Reducing Enteric Methane Emissions from Beef Cattle

Federal Offset Protocol

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Canada's Greenhouse Gas Offset Credit System

Environment and Climate Change Canada
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Foreword

Canada's Greenhouse Gas (GHG) Offset Credit System is established under Part 2 of the *Greenhouse Gas Pollution Pricing Act* (GGPPA) to provide an incentive to undertake projects that result in domestic GHG reductions that would not have been generated in the absence of the project, that go beyond legal requirements and that are not subject to carbon pollution pricing mechanisms.

Canada's GHG Offset Credit System consists of:

- The *Canadian Greenhouse Gas Offset Credit System Regulations* (the Regulations), which establish the system, implement operational aspects and set general requirements applicable to all project types;
- Federal offset protocols, included in the *Compendium of Federal Offset Protocols* (the Compendium), each containing requirements for project implementation and methods for quantifying GHG reductions for a given project type; and
- The Credit and Tracking System (CATS) to register offset projects, issue and track offset credits, and share key information through a public registry.

Only projects following a federal offset protocol included in the Compendium and meeting all requirements outlined in the Regulations can generate offset credits under the Regulations.

> Text in blue boxes is provided throughout this draft version for context only but will not be included in the final protocol.

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1.0 Introduction

Enteric fermentation is a natural digestive process in ruminants whereby microbial populations in the digestive system assist in the breakdown of feed into more readily available molecules and nutrients. As part of this process, a portion of the feed is converted into methane and released back into the atmosphere by the cattle as an enteric emission through eructation.

The *Reducing Enteric Methane Emissions from Beef Cattle* federal offset protocol will be intended for use by a proponent undertaking a project to reduce enteric methane emissions in confined beef cattle feeding operations through improved management, diet reformulation, the use of feed additives, growth promotors or other innovative strategies in order to generate offset credits under the *Canadian Greenhouse Gas Offset Credit System Regulations* (the Regulations). Implementation of project activities will reduce the quantity of greenhouse gases (GHGs) emitted per unit mass of beef produced by improving animal performance or directly reducing enteric methane emissions. Improvements to animal performance may also result in decreased methane and nitrous oxide emissions from manure.

The proponent must follow the methodology and requirements set out in this protocol, including to quantify and report GHG emission reductions generated by the eligible project activities. The requirements contained in this protocol are part of the Regulations and must be read in conjunction with provisions in the Regulations.

This protocol is designed to ensure a project generates GHG emission reductions that are real, additional, quantified, verified, unique and permanent. The protocol is also developed in accordance with the principles of ISO 14064-2:2019 *Greenhouse gases – Part 2 – Specification with guidance at the project level for quantification, monitoring and reporting greenhouse gas emission reductions or removal enhancements* to ensure reported GHG emission reductions generated as a result of implementing a project are relevant, complete, consistent, accurate, transparent, and conservative.

A project undertaken using this protocol cannot generate GHG emission reductions during cattle grazing, from dairy cattle or from the use of emerging feeds or technologies that directly inhibit enteric methane production without improved animal performance.

> GHG emissions reductions from cattle other than beef cattle and from technologies that directly inhibit enteric methane emissions will be considered for incorporation in the protocol in the future.

2.0 Terms and Definitions

Act

means the *Greenhouse Gas Pollution Pricing Act* (GGPPA).

Animal group

means a specific sub-set of animals in a stratum that all coincide at the project site for at least one day during a production period.

Concentrates

means a feed or feed ingredient that is high in energy and low in fiber.

Confinement area

means an indoor or outdoor enclosure for cattle including but not limited to barns, boxes, stalls, barnyards, winter feeding yards, or feedlots.

Daily dry matter intake (DDMI)

means the quantity of feed consumed per day by animals on a dry weight basis.

Diet

means the feed ingredients or mixture of ingredients that is consumed by animals including the amount and composition of feed given to animals over a defined period of time.

Dressing percentage

means the mass of the animal after slaughter and dressing (removal of internal organs and inedible portions) over the live weight.

Emission intensity

means a ratio of the GHG emissions per unit mass of beef produced.

Enteric methane emissions

means the methane emissions produced in the rumen of an animal by enteric fermentation and eructated to the atmosphere.

Forage

means hay, silage, pasture, straw, or high-fiber crop by-products provided to animals as feed.

Global warming potential (GWP)

means a metric representing the ability of a GHG to trap heat in the atmosphere compared to CO_2, as provided in Column 2 of Schedule 3 to the Act.

Grazing

means the activity of allowing cattle to directly seek out and consume forage such as grasses, forbs or legumes in a pasture or rangeland.

Gross energy (GE)

means the total quantity of energy contained in animal feed.

Hot carcass weight

means the measured mass of the un-chilled animal carcass after the head, hide and internal organs have been removed.

Median date of animal exit

means the median date animals in a group exit the project site.

Neutral detergent fiber (NDF)

means the total quantity of structural plant ingredients and is used as an indicator of animal feed quality and determined by boiling the forage in a neutral detergent solution and measuring the insoluble residue.

Production period

means the period of time an animal group remains continuously housed and fed on the project site starting on the date of entry for the first animal in the group and ending on the date of exit for the last animal in the group.

Project site

means the spatial boundaries of the area and buildings used to house and feed cattle and store manure in the baseline and project scenarios.

Qualified professional

means a person who has appropriate education, training, or experience and any licensure or certification required for the province or territory in which the project is located to perform a task or make a decision at hand.

Regulations

means the *Canadian Greenhouse Gas Offset Credit System Regulations*.

Rumen

means the reticulo-rumen and is the largest compartment in a ruminant animal’s stomach. Also referred to as the forestomach.

Rumen-protected lipid

means a lipid source fed to animals that is protected from microbial fermentation in the rumen. May also be referred to as rumen bypass lipid or rumen bypass fat.

Stratum

means a set of cattle in either the baseline or the project scenarios, identified by the proponent for the purpose of quantifying GHG emissions reductions and made up of one or more animal groups.

Supplemented lipid

means a rumen-unprotected lipid that is added to the diet as a distinct feed ingredient for the purpose of inhibiting methane emissions and is also referred to as added fat, oilseeds or edible oils.

Total digestible nutrients (TDN)

means the energy content of the digestible carbohydrate, protein, and lipid ingredients in an animal feed.

3.0 Baseline scenario

3.1 Baseline conditions

The following baseline conditions must apply in the baseline scenario in order for a project to be eligible under this protocol:

- Historical reference data is available to quantify baseline scenario GHG emission intensity as described in Section 3.2 and 8.1.
- Beef cattle in the baseline scenario are not grazed for the period of time where GHG emissions are quantified.

3.2 Determining the baseline scenario

The proponent must determine the baseline scenario using the GHG emission intensity of historical practices at the project site prior to the project start date. The proponent must quantify the GHG emissions from baseline scenario sources, sinks and reservoirs (SSRs) referred to in Section 7.0 that would have been generated in the absence of the project to produce the quantity beef determined in the project scenario.

The proponent must quantify the GHG emission intensity for the baseline scenario for each stratum. The GHG emission intensity for the baseline scenario is an average GHG emission intensity of at least one animal group per year from at least three continuous years starting no more than five years prior to the project start date for each stratum (see Equations 3 to 10). The proponent may use animal groups from three non-continuous years from within the past five years if the crude protein content of the diet for each animal group did not exceed 14%.

Reference data for the baseline scenario must be derived from animals and activities undertaken at the project site.

4.0 Project scenario

The project scenario represents the GHG emission reductions generated by the project for the included project scenario SSRs referred to in Section 7.0.

4.1 Project conditions

The following project conditions must apply in the project scenario in order for a project to be eligible under this protocol:

- Within the project site one or more eligible project activities from the categories of eligible project activities listed in Table 1 are implemented.
- Eligible project activities must not have been implemented before January 1st, 2017.
- All feed, feed additives, or drugs delivered to cattle must be approved for regulatory use in Canada and used in accordance with all relevant legislation.

- GHG emissions reductions resulting from eligible project activities must be quantifiable using the quantification methodology outlined in Section 8.0.
- Beef cattle in the project scenario are not grazed for the period of time where GHG emissions are quantified.

Each stratum in the project scenario must consist of a single animal group. Each stratum in the project scenario must have a corresponding stratum in the baseline scenario that must be comparable based on the stratification conditions in Section 8.3.

4.2 Eligible project activities

Project activities will reduce the GHG emission intensity in cattle feeding operations for the included project SSRs referred to in Section 7.0. No single activity, management practice, or diet is prescribed by the protocol. It is recognized that each cattle feeding operation has unique needs, and the proponent may choose to undertake one or more project activities based on the unique circumstances of each project.

As part of a project, the proponent must implement at least one eligible project activity from the categories of eligible project activities listed in Table 1. Descriptions in Table 1 provide examples of specific eligible project activities for each category, but do not constitute an exhaustive list of all possible project activities in these categories.

Table 1: Categories of eligible project activities

Category	Description
Improved management	Activities that increase animal performance through improved animal management such as but not limited to, improved animal health, tracking, sorting, customized feeding, and pen-cleanliness.
Diet reformulation	Changes to the diet of cattle to improve digestion or supress methane emissions such as reducing forage content of the diet, improving forage quality, or adding supplemented lipid to the diet. Supplemented lipid must not be rumen-protected and must be added in addition to the normal lipid content of the diet.
Feed additives	The addition of minor ingredients to the diet to improve animal performance, feed efficiency or weight gain such as ionophores, yeasts, essential oils, or other digestion enhancers. Adjusting the prescribed dose of ionophores for the purpose of improving feed efficiency or cattle weight gain is an eligible project activity.
Growth promoters	The use of growth promoters such as beta-agonists or hormonal implants to improve animal growth and / or feed efficiency.
Other innovative strategies	Other innovative strategies that improve the feed efficiency or animal performance.

As part of a project, the proponent may implement the GHG mitigation activity described in Table 2 provided that they also implement at least one eligible project activities in Table 1.

Table 2: Other permitted GHG mitigation activities

Activity	Description
Genetic Selection	The breeding or procurement of animals with improved genetics that reduce enteric methane emissions and / or improve feed efficiency.

The proponent must clearly describe the project activities implemented at the project site. The description must include:

- All project activities derived from the categories of eligible project activities in Table 1 being implemented at the project site.
- Whether the GHG mitigation activity from Table 2 is being implemented at the project site.
- The dates on which each identified activity from Table 1 or Table 2 was implemented at the project site for each stratum.
- How the project activities are expected to reduce GHG emissions compared to the baseline scenario.

5.0 Additionality

5.1 Legal additionality

GHG emission reductions generated by a project must not occur as a result of federal, provincial or territorial regulations, municipal by-laws, or any other legally binding mandates.

A project with a legal requirement to implement the project activities is not considered to be additional, and therefore is not eligible for registration.

If at any time after project registration the GHG emission reductions generated by the project become required by law or the result of a legal requirement, the GHG emission reductions will no longer be additional and, therefore, offset credits can only be issued for GHG emission reductions generated up to the date immediately preceding the date on which the law or the legal requirement comes into force.

5.2 Performance standard test

The determination of the baseline scenario supports the assertion of additionality as it establishes the business-as-usual GHG mitigation practices that were in place on the project site prior to the project start date. Only GHG emission reductions beyond the baseline scenario are additional.

6.0 General requirements

6.1 Project start date

The start date of a project corresponds to the first day one or more eligible project activities were implemented at the project site. In the case of a project that implements multiple project activities with different implementation dates, or with strata that have different project activity implementation dates, the project start date is the day on which the first project activity was implemented for the first stratum at the project site.

6.2 Project site and geographic boundaries

The proponent must document and report the location and geographic boundaries of the project site and submit a site plan. The site plan must show:

- The location of all animal housing and confinement areas used to house or feed animals in the baseline and project scenarios.
- The location and type of each manure storage system used to manage manure within the project site.

The geographic boundary of the project site cannot change after the first reporting period, but project activities can expand within the boundary. Any changes to the site plan must be communicated as specified in the Regulations.

6.3 Environmental and social safeguards

The proponent must ensure that:

- The project site is in compliance with all applicable federal, provincial, territorial, and municipal by-laws or regulations, including those related to the management of manure.
- The quantity of supplemented lipid fed to cattle at any given time during the reporting period must not exceed 6% of the diet by dry weight to prevent negative health impacts to cattle.

7.0 Project GHG boundary

The project GHG boundary (Figure 1) contains the GHG SSRs that must be included by the proponent in the baseline and / or the project scenarios to determine the GHG emission reductions generated by the project.

Table 3 provides additional details on the SSRs identified for the baseline and project scenarios, as well as justification for their inclusion or exclusion in the quantification of GHG emission reductions.

Three GHGs are relevant to the SSRs in this protocol: Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

Figure 1: Illustration of the project GHG boundary

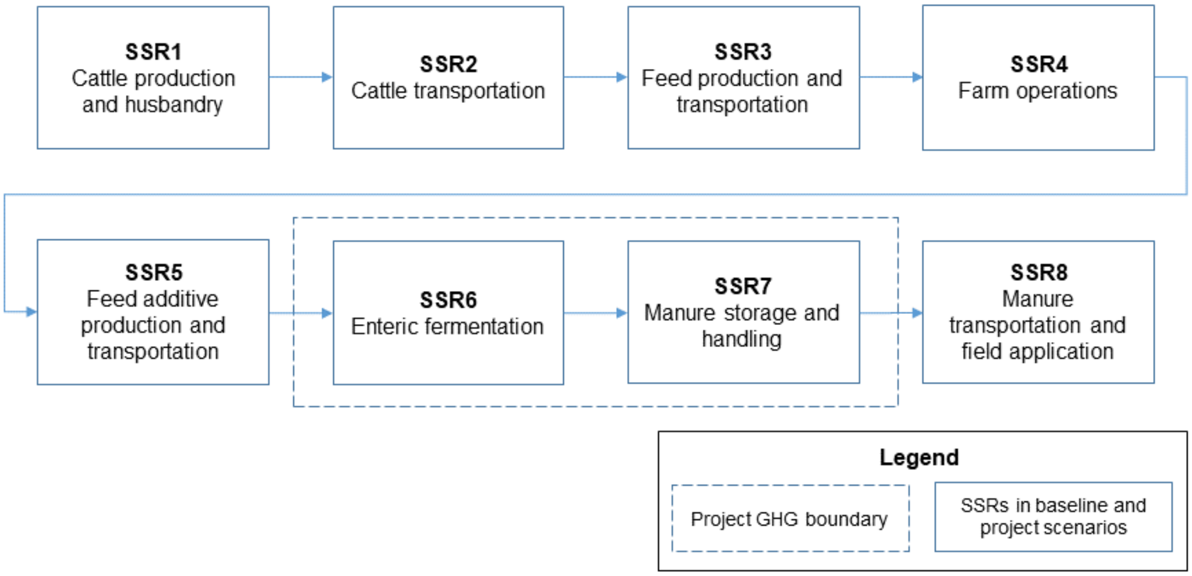

Table 3: Details on baseline and project scenario SSRs

SSR	Title	Type	Description	Baseline or Project	GHG	Included or Excluded
1	Cattle production and husbandry	Related	Emissions upstream or downstream from the project site associated with the birth, rearing, maintenance and growth of cattle.	Baseline (B1) Project (P1)	CO_2	**Excluded:** No significant change in GHG emission intensity expected as a result of the project activities.
					CH_4	
					N_2O	
2	Cattle transportation	Related	Emissions from energy associated with the movement and transport of cattle to and from the project site.	Baseline (B2) Project (P2)	CO_2	**Excluded:** No significant change in GHG emission intensity expected as a result of the project activities.
					CH_4	
					N_2O	
3	Feed production and transportation	Related	Emissions associated with the growth, processing and transportation of feed.	Baseline (B3) Project (P3)	CO_2	**Excluded:** No significant change in GHG emission intensity expected as a result of the project activities.
					CH_4	
					N_2O	

4	Farm operations	Controlled	Emissions associated with the operation and maintenance of the cattle operation such as from the energy used by vehicles or for heat.	Baseline (B4) Project (P4)	CO_2 CH_4 N_2O	**Excluded:** No significant change in GHG emission intensity expected as a result of the project activities.
5	Feed additive production and transportation	Affected	Emissions associated with the manufacturing, production, creation, and transport of feed additives.	Baseline (B5) Project (P5)	CO_2 CH_4 N_2O	**Excluded:** Feed additives are administered in small quantities and will displace feed. Net change in emissions would likely be negligible.
6	Enteric fermentation	Controlled	Emissions from enteric fermentation of the feed consumed by cattle.	Baseline (B6) Project (P6)	CH_4	**Included:** Eligible project activities will affect methane produced through enteric fermentation.
7	Manure storage and handling	Controlled	Emissions from decomposition of managed manure from the project site.	Baseline (B7) Project (P7)	CH_4 N_2O	**Included:** Eligible project activities may affect GHG emissions due to changes in the composition and quantity of manure produced.
8	Manure transportation and field application	Related	Emissions associated with energy used for transportation, field application and decomposition manure at its final destination.	Baseline (B8) Project (P8)	CO_2 CH_4 N_2O	**Excluded:** This SSR is conservatively excluded.

8.0 Quantification methodology

This section contains the quantification methodology that must be followed to quantify baseline and project scenario GHG emissions, which are subsequently used to quantify the GHG emission reductions generated by the project.

Baseline scenario GHG emissions are the GHG emissions that would have been generated in the absence of the project, based on SSRs within the project GHG boundary, relative to the beef production in the project scenario. To enable this quantification, the methodology uses the GHG emission intensity of historical practices at the project site prior to the offset project, based on the GHG emissions and beef production in the baseline scenario.

Project scenario GHG emissions are the actual GHG emissions that occur from SSRs within the project GHG boundary. The GHG emission reductions generated by the project are quantified by deducting the project scenario GHG emissions from the baseline scenario GHG emissions as outlined in Section 8.5.

The quantification of both baseline and project scenario GHG emission must include all the GHG emissions that occurred during the reporting period and must include sub-totals in tonnes of CO_2 equivalent (tCO_2e) for each full or partial calendar year to support issuance of the resulting offset credits by calendar year.

For the purposes of reporting GHG emission reductions and issuance of offset credits for projects under this protocol, GHG emissions reductions are quantified and attributed to the reporting period and the calendar year in which the median date of animal exit of each stratum in the project scenario falls.

For projects within an aggregation, the proponent must quantify GHG emission reductions for each project separately. Subsequently, the GHG emission reductions for each project will be summed together to determine the GHG emissions reductions for the aggregation of projects.

8.1 Baseline scenario GHG emissions

8.1.1 Total baseline scenario GHG emissions

The proponent must use Equation 1 to quantify the baseline scenario GHG emissions for each full or partial calendar year covered by the reporting period, based on the included SSRs outlined in Table 3.

Equation 1 must include all strata in the baseline scenario that correspond to the strata in the project scenario with a median date of animal exit that falls within a specific calendar year covered by the reporting period. Multiple strata in the project scenario may correspond to the same stratum in the baseline scenario and hence reference the same GHG emission intensity value.

Equation 1: Baseline scenario GHG emissions for a calendar year in the reporting period

$$BE_C = \sum_{k}^{n} \left(EI_{BE,i} \times Production_{PE,k} \right)$$

Where,			*Units*
BE_C	=	GHG emissions from the strata in the baseline scenario that correspond to the strata in the project scenario with a median date of animal exit that falls within a calendar year covered by the reporting period	tCO_2e
$EI_{BE,i}$	=	GHG emission intensity from stratum i in the baseline scenario, as per Equation 2.	$tCO_2e\ kg^{-1}$
$Production_{PE,k}$	=	Beef production for stratum k in the project scenario, as per Equation 20	kg
i	=	Specific stratum in the baseline scenario that corresponds to stratum k in the project scenario	-
k	=	Specific stratum in the project scenario with a median date of animal exit that falls within a calendar year covered by the reporting period	-
n	=	Number of strata k in the project scenario with a median date of animal exit that falls within a calendar year covered by the reporting period	-
C	=	Calendar year	-

Equation 2: GHG emission intensity for a stratum in the baseline scenario

$$EI_{BE,i} = \left(EM_{BE,i} + MM_{BE,i} + SN_{BE,i} + VN_{BE,i} + LN_{BE,i} \right) \div Production_{BE,i}$$

Where,			Units
$EI_{BE,i}$	=	GHG emission intensity for stratum i in the baseline scenario	$tCO_2e\ kg^{-1}$
$EM_{BE,i}$	=	Enteric methane (CH_4) emissions from stratum i in the baseline scenario, as per Equation 3 (SSR 6)	tCO_2e
$MM_{BE,i}$	=	CH_4 emissions from manure storage for stratum i in the baseline scenario, as per Equation 5 (SSR 7)	tCO_2e
$SN_{BE,i}$	=	Direct nitrous oxide (N_2O) emissions from manure storage for stratum i in the baseline scenario, as per Equation 7 (SSR 7)	tCO_2e

$VN_{BE,i}$	=	Indirect N_2O emissions from volatilization of managed manure for stratum i in the baseline scenario, as per Equation 9 (SSR 7)	tCO_2e
$Production_{BE,i}$	=	Indirect N_2O emissions from leaching of managed manure for stratum i in the baseline scenario, as per Equation 10 (SSR 7)	tCO_2e
Production $_{BE,i}$	=	Beef production for stratum i in the baseline scenario, as per Equation 11	kg
i	=	Specific stratum in the baseline scenario	-

8.1.2 Enteric methane emissions in the baseline scenario

Equation 3 must be used to quantify enteric methane emissions associated with each stratum for the baseline scenario, which corresponds to SSR 6. Enteric methane emissions must be quantified for each animal group in the baseline scenario and then averaged over the total number of animal groups chosen to represent a stratum in the baseline scenario in accordance with Section 3.2.

Equation 3: Enteric methane emissions for a stratum in the baseline scenario

$$EM_{BE,i} = \sum_{g}^{n} \left(AN_g \times GE_g \times DDMI_g \times Y_{m,g} \times EF_{lip,g} \times DOF_g \div 55.65 \times GWP_{CH4} \div 1000 \right) \div n$$

Where,			Units
$EM_{BE,i}$	=	Enteric methane (CH_4) emissions for stratum i in the baseline scenario	tCO_2e
AN_g	=	Number of animals in animal group g in stratum i	head
GE_g	=	Gross energy intake for the diet of animal group g in stratum i	MJ kg^{-1}
$DDMI_g$	=	Average daily dry matter intake per head of cattle for animal group g in stratum i, as per Equation 4	kg $head^{-1}$ $days^{-1}$
$Y_{m,g}$	=	Default enteric CH_4 conversion factor for the diet of animal group g in stratum i, as set out in Schedule A – Table 6	-
$EF_{lip,g}$	=	Default emissions factor for the addition of supplemented lipid fed to animal group g in stratum i, as set out in Schedule A – Table 7	-
DOF_g	=	Days on feed for animal group g in stratum i	days

55.65	=	The specific energy content of CH_4	MJ kg CH_4^{-1}
GWP_{CH4}	=	GWP of CH_4, as provided in Column 2 of Schedule 3 to the Act	-
1000	=	Kilograms per metric tonne	kg t^{-1}
i	=	Specific stratum in the baseline scenario	-
g	=	Specific animal group in stratum i	-
n	=	Number of animal groups in stratum i for the baseline scenario	-

Equation 4: Average daily dry matter intake per head of cattle in an animal group

$$\mathrm{DDMI_g} = \left(\mathrm{DM_g} - \mathrm{DM_{waste,g}}\right) \div \mathrm{AN_g} \times \mathrm{DOF_g}$$

Where,			Units
$DDMI_g$	=	Average daily dry matter intake per head of cattle for animal group g in a stratum	kg $head^{-1}$ day^{-1}
DM_g	=	Quantity of dry matter delivered to animal group g in a stratum	kg
$DM_{waste,g}$	=	Quantity of dry matter delivered that was wasted or uneaten by animal group g in a stratum	kg
AN_g	=	Number of animals in animal group g in a stratum	head
DOF_g	=	Days on feed for animal group g in a stratum	days
g	=	Specific animal group of a stratum	-

8.1.3 GHG emissions from manure storage and handling in the baseline scenario

Equations 5 through 10 must be used to quantify manure methane and nitrous oxide emissions from manure storage and handling for the baseline scenario. Equations 5, 7, 9 and 10 rely on default parameters for conversion, emissions, and fraction factors based on the type of manure storage system. Default parameters for these factors are in Schedule A.

The Schedule A parameters for manure storage and handling emissions must be selected for the type of manure storage system in the project scenario. If the manure storage system changes for a stratum after the initial establishment of the baseline scenario GHG emission intensity, the baseline scenario GHG emission intensity for that stratum moving forward must be re-quantified using the updated information. The re-quantified baseline scenario GHG emission intensity is not retroactively applied and is used after the year in which the manure storage system changed.

The parameters selected from Schedule A must apply to all animals within an animal group. If manure is directed to multiple manure storage systems, an average factor weighted to the estimated proportion of manure being contained in each system must be used.

Equation 5: Methane emissions from manure storage for a stratum in the baseline scenario

$$MM_{BE,i} = \sum_{g}^{n}\left(AN_g \times DOF_g \times VS_g \times 0.19 \times \rho_{CH4} \times MCF \times GWP_{CH4} \div 1000\right) \div n$$

Where,			Units
$MM_{BE,i}$	=	Methane (CH_4) emissions from manure storage for stratum i in the baseline scenario	tCO_2e
AN_g	=	Number of animals in animal group g in stratum i	head
DOF_g	=	Days on feed for animal group g in stratum i	days
VS_g	=	Daily volatile solids excreted per head of cattle in animal group g in stratum i, as per Equation 6	kg $head^{-1}$ day^{-1}
0.19	=	Maximum CH_4 producing capacity for manure expressed as a constant of 0.19 CH_4 kg^{-1} of volatile solids excreted	m^3 CH_4 kg^{-1}
ρ_{CH4}	=	CH_4 density conversion factor of 0.67 kg m^{-3}	kg m^{-3}
MCF	=	CH_4 conversion factor for the manure storage system as set out in Schedule A – Table 8	-
GWP_{CH4}	=	GWP of CH_4, as provided in Column 2 of Schedule 3 to the Act	-
1000	=	Kilograms per metric tonne	kg t^{-1}
i	=	Specific stratum the baseline scenario	-
g	=	Specific animal group in stratum i	-
n	=	Number of animal groups in stratum i for the baseline scenario	-

Equation 6: Daily volatile solids excreted for an animal group

$$VS_g = [DDMI_g \times GE_g \times (1 - TDN_g) + (UE \times DDMI_g \times GE_g)] \times (1 - ASH) \div GE_g$$

Where,			Units
VS_g	=	Daily volatile solids excreted per head of cattle in animal group g in stratum	kg day^{-1}
$DDMI_g$	=	Average daily dry matter intake per head of cattle for animal group g in a stratum, as per Equation 4	kg $head^{-1}$ $days^{-1}$
GE_g	=	Gross energy intake for the diet of animal group g in a stratum	MJ kg^{-1}
TDN_g	=	Total digestible nutrients percentage expressed as a decimal for animal group g in a stratum	-
UE	=	Default factor for urinary energy. Use 0.04 for diets with less than 85 % concentrates and 0.02 for diets with greater than or equal to 85 % concentrates	-
ASH	=	Default factor of 0.08 for ash content of manure	-
g	=	Specific animal group in a stratum	-

Equation 7: Direct nitrous oxide emissions from manure storage for a stratum in the baseline scenario

$$SN_{BE,i} = \sum_{g}^{n} \left(AN_g \times DOF_g \times NEX_g \times EF_{MS} \times \frac{44}{28} \times GWP_{N2O} \div 1000 \right) \div n$$

Where,			Units
$SN_{BE,i}$	=	Direct nitrous oxide (N_2O) emissions from manure storage from stratum i for the baseline scenario	tCO_2e
AN_g	=	Number of animals in animal group g in stratum i	head
DOF_g	=	Days on feed for animal group g in stratum i	days
NEX_g	=	Daily mean nitrogen (N) excreted in manure for animal group g in stratum i, as per Equation 8	kg $head^{-1}$ $days^{-1}$
EF_{MS}	=	Emission factor related to the direct N_2O emissions from the manure storage system, as set out in Schedule A – Table 8	kg N_2O-N per kg N stored

44/28	=	Conversion of N_2O-N to N_2O emissions based on molecular mass of N_2O and N_2O-N	-
GWP_{N2O}	=	GWP of N_2O, as provided in Column 2 of Schedule 3 to the Act	-
1000	=	Kilograms per metric tonne	kg t^{-1}
i	=	Specific stratum in the baseline scenario	-
g	=	Specific animal group in stratum i	-
n	=	Number of animal groups in stratum i for the baseline scenario	-

Equation 8: Daily mean nitrogen excreted in manure for an animal group

$$\mathrm{NEX_g} = \mathrm{DDMI_g} \times \mathrm{CP} \times \mathrm{CF_p} \times (1 - \mathrm{NR})$$

Where,			Units
NEX_g	=	Daily mean nitrogen (N) excreted in manure for animal group g in a stratum	kg $head^{-1}$ $days^{-1}$
$DDMI_g$	=	Average daily dry matter intake per head of cattle for animal group g in a stratum, as per Equation 4	kg $head^{-1}$ $days^{-1}$
CP_g	=	Percentage of crude protein in the diet of animal group g in a stratum expressed as a decimal	-
CF_p	=	Default protein conversion factor to describe the dietary protein converted to dietary N. Equal to 6.25 kg of protein per kg of dietary N	kg-protein kg-N^{-1}
NR	=	Default N retention fraction of 0.07 kg N retained per kg N consumed	kg-N-retained kg-$intake^{-1}$
g	=	Specific animal group in a stratum	-

Equation 9: Indirect nitrous oxide emissions from volatilization of managed manure for a stratum in the baseline scenario

$$VN_{BE,i} = \sum_{g}^{n}\left(AN_g \times DOF_g \times NEX_g \times Frac_V \times EF_V \times \frac{44}{28} \times GWP_{N2O} \div 1000\right) \div n$$

Where,			Units
$VN_{BE,i}$	=	Indirect nitrous oxide (N_2O) emissions from volatilization of managed manure from stratum i in the baseline scenario	tCO_2e
AN_g	=	Number of animals in animal group g in stratum i	head
DOF_g	=	Days on feed for animal group g in stratum i	days
NEX_g	=	Daily mean nitrogen (N) excreted in manure for animal group g in stratum i, as per Equation 8	kg $head^{-1}$ $days^{-1}$
$Frac_V$	=	Fraction of nitrogen excreted in manure that volatilizes as ammonia (NH_3) and NO_x from the manure storage system, as set out in Schedule A – Table 8	
EF_V	=	Emission factor for indirect N_2O emissions from volatilization of managed manure by ecozone, as set out in Schedule A – Table 9	kg N_2O-N per kg N deposited
44/28	=	Conversion of N_2O-N to N_2O emissions based on molecular mass of N_2O and N_2O-N	-
GWP_{N2O}	=	GWP of N_2O as provided in Column 2 of Schedule 3 to the Act	-
1000	=	Kilograms per metric tonne	kg t^{-1}
i	=	Specific stratum in the baseline scenario	-
g	=	Specific animal group in stratum i	-
n	=	Number of animal groups in stratum i for the baseline scenario	-

Equation 10: Indirect nitrous oxide emissions from leaching of managed manure for a stratum in the baseline scenario

$$LN_{BE,i} = \sum_{g}^{n} \left(AN_g \times DOF_g \times NEX_g \times Frac_L \times EF_L \times \frac{44}{28} \times GWP_{N2O} \div 1000 \right) \div n$$

Where,			Units
$LN_{BE,i}$	=	Indirect nitrous oxide (N_2O) emissions from leaching of managed manure from stratum i in the baseline scenario	tCO_2e
AN_g	=	Number of animals in animal group g in stratum i	head
DOF_g	=	Days on feed for animal group g in stratum i	days
NEX_g	=	Daily mean nitrogen (N) excreted in manure for animal group g in stratum i, as per Equation 8	kg $head^{-1}$ $days^{-1}$
$Frac_L$	=	Fraction of N excreted in manure leached from the manure storage system, as set out in Schedule A – Table 8	-
EF_L	=	Emission factor from N leaching and runoff set at 0.0075	kg N_2O-N per kg N leached
44/28	=	Conversion of N_2O-N to N_2O emissions based on molecular mass of N_2O and N_2O-N.	-
GWP_{N2O}	=	GWP of N_2O as provided in Column 2 of Schedule 3 to the Act	-
1000	=	Kilograms per metric tonne	kg t^{-1}
i	=	Specific stratum in the baseline scenario	-
g	=	Specific animal group in stratum i	-
n	=	Number of animal groups in stratum i for the baseline scenario	-

8.1.4 Beef production in the baseline scenario

The proponent must used Equation 11 to quantify the beef production value for each stratum in the baseline scenario, which represents the average mass gained. The value used for the average mass of animals at entry and exit in Equation 11 is selected by stratum based on the destination of the animals exiting the project site. For a stratum that is not sent directly to a meat processing facility upon exiting the project site (*e.g.* backgrounding operation), the average mass of animals upon entry and exit is determined by the measure of average live weight of cattle entering ($LW_{enter,g}$) and exiting ($LW_{exit,g}$) the project site. For a stratum sent directly to a meat processing facility after exiting the project site (*e.g.* finishing operation), the average mass of animals upon entry and exit is determined by the calculation of the hot carcass weight (HCW) as per Equation 12. If the average mass of animals for a stratum in the baseline scenario is determined through Equation 12, the average mass of animals for the corresponding stratum in the project scenario must also be determined through Equation 12. The same approach and metric (LW or HCW) must be used for all groups in a stratum.

Equation 11: Beef production for a stratum in the baseline scenario

$$\text{Production}_{\text{BE,i}} = \sum_{g}^{n} (\text{Mass}_{\text{exit,g}} - \text{Mass}_{\text{enter,g}}) \div n$$

Where,			Units
$Production_{BE,i}$	=	Beef production for stratum i in the baseline scenario	kg
$Mass_{exit,g}$	=	Average mass of animals exiting the project site for animal group g in stratum i, determined by either live weight (measured) or hot carcass weight, as per Equation 12	kg
$Mass_{enter,g}$	=	Average mass of animals entering the project site for in animal group g in stratum i, determined by either live weight (measured) or hot carcass weight, as per Equation 12	kg
i	=	Specific stratum in the baseline scenario	-
g	=	Specific animal group in stratum i	-
n	=	Number of animal groups in stratum i for the baseline scenario	-

Equation 12 must be used to calculate both $HCW_{exit,g}$ and $HCW_{enter,g}$. For the purposes of quantification, it is assumed that the dressing percentage is the same at animal entry and exit from the project site. Therefore, the dressing percentage provided by the meat processing facility must be used to calculate both the entry and exit value of HCW_g.

If the meat processing facility does not provide a dressing percentage and only provides hot carcass weight (applicable only to animals exiting the project site, $HCW_{exit,g}$), Equation 13 must be used to solve for dressing percentage and perform the final calculation for $HCW_{enter,g}$. If sufficient data is not available from the meat processing facility, use a default dressing percentage of 59%.

Average values for animal mass entering and exiting the project site and dressing percentage must be quantified using data from all animals within a stratum.

Equation 12: Hot carcass weight for an animal group at either entry or exit from the project site

$$\mathrm{HCW_g} = \mathrm{Dressing_g} \times \mathrm{LW_g}$$

Where,			Units
HCW_g	=	Average hot carcass weight of animals entering ($HCW_{enter,g}$) or exiting ($HCW_{exit,g}$) the project site for animal group g	kg
$Dressing_{,g}$	=	Dressing percentage for animal group g, either directly provided by the meat processing facility or quantified using Equation 13. If data is not available, the proponent must use a default value of 0.59	-
LW_g	=	Average live weight of animals entering ($LW_{enter,g}$) or exiting ($LW_{exit,g}$) the project site for animal group g	kg
g	=	Specific animal group in a stratum	-

Equation 13: Dressing percentage of an animal group in the baseline scenario

$$\mathrm{Dressing_g} = \mathrm{HCW_{exit,g}} \div \mathrm{LW_{exit,g}}$$

Where,			Units
$Dressing_g$	=	Dressing percentage for animal group g	-
$HCW_{exit,g}$	=	Average hot carcass weight of animals exiting the project site for animal group g	kg
$LW_{exit,g}$	=	Average live weight of animals exiting the project site for animal group g	kg
g	=	Specific animal group in a stratum	-

8.2 Project scenario GHG emissions

8.2.1 Project scenario GHG emissions

The proponent must use Equation 14 to quantify the project scenario GHG emissions for each full or partial calendar year of the reporting period based on the included SSRs outline in Table 3.

Equation 14 must include all strata with a median date of animal exit that falls within a specific calendar year covered by the reporting period.

Equation 14: GHG emissions in the project scenario for a calendar year covered by the reporting period

$$PE_c = \sum_{k}^{n}\left(EM_{PE,k} + MM_{PE,k} + SN_{PE,k} + VN_{PE,k} + LN_{PE,k}\right)$$

Where,			Units
PE_C	=	GHG emissions for the strata in the project scenario with a median date of animal exit that falls within a calendar year covered by the reporting period	tCO_2e
$EM_{PE,k}$	=	Enteric methane (CH_4) emissions for stratum k in the project scenario, as per Equation 15 (SSR 6)	tCO_2e
$MM_{PE,k}$	=	Manure CH_4 emissions from manure storage for stratum k in the project scenario, as per Equation 16 (SSR 7)	tCO_2e
$SN_{PE,k}$	=	Direct nitrous oxide (N_2O) emissions from manure storage for stratum k in the project scenario, as per Equation 17 (SSR 7)	tCO_2e
$VN_{PE,k}$	=	Indirect N_2O emissions from volatilization of managed manure for stratum k in the project scenario, as per Equation 18 (SSR 7)	tCO_2e
$LN_{PE,k}$	=	Indirect N_2O emissions from leaching of managed manure for stratum k in the project scenario, as per Equation 19 (SSR 7)	tCO_2e
k	=	Specific stratum in the project scenario	-
n	=	Number of strata with a median date of animal exit that falls within a calendar year covered by the reporting period	-
C	=	Calendar year	-

8.2.2 Enteric methane emissions in the project scenario

Equation 15 must be used to quantify the enteric methane emissions associated with each stratum for the project scenario.

Equation 15: Enteric methane emissions for a stratum in the project scenario

$$EM_{PE,k} = AN_g \times GE_g \times DDMI_g \times Y_{m,g} \times EF_{lip,g} \times DOF_g \div 55.65 \times GWP_{CH4} \div 1000$$

Where,			Units
$EM_{PE,k}$	=	Enteric methane (CH_4) emissions for stratum k in the project scenario	tCO_2e
AN_g	=	Number of animals in animal group g in stratum k	head
GE_g	=	Gross energy intake for the diet of animal group g in stratum k	MJ kg^{-1}
$DDMI_g$	=	Average daily dry matter intake per head of cattle for animal group g in stratum k, as per Equation 4	kg $head^{-1}$ $days^{-1}$
$Y_{m,g}$	=	Default enteric CH_4 conversion factor for the diet of animal group g in stratum k, as set out in in Schedule A – Table 6	-
$EF_{lip,g}$	=	Default emissions factor for the addition of supplemented lipid for animal group g in stratum k, as set out in Schedule A – Table 7	-
DOF_g	=	Days on feed for animal group g in stratum k	days
55.65	=	Specific energy content of CH_4	MJ $kgCH_4^{-1}$
GWP_{CH4}	=	GWP of CH_4 as provided in Column 2 of Schedule 3 to the Act	-
1000	=	Kilograms per metric tonne	kg t^{-1}
g	=	Specific animal group in stratum k	-
k	=	Specific stratum in the project scenario	-

8.2.3 GHG emissions from manure storage and handling in the project scenario

Equations 16 through 19 must be used to quantify methane and nitrous oxide emissions from manure storage and handling for the project scenario. They rely on default parameters for conversion, emissions, and fraction factors based on the type of manure storage system in the project scenario. Default values for these parameters are in Schedule A.

If manure from a stratum is directed to multiple manure storage systems, an average factor weighted to the estimated proportion of manure being contained in each system must be used.

Equation 16: Manure methane emissions from manure storage for a stratum in the project scenario

$$MM_{PE,k} = AN_g \times DOF_g \times VS_g \times 0.19 \times \rho_{CH4} \times MCF \times GWP_{CH4} \div 1000$$

Where,			Units
$MM_{PE,k}$	=	Manure methane (CH_4) emissions from manure storage from stratum k in the project scenario	tCO_2e
AN_g	=	Number of animals in animal group g in stratum k	head
DOF_g	=	Days on feed for animal group g in stratum k	days
VS_g	=	Daily volatile solids excreted per head of cattle in animal group g in animal stratum k, as per Equation 6	kg head^{-1} day^{-1}
0.19	=	Maximum CH_4 producing capacity for manure expressed as a constant of 0.19 CH_4 kg^{-1} of volatile solids excreted	m^3 CH_4 kg^{-1}
ρ_{CH4}	=	CH_4 density conversion factor 0.67 kg m^{-3}	kg m^{-3}
MCF	=	CH_4 conversion factor for the manure storage system, as set out in Schedule A – Table 8	-
GWP_{CH4}	=	GWP of CH_4 as provided in Column 2 of Schedule 3 to the Act	-
1000	=	Kilograms per metric tonne	kg t^{-1}
g	=	Specific animal group in stratum k	
k	=	Specific stratum the project scenario	-

Equation 17: Direct nitrous oxide emissions from manure storage for a stratum in the project scenario

$$SN_{PE,k} = AN_g \times DOF_g \times NEX_g \times EF_{MS} \times \frac{44}{28} \times GWP_{N2O} \div 1000$$

Where,			Units
$SN_{PE,k}$	=	Direct nitrous oxide (N_2O) emissions from manure storage for stratum k in the project scenario	tCO_2e
AN_g	=	Number of animals in animal group g in stratum k	head
DOF_g	=	Days on feed for animal group g in stratum k	days
NEX_g	=	Daily mean nitrogen (N) excreted in manure for animal group g in stratum k, as per Equation 8	kg head^{-1} days^{-1}
EF_{MS}	=	Emission factor related to the direct N_2O emissions from the manure storage system, as set out in Schedule A – Table 8	kg N_2O-N per kg N stored
44/28	=	Conversion of N_2O-N to N_2O emissions based on molecular mass of N_2O and N_2O-N	-
GWP_{N2O}	=	GWP of N_2O as provided in Column 2 of Schedule 3 to the Act	-
1000	=	Kilograms per metric tonne	kg t^{-1}
g	=	Specific animal group in stratum k	-
k	=	Specific stratum in the project scenario	-

Equation 18: Indirect nitrous oxide emissions from volatilization of managed manure for a stratum in the project scenario

$$VN_{PE,k} = AN_g \times DOF_g \times NEX_g \times Frac_V \times EF_V \times \frac{44}{28} \times GWP_{N2O} \div 1000$$

Where,			Units
$VN_{PE,k}$	=	Indirect nitrous oxide (N_2O) emissions from volatilization of managed manure for stratum k in the project scenario	tCO_2e
AN_g	=	Number of animals in animal group g in stratum k	head
DOF_g	=	Days on feed for animal group g in stratum k	days

NEX_g	=	Daily nitrogen (N) excreted in manure for animal group g in stratum k, as per Equation 8	kg $head^{-1}$ $days^{-1}$
$Frac_v$	=	Fraction of N excreted in manure that volatilizes as ammonia (NH_3) and NO_x from the manure storage system, as set out in Schedule A – Table 8	
EF_V	=	Emission factor for indirect N_2O emissions from volatilization of managed manure based on ecozone, as set out in Schedule A – Table 9	kg N_2O-N per kg N deposited
44/28	=	Conversion of N_2O-N to N_2O emissions based on molecular mass of N_2O and N_2O-N	-
GWP_{N2O}	=	GWP of N_2O as provided in Column 2 of Schedule 3 to the Act	tCO_2e tN_2O^{-1}
1000	=	Kilograms per metric tonne	kg t^{-1}
g	=	Specific animal group in stratum k	-
k	=	Specific stratum in the project scenario	-

Equation 19: Indirect nitrous oxide emissions from leaching of managed manure for a stratum in the project scenario

$$LN_{PE,k} = AN_g \times DOF_g \times NEX_g \times Frac_L \times EF_L \times \frac{44}{28} \times GWP_{N2O} \div 1000$$

Where,			Units
$LN_{PE,k}$	=	Indirect nitrous oxide (N_2O) emissions from leaching of managed manure for stratum k in the project scenario	tCO_2e
AN_g	=	Number of animals in animal group g in stratum k	head
DOF_g	=	Days on feed for animal group g in stratum k	days
NEX_g	=	Daily nitrogen (N) excreted in manure by animal group g in stratum k, as per Equation 8	kg $head^{-1}$ $days^{-1}$
$Frac_L$	=	Fraction of N excreted in manure leached from the manure storage system, as set out in Schedule A – Table 8	-
EF_L	=	Emission factor from N leaching and runoff set at 0.0075	kg N_2O-N per kg N leached
44/28	=	Conversion of N_2O-N to N_2O emissions based on molecular mass of N_2O and N_2O-N.	-

GWP_{N2O}	=	GWP of N_2O as provided in Column 2 of Schedule 3 to the Act	-
1000	=	Kilograms per metric tonne	kg t^{-1}
g	=	Specific animal group in stratum k	-
k	=	Specific stratum in the project scenario	-

8.2.4 Beef production in the project scenario

The proponent must used Equation 20 to quantify the beef production value for each stratum in the project scenario, which represents the average mass gained. The value used for the average mass of animals at entry and exit in Equation 20 is selected by stratum based on the destination of the animals exiting the project site. For a stratum that is not sent directly to a meat processing facility upon exiting the project site (*e.g.* backgrounding operation), the average mass of animals upon entry and exit is determined by the measure of average live weight of animals entering ($LW_{enter,g}$) and exiting ($LW_{exit,g}$) the project site. For a stratum sent directly to a meat processing facility after exiting the project site (*e.g.* finishing operation), the average mass of animals upon entry and exit is determined by the calculation of the hot carcass weight (HCW) as per Equation 12. If the average mass of animals for a stratum in the project scenario is determined through Equation 12, the average mass of animals for the corresponding stratum in the baseline scenario must also be determined through Equation 12.

Equation 20: Beef production for a stratum in the project scenario

$$\mathrm{Production}_{\mathrm{PE,k}} = \mathrm{Mass}_{\mathrm{exit,g}} - \mathrm{Mass}_{\mathrm{enter,g}}$$

Where,			Units
$Production_{PE,k}$	=	Beef production for stratum k in the project scenario	kg
$Mass_{exit,g}$	=	Average mass of animals exiting the project site for animal group g in stratum k, determined by either the live weight (measured) or the hot carcass weight (Equation 12)	kg
$Mass_{enter,g}$	=	Average mass of animals entering the project site for animal group g in stratum k, determined by either the live weight (measured) or the hot carcass weight (Equation 12)	kg
g	=	Specific animal group in stratum k	
k	=	Specific stratum in the project scenario	-

8.3 Stratification and animal groups

For the purpose of quantifying the baseline and project scenario GHG emissions, the proponent must identify strata for the project. Strata may be identified based on parameters including but not limited to production system, diet, feeding system, breed, age class, gender, weight, and marketing program. Stratification must adhere to the following requirements:

- Each stratum in the project scenario must have a corresponding and comparable stratum in the baseline scenario.
- When comparing strata between the project and the baseline scenario, the selected parameter type (live weight or hot carcass weight) for determining average mass of animals at entry and exit in Equation 11 must be the same selected parameter type used in Equation 20.
- Eligible project activities must be the same for all animals within a stratum in the project scenario.

In instances where physical separation of all animals in an animal group is not operationally possible, animals in different confinement areas within the project site can be grouped together for the purpose of quantifying GHG emissions for the protocol.

For an aggregation of projects, animals within a stratum must be housed at the same project site. Stratification cannot occur across projects in an aggregation.

Parameters and factors used for the quantification of GHG emissions must apply to all animals in an animal group in the baseline or project scenario.

8.4 Leakage

Market leakage may occur if the quantity of beef produced in the project scenario declines lower than the baseline scenario. Market leakage is addressed in the quantification methodology by quantifying GHG emissions in the baseline scenario relative to the unit mass of beef produced in the project scenario to ensure functional equivalency between the baseline and project scenarios. Therefore, there are no other conditions, discounts or factors to be applied in the protocol.

As a result, there is no leakage discount factor (which corresponds to variable Ci in the formula in subsection 20(2) of the Regulations) to be applied for the quantification of GHG emission reductions generated by a project undertaken under the protocol.

8.5 GHG emission reductions

The GHG emission reductions (ER), determined in accordance with Equation 21, correspond to the GHG reductions generated by the project determined in accordance with section 20 of the Regulations.

Equation 21: GHG emission reductions

$$ER_C = BE_C - PE_C$$

Where,			Units
ER_C	=	GHG emission reductions during a calendar year covered by the reporting period	tCO_2e
BE_C	=	GHG emissions from the strata in the baseline scenario that correspond to the strata in the project scenario with a median date of animal exit that falls within a calendar year covered by the reporting period, as per Equation 1	tCO_2e
PE_C	=	GHG emissions for the strata in the project scenario with a median date of animal exit that falls within a calendar year covered by the reporting period, as per Equation 14	tCO_2e
C	=	Calendar year	-

9.0 Measurement and Data

9.1 Measurement method and frequency

Table 4 identifies the parameters in the quantification methodology that must be measured and provides details regarding their measurement method and frequency.

Table 4: Measurement method and frequency for measured parameters

Parameter	Description	Units	Measurement Method and Frequency	Equation(s)
AN	Number of animals in an animal group	head	Counted once per production period	3, 4, 5, 7, 9, 10, 15, 16, 17, 18, 19
DOF	Number of days on feed	days	Determined once at the end of the production period per animal and averaged over the animal group	3, 4, 5, 7, 9, 10, 15, 16, 17, 18, 19
DM	Quantity of dry matter delivered to animals	kg	Weighed as feed is delivered to animals and added together for an animal group at the end of the production period. Separation required by forage and concentrate content to inform enteric methane conversion factor (Y_m)	4

Parameter	Description	Units	Measurement Method and Frequency	Equation(s)
DM_{waste}	Quantity of dry matter delivered to animals that was wasted or uneaten	kg	Weighed as needed and added together for the animal group at the end of the production period	4
GE	Gross energy intake for the diet per unit of dry mass of feed delivered	MJ kg^{-1}	Determined through feed analysis, as per Section 9.2. Measured once for each unique diet or each feed ingredient in the diet fed to an animal group	3, 6, 15
Y_m	Default enteric methane conversion factor for a diet based on forage content and quality	-	Forage content determined by weight of dry matter (DM) delivered to animals and quality (TDN) determined through feed analysis, as per Section 9.2	3, 15
EFlip	Default emissions factor based on percentage of supplemented lipid added to the diet	-	Determined through feed analysis, as per Section 9.2. (measurement of total ether extract concentration). Measured once for each unique diet or each feed ingredient in the diet fed to an animal group	3, 15
CP	Percentage of crude protein in the diet fed	%	Determined through feed analysis, as per Section 9.2. Measured once for each unique diet or each feed ingredient in the diet fed to an animal group	8
TDN	Percentage of total digestible nutrients in the diet fed	%	Determined through feed analysis, as per Section 9.2. Measured once for each unique diet or each feed ingredient in the diet fed to an animal group. Also used to inform enteric methane conversion factor (Ym)	6
Dressing	Dressing percentage of the animal	%	Determined once at the end of the production period per animal and averaged over the animal group. Measured by meat processing facility	12, 13
LW	Average live weight of animals in an animal group entering or exiting the project site	kg	Animals are weighed at the start and end of the production period and averaged over the animal group	12, 13

The Y_m and EF_{lip} factors are default factors that are not directly measured; however, these parameters must be selected based on the composition and quantity of certain feed ingredients which require measurement. Some Table 4 parameters require measurement by animal or diet and must be averaged for use in the quantification equations of Section 8.0.

Dressing percentage is determined by the meat processing facility and may not be applicable to all strata. A default factor may be used instead of measurement under the circumstances described in Sections 8.1.4 and 8.2.4.

9.2 Feed analysis

9.2.1 Parameters requiring feed analysis

Several equations in Section 8.0 use parameters that are based on detailed information regarding the composition of the diet delivered to an animal group. These parameters must be determined through feed analysis, as described in Table 4.

Feed analysis of the diet must be completed using one of the following methods:

- Sampling and laboratory analysis of the feed.
- On-farm near infrared spectroscopy analysis.
- Guaranteed analysis for nutrients provided by the feed manufacturer.

The proponent must ensure that feed samples collected and sent for laboratory analysis are representative of the selected feed or diet and must be completed by a qualified professional as described in Section 10.6. All feed parameters must be calculated on a dry weight basis.

9.2.2 Weighted values for feed parameters

Values for the parameters in Table 4 must be representative of the entire diet for the animal group. If the diet of an animal group varies in source or nutrient composition throughout the production period, a mean value must be used and weighted to the number of days each unique diet was delivered to the animal group. The proponent must use Equation 22 to determine the weighted mean for each parameter determined by feed analysis identified in Table 4 for use in any applicable Equations in Section 8.0.

Equation 22: Weighted mean of Table 4 parameters requiring feed analysis

$$\mathrm{WM} = \sum_{x}^{n} (\mathrm{FP_x} \times \mathrm{Days_x}) \div \mathrm{DOF}$$

Where,			Units
WM	=	Weighted mean of the feed parameter in Table 4	Units of Table 4 parameter
$\mathrm{FP_x}$	=	Feed parameter value for diet x measured or mean calculated using Equation 23	Units of Table 4 parameter

$Days_x$	=	Numbers of days an animal group was fed diet x	Days
x	=	Specific diet fed to an animal group	-
n	=	Number of different diets that were fed to an animal group	-
DOF	=	Days on feed for an animal group	Days

If on-farm near infrared spectroscopy or feed manufacturer guarantees are used to determined feed parameter values (FP_x), feed analysis must be conducted for each unique diet (x). If sampling and laboratory analysis is used to determine the feed parameter values (FP_x) for each unique diet (x), feed analysis may be conducted by diet or by each individual feed ingredient in the diet. For feed analysis conducted by sampling each feed ingredient, the proponent must use Equation 23 to calculate the mean value of the unique diet for input into Equation 22.

Equation 23: Mean value of a specific diet fed to an animal group weighted to the dry matter of each feed ingredient contained in the diet

$$FP_x = \sum_{y}^{n} (FI_y \times DM_y) \div DM_x$$

Where,			Units
FP_x	=	Mean feed parameter value for diet x	Units of Table 4 parameter
FI_y	=	Measured value of feed ingredient y	Units of Table 4 parameter
DM_y	=	Dry matter of feed ingredient y	kg
DM_x	=	Dry matter of all feed ingredients in a diet	kg
x	=	Specific diet fed to an animal group	-
y	=	Specific feed ingredient in diet x	-
n	=	Number of different feed ingredients in diet x	-

9.3 Quality assurance and quality control

The proponent must have documented quality assurance and quality control (QA/QC) procedures and must implement them to ensure that all measurements and calculations have been made correctly and can be verified.

For feed analysis conducted using on-farm near infrared spectroscopy, the proponent must check each on-farm near infrared spectroscopy devices for accuracy by following manufacturer specifications at least once each calendar year. On-farm near infrared spectroscopy devices must also be calibrated by the manufacturer or by a third party certified for that purpose and in accordance with the manufacturer specifications, or every 5-years which ever is sooner.

The measurement accuracy of all on-farm near infrared spectroscopy devices must show that each device provides a reading that is within a ± 5% accuracy range compared to laboratory analysis. When the accuracy of an on-farm near infrared spectroscopy device deviates from the ± 5% range, the appropriate corrective action(s) must be taken, in accordance with the manufacturer specifications.

After the corrective action(s), the on-farm near infrared spectroscopy device must be rechecked for accuracy. If the accuracy of the on-farm near infrared spectroscopy device is still not within the ± 5% range, it must be calibrated by the manufacturer or by a third party certified for that purpose and following manufacturer specifications.

For the entire period from the last time the on-farm near infrared spectroscopy device showed a reading within ± 5% accuracy, until the time it shows a return to ± 5% accuracy:

- When the inaccuracy of the on-farm near infrared spectroscopy device indicates an under-reporting, the measured values must be used without correction.
- When the inaccuracy of the on-farm near infrared spectroscopy device indicates an over-reporting, the measured values must be corrected by the percentage that the accuracy of the measuring device deviated from the ± 5% range.

10.0 Records

10.1 General records requirements

In addition to the record keeping requirements in the Regulations, the proponent must retain all data and records that support the implementation of the project.

10.2 Project site

The proponent must retain information about the project site, including:

- Documentation demonstrating the manure produced by the animals in the baseline and project scenarios was managed according to any provincial or territorial legislation applicable to the project site such as but not limited to manure handling plans or nutrient management plans.

10.3 Animal inventory and performance information

The proponent must retain information about the cattle and their performance, including:

- Documentation that identifies each animal in the baseline and project scenarios using radio-frequency identification (RFID) tags.
    - For animals with lost or damaged RFID tags, records must be retained demonstrating the animal was removed from the project or the tag was retired and replaced for each animal to which this situation applies.

- Documentation demonstrating the date of animal entry and exit from the project site linked to the RFID tags for each animal. Documentation must be in a format that confirms the date of entry and exit to calculate number of days on feed for each animal group.
- Records demonstrating the average incoming and outgoing mass of animals in an animal group. Records can be based on individual cattle weights or records that demonstrate the weight of more than one animal such as purchase information or weigh scale tickets. Records provided must only apply to animals within an animal group.
- If applicable, records from the meat processing facility confirming hot carcass weight and / or dressing percentage for an animal group.
- Documentation showing corrected hot carcass weights for the animal group on an outgoing basis unless live weights are used.

10.4 Project activities and diet information

The proponent must retain information about the records from Table 5 for each animal group.

Table 5: Information and records required to support project activities and diet

Required information		Source and description of required records
Feed delivered	Dry matter intake	• Documentation showing the dry mass of feed delivered and consumed for each unique diet. • Records and procedures demonstrating the conversion of wet mass feed to dry mass.
	Dry matter wasted or uneaten	• Documentation showing the dry mass of feed delivered that was not eaten or wasted if applicable.
	Days on each diet	• Documentation showing the days each unique diet was fed to an animal group to verify the appropriateness of the weighted mean for the Table 4 parameters requiring feed analysis.
Diet composition	Feed analysis	• Dated documentation or records from a laboratory, near infrared spectroscopy analyzer, or feed manufacturer confirming the values for parameters in Table 4 requiring feed analysis for each unique diet or feed ingredient.
Project activities	Improved management	• Documentation outlining the change in management practice(s) undertaken to reduce GHG emissions. Information must be supported by sign-off from a qualified professional indicating the practice is expected to improve the GHG emission intensity of the project as quantified in Section 8.0.
	Diet reformulation	• Documentation outlining the dietary changes undertaken to reduce GHG emissions.
	Feed additives	• Documentation showing the feed additives administered to cattle in both the baseline and project scenarios. Documentation must show the name of the additive, quantity, date(s) administered and method of delivery.

		• If the eligible project activity is modifying or adjusting the dosage of a feed additive, sign-off must be provided from a qualified professional indicating the newly prescribed dosage is expected to improve the GHG emission intensity of the project as quantified in Section 8.0.
	Growth promoters	• Documentation showing the growth promoters administered to cattle in both the baseline and project scenarios. Documentation must show the name of the product, quantity, date(s) administered and method of delivery
	Other innovative strategies	• Documentation outlining the strategy or strategies undertaken to reduce GHG emissions. Information must be supported by sign-off from a qualified professional indicating the practice is expected to improve the GHG emission intensity of the project as quantified in Section 8.0.

If on-farm near infrared spectroscopy is used by the project, the proponent must also retain:

- Maintenance records for the on-farm near infrared spectroscopy devices used including records or accuracy checks.
- Documentation describing the corrective measures applied if a measuring device or meter fails to meet the requirements for measurement accuracy.
- The calibration certificates and / or other records from either the manufacturer or a third-party certified for that purpose for each measuring device or meter which indicate calibration date, time, and results.

10.5 Stratification and animal groups

The proponent must retain the methods and procedures used to stratify animals including the factors forming the basis for stratification decisions. Animals in each stratum must be identifiable using the animal inventory information in Section 10.3. Records must also indicate if all animals in each animal group were physically separated from other animals on the operation, or if the animal group exists solely for the purpose of calculating GHG emissions. The information must be verifiable by the verification body to verify if the strata in the project and the baseline conditions are comparable for the purposes of quantifying GHG emission reductions.

10.6 Qualified professionals

Records from qualified professionals are required to support the project documentation where listed. Qualified professionals include veterinarians, Professional Agrologists (P.Ag.) and feed nutritionists.

The proponent may work with third parties to collect, store and manage data for the project. Data used to satisfy the records requirements stored and managed by a third party must be collected from the project site, feed, or animals being quantified.

11.0 Reporting

In addition to the reporting requirements specified in the Regulations, the proponent must include in a project report:

- A clear description of the eligible project activities undertaken for each full or partial calendar year of a reporting period and the strata for which they apply.
- Rationale to explain and justify stratification decisions.
- The quantified GHG emissions for each SSR included in the baseline and project scenarios in tCO_2e for each full or partial calendar year covered by the reporting period.

Schedule A

Default conversion, emission and fraction factors for varying diets and manure storage systems

Table 6: Enteric methane conversion factors based on diet composition and quality[1]

Diet Description	Enteric methane conversion factor (Y_m)
Diets of more than 75% low to medium quality forage containing < 60% total digestible nutrients	0.07
Diets of more than 75% high quality forage containing ≥ 60% total digestible nutrients	0.063
Mixed diets with forage content of 15 to 75% and the total diet is mixed with grain	0.063
All other grains with 0 to 15% forage	0.04
Steam-flaked corn and ionophore supplement with 0 to 10% forage	0.03

Table 7: Emission factors for the addition of supplemented lipid determined as a percentage of total dry weight of feed delivered

Supplemented Lipid Added (%)	Emission Factor (EF_{lip})
≤ 1	1.0
1.0 to 1.99	0.96
2 to 2.99	0.92
3.0 to 3.99	0.88
4.0 to 4.99	0.84
5.0 to 6.0	0.80
Note: The maximum allowable quantity of supplemented lipids is 6% as described in Section 6.3.	

[1] Values from Table 6 are adapted from International Panel on Climate Change. (2019). Chapter 10: Agriculture, Forestry and Other Land Use. Calvo Buendia, E., Tanabe, K., Kranjc, A., Baasansuren, J., Fukuda, M., Ngarize S., Osako, A., Pyrozhenko, Y., Shermanau, P. and Federici, S. (eds). in 2019 refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Table 8: Conversion, emission and fraction factors based on manure storage system[2]

	Solid storage and dry lot	Liquid, slurry or pit storage below confinements	Other manure storage system
Manure methane conversion factor (MCF)	0.02	0.2	0.01
Nitrous Oxide Emission Factor (EF_{MS}) (kg N_2O-N per kg N stored)	0.02	0.001	0.005
$Frac_V$	0.3	0.4	0.24
$Frac_L$	0.03	0	0.05
Descriptions	Descriptions of each type of manure storage system can be found in Table 10.18 of the 2019 refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4, Chapter 10 Emissions from Livestock and Manure Management.		

Table 9: Nitrous oxide emissions factors for nitrogen volatilized from manure storage by ecozone[3]

Ecozone	Nitrous oxide emissions factor for nitrogen volatilized from manure storage (EFv) (kg N_2O-N per kg N deposited)
Taiga Plains	0.005
Boreal Shield	0.014
Atlantic Maritime	0.014
Mixedwood Plains	0.014
Boreal Plains	0.005
Prairies	0.005
Pacific Maritime	0.014
Montane Cordillera	0.005

[2] Environment and Climate Change Canada. (2023). Chapter 5: Agriculture. National inventory report 1990-2021: greenhouse gas sources and sinks in Canada. Canada's submission to the United Nations framework convention on climate change.
[3] Environment and Climate Change Canada. (2023). Chapter 5: Agriculture. National inventory report 1990-2021: greenhouse gas sources and sinks in Canada. Canada's submission to the United Nations framework convention on climate change.