the appropriate live weight for the input class.
Method 2 data source	Farm stock records and herd flow model (see Chapter 1 Section 1.9)
Quality assurance / quality control considerations	Ensure farm source data isn't significantly different when compared to NIR default values indicating potential data entry error. Checking purchase and sale weight records against entered values can be used for data assurance and control.

840

Data / Parameter	LWG _j
Data unit	kg/head/day
Description	Liveweight gain
Method 1 data source	Table 5.5.1.2 National Inventory Report, Volume 2 [4]
Method 1 value	See Table 12.1.3.3 in Chapter 12 Appendix Select the appropriate live weight gain for the input class.
Method 2 data source	Farm stock records and herd flow model (see Chapter 1 Section 1.9)
Quality assurance / quality control considerations	Ensure farm source data isn't significantly different when compared to NIR default values indicating potential data entry error. Additional checks of farm source data are within expected ranges. Typical liveweight gain for heifers of various milking breeds are (ADCC, 2025): <ul style="list-style-type: none"> • smaller breeds, such as Jerseys, approximately 0.45 to 0.5 kg/head/day; • medium breeds, such as Friesians, approximately 0.60 to 0.65 kg/head/day • larger breed, such as Holstein Friesians, approximately 0.7 to 0.75 kg/head/day. Checking purchase and sale weight records against entered values can be used for data assurance and control.

Data / Parameter	Frac _{WET}
Data unit	fraction
Description	Fraction of nitrogen available for leaching and run-off
Method 1 data source	National Inventory Report Volume 2, Table A5.5.10.2 [4]
Method 1 value	1
Method 2 data source	A Method 2 approach can be used to determine whether the farm enterprise is located in an area where leaching occurs (refer to guidance in see Chapter 1 Section 1.8 to determine whether the enterprise is located in a leaching zone). Where it is determined that leaching does occur, Frac _{WET,soil} = 1 Where it is determined that leaching does not occur, Frac _{WET,soil} = 0

841

Quality assurance / quality control considerations	Complete an inventory guided calculation and compare. If 10-15% higher or lower than inventory defaults flag as possibly erroneous.
-----------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------

Data / Parameter	EF_{PRP}
Data unit	kg N ₂ O-N/kg N
Description	Emission factor for nitrous oxide emissions per amount of urine and dung deposited
Method 1 data source	IPCC 2019, Volume 4, Chapter 11, Table 11.1 [11]
Method 1 value	0.004
Method 2 data source	A farm-specific approach to EF_{PRP} can be employed by using the IPCC values for EF_{PRP} specific to the climate zone (wet vs dry). Please see table 12.2.2.4 in Chapter 12 Appendix Refer to Chapter 1 Section 1.8 for guidance on how to determine the climate zone the enterprise is located in. Wet and dry climates used in this classification are a subset of the temperate and tropical climate zones – this is not to be confused with rainfall zones.
Quality assurance / quality control considerations	Ensure the most recently available published data is used in alignment with the Australian NIR.

842

843 4.3.2.3 CONSTANTS

Data / Parameter	GWP_{CH_4}
Data unit	fraction
Description	Global warming potential of methane to convert tCH ₄ to tCO _{2e}
Data source	IPCC (2014), AR5 [15]
Value	28
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report.

844

Data / Parameter	B_0
Data unit	m ³ CH ₄ /kg VS
Description	Emissions potential.
Data source	IPCC (2019), Chapter 10 [5]
Value	0.24
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report.

845

Data / Parameter	ρ
-------------------------	--------

Data unit	kg/m ³
Description	Density of methane
Data source	National Greenhouse and Energy Reporting (Measurement) Determination 2008 [6]
Value	0.6784
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report.

846

Data / Parameter	A
Data unit	fraction
Description	Ash content of manure
Data source	National Inventory Report, Volume 1 [1]
Value	0.08
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report.

847

Data / Parameter	MCF _{im}
Data unit	Methane conversion factor by MMS
Description	fraction
Data source	National Inventory Report, Volume 2 [4]
Value	See Table 12.1.3.6 in Chapter 12 Appendix Select appropriate value based on MMS and state.
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

848

Data / Parameter	VS _{j=3,5}
Data unit	kg/head/day
Description	Volatile solids production for pre-weaned calves
Data source	Table A5.5.1.5, National Inventory Report, Volume 2 [4]
Value	See Table 12.1.3.5 in Chapter 12 Appendix Default values for are only provided for pre-weaned calves. For all other classes volatile solids must be calculated as described in Section 4.3.1.
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

849

Data / Parameter	C_{g,N_2O}
Data unit	fraction
Description	Factor to convert elemental mass of nitrous oxide to molecular mass
Data source	IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Chapter 5: Agriculture [7]
Value	44/28
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

850

Data / Parameter	$FPW_{j=7,8}$
Data unit	kg/head/day
Description	Nitrogen excreted in faeces in pre-weaned calves
Data source	Table A5.5.1.5, National Inventory Report, Volume 2 [4]
Value	See Table 12.1.3.5 in Chapter 12 Appendix Default values for are only provided for pre-weaned calves. For all other classes nitrogen excreted in faeces must be calculated as described in Section 4.3.1.
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

851

Data / Parameter	$UPW_{j=3,5}$
Data unit	kg/head/day
Description	Nitrogen excreted in urine in pre-weaned calves. It is assumed that pre-weaned dairy calves are removed from their mothers and receive milk or milk replacer and feed pellets.
Data source	National Inventory Report, Volume 2, A5.5.1.5 [4]
Value	See Table 12.1.3.5 in Chapter 12 Appendix Default values for are only provided for pre-weaned calves. For all other classes nitrogen excreted in urine must be calculated as described in Section 4.3.1.
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

852

Data / Parameter	MR_j
Data unit	kg DM/head/day
Description	Increase in metabolic rate when producing milk
Data source	National Inventory Report, Volume 1 [1]

853

Value	See Table 12.1.3.11 in Chapter 12 Appendix Select appropriate value based on livestock class
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian NIR.

854

Data / Parameter	NE
Data unit	MJ net energy/kg milk
Description	Net energy required for milk production
Data source	National Inventory Report, Volume 1 [1]
Value	3.054
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian NIR.

855

Data / Parameter	GEC
Data unit	MJ/kg DM
Description	Gross energy content of feed dry matter
Data source	National Inventory Report, Volume 1 [1]
Value	18.4
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian NIR.

856

Data / Parameter	k
Data unit	fraction
Description	Efficiency of use of metabolisable energy for milk production
Data source	National Inventory Report, Volume 1 [1]
Value	0.60
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian NIR.

Data / Parameter	SRW _j
Data unit	kg
Description	Standard reference weight
Data source	National Inventory Report Volume 2, Table A5.5.1.3 [4]
Value	See Table 12.1.3.4 in Chapter 12 Appendix

857

Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian NIR.
-----------------------------------------------------------	-----------------------------------------------------------------

858

Data / Parameter	EF _{ad}
Data unit	kg N ₂ O-N/kg N
Description	Emission factor for atmospheric deposition
Data source	National Inventory Report, Volume 1, Table 5.21 [1]
Value	0.0059
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian NIR.

859

Data / Parameter	FracGASMsoil
Data unit	(kg NH ₃ -N + NO _x -N)/kg N
Description	Fraction of nitrogen volatilized from urine and faeces deposited on pasture.
Data source	National Inventory Report, Volume 1 [1]
Value	0.21
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian NIR.

860

Data / Parameter	EF _{leach}
Data unit	kg N ₂ O-N/kg N
Description	Emission factor for leaching and runoff
Data source	IPCC 2019, Volume 4, Chapter 11, Table 11.3 [10]
Value	0.011
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian NIR.

Data / Parameter	FraC _{LEACH}
Data unit	fraction
Description	Default fraction of N that is lost through leaching and runoff
Data source	IPCC 2019, Volume 4, Chapter 11, Table 11.3 [10]
Value	0.24
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian NIR.

861

Data / Parameter	EF _m
Data unit	kg N ₂ O-N/kg N
Description	Emission factor for nitrous oxide emissions per MMS
Data source	Table A5.5.1.9, National Inventory Report, Volume 2 [4]
Value	See Table 12.1.3.11 in Chapter 12 Appendix Select the appropriate emission factor based on the MMS in place
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian NIR.

862

Data / Parameter	EF _{N₂O}
Data unit	kg N ₂ O-N/kg N
Description	Inorganic fertilizer emission factor for irrigated pasture
Data source	NIR
Value	See Table 12.2.2.5 in Chapter 12 Appendix Refer to Chapter 1 Section 1.8 for guidance on how to determine the rainfall zone the enterprise is located in
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian NIR.

863

Data / Parameter	FracGASM _m
Data unit	(kg NH ₃ -N + NO _x -N)/kg N
Description	Fraction of nitrous oxide volatilised from each MMS
Method 1 data source	Table A5.5.1.9, National Inventory Report, Volume 2 [4]
Method 1 value	See Table 12.1.3.7 in Chapter 12 Appendix Select the appropriate value based on the MMS in place
Quality assurance / quality control considerations	Ensure the most recently available published data is used.

864

Data / Parameter	Fra _{CLEACH_MS}
Data unit	fraction
Description	Fraction of nitrogen lost through leaching and runoff for solid storage MMS only
Method 1 data source	National Inventory Report Vol 1 [13]
Method 1 value	0.02

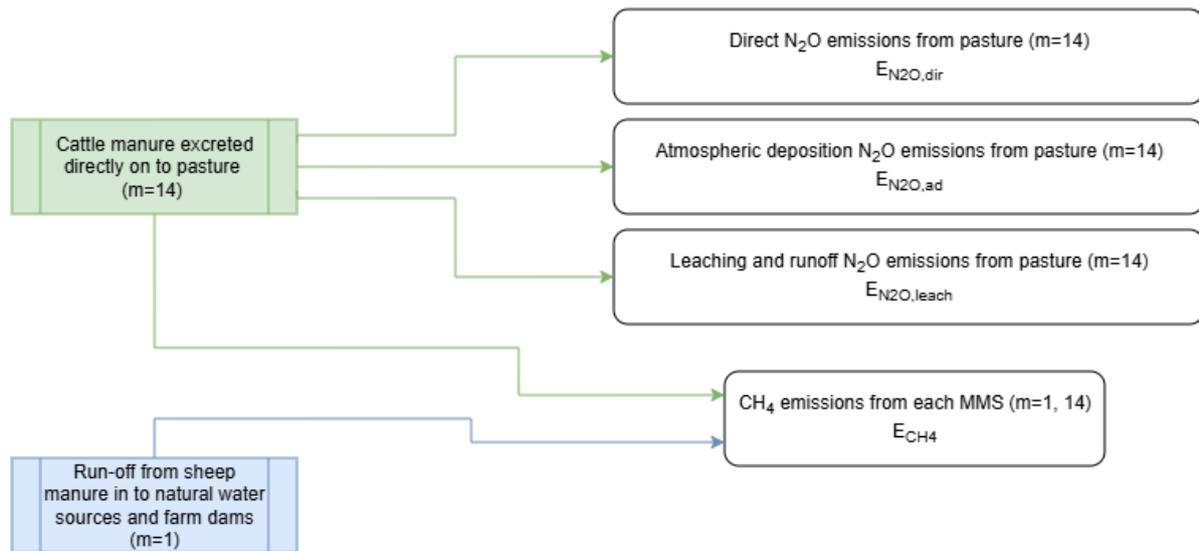
**Quality assurance /
quality control
considerations**

Ensure alignment with the latest version of the Australian NIR.

865

866 4.4 Sheep

867 This module covers the estimation of methane and nitrous oxide that result from sheep
 868 manure management. Figure 4.6 summarises the emission sources from the manure of
 869 sheep. There are two components to methane emission estimates –manure excreted directly
 870 onto pasture, rangeland and paddock (PRP) , and manure that runs-off into natural water
 871 sources and farm dams. There are no nitrous oxide emissions from manure management for
 872 manure excreted to PRP, however emissions from the soil occur from the metabolism of the
 873 deposited urine and faeces, and indirectly through atmospheric deposition and leaching and
 874 runoff.



875
 876 Figure 4.6: Emissions that result from sheep manure

877
 878 The following subscripts are used in this module:

Subscript	Meaning
<i>i</i>	Climate zone
<i>j</i>	time-period
<i>k</i>	Sheep Class
<i>m</i>	Manure management system (MMS)

879
 880 Emissions are estimated based on age and sex classes of sheep, time of the year and
 881 manure management system. The climate zone will affect the selection of appropriate
 882 emissions factors. The emissions are summed across each class, manure management
 883 system and time-period spent on farm during the reporting period.

884 The classes of sheep on the farm ('sheep input class') will depend on the diversity of the
 885 farming operation. These classes need to be mapped back to default categories ('sheep
 886 class k') to allow the use of default inventory values under Method 1

887 The time-period selected will depend on availability of stock numbers and liveweight and
 888 liveweight gain data (see Herd Flow modelling guidance in Section 1.3.7).

Sheep Class <i>k</i>	Possible Sheep Input Class
1 = Rams	Rams
2 = Wethers	Wethers
3 = Maiden ewes	Maiden ewes (1-2 years) intended for breeding
4 = Breeding ewes	Breeding ewes
5 = Other ewes	Other ewes
6 = Lambs and hoggets	Ewe lambs (<1 year)
	Wether lambs (<1 year)
	Ram lambs (<1 year)

889

890 The only relevant manure management systems (m) for grazing beef are PRP (m=14) and
 891 anaerobic lagoons (m=1). Where farmers have unfenced natural water sources and farm
 892 dams, anaerobic lagoons are used as a proxy to estimate the runoff of manure into these
 893 water sources.

894

895 **4.4.1 Estimation methodology**

896 **4.4.1.1 METHOD 1 — MANURE METHANE SHEEP**

897

898 (1) Total annual methane production from manure management for sheep E_{CH_4}
899 (kgCH₄) is calculated as:

900
$$E_{CH_4} = \sum_j \sum_k \sum_m N_{jk} \times Mm_{jkm} \times D_j$$

901 Where N_{jk} = number of sheep in each time-period and input class (head)

902 Mm_{jkm} = daily methane produced from the manure in each time-period,
903 sheep class and MMS (kgCH₄/head/day)

904 D_j = number of days in each time-period (days). This is 91.25 days under
905 Method 1 as the default time-period is a season

906 (2) Methane produced from the manure of sheep Mm_{jk} (kgCH₄/head/day) is calculated
907 as:

908
$$Mm_{jkm} = VS_{ijk} \times B_o \times MMS_m \times MCF_{im} \times \rho$$

909 Where VS_{ijk} = volatile solid production in each time-period and class(kg/head/day)

910 B_o = emissions potential (m³ CH₄/kgVS)

911 MMS_m = fraction of waste in each manure management system

912 MCF_{im} = methane conversion factor for climate zone and MMS. Under
913 Method 1, the default state climate zone is applied

914 ρ = density of methane (kg/m³)

915 The primary manure management system (MMS) for sheep is pasture range and paddock
916 (m=14). Where natural water sources, such as farm dams, are present the anaerobic lagoon
917 (m=1) MMS is used to estimate the run-off of manure into these water sources. Where
918 farmers can demonstrate animals are on bore or reticulated water systems, where water is
919 provided in troughs (i.e., no unfenced natural water sources), then the only relevant MMS to
920 be considered shall be pasture range and paddock (m=14).

921 The assumption regarding % run-off in to farm dams is under review and may change. Until
922 new assumptions are confirmed the allocation to MMS for unfenced water sources is aligned
923 with the current NIR approach.

924 A new method for estimating VS production will be implement in the next NIR and has been
925 reflected here.

926 Volatile solid production from sheep VS_{ijk} (kg/head/day) is calculated by:

927
$$VS_{jk} = \left(I_{jk} \times \left((1 - DMD_{jk}) + (0.04 \times I_{jk}) \right) \right) \times (1 - A)$$

928 Where I_{ijk} = dry matter intake as calculated in Chapter 3 Section 3.4

929 (kgDM/head/day)

930 DMD_{ijk} = dry matter digestibility expressed as a fraction. Default values
 931 applied under Method 1

932 A = ash content of feed intake

933 4.4.1.2 METHOD 2 — MANURE METHANE SHEEP

934 Method 2 is the same as Method 1 except that under equations 4.2.1.1 (3) feed intake I_{jkl} is
 935 estimated as per section 3.4.1.2 and farm specific data is applied for DMD_{jk} for the selected
 936 time-period (i.e. seasonal, monthly or other) and for MCF_{im}

937 Under Method 2 the selected time-period and associated L_j used in equation 4.2.1.1 (1) may
 938 be a season ($L_j = 91.25$ days), month ($L_j = 28-31$ day depending on month) or a specific
 939 number of days in a month or season if the entry and exit from farm of a specific cohort of
 940 animals is being estimated

941 4.4.1.3 METHOD 1 — SOIL DIRECT N₂O SHEEP

942 (1) Total annual direct nitrous oxide emissions from agricultural soils from deposition of
 943 urine and dung $E_{N_2O,dir}$ (t N₂O) are calculated as:

944
$$E_{N_2O,dir} = \{(AF \times EF_{PRP} \times C_{g,N_2O}) + (AU \times EF_{PRP} \times C_{g,N_2O})\} \times 10^{-3}$$

945 Where AF = total mass of faecal nitrogen excreted on PRP by sheep (kg N)

946 AU = total mass of urinary nitrogen excreted on PRP by sheep (kg N)

947 EF_{PRP} = emission factor for nitrous oxide from urine and dung deposited to soil
 948 (kg N₂O-N/kg N deposited)

949 C_{g,N_2O} = factor to convert elemental mass of nitrous oxide to molecular mass

950 (2) Total faecal nitrogen excreted to pasture, range and paddock AF (kg N) is calculated
 951 as:

952
$$AF = \sum_j \sum_k (N_{jk} \times F_{jk} \times L_j)$$

953 Where N_{jk} = number of sheep in each time-period and class k (head)

954 F_{jk} = nitrogen excreted in faeces per sheep per day (kg N/head/day)

955 L_j = number of days in each time-period (days). This is 91.25 days under
 956 Method 1 as the default time-period is a season

957 (3) Nitrogen excreted in faeces F_{ijk} (kg N/head/day) is calculated using equations
 958 developed by the SCA (1990) [8] and Freer et al. (1997) [9] as:

959

960
$$F_{ijk} = \left\{ 0.3 \times \left(CPI_j \times (1 - (DMD_j + 0.1)) \right) + 0.105 \times (ME_{jk} \times I_{jk} \times 0.008) \right.$$

 961
$$\left. + 0.08 \times (0.045 \times MC_{jk=6}) + (0.0152 \times I_{jk}) \right\} \div 6.25$$

962 Where CPI_j = crude protein intake (kg/head/day)
 963 DMD_{jk} = dry matter digestibility (per cent). Under Method 1, default values are
 964 applied
 965 I_{jk} = dry matter intake (kgDM/head/day) as calculated in Section 3.4
 966 ME_{jk} = metabolizable energy (MJ/kgDM)
 967 $MC_{jk=6}$ = milk intake (kg/head/day)
 968

969 (4) Crude protein intake CPI_{ijk} (kg/head/day) of sheep is calculated as:

$$970 \quad CPI_{ijk} = (I_{jk} \times CP_{jk}) + (0.045 \times MC_{jk=6})$$

971 Where CP_{jk} = crude protein content of feed intake expressed as a fraction. Under
 972 Method 1, default values are applied
 973

974 (5) Milk intake for sheep $MC_{jk=6}$ (kg/head/day) is calculated as:

$$975 \quad MC_{jk=6} = 1.6 \times PL_{jk=6}$$

976 Where 1.6 = milk production for time-period lambs are born (kg/head/day).

977 $PL_{jk=6}$ = proportion of lambs born in the time-period
 978

979 (6) Metabolizable energy ME_{jk} (MJ/kgDM) can be calculated based on Minson and
 980 McDonald (1987) [10] as:

$$981 \quad ME_{jk} = (0.1604 \times (DMD_{jk} \times 100)) - 1.037$$

982

983 (7) Total urinary nitrogen excreted to pasture, range, and paddock AU_i (kg N) is
 984 calculated as:

$$985 \quad AU = \sum_j \sum_k (N_k \times U_{jk} \times L_j)$$

986 Where

987 U_{jk} = nitrogen excreted in urine in each time-periods and class (kg
 988 N/head/day)

989 L_j = number of days in each time-period (days). This is 91.25 days under
 990 Method 1 as the default time-period is a season

991

992 (8) Nitrogen excreted in urine U_{jk} (kg N/head/day) is calculated as:

$$993 \quad U_{jk} = (CPI_{ijk} \div 6.25) - NR_{ijk} - F_{ijk}$$

994 Where NR_{ijk} = amount of nitrogen retained by the body (kg N/head/day)

995

996 (9) The amount of nitrogen retained by the body NR_{jk} (kg N/head/day) is calculated as:

$$997 \quad NR_{ijk} = \left\{ (0.045 \times MP_{jk=3,4}) + (WP_k \times 0.84) + \left\{ EBG_{jk} \times \left[\left(212 - 4 \times \left(\frac{EBG_{jk} \times 1000}{4 \times SRW_k^{0.75}} - 1 \right) \right) - \right. \right. \right. \\ 998 \quad \left. \left. \left. \frac{\left(140 - 4 \times \left(\frac{EBG_{jk} \times 1000}{4 \times SRW_k^{0.75}} - 1 \right) \right) \right]}{1 + e^{-6(Z_{jk} - 0.4)}} \right\} \times 10^{-3} \right\} \div 6.25$$

999 Where $MP_{jk=3,4}$ = milk production (kg/head/day)

1000 WP_k = clean wool production (kg/head/day)

1001 EBG_{jk} = empty body gain (kg)

1002 SRW_k = standard reference weight (kg)

1003 Z_{jk} = relative size

1004

1005 (10) Milk production of sheep $MP_{jk=3,4}$ (kg/head/day) is calculated as:

$$1006 \quad MP_{jk=3,4} = LE_{jk=3,4} \times 1.6$$

1007 Where $LE_{jk=3,4}$ = proportion of ewes lactating each season or time period as
1008 calculated in Chapter 3 Section 3.4

1009 1.6 = milk production for the season the lambs are born in (kg/head/day)

1010 For sheep classes other than breeding ewes and maidens, milk production should be set to
1011 zero, i.e., $MP_{jk=1,2,5,6} = 0$ and in non-breeding seasons milk production should be set to zero
1012 for all sheep classes.

1013

1014 **Question Reference 4.6.**

1015 The Guidance assumes producers will be able to provide average greasy fleece weights and
1016 average clean wool yield per class. Is this appropriate?

1017 Should defaults be provided for clean wool yield percentage as in the SB-GAF or are there
1018 other approaches, such as the Agriculture Victoria Data Request template, that could be
1019 used to help producers estimate clean wool production?

1020

1021 (11) Clean wool production WP_k (kg/head/day) is calculated as:

$$1022 \quad WP_k = \frac{GW_k \times Y_k}{365}$$

1023 Where GW_k = greasy wool production p class (kg/head)

1024 Y_k = average clean wool yield per sheep class (fraction)

1025 365 = number of days in a year

1026 (12) The empty body gain EBG_{jk} (kg) is calculated as:

$$1027 \quad EBG_{jk} = LWG_{jk} \times 0.92$$

1028 Where LWG_{jk} = liveweight gain (kg). Under Method 1, default values are applied.

1029

1030 (13) The relative size of the sheep Z_{jk} is calculated as:

$$1031 \quad Z_{jk} = \frac{W_{jk}}{SRW_k}$$

1032 Where W_{jk} = liveweight (kg). Under Method 1, default values are applied.

1033

1034 4.4.1.4 METHOD 2 — SOIL DIRECT N₂O SHEEP

1035 Method 2 is the same as Method 1 except that under equations 4.4.1.3 (3) and (4) feed
 1036 intake I_{jkl} is estimated as per section 3.2.1.2 and farm specific data is applied for the
 1037 selected time-period (i.e. seasonal, monthly or other) for CP_{jk} (Eq 4.2.1.3 (4) and (6)), DMD_{jk}
 1038 (Eq 4.2.1.3 (3) and (6)), W_{jk} (Eq 4.2.1.3 (13)), LWG_{jk} (Eq 4.2.1.3 (12)).

1039 Under Method 2 the selected time-period and associated L_j used in equation 4.2.1.3 (2) may
 1040 be a season ($L_j = 91.25$ days), month ($L_j = 28-31$ day depending on month) or a specific
 1041 number of days in a month or season if the entry and exit from farm of a specific cohort of
 1042 animals is being estimated

1043 4.4.1.5 METHOD 1 — SOIL DEPOSITION N₂O SHEEP

1044

1045 (1) Annual atmospheric deposition emissions from urine and dung deposited on pasture
 1046 $ES_{N_2O,ad}$ (t N₂O) is calculated as:

$$1047 \quad E_{N_2O,ad} = M_{vol} \times EF_{ad} \times C_{g,N_2O} \times 10^{-3}$$

1048 Where M_{vol} = mass of nitrogen volatilised from urine and faeces deposited on
 1049 pasture (kg N)

1050 EF_{ad} = emission factor for atmospheric deposition (kg N₂O-N/kg N)

1051

1052 The mass of nitrogen volatilised M_{vol} (kg N) is calculated as:

$$1053 \quad M_{vol} = (AU + AF) \times FracGASMsoil$$

1054 Where $FracGASM_{soil}$ = fraction of nitrogen volatilised from urine and faeces
 1055 deposited on pasture ((kg NH₃-N + NO_x-N)/kg N)

1056

1057 4.4.1.6 METHOD 2 — SOIL DEPOSITION N₂O SHEEP

1058 There is no Method 2 quantification option for this emission source.

1059

1060 4.4.1.7 METHOD 1 — SOIL LEACHING AND RUNOFF N₂O SHEEP

1061

1062 (1) Leaching and runoff emissions from urine and dung deposited on pasture $ES_{N_2O,leach}$
 1063 (t N₂O) are calculated as:

$$1064 \quad ES_{N_2O,leach} = M_{leach} \times EF_{leach} \times C_{g,N_2O} \times 10^{-3}$$

1065 Where M_{leach} = mass of nitrogen lost to leaching and runoff (kg N)

1066 EF_{leach} = emission factor for leaching and run off (kg N₂O-N/kg N)

1067

1068 (2) The mass of nitrogen lost to leaching and runoff M_{leach} (kg N) is calculated as:

$$1069 \quad M_{leach} = (AU + AF) \times FracWet \times FracLEACH$$

1070 Where $FracWet$ = fraction of N that is available for leaching and runoff in each
 1071 climate zone.

1072 $FracLEACH$ = fraction of all N that is lost through leaching and runoff

1073

1074 4.4.1.8 METHOD 2 — SOIL LEACHING AND RUNOFF N₂O SHEEP

1075 There is no Method 2 quantification option for this emission source.

1076

1077 **4.4.2 Data/Parameters**1078 **4.4.2.1 INPUT DATA (REQUIRED)**

Data / Parameter	N_{jk}
Data unit	head
Description	Number of sheep in each time-period and class
Data source	Farm records and see herd flow model see Chapter 1 Section 1.9
Quality assurance / quality control considerations	<p>All animals purchased or sold in the reporting period are assumed to be reported.</p> <p>Number of sheep reported can be cross checked with stocking density allowances for system size. If value is significantly higher or lower than expected stocking density, flagged as possibly erroneous.</p> <p>Check the class of animals on farm marry up with expected enterprise on farm. For example, self-replacing systems vs purchased breeder or trading systems.</p>

1079

Data / Parameter	GW_k
Data unit	kg/head
Description	Average greasy wool fleece weight for each sheep class
Data source	<p>Farm source data – based on average wool fleece weight for each class.</p> <p>If not known this can be calculated from the total greasy weight sold divided by the number of head in each class shorn. .</p>
Quality assurance / quality control considerations	<p>Invoices from wool sales can be used to confirm the weight of wool sold in the reporting period.</p> <p>The average fleece weight can be considered in the context of the farming operation and breed of sheep farmed. Industry averages can be used to sense check average fleece weights for different breeds and age classes to help prevent data entry errors.</p>

1080

1081

Data / Parameter	Y_k
Data unit	fraction
Description	Average clean wool yield for each sheep class
Data source	<p>Farm source data – based on wool testing results at point of sale for the clean wool percentage for each class.</p> <p>If only total greasy and total clean weights are known the fraction of clean can be calculated as:</p> $Y = \frac{\text{cleanweight}}{\text{greasyweight}}$ <p>For more accurate estimation, it is recommended this value is calculated for ewes and lambs separately and applied to each class appropriately.</p>
Quality assurance / quality control considerations	<p>Invoices from wool sales can be used to confirm the percent clean wool sold in the reporting period.</p> <p>The clean wool yield can be considered in the context of the farming operation and breed of sheep farmed. Industry averages can be used to sense check average fleece weights for different breeds and age classes to help prevent data entry errors.</p>

1082

1083 4.4.2.2 DATA (METHOD 1 AND 2 OPTIONS)

Data / Parameter	D_j
Data unit	days
Description	Duration of stay for each sheep input class
Method 1 data source	National Inventory Report Volume 1 [1]
Method 1 value	91.25
Method 2 data source	Farm stock records; system type records or purchase and sales can be evaluated to determine average duration of each sheep input class (see Chapter 1 Section 1.9 for more details on herd flow modelling)
Quality assurance / quality control considerations	<p>Ensure that if animals are on the farm all year round the duration of stay is 365 days</p> <p>Ensure that if animals are only born part way through the reporting period their duration of stay reflect this.</p> <p>If Method 1 is used inputs must be entered seasonally throughout the calculations.</p>

1084

1085

1086

Data / Parameter	DMD _{jk}
Data unit	fraction
Description	Dry matter digestibility of feed
Method 1 data source	National Inventory Report Volume 2, Table A5.5.4.2 [4]
Method 1 value	See Table 12.1.4.2 in Chapter 12 Appendix Select the appropriate default value for location of sheep, sheep class and season
Method 2 data source	Farm records - user input values for each season and class of stock. Noting that if farm specific DMD can be used for some classes or seasons if known and inventory defaults for other unknown classes of stock.
Quality assurance / quality control considerations	Compare Method 2 values to NIR default values with entered values to flag potential data entry errors

1087

Data / Parameter	CP _{jk}
Data unit	fraction
Description	Crude protein content of feed
Method 1 data source	National Inventory Report Volume 2, Table A5.5.4.4 [4]
Method 1 value	See Table 12.1.4.4 in Chapter 12 Appendix. Select the appropriate default value for location of sheep, sheep class and season
Method 2 data source	Farm records - user input values for each season and class of stock. Noting that if farm specific CP can be used for some classes or seasons if known and inventory defaults for other unknown classes of stock.
Quality assurance / quality control considerations	Compare Method 2 values to NIR default values with entered values to flag potential data entry errors

1088

1089

1090

Data / Parameter	LWG _{jk}
Data unit	kg
Description	Liveweight gain per time period and sheep class
Method 1 data source	National Inventory Report Volume 2, Table A5.5.4.5 [4]
Method 1 value	See Table 12.1.4.5 in Chapter 12 Appendix Select the appropriate default value for location of sheep, sheep class and season
Method 2 data source	Farm records and see herd flow model see Chapter 1 Section 1.9
Quality assurance / quality control considerations	Purchase and sale weight records (invoices) can be used for data assurance and control of entered values. Dated print out, screen shot, or photo of scale unit records can also be used for quality assurance of entered values. It is recommended Method 1 default values are sense checked against production data and system to ensure they are appropriate e.g. that default liveweight gain reflects when stock are expected to be growing more due to feed quality and availability.

1091

Data / Parameter	W _{jk}
Data unit	kg
Description	Liveweight of livestock per time period and sheep class
Method 1 data source	National Inventory Report Volume 2, Table A5.5.4.1 [4]
Method 1 value	See Table 12.1.4.1 in Chapter 12 Appendix Select the appropriate default value for location of sheep, sheep class and season
Method 2 data source	Farm records and see herd flow model see Chapter 1 Section 1.9
Quality assurance / quality control considerations	Purchase and sale weight records (invoices) can be used for data assurance and control of entered values. Dated print out, screen shot, or photo of scale unit records can also be used for quality assurance of entered values. It is recommended Method 1 default values are sense checked against production data and system to ensure they are appropriate e.g. if lambing in spring ensure default weights reflect this with lowest weigh value applied in spring for stock <1 year and/or that default weights reflect when stock are expected to be at the lightest and heaviest due to feed availability and quality.

1092

1093

1094 4.4.2.3 CONSTANTS

Data / Parameter	B_0
Data unit	$m^3 CH_4/kg VS$
Description	Emissions potential
Data source	IPCC (2019), Chapter 10 [5]
Value	0.24
Quality assurance / quality control considerations	Ensure the most recently available published data is used in alignment with the Australian NIR.

1095

Data / Parameter	MMS_m
Data unit	fraction
Description	Fraction of waste in each MMS
Data source	National Inventory Report, Volume 1 [1]
Value	If the farm has unfenced water sources inventory defaults of $MMS_{m=14} = 0.95$ and $MMS_{m=1} = 0.05$ If animals are on bore or reticulated water systems where water is provided in troughs (i.e. no unfenced natural water sources) then all waste should be allocated to pasture range and paddock and $MMS_{m=14} = 1$ and $MMS_{m=1} = 0$.
Quality assurance / quality control considerations	Ensure the most recently available published data is used in alignment with the Australian NIR. High resolution aerial imagery can be used to cross check that water sources are stock excluded.

1096

Data / Parameter	MCF_{im}
Data unit	fraction
Description	Methane conversion factor
Data source	M_{14} = National Inventory Report, Volume 1 [1] M_1 = IPCC 2019, Volume 4, Chapter 10, Table 10.17 [12]
Value	Methane conversion factor is dependent on climate zone. See Table 12.1.4.8 in Chapter 12 Appendix for these climate zone dependent values. Refer to Chapter 1 Section 1.8 on guidance for determining which climate zone the farm is located in.
Quality assurance / quality control considerations	Ensure the most recently available published data is used in alignment with the Australian NIR and IPCC refinements.

1097

1098

1099

1100 **Question Reference 4.7.**

1101 The current Guidance allows users to select the most appropriate emission factor for
 1102 atmospheric deposition based on the grazing system (e.g irrigated or non-irrigated pasture).

1103 For sheep, should the default assumption be that they graze on non-irrigated pasture? Or
 1104 does this vary between locations or animal classes? For example, are lambs commonly
 1105 finished on irrigated pastures or crops, while breeding ewes are typically maintained on non-
 1106 irrigated pasture?

Data / Parameter	EF _{ad}
Data unit	kg N ₂ O-N/kg N
Description	Emission factor for atmospheric deposition.
Data source	National Inventory Report Volume 1, Table 5.21 [1]
Value	See Table 12.2.2.3 in Chapter 12 Appendix This is the same emissions factor as used for direct nitrous oxide emissions from inorganic fertilisers. Apply the EF that best represent the production system In some farm systems animals may graze on crops. Apply the inorganic fertiliser EF that best representing how the sheep are grazed for the majority of the year or calculate a weighted average if the number of days on each grazing system is known. For non-irrigated cropping systems, the emission factor varies depending on whether the agricultural system is in a high rainfall or low rainfall zone. Refer to Chapter 1 Section 1.8 for guidance on determining the relevant rainfall zone.
Quality assurance / quality control considerations	Ensure alignment with the latest version of the Australian National Inventory Report

1107

Data / Parameter	FracWET
Data unit	Fraction
Description	Fraction of nitrogen that is available for leaching and runoff
Data source	National Inventory Report Volume 1 [1]
Value	To determine whether the entity is located in an area where leaching occurs refer to Chapter 1 Section 1.8 on how to determine whether the enterprise is located in a leaching zone. Where it is determined that leaching does occur, FracWET = 1 Where it is determined that leaching does not occur, FracWET = 0
Quality assurance / quality control considerations	Farm title data can be checked to ensure spatial farm boundaries used to define climate zone are correct. Other inputs such as electricity or fuel of irrigation purposes can be used to highlight if pastures are irrigated and therefore leaching will be occurring.

1108

Data / Parameter	ρ
Data unit	kg/m ³
Description	Density of methane
Data source	National Greenhouse and Energy Reporting (Measurement) Determination 2008 [6]
Value	0.6784
Quality assurance / quality control considerations	Ensure the most recently available published data is used in alignment with the Australian NIR.

1109

1110

Question Reference 4.8.

1111

Ash content of feed intake for sheep is currently set at 0.08. Stakeholders have previously suggested this value should be higher. Is there data available to support a revision to this parameter?

1112

1113

Data / Parameter	A
Data unit	fraction
Description	Fractional ash content of feed intake.
Data source	National Inventory Report, Volume 1 [1]
Value	0.08
Quality assurance / quality control considerations	Ensure the most recently available published data is used in alignment with the Australian NIR.

1114

Data / Parameter	EF _{PRP}
Data unit	kg N ₂ O-N/kg N
Description	Emission factor urine and dung deposited on pasture, range and paddock
Data source	IPCC 2019, Volume 4, Chapter 11, Table 11.1 [11]
Value	0.004
Quality assurance / quality control considerations	Ensure the most recently available published data is used in alignment with the Australian NIR.

1115

1116

1117

Data / Parameter	SRW _k
Data unit	kg
Description	Standard reference weight
Data source	National Inventory Report Volume 2, Table A5.5.4.7 [4]
Value	See Table 12.1.4.6 in Chapter 12 Appendix Select appropriate default value for location of sheep and sheep class
Quality assurance / quality control considerations	Ensure the most recently available published data is used in alignment with the Australian NIR.

1118

Data / Parameter	FracGASMsoil
Data unit	(kg NH ₃ -N + NO _x -N)/kg N
Description	Fraction of nitrogen volatilised from urine and faeces deposited on pasture
Data source	IPCC 2019, Volume 4, Chapter 11, Table 11.3 [11]
Value	0.21
Quality assurance / quality control considerations	Ensure the most recently available published data is used in alignment with the Australian NIR.

1119

Data / Parameter	FracLEACH
Data unit	fraction
Description	Fraction of N that is lost through leaching and runoff
Data source	National Greenhouse Gas Inventory Volume 1 [13, p. 1]
Value	0.24
Quality assurance / quality control considerations	Ensure the most recently available published data is used in alignment with the Australian National Greenhouse Gas Inventory.

1120

Data / Parameter	EF _{leach}
Data unit	kg N ₂ O-N/kg N
Description	Emission factor for leaching and runoff
Data source	National Greenhouse Gas Inventory Volume 1 [13, p. 1]
Value	0.011
Quality assurance / quality control considerations	Ensure the most recently available published data is used in alignment with the Australian NIR.

1121

1122 4.5 References

- 1123 [1] Department of Climate Change, Energy, the Environment and Water, “National Inventory
1124 Report 2023, Volume I.” Australian Government, 2023. [Online]. Available:
1125 <https://www.dcceew.gov.au/sites/default/files/documents/national-inventory-report-2023->
1126 [volume-1.pdf](https://www.dcceew.gov.au/sites/default/files/documents/national-inventory-report-2023-)
- 1127 [2] E. J. McGahan, K. D. Casey, H. van Sliedregt, E. A. Gardner, P. J. Watts, and R. W.
1128 Tucker, “Beefbal – A nutrient balance model for feedlots,” Department of Primary
1129 Industries, Toowoomba, version 1.1, 2004.
- 1130 [3] S. Wiedemann, T. Sullivan, and E. McGahan, “GHG prediction methods for feedlots,
1131 poultry and pigs.,” Federal Department of the Environment, Canberra, Technical report
1132 for the Department of Environment Greenhouse Gas Inventory Team.
- 1133 [4] Department of Climate Change, Energy, the Environment and Water, “National Inventory
1134 Report 2023, Volume II.” Australian Government, 2023. [Online]. Available:
1135 <https://www.dcceew.gov.au/sites/default/files/documents/national-inventory-report-2023->
1136 [volume-2.pdf](https://www.dcceew.gov.au/sites/default/files/documents/national-inventory-report-2023-)
- 1137 [5] IPCC, “Volume 4: Agriculture, Forestry and Other Land Use. Chapter 10: Emissions from
1138 Livestock and Manure Management.” IPCC, 2019.
- 1139 [6] Office of Parliamentary Counsel, Canberra, “National Greenhouse and Energy Reporting
1140 (Measurement) Determination 2008.” Department of Climate Change, Energy, the
1141 Environment and Water, 2024. [Online]. Available:
1142 <https://www.legislation.gov.au/F2008L02309/latest/downloads>
- 1143 [7] IPCC Expert Groups, “IPCC Good Practice Guidance and Uncertainty Management in
1144 National Greenhouse Gas Inventories. Chapter 4: Agriculture.” IPCC. [Online]. Available:
1145 https://www.ipcc-nggip.iges.or.jp/public/gp/english/4_Agriculture.pdf
- 1146 [8] SCA, “Feeding Standards for Australian Livestock: Ruminants.,” CSIRO, Melbourne,
1147 Australia, 1990.
- 1148 [9] M. Freer, A. D. Moore, and J. R. Donnelly, “GrazPlan – Decision Support Systems For
1149 Australian Grazing Enterprises. II. The Animal Biology Model For Feed Intake,
1150 Production and Reproduction and the Grazfeed DSS,” *Agricultural Systems*, vol. 54, pp.
1151 77–126, 1997.
- 1152 [10] D. J. Minson and C. K. McDonald, “Estimating Forage Intake from the Growth of Beef
1153 Cattle,” *Tropical Grasslands*, vol. 21, no. 3, Sept. 1987, [Online]. Available: [chrome-
1154 extension://dbchgeokljmcmdjbpfiaagmjdkohkneq/content-
1155 script/index.html?file=https%253A%252F%252Fwww.tropicalgrasslands.info%252Fpubli
1156 c%252Fjournals%252F4%252FHistoric%252FTropical%252520Grasslands%252520Jou
1157 rnal%252520archive%252FPDFs%252FVol_21_1987%252FVol_21_03_87_pp116_122
1158 .pdf](chrome-extension://dbchgeokljmcmdjbpfiaagmjdkohkneq/content-script/index.html?file=https%253A%252F%252Fwww.tropicalgrasslands.info%252Fpublic%252Fjournals%252F4%252FHistoric%252FTropical%252520Grasslands%252520Journal%252520archive%252FPDFs%252FVol_21_1987%252FVol_21_03_87_pp116_122.pdf)
- 1159 [11] IPCC, “Chapter 11: N2O Emissions from Managed Soils, and CO2 Emissions from Lime
1160 and Urea Application,” IPCC Guidelines for National Greenhouse Gas Inventories,
1161 Volume 4, 2019. [Online]. Available: [chrome-
1162 extension://dbchgeokljmcmdjbpfiaagmjdkohkneq/content-
1163 script/index.html?file=https%253A%252F%252Fwww.ipcc-
1164 nggip.iges.or.jp%252Fpublic%252F2019rf%252Fpdf%252F4_Volume4%252F19R_V4_
1165 Ch10_Livestock.pdf](chrome-extension://dbchgeokljmcmdjbpfiaagmjdkohkneq/content-script/index.html?file=https%253A%252F%252Fwww.ipcc-nggip.iges.or.jp%252Fpublic%252F2019rf%252Fpdf%252F4_Volume4%252F19R_V4_Ch10_Livestock.pdf)
- 1166 [12] IPCC, “Chapter 10: Emissions from Livestock and Manure Management,” IPCC
1167 Guidelines for National Greenhouse Gas Inventories, Volume 4, 2019. [Online].
1168 Available: [chrome-
1169 extension://dbchgeokljmcmdjbpfiaagmjdkohkneq/content-
1170 script/index.html?file=https%253A%252F%252Fwww.ipcc-
1171 nggip.iges.or.jp%252Fpublic%252F2019rf%252Fpdf%252F4_Volume4%252F19R_V4_
1172 Ch10_Livestock.pdf](chrome-extension://dbchgeokljmcmdjbpfiaagmjdkohkneq/content-script/index.html?file=https%253A%252F%252Fwww.ipcc-nggip.iges.or.jp%252Fpublic%252F2019rf%252Fpdf%252F4_Volume4%252F19R_V4_Ch10_Livestock.pdf)
- 1172 [13] Department of Climate Change, Energy, the Environment and Water, “National Inventory
1173 Report 2022: Volume 1,” Australian Government, 2024. [Online]. Available:
1174 <https://www.dcceew.gov.au/sites/default/files/documents/national-inventory-report-2022->
1175 [volume-1.pdf](https://www.dcceew.gov.au/sites/default/files/documents/national-inventory-report-2022-)

- 1176 [14]KM Christie-Whitehead and Dairy Australia, “Australian Dairy Carbon Calculator,”
1177 Tasmanian Institute of Agriculture; Dairy Australia, Launceston, Tasmania; Melbourne,
1178 Victoria, Feb. 2025. [Online]. Available: [https://www.dairyaustralia.com.au/en/climate-](https://www.dairyaustralia.com.au/en/climate-and-environment/greenhouse-gas-emissions/australian-dairy-carbon-calculator)
1179 [and-environment/greenhouse-gas-emissions/australian-dairy-carbon-calculator](https://www.dairyaustralia.com.au/en/climate-and-environment/greenhouse-gas-emissions/australian-dairy-carbon-calculator)
1180 [15][Core Writing Team IPCC R. K. Pachauri and L. A. Meyer (eds.)], “Climate Change
1181 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth
1182 Assessment Report of the Intergovernmental Panel on Climate Change.” IPCC, 2014.
1183
- 1184